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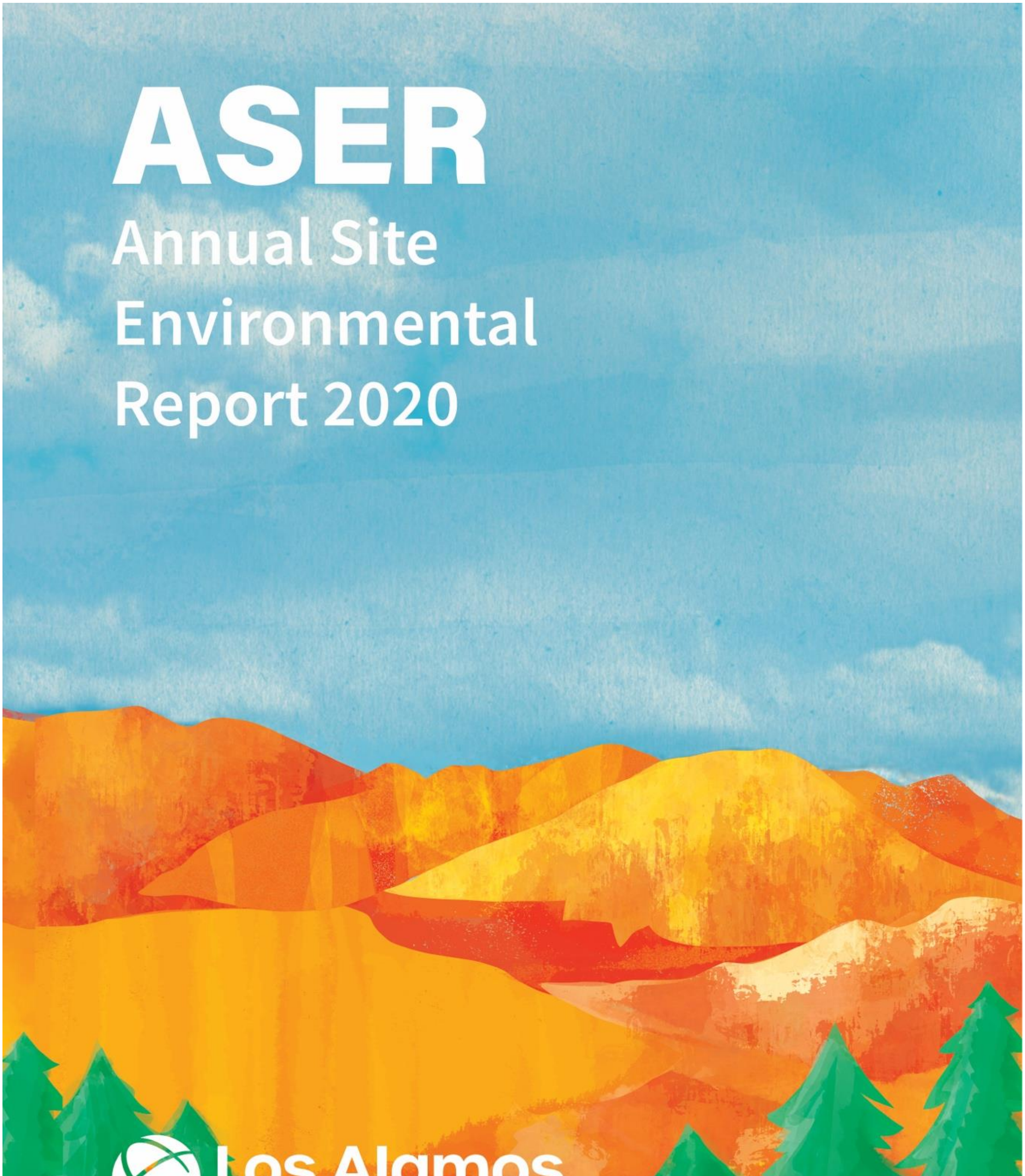

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- We are committed to act as stewards of our environment to achieve our mission in accordance with all applicable environmental requirements.
- We set continual improvement objectives and targets, measure and document our progress, and share our results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

ANNUAL SITE ENVIRONMENTAL REPORT FOR 2020
LA-UR-21-28555
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Abstract

Los Alamos National Laboratory's (the Laboratory's) annual site environmental reports are prepared each year 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 4, *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 and Analytical Data Quality); 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 Protection); 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. 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 questions or suggestions to improve this report or want a copy of this report, please contact us at envoutreach@lanl.gov, or call the Communications Office at (505) 665-7000.

This report, its supplemental tables, and the 2020 *Annual Site Environmental Report Summary* are available at http://www.lanl.gov/environment/environmental-report.php.

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Executive Summary

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 mission is our commitment to environmental stewardship and full compliance with environmental protection laws. Part of that commitment includes reporting on the Laboratory's environmental performance. This site environmental report.

Elk in mixed conifer forest

- 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.

Los Alamos National Laboratory has changed substantially since it was founded as part of the Manhattan Project in 1943. 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.

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.

Environmental stewardship requires an active management system to provide environmental policy, planning, implementation, corrective actions, and management review. We use an Environmental Management System to accomplish this. The Laboratory has been certified to the International Organization for Standardization's 14001 standard for the Environmental Management System since April 2006.

The following chapters in this report discuss a range of topics: 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 and Analytical Data Quality); 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 Protection); 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).

Laboratory operations, including some monitoring and remediation activities, were somewhat curtailed during part of 2020 because of restrictions related to the COVID-19 pandemic.

2020 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 2-20 in Chapter 2).
- Work was substantially completed on supplemental environmental projects agreed to under a 2016 settlement agreement with the State of New Mexico.
- The New Mexico Environment Department granted certificates of completion for five remedial sites in fiscal year 2020. Of the remaining sites, 134 are deferred because of ongoing operations, and 909 have investigations or corrective actions either in progress or pending.
- Mixed wastes managed under the Laboratory's Site Treatment Plan decreased by approximately 40 cubic yards for mixed low-level waste and 223 cubic yards for mixed transuranic wastes.
- The Laboratory was fully in compliance with its Clean Air Act, Title V Operating Permit emission limits.
- Two loads of asbestos-containing waste were mistakenly taken to the Los Alamos County Eco Station by a construction subcontractor. As soon as the issue was discovered, we submitted an emergency notification to the New Mexico Environment Department, and the waste was cleaned up and taken to an approved disposal site.
- We discharged approximately 122 million gallons of liquid effluents from eight permitted outfalls. Seven of the 654 outfall samples collected (1.1 percent) exceeded effluent quality limits in the outfall permit (Table 2-6 in Chapter 2).
- Two areas of the regional aquifer at the Laboratory have groundwater contaminants that are of sufficient concentration and extent to warrant actions, such as interim measures, further characterization, and potential remediation under the 2016 Consent Order: RDX contamination in the vicinity of Technical Area 16 and chromium contamination beneath Sandia and Mortandad Canyons. Interim measures to control the chromium plume boundary are ongoing and are showing positive results (Chapter 5).
- No environmental occurrences were reported under DOE Order 232.2, Occurrence Reporting and Processing of Operations Information.
- The Laboratory had 4 inspections or audits conducted by regulating agencies or external auditors in 2020 (Table 2-18 in Chapter 2).
- We made 19 reports of unplanned nonradioactive liquid releases to the New Mexico Environment Department (Table 2-19 in Chapter 2).
- Radiological doses to the public from Laboratory operations were less than 1 millirem per year, and health risks are indistinguishable from zero.

- Newly discovered buried waste from the Manhattan Project era on a land tract that was previously transferred from the Laboratory to Los Alamos County is being characterized and remediated (Chapters 3 and 4).

2020 Environmental Monitoring Highlights

During 2020, we completed the following:

- The Laboratory operated 41 environmental air-monitoring stations and conducted stack monitoring at nine facilities to measure levels of airborne radiological materials. During 2020, the radioactive emissions from all Laboratory sources amounted to less than 1 percent of the regulatory limit, and concentrations of airborne radioactive material measured in ambient air samples were below the applicable concentration levels for environmental compliance.
- Comparing results of the storm water, base flow, and sediment sampling in 2020 to previous results continued to verify 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 a given stream reach.
- The Laboratory completed an aquatic ecosystem health assessment of the Rio Grande upstream and downstream of the Laboratory, as well as in Abiquiu and Cochiti Lake reservoirs. We collected fish, crayfish, and sediments, conducted sediment biotoxicity assays, and evaluated benthic macroinvertebrate communities. With a few exceptions, the majority of constituents did not statistically differ in the Rio Grande above and below its confluence with Los Alamos Canyon or between the reservoirs. Additionally, there were no differences in benthic macroinvertebrate indices or communities in the Rio Grande. All concentrations of radionuclides in sediment were below biota dose screening levels and chemicals were below the low effect screening levels. All concentrations of chemicals in biota were below the lowest observed adverse effect level. These results indicate that chemicals and radionuclides resulting from Laboratory operations that may be present in storm water and snow melt flows have not had an adverse effect on the Rio Grande aquatic ecosystem during 2011–2020.
- The 2020 biota dose assessment confirms previous assessments and shows no harmful effects to the biota populations at LANL from Laboratory radioactive materials.

An additional summary of this report can be found in the Los Alamos National Laboratory 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.

Chapter 1: Introduction

Los Alamos National Laboratory (the Laboratory) was established in 1943. As Project Y of the Manhattan Project, its objective was to design and build the world's first atomic bombs. The Laboratory continues today with a mission to solve national security challenges, surrounded by the diverse communities of Northern New Mexico and employing approximately 13,500 people.

The COVID-19 pandemic of 2020 changed some of the ways the Laboratory operated (Figure 1-1). The workforce was directed to work from home as much as possible starting in mid-March. During the remainder of 2020, the Laboratory's status varied between "maintaining minimum safe and secure operations onsite [. . .] and requiring that all other staff telecommute" to "normal operations with maximized telework." During this entire period, well over half of the Laboratory's workforce worked at offsite locations on any given day.

Figure 1-1. In Los Alamos, New Mexico, statues of Robert Oppenheimer and General Leslie Groves wear masks during the COVID-19 pandemic.

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Background and Purpose

Background

In March 1943, a small group of scientists came to Los Alamos, New Mexico, for Project Y of the Manhattan Project. Their goal was to develop the world's first atomic bombs. By 1945, more than 3,000 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 over time. The current mission is to solve national security challenges through scientific excellence.

The Laboratory was established in 1943 by the U.S. Army Corps of Engineers. The U.S. Atomic Energy Commission took control of Los Alamos Laboratory in 1946. In 1947, Los Alamos Laboratory became Los Alamos Scientific Laboratory. The U.S. Department of Energy (DOE) took charge in 1977. Los Alamos Scientific Laboratory became Los Alamos National Laboratory (LANL or the Laboratory) in 1981. The National Nuclear Security Administration, a semiautonomous agency within DOE, has 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, Los Alamos National Security, LLC took over as the contractor responsible for managing and operating the Laboratory. In 2014, DOE decided to separate the cleanup of legacy waste from the management and operating contract. Legacy waste cleanup work was transitioned to a bridge contract under DOE's Office of Environmental Management in October 2015. A new contractor, Newport News Nuclear BWXT–Los Alamos, LLC (N3B), became responsible for legacy waste cleanup operations in April 2018. Triad National Security, LLC (Triad) was awarded the most recent management and operating contract for the Laboratory and began managing the Laboratory in November 2018. Currently, both the National Nuclear Security Administration and DOE's Office of Environmental Management maintain field offices in Los Alamos, New Mexico.

Purpose

This document is a consolidated site environmental report and fulfils the annual reporting requirements of the National Nuclear Security Administration and DOE's Office of Environmental Management 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*.

In this document, "we" refers to the people who work at Los Alamos National Laboratory, including employees of DOE and contractor organizations.

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 discharges, air emissions, 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 and assure the quality of data from analysis of environmental samples (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 Protection); how we monitor the movement of chemicals and radionuclides in stormwater 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 radioactive 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 and Demographics

Los Alamos National Laboratory is located in Los Alamos County and Santa Fe County, in north-central New Mexico, approximately 60 miles north-northeast of Albuquerque and 25 miles northwest of Santa Fe (Figure 1-2). The Laboratory sits on the Pajarito Plateau, a series of fingerlike mesas separated by canyons at the eastern edge of the Jemez Mountains. The Sierra de los Valles range of the Jemez Mountains is directly west of the Laboratory, and White Rock Canyon, containing the Rio Grande, is east. Mesa tops range in elevation from approximately 7,800 feet on the western side to about 6,200 feet on the eastern side. The Laboratory property is about 40 square miles. This includes areas with active operations as well as some additional DOE properties, such as a proposed land transfer tract in Rendija Canyon (labeled "DOE" in Figure 1-2).

The land surrounding the Laboratory is largely undeveloped. Large tracts of land north, west, and south of the Laboratory site are managed by the Santa Fe National Forest, the U.S. Bureau of Land Management, Bandelier National Monument, and Los Alamos County. The townsite of Los Alamos borders the Laboratory to the north. The Pueblo de San Ildefonso and the townsite of White Rock border it to the east. Santa Clara Pueblo is north of the Laboratory but does not share a border (Figure 1-2).

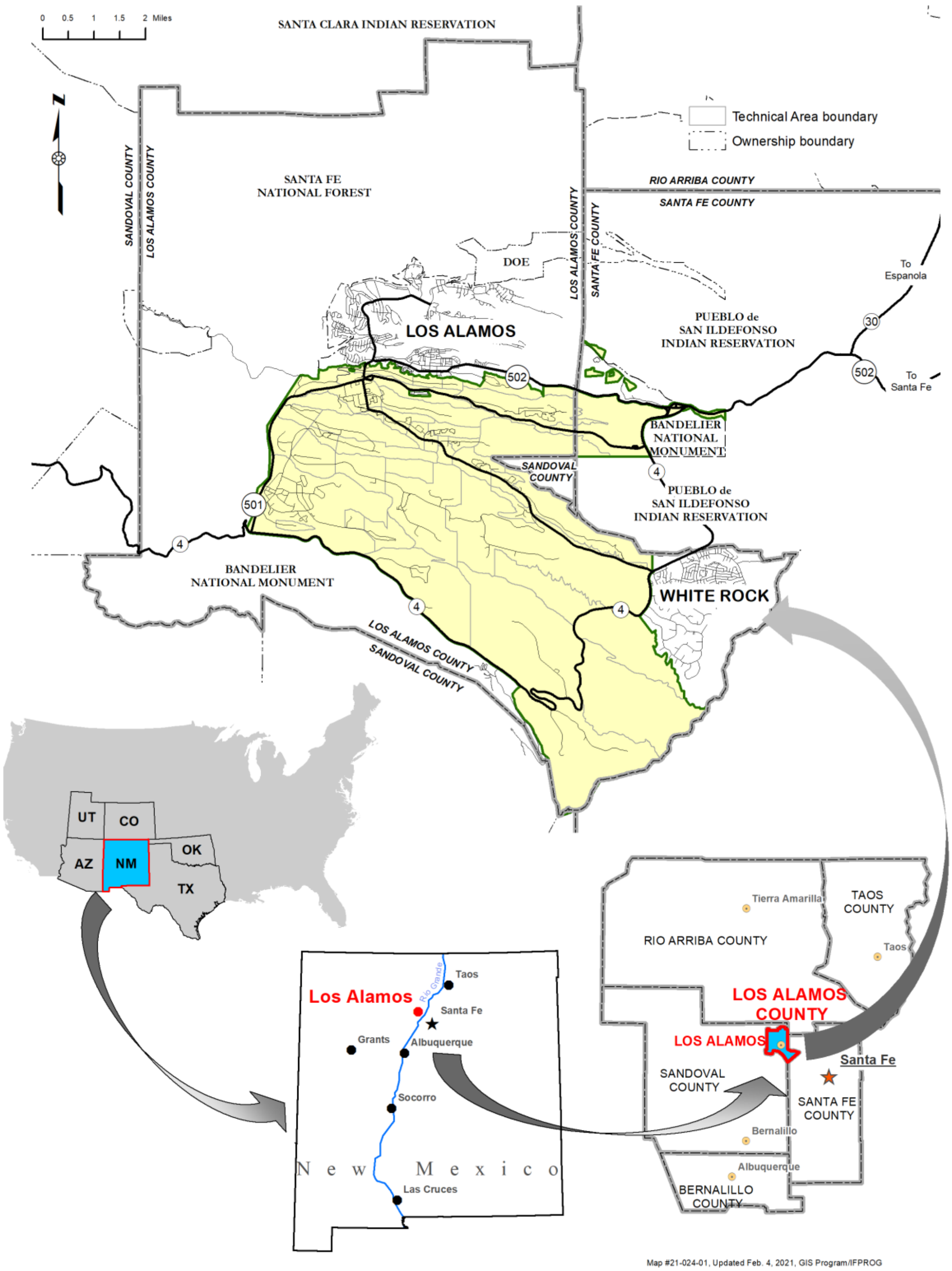

Figure 1-2. Regional location of the Laboratory

New Mexico's 2020 population was 2,117,522 people (Census 2021a) and the estimated population within a 50-mile radius of Los Alamos was 572,004 residents (CIESIN 2021). The counties with substantial land area within 50 miles of the Laboratory are Los Alamos, Santa Fe, Sandoval, and Rio Arriba counties. The estimated racial and ethnic composition of the population within these counties, based on data from the U.S. Census Bureau's American Community Survey from 2015–2019, is shown in Table 1-1 (Census 2021b). Figure 1-3 shows municipalities and tribal properties within 50 miles of the Laboratory.

Table 1-1. Estimated Racial and Ethnic Composition of the Population Within Los Alamos, Santa Fe, Sandoval, and Rio Arriba counties 2015–2019 (Census 2021b)

Race	**Number of People**
White alone	264,653
Black or African American alone	5,259
American Indian and Alaska Native alone	29,705
Asian alone	4,982
Some other race alone	33,705
Two or more races	11,477
Ethnicity	**Number of People**
Hispanic or Latino, of any race	163,213
Not Hispanic or Latino	186,568

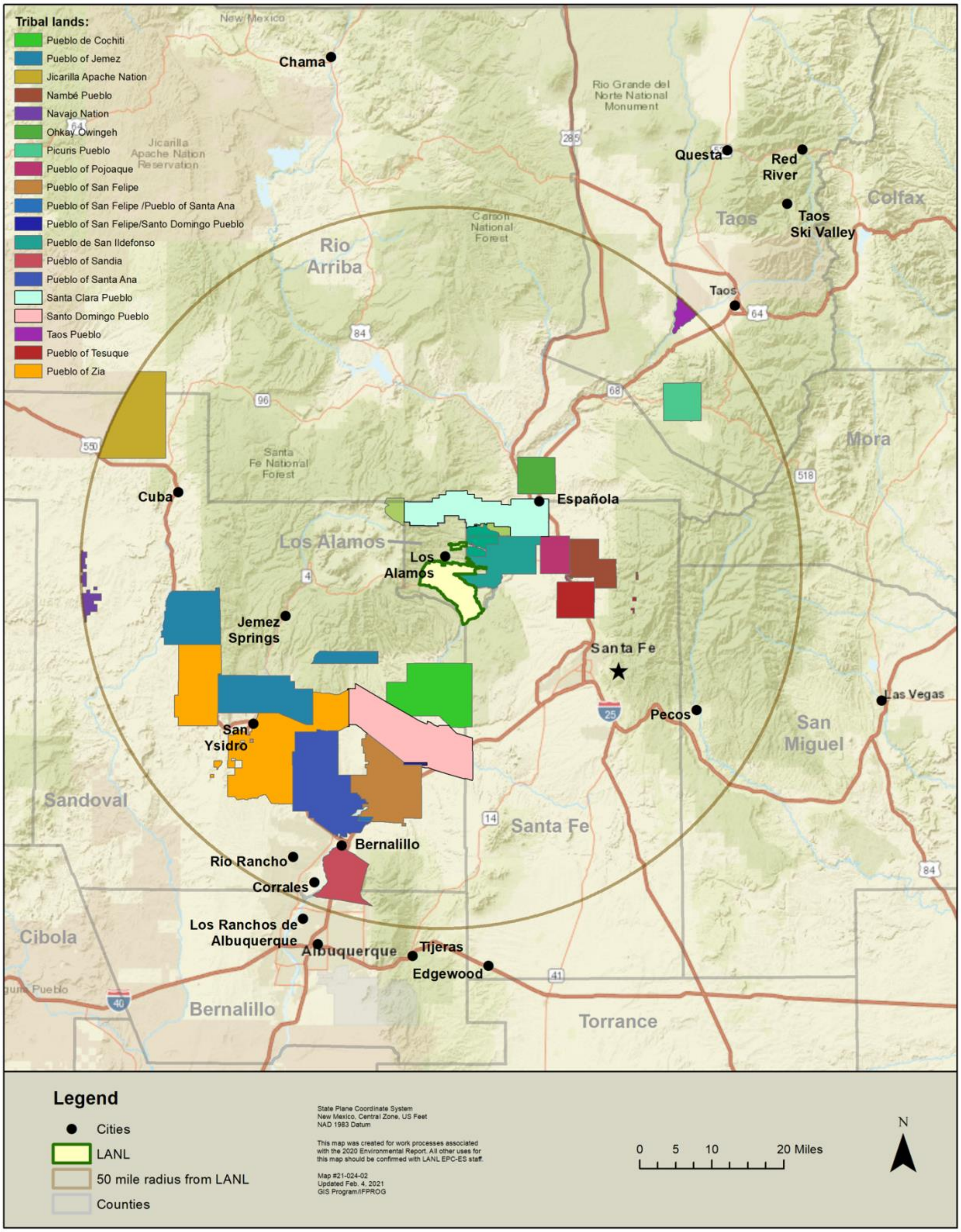

Figure 1-3. Municipalities and tribal properties within a 50-mile radius of the Laboratory

Geology

Los Alamos National Laboratory lies along a continental rift named the Rio Grande Rift. Continental rifts result when tectonic plates in the Earth's crust move apart. A rift allows magma to rise near the Earth's surface, and volcanoes are common features of rifts. The Jemez Mountains are the remnant of a large collapsed volcanic field. Most of the rock formations that make up the Pajarito Plateau come from materials expelled during volcanic eruptions.

The mesas of the Pajarito Plateau are mostly composed of Bandelier Tuff. Tuff is a type of soft rock that forms from volcanic ash. The Bandelier Tuff is more than 1,000 feet thick in the western part of the plateau and thins to about 260 feet thick on the eastern edge of the plateau above the Rio Grande.

On the western side of the Pajarito Plateau, the Bandelier Tuff overlaps the Tschicoma Formation of the Jemez Mountains. The Tschicoma Formation is an older rock layer of volcanic dacite. Eastward near the Rio Grande, the Puye Formation, a layer of sand and gravel that underlies the Bandelier Tuff, becomes visible in places. The Puye Formation can store groundwater. Basalt rocks originating 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 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 3,300 feet thick. The Santa Fe Group sediments form the regional aquifer.

Rifts are associated with faults (fractures between two blocks of rocks). The rift boundary in the Los Alamos area consists of a local master fault and three subsidiary faults, known as the Pajarito fault zone. Past and present studies at the Laboratory investigate the earthquake hazards associated with these faults (Gardner et al. 1990, Larmat 2019).

Climate

Los Alamos County has a semiarid climate, meaning that more water is lost from the soil and plants through evaporation and transpiration than is received as annual precipitation. Annual temperatures and amounts of precipitation differ across the county because of the 5,000-foot elevation range 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.

On average, winter temperatures range from 30°F to 50°F during the day and from 15°F to 25°F during the night. The Sangre de Cristo Mountains to the east of the Rio Grande 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.

The rainy season begins in early July and ends in early September. Afternoon thunderstorms form in the summer as moist air from the Pacific Ocean and the Gulf of Mexico lifts over the Jemez Mountains, and then often move eastward across the Laboratory. These thunderstorms produce short, heavy downpours and an abundance of lightning. Local lightning density is estimated at 15 strikes per square mile per year.

The average annual precipitation (which includes both rain and the water equivalent of snow, hail, and any other frozen precipitation) is about 19 inches. The average annual snowfall is about 57 inches.

The complex topography of the Pajarito Plateau influences local wind patterns. Daytime winds in the Los Alamos area are predominantly 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 the downslope flow of cooled mountain air.

The information above is based on 1981–2000 data. Next year, we will use averages from 1991–2010 data. Please see the Meteorology section in Chapter 4, Air Quality, for more information.

Hydrology

Surface water on the Laboratory occurs primarily as ephemeral flow, associated with individual rain 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. Some springs on the edge of the Jemez Mountains supply water year-round to western sections of some canyons on Laboratory property, but the amount of water is not enough to maintain surface flows across the plateau to the eastern Laboratory boundary.

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 underground 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, located in 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 water added 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 the springs in White Rock Canyon.

Biological Resources

The Pajarito Plateau is biologically diverse, partly because of the dramatic 5,000-foot elevation change from the Rio Grande up to the top of the Jemez Mountains and partly because of the many steep canyons that dissect the area. The major types of vegetative cover in this 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 5,600 and 6,200 feet; (2) juniper woodlands with scattered piñon (*Pinus edulis*) trees, generally between 6,200 and 6,900 feet in elevation and covering large portions of the mesa tops and north-facing canyon slopes at the lower elevations; (3) ponderosa pine (*Pinus ponderosa*) woodlands on the western portion of the plateau at between 6,900 and 7,500 feet in elevation; and (4) mixed-conifer woodlands and forests at elevations of 7,500 to 9,500 feet, overlapping the ponderosa pine community both in the deeper canyons and on north-facing canyon 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 occurring throughout New Mexico since 1998 have resulted in the loss of many forest and woodland trees. Between 2002 and 2005, more than 90 percent 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). Many 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. 2013).

Two major wildfires have also affected the Laboratory: the Cerro Grande fire in 2000 and the Las Conchas fire in 2011. Both fires resulted in loss of forest trees on the slopes of the Jemez Mountains west of the Laboratory and were followed by large flash floods that caused extensive soil erosion and some damage to infrastructure. A 1,000-year storm event in September 2013 also resulted in flooding and damage.

Cultural Resources

Surveys of approximately 90 percent of the DOE land in Los Alamos County have identified over 1,900 prehistoric and historic cultural sites. Nearly 79 percent of the sites were constructed and used by Ancestral Pueblo people during the thirteenth, fourteenth, and fifteenth centuries. However, evidence suggests human activity from the Paleoindian Period (16,000–8,000 BC) through the Historic Period (seventeenth century–present). Cultural resource specialists at the Laboratory document and evaluate these cultural sites for their eligibility in the National Register of Historic Places.

The Laboratory itself is also associated with events of national significance in recent history. We have evaluated over 300 buildings and structures at the Laboratory used during the Manhattan Project and Cold War historical periods (1943–1990) for listing in the National Register of Historic Places. Of these, 171 buildings have been declared eligible.

Established in 2014, the Manhattan Project National Historical Park, managed by the National Park Service, includes units at Hanford, Washington; Oak Ridge, Tennessee; and Los Alamos. Nine buildings associated with the design and assembly of Gadget (the atomic bomb tested at Trinity Site), the Little Boy weapon (the atomic bomb detonated over Hiroshima, Japan), and the Fat Man weapon (the atomic bomb detonated over Nagasaki, Japan) are currently part of the Manhattan Project National Historical Park at Los Alamos National Laboratory. Eight additional Laboratory buildings and structures, identified in the park legislation, are considered eligible properties for inclusion in the Park.

Laboratory Activities and Facilities

The mission of the Laboratory is to solve national security challenges through scientific excellence. The current goals of the Laboratory are to: (1) deliver national nuclear security and broader global security mission solutions; (2) attract, inspire, and develop world-class talent to ensure a vital future workplace; (3) foster excellence in science and engineering disciplines essential for national security missions; and (4) enable 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 property is organized into 49 technical areas, which contain buildings, experimental areas, support facilities, roads, and utility rights-of-way (Figure 1-4 and Appendix C, Descriptions of Technical Areas and their Associated Programs). Developed areas account for less than half of the total land area; many portions of the Laboratory act as buffer areas for security, safety, and possible future expansion. The Laboratory has about 897 buildings, trailers, and transportable buildings containing 8.2 million square feet under roof (LANL 2020).

At the end of 2020, 12,771 people were employed by the primary contractors at the Laboratory and an additional 826 people were employed by staff augmentation, protective force, and legacy waste cleanup subcontractors. The LANL-affiliated workforce resides predominantly in Los Alamos, Santa Fe, Rio Arriba, Bernalillo, Sandoval, and Taos counties and includes regular workers, temporary workers, and students.

The DOE/National Nuclear Security Administration issued a site-wide environmental impact statement for continued operation of the Laboratory in May 2008 (DOE 2008). In the 2008 Site-Wide Environmental Impact Statement, the Laboratory identified 15 facilities as being key for evaluating the potential environmental impacts of continued operation (Table 1-2 and Figure 1-4). Activities in the key facilities represent the majority of environmental impacts associated with Laboratory operations.

The remaining Laboratory facilities were identified as non-key facilities. Examples of 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.

In April 2018, the DOE/National Nuclear Security Administration published a supplement analysis that reviewed changes at the Laboratory and evaluated the adequacy of the 2008 Site-Wide Environmental Impact Statement in analyzing anticipated impacts from LANL operations during 2018 through 2022 (DOE 2018). The supplement analysis indicated that the environmental impacts occurring from 2008 through 2017 and those projected for 2018 through 2022 have not substantially changed from the impacts projected in the Site-Wide Environmental Impact Statement Record of Decisions, and are bounded by the analyses presented in the 2008 Site-Wide Environmental Impact Statement.

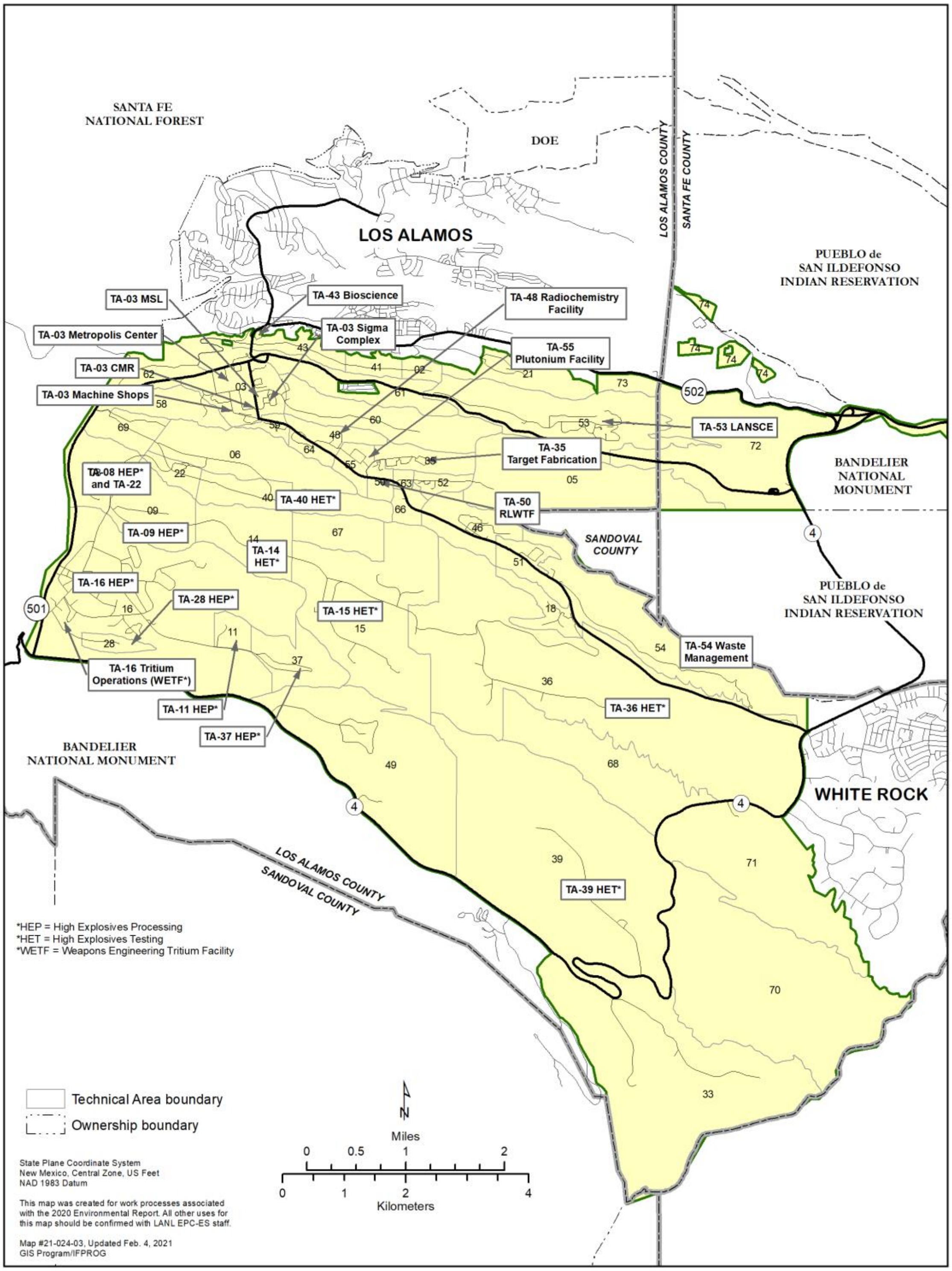

Figure 1-4. Technical Areas (TAs) and key facilities of the Laboratory in relation to surrounding landholdings

Table 1-2. Key Facilities

Facility	Technical Area(s)
Plutonium Facility Complex	55
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) Facilities	08, 09, 11, 16, 22, 37
High Explosives Testing (HET) Facilities	14, 15, 36, 39, 40
Los Alamos Neutron Science Center (LANSCE)	53
Biosciences Facilities (formerly Health Research Laboratory)	03, 16, 35, 43, 46
Radiochemistry Facility	48
Radioactive Liquid Waste Treatment Facility (RLWTF)	50
Solid Radioactive and Chemical Waste Facilities	50, 54
Weapons Engineering Tritium Facility (WETF)	16

Response to the COVID-19 Pandemic

In 2020, the COVID-19 pandemic produced dramatic changes in some Laboratory operations. The Laboratory was identified as an essential business, and it never shut down. However, the Laboratory workforce was directed to work from home as much as possible starting in mid-March (Table 1-3). During the remainder of 2020, the Laboratory's operational status varied from "maintaining minimum safe and secure operations onsite [. . .] and requiring that all other staff telecommute" to "normal operations with maximized telework."

Table 1-3. Dates, Operations Status, and Workforce Actions Taken by Los Alamos National Laboratory in Response to the COVID-19 Pandemic in 2020

Date	Status/Action
February 5, 2020	Travelers and visitors that have passed through China are directed to work from home for 14 days and self-monitor for COVID-19 symptoms. Travel to China is canceled.
March 6, 2020	All international travel is restricted, and mission-essential international travel is approved only on a case-by-case basis. COVID-19 website and hotline are set up.
March 13, 2020	Line managers are directed to explore telecommuting, work-at-home, and staggered shift options to reduce the onsite workforce presence. Employees are directed to have virtual meetings whenever possible.
March 16, 2020	The Laboratory Director states that telecommuting is the default for all employees that can do so. Nonessential domestic travel is suspended. Many employee services are limited and offices closed.
March 19, 2020	The Laboratory announces the Special Office for COVID-19 to coordinate LANL scientific and technical capabilities to support the nation's COVID-19 response.

Date	Status/Action
March 20, 2020	The Laboratory defines quarantine requirements for employees who have traveled out of state and limits the size of in-person meetings to 10 people.
March 24, 2020	Onsite operations are further curtailed. All staff are required to telecommute except for minimum key national security activities.
May–mid-November 2020	Workers are increasingly allowed onsite with the permission of their line managers. The Laboratory assigns training and a daily self-assessment for workers coming onsite. Conference and other rooms are assigned new occupancy limits.
Late November–December 2020	As the number of COVID-19 cases rise in local communities and among Laboratory employees, workers return to increased levels of offsite work.

The Laboratory asked its employees to identify their working status (either primarily working onsite, primarily working offsite, or not working) on specific days once per month following the implementation of telecommuting. During this entire period, well over half of the employees working on any given day worked at offsite locations (Figure 1-5). Teleworking and other changes in the Laboratory's operations affected several aspects of its environmental performance, as we will discuss in the following chapters.

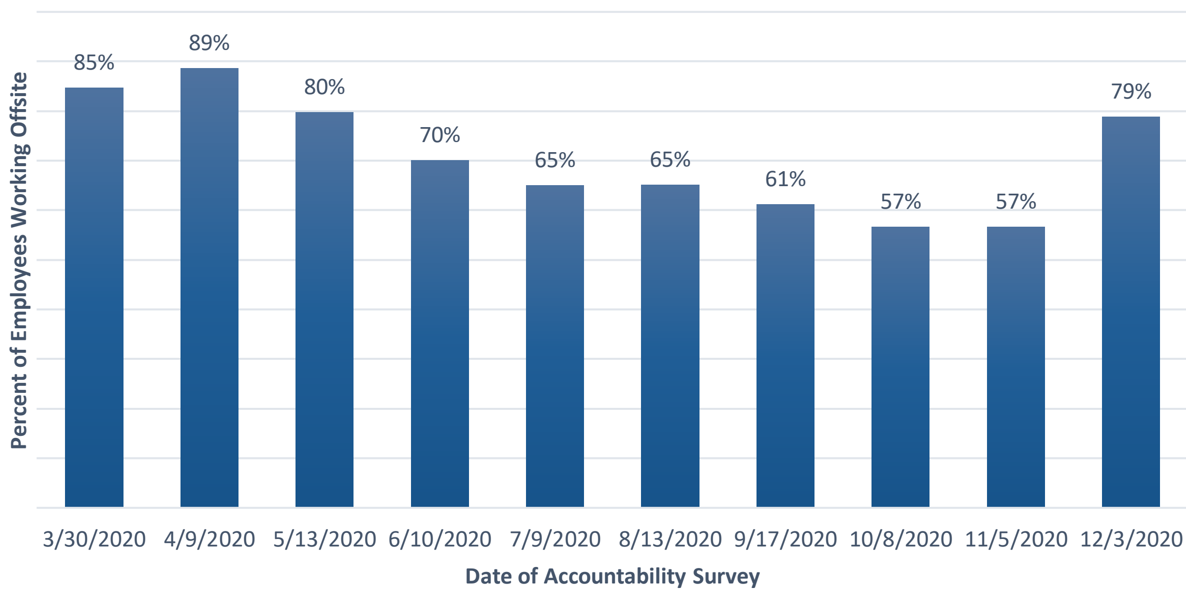

Figure 1-5. Percent of working employees who were working offsite on the day of a monthly accountability survey in 2020. Employees included LANL staff, LANL craft workers, and LANL subcontractors stationed in LANL facilities. Employees not working included those not scheduled to work on that date, those on leave, and employees who did not respond to the survey.

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Chapter 2: Compliance Summary

Compliance with environmental laws and orders is part of Los Alamos National Laboratory's (LANL's or the Laboratory's) environmental stewardship. This chapter provides a summary of the Laboratory's compliance with these laws and orders during 2020, including compliance with permit conditions and limits, inspections, notices of violations, occurrences, and accomplishments. Below is a partial list of the environmental laws and DOE Orders that apply to the Laboratory. A table summarizing the Laboratory's permits and compliance orders is provided at the end of this chapter.

Radiation Protection

- DOE Order 458.1, Radiation Protection of the Public and the Environment
- Clean Air Act – Radionuclide National Emission Standards for Hazardous Air Pollutants

Waste Management

- DOE Order 435.1, Radioactive Waste Management
- Resource Conservation and Recovery Act
- Federal Facility Compliance Act

Air Quality

- Clean Air Act
- New Mexico Air Quality Control Act

Water Quality

- Clean Water Act
- New Mexico Water Quality Act
- Energy Independence and Security Act

Natural and Cultural Resources

- National Environmental Policy Act
- National Historic Preservation Act
- Endangered Species Act
- Migratory Bird Treaty Act
- Floodplain, Wetland, and Invasive Species Executive Orders

Other Environmental Protections

- Toxic Substances Control Act
- Federal Insecticide, Fungicide, and Rodenticide Act
- New Mexico Pesticide Control Act
- DOE Order 231.1B, Environment, Safety, and Health Reporting
- DOE Order 231.2, Occurrence Reporting and Processing of Operations Information
- Emergency Planning and Community Right-to-Know Act
- DOE Order 436.1, Departmental Sustainability

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Introduction

Environmental laws are designed to protect human health and the environment by

- regulating the handling, transportation, and disposal of materials;
- regulating impacts to biological and cultural resources, air and water; and
- requiring analysis of the environmental impacts of new operations.

This chapter provides a summary of our compliance with state and federal environmental regulations and permits and DOE environmental orders during 2020, including inspections, notices of violations, and accomplishments. A table summarizing the Laboratory's environmental permits and legal orders is provided at the end of this chapter.

Radiation Protection

DOE Order 458.1 Chg 4, *Radiation Protection of the Public and the Environment*

DOE Order 458.1 directs DOE facilities to keep radiological doses to the public and the environment as low as reasonably achievable and to monitor for routine and non-routine releases of radioactive materials. The order requires DOE sites to do the following:

- Ensure the radiological dose to the public from their site activities does not exceed 100 millirem in any given year.
- Comply with the order's dose limits for wildlife and plants.
- Notify the public about any radiation doses resulting from operations.
- Use radiological limits authorized by the DOE to evaluate property that has potential to contain residual radioactivity (for example, surplus equipment, waste shipped for disposal offsite, or land parcels transferred to new owners) before releasing it to ensure that the dose does not exceed 25 millirem per year above background for real estate or 1 millirem per year above background for moveable items.

Estimated Maximum Possible Radiological Dose to the Public

During 2020, the estimated maximum radiological dose to a member of the public from Laboratory operations was less than 1 millirem, and radiation doses to wildlife and plants were below the annual DOE dose limits (Bullock et al. 2021). 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 Released from the Laboratory

Real Estate

We did not convey or transfer any land parcels during 2020.

Recycled Metals

Metals that have been exposed to ionizing radiation during Laboratory operations are evaluated for levels of radioactivity before being released for recycling. About 237.5 tons of potentially activated metal were recycled in 2020. Approximately 50% of that amount was from the Los Alamos Neutron Science Center's accelerator operations. Releases from the Los Alamos Neutron Science Center were evaluated using the protocol in the Multi-Agency Radiation Survey and Assessment for Materials and Equipment manual, and were independently reviewed by DOE. Releases from Technical Area 21 met the criteria for unrestricted radiological release under Title 10, Part 835 of the Code of Federal Regulations, *Occupational Radiation Protection*, and DOE Order 458.1.

Portable Property

Laboratory staff survey smaller personal property items (for example, tools, furniture) from radiologically controlled areas on an on-demand basis. These items typically remain onsite and, once cleared, their use is unrestricted. The policies and procedures for releasing these items comply with Title 10, Part 835 of the Code of Federal Regulations, *Occupational Radiation Protection*.

Newport News Nuclear BWXT – Los Alamos, LLC (N3B; the Laboratory's legacy waste cleanup contractor) surveyed and released portable property throughout 2020 as part of ongoing environmental remediation, waste packaging, and shipping operations. Leased equipment was also routinely surveyed and released from N3B-controlled sites. Notable campaigns include 218 bins that were surveyed and released; 74 were N3B-owned, and 144 were rented. Fabric from Dome 229 at Technical Area 54 was surveyed and released in February 2020 as part of the dome's 'reskinning' operation (Dome 229 dimensions are approximately 11 meters x 75 meters x 27 meters).

Establishment and Use of Authorized Limits

Screening action levels for radionuclides in soils are evaluated every year to determine if an update is needed. There were no updates to the screening action levels in 2020.

Waste Management Summary

Management of wastes generated by LANL operations is a crucial component of our compliance with environmental laws and is discussed in the next several sections. Table 2-1 summarizes radiological and some hazardous wastes that are generated at LANL and their current disposal pathways. The callout below provides an explanation of some waste types.

What are the types of radioactive waste?

Transuranic Waste – Waste is classified as transuranic waste when the activity of alpha-emitting transuranic radionuclides with half-lives of 20 years or more (such as plutonium, cesium, and strontium) is greater than 100 nanocuries per gram of waste.

Mixed Transuranic Waste – Mixed transuranic waste is transuranic waste along with at least one waste defined as hazardous under the Resource Conservation and Recovery Act.

Low-level Waste – Low-level radiological waste contains added radioactivity, but does not contain high-level waste (the highly radioactive waste resulting from the reprocessing of spent nuclear fuel, transuranic waste, or tailings from the milling of uranium or thorium ore);. It also does not contain any waste defined as hazardous under the Resource Conservation and Recovery Act.

Mixed Low-level Waste – Mixed low-level waste is low-level waste along with at least one waste defined as hazardous under the Resource Conservation and Recovery Act.

Table 2-1. LANL Waste Types and Disposal Methods

Waste Type	Method for Disposal	2020 Disposal Amount
Solid Transuranic Waste and Solid Mixed Transuranic Waste	The Laboratory sends solid transuranic and mixed transuranic wastes offsite to the Waste Isolation Pilot Plant in Carlsbad, New Mexico, when the transuranic or mixed transuranic waste meets the plant's waste acceptance criteria. Some transuranic and mixed transuranic waste is stored at LANL while waiting for an acceptable disposal pathway to be identified.	535 cubic yards (409 cubic meters)
Solid Low-level Radioactive Waste	The Laboratory sends solid low-level radioactive waste offsite to licensed treatment, storage, and disposal facilities. these sites include the Nevada Nuclear Security Site , operated by the DOE, and commercial facilities operated by Energy Solutions (Clive, Utah); Perma-Fix Northwest, Inc. (Richland, Washington), and Waste Control Specialists (Andrews County, Texas).	4102 cubic yards (3136 cubic meters)
Liquid Radioactive Waste	The Laboratory treats liquid radioactive waste onsite at the Radioactive Liquid Waste Treatment Facility in Technical Area 50. The treated water is either evaporated or released at permitted outfall 051.	222,241 gallons (841,274 liters)
Solid Hazardous Waste	The Laboratory sends solid hazardous waste offsite for treatment and disposal at licensed treatment, storage, and disposal facilities. In 2020, these included Veolia North America (Henderson, Colorado) and Clean Harbors (Clive, Utah).	31 tons (27,823 kilograms)

Waste Type	Method for Disposal	2020 Disposal Amount
Solid Mixed Low-level Waste	The Laboratory sends solid mixed low-level waste offsite to licensed treatment, storage, and disposal facilities. In 2020, these sites include Energy Solutions (Clive, Utah), Perma-Fix of Florida, Inc. (Gainsville, Florida), and Waste Control Specialists (Andrews County, Texas). Some of the mixed low-level waste is treated at one of the licensed treatment, storage, and disposal facilities to meet land disposal restrictions and is then disposed of at the Nevada Nuclear Security Site.	24,332 cubic feet (689 cubic meters)
Sanitary Solid Waste	The Laboratory sends sanitary solid waste, such as its office and cafeteria trash, to the Los Alamos County Eco Station for transfer to municipal landfills. Los Alamos County operates this transfer station and is responsible to the State of New Mexico for obtaining all related permits for these activities.	1499 tons (1,359,870 kilograms)
Liquid Sanitary Waste	The Laboratory treats liquid sanitary waste onsite at the Sanitary Wastewater Treatment Plant. Treated water is reused in Laboratory cooling towers and is ultimately released at permitted outfall 001.	3,099,003 gallons (11,731,002 liters)
PCB Wastes*	Waste containing polychlorinated biphenyls (PCBs), including transformers and objects contaminated with at least 50 parts per million PCBs, were are sent to U.S. Environmental Protection Agency–authorized treatment and disposal facilities, including Clean Harbors (Clive, Utah) and Veolia North America (Henderson, Colorado).	5 tons (4630 kilograms)
Asbestos-containing Waste	Asbestos-containing waste is deposited at any of several waste disposal sites operated in accordance with Title 40, Part 61, Section 154 of the Code of Federal Regulations.	403 tons (365,582 kilograms)

**This total includes waste containing only PCBs. If a waste with PCBs also contains hazardous or low-level waste, the weight of that waste is captured in the other category.*

Radioactive Wastes

DOE Order 435.1 Chg 1, *Radioactive Waste Management*

Laboratory operations using nuclear materials generate four types of radioactive wastes: low-level radioactive waste (also called low-level waste), mixed low-level waste, transuranic waste, and mixed transuranic waste. Radioactive waste generated during Laboratory operations must (1) meet Laboratory onsite 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, *Radioactive Waste Management*, and DOE Manual 435.1-1.

Onsite Low-level Radioactive Waste Disposal

Material Disposal Area G at Technical Area 54 (Area G) is the only active waste disposal facility at the Laboratory. Operations began at Area G in 1957 and included the disposal of low-level radioactive waste, certain infectious waste containing radioactive materials, asbestos-containing material, PCBs, and temporary storage of transuranic waste. Mixed low-level waste and mixed transuranic waste have been stored in surface structures at Area G. The capacity to dispose of low-level waste at Area G is very limited; waste is accepted for disposal only under special circumstances and with prior authorization. In 2020, we did not dispose of any low-level waste in Area G.

Planning for the closure of Area G has been underway since 1992. We are working with the New Mexico Environment Department Hazardous Waste Bureau under the 2016 Compliance Order on Consent to develop and implement corrective measures for the solid waste management units at Area G. Environmental monitoring at Area G currently includes (1) a direct radiation thermoluminescent dosimeter monitoring network (Chapter 4); (2) an environmental air station monitoring network (Chapter 4); (3) a groundwater monitoring network (Chapter 5); and (4) periodic soil, vegetation, and small mammal sampling (Chapter 7). Table 2-2 provides the 2020 status of the DOE low-level waste disposal facility management process for Area G.

Table 2-2 DOE Low-Level Waste Disposal Facility Management Status for Area G

Management Process Phase	Status
Performance Assessment/ Composite Analysis	Revision 4 was approved in 2009 (LANL 2008). The annual determination of adequacy for fiscal year 2020 was published in April 2021.
Closure Plan	Plan issued in 2009 (LANL 2009).
Performance Assessment/ Composite Analysis Maintenance Program	Revised plan issued in 2021 (Neptune 2021a). Updated analyses and modeling of erosion, cliff retreat, and infiltration were completed during fiscal year 2020 (Neptune 2021b, Neptune 2021c).
Disposal Authorization Statement	Revision 2 was issued November 15, 2018. This revision identifies the DOE Environmental Management field office in Los Alamos as the responsible field office.

Hazardous Wastes

Resource Conservation and Recovery Act

The Resource Conservation and Recovery Act regulates wastes from generation to disposal. Hazardous wastes include all solid wastes that are (1) listed as hazardous by the U.S. Environmental Protection Agency (listed wastes); (2) ignitable, corrosive, reactive, or toxic (characteristic wastes); or (3) batteries, pesticides, lamp bulbs, or contain mercury. Mixed radioactive waste (also called mixed waste) is listed or characteristic hazardous waste commingled with radioactive waste. Under the Resource Conservation and Recovery Act, facilities that treat, store, or dispose of hazardous wastes, including mixed radioactive wastes, must obtain a permit from their regulatory authority.

LANL's Hazardous Waste Facility Permit

The State of New Mexico is authorized by the U.S. Environmental Protection Agency to administer its hazardous waste management program and issue and enforce hazardous waste facility permits. On November 8, 1989, the New Mexico Environment Department issued the first LANL Hazardous Waste

Facility Permit for the storage and treatment of hazardous and mixed radioactive waste at the Laboratory. The permit includes requirements that allow for the storage and sometimes treatment of hazardous and mixed radioactive wastes at 27 separate hazardous waste management units (sites) at the Laboratory. It also contains requirements for waste management, sampling, reporting, inspection, training, waste minimization, preparedness and prevention, emergencies and contingency planning. In addition, the permit also requires the Laboratory to post certain information for public review in an electric information repository (electronic public reading rooms). The permit is issued to the DOE (through its field offices, the National Nuclear Security Administration [NNSA] Los Alamos Field Office and the DOE-Environmental Management Los Alamos Field Office), the management and operating contractor Triad National Security LL (Triad), and the legacy waste cleanup contractor, N3B.

On June 29, 2020, the Laboratory submitted an application to the New Mexico Environment Department to renew and modify the 2010 LANL Hazardous Waste Facility Permit. This renewal application consisted of the LANL General Part A Permit Application, Revision 10 and the Part B Renewal Permit Application.

Permit Modifications, Reports, and Other Activities

The Hazardous Waste Facility Permit sometimes needs modification to address new information, changes in a facility, or changes in regulatory requirements. There are three classes of modifications consisting of minor modifications (Class 1 and Class 2) and major modifications (Class 3). Notices of all proposed permit modifications are published in a newspaper of general circulation, and for most types of permit modifications include a request for public comment prior to Agency approval. Notices of approvals of permit modifications are mailed to members of the public who sign up for a LANL facility mailing list maintained by the New Mexico Environment Department.

Three requests to modify the permit were submitted by the Laboratory in 2020. The first Class 1 modification request was submitted in January 2020 to add a waste treatment process at Technical Area 54, Dome 231. This modification was approved by New Mexico Environment Department on June 29, 2020. The remaining two modifications were administrative Class 1 modifications, which are minor changes that keep a permit current with routine changes to the facility or its operations. The two permit modification requests involved (1) changes to the Contingency Plan in Attachment D that included an updated telephone number for the Alternate Incident Response Commander, and (2) changes to the requirements for newspaper publications associated with the Information Repository. The two administrative Class 1 permit modifications were approved by the New Mexico Environment Department in November 2020.

Triad, the management and operating contractor, and N3B, the legacy waste cleanup contractor coordinated to send demolition activity notifications to the New Mexico Environment Department

What do these waste terms mean?

Treatment – Waste treatment is any process that changes the physical, chemical, or biological characteristics of a waste to minimize its threat to the environment.

Storage – Waste storage is the temporary holding of waste before the waste is treated, disposed of, or stored somewhere else. A **storage unit** stores hazardous waste. Examples include tanks, containers, drip pads, and containment buildings.

Disposal – Waste disposal is the discharge, deposit, injection, or placing of any waste on or in the land or water. A disposal facility is any site where the waste is intentionally placed and where it will remain.

Remediated Waste – Waste that has undergone treatment.

for the quarters ending in March, June, September, and December in 2020. One fiscal year 2020 notification was also sent for the Laboratory covering all relevant demolition activities from October 1, 2019, to September 30, 2020. The fiscal year notification was submitted to the New Mexico Environment Department along with the December 2020 quarterly report. Annual waste minimization reporting, biennial hazardous waste reporting, responses to requests for information from the New Mexico Environment Department, and annual electronic public reading room training were also coordinated between the operating contractor and legacy waste cleanup contractor Triad and N3B.

A closure certification report was submitted in February 2020 documenting closure activity at the Technical Area 16-399 Burn Tray. In November 2020, the New Mexico Environment Department issued a disapproval letter for the Technical Area 16-399 Burn Tray that included seven general comments and 10 specific comments.

From January 2020 through December 2020, five soil vapor monitoring reports were submitted in accordance with the Permit requirements for the Technical Area 63 Transuranic Waste Facility.

Inspections, Noncompliances, and Notices of Violation

The LANL Hazardous Waste Facility Permit requires that the Laboratory provide advance written notice to the New Mexico Environment Department of any changes to any permitted unit or activity that may result in a noncompliance with the permit, and it requires verbal and written reports of the discovery of any noncompliance that may endanger human health or the environment. Instances of permit noncompliances that do not threaten human health or the environment, such as an exceedance of a storage holding time, are compiled and reported annually to the New Mexico Environment Department as required by the permit. During the reporting period (October 1, 2019, through September 30, 2020), there were no releases within or from a permitted unit under operational control of Triad.

The Laboratory submitted the fiscal year 2020 noncompliance report to the New Mexico Environment Department in November 2020. Triad reported four instances of noncompliance with the LANL Hazardous Waste Facility Permit. Reported instances included container labeling issues and inadequate aisle spacing. These instances of noncompliance were identified by internal assessments conducted by hazardous waste management experts, and were promptly corrected. N3B reported 17 instances of noncompliance with the LANL Hazardous Waste Facility Permit. Reported instances included improper labeling, containers with free liquids that were not on secondary containment pallets, and inadequate aisle spacing. N3B personnel conducted weekly inspections to identify noncompliance with the Permit in the legacy waste cleanup program. The above mentioned noncompliances were corrected within 24 hours except for one item; this item was corrected within two days.

The New Mexico Environment Department conducted its annual compliance inspection on August 10, 2020. On November 16, 2020, the Department issued its Compliance Evaluation Inspection Report and Findings and identified two potential violations of the LANL Hazardous Waste Facility Permit and 14 potential violations of the New Mexico Hazardous Waste Regulations. As a result of this inspection, Triad immediately corrected several of the potential non-compliances identified by the New Mexico Environment Department and implemented corrective actions to prevent recurrence. N3B implemented corrective actions to address items identified in the inspection by the New Mexico Environment Department and to more broadly evaluate and address the extent of condition and causes to minimize the potential for recurrence.

Settlement Agreement and Stipulated Final Order

On January 22, 2016, DOE NNSA, Los Alamos National Security, LLC, (the previous management and operating contractor for the Laboratory) and the State of New Mexico signed a Settlement Agreement for resolution of potential penalties associated with the drum of transuranic waste that resulted in a 2014 contamination event at the Waste Isolation Pilot Plant in Carlsbad, New Mexico. The settlement agreement includes five supplemental environmental projects, which NNSA and the Laboratory implemented. Below are the 2020 activities on the supplemental environmental projects.

1. Road Improvement Project – Improve routes at the Laboratory used for the transportation of transuranic waste to the Waste Isolation Pilot Plant.

   The redesign for the State Route 4 and East Jemez Road intersection was completed in August 2019. Funding for the construction activities is being pursued.

2. Triennial Review Project – Conduct an independent, external triennial review of environmental regulatory compliance and operations.

   In accordance with the January 2016 Settlement Agreement and Stipulated Final Order, LANL and the National Nuclear Security Administration agreed to conduct independent, external triennial reviews of environmental regulatory compliance and operations at LANL. The first triennial review was conducted in 2018. A second triennial review will be conducted in 2021 and a final report is expected in September 2021.

3. Watershed Enhancement Project – Design and install engineering structures in and around the Laboratory to reduce storm water velocity and decrease sediment load to improve water quality in the area. This project includes a Low Impact Development Master Plan for the Laboratory (LANL 2017a).

   Construction on the mid-Mortandad slope drain project began in October 2018 and was completed in February 2020; it was certified to the New Mexico Environment Department in March 2020. Final certification of the entire Watershed Enhancement Project to New Mexico Environment Department occurred in April 2020. This project is now complete.

4. Surface Water Sampling Project – Conduct targeted sampling for sediment, storm water run-off, atmospheric deposits, and aquatic life in watersheds in and around the Laboratory to better understand surface water quality and stream reach characteristics in the region, and share these results with the public and the New Mexico Environment Department.

   We evaluated four locations in and around the Laboratory using the New Mexico Environment Department's Hydrology Protocol Level 2 Criteria (NMED 2011). The Hydrology Protocol distinguishes between ephemeral, intermittent, and perennial stream reaches and documents the uses supported by those waters.

5. Potable Water Line Replacement Project – Replace aging potable water lines and install metering equipment for Laboratory potable water systems.

   In 2019, the project achieved substantial completion after the installation of the Phase A and B waterlines, meters, air-relief valves, and pressure relief valves. In 2020, the project finished the remaining punch list items. Approval of the final certification of this Supplemental Environmental Project by the New Mexico Environment Department is anticipated in 2021.

The 2016 Compliance Order on Consent

The 2016 Compliance Order on Consent (modified in 2017; available at https://www.env.nm.gov/hazardous-waste/lanl/) is a settlement agreement between the New Mexico Environment Department and DOE addressing cleanup of legacy wastes. It supersedes the Compliance Order on Consent that was issued in 2005. The order guides and governs the ongoing cleanup of legacy waste at the Laboratory through an annual work planning process. Campaigns are planned using risk-based criteria to group, prioritize, and implement corrective actions. The annual planning process allows for revisions to cleanup campaigns based on actual work progress, changed conditions, and funding.

The Laboratory has two types of legacy waste corrective action sites: (1) Solid Waste Management Units and (2) Areas of Concern. Solid Waste Management Units are areas where solid wastes were spilled or disposed of. Examples of these units include certain septic tanks, firing sites, landfills, sumps, and areas that historically received liquid effluents from outfalls. Areas of Concern are areas that may have received a hazardous waste or hazardous constituents through soil movement or the flow of liquid wastes from Laboratory facilities. Examples include canyon bottoms downstream from historical outfalls.

As of October 1, 2020, the Laboratory had 1,405 corrective action sites listed in Appendix A of the 2016 Compliance Order on Consent. During fiscal year 2020, no sites received certificates of completion with controls, 5 sites received certificates of completion without controls, and no sites were changed to a deferred status. Therefore, at the end of fiscal year 2020, out of the 1,405 corrective action sites listed in Appendix A, 85 corrective action sites had certificates of completion with controls, 277 had certificates of completion without controls, and 134 sites were deferred until they no longer have active operations. The remaining 909 Solid Waste Management Units and Areas of Concern had investigations or corrective actions (or both) either in progress or pending.

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 Protection.

During the fiscal year we submitted the following documents to the New Mexico Environment Department Hazardous Waste Bureau as part of the Consent Order deliverables:

- six investigation reports,
- seven Periodic Monitoring Reports for five groundwater monitoring groups,
- one annual update on the Integrated Facility Groundwater Monitoring Program,
- one annual update for Los Alamos/Pueblo Canyon Sediment Monitoring,
- one report on the Sandia Canyon wetland performance,
- two biennial erosion control inspection reports,
- three progress letter reports for investigation work completed under the Consent Order, and
- two Corrective Measures Study/Corrective Measures Implementation progress report.

Facility Groundwater Monitoring Program

The Hazardous Waste Facility Permit contains requirements for groundwater monitoring of operational facilities. During 2020, groundwater monitoring completed under the 2016 Compliance Order on Consent met this requirement. Chapter 5, Groundwater Protection, provides more details on groundwater monitoring activities and monitoring results in 2020.

Mixed Wastes

Federal Facility Compliance Act

The Federal Facility Compliance Act requires federal facilities that generate or store mixed radioactive and hazardous wastes to submit a Site Treatment Plan that includes a schedule for developing capacities and technologies to treat all mixed waste. 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.

While identifying treatment and disposal options for the mixed waste inventory, the Laboratory's Site Treatment Plan allows the Laboratory to store accumulated mixed waste at permitted storage units for more than one year, which is otherwise prohibited by the Land Disposal Restrictions provision of the Resource Conservation and Recovery Act. The Site Treatment Plan provides enforceable time periods in which the facility is required to treat or otherwise meet land disposal restriction requirements for the accumulated waste.

The Laboratory updates its Site Treatment Plan every year. An annual report describes the amount of mixed waste that has been stored at LANL under the plan provisions during the previous fiscal year and the amount shipped to approved Treatment, Storage, and Disposal Facilities. The Site Treatment Plan Report must be submitted to the New Mexico Environment Department on March 31 each year and contains data from the previous fiscal year (October 1 to September 30).

During the fiscal year 2020, the mixed low-level waste covered under the Site Treatment Plan decreased from 325 cubic yards (248 cubic meters) to 285 cubic yards (218 cubic meters). This change was due to offsite shipments of 74 cubic yards (57 cubic meters), administrative adjustments of 31 cubic yards (24 cubic meters) and 3.3 cubic yards (2.6 cubic meters) of new waste.

During the fiscal year 2020, the mixed transuranic waste covered under the Site Treatment Plan decreased from approximately 2291 cubic yards (1752 cubic meters) to 2058 cubic yards (1574 cubic meters). This change was due to 226 cubic yards (172 cubic meters) shipped to the Waste Isolation Pilot Plant, administrative adjustments of 91 cubic yards (70 cubic meters), and 88 cubic yards (67 cubic meters) of new waste.

Volumes of mixed waste managed under the Site Treatment Plan at the Laboratory during fiscal year 2020 are provided in Table 2-3. These waste volumes may be adjusted slightly by reconciliation during the New Mexico Environment Department review of the Site Treatment Plan update. Approved Site Treatment Plan updates are available at http://www.env.nm.gov/hazardous-waste/lanl-ffco-stp/.

Table 2-3. Approximate Volumes of Mixed Wastes Stored and Shipped Offsite for Treatment and/or Disposal under LANL's Site Treatment Plan by the Management and Operating Contractor (Triad) and the Legacy Waste Cleanup Contractor (N3B) during Fiscal Year 2020

LANL Contractor	Volume of mixed wastes stored at LANL under the Site Treatment Plan	Volume of mixed wastes shipped offsite under the Site Treatment Plan
Mixed Low-level Waste		
Triad	35 cubic yards (27 cubic meters)	0 cubic yards (0 cubic meters)
N3B	250 cubic yards (191 cubic meters)	74 cubic yards (57 cubic meters)
Mixed Transuranic Waste		
Triad	284 cubic yards (217 cubic meters)	206 cubic yards (157 cubic meters)
N3B	1,775 cubic yards (1,357 cubic meters)	20 cubic yards (15 cubic meters)

Other Wastes

Toxic Substances Control Act

The Toxic Substances Control Act addresses the production, import, use, and disposal of specific chemicals, including PCBs. The Laboratory is responsible for record keeping and reporting the import or export of small quantities of chemicals used for LANL research activities and the disposal of PCB-containing substances. PCB-containing substances include: (1) dielectric fluids, (2) solvents, (3) oils, (4) waste oils, (5) heat-transfer fluids, (6) hydraulic fluids, (7) slurries, (8) soil, and (9) materials contaminated by spills.

Laboratory staff conducted eight Toxic Substances Control Act reviews for chemicals imported or exported by the Laboratory's Property Management Group Customs Office in 2020. These reviews are to ensure certain chemical compounds follow the Toxic Substance Control Act requirements prior to them being imported or exported out of the country. These shipments were all properly categorized, and the chemical compound samples were sent to collaborative researchers in other countries.

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 regulated pollutants below permit limits. In 2019, we submitted a 5-year Title V renewal application. The Laboratory continues to operate under its existing Title V Operating permit until a final renewal permit is issued. This permitting action is summarized as follows:

- The current Title V Operating Permit has an expiration date of February 27, 2020. We were required to submit a Title V renewal application 12 months prior to the expiration date. We submitted the renewal application on February 26, 2019. The New Mexico Environment Department issued a draft renewal permit in 2020 and solicited public comments. Based on public comments received, the New Mexico Environment Department Air Quality Bureau granted a public hearing on this draft permit, scheduled for mid-2021.

The Laboratory annually certifies its compliance with the conditions of its Title V Operating Permit and reports any permit deviations that occurred to the New Mexico Environment Department. Deviations occur when any permit condition is not met. In 2020, the Laboratory reported two deviations described below:

1. The device to continually measure the pressure drop across the asphalt plant baghouse was inoperable for a two-month period in 2020 due to equipment malfunction. This resulted in missing differential pressure data across the baghouse for brief periods of operation. Opacity readings during this period demonstrate that the baghouse was operating correctly and no visible emissions were observed. Corrective actions to replace the faulty monitoring device were implemented as soon as the issue was identified.
2. In 2020, two loads of waste containing asbestos, totaling about 11 tons of soil, concrete, and presumed transite (asbestos-containing cement) piping, were taken to the Los Alamos County Eco Station by an outside contractor. The Eco Station is not authorized to accept waste containing asbestos. As soon as the issue was discovered, Triad submitted an emergency notification to the New Mexico Environment Department; the waste was cleaned up and taken to an approved waste site.

Table 2-4 summarizes the Laboratory's emissions data and provides a list of the major sources of these air pollutants at the Laboratory.

Table 2-4. Calculated Emissions of Regulated Air Pollutants Reported to the New Mexico Environment Department in 2020

	Pollutants (tons)					
Emission Unit	**Nitrous Oxides**	**Sulfur Oxides**	**Particulate Matter**	**Carbon Monoxide**	**Volatile Organic Compounds**	**Other Hazardous Air Pollutants**
Asphalt plant	0.001	0.001	0.0005	0.03	0.001	0.0005
Technical Area 3 power plant (3 boilers)	9.86	0.10	1.29	6.80	0.94	0.32
Technical Area 3 power plant (combustion turbine)	5.54	0.38	0.75	0.75	0.24	0.15
Research and development chemical use	n/a*	n/a	n/a	n/a	6.10	4.42
Degreaser	n/a	n/a	n/a	n/a	0.057	0.057
Data disintegrator	n/a	n/a	0.27	n/a	n/a	n/a
Stationary standby generators†	6.65	0.18	0.26	1.48	0.26	0.002

Emission Unit	Pollutants (tons)					
	Nitrous Oxides	Sulfur Oxides	Particulate Matter	Carbon Monoxide	Volatile Organic Compounds	Other Hazardous Air Pollutants
Miscellaneous small boilers	19.62	0.12	1.57	15.75	1.12	0.37
Permitted generators (11 units)	6.84	0.22	0.29	2.73	0.54	0.002
TOTAL	48.51	1.00	4.43	27.53	9.26	5.33
Permit Limits (tons/year)	245	150	120	225	200	120

**n/a = not applicable*

†The stationary standby generators are no longer sources in the Laboratory's Title V permit. However, they are included in this Table for comparison with previous annual site environmental reports.

The Laboratory's emissions in 2020 were significantly lower than the permit limits; for example, nitrogen oxide emissions were approximately 20 percent of the permit limit, carbon monoxide emissions were 12 percent of the permit limit, and particulate matter emissions were 4 percent of the permit limit. No emissions in excess of permit limits occurred from any of the permitted sources.

Figure 2-1 depicts a five-year history of pollutant emissions at the Laboratory. Emissions from 2016 through 2020 remained relatively constant.

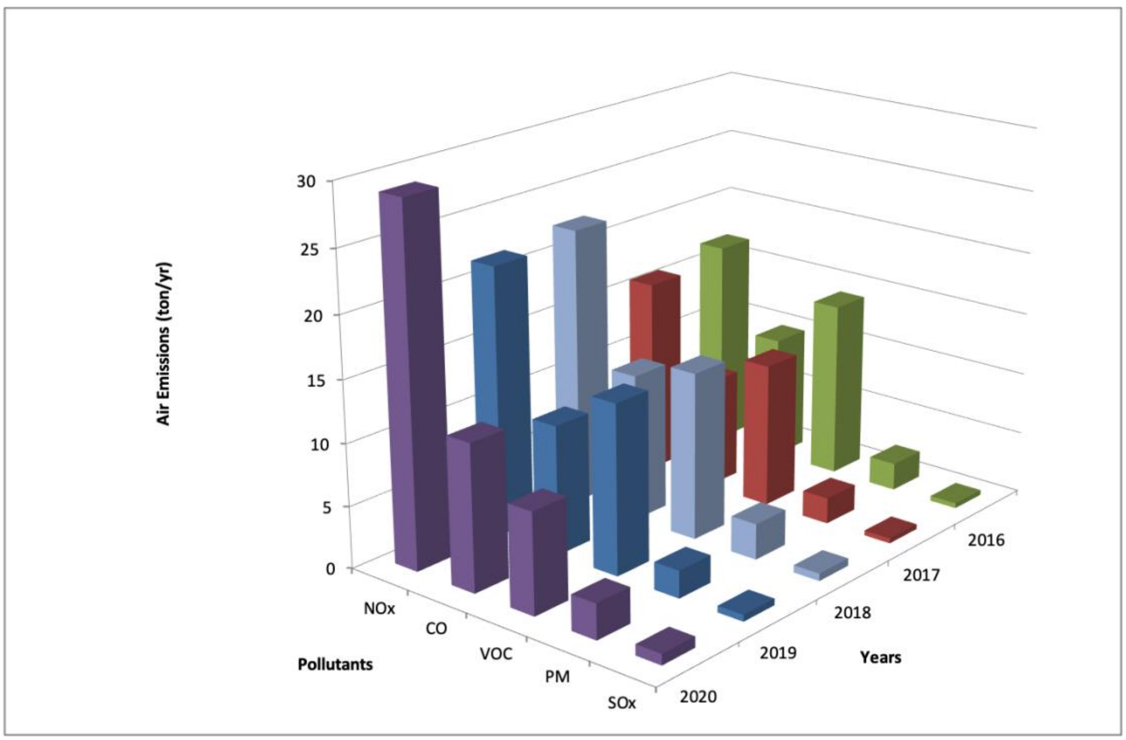

Figure 2-2. LANL criteria pollutant emissions from 2016 through 2020. These totals do not include small boilers or standby generators.

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

Title VI of the Clean Air Act regulates chemicals known to deplete the ozone layer in our atmosphere, such as halons, chlorofluorocarbons, and hydrochlorofluorocarbons, as well as some other non-ozone-depleting chemicals such as hydrofluorocarbons. These chemicals are primarily used as refrigerants, solvents, propellants, and foam-blowing agents. The law prohibits the Laboratory from knowingly venting or otherwise releasing into the environment any of these chemicals during maintenance, service, repair, or disposal of refrigeration equipment (such as air conditioners, refrigerators, chillers, or freezers) or fire-suppression systems. All technicians who work on refrigeration equipment at the Laboratory are certified by the U.S. Environmental Protection Agency. The Laboratory is working to remove refrigeration equipment that uses ozone-depleting substances and replace it with equipment using more environmentally-friendly refrigerants listed as acceptable under the U.S. Environmental Protection Agency's Significant New Alternatives Program. In 2020, 1,797 pounds of refrigerant were shipped off-site. Of that amount, 627 pounds were hydrochlorofluorocarbons and 1,170 pounds were hydrofluorocarbons. Additionally, the Laboratory has one remaining fire-suppression system that uses halon.

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 for air emissions. The estimated maximum dose of air emissions to a member of the public in 2020 was 0.29 millirem, less than one percent of the limit allowed by the Clean Air Act regulations (see Chapter 8, Public Dose and Risk Assessment).

Asbestos Notifications

The Asbestos National Emission Standards for Hazardous Air Pollutants require the Laboratory to provide advance notice to the New Mexico Environment Department Air Quality Bureau 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. In 2020, 18 large renovation and demolition projects were completed by Triad. Advance notification to the New Mexico Environment Department was submitted for each of these projects. Also in 2020, one construction project resulted in asbestos waste that was inadvertently sent to the Los Alamos County Eco Station. Upon discovery, an Emergency Notification was sent to the New Mexico Environment Department and the waste was cleaned up and sent to an approved landfill. All other asbestos waste was properly packaged and disposed of at approved landfills. N3B did not complete any large renovation or demolition projects in 2020.

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 a construction permit. In 2020, we submitted to the New Mexico Environment Department Air Quality Bureau two administrative revision notifications for air emissions from the following exempt activities:

- In August 2020, LANL submitted an administrative revision for 30 small exempt boilers and heaters. The New Mexico Environment Department Air Quality Bureau approved this administrative revision on September 25, 2020.
- In October 2020, LANL submitted an administrative revision for installation of an exempt emergency stand-by generator. The New Mexico Environment Department Air Quality Bureau approved this administrative revision on November 23, 2020.

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 requires National Pollutant Discharge Elimination System permits for several types of effluent and storm water discharges. The permits below contain specific chemical, physical, and biological criteria and management practices the Laboratory must meet when discharging water. The U.S. Environmental Protection Agency, Region 6, provides 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 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

The Laboratory's current National Pollutant Discharge Elimination System Industrial and Sanitary Point-Source Outfall Permit NM0028355 [Outfall Permit] became effective on October 1, 2014, with final modifications implemented May 2015. It includes one sanitary and ten industrial outfalls that discharge into four watersheds in the region, with the amount of discharge varying from year to year (Table 2-5).

Table 2-5. Volume of Effluent Discharged from Permitted Outfalls in 2020

Outfall No.	Building No.	Description	Canyon Receiving Discharge	2020 Discharge (gallons)
03A048	53-963/978	Los Alamos Neutron Science Center cooling tower	Los Alamos	24,366,600
051	50-1	Technical Area 50 Radioactive Liquid Waste Treatment Facility	Mortandad	26,462
04A022*	3-2238	Sigma emergency cooling system	Mortandad	3,029,328
03A160	35-124	National High Magnetic Field Laboratory cooling tower	Mortandad	0
03A181	55-6	Plutonium Facility cooling tower	Mortandad	3,182,326
13S	46-347	Sanitary wastewater system plant	Sandia	0
001	3-22	Power plant (includes treated effluent from sanitary wastewater system plant)	Sandia	78,044,000
03A027	3-2327	Strategic Computing Complex cooling tower	Sandia	0

Outfall No.	Building No.	Description	Canyon Receiving Discharge	2020 Discharge (gallons)
03A113	53-293/952	Los Alamos Neutron Science Center cooling tower	Sandia	167,900
03A199	3-1837	Laboratory Data Communications Center	Sandia	12,761,700
05A055	16-1508	High Explosives Wastewater Treatment Facility	Water	0
			2020 Total:	121,578,316

**This outfall's designation was changed from 03A022 to 04A022 in the October 2014 permit renewal 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).*

The Laboratory's current Outfall Permit requires weekly, monthly, quarterly, yearly, and term sampling of the effluents (treated wastewater) released to the environment to demonstrate compliance with the permit's water quality limits. The sampling results are compared to the permit limits and are reported every month in a Discharge Monitoring Report to the U.S. Environmental Protection Agency and the New Mexico Environment Department. Additionally, any engineering changes or flow changes that would affect quality or quantity of the effluents are reported in a Notice of Planned Change to the U.S. Environmental Protection Agency and the New Mexico Environment Department.

Laboratory personnel collected 654 samples in 2020 from Outfalls 001, 03A048, 03A113, 03A181, 03A199, 04A022, and 051. Seven of these samples (1.1 percent) indicated an exceedance of a permit limit (Table 2-6). Each exceedances was addressed immediately by correcting the cause or ceasing the discharge until corrective actions could be implemented that would return the effluent to compliance. Outfalls 13S, 03A027, 03A160, and 05A055 did not discharge in 2020. On September 30, 2020, the U. S. Environmental Protection Agency issued a Notice of Violation and Compliance Order alleging specific reporting non-compliances. The Laboratory responded to the Notice Of Violation within 30 days.

Table 2-6. Exceedances at National Pollutant Discharge Elimination System Permitted Industrial and Sanitary Outfalls in 2020

Outfall No.	Parameter	Date	Permit Limit (milligrams /liter)	Result (milligrams /liter)	Corrective Action
03A048	Total Residual Chlorine	3/11/20	0.011	0.06	Replaced a malfunctioning chemical feed pump.
03A048	Total Residual Chlorine	3/17/20	0.011	0.77	Replaced a malfunctioning check valve.
03A048	Total Residual Chlorine	3/24/20	0.011	0.04	Replaced a malfunctioning control valve.
03A048	Total Residual Chlorine	4/13/20	0.011	0.23	Changed the chemical feed pump from "prime" mode to "operation" mode.
04A022	Total Residual Chlorine	5/6/20	0.011	0.37	Raised the pressure on a potable water supply line to reduce the flow of water to the outfall. Repaired the leak that caused the drop in pressure. Replaced a solenoid valve on the emergency cooling system.

Outfall No.	Parameter	Date	Permit Limit (milligrams /liter)	Result (milligrams /liter)	Corrective Action
001	Temperature Daily Maximum	7/8/20	24 °C	25.3 °C	Modified piping to route effluent to the power plant cooling tower before it is discharge to the outfall.
03A113	Copper, Dissolved	8/11/20	0.0218	0.0435	Replaced a deteriorating copper pipe with polyvinylchloride.

The Laboratory has been working on projects to identify and reduce PCBs in water discharged to Outfall 001. Efforts have included cleaning out PCBs in upstream sumps, tanks, cleanouts, and manholes. We have also optimized the treatment process at the sanitary wastewater system treatment plant to increase its ability to reduce PCBs in its effluent. These combined efforts resulted in an annual compliance sample result at Outfall 001 of 0.000629 milligrams/liter Total PCB in September 2020.

The current National Pollutant Discharge Elimination System Permit NM002835 expired on September 30, 2019, and was administratively continued on October 22, 2019, by the U.S. Environmental Protection Agency. The National Pollutant Discharge Elimination System permit and regulations require the Permittees to submit a re-application to the U.S. Environmental Protection Agency 180 days prior to the expiration of the existing permit. The Laboratory submitted a permit reapplication on March 26, 2019, and the U.S. Environmental Protection Agency issued a draft permit for public comment on November 30, 2019. A public hearing was held on January 15, 2020, and the public comment period was extended to November 2, 2020. On November 15, 2020, the Laboratory requested that the U.S. Environmental Protection Agency re-open the comment period to allow the Permittees to address comments submitted by a coalition of citizen groups.

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, or projects less than one acre that are part of a common plan of development. Laboratory compliance with the Construction General Permit includes developing storm water pollution prevention plans and conducting site inspections during construction. A storm water pollution prevention plan describes the project activities, site conditions, best management practices for sediment and erosion control, and permanent control measures, such as storm water detention ponds, required for reducing pollutants in storm water discharges. LANL staff inspect the location and condition of storm water controls during construction and identify corrective actions if needed.

In 2020, Triad was responsible for 31 storm water pollution prevention plans and performed 845 inspections, with 96.6 percent of the sites fully compliant. N3B implemented eight construction projects under the Construction General Permit in 2020 and performed 217 Construction General Permit inspections. The non-compliant items were successfully addressed with 50 corrective actions that rehabilitated storm water pollution prevention measures.

Construction projects at LANL did not stop during the COVID-19 pandemic. Work continued and inspections were completed following the Centers for Disease Control and Prevention guidelines and LANL policies for ensuring work to be done safely and following COVID-safe practices.

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 for Storm Water Discharges Associated with Industrial Activities (Multi-Sector General Permit) regulates storm water discharges from specific industrial activities and their associated facilities. The U.S. Environmental Protection Agency issued a new draft 2020 Multi-Sector General Permit on March 2, 2020, for public comment. Triad National Security, LLC (Triad) provided public comment on June 1, 2020. Although the 2015 Multi-Sector General Permit expired at midnight on June 4, 2020, it is administratively continued pending issuance of a new Multi-Sector General Permit.

Industrial activities conducted at the Laboratory and covered under the Multi-Sector General Permit include: (1) metal and ceramic fabrication, (2) wood product fabrication, (3) hazardous waste treatment and storage, (4) vehicle and equipment maintenance, (5) recycling activities, (6) electricity generation, (7) warehousing activities, and (8) asphalt manufacturing. The purpose of the Multi-Sector General Permit is to minimize off-site migration of pollutants in storm water.

In 2020, responsibilities for Multi-Sector General Permit compliance at the Laboratory are identified by Permit Tracking Number and Operator in Table 2-7. Newport News Nuclear BWXT – Los Alamos, LLC (N3B) is responsible for legacy waste cleanup work, and Triad for management and operation of the Laboratory. The Multi-Sector General Permit requires the development of storm water pollution prevention plans, identification of potential pollutants, implementation of storm water control measures, and monitoring of storm water discharges. Additional permit requirements are identified below and include:

- inspecting facility storm water controls, identifying conditions requiring corrective action, and performing corrective actions as needed;
- sampling storm water run-off at monitored discharge points at each industrial facility and comparing results to benchmark values, impaired water limits (the New Mexico surface water quality standards), and effluent limitations; and
- visually inspecting storm water run-off samples to assess color; odor; floating, settled, or suspended solids; foam; oil sheen; and other indicators of storm water pollution.

Table 2-7. Multi-Sector General Permit Tracking Numbers by Operator and Covered Industrial Activity

Permit Tracking Number	Industrial Activities Covered	Responsible Operator	Operator Role	Date Permit Coverage Began
NMR050011	Technical Area 54 Maintenance Facility West	N3B	Environmental Management Legacy Cleanup	5/2/2018
NMR050012	Technical Area 54 Areas G and L	N3B	Environmental Management Legacy Cleanup	5/2/2018
NMR050013	Metal and ceramic fabrication, wood product fabrication, vehicle and equipment maintenance, recycling	Triad National Security, LLC	National Nuclear Security Administration	11/1/2018

Permit Tracking Number	Industrial Activities Covered	Responsible Operator	Operator Role	Date Permit Coverage Began
	activities, electricity generation, warehousing activities, and asphalt manufacturing		Operations and Management	

As the Laboratory's Multi-Sector General Permit implementation and compliance are operator specific, annual compliance activities are reported separately for each operator.

Management and Operating Contractor (Triad) Compliance Summary

Nine facilities operated by Triad are permitted under the Multi-Sector General Permit. Storm water monitoring under the permit occurs from April 1 through November 30 each year. Under the current permit, the benchmark values for some pollutants are the same as New Mexico surface water quality standards.

If an exceedance occurs, it is documented as a condition that triggers corrective action, which includes evaluation of potential sources and either follow-up action or documentation of why no action is required. All of the identified corrective actions associated with exceedances in 2020 have been completed. An exceedance of a benchmark value does not trigger a corrective action if it is determined that the exceedance is solely attributable to natural background sources.

In 2020, Triad staff completed the following tasks as part of the Multi-Sector General Permit compliance:

- 97 inspections of storm water controls at the nine active permitted facilities,
- one annual inspection at each of 38 sites having "no exposure" status,
- collection of 67 samples at seven active permitted sites,
- 418 inspections of ISCO® automated sampler equipment,
- 96 inspections of single stage samplers at substantially identical discharge points (discharge points that discharge storm water from the same source and with the same control measures and amount of storm water runoff per unit area),
- 33 visual inspections at 11 monitored discharge points,
- 54 visual inspections at 16 substantially identical discharge points, and
- 243 corrective actions including:
    - 36 corrective actions to mitigate exceedances,
    - maintenance, repair, or replacement of 40 control measures at five active permitted sites,
    - 123 actions to remedy control measures inadequate to meet non-numeric effluent limits, and
    - 44 corrective actions to address unauthorized releases (spills) or discharges.

By meeting permit-defined criteria under Triad's Permit Tracking Number NMR050013, we were able to discontinue monitoring for three types of pollutants at two active permitted sites for 2020. Two pollutants registered below the benchmark value at one site, so monitoring for these pollutants was discontinued. Also, monitoring for one other pollutant was discontinued at two sites because this constituent was not detected in storm water samples obtained at the monitored outfalls.

Tables 2-8 and 2-9 summarize the exceedance of water quality standards (that is, impaired waters) or quarterly benchmarks for the management and operating contractor's National Pollutant Discharge Elimination System Multi-Sector General Permit.

Table 2-8. 2020 Exceedances of the Management and Operating Contractor's National Pollutant Discharge Elimination System Multi-Sector General Permit Impaired Waters* Limits

Discharge Point	Exceeded Parameters		Date(s) Exceeded
	Copper, dissolved	Aluminum, Total Recoverable	
005	✓		05/11/2020
009	✓	✓	4/13/2020
012	✓	✓	08/01/2020
022	✓	✓	04/13/2020 – aluminum; 06/06/2020 – copper
026	✓		04/13/2020
029	✓		04/13/2020
032	✓		08/01/2020
074	✓		08/03/2020
075	✓	✓	06/14/2020
076	✓		05/29/2020
077		✓	11/08/2020

**An impaired waters exceedance means that the value exceeds a New Mexico surface water quality standard, as provided in Standards for Interstate and Intrastate Surface Waters, Title 20 Chapter 6 Part 4 of the New Mexico Administrative Code. Fifteen of 24 impaired waters results (63 percent) exceeded a New Mexico surface water quality standard.*

Table 2-9. 2020 Exceedances of the Management and Operating Contractor's National Pollutant Discharge Elimination System Multi-Sector General Permit Quarterly Benchmarks*

Discharge Point	Exceeded Parameters				Date(s) Exceeded
	Total Recoverable Aluminum	Iron, Total	Zinc, Dissolved	Nitrate plus Nitrite Nitrogen	
005		✓			05/29/2020; 07/05/2020; 08/28/2020; 11/08/2020
009		✓			04/13/2020; 06/06/2020; 11/08/2020
012		✓			08/01/2020
022	✓	✓	✓	✓	06/06/2020 – aluminum, iron, zinc, nitrate plus nitrite nitrogen; 08/28/8080 – iron, zinc; 11/08/2020 – iron
076		✓	✓		05/29/2020 – iron; 06/14/2020 – iron; 08/28/2020 – iron; 11/08/2020 – zinc
077	✓	✓			11/08/2020

**A quarterly benchmark exceedance means the value exceeded a benchmark value defined in the Multi-Sector General Permit. Benchmarks are not permit limits. The benchmark values for copper, aluminum, and zinc are the same as New Mexico surface water quality standards. Twenty-one of 42 benchmark results measured (50 percent) resulted in a benchmark value exceedance.*

Legacy Cleanup Contractor (N3B) Compliance Summary

Two Laboratory facilities (TA-54 Areas G and L and Maintenance Facility West) subject to N3B control are permitted under the 2015 Multi-Sector General Permit. This permit expired on June 4, 2020, and was administratively continued pending issuance of a new Multi-Sector General Permit. Monitoring of storm water discharges at N3B permitted facilities occurs between April 1 and November 30 each year to account for precipitation trends typical in Los Alamos. Due to COVID-19 pandemicrelated restrictions in place beginning on March 24, 2020, initiation of monitoring and other Multi-Sector General Permit requirements was delayed in 2020. Multi-Sector General Permit requirements that were impacted in 2020 due to COVID-19 restrictions include:

- Storm water monitoring was not initiated until approximately July 1, 2020, and consequently quarterly benchmark monitoring during quarter 1 of 2020 (April 1–May 31) was not conducted at TA-54, Areas G and L in accordance with Part 6.2.1 of the 2015 Multi-Sector General Permit. (Quarterly monitoring for benchmark parameters is not required for TA-54 Maintenance Facility West.)
- Quarterly visual assessments of storm water discharges were not conducted at either facility during quarter 1 as required by Part 3.2 of the Multi-Sector General Permit.
- Routine facility inspections required by Part 3.1 of the Multi-Sector General Permit were not conducted during quarter 1 at either facility.

The following tasks were completed by N3B during 2020 as part of Multi-Sector General Permit compliance:

Routine facility inspections were conducted of all Multi-Sector General Permit covered facilities during quarters 2-4.

- 80 quarterly visual inspections of storm water discharges from monitored outfalls/substantially identical outfalls were completed during quarters 2-4.
- Four annual impairment samples were collected from four monitored outfalls at TA-54 Areas G and L and Maintenance Facility West.
- Nine quarterly benchmark samples were collected during quarters 2-4 from four monitored outfalls at TA-54, Areas G and L.
- 14 corrective actions were initiated to address storm water exceedances of benchmark values or a New Mexico surface water quality standard.
- Employee training in accordance with Part 2.1.2.8 of the Multi-sector General Permit was conducted.

2020 was N3B's third year of operations at these facilities under the 2015 Multi-sector General Permit. Based on storm water monitoring results from 2018 to 2019, nine benchmark parameters, including cyanide, silver, arsenic, cadmium, mercury, lead, selenium, chemical oxygen demand and ammonia were discontinued from one or more monitored outfall in 2020. Table 2-10 summarizes exceedances of annual water quality impairment parameters and quarterly, industrial sector-specific benchmark values reported in storm water samples collected in 2020 from N3B-controlled facilities covered by the Multi-sector General Permit.

Table 2-10. 2020 Exceedances of the N3B's National Pollutant Discharge Elimination System Multi-Sector General Permit Quarterly Benchmarks*

N3B Facility	Monitored Discharge Point	Exceedance				Sample Date(s)
		Quarterly Benchmark	Impaired Water			
		Total Magnesium	Adjusted Gross Alpha	Total Recoverable Aluminum	Dissolved Copper	
TA-54 Maintenance Facility West	049	n/a	X	X	X	7/18/20
TA-54 Areas G and L	050	X				7/16/20, 8/28/20, 10/26/20
TA-54 Areas G and L	053	X	X			7/18/20, 8/28/20 – total magnesium only; 10/28/20 – total magnesium only
TA-54 Areas G and L	069	X			X	7/18/20, 8/3 – total magnesium only; 11/8/20 – total magnesium only

NOTES: A quarterly benchmark exceedance means the reported concentration of the identified parameter in a representative storm water sample exceeded an industry sector-specific benchmark value specified in the Multi-Sector General Permit. Benchmark values are not permit limits.
An impaired water exceedance means the reported concentration of the identified parameter in a representative storm water sample exceeded a receiving water segment-specific New Mexico surface water quality standard defined by New Mexico Administrative Code 20.6.4.

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

The Individual Permit Authorization to Discharge under the National Pollutant Discharge Elimination System (Individual Permit) authorizes discharges of storm water from certain Solid Waste Management Units and Areas of Concern (hereafter called sites) at the Laboratory. The permit lists 405 sites that must be managed to remain in compliance with its terms and conditions. The objective is to prevent storm water run-off from transporting pollutants of concern from these sites to surface waters. Pollutants of concern potentially occurring at these sites include metals, organic chemicals, high explosives, and radionuclides.

The U.S. Environmental Protection Agency issued the original permit in 2010, and it has been administratively continued. A new draft permit was issued by the U.S. Environmental Protection Agency in November 2019 for public comment; a public hearing was conducted October 26, 2020, and the public comment period for the draft permit ended November 2, 2020. On November 30, 2020, the New Mexico Environment Department issued the state certification of the Individual Permit NM0030759. The final permit has not been issued by the U.S. Environmental Protection Agency.

The Individual Permit has technology-based requirements for storm water control. This means that storm water controls that reflect best industry practices, considering their availability, economic achievability, and practicability, are required at each of the 405 permitted sites. Examples of controls used to manage storm water under the Individual Permit include retention berms and coir logs. These storm water controls are routinely inspected and are maintained as needed. The permit required LANL to install baseline controls at all 405 sites. These were completed and certified to the U.S. Environmental Protection Agency by 2011.

The 405 sites have been grouped into 250 small sub-watersheds, called site-monitoring areas, for permit monitoring. Specific locations within each of the site-monitoring areas are used to sample the storm water run-off from the sites.

If target action levels of pollutants, which are based on the New Mexico surface water quality standards, are exceeded in the storm water samples, the sites enter into corrective action and additional controls are installed. Additional storm water sampling is required and is referred to as “corrective action monitoring.” Site-monitoring areas where we have not collected sufficient storm water samples to evaluate the target action levels, for example, because of a lack of local rainfall, are referred to as being in “extended baseline monitoring.”

If all control measures have been installed and the results of sampling confirm that all pollutants of concern for a site-monitoring area are below the target action levels, the Laboratory certifies to the U.S. Environmental Protection Agency that the corrective actions are complete for the sites in that site-monitoring area.

If all the storm water control measures have been installed, but the Laboratory cannot demonstrate that all results are below target action levels (for example, if natural background concentrations at the site are above the target action levels), the Laboratory can request that a site be placed into alternative compliance. For a site placed into alternative compliance, the corrective action is completed under an individual site compliance schedule determined by the U.S. Environmental Protection Agency.

In summary, the process of complying with the Individual Permit can be broken down into five steps: (1) installation and maintenance of control measures, (2) storm water sampling to determine effectiveness of control measures, (3) additional corrective action if a target action level is exceeded, (4) reporting results of fieldwork and monitoring to the U.S. Environmental Protection Agency and the New Mexico Environment Department, and (5) certification of corrective action complete or requests for alternative compliance to the U.S Environmental Protection Agency.

Effects of the COVID-19 Pandemic on the Individual Permit Activities in 2020

The 2020 monitoring year was affected by the COVID-19 pandemic. A partial stop-work order was issued by the DOE Environmental Management’s Los Alamos Field Office to N3B on March 24, 2020. Fieldwork was limited to only the activities necessary to ensure the safety of the public, the workers, and the environment. The U.S. Environmental Protection Agency issued a letter, “COVID-19 Implications for EPA’s Enforcement and Compliance Assurance Program,” to all governmental and private sector partners on March 26, 2020, that described COVID-19 implications for the agency’s Enforcement and Compliance Assurance Program.

On April 17, 2020, the DOE Environmental Management’s Field Office sent a “Notification of Force Majeure and Anticipated Noncompliance due to Partial Stop-Work Order for Activities under National Pollutant Discharge Elimination System Permit Number NM0030759” to the U.S. Environmental Protection Agency. This letter described how storm water samplers were not activated by the traditional target date of April 1, and therefore sampling directed by Part I.D. of the Individual Permit would not initially be conducted. In addition, control measures and storm water management devices at any site affected by a storm rain event would not be inspected as directed by Part I.G.2 of the Individual Permit until the stop-work order ended.

On July 22, 2020, the DOE Environmental Management's Field Office sent the U.S. Environmental Protection Agency a letter, "Notification of Resumption of Operations for Activities under National Pollutant Discharge Elimination System Permit Number NM0030759". As described in the letter, the resumption of N3B's operations at LANL occurred in phases, starting with additional mission critical activities that are both high-priority and low-risk.

2020 Accomplishments

Despite the COVID-19 related impacts, in 2020, we completed the following tasks to comply with the requirements of the Individual Permit:

- Published an update to the 2019 Site Discharge Pollution Prevention Plan, which identified pollutant sources, described control measures, and defined monitoring at all permitted sites
- Published the "Storm Water Individual Permit Annual Report for Reporting Period January 1–December 31, 2020," which presents the compliance status for all permitted sites, activities conducted, and milestones accomplished to comply with the Individual Permit
- Completed 446 inspections of storm water controls at the 250 site monitoring areas
- Completed 508 sampling equipment inspections
- Conducted storm water monitoring at 127 site monitoring areas
- Collected extended baseline confirmation samples at one site monitoring area
- Installed 16 additional control measures at 10 site monitoring areas
- Held two public meetings as required by the Individual Permit
- Submitted alternative compliance requests for six site/site monitoring area combinations
- Submitted certification of enhanced controls at seven site monitoring areas
- Submitted certification of corrective action complete following a certificate of completion from the New Mexico Environmental Department at one site/site monitoring area combination
- Submitted Individual Permit reapplication on June 15, and continued to support the reapplication effort

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

Table 2-11 summarizes the exceedance of target action levels for storm water samples collected in 2020 for the Individual Permit.

Table 2-11. 2020 Exceedances of LANL's National Pollutant Discharge Elimination System Individual Permit Target Action Levels

Site Monitoring Area (SMA)	Parameter	Type of Exceedance*	Number of Exceedances	Total Number of Samples Taken	Sample Date(s)
R-SMA-2.05	Gross alpha	average target action level	1	1	08/29/2020

**The maximum target action level is the target for individual maximum values recorded at a site, and the average target action level is the target for the geometric mean of applicable monitoring results at a site. Target action levels are benchmarks, not permit limits.*

Aboveground Storage Tank Program

The Laboratory's Aboveground Storage Tank Program manages 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. The Laboratory operates 10 tank systems with 12 storage tanks.

Because of the COVID-19 pandemic there were not any on-site compliance inspections by the Petroleum Storage Tank Bureau in 2020. We completed the work to resolve a 2019 Notice of Violation and received a certificate of compliance, effectively closing out this Notice of Violation. Corrective actions were completed at another facility based on 2019 Petroleum Storage Tank Bureau findings, and LANL is currently working through the certified tester qualifications with the Petroleum Storage Tank Bureau. LANL is working with the Petroleum Storage Tank Bureau to develop a permanent closure plan for a fuel storage tank system that has been out of service since 2013.

The U.S. Environmental Protection Agency requires spill prevention, control, and countermeasure plans for facilities with aboveground storage tank systems. In 2020, Laboratory staff completed updates to six plans, amended one plan, began updates to one other plan, and began preparing two new plans due to planned increases in oil volume storage at two facilities. Laboratory staff conducted all annual and monthly inspections for the facilities. In 2020, the Laboratory was in full compliance with the Federal Clean Water Act requirements for the tanks.

Clean Water Act Section 404/401 Permits

Section 404 of the Clean Water Act requires that the Laboratory receive verification from the U.S. Army Corps of Engineers that proposed projects within perennial or intermittent watercourses comply with Clean Water Act nationwide permit conditions. Effective June 22, 2020, ephemeral streams are no longer considered Waters of the United States under the 2020 Navigable Water Protection Rule.

Section 401 of the Clean Water Act requires states to certify that Section 404 permits issued by the 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 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 2020 are listed in Summary of Permits and Legal Orders section at the end of this chapter.

The Energy Independence and Security Act: Storm Water Management Practices

Section 438 of the Energy Independence and Security Act of 2007 establishes storm water run-off requirements for federal development and redevelopment projects. Any federal project over 5,000 square feet that alters the flow of water over the surface of the ground must implement low-impact development controls to maintain pre-development water temperatures, flow rates, flow volumes, and duration. Examples of appropriate controls include vegetated swales, infiltration basins, permeable pavement, vegetated strips, rain barrels, and cisterns. The goal is to manage run-off through infiltration, evapotranspiration, or harvest and reuse.

The Laboratory currently identifies projects for Section 438 compliance through the permits and requirements identification process and excavation permitting. LANL's Environmental Protection and Compliance Division is responsible for implementing Section 438 compliance. Staff work with internal and subcontractor design and construction personnel to meet the requirements. Section 438 guidance is published in the LANL Engineering Standards Manual.

In 2020, there were five projects completed that required Energy Independence and Security Act compliance. As part of their Section 438 compliance, the Sidewalk Installation Project in Technical Area 22, the Office Trailer Construction Project in Technical Area 15, the Modular Office Building Construction Project in Technical Area 3, the Firing Range Improvement Project in Technical Area 72, and the Calibration Site Project in Technical Area 68 used swales, detention/infiltration basins, and revegetation to manage storm water discharge. All Energy Independence and Security Act requirements for these projects were completed in 2020.

New Mexico Water Quality Act: Surface Water Protection

Under the New Mexico Water Quality Act, the New Mexico Water Quality Control Commission adopts standards for surface waters of the state. *Standards for Interstate and Intrastate Surface Waters*, Title 20 Chapter 6 Part 4 of the New Mexico Administrative Code, defines designated surface water uses for the state, sets water quality criteria to protect those uses, and provides an anti-degradation policy. The Laboratory's National Pollutant Discharge Elimination System permits, along with any dredge and fill activities approved under Section 404 of the Clean Water Act, must be certified by the New Mexico Environment Department to ensure New Mexico water quality standards are met.

Additionally, under Section 303(d) of the Clean Water Act, the New Mexico Environment Department determines which stream reaches (delineated as assessment units) within the state are impaired for their the assessment units' designated use(s). The New Mexico Environment Department uses the Laboratory's surface water monitoring data in developing its list of impaired waters for the assessment units on Laboratory property. The discharge limits and monitoring requirements in the Laboratory's National Pollutant Discharge Elimination System permits are determined, in part, by the impairment status of affected water courses. In 2020, most assessment units at the Laboratory were listed as impaired, sometimes because of naturally occurring substances. See Chapter 6, Watershed Quality, for more information.

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 issues an annual drinking water quality report, as required by the Safe Drinking Water Act. The report is available at https://indd.adobe.com/view/fa97a051-59cf-4c7e-abb1-90f1cedbc915. For 2020, the drinking water quality for Los Alamos met all U.S. Environmental Protection Agency regulations.

New Mexico Water Quality Act: Groundwater Quality Standards

In fiscal year 2020, we reported to the New Mexico Environment Department 15 instances of a contaminant detected in groundwater at a location where the contaminant had not been previously detected above a standard or screening level (Table 2-12). The standards and screening levels for this reporting requirement include: (1) the New Mexico Environment Department Soil Screening Levels Summary Table A-1 Values for Tap Water, (2) the New Mexico Water Quality Control Commission groundwater standards, and (3) the U.S. Environmental Protection Agency maximum contaminant levels.

Table 2-12. 2020 Locations with First-time Groundwater Quality Standard or Screening Level Exceedances

Parameter Name	Location (well or spring)	Groundwater Zone	Sample Date	Result	Standard or Screening Level Value	Units	Type of Standard or Screening Level
Bis(2-ethylhexyl)phthalate	R-26 PZ-2	Intermediate	7/20/2020	8.29	6	µg/L	U.S. Environmental Protection Agency maximum contaminant level
Nitrosodiethylamine[N-]	CDV-9-1(i) S1	Intermediate Perched	7/21/2020	0.00199	0.00167	µg/L	New Mexico Environment Department Tap Water Screening Level
Nitrosodimethylamine[N-]	Martin Spring	Intermediate Spring	7/23/2020	0.00858	0.00491	µg/L	New Mexico Environment Department Tap Water Screening Level
Nitrosodiethylamine[N-]	CDV-16-4ip S1	Intermediate Perched	7/27/2020	0.00197	0.00167	µg/L	New Mexico Environment Department Tap Water Screening Level
Nitrosodimethylamine[N-]	CDV-16-4ip S1	Intermediate Perched	7/27/2020	0.00838	0.00491	µg/L	New Mexico Environment Department Tap Water Screening Level
Nitrosodimethylamine[N-]	CdV-16-2(i)r	Intermediate Perched	7/27/2020	0.00522	0.00491	µg/L	New Mexico Environment Department Tap Water Screening Level
RDX	R-29	Regional Aquifer Top Level	8/1/2020	14.90[a]	9.66	µg/L	New Mexico Environment Department Tap Water Screening Level
Chromium	R-70 S2	Regional Aquifer Deep Level	8/4/2020	268.00 272.00[a]	50	µg/L	New Mexico Groundwater Standard[b]
Total PFAS[c]	MCO-7	Alluvial	8/18/2020	82.00	70.00	ng/L	New Mexico Environment Department Tap Water Screening Level

Parameter Name	Location (well or spring)	Groundwater Zone	Sample Date	Result	Standard or Screening Level Value	Units	Type of Standard or Screening Level
Total PFAS	PAO-5n	Alluvial	09/01/2020	179.4	70.00	ng/L	New Mexico Environment Department Tap Water Screening Level
Total PFAS	POI-4	Intermediate Perched	09/08/2020	107.6	70.00	ng/L	New Mexico Environment Department Tap Water Screening Level
Total PFAS	R-3i	Intermediate Perched	09/08/2020	84.7 83.1[a]	70.00	ng/L	New Mexico Environment Department Tap Water Screening Level
Nitrosodimethylamine[N-]	R-55 S2	Regional Aquifer Deep Level	10/14/2020	0.0134	0.00491	µg/L	New Mexico Environment Department Tap Water Screening Level
Nitrosodiethylamine[N-]	R-20 S2	Regional Aquifer Deep Level	10/15/2020	0.00761	0.00167	µg/L	New Mexico Environment Department Tap Water Screening Level
Nitrosodimethylamine[N-]	R-20 S2	Regional Aquifer Deep Level	10/15/2020	0.0153	0.00491	µg/L	New Mexico Environment Department Tap Water Screening Level
Benzo(a)anthracene	R-70 S1	Regional Aquifer Top Level	11/09/2020	0.373	0.12	µg/L	New Mexico Environment Department Tap Water Screening Level
Benzo(b)fluoranthene	R-70 S1	Regional Aquifer Top Level	11/09/2020	0.589	0.343	µg/L	New Mexico Environment Department Tap Water Screening Level
Chromium	R-45 S2	Regional Aquifer Deep Level	12/16/2020	55.0	50.00	µg/L	New Mexico Groundwater Standard

[a] These values are results from field duplicates taken for quality assurance and quality control at the location.
[b] New Mexico Water Quality Control Commission groundwater standards published December 21, 2018.
[c] PFAS are per- and polyfluoroalkyl substances, a group of man-made chemicals that includes PFOA, PFOS, GenX, and many other chemicals.
Note: µg/l = micrograms per liter; ng/l = nanograms/liter

New Mexico Water Quality Act: Groundwater Discharge Regulations

Under the New Mexico Water Quality Act, the New Mexico Water Quality Control Commission sets regulations for liquid discharges onto or below ground surfaces to protect groundwater. 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. At the beginning of 2020, the Laboratory had four discharge permits and one discharge permit application pending a decision.

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, (2) effluent from Outfalls 001, 03A027, and 13S (outfalls that can discharge water from the sanitary wastewater system plant), and (3) alluvial groundwater well SCA-3 in Sandia Canyon. In 2020, none of the samples collected exceeded the New Mexico groundwater standards and no inspection of Discharge Permit DP-857 facilities were conducted.

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. In 2020, two inactive septic tanks were closed and one inactive septic tank was reactivated. There are currently six active septic tank disposal systems at the Laboratory.

Discharge Permit DP-1589 requires monitoring and inspections for the Laboratory's septic tank disposal systems. These actions include, but are not limited to, the following: (1) routine septic tank sampling, (2) septic tank water-tightness testing, (3) inspection of the septic tank for the accumulation of scum and solids, and (4) inspection of the leach field disposal system.

The permit conditions require semi-annual and annual sampling of active septic tank disposal systems. In 2020, the following exceedances were detected: the Technical Area 33-0375 septic tank exceeded for total nitrogen and iron, and the Technical Area 33-0179 and Technical Area 58-0052 septic tanks each exceeded for total nitrogen. The total nitrogen exceedances were anticipated since the samples collected are untreated domestic wastewater. The iron exceedance may have been related to iron pipes connected to the Technical Area 33-0375 septic tank. No inspections of Discharge Permit DP-1589 facilities were conducted in 2020.

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

On August 19, 1996, the DOE and Triad's predecessor contractor LANS (the permittees) submitted a discharge plan and permit application for the Radioactive Liquid Waste Treatment Facility at Technical Area 50. On February 16, 2012, the New Mexico Environment Department requested an updated permit application for this facility, to include plans and specifications for a new facility (the solar evaporative tank) and upgraded units as well as closure requirements. On May 5, 2017, the New Mexico Environment Department issued a notice for public comment on a draft of DP-1132, and a public hearing was held on April 19, 2018. Following issuance of the Hearing Officer's Report, the Secretary of the New Mexico Environment Department issued DP-1132 on August 29, 2018.

On February 4, 2019, a Motion to Vacate DP-1132 was filed by Communities for Clean Water with the New Mexico Water Quality Control Commission. This motion was denied on April 9, 2019; however, the Commission reconsidered its' denial and on June 18, 2019, issued a Revised Order Granting the Motion and Vacating DP-1132. As a result, DP-1132 was remanded for a new hearing with a newly appointed hearing officer. On November 14, 2019, the New Mexico Environment Department held a second public hearing, and on February 10, 2020, a Hearing Officer's Report was issued recommending issuance of DP-1132 by the Secretary of the New Mexico Environment Department. However, on June 24, 2020, the Secretary issued an Order to Remand the DP-1132 proceeding to the New Mexico Environment Department's Ground Water Quality Bureau to include an additional permit condition that considers "financial assurance" for closure, post-closure and clean-up activities, and to schedule a public hearing on any such proposal. On October 14, 2021, the permittees and NMED filed a Joint Motion requesting that the Secretary reconsider his decision and to allow the parties to discuss the potential for alternative financial assurance. The motion is currently pending in front of the Secretary.

After the Secretary's remand of the DP-1132 proceeding, the permittees requested that the New Mexico Environment Department issue a 120-day Temporary Permission to continue to discharge. The New Mexico Environment Department granted this Temporary Permission and has granted several additional requests since the regulations limit a Temporary Permission to 120 days. The Temporary Permissions require the Laboratory to implement operational, monitoring, and closure actions through work plans for certain units and/or systems at the Radioactive Liquid Water Treatment Facility. Examples of these actions are (1) monthly sampling of treated effluent, (2) quarterly and annual groundwater monitoring at seven alluvial, perched-intermediate, and regional aquifer wells, (3) the installation of a soil moisture monitoring system beneath the Technical Area 52 solar evaporation tank, and (4) the removal from service of seven tanks that do not have secondary containment. In 2020, all effluent sample results met groundwater quality standards, and no compliance inspections were conducted. All groundwater monitoring well samples met groundwater quality standards except for exceedances associated with the chromium project as presented in Chapter 5, Groundwater Protection.

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 treated groundwater onto the surface of the ground). Activities involving land application of treated groundwater include well pumping tests, aquifer tests, and well rehabilitation. Under the permit, individual work plans must be submitted for each land application project. Work plans are posted to the Laboratory's Electronic Public Reading Room for a 30-day public comment period. Each work plan addresses how groundwater will be treated so that constituent concentrations are less than 90 percent of the New Mexico groundwater standards before discharge.

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. This permit authorized the withdrawal of chromium-contaminated groundwater from extraction wells, treatment by ion exchange, and the injection of treated groundwater back into the regional aquifer by up to six underground injection control wells. On July 21, 2017, the New Mexico Environment Department approved this request. Treated groundwater is sampled to demonstrate that chromium concentrations are less than 90 percent of the New Mexico groundwater standard for chromium (50 micrograms per liter) before injection.

Discharge Permit DP-1835 requires quarterly reporting to document (1) influent and discharge volumes, flow rates, and effluent sample results of the treatment systems; (2) volumes injected and water levels above static (no pumping) level for the injection wells; (3) volumes extracted from the extraction wells; (4) groundwater sample results and groundwater contour maps from the monitoring wells; (5) any operations or maintenance activities completed, including replacement of ion exchange vessels or well work-overs; (6) any periodic mechanical integrity testing completed; and (7) changes to operations.

Compliance Order on Consent Groundwater Activities

In 2020, the Laboratory performed groundwater protection activities as directed by the New Mexico Environment Department under the Compliance Order on Consent. Activities included sampling and testing groundwater from wells and springs for general monitoring of groundwater quality, investigating the chromium and RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine) groundwater plumes, and implementing the chromium interim measures.

Interim measures are actions taken at a contaminated site to reduce chances of human or environmental exposures while a remedial investigation continues. The goal of the chromium interim measures is to control migration of the chromium groundwater plume while the Laboratory assesses cleanup methods. In 2020, operations supporting the chromium interim measures included (1) withdrawing chromium-contaminated groundwater from the regional aquifer using extraction wells (referred to as CrEX wells, for chromium extraction), (2) treating the water using ion exchange to remove chromium, and then (3) injecting the treated groundwater back into the regional aquifer using injection wells (referred to as CrIN wells, for chromium injection).

First quarter 2020 interim measures operations consisted of pumping from three extraction wells, CrEX-1, CrEX-2, and CrEX-5, and injection of treated water through injection wells CrIN-1, CrIN-2, CrIN-3, CrIN-4, and CrIN-5. CrEX-4 was operated for short-term functional testing. Beginning on March 25, 2020, the DOE Environmental Management Los Alamos Field Office initiated an Essential Mission Critical Activities status in response to the COVID-19 pandemic. Under Essential Mission Critical Activities status, interim measures operations were paused. Portions of the interim measures system were put back into operation in July 2020. Third- and fourth-quarter 2020 interim measures operations consisted of pumping from four chromium plume extraction wells, CrEX-1, CrEX-2, CrEX-4, and CrEX-5, and injection of treated water through five injection wells CrIN-1, CrIN-2, CrIN-3, CrIN-4, and CrIN-5. Extraction well CrEX-3 remained offline during 2020 except for limited sampling purposes.

More information is available in Chapter 5, Groundwater Protection.

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. The DOE has analyzed the impacts of LANL operations and activities in a Site-Wide Environmental Impact Statement (DOE 2008a). The Records of Decision for the Site-Wide Environmental Impact Statement (DOE 2008b, DOE 2009) describe the operations and activities the DOE has approved and any required mitigations.

Laboratory staff specializing in the National Environmental Policy Act review proposed projects to determine if associated impacts have been analyzed in the 2008 Site-Wide Environmental Impact Statement for the Continued Operation of Los Alamos National Laboratory or other existing National Environmental Policy Act documents.

In 2020, staff reviewed approximately 900 proposed projects. Those projects or activities that do not have coverage under existing documents require new or additional analyses. Laboratory projects that required additional National Environmental Policy Act analyses in 2020 are explained below.

In June 2019, the National Nuclear Security Administration announced its National Environmental Policy Act strategy for pit production across the complex. The strategy outlined the National Nuclear Security Administration's intent to prepare a site-specific analysis of the proposal to expand pit production at Los Alamos National Laboratory to no fewer than 30 pits per year by 2026 (DOE 2019a). On September 2, 2020, the National Nuclear Security Administration published an Amended Record of Decision for the Complex Transformation Supplemental Programmatic Environmental Impact Statement (DOE 2020a). In the Amended Record of Decision, NNSA announced its programmatic decision to implement elements of a Modified Distributed Centers of Excellence Alternative whereby Los Alamos National Laboratory would produce a minimum of 30 war reserve pits per year for the national pit production mission during 2026 and implement surge efforts to exceed 30 pits per year as needed, without construction of the Chemistry and Metallurgy Research and Replacement Nuclear Facility.

A sixth supplement analysis to the 2008 Site-Wide Environmental Impact Statement for the Continued Operation of Los Alamos National Laboratory was prepared for production of no fewer than 30 pits per year at Los Alamos National Laboratory (DOE 2020b). The National Nuclear Security Administration published an amended Record of Decision based on this supplement analysis in September 2020, addressing implementation of additional elements of the Expanded Operations Alternative for an increase in pit production (DOE 2020c).

On December 16, 2020, the National Nuclear Security Administration announced its Notice of Intent to prepare an Environmental Impact Statement for the Surplus Plutonium Program. NNSA announced that it will prepare a Surplus Plutonium Disposition Program Environmental Impact Statement to evaluate the dilute and dispose alternative, also known as "plutonium downblending," and any other identified reasonable alternatives for the disposition of surplus plutonium. The dilute and dispose approach would require new, modified, or existing capabilities at the Savannah River Site, Los Alamos National Laboratory, Pantex Plant, and the Waste Isolation Pilot Plant (DOE 2020d).

Six Los Alamos National Laboratory projects were categorically excluded from further DOE National Environmental Policy Act review in 2020:

- Tracking Aerosol Convection Interactions Experiment (TRACER) (CX-270533)
- Hazardous Waste Permit Modification to Create a Treatment and Storage Facility (CX-270534)
- Leasing Property (CX-270530)
- Decommissioning and Demolition Project at Technical Area 41, Los Alamos National Laboratory, Los Alamos County, New Mexico (CX 270542)
- Primary Circuit Electrical Power Line Extension from Technical Area 36 to Technical Area 68 (CX 270543)
- New Mexico State Road 4 and East Jemez Road Intersection Improvements, Right-of-Way Expansion and Land Conveyance (CX 270544)

National Historic Preservation Act

The National Historic Preservation Act of 1966, as amended, requires federal agencies to consider the effects of their activities on historic properties, including archaeological sites and historic buildings, and requires a mitigation plan for any adverse effects to the properties. LANL's Cultural Resources Management Plan (LANL 2017b) describes the Laboratory's process for complying with the National Historic Preservation Act and other cultural resources laws and regulations, and its strategy for managing cultural resources.

In 2020, N3B archaeologists reviewed 14 environmental remediation projects for cultural resources requirements. They also coordinated with members of the Triad cultural resources team to write a damage assessment of site LA 4619 in Technical Area 54 due to a small brush fire inside the site.

In fiscal year 2020, Triad archaeologists supported 9 projects by conducting historic property surveys or verifying results from previous surveys. Additionally, archaeologists evaluated two archaeological sites for eligibility for inclusion in the National Register of Historic Places (Register). These findings were reported to the New Mexico State Historic Preservation Office, which concurred that both sites were eligible for inclusion in the Register. Also, a legacy report on the excavation and updated eligibility for inclusion in the Register was completed for a historic homestead site and submitted to the State Historic Preservation Office. This report was accepted by the State Historic Preservation Office as the final documentation and fulfillment of terms of a Memorandum of Agreement for the excavation of this historic homestead site.

Archaeologists conducted an annual inspection of the Museum of Indian Arts and Culture located in Santa Fe, New Mexico. The focus of the inspection was to ensure compliance with regulations for the preservation and curation of artifacts from archaeological sites excavated on Laboratory property since 1949. These inspections are required under *Curation of Federally-Owned and Administered Archaeological Collections*, Title 36 Part 79 of the Code of Federal Regulations.

Triad historic buildings staff supported 27 Laboratory projects by performing inspections and research on the historical use of the buildings using the LANL National Security Research Center, documents available through the public reading room, and historical photographs. Staff conducted archival documentation for five projects impacting historic buildings at Technical Areas 3, 15, 16, and 52, including taking interior and exterior photographs of the buildings. Historic buildings staff also participated in surveillance and maintenance evaluations for the most significant historic properties located at the Laboratory, including the 17 buildings and structures that are either included in the Manhattan Project National Historical Park or that are Park eligible (see Chapter 3).

Cultural resources staff continues to conduct consultations with the Accord Pueblos (Pueblo de San Ildefonso, Santa Clara Pueblo, Pueblo of Jemez, and Pueblo de Cochiti) regarding the identification and preservation of 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 the Habitat Management Plan (LANL 2017c).

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 (Berryhill et al. 2020; BISON-M 2021; Table 2-13).

Table 2-13. Threatened, Endangered, and Other Sensitive Species Occurring or Potentially Occurring at the Laboratory

Scientific Name	Common Name	Protected Status*	Potential to Occur†
Empidonax traillii extimus	Southwestern willow flycatcher	E, NME, S1	Moderate
Mustela nigripes	Black-footed ferret	E	Low
Strix occidentalis lucida	Mexican spotted owl	T, NMS	High
Coccyzus americanus	Yellow-billed cuckoo (western distinct population segment)	T, NMS	Low
Zapus hudsonius luteus	New Mexico meadow jumping mouse	E, NME, S1	Low
Haliaeetus leucocepahlus	Bald eagle	NMT, S1	High
Cynanthus latirostris magicus	Broad-billed hummingbird	NMT, S1	Low
Amazilia violiceps	Violet-crowned hummingbird	NMT, S1	Low
Gila Pandora	Rio Grande chub	NMS	Moderate
Plethodon neomexicanus	Jemez Mountains salamander	E, NME	High
Falco peregrinus	Peregrine falcon	NMT	High
Accipiter gentiles	Northern goshawk	NMS	High
Lanius ludovicianus	Loggerhead shrike	NMS	High
Vireo vicinior	Gray vireo	NMT	High
Myotis ciliolabrum melanorhinus	Western small-footed myotis bat	NMS	High
Myotis volans interior	Long-legged bat	NMS	High

Scientific Name	Common Name	Protected Status*	Potential to Occur†
Euderma maculatum	Spotted bat	NMT	High
Corynorhinus townsendii pallescens	Townsend's pale big-eared bat	NMS	High
Nyctinomops macrotis	Big free-tailed bat	NMS	High
Bassariscus astutus	Ringtail	NMS	High
Vulpes vulpes	Red fox	NMS	Moderate
Lilium philadelphicum var. andinum	Wood lily	NME	High
Cypripedium calceolus var. pubescens	Greater yellow lady's slipper	NME	Moderate
Mentzelia springeri	Springer's blazing star	FSS	Moderate
Cynomys gunnisoni	Gunnison's prairie dog	NMS	Moderate
Danaus plexippus	Monarch Butterfly	**	High
Strix occidentalis lucida	Mexican spotted owl	T, NMS	High

*E = Federal Endangered; T = Federal Threatened; NME = New Mexico Endangered; NMT = New Mexico Threatened; NMS = New Mexico Sensitive Taxa (informal); S1 = Heritage New Mexico: Critically Imperiled in New Mexico; FSS = Forest Service Sensitive Species; **Warranted but precluded by higher priorities December 15, 2020.*
†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 they have the potential to impact federally listed species or their habitats. In 2020, biologists reviewed 646 excavation permits, 184 project profiles in the permits and requirements identification system, 24 minor siting proposals, and 13 storm water pollution prevention plans for potential impacts to threatened or endangered species. If there is a potential for impacts, biologists 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. In 2020, we prepared three biological assessments to analyze the impacts to listed species. The first assessment addressed the construction of a new multistory parking structure at TA-50 that was in a partially developed area (LANL 2020a). The second assessment addressed the decommissioning and demolition of the Ice House building at TA-41 as well as the reinforcement of Omega Road to facilitate transportation of heavy equipment to the site (LANL 2020b). The third assessment addressed the decommissioning and demolition of an older building to construct two new office buildings in TA-35 (LANL 2020c). These biological assessments received concurrence from the U.S. Fish and Wildlife Service. In 2020, we did not find any projects out of compliance with endangered species protection requirements.

We also conducted surveys for the Mexican spotted owl and southwestern willow flycatcher. The Jemez Mountains salamander surveys were not conducted in 2020 because forest soils were too dry. In 2020, Mexican spotted owls were found on Laboratory property in the same nesting locations as past years. We found two Mexican spotted owl nests and breeding was confirmed at both nests. Southwestern willow flycatchers were not found during surveys, but one willow flycatcher of unknown subspecies was recorded during bird banding operations.

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. As part of the Laboratory’s Migratory Bird Treaty Act compliance, we review projects for potential impacts to migratory birds and conducts bird population monitoring projects. These efforts support 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.

In project reviews, Laboratory biologists provide specific comments for projects that have 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. In 2020, we did not find any projects out of compliance with migratory bird protection requirements.

In 2020, we continued annual breeding season and winter surveys for birds in all major habitat types and continued monitoring nest boxes for use by birds. As part of a long-term monitoring project at two open detonation sites and one open burn site, our point count surveys and nest box monitoring results continue to suggest that operations at these sites are not negatively affecting bird populations. In addition, biologists captured and banded birds during the breeding season in Sandia Canyon, to monitor breeding bird populations, and during fall migration in Pajarito Canyon, to monitor use of Laboratory lands by migrating birds. In 2020, 729 birds were banded at the Laboratory.

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. In 2020, three floodplain assessments were prepared. One was for a primary circuit extension project in Fence and Water Canyons (Technical Areas 36 and 68). One was for a road maintenance and building demolition project in Los Alamos Canyon (Technical Area 41). One was for modifications and upgrades to the intersection of New Mexico State Route 4 and East Jemez Road and installation of a four-wire fence and a prefabricated bridge at the Shooting Range Facility in Sandia Canyon (Technical Area 72). No violations of the DOE floodplain/wetland environmental review requirements were recorded.

Invasive Species Executive Order

In accordance with Executive Order 13751, *Safeguarding the Nation from the Impacts of Invasive Species*, we identify invasive species and treat isolated invasive plant species populations. Larger, well-established populations of some species like Siberian elm (*Ulmus pumila*), Russian olive (*Elaeagnus angustifolia*), and saltcedar (*Tamarix ramosissima*) are removed opportunistically, in conjunction with other construction projects. Developing an invasive species best management practices document is a mitigation requirement of the Finding of No Significant Impact for the Final Supplemental Environmental Assessment for the Wildfire Hazard Reduction and Forest Health Improvement Program at Los Alamos National Laboratory, Los Alamos, New Mexico (DOE 2019b), and we plan to complete it in 2021. We have developed a software application for electronic devices that allows users to identify and mark the locations of invasive plant species at the Laboratory to track spread and for future removals. A current list of invasive species known to occur at LANL is presented below in Table 2-14.

Table 2-14. List of Common Names and Latin Names of Invasive Species Known to Occur at LANL

Common Name	Latin Name
Giant leopard slug	*Limax maximus*
Eurasian collared-dove	*Streptopelia decaocto*
European starling	*Sturnus vulgaris*
Bull thistle	*Cirsium vulgare*
Canada thistle	*Cirsium arvense*
Cheatgrass	*Bromus tectorum*
Dalmatian toadflax	*Linaria dalmatica*
Field bindweed	*Convolvulus arvensis*
Jointed goatgrass	*Aegilops cylindrica*
Kochia	*Kochia scoparia*
Leafy spurge	*Euphorbia esula*
Lehmann lovegrass	*Eragrostis lehmanniana*
Mullein	*Verbascum spp.*
Myrtle spurge	*Euphorbia myrsinites*
Nodding plumeless thistle	*Carduus nutans*
Oxeye daisy	*Leucanthemum vulgare*
Puncturevine	*Tribulus terrestris*
Redtop	*Agrostis gigantea*
Rough cocklebur	*Xanthium strumarium*
Russian knapweed	*Acroptilon repens*
Russian olive	*Elaeagnus angustifolia*
Russian thistle	*Salsola kali*
Saltcedar	*Tamarix ramosissima*
Scotch cottonthistle	*Onopordum acanthium*
Siberian elm	*Ulmus pumila*
Smooth brome	*Bromus inermis*
Teasel	*Dipsacus spp.*
Tree of heaven	*Ailanthus altissima*
Whitetop	*Cardaria draba*
Yellow salsify	*Tragopogon dubius*

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

Two laws and one nationwide Clean Water Act permit regulate how the Laboratory uses and reports on its use of pesticides (chemicals that destroy plant, fungal, or animal pests). The Federal Insecticide, Fungicide, and Rodenticide Act regulates the distribution, sale, and use of pesticides. The New Mexico Pesticide Control Act regulates (1) licensing and certification of pesticide workers, (2) record keeping, (3) equipment inspection, (4) application of pesticides, and (5) storage and disposal of pesticides. The National Pollutant Discharge Elimination System Pesticide General Permit requires annual reporting of pesticide use to the U.S. Environmental Protection Agency.

In 2020, pesticide usage was reported to the U.S. Environmental Protection Agency in accordance with the National Pollutant Discharge Elimination System Pesticide General Permit. Table 2-15 shows the amounts of pesticides the Laboratory used in 2020.

Table 2-15. Pesticides Used by LANL in 2020

Herbicide	Amount
Velossa	43.41 gallons
Ranger Pro Herbicide	25.19 gallons
Insecticide	**Amount**
Maxforce Complete Brand Granular Insect Bait	0.0039 gallons
PT Wasp Freeze II and Hornet Insecticide	0.0125 pounds
Water Treatment Chemical	**Amount**
Garratt-Callahan Formula 314-T	275 pounds
Garrett-Callahan Formula 316	10 pounds 5 ounces
Houghton Chemical Purobrom Tablets	3492 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, performance measures programs, or both; and

- summarize property clearance activities.

The Laboratory began environmental monitoring in 1945 and published the first comprehensive environmental monitoring report in 1970. Current and past reports are available at https://www.lanl.gov/environment/environmental-report.php.

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 Laboratory facility in amounts above specified thresholds. We are required to notify state and local officials and the community under this Act about the following items: (1) changes at the Laboratory that might affect the local emergency plan or if the Laboratory's emergency planning coordinator changes; (2) leaks, spills, and other releases of listed chemicals into the environment if these releases exceed specified quantities; (3) the annual inventory of the quantities and locations of hazardous chemicals above specified thresholds present at the facility; and (4) total annual releases to the environment of listed chemicals that exceed specified thresholds. Table 2-16 identifies what community and emergency planning reporting the Laboratory did in 2020.

Table 2-16. Status of Emergency Planning and Community Right-to-Know Act Reporting in 2020

Emergency Planning and Community Right-to-Know Act Section	Description of Reporting	Status (Yes, No, or Not Required)
Section 302-303	Planning notification	Not required
Section 304	Extremely hazardous substance or hazardous substance release notification	Not required
Section 311-312	Material safety data sheet/Hazardous chemical inventory	Yes
Section 313	Toxics release inventory reporting	Yes

For Section 313 reporting, the listed chemical that met the criteria for reporting in 2020 was lead. The largest use of reportable lead was from offsite waste transfers. Table 2-17 summarizes the reported releases in 2020. There are no compliance violations associated with this use or release of lead.

Table 2-17. Summary of 2020 Total Annual Releases under Emergency Planning and Community Right-to-Know Act, Section 313

Reported Release	Lead (pounds)
Air emissions	3.1
Water discharges	0.25
Onsite land disposal (firing range)	725
Offsite waste transfers	14,388

DOE Order 232.2A, Occurrence Reporting and Processing of Operations Information

DOE Order 232.2A, Occurrence Reporting and Processing of Operations Information, requires reporting of abnormal events or conditions that occur during facility operations. An “occurrence” is one or more events or conditions that may adversely affect workers, the public, property, the environment, or the DOE mission. In 2020, Triad had no reportable environmental occurrences. There was one incident in which the U.S. Environmental Protection Agency initially claimed that the Laboratory did not submit certain water monitoring data, but the Laboratory proved that the data was submitted on time. The U.S. Environmental Protection Agency is in the process of writing a retraction. N3B did not have any reportable environmental occurrences in 2020.

DOE Order 436.1, Departmental Sustainability

The purpose of this DOE order is to ensure that the DOE carries out its missions in a sustainable manner that addresses national energy security and global environmental challenges. As directed by this order, the Laboratory had adopted an Environmental Management System, and prepares and implements an annual Site Sustainability Plan. LANL’s Environmental Management System and Site Sustainability Plan are discussed in detail in Chapter 3.

Inspections and Audits

Table 2-18 lists the environmental inspections conducted by regulating agencies and external auditors at the Laboratory during 2020.

Table 2-18. Environmental Inspections and Audits Conducted at the Laboratory during 2020

Date	Purpose	Performing Entity
9/14–18/2020	Environmental Management System Surveillance Audit, covering clauses of the ISO 14001:2015 standard	NSF International
6/23–8/5/2020	Carlsbad Field Office Annual Re-certification	Environmental Protection Agency, Carlsbad Field Office
9/2/2020	Waste Control Specialists Annual Recertification Audit at N3B	Waste Control Specialists
08/10–12/2020	Annual Audit and Resource Conservation and Recovery Act Permit Site Inspections	New Mexico Environment Department Hazardous Waste Bureau

Unplanned Releases

Air Releases

In 2020, there were no unplanned air releases.

Liquid Releases

Triad reported 16 unplanned liquid releases to the New Mexico Environment Department in 2020, as required by the New Mexico Water Quality Control Commission regulations, and N3B reported three (Table 2-19). Corrective actions were taken for all liquid releases and were communicated to the New Mexico Environment Department Ground Water Quality Bureau.

Table 2-19. 2020 Unplanned Reportable Liquid Releases

Material Released	Number of Instances	Approximate Total Release (gallons)
Potable Water	4	455,850
Sanitary Waste Water	5	3,415
Sanitary Effluent Blended Water	1	1,000
RLWTF Treated Effluent	1	0.5
Hydraulic Fluid	1	30
Antifreeze	1	5
Asphalt Cement	1	5700
Cooling Tower Water	1	100
Bearing Cooling Water	1	1,600
Treated Water from Chromium Treatment System (N3B)	1	2500-5000
Groundwater well purge water (N3B)	1	40
Purge water, drilling fluids, development water from well development activities (N3B)	1	1400

Site Resilience

Updated in 2018, the National Climate Assessment explains what current and future climate change is likely to mean for the United States (Gonzalez et al. 2018). 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.

In 2015, we began tracking climatic risk indices relating to temperature, precipitation, wind, indicator species, and storm water flow. These indices will assist us in identifying when actions are necessary to protect facilities and operations. Below are the results of indices that were available in 2020.

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 and are shown in Figure 2-2. The temperatures between 1960 and 2000 had no trend. The years 2001–2010 were approximately 1.5°F warmer than the previous 40 years, and the years 2011–2018 were approximately 3°F warmer than the 1960–2000 averages. When average temperatures are broken down into summer and winter minimums and maximums, the summer minimum temperatures (Figure 2-3) demonstrate the strongest increasing trend from 1990 onward (an increase of approximately 4°F).

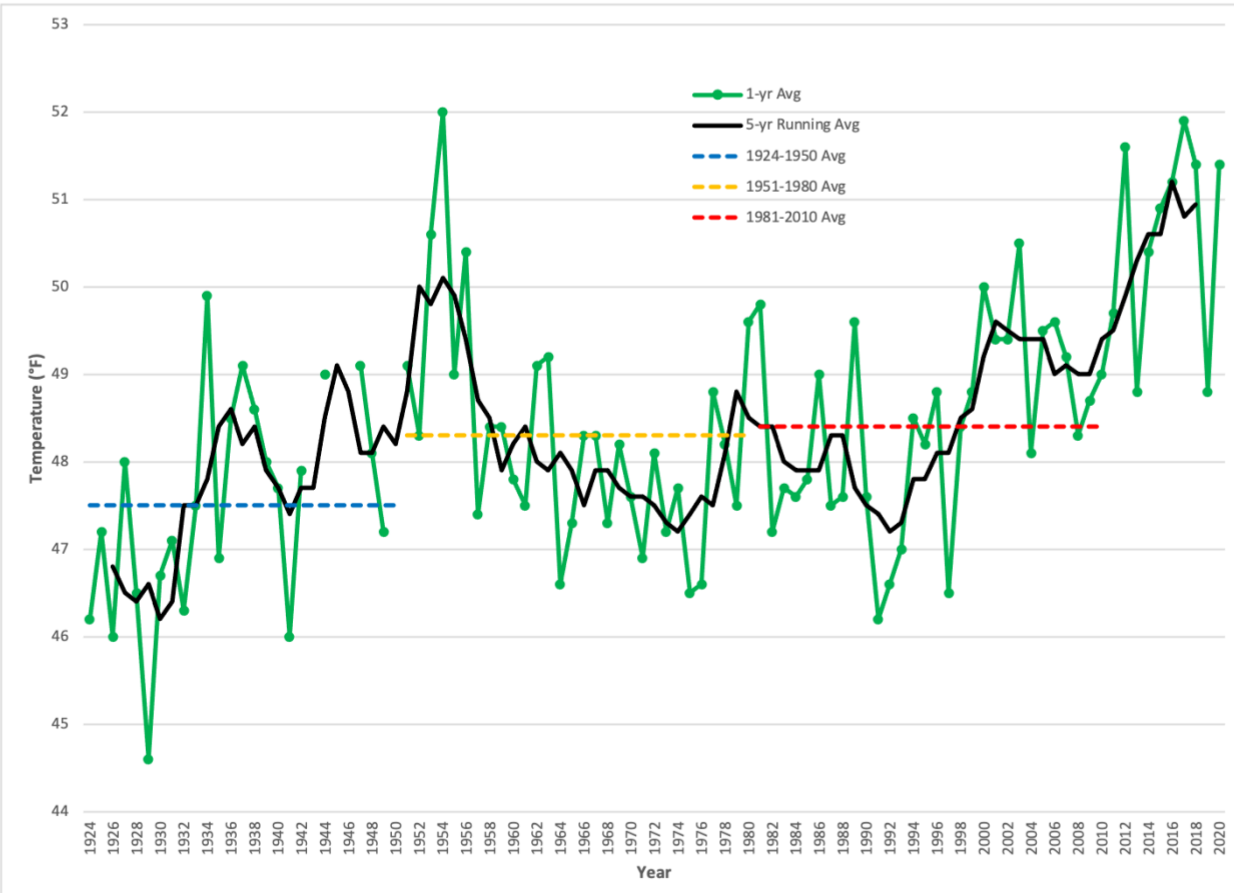

Figure 2-3. Annual average temperatures for Los Alamos. The dashed lines represent long-term climatological average temperatures, the black line represents the 5-year running average temperature, and the green line represents the 1-year average.

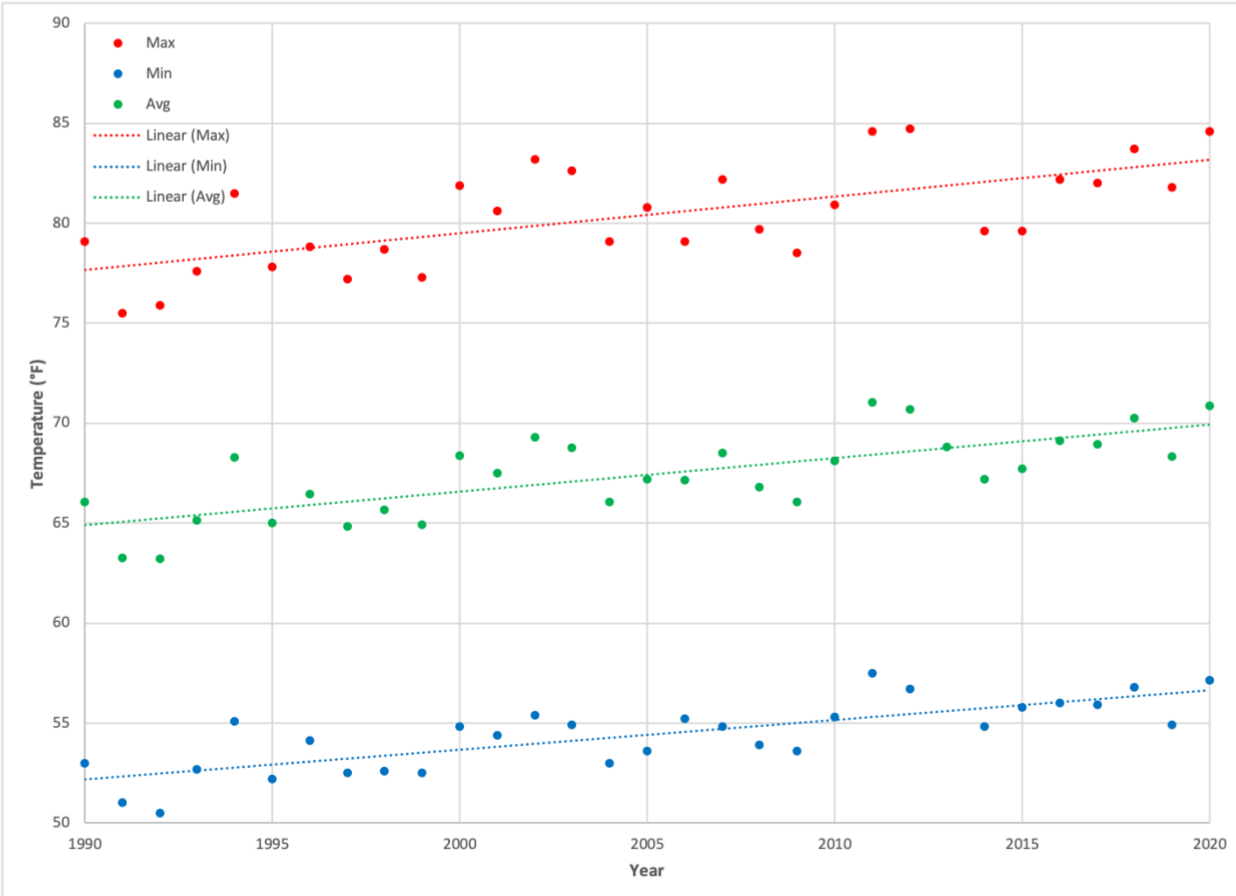

Figure 2-4. Average summer (June, July, August) Los Alamos temperatures. The dashed lines represent the trend line for maximum, minimum, and average summer temperatures, which show summer temperatures have been continuously increasing since 1990.

Changes in temperature can also be assessed by changes in the number of cooling and heating degree days. The number of cooling and heating degree days is used to estimate the annual power usage needed to heat or air conditioning condition- buildings. A cooling degree day represents a one-degree increase in the average daily temperature above 65°F. As an example, if the average daily temperature was 80°F, that day would represent 15 cooling degree days. Heating degree days are calculated in the same way from the number of degrees an average daily temperature is below 65°F. Shown in Figure 2-4, cooling degree days have been increasing since 1990, while heating degree days have been decreasing (Figure 2-5).

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 2-4) have increased and heating degree days (Figure 2-5) have decreased. Thus, less energy has been needed to heat buildings, but more energy has been needed to cool buildings. In 2020, the number of cooling degree days was the highest recorded to date, due in part to significantly warm days in July.

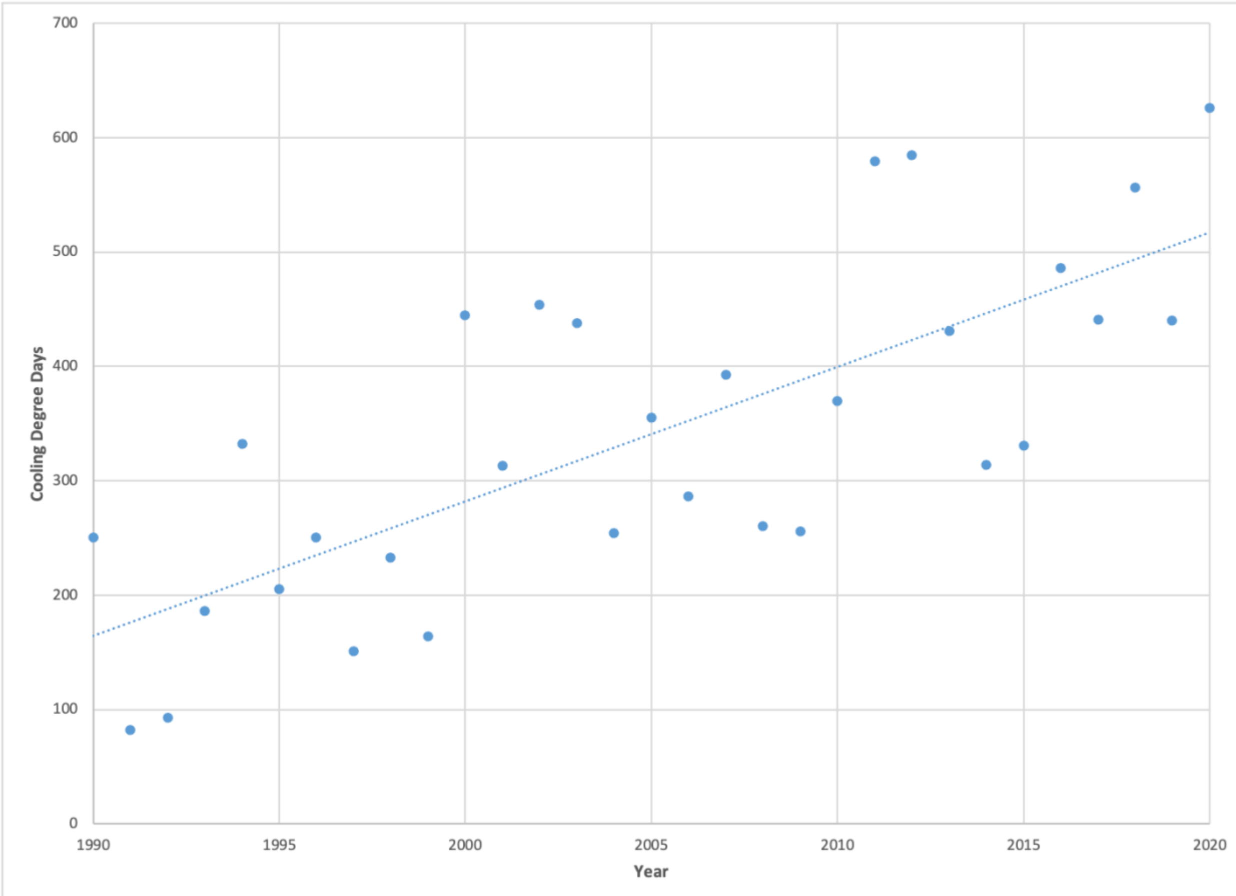

Figure 2-5. Los Alamos cooling degree days per year. The dashed line represents the trend line for cooling degree days, which shows cooling degree days have increased, resulting in more energy needed to cool buildings.

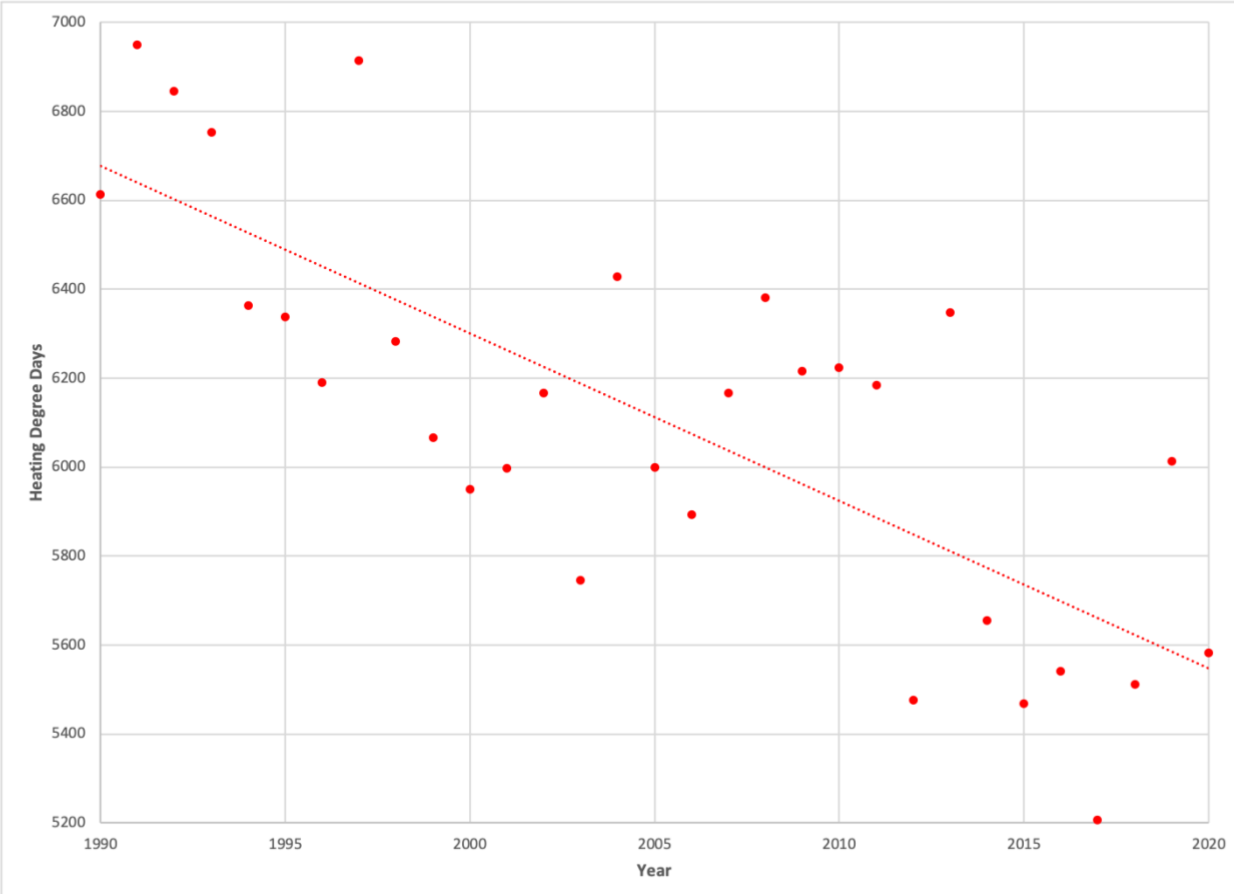

Figure 2-6. Los Alamos heating degree days. The dashed line represents the trend line for heating degree days, which shows heating degree days have decreased, resulting in less energy needed to heat buildings.

Wind Speed

The annual average wind speed measured at the Laboratory's meteorological tower of record at Technical Area 6 has increased approximately 20 percent over the past 25 years (Figure 2-6). Although not shown here, the monthly average wind speed during the spring months (windiest months) shows an increase by approximately 1 meter per second. 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, 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 6 since 1990 (Kelly et al. 2015).

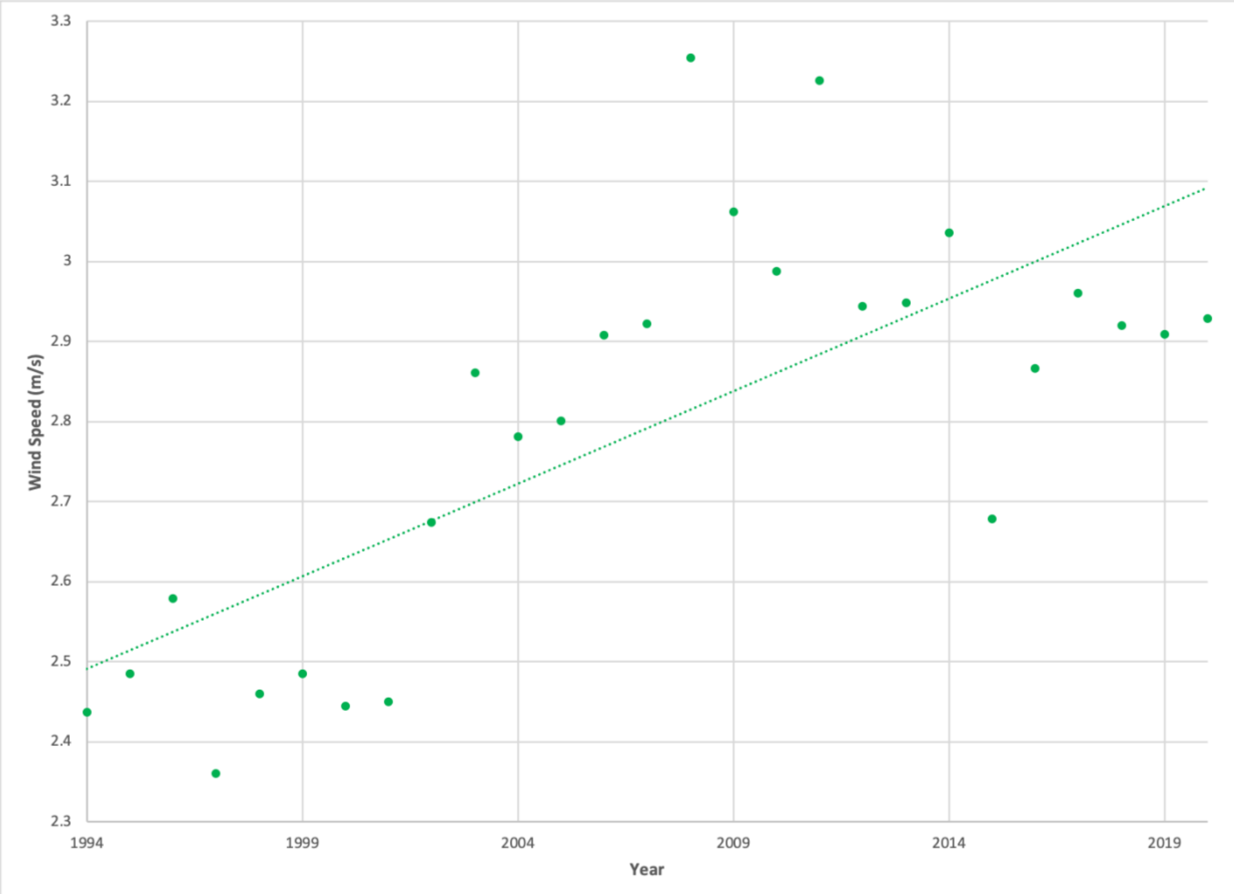

Figure 2-7. Technical Area 6 annual average wind speed at 12 meters above the ground. The dashed line represents the trend line for wind speed, which shows the annual average wind speed has been increasing since 1994.

Annual Red Flag Warnings

The National Weather Service issues Red Flag Warnings when critical weather conditions may result in extreme fire behavior. The National Weather Service began recording the number of Red Flag Warnings per year for the Los Alamos area in 2012 (Figure 2-7). Red Flag Warnings have increased over the past four years, but since 2012, there has not been a trend. Some Laboratory operations, including explosives testing, are restricted on days with Red Flag Warnings.

If the following weather conditions occur simultaneously for three or more hours, a Red Flag Warning can be issued:

- sustained winds at or above 20 miles per hour,
- relative humidity less than 15 percent, and
- above average temperatures.

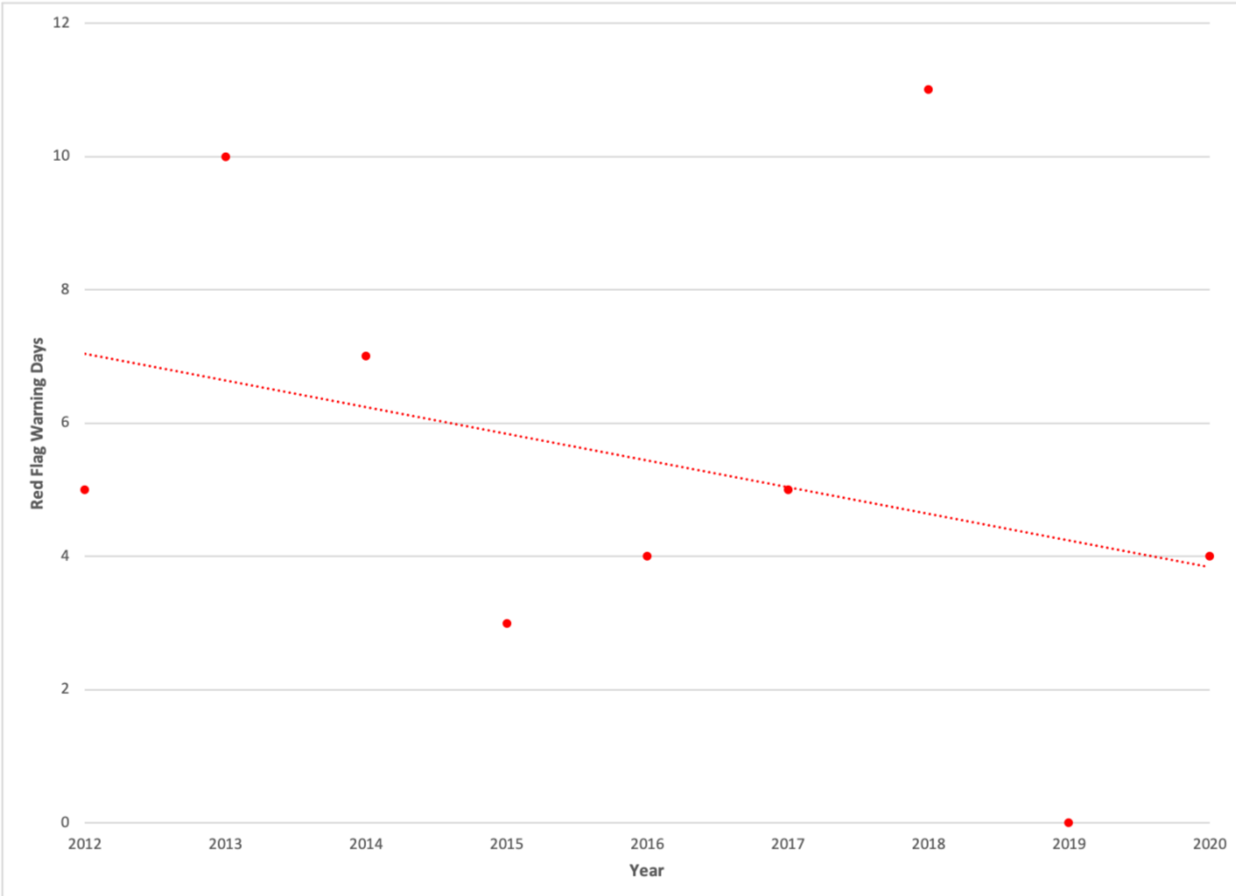

Figure 2-8. Number of National Weather Service Red Flag Warning days for zone 102 (Los Alamos)

Precipitation

We analyzed the annual average precipitation (Figure 2-8) and the number of days per year with heavy rain events (Figure 2-9). 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 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.

The frequency of heavy rain events (Figure 2-9), defined as precipitation greater than 0.5 inches in one day, does not demonstrate a significant long-term trend since 1950. 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.

Annual average snowfall (Figure 2-10) demonstrates a decrease in the long-term trend since 1950. Since the drought began in 1998, there have been only three years with above-average recorded snowfall (1981–2010 average = 57 inches).

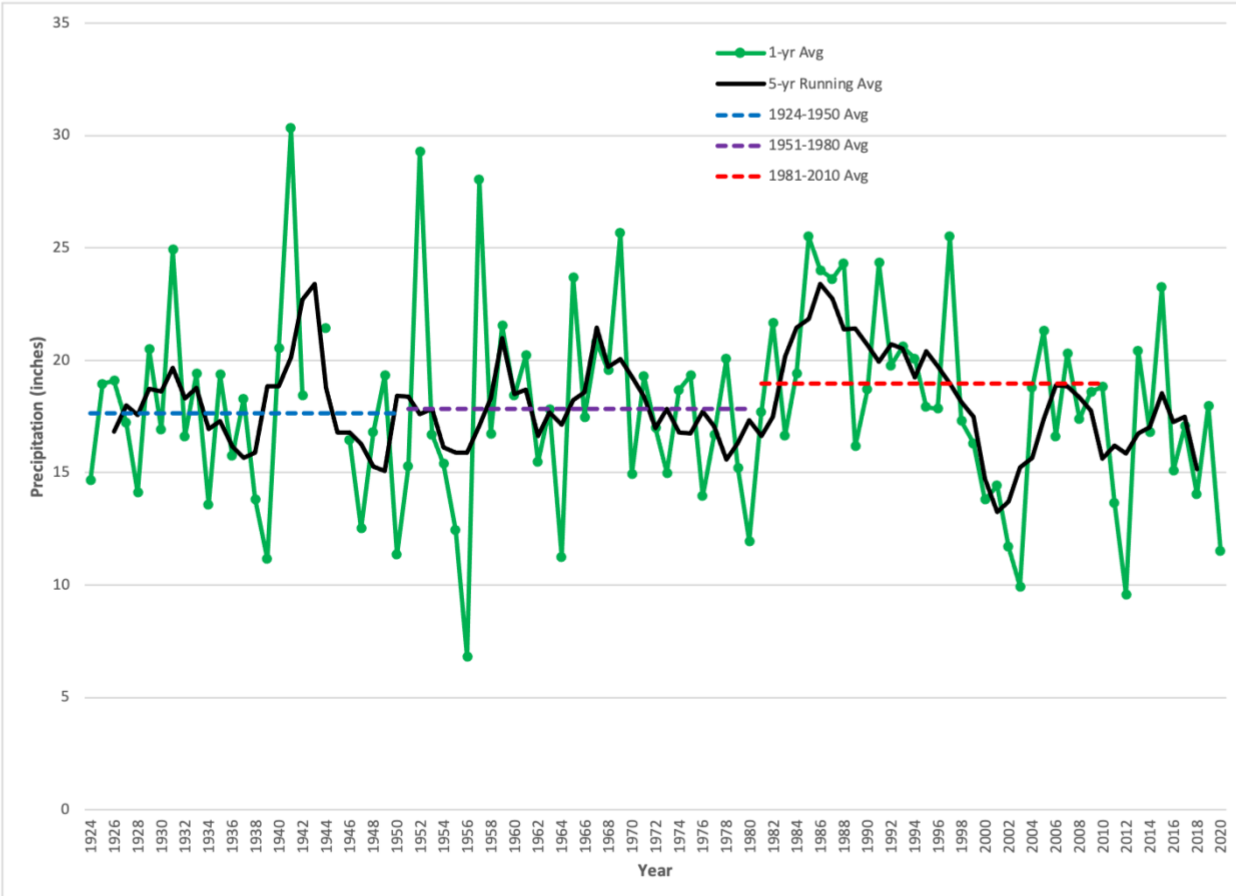

Figure 2-9. Annual precipitation totals for Los Alamos. The dashed lines represent long-term climatological average total precipitation, the black line represents the 5-year running average precipitation, and the green line represents the 1-year total precipitation. Significant drought since the 1990s has resulted in below average precipitation in many recent years.

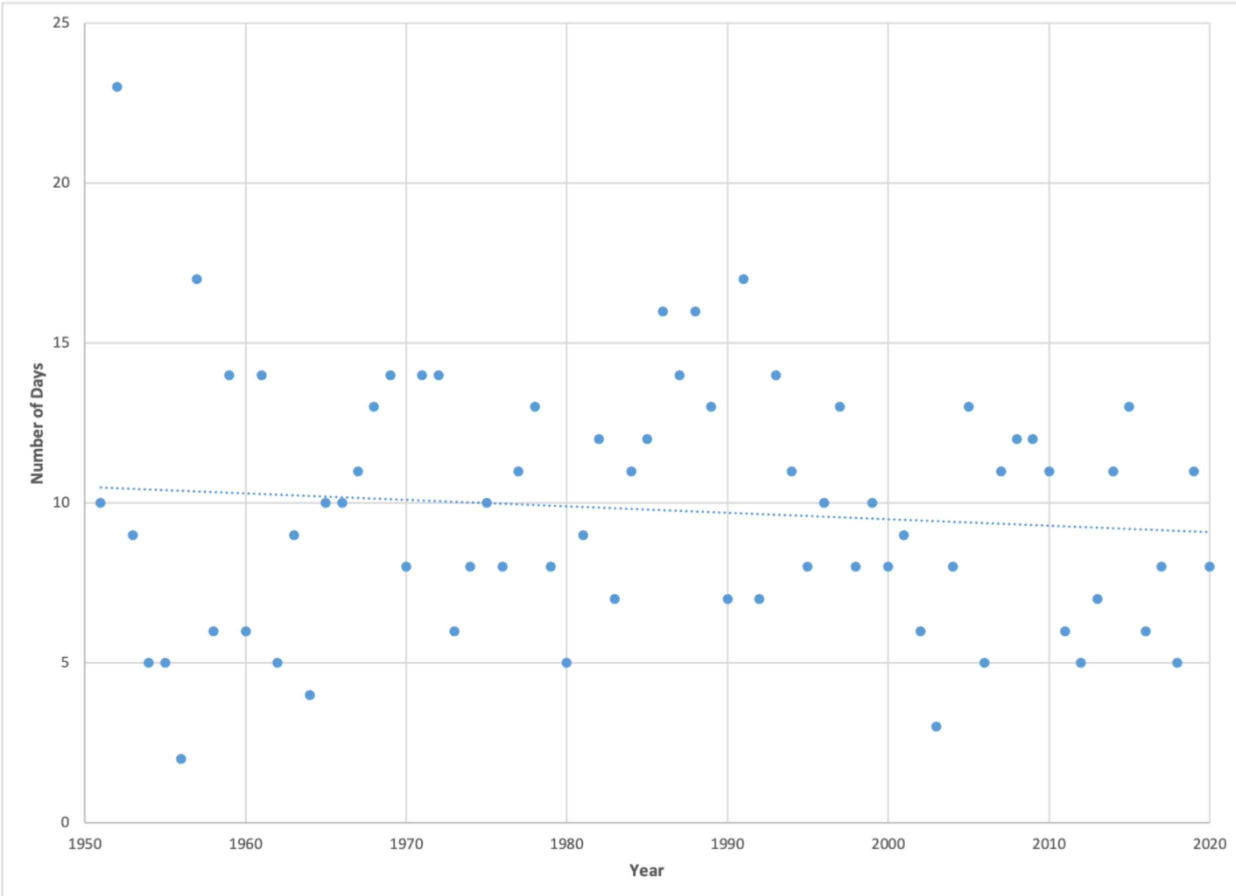

Figure 2-10. Number of days per year with precipitation >0.5 inches. The dashed line represents the trend line for days with precipitation >0.5 inches. The slight decreasing trend since 1950 is not statistically significant.

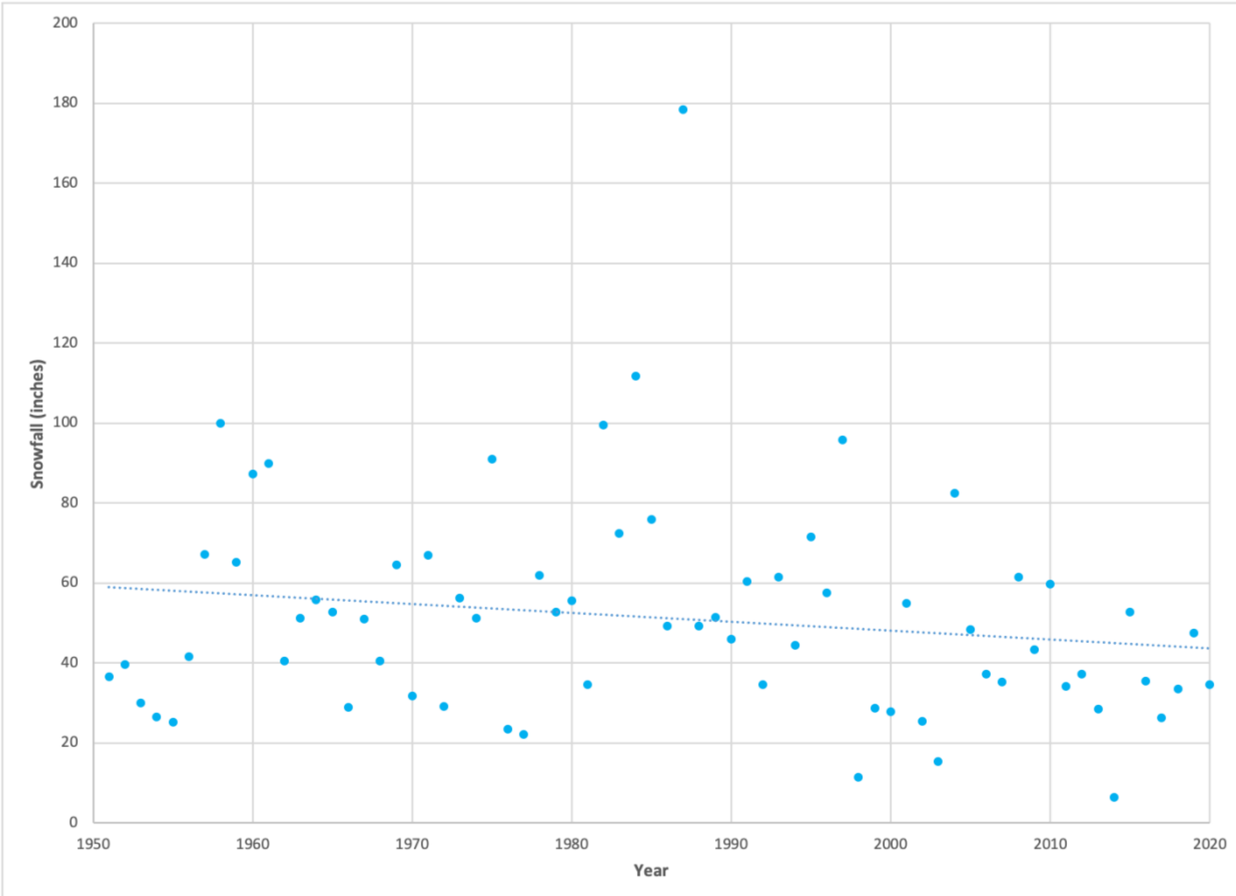

Figure 2-11. Annual average Los Alamos snowfall. The dashed line represents the trend line for snowfall, which shows a decrease in annual snowfall.

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 U.S. The annual average temperatures for the southwest are predicted to rise by 3.7°F–4.8°F by 2036–2065, and the temperatures measured at Los Alamos 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. The Laboratory's data are consistent with these predictions, in particular over the past 22 years, with below-average snowfall in 86 percent of the years. The National Climate Assessment does not make a specific prediction for the southwest for heavy precipitation events. The Laboratory's data does 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. Two major wildland fires have impacted the Laboratory in the past 20 years: the 2000 Cerro Grande fire and the 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. Increases in average wind speeds affect emergency planning in the event of an aerial release of hazardous substances.

Summary of Permits and Compliance Orders

Table 2-20 presents the environmental permits and administrative compliance orders the Laboratory operated under in 2020.

Table 2-20. Environmental Permits and Legal Orders which the Laboratory operated under in 2020

Name	Activity	Issuing and Revision Dates	Expiration Date	Administering Agency	Page in Chapter
Los Alamos National Laboratory Hazardous Waste Facility Permit	A permit regulating management of hazardous wastes at the Laboratory, including storage and treatment. This permit also has standards for closure of indoor and outdoor areas used for hazardous waste storage or treatment. https://www.env.nm.gov/hazardous-waste/lanl-permit/	Renewed November 2010	December 2020 [Administratively Continued until new permit is effective]	New Mexico Environment Department	2-7
Administrative Compliance Order No. HWB-14-20 Settlement Agreement and Stipulated Final Order (SEP Projects)	Settlement of Administrative Compliance Order No. HWB-14-20 issued on December 6, 2014 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 Supplemental Environmental Projects (SEPs), including road improvements on transport routes to the Waste Isolation Pilot Plant. https://www.energy.gov/sites/prod/files/2015/01/f19/LANL%20ACO%20120614.pdf	Settlement Agreement and Stipulated Final Order finalized on January 22, 2016	None	New Mexico Environment Department	2-9
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	Issued October 4, 1995 Amended May 20, 1997	None	New Mexico Environment Department	2-11

Name	Activity	Issuing and Revision Dates	Expiration Date	Administering Agency	Page in Chapter
	https://www.env.nm.gov/HWB/documents/LANL_FFCO_5-20-1997_Ammendment.pdf				
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 Permit Re-Application Submitted March 26, 2019 Administratively Continued October 22, 2019	September 30, 2019 [Administratively Continued until New new Permit is effective]	U.S. Environmental Protection Agency	2-17
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	2-44
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.	Issued August 7, 2009 Reissued October 17, 2018	February 27, 2020 [Administratively Continued until new permit is effective]	New Mexico Environment Department	2-13
New Mexico Air Quality Control Act Construction Permits	Permits regulating construction or modification of air emissions sources, including the following:			New Mexico Environment Department	2-16
	• Technical Area 03 power plant Permit modification 2 (NSR 2195-B-M3)	Issued September 27, 2000 Reissued November 1, 2011 Major Modification July 26, 2018	None		
	• Asphalt plant at Technical Area 60 Permit revision 1 (GCP3-2195-G)	Issued October 29, 2002 Reissued September 12, 2006	None		
	• 1600-kilowatt generator at Technical Area 33 Permit revision 4 (NSR 2195-F R4)	Issued October 10, 2002 Reissued December 12, 2013	None		

Name	Activity	Issuing and Revision Dates	Expiration Date	Administering Agency	Page in Chapter
	• Two 20-kilowatt generators and one 225-kilowatt generator at Technical Area 33 (NSR 2195-P)	Issued August 8, 2007	None		
	• Data disintegrator (NSR 2195-H R1)	Issued October 22, 2003 Revised June 14, 2006	None		
	• Chemistry and Metallurgy Research Replacement facility, Radiological Laboratory/Utility/Office Building Permit revision 2 (NSR 2195-N R2)	Issued September 16, 2005 Reissued September 25, 2012	None		
	• LANL exemption notifications - rock crusher removed (NSR 2195)	Issued June 16, 1999	None		
	• Technical Area 35, building 213, beryllium machining (NSR 632)	Issued December 26, 1985	None		
	• Technical Area 03, building 141, beryllium technology facility (NSR 634 M2)	Issued March 19, 1986 Revised October 30, 1998	None		
	• Technical Area 55 beryllium machining (NSR 1081 M1R6)	Issued July 1, 1994 Revised May 12, 2006	None		
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.	Effective March 19, 2017 (all current nationwide Section 404 permits) – a previous version was in effect until March 18, 2017.	March 18, 2022 (all current nationwide Section 404 permits)	U.S. Army Corps of Engineers and New Mexico Environment Department (all permits and verifications)	2-16
Clean Water Act, Section 404/401 Permits (cont.)	The following projects had an ongoing annual monitoring requirement: • Water Canyon storm drain reconstruction project • Mortandad Wetland Enhancement	 Annual monitoring and reporting required through 2021 Annual monitoring and reporting required through 2022			

Name	Activity	Issuing and Revision Dates	Expiration Date	Administering Agency	Page in Chapter
National Pollutant Discharge Elimination System General Permit for Discharges of Storm Water from Construction Sites	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, 2017	February 16, 2022	U.S. Environmental Protection Agency	2-19
National Pollutant Discharge Elimination System Multi-Sector General Permit for Storm Water 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 run-off. 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 The 2021 Multi-Sector General Permit was issued on January 15, 2021 and became effective on March 1, 2021. Coverage for existing facilities under the 2015 Multi-Sector General Permit was administratively continued to allow for transition to the new permit.	U.S. Environmental Protection Agency	2-19
[Individual Permit] Authorization to	A permit authorizing the Laboratory to discharge storm water from 405 Solid Waste Management Units and Areas of Concern under specific conditions.	Issued November 1, 2010	October 31, 2015 Application for renewal	U.S. Environmental	2-24

Name	Activity	Issuing and Revision Dates	Expiration Date	Administering Agency	Page in Chapter
Discharge [from Solid Waste Management Units and Areas of Concern] Under the National Pollutant Discharge Elimination System	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)		submitted to the U.S. Environmental Protection Agency in 2019 Administratively extended by the U.S. Environmental Protection Agency pending issuance of new permit.	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	December 16, 2021	New Mexico Environment Department	2-35
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	2-35
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 Transferred to N3B on April 30, 2018 Permit renewal application submitted to the New Mexico Environment Department Ground Water Quality Board on January 29, 2020. The application	New Mexico Environment Department	2-36

Name	Activity	Issuing and Revision Dates	Expiration Date	Administering Agency	Page in Chapter
			was determined administratively complete on February 7, 2020. Currently awaiting issuance of Draft Permit.		
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 Transferred to N3B on April 30, 2018	New Mexico Environment Department	2-36
Groundwater Discharge Permit DP-1132	A permit authorizing discharges to groundwater from the Laboratory's Radioactive Liquid Waste Treatment Facility to three discharge locations: Outfall 051, mechanical evaporator system, or solar evaporation tank system.	Pending. Discharges occurring under Temporary Permission authorized by New Mexico Environment Department.	Pending	New Mexico Environment Department	2-37
Compliance Order on Consent	An order giving requirements for the investigation, corrective actions, and monitoring of solid waste management units and areas of concern. (https://www.env.nm.gov/wp-content/uploads/2016/05/Consent-Order-modified-Feb-2017.pdf)	Issued March 1, 2005 Revised October 29, 2012 Replaced by 2016 Compliance Order on Consent on June 24, 2016 M2016 Compliance Order on Consent modified February 2017	None	New Mexico Environment Department	2-10

Quality Assurance

Waste Management

Triad's programs for waste management, including quality assurance, are described in the institutional procedure P409, LANL Waste Management, and flow-down documents. N3B's programs for waste management, including quality assurance, are described in the procedure N3B-P409-1, N3B Waste Management, and flow-down documents.

Air Quality and Protection

Air quality compliance activities are performed in accordance with the procedures and processes described in EPC-CP-QAP-001, *Environmental Compliance Programs Quality Assurance Plan*; EPC-CP-QAP-901, *EPC-CP Quality Procedure to Supplement ADESH-0007, Document Control;* and a series of Program Implementation Plans (PIP):

- EPC-CP-PIP-0101, Rad-NESHAP Compliance Program
- EPC-CP-PIP-0340, Title V Operating Permit Program
- EPC-CP-PIP-0301, Greenhouse Gas Monitoring and Emissions Reporting
- EPC-CP-PIP-0310, Air Quality Refrigerants
- EPC-CP-PIP-0320, Emergency Planning and Community Right-to Know Act (EPCRA) Section 313 Reporting
- EPC-CP-PIP-0330: Air Quality Regulatory Review and Permitting
- EPC-CP-PIP-0370, Asbestos NESHAP Compliance
- EPC-CP-PIP-0380, Beryllium NESHAP Compliance

These documents ensure that compliance activities are planned, performed, and documented using approved procedures, data quality objectives, and integrated work processes. Over 20 detailed Quality Procedures (QPs) are in place that flow down from these Program Implementation Plans.

Air Quality Compliance team personnel conduct semi-annual internal inspections of all permitted sources using detailed checklists to ensure all permit requirements are being met. Additionally the New Mexico Environment Department Air Quality Bureau conducts annual external inspections of LANL's compliance with their Title V Operating Permit.

Analytical data is used to generate various compliance monitoring reports and deliverables that are submitted to regulatory agencies as required by the permit. Each report is subjected to a quality peer review prior to submittal to ensure that the data is correct, representative, and meets the established data quality objectives. All reports submitted to regulatory agencies are maintained as quality records in accordance with the permit and ADESH-QP-006, *Records Management Plan*.

Refrigerant program personnel also conduct internal semi-annual audits to ensure that refrigerant used in service, maintenance, repair and disposal activities on refrigeration equipment is accounted for thereby assuring compliance with the no venting prohibition under federal regulations.

Members of the Radioactive Air Emissions Management team conduct stack sampling and monitoring activities, sampler inspections, flow measurements, and data analyses to meet regulatory requirements. All activities are conducted per procedure and with peer review. Representatives of the U.S. Environmental Protection Agency Region 6 periodically visit the site to evaluate operations. Analytical data calculations and compliance reports for the Radioactive Air Emission Team are subject to reviews similar to those described for the Air Quality Control program.

Surface Water Quality and Protection

Triad surface water compliance activities are performed in accordance with the procedures and processes described in EPC-CP-QAP-001, *Environmental Compliance Programs Quality Assurance Plan*; EPC-CP-QAP-901, *EPC-CP Quality Procedure to Supplement*; and EPC-CP-QAPP – *National Pollutant Discharge Elimination System Industrial Point Source Permit, Quality Assurance Project Plan for the National Pollutant Discharge Elimination System Industrial Point Source Permit Self-Monitoring Program*. These documents ensure that compliance activities are planned, performed, and documented using approved procedures, data quality objectives, monthly/quarterly/yearly sampling plans, and integrated work processes. In 2020, the following procedures were used to collect samples, prepare discharge monitoring reports, and prepare reapplications surveys:

- EPC-CP-PIP-1201, National Pollutant Discharge Elimination System Program Implementation Plan
- EPC-DO-QP-100, General Field Safety. EPC-CP-QP-1204, Performing National Pollutant Discharge Elimination System Reapplication Surveys
- EPC-CP-TP-1202, Sampling at National Pollutant Discharge Elimination System Permitted Point-Source Outfalls
- EPC-CP-QP-060, Preparing Discharge Monitoring Reports for the National Pollutant Discharge Elimination System Industrial Point Source Permit Self-Monitoring Program

Surface water compliance samples are collected and the associated data are analyzed using established data quality objectives that define the appropriate type of data to collect and establish guidelines for the acceptance and use of the analytical data to make decisions regarding the compliance at each outfall. These data quality objectives are developed in accordance with U.S. Environmental Protection Agency QA/G-4, *Guidance for the Data Quality Objectives Process*.

In 2020, the following procedures were used to collect samples and prepare reports for the Triad Construction General Permit and the Multi-Sector General Permit programs:

National Pollutant Discharge Elimination System Construction General Permit

- ENV-RCRA-QAPP-NPDES CGP, Quality Assurance Project Plan for the NPDES Construction General Permit Program
- EPC-CP-QP-2002, Performing CGP Stormwater Inspections
- EPC-CP-TP-2003, CGP Rain Gage Operation and Maintenance

National Pollutant Discharge Elimination System Multi-Sector General Permit

- ENV-CP-QAPP-MSGP, Quality Assurance Project Plan for Stormwater Multi-Sector General Permit for Industrial Activities Program

- EPC-CP-TP-2102, Installing, Setting Up, and Operating ISCO Samplers
- EPC-CP-TP-2103, Inspecting Stormwater Runoff Samplers and Retrieving Samples for the MSGP
- EPC-CP-QP-027, Installing, Inspecting, and Maintaining MSGP Single Stage Samplers
- EPC-CP-QP-064, MSGP Stormwater Visual Assessments
- EPC-CP-QP-2106, Processing MSGP Stormwater Samples
- ENV-CP-QP-044, Preparing Stormwater Discharge Monitoring Reports for the NPDES Multi-Sector General Permit
- EPC-CP-QP-023, MSGP Routine Facility Inspections
- EPC-CP-QP-022, MSGP Corrective Actions
- EPC-CP-QP-2110, MSGP Stormwater Pollution Prevention Plan Preparation and Maintenance (new procedure draft in progress)

In 2020, N3B used the following procedures to collect samples and prepare reports for the surface water monitoring under the Individual Permit, Multi-Sector General Permit and environmental surveillance programs:

- N3B-AP-ER-5008, Verifying and Certifying Individual Permit Corrective Action Measures
- N3B-DI-ER-4010, Desk Instruction for Managing Electronic Precipitation Data for Storm Water Projects
- N3B-DI-ER-4011, Desk Instruction for Managing Electronic Stage and Discharge Data from Stream Gage Stations
- N3B-SOP-ER-3002, Spring and Surface Water Sampling
- N3B-SOP-ER-4001, Processing Surface Water Samples
- N3B-SOP-ER-4002, Splitting Surface Water Samples with a Dekaport Splitter
- N3B-SOP-ER-4003, Operation and Maintenance of Gage Stations for Storm Water Projects
- N3B-SOP-ER-4004, Installing, Setting Up and Operating Automated Storm Water Samplers
- N3B-SOP-ER-5002, Inspection, Installation, and Maintenance of Non-Engineered NPDES Individual Permit Storm Water Control Measures
- N3B-SOP-ER-5004, Inspecting Automated Storm Water Samplers and Retrieving Samples
- N3B-SOP-ER-5006, Determining and Evaluating Drainage Area Boundaries
- N3B-GDE-ER-5013, Inspection Guidance for Environmental Programs Watershed, Retention, and No Exposure Controls
- N3B-ER-GUIDE-5014, Geomorphic Characterization
- N3B-GDE-ER-5011, Hydrology for Individual Permit Corrective Actions and Control Measures – Design Guide
- N3B-GDE-ER-5015, Stormwater Best Management Practices Manual
- N3B-SOP-ER-5016, Multi-Sector General Permit Storm Water Corrective Actions
- N3B-QP-RGC-003, Land Application of Drill Cuttings
- N3B-AP-RGC-0002, Minor Spill Response Reporting Procedure
- N3B-PLN-RGC-0001, Sediment Management Decision Tree Guidance
- N3B-PLN-RGC-0003, Un-permitted Discharge Reporting
- N3B-QP-RGC-0002, Land Application of Groundwater
- N3B-EPC-CP-QP-064, MSGP Stormwater Visual Assessments
- N3B-AOP-TRU-3003 Material Release or Spill
- N3B-SOP-RP-0005 Radiological Emergency Response

Groundwater Quality and Protection

Triad's Ground Water Quality and Protection program operates in accordance with EPC-CP-QAP-001, *Environmental Compliance Programs Quality Assurance Plan*. Discharges to treatment facilities which are part of this program are conducted in accordance with the Laboratory's P409.1 LANL's Waste Acceptance Criteria.

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Chapter 3: Environmental Programs and Analytical Data Quality

This chapter highlights the programs that Los Alamos National Laboratory (the Laboratory or LANL) has in place to (1) comply with environmental laws and regulations and (2) reduce the risk of Laboratory operations adversely affecting the environment. All of the Laboratory's environmental programs contribute to and are part of the Laboratory's Environmental Management System.

We first discuss processes and programs that support Laboratory-wide activities to improve our environmental performance. These include the Pollution Prevention Program, the Site Sustainability Program, the Site Cleanup and Workplace Stewardship Program, and the Project Review process.

Next, we discuss our dedicated "core" programs that lead our compliance with specific environmental laws. Core programs are generally composed of subject matter experts in the requirements of laws such as the Clean Air Act, the Clean Water Act, and the Resource Conservation and Recovery Act.

Finally, we discuss the process the Laboratory uses to ensure that the results from its monitoring and compliance sampling meet DOE standards for data quality.

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Introduction

The Laboratory has three overarching objectives for our environmental performance: clean the past, control the present, and create a sustainable future. This chapter describes the institutional processes and dedicated “core” programs we use to manage the Laboratory’s environmental performance. These institutional processes and programs combine to form the Laboratory’s Environmental Management System.

This chapter includes information from both the management and operating contractor, Triad National Security LLC (Triad), and the legacy waste cleanup contractor, Newport News Nuclear – BWTX Los Alamos (N3B). Both organizations have processes and programs to manage and improve the Laboratory’s environmental performance. However, Triad manages an overall much greater scope of work at the Laboratory than does N3B. Therefore, with the exception of analytical data quality for sampling of environmental media, the bulk of the discussion in this chapter relates to programs managed by Triad. Analytical data quality for environmental media sampling, which is crucial for both environmental compliance and legacy waste cleanup, is managed in partnership by N3B and Triad.

Institutional Processes and Programs

Environmental Management System

Certification of the Laboratory’s Environmental Management System to the International Organization for Standardization’s 14001 Standard

The International Organization for Standardization is independent and nongovernmental. It brings together experts to develop voluntary international standards that provide solutions to global challenges. These standards describe the best practices for conducting a wide range of activities. The 14001 standard specifies the best practices for an environmental management system to improve an organization’s environmental performance, including reducing environmental impacts such as waste and becoming more environmentally sustainable. The Laboratory has maintained independent, third-party certification for its environmental management system under the 14001 standard since April 2006.

When the legacy waste clean-up contract was separated from the management and operating contract in 2018, each contractor organization took responsibility for its own Environmental Management System. Triad, the management and operating contractor, currently manages the certified Environmental Management System described above.

N3B is building its Environmental Management System to align with its specific procedures and work controls. N3B is working toward International Organization for Standardization 14001 certification for its Environmental Management System.

Environmental Management System Program Activities

The Deputy Laboratory Director for Operations chairs Triad's Environmental Senior Management Steering Committee. The committee sets institutional objectives and annual targets for environmental performance. The three institutional objectives for the Laboratory's environmental performance are (1) clean the past, (2) control the present, and (3) create a sustainable future.

Within these three objectives, Triad's Senior Environmental Management Steering Committee identified the following targets (desired actions) for the 2020 fiscal year.

Clean the Past

Targets

- Identify and dispose of equipment, materials, and metals no longer in use.
- Right-purpose existing space; upgrade for ongoing and future use.
- Identify, characterize, and process wastes on time.

Control the Present

Targets

- Create a world-class waste management system (turnkey, cradle-to-grave support).
- Evaluate facilities and programmatic, operations, and research and development–owned equipment; implement measures to improve maintenance processes to reduce associated risks to environmental performance.
- Improve site-wide water and energy efficiency by incorporating best-in-class sustainable design criteria into new construction and campus planning efforts.
- Implement an effective chemical management program.
- Educate workers about environmental initiatives and successes.
- Reduce the environmental impacts for material acquisition and lifecycle management.

Create a Sustainable Future

Targets

- Improve waste operations, advance characterization technologies, and reduce waste life cycle by using research and development to address key science and technology gaps.
- Interact with stakeholders (internal, external) and neighbors (municipal and tribal governments, federal agencies) to manage and reduce LANL's impact on the environment.

The Laboratory annually updates a list of the significant environmental aspects that could be associated with its activities. Table 3-1 lists and describes the environmental aspects identified for 2020, 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 2020, Triad managed and tracked 213 actions in 12 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 • Diffuse air emissions from activities such as remediation and construction activities • Use of greenhouse gas contributors such as refrigerants, vehicles, and fluorinated gases
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 • Activity within the boundary of a watercourse • Application of pesticides
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).	• 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 a drinking water supply system or into the groundwater. This includes planned or unplanned releases onto the ground or into surface water that have the potential to migrate to groundwater. Impacts can be positive or negative.	• Cooling tower water supply use • Installation or abandonment of groundwater wells or associated systems • Land application of water • Septic systems and sanitary holding tanks • Permitted wastewater storage basins
Work within or near floodplains and wetlands	Building 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 • Structures built in a floodplain or wetland • Activities or emergencies that disrupt the integrity of a floodplain or wetland

Environmental Aspects	Description	Examples
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.	• Removal of weeds, trees, brush, or invasive species • Installation and operation of fencing, buildings, power lines, towers, drainage, or other structures • Installation and operation of night 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 byproducts
Interaction with soil resources	Activities that disturb surface or subsurface soils, or release or have 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, and activities that may result in migration or deposition of radioactive constituents onto or into the ground. Activities may result from routine work or from emergency or off-normal events.	• 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 detonation, remediation activities, and decontamination and decommissioning projects • New construction, site selection, brownfield versus greenfield development
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 • Smoking
Cultural/historical resources	Activities that impact or have the potential to impact cultural or historical resources. Resources include, but are not limited to, historical buildings, buildings of special significance, archaeological sites, traditional cultural properties, historic homesteads, and trails. Activities may result from routine work or from emergencies or off-normal events.	• Maintenance or expansion of existing areas (trails, walkways, roads, easements) • Ground-disturbing activities below grade or surface areas • Maintenance, modification, or demolition of structures, including potentially or designated historic structures • Off-road vehicle use • Vegetation removal and weed mitigation activities • Archaeological excavations

Environmental Aspects	Description	Examples
Visual resources	Activities that impact or have the potential to impact visual landscapes.	• Construction, management, and maintenance of access roads, fencing, utility corridors, and power transmission systems • Construction, management, and maintenance of staging areas, storage yards, debris piles, litter, and other "eye-sores" • Tree thinning • Security or after-hours lighting
Hazardous or radioactive material and 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
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
Solid or sanitary waste generation and management	Activities that generate or manage (handle, store, treat, or dispose of) non-hazardous and nonradioactive waste intended for disposal at a municipal or industrial waste landfill.	• Laboratory, machining, and process operations wastes (non-hazardous or nonradioactive) • Non-recyclable waste, for example, some office waste and some construction and demolition debris
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 • Mitigation • Demolition • Open detonation

Environmental Aspects	Description	Examples
Chemical (industrial and laboratory) use and storage	Activities that result in the purchase, use, management, movement, or storage of chemicals. Activities may result from routine work or from emergency or off-normal events.	• Chemical use in research laboratories • Vehicle operation and maintenance (fuels, coolants, lubricants, etc.) • Building cleaning and maintenance (janitorial supplies) • Application of pesticides, fertilizers, and other roads and grounds maintenance chemicals
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) in-use materials, surplus supplies, real estate, or other property.	• Managing (leasing, renting, selling, or purchasing) active or inactive real estate, includes evaluation of property for contamination • Managing (storing, using, recycling, reusing, disposing of) surplus property • Cleanup and recommissioning of work areas • Decontamination and decommissioning facilities
Resource use and conservation	Activities or practices that affect resource use and conservation, may increase or reduce demand or wastes, or 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 • 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 involve handling or storing materials in tanks.	• Operating and/or maintaining aboveground tanks in accordance with the Laboratory’s hazardous waste permit
Engineered nanomaterials	Activities involving intentionally created particles with one or more dimensions between 1 and 100 nanometers.	• Nanotechnology research and development that generates nanoparticles requiring environmental or worker safety controls • Nanoparticle waste characterization, packaging, storage, transport, treatment, or disposal

The online course *Environmental Awareness Training* is required for all employees, including subcontractors, who are onsite for longer than two weeks. Retraining is required every two years. The course is an overview of environmental requirements for the site.

The Laboratory's Environmental Management System has both external audits and internal assessments every year. All findings and corrective actions generated from these audits and assessments are tracked to closure in an issues management system. In 2020, one external certification audit and one internal assessment found no minor nonconformities (a minor deficiency that does not seriously affect the efficiency of the Environmental Management System), and several opportunities for improvement, including improving environment-related work control awareness for construction subcontractors, upgrading tools for environmental risk identification and assessment, and improvements to tracking of environment-related inquiries. In fiscal year 2020, the Laboratory's Environmental Management System scored green on all of the following federal government metrics:

- Activities, products, and services and their associated environmental aspects were evaluated for significance and documented. Any necessary changes were made or are scheduled to be made.
- Measurable environmental objectives were in place.
- Operational controls were established, implemented, controlled, and maintained in accordance with operating criteria.
- An environmental compliance audit program was in place and audits were completed according to schedule. Audit findings were documented and corrective actions were implemented.
- As directed by Executive Order 13834, Efficient Federal Operations, sustainability goals were addressed.

Site Sustainability

The Laboratory's sustainability efforts and goals align with Executive Order 13990, Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis. This executive order promotes policies to protect our environment, reduce greenhouse gas emissions, and bolster resilience to the impacts of climate change.

Current site sustainability initiatives include replacing a steam plant built in the 1950s with new gas supply pipelines and a more efficient Combustion Gas Turbine Generator; developing an onsite 10-megawatt photovoltaic system; and implementing a Smart Labs program to enhance the scientific and technological capabilities of existing facilities while ensuring safe and efficient work spaces.

The fiscal year 2020 Site Sustainability Plan focused on three primary strategies: (1) make targeted investments for efficiency, (2) transparently track our progress through metrics to achieve a more efficient and resilient laboratory, and (3) engage employees and programs at all levels in the Laboratory. The intent of the Site Sustainability Program is to include energy and water conservation and cleaner production measures into everyday business practices.

Successes and Challenges

Site Sustainability successes from 2020 include the following:

- Upgraded heating, ventilation, and air conditioning systems in 40 facilities (1.5 million square feet)
- Upgraded or replaced building automation systems in 15 facilities
- Implemented facility fault detection and data analytics software SkySpark in 60 facilities

- Continued implementing an Energy Savings Performance Contract for heating, ventilation, and air conditioning and lighting upgrades over a 20-year period ($1.2 million annual savings)
- Continued implementing an Energy Savings Performance Contract for the Power Plant Replacement Project
- Completed analysis and environmental assessment of potential photovoltaic system sites (no significant environmental impacts)
- Updated the LANL Engineering Standards Manual to incorporate more comprehensive sustainable design criteria and programs such as Guiding Principles and Smart Labs
- Insulated LANL steam pits using thermal system insulation infrared technology
- Added light emitting diodes and motion sensing lighting in parking garages and solar lighting in parking lots
- Installed electric vehicle charging stations to serve personal and government vehicles
- Acquired a mobile shredding truck to improve the efficiency of paper recycling through lower fuel, labor, and operating costs

We target our sustainability investments to reduce growth in energy demand while supporting hiring and planned mission activities. In 2020, the Laboratory reduced its water use intensity (gallons used per square foot of building) by 20.3 percent compared with fiscal year 2007 and achieved an 8.3 percent reduction in energy intensity (British thermal units used per square foot of building) compared with fiscal year 2015. Table 3-2 provides the Laboratory's specific site sustainability goals, our progress toward meeting those goals in fiscal year 2020, and planned strategies for making additional progress towards those goals.

Table 3-2. Fiscal year 2020 status and planned strategies for the Laboratory's site sustainability goals

DOE Goal	Current Performance Status	Planned Actions & Contribution
75% of light-duty vehicle acquisitions consist of alternative fuel vehicles.	Federal Automotive Statistical Tool data is not yet available.	LANL Fleet Management will continue to acquire low greenhouse gas vehicles as available, and LANL will continue to acquire electric vehicles as needed and supported by LANL's infrastructure. Due to a shortage of charging station infrastructure and the type of light-duty vehicles our customers require, we are unable to meet the 75% DOE goal at this time. We will make every effort to work toward meeting this goal.
Renewable electric energy accounts for not less than 7.5% of total agency electric consumption by fiscal year 2013 and each year thereafter.	6.1% of LANL's electrical energy is from renewable sources.	The main coal-fired source of power for LANL is shutting down. LANL is pursuing a 10-megawatt photovoltaic array onsite funded through a power purchase agreement. We are also pursuing low carbon energy sources such as offsite firmed-wind and/or photovoltaic power purchase agreements.
Increase renewable non-electric energy use. The goal is for year-over-year	LANL remains at 13% with no changes in fiscal year 2020.	We will ask planners for new facilities to make design decisions based on total life-cycle costs for solar thermal systems.

DOE Goal	Current Performance Status	Planned Actions & Contribution
increases, but with no set target.		
At least 15% (by count) of owned existing buildings are compliant with the revised Guiding Principles for Sustainable Buildings by fiscal year 2021, with annual progress thereafter.	9% of LANL's buildings have achieved compliance with the Guiding Principles.	LANL will evaluate life-cycle costs to determine if some guiding principles might not be applicable and allow more buildings to be certified. In the meantime, LANL will continue to focus on high return-on-investment improvements to meet the energy and water saving guiding principles. LANL will also incentivize new facilities meet the guiding principles.
Promote sustainable acquisition and procurement to the maximum extent practicable, ensuring bio-preferred and bio-based provisions and clauses are included in all applicable contracts.	LANL's Pollution Prevention Program initiated adoption of the SAP Ariba system of cloud-based software and applications for procurement. This software system will improve data collection regarding sustainable product characteristics.	The Ariba system will have the capability of a dedicated LANL catalog for hand-picked sustainable acquisition products. This will provide LANL staff more opportunity for sustainable choices while ordering.
Set site-specific targets for sustainability investment with appropriated funds and/or financed contracts for implementation.	Phase 1 of the Steam Plant Acquisition Project will be completed in fiscal year 2022.	LANL is pursuing a 10-megawatt photovoltaic power purchase agreement onsite and will pursue investments in firmed-wind and/or photovoltaics power purchase agreements as needed to support mission growth.
End of Life: 100% of used electronics are reused or recycled using environmentally sound disposition options each year.	100% of electronics were recycled.	LANL intends to continue disposing of electronics per the Transfer and Sanitizing of Electronic Storage Media Procedure
Data Center Efficiency: Establish a power usage effectiveness target for new and existing data centers.	The Strategic Computing Complex is achieving its power usage effectiveness goal of 1.3. Goals have not been defined for the Laboratory Data Communications Center and Central Computing Facility.	The Laboratory Data Communications Center will continue transitioning to high-density liquid-cooled supercomputing in fiscal year 2021.
Discuss overall integration of climate resilience in emergency response, workforce, and operations procedures and protocols.	This integration has not yet been pursued.	Performing a climate change vulnerability assessment will be considered in fiscal year 2021, in which case climate change preparedness would be integrated into operations, policies, and procedures.

DOE Goal	Current Performance Status	Planned Actions & Contribution
Year-over-year scope 1 and 2 greenhouse gas emissions reduction from a fiscal year 2008 baseline.	LANL achieved a 27.7% reduction from the fiscal year 2008 baseline.	LANL has developed a Power Procurement Strategy to plan for low-carbon electricity sources, as LANL's main coal powered source will be shutting down. LANL will pursue a power purchase agreement for a 10-megawatt photovoltaic installation on site.
Year-over-year scope 3 greenhouse gas emissions reduction from a fiscal year 2008 baseline.	LANL achieved a 51% reduction from the fiscal year 2008 baseline.	LANL is piloting a work-from-home strategy during the COVID-19 pandemic. This is planned to continue postpandemic as well. LANL will continue to install personal vehicle charging stations as demand grows.

Operating Experience Program

The Laboratory has an operating experience and lessons learned program called "OPEX at LANL." The purpose of the program is to capture and apply lessons from experiences and to communicate best practices to prevent or reduce the severity of future undesirable events. OPEX at LANL collects and distributes information internal to the Laboratory and from other sources, including the other DOE sites. The program provides an online database of relevant lessons learned, best practices, safety information, security information, and programmatic information for workers to use and share, as well as a quarterly publication that provides event trends, causes, and learning opportunities.

Pollution Prevention

The Laboratory's Pollution Prevention Program works to reduce waste and pollution resulting from Laboratory operations. The program activities include but are not limited to (1) reducing all types of radioactive waste; (2) funding and supporting projects that reduce or eliminate the use of hazardous chemicals; and (3) identifying and researching emerging contaminants. Program staff support the Laboratory's Site Sustainability Plan and prepare an annual Hazardous Waste Minimization Report for the New Mexico Environment Department.

The program supports site-wide initiatives to address waste-related risks that could affect the successful completion of the LANL mission. For example, the Pollution Prevention Program is currently addressing per- and polyalkylfluoroalkyl substances (PFAS), a group of emerging contaminants. Program staff are working alongside compliance personnel to prepare the Laboratory for state and federal regulation of these substances. These preparations include the proactive investigation into legacy and current uses of PFAS through record searches or otherwise, cataloguing existing PFAS containing products on the site, environmental and operational sampling to determine PFAS presence, as well as investigating alternatives to current PFAS containing products.

The Pollution Prevention Program recognizes projects across the Laboratory through annual environmental awards and internal and external communications. The following are examples of funded pollution prevention projects that illustrate the work of LANL scientists and engineers to achieve reduction of waste and pollution at its source at the Laboratory.

Planetary Ball Milling for Waste Reduction in Explosives Processes

This activity consists of scientists experimenting with the use of planetary ball milling in high explosives processing. Traditional concentrated acid wet chemistry produces hazardous wastes. Ball milling is a mechanical technique used to grind powders into fine particles and to blend materials. Planetary ball milling is a relatively recent innovation that produces extremely small particle sizes, enabling chemical reactions previously unachievable with traditional ball milling techniques. Research into this method will continue. Increased use of planetary ball milling could lead to reduced purchase and disposal costs for concentrated acids and less exposure of workers to hazardous chemicals.

Resonant Acoustic Mixing

The wet slurry method used to make explosives generates waste consisting of hazardous solvents and water. To address the issue, scientists at LANL are working to use resonant acoustic mixing technology to eliminate watery waste and capture solvents, essentially creating a zero-waste process. Resonant acoustic mixing uses resonance and effects of sound energy to facilitate mixing without the use of impellers or other mechanical means inside a mixing vessel.

The Laboratory will benefit from using resonant acoustic mixing method with reduced purchase and disposal costs associated with concentrated acids. Due to the sealed system, workers will be exposed to fewer hazardous chemicals.

Site Cleanup and Workplace Stewardship Program

In some locations at the Laboratory, materials and equipment have been abandoned after projects ended or staff retired. The Site Cleanup and Workplace Stewardship Program was established in 2013 to assist organizations with the proper disposition of these items and to prevent similar occurrences in the future. The program staff work with responsible organization(s) to develop a work plan for abandoned items, clean indoor and outdoor spaces, and implement sustainable housekeeping practices. The Site Cleanup and Workplace Stewardship Program works closely with the Property Management Group, Environmental Protection and Compliance Division, and other organizations to improve processes and policy. In 2020, the program moved into the Infrastructure Programs Office at LANL, allowing better integration with site planning activities. One goal of the program is to divert as much material as possible from waste streams.

In 2020, the Site Cleanup and Workplace Stewardship Program

- Continued improving the management of sheds and transportable storage buildings at LANL by working with organizations on identifying points of contacts, installing point-of-contact signage, and updating structure number signage as well as drafting a reuse assessment and reassignment process to better track and manage structures;
- Coordinated over 20 cleanup and metal recycling projects across the Laboratory, including
    - Preparing, downsizing, releasing, and recycling potentially activated and free release metal at Technical Area 53,
    - Dismantling a shed at Technical Area 53 and two sheds at Technical Area 3
    - Cleaning out space at Technical Area 35 for Physics Division, which included draining and recycling several legacy capacitors,
    - Continuing cleanup along Sigma Mesa, including additional identified abandoned metal, wood, and equipment,

- Cleaning up the Logistics Division laydown yard, reducing legacy equipment and consolidating metal; and
- Cleaned up outside area of legacy environmental monitoring stations.

Greenhouse Gas Reduction

In fiscal year 2020, the Laboratory achieved a 27.7 percent reduction in Scope 1 and 2 greenhouse gas emissions compared to fiscal year 2008. Scope 1 emissions are direct emissions from Laboratory-owned or leased equipment and vehicles. Scope 2 emissions are emissions generated by utility companies while producing electricity, heat, or steam purchased by the Laboratory. The Site Sustainability Program's initiatives to reduce energy use contributed to reducing greenhouse gas emissions.

The Laboratory's energy use is expected to steadily increase over the next 10 years as high performance computing and expanded activities at the Los Alamos Neutron Science Center consume more electrical power. We plan to reduce greenhouse gas emissions by completing Phase I of the Steam Plant Replacement project, which will add a more efficient generator and controls. We are also pursuing a 10-megawatt photovoltaic installation onsite.

Project Review

All new and modified work, activities, operations, and projects at the Laboratory, including changes in scope or location, must be reviewed for environmental and other compliance requirements prior to executing the work.

The Integrated Review Tool includes the Permits and Requirements Identification system, the Excavation/Fill/Soil Disturbance Permit Request system, and the Major and Minor Site-Selection process in a single web-based platform. Work owners or planners enter their project information into the application, and subject matter experts review the projects and identify the relevant requirements and any permits needed to perform the work.

The Integrated Project Review Program coordinates environmental subject matter expert reviews and interacts with work owners and planners. The program is represented by subject matter experts employed by Triad from the following compliance programs: Air Quality, Biological Resources, Consent Order sites (Solid Waste Management Units and Areas of Concern), Cultural Resources, Environmental Health Physics, National Environmental Policy Act, Resource Conservation and Recovery Act, Waste and Materials Management, and Water Quality.

N3B project managers use the Integrated Review Tool for some projects and internal N3B procedures for the remaining projects. N3B uses procedures N3B-P351, *Project Review Process* and N3B-P101-17, *Excavation/Fill/Soil Disturbance,* to identify compliance requirements for new or modified activities. The procedures engage subject matter experts from the following N3B compliance programs: Air Quality, Biological Resources, Cultural Resources, Safety and Industrial Hygiene, National Environmental Policy Act, Resource Conservation and Recovery Act, Waste and Materials Management, and Water Quality.

In 2020, Triad subject matter experts reviewed 178 management and operating contractor projects for permits and requirements identification and 649 projects for excavation, fill, and soil disturbance permitting. In addition, 12 legacy waste cleanup projects (performed by N3B) were reviewed in the Integrated Review Tool for permits and requirements identification.

Over the past several years, the Integrated Project Review Program has supported integration of project review processes as well as improvements in the integrated review tool. *Permits and Requirements Identification for the Requestor* training was developed in 2018 and implemented through the Laboratory's training system in 2019. *Integrated Review Tool – Geographic Information Systems Mapping Training* was developed and launched in 2019. *Excavation, Fill, and Soil Disturbance Permit Process* training was developed in 2019 and launched in 2020.

Dedicated Core Programs

Air Quality Program

The Laboratory maintains a rigorous Air Quality program that addresses emissions of radioactive and non-radioactive air pollutants. The program consists of three main parts: compliance and permitting, stack monitoring, and ambient air monitoring.

Compliance and Permitting

LANL operates under several air emission permits issued by the New Mexico Environment Department Air Quality Bureau as well as under approvals issued by the U.S. Environmental Protection Agency for construction of new facilities or operations involving radionuclide emissions. These permits and approvals have federally enforceable emission limits and require specific pollution-control devices, monitoring of emissions from stacks, and detailed recordkeeping and reporting.

LANL is authorized to use materials and operate equipment that produce some air pollutants under the conditions defined in our Title V Operating Permit. Our permitted emission sources include a steam plant, a combustion turbine, boilers and heaters, emergency generators, beryllium operations, chemical use, degreasers, data destruction (paper shredder), evaporative sprayers, and a small asphalt batch plant. Each source type has its own emission limits for criteria air pollutants and hazardous air pollutants. The Title V Operating Permit also includes facility-wide emission limits for criteria and hazardous air pollutants. As part of compliance with the Title V Operating Permit, we report emissions and provide monitoring records from the permitted sources twice a year to the New Mexico Environment Department, which inspects the Laboratory periodically for compliance.

Stack Monitoring

As described in greater detail in Chapters 2 and 4, the Laboratory rigorously controls and monitors emissions of radionuclides from building stacks, as required by the Clean Air Act. We evaluate operations to determine the potential for stack emissions to adversely affect the public or the environment. In 2019, 27 stacks were continuously sampled for the emission of radioactive materials to the air.

What are these air quality terms?

A **stack** is a vertical chimney or pipe that releases gases produced by industrial processes into the air.

Ambient air is atmospheric air in its natural state.

Criteria air pollutants are six specific pollutants regulated by the U.S. Environmental Protection Agency under the Clean Air Act because they cause smog, acid rain, or other health hazards.

Hazardous air pollutants are chemicals and radionuclides that at high-enough levels are known or suspected to cause cancer, other serious health effects, or adverse environmental effects.

Ambient Air Monitoring

The Laboratory operates a network of ambient air quality monitoring stations to detect other possible radioactive air emissions (discussed further in Chapter 4). The network includes stations located onsite, in adjacent communities, and in regional locations. In 2020, we operated 44 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 and groundwater. We comply with the following 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 (all discussed further in Chapter 2). The Laboratory monitors and remediates groundwater (see Chapter 5) and conducts environmental surveillance monitoring on surface water base flow, storm water flow, and deposited sediments (see Chapter 6). We have also implemented low-impact development projects at Technical Areas 3 and 53 that reduce the amount of storm water runoff from developed areas to improve the quality of the storm water flow.

In 2020, we continued the process to renew the Laboratory's individual permit for storm water discharges. Our original renewal application was submitted in 2014. We resubmitted the renewal application to the U.S. Environmental Protection Agency on June 15, 2019. A new draft permit was issued by the U.S. Environmental Protection Agency on November 27, 2019, for public comment; a public hearing was conducted October 26, 2020, and the public comment period for the draft permit ended November 2, 2020. On November 30, 2020, the New Mexico Environment Department issued the state certification of the Individual Permit NM0030759. The final permit has not been issued by the U.S. Environmental Protection Agency. The Laboratory's current individual permit has been administratively continued until a new final permit is issued by the U.S. Environmental Protection Agency.

In 2020, the Laboratory operated under four groundwater discharge permits issued 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. Previously, in 2019 the New Mexico Water Quality Control Commission vacated the Laboratory's discharge permit DP-1132 for discharges from the Technical Area 50 Radioactive Liquid Waste Treatment Facility and remanded it back to the New Mexico Environment Department for a public hearing. The public hearing was completed in 2019, the Hearing Officer Report was issued in 2020, the Secretary of the New Mexico Environment Department remanded the permit to the New Mexico Environment Department's Ground Water Quality Bureau in June 2020, and this discharge permit application is pending.

In 2020, we continued operating the Laboratory's site-wide network of storm water gage stations to monitor stream flow and collect storm water samples in all major canyons. We also continued operating the early notification system that provides the operators of Santa Fe's Buckman Direct Diversion (which diverts water from the Rio Grande for Santa Fe's drinking water supply) early notification of storm water flows through Los Alamos Canyon into the Rio Grande. Finally, we documented the effectiveness of installed sediment-control measures for the Los Alamos/Pueblo Canyon watershed and the Sandia Canyon wetland to the New Mexico Environment Department.

Hydrology Protocol Study

In the New Mexico *Standards for Interstate and Intrastate Surface Waters* (Title 20 Chapter 6 Part 4 of the New Mexico Administrative Code), Section 128 uniquely classifies some stream reaches on Los Alamos National Laboratory property as ephemeral-intermittent reaches. These waters, referred to as "Section 128 waters" or "Segment 128 waters," are the only waters within the state of New Mexico with this designation. Understanding the actual flow regime (either ephemeral or intermittent) for these stream reaches could give the New Mexico Environment Department better information to identify and apply the appropriate surface water quality standard.

The Segment 128 waters at the Laboratory mostly have semi-arid hydrologic characteristics and likely represent ephemeral waters (having water briefly only in direct response to precipitation). However, intermittent surface water conditions (having water for extended periods at certain times of the year) may occur in some locations. These include locations below springs and areas where groundwater flowing in unconsolidated sand or gravel (known as alluvium) under a stream bed reaches the surface. Structures installed by the Laboratory to slow storm water and promote sediment deposition may promote increased water storage in the alluvium, thereby increasing the potential for persistent flows. Portions of streams above and below these water control structures need a flow regime evaluation. The New Mexico Environment Department developed a Hydrology Protocol to distinguish between perennial, intermittent, and ephemeral water courses in New Mexico. In principle, different water quality protections could apply if a water course is intermittent rather than ephemeral.

During the 2015 triennial review of New Mexico's water quality standards, the New Mexico Environment Department, the DOE, the Laboratory, and Amigos Bravos (a nonprofit organization that works on water-related issues in the state) entered into a formal legal agreement to meet and confer on the appropriate level of water quality protections for the Segment 128 waters. Part of the agreement was for all parties to share information and data to identify (a) which Segment 128 waters are ephemeral and which are intermittent, (b) the existing uses of Segment 128 waters, (c) the presence of macroinvertebrates or shellfish in these waters, and (d) any significant change to the chemical, physical, or biological integrity of these waters. The agreement specifies that if the parties reach agreement on new protections for Segment 128 waters, a proposal could be brought to the New Mexico Water Quality Control Commission to apply new water quality standards.

Between 2015 and 2019, key milestones from the legal agreement were achieved and Hydrology Protocol assessments were completed on Segment 128 stream reaches. Work was suspended in 2018 because of drought conditions and other LANL priorities. In 2020, Laboratory staff conducted 11 Hydrology Protocol assessments. Data from Hydrology Protocol assessments alone are not sufficient to identify the appropriate designated use and water quality protections needed for these stream reaches. However, assessment data along with additional data from LANL studies and water quality monitoring programs can be used to determine if increased protections are justified.

In December 2020, the parties met and reached a tentative agreement on three stream reaches in the Mortandad, Pajarito, and Water Canyon watersheds. The Water Quality Control Commission may consider increased protection for LANL's Segment 128 waters in 2021. If approved by the Water Quality Control Commission, these waters will would move from limited aquatic life use protections in Segment 128 to a new LANL Segment 140 with marginal warmwater aquatic life protections.

Sanitary Sewage Sludge Management

On March 24, 2014, the New Mexico Environment Department Solid Waste Bureau approved the Laboratory's application to operate a facility to compost solid wastes produced by the Laboratory's

Sanitary Waste Water System. The goal of this project is to eliminate the transport of sewage biosolids offsite for landfill disposal. Full-scale operations at the Technical Area 46 Sanitary Waste Water System Compost Facility began in late 2014. On April 18, 2018, the New Mexico Environment Department approved a registration renewal. The compost will be land-applied at the Laboratory for beneficial use. This use 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 the Code of Federal Regulations Title 40, Part 503.

In 2020, the Sanitary Waste Water System Compost Facility produced 41.2 tons of composted biosolids. Finished compost was stockpiled at the facility. The Sanitary Waste Water System Compost Facility uses an in-vessel composter. The in-vessel system controls temperature, moisture, and airflow. We plan to land-apply compost at predetermined sites within Laboratory boundaries in the near future. The final locations and rates for compost application are subject to site selection criteria, best management practices, and administrative controls. 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 (Robert Flynn, personal communication, 5 February 2013).

Cultural Resources Management

Approximately 90 percent of DOE land in Los Alamos County has been surveyed by the Laboratory's cultural resources staff for prehistoric and historic cultural resources. These surveys have identified nearly 1,900 sites with a history of occupation dating back up to 10,000 years. About 79 percent of the Laboratory's cultural resources sites are associated with Ancestral Pueblo people: structures, villages, trails, agricultural features, rock art, and more. However, the sites at the Laboratory also include Archaic Period lithic scatters; late 19th and early 20th century homestead, ranching, and logging sites; and Laboratory buildings used during the Manhattan Project and Cold War eras (~1943–1990).

Current cultural resource management initiatives at the Laboratory include (1) completing cultural resources surveys on all DOE property; (2) evaluating and determining the eligibility of historic buildings and archeological sites for the National Register of Historic Places; and (3) conducting outreach activities and tours.

Archaeologists working for the legacy waste cleanup contractor N3B facilitate the cultural resources compliance reviews for legacy waste cleanup projects. The N3B archaeologists, the DOE Environmental Management Los Alamos Field Office cultural resources program manager, the DOE National Nuclear Security Administration Los Alamos Field Office cultural resources program manager, and management and operating contractor archaeologists meet every two weeks to discuss legacy waste cleanup activities across the Laboratory on lands managed by National Nuclear Security Administration Los Alamos Field Office.

In 2020, we recorded archaeological sites and guided projects in avoiding them for a wide variety of ground-disturbing activities. To assist in legacy waste cleanup at the Laboratory, N3B archaeologists conducted project avoidance and monitoring for ground-disturbing undertakings for the Aggregate Area program in Technical Area 33, for storm water controls in Technical Area 22, and for ground water monitoring at Technical Area 5. Major projects supported by Triad cultural resources staff included (1) the Second Fiber Optics Line Project in Technical Areas 70 and 71, and on Santa Fe National Forest, Bureau of Land Management, Santa Fe County, and private lands; (2) the Calibration Site Project in

Technical Area 68; (3) legacy site recording in Technical Area 16; and (4) the Area 1 Waterline Installation Project in Technical Areas 15 and 36.

Triad cultural resources staff assessed the condition and updated photographic records of Nake'muu Pueblo in September 2020. Staff supported Laboratory and DOE technical meetings with Santa Clara Pueblo, the Pueblo of Jemez, and Pueblo de San Ildefonso. We continued to monitor seasonal recreational use of trails in Technical Areas 70 and 71 and DOE preservation districts in Pueblo Canyon (Technical Area 74). Staff began developing a cultural resources exhibit at Technical Area 53 focusing on the archaeological resources within that Technical Area, and completed and submitted to the New Mexico State Historic Preservation Office an excavation report for the site of the Vigil *y* Montoya homestead.

We completed context and documentation reports for five properties in Technical Area 16 to support their decontamination and decommissioning, and developed documentation strategies for 14 buildings in Technical Area 46 planned for decontamination and decommissioning in future years. Other historic building work included evaluating two properties in Technical Area 52 for eligibility for the National Register of Historic Places, coordinating with and supporting a subcontractor that is evaluating buildings on the Laboratory's historic buildings list, and overseeing projects to restore Manhattan Project National Historical Park properties and Park-eligible structures (see Manhattan Project National Historical Park section below). Archival photography of buildings in Technical Areas 3, 15, and 16 was conducted, and staff continued to work with the Bradbury Science Museum to integrate the Laboratory's historical artifacts into the museum's catalog system.

Manhattan Project National Historical Park

The Manhattan Project was a research and development effort during World War II to produce the world's first nuclear weapons. Legislation establishing the Manhattan Project National Historical Park was passed in 2014. The park has units in Los Alamos, New Mexico; Oak Ridge, Tennessee; and Hanford, Washington. Nine Manhattan Project–era buildings at the Laboratory 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, Japan), and the "Fat Man" weapon (the bomb detonated over Nagasaki, Japan) are part of the park properties at the Laboratory. Eight additional Laboratory buildings and structures, identified in the establishing legislation, are considered "park-eligible" properties.

In 2020, Laboratory cultural resources staff worked with National Park Service staff to repair, stabilize, and restore concrete features at the Manhattan Project National Park properties V-Site in Technical Area 16 (Figures 3-1 and 3-2) and Gun Site in Technical Area 8 (Figures 3-3, 3-4, and 3-5). These projects repaired degraded concrete on stem walls at V-Site associated with former Manhattan Project Buildings 16-518, 16-519, and 16-520 that burned down in May 2000 in the Cerro Grande Fire, and removed degraded portions of a concrete parapet wall cap at the Gun Site Park buildings in Technical Area 8. We also removed vegetation from the Concrete Bowl in Technical Area 6 (a Park-eligible property), including removing a tree that was growing inside of the Bowl itself.

Also in 2020, we consulted with the New Mexico State Historic Preservation Office and the National Park Service on the replacement of degraded cement asbestos siding shingles with non-asbestos replicas on all Manhattan Project National Historical Park buildings and Park-eligible buildings and the replacement of the roof of the Slotin Building (Technical Area 18 Building 1). We also began the initial steps to repair the interior of the Slotin Building and restore it to its Manhattan Project–era appearance. We conducted surveillance and maintenance inspections at all 17 Park and Park-eligible properties, and on 18 Cold War–era buildings identified as candidates for long-term preservation.

Figures 3-1 and 3-2. V-Site concrete stem walls and pad during concrete restoration in August 2020

Figure 3-3. Gun Site parapet wall concrete cap after removal of loose concrete pieces in April 2020

Figures 3-4 and 3-5. Gun Site parapet wall concrete cap before (left) and after (right) removal of loose concrete pieces in April 2020

Biological Resources Management

Our goal is to minimize impacts to sensitive species and their habitats and to ensure all activities comply with federal and state requirements for biological resources protection. The Laboratory contains habitat for three species that are federally listed as either threatened or endangered. Two of these species, the Mexican spotted owl (*Strix occidentalis lucida*) and the Jemez Mountains salamander (*Plethodon neomexicanus*), have been found on the site. Willow flycatchers of unknown subspecies are sometimes detected during migration, but no southwestern willow flycatchers (*Empidonax traillii extimus*) have been documented breeding on Laboratory property.

Accomplishments

We annually inform and educate the Laboratory workforce about biological resources compliance requirements, including restrictions on the timing and location of work activities to protect federally listed species. The biological resources staff also provide safety briefings on encountering wildlife and information on avoiding impacts to migratory birds from vegetation removal projects and other known hazards to birds, such as open pipes and bollards.

Laboratory biologists annually conduct surveys for the presence of threatened and endangered species that have habitat on LANL property. In 2020, surveys for the Mexican spotted owl confirmed the presence of owls in two canyons. Both nests produced young in 2020. Southwestern willow flycatchers were not found during surveys in 2020. Jemez Mountains salamander surveys were not conducted in 2020. Conditions were not suitable for salamander surveys because forest soils were dry.

Throughout 2020, we attended or presented at conferences, workshops, and meetings for professional and educational development, collaboration, and outreach. Notable activities included presenting at the Joint Annual Meeting of the Arizona and New Mexico chapters of the Wildlife Society and the American Fisheries Society, and attending the 2020 Virtual Event of the Raptor Research Foundation. We were unable to participate in several professional and educational activities in 2020 because of the coronavirus pandemic.

LANL biologists were authors on two peer-reviewed publications in 2020. The papers addressed a range extension for Los Alamos County for the eastern collared lizard (*Crotaphytus collaris*; Abeyta and

Hathcock 2020) and the effects of soil chemical concentrations on the density of small mammals (Gaukler et al. 2020).

Biological Resources Program Reports

LANL biologists supported many projects across the Laboratory with compliance and monitoring activities in 2020. Published reports supporting projects included the following:

- “Large Game Movement between Los Alamos National Laboratory and Pueblo de San Ildefonso” (LA-UR-20-28819)
- “Migratory Bird Best Management Practices Source Document for Los Alamos National Laboratory, Revised June 2020” (LA-UR-20-24292)
- “Monitoring Avian Productivity and Survivorship at the Sandia Wetlands at Los Alamos National Laboratory 2014-2019” (LA-UR-20-22996)
- “Sensitive Species Best Management Practices Source Document, Revision 5” (LA-UR-20-24514)
- “Site-wide Occupancy Assessment Using Camera Traps for Seven Mammalian Species at Los Alamos National Laboratory” (LA-UR-20-22684)
- “2019 Results for Avian Monitoring at the Technical Area 36 Minie Site, Technical Area 39 Point 6, and Technical Area 16 Burn Ground at Los Alamos National Laboratory” (LA-UR-20-20436)

Wildland Fire Management

The primary objective of the LANL Wildland Fire Program is to provide wildland fire preparedness through fuels mitigation, integration of wildland fire technology, and interagency planning and training. The program staff are located at the Emergency Operations Center and Technical Area 49 Interagency Fire Center along with personnel from the United States Forest Service and National Park Service. The program collaborates with the Los Alamos Fire Department, National Park Service, United States Forest Service, Bureau of Indian Affairs, Northern Pueblo Agencies, and the New Mexico State Forestry Division.

The key functions of the LANL Wildland Fire Program are listed below:

- Conduct or coordinate the site wildland fire hazard analysis.
- Develop wildland fire plans, procedures, and checklists.
- Conduct LANL wildfire mitigation projects, such as thinning trees and establishing and maintaining fire breaks, defensible space, and fire roads.
- Update the LANL website to ensure fire conditions and fire danger ratings are available to the workforce.
- Maintain the LANL Wildland Fire Program database and ensure the program has map-making capabilities for response.
- Conduct training, drills, and exercises with internal and external wildland fire organizations.

Waste Management

The Laboratory produces several types of wastes regulated by either the federal government or the state of New Mexico, including low-level radioactive wastes, hazardous waste, mixed wastes (which are both radioactive and hazardous), transuranic wastes, New Mexico Special Wastes, and others. Transuranic wastes are wastes containing manmade elements heavier than uranium on the periodic table (such as plutonium). Wastes from current and recent operations at the Laboratory are managed by the management and operating contractor, while legacy wastes—defined as the wastes generated before 1999—are managed by the legacy waste cleanup contractor.

The LANL Enduring Mission Waste Management Plan outlines the strategies employed by the Laboratory to compliantly and efficiently dispose of the wastes produced since January 1, 1999. The plan also incorporates pollution prevention strategies to significantly reduce the volume and toxicity of waste generated going forward. Waste minimization efforts have greatly reduced or eliminated many sources of radioactive and hazardous waste across the Laboratory. Offsite shipping to government and commercial treatment, storage, and disposal facilities has minimized onsite waste disposal. The Laboratory is operating a new Transuranic Waste Facility that stages transuranic waste for offsite shipment to the Waste Isolation Pilot Plant. Construction has begun on replacement low-level radioactive and transuranic liquid waste facilities. As part of the long-term strategy to safely and effectively manage waste at the Laboratory, a budget proposal was submitted to DOE for a new state-of-the-art Consolidated Waste Facility. To strengthen support for Laboratory missions and improve efficiency, separate waste management functions at the Laboratory were recently restructured into one organization.

Environmental Remediation

In accordance with the 2016 Compliance Order on Consent, the Legacy Waste Cleanup Program investigates and, where necessary, remediates sites to ensure that chemicals and radionuclides in the environment associated with releases from past operations do not result in an unacceptable chemical risk or radiological dose to human health or the environment. (For more information about the 2016 Compliance Order on Consent, see Chapter 2.) 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, the environment, or both. Corrective actions are complete at a site when we have demonstrated and documented to the regulatory authority's satisfaction that further sampling is not warranted and that the chemicals and radionuclides present do not pose an unacceptable risk or dose to humans, plants, or wildlife. Table 3-3 presents a summary of the reports submitted and site investigations conducted in 2020 by N3B in support of the 2016 Compliance Order on Consent.

Table 3-3. Summary of Reports Submitted and Site Investigations Conducted in 2020 under the N3B Environmental Remediation Program

Document/Activity	Technical Area	Number of Sites	Sampling and Remediation
Investigation Report for Chaquehui Canyon Aggregate Area Investigation Report (Appendix B Consent Order Milestone)	33	43	Forty-three Solid Waste Management Units and Areas of Concern within the Chaquehui Canyon Aggregate Area were investigated to determine the nature and extent of contamination and potential human health and ecological risks. Approximately 1148 samples were collected and 560 cubic yards of contaminated soil and debris were containerized and transported to Energy Solutions in Utah for disposal. The investigation results determined the following:

Document/Activity	Technical Area	Number of Sites	Sampling and Remediation
			• Corrective action complete without controls for 16 sites for which extent is defined and which pose no potential unacceptable human health risk under the residential scenario and no unacceptable ecological risk. • Corrective action complete with controls for 6 sites for which extent is defined and which pose no potential unacceptable human health risk under the industrial scenario and no unacceptable ecological risk. Sixteen of the 43 Solid Waste Management Units and Areas of Concern require additional sampling and analysis to define the vertical and/or lateral extent of one or more contaminants. Soil removal and confirmation sampling and analyses are necessary for 8 of the 16 sites that pose a potential unacceptable risk under the industrial scenario or a potential unacceptable ecological risk. Five of the sites required completion of tritium borehole investigations that were delayed by the COVID-19 pandemic field stop and rescheduled for 2021.
Conclusions/Recommendations: Cleanup objectives were met for 22 sites. Further corrective actions are necessary for 21 sites that will addressed in 2021.			
South Ancho Canyon Aggregate Area Progress Report (Appendix B Consent Order Milestone)	33	11	Eleven Solid Waste Management Units and Areas of Concern within the South Ancho Canyon Aggregate Area were investigated to determine the nature and extent of contamination and potential human health and ecological risks. Field investigations for the South Ancho Canyon Aggregate Area were impacted and postponed by the COVID-19 pandemic. Therefore, this progress report summarizes the field investigations that were completed before and during the pandemic. Approximately 21% (129) of the initially planned samples under the South Ancho Canyon Aggregate Area investigation work plan were completed before the COVID-19 shutdown on March 24, 2020. In addition, approximately 125 cubic yards of soil and debris were excavated before the shutdown. Following completion of required COVID-19 training and restart checklist completion and approvals, sampling resumed on July 8, 2020. An additional 162 samples were collected from July 8 through August 7, resulting in 47% of samples (291 out of 618) being collected under the South Ancho Canyon Aggregate Area Integrate Work Plan. The COVID-19 pandemic significantly reduced available field days left in fiscal year 2020; therefore, the remaining sampling activities for South Ancho were postponed so that resources could be focused on the site investigations planned for the Lower Water/Indio Canyons Aggregate Area in August. Site

Document/Activity	Technical Area	Number of Sites	Sampling and Remediation
			investigations and risk evaluations will continue in 2021, with the investigation results and recommendations reported in the 2021 Investigation Report.
Conclusions/Recommendations: Initial investigations were interrupted due to the COVID-19 pandemic; therefore, the investigations will resume in 2021.			

Environmental Health Physics Program

The Environmental Health Physics Program provides technical support to the Laboratory for radiation protection of the public and the environment. We use sampling results and radiological assessment models to calculate dose estimates for the public and for plants and animals. These estimates are communicated to regulatory agencies and the public.

What is health physics?

Health physics is the branch of radiation science that deals with effects of ionizing radiation on human health.

DOE Order 458.1, *Radiation Protection of the Public and the Environment*, also requires us to oversee releases to the public of real estate and portable property (such as surplus equipment and wastes) that could contain residual radioactivity. Examples include land tracts transferred to other owners and debris from building demolition activities.

Our environmental health physicists support emergency planning and response by providing technical support and dispersion modeling in the case of an accident as well as recommendations for protective actions. We also support environmental remediation projects.

Soil, Foodstuffs, and Biota Monitoring

The Soil, Foodstuffs, and Biota Monitoring Program monitors levels of radionuclides, inorganic elements (mostly metals), and organic chemicals (for example, PCBs and per- and polyalkylfluoroalkyl substances) in local soil, plants, and animals. The program routinely samples surface soil; native vegetation; foodstuffs (including fruits, vegetables, grains, milk, eggs, fish, meat, and honey); small mammals, such as mice; and other animals that have died due to natural causes or accidents, such as roadkill. These samples are collected from Laboratory property, the surrounding communities, and regional background locations. The data are used to (1) determine whether Laboratory operations are affecting levels of chemicals or radionuclides in the environment, (2) monitor for new releases, (3) calculate estimates of radiation dose for the public and for biota, and (4) conduct risk assessments. We compare levels of chemicals in our samples with background levels, screening levels, and effects levels, and we examine wildlife population and community characteristics. The program is described in detail in Chapter 7.

Accomplishments

In 2020, we assessed several aquatic ecological parameters. Specifically, we collected fish, crayfish, sediment, and benthic macroinvertebrates samples from the Rio Grande (upstream and downstream of Los Alamos Canyon) and from Abiquiu Reservoir (upstream of the Laboratory) and Cochiti Lake (downstream of the Laboratory). Fish, crayfish, and sediment samples were analyzed for radionuclides, inorganic elements (mostly metals), and organic chemicals. Sediment samples were also used in biotoxicity assays, which measure growth and survival of aquatic organisms exposed to the sediment. Benthic macroinvertebrate community assemblages and ecological metrics were compared between locations.

Annual sampling of soil, native vegetation, and biota took place at several locations. Soil and tree samples were collected around the perimeter of Area G and near the boundary between Technical Area 54 and the Pueblo de San Ildefonso and analyzed for radionuclides. Soil, sediment, vegetation, nonviable bird eggs, and bird nestlings that died of natural causes were collected around the Dual-Axis Radiographic Hydrodynamic Test Facility and analyzed for radionuclides, inorganic elements (mostly metals), and/or organic chemicals. Small mammals and vegetation were collected upstream of the sediment retention structures located in Los Alamos and Pajarito canyons and analyzed for radionuclides, inorganic elements, and/or organic chemicals.

Nonviable bird eggs and nestlings that died of natural causes were also collected near Laboratory firing sites and from Bandelier National Monument and were analyzed for metals and/or organic chemicals. We collected and analyzed tissues from mule deer (*Odocoileus hemionus*), American badger (*Taxidea taxus*), gopher snake (*Pituophis catenifer*), and great horned owl (*Bubo virginianus*), primarily from individuals found as roadkill. Results from the program's 2020 monitoring efforts are reported in Chapter 7, Ecosystem Health.

Meteorology Program

DOE Order 458.1, *Radiation Protection of the Public and the Environment*, and DOE Order 151.1D, *Comprehensive Emergency Management System*, require DOE sites to measure weather variables. The variables to be measured are determined by the radiation-producing activities taking place at the site, its topography, and the distances to critical receptors. The LANL Meteorology Program maintains a network of five meteorological towers that measure temperature, wind, humidity, pressure, precipitation, and solar radiation across the site. These data are used for emergency planning in the event of a chemical or radiological release, regulatory compliance in the areas of air quality, water quality, and waste management, and for supporting monitoring programs for surface water and environmental radiation. Weather data can be accessed internally at the Laboratory (https://weather.lanl.gov) or externally to the Laboratory network (https://weathermachine.lanl.gov). No new weather stations were added in 2020. Meteorological conditions at LANL for 2020 are reported in Chapter 4, Air Quality.

Natural Phenomena Hazard Assessment

DOE Order 420.1C, *Facility Safety*, requires that nuclear facility structures, systems, and components must effectively perform their intended safety functions in the face of natural phenomena hazards (for example, earthquakes, floods, and high winds). As a part of this requirement, natural phenomena hazards are reviewed every 10 years to determine if major modifications to nuclear facilities are required by significant increases in risk from natural phenomena. No meteorological assessments were conducted in 2020. The LANL Seismic Engineering Team provides seismic hazard analyses of key Laboratory facilities and is focused on improving seismic monitoring, site characterization, and our understanding of the Pajarito Fault system, path effects, and site effects. The Seismic Hazards Geology program conducts field mapping of the Pajarito Fault system in the vicinity of Los Alamos and performs site-specific hazard studies at current and planned facility sites.

Land Conveyance and Transfer

In 1997, 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. The 10 original land tracts located at LANL, identified for conveyance or transfer in an Environmental Impact

Statement (DOE/EIS 0293), were subdivided into 32 tracts. To date, 26 of these tracts have been conveyed or transferred in the following way: 20 tracts have been conveyed to Los Alamos County, three tracts have been conveyed to the Los Alamos County School District, and three tracts have been transferred to the Bureau of Indian Affairs to be held in trust for the Pueblo de San Ildefonso.

Tracts remaining that could be conveyed to Los Alamos County include Tract A-14 in Rendija Canyon, Tracts C-2 and C-4 along New Mexico Route 4, Tract A-18-2 in Bayo Canyon, and additional tracts at Technical Area 21. 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.

Conveyances to Los Alamos County support local community economic development by providing lands for housing, commercial uses, and recreation. Nearly 460 housing units, including low-income apartments and about 160 market-rate single-family homes, are being developed on tracts previously conveyed to Los Alamos County.

Investigation and remediation of historical wastes found on tracts along DP Road previously transferred to Los Alamos County are discussed in Chapter 4 (the Newly-Discovered Waste near DP Road section).

Awards and Recognition

The Laboratory did not receive any environmental awards or recognitions in 2020.

Data Quality Process for Analytical Data

Data management consists of collecting and maintaining sampling data using procedures that ensure that the data comply with established requirements and that data are suitable for their intended use (for example, compliance monitoring or site characterization). Below, we describe the elements of the quality system for sample and data processing and quality assurance for both the management and operating contractor (Triad) and the legacy waste cleanup contractor (N3B) at the Laboratory.

N3B and Triad have similar data collection and management programs. Each contractor maintains its own sample management office, but they use the same environmental data management platform (see Environmental Data Management Platform section below). Sample planning and collection is performed by individual programs in coordination with their sample management office (Figure 3-6). Sample handling, analysis, and data review and evaluation are conducted or overseen by the sample management office. Individual programs are responsible for reporting on data results; the sample management office may assist by providing data sets, but final reports are the responsibility of the program.

N3B and Triad received and reviewed more than 477,000 (N3B) and 103,000 (Triad) analytical results in 2020. Not all of these results were used in this report. Some results may be related to programs that are not included in the Annual Site Environmental Report.

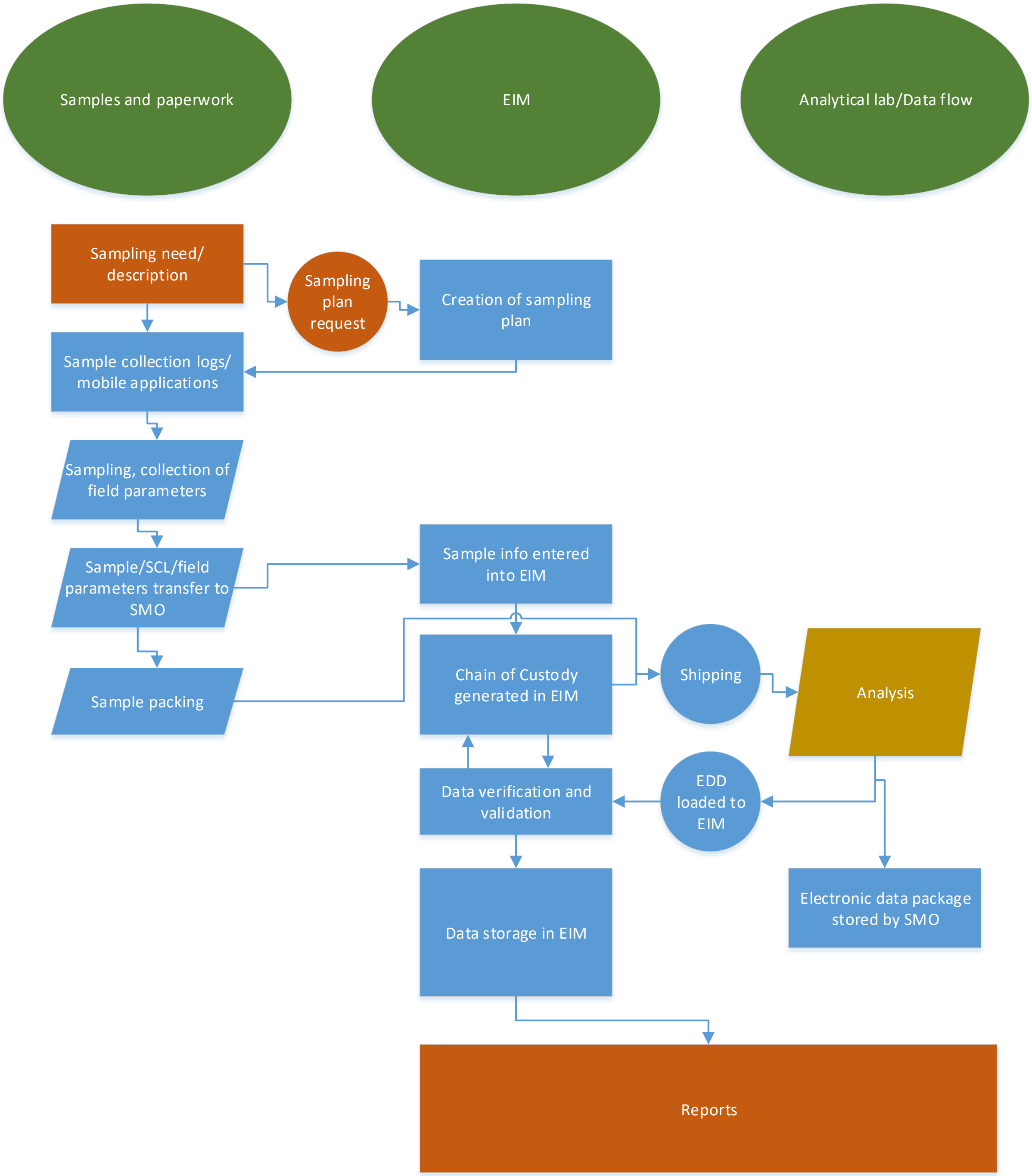

Figure 3-6. Functional diagram of the Sample Management Office work. Green ovals represent the three main Sample Management Office functions. Figures with blue background show data collection steps that directly involve the Sample Management Office. Abbreviations used in this figure: SMO – Sample Management Office; EIM – Environmental Information Management database; SCL – Sample Collection Log, serves as a field chain of custody; EDD – Electronic Data Deliverable text file used to load analytical data into Environmental Information Management database.

Environmental Data Management Platform

The Environmental Information Management database is the core platform used by both N3B and Triad for managing analytical data. This data platform is jointly used by N3B, Triad, and the DOE Oversight Bureau of the New Mexico Environment Department for all LANL environmental analytical data. It interfaces with Intellus, a fully searchable database available to the public through the Intellus website (http://www.intellusnm.com).

Locus Technologies wrote and maintains the database structure, which consists of a cloud-based Structured Query Language server database platform with a web-based user interface. It is designed to manage the sample collection and analysis process from planning through data review and reporting. It includes modules for planning sample collection, tracking samples, uploading field data, uploading electronic data deliverables, and conducting automated data review, as well as tools for notifications and reporting. In 2020, the new automated data review module was fully deployed. The module underwent extensive testing and review to meet current standards. This module is used in conjunction with manual examinations and full manual validation of selected data.

A Software Change Control Board—consisting of N3B, Triad, and New Mexico Environment Department representatives—oversees modifications made to database functionality and user interfaces. This process ensures that changes requested by one organization will not adversely affect the others. Standardized naming conventions are used for sampling locations to create a single list of shared location names.

Data Quality Objective Process

N3B and Triad ensure that the data reported from the analytical laboratories are of sufficient quality to fulfill their intended purpose and that the data quality is documented so the data can be evaluated for current and future use. The data collected should support defensible decision-making as described in the *Guidance on Systematic Planning Using the Data Quality Objectives Process (EPA QA/G-4)* (U.S. Environmental Protection Agency 2006).

N3B data quality objectives detail minimum required quality assurance and quality control on a project-specific basis. Examples of projects include all of the sampling events and samples collected to fulfill a set of permit requirements; all sampling events and samples collected to determine waste disposition; or all samples and sampling events collected to fulfill a memorandum of understanding or regulated agreement.

The project manager determines the project’s specific data quality objectives within the boundaries of contracted services and standard operating procedures. If the project’s needs exceed contracted services or standard operating procedures, the Sample Data Management Director may initiate revisions to contracts and standard operating procedures.

Sample Collection and Handling

Sample and data management begins with planning the sampling to ensure that the data will meet the data quality objectives for the project. Sample collection and handling follows established methods. Whenever possible, standard U.S. Environmental Protection Agency methods are used. When federal or state approved standard methods are unavailable, LANL-specific procedures are used.

A sampling plan is created in the Environmental Information Management data system. As part of the sampling plan, the system generates sample collection logs and chain-of-custody forms. The sample collection log lists the sampling containers and preservatives needed for each analysis requested. Personnel conducting the sampling record information on the sample collection log, including location of sampling (if different from planned), sampling date and time (necessary to establish holding time), and field parameters if required by the project, and any other comments that may be applicable. Collected samples are placed in coolers, cooled with ice (if required for the analytical method), and delivered to the Sample Management Office. From the time of sampling until delivery to the Sample Management Office, samples are under direct custody of the samplers. At the Sample Management Office, custody is transferred to Sample Management Office staff. Custody transfer is confirmed by signatures. Additionally, before the Sample Management Office accepts samples, tamper indicating devices, or custody seals as they are also known, are placed on every sample container.

Prior to shipping, Sample Management Office staff store samples as required by the analytical method, including in temperature-controlled refrigerators if needed. Glass sample containers are wrapped in bubble bags to prevent breakage. Samples are packed in coolers with blue ice and/or bagged ice to assure proper shipping temperature. The signed chain of custody documents are placed inside the coolers. Coolers are taped shut and protected with tamper indicating devices. Samples are shipped overnight to the designated analytical laboratory. If both the cooler and sample tamper indicating devices have been damaged or tampered with, the sample is considered unusable. Upon arrival at the designated lab, the integrity of tamper indicating devices is verified, shipping temperature on arrival is measured, and samples are compared with their respective chain of custody. After the analytical laboratory logs samples into their information management system, the samples are analyzed.

Selection of Analytical Laboratories

Analytical laboratories have been selected through the request for proposal process. N3B and Triad have selected laboratories that meet the DOE Consolidated Audit Program – Accreditation Program requirements (see section on *DOE Consolidated Audit Program – Accreditation Program for commercial analytical laboratories*). For Triad, National Environmental Laboratory Accreditation Program accredited laboratories are chosen when a given analysis is not available from a contracted DOE Consolidated Audit Program accredited laboratory. Along with the DOE Consolidated Audit Program accreditation, N3B selects laboratories that meet requirements in their Scope of Work Exhibit "D," *Scope of Work and Technical Specifications for Off-Site Analytical Laboratory Services*. The Scope of Work Exhibit "D" was developed using the *Department of Defense/Department of Energy Consolidated Quality Systems Manual for Environmental Laboratories*. N3B has contracted with 10 analytical laboratories, eight of which performed certifiable analyses for N3B in 2020. When selecting a laboratory to perform a specific analysis, in addition to meeting the minimum requirements of the DOE Consolidated Audit Program and the scope of work, consideration was given to maintaining projects' continuity of data, adding laboratory capabilities to prevent disruptions caused by unforeseen lab closures or instrument failures, and cost. This approach allows for split sampling and data quality comparison.

Sample Analysis

Sample preparation and analyses are performed in the laboratories using industry-standard methods such as those from the U.S. Environmental Protection Agency's *Test Methods for Evaluating Solid Waste: Physical/Chemical Methods*, the American Industrial Hygiene Association, the Occupational Safety and Health Administration, the National Institute of Safety and Health, the American Society for Testing and

Materials, and the American Public Health Association. In the absence of an industry standard method, analyses are performed using methods that meet the project-specific data quality objectives.

The choice of a specific method is determined by program or permit requirements or the desired detection limit. All laboratory quality control samples are reported back to Triad or N3B. Additionally, we send field quality control samples (blank samples and duplicate samples) periodically for analysis. The frequency of field quality control samples is determined by analytical methods, permits, or LANL procedures.

Data Review and Evaluation

Analytical results are generally returned to LANL in two forms: as an electronic data deliverable and as a data package. An electronic data deliverable is a data file transmitted in a format that can be directly uploaded in database programs. Data packages consist of the combined analytical chain of custody, signed sample collection logs, validation report (if available), and the analytical data report and are usually delivered as a portable document format (pdf) file. Some data users additionally request a hard copy of the data package. For N3B, laboratory data packages and electronic data deliverables adhere to the requirements specified in Exhibit "D" *Scope of Work and Technical Specifications for Off-Site Analytical Laboratory Services*.

Electronic data deliverables are loaded into holding tables in the Environmental Information Management database. Automated programs in the database verify the data in these files by checking for the following:

- Correct format of the electronic data deliverable file, including the number and types of fields (text/numeric/date-time)
- Analyses reported that agree with those ordered
- Data that were already reported (avoiding duplicates)
- The sampling date used by the lab agrees with database sampling date (important for holding time evaluation by the lab)
- Dates listed by the lab are consistent (for example, sampling before preparation date, preparation before analysis date)

Upon verification, a Sample Management Office chemist runs an auto-validation routine in the Environmental Information Management database to validate reported data. Auto-validation follows the U.S. Environmental Protection Agency's National Functional Guidance documents and the *Department Of Energy/Department of Defense Consolidated Quality Systems Manual* for validation of the analytical data. The important exclusions from auto-validation are examination of the spectra (mass spectra, ultraviolet spectra, rad alpha spectra), chromatograms (for methods using confirmation column), and filed blank/duplicate samples. The auto-validation checks and applies proper validation qualifiers and validation reason codes for the following:

- Holding time
- Method blank contamination
- Laboratory control samples and duplicates within limits
- Matrix spike recoveries within limits
- Missing laboratory quality control samples

When verification and auto-validation are completed, data are transferred to production tables in the database.

Data may undergo a manual validation. There are two mechanisms for selecting data for manual validation: randomly selected data across different analytical methods and laboratories, or a triggered validation of data where a new detection of a substance or a data quality issue requires an elevated in depth review. For N3B, a minimum of 10 percent of analytical data is manually validated by a chemist. Projects will determine if a greater frequency of full validation is required to meet project specific data quality objectives and will notify the Sample Management Office. Triggered validation is performed on specific data at the request of the data owner or the person preparing reports.

During manual validation, selected samples undergo full validation. Data stored in the Environmental Information Management tables and the data packages are reviewed. All aspects of data quality are evaluated, including spectral data. If manual validation results in a change of the data qualification, the changes are entered into the Environmental Information Management database. A description of the changes and a short explanation of reasons for the changes are included. All such changes are tracked in the Environmental Information Management database's audit tables.

Field quality control samples are evaluated when data sets are prepared for individual programs or data owners. Any detections found in blank samples or large discrepancies in results between duplicated samples are reported back to a Sample Management Office chemist. If the chemist decides that field quality control samples warrant changes in the validation qualifiers or detection status, the changes are entered into Environmental Information Management database.

The primary purpose of data validation is to assess and summarize the quality and defensibility of analytical data for the end users. The combined guidelines and requirements ensure the necessary level of confidence in data quality and usability for project activities. The entire data validation process includes a description of the reasons for any failure to meet method, procedural, or contractual requirements, and an evaluation of the impact of such failure on the associated data or data set.

Environmental Information Management Platform Performance Testing

N3B chemists performed extensive testing of the Automated Data Review Data Validation Module of the Environmental Information Management database, including using electronic data deliverables from actual laboratory analyses. They identified certain specific issues and opportunities for enhancements. N3B personnel worked with Locus Technology to implement corrections and improvements to ensure that the outputs meet the requirements in the Quality Systems Manual and the recommendations in the U.S. Environmental Protection Agency's National Functional Guidelines. This work was performed in coordination with Triad and the New Mexico Environment Department. The final Automated Data Review Module was implemented in January 2021. An increased number of full validations were performed to monitor Automated Data Review performance. No major issues were identified.

The validation changes increase transparency and ensure a unified treatment of all data being displayed to the public on Intellus. Testing the system's configuration provided proof of the system's capabilities to accurately perform routine data checks based on analytical methods and regulatory requirements. In addition, the Automated Data Review module was improved for all analytes, particularly radiochemistry data. During this process, N3B chemists manipulated example information to verify that the actual outcomes matched the expected outcomes. The results of this testing were shared with the data system architects, and improvements were identified. Additionally, during this process, N3B identified that the radiochemical capabilities were underutilized and so enhanced the Automated Data Review functionality with respect to radioanalytical assessment.

Records Retention

Original hard copies of chain-of-custody forms and sample collection logs are temporarily stored at the Sample Management Office, and then final records are transmitted to Records Management. Annually, older forms are transferred to the Federal Records Center. The ambient air monitoring program requires a hard copy Level IV data package to remain on site. These records are packaged by fiscal year and transferred to the LANL Records Center, where they remain on site for five years. At the end of five years, these records are also transferred to the Federal Records Center.

Analytical records are stored in the Environmental Information Management database. The entire N3B and Triad Environmental Information Management database is backed up at least quarterly on N3B or Triad servers. The analytical results are copied daily to the publicly available Intellus database (www.intellusnm.com). Level IV data packages are also uploaded into the LANL Electronic Records Management System to fulfill the long-term record retention requirement. Approximately once a month, the Level IV data packages are copied to Intellus.

Some data and analytical packages are withheld from public view for up to 90 days from the date of receipt. These are usually results from samples collected offsite that LANL shares first with other entities like counties or Native American tribes.

Quality Assurance

N3B's Sample Data Manager and the Sample Management Office are subject to the N3B Quality Assurance and Transformation Audit and Surveillance program and the following:

- Supporting the DOE Consolidated Audit Program audits of analytical laboratories used for environmental sampling (LLCC C.3.7.6 Analytical Laboratories) per the Los Alamos Legacy Cleanup Contract
- Participating in internal audits under the management assessments program
- Supporting quality assurance and transformation in developing project assessment criteria and issues responses in the N3B integrated Contractor Assurance System
- Performing management observation and verifications
- Designating personnel by the sample data management director to track performance of activities conducted under the scope of this sample and data management plan

DOE's Analytical Services Program

The DOE's Analytical Services Program provides environmental management–related services and products to DOE Program Offices and field sites. The various parts of the Analytical Services Program that the Laboratory participates in are described here.

DOE Consolidated Audit Program – Accreditation Program for commercial analytical laboratories

The DOE Consolidated Audit Program provides for assessments of commercial analytical laboratories that analyze environmental samples. Use of third-party auditors replaced the traditional DOE Consolidated Audit Program audits beginning in fiscal year 2018. This has allowed for more in-depth approaches to quality control and oversight of these laboratory facilities in meeting the needs of the DOE. The DOE Consolidated Audit Program has qualified the following three accrediting bodies to perform these audits:

- Perry Johnson Laboratory Accreditation, Inc.
- The American Association for Laboratory Accreditation
- The American National Standards Institute National Accreditation Board

Analytical laboratories are audited against the International Organization of Standardization's Standard 17025, *General Requirements for the Competence of Testing and Calibration Laboratories*; the National Environmental Laboratory Accreditation Conference Standard; and the *Department of Energy/Department of Defense Consolidated Quality Systems Manual*. N3B uses the results from these third-party accreditation assessment reports as part of its oversight for its subcontracted commercial analytical laboratories.

Table 3-4 summarizes the DOE Consolidated Audit Program laboratories currently subcontracted to perform samples analysis for N3B and/or Triad.

Table 3-4. DOE Consolidated Audit Program-Accreditation Program Audits of Laboratories Contracted by N3B and/or Triad in Fiscal Year 2020

Laboratory	Audit Dates	Accrediting Body	Used in FY20
ARS Aleut Analytical, LLC	August 10–12, 2020	ANAB[1]	Y
Brooks Applied Labs	August 10–12, 2020	ANAB	Y
Southwest Research Institute	February 24, 2020	A2LA[2]	Y
ALS Environmental-Salt Lake City, UT	Alternate year, Desktop surveillance, September 2020	PJLA[3]	Y
Materials and Chemistry Laboratory, Inc.	August 26–27, 2020	PJLA	N

[1] *The American National Standards Institute National Accreditation Board*
[2] *The American Association for Laboratory Accreditation*
[3] *Perry Johnson Laboratory Accreditation, Inc.*

N3B provided support to the DOE Consolidated Audit Program in various ways throughout fiscal year 2020. The team participated in the Analytical Services Program annual training workshop, which consisted of presentations related to the Analytical Services Program activities, future direction of the program, and technical presentations with regard to data quality and data management. N3B supported four DOE Consolidated Audit Program audits by providing audit observers to the GEL Laboratories Southwest Research Institute, ARS Laboratories, and the Brooks Applied Laboratory audits. Finally, N3B staff played an active role in the DOE Consolidated Audit Program Data Quality Work Group, participating in conference calls and answering questions or requests with regard to issues that came up during laboratory audits and general laboratory or data quality questions from around the complex. N3B radiochemists actively participated in the development of the radiochemistry module 6 of the *Department of Energy/Department of Defense Consolidated Quality System Manual for Environmental Laboratories Version 6.0,* which will replace version 5.3.

Findings from the third-party audits are reported back to the interested DOE sites through the DOE Consolidated Audit Program administrator. N3B tracks all findings from the analytical laboratories it has under contract. Several findings from fiscal year 2020 are considered to be major findings for the purpose of this report. The significant findings are outlined here:

- Finding: Analytical laboratories do not document all procedural deviations from standard test methods.

- Finding: The analytical laboratories do not maintain all of the records necessary for recreation of the data package. Recurring examples of this included identification of the balances and cocktails used for various processes.
- Finding: The analytical laboratory does not always record data at the time that observations were made.
- Finding: The analytical laboratory did not use appropriate methods and procedures for all laboratory activities.
- Finding: Examples were cited where standards and reference materials were not stored separately from samples.
- Finding: Examples were cited where proficiency-testing samples were not being analyzed in the same manner as regular client samples.

Prior to receiving certificates of accreditation, analytical laboratories are required to submit corrective action reports to the accrediting bodies. The accrediting bodies must accept these corrective actions as sufficient prior to granting accreditation. All N3B subcontracted laboratories received their accreditations in fiscal year 2021, indicating that the corrective actions were determined to be sufficient in fixing the identified issues.

DOE Mixed Analyte Performance Evaluation Program

The Mixed Analyte Performance Evaluation Program provides proficiency testing in various environmental matrices primarily for radionuclide identification and quantification. Results for proficiency testing help to assure field managers about the quality and reliability of environmental data for decision-making. Laboratories are required through the National Laboratory Accreditation Conference Standard and the Quality Systems Manual to participate in proficiency testing in all fields of accreditation, where available.

Although not a mandatory requirement of the Quality Systems Manual, the Mixed Analyte Performance Evaluation Program can be a very useful tool in determining a commercial laboratory's analytical radiological capabilities across most environmental matrices. Participation in the Mixed Analyte Performance Program is required for laboratories that perform radiochemical analyses for N3B.

DOE Consolidated Audit Program – Treatment, Storage, and Disposal Facility Audits

Treatment, Storage, and Disposal Facility audit reports generated by the DOE Consolidated Audit Program are one tool that DOE Field Office Managers can use in performing their DOE O 435.1 annual acceptability reviews for these commercial sites. These audits are conducted by volunteers from the DOE and site contractors who use these sites for the disposal of waste. Table 3-5 provides a summary of the Treatment, Storage, and Disposal Facilities that were audited by the DOE Consolidated Audit Program in fiscal year 2020 and were subcontracted to accept radioactive waste from N3B for disposal.

Table 3-5. Audits of Treatment, Storage, and Disposal Facilities Used by N3B in Fiscal Year 2020 under the DOE Consolidated Audit Program

Treatment, Storage, and Disposal Facility	Audit Dates
Waste Control Specialists, LLC	August 18–19, 2020
Perma-Fix Northwest, Inc.	August 18–19, 2020
Clean Harbors Aragonite, LLC	August 25–26, 2020
Veolia North America	August 31–September 1, 2020
Diversified Scientific Services, Inc.	September 28–29, 2020
Energy Solutions	September 10, 2020

Findings from all of the Treatment, Storage, and Disposal Facilities that N3B uses are reviewed and tracked by the Waste Management Program. Several findings from fiscal year 2020 are considered to be major findings for the purpose of this report. Although several issues were identified as significant, these issues were not of immediate significance to compliance, policy, or performance. The significant findings are outlined below:

Waste Control Specialist, LLC (Texas)

- No significant findings identified during this audit.

Perma-Fix Northwest (Richland, Washington)

- Finding: Perma-Fix did not provide a copy of contingency plan.
- Finding: Perma-Fix documentation unavailable that Hazard Analysis are being reviewed or revised as necessary.
- Finding: Vendors had expired qualifications dates.

Clean Harbors, LLC (Utah)

- Finding: The Contingency Plan did not include applicable procedures required by Resource Conservation and Recovery Act Part B.
- Finding: The Chemical Hygiene plan had not been reviewed and updated as necessary.
- Finding: Emergency Contingency Plan had not been submitted to local emergency responders.

Veolia North America (Colorado)

- No significant findings identified during this audit.

Diversified Scientific Services, Inc. (Kingston, Tennessee)

- No significant findings identified during this audit.

Energy Solutions (Clive, Utah)

- No significant findings identified during this audit.

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U.S. Environmental Protection Agency. 2006. Guidance on Systematic Planning Using the Data Quality Objectives Process (EPA QA/G-4). U. S. Environmental Protection Agency report EPA/240/B-06/001, Washington, D.C.

Chapter 4: Air Quality

The purpose of Los Alamos National Laboratory's (LANL's or the Laboratory's) air-quality surveillance program is to protect public health and the environment. Air quality is monitored by five programs, each is described in a section of this chapter: (1) ambient air sampling at public locations, (2) exhaust stack sampling at Laboratory facilities, (3) gamma and neutron direct radiation monitoring near radiation sources and in public locations, (4) particulate matter monitoring, and (5) meteorological monitoring of the local climate and weather.

A primary objective of air quality surveillance is to measure levels of airborne radiological materials in order to calculate radiological doses to humans, plants, and animals. Results are compared with U.S. Department of Energy and U.S. Environmental Protection Agency standards. During 2020, the emissions from Laboratory operations were below the applicable regulatory limits. We use the radiological air sampling data reported in Chapters 7 and 8 (Ecosystem Health and Public Dose and Risk Assessment, respectively) to help address the question, "Are there adverse effects to humans, plants, or animals from Laboratory-produced radioactive airborne materials or direct radiation?" Weather data support many Laboratory activities, including emergency management and response, regulatory compliance, safety analysis, engineering studies, and environmental surveillance programs.

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Introduction

The purpose of Los Alamos National Laboratory's (LANL's or the Laboratory's) air-quality surveillance program is to protect public health and the environment. Air quality is monitored by five programs, each is described in a section of this chapter: (1) ambient air sampling at public locations, (2) exhaust stack sampling at Laboratory facilities, (3) gamma and neutron direct radiation monitoring near radiation sources and in public locations, (4) particulate matter monitoring, and (5) meteorological monitoring of the local climate and weather.

A primary objective of air quality surveillance is to measure levels of airborne radiological materials in order to calculate radiological doses to humans, plants, and animals. Results are compared with U.S. Department of Energy and U.S. Environmental Protection Agency standards. Radioactivity levels in the air are compared with the limits for members of the public provided in DOE Order 458.1 Chg 4, *Radiation Protection of the Public and the Environment*, and in *National Emission Standards for Hazardous Air Pollutants*, Title 40 Part 61 of the Code of Federal Regulations. Estimates of public doses prepared using this data are provided in Chapter 8, Public Dose and Risk Assessment.

Ambient Air Sampling for Radionuclides

The Laboratory's air-sampling network measures levels of airborne radionuclides to monitor the releases from Laboratory operations. Radioactivity levels in the air are compared with the U.S. Environmental Protection Agency's concentration levels for environmental compliance, provided in *National Emission Standards for Hazardous Air Pollutants*, Title 40 Part 61 of the Code of Federal Regulations, Appendix E, Table 2.

During 2020, the Laboratory operated approximately 41 environmental air-monitoring stations to monitor radionuclides in the air (Figure 4-1 and Figure 4-2). Station locations are categorized as regional (away from the Laboratory), perimeter, onsite, or waste site. The waste site locations monitor radionuclides near the Laboratory's low-level radioactive waste disposal area and radioactive waste storage area, Area G, at Technical Area 54. These stations operate continuously by pulling ambient air through a filter to capture airborne particulate matter. The filters are changed out every two weeks and sent to an offsite analytical laboratory for analysis.

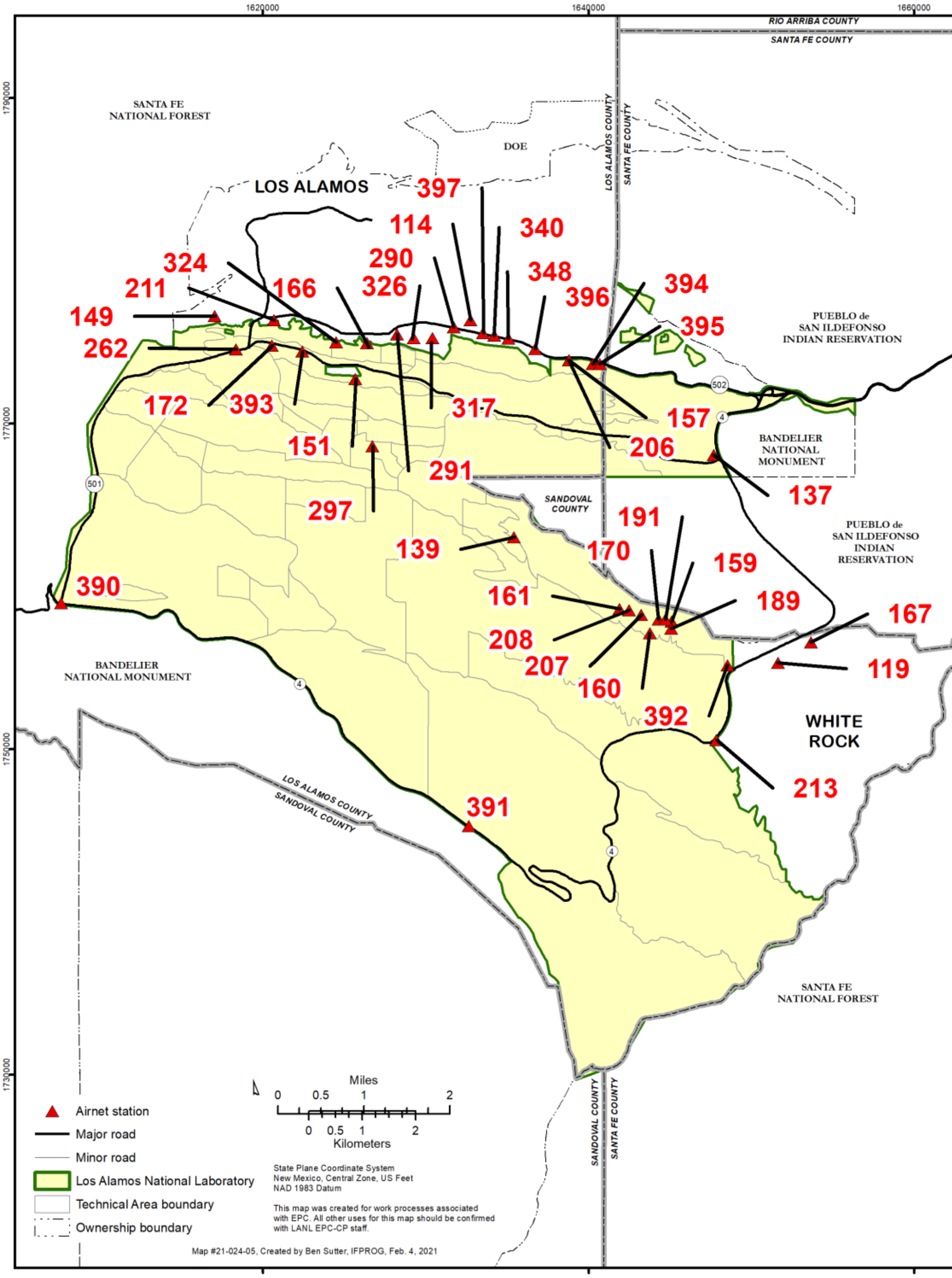
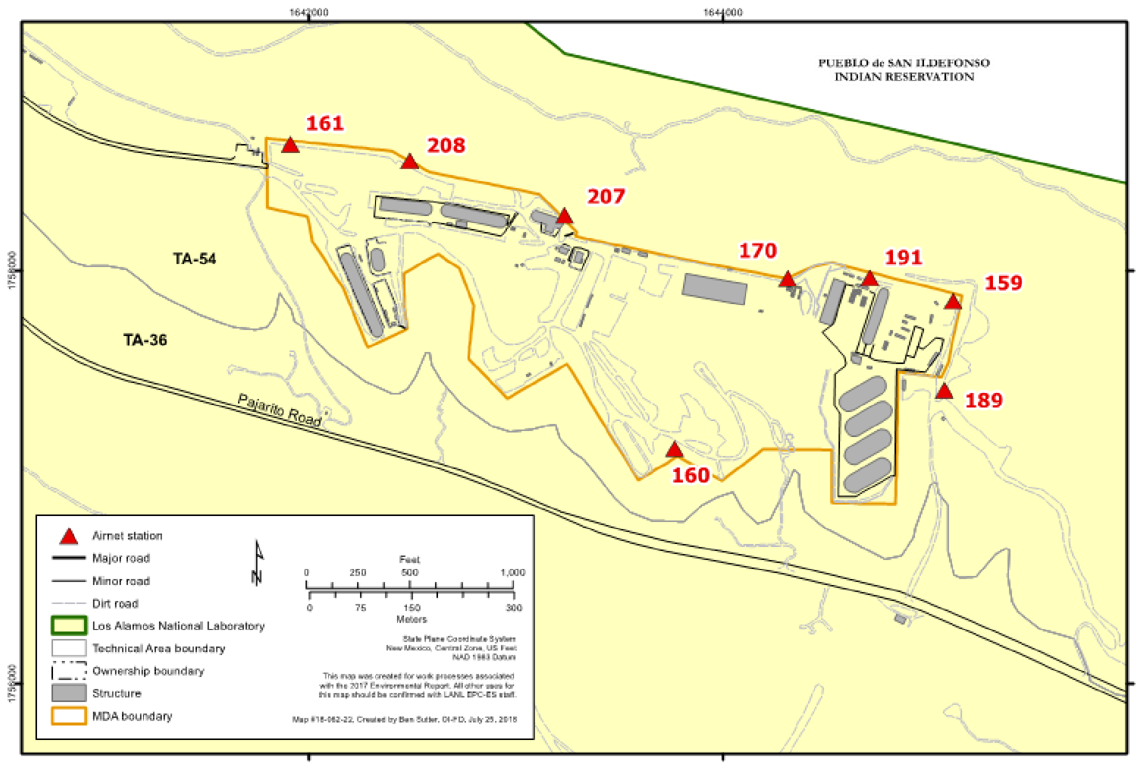


Figure 4-1. Environmental air-monitoring stations at and near the Laboratory



Note: MDA = Material disposal area; TA = Technical area

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

Regional Background Levels

The atmosphere contains background levels of radioactivity from naturally occurring radionuclides and airborne radioactive materials resulting from nuclear weapons tests and nuclear accidents. Background levels are measured at regional monitoring stations located in the communities of El Rancho, Española, and Santa Fe. The 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 Concentration Level for Environmental Compliance	Average Regional Background Activities
Tritium	pCi/m^3	1500	0 ± 1
Americium-241	aCi/m^3	1900	0 ± 1
Plutonium-238	aCi/m^3	2100	0 ± 1
Plutonium-239/240	aCi/m^3	2000	0 ± 1

Analyte	Units	U.S. Environmental Protection Agency Concentration Level for Environmental Compliance	Average Regional Background Activities
Uranium-234	aCi/m^3	7700	9 ± 5
Uranium-235	aCi/m^3	7100	1 ± 1
Uranium-238	aCi/m^3	8300	9 ± 6

Note: pCi/m^3 = picocuries per cubic meter; aCi/m^3 = attocuries per cubic meter.

Perimeter, Onsite, and Waste Site Radionuclides

What are cosmic rays?

Cosmic rays are fragments of atoms that rain down upon the Earth from outside the solar system.

Tritium

Tritium is present in the environment primarily as the result of past nuclear weapons tests and cosmic-ray interactions with the air (Eisenbud and Gesell 1997). Measurements of water vapor in the air and tritium in the water vapor are used to calculate the amount of tritium in the air. During 2020, tritium concentrations were similar to recent years and below U.S. Environmental Protection Agency's concentration level for environmental compliance of 1,500 picocuries per cubic meter (Table 4-2). The highest annual tritium activity at any offsite station was 0.2 percent of the concentration level for environmental compliance.

Table 4-2. Airborne Tritium as Tritiated Water Activities for 2020—Group Summaries

Station Grouping	Number of Stations	Mean ± 2 Standard Deviations (pCi/m^3)		Maximum Annual Station Activity (pCi/m^3)	U.S. Environmental Protection Agency Concentration Level for Environmental Compliance (pCi/m^3)
Regional	3	1	±1	1	1500
Perimeter	28	1	±1	3	1500
Onsite	2	4	N/A	7	1500
Waste site	8	51	N/A	367	1500

Note: pCi/m^3 = picocuries per cubic meter, N/A = not applicable.

For the waste site, the largest tritium concentration is at the southern boundary of Area G (station 160, Figure 4-2). The annual average concentration is well below 1,500 picocuries per cubic meter, which is the U.S. Environmental Protection Agency concentration level for the public.

The analytical methods comply with U.S. Environmental Protection Agency requirements in *National Emission Standards for Hazardous Air Pollutants*, Title 40 Part 61 of the Code of Federal Regulations, Appendix B, Method 114.

Americium-241

Table 4-3 summarizes the 2020 sampling data for americium-241. The results are similar to recent years and less than one percent of the americium-241 concentration level for environmental compliance.

Table 4-3. Airborne Americium-241 Activities for 2020—Group Summaries

Station Grouping	Number of Stations	Mean ± 2 Standard Deviations (aCi/m^3)		Maximum Annual Station Activity (aCi/m^3)
Regional	3	3	±11	9
Perimeter	28	0	±2	5
Onsite	2	0	±1	0
Waste site	8	1	±3	4

Note: aCi/m^3 = attocuries per cubic meter

Plutonium

Table 4-4 summarizes the LANL plutonium-238 and plutonium-239/240 data for 2020, which are similar to previous years.

Table 4-4. Airborne Plutonium-238 and Plutonium-239/240 Activities for 2020—Group Summaries

Station Grouping	Number of Stations	Group Mean ± 2 Standard Deviations (aCi/m^3)		Maximum Annual Station Activity (aCi/m^3)	
		Plutonium-238	Plutonium-239/240	Plutonium-238	Plutonium-239/240
Regional	3	0 ± 1	0 ± 1	0	0
Perimeter	28	0 ± 1	2 ± 7	2	15
Onsite	2	0 ± 1	1 ± 3	0	2
Waste site	8	1 ± 1	1 ± 2	2	3

Note: aCi/m^3 = attocuries per cubic meter

Every year, dust blown from areas where Manhattan Project–era operations took place results in detectable amounts of plutonium-239 in the air near Technical Areas 01 and 21. The plutonium-239 concentrations at perimeter environmental air-monitoring stations 317 (DP Road), 324 (Hillside 138), 326 (Middle DP Road), 340 (DP East), and 348 (downwind of Technical Area 21) are about one percent of the U.S. Environmental Protection Agency's plutonium-239 concentration level for environmental compliance, which is 2,000 attocuries per cubic meter.

Uranium

Table 4-5 summarizes the uranium data. The results are consistent with naturally occurring uranium and are below the applicable concentration levels.

Table 4-5. Airborne Uranium-234, -235, and -238 Activities for 2020—Group Summaries

Station Grouping	Number of Stations	Group Mean ± 2 Standard Deviations (aCi/m³)		
		Uranium-234	Uranium-235	Uranium-238
Regional	3	9 ± 5	1 ± 1	9 ± 6
Perimeter	27	9 ± 14	1 ± 1	9 ± 14
Onsite	2	6 ± 1	0 ± 1	6 ± 2
Waste site	8	8 ± 5	1 ± 1	10 ± 8

Note: aCi/m³ = attocuries per cubic meter

Gamma Spectroscopy Measurements

Air samples are analyzed by gamma spectroscopy for the following gamma ray–producing radionuclides: cobalt-60, cesium-134 and -137, iodine-131, sodium-22, and protactinium-234m. These radionuclides were not detected.

Newly-Discovered Waste Near DP Road

On February 14, 2020, a Los Alamos County subcontractor unearthed buried material that was later identified as Manhattan Project material from the 1940s. The material was buried more than six feet under the ground west of Material Disposal Area B, near Technical Area 21, and about 260 feet southwest of environmental air-monitoring station 326 (Figure 4-1). The land had been conveyed to Los Alamos County in 2018 for industrial and commercial uses. Reports on initial investigations of the site have been submitted to the Department of Energy, the New Mexico Environment Department, and the County of Los Alamos, and further reports are in preparation (see https://ext.em-la.doe.gov/eprr/repo-file.aspx?oid=0902e3a6800e62e4&n=EMID-701169_EMLA-2021-0096-02-001_MDPR_WP_122120.pdf). Plans are being developed for further investigations and remediation.

Station 326 (which had been shut down following the remediation of Material Disposal Area B was restarted together with two high-volume air samplers to monitor both the first discovery and subsequent discoveries of Manhattan Project material buried an additional 160 feet south. During 2020, station 326 measured an average plutonium-239 concentration of 11 attocuries per cubic meter, which is similar to previous measurements on DP Road.

The same station measured 38 attocuries per cubic meter of uranium-234 and -238 during the fourth quarter of 2020. This is most likely the result of soil suspended in the air during construction activities 150 to 1,000 feet to the west. For comparison, station 291 at the west end of DP Road measured 55 attocuries per cubic meter of natural uranium during this same quarter.

Calculations and ongoing investigations indicate that the newly discovered Manhattan-Project material did not contribute measurably to airborne material during 2020. The measured concentrations are approximately one percent of the concentration levels for environmental compliance.

Conclusion

All concentrations of airborne radioactive material measured in ambient air samples were below the applicable concentration levels for environmental compliance.

Exhaust Stack Sampling for Radionuclides

Radioactive materials are used in some Laboratory operations. The buildings that house those operations may vent radioactive materials to the environment through an exhaust stack or other release point. The Laboratory's stack monitoring team monitors emission points that could cause a public dose greater than 0.1 millirem during a one-year period. Each of these stacks is sampled in accordance with the *National Emission Standards for Emissions of Radionuclides Other Than Radon from Department of Energy Facilities*, Title 40 Part 61 Subpart H of the Code of Federal Regulations.

Sampling Methodology

Radioactive stack emissions can be one of four types: (1) particulate matter, (2) activated vapors and volatile compounds, (3) tritium, or (4) gaseous mixed activation products. Activated materials are made radioactive by exposure to neutron radiation. This section describes the sampling method for each of these emission types.

Emissions of particulate matter are sampled using a glass-fiber filter. A continuous sample of air from the stack is pulled through a filter that captures small particles. Filters are collected weekly and shipped to an offsite analytical laboratory for analysis.

Charcoal cartridges are used to sample emissions of vapors and volatile compounds generated by operations at the Los Alamos Neutron Science Center at Technical Area 53, the Chemistry and Metallurgy Research Building, and 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. Then, the air is passed through a palladium catalyst that converts the elemental tritium to the oxide form. Following this conversion, the sample is pulled through three additional vials containing ethylene glycol, which collect the newly formed tritium oxide.

The stack monitoring team measures activities of gaseous mixed activation products emitted from the Los Alamos Neutron Science Center using real-time air monitoring data. For this, a sample of air from the stack 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 used for each type of the Laboratory's emissions. The sampling methods comply with U.S. Environmental Protection Agency requirements in the *National Emission Standards for Hazardous Air Pollutants*, Title 40, Part 61 of the Code of Federal Regulations, Appendix B, Method 114.

Check of the Total Activity

Each week the glass-fiber filters are collected. The total activity is measured before the filters are shipped to an offsite analytical laboratory where they are analyzed using spectroscopy to identify radionuclides. These data are used to quantify emissions of radionuclides; and, the results are compared with the total activity measurements to ensure that all radionuclides are identified.

Vaporous Activation Products

Each week the charcoal cartridges are collected and shipped to an offsite analytical laboratory where they are analyzed using spectroscopy. These data are used to identify and quantify the presence of vaporous material.

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 offsite. The monitoring system includes a flow-through ionization chamber in series with a gamma spectroscopy system. The real-time current measured by this ionization chamber is recorded. And, the total amount of charge collected in the chamber is integrated on a daily basis. The gamma spectroscopy system analyzes the composition of these gaseous mixed activation products.

Results

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.

Conclusions and Trends

Emission-control systems in Laboratory facilities for particulates such as plutonium and uranium continue to work as designed, and particulate emissions remain very low, in the micro-curie range. Emissions of short-lived gases and vapors were lower in 2020 than 2019. During 2020, the radioactive emissions from all Laboratory sources amounted to approximately one percent of the regulatory limit.

Table 4-6. Airborne Radioactive Emissions* from LANL Buildings with Sampled Stacks in 2020

Technical Area and 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		5.9×10^{-6}	1.9×10^{-5}	4.0×10^{-6}	6.1×10^{-7}	1.7×10^{-5}	
TA-16-205/450	36.1						
TA-48-001				4.8×10^{-9}	1.6×10^{-9}	1.3×10^{-2}	
TA-50-001				7.9×10^{-8}	2.5×10^{-8}		
TA-50-069		1.6×10^{-10}	6.8×10^{-10}		3.8×10^{-10}		
TA-53-003	12.4					3.1×10^{-1}	36
TA-53-007	2.9					6.4×10^{-1}	119
TA-54-231/375/412				3.3×10^{-9}	1.4×10^{-8}		
TA-55-004			1.9×10^{-8}	4.9×10^{-8}	2.4×10^{-8}		
Total	52.4	5.9×10^{-6}	1.9×10^{-5}	4.1×10^{-6}	6.7×10^{-7}	9.6×10^{-1}	155

** Values are expressed in scientific notation.*

Table 4-7. Activation Products in 2020

Building Number	Nuclide	Emission (curies)*	
TA-48-001	Gallium-68	0.00021	2.1×10^{-4}
TA-48-001	Germanium-68	0.00021	2.1×10^{-4}
TA-48-001	Mercury-197	0.0064	6.4×10^{-3}
TA-48-001	Mercury-197m	0.0064	6.4×10^{-3}
TA-48-001	Selenium-75	0.00019	1.9×10^{-4}
TA-48-001	Sodium-22	0.0000000064	6.4×10^{-9}
TA-53-003	Argon-41	1.5	1.5
TA-53-003	Beryllium-7	0.000017	1.7×10^{-5}
TA-53-003	Bromine-77	0.0000063	6.3×10^{-6}
TA-53-003	Bromine-82	0.00020	2.0×10^{-4}
TA-53-003	Carbon-11	39	3.9×10^{1}
TA-53-003	Iodine-135	0.31	$3.1x10^{-1}$
TA-53-003	Sodium-24	0.00039	$3.9x10^{-4}$
TA-53-007	Argon-41	8.4	8.4
TA-53-007	Bromine-76	0.000059	5.9×10^{-5}
TA-53-007	Bromine-82	0.0018	1.8×10^{-3}
TA-53-007	Carbon-10	0.31	3.1×10^{-1}
TA-53-007	Carbon-11	49	49×10^{1}
TA-53-007	Mercury-197	0.00018	1.8×10^{-4}
TA-53-007	Mercury-197m	0.00018	1.8×10^{-4}
TA-53-007	Nitrogen-13	19	1.9×10^{1}
TA-53-007	Nitrogen-16	0.45	4.5×10^{-1}

Building Number	Nuclide	Emission (curies)*	
TA-53-007	Sodium-24	0.64	6.4×10^{-1}
TA-53-007	Oxygen-14	0.74	7.4×10^{-1}
TA-53-007	Oxygen-15	41	4.1×10^{1}
TA-53-007	Osmium-191	0.00000018	1.8×10^{-5}

**The value for emission for each building and nuclide is listed in both standard and scientific notation.*

Table 4-8. Radionuclide Half-Lives

Nuclide	Half-Life
Tritium	12.3 years
Beryllium-7	53.1 days
Carbon-10	19.3 seconds
Carbon-11	20.4 minutes
Nitrogen-13	10.0 minutes
Nitrogen-16	7.1 seconds
Oxygen-14	70.6 seconds
Oxygen-15	122.2 seconds
Sodium-22	2.6 years
Sodium-24	15.0 hours
Argon-41	1.82 hours
Cobalt-60	5.3 years
Arsenic-73	80.3 days
Arsenic-74	17.8 days
Bromine-76	16.2 hours
Bromine-77	2.4 days
Bromine-82	1.5 days
Selenium-75	119.8 days
Strontium-90	28.8 years
Cesium-134	2.1 years
Cesium-137	30.1 years
Osmium-191	15.4 days
Mercury-197	2.7 days
Mercury-197m	23.8 hours
Uranium-234	245,500 years
Uranium-235	703,800,000 years
Uranium-238	4,468,000,000 years
Plutonium-238	87.7 years
Plutonium-239	24,110 years
Plutonium-240	6,563 years
Plutonium-241	14.4 years
Americium-241	432 years

Monitoring for Gamma and Neutron Direct-Penetrating Radiation

Gamma and neutron radiation levels are monitored by the Direct-Penetrating Radiation Network (McNaughton 2018) and supplemented by the Neighborhood Environmental Watch Network. The objectives are to monitor gamma and neutron radiation in the environment as required by DOE Order 458.1.

Dosimeters are devices that measure exposure to ionizing radiation. We deployed dosimeters at a total of 83 locations to monitor direct-penetrating radiation in the environment during 2020. Thermoluminescent dosimeters (which monitor gamma and neutron radiation) are deployed at every environmental air-monitoring station (Figure 4-1 and Figure 4-2). Additional thermoluminescent dosimeters are deployed at Technical Areas 53 and 54, which are potential Laboratory sources of direct-penetrating radiation (Figure 4-3 and Figure 4-4). Together, all these locations make up the Direct-Penetrating Radiation Network.

Gamma radiation occurs naturally, typically 100 to 200 millirem per year, so it is difficult to distinguish the much smaller levels of radiation contributed by the Laboratory. Radiation from the Laboratory is identified by higher radiation levels near the source and reduced radiation levels at greater distances.

Neutron doses are measured near known or suspected sources of neutrons, including Technical Areas 53 and 54. At 52 locations, the accuracy of the neutron measurements is enhanced by the addition of Lucite blocks that reflect neutrons into the dosimeter. The neutron background is measured at locations far from Laboratory sources.

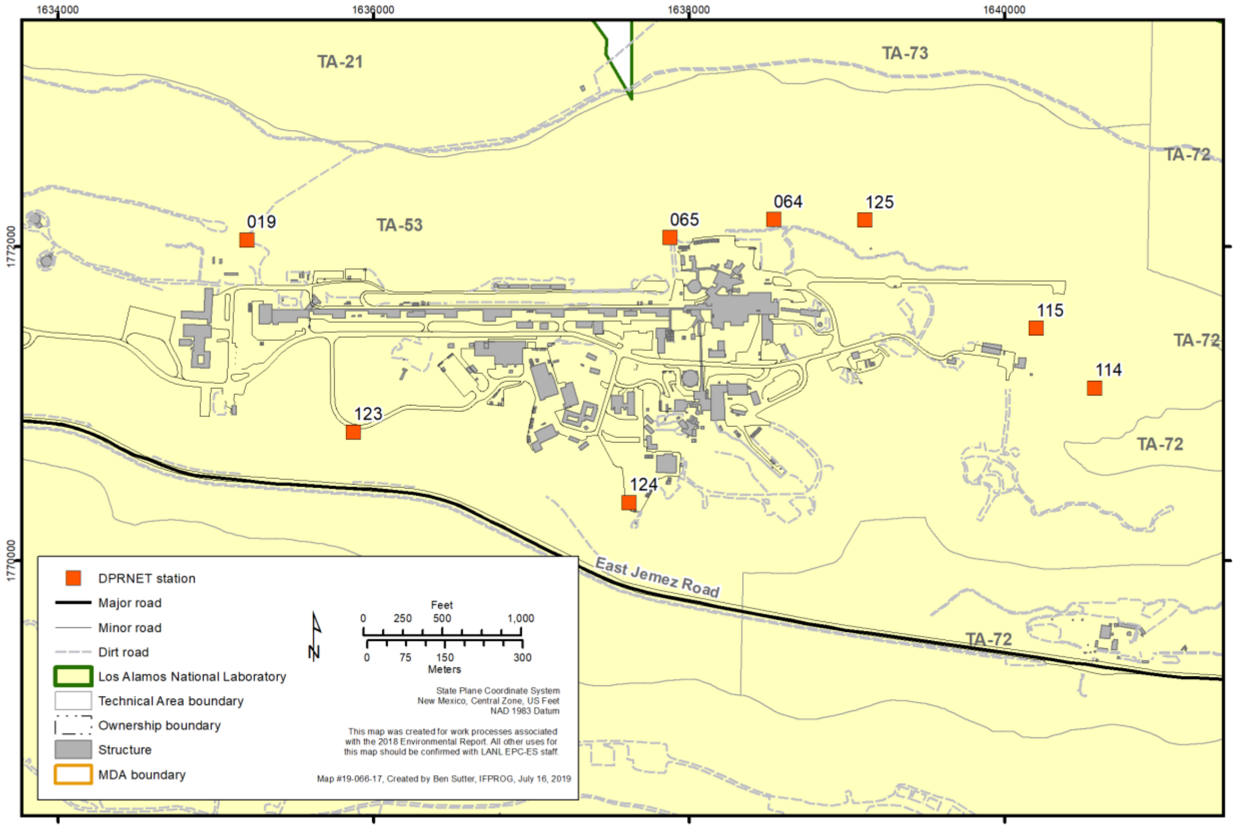


Figure 4-3. Locations of thermoluminescent dosimeters at Technical Area (TA) 53 that are part of the direct-penetrating radiation monitoring network (DPRNET)

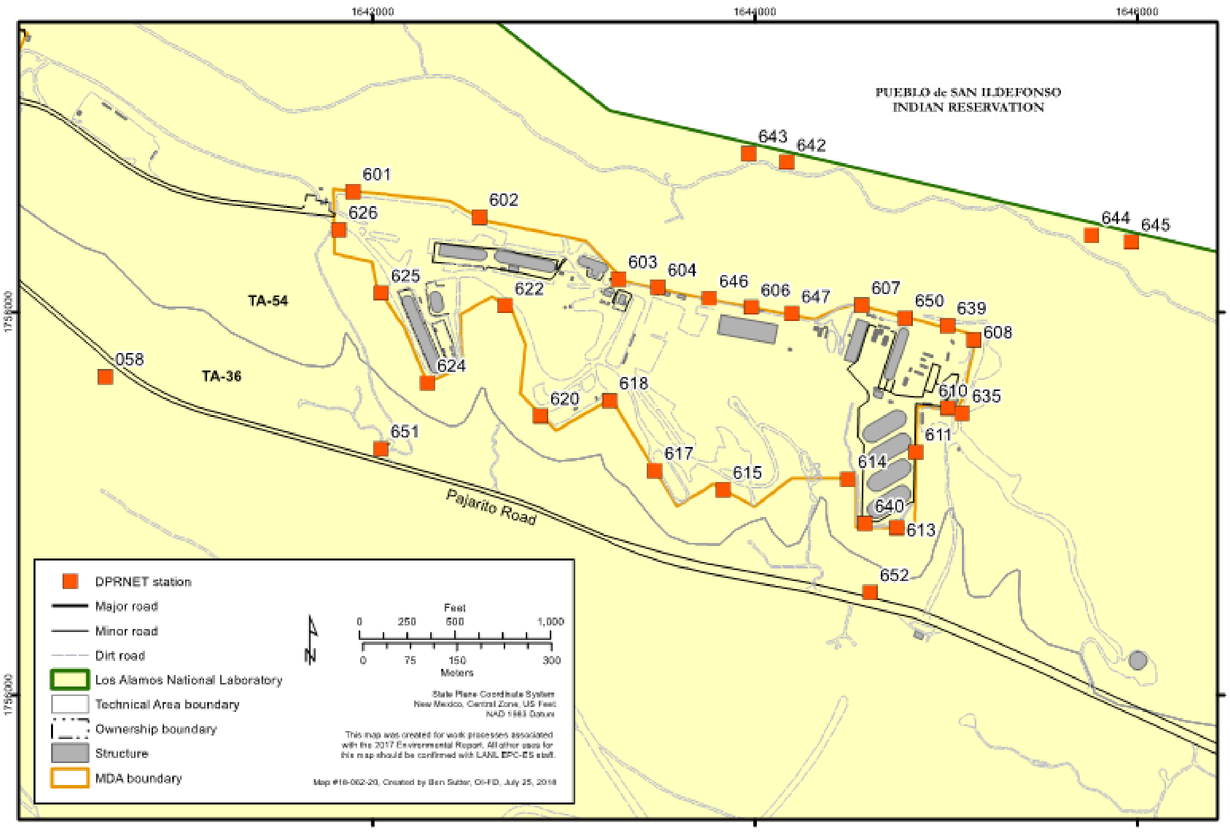


Figure 4-4. Locations of thermoluminescent dosimeters at Area G that are part of the direct-penetrating radiation monitoring network (DPRNET)

Quality Assurance

The Radiation Protection Division dosimetry laboratory is accredited by the DOE Laboratory Accreditation Program and provides quality assurance for the dosimeters.

Results

Table 4-9 summarizes the gamma radiation data for 2020. We compared the results to the values recorded in previous years at those stations. At regional locations, the gamma radiation is natural and, as expected, has not changed. At the perimeter stations, the gamma radiation is generally higher than at the regional stations because of increased cosmic radiation at higher altitudes and increased uranium and thorium in the soil. At these stations, the radiation is mostly natural and, as expected, 2020 data are similar to data from previous years. Onsite, the slight decrease likely is not statistically significant. At the Los Alamos Neutron Science Center accelerator facility, there is measurable radiation from the accelerator, which varies from year to year. At the Area G waste site, there is a downward trend as waste is sent to the Waste Isolation Pilot Plant in Carlsbad, New Mexico.

Table 4-9. Gamma Radiation for 2020—Group Summaries

Station Grouping	Number of Stations	Group Mean ± 1 Standard Deviation (millirem)	
		Previous	2020
Regional	11	118 ± 15	121 ± 14
Perimeter	28	127 ± 10	131 ± 10
Onsite	3	130 ± 10	137 ± 15
Los Alamos Neutron Science Center	8	143 ± 23	134 ± 14
Area G Waste Site	33	205 ± 117	148 ± 42

Table 4-10 summarizes the neutron radiation data. At regional stations, the radiation is natural and there is no change. Similar to the gamma radiation data, for waste site locations near Area G, there is a decreasing trend as waste is sent offsite.

Table 4-10. Neutron Radiation for 2020—Group Summaries

Station Grouping	Number of Stations	Group Mean ± 1 Standard Deviation (millirem)	
		Previous	2020
Regional	7	2.6 ± 1.5	3.0 ± 1.5
Perimeter	3	4.6 ± 3.7	2.5 ± 0.9
Onsite	10	2.4 ± 0.5	1.4 ± 1.9
Los Alamos Neutron Science Center	8	3.6 ± 1.1	5.3 ± 1.2
Area G Waste Site	33	148 ± 185	32 ± 32

Locations with a measurable contribution from Laboratory operations are discussed in the following section.

Los Alamos Neutron Science Center at Technical Area 53

Figure 4-3 shows the locations of the dosimeters at Technical Area 53. Previous studies (McNaughton 2013) discuss the possibility that a member of the public on East Jemez Road, south of Technical Area 53, could be exposed to gamma and neutron radiation from the Los Alamos Neutron Science Center in Technical Area 53.

During 2020, dosimeter #115 in Technical Area 53 measured a gamma dose of 161 millirem per year, which is 36 millirem per year above the background of 125 millirem per year. Calculations

(McNaughton 2013) show that the gamma dose at East Jemez Road is 0.2 percent of the dose measured by dosimeter #115. Therefore, the gamma dose from Laboratory operations at East Jemez Road was approximately 0.1 millirem per year near this location.

Also, dosimeter #124 at Technical Area 53 measured a neutron dose 6 millirem per year above background. Calculations (McNaughton 2013) show that the neutron dose at East Jemez Road is 10 percent of this value. Therefore, the neutron dose from Laboratory operations at East Jemez Road was 0.6 millirem per year near this location.

Technical Area 54, Area G

Figure 4-4 shows the locations of the dosimeters at Technical Area 54, Area G. Area G is a controlled-access area, so Area G data do not represent a potential public dose.

Dosimeters #642 through #645 are in Cañada del Buey. After subtracting background, the 2020 annual neutron dose measured by these dosimeters was 3 millirem. 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 (Public Dose and Risk Assessment), an occupancy factor of 1/20 is applied (National Council on Radiation Protection and Measurements 2005). Therefore, the dose in Cañada del Buey at the dosimeters is calculated to be 3 millirem multiplied by 1/20, equaling approximately 0.2 millirem per year, which is similar to previous years.

Neighborhood Environmental Watch Network

During 2020, the Neighborhood Environmental Watch Network detected gamma-ray emissions from airborne radioactive material on September 18, November 10 and 12, and December 5. The total measured dose from these events was less than 0.01 millirem. Although they are not quantitative measurements, these observations indicate that the total dose from gamma-emitting material was far below the annual limit of 10 millirem.

Conclusion

Generally, the data are similar to previous years and show that emissions of direct-penetrating radiation from Laboratory facilities were far below the DOE limits.

Total Particulate Matter Air Monitoring

Particulate matter consists of smoke, dust, and other material that can be inhaled. Generally, it is not radioactive. Particulate matter can be harmful in high concentrations.

The total amount of respirable particulate matter is monitored at two locations: near the intersection of New Mexico State Road 4 and Rover Boulevard in White Rock, and at the Los Alamos Medical Center in Los Alamos.

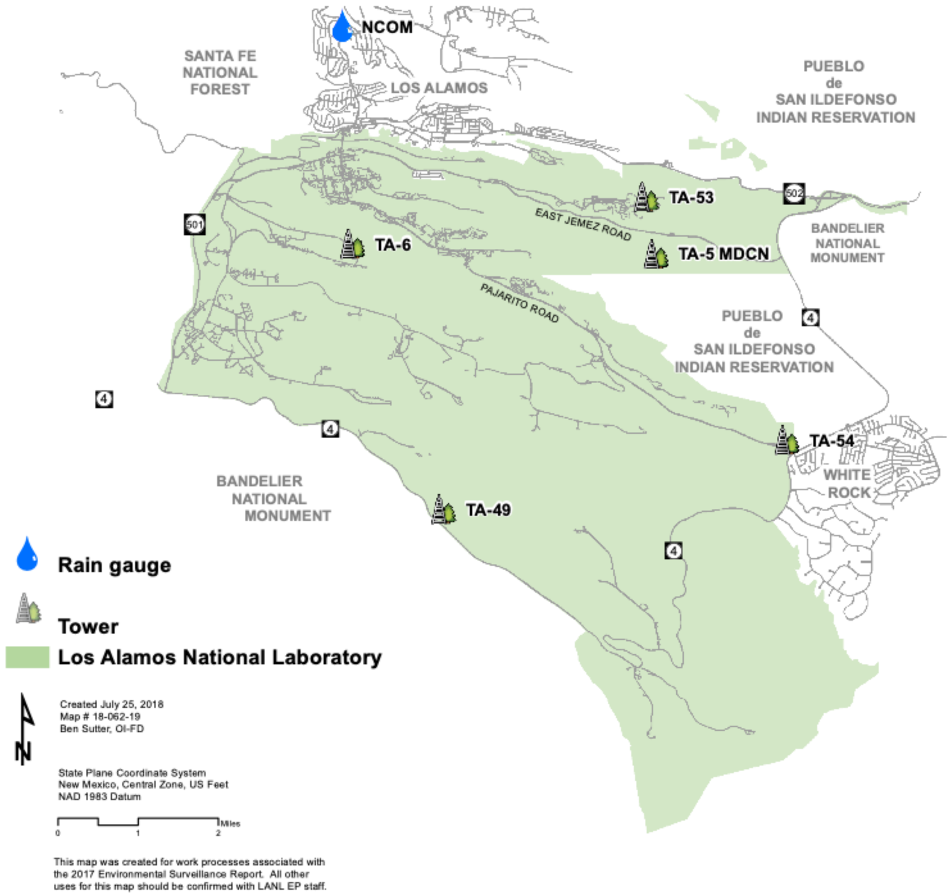
During 2020, the particulate matter concentrations remained well below the U.S. Environmental Protection Agency standard of 35 micrograms per cubic meter for particulate matter smaller than 2.5 micrometers. Typical concentrations (>95 percent of the time) were less than 10 micrograms per cubic meter. The highest concentrations occurred during the spring from windblown dust and during the summer from wildfires.

Meteorological Monitoring

We collect weather data to support 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, atmospheric pressure, relative humidity, dew point, precipitation, and solar and terrestrial radiation, among other atmospheric variables. 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 https://weathermachine.lanl.gov.

Monitoring Network

Currently, five meteorological towers gather weather data at the Laboratory (Figure 4-5). Four of the towers are located on mesa tops (Technical Areas 6, 49, 53, and 54) and one tower is in the bottom of Mortandad Canyon (Technical Area 5). An additional precipitation gauge is located at the North Community of the Los Alamos town site. The Technical Area 06 tower is the official meteorological measurement station for the Laboratory.



Note: MDCN = Mortandad Canyon; NCOM = North Community.

Figure 4-5. Locations of five LANL meteorological monitoring towers and an offsite rain gauge

Sampling Procedures and Data Management

Weather-sensing instruments are located at areas with good exposure, usually in open fields, to avoid impacts on wind and precipitation measurements. Temperature and wind are measured at multiple height levels on open-lattice towers at Technical Areas 6, 49, 53, and 54. The multiple levels provide a vertical profile of these meteorological variables, which is important in assessing wind speed and direction at different heights above ground and in determining atmospheric stability conditions. The multiple levels also provide redundant measurements that enhance data quality checks. Boom-mounted temperature sensors on the towers are shielded from solar radiation and aspirated (provided with constant air circulation) to minimize effects from direct sunlight. The Mortandad Canyon station is a 10-meter tripod tower that measures wind speed, direction, and temperature at the top of the tower. Temperature is measured near ground level (approximately five feet high) at all stations except North Community, and humidity is measured at the same level at all stations except Mortandad Canyon and North Community. The North Community station only measures precipitation.

Data recorders at the stations collect most of the instrument results every three seconds, average the results over a 15-minute period, and transmit the averaged data by network connection, telephone modem, or cell phone to a computer workstation. The workstation program automatically edits measurements that fall outside of realistic ranges.

For more than 50 years, these daily weather statistics have been provided to the National Weather Service.

Climate

Los Alamos has a temperate, semiarid mountain climate. The humidity is generally low, and clear skies are present about 75 percent of the time. These conditions lead to high solar heating during the day and strong long wave radiative cooling at night. Winters are generally mild, with occasional winter storms. Spring is the windiest season. Summer is the rainy season, due to the Southwest monsoon, with frequent afternoon thunderstorms. Fall is typically dry and cool, with light wind speeds. Climate statistics are based on analyses of historical meteorological databases maintained by the Laboratory's meteorology program (Bowen 1990, Bowen 1992, Dewart et al. 2017).

December and January are the coldest months, when 90 percent 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 moderate somewhat before they reach the southern latitude of Los Alamos, and are sometimes blocked by the Sangre de Cristo Mountains, so subzero temperatures are not common. Winds during the winter are relatively light, so extreme wind chills are not common.

June through August are the warmest months, when 90 percent of maximum temperatures are between 67°F and 89°F. During the summer months, 90 percent of minimum temperatures are between 45°F and 61°F.

Average precipitation is calculated using 30 years of data measured at the official Laboratory weather station at Technical Area 06. This is a nationally standardized time period updated every decade (the averaged results are called the climate normals or climatological normals). The averaged years for 2020 climatological normals are 1981 to 2010. Other Laboratory stations do not have data going back 30 years.

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 greatest winter precipitation events in Los Alamos are caused by storms approaching from the west to southwest. Snowfall amounts are occasionally enhanced from orographic lifting as the storms travel up the high terrain.

Table 4-11 presents temperature and precipitation records for Los Alamos from 1924 to 2020.

Table 4-11. Records Set Between 1924 and 2020 for Los Alamos

Measurement	Record	Date or Period
Low temperature	–18°F	January 13, 1963
High temperature	97.5°F	July 11, 2020
Single-day rainfall	3.52 inches	September 13, 2013
Single-day snowfall	39 inches	January 15, 1987
Single-season snowfall	153 inches	1986–1987

The rainy season, when the Southwest monsoon is present, typically begins in early July and ends in mid-September. Afternoon thunderstorms form as moist air from the Gulf of California and the Gulf of Mexico is convectively, orographically, or both convectively and orographically lifted by the Jemez Mountains. The thunderstorms yield short heavy downpours and abundant lightning.

The complex topography of Los Alamos influences local wind patterns, and often a distinct daily cycle of winds occurs. As air close to the ground is heated during the day, it becomes less dense and tends to flow uphill. During the night, as air close to the ground cools, it becomes denser and 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. Therefore, canyon winds are usually from the west at night and from the east during the day. Winds on the Pajarito Plateau are usually faster during the day than at night. This is a result of vertical mixing that is driven by solar heating. During the day, the vertical mixing is strong and brings momentum from higher wind speeds aloft down to the surface, thereby increasing the wind speed.

2020 in Perspective

Table 4-12 presents Los Alamos climatological data for 2020. Figure 4-6 presents a graphical summary of Los Alamos temperatures for 2020, with a comparison of the daily high and low temperatures at Technical Area 06 to the 1981 to 2010 climatological normal values, and to the record values from 1924 to the present. Temperatures were above average for 11 of the 12 months, and a dramatic shortfall of monsoon precipitation during the summer was associated with a new all-time high temperature of 97.5°F on July 11, along with August temperatures that were more than 6°F above average. The last line of Table 4-12 summarizes the year and shows that the overall average temperature was 3.0°F above the 1981 to 2010 average, total precipitation was 7.45 inches below average, and snowfall was 23.0 inches below average. The average wind speed was 0.6 mph above the 1981-2010 average.

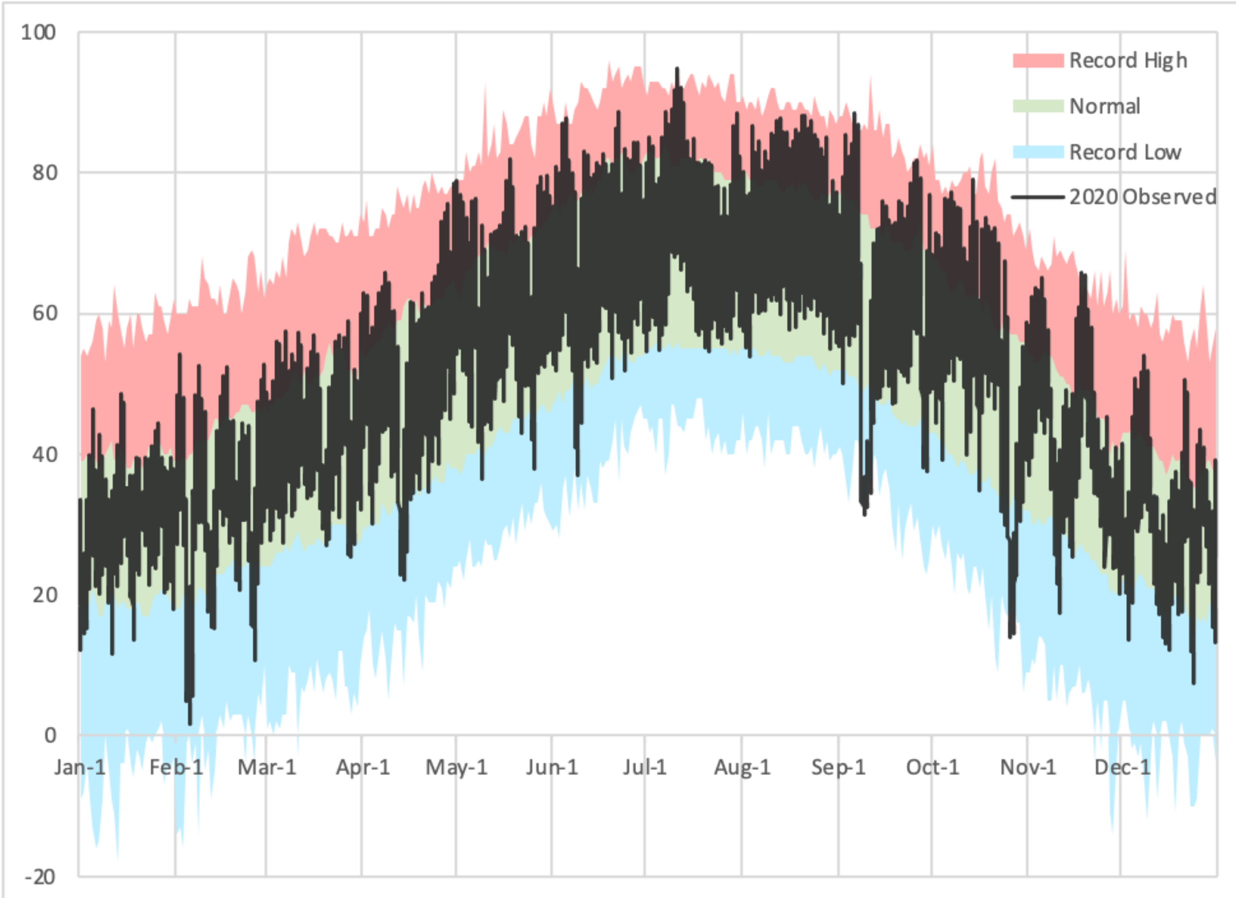


Figure 4-6. Los Alamos daily high and low temperatures in 2020 in degrees Fahrenheit (black line) compared with record (red – record highs; blue – record lows) and normal (green) values

Table 4-12. Monthly and Annual Climatological Data for 2020 at Los Alamos

Month	Temperatures (°Fahrenheit)*								Precipitation (inches)*				12-meter† Wind (miles per hour)*				
	Averages				Extremes						Snowfall				Peak Gusts		
	Daily Maximum	Daily Minimum	Overall	Departure‡	Highest	Date	Lowest	Date	Total	Departure‡	Total	Departure‡	Average Speed	Departure§	Speed	From	Date
January	39.5	20.5	30.0	0.7	49	14	11	11	0.75	-0.20	7.6	-5.7	4.8	-0.2	55	WSW	17
February	43.7	22.1	32.9	-0.1	55	2	0	5	0.69	-0.17	9.0	-1.9	6.0	0.2	53	WNW	24
March	53.5	31.3	42.4	3.1	62	31	24	28	1.70	0.50	0.3	-10.1	7.3	0.8	43	SSE	18
April	63.5	37.2	50.3	3.5	80	30	20	14	0.35	-0.71	2.1	-1.3	8.3	0.7	39	S	5
May	75.3	47.7	61.5	5.5	84	18	36	9	0.57	-0.82	0	–0.3	8.4	1.0	45	SW	19
June	82.8	53.4	68.1	3.0	91	22	36	9	0.86	-0.65	0	0	8.1	1.0	46	WNW	8
July	85.4	59.1	72.3	4.1	98	11	53	1	1.80	-1.02	0	0	6.2	0.6	49	W	12
August	85.4	58.8	72.1	6.3	91	20	53	3	1.84	-1.77	0	0	5.8	0.1	42	WSW	9
September	74.7	47.5	61.1	1.3	90	6	31	9	0.93	-1.08	0.7	0.7	6.0	0.2	40	NNW	5
October	66.9	40.4	53.6	4.4	81	14	14	26	0.74	-0.81	9.7	7.5	6.2	0.2	53	SW	25
November	52.3	32.1	42.2	4.4	67	18	16	11	0.93	-0.05	1.7	-3.2	6.4	1.1	45	SSE	6
December	40.5	20.1	30.3	0.9	55	8	6	24	0.36	-0.65	3.4	-8.8	5.3	0.8	40	W	22
Year	63.6	39.2	51.4	3.0	98	Jul 11	0	Feb 5	11.52	–7.45	34.5	–23.0	6.6	0.6	55	WSW	Jan 17

**Data from Technical Area 06, the official Los Alamos weather station*
†Wind data measured at 12 meters above the ground
‡Departure column indicates positive or negative departure from 1981 to 2010 (30-year) climatological average
§Departure column indicates positive or negative departure from 1990 to 2010 (21-year) climatological average

Figure 4-7 shows the Los Alamos cumulative precipitation for 2020. Cumulative precipitation was slightly above average at the end of March, but then there were large deficits for each month from April through October, including the important monsoon months. As a result, the U.S. Drought Monitor (https://droughtmonitor.unl.edu) classification for Los Alamos deteriorated steadily throughout the year, finally reaching the driest category ("Exceptional Drought") by October. By the end of the year, the Exceptional Drought category expanded to cover just over 50 percent of New Mexico.

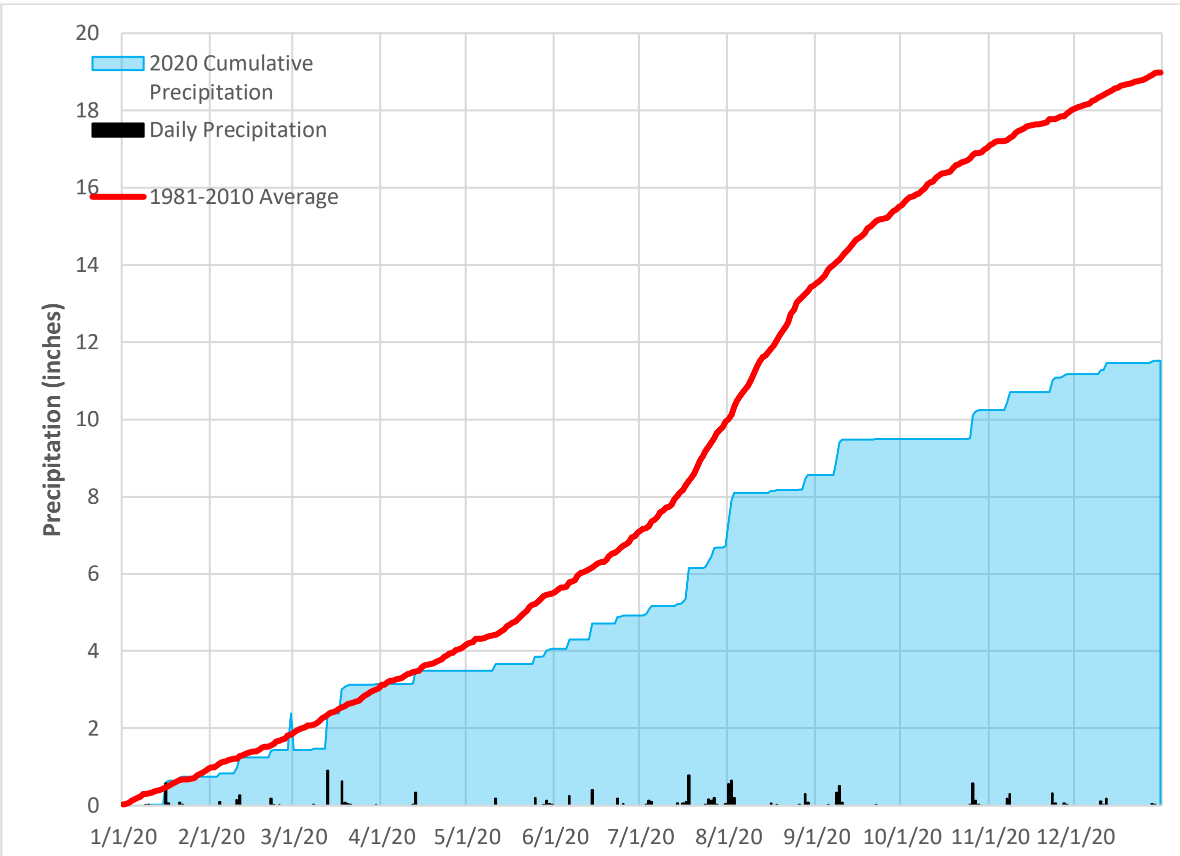


Figure 4-7. Technical Area 06 daily and cumulative precipitation in 2020 versus 30-year average

At the Laboratory's monitoring stations across Los Alamos, approximately 50 percent 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 at locations closer to the Jemez Mountains, and the Technical Area 54 tower near White Rock measures the least precipitation since it is farthest from the Jemez Mountains. Although not shown here, more precipitation fell during 2020 at Technical Area 06 and North Community compared to Technical Area 54.

Daytime (sunrise to sunset) winds and nighttime (sunset to sunrise) winds are shown in wind roses in Figure 4-8. The wind roses are based on 15-minute average wind observations for 2020 at the four mesa-top stations. Wind roses depict the percentage of time that wind blows from each of 16 cardinal compass point directions and the distribution of wind speed for each direction. During the day, winds are typically from the south and southwest, while at night the winds are usually from the west and northwest. Although not shown in this figure, wind roses from different years are almost identical in terms of the distribution of wind directions, indicating that wind patterns are consistent when averaged over a year.

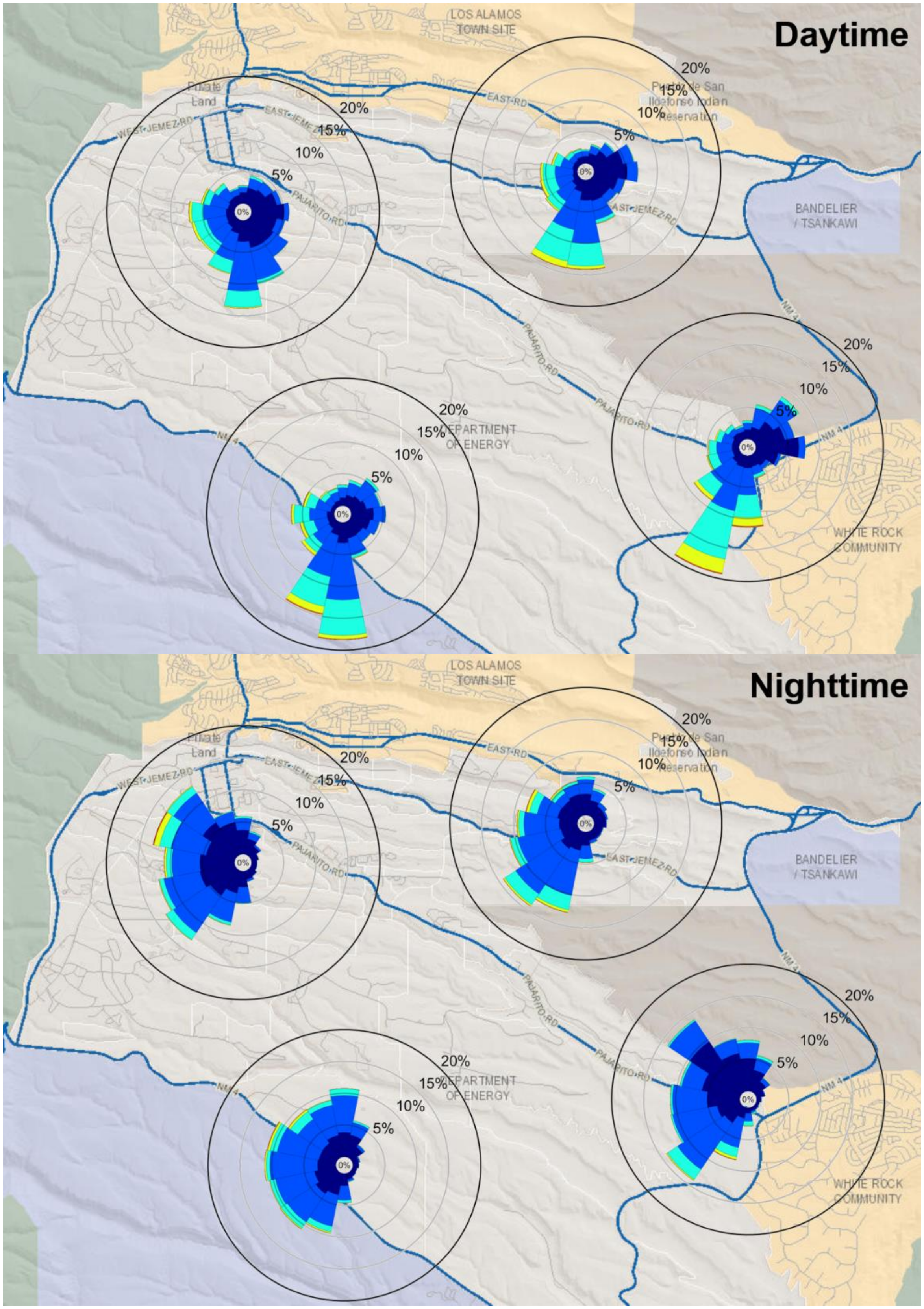


Figure 4-8. Wind roses for 2020 at the four mesa-top meteorological towers

Long-Term Climate Trends

Temperature and precipitation data have been collected in the Los Alamos area since 1910. Figure 4-9 shows the historical record of temperatures at Los Alamos from 1924 through 2020. 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 4-9 and a five-year running average, to show longer-term trends, is shown in black. The five-year average shows that the warm spell during the past 15 years is more extreme than the warm spell during the early-to-mid 1950s and is longer-lived. Although not shown on the figure, five of the hottest summers on record have occurred since 2002, and the highest summertime (June, July, and August) average temperature on record was 71.1°F, recorded during 2011.

The average temperatures per decade, recorded at Technical Area 06, along with two times the standard deviation, are plotted in Figure 4-10 with the annual average temperature for 2020. Ninety-five percent of the annual average temperatures during each decade are within the standard deviation bars. During the decades between 1960 and 2000, the annual average temperatures in Los Alamos varied only slightly from 48°F. However, during the 2001–2010 decade, the annual average temperature increased to above 49°F, and this value is statistically significantly higher than previous decades. During the recent 2011–2020 decade, the average temperature increased even more than the previous decade, with annual average temperatures above 50°F. The annual average temperature in 2020 continues to demonstrate a warming climate for Los Alamos, consistent with predictions for a warming climate in the southwestern United States (Intergovernmental Panel on Climate Change 2014).

Figure 4-11 presents the historical record of the annual precipitation at Technical Area 06. As with the historical temperature profiles, the five-year running averages and three long-term averages (25 or 30-year periods) are also shown. The 1998 through 2020 period shows the most recent drought, although near-average precipitation from 2004 to 2010 and above-average precipitation in 2015 did occur during this period.

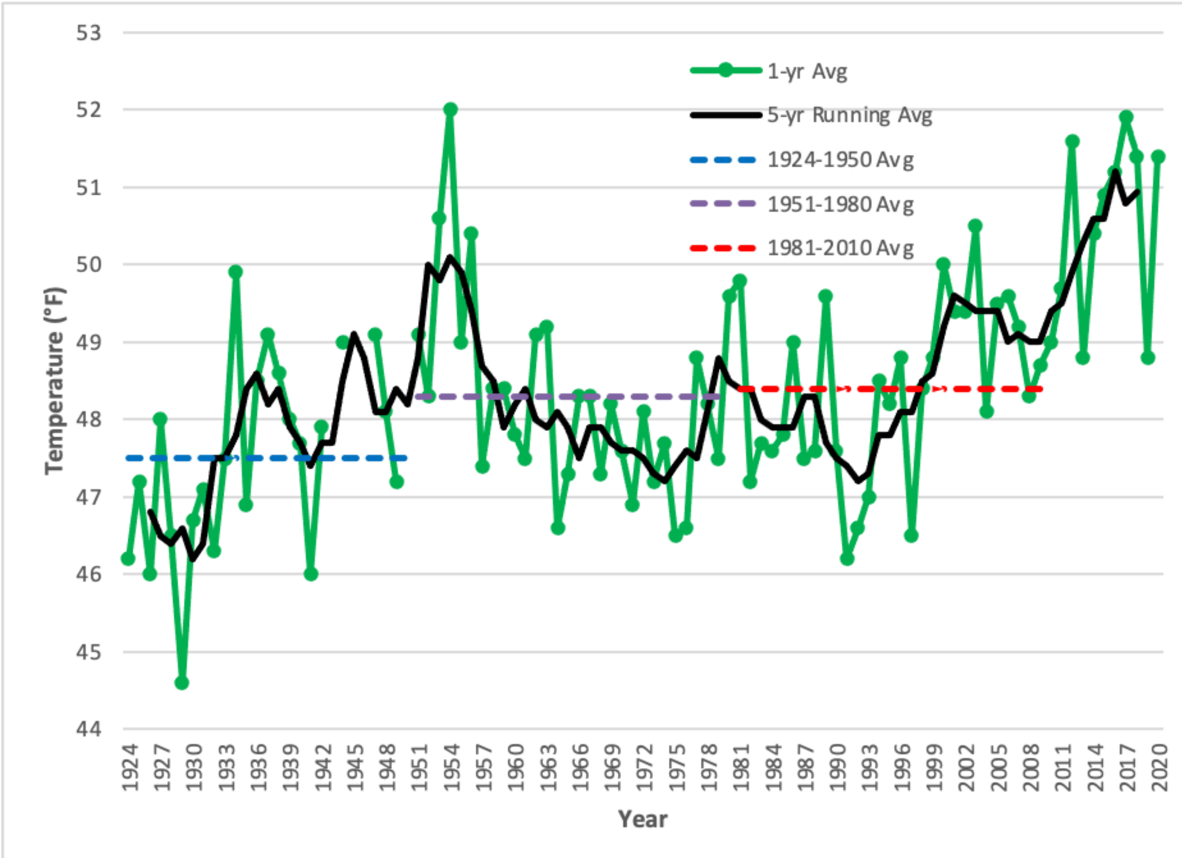


Figure 4-9. Temperature history for Los Alamos with the one-year average in green and five-year running average in black. The dashed lines represent long-term averages (25 and 30 years).

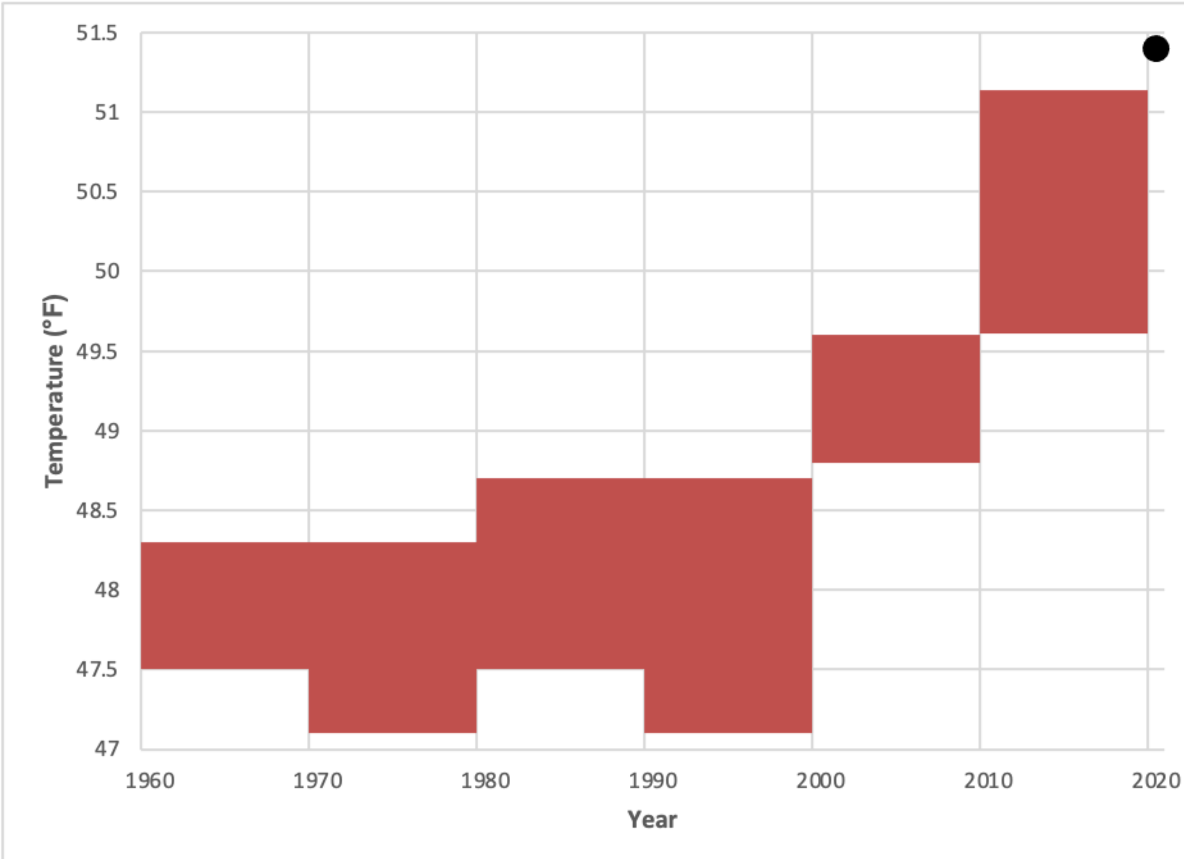


Figure 4-10. Technical Area 06 decadal average temperatures with two times the standard deviation for 1960 through 2020, and the average temperature for 2020 (black point)

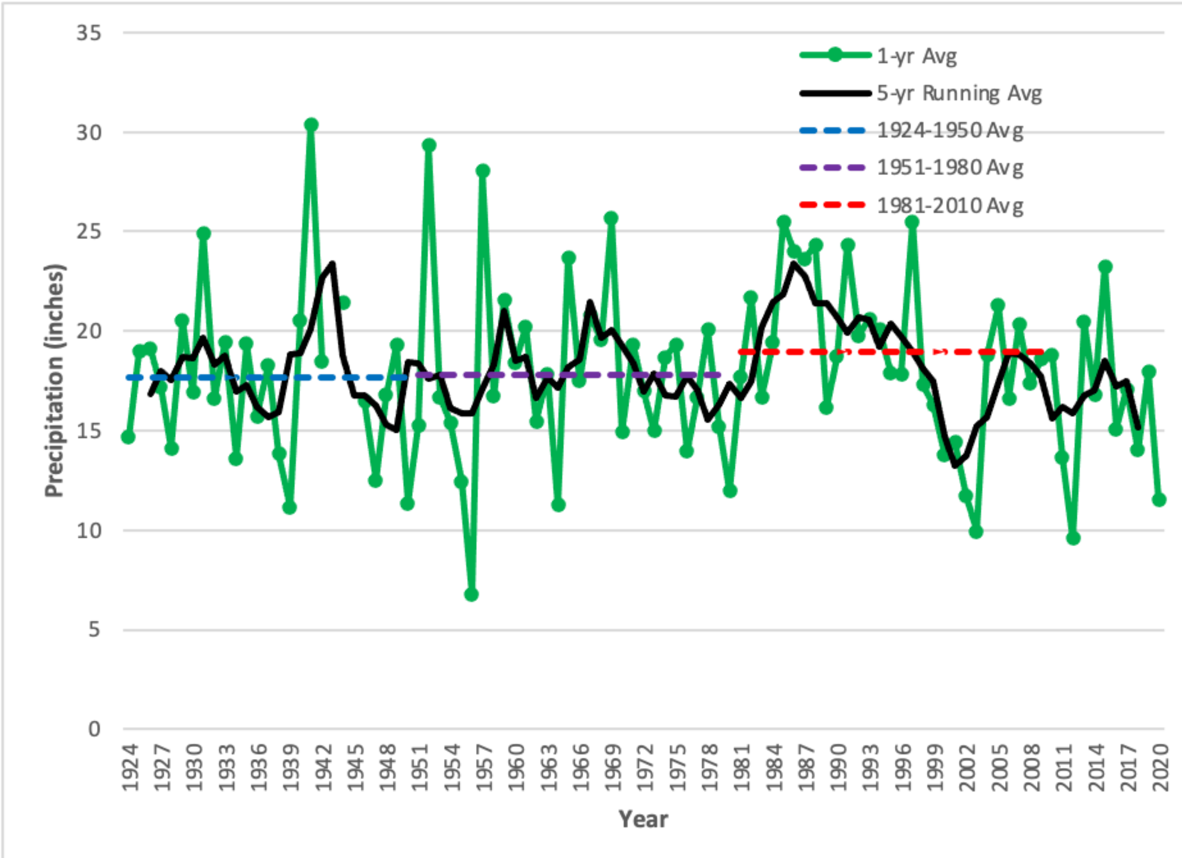


Figure 4-11. Total precipitation history for Los Alamos with the one-year total in green, five-year running average in black, and the dashed lines representing long-term averages (25 and 30 years)

Quality Assurance

Air Quality Sampling

The quality assurance program satisfies requirements in the U.S. Environmental Protection Agency's *National Emission Standards for Hazardous Air Pollutants*, Title 40 Part 61 of the Code of Federal Regulations, Appendix B, Method 114. The quality assurance project plans 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.

The quality assurance plan for ambient air sampling is described in the procedure "Quality Assurance Project Plan for the Radiological Air Sampling Network," SOP-5140, and 25 supporting procedures. The stack sampling quality assurance plan is described in the procedure "Rad-NESHAP Compliance Program, Program Implementation Plan," EPC-CP-PIP-0101, and 42 supporting procedures.

Direct Radiation Monitoring

The quality assurance plan for direct penetrating radiation is described in the procedure "Direct Penetrating Radiation Monitoring Network (DPRNET)," EPC-ES-TPP-007, and the procedure "Obtaining the Environmental Dose from the Model 8823 Dosimeter," EPC-ES-TP-002. Quality Assurance for the Model 8823 Dosimeter is provided by the Radiation Protection Division dosimetry laboratory, which is accredited by the DOE Laboratory Accreditation Program.

Meteorological Monitoring

Time-series plots of the data are generated for a meteorologist to conduct data quality reviews. Daily statistics such as daily minimum and maximum temperatures, daily total precipitation, and maximum wind gust are also generated and checked for quality and out-of-range values.

Meteorological instrument and data logger manufacturers' recommendations are followed, and operating conditions determine how often to calibrate the weather sensing instruments. All wind instruments are calibrated every six months, while all other sensors are calibrated annually, except the solar radiation sensors, which are calibrated once every five years.

Internal self-assessments and external audits of the meteorological program (inclusive of the instruments and methods) are performed periodically.

Annually, a qualified subcontractor inspects the tower and the instruments of all five towers, and performs maintenance.

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Chapter 5: Groundwater Protection

Los Alamos National Laboratory (LANL or the Laboratory) monitors and characterizes groundwater for the groundwater protection program and the 2016 Consent Order. We collect hundreds of groundwater samples each year and analyze them for a wide range of organic and inorganic constituents and radionuclides. We also implement measures to control contaminant migration.

LANL's groundwater monitoring network includes 195 sampling locations in four types of water: base flow (persistent surface water), alluvial groundwater, perched-intermediate groundwater, and regional aquifer groundwater. Many locations are grouped to monitor area-specific water quality and other characteristics. Areas with monitoring groups include Technical Area 16 260, Technical Area 21, Technical Area 54, the Chromium Investigation area, Material Disposal Area AB, and Material Disposal Area C.

We use sampling results from some groundwater wells to define the nature and extent of known contaminant plumes. Sampling results are also used to evaluate and model changes in plume location and concentrations over time. This information guides corrective actions where they are needed. We use other wells to monitor for any new contamination. The results help us comply with the requirements of U.S. Department of Energy orders and New Mexico and federal regulations.

Site-wide groundwater monitoring indicates only two notable areas of groundwater contamination at the Laboratory: an RDX (Royal Demolition Explosive; hexahydro-1,3,5-trinitro-1,3,5-triazine) plume beneath Cañon de Valle in the vicinity of Technical Area 16, and a chromium plume beneath Sandia and Mortandad Canyons.

RDX, primarily associated with historical machining of high explosives at Technical Area 16, has infiltrated into groundwater beneath Cañon de Valle. In some areas, RDX concentrations exceed the New Mexico tap water screening level of 9.66 micrograms per liter in perched-intermediate groundwater and the regional aquifer. The RDX plume is completely within the LANL boundary and is approximately three miles from the nearest public water supply wells.

Hexavalent chromium is present in the regional aquifer beneath Sandia and Mortandad Canyons at concentrations above the New Mexico groundwater standard of 50 micrograms per liter. The hexavalent chromium releases occurred from 1956 to 1972. Corrective actions to address the plume are ongoing.

The groundwater protection program also provides monitoring to support current Laboratory operations. This includes monitoring required by authorizations issued by New Mexico Environment Department's Groundwater Quality Bureau, such as groundwater discharge permits and monitoring required to meet facility groundwater monitoring plan requirements under the Laboratory's Hazardous Waste Facility Permit.

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Introduction

Los Alamos National Laboratory (LANL or the Laboratory) routinely monitors the quality of local groundwater. A regional aquifer is present beneath the Laboratory at depths ranging from 600 to 1,200 feet below the ground surface. Our groundwater monitoring and protection efforts focus on the regional aquifer because it not only supplies drinking water but also includes groundwater found within canyon-floor sediments and within rocks and sediments at intermediate depths below the canyon bottoms and above the regional aquifer.

What is an aquifer?

The word aquifer literally means "water bearer" and refers to an underground layer of rock or sediment that contains enough accessible water to be of interest to humans (Buddemeier et al. 2000).

U.S. Department of Energy (DOE) Order 458.1 Chg 4, *Radiation Protection of the Public and the Environment*, requires operators of DOE facilities to ensure that radionuclides from DOE activities do not cause private or public drinking water systems to exceed the drinking water maximum contaminant levels in the *National Primary Drinking Water Regulations*, Title 40 Part 141 of the Code of Federal 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 (Consent Order) addressing legacy waste cleanup. The previous consent order was signed in 2005. The Consent Order continues to require the Laboratory to submit an Interim Facility-Wide Groundwater Monitoring Plan to the New Mexico Environment Department for approval each year. The monitoring locations, frequency of monitoring, and substances to be monitored are updated in the plan each year. The legacy waste cleanup contractor Newport News Nuclear BWXT-Los Alamos, LLC (N3B) is responsible for implementing the groundwater program in accordance with the approved Interim Facility-Wide Groundwater Monitoring Plans (N3B 2019, 2020). Some additional groundwater monitoring activities at the Laboratory are required under LANL's Hazardous Waste Facility Permit and groundwater discharge permits (see Chapter 2).

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 details can be found in reports available at the Laboratory's electronic public reading room, located at http://eprr.lanl.gov, and at the DOE Environmental Management – Los Alamos electronic public reading room, located at https://ext.em-la.doe.gov/EPRR/.

The Laboratory is located in Northern New Mexico on the Pajarito Plateau. The Pajarito Plateau extends from the Sierra de los Valles range of the Jemez Mountains eastward to the Rio Grande. Rocks composed of Bandelier Tuff are the uppermost layer of the plateau (Figure 5-1). The tuff was formed from ash and other volcanic materials that erupted 1.6 to 1.2 million years ago from the volcanic field of the Jemez Mountains (a volcanic field is an area with a geologic history of volcanic activity). The tuff is more than 1,000 feet thick in the western part of the plateau and thins to about 260 feet above the Rio Grande.

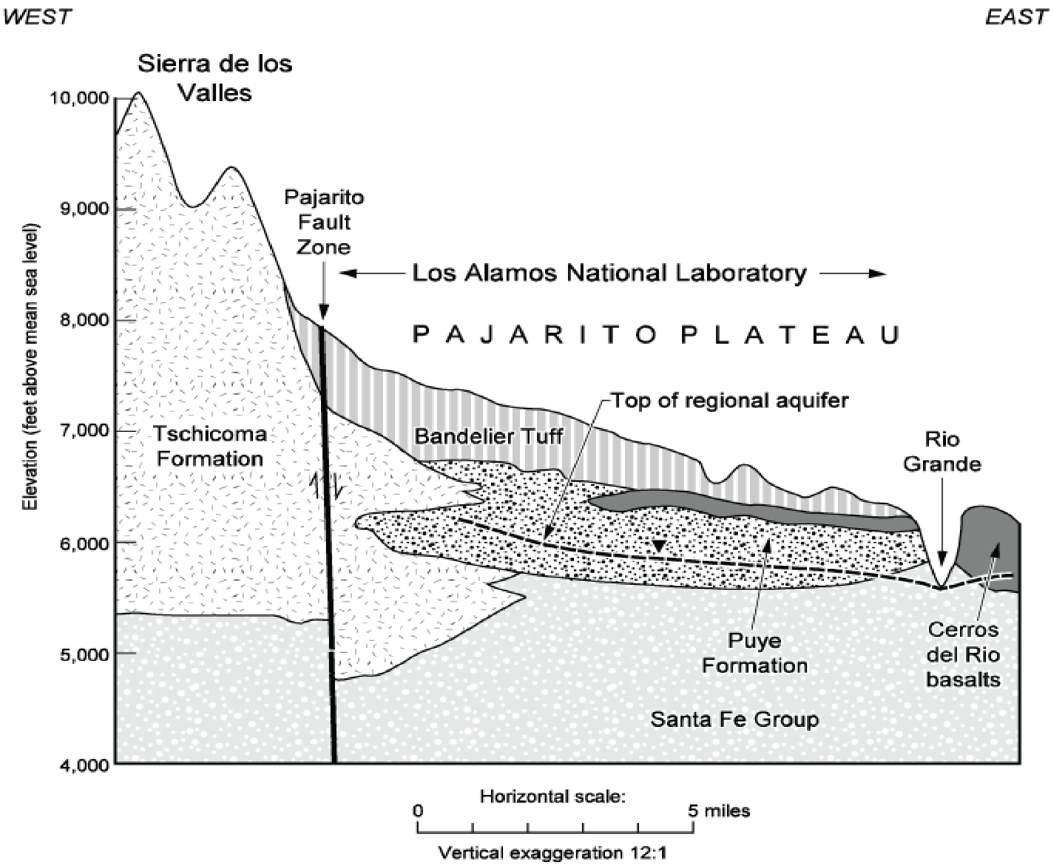


Figure 5-1. Generalized geologic cross-section of the Pajarito Plateau

On the western edge of the Pajarito Plateau, the Bandelier Tuff overlaps the Tschicoma Formation, which consists of older volcanic deposits (Figure 5-1). The Puye Formation, a largely unconsolidated sedimentary deposit, underlies the tuff beneath the central and eastern portion of the plateau. The Puye Formation consists of sand and gravel that washed off the Sierra de los Valles range prior to the eruptions producing the Bandelier Tuff. The Cerros del Rio basalt flows, which originated mostly from a volcanic center east of the Rio Grande, extend into the Puye Formation beneath the Laboratory. These formations all overlie the sediments of the Santa Fe Group, which cross the Rio Grande valley and are more than 3,300 feet thick.

The Laboratory sits atop a thick zone of mainly unsaturated rock and sediments. Groundwater beneath the Pajarito Plateau occurs in three modes (Figure 5-2): (1) perched alluvial groundwater in the bottom of some canyons, (2) small areas of intermediate-depth perched groundwater, and (3) the regional aquifer.

Perched alluvial groundwater is a limited area of saturated rocks and sediments directly below canyon bottoms. Surface water moves through the alluvium (clay, sand, silt, or gravel deposited by running water) until downward flow is disrupted by less-

Hydrogeologic Terms

Saturated rock or sediment is completely wet. **Unsaturated** rock or sediment has air in its pore spaces.

Perched groundwater is a zone of saturation of limited thickness that occurs above the regional aquifer.

Alluvial groundwater is a zone of saturation that exists in sands and gravels in the bottoms of canyons.

permeable layers of rock, resulting in shallow perched bodies of groundwater. Most of the canyons on the Pajarito Plateau have infrequent surface water flow and, therefore, little or no alluvial groundwater. A few canyons have saturated alluvium in their western ends supported by runoff from the Jemez Mountains. In some locations, surface water is supplemented or maintained by discharges from Laboratory outfalls. As alluvial groundwater moves down a canyon, it is used and transpired by plants, or percolates into underlying rock or sediments.

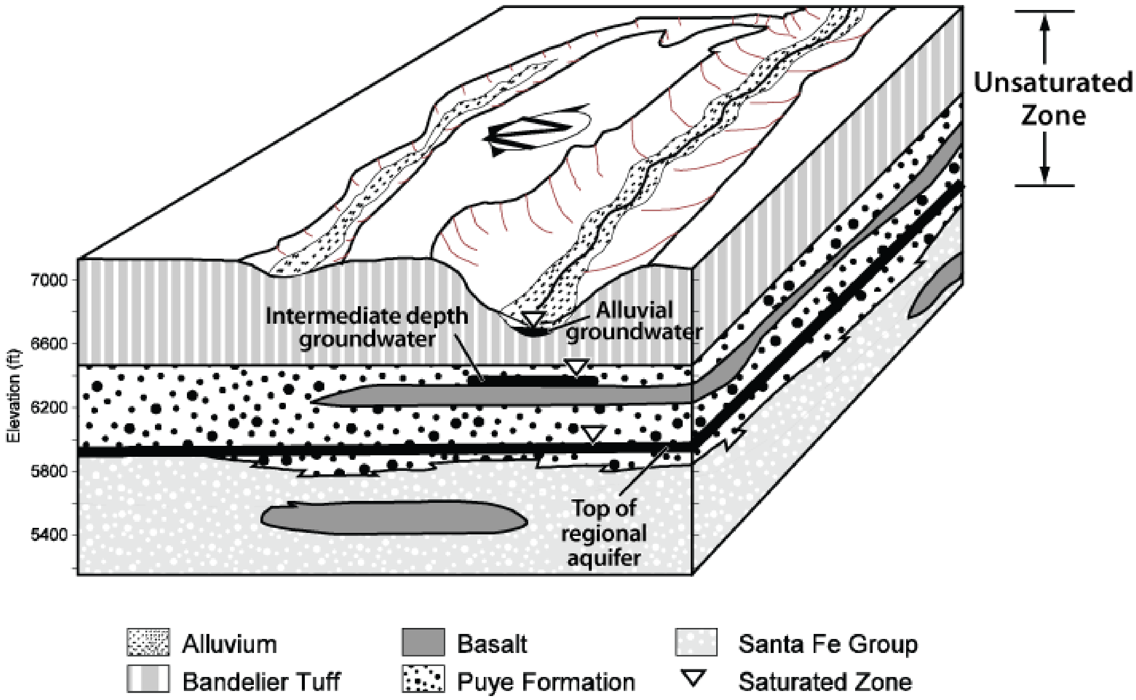


Figure 5-2. Illustration of geologic and hydrologic relationships on the Pajarito Plateau, showing the three modes of groundwater occurrence: perched alluvial groundwater, perched intermediate-depth groundwater, and groundwater within the regional aquifer

Perched-intermediate groundwater occurs within the lower part of the Bandelier Tuff, within the Puye Formation, and within the Cerros del Rio basalt layer beneath some canyons. These intermediate-depth groundwater bodies are formed in part by water moving downward from beneath the canyons until it reaches a layer of rock that allows little or no water to pass through. 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 uppermost level of water in the regional aquifer, known as the water table, occurs at a depth of approximately 1,200 feet below ground surface along the western edge of the plateau and 600 feet below ground surface along the eastern edge (Figure 5-1 and Figure 5-3). Studies indicate that water from the Sierra de los Valles range is the main source of recharge for the regional aquifer (LANL 2005a). Groundwater near the water table generally flows east with local northeast or southeast flows observed. 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 layers of unsaturated tuff, basalt, and sediment. The limited extent of the alluvial and intermediate groundwater bodies, along with unsaturated rock and sediment that underlies them, restricts their contribution to recharging the regional aquifer—although locally they are important parts of the complete hydrologic pathway to the regional aquifer.

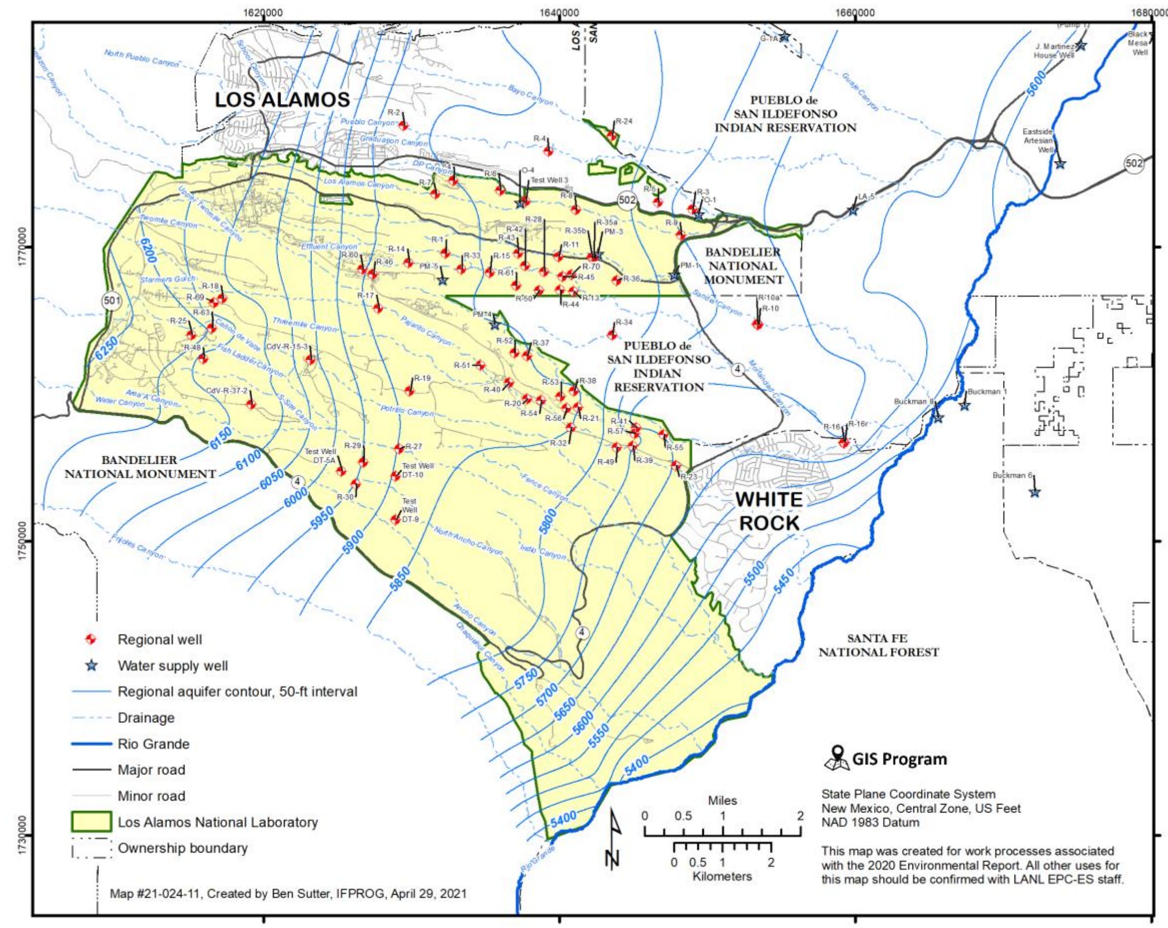


Figure 5-3. Contour map of average water table elevations for the regional aquifer. This map is a generalization of the data.

Regulatory Overview

The screening levels listed in Table 5-1 are used to evaluate results reported in this chapter. In general, standards developed for drinking water systems are frequently used as screening criteria for evaluating groundwater quality. Exceedance of a screening level indicates that further evaluation of risk may be needed.

Groundwater standards and screening levels are set by three regulatory agencies. DOE has authority under the Atomic Energy Act of 1954 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 4, *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 drinking water dose limit.

The U.S. Environmental Protection Agency Safe Drinking Water Act's 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, found in *Ground and Surface Water Protection*, Title 20 Chapter 6 Part 2 of the New Mexico Administrative Code, apply to all groundwater with a total dissolved solids concentration of 10,000 milligrams per liter or less. These standards include numeric criteria for many substances. In addition, the standards contain a separate list of toxic pollutants.

The Consent Order requires screening and reporting of groundwater data, and describes the screening criteria. In general, the screening levels are the lower of either the New Mexico groundwater quality standard or the federal maximum contaminant level. If neither of these exist for a given chemical, the New Mexico Environment Department's tap water screening levels, provided in the Risk Assessment Guidance for Site Investigations and Remediation: Volume I, Soil Screening Guidance for Human Health Risk Assessments (NMED 2019), are applied. These values are available in Table A-1 of that document. If no New Mexico Environment Department tap water screening level has been established for the chemical, then the U.S. Environmental Protection Agency's regional human health medium-specific screening level for tap water, adjusted to a 1×10^{-5} excess risk for carcinogenic contaminants, is used. The U.S. Environmental Protection Agency updates the regional screening levels for tap water periodically; 2018 values were used to prepare this chapter. Updated New Mexico Water Quality Control Commission groundwater standards went into effect in December 2018, with revised standards for some additional constituents becoming effective in July 2020.

The New Mexico Water Quality Control Commission numeric criteria for contaminant concentrations mostly apply to filtered water samples, which represent the concentration of a constituent dissolved in groundwater. However, the standards for mercury, organic compounds, and nonaqueous phase liquids apply to unfiltered samples, which represent both the dissolved concentration of the constituent and the concentration associated with suspended sediments in the groundwater sample. 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, depending on the standard.

For radioactivity in groundwater, we compare sample results with screening levels including the New Mexico Water Quality Control Commission groundwater standards for combined radium-226 and radium-228, DOE's drinking water concentration technical standards (derived from DOE's 4-millirem-per-year dose limit), and the U.S. Environmental Protection Agency maximum contaminant level drinking water standards.

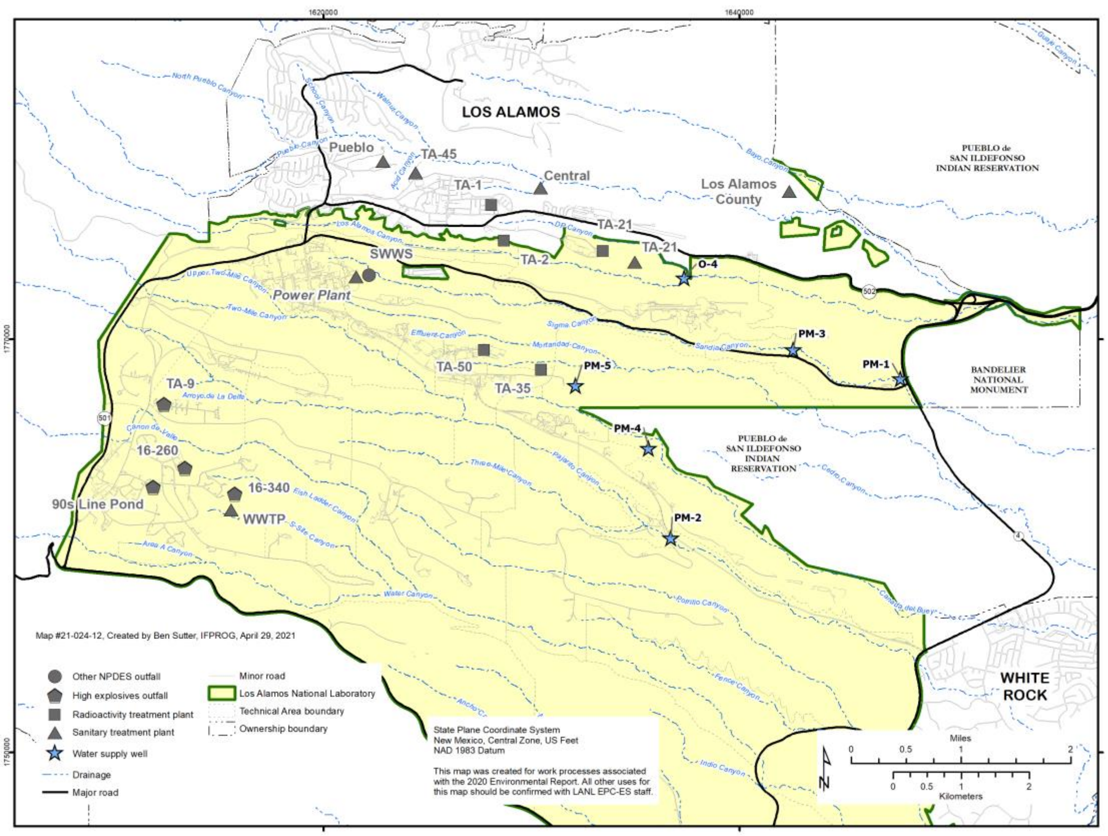
Table 5-1. Application of Screening Levels to LANL Groundwater Monitoring Data

Sample Type	Constituent	Screening Levels	References	Notes
Water supply wells	Radionuclides	• New Mexico groundwater standards • Concentration technical standards derived from DOE's 4-millirem-per-year drinking water dose limit • U.S. Environmental Protection Agency maximum contaminant levels	• 20.6.2 New Mexico Administrative Code • DOE Order 458.1 Chg 4 • Code of Federal Regulations Title 40 Parts 141–143	This sampling is in addition to the regulatory compliance sampling conducted by the water supply system operator (see Water Supply Monitoring section below)
Water supply wells	Nonradionuclides	• New Mexico groundwater standards • U.S. Environmental Protection Agency maximum contaminant levels	• 20.6.2 New Mexico Administrative Code • Code of Federal Regulations Title 40 Parts 141–143	This sampling is in addition to the regulatory compliance sampling conducted by the water supply system operator (see Water Supply Monitoring section below).
Non-water–supply groundwater samples	Radionuclides	• New Mexico groundwater standards • Concentration technical standards derived from DOE's 4-millirem-per-year drinking water dose limit • U.S. Environmental Protection Agency maximum contaminant levels	• 20.6.2 New Mexico Administrative Code • DOE Order 458.1 Chg 4 • Code of Federal Regulations Title 40 Parts 141–143	New Mexico groundwater standards apply to all groundwater. The concentration technical standards (derived from DOE's 4-millirem-per-year drinking water dose limit) 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	• 20.6.2 New Mexico Administrative Code • Code of Federal Regulations Title 40 Parts 141–143 • 2016 Compliance Order on Consent	A hierarchy of levels applies as screening levels for groundwater. See the following section for explanation.

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. Rogers (2001) and Emelity (1996) summarize effluent discharge history at the Laboratory.

Drainages that received some Laboratory effluents in the past include Mortandad Canyon, Pueblo Canyon from its tributary Acid Canyon, and Los Alamos Canyon from its tributary DP Canyon. Water Canyon and its tributary Cañon de Valle received effluents produced by high-explosives processing and experimentation. Sandia Canyon received discharges of power plant cooling water, other cooling tower water, and water from the Laboratory's Sanitary Wastewater Systems Plant. Over the years, Los Alamos County has operated several sanitary wastewater treatment plants in the area, and currently operates one in Pueblo Canyon.



Note: NPDES = National Pollutant Discharge Elimination System; SWWS = sanitary wastewater system; TA = technical area; WWTP = wastewater treatment plant

Figure 5-4. Major liquid release outfalls potentially affecting groundwater; most outfalls shown are currently inactive

Since the early 1990s, the Laboratory has significantly reduced both the number of industrial outfalls and the volume of water discharged. The remaining discharge amounts have been reduced through treatment process upgrades so that they meet applicable standards.

A site-wide sampling program for the emerging contaminants known as per- and polyfluoroalkyl substances (PFAS) took place during 2020. A handful of locations had results above the New Mexico Environment Department tap water screening level of 70 nanograms per liter; none of these locations are in the regional aquifer (which serves as the water supply for the Laboratory and community). Sampling for PFAS may be discontinued after two rounds of sampling unless results exceed 70 nanograms per liter.

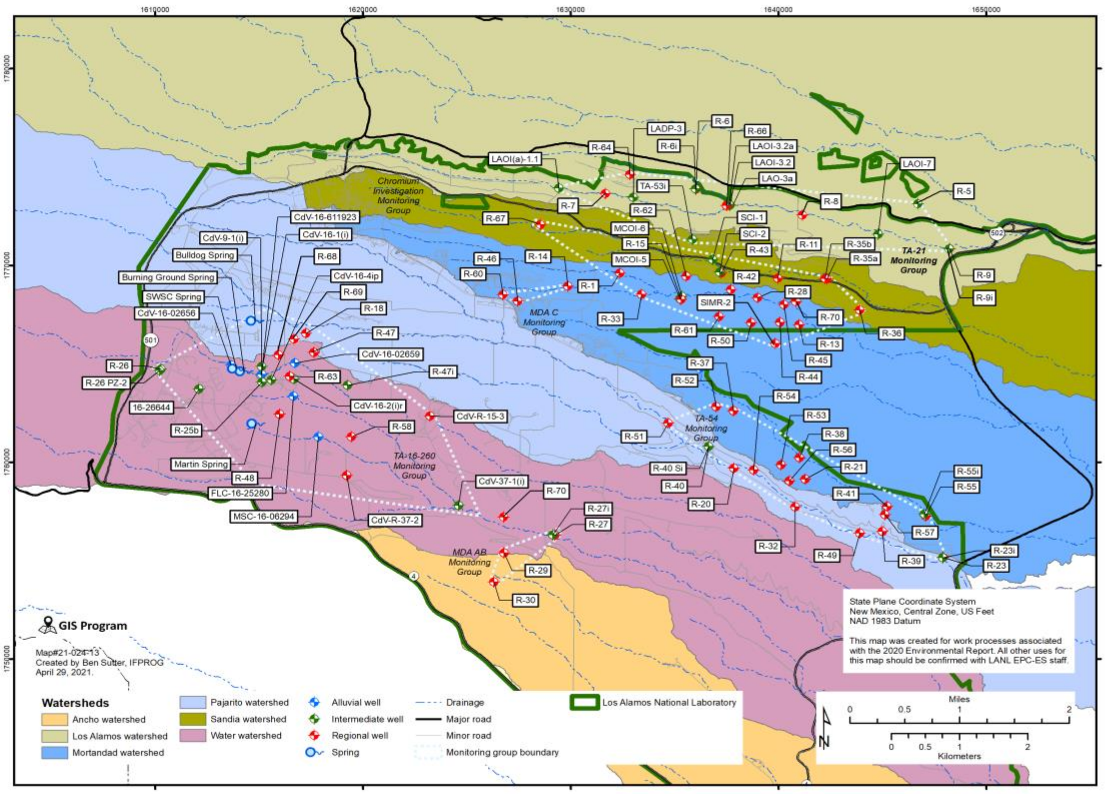
Groundwater Monitoring Network

We monitor water quality and other characteristics by taking samples from wells in alluvial groundwater, perched-intermediate groundwater, and the regional aquifer; springs that discharge perched-intermediate and regional aquifer groundwater; and streams that maintain perennial base flow. Some wells have multiple screens (entry points for water) at different depths.

Some wells and springs are part of six area-specific monitoring groups defined to address monitoring objectives unique to the area. Area-specific monitoring groups include Technical Area 54, Technical Area 21, Material Disposal Area AB, Material Disposal Area C, the Chromium Investigation area, and the Technical Area 16 260 outfall (Figure 5-5). Wells and springs 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 (Figure 5-7; Purtymun et al. 1980).

In addition, we monitor groundwater quality at three alluvial, two intermediate, and four regional aquifer wells for compliance with our groundwater discharge permits (see Chapter 2, New Mexico Water Quality Act: Groundwater Discharge Regulations). Alluvial wells SCA-3, MCA-RLW-1, and MCA-RLW-2 are operated for discharge permit purposes only, and results are summarized in the Groundwater Discharge Permit Monitoring section below. Monitoring required under LANL's Hazardous Waste Facility Permit is included within the Interim Facility-Wide Groundwater Monitoring Plan and results are reported throughout this chapter.

We collected samples from 11 Los Alamos County water supply wells (Figure 5-7). Samples were also collected from wells located on Pueblo de San Ildefonso lands and from the Buckman well field operated by the City of Santa Fe. Groundwater monitoring locations on the Pueblo de San Ildefonso are shown in Figure 5-7; they mostly represent the regional aquifer. However, Vine Tree Spring and Los Alamos Spring discharge from perched-intermediate groundwater, and wells LLAO-1b and LLAO-4 monitor alluvial groundwater.



Note: MDA = Material disposal area

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

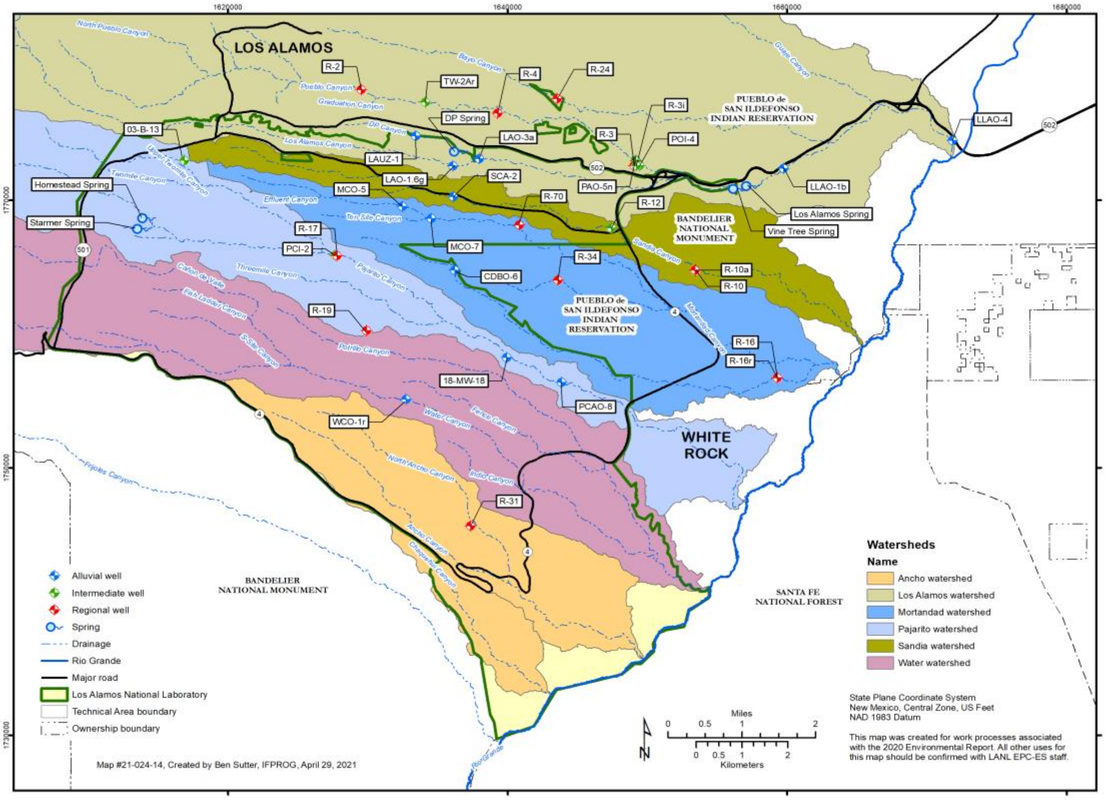


Figure 5-6. Groundwater monitoring wells and springs assigned to watershed-specific portions of the General Surveillance monitoring group.

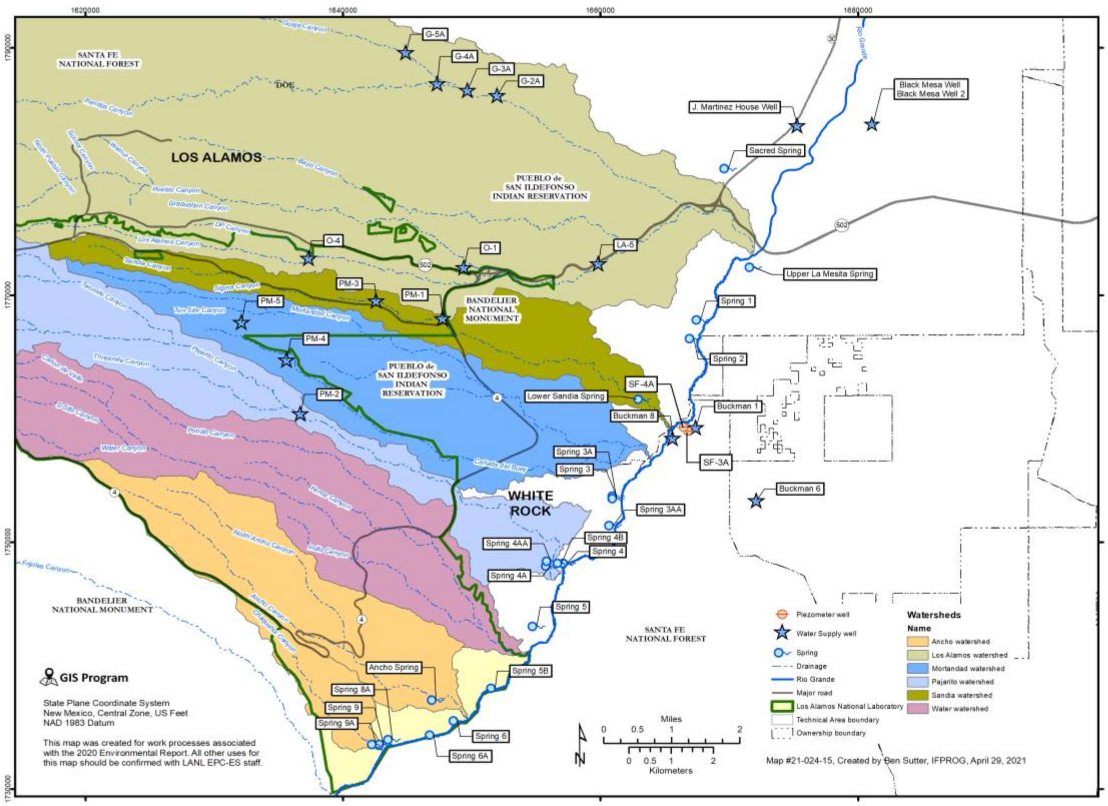


Figure 5-7. Water supply wells and piezometers used for monitoring at Los Alamos County, the city of Santa Fe Buckman well field, and Pueblo de San Ildefonso, and springs used for groundwater monitoring in White Rock Canyon

Groundwater Data Summary and Interpretation

The groundwater monitoring data for 2020 are available from the Intellus New Mexico website at https://www.intellusnm.com.

Analytical laboratory results are reported in relation to several limits. The **method detection limit** is the lowest concentration of a substance that the analytical laboratory can state with 99 percent confidence is greater than zero. It is determined from analysis of a set of standardized samples containing the substance. The **practical quantitation limit** is the lowest concentration of a substance that can be accurately measured. The practical quantitation limit is approximately (but not always) three times the method detection limit. Concentrations between the method detection limit and the practical quantitation limit are identified as estimated concentrations and marked with a “J” qualifier in the analytical report and in the results from the Intellus website.

A **nondetect** result means that the analytical laboratory did not detect the substance in the sample. These results are marked with a “U” qualifier. In the past, the Laboratory sometimes reported nondetect results at the practical quantitation limit value. Therefore, for older results, the detected but estimated results (results between the method detection limit and the practical quantitation limit) may have a lower reported value than nondetect results for the same substance. Recent groundwater sample nondetect results are reported at the method detection limit.

The method detection limit and practical quantitation limit do not apply to radiological measurements. For radiological measurements, the minimum detectable activity is similar to the method detection limit. 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, 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 the groundwater zone, proceeding from deepest (the regional aquifer) to shallowest (the alluvial groundwater). The accompanying tables and text mainly address constituents found at levels above screening levels. Other constituents that are below screening levels, such as tritium, are discussed in a few cases to track trends where potential Laboratory influences are observed. The discussion addresses radionuclides, inorganic compounds, inorganic elements (primarily metals), and organic compounds for each groundwater zone.

Water Supply Well Monitoring

Los Alamos County

We collected samples from 12 Los Alamos County water supply wells that produce water for the community and the Laboratory (Figure 5-7). These samples are in addition to Los Alamos County's regular 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/fa97a051-59cf-4c7e-abb1-90f1cedbc915). No water supply wells showed detections of Laboratory-related constituents above applicable drinking water standards in 2020.

City of Santa Fe

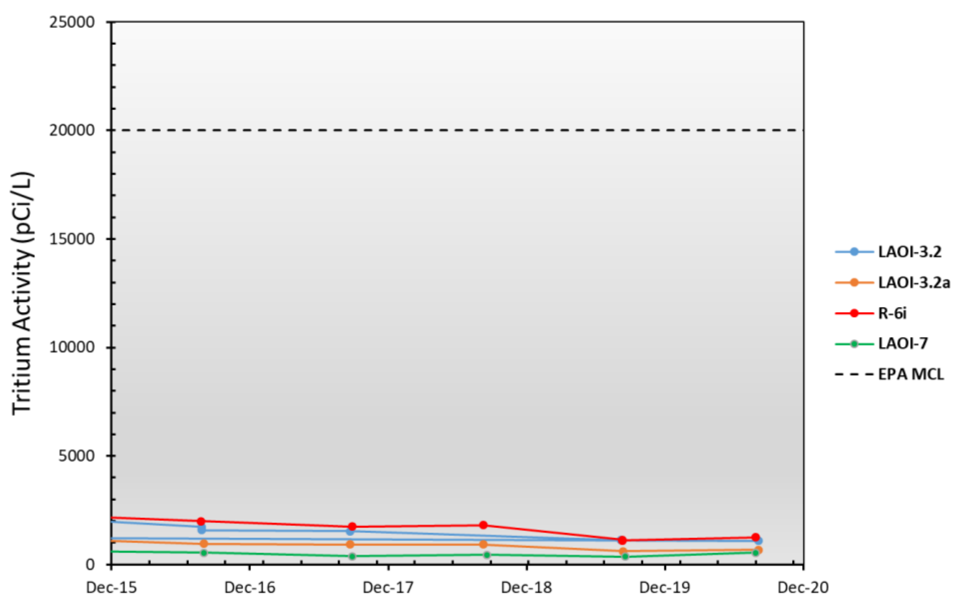
In 2020, we sampled three water supply wells (Buckman-1, Buckman-6, Buckman-8) in the City of Santa Fe's Buckman well field. Samples were also collected from two piezometers (wells typically used to measure water levels; SF-3A, SF-4A) in the well field (LANL 2012a). These samples are in addition to the City of Santa Fe's regular 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 (https://www.santafenm.gov/water_quality).

Technical Area 21 Monitoring Group

Technical Area 21 is located on a mesa bordered by Los Alamos Canyon on the north and DP Canyon on the south. It contains two historical operational areas, DP West and DP East, which produced liquid and solid radioactive wastes. The operations at DP West included plutonium processing, and at DP East included weapons initiators production and tritium research. From 1952 to 1986, a liquid waste treatment plant discharged effluent containing radionuclides from the plutonium-processing facility into DP Canyon (Figure 5-4).

Potential sources of groundwater pollutants in the vicinity of Technical Area 21 include the outfall of the liquid waste treatment plant (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 Technical Area 21 monitoring group includes wells in perched-intermediate groundwater and in the regional aquifer.

Samples from several wells that monitor perched-intermediate groundwater in the Technical Area 21 monitoring group have tritium that likely originated from the former liquid waste treatment plant, the Omega West Reactor, or both. Tritium concentrations in perched-intermediate wells R-6i, LAOI-3.2, LAOI-3.2a, and LAOI-7 in 2020 are generally consistent with concentrations measured in recent years (Figure 5-8; see Figure 5-5 for well locations), and show long-term declines over time. The highest tritium concentration among these wells in 2020 was 1,260 picocuries per liter in R-6i, up from 1,140 picocuries per liter in 2019. For comparison, the U.S. Environmental Protection Agency maximum contaminant level for tritium in drinking water is 20,000 picocuries per liter.



EPA MCL = The U.S. Environmental Protection Agency maximum contaminant level for tritium in drinking water

Figure 5-8. Tritium concentrations in sampled perched-intermediate groundwater from wells in the Technical Area 21 monitoring group in Los Alamos Canyon

Chromium Investigation Monitoring Group

The Chromium Investigation monitoring group is located in Sandia and Mortandad Canyons. Chromium is present in the regional aquifer below these canyons at levels above the New Mexico Environment

Department groundwater standard of 50 micrograms per liter in an area that is estimated to be approximately one mile in length and about a half mile wide (Figure 5-9 and Figure 5-10).

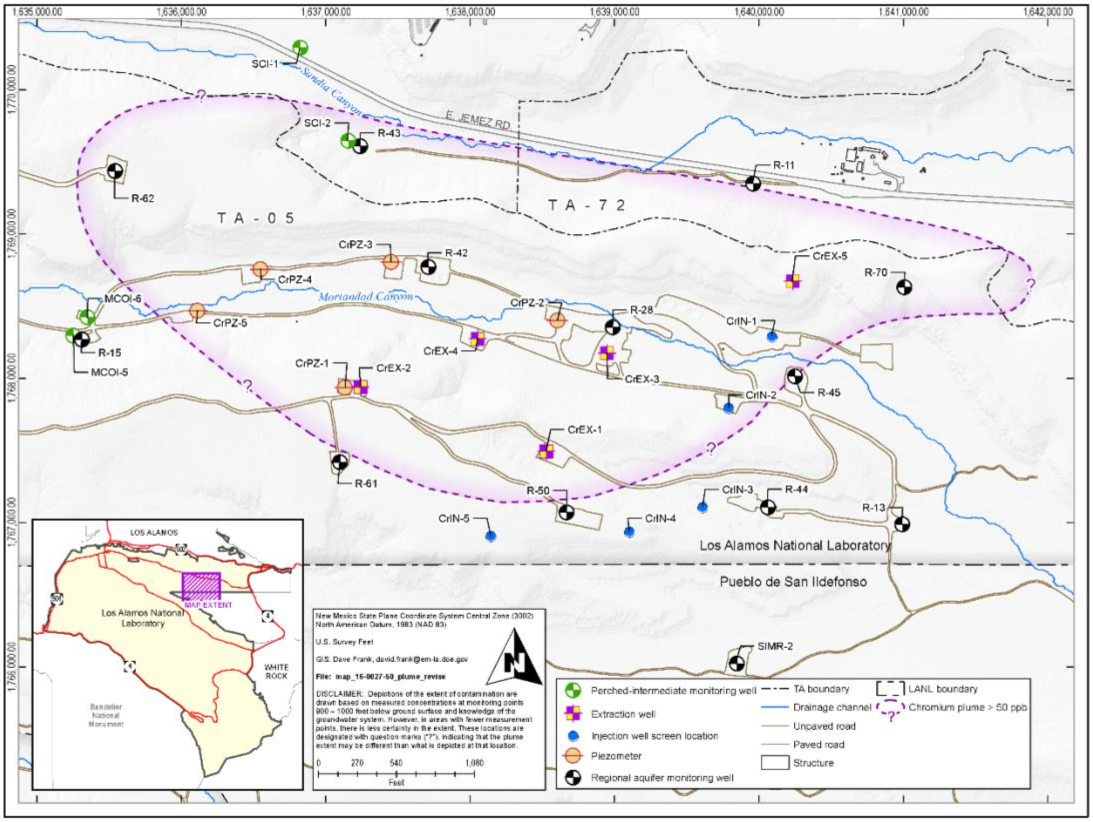


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Figure 5-9. Approximation of the chromium plume footprint in the regional aquifer, as defined by the 50 microgram per liter New Mexico Environment Department groundwater standard

From 1956 to 1972, potassium dichromate was used as a corrosion inhibitor in the cooling system at the Laboratory's power plant (LANL 1973) and was present in the effluent discharged through an outfall to Sandia Canyon. These past discharges of potassium dichromate are the source of the hexavalent chromium observed in groundwater beneath Sandia and Mortandad Canyons. A conceptual model for the sources and spatial distribution of chemicals and radionuclides in groundwater in this area is presented in the Investigation Report for Sandia Canyon (LANL 2009a), the Phase II Investigation Report for Sandia Canyon (LANL 2012b), and the Compendium of Technical Reports Conducted Under the Work Plan for Chromium Plume Center Characterization (LANL 2018a). The conceptual model indicates that chromium originated from releases into Sandia Canyon and then migrated below ground along geologic perching horizons to locations in the regional aquifer beneath Sandia and Mortandad Canyons.

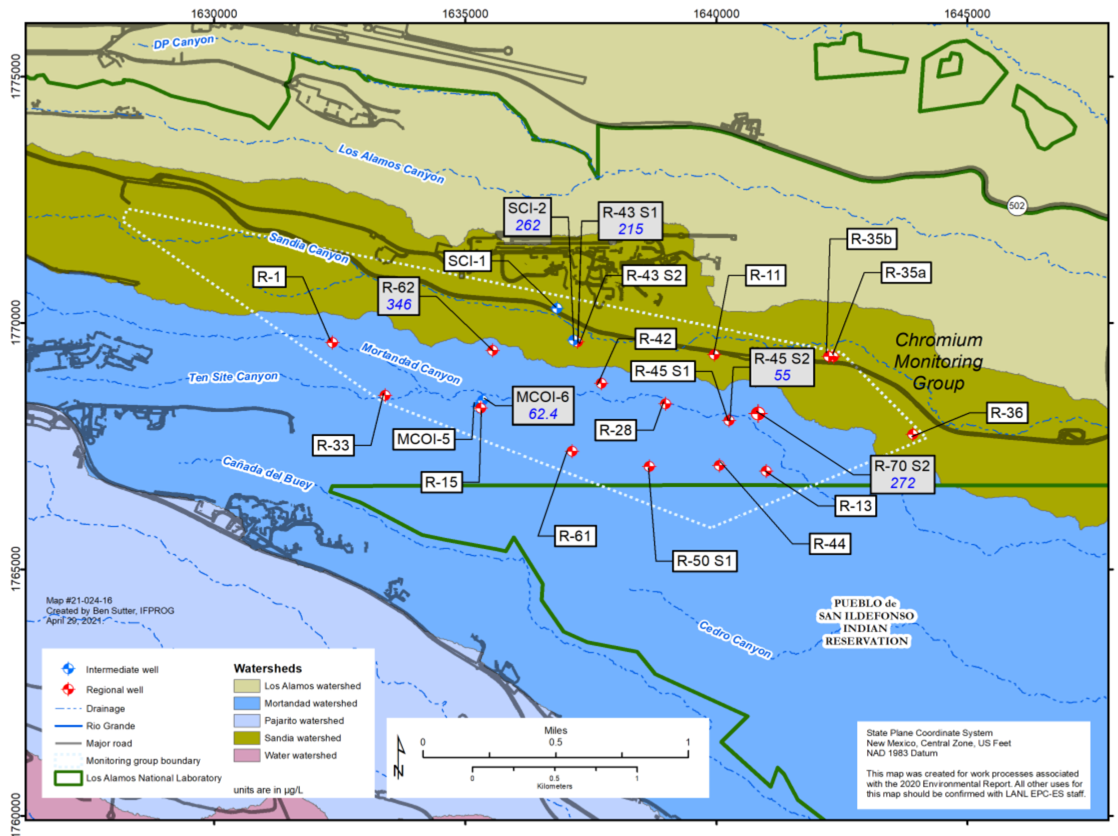


Figure 5-10. The Chromium Investigation monitoring group perched-intermediate and regional aquifer monitoring wells. The white dashed outline encompasses the wells included in the monitoring group. Labels for the wells include maximum chromium concentrations in 2020 at wells with recorded concentrations greater than the New Mexico groundwater standard of 50 micrograms per liter (µg/L).

Chromium is found within approximately the upper 100 feet of the water table of the regional aquifer (LANL 2009a, 2012b, 2017, 2018b). The 2020 chromium concentrations exceeded the New Mexico groundwater standard of 50 micrograms per liter in four regional aquifer wells within the monitoring group: R-43 screen 1, R-45 screen 2, R-62, and R-70 screen 2 (Figures 5-10 and 5-11). Monitoring in 2020 primarily focused on continuing to characterize and understand the fate and transport of chromium and related contaminants in perched-intermediate groundwater and within the regional aquifer. We also evaluated the performance of the interim measures being conducted to mitigate the chromium plume migration while alternatives for a final remedy for the plume are evaluated.

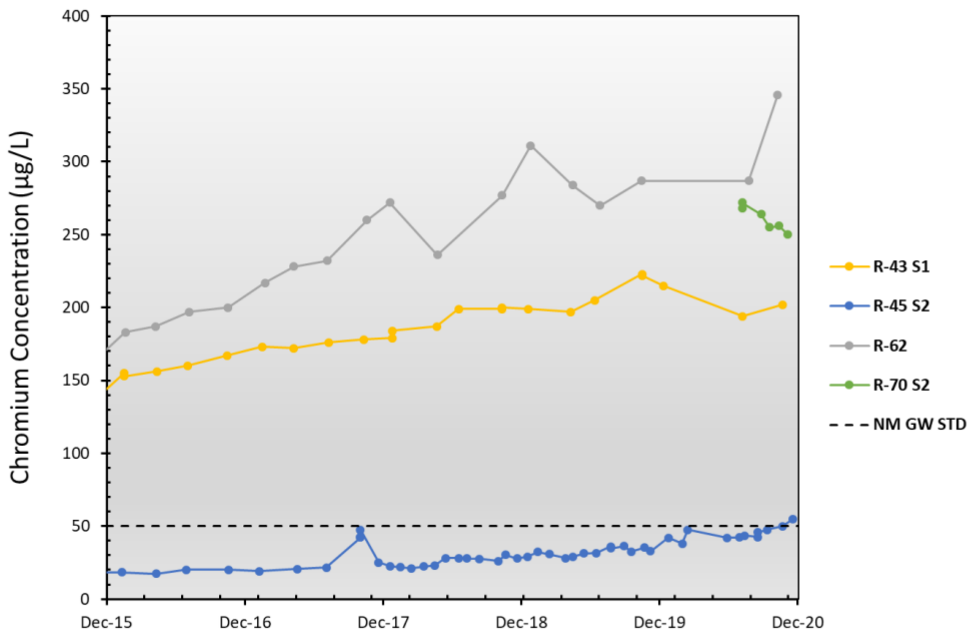


Figure 5-11. Trends in chromium concentrations for four regional aquifer wells that exceeded the New Mexico Groundwater Standard (NM GW STD) for chromium of 50 micrograms per liter (µg/L)

The Laboratory's Interim Measures Work Plan for Chromium Plume Control (LANL 2015) presented an approach to use extraction wells and injection wells to control plume migration. The Laboratory's objective for the interim measures operations is to establish and maintain the portion of the plume containing 50 micrograms per liter or more of chromium completely within the Laboratory boundary. To accomplish this, we are extracting contaminated groundwater from five extraction wells, piping the extracted water to an above-ground ion exchange treatment system, and, following treatment, injecting the treated water back into the regional aquifer through five injection wells located in the downgradient portion of the plume.

To date, the interim measures operations have focused along the boundary between the Laboratory and the Pueblo de San Ildefonso (Figure 5-9). Two regional aquifer wells, R-50 and R-44, monitor the effectiveness of the interim measure at the downgradient plume edge along that boundary. Wells R-44 and R-50 each have two screens; R-44 screen 2 is near the water table, measuring 985.3 to 995.2 feet below the ground surface, and R-50 screen 2 is approximately 100 feet below the water table at 1185.0 to 1205.6 feet below the ground surface. The deeper of the two screens has shown consistent chromium concentrations within naturally occurring (background) levels, indicating that the chromium contamination at that location is less than the depth of that screen (Figure 5-12). The levels of chromium in R-50 screen 1 continue to steadily decrease over time in response to the interim measures, but showed a slight increase during the several months when the system was shut down because of the COVID-19 pandemic (Figure 5-12). Chromium concentrations in R-44 screen 1 and screen 2 have historically been below the New Mexico groundwater standard for chromium, and are dropping further in response to the interim measures (Figure 5-12).

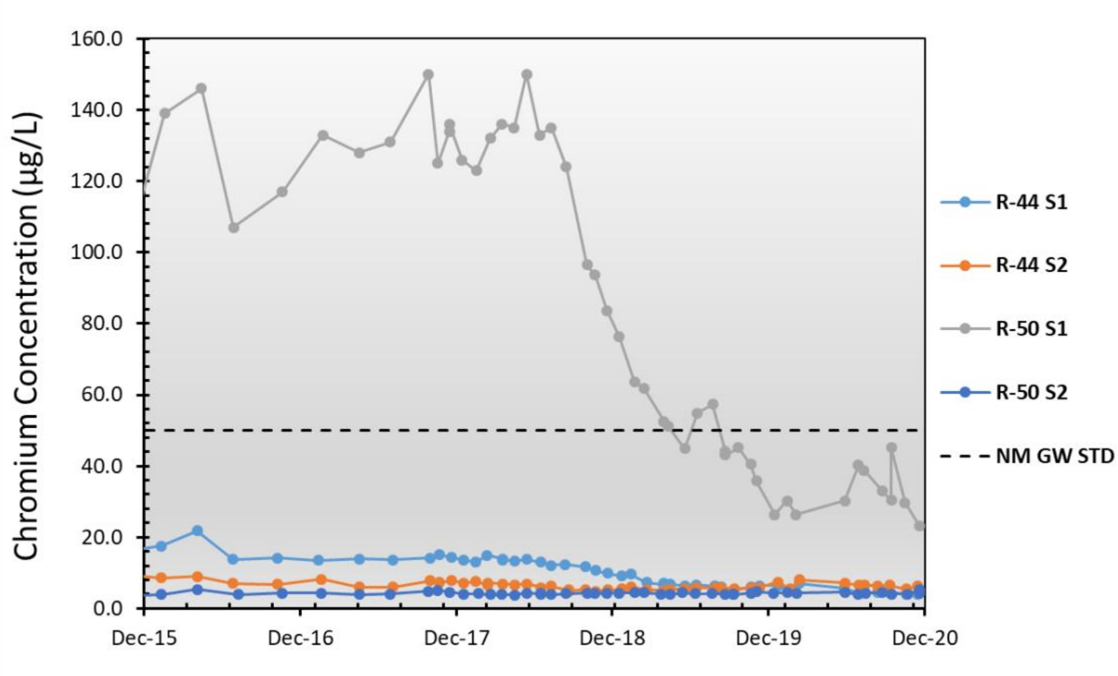


Figure 5-12. Trends in the chromium concentrations for the regional aquifer wells that monitor the effectiveness of the interim measure at the downgradient plume edge. The New Mexico Groundwater Standard (NM GW STD) for chromium is 50 micrograms per liter (µg/L).

Interim measure operations along the northeastern portion of the plume began in late 2019. Therefore, chromium concentration data from monitoring wells in that portion of the plume, specifically R-11 and R-45 (two screens), do not yet reflect the effects of the operations. Instead, results from those wells represent other factors that may affect trends in chromium concentrations such as changes in chromium levels in water recharging the regional aquifer. Both R-11 and R-45 screen 1 showed decreasing concentrations in chromium apparently independent of the interim measures (Figure 5-13).

Two wells located along the northwestern upgradient portion of the chromium plume, R-62 and R-43 (two screens) continued to show increases in chromium concentrations in 2020 (Figure 5-14). A new monitoring well is scheduled for installation in this area to further characterize the extent of chromium contamination. Data from these wells will be used to evaluate whether mitigation actions are necessary in this area.

Two perched-intermediate wells had chromium concentrations above the standard: SCI-2 and MCOI-6. Chromium concentrations continue to decline in SCI-2 and remain steady in MCOI-6 (Figure 5-15).

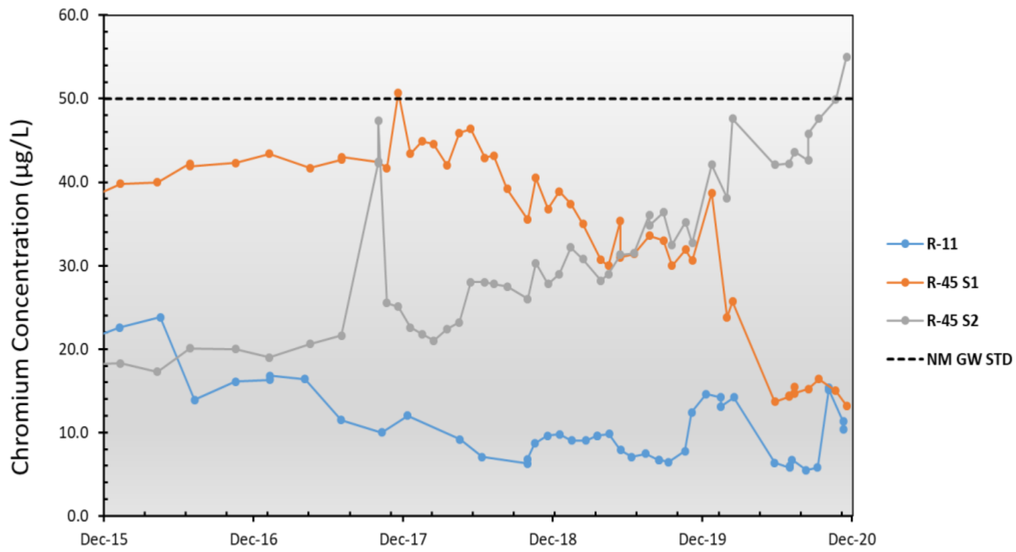


Figure 5-13. Trends in chromium concentrations of two regional wells (R-11 and the two screens of R-45) in the Chromium Investigation monitoring group located along the northeast edge of the plume; these trends are not a reflection of the interim measures, rather a trend in chromium concentrations in water recharging the regional aquifer. The New Mexico Groundwater Standard (NM GW STD) for chromium is 50 micrograms per liter (µg/L).

A small area with perchlorate contamination is also present in groundwater beneath Mortandad Canyon. The primary source of perchlorate is effluent discharges from the Radioactive Liquid Waste Treatment Facility from 1963 until March 2002. Perchlorate is present above the New Mexico Environment Department tap water screening level of 13.8 parts per billion in two perched-intermediate wells, MCOI-5 and MCOI-6 (Figure 5-16). In perched-intermediate well MCOI-6, the perchlorate concentration trends are relatively stable. Perchlorate concentrations at MCOI-5 have been decreasing, although the well has not been sampled since 2019 due to insufficient water. Perchlorate is also present in the regional aquifer, specifically at wells R-61 and R-15. Although R-15 perchlorate levels are below 13.8 parts per billion, the R-61 screen 1 has historically shown concentrations near or slightly above 13.8 parts per billion. We continue to monitor perchlorate and will incorporate remedial actions for perchlorate as part of the chromium project.

Other constituents detected in the Chromium Investigation monitoring group include 1,4-dioxane and tritium in perched-intermediate wells MCOI-5 and MCOI-6 (Figure 5-17 and Figure 5-18). The trend for 1,4-dioxane has been primarily flat at MCOI-6, but has recently shown an upward trend. Well MCOI-5 has had a continued increasing trend in 1,4-dioxane over the past few years, although between 2018 and 2019, we saw a decrease in concentration from 27.9 micrograms per liter to 22.9 micrograms per liter. However, as noted above, additional sampling of MCOI-5 has not been completed since 2019 due to insufficient water. Concentrations of 1,4-dioxane are not present above the screening level of 4.59 micrograms per liter in the regional aquifer. 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 picocuries per liter.

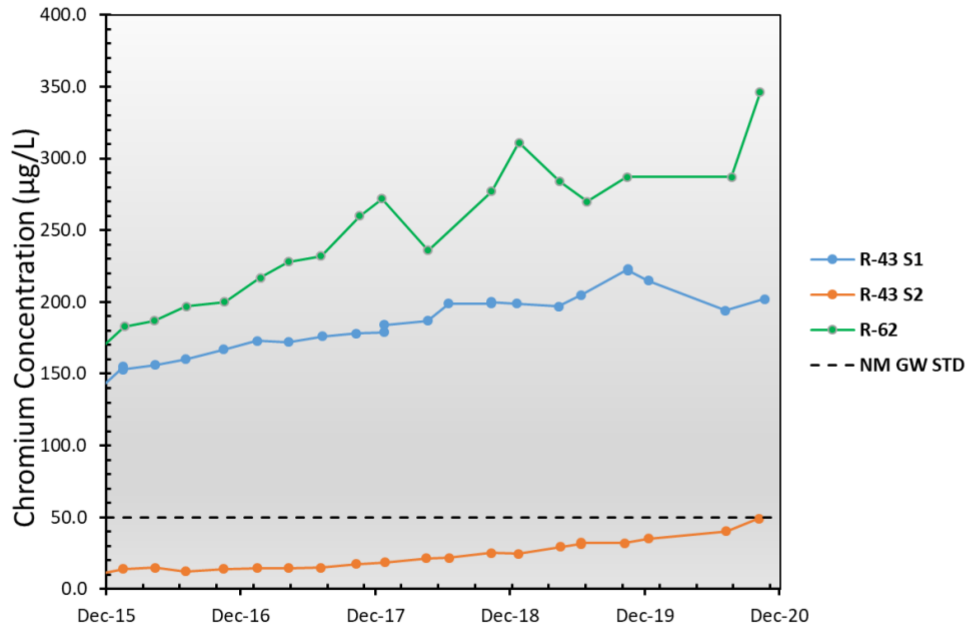


Figure 5-14. Regional monitoring wells R-43 (two screens) and R-62 are located on the northwestern portion of the chromium plume. These two wells show a continued increase in chromium concentrations in 2020.

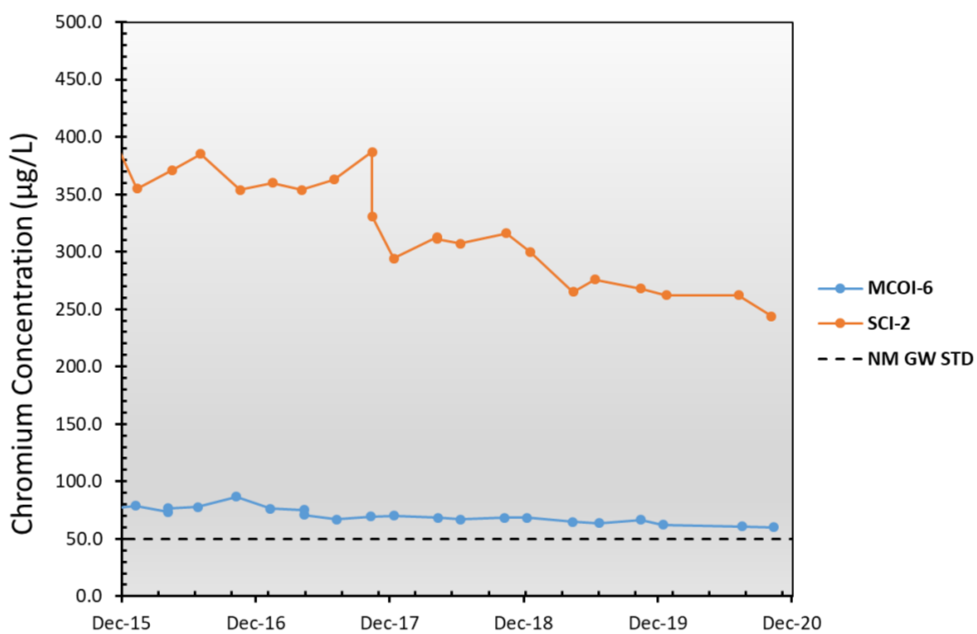
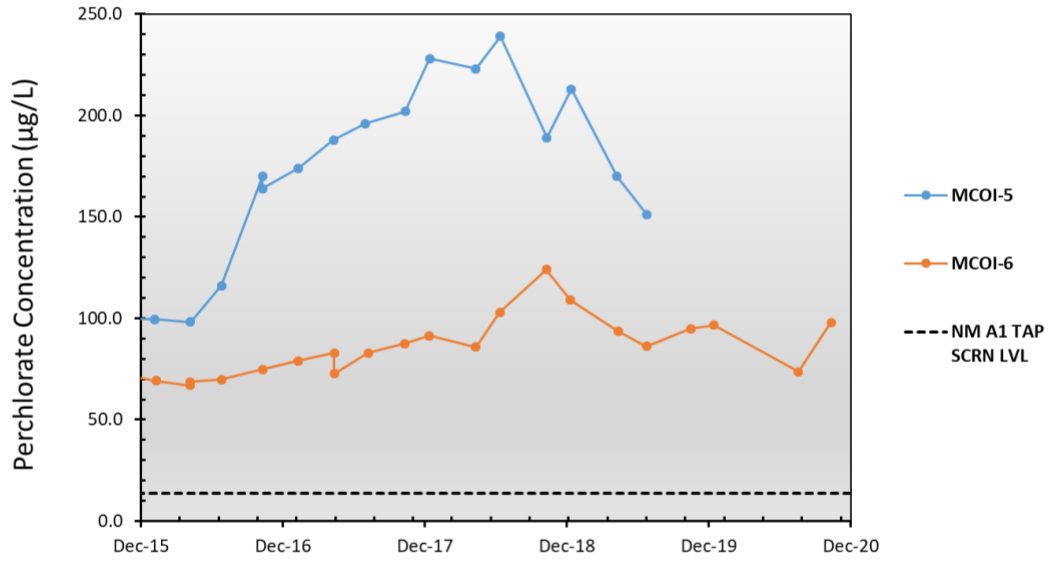


Figure 5-15. Trends in chromium concentrations for perched-intermediate groundwater monitoring wells in the Chromium Investigation monitoring group with chromium concentrations that exceeded the New Mexico Groundwater Standard (NM GW STD) of 50 micrograms per liter (µg/L)



NMED A1 TAP SCRN LVL = New Mexico Environment Department tap water screening level

Figure 5-16. Trends in perchlorate concentrations for perched-intermediate groundwater monitoring wells in the Chromium Investigation monitoring group with perchlorate detections above the New Mexico tap water screening level of 13.8 micrograms per liter (µg/L)

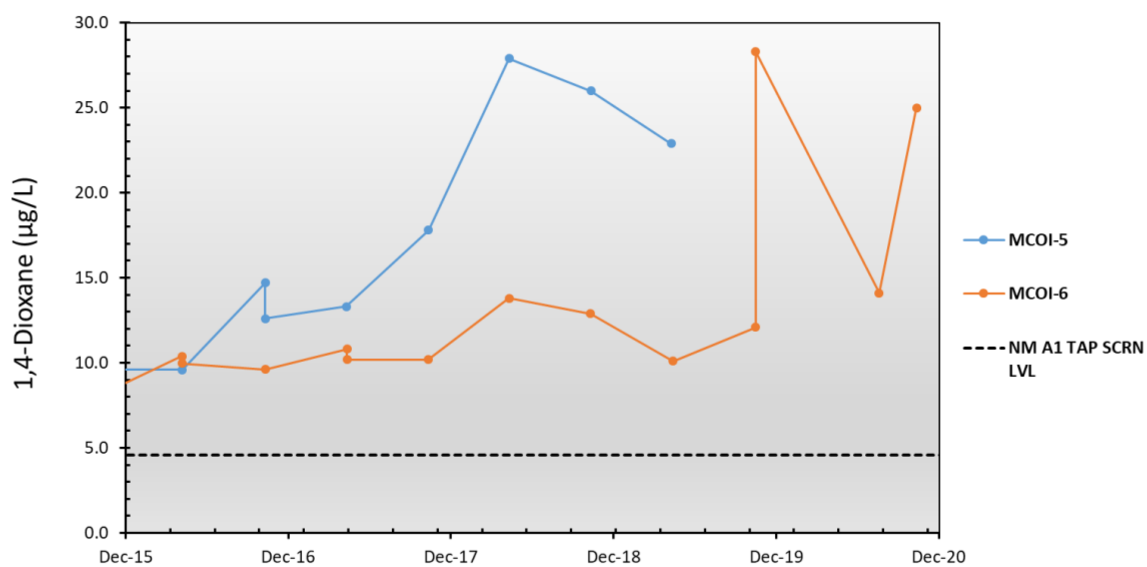


Figure 5-17. Concentrations of 1,4-dioxane in perched-intermediate groundwater monitoring wells with detections of 1,4-dioxane in the Chromium Investigation monitoring group. The New Mexico groundwater standard for 1,4-dioxane is 4.59 micrograms per liter (µg/L). (NMED A1 TAP SCRN LVL = New Mexico Environment Department tap water screening level). Note: samples were analyzed by two methods for samples collected in August and November. Additional samples will be collected to verify the trends.

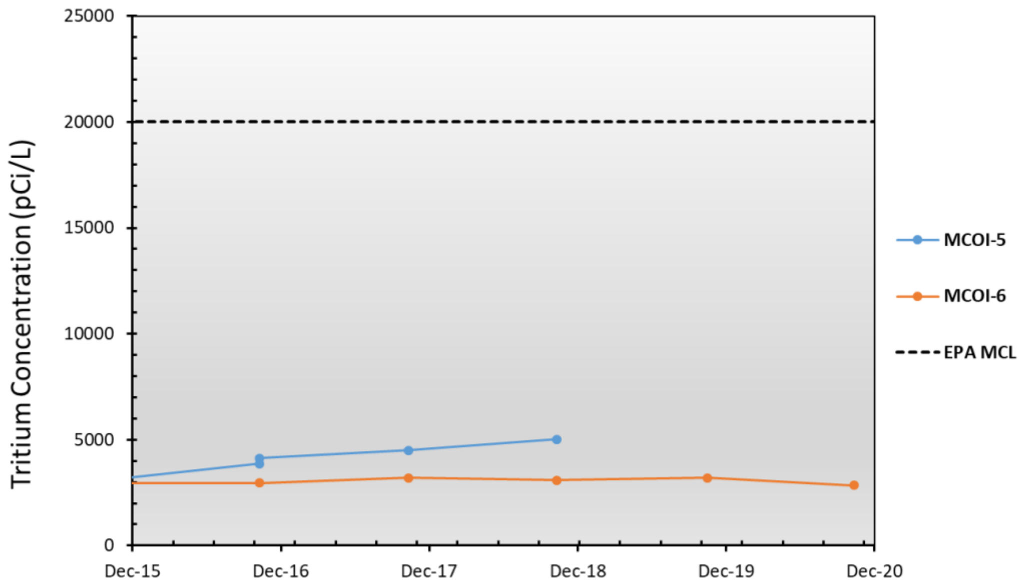


Figure 5-18. Tritium concentrations in perched-intermediate groundwater monitoring wells in the Chromium Investigation monitoring group. The U.S. Environmental Protection Agency maximum contaminant level for tritium in drinking water is 20,000 picocuries per liter (pCi/L).

Material Disposal Area C Monitoring Group

Material Disposal Area C is located in Technical Area 50, at the head of Ten Site Canyon. It 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 soil and rock beneath Material Disposal Area C (LANL 2011a). The primary volatile organic compound is trichloroethene. The Material Disposal Area C monitoring group includes nearby regional aquifer monitoring wells (Figure 5-5). Monitoring data indicate no contamination is present in the groundwater in the regional aquifer immediately downgradient of Material Disposal Area C. No perched-intermediate groundwater is present beneath Material Disposal Area C.

Technical Area 54 Monitoring Group

Technical Area 54 is located in the east-central portion of the Laboratory on Mesita del Buey. The technical area 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 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 Hazardous Waste Facility Permit. The Technical Area 54 monitoring group includes perched-intermediate and regional wells (Figure 5-5).

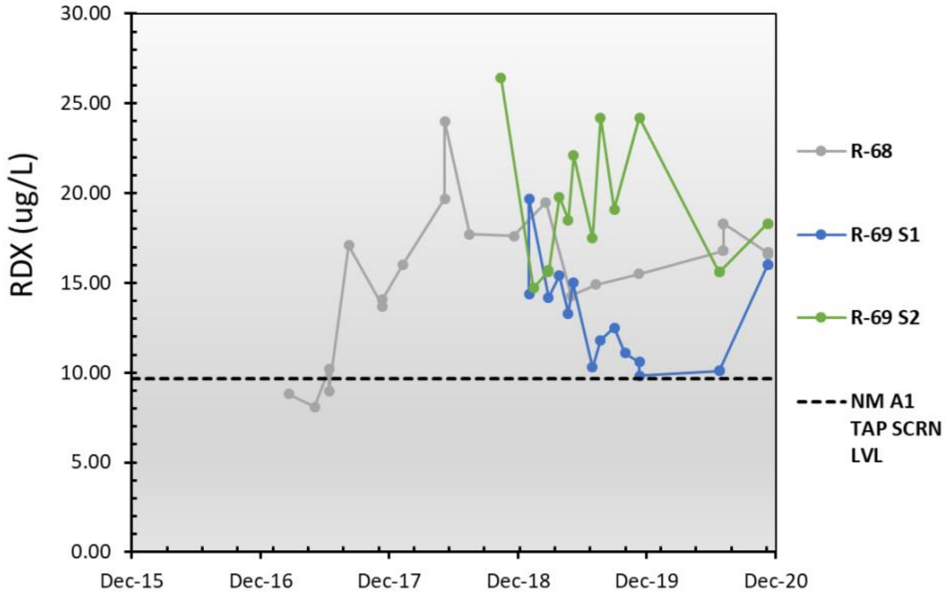
Monitoring data show vapor-phase volatile organic compounds are present in the upper portion of the unsaturated zone beneath Areas G and L. The primary vapor-phase volatile organic compounds at Technical Area 54 are 1,1,1-trichloroethane; trichloroethene; and Freon-113. Tritium is also present (LANL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

There have been periodic detections of a variety of substances, including several volatile organic compounds from the groundwater monitoring network around Technical Area 54. In 2020, tritium was detected in the regional aquifer groundwater monitoring wells R-20 screen 1, R-49 screen 1, R-51 screen 2, and R-57 screen 1. All detections of tritium at these locations were well below the 20,000 picocuries per liter U.S. Environmental Protection Agency maximum contaminant level. The chemical 1,4-dioxane was detected above the U.S. Environmental Protection Agency maximum contaminant level of 4.59 micrograms per liter at well R-37 screen 1, with a concentration of 5.41 microgram per liter. This is the second detection of 1,4-dioxane above the screening level at this well. We will continue to monitor the trend here. The sporadic and limited spatial nature of the volatile organic compound detections and the minimal amount of tritium data suggest that Technical Area 54 may not be the source of the detected compounds (LANL 2009b).

Technical Area 16 260 Monitoring Group

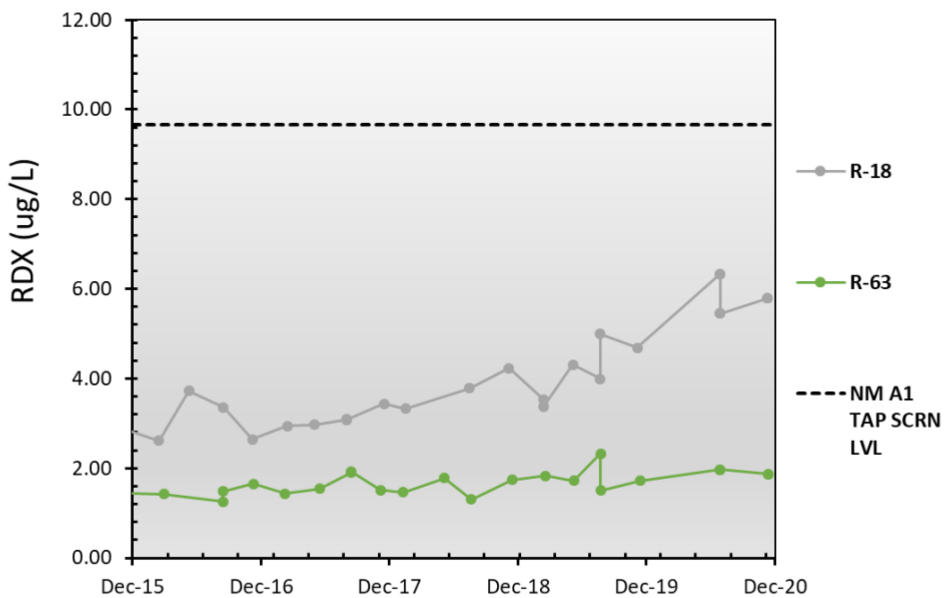
Water Canyon and Cañon de Valle (a tributary of Water Canyon) cross the southwest portion of LANL where the Laboratory develops and tests explosives. In the past, the Laboratory released wastewater into both canyons from several high-explosives-processing facilities in Technical Areas 16 and 09 (Figure 5-4). 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, 2011b). Current evidence indicates that over time the effluent from the Technical Area 16 260 outfall, sometimes mixed with naturally occurring surface water and alluvial groundwater in Cañon de Valle, infiltrated from Cañon de Valle, and percolated through unsaturated rock layers to perched-intermediate groundwater zones and ultimately into the regional aquifer.

Springs, surface water, alluvial groundwater, and perched-intermediate groundwater in the area 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, R-63, R-68, and R-69 screens 1 and 2 (Figure 5-19 and Figure 5-20). In addition, barium, bis(2-ethylhexyl)phthalate, iron, manganese, nitrosodiethylamine[N-], nitrosodimethylamine[N-], RDX, and boron have been detected above their respective screening levels in springs, alluvial groundwater, and perched-intermediate groundwater. In 2020, low concentrations of tetrachloroethene were detected in the regional aquifer in well R-69 screens 1 and 2.



NMED A1 TAP SCRN LVL = New Mexico Environment Department tap water screening level

Figure 5-19. RDX concentrations in regional aquifer well R-68 and R-69 screens 1 and 2. The New Mexico groundwater standard for RDX is 9.66 micrograms per liter (µg/L).



NMED A1 TAP SCRN LVL = New Mexico Environment Department tap water screening level.

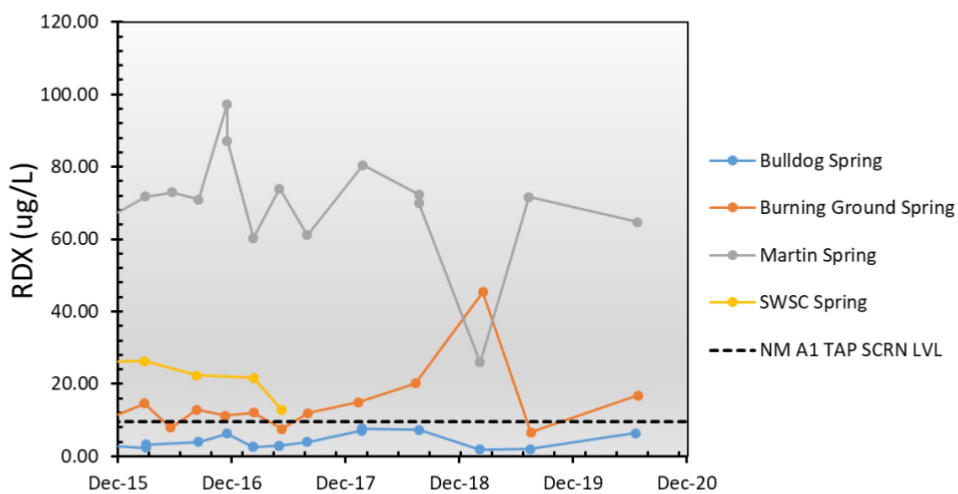
Figure 5-20. RDX concentrations in regional aquifer wells R-18 and R-63. The New Mexico groundwater standard for RDX is 9.66 micrograms per liter (µg/L).

RDX is the primary groundwater contaminant in this area and the only contaminant that exceeds its groundwater standard in the regional aquifer. Two regional aquifer wells, R-68 and R-69 screens 1 and 2, have had RDX concentrations above the tap water screening level of 9.66 micrograms per liter. RDX concentrations in regional monitoring wells R-63 and R-18 were below the groundwater standard, but are exhibiting stable to increasing trends (Figure 5-20).

Figure 5-21, Figure 5-22, and Figure 5-23 show RDX concentrations in springs, alluvial wells, and perched-intermediate wells in the Technical Area 16 260 Monitoring Group. The springs discharge from perched-intermediate groundwater zones.

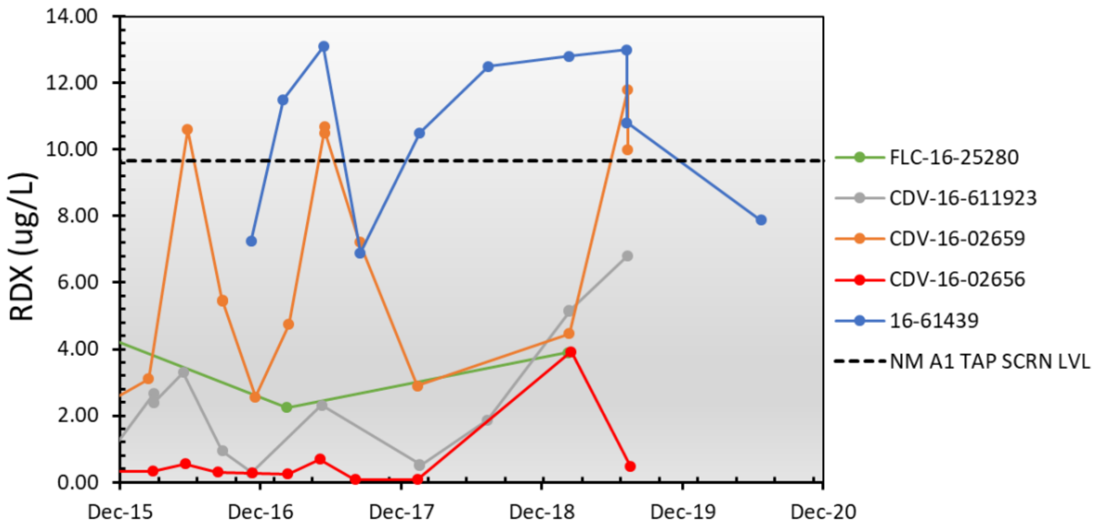
Of the springs sampled, the concentrations of RDX are highest in Martin Spring (Figure 5-21). RDX concentrations at Burning Ground Spring have been relatively steady over the past five years (Figure 5-21), with the exception of samples collected in July 2015 and March of 2019. SWSC Spring, near the former location of the Technical Area 16 260 outfall, does not have consistent flow; it was not sampled in 2020.

RDX concentrations in alluvial monitoring wells show significant variability because of seasonal influences, but remain relatively low (Figure 5-22). RDX concentrations in each of the perched-intermediate wells show some variability (Figure 5-23). Long-term monitoring of some of these springs and alluvial wells is now included in the annual Interim Facility-Wide Groundwater Monitoring Plan (N3B 2020).



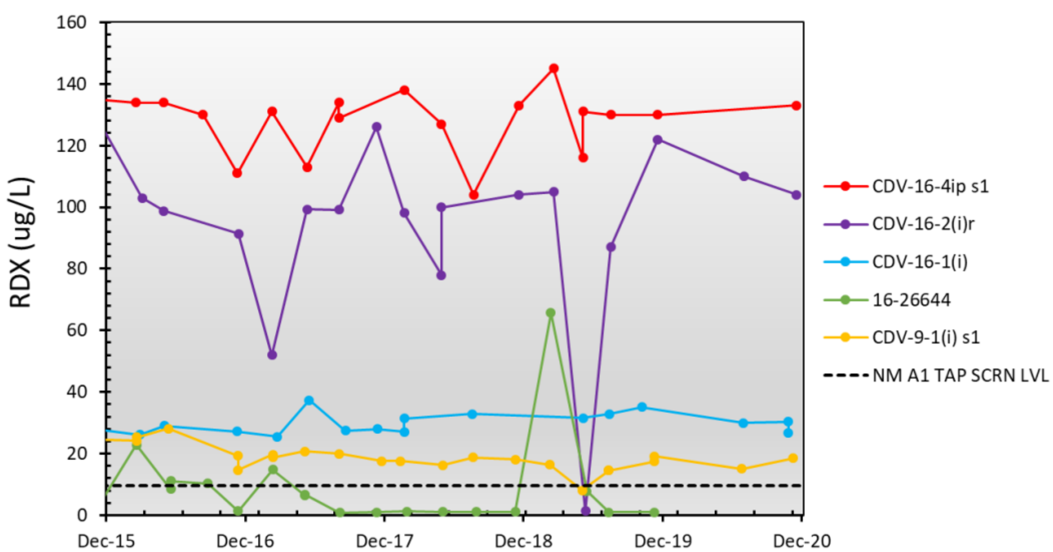
NMED A1 TAP SCRN LVL = New Mexico Environment Department tap water screening level

Figure 5-21. RDX concentrations in two springs in Cañon de Valle, one spring in Martin Spring Canyon, and one spring in Bulldog Gulch, in Technical Area 16 (see locations in Figure 5-5). The New Mexico groundwater standard for RDX is 9.66 micrograms per liter (µg/L).



NMED A1 TAP SCRN LVL = New Mexico Environment Department tap water screening level

Figure 5-22. RDX concentrations in alluvial groundwater wells in Cañon de Valle and Fishladder Canyon. The New Mexico groundwater standard for RDX is 9.66 micrograms per liter (µg/L).



NMED A1 TAP SCRN LVL = New Mexico Environment Department tap water screening level

Figure 5-23. RDX concentrations in perched-intermediate groundwater wells. The New Mexico groundwater standard for RDX is 9.66 micrograms per liter (µg/L).

Other substances, including tetrachloroethene, trichloroethene, boron, and barium, are present in all groundwater zones but are well below applicable standards in the regional aquifer. An investigation report on the extent and implications of RDX contamination in perched-intermediate and regional groundwater was submitted to the New Mexico Environment Department in August 2019. We submitted a report on the fate, transport modeling, and risk assessment for RDX in groundwater to the

New Mexico Environment Department in May 2020. The report concluded that there is no current risk to human health. Risks to human health in the future will be evaluated in a revision of this report.

Material Disposal Area AB Monitoring Group

The Material Disposal Area AB monitoring group is located in Technical Area 49. Also known as the Frijoles Mesa Site, Technical Area 49 is located on a mesa near the western end of Ancho Canyon. Part of the area drains into Water Canyon. The canyons in the Ancho Canyon watershed are mainly dry with no known persistent alluvial groundwater zones and no known perched-intermediate groundwater.

The site of Material Disposal Area AB was used to test nuclear weapons components 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 in the mesa top. Further information about activities, solid waste management units, and areas of concern at Technical Area 49 can be found in earlier Laboratory reports (LANL 2010a, 2010b).

In 2020, no constituents were found in Material Disposal Area AB monitoring group wells at concentrations above standards or screening levels.

White Rock Canyon Monitoring Group

The springs that flow 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. Some other springs may discharge 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 important monitoring points for evaluating the Laboratory's potential to impact the Rio Grande (Figure 5-7). The Fall 2020 sampling campaign was abbreviated due to the COVID-19 pandemic. Instead of accessing the 26 locations using river rafts, nine locations were accessed either by short hikes or by vehicle.

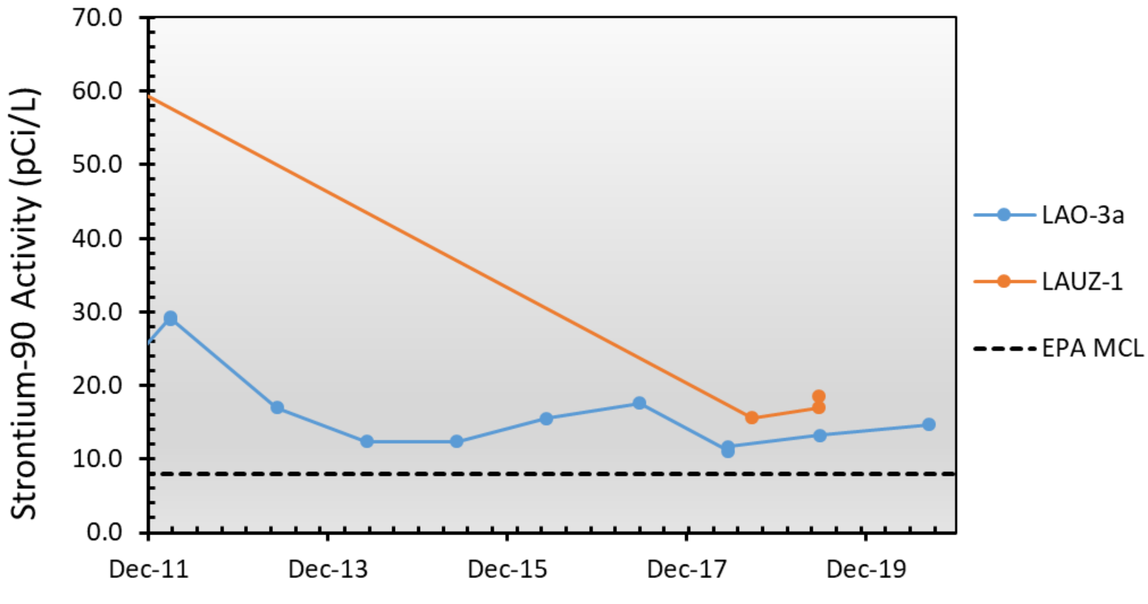
Two constituents, iron and indeno(1,2,3-cd)pyrene, were detected above applicable groundwater standards or screening levels in 2020. The New Mexico groundwater standard for iron is 1000 micrograms per liter. Iron was detected at Rio Grande at Otowi Bridge at a concentration of 2930 micrograms per liter. The New Mexico Environmental Department tap water screening level for indeno(1,2,3-cd)pyrene is 0.343 micrograms per liter. It was detected at Spring 4 at 0.370 micrograms per liter.

General Surveillance Monitoring

Los Alamos and Pueblo Canyon

Alluvial well LAO-3a in Los Alamos Canyon (Figure 5-6) continues to show strontium-90 concentrations above the U.S. Environmental Protection Agency's 8 picocuries per liter maximum contaminant level (Figure 5-24). Alluvial well LAUZ-1 had not been sampled since 2011, but was sampled in 2018 and 2019. In 2019, the concentration of strontium-90 was 18.6 picocuries per liter, which is below the 2011 concentration of 64.5 picocuries per liter. LAUZ-1 was not sampled in 2020 because it was submerged in water. The source of the strontium-90 is Solid Waste Management Unit 21-011(k), which was an outfall from industrial waste treatment at Technical Area 21. Strontium-90 is persistent at this location and in several downgradient alluvial wells near the confluence of DP Canyon with Los Alamos Canyon. But, it has not been migrating to alluvial locations further down Los Alamos Canyon (LANL 2004).

Alluvial well PAO-5n and intermediate wells POI-4 and R-3i in Pueblo Canyon have results above the New Mexico Environment Department tap water screening level of 70 nanograms per liter for PFAS; respectively, the results were 179.4, 107.6, and 84.7 nanograms per liter. As a new emerging contaminant, this was the first sampling event for PFAS, and it will continue to be monitored at these locations.

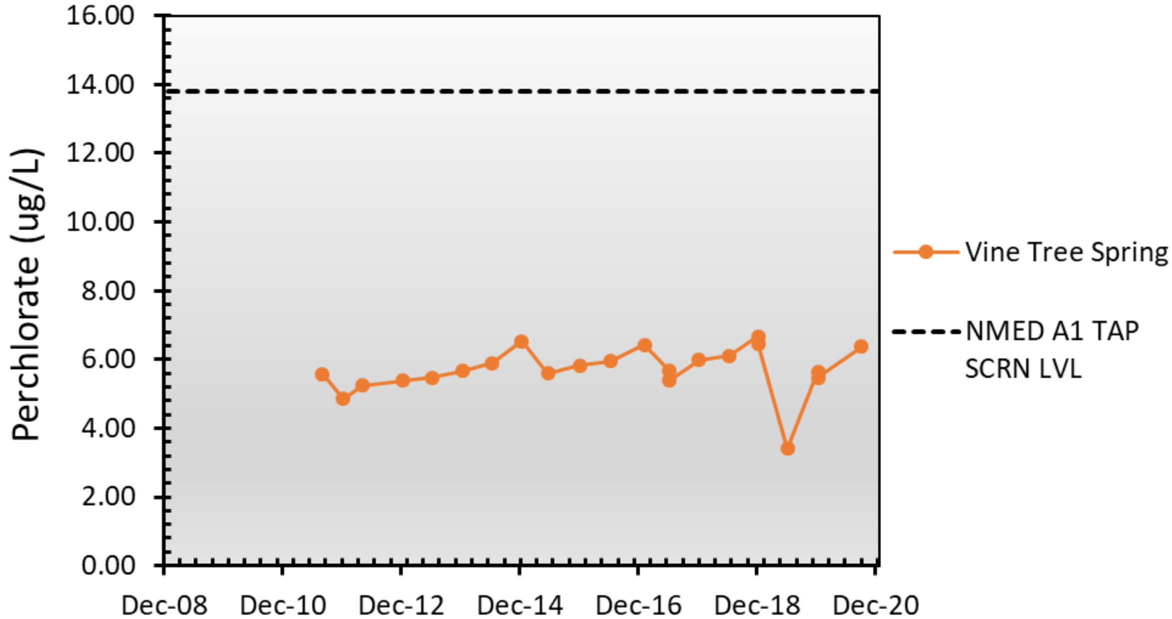


EPA MCL = U.S. Environmental Protection Agency maximum contaminant level for drinking water

Figure 5-24. Strontium-90 levels at alluvial monitoring well LAO-3a and LAUZ-1. The U.S. Environmental Protection Agency maximum contaminant level for strontium-90 in drinking water value is 8 picocuries per liter (pCi/L).

Lower Los Alamos Canyon

Vine Tree Spring on Pueblo de San Ildefonso land represents discharge of perched-intermediate groundwater. Sampling at Vine Tree Spring began as a replacement for nearby Basalt Spring, which had been sampled since the 1950s until it dried up around 2010. The perchlorate concentration in Vine Tree Spring for 2020 is consistent with prior years' data (Figure 5-25). The perchlorate contamination may be associated with historical Laboratory operations. For context, the perchlorate values are below the risk-based screening level of 13.8 micrograms per liter. The screening level for perchlorate is determined according to a hierarchical data-screening process required under the 2016 Consent Order.



NMED A1 TAP SCRN LVL = New Mexico Environment Department tap water screening level

Figure 5-25. Perchlorate concentrations at Vine Tree Spring. The New Mexico risk-based screening level for perchlorate is 13.8 micrograms per liter (µg/L).

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 or screening levels in these wells during 2020.

Mortandad Canyon

Several regional aquifer wells in Mortandad Canyon are part of the General Surveillance monitoring group. No constituents in the regional aquifer during 2020 were above their respective screening values for these wells.

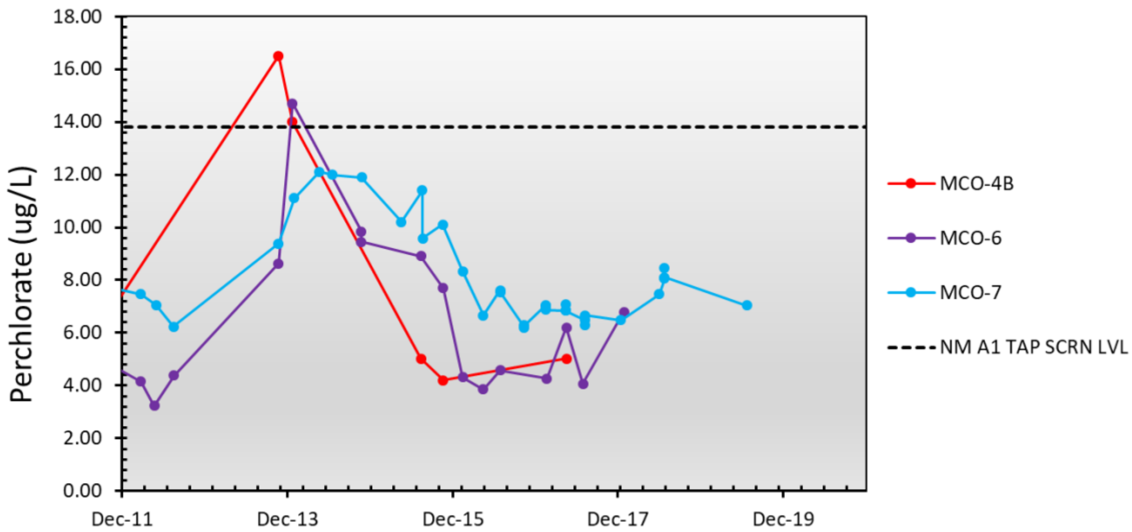
Under the groundwater discharge plan application for the Technical Area 50 Radioactive Liquid Waste Treatment Facility outfall, quarterly and annual samples are collected from seven alluvial, perched-intermediate, and regional aquifer wells to monitor impacts from discharges to the outfall in Mortandad Canyon, as discussed in Chapter 2 and later in this chapter.

Total PFAS was detected above the screening level at alluvial location MCO-7. The New Mexico Environmental Department tap water screening level for total PFAS is 70 nanograms per liter. Total PFAS was detected at MCO-7 at 82 nanograms per liter. As a newly monitored and emerging contaminant, total PFAS will continue to be monitored at MCO-7.

Historically, perchlorate has been detected in alluvial monitoring wells MCO-4B, MCO-6, and MCO-7 (Figure 5-26). Since the 2002 Radioactive Liquid Water Treatment Facility upgrades, the perchlorate concentrations from these wells are low relative to past perchlorate concentrations in Mortandad

Canyon alluvial groundwater. Due to insufficient water, both MCO-4B and MCO-6 have not been sampled since 2017 and 2018, respectively. All 2020 perchlorate results were non-detectable. Non-detected results are not included in Figure 5-26.

Nitrate, fluoride, and total dissolved solids are far below applicable standards in these alluvial wells.



NMED A1 TAP SCRN LVL = New Mexico Environment Department tap water screening level

Figure 5-26. Perchlorate concentrations at General Surveillance monitoring group and groundwater discharge plan monitoring wells MCO-4B, MCO-6, and MCO-7 in Mortandad Canyon alluvial groundwater. The New Mexico tap water screening level for perchlorate is 13.8 micrograms per liter (µg/L).

Cañada del Buey

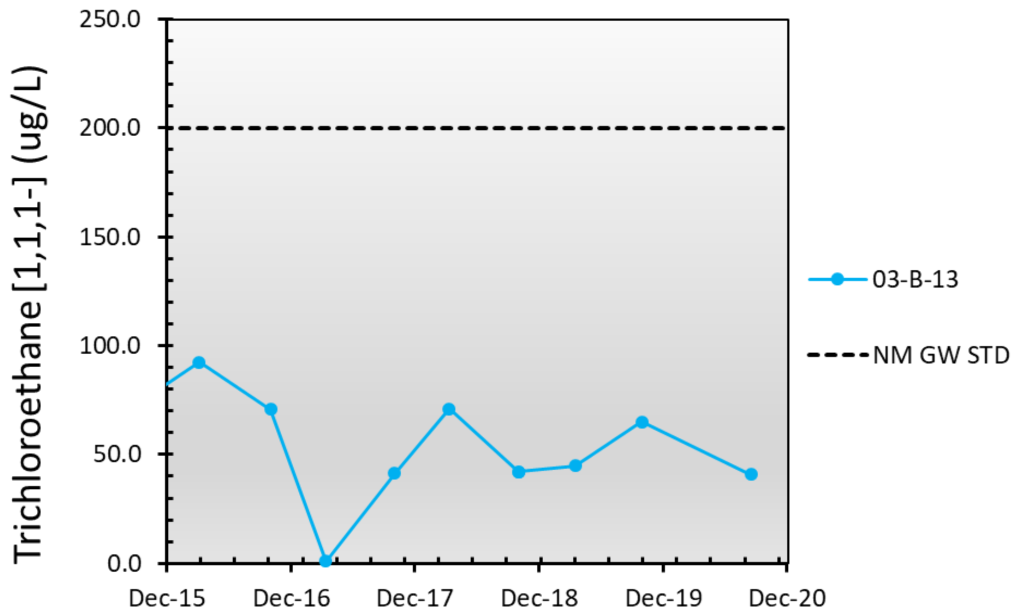
Alluvial well CDBO-6 in Cañada del Buey was dry in 2020 and, thus, not sampled.

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 in portions of Pajarito Canyon, including a reach in lower Pajarito Canyon, but does not extend beyond the Laboratory's eastern boundary. 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.

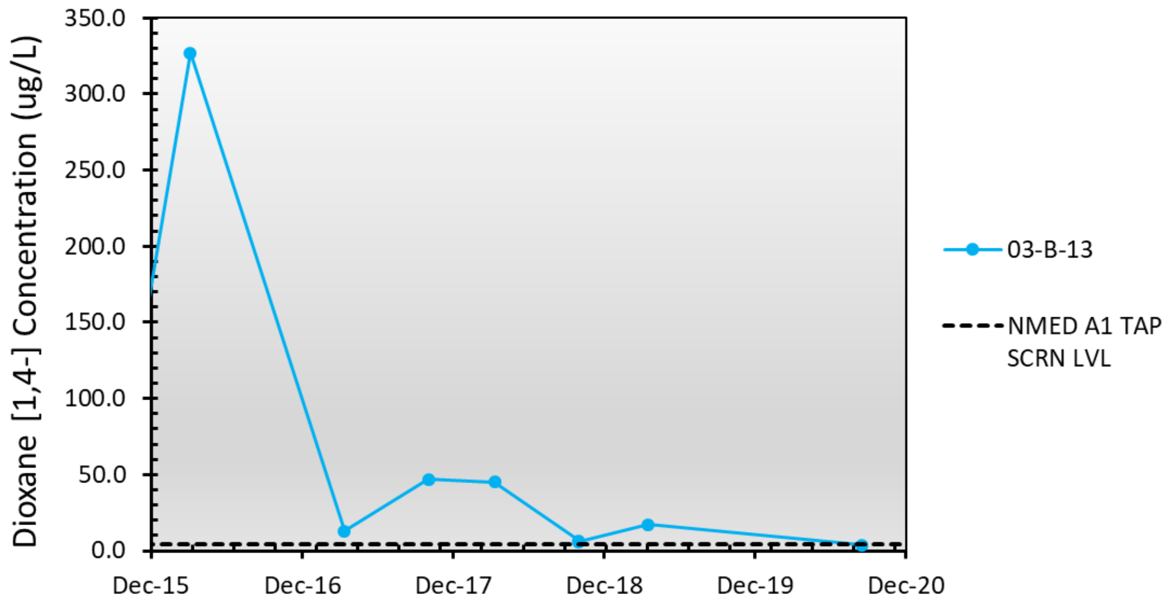
Solid Waste Management Unit 03-010(a) is the outfall area from a former vacuum repair shop behind the warehouse at Technical Area 03. The outfall area is located on a small tributary to Twomile Canyon. A small zone of shallow perched-intermediate groundwater is present and is apparently recharged by runoff from adjacent parking lots and building roofs. This perched groundwater is sampled at a depth of approximately 21 feet by well 03-B-13. In 2020, samples from this well contained 1,1,1-trichloroethane at concentrations below the New Mexico groundwater standard (Figure 5-27). Additionally, 03-B-13 contained aluminum at 5430 micrograms per liter and iron at 3240 micrograms per liter which were above the New Mexico groundwater standard of 5000 and 1000 micrograms per liter, respectively. Concentrations of 1,4-dioxane in 03-B-13 were the lowest ever recorded (Figure 5-28).

Several other alluvial and perched-intermediate groundwater and regional aquifer wells in Pajarito Canyon are part of the General Surveillance monitoring group. At alluvial well 18-MW-18, chloride was measured at 332 milligrams per liter, above the New Mexico groundwater standard of 250 milligrams per liter.



NM GW STD = New Mexico groundwater standard

Figure 5-27. Concentrations of 1,1,1-trichloroethane in Pajarito Canyon perched-intermediate groundwater at General Surveillance monitoring group well 03-B-13. The New Mexico groundwater standard for 1,1,1-trichloroethane is 200 micrograms per liter (µg/L).



NMED A1 TAP SCRN LVL = New Mexico Environment Department tap water screening level

Figure 5-28. Concentrations of 1,4-dioxane in Pajarito Canyon perched-intermediate groundwater at General Surveillance monitoring group well 03-B-13. The New Mexico groundwater standard for 1,4-dioxane is 4.59 micrograms per liter (µg/L).

Water Canyon

Water Canyon has only one General Surveillance monitoring group location, alluvial well WCO-1r. The 2020 sampling event was canceled due to insufficient water during the time of sampling. During the previous sampling event in 2019, iron was detected at 1560 micrograms per liter, which is above the 1000 micrograms per liter New Mexico groundwater standard.

Groundwater Discharge Permit Monitoring

In samples collected in support of groundwater discharge permits (from wells MCA-RLW-1, MCA-RLW-2, SCA-3, SCI-1, R-1, R-14 screen 1, R-46, and R-60), no permit-related constituents were above applicable standards or screening levels in 2020. Alluvial wells MCA-RLW-1, MCA-RLW-2, and SCA-3 were dry during the monitoring period. It should be noted, several analytes related to historical operations were detected in perched/intermediate aquifer wells. MCOI-6 contained various analytes above applicable standards or screening levels as presented in the Chromium Investigation Monitoring Group portion of this report.

Summary

The Laboratory has been monitoring groundwater for many years. As described in this chapter, only two areas are showing groundwater contaminants of sufficient concentration and extent to warrant an action such as interim measures, further characterization, and potential remediation under the 2016 Consent Order: (1) RDX contamination in the vicinity of Technical Area 16, and (2) chromium contamination beneath Sandia and Mortandad Canyons. We will continue to implement interim measures in the chromium plume in 2021 and beyond. Further characterization work and studies to evaluate groundwater risks and potential remediation strategies are ongoing in both of these areas.

Quality Assurance

All methods and procedures used to perform the field activities associated with this data are documented in the 2020 Interim Facility-Wide Groundwater Monitoring Plan (N3B 2019).

Sampling and data validation were conducted using standard operating procedures that are part of a comprehensive quality assurance program. For a comprehensive list of these standard operating procedures, refer to Appendix B of the 2020 Interim Facility-Wide Groundwater Monitoring Plan (N3B 2019).

Analytical results meet the N3B minimum data quality objectives as outlined in N3B-PLN-SDM-1000, “Sample and Data Management Plan.” N3B-PLN-SDM-1000 sets the validation frequency criteria at 100% Level 1 examination and Level 2 verification of data and at 10% minimum Level 3 validation of data. A Level 1 examination assesses the completeness of the data as delivered from the analytical laboratory, identifies any reporting errors, and checks the usability of the data based on the analytical laboratory’s evaluation of the data. A Level 2 verification evaluates the data to determine the extent to which the laboratory met the analytical method and the contract-specific quality control and reporting requirements. A Level 3 validation includes Levels 1 and 2 criteria and determines the effect of potential anomalies encountered during analysis and possible effects on data quality and usability. A Level 3 validation is performed manually with method-specific data validation procedures. Laboratory analytical data are validated by N3B personnel as outlined in N3B-PLN-SDM-1000; N3B-AP-SDM-3000, “General Guidelines for Data Validation;” N3B-AP-SDM-3014, “Examination and Verification of Analytical Data;” and additional method-specific analytical data validation procedures. All associated validation procedures have been developed, where applicable, from the U.S. Environmental Protection Agency document EPA QA/G-8, “Guidance on Environmental Data Verification and Data Validation,” the “Department of Defense/Department of Energy Consolidated Quality Systems Manual for Environmental Laboratories,” the U.S. Environmental Protection Agency “National Functional Guidelines for Data Validation,” and the American National Standards Institute/American Nuclear Society 41.5-2012 (R2018), “Verification and Validation of Radiological Data for Use in Waste Management and Environmental Remediation.”

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Chapter 6: Watershed Quality

Los Alamos National Laboratory (LANL or the Laboratory) collects and analyzes storm water runoff to check 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 compare these sampling results with New Mexico water quality standards, target action levels, and radiological dose guidelines. The State of New Mexico uses our surface water data in updating its determinations of impaired waters on and near the Laboratory every two years.

We also analyze newly deposited sediment samples each year for chemical and radionuclide levels. We compare sediment sampling results with human and ecological health screening criteria. We have found that over time, at any given sampling location, storm water–related transport of sediment generally results in similar or lower levels of Laboratory-released chemicals and radionuclides at that location than previously existed because of the deposition of new sediment.

The results of the sediment and surface water data collected in 2020 support the conclusion that the risk assessments presented in the canyons investigation reports conducted during 2004 through 2011 represent an upper bound of risks from these substances in the canyons for the foreseeable future. The Laboratory continues to have several impaired stream reaches, as defined by the New Mexico Environment Department. Laboratory industrial outfalls and dredge and fill activities are regulated to help minimize these impairments.

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Introduction

Effluents (liquid discharges from industrial operations) containing radionuclides, inorganic chemicals, and organic chemicals were released into canyons around Los Alamos National Laboratory (LANL or the Laboratory) during the early years of its 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 non-Laboratory but human-related sources of chemicals and radionuclides, such as the natural composition of rocks and soils, substances associated with trees burned during forest fires, atmospheric fallout of radionuclides and of chemicals such as polychlorinated biphenyls (PCBs), and releases from other developed areas on the Pajarito Plateau. All of the above sources contribute to the measured levels of chemicals and radionuclides in surface water and sediment across the Pajarito plateau.

We monitor chemical and radionuclide levels 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 data presented in this chapter is compiled from three Laboratory programs:

- Annual environmental surveillance sampling of storm water runoff and sediment (N3B 2020a, N3B 2021a, N3B 2021b)
- Implementation of the annual Interim Facility-Wide Groundwater Monitoring Plans (N3B 2019, N3B 2020b), which includes sampling of springs and persistent surface water in streams
- Storm water runoff monitoring associated with the Individual Permit (Permit No. NM0030759; the authorization to discharge [from solid waste management units and areas of concern] under the National Pollutant Discharge Elimination System, N3B 2021c).

The legacy waste cleanup contractor Newport News Nuclear BWXT–Los Alamos (N3B) assumed responsibility for implementing the Laboratory’s surface water and sediment surveillance program, groundwater protection program, and the Individual Permit in April 2018. The managing and operating contractor Triad manages Clean Water Act compliance for current operations, including compliance with outfall permit limits and implementing stormwater pollution prevention plans and low-impact development controls. Triad also installed several engineered structures for watershed enhancement (see Chapter 2).

At the Laboratory, we consider any soil that is either suspended in water or that has been deposited by surface water flows as sediment. Many of our sediment samples are collected from dry stream channels or adjacent floodplains, and not from aquatic habitats.

Hydrologic Setting

Laboratory lands contain all or parts of seven watersheds that drain into the Rio Grande basin (Figure 6-1). The watersheds are named after the major drainage canyon in the watershed. Listed from north to south, the major canyons for these watersheds are Los Alamos, Sandia, Mortandad, Pajarito, Water, Ancho, and Chaquehui canyons. Los Alamos, Pajarito, and Water Canyon watersheds have their headwaters west of the Laboratory in the eastern Jemez Mountains, mostly within the Santa Fe National Forest. The remainder of the watersheds have their headwaters on the Pajarito Plateau. Only the Ancho Canyon watershed is located entirely on Laboratory land. Pueblo Canyon, which is north of Los Alamos Canyon but not on Laboratory land, is also monitored due to historic Laboratory activities in the area.

In 2020, snowmelt runoff crossed the downstream (eastern) boundary of the Laboratory at gaging stations in Ancho, Pueblo, Sandia, and Water canyons. Total snowmelt runoff for 2020 measured at these stations is estimated at 2 acre-feet, with most of the runoff occurring in Ancho and Water canyons. Total storm water runoff for June to October 2020 measured at the downstream Laboratory boundary is estimated at 18 acre-feet. Most of this runoff occurred in Ancho and Water canyons; minimal runoff (less than 1.5 acre-feet) occurred in Pueblo, Sandia, Mortandad, and Chaquehui canyons, and Cañada del Buey (a subwatershed of Mortandad Canyon). No runoff occurred in Potrillo Canyon (a subwatershed of Water Canyon) or Pajarito Canyon. No effluent from the Los Alamos County Waste Water Treatment Facility reached the gaging station in lower Pueblo Canyon during storm events in 2020. This is evidenced by gaging station records showing that no flow recorded at gaging station E059.5 (directly below the facility) reached the downstream gaging station E060.1. Figure 6-2 shows the precipitation and storm water runoff volume for the Laboratory for the monsoonal period of June through October during the years 1995 to 2020.

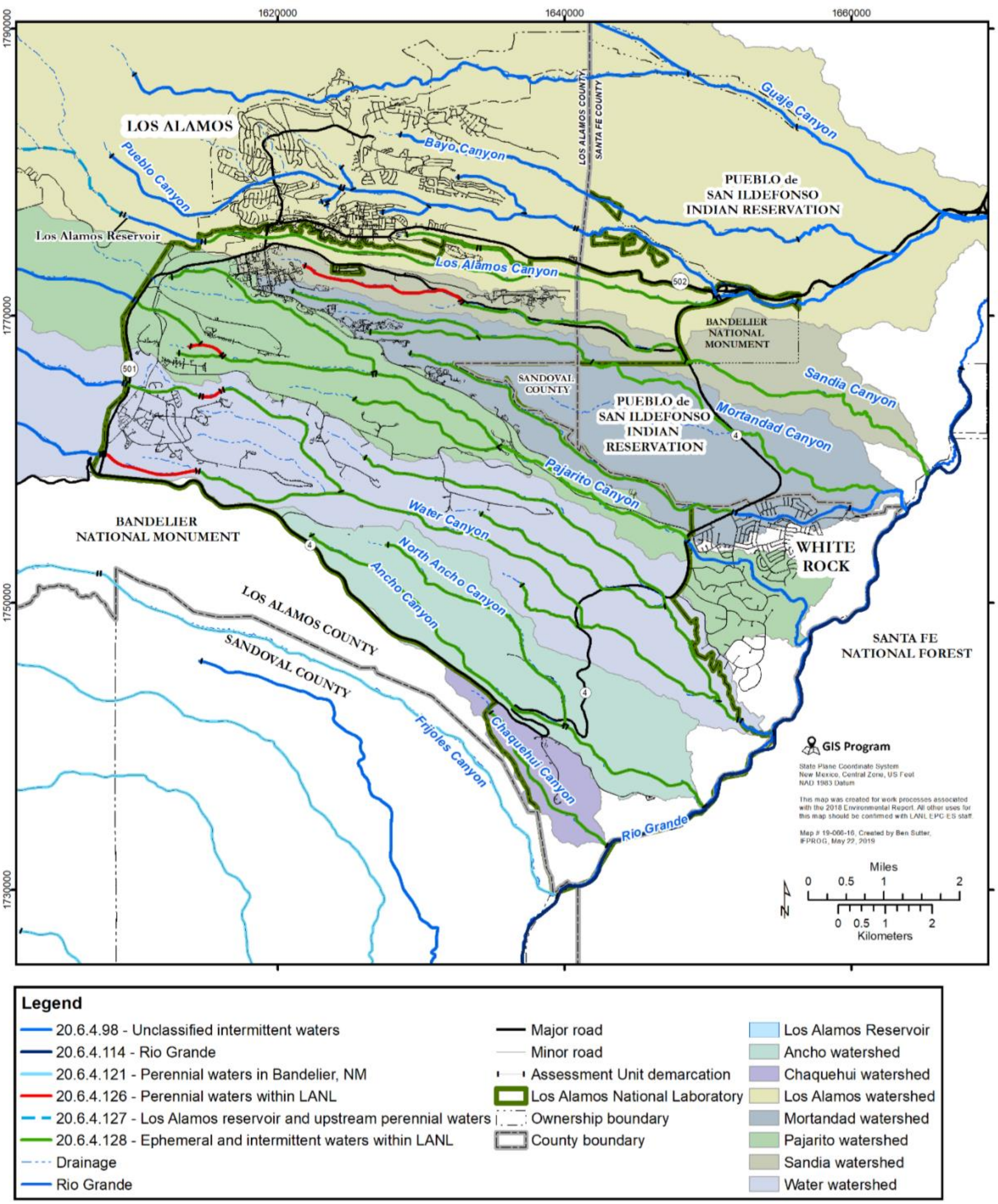


Figure 6-1. Stream reaches and watersheds within and around the Laboratory. Map shows the classifications of streams from Standards for Interstate and Intrastate Surface Waters, Title 20 Chapter 6 Part 4 of the New Mexico Administrative Code (20.6.4 NMAC; New Mexico Water Quality Control Commission 2020).

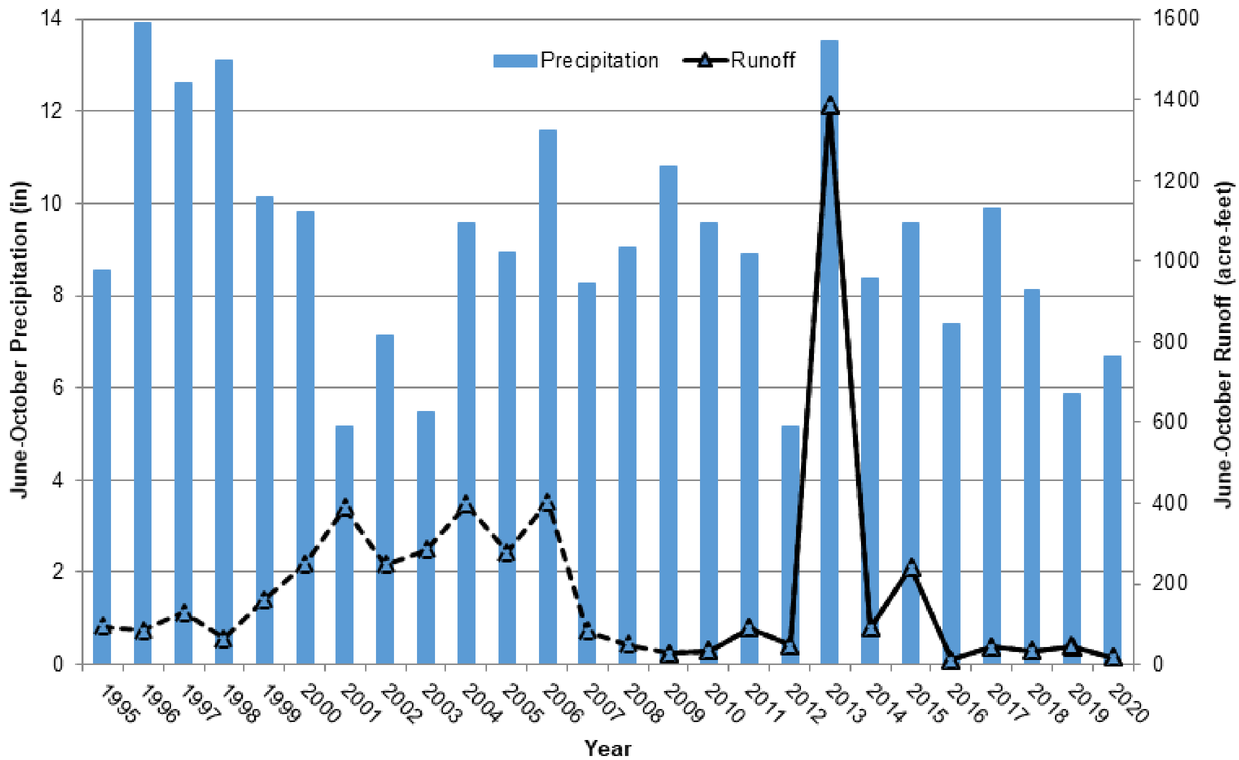


Figure 6-2. Total June–October precipitation from 1995 to 2020 averaged across the Laboratory's meteorological tower network (Technical Area 06, Technical Area 49, Technical Area 53, Technical Area 54, and northern community), and estimated June–October storm water runoff volume in Laboratory canyons from 1995 to 2020. Dashed line indicates data with potential quality issues.

Standards, Screening Levels, and Designated Uses for Stream Reaches

Surface Water Standards and Screening Levels

The New Mexico Water Quality Control Commission establishes surface water quality standards for New Mexico in *Standards for Interstate and Intrastate Surface Waters*, Title 20 Chapter 6 Part 4 of the New Mexico Administrative Code. The current standards were approved by the U.S. Environmental Protection Agency on July 24, 2020, and can be found online at https://www.env.nm.gov/surface-water-quality/wqs/. We use the New Mexico Environment Department's protocol for assessing attainment of surface water quality standards (NMED 2019a). Hardness-dependent aquatic life criteria for metals are calculated using water hardness values of concurrent samples (EPA 2006a, New Mexico Water Quality Control Commission 2020).

U.S. Department of Energy (DOE) Order 458.1 Chg 4, *Radiation Protection of the Public and the Environment*, sets total dose limits for radioactivity released during Laboratory operations. Limits apply to members of the public, plants, and animals. Therefore, our radiological assessment of surface water studies the potential exposures of aquatic organisms as well as animals living on land (collectively called "biota"). We compare radionuclide activities in surface water with the DOE biota concentration guides (DOE 2002, 2004) and with site-specific modifications by McNaughton et al. (2013). Biota concentration guides for either aquatic, riparian, or terrestrial animals are used for evaluation, depending on how often surface water is present at each location being evaluated. Both perennial reaches and intermittent reaches are screened using aquatic, terrestrial, and riparian animal biota concentration guides; ephemeral reaches are screened using terrestrial animal biota concentration guides. Biota dose results are provided in Chapter 7. (Note: No drinking water systems that deliver water to people on the Pajarito Plateau rely on surface water.)

We compare surface water results for gross alpha radioactivity and isotopes of radium 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 the Individual Permit site monitoring areas with the target action levels specified in the Individual Permit. Individual Permit site monitoring areas are described further in the Chapter 2 section titled "LANL's Individual Permit Authorization to Discharge under the National Pollutant Discharge Elimination System (from Solid Waste Management Units and Areas of Concern)." Additional details for site monitoring area results are provided in the Individual Permit Annual Report (N3B 2021d).

Terms related to surface water

Base flow – the portion of a perennial stream's flow that is sustained between precipitation events.

Effluent – water resulting from industrial processes that is discharged to the environment

Floodplain – an area of land adjacent to a stream that may receive water when the stream floods

Storm water – water that comes as runoff from rain and snowmelt events

Stream reach – a section of a stream or river along which similar hydrologic conditions exist, such as discharge, depth, area, geology, and slope

Surface water – water on the surface of a continent, such as in a river, lake, or wetland

Watershed – the area of land that contributes water flow to a particular stream or river

Sediment Screening Levels

We compare analytical results for levels of chemicals in sediment to the New Mexico Environment Department's risk-based soil screening levels (NMED 2019b) and radionuclide levels in sediment to the Laboratory's risk-based screening action levels (LANL 2015). 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 2020). 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).

The screening levels provide a high level of confidence in determining a low probability of 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, onsite data are compared with residential screening levels, although no residences are nearby. We evaluate human health effects from exposure to storm water in Chapter 8, Public Dose and Risk Assessment.

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

State of New Mexico Assessments of Stream Reaches

The New Mexico Environment Department Surface Water Quality Bureau uses surface water sampling results to evaluate impairment of the state's stream reaches (delineated as assessment units) under Section 303(d) of the Clean Water Act. They update the list of impaired stream reaches, including those on Laboratory property, every two years (NMED 2021).

Under *Standards for Interstate and Intrastate Surface Waters*, Title 20 Chapter 6 Part 4 of the New Mexico Administrative Code, stream reaches within the Laboratory boundary are classified as perennial (having water throughout the year), or ephemeral and intermittent (having water for extended periods only at certain times of the year or having water briefly only in direct response to precipitation) (New Mexico Water Quality Control Commission 2020). A stream reach is assigned one or more of the following designated uses based on its stream flow (perennial or ephemeral/intermittent) and other characteristics: cold water aquatic life, marginal warm water aquatic life, limited aquatic life, livestock watering, wildlife habitat, primary (human) contact, and secondary (human) contact.

Stream reaches within the Laboratory boundary are divided into assessment units. 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. The standards applied to each assessment unit depend on the designated use(s) of that assessment unit.

The locations of assessment units on and around the Laboratory are shown in Figure 6-1. The current status of each designated use (supported, not supported, or not assessed) for each assessment unit, and the identified cause of impairment, if any, are listed in Table 6-1 (NMED 2021).

Table 6-1. 2020–2022 LANL Assessment Units, Impairment Cause, and Designated Use(s) Supported, Not Supported, or Not Assessed

Assessment Unit Name	Impairment Cause	Designated Use Supported	Designated Use Not Supported	Designated Use Not Assessed
Acid Canyon (Pueblo Canyon to headwaters)	Gross alpha‡, aluminum, PCBs,* copper	None	Wildlife habitat, livestock watering, marginal warm water aquatic life	Primary contact
Ancho Canyon (North Fork to headwaters)	PCBs	Wildlife habitat	Limited aquatic life	Secondary contact, livestock watering
Ancho Canyon (Rio Grande to North Fork Ancho)	PCBs, mercury	Livestock watering	Limited aquatic life, wildlife habitat	Secondary contact
Arroyo de la Delfe (Pajarito Canyon to headwaters)	Copper, PCBs, aluminum, gross alpha	None	Limited aquatic life, livestock watering, wildlife habitat	Secondary contact
Cañada del Buey (within LANL)	PCBs, gross alpha	None	Limited aquatic life, livestock watering	Secondary contact, wildlife habitat
Cañon de Valle (below LANL gage E256)	Gross alpha	Wildlife habitat, limited aquatic life	Livestock watering	Secondary contact
Cañon de Valle (LANL gage E256 to Burning Ground Spring)	PCBs	Livestock watering	Cold water aquatic life, wildlife habitat	Secondary contact
Cañon de Valle (upper LANL boundary to headwaters)	Gross alpha, PCBs	Wildlife habitat	Marginal warm water aquatic life, livestock watering	Primary contact
Cañon de Valle (within LANL above Burning Ground Spring)	Not assessed	Not applicable	Not applicable	Livestock watering, limited aquatic life, wildlife habitat, secondary contact
Chaquehui Canyon (within LANL)	PCBs	Wildlife habitat, livestock watering	Limited aquatic life	Secondary contact
DP Canyon (Grade Control to upper LANL boundary)	Copper, PCBs, aluminum, gross alpha	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact
DP Canyon (Los Alamos Canyon to grade control)	PCBs, aluminum, gross alpha	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact

Assessment Unit Name	Impairment Cause	Designated Use Supported	Designated Use Not Supported	Designated Use Not Assessed
Fence Canyon (above Potrillo Canyon)	Not assessed	Not applicable	Not applicable	Livestock watering, limited aquatic life, wildlife habitat, secondary contact
Graduation Canyon (Pueblo Canyon to headwaters)	Copper, PCBs	Livestock watering	Wildlife habitat, marginal warm water aquatic life	Primary contact
Indio Canyon (above Water Canyon)	Not assessed	Not applicable	Not applicable	Livestock watering, limited aquatic life, wildlife habitat, secondary contact
Kwage Canyon (Pueblo Canyon to headwaters)	Not assessed	Not applicable	Not applicable	Primary contact, wildlife habitat, livestock watering, marginal warm water aquatic life
Los Alamos Canyon (DP Canyon to upper LANL boundary)	PCBs, cyanide, selenium, gross alpha, mercury	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact
Los Alamos Canyon (New Mexico -4 to DP Canyon)	Aluminum, PCBs, cyanide, radium, gross alpha, mercury	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact
Mortandad Canyon (within LANL)	Copper, PCBs, gross alpha, mercury	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact
North Fork Ancho Canyon (Ancho Canyon to headwaters)	Gross alpha, PCBs	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact
Pajarito Canyon (Arroyo de La Delfe to Starmers Spring)	None	Livestock watering, cold water aquatic life wildlife habitat	None	Secondary contact
Pajarito Canyon (lower LANL boundary to Two Mile Canyon)	Aluminum, PCBs, copper, gross alpha, cyanide	Wildlife habitat, limited aquatic life livestock watering	None	Secondary contact
Pajarito Canyon (Two Mile Canyon to Arroyo de La Delfe)	PCBs, silver, copper, gross alpha	Wildlife habitat	Livestock watering, limited aquatic life	Secondary contact

Assessment Unit Name	Impairment Cause	Designated Use Supported	Designated Use Not Supported	Designated Use Not Assessed
Pajarito Canyon (upper LANL boundary to headwaters)	Gross alpha, cyanide, PCBs, aluminum, mercury	None	Warm water aquatic life, livestock watering, wildlife habitat	Primary contact
Pajarito Canyon (within LANL above Starmers Gulch)	Aluminum, gross alpha	Wildlife habitat	Livestock watering, limited aquatic life	Secondary contact
Potrillo Canyon (above Water Canyon)	Gross alpha	Limited aquatic life, wildlife habitat	Livestock watering	Secondary contact
Pueblo Canyon (Acid Canyon to headwaters)	Gross alpha, PCBs, copper, aluminum	None	Marginal warm water aquatic life, livestock watering, wildlife habitat	Primary contact
Pueblo Canyon (Los Alamos Canyon to Los Alamos Waste Water Treatment Plant)	Gross alpha, aluminum, PCBs, selenium	None	Marginal warm water aquatic life, livestock watering, wildlife habitat	Primary contact
Pueblo Canyon (Los Alamos Waste Water Treatment Plant to Acid Canyon)	Gross alpha, PCBs	None	Marginal warm water aquatic life, livestock watering, wildlife habitat	Primary contact
Sandia Canyon (Sigma Canyon to National Pollutant Discharge Elimination System outfall 001)	PCBs, aluminum[§], copper[§], temperature	Livestock watering	Wildlife habitat, cold water aquatic life	Secondary contact
Sandia Canyon (within LANL below Sigma Canyon)	PCBs, aluminum[§], gross alpha, mercury[§], copper[§]	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact
South Fork Acid Canyon (Acid Canyon to headwaters)	Gross alpha, copper, PCBs	None	Marginal warm water aquatic life, livestock watering, wildlife habitat	Primary contact
Ten Site Canyon (Mortandad Canyon to headwaters)	PCBs, gross alpha	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact
Three Mile Canyon (Pajarito Canyon to headwaters)	Gross alpha	Limited aquatic life, wildlife habitat	Livestock watering	Secondary contact
Two Mile Canyon (Pajarito to headwaters)	PCBs, aluminum, copper, gross alpha	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact

Assessment Unit Name	Impairment Cause	Designated Use Supported	Designated Use Not Supported	Designated Use Not Assessed
Walnut Canyon (Pueblo Canyon to headwaters)	PCBs, copper	Livestock watering, wildlife habitat	Marginal warm water aquatic life	Primary contact
Water Canyon (Area-A Canyon to New Mexico 501)	None	Cold water aquatic life, livestock watering, wildlife habitat	None	Secondary contact
Water Canyon (within LANL above New Mexico 501)	Not assessed	Not applicable	Not applicable	Livestock watering, limited aquatic life, wildlife habitat, secondary contact
Water Canyon (within LANL below Area-A Canyon)	PCBs, aluminum, gross alpha, mercury	None	Livestock watering, limited aquatic life, wildlife habitat	Secondary contact

**PCBs are total PCBs in the water column.*

†Levels of these metals are considered an impairment for acute aquatic life standards.

‡Gross alpha levels 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.

§LANL submitted a third-party IR Category 4b demonstration entitled "Sandia Canyon Assessment Unit NM-9000.A_047 and NM-128.A_11 Dissolved Copper, Mercury and Total Recoverable Aluminum 4B Demonstration" (https://www.env.nm.gov/surface-water-quality/303d-305b/). Accordingly, the associated aluminum and copper listings in this assessment unit are noted as IR Category 4B.

Surface Water and Sediment Sampling

Surface Water Sampling Locations and Methods

We sample surface water 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 New Mexico State Road 4.

We maintain 37 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 eight additional stream channel locations that do not have active gaging stations. The number of gaging stations and stream channel sampling locations remains fairly constant over time. However, not all gaging stations or channel sampling locations experience storm water flow in any given year, so the number of locations with samples varies from year to year. The 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 automated samplers at gaging stations are programmed to start collecting water ten minutes after the peak flow during a runoff event, referred to as “Peak + 10.” The year 2020 was the tenth year that the Peak + 10 sampling method was employed at the gaging stations. This method was implemented based on comments by the New Mexico Environment Department that results from water samples collected before the peak of the storm flow were highly variable and, therefore, not ideal for monitoring contaminant and sediment transport. Programming the automated samplers to sample 10 minutes after the peak ensures that samples are not collected on the rising limb of the hydrograph. Previously, from 2004–2010, samples were collected right at the peak of the runoff event. As a result, current storm water sampling results are not directly comparable to data collected prior to the 2011 monitoring season.

To meet monitoring requirements under the Individual Permit, we have also installed samplers in 250 site monitoring areas to sample storm water runoff directly from 405 solid waste management units and areas of concern. These samplers do not remain in operation during months with freezing temperatures. Because rainstorms on the Pajarito Plateau are frequently very localized and not all rainfall events produce storm water runoff, 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 2020 Monitoring Year, October 2019–September 2020” and the “Interim Facility-Wide Groundwater Monitoring Plan for the 2021 Monitoring Year, October 2020–September 2021” (N3B 2019, N3B 2020b).

Figure 6-3 shows locations where samples were collected in 2020 for storm water at stream gaging stations, at sediment-detention basins, and for base flow below springs. Figure 6-4 shows Individual Permit site monitoring areas where compliance samples were collected in 2020. Due to a lack of precipitation, only one Individual Permit site monitoring area collected a sample in 2020.

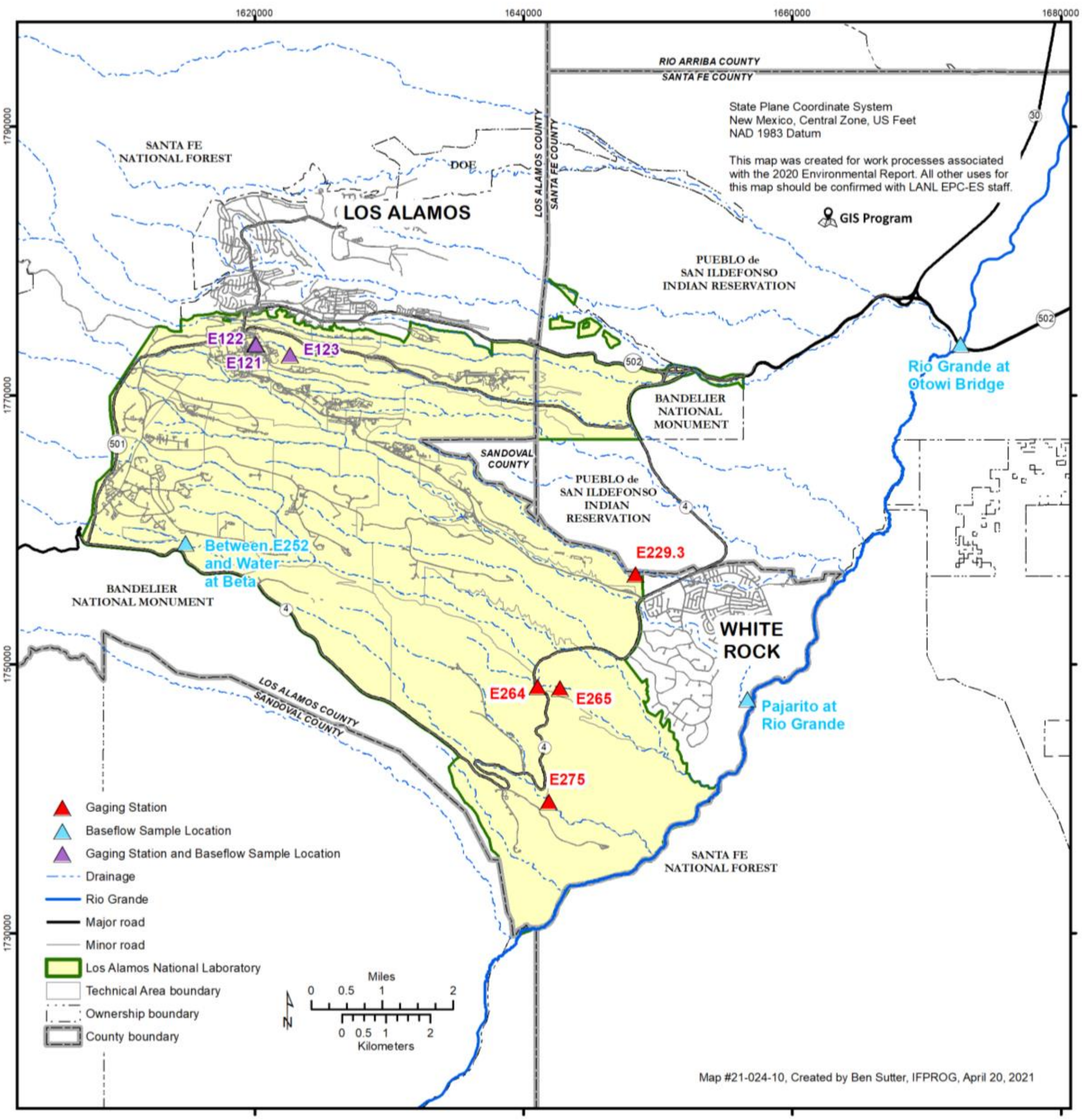


Figure 6-3. Locations sampled for storm water in 2020 at stream gaging stations and at sediment-detention basins in upper Los Alamos Canyon and for base flow below springs

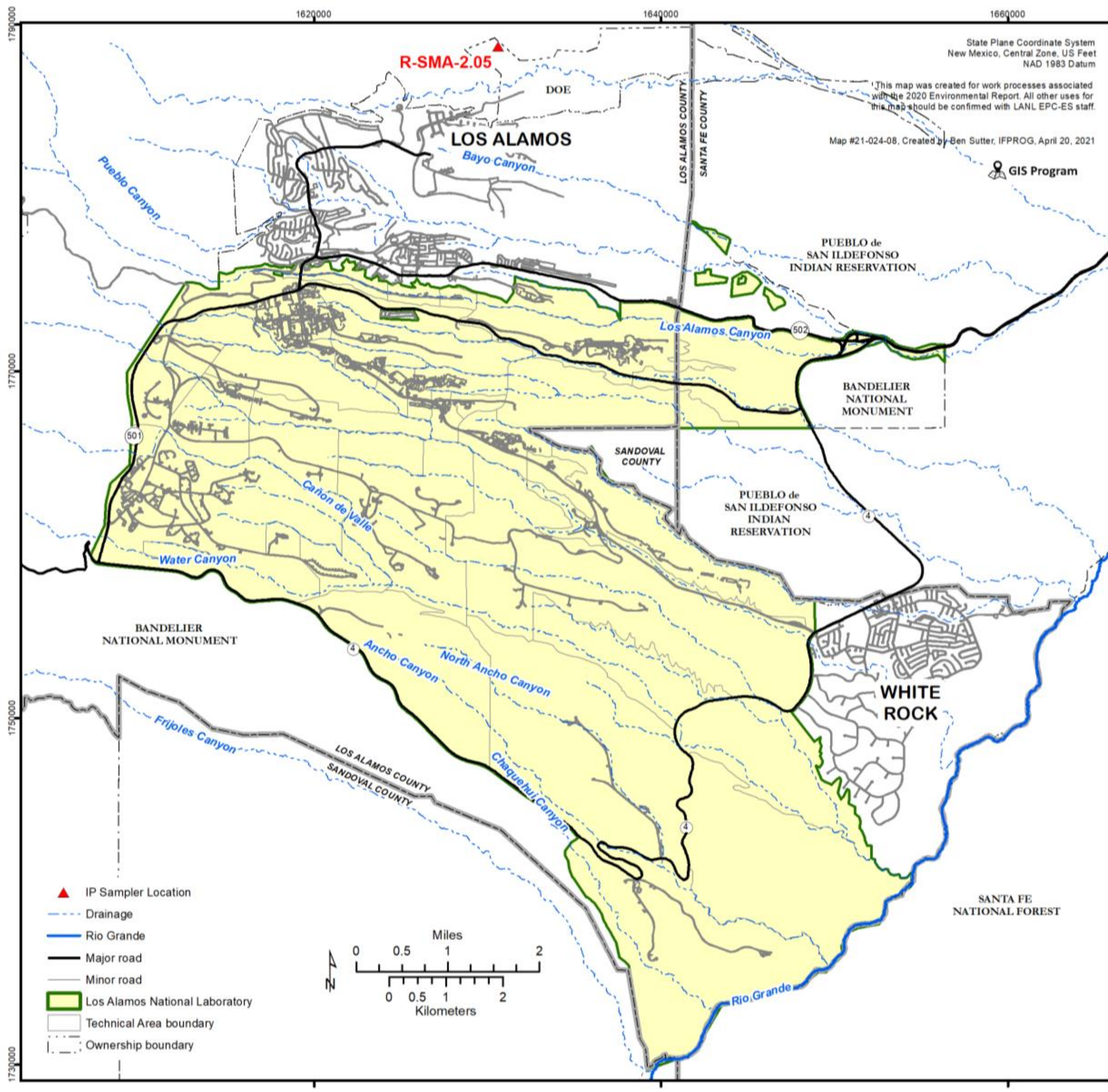
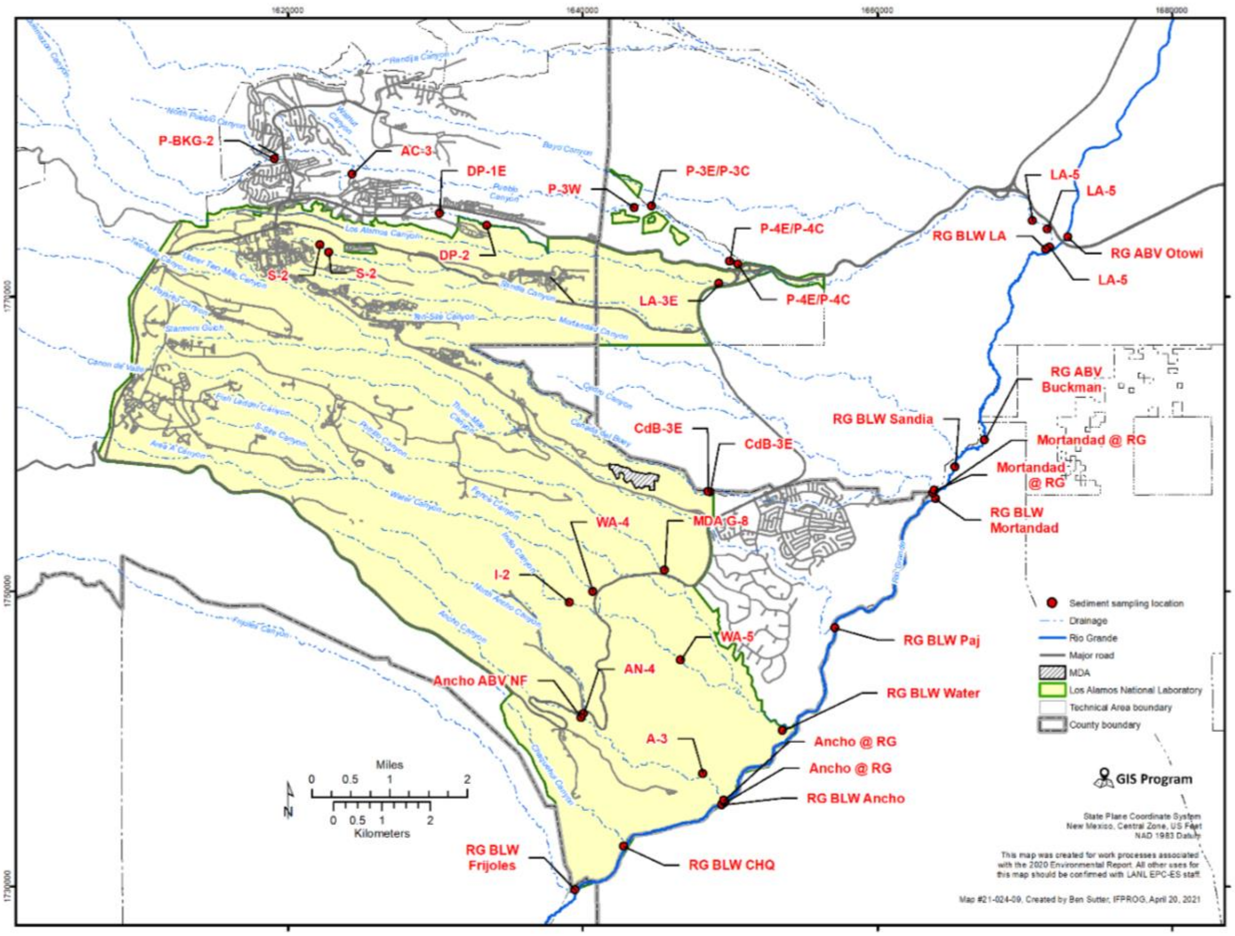


Figure 6-4. Individual Permit (IP) site monitoring areas where automated samplers collected compliance storm water samples in 2020

Sediment Sampling Locations and Methods

Figure 6-5 shows locations sampled for sediment in 2020 as part of the annual environmental surveillance program. Sediment samples were collected at a depth of between 0 and 6 inches, depending on the thickness of the uppermost sediment layer. We collected samples from stream channels and floodplains where new sediment was deposited during 2020. For streams with flowing water, sediment samples were collected near the edge of the main channel adjacent to, but not in, the water. During 2020, storm water runoff flowed in every canyon on Laboratory property except for

Pajarito Canyon and Potrillo Canyon (a subwatershed of Water Canyon); therefore, sediment samples were collected from most watersheds.



Note: MDA = Material disposal area; RG = Rio Grande; BLW = below; @ = at; LA = Los Alamos Canyon; P = Pueblo Canyon; A or AN = Ancho Canyon; AC = Acid Canyon; S = Sandia Canyon; WA = Water Canyon; ABV = above; CdB = Cañada del Buey; PA = Pajarito Canyon; M or Mort = Mortandad Canyon; BKG = background; I = Indio Canyon

Figure 6-5. Locations sampled in 2020 for sediment as part of the annual environmental surveillance program

Results

Table 6-2 summarizes inorganic chemical results for 2020 storm water and base flow samples and Table 6-3 summarizes organic chemical and radionuclide results for 2020 storm water and base flow samples. The surface water monitoring data for 2020 and previous years are available through the Intellus New Mexico website (https://intellusnm.com).

Table 6-4 summarizes chemical results for 2020 sediment samples at locations that exceeded screening levels for at least one chemical. There were minimal exceedances of screening levels for sediment samples collected in 2020. Out of 38 sediment samples collected, only three samples had exceedances. All radionuclide concentrations in sediment samples collected in 2020 were below screening action levels and the DOE biota concentration guides, so there were no exceedances to report.

Results from compliance sampling for the Individual Permit are not presented in the following tables, but are discussed in the text and included in the figures in the Discussion and Trends section below. Tables of the Individual Permit sampling results for 2020 are available in the Storm Water Individual Permit Annual Report (N3B 2021d). Tests are not performed for every substance in every Individual Permit sample; the analyses that are requested in a given year vary depending on the chemicals or radionuclides that have previously been detected in the solid waste management units and areas of concern within a site monitoring area.

Table 6-2. 2020 Storm Water and Base Flow Results for Inorganic Chemicals with at Least One Exceedance

Location Description	Stream Gage Number	Total Aluminum**			Dissolved Copper			Dissolved Lead			Total Selenium			Dissolved Zinc		
		Analyses*	Detects†	Exceedances‡	Analyses	Detects	Exceedances	Analyses	Detects	Exceedances	Analyses	Detects	Exceedances	Analyses	Detects	Exceedances
Ancho below New Mexico SR-4	E275	1	1	1	1	1	1	1	1	0	1	1	1	1	0	0
Between E252 and Water at Beta§	NA	0	0	0	1	0	0	1	0	0	1	0	0	1	0	0
Canada del Buey above New Mexico SR-4‖	E229.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Indio at New Mexico SR-4	E264	0	0	0	1	1	0	1	1	0	0	0	0	1	1	0
Pajarito at Rio Grande§	NA	0	0	0	1	0	0	1	0	0	1	0	0	1	1	0
Rio Grande at Otowi Bridge§	NA	0	0	0	1	0	0	1	0	0	1	0	0	1	0	0
Sandia below Wetlands	E123	1	1	1	1	1	1	1	1	1	1	0	0	1	0	0
Sandia below Wetlands§	E123	5	0	0	5	1	0	5	0	0	5	0	0	5	2	0
Sandia left fork at Asphalt Plant	E122	2	2	1	2	2	2	2	2	1	2	0	0	2	2	2
South fork of Sandia at E122§	E122	4	2	0	4	3	2	4	1	0	4	0	0	4	2	0
Sandia right fork at Power Plant	E121	1	1	1	1	1	1	1	0	0	1	0	0	1	1	1
Sandia right fork at Power Plant§	E121	5	1	0	5	3	0	5	0	0	5	0	0	5	3	0
Water below New Mexico SR-4	E201	1	1	1	1	1	0	1	1	0	1	1	1	1	0	0

***Unfiltered aluminum is screened for base flow samples and aluminum filtered to 10 µm is screened for storm water samples.*
**Analyses are the number of samples analyzed for that constituent.*
†Detects are the number of samples in which that constituent was detected.
‡Exceedances are the number of results that were detected above the screening level.
§Indicates base flow sampling locations; all other locations are storm flow sampling locations (note some locations have both storm flow and base flow samples).
‖ A sample was collected, but was not analyzed for any of the chemicals shown (analysis suites are based on site history). Of the chemicals analyzed, no exceedances occurred.
Gray highlighting indicates that a chemical exceeded its screening level in at least one sample from a given location.

Table 6-3. 2020 Storm Water and Base Flow Results for Organic Chemicals and Radionuclides with at Least One Exceedance

Location Description	Stream Gage Number	Dibenz(a,h) anthracene			Dioxins**			Gross alpha			Indeno(1,2,3-cd) pyrene			Total PCB		
		Analyses*	Detects†	Exceedances‡	Analyses	Detects	Exceedances	Analyses	Detects	Exceedances	Analyses	Detects	Exceedances	Analyses	Detects	Exceedances
Ancho below New Mexico SR-4	E275	0	0	0	1	1	1	1	1	1	0	0	0	1	1	1
Between E252 and Water at Beta§	NA	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0
Canada del Buey above New Mexico SR-4‖	E229.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Indio at New Mexico SR-4‖	E264	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pajarito at Rio Grande§	NA	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0
Rio Grande at Otowi Bridge§	NA	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0
Sandia below Wetlands	E123	2	0	0	1	1	1	1	1	0	2	0	0	1	1	1
Sandia below Wetlands§	E123	9	0	0	5	5	1	1	0	0	9	0	0	4	4	4
Sandia left fork at Asphalt Plant	E122	4	0	0	2	2	2	2	2	0	4	0	0	2	2	2
South fork of Sandia at E122§	E122	8	0	0	3	3	0	0	0	0	8	0	0	4	3	3
Sandia right fork at Power Plant	E121	2	0	0	1	1	1	1	1	0	2	1	0	1	1	1
Sandia right fork at Power Plant§	E121	9	1	1	4	4	0	1	0	0	9	1	1	4	4	3
Water below New Mexico SR-4	E201	0	0	0	1	1	0	0	0	0	0	0	0	1	1	0

**Analyses are the number of samples analyzed for that constituent.*
†Detects are the number of samples in which that constituent was detected.
‡Exceedances are the number of results that were detected above the screening level.
§Indicates base flow sampling locations; all other locations are storm flow sampling locations (note some locations have both storm flow and base flow samples).
‖ A sample was collected, but was not analyzed for any of the chemicals shown (analysis suites are based on site history). Of the chemicals analyzed, no exceedances occurred.
***The dioxin criteria apply to the sum of the dioxin toxicity equivalents expressed as tetrachlorodibenzo-p-dioxin(2,3,7,8-).*
Gray highlighting indicates that a chemical exceeded its screening level in at least one sample from a given location.

Table 6-4. 2020 Sediment Locations Where Sample Result Exceeded at Least One Screening Level

Canyon	Reach Name	Location ID	Chemical	Result (mg/kg)	Residential Soil Cancer Screening Level (mg/kg)	Residential Soil Non-cancer Screening Level (mg/kg)	Industrial Soil Cancer Screening Level (mg/kg)	Industrial Soil Non-cancer Screening Level (mg/kg)	Construction Worker Soil Cancer Screening Level (mg/kg)	Construction Worker Soil Non-cancer Screening Level (mg/kg)
Ancho	Ancho @ RG	AN-61346	Manganese	465	—*	10548	—	160183	—	464
Sandia	S-2	SA-61633	Chromium	187	97	45183	505	313931	468	134
			Manganese	1030	—	10548	—	160183	—	464
		SA-61634	Manganese	3370	—	10548	—	160183	—	464
			PCB-126	0.00046	0.000375	0.000398	0.001719	0.005739	0.013118	0.001718

**A dash (—) indicates that there is not a screening level for a given chemical.*
Gray highlighting indicates a particular soil screening level exceeded by a given chemical. The units mg/kg = milligram per kilogram.

Table 6-5 summarizes all surface water exceedances in 2020. Exceedances for each analyte are categorized by applicable New Mexico water quality standards. The number and percent of locations exceeding these standards is included.

Table 6-5. Number of Locations Where New Mexico Water Quality Standards Were Exceeded for Storm Water or Base Flow Results in 2020 for Constituents with at Least One Exceedance

Analyte	Livestock Watering	Wildlife Habitat	Acute Aquatic Life	Chronic Aquatic Life	Human Health-Organism Only
Total Aluminum	—‡	—	5 (63%)	3 (38%)	—
Dissolved Copper	0	—	4 (44%)	3 (33%)	—
Dissolved Lead	0	—	0	2 (22%)	—
Total Selenium	—	2 (22%)	0	2 (22%)	—
Dissolved Zinc	0	—	2 (22%)	2 (22%)	0
Gross alpha	1 (14%)	—	—	—	—
Total PCB	—	4 (80%)	0	3 (60%)	4 (80%)
Dioxin*	—	—	—	—	4 (80%)
Dibenzo(a,h)anthracene	—	—	—	—	1 (20%)
Ideno(1,2,3-cd)pyrene	—	—	—	—	1 (20%)

‡A dash indicates there is no standard for this chemical or radionuclide in this category.
**The dioxin criteria apply to the sum of the dioxin toxicity equivalents expressed as tetrachlorodibenzo-p-dioxin(2,3,7,8-).*
Note: The percentage in parentheses represents the percent of locations that have an exceedance for that analyte.

Discussion and Trends

Annual assessments of chemical concentrations in surface water, base flow, and sediment 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. In this way, the Laboratory is able to track the movement and concentration of contaminants over time and take appropriate action to mitigate or slow transport where needed. The results from 2020 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.

The following sections discuss the chemical and radionuclide results, broken out by whether they are related to background sources (either natural or human-derived) or specifically related to Laboratory operations. Figures 6-6 through 6-9 show the results for chemicals in water samples from human or Laboratory sources that exceeded screening levels more than once at a particular location in 2020. In the figures, the colored circles in the top panel show the locations of surface water samples collected at stream gaging stations, sediment detention basins, base flow sampling locations, and Individual Permit site monitoring areas. The color of a circle corresponds to the percentile in which the median concentration of samples collected at that location fall relative to the median concentrations at other sample locations in the same watershed. The median concentrations and the percentiles were calculated from data collected from 2011 through 2020. The percentiles were calculated from a dataset of median concentrations of the constituent at each sampled location in the watershed. The range in concentrations represented by each percentile is provided at the top of the figure. The plots in the bottom panel(s) show all results in the watershed for the constituent of interest for each year, with different colors for Individual Permit samples and stream gaging station samples. Because of the smaller number of samples per location, the sediment data are not presented in figures, but exceedances are reported in Table 6-4.

Constituents Related to Background Sources

Some chemicals and radionuclides may come from both naturally occurring sources and human-derived sources. Chemicals that are mainly or completely naturally occurring are discussed below, but results are not presented in figures.

Aluminum: Storm water samples collected on the Pajarito Plateau in 2020 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, Ryan et al. 2019). Aluminum is a natural component of soil and Bandelier Tuff, and it is not known to be derived from Laboratory operations in any significant quantity. In 2020, total aluminum concentrations in storm water exceeded the acute aquatic life standard at five sampling locations (63% of locations) and the chronic aquatic life standard at three sampling locations (38% of locations). There were no exceedances of the target action level for total aluminum concentrations in the one Individual Permit–related runoff sample collected in 2020. Fourteen of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands are listed as impaired for aluminum in Table 6-1. 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 (the acute aquatic life standard for a hardness of 30 mg $CaCO_3$/L) in other parts of the Jemez Mountains area (NMED 2009a).

In 2020, no sediment samples exceeded soil screening levels for aluminum.

Arsenic: Arsenic has both natural and human-derived sources. Coal-fired power plants emit gaseous arsenic. While the Four Corners Generating Station coal-fired power plant has contributed to arsenic contamination, the Laboratory also operated coal-fired power plants historically. Arsenic is also found naturally in the local volcanic rocks. In 2020, none of the filtered gaging station storm water or base flow results exceeded the surface water quality standards for arsenic. The one Individual Permit-related sample from 2020 did not exceed the target action level for arsenic. None of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands are listed as impaired for arsenic as listed in Table 6-1.

In 2020, no sediment samples exceeded soil screening levels for arsenic.

Copper: Copper is naturally occurring and it is also associated with explosives firing sites, forest fires, and developed areas, such as buildings and parking lots. 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 2020, copper concentrations in filtered storm water and base flow samples were detected above the acute aquatic life standard at four sampling locations (44% of locations) and above the chronic aquatic life standard at three sampling locations (33% of locations).

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. Thirteen of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands are listed as impaired for copper, see Table 6-1. In 2020, there was only one Individual Permit-related runoff sample and it did not exceed the target action level for copper. Figure 6-6 shows copper concentrations in filtered storm water and base flow for the Sandia and Mortandad canyons watershed, which was the only area with more than one copper exceedance at a single sampling location. Concentrations measured in 2020 were similar to those measured in previous years.

In 2020, no sediment samples exceeded soil screening levels for copper.

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 and base flow in 2020 were detected above the chronic aquatic life standard at two sampling locations (22% of locations). None of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands are listed as impaired for lead as shown in Table 6-1. There were no exceedances of the target action level for filtered lead concentrations in the one Individual Permit-related runoff sample in 2020.

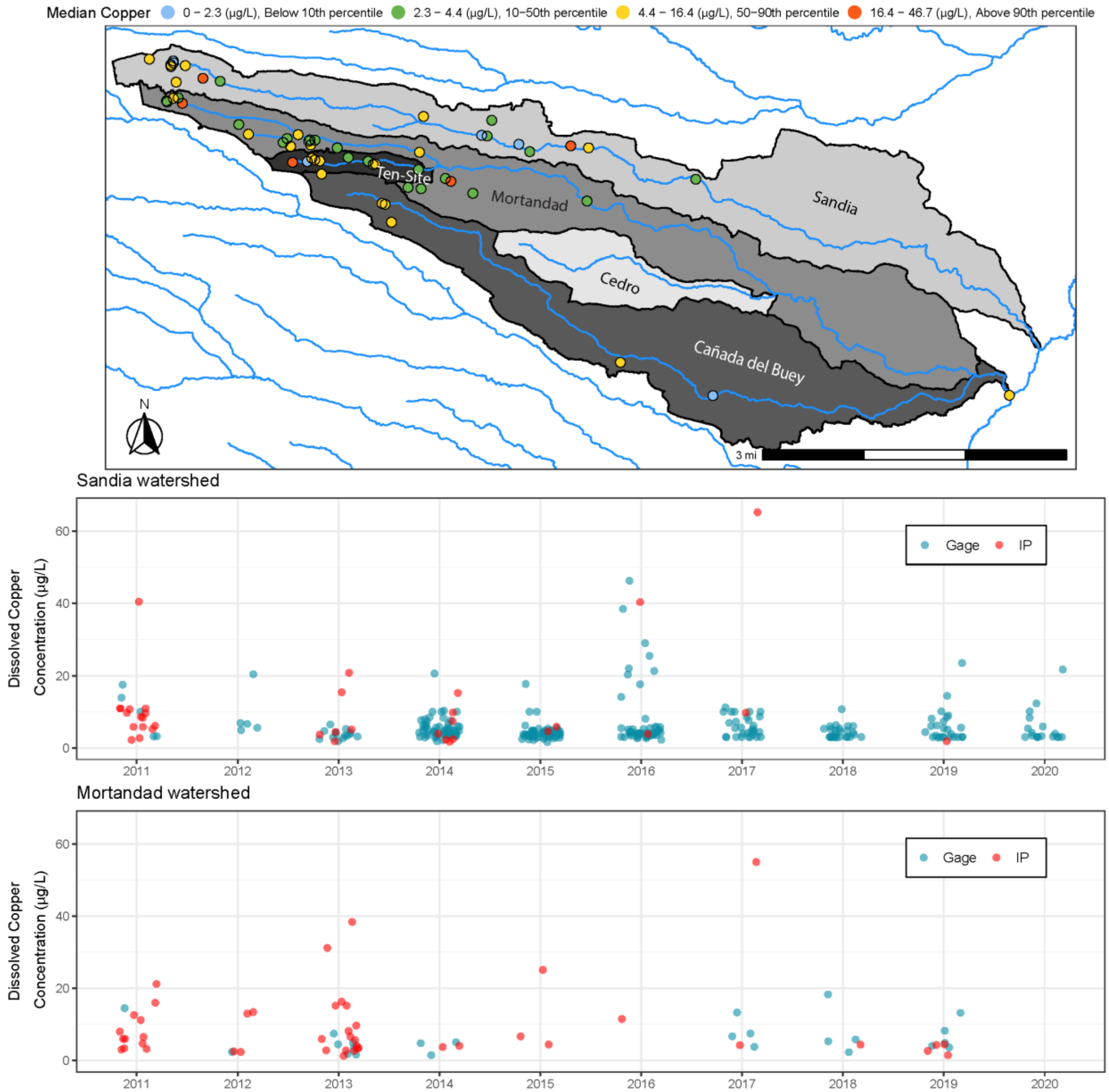
In 2020, no sediment samples exceeded soil screening levels for lead.

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 or base flow samples collected in 2020. None of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands are listed as impaired for manganese as shown in Table 6-1.

In 2020, manganese concentrations in sediment exceeded the construction worker non-cancer soil screening level in three samples. Two of the exceedances occurred in Sandia Canyon, and the third occurred in Ancho Canyon, as shown in Table 6-4.

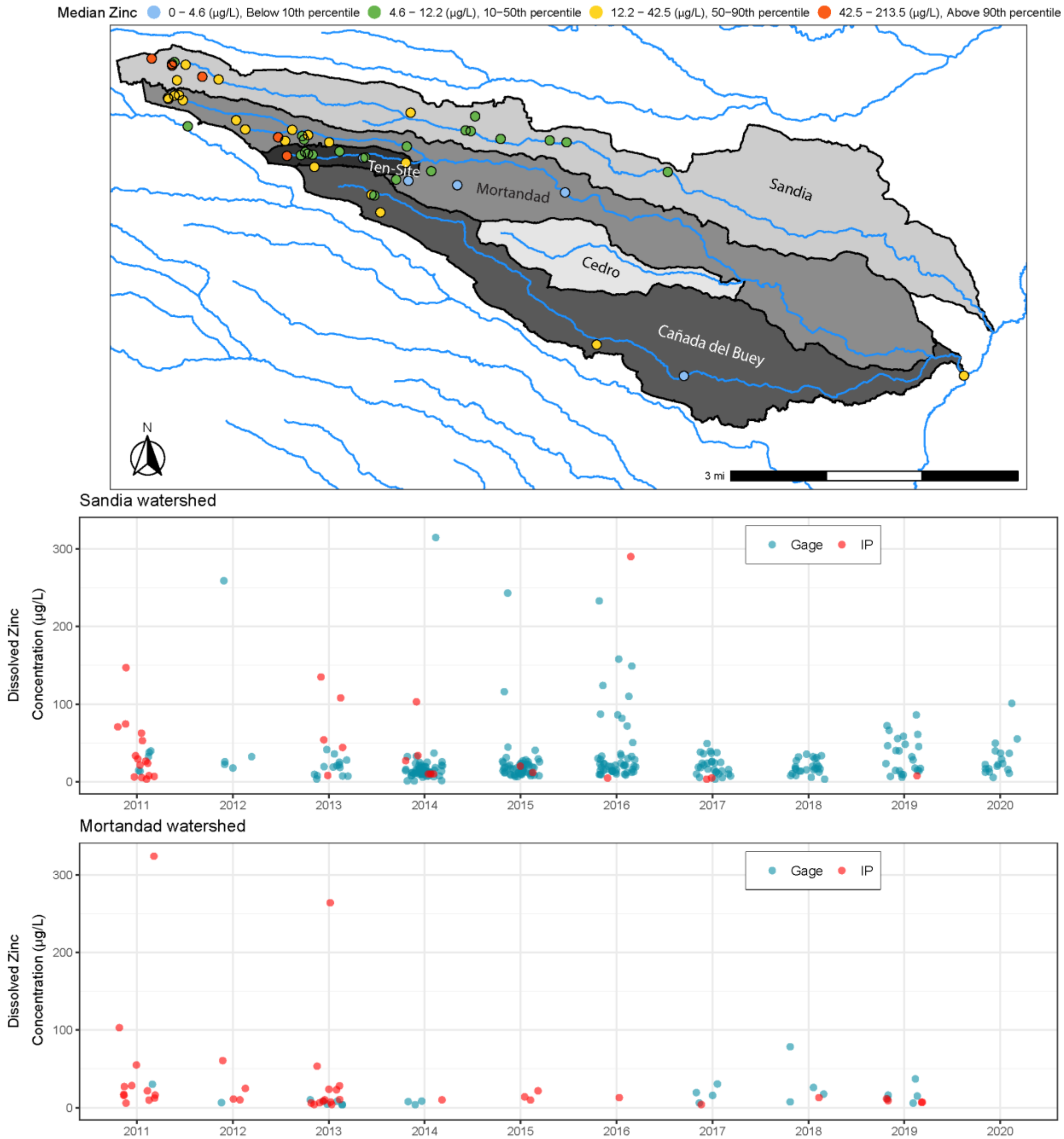
Selenium: Selenium is naturally occurring on the Pajarito Plateau. Laboratory operations have not generated or released significant quantities of selenium. Total selenium concentrations were elevated following the Cerro Grande fire and then decreased quickly in subsequent years (Gallaher and Koch 2004, 2005). In 2020, total selenium concentrations in storm water and base flow were detected above the wildlife habitat standard at two sampling locations (22% of locations) and above the chronic aquatic life standard at two sampling locations (22% of locations). Total selenium concentrations did not exceed the Individual Permit target action level in the one Individual Permit-related storm water sample collected in 2020. Two of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands are listed as impaired for selenium in Table 6-1.

In 2020, no sediment samples exceeded soil screening levels for selenium.



Note: µg/L = microgram per liter.

Figure 6-6. Sandia and Mortandad canyons watershed copper concentrations in filtered storm water from Individual Permit samplers and gaging stations and base flow from 2011 to 2020. Top Panel: median storm water copper values for each sampling location between 2011 and 2020. Bottom panels: dissolved copper concentrations from Individual Permit and gage station samples from 2011 and 2020. Note: No samplers located at gaging stations or Individual Permit sites in Mortandad Canyon collected samples in 2020.



Note: µg/L = microgram per liter.

Figure 6-7. Sandia and Mortandad canyons watershed zinc concentrations in filtered storm water from Individual Permit samplers and gaging stations and base flow from 2011 to 2020. Top Panel: median storm water zinc values for each sampling location between 2011 and 2020. Bottom panels: dissolved zinc concentrations from Individual Permit and gage station samples from 2011 to 2020. Note: No samplers located at gaging stations or Individual Permit sites in Mortandad Canyon collected samples in 2020.

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 2020, filtered zinc concentrations in storm water and base flow samples were detected above the acute aquatic life standard at two sampling locations (22% of locations) and above the chronic aquatic life standard at two sampling locations (22%). None of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands are listed as impaired for zinc as shown in Table 6-1. Filtered zinc concentrations did not exceed the Individual Permit target action level in the one Individual Permit-related storm water sample collected in 2020. Figure 6-7 shows zinc concentrations in filtered storm water and base flow for Sandia and Mortandad canyons. Zinc concentrations in 2020 were similar to those measured in 2019.

In 2020, no sediment samples exceeded soil screening levels for zinc.

Gross Alpha: The gross alpha activity 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 2020, one sampling location (14% of locations) had gross alpha activities above the livestock watering standard. In 2011, 2012, and 2013, the highest gross alpha activities in storm water were measured in samples containing ash and sediment from the 2011 Las Conchas fire. Gross alpha activities were also particularly high in runoff samples from the large September 2013 flood event. For sampling under the Individual Permit in 2020, gross alpha activity was above the target action level in the one sample that was collected. Twenty-five of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands are listed as impaired for gross alpha radioactivity as shown in Table 6-1. However, the analytical results from 2020 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 (for example, see Gallaher 2007).

Sediment is not analyzed for gross alpha levels because sediment analysis 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 were known to be released during historical Laboratory operations. The nature and extent of the constituents in sediment are described in detail in the canyons investigation reports referenced in the beginning of the Discussion and Trends section.

The following text describes the occurrences of key constituents in 2020 storm water, base flow, and sediment samples. Results for constituents that exceeded screening levels or standards more than once in 2020 at a particular sample location for storm water and base flow are shown in the figures associated with each chemical below.

Cadmium: 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 (Agency for Toxic Substances and Disease Registry 2012). In 2020, there were no exceedances observed for filtered storm water samples or base flow samples. There were no exceedances of the target action level for filtered cadmium concentrations in the one Individual Permit-related runoff sample in 2020. None of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands are listed as impaired for cadmium, see Table 6-1.

In 2020, no sediment results exceeded soil screening levels for cadmium.

Cesium-137: Cesium-137 is a radionuclide that is a byproduct of nuclear fission processes in nuclear reactors and nuclear weapons testing. In 2020, 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.

In 2020, cesium-137 activity in sediment samples did not exceed the screening action level.

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 2020 for total chromium or chromium (VI). There were no exceedances of the target action levels for filtered chromium concentrations in the one Individual Permit-related runoff sample in 2020. None of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands are listed as impaired for chromium, see Table 6-1.

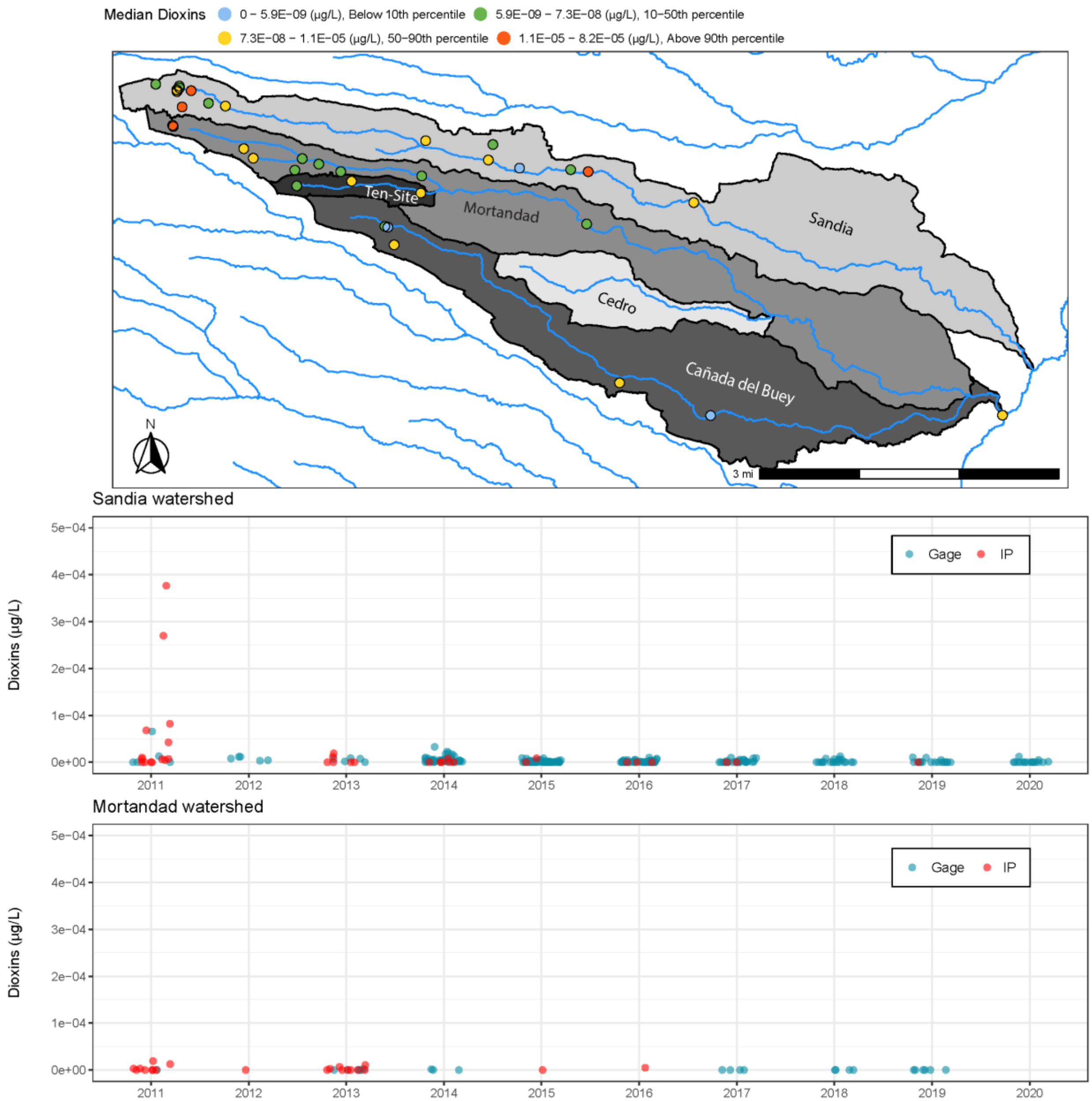
In 2020, one sediment sample exceeded both the residential cancer and the construction worker non-cancer soil screening levels for chromium. This sample was from Sandia Canyon, where chromium was known to have been released.

Dioxins and Furans: Dioxins and 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 and furans. This is more meaningful than reporting the number of grams of dioxins or 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 or furans. In 2020, dioxin concentrations in storm water and base flow samples exceeded the human health–organism only standard at four sampling locations (80% of locations). There were no Individual Permit-related samples tested for 2,3,7,8-tetrachlorodibenzodioxin (one of the more toxic compounds) in 2020. None of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands are listed as impaired for dioxins or furans, see Table 6-1. Figure 6-8 shows dioxin concentrations in storm water and base flow for the Sandia and Mortandad canyons watershed, which was the only area with more than one dioxin exceedance at a single location. Dioxin concentrations in 2020 were similar to those in 2019.

In 2020, no sediment samples exceeded soil screening levels for dioxins or furans.

What is the Human Health–Organism Only Surface Water Quality Standard?

This is one of the surface water quality standards used by the state of New Mexico to identify whether a water body or stream reach has adequate water quality for its designated use(s). The intent of this standard is to protect the health of humans who eat fish or other aquatic wildlife (such as crayfish) that live in a lake, river, or stream.



Note: µg/L = microgram per liter.

Figure 6-8. Sandia and Mortandad canyons watershed dioxin concentrations in filtered storm water from Individual Permit samplers and gaging stations and base flow from 2011 to 2020. Top Panel: median storm water dioxin values for each sampling location between 2011 and 2020. Bottom panels: dioxin concentrations from Individual Permit and gage station samples from 2011 and 2020. Note: no samplers located at gaging stations or Individual Permit sites in Mortandad Canyon collected samples in 2020.

Mercury: Natural sources of mercury include forest fires and fossil fuels such as coal and petroleum. 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, the Laboratory also operated coal-fired power plants historically. In 2020, none of the filtered or unfiltered storm water or base flow samples had exceedances for mercury. The single Individual Permit–related sample did not exceed the target action level for mercury in 2020. Seven of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands are listed as impaired for mercury, see Table 6-1.

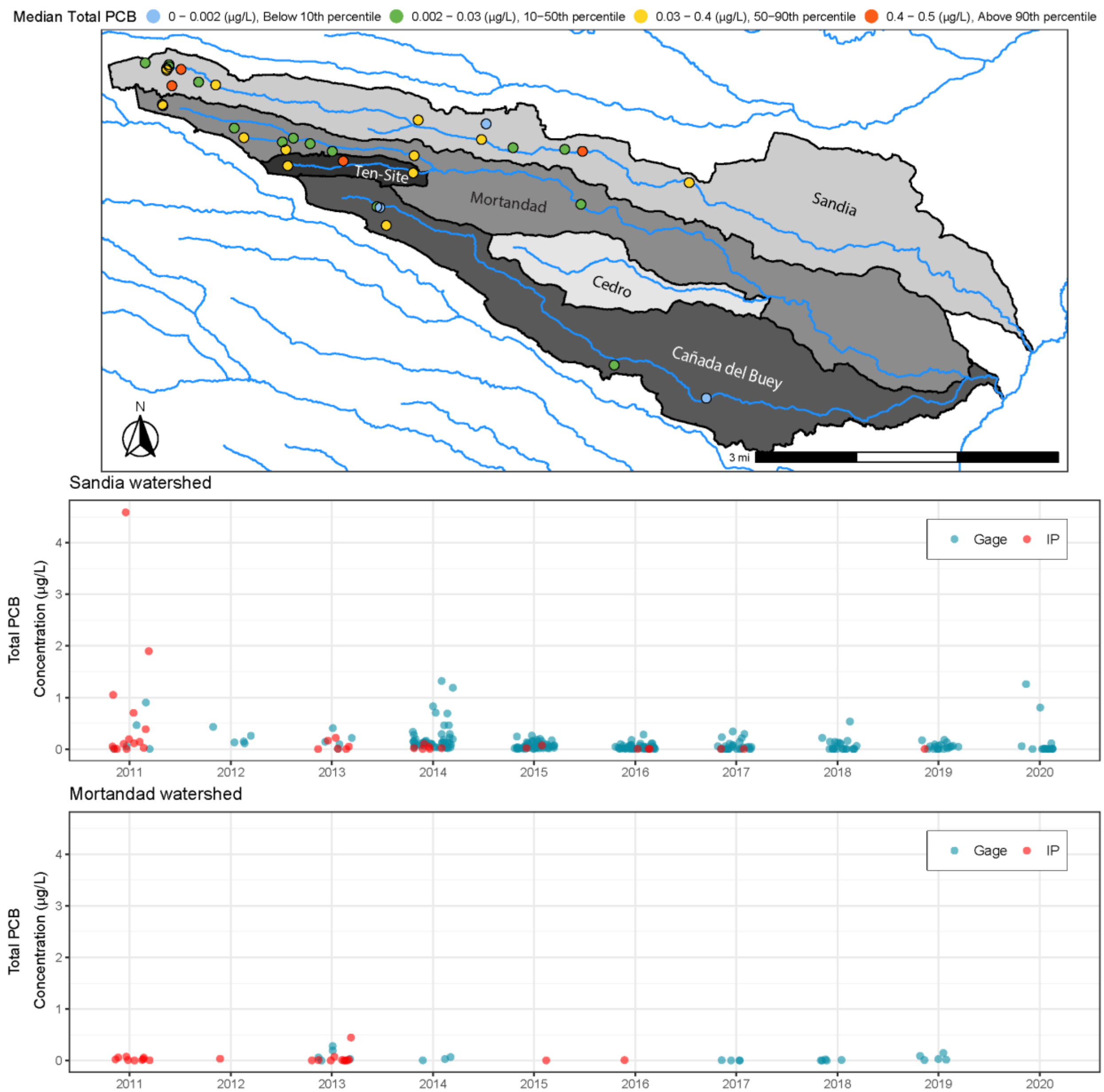
In 2020, no sediment samples exceeded soil screening levels for mercury.

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 and deteriorate, 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, and paints used in industrial activities; and a former asphalt batch plant in Sandia Canyon.

In 2020, four sampling locations (80% of locations) had PCB concentrations above the human health–organism only standard, three sampling locations (60% of locations) had concentrations above the chronic aquatic life standard, and four sampling locations (80% of locations) had concentrations above the wildlife standard. The single Individual Permit storm water sample collected in 2020 did not exceed the target action level for total PCBs. Twenty-eight of the 39 assessment units on Laboratory or former Laboratory lands are listed as impaired for PCBs, see Table 6-1. Figure 6-9 shows total PCB concentrations in unfiltered storm water and base flow for the Sandia and Mortandad canyons watershed, which was the only area with more than one total PCB exceedance at a single location. The scatter plot in the second panel shows there were two samples in Sandia Canyon that had total PCB concentrations that were higher than those observed over the previous five monitoring years, although still within range of what has been measured during the monitoring program. Relatively small sample sizes make it difficult to detect trends, but the PCB concentrations in this area will be closely monitored in future sampling.

In 2020, one sediment sample exceeded both the residential cancer and residential non-cancer soil screening levels for PCBs. This sample was from Sandia Canyon, where there were also PCB exceedances in surface water samples.



Note: µg/L = microgram per liter.

Figure 6-9. Sandia and Mortandad canyons watershed total PCB concentrations in filtered storm water from Individual Permit samplers and gaging stations and base flow from 2011 to 2020. Top Panel: median storm water dioxin values for each sampling location between 2011 and 2020. Bottom panels: total PCB concentrations from Individual Permit and gage station samples from 2011 and 2020. Note: no samplers located at gaging stations or Individual Permit sites in Mortandad Canyon collected samples in 2020.

Polycyclic Aromatic Hydrocarbons: Asphalt is prepared using petroleum products that contain polycyclic aromatic hydrocarbons, and operations at the former asphalt batch plant in Sandia Canyon released effluent from operations to the stream. In 2020, one sampling location (20% of locations) exceeded the human–health organism only standard for two of 19 polycyclic aromatic hydrocarbons with water quality standards (dibenzo(a,h)anthracene and indeno(1,2,3-cd)pyrene). A focused validation was conducted on these polycyclic aromatic hydrocarbon results and N3B data stewards determined that there were data quality issues from the analytical laboratory, but that the results were still usable. However, these results have a higher uncertainty and a potential positive bias; no polycyclic aromatic hydrocarbon exceedances occurred in subsequent samples. There were no Individual Permit-related exceedances in 2020. None of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands are listed as impaired for polycyclic aromatic hydrocarbons; see Table 6-1.

For 12 of 19 polycyclic aromatic hydrocarbon compounds that have screening levels, none of their sediment results from 2020 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, the Laboratory also operated coal-fired power plants historically. In 2020, none of the filtered gaging station storm water or base flow results exceeded the surface water quality standards for thallium. There were no Individual Permit-related exceedances for thallium in 2020. None of the 39 assessment units, or stream reaches, on Laboratory or former Laboratory lands are listed as impaired for thallium; see Table 6-1.

In 2020, no sediment samples exceeded soil screening levels for thallium.

Watershed Protection Measures

In addition to monitoring surface water and sediment, the Laboratory has constructed engineered controls to prevent or minimize the migration of sediment and contaminants to the Rio Grande. This section outlines some of the controls that are in place at the Laboratory. Figure 6-10 shows the locations of the controls discussed in detail below. In this 2020 report, this section provides a background of the controls already in place and fully functioning. In future years, this section will include any newly constructed controls.

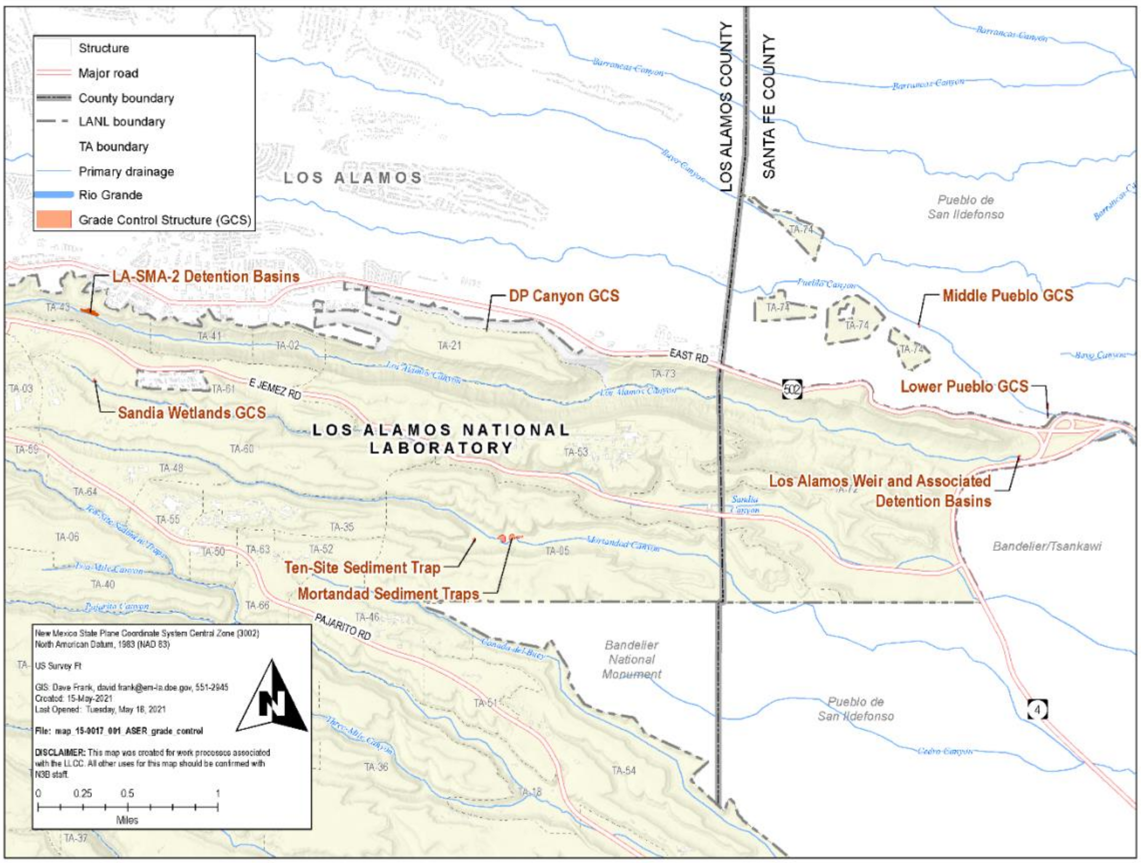


Figure 6-10. Watershed control measures at the Laboratory in Pueblo, Los Alamos, Sandia, and Mortandad canyons

Current Controls

Los Alamos Site Monitoring Area 2 (LA-SMA-2) Detention Basins

We built two detention basins in the bottom of Los Alamos Canyon in 2010 below a corrective action site on the side of the canyon (LANL 2010); see Figure 6-11. Two remediation projects were conducted on the hillslope to remove PCB-contaminated soil before the basins were installed (LANL 2008a, NMED

2009b). To increase the probability that sediment in storm water runoff would settle out before entering the basins, willow trees were planted along with the construction of the detention basins to slow the flow of water off the hillslope. In 2015 a pipeline was built to divert storm water runoff from the mesa top past the hillslope site, minimizing the amount of water traveling over the area. A third detention basin was then constructed to capture the runoff from the pipeline. The three detention basins are designed as a series with spillways connecting them. Automated storm water samplers are located below the drainage area of the hillslope and downstream of the detention basins to sample storm water runoff. The performance of the Los Alamos Site Monitoring Area 2 detention basins and their associated vegetative buffer is assessed annually in the Monitoring Report for the Los Alamos/Pueblo Watershed Transport Mitigation Project (N3B 2021a). The detention basins have been effective in containing contaminated sediment and minimizing transport downstream.

Figure 6-11. Upper basin of LA-SMA-2 Detention Basins, looking upstream (photo taken May 2019).

Delta Prime (DP) Canyon Grade Control Structure

The DP Canyon Grade Control Structure was completed in 2010 as part of the 2008 Supplemental Interim Measure Work Plan to mitigate contaminated sediment transport in Los Alamos and Pueblo canyons (LANL 2008b, NMED 2009c); see Figure 6-12. The grade control structure was designed to increase sediment deposition and stabilize the ground surface upstream of the structure, which decreases erosion of stream banks below the structure. A new gaging station, E039.1, was installed downstream of the DP Canyon Grade Control Structure to monitor the amount of stream flow and collect storm water runoff samples for analysis. The performance of the grade control structure is assessed annually in the Monitoring Report for the Los Alamos/Pueblo Watershed Transport Mitigation Project (N3B 2021a). Data from gaging stations has shown that the structure has significantly reduced the sediment load transported downstream.

Figure 6-12. DP Canyon Grade Control Structure, looking upstream (photo taken May 2019)

Los Alamos Weir and Associated Detention Basins

The Los Alamos Weir and three associated detention basins were built near the eastern Laboratory boundary in Los Alamos Canyon in 2001, following the Cerro Grande fire, to help prevent contaminated sediment from being transported further downstream; see Figure 6-13. The sediment detention basins are upstream of the Los Alamos Weir to reduce stream flow, allowing more sediment to settle out of storm water runoff. Sediment is excavated from the basins once a sufficient amount has accumulated. The most recent sediment removal occurred in 2014. The performance of the Los Alamos Weir and the detention basins is assessed annually in the monitoring report for the Los Alamos/Pueblo Watershed Transport Mitigation Project (N3B 2021a). Since their construction, the Los Alamos Weir and the detention basins have reduced the rate of streamflow and the amount of sediment transported downstream.

Figure 6-13. Los Alamos Weir, looking south (photo taken September 2020)

Lower Pueblo Canyon Grade Control Structure

The Lower Pueblo Canyon Grade Control Structure was completed in 2010 in Pueblo Canyon near the intersection of New Mexico 502 and New Mexico 4; see Figures 6-10 and 6-14. Like the DP Canyon Grade Control Structure, its construction was part of the 2008 Supplemental Interim Measure Work Plan that required the Laboratory to take actions to mitigate the transport of contaminated sediments (LANL 2008b, NMED 2009a). The grade control structure was designed to promote sediment deposition upstream of the structure, which controls the grade of the channel and provides stability to a headcut (an abrupt vertical drop in a stream channel associated with erosion and channel incision) that formed in the stream channel after a large storm event in 2008. In addition to stabilizing the area, the structure also promotes expansion of the wetland area above it. A new gaging station, E060.1, was installed below the grade control structure to monitor its efficacy in reducing sediment transport. The performance of the Lower Pueblo Canyon Grade Control Structure is assessed annually in the Monitoring Report for the Los Alamos/Pueblo Watershed Transport Mitigation Project (N3B 2021a). Stream flow in Pueblo Canyon has been effectively slowed by the Lower Pueblo Canyon Grade Control Structure, in concert with the other controls upstream, and sediment transport has been reduced.

Figure 6-14. Lower Pueblo Canyon Grade Control Structure, weir crest and flow-way, looking north (photo taken August 2020)

Middle Pueblo Canyon Grade Control Structure

The Middle Pueblo Canyon Grade Control Structure (also referred to as the Pueblo Canyon Drop Structure) was completed in 2015; see Figure 6-15. A large flood event in September 2013 caused significant erosion that widened an existing headcut that had initially formed following the Cerro Grande Fire in 2000. The three-tiered structure was designed to arrest headcutting, stabilize banks, and prevent the migration of sediment-containing chemicals or radionuclides from historic Laboratory activities. The performance of the Middle Pueblo Canyon Grade Control Structure is assessed annually in the Monitoring Report for the Los Alamos/Pueblo Watershed Transport Mitigation Project (N3B 2021a). The structure has been effective in stabilizing the banks and channel and has contributed to decreasing the rate of stream flow within the canyon.

Figure 6-15. Middle Pueblo Canyon Grade Control Structure looking southeast (photo taken August 2020)

Sandia Wetland Grade Control Structure

The Sandia Wetland Grade Control Structure was completed in 2013; see Figure 6-16. It is at the downstream end of the Sandia Wetland, just upstream of gaging station E123. The purpose of this structure was to stop a large headcut and maintain favorable wetland conditions that help minimize movement of contaminated sediment downstream. The efficacy of the Sandia Wetland Grade Control Structure is assessed annually in the Sandia Canyon Wetland Performance Report (N3B 2021b). This project and the annual assessment fulfill requirements set forth in the "Work Plan and Final Design for Stabilization of the Sandia Canyon Wetland" (LANL 2011d). Since reporting began, the structure has functioned as intended and has promoted the expansion of the Sandia Wetland while also retaining sediment.

Figure 6-16. Upper portion of Sandia Wetland Grade Control Structure, looking north (photo taken September 2020)

Mortandad and Ten Site Sediment Traps

The Mortandad Sediment Traps are located within the stream channel of Mortandad Canyon downstream of its confluence with Ten Site Canyon; see Figure 6-17. These "traps" are sediment detention basins. Two traps were constructed in 1976, with a third being built in 1980. Since then, the Mortandad Sediment Traps have been re-excavated when sediment filled the basins, usually due to large storms or increased runoff and erosion following wildfires. Major improvements were made in 2014 after a large flood in September 2013 caused significant damage to the traps. The traps were excavated and the material was moved upstream to help stabilize new berms, which serve to reduce the rate of runoff and reduce sediment transport during storm events. The Ten Site Sediment Trap was also constructed during the 2014 improvements; it is located just upstream of the Mortandad and Ten Site Canyon confluence. The Mortandad and Ten Site Sediment Traps are inspected regularly and are reported on in the annual updates to the Site Discharge Pollution Prevention Plan (N3B 2021e).

Figure 6-17. Mortandad Sediment Traps during the revitalization project in October 2014

Conclusion

The results of the storm water, base flow, and sediment data comparisons from samples collected in 2020 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 canyons investigation reports represent an upper bound of potential human and ecological health risks in the canyons for the foreseeable future. Although some chemical concentrations in storm water, base flow, and sediment were above screening levels in 2020, these transient events do not significantly affect human or biota health.

The scatter plots in Figures 6-6 through 6-9 show that the concentrations of chemicals exceeding screening levels in storm flow and base flow samples in 2020 fall within or below the ranges recorded in previous years. Total PCB concentrations in Sandia Canyon tended to be higher than in recent years, although still within range of what has been observed. This area will continue to be monitored closely to detect any upward trends.

We continue to observe very few sediment exceedances in 2020. All sediment exceedances were for manganese, except for one chromium exceedance and one PCB-126 exceedance in Sandia Canyon, where PCB exceedances were also recorded in surface water. Sediment results will be tracked over multiple years and compared with nearby surface water results to detect spatial patterns or trends.

Through the human health risk assessments in the canyons investigation reports, 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 sediment are below levels that would impact human or biota health.

Additionally, the Laboratory's continued maintenance and construction of watershed-scale engineered controls has been effective in minimizing the migration of contaminated sediment downstream to the Rio Grande.

Quality Assurance

Sampling of storm flow, base flow, and sediment, as well as measuring stream flow, is performed according to written quality assurance and quality control procedures and protocols. Current versions of all procedures and guides are listed at https://ext.em-la.doe.gov/EPRR/ReadingRoom.aspx?room=2. 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.

Analytical results meet the N3B minimum data quality objectives (DQOs) as outlined in N3B-PLN-SDM-1000: "Sample and Data Management Plan." N3B-PLN-SDM-1000 sets the validation frequency criteria at 100% Level 1 examination and Level 2 verification of data, and at 10% minimum Level 3 validation of data. A Level 1 examination assesses the completeness of the data as delivered from the analytical laboratory, identifies any reporting errors, and checks the usability of the data based on the analytical laboratory's evaluation of the data. A Level 2 verification evaluates the data to determine the extent to which the laboratory met the analytical method and the contract-specific quality control and reporting requirements. A Level 3 validation includes Levels 1 and 2 criteria and determines the effect of potential anomalies encountered during analysis and possible effects on data quality and usability. A Level 3 validation is performed manually with method-specific data validation procedures. Laboratory analytical data are validated by N3B personnel as outlined in N3B-PLN-SDM-1000; N3B-AP-SDM-3000: "General Guidelines for Data Validation"; N3B-AP-SDM-3014: "Examination and Verification of Analytical Data"; and additional method-specific analytical data validation procedures. All associated validation procedures have been developed, where applicable, from the U.S. Environmental Protection Agency QA/G-8 Guidance on Environmental Data Verification and Data Validation, the Department of Defense/Department of Energy Consolidated Quality Systems Manual for Environmental Laboratories, the U.S. Environmental Protection Agency National Functional Guidelines for Data Validation, and the American National Standards Institute/American Nuclear Society 41.5: Verification and Validation of Radiological Data.

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Chapter 7: Ecosystem Health

We monitor ecosystem health to determine whether operations at Los Alamos National Laboratory (LANL or the Laboratory) affect plant or animal populations (collectively called "biota"). We collect samples of soil, sediment, plants, and animals on Laboratory property, near the Laboratory perimeter, and from background locations. Then, we test these samples for radionuclides, inorganic elements (such as metals), and organic chemicals (such as polychlorinated biphenyls [PCBs], per- and polyfluoroalkyl substances [PFAS], dioxins, furans, and high explosives). We also assess radiation dose for plants and animals living around Laboratory facilities and around sediment retention structures in canyon bottoms. The calculated doses are compared with background levels of radiation, screening levels, and federal standards for plants and animals.

During 2020, soil and vegetation samples were collected around the perimeter of Material Disposal Area G at Technical Area 54. Soil, sediment, vegetation, and bird egg samples were collected around the Dual-Axis Radiographic Hydrodynamic Test Facility at Technical Area 15. Bird egg and nestling samples were collected at two open detonation sites and at the open burn grounds. Small mammals and vegetation samples were collected in Los Alamos and Pajarito canyons. Deceased animals (primarily from animal-vehicle collisions) were collected opportunistically from various sites on and off the Laboratory.

We also completed an aquatic ecosystem health assessment of the Rio Grande upstream and downstream of the Laboratory, as well as in Abiquiu and Cochiti Lake reservoirs. We collected fish, crayfish, and sediments, conducted sediment biotoxicity assays, and evaluated benthic macroinvertebrate communities.

The Laboratory reports our sampling results in this chapter. We also report results from avian monitoring projects and from surveys for threatened and endangered species.

In most soil, sediment, plant, and animal samples from onsite and perimeter locations, radionuclides and chemicals were either not detected, had levels similar to background, or had levels below the screening levels protective of biota. Biota dose assessments indicate that the radiation doses are far below the levels that have adverse effects on plants and animals. Endangered species surveys in 2020 confirmed that two Mexican spotted owl habitats were again occupied and that both pairs of Mexican spotted owls produced young.

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Introduction

An ecosystem includes living organisms, such as plants, animals, and bacteria; nonliving factors, such as soil, air, and water; and the interactions among these components (Smith and Smith 2012). The health of an ecosystem can be affected by disturbances including wildfire, flooding, drought, invasive species, climate shifts, chemical spills, construction projects, vegetation removal, and other events (Rapport 1998). Los Alamos National Laboratory (LANL or the Laboratory) provides habitat to many species of plants and animals (collectively called "biota"). We monitor ecosystem health to determine if past or current releases of radionuclides and chemicals from Laboratory operations are affecting local plants and animals.

Two types of monitoring are conducted: facility-specific and institutional. Facility-specific monitoring is used to measure radionuclides and chemical levels associated with specific facilities and operations at the Laboratory. Institutional monitoring occurs on Laboratory property, around the perimeter of the Laboratory, and at regional background locations. It measures the levels of radionuclides and chemicals in the areas outside of designated solid waste management units. Some of the samples collected for institutional monitoring rotate on a three-year cycle: (1) soils, (2) foodstuffs (results for the years they were collected are reported in Chapter 8), and (3) samples from the Rio Grande and nearby reservoirs. In 2020, we collected the Rio Grande and reservoir samples.

Both institutional and facility-specific results are used to assess the 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 on Laboratory property and near the perimeter of the Laboratory, and then comparing these levels with
    1. levels measured from background locations not affected by Laboratory operations,
    2. levels that scientists have determined should trigger further investigation, such as screening levels, and
    3. levels that may cause adverse health effects.
- Evaluating trends in radionuclide and chemical levels in soil, plants, and animals over time
- Assessing population parameters and species diversity of animals in areas potentially affected by Laboratory operations
- Estimating radiation dose and chemical risk to biota using the monitoring results

Ecosystem Health Assessment Methods

One way we assess ecosystem health is by collecting a variety of environmental samples, including soil, sediments, native vegetation, honey, small mammals, bird eggs, crayfish, fish, and other animals, and analyzing them for substances such as radionuclides, inorganic elements such as metals, and organic chemicals such as polychlorinated biphenyls (PCBs), high explosives, dioxins, furans, volatile organic compounds, semi-volatile organic compounds, and per- and polyfluoroalkyl substances (PFAS).

Soil and Sediment

Soil receives substances that are released in air emissions and particles that are transported by wind and water. Monitoring soil over time directly measures long-term trends of radionuclide and other chemical concentrations around nuclear facilities (DOE 2015).

Levels of constituents in soil and sediment collected at and near the Laboratory are compared with regional statistical reference levels. The regional statistical reference level for a chemical or radionuclide in soil is calculated using results from all of the soil samples collected at regional background locations during the past 10 years. The regional statistical reference level is the level below which precisely 99 percent of the results from regional background soil samples fall. As required by the U.S. Department of Energy (DOE), all background locations are: at a similar elevation to the Laboratory, more than 9.3 miles away from the Laboratory, and beyond the range of potential influence from normal Laboratory operations (DOE 2015). Radionuclides and other chemicals in soil collected from regional background locations come from naturally occurring sources and from manmade sources other than the Laboratory, including past testing of atomic weapons, power plant emissions, and automobile emissions.

Levels of constituents in soil and sediment are also compared with ecological screening levels (LANL 2021). One type of ecological screening level is the highest level of a radionuclide or chemical in the soil that is known to not affect selected animals or plants (the no-effect ecological screening level). Another type is the lowest level in the soil and sediment known to be associated with an adverse effect on selected animals or plants (the low-effect ecological screening level) (LANL 2021). We compare our soil results to ecological screening levels for the following terrestrial ecological receptors: generic plant; earthworm—representing soil-dwelling invertebrates; desert cottontail (*Sylvilagus audubonii*)—representing mammalian herbivores; deer mouse (*Peromyscus maniculatus*)—representing mammalian omnivores; montane shrew (*Sorex monticolus*)—representing mammalian terrestrial insectivores; Botta's pocket gopher

What are PFAS?

Per- and polyfluoroalkyl substances (PFAS) are a class of synthetic compounds that are found in many manufactured items such as cookware, food packaging, stain repellents, and fire-fighting foams. They can repel oil, stains, grease, and water, and are fire-resistant. There are nearly 6,000 types of PFAS compounds known, some of which have been more widely used and studied than others.

The widespread use of PFAS and their ability to persist in the environment means that past and current uses may result in increasing PFAS levels in the environment and bioaccumulation in animal tissue. PFAS also have possible impacts on human health.

Currently, neither the U.S. Environmental Protection Agency nor the State of New Mexico regulate PFAS compounds. In 2016, the U.S. Environmental Protection Agency issued a health advisory level of 70 parts per trillion in drinking water for three individual PFAS compounds. This health advisory level is non-enforceable and non-regulatory.

In December 2018, the New Mexico Water Quality Control Commission listed three PFAS compounds (PFOS, PFHxS, PFOA) as toxics in groundwater, but without levels for standards.

In the beginning of 2020, the U.S. Environmental Protection Agency added specific PFAS to the list of reportable compounds under the Toxic Release Inventory. In addition, specific PFAS have been proposed to be added to the Comprehensive Environmental Response, Compensation, and Liability Act list of hazardous substances.

> **What is a receptor?**
>
> A receptor is any animal or plant that will be potentially exposed to and adversely affected by the release or migration of contaminants.

(*Thomomys bottae*)—representing burrowing mammals; gray fox (*Urocyon cinereoargenteus*)—representing mammalian carnivores; occult little brown bat (*Myotis lucifugus occultus*)—representing mammalian aerial insectivores; American robin (*Turdus migratorius*)—representing avian omnivores, herbivores, and insectivores; violet-green swallow (*Tachycineta thalassina*)—representing avian aerial insectivores; and American kestrel (*Falco sparverius*)—representing avian carnivores (LANL 2021). Ecological screening levels have also been developed for the following aquatic ecological receptors: algae—representing aquatic autotrophs; aquatic snails—representing aquatic herbivore/grazer; daphnids—representing aquatic omnivore/herbivore; fish—representing aquatic intermediate carnivore; and aquatic community organisms (LANL 2021).

Plants and Animals

Levels of constituents in plant and animal tissues are compared with lowest observable adverse effect levels when available. A lowest observable adverse effect level is the lowest concentration measured in a plant or animal's tissues that has been associated with an adverse effect (EPA 2014). Levels of radionuclides in tissues are compared with biota dose screening levels, which are set at 10 percent of the DOE limit for radiation doses to biota (DOE 2019, McNaughton 2006).

If a radionuclide is detected in soil, plants, or animals at a level that is higher than the screening levels, then the dose to biota is calculated using RESRAD-BIOTA software (version 1.8) (http://resrad.evs.anl.gov/codes/resrad-biota/). This is DOE's methodology for evaluating radiation doses to aquatic and terrestrial biota. This calculated dose is compared with DOE limits: 1 rad per day for terrestrial plants and aquatic animals, and 0.1 rad per day for terrestrial animals (DOE 2019).

Comparisons Among Sites and Over Time

We perform statistical tests to evaluate differences in constituents among sites and to examine trends in constituent levels over time. Examples of these tests include *t*-tests, analysis of variance, Kruskal-Wallis tests, Kendall's Tau tests, linear regressions, and generalized linear models. Samples collected within approximately the past 10 years are used to study trends over time because the samples are directly comparable: They were analyzed with similar analytical methods and instruments and have similar detection limits. We test a null hypothesis for each set of data, typically there are no differences among locations, or there are no increasing trends over time. For each test, we select a probability level, or p-value, of the null hypothesis being correct at which we accept or reject the null hypothesis. A p-value of less than 5 percent ($p < 0.05$) is used as our threshold to reject the null hypothesis of no difference between locations or no trend over time. If the p-value is greater than 5 percent ($p > 0.05$), we accept the null hypothesis of no difference or no trend.

Facility-Specific 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 7-1). Tritium, plutonium, americium, and uranium are the main radionuclides in waste materials at Area G (Mayfield and Hansen 1983). 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).

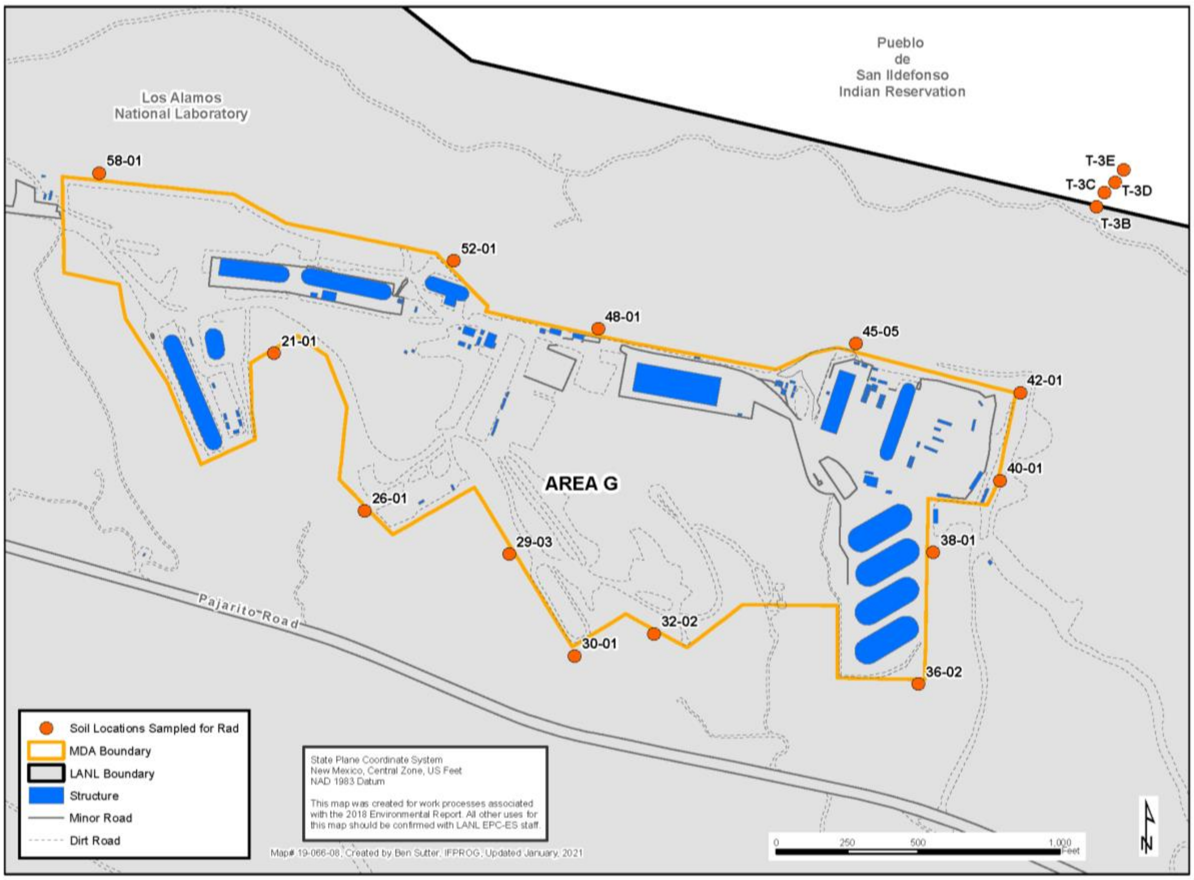

Figure 7-1. Locations of soil and vegetation samples collected around Area G and near the Laboratory and Pueblo de San Ildefonso boundary in 2020. Note: MDA is Material Disposal Area.

We collect surface soil and vegetation at Area G each year for testing. Surface soil grab samples (0 to 6 inches deep) and composite tree samples, primarily of one-seed juniper (*Juniperus monosperma*), were collected in June 2020 at 13 designated locations around the perimeter of Area G. Four soil and one composite tree samples were collected at the bottom of Cañada del Buey near the boundary between the Laboratory and the Pueblo de San Ildefonso (Figure 7-1). All samples were analyzed for tritium, americium-241, cesium-137, plutonium-238, plutonium-239/240, strontium-90, uranium-234, uranium-235/236, and uranium-238.

Soil Results

The 2020 soil results at Area G are summarized as follows (see supplemental table S7-1 for individual results):

- Cesium-137, strontium-90, and uranium-235/236 activities were below the regional statistical reference levels.
- Uranium-234 and uranium-238 activity were similar to or below the regional statistical reference levels.
- Americium-241, plutonium-238, plutonium-239/240, and tritium activities were above the regional statistical reference levels in several locations.

Americium-241, plutonium-238, and plutonium-239/240 in soil samples collected on the north, northeastern, and eastern side of Area G were above the regional statistical reference level. These concentrations are similar with previous years and are not increasing over time (Kendall's Tau, $p > 0.05$; Figure 7-2). Levels of tritium in soil samples collected on the southern side of Area G were above the regional statistical reference level, which are consistent with data from previous years. Tritium levels are not statistically increasing over time (Kendall's Tau, $p > 0.05$; Figure 7-2).

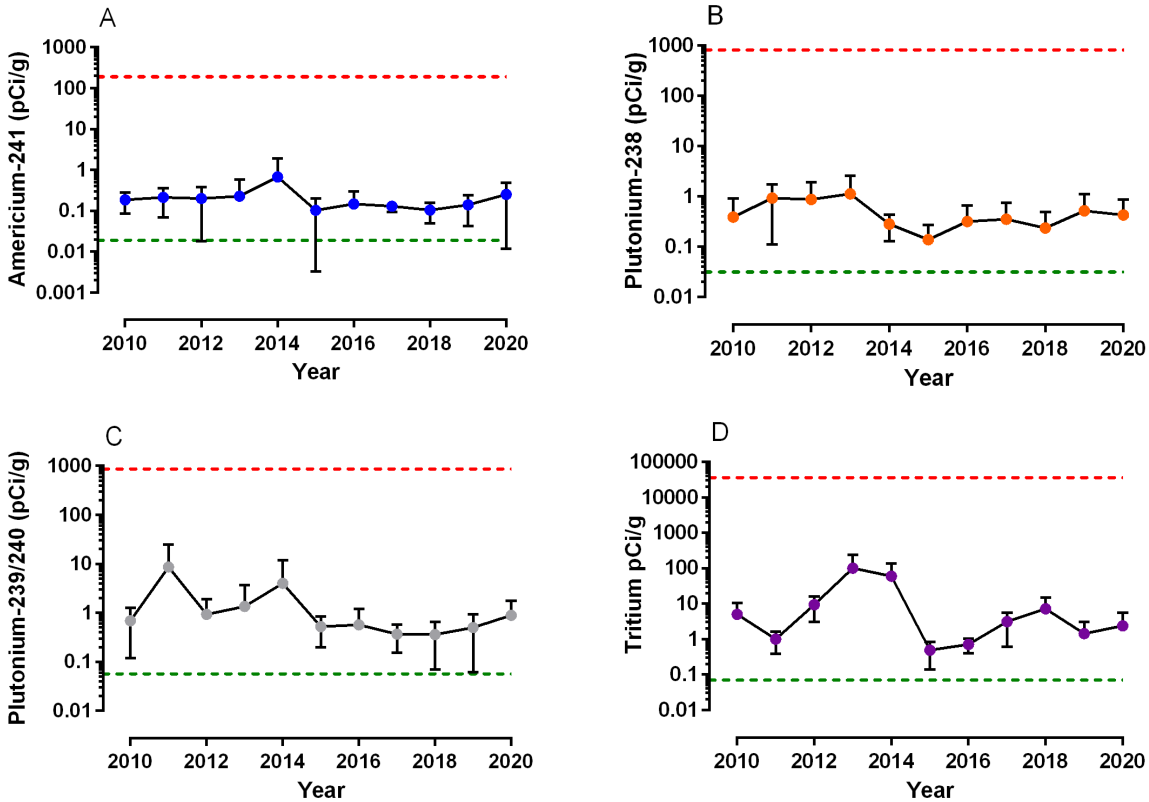

Figure 7-2. (A) Americium-241, (B) plutonium-238, (C) plutonium-239/240 activities in surface soil samples collected from five locations on the northern, northeastern, and eastern side (locations 38-01, 40-01, 42-01, 45-05 and 48-01), and (D) tritium activities in surface soil samples collected from two locations on the southern side (locations 29-03 and 30-01) of Area G at Technical Area 54 from 2010 to 2020. Data are compared with the regional statistical reference level (green dashed line) and the lowest no-effect ecological screening level (red dashed line). Note the logarithmic scale on the vertical axis. Points represent mean and error bars represent standard deviation. Bottom error bars are absent on some points as the error would have been a negative value; however, negative values cannot be shown on a logarithmic axis. Note: pCi/g = picocuries per gram.

Vegetation Results

Tree samples were collected at the same general locations as the soil samples (Figure 7-1). However, because of a firebreak along the fence line, some of the trees were located more than 30 feet away from the fence around Area G, particularly on the northern and eastern sides. Levels of radionuclides in native tree samples (primarily one-seed juniper) can be caused by uptake by roots and by deposition of radionuclides on the surfaces of leaves and branches.

The 2020 native tree results at Area G are summarized as follows (see supplemental table S7-2 for individual results):

- The majority of radionuclides in overstory vegetation samples were either not detected or were below the regional statistical reference levels.
- All activities were below the biota dose screening levels.
- Radionuclides in vegetation are not increasing over time (Kendall’s Tau, $p > 0.05$).

Americium-241 levels in overstory vegetation samples are decreasing over time at several locations at the northeastern corner of Area G, including 40-01, 42-01, 45-05, 48-01 (Kendall's Tau, $p < 0.05$; Figure 7-3). After including the 2020 results, there was no longer a significant decreasing trend in americium-241 values at location 38-01. The percent of nondetects for americium-241 in these vegetation samples ranges from 35 to 90 percent, and could be influencing the trend analyses results.

Similar to previous years, tritium in overstory vegetation was highest (up to 590 picocuries per milliliter) in trees growing in the southern sections near the tritium disposal shafts. The overall trend in plant tritium is highly variable from year to year but the levels have not been increasing over time (Kendall’s Tau, $p > 0.05$; Figure 7-3). Variability in plant tritium levels may be a result of any, or a combination, of the following: soil moisture, depth of roots, time of sampling, distance from the perimeter fence, temperature, or barometric pressure.

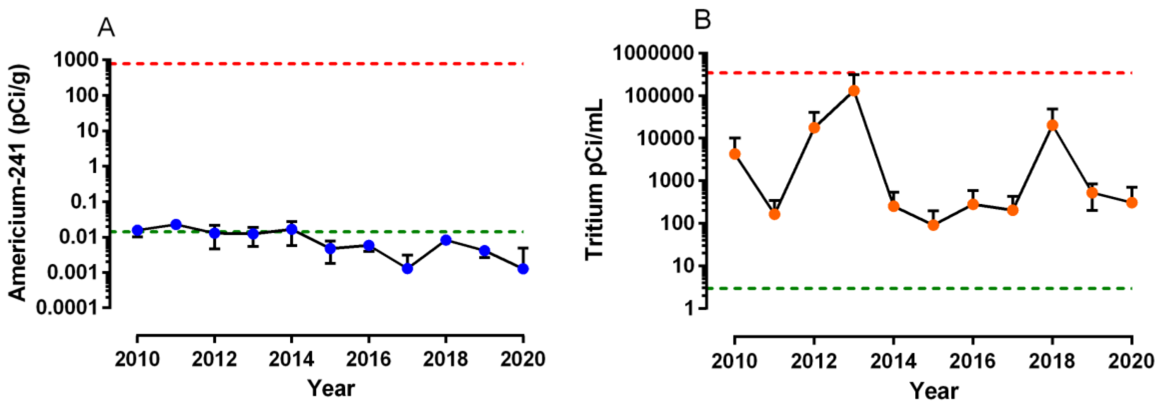

Figure 7-3. (A) Americium-241 activities in overstory vegetation samples collected from five locations on the northeastern corner of Area G (locations 38-01, 40-01, 42-01, 45-05, and 48-01), and (B) tritium activities in overstory vegetation samples collected from two southern locations (locations 29-03 and 30-01) around Area G at Technical Area 54 from 2010 to 2020. Data are compared with the regional statistical reference level (green dashed line) and biota dose screening level for overstory vegetation (red dashed line). Note the logarithmic scale on the vertical axis. Points represent mean and error bars represent standard deviation. Bottom error bars are absent on some points as the error would have been a negative value; however, negative values cannot be shown on a logarithmic axis. Note: pCi/g = picocuries per gram and pCi/mL = picocuries per milliliter.

Laboratory/Pueblo de San Ildefonso Boundary in Cañada del Buey

In 2020, a duplicate-split soil sample (where soil is thoroughly mixed in a bag and split into two sample containers) was collected at location T3-B on Laboratory property near the Technical Area 54 and Pueblo de San Ildefonso boundary (Figure 7-1). This location has been sampled from 2016 through 2020. An additional three soil samples were collected on Pueblo de San Ildefonso property at locations T3-C, T3-D, and T3-E, near the Laboratory and Pueblo de San Ildefonso boundary (Figure 7-1).

The 2020 soil results at the Laboratory/Pueblo de San Ildefonso Boundary in Cañada del Buey are summarized as follows (see supplemental table S7-1 for individual results):

- The majority of radionuclide activities in soil were not detected or were below the regional statistical reference level.
- Soil activities of Plutonium-238 and 239/240 were above the regional screening levels at location T-3B.
- All soil radionuclide activities were below the ecological screening levels.
- All radionuclides in overstory vegetation were below their regional statistical reference levels.

Americium-241 was not detected in one of the duplicate samples at T-3B (measured activity of 0.0152 picocuries per gram). Yet, it was detected in the other duplicate sample at 0.0252 picocuries per gram. This value is slightly above the regional statistical reference level of 0.0187 picocuries per gram. Americium-241 activities at T3-C, T3-D, and T3-E were 0.0142, 0.0076, and 0.0020 picocuries per gram, respectively, and were all below the regional statistical reference level of 0.0187 picocuries per gram.

Plutonium-238 was detected in both duplicate soil samples at T-3B with activities of 0.6310 and 0.6980 picocuries per gram, above the regional statistical reference level of 0.0314 picocuries per gram. Plutonium-238 activities at T3-C, T3-D, and T3-E were 0.0256, 0.0230, and 0.0054 picocuries per gram, respectively, and were all below the regional statistical reference level of 0.0314 picocuries per gram.

Plutonium-239/240 was detected in both duplicate soil samples at T-3B with activities of 0.0675 and 0.0810 picocuries per gram, which are above the regional statistical reference level of 0.0571 picocuries per gram. Plutonium-239/240 activities at T3-C, T3-D, and T3-E were 0.0479, 0.0390, and 0.0336 picocuries per gram, respectively, and were all below the regional statistical reference level of 0.0571 picocuries per gram.

All of these observations are well below the no-effect ecological screening levels for americium-241, plutonium-238, and plutonium 239/240 of 190, 820, and 870 picocuries per gram, respectively. Between 2016 and 2020, concentrations of radionuclides in soil at T3-B near the Technical Area 54 and Pueblo de San Ildefonso boundary did not show any trends over time (Kendall's Tau, $p > 0.05$; Figure 7-4).

All three uranium isotopes were detected in all soil samples collected near Technical Area 54 and the Pueblo San Ildefonso boundary. Most observations were below the regional statistical reference level (Table S7-1). However, at T3-D, uranium-234 and uranium-238 were detected at 1.520 and 1.540 picocuries per gram, respectively, and were slightly above the regional statistical reference level of 1.496 and 1.481 picocuries per gram (Table S7-1). The near 1:1 ratio of uranium-234 to uranium-238 activities indicate that these uranium activities are from naturally occurring sources (U.S. Nuclear Regulatory Commission 2019) and the concentrations observed here are similar to Laboratory background concentrations (Ryti et al. 1998).

Radionuclides in overstory vegetation collected near the Technical Area 54 and Pueblo de San Ildefonso boundary were all below the regional statistical reference level. All radionuclides are far below the biota dose screening level, which are protective of biota, and no radionuclides levels are increasing over time in vegetation (Kendall's Tau, p > 0.05; Table S7-2).

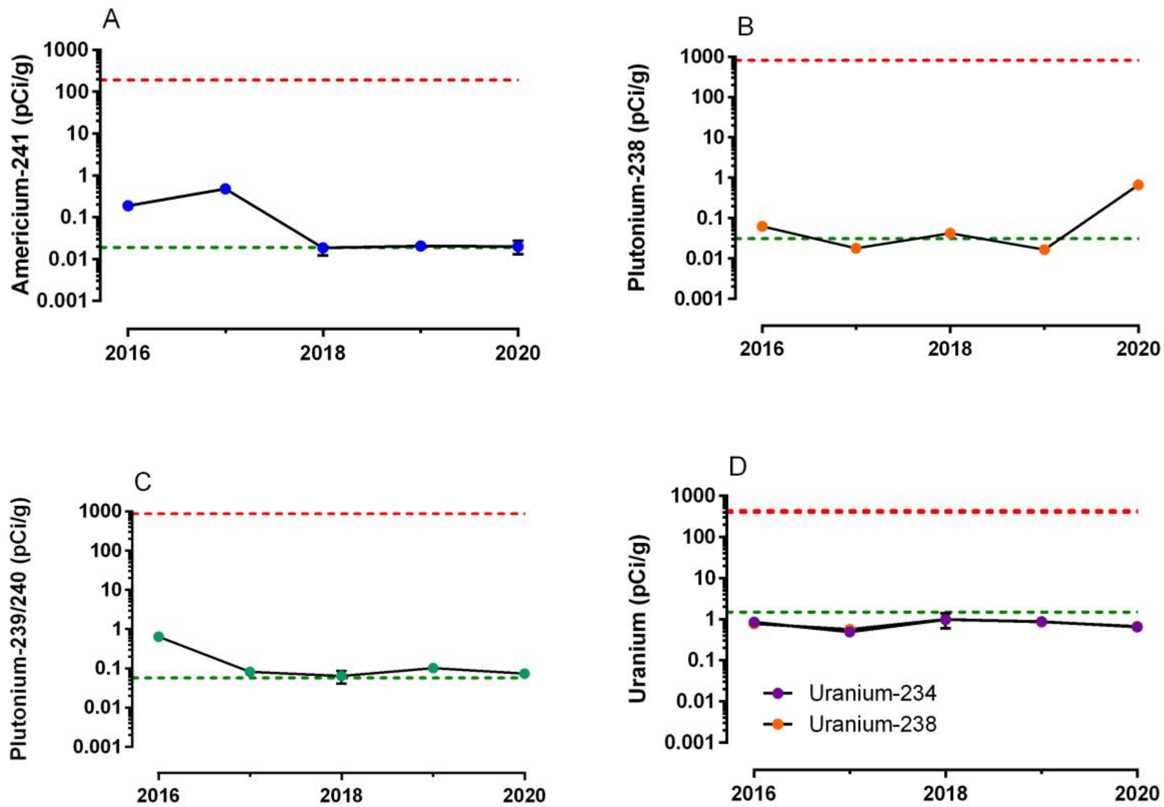

Figure 7-4. (A) Americium-241, (B) plutonium-238, (C) plutonium-239/240, and (D) uranium-234 and uranium-238 activities in soil collected near the Technical Area 54 and Pueblo de San Ildefonso border from 2016 through 2020 at the T3-B location on Laboratory property. Results from 2018 through 2020 are the average of duplicated samples. Data are compared with the regional statistical reference level (green dashed line) and the lowest no-effect ecological screening level (red dashed line). Note the logarithmic scale on the vertical axis. Points represent true values (between 2016 and 2017, n = 1 each) or represent mean values (between 2018 and 2020, n = 2 each), and error bars represent standard deviation. Error bars may appear absent on some points, as standard deviations are too small to plot. Note: pCi/g = picocuries per gram.

Other Samples Collected from Pueblo de San Ildefonso

In 2020, two other soil samples were collected from Pueblo de San Ildefonso property. One was collected on Pueblo de San Ildefonso Sacred Area lands on the north side of the fence line across from Area G. The other was collected further north near Tsankawi. Several radionuclides were not detected in the soil samples and all detectable levels of radionuclides were below the regional statistical reference level and were well below the no-effect ecological screening levels protective of biota (Table S7-3). No radionuclides are increasing over time (Kendall's Tau, $p > 0.05$).

All inorganic elements were detected in soil samples from Pueblo de San Ildefonso and all concentrations were below their regional statistical reference levels. However, mercury, selenium, thallium, and vanadium exceeded the no effect ecological screening level in one or both of the soil samples (Table S7-4). As a note, the regional statistical reference level of these elements is also above the no-effect ecological screening level (Table S7-4). Selenium was increasing in soil collected from the Sacred Area (Kendall's Tau, $p < 0.05$). However, all observed levels are below the regional statistical reference levels. This trend will be monitored closely in future sampling. No other elements are increasing over time in soil collected from Pueblo de San Ildefonso (Kendall's Tau, $p > 0.05$).

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. Soil, sediment from drainages, plants, and animals are monitored at the facility to determine whether constituents released from operations may be affecting plants or animals and if the levels are consistent with our expectations of radionuclide and chemical uptake. Environmental 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 have been conducted since 2007.

Monitored constituents in soil and sediment include radionuclides, beryllium (and other inorganic elements), and organic chemicals such as high explosives, dioxins and furans, and recently PFAS chemicals. Routine biological samples collected around the Dual-Axis Radiographic Hydrodynamic Test Facility have included overstory vegetation, small mammals, honey bees and/or honey, and bird eggs and nestlings. Samples of soil, sediment, and one type of biota are collected annually. Typically, the collection of vegetation, honey bees and/or honey, and small mammals sampling is rotated, so that each is sampled once in a three-year period. Bird samples are collected opportunistically when abandoned or infertile eggs or deceased nestlings are found in local nest boxes. In 2020, we collected soil, sediment, overstory vegetation and egg samples at the facility. All sample locations are shown in Figure 7-5.

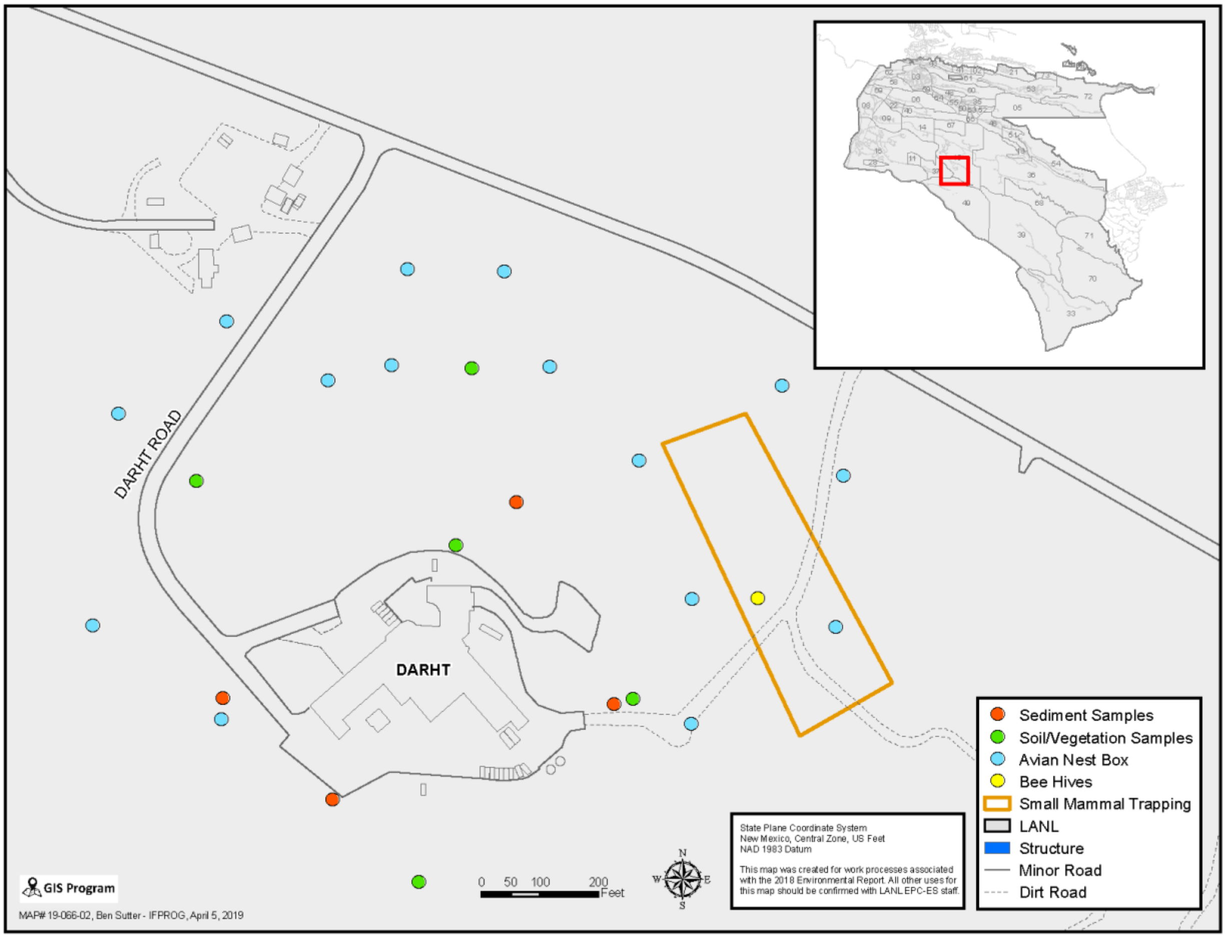

Figure 7-5. Soil, sediment, and biota sample locations at the Dual-Axis Radiographic Hydrodynamic Test Facility (DARHT) at Technical Area 15.

For soil samples, we collect five surface soil subsamples at a depth from zero to two inches, and mix them to prepare a composite soil sample at each location. The soil and overstory vegetation samples were collected in May 2020 on the north, east, south, and west sides of the Dual-Axis Radiographic Hydrodynamic Test Facility perimeter along the fence line. An additional composite soil sample was collected about 75 feet north of the firing point along the side of the protective berm. We collected sediment grab samples at depths from zero to six inches on the north, east, south, and southwest sides within drainages around the facility. All soil, sediment and vegetation samples were analyzed for the following: (1) the radionuclides americium-241, cesium-137, plutonium-238, plutonium-239/240, strontium-90, tritium, uranium-234, uranium-235/236, and uranium-238; (2) inorganic elements including aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, potassium, selenium, silver, sodium, thallium, vanadium, and zinc; and (3) PFAS chemicals including ethyl perfluorooctanesulfonamidoacetic acid[N-] (NEtFOSAA), methyl perfluorooctanesulfonamidoacetic acid[N-] (NMeFOSAA), perfluorobutanesulfonic acid (PFBS), perfluorodecanoic acid (PFDA), perfluorododecanoic acid (PFDoDA), Perfluoroheptanoic acid (PFHxS), perfluorohexanoic acid (PFHxA), perfluorononanoic acid (PFNA), perfluorooctanesulfonic acid (PFOS), perfluorooctanoic acid (PFOA), perfluorotetradecanoic acid (PFTeDA), perfluorotridecanoic acid (PFTrDA), and perfluoroundecanoic acid (PFUnDA). All soil and sediment samples were analyzed for high explosives, and the sample nearest to the firing point was also analyzed for dioxins and furans.

In 2020, we collected four overstory vegetation samples at the same locations as soil samples; species include ponderosa pine (*Pinus ponderosa*), pinyon pine (*Pinus edulis)*, gambel's oak (*Quercus gambelii*), and Russian olive (*Elaeagnus angustifolia*). Overstory vegetation samples were analyzed for radionuclides, inorganic elements, and PFAS chemicals as describe above. Eggs that did not hatch and nestlings that died of natural causes were collected from nest boxes surrounding the Dual-Axis Radiographic Hydrodynamic Test Facility and chemically analyzed. One sample consisting of an individual mountain bluebird (*Sialia currucoides*) egg, one sample consisting of an individual western bluebird (*Sialia mexicana*) egg, and a composite of four western bluebird eggs were collected and analyzed for inorganic elements as described above.

Constituent results in soil, sediment, and overstory vegetation samples are compared with the baseline statistical reference levels. The baseline statistical reference levels for the Dual-Axis Radiographic Hydrodynamic Test Facility are based on samples collected at the facility during 1996 to 1999, before the beginning of firing site operations. The baseline level for each constituent is the precise level below which 99 percent of samples from this time occurred (Nyhan et al. 2001). In cases where there are no baseline statistical reference levels (mostly inorganic elements like aluminum, calcium, cobalt, iron, magnesium, manganese, potassium, sodium, vanadium, and zinc), the soil and biota chemical results are compared with regional statistical reference levels.

Soil and Sediment Radionuclide Results

The 2020 soil and sediment results at the Dual-Axis Radiographic Hydrodynamic Test Facility are summarized as follows (see supplemental table S7-5 for individual results):

- Soil and sediment samples collected around the Dual-Axis Radiographic Hydrodynamic Test Facility did not contain detectable levels of americium-241.
- The majority of samples did not contain detectable levels of cesium-137, strontium-90, or tritium.
- Most of the detectable activities of cesium-137, plutonium-238, plutonium-239/240, and all activities of strontium-90 were below the baseline regional statistical reference level, and/or regional statistical reference level.
- All activities were far below ecological screening levels that are protective of biota.

In 2020, soil and sediment samples contained all three isotopes of uranium. This observation is consistent with previous years. Several samples contained activities of uranium that were higher than the regional statistical reference level and the baseline statistical reference level. The relative isotopic abundance of uranium-234, uranium-235, and uranium-238 activities (15.2 percent uranium-234, 1.1 percent uranium-235, and 84.7 percent uranium-238) indicate that the uranium in these samples are depleted uranium from testing activities rather than natural uranium (International Atomic Energy Agency 2019). The levels of uranium are far below ecological screening levels that are protective of biota.

Operations at the Dual-Axis Radiographic Hydrodynamic Test Facility have changed since 2007 to include the use of closed-containment vessels. Since 2008, uranium-238 activity near the firing point has mostly been similar to the baseline statistical reference level (Figure 7-6). Levels of radionuclides in soil and sediment samples collected around the Dual-Axis Radiographic Hydrodynamic Test Facility are not increasing over time (Kendall's Tau, p > 0.05).

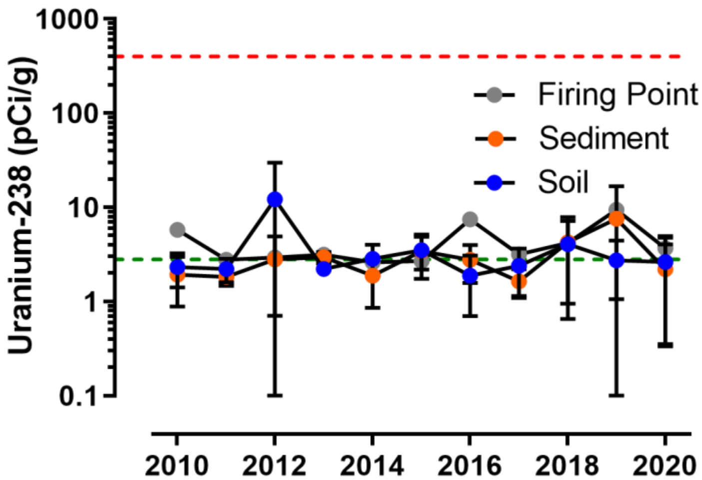

Figure 7-6. Uranium-238 activities in surface soil and sediment samples collected around the Dual-Axis Radiographic Hydrodynamic Test Facility and in the firing point soil sample from 2010 to 2020 compared with the baseline statistical reference level (mean plus three standard deviations of soil uranium-238 pre-operations; green dashed line) and the lowest no-effect ecological screening level for the plant (red dashed line). Note the logarithmic scale on the vertical axis. Points represent true values (firing point 2010-2019) or represent means (sediment, and soil samples and the firing point in 2020) and error bars represent standard deviation. Bottom error bars are absent on some points as the error would have been a negative value; however, negative values cannot be shown on a logarithmic axis. Note: pCi/g = picocuries per gram.

Soil and Sediment Inorganic Element Results

The 2020 soil and sediment inorganic element results at the Dual-Axis Radiographic Hydrodynamic Test Facility are summarized as follows (see supplemental Table S7-6 for individual results):

- All inorganic elements were found at detectable concentrations in all soil and sediment samples collected in 2020.
- Concentrations of the majority of inorganic elements (aluminum, antimony, arsenic, beryllium, cadmium, calcium, chromium, cobalt, iron, lead, magnesium, nickel, potassium, and silver) were below all reference and screening levels.
- Concentrations of nine inorganic elements (barium, copper, lead, manganese, mercury, selenium, thallium, vanadium, and zinc) exceeded the no-effect ecological screening level for the plant, montane shrew, or American robin and/or the low-effect ecological screening level for the American robin in some samples.
- The number of locations with concentrations potentially associated with adverse effects at an individual level are minimal, and no impacts to populations or communities of plants and animals are expected.

Consistent with observations in previous years, some soil and sediment samples contained concentrations of barium (three samples), copper (one sample), lead (two samples), manganese (seven samples), mercury (seven samples), selenium, (nine samples), thallium (ten samples), vanadium (ten samples), and zinc (two samples) that exceeded the no-effect ecological screening level for the plant, montane shrew, or American robin and/or the low-effect ecological screening level for the American robin. This included the soil sample collected at the firing point. All concentrations of barium, copper, lead, manganese, mercury, thallium, and vanadium were below the regional statistical reference levels and the baseline statistical reference levels (when available). As a note, the regional statistical reference level of these elements is also above the no-effect ecological screening level (Table S7-6).

Nine soil and sediment samples contained selenium concentrations (range 0.61–1.1 milligrams per kilogram) that were above the baseline statistical reference level (0.68 milligrams per kilogram) and/or the no-effect ecological screening level for the plant (0.52 milligrams per kilogram) and/or montane shrew (0.70 milligrams per kilogram). All the selenium concentrations were below the regional statistical reference level (1.79 milligrams per kilogram). Two sediment samples contained zinc concentrations (70 and 82 milligrams per kilogram) that were higher than the regional statistical reference level (50 milligrams per kilogram) and were above the no-effect ecological screening level for the American robin (47 milligrams per kilogram). Two sediment samples also exceeded the regional statistical reference level for sodium (140 milligrams per kilogram; observations 340 and 740 milligrams per kilogram).

Consistent with data in previous years, selenium, copper, and zinc concentrations were increasing over time in the sediment sample collected from the east side of the Dual-Axis Radiographic Hydrodynamic Test Facility (Kendall’s Tau, $p < 0.05$; Figure 7-7). Cadmium, chromium, and sodium were also increasing at this location in 2020 (Kendall’s Tau, $p < 0.05$). Unlike previous years, calcium and sodium were increasing over time in soil collected from the south side; cadmium and manganese were increasing over time in soil collected from the north side; and sodium and zinc were increasing over time in sediment collected from the south side of the Dual-Axis Radiographic Hydrodynamic Test Facility (Kendall’s Tau, $p < 0.05$). These trends will be monitored closely in future sampling. No other elements are increasing over time around the Dual-Axis Radiographic Hydrodynamic Test Facility.

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 milligrams per kilogram) in any of the soil or sediment samples during 2020. Beryllium concentrations in all soil and sediment samples from 2010 to 2020 have been below the baseline statistical reference level (Figure 7-7).

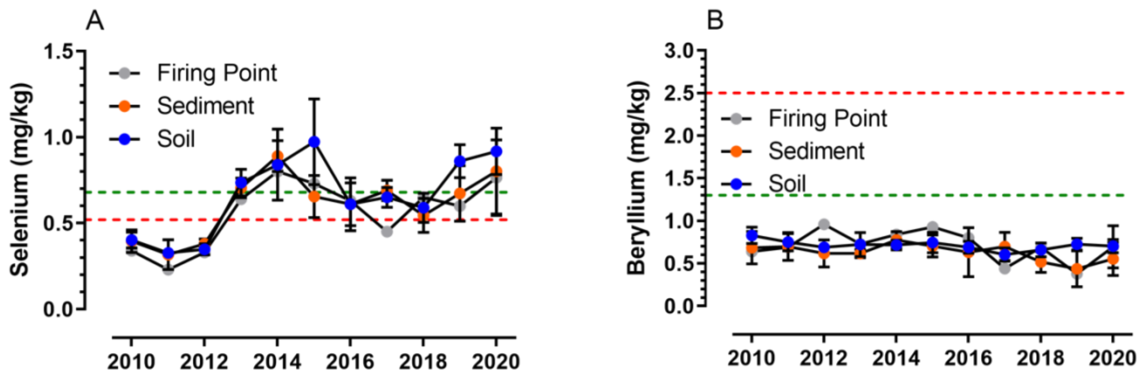

Figure 7-7. (A) Selenium and (B) beryllium concentrations in surface soil and sediment samples collected around the Dual-Axis Radiographic Hydrodynamic Test Facility and near the firing point soil sample from 2010 to 2020, compared with the baseline statistical reference level (mean plus three standard deviations of soil concentrations pre-operations; green dashed line) and the lowest no-effect ecological screening level (red dashed line). Note the linear scale on the vertical axis. Points represent true values (firing point 2010–2019) or represent means (sediment and soil samples, and the firing point in 2020) and error bars represent standard deviation. Note: mg/kg = milligrams per kilogram.

Soil and Sediment Organic Compound Results

The 2020 soil and sediment organic compound results at the Dual-Axis Radiographic Hydrodynamic Test Facility are summarized as follows (see supplemental table S7-7 for individual results):

- No high-explosives chemicals were detected in any of the soil or sediment samples in 2020.
- No furans were detected at the firing point.
- Dioxins were detected at the firing point at concentrations with toxic equivalency values orders of magnitude less than the montane shrew no-effect ecological screening level for TCDD.
- PFAS chemicals were detected at concentrations below ecological screening levels.

Consistent with previous years, 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 in 2020, including the sample closest to the firing point. Dioxins and furans were evaluated in the duplicate soil sample collected at the firing point; all furans and most dioxins, including 2,3,7,8-tetrachlorodibenzodioxin (TCDD), were not detected. The only detected dioxin congeners were 1,2,3,4,6,7,8-heptachlorodibenzodioxin at concentrations of 0.787 and 0.892 nanograms per gram and 1,2,3,4,6,7,8,9-octachlorodibenzodioxin at concentrations of 7.3 and 8.26 nanograms per gram. There are no ecological screening levels for these dioxin congeners, however, toxic equivalent factors for TCDD-like compounds can be used to calculate the TCDD toxic equivalent for dioxin-like compounds. The toxic equivalent factor is 0.01 for 1,2,3,4,6,7,8-heptachlorodibenzodioxin and 0.0003 for 1,2,3,4,6,7,8,9-octachlorodibenzodioxin (Van den Berg et al. 2006). Multiplying the detectable concentrations of these congeners by their respective toxic equivalents factors yields a value that is orders of magnitude less than the montane shrew no-effect ecological screening level for TCDD (0.29 nanograms per gram).

At least one PFAS chemical was detected in all soil and sediment samples except for the soil sample collected on the north side of the Dual-Axis Radiographic Hydrodynamic Test Facility in 2020. PFOS was the most frequently detected PFAS chemical with a range of 0.226 to 42.7 nanograms per gram, however, all concentrations were below the ecological screening levels which are protective of biota. PFNA and PFOA chemicals were also detected frequently in soil and sediment samples with a range of 0.165 to 3.82 and 0.303 to 5.06 nanograms per gram, respectively, again, all concentrations were below ecological screening levels. Sediment collected on the east and south sides of the Dual-Axis Radiographic Hydrodynamic Test Facility contained the highest levels of PFAS chemicals with the greatest number of detects (detections of 11 of the 14 types of PFAS compounds tested for). We have not yet analyzed PFAS chemicals in soil from regional background location; therefore, there currently are no regional statistical reference levels for comparisons. However, concentrations of PFAS chemicals observed here are within the range of global observations of concentrations in soil collected from non-polluted sites (Brusseau et al. 2020).

Vegetation Results

The 2020 overstory vegetation results at the Dual-Axis Radiographic Hydrodynamic Test Facility are summarized as follows (see supplemental tables S7-8 and S7-9 for individual results):

- All radionuclide activities were below the baseline regional statistical reference level, the regional statistical reference level, and the biota dose screening levels.
- All concentrations of inorganic elements in overstory vegetation were below their baseline statistical reference level and the regional statistical reference level.
- PFAS chemicals were not detected in overstory vegetation samples collected around the perimeter of the Dual-Axis Radiographic Hydrodynamic Test Facility.

Overstory vegetation samples collected around the Dual-Axis Radiographic Hydrodynamic Test Facility did not contain detectable levels of americium-241 or cesium-137 and the majority of samples did not contain detectable levels of plutonium-238. Most overstory vegetation samples contained all three uranium isotopes; the near 1:1 ratio of uranium-234 to uranium-238 activities indicate that these uranium activities are from naturally occurring sources (U.S. Nuclear Regulatory Commission 2019). Operations at the Dual-Axis Radiographic Hydrodynamic Test Facility changed in 2007 to include the use of closed-containment vessels. Since 2010, uranium-238 activity in overstory vegetation has been below the baseline statistical reference level (Figure 7-8). All radionuclide activities were below the baseline regional statistical reference level, the regional statistical reference level, and the biota dose screening levels, which are protective of biota. Levels of radionuclides in overstory vegetation samples collected around the Dual-Axis Radiographic Hydrodynamic Test Facility are not increasing over time (Kendall's Tau, $p > 0.05$).

Several inorganic elements were not detected in overstory vegetation collected around the Dual-Axis Radiographic Hydrodynamic Test Facility and all concentrations were below their baseline statistical reference level and the regional statistical reference level. Contrary to observations in soil and sediment, antimony was increasing over time in the overstory vegetation samples collected on the north, west, and south sides of the Dual-Axis Radiographic Hydrodynamic Test Facility (Kendall's Tau, $p < 0.05$). Selenium in vegetation was increasing over time on the south side (Kendall's Tau, $p < 0.05$). Similar to observations in soil, manganese was increasing in overstory vegetation collected on the north side; nickel was also increasing in vegetation at this location (Kendall's Tau, $p < 0.05$). However, all observed levels are below the baseline and regional statistical reference levels; thus, these levels are not of concern at this time. These trends will be monitored closely in future sampling. No other elements are increasing over time around the Dual-Axis Radiographic Hydrodynamic Test Facility (Kendall's Tau, $p > 0.05$).

PFAS chemicals were not detected in the overstory vegetation samples collected around the perimeter of the Dual-Axis Radiographic Hydrodynamic Test Facility in 2020.

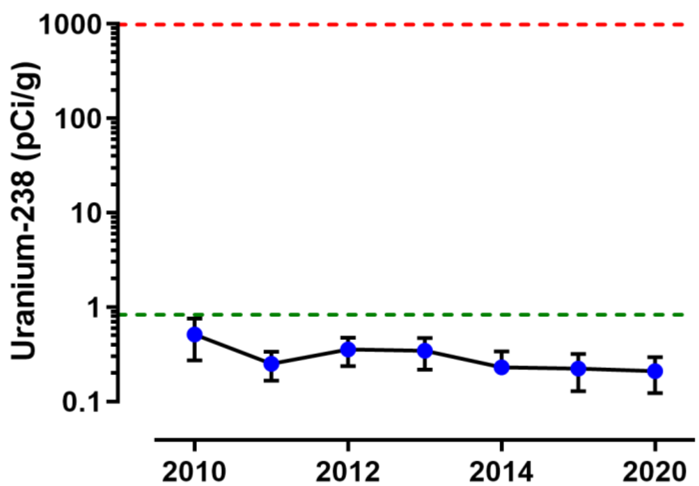

Figure 7-8. Uranium-238 activities in overstory vegetation collected around the Dual-Axis Radiographic Hydrodynamic Test Facility from 2010 to 2020 compared with the baseline statistical reference level (mean plus three standard deviations of soil uranium-238 pre-operations; green dashed line) and the biota dose screening level (red dashed line). Note the logarithmic scale on the vertical axis. Points represent means and error bars represent standard deviation. Bottom error bars are absent on some points as the error would have been a negative value; however, negative values cannot be shown on a logarithmic axis. Note: pCi/g = picocuries per gram.

Bird Egg Results

In avian egg samples, observations were similar with previous years. Several inorganic elements were not detected, including aluminum, arsenic, beryllium, cadmium, chromium, cobalt, lead, nickel, silver, and vanadium. All detectable concentrations of elements were below the regional statistical reference level and below the lowest observable adverse effect levels, when available (Table S7-10).

Open Detonation and Open Burn Firing Sites

Bird eggs and nestlings are useful for monitoring chemicals and radionuclide exposures and uptake in biological systems because different bird species occupy different trophic levels. Additionally, the collection of nonviable eggs and/or nestlings that die of natural causes is noninvasive and nondestructive to populations. Wild bird eggs have sometimes been shown to reflect chemical exposures from the location where a female bird feeds during egg formation (Dauwe et al. 2005). However, chemicals from the female’s previous exposures, such as on migration routes or wintering grounds, can also be deposited into eggs (Bustnes et al. 2010). Nestlings tend to reflect local chemical exposures due to their limited mobility.

Inorganic elements and organic chemicals can pose risks of adverse effects to birds if exposed at high enough concentrations (Jones and de Voogt 1999). Sources of inorganic elements include both releases from human activities and natural geological sources. Birds can be exposed through a number of routes including food items, ingestion of soil, drinking water, and inhalation.

Avian nest boxes have been placed at two open detonation firing sites, Minie (located at Technical Area 36) and Technical Area 39 Point 6, and at the open burn grounds located at Technical Area 16. Inorganic elements (mostly metals), dioxins, and furans are substances of interest at these locations (Fresquez 2011). Nonviable eggs and nestlings that died from natural causes are collected and analyzed for levels of chemicals. We collected six nonviable eggs on Laboratory property and 18 nonviable eggs in background areas located at Bandelier National Monument. Two deceased western bluebird nestlings were obtained at the Laboratory in 2020 from nest boxes.

Results from eggs collected from the Laboratory were compared with regional statistical reference levels calculated from the nonviable eggs of western bluebirds and ash-throated flycatchers (*Myiarchus cinerascens*) collected from the background locations in 2020 (n=18 samples). Due to limited sample mass, nonviable eggs were evaluated for inorganic elements only.

Results from nestlings were compared to the regional statistical reference levels calculated from deceased nestlings of western bluebirds and ash-throated flycatcher nestlings from background locations between 2018 and 2020 (n=5 samples) for inorganic elements, TCDD toxic equivalents values, and one nesting sample collected from a background location in 2020 for organic compounds.

Nonviable egg and nestling results were also compared with the lowest observable adverse effect levels from peer reviewed literature when available.

Bird Egg Results

Inorganic elements in bird eggs collected from Technical Area 36 (Minie) (five samples) and the open burn grounds (one sample) were either not detected or were below the regional statistical reference levels (Table S7-11). No nonviable eggs were collected from Technical Area 39 Point 6 in 2020. The overall results indicate that the levels of inorganic elements in the eggs of western bluebirds at the open detonation firing site and at the open burn grounds are not likely to cause adverse effects in breeding bird populations. Many constituents were not detected in the nonviable egg samples, and those constituents that were detected were below regional statistical reference levels and the lowest observable effect levels (when available).

Bird Nestling Results

Two deceased western bluebird nestlings were obtained at the Laboratory in 2020, one from the Technical Area 16 open burn grounds and one from Technical Area 39 Point 6. The nestling from Technical Area 39 was analyzed for dioxins and furans. Most dioxins and furans were not detected in the nestling sample. The sample contained detectable concentrations of 1,2,3,4,6,7,8,9-octachlorodibenzodioxin at 4.51 picograms per gram and 1,2,3,4,6,7,8-heptachlorodibenzodioxin at 1.83 picograms per gram, which exceeded the regional statistical reference level of 2.36 picograms per gram and 1.43 picograms per gram, respectively.

Lowest observable adverse effect levels are not available for each dioxin and furan congener. However, TCDD, the most potent dioxin congener, induces toxic effects in concentrations between 1,000 to 10,000 picograms per grams wet weight (Harris and Elliott 2011). Toxic equivalent factors can be used to calculate the toxic equivalent values of dioxin-like compounds. The toxic equivalent factor for

1,2,3,4,6,7,8,9-octachlorodibenzodioxin and 1,2,3,4,6,7,8-heptachlorodibenzodioxin for avian species is 0.0001 and 0.001, respectively (Van den Berg et al. 1998). Multiplying the detectable concentration by the toxic equivalent factors yield values that are orders of magnitude less than the lowest observable adverse effect level for TCDD seen in eastern bluebird eggs (Harris and Elliott 2011).

Many inorganic constituents were not detected in the nonviable nestling sample from the open burn grounds. Detection patterns and concentrations of inorganic elements between the nestling from Technical Area 16 and the nestling sample from background are similar (Table S7-11).

These findings suggest that the concentrations of inorganic elements and dioxin-like compounds are not of ecological concern at this time. More data are needed, including additional nestling samples from firing sites, to make robust assessments and to evaluate trends over time.

Sediment and Flood-Retention Structures

The Laboratory has constructed flood- and sediment-retention structures to reduce flood risks and to stop or slow the movement of sediments and associated chemicals and radionuclides off Laboratory property. 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 Los Alamos Canyon weir and the Pajarito Canyon flood-retention structure were built following the Cerro Grande fire in 2000. As part of an environmental analysis of actions taken in response to the Cerro Grande fire, DOE identified various measures to minimize impacts resulting from the fire (DOE 2000). One of the measures is monitoring 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 affect plants or animals.

To this end, we collect native grasses, forbs, and wild mice in the retention basins of the Los Alamos Canyon weir and the Pajarito Canyon flood-retention structure on an annual basis for environmental monitoring purposes. Small mammals, such as wild mice, are well-suited for monitoring chemical and radionuclide exposures and uptake in biological systems because of their close contact with soil, burrowing behavior, and because of their omnivorous diets (Smith et al. 2002, Talmage and Walton 1991).

We attempt to collect the following samples from each location annually: (1) a composite understory vegetation sample for radionuclide and inorganic element analyses; (2) a composite sample of approximately 100 grams of whole-body deer mice for radionuclide analyses; (3) three individual wild mice for inorganic elements analyses; and (4) three individual wild mice for PCB analysis. New in 2020, a composite understory vegetation sample and three individual wild mice were also collected for PFAS analyses. The following two sections report the 2020 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. The weir was built in Los Alamos Canyon near the northeastern boundary of the Laboratory. The retention basin upstream of the weir covers more than one acre. 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.

Vegetation Results

A composite understory vegetation sample was collected within the retention basin and submitted for radionuclide and inorganic element analyses in July 2020. Plants we collected include Canadian horseweed (*Erigeron canadensis*), curly dock (*Rumex crispus)*, kochia (*Bassia scoparia*), lambsquarters (*Chenopodium album*), common mullein (*Verbascum thapsus*), primose (*Primula vulgaris*), mustard species (*Brassicaceae sp.*), tarragon *(Artemisia dracunculus),* and yellow sweetclover (*Melilotus officinalis*).

Radionuclides in understory vegetation were either not detected or were below the regional statistical reference levels (Table S7-12). Americium-241 and plutonium-239/240 activities vary from year to year but are not increasing over time (Kendall's Tau, $p > 0.05$; Figure 7-9). The high variability may be a result of disturbances due to soil excavation at the weir or due to sampling variability. Plants are collected at different locations within the basin each year. In addition, because of 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 influence radionuclide results.

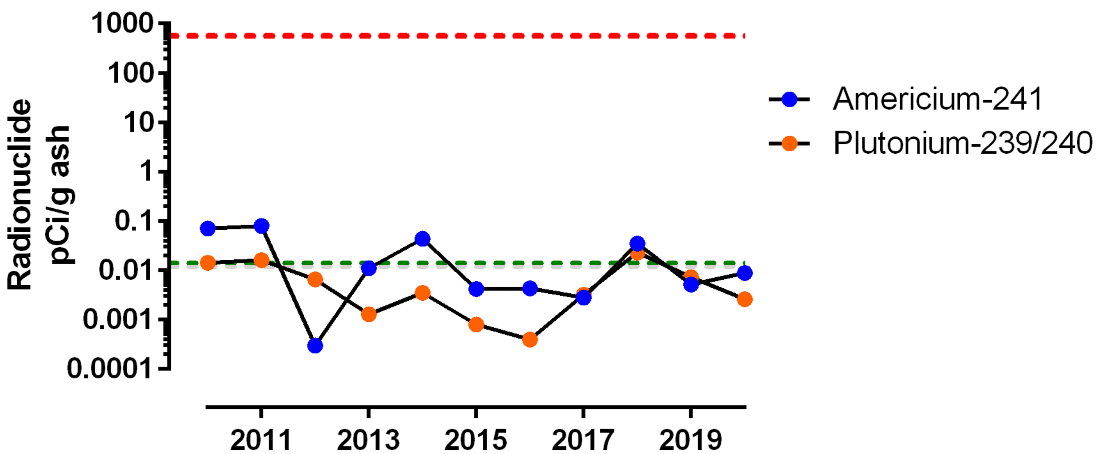

Figure 7-9. Americium-241 and plutonium-239/240 in understory vegetation collected on the upstream side (retention basin) of the Los Alamos Canyon weir from 2010 to 2020 compared with the biota dose screening level (red dashed line), and with the regional statistical reference level (green dashed line for americium-241 and gray dashed line for plutonium-239/240). Note the logarithmic scale on the vertical axis. Points represent true values; error bars are not available as only one sample is collected annually. Note: pCi/g = picocuries per gram.

Most inorganic elements were detected in understory vegetation and most concentrations of elements were below the regional statistical reference levels (Table S7-13). Beryllium was detected at 0.130 milligrams per kilogram and zinc was detected at 79.0 milligrams per kilogram, which exceed the regional statistical reference levels of 0.109 and 46.3 milligrams per kilogram, respectively. Similar to 2019, antimony, beryllium, selenium, and silver were increasing over time (Kendall's Tau, $p < 0.05$). However, the percentage of nondetects in these vegetation samples are high; therefore, these trends are likely arbitrary. All other levels of inorganic elements in vegetation are not changing over time (Kendall's Tau, $p > 0.05$).

PFAS chemicals were not detected in the composite understory vegetation sample collected upstream of the Los Alamos Canyon weir in 2020.

Small Mammal Results

Small mammals were collected from the retention basin in July 2020 using Sherman® live traps. All animal handling procedures were approved by LANL's Institutional Animal Care and Use Committee. We captured one individual Mexican woodrat (*Neotoma mexicana*) for radionuclide analyses, one individual deer mouse and two pinyon mice (*Peromyscus truei*) for inorganic element analyses, two individual deer mice and one pinyon mouse for PCB congeners, and two individual pinyon mice and one deer mouse for PFAS analyses.

The 2020 small mammal results at the Los Alamos Canyon Weir are summarized as follows (see supplemental tables S7-14, S7-15, and S7-16 for individual results):

- Most radionuclides in small mammals were detected
- All radionuclide levels in small mammals were below their biota dose screening level
- Most inorganic elements were not changing over time
- Zinc is increasing over time but the overall concentration is similar to or below its regional statistical reference level
- PCBs were detected above the regional statistical reference levels but below the reported lowest observable effect level
- PCBs are increasing over time
- Concentrations of detected PFAS chemicals were within the range of observations in mammals collected from non-polluted sites in published literature.

Most radionuclides in small mammals were detected (Table S7-14). Americium-241 (0.0298 picocuries per gram), plutonium-239/240 (0.0179 picocuries per gram), and strontium-90 (5.15 picocuries per gram) were detected above the regional statistical reference level of 0.0116, 0.0128, and 0.432 picocuries per gram, respectively (Table S7-14). Additionally, all three uranium isotopes were detected above the regional statistical reference level. However, the near 1:1 ratio of uranium-234 to uranium-238 activities (Table 7-14) indicate that these uranium activities are from naturally occurring sources (U.S. Nuclear Regulatory Commission 2019). All radionuclides are well below their biota dose screening levels, which are protective of biota (Table S7-14). No radionuclides are changing over time (Kendall's Tau, $p > 0.05$).

Many inorganic elements were detected in small mammals (Table S7-15). All concentrations of elements were below their regional statistical reference levels. Most inorganic elements were not changing over time; however, similar to 2019, antimony, cadmium, silver, and zinc were increasing (Kendall's Tau, $p < 0.05$, Figure 7-10). Zinc has shown an increasing trend in previous years that could suggest this is a true trend and not a result of environmental variability. Though zinc is increasing over time, the overall concentration is similar to or below the regional statistical reference level; thus, this level is not of ecological concern. These trends will continue to be monitored in the future.

PCBs were detected in the three mice collected upstream from the Los Alamos Canyon weir at concentrations of 0.0237, 0.0308, and 0.0488, milligrams per kilogram. These values were higher than the regional statistical reference level of 0.0129 milligrams per kilogram (Table S7-16). All concentrations observed here are two orders of magnitude below the lowest observable adverse effect level observed in mice (2.5 milligrams per kilogram) reported from PCB-contaminated sites where wild mouse populations were negatively affected (Batty et al. 1990). Thus, these levels are not expected to negatively affect the wild mouse population near the retention basin. The levels of PCBs in small mammals collected from the upstream side of the retention basin are increasing over time (Kendall's Tau, $p < 0.05$; Figure 7-10). The variability in PCB concentrations may be related to the removals of sediment from the basin between 2009 and 2014 and accumulation of sediment since that time.

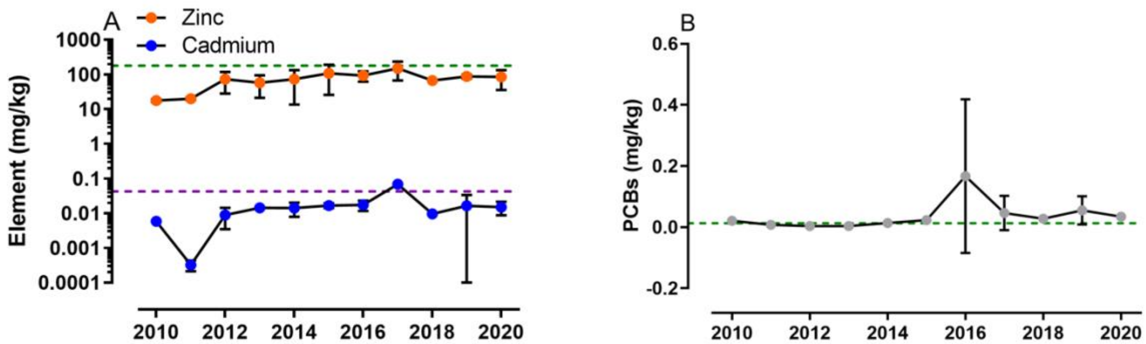

Figure 7-10. (A) Cadmium and zinc and (B) PCB concentrations in individual whole-body mice samples collected upstream (in the retention basin) of the Los Alamos Canyon weir from 2010 to 2020 compared with the regional statistical reference level (mean plus three standard deviations of small mammals collected from background locations; zinc and PCBs: green dashed line; cadmium: purple dashed line). Note vertical axis is a logarithmic scale for chromium and zinc, and a linear scale for PCBs. Points represent true values or the mean when multiple results were available; error bars represent standard deviation. Note: mg/kg = milligrams per kilogram.

A total of 14 PFAS chemicals evaluated were in small mammals and the majority were not detected. PFOS was detected in all three individual mouse samples at 2.90, 3.41, and 4.49 nanograms per gram. PFUnDA was also detected in two of the mouse samples at 0.407 and 0.412 nanograms per gram. PFDoDA was detected in one mouse sample at 0.285 nanograms per gram. PFUnDA and PFDoDA are longer chain PFAS molecules and have a greater propensity to bioaccumulate in animal tissues, as these molecules are difficult to metabolize. Small mammals from regional background locations have not yet been collected or analyzed for PFAS chemicals. However, concentrations of PFAS chemicals observed here are within the range of observations in mammals collected from non-polluted sites in published literature (Aas et al. 2014, Bossi et al. 2015).

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 culvert, which allows storm water to drain. Accumulated water is retained no longer than 96 hours behind the retention structure; water drains naturally into the existing streambed.

Vegetation Results

In July 2020, a composite understory vegetation sample was collected on the upstream side of the Pajarito Canyon flood-retention structure and analyzed for radionuclides, inorganic elements, and PFAS chemicals. Plants we collected include curly dock, common mullein, rubber rabbitbrush (*Ericameria nauseosa),* tarragon, yarrow (*Achillea millefolium*), and yellow sweetclover.

In the composite vegetation sample, most radionuclides were either not detected or were below the regional statistical reference levels, and all radionuclide activities were below the biota dose screening level (Table S7-18). No trends over time in radionuclide activities in vegetation collected upstream of the Pajarito Canyon flood-retention structure were observed from 2010 to 2020 (Kendall's Tau, $p > 0.05$).

Several inorganic elements were not detected in the composite vegetation sample, and all elements were below the regional statistical reference level (Table S7-19). Similar to 2019, beryllium and selenium were found to be increasing in vegetation over time (Kendall's Tau, $p < 0.05$). However, the percentage (60–90 percent) of nondetects in these vegetation samples are high; therefore, these increasing trends are likely arbitrary.

PFTeDA was the only PFAS chemical that was observed at a detectable concentration of 0.202 nanograms per gram. PFAS in native vegetation is poorly studied and we currently do not have regional data for comparisons.

Small Mammal Results

Small mammals were collected from the Pajarito Canyon flood-retention structure in July 2020. Small mammals were captured using Sherman® live traps. All animal handling procedures were approved by LANL's Institutional Animal Care and Use Committee. We captured four deer mice and one brush mouse (*Peromyscus boylii*), which were composited for radionuclide analyses, three individual deer mice were analyzed for inorganic elements, one brush mouse and two individual deer mice were analyzed for PCB congeners, and three individual deer mice were analyzed for PFAS chemicals.

The 2020 small mammal results at the Pajarito Canyon flood-retention structure are summarized as follows (see supplemental tables S7-20, S7-21, and S7-22 for individual results):

- All radionuclides in small mammals were either not detected or below their regional statistical reference level.
- Most inorganic element concentrations in whole body mice were detected and were below the regional statistical reference levels.
- PCBs were detected at levels below the regional statistical reference level.
- Concentrations of detected PFAS chemicals were within the range of observations in mammals collected from non-polluted sites in published literature.

All radionuclides were either not detected or were below the regional statistical reference levels in the composite mouse sample. No radionuclides are changing over time (Kendall's Tau, $p > 0.05$).

Most inorganic element concentrations in whole body mice were detected and were below their regional statistical reference levels. Chromium, silver, thallium, and zinc exceeded their regional statistical reference level in at least one of the mouse samples. Most inorganic elements in wild mice are not changing over time, however, in 2020 chromium and zinc were increasing and are consistent with previous observations (Kendall's Tau, $p < 0.05$, Figure 7-11). In 2020, antimony, barium, cobalt, manganese, and nickel were also increasing over time (Kendall's Tau, $p < 0.05$). However, as the majority of these constituents are below the regional statistical reference levels and because many are essential minerals, these observations are not of ecological concern. Trends over time will continue to be monitored.

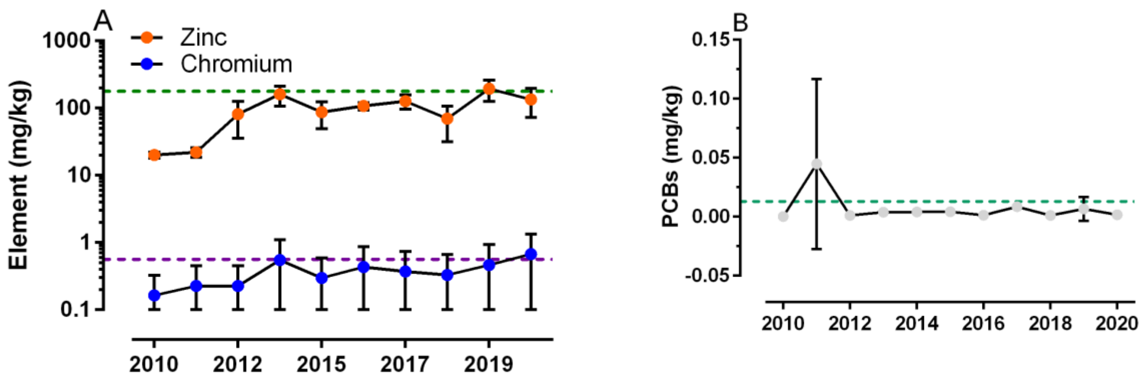

Figure 7-11. (A) Chromium and zinc and (B) PCB concentrations in individual whole-body mouse samples collected upstream (in the retention basin) of the Pajarito Canyon flood-retention structure from 2010 to 2020 compared with the regional statistical reference level (mean plus three standard deviations of small mammals collected from background locations; zinc and PCBs: green dashed line; chromium: purple dashed line). Note vertical axis is a logarithmic scale for chromium and zinc, and a linear scale for PCBs. Points represent true values or the mean when multiple results were available; error bars represent standard deviation. Note: mg/kg = milligrams per kilogram.

PCBs were detected in the three mice collected upstream from the Pajarito Canyon flood-retention structure at concentrations of 0.0004, 0.0012, and 0.0031 milligrams per kilogram. These values are all below the regional statistical reference level of 0.0129 milligrams per kilogram (Table S7-22). All PCB concentrations are three orders of magnitude below the lowest observable adverse effect level observed in mice (2.5 milligrams per kilogram) reported from PCB-contaminated sites where wild mouse populations were negatively affected (Batty et al. 1990). Thus, the current PCB levels are not expected to negatively affect the wild mouse population near the retention basin. PCB concentrations in whole-body wild mice collected upstream of the Pajarito Canyon flood-retention structure are not changing over time (Kendall's Tau, $p > 0.05$; Figure 7-11).

Similar to PFAS observations in small mammals collected in Los Alamos Canyon, the majority of PFAS chemicals were not detected. PFOS was observed in all three of the mouse samples collected in Pajarito Canyon at 0.485, 2.07, 3.05 nanograms per gram. PFNA, PFDoDA, and PFUnDA were also detected in one deer mouse at 0.313, 0.399, and 0.483 nanograms per gram, respectively. PFNA, PFUnDA and PFDoDA are longer chain PFAS molecules and have a greater propensity to bioaccumulate in animal tissues, as these molecules are difficult to metabolize. Small mammals from regional background locations have not yet been analyzed for PFAS chemicals. However, concentrations of PFAS chemicals observed here are within the range of observations in mammals collected from non-polluted sites in published literature (Aas et al. 2014, Bossi et al. 2015).

Institutional monitoring

Large Animal Monitoring

Monitoring Network

The environmental monitoring and surveillance program has opportunistically collected road-killed mule deer (*Odocoileus hemionus*) and elk (*Cervus canadensis*), from onsite, perimeter, and background locations since the 1970s (LASL 1973). To date, the program has collected and analyzed approximately 59 deer and 61 elk.

In 2015, the program expanded and began collecting other species including mountain lion (*Puma concolor*), bobcat (*Lynx rufus*), black bear (*Ursus americanus*), coyote (*Canis latrans*), gray fox (*Urocyon cinereoargenteus*), great horned owl (*Bubo virginianus*), western screech-owl (*Megascops kennicottii*), red-tailed hawk (*Buteo jamaiciensis*), gopher snake (*Pituophis catenifer*), and additional species killed by vehicles or by other accidents.

In 2020, we collected four mule deer, one elk, one bobcat, one American badger (*Taxidea taxus*), one gopher snake, and one great horned owl from on-site, perimeter, and background locations (Figure 7-12). The majority of animals collected were casualties of vehicle strikes, though others came from different sources, such as hunter donations. Animal tissue samples were analyzed for radionuclides, inorganic elements, PCBs, and some of the animals were also analyzed for PFAS. Leg muscle and leg bone were harvested from the deer, elk, bobcat, and badger. The muscle was analyzed for radionuclides, inorganic elements, PCBs, and PFAS, and the bone was analyzed for radionuclides. Unwashed whole body birds (feathers included) and snakes were analyzed for all constituents.

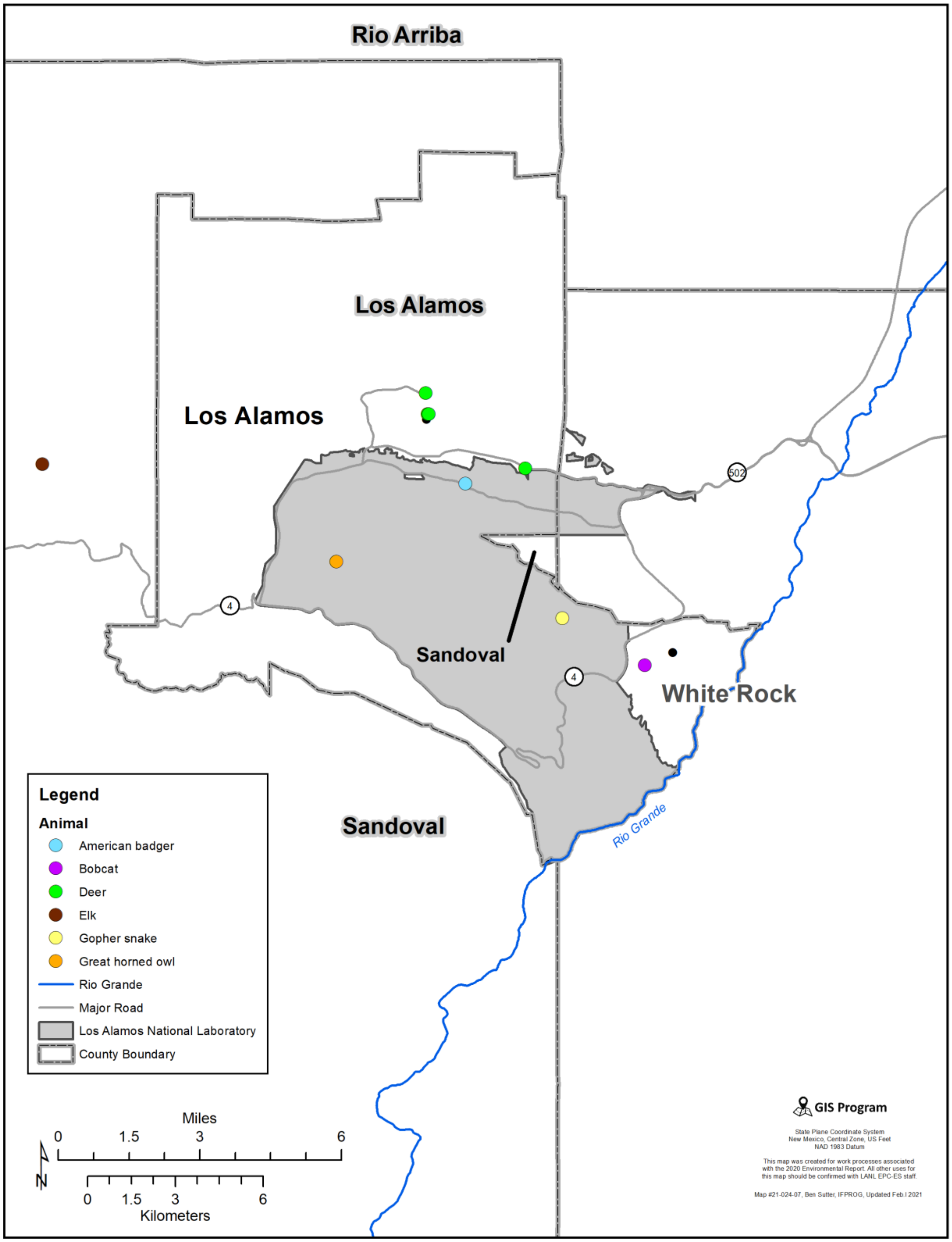

Figure 7-12. Locations of animals collected opportunistically from within and around the Laboratory in 2020.

Radionuclide Results

In 2020, deer were collected from perimeter locations only. Radionuclides in deer muscle and bone were either below the minimum detectable activity (most results) or below the regional statistical reference levels (Tables S7-24). Levels of radionuclides are also not increasing in the muscle or bone of deer collected from perimeter locations (Kendall's Tau, $p > 0.05$). These data are similar with previous years.

All radionuclides were either not detected or were below their regional statistical reference levels in the gopher snake and great horned owl (Table S7-25). Most radionuclides were not detected in the bobcat collected from a perimeter location or the American badger that was collected onsite (Table S7-25). Currently, there are no regional statistical reference levels for bobcat and American badger as these animals have not been collected from background locations. Additionally, the regional statistical reference levels for gopher snake and great horned owl based on a small sample size (n=3 and n=2, respectively). More data from background locations are needed to make robust assessments. However, levels of radionuclides observed in all animals were well below the biota dose screening level, which is protective of biota.

Inorganic Element Results

Most inorganic elements in deer were below the regional statistical reference levels. Aluminum, arsenic, barium, cobalt, lead, manganese, nickel, and silver were higher than the regional statistical reference in one or more of the deer (Tables S7-24). Concentrations of inorganic elements are not increasing over time in muscle of deer collected from perimeter locations (Kendall's Tau, $p > 0.05$).

In the gopher snake and great horned owl, most inorganic elements were detected and are consistent with previous years. All inorganic elements were below their respective regional statistical reference levels (Table S7-27). As previously mentioned, the regional statistical reference levels for these groups of animals are based on small sample sizes, and more data are needed to make robust assessments. Currently, there are no regional statistical reference levels for the bobcat or the American badger, however, the detection patterns and levels of inorganic element concentrations were similar to other road killed animals (Table S7-27).

PCB Results

PCBs were detected in all animal samples. PCB concentrations in deer ranged from 0.00012 to 0.06330 milligrams per kilogram and were above the regional statistical reference level of 0.000017 milligrams per kilograms (Tables S7-28). Our observations are well below the U.S. Food and Drug Administration standard of 3 milligrams per kilogram for red meat consumption by humans (FDA 1987). Total PCBs are not changing over time in deer muscle collected from perimeter locations (Kendall's Tau, $p > 0.05$).

PCBs were detected in the gopher snake, great horned owl, bobcat, and American badger samples at 0.0001, 0.0422, 0.0399, and 0.2390 milligrams per kilogram, respectively (Table S7-29). The gopher snake and great horned owl contained PCB levels that were below the regional statistical reference level, whereas no regional statistical reference levels were available for the bobcat or American badger. PCB concentrations are typically higher in predator species, such as the owls reported here, because these organic chemicals are lipophilic (absorbed by fats) and increase in concentration in animals that eat other animals (Eisler and Belisle 1996, Hornbuckle et al. 2006). The lowest observable adverse effect level of PCBs is between 1 and 30 milligrams per kilogram in avian eggs and 2 to 4 milligrams per kilograms in avian adult plasma (Harris and Elliott 2011). All levels observed here are well below the lowest observable adverse effect level for birds. The total PCB concentrations in all animals monitored and reported here are overall quite low. And while there are no specific lowest observable adverse effect levels of PCBs for deer, snakes, bobcat, and badgers, adverse effects in other animals are not observed until concentrations are above 1 milligrams per kilogram (Batty et al. 1990, Harris and Elliott 2011).

PFAS Results

Three deer and the gopher snake were analyzed for PFAS chemicals. PFOS was detected in one deer and the gopher snake at 0.544 and 0.734 nanograms per gram, respectively, while all remaining PFAS chemicals were not detected. PFOS was the most commonly detected PFAS chemicals in road kill samples in 2019. PFOS in the gopher snake was below the regional statistical reference level, while currently, no regional statistical reference levels are available for deer.

Our observations are within the ranges of PFAS concentration observed in animal tissues from published studies, including studies that occurred away from point-source pollution and in the Antarctic where global fallout is the primary source of PFAS in the environment (Aas et al. 2014, Bossi et al. 2015). As PFAS are recently emerging chemicals of concern, little is known about wildlife tissue concentrations and their relation to adverse effects.

Aquatic Health Assessment

To assess whether Laboratory operations are affecting aquatic ecosystems associated with the Rio Grande, we (1) evaluated levels of chemicals in fish and crayfish, (2) evaluated chemical concentrations in sediment, (3) conducted a sediment biotoxicity assay, and (4) measured indices of benthic macroinvertebrate community health in locations upstream and downstream of the Laboratory in the main stem of the Rio Grande and in the Abiquiu and Cochiti Lake reservoirs.

Fish Monitoring

Fish are collected from Abiquiu Lake reservoir (upstream of LANL), Cochiti Lake reservoir (downstream of LANL), and from the Rio Grande, upstream and downstream of its confluence with Los Alamos Canyon. Los Alamos Canyon is the northern-most watershed draining from Laboratory property, discharging into the Rio Grande near Otowi Bridge (Figure 7-13). Fish have been sampled from these locations and analyzed for radionuclides since the early 1980s.

Predator fish and bottom-feeding fish are collected and analyzed for radionuclides, inorganic elements, PCBs, and PFAS chemicals. Predator fish primarily eat other fish. Bottom-feeding fish eat both plant and animal matter and feed at the bottom of lakes and rivers.

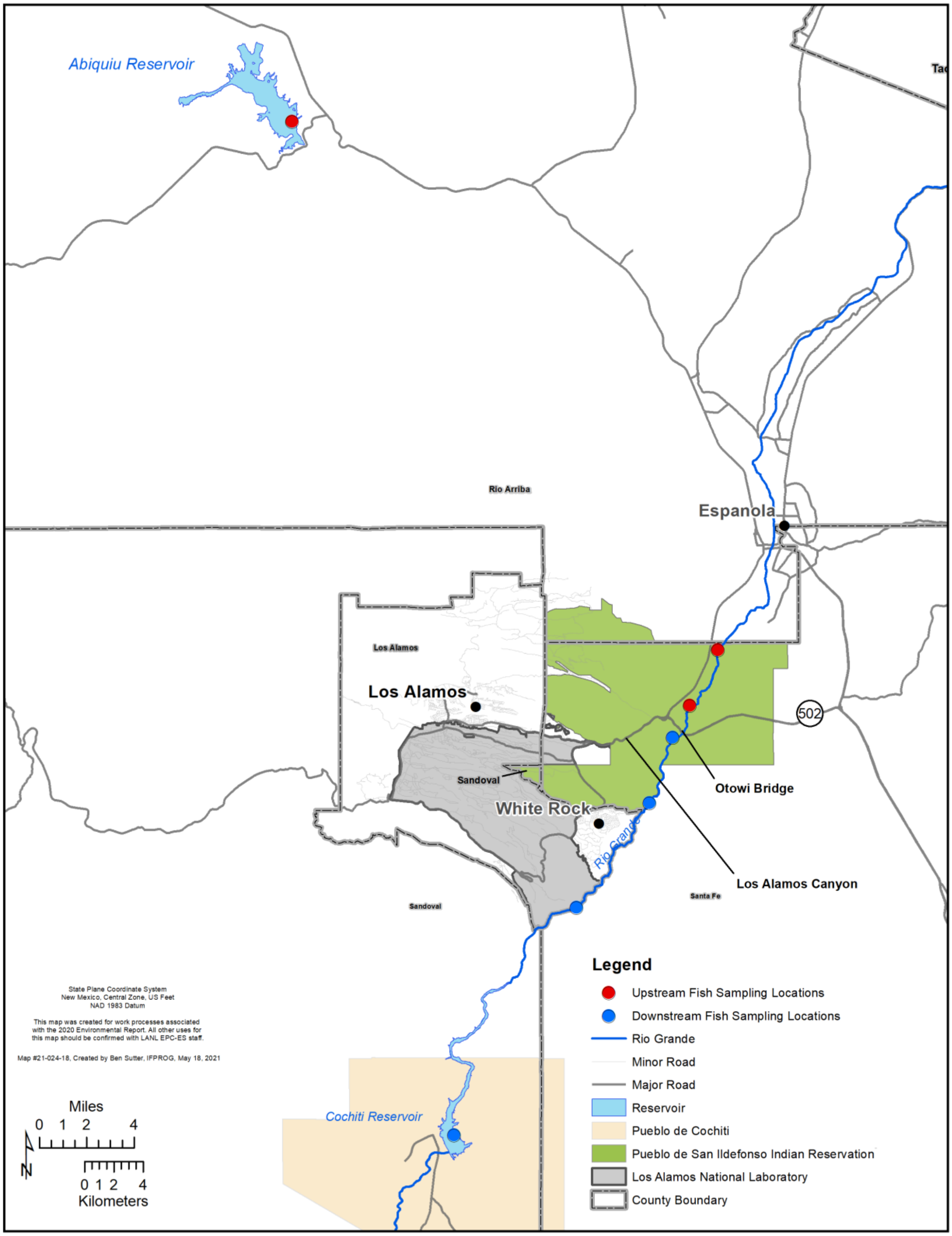

Figure 7-13. Locations of fish collected from locations upstream and downstream of the Laboratory in 2020.

In reservoirs, fish were collected using gill nets and rod and reel. In the Rio Grande, fish were collected using hoop nets, trot lines, and rod and reel. After a fish was captured, it was euthanized using methods approved by the Laboratory's Institutional Animal Care and Use Committee. We then removed the viscera and head, rinsed the fish thoroughly, and filleted both sides of the fish. One fillet (muscle plus skin) was analyzed for inorganic elements, the other fillet was analyzed for PCB congeners and PFAS; the remaining body was analyzed for radionuclides. All samples were labeled, sealed with chain-of-custody tape, placed into a cooler with ice, and submitted under full chain-of-custody procedures to the sample management office at the Laboratory. The sample management office sent fish samples to ALS (Australian Laboratory Services) in Fort Collins, Colorado for radionuclide and inorganic element analysis, to Cape Fear Analytical, LLC in Wilmington, North Carolina for PCB analysis, and to GEL Laboratories in Charleston, South Carolina for PFAS analyses.

We statistically tested the results from our fish analyses from 2011 through 2020. Generalized linear models were used to assess the effects of year, location (upstream or downstream), and the interaction of year by location on levels of chemicals and radionuclides. For fish from reservoirs, we also included the effects of feeding strategy (bottom-feeding or predator), feeding strategy by year, feeding strategy by location, and feeding strategy by year by location on levels of chemicals and radionuclides. Year and location were modeled as fixed effects and feeding strategy was modeled as a random effect. Models were not run when 80% or more of the results for a specific chemical or radionuclide were nondetects (Helsel 2012).

Fish Monitoring Results

In 2020, ten fish samples were collected from Abiquiu Lake reservoir, ten samples from Cochiti Lake reservoir, six samples from upstream Rio Grande, and eleven samples from downstream Rio Grande. Bluegill (*Lepomis macrochirus*), a predator fish, were collected from Abiquiu Lake reservoir. Bottom-feeding fish were collected from both reservoirs as well as from the Rio Grande and included the white sucker (*Catostomus commersonii*), channel catfish (*Ictalurus punctatus*), carp (*Cyprinus carpio*), and carp sucker (*Carpiodes carpio*).

Radionuclide Results in Fish from the Rio Grande

Americium-241, cesium-137, and radium-228 were not detected in any fish (Table S7-30). Uranium-234 and uranium-238, two naturally occurring radionuclides, were detected in all fish. Radium-226 was detected at 0.50 picocuries per gram in a white sucker collected downstream, which was slightly above the regional statistical reference level of 0.49 picocuries per gram. All other radionuclides were below their regional statistical reference levels and all radionuclide activities were far below the biota dose screening level (Table S7-30).

Strontium-90 activities decreased from 2011 to 2020 in fish collected from both upstream and downstream locations (Figure 7-14). Fish collected from downstream locations had higher uranium-238 levels when compared with upstream fish. Uranium-238 decreased over time in fish collected from both upstream and downstream locations (Figure 7-14). The uranium isotope ratio observed in our sampled fish is consistent with the isotope ratio of natural uranium when dissolved in water.

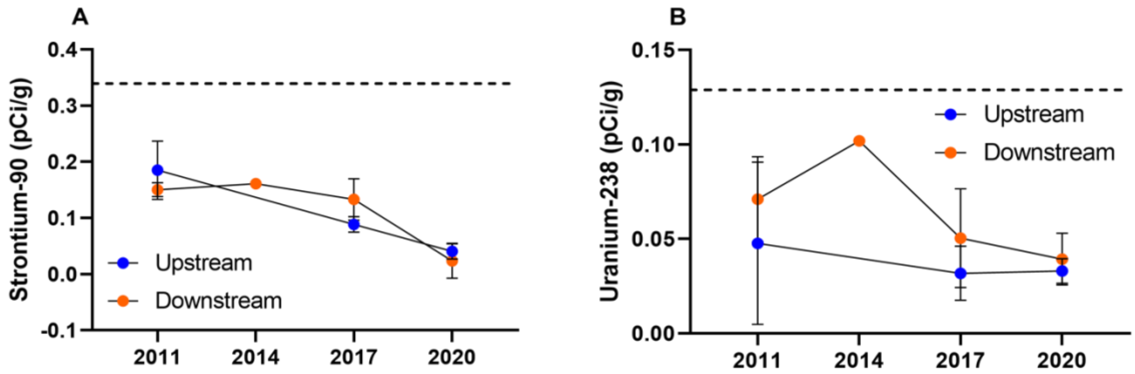

Figure 7-14. (A) Strontium-90 and (B) uranium-238 activities in fish samples collected in 2020 from the Rio Grande, upstream and downstream of the Los Alamos Canyon confluence, compared with the regional statistical reference level (mean plus three standard deviations of sediment samples collected from background locations black dashed line). Points represent true values or the mean when multiple results were available; error bars represent standard deviation. Note: pCi/g = picocuries per gram.

Inorganic Element Results in Fish from the Rio Grande

Most concentrations of inorganic elements in the muscle of bottom-feeding fish collected from downstream Rio Grande did not differ from concentrations in bottom-feeding fish collected from upstream Rio Grande (Table S7-31). Iron levels were higher in fish from upstream locations (Generalized Linear Mixed Model, $p < 0.05$). All iron concentrations were below the regional statistical reference level. Magnesium levels were higher in fish from downstream locations (Generalized Linear Mixed Model, $p < 0.05$). Between 2011 and 2020, magnesium levels in fish decreased in upstream locations, but increased in downstream locations (Generalized Linear Mixed Model, $p < 0.05$). One fish from a downstream location contained magnesium of 470 milligrams per kilogram, which exceeded the regional statistical reference level of 355 milligrams per kilogram. As magnesium is an essential element and only one fish exceeded the reference level, there are no concerns to the fish population.

Arsenic levels did not differ between upstream and downstream locations. One fish collected upstream had an arsenic concentration (0.14 milligrams per kilogram) which exceeded the regional statistical reference level of 0.12 milligrams per kilogram (Table S7-31). Aluminum, antimony, chromium, copper, mercury, selenium, and thallium decreased over time and were consistent between upstream and downstream locations (Generalized Linear Mixed Model, $p < 0.05$; Table S7-31). There was a significant interaction of year by location in fish chromium concentrations, indicating that the rate of change differed between upstream and downstream locations. Trends in these chemical concentrations will continue to be monitored.

In 2020, mercury was detected in all fish. There was no statistical difference in mercury concentrations between upstream and downstream locations, with upstream fish containing 0.079 ± 0.034 milligrams per kilogram and downstream fish containing 0.103 ± 0.062 milligrams per kilogram (Generalized Linear Mixed Model, $p > 0.05$). Mercury concentrations decreased over time (Generalized Linear Mixed Model, $p < 0.05$; Table- S7-31; Figure 7-15). No fish sampled from the Rio Grande exceeded the U.S. Environmental Protection Agency human health screening value of 0.3 milligrams per kilogram (EPA

2018). All mercury concentrations observed in fish collected from the Rio Grande are below the regional statistical reference level and are an order of magnitude less than the lowest observable adverse effect level of 5 milligrams per kilogram in muscle tissue (Scherer et al. 1975).

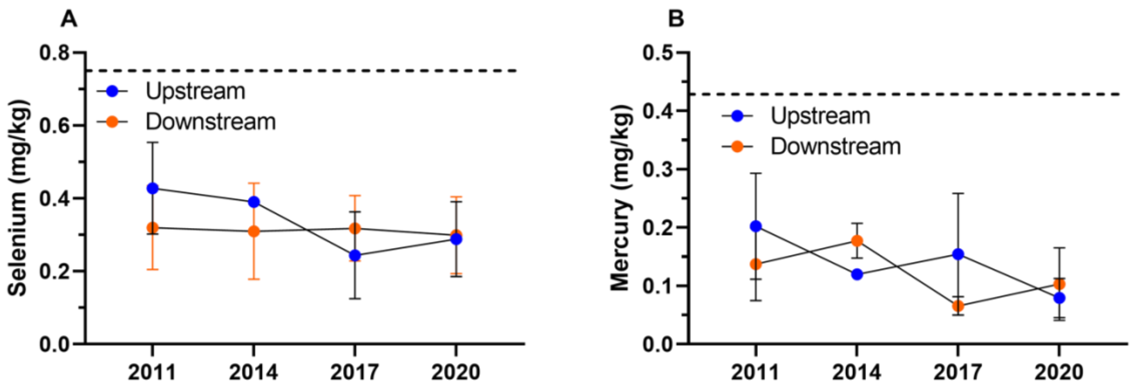

Figure 7-15. (A) Selenium and (B) mercury concentrations in fish samples collected in 2020 from the Rio Grande, upstream and downstream of the Los Alamos Canyon confluence, compared with the regional statistical reference level (mean plus three standard deviations of sediment samples collected from background locations black dashed line). Points represent true values or the mean when multiple results were available; error bars represent standard deviation. Note: mg/kg = milligrams per kilogram.

PCB Results in Fish from the Rio Grande

In 2020, total PCBs in bottom-feeding fish collected from the Rio Grande were higher (2,605 ± 1,106 picograms per gram) at upstream locations than downstream locations (2,282 ± 1,442 picograms per gram; $p < 0.05$; Table S7-32; Figure 7-16). No other variables or interactions of variables were significant. No fish collected from the Rio Grande exceeded the U.S. Environmental Protection Agency human health consumption screening value of 12,000 picograms per gram (EPA 2018). PCB concentrations in fish were well below the range of values associated with adverse effects on growth and reproduction (50 million to 100 million picograms per gram PCBs in fish tissue) (Niimi 1996).

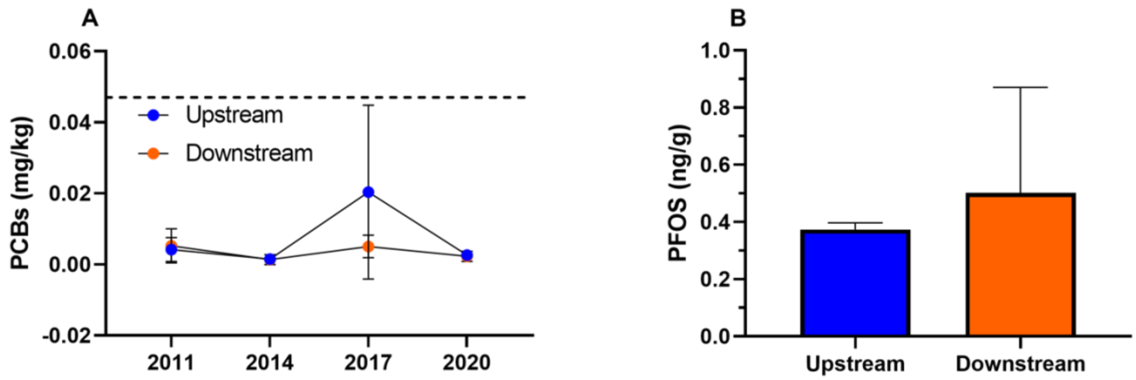

Figure 7-16. (A) PCBs and (B) PFOS concentrations in fish samples collected in 2020 from the Rio Grande, upstream and downstream of the Los Alamos Canyon confluence, compared with the regional statistical reference level (mean plus three standard deviations of sediment samples collected from background locations black dashed line). Points and columns represent the mean; error bars represent standard deviation. Note: mg/kg = milligrams per gram and ng/g = nanograms per gram.

PFAS Results in Fish from the Rio Grande

The majority of PFAS chemicals were not detected in fish in the Rio Grande. PFOS was the most commonly detected PFAS chemical and was detected in six fish with a range of 0.35 to 1.65 nanograms per gram. No significant differences in concentrations were observed between upstream and downstream locations (Mann-Whitney U, $p > 0.05$; Figure 7-16). New Mexico does not currently have fish consumption advisory limits for PFAS chemicals. However, an exposure assessment suggests that fish containing PFOS at less than 10 nanograms per gram are safe for unrestricted consumption (Great Lakes Consortium for Fish Consumption Advisories 2019). All fish collected contained PFOS concentrations that were below this guideline. PFTrDA was detected in one fish (0.315 nanograms per gram) and PFUnDA was detected in two fish (0.32 and 0.39 nanograms per gram). No other PFAS chemicals were detected including PFOA and PFHxS. Our observations are within the ranges of PFAS concentration observed in fish tissues in published studies, including studies that occurred in remote areas where global fallout is the primary source of PFAS in the environment (Bossi et al. 2015). As PFAS are recently emerging chemicals of concern, little is known about wildlife tissue concentrations and their relation to adverse effects.

Radionuclide Results in Fish from Reservoirs

Fish collected from Abiquiu and Cochiti Lake reservoirs did not contain americium-241, cesium-137, plutonium-238 or plutonium239/240 (Table S7-33). Radium-228 concentrations in one channel catfish from Cochiti Lake reservoir (1.14 picocuries per gram) slightly exceeded the regional statistical reference level of 1.11 picocuries per gram. All remaining radionuclides were not detected or were below the regional statistical reference level and all levels were far below the biota dose screening level and are not a health concern to the fish.

Strontium-90 activities in fish were not significantly different between reservoirs, and are decreasing over time. There was a significant interaction among year by feeding strategy indicating strontium-90 activity is decreasing at a faster rate in bottom feeding fish. Additionally, there was a significant interaction among year by feeding strategy by reservoir suggesting that variations in strontium-90 activities occurred independently in the reservoirs (Table S7-33).

Levels of uranium-234 and uranium-238 differed significantly between bottom-feeding and predator fish (Table S7-33; Figure 7-17). Bottom-feeding fish had significantly higher activities of uranium isotopes compared with predator fish. Several radionuclides readily bind to sediments, and bottom feeders are more likely to be exposed to these sediments (DOE 2015). Additionally, there was a significant interaction of uranium-234 and uranium-235/236 in feeding strategy by year, where uranium concentrations were decreasing in bottom feeding fish. There was no difference between reservoirs.

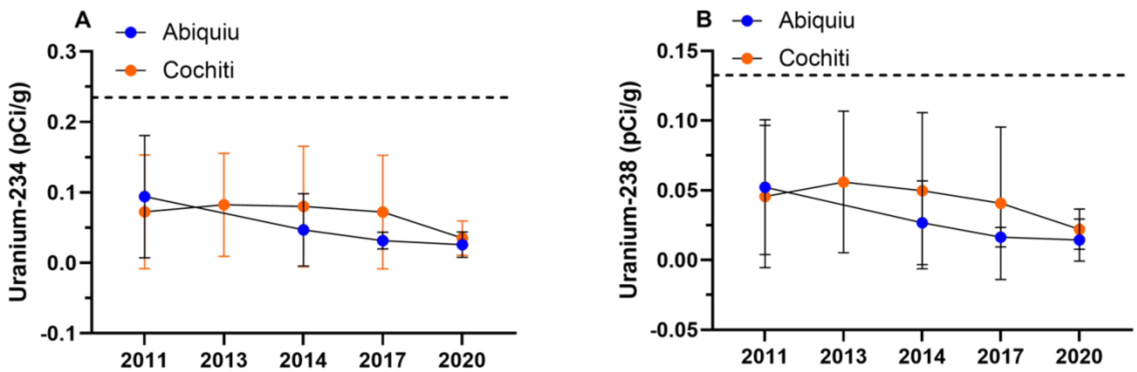

Figure 7-17. (A) Uranium-234 and (B) uranium-238 activities in fish samples collected in 2020 from Abiquiu (upstream) and Cochiti (downstream), compared with the regional statistical reference level (mean plus three standard deviations of sediment samples collected from background locations black dashed line). Points represent the mean and error bars represent standard deviation. Note: pCi/g = picocuries per gram.

Inorganic Element Results in Fish from Reservoirs

Most concentrations of inorganic elements in fish muscle collected from Cochiti Lake reservoir did not differ from concentrations observed in fish collected from Abiquiu Lake reservoir. However, selenium concentrations did statistically differ between the two reservoirs (Table S7-34). Selenium concentrations are consistently higher in fish collected from Abiquiu Lake reservoir (Figure 7-18). All selenium concentrations observed in fish collected from both reservoirs are below the regional statistical reference level and are an order of magnitude less that the lowest observable adverse effect level of 8 milligrams per kilogram in muscle tissue (Lemly 1996). Aluminum and magnesium concentrations were higher in fish collected from Abiquiu Lake reservoir while copper was higher in fish collected from Cochiti Lake reservoir (Generalized Linear Mixed Model, $p < 0.05$, Table S7-34). All concentrations of these elements are below the regional statistical reference level and will continue to be monitored.

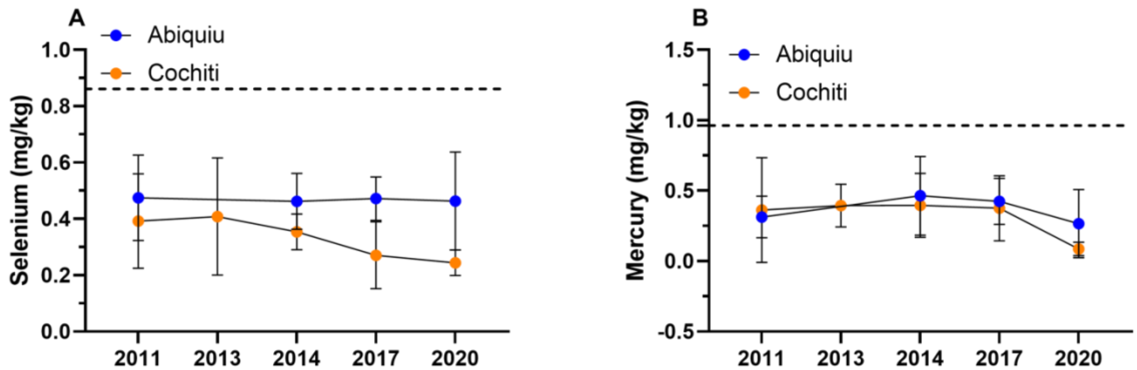

Figure 7-18. (A) Selenium and (B) mercury concentrations in fish samples collected in 2020 from Abiquiu (upstream) and Cochiti (downstream), compared with the regional statistical reference level (mean plus three standard deviations of sediment samples collected from background locations black dashed line). Points represent the mean and error bars represent standard deviation. Note: mg/kg = milligrams per kilogram.

Similar with previous years, mercury was detected in all fish and mercury concentrations were significantly higher in predator fish compared to bottom-feeding fish; however there was no difference between reservoirs. This suggests that Laboratory operations have not affected fish mercury concentrations (Table S7-34; Figure 7-18). Mercury concentrations are not changing over time and this is consistent between reservoirs (Generalized Linear Mixed Model $p > 0.05$). In 2020, mercury concentrations in fish collected from Abiquiu Lake reservoir were 0.193 ± 0.042 milligrams per kilogram in predator fish and 0.316 ± 0.311 milligrams per kilogram in a bottom-feeding fish. Fish from Cochiti Lake reservoir contained 0.086 ± 0.047 milligrams per kilogram in bottom-feeding fish; no predator fish were collected from Cochiti Lake reservoir in 2020 (Table S7-18). In general, predator fish are predicted to contain higher levels of mercury than bottom-feeding fish because mercury biomagnifies, or builds up, in the food chain. Also, because the conversion of inorganic mercury to methyl mercury is primarily conducted by bacteria under anaerobic conditions—such as those found in bottom sediments of deeper and slower waters (Driscoll et al. 1994; Bunce 1991), we expect that higher levels of mercury in reservoir fish than in Rio Grande fish.

Several bottom-feeding and predator fish collected from both reservoirs since 2011 have exceeded the U.S. Environmental Protection Agency's human health consumption screening value for mercury of 0.3 milligrams per kilogram (EPA 2018). In 2020, two bottom-feeding fish from Abiquiu Lake reservoir exceeded this level. All fish from both reservoirs contained mercury concentrations that were below the regional statistical reference level and were an order of magnitude less than the lowest observable adverse effect level for fish of 5 milligrams per kilogram in muscle tissue (Scherer et al. 1975), suggesting that levels observed here are not adversely affecting the fish populations.

PCB Results in Fish from Reservoirs

In 2020, the average level of total PCBs in fish collected from Abiquiu Lake reservoir was 1,276 ± 1,777 picograms per gram and from Cochiti Lake reservoir was 3,730 ± 2,087 picograms per gram (Table S7-35). Three individual fish (range 5,730 through 7,800 picograms per gram) collected from Cochiti Lake reservoir exceeded the regional statistical reference level of 5,647 picograms per gram. No fish collected from either reservoir exceeded the U.S. Environmental Protection Agency human health consumption screening value of 12,000 picograms per gram (EPA 2018). Similar to the PCB concentrations in fish collected in the Rio Grande, all PCB concentrations in fish from the reservoirs were well below the range of values that are associated with adverse effects on growth and reproduction (50 million to 100 million picograms per gram PCBs in fish tissue (Niimi 1996).

PCB concentrations in fish collected from Cochiti Lake reservoir were higher than in fish collected from Abiquiu Lake reservoir. PCBs were higher in bottom-feeding fish, which is consistent with previous findings. There was a significant reservoir by feeding strategy interaction, indicating PCB concentrations differed between the feeding strategies and reservoirs. PCB concentrations in bottom-feeding fish from Cochiti Lake reservoir appear to be more variable among years than in fish from Abiquiu Lake reservoir (Figure 7-19). This might result from the number and intensity of flooding events affecting Cochiti Lake reservoir during 2011 through 2020, the fact that Cochiti Lake reservoir is influenced by two rivers (Rio Grande and Rio Chama), or a combination of these effects.

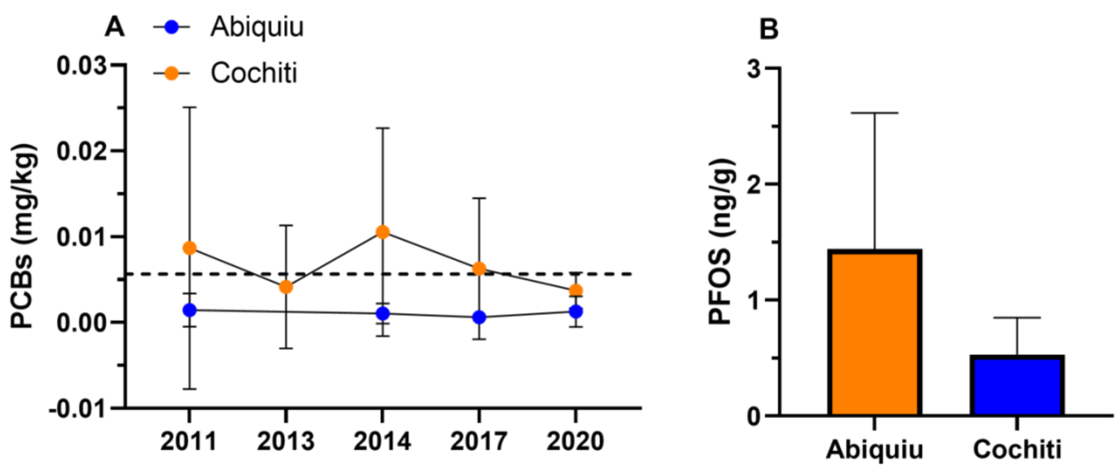

Figure 7-19. (A) PCBs and (B) PFOS concentrations in fish samples collected in 2020 from Abiquiu (upstream) and Cochiti (downstream), compared with the regional statistical reference level (mean plus three standard deviations of sediment samples collected from background locations black dashed line). Points and columns represent the mean; error bars represent standard deviation. Note: mg/kg = milligrams per kilogram and ng/g = nanograms per gram.

PFAS Results in Fish from Reservoirs

The majority of PFAS chemicals were not detected in fish collected from Abiquiu and Cochiti Lake reservoirs. PFOS and PFUnDA were the most commonly detected PFAS chemicals and were detected in 19 and 12 fish, respectively, with a range of 0.392 to 4.65 and 0.317 to 1.57 nanograms per gram, respectively. PFOS was higher in Abiquiu Lake reservoir fish when compared with Cochiti Lake reservoir fish (Mann-Whitney U, $p < 0.05$), while there was no difference in the concentrations of PFUnDA between reservoirs (Mann-Whitney U, $p > 0.05$). New Mexico does not currently have fish consumption advisory limits for PFAS chemicals, however, an exposure assessment suggests that fish containing PFOS at less than 10 nanograms per gram are safe for unrestricted consumption (Great Lakes Consortium for Fish Consumption Advisories 2019). All sampled fish contained PFOS concentrations below this guideline. PFOA was detected in one fish as 1.08 nanograms per gram, PFDA was detected in three fish (range of 0.78 to 1.05 nanograms per gram), PFDoDA was detected in three fish (range 0.365 to 0.466 nanograms per gram), and PFTrDA was detected in four fish (range 0.289 to 0.834 nanograms per gram). All remaining PFAS chemicals were not detected in fish, including PFHxS. Our observations are within the ranges of PFAS concentration observed in fish tissues in published studies, including studies that occurred in remote areas where global fallout is the primary source of PFAS in the environment (Bossi et al. 2015). As PFAS are recently emerging chemicals of concern, little is known about wildlife tissue concentrations and their relation to adverse effects.

Crayfish Monitoring

Baited crayfish traps were set in the Rio Grande upstream and downstream of Los Alamos Canyon and at Abiquiu and Cochiti Lake reservoirs (Figure 7-13). Captured crayfish were euthanized and whole body samples were submitted to the sample management office and shipped to analytical laboratories. Crayfish were analyzed for PCB congeners by Cape Fear Analytical, LLC in Wilmington, North Carolina, for PFAS chemicals by GEL Laboratories LLC in Charleston, South Carolina, and for radionuclides and inorganic elements by ALS in Fort Collins, Colorado.

Overall, capture rate was low across locations, except for Rio Grande upstream locations. No crayfish were collected from Abiquiu Lake reservoir, two crayfish were collected from Cochiti Lake reservoir, four crayfish were collected from Rio Grande downstream and twelve crayfish were collected from Rio Grande upstream.

Radionuclide Results

Radionuclides were evaluated in crayfish samples collected from Rio Grande upstream. As these samples were collected upstream of Los Alamos canyon and above potential influence from the Laboratory, results serve as background comparisons to crayfish collected downstream. Radionuclides were not evaluated in crayfish downstream due to low capture rate, however, most radionuclides were not detected in Rio Grande upstream crayfish. Those radionuclides detected were far below the biota dose screening levels which are protective of biota.

Inorganic Element Results

Inorganic elements were evaluated in three crayfish collected from Rio Grande upstream, two crayfish collected from Rio Grande downstream, and one crayfish collected from Cochiti Lake reservoir. Most inorganic elements were detected, which is consistent with observations in other biota. One crayfish from Rio Grande downstream contained thallium concentrations of 0.036 milligrams per kilogram, which exceeded the regional statistical reference level of 0.010 milligrams per kilogram. All other inorganic elements were below the regional statistical reference level (Table S7-36). The crayfish sample results from Cochiti Lake reservoir was compared with the Rio Grande regional statistical reference levels, and all concentrations were below those levels (Table S7-36).

PCB Results

PCBs were evaluated in three crayfish collected from Rio Grande upstream, and one crayfish collected from Rio Grande downstream. PCBs were detected in all crayfish with a range of 340 to 936 picograms per gram in Rio Grande upstream crayfish and a value of 615 picograms per gram in the Rio Grande downstream crayfish. All crayfish samples contained PCB levels well below the regional statistical reference level of 1,635 picograms per gram. No crayfish were available from Abiquiu or Cochiti Lake reservoirs for PCB analyses.

PFAS Results

PFAS chemicals were evaluated in three crayfish collected from Rio Grande upstream, one crayfish collected from Rio Grande downstream, and one crayfish collected from Cochiti Lake reservoir. Most PFAS chemicals were not detected. PFOS was detected in two of the crayfish collected from Rio Grande upstream at 0.430 and 0.439 nanograms per gram. PFUnDA was observed in all three Rio Grande upstream crayfish with a range of 0.322 to 0.527 nanograms per gram. The one crayfish collected from Rio Grande downstream contained PFUnDA and PFNA at 0.362 and 0.372 nanograms per gram, respectively. PFUnDA was also observed in the Cochiti Lake reservoir crayfish at 0.322 nanograms per gram, and was the only PFAS chemical detected in that crayfish. PFUnDA levels were below regional statistical reference levels but PFNA in the Rio Grande downstream crayfish slightly exceeded the regional statistical reference level of 0.316 nanograms per gram. Our observations are within the ranges of PFAS concentration observed in fish tissues in published studies, including studies that occurred in remote areas where global fallout is the primary source of PFAS in the environment (Bossi et al. 2015). As PFAS are recently emerging chemicals of concern, little is known about wildlife tissue concentrations and their relation to adverse effects.

Sediment Monitoring

Rio Grande Sediment

Upstream sediment samples were collected in the Rio Grande from Los Alamos Canyon north, and downstream sediment samples were collected in the Rio Grande from Los Alamos Canyon south, specifically downstream of the Los Alamos, Sandia, Mortandad and Ancho Canyon confluences (Figure 7-20). Sediment samples were collected in the active channel between September 03 and October 08, 2020. The top portion of sediment (0–2-inch depth) was collected with a shovel and placed into a five-gallon polyethylene bucket until approximately ¾ full. The sediment was then homogenized and scooped into appropriate sampling containers. Samples were submitted to the sample management office and shipped to analytical laboratories. Sediments were analyzed for PCB congeners by Cape Fear Analytical, LLC in Wilmington, North Carolina, for PFAS chemicals by GEL Laboratories LLC in Charleston, South Carolina, and for radionuclides and inorganic elements by ALS in Fort Collins, Colorado.

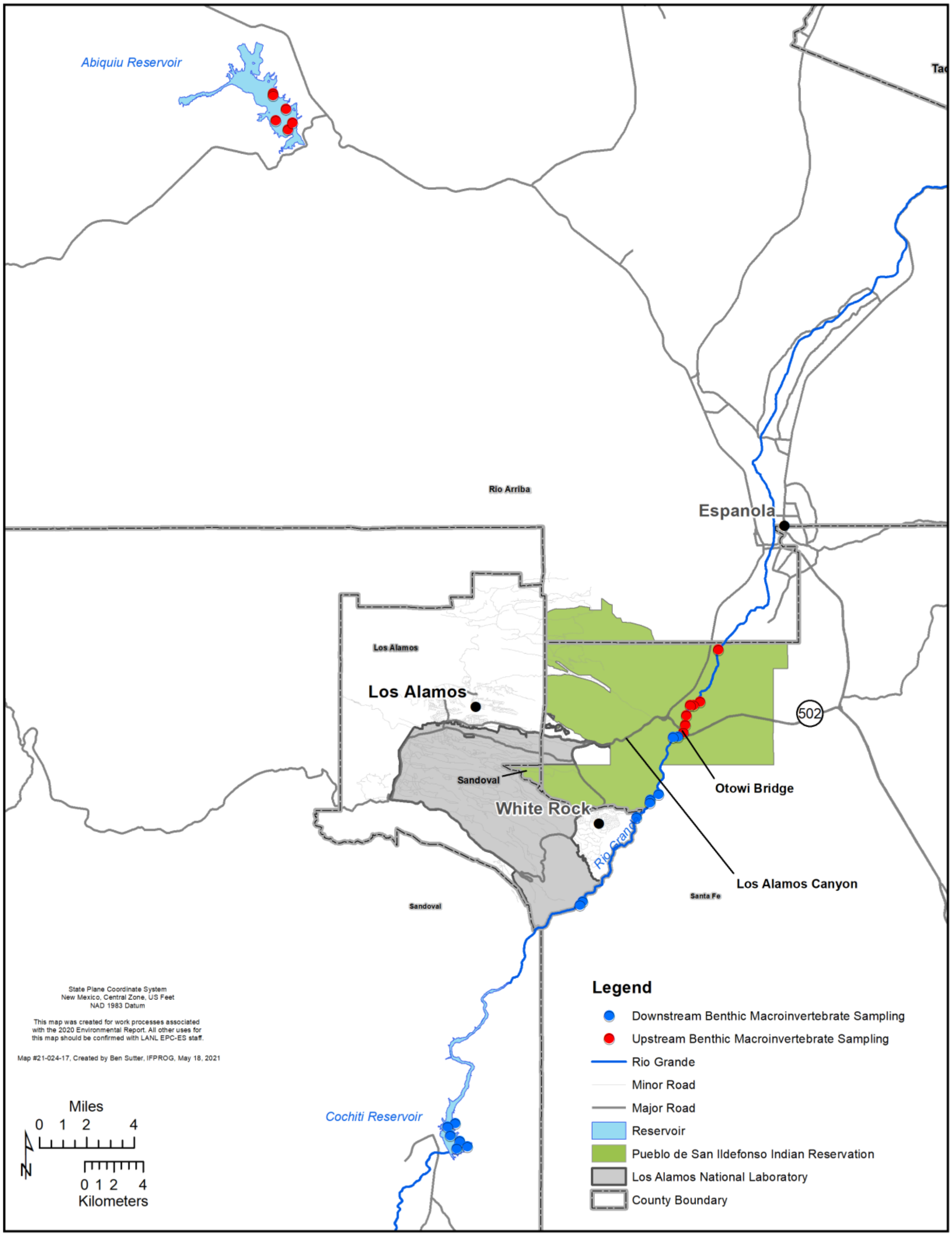

Figure 7-20. Locations of sediment and benthic macroinvertebrate samples collected from locations upstream and downstream of the Laboratory in 2020.

Radionuclide Results

Americium-241 and cesium-137 were not detected in any of the Rio Grande sediment samples. All detectable concentrations of radionuclides were below the regional statistical reference level and were well below the no-effect ecological screening levels (Table S7-37). There were no significant differences in radionuclide activities between upstream and downstream reaches ($p > 0.05$). These data are similar to previous data.

Inorganic Element Results

Inorganic element concentrations did not differ statistically between upstream and downstream locations. Beryllium in one upstream sample and iron and vanadium in one downstream sample exceeded the regional statistical reference levels, but were below available no-effect ecological screening levels (Table S7-38). Barium and selenium concentrations exceeded the no-effect ecological screening level for aquatic community organisms in one downstream location each; however, these concentrations were below the low-effect ecological screening levels (Table S7-38). No other elements exceeded the no-effect ecological screening level. All elements were below the low-effect ecological screening level for aquatic community organisms (Table S7-38). These data are similar to the data collected in 2014.

Sediment collected from several locations, both upstream and downstream, did not contain detectable concentrations of PCBs (Table S7-39). There was no significant difference in total PCB concentrations between upstream (16.0 ± 42.3 picograms per gram) and downstream (6.2 ± 11.4 picograms per gram) sediment. Sediment from one location collected upstream contained PCB levels of 112 picograms per gram that was higher than the regional statistical reference level of 86.1 picograms per grams. All PCB concentrations were far below the lowest no-effect ecological screening level. These results are similar to previous data.

PFAS Results

Nearly all PFAS chemicals were not detected in Rio Grande sediment samples. PFHxA was the only PFAS chemical detect in one sample collected upstream at 0.391 nanograms per gram. There were no significant differences in PFAS chemical concentrations between upstream and downstream reaches ($p > 0.05$).

Sediment from Abiquiu and Cochiti Lake Reservoirs

We collected sediment from six locations in Abiquiu Lake reservoir (upstream of Los Alamos Canyon) and six locations in Cochiti Lake reservoir (downstream of Los Alamos Canyon) between August 25 and September 17, 2020 (Figure 7-20). Reservoir sediment samples were collected with a Ponar grab. Three samples from each reservoir were collected from the littoral zone (e.g. approximately 0-30 feet) and three samples from the pelagic zone (a zone deeper than the thermocline, which is a steep temperature gradient, and typically deeper than 22 feet). Sampling depths ranged from 24 to 60 feet in Abiquiu Lake reservoir and 2 to 76 feet deep in Cochiti Lake reservoir. Sediment was placed into a five-gallon polyethylene bucket, homogenized and scooped into appropriate sampling containers. Samples were submitted to the sample management office and shipped to analytical laboratories. Sediments were analyzed for PCB congeners by Cape Fear Analytical, LLC in Wilmington, North Carolina, for PFAS chemicals by GEL Laboratories LLC in Charleston, South Carolina, and for radionuclides and inorganic elements by ALS in Fort Collins, Colorado.

Radionuclide Results

Americium-241 and strontium-90 were not detected in any of the reservoir sediment samples (Table S7-40). In two Cochiti Lake reservoir sediment samples, plutonium-239 and uranium-234 were detected at 0.037 and 1.29 picocuries per gram respectively, which exceeded the regional statistical levels of 0.024 and 1.28 picocuries per gram (Table S7-40). All other detectable concentrations of radionuclides are below the regional statistical reference level and all concentrations were well below the no-effect ecological screening levels (Table S7-40). There were no significant differences in radionuclide activities between upstream and downstream reaches ($p > 0.05$).

Inorganic Element Results

Most inorganic element concentrations did not differ statistically between Abiquiu and Cochiti Lake reservoirs. Mercury sediment concentrations were higher in Abiquiu Lake reservoir (0.039 ± 0.003 milligrams per kilogram) when compared with Cochiti Lake reservoir (0.016 ± 0.016 milligrams per kilogram; T-test, $p < 0.01$); and vanadium sediment concentrations were higher in Cochiti Lake reservoir (24.3 ± 12.4 milligrams per kilogram) when compared with Abiquiu Lake reservoir (11.4 ± 3.6 milligrams per kilogram; T-test $p < 0.05$; Figure 7-21). However, all concentrations of mercury and vanadium were below the regional statistical reference level and the no-effect ecological screening level for aquatic community organisms; thus, these levels are not of concern (Table S7-41). Beryllium and potassium in one pelagic Cochiti Lake reservoir sediment sample exceeded the regional statistical reference level; no ecological screening level are available for these elements (Table S7-41). Iron concentrations exceeded the no-effect ecological screening level in two pelagic Cochiti Lake reservoir samples but were below the regional statistical reference level (Table S7-41). Manganese exceeded the no-effect ecological screening level in all three pelagic Cochiti Lake reservoir samples and two also exceeded the regional statistical reference level (Table S7-41). Selenium concentrations exceeded the no-effect ecological screening level for aquatic community organisms at some pelagic locations in both Abiquiu and Cochiti Lake reservoirs, however, the observed concentrations were below the regional statistical reference level. No other elements exceeded the regional statistical reference level or no-effect ecological screening level. All elements were below the low-effect ecological screening level for aquatic community organisms (Table S7-41) and are not of ecological concern.

All sediment samples collected from Abiquiu Lake reservoir and half of the sediment samples collected from Cochiti Lake reservoir contained detectable concentrations of PCBs (Table S7-42). There was no significant difference in total PCB concentrations in sediment between Abiquiu (18.9 ± 12.9 picograms per gram) and Cochiti (15.7 ± 14.3 picograms per gram) reservoirs. Sediment from one location collected from Cochiti Lake reservoir contained PCB levels of 87.3 picograms per gram that was higher than the regional statistical reference level of 50.8 picograms per grams. All PCB concentrations were far below the lowest no-effect ecological screening level.

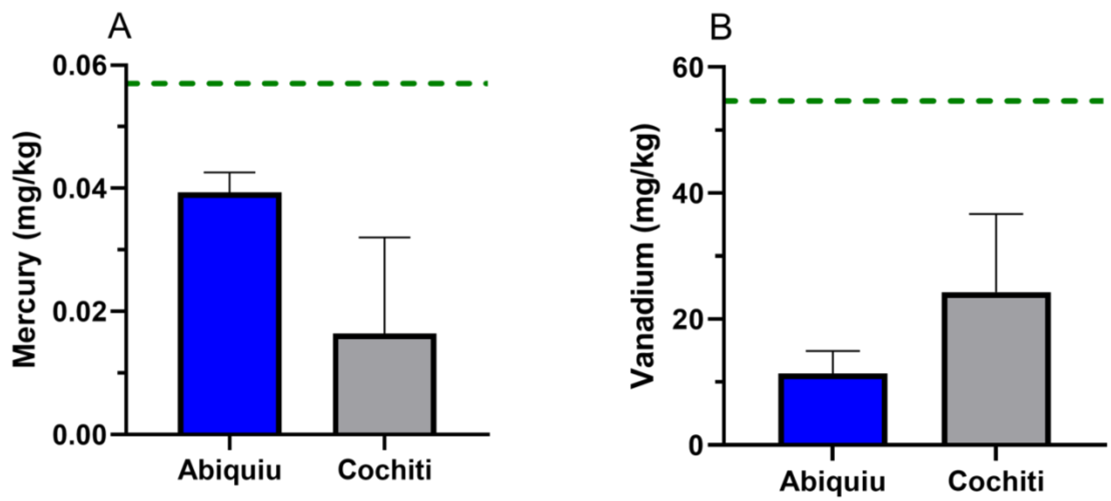

Figure 7-21. (A) Mercury and (B) vanadium concentrations in reservoir sediment samples collected upstream in Abiquiu reservoir and downstream in Cochiti reservoir in 2020 compared with the regional statistical reference level (mean plus three standard deviations of sediment samples collected from background locations green dashed line). Note vertical axis is a linear scale. Columns represent the mean and error bars represent standard deviation. Note: mg/kg = milligrams per kilogram.

PFAS Results

Nearly all PFAS chemicals were not detected in reservoir sediment samples. PFOS was the only PFAS chemical detected in one sample collected from Abiquiu Lake reservoir at 0.425 nanograms per gram. There were no significant differences in PFAS chemical concentrations between Abiquiu and Cochiti Lake reservoirs ($p > 0.05$).

Sediment Toxicity Bioassays

River and reservoir sediment was collected as described above and sent to Pacific EcoRisk in Fairfield, California for sediment acute toxicity testing. The testing procedure followed U.S. Environmental Protection Agency guidelines. The toxicity assay consists of exposing two different aquatic organisms, *Chironomus dilutus* and *Hyalella azteca,* to the sediment and monitoring their growth and survival over a 10-day period (EPA 2000). The test was replicated eight times for each sediment sample and test species. Each replicate contained 100 mL of homogenized sediment, clean overlying water, and 10 organisms; they were placed in a temperature controlled room at 23° C for 10 days. All replicates were checked daily, and any dead animals were removed. After 10 days, percent survival and growth (determined by dry mass) of the two species was determined.

There were no significant differences in the percent survival or in growth of *Chironomus dilutus* or *Hyalella azteca* housed in Rio Grande sediments collected from downstream of Los Alamos Canyon when compared with organisms exposed to upstream sediments (Figure 7-22; Table S7-43; T-test, $p > 0.05$). These observations are similar with previous years.

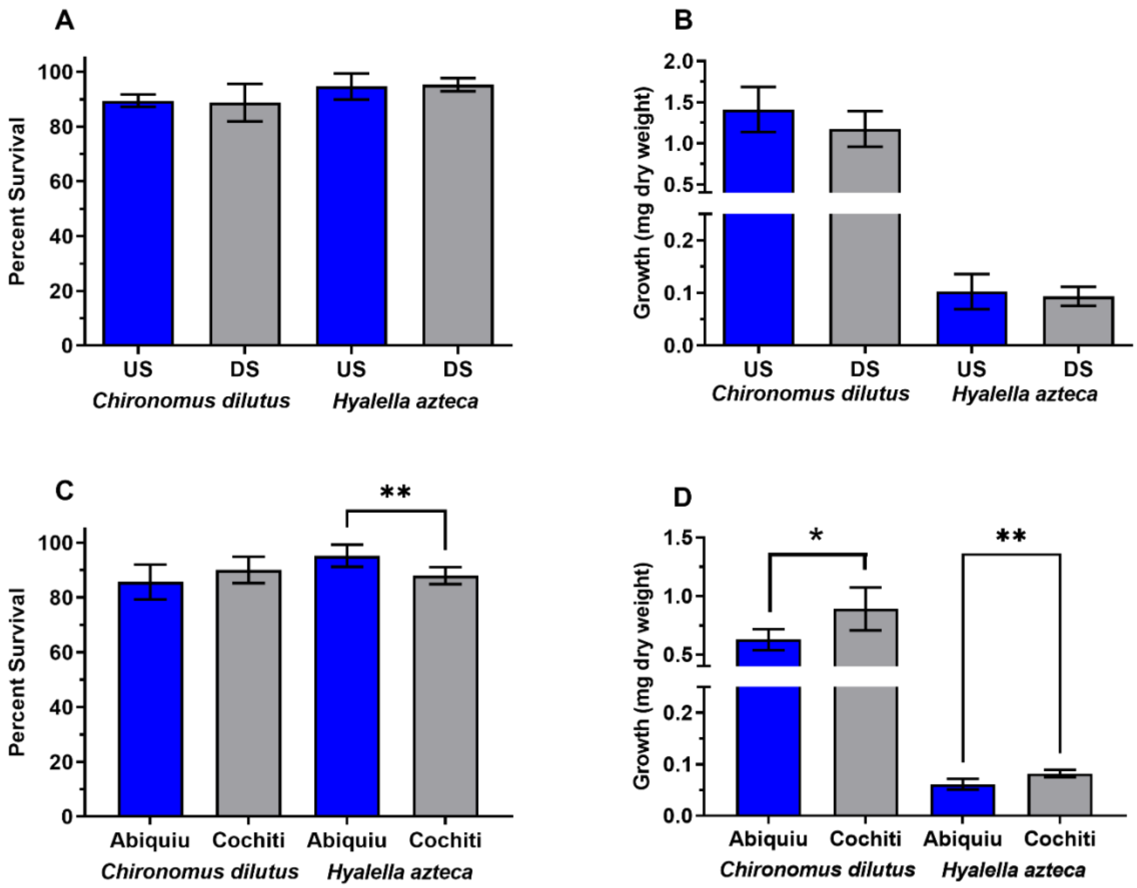

Figure 7-22. Survival and growth of Chironomus dilutus and Hyalella azteca exposed to Rio Grande sediments collected upstream (US) and downstream (DS) of the confluence with Los Alamos Canyon and collected from Abiquiu reservoir (upstream) and Cochiti reservoir (downstream) in 2020. (A) No significant differences were observed in percent survival exposed to downstream sediments when compared with upstream sediment in the Rio Grande. (B) No significant differences were observed in growth when exposed to downstream sediments when compared with upstream sediment in the Rio Grande. (C) No significant difference was observed in percent survival of Chironomus dilutus in reservoir sediment but a significant reduction was observed in the percent survival of Hyalella azteca in Cochiti sediment (T-test, p < 0.01). (D) Growth of Chironomus dilutus and Hyalella azteca was significantly higher when housed in Cochiti sediment when compared with Abiquiu sediment (T-test, p < 0.05 and p < 0.01, respectively). Note: mg = milligrams.

There was no significant difference in the percent survival of *Chironomus dilutes* between Abiquiu and Cochiti Lake reservoirs (T-test, $p > 0.05$) but the percent survival in *Hyalella Azteca* was reduced in Cochiti Lake reservoir sediment when compared with Abiquiu Lake reservoir sediment (Figure 7-22; Table S7-44; T-test, $p < 0.01$). Most sediment chemistry results did not differ between the two reservoirs; however, mercury sediment concentrations were higher in Abiquiu Lake reservoir and vanadium was higher in Cochiti Lake reservoir. Nedrich et al. (2018) studied vanadium toxicity in aquatic sediments at levels of 635 to 1620 milligrams per kilogram (average vanadium concentration in Cochiti

Lake reservoir was 24.3 ± 12.4 milligrams per kilogram) and determined that vanadium is not readily bioavailable nor did it have effects on growth and survival to *Hyalella azteca* or *Daphnia magna*. Therefore, the higher levels of vanadium in Cochiti Lake reservoir are unlikely to drive the reduced survival of *Hyalella Azteca* in Cochiti sediments. Other non-chemical paramaters may be driving this observation.

Both *Chironomus dilutus* and *Hyalella Azteca* had greater growth when housed in Cochiti Lake reservoir sediment when compared with Abiquiu Lake reservoir sediment (Figure 7-22; Table S7-48; T-test, $p < 0.05$). Abiquiu Lake reservoir sediment contained higher concentrations of mercury when compared with Cochiti Lake reservoir sediment, 0.039 ± 0.003 and 0.016 ± 0.016 milligrams per kilogram, respectively. However, all mercury concentrations were well below the no-effect ecological screening level of 0.18 milligrams per kilogram; thus, they are not expected to be driving this observation. Other non-chemical parameters may be driving this observation.

Benthic Macroinvertebrate Surveys

The presence and types of benthic macroinvertebrates in a stream reach serve as indicators of water quality in that reach. The different species have varying tolerances for disturbance, including pollutants. The primary goal of this work is to determine if there are any impacts to waters downstream of Los Alamos National Laboratory operations.

What are benthic macroinvertebrates?

Benthic macroinvetebrates are small animals (frequently worms or insect larvae) living among the stones, sediments, downed woody material, and plants at the bottom of streams, rivers, and lakes.

To investigate the differences in aquatic organisms found downstream and upstream of Los Alamos National Laboratory, we assessed benthic macroinvertebrate communities in downstream and upstream reaches of the Rio Grande. We conducted stream surveys along the Rio Grande at eight locations downstream and seven locations upstream of the confluence of Los Alamos Canyon with the Rio Grande in September and October of 2020 (Figure 7-20). Additionally, we sampled for benthic macroinvertebrates at six locations in Abiquiu Lake reservoir (upstream) and six locations in Cochiti Lake reservoir (downstream). The locations for benthic macroinvertebrate samples at the reservoirs were at the same location as our sediment collection samples (Figure 7-20).

We also collected environmental parameters during stream and reservoir sample collection because these parameters are known to influence benthic macroinvertebrate community assemblages (Cummins et al. 2008). Parameters included water temperature, conductivity, pH, dissolved oxygen, and total dissolved solids. Conductivity is an estimate of the amount of salts dissolved in a water body, pH is a measure of hydrogen ion concentration, dissolved oxygen is the amount of oxygen in the water, and total dissolved solids is a measure of the combined total of organic and inorganic substances in a liquid.

In streams, benthic macroinvertebrates were collected at sample locations using a D-frame kick net to cover an approximately 3 m^2 sampling area. In reservoirs, we collected benthic macroinvertebrates with a ponar grab apparatus deployed from a boat. We collected six benthic macroinvertebrate samples from three different regions at each reservoir: inlet, middle, and outlet; and two zones within each region: littoral (0-10 meters depth) and profundal (>10 meters depth). Benthic macroinvertebrates samples from reservoirs and streams were processed on a 500-micron sieve and all material on the sieves were transferred to a sample container and preserved with 95% ethanol. All samples were shipped to EcoAnalysts in Moscow, Idaho, for taxonomic identification.

We compared benthic macroinvertebrate samples from upstream and downstream locations to assess differences in the benthic macroinvertebrate communities. We compiled results for abundance, species richness, Simpson's diversity index, and overall community composition. We used three metrics to evaluate water quality based on the benthic macroinvertebrate community composition: the Hilsenhoff Biotic Index (Hilsenhoff 1988), metals tolerance index (McGuire 2009), and the percent of pollution sensitive taxa (Ephemeroptera, Plecoptera, and Trichoptera).

Abundance is the total number of individuals in a sample. Species richness is the number of species (taxa) in a sample. The Simpson's diversity index incorporates species richness and evenness and gives the probability that two individuals randomly selected from a sample will belong to the same species. Simpson's diversity index values range between zero and one, where values close to one represent maximum diversity, and a zero represents no diversity (all individuals are of the same species). The Hilsenhoff Biotic Index estimates the overall tolerance of the community to disturbance, including pollution. It is calculated by weighting the relative abundance of each taxonomic group with their tolerance of disturbance. The values range from zero to 10. A low value reflects a higher abundance of sensitive groups, indicating that the sampled area has a lower level of disturbance. The metals tolerance index is used to identify samples with a high percentage of organisms tolerant of metals. This index is on a scale from zero to 10, with higher values indicating a higher percentage of tolerant organisms, indicating more metal pollution. The percent of Ephemeroptera, Plecoptera, and Trichoptera index evaluates water quality by the relative abundance of three major orders of stream insects that have a low tolerance to water pollution. Population metrics and water quality indices for benthic macroinvertebrates were all normally distributed and were evaluated with an unpaired t-test.

What are taxa?

Scientists use a hierarchy of classification categories to describe and name each animal and plant. Any group of organisms having the same name in a classification category is called a taxon. Multiple taxons are taxa. In this study, the authors mostly grouped organisms according to their **order** or their **family,** or the authors named organisms specifically by using italicized **genus** and **species**. Here is an example of how humans are named using this taxonomic hierarchy:

Domain: Eukaryota

Kingdom: Animalia

Phylum: Chordata

Class: Mammalia

Order: Primates

Family: Hominidae

Genus: *Homo*

Species: *sapiens*

We used non-metric multidimensional scaling with a Bray-Curtis dissimilarity matrix to assess differences in the benthic macroinvertebrate community compositions from downstream and upstream locations taken in both 2017 and 2020 to increase our sample size for this multivariate analysis. We also performed a subset non-metric multidimensional scaling analysis using only 2020 benthic macroinvertebrate data. For the 2020 analysis, we overlaid environmental variables (pH, temperature, total dissolved solids) onto the non-metric multidimensional scaling biplot and used a permutation test to see if parameters significantly influenced the benthic macroinvertebrate assemblages. We tested differences in the benthic macroinvertebrate community compositions between upstream and downstream locations using the nonparametric statistical method Adonis. We used the package vegan (Oksanen et al. 2019) in the R statistical software version 3.5.3 for all data analyses (R Core Team 2021).

Results

In the Rio Grande, benthic macroinvertebrates were found in all 15 samples that were taken from upstream and downstream locations. We saw no differences between benthic macroinvertebrate abundance, species richness, Simpson's diversity index, the percent of Ephemeroptera, Plecoptera, and Trichoptera, the Hilsenhoff Biotic Index, or tolerance of metals index between locations downstream of Laboratory property and upstream locations (Figure 7-23, Table S7-44, T-test, $p > 0.05$). Results showed no differences in community composition of benthic macroinvertebrates upstream and downstream of the Los Alamos National Laboratory property when we analyzed data from 2017 and 2020 combined (Figure 7-24, PERMANOVA, $p > 0.05$), or when 2020 data was assessed alone (Figure 7-25, PERMANOVA, $p > 0.05$). We did see significant influences on the benthic macroinvertebrate community from one of the environmental parameters, total dissolved solids, but the differences were not associated with upstream or downstream locations (total dissolved solids: $R^2 = 0.563$, Permutation test, $p = 0.006$).

In reservoirs, benthic macroinvertebrates were found in 8 of the 12 samples. Overall, the abundance of benthic macroinvertebrates was low (< 80 total individuals for all samples). The dominate species found in both reservoirs were aquatic worms and water mites. We saw that there was a greater abundance of macroinvertebrates in Cochiti Lake reservoir (downstream) compared to Abiquiu Lake reservoir (upstream). However, due to the small samples size and some sample locations not containing any benthic macroinvertebrates, we cannot make robust conclusions based on these data. Due to the lack of benthic macroinvertebrates in samples taken at reservoirs, we did not compare benthic macroinvertebrate water quality metrics from the reservoirs downstream and upstream of the Laboratory.

We did not detect differences in any of our metrics between stream systems downstream of Los Alamos National Laboratory and upstream locations, including tolerance values of the benthic macroinvertebrate community and water quality metrics. These data suggest that our sample locations downstream of and on Los Alamos National Laboratory property support healthy communities of aquatic life and are not of ecological concern.

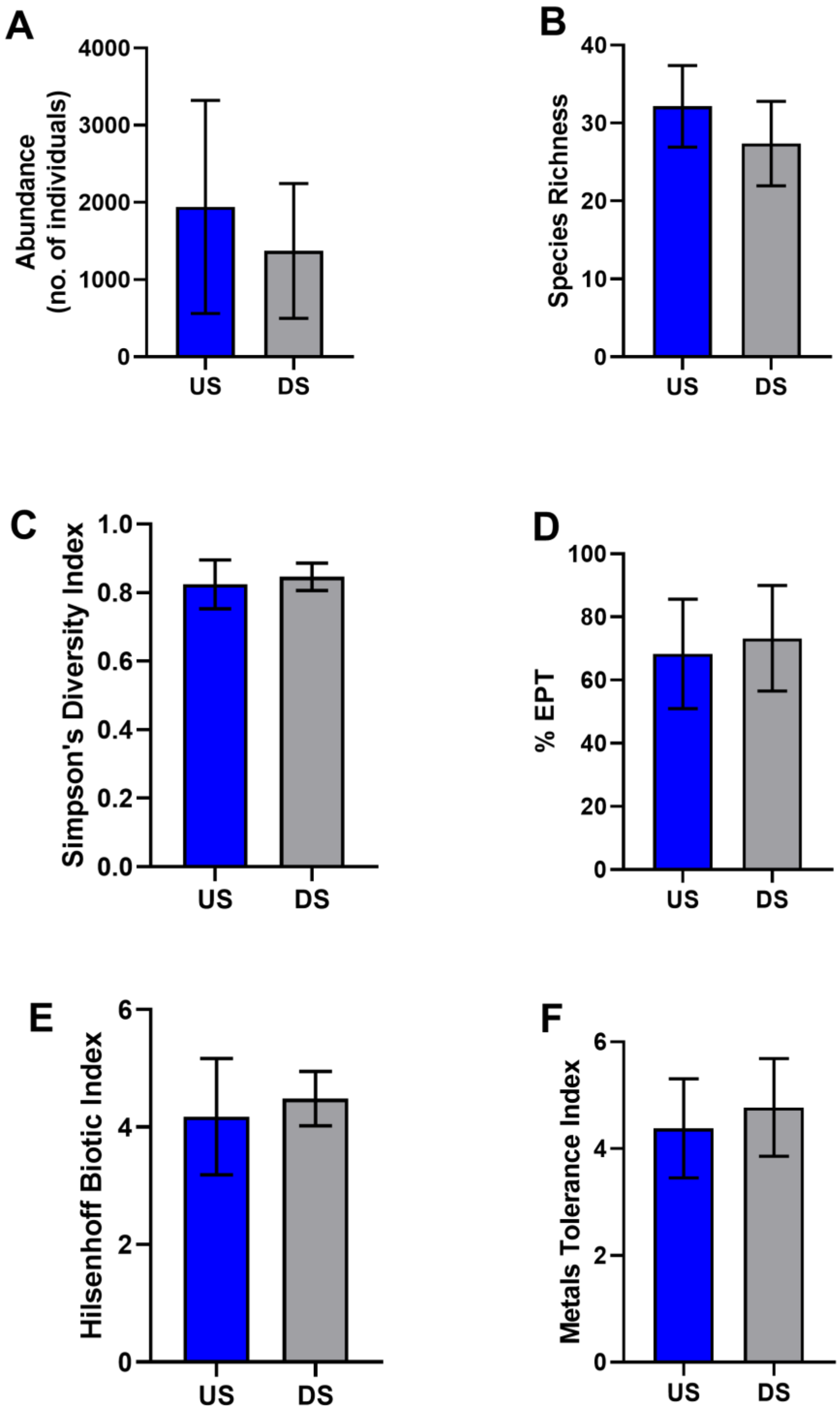

Figure 7-23. Benthic macroinvertebrate comparisons of (A) abundance, (B) species richness, (C) Simpson's diversity index; and (D) % EPT, (E) the Hilsenhoff Biotic, and (F) Metal Tolerance Index of locations collected upstream (US) in the Rio Grande compared to downstream (DS) locations. Columns represent mean and error bars represent standard deviation.

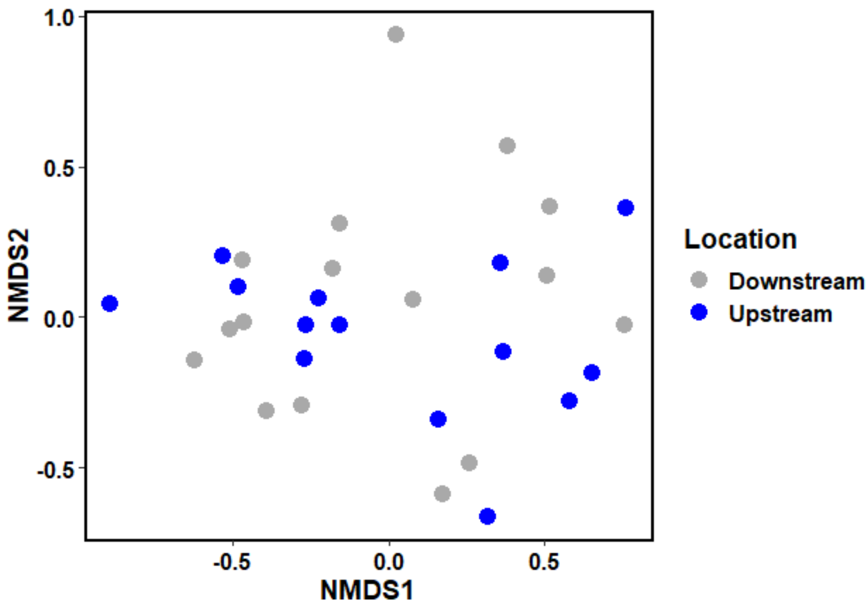

Figure 7-24. Non-metric multidimensional scaling results for 2017 and 2020. Community composition for upstream and downstream locations in the Rio Grande are not significantly different (p > 0.05). Points represent the community composition from each sample and axes are arbitrary. NMDS = non-metric multidimensional scaling.

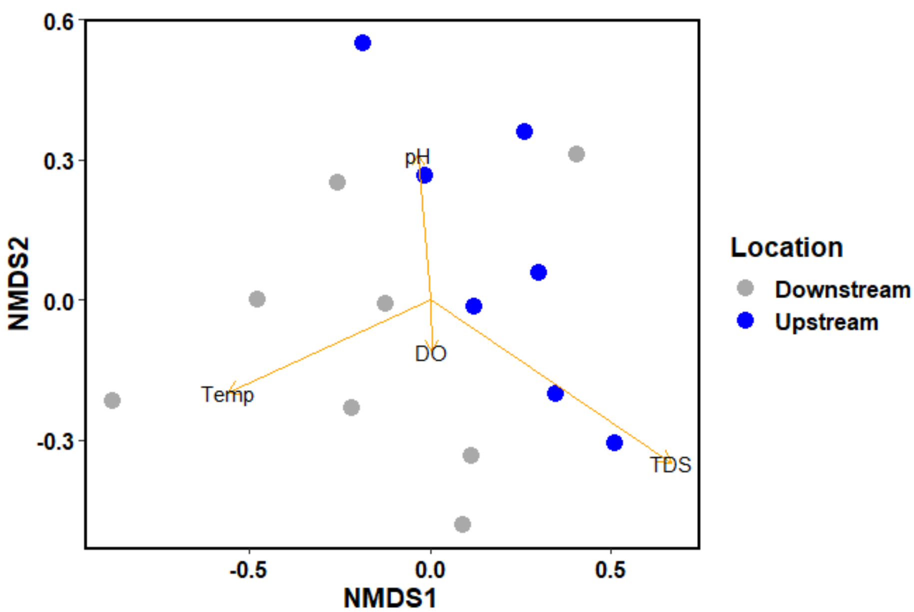

Figure 7-25. Non-metric multidimensional scaling results from 2020 data only. Points represent the community composition from each sample and axes are arbitrary. Community composition for upstream and downstream locations are not significantly different (p > 0.05). Arrows show environmental data influencing benthic macroinvertebrate communities. Only TDS had a significant influence on benthic macroinvertebrate communities (R2 = 0.563, p = 0.006). TDS = Total Dissolved Solids, DO = Dissolved Oxygen, pH = pH, Temp = Temperature, NMDS = non-metric multidimensional scaling.

Aquatic Health Assessment Summary

Our evaluation of radionuclide, inorganic elements, and organic chemicals in fish, crayfish, and sediment, and the sediment biotoxicity assay revealed that, with a few exceptions, the majority of constituents did not statistically differ in the Rio Grande above and below its confluence with Los Alamos Canyon or between the reservoirs. Additionally, there were no differences in benthic macroinvertebrate indices or communities in the Rio Grande. All concentrations of radionuclides in sediment were below biota dose screening levels and chemicals were below the low effect screening levels; these levels are protective of biota. All concentrations of chemicals in biota were below the lowest observed adverse effect level. No fish in this study exceeded the PCB human consumption advisory limit and only two fish collected from Abiquiu Lake reservoir contained mercury concentrations that exceeded the human consumption advisory limit. This exceedance occurred above the confluence of Los Alamos Canyon with the Rio Grande, which is upstream of the area potentially affected by Laboratory operations. These results indicate that chemicals and radionuclides resulting from Laboratory operations that may be present in storm water and snow melt flows have not had an adverse effect on the Rio Grande aquatic ecosystem during 2011–2020.

Biota Radiation Dose Assessment

The purpose of the biota dose assessment is to ensure that plant and animal populations are protected from the effects of Laboratory radioactive materials, as required by DOE Order 458.1. This assessment follows the guidance of the DOE standard, "A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota" (DOE 2019), and uses the standard DOE dose calculation program, RESRAD-BIOTA version 1.8.

Previous biota dose assessments were reported in the Annual Site Environmental Reports and concluded that biota doses for populations 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 2019).

What is a rad?

"Rad" is an acronym for radiation absorbed dose. A dose of 1 rad means that 1 gram of material absorbed 100 ergs of energy as a result of exposure to ionizing radiation. One rad is the same as 0.01 Gray. Different materials that receive the same exposure may not absorb the same amount of radiation.

Plants receive doses from external radiation, and they receive internal doses from radionuclides taken up through their roots. Plants in some locations at the Laboratory may grow roots into material buried in material disposal areas. Animals also receive an external dose and an internal dose from their food—plants or other animals. When a predator eats its prey, bioaccumulation is possible as ingested material passes up the food chain. Bioaccumulation is accounted for by introducing "bioaccumulation factors" or "concentration ratios," which are the ratios of the radionuclides in living tissue to the concentrations in the underlying soil and water.

The well-established concentration ratios provide the option of calculating the concentrations in living tissue from the concentrations in soil. Alternatively, the concentration ratios can be used to calculate the soil concentration from measured concentrations in biota tissue. The comparison of these two methods shows that in most cases using the concentration ratios provides overestimates of dose, which allows for conservative screening of the results.

The biota doses reported below are calculated using site-representative values as described in Appendix F of DOE-STD-1153-2019 (DOE 2019). Whenever the data allow calculations of the dose from either soil or tissue data, the largest dose is reported below.

The material potentially contributing to the biota doses at the Laboratory is legacy waste material. Ongoing remediation and radioactive decay result in decreasing concentrations over time, so a generally-decreasing trend in biota doses is expected. However, ongoing operations and movement of soil or sediment may cause an accumulation of radioactive material, so key locations are re-assessed annually.

Mesa-Top Facilities

Area G

This chapter reports new measurements of soil and vegetation around material disposal Area G, known as "Area G." The results are generally comparable with previous years, though there is some year-to-year variation depending on the exact locations sampled. This year-to-year variation is shown in the trend graphs of this chapter.

As recommended by the DOE standard (DOE 2019), this assessment uses the highest measured concentrations, and the resulting doses are reported in Tables 7-1 and 7-2.

At Area G, the largest dose contribution is from tritium, which is mostly concentrated near the southern edge of Area G, near locations 29-03 and 30-1. 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 the doses are also below the limit of 1 rad/day for plants. Overall, there are no measurable impacts to biota health.

Table 7-1. Dose to Terrestrial Animals at Area G for 2020
DOE Limit: 0.1 rad/day for terrestrial animals

Nuclide	External		Internal		Nuclide Total (rad/day)
	Water (rad/day)	Soil (rad/day)	Water (rad/day)	Soil (rad/day)	
Am-241	1.3E-10	1.3E-06	4.4E-08	1.0E-05	1.2E-05
Cs-137	1.8E-08	1.8E-05	2.3E-09	1.2E-06	1.9E-05
H-3	8.7E-05	1.7E-04	1.7E-04	1.7E-04	6.0E-04
Pu-238	1.5E-10	6.0E-07	3.1E-07	2.2E-05	2.3E-05
Pu-239	1.6E-10	6.4E-07	5.7E-07	3.6E-05	3.8E-05
Sr-90	2.5E-07	1.5E-05	2.0E-06	6.0E-05	7.7E-05
U-234	1.1E-08	1.1E-06	8.3E-06	3.2E-05	4.1E-05
U-235	1.6E-08	1.6E-06	4.0E-07	1.5E-06	3.5E-06
U-238	1.0E-06	1.0E-04	9.6E-06	3.6E-05	1.5E-04
Medium Total	8.8E-05	3.1E-04	1.9E-04	3.7E-04	Overall Dose 9.6E-04

Table 7-2. Dose to Terrestrial Plants at Area G for 2020
DOE Limit: 1.0 rad/day for terrestrial plants

Nuclide	External Water (rad/day)	External Soil (rad/day)	Internal Soil (rad/day)	Nuclide Total (rad/day)
Am-241	1.3E-10	1.3E-06	2.0E-05	2.1E-05
Cs-137	1.8E-08	1.8E-05	1.2E-06	1.9E-05
H-3	8.7E-05	1.7E-04	1.8E-04	4.4E-04
Pu-238	1.5E-10	6.0E-07	6.8E-05	6.8E-05
Pu-239	1.6E-10	6.4E-07	1.8E-04	1.8E-04
Sr-90	2.5E-07	1.5E-05	6.0E-05	7.5E-05
U-234	1.1E-08	1.1E-06	3.1E-05	3.2E-05
U-235	1.6E-08	1.6E-06	1.5E-06	3.2E-06
U-238	1.0E-06	1.0E-04	3.6E-05	1.4E-04
Medium Total	8.8E-05	3.1E-04	5.8E-04	Overall Dose 9.8E-04

Dual-Axis Radiographic Hydrodynamic Test Facility

The Dual-Axis Radiographic Hydrodynamic Test Facility biota dose assessment uses the same methods described in the previous section. The largest doses were calculated from the soil data, indicating that the tissue to soil concentration ratios produce overestimates, as discussed above. The largest soil activities were entered into RESRAD-BIOTA.

The largest dose contribution is from uranium, most of which is the result of Laboratory 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 are well below the DOE limits of 0.1 rad/day for animals and 1 rad/day for plants. There are no measurable impacts to biota health.

Table 7-3. Dose to Terrestrial Animals at Dual-Axis Radiographic Hydrodynamic Test Facility for 2020; DOE Limit: 0.1 rad/day for terrestrial animals

Nuclide	External Water (rad/day)	External Soil (rad/day)	Internal Water (rad/day)	Internal Soil (rad/day)	Nuclide Total (rad/day)
Am-241	5.1E-12	5.1E-08	1.7E-09	4.0E-07	4.5E-07
Cs-137	2.7E-08	2.7E-05	3.4E-09	1.7E-06	2.9E-05
H-3	3.5E-09	7.0E-09	6.9E-09	6.9E-09	2.4E-08
Pu-238	1.6E-12	6.2E-09	3.2E-09	2.3E-07	2.4E-07
Pu-239	3.2E-12	1.3E-08	1.1E-08	7.3E-07	7.6E-07
Sr-90	3.1E-07	1.9E-05	2.5E-06	7.5E-05	9.7E-05
U-234	3.4E-08	3.4E-06	2.6E-05	9.8E-05	1.3E-04
U-235	5.0E-08	5.0E-06	1.3E-06	4.7E-06	1.1E-05
U-238	2.8E-06	2.8E-04	2.7E-05	1.0E-04	4.1E-04
Medium Total	3.2E-06	3.3E-04	5.6E-05	2.8E-04	Overall Dose 6.7E-04

Table 7-4. Dose to Terrestrial Plants at Dual-Axis Radiographic Hydrodynamic Test Facility for 2020; DOE Limit: 1.0 rad/day for terrestrial plants

Nuclide	External Water (rad/day)	External Soil (rad/day)	Internal Soil (rad/day)	Nuclide Total (rad/day)
Am-241	5.1E-12	5.1E-08	7.5E-07	8.0E-07
Cs-137	2.7E-08	2.7E-05	1.7E-06	2.9E-05
H-3	3.5E-09	7.0E-09	7.4E-09	1.8E-08
Pu-238	1.6E-12	6.2E-09	6.9E-07	7.0E-07
Pu-239	3.2E-12	1.3E-08	3.6E-06	3.6E-06
Sr-90	3.1E-07	1.9E-05	7.5E-05	9.4E-05
U-234	3.4E-08	3.4E-06	9.7E-05	1.0E-04
U-235	5.0E-08	5.0E-06	4.8E-06	9.8E-06
U-238	2.8E-06	2.8E-04	1.0E-04	3.9E-04
Medium Total	3.2E-06	3.3E-04	2.9E-04	Overall Dose 6.2E-04

Sediment-Retention Sites in Canyons

Los Alamos Canyon Weir

The Los Alamos Canyon weir receives drainage from Technical Areas 01, 02, and 21, which contain legacy waste materials. The soil and sediment trapped by the weir include slightly elevated activities of fission products (cesium-137 and strontium-90) and transuranics (americium and plutonium isotopes). The largest doses were from natural uranium.

As shown in Tables 7-5 and 7-6, the doses are all less than 0.1 percent of the DOE limits.

Table 7-5. Dose to Terrestrial Animals in Los Alamos Canyon Weir for 2020
DOE Limit: 0.1 rad / day for terrestrial animals

	External		Internal		
Nuclide	**Water (rad/day)**	**Soil (rad/day)**	**Water (rad/day)**	**Soil (rad/day)**	**Nuclide Total (rad/day)**
Am-241	1.3E-10	1.3E-06	4.2E-08	9.7E-06	1.1E-05
Cs-137	3.0E-09	3.0E-06	3.9E-10	1.9E-07	3.2E-06
H-3	7.8E-08	1.6E-07	1.5E-07	1.5E-07	5.4E-07
Pu-238	7.4E-12	2.9E-08	1.5E-08	1.1E-06	1.1E-06
Pu-239	2.6E-11	1.0E-07	9.2E-08	5.9E-06	6.1E-06
Sr-90	7.1E-08	4.3E-06	5.7E-07	1.7E-05	2.2E-05
U-234	1.4E-08	1.4E-06	1.1E-05	4.1E-05	5.3E-05
U-235	2.6E-08	2.6E-06	6.6E-07	2.5E-06	5.8E-06
U-238	9.0E-07	9.0E-05	8.6E-06	3.2E-05	1.3E-04
Medium Total	1.1E-06	1.0E-04	2.1E-05	1.1E-04	Overall Dose 2.4E-04

Table 7-6. Dose to Terrestrial Plants in Los Alamos Canyon Weir for 2020
DOE Limit: 1 rad/day for terrestrial plants

	External		Internal	
Nuclide	**Water (rad/day)**	**Soil (rad/day)**	**Soil (rad/day)**	**Nuclide Total (rad/day)**
Am-241	1.3E-10	1.3E-06	1.9E-05	2.0E-05
Cs-137	3.0E-09	3.0E-06	1.9E-07	3.2E-06
H-3	7.8E-08	1.6E-07	1.7E-07	4.0E-07
Pu-238	7.4E-12	2.9E-08	3.3E-06	3.3E-06
Pu-239	2.6E-11	1.0E-07	2.9E-05	2.9E-05
Sr-90	7.1E-08	4.3E-06	1.7E-05	2.1E-05
U-234	1.4E-08	1.4E-06	4.1E-05	4.2E-05
U-235	2.6E-08	2.6E-06	2.5E-06	5.2E-06
U-238	9.0E-07	9.0E-05	3.3E-05	1.2E-04
Medium Total	1.1E-06	1.0E-04	1.4E-04	Overall Dose 2.5E-04

Pajarito Canyon Flood-Retention Structure

The Pajarito Canyon flood-retention structure does not receive significant quantities of radionuclides from LANL legacy waste materials. During 2020, any contribution from DOE operations was indistinguishable from background. The total biota dose in Pajarito Canyon is much less than one percent of the DOE limits and has no measurable impact on biota health.

Animals at All Other Locations

Road-Killed Animals

At other locations, road-killed animals provide information about the presence of radioactive material within their home ranges.

Measurements of radioactive materials in large animals are reported in Tables S7-24 (deer) and S7-25 (bird, snake, bobcat, badger). The data are consistent with regional data, the doses are much less than one percent of the DOE limits, and there is no measurable impact to the health of these animals from radioactive material.

Rio Grande

Sediment transport carries laboratory material to the Rio Grande where it is mixed with material from upstream and also with naturally-occurring material that may be taken up by animals and plants in the Rio Grande. Measurements of fish and crayfish show that the levels in biota are similar upstream and downstream of the Laboratory, and furthermore are far below all biota-dose screening levels. We conclude that the dose to biota in the Rio Grande is much less than one percent of the DOE limits, and there is no measurable impact to these animals from radioactive material.

Conclusion

Previous biota dose assessments have shown that biota doses at LANL are far below the DOE limits. This 2020 assessment confirms the previous assessments and shows that there are no harmful effects to the health of biota populations at LANL.

Biological Resources Management Program

We monitor federally listed threatened or endangered species and migratory bird species, and provide guidelines and requirements for Laboratory operations to minimize impacts to sensitive species and their habitats and ensure that all Laboratory operations comply with federal and state regulatory requirements.

Threatened and Endangered Species Surveys

In 2020, surveys were completed for two species protected under the Endangered Species Act, the Mexican spotted owl (*Strix occidentalis lucida*), and the southwestern willow flycatcher (*Empidonax trailii extimus).* The Jemez Mountains salamander (*Plethodon neomexicanus*) is also protected under the Endangered Species Act and can be found on Laboratory property. Surveys to detect this species of salamander are performed when moisture levels are high enough to proceed with surveys. No surveys were conducted in 2020 for Jemez Mountains salamanders due to lack of sufficient moisture.

Mexican spotted owl

The Mexican spotted owl generally inhabits mixed conifer, ponderosa pine, and Gambel oak forests in mountains and canyons (U.S. Fish and Wildlife Service 2012). Mexican spotted owls in the Jemez

Mountains of northern New Mexico prefer cliff faces in canyons for their nest sites (Johnson and Johnson 1985).

Under the Laboratory's Threatened and Endangered Species Habitat Management Plan, Mexican spotted owl habitat has been identified based on a combination of cliff habitat and forest characteristics (LANL 2017). Mexican spotted owl habitats are called areas of environmental interest at LANL. Currently, five Mexican spotted owl areas of environmental interest span seven canyons at the Laboratory.

Surveys for breeding Mexican spotted owls are conducted every year in all areas of environmental interest. In 2020, we detected Mexican spotted owls in the Mortandad, Sandia, and Three-mile canyon areas of environmental interest, with both nests producing young. These two sites have had Mexican spotted owls in previous years (Thompson et al. 2019).

Southwestern willow flycatcher

The Southwestern willow flycatcher is found in close association with dense stands of willows, arrowweed (*Pluchea* sp.), buttonbush (*Cephalanthus occidentalis*), tamarisk (*Tamarix*), Russian olive, and other riparian vegetation, often with a scattered overstory of cottonwood (*Populus* sp.; U.S. Fish and Wildlife Service 2002).

Under the Laboratory's Threatened and Endangered Species Habitat Management Plan, southwestern willow flycatcher habitat has been identified based on the presence of riparian habitat with suitable wetland vegetation (LANL 2017). There is only one area of environmental interest for the southwestern willow flycatcher at the Laboratory, located in the bottom of Pajarito Canyon. The survey results in 2020 were all negative for the southwestern willow flycatchers.

Jemez Mountains salamander

The Jemez Mountains salamander occurs predominantly at elevations between 7,000 and 11,000 feet in mixed-conifer and spruce-fir forests, consisting primarily of Douglas fir (*Pseudotsuga menziesii*), blue spruce (*Picea pungens*), Engelmann spruce (*Picea Engelmannii*), white fir (*Abies concolor*), limber pine (*Pinus flexilis*), ponderosa pine, Rocky Mountain maple (*Acer glabrum*), and aspen (*Populus tremuloides*; Degenhardt et al. 1996).

Under the Laboratory's Threatened and Endangered Species Habitat Management Plan, Jemez Mountains salamander habitat has been identified based on a geographical information systems analysis and a field-validated inspection of suitable habitat components (LANL 2017). Currently, there are five Jemez Mountains salamander areas of environmental interest at the Laboratory spanning across four canyons. Surveys are conducted when suitable environmental conditions are met. Surveys were not conducted in areas of environmental interest in 2020 due to lack of moisture in the soil.

Migratory Bird Monitoring

Breeding Season Bird Banding at the Sandia Wetlands

We have been operating a bird banding station in the Sandia Canyon wetland since 2014. This wetland contains primarily broadleaf cattail (*Typha latifolia*), lanceleaf cottonwood (*Populus acuminata*) narrowleaf willow (*Salix exigua*), and Russian olive (N3B 2019). The Sandia Wetlands support numerous species of breeding birds, including many species of conservation concern. The purpose of the study is to monitor the species, age, breeding status, and return rates of songbirds using the area around the wetland.

Beginning in May each year, we operate the bird banding station following a protocol called Monitoring Avian Productivity and Survivorship (DeSante et al. 2021) administered by the Institute for Bird Populations. Use of the Monitoring Avian Productivity and Survivorship protocol is a continent-wide collaborative effort among public agencies, non-governmental groups, and individuals. Following a standard protocol, under which methods are the same at every site, provides data that can be compared among sites.

During banding sessions, we deploy 12 mist nets that are 12 meters long with 30-millimeter mesh webbing in and around the wetland. A standard U.S. Fish and Wildlife Service numbered band is put on each captured bird. All birds are identified, aged, sexed, weighed, measured, fat scored, and checked for signs of molt. We use the aging and sexing criteria provided in Pyle (1997).

A total of 1,596 birds representing 73 species have been captured during the breeding seasons of 2014 through 2020. In 2020, we captured 285 birds representing 42 species. The most commonly captured species in 2020 was the pygmy nuthatch (*Sitta pygmaea*). The most commonly recaptured bird at this site, and second most commonly captured bird overall at this site is the song sparrow (*Melospiza melodia).*

Fall Migration Bird Banding at Pajarito Wetlands

Biologists at the Laboratory also document fall migration patterns of birds on Laboratory property. During the fall of 2020, we completed the eleventh year of monitoring fall migration songbirds. Songbirds were captured at a mist-netting station located in a wetland and riparian complex in Technical Area 36 on the north side of Pajarito Road.

The fall banding station uses 14 mist-nets that are 12 meters long with 30-millimeter mesh. A standard U.S. Fish and Wildlife Service numbered band is put on each bird. All birds are identified, aged, sexed, weighed, measured, fat scored, and checked for signs of molt. The aging and sexing criteria are based on Pyle (1997).

In 2019, which is the year with the highest total to date, we banded 1,375 birds. In 2020, only 193 birds representing 43 species were captured. Although the number of nets and banding days in 2020 did not change from previous years, the number of birds banded in 2020 was very low, likely because moisture levels were below average in 2020 and temperatures were above average. In addition, an unusually early and cold storm system in September 2020 contributed to a mass mortality event of migratory songbirds across New Mexico (New Mexico Department of Game and Fish 2020). The most commonly captured bird at this site was the bushtit (*Psaltriparus minimus).* The second most commonly captured bird was the Wilson's warbler (*Cardellina pusilla*). Capture rates at another local bird banding station at Bandelier National Monument were not as unusually low as observed at the LANL station (unpublished data).

Bird Monitoring at Open-Detonation and Open-Burn Firing Sites

We began bird population monitoring in 2013 for two open detonation sites and at the open burn grounds as part of a Resource Conservation and Recovery Act permitting process. Open detonation sites are locations at the Laboratory where explosives are set off. The open burn grounds is a facility where materials are ignited for self-sustained combustion (for example, to remove residues of high explosives). The two open detonation sites included in the permitting process are Technical Area 36 (Minie) and Technical Area 39 Point 6; the open burn grounds is in Technical Area 16. Together these are referred to as the treatment sites (Hathcock and Fair 2013; Hathcock 2014, 2015; Hathcock et al. 2017, 2018, 2019, 2020). The ongoing objective of the population monitoring is to determine whether Laboratory operations at these sites impact bird species richness (the number of different species present), species diversity (a combination of the number of species present and their relative abundance), or composition (the presence or absence of each individual species).

Point-Count Surveys

Biologists at the Laboratory use point count methodology to survey birds along transects at the three treatment sites and compare the results to surveys conducted in control sites, similar habitats in less developed areas. The habitat type at Technical Area 36 (Minie) and Technical Area 39 is a two-needle pinyon pine and oneseed juniper woodland habitat referred to as pinyon-juniper. The habitat type at Technical Area 16 is a ponderosa pine–forested habitat referred to as ponderosa pine. Surveys reported here are conducted in the summer during the bird breeding season.

A total of 1,005 birds representing 63 species were recorded at the three treatment sites combined in 2020 (Rodriguez and Abeyta 2021). The species richness and diversity at the treatment sites were statistically different from their associated controls at Technical Area 36 (Minie) and Technical Area 16, but not at Technical Area 39. The species diversity at all three treatment sites has been diverging from the controls over the past few years. Diversity is higher at the treatment sites than the controls.

Avian Nest Box Use and Success

The Laboratory's overall avian nest box network, excluding the three treatment sites, had 157 monitored nest boxes in 2020. This was fewer nest boxes compared to previous years; because of the COVID-19 pandemic, fewer personnel were onsite. Of those, 117 contained active nests and 69 of those nests fledged young successfully. This was an overall occupancy rate of 58 percent with a 59 percent success rate for active nests. Forty-four percent of all nest boxes successfully fledged young.

During the 2020 nesting season, 15 nest boxes at each treatment site were actively monitored. There were six nests (40 percent) that fledged young at Technical Area 36 (Minie), three (20 percent) at Technical Area 39, and seven (47 percent) at Technical Area 16. Occupancy rates at Technical Area 39 were low in comparison to the other treatment sites and the overall network. Technical Area 39 is the lowest elevation treatment site, and occupancy has been decreasing over time at both this site and other areas of the avian nest box network at a similar elevation. Wysner et al. (2019) found that western bluebirds, one of the target species of the network, have increased the elevation they select for nesting over time, which may be affecting use of the lower-elevation sites. Occupancy and success rates at the other two treatment sites seem to be fluctuating in the same manner as the overall network and have not displayed a decreasing trend over time.

The results from 2020 continue to indicate that operations at the three treatment sites are not negatively affecting their local bird populations.

Quality Assurance

The Soil, Foodstuffs, and Biota Program collect samples according to written, standard quality assurance and quality control procedures and protocols. These procedures and protocols are identified in the Laboratory's *Implementation of the Soil, Foodstuffs, and Biota Program, Quality Assurance Project Plan* (EPC-ES-QAPP-001) and in the following Laboratory procedures:

- Soil and Vegetation Sampling for the Environmental Surveillance Program (EPC-ES-TP-003)
- Soil and Vegetation Sampling at Facility Sites (EPC-ES-TP-006)
- Soil Sampling for Land Transfer and Conveyance and Other Special Projects (EPC-ES-TP-017)
- Produce Sampling (EPC-ES-TP-004)
- Road Kill Sampling (EPC-ES-TP-007)
- Crayfish Sampling (EPC-ES-TP-008)
- Benthic Macroinvertebrate Sampling (EPC-ES-TP-013)
- Fish Sampling (EPC-ES-TP-005)
- Managing and Sampling Honey Bee Hives (EPC-ES-TP-219)
- Live Trapping of Small Mammals (EPC-ES-TP-201)
- Sediment Sampling in Reservoirs and Rivers (EPC-ES-TP-035)
- General PFAS Sampling Guidance for the Soil, Foodstuffs, and Biota Program (EPC-ES-GUIDE-015)

The Soil, Foodstuffs, and Biota program collects biological samples under approved New Mexico Game and Fish Scientific Collection Permits as well as approved Institutional Animal Care and Use Committee protocols.

In addition, procedures and protocols for biota dose assessment can be found in the *Technical Project Plan for Biota Dose Assessment* (EPC-ES-TPP-002).

These procedures ensure that (1) the collection, processing, and chemical analysis of samples, (2) the validation and verification of data, and (3) 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.

The Biological Resources program collects field data according to written quality control procedures.

- Institutional Animal Care and Use Committee Operations (EPC-ES-AP-014)
- Threatened and Endangered Species Surveys (EPC-ES-TP-203)
- Avian Monitoring (EPC-ES-TP-205)

In addition to these procedures, some parts of our work require the following federal and state permits. These permits are individual permits and not institutional. Personnel working as wildlife biologists at LANL must have the training and background to be able to obtain such permits.

- Federal bird banding permits issued by the U.S. Geological Survey's bird banding laboratory.
- Federal recovery permits to survey or handle federally listed species issued by the U.S. Fish and Wildlife Service.
- State permits for scientific research issued by the New Mexico Department of Game and Fish.

- Surveys for federally listed species follow specific protocols set forth by the U.S. Fish and Wildlife Service and training to these protocols are a prerequisite to obtaining a permit.

The Health Physics program calculates dose to nonhuman biota according to a written quality control procedure.

- Calculating Dose to Nonhuman Biota (EPC-ES-TP-001)

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.

Samples are collected under full chain-of-custody procedures to minimize the chance 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 in the data package. Field data completeness for sample collection in 2020 was 92 percent. Crayfish sampling was the only event where 100 percent of samples were not collected; this was due to poor capture success despite numerous sampling attempts.

Analytical Laboratory Quality Assessment

In 2020, Pacific EcoRisk in Fairfield, California, was unable to conduct the sediment biotoxicity assay on one sample collected from Cochiti Lake reservoir because the sample contained too much gravel to conduct the test. Therefore, in total, we lost sediment biotoxicity results from one sample in 2020 due to error in collection and analyses.

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Chapter 8: Public Dose and Risk Assessment

U.S. Department of Energy regulations limit the total annual radiological 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. The annual dose received by the public from airborne emissions of radionuclides is limited by Clean Air Act regulations to 10 millirem.

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 doses and risks to the public from the Laboratory's operations?" All known radionuclides released in significant quantities from LANL are reported and used in dose calculations. The assessments show that during 2020 all doses to the public were far below all regulatory limits and guidance, and that 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.

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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, using standard methods to calculate the potential effects of radiological dose and risk. These methods do not include tribal-specific exposure scenarios. The results are compared with regulatory limits and international standards.

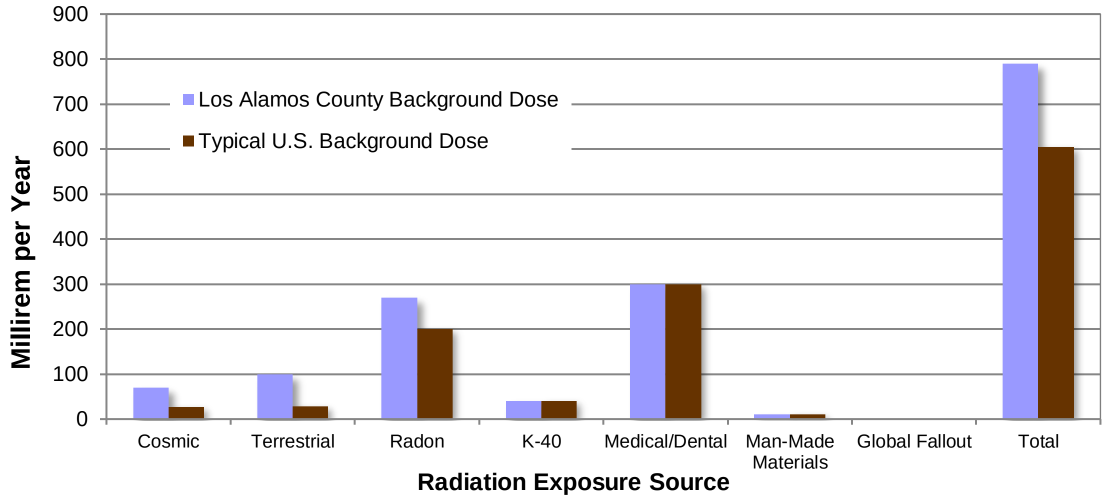
Radiological Materials

Overview of Radiological Dose

Radiological dose is the primary measure of harm from radiation. We calculate doses using the standard DOE and U.S. Environmental Protection Agency methods (DOE 2011, DOE 2020, EPA 2020). 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 (LANL 2020a). The annual dose received by the public from airborne emissions of radionuclides is limited to 10 millirem by the *National Emission Standards for Hazardous Air Pollutants Other Than Radon from Department of Energy Facilities*, Title 40, Part 61, Subpart H of the Code of Federal Regulations. The annual dose from community drinking water supplies is limited under the Safe Drinking Water Act to 4 millirem (*National Primary Drinking Water Regulations*, Title 40 Part 141 of the Code of Federal Regulations).

To place these limits in context, the dose from natural background and from medical and dental procedures is about 800 millirem per year (Figure 8-1). The origins and reasons for the Los Alamos background dose are discussed briefly in the following section and in detail in the paper by Gillis et al. (2014). In contrast, doses from Laboratory operations are typically less than 1 millirem per year.



Note: K-40 = Potassium-40

Figure 8-1. The average Los Alamos County radiation background dose compared with average U.S. radiation background dose (Gillis et al. 2014)

Overview of Exposure Pathways

Potential doses to the public from radionuclides associated with Laboratory operations are calculated by evaluating all exposure pathways. Total dose is the sum of three principal exposure pathways: (1) direct-penetrating (photon or neutron) radiation, (2) inhalation of airborne radioactive particles, and (3) ingestion of radionuclides in water or food.

Direct Radiation

We monitor direct-penetrating radiation from photons and neutrons at 80 locations in and around the Laboratory (see Chapter 4). Direct-penetrating radiation from Laboratory sources contributes to a measurable dose only within about one kilometer of the source. At distances more than one kilometer, dispersion, scattering, and absorption of the photons and neutrons attenuate the dose to much less than 0.1 millirem per year, which cannot be distinguished from natural background radiation. The only measurable above-background doses from direct-penetrating 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 dose related to Laboratory operations is almost entirely from airborne radioactive emissions. Whenever possible, we use the airborne radioactivity levels directly measured by the environmental air-sampling network reported in Chapter 4 (the Ambient Air Sampling for Radionuclides section) to calculate 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 4.1) (EPA 2013, 2020). CAP88 is an atmospheric-dispersion and dose-calculation computer code that combines stack emissions with meteorological data to calculate dose.

Some of the radionuclide emissions from Technical Area 53 are short-lived and cannot be measured by the environmental air monitoring stations. These emissions are measured at the stacks as reported in 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 (Lattin and Fuehne 2021) and in Chapter 4.

Ingestion

Ingestion includes drinking liquids and eating food. We report measurements from water in Chapters 5 and 6 and measurements from soil, plants, and animals here and in Chapter 7.

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 "2020 Annual Drinking Water Quality Report" (Los Alamos County 2021).

Surface water in Los Alamos County is not a source of drinking water so the dose pathway from surface water to humans is through foodstuffs, which are discussed in the following section.

Dose from Naturally Occurring Radiation

Near Los Alamos, naturally occurring sources of radioactivity include (1) cosmic rays, (2) direct-penetrating radiation from terrestrial sources, (3) radon gas, and (4) elements that occur naturally inside the human body, such as potassium-40 (Figure 8-1).

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).

Annual background doses from external gamma radiation (from natural terrestrial sources such as uranium and thorium and their decay products) 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.

Additional human-made sources of radiation, including medical and dental uses of radiation and building products such as stone walls, raise the total average annual background dose (Gillis et al. 2014). 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.

Generally, any additional dose of less than 0.1 millirem per year cannot be distinguished from the dose generated by background levels of radiation.

Dose from Foodstuffs

Monitoring Network

The Soil, Foodstuffs, and Biota program monitors constituents in a wide variety of foodstuffs to determine whether Laboratory operations are affecting human health via the food chain. Foodstuffs samples are collected once every three years, most recently in 2019. In general, we collect foodstuffs from sites on the Laboratory, from communities surrounding the Laboratory (i.e., perimeter locations), from areas downstream of the Laboratory that are irrigated with Rio Grande water, and from background locations that are more than 9 miles from the Laboratory and represent worldwide fallout or natural levels. In 2019, wild foods, fruits, and vegetables (hereafter referred to as crops) were collected from the Laboratory, from gardens and farms located in Los Alamos town site, White Rock/Pajarito Acres, Pueblo de San Ildefonso (perimeter locations), Pueblo de Cochiti (downstream of LANL), and from regional background locations. Eggs, milk, and tea were also collected from select locations. Additionally, deer and elk samples are collected on an annual basis, primarily as road kill or hunter donations; detailed results regarding deer and elk samples can be found in Chapter 7.

Dose from Food

DOE Standard 1196 (DOE 2011) is used to calculate the dose from ingestion of locally grown food.

The data demonstrate that the dose from eating local or regional foodstuffs, including crops, eggs, milk, tea, deer, and elk is less than 0.01 millirem per year. Radionuclide concentrations in publicly available food is consistent with global fallout or naturally occurring material and any contributions from the Laboratory are too small to measure.

The conclusion is that the ingestion dose from Los Alamos National Laboratory operations is less than 0.01 millirem per year and consistent with zero.

Radiological Dose Results

The objective of this section is to calculate doses to the public from Laboratory operations.

As required by DOE Order 458.1 Chg 4, *Radiation Protection of the Public and the Environment*, we calculated doses from the Laboratory to the following members of the public:

- the total human population within 80 kilometers (50 miles) of the Laboratory, and
- the hypothetical "maximally exposed individual."

To identify the location of and the total dose to the hypothetical maximally exposed individual, the following are considered:

- the air-pathway dose,
- the onsite dose at publicly accessible locations,
- other locations with measurable doses, and
- the offsite dose.

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 2020). Outside of Los Alamos County, the doses are too small to measure directly, so the collective dose is calculated by modeling the transport of radioactive air emissions using CAP88. As discussed on pages 8-4 through 8-6, the dose from the other pathways are consistent with zero.

The 2020 collective population dose to people living within 80 kilometers of the Laboratory is 0.08 person-rem (Lattin and Fuehne 2021). This dose is less than 0.001 millirem per person and is much less than the background doses shown in Figure 8-1.

Collective population doses for recent years are shown in Figure 8-2. The trend-line for the past ten years shows a general decrease, which is the result of improved engineering controls at the Los Alamos Neutron Science Center and the tritium facilities.

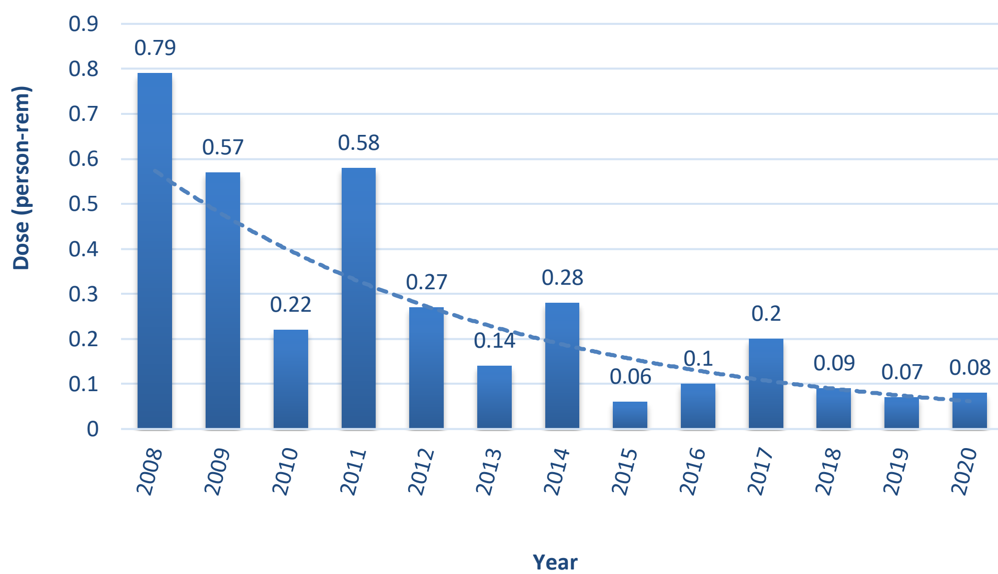


Figure 8-2. Annual collective dose (person-rem) to the population within 80 kilometers of the Laboratory

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 (DOE 2020). We consider all exposure pathways that could cause a dose and all publicly accessible locations, both within the Laboratory boundary (onsite) and outside the boundary (offsite.)

Maximally Exposed Individual Offsite Dose

The air-pathway dose calculations are described in the annual air emissions report (Lattin and Fuehne 2021). In 2020, the offsite location of the hypothetical maximally exposed individual was at 132 DP Road, close to environmental air-monitoring station 326 (Chapter 4, Figure 4-1). The total offsite dose for the maximally exposed individual during 2020 was 0.29 millirem (Lattin and Fuehne 2021).

Contributions to this annual dose were from: short-lived activation products from the Los Alamos Neutron Science Center stacks (0.002 millirem); other stack emissions (0.002 millirem); environmental measurements at the environmental air-monitoring stations (0.132 millirem); and the potential dose contribution from unmonitored stacks (0.150 millirem).

As mentioned in Chapter 4 (the Newly Discovered Waste near DP Road section), some previously unrecorded waste from the Manhattan Project era was uncovered near DP Road in 2020. DP Road and the adjacent land was conveyed by DOE to Los Alamos County or the Los Alamos Public Schools, and some of this property has been re-sold to private developers. During 2020, excavations associated with construction, especially in the western half of the tract, created considerable suspended dust in the air.

On February 14, 2020, a Los Alamos County subcontractor working south of DP Road unearthed material that was later identified as Manhattan Project material from the 1940s. The location was not marked on any historical maps or engineering drawings. Investigations are ongoing and remediation plans are being developed (LANL 2020b).

The material was buried more than 6 feet under the ground west of Material Disposal Area B at a site that is now named the "Middle DP Road" site. The material was dated to the 1940s because the plutonium included no detectable americium—a characteristic of the plutonium used for research in 1944 (Seaborg 1958, Hammel 1998, Schwantes 2009). In contrast, the 1945 plutonium from Hanford includes 1% americium activity, and later plutonium includes more than 10% americium activity.

The excavated soil was covered to protect it from erosion by wind or water until it was placed back into the excavated area in June 2020. Most of the plutonium at this site was attached to the surfaces of laboratory material such as broken glass and ceramic plates, and it is not easily removed by wind or rain. The site is undergoing continued characterization and remediation.

The DP Road air monitoring data are summarized in Table 8-1.

Table 8-1. DP Road Air Monitoring Data for Plutonium (Pu) and Uranium (U) during Calendar Year 2020

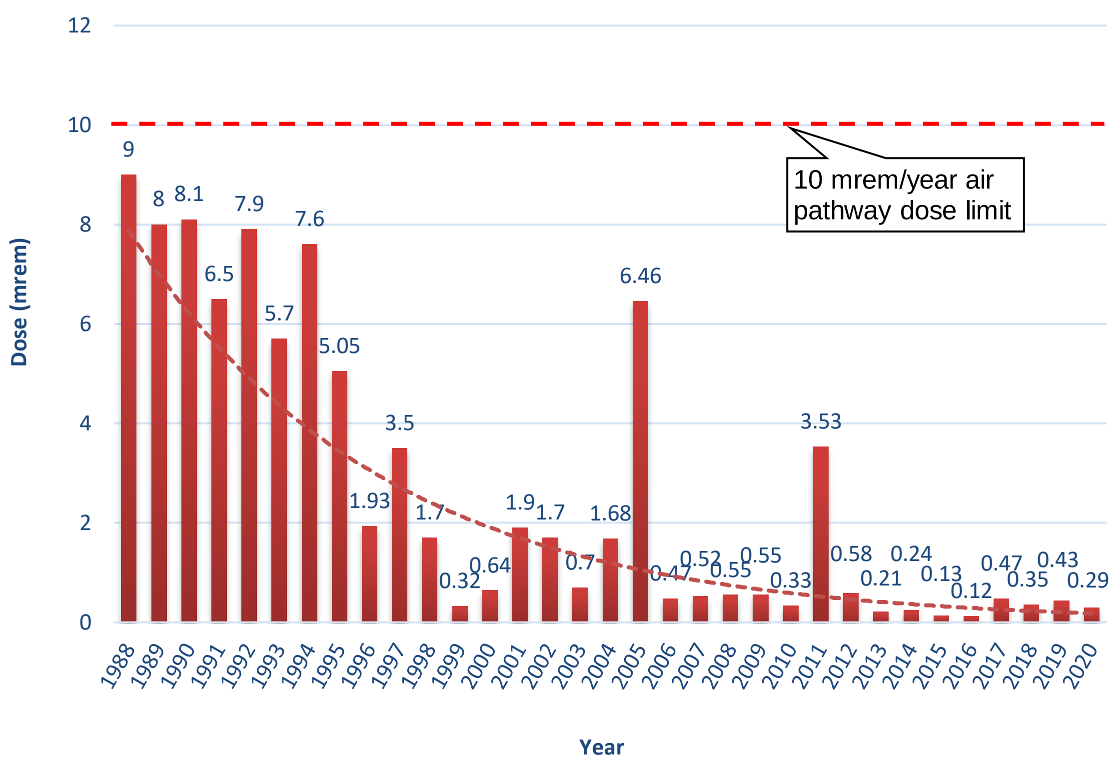
Location on DP Rd	Station ID	Pu (mrem)	U (mrem)	Other (mrem)	Total (mrem)
West	#291	0.011	0.084	0.002	0.097
Middle	#326	0.070	0.060	0.002	0.132
East	#317	0.074	0.029	0.005	0.108

At the west end of DP Road, near station 291 (see Figure 4-1 in Chapter 4), the plutonium dose is lowest because it is far from the site of the historical plutonium facilities, whereas the uranium dose is highest because the construction work at the west end suspends soil containing natural uranium in the air.

At the east end near station 317, the plutonium dose is higher because it is nearer to the site of the historical plutonium facilities and to Material Disposal Area B, whereas the uranium dose is lower because it is farther from the construction work.

In the middle, near station 326 at the west end of Material Disposal Area B, the plutonium dose is slightly lower than at station 317. This location is also at the east end of the construction work, so the uranium dose is slightly lower than at station 291. As shown in Table 8-1, the total dose is slightly higher in the middle than at either end.

The maximally exposed individual dose was less in 2020 than during 2011 and 2019 (Figure 8-3). The radioactive material measured at station 326 included: (1) material from the general area (Solid Waste Management Unit 21-021), (2) material from Material Disposal Area B, (3) material from the construction work to the west, and (4) material from the Middle DP Road site to the south. Measurements and calculations indicate that the total dose from the Middle DP Road site was a fraction of that measured at station 326 and was less than 0.1 millirem.



Note: mrem = millirem

Figure 8-3. Annual maximally exposed individual dose

Comparison with Previous Years

The annual maximally exposed individual doses are shown in Figure 8-3. The general downward trend is the result of improved engineering controls and ongoing remediation.

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 2019 maximally exposed individual location was the same as the 2011 location and was the result of suspended material that remained after the remediation of Material Disposal Area B.

Maximally Exposed Individual Onsite Dose

The onsite locations where a member of the public could receive a measurable dose are on or near publicly accessible roads (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 Monitoring for Gamma and Neutron Direct-Penetrating Radiation section), at this location in 2020 the neutron dose was 0.6 millirem and the gamma dose was 0.1 millirem for a total of 0.7 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 for 365 days per year. However, members of the public, such as joggers, bus drivers, or cyclists, spend no more than 1/40 of their time at this location (NCRP 2005). Therefore, the onsite dose for a maximally exposed individual is $0.7/40 \approx 0.02$ millirem, which is less than the offsite 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, and near the Pueblo de San Ildefonso boundary. 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 in 2020 was 3 millirem. After applying the standard factor of 1/20 for occasional occupancy (NCRP 2005), the individual neutron dose in 2020 was $3/20 \approx 0.15$ millirem. The contribution from Laboratory stack emissions was less than 0.001 millirem. Within the boundaries of Area G, the average air concentration of americium and plutonium was 3 attocuries per cubic meter (Chapter 4, Tables 4-3 and 4-4), and the average uranium-238 concentration was 9 attocuries per cubic meter (Chapter 4, Table 4-5). Using the dose conversion factors from DOE Standard 1196 (DOE 2011), and assuming 1/20 occupancy, the annual dose both within and near Area G was much less than 0.001 millirem from air concentrations of transuranic materials.

Thus, in 2020, the total dose in Cañada del Buey was 0.15 millirem.

Maximally Exposed Individual Summary

At the offsite location for the maximally exposed individual, 132 DP Road, the direct-penetrating radiation and ingestion doses are consistent with zero, so the largest all-pathway dose for 2020 was the same as the air-pathway dose of 0.29 millirem.

The dose of 0.29 millirem in 2020 is far below the 10 millirem annual air-pathway limit in the *National Emission Standards for Hazardous Air Pollutants Other Than Radon From Department of Energy Facilities*, Title 40, Part 61, Subpart H of the Code of Federal Regulations, and the 100 millirem all pathway DOE limit (DOE 2020). The dose for the maximally exposed individual is less than 0.1 percent 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 8-2. Doses are far below all regulations and standards.

Table 8-2. LANL Radiological Doses for Calendar Year 2020

Pathway	Dose to Maximally Exposed Individual (millirems per year)	Percentage of DOE 100-millirem-per-year Limit	Estimated Population Dose (person-rem)	Number of People within 80 kilometers	Estimated Background Population Dose (person-rem)
Air	0.29	0.29%	0.08	n/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	0.29	0.29%	0.08	~ 343,000	~ 268,000†

**n/a = Not applicable. Background population dose is not calculated for individual exposure pathways*
†Based on 780 millirem per person as shown in Figure 8-1

Nonradiological Materials

This section summarizes the potential human health risk from non-radiological materials released from the Laboratory in 2020. Air emissions are reported in Chapters 2 and 4; groundwater is reported in Chapter 5; surface water and sediment are reported in Chapter 6; and soil, plants, and animals are reported in Chapter 7. Foodstuffs are reported in this chapter. The results are summarized below.

Results Summary

Air

The data reported in Chapters 2 and 4 show that in general the Los Alamos air quality is good and well below all applicable state and federal air quality standards. The Laboratory's emissions of regulated pollutants 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.

Los Alamos County monitors its water supply in compliance with the Safe Drinking Water Act, and we analyzed additional samples from Los Alamos County water supply wells in 2020. No water supply wells showed detections of Laboratory-related constituents above an applicable drinking water standard. The drinking water supply meets New Mexico Environment Department and U.S. Environmental Protection Agency drinking water standards (Los Alamos County 2020, 2021).

Additional supplemental water sampling was conducted in the City of Santa Fe's Buckman well field. No Laboratory-related constituents were present above state or federal drinking water quality 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 the regional aquifer below Mortandad Canyon. As described in Chapter 5, the Laboratory has begun remediation to control migration of this chromium plume.

Los Alamos County drinking water contains 5 micrograms per liter of naturally occurring chromium that is unrelated to the Laboratory (Los Alamos County 2020, 2021). More information on groundwater quality is available in Chapter 5.

Surface Water and Sediment

The concentrations of chemicals in surface water and sediment are reported in Chapter 6. The sediment data verify the conceptual model that movement and addition of sediment from repeated flood events results in lower concentrations of Laboratory-related constituents in newer sediment deposits compared with previous deposits. The data also show that the human health risk 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 constituent concentrations decrease with time.

In Chapter 6, we compared unfiltered storm water concentrations with drinking water standards as screening levels. However, storm water is not a drinking water source and, therefore, is not a significant pathway to human exposure. The plant and animal measurements reported in Chapters 7 and 8 confirm that there is not significant uptake into the food chain.

Chapter 6 presents data for Polychlorinated Biphenyls (PCBs) in the surface water of the Pajarito Plateau. The foodstuffs that may use this water are primarily terrestrial animals, such as deer and elk. The data reported in Chapter 7 show that the concentrations of PCBs in deer and elk are far below the human health screening values and are unlikely to cause adverse human-health effects.

The only aquatic animals eaten by people that may be influenced by surface water runoff from the Laboratory are in the Rio Grande. In the Rio Grande, PCB concentrations in aquatic animals are similar upstream and downstream of LANL influence (Chapter 7). There is no detectable contribution from the Laboratory to PCB concentrations in aquatic animals in the Rio Grande.

We conclude there is no risk to the public from exposure to surface water and sediment resulting from either current or legacy Laboratory releases.

Soil, Plants, and Animals

Soil and biota sampling results are reported in Chapter 7. The results are similar to previous years. At offsite locations in 2020, chemical concentrations above human-health–based screening criteria were not detected.

Conclusion

The environmental data collected in 2020 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.

Quality Assurance

Quality assurance for the dose calculations is described in procedure EPC-ES-TPP-006.

The Soil, Foodstuffs, and Biota program collect samples according to written, standard quality assurance and quality control procedures and protocols. These procedures and protocols are identified in the Laboratory's *Implementation of the Soil, Foodstuffs, and Biota Program, Quality Assurance Project Plan* (EPC-ES-QAPP-001) and in the following Laboratory procedures pertaining to foodstuffs collections:

- *Produce Sampling* (EPC-ES-TP-004)
- *Road Kill Sampling* (EPC-ES-TP-007)
- *Crayfish Sampling* (EPC-ES-TP-008)
- *Fish Sampling* (EPC-ES-TP-005)

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Whicker 2009b: Whicker, J. J. “Work to Save Dose: Contrasting Effective Dose Rates from Radon Exposure in Workplaces and Residences Against the Backdrop of Public and Occupational Regulatory Limits,” Health Physics 97:248–256.

Appendix A: Standards and Screening Levels for Radionuclides and Other Chemicals in Environmental Samples

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, for example, the general public, animals, or a sensitive population such as 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 can have adverse health effects, as can a short exposure to high levels. Scenarios describe the activities of a target group at the site, which influence both the length and likelihood of exposures. Examples of exposure scenarios include residential (living on a site) and a 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).

DOE Order 458.1, Chg 4, *Radiation Protection of the Public and the Environment,* describes the current radiation protection standards for the public, 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 (Code of Federal Regulations Title 40, Part 61, Subpart H).*

Radionuclide activities in water are compared with DOE's derived concentration standards (DOE 2021) to evaluate potential impacts to members of the public. The derived concentration standards for water are those concentrations in water that if consumed by a reference person, would give a dose of 100 mrem/yr.

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," in Title 40, Part 61, Subpart H of the Code of Federal Regulations. 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 millirem per year. 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 millirem to a member of the public.

Table A-2. DOE Derived Concentration Standards for Radionuclide Levels in Water

Nuclide	Derived Concentration Standards for Water (pCi/L)
Hydrogen-3	2,600,000
Beryllium-7	2,500,000
Strontium-89	39,000
Strontium-90	1700
Cesium-137	4100
Uranium-234	1200
Uranium-235	1300
Uranium-238	1400
Plutonium-238	430
Plutonium-239	400
Plutonium-240	400
Americium-241	740

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 https://www.env.nm.gov/drinking_water/laws-and-regs.

Radioactivity in drinking water is regulated by U.S. Environmental Protection Agency regulations contained in Title 40, Part 141 of the Code of Federal Regulations and by the New Mexico Drinking Water Regulations, Sections 206 and 207. These regulations stipulate that combined radium-226 and radium-228 activity in drinking water may not exceed 5 picocuries per liter. Gross-alpha activity (including radium-226 but excluding radon and uranium) may not exceed 15 picocuries per liter.

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 millirem per year.

Surface Water Standards

Activities of radionuclides in surface water samples may be compared with either the DOE-derived concentration standards (DOE 2021) 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 stream standards, available at https://www.env.nm.gov/surface-water-quality/wqs. The New Mexico Water Quality Control Commission groundwater standards can also be applied in cases where discharges could affect groundwater.

Soils and Sediments

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 from publicly accessible locations is the level that would produce (1) a dose of 15 millirem 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 hazardous chemicals that do not cause cancer. The screening levels are different for different exposure scenarios. Screening levels for radionuclides are found in a Laboratory document (LANL 2015); 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. 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 millirem per year 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 2000) 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 percent of the DOE standard (which is 1 rad per day for terrestrial plants and aquatic biota and 0.1 rad per day for terrestrial animals) by the Laboratory (DOE 2019). 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 2017).

References

DOE 2019: "A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota," U.S. Department of Energy Standard DOE-STD-1153-2019 (2019).

DOE 2021: "Derived Concentration Technical Standard," U.S. Department of Energy Standard DOE-STD-1196-2021 (July 2021).

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

EPA 2000: “Section 4, Risk-Based Consumption Limit Tables” in Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 2: Risk Assessment and Fish Consumption Limits, Third Edition, U.S. Environmental Protection Agency, available at https://www.epa.gov/sites/production/files/2015-06/documents/volume2.pdf (2000).

LANL 2015: “Derivation and Use of Radionuclide Screening Action Levels, Revision 4,” Los Alamos National Laboratory document LA-UR-15-24859 (September 2015).

LANL 2017: “ECORISK Database,” Release 4.1, Los Alamos National Laboratory, available at https://www.intellusnm.com (October 2017).

NMED 2015: “Risk Assessment Guidance for Site Investigations and Remediation,” New Mexico Environment Department report (July 2015).

Appendix B: Units of Measurement

Throughout the Annual Site Environmental Report, the U.S. customary (English) system of measurement has generally been used. For units of radiation activity, exposure, and dose, U.S. customary units (i.e., 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

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

Multiply U.S. Customary (English) 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

converting U.S. customary units into units from the International System of Units (metric).

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 (offsite regional, offsite perimeter, and onsite) means are calculated using the standard equation:

$$s = (\Sigma (c_i - \bar{c})^2 / (N - 1))^{½}$$

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).

Appendix C: Descriptions of Technical Areas and their Associated Programs

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	Location and Activities
00 (offsite 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)	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 many key Laboratory 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)	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 Laboratory's interim measure to control chromium plume migration in the regional aquifer.
06 (Twomile Mesa Site)	Located in the northwestern part of the Laboratory and mostly undeveloped. It contains a meteorological tower, gas-cylinder-staging buildings, the Western Technical Area Substation, and buildings awaiting demolition.
08 (GT Site [Anchor Site West])	Located along West Jemez Road; 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)	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)	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 can be controlled and observed remotely, allowing devices that contain explosives, radioactive materials, and nonhazardous materials to be safely tested and observed.
14 (Q-Site)	Located in the northwestern part of the Laboratory; one of 14 firing areas. Most operations are remotely controlled and involve detonations, certain types of high-explosives machining, and permitted burning.

Technical Area	Location and Activities
15 (R-Site)	In the central portion of the Laboratory; used for high-explosives research, development, and testing, mainly through hydrodynamic testing and dynamic experimentation. 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)	In the western part of the Laboratory; location of the Weapons Engineering Tritium Facility, a state-of-the-art tritium processing facility. 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)	In Pajarito Canyon; was the location of the Los Alamos Critical Experiment Facility, a general-purpose nuclear experiments facility. All operations here have ceased. The technical area, including the Pond Cabin and the Slotin Building, is now part of the Manhattan Project National Historical Park.
21 (DP Site)	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.
22 (TD Site)	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)	Near the southern edge of the Laboratory; was an explosives storage area. Contains five empty storage magazines that are being decontaminated and decommissioned.
33 (HP Site)	Remotely located technical area at the southeastern boundary of the Laboratory. Used for experiments that require isolation but do not require daily oversight. The National Radioastronomy Observatory's Very Long Baseline Array telescope is located here.
35 (Ten Site)	In the north-central portion of the Laboratory; 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 here, conducts precision machining and target fabrication, polymer synthesis, and chemical and physical vapor deposition. Additional activities here 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 here.
36 (Kappa Site)	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)	Used as an explosives storage area. Located along the eastern perimeter of Technical Area 16.

Technical Area	Location and Activities
39 (Ancho Canyon Site)	At the bottom of Ancho Canyon. Used to study the behavior of nonnuclear weapons (primarily by photographic techniques) and various phenomenological aspects of explosives.
40 (DF Site)	Centrally located within the Laboratory; used for general testing of explosives or other materials and development of special detonators for initiating high-explosives systems.
41 (W-Site)	In Los Alamos Canyon; 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)	Adjacent to the Los Alamos Medical Center at the northern border of the Laboratory; 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)	Between Pajarito Road and the Pueblo de San Ildefonso. 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 here.
48 (Radiochemistry Site)	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)	Near Bandelier National Monument. 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)	Near the center of the Laboratory; 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 here.
51 (Environmental Research Site)	On Pajarito Road in the eastern portion of the Laboratory; 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 here.
52 (Reactor Development Site)	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 here.

Technical Area	Location and Activities
53 (Los Alamos Neutron Science Center)	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 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)	On the eastern border of the Laboratory; one of the largest technical areas at the Laboratory. Its primary function is management of solid radioactive and hazardous chemical wastes, including storage.
55 (Plutonium Facility Complex Site)	In the center of the Laboratory along Pajarito Road; location of the Plutonium Facility Complex. The Plutonium Facility provides chemical and metallurgical processes for recovering, purifying, and converting plutonium and other actinides into many compounds and forms. Radiological operations in the Radiological Laboratory/Utility/Office Building began in 2014.
57 (Fenton Hill Site)	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)	Near the Laboratory's northwest border on Twomile Mesa North; 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)	On the south side of Pajarito Road adjacent to Technical Area 03. 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 here includes a clinical laboratory and provides bioassay sample analytical support.
60 (Sigma Mesa)	Southeast of Technical Area 03; primarily used for physical support and infrastructure activities. The Nevada Test Site Test Fabrication Facility and a test tower are also located here. This facility is now used as a waste storage area.
61 (East Jemez Site)	In the northern portion of the Laboratory; contains physical support and infrastructure facilities, including a sanitary waste transfer station operated by Los Alamos County, a photovoltaic array, and sewer pump stations. This is the former site of the Los Alamos County landfill, which is now closed and capped.
62 (Northwest Site)	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)	In the north-central portion of the Laboratory; contains physical support and infrastructure facilities and the new Transuranic Waste Facility.

Technical Area	Location and Activities
64 (Central Guard Site)	In the north-central portion of the Laboratory; provides offices and storage space.
66 (Central Technical Support Site)	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)	Forested buffer zone in the north-central portion of the Laboratory. No operations or facilities are currently located here.
68 (Water Canyon Site)	In the southern portion of the Laboratory; a testing area for dynamic experiments. Twenty acres of land have been converted into a testing area for detecting materials of interest.
69 (Anchor North Site)	In the northwestern corner of the Laboratory; serves as a forested buffer zone. The Emergency Operations Center is located here.
70 (Rio Grande Site)	On the southeastern boundary of the Laboratory. It is an undeveloped technical area that serves as a buffer zone. Part of the White Rock Canyon Reserve is located here.
71 (Southeast Site)	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. Part of the White Rock Canyon Reserve is located here.
72 (East Entry Site)	Along East Jemez Road on the northeastern boundary of the Laboratory; used by protective force personnel for required firearms training and practice purposes.
73 (Airport Site)	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)	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.

Appendix D: Related Websites

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 overview	https://www.energy.gov/nnsa/locations
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
N3B – Los Alamos (Legacy Waste Cleanup Contractor) website	https://n3b-la.com
The Laboratory's Electronic Public Reading Room website	https://eprr.lanl.gov
Environmental Cleanup Electronic Public Reading Room website	https://ext.em-la.doe.gov/EPRR
The Laboratory's environmental database	https://www.intellusnm.com

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, Health, Quality, Safeguards, and Security
Environmental Protection and Compliance Division
Waste Programs Division

N3B Los Alamos
Environmental Remediation Program

Previous reports in the series are LA-UR-20-26673, LA-UR-19-28565, LA-UR-17-27987, 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-14162-ENV, LA-14239-ENV, LA-14304-ENV, LA-14341-ENV, LA-14369-ENV, LA-14407-ENV, LA-14427-ENV, LA-14445-ENV, LA-14461-ENV.

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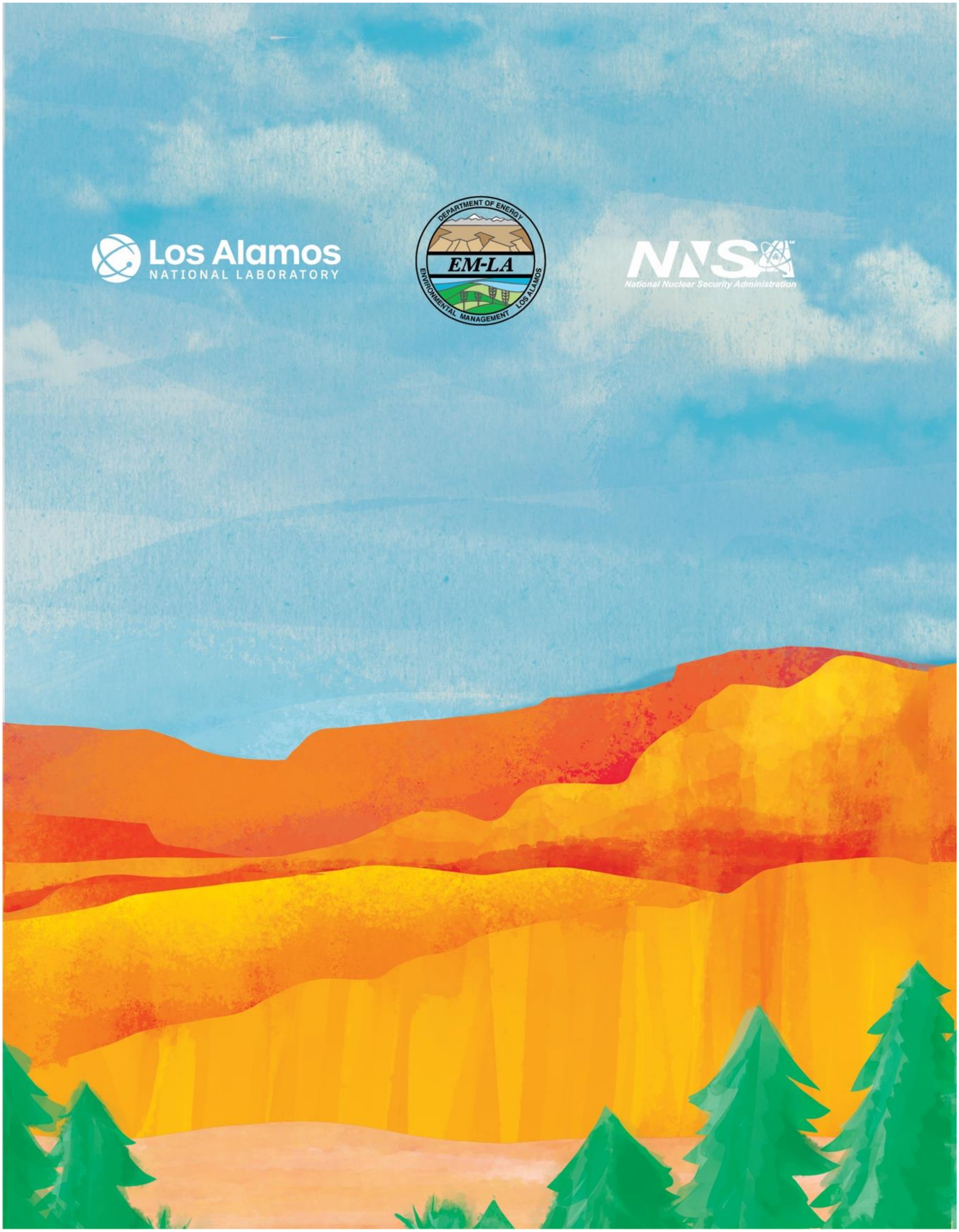
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