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Environmental Surveillance at Los Alamos during 1998

Los Alamos
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The following four Los Alamos National Laboratory groups in the Environmental, Safety, and Health (ESH) Division perform environmental surveillance, ensure environmental compliance, and provide environmental data for this report:

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Los Alamos
NATIONAL LABORATORY
Los Alamos, New Mexico 87545

In Memoriam

Two people, both key players in the development of environmental reports, died this year. Bill Purtymun was instrumental in developing the science of environmental monitoring and initiating this series of environmental reports. Louisa Luján-Pacheco served for several years as the report's editor and helped transform it into the widely distributed and easily read publication that it is today. These two Los Alamos National Laboratory staff members touched the lives of all who knew them. The Laboratory honors their contributions to our environmental monitoring program.

William D. (Bill) Purtymun

February 26, 1927–May 19, 1999

Bill Purtymun's career spanned over 40 years as a geologist and hydrologist associated with the Los Alamos National Laboratory—15 years as a US Geological Survey (USGS) employee assigned to the Laboratory and from 1969 on as a University of California employee. Bill authored and contributed to over 100 Laboratory publications and to over 50 USGS special reports and studies. Bill established water quality monitoring as a Laboratory activity and was a founding author of the Laboratory's annual Environmental Surveillance Report, which now goes back almost 30 years.

Bill was born in Clemenceau, a central Arizona smelter town. Clemenceau later became a ghost town, which caused Bill a good deal of grief during his "Q" clearance recertifications.

The Laboratory recognized Bill's career achievements in 1995 with the publication of his magnum opus "Geologic and Hydrogeologic Records...in the Los Alamos Area," a compilation of 40 years of hydrologic data on the Pajarito Plateau.

Besides his career achievements and contributions to the understanding of the geology and hydrology of the area, Bill was also known for his caring and supporting attitude in mentoring his junior colleagues at the Laboratory. Bill always took the time to show aspiring geologists and hydrologists "the ropes," and he had a profound and positive influence on many careers at the Laboratory and in the environmental surveillance field.

Louisa Luján-Pacheco

May 29, 1968–July 25, 1999

Louisa Luján-Pacheco, a writer-editor with Los Alamos National Laboratory, died on July 25, 1999. She was a graduate of Santa Fe High School and held a bachelor's degree in English Literature and a Master's of English in technical writing. Louisa received both state- and national-level awards as a collaborator on environmental publications.

Her career at the Laboratory began in 1993 in the Communication Arts and Services Group; she served on assignment to three other groups: Stakeholder Involvement, Ecology, and Applied Theoretical and Computational Physics. While working with us here in the Ecology Group, her main task was editing and overseeing the publication of the last five issues of this annual report, *Environmental Surveillance at Los Alamos*. She authored several articles in the award-winning *For the Seventh Generation–Environment, Safety, and Health at Los Alamos National Laboratory: A Report to Our Communities*.

As a working mother of two small children, she took time to pursue two of her passions—women's rights and family rights.

At the Laboratory, she was greatly respected for organizing initiatives for the Women's Diversity Working Group, especially in the area of dependent care for the children of Laboratory workers. Louisa was a superb athlete who kept proving there were no obstacles big enough to stop her.

We remember Louisa most for her vibrant personality, enthusiasm, winning smile, and positive outlook.

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Environmental Surveillance at Los Alamos reports are prepared annually by the Los Alamos National Laboratory (the Laboratory), Environment, Safety, and Health Division, as required by US Department of Energy Order 5400.1, *General Environmental Protection Program*, and US Department of Energy Order 231.1, *Environment, Safety, and Health Reporting*.

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

Chapter 1 provides an overview of the Laboratory's major environmental programs. Chapter 2 reports the Laboratory's compliance status for 1998. Chapter 3 provides a summary of the maximum radiological dose a member of the public could have potentially received from Laboratory operations. The environmental data are organized by environmental media (Chapter 4, air; Chapter 5, water; and Chapter 6, soils, foodstuffs, and biota) in a format to meet the needs of a general and scientific audience. A glossary and a list of acronyms and abbreviations are in the back of the report. Appendix A explains the standards for environmental contaminants, Appendix B explains the units of measurements used in this report, and Appendix C describes the Laboratory's technical areas and their associated programs.

We've also enclosed a booklet, *Overview of Environmental Surveillance during 1998* that briefly explains important concepts, such as radiation, and provides a summary of the environmental programs, monitoring results, and regulatory compliance.

Inquiries or comments regarding these annual reports may be directed to

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This report is also available on the World Wide Web at
http://lib-www.lanl.gov/la-pubs/la-13633.pdf

Abstract

This report presents environmental data that characterize environmental performance and addresses compliance with environmental standards and requirements at Los Alamos National Laboratory (LANL or the Laboratory) during 1998. The Laboratory routinely monitors for radiation and for radioactive and nonradioactive materials at Laboratory sites, as well as at sites in the surrounding region. LANL uses the monitoring results to determine compliance with appropriate standards and to identify potentially undesirable trends. This information is then used for environmental impact analyses, site planning, and annual operational improvements. Data were collected in 1998 to assess external penetrating radiation and concentrations of chemicals and radionuclides in stack emissions, ambient air, surface waters and groundwaters, the drinking water supply, soils and sediments, foodstuffs, and biota. Using comparisons with standards and regulations, this report concludes that environmental effects from Laboratory operations are small and do not pose a threat to the public, Laboratory employees, or the environment. Laboratory operations were in compliance with all environmental regulations.

A. Laboratory Overview

1. Introduction to Los Alamos National Laboratory

In March 1943, a small group of scientists came to Los Alamos for Project Y of the Manhattan Project. Their goal was to develop the world's first nuclear weapon. Although planners originally expected that the task would be completed by a hundred scientists, by 1945, when the first nuclear bomb was tested at Trinity Site in southern New Mexico, more than 3,000 civilian and military personnel were working at Los Alamos Laboratory. In 1947, Los Alamos Laboratory became Los Alamos Scientific Laboratory, which in turn became Los Alamos National Laboratory (LANL or the Laboratory) in 1981. The Laboratory is managed by the Regents of the University of California (UC) under a contract that is administered through the Department of Energy (DOE) Los Alamos Area Office (LAAO) and the Albuquerque Operations Office.

The Laboratory's original mission to design, develop, and test nuclear weapons has broadened and evolved as technologies, US priorities, and the world community have changed. Los Alamos National Laboratory is a multiprogram facility with the central mission of reducing the global nuclear danger, including four major components:

- ensure that the national nuclear stockpile is reliable and safe;
- manage the production and use of nuclear materials;
- ensure that the environment is both restored from past nuclear activities and minimally impacted by future activities; and
- develop technology and processes to eliminate the proliferation of nuclear materials and weapons capability.

The Laboratory will continue its role in defense, particularly in nuclear weapons technology, and will increasingly use its multidisciplinary capabilities to solve important civilian problems, including initiatives in the areas of health, national infrastructure, energy, education, and the environment (LANL 1998).

2. Geographic Setting

The Laboratory and the associated residential and commercial areas of Los Alamos and White Rock are located in Los Alamos County, in north-central New Mexico, approximately 60 miles north-northeast of Albuquerque and 25 miles northwest of Santa Fe (Figure 1-1). The 43-square-mile Laboratory is situated on the Pajarito Plateau, which consists of a series of finger-like mesas separated by deep east-to-west oriented canyons cut by intermittent streams.

1. Introduction

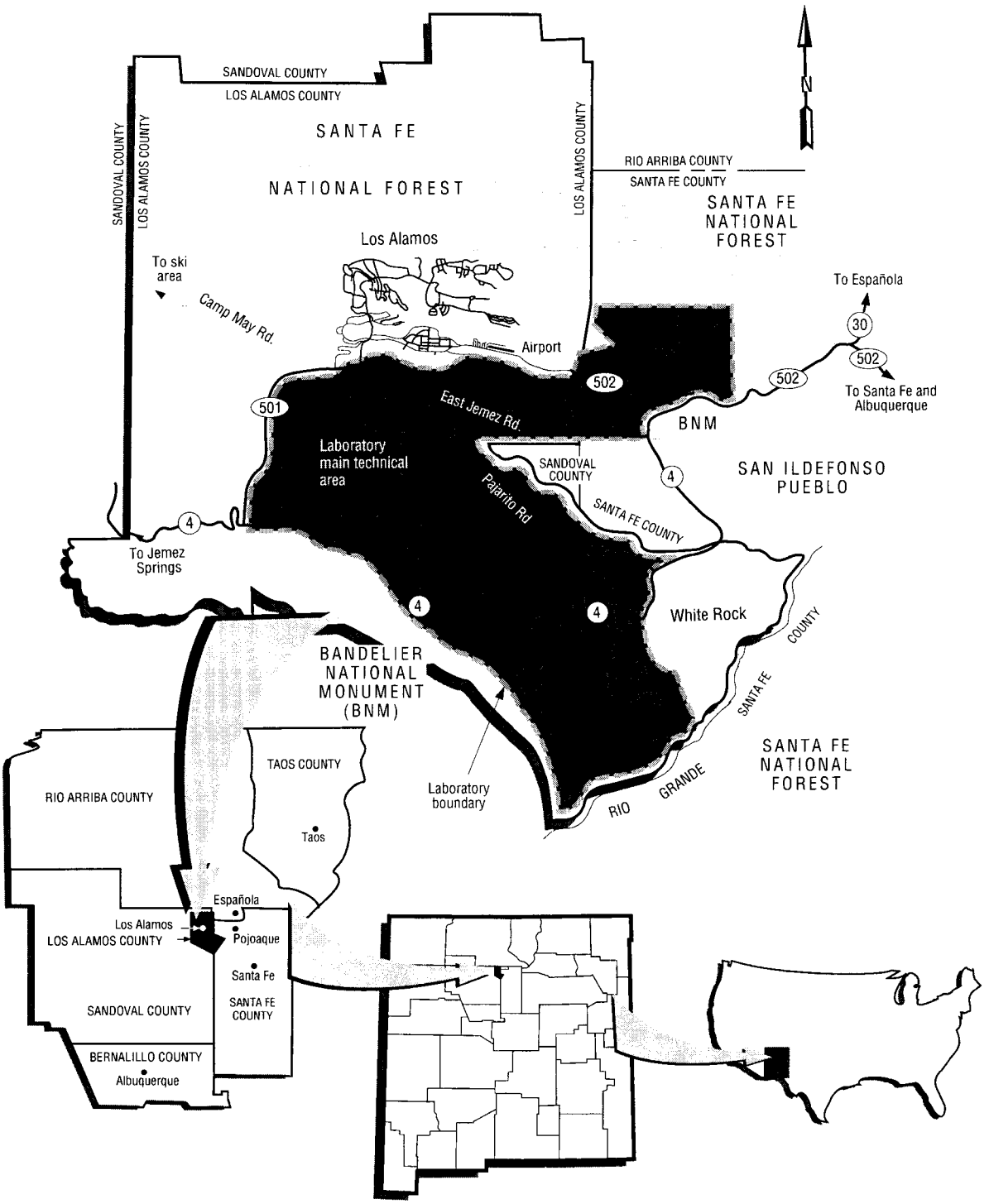

Figure 1-1. Regional location of Los Alamos National Laboratory.

Mesa tops range in elevation from approximately 7,800 feet on the flanks of the Jemez Mountains to about 6,200 feet above the Rio Grande Canyon.

Most Laboratory and community developments are confined to mesa tops. The surrounding land is largely undeveloped, and large tracts of land north, west, and south of the Laboratory site are held by the Santa Fe National Forest, Bureau of Land Management, Bandelier National Monument, General Services Administration, and Los Alamos County. The Pueblo of San Ildefonso borders the Laboratory to the east.

The Laboratory is divided into technical areas (TAs) that are used for building sites, experimental areas, waste disposal locations, roads, and utility rights-of-way (see Appendix C and Figure 1-2). However, these uses account for only a small part of the total land area; most land provides buffer areas for security and safety and is held in reserve for future use.

3. Geology and Hydrology

The Laboratory lies at the western boundary of the Rio Grande rift, a major North American tectonic feature. Three local major faults constitute the modern rift boundary and each is potentially seismogenic. Recent studies indicate that the seismic surface rupture hazard associated with these faults is localized (Gardner et al., 1999). Most of the finger-like mesas in the Los Alamos area (Figure 1-3) are formed from Bandelier Tuff, which includes ash fall, ash fall pumice, and rhyolite tuff. The tuff is more than 1,000 feet thick in the western part of the plateau and thins to about 260 feet eastward above the Rio Grande. It was deposited as a result of major eruptions in the Jemez Mountains' volcanic center about 1.2 to 1.6 million years ago.

On the western part of the Pajarito Plateau, the Bandelier Tuff overlaps onto the Tschicoma Formation, which consists of older volcanics that form the Jemez Mountains. The tuff is underlain by the conglomerate of the Puye Formation in the central plateau and near the Rio Grande. Chino Mesa basalts interfinger with the conglomerate along the river. These formations overlie the sediments of the Santa Fe Group, which extend across the Rio Grande Valley and are more than 3,300 feet thick.

Surface water in the Los Alamos area occurs primarily as short-lived or intermittent reaches of streams. Perennial springs on the flanks of the Jemez Mountains supply base flow into upper reaches of some canyons, but the volume is insufficient to maintain surface flows across the Laboratory site before they are depleted by evaporation, transpiration, and infiltration.

Groundwater in the Los Alamos area occurs in three modes: (1) water in shallow alluvium in canyons, (2) perched water (a body of groundwater above a less permeable layer that is separated from the underlying main body of groundwater by an unsaturated zone), and (3) the main aquifer of the Los Alamos area.

The main aquifer of the Los Alamos area is the only aquifer in the area capable of serving as a municipal water supply. Water in the main aquifer is under artesian conditions under the eastern part of the Pajarito Plateau near the Rio Grande (Purtymun and Johansen 1974). The source of recharge to the aquifer is presently uncertain. Isotopic and chemical composition of some waters from wells near the Rio Grande suggest that the source of water underlying the eastern part of the Pajarito Plateau may be the Sangre de Cristo Mountains (Blake et al., 1995). Groundwater flow along the Rio Grande rift from the north is another possible recharge source. The main aquifer discharges into the Rio Grande through springs in White Rock Canyon. The 11.5-mile reach of the river in White Rock Canyon between Otowi Bridge and the mouth of Rito de los Frijoles receives an estimated 4,300 to 5,500 acre-feet annually from the aquifer.

4. Ecology and Cultural Resources

The Pajarito Plateau is a biologically diverse and archaeologically rich area. The plants and animals found on or near LANL property include approximately 500 plant species, 29 mammal species, 200 bird species, 19 reptile species, 8 amphibian species, and hundreds of insect species. Roughly 20 plant and animal species are designated as a threatened species, an endangered species, or a species of concern at the federal and/or state level.

Approximately 70% of DOE land in Los Alamos County has been surveyed for prehistoric and historic cultural resources, and about 1,470 sites have been recorded. More than 85% of the ruins date from the 14th and 15th centuries. Most of the sites are found in the piñon-juniper vegetation zone, with 80% lying between 5,800 and 7,100 feet in elevation. Almost three-quarters of all ruins are found on mesa tops. Approximately 500 buildings and structures are being

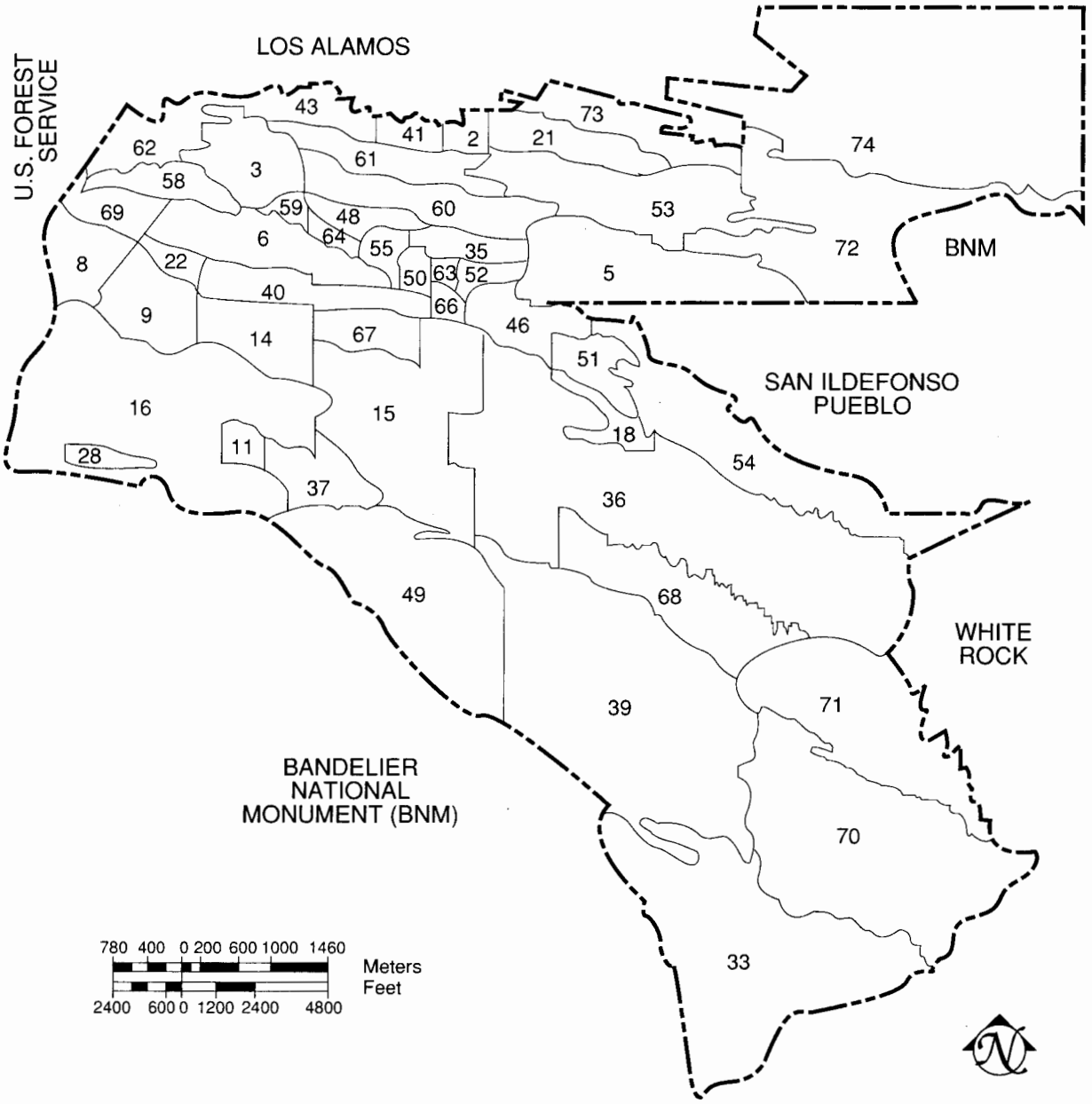

Figure 1-2. Technical Areas of Los Alamos National Laboratory in relation to surrounding landholdings.

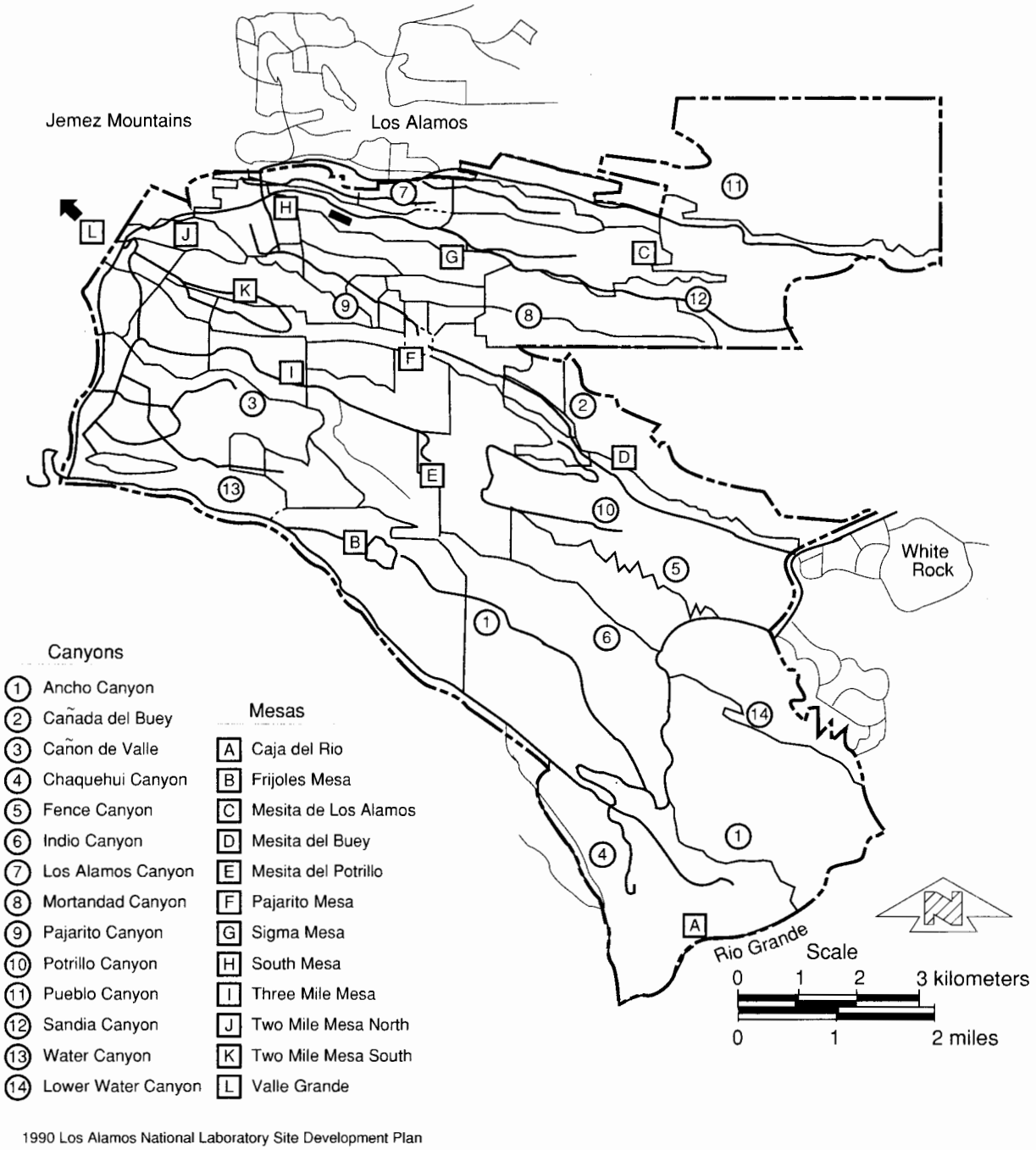

Figure 1-3. Major canyons and mesas.

evaluated for eligibility to be placed on the National Historic Register.

B. Management of Environment, Safety, and Health

1. Introduction

The protection of workers, the public, and the environment is a responsibility of every Laboratory worker. Workers, and their line management through the Laboratory Director, are responsible for conducting all of their activities in an environmentally sound manner. Technical and administrative responsibility and authority have been delegated to the Environment, Safety, and Health (ESH) Division for environmental monitoring and surveillance and to the Environmental Management (EM) Program for environmental restoration and centralized waste management responsibilities.

2. Integrated Safety Management

In 1998, the Laboratory Director issued an environmental, safety, and health (ES&H) policy that stated that "safety is first at LANL" and listed Laboratory goals as

- zero injuries and illnesses on the job,
- zero injuries and illnesses off the job,
- zero environmental incidents,
- zero ethics incidents,
- zero people mistreatment incidents, and
- zero safeguards and security violations.

Integrated Safety Management is the Laboratory's management system for performing work safely and for assuring protection of employees, the public, and the environment. The term "integrated" indicates that the safety management system is a normal and natural element in performing the work; safety isn't a workplace addition, it is how the Laboratory does business.

The Integrated Safety Management system provides the framework for an environmental management system with the following objectives:

- conduct Laboratory operations in full compliance with all environmental laws and regulations;
- prevent adverse environmental impacts and enhance environmental protection; and
- adopt proactive approaches to achieve environmental excellence. For example, it is better to minimize waste generation, wastewater discharges, air emissions, ecological impacts, and cultural impacts than to have to clean up problems.

3. Environment, Safety, & Health Division

The ESH Division is in charge of performing environmental monitoring, surveillance, and compliance activities to help ensure that Laboratory operations do not adversely affect human health and safety or the environment. The Laboratory conforms to applicable environmental regulatory requirements and reporting requirements of DOE Orders 5400.1 (DOE 1988), 5400.5 (DOE 1990), and 231.1 (DOE 1995).

The ESH Division provides line managers with assistance in preparing and completing environmental documentation such as reports required by the National Environmental Policy Act (NEPA) of 1969 and the federal Resource Conservation and Recovery Act (RCRA) and its state counterpart, the New Mexico Hazardous Waste Act (HWA), as documented in Chapter 2 of this report. With assistance from the Laboratory Counsel, ESH Division helps to define and recommend Laboratory policies with regard to applicable federal and state environmental regulations and laws and DOE orders and directives. ESH Division is responsible for communicating environmental policies to Laboratory employees and for ensuring that appropriate environmental training programs are available. The environmental surveillance program resides in four groups in ESH Division—Air Quality (ESH-17), Water Quality and Hydrology (ESH-18), Hazardous and Solid Waste (ESH-19), and Ecology (ESH-20)—that initiate and promote Laboratory programs for environmental assessment and are responsible for environmental surveillance and regulatory compliance.

Approximately 600 sampling locations are used for routine environmental monitoring. The general location of monitoring stations is presented in maps in this report. For 1998, over 250,000 analyses for chemical and radiochemical constituents were performed on more than 12,000 environmental samples. Samples of air particles and gases, water, soils, sediments, foodstuffs, and associated biota are routinely collected at monitoring stations and then analyzed. The results of these analyses help identify impacts of LANL operations on the environment.

Additional samples are collected and analyzed to obtain information about particular events, such as major surface water runoff events, nonroutine releases, or special studies. Methods and procedures for acquiring, analyzing, and recording data are presented later in this report in Chapters 2, 3, 4, 5, and 6. Information about environmental standards is presented in Appendix A.

a. Air Quality. ESH-17 personnel assist Laboratory organizations in their efforts to comply with federal and state air quality regulations. ESH-17 personnel report on the Laboratory's compliance with the air quality standards and regulations discussed in Chapter 2. Various environmental surveillance programs are conducted to evaluate the potential impact of Laboratory emissions on the local environment and public health. These programs include measuring direct penetrating radiation, meteorological conditions, and stack emissions and sampling for ambient air contaminants. Chapter 4 contains a detailed exploration of the methodologies and results of the ESH-17 air monitoring and surveillance program for 1998. Personnel from ESH-17 monitor meteorological conditions to assess the transport of contaminants in airborne emissions to the environment and to aid in forecasting local weather conditions. Chapter 4 summarizes meteorological conditions during 1998 and provides a climatological overview of the Pajarito Plateau.

Dose Assessment. ESH-17 personnel calculate the radiation dose assessment that is presented in Chapter 3, including the methodology and assessments for specific pathways to the public and the environment.

b. Water Quality and Hydrology. Personnel from ESH-18 are responsible for providing environmental monitoring activities to demonstrate regulatory compliance and to help ensure that Laboratory operations do not adversely affect public health or the environment.

ESH-18 provides technical and regulatory support for the Laboratory to achieve compliance with the following major state and federal regulations: Clean Water Act, National Pollutant Discharge Elimination System (NPDES), and Section 404/401 Dredge and Fill Permitting; Safe Drinking Water Act; New Mexico Drinking Water Regulations; New Mexico Water Quality Control Commission Regulations; Federal Insecticide, Fungicide, and Rodenticide Act; and New Mexico Pesticide Control Act. Surveillance programs and activities include groundwater, surface water, and sediments monitoring; water supply reporting for Los Alamos County; and the Groundwater Protection Management Program. Chapter 2 contains documentation on the Laboratory's compliance status with water quality regulations and reports on the closeout of the NPDES Federal Facilities Compliance Agreement. Chapter 5 presents results of the data collected and analyzed by ESH-18 personnel from routine monitoring.

c. Hazardous and Solid Waste. ESH-19 personnel provide services in developing and monitoring permits under hazardous and solid waste rules, RCRA/HWA, Solid Waste Act (SWA), and letters of authorization for landfilling polychlorinated biphenyls (PCB) solids contaminated with radionuclides under the Toxic Substances Control Act (TSCA); providing technical support, regulatory interpretation, and Laboratory policy on hazardous, toxic, and solid waste issues and underground storage tank regulations to Laboratory customers; and documenting conditions at past waste sites. The Laboratory's compliance status with hazardous and solid waste regulations is presented in Chapter 2.

d. Ecology. Personnel in ESH-20 investigate and document biological and cultural resources within the Laboratory boundaries; prepare environmental reports, including Environmental Assessments required under NEPA; and monitor the environmental impact of Laboratory operations on soil, foodstuffs, and associated biota. Chapter 2 documents the 1998 work in the areas of NEPA reviews and biological and archaeological reviews of proposed projects at the Laboratory. Chapter 6 contains information on the results and trends of the soil, foodstuff, and biota monitoring programs and related research and development activities at the Laboratory.

4. Environmental Management Program

a. Waste Management. Waste management activities are focused on minimizing the adverse effects of radioactive wastes on the environment, maintaining compliance with regulations and permits, and ensuring that wastes are managed safely. Wastes generated at the Laboratory are divided into categories based on the radioactive and chemical content. No high-level radioactive wastes are generated at the Laboratory. Major categories of waste managed at the Laboratory are low-level radioactive waste, transuranic (TRU) waste, mixed waste, hazardous waste, and nonhazardous waste.

In 1997, the Laboratory became the first DOE site granted authority to certify TRU waste for shipment to the Waste Isolation Pilot Plant (WIPP). The EM-Waste Management Program certified waste during 1998 and shipped the first truckload of TRU waste to WIPP on March 25, 1999.

b. Pollution Prevention. The Laboratory's Environmental Stewardship Office (EM-ESO) coordinates the integrated Laboratory pollution prevention program. Specific amounts of source material reduction and recycling are provided in Section 2.B.1.i. Descriptions of successful pollution prevention projects are presented in Section 2.E.2. Other waste management activities that reduce waste generation include the following:

- continuing financial incentives for waste reduction and innovative pollution prevention ideas;
- developing databases to track waste generation; and
- providing pollution prevention expertise to Laboratory organizations in source reduction, material substitution, internal recycle/reuse, lifetime extension, segregation, external recycle/reuse, volume reduction, and treatment.

In 1998, the EM-ESO published *The Los Alamos National Laboratory 1998 Environmental Stewardship Roadmap,* in accordance with the Hazardous and Solid Waste Amendments Module VIII of the RCRA Hazardous Waste Permit and 40 CFR 264.73. This document is available at *http://emeso.lanl.gov/publications* on the World Wide Web.

Two of the six Laboratory environmental excellence goals have an environmental focus: zero environmental incidences and zero RCRA violations. The roadmap document describes the Laboratory's current operations and the improvements that will eliminate the sources of environmental incidents.

The stewardship solution for zero incidents and zero RCRA violations is to eliminate their source. This goal is being accomplished by continuously improving operations to achieve

- zero waste,
- zero pollutants released,
- zero natural resources wasted, and
- zero natural resources damaged.

c. Environmental Restoration Project. The Environmental Restoration (EM/ER) Project at the Laboratory augments the Laboratory's environmental surveillance program by identifying and characterizing potential threats to human health and the environment from past Laboratory operations and by mitigating those threats through corrective actions that comply with applicable environmental regulations. Corrective actions may include source containment to prevent contaminant migration, controls on future land use, and excavation and/or treatment of the source to remove or, at a minimum, reduce chemical and/or radiological hazards to acceptable human health and environmental levels. The project, operating out of the EM Program, also oversees decontamination and decommissioning of surplus facilities at the Laboratory.

The EM/ER Project at the Laboratory responds to two federal laws: RCRA, which is the statutory basis for the EM/ER Project at the Laboratory; and the Comprehensive Environmental Response, Compensation, and Liability Act, which offers a reference for remediating sites at the Laboratory that contain certain hazardous substances not covered by RCRA. The Hazardous and Solid Waste Amendments to RCRA mandate that certain facilities, including the Laboratory, that store, treat, and dispose of hazardous wastes operate under a formal permit system. The corrective action provisions of the RCRA permit are contained in Module VIII of the Laboratory's Hazardous Waste Permit. The Environmental Protection Agency (EPA) and the New Mexico Environment Department (NMED) regulate the Laboratory's corrective action program under RCRA. DOE has oversight for those sites not subject to RCRA and for the decommissioning program. A summary of EM/ER Project activities completed in 1998 is presented in Section 2.B.1.k of this report. A description of the EM/ER Project is presented at *http://erproject.lanl.gov* on the World Wide Web.

5. Land Conveyance and Transfer Under Public Law 105-119

On November 26, 1997, Congress passed Public Law 105-119 that requires the Secretary of Energy to identify parcels of land at or near the Laboratory that would be considered for conveyance and transfer to one of two entities: either Los Alamos County or the Secretary of the Interior (held in trust for the Pueblo of San Ildefonso). DOE identified 10 land parcels for such conveyance and transfer in the "Land Transfer

Report to Congress under Public Law 105-119, A Preliminary Identification of Parcels of Land in Los Alamos, New Mexico for Conveyance or Transfer" (April 1998).

Public Law 105-119 also directs DOE to identify any environmental restoration or remediation that would be necessary within any of these tracts before conveyance and transfer. NMED and DOE require that the cleanup process provide long-term protection to human and environmental health and be compatible with local visions of appropriate land use.

Public Law 105-119 states that the conveyed or transferred parcels of land shall be used for historical, cultural, or environmental preservation purposes; economic diversification purposes; or community self-sufficiency. Both Los Alamos County and the Pueblo of San Ildefonso submitted preliminary statements of interest in some or all of the 10 parcels to DOE in June 1998, and both parties identified preliminary potential land uses for the parcels. In general, both the Pueblo of San Ildefonso and Los Alamos County identified uses of some of the parcels for commercial and industrial development, residential development, or cultural or environmental preservation. The potential uses by the identified recipients of each parcel are not always the same.

6. Community Involvement

The Laboratory continues to encourage public access to information about environmental conditions and the environmental impact of operations at the Laboratory. Although the Community Relations Office, renamed in 1998 from the Community Involvement and Outreach Office, has a responsibility to help coordinate activities between the Laboratory and northern New Mexico, many organizations at the Laboratory are active in working with the public. Frequently, the subject of these interactions is related to environmental issues because of concerns about the Laboratory's potential impact on local environment, safety, and health.

Some examples of how the Laboratory distributes and makes environmental information available to the public are listed below.

Outreach Centers

During 1998, the Community Relations Office operated three outreach centers located in Los Alamos (505-665-4400), Española (505-753-3682), and Santa Fe (505-982-3771). Approximately 250 people visited the centers each year. Access to environmental information is available at all the outreach centers.

Bradbury Science Museum

Because many of the Laboratory's facilities are closed to the public, the Bradbury Science Museum provides a way for the public to learn about the kinds of work the Laboratory does, whether it is showing how lasers are used to assess air pollution or demonstrating ecology concepts. In 1998, the museum hosted approximately 101,000 visitors.

Inquiries

In 1998, the Community Relations Office—with the assistance of a wide variety of Laboratory organizations—responded to hundreds of public inquiries, many of which had an environmental theme. These inquiries came to the Community Relations Office by letter, phone, fax, e-mail, and personal visits.

To learn more about the Community Relations Office and the Laboratory's community involvement efforts, you can read the Community Relations Office Annual Report at *http://ext.lanl.gov/orgs/cr/final.pdf* on the World Wide Web.

7. Public Meetings

The Laboratory holds public meetings to inform surrounding communities about activities and operations at the Laboratory. During 1998, the Laboratory held three public meetings as part of a continuing series called the "Community Environmental Meetings." The first one of these meetings titled "Environmental Monitoring" was held in February 1998. A second meeting, "Wildland Fires—Are We Ready," took place in August 1998. The third meeting, "Habitat Management Plan for Threatened and Endangered Species," was held in December 1998.

8. Tribal Interactions

During 1998, executive and staff meetings were held with Cochiti Pueblo, Jemez Pueblo, the Pueblo of San Ildefonso, and Santa Clara Pueblo along with DOE and Laboratory personnel. Subjects for the meetings included DOE-funded environmental programs, environmental restoration, environmental surveillance, cultural resource protection, emergency response, and other environmental issues.

Additional personnel were added to the Community Relations Office Tribal Relations Team, specifically to help with emergency response issues that are

of concern because of the start of transporting TRU waste containers from the Laboratory to WIPP on state highways that cross tribal lands. Additional interactions include a technical assessment of asbestos contamination on Pueblo of San Ildefonso lands, a workshop for the Navajo Nation on radiation effects, and preparation of a feasibility study on the use of wind power for Jemez Pueblo.

9. A Report for Our Communities

In September 1998, ESH Division published 20,000 copies of the annual report, "For The Seventh Generation: Environment, Safety, and Health at Los Alamos National Laboratory: A Report to Our Communities 1997–1998 Volume II" (ESH 1998). This report gives the Laboratory, its neighbors, and other stakeholders a snapshot of some of the Laboratory programs and issues.

Volume I of this report (ESH 1997), published the previous year, has received two prestigious awards. One of these is the "Excellence Award" in the Society for Technical Communications International Competition. This report was also submitted to The Communicator Awards, a national organization that recognizes outstanding work in the communications field; this report subsequently received the "Crystal Award of Excellence" presented to those entrants whose ability to communicate elevates them above the best in the field and serves as a benchmark for the industry.

Both of these reports are available from the Laboratory's Community Reading Room and the Outreach Offices. Volume II is also at *http://lib-www.lanl.gov/pubs//la-pubs/00418582.pdf* and Volume I at *http://lib-www.lanl.gov/pubs/la-pubs/00326319.pdf* on the World Wide Web.

D. Assessment Programs

1. Overview of Los Alamos National Laboratory Environmental Quality Assurance Programs

Monitoring activities for each environmental program performed by groups in ESH Division have been included in the LANL Environmental Monitoring Plan for 1999–2001. Each monitoring activity sponsored by the ESH Division has its own Quality Assurance Plan or operating procedure. These plans and procedures are unique to activities but are guided by the need to establish policies, requirements, and guidelines for the effective implementation of regulatory requirements and to meet the requirements of DOE Orders 5400.1 (DOE 1988), 5400.5 (DOE 1990), and 5700.6C (DOE 1991). Each Quality Assurance Plan must address the criteria for management, performance, and assessments.

Quality is the extent to which an item or activity meets or exceeds requirements. Quality assurance includes all the planned and systematic actions and activities necessary to provide adequate confidence that a facility, structure, system, component, or process will perform satisfactorily. The Quality Assurance Support Group (ESH-14) provides support for quality assurance functions at the Laboratory. ESH-14 personnel perform quality assurance and quality control audits and surveillance of Laboratory and subcontractor activities in accordance with the Quality Assurance Plan for the Laboratory and for specific activities, as requested. The Laboratory's Internal Assessment Group (AA-2) manages an independent environmental appraisal and auditing program that verifies implementation of environmental requirements. The Quality and Planning Program Office manages and coordinates the effort to become a customer-focused, unified Laboratory.

2. Overview of University of California/ Department of Energy Performance Assessment Program

During 1998, UC and DOE evaluated the Laboratory based on mutually negotiated ES&H performance measures. The performance measure rating periods run from July to June. The performance measures are linked to the principles and key functions of Integrated Safety Management.

The environmental components of these performance measures include the following categories:

- radiation protection of workers,
- routine waste minimization,
- management walkarounds,
- hazard analysis and control,
- maintenance of authorization basis, and
- injury/illness prevention.

Specific information on the categories and the assessment scoring can be obtained at *http://drambuie.lanl.gov~eshiep/* on the World Wide Web.

3. Environment, Safety, & Health Panel of the University of California President's Council on the National Laboratory

The UC-ES&H Panel met at the Laboratory July 27–29, 1998, and discussed the following topics:

- critical management focus on ES&H implementation,
- new beryllium facility,
- biosafety issues related to bioweapons nonproliferation research,
- nonproliferation research,
- community/tribal/stakeholder meetings,
- a review of preparation for movement of TRU wastes to WIPP,
- LANL special provisions as part of the UC/DOE contract, and
- LANL whistleblower procedures.

The UC-ES&H Panel has forwarded its observations and recommendations on these topics to the Laboratory Director and the Chair of the UC President's Council on the National Laboratories.

4. Division Review Committee

The ES&H Division Review Committee reviewed 12 ESH Division research projects in 1998. The committee assigned an overall grade of outstanding/excellent for these projects and noted the following projects as truly outstanding:

- RADNET: a working protocol for radiation monitoring equipment;
- uptake of radionuclides by beans, squash, and corn growing in contaminated alluvial soils at the Laboratory (see Chapter 6.C);
- environmental alpha continuous air monitoring;
- a real-time beryllium monitor and the implications for its use;
- development and implementation of improved dosimeters;
- study of organic vapor air purifying respirator cartridges;
- development of a method to understand pressure effects and deformation of waste containers;
- human health risk assessment related to the consumption of elk and deer that forage around the Laboratory (see Chapter 6.C); and
- spatially dynamic risk assessments of threatened and endangered species at the Laboratory (see Chapter 6.C).

5. Department of Energy Audits and Assessments

The local DOE Office of Oversight, Environment, Safety, and Health, published an updated "Profile of Los Alamos National Laboratory" in December 1998. The profile documents how effectively DOE and Laboratory line management have implemented safety management and ES&H programs. Numerous aspects of ES&H were evaluated, including portions of the environmental programs. The environmental programs covered by external regulations were determined to be effective.

Additional information on DOE audits and assessments of LANL ES&H programs is available through the DOE home page on the World Wide Web.

6. Cooperative and Independent Monitoring

DOE, UC, and the Laboratory have signed agreements with the State of New Mexico and four surrounding Pueblos that enable independent environmental monitoring at and near the Laboratory. The main agreements are the following:

- **Agreement-In-Principle** between DOE and the State of New Mexico (see Section 2.C.2 for more information).
- **Accords** between DOE and the individual Pueblos of San Ildefonso, Cochiti, Jemez, and Santa Clara.
- **Cooperative Agreements** between UC and the individual Pueblos of San Ildefonso, Cochiti, Jemez, and Santa Clara.
- **Memorandum of Understanding** with the Pueblo of San Ildefonso for environmental monitoring (see Chapter 5.C for more information).

The main purposes of these agreements are to build more open and participatory relationships, to improve communications, and to cooperate on issues of mutual concern. The agreements allow access to monitoring locations and encourage cooperative sampling

activities, improve data sharing, and enhance communications on technical subjects. The agreements also provide frameworks for grant support that allow development and implementation of independent monitoring programs.

Environmental monitoring at and near the Laboratory involves other state and federal agencies such as the Defense Nuclear Facilities Safety Board, the Agency for Toxic Substances and Disease Registry, the Bureau of Indian Affairs, the US Geological Survey, the US Fish and Wildlife Service, the US Forest Service, and the National Park Service.

7. Cooperative Resource Management

The Laboratory frequently collaborates with other agencies when managing our land and resources.

Oso Complex Fire. The Oso Fire was an arson-caused fire that burned more than 5,364 acres of Santa Fe National Forest and Santa Clara Pueblo lands. It was located approximately 8 miles north of Los Alamos and 10 miles northwest of Española. The fire burned primarily in ponderosa pine and mixed conifer at elevations between 7,900 and 10,600 feet in Oso, Santa Clara, and Gallina Canyons in the Jemez Mountains. The fire started on June 27 and was controlled on July 9, 1998. Cooperating agencies included LANL, Santa Clara Pueblo, US Forest Service, Bureau of Indian Affairs, US Fish and Wildlife Service, Bureau of Land Management, and Johnson Controls Northern New Mexico.

Interagency Wildfire Management Team. The Interagency Wildfire Management Team continues to be a vehicle for addressing wildfire issues of mutual concern to the regional land management agencies. In addition, the Interagency Wildfire Management Team collaborates in public outreach activities, agrees on lines of authority that would be in place during a wildfire, provides cross-disciplinary training, and shares the expertise that is available from agency to agency. The result of this collaboration has been an increased coordination of management activities between agencies and a heightened response capability in wildfire situations. In addition to the Laboratory, regular participants of the Interagency Wildfire Management Team include representatives of the Los Alamos County Fire Department, US Forest Service, Bandelier National Monument, the Pueblo of San Ildefonso, NM State Forester's Office, and NM DOE Oversight Bureau.

During 1998, under a Memorandum of Understanding between DOE/LAAO and the National Park Service, DOE authorized Bandelier to construct a 2,500-square-foot building at TA-49. Bandelier is using this building as a fire cache for storing fire tools and equipment as well as for stationing of fire personnel and Bandelier fire engines. LANL constructed a helipad close to the building for use as helicopter support during a fire or other emergency. The helipad contains an area for the setup of a 5,000-gallon-storage tank for fighting fires in the area.

East Jemez Resource Council. In 1998, the East Jemez Resource Council was formed in an effort to better communicate and cooperate in the management of resources on a regional basis. The Council's main goal is to maintain and enhance the natural and cultural resources of the East Jemez Mountains so that they can be sustained and appreciated by current and future generations. Charter members of the Council include Bandelier National Monument, Santa Fe National Forest, US Fish and Wildlife Service, NM Fish and Game, the Pueblo of San Ildefonso, Santa Clara Pueblo, Cochiti Pueblo, DOE/LAAO, and LANL/ESH-20.

Cochiti Lake Ecological Resources Team. In 1998, the Cochiti Lake Ecological Resources Team finalized a Memorandum of Understanding between the US Army Corps of Engineers, Bandelier National Monument, DOE/LAAO, US Geological Survey, US Fish and Wildlife Service, NM Game and Fish, Pueblo de Cochiti, US Forest Service, and UC/LANL. ESH-20 provides the Laboratory's representative. The Council serves as a forum for discussing issues pertaining to the status or management of physical, biological, and recreational resources in the vicinity of Cochiti Lake and White Rock Canyon.

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2. Compliance Summary

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Highlights from 1998

Los Alamos National Laboratory (LANL or the Laboratory) staff frequently interacted with regulatory personnel during 1998 regarding Resource Conservation and Recovery Act and New Mexico Hazardous Waste Act requirements and compliance activities. The Legacy Materials Cleanup Project was completed on September 30, 1998. The New Mexico Environment Department (NMED) conducted its annual inspection intermittently from August through September 1998. Inspectors visited 544 sites and noted 35 apparent findings of noncompliance; NMED has not yet issued formal Compliance Orders for either 1997 or 1998 annual inspections.

Laboratory operations were in compliance with all federal radiological and federal and state nonradiological air quality requirements. Radioactive emissions generated at the Laboratory during 1998 were in compliance and well below the Environmental Protection Agency's (EPA's) effective dose equivalent (EDE) limitation of less than 10 mrem per year to members of the public from airborne emissions. For 1998, the LANL EDE is calculated to be 1.72 mrem using EPA-approved methods.

In 1998, the Laboratory was in compliance with its National Pollutant Discharge Elimination System (NPDES) permit liquid discharge requirements in 99.4% of the samples from its sanitary effluent outfalls and in 99.3% of the samples from its industrial effluent outfalls. The Laboratory was in compliance with its NPDES permit liquid discharge requirements in 100% of the water quality parameter samples collected in the period from August 1, 1997, through July 31, 1998, at sanitary and industrial outfalls. Concentrations of chemical, microbiological, and radioactive constituents in the drinking water system remained within federal and state drinking water standards. Six groundwater samples collected at Monitoring Well R-25, drilled at Technical Area 16 in accordance with the Hydrogeologic Workplan, contained high explosives and chemicals associated with the breakdown of high explosives. Concentrations of these chemicals were above EPA health advisories for drinking water. Wells that supply drinking water to the Los Alamos water supply system were sampled, and no evidence of high explosives was found.

In 1998, Laboratory staff received approximately 430 proposed projects to review for compliance with the National Environmental Policy Act (NEPA) and sent 102 NEPA Environmental Review Forms to the Department of Energy (DOE). In addition, Laboratory archaeologists evaluated 846 proposed actions for possible effects on cultural resources, which required 26 intensive field surveys. Laboratory biologists reviewed approximately 400 proposed Laboratory projects for their impact on biological resources; 160 of the actions required additional study. The Threatened and Endangered Species Habitat Management Plan for the Laboratory was completed, and the implementation phase began in 1998.

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2. Compliance Summary

A. Introduction

Many activities and operations at Los Alamos National Laboratory (LANL or the Laboratory) involve or produce liquids, solids, and gases that may contain nonradioactive hazardous and/or radioactive materials. Laboratory policy implements Department of Energy (DOE) requirements by directing its employees to protect the environment and meet compliance requirements of applicable federal and state environmental protection regulations.

Federal and state environmental laws address handling, transport, release, and disposal of contaminants, pollutants, and wastes, as well as protection of ecological, archaeological, historic, atmospheric, soil, and water resources. Regulations provide specific requirements and standards to ensure maintenance of environmental qualities. The Environmental Protection Agency (EPA) and the New Mexico Environment Department (NMED) are the principal administrative authorities for these laws. DOE and its contractors are also subject to DOE-administered requirements regarding control of radionuclides. Table 2-1 presents the environmental permits or approvals issued by these organizations and the specific operations and/or sites affected.

B. Compliance Status

1. Resource Conservation and Recovery Act

a. Introduction. The Laboratory produces a wide variety of hazardous wastes, most of which are produced in small quantities relative to industrial facilities of comparable size. The Resource Conservation and Recovery Act (RCRA), as amended by the Hazardous and Solid Waste Amendments (HSWA) of 1984, creates a comprehensive program to regulate hazardous wastes, from generation to ultimate disposal. The HSWA emphasize reducing the volume and toxicity of hazardous waste. The applicable federal regulation, 40 Code of Federal Regulations (CFR) 268, requires treatment of hazardous waste before land disposal.

EPA or an authorized state issues RCRA permits to regulate the storage, treatment, or disposal of hazardous waste and the hazardous component of radioactive mixed waste that is stored, treated, or disposed of on-site. A RCRA Part A permit application identifies (1) facility location, (2) owner and operator, (3) hazardous or mixed wastes to be managed, and (4) hazardous waste management methods and units (RCRA hazardous waste management areas). A facility that has submitted a RCRA Part A permit application for an existing unit is allowed to manage hazardous or mixed wastes under transitional regulations known as the Interim Status Requirements pending issuance (or denial) of a RCRA Hazardous Waste Facility permit. The RCRA Part B permit application consists of a detailed narrative description of all facilities and procedures related to hazardous or mixed waste management, including contingency, training, and inspection plans. The State of New Mexico issued LANL's current Hazardous Waste Facility Permit to DOE and the University of California (UC) in November 1989.

In 1996, EPA adopted new standards, under the authority of RCRA, as amended, commonly called "Subpart CC" standards. These standards apply to air emissions from certain tanks, containers, less-than-90-day storage facilities, and surface impoundments that manage hazardous waste capable of releasing volatile organic compounds (VOCs) at levels that can harm human health and the environment.

b. Resource Conservation and Recovery Act Permitting Activities. The RCRA Hazardous Waste Facility Permit for the waste management operations at Technical Areas (TAs) 50, 54, and 16 is due for renewal. The 10-year permit expires in November 1999.

On February 5, 1998, LANL received approval from the NMED for a new strategy regarding the format and construction of the permit. The strategy involved the submittal of a LANL General Part B permit application that would be used as a comprehensive resource document for Laboratory-wide hazardous waste management procedures and the submittal of independent TA-specific permit applications to provide additional information for site-specific or unique procedures. This approach was proposed to consolidate previously submitted and new permit renewal applications and to alleviate repetitive reviews of plans and documents common to all or most LANL waste management organizations. The new permit renewal applications will facilitate NMED issuing a general permit for common waste management operations supported by specific chapters for each waste management area. Extensive work on the LANL Part B Permit Application and on site-specific Part B permit applications for TA-50 and TA-54 began in mid-1998.

The Hazardous and Solid Waste Group (ESH-19) submitted a revised Part A permit application to NMED in April 1998. The Part A incorporated both

Table 2-1. Environmental Permits or Approvals under which the Laboratory Operated during 1998

Category	Approved Activity	Issue Date	Expiration Date	Administering Agency
RCRA Hazardous Waste Facility	Hazardous and mixed waste storage, and treatment permit	November 1989	November 1999	NMED
	RCRA mixed waste Revised Part A application	submitted April 1998	---	NMED
HSWA	RCRA Corrective Activities	March 1990	December 1999	NMED
TSCA[a]	Disposal of PCBs at TA-54, Area G	June 25, 1996	None	EPA
CWA/NPDES[b], Los Alamos	Discharge of industrial and sanitary liquid effluents	August 1, 1994	October 31, 1998[c]	EPA
	Storm water associated with industrial activity	December 23, 1998	October 1, 2000	EPA
	Storm water associated with construction			
	DARHT Facility	October 2, 1998	July 7, 2003	EPA
	TA-9 and 16 Steam System Upgrade	September 1, 1998	October 1, 1998[d]	EPA
	RLW Cross Country Line	July 25, 1996	October 1, 1998	EPA
	Guaje Well Field Improvements	October 2, 1998	July 7, 2003	EPA
	Wildlands Fire Management	September 5, 1996	October 1, 1998	EPA
	Fire Protection Improvements	October 2, 1998	July 7, 2003	EPA
CWA/NPDES, Fenton Hill	Discharge of industrial liquid effluents	October 15, 1979	December 29, 1997[d]	EPA
CWA Sections 404/401 Permits	F.U. 4 Stream Crossing Restoration	July 24, 1997	July 24, 1999	COE[e]/NMED
	Guaje Canyon/Utility Line Discharges	September 9, 1997	September 9, 1999	COE/NMED
	Guaje Canyon/Road Crossings	September 9, 1997	September 9, 1999	COE/NMED
	Guaje Canyon/Headwaters and Isolated Water	September 9, 1997	September 9, 1999	COE/NMED
	Pueblo Canyon/Wetland/Riparian Activities	September 8, 1997	September 8, 1999	COE/NMED
	Pueblo Canyon/Headwaters and Isolated Water	September 18, 1997	September 18, 1999	COE/NMED
	LA Canyon, Ancho Canyon, DP Canyon/Fire Protection Improvement Project	November 14, 1997	November 14, 1999	COE/NMED
	Sandia Canyon/Survey Activities	March 4, 1998	March 4, 2000	COE/NMED
	Guaje Canyon/Bank Stabilization	March 2, 1998	March 2, 2000	COE/NMED

Table 2-1. Environmental Permits or Approvals under which the Laboratory Operated during 1998 (Cont.)

Category	Approved Activity	Issue Date	Expiration Date	Administering Agency
CWA Sections 404/401 Permits (Cont.)	Three Mile Canyon/Headwaters and Isolated Waters	July 14, 1998	January 28, 1999	COE/NMED
	Lab-wide Gaging Stations/Sci. Meas. Devices	August 28, 1998	August 28, 2000	
Groundwater Discharge Plan, Fenton Hill	Discharge to groundwater	June 5, 1995	June 5, 2000	NMOCD[f]
Groundwater Discharge Plan, TA-46 SWS Facility[g]	Discharge to groundwater	January 7, 1998	January 7, 2003	NMED
Groundwater Discharge Plan, Sanitary Sewage Sludge Land Application	Land application of dry sanitary sewage sludge	June 30, 1995	June 30, 2000	NMED
Groundwater Discharge Plan, TA-50, Radioactive Liquid Waste Treatment Facility	Discharge to groundwater	submitted August 20, 1996 approval pending		NMED
Air Quality Operating Permit (20 NMAC[h] 2.70)	LANL air emissions	submitted December 1995		NMED
Air Quality (NESHAP)[i]	Beryllium machining at TA-3-39	March 19, 1986	None	NMED
	Beryllium machining at TA-3-102	March 19, 1986	None	NMED
	Beryllium machining at TA-3-141	October 30, 1998	None	NMED
	Beryllium machining at TA-35-213	December 26, 1985	None	NMED
	Beryllium machining at TA-55-4	March 11, 1998	None	NMED
Open Burning (20 NMAC 2.60) Operational Burning	Burning of jet fuel and wood for ordnance testing, TA-11	August 18, 1997	December 31, 2002	NMED
	Burning of HE-contaminated[j] materials, TA-14			
	Burning of HE-contaminated materials, TA-16			
	Burning of scrap wood from experiments, TA-36			
	Fuel Fire Burn of wood or propane TA-16, Site 1409			

Table 2-1. Environmental Permits or Approvals under which the Laboratory Operated during 1998 (Cont.)

Category	Approved Activity	Issue Date	Expiration Date	Administering Agency
Open Burning (20 NMAC 2.60) Prescribed Burning	West Jemez Fuel Break Maintenance	January 8, 1998	December 31, 1998	NMED

[a]Toxic Substances Control Act.
[b]National Pollutant Discharge Elimination System.
[c]Administratively extended by EPA.
[d]Permit discontinued by EPA.
[e]Corps of Engineers.
[f]New Mexico Oil Conservation Division.
[g]Sanitary Wastewater Systems (SWS) Facility.
[h]New Mexico Administrative Code.
[i]National Emission Standards for Hazardous Air Pollutants.
[j]High-explosive.

hazardous and mixed waste management units as a consolidation of all active waste management treatment or storage units. This document was a precursor to developing the permit applications described above and a result of an NMED request.

One active waste management unit was closed in 1998. The final report and certification for closure of the controlled air incinerator at TA-50, Building 37, was submitted to NMED on April 22, 1998. NMED approved the closure on July 2, 1998. Decontamination activities for the container storage area inside Building 61 at TA-21 continued. ESH-19 also submitted closure plans for Material Disposal Areas (MDAs) H and L at TA-54 to NMED in April.

Other permitting activities in 1998 included approval of a request for a Temporary Authorization for equipment upgrades at TA-16-388 and the withdrawal of previously submitted applications for research, development, and demonstration permits. An authorization for conditional storage at TA-50, Building 37, was obtained on April 21, 1998, for mixed transuranic (TRU) waste characterization activities supporting the Transuranic Waste Inspectable Storage Project (TWISP) at TA-54. In addition, LANL participated in review meetings with NMED and other regulated facilities for the new fee regulation (New Mexico Administrative Code [NMAC], Title 20, Chapter 4, Part 2, "Hazardous Waste Fees") approved by the New Mexico Environmental Improvement Board in November 1998.

c. Resource Conservation and Recovery Act Corrective Action Activities. Several solid waste management units (SWMUs) are subject to both the HSWA Module VIII corrective action requirements and the closure provisions of RCRA. The corrective action process occurs concurrently with the closure process, thereby satisfying both sets of regulations. The history of RCRA closures is presented in previous LANL environmental reports (ESP 1998, ESP 1997, ESP 1996).

- TA-35 surface impoundments—NMED approved an amended closure plan in September 1996. The Laboratory completed Phase VI verification sampling at TA-35, TSL-85, during July 1996. In 1998, NMED approved the amended closure certification report.
- TA-16, landfill at MDA P—Implementation of clean closure of the TA-16 MDA P landfill began in 1998. The first activity was digging test pits in the landfill to characterize waste types and volumes. High explosives (HE) that could be detonated were detected in some of the pits, requiring extensive modification of the Site-Specific Health and Safety Plan and the Closure Implementation Plan.
- TA-53 surface impoundments—In July 1997, NMED notified DOE and the Laboratory that the change in status of the three surface impoundments at TA-53 from treatment, storage, and disposal (TSD) units to corrective action units under HSWA had been approved. A closure plan for the impoundments is no longer necessary. A RCRA Facility Investigation work plan for the impoundments was submitted on January 21, 1998, and the fieldwork is planned to begin in mid-1999.

d. Other Resource Conservation and Recovery Act Activities. In 1998, ESH-19 completed 645 quarterly self-assessments. In 1995, ESH-19 began the self-assessment program in cooperation with waste management coordinators to assess the Laboratory's performance in the proper storage and handling of hazardous and mixed waste to meet federal and state regulations, DOE orders, and Laboratory policy. Findings from individual self-assessments are communicated to waste generators, waste management coordinators, and management to help line managers implement appropriate corrective actions to ensure continual improvement in LANL's hazardous waste program.

e. Resource Conservation and Recovery Act Compliance Inspection. NMED conducted its annual hazardous waste compliance inspection from August through September 1998 (Table 2-2). The inspection team visited approximately 544 sites at the Laboratory. Inspectors noted 35 apparent violations of RCRA including exceeding storage time limits, failing to label a waste container, and failing to document required RCRA training. Formal Compliance Orders have not been issued by the end of 1998 for either the 1998 or 1997 NMED RCRA inspections.

f. Mixed Waste Federal Facility Compliance Order. The Laboratory met all 1998 Site Treatment Plan deadlines and milestones. In October 1995, the State of New Mexico issued a Federal Facility Compliance Order to both DOE and UC requiring compliance with the Site Treatment Plan. That plan describes the development of treatment capacities and technologies or use of off-site facilities for treating mixed waste generated at LANL being stored beyond

Table 2-2. Environmental Inspections and Audits Conducted at the Laboratory during 1998

Date	Purpose	Performing Agency
January–May 1998	Continuation of FFCA Compliance Audit	RAC[a]
January 27, 1998	Visual Verification of Beryllium Permit	NMED
January 31, 1998	Open Burn Permit Inspection	NMED
March 31, 1998	DOE Audit	DOE/IG Office
April 10, 1998	Beryllium Inspection	NMED
May 14–15, 1998	NPDES Storm Water Program Inspection	EPA
June 1, 1998	Asbestos	NMED
June 23, 1998	FFCA Compliance Audit	RAC[a]
June 24, 1998	Asbestos Inspection	NMED
July 9, 1998	Open Burn Permit Inspection	NMED
August–September 1998	Hazardous Waste Facility Inspection	NMED
October 6, 1998	TA-54 Area J Commercial/Special	NMED/SWQB[b]
October 9, 1998	Asbestos Incident Investigation Waste Landfill	NMED
November 12, 1998	Asbestos Inspection	NMED
March 1998	FIFRA Inspection	NMDA[c]

[a] Radiological Assessments Corporation.
[b] New Mexico Environment Department/Surface Water Quality Bureau.
[c] New Mexico Department of Agriculture.

the one-year time frame (Section 3004[j] of RCRA and 40 CFR Section 268.50). Over 500 cubic meters of mixed waste were treated and disposed of through FY98.

g. Underground Storage Tanks. In August 1998, the EPA confirmed that all underground storage tanks (USTs) that had been installed before December 22, 1988, and that had not already been protected against corrosion, spills, and overfills would have to be upgraded, replaced, or properly closed by December 22, 1998. During 1998, the Laboratory closed five of its remaining seven USTs, including tanks registered as TA-2-1, TA-3-73, TA-21-155, TA-35-197, and TA-41-W2. As a result of closing these five tanks, the Laboratory has reduced its total number of USTs from 39 in 1988 to 2 in 1998, the largest reduction of USTs at any registered facility in the state.

Closures of USTs TA-21-155 and TA-41-W2 were listed as clean closures where no contamination was detected at the location. Suspect releases were reported to NMED for sites associated with TA-2-1, TA-3-73, and TA-35-197. By the end of 1998, the only confirmed release occurred at TA-35-197, where leaking pipes exiting a pump pit associated with the UST created localized pockets of contamination. The majority of this contamination was eliminated through the removal of contaminated soil, and the site was closed under a work plan approved by the NMED.

The suspected contamination at TA-3-73 was found to be associated with past disposal practices involving materials containing asphalt at the TA-3 Asphalt Batch Plant and did not result from releases from the UST. The Laboratory's Environmental Restoration (ER) Project will investigate the contamination pursuant to Module VIII of the RCRA/HSWA permit.

The site at TA-2-1 is still under investigation; necessary sampling could not be completed because of weather conditions. We believe that any contamination at this site will be confined to one location along the UST "fill line," where concentrations of total petroleum hydrocarbons were slightly above the 100 ppm standard of the NM UST Regulations. Previous samples taken from the site indicate no leakage from the UST itself or from other segments of the fill line.

The two remaining USTs, TA-16-197 and TA-15-R312-DAHRT, meet all of the upgrade requirements in state (20 NMAC 5) and federal (40 CFR 280) regulations. Additionally, the DAHRT UST is solely for secondary containment and does not routinely store petroleum products, further reducing any

possibility of an accidental release. The NMED UST Bureau will inspect these tanks on a triennial basis, beginning in 1999, to ensure that they continue to meet the new release detection, corrosion control, and spill containment requirements of RCRA, Subpart I, and the NM UST Regulations.

h. Solid Waste Disposal. The Laboratory has a commercial/special waste landfill located at TA-54, Area J, that is subject to NM Solid Waste Management Regulations (NMSWMR). In December 1998, the NMED Solid Waste Bureau requested a permit for the facility, which has been operating under a Notice of Intent since the NMSWMR were issued in 1995. Area J is closing in 1999 because the Laboratory decided not to retrofit Area J with a liner and other equipment needed to meet the regulations. Personnel from the NM Solid Waste Bureau inspected Area J on October 6, 1998; there were no apparent violations of the NMSWMR.

In 1998, the TA-54, Area J landfill received and disposed of 55.5 yd^3 of solid waste in its pits and shafts. The asbestos transfer station at Area J staged 262 yd^3 of asbestos to both in- and out-of-state special-waste landfills. In 1998, LANL completed the required Solid Waste Facility annual report for the calendar year 1997.

LANL also disposes of sanitary solid waste (trash), concrete/rubble, and construction and demolition debris at the Los Alamos County landfill on East Jemez Road. DOE owns the property; it is leased to Los Alamos County under a special use permit. Los Alamos County owns and operates this landfill and is responsible for obtaining all related permits for this activity from the state. The landfill is registered with NMED Solid Waste Bureau. The Laboratory contributed 17% (7,452 tons) of the total volume of trash landfilled at this site during 1998, with the 83% remainder contributed by residents of Los Alamos County and the City of Española. Laboratory trash landfilled included 2,345 tons of trash, 4,467 tons of concrete/rubble, and 640 tons of construction and demolition debris. During 1998, the Laboratory also sent to the county landfill 343 tons of brush for composting and 53 tons of metal for recycling.

i. Waste Minimization and Pollution Prevention. To comply with the HSWA Module of the RCRA, RCRA Subtitle A, DOE Order 5400.1, Executive Order (EO) 12856, Federal Compliance with Right-to-Know Laws and Pollution Prevention Requirements, and other regulations, the Laboratory must have a waste minimization and pollution prevention program. A copy of that Laboratory program, the *1998 Environmental Stewardship Roadmap*, is located at *http://emeso.lanl.gov/publications/default.asp* on the World Wide Web.

Section 1003 of the Waste Disposal Act cites the minimization of the generation and land disposal of hazardous wastes as a national objective and policy. All hazardous waste must be handled in ways that minimize the present and future threat to human health and the environment. The Waste Disposal Act promotes process substitution; materials recovery, recycling, and reuse; and treatment as alternatives to land disposal of hazardous waste.

The *1998 Annual Report on Waste Generation and Waste Minimization Progress as Required by DOE Order 5400.1* provides the amounts of routine, nonroutine, and total RCRA-hazardous, low-level, and mixed low-level wastes generated by Laboratory operations during 1998. A copy of this report and additional information concerning waste minimization can be found at *http://twilight.saic.com/WasteMin* on the World Wide Web.

Routine/normal waste generation at LANL is defined as waste produced from any type of production, operation, analytical, and/or research and development (R&D) laboratory operations; TSD operations; work for others; or any other periodic and recurring work that is considered ongoing in nature.

Nonroutine/off-normal waste generation is defined as one-time operations waste such as wastes produced from ER Project activities, including primary and secondary wastes associated with removal and remediation operations; wastes associated with the legacy waste program cleanup, and decontamination and decommissioning (D&D) operations.

In 1998, source reduction and recycling activities reduced the following amounts of wastes:

TRU waste	132.4 m^3
Low-level radioactive waste	1,469.51 m^3
Mixed low-level radioactive waste	700.04 m^3
RCRA-hazardous waste	339.31 m^3
Sanitary solid waste	7,958.45 metric tons
State-regulated waste	123.09 metric tons
Toxic Substances Control Act (TSCA) waste	2.92 metric tons

j. Greening of the Government Executive Order. The Laboratory purchases products made with recovered materials in support of Executive Order 13101, "Greening the Government Through Waste

Prevention, Recycling, and Federal Acquisition," signed by President Clinton on September 14, 1998, and to comply with RCRA. EPA designates the categories of these items, referred to as Affirmative Procurement. Based on past reports, the Laboratory purchases the largest number of items in three categories: paper, toner cartridges, and plastic desktop accessories whenever available. The Laboratory submits a summary report to DOE after each fiscal year end.

k. Resource Conservation and Recovery Act Training. The RCRA training program is a required component of and is described in the RCRA Hazardous Waste Facility Permit. This Laboratory training program is complete and only experienced minor modifications and revisions in 1998 to reflect regulatory, organizational, and/or programmatic changes.

During 1998, 147 workers completed RCRA Personnel Training, 420 workers completed RCRA Refresher Training, and 548 workers completed Waste Generation Overview. Of the 420 workers who required RCRA Refresher Training during 1998, 323 met this requirement through completing the combined course.

The following RCRA courses were upgraded and/or revised by the Environment, Safety, and Health Training Group (ESH-13) during 1998:

RCRA Refresher Training

HAZWOPER: Refresher for Environmental Restoration Workers

HAZWOPER: Refresher for Treatment, Storage, and Disposal Workers

Waste Documentation Forms

Waste Generator Overview

Waste Management Coordinator Refresher

The following RCRA self-study courses were developed in 1998:

Environmental Regulation Overview

Waste Management Overview

Waste Characterization Overview

Temporary Waste Storage Overview

l. Hazardous and Solid Waste Amendments Compliance Activities. In 1998, the ER Project remained in compliance with Module VIII of the RCRA permit. The Laboratory's ER Project originally involved approximately 2,100 potential release sites. At the end of FY98, approximately 1,200 potential release sites remained that require investigation and/or remediation and 109 buildings awaited D&D. The ER Project continues to reevaluate previously submitted proposals for No Further Action for additional requirements that must be achieved before NMED approves them as a No Further Action. Of those submitted, 266 proposals were found to be valid. The remainder of the proposals will continue to be evaluated to determine if additional work is necessary to support No Further Action. The Laboratory's ER Project has targeted 2006 for completion of its corrective action work.

In 1998, the LANL ER Project activities included remedial site assessments, site remediations, and the decommissioning of surplus facilities. The assessment portion of the ER Project included submission of six RCRA facility investigation (RFI) reports to NMED and RFI fieldwork on numerous sites. Remedial activities conducted included cleanup of seven sites including surface disposal areas, septic systems, and firing sites. In addition, during the evaluation of other potential remedial sites, 35 sites were determined by human health risk assessments not to require remedial action. Five contaminated facilities at TA-16 and TA-61 were demolished.

2. Comprehensive Environmental Response, Compensation, and Liability Act

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980, as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986, mandates actions for certain releases of hazardous substances into the environment. The Laboratory is not listed on the EPA's National Priority List but follows the CERCLA guidelines for remediating ER Project sites that contain certain hazardous substances not covered by RCRA.

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

a. Introduction. The Laboratory is required to comply with the Emergency Planning and Community Right-to-Know Act (EPCRA) of 1986 and EO 12856.

b. Compliance Activities. In 1998, the Laboratory submitted two annual reports to fulfill its requirements under EPCRA, as shown on Table 2-3 and described below.

Emergency Planning Notification. Title III, Sections 302-303, of EPCRA, requires the preparation of emergency plans for more than 360 extremely

Table 2-3. Compliance with Emergency Planning and Community Right-to-Know Act during 1998

Statute		Reporting required and reported	Reporting required and not reported	Reporting not required
EPCRA 302-303:	Emergency Planning Notification			×
EPCRA 304:	Emergency Release Notification			×
EPCRA 311-312:	Material Safety Data Sheet/ Chemical Inventory Reporting	×		
EPCRA 313:	Toxic Release Inventory Reporting	×		

hazardous substances when they are stored in amounts above threshold limits. The Laboratory is required to notify state and local emergency planning committees of any changes at the Laboratory that might affect the local emergency plan or if the Laboratory's emergency planning coordinator changes. During 1998, no changes at the Laboratory required notification to the state and local emergency planning committees.

Emergency Release Notification. Title III, Section 304 of EPCRA, requires facilities to provide emergency release notification of leaks, spills, and other releases of specified chemicals over a specified reporting quantity into the environment. Releases are to be reported immediately to the state and local emergency planning committees and to the National Response Center. There were no leaks, spills, or other releases of specific chemicals into the environment that required EPCRA reporting during 1998.

Material Safety Data Sheet/Chemical Inventory Reporting. Title III, Sections 311-312, of EPCRA requires facilities to provide an annual inventory of the quantity and location of hazardous chemicals present at the facility above specified thresholds; the inventory includes the material safety data sheet (MSDS) for each chemical. The Laboratory submitted a report to the state emergency response commission, the local emergency planning committee, and the Los Alamos County Fire Department listing 47 chemicals and explosives that were at the Laboratory during 1998 in quantities exceeding threshold limits.

Toxic Release Inventory Reporting. Title III, Section 313, of EPCRA, as modified by EO 12856, requires all federal facilities to report total annual releases of listed toxic chemicals. Nitric acid was the only Section 313 listed toxic chemical that was used in quantities above the reportable threshold of 10,000 lb in 1997. Approximately 29,400 lb of nitric acid were used for plutonium processing. LANL submitted a Toxic Release Inventory Form (Form R) to EPA and the state emergency response commission in June 1998. The Form R reported the release of 720 lb of nitric acid emissions. There were no other Section 313 reportable releases in 1997 to the environment. In 1998, LANL used no listed toxic chemicals in quantities exceeding thresholds. Therefore, no Form R will be submitted in 1999.

c. Emergency Planning. The Laboratory's Emergency Management Plan is a document that describes the entire process of planning, responding to, and mitigating the potential consequences of an emergency. The most recent revision of the plan, incorporating DOE Order 151.1, was published in July 1998. In accordance with DOE Order 151.1, it is the Laboratory's policy to develop and maintain an emergency management system that includes emergency planning, emergency preparedness, and effective response capabilities for responding to and mitigating the consequences of an emergency. In 1998, 518 employees received training as a result of Emergency Management Plan requirements and the Emergency Management & Response organization's internal training program.

4. Toxic Substances Control Act

Because the Laboratory's activities are in the realm of research and development and do not involve introducing chemicals into commerce, the polychlorinated biphenyls (PCB) regulations (40 CFR 761) have been the Laboratory's main concern under the TSCA. The PCB regulations govern substances including but not limited to dielectric fluids, contaminated solvents, oils, waste oils, heat transfer fluids, hydraulic fluids, slurries, soils, sanitary treatment solids from the

Sanitary Wastewater Systems (SWS) Facility, and materials contaminated as a result of spills. Most of the provisions of the regulations apply to transformers, capacitors, and other PCB items at a concentration above 50 ppm.

In 1998, the Laboratory had 31 off-site shipments of PCB waste. The quantities of waste disposed include 11 55-gal. drums of capacitors; 23 55-gal. drums of light ballast; 10 55-gal. drums of water; 7,288 kg of PCB-contaminated soil; 33 55-gal. drums of PCB-contaminated debris; 10 55-gal. drums of sludge, grit, and screening with PCB; 13 55-gal. drums of various pieces of PCB electrical equipment; and 8,549 kg of PCB oil. All wastes are managed in accordance with 40 CFR 761 manifesting, record keeping, and disposal requirements. PCB wastes are sent to EPA-permitted disposal and treatment facilities. Light ballast is sent off-site for recycling. Section 2.B.8.b describes the status of sanitary sewer sludge from the TA-46 SWS Facility in which low-level PCB have been detected.

In 1998, the Laboratory generated radioactively contaminated PCBs in two forms, resulting in a total of 22 kg of liquids and less than 1 kg of solids. Nonliquid wastes containing greater than 50 ppm PCB and PCB contaminated with radioactive constituents are disposed of at the Laboratory's EPA-authorized TSCA landfill located at TA-54, Area G. No nonliquid nonradioactive or radioactive PCB wastes were disposed of on-site in 1998. Radioactively-contaminated PCB liquid wastes are stored at the TA-54, Area L, TSCA-authorized storage facility. Many of these items have exceeded TSCA's one-year storage limitation and are covered under the Final Rule for the Disposal of PCB, dated August 28, 1998.

The primary compliance document related to 40 CFR 761.180 is the annual PCB report submitted to EPA, Region 6. EPA did not conduct an audit of the Laboratory's PCB management program during 1998.

5. Federal Insecticide, Fungicide, and Rodenticide Act

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) regulates the manufacturing of pesticides, with requirements for registration, labeling, packaging, record keeping, distribution, worker protection, certification, experimental use, and tolerances in foods and feeds. Sections of this act that are applicable to the Laboratory include requirements for certification of workers who apply pesticides. The Laboratory is also regulated by the New Mexico Pesticide Control Act, administered by the New Mexico Department of Agriculture (NMDA). NMDA conducted an inspection of the Laboratory's pesticide application program during March 1998; no deficiencies were noted.

6. Federal Clean Air Act

a. Federal Regulations. The Laboratory is subject to a number of federal air quality regulations. These include the following:

- National Emission Standards for Hazardous Air Pollutants (NESHAP),
- National Ambient Air Quality Standards (NAAQS),
- New Source Performance Standards (NSPS),
- Stratospheric Ozone Protection (SOP), and
- Operating Permit Program.

All of these requirements, except the NESHAP for radionuclides and provisions relating to SOP, have been adopted by the State of New Mexico as part of its State Implementation Plan. The requirements adopted by the State of New Mexico are discussed in Section 2.B.7, New Mexico Air Quality Control Act.

The 1990 amendments to the Clean Air Act (CAA) mandated new programs that may affect the Laboratory. The new requirements include control technology for hazardous air pollutants, compliance assurance monitoring, prevention of accidental releases, and chlorofluorocarbon replacement. The Laboratory will continue to track new regulations written to implement the act, determine their effects on Laboratory operations, and develop programs as needed.

b. Compliance Activities

Radionuclide NESHAP. Under 40 CFR 61, Subpart H, EPA limits the effective dose equivalent (EDE) to any member of the public from radioactive airborne releases from a DOE facility, including LANL, to 10 mrem per year. The 1998 EDE (as calculated using EPA-approved methods) was 1.72 mrem, primarily from the Los Alamos Neutron Science Center (LANSCE) operations.

EPA must approve any new construction or modifications undertaken at LANL that will increase airborne radioactive emissions causing a potential increase in the EDE of 0.1 mrem per year or greater. In 1998, the Air Quality Group (ESH-17) reviewed

more than 100 projects for regulatory requirements; none required EPA preconstruction approval.

Stratospheric Ozone Protection. The CAA contains specific sections establishing regulations and requirements for ozone-depleting substances (ODS). The sections applicable to the Laboratory include

- Section 608, National Recycling and Emission Reduction Program, implemented by 40 CFR 82 Subpart F, which prohibits individuals from knowingly venting ODS into the atmosphere during maintenance, repair, service, or disposal of air conditioning or refrigeration equipment and requires technician certification and the use of certified recovery equipment;
- Section 609, Servicing of Motor Vehicle Air Conditioners, implemented by 40 CFR 82 Subpart B, which includes standards and requirements for recycling equipment that services motor vehicle air conditioners and for training and certification of maintenance and repair technicians; and
- Section 611, Labeling of Products Using ODS, implemented by 40 CFR 82 Subpart E, which establishes requirements to attach warning labels to products containing or manufactured with Class I or II ODS.

LANL complies by using certified personnel and equipment for maintaining, servicing, repairing, and disposing of air conditioning and refrigeration equipment; by contracting automotive repair work to qualified local automotive repair shops and Johnson Controls Northern New Mexico (JCNNM); and by ensuring that products containing ODS and ODS-containing waste that are shipped off-site are properly labeled.

7. New Mexico Air Quality Control Act

a. State Regulations. The New Mexico Air Quality Bureau, as provided by the New Mexico Air Quality Control Act, regulates air quality through a series of air quality control regulations in the NMAC. NMED administers these regulations. The air quality regulations relevant to Laboratory operations are discussed below.

b. Compliance Summary.

20 NMAC 2.3—Ambient Air Quality Standards. Provisions of 20 NMAC 2.3 establish ambient air quality standards intended to protect the quality of the air in New Mexico. The regulation specifies maximum allowable concentrations for certain pollutants that are not to be exceeded in the ambient air. Additionally, EPA has established NAAQS under 40 CFR 50. Los Alamos County meets all NMAAQS and NAAQS. NMAAQS are more stringent than the federal standards (see Table A-3). The Laboratory must demonstrate that emissions from new or modified permitted sources do not exceed the federal or state ambient standards.

20 NMAC 2.7—Excess Emissions during Malfunction, Start-up, Shutdown, or Scheduled Maintenance. This provision allows for excess emissions from process equipment during malfunction, start-up, shutdown, or scheduled maintenance, provided the operator verbally notifies NMED either before or within 24 hours of the occurrence, followed by written notification within 10 days of the occurrence. No excess emissions were reported for 1998.

20 NMAC 2.11—Asphalt Process Equipment. Provisions of 20 NMAC 2.11 set emission standards according to process rate and require the control of fugitive dust emissions from asphalt-processing equipment. The asphalt plant that JCNNM operates at LANL is subject to this regulation. The plant is in compliance with an emission limit of 34 lb of particulate matter (PM) per hour.

20 NMAC 2.33—Gas Burning Equipment, Nitrogen Dioxide. Provisions of 20 NMAC 2.33 require gas burning equipment built before February 17, 1972, to meet an emission standard of 0.3 lb of nitrogen dioxide per million Btu when natural gas consumption exceeds 1×10^{12} Btu per year per unit. The TA-3 steam plant has the capacity to operate at this level, although it never has. The operating permit application proposes compliance by setting voluntary limits for the operation of the boiler units to less than 1×10^{12} Btu per year per unit.

20 NMAC 2.34—Oil Burning Equipment, Nitrogen Dioxide. This regulation requires oil burning equipment to meet an emission standard of 0.3 lb of nitrogen dioxide per million Btu when the units operate at a heat input of greater than 1×10^{12} Btu per year. The TA-3 steam plant has the capacity to operate at this level, although it never has. The operating permit application proposes voluntary limits for the operation of these units to less than 1×10^{12} Btu per year per unit.

20 NMAC 2.60—Open Burning. This regulation controls the open burning of materials. Open burning of explosive materials is allowed when transport of these materials to other facilities may be dangerous. Research projects often require open burn

permits. In August 1997, the Laboratory consolidated open burn permits into a single permit for operational burns as listed in Table 2-1. The Laboratory also had a burn permit for prescribed burns as a preventive measure against wildfires for 1998; however, no prescribed burning was conducted in 1998.

20 NMAC 2.61—Smoke and Visible Emissions. This regulation limits visible emissions from various combustion sources, including the Laboratory boilers, to less than 20% opacity. Opacity is the degree to which emissions reduce the transmission of light and obscure the view of a background object. Because the Laboratory boilers are fueled by clean-burning natural gas, exceeding this standard is unlikely. However, oil is used as a backup fuel for the boilers. To ensure that the backup system is working properly, the boilers must be periodically switched to oil. The Laboratory boilers may exceed the opacity standard while switching from gas to oil. An NMED-certified opacity observer reads the opacity while the switches are being made, at the start-up of cold boilers, or during periods of malfunction. If the Laboratory exceeds the opacity standard during designated activities, 20 NMAC 2.7 notification procedures are then followed. There were no opacity exceedances during 1998.

20 NMAC 2.70—Operating Permits. This regulation requires major sources of regulated air pollutants to obtain an operating permit from NMED. Because of LANL's large potential to emit regulated air pollutants (primarily nitrogen oxides from the steam plants), LANL is a major source. The permit application specifies the operational terms and limitations required to meet all federal and state air quality regulations. The Laboratory submitted its permit application to NMED in December 1995 and does not expect to receive a final permit for several years.

20 NMAC 2.71—Operating Permit Emission Fees. As part of the new operating permit program, the State of New Mexico collects fees from emission sources that are required to obtain an operating permit. Fees depend on the allowable emission rates or the potential to emit. Laboratory fees for 1997, paid in 1998, totaled $14,165.50. Laboratory fees for 1998 totaled $13,017.50.

20 NMAC 2.72—Construction Permits. Provisions of 20 NMAC 2.72 require construction permits for new or modified sources of air pollutants. The Laboratory reviews plans for each new and modified source and makes conservative estimates of maximum hourly chemical usage and emissions. These estimates are compared with the applicable 20 NMAC 2.72 limits to determine if construction permits or notifications are required. During 1998, over 200 source reviews were conducted. The Laboratory operates under five construction permits for beryllium machining operations. Beryllium emission limits for these permits are presented in Table A-4. A construction permit application was submitted to NMED in November 1998 for a rock crusher.

20 NMAC 2.73—Notice of Intent and Emissions Inventory Requirements. Provisions of 20 NMAC 2.73 require that notices of intent be filed with NMED for new or modified stationary sources with a potential emission rate greater than 10 tons of any regulated air contaminant per year or one ton of lead per year. In addition, the provisions of 20 NMAC 2.73 specify requirements for submittal of annual emission inventories for regulated air pollutants. The Laboratory 1998 inventory was submitted to NMED.

Table 2-4 shows the 1998 calculated actual emissions for the criteria pollutants from industrial-type sources. Following is an explanation of the different industrial-type sources at LANL. The steam plants produce steam for heat and electricity when sufficient power from outside sources is not available. The water pump pumps water from underground wells. Small amounts of asphalt are produced for road repairs at LANL. Boilers provide comfort and process heat. These industrial-type sources are primarily operated on natural gas. The TA-3 steam plant can use fuel oil as a backup.

We used various methods and resources to estimate source emissions. Emissions from the asphalt plant are based on the 1,761 tons of asphalt produced in 1998. The PM emissions from the asphalt plant were calculated using an emission factor obtained from a stack test. Emissions from fuel combustion equipment are based on the actual or estimated fuel consumption. The nitrogen oxide (NO_X) emissions from the TA-3 steam plant were calculated using an emission factor obtained from a stack test. The NO_X and carbon monoxide (CO) emission factors for the TA-16 boilers and the water pump were calculated using data provided by the manufacturers. We estimated all other criteria pollutant emissions using EPA guidance documents.

In addition, the emissions inventory was updated for 1998 to include new sources of emissions: a paper shredder and a rock crusher. The paper shredder destroys classified documents. Estimates of actual PM emissions are based on an averaged monthly shredding rate for the fiscal year and engineering

Table 2-4. Calculated Actual Emissions for Criteria Pollutants (Tons)

Source	PM	CO	NO_x	SO_x
Asphalt Plant	0.062	0.30	0.022	0.0044
TA-3 Steam Plant	1.7	13	54	0.20
TA-16 Steam Plant	0.33	1.0	1.0	0.017
TA-21 Steam Plant	0.33	0.8	3.3	0.014
Water Pump	0.0024	1.3	4.0	0.0016
Large Boilers (TA-48, -53, and -55)	0.67	1.2	5.6	0.033
Paper Shredder	0.0003	NA	NA	NA
Rock Crusher	0.029	0.053	0.25	0.016
Total	3.1	18	68	0.28

judgment for control efficiency. The PM emissions are controlled by a cyclone and a baghouse. The rock crusher crushes concrete and rock removed from buildings as part of LANL's D&D efforts. The crusher is equipped with a 200-horsepower diesel-fired engine. Air emissions from the rock crusher include PM from the crushing activities and combustion products from the diesel-fired engine. Emission estimates are based on the actual hours of operation and EPA emission factors.

There are additional criteria pollutant emissions from small, nonregulated boilers, emergency generators, space heaters, etc. These sources are located across the Laboratory and are not required to be included in the 20 NMAC 2.73 emissions inventory. Total Laboratory criteria pollutant emissions are estimated to be an additional 25% higher than the values listed in Table 2-4 if these smaller sources are included.

An assessment of the ambient impacts of criteria pollutant emissions, presented in the Site-Wide Environmental Impact Statement for Los Alamos (DOE 1999), indicates that no adverse air quality impacts result from the Laboratory's combustion and industrial sources. The actual amounts of criteria pollutant emissions during 1998 are less than the amounts for which impacts are analyzed in the Environmental Impact Statement.

In addition to the criteria pollutants, VOC emissions are reported to NMED under 20 NMAC 2.73. The 1998 calculated actual emissions of VOCs are shown in Table 2-5. VOCs are any carbon compounds, with the exception of specific compounds listed in the regulation, that participate in atmospheric photochemical reactions. VOCs include commonly used chemicals such as ethanol, methanol, and isopropyl alcohol. In 1998, an estimated 12.5 tons of VOCs were emitted from research and development activities based on chemical procurement records. For this estimate, we conservatively assumed that air releases were equivalent to the quantity purchased. In September 1998, the Laboratory began using a halogenated solvent cleaning machine (degreaser) that was installed at TA-55, Building PF-4. The VOC-producing solvent trichloroethylene is used to clean parts. The VOC emissions were calculated based on monthly measurements of solvent loss for September through December 1998. LANL operates another parts cleaner; however, it uses a solvent (1,1,1-trichloroethane) that is not a VOC. Therefore, the 1998 emissions of 1,1,1-trichloroethane of 690 lb do not appear in the table. The industrial-type sources and the rock crusher also generate small amounts of VOC emissions. The manufacturer of the water pump provided the VOC emission factor. Otherwise, the VOC emission estimates are based on the actual hours of operation and EPA emission factors.

20 NMAC 2.74—Permits, Prevention of Significant Deterioration. This regulation has stringent requirements that must be addressed before the construction of any new, large stationary emission source can begin. Class I areas, such as wilderness areas, national parks, and national monuments, receive special protection under this regulation. Prevention of

Table 2-5. Calculated Actual Emissions for Volatile Organic Compounds (Tons)

Source	Emissions
Asphalt Plant	0.015
TA-3 Steam Plant	0.46
TA-16 Steam Plant	0.15
TA-21 Steam Plant	0.066
Water Pump	0.080
Large Boilers[a]	0.29
Rock Crusher	0.020
Degreaser	0.024
Research and Development Activities	12.5
Total	13.6

[a]Boilers located at TA-48, -53, and -55.

Significant Deterioration could affect the Laboratory because of the proximity of Bandelier National Monument's Wilderness Area. Each new or modified source at the Laboratory is reviewed for applicability under this regulation and compared to overall emissions from the Laboratory. None of the new or modified sources in 1998 have resulted in emission increases that would cause the Laboratory to exceed the Prevention of Significant Deterioration emission threshold limits.

20 NMAC 2.77—New Source Performance Standards. This regulation adopts the federal NSPS for new construction or modifications to stationary sources. Sources subject to this regulation may also be subject to the monitoring requirements in 40 CFR 60. The only sources at LANL that have NSPS requirements are storage tanks affected by 40 CFR 60, Subpart Kb - Standards of Performance for Volatile Organic Liquid Storage Vessels. The tanks at the Laboratory, because of size and low volatility of the materials stored, are exempt from monitoring requirements specified in 40 CFR 60, Subpart Kb.

20 NMAC 2.78—Emission Standards for Hazardous Air Pollutants. This regulation adopts, by reference, all of the federal NESHAP, except those for radionuclides and residential wood heaters. The impact of each applicable NESHAP is discussed below.

Asbestos NESHAP. Under the NESHAP for asbestos (40 CFR 61, Subpart M), the Laboratory must ensure that asbestos removal operations produce no visible asbestos emissions to the atmosphere. During 1998, no Laboratory operation produced visible asbestos emissions. However, an external contractor received a violation while working on a LANL project. The Laboratory is also required to notify NMED of asbestos removal activities and disposal quantities. Such activities involving less than 15 m^3 or 80 linear meters or 1 m^3 of asbestos waste are covered by an annual small-job notification to NMED. For projects involving greater than these amounts of asbestos, separate notification to NMED is required in advance of each project. NMED is notified of asbestos waste disposal (both small and large jobs) on a quarterly basis, which includes any material contaminated with radionuclides. Radioactively contaminated material is disposed of on-site in a designated radioactive asbestos burial area at TA-54, Area G. Nonradioactive asbestos is transported off-site to designated asbestos disposal areas.

During 1998, small-job activity accounted for 93 m^3 of asbestos waste. Several large demolition jobs accounted for 68 m^3 of asbestos waste. From the large and small jobs combined, 14 m^3 of radioactively contaminated asbestos waste were disposed of on-site.

Beryllium NESHAP. The beryllium NESHAP (40 CFR 61, Subpart C) includes requirements for notification, emission limits, and stack performance testing for beryllium sources. The Laboratory currently operates under five beryllium permits issued by NMED (Table 2-1) and has registered several additional facilities. The registered facilities do not require permits under the regulations because they existed before the adoption of the federal NESHAP. Exhaust air from each of the beryllium operations passes through air pollution control equipment before exiting from a stack. All beryllium operations meet the permitted emission limits (Table A-4) set by NMED.

Halogenated Solvent Cleaning NESHAP. The solvent cleaning NESHAP (40 CFR 63, Subpart T) requires that all solvent cleaning machines containing any of six listed halogenated solvents be registered. In addition, annual emissions for some types of cleaning machines must be reported on a three-month rolling average. In 1998, the Laboratory operated two halogenated solvent cleaning machines and reported three-month rolling average emissions as required.

8. Clean Water Act

a. National Pollutant Discharge Elimination System Outfall Program. The primary goal of the Clean Water Act (CWA) (33 U.S.C. 1251 *et seq.*) is to

restore and maintain the chemical, physical, and biological integrity of the nation's waters. The act established the requirements for National Pollutant Discharge Elimination System (NPDES) permits for point-source effluent discharges to the nation's waters. The NPDES outfall permit establishes specific chemical, physical, and biological criteria that an effluent must meet before it is discharged. Although most of the Laboratory's effluent is discharged to normally dry arroyos, the Laboratory is required to meet effluent limitations under the NPDES permit program.

UC and DOE are co-permittees of the NPDES permit covering Laboratory operations. EPA Region 6 in Dallas, Texas, issues and enforces the permit. However, NMED certifies the EPA-issued permit and performs some compliance evaluation inspections and monitoring for EPA through a Section 106 water quality grant.

The current Laboratory NPDES Permit, No. NM0028355, expired October 31, 1998, but has been administratively continued by EPA until a new permit is issued. As required by the NPDES regulations, the Laboratory submitted an application for renewal of the NPDES permit on May 4, 1998.

Each year, the number of permitted outfalls at the Laboratory is decreasing in response to the success of the Waste Stream Characterization Program and Corrections Project and the NPDES Outfall Reduction Program. Before initiating the Waste Stream Characterization Program and Corrections Project and the NPDES Outfall Reduction Program, the Laboratory's NPDES outfall permit for Los Alamos included 2 sanitary outfalls and 86 industrial outfalls. By January 1998, 22 of the industrial outfalls had been eliminated. By the end of 1998, the Laboratory had eliminated the sanitary outfall at TA-21 and another 29 permitted industrial outfalls from the NPDES permit. The goal of the NPDES Outfall Reduction Program is 20 permitted outfalls, 1 sanitary wastewater treatment facility and 19 industrial outfalls. This goal will be achieved by completion of the transfer of the drinking water system to Los Alamos County by DOE and by encouraging new construction design and existing plant modifications at the Laboratory that provide for reduced or no-flow effluent discharge systems.

Under the Laboratory's NPDES outfall permit, samples for effluent quality limits are collected for analysis weekly, monthly, and quarterly depending on the outfall category. Water quality parameters are collected for analysis annually at all outfalls. Results are reported to EPA and NMED at the end of the monitoring period for each respective outfall category. During 1998, effluent limits were exceeded once in the 161 samples collected from the sanitary outfalls and 7 times in the 1,003 samples collected from the industrial outfalls (see Table 2-6). A summary of these outfalls and a listing of the permit's monitoring limits are presented in Table A-5. The annual water quality parameters for sanitary and industrial outfalls are presented in Table A-6.

The following is a summary of the corrective actions the Laboratory took during 1998 to address permit noncompliances.

TA-53, Cooling Towers 293, 365, 1032 (NPDES Outfall 03A113). Two chlorine exceedances (daily average/daily maximum) occurred at NPDES Outfall 03A113 on February 11, 1998. When the operating group discovered the elevated chlorine levels, it immediately shut off and locked out the blowdown valves. The cooling tower basin (tower 293) that was overchlorinated was treated with a chlorine neutralizing agent. An interim written procedure for disinfection and neutralization at cooling towers 1032, 365, and 293 was developed and implemented pending the design and installation of automated control systems to regulate the addition of water treatment chemicals for towers 293 and 1032 and neutralize chlorine during cooling tower blowdown. A review of the operating procedures and equipment for all cooling towers at TA-53 was performed. The review revealed that equipment and operating procedures were not consistent and that an update was required. Cooling towers were inspected for mechanical deficiencies that could lead to a NPDES exceedance. All deficiencies were repaired.

TA-21, Cooling Tower 209 (NPDES Outfall 03A158). One pH exceedance (daily maximum) occurred at NPDES Outfall 03A158 on May 28, 1998. The source of the elevated pH was a leaking chiller evaporator pan. Facility representatives have developed preventative maintenance procedures for the inspection of the chiller evaporator pans. Additionally, the site operators developed a schedule to bleed the chiller pans to prevent concentration of minerals.

TA-3, Building 127 (NPDES Outfall 03A022). On July 6, 1998, two total suspended solid (TSS) exceedances (daily maximum/daily average) occurred at NPDES Outfall 03A022. Upon discovery of the noncompliant condition, the discharge was stopped. The estimated duration of the noncompliant discharge was 15 minutes. Facility maintenance

Table 2-6. National Pollutant Discharge Elimination System Permit Monitoring of Effluent Quality and Water Quality Parameters at Industrial and Sanitary Outfalls: Exceedances during 1998[a]

EPA ID	Outfall Type	Technical Area	Date	Parameter		Results/Limits	
February							
03A113	Industrial	TA-53-293	02/11/98	Cl_2[b]	(daily max)	4.1/0.5	mg/L
03A113	Industrial	TA-53-293	02/01/98–04/30/98	Cl_2	(daily avg)	2.1/0.2	mg/L
May							
03A158	Industrial	TA-21-209	05/28/98	pH	(daily max)	9.1/9.0	s. u.
July							
03A022	Industrial	TA-03-127	07/06/98	TSS[c]	(daily max)	219.3/100	mg/L
03A022	Industrial	TA-03-127	05/01/98–07/31/98	TSS	(daily avg)	75/30	mg/L
December							
051	Industrial	TA-50-1	12/14/98	TSS	(daily max)	106.2/62.6	lb/day
051	Industrial	TA-50-1	12/01/98–12/31/98	TSS	(daily avg)	32.3/18.8	lb/day
13S	Sanitary	TA-46 SWS	12/15/98	BOD[d]	(daily max)	48.2/45	mg/L

Note: During January, March, April, June, August, September, October, and November, there were no exceedances.

[a]Effluent quality limits are presented in Table A-5; water quality parameters are presented in Table A-6.
[b]Chlorine.
[c]Total Suspended Solids.
[d]Biochemical oxygen demand.

crews were conducting corrective maintenance of cooling tower 2274 at TA-3-127. This maintenance involved the acid wash of piping within the cooling tower basin. Draining excessive solids from the cooling tower basin caused the high total suspended value. A 5-micron bag filter filtered out solids from the cleaning operations. Following the incident, a review of the operation and maintenance (O&M) procedures for the cooling tower was performed. The review revealed that both maintenance of the cooling tower system equipment and O&M procedures were inconsistent with the Laboratory's engineering standard for operating and maintaining cooling towers. The O&M procedures have been revised and implemented at this facility.

TA-50, Building 1 (NPDES Outfall 051). On December 14, 1998, there were two TSS exceedances (daily maximum/daily average) at NPDES Outfall 051. The Laboratory Environmental Management's Radioactive Liquid Waste Group is in the process of reconfiguring the wastewater treatment units at the TA-50 Radioactive Liquid Wastewater Treatment Facility (RLWTF). The treatment reconfiguration includes the installation of a modular ultrafiltration unit and reverse osmosis equipment to improve effluent quality. On December 10, 1998, operators at the RLWTF flushed and cleaned the new ultrafiltration unit, causing a TSS exceedance. TA-50 RLWTF personnel have revised their testing procedures.

TA-46, Sanitary Wastewater Systems Facility (NPDES Outfall 13S). There was one biochemical oxygen demand (BOD) exceedance (daily maximum) at the TA-46 SWS Facility on December 15, 1998. An investigation into the BOD exceedance was conducted. An initial investigation into the occurrence did not identify any unusual conditions at the facility. At the request of the Laboratory, personnel from the New Mexico State University's Water Utility Technical Assistance Program conducted a follow-up investigation on February 9–10, 1999; they reviewed the TA-46 SWS Facility operations, compliance sampling procedures, and analytical methods. Corrective actions include recommendations to improve BOD analysis and increase operational sampling.

b. National Pollutant Discharge Elimination System Sanitary Sewage Sludge Management Program. In July 1997, the Laboratory requested approval from the EPA Region 6 to make a formal change in its sewage sludge disposal practices from land application under 40 CFR Part 503 regulations to landfill disposal as a 50–499 ppm PCB-contaminated waste. This change was necessary because of the repeated detection of low-level PCB (less than 5 ppm)

in the SWS Facility's sewage sludge. The EPA approved the Laboratory's request in September 1997. In November 1997, the Laboratory formally adopted the following interim management practice: all sewage sludge generated at the SWS Facility will, until further notice, be handled, sampled, and disposed of in accordance with TSCA regulations for 50–499 ppm PCB-contaminated waste.

During 1998, the SWS Facility generated approximately 29.2 dry tons (58,387 dry lb) of sewage sludge. All of this sludge was, or will be, disposed of as 50–499 ppm PCB-contaminated waste at a TSCA-permitted landfill.

c. National Pollutant Discharge Elimination System Permit Compliance Evaluation Inspection. In May 1997, the NMED Surface Water Quality Bureau conducted a Compliance Evaluation Inspection at the SWS Facility (NPDES Outfall 13S). As a follow-up to the inspection, the Laboratory submitted additional information to NMED in June 1998. NMED submitted the Compliance Evaluation Inspection report to the EPA and the Laboratory on January 23, 1998. On March 30, 1998, the Laboratory responded in writing to the concerns NMED noted in the Compliance Evaluation Inspection. Additionally, the Laboratory met with EPA on January 30, 1998, to discuss NMED Compliance Evaluation Inspection concerns. The Laboratory has since completed all necessary corrective actions. The NMED did not conduct a NPDES Outfall Compliance Evaluation Inspection during 1998.

d. National Pollutant Discharge Elimination System: Waste Stream Characterization Program and Corrections Project. In April 1997, the Laboratory submitted the final Quarterly Progress Report (January 1, 1997, through March 31, 1997) to EPA certifying completion of the Waste Stream Corrections Project in compliance with Administrative Order (AO) Docket No. VI-96-1236. EPA closed out the AO and Federal Facilities Compliance Agreement (FFCA) for the Waste Stream Characterization Program and High-Explosives Wastewater Treatment Facility (HEWTF) on August 5, 1998.

e. National Pollutant Discharge Elimination System Storm Water Program. NPDES permits are also required for storm water discharges. During 1998, the Laboratory had four NPDES permits for its storm water discharges (see Table 2-1). The existing NPDES Baseline General Permit for construction activities was reissued in July 6, 1998. The Laboratory applied for coverage under the new NPDES Storm Water Construction permit for three existing projects: the Dual Axis Radiographic Hydrodynamic Test Facility (DARHT), Guaje Well Improvements Project, and the Fire Protection Improvements Project.

UC and DOE applied for and received coverage under the new NPDES Multisector General Permit for the Laboratory site in December 1998. The Multisector General Permit includes the following industrial activities: hazardous waste treatment, storage, and disposal facilities operating under interim status or a permit under Subtitle C of RCRA (this category includes SWMUs); landfills, land application sites, and open dumps including those that are subject to regulation under Subtitle D of RCRA; steam and electric power generating facilities; metal fabrication activities; vehicle maintenance activities; primary metal activities; and chemical manufacturing activities.

The NPDES permit requires the development and implementation of a Storm Water Pollution Prevention Plan. During 1998, the Laboratory developed and implemented Storm Water Pollution Prevention Plans for its industrial activities.

Under the NPDES Baseline General Storm Water Permit, monitoring activities are required at landfills and EPCRA Section 313 facilities. In 1998, monitoring was conducted at TA-54, Areas G and J, and at TA-55. The monitoring data were submitted to EPA in the form of a Discharge Monitoring Report (DMR). The Laboratory submitted DMRs to EPA on October 28, 1998, for landfills and on January 27, 1999, for EPCRA Section 313 facilities.

As part of the NPDES Storm Water Program, the Laboratory is operating stream monitoring stations on the canyons entering and leaving the Laboratory. In 1998, there were 19 stations on watercourses at the Laboratory. The discharge information for 1998 is reported in "Surface Water Data at Los Alamos National Laboratory: 1998 Water Year" (Shaull et al., 1999).

f. National Pollutant Discharge Elimination System Storm Waste Program Inspection. On May 14–15, 1998, EPA Region 6 and NMED conducted a compliance inspection of the Laboratory's Storm Water Program. The Laboratory had not received a final inspection report by the end of 1998.

g. Spill Prevention Control and Countermeasures Program. The Laboratory's Spill Prevention Control and Countermeasures (SPCC) Plans, as required by the CWA in accordance with 40 CFR 112,

are comprehensive plans developed to meet the requirements of EPA and NMED that regulate water pollution from oil spills. The Laboratory has SPCC Plans for the 26 aboveground oil storage tanks that operated during 1998.

h. Dredge and Fill Permit Program. Under Section 404 of the CWA, the Laboratory is required to obtain permits from the Army Corps of Engineers (the Corps) to perform work within perennial or intermittent watercourses. Projects involving excavation or fill below the normal high-water mark must be performed with attention to the water quality and riparian habitat preservation requirements of the Act. The Corps has issued a number of nationwide permits that cover specific activities. Each nationwide permit contains conditions to protect water quality. Section 401 of the CWA requires states to certify that 404 permits issued by the Corps will not prevent attainment of state-mandated stream standards. The NMED reviews Section 404 permit applications and issues separate Section 401 certification letters, which include additional permit requirements to meet state stream standards for individual projects at the Laboratory.

As shown on Table 2-1, the Laboratory had 11 nationwide permits under the Sections 404/401 program during 1998. Discharge activities permitted include utility lines, road crossings, headwaters and isolated waters, and wetland/riparian areas.

9. Safe Drinking Water Act

a. Introduction. This program includes sampling from various points in the Laboratory's, Los Alamos County's, and Bandelier National Monument's water distribution systems and from the water supply wellheads to ensure compliance with the Safe Drinking Water Act (SDWA) (40 CFR 141). The EPA has established maximum contaminant levels (MCLs) for microbiological organisms, organic and inorganic constituents, and radioactivity in drinking water. The state has adopted these standards, and they have been included in the New Mexico Drinking Water Regulations (NMEIB 1995). The EPA has authorized the NMED to administer and enforce federal drinking water regulations and standards in New Mexico.

On September 8, 1998, operation of the Los Alamos Water Supply System was transferred from LANL to Los Alamos County under a lease agreement. The Laboratory retained responsibility for operation of the distribution system within the Laboratory's boundaries, whereas the county assumed responsibility for compliance monitoring under the SDWA and the New Mexico Drinking Water Regulations. To ensure a smooth transition, the Laboratory continued to collect SDWA compliance samples throughout the remainder of calendar year 1998. The Laboratory will continue to be responsible for maintaining quality drinking water within the Laboratory's distribution system.

The particular locations within the water system for collecting SDWA compliance samples are specified in the regulations for each contaminant or group of contaminants. In 1998, the monitoring network for SDWA compliance sampling consisted of the following four location groups:

(1) wellhead sampling from the water supply wells in operation at the time of sampling (Guaje wells G-1A, G-6; Pajarito Mesa wells PM-1, PM-2, PM-3, PM-4, PM-5; and Otowi wells O-4, O-1);

(2) the 5 entry points into the distribution system (Pajarito Booster station #2, Guaje Booster station #2, PM-1 and PM-3 wellheads, and Otowi Booster station #2 [formerly Los Alamos Booster station #4]);

(3) the 6 total trihalomethane (TTHM) sampling locations within the distribution system; and

(4) the 41 microbiological sampling sites located throughout the Laboratory, Los Alamos County, and Bandelier National Monument.

The sampling program for drinking water quality is designed to meet or exceed regulatory requirements under the federal SDWA (see Table A-7) and the New Mexico Environmental Improvement Act. Sampling locations, frequencies, preservation, handling, and analyses follow the requirements specified in federal and state regulations. Laboratory staff performed chemical and radiological sampling and submitted the samples for analysis to the New Mexico Health Department's Scientific Laboratory Division (SLD) in Albuquerque. Triangle Laboratories, Inc., of Durham, NC, performs dioxin analyses. The JCNNM Health and Environmental (HENV) laboratory performs microbiological sampling and analysis. NMED has certified the HENV laboratory for microbiological compliance analysis. Certification requirements include proficiency samples, maintenance of an approved quality assurance/quality control program, and periodic NMED audits. NMED certifies Laboratory and HENV personnel to perform drinking water compliance sampling.

All data collected from SDWA compliance testing are submitted to the NMED's Drinking Water and

Community Services Bureau for review and filing. The SLD and HENV laboratory report their analytical results directly to NMED. The Water Quality and Hydrology Group (ESH-18) maintains both electronic and hard copy files of all data collected from SDWA compliance testing.

b. Radiochemical Analytical Results. In 1998, the Laboratory collected drinking water samples at the five entry points into the distribution system to determine the radiological quality of the drinking water. As shown in Table 2-7, the concentrations of gross alpha and gross beta activity were less than the EPA screening levels. When gross alpha and beta activity measurements are below the screening levels, the Laboratory does not need to perform further isotopic analyses or perform dose calculations under the SDWA program. However, it should be noted that ESH-18 conducts comprehensive monitoring of the water supply wells for radiochemical constituents (see Table 5-12).

In 1997 and 1998, the Laboratory conducted baseline sampling on the new Otowi well O-1. The SWDA requires four consecutive quarters of baseline sampling for all new sources of water in a drinking water supply system. The three quarters of baseline sampling conducted in 1997 and the one quarter conducted in 1998 at the Otowi well O-1 were in compliance with the SWDA screening levels for gross alpha and gross beta activities.

Radon is a naturally occurring radionuclide produced during the decay of geological sources of uranium. In 1998, staff performed radon sampling at the nine operating water supply wellheads and the five entry points into the distribution system. This sampling collected information before the EPA issued final regulations governing radon in drinking water. As shown in Table 2-8, the concentrations ranged from 238 to 636 pCi of radon per liter of water. On July 30, 1997, EPA withdrew the proposed MCL of 300 pCi of radon per liter of water. Congress has directed EPA to propose a new MCL for radon by August 1999 and promulgate a final rule by August 2000.

c. Nonradiological Analytical Results. In 1998, TTHM samples were collected during each quarter from six locations in the Laboratory and Los Alamos County water distribution systems. As shown in Table 2-9, the annual average for samples in 1998 was 6.2 µg of TTHM per liter of water, less than the SDWA MCL of 100 µg of TTHM per liter of water.

In 1998, inorganic constituents in drinking water (except nitrates) were sampled at the five entry points into the distribution system. Nitrates (NO^3, as N) were sampled at the nine operating water supply

Table 2-7. Radioactivity in Drinking Water (pCi/L) during 1998

	Gross Alpha			Gross Beta		
Sample Location	**Calibration Std.**	**Value**	**(Uncertainty)**	**Calibration Std.**	**Value**	**(Uncertainty)**
Wellheads:						
Otowi Well-O1	^{241}Am	1.2	(0.5)	^{137}Cs	1.2	(0.8)
(1st Qtr 1998)	Natural U	1.3	(0.5)	^{90}Sr, ^{90}Y	1.2	(0.8)
Entry Points:						
Pajarito Booster #2	^{241}Am	0.4	(0.4)	^{137}Cs	3.3	(0.9)
	Natural U	0.5	(0.4)	^{90}Sr, ^{90}Y	3.3	(0.9)
Guaje Booster #2	^{241}Am	1.0	(0.5)	^{137}Cs	3.1	(0.9)
	Natural U	1.1	(0.6)	^{90}Sr, ^{90}Y	3.1	(0.8)
Pajarito Well-PM1	^{241}Am	1.7	(0.5)	^{137}Cs	3.3	(1.0)
	Natural U	1.9	(0.6)	^{90}Sr, ^{90}Y	3.2	(1.0)
Pajarito Well-PM3	^{241}Am	0.9	(0.5)	^{137}Cs	3.5	(0.9)
	Natural U	1.1	(0.6)	^{90}Sr, ^{90}Y	3.4	(0.9)
Otowi Booster #2	^{241}Am	1.5	(0.5)	^{137}Cs	2.3	(1.0)
	Natural U	1.6	(0.6)	^{90}Sr, ^{90}Y	2.3	(0.9)
EPA Maximum Contaminant Level		15			none	
EPA Screening Level		5			50	

Table 2-8. Radon in Drinking Water (pCi/L) during 1998

Sample Location	Value	(Uncertainty)
Entry Points:		
Pajarito Booster #2	501	(29)
Guaje Booster #2	238	(17)
Pajarito Well-PM1	283	(18)
Pajarito Well-PM3	340	(21)
Otowi Booster #2	350	(21)
Wellheads:		
Pajarito Well-PM1	283	(18)
Pajarito Well-PM2	636	(35)
Pajarito Well-PM3	340	(21)
Pajarito Well-PM4	453	(26)
Pajarito Well-PM5	471	(27)
Guaje Well-G1A	380	(24)
Guaje Well-G6	466	(27)
Otowi Well-O4	524	(30)
Otowi Well-O1	285	(19)

wellheads. As shown in Table 2-10, all inorganic constituents at all locations were less than the SDWA MCLs.

In 1998, VOC samples were collected at the five entry points into the distribution system. No VOCs were detected at any of the sampling locations.

Baseline sampling at Otowi well O-1 for synthetic organic compounds (SOCs) was conducted during the last three quarters of 1997 and the first quarter of 1998. No SOCs were detected during the baseline sampling.

The SDWA did not require sampling for the presence of lead and copper from residential taps in 1998. Sampling for lead and copper will resume in 1999.

d. Microbiological Analyses of Drinking Water. Each month during 1998, the Laboratory collected an average of 47 samples from the Laboratory's, Los Alamos County's, and Bandelier National Monument's water distribution systems to determine the free chlorine residual available for disinfection and the microbiological quality of the drinking water. Of the 559 samples analyzed during 1998, one indicated the presence of total coliforms. None of the samples indicated the presence of fecal coliforms. Noncoliform bacteria were present in 33 of the microbiological samples. Noncoliform bacteria are not regulated, but their repeated presence in samples may serve as an indicator of stagnation and biofilm growth in water pipes. Table 2-11 presents a summary of the monthly analytical data.

e. Long-Term Trends. The Los Alamos water system has never incurred a violation for a SDWA-regulated chemical or radiological contaminant. The water supply wells have, on occasion, exceeded the proposed SDWA MCL for radon because of its natural occurrence in the main aquifer.

f. Drinking Water Inspection. The District II Field Office of the NMED did not conduct an inspection of the drinking water system during 1998.

Table 2-9. Total Trihalomethanes in Drinking Water (μg/L) during 1998

	1998 Quarters			
Sample Location	**First**	**Second**	**Third**	**Fourth**
Distribution Sites:				
Los Alamos Airport	3.4	4.9	20.9	12.5
White Rock Fire Station	<0.5	<0.5	1.4	1.1
North Community Fire Station	3.0	1.2	9.1	4.4
S-Site Fire Station	2.3	2.6	7.9	3.4
Barranca Mesa School	2.8	1.7	9.7	5.2
TA-39, Bldg. 02	11.7	6.5	19.5	12.3
1998 Average of 6.2 μg/L				
EPA Maximum Contaminant Level			100.0	
Sample Detection Limit			0.5	

Table 2-10. Inorganic Constituents in Drinking Water (mg/L) during 1998

Sample Location	As	Ba	Be	Cd	Cr	F	CN	Hg	Ni	NO_3 (as N)	Se	Sb	Tl
Entry Points:													
Pajarito Booster #2	0.001	<0.1	<0.001	<0.001	0.004	<0.1	NA	<0.0002	<0.01		<0.005	<0.001	<0.001
Guaje Booster #2	0.008	<0.1	<0.001	<0.001	0.004	0.44	NA	<0.0002	<0.01		<0.005	<0.001	<0.001
Pajarito Well-PM1	0.002	<0.1	<0.001	<0.001	0.003	<0.1	NA	<0.0002	<0.01		<0.005	<0.001	<0.001
Pajarito Well-PM3	0.002	<0.1	<0.001	<0.001	0.003	<0.1	NA	<0.0002	<0.01		<0.005	<0.001	<0.001
Otowi Booster #2	0.003	<0.1	<0.001	<0.001	0.004	<0.1	NA	<0.0002	<0.01		<0.005	<0.001	<0.001
Wellheads:													
Pajarito Well-PM1										0.49			
Pajarito Well-PM2										0.34			
Pajarito Well-PM3										0.47			
Pajarito Well-PM4										0.35			
Pajarito Well-PM5										0.32			
Guaje Well-G1A										0.43			
Guaje Well-G6										0.50			
Otowi Well-O4										0.42			
Otowi Well-O1 (2/12/98)										0.39			
Otowi Well-O1 (5/19/98)										1.45			
EPA Maximum Contaminant Levels	0.05[a]	2.0	0.004	0.005	0.1	4.0	0.2	0.002	0.1	10.0	0.05	0.006	0.002

[a]Proposed SDWA Primary Drinking Water Standard.

Table 2-11. Bacteria in Drinking Water at Distribution System Taps during 1998

Month	No. of Samples Collected	No. of Positive Tests		
		Coliform	Fecal Coliform	Noncoliform
January	45	0	0	1
February	45	0	0	1
March	46	0	0	1
April	49	0	0	3
May	45	0	0	4
June	46	0	0	3
July	48	0	0	5
August	47	0	0	3
September	47	0	0	2
October	49	1	0	3
November	47	0	0	5
December	45	0	0	2
Total 1998	559	1	0	33
Maximum Contaminant Level (MCL)		[a]	[b]	[c]

[a]The MCL for coliforms is positive samples not to exceed 5% of the monthly total.
[b]The MCL for fecal coliforms is no coliform positive repeat samples following a fecal coliform positive sample.
[c]There is no MCL for noncoliforms.

10. Groundwater

a. Groundwater Protection Compliance Issues. Groundwater monitoring and protection efforts at the Laboratory have evolved from the early programs initiated by the US Geological Survey to present efforts. The major regulations, orders, and policies pertaining to groundwater are as follows.

DOE Order 5400.1 requires the Laboratory to prepare a Groundwater Protection Management Program Plan that focuses on protection of groundwater resources in and around the Los Alamos area and ensures that all groundwater-related activities comply with the applicable federal and state regulations.

Module VIII of the RCRA Hazardous Waste Facility Permit, i.e., HSWA Module, Task III, requires the Laboratory to collect information to supplement and verify existing information on the environmental setting at the facility and collect analytical data on groundwater contamination. Task III, Section A.1, requires the Laboratory to conduct a program to evaluate hydrogeologic conditions. Task III, Section C.1, requires the Laboratory to conduct a groundwater investigation to characterize any plumes of contamination at the facility.

In March 1997, NMED approved a comprehensive hydrogeologic characterization work plan for the Laboratory. The Hydrogeologic Work Plan was developed partially in response to NMED's denial of the Laboratory's RCRA groundwater monitoring waiver demonstrations. The plan proposes a major long-term drilling and hydrogeologic analysis program to characterize broadly the hydrogeology of the Pajarito Plateau and to assess in detail the potential for groundwater contamination to occur from individual waste disposal operations. The goal of the project is to develop greater understanding of the geology, groundwater flow, and geochemistry beneath the 43-square-mile Laboratory area and to assess any impacts that Laboratory activities may have had on groundwater quality.

New Mexico Water Quality Control Commission regulations control liquid discharges onto or below the ground surface to protect all groundwater in the State of New Mexico. Under the regulations, when required by NMED, a groundwater discharge plan must be submitted by the facility and approved by NMED or the Oil Conservation Division for energy/mineral extraction activities. Subsequent discharges must be

consistent with the terms and conditions of the discharge plan.

The Laboratory has three approved groundwater discharge plans to meet NM Water Quality Control Commission regulations (Table 2-1): one for TA-57 (Fenton Hill); one for the SWS Facility; and one for the land application of dried sanitary sewage sludge from the SWS Facility. On January 7, 1998, the NMED approved a five-year renewal of the SWS Facility's groundwater discharge plan. On August 20, 1996, the Laboratory submitted a groundwater discharge plan application for the Radioactive Liquid Waste Treatment Facility at TA-50. As of December 31, 1998, NMED approval of the plan was still pending.

b. Compliance Activities. The Laboratory continued an ongoing study of the hydrogeology and stratigraphy of the region, as required by the HSWA Module of the RCRA Hazardous Waste Facility Permit, DOE Order 5400.1, and the Hydrogeologic Work Plan. The Groundwater Protection Management Program Plan that ESH-18 administers integrates studies by various Laboratory programs. The Laboratory's Groundwater Annual Status Summary Report (Nylander et al., 1999) provides a location map and more detailed information on newly collected groundwater

In August and September 1998, EPA conducted a groundwater sampling inspection of the Laboratory. Approximately 40 water samples were collected from wells, effluent sources, and springs located on DOE and Pueblo of San Ildefonso lands. The Laboratory and the NMED collected split samples at many of the sampling sites for comparison with the EPA results.

Since September 1997, three deep characterization monitoring wells have been drilled to almost their final target depths, as required by the Hydrogeologic Work Plan. All the monitoring wells were drilled using air rotary/dual-wall casing advance methods. Geologic core and water samples collected during the drilling operations were analyzed for the presence of natural and man-made chemical constituents at defined intervals. Geologic core was also being collected to understand how water moves through the rocks. The monitoring wells have provided very detailed descriptions of the stratigraphy and water quality of the zone between the land surface and the regional aquifer. When completed with well casings and sampling pumps, they will be the first regional aquifer test wells drilled at the Laboratory since 1961. The final well completion depths and design will be decided upon in concert with NMED. A brief description of the monitoring well locations and key initial findings follows.

- Monitoring Well R-9 is located at the Laboratory's eastern boundary in Los Alamos Canyon. Five perched water zones were encountered during the drilling of the monitoring well to the regional aquifer, to a depth of 710 feet. Contaminant levels were generally consistent with other test wells located nearby in lower Pueblo Canyon. Tritium levels were highest in the uppermost perched zone (347 pCi/L) and lowest in the regional aquifer (14 pCi/L). While far below levels of health concern (20,000 pCi/L), the tritium levels have significant hydrologic implications as they indicate the movement of some water from the land surface to the groundwater zones within the past 40 years or so.
- Monitoring Well R-12 is located at the Laboratory's eastern boundary in Sandia Canyon. R-12 is primarily designed to provide water quality and water-level data for potential intermediate-depth perched zones and for the regional aquifer. It was drilled to a depth of 874 feet. A 75-ft-thick perched zone was contacted at a depth of 424 feet; it is one of the thickest intermediate-depth perched groundwater bodies identified yet on the Pajarito Plateau. Contaminant levels in the regional aquifer were below SDWA MCLs. Tritium levels in the regional aquifer (47 pCi/L) indicate the presence of some recent recharge water.
- Monitoring Well R-25 is located near the Laboratory's western boundary with TA-16 on the south rim of Cañon de Valle. TA-16 operations include high-explosives R&D, testing, and manufacturing activities. The monitoring well is designed to provide information about hydrologic and geologic conditions beneath the relatively unstudied southwest part of the Laboratory. When completed, this monitoring well will be the first test well to penetrate the regional aquifer in this area. Drilling activities began in late July 1998 and should be completed in 1999. The planned depth for this monitoring well is approximately 1,700 feet. In 1998, six groundwater samples were collected at depths ranging from 747 to 1,286 feet. High explosives and chemicals associated with their breakdown were present in all but the deepest of the six samples. Five water samples contained at least one high-explosive

constituent at concentrations above the guidance values published in the EPA Health Advisories for drinking water. Water from deep wells supplying drinking water to county residents and to the Laboratory was also tested and contained no high explosives; the closest drinking water supply well is three miles to the east. The Laboratory is collaborating with regulatory agencies to define the extent of the contamination and to ensure that drinking water supplies are adequately protected.

The Laboratory believes that discharges from past high-explosive manufacturing activities at TA-16 are the source of the constituents found in the groundwater samples taken from Monitoring Well R-25. The Laboratory has already taken steps to reduce the amount of high-explosives processing water being discharged in the TA-16 area. The installation of the HEWTF and the elimination of the wastewater outfalls have reduced discharges to 1% of the previous annual amount (120,000 gal. per year). Additional investigations in the TA-16 area will improve understanding of the nature and extent of groundwater contamination identified by the Monitoring Well R-25 drilling effort.

11. National Environmental Policy Act

a. Introduction. The National Environmental Policy Act (NEPA) of 1969 (42 U.S.C. 4331 *et seq.*) requires federal agencies to analyze the environmental impacts of proposed actions before making decisions. NEPA also requires that the decision-making process be open to public scrutiny. All activities proposed by DOE or the Laboratory are subject to NEPA review. DOE is the sponsoring agency for most LANL activities. DOE must comply with the regulations for implementing NEPA published by the Council on Environmental Quality at 40 CFR Parts 1500–1508 and its own NEPA Implementing Procedures as published at 10 CFR Part 1021. Under these regulations and DOE Order 451.A, DOE reviews proposed LANL activities and determines whether the activity qualifies for a categorical exclusion from the need to prepare further NEPA documentation based on previous agency experience and analysis or whether to prepare one or both of the following:

- An Environmental Assessment (EA), which should briefly provide sufficient evidence and analysis for determining whether to prepare an Environmental Impact Statement (EIS) or a Finding of No Significant Impact (FONSI) for the proposed action or
- An EIS, which is a detailed written statement of impacts with a subsequent Record of Decision (ROD).

If an EA or an EIS is required, DOE is responsible for its preparation. In some situations, a LANL project may require an EA or EIS, but because the project is connected to another larger action that requires an EIS, the LANL Site-Wide EIS (SWEIS) or a programmatic EIS done at the nationwide level, the LANL project may be included in the larger EIS. The LANL project is then analyzed in the larger action or may later tier off the final programmatic EIS after a ROD is issued.

LANL project personnel initiate NEPA reviews by completing environment, safety, and health identification documents. These documents create the basis of a DOE NEPA Environmental Review Form, formerly known as a DOE Environmental Checklist. The LANL Ecology Group (ESH-20) prepares these documents using the streamlined format known as a NEPA Environmental Review Form, as specified by the DOE/Los Alamos Area Office (LAAO).

b. Compliance Activities. In 1998, LANL sent 102 NEPA Environmental Review Forms to DOE for review. DOE categorically excluded 107 actions and amended the categorical exclusion for 49 actions. DOE made other determinations on 12 actions, including 2 EA determinations, both of which resulted in FONSIs. One action was unresolved in 1998. Pursuant to authority delegated by DOE, LANL applied "umbrella" categorical exclusion determinations for 191 actions.

c. Environmental Impact Statements. The status of two of the DOE EIS-level NEPA documentation and project descriptions follows.

Site-Wide Environmental Impact Statement. Under DOE's compliance strategy for NEPA, a SWEIS is prepared to examine the environmental impacts of operations at a multiprogram site. An earlier SWEIS for LANL operations was prepared in 1979; that document and subsequent NEPA reviews for specific project or program activities have served as the NEPA basis for operations at LANL until now. DOE is now preparing an updated SWEIS, and NEPA documents at LANL will be tiered from or reference this SWEIS for the next 10 years. DOE is the lead agency, and Los Alamos County is a cooperating agency (because of the interdependence of county and

DOE planning) in the preparation of this SWEIS.

The draft SWEIS was released on May 15, 1998, for review and comment by the state, tribal, and local governments; other federal agencies; and the general public. The formal public comment period lasted 60 days, ending on July 15, 1998. Comments received after close of the comment period were considered in the preparation of the final SWEIS to the extent practical. Work on the final SWEIS continued through the rest of 1998.

Conveyance and Transfer of Certain Land Tracts Located within Los Alamos and Santa Fe Counties and Los Alamos National Laboratory. DOE is preparing an EIS to assess the environmental impacts of conveying or transferring certain land tracts under the administrative control of DOE within Los Alamos and Santa Fe Counties. The EIS is evaluating the congressionally mandated action required under PL 105-119 to convey certain land tracts to the County of Los Alamos and to the Secretary of the Interior in trust for the Pueblo of San Ildefonso.

d. Environmental Assessments Completed during 1998. The status of the Laboratory's EA-level NEPA documentation and project descriptions follows.

Pit Disassembly and Conversion Demonstration. The environmental impacts of a proposed development and demonstration project of an integrated pit disassembly and conversion process for fissile material disposition were examined. The demonstration involves the disassembly of up to 250 weapons components (pits) over four years and conversion of the recovered plutonium to plutonium oxide. The proposed work would be conducted at LANL's Plutonium Facility at TA-55. It is not necessary to construct new facilities to support the demonstration, although internal modifications to the facility would be required. All work would be performed in a series of interconnected gloveboxes, using remote handling and computerized control systems. DOE determined that this proposed action would not significantly affect the quality of the human environment, completed the EA for this proposed action, and issued a FONSI in August 1998. This EA is at *http://nepa.eh.doe.gov/ea/ea1207/ea_1207.pdf* on the World Wide Web.

Strategic Computing Complex. The proposed action is to construct and operate a Strategic Computing Complex at TA-3. The facility will house and operate an integrated system of computer processors capable of performing approximately 50 trillion floating point operations per second as part of the Accelerated Strategic Computing Initiative in support of the Stockpile Stewardship and Management Program. LANL is the only site under consideration for the facility. The major impacts of the operations of the project will be on water consumption and use of electric power. Based on the EA, DOE determined that the proposed action would not significantly affect the quality of the human environment and issued a FONSI in December 1998. This EA is at *http://nepa.eh.doe.gov/ea/ea1250/ea1250.htm* on the World Wide Web.

e. Environmental Assessments in Progress during 1998.

Electric Power System Upgrade. The proposed action consists of constructing and operating a 19.5-mi electric power transmission line from the Norton Station west across the Rio Grande to locations within TA-3 and TA-5. The project includes the construction of associated electric substations at the Laboratory, as well as the construction of two short line segments that would allow a portion of two existing power lines to be uncrossed. Additionally, a fiber optics communications line is included as part of the required grounding conductor for the power line. Work on the EA continued through 1998.

Decontamination and Volume Reduction System. The proposed action is to begin a decontamination and volume reduction system within an existing structure at TA-54, preferably at Dome 226. The process would reduce the volume of oversized metallic Laboratory-generated TRU wastes with a decontamination and compaction process before transporting the wastes to the Waste Isolation Pilot Plant. Work on the EA continued through 1998.

National Health Security Center. The proposed action is to remodel two buildings inside an existing fenced area at TA-54 for use as offices and laboratories for the National Health Security Center that DOE would operate. In 1998, work began to prepare an EA to cover the potential upgrade of an existing research laboratory from biosafety level 2 to the required biosafety level 3.

f. Mitigation Action Plans. As part of the implementation requirements under NEPA, DOE prepares and is responsible for implementing Mitigation Action Plans (MAPs) (10 CFR 1021, Section 331 [a] July 9, 1996). MAPs are generally project specific and are designed to (1) document potentially adverse

environmental impacts of a proposed action, (2) identify impact mitigation commitments made in the final NEPA documents (FONSIs or RODs), and (3) establish action plans to carry out each commitment.

The implementation status of each MAP is reported to the public in a MAP Annual Report (MAPAR). ESH-20 coordinates the implementation of the following DOE MAPs at the Laboratory.

Dual Axis Radiographic Hydrodynamic Test Facility Mitigation Action Plan. DOE issued this MAP in 1995. On January 15, 1998, the DARHT MAPAR was released to the public for review and comment. All mitigation action commitments for protecting workers, soils, water, biotic resources, and cultural resources in and around the DARHT facility are being implemented and are on schedule.

Low-Energy Demonstration Accelerator Mitigation Action Plan. DOE issued this MAP in 1996. On January 15, 1998, the Low-Energy Demonstration Accelerator (LEDA) MAPAR was released to the public for review and comment. All MAP commitments for preventing soil erosion and monitoring industrial NPDES outfalls and potential wetlands formation in and around the LEDA facility are being implemented and are on schedule.

Lease of Land for the Development of a Research Park at LANL Mitigation Action Plan. DOE issued this MAP in October 1997. Implementation of the MAP is contingent on the completion and approval of the formal lease agreement between DOE and the lessee. The lease agreement is being prepared and is expected to be completed and approved in early 1999.

12. Cultural Resources

a. Introduction. The ESH-20 Cultural Resources Team is responsible for maintaining a database of all cultural resources found on DOE land, supporting DOE's compliance requirements with appropriate cultural resource legislation as listed below, and providing appropriate information to the public on cultural resource management issues. Cultural resources are defined as archaeological sites, prehistoric or historic districts, sites, buildings, structures, traditional use areas, or objects included in, or eligible for inclusion in, the National Register of Historic Places. Artifacts, records, and remains related to and located within such properties are considered cultural resources.

b. Compliance Overview. Section 106 of the National Historic Preservation Act Public Law 89-665 (implemented by 36 CFR 800) requires federal agencies to evaluate the impact of all proposed actions on cultural resources. Federal agencies must also consult with the State Historic Preservation Officer (SHPO) and/or National Advisory Council on Historic Preservation concerning possible effects on identified resources.

During 1998, Laboratory archaeologists evaluated 846 Laboratory proposed actions and conducted 26 new field surveys to identify cultural resources. DOE sent 13 survey results to the SHPO for concurrence in findings of effects and determinations of eligibility for National Register inclusion of cultural resources located during the survey. Copies were also sent to the governors of the Pueblos of San Ildefonso, Santa Clara, Cochiti, and Jemez and to the President of the Mescalero Apache Tribe for comment and identification of any traditional cultural properties that may be affected by a proposed action. No adverse effects to prehistoric cultural resources were identified in 1998.

The American Indian Religious Freedom Act of 1978 (Public Law 95-341) stipulates that it is federal policy to protect and preserve the right of American Indians to practice their traditional religions. Notification must be given to tribal groups of possible alteration of traditional and sacred places. The Native American Grave Protection and Repatriation Act of 1990 (Public Law 101-601) states that if burials or cultural objects are inadvertently disturbed by federal activities, work must stop in that location for 30 days, and the closest lineal descendent must be consulted for disposition of the remains. Laboratory archaeologists made one inadvertent discovery of burials or cultural objects during 1998.

The Archeological Resources Protection Act of 1979 (implemented by 43 CFR 7, Public Law 96-95, 16 USC 470) provides protection of cultural resources and sets penalties for their damage or removal from federal land without a permit. One illicit pot-hunting incident was discovered on DOE land in 1998.

13. Biological Resources including Floodplain and Wetland Protection

a. Introduction. The DOE and the Laboratory comply with the Endangered Species Act; the Migratory Bird Treaty Act; the Bald Eagle Protection Act; Presidential Executive Order 11988, Floodplain Management; Presidential Executive Order 11990, Protection of Wetlands (Corps 1989); and Section 404 of the Clean Water Act. The Laboratory also consid-

ers plant and animal species protected by the New Mexico Conservation Act and the New Mexico Endangered Species Act.

b. Compliance Activities. During 1998, the ESH-20 Biology Team reviewed approximately 400 proposed Laboratory activities and projects for potential impact on biological resources including federally listed threatened and endangered species. These reviews are designed to evaluate the amount of previous development or disturbance at the site, to determine the presence of wetlands or floodplains in the project area, and to determine whether habitat evaluations or species-specific surveys are needed. Of the 400 reviews, the Biology Team identified 133 projects that required habitat evaluation surveys to assess whether the appropriate habitat types and parameters were present to support any threatened or endangered species. Of the 400 reviews, the Biology Team identified 27 projects that required a species-specific survey designed to determine the presence or absence of a threatened or endangered species at the project site. The Laboratory adhered to protocols set by the US Fish and Wildlife Service and to permit requirements of the New Mexico State Game and Fish Department.

c. Biological Resource Compliance Documents. The Biology Team prepared numerous biological resource documents (biological assessments, biological evaluations, and other compliance documents) in 1998. The team received findings of concurrence on the potential for impact to threatened and endangered species from the US Fish and Wildlife Service in 1998 for those documents submitted under the Endangered Species Act as indicated below in the summaries of the pertinent documents.

The Biology Team contributed to the completion of a three-year study culminating in the development of a threatened and endangered species habitat management plan (HMP) (LANL 1998a) on behalf of the DOE as part of the DARHT Mitigation Action Plan commitments by DOE. The HMP received concurrence by the US Fish and Wildlife Service. Site plans were completed and will be used to further evaluate and manage the threatened and endangered species occupying DOE/Laboratory property (see Sections 2.E.4 and 6.C.20).

Hydrodynamic Test Operations Center. This biological assessment documents the potential impacts to seven federally listed threatened and endangered species (six bird and one mammal) from the construction of DARHT (Keller 1997). The facility will consolidate operations at TA-15 and provide working space for visiting scientists. The assessment also contains site-specific mitigating actions. DOE received concurrence on this biological assessment from the US Fish and Wildlife Service on February 11, 1998.

Applied Research Optics and Electronics Laboratory. This biological assessment evaluates potential impacts to seven federally listed species (six birds and one mammal) from the construction of the Applied Research Optics and Electronic Laboratory facility (Keller 1998a). The facility, located at TA-15, will consolidate computing operations. The assessment also includes site-specific mitigation actions. DOE received concurrence on this biological assessment from the US Fish and Wildlife Service on August 20, 1998.

Monitoring Wells. This assessment evaluates and documents the potential impacts to four bird species from the proposed construction of 84 new groundwater monitoring wells on DOE property (Keller 1998b). DOE received concurrence on this biological assessment from the US Fish and Wildlife Service on May 8, 1998.

Conveyance and Transfer Biological Evaluation. This biological evaluation documents the potential impacts to State of New Mexico protected species from the potential conveyance and transfer of 10 tracts of DOE-owned land (Haarmann and Loftin 1998a).

Conveyance and Transfer Biological Assessment. This biological assessment documents the potential impacts to seven federally listed threatened and endangered species (six bird and one mammal) from the potential conveyance and transfer of 10 tracts of DOE-owned land (Haarmann and Loftin 1998b).

Conveyance and Transfer Environmentally Sensitive Natural Resources. This document describes the application of six environmental laws, regulations, and requirements to the potential conveyance and transfer of 10 tracts of DOE-owned land (LANL 1998b).

d. Floodplain and Wetland Assessment. The Floodplain and Wetland Assessment addressed potential impacts to floodplains and wetlands associated with the proposed conveyance and transfer of 10 tracts of DOE-owned tracts of land (Sigler et al., 1998). This report documents the potential impacts to floodplains and wetlands from possible urbanization associated with the potential conveyance and transfer of 10 tracts of land. Floodplains and wetlands exist on six of the 10 tracts.

e. Endangered Species Special Studies. In 1998, the Biology Team completed numerous contaminant studies and, in collaboration with the Environ-

mental Science Group (EES-15), completed preliminary risk assessments of the Mexican spotted owl, American peregrine falcon, bald eagle, and southwestern willow flycatcher (Gonzales et al., 1997; Gonzales et al., 1998a, 1998b, and 1998c; and Gallegos et al., 1997a and 1997b).

C. Current Issues and Actions

1. Compliance Agreements

a. Federal Facility Compliance Agreement on Storage of Polychlorinated Biphenyls. On August 28, 1998, the EPA released its Final Rule for the Disposal of PCB, thereby superseding and voiding the PCB FFCA that pertained specifically to radioactive PCB and PCB waste containing RCRA wastes.

b. National Pollutant Discharge Elimination System Federal Facility Compliance Agreement and Administrative Order. As a result of the completion of the Waste Stream Characterization Program and Corrections Project and the High-Explosives Wastewater Treatment Facility Project, on August 5, 1998, EPA closed out the Laboratory's Administrative Order and Federal Facilities Compliance Agreement.

c. New Mexico Hazardous Waste Management Regulations Compliance Order. The Laboratory received Compliance Order (CO) 98-01 on June 8, 1998, which alleged noncompliance with the NM Hazardous Waste Management Regulations at the DP Tank Farm, PRS 21-029. As part of the ordered actions, the Laboratory submitted a Sampling and Analysis Plan to NMED to address the alleged deficiencies in October 1998. Upon approval by NMED, the Laboratory will begin remedial activities.

On June 25, 1998, the Laboratory received CO-98-02 that alleged two violations of the NM Hazardous Waste Management Regulations at TA-21 concerning the storage of gas cylinders. NMED proposed civil penalties of over $950,000. The Laboratory filed its answer to the CO on August 10, 1998, meeting the Schedule of Compliance by demonstrating that all gas cylinders had been disposed of properly. This CO was not resolved by the end of 1998.

On June 26, 1998, the Laboratory received CO-98-03 alleging four violations of the NM Hazardous Waste Management Regulations concerning the waste determination and disposal status of asphalt and soil removed from TA-54 during construction activities. The CO proposed penalties totaling $588,000. In its answer, the Laboratory denied that the materials constituted a hazardous waste and disagreed on the need for a corrective action. The CO has been settled; there were no findings of fact and conclusions of law. NMED dismissed the CO, and the Laboratory agreed to pay a civil penalty of $35,000 in full settlement. The Laboratory will review if additional administrative or physical controls are needed to preclude recurrence.

2. Environmental Oversight and Monitoring Agreement

The Environmental Oversight and Monitoring Agreement—known as the Agreement in Principle (AIP)—between DOE and the State of New Mexico provides technical and financial support by DOE for state activities in environmental oversight, environmental surveys and sampling, site visits, and document review. The current AIP is effective through September 30, 2000. This independent monitoring program allows the Laboratory's data to be verified. NMED regularly holds public meetings and publishes reports on its independent assessments of quality at the Laboratory. Highlights of these activities are presented below.

Air particulate and water vapor monitoring: The DOE Oversight Bureau of the NMED maintains five air particulate samplers co-located with ESH-17's Air Monitoring Network (AIRNET) samplers; these samplers are generally located at the perimeter of Laboratory boundaries to monitor any releases that might move off-site. In 1998, the Bureau published a report comparing data collected by NMED and AIRNET in 1996 and concluding that this ESH-17 program is adequate and that the data quality is good.

Surface water and groundwater: In 1998, the Bureau continued split-sampling with ESH-18 at on-site and off-site monitoring stations. Bureau personnel collected groundwater split samples with EPA during an independent sampling event that focused on Mortandad and Los Alamos Canyons and collected samples of storm water and water from springs.

The Bureau worked with ESH-18 to identify and prioritize the Laboratory's original 44 stream gaging stations as part of the Watershed Management Plan. Activities related to the Hydrogeologic Work Plan included collecting groundwater split samples during the drilling of regional aquifer monitoring wells R-9, R-12, and R-25. Samples taken by Bureau personnel

confirmed ESH-18's findings that high-explosive constituents found in R-25 are above health advisory levels.

During 1998, Bureau staff conducted 23 informal inspections at the Laboratory for liquid release notifications, the NPDES outfall reduction program, and construction activities.

Sediments, soils, vegetation, and foodstuffs: Comparisons of the analysis of split samples from selected locations indicate ESH-20 data are consistent with the Bureau's data. Bureau personnel proposed an alternative method of uranium analysis, which ESH-20 is reviewing.

Environmental Restoration Project: Bureau personnel continued to participate in the NMED working group to integrate the regulatory and technical requirements of the regulations governing the ER Project at the Laboratory. The DOE Oversight Bureau staff actively participated with all ER Project Focus Groups and were particularly active in sampling and document review at stations relevant to the hydrologic/hydrochemical characterization at TA-16.

NEPA: The DOE Oversight Bureau submitted an in-depth review of the LANL SWEIS.

D. Lawsuits

1. Clean Air Act Consent Decree/Settlement Agreement

During 1997, the DOE and the Laboratory Director entered into a Consent Decree and a Settlement Agreement to resolve a lawsuit filed by Concerned Citizens for Nuclear Safety (CCNS) in 1994 that alleged that LANL was not in full compliance with the Clean Air Act Radionuclide NESHAP, 40 CFR 61 Subpart H. Many of the provisions of the decree and the agreement were completed or continued in 1998 and are as follows:

- Independent technical audits of the Laboratory's Radionuclide NESHAP program. Per the provisions of the decree and agreement, the first independent audit, conducted by Risk Assessment Corporation (RAC), continued during 1998. A draft interim report was published in May, reporting that the Laboratory had been out of compliance during 1996 with some technical provisions of the radionuclide NESHAP regulation. In addition, the audit reported that the Laboratory was in compliance with the 10-mrem NESHAP standard. Although the Laboratory agrees that technical improvements can and are being made in the radionuclide program, we do not agree that these findings demonstrate noncompliance with the NESHAP regulation during 1996. The Laboratory formally notified the EPA of the contents of the RAC draft report as well as the Laboratory's position regarding its compliance status. Because of the comments received by RAC on the final report, EPA was asked to clarify several regulatory interpretations that were the basis of some of RAC's findings. EPA responded to this request, and their reply will be included in the final RAC report. The RAC final audit report is expected during the summer of 1999. The final report will be submitted to DOE, which will provide copies to EPA, Region 6, CCNS, and to the Laboratory's Community Reading room. Additional audits will be performed in future years as required. On December 2, 1998, CCNS filed a motion in US District Court to increase the funding for the first independent audit by $124,000. This motion was denied on February 2, 1999.
- AIRNET stations. AIRNET stations continue to operate in accordance with the Consent Decree, and quarterly data are provided to the Laboratory's Community Reading Room and to CCNS.
- Thermoluminescent dosimeters (TLDs). TLDs continue to be operated in accordance with the Consent Decree and quarterly data are provided to the Laboratory's Community Reading Room and to CCNS.
- NEWNET. The Laboratory continues to operate the northern New Mexico NEWNET stations in accordance with the Consent Decree. CCNS filed a motion in US District Court on December 2, 1998, indicating that portions of the northern New Mexico NEWNET program were not being operated in accordance with the Consent Decree. The court denied these claims on February 2, 1999.
- Quarterly meetings on environmental, safety, and health issues. Per the Consent Decree, these meetings were initiated in 1997. The Laboratory, apart from the Consent Decree, has continued to hold public meetings on environment, safety, and health topics on a quarterly basis.
- Payment to the University of New Mexico (UNM) School of Medicine. Per the Settlement Agreement, in March 1998, DOE allocated $150,000 to the UNM School of Medicine to

fund development of a curriculum in the Masters of Public Health degree program on environmental health issues.

- Radiation detection equipment loan program. Per the Settlement Agreement, radiation monitoring equipment is available for use by individuals who attended training. The equipment was used at four different locations during 1998, and it detected no radiation above background levels. Additional equipment was purchased for this program, and a special training course was offered.

2. Stockpile Stewardship Management Programmatic Environmental Impact Statement

In May 1997, 39 organizations challenged the adequacy of the Stockpile Stewardship and Management Programmatic EIS (SSM PEIS) by filing a complaint in US District Court for the District of Columbia. The complaint cited a total of 13 claims to support this allegation. In January 1998, these organizations amended the complaint, replacing the original 13 claims with two new claims that alleged that DOE is required to prepare a Supplemental PEIS because of new information made available since the SSM PEIS was issued. One of the two new claims involved information concerning pit manufacturing at LANL. Pursuant to its regulations implementing NEPA, DOE prepared a Supplement Analysis of the pit manufacturing information contained in the amended complaint. Based on this Supplement Analysis, DOE determined that a Supplemental PEIS was not required.

In an opinion and order issued on August 19, 1998, the federal court agreed that a Supplemental PEIS was not required at this time and dismissed that part of the lawsuit. DOE agreed to prepare an additional Supplement Analysis of pit production based on (1) the results of several pending peer-reviewed seismic reports to be issued by March 1999 and (2) technical analysis of the plausibility of a building-wide fire at TA-55 from a glovebox fire, seismic event, or sabotage initiation.

E. Significant Accomplishments

1. Completion of Legacy Materials Cleanup

The Legacy Materials Cleanup project was completed on September 30, 1998. ESH-19, at the direction of the Laboratory Director, designed this project as an expedited plan to address the Laboratory's historical legacy materials problem within a nine-month period. The remedial phase of the project required that all line organizations systematically survey all their sites to identify, inventory, and stage all materials for which an owner or programmatic purpose could not be identified. A legacy materials work-off team was chartered to visit all sites in the Laboratory and collect the materials identified by the organizations, properly characterize them, and determine a disposition path.

The team collected and appropriately managed more than 22,500 items during this project. The Laboratory can now confidently state that it has addressed all legacy materials that could be identified as waste products. In addition, a major environmental liability for the Laboratory has been resolved. For example, during the 1997 and 1998 NMED RCRA annual inspections, a significant number of the apparent violations NMED cited were for alleged failures to characterize waste or for not having knowledge of the contents of materials alleged to be waste. A key requirement of the project plan was the certification by Division Directors that all legacy materials were removed from Laboratory facilities and that all current and future materials and chemical purchases will be appropriately handled and managed in compliance with all applicable regulations. All 41 Division Directors submitted the certification. The strategic benefit resulting from the legacy materials cleanup effort is that the Laboratory is now better positioned to implement its work on the preventative aspects of chemical and hazardous waste management, while continuing its efforts to reach the goal of zero RCRA violations.

The Laboratory also incorporated some new procedures. Occupying and Vacating Workspaces was a procedure written to eliminate creation of legacy materials when vacating workspaces and has been fully implemented. A new chemical management system is under development to allow tracking and identification of ownership of chemicals from initial purchase to final use or disposal. In addition, the ESH-19 self-assessment program included inspection of chemical storage areas (see Section 2.B.1.d) to provide institutional assurance that line organizations are maintaining effective control of their chemicals and waste-generating processes.

2. Pollution Prevention

A day-long Green Day open house highlighted technologies developed by the Laboratory and DOE sites to address waste management, environmental remediation, and decontamination problems in September 1998. Principal investigators for several projects talked about their research, technology development, and deployment. Technologies have been developed to assist DOE in areas such as waste management, D&D, pollution prevention, decision analysis, and waste characterization.

The following are specific Laboratory R&D projects of pollution prevention technologies completed in 1998:

- Los Alamos Neutron Science Center conducted a cleanup of TA-53. Lead material used for shielding was surveyed, decontaminated if needed, and then recycled. This effort prevented approximately 690 m^3 of mixed low-level waste, resulting in a savings of over $50 million in disposal costs.
- The Facilities Engineering Division recycled asphalt for a road upgrading project. Approximately 3,640 metric tons of solid sanitary waste was reused as fill material rather than being disposed.
- An ER Project cleanup at TA-33 used a segmented gate system in conjunction with containerized vat leaching to segregate contaminated soils during the cleanup process. In a segmented gate system, soils move along a conveyor belt and are scanned and segregated into clean or contaminated categories. The project avoided generating 420 m^3 of low-level waste with this technology.
- Waste Acceptance for Nonradioactive Disposal. An ultralow radiation detection system based on phoswich detectors has been developed that will allow operators to survey low-density wastes before such wastes are free-released to a sanitary landfill.
- Supercritical Carbon Dioxide for Solvent Replacement. Cleaning of parts in both industry and the DOE complex utilizes various organic solvents that are toxic, carcinogenic, and implicated in ozone depletion. The inherent properties of supercritical carbon dioxide and its demonstrated use experimentally and industrially for extraction and fractionation of many organic compounds prove it to be an attractive alternative solvent. Supercritical carbon dioxide is recyclable, nontoxic, and environmentally benign.

3. New Mexico Water Quality Control Commission 1998 Triennial Review

On September 21–30, 1998, the Laboratory provided testimony as an interested party in a hearing conducted by the NMWQCC as part of the 1998 triennial review of water quality standards for the State of New Mexico. The amendments that will result from this hearing will affect the effluent limitations that apply to Laboratory discharges regulated by the NPDES permit. Representatives from ESH-18, Laboratory Counsel, an independent law firm, water resource experts, and an aquatic biologist prepared and presented the Laboratory's testimony.

In its testimony the Laboratory proposed new wildlife habitat standards and development of a more detailed implementation plan for water quality standards through the state's continuing planning process. The Laboratory suggested changes to the proposed water quality standards that protected the environment and that were technically feasible and achievable. The New Mexico Municipal League, San Juan Water Commission, Middle Rio Grande Conservancy District, Elephant Butte Irrigation District, Carlsbad Irrigation District, New Mexico Cattle Growers Association, and New Mexico Dairy Association supported the Laboratory's proposal.

4. Threatened and Endangered Species Habitat Management Plan

In 1998, DOE and ESH-20 completed a three-year effort to develop a habitat management plan (HMP) for the threatened and endangered species at the Laboratory. The plan was initiated as part of the MAP commitments for the DARHT facility. The four threatened or endangered species that could potentially reside on LANL property include the bald eagle, American peregrine falcon, Mexican spotted owl, and Southwestern willow flycatcher. The HMP identifies the location of habitat for these species at LANL. It also provides guidelines to protect these species and their habitats from disturbance or adverse habitat alteration caused by LANL operations. The HMP will be amended to address new species as changes occur in the status of species over time.

The HMP consists of two components: Area of Environmental Interest Site Plans and Monitoring

Plans. The Area of Environmental Interest Site Plans establish species-specific restrictions and criteria for planning and implementing projects and activities at the Laboratory. The Monitoring Plans provide the technical basis for conducting the species-specific research and activities necessary for maintaining the HMP's technical viability. The Monitoring Plans also provide the technical basis and justification for future studies associated with the HMP. These components are tightly integrated to ensure that the short- and long-term implementation of the plan is functional, effective, and accurate.

F. Awards

1. Water Quality

Members of the ESH-18 SDWA/Engineering, NPDES Outfall, and Storm Water/SPCC Teams received awards during 1998: the 1998 Pollution Prevention Success Award (EM Division) for NPDES Outfall Reduction and the 1998 Los Alamos Achievement Award (ESH Division) for the NPDES Permit Re-application Project.

2. Air Quality

ESH-17 received a Los Alamos Achievement Award for improvements made in atmospheric tritium measurements. These improvements provide for more accurate estimates of public health impacts from Laboratory operations.

3. Solid and Hazardous Waste

Members of ESH-19 received a 1998 Los Alamos Achievement Award for their work developing the HAZCAT program that resulted in significant dollar savings to the Laboratory. ESH-19 staff received a Pollution Prevention Award for providing RCRA regulatory support to a project that allowed printed circuit boards to be recycled after determining that the boards did not contain radioactive constituents.

4. Ecology

ESH-20 staff received a Los Alamos National Laboratory Distinguished Performance Award for contributions to the LANL Pit Manufacturing Integrated Plan Team. The award recognized the efforts that ESH-20 staff made to facilitate NEPA compliance planning in support of future pit manufacturing operations at LANL. In addition, ESH-20 staff received a DOE Achievement Award and plaque for preparation of Appendix II, Enhancement of Plutonium Pit Manufacturing, and for technical support and review in completion of the final LANL SWEIS.

ESH-20 nominated the Habitat Management Plan Reports Compilation Compact Disk for three separate pollution prevention awards: The Office of the Federal Environmental Executive's "Closing the Circle," the Department of Energy's Nationwide Pollution Prevention Program, and our Laboratory's Pollution Prevention Program. We received certificates of appreciation from the first two nominations and an award from the third.

ESH-20 nominated the "Threatened and Endangered Species Habitat Management Plan First Annual Review" notebook for an award at the Society for Technical Communication New Mexico Kachina Chapter Annual Conference (1998) where it received an Award of Achievement in Technical Publications. The STC awards were given in 1998 for work done in 1997.

ESH-20 staff received a Los Alamos Achievement Award for "significant accomplishments in compiling the administrative records for three NEPA environmental assessments."

Other ESH-20 Awards

- Several Laboratory staff members received a Los Alamos Achievement Award for Volume One of "For the Seventh Generation: Environment, Safety, and Health at Los Alamos National Laboratory-A Report to Our Communities." This publication was the first of its kind to be produced by ESH Division. (Note: Refer to Chapter 1.B.9., which provides details of other noteworthy awards for that same publication.)
- The Laboratory nominated Volume One of "For the Seventh Generation: Environment, Safety, and Health at Los Alamos National Laboratory-A Report to Our Communities" for awards in two separate categories at the Society for Technical Communication New Mexico Kachina Chapter Annual Conference (1998). We received the Award of Merit in Technical Art and the Award of Distinguished Technical Communication in Technical Publication, which made the document eligible for an international award for the national annual conference (1998) where it received an Award of Excellence for Informational Materials.

- The Interagency Wildfire Management Team, chaired by ESH-20, received an Innovative Pollution Prevention Award from the City of Albuquerque-Industry and Government Partnership.
- US Forest Service Award for "outstanding contributions to wildfire prevention and mitigation."
- Los Alamos Achievement Award for organizing and implementing a seminar series graduate course at New Mexico State University for the Waste-Management Education Research Consortium.
- Los Alamos Achievement Award for organizing and presenting a class on Insect Awareness.
- Several staff received a Certificate of Appreciation from the LANL Community Relations Office and the LANL Diversity Office for "support of the Laboratory American Indian Programs."
- A student won the Health Physics Society's Student Award for the best student poster, presented at their Annual Meeting.

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3. Environmental Radiological Dose Assessment

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Highlights from 1998

We calculate potential radiological doses to members of the public who may be exposed to Los Alamos National Laboratory (LANL or the Laboratory) operations. To fully understand potential radiological impacts, we calculate the doses to the population nearby, to potentially maximally exposed individuals on- and off-site, to "average" members of Los Alamos and White Rock, and from ingesting food products grown or gathered in the area. The population and individual doses include consideration of all potential exposure pathways (primarily inhalation, ingestion, and direct exposure). Our calculations indicate the population within 80 km of LANL received a dose of 0.8 person-rem, smaller than last year's 0.9 person-rem. The calculated maximum off-site radiation dose to a member of the public from Laboratory sources is near East Gate, north of the Los Alamos Neutron Science Center. This all-pathway annual dose of 1.1 mrem is well below the Department of Energy (DOE) dose limit of 100 mrem and is about the same as last year's reported dose of 1.2 mrem. This dose is calculated using all exposure pathways to satisfy DOE requirements and is different from the dose presented in Chapter 2, which is calculated for compliance with National Emission Standards for Hazardous Air Pollutants, and considers only the dose from the air pathway. The calculated maximum on-site individual exposure to a member of the public is 3.1 mrem, which compares to 6.1 mrem in 1997. This member of the public is a hypothetical individual who passes along Pajarito Road near the Technical Area 18 Criticality Facility during several small experiments. Most of this dose would be from direct radiation for which the applicable dose limit is 100 mrem, the allowed dose from all pathways. Ingestion doses were calculated for produce, fish, eggs, chicken, deer, elk, and other locally grown or gathered foods. Among these, there were no significant net doses calculated.

Health effects from radiation exposure have been observed in humans only at doses in excess of 10 rem. The doses calculated here, which are, in the mrem (one one-thousandth of a rem) or lower range are not expected to cause any harmful effects. They are also much smaller than typical variations in the background radiation dose. The total dose from background radiation, greater than 99% of which is from natural sources, is about 350 mrem in this area and can easily vary by 10 mrem from year to year.

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A. Overview of Radiological Dose Equivalents

Radiological dose equivalents are calculated doses received by individuals exposed to radioactivity. Radiation can damage living cells because of its ability to deposit energy as it passes through living matter. Energy deposited in the cell can result in cell damage, cell death, and, rarely, cell mutations that survive and can cause cancer. Because energy deposition is the mechanism that causes cell damage, radiation doses are measured in the quantity of radiation energy deposited per unit mass in the body. Different types of radiation carry different amounts of energy and are multiplied by adjustment factors for the type of radiation absorbed. Radiation affects different parts of the body with different degrees of effectiveness, but we need to report the "effective" dose the whole body has received. The term "effective dose equivalent" (EDE), referred to here as dose, is the "effective" dose calculated to have been received by the whole body, generally from an external radiation source. This dose is calculated by summing the doses to individual organs or tissues.

3. Environmental Radiological Dose Assessment

Long-lived radionuclides that are taken into the body by inhalation or ingestion continue to deposit energy in the body and give doses for a long time after their intake. To account for this extended dose period, a "committed effective dose equivalent" (CEDE), also referred to in this report as "dose," is calculated. The CEDE gives the total dose, integrated over 50 years, that would result from the intake of radionuclides taken into the body from short-term exposures. In this report, CEDEs are calculated for radionuclides taken into the body during 1998. The doses reported below include the contributions from internally deposited radionuclides (CEDE) and from radiation exposures received from sources outside the body (EDE) all under the general term "dose."

Federal government standards limit the dose that the public may receive from Laboratory operations. The Department of Energy (DOE 1990) public dose limit is 100 mrem per year received from all pathways (i.e., all ways in which people can be exposed to radiation, such as inhalation, ingestion, and direct exposure). The dose received from airborne emissions of radionuclides is further restricted by the Environmental Protection Agency's (EPA's) dose standard of 10 mrem per year, which is codified in the Code of Federal Regulations (40 CFR 61), (see Appendix A). These limitations are in addition to exposures from normal background, consumer products, and medical sources. Dose calculations performed to show compliance with 40 CFR 61 (EPA 1986b) are presented in Chapter 2 and are based on different pathways and use different modeling programs than those for DOE requirements, which are presented here in Chapter 3.

The purpose of this chapter is to report environmental data and potential impacts to members of the public. Therefore, we don't present worker doses in this report. Information on LANL worker radiation doses is published quarterly in the report "Los Alamos National Laboratory, Radiological Protection Program, Performance Indicators for Radiation Protection," which can be found in the Community Reading Room.

B. Public Dose Calculations

1. Scope

Annual radiation doses to the public are evaluated for three principal exposure pathways: inhalation, ingestion, and external (also referred to as direct) exposure. Evaluations focus on calculating doses that the population as a whole within 80 km may have received and also on calculating doses to specific hypothetical individuals within that population. We calculate doses for the following hypothetical people:

(1) The entire population within 80 km of the Laboratory. This modeled dose is based on all sources of radioactive air emissions at LANL. The modeling includes direct exposure to the radioactive material as it passes, direct inhalation of radioactive material, and ingestion of material that is deposited on or incorporated into vegetation and food from animal products such as poultry, eggs, and beef.

(2) The maximally exposed individual (MEI) who is not on LANL/DOE property (referred to as the off-site MEI). For this calculation, the definition of location is taken from 40 CFR 61, which defines the receptor as someone who lives or works at the off-site location. Any school, residence, place of worship, or non-LANL workplace would be considered a potential location for the off-site MEI. Please note that although the definition for the location of this hypothetical individual is taken from 40 CFR 61, the dose calculation performed here is more comprehensive than the one required for compliance with 40 CFR 61 (presented in Chapter 2). The calculated dose to the off-site MEI includes contributions from air emissions from all stack and diffuse sources at LANL, ingestion of food gathered locally, drinking water from local wells, and exposure to soils in the vicinity.

(3) The MEI who is in transit through LANL/DOE property but not necessarily employed by LANL. DOE-owned roads are generally open to public travel. Doses are calculated for a hypothetical member of the public traveling these roads frequently.

(4) An "average" resident of Los Alamos and White Rock. These doses are calculated based on average air concentrations (from LANL's Air Monitoring Network [AIRNET]) in Los Alamos and White Rock. To these calculated doses, we add the contributions from the Los Alamos Neutron Science Center (LANSCE) and Technical Area (TA) 18 (LANSCE and TA-18 emissions are not captured by AIRNET), from ingestion of local food products and water, and from exposure to radionuclides in local soils.

(5) Ingestion doses for various population locations in northern New Mexico from ingestion of food grown (fruits and vegetables) or harvested (deer,

elk, beef, and fish) locally. Because not all food products are available everywhere within the 80-km radius, we do not have a uniform set of ingestion data on which to calculate doses. We report doses for all locations from which food was gathered.

(6) Special Scenarios

Each year, we look at a number of special situations that could result in the exposure of a member of the public. This year, we report doses calculated for

- Ingestion of Radioactive Effluent from the TA-50 Outfall (Mortandad Canyon) and
- Exposure to Soils in the Vicinity of Los Alamos and White Rock.

Other scenarios, which were analyzed and reported in last year's report (ESP 1998), have not changed since that time and, therefore, were not reanalyzed. For example, in previous reports (ESP 1996, 1997), we modeled potential doses from contaminated sediments in Mortandad Canyon. Sediment sampling from 1998 indicates no significant changes from past years, so new dose calculations were not performed for this exposure pathway. The best estimate of potential doses from exposure to contaminated sediments in Mortandad or Los Alamos Canyon can be found in last year's report (ESP 1998). And, finally, because wild fruits and vegetables were collected in Mortandad Canyon during 1997 but not 1998, the best assessment of the dose from ingestion of fruits and vegetables is in Chapter 3 of last year's report (ESP 1998).

2. General Methodology

Our radiological dose calculations follow methodologies recommended by federal agencies to determine radiation doses (DOE 1991, NRC 1977) where possible. However, where our calculations do not lend themselves easily to standard methodologies, we have developed appropriate methods described below. The general process for calculating doses from ingestion or inhalation is to multiply the concentration of each radionuclide in the food product, water, or air by the amount of food or water ingested or air inhaled to calculate the amount of radioactivity taken into the body. Then, we multiply this amount by factors specific for each radionuclide (DOE 1988b) to calculate the dose from each radionuclide. These amounts are summed to give the total dose from ingestion and from inhalation throughout the year. Where local concentrations are not known but source amounts (amounts released from stacks or from diffuse emission sources) are known, we can calculate the doses at receptor locations using a model. The model combines source term information with meteorological data to estimate where the radioactive material went. By determining air concentrations in all directions around the source, the model can then calculate doses at any location. The models are also capable of calculating how much of the airborne radioactive material finds its way into nearby vegetation and animal material. Direct doses from radiation sources external to the body are calculated by multiplying the concentration of the radionuclide by the appropriate exposure factors (DOE 1988a). We use the Generation II (GENII) model for all dispersion evaluations (Napier et al., 1988) because this is the model DOE has accepted for dose calculation. Some of the specifics of the modeling are provided in following sections.

C. Dose Calculations and Results

Explanation of Reported Negative Doses: Because the concentrations of radionuclides are extremely low in most environmental samples, it is common that some of these concentrations will be reported as negative values by the analytical laboratory that performs the analysis. This result should be expected when very small concentrations are being analyzed. In fact, if all of our samples truly contained zero radioactivity, about half of our analyses would show positive numbers, about half would show negative results, and a few would actually show zero.

In Environmental Surveillance at Los Alamos reports before 1997, we carried these negative concentrations through all calculations, but then, if the calculated dose was less than zero, it was reported as zero. Starting last year and continuing with this report, we report doses exactly as calculated based on analytical results. Therefore, you will see that some of the reported doses are less than zero. Obviously, a person could not receive a negative dose, and it may seem incorrect to report these numbers. However, many of the positive numbers we report are also not meaningfully positive. By reporting all of the calculated doses here whether negative or positive and using all these data over a period of years, it is possible to accurately evaluate doses to individuals.

The average or maximum dose reported also includes a number in parentheses. This number is two

standard deviations of the dose. It means that approximately 96% of the dose values lie within the dose plus or minus the two standard deviations. A large standard deviation means there is much uncertainty in the reported dose, most likely because it is very near zero. As doses get larger and more meaningful, the standard deviation generally decreases dramatically, relative to the size of the dose, and we can have more confidence that a dose really occurred.

1. Dose to the Population Within 80 km

We used the local population distribution to calculate the dose from 1998 Laboratory operations to the population within 80 km (50 miles) of LANL. For 1998, the population estimate we used to calculate population doses for Los Alamos County (Figure 1-1) was approximately 18,300 people (BBER 1998). It is estimated that approximately 234,000 persons lived within an 80-km radius of the Laboratory.

The collective EDE (or dose) from Laboratory operations is the sum of the estimated dose received by each member of the population within an 80-km radius of LANL. Because 99% of this dose results from airborne radioactive emissions, the collective dose was estimated by modeling the transport of radioactive air emissions. We used the population distribution given in Table 3-1 in the dose calculation.

We calculated the collective dose with the GENII collection of computer programs (Napier et al., 1988). The analysis included airborne radioactive emissions from all types of releases. Stack emissions were modeled from all monitored stack sources. Diffuse emissions from LANSCE and Area G were also included in the modeling. Air concentration data from the nine AIRNET stations at Area G were used to calculate the diffuse emission source term from Area G. The exposure pathways included inhalation of radioactive materials; external radiation from materials present in the atmosphere and deposited on the ground; and ingestion of radionuclides in meat, produce, and dairy products.

The 1998 collective population dose attributable to Laboratory operations to persons living within 80 km of the Laboratory was calculated to be 0.8 person-rem,

Table 3-1. Estimated Population within 80 km of Los Alamos National Laboratory[a]

	Distance from TA-53 (km)									
Direction	**0–1**	**1–2**	**2–4**	**4–8**	**8–15**	**15–20**	**20–30**	**30–40**	**40–60**	**60–80**
S	3	3	0	0	21	0	15	127	381	2,962
SSW	3	3	0	0	31	1	711	1,244	6,463	49,597
SW	3	11	0	0	4	1	0	0	2,037	164
WSW	1	16	29	0	7	0	26	355	2,340	4
W	0	3	83	216	0	6	61	267	57	68
WNW	2	15	969	6,155	0	0	24	28	58	2,427
NW	5	31	887	1,407	0	2	23	47	418	553
NNW	7	63	639	288	0	5	19	253	154	284
N	7	68	240	129	0	13	87	917	786	566
NNE	7	61	83	16	2	10	2,311	386	646	296
NE	4	7	0	0	1	1,185	14,165	2,436	2,363	3,483
ENE	0	0	0	0	540	1,456	4,282	3,426	1,369	1,493
E	0	0	0	1	313	1,291	3,852	362	21	401
ESE	0	0	0	0	7	11	652	7,408	679	2,108
SE	0	1	0	4,552	496	0	947	69,214	7,129	640
SSE	2	3	0	604	354	0	289	5,397	2,444	101
Totals	44	285	2,930	13,368	1,776	3,981	27,464	91,867	27,345	65,147

[a]Total population within 80 km of Los Alamos National Laboratory is 234,207.

which is comparable to the population dose of 0.9 person-rem reported for 1997 (ESP 1998). Figure 3-1 shows the different contributors to the population dose. Short-lived air activation products such as carbon-11, nitrogen-13, and oxygen-15 that are created by the accelerator at LANSCE contribute about 50% to the calculated population dose. Diffuse emissions of uranium, plutonium, and tritium from Area G are about 5% of the dose, and tritium from stack sources is about 44% of the dose. Plutonium, uranium, and americium from stack sources contribute slightly more than 1% of the dose.

2. Dose to Maximally Exposed Individual not on Los Alamos National Laboratory Property (Off-Site MEI)

The location of the off-site MEI, the hypothetical highest exposure to a member of the public for the off-site MEI, is at East Gate along State Road (SR) 502 entering the east side of Los Alamos County, which has traditionally been the site because of its proximity to LANSCE. During experimentation at LANSCE, short-lived positron emitters are released from the stacks and diffuse from the buildings. These emitters release photon radiation as they decay, producing a potential external radiation dose. Most of the emitters decay very quickly, and within a few kilometers from LANSCE the dose is negligible. However, the dose at East Gate (the Laboratory boundary north-northeast of LANSCE) is elevated by these Laboratory emissions. The Laboratory's contribution to the penetrating radiation dose at East Gate is derived by modeling.

We calculated the dose for the off-site MEI by modeling the releases from LANSCE using the GENII computer code, which was developed by DOE for use in modeling doses from its facilities. To this modeled dose, we add the dose calculated using air concentration data from the AIRNET station (#10). We also add the contribution from ingesting food grown or gathered locally, from drinking water from local supply wells, and from living on contaminated soils in the vicinity (even though nobody actually lives at the location of these soils). The 1998 MEI air pathway dose calculated using GENII for all LANSCE sources is 1.0 mrem (Table 3-2).

Annual average air concentrations of tritium; plutonium-238; plutonium-239, -240; uranium-234; uranium-235; uranium-238; and americium-241 are calculated from annual air concentration data from AIRNET station #10. The total dose calculated from the AIRNET data is 0.071 mrem. This is a gross dose; we did not subtract background concentrations. Airborne tritium, which gave a dose of 0.026 mrem, was the largest dose contributor.

We calculated the dose contribution from food grown or gathered locally for all food products that were gathered around Los Alamos. These studies indicate contributions from produce (fruits and vegetables), piñon, milk, Navajo tea, eggs, deer, fish, and elk (Table 3-3). The total calculated dose is -0.097 mrem. (Section 3.C explains how we obtain negative values for some calculations.)

For 1998, no radionuclides other than uranium were detected in Los Alamos water supply wells. Because uranium is a natural constituent in subsurface waters, no dose was calculated from uranium in groundwater.

Soils were collected from a number of sites near or within Los Alamos (Table 6-1). Using the data from sites in or near Los Alamos and parameters shown in

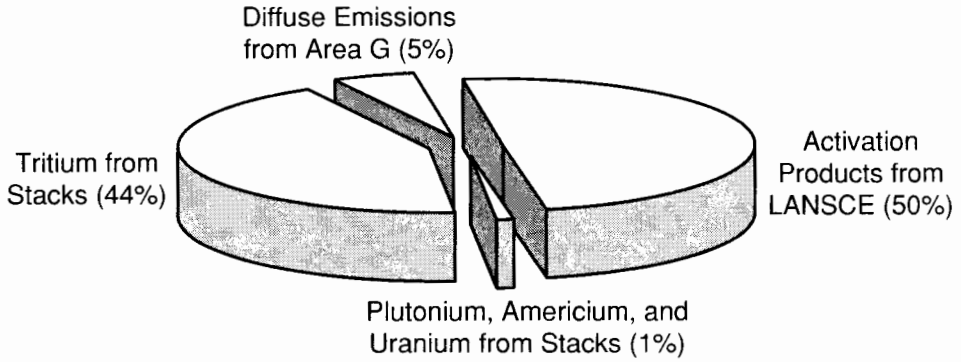

Figure 3-1. Contributions to the 0.8 person-rem air-pathway population dose.

Table 3-2. Compiled Doses during 1998[a]

Sources	Receptors: Off-Site MEI Eastgate (mrem)	On-Site MEI Pajarito Road (mrem)	LA Average Resident (mrem)	WR Average Resident (mrem)
LANSCE[b]	1.0	0.04	0.006	0.01
TA-18	0.00001	3	0.0000023	0.000015
AIRNET[c]	0.071	0.062	0.062	0.051
Food Stuffs Ingestion[d]	-0.097	-0.097	-0.097	0.014
Well Water Ingestion[e]	0	0	0	0
Soils Exposure[f]	0.1	0.1	0.1	0.1
Total	1.1	3.1	0.07	0.18

[a]The DOE permissible annual dose for all pathways is 100 mrem for a member of the public.
[b]These doses are modeled using GENII.
[c]These doses are calculated based on data from AIRNET stations in these areas. The calculations do not include background subtraction. The dose at Pajarito Road assumes the receptor is an average Los Alamos resident.
[d]Calculated from ingestion of foods grown or gathered locally.
[e]There were no radionuclides above detection limits other than presumably naturally occurring uranium.
[f]These doses are modeled with the RESRAD Code 5.82 using radionuclide data from local soil concentrations and include subtraction of dose from background soils.

Table 3-4 as input to the RESRAD computer code (Version 5.82), the net dose from living on these soils was calculated to be 0.10 (0.47) mrem for 1998. The dose calculation includes subtraction of the dose from living on "background" soils away from the Los Alamos area and considers direct exposure to soil and inhalation and ingestion of the soil.

Figure 3-2 shows that the combination of the AIRNET calculated dose of 0.071 mrem, the GENII modeled dose of 1.0 mrem, the food ingestion dose of -0.097 mrem, the water ingestion dose of 0 mrem, and the soils dose of 0.10 mrem gives a total off-site MEI dose of 1.1 mrem (Table 3-2). This level is far below the applicable 100 mrem standard and no adverse effects are expected.

This dose is not comparable directly to the 1.72 mrem dose reported in Chapter 2, which is calculated for compliance with 40 CFR 61. The Chapter 2 dose includes only the air pathway and is modeled using a different computer model, CAP88, as required by 40 CFR 61. The dose presented here is for all pathways and uses the DOE GENII computer code. We believe the main difference in the Chapter 2 and 3 calculated air pathway doses is caused by differences in the two codes that model the doses. In this case, CAP88 gives a more conservative but probably less realistic calculation.

3. Dose to Maximally Exposed Individual on Los Alamos National Laboratory/Department of Energy Property (On-Site MEI)

The Laboratory's largest contributor to the on-site MEI is the Criticality Facility at TA-18. Criticality experiments produce neutrons and photons, both of which contribute to the external penetrating radiation dose. During experiments, neutrons and photons from the experiments reach Pajarito Road, a local, LANL/DOE-owned road that is open to the public most of the time. During experiments that have the potential to produce a dose in excess of 1 mrem per operation,

Table 3-3. Ingestion Doses from Foods Gathered or Grown in the Area during 1998

	Dose per Unit Consumed in 1998 (mrem)	Average Consumption[a] Dose[b] (mrem)		Maximum Consumption[a] Dose[b] (mrem)	
Produce					
Regional Background (see text)	0.0016/lb	0.21	(0.33)	0.57	(0.89)
LANL On-Site Stations	–0.00051/lb[c]	–0.066	(0.40)	–0.18	(1.1)
Los Alamos Townsite	–0.00079/lb	–0.10	(0.36)	–0.28	(0.97)
White Rock & Pajarito Acres	0.00027/lb	0.035	(0.56)	0.095	(1.52)
San Ildefonso Pueblo	–0.00052/lb	–0.068	(0.35)	–0.18	(0.94)
Cochiti Pueblo	–0.00038/lb	–0.049	(0.39)	–0.13	(1.1)
Piñon					
Regional Background (see text)	0.0088/lb	**0.026**	**(0.011)**	**0.088**	**(0.036)**
Los Alamos	–0.0030/lb	–0.0084	(0.014)	–0.0830	(0.047)
White Rock	–0.0027/lb	–0.0082	(0.015)	–0.027	(0.049)
San Ildefonso Pueblo	–0.0014/lb	0.0043	(0.015)	–0.014	(0.050)
Mushrooms					
Regional Background	0.0029/lb				
Los Alamos	0.0014/lb				
White Rock	0.012/lb				
San Ildefonso Pueblo	–0.0038/lb				
TA-49	–0.00032/lb				
Goat's Milk					
Regional Background (Albuquerque)	0.0102/gal.	0.32	(0.39)	0.80	(0.97)
Los Alamos	–0.0051/gal.	–0.16	(0.41)	–0.40	(1.0)
White Rock	–0.0025/gal.	–0.078	(0.46)	–0.20	(1.1)
Navajo Tea (Cota)					
Regional Background (Española)	0.00097/L	0.39	(0.79)	0.53	(1.1)
Los Alamos	–0.000040/L	–0.016	(0.80)	–0.022	(1.1)
White Rock	–0.000047/L	–0.019	(1.12)	–0.026	(2.3)
San Ildefonso Pueblo	0.000034/L	–0.014	(1.1)	–0.019	(1.5)
Eggs					
Regional Background (Española)	0.000095/2 eggs	0.0021	(0.029)	0.035	(0.048)
Los Alamos	0.000049/2 eggs	0.011	(0.038)	0.018	(0.062)
White Rock/Pajarito Acres	–0.000039/2 eggs	–0.0088	(0.030)	–0.014	(0.049)
San Ildefonso Pueblo	–0.0000053/2 eggs	–0.0012	(0.037)	–0.019	(0.059)
Steer					
Regional Background (see text)	–0.017/lb muscle 0.056/lb bone	**2.9**	**(1.6)[d]**	**3.4**	**(1.8)[d]**
Cochiti	0.0070/lb muscle –0.015/lb bone	–0.79	(2.7)[d]	–0.92	(3.1)[d]
Squirrel					
Regional Background	0.00098/lb muscle 0.0086/lb bone				
Los Alamos	–0.00089/lb muscle 0.014/lb bone				
TA-53	–0.024/lb muscle 0.10/lb bone				

Table 3-3. Ingestion Doses from Foods Gathered or Grown in the Area during 1998 (Cont.)

	Dose per Unit Consumed in 1998 (mrem)	Average Consumption[a] Dose[b] (mrem)		Maximum Consumption[a] Dose[b] (mrem)	
Deer					
Regional Background (Dulce, NM)	0.0028/lb muscle 0.038/lb bone	**0.18**	**(0.040)**[e]	**0.43**	**(0.096)**[e]
Los Alamos Area Roads	0.0026/lb muscle 0.076/lb bone	0.39	(0.71)[e]	0.94	(1.7)[e]
Elk					
Regional Background (Coyote, NM)	0.00060/lb muscle 0.062/lb bone	**0.35**	**(0.46)**[d]	**0.81**	**(1.0)**[d]
Los Alamos Area Roads	0.00072/lb muscle 0.035/lb bone	**0.21**	**(0.52)**[d]	**0.47**	**(1.2)**[d]
Game Fish					
Regional Background (upstream)	0.00035/lb	0.0044	(0.0050)	0.016	(0.018)
Cochiti (downstream)	0.00086/lb	0.011	(0.021)	0.040	(0.079)
Nongame Fish					
Regional Background (upstream)	0.00043/lb	0.0054	(0.0070)	0.020	(0.026)
Cochiti (downstream)	0.00041/lb	0.0051	(0.062)	0.019	(0.23)

[a] Average and maximum consumption values used in calculations are reported in text for specific food product.
[b] The mean dose is reported with two standard deviations (2s) given in parentheses. Because most of the means are very close to zero, the 2s range usually includes zero, small positive, and small negative values. If the mean is greater than 2s, it is more likely that the mean is significant. **Numbers where the mean is greater than or equal to the 2s value are bolded in the table.**
[c] See Section 3.C for an explanation of negative numbers.
[d] Consumption of 0.25 lb of bone included for every pound of muscle.
[e] Consumption of 0.21 lb of bone included for every pound of muscle.
Note—doses presented in this table are based on foodstuffs and biota data included in Chapter 6.
Note—Background doses (indicated in the table as "Regional Background") are calculated based on food products from areas distant from LANL. Net doses are calculated by subtracting background doses from those at a sampled location near LANL.

public access is restricted by closing Pajarito Road between White Rock and TA-51. Exposure to a member of the public would be negligible during road closures. However, we evaluated doses that might be received by an individual who passes by the facility frequently and received very small exposures from operations during which the road remained open. After reviewing a number of exposure scenarios, we determined that the scenario with the greatest realistic potential exposure to a member of the public is a slow jogger who passes the facility twice each day (one trip out and back), 250 round trips per year, at a speed of 3 miles per hour. Probabilistic statistics were used to calculate the chance an exposure would occur while the jogger was within the 0.5-mile stretch of roadway passing by TA-18.

The calculations predicted that the jogger would receive a dose of 3 mrem. These are conservative calculations; they assume that, if an exposure occurred, it would be at the maximum possible level. Furthermore, fractional probabilities of exposure are rounded up; for example, if the calculated probability of exposure were 1.3, it is assumed that 2 exposures would occur.

Assuming that the jogger was a resident of Los Alamos during 1998, the dose from food and water ingestion, from LANSCE operation, and from exposure to contaminated soils and air would add to

Table 3-4. RESRAD Input Parameters for Mortandad Canyon Sediments Collected in 1998

Parameter	Value	Comments
Area of contaminated zone	100 m^2	RESRAD default value; a larger area maximizes exposure via external gamma, inhalation, and ingestion pathways
Thickness of contaminated zone	3 m	Based on mesa top conditions (Fresquez et al., 1996)
Time since placement of material	0 yr	Assumes current year (i.e., no radioactive decay) and minimal weathering
Cover depth	0 m	Assumption of no cover maximizes dose
Density of contaminated zone	1.6 g/cm^3	Based on previous models [Buhl 1989] and mesa top conditions (Fresquez et al., 1996)
Contaminated zone erosion rate	0.001 m/yr	RESRAD default value
Contaminated zone total porosity	0.5	Average from several samples in Mortandad Canyon [Stoker et al., 1991]
Contaminated zone effective porosity	0.3	Table 3.2 in data handbook [Yu et al., 1993]
Contaminated zone hydraulic conductivity	440 m/yr	An average value for soil (not tuff) [Nyhan et al., 1978)
Contaminated zone b parameter	4.05	Mortandad Canyon consists of two units, the topmost unit being sand (Purtyman et al., 1983) and Table 13.1 in the data handbook (Yu et al., 1993)
Humidity in air	4.8 g/cm^3	Average value from Los Alamos Climatology (Bowen 1990)
Evapotranspirations coefficient	0.85	Based on tritium oxide tracers in Mortandad Canyon (Penrose et al., 1990)
Wind Speed	2 m/s	RESRAD default value
Precipitation	0.48 m/yr	Average value from Los Alamos Climatology (Bowen 1990)
Irrigation rate	0 m/yr	Water in Mortandad Canyon is not used
Runoff coefficient	0.52	Based on mesa top conditions (Fresquez et al., 1996)
Inhalation rate	8400 m^3/yr	RESRAD default value
Mass loading for inhalation	9×10^{-5}	Phermex (OU 1086) Risk Assessment for respirable particles
Exposure duration	1 year	Assumes current year exposure only
Dilution length for airborne dust	3 m	RESRAD default value
Shielding factor, inhalation	0.4	RESRAD default value
Shielding factor, external gamma	0.7	RESRAD default value
Fraction of time spent indoors each year	0.7	Based on 18 h/d (Fresquez et al., 1996)
Fraction of time spent outdoors	0.01	Assumes an industrial scenario where access to site is somewhat limited (Robinson and Thomas 1991)
Shape factor	1	Corresponds to a contaminated area larger than a circular area of 1200 m^2
Depth of soil mixing layer	0.15 m	RESRAD default value
Soil ingestion rate	44 g/yr	Calculated based on 100 mg/d for 24 yr (adult) and 200 mg/d for 6 yr (child) [Fresquez et al., 1996]

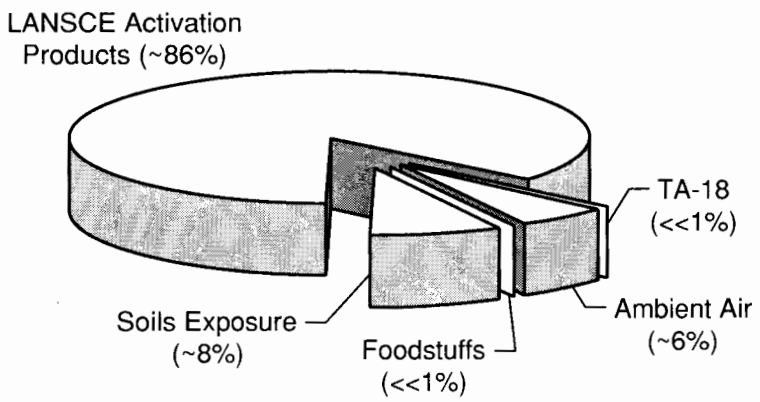

Figure 3-2. Contributions to total 1.1 mrem dose at East Gate.

the dose from TA-18. These additional doses are shown in Table 3-2 and in Figure 3-3. The total calculated dose to this hypothetical resident of Los Alamos would be 3.1 mrem. This dose is 3% of the DOE public dose limit of 100 mrem.

4. Doses to Average Residents of Los Alamos and White Rock

We calculated doses to the average residents of Los Alamos and White Rock based on average air concentrations (as determined from AIRNET data) in these areas. To these calculated doses, we add the contributions from LANSCE and TA-18 (emissions from LANSCE and TA-18 are not captured by AIRNET), from ingestion of local food products and water, and from exposure to radionuclides in soil. In years previous to 1997, the Laboratory's annual environmental surveillance report did not include doses other than those from LANSCE and those calculated from AIRNET data in estimating average doses to Los Alamos and White Rock residents. Therefore, the doses reported below are higher than, and not directly comparable to, earlier estimates of average doses in Los Alamos and White Rock.

a. Los Alamos Dose. The total LANL contribution of the dose to an average member of Los Alamos during 1998 was 0.07 mrem from all pathways (Table 3-2). Figure 3-4 shows the various Laboratory contributions to this dose. The remainder of this section explains what contributed to this 0.07 mrem calculated dose.

We compiled air concentration data for uranium, plutonium, americium, and tritium from stations #4 (Barranca School), #5 (Urban Park), #6 (48th Street), #7 (Shell Station), #8 (McDonalds), #9 (Los Alamos Airport), #10 (East Gate), #12 (Royal Crest Trailer Court), #60 (Los Alamos Canyon), #61 (Los Alamos Hospital), and #62 (Trinity Bible Church). The

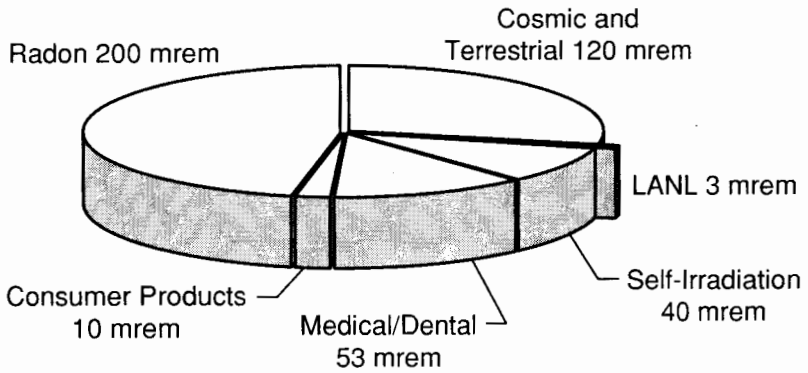

Figure 3-3. Significant contributions to the 1998 radiation dose for the Laboratory's maximally exposed individual.

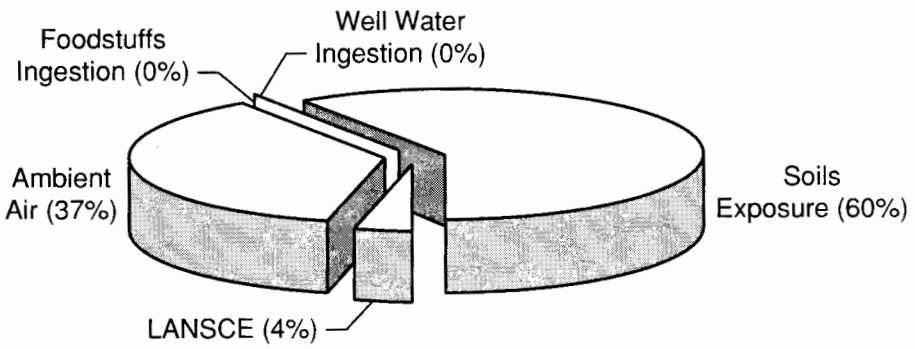

Figure 3-4. Laboratory contributions of the dose (0.07 mrem) to an average Los Alamos resident.

modeling to calculate doses from the AIRNET data includes the dose a person would receive from air inhalation, food ingestion, and exposure to soil from the immediate area. The total dose calculated from the Los Alamos AIRNET data is 0.062 mrem and does not incorporate a subtraction for background air concentrations. Not including a background subtraction is conservative because much of the dose received is from naturally occurring uranium isotopes.

Because most of the radioactive emissions from LANSCE and TA-18 are not captured by AIRNET, we modeled the dose from these emissions to a central point in Los Alamos using the GENII computer code. Exposure to the radioactive plume as it passes is the only significant pathway. The dose to a typical Los Alamos resident was calculated to be 0.006 mrem from LANSCE and 0.0000023 mrem from TA-18 (Table 3-2).

As discussed earlier, the dose calculated from exposure to contaminated soil in Los Alamos is 0.10 mrem. The net dose is statistically indistinguishable from zero.

Ingestion of locally grown or gathered food could provide additional dose. Ingestion of food gathered or grown in the Los Alamos area, including consumption of fish caught in Cochiti Reservoir, is calculated to give a dose of -0.097 mrem (Table 3-2).

Ingestion of water from local wells could be another exposure source for residents of Los Alamos. For 1998, none of the Los Alamos water supply wells showed any radionuclides above the detection limit except uranium. Uranium is considered to be a natural component of subsurface waters.

b. White Rock Dose. The total dose from all pathways to an average member of White Rock from Laboratory operations was 0.18 mrem in 1998. The methodology for calculating the White Rock dose was identical to that used for Los Alamos. We used the following AIRNET stations to calculate average White Rock air concentrations: #13 (Rocket Park Tennis Courts), #14 (Pajarito Acres), #15 (White Rock Fire Station), #16 (White Rock Church of the Nazarene), and #63 (Monte Rey South). The gross dose (no background subtraction) calculated from these data is 0.051 mrem. The dose contribution from LANSCE operations in 1998 was 0.01 mrem, and the contribution from TA-18 was 0.000015 mrem (Table 3-2).

Because none of the water supply wells for White Rock showed detectable radionuclides other than presumably naturally occurring uranium, there is no calculated water ingestion dose for White Rock. Living on local soils provides the same dose potential as to a member of Los Alamos (because all sites in the Los Alamos/White Rock area were grouped together for the soil exposure evaluation); the dose would be 0.10 mrem from exposure to soils. Ingestion of locally grown or gathered food products would provide a dose of 0.014 mrem (Table 3-2).

5. Ingestion Doses for Various Locations in Northern New Mexico

We collected and analyzed many different types of food products for their radionuclide content. The following section presents the details of calculating food ingestion doses for various locations and food types in northern New Mexico. The food ingestion doses described here are included in the total doses reported above for average and maximally exposed residents of Los Alamos and White Rock. These doses are tabulated in Table 3-3.

The following sections describe the doses calculated for each type of food. Doses are calculated (Table 3-3) for regional background concentrations (foods that were grown or gathered distant from LANL and which are presumed to reflect concentrations not affected by LANL operations) and for net concentrations at all other locations. Net concentrations are calculated by subtracting background concentrations from those at the location of interest.

We performed three calculations for foodstuffs whose average and maximum consumptions values are documented: one assuming average consumption rates, one assuming maximum hypothetical consumption rates, and one for dose-per-unit of food consumed. The consumption rates we used in these calculations are reported in the subsections below. We report the dose-per-unit of food consumed so that individuals may calculate their own hypothetical doses based on their knowledge of their actual consumption rates. Consumption doses are calculated for all foodstuffs for which we had acceptable data.

a. Ingestion of Produce (Fruits and Vegetables). Fruits and vegetables were collected at a number of locations throughout northern New Mexico. Because the plant types collected differed according to site, it was not possible to compare produce ingestion doses from location to location. Although the specific food types differed at various locations, the values for fruits and vegetables collected are shown in Table 6-3. For this report we used consumption rates assuming an average of 130 lb per year and a maximum of 352 lb per year of fruits and vegetables (NRC 1977). The contributions from cesium-137, strontium-90, uranium, plutonium-238, uranium-239, -240, and americium-241 were included in this ingestion calculation (Table 3-3). The highest doses were calculated to have occurred from ingestion of food products in regional background locations. The average consumption net dose at LANL on-site locations was -0.0005 (0.003) mrem.

b. Ingestion of Piñon. Doses for ingestion of piñon tree nuts are calculated and presented separately from other produce because of the traditional importance of piñon in the native diet. Piñon nuts are produced irregularly in non-annual cycles about every seven to 10 years. Although there was a crop in 1998, analytical results from the nuts were not available in time for inclusion in this report. Because results from piñon nuts were not available, piñon shoot tips were collected and analyzed, and Table 6-14 reports those results. Most literature suggests that the nonedible portions of plants tend to have higher concentrations of radionuclides than the edible portions of plants (Fresquez et al., 1998a). Therefore, the use of piñon tree foliage to estimate doses for the ingestion of pine nuts is probably an overestimation (conservative) of risk. All radionuclides shown in Table 6-14 were included in the dose calculation. The highest (and only positive) unit dose of 0.0088 mrem per pound of piñon was calculated for the background station average. We assumed that the average annual consumption was about 3 lb and that the maximum annual consumption was 10 lb. The dose from average consumption of piñons at the Pueblo of San Ildefonso for 1998 was calculated to be -0.0014 (0.0050) mrem.

c. Ingestion of Goat's Milk. Goat's milk was collected from Los Alamos, White Rock/Pajarito Acres, and Albuquerque (the background location) and analyzed (Table 6-7). We calculated the dose (Table 3-3) from cesium-137, iodine-131, strontium-90, uranium, and plutonium-239, -240. The only positive doses were calculated for the Albuquerque milk. Net doses in Los Alamos and White Rock/Pajarito Acres were negative but were smaller than their associated uncertainty. The ingestion rates for goat's milk were assumed to be the same as those used for cow's whole milk (EPA 1984).

d. Ingestion of Navajo Tea. Navajo tea (Cota) stems were collected from Los Alamos, White Rock/Pajarito Acres, the Pueblo of San Ildefonso, and background locations. Strontium, cesium, uranium, plutonium isotopes, and americium were included in the dose calculation. The largest, and only positive, dose was calculated for the background location and was 0.00097 (0.0020) mrem per liter of tea consumed (Table 3-3). The net dose we calculated for the Pueblo of San Ildefonso for annual consumption of 402 L (considered an average consumption rate) was -0.014 (1.1) mrem. A maximum annual consumption of 548 L would have given a dose of -0.019 (1.5) mrem.

e. Ingestion of Chicken Eggs. We collected and analyzed chicken eggs from Los Alamos, White Rock/Pajarito Acres, the Pueblo of San Ildefonso, and from Española (the background location). All of the doses we calculated from egg consumption were extremely small; none were statistically different from zero. The only positive doses were calculated for the background location in Española, where the unit dose from eating two eggs was 0.000095 mrem (Table 3-3). An annual dose from an average consumption of about 1.25 eggs per day (EPA 1984) from the background

location would be 0.021 (0.029) mrem, and a maximum consumption of about 2 eggs per day would give a dose of 0.035 (0.048) mrem. The dose calculations included hydrogen-3, strontium-90, cesium-137, uranium, plutonium-239, and americium-241.

f. Ingestion of Steer Meat and Bone. A free-range steer was collected from Pueblo of Cochiti lands and we compared the results of the analysis to regional background averages (Table 6-12). Doses for consumption of meat and bone from the average background steer and for consumption of the steer from the Pueblo of Cochiti are presented in Table 3-3. (Note: Pieces of bone sometimes end up in foodstuffs we consume.) The background dose from consuming 209 lb of muscle and about 53 lb of bone is 2.9 (1.6) mrem. At maximum consumption rates of 242 lb of muscle and 61 lb of bone, the dose would be 3.4 (1.8) mrem. The net dose from average consumption at the Pueblo of Cochiti is -0.79 (2.7) mrem, and the dose from maximum consumption is -0.92 (3.1) mrem. Consuming muscle or bone from the Cochiti sample would give doses 0.007 and -0.015 per pound, respectively. For the calculation of dose from bone ingestion, tritium, strontium-90, cesium-137, uranium isotopes, and americium-241 were used. For the muscle ingestion calculation, all radionuclides were used (tritium, strontium, cesium, uranium, plutonium isotopes, and americium).

g. Ingestion of Deer Meat and Bone. We collected deer killed along roadways within and around Los Alamos, analyzed their meat and bone tissue, and compared the results to regional background samples. We calculated the dose from the background deer to be 0.0026 mrem per pound of muscle consumed and 0.076 mrem per pound of bone consumed. At an average consumption rate of 20.9 lb of muscle and 4.4 lb of bone, the 1998 background dose was 0.18 (0.040) mrem. Maximum consumption of 50 lb of muscle and 11 lb of bone would have given a dose of 0.43 (0.096) mrem. For average consumption, the calculated net dose was 0.39 (0.71) mrem. All data were used in the calculation except the plutonium-238 value for bone from a buck collected from Diamond Drive, which was rejected because it was significantly negative.

h. Ingestion of Elk Meat and Bone. We collected elk around Los Alamos, analyzed their meat and bone tissues, and compared the results to regional background elk samples. We calculated the dose from the background elk to be 0.00060 mrem per pound of muscle consumed and 0.062 mrem per pound of bone consumed. At an annual average consumption rate of 20.9 lb of muscle and 5.3 lb of bone in 1998, the background dose would have been 0.35 (0.46) mrem. The maximum consumption of 50 lb of muscle and 13 lb of bone would have given a dose of 0.81 (1.0) mrem. Calculated net dose for consumption of the Los Alamos elk was 0.00072 mrem per pound of muscle and 0.035 mrem per pound of bone consumed. At an average consumption rate, the calculated dose is 0.21 (0.52) mrem, and at maximum consumption rate, the dose would be 0.47 (1.2) mrem (Table 3-3). There were no values for americium-241 in bone for LANL elk, so americium-241 was not included in any of the bone dose calculations. For muscle and bone, the radionuclides included in the calculation were tritium, strontium-90, cesium-137, uranium isotopes, and americium-241 (for muscle only).

Note on Deer and Elk Analyses:

A two-year elk tracking study concluded that elk that spent an average of 50% of their time on LANL lands contained radionuclide concentrations in muscle and bone similar to those in elk that have been collected as road kill as part of the Laboratory's environmental surveillance program (Fresquez et al., 1998b). Therefore, it is our conclusion that these road-kill deer and elk provide a reasonable representation of the contamination levels in deer and elk populations that frequent LANL properties.

i. Ingestion of Fish. We compared surface-feeding fish (referred to as game fish), including trout, walleye, and bass, collected from reservoirs upstream of LANL (Abiquiu, Heron, and El Vado) with game fish collected from Cochiti Reservoir, downstream of LANL. The calculated net dose (assuming average consumption) from downstream game fish was slightly higher than the 0.0044 (0.0050) mrem dose for upstream fish although, the uncertainties indicate the doses are not statistically different from each other (Table 3-3). At an average annual consumption of 12 lb of fish, the net downstream dose would be 0.011 (0.021) mrem, and it would be 0.040 (0.079) at maximum consumption of 46 lb of fish.

We collected bottom-feeding fish (referred to as nongame fish), including carp, catfish, and sucker, from the same reservoirs as game fish. For nongame fish, the background dose was slightly higher than the net downstream dose although, as for the game fish, the differences were not statistically meaningful (Table 3-3). The assumed average and maximum consumption rates were the same for nongame fish as were those for game fish.

The dose calculations included cesium-137, uranium isotopes, plutonium isotopes, and americium-241.

j. Ingestion Doses for the Pueblo of San Ildefonso. Residents of the Pueblo of San Ildefonso may receive doses from ingestion of food products grown or gathered locally and from drinking water from local supply wells.

Food products were analyzed for radionuclide content (see Chapter 6), and we used these analyses to calculate doses from ingestion. The doses from ingestion of all foods grown or gathered locally are tabulated in Table 3-3. The foods that were grown or gathered on or near Pueblo of San Ildefonso lands are summarized in Table 3-5. The total dose from consumption at average rates (as defined in the text of Section 3.C.5) was calculated to be 0.54 (1.5) mrem. The large uncertainty indicates that the actual dose may be zero. The largest contributor to this dose was consumption of deer killed in the Los Alamos area. We included the potential dose from consuming these deer here because San Ildefonso lands abut the Los Alamos area, and deer migrate freely across the boundaries.

Sampling from wells in and around the Pueblo of San Ildefonso revealed one case where uranium in the groundwater exceeded the EPA-proposed drinking water maximum contaminant level (MCL) of 20 µg per liter of water. The dose from ingesting groundwater pumped from wells near San Ildefonso was calculated assuming 2 liters per day were consumed of this water (EPA 1989). The ratio of the uranium isotopes was assumed to be the same as natural isotopic ratios. The doses from drinking these well waters are shown in Table 3-6. The highest calculated dose was from the New Community Well with a dose of 3.0 (0.55) mrem, which was essentially all from the uranium in the water. The valley area, including the Pueblo of San Ildefonso, is known to contain high concentrations of natural uranium in subsurface deposits and groundwater. The uranium in the groundwater below the Pueblo of San Ildefonso is natural in origin.

k. Summary of Food Product Ingestion Doses. Statistically significant doses were seen for consumption of piñon, steer, and deer from background locations. By significant, we mean that the uncertainty in the measurements (which is shown in parentheses) is smaller than the measured number. When the uncertainty range includes zero (i.e., when the reported number minus the uncertainty is less than zero), then the number itself is not different from zero in a statistically significant sense.

The largest statistically significant dose would be from ingestion of steer collected in El Rito, NM. This dose totaled 2.9 (1.6) mrem for average consumption rates. We don't report doses from the El Rito steer for Los Alamos or other hypothetical receptors near the Laboratory because this was our background steer and does not represent Laboratory contributions to the environment. Consumption of an average quantity of deer from the Los Alamos area would give a dose of

Table 3-5. Dose from Foodstuff Grown or Gathered Near Pueblo of San Ildefonso Lands

Food Product	Dose[a] (mrem)
Produce	–0.068[b] (0.35)
Piñon	–0.00043(0.033)
Navajo Tea	–0.014 (1.1)
Eggs	–0.012 (0.037)
Mushrooms	0.038 (0.0041)
Deer	0.39 (0.71)
Elk	0.21 (0.52)
Total Annual	0.54 (1.5)

[a]Dose assumes average consumption rates as defined in the text. Mushroom dose assumes consumption of 10 lbs. Two standard deviation values are shown in parentheses.
[b]See Section 3.C for an explanation of negative numbers.

Table 3-6. Dose from Ingestion of Two Liters of Water per Day from Wells Near San Ildefonso

Well Name	Committed Dose[a] (mrem)
Pajarito Well	1.3 (0.38)
Don Juan Playhouse Well	2.1 (0.40)
New Community Well	3.0 (0.55)
Sanchez House Well	2.1 (0.43)
Eastside Artesian Well	–0.017(0.26)
Otowi House Well	0.64 (0.35)

[a]Two standard deviation values are reported in parentheses.

0.18 (0.040) mrem. The net dose of 0.18 mrem from consuming deer in this area is about two one-thousandths of the applicable all-pathway limit of 100 mrem. At such low doses, no health or other effects are expected.

6. Special Scenarios

a. Ingestion of Radioactive Effluent from the Technical Area 50 Outfall. TA-50 discharges residual radioactive effluent to Mortandad Canyon. During 1998, the effluent included tritium; strontium-89; strontium-90; cesium-137; uranium-234; uranium-235; plutonium-238; plutonium-239, -240; and americium-241. No water is derived from Mortandad Canyon for drinking, industrial, or agricultural purposes, and comparisons with drinking water standards are not appropriate. However, because no physical barriers prevent public access, it is possible, though unlikely, that an ingestion of the effluent could occur. The most likely scenario involves a very thirsty jogger or hiker who hears the water trickling and, in desperation, drinks from the end of the pipe. Rather than attempt to estimate a "reasonable" amount that someone might consume, the dose per liter consumed is presented here so that others may draw conclusions about the radiological dose and relative hazard that this effluent represents. The dose from effluent consumed is calculated to be 0.99 mrem per liter. Last year, the dose was reported as 1.2 mrem per liter (ESP 1998). The plutonium isotopes (238, 239, and 240) and americium-241 contribute the majority of this calculated dose.

b. Exposure to Soils in the Vicinity of Los Alamos and White Rock. We used a simplified version of the residential scenario originally developed by Fresquez and others (1996) in a computer model, RESRAD Version 5.82, to estimate the EDE from external radiation and the CEDE from internally deposited radiation (Yu et al., 1993). The primary simplification was that the modeling performed here did not consider horizons other than the surface zone from which the soil samples were taken. We decided not to include the plant or drinking water ingestion pathways because they are evaluated through direct measurement of these media. We have included direct exposure to, inhalation of, and ingestion of contaminated soil in this assessment. Inclusion of zones other than where the sampling occurred is not important. The radon pathway is not included because these soil measurements of uranium (the parent material for radium-226, which generates radon-222) are of recent, shallow soils. Because of the 4.5-billion-year half-life of uranium-238 and the 1,600-year half-life of radium-226, no appreciable radon would be generated in the short time since deposition of these shallow soils. The dose is compared to that from exposure to background soils from Embudo, Cochiti Pueblo, and Jemez Pueblo.

We combined analyses from all soil samples from the entire area in or near Los Alamos and White Rock to estimate average soil concentrations in the Los Alamos/White Rock area. These average soil concentrations (Table 6-1) were the RESRAD input concentrations used to calculate the dose from gross (no background subtraction) soil concentrations. We calculated the net dose by subtracting the dose from background soil concentrations from the dose from gross concentrations. The net dose and two standard deviations for Los Alamos/White Rock area were found to be 0.10 (0.47) mrem. The background dose was 0.54 (0.08) mrem. The Los Alamos/White Rock doses are included in the dose summary table (Table 3-2). They are added to the dose to an average member of Los Alamos or White Rock from other pathways or sources. These doses are very similar to the doses reported last year, as would be expected in the absence of any large-scale ground-contaminating event.

D. Estimation of Radiation Dose Equivalents for Naturally Occurring Radiation

Operations at LANL contribute radiation and radioactive materials to the environment. To put the Laboratory's impact into perspective, it is important to understand its contribution relative to existing natural and man-made radiation and radioactive materials in the environment.

External radiation, which affects the body by exposure to sources external to the body (not from inhalation or ingestion), comes from two sources that are approximately equal: cosmic radiation from space and terrestrial gamma radiation from radionuclides naturally in the terrestrial environment. Estimates of dose rates from natural radiation are based on a comprehensive report by the National Council on Radiation Protection and Measurements (NCRP 1987b) and assume the dose from cosmic radiation dose is reduced 20% because of time spent indoors and the dose from terrestrial radiation sources is reduced by 30% because our bodies provide some shielding for our internal organs from terrestrial

photons. In general, doses from direct radiation from cosmic sources are higher in Los Alamos than White Rock because White Rock is at a lower elevation and less cosmic radiation reaches the earth's surface. Actual annual external background radiation exposures vary depending on factors such as snow cover and fluctuations of solar radiation (NCRP 1975).

The largest component of our annual dose is from the decay of natural uranium. Uranium products occur naturally in soil and are commonly incorporated into building construction materials. Radon-222 is produced by decay of radium-226, which is a member of the uranium decay series. Inhalation of radon-222 results in a dose to the lung, which is the largest component of natural background radiation dose. The dose from radon-222 decay products to local residents is assumed to be equal to the national average of 200 mrem per year. We may revise this estimate if a nationwide study of background levels of radon-222 in homes is undertaken or if we obtain reliable data on average radon concentrations in homes in northern New Mexico. A national survey has been recommended by the NCRP (NCRP 1984, 1987a).

Another naturally occurring source of dose to the body is from natural radioactive materials incorporated into the body. Most importantly, a small percentage of all potassium is radioactive potassium-40. Because our bodies require potassium, we have a certain amount of radioactive potassium within us, and the decay of this potassium-40 gives us a dose of about 18 mrem per year. Natural uranium and carbon-11 contribute another 21 mrem or so to give a total dose from internal radionuclides of about 40 mrem each year. Global fallout doses resulting from atmospheric testing of nuclear weapons are only a small fraction, less than 0.3%, of total environmental doses.

Members of the US population receive an average dose of 53 mrem per year from medical and dental uses of radiation (NCRP 1987a). The various contributors to radiation dose to the maximally exposed individual in the Los Alamos area are shown graphically in Figure 3-3. In the Los Alamos area, we receive roughly 120 mrem from terrestrial and cosmic external sources, 200 mrem from radon, 40 mrem from internal sources, 53 mrem from medical and dental procedures, and perhaps 1 mrem from global fallout to give a total "background" dose of about 413 mrem.

E. Risk to an Individual from Laboratory Operations

In the 1995 Environmental Surveillance Report, we discontinued our practice of calculating and reporting cancer risks associated with doses received as a result of LANL operations. We did this because health effects from radiation exposure have been observed in humans only at doses in excess of 10 rem delivered at high dose rates (HPS 1996). Doses resulting from LANL operations are typically in the low mrem or fractional mrem range, and our conclusion is that there would be no adverse health effects, including cancer, from these doses.

If a reader believes that there is a direct relationship between low radiation dose and cancer, she/he could calculate that risk by multiplying the doses reported in this report by the cancer risk factor (which should be given in terms of excess cancer death risk per mrem of exposure). If one chooses to use the BEIR or EPA risk estimates (factors) to calculate the potential excess cancer rates from a small radiation dose, a sizable body of research indicates that the calculation will overestimate the actual risk.

The risks calculated from natural background radiation and medical and dental radiation can be compared with the incremental risk caused by radiation from Laboratory operations. The average doses to individuals in Los Alamos and White Rock from 1998 Laboratory activities were 0.07 and 0.2 mrem, respectively. The exposure to Los Alamos County residents from Laboratory operations is well within variations in exposure of these people to natural cosmic and terrestrial sources and global fallout. For example, variation in the amount of snow cover and in the solar sunspot cycle can cause a 10-mrem difference from year to year (NCRP 1975).

For Americans, the average lifetime risk is a 1-in-4 chance of contracting cancer and a 1-in-5 chance of dying of cancer (EPA 1979). Assuming one accepts the most conservative risk estimates (BEIR V 1990 and EPA 1994), the incremental risk from exposure to Laboratory operations is negligible.

F. References

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4. Air Surveillance

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Highlights from 1998

Los Alamos National Laboratory (LANL or the Laboratory) operations emit radioactive and nonradioactive air pollutants and direct penetrating radiation into the atmosphere. Air surveillance at Los Alamos includes monitoring emissions, ambient air quality, direct penetrating radiation, and meteorological parameters to determine the air quality impacts of Laboratory operations.

The ambient air quality in and around the Laboratory meets all Environmental Protection Agency (EPA) and Department of Energy (DOE) standards for protecting the public and workers.

During 1998, radioactive air emissions were much less than during 1997 because of a shorter run cycle at Los Alamos Neutron Science Center (LANSCE). Criteria pollutant emissions from industrial sources for 1998 were similar to 1997 emissions. Temperatures were somewhat above normal for 1998. Total precipitation for the year was near average: the result of 2 wet months offsetting 10 dry to near-normal months. Snowfall was less than 20% of 30-year average values.

Radioactive ambient air quality was very similar to 1997. Highest air concentrations caused by Laboratory operations were measured at on-site locations: Technical Area (TA) 54, Area G; TA-21; and TA-16. Several instances of elevated air concentrations were investigated in 1998. These elevated air concentrations were produced by routine Laboratory operations, and in one case, by elevated tritium emissions that resulted from an equipment failure. None of these elevated air concentrations exceeded DOE or EPA protection standards for workers or the public.

During 1998, measurements of direct penetrating radiation were similar to 1997 values. Highest doses are measured at locations on-site at Mortandad Canyon; the LANSCE lagoons; Area A at LANSCE; TA-54, Area G; and TA-21, Area T. An evaluation of alternate direct penetrating radiation measurement systems supports the conclusion that our thermoluminescent dosimeters (TLDs) overrespond by about 50% to low-energy gamma radiation; therefore, actual doses at many TA-54, Area G, locations are much smaller than reported here. We report one full year of albedo dosimeter (neutron) measurements, taken on-site in the vicinity of TA-18. The highest dose, 7.4 mrem, was measured at the entrance to TA-36.

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4. Air Surveillance

A. Ambient Air Sampling *(Craig Eberhart)*

1. Introduction

The radiological air sampling network, referred to as AIRNET, at Los Alamos National Laboratory (LANL or the Laboratory) measures environmental levels of airborne radionuclides that may be released from Laboratory operations. Laboratory emissions include plutonium, americium, uranium, tritium, and activation products. Each AIRNET station collects two types of samples for analysis: a total particulate matter sample and a water vapor sample.

Natural atmospheric and fallout radioactivity levels fluctuate and affect measurements made by the Laboratory's air sampling program. Regional airborne radioactivity is largely composed of fallout from past atmospheric nuclear weapons tests by several countries, natural radioactive constituents from the decay of thorium and uranium attached to dust particles, terrestrial radon diffusing out of the earth, and materials resulting from interactions with cosmic radiation (for example, natural tritiated water vapor produced by interactions of cosmic radiation and stable water). Table 4-1 summarizes regional levels of radioactivity in the atmosphere, which are useful in interpreting air sampling data.

Particulate matter in the atmosphere is primarily caused by the resuspension of soil, which is dependent on meteorological conditions. Windy, dry days can increase the soil resuspension, but precipitation (rain or snow) can wash particulate matter out of the air. Consequently, changing meteorological conditions often cause large daily and seasonal fluctuations in airborne radioactivity concentrations.

The summed dose, as calculated from the measured airborne concentrations, excluding lead-210, which is a naturally occurring radon decay product, is less than the Environmental Protection Agency (EPA) annual dose limit of 10 mrem (see Section 2.B.6.b).

2. Air Monitoring Network

During 1998, the Laboratory operated more than 50 environmental air samplers to sample radionuclides by collecting water vapor and particulate matter. AIRNET sampling locations (Figures 4-1 through 4-3) are categorized as regional, pueblo, perimeter, quality assurance (QA), Technical Area (TA) 21, TA-15 and TA-36, TA-54 (Area G), or other on-site locations. Four regional sampling stations determine regional background and fallout levels of atmospheric radioactivity. These regional stations are located in Española and El Rancho and at two locations in Santa Fe. The pueblo monitoring stations are located at the Pueblos of San Ildefonso and Jemez. In 1998, more than 20 perimeter stations were located within 4 km of the Laboratory boundary.

Because maximum concentrations of airborne releases of radionuclides would most likely occur on-site, more than 30 stations are within the Laboratory boundary. For QA purposes, two samplers are co-located as duplicate samplers, one at TA-54 and one at TA-49. In addition, a backup station is located at East Gate. Stations can also be classified as being inside or outside a controlled area. A controlled area is a posted area that potentially has radioactive materials or elevated radiation fields (DOE 1988). The active waste disposal site at TA-54, Area G, is an example of a controlled area.

3. Sampling Procedures, Data Management, and Quality Assurance

a. Sampling Procedures. Each sampler has a filter that collects a particulate matter sample for counting and radiochemical determinations and a silica gel cartridge that collects water vapor for tritium analysis. The filter and the gel cartridge are typically collected and analyzed biweekly. After collection, the particulate matter filters are cut in half, and one-half is promptly sent to an analytical laboratory for alpha, beta, and gamma analyses. The other half is retained and composited quarterly for isotopic analysis to increase our ability to detect specific radionuclides. Details about the sample collection, sample management, chemical analysis, and data management activities are provided in the AIRNET project plan (ESH-17 1999) and in the numerous procedures through which the plan is implemented.

b. Data Management. The 1998 field data, including timer readings, volumetric airflow rates at the start and stop of the sampling period, and comments pertaining to these data, were recorded electronically in the field on a palm-top microcomputer. We later transferred these data to an electronic table format within the Air Quality Group (ESH-17) AIRNET Microsoft Access database. The analytical data described in the next section were also delivered in electronic form and loaded into the database.

c. Analytical Chemistry. A commercial laboratory analyzed one-half of each 1998 particulate matter filter biweekly for gross alpha and gross beta.

These half filters were also grouped across sites, designated "clumps," and analyzed for potential gamma-emitting radionuclides. For 1998, clumps ranged from three to nine half filters. A composite for isotopic analyses and gamma spectroscopy was prepared quarterly for each Federal Facilities Compliance Agreement station by combining the remaining half filters from the six or seven sampling periods during the quarter. Every two weeks, ESH-17 staff distilled the water from the silica gel cartridges and submitted the distillate to a commercial laboratory for tritium determination using liquid scintillation spectrometry. All analytical procedures meet the requirements of 40 Code of Federal Regulations (CFR) 61, Appendix B, Method 114. A summary of the target minimum detectable amounts (MDA) for the biweekly and quarterly samples is provided in the AIRNET project plan.

d. Laboratory Quality Control Samples. For 1998, ESH-17 and the contractor analytical laboratories maintained a program of blank, spike, duplicate, and replicate analyses. This program provided information on the quality of the data received from analytical chemistry laboratories. The chemistry met the QA requirements for the AIRNET program.

4. Radiochemical Analytical Results

a. Explanation of Reported Doses including Negative Values. All data in this AIRNET section, whether in the tables or the text, that are expressed as a value plus or minus (±) another value represent a 95% confidence interval. Because these confidence intervals are calculated with data from multiple sites and throughout the year, they include not only random measurement and analytical errors, but also seasonal and spatial variations as well. As such, the calculated 95% confidence intervals are overestimated (wider) for the average concentrations and probably represent confidence intervals that are essentially 100%. In addition, the air concentration standard deviations in the tables represent one standard deviation as calculated from the sample data. Finally, all AIRNET concentrations and doses are total measurements without any type of regional background subtractions or corrections unless otherwise stated.

Some values in the tables indicate that we measured negative concentrations of radionuclides in the ambient air, which, of course, is impossible. However, it is possible for the measured concentration to be negative because the measured concentration is a sum of the true value and all random errors. As the true value approaches zero, the measured value approaches the total random errors, which can be negative or positive and overwhelm the true value. Arbitrarily discarding negative values when the true value is near zero will result in overestimated ambient concentrations.

b. Gross Alpha and Beta Radioactivity. We use gross alpha and gross beta analyses primarily to evaluate general radiological air quality and to identify potential trends. If gross activity in a sample is consistent with past observations and background, immediate special analyses for specific radionuclides are not necessary. If the gross analytical results appear to be elevated, then immediate analyses for specific radionuclides may be performed to investigate whether there has been a problem, such as an unplanned release. Gross alpha and beta activity in air exhibits considerable environmental variability and, for alpha measurements, analytical variability. These naturally occurring sources of variability generally overwhelm any Laboratory contributions.

The National Council on Radiation Protection and Measurements (NCRP) estimated the average concentration of long-lived gross alpha activity in air to be 2 fCi per cubic meter. The primary alpha activity is due to polonium-210 (a decay product of radon) and other naturally occurring radionuclides (NCRP 1975, NCRP 1987). The NCRP also estimated average concentration levels of long-lived gross beta activity in air to be 20 fCi per cubic meter. This activity is primarily because of the presence of lead-210 and bismuth-210 (also decay products of radon) and other naturally occurring radionuclides.

More than 1,000 air samples were collected in 1998 and analyzed for gross alpha and gross beta activity. As shown in Table 4-2, the annual mean for all of the stations is less than the NCRP's estimated average (2 fCi per cubic meter) for gross alpha concentrations. Gross alpha activity is almost entirely from the decay of natural radionuclides, primarily radon, and is dependent on variations in natural conditions such as atmospheric pressure, temperature, and soil moisture. The differences among the groups are most likely attributable to these factors (NCRP 1975, NCRP 1987).

Table 4-3 shows gross beta concentrations within and around the Laboratory. These data show variability similar to the gross alpha concentrations. All of the annual averages are below 20 fCi per cubic meter, the NCRP estimated national average for gross beta concentrations.

c. Tritium. Tritium is present in the environment primarily as the result of nuclear weapons tests and natural production by cosmogenic processes (Eisenbud and Gesell 1997). Tritium is released by the Laboratory in curie amounts; in 1998, Laboratory operations released approximately 825 Ci of tritium.

Two factors are needed to estimate ambient levels of tritium as an oxide (water): water vapor concentrations in the air and tritium concentrations in the water vapor. Both of these need to be representative of the true concentrations to obtain an accurate estimate of the ambient tritium concentrations. In early 1998, it was found that the silica gel collection medium was not capable of removing all of the moisture from the atmosphere (Eberhart 1999). Collection efficiencies were as low as 10% to 20% in the middle of the summer when the ambient concentrations of water vapor were the highest. Because 100% of the water was not collected on the silica gel and this water was used to measure water vapor concentrations, the atmospheric water vapor, and therefore tritiated water, has been underestimated. However, data from the meteorological monitoring network provide accurate measurements of atmospheric water vapor concentrations and have been combined with the analytical results to calculate all ambient tritium concentrations in this report. The EPA approved use of this method for compliance calculations of atmospheric tritium concentrations in March 1999.

The sampling results for tritiated water concentrations are presented in Table 4-4. Average annual concentrations for 1998 at all of the on-site stations and perimeter stations were higher than all of the regional and pueblo stations. In addition, every on-site station in technical areas with tritium sources (TA-16, TA-21, and TA-54) was higher than any of the perimeter stations. These data indicate that the Laboratory is a measurable source of tritium based on ambient concentrations. However, all annual mean concentrations at all sampling sites were well below the applicable EPA and the Department of Energy (DOE) guidelines.

The highest off-site annual concentration, 4.2 pCi per cubic meter, was at station 9 in Los Alamos. This represents only 0.3% of the EPA public dose limit. Elevated concentrations were observed at a number of on-site stations, with the highest maximum and annual mean concentrations at station 35 within TA-54, Area G. This sampler is located in a radiological control area, near shafts containing tritium-contaminated waste. The annual mean concentration, 864 pCi per cubic meter, is only 0.004% of the DOE derived air concentration (DAC) for worker exposure.

Elevated mean air concentrations were also seen at other Area G stations, at TA-21 stations, and a station located at TA-16 (25). Station 25 is located near a tritium facility, but the source of the higher tritium levels appears to be off-gassing from some used tritium processing equipment that is stored nearby.

d. Plutonium. While plutonium occurs naturally at extremely low concentrations from cosmic radiation and spontaneous fission (Eisenbud and Gesell 1997), it is not naturally present in measurable quantities in the ambient air. All measurable sources are from plutonium research and development activities, nuclear weapons production and testing, the nuclear fuel cycle, and other related activities. With few exceptions, worldwide fallout from atmospheric testing of nuclear explosives is the primary source of plutonium in ambient air. Four isotopes of concern can be present in the atmosphere: plutonium-238, plutonium-239, plutonium-240, and plutonium-241. Plutonium-241 is not measured because it is a low-energy beta emitter that decays to americium-241, which is measured. This beta decay is not only hard to measure, but the dose is small when compared to americium-241. Plutonium-239 and plutonium-240 are indistinguishable by alpha spectroscopy and are grouped together for analytical purposes.

Sampling results for plutonium-238 are presented in Table 4-5. Most of the analytical results, including the on-site stations, were below the MDA. The highest group summary mean was for the TA-21 stations, with an annual mean of 2.4 aCi per cubic meter. This result corresponds to 0.1% of the EPA public dose limit. The highest annual mean for an individual station was 72 at TA-21 with an annual mean activity of 8.6 aCi per cubic meter, which corresponds to 0.4% of the EPA public dose limit, or 0.04 mrem.

Sampling results for plutonium-239 appear in Table 4-6. As with the plutonium-238 analyses, most of the analytical results were below the MDA. The off-site stations (regional, pueblo, and perimeter stations) all indicate annual means near zero. The highest annual mean at any off-site station occurred at a perimeter sampler in the Los Alamos townsite (07) with an annual concentration of 4.1 aCi/m^3 of plutonium-239, -240. This annual mean concentration corresponds to 0.2% of the EPA's public dose limit, or 0.02 mrem. The stations at TA-21 have an annual group mean concentration of 24 aCi/m^3 with the maximum annual concentration at station 72. This group and site have

the highest averages, yet the maximum concentration is only 4% of the EPA public dose limit. The elevated concentrations at TA-21 may have resulted from decontamination and decommissioning (D&D) materials handling and/or increased ground-level emissions associated with resuspension of soil containing elevated plutonium concentrations.

The TA-54, Area G stations were the only other group of sites that had elevated ambient concentrations with an annual average of about 15 aCi/m^3. The annual average for the highest Area G station (27) dropped from 679 aCi/m^3 in 1997 to 73 aCi/m^3 in 1998 indicating that the mitigation activities, covering the surface contamination with gravel and sand, are still working (for further discussion see 4.A.5.e).

e. Americium. Americium-241, a decay product of plutonium-241, is the primary source of radiation from this isotope of plutonium. Plutonium-241 is released to the environment from nuclear explosions, the nuclear fuel cycle, and other processing of plutonium.

Americium results are presented in Table 4-7. As with plutonium-238 and -239, americium is present in very low concentrations in the environment; this result is indicated by the low annual mean concentrations seen at the regional, pueblo, and perimeter station summaries. All of these off-site measurements are below the MDA. Several elevated measurements at the TA-21 sites may be due to increased ground-level emissions caused by resuspension of dust. The highest concentrations of americium-241 were measured at the TA-54, Area G stations, especially at site 27 where the annual concentration was nearly 4 times higher than the next highest annual concentration. However, the concentration dropped an order of magnitude (469 aCi/m^3 to 48 aCi/m^3) from 1997 to 1998 because of mitigation efforts. The concentration at this Area G site, which is a controlled-access area, is equivalent to a dose of 0.25 mrem or only 0.002% of the applicable DOE DAC.

f. Uranium. Three isotopes of uranium are normally found in nature: uranium-234, uranium-235, and uranium-238. The natural sources of uranium are crustal rocks and soils. Therefore, the ambient concentrations are dependent upon the mass of suspended particulate matter, the uranium concentrations in the parent material, and any local sources. Typical uranium crustal concentrations range from 0.5 ppm to 5 ppm, but local concentrations can be well above this range (Eisenbud and Gesell 1997). Relative isotopic abundances are constant and well characterized. In addition, uranium-238 and uranium-234 are essentially in radioactive equilibrium, with a measured uranium-238 to uranium-234 isotopic activity ratio of 0.993 (as calculated from Walker et al., 1989). Because the uranium normally used at LANL is enriched or depleted, significant changes in this ratio are a good indicator of possible Laboratory impacts. Excess uranium-238 indicates an impact resulting from depleted uranium, whereas excess uranium-234 indicates enriched uranium. Tables 4-8 through 4-10 give uranium results. The quarterly uranium-234 and -238 measurements that are above the MDA for both isotopes are plotted in Figure 4-4 along with a line representing the natural abundance of the two isotopes.

All annual mean concentrations of the three uranium isotopes were well below the applicable EPA and DOE guidelines. The maximum annual concentrations were all measured at site 38, the QA station in Area G. The concentrations at the adjacent station, site 27, were comparable, but slightly lower. The maximum annual uranium-234 concentration was 61 aCi/m^3, which is equivalent to a dose of about 0.08 mrem. The uranium-235 concentration was 4.4 aCi/m^3, equivalent to a dose of less than 0.01 mrem, but three of the four quarterly concentrations were below the MDA, and the remaining value was only equal to the MDA. The uranium-238 concentration was 62 aCi/m^3, which is equivalent to a dose of about 0.07 mrem. Most of the uranium-235 measurements (89%), both on- and off-site, were below the MDA, whereas only about 17% of the uranium-234 and uranium-238 concentrations were below the MDA. Consequently, the uranium-235 data should not be considered quantitative measurements.

Both the regional and pueblo groupings had higher average concentrations of uranium-234 than all of the other groupings except for the TA-54, Area G stations. The higher concentrations for the regional and pueblo groups are caused by increased particulate matter concentrations associated with unpaved roads, unpaved parking lots, other soil disturbances such as construction activities, and even grazing but not any known "man-made" sources of uranium. Dry weather or a drier climate can also increase ambient concentrations of particulate matter and therefore uranium. The regional and pueblo groups were also higher than the perimeter group for uranium-238 but comparable to or lower than on-site concentrations possibly because of various Laboratory sources of uranium-238. Annual mean concentrations for both uranium-234 and

uranium-238 were above 50 aCi/m^3 at four sites for 1998. Three of these sites are located at Area G (27, 38, and 45), and one is located at the Los Alamos County landfill (32).

Figure 4-4 also shows that most of the quarterly uranium measurements above 40 aCi/m^3 were measured at Area G or at the Los Alamos County Landfill. The Area G sites also typically have plutonium and americium concentrations that are above background levels. However, the relative abundance of uranium-238 and uranium-234 indicate that the higher uranium concentrations at Area G and at the County Landfill sites are attributable to natural uranium. Therefore, these higher uranium concentrations are apparently caused by the natural uranium associated with higher levels of resuspended particulate matter from unpaved roads and surface soil disturbances.

Three quarterly samples (Figure 4-4) had uranium-238 to -234 ratios greater than 2.0, indicating excess uranium-238 concentrations. All three of these quarterly samples were collected from site 77 at TA-36. The other quarterly sample from site 77 also had a ratio greater that 2, but the uranium-234 concentration was not above the MDA. The two TA-15 sites nearby, 76 and 78, did not show elevated uranium-238 levels. The average ratio of the four samples from sites 76 and 78 with concentrations above the MDA is 0.998, which is virtually identical to the natural abundance of 0.993. [It should be noted that previous Laboratory publications have listed site 77 as an AIRNET sampler at IJ site in TA-15. This identification is not completely correct. The AIRNET sampler is at IJ site but within the TA-36 boundaries and close to TA-15.]

TA-15 and TA-36 are the primary technical areas for high-explosive testing. Depleted uranium, consisting primarily of uranium-238, has been dispersed for many years by these high-explosive experiments. The 1998 experiments used about 121 kg of depleted uranium, containing approximately 45 millicuries of radioactivity. More than 95% of the 1998 usage occurred at the "Minie" firing site near TA-36-8. Most of the debris from these experiments was deposited on the ground in the vicinity of the firing sites. Limited experimental data show that no more than about 10% of the uranium becomes aerosolized in a high-explosive test (Dahl and Johnson 1977).

Site 77 is the closest AIRNET sampler to "Minie," but the TA-15 sites are not much further away, and they are in the same basic direction from "Minie." If the consistently high uranium-238 at site 77 was due to the 1998 experiments, the other two sites should also show some elevated ratios. The absence of excess uranium-238 at the TA-15 sites and its consistent presence at site 77 indicate that the source is nearby and the impact is localized. Resuspension of the depleted uranium from historical testing at IJ site is the most likely cause.

The 1998 uranium-238 concentration at site 77 was 36 aCi/m^3. If we presume that all of the measured uranium-234 at this site is natural, then about one third or 12 aCi/m^3 of the uranium-238 would also be natural, leaving an estimated LANL contribution of 24 aCi/m^3, which is equivalent to an on-site dose of about 0.03 mrem.

g. Gamma Spectroscopy Measurements. In 1998, gamma spectroscopy measurements were made on groups of filters including analyses of "clumps" (biweekly filters grouped across sites for a single sampling period) and quarterly composites (biweekly filters grouped across time for a single site). Even though there are no action levels *per se* for these gamma emitters, we would investigate any measurement above the MDA, other than beryllium-7 and lead-210, because the existing data indicate that such a measurement is highly unlikely unless there is an accidental release. Instead of action levels, there is a list of minimum detection levels in the AIRNET Sampling and Analysis Plan (ESH-17 1999) for 16 gamma emitters that could either be released from Laboratory operations or occur naturally in measurable amounts (beryllium-7 and lead-210). The minimum levels are equivalent to a dose of 0.5 mrem. The beryllium-7 and lead-210 measurements were the only isotopes above their minimum detectable activities.

Table 4-11 summarizes the "less than" concentrations. The average annual MDA for every radionuclide in this table meets the required minimum detection levels. Because every value used to calculate the average annual MDA was a "less than" value for the 14 radionuclides listed in the table, it is likely that the actual concentrations are three or more standard deviations away from the average MDA. As such, the ambient concentrations, which were calculated from the MDA values, are expressed as "much less" (<<) values.

Table 4-12 summarizes the beryllium-7 and lead-210 data. Both beryllium-7 and lead-210 occur naturally in the atmosphere. Beryllium-7 is cosmogenically produced, whereas lead-210 is a decay product of radon-222. Even though some lead-

210 is related to suspension of terrestrial particulate matter, the primary source is atmospheric decay of radon-222. Because gases produce both radionuclides, they will quickly coalesce into fine particles and also deposit on the surfaces of other suspended particles. The effective source is cosmic for beryllium-7 and terrestrial for lead-210, so the ratio of the two concentrations will vary, but they should be relatively constant for a given sampling period. Because all of the other radionuclides measured by gamma spectroscopy are "less than" values, measurements of these two radionuclides provide verification that the sample analysis process is working properly. In addition, the lead-210 measurements calculate the contribution (38 mrem) to the total dose from radon.

5. Investigation of Elevated Air Concentrations

In 1998, a number of air sampling values exceeded all ESH-17 investigation levels. See the discussion of how we determined investigation levels in the AIRNET sampling and analysis plan (ESH-17 1999). When a measured air concentration exceeds an investigation level, ESH-17 verifies that the calculations were done correctly and that the sampled air concentrations are likely to be representative, i.e., that no cross contamination has taken place. Next, we work with personnel from the appropriate operations to assess potential sources and possible mitigation for the elevated concentrations.

Numerous tritium measurements exceeded action levels because tritium concentrations are now calculated using absolute humidity from meteorological measurements. With this change, more values will be above the action levels because the action levels were set based on the old method that used the mass of water collected on the silica gel. This old method had a negative bias (Eberhart, 1999), so the action levels may be too low when applied to tritium concentrations calculated using absolute humidity. We are revising the action levels with tritium concentrations calculated using absolute humidity.

The following sections identify six incidents of elevated air concentrations that warrant further discussion.

a. Fourth Quarter Investigation of Increased Tritium Concentrations at Technical Area 21. We observed elevated tritium air concentrations at four AIRNET stations surrounding TA-21 and the AIRNET station at Trinity Bible Church during the sampling period beginning September 28 and ending October 12, 1998. The concentrations measured at Station 71 and 72 were approximately 250 pCi/m^3, well below any federal regulations or DOE standards. The maximum annual air concentration measured at any of the TA-21 sites was 15 pCi/m^3, which is equivalent to a dose of 0.1 mrem. The EPA allowable dose limit to a member of the public is 10 mrem per year. Atmospheric dispersion calculations indicate that routine operational releases of tritium from TA-21-209 are the most probable cause of these air concentrations. While the total quantity released during this two-week period was typical of normal operations (19 Ci), the majority of the release occurred during the morning hours (8 am–noon) of two specific days. The meteorological conditions on each of these mornings were similar: light east-southeast winds with an unstable atmosphere. Thus, the winds carried the release toward the west-northwest of the facility and produced the higher than average air concentrations at the monitoring stations. During the next two-week sampling period, air concentrations of tritium at these stations returned to typical values.

b. Evaluation and Investigation of Increased Tritium Concentrations at Technical Areas 16 and 49. Site 25 at TA-16 consistently exceeded historical levels beginning with the sampling period starting May 25, 1998, through the end of the year. These values are higher than any measured since early 1995, with a peak value of 1528 pCi/m^3 and an annual average of 247 pCi/m^3, which is equivalent to a dose of 1.6 mrem. Measurements at the paired TA-49 sites have exceeded investigation levels with a maximum two-week concentration of 32 pCi/m^3. These paired TA-49 sites have also shown increased concentrations since the early summer of 1998. The source or sources of these higher concentrations at the TA-16 and TA-49 samplers have not been positively identified. However, the most likely source is the tritium processing equipment stored near Station 25 or a combination of the equipment and higher emissions from the Weapons Engineering Tritium Facility (WETF) (TA-16-450) for August and September (99 Ci of tritium as tritiated water). One of the dryer beds that removes tritiated water from the WETF exhaust was replaced to reduce emissions. Environmental restoration activities at TA-49 were also considered as potential tritium sources for these high values, but the concentrations from the AIRNET samplers (57 and 58) specifically installed to measure the impact of these activities are lower than the paired TA-49 samplers and much lower than the TA-16 sampler.

c. Investigation of Airborne Tritium at Technical Area 54, Area G. In 1998, tritium air concentrations increased for three stations at the far western end of Area G. Station 36, which is located at the entrance gate to Area G, has shown the largest increase while Stations 50 and 51 have increased slightly. Annual concentrations at site 36 have increased from 5 pCi/m^3 in 1996 to 33 pCi/m^3 in 1997 and finally to 107 pCi/m^3 in 1998. These increases appear to be limited to this area and apparently began in the summer of 1997. Area G personnel believe that these increases are due to disposal of additional tritium-contaminated material. Concentrations at site 36 are well below any federal regulations or DOE standards.

d. First Quarter 1998 Investigation of Increased Tritium Concentrations at Technical Area 21. A number of sites exceeded action levels for tritium. Sites 4, 8, 9, 10, 11, 20, 23, 62, 72, and 73 all exceeded the "Investigate" level, and sites 74 and 75 exceeded the "Alert" level. The two-week concentrations for sites 74 and 75 were 59 and 62 pCi/m^3. These results were due to an unplanned release from TA-21 tritium operations. The release came from the Tritium Science and Fabrication Facility (TSFF), Building 209. The approximate period of release was from January 30, 1998, through February 2, 1998. The facility has reported an estimated release of 59 Ci. This number was determined from the integrating ion chamber stack monitor. Predicted ambient concentrations based on these releases are comparable to the measured concentrations.

e. Elevated Plutonium-239 and Americium-241 Concentrations at Technical Area 54, Area G. The 1998 elevated plutonium-239 and americium-241 concentrations at Area G (sites 27 and 38) are consistent with previous quarterly data that have shown dramatic decreases in ambient concentrations since the middle of 1997. The source of these elevated levels, resuspension of contaminated particulate matter from material unearthed during a trenching operation, was mitigated in 1997 (Kraig and Conrad 1997; ESP 1998). Nevertheless, concentrations have not dropped to pre-1995 levels. Concentrations of uranium-234 and uranium-238 are also typically elevated at these two sites, but the ratio of the two isotopes indicates that the high levels are due to high dust loading and the natural uranium associated with this dust.

f. Investigation of Elevated Plutonium and Americium at Technical Area 21. Two AIRNET sites, 72 and 73, at TA-21 exceeded "Investigate" levels for plutonium and/or americium during the second and third quarters of 1998. The maximum quarterly plutonium-238, plutonium-239, and americium concentrations were 18, 196, and 23 aCi/m^3 respectively. Air concentrations at other TA-21 stations (71 and 74) were elevated slightly to moderately, compared with historical levels, but did not exceed "Investigate" levels. Our general conclusion is that concentrations of americium and plutonium were somewhat elevated at several stations at TA-21 during the second and third quarters of 1998, but concentrations had dropped by the fourth quarter. Other TA-21 stations farther from the sources didn't show increases in these radionuclides during this time frame. Investigation into activities in the vicinity of these stations indicated that various material sorting, transporting, and crushing activities commenced during May and were finished in August. The crushing of the materials was not a likely source for increased air contaminants because the operations were enclosed and the air was filtered before release. We concluded that related activities such as material segregation or increased truck traffic over contaminated debris caused the increase in airborne concentrations of the radionuclides listed above. These increased levels are well below any federal regulations or DOE standards.

6. Long-Term Trends

As noted in the discussion of the 1998 tritium measurements earlier in this chapter, we are now using absolute humidity measurements and tritium analyses of collected water vapor samples to calculate atmospheric tritium concentrations. This change has generally increased estimates of ambient concentrations two to three times. This new calculation has also been used to recalculate historical concentrations. We averaged individual AIRNET sample concentrations from 1989 to 1998 to calculate annual concentrations for on-site, perimeter, pueblo, and regional stations as shown in Figure 4-5 and Figure 4-6. Four sample periods (931018, 940620, 950213, and 950814) were eliminated from these calculations because it appeared that one or more samples from these periods were either contaminated or accidentally switched between sites.

Figure 4-5, which includes on-site and off-site averages, shows that on-site measurements are one to two orders of magnitude higher than off-site measurements. However, the on-site averages should not be considered an unbiased estimate that represents an average Laboratory-wide concentration because many of the samplers are located near known sources of tritium, such as TA-54 and TA-21, to measure their

maximum impact on local ground-level concentrations. The installation or removal of an on-site AIRNET sampler at a location with high concentrations can have a relatively large influence on the overall average. For example, if site 35 next to the tritium waste disposal shafts had been removed at the beginning of 1998, the Laboratory-wide concentrations would have been 23 pCi/m^3 instead of the 53 pCi/m^3 actually measured.

Figure 4-6, which is a graph of the three off-site group averages for 1989–1998, shows that perimeter sites consistently have higher concentrations of tritium than regional or pueblo sites. A similar pattern is apparent when comparing the biweekly concentrations for 1997 and 1998 (Figure 4-7). If the regional and pueblo measurements represent background levels of tritium, the difference between the perimeter stations and these stations represents Laboratory impact. This impact has dropped from about 8 pCi/m^3 to about 2 pCi/m^3 in the last ten years. Because the perimeter samplers are more distant from the tritium sources than the on-site samplers, the impact of adding or removing a single sampler should be smaller. Removal of the highest site for 1998 (site 09) would only have dropped the 1998 perimeter average about 5%. Even though the perimeter average would increase or decrease by adding or removing samplers downwind from the Laboratory, the ten-year off-site concentrations, as shown in Figure 4-6, were probably representative of the off-site concentrations close to the Laboratory.

Many of the regional and pueblo biweekly measurements and all of the annual averages are below the typical MDA for tritium, which is about 2 pCi/m^3. Some of the biweekly measurements are even negative, also demonstrating that the analytical variability is comparable to or larger than the true concentrations. Over the long term, this analytical variability is minimized, and the averages should be good estimates of the ambient tritium concentrations. Consistently positive values for the regional and pueblo averages confirm that these are good estimates of the true concentrations.

B. Stack Air Sampling for Radionuclides *(Scott Miller)*

1. Introduction

Radioactive materials are an integral part of many activities at the Laboratory. Some operations involving these materials may vent emissions to the environment through a stack. We evaluate these operations to determine impacts on the public and the environment. If this evaluation shows that emissions from a stack may potentially result in a member of the public receiving 0.1 mrem or more in a year, this stack must be sampled in accordance with 40 CFR 61, Subpart H, "National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities" (EPA 1989). As of the end of 1998, we have identified 28 stacks as meeting this criterion. An additional three sampling systems were in place to meet DOE requirements for nuclear facilities. Where sampling is not required, emissions are estimated using engineering calculations and radionuclide materials usage information.

2. Sampling Methodology

As of the end of 1998, LANL was continuously sampling 31 stacks (28 of which are required as noted above) for the emission of radioactive material to the ambient air. LANL has categorized its radioactive stack emissions into four areas: (1) particulate matter, (2) vaporous activation products (VAP), (3) tritium, and (4) gaseous/mixed air activation products (G/MAP). For each of these emission types, the Laboratory employs an appropriate sampling method, as described below.

We sample emissions of radioactive particulate matter, generated by operations at facilities such as the Chemistry and Metallurgy Research Building (CMR) and TA-55, using a glass-fiber filter. A continuous sample of stack air is pulled through the filter, where small particles of radioactive material are captured. These samples are analyzed weekly using gross alpha/beta counting and gamma spectroscopy to identify any increase in emissions and to identify short-lived radioactive materials. Every six months, ESH-17 composites these samples for analysis at an off-site laboratory. These composited samples are analyzed to determine the total activity of materials such as uranium-234, -235, -238; plutonium-238, -239, -240; and americium-241. We then use these data to calculate emissions.

VAP emissions, generated by LANSCE operations and by hot-cell activities at CMR and TA-48, are sampled using a charcoal filter or canister. A continuous sample of stack air is pulled through a charcoal filter where vaporous emissions of radionuclides are adsorbed. Gamma spectroscopy determines the amount and identity of the radionuclide(s) present on the filter.

We measure tritium emissions from the Laboratory's tritium facilities using a collection device known as a bubbler. This device enables the Laboratory to determine not only the total amount of tritium released but also whether it is in the elemental (i.e., HT) or oxide (i.e., HTO) form. The bubbler operates by pulling a continuous sample of air from the stack, which is then "bubbled" through three sequential vials containing ethylene glycol. The ethylene glycol collects the water vapor from the sample of air, including any tritium that may be part of a water molecule (HTO). "Bubbling" through these three vials essentially removes all HTO from the air, leaving only elemental tritium. The sample containing the elemental tritium is then passed through a palladium catalyst, which converts the elemental tritium to HTO. The sample is then pulled through three additional vials containing ethylene glycol, which collects the newly formed HTO. The amounts of HTO and HT are determined by analyzing the ethylene glycol for the presence of tritium using liquid scintillation counting (LSC).

Tritium emissions from LANSCE are determined using a silica gel sampler. A sample of stack air is pulled through a cartridge containing silica gel. The silica gel collects the water vapor from the air, including any HTO. The water is distilled from the sample, and the amount of HTO is determined by analyzing the water using LSC. Because the primary source for tritium is activated water, sampling for only HTO is appropriate.

G/MAP emissions resulting from activities at LANSCE are measured using real-time monitoring data. A sample of stack air is pulled through an ionization chamber, which measures the total amount of radioactivity in the sample. Gamma spectroscopy and decay curves identify specific radioisotopes.

3. Sampling Procedure and Data Management

a. Sampling and Analysis. We chose analytical methods for compliance with EPA requirements (40 CFR 61, Appendix B, [EPA 19] Method 114). These methods were selected during 1995, as part of the development of quality assurance project plans for tritium, particulate, and vapor sampling. General discussions on the sampling and analysis methods for each of LANL's emissions follow.

Particulate Matter Emissions. Glass-fiber filters that sample facilities with significant potential for radioactive particulate emissions were generally removed and replaced weekly and transported to the Health Physics Analysis Laboratory (HPAL). Before screening the samples for the presence of alpha and beta activity, the HPAL allowed approximately 72 hours for the short-lived progeny of radon to decay. These initial screening analyses ensured that potential emissions were within normal values. Final analyses were performed after the sample had been allowed to decay for approximately one week. In addition to alpha and beta analyses, the HPAL, using gamma spectroscopy, identified gamma-emitting isotopes in the samples by determining the energy of the gamma photon(s) emitted during radioactive decay. Because the energy of decay is specific to a given radioactive isotope, the HPAL could determine the identity of any isotopes gamma spectroscopy detected. The amount, or activity, of an isotope could then be found by noting the number of photons detected during analysis. Glass-fiber filters from LANSCE were analyzed using only gamma spectroscopy.

Because gross alpha/beta counting cannot identify specific radionuclides, the glass-fiber filters were periodically composited for radiochemical analysis at a commercial laboratory. This program was added in 1995. During 1998, we continued with changes to our composite analyses that were implemented in 1997. Specifically, rather than using isotopic data only to identify radionuclides as was done in the past, these data also quantified these emissions. We consider this method an improvement in sample analysis and in emissions determination. To ensure that the analyses requested (e.g., uranium-234, -235, -238, plutonium-238 and -239, etc.) identify any significant activity in the composites, ESH-17 compares the results of the isotopic analysis to gross activity measurements.

VAP Emissions. Charcoal canisters that sampled facilities with the potential for significant VAP emissions were generally removed and replaced weekly. These samples were transported to the HPAL where gamma spectroscopy, as described above, identified and quantified the presence of vaporous radioactive isotopes.

Tritium Emissions. Tritium bubbler samples that sampled facilities with the potential for significant elemental and oxide tritium emissions were generally collected and transported to the HPAL on a weekly basis. The HPAL added an aliquot of each sample to the appropriate amount of liquid scintillation cocktail and determined the amount of tritium in each vial by LSC.

Silica gel samples sampled facilities with the potential for significant tritium emissions in the oxide form only. These samples were transported to the

Inorganic Trace Analysis Group (CST-9), where the water was distilled from the silica gel, and the amount of tritium in the sample was determined using LSC.

G/MAP Emissions. We used continuous monitoring to record and report G/MAP emissions for two reasons. First, the nature of the emissions is such that standard filter paper and charcoal filters will not collect the radionuclides of interest. Second, the half-lives of these radionuclides are so short that the activity would decay away before any sample could be analyzed off line. The G/MAP monitoring system includes a flow-through ionization chamber in series with a gamma spectroscopy system. Total G/MAP emissions were measured with the ionization chamber. The real-time current measured by this ionization chamber was recorded on a strip chart, and the total amount of charge collected in the chamber over the entire beam operating cycle was integrated on a daily basis. The gamma spectroscopy system analyzed the composition of these G/MAP emissions. Using decay curves and energy spectra to identify the various radionuclides, LANSCE personnel determined the relative composition of the emissions. Decay curves were typically taken one to three times per week based on accelerator operational parameters. When major ventilation configuration changes were made at LANSCE, new decay curves and energy spectra were recorded.

4. Analytical Results

Measurements of Laboratory stack emissions during 1998 totaled 8690 Ci. Of this total, tritium emissions composed 825 Ci, and air activation products from LANSCE contributed 7860 Ci. Combined airborne emissions of materials such as plutonium, uranium, americium, and particulate/vapor activation products were 3.5 Ci. Detailed emissions data for Laboratory buildings with sampled stacks are provided in Table 4-13. Table 4-14 provides a detailed listing of the constituent radionuclides in G/MAP and particulate/vapor activation products (P/VAP) groupings. Table 4-15 presents the half-lives of the radionuclides emitted by the Laboratory. During 1998, nonpoint source emissions of activated air from the LANSCE facility (TA-53) comprised 410 Ci carbon-11 and 17 Ci argon-41, whereas TA-18 contributed 0.2 Ci argon-41.

5. Long-Term Trends

Radioactive emissions from sampled Laboratory stacks are presented in Figures 4-8 through 4-12. These figures illustrate trends in measured emissions for plutonium, uranium, tritium, and G/MAP emissions, respectively. As the figures demonstrate, emissions of these radioactive materials remained relatively constant from 1997 to 1998, with G/MAP emissions showing a slight decrease from previous years.

Figure 4-12 shows the total contribution of each of these emission types to the total Laboratory emissions. It clearly shows that G/MAP emissions and tritium emissions make up the vast majority of radioactive stack emissions.

Because G/MAP emissions account for most of the airborne radioactivity and the FE-3 stack at LANSCE is the primary source of G/MAP isotopes, LANSCE operating personnel have developed and implemented a delay line to reduce these emissions. The delay line operates by removing a large part of the concentrated activated air from the production point at the LANSCE beam stop. This air passes through a 1,200-m tube, allowing approximately 100 minutes of additional decay time (Fuehne 1996). The half-lives of the G/MAP isotopes are quite short, (carbon-10 [19.5 s], carbon-11 [20 min], nitrogen-13 [10 min], nitrogen-16 [7 s], oxygen-14 [71 s], oxygen-15 [123 s], and argon-41 [1.8 h]), so this delay is sufficient to significantly reduce the total activity before returning the air to the stack. A recent study shows that, with the delay line operating, G/MAP emissions were reduced by 28.8%, as compared with similar operations without the benefit of the delay line (Fuehne 1996). Through such efforts, emissions of airborne radioactivity can be reduced while limiting the impact on the operating schedule.

C. Cosmic, Gamma, and Neutron Radiation Monitoring Program *(Allen Treadaway and Jean Dewart)*

1. Introduction

Naturally occurring external penetrating radiation originates from terrestrial and cosmic sources in the form of gamma rays, neutral particles, charged particles, and heavy nuclei. Man-made radiation consists of the same types of radioactive materials. To evaluate natural and man-made direct penetrating radiation, the Laboratory's environmental monitoring program uses thermoluminescent dosimeters (TLDs). Because the natural background radiation doses from terrestrial and cosmic sources are much larger than those from

man-made sources, it is extremely difficult to distinguish man-made sources from the natural background. Several environmental mechanisms contribute to this difficulty.

The terrestrial component results primarily from naturally occurring potassium-40, radionuclides in the thorium and uranium decay chains, and radionuclides deposited as a result of nuclear atmospheric testing (strontium-90, cesium-137, and small amounts of plutonium). Terrestrial radiation varies diurnally, seasonally, and geographically. External penetrating radiation levels can vary from 15% to 25% at a given location because of changes in soil moisture and snow cover that reduce or block the radiation from terrestrial sources (NCRP 1975). Spatial variations result from the soil type and the placement of the dosimeters. For example, those dosimeters that are placed in a narrow canyon will receive radiation from the sidewalls and the floor of the canyon as well as from the cosmic sources (NCRP 1975).

Naturally occurring ionizing radiation from cosmic sources increases with elevation because of reduced atmospheric shielding. At sea level, cosmic sources yield between 25 and 30 mrem/yr. Los Alamos, with a mean elevation of about 7,000 ft, receives about 75 mrem/yr from cosmic sources. However, different locations in the region range in elevation from about 5,800 ft at Española to 9,000 ft at the Pajarito Ski Hill, resulting in a corresponding range of 45 to 90 mrem/yr from cosmic sources. This component can also vary ±10% because of solar modulations (NCRP 1987). These fluctuations along with those from terrestrial sources make it difficult to detect an increase in radiation levels from man-made sources, especially when the increase is small relative to the magnitude of natural fluctuations.

2. Monitoring Network

a. Laboratory and Regional Areas. In an attempt to be able to distinguish any impact from Laboratory operations, we place 95 TLD stations around the Laboratory and in the surrounding communities. This network of dosimeters is divided into three groups. (1) The off-site regional group has five locations ranging from approximately 4 to 38 mi from the Laboratory boundary. These regional stations are located in the neighboring communities of Española, El Rancho, Santa Fe, San Ildefonso Pueblo, and Santa Clara Pueblo. (2) The off-site perimeter group has 28 locations within 2.5 mi of the Laboratory boundary (see Figure 4-13). These stations are placed in residential areas surrounding the Laboratory and in locations where people work. (3) In 1997, the number of on-site monitoring stations was significantly expanded from 27 to 62. The on-site locations are within Laboratory boundaries, generally around operations that may produce ionizing radiation. Most of the additional stations are located near the LANSCE lagoons, TA-50 locations and Mortandad Canyon, and TA-15-Phermex. Other locations include TA-16, TA-36 Kappa Site, TA-33, and TA-8.

b. Technical Area 53. To monitor external penetrating radiation from airborne gases, particles, and vapors resulting from LANSCE operations at TA-53, we use a network of 24 TLD stations. Twelve of these monitoring locations are approximately 0.5 mi north of and downwind from the LANSCE stack. The other 12 TLD stations are located about 5.5 mi from LANSCE, near the southern boundary of the Laboratory, and provide background measurements. Both sets of 12 monitoring locations are placed at approximately the same elevations to help eliminate elevation effects from the cosmic component of the natural radiation.

c. Low-Level Radioactive Waste Management Areas. The Laboratory has 10 inactive and one active (TA-54, Area G) low-level radioactive waste management areas. To monitor external penetrating radiation from these areas, we placed 97 dosimeters around the perimeter of these waste management areas. All waste management areas are controlled-access areas and are not accessible to the general public.

d. Technical Area 18 Albedo Dosimeters. To monitor potential neutron doses from criticality experiments at TA-18, we maintained seven albedo TLD stations on the north, south, and east sides of TA-18. Albedo dosimeters are sensitive to neutrons and use a polyethylene phantom to simulate the human body, which causes neutron backscatter. Because the human body is primarily composed of water, of which hydrogen atoms are a principal component, a significant fraction of intermediate energy and fast neutrons can be slowed down to epithermal energies and backscattered. These backscattered neutrons interact with the neutron-sensitive thermoluminescent material in the albedo dosimeters.

The albedo dosimeters were sited early in the second quarter of 1997 at locations where public access is possible. Two albedo TLDs were placed at each monitoring station. When Pajarito Road closed during TA-18 experiments, the second of the dosimeters was removed and stored at a control location

until the road was reopened. With this procedure, we can compare the total annual dose measured at these stations with the total annual dose that a member of the public could receive at these stations. Two background stations were located at Santa Fe and TA-49. Neutron background is essentially zero.

3. Sampling Procedures, Data Management, and Quality Assurance.

Environmental TLDs used at the Laboratory are composed of natural lithium fluoride (LiF:Mg,Ti) crystals containing 7.5% lithium-6 and 92.5% lithium-7 in the form of 3.2-mm by 3.2-mm by 0.9-mm-thick chips, referred to by their trade name of TLD-100. After exposure to radiation, the TLD chips are collected, then heated in a laboratory to measure the energy stored in the crystal. This stored energy is released in the form of light that is proportional to the amount of radiation the TLD has absorbed. The TLD-100 overresponds to and is extremely sensitive to thermal neutrons but is insensitive to fast or high-energy neutrons. These neutrons must be moderated before TLD-100 chips can measure them. Procedures that outline the QA/QC (quality assurance/quality control) protocols; placement and retrieval of the dosimeters; reading of the dosimeters; data handling, validation, and tabulation can be found in ESH-17's operating procedures (ESH-17 1997).

The Health Physics Measurements Group, ESH-4, provides albedo dosimeters and performs the analysis to measure the neutron dose produced by TA-18 criticality experiments. The dose the albedo dosimeters has measured is multiplied by a neutron correction factor, determined from Bonner sphere measurements made at TA-18, to obtain the actual neutron dose. The DOE Laboratory Accreditation Program for personnel dosimetry has accredited the ESH-4 dosimeter laboratory and the dosimeters.

4. Analytical Results

a. On-Laboratory and Regional Areas. Table 4-16 presents results from these locations. One or more quarters of data are not available for some stations as a result of dosimeter loss, animal damage, processing error, removal requests by the public, as well as new station installation after the beginning of the monitoring year.

The dose equivalent ranges we observed in 1998 are consistent with natural background radiation or the 1997 measurements. We discontinued the regional station at the old Santa Fe armory beginning the second quarter of 1998 because of the continued loss of the sample by theft. Another station for Santa Fe was established at the Buckman Booster Well on Buckman Mesa at that time. The approximate annual dose equivalents at the off-site regional stations ranged from 95 to 140 mrem. The annual measurements at off-site perimeter stations having complete data sets ranged from 100 to 185 mrem.

Annual measurements at on-site stations reporting 100% data completeness ranged from 130 to 450 mrem. Two of the on-site stations recorded much higher doses in 1998 than 1997. In Mortandad Canyon, maximum annual doses rose from 170 mrem for 1997 to 447 mrem for 1998. The maximum annual dose for 1998 is higher because the Mortandad Canyon stations were established as new locations mid-1997, and so the 1997 data represent only two quarters. The monitoring locations near the LANSCE lagoons and stacks indicated doses ranging from 225 to 875 mrem for the monitoring period. These results in Mortandad Canyon and at LANSCE are not representative of potential doses to a member of the public, because these stations are located in areas where public access was restricted.

b. Technical Area 53. The TLD measurements collected at the 12 stations located directly to the north of LANSCE were statistically compared to the 12 background stations located at TA-49. There is no significant difference ($p>.05$) between the site and background TLD measurements. The average dose at the 12 LANSCE stations was 167 ± 10 mrem; the background was 173 ± 10 mrem.

c. Low-Level Radioactive Waste Management Areas. Table 4-17 presents results from monitoring the waste management areas. Among the sites with a complete data set, the annual doses at all inactive waste management areas during 1998 ranged from 135 to 295 mrem. The 1998 annual doses for three stations at TA-21, Area B, and one station at TA35, Area W, are incomplete because of lost dosimeters. One of the monitoring sites at TA-21, Area T, had an elevated reading of 295 ± 17 mrem in 1998. This value is consistent with values observed at this location in the past and is attributed to cesium-137 on the ground at that location.

The 32 environmental surveillance TLDs, at TA-54, Area G, are located within the waste site and along the perimeter fence. The doses measured at this site are representative of storage and disposal opera-

tions that occur at the facility. Evaluation of these data is useful in minimizing occupational doses. However, this is a controlled-access area, and these measurements are not representative of a potential public dose.

The highest waste management area annual average dose for 1998 (213 mrem) was measured at TA-54, Area G, LANL's only active low-level radioactive waste area. During the second half of 1998, several TLD stations at TA-54, Area G in the vicinity of the TWISP (Transuranic Waste Inspectable Storage Project) were higher than the 10-year historical means (1985–1995). The TWISP project entails bringing transuranic (TRU) waste out of below-ground storage for further characterization and ultimate shipment to the Waste Isolation Pilot Plant (WIPP). The radiological constituents of these drums vary greatly, and the drum inventory near the TLDs is changing constantly. As the TWISP project progresses, external penetrating radiation doses near the project are expected to vary. These TLD locations are on-site and not in an area capable of being routinely accessed by members of the public.

During 1998, we had two systems deployed at Area G for monitoring the direct penetrating radiation: TLDs and E-Perms (also known as EICs or electrets). Because of large differences between the two systems at locations near certain TWISP operations, we performed tests to assess TLD and E-Perm response to gamma energy levels similar to those in TRU waste. We found that our TLD dosimeters overrespond by about 50% to low-energy gamma radiation (Kraig et al., 1999). Therefore, some of the results in Table 4-17 reflect this overresponse. Actual doses at many Area G locations are much smaller than reported. We are considering changing the monitoring system at Area G to more accurately monitor the environment.

d. Technical Area 18 Albedo Dosimeters. Table 4-18 presents the monitoring results from the TA-18 albedo dosimeter monitoring network. In all cases except the Santa Fe background result, the doses are presented for all four quarters of 1998. Because of loss or theft, only two quarters of data are available for the Santa Fe background station. We moved this dosimeter to the Santa Fe Buckman Booster well location to improve this situation for the fourth quarter 1998. Neutron doses are presented both for albedo dosimeters that were continuously present and for those removed during road closure. TA-18 operations closed Pajarito Road only once in 1998. Members of the general public could only be exposed at times when Pajarito Road, in front of TA-18, was open. The average neutron dose at the seven stations was 3.4 mrem during 1998 during road open conditions. The maximum dose of 7.2 mrem occurred at the TA-36 Entrance station. Initial studies give a detection limit of approximately 2 mrem for neutron dose measurement. For some stations, the dose during the Pajarito Road open period is greater than the dose during the road closed period. The higher analytical uncertainty of the measurement technique when the dose is near or less than the detection limit causes this apparent anomaly.

D. Nonradioactive Emissions Monitoring *(Jean Dewart and Craig Eberhart)*

1. Introduction

The Laboratory, in comparison to industrial sources such as power plants, semiconductor manufacturing plants, and refineries, is a relatively small source of nonradioactive air pollutants. Thus, opacity monitoring was the only nonradioactive air emissions monitoring performed as required by state or federal air quality regulations during 1998.

Emissions from industrial-type sources are calculated annually as required. These sources are responsible for the majority of all the nonradiological air pollutant emissions at the Laboratory. See Chapter 2 for these data. Research sources vary continuously and have very low emissions. As such, they are not calculated annually; instead, each new or modified research source is addressed in the new source review process.

Because Laboratory nonradioactive air emissions are small, the ambient monitoring program is limited in scope. We conduct particulate matter monitoring during wildland fires in the vicinity of the Laboratory. Ambient sampling is also performed for beryllium to determine the impact of Laboratory beryllium emissions. NMED permits for prescribed burns for forest fire management require particulate matter monitoring; however, the Laboratory conducted no prescribed burns during 1998.

2. Particulate Matter Sampling

We took particulate matter (PM-10) samples (particles less than 10 μm in aerodynamic diameter) in White Rock during the Oso Complex fire in June 1998. The measured values on June 29 and 30 were 19.5 ug/m^3 and 16.2 ug/m^3 respectively. These values

are well below the 24-hour National Ambient Air Quality Standard for PM-10 of 150 ug/m^3.

3. Detonation and Burning of Explosives

a. Total Quantities. The Laboratory tests explosives by detonating them at firing sites operated by the Dynamic Testing Division. The Laboratory maintains monthly shot records that include the type of explosives used as well as other material expended at each site. Table 4-19 summarizes the amounts of expended materials. The Laboratory also burns scrap and waste explosives because of treatment requirements and safety concerns. In 1998, the Laboratory burned 3.6 tons of high explosives.

An assessment of the ambient impacts of high-explosives testing, presented in the Site-Wide Environmental Impact Statement for Los Alamos (DOE 1999), indicates that high-explosives testing produces no adverse air quality impacts. The actual quantities of materials detonated during 1998 were less than the amounts for which impacts are analyzed in the Site-Wide Environmental Impact Statement.

b. Beryllium Quantities. In the early 1990s, we analyzed a limited number of AIRNET samples for beryllium in an attempt to detect potential impact from regulated sources and releases from explosive testing. All values were well below the New Mexico 30-day ambient air quality standard of 10 nanograms per cubic meter. With the recent heightened interest in the health effects of beryllium, AIRNET samples are again being analyzed for this contaminant.

However, there is no longer a New Mexico ambient air quality standard for beryllium for comparison with AIRNET measurements. Therefore, we selected another air quality standard to use for comparison purposes. The National Emission Standards for Hazardous Air Pollutants (NESHAP) standard of 10 ng/m^3 (40 CFR, Part 61, Subpart C, National Emission Standard for Beryllium) can be used, with EPA approval, as an alternative to meeting the emission standard for beryllium. LANL is not required to use this alternative standard because the permitted sources meet the emission standards. In this case, however, we will use it for comparative purposes.

We analyzed quarterly composited samples from 19 sites for beryllium in 1998. These 19 sites were generally selected because they were located near potential beryllium sources or in nearby communities. As Table 4-20 shows, all quarterly concentrations were below 0.04 ng/m^3 except for site 32, the Los Alamos County landfill site, where the average concentration was 0.10 ng/m^3 with a high value of 0.11 ng/m^3. These highest measured values are about one percent of the NESHAP standard. These quarterly concentrations have not been corrected for the small amounts of beryllium present in the filter material.

The highest measured concentrations at the landfill are most likely caused by naturally occurring beryllium in the soils being resuspended by vehicles on dirt roads and earth-moving operations. Based on visual comparisons of the AIRNET filters, the highest concentrations of particulate matter at all AIRNET sampling sites occur at the County landfill. If we presume that the dust being resuspended has elemental concentrations comparable to background concentrations measured at Sigma Mesa in 1979 (Ferenbaugh et al., 1990), the dust would have an average concentration of about 2 ppm beryllium. This beryllium concentration in the dust at the landfill would represent about 55 µg/m^3 of particulate matter, which is comparable to some of the higher concentrations measured in New Mexico (NMED 1997). However, it should be noted that the NMED measurements are from PM-10 samplers that do not collect particles as large as those collected on AIRNET filters.

Earlier in this chapter, we used the ratio of uranium-238 to uranium-234 to detect impacts from LANL because these isotopes are naturally present at a constant ratio. No comparable situation exists for beryllium isotopes, but the ratio of beryllium to other elements or radionuclides will be relatively constant if the local sources of particulate matter are similar. Because most of our sites are located on the Pajarito Plateau, it is likely that there is a direct relationship between the ambient concentrations of uranium-234 and beryllium unless there are naturally-occurring local variations or releases to the environment. The direct correlation of beryllium to uranium-234 for all 1998 samples, as shown in Figure 4-14, indicates not unexpectedly high beryllium concentrations at any of the 19 sampling locations including the TA-15 sites where beryllium has been used in explosives testing.

It is still possible that the high beryllium concentrations at the landfill may be caused by the materials that are being handled, recycled, or buried. Therefore, we plan to collect additional beryllium data at other sites with high dust levels in 1999.

E. Meteorological Monitoring *(Jeff Baars)*

1. Introduction

Meteorological data obtained from the meteorological monitoring network support many Laboratory activities, including emergency management and response, regulatory compliance, safety analysis, and engineering studies. To accommodate the broad demands for weather data at the Laboratory, a wide variety of meteorological variables are measured across the network, including wind, temperature, pressure, relative humidity and dew point, and solar and terrestrial radiation. Details of the meteorological monitoring program are discussed in the Meteorological Monitoring Plan (Baars et al., 1998).

2. Climatology

Los Alamos has a temperate, semiarid mountain climate. However, its climate is strongly influenced by elevation, and large temperature and precipitation differences are observed in the area because of the 1,000-ft change in elevation across the site.

Four distinct seasons occur in Los Alamos. Winters are generally mild, but occasionally winter storms dump large snows and cause frigid temperatures. Spring is the windiest season of the year. Summer is the rainy season, when afternoon convective-type thunderstorms and associated hail and lightning are common. Fall marks the end of the rainy season and a return to drier, cooler, and calmer weather. The climate statistics given below summarize analyses given in Bowen (1990 and 1992).

Several factors influence the temperature in Los Alamos. An elevation of 7,400 ft helps to counter its southerly location, making for cooler summers than those in nearby locations at lower elevations. The sloping nature of the Pajarito Plateau causes cooled air to drain off the plateau at night; thus, nighttime temperatures on the plateau are often warmer than those at lower elevations. Also, the Sangre De Cristo Mountains to the east act as a barrier to arctic air masses affecting the central United States, although the temperature does occasionally drop below 0°F. Another factor affecting the temperature is the lack of moisture in the atmosphere. With less moisture, there is less cloud cover, which allows a significant amount of solar heating during the daytime and radiative cooling during the nighttime. This heating and cooling pattern often causes a wide range of daily temperature (the average diurnal temperature range is 23°F).

Winter temperatures range from 30°F to 50°F during the daytime to -15°F to 25°F during the nighttime. The record low temperature recorded is -18°F. Winter is usually not particularly windy, so extreme wind chills are uncommon.

Summer temperatures range from 70°F to 88°F during the daytime to 50°F to 59°F during the nighttime. Temperatures occasionally will break 90°F. The highest temperature ever recorded was 95°F.

The average annual precipitation (including both rain and water equivalent of frozen precipitation) is 18.73 in. The average snowfall for a year is 58.9 in. Freezing rain and sleet are rare.

Winter precipitation in Los Alamos is often caused by storms entering the US from the Pacific Ocean or by cyclones forming or intensifying in the lee of the Rockies. When these storms cause upslope flow over Los Alamos, large snowfalls can occur. The record snowfall for one day is 22 in., and the record snowfall in one season is 153 in. The snow is usually a dry, fluffy powder, with an average equivalent water to snowfall ratio of 1:20.

The summer rainy season accounts for 37% of the annual precipitation. During the July to August period, afternoon thunderstorms form as a result of the flow of moist air from the Gulf of Mexico and from the Pacific Ocean and because of convection and the orographic uplift as air flows up the sides of the Jemez Mountains. These thunderstorms can bring large downpours, but sometimes they only cause strong winds and dangerous lightning. Hail frequently occurs from these rainy season thunderstorms.

The complex topography also affects winds in Los Alamos, particularly in the absence of a large-scale disturbance affecting the area. Often a distinct daily cycle of the winds can be seen. During the daytime, upslope flow sometimes exists on the Pajarito Plateau, causing an southeasterly component to the winds on the plateau (Figure 4-15). During the nighttime, as the mountain slopes and plateau cool, the flow becomes downslope, causing light westerly and northwesterly flow (see Figure 4-16). Cyclones moving through the area disturb and override the cycle. Flow within the canyons of the Pajarito Plateau is quite complex and very different from flow over the plateau itself.

3. Monitoring Network

A meteorological network of six towers gathers data at the Laboratory (see Fig. 13.1 in the Meteorological Monitoring Plan [Baars et al., 1998]). Four of

the towers are located on mesa tops, one is in a canyon, and one is on top of a local mountain summit. The mesa top towers are at TA-6 (the official measurement site of the Laboratory), TA-49, TA-53, and TA-54, and the canyon tower is located at TA-41. The mountain tower, which was added in late 1997, is on top of Pajarito Mountain. A sodar (sonic detection and ranging) and three precipitation measurement sites also supplement the data collected. The sodar is located at TA-6, and the precipitation measurement sites are located at TA-74, North Community in the Los Alamos townsite, and at TA-16.

4. Sampling Procedures, Data Management, and Quality Assurance

Instruments in the meteorological network are located in areas with adequate exposure to the elements being measured and in open fields to avoid wake effects from trees and buildings on measurements of wind and precipitation. The open fields also provide an unobstructed view of the sky for the upward-directed radiometers that measure long-wave radiation and solar radiation.

Temperature and wind are measured at multiple levels on open-lattice towers, with instruments positioned on west-pointing booms having a length of two times the tower width. The length of the boom helps to decrease wake effects from the tower, as does the west-pointing direction of the booms, because winds from the east are uncommon. The multiple levels give duplicate measurements for QA. Temperature sensors are shielded and aspirated with small fans to minimize radiative heating effects.

Data loggers store meteorological data located at the tower sites and then feed them to a Hewlett Packard workstation through telephone lines. The workstation performs automatic range checking on the data and performs automatic data edits on variables falling outside of preset ranges. Next, electronic time-series plots are constructed. A meteorologist used these plots to perform quality checking on the data. Daily statistical quantities are also included on the time-series plots (such as daily maximum and minimum temperature, total solar radiation, maximum wind gust, etc.) and are also checked for quality.

All meteorological instruments undergo an internal calibration inspection each year. An external audit is performed every two to three years in addition to the annual internal calibration inspection. All instrument calibrations are traceable to the National Institute of Standards and Technology. In 1998, no external calibration inspection was conducted, but the internal calibration inspection found no significant problems.

5. Analytical Results

A graphical summary of the weather at Los Alamos (TA-6) for 1998 is presented in Figure 4-17. This figure shows the average temperature range and precipitation by month, compared with the normals, which are averages based on a 30-year record (1961–1990). Significant departures from normal include above normal temperatures in January, May, and September and below normal temperatures in April. For the year, temperatures were above normal. On June 28 and on June 29, the all-time record high of 95°F was tied. Since 1910, this all-time high has only been observed in Los Alamos on two other occasions (June 22, 1981, and July 11, 1935).

Precipitation was below normal monthly totals in all but three months of the year. Still, much greater than normal precipitation in July and October caused near normal precipitation for the year. A total of 17.30 in. precipitation was recorded, which is 92% of normal. Snowfall was well below normal for the year. Only 11.5 in. of snow was recorded, which is 19% of normal. The total is the second lowest annual snowfall total on record. The lowest snowfall total occurred in 1950 when 8.9 in. of snow was recorded. Precipitation data for 1998 for all recording sites are listed in Table 4-21.

Wind statistics based on 15-min average wind observations at the four towers on the Pajarito Plateau are shown in the form of wind roses in Figures 4-15, 4-16, and 4-18. Wind roses show the percentage of the time the wind blows from each of 16 different wind directions. Also shown in the wind roses are the distributions of wind speed for each of the 16 directions; these are displayed by the shading of the wind rose barbs, as shown in the legend. For example, at TA-49 (Figure 4-15), the most frequent wind direction is southerly, which occurs over 20% of the time. The wind speed for that direction is most often in the 2.5 to 5.0 m/s category, followed by the 5.0 to 7.5 m/s category, the 0.5 to 2.5 m/s category, and the 7.5+m/s category. Winds were calm 0.5% of the time at TA-49 during the daytime in 1998.

During the daytime (Figure 4-15), winds were predominately southerly at all four towers. The nighttime wind roses (Figure 4-16) show that the winds were more westerly and northwesterly, and that

the winds are generally weaker. Figure 4-18 gives wind roses for all times.

F. Quality Assurance Program in the Air Quality Group *(Terry Morgan)*

1. Quality Assurance Program Development

During 1998, ESH-17 revised three quality plans that affect collection and use of air quality compliance data: the group quality management plan, the project plan for the AIRNET system, and the project plan for the Rad-NESHAP project. The revisions reflect a new safety review process, revised methods for filter sample analysis and tritium concentration calculation, and updates and improvements in the stack monitoring and sampling project, respectively. We also revised numerous implementing procedures. QA plans for sampling systems follow the EPA QA-R/5 data quality objective process and incorporate required elements of DOE QA programs. Together, these plans and procedures describe or prescribe all the planned and systematic activities believed necessary to provide adequate confidence that ESH-17 processes perform satisfactorily.

2. Analytical Laboratory Assessments

During 1998, the Wastren-Grand Junction analytical laboratory associated with the DOE's Grand Junction Project Office provided biweekly gross alpha, gross beta, and isotopic gamma analytical services. Biweekly tritium analytical services were provided by Paragon Analytics, Inc., Fort Collins, CO. Analytical chemistry services for alpha-emitting isotopes (americium, plutonium, and uranium) on quarterly composite samples were also provided by Wastren-Grand Junction. Application of the data quality objectives (DQO) process led to definition of analytical chemistry requirements. These requirements were summarized in statements of work used to procure chemical analyses from the commercial laboratories. Before awarding the purchases, ESH-17 evaluated the lab procedures, quality plans, and national performance evaluation program results of these suppliers and found that they met purchase requirements. ESH-17 also performed formal on-site assessments at the Grand Junction and Paragon laboratories during 1998.

Both Paragon and the Grand Junction analytical laboratories participated in national performance evaluation studies during 1998. Two federal agencies, EPA and DOE, sponsor intercomparison studies: the EPA Environmental Monitoring Systems Laboratory in Las Vegas, NV, and the DOE Environmental Measurements Laboratory in New York, NY. The DOE laboratory sends spiked air filters twice a year to the participating laboratories; the EPA laboratory sends spiked filters and water from one to three times a year.

G. Unplanned Releases *(Scott Miller)*

During 1998, there were several instances of emissions of radioactive material exceeding routine levels. In terms of doses, the impacts from these releases were small (<0.1 mrem) and well within the regulatory limits. For 1998, no instances of increased emissions of radioactive particles qualified as unplanned releases. However, two unplanned releases of tritium exceeded expected emission rates as a result of equipment malfunction or nonroutine operations; they are described in more detail below.

An increased release of tritium from TA-21 occurred during the week of January 27, 1998. The total amount of tritium released during the event was approximately 60 Ci, almost 100% HTO. A leaking gasket seal in some process equipment caused this release. This amount of tritium was approximately twice the maximum expected value and was readily detected on our ambient monitoring system around TA-21. A second release occurred from this facility during the week of October 6, 1998, when approximately 30 Ci, approximately 2/3 HTO, was exhausted. This value was barely above the maximum expected value and was a result of some nonroutine tritium handling operations, as opposed to an equipment malfunction.

Occasionally, emissions may increase because of planned operations or maintenance. In general, these increases are small and are considered part of normal operations and are not included as unplanned releases. As an example, emissions of radioactive particles from a stack could be temporarily increased as a result of modifications to a ventilation system such as maintaining a fan motor. Stopping and starting a fan can cause ducting to compress and release. This action can result in materials held up in the ducting being resuspended. Therefore, emissions may be slightly increased for a short period of time.

H. Special Studies

1. Neighborhood Environmental Watch Network Community Monitoring Stations

Neighborhood Environmental Watch Network (NEWNET) is a LANL Dynamic Experiment Division program for radiological monitoring in local communities. It establishes meteorological and external penetrating radiation monitoring stations in local communities and around radiological sources. These stations are the responsibility of a station manager from the local community. The stations have a local readout, and the data can be downloaded onto a personal computer at the station if this process is coordinated with the station manager.

Station measurements include wind speed and wind direction, ambient temperature, relative humidity, and barometric pressure. Also, the station measures gross gamma radiation using a pressurized ion chamber; the radiation sensors are sampled at 5-second intervals and averaged every 15 min.

The data from these stations are transmitted via satellite communications to a downlink station at LANL. The data are converted to engineering units, checked and annotated for transmission errors or station problems, stored in a public access database, and presented on the World Wide Web. The data from all the stations are available to the public with, at most, a 24-hour delay. The NEWNET web page also includes a Spanish language version.

More information about NEWNET and the data is available at *http://newnet.jdola.lanl.gov/* on the World Wide Web.

I. Tables

Table 4-1. Average Background Concentrations of Radioactivity in the Regional Atmosphere

	Units	Northern New Mexico (LANL)[a] 1998	EPA Concentration Limit[b]
Gross Alpha	fCi/m^3	0.8	NA[c]
Gross Beta	fCi/m^3	12.3	NA
^{234}U	aCi/m^3	15.1	7,700
^{235}U	aCi/m^3	1.8	7,100
^{238}U	aCi/m^3	14.0	8,300
^{238}Pu	aCi/m^3	0.1	2,100
^{239,240}Pu	aCi/m^3	0.9	2,000
Tritium	pCi/m^3	0.4	1,500
^{241}Am	aCi/m^3	2.7	1,900

[a]Data from regional air sampling stations operated by LANL at Santa Fe (2 sites), El Rancho, and Española.
[b]Each EPA limit equals 10 mrem/yr.
[c]Not available.

Table 4-2. Airborne Long-Lived Gross Alpha Concentrations for 1998

Station Location	Number of Results	Number of Results <MDA	Maximum (fCi/m^3)	Minimum (fCi/m^3)	Mean (fCi/m^3)	Sample Standard Deviation
Regional Stations						
01 Española	25	1	1.46	0.00	0.84	0.35
03 Santa Fe	25	2	1.71	0.05	0.88	0.41
55 Santa Fe West (Buckman Booster #4)	25	1	1.77	0.22	0.74	0.38
56 El Rancho	24	1	2.05	0.17	0.94	0.44
Pueblo Stations						
41 Pueblo of San Ildefonso	25	1	1.52	0.13	0.87	0.39
42 Jemez Pueblo-tribal office	3	0	0.77	0.47	0.66	0.17
59 Jemez Pueblo-Visitor's Center	16	0	2.68	0.41	1.40	0.57
Perimeter Stations						
04 Barranca School	24	0	1.88	0.25	0.75	0.35
05 Urban Park	25	2	1.56	0.16	0.69	0.34
06 48th Street	25	2	1.24	0.07	0.59	0.29
07 Gulf/Exxon/Shell Station	25	2	1.38	0.11	0.69	0.33
08 McDonalds Restaurant	25	3	1.13	0.07	0.63	0.29
09 Los Alamos Airport	25	3	1.89	0.10	0.62	0.38
10 East Gate	24	3	1.33	0.18	0.61	0.30
11 Well PM-1 (E. Jemez Road)	25	3	1.27	0.09	0.62	0.29
12 Royal Crest Trailer Court	25	4	1.73	–0.05[a]	0.59	0.36
13 Piñon School	25	2	1.09	0.16	0.69	0.27
14 Pajarito Acres	25	2	1.20	0.13	0.66	0.30
15 White Rock Fire Station	25	3	1.20	0.08	0.63	0.32
16 White Rock Nazarene Church	25	1	1.52	0.21	0.67	0.29
17 Bandelier Entrance (Lookout) (Rim)	25	1	1.45	0.07	0.65	0.37
60 LA Canyon	25	2	2.31	–0.01	0.70	0.43
61 LA Hospital	25	0	1.44	0.34	0.84	0.29
62 Trinity Bible Church	24	2	1.37	0.14	0.67	0.31
63 Monte Rey South	25	2	1.18	0.13	0.66	0.30
90 East Gate-Backup	1	0	0.25	0.25	0.25	
TA-15 and TA-36 Stations						
76 TA-15-61	24	4	3.27	0.03	0.78	0.74
77 TA-36-IJ Site	25	2	1.27	0.13	0.62	0.29
78 TA-15-N	25	4	1.59	0.07	0.54	0.32
TA-21 Stations						
20 TA-21 Area B	25	2	1.30	0.20	0.74	0.32
71 TA-21.01 (NW Bldg 344)	23	1	1.24	0.00	0.75	0.34
72 TA-21.02 (N Bldg 344)	25	0	3.63	0.27	0.93	0.89
73 TA-21.03 (NE Bldg 344)	25	1	1.96	0.11	0.81	0.40
74 TA-21.04 (SE Bldg 344)	25	0	1.60	0.23	0.71	0.33
75 TA-21.05 (S Bldg 344)	25	2	1.29	0.16	0.68	0.30

Table 4-2. Airborne Long-Lived Gross Alpha Concentrations for 1998 (Cont.)

Station Location	Number of Results	Number of Results <MDA	Maximum (fCi/m^3)	Minimum (fCi/m^3)	Mean (fCi/m^3)	Sample Standard Deviation
TA-54 Area G Stations						
27 Area G (by QA)	25	0	2.48	0.66	1.27	0.51
34 Area G-1 (behind trailer)	25	1	1.84	0.25	0.95	0.42
35 Area G-2 (back fence)	25	0	2.06	0.21	0.76	0.44
36 Area G-3 (by office)	25	1	1.37	0.25	0.71	0.24
45 Area G/South East Perimeter	25	0	1.68	0.53	1.10	0.35
47 Area G/North Perimeter	25	1	1.35	0.20	0.81	0.29
50 Area G-expansion	25	0	1.96	0.43	1.08	0.41
51 Area G-expansion pit	25	0	2.10	0.32	0.99	0.41
Other On-Site Stations						
23 TA-52 Beta Site	25	1	1.25	0.22	0.71	0.29
25 TA-16-450	25	0	1.33	0.34	0.77	0.25
26 TA-49	25	1	1.18	0.08	0.67	0.28
30 Pajarito Booster 2 (P-2)	25	0	1.36	0.36	0.67	0.24
31 TA-3	25	0	1.06	0.25	0.65	0.22
32 County Landfill (alias TA-48)	25	0	1.97	0.56	1.08	0.42
33 TA-49 Area AB	9	0	1.15	0.37	0.89	0.25
49 Pajarito Road (TA-36)	25	0	1.14	0.23	0.68	0.26
54 TA-33 East	25	1	1.21	0.20	0.60	0.23
57 TA-49 Area AB 2A North	9	0	1.27	0.31	0.78	0.31
58 TA-49 Area AB Test Well 5A	9	0	1.52	0.41	0.84	0.33
QA Stations						
38 TA-54 Area G (adjacent to station 27)	22	0	2.47	0.58	1.26	0.43
39 TA-49 (adjacent to station 26)	25	3	1.58	0.07	0.58	0.34

Group Summaries

Station Location	Number of Results	Number of Results <MDA	Maximum (fCi/m^3)	Minimum (fCi/m^3)	Mean (fCi/m^3)	95% Confidence Interval[b]	Sample Standard Deviation
Regional	99	5	2.05	0.00	0.85	±0.08	0.40
Pueblo	44	1	2.68	0.13	1.05	±0.16	0.52
Perimeter	448	37	2.31	–0.05	0.66	±0.03	0.32
TA-15 and TA-36	74	10	3.27	0.03	0.65	±0.11	0.49
TA-21	148	6	3.63	0.00	0.77	±0.04	0.48
TA-54 Area G	200	3	2.48	0.20	0.96	±0.06	0.42
Other On-Site	227	3	1.97	0.08	0.74	±0.04	0.31

Concentration guidelines are not available for gross alpha concentrations.

[a]See Appendix B for an explanation of negative numbers.

[b]95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.

Table 4-3. Airborne Long-Lived Gross Beta Concentrations for 1998

Station Location	Number of Results	Number of Results <MDA	Maximum (fCi/m^3)	Minimum (fCi/m^3)	Mean (fCi/m^3)	Sample Standard Deviation
Regional Stations						
01 Española	25	0	21.2	8.5	12.3	3.2
03 Santa Fe	25	0	18.8	5.1	11.0	3.6
55 Santa Fe West (Buckman Booster #4)	25	0	22.4	9.2	12.7	3.3
56 El Rancho	24	0	23.2	9.0	13.3	3.7
Pueblo Stations						
41 Pueblo of San Ildefonso	25	0	16.6	8.2	11.4	2.5
53 Jemez Pueblo-tribal office	3	0	12.0	6.6	9.1	2.7
59 Jemez Pueblo-Visitor's Center	16	0	17.6	5.7	10.6	3.4
Perimeter Stations						
04 Barranca School	24	0	19.7	7.4	11.9	3.0
05 Urban Park	25	0	17.9	7.8	10.7	2.4
06 48th Street	25	0	16.1	6.9	10.0	2.3
07 Gulf/Exxon/Shell Station	25	0	16.2	8.5	11.3	2.2
08 McDonalds Restaurant	25	0	16.3	6.7	11.2	2.5
09 Los Alamos Airport	25	0	16.9	8.4	11.5	2.3
10 East Gate	24	0	17.8	7.6	11.5	2.6
11 Well PM-1 (E. Jemez Road)	25	0	16.7	8.4	11.7	2.2
12 Royal Crest Trailer Court	25	0	17.2	8.8	12.9	2.4
13 Piñon School	25	0	20.6	7.5	11.9	3.0
14 Pajarito Acres	25	0	19.0	7.4	11.3	3.0
15 White Rock Fire Station	25	0	17.6	7.2	11.2	2.7
16 White Rock Nazarene Church	25	0	16.4	7.9	11.5	2.3
17 Bandelier Entrance (Lookout) (Rim)	25	0	20.4	7.7	12.2	3.2
60 LA Canyon	25	0	18.7	8.2	11.3	2.5
61 LA Hospital	25	0	20.2	7.7	11.4	2.6
62 Trinity Bible Church	24	0	19.4	8.8	12.5	3.0
63 Monte Rey South	25	0	19.3	6.4	11.7	2.7
90 East Gate-Backup	1	0	11.5	11.5	11.5	
TA-15 and TA-36 Stations						
76 TA-15-61	24	0	19.4	7.9	10.8	2.8
77 TA-36-IJ Site	25	0	19.7	8.1	11.8	2.8
78 TA-15-N	25	0	16.9	7.6	11.7	2.7
TA-21 Stations						
20 TA-21 Area B	25	0	16.4	7.9	11.5	2.3
71 TA-21.01 (NW Bldg 344)	23	0	17.7	9.3	11.7	2.7
72 TA-21.02 (N Bldg 344)	25	0	32.5	8.5	13.0	5.1
73 TA-21.03 (NE Bldg 344)	25	0	19.5	8.1	11.8	2.6
74 TA-21.04 (SE Bldg 344)	25	0	17.7	8.2	11.6	2.3
75 TA-21.05 (S Bldg 344)	25	0	19.6	9.2	12.5	2.5

Table 4-3. Airborne Long-Lived Gross Beta Concentrations for 1998 (Cont.)

Station Location	Number of Results	Number of Results <MDA	Maximum (fCi/m^3)	Minimum (fCi/m^3)	Mean (fCi/m^3)	Sample Standard Deviation
TA-54 Area G Stations						
27 Area G (by QA)	25	0	19.7	3.3	10.4	4.1
34 Area G-1 (behind trailer)	25	0	22.1	7.5	12.1	3.3
35 Area G-2 (back fence)	25	0	21.9	8.1	11.7	3.4
36 Area G-3 (by office)	25	0	18.1	8.0	11.8	2.8
45 Area G/South East Perimeter	25	0	24.7	6.6	11.8	3.7
47 Area G/North Perimeter	25	0	20.9	9.1	13.3	2.8
50 Area G-expansion	25	0	24.2	6.5	12.6	4.1
51 Area G-expansion pit	25	0	18.5	8.5	12.4	3.0
Other On-Site Stations						
23 TA-52 Beta Site	25	0	18.5	8.8	11.8	2.0
25 TA-16-450	25	0	19.1	7.6	11.2	2.6
26 TA-49	25	0	15.4	8.5	11.0	1.9
30 Pajarito Booster 2 (P-2)	25	0	19.0	7.6	11.5	2.7
31 TA-3	25	0	19.1	7.0	11.1	2.8
32 County Landfill (alias TA-48)	25	0	17.8	4.2	9.7	3.9
33 TA-49 Area AB	9	0	20.3	11.1	14.3	2.9
49 Pajarito Road (TA-36)	25	0	21.3	7.2	12.5	3.2
54 TA-33 East	25	0	23.6	8.4	12.9	3.6
57 TA-49 Area AB 2A North	9	0	18.2	9.8	13.8	2.9
58 TA-49 Area AB Test Well 5A	9	0	19.6	9.6	13.0	3.1
QA Stations						
38 TA-54 Area G (adjacent to station 27)	22	0	18.6	3.5	10.8	3.7
39 TA-49 (adjacent to station 26)	25	0	15.4	6.8	9.8	2.4

Group Summaries

Station Location	Number of Results	Number of Results <MDA	Maximum (fCi/m^3)	Minimum (fCi/m^3)	Mean (fCi/m^3)	95% Confidence Interval[a]	Sample Standard Deviation
Regional	99	0	23.2	5.1	12.3	±0.7	3.5
Pueblo	44	0	17.6	5.7	10.9	±0.9	2.9
Perimeter	448	0	20.6	6.4	11.5	±0.2	2.6
TA-15 and TA-36	74	0	19.7	7.6	11.5	±0.6	2.7
TA-21	148	0	32.5	7.9	12.0	±0.2	3.1
TA-54 Area G	200	0	24.7	3.3	12.0	±0.5	3.4
Other On-Site	227	0	23.6	4.2	11.7	±0.4	3.1

Concentration guidelines are not available for gross beta concentrations.

[a] 95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.

Table 4-4. Airborne Tritium as Tritiated Water Concentrations for 1998

Station Location	Number of Results	Number of Results <MDA	Maximum (pCi/m^3)	Minimum (pCi/m^3)	Mean (pCi/m^3)	Sample Standard Deviation
Regional Stations						
01 Española	25	23	1.5	–1.3[a]	0.2	0.6
03 Santa Fe	25	19	3.0	–1.0	0.5	1.0
55 Santa Fe West (Buckman Booster #4)	25	21	2.0	–0.5	0.4	0.6
56 El Rancho	24	22	2.9	–1.2	0.3	0.9
Pueblo Stations						
41 Pueblo of San Ildefonso	25	22	2.1	–1.2	0.6	0.8
53 Jemez Pueblo-tribal office	3	3	0.3	–0.4	0.0	0.4
59 Jemez Pueblo-Visitor's Center	16	13	2.4	–1.6	0.5	1.0
Perimeter Stations						
04 Barranca School	28	13	9.3	0.1	1.7	1.9
05 Urban Park	25	20	7.3	–0.6	0.9	1.4
06 48th Street	25	22	3.2	–0.9	0.8	1.0
07 Gulf/Exxon/Shell Station	25	12	4.0	–0.6	1.7	1.0
08 McDonalds Restaurant	25	2	11.5	0.0	3.6	2.5
09 Los Alamos Airport	25	1	21.8	1.3	4.2	4.1
10 East Gate	22	3	14.3	0.6	3.9	3.1
11 Well PM-1 (E. Jemez Road)	25	13	9.2	0.5	1.9	1.9
12 Royal Crest Trailer Court	25	8	3.8	0.5	2.0	1.1
13 Piñon School	25	5	9.2	0.4	2.9	2.3
14 Pajarito Acres	25	16	4.5	–0.8	1.3	1.2
15 White Rock Fire Station	25	10	5.5	0.0	2.0	1.5
16 White Rock Nazarene Church	25	8	12.4	0.2	3.3	2.9
17 Bandelier Entrance (Lookout) (Rim)	25	15	4.4	–0.3	1.3	1.0
60 LA Canyon	25	9	8.0	–0.5	2.4	1.8
61 LA Hospital	25	13	3.1	–0.3	1.4	0.9
62 Trinity Bible Church	25	7	49.8	0.5	4.1	9.6
63 Monte Rey South	25	14	4.2	–0.5	1.5	1.3
90 East Gate-Backup	3	0	6.3	2.7	5.1	2.0
TA-15 and TA-36 Stations						
76 TA-15-61	24	7	5.0	0.0	2.1	1.5
77 TA-36-IJ Site	25	11	4.2	–0.3	1.7	1.3
78 TA-15-N	25	11	7.1	–0.1	2.0	1.9
TA-21 Stations						
20 TA-21 Area B	25	0	99.7	1.2	8.6	19.5
71 TA-21.01 (NW Bldg 344)	24	1	256.2	0.9	13.9	51.6
72 TA-21.02 (N Bldg 344)	25	0	247.4	2.0	14.7	48.6
73 TA-21.03 (NE Bldg 344)	25	0	77.6	3.6	13.5	15.0
74 TA-21.04 (SE Bldg 344)	25	0	58.7	2.4	8.0	10.9
75 TA-21.05 (S Bldg 344)	25	0	62.4	2.8	8.9	11.5

Table 4-4. Airborne Tritium as Tritiated Water Concentrations for 1998 (Cont.)

Station Location	Number of Results	Number of Results <MDA	Maximum (pCi/m^3)	Minimum (pCi/m^3)	Mean (pCi/m^3)	Sample Standard Deviation
TA-54 Area G Stations						
27 Area G (by QA)	25	0	106.0	2.6	31.4	30.8
34 Area G-1 (behind trailer)	25	1	64.2	–0.4	22.3	17.9
35 Area G-2 (back fence)	25	0	3368.2	18.4	864.3	1041.9
36 Area G-3 (by office)	25	0	247.8	17.5	110.8	82.6
45 Area G/South East Perimeter	25	0	47.4	1.7	17.2	14.5
47 Area G/North Perimeter	25	0	89.3	3.3	26.3	25.4
50 Area G-expansion	25	0	55.3	2.6	14.3	13.4
51 Area G-expansion pit	25	0	37.6	2.2	15.6	10.9
Other On-Site Stations						
23 TA-52 Beta Site	25	7	21.5	–0.3	3.3	4.3
25 TA-16-450	25	0	1528.7	38.3	246.6	349.0
26 TA-49	25	1	25.5	0.8	7.5	7.1
30 Pajarito Booster 2 (P-2)	25	11	7.3	–0.2	2.0	1.7
31 TA-3	25	5	5.7	0.2	2.7	1.5
32 County Landfill (alias TA-48)	25	11	4.5	0.0	1.7	1.1
33 TA-49 Area AB	9	0	17.7	2.3	6.6	4.9
49 Pajarito Road (TA-36)	25	9	5.2	–0.1	1.9	1.4
54 TA-33 East	25	15	4.1	–0.7	1.3	1.3
57 TA-49 Area AB 2A North	9	0	15.1	1.9	6.1	3.9
58 TA-49 Area AB Test Well 5A	9	1	15.1	1.4	5.8	4.1
QA Stations						
38 TA-54 Area G (adjacent to station 27)	22	0	117.4	3.4	32.7	32.1
39 TA-49 (adjacent to station 26)	25	1	32.3	0.5	7.7	7.5

Group Summaries

Station Location	Number of Results	Number of Results <MDA	Maximum (pCi/m^3)	Minimum (pCi/m^3)	Mean (pCi/m^3)	95% Confidence Interval[b]	Sample Standard Deviation
Regional	99	85	3.0	–1.3	0.4	±0.2	0.8
Pueblo	44	38	2.4	–1.6	0.5	±0.3	0.9
Perimeter	450	191	49.8	–0.9	2.3	±0.2	3.1
TA-15 and TA-36	75	29	7.1	–0.3	1.9	±0.4	1.6
TA-21	149	1	256.2	0.9	11.2	±5.0	30.7
TA-54 Area G	200	1	3368.2	–0.4	137.8	±63.3	456.8
Other On-Site	227	60	1528.7	–0.7	30.1	±17.8	137.0

Concentration Guidelines

DOE Derived Air Concentation (DAC) Guide for workplace exposure is 20,000,000 pCi/m^3. See Appendix A.
EPA 40 CFR 61 Concentration Guide 1,500 pCi/m^3.

[a] See Appendix B for an explanation of negative numbers.

[b] 95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.

Table 4-5. Airborne Plutonium-238 Concentrations for 1998

Station Location	Number of Results	Number of Results <MDA	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	Sample Standard Deviation
Regional Stations						
01 Española	4	2	0.8	–0.2[a]	0.1	0.5
03 Santa Fe	4	3	0.4	–0.3	0.1	0.3
55 Santa Fe West (Buckman Booster #4)	4	1	0.3	–0.3	–0.1	0.2
56 El Rancho	4	3	0.5	–0.6	0.2	0.6
Pueblo Stations						
41 Pueblo of San Ildefonso	4	1	0.3	–0.5	–0.2	0.3
59 Jemez Pueblo-Visitor's Center	3	0	–0.1	–0.6	–0.4	0.3
Perimeter Stations						
04 Barranca School	4	3	0.6	–0.1	0.2	0.3
05 Urban Park	4	3	0.2	–0.1	0.1	0.2
06 48th Street	4	1	0.0	–0.4	–0.2	0.2
07 Gulf/Exxon/Shell Station	4	2	0.8	–0.4	0.2	0.6
08 McDonalds Restaurant	4	2	0.3	–0.4	–0.1	0.3
09 Los Alamos Airport	4	4	0.9	0.0	0.4	0.4
10 East Gate	4	1	0.2	–0.1	0.0	0.2
11 Well PM-1 (E. Jemez Road)	4	2	1.2	–0.5	0.2	0.7
12 Royal Crest Trailer Court	4	4	0.8	0.0	0.3	0.3
13 Piñon School	4	4	0.6	0.0	0.3	0.3
14 Pajarito Acres	4	3	0.3	–0.1	0.1	0.2
15 White Rock Fire Station	4	1	1.0	–0.6	0.0	0.7
16 White Rock Nazarene Church	4	4	0.7	0.0	0.4	0.3
17 Bandelier Entrance (Lookout) (Rim)	4	4	1.5	0.1	0.7	0.6
60 LA Canyon	4	1	0.0	–0.6	–0.4	0.3
61 LA Hospital	4	3	0.4	–0.3	0.0	0.3
62 Trinity Bible Church	4	1	0.1	–0.3	–0.1	0.2
63 Monte Rey South	4	3	0.3	–0.3	0.0	0.2
TA-15 and TA-36 Stations						
76 TA-15-61	4	1	0.6	–0.5	–0.2	0.5
77 TA-36-IJ Site	4	2	0.5	–0.1	0.1	0.3
78 TA-15-N	4	4	1.9	0.0	0.5	0.9
TA-21 Stations						
20 TA-21 Area B	4	3	0.9	–0.6	0.1	0.6
71 TA-21.01 (NW Bldg 344)	4	3	2.8	–0.4	1.0	1.4
72 TA-21.02 (N Bldg 344)	4	2	17.6	1.0	8.6	8.8
73 TA-21.03 (NE Bldg 344)	4	2	8.1	0.3	3.5	3.8
74 TA-21.04 (SE Bldg 344)	4	4	1.7	0.0	0.8	0.8
75 TA-21.05 (S Bldg 344)	4	4	0.6	0.0	0.3	0.3

Table 4-5. Airborne Plutonium-238 Concentrations for 1998 (Cont.)

Station Location	Number of Results	Number of Results <MDA	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	Sample Standard Deviation
TA-54 Area G Stations						
27 Area G (by QA)	4	4	5.0	1.8	2.7	1.5
34 Area G-1 (behind trailer)	4	4	1.7	0.2	0.9	0.7
35 Area G-2 (back fence)	4	2	0.4	–0.4	0.0	0.4
36 Area G-3 (by office)	4	4	0.6	0.1	0.3	0.2
45 Area G/South East Perimeter	4	4	1.4	0.3	0.8	0.6
47 Area G/North Perimeter	4	3	1.0	–0.3	0.5	0.6
50 Area G-expansion	4	3	1.9	–0.1	0.6	0.9
51 Area G-expansion pit	4	4	0.9	0.0	0.4	0.5
Other On-Site Stations						
23 TA-52 Beta Site	4	2	0.1	–0.6	–0.2	0.3
25 TA-16-450	4	4	0.1	0.0	0.0	0.1
26 TA-49	4	3	0.7	–0.1	0.3	0.4
30 Pajarito Booster 2 (P-2)	4	4	1.0	0.0	0.3	0.5
31 TA-3	4	3	1.0	–1.3	0.1	1.0
32 County Landfill (alias TA-48)	4	2	0.2	–0.1	0.0	0.1
33 TA-49 Area AB	2	1	0.8	–0.1	0.3	0.7
49 Pajarito Road (TA-36)	4	1	0.3	–0.4	–0.2	0.3
54 TA-33 East	4	2	0.1	–0.5	–0.1	0.3
57 TA-49 Area AB 2A North	2	2	0.6	0.3	0.4	0.2
58 TA-49 Area AB Test Well 5A	2	2	1.3	1.0	1.2	0.2
QA Stations						
38 TA-54 Area G (adjacent to station 27)	4	4	5.1	1.5	3.7	1.7
39 TA-49 (adjacent to station 26)	4	2	0.5	–0.4	0.1	0.5

Group Summaries

Station Location	Number of Results	Number of Results <MDA	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	95% Confidence Interval[b]	Sample Standard Deviation
Regional	16	9	0.8	–0.6	0.1	0.2	0.4
Pueblo	7	1	0.3	–0.6	–0.3	0.3	0.3
Perimeter	72	46	1.5	–0.6	0.1	0.1	0.4
TA-15 and TA-36	12	7	1.9	–0.5	0.2	0.4	0.7
TA-21	24	18	17.6	–0.6	2.4	2.0	4.7
TA-54 Area G	32	28	5.0	–0.4	0.8	0.4	1.0
Other On-Site	38	26	1.3	–1.3	0.1	0.2	0.5

Concentration Guidelines

DOE Derived Air Concentation (DAC) Guide for workplace exposure is 3,000,000 aCi/m^3. See Appendix A.
EPA 40 CFR 61 Concentration Guide 2,100 aCi/m^3.

[a] See Appendix B for an explanation of negative numbers.

[b] 95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.

Table 4-6. Airborne Plutonium-239 Concentrations for 1998

Station Location	Number of Results	Number of Results <MDA	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	Sample Standard Deviation
Regional Stations						
01 Española	4	3	1.3	–0.5[a]	0.7	0.8
03 Santa Fe	4	3	3.6	–0.1	1.1	1.8
55 Santa Fe West (Buckman Booster #4)	4	3	1.6	0.0	1.0	0.7
56 El Rancho	4	3	1.3	0.5	0.9	0.4
Pueblo Stations						
41 Pueblo of San Ildefonso	4	4	2.1	0.1	0.8	0.8
59 Jemez Pueblo-Visitor's Center	3	3	1.3	0.0	0.5	0.7
Perimeter Stations						
04 Barranca School	4	4	1.3	0.4	0.7	0.4
05 Urban Park	4	4	1.9	0.0	0.6	0.8
06 48th Street	4	3	2.0	–0.1	0.8	0.9
07 Gulf/Exxon/Shell Station	4	3	9.2	0.7	4.1	3.7
08 McDonalds Restaurant	4	4	1.4	0.4	0.7	0.5
09 Los Alamos Airport	4	4	3.8	0.7	3.0	1.5
10 East Gate	4	3	1.5	–0.4	0.7	0.8
11 Well PM-1 (E. Jemez Road)	4	3	2.8	–0.4	0.9	1.4
12 Royal Crest Trailer Court	4	3	2.5	–0.8	0.8	1.4
13 Piñon School	4	4	0.3	0.1	0.2	0.1
14 Pajarito Acres	4	3	1.7	–0.1	1.1	0.9
15 White Rock Fire Station	4	4	2.9	0.6	1.4	1.0
16 White Rock Nazarene Church	4	3	1.7	–0.1	0.7	0.8
17 Bandelier Entrance (Lookout) (Rim)	4	4	1.3	0.3	0.9	0.5
60 LA Canyon	4	3	1.5	–0.4	0.7	0.8
61 LA Hospital	4	4	2.2	0.8	1.7	0.6
62 Trinity Bible Church	4	4	1.7	0.4	1.2	0.6
63 Monte Rey South	4	4	1.3	0.1	0.8	0.6
TA-15 and TA-36 Stations						
76 TA-15-61	4	3	2.0	–0.3	0.5	1.0
77 TA-36-IJ Site	4	4	0.7	0.0	0.4	0.4
78 TA-15-N	4	3	1.6	–0.3	0.7	0.8
TA-21 Stations						
20 TA-21 Area B	4	4	1.6	0.0	0.8	0.8
71 TA-21.01 (NW Bldg 344)	4	2	20.7	1.9	9.9	9.0
72 TA-21.02 (N Bldg 344)	4	1	196.4	5.1	78.2	89.3
73 TA-21.03 (NE Bldg 344)	4	2	84.4	4.1	35.4	38.2
74 TA-21.04 (SE Bldg 344)	4	1	21.4	4.3	14.8	7.5
75 TA-21.05 (S Bldg 344)	4	4	4.5	1.0	2.1	1.6

Table 4-6. Airborne Plutonium-239 Concentrations for 1998 (Cont.)

Station Location	Number of Results	Number of Results <MDA	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	Sample Standard Deviation
TA-54 Area G Stations						
27 Area G (by QA)	4	0	116.9	27.3	72.6	36.8
34 Area G-1 (behind trailer)	4	3	8.1	1.7	3.8	2.9
35 Area G-2 (back fence)	4	4	0.8	0.0	0.5	0.3
36 Area G-3 (by office)	4	4	4.5	0.7	2.1	1.7
45 Area G/South East Perimeter	4	1	76.8	5.9	26.6	33.6
47 Area G/North Perimeter	4	2	17.4	1.0	7.9	6.9
50 Area G-expansion	4	2	7.9	1.4	4.6	3.4
51 Area G-expansion pit	4	2	9.1	2.0	5.3	3.2
Other On-Site Stations						
23 TA-52 Beta Site	4	4	2.2	0.3	1.0	0.8
25 TA-16-450	4	4	1.6	0.1	0.9	0.6
26 TA-49	4	4	1.1	0.3	0.6	0.3
30 Pajarito Booster 2 (P-2)	4	3	0.7	–0.6	0.3	0.6
31 TA-3	4	3	0.6	–0.2	0.3	0.4
32 County Landfill (alias TA-48)	4	3	12.8	1.1	5.3	5.2
33 TA-49 Area AB	2	2	2.0	1.1	1.6	0.7
49 Pajarito Road (TA-36)	4	3	0.3	–0.2	0.1	0.2
54 TA-33 East	4	4	2.2	0.2	1.4	0.9
57 TA-49 Area AB 2A North	2	1	0.4	–0.8	0.4	1.7
58 TA-49 Area AB Test Well 5A	2	1	0.4	–0.3	0.1	0.5
QA Stations						
38 TA-54 Area G (adjacent to station 27)	4	0	111.3	29.5	72.9	33.5
39 TA-49 (adjacent to station 26)	4	4	1.7	0.7	1.3	0.4

Group Summaries

Station Location	Number of Results	Number of Results <MDA	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	95% Confidence Interval[b]	Sample Standard Deviation
Regional	16	13	3.6	–0.5	0.9	±0.5	1.0
Pueblo	7	7	2.1	0.0	0.7	±0.7	0.7
Perimeter	72	64	9.2	–0.8	1.2	±0.3	1.4
TA-15 and TA-36	12	10	2.0	–0.3	0.5	±0.4	0.7
TA-21	24	14	196.4	0.0	23.6	±18.9	44.8
TA-54 Area G	32	18	116.9	0.0	15.4	±10.1	28.1
Other On-Site	38	32	12.8	–0.8	1.1	±0.7	2.2

Concentration Guidelines

DOE Derived Air Concentation (DAC) Guide for workplace exposure is 2,000,000 aCi/m^3. See Appendix A.
EPA 40 CFR 61 Concentration Guide 1,900 aCi/m^3.

[a] See Appendix B for an explanation of negative numbers.

[b] 95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.

Table 4-7. Airborne Americium-241 Concentrations for 1998

Station Location	Number of Results	Number of Results <MDA	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	Sample Standard Deviation
Regional Stations						
01 Española	4	4	4.4	0.7	2.3	1.6
03 Santa Fe	4	4	3.8	2.6	3.1	0.5
55 Santa Fe West (Buckman Booster #4)	4	4	3.2	2.6	2.8	0.3
56 El Rancho	4	4	3.5	2.0	2.8	0.7
Pueblo Stations						
41 Pueblo of San Ildefonso	4	4	3.0	0.8	2.1	1.1
59 Jemez Pueblo-Visitor's Center	3	3	7.5	1.8	3.7	3.2
Perimeter Stations						
04 Barranca School	4	4	2.9	1.0	2.1	0.9
05 Urban Park	4	4	3.1	1.3	2.4	0.9
06 48th Street	4	4	3.1	0.7	2.0	1.1
07 Gulf/Exxon/Shell Station	4	4	3.4	1.3	2.4	1.1
08 McDonalds Restaurant	4	4	4.6	1.7	2.8	1.4
09 Los Alamos Airport	4	4	2.9	1.2	2.3	0.8
10 East Gate	4	4	3.7	0.6	2.5	1.3
11 Well PM-1 (E. Jemez Road)	4	4	3.0	1.6	2.3	0.6
12 Royal Crest Trailer Court	4	4	3.6	1.8	2.4	0.8
13 Piñon School	4	4	3.5	1.7	2.3	0.6
14 Pajarito Acres	4	4	4.9	1.6	2.7	1.5
15 White Rock Fire Station	4	4	2.3	1.2	1.8	0.5
16 White Rock Nazarene Church	4	4	4.4	2.1	3.3	1.0
17 Bandelier Entrance (Lookout) (Rim)	4	4	3.2	0.6	2.0	1.1
60 LA Canyon	4	4	4.6	2.7	3.3	0.9
61 LA Hospital	4	4	4.8	1.3	2.9	1.5
62 Trinity Bible Church	4	4	3.6	1.8	2.8	0.9
63 Monte Rey South	4	4	3.7	2.1	2.9	0.7
TA-15 and TA-36 Stations						
76 TA-15-61	4	4	3.6	0.9	2.0	1.2
77 TA-36-IJ Site	4	4	3.9	2.0	2.7	0.8
78 TA-15-N	4	4	3.1	1.4	2.3	0.7
TA-21 Stations						
20 TA-21 Area B	4	4	3.2	1.6	2.5	0.7
71 TA-21.01 (NW Bldg 344)	4	4	6.0	1.8	3.9	1.8
72 TA-21.02 (N Bldg 344)	4	2	23.0	2.6	11.4	10.1
73 TA-21.03 (NE Bldg 344)	4	2	21.0	3.4	9.4	7.9
74 TA-21.04 (SE Bldg 344)	4	3	11.5	1.5	4.7	4.6
75 TA-21.05 (S Bldg 344)	4	4	2.5	1.3	1.9	0.6

Table 4-7. Airborne Americium-241 Concentrations for 1998 (Cont.)

Station Location	Number of Results	Number of Results <MDA	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	Sample Standard Deviation
TA-54 Area G Stations						
27 Area G (by QA)	4	0	77.7	25.2	47.9	22.0
34 Area G-1 (behind trailer)	4	4	4.2	1.8	3.3	1.0
35 Area G-2 (back fence)	4	4	5.0	1.6	3.0	1.4
36 Area G-3 (by office)	4	4	2.7	1.8	2.2	0.5
45 Area G/South East Perimeter	4	3	25.6	3.5	9.6	10.6
47 Area G/North Perimeter	4	3	9.6	3.2	5.7	2.8
50 Area G-expansion	4	4	4.9	2.2	3.6	1.1
51 Area G-expansion pit	4	4	4.2	2.6	3.6	0.7
Other On-Site Stations						
23 TA-52 Beta Site	4	4	2.5	1.6	2.0	0.4
25 TA-16-450	4	4	2.9	2.1	2.6	0.4
26 TA-49	4	4	4.0	1.2	2.7	1.3
30 Pajarito Booster 2 (P-2)	4	4	2.9	0.6	2.1	1.1
31 TA-3	4	4	5.5	1.6	3.5	1.7
32 County Landfill (alias TA-48)	4	4	5.1	0.9	2.6	1.8
33 TA-49 Area AB	2	2	4.4	3.2	3.8	0.9
49 Pajarito Road (TA-36)	4	4	2.3	0.9	1.5	0.7
54 TA-33 East	4	4	3.5	1.4	2.4	0.9
57 TA-49 Area AB 2A North	2	2	2.2	0.6	1.4	1.1
58 TA-49 Area AB Test Well 5A	2	2	10.5	2.4	6.4	5.8
QA Stations						
38 TA-54 Area G (adjacent to station 27)	4	0	66.1	26.7	46.2	16.4
39 TA-49 (adjacent to station 26)	4	4	2.4	0.7	1.5	0.7

Group Summaries

Station Location	Number of Results	Number of Results <MDA	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	95% Confidence Interval[a]	Sample Standard Deviation
Regional	16	16	4.4	0.7	2.7	±0.5	0.9
Pueblo	7	7	7.5	0.8	2.8	±2.0	2.2
Perimeter	72	72	4.9	0.6	2.5	±0.2	1.0
TA-15 and TA-36	12	12	3.9	0.9	2.3	±0.6	0.9
TA-21	24	19	23.0	1.3	5.6	±2.6	6.1
TA-54 Area G	32	26	77.7	1.6	9.9	±6.0	16.6
Other On-Site	38	38	10.5	0.6	2.7	±0.6	1.7

Concentration Guidelines

DOE Derived Air Concentation (DAC) Guide for workplace exposure is 2,000,000 aCi/m^3. See Appendix A.
EPA 40 CFR 61 Concentration Guide 1,900 aCi/m^3.

[a] 95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.

Table 4-8. Airborne Uranium-234 Concentrations for 1998

Station Location	Number of Results	Number of Results <MDA	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	Sample Standard Deviation
Regional Stations						
01 Española	4	0	23.1	9.7	16.0	5.5
03 Santa Fe	4	0	28.7	11.5	18.1	7.4
55 Santa Fe West (Buckman Booster #4)	4	1	22.1	5.6	11.4	7.4
56 El Rancho	4	0	26.8	6.3	14.9	8.6
Pueblo Stations						
41 Pueblo of San Ildefonso	4	0	23.2	16.8	19.5	2.8
59 Jemez Pueblo-Visitor's Center	3	0	32.9	20.1	27.9	6.8
Perimeter Stations						
04 Barranca School	4	0	21.2	7.5	13.6	5.9
05 Urban Park	4	2	16.4	2.3	7.4	6.2
06 48th Street	4	1	8.0	2.7	5.3	2.2
07 Gulf/Exxon/Shell Station	4	1	23.3	5.7	11.6	8.0
08 McDonalds Restaurant	4	2	15.1	4.2	7.9	4.9
09 Los Alamos Airport	4	0	15.0	5.3	8.4	4.4
10 East Gate	4	0	18.4	6.6	10.9	5.2
11 Well PM-1 (E. Jemez Road)	4	0	9.6	4.3	6.1	2.4
12 Royal Crest Trailer Court	4	2	12.1	2.9	7.5	4.0
13 Piñon School	4	1	11.2	4.4	7.7	3.2
14 Pajarito Acres	4	2	8.4	1.6	4.8	2.8
15 White Rock Fire Station	4	1	11.1	4.5	8.6	3.2
16 White Rock Nazarene Church	4	3	8.4	4.1	5.7	2.0
17 Bandelier Entrance (Lookout) (Rim)	4	2	10.9	4.5	6.2	3.2
60 LA Canyon	4	0	18.0	6.3	10.6	5.1
61 LA Hospital	4	0	22.5	9.7	15.3	5.3
62 Trinity Bible Church	4	1	12.0	5.3	7.5	3.1
63 Monte Rey South	4	2	10.5	2.2	5.5	3.6
TA-15 and TA-36 Stations						
76 TA-15-61	4	1	13.5	4.6	7.6	4.2
77 TA-15-IJ Site	4	1	24.6	5.1	12.1	8.6
78 TA-15-N	4	1	9.0	4.0	5.9	2.4
TA-21 Stations						
20 TA-21 Area B	4	1	13.2	3.5	7.0	4.3
71 TA-21.01 (NW Bldg 344)	4	1	10.5	5.0	7.7	2.5
72 TA-21.02 (N Bldg 344)	4	0	18.3	6.1	11.8	5.6
73 TA-21.03 (NE Bldg 344)	4	2	15.8	4.2	8.6	5.4
74 TA-21.04 (SE Bldg 344)	4	0	9.4	6.3	7.5	1.4
75 TA-21.05 (S Bldg 344)	4	3	11.2	2.5	5.9	3.7

Table 4-8. Airborne Uranium-234 Concentrations for 1998 (Cont.)

Station Location	Number of Results	Number of Results <MDA	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	Sample Standard Deviation
27 Area G (by QA)	4	0	67.4	52.8	58.5	6.8
34 Area G-1 (behind trailer)	4	0	58.6	13.3	27.6	20.9
35 Area G-2 (back fence)	4	0	14.2	7.3	9.9	3.0
36 Area G-3 (by office)	4	0	24.5	8.3	14.5	7.0
45 Area G/South East Perimeter	4	0	88.1	32.3	56.2	23.3
47 Area G/North Perimeter	4	0	29.7	13.1	17.5	8.2
50 Area G-expansion	4	0	72.0	38.5	48.1	15.9
51 Area G-expansion pit	4	0	61.1	23.9	34.8	17.6
Other On-Site Stations						
23 TA-52 Beta Site	4	0	17.5	6.7	10.4	4.8
25 TA-16-450	4	0	28.9	7.2	14.2	10.1
26 TA-49	4	2	8.7	3.4	5.0	2.5
30 Pajarito Booster 2 (P-2)	4	1	13.9	4.8	8.1	4.0
31 TA-3	4	1	9.9	4.1	6.2	2.6
32 County Landfill (alias TA-48)	4	0	62.3	44.4	52.2	8.0
33 TA-49 Area AB	2	1	20.3	10.8	15.6	6.7
49 Pajarito Road (TA-36)	4	0	14.1	4.8	8.5	4.0
54 TA-33 East	4	2	13.9	4.6	7.7	4.3
57 TA-49 Area AB 2A North	2	0	13.9	9.4	11.6	3.2
58 TA-49 Area AB Test Well 5A	2	2	6.1	4.3	5.2	1.2
QA Stations						
38 TA-54 Area G (adjacent to station 27)	4	0	65.6	56.3	60.7	3.8
39 TA-49 (adjacent to station 26)	4	3	10.2	2.5	5.4	3.4

Group Summaries

Station Location	Number of Results	Number of Results <MDA	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	95% Confidence Interval[a]	Sample Standard Deviation
Regional	16	1	28.7	5.6	15.1	±3.7	7.0
Pueblo	7	0	32.9	16.8	23.1	±5.6	6.3
Perimeter	72	20	23.3	1.6	8.4	±1.1	4.8
TA-15 and TA-36	12	3	24.6	4.0	8.5	±3.7	5.8
TA-21	24	7	18.3	2.5	8.1	±1.7	4.1
TA-54 Area G	32	0	88.1	7.3	33.4	±8.0	22.3
Other On-Site	38	9	62.3	3.4	13.5	±4.8	14.6

Concentration Guidelines

DOE Derived Air Concentation (DAC) Guide for workplace exposure is 20,000,000 aCi/m^3. See Appendix A.
EPA 40 CFR 61 Concentration Guide 7,700 aCi/m^3.

[a] 95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.

Table 4-9. Airborne Uranium-235 Concentrations for 1998

Station Location	Number of Results	Number of Results <MDA	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	Sample Standard Deviation
Regional Stations						
01 Española	4	4	2.6	1.1	2.0	0.7
03 Santa Fe	4	3	5.2	0.3	2.8	2.0
55 Santa Fe West (Buckman Booster #4)	4	4	1.5	0.6	1.1	0.5
56 El Rancho	4	4	1.5	1.0	1.3	0.2
Pueblo Stations						
41 Pueblo of San Ildefonso	4	4	3.9	1.2	2.3	1.1
59 Jemez Pueblo-Visitor's Center	3	3	4.5	1.8	2.7	1.6
Perimeter Stations						
04 Barranca School	4	4	2.2	0.1	1.3	0.9
05 Urban Park	4	4	2.6	0.7	1.5	0.8
06 48th Street	4	3	2.5	0.0	1.4	1.0
07 Gulf/Exxon/Shell Station	4	4	3.1	0.2	1.5	1.2
08 McDonalds Restaurant	4	4	1.2	0.6	0.9	0.3
09 Los Alamos Airport	4	4	2.8	0.6	1.2	1.0
10 East Gate	4	4	2.4	0.6	1.5	0.8
11 Well PM-1 (E. Jemez Road)	4	4	0.9	0.0	0.6	0.4
12 Royal Crest Trailer Court	4	4	1.8	0.3	1.0	0.7
13 Piñon School	4	3	4.1	0.8	2.3	1.5
14 Pajarito Acres	4	4	1.1	0.0	0.7	0.5
15 White Rock Fire Station	4	4	4.3	0.1	1.6	1.9
16 White Rock Nazarene Church	4	4	1.4	0.1	0.6	0.6
17 Bandelier Entrance (Lookout) (Rim)	4	3	1.7	–0.1[a]	1.1	0.9
60 LA Canyon	4	3	2.3	–0.2	0.8	1.1
61 LA Hospital	4	3	1.2	–0.1	0.5	0.6
62 Trinity Bible Church	4	3	2.7	–0.3	1.5	1.3
63 Monte Rey South	4	4	1.9	0.1	1.0	0.7
TA-15 and TA-36 Stations						
76 TA-15-61	4	4	1.5	0.9	1.1	0.3
77 TA-36-IJ Site	4	4	1.2	0.7	0.9	0.2
78 TA-15-N	4	4	1.7	0.4	1.0	0.5
TA-21 Stations						
20 TA-21 Area B	4	4	1.6	0.1	0.6	0.7
71 TA-21.01 (NW Bldg 344)	4	3	2.2	–0.1	0.6	1.3
72 TA-21.02 (N Bldg 344)	4	4	2.0	0.0	0.6	0.9
73 TA-21.03 (NE Bldg 344)	4	4	1.5	0.3	0.8	0.6
74 TA-21.04 (SE Bldg 344)	4	2	2.0	–0.3	0.4	1.1
75 TA-21.05 (S Bldg 344)	4	4	1.6	0.7	1.2	0.4

Table 4-9. Airborne Uranium-235 Concentrations for 1998 (Cont.)

Station Location	Number of Results	Number of Results <MDA	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	Sample Standard Deviation
TA-54 Area G Stations						
27 Area G (by QA)	4	3	3.1	1.8	2.5	0.7
34 Area G-1 (behind trailer)	4	4	2.4	0.9	1.8	0.7
35 Area G-2 (back fence)	4	4	1.7	0.6	1.0	0.5
36 Area G-3 (by office)	4	4	3.5	0.7	1.8	1.3
45 Area G/South East Perimeter	4	4	4.3	1.8	2.8	1.2
47 Area G/North Perimeter	4	3	2.9	–0.7	1.3	1.8
50 Area G-expansion	4	2	5.5	2.0	3.9	1.6
51 Area G-expansion pit	4	3	4.9	2.0	2.9	1.3
Other On-Site Stations						
23 TA-52 Beta Site	4	4	3.9	0.4	1.9	1.5
25 TA-16-450	4	4	3.1	0.4	1.5	1.1
26 TA-49	4	4	1.9	0.0	0.9	0.8
30 Pajarito Booster 2 (P-2)	4	4	1.1	0.3	0.8	0.4
31 TA-3	4	2	1.6	0.5	0.5	1.0
32 County Landfill (alias TA-48)	4	4	4.6	3.3	3.9	0.5
33 TA-49 Area AB	2	1	4.6	1.7	3.2	2.1
49 Pajarito Road (TA-36)	4	0	5.6	–0.3	2.5	3.1
54 TA-33 East	4	4	1.6	0.1	0.8	0.6
57 TA-49, Area AB 2A North	2	2	3.6	1.0	2.3	1.8
58 TA-49, Area AB Test Well 5A	2	2	1.3	0.3	0.8	0.7
QA Stations						
38 TA-54 Area G (adjacent to station 27)	4	3	7.0	3.1	4.4	1.8
39 TA-49 (adjacent to station 26)	4	4	1.2	0.0	0.8	0.6

Group Summaries

Station Location	Number of Results	Number of Results <MDA	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	95% Confidence Interval[b]	Sample Standard Deviation
Regional	16	15	5.2	0.3	1.8	±0.6	1.2
Pueblo	7	7	4.5	1.2	2.5	±1.1	1.2
Perimeter	72	66	4.3	–0.3	1.2	±0.2	1.0
TA-15 and TA-36	12	12	1.7	0.4	1.0	±0.2	0.3
TA-21	24	21	2.2	–1.0	0.7	±0.4	0.8
TA-54 Area G	32	27	5.5	–0.7	2.2	±0.5	1.4
Other On-Site	38	31	5.6	–0.5	1.7	±0.5	1.6

Concentration Guidelines

DOE Derived Air Concentation (DAC) Guide for workplace exposure is 20,000,000 aCi/m^3. See Appendix A.
EPA 40 CFR 61 Concentration Guide 7,100 aCi/m^3.

[a] See Appendix B for an explanation of negative numbers.

[b] 95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.

Table 4-10. Airborne Uranium-238 Concentrations for 1998

Station Location	Number of Results	Number of Results <MDA	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	Sample Standard Deviation
01 Española	4	0	19.7	10.8	15.4	3.7
03 Santa Fe	4	0	27.5	10.6	16.6	7.5
55 Santa Fe West (Buckman Booster #4)	4	0	18.1	6.7	10.0	5.5
56 El Rancho	4	0	24.5	8.1	14.0	7.2
Pueblo Stations						
41 Pueblo of San Ildefonso	4	0	22.4	16.0	19.4	2.6
59 Jemez Pueblo-Visitor's Center	3	0	29.2	17.9	25.3	6.4
Perimeter Stations						
04 Barranca School	4	0	21.8	8.0	14.7	6.4
05 Urban Park	4	1	13.0	3.8	7.4	3.9
06 48th Street	4	3	4.5	1.7	3.1	1.2
07 Gulf/Exxon/Shell Station	4	0	23.0	4.7	12.1	7.9
08 McDonalds Restaurant	4	2	14.2	3.8	7.5	4.8
09 Los Alamos Airport	4	1	14.1	3.8	7.9	4.4
10 East Gate	4	0	16.5	6.4	10.1	4.6
11 Well PM-1 (E. Jemez Road)	4	0	11.2	4.9	6.8	3.0
12 Royal Crest Trailer Court	4	2	11.3	3.9	6.4	3.3
13 Piñon School	4	1	11.7	3.5	7.7	3.4
14 Pajarito Acres	4	1	6.8	2.9	4.9	1.6
15 White Rock Fire Station	4	0	11.4	5.8	7.8	2.4
16 White Rock Nazarene Church	4	2	8.6	3.2	5.7	2.2
17 Bandelier Entrance (Lookout) (Rim)	4	1	8.7	3.5	4.9	2.5
60 LA Canyon	4	0	20.9	5.6	10.4	7.1
61 LA Hospital	4	0	24.4	5.9	15.1	7.6
62 Trinity Bible Church	4	0	12.8	5.5	7.4	3.6
63 Monte Rey South	4	1	10.4	3.1	6.0	3.2
TA-15 and TA-36 Stations						
76 TA-15-61	4	1	9.3	4.0	6.3	2.3
77 TA-36-IJ Site	4	0	68.5	13.9	36.4	23.3
78 TA-15-N	4	0	11.2	5.0	6.9	2.9
TA-21 Stations						
20 TA-21 Area B	4	1	8.6	4.5	6.3	2.1
71 TA-21.01 (NW Bldg 344)	4	1	10.0	2.7	5.7	3.2
72 TA-21.02 (N Bldg 344)	4	0	13.4	5.7	8.1	3.6
73 TA-21.03 (NE Bldg 344)	4	0	11.3	6.1	7.7	2.4
74 TA-21.04 (SE Bldg 344)	4	1	9.1	4.6	6.9	2.4
75 TA-21.05 (S Bldg 344)	4	1	17.4	0.6	8.2	7.0

Table 4-10. Airborne Uranium-238 Concentrations for 1998 (Cont.)

Station Location	Number of Results	Number of Results <MDA	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	Sample Standard Deviation
27 Area G (by QA)	4	0	66.5	41.2	56.9	11.3
34 Area G-1 (behind trailer)	4	0	58.0	14.6	29.5	19.6
35 Area G-2 (back fence)	4	0	13.0	7.9	9.8	2.4
36 Area G-3 (by office)	4	0	27.9	8.8	15.3	8.7
45 Area G/South East Perimeter	4	0	92.7	33.8	58.0	24.8
47 Area G/North Perimeter	4	0	26.8	9.6	16.0	7.5
50 Area G-expansion	4	0	70.1	41.5	49.1	14.0
51 Area G-expansion pit	4	0	75.5	23.6	39.1	24.5
Other On-Site Stations						
23 TA-52 Beta Site	4	0	12.8	9.8	11.3	1.4
25 TA-16-450	4	0	29.7	5.5	13.6	11.2
26 TA-49	4	2	7.7	3.1	4.5	2.1
30 Pajarito Booster 2 (P-2)	4	1	9.7	4.4	7.3	2.6
31 TA-3	4	1	12.3	3.7	8.2	4.2
32 County Landfill (alias TA-48)	4	0	66.7	47.7	55.5	9.0
33 TA-49 Area AB	2	0	16.1	10.8	13.5	3.7
49 Pajarito Road (TA-36)	4	1	17.0	3.5	9.3	5.8
54 TA-33 East	4	1	12.2	3.8	6.8	3.8
57 TA-49, Area AB 2A North	2	0	13.1	10.1	11.6	2.1
58 TA-49, Area AB Test Well 5A	2	2	4.1	3.5	3.8	0.5
QA Stations						
38 TA-54 Area G (adjacent to station 27)	4	0	65.6	59.9	62.0	2.5
39 TA-49 (adjacent to station 26)	4	3	8.1	2.3	4.4	2.5

Group Summaries

Station Location	Number of Results	Number of Results <MDA	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	95% Confidence Interval[a]	Sample Standard Deviation
Regional	16	0	27.5	6.7	14.0	±3.2	6.1
Pueblo	7	0	29.2	16.0	21.9	±4.6	5.2
Perimeter	72	15	24.4	1.7	8.1	±1.2	5.1
TA-15 and TA-36	12	1	68.5	4.0	16.5	±12.1	19.2
TA-21	24	4	17.4	0.6	7.2	±1.5	3.5
TA-54 Area G	32	0	92.7	7.9	34.2	±8.4	23.2
Other On-Site	38	8	66.7	3.1	13.8	±5.1	15.6

Concentration Guidelines

DOE Derived Air Concentation (DAC) Guide for workplace exposure is 20,000,000 aCi/m^3. See Appendix A.
EPA 40 CFR 61 Concentration Guide 8,300 aCi/m^3.

[a] 95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.

Table 4-11. Airborne Gamma-Emitting Radionuclides that are Potentially Released by LANL Operations

Gamma-Emitting Radionuclide	Number of Results	Number of Results ≤MDA	Mean (fCi/m^3)	Measured Average MDA as a Percent of the Required MDA
^{73}As	329	329	<<1.18	0.2
^{74}As	329	329	<<1.26	1.1
^{109}Cd	329	329	<<0.05	0.2
^{57}Co	329	329	<<0.20	0.3
^{60}Co	329	329	<<0.46	53.7
^{134}Cs	329	329	<<0.44	32.7
^{137}Cs	329	329	<<0.39	41.2
^{54}Mn	329	329	<<0.44	3.1
^{22}Na	329	329	<<0.46	35.4
^{83}Rb	329	329	<<0.79	4.7
^{86}Rb	329	329	<<9.31	33.3
^{103}Ru	329	329	<<0.46	0.4
^{75}Se	329	329	<<0.33	3.9
^{65}Zn	329	329	<<0.97	21.4

Table 4-12. Airborne Concentrations of Gamma-Emitting Radionuclides that Naturally Occur in Measurable Quantities

Gamma-Emitting Radionuclide	Number of Results	Number of Results <MDA	Mean (fCi/m^3)	Estimated Dose (mrem)
^{7}Be	327	0	86	0.04
^{210}Pb	328	0	11	38

Table 4-13. Airborne Radioactive Emissions from Laboratory Buildings with Sampled Stacks in 1998 (Ci)

TA-Building	^{3}H[a]	^{241}Am	Pu[b]	U[c]	Th	P/VAP[d]	G/MAP[e]
TA-03-029		1.6×10^{-6}	1.1×10^{-5}	1.3×10^{-5}	4.1×10^{-7}	6.7×10^{-6}	
TA-03-035				1.4×10^{-7}			
TA-03-102			1.0×10^{-10}	1.8×10^{-5}	1.1×10^{-8}		
TA-16-205	2.4×10^{2}						
TA-21-155	8.2×10^{1}						
TA-21-209	3.8×10^{2}						
TA-33-086	6.5×10^{1}						
TA-41-004	3.6×10^{1}						
TA-48-001		3.7×10^{-10}		1.4×10^{-7}		1.1×10^{-4}	
TA-50-001		6.5×10^{-9}	1.4×10^{-8}	1.8×10^{-7}	7.7×10^{-8}		
TA-50-037				1.1×10^{-8}			
TA-50-069			1.3×10^{-9}	4.2×10^{-10}	3.1×10^{-10}		
TA-53-003	3.5					3.3	7.7×10^{3}
TA-53-007	2.7×10^{-1}					6.0×10^{-3}	1.3×10^{2}
TA-55-004	1.2×10^{1}	3.8×10^{-9}	6.2×10^{-8}		3.0×10^{-8}		

[a]Includes both gaseous and oxide forms of tritium.
[b]Includes ^{238}Pu, ^{239}Pu, and ^{240}Pu.
[c]Includes ^{234}U, ^{235}U, and ^{238}U.
[d]Particulate/vapor activation products.
[e]Gaseous/mixed activation products.

Table 4-14. Detailed Listing of Activation Products Released from Sampled Laboratory Stacks in 1998 (Ci)

TA-Building	Radionuclide	Emission
TA-03-029	^{75}Se	6.7×10^{-6}
TA-48-001	^{74}As	9.5×10^{-7}
TA-48-001	^{77}Br	8.7×10^{-5}
TA-48-001	^{75}Se	5.4×10^{-6}
TA-48-001	^{75}Se	1.9×10^{-5}
TA-53-003	^{41}Ar	1.5×10^{2}
TA-53-003	^{10}C	1.9×10^{2}
TA-53-003	^{11}C	3.3×10^{3}
TA-53-003	^{13}N	1.3×10^{3}
TA-53-003	^{16}N	1.5×10^{2}
TA-53-003	^{14}O	5.8×10^{1}
TA-53-003	^{15}O	2.7×10^{3}
TA-53-003	^{7}Be	1.2×10^{-4}
TA-53-003	^{76}Br	3.6×10^{-2}
TA-53-003	^{77}Br	3.6×10^{-2}
TA-53-003	^{82}Br	6.8×10^{-3}
TA-53-003	^{39}Cl	3.3
TA-53-003	^{197}Hg	1.7×10^{-3}
TA-53-003	^{24}Na	1.8×10^{-4}
TA-53-003	^{44m}Sc	5.8×10^{-7}
TA-53-003	^{48}V	5.3×10^{-6}
TA-53-007	^{41}Ar	4.1
TA-53-007	^{10}C	5.0×10^{-2}
TA-53-007	^{11}C	1.1×10^{2}
TA-53-007	^{13}N	7.2
TA-53-007	^{14}O	1.2
TA-53-007	^{15}O	1.4×10^{1}
TA-53-007	^{73}As	1.3×10^{-4}
TA-53-007	^{76}Br	3.9×10^{-4}
TA-53-007	^{77}Br	7.4×10^{-6}
TA-53-007	^{82}Br	9.6×10^{-4}
TA-53-007	^{197}Hg	4.4×10^{-3}
TA-53-007	^{40}K	7.6×10^{-5}

Table 4-15. Radionuclide: Half-Life Information

Nuclide	Half-Life
^{3}H	12.3 yr
^{7}Be	53.4 d
^{10}C	19.3 s
^{11}C	20.5 min
^{13}N	10.0 min
^{16}N	7.13 s
^{14}O	70.6 s
^{15}O	122.2 s
^{22}Na	2.6 yr
^{24}Na	14.96 h
^{32}P	14.3 d
^{40}K	1,277,000,000 yr
^{41}Ar	1.83 h
^{54}Mn	312.7 d
^{56}Co	78.8 d
^{57}Co	270.9 d
^{58}Co	70.8 d
^{60}Co	5.3 yr
^{72}As	26 h
^{73}As	80.3 d
^{74}As	17.78 d
^{76}Br	16 h
^{77}Br	^{77}Br
^{82}Br	1.47 d
^{75}Se	119.8 d
^{85}Sr	64.8 d
^{89}Sr	50.6 d
^{90}Sr	28.6 yr
^{131}I	8 d
^{134}Cs	2.06 yr
^{137}Cs	30.2 yr
^{183}Os	13 h
^{185}Os	93.6 d
^{191}Os	15.4 d
^{193}Hg	3.8 hr
^{195}Hg	9.5 hr
^{195m}Hg	1.67 d
^{197}Hg	2.67 d
^{197m}Hg	23.8 hr
^{234}U	244,500 yr
^{235}U	703,800,000 yr
^{238}U	4,468,000,000 yr
^{238}Pu	87.7 yr
^{239}Pu	24,131 yr
^{240}Pu	6,569 yr
^{241}Pu	14.4 yr
^{241}Am	432 yr

Table 4-16. Thermoluminescent Dosimeter (TLD) Measurements of External Radiation 1997–1998

	TLD Station ID #	Location	1998 Annual Dose (mrem)[a,b]	1998 Quarters Monitored[d]	1997 Annual Dose (mrem)
Regional	01	Española	96 ± 7	2, 3, 4	30 ± 5[d]
	03	Santa Fe	71 ± 5	1, 2	98 ± 6[d]
	53	Pueblo of San Ildefonso	121 ± 7	1–4	109 ± 6
	95	El Rancho	101 ± 8	2–4	71 ± 7[d]
	101	Santa Fe West Buckman Mesa[c]	138 ± 8	1–4	
Perimeter	05	Barranca School, Los Alamos	148 ± 8	1–4	139 ± 9
	07	Cumbres School, Los Alamos	140 ± 8	1–4	136 ± 8
	08	48th Street, Los Alamos	159 ± 9	1–4	138 ± 8
	09	Los Alamos Airport	140 ± 9	1–4	130 ± 8
	10	Bayo Canyon, Los Alamos	182 ± 10	1–4	174 ± 8
	11	Shell Station, Los Alamos	161 ± 9	1–4	109 ± 8
	12	Royal Crest Trailer Court, Los Alamos	148 ± 8	1–4	143 ± 8
	13	White Rock	149 ± 9	1–4	141 ± 8
	14	Pajarito Acres, White Rock	141 ± 8	1–4	138 ± 8
	15	Bandelier National Monument Lookout Station	160 ± 9	1–4	152 ± 9
	16	Pajarito Ski Area	98 ± 5	1–3	139 ± 9
	41	McDonald's Restaurant, Los Alamos	162 ± 9	1–4	126 ± 8[d]
	42	Los Alamos Airport-South	162 ± 10	1–4	154 ± 10
	43	East Gate Business Park, Los Alamos	155 ± 9	1–4	141 ± 8
	44	Big Rock Loop, Los Alamos	186 ± 11	1–4	137 ± 11
	45	Cheyenne Street, Los Alamos	176 ± 10	1–4	156 ± 9
	46	Los Pueblos Street, Los Alamos	174 ± 10	1–4	157 ± 9
	47	Urban Park, Los Alamos	154 ± 9	1–4	152 ± 9
	49	Piñon School, White Rock	105 ± 7	1–4	129 ± 8
	50	White Rock Church of the Nazarene	100 ± 6	1–4	107 ± 7
	51	Bayo Canyon Well, Los Alamos	177 ± 10	1–4	164 ± 10
	55	Monte Rey South, White Rock	136 ± 7	1–4	136 ± 8
	56	East Gate (mid station)	175 ± 10	1–4	159 ± 10
	60	Piedra Drive, White Rock	135 ± 8	1–4	138 ± 8
	67	Los Alamos Hospital	114 ± 8	2–4	75 ± 7[d]
	68	Trinity Church	169 ± 10	1–4	83 ± 7[d]
	80	TA-16 SR4 Back Gate	152 ± 9	2–4	111 ± 8[d]
	81	TA-16 SR4 Ponderosa Camp	143 ± 20	2–4	149 ± 11[d]
On-Site	17	TA-21 (DP West)	172 ± 10	1–4	166 ± 10
	18	TA-6 (Two Mile Mesa)	154 ± 9	1–4	148 ± 9
	19	TA-53 (LANSCE)	190 ± 11	1–4	173 ± 10
	20	Well PM-1 (SR4 and Truck Rt.)	179 ± 10	1–4	163 ± 9
	21	TA-16 (S-Site)	146 ± 10	1–4	151 ± 9
	22	Booster P-2	155 ± 9	1–4	147 ± 10
	23	TA-3 East Gate of SM 43	104 ± 8	1, 2, 4	135 ± 8
	24	State Highway 4	194 ± 11	1–4	178 ± 11
	25	TA-49 (Frijoles Mesa)	150 ± 8	1–4	148 ± 10
	26	TA-2 (Omega Stack)	156 ± 9	1–4	154 ± 9
	27	TA-2 (Omega Canyon)[e]			37 ± 4[d]

Table 4-16. Thermoluminescent Dosimeter (TLD) Measurements of External Radiation 1997–1998 (Cont.)

	TLD Station ID #	Location	1998 Annual Dose (mrem)[a,b]	1998 Quarters Monitored	1997 Annual Dose (mrem)
On-Site (Cont.)	28	TA-18 (Pajarito Site)	153 ± 11	1, 3–4	166 ± 10
	29	TA-35 (Ten Site A)	137 ± 8	1–4	145 ± 9
	30	TA-35 (Ten Site B)	133 ± 8	1–4	137 ± 8
	31	TA-59 (Occupational Health Lab)	119 ± 10	2–4	146 ± 9
	32	TA-3-16 (Van de Graaff)	158 ± 9	1–4	148 ± 9
	33	TA-3-316 (Ion Beam Bldg.)	156 ± 9	1–4	150 ± 9
	34	TA-3-440 (CAS)	174 ± 10	1–4	147 ± 9
	35	TA-3-420 (CMR Bldg. West Fence)	146 ± 8	1–4	136 ± 8
	36	TA-3-102 (Shop)	149 ± 9	1–4	146 ± 9
	37	TA-72 (Pistol Range)	168 ± 10	1–4	172 ± 11
	38	TA-55 (Plutonium Facility South)	164 ± 8	1–4	153 ± 10
	39	TA-55 (Plutonium Facility West)	183 ± 10	1–4	165 ± 10
	40	TA-55 (Plutonium Facility North)	142 ± 8	1–4	148 ± 9
	48	Los Alamos County Landfill	148 ± 9	1–4	136 ± 8
	56	East Gate Mid Station	175 ± 10	1–4	159 ± 10
	57	TA-54 West (TLD Lab)	182 ± 10	1–4	157 ± 9
	58	TA-54 Lagoon	170 ± 10	1–4	159 ± 9
	59	Los Alamos Canyon	119 ± 8	1, 3–4	167 ± 10
	61	S. LANSCE Lagoons	514 ± 41	2, 4	934 ± 75[d]
	62	N. LANSCE Lagoons	414 ± 23	2–4	332 ± 24[d]
	63	E. LANSCE Lagoons	874 ± 61	1, 2, 4	741 ± 57[d]
	64	NE LANSCE Area A Stack	336 ± 24	2–4	369 ± 27[d]
	65	NW LANSCE Area A Stack	226 ± 14	2–4	222 ± 16[d]
	69	TA-50 Old Outfall	189 ± 10	1–4	82 ± 7[d]
	70	TA-50 Dirt Road to Outfall	163 ± 9	1–4	96 ± 9[d]
	71	TA-50 Dirt Road Turnoff	159 ± 9	1–4	123 ± 10[d]
	72	TA-50 East Fence	157 ± 9	1–4	116 ± 8[d]
	73	TA-50 South Corner	142 ± 8	1–4	113 ± 8[d]
	74	TA-50 Pecos Drive	146 ± 8	1–4	107 ± 8[d]
	75	TA-50-37 West	155 ± 9	1–4	118 ± 8[d]
	76	TA-16 WETF	159 ± 9	1–4	111 ± 8[d]
	77	TA-16 Guard Station	159 ± 9	1–4	82 ± 8[d]
	78	Fitness Trail SW TA-8-24	154 ± 14	1–4	116 ± 8[d]
	79	Fitness Trail SE TA-8-24	162 ± 9	1–4	115 ± 8[d]
	82	TA-15 Phermex N TA-15-185	169 ± 10	1–4	111 ± 8[d]
	83	TA-15 Phermex Entrance	144 ± 10	1–4	100 ± 7[d]
	84	TA-15 Phermex NNE Entrance	151 ± 9	1–4	105 ± 8[d]
	85	TA-15 Phermex N DAHRT	149 ± 10	1–4	100 ± 7[d]
	86	TA-15-312 DAHRT Entrance	155 ± 9	1–4	96 ± 8[d]
	87	TA-15-183 Access Control	174 ± 10	1–4	114 ± 9[d]
	88	TA-15 R-Site Road	163 ± 10	1–4	107 ± 8[d]
	89	TA-15-45 SW	169 ± 10	1–4	110 ± 8[d]
	90	TA-15-306 North	126 ± 9	1, 2–4	105 ± 8[d]
	91	TA-15, IJ Firing Pit	164 ± 9	1–4	63 ± 5[d]
	92	TA-36 Kappa Site	127 ± 10	2–4	111 ± 8[d]
	93	TA-15 Ridge Road Gate	141 ± 8	1–4	25 ± 3[d]
	94	TA-33 VLBA Dish	129 ± 8	1–4	60 ± 5[d]

Table 4-16. Thermoluminescent Dosimeter (TLD) Measurements of External Radiation 1997–1998 (Cont.)

	TLD Station ID #	Location	1998 Annual Dose (mrem)[a,b]	1998 Quarters Monitored	1997 Annual Dose (mrem)
On-Site (Cont.)	97	TA-50, GS-1-1, Mortandad Canyon	182 ± 11	1–4	74 ± 6[d]
	98	TA-50, GS-1-2, Mortandad Canyon	426 ± 22	1–4	160 ± 14[d]
	99	Mortandad Canyon, MCO-5	447 ± 24	1–4	170 ± 149[d]
	100	Mortandad Canyon, MCO-13	175 ± 8	1–4	63 ± 5[d]

[a]Dose is the sum of all quarterly data accepted upon quality assurance review.
[b]The uncertainty of each measurement is the propagated error of the quarterly measurements.
[c]New stations placed into operation in 1998.
[d]One or more quarters is less than 4; data have not been reported because of loss of TLDs, analytical problems, or new stations.
[e]Station ceased operation in 1997.

Table 4-17. Thermoluminescent Dosimeter (TLD) Measurements of External Radiation at Waste Disposal Areas during 1997–1998

TLD Station	ID #	Location	1998 Annual Dose (mrem)[a,b]	1998 Quarters Monitored[c]	1997 Quarters Dose (mrem)[a,b]
Area A	201	TA-21 Area A-1	141 ± 9	1–4	143 ± 12
	202	TA-21 Area A-2	159 ± 9	1–4	145 ± 11
	203	TA-21 Area A-3	155 ± 8	1–4	146 ± 12
	204	TA-21 Area A-4	154 ± 9	1–4	144 ± 11
	205	TA-21 Area A-5	150 ± 9	1–4	142 ± 11
Area AB	221	TA-49 AB-1	142 ± 9	1–4	145 ± 11
	222	TA-49 AB-2	149 ± 9	1–4	146 ± 11
	223	TA-49 AB-3	151 ± 9	1–4	146 ± 11
	224	TA-49 AB-4	143 ± 9	1–4	143 ± 12
	225	TA-49 AB-5	142 ± 9	1–4	149 ± 11
	226	TA-49 AB-6	146 ± 8	1–4	149 ± 11
	227	TA-49 AB-7	141 ± 8	1–4	145 ± 11
	228	TA-49 AB-8	66 ± 5	1–2	145 ± 11
	229	TA-49 AB-9	141 ± 8	1–4	140 ± 12
	230	TA-49 AB-10	142 ± 8	1–4	148 ± 12
Area B	241	TA-21 Area B-1	158 ± 15	1–4	100 ± 9[c]
	242	TA-21 Area B-2	161 ± 9	1–4	141 ± 11
	243	TA-21 Area B-3	158 ± 9	1–4	116 ± 9[c]
	244	TA-21 Area B-4	98 ± 6	1, 3, 4	138 ± 10
	245	TA-21 Area B-5	111 ± 5	1, 2, 3	126 ± 10
	246	TA-21 Area B-6	152 ± 8	1–4	149 ± 10
	247	TA-21 Area B-7	115 ± 8	1, 2, 4	155 ± 11
	248	TA-21 Area B-8	161 ± 9	1–4	163 ± 10
	249	TA-21 Area B-9	157 ± 9	1–4	146 ± 10
	250	TA-21 Area B-10	157 ± 8	1–4	158 ± 11
	251	TA-21 Area B-11	163 ± 8	1–4	155 ± 11
	252	TA-21 Area B-12	167 ± 9	1–4	163 ± 11
	253	TA-21 Area B-13	164 ± 9	1–4	159 ± 10
	254	TA-21 Area B-14	171 ± 9	1–4	153 ± 11
Area C	261	TA-50 N Area C-1	150 ± 8	1–4	141 ± 11
	262	TA-50 N Area C-2	162 ± 9	1–4	162 ± 12
	263	TA-50 Area C-3	160 ± 10	1–4	44 ± 5[c]
	264	TA-50 Area C-4	165 ± 9	1–4	172 ± 12
	265	TA-50 SE Area C-5	163 ± 10	1–4	161 ± 12
	266	TA-50 Area C-6	164 ± 9	1–4	161 ± 12
	267	TA-50 Area C-7	151 ± 8	1–4	150 ± 11
	268	TA-50 S Area C-8	147 ± 9	1–4	150 ± 11
	269	TA-50 Area C-9	159 ± 9	1–4	118 ± 11
	270	TA-50 W Area C-10	157 ± 8	1–4	152 ± 11
Area E	281	TA-33 Area E-1	155 ± 9	1–4	115 ± 11[c]
	282	TA-33 Area E-2	162 ± 9	1–4	159 ± 12
	283	TA-33 Area E-3	168 ± 10	1–4	162 ± 12
	284	TA-33 Area E-4	169 ± 10	1–4	157 ± 13

Table 4-17. Thermoluminescent Dosimeter (TLD) Measurements of External Radiation at Waste Disposal Areas during 1997–1998 (Cont.)

	TLD Station ID #	Location	1998 Annual Dose (mrem)[a,b]	1998 Quarters Monitored[c]	1997 Quarters Dose (mrem)[a,b]
Area F	301	TA-6 Area F-1	135 ± 8	1–4	153 ± 11
	302	TA-6 Area F-2	142 ± 9	1–4	150 ± 11
	303	TA-6 Area F-3	143 ± 8	1–4	146 ± 11
	304	TA-6 Area F-4	159 ± 9	1–4	150 ± 11
Area G	601	TA-54 Area G, 1	179 ± 10	1–4	169 ± 10
	602	TA-54 Area G, 2	289 ± 16	1–4	219 ± 13
	603	TA-54 Area G, 3	178 ± 12	1–4	152 ± 9
	604	TA-54 Area G, 4	163 ± 9	1–4	158 ± 9
	605	TA-54 Area G, 5	190 ± 13	1–4	165 ± 10
	606	TA-54 Area G, 6	175 ± 10	1–4	160 ± 9
	607	TA-54 Area G, 7	224 ± 15	1–4	207 ± 12
	608	TA-54 Area G, 8	261 ± 16	1–4	195 ± 11
	610	TA-54 Area G, 10	224 ± 12	1–4	179 ± 11
	611	TA-54 Area G, 11	355 ± 21	1–4	160 ± 11[c]
	613	TA-54 Area G, 13	297 ± 17	1–4	220 ± 13
	614	TA-54 Area G, 14	252 ± 14	1–4	205 ± 13
	615	TA-54 Area G, 15	186 ± 10	1–4	175 ± 11
	616	TA-54 Area G, 16	177 ± 13	1–4	166 ± 9
	617	TA-54 Area G, 17	189 ± 18	1–4	168 ± 10
	618	TA-54 Area G, 18	189 ± 12	1–4	187 ± 11
	619	TA-54 Area G, 19	241 ± 14	1–4	209 ± 12
	620	TA-54 Area G, 20	168 ± 11	1–4	172 ± 10
	622	TA-54 Area G, 22	245 ± 14	1–4	223 ± 13
	623	TA-54 Area G, 23	168 ± 12	1–4	278 ± 16
	624	TA-54 Area G, 24	172 ± 9	1–4	174 ± 10
	625	TA-54 Area G, 25	207 ± 11	1–4	189 ± 11
	626	TA-54 Area G, 26	178 ± 10	1–4	166 ± 10
	628	TA-54 Area G, 28	208 ± 12	1–4	201 ± 11
	629	TA-54 Area G, 29	197 ± 12	1–4	250 ± 16
	630	TA-54 Area G, 30	190 ± 11	1–4	117 ± 9
	631	TA-54 Area G, 31	204 ± 13	1–4	183 ± 11
	634	TA-54 Area G, 34	289 ± 16	1–4	166 ± 11
	635	TA-54 Area G, 35	251 ± 15	1–4	158 ± 11
	636	TA-54 Area G, 36	176 ± 10	1–4	83 ± 7[c]
	637	TA-54 Area G, 37	184 ± 10	1–4	117 ± 8
	638	TA-54 Area G, 38	219 ± 11	1–4	211 ± 12
Area T	321	TA-21 Area T-1	162 ± 9	1–4	161 ± 12
	322	TA-21 Area T-2	154 ± 8	1–4	157 ± 12
	323	TA-21 Area T-3	295 ± 17	1–4	307 ± 17
	324	TA-21 Area T-4	158 ± 11	1–4	151 ± 11
	325	TA-21 Area T-5	131 ± 7	1–4	143 ± 11
	326	TA-21 Area T-6	153 ± 9	1–4	148 ± 11
	327	TA-21 Area T-7	165 ± 9	1–4	152 ± 11

Table 4-17. Thermoluminescent Dosimeter (TLD) Measurements of External Radiation at Waste Disposal Areas during 1997–1998 (Cont.)

	TLD Station ID #	Location	1998 Annual Dose (mrem)[a,b]	1998 Quarters Monitored[c]	1997 Quarters Dose (mrem)[a,b]
Area U	341	TA-21 Area U-1	152 ± 8	1–4	142 ± 11
	342	TA-21 Area U-2	169 ± 9	1–4	149 ± 11
	343	TA-21 Area U-3	147 ± 9	1–4	157 ± 13
	344	TA-21 Area U-4	154 ± 9	1–4	145 ± 11
Area V	361	TA-21 Area V-1	143 ± 9	1–4	141 ± 11
	362	TA-21 Area V-2	152 ± 8	1–4	156 ± 16
	363	TA-21 Area V-3	156 ± 9	1–4	159 ± 12
	364	TA-21 Area V-4	154 ± 8	1–4	145 ± 12
Area W	381	TA-35 Area W-1	141 ± 8	1–4	156 ± 10
	382	TA-35 Area W-2	117 ± 8	1–3	153 ± 10[c]
	383	TA-35 Area X	139 ± 8	1–4	132 ± 10

[a]Dose is the sum of all quarterly data accepted upon quality assurance review.
[b]The uncertainty of each measurement is the propagated error of the quarterly measurements.
[c]If number of quarters is less than 4, data have not been reported because of loss of TLDs, analytical problems, or new stations.

Table 4-18. TA-18 Albedo Dosimeter Network

Location ID #	Location	Dosimeter Reading (mrem) Continuous	Dosimeter Reading (mrem) Road Open
1	NEWNET Kappa Site	2.0	2.6
2	TA-36 Entrance	7.4	7.2
3	TA-18 Personnel Gate at Parking Lot	5.5	5.1
4	P2 Booster Station at TA-54 Entrance	5.5	2.1
5	TA-51 Entrance	1.6	2.1
6	Pajarito Hill West of TA-18 Entrance	2.5	3.1
7	TA-18 Entrance at Pajarito Road	2.1	1.9
8	Santa Fe Background	4.1	NA[a]
8	TA-49 Background	0.4[b]	NA[a]
9	Vault Control	–0.2	NA[a]

[a]Not Applicable—background or control location with continuous exposure.
[b]This dose represents only 2 quarters of data.

Table 4-19. DX Division Firing Sites Expenditures for Calendar Year 1998

(All units are in kilograms unless otherwise noted)

CY 1998 Materials Expended	Material Totals
He	2263
Aluminum	662
Beryllium	1
Brass	89
Copper	93
D-38	121
Lead	2
PMMA	2
Polycarbonate	7
Polyethylene	2
Stainless Steel	339
Steel	61
Tantalum	5
Teflon	1
Tin	<1
Transformer Oil	70 gal
Water	2473 gal

Table 4-20. Airborne Beryllium Concentrations

Station Location	Number of Results	Maximum (ng/m^3)	Minimum (ng/m^3)	Mean (ng/m^3)	Sample Standard Deviation
Off-Site Stations					
01 Española	4	0.028	0.015	0.020	0.006
03 Santa Fe	4	0.032	0.011	0.022	0.009
04 Barranca School	4	0.022	0.007	0.016	0.007
07 Gulf/Exxon/Shell Station	4	0.034	0.010	0.020	0.010
09 Los Alamos Airport	4	0.013	0.004	0.008	0.004
12 Royal Crest Trailer Court	4	0.015	0.004	0.009	0.005
16 White Rock Nazarene Church	4	0.010	0.003	0.007	0.003
41 Pueblo of San Ildefonso	4	0.028	0.019	0.023	0.004
56 El Rancho	4	0.022	0.006	0.014	0.007
61 LA Hospital	4	0.036	0.012	0.025	0.010
County Landfill					
32 County Landfill (TA-48)	4	0.111	0.086	0.098	0.011
On-Site Stations					
23 TA-52 Beta Site	4	0.013	0.006	0.010	0.003
31 TA-3	4	0.010	0.004	0.008	0.003
33 TA-49, Area AB	2	0.025	0.019	0.022	0.005
57 TA-49, Area AB 2 A North	2	0.030	0.015	0.022	0.011
58 TA-49, Area AB Test Well 5A	2	0.009	0.003	0.006	0.005
76 TA-15-61	4	0.011	0.003	0.007	0.004
77 TA-15-IJ site	4	0.015	0.004	0.008	0.005
78 TA-15-N	4	0.009	0.002	0.005	0.003

Group Summaries

Station Location	Number of Results	Maximum (ng/m^3)	Minimum (ng/m^3)	Mean (ng/m^3)	95% Confidence Interval[a]	Sample Standard Deviation
Off-Site Stations	40	0.036	0.003	0.016	±0.003	0.009
County Landfill	4	0.111	0.086	0.098	±0.015	0.011
On-Site Stations	26	0.030	0.002	0.010	±0.003	0.007

[a] 95% confidence intervals are calculated using all calculated sample concentrations from every site within the group.

Table 4-21. 1998 Precipitation (in.)

	North Community	TA-16	TA-6	TA-49	TA-53	TA-54	TA-74
January	0.13	0.15	0.12	0.05	0.07	0.03	0.05
February	0.48	0.57	0.39	0.31	0.18	0.20	0.11
March	1.81	1.86	1.59	1.47	1.33	1.46	1.24
April	0.70	0.77	0.61	0.66	0.34	0.61	0.42
May	0.00	0.02	0.00	0.01	0.03	0.01	0.03
June	0.28	0.51	0.44	0.43	0.51	0.45	0.48
July	6.93	6.11	5.29	4.99	5.20	3.35	2.92
August	4.38	3.57	3.32	2.84	2.18	1.66	1.98
September	1.44	0.87	0.80	0.81	0.73	1.25	0.94
October	4.52	4.85	4.16	3.12	3.07	3.35	1.48
November	0.58	0.80	0.52	0.41	0.30	0.30	0.00
December	0.03	0.07	0.06	0.05	0.01	0.02	0.00
Total	21.28	20.15	17.30	15.15	13.95	12.69	9.65

J. Figures

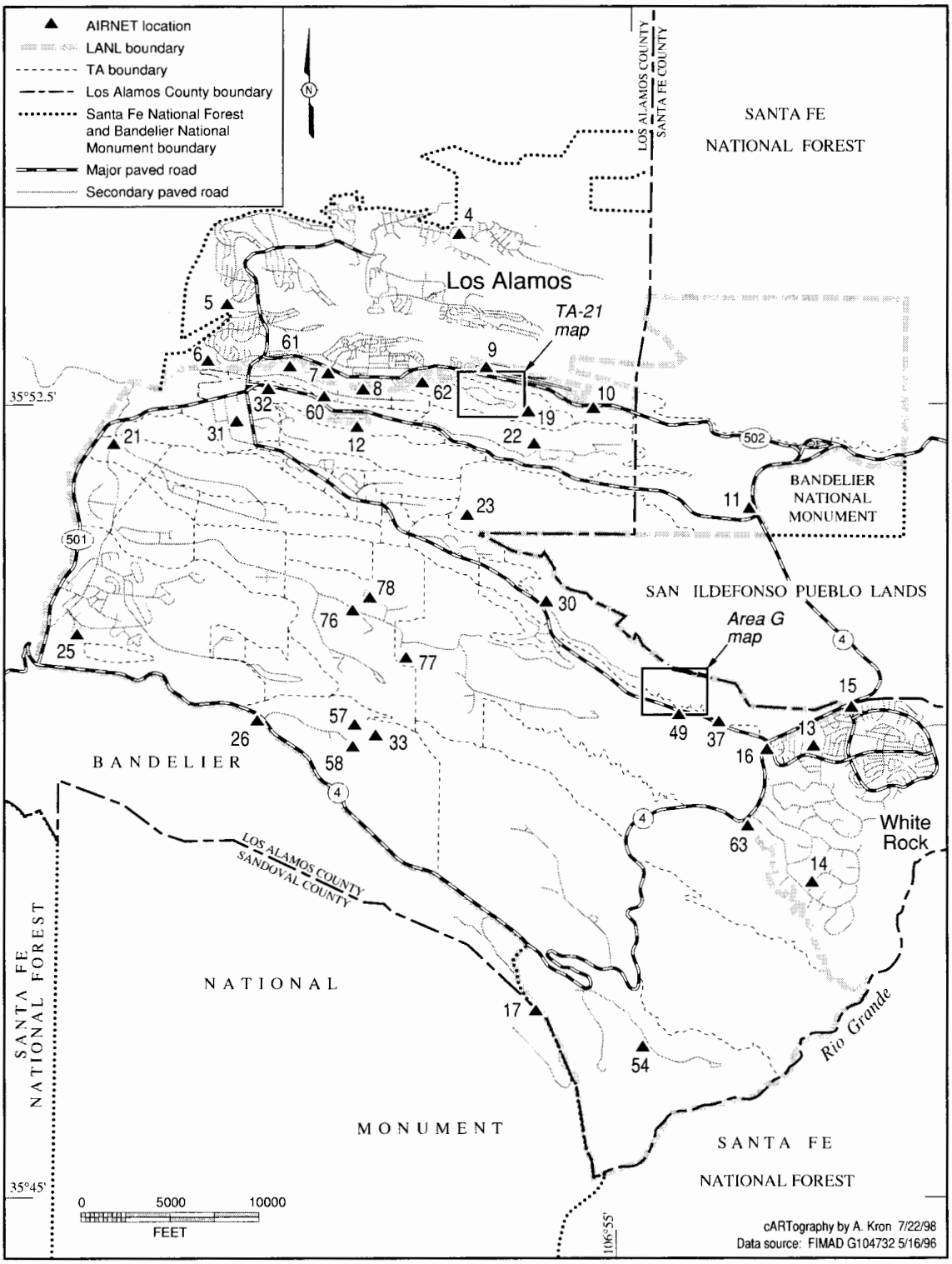

Figure 4-1. Off-site perimeter and on-site Laboratory AIRNET locations.

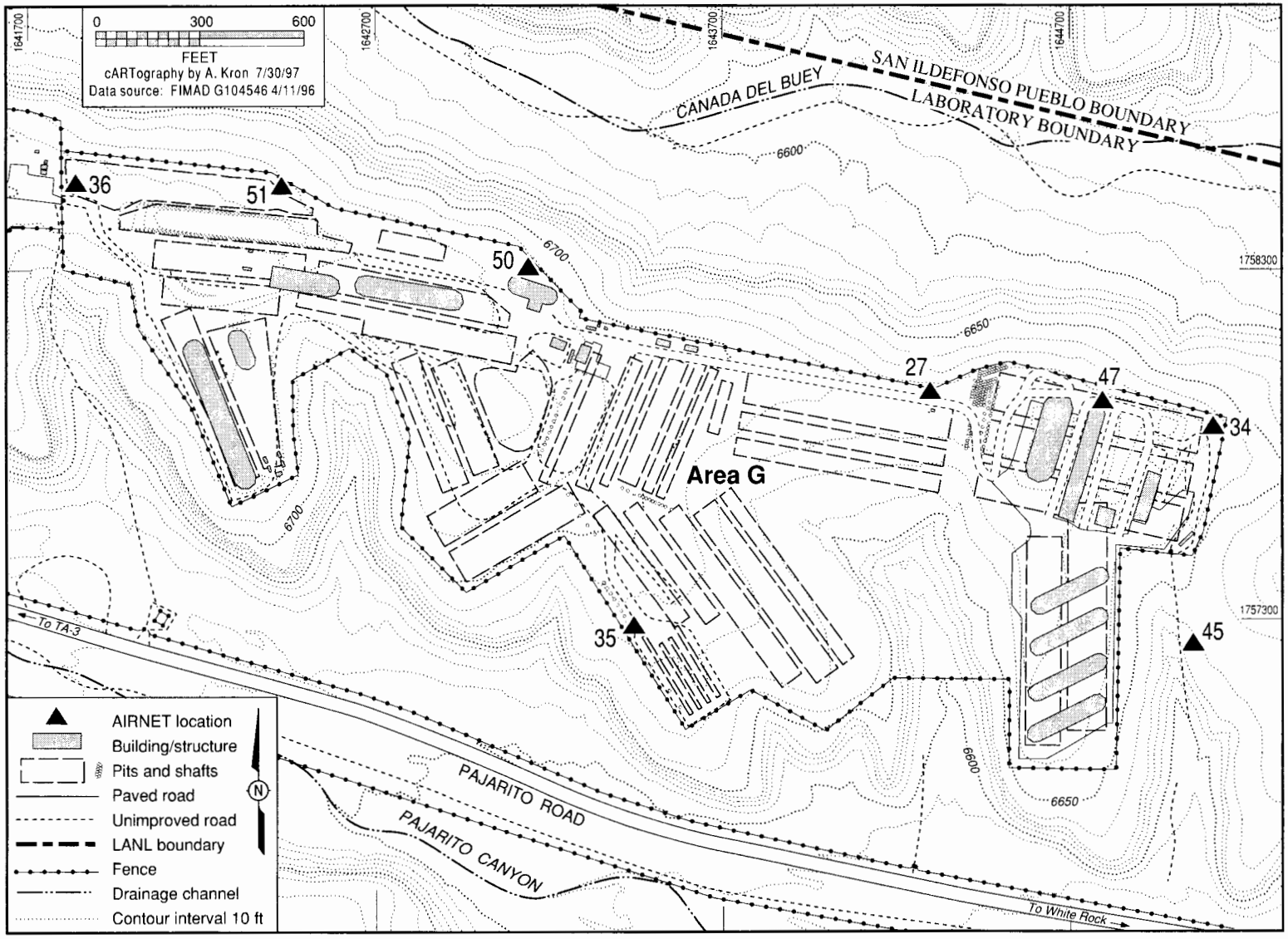

Figure 4-2. Technical Area 54, Area G, map of AIRNET locations.

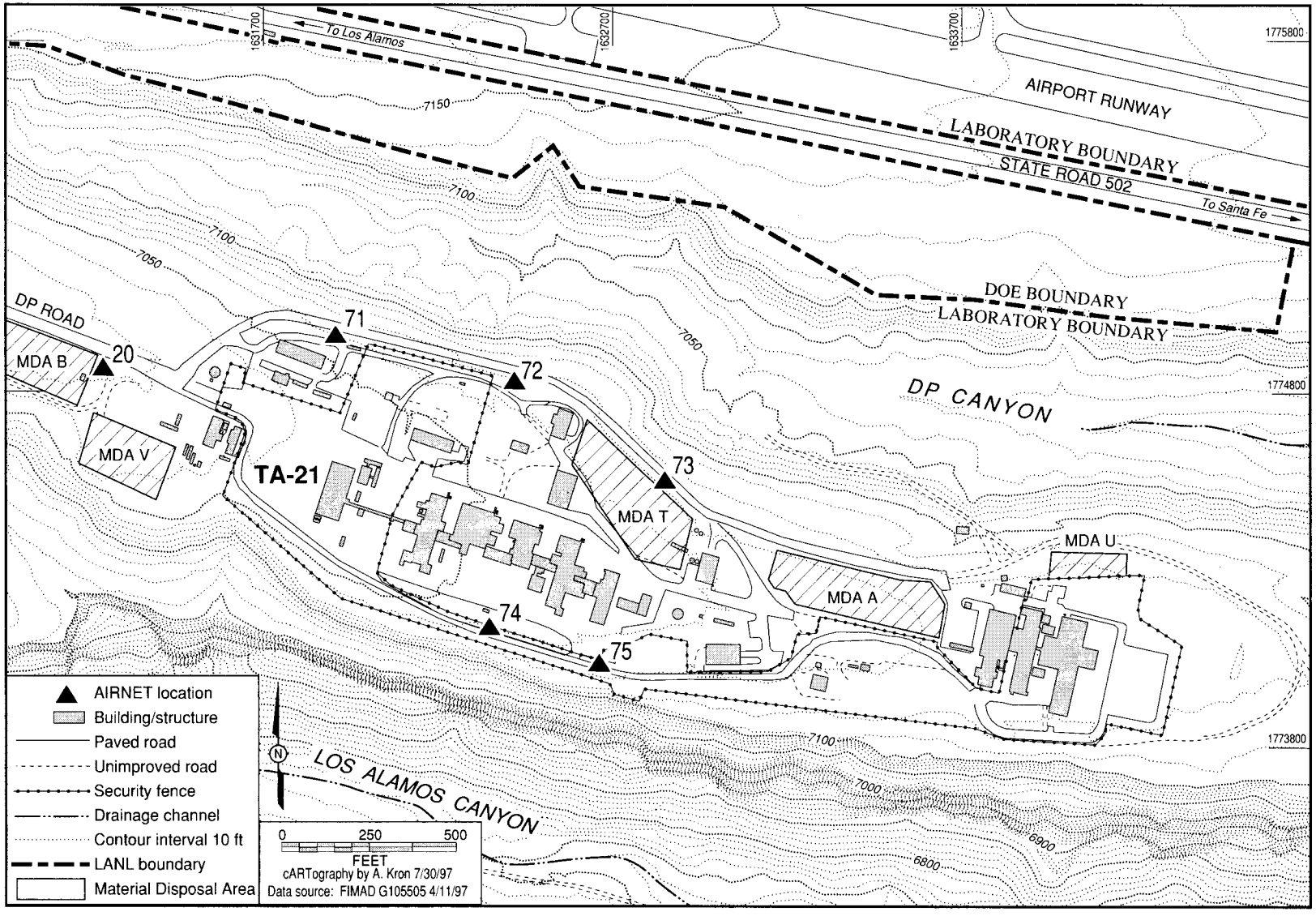

Figure 4-3. Technical Area 21 map of AIRNET locations.

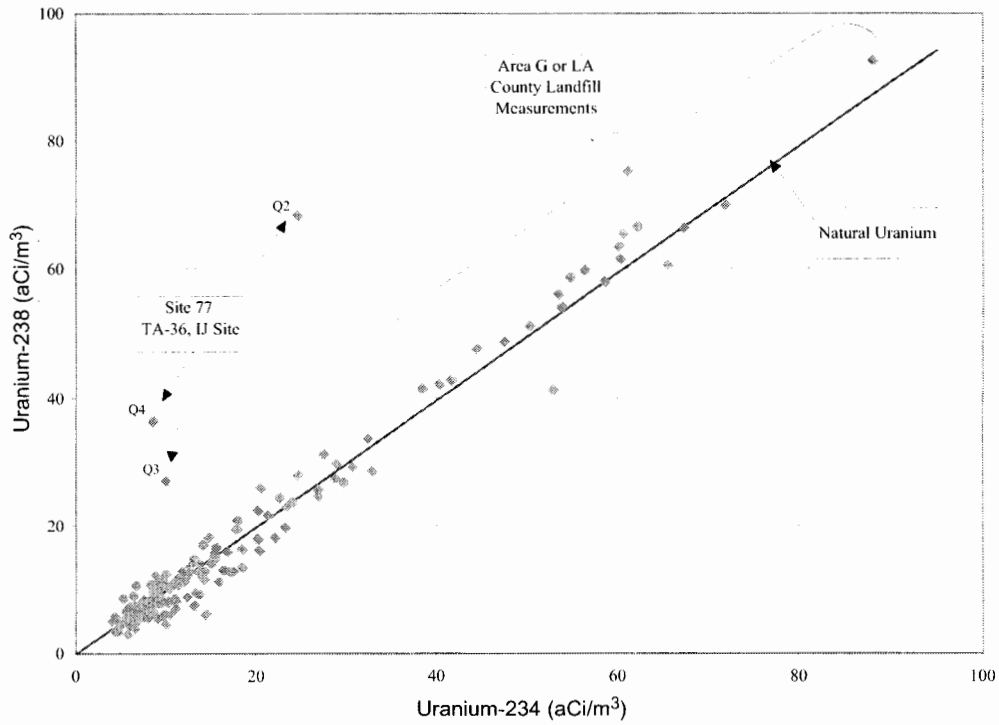

Figure 4-4. Uranium-234 and uranium-238 concentrations for 1998.

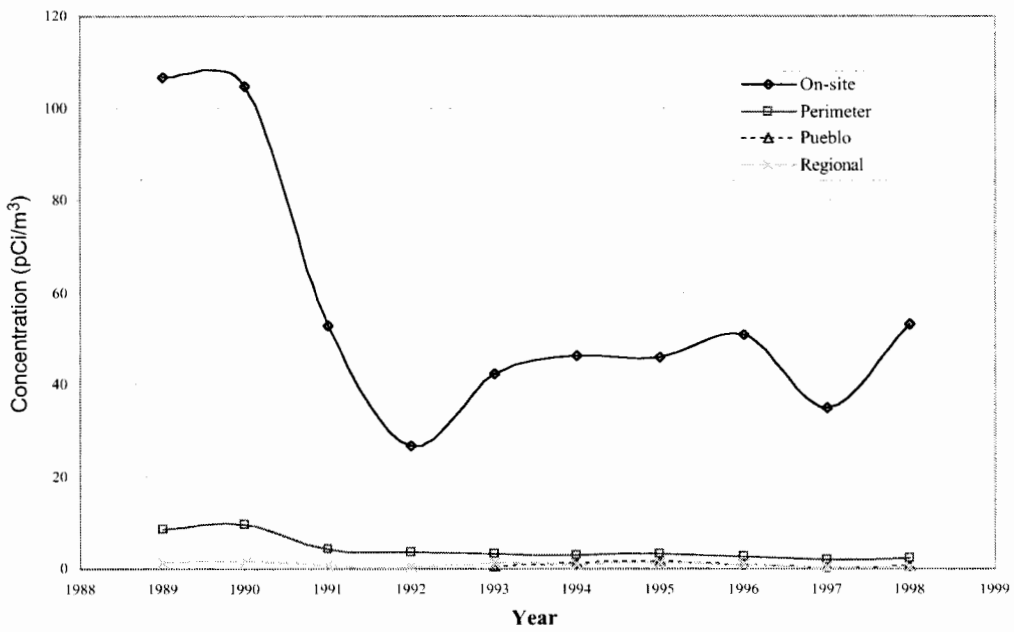

Figure 4-5. Annual tritium concentrations.

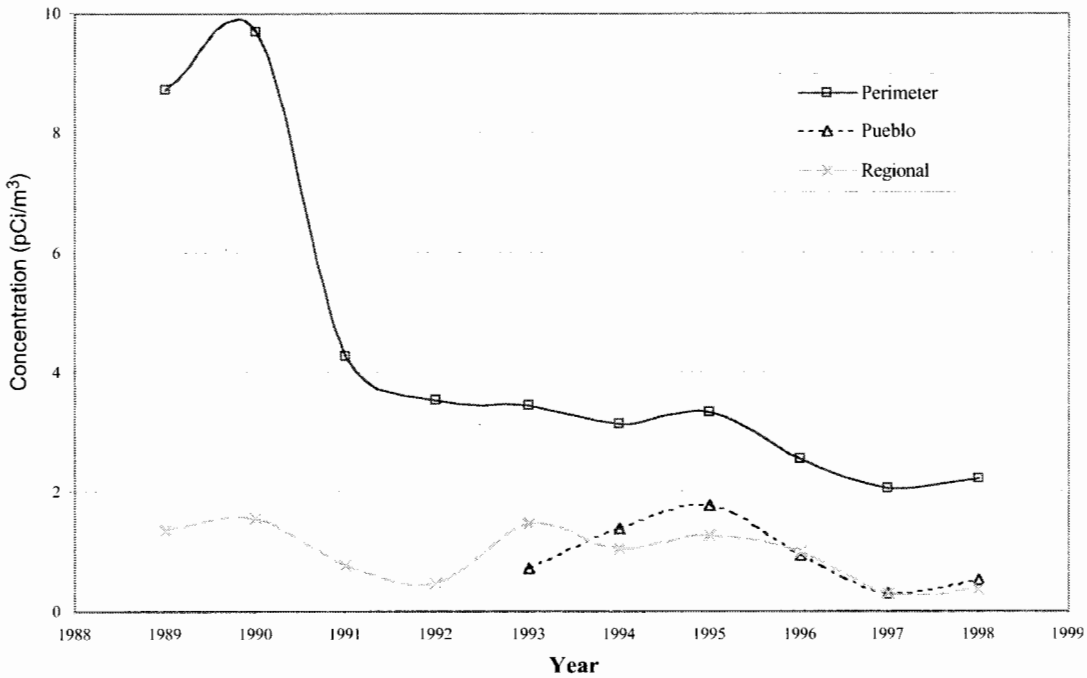

Figure 4-6. Annual off-site tritium concentrations.

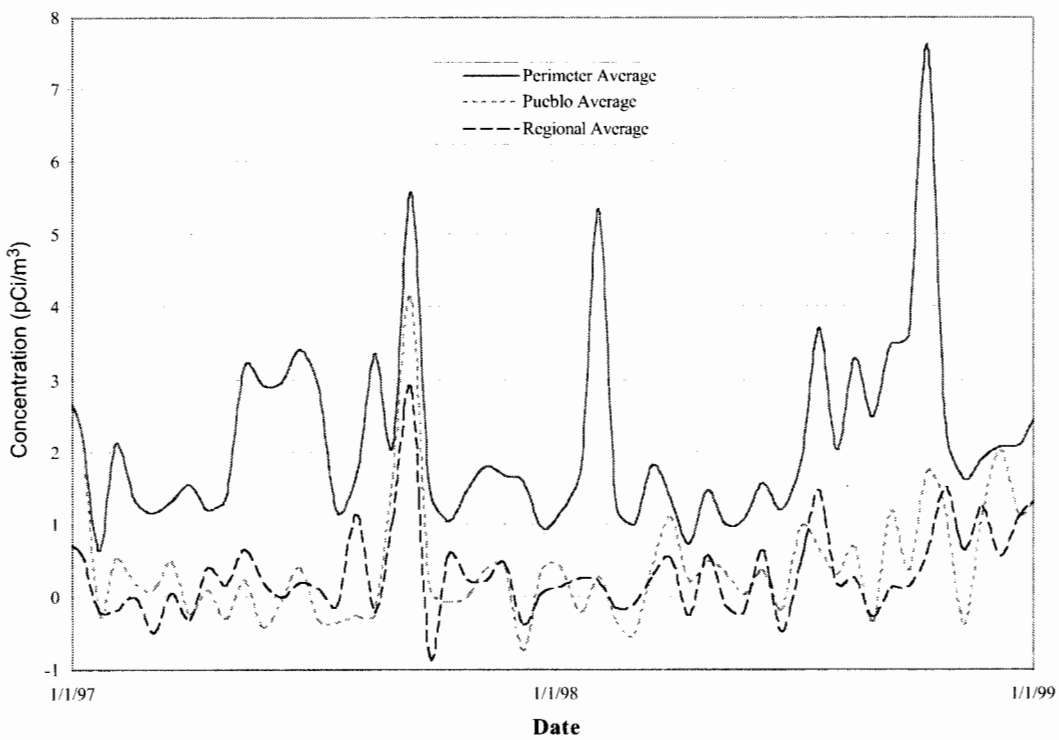

Figure 4-7. Biweekly off-site tritium concentrations (1997–1998).

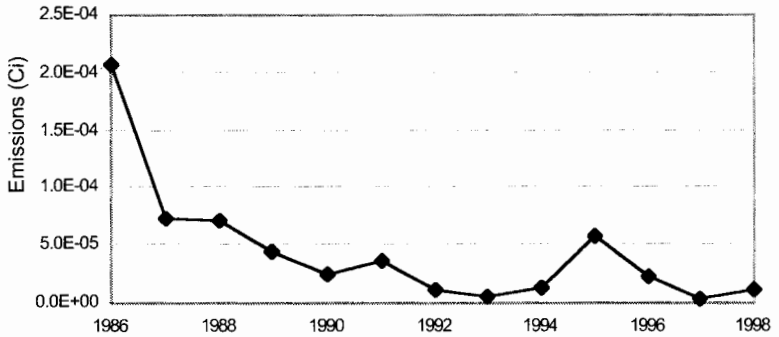

Figure 4-8. Plutonium emissions from sampled Laboratory stacks since 1986.

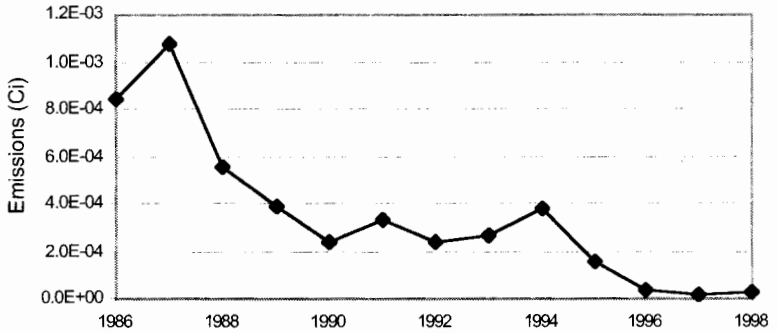

Figure 4-9. Uranium emissions from sampled Laboratory stacks since 1986.

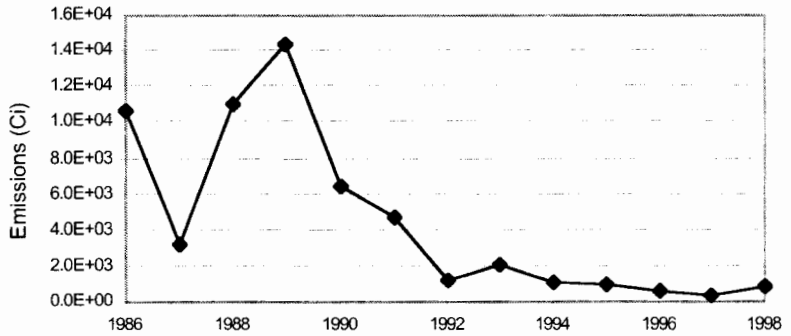

Figure 4-10. Tritium emissions from sampled Laboratory stacks since 1986.

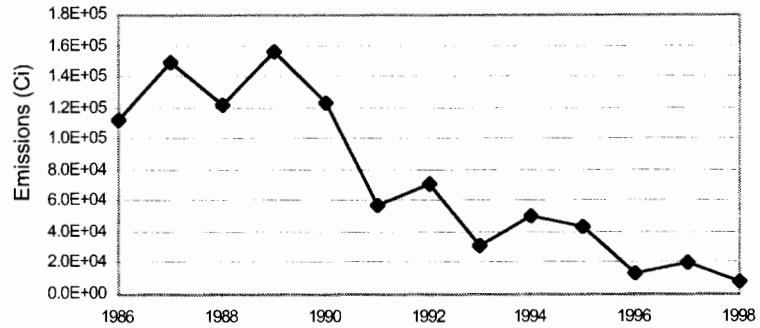

Figure 4-11. G/MAP emissions from sampled Laboratory stacks since 1986.

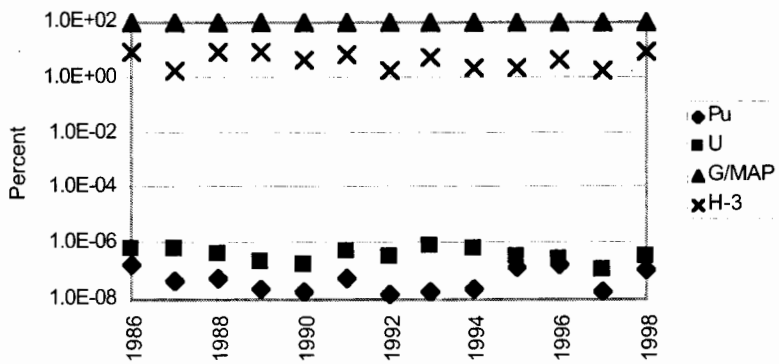

Figure 4-12. Percent of total emissions resulting from plutonium, uranium, tritium, and G/MAP.

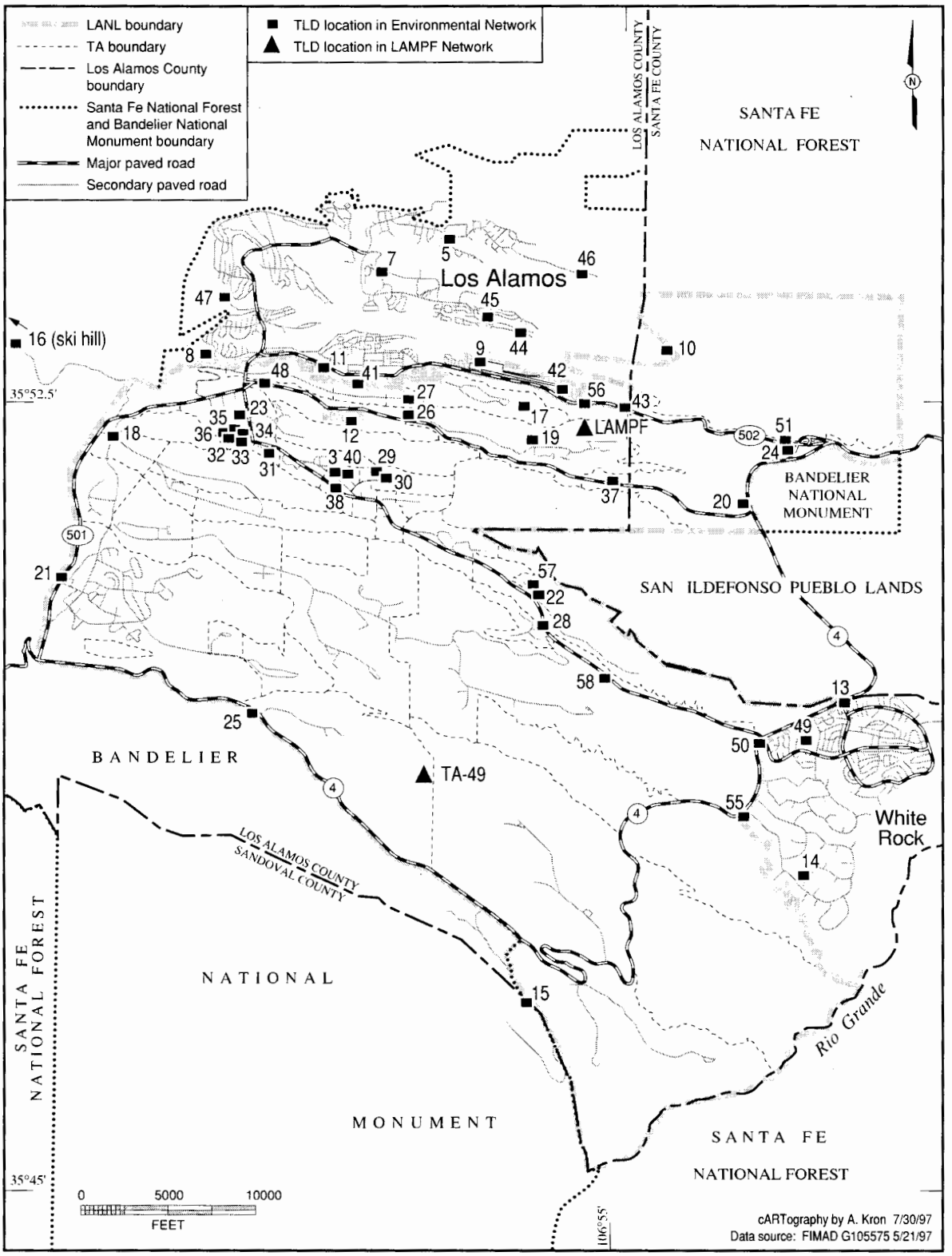

Figure 4-13. Off-site perimeter and on-site Laboratory TLD locations.

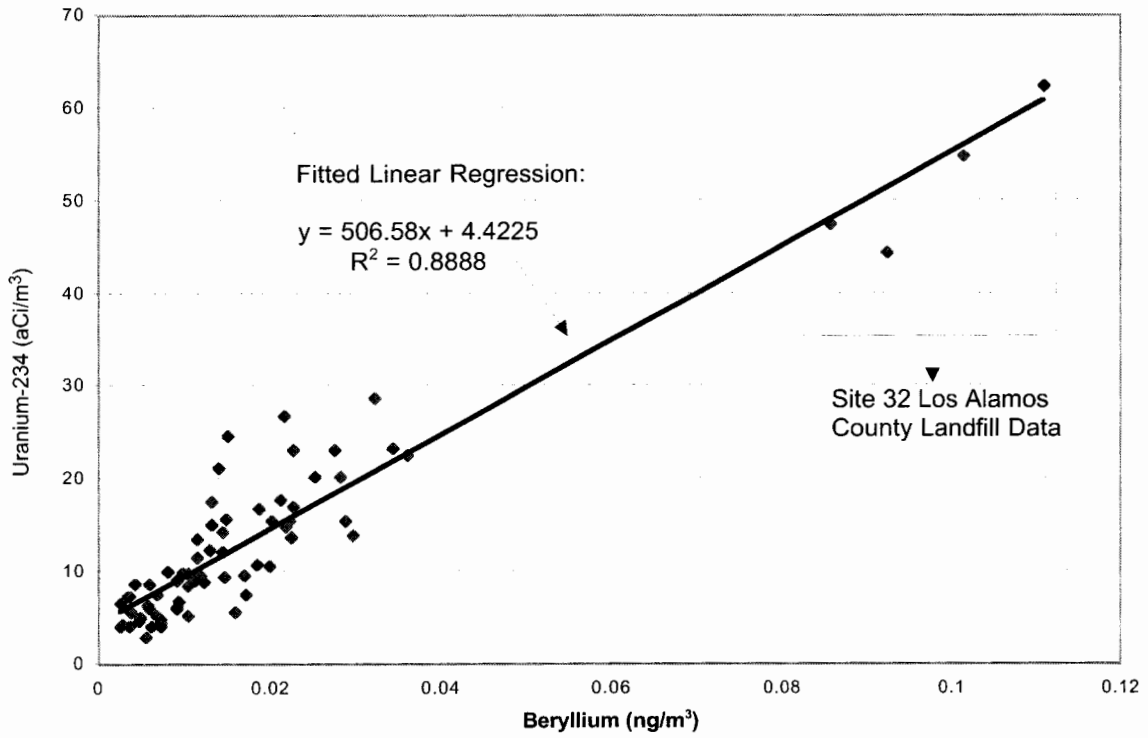

Figure 4-14. Quarterly beryllium and uranium-234 concentrations for 1998.

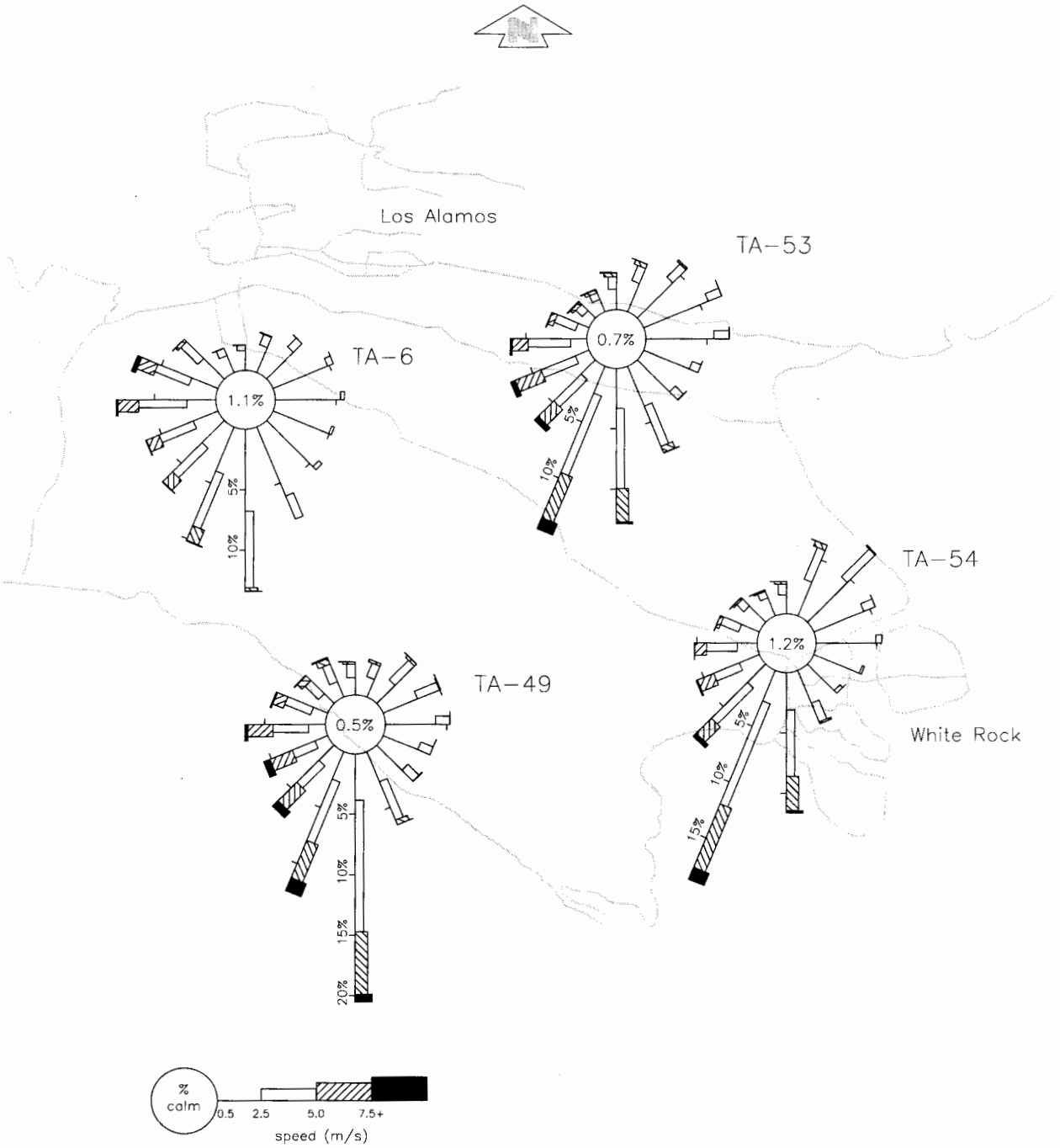

Figure 4-15 Daytime wind roses.

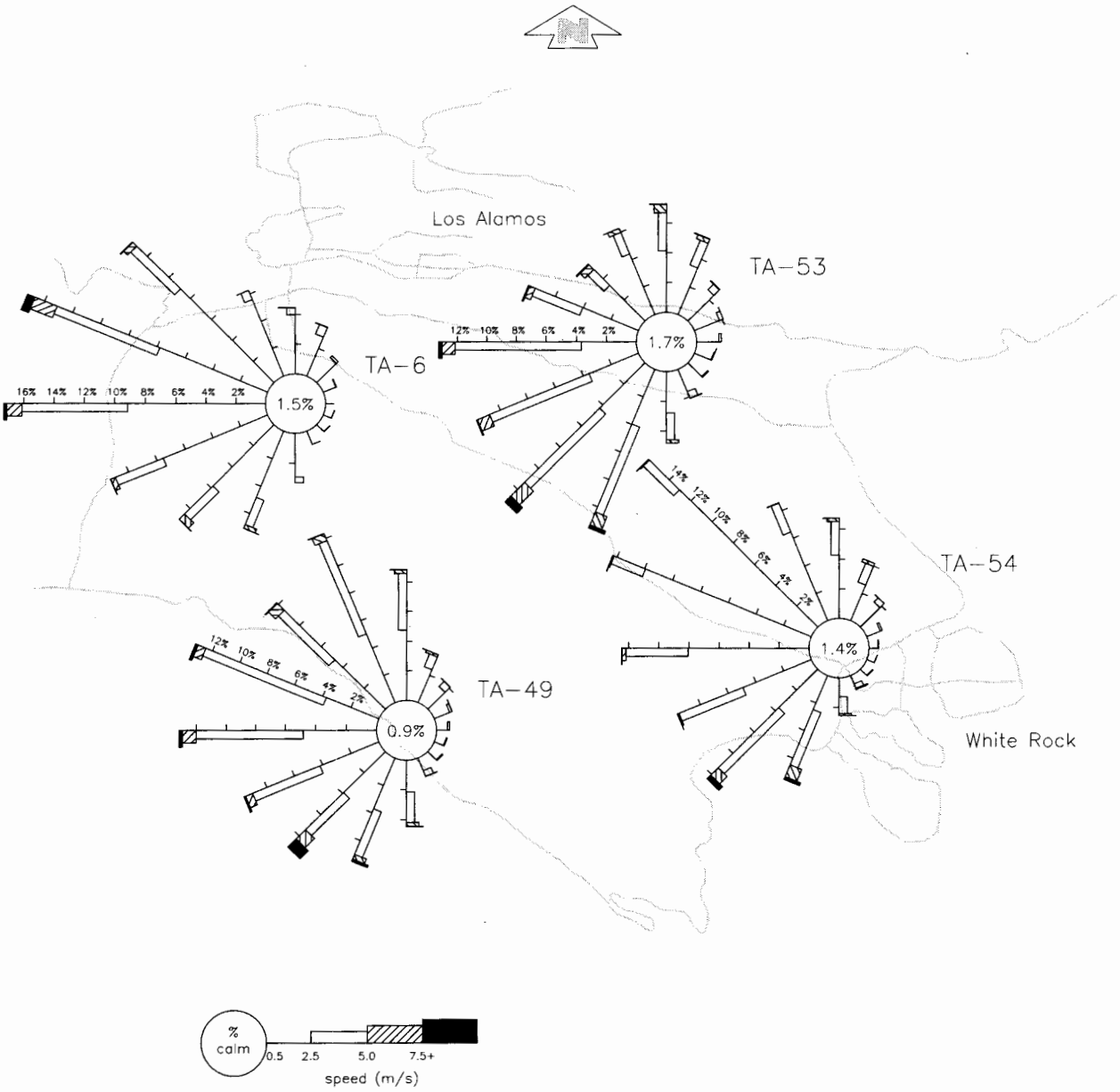

Figure 4-16. Nighttime wind roses.

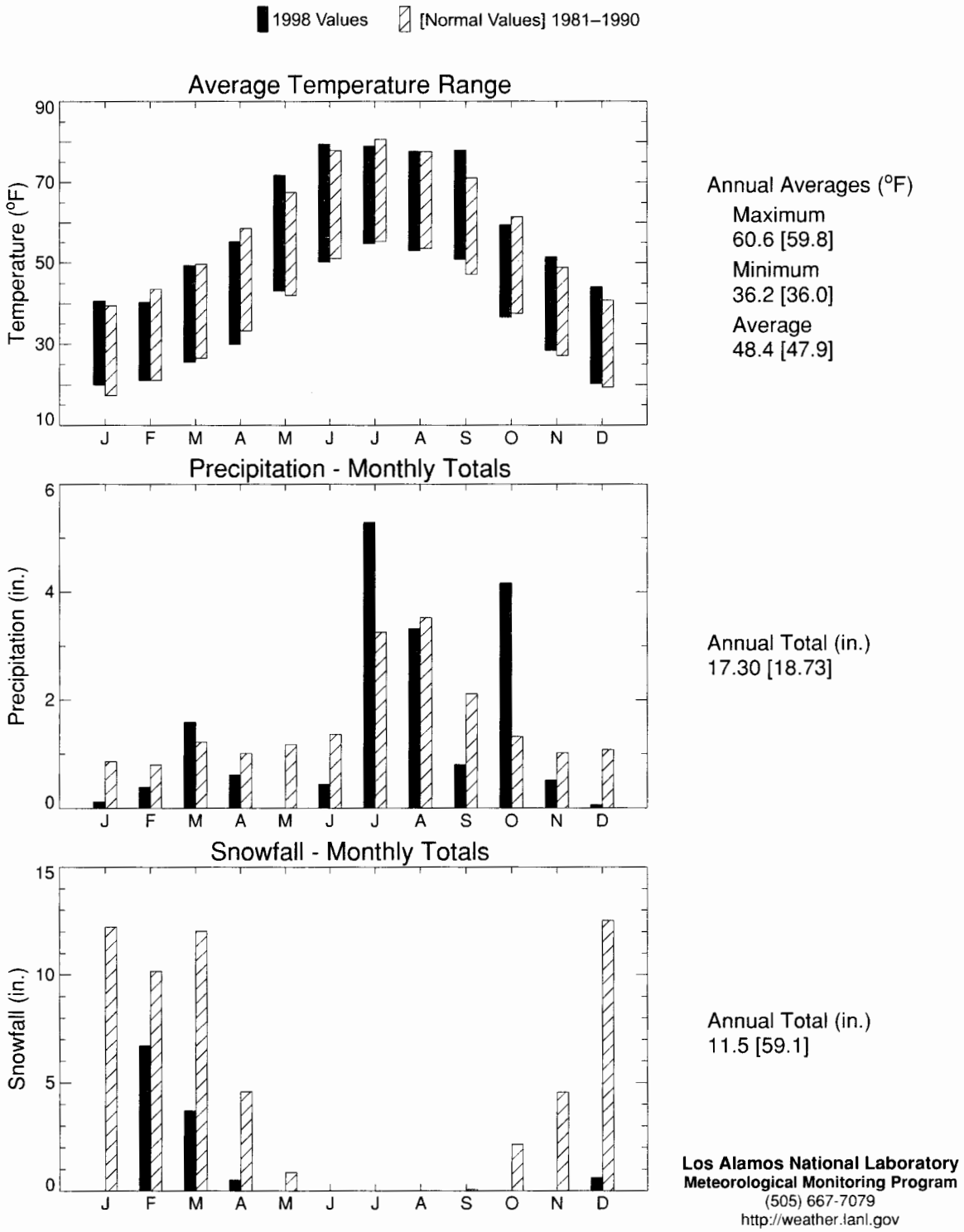

Figure 4-17. 1998 weather summary for Los Alamos.

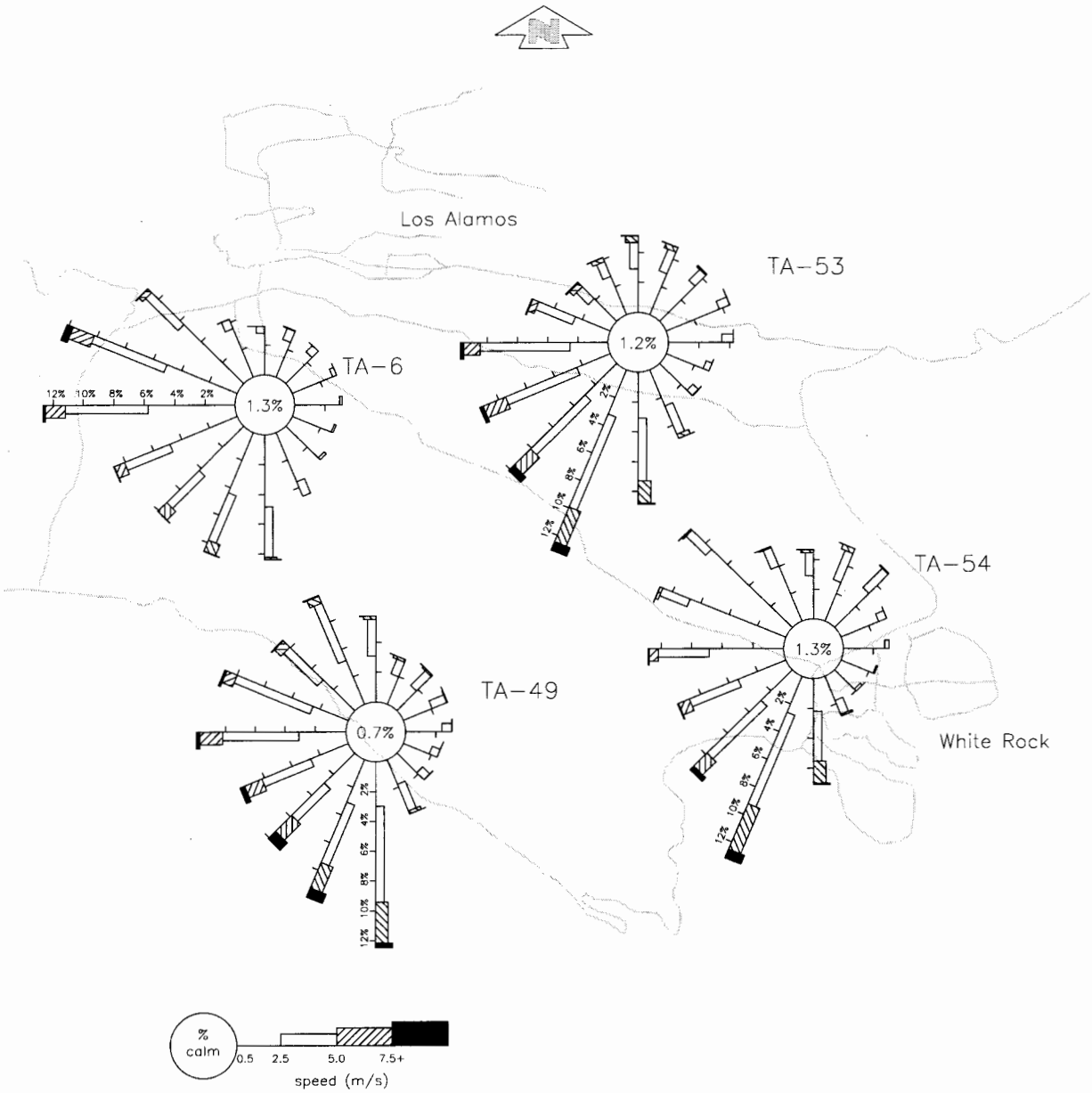

Figure 4-18. Total wind roses.

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5. Surface Water, Groundwater, and Sediments

primary authors:

David B. Rogers, Billy R. J. R. Turney

Highlights from 1998

The 1998 surface water and runoff analysis results are consistent with past findings. Runoff samples are collected using automated samplers; the samplers are actuated when a significant precipitation event causes flow in a drainage crossing Los Alamos National Laboratory's (LANL's or the Laboratory's) boundaries. Seven gross alpha measurements and one plutonium-238 measurement exceeded the Department of Energy (DOE) dose concentration guidelines (DCG) for public dose values in surface water or runoff samples in 1998. These samples came from Mortandad Canyon and from around Material Disposal Area (MDA) G, the Laboratory's low-level radioactive waste disposal facility. The gross alpha value in runoff at Cañada del Buey at White Rock exceeded the DOE public dose DCG. The DOE DCGs for public dose are determined assuming that two liters per day of water are consumed each year. This assumption will not be met for runoff, which is present only a few days each year.

Drilling characterization well R-25 at TA-16 in the southwest portion of the Laboratory revealed the presence of high-explosives constituents in the regional aquifer at concentrations that are above the Environment Protection Agency Health Advisory guidance values for drinking water. Testing of water supply wells showed that these compounds are not present in drinking water. Other groundwater samples from the regional aquifer were consistent with previous results. Trace levels of tritium are present in the regional aquifer in a few areas where liquid waste discharges occurred, notably beneath Los Alamos, Pueblo, and Mortandad Canyons. The highest tritium level found in a regional aquifer test well is about 2% of the drinking water standard and poses no health risk according to the US Public Health Service. In recent years, apparent strontium-90 detections (near the detection limit) occurred in samples from two regional aquifer test wells and two water supply wells. However, continued testing shows no detections, suggesting that these values were due to variations in laboratory analyses. Nitrate concentrations in a test well beneath Pueblo Canyon remain elevated, but in 1998 they were only about half the drinking water standard. In 1998, we detected no radionuclides other than naturally occurring uranium in Pueblo of San Ildefonso water supply wells.

Analytical results for alluvial and intermediate depth groundwater are similar to those of past years. Waters near former or present effluent discharge points show the effects of these discharges. Only one gross alpha value, from Cañada del Buey, exceeded DOE DCGs for public exposure. Alluvial groundwater samples in Los Alamos and Mortandad Canyons exceeded DOE DCGs for a DOE-operated drinking water system. The constituents exceeding drinking water DCGs were gross beta and strontium-90.

The 1998 sediment sampling analysis is generally consistent with historical data. We detected strontium-90 at levels above background in several sediment samples collected on the Pajarito Plateau and at background stations. The strontium-90 measurements result from a high analytical bias in the strontium-90 technique. Plutonium occurs above fallout levels in Pueblo and Los Alamos Canyons and extends off-site from the Laboratory. Within Mortandad Canyon, the greatest radionuclide levels in sediments are found between the point where Radioactive Liquid Waste Treatment Facility effluent enters the drainage and the sediment traps, approximately a 3-km distance. Radionuclide levels near or slightly exceeding background levels are found downstream of the sediment traps, extending to the Laboratory/San Ildefonso Pueblo boundary. A number of sediment samples near and downstream of the Technical Area (TA)-54 Solid Waste Operations at MDA G contained plutonium-238 at activities greater than background. We also found above background levels of plutonium and americium in sediments downstream of MDA AB. Sample results from Cochiti Reservoir showed radionuclides near background levels.

5. Surface Water, Groundwater, and Sediments

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A. Description of Monitoring Program

Studies related to development of groundwater supplies began at Los Alamos in 1945 under the direction of the US Geological Survey (USGS). Studies specifically aimed at environmental monitoring and protecting groundwater quality were initiated as joint efforts between the Atomic Energy Commission, the Los Alamos Scientific Laboratory, and the USGS in about 1949. These initial efforts were focused on Pueblo and DP/Los Alamos Canyons, which received radioactive industrial waste discharges in the early days of the Laboratory.

The current network of annual sampling stations for surface water and sediment surveillance includes a set of regional (or background) stations and a group of stations near or within the Los Alamos National Laboratory (LANL or the Laboratory) boundary. The regional stations are used to establish the background quantities of radionuclides and radioactivity derived from natural minerals and from fallout affecting northern New Mexico and southern Colorado.

Groundwater samples are taken from wells and springs within or adjacent to the Laboratory and from the nearby Pueblo of San Ildefonso. The on-site stations are, for the most part, focused on areas of present or former radioactive waste disposal operations, particularly canyons (Figure 1-3). To provide context for discussion of monitoring results, the setting and operational history of currently monitored canyons that have received radioactive or other liquid discharges are briefly summarized below.

For a discussion of sampling procedures, analytical procedures, data management, and quality assurance, see Section F below.

1. Acid Canyon, Pueblo Canyon, and Lower Los Alamos Canyon

Acid Canyon, a small tributary of Pueblo Canyon, was the original disposal site for liquid wastes generated by research on nuclear materials for the World War II Manhattan Engineer District atomic bomb project. Acid Canyon received untreated radioactive industrial effluent from 1943 to 1951. The Technical Area (TA) 45 treatment plant was completed in 1951, and from 1951 to 1964 the plant discharged treated effluents that contained residual radionuclides into nearby Acid Canyon. Several decontamination projects have removed contamination from the area, but remaining residual radioactivity from these releases is now associated with the sediments in Pueblo Canyon (ESP 1981).

The inventory of radioactivity remaining in the Pueblo Canyon system is only approximately known. Several studies (ESP 1981, Ferenbaugh et al., 1994) have concluded that the plutonium does not present a health risk to the public. Based on analysis of radiological sediment survey data, the estimated total plutonium inventory in Acid Canyon, Pueblo Canyon, and Lower Los Alamos Canyon ranges from 246 mCi to 630 ± 300 mCi (ESP 1981). The estimated plutonium releases were about 177 mCi, in satisfactory agreement with the measured inventory considering uncertainties in sampling and release estimates. About two-thirds of this total is in the Department of Energy (DOE)-owned portion of lower Pueblo Canyon.

Pueblo Canyon currently receives treated sanitary effluent from the Los Alamos County Bayo Sewage

Treatment Plant in the middle reach of Pueblo Canyon. Water occurs seasonally in the alluvium, depending on the volume of surface flow from snowmelt, thunderstorm runoff, and sanitary effluents. Tritium, nitrate, and chloride, apparently derived from these industrial and municipal disposal operations, have infiltrated to the intermediate perched ground water (at depths of 37 to 58 m [120 to 190 ft]) and to the regional aquifer (at a depth of 180 m [590 ft]) beneath the lower reach of Pueblo Canyon. Except for occasional nitrate values, levels of these constituents are a small fraction of the Environmental Protection Agency (EPA) drinking water standards.

Starting in 1990, increased discharge of sanitary effluent from the county treatment plant resulted in nearly continual flow during most months except June and July in the lower reach of Pueblo Canyon and across DOE land into the lower reach of Los Alamos Canyon on Pueblo of San Ildefonso land. From mid-June through early August, higher evapotranspiration and the diversion of sanitary effluent for golf course irrigation eliminate flow from Pueblo Canyon into Los Alamos Canyon. Hamilton Bend Spring, which in the past discharged from alluvium in the lower reach of Pueblo Canyon, has been dry since 1990, probably because there was no upstream discharge from the older, abandoned Los Alamos County Pueblo Sewage Treatment Plant. Farther east, the alluvium is continuously saturated, mainly because of infiltration of effluent from the Los Alamos County Bayo Sewage Treatment Plant. Effluent flow from Pueblo Canyon into Los Alamos Canyon generally extends to somewhere between the DOE/Pueblo of San Ildefonso boundary and the confluence of Guaje and Los Alamos Canyons.

2. DP Canyon and Los Alamos Canyon

In the past, Los Alamos Canyon received treated and untreated industrial effluents containing some radionuclides. In the upper reach of Los Alamos Canyon, there were releases of treated and untreated radioactive effluents during the earliest Manhattan Project operations at TA-1 (1942–1945) and some release of water and radionuclides from the research reactors at TA-2. An industrial liquid waste treatment plant that served the old plutonium processing facility at TA-21 discharged effluent containing radionuclides into DP Canyon, a tributary to Los Alamos Canyon, from 1952 to 1986. Los Alamos Canyon also received discharges containing radionuclides from the sanitary sewage lagoon system at the Los Alamos Neutron Science Center (LANSCE) at TA-53. The low-level radioactive waste stream was separated from the sanitary system at TA-53 in 1989 and directed into a total retention evaporation lagoon.

The reach of Los Alamos Canyon within the Laboratory boundary presently carries flow from the Los Alamos Reservoir (west of the Laboratory) as well as National Pollutant Discharge Elimination System (NPDES)-permitted effluents from TA-53 and TA-21. Infiltration of effluents and natural runoff from the stream channel maintain a shallow body of groundwater in the alluvium of Los Alamos Canyon within the Laboratory boundary west of State Road 4. Groundwater levels are highest in late spring from snowmelt runoff and in late summer from thundershowers. Water levels decline during the winter and early summer when runoff is at a minimum. Groundwater also occurs within alluvium in the lower portion of Los Alamos Canyon on the Pueblo of San Ildefonso lands.

3. Sandia Canyon

Sandia Canyon has a small drainage area that heads at TA-3. The canyon receives water from the cooling tower at the TA-3 power plant. Treated effluents from the TA-46 Sanitary Wastewater Systems (SWS) Facility are rerouted to Sandia Canyon. These effluents support a continuous flow in a short reach of the upper part of the canyon. Only during summer thundershowers does stream flow approach the Laboratory boundary at State Road 4, and only during periods of heavy thunderstorms or snowmelt does surface flow extend beyond the Laboratory boundary.

4. Mortandad Canyon

Mortandad Canyon has a small drainage area that heads at TA-3. Its drainage area receives inflow from natural precipitation and a number of NPDES outfalls, including one from the Radioactive Liquid Waste Treatment Facility (RLWTF) at TA-50. The TA-50 facility began operations in 1963. The effluents infiltrate into the stream channel and maintain a saturated zone in the alluvium extending about 3.5 km (2.2 mi) downstream from the outfall. The easternmost extent of saturation remains on-site, ending about 1.6 km (1 mi) west of the Laboratory boundary with the Pueblo of San Ildefonso. Over the period of operation, the radionuclides in the RLWTF effluent have often exceeded the DOE dose concentration guidelines

(DCGs) for public dose. The effluent also contains nitrate that causes alluvial groundwater concentrations to exceed the New Mexico groundwater standard of 10 mg/L (nitrate as nitrogen). The groundwater standard applies because the TA-50 effluent is a source of groundwater in the canyon alluvium. In 1999, the new reverse osmosis and ultrafiltration system at the RLWTF will begin operation. This system will remove additional radionuclides and nitrate from the effluent, and discharges from the plant will meet the DOE public dose DCGs and the New Mexico groundwater standard for nitrate.

Continuous surface flow across the drainage has not reached the Pueblo of San Ildefonso boundary since observations began in the early 1960s (Stoker et al., 1991). Three sediment traps are located about 3 km (2 mi) downstream from the effluent discharge in Mortandad Canyon to dissipate the energy of major thunderstorm runoff events and settle out transported sediments. From the sediment traps, it is approximately 2.3 km (1.4 mi) downstream to the Laboratory boundary with the Pueblo of San Ildefonso.

The alluvium is less than 1.5 m thick in the upper reach of Mortandad Canyon and thickens to about 23 m at the easternmost extent of saturation. The saturated portion of the alluvium is perched on weathered and unweathered tuff, and generally there is no more than 3 m of saturation. There is considerable seasonal variation in saturated thickness, depending on the amount of runoff experienced in any given year (Stoker et al., 1991). Velocity of water movement in the alluvium ranges from 18 m/day in the upper reach to about 2 m/day in the lower reach of the canyon (Purtymun 1974; Purtymun et al., 1983). The high turnover rate for water in the alluvial groundwater prevents accumulation of chemicals from the RLWTF effluent (Purtymun et al., 1977). The top of the regional aquifer is about 290 m below the alluvial groundwater.

5. Pajarito Canyon

In Pajarito Canyon, water in the alluvium is perched on the underlying tuff and is recharged mainly through snowmelt and thunderstorm runoff. Saturated alluvium does not extend beyond the facility boundary. Three shallow observation wells were constructed in 1985 as part of a compliance agreement with the State of New Mexico to determine whether Technical Areas in the canyon or solid waste disposal activities on the adjacent mesa were affecting the quality of shallow groundwater. No effects were observed; the alluvial groundwater is contained in the canyon bottom and does not extend under the mesa (Devaurs 1985).

6. Cañada del Buey

Cañada del Buey contains a shallow alluvial groundwater system of limited extent. The thickness of the alluvium ranges from 1.2 to 5 m, but the underlying weathered tuff ranges in thickness from 3.7 to 12 m. In 1992, saturation was found within only a 0.8-km long segment, and only two observation wells have ever contained water (ESP 1994). We previously identified the source of the saturation as purge water from nearby municipal water supply well PM-4, because the alluvium is dry upstream of the purge water entry point. However, while discharges from PM-4 occurred twice in 1998, there was only one discharge in the previous four years. Such limited releases would be insufficient to maintain saturation found annually at two alluvial observation wells. Because treated effluent from the Laboratory's SWS Facility may at some time be discharged into the Cañada del Buey drainage system, a network of five shallow groundwater monitoring wells and two moisture monitoring holes was installed during the early summer of 1992 within the upper and middle reaches of the drainage (ESP 1994). Construction of the SWS Facility was completed in late 1992.

B. Surface Water Sampling

1. Introduction

The Laboratory monitors surface waters from regional and Pajarito Plateau stations to evaluate the environmental effects of its operations. No perennial surface water flows extend completely across the Laboratory in any canyon. Periodic natural surface runoff occurs in two modes: (1) spring snowmelt runoff that occurs over days to weeks at a low discharge rate and sediment load and (2) summer runoff from thunderstorms that occurs over hours at a high discharge rate and sediment load. The surface water within the Laboratory is not a source of municipal, industrial, or irrigation water, though the waters are used by wildlife. Activities of radionuclides in surface water samples may be compared to either the DOE DCGs or the New Mexico Water Quality Control Commission (NMWQCC) stream standards, which in turn reference the New Mexico Environment

Department's New Mexico Radiation Protection Regulations (Part 4, Appendix A). However, New Mexico radiation protection activity levels are in general two orders of magnitude greater than the DOE DCGs for public dose, so we will discuss only the DCGs here. The concentrations of nonradioactive constituents may be compared with the NMWQCC General, Livestock Watering, and Wildlife Habitat standards. The NMWQCC groundwater standards can also be applied in cases where groundwater outflow may affect stream water quality. Appendix A presents information on these standards.

2. Monitoring Network

We collected surface water samples from Pajarito Plateau stations near the Laboratory and from regional stations. Surface water grab samples are collected annually from locations where effluent discharges or natural runoff maintain stream flow. Runoff samples have historically been collected as grab samples from usually dry portions of drainages during or shortly after runoff events. As of 1996, runoff samples are collected using stream monitoring stations, some with automated samplers (Shaull et al., 1996). Samples are collected when a significant rainfall event causes flow in a monitored portion of a drainage. Many runoff stations are located where drainages cross the Laboratory's boundaries.

Regional surface water samples (Figure 5-1) are collected from stations on the Rio Grande, Rio Chama, and Jemez River. These waters provide background data from areas beyond the Laboratory boundary.

Surface water monitoring stations located on the Pajarito Plateau are shown in Figures 5-2 and 5-3. We use samples from the stations to monitor water quality effects of past or potential contaminant sources, such as industrial outfalls and nonpoint sources, including possible soil contamination sites.

3. Radiochemical Analytical Results

The results of radiochemical analyses for surface water and runoff samples for 1998 are listed in Table 5-1. To emphasize values that are detections, Tables 5-2 and 5-3 contain lists of radionuclides detected in surface water and runoff samples and in suspended sediments in runoff samples. Detections are defined as values exceeding both the analytical method detection limit and three times the individual measurement uncertainty. For suspended sediments, values in the table are also greater than the range for background levels attributed to fallout levels or (for uranium) naturally occurring concentrations (Purtymun et al., 1987; McLin in prep). Because uranium, gross alpha, and gross beta are ubiquitous at detectable levels, we report only occurrences of these measurements above levels chosen to be below the EPA maximum contamination levels (MCLs) or screening levels. The specific levels are 5 µg/L for uranium, 5 pCi/L for gross alpha, and 20 pCi/L for gross beta.

Radiochemical detections that are greater than 1/25 of the DOE DCGs for Public Dose for Ingestion of Environmental Water (1/25 of the DOE DCG for Public Dose is the DOE drinking water system DCG) are indicated in the righthand columns of Table 5-2. The EPA drinking water limits for gross alpha and gross beta values are higher than 1/25 of the DOE public dose DCG (that is, greater than the DOE drinking water system DCGs), so we use the EPA values to screen gross alpha and gross beta values. The DOE public dose DCG value for gross beta is actually the strontium-90 DCG, and the DCG for gross alpha is the plutonium-239, -240 DCG. These DCGs were chosen because the isotopes represented had the lowest DCGs for alpha and beta emitters.

Runoff samples have high turbidity and present special interpretation problems. The DOE DCGs for Public Dose are determined assuming that two liters of water per day are consumed each year. This assumption will not be met for runoff, which is present only a few days each year. High levels of suspended solids (up to 18,000 mg/L) are frequently found in runoff samples. The analytical uncertainties associated with measurement of gross alpha and beta levels in samples with high suspended solids are probably greater than reported on the accompanying tables. This means that the high gross alpha and beta values may have low precision. The higher than reported uncertainties are results of the analytical process. Gross alpha and beta counting uses a small portion of the sample so the counted sample does not shield alpha or beta emissions from reaching the detector. In samples with high suspended solids, this means that very little sample volume is used. The measured concentration is then extrapolated to a one-liter volume. Because the sample is not homogeneous, it is unlikely that a small portion of a runoff sample will represent the concentration of constituents in the total sample.

Seven gross alpha measurements and one plutonium-238 measurement exceeded the DOE public

dose DCG values in surface water or runoff samples in 1998. These samples were the surface water sample from Mortandad Canyon at GS-1 and runoff samples from MDA G stations G-SWMS-1, G-SWMS-2, G-SWMS-3, and G-SWMS-6 and Cañada del Buey at White Rock. Plutonium-238 exceeded the DOE public dose DCG at Mortandad Canyon at GS-1, while americium-241, plutonium-239, -240, and gross beta were near or were substantial fractions of the DCG at this station. These three constituents exceeded the DCG in discharge from the TA-50 RLWTF in 1998 and in the previous several years. The sample from Rio Grande at Frijoles had a gross alpha value just below the DCG.

Most of the measurements at or above detection limits are from locations with previously known contamination: the perimeter of MDA G, Acid/Pueblo Canyon, DP/Los Alamos Canyon, and Mortandad Canyon. The remainder of the results are near or below the detection limits of the analytical methods used and are well below the DOE DCGs for drinking water systems. A few of the measurements at or above detection limits were from locations that do not typically show detectable activity. Detections from locations outside the known contaminated areas near TA-54, MDA G, and in Pueblo, DP/Los Alamos, and Mortandad Canyons are discussed below.

a. Radiochemical Analytical Results for Surface Water. The Rio Grande at Otowi station is located upstream of the confluence with Los Alamos Canyon and is intended to measure sediments unaffected by possible contaminants from the Laboratory. The 1995 bank sample from this station showed a detection of americium-241, and the 1996 sample had detections of plutonium-238 and gross beta. An additional station (Rio Grande at Otowi Upper) was located farther upstream in 1997, based on the possibility that the original station was detecting Laboratory-derived radionuclides present in flood deposits upstream of the mouth of Los Alamos Canyon. Neither of these stations had any radionuclide detections in 1997. In 1998, both Rio Grande at Otowi and Rio Grande at Otowi Upper had gross beta detections. These measurements may indicate an upstream source for radiochemical detections at these stations. The gross beta values of 21.0 and 29.9 pCi/L at these stations compare to an average of 9.5 pCi/L for 32 detections since 1967 at Rio Grande at Otowi, with a maximum of 125 pCi/L occurring in 1996.

Several regional and perimeter stations had detections of radiochemical parameters with no apparent source. The samples from the Rio Grande at Frijoles had detections of gross alpha, plutonium-239, -240, strontium-90, and uranium. While the Laboratory is a likely source for this radioactivity, we have not been able to tie it to a particular Laboratory facility. The Frijoles at Rio Grande station had a gross alpha detection at a lower value. We collected samples at these two stations on September 30 during a period of high runoff following strong rains the previous night. Suspended sediments are probably the source of the high levels: the Rio Grande at Frijoles sample had a total suspended solids measurement of 9,312 mg/L, more than ten times that of other Rio Grande samples. Two measurements of total suspended solids at Frijoles at Rio Grande were 227 and 515 mg/L, high compared to most other surface water values. The Jemez River station had gross beta and strontium-90 detections. The strontium-90 values at Jemez River and Rio Grande at Frijoles were near or greater than the drinking water limit of 8 pCi/L. These values were at the high end of the range found at these stations over the last ten years. Rio Grande at Cochiti and Rio Grande at Embudo had detections of gross alpha and gross gamma.

b. Radiochemical Analytical Results for Runoff. Automated samplers collected runoff samples whenever rainfall events caused significant runoff at these stations. See Section 5.F.1 for a description of the runoff samplers and sampling protocols.

As with 1997 samples, comparison of results for filtered and unfiltered samples collected at several stations raised questions about whether samples were filtered. The quantities of strontium-90, uranium, plutonium, and americium-241 should be smaller in filtered samples but in many cases are comparable in both the filtered and unfiltered samples. In some cases, filtered values are larger. These findings suggest that samples were not filtered in the analytical laboratory as instructed.

At station Los Alamos Canyon near Los Alamos (LA), all radiochemical parameters measured except tritium were detected in either the runoff samples or associated suspended sediments. The sediment screening action level was exceeded for cesium-137 in one suspended sediment sample. This is consistent with earlier findings for this station (see Table 5-3).

In the four runoff samples collected at Cañada del Buey at White Rock, all radiochemical parameters measured, except tritium and cesium-137, were

detected in at least one runoff sample or in the associated suspended sediments. High suspended sediment levels in the samples are probably the source of the radioactivity. These samples also contained some metals in high amounts as described below. The September 29 sample had gross alpha exceeding the DOE public dose DCG by a factor of seven; this sample also had gross beta values at about half the DOE public dose DCG. Recall, that the DCG is based on assumed consumption of two liters of water per day on an annual basis, which is unlikely for runoff that is seldom present in a drainage area.

The high gross alpha and gross beta readings from these samples are not accounted for by radionuclides measured in our analyses, suggesting that additional radionuclides may be present. The runoff samples had strontium-90 values ranging from half to twice the drinking water MCL. The strontium-90 value in the October 26 suspended sediment sample was about half the sediment screening action level (SAL). In suspended sediment samples, uranium and both plutonium isotopes were above the range of sediment background levels. Samples from this station had high uranium levels in 1996 and in 1997 had similar gross beta and gross alpha values and detectable plutonium-239, -240.

Sources for the radioactivity seen at station Cañada del Buey at White Rock may include MDA G at TA-54 or other Laboratory facilities along Cañada del Buey. Runoff samples from MDA G showed radioactivity comparable to the Cañada del Buey at White Rock runoff samples in 1998. The sample G-SWMS-6 collected on September 29 had a gross alpha value exceeding the DOE public dose DCG, and this gross alpha value was equal to that from the runoff sample collected at Cañada del Buey at White Rock on the same day. While these samples were collected in the same drainage on the same day, it does not mean that continuous flow occurred in the drainage between the two stations. Instead, local portions of the drainage may have experienced runoff in response to intense rainfall.

Levels of radioactivity similar to those in the 1998 Cañada del Buey at White Rock runoff samples have not been seen in the past at the nearby sediment station. Another surface water station and two alluvial wells (CDBO-6 and CDBO-7) located upstream of MDA G in Cañada del Buey have also not shown such high levels of radioactivity. However, the wells have had fairly large gross alpha and gross beta values as discussed below; the gross alpha value at CDBO-6 also exceeded the DOE public dose DCG in 1998. The Laboratory plans to conduct additional radiological screening measurements on future samples collected from this area to determine the source of these readings. Because runoff from Cañada del Buey leaves the Laboratory boundary just downstream from this station, Laboratory scientists plan to conduct additional sediment surveys in the area to evaluate the need for sediment containment or remediation activities.

For runoff samples at TA-54, MDA G, all radiochemical parameters measured except tritium and cesium-137 were detected in at least one runoff sample. These radionuclides have previously been detected in sediment and runoff samples collected around MDA G and indicate that a small amount of radioactivity leaves the area because of surface erosion and runoff. As noted above, the sample from G-SWMS-6 collected on September 29 had a gross alpha value exceeding the DOE public dose DCG. Station G-SWMS-6 is on the flank of Cañada del Buey.

c. Technical Area 50 Discharges. The cumulative discharge of radionuclides from the RLWTF into Mortandad Canyon between 1963 and 1977 and yearly discharge data for 1996 through 1998 are given in Table 5-4. In addition to total annual activity released for 1996 through 1998, Table 5-4 also shows mean annual activities in effluent for each radionuclide and the ratio of this activity to the DOE DCG for public dose. In 1998, the DCG was again exceeded for americium-241, plutonium-238, and plutonium-239, -240. For 1998, the effluent nitrate concentration (average value of 61.1 mg/L, nitrate as nitrogen) exceeded the New Mexico groundwater standard of 10 mg/L. As mentioned above, the new reverse osmosis and ultrafiltration system will begin operation at the RLWTF in 1999. This system is designed to remove additional radionuclides from the effluent, and the discharges will meet the DOE public dose DCGs and the New Mexico groundwater standard for nitrate.

4. Nonradiochemical Analytical Results

a. Major Chemical Constituents. The results of analyses for major chemical constituents in surface water and runoff samples for 1998 are listed in Table 5-5. The results are generally consistent with those observed in previous years, with some variability. The measurements in waters from areas receiving effluents show the effect of these effluents. None of the results were outside the ranges for standards except for some

pH measurements below 6.8 and above 8.5. The fluoride value in the sample from the Jemez River was 60% of the NMWQCC Groundwater Standard. The nitrate value for Mortandad at Rio Grande was about 60% of the NMWQCC Groundwater Standard.

b. Trace Metals. The results of trace metal analyses on surface water and runoff samples for 1998 are listed in Table 5-6. Samples collected for trace metal analysis (with the exception of unfiltered runoff samples) after May 30, 1997, were filtered so that they could be compared to the NMWQCC standards that apply to dissolved constituents. Samples collected for mercury and selenium analysis were unfiltered, as the NMWQCC standards for these analytes apply to total metal content. The levels of trace metals in samples for 1998 are generally consistent with previous observations.

As with 1997 runoff samples, comparison of results for filtered and unfiltered samples collected at several stations raises questions about whether samples were filtered. The quantities of some metals should be smaller in filtered samples but are comparable in both the filtered and unfiltered samples. In some cases, filtered values are larger. These findings suggest that samples were not filtered in the analytical laboratory as instructed.

Several surface water and groundwater samples showed apparent detection of selenium in 1998. Typically, selenium has not been detected in surface water or groundwater on the Pajarito Plateau. The analytical detection limit for selenium in 1998 samples was 3 µg/L, higher than in previous years and higher than the New Mexico Wildlife Habitat Standard of 2 µg/L. Numerous selenium results reported as 3 µg/L do not appear to be detections (having three sigma uncertainties equal to the reported value), raising the question of whether these values indicate the presence of selenium. Selenium was present in surface water samples at Rio Grande at Frijoles and Rio Grande at Embudo and a runoff sample at Cañada del Buey near White Rock. Selenium was possibly present in surface water samples at Rio Grande at Cochiti, Guaje Canyon, Pajarito Canyon at Rio Grande, and Pueblo 1. In 1997, selenium values exceeded the New Mexico Wildlife Habitat Stream Standard at Guaje Canyon and Frijoles at Monument HQ.

The surface water sample from Rio Grande at Frijoles was not filtered. The sample had unusually high levels of arsenic, barium, beryllium, cobalt, chromium, nickel, lead, selenium, and strontium. The high values are related to high total suspended solids and collection of the sample following a large rainstorm. Many of these concentrations exceeded regulatory standards (barium, beryllium, lead, and selenium) and were above the range of values for the past ten years at this station. A source for these materials in the water is not known at present. Except for mercury and selenium, the surface water standards apply to dissolved rather than total metals content. Some of these regulatory standards apply to groundwater or drinking water rather than expressly to surface water and are used for purposes of comparison.

As in prior years, the surface water sample from the Jemez River had arsenic and boron values near or exceeding drinking water or NMWQCC groundwater limits. Boron, arsenic, and fluoride are common constituents of water in volcanic areas or in thermal springs (Hem 1989). The thermal waters from the Valles Caldera have been shown to discharge through the Jemez River drainage, and wells and springs in the area have high boron, arsenic, and fluoride levels (Goff et al., 1988).

Runoff samples we collected at Los Alamos Canyon near Los Alamos again had lead levels exceeding NM Groundwater and Livestock Watering standards and showed the presence of beryllium. This station is upstream of State Road 4 in Los Alamos Canyon. These results came from both filtered and unfiltered samples.

The surface water sample at Pueblo 1 showed levels of silver, antimony, and selenium near or exceeding regulatory limits.

In addition to high levels of radioactivity as described earlier, filtered and unfiltered runoff samples from Cañada del Buey at White Rock contained levels of barium, beryllium, cobalt, nickel, lead, and selenium near or exceeding regulatory standards. Several of these elements were present in three or four samples taken on different dates. Note that some of these regulatory standards apply to groundwater or drinking water rather than expressly to surface water and are used for purposes of comparison. Farther upstream in Cañada del Buey, beryllium was detected in groundwater in wells CDBO-6 and CDBO-7 at concentrations above the drinking water MCL. Barium was found in both wells in 1998; in CDBO-7, the concentration was over three times the New Mexico groundwater limit. The groundwater results are discussed in more detail in Section 5.D below.

The analytical detection limit for mercury (0.2 µg/L) is not adequate to determine whether it is present in excess of the New Mexico Wildlife Habitat

stream standard of 0.012 µg/L. In 1998, mercury was not detected at any location with the exception of a runoff sample at Cañada del Buey at White Rock.

Aluminum, iron, and manganese concentrations exceed EPA secondary drinking water standards in surface water and runoff samples at many locations. These results reflect the presence of suspended solids in the water samples. Some of these cases occur with filtered samples. The results are due to naturally occurring constituents (e.g., aluminum, iron, and manganese) of minerals in the suspended solids.

c. Organic Constituents in Surface Water and Runoff. The locations where organic samples were collected in 1998 are summarized in Table 5-7. (See Section 5.F.2.c. for analytical methods and analytes.) Samples were analyzed for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), and polychlorinated biphenyls (PCBs). Some samples were also analyzed for high-explosive (HE) constituents. No HE or other organic compounds were detected at any stations in 1998.

5. Long-Term Trends

Long-term trends for surface water are discussed in Section 5.D with groundwater trends.

C. Sediment Sampling

1. Introduction

Sediment transport associated with surface water runoff is a significant mechanism for contaminant movement. Contaminants originating from airborne deposition, effluent discharges, or unplanned releases can become attached to soils or sediments by adsorption or ion exchange.

No federal or state regulatory standards exist for soil or sediment contaminants that can be used for comparison with the Laboratory's environmental surveillance data. Instead, contaminant levels in sediments may be interpreted in terms of toxicity as a result of ingestion, inhalation, or direct exposure. The Laboratory's Environmental Restoration Project uses SALs to identify contaminants at concentrations or activities of concern. SALs are screening levels selected to be less than levels that would constitute a human health risk. SAL values are derived from toxicity values and exposure parameters using data from the EPA.

The data can also be compared with activities of radionuclides resulting from atmospheric fallout or from naturally occurring radionuclides. Radionuclide analyses of sediment samples collected from regional stations for the period 1974 to 1986 were used to establish background activities from atmospheric fallout of selected radionuclides and to determine the background concentrations of naturally occurring uranium (Purtymun et al., 1987). McLin et al. (in preparation) developed provisional background levels for data from the period 1974 to 1996. The average activity of each of the radionuclides in the regional station samples, plus twice its standard deviation, approximates the background value. If the activity of an individual sediment sample is greater than the established background, the Laboratory is considered as a possible source of contamination. Both background and SAL values for sediments are listed in tables summarizing analytical results.

2. Monitoring Network

Sediments are sampled in all major canyons that cross the Laboratory, including those with either perennial or ephemeral flows. Sediments from regional reservoirs and stream channels are also sampled annually.

Regional sediment sampling stations (Figure 5-1) are located within northern New Mexico and southern Colorado at distances up to 200 km from the Laboratory. Samples from regional stations provide a basis for estimating background activities of radionuclides resulting from atmospheric fallout or from naturally occurring radionuclides. We obtained regional sediment samples from reservoirs on the Rio Grande and the Rio Chama and at stations on the Rio Grande and Jemez River.

Stations on the Pajarito Plateau (Figure 5-4) are located within about 4 km of the Laboratory boundary, with the majority located within the Laboratory boundary. The information gathered from these stations documents conditions in areas potentially affected by Laboratory operations. Many of the sediment sampling stations on the Pajarito Plateau are located within canyons to monitor sediment transport that is possibly related to past and/or present effluent release sites. Three major canyons (Pueblo, Los Alamos, and Mortandad Canyons) that have experienced past or present liquid radioactive releases were sampled from upstream of the Laboratory to their confluence with the Rio Grande.

Sediments were also collected from drainages downstream of two MDAs. MDA G at TA-54 is an

active waste storage and disposal area. Nine sampling stations were established outside its perimeter fence in 1982 (Figure 5-3) to monitor possible transport of radionuclides from the area. The surface drainage changed, and two sampling stations were dropped in 1998 and four others added. Station G-4 was replaced by G-4A and G-4B. G-6 was located in a channel that received runoff that was not entirely from MDA G. G-6A replaced G-6 and is located in a stream channel that receives runoff only from MDA G. Station G-10 was added on the north side of MDA G in a drainage that flows to Cañada del Buey.

MDA AB at TA-49 was the site of underground subcritical weapons testing from 1959 to 1961. The site of the experiments is designated MDA AB (Purtymun and Stoker 1987, ESP 1988). We established eleven stations in 1972 to monitor surface sediments in drainages adjacent to MDA AB (Figure 5-5). We added another station (AB-4A) in 1981 as the surface drainage changed.

3. Radiochemical Analytical Results for Sediments

The results of radiochemical analysis of sediments samples collected in 1998 are shown in Table 5-8. The sample size for most sediment samples is 100 g. Reservoir sample sizes for plutonium-238 and plutonium-239, -240 are 1,000 g, resulting in limits of detection of 0.0001 pCi/g. Table 5-9 lists radiochemical detections for values that are higher than fallout or background levels and also identifies values that are near or above SALs. For tritium, there is no established background value for sediments, so all tritium detections are shown in Table 5-9. Results from the 1998 sediment sample analysis are generally consistent with historical data.

Strontium-90 was detected above fallout levels in twelve sediment samples collected on the Pajarito Plateau and at regional stations in 1998. These high values resulted from a high analytical bias in the strontium-90 laboratory technique. Strontium-90 has been detected infrequently at these stations previously.

Sediment samples from all three stations in Rio Grande Reservoir (Colorado) contained cesium-137 at activities up to 70 percent above background. Cesium-137 activity in sediments analyzed from that reservoir in 1996 and 1997 was 20 to 30 percent greater than background. Gross alpha activity was 50 percent greater than background at one of those three stations in 1998. The levels of tritium, strontium-90, plutonium-238, plutonium-239, -240, americium-241, gross beta, and gross gamma in all other reservoirs were consistent with historical data.

A sediment sample collected from station Rio Grande at Frijoles yielded a high tritium level. The sample was obtained immediately following a large rainfall event in which the river rose about a meter in height and transported a considerable amount of sediment. A resample of the same station six weeks later indicated a tritium activity one tenth that of the first sample. The high tritium sediment was evidently deposited during the large rainfall event, and the source of the tritium is not clear.

Many 1998 sediment samples from the known radioactive effluent release areas in Acid/Pueblo, DP/Los Alamos, and Mortandad Canyons exceeded background levels for tritium, cesium-137, plutonium-238, plutonium-239, -240, americium-241, gross alpha, gross beta, and gross gamma activities. These levels are consistent with historical data.

Within both Los Alamos and Pueblo Canyon sediments, above-background levels of plutonium are evident for distances greater than 16 km downstream from the sources in Acid and DP Canyons. The contamination extends off-site across San Ildefonso Pueblo lands and reaches the Rio Grande near the Otowi Bridge. Plutonium-238 and plutonium-239, -240 activities downstream of historical release sites in those canyons have remained relatively constant during the past. These patterns have been documented for several decades in Laboratory reports (ESP 1981).

At station DPS-4 in DP Canyon, plutonium-239, -240 activity was more than eight times background in 1998, consistent with historical data.

At Acid Weir (at the confluence of Acid Canyon and Pueblo Canyon), plutonium-238 was seven times background, and plutonium-239, -240 activity was nearly 400 times background (and about one-half of the SAL). Americium-241 was four times background. These values are all consistent with historical data.

Plutonium-239, -240 was seven times background at Pueblo 1 and was 41 times greater than background at Pueblo State Road 502. Plutonium-239, -240 levels have generally decreased with time at Pueblo 1. A slight upward trend in plutonium-239, -240 is observed at State Road 502 (see Section 5.C.5).

The Pueblo 3 station had a cesium-137 activity nearly 50 times greater than background (and four times greater than the SAL of 5.1 pCi/g). Records

from the last 20 years show the 1998 cesium-137 activity at Pueblo 3 is 40 times greater than the highest previous value at Pueblo 3.

The activities of radionuclides at other sediment stations in Acid/Pueblo Canyons and DP/Los Alamos Canyons in 1998 were near background.

Within Mortandad Canyon, the greatest radionuclide levels in sediments are found between the point where the TA-50 RLWTF effluent enters the drainage (Station GS-1) and the sediment traps (MCO-7), approximately a 3-km distance. Radionuclide levels decrease rapidly in the downstream direction from TA-50 to the sediment traps. Radionuclide levels near, or slightly exceeding, background levels are found downstream of the sediment traps, extending to the Laboratory/Pueblo of San Ildefonso boundary Station A-6. Based on mass spectrometry analysis, Gallaher concluded that off-site plutonium contamination at levels near fallout values may extend two miles beyond the Laboratory boundary (Gallaher et al., 1997).

In 1998, sediment samples from GS-1, MCO-5, and MCO-7 in Mortandad Canyon showed cesium-137 concentrations that were up to four times greater than the SAL value. Median values since 1980 for cesium-137 at these stations range up to six times greater than the SAL value. Cesium-137 levels at these stations have declined by factors of 5 to 35 since the early 1980s because of lower cesium-137 discharges from the RLWTF. During 1998, no other sediment samples in Mortandad Canyon showed any values that exceeded SAL values.

In 1998, plutonium-238 activity in sediments between the RLWTF and MCO-7 ranged from more than 400 times to more than 1,000 times greater than background, but only to a maximum of 20 percent of the SAL (of 27 pCi/g). Plutonium-239, -240 activity ranged from nearly 100 times background to more than 300 times background (and 30 percent of the SAL of 24 pCi/g). Americium-241 activity in those sediments was as much as 117 times background (40 percent of the SAL). Strontium-90 activity in sediments between the RLWTF and the sediment traps was 2.5 times greater than background and 40 percent of the SAL.

On Laboratory lands in Mortandad Canyon, plutonium-238, plutonium-239, -240, and cesium-137 activities, and uranium concentrations were near background activities downstream of the sediment traps at Stations MCO-9 and MCO-13. This result is consistent with data from the last fifteen years.

A number of sediment samples in the vicinity and downstream of MDA-G contained plutonium-238 at activities greater than background. Plutonium-238 was nearly 20 times background at G-7, three times background at G-6, and slightly above background at G-5 and G-9. Those values are consistent with plutonium-238 activity from sediments sampled in 1997. The Station Pajarito at State Road 4, which is located more than one kilometer downstream of MDA G, had cesium-137 and plutonium-238 at levels 20 percent greater than background and strontium-90 at nearly three times background.

Plutonium-238 and plutonium-239, -240 were found at activities greater than background in a number of sediment samples collected at TA-49, MDA AB. Station AB-3 is located immediately downstream of a known surface-contamination area dating to 1960 (Purtymun and Stoker, 1987). At AB-3, plutonium-239, -240 was 50 times background, and plutonium-238 and americium-241 were three times background activity. These values are consistent with past results.

The remainder of sediment samples collected at locations at the Laboratory in 1998 were near background levels.

4. Nonradiochemical Analytical Results

a. Trace Metals. Beginning in 1992, we have analyzed sediments for trace metals. Trace metal results for the sediment samples collected in 1998 are presented in Table 5-10.

Since 1990, trace metals analysis has indicated the presence of mercury at near detection limit concentrations (0.025 mg/kg) in nearly 200 sediment samples. The largest numbers of those historic samples (from 1990–1998) were from Los Alamos Canyon (22 samples), followed by Mortandad Canyon (21 samples since 1992), MDA AB (19 samples), and MDA G (15 samples since 1994).

Analysis of sediments from three stations at the TA-54 solid waste operations area, G-4A, G-4B, and G-5, located in adjacent drainages below MDA G, indicated the presence of mercury at near detection limit concentrations in 1998. Mercury was previously detected at G-5 in 1996. No mercury was detected at G-8 in 1998, though it was found there at a concentration of 4.2 mg/kg in 1997.

b. Organic Analysis. Beginning in 1993, we have analyzed sediments for PCBs and SVOCs. Some sediment samples have been analyzed for HE

constituents since 1995. Samples from only a portion of the sediment stations are analyzed each year; in 1998, about one-seventh of the stations were sampled for organics. These are listed in Table 5-11. The analytical results showed that there were no PCBs, SVOCs, or HE constituents detected above the limit of quantitation in any of the sediment samples collected during 1998.

5. Long-Term Trends

For all plots discussed in this section, only detections of a particular radionuclide in sediments are shown; samples without such detections are not shown.

Plutonium-238 and plutonium-239, -240 activities observed since the late 1970s in sediments at five locations in Acid, Pueblo, and lower Los Alamos Canyons are shown in Figures 5-6a and 5-6b. Stations Acid Weir and Pueblo at State Road 502 are located in Pueblo Canyon. LAO-3 is located in Los Alamos Canyon above the confluence of Los Alamos and Pueblo Canyons. Los Alamos at Totavi and Los Alamos at Otowi are located below the confluence of the two canyons. The overall activities of the plutonium-238 and plutonium-239, -240 in sediments from Acid Weir, Los Alamos at Totavi, and Los Alamos at Otowi have been relatively constant since 1980, with some yearly variability. Plutonium-239, -240 levels appear to be gradually increasing at Pueblo at State Road 502 and gradually decreasing at LAO-3. Plutonium-238 activities at these two stations typically range from one to two orders of magnitude less than plutonium-239, -240, with plutonium-238 levels gradually rising at LAO-3 but remaining relatively stable at Pueblo at State Road 502.

Figure 5-6c shows cesium-137 in sediments at Acid Weir, Pueblo 3, and Pueblo 502 since the late 1970s. Before the 1990s, cesium-137 levels exceeded background at Acid Weir. Cesium-137 levels in the 1990s have been near background. Except for a sample collected at station Pueblo at State Road 502 in 1992 that was near the SAL, cesium-137 has been present at background levels. Cesium-137 at Pueblo 3 has been near background until 1998, when it was detected at 50 times background and four times the SAL.

Cesium-137 at LAO-3 has exceeded background since the 1980s, on occasion exceeding the SAL, as shown in Figure 5-6d. Cesium-137 at Los Alamos at Totavi exceeded background and approached the SAL in the 1980s but has been near background levels in the 1990s. At Los Alamos at Otowi, cesium-137 levels exceeded background during four of the last 23 years but have typically been near background levels.

Figure 5-7a depicts plutonium-238 activities at five stations in Mortandad Canyon from 1976 to 1998. GS-1, MCO-5, and MCO-7 are located downstream of the RLWTF discharge point and upstream of the sediment traps. Plutonium-238 has decreased by a factor of about ten during that time period and has not exceeded the SAL since 1985. MCO-9 and MCO-13 are located downstream of the sediments traps. Plutonium-238 is infrequently above background at those stations and is not regularly detected. Figure 5-7b shows plutonium-239, -240 levels on Laboratory lands in Mortandad Canyon. Plutonium-239, -240 levels upstream of the sediment traps have declined by approximately a factor of ten since the 1980s, presumably because of decreased radioactivity in the RLWTF discharges and the dispersion of previously contaminated sediments. Downstream of the sediment traps, plutonium activities have remained relatively constant; the activities are two orders of magnitude less than upstream of the sediment traps and are near background activities.

Figure 5-8a shows that plutonium exists on San Ildefonso Pueblo lands in Mortandad Canyon at background levels. Figure 5-8b, however, shows that plutonium-239, -240 has often been present at levels above background on San Ildefonso Pueblo land for the last thirteen years.

Figure 5-7c shows that cesium-137 has been present in Mortandad Canyon since the 1970s. Between TA-50 and the sediment traps, cesium-137 levels have often exceeded the SAL. Cesium-137 levels below the sediment traps have gradually declined to near background levels.

Figure 5-8c shows that cesium-137 levels on San Ildefonso Pueblo lands in Mortandad Canyon have ranged from six times background at Station A-6 to near background at stations A-7, A-8, and A-9.

D. Groundwater Sampling

1. Introduction

Groundwater resource management and protection efforts at the Laboratory are focused on the regional (or main) aquifer underlying the region (see Section 1.A.3) but also consider groundwater found within canyon alluvium and perched at intermediate depths above the regional aquifer. The Los Alamos public

water supply comes from supply wells drawing water from the regional aquifer.

The early groundwater management efforts by the USGS evolved through the growth of the Laboratory's current Groundwater Protection Management Program, required by DOE Order 5400.1 (DOE 1988). This program addresses environmental monitoring, resource management, aquifer protection, and hydrogeologic investigations. Formal documentation for the program, the "Groundwater Protection Management Program Plan," was issued in April 1990 and revised in 1995 (LANL 1996a). During 1996, the Laboratory developed and submitted an extended groundwater characterization plan, known as the Hydrogeologic Workplan (LANL 1996b), to the New Mexico Environment Department (NMED). NMED approved the Hydrogeologic Workplan on March 25, 1998. Investigations under the Hydrogeologic Workplan are described elsewhere in this document.

Concentrations of radionuclides in environmental water samples from the regional aquifer, the alluvial groundwater in the canyons, and the intermediate-depth perched systems may be evaluated by comparison with DCGs for ingested water calculated from DOE's public dose limit (see Appendix A for a discussion of standards). The NMWQCC has also established standards for groundwater quality (NMWQCC 1993). Concentrations of radioactivity in drinking water samples from the water supply wells, which draw water from the regional aquifer, are compared to New Mexico Environmental Improvement Board (NMEIB) and EPA MCLs or to the DOE DCGs applicable to radioactivity in DOE drinking water systems, which are more restrictive in a few cases.

The concentrations of nonradioactive chemical quality parameters may be evaluated by comparing them to NMWQCC groundwater standards and to the NMEIB and EPA drinking water standards, although these latter standards are only directly applicable to the public water supply. Although it is not a source of municipal or industrial water, shallow alluvial groundwater is a source of return flow to surface water and springs used by livestock and wildlife and may be compared to the Standards for Groundwater or the Livestock Watering and Wildlife Habitat Stream Standards established by the NMWQCC (NMWQCC 1993, NMWQCC 1995). However, it should be noted that these standards are for the most part based on dissolved concentrations. Many of the results reported here are total concentrations (that is, they include both dissolved and suspended solids concentrations), which may be higher than dissolved concentrations alone.

2. Monitoring Network

Groundwater sampling locations are divided into three principal groups, related to the three modes of groundwater occurrence: the regional (or main) aquifer, alluvial groundwater in the canyons, and localized intermediate-depth perched groundwater systems. The sampling locations for the regional aquifer and the intermediate-depth perched groundwater systems are shown in Figure 5-9. The sampling locations for the canyon alluvial groundwater systems are shown in Figure 5-10. Purtymun (1995) describes the springs and wells.

Sampling locations for the regional aquifer include test wells, supply wells, and springs. New wells constructed by the Hydrogeologic Workplan activities are not yet part of the monitoring network.

Eight deep test wells, completed within the regional aquifer, are routinely sampled. The test wells were drilled by the USGS between 1949 and 1960 using the cable tool method. The Laboratory located these test wells where they might detect infiltration of contaminants from areas of effluent disposal operations. These wells penetrate only a few hundred feet into the upper part of the regional aquifer, and the casings are not cemented, which would seal off surface infiltration along the boreholes.

Samples are collected from 13 deep water supply wells in three well fields that produce water for the Laboratory and community. The well fields include the off-site Guaje well field and the on-site Pajarito and Otowi well fields. The Guaje well field, located northeast of the Laboratory, contains seven wells, six of which had significant production during 1998. These wells will be retired after 1999 because of their age. Four new wells, which will replace the existing wells, were drilled in this field in 1998. The five wells of the Pajarito well field are located in Sandia and Pajarito Canyons and on mesa tops between those canyons. Two wells make up the Otowi well field, located in Los Alamos and Pueblo Canyons. Additional regional aquifer samples were taken from wells located on the Pueblo of San Ildefonso.

Numerous springs near the Rio Grande are sampled because they represent natural discharge from the regional aquifer (Purtymun et al., 1980). As such, the springs serve to detect possible discharge of contami-

nated groundwater from beneath the Laboratory into the Rio Grande. Based on their chemistry, the springs in White Rock Canyon are divided into four groups, three of which have similar, regional aquifer-related chemical quality. The chemical quality of springs in a fourth group reflects local conditions in the aquifer, probably related to discharge through faults or from volcanics. Two additional springs, Indian and Sacred Springs are west of the river in lower Los Alamos Canyon. Indian Spring was last sampled in 1995; it was later covered by highway construction.

Beginning in 1995, approximately half of the White Rock Canyon springs were sampled in each year. Larger springs and springs on Pueblo of San Ildefonso lands are sampled annually, with the remainder scheduled for alternate years.

We sample the alluvial groundwater in five canyons (Pueblo, Los Alamos, Mortandad, and Pajarito Canyons, and Cañada del Buey) with shallow observation wells to determine the impact of NPDES discharges and past industrial discharges on water quality. In any given year, some of these alluvial observation wells may be dry, and thus no water samples can be obtained. Observation wells in Water, Fence, and Sandia Canyons have been mostly dry since their installation in 1989. All but two of the wells in Cañada del Buey are generally dry.

As a condition of Module 8, Section C, of the Laboratory's Hazardous and Solid Waste Amendments (HSWA) permit, the Laboratory installed several alluvial observation wells (or, in some cases, boreholes). This work was completed in 1990 according to EPA's Resource Conservation and Recovery Act (RCRA) guidelines (Purtymun and Stoker 1990, Stoker 1990, ESP 1992). Some of the wells were drilled near existing wells to compare observations with older wells. Because these wells are of more modern construction, during 1997 they were substituted for the older wells in the monitoring network. These RCRA wells included

- Three wells in Los Alamos Canyon (LAO-3A, LAO-4.5C, and LAO-6A) and
- Three wells in Mortandad Canyon (MCO-4B, MCO-6B, and MCO-7A).

Intermediate-depth perched groundwater of limited extent occurs in conglomerates and basalt at depths of several hundred feet beneath the alluvium in portions of Pueblo, Los Alamos, and Sandia Canyons. We obtain samples from two test wells and one spring. The well and spring locations were selected to monitor possible infiltration of effluents beneath Pueblo and Los Alamos Canyons.

Some perched water occurs in volcanics on the flanks of the Jemez Mountains to the west of the Laboratory. This water discharges at several springs (Armstead and American) and yields a significant flow from a gallery in Water Canyon, where this perched water is sampled. During the winter of 1996–97, a falling tree broke the connecting pipe, and the water now flows down Water Canyon. The gallery is now sampled at the point where the pipe broke. Additional perched water extends eastward from the Jemez Mountains beneath TA-16 in the southwestern portion of the Laboratory. The existence of this perched water, at a depth of about 750 ft below the mesa top, was confirmed in 1998 by drilling of Hydrogeologic Workplan well R-25. The water was found to contain high-explosives compounds resulting from past Laboratory discharges. Further work to characterize this perched zone will occur in the near future.

3. Radiochemical Analytical Results for Groundwater

The results of radiochemical analyses of groundwater samples for 1998 are listed in Table 5-12. To emphasize values that are detections, Table 5-13 contains lists of radionuclides where values exceed both the analytical method detection limit and three times the individual measurement uncertainty. Because uranium, gross alpha, and gross beta are ubiquitous at detectable levels, only occurrences of these measurements above levels chosen to be below the EPA MCLs or screening levels are reported. The specific values are 5µg/L for uranium, 5 pCi/L for gross alpha, and 20 pCi/L for gross beta.

Radiochemical detections that are greater than 1/25 of the DOE DCGs for Public Dose for Ingestion of Environmental Water (1/25 of the DOE DCG for Public Dose is the DOE drinking water system DCG) are indicated in the righthand columns of Table 5.13. The EPA drinking water limits for gross alpha and gross beta values are higher than 1/25 of the DOE public dose DCG (that is, greater than the DOE drinking water system DCGs), so we use the EPA values to screen gross alpha and gross beta values. The DCG value for gross beta is actually the strontium-90 DCG, and the DCG for gross alpha is the plutonium-239, -240 DCG. These DCGs were chosen because the isotopes represented had the lowest DCGs for alpha and beta emitters.

Two gross alpha values exceeded half the DOE public dose DCG values, at CDBO-6 (144% of the DCG) and New Community Well on San Ildefonso Pueblo (89% of the DCG). In 1997, CDBO-7 had a large gross alpha value that was not a detection because of the large uncertainty. The 1998 gross beta results for DP Spring and several wells in Mortandad Canyon were about 10% of the DCG.

Discussion of the results will address the regional aquifer, the canyon alluvial groundwater, and the intermediate perched groundwater system.

a. Radiochemical Constituents in the Regional Aquifer. For samples from wells or springs in the regional aquifer, most of the results for tritium; strontium-90; uranium; plutonium-238; plutonium-239, -240; americium-241; and gross beta were below the DOE drinking water DCGs or the EPA or New Mexico standards applicable to a drinking water system. In addition, most of the results were near or below the detection limits of the analytical methods used. The exceptions are discussed below. The main exception was uranium found in springs and wells on Pueblo of San Ildefonso land. Because dissolved uranium is a common constituent of groundwater (Hem 1989), only occurrences close to the proposed EPA MCL of 20 µg/L are discussed here.

We detected uranium at 5.85 µg/L in well G-5. This uranium concentration is below the proposed EPA primary drinking water MCL of 20 µg/L. The highest previous value for this well was 2.60 µg/L in 1989. The average of the 12 values for G-5 is 1.41 µg/L; the average of 78 pre-1998 values from the entire Guaje field is 1.20 µg/L with a maximum of 5.20 µg/L. This maximum value came from well G-1 in 1968.

La Mesita Spring has a significant uranium concentration of 10.6 µg/L. Samples from springs in this area have always contained a relatively high concentration of natural uranium (Purtymun et al., 1980). However, the uranium concentration for La Mesita Spring is below the proposed EPA primary drinking water MCL of 20 µg/L. The spring also has a high gross alpha value of about 10.2 pCi/L, near the EPA primary drinking water standard of 15 pCi/L. The EPA standard applies to gross alpha not arising from radon and uranium, however.

No test wells were sampled for low-detection-limit tritium in 1998.

Two water supply wells in the Guaje Well Field, G-1 and G-1A, have shown apparent strontium-90 detections in recent years (but not in 1998). Other samples from these wells have not shown the presence of strontium-90. Regarding possible strontium-90 contamination of water in this area by past Laboratory activities, consider the following:

- Strontium-90 was apparently detected in G-1A on 6/12/95 at 3.9 ± 0.7 pCi/L (a duplicate showed 7.4 ± 3.5 pCi/L, a nondetection) and in G-1 on 12/8/97 at 5.2 ± 1.4 pCi/L.
- The Guaje wells were sampled for strontium-90 in 1976, 1980, and 1995 through 1998 (39 samples). The four Guaje replacement wells were each sampled at five depths in 1998 (32 samples). Of these 71 values, only two were detections. For G-1 and G-1A, six samples for each well were analyzed (the latter had three duplicates resulting in nine analyses).
- The strontium-90 analytical method is not very precise near the detection limit (which is usually about 3 pCi/L).
- Individual sample values should not be compared to standards unless the sample value is near 10 times the uncertainty; this is the level of quantification.
- Individual sample values can be affected by sampling techniques, sample handling, sample processing, measurement errors, cross-contamination, and data recording errors.
- Solute transport theory (supported by examples from Mortandad and Los Alamos Canyons, discussed below) indicates that a dissolved analyte like strontium-90 would be present over a large interval in space and time, thus the analyte would be detected in more than one well and more than one sample.
- These water supply wells draw water from a large depth interval. Over a 1700-ft interval in well G-1, 490 ft are slotted, and for a 1241-ft interval in G-1A, 560 ft are slotted. Water supply wells are not designed to detect contamination that may be present in the shallow portions of their screened sections.
- The ages of the Guaje well field water indicated by tritium and radiocarbon are old, suggesting the water is for the most part isolated from surface recharge. The minimum C-14 age for G-5 is 6100 years.
- High-precision tritium values collected in recent years for the Guaje wells average 0.99 pCi/L,

ranging from 0.26 to 1.79 pCi/L. Two values for G-5 are 0.26 and 1.37 pCi/L; the values for G-1 and G-1A are 1.09 and 0.89 pCi/L respectively. Groundwater with a tritium activity below about 1.6 pCi/L is probably old and isolated from surface recharge. The age of such groundwater is more than 3,000 years, but small tritium activities may be associated with large dating uncertainties (Blake 1995).

- A possible source for strontium-90 is the former TA-10, located in Bayo Canyon. Five other Guaje wells and the four new replacement wells are closer to the TA-10 site than are G-1 and G-1A. None of these other wells have shown strontium-90.
- The depth of the regional aquifer beneath the former TA-10 is not exactly known, but it probably lies between 600 and 700 ft deep.
- The generalized groundwater flow direction near the Guaje well field and TA-10 is towards the east-southeast. Groundwater flow directions near the Guaje well field are not known in detail. Capture zones for each well probably vary in size with depth and are not known.

b. Radiochemical Constituents in Alluvial Groundwater. Except for a detection of gross alpha activity in CDBO-6, none of the radionuclide activities in alluvial groundwater are above the DOE DCGs for Public Dose for Ingestion of Environmental Water. Except for gross beta and strontium-90 values from Mortandad, DP, and Los Alamos Canyons, none of the radiochemical measurements exceed DOE DCGs applicable to a drinking water system. Levels of tritium; cesium-137; uranium; plutonium-238; plutonium-239, -240; strontium-90; and gross alpha, beta, and gamma are all within the range of values observed in recent years.

In Pueblo Canyon, samples from APCO-1 showed detections of americium-241 and plutonium-239, -240. This well had plutonium-239, -240 above the detection limit from 1994 through 1996; none was detected in this well in 1997. Similar values have been seen in previous years in surface water and alluvial groundwater in Pueblo Canyon, as a consequence of past Laboratory discharges.

The samples of alluvial groundwater in Los Alamos and DP Canyons show residual contamination, as we have seen since the original installation of monitoring wells in the 1960s. In particular, for LAO-1, LAO-2, DP Spring, and LAO-3A, the activity of strontium-90 approaches or exceeds the EPA primary drinking water MCL of 8 pCi/L. We also detected strontium-90 at LAO-4. Plutonium-239, -240 was detected in LAO-0.7 (and has been every year since 1993). DP Spring, LAO-2, and LAO-3A showed gross beta activities approaching or exceeding the drinking water screening level of 50 pCi/L. Further discussion of strontium-90 in Los Alamos and DP Canyons is given below under Long-Term Trends (see Section 5.D.5.b).

The alluvial groundwater samples from Mortandad Canyon showed activities of radionuclides within the ranges observed previously. Further discussion of radionuclides in this canyon is given below under Long-Term Trends (see Section 5.D.5.c). Tritium; strontium-90; cesium-137; plutonium-238; plutonium-239, -240; americium-241; and gross alpha, beta, and gamma are detected in many of the wells. The radionuclide levels are in general highest at well MCO-3, which is nearest to the TA-50 RLWTF outfall, and decrease down the canyon. The levels of tritium, strontium-90, and gross beta exceed EPA drinking water criteria in many of the wells. In some years, the levels (except for tritium) exceed the DOE drinking water system DCGs, but the levels do not exceed the DOE DCGs for public dose for ingestion of environmental water. EPA has no drinking water criteria for plutonium-238; plutonium-239, -240; or americium-241. The DOE Drinking Water System DCGs for these latter radionuclides were not exceeded in Mortandad Canyon alluvial groundwater in 1998 samples.

Two wells in Cañada del Buey contain little water and yield very turbid samples. Cañada del Buey well CDBO-6 had detections of gross alpha and gross beta in 1998. The values of radioactivity detected in these wells are of particular interest because of the high gross alpha values detected in runoff at station Cañada del Buey at White Rock discussed earlier. High gross alpha values of about 25 pCi/L were detected in this well in 1993 and 1994. Gross beta values above 20 pCi/L occurred in 1992 through 1994 and in 1997. For CDBO-7, slightly smaller gross alpha and gross beta detections occurred over the same time period. Aside from one tritium detection of 900 ± 300 pCi/L in CDBO-6 in 1992, the only other radionuclide detected in these wells has been uranium at levels averaging 2.4 µg/L in CDBO-6 and 2.9 µg/L in CDBO-7.

c. Radiochemical Constituents in Intermediate-Depth Perched Groundwater. In the 1950s,

based on measurements of water levels and major inorganic ions, the USGS established that contaminated surface water and alluvial groundwater in Pueblo Canyon recharge the intermediate-depth perched zone water that underlies the canyon floor (Weir et al., 1963; Abrahams 1966). Taken over time, the radionuclide activity measurements in samples from TW-1A, TW-2A, and Basalt Spring in Pueblo and Los Alamos Canyons confirm this connection. TW-2A, furthest upstream and closest to the historical discharge area in Acid Canyon, has shown the highest levels. We detected tritium in TW-2A at 3301 ± 920 pCi/L in 1998; it was not detected in 1997, for the first year since 1991. Tritium levels in that well averaged at about 2,590 pCi/L from 1992 through 1996. We found no detectable plutonium-239, -240 in Basalt Spring, TW-1A, or TW-2A, in contrast to earlier years. In 1997, Basalt Spring showed detectable plutonium-239, -240, as well as gross beta. Because the sample at Basalt Spring is collected in contact with the canyon soils, the source of the plutonium could be surface sediments rather than groundwater. The sample from the Water Canyon Gallery, which lies southwest of the Laboratory, was consistent with previous results, showing no evidence of radionuclides from Los Alamos operations.

4. Nonradiochemical Analytical Results

The results of general chemical analyses of groundwater samples for 1998 are listed in Table 5-14, and results of trace metal analyses appear in Table 5-15.

a. Nonradiochemical Constituents in the Regional Aquifer. With the exceptions discussed here, values for all parameters measured in the water supply wells are within drinking water limits. Separate samples were collected to determine regulatory compliance for the public water supply system, and these samples were all in compliance for 1998.

The pH values in wells G-1A and Otowi-1 were above the EPA secondary standard limit of 8.5. For well G-2, the arsenic level was slightly above the standard of 50 µg/L and was similar to previous measurements. The vanadium value in well G-2 was above the EPA health advisory range of 80 to 110 µg/L.

The test wells in the regional aquifer showed levels of several constituents that approach or exceed standards for drinking water distribution systems. However, it should be noted that the test wells are for monitoring purposes only and are not part of the water supply system. TW-1 had a nitrate value of 5.3 mg/L (nitrate as nitrogen), again below the EPA primary drinking water standard of 10 mg/L. This test well has shown nitrate levels in the range of about 5 to 20 mg/L (nitrate as nitrogen) since the early 1980s. The source of the nitrate might be infiltration from sewage treatment effluent released into Pueblo Canyon or residual nitrates from the now decommissioned TA-45 radioactive liquid waste treatment plant that discharged effluents into upper Pueblo Canyon until 1964. Nitrogen isotope analyses the ER Project made during 1998 indicate that the nitrate is from a sewage source (Nylander et al., 1999). The pH in TW-3 was below the EPA secondary drinking water standard range of 6.8–8.5.

Six groundwater samples showed an apparent detection of selenium in 1998. Typically, selenium has not been detected in groundwater on the Pajarito Plateau. We also saw unusual selenium values in surface water samples as described above. The analytical detection limit for selenium in 1998 samples was 3 µg/L, higher than in previous years and higher than the New Mexico Wildlife Habitat Standard of 2 µg/L. The EPA drinking water and New Mexico groundwater standards for selenium are 50 µg/L. Numerous selenium results reported as 3 µg/L have three sigma uncertainties equal to the reported value, raising the question of whether these values indicate the presence of selenium. Three of the samples with selenium were in Los Alamos Canyon alluvial groundwater (discussed below). Selenium was also detected in each of the three DT series test wells at TA-49 at 3 ± 2 µg/L. As selenium has not been seen before at these wells, as the values are near the detection limit, and as they were all analyzed in the same batches, it is likely that the values reflect analytical variation rather than presence of selenium. We will continue to monitor these wells for trace metals in the future.

Levels of trace metals that approach water quality standards in some of the test wells are believed to be associated with turbidity of samples and with the more than 40-year-old steel casings and pump columns. In the last few years, iron, manganese, cadmium, nickel, antimony, and zinc have been high in several of the regional aquifer test wells. These trace metal values represent total, rather than dissolved concentrations, in that they include the composition of any suspended sediment contained in the water samples. In 1998, Test Wells 1 and 4 had lead levels above the 15 µg/L EPA action level. Test Wells 1 and 4 had antimony values at or above the 6 µg/L EPA drinking water

standard. The lead levels appear to result from flaking from piping installed in the test wells and do not represent lead in solution in the water (ESP 1996a). There are no known sources of lead near these wells, and dissolved lead levels in natural waters of near neutral pH (pH ~7) are usually extremely low (Hem 1989).

Samples collected for metals analysis from most of the White Rock Canyon springs were filtered in 1998. Many of the springs have very low flow rates, and samples are collected in small pools in contact with the surrounding soils. Spring 2 had an arsenic value of 28 µg/L, in line with the average of 27 µg/L for nine samples over the past 12 years. This spring had a fluoride value of 1.11 mg/L, near the average of 1.14 mg/L for 22 samples.

b. Nonradiochemical Constituents in Alluvial Groundwater. The canyon bottom alluvial groundwater in Pueblo, Los Alamos, and Mortandad Canyons receives effluents. The groundwater shows the effects of those effluents in that values of some constituents are elevated above natural levels. Mortandad Canyon groundwater samples exceeded or approached the NMWQCC Groundwater Standards for fluoride and nitrate. The nitrate source is nitric acid from plutonium processing at TA-55 that enters the TA-50 waste stream.

The pH in LAO-2 and PCO-1 was below the EPA secondary drinking water range of 6.8–8.5. The pH of MCO-7A was reported as 1.6, with a conductance reported as 11,140 µS/cm. Neither of these values is realistic; both probably represent analytical laboratory aberrations. Usual values are pH of 7.3 and conductance of 600 µS/cm.

PCO-3 had unusually high values of chloride, sodium, and total dissolved solids (TDS). The average chloride concentration for 13 previous samples was 108 mg/L, compared to the 1998 value of 382 mg/L. This average is raised by three values over 200 mg/L, which occurred in 1991, 1993, and 1998; the other values are below 100 mg/L. Similarly, for sodium, the average is 60 mg/L, with most values below 40 mg/L and three over 100 mg/L. The reason for this variability in water quality is unknown; the two upstream wells PCO-1 and PCO-2 do not show these higher values.

Three of the groundwater samples with apparent selenium detections were in Los Alamos Canyon alluvial groundwater (LAO-C, LAO-0.7, and LAO-1) at 3 ± 3 µg/L. Here the three-sigma uncertainty is 3 µg/L. As noted earlier, it is likely that the values reflect analytical variation rather than presence of selenium. We will continue to monitor these wells for trace metals in the future.

In 1998, we detected beryllium in Cañada del Buey wells CDBO-6 and CDBO-7 at 4 µg/L and 18 µg/L, compared to the drinking water MCL of 4 µg/L. For a total of 11 samples collected for these wells from 1992 through 1997, beryllium was detected 6 times. Barium was found in both wells in 1998; in CDBO-7, the concentration was 3123 µg/L, or over 3 times the New Mexico groundwater limit. For a total of 11 samples collected for these wells from 1992 through 1997, the average barium concentration was 573 µg/L, with high values of 1500 µg/L in 1993 for CDBO-6 and 1600 µg/L in 1994 for CDBO-7. We also found lead at high levels in these wells in 1998: the value of 107 µg/L in CDBO-7 was over 7 times the EPA drinking water action level. For a total of 9 samples analyzed for lead from these wells from 1992 through 1997, lead was detected 8 times. The average for the eight detections was 60 µg/L, with high values of 242 µg/L in 1993 for CDBO-6 and 62 µg/L in 1995 for CDBO-7. Samples are often quite turbid when collected from the wells. For 1998, lead and beryllium were only detected in the unfiltered samples. Barium was found at lower concentrations in the filtered samples than the unfiltered samples. Significant concentrations of arsenic, chromium, and vanadium were also found in CDBO-7. Some of these constituents are of particular interest because of radioactivity and metals found in runoff samples farther down the canyon. Runoff samples from Cañada del Buey at White Rock, in addition to high levels of radioactivity as described earlier, contained levels of barium, beryllium, cobalt, nickel, lead, and selenium near or exceeding regulatory standards.

Several of the alluvial groundwater samples showed levels of aluminum, iron, and manganese that would exceed standards for drinking water systems. These metal concentrations reflect the presence of suspended sediment that had entered the well casings. The concentrations are generally much lower in samples that are filtered than in those not filtered. Lead was found in LAO-3A at up to 61 µg/L (in a filtered sample, compared to 16 µg/L in an unfiltered sample), about six times the average of eleven previous lead analyses and at the upper end of the range of results for the past ten years.

c. Nonradiochemical Constituents in Intermediate-Depth Perched Groundwater. In 1998, the

nitrate values for TW-1A, TW-2A, and Basalt Spring were well below NMWQCC Groundwater and EPA Drinking Water Standards. These sample locations have occasionally shown higher nitrate values in recent years. The source of the nitrate is infiltration of contaminated surface water and shallow groundwater from Pueblo Canyon.

TW-1A and TW-2A had levels of iron, lead, manganese, and zinc approaching or exceeding water quality standards. Again, the detection of metals in these test wells probably reflects either suspended sediments or the flaking of metals from pump hardware and the well casing rather than the existence of dissolved metals in the groundwater. The pH of 5.7 in TW-2A was below the EPA secondary drinking water range of 6.8–8.5. Otherwise, the intermediate-perched groundwater samples from these stations and the Water Canyon gallery did not show any concentrations of nonradiochemical constituents that are of concern.

d. Organic Constituents in Groundwater. We performed analyses for organic constituents on selected springs and test wells in 1998. The stations sampled appear in Table 5-16. Some samples were analyzed for VOCs, SVOCs, and PCBs. Water supply wells, test wells at TA-49, and most springs were analyzed for HE constituents. With two exceptions at Basalt Spring discussed below, no organic or high-explosive constituents were detected in the groundwater samples listed in Table 5-16 at Los Alamos during 1998. Most of the possible organic detections the Organic Analysis Group reported were rejected because the compounds were either detected in method blanks (introduced during laboratory analysis) or detected in trip blanks. Trip blanks are sent along during sampling to determine if organic constituents come from sample preparation.

In 1998, drilling of characterization well R-25 at TA-16 in the southwest portion of the Laboratory revealed the presence of high-explosive constituents at concentrations above the EPA Health Advisory guidance values for drinking water. As a result, the Laboratory tested all nearby water supply wells for these compounds. In November, we collected samples from PM-1, PM-2, PM-3, PM-5, Otowi-1, and Otowi-4. We submitted samples for each well to three separate analytical laboratories for analysis. PM-4 was out of service at the time but was sampled in March 1999. None of the analytical laboratories detected any high explosives or their degradation products in any of the water samples from any of the supply wells sampled.

HE constituents were detected in Ancho Spring during 1995 sampling but not in 1996, 1997, or 1998. This spring is fairly far downstream from the explosives testing sites in the southern portion of the Laboratory.

The only organic detections in groundwater were methylene chloride (19 ± 5.7 µg/L) and methyl-2-pentanone [4-] (55 ± 16.5 µg/L) in Basalt Spring. This sample exceeded the analytical holding time, and no method blank was run with the sample, so these compounds could be the result of analytical laboratory contamination. A number of organic compounds were detected in Basalt Spring in 1995: most were tentatively identified compounds (compounds not specifically measured by the analysis) except for chloroethane. No organic compounds were found in 1997 samples from Basalt Spring.

5. Long-Term Trends

a. Regional Aquifer. The long-term trends of the water quality in the regional aquifer have shown limited impact resulting from Laboratory operations. In 1998, drilling characterization well R-25 at TA-16 in the southwest portion of the Laboratory revealed the presence of high-explosive constituents. No high-explosives constituents have been found in water supply wells. The extent of high explosives in the regional aquifer is presently unknown. The Laboratory will take action in cooperation with regulatory agencies to define the extent of the contamination and ensure that drinking water supplies are adequately protected. Drilling schedules for several characterization wells have been altered so that additional wells will soon be drilled in the area of TA-16.

Aside from naturally occurring uranium, the only radionuclide consistently detected in water samples from production wells or test wells within the regional aquifer is tritium, which is found at trace levels. The tritium contamination is found at four locations in Los Alamos and Pueblo Canyons and one location in Mortandad Canyon. Measurements of tritium by low-detection-limit analytical methods (ESP 1995; ESP 1996a) show the presence of some recent recharge (meaning within the last four decades) in water samples from six Environmental Surveillance Program wells penetrating the regional aquifer at Los Alamos. Recent drilling of additional characterization wells in Los Alamos and Sandia Canyons has confirmed the results. The tritium levels measured range from less than 2% to less than 0.01% of current drinking water standards, and all are below levels

detectable by the EPA-specified analytical methods normally used to determine compliance with drinking water regulations.

Other measurements of radionuclides above detection limits in the regional aquifer reflect occasional analytical outliers not confirmed by analysis of subsequent samples. The apparent detection of strontium-90 in TW-3 in 1994 (ESP 1996a) appears to result from analytical error because the gross beta measurement does not support the strontium-90 result. Previous or subsequent measurements have not substantiated the apparent detection of strontium-90 in TW-4 in 1994 (ESP 1996a). The same conclusion applies to apparent detections of strontium-90 in Guaje well field water supply wells G-1 and G-1A in 1997 and 1995 (see Section 5.D.3.a).

Detection of lead in some regional aquifer test wells appears to have resulted from contamination by well casings, pumps, and monitoring devices (ESP 1995). Nitrate concentrations in TW-1 have been near the EPA MCL since 1980. The source of the nitrate might be infiltration of sewage-effluent-contaminated shallow groundwater and surface water in Pueblo Canyon or residual nitrates from the now decommissioned TA-45 radioactive liquid waste treatment plant that discharged effluents into upper Pueblo Canyon until 1964. Nitrogen isotope analyses the ER Project made during 1998 indicate that the nitrate is from a sewage source (Nylander et al., 1999).

The long-term trends of water levels in the water supply and test wells in the regional aquifer indicate that there is little depletion of the resource as a result of pumping for the Los Alamos water supply (McLin et al., 1998).

b. Surface Water and Alluvial Groundwater in DP and Los Alamos Canyon. Because of moderate adsorption, strontium-90 is persistent in soils and groundwater. Strontium-90 activity remains high in surface water and shallow alluvial groundwater within much of Los Alamos Canyon and its tributary DP Canyon despite a cessation of discharges by the Laboratory. While strontium-90 dissolves in water, it is also adsorbed onto mineral surfaces and solid organic matter and could form mineral precipitates. The formation and breakdown of these chemical attachments slow its movement along a flow path. The reservoir of adsorbed strontium-90 provides a continual (though decreasing) supply of this radionuclide to passing water. The activities remain in the range of the EPA drinking water standard (8 pCi/L) and the DOE DCG for a DOE-maintained drinking water system (40 pCi/L).

Long-term trends of strontium-90 activity in surface water and alluvial groundwater in DP and Los Alamos are shown in Figure 5-11. The samples are from observation wells in Los Alamos Canyon (except LAO-2, which is in the mouth of DP Canyon) and surface water stations in DP Canyon. Only strontium-90 detections are plotted in the figure. If more than one sample was collected in a year, the average value for the year is plotted. No other regularly monitored surveillance stations in this area (such as downstream stations) had strontium-90 detections during this period.

The strontium-90 level in LAO-1, which is located downstream of the former reactors at TA-2, was high in the late 1970s when monitoring began and has declined since then. In the late 1960s, strontium-90 in DP Canyon surface water exceeded the DOE public dose DCG (1000 pCi/L) as a result of discharges from the TA-21 industrial liquid waste treatment plant. These strontium-90 levels have subsequently decreased, beginning before discharges ceased in 1986. The impact of strontium-90 from DP Canyon is seen in downstream wells LAO-2 and LAO-3 (LAO-3 is combined with LAO-3A). The activities in these wells are higher than in LAO-1, which is farther upstream in Los Alamos Canyon. The strontium-90 history in wells LAO-3 and LAO-4 suggests that the crest of a slowly moving front of the radionuclide passed these locations during the early 1990s.

c. Surface Water and Alluvial Groundwater in Mortandad Canyon. Long-term trends of radionuclide concentrations in surface water and shallow alluvial groundwater in Mortandad Canyon downstream from the outfall for the RLWTF at TA-50 are depicted in Figure 5-12. Because of strong adsorption to sediments, cesium-137 is not detected in groundwater samples. The figure only shows radionuclide detections. If more than one sample was collected in a year, the average value for the year is plotted. The surface water samples are from the station Mortandad at GS-1, a short distance downstream of the TA-50 effluent discharge. Radioactivity levels at this station vary daily depending on whether individual samples are collected shortly after a release from the RLWTF. These samples also vary in response to changes in amount of runoff from other sources in the drainage. The groundwater samples are from observation well MCO-5 in the middle reach of the canyon. Groundwater radioactivity at MCO-5 is more stable than at Mortandad at GS-1 as groundwater responds more

slowly to variations in runoff water quality.

Chemical reactions such as adsorption do not delay tritium transport, and high tritium activities are found throughout the groundwater within the Mortandad Canyon alluvium. All of the tritium levels in Mortandad Canyon alluvial groundwater in 1998 were slightly below the EPA MCL of 20,000 pCi/L. The surface water tritium activity at Mortandad at GS-1 reflects diluted values of effluent from TA-50 as the effluent mixes with other stream water. The tritium activity at MCO-5 has fluctuated almost in direct response (with a time lag of about one year) to the average annual activity of tritium in the TA-50 outfall effluent. Tritium values at both stations have decreased since the mid-1980s because of decreased tritium content of the TA-50 effluent.

The americium-241 activity of RLWTF discharges has exceeded the DOE DCG for public dose of 30 pCi/L for all but four years since 1973. Americium-241 activity has not been measured regularly at monitoring stations in Mortandad Canyon. Under many environmental conditions americium is less strongly adsorbed than cesium or strontium and moves more readily in groundwater. Americium-241 was detected in every Mortandad Canyon alluvial groundwater well in 1998, suggesting that it has migrated farther and in larger amounts than has plutonium or strontium-90. The americium-241 activity in the observation wells was below the DOE drinking water DCG of 1.2 pCi/L. Data for the last four years at Mortandad at GS-1 show an increase in americium-241 activity to near the DOE DCG for public dose. At MCO-5, the americium-241 activity shows only a slight increase over the past few years.

We detected strontium-90 in surface water at Mortandad at GS-1 and in all alluvial observation wells upstream of and including MCO-6B in 1998. The activities remain at values in the range of the EPA drinking water standard (8 pCi/L) and the DOE DCG for a DOE-maintained drinking water system (40 pCi/L) and range up to over 100 pCi/L. Strontium-90 has been detected only once downstream of MCO-6B, in MCO-8 in 1976. Adsorption or mineral precipitation appears to have retained strontium-90 within the upstream portion of the alluvium. The level of strontium-90 has risen gradually at downstream wells MCO-5 and MCO-6 over the last 20 years suggesting that the mass of the radionuclide is moving slowly downstream.

We detected plutonium isotopes at Mortandad at GS-1 and MCO-3 in 1998 but at no other alluvial observation wells. Both isotopes have been detected at these stations at levels near the DOE public dose DCGs (30 pCi/L for plutonium-239, -240 and 40 pCi/L for plutonium-238) over the past few years. Values at other alluvial observation wells except for MCO-4 have been near the detection limit in the 1990s. Plutonium has in general been detected in all alluvial observation wells in Mortandad Canyon but appears to be decreasing in activity at downstream locations. Plutonium-238 was last detected in MCO-8 in 1976 and in MCO-7 and MCO-7.5 in 1985. Plutonium-239, -240 was last detected in MCO-8 in 1969, MCO-7.5 in 1987, and MCO-7 and MCO-7A in 1995.

E. Groundwater and Sediment Sampling at the Pueblo of San Ildefonso

To document the potential impact of Laboratory operations on lands belonging to the Pueblo of San Ildefonso, DOE entered into a Memorandum of Understanding (MOU) with the Pueblo and the Bureau of Indian Affairs in 1987 to conduct environmental sampling on pueblo land. This section deals with hydrologic and sediment sampling. The groundwater, surface water, and sediment stations sampled on the Pueblo of San Ildefonso are shown in Figures 5-13 and 5-14. Aside from stations shown on those figures, the MOU also specifies collection and analysis of additional water and sediment samples from sites that have long been included in the Laboratory's Environmental Surveillance Program, as well as special sampling of storm runoff in Los Alamos Canyon. These locations appear in Figures 5-1, 5-2, 5-4, and 5-9, and the results of analyses are discussed in previous sections.

1. Groundwater

Table 5-12 lists the results of radiochemical analyses of groundwater samples for 1998. Table 5-13 contains lists of radionuclides detected where values exceed both the method detection limit and three times the individual measurement uncertainty. Because uranium, gross alpha, and gross beta are ubiquitous at detectable levels, we report occurrences of these measurements above levels chosen to be below the EPA MCLs or screening levels. The specific values are 5µg/L for uranium, 5 pCi/L for gross alpha, and 20 pCi/L for gross beta.

Radiochemical detections that are greater than 1/25 of the DOE DCGs for Public Dose for Ingestion of

Environmental Water (that is, greater than the DOE drinking water system DCGs) are indicated in the righthand columns of Table 5-13. Gross alpha and gross beta values noted in the extra columns are also greater than their respective EPA drinking water limits, which in turn are higher than 1/25 of the DOE public dose DCG. The DCG value for gross beta is actually the strontium-90 DCG, and the DCG for gross alpha is the plutonium-239, -240 DCG. These DCGs were chosen because the isotopes represented had the lowest DCGs for alpha and beta emitters.

See Section 5.D for a discussion of most of the groundwater stations (wells and springs) listed in the MOU. The present section focuses on the Pueblo of San Ildefonso water supply wells.

As in previous years, the groundwater data for the Pueblo of San Ildefonso indicate the widespread presence of naturally occurring uranium at levels approaching or in excess of proposed EPA drinking water limits. Naturally occurring uranium concentrations near or even much greater than the proposed MCL of 20 µg/L are prevalent in well water throughout the Pojoaque area and the Pueblo of San Ildefonso. The high gross alpha readings for these wells are related to uranium occurrence.

In 1998, there were no detections of radionuclides other than uranium in Pueblo of San Ildefonso water supply wells. In previous years, the Pueblo of San Ildefonso water supply well data have suggested the occasional detection of trace levels of plutonium and americium. In most cases, these values are near the detection limit of the analytical method so that it is uncertain whether detection has occurred. At such measurement levels, precise quantification of the amount detected is not possible.

New Community Well had a uranium concentration exceeding the proposed EPA primary drinking water standard of 20 µg/L. Uranium concentrations at the Pajarito Pump 1, Don Juan Playhouse, and Sanchez House wells were more than half of the proposed EPA standard. These measurements are consistent with the levels in previous samples and with the relatively high levels of naturally occurring uranium in other wells and springs in the area.

The gross alpha levels in these wells are attributable to the presence of uranium. The gross alpha level in the sample from the New Community Well was 26.6 pCi/L, above the EPA primary drinking water standard of 15 pCi/L. The gross alpha level in samples from the Don Juan Playhouse, Sanchez House, and Pajarito Pump 1 wells was below the drinking water standard. This standard applies to gross alpha from radionuclides other than radon and uranium.

The chemical quality of the groundwater, shown in Table 5-14, is consistent with previous observations. The sample from the Pajarito Pump 1 Well exceeded the drinking water standard for total dissolved solids; this level is similar to those previously measured. This well also has a chloride concentration at 80% of the EPA secondary drinking water standard and 40% of the primary drinking water standard.

The fluoride values for some wells (Eastside Artesian and Sanchez House) are near the NMWQCC Groundwater Standard of 1.6 mg/L, similar to previous values. Several of the wells (Eastside Artesian, New Community, and Don Juan Playhouse) have alkaline pH values, above the EPA secondary standard range of 6.8 to 8.5; these values do not represent a change from those previously observed in the area.

Many of the wells have sodium values significantly above the EPA health advisory limit of 20 mg/L. The values from Pajarito Pump 1, Sanchez House, and Eastside Artesian wells are especially high.

Table 5-15 shows trace metal analyses. The boron value in Pajarito Pump 1 was nearly twice the NMWQCC groundwater limit of 750 µg/L. This value was similar to those of past years.

2. Sediments

We collected sediments from Pueblo of San Ildefonso lands in Mortandad Canyon in 1998 from five permanent sampling stations. The results of these and other sediment analyses are shown in Tables 5-8, 5-9, and 5-10. Section 5.C presents related information. Results are comparable to sediment data collected from these same stations in previous years; exceptions are discussed below.

Analyses of sediments collected at station Mortandad A-6 in 1998 showed cesium-137 and plutonium-239, -240 at activities slightly greater than background. Since 1987, cesium-137 activity in sediments at station A-6 has ranged from near background to more than five times background. Sediments collected at station A-7 had a total uranium concentration 20 percent greater than background. All other sediment stations downstream of Mortandad A-7 showed only background activities of radionuclides.

Sediments from the sampling station located on San Ildefonso Pueblo lands at Los Alamos at Otowi showed the activity of plutonium-239, -240 as twice back-

ground. This activity is slightly less than typical sediment samples previously collected at that station.

F. Sampling Procedures, Analytical Procedures, Data Management, and Quality Assurance

1. Sampling

The Draft Quality Assurance Project Plan (ESH-18 1996) is the basic document covering sampling procedures and quality assurance (QA). The formal procedures developed to address sampling for each sample matrix (Mullen and Naranjo 1996, 1997) provide more focused guidance. All sampling is conducted using strict chain-of-custody procedures, as described in Gallaher (1993). The completed chain-of-custody form serves as an analytical request form and includes the requester or owner, sample barcode number, program code, date and time of sample collection, total number of bottles, the list of analytes to be measured, and the bottle sizes and preservatives for each analysis required. We send the samples to the Chemical Science and Technology (CST) Division or to other analytical laboratories. Detailed analytical methods are published in Gautier (1995). We submit samples using blind sample numbers to prevent possible bias that might occur if the analyst knows the sampled location.

We filtered in the field samples collected for radionuclide and metals analysis at the White Rock Canyon Springs to minimize the effects of surface soils and to represent groundwater surfacing at the springs. The "F/UF" column on the tables of analytical results shows a "UF" for unfiltered samples and an "F" for samples filtered through a 0.45-micron filter.

We filtered in the field surface water samples collected for metals analysis. This procedure allows for comparison of analytical results with the NMWQCC standards. These standards are mainly for dissolved concentrations, except mercury and selenium, for which standards are based on total concentrations. Mercury and selenium were not filtered in the field and were analyzed to determine total concentration.

Automated samplers located at recently installed gaging stations (Shaull et al., 1998) collected runoff. The contents of bottles collected by the automated sampler were first transferred to a churn splitter, which agitates the samples to ensure that they are well mixed and that the sediments are suspended. If the automated sampler collected adequate water, two sets of samples were submitted to the analytical laboratory. One set was unfiltered and preserved for total concentration analysis, whereas the other set was submitted unfiltered and unpreserved. The analytical laboratory filtered the latter samples, preserved them, and routed them to the appropriate analyst. If insufficient water was available, only unfiltered samples were analyzed to determine total concentrations.

2. Analytical Procedures

a. Metals and Major Chemical Constituents. Metals and major chemical constituents are analyzed using EPA SW-846 methods. Filtering in the analytical laboratory and digestion methods have changed over time. Before 1993, water samples were preserved in the field and filtered in the laboratory before digestion. From 1993 forward, the analytical laboratory has not filtered water samples submitted for metals analyses, with the exception of runoff samples as mentioned above.

b. Radionuclides. Radiochemical analysis is performed using the methods as updated in Gautier (1995). Sediment samples are screened through a number 12 US standard testing sieve before digestion. The sieve meets ASTM E-11 specifications and screens out materials larger than 1.7 mm. Ten-gram samples are analyzed from stream channels; larger 1,000-g samples are analyzed from reservoirs for plutonium-238 and plutonium-239, 240. Larger 1,000-g samples give a 10-fold improvement in detection limits of plutonium-238 and plutonium-239, -240 for reservoir samples.

Water samples for radiochemical analyses are preserved with nitric acid in the field to a pH of 2 or less. Before 1996, the analytical laboratory filtered water samples before digesting. Samples collected in 1996 and after are preserved in the field as before but not filtered by the analytical laboratory. At the analytical laboratory, both water and sediment samples are completely digested in a mixture of nitric and hydrofluoric acids. A separate, unpreserved sample is collected for tritium analysis.

When especially precise trace level tritium analyses are required, samples are shipped to the University of Miami Tritium Laboratory. These samples are collected and analyzed according to procedures described in Tritium Laboratory (1996).

Negative values are reported for some radiological measurements. Negative numbers occur because measurements of radiochemical samples require that

analytical or instrumental backgrounds be subtracted to obtain net values. Consequently, individual measurement values can result in positive or negative numbers. Although negative values do not represent a physical reality, they are reported as they are received from the analytical laboratory. Valid long-term averages can be obtained only if negative values are included in the analytical results.

c. Organics. Organics are analyzed using SW-846 methods as shown on Table A-10. This table shows the number of analytes included in each analytical suite. The specific compounds that are analyzed in each suite are listed in Tables A-11 through A-14. All organic samples are collected in brown glass bottles, and the VOC samples are preserved with hydrochloric acid. A trip blank, or field blank, always accompanies the VOC sample. A trip blank is a sample of de-ionized water that accompanies the field samples and is submitted for analysis like any other sample. Method blanks are prepared by the analytical laboratory and are also analyzed with samples. If trip or method blanks contain organic compounds, they were introduced during sampling or analytical procedures. Certain organic compounds used in analytical laboratories are frequently detected in the method blanks. These compounds include acetone, methylene chloride, toluene, 2-butanone, di-n-butyl phthalate, di-n-octyl phthalate, and bis (2-ethylhexyl) phthalate (Fetter 1993).

3. Data Management and Quality Assurance

a. Data Management. CST transfers analytical results to the Water Quality and Hydrology Group (ESH-18) both electronically and as a hard copy. Samples submitted to CST go through the SQL Laboratory Information Management System. A data retrieval query generates a table of ESH-18 data every week. The data set is downloaded to ESH-18 computers every week. The sample location name, the sample number, and the field data are stored in a separate table, providing the link for associating a blind sample number with a location name.

b. Quality Assurance. Each analytical batch of water samples (20 samples or less) contains at least one blank, one matrix spike, and a duplicate as dictated by SW-846 protocols. These quality control samples are provided by CST and submitted along with environmental surveillance samples. ESH-18 also submits blanks, spikes, and duplicate water samples. The analytical results of the blanks and spikes are presented in Tables 5-17 and 5-18. The analytical results for the duplicates are presented on the analytical result tables. No quality control samples were submitted for sediment analysis.

ESH-18 submits de-ionized water (DI) trip blanks and spiked samples as regular samples, without any indication that they are QC samples. They go through the same analytical process as the regular field samples. The DI blanks and spiked samples are measured with the same background contributions from reagents and biases as the regular samples and give an estimate of background and systematic analytical errors. Trip blanks are also submitted to detect if any organics are inadvertently introduced during the sampling or analytical laboratory procedures. Using DI blank sample values, we correct the radiochemical sample analyses results by subtracting the average of the blanks from each of the reported sample values. The original analytical value for radiochemical results may be recovered by adding the average blank value found in Table 5-17 to the values reported in the analytical result tables.

Ideally, the values for all analytes in the blanks should be zero. Results in Table 5-17 show that the average concentration of americium-241 in the DI blanks was equal to the detection limit. The likely causes for these concentrations of americium-241 are the plutonium-242 and americium-243 tracers that are added to each sample during analysis. Both of those tracers contain americium-241.

A high analytical bias is indicated for several other analytes. A high bias of about one-fourth of the detection limit is apparent in the cesium-137 and plutonium-238 in the DI blank results, and a high bias on the order of one-half of the detection limit is apparent in the uranium, plutonium-239,-240 and gross gamma DI blank results. The high bias in uranium is the result of a single sample.

The concentrations reported in Table 5-17 for the spiked samples are the concentrations after subtraction of the average blank values. For tritium; stronium-90; cesium-137; uranium; plutonium-239, -240; and americium-241, there is good agreement, relative to their respective detection limits, between the analytical results and the spiked concentrations after blank correction. Plutonium-238 was not as close with the result more than 35 percent less than the actual spiked concentration.

Taylor (1987) suggests a method for evaluating detection limits based on the analytical results for spiked samples. The standard deviation of the average

spiked sample result can be used as a measure of the one sigma analytical uncertainty. Table 5-17 presents the results of this analysis in its last two lines. Detection limits calculated using this method are as much as four times higher than the values that the analytical laboratory reports.

Analytical concentrations for DI blanks submitted for trace metals were generally reported as less-than-detection limits. Spiked samples for metals analyses contained four metals; silver, barium, mercury, and lead. There was generally good agreement between spike concentrations and the analytical results. Standard deviations associated with the average values of barium and lead for the DI blanks and spiked samples were significantly less than the reported concentrations, suggesting relatively precise measurements for those analytes.

As noted in the 1997 ESR, we had observed low mercury values for our spiked samples. We attribute this to loss of mercury through the walls of the plastic sample bottles. To avoid this loss we started submitting mercury samples in amber glass bottles in September of 1998. This change appears to have significantly improved the accuracy of our mercury analysis. It is unclear why the spiked sample submitted on November 11 was reported as below detection limits.

The lead results for the spiked samples were generally in good agreement with the spiked values. The results for two samples submitted on November 28 are shown on Table 5-18 as <10 µg/L. The actual lab results for these samples were 8.0 ± 10 µg/L. (Please note that, for metals analyses, the lab reports a three-sigma uncertainty. In this case, the three-sigma uncertainty is 10 µg/L.) For metals, if the sample value reported by the lab is less than the three-sigma uncertainty, we report the sample value as less than the three-sigma uncertainty to make our metals results consistent with those reported by other labs. The reported value of 8.0 µg/l is in good agreement with the known concentration of 7.5 µg/L.

CST observed silver contamination in some sample submissions in early 1998. The preparation blanks showed silver over the detection limits, and the control samples and samples spikes were also high. Later in 1998, the contamination problem was identified and remedied.

In the past, soils were dried and then sieved before the sample analysis process was undertaken. Starting in 1998, samples were dried and then ball milled for a more complete homogenization of the sample. Also in 1998, CST reported a high bias of about 1 cpm in the determination of stronium-90 in soils using liquid scintillation counting. That high bias resulted in a method detection limit of 2 pCi/g.

CST performed a review of its analytical methods following 1998 to verify that new methods used during the year were consistent with earlier methods. The review indicated that 1998 analyses were typically consistent with the methods used in 1997.

4. Determination of Radiochemical Detections

CST has determined detection limits for each analytical method. Radiological detection limits are based on Currie's formula (Currie 1968). Detection limits are reported at the bottom of the tables summarizing the radiochemical analytical results. In deriving the detection limits, CST included the average uncertainties associated with the entire analytical method. Sources of error considered include average counting uncertainties, sample preparation effects, digestion, dilutions, gravimetric and pipetting uncertainties, and spike recoveries.

While these method detection limits determined by CST or other analytical laboratories give an idea of the average limit of detection for a particular measurement technique, the detection limits do not apply to each individual sample measurement. Instead, the question of whether or not an individual measurement is a detection is evaluated in light of its individual measurement uncertainty. For radiochemical analytical results, the analytical uncertainties are reported in the tables. These uncertainties represent a one standard deviation (one sigma) propagated uncertainty. "It is virtually unanimously accepted that an analyte should be reported as present when it is measured at a concentration three-sigma or more above the corresponding method blank" (Keith 1991). Our reported values are corrected by blank subtraction to eliminate the effects of positive or negative analytical laboratory biases. Therefore, we report radiochemical detections as values greater than three times the reported uncertainty. For sediments, the values reported as detections in the table are also above background levels determined for fallout, or natural background levels in the case of uranium.

The limit of quantification or LOQ is the level where the concentration of an analyte can be quantified with confidence. "When the analyte signal is 10 or more times larger than the standard deviation of the measurements, there is a 99% probability that the true

concentration of the analyte is (30% of the calculated concentration" (Keith 1991). Thus, measured values near the detection limit or less than 10 times the analytical uncertainty do not provide a reliable indication of the amount present. The importance of this number is demonstrated when analytical results are compared against standards; the analytical result should be greater than 10 times the analytical uncertainty for the comparison to be meaningful.

G. Unplanned Releases

ESH-18 investigated all unplanned releases of nonradioactive liquid. Upon cleanup, personnel from NMED-DOE/OB (Oversight Bureau) inspected the unplanned release site to ensure adequate cleanup. NMED-DOE/OB recommended administratively closing seven of the 12 unplanned releases that occurred in 1998. It is anticipated that the remainder of the unplanned release investigations will be closed when NMED-DOE/OB personnel become available for inspections.

1. Radioactive Liquid Materials

No unplanned radioactive liquid releases occurred in 1998.

2. Nonradioactive Liquid Materials

There were 12 unplanned releases of nonradioactive liquid in 1998. The following is a summary of these discharges.

- Two releases of treated cooling water.
- Two releases of sanitary sewage from the Laboratory's TA-46 SWS Facility's collection system.
- Three releases of diesel, gasoline, or hydraulic oil from vehicles or equipment.
- Two releases of potable water that impacted ER Project solid waste management unit (SWMU) sites.
- Two releases of drilling water/mud to a watercourse.
- One release of potentially contaminated rainwater from the overflow of a high-explosives wastewater collection sump.

H. Special Studies

1. Regional Aquifer Hydrologic Properties Study: Water Production Records

On September 8, 1998, DOE began leasing the Los Alamos municipal water production and distribution system to the County Department of Public Utilities (the County). This three-year lease authorizes the County to routinely operate and maintain all production wells, storage tanks, water transmission lines, booster stations, chlorination units, and other related equipment. In addition, routine system discharges into the environment will continue under the Laboratory's NPDES permit during the lease period. However, Safe Drinking Water Act (SDWA) compliance sampling will become the responsibility of the County. The State of New Mexico's Water Conservation Program will collect a fee of $0.03 per 1,000 gallons from the County. These funds will support water sample collection and analyses for SDWA compliance by the New Mexico Drinking Water Bureau. The County has also assumed all other responsibilities associated with system operation. The system will likely be permanently transferred from the DOE to Los Alamos County during the lease period, perhaps by the end of 1999. DOE will retain a 30% ownership of existing system water rights, while the County will permanently acquire ownership of 70% of these rights. The County will then lease DOE's remaining water rights and sell water to the Laboratory under a special contract.

In October 1998, Los Alamos County began reporting monthly water production records for the municipal water supply system directly to the State Engineer Office; the Laboratory was responsible for these reports between January and September. During 1998, total water production from 14 wells in the Guaje, Pajarito, and Otowi municipal well fields, the Water Canyon Gallery, and Los Alamos and Guaje Reservoirs was 4.95 million cubic meters (1,307 million gallons or 4,011.3 ac-ft). This total production amounts to 72.4% of the total water right of 6.84 million cubic meters (5,541.3 ac-ft) available to the County under the State Engineer Office water rights permit. In addition, the drilling of four new Guaje replacement wells that began during 1997 was completed in 1998. Details of the performance of the water supply wells, including their operation and a water quality summary, are published in a series of

separate reports. The most recent report is entitled "Water Supply at Los Alamos during 1997" (McLin et al., 1998).

2. Regional Aquifer Hydraulic Properties Study: Measurement of Water Levels

In October 1992, the Laboratory began measuring and recording water level fluctuations in test wells completed into the regional aquifer below Pajarito Plateau and in various other monitoring wells completed within intermediate and alluvial groundwater located throughout the facility. These data are automatically recorded at hourly intervals using calibrated pressure transducers. Water level data are presented in the Laboratory report entitled "Water Supply at Los Alamos during 1997" (McLin et al., 1998), which summarizes the locations, start and end dates for data collection, and final water levels recorded during 1997.

3. Surface Water Data at Los Alamos National Laboratory: 1998 Water Year

Surface water discharge data were collected from 19 stream-gaging stations that cover most of the Laboratory. The data, published in the report "Surface Water Data at Los Alamos National Laboratory: 1998 Water Year" (Shaull et al., 1999), show less runoff than do data for the 1997 water year. Water chemistry data from larger storm events occurring at some stations are also published in this report.

The annual surface water data report from LANL contains flow data. The data collection focused on the Laboratory's downstream boundary, close to State Road 4; the upstream boundary is approximated by State Road 501. Some of the gaging stations are within Laboratory boundaries and were originally installed to assist groups other than ESH-18 that also conduct site-specific earth science research.

Table 5-1. Radiochemical Analysis of Surface Water and Runoff Samples for 1998

Water Samples (pCi/L[a])

Station Name	Date	Code[b]	F/UF[b]	^{3}H	^{90}Sr	^{137}Cs	U (µg/L)	^{238}Pu	$^{239,240}Pu$	^{241}Am	Gross Alpha	Gross Beta	Gross Gamma
Regional Stations													
Rio Chama at Chamita	06/05	SW	UF	61 640	0.0 1.2	0.93 0.40	0.84 0.09	–0.011 0.002	–0.002 0.009	0.003 0.018	1.7 1.1	3.3 0.4	19 48
Rio Grande at Embudo	10/28	SW	UF	–179 650	0.1 0.6	1.18 3.25	2.51 0.26	–0.002 0.008	0.011 0.011	0.038 0.044	7.7 2.2	6.5 0.6	187 50
Rio Grande at Otowi Upper (bank)	08/05	SW	UF	–219 650	1.2 0.4	0.90 2.83	3.61 0.37	0.001 0.009	0.006 0.011	–0.025 0.015	15.5 8.5	29.9 2.6	–1 48
Rio Grande at Otowi (bank)	08/05	SW	UF	81 670	0.4 0.3	0.69 0.37	3.36 0.34	–0.011 0.006	0.007 0.013	0.074 0.035	12.3 4.7	21.0 2.0	30 48
Rio Grande at Frijoles (bank)	09/30	SW	UF	61 650	9.2 0.9	0.27 0.30	6.66 0.67	–0.021 0.008	0.150 0.032	0.030 0.023	27.6 8.7	21.2 15.6	–3 48
Rio Grande at Cochiti	11/11	SW	UF	–109 670	0.0 0.5	1.01 3.00	4.75 0.48	–0.016 0.007	–0.005 0.018	–0.009 0.025	5.5 1.8	4.8 0.8	364 51
Jemez River	07/20	SW	UF	–149 630	5.3 1.2	0.12 1.67	1.06 0.11	–0.006 0.009	–0.003 0.009	–0.010 0.011	8.3 5.6	58.4 4.2	46 49
Pajarito Plateau													
Guaje Canyon:													
Guaje Canyon	11/11	SW	UF	–289 650	0.2 0.3	–0.32 1.00	0.97 0.10	–0.008 0.013	0.011 0.014	–0.009 0.017	0.7 0.4	1.9 0.3	34 49
Acid/Pueblo Canyon:													
Acid Weir	11/07	SW	UF	–39 670	6.5 0.8	1.45 3.67	0.26 0.03	0.002 0.011	0.711 0.051	0.028 0.050	1.6 4.8	17.3 1.3	43 49
Pueblo 1	11/07	SW	UF	–79 670	–0.6 0.6	–1.43 0.80	0.19 0.03	0.003 0.013	0.032 0.015	–0.005 0.012	0.6 2.7	16.9 1.1	18 49
Pueblo 3	11/12	SW	UF	–19 670	0.1 1.2	0.23 1.83	0.34 0.04	–0.003 0.011	0.104 0.028	0.080 0.090	0.5 1.9	11.7 1.1	–29 48
Pueblo at SR-502	09/03	SW	UF	701 780	0.5 0.4	1.33 0.48	0.25 0.03	–0.006 0.010	0.153 0.025	0.093 0.025	–0.9 1.3	9.3 1.1	101 49
DP/Los Alamos Canyon:													
Los Alamos Canyon Reservoir	07/07	SW	UF	331 680	0.8 0.8	0.11 1.70	0.08 0.01	–0.009 0.005	–0.003 0.007	0.006 0.014	0.3 0.3	2.1 0.3	15 49
DPS-1	07/07	SW	UF	301 680	13.1 1.8	8.71 1.30	0.39 0.05	–0.008 0.006	0.204 0.025	0.288 0.037	2.7 7.1	41.7 2.8	–38 48
DPS-4	07/07	SW	UF	301 680	23.3 2.3	0.41 0.30	1.45 0.15	0.005 0.008	0.083 0.018	0.128 0.026	–0.1 14.2	58.5 3.9	72 49
Sandia Canyon:													
SCS-1	06/08	SW	UF	361 660	0.6 0.8	–0.10 1.33	0.33 0.04	0.003 0.009	0.004 0.012	–0.014 0.012	–1.2 1.0	2.0 1.5	1.2 47
SCS-2	06/08	SW	UF	–29 630	0.8 0.8	–0.29 1.06	0.41 0.05	0.001 0.011	–0.002 0.009	0.031 0.019	1.8 2.6	9.4 0.9	7.2 48
SCS-3	06/08	SW	UF	151 640	0.6 0.8	0.91 0.41	0.44 0.05	0.004 0.009	0.022 0.012	0.013 0.015	1.0 2.5	8.9 0.9	12 48
SCS-3	06/08	SW	UF	–19 630	0.1 1.0	1.22 0.45	0.33 0.04	–0.012 0.006	0.002 0.010	0.020 0.015	0.3 1.7	8.9 1.1	5.9 48
Mortandad Canyon:													
Mortandad at GS-1	08/28	SW	UF	3,501 930	11.0 1.0	47.31 5.40	1.85 0.19	52.020 1.431	16.910 0.509	24.901 0.641	200.4 47.3	294.3 17.1	378 51
Mortandad at Rio Grande (A-11)	09/28	SW	UF	61 650	0.1 0.4	–1.28 0.36	0.45 0.05	0.006 0.009	0.007 0.012	0.007 0.019	1.6 2.1	13.7 1.5	67 49
Cañada del Buey:													
Cañada del Buey	07/24	SW	UF	–239 630	1.1 0.9	0.41 0.32	0.72 0.08	0.034 0.021	0.037 0.021	0.004 0.016	3.7 1.2	4.9 0.4	10 50
Pajarito Canyon:													
Pajarito	04/08	SW	UF	231 670	0.6 0.9	–0.72 0.40	0.11 0.02	0.015 0.011	0.001 0.011	0.010 0.015	1.5 1.0	0.7 0.3	75 50
Pajarito at Rio Grande	09/28	SW	UF	111 650	0.4 0.3	–0.09 0.23	1.03 0.11	–0.008 0.009	0.003 0.011	0.003 0.014	0.7 0.6	2.9 0.3	49 49
Pajarito at Rio Grande	09/29	SW	UF	–69 640	0.1 0.3	–1.38 0.36	0.94 0.10	–0.021 0.006	–0.003 0.007	–0.009 0.015	0.2 0.6	2.7 0.3	38 49
Water Canyon:													
Water Canyon at Beta	11/13	SW	UF	151 680	–0.1 0.5	–0.88 0.17	0.20 0.03	–0.036 0.006	–0.002 0.015	0.150 0.090	1.2 0.9	5.2 0.4	–20 49
Ancho Canyon:													
Ancho at Rio Grande	09/29	SW	UF	91 650	0.1 0.4	0.79 2.67	0.13 0.02	–0.019 0.008	–0.003 0.010	0.002 0.018	–0.2 0.4	2.8 0.3	40 49

Table 5-1. Radiochemical Analysis of Surface Water and Runoff Samples for 1998 (Cont.)

Water Samples (pCi/L[a])

Station Name	Date	Code[b]	F/UF[b]	^{3}H	^{90}Sr	^{137}Cs	U (µg/L)	^{238}Pu	$^{239,240}Pu$	^{241}Am	Gross Alpha	Gross Beta	Gross Gamma
Pajarito Plateau (Cont.)													
Frijoles Canyon:													
Frijoles at Monument HQ	06/05	SW	UF	441 660	0.6 0.7	1.23 3.33	0.69 0.08	–0.014 0.010	–0.003 0.010	–0.019 0.010	0.5 0.3	1.7 0.3	69 48
Frijoles at Rio Grande	09/30	SW	UF	161 650	1.1 0.4	–0.86 0.20	0.47 0.05	0.004 0.010	0.000 0.015	0.030 0.022	14.1 3.6	14.2 1.4	–30 48
Frijoles at Rio Grande	09/30	SW	UF	51 650	0.8 0.3	–0.06 0.24	0.30 0.04	–0.026 0.022	–0.008 0.025	–0.025 0.009	5.5 1.6	7.2 0.9	–9 48
Runoff Stations													
LA Canyon near LA	07/28	RO/D	F		7.8 0.9	0.45 2.17	0.05 0.01	–0.007 0.004	0.026 0.013	0.140 0.060	0.1 0.1	0.1 0.2	–37 48
LA Canyon near LA	07/28	RO/D	UF	281 700									
LA Canyon near LA	10/31	RO/D	F		11.2 0.9	–1.07 0.36	2.82 0.29	0.028 0.015	0.126 0.025	3.509 0.133			112 50
LA Canyon near LA	10/31	RO/TOT	UF	91 660	13.1 2.5	3.69 0.78	3.91 0.40	0.045 0.029	0.498 0.064	1.940 0.095	21.3 10.0	75.1 4.7	119 50
Cañada del Buey at WR	07/23	RO/T	UF	261 650									
Cañada del Buey at WR	07/28	RO/D	F		0.8 0.4	0.11 0.30	0.52 0.06	–0.005 0.005	0.001 0.009	–0.001 0.016	0.4 1.0	4.9 0.4	–20 48
Cañada del Buey at WR	07/28	RO/T	UF		11.3 1.0	1.01 0.43	3.70 0.38	0.070 0.019	0.639 0.055	0.742 0.107	12.8 4.0	12.6 0.9	141 50
Cañada del Buey at WR	08/13	RO/D	F		0.6 0.4	0.43 0.32	0.20 0.03	–0.014 0.007	–0.007 0.010	0.014 0.023	0.1 0.6	3.5 0.4	66 49
Cañada del Buey at WR	08/13	RO/D	UF	91 690									
Cañada del Buey at WR	09/29	RO/D	F		5.3 0.6	2.45 5.17	5.68 0.57	0.063 0.023	0.424 0.051	0.194 0.047	200.0 47.5	354.3 25.0	160 50
Cañada del Buey at WR	09/29	RO/TOT	UF	–149 640	5.4 0.7	1.57 3.83	4.94 0.50	0.090 0.080	0.733 0.180	0.406 0.045	229.0 68.8	499.3 67.4	168 50
Cañada del Buey at WR	10/26	RO/D	F		15.9 1.3	2.01 4.50	3.01 0.31	–0.018 0.021	0.011 0.023	0.003 0.015			53 50
Cañada del Buey at WR	10/26	RO/D	UF	–169 650									
Area G:													
G-SWMS-1	10/31	RO/TOT	UF	51 660	0.7 0.6	–0.28 1.07	1.16 0.12	0.070 0.028	0.106 0.034	0.019 0.021	92.7 19.0	85.4 8.7	146 50
G-SWMS-2	07/27	RO/TOT	UF	61 670	2.5 0.5	0.63 0.39	1.48 0.15	0.053 0.017	0.189 0.029	0.186 0.039	0.0 0.0	0.3 0.0	62 49
G-SWMS-2	08/13	RO/TOT	UF	551 720	4.7 0.5	0.89 0.39	3.01 0.31	0.104 0.028	0.449 0.054	0.841 0.089	127.0 27.5	73.7 5.0	24 49
G-SWMS-3	07/28	RO/TOT	UF	61 670	8.4 0.7	0.40 0.31	3.05 0.31	0.076 0.018	4.357 0.146	1.072 0.100	0.1 0.0	0.4 0.0	111 49
G-SWMS-3	08/13	RO/TOT	UF	291 700	9.7 0.8	1.15 0.42	6.49 0.66	0.804 0.075	3.184 0.160	1.815 0.140	109.0 28.3	78.0 5.4	118 49
G-SWMS-4	06/11	RO/TOT	UF	141	1.5 0.9	0.03 1.53	1.37 0.14	0.095 0.026	2.313 0.118	0.592 0.054	16.1 4.2	22.3 1.6	47 49
G-SWMS-6	07/28	RO/TOT	UF	471 690	5.6 0.5	1.01 0.43	3.88 0.39	0.335 0.036	1.936 0.093	1.144 0.098	0.1 0.0	0.4 0.0	159 49
G-SWMS-6	08/13	RO/TOT	UF	861 740	6.6 0.6	0.72 0.37	4.33 0.44	0.314 0.041	2.537 0.126	1.374 0.140	110.0 34.7	61.2 4.4	107 49
G-SWMS-6	09/29	RO/TOT	UF	641 690	3.6 0.7	1.68 4.00	3.31 0.34	0.030 0.023	0.190 0.041	0.170 0.090	218.0 64.2	281.3 18.5	107 50
Detection Limits				700	3	4	0.1	0.04	0.04	0.04	3	3	120
Water Quality Standards[c]													
DOE DCG for Public Dose				2,000,000	1,000	3,000	800	40	30	30	30	1,000	
DOE Drinking Water System DCG				80,000	40	120	30	1.6	1.2	1.2	1.2	40	
EPA Primary Drinking Water Standard				20,000	8		20				15		
EPA Screening Level												50	
NMWQCC Groundwater Limit							5,000						

Table 5-1. Radiochemical Analysis of Surface Water and Runoff Samples for 1998 (Cont.)

Suspended Sediments in Runoff Samples (pCi/g[a])

Station Name	Date	Code[b]	^{3}H (pCi/L)	^{90}Sr	^{137}Cs	U (µg/g)	^{238}Pu	^{239,240}Pu	^{241}Am	Gross Alpha	Gross Beta	Gross Gamma
LA Canyon near LA	07/28	RO/SS		1.26 0.38	5.96 0.55	2.78 0.28	0.082 0.004	3.588 0.087	1.050 0.050	27.5 5.6	18.8 1.3	15.9 1.6
Cañada del Buey at WR	08/13	RO/SS		1.47 0.31	0.29 0.04	2.69 0.27	0.007 0.001	0.028 0.002	0.012 0.002	15.6 3.2	11.4 1.0	14.0 1.4
Cañada del Buey at WR	10/26	RO/SS		3.06 0.45	0.25 0.04	5.04 0.50	0.003 0.001	0.008 0.001	0.005 0.001	6.0 1.8	5.1 0.4	3.6 0.4
Cañada del Buey at WR	10/26	RO/SS	331 650									
Detection Limits			700	2.00	0.05	0.25	0.005	0.005	0.005	1.5	1.5	0.8
Sediment Comparisons[c]												
Background (x + 2s)[d]				0.9	0.44	4.40	0.006	0.023	0.090[e]	14.8[e]	12.0[e]	8.2[e]
SAL[f]				5.9	4.0	95	20	18	17			

[a]Except where noted. Two columns are listed: the first is the analytical result; the second is the radioactive counting uncertainty (1 std dev). Radioactivity counting uncertainties may be less than the analytical method uncertainties.
[b]Codes: SW-surface water; RO-runoff; D-dissolved (not for radiochemical analysis); TOT-total; SS-suspended sediments; UF-unfiltered; F-filtered.
[c]Standards given here for comparison only, see Appendix A.
[d]Purtymun, 1987a; upper limit for background.
[e]Preliminary background value for channel sediments from 1974–1996 (McLin in prep).
[f]Screening Action Level; Environmental Restoration, 1997; see text for details.

Table 5-2. Detections of Radionuclides[a] and Comparison to Derived Concentration Guides[b] in Surface Water and Runoff Samples for 1998

Station Name	Date	Code[c]	F/UF[c]	Analyte	Value	Uncertainty[d]	Units	Detection Limit	DOE DCG	Ratio of Value to DCG	Minimum Standard	Minimum Standard Type
Acid Weir	11/07	SW	UF	$^{239,240}Pu$	0.711	0.051	pCi/L	0.04				
Acid Weir	11/07	SW	UF	^{90}Sr	6.5	0.8	pCi/L	3				
DPS-1	07/07	SW	UF	^{241}Am	0.288	0.037	pCi/L	0.04				
DPS-1	07/07	SW	UF	Beta	41.7	2.8	pCi/L	3				
DPS-1	07/07	SW	UF	^{137}Cs	8.71	1.3	pCi/L	4				
DPS-1	07/07	SW	UF	$^{239,240}Pu$	0.204	0.025	pCi/L	0.04				
DPS-1	07/07	SW	UF	^{90}Sr	13.1	1.8	pCi/L	3				
DPS-4	07/07	SW	UF	^{241}Am	0.128	0.026	pCi/L	0.04				
DPS-4	07/07	SW	UF	Beta	58.5	3.9	pCi/L	3	1,000	0.06	50	EPA Screening Level
DPS-4	07/07	SW	UF	$^{239,240}Pu$	0.083	0.018	pCi/L	0.04				
DPS-4	07/07	SW	UF	^{90}Sr	23.3	2.3	pCi/L	3				
Frijoles at Rio Grande	09/30	SW	UF	Alpha	14.1	3.6	pCi/L	3				
Frijoles at Rio Grande	09/30	SW	UF	Alpha	5.5	1.6	pCi/L	3				
Jemez River	07/20	SW	UF	Beta	58.4	4.2	pCi/L	3	1,000	0.06	50	EPA Screening level
Jemez River	07/20	SW	UF	^{90}Sr	5.3	1.2	pCi/L	3				
Mortandad at GS-1	08/28	SW	UF	Alpha	200.4	47.3	pCi/L	3	30	6.68	15	EPA Primary Drinking Water Standard
Mortandad at GS-1	08/28	SW	UF	^{241}Am	24.901	0.641	pCi/L	0.04	30	0.83	1.2	DOE Drinking Water DCG
Mortandad at GS-1	08/28	SW	UF	Beta	294.3	17.1	pCi/L	3	1,000	0.29	50	EPA Screening Level
Mortandad at GS-1	08/28	SW	UF	^{137}Cs	47.31	5.4	pCi/L	4				
Mortandad at GS-1	08/28	SW	UF	Gamma	378	51	pCi/L	120				
Mortandad at GS-1	08/28	SW	UF	^{3}H	3,501	930	pCi/L	700				
Mortandad at GS-1	08/28	SW	UF	^{238}Pu	52.020	1.431	pCi/L	0.04	40	1.30	1.6	DOE Drinking Water DCG
Mortandad at GS-1	08/28	SW	UF	$^{239,240}Pu$	16.910	0.509	pCi/L	0.04	30	0.56	1.2	DOE Drinking Water DCG
Mortandad at GS-1	08/28	SW	UF	^{90}Sr	11.0	1.0	pCi/L	3				
Pueblo 3	11/12	SW	UF	$^{239,240}Pu$	0.104	0.028	pCi/L	0.04				
Pueblo at SR-502	09/03	SW	UF	^{241}Am	0.093	0.026	pCi/L	0.04				
Pueblo at SR-502	09/03	SW	UF	$^{239,240}Pu$	0.153	0.025	pCi/L	0.04				
Rio Grande at Cochiti	11/11	SW	UF	Alpha	5.5	1.8	pCi/L	3				
Rio Grande at Cochiti	11/11	SW	UF	Gamma	384	51	pCi/L	120				
Rio Grande at Embudo	10/28	SW	UF	Alpha	7.7	2.2	pCi/L	3				
Rio Grande at Embudo	10/28	SW	UF	Gamma	187	50	pCi/L	120				
Rio Grande at Frijoles (bank)	09/30	SW	UF	Alpha	27.6	8.7	pCi/L	3	30	0.92	15	EPA Primary Drinking Water Standard
Rio Grande at Frijoles (bank)	09/30	SW	UF	$^{239,240}Pu$	0.150	0.032	pCi/L	0.04				
Rio Grande at Frijoles (bank)	09/30	SW	UF	^{90}Sr	9.2	0.9	pCi/L	3				

Table 5-2. Detections of Radionuclides[a] and Comparison to Derived Concentration Guides[b] in Surface Water and Runoff Samples for 1998 (Cont.)

Station Name	Date	Code[c]	F/UF[c]	Analyte	Value	Uncertainty[d]	Units	Detection Limit	DOE DCG	Ratio of Value to DCG	Minimum Standard	Minimum Standard Type
Rio Grande at Frijoles (bank)	09/30	SW	UF	U	6.66	0.67	µg/L	0.1				
Rio Grande at Otowi (bank)	08/05	SW	UF	Beta	21.0	2.0	pCi/L	3				
Rio Grande at Otowi Upper (bank)	08/05	SW	UF	Beta	29.9	2.6	pCi/L	3				
Cañada del Buey at WR	07/28	RO/TOT	UF	Alpha	12.8	4.0	pCi/L	3				
Cañada del Buey at WR	07/28	RO/TOT	UF	^{241}Am	0.742	0.107	pCi/L	0.04				
Cañada del Buey at WR	07/28	RO/TOT	UF	^{238}Pu	0.070	0.019	pCi/L	0.04				
Cañada del Buey at WR	07/28	RO/TOT	UF	^{239,240}Pu	0.639	0.055	pCi/L	0.04				
Cañada del Buey at WR	07/28	RO/TOT	UF	^{90}Sr	11.3	1.0	pCi/L	3				
Cañada del Buey at WR	09/29	RO/TOT	UF	Alpha	229.0	68.8	pCi/L	3	30	7.63	15	EPA Primary Drinking Water Standard
Cañada del Buey at WR	09/29	RO/D	F	Alpha	200.0	47.5	pCi/L	3	30	6.67	15	EPA Primary Drinking Water Standard
Cañada del Buey at WR	09/29	RO/TOT	UF	^{241}Am	0.406	0.045	pCi/L	0.04				
Cañada del Buey at WR	09/29	RO/D	F	^{241}Am	0.194	0.047	pCi/L	0.04				
Cañada del Buey at WR	09/29	RO/TOT	UF	Beta	499.3	67.4	pCi/L	3	1,000	0.50	50	EPA Screening Level
Cañada del Buey at WR	09/29	RO/D	F	Beta	354.3	25.0	pCi/L	3	1,000	0.35	50	EPA Screening Level
Cañada del Buey at WR	09/29	RO/TOT	UF	Gamma	168	50	pCi/L	120				
Cañada del Buey at WR	09/29	RO/D	F	Gamma	160	50	pCi/L	120				
Cañada del Buey at WR	09/29	RO/TOT	UF	^{239,240}Pu	0.733	0.180	pCi/L	0.04				
Cañada del Buey at WR	09/29	RO/D	F	^{239,240}Pu	0.424	0.051	pCi/L	0.04				
Cañada del Buey at WR	09/29	RO/TOT	UF	^{90}Sr	5.4	0.7	pCi/L	3				
Cañada del Buey at WR	09/29	RO/D	F	^{90}Sr	5.3	0.6	pCi/L	3				
Cañada del Buey at WR	09/29	RO/D	F	U	5.68	0.57	µg/L	0.1				
Cañada del Buey at WR	10/26	RO/D	F	^{90}Sr	15.9	1.3	pCi/L	3				
G-SWMS-1	10/31	RO/TOT	UF	Alpha	92.7	19.0	pCi/L	3	30	3.09	15	EPA Primary Drinking Water Standard
G-SWMS-1	10/31	RO/TOT	UF	Beta	85.4	8.7	pCi/L	3	1,000	0.09	50	EPA Screening Level
G-SWMS-1	10/31	RO/TOT	UF	^{239,240}Pu	0.106	0.034	pCi/L	0.04				
G-SWMS-2	07/27	RO/TOT	UF	^{241}Am	0.186	0.039	pCi/L	0.04				
G-SWMS-2	07/27	RO/TOT	UF	^{238}Pu	0.053	0.017	pCi/L	0.04				
G-SWMS-2	07/27	RO/TOT	UF	^{239,240}Pu	0.189	0.029	pCi/L	0.04				
G-SWMS-2	08/13	RO/TOT	UF	Alpha	127.0	27.5	pCi/L	3	30	4.23	15	EPA Primary Drinking Water Standard
G-SWMS-2	08/13	RO/TOT	UF	^{241}Am	0.841	0.089	pCi/L	0.04				
G-SWMS-2	08/13	RO/TOT	UF	Beta	73.7	5.0	pCi/L	3	1,000	0.07	50	EPA Screening Level
G-SWMS-2	08/13	RO/TOT	UF	^{238}Pu	0.104	0.028	pCi/L	0.04				

Table 5-2. Detections of Radionuclides[a] and Comparison to Derived Concentration Guides[b] in Surface Water and Runoff Samples for 1998 (Cont.)

Station Name	Date	Code[c]	F/UF[c]	Analyte	Value	Uncertainty[d]	Units	Detection Limit	DOE DCG	Ratio of Value to DCG	Minimum Standard	Minimum Standard Type
G-SWMS-2	08/13	RO/TOT	UF	$^{239,240}Pu$	0.449	0.054	pCi/L	0.04				
G-SWMS-2	08/13	RO/TOT	UF	^{90}Sr	4.7	0.5	pCi/L	3				
G-SWMS-3	07/28	RO/TOT	UF	^{241}Am	1.072	0.100	pCi/L	0.04				
G-SWMS-3	07/28	RO/TOT	UF	^{238}Pu	0.076	0.018	pCi/L	0.04				
G-SWMS-3	07/28	RO/TOT	UF	$^{239,240}Pu$	4.357	0.146	pCi/L	0.04	30	0.15	1.2	DOE Drinking Water DCG
G-SWMS-3	07/28	RO/TOT	UF	^{90}Sr	8.4	0.7	pCi/L	3				
G-SWMS-3	08/13	RO/TOT	UF	Alpha	109.0	28.3	pCi/L	3	30	3.63	15	EPA Primary Drinking Water Standard
G-SWMS-3	08/13	RO/TOT	UF	^{241}Am	1.815	0.140	pCi/L	0.04	30	0.06	1.2	DOE Drinking Water DCG
G-SWMS-3	08/13	RO/TOT	UF	Beta	78.0	5.4	pCi/L	3	1,000	0.08	50	EPA Screening Level
G-SWMS-3	08/13	RO/TOT	UF	^{238}Pu	0.804	0.075	pCi/L	0.04				
G-SWMS-3	08/13	RO/TOT	UF	$^{239,240}Pu$	3.184	0.160	pCi/L	0.04	30	0.11	1.2	DOE Drinking Water DCG
G-SWMS-3	08/13	RO/TOT	UF	^{90}Sr	9.7	0.8	pCi/L	3				
G-SWMS-3	08/13	RO/TOT	UF	U	6.49	0.66	µg/L	0.1				
G-SWMS-4	06/11	RO/TOT	UF	Alpha	16.1	4.2	pCi/L	3	30	0.54	15	EPA Primary Drinking Water Standard
G-SWMS-4	06/11	RO/TOT	UF	^{241}Am	0.592	0.054	pCi/L	0.04				
G-SWMS-4	06/11	RO/TOT	UF	Beta	22.3	1.6	pCi/L	3				
G-SWMS-4	06/11	RO/TOT	UF	^{238}Pu	0.095	0.026	pCi/L	0.04				
G-SWMS-4	06/11	RO/TOT	UF	$^{239,240}Pu$	2.313	0.118	pCi/L	0.04	30	0.08	1.2	DOE Drinking Water DCG
G-SWMS-6	07/28	RO/TOT	UF	^{241}Am	1.144	0.098	pCi/L	0.04				
G-SWMS-6	07/28	RO/TOT	UF	Gamma	159	49	pCi/L	120				
G-SWMS-6	07/28	RO/TOT	UF	^{238}Pu	0.335	0.037	pCi/L	0.04				
G-SWMS-6	07/28	RO/TOT	UF	$^{239,240}Pu$	1.936	0.093	pCi/L	0.04	30	0.06	1.2	DOE Drinking Water DCG
G-SWMS-6	07/28	RO/TOT	UF	^{90}Sr	5.6	0.5	pCi/L	3				
G-SWMS-6	08/13	RO/TOT	UF	^{241}Am	1.374	0.140	pCi/L	0.04	30	0.05	1.2	DOE Drinking Water DCG
G-SWMS-6	08/13	RO/TOT	UF	Beta	61.2	4.4	pCi/L	3	1,000	0.06	50	EPA Screening Level
G-SWMS-6	08/13	RO/TOT	UF	^{238}Pu	0.314	0.041	pCi/L	0.04				
G-SWMS-6	08/13	RO/TOT	UF	$^{239,240}Pu$	2.537	0.126	pCi/L	0.04	30	0.08	1.2	DOE Drinking Water DCG
G-SWMS-6	08/13	RO/TOT	UF	^{90}Sr	6.6	0.6	pCi/L	3				
G-SWMS-6	09/29	RO/TOT	UF	Alpha	218.0	64.2	pCi/L	3	30	7.27	15	EPA Primary Drinking Water Standard
G-SWMS-6	09/29	RO/TOT	UF	Beta	281.3	18.5	pCi/L	3	1,000	0.28	50	EPA Screening Level
G-SWMS-6	09/29	RO/TOT	UF	$^{239,240}Pu$	0.190	0.041	pCi/L	0.04				
G-SWMS-6	09/29	RO/TOT	UF	^{90}Sr	3.6	0.7	pCi/L	3				

Table 5-2. Detections of Radionuclides[a] and Comparison to Derived Concentration Guides[b] in Surface Water and Runoff Samples for 1998 (Cont.)

Station Name	Date	Code[c]	F/UF[c]	Analyte	Value	Uncertainty[d]	Units	Detection Limit	DOE DCG	Ratio of Value to DCG	Minimum Standard	Minimum Standard Type
LA Canyon near LA	07/28	RO/D	F	^{90}Sr	7.8	0.9	pCi/L	3				
LA Canyon near LA	10/31	RO/TOT	UF	^{241}Am	1.940	0.095	pCi/L	0.04	30	0.06	1.2	DOE Drinking Water DCG
LA Canyon near LA	10/31	RO/D	F	^{241}Am	3.509	0.134	pCi/L	0.04	30	0.12	1.2	DOE Drinking Water DCG
LA Canyon near LA	10/31	RO/TOT	UF	Beta	75.1	4.7	pCi/L	3	1,000	0.08	50	EPA Screening Level
LA Canyon near LA	10/31	RO/TOT	UF	$^{239,240}Pu$	0.498	0.064	pCi/L	0.04				
LA Canyon near LA	10/31	RO/D	F	$^{239,240}Pu$	0.126	0.025	pCi/L	0.04				
LA Canyon near LA	10/31	RO/TOT	UF	^{90}Sr	13.1	2.5	pCi/L	3				
LA Canyon near LA	10/31	RO/D	F	^{90}Sr	11.2	0.9	pCi/L	3				

[a]Detection defined as value ≥ 3× uncertainty and ≥ detection limit, except values shown for uranium ≥ 5 µg/L, for gross alpha ≥ 5 pCi/L, and for gross beta ≥ 20 pCi/L.
[b]Values indicated by entries in right-hand columns are greater than 1/25 of the DOE public dose DCG and greater than the minimum standard shown. The minimum standard is either a DOE DCG for DOE-administered drinking water systems or an EPA drinking water standard.
[c]Codes: SW–surface water; RO–runoff; D–dissolved; TOT–total; UF-unfiltered; F–filtered.
[d]One standard deviation radioactivity counting uncertainty.

Table 5-3. Detections of Above-Background Radionuclides in Suspended Sediments from Runoff Samples for 1998[a]

Station Name	Date	Analyte	Value	Uncertainty	Units	Detection Limit	Background[b]	Ratio of Value to Background
Pajarito Plateau Stations								
Cañada del Buey at WR	08/13	Alpha	15.6	3.2	pCi/g	1.5	14.8	1.05
Cañada del Buey at WR	08/13	Gamma	14	1.4	pCi/g	0.8	8.2	1.71
Cañada del Buey at WR	08/13	^{238}Pu	0.0066	0.0011	pCi/g	0.005	0.006	1.10
Cañada del Buey at WR	08/13	^{239,240}Pu	0.0278	0.0023	pCi/g	0.005	0.023	1.21
Cañada del Buey at WR	10/26	^{90}Sr	3.06	0.45	pCi/g	2	.87	3.52
Cañada del Buey at WR	10/26	U	5.04	0.5	mg/kg	0.25	4.4	1.15
LA Canyon near LA	07/28	Alpha	27.5	5.6	pCi/g	1.5	14.8	1.86
LA Canyon near LA	07/28	^{241}Am	1.05	0.05	pCi/g	0.005	0.09	11.67
LA Canyon near LA	07/28	Beta	18.8	1.3	pCi/g	1.5	12	1.57
LA Canyon near LA	07/28	^{137}Cs	5.96	0.55	pCi/g	0.05	0.44	13.55
LA Canyon near LA	07/28	Gamma	15.9	1.6	pCi/g	0.8	8.2	1.94
LA Canyon near LA	07/28	^{238}Pu	0.0816	0.0038	pCi/g	0.005	0.006	13.60
LA Canyon near LA	07/28	^{239,240}Pu	3.5876	0.0869	pCi/g	0.005	0.023	155.98

[a] Detection defined as value ≥ 3× uncertainty and ≥ detection limit and ≥ background.
[b] See sediment for discussion of background values.

Table 5-4. Summary of TA-50 Radionuclide and Nitrate Discharges[a]

	1963–1977	1996			1997			1998		
Radionuclide	Total Activity Released (mCi)[b]	Total Annual Activity (mCi)	Mean Activity (pCi/L)	Ratio of Activity to DCG[c]	Total Annual Activity (mCi)	Mean Activity (pCi/L)	Ratio of Activity to DCG[c]	Total Annual Activity (mCi)	Mean Activity (pCi/L)	Ratio of Activity to DCG[c]
^{3}H	25,150	1,020	61,700	0.03	1,330	76,300	0.04	1,228	52,840	0.03
^{241}Am	7	1.99	120	4.00	2.56	147	4.90	2	99.1	3.30
^{137}Cs	848	2.20	133	0.04	2.48	142	0.05	1	43.4	0.01
^{238}Pu	51	2.25	136	3.40	1.34	76.7	1.92	2	97.9	2.45
$^{239,240}Pu$	39	0.39	23.8	0.79	0.80	45.9	1.53	0.91	39	1.30
^{89}Sr	<1	0.66	40.2	0.002	0.83	47.7	0.002	2	86.8	0.004
^{90}Sr	295	0.60	36.1	0.04	0.50	28.5	0.03	0.82	35.3	0.04
^{234}U	NA	0.19	11.7	0.02	0.08	4.88	0.01	0.12	5.1	0.01
^{235}U	2	0.003	0.18	0.0003	0.007	0.44	0.0007	0.053	2.3	0.004
Constituent		**Total Annual Mass (kg)**	**Mean Concentration (mg/L)**	**Ratio of Concentration to MCL**	**Total Annual Mass (kg)**	**Mean Concentration (mg/L)**	**Ratio of Concentration to MCL**	**Total Annual Mass (kg)**	**Mean Concentration (mg/L)**	**Ratio of Concentration to MCL**
NO_3-N		1,260	76.4	7.6	1,220	69.6	7.0	1,420	61.1	6.1
Total effluent volume ($\times 10^7$ liters)		1.65			1.75			2.32		

[a]Compiled from Radioactive Liquid Waste Group (EM-RLW) Annual Reports. Data for 1998 are preliminary.
[b]DOE 1979; decay corrected through 12/77.
[c]Public dose limit.

Table 5-5. Chemical Quality of Surface Waters and Runoff Samples for 1998 (mg/L[a])

Station Name	Date	Code[b]	F/UF[b]	SiO_2	Ca	Mg	K	Na	Cl	SO_4	CO_3 Alkalinity	Total Alkalinity	F	PO_4-P	NO_3-N	CN	TDS[c]	TSS[d]	Hardness as $CaCO_3$	pH[e]	Conductance (µS/cm)
Regional Stations																					
Rio Chama at Chamita	06/05	SW	F	17	30.4	5.9	<1.8	10.7	3.0	51	<5	82	0.13	0.32	0.08		168		100	8.0	270
Rio Chama at Chamita	06/05	SW	UF													<0.01		25			
Rio Grande at Embudo	10/28	SW	F	23	35.5	7.0	3.1	19.4	7.5	37	<5	123	0.44	0.02	0.30		216		118	8.2	322
Rio Grande at Embudo	10/28	SW	UF													<0.01		107			
Rio Grande at Otowi Upper (bank)	08/05	SW	F	19	31.4	4.9	<3.7	15.6	6.3	38	<5	105	0.29	0.02	0.11		197		99	8.1	290
Rio Grande at Otowi Upper (bank)	08/05	SW	UF													<0.01		613			
Rio Grande at Otowi (bank)	08/05	SW	F	19	35.2	5.5	1.5	17.9	6.2	38	<5	104	0.35	0.02	0.25		205		111	8.1	296
Rio Grande at Otowi (bank)	08/05	SW	UF													<0.01		655			
Rio Grande at Frijoles (bank)	09/30	SW	UF	21	205.4	45.4	17.5	26.8	10.0	40	<5	126	0.28	3.92	0.34		13,600		700	7.8	321
Rio Grande at Frijoles (bank)	09/30	SW	UF													<0.01		9,312			
Rio Grande at Cochiti	11/11	SW	F	21	47.7	9.4	2.7	31.6	15.8	73	<5	155	0.28	0.02	0.86		214		158	7.9	464
Rio Grande at Cochiti	11/11	SW	UF													<0.01		56			
Cochiti Upper	09/24	SW	F	16	36.1	6.3	2.4	14.6	4.9	48	<5	95	0.22	<0.02	0.07		184		116	7.9	297
Cochiti Upper	09/24	SW	UF													<0.01		15			
Cochiti Middle	09/24	SW	F	16	36.2	6.3	2.2	14.7	4.8	49	<5	91	0.21	<0.02	0.08		190		116	8.1	295
Cochiti Middle	09/24	SW	UF													<0.01		13			
Cochiti Lower	09/24	SW	F	17	35.4	6.1	2.5	14.4	4.8	48	<5	92	0.22	<0.02	0.14		200		114	8.0	294
Cochiti Lower	09/24	SW	UF													<0.01		6			
Jemez River	07/20	SW	F	44	41.0	4.5	11.0	65.0	83.0	11	21	156	0.97	0.03	0.07		370		121	8.6	585
Jemez River	07/20	SW	UF													<0.01		26			
Pajarito Plateau																					
Guaje Canyon:																					
Guaje Canyon	11/11	SW	F	63	16.0	3.6	2.0	10.5	4.8	5	<5	75	0.25	<0.02	0.70		180		55	8.1	171
Guaje Canyon	11/11	SW	UF													<0.01		<1			
Acid/Pueblo Canyon:																					
Acid Weir	11/07	SW	F	22	13.6	1.4	3.1	34.9	42.9	6	<5	59	0.22	0.29	0.89		180		40	7.0	270
Acid Weir	11/07	SW	UF													<0.01		7			
Pueblo 1	11/07	SW	F		11.4	2.2	3.0	27.5											37		
Pueblo 1	11/07	SW	UF															3			
Pueblo 3	11/12	SW	F	81	17.2	4.1	12.2	58.0	41.0	23	<5	178	0.38	5.25	1.11		384		60	7.2	553
Pueblo 3	11/12	SW	UF													<0.01		3,144			
Pueblo at SR-502	09/03	SW	F	79	18.0	4.8	12.9	68.0	41.0	20	<5	141	0.58	4.87	1.11		352		65	7.1	453
Pueblo at SR-502	09/03	SW	UF													<0.01		<1			
DP/Los Alamos Canyon:																					
Los Alamos Canyon Reservoir	07/07	SW	F	33	6.8	2.4	1.1	6.6	6.0	4	<5	31	0.08	<0.02	0.10		69		27	5.1	88
Los Alamos Canyon Reservoir	07/07	SW	UF													<0.01		1			
DPS-1	07/07	SW	F		24.3	1.6	4.0	42.7											67		
DPS-1	07/07	SW	UF															8			
DPS-4	07/07	SW	F		1.1	3.9	1.0	13.1											44		
DPS-4	07/07	SW	UF															31			

Table 5-5. Chemical Quality of Surface Waters and Runoff Samples for 1998 (mg/L[a]) (Cont.)

Station Name	Date	Code[b]	F/UF[b]	SiO_2	Ca	Mg	K	Na	Cl	SO_4	CO_3 Alkalinity	Total Alkalinity	F	PO_4-P	NO_3-N	CN	TDS[c]	TSS[d]	Hardness as $CaCO_3$	pH[e]	Conductance (µS/cm)
Pajarito Plateau (Cont.)																					
Sandia Canyon:																					
SCS-1	06/08	SW	F	101	17.5	5.1	12.6	79.4	62.0	18	<5	128	0.53	3.33	2.43		410		65	8.3	546
SCS-1	06/08	SW	UF													<0.01		6			
SCS-2	06/08	SW	F	89	18.0	4.5	12.7	97.9	68.0	45	<5	147	0.68	3.31	1.68		464		64	8.7	632
SCS-2	06/08	SW	UF													<0.01		17			
SCS-3	06/08	SW	F	90	17.2	4.2	11.9	95.6	65.0	47	15	147	0.71	3.48	1.57		486		60	8.9	636
SCS-3	06/08	SW	F	89	16.3	4.0	11.3	90.0	66.0	47	15	145	0.71	3.46	1.54		468		57	8.9	634
SCS-3	06/08	SW	UF													<0.01		18			
SCS-3	06/08	SW	UF													<0.01		22			
Mortandad Canyon:																					
Mortandad at GS-1	08/28	SW	F		58.2	1.5	4.4	56.6											152		
Mortandad at GS-1	08/28	SW	UF															37			
Mortandad at Rio Grande (A-11)	09/28	SW	F	92	24.2	7.2	15.8	74.5	56.0	33	<5	130	0.79	4.92	6.06		434		90	8.4	584
Mortandad at Rio Grande (A-11)	09/28	SW	UF													<0.01		2			
Cañada del Buey:																					
Cañada del Buey	07/24	SW	F	34	9.6	2.1	2.5	12.0	7.3	2	<5	47	0.33	0.03	0.16		130		33	5.7	122
Cañada del Buey	07/24	SW	UF													<0.01		8			
Pajarito Canyon:																					
Pajarito	04/08	SW	F	28	16.3	4.7	1.6	19.8	35.0	9	<5	50	0.09	<0.02	0.11		132		60	7.4	241
Pajarito	04/08	SW	UF													<0.01		28			
Pajarito at Rio Grande	09/28	SW	F	70	19.9	4.3	2.5	13.4	6.0	6	<5	84	0.37	<0.02	0.71		174		67	8.1	196
Pajarito at Rio Grande	09/28	SW	UF													<0.01		24			
Pajarito at Rio Grande	09/29	SW	F	71	19.5	4.2	2.4	12.9	5.9	6	<5	81	0.37	<0.02	0.70		176		66	8.1	195
Water Canyon:																					
Water Canyon at Beta	11/13	SW	F	38	9.6	3.5	4.1	13.3	10.9	6	<5	58	0.14	0.10	<0.02		312		38	7.4	146
Water Canyon at Beta	11/13	SW	UF													<0.01		<1			
Ancho Canyon:																					
Ancho at Rio Grande	09/29	SW	F	72	12.5	3.1	3.1	10.5	5.4	4	<5	63	0.32	<0.02	0.02		144		44	8.8	142
Ancho at Rio Grande	09/29	SW	UF													<0.01		<1			
Frijoles Canyon:																					
Frijoles at Monument HQ	06/05	SW	F	63	8.7	2.8	2.7	11.3	5.0	3	<5	50	0.14	0.04	0.06		90		33	7.6	114
Frijoles at Monument HQ	06/05	SW	UF													<0.01		13			
Frijoles at Rio Grande	09/30	SW	F	63	8.6	2.5	1.7	9.8	4.3	3	<5	48	0.16	0.04	<0.02		122		32	8.1	114
Frijoles at Rio Grande	09/30	SW	F	63	8.9	2.6	1.8	10.1	4.4	3	<5	53	0.16	0.05	0.03		128		33	8.2	112
Frijoles at Rio Grande	09/30	SW	UF													<0.01		515			
Frijoles at Rio Grande	09/30	SW	UF													<0.01		227			

Table 5-5. Chemical Quality of Surface Waters and Runoff Samples for 1998 (mg/L[a]) (Cont.)

Station Name	Date	Code[b]	F/UF[b]	SiO_2	Ca	Mg	K	Na	Cl	SO_4	CO_3 Alkalinity	Total Alkalinity	F	PO_4-P	NO_3-N	CN	TDS[c]	TSS[d]	Hardness as $CaCO_3$	pH[e]	Conductance (µS/cm)
Runoff Stations																					
LA Canyon near LA	07/28	RO/D	F		15.8	5.8	8.6	7.2													
LA Canyon near LA	07/28	RO/D	UF															5,217			
LA Canyon near LA	10/31	RO/D	F		21.2	2.8	3.6	7.7													
LA Canyon near LA	10/31	RO/TOT	UF		22.2	3.0	4.3	7.7										3,016			
Cañada del Buey at WR	07/28	RO/D	F		24.0	4.2	4.9	1.8											24		
Cañada del Buey at WR	07/28	RO/T	UF		140.5	16.5	13.3	2.2										18,464	419		
Cañada del Buey at WR	08/13	RO/D	F		29.0	2.6	3.8	2.2											83		
Cañada del Buey at WR	08/13	RO/D	UF															14,760			
Cañada del Buey at WR	09/29	RO/TOT	UF															13,732			
Cañada del Buey at WR	10/26	RO/D	F		127.8	13.4	10.2	1.2													
Cañada del Buey at WR	10/26	RO/D	UF															12,276			
Area G:																					
G-SWMS-1	10/31	RO/TOT	UF															1,256			
G-SWMS-2	07/27	RO/TOT	UF															1,403			
G-SWMS-2	08/13	RO/TOT	UF															4,753			
G-SWMS-3	07/28	RO/TOT	UF															7,120			
G-SWMS-3	08/13	RO/TOT	UF															5,433			
G-SWMS-4	06/11	RO/TOT	UF		32.1	4.9	5.9	8.8										490	100		
G-SWMS-6	07/28	RO/TOT	UF															7,720			
G-SWMS-6	08/13	RO/TOT	UF															6,313			
G-SWMS-6	09/29	RO/TOT	UF															2,424			
Water Quality Standards[g]																					
EPA Primary Drinking Water Standard										500			4		10	0.2					
EPA Secondary Drinking Water Standard									250	250							500			6.8–8.5	
EPA Health Advisory								20													
NMWQCC Groundwater Limit									250	600			1.6		10	0.2	1,000			6.9	

Suspended Sediments in Runoff Samples (mg/kg)

Station Name	Date	Code[b]	Ca	Mg	K	Na
LA Canyon near LA	07/28	RO/SS	1,069.3	783.0	815.2	159.6
Cañada del Buey at WR	08/13	RO/SS	3,800.0	2,500.0	2,900.0	290.0
Cañada del Buey at WR	10/16	RO/SS	277.6	847.5	851.6	127.2

[a] Except where noted.
[b] Codes: SW–surface water; RO–runoff; D–dissolved; TOT–total; SS–suspended sediments; UF–unfiltered; F–filtered.
[c] Total dissolved solids.
[d] Total suspended solids.
[e] Standard units.
[f] Less than symbol (<) means measurement was below the specified limit of detection of the analytical method.
[g] Standards given here for comparison only, see Appendix A.

Table 5-6. Trace Metals in Surface Waters and Runoff Samples for 1998 (µg/L)

Station Name	Date	Code[a]	F/UF[a]	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg
Regional Stations															
Rio Chama at Chamita	06/05	SW	F	14	<50[b]	<2	21	45	<3	<7	<8	<7	<10	<40	
Rio Chama at Chamita	06/05	SW	UF												<0.2
Rio Grande at Embudo	10/28	SW	F	<10	<89	<2	54	74	<3	<7	<8	<7	<10	<40	
Rio Grande at Embudo	10/28	SW	UF												<0.2
Rio Grande at Otowi Upper (bank)	08/05	SW	F	<10	<50	2	36	68	<3	<7	<8	<7	<10	<40	
Rio Grande at Otowi Upper (bank)	08/05	SW	UF												<0.2
Rio Grande at Otowi (bank)	08/05	SW	F	<10	<50	3	45	90	<3	<7	<8	<7	<10	87	
Rio Grande at Otowi (bank)	08/05	SW	UF												<0.2
Rio Grande at Frijoles (bank)	09/30	SW	UF	<10	76,231	26	66	1,774	10	<7	42	32	39	40,411	
Rio Grande at Frijoles (bank)	09/30	SW	UF												<0.2
Rio Grande at Cochiti	11/11	SW	F	<10	79	5	38	102	<3	<7	<8	<7	<10	<40	
Rio Grande at Cochiti	11/11	SW	UF												<0.2
Cochiti Upper	09/24	SW	F	<10	50	3	22	75	<3	<7	<8	<7	<10	<40	
Cochiti Upper	09/24	SW	UF												<0.2
Cochiti Middle	09/24	SW	F	<10	<50	3	25	76	<3	<7	<8	<7	<10	<40	
Cochiti Middle	09/24	SW	UF												<0.2
Cochiti Lower	09/24	SW	F	<10	<50	2	25	74	<3	<7	<8	<7	<10	<40	
Cochiti Lower	09/24	SW	UF												<0.2
Jemez River	07/20	SW	F	<10	77	69	690	72	<3	<7	<8	<7	<10	<40	
Jemez River	07/20	SW	UF												<0.2
Pajarito Plateau															
Guaje Canyon:															
Guaje Canyon	11/11	SW	F	<10	<50	2	<20	14	<3	<7	<8	<7	13	<40	
Guaje Canyon	11/11	SW	UF												<0.2
Acid/Pueblo Canyon:															
Acid Weir	11/07	SW	F	<10	283	2	45	31	<3	<7	<8	<7	<10	172	
Acid Weir	11/07	SW	UF												<0.2
Pueblo 1	11/07	SW	F	37	3,550	2	47	34	<3	<7	<8	<7	<10	1,925	
Pueblo 1	11/07	SW	UF												<0.2
Pueblo 3	11/12	SW	F	<10	128	7	249	10	<3	<7	<8	<7	13	<40	
Pueblo 3	11/12	SW	UF												<0.2
Pueblo at SR-502	09/03	SW	F	<10	<50	8	303	20	<3	<7	<8	<7	<10	593	
Pueblo at SR-502	09/03	SW	UF												<0.2
DP/Los Alamos Canyon:															
Los Alamos Canyon Reservoir	07/07	SW	F	<10	<50	<2	22	18	<3	<7	<8	<7	<10	51	
Los Alamos Canyon Reservoir	07/07	SW	UF												<0.2

Table 5-6. Trace Metals in Surface Waters and Runoff Samples for 1998 (µg/L) (Cont.)

Station Name	Date	Code[a]	F/UF[a]	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg
Pajarito Plateau (Cont.)															
DPS-1	07/07	SW	F	<10	<50	<2	36	66	<3	<7	<8	<7	<10	<40	
DPS-1	07/07	SW	UF												<0.2
DPS-4	07/07	SW	F	<10	<50	<2	21	29	<3	<7	<8	<7	<10	43	
DPS-4	07/07	SW	UF												<0.2
Sandia Canyon:															
SCS-1	06/08	SW	F	<10	99	2	81	20	<3	<7	<8	<7	<10	151	
SCS-1	06/08	SW	UF												<0.2
SCS-2	06/08	SW	F	<10	<50	3	75	21	<3	<7	<8	<7	<10	111	
SCS-2	06/08	SW	UF												<0.2
SCS-3	06/08	SW	F	<10	<50	3	77	20	<3	<7	<8	<7	<10	123	
SCS-3	06/08	SW	F	<10	<50	3	81	19	<3	<7	<8	<7	<10	106	
SCS-3	06/08	SW	UF												<0.2
SCS-3	06/08	SW	UF												<0.2
Mortandad Canyon:															
Mortandad at GS-1	08/28	SW	F	<10	194	<2	66	30	<3	<7	<8	<7	101	<40	
Mortandad at GS-1	08/28	SW	UF												<0.2
Mortandad at Rio Grande (A-11)	09/28	SW	F	<10	<50	<2	424	38	<3	<7	<8	<7	27	47	
Mortandad at Rio Grande (A-11)	09/28	SW	UF												<0.2
Cañada del Buey:															
Cañada del Buey	07/24	SW	F	<10	130	<2	45	56	<6	<7	<8	<7	11	180	
Cañada del Buey	07/24	SW	UF												<0.2
Pajarito Canyon:															
Pajarito at Rio Grande	09/28	SW	F	<10	<50	<2	29	40	<3	<7	<8	<7	<10	<40	
Pajarito at Rio Grande	09/28	SW	UF												<0.2
Pajarito at Rio Grande	09/29	SW	F	<10	<50	<2	28	39	<3	<7	<8	<7	<10	<40	
Pajarito at Rio Grande	09/29	SW	UF												<0.2
Water Canyon:															
Water Canyon at Beta	11/13	SW	F	<10	6,079	2	<20	226	<3	<7	<8	<7	<10	3,203	
Water Canyon at Beta	11/13	SW	UF												<0.2
Ancho Canyon:															
Ancho at Rio Grande	09/29	SW	F	<10	<50	<2	<20	30	<3	<7	<8	<7	<10	92	
Ancho at Rio Grande	09/29	SW	UF												<0.2
Frijoles Canyon:															
Frijoles at Monument HQ	06/05	SW	F	14	214	<2	<20	17	<3	<7	<8	<7	<10	148	
Frijoles at Monument HQ	06/05	SW	UF												<0.2
Frijoles at Rio Grande	09/30	SW	F	<10	<50	<2	33	22	<3	<7	<8	<7	<10	<40	
Frijoles at Rio Grande	09/30	SW	F	<10	<50	<2	34	21	<3	<7	<8	<7	<10	82	
Frijoles at Rio Grande	09/30	SW	UF												<0.2
Frijoles at Rio Grande	09/30	SW	UF												<0.2

Table 5-6. Trace Metals in Surface Waters and Runoff Samples for 1998 (µg/L) (Cont.)

Station Name	Date	Code[a]	F/UF[a]	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg
Runoff Stations															
LA Canyon near LA	07/28	RO/D	F	<10	37,529	7	50	226	<3	<7	<8	25	<10	19,329	
LA Canyon near LA	07/28	RO/D	UF												<0.2
LA Canyon near LA	10/31	RO/D	F	<10	3,344	2	37	355	3	<7	8	<7	28	1,998	
LA Canyon near LA	10/31	RO/TOT	UF	<10	3,554	<2	45	386	3	<7	11	<7	29	2,075	<0.2
Cañada del Buey at WR	07/28	RO/D	F	<10	14,972	4	22	192	<3	<7	<8	9	<10	7,830	
Cañada del Buey at WR	07/28	RO/T	UF	<10	26,286	<2	21	3,486	18	<7	74	<7	32	1,506	0.2
Cañada del Buey at WR	08/13	RO/D	F	<10	510	5	<20	120	<3	<7	<14	<7	<10	44	
Cañada del Buey at WR	08/13	RO/D	UF												<0.2
Cañada del Buey at WR	09/29	RO/TOT	UF	<10	85,965	11	35	3,487	22	<7	89	35	59	47,646	<0.2
Cañada del Buey at WR	10/26	RO/D	F	<10	19,931	<2	41	3,172	16	<7	71	<7	14	912	
Cañada del Buey at WR	10/26	RO/D	UF												<0.2
Area G:															
G-SWMS-4	06/11	RO/TOT	UF	<10	12,000	7	41	201	<3	<7	<8	10	18	6,970	<0.2
Water Quality Standards[c]															
EPA Primary Drinking Water Standard						50		2,000	4	5		100			2
EPA Secondary Drinking Water Standard					50-200									300	
EPA Action Level													1,300		
EPA Health Advisory															
NMWQCC Livestock Watering Standard					5,000	200	5,000			50	1,000	1,000	500		10
NMWQCC Groundwater Limit				50	5,000	100	750	1,000		10	50	50	1,000	1,000	2
NMWQCC Wildlife Habitat Standard															0.012

Suspended Sediments in Runoff Samples (mg/kg)

Station Name	Date	Code[a]	F/UF[a]	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg
LA Canyon near LA	07/28	RO/SS		<2	4,986	0.8	<3	49	0.5	<0.9	1.4	4.0	6.4	5,133	
Cañada del Buey at WR	08/13	RO/SS		<2	17,000	2.9	5	160	1.1	<0.9	4.7	13.0	7.9	12,000	
Cañada del Buey at WR	10/26	RO/SS		<2	6,216	0.7	<3	26	0.3	<0.9	<1.0	3.6	1.2	4,200	
Sediment Comparisons[c]															
SAL[d]				380	78,000		5,900	5,300		38	4,600	30[e]	2,800		23

Table 5-6. Trace Metals in Surface Waters and Runoff Samples for 1998 (µg/L) (Cont.)

Station Name	Date	Code[a]	F/UF[a]	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Ti	V	Zn
Regional Stations														
Rio Chama at Chamita	06/05	SW	F	4	<30	<20	<3	<3		<30	214	<3	<8	<50
Rio Chama at Chamita	06/05	SW	UF						<2					
Rio Grande at Embudo	10/28	SW	F	19	<30	<20	<3	<3		<30	267	<3	<8	<50
Rio Grande at Embudo	10/28	SW	UF						3					
Rio Grande at Otowi Upper (bank)	08/05	SW	F	<3	<30	<20	<3	<3		<30	274	<3	<13	<50
Rio Grande at Otowi Upper (bank)	08/05	SW	UF						<4					
Rio Grande at Otowi (bank)	08/05	SW	F	<3	<30	<20	<3	<3		<30	318	<3	<8	<50
Rio Grande at Otowi (bank)	08/05	SW	UF						<4					
Rio Grande at Frijoles (bank)	09/30	SW	UF	3,255	<30	73	60	<3		<30	1,455	<3	94	159
Rio Grande at Frijoles (bank)	09/30	SW	UF						7					
Rio Grande at Cochiti	11/11	SW	F	9	<30	<20	<3	<3		<30	424	<3	<8	<50
Rio Grande at Cochiti	11/11	SW	UF						3					
Cochiti Upper	09/24	SW	F	5	<30	<20	<3	<3		<30	293	<3	<8	<50
Cochiti Upper	09/24	SW	UF						2					
Cochiti Middle	09/24	SW	F	<2	<30	<20	<3	<3		<30	298	<3	<8	<50
Cochiti Middle	09/24	SW	UF						<2					
Cochiti Lower	09/24	SW	F	<2	<30	<20	<3	<3		<30	291	<3	<8	<50
Cochiti Lower	09/24	SW	UF						2					
Jemez River	07/20	SW	F	14	<30	<20	<3	<3		<30	17	<3	<8	<50
Jemez River	07/20	SW	UF						<2					
Pajarito Plateau														
Guaje Canyon:														
Guaje Canyon	11/11	SW	F	<2	<30	<20	<3	<3		<30	79	<3	14	<50
Guaje Canyon	11/11	SW	UF						3					
Acid/Pueblo Canyon:														
Acid Weir	11/07	SW	F	4	<30	<20	<3	<4		<30	73	<3	<8	<50
Acid Weir	11/07	SW	UF						2					
Pueblo 1	11/07	SW	F	32	<30	<20	3	9		<30	65	<3	<8	<50
Pueblo 1	11/07	SW	UF						3					
Pueblo 3	11/12	SW	F	143	<30	<20	<3	<3		<30	69	<3	11	<50
Pueblo 3	11/12	SW	UF						<3					
Pueblo at SR-502	09/03	SW	F	299	<30		20	3	<3	<163	87	<3	<8	<50
Pueblo at SR-502	09/03	SW	UF						<2					
DP/Los Alamos Canyon:														
Los Alamos Canyon Reservoir	07/07	SW	F	6	<30	<20	<3	<3		<30	52	<3	<8	<50
Los Alamos Canyon Reservoir	07/07	SW	UF						<2					

Table 5-6. Trace Metals in Surface Waters and Runoff Samples for 1998 (µg/L) (Cont.)

Station Name	Date	Code[a]	F/UF[a]	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Ti	V	Zn
Pajarito Plateau (Cont.)														
DPS-1	07/07	SW	F	64	<30	<20	<3	<3		<30	112	<3	<8	<50
DPS-1	07/07	SW	UF						<2					
DPS-4	07/07	SW	F	<2	<30	<20	<3	<3		<30	53	<3	13	<50
DPS-4	07/07	SW	UF						<2					
Sandia Canyon:														
SCS-1	06/08	SW	F	9	84	<20	<3	<3		<30	77	<3	<8	67
SCS-1	06/08	SW	UF						<2					
SCS-2	06/08	SW	F	4	58	<20	<3	<3		<30	81	<3	<8	<50
SCS-2	06/08	SW	UF						<2					
SCS-3	06/08	SW	F	4	62	<20	<3	<3		<30	77	<3	<8	<50
SCS-3	06/08	SW	F	4	58	<20	<3	<3		<30	74	<3	<8	<50
SCS-3	06/08	SW	UF						<2					
SCS-3	06/08	SW	UF						<2					
Mortandad Canyon:														
Mortandad at GS-1	08/28	SW	F	8	145	41	4	<3		<30	75	<3	<8	<50
Mortandad at GS-1	08/28	SW	UF						2					
Mortandad at Rio Grande (A-11)	09/28	SW	F	8	<30	<20	<10	<3		<30	109	<3	9	69
Mortandad at Rio Grande (A-11)	09/28	SW	UF						<2					
Cañada del Buey:														
Cañada del Buey	07/24	SW	F	300	220	<20	<3	<3		<30	59	<3	<8	<50
Cañada del Buey	07/24	SW	UF						<2					
Pajarito Canyon:														
Pajarito at Rio Grande	09/28	SW	F	<2	<30	<20	<10	<3		<30	122	<3	9	<50
Pajarito at Rio Grande	09/28	SW	UF						3					
Pajarito at Rio Grande	09/29	SW	F	<2	<30	<20	<10	<3		<30	121	<3	10	<50
Pajarito at Rio Grande	09/29	SW	UF						2					
Water Canyon:														
Water Canyon at Beta	11/13	SW	F	9	<30	<20	3	<3		<30	68	<3	9	<50
Water Canyon at Beta	11/13	SW	UF						<3					
Ancho Canyon:														
Ancho at Rio Grande	09/29	SW	F	<2	<30	<20	<10	<3		<30	64	<3	8	<50
Ancho at Rio Grande	09/29	SW	UF						<2					
Frijoles Canyon:														
Frijoles at Monument HQ	06/05	SW	F	5	<30	<20	<3	<3		<30	52	<3	<8	<50
Frijoles at Monument HQ	06/05	SW	UF						<2					
Frijoles at Rio Grande	09/30	SW	F	17	<30	<20	<10	<3		<30	61	<3	<8	<50
Frijoles at Rio Grande	09/30	SW	F	15	<30	<20	<10	<3		<30	62	<3	<8	<50
Frijoles at Rio Grande	09/30	SW	UF						2					
Frijoles at Rio Grande	09/30	SW	UF						2					

Table 5-6. Trace Metals in Surface Waters and Runoff Samples for 1998 (µg/L) (Cont.)

Station Name	Date	Code[a]	F/UF[a]	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Ti	V	Zn
Runoff Stations														
LA Canyon near LA	07/28	RO/D	F	359	<30	<20	34	3		<30	97	<3	45	125
LA Canyon near LA	07/28	RO/D	UF						<2					
LA Canyon near LA	10/31	RO/D	F	1,370	<30	<20	115	<3		<30	114	<3	19	299
LA Canyon near LA	10/31	RO/TOT	UF	1,437	<30	<20	133	<3	2	<30	120	<3	20	282
Cañada del Buey at WR	07/28	RO/D	F	604	<30	<20	7	<3		<30	117	<3	16	<50
Cañada del Buey at WR	07/28	RO/T	UF	7,145	<30	77	42	<3	2	<30	704	<3	59	69
Cañada del Buey at WR	08/13	RO/D	F	100	<30	<20	9	<3		<30	120	<3	10	<50
Cañada del Buey at WR	08/13	RO/D	UF						5					
Cañada del Buey at WR	09/29	RO/TOT	UF	7,231	<30	111	210	<3	6	<30	654	<3	134	210
Cañada del Buey at WR	10/26	RO/D	F	6,973	<30	72	33	<3		<30	612	<3	37	50
Cañada del Buey at WR	10/26	RO/D	UF						3					
Area G:														
G-SWMS-4	06/11	RO/TOT	UF	423	<30	<20	16	<3	<2	<49	125	<3	21	156
Water Quality Standards[c]														
EPA Primary Drinking Water Standard						100		6	50			2		
EPA Secondary Drinking Water Standard				50										5,000
EPA Action Level							15							
EPA Health Advisory											25,000–90,000		80–110	
NMWQCC Livestock Watering Standard							100		50				100	25,000
NMWQCC Groundwater Limit				200	1,000	200	50		50					10,000
NMWQCC Wildlife Habitat Standard									2					

Suspended Sediments in Runoff Samples (mg/kg)

Station Name	Date	Code[a]	F/UF[a]	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Ti	V	Zn
LA Canyon near LA	07/28	RO/SS		143	<5	<4	15.7	<0.3		<5	9.3	<0.3	6.7	35.7
Cañada del Buey at WR	08/13	RO/SS		350	<5	11	12.2	<0.3		<5	28.0	<0.3	18.0	41.0
Cañada del Buey at WR	10/26	RO/SS		55	<5	<4	5.0	0.5		<5	5.1	<0.3	5.4	14.1
Sediment Comparisons[c]														
SAL[d]				390	380	1,500	400	31	380		46,000	6.4	540	23,000

[a] Codes: SW–surface water; RO–runoff; D–disssolved; TOT–total; SS–suspended sediments; UF–unfiltered, F–filtered.
[b] Less than symbol (<) means measurement was below the specified limit of detection of the analytical method.
[c] Standards given here for comparison only, see Appendix A. Note that New Mexico Livestock Watering and Groundwater limits are based on dissolved concentrations, while many of these analyses are of unfiltered samples, thus concentrations may include suspended sediment quantities.
[d] Screening Action Level; Environmental Restoration, 1997; see text for details.
[e] SAL value for hexavalent chromium is listed; SAL value for trivalent or total chromium is 210 mg/kg.

Table 5-7. Number of Samples Collected for Each Suite of Organic Compounds in Surface Water and Runoff Samples in 1998

			Organic Suite[a]			
Station Name	Date	Code[b]	HE	PCB	Semivolatile	Volatile
Cañada del Buey at WR	10/26	RO	1	1	1	2
Acid Weir	11/07	SW		1	1	2
Ancho at Rio Grande	09/29	SW	1	1	1	1
Cañada del Buey	07/24	SW	1	3	3	2
DPS-1	07/07	SW		3	3	2
Frijoles at Monument HQ	06/05	SW	1	3	3	2
Frijoles at Rio Grande	09/30	SW	2	2	2	4
Los Alamos Canyon Reservior	07/07	SW		1	1	2
Pajarito at Rio Grande	09/28	SW	1	1	1	2
Pajarito at Rio Grande	09/29	SW	1	1	1	2
Pajarito Canyon	04/08	SW	1			
Pueblo 3	11/12	SW		3	3	2
Pueblo at SR-502	09/03	SW		3	3	2
SCS-2	06/08	SW		3	3	2
Water Canyon at Beta	11/13	SW	1	3	3	2

[a] High explosives, polychlorinated biphenyls, semivolatiles, and volatiles.
[b] Codes: RO–runoff; SW-surface water.

Table 5-8. Radiochemical Analysis of Sediments for 1998 (pCi/g)[a]

Station Name	Date	^{3}H (pCi/L)	^{90}Sr	^{137}Cs	U (mg/kg)	^{238}Pu	$^{239,240}Pu$	^{241}Am	Gross Alpha	Gross Beta	Gross Gamma
Reservoirs on Rio Grande (Colorado)											
Rio Grande Upper	06/24	201 680	1.43 0.65	0.64 0.08	3.35 0.34	0.0008 0.0001	0.0194 0.0005	0.0100 0.0050	15.10 4.32	7.30 0.52	3.4 0.3
Rio Grande Middle	06/24	31 670	1.47 0.75	0.75 0.09	3.39 0.34	0.0009 0.0001	0.0237 0.0011	0.0101 0.0017	16.60 4.58	7.89 0.55	3.5 0.4
Rio Grande Lower	06/24	591 700	1.98 0.73	0.72 0.09	3.37 0.34	0.0018 0.0003	0.0187 0.0013	0.0115 0.0022	21.50 6.39	10.40 0.73	3.6 0.4
Rio Grande Lower	06/24	391 690	1.71 0.71	0.53 0.07	3.35 0.34	0.0009 0.0001	0.0209 0.0005	0.0114 0.0021	20.20 6.02	8.83 0.63	3.2 0.3
Reservoirs on Rio Grande (New Mexico)											
Cochiti Upper	09/24	331 670	0.94 0.33	0.29 0.04	2.59 0.26	0.0005 0.0000	0.0091 0.0002	0.0020 0.0030	7.06 2.14	4.42 0.42	2.6 0.3
Cochiti Middle	09/24	101 650	0.67 0.32	0.43 0.05	2.60 0.26	0.0008 0.0000	0.0129 0.0003	0.0060 0.0040	16.50 4.24	8.13 0.68	3.7 0.4
Cochiti Lower	09/24	41 650	0.81 0.30	0.40 0.05	2.70 0.27	0.0008 0.0002	0.0126 0.0004	0.0100 0.0050	12.20 3.20	10.00 0.76	4.0 0.4
Reservoirs on Rio Chama (New Mexico)											
Heron Upper	06/23	251 680	1.26 0.65	0.30 0.04	3.30 0.33	0.0003 0.0000	0.0055 0.0002	0.0040 0.0020	9.68 2.52	5.91 0.50	3.4 0.3
Heron Middle	06/23	1,191 740	1.86 0.74	0.30 0.04	4.30 0.43	0.0002 0.0002	0.0058 0.0002	0.0043 0.0012	12.70 3.37	7.19 0.58	4.4 0.4
Heron Lower	06/23	1,881 780	1.41 0.68	0.36 0.05	0.01 0.01	0.0004 0.0000	0.0049 0.0002	0.0032 0.0012	11.20 3.06	6.55 0.52	4.0 0.4
Abiquiu Upper	06/22	1 660	0.75 0.90	0.17 0.03	2.91 0.29	0.0001 0.0000	0.0011 0.0001	0.0017 0.0009	4.91 1.62	2.24 0.30	2.0 0.2
Abiquiu Middle	06/22	1,921 790	1.48 0.82	0.38 0.05	3.15 0.32	0.0005 0.0001	0.0097 0.0004	0.0055 0.0012	15.30 3.75	8.67 0.65	3.3 0.3
Regional Stations											
Rio Chama at Chamita	10/28	−169[b] 650	2.00 0.43	0.45 0.05	3.12 0.31	0.0010 0.0006	0.0129 0.0018	0.0047 0.0016	6.09 1.59	4.94 0.50	2.9 0.3
Rio Grande at Embudo	10/28	201 670	1.59 0.42	0.30 0.04	3.05 0.31	0.0005 0.0005	0.0048 0.0011	0.0065 0.0013	3.65 1.10	3.39 0.36	2.9 0.3
Rio Grande at Otowi (bank)	08/05	61 670	0.39 0.24	0.15 0.02	2.67 0.27	0.0002 0.0005	0.0010 0.0006	0.0131 0.0018	2.27 0.65	1.78 0.27	2.3 0.2
Rio Grande at Frijoles (bank)	09/30	10,411 1,200	1.33 0.36	0.22 0.03	2.06 0.21	0.0001 0.0002	0.0048 0.0009	0.0044 0.0013	4.36 1.19	2.66 0.30	3.8 0.4
Rio Grande at Frijoles (bank)	12/15	951 700									
Rio Grande at Cochiti Spillway	11/10	141 660	0.69 0.20	0.09 0.02	2.49 0.25	0.0002 0.0004	0.0020 0.0008	0.0029 0.0016	2.06 0.62	1.38 0.21	2.1 0.2
Rio Grande at Bernalillo	10/28	741 710	2.00 0.44	0.27 0.04	2.78 0.28	0.0000 0.0000	0.0037 0.0012	0.0033 0.0012	3.25 0.95	3.10 0.36	2.8 0.3
Jemez River	11/20	1,351 740	3.65 0.48	0.19 0.03	3.98 0.4	0.0002 0.0002	0.0031 0.0008	0.0041 0.0012	8.07 1.99	4.98 0.53	4.1 0.4
Pajarito Plateau Stations											
Guaje Canyon:											
Guaje at SR-502	08/05	381 690	0.67 0.22	0.08 0.02	2.63 0.26	0.0001 0.0002	0.0018 0.0006	0.0150 0.0023	1.34 0.29	0.96 0.14	2.4 0.2
Bayo Canyon:											
Bayo at SR-502	11/10	−129 650	1.21 0.37	0.07 0.01	2.19 0.22	0.0011 0.0008	0.0014 0.0007	0.0030 0.0016	1.49 0.31	0.79 0.13	2.5 0.3
Acid/Pueblo Canyons:											
Acid Weir	11/05	201 720	0.71 0.44	0.31 0.04	3.26 0.33	0.0410 0.0050	8.9000 0.4000	0.4000 0.0300	15.10 2.73	2.81 0.23	3.8 0.4
Pueblo 1	11/05	961 770	1.01 0.44	0.09 0.02	2.64 0.26	0.0018 0.0007	0.1704 0.0076	0.0058 0.0013	2.39 0.46	1.32 0.15	2.9 0.3
Pueblo 2	11/05	−59 710	1.58 0.44	0.10 0.02	3.13 0.31	0.0006 0.0004	0.0050 0.0010	0.0030 0.0030	3.68 0.71	2.28 0.20	3.9 0.4
Hamilton Bend Spring	05/05	−89 690	1.07 0.53	0.03 0.01	1.53 0.15	0.0007 0.0005	0.0034 0.0008	0.0021 0.0010	1.24 0.24	0.50 0.09	2.6 0.3
Pueblo 3	05/05	−529 660	1.02 0.52	21.54 1.63	1.24 0.12	0.0003 0.0005	0.0065 0.0012	0.0030 0.0040	1.84 0.34	0.80 0.10	2.2 0.2
Pueblo at SR-502	08/05	251 690	0.57 0.26	0.09 0.02	2.46 0.25	0.0060 0.0010	0.9446 0.0219	0.0425 0.0033	1.28 0.26	0.67 0.12	2.2 0.2

Table 5-8. Radiochemical Analysis of Sediments for 1998 (pCi/g)[a] (Cont.)

Station Name	Date	^{3}H (pCi/L)	^{90}Sr	^{137}Cs	U (mg/kg)	^{238}Pu	$^{239,240}Pu$	^{241}Am	Gross Alpha	Gross Beta	Gross Gamma
Pajarito Plateau Stations (Cont.)											
DP/Los Alamos Canyons:											
Los Alamos at Bridge	07/21	391 710	1.58 0.28	0.13 0.02	1.99 0.2	0.0016 0.0008	0.0045 0.0012	0.0033 0.0014	2.74 0.54	1.95 0.18	3.1 0.3
Los Alamos at LAO-1	07/21	501 720	1.39 0.35	0.10 0.02	1.08 0.11	0.0024 0.0008	0.1832 0.0076	0.0037 0.0011	2.23 0.43	1.22 0.15	2.1 0.2
Los Alamos at LAO-1	07/21	501 720	1.49 0.32	0.11 0.02	1.68 0.17	0.0011 0.0006	0.3419 0.0104	0.0065 0.0015	2.39 0.46	1.17 0.14	2.0 0.2
Los Alamos at GS-1	07/21	−129 680	0.84 0.21	0.86 0.09	1.49 0.15	0.0130 0.0017	0.1155 0.0051	0.1056 0.0076	1.63 0.34	2.45 0.20	3.0 0.3
Los Alamos at GS-1	07/21	−139 680	1.19 0.33	0.77 0.08	1.27 0.13	0.0158 0.0019	0.0827 0.0045	0.0916 0.0064	1.59 0.34	2.27 0.19	3.1 0.3
DPS-1	07/21	771 740	1.34 0.35	0.21 0.03	1.11 0.11	0.0031 0.0011	0.0109 0.0015	0.0280 0.0026	1.51 0.31	1.41 0.15	3.2 0.3
DPS-4	07/22	811 740	0.72 0.19	0.12 0.02	1.70 0.17	0.0026 0.0009	0.1866 0.0069	0.0087 0.0016	1.33 0.27	0.66 0.12	3.5 0.3
Los Alamos at Upper GS	07/21	621 730	1.31 0.31	0.14 0.02	2.12 0.21	0.0034 0.0011	0.2293 0.0081	0.0080 0.0030	2.53 0.50	1.70 0.17	2.6 0.3
Los Alamos at Upper GS	07/21	−9 690	1.50 0.32	0.14 0.02	1.49 0.15	0.0031 0.0009	0.2135 0.0076	0.0065 0.0013	2.04 0.40	1.15 0.14	2.4 0.2
Los Alamos at LAO-3	11/13	−379 630	1.51 0.43	0.06 0.02	2.53 0.25	−0.0004 0.0003	0.0001 0.0006	0.0040 0.0020	1.44 0.33	1.82 0.17	1.9 0.2
Los Alamos at LAO-3	07/21	621 730	1.50 0.32	0.93 0.09	1.87 0.19	0.0185 0.0022	0.1139 0.0058	0.0867 0.0053	2.99 0.58	3.71 0.27	3.7 0.4
Los Alamos at LAO-4.5	07/21	321 710	0.90 0.28	0.88 0.09	1.57 0.16	0.0199 0.0021	0.0961 0.0047	0.0760 0.0045	1.62 0.35	3.33 0.25	2.7 0.3
Los Alamos at SR-4	07/21	271 710	1.00 0.26	0.81 0.08	3.72 0.37	0.0100 0.0015	0.0776 0.0042	0.0589 0.0043	0.93 0.20	0.72 0.12	2.8 0.3
Los Alamos at Totavi	11/10	141 660	0.84 0.33	0.20 0.03	1.51 0.15	0.0011 0.0006	0.0009 0.0006	0.0025 0.0010	1.36 0.29	1.01 0.14	1.7 0.2
Los Alamos at Otowi	11/10	361 680	1.20 0.43	0.13 0.02	1.87 0.19	0.0008 0.0014	0.0516 0.0060	0.0110 0.0330	1.34 0.28	0.61 0.12	2.0 0.2
Sandia Canyon:											
Sandia at SR-4	08/05	361 690	0.58 0.24	0.12 0.02	2.12 0.21	0.0008 0.0005	0.0000 0.0001	0.0122 0.0017	1.54 0.31	1.02 0.14	2.2 0.2
Mortandad Canyon:											
Mortandad near CMR Building	07/22	1,011 750	1.01 0.23	0.09 0.02	1.30 0.13	0.0108 0.0017	0.0043 0.0011	0.0056 0.0013	2.72 0.59	2.06 0.19	2.6 0.3
Mortandad west of GS-1	07/21	461 720	1.07 0.26	0.19 0.03	1.29 0.13	0.0146 0.0016	0.0129 0.0015	0.0070 0.0030	2.88 0.55	2.05 0.18	2.4 0.2
Mortandad at GS-1	07/22	3,491 890	1.42 0.24	17.80 1.37	1.67 0.17	6.4507 0.1292	7.1932 0.1435	10.5815 0.2991	33.10 6.07	24.00 1.37	18.8 1.9
Mortandad at MCO-5	07/22	8,611 1,100	2.17 0.29	20.38 1.55	1.51 0.15	2.5097 0.0539	6.3023 0.1279	7.3926 0.1866	17.40 3.20	19.00 1.09	24.1 2.4
Mortandad at MCO-7	07/22	761 740	0.57 0.20	3.64 0.31	0.88 0.09	0.6544 0.0169	2.0410 0.0439	1.5568 0.0460	6.80 1.30	7.69 0.48	5.6 0.6
Mortandad at MCO-9	07/22	701 730	2.86 0.39	0.26 0.04	3.56 0.36	0.0023 0.0008	0.0095 0.0014	0.0108 0.0026	4.37 0.90	3.77 0.27	3.7 0.4
Mortandad at MCO-13 (A-5)	08/05	441 700	0.85 0.22	0.18 0.03	2.17 0.22	0.0005 0.0004	0.0035 0.0013	0.0120 0.0040	2.64 0.51	2.13 0.19	3.2 0.3
Mortandad A-6	08/05	341 690	1.21 0.24	0.46 0.05	3.29 0.33	0.0010 0.0004	0.0283 0.0023	0.0120 0.0040	5.38 1.06	4.56 0.31	3.7 0.4
Mortandad A-7	08/05	571 710	0.49 0.21	0.25 0.03	5.19 0.52	0.0044 0.0010	0.0080 0.0013	0.0150 0.0040	3.66 0.68	2.32 0.19	2.8 0.3
Mortandad at SR-4 (A-9)	08/05	171 680	0.63 0.21	0.18 0.03	2.87 0.29	0.0009 0.0005	0.0037 0.0010	0.0120 0.0040	4.61 0.90	3.42 0.25	3.3 0.3
Mortandad at Rio Grande (A-11)	09/30	81 680	0.87 0.27	0.10 0.02	1.25 0.13	0.0002 0.0002	0.0009 0.0005	0.0035 0.0012	2.05 0.44	1.58 0.16	1.8 0.2
Mortandad at Rio Grande (A-11)	09/30	−369 650	0.81 0.24	0.12 0.02	1.08 0.11	0.0013 0.0006	0.0020 0.0008	0.0020 0.0020	1.74 0.38	1.22 0.15	2.9 0.3
Cañada del Buey:											
Cañada del Buey at SR-4	05/04	511 730	1.29 0.51	0.05 0.01	1.51 0.15	0.0013 0.0006	0.0019 0.0008	0.0024 0.0008	2.69 0.50	1.53 0.13	2.8 0.3
Cañada del Buey at SR-4	05/04	281 720	1.12 0.53	0.04 0.01	1.59 0.16	0.0007 0.0005	0.0017 0.0007	0.0024 0.0008	2.28 0.42	1.32 0.12	2.3 0.2

Table 5-8. Radiochemical Analysis of Sediments for 1998 (pCi/g)[a] (Cont.)

Station Name	Date	^{3}H (pCi/L)	^{90}Sr	^{137}Cs	U (mg/kg)	^{238}Pu	$^{239,240}Pu$	^{241}Am	Gross Alpha	Gross Beta	Gross Gamma
Pajarito Plateau Stations (Cont.)											
Pajarito Canyon:											
Two Mile at SR-501	05/05	–169 690	1.02 0.57	0.05 0.07	1.78 0.18	0.0007 0.0006	0.0070 0.0012	0.0020 0.0070	2.14 0.39	1.17 0.11	2.3 0.2
Pajarito at SR-501	05/05	–89 690	1.30 0.64	0.06 0.01	1.57 0.16	0.0001 0.0002	0.0030 0.0008	0.0019 0.0008	1.92 0.36	1.48 0.13	2.1 0.2
Pajarito at SR-4	05/04	281 720	2.39 0.74	0.51 0.06	3.27 0.33	0.0074 0.0013	0.0198 0.0020	0.0072 0.0014	7.21 1.82	5.34 0.35	3.1 0.3
Potrillo Canyon:											
Potrillo at SR-4	05/04	–409 670	1.32 0.50	0.03 0.01	1.44 0.14	0.0002 0.0004	0.0050 0.0011	0.0028 0.0008	2.20 0.41	1.13 0.11	2.0 0.2
Fence Canyon:											
Fence at SR-4	05/04	351 720	1.75 0.61	0.10 0.02	1.93 0.19	0.0028 0.0017	0.0019 0.0014	0.0038 0.0010	1.77 0.33	1.20 1.14	2.2 0.2
Fence at SR-4	05/04	611 740	2.07 0.59	0.08 0.02	2.06 0.21	0.0008 0.0006	0.0043 0.0009	0.0032 0.0010	2.58 0.47	2.04 0.15	2.3 0.2
Cañon de Valle:											
Canon de Valle at SR-501	05/04	171 710	0.94 0.60	0.07 0.11	1.87 0.19	0.0008 0.0006	0.0064 0.0011	0.0039 0.0011	2.56 0.48	1.43 0.13	2.5 0.3
Water Canyon:											
Water at SR-501	11/12	–29 650	1.33 0.34	0.10 0.02	2.73 0.27	0.0003 0.0009	0.0010 0.0010	0.0033 0.0014	1.46 0.30	0.77 0.13	2.5 0.3
Water at SR-501	11/13	161 670	1.87 0.47	0.10 0.02	2.81 0.28	0.0027 0.0033	–0.0004 0.0025	0.0024 0.0014	1.84 0.36	1.07 0.14	2.8 0.3
Water at SR-4	05/04	461 730	1.72 0.49	0.42 0.07	2.66 0.27	0.0001 0.0003	0.0052 0.0009	0.0043 0.0010	2.70 0.50	1.68 0.14	2.4 0.2
Indio Canyon:											
Indio at SR-4	05/04	–139 690	1.50 0.52	0.04 0.01	2.06 0.21	0.0009 0.0006	0.0025 0.0008	0.0030 0.0040	1.89 0.36	1.45 0.13	2.2 0.2
Ancho Canyon:											
Ancho at SR-4	05/04	–389 670	1.50 0.53	0.07 0.02	3.23 0.32	0.0007 0.0018	0.0001 0.0018	0.0028 0.0010	2.50 0.46	1.78 0.14	2.7 0.3
Above Ancho Spring	09/29	221 690	1.27 0.26	0.12 0.02	1.24 0.12	0.0001 0.0003	0.0031 0.0008	0.0025 0.0014	1.73 0.35	1.07 0.14	1.1 0.2
Ancho at Rio Grande	09/29	–129 670	2.20 0.38	0.13 0.02	1.72 0.17	0.0007 0.0005	0.0021 0.0008	0.0050 0.0040	1.88 0.41	1.89 0.17	2.6 0.3
Chaquehui Canyon:											
Chaquehui at Rio Grande	09/30	–269 660	2.37 0.34	0.51 0.06	3.43 0.34	0.0019 0.0007	0.0124 0.0014	0.0050 0.0030	5.88 1.45	4.64 0.34	2.9 0.3
Frijoles Canyon:											
Frijoles at Monument HQ	05/05	981 760	1.13 0.50	0.07 0.01	2.31 0.23	–0.0007 0.0005	0.0014 0.0008	0.0026 0.0009	1.52 0.28	0.93 0.10	2.5 0.2
Frijoles at Rio Grande	09/30	–89 670	3.32 0.73	0.27 0.41	2.67 0.27	0.0014 0.0005	0.0097 0.0013	0.0050 0.0014	8.11 2.35	4.13 0.39	2.0 0.2

Table 5-8. Radiochemical Analysis of Sediments for 1998 (pCi/g)[a] (Cont.)

Station Name	Date	^{3}H (pCi/L)	^{90}Sr	^{137}Cs	U (mg/kg)	^{238}Pu	$^{239,240}Pu$	^{241}Am	Gross Alpha	Gross Beta	Gross Gamma
Pajarito Plateau Stations (Cont.)											
TA-54 Area G:											
G-1	03/20	861 750	1.52 0.81	0.23 0.03	2.31 0.23	0.0015 0.0008	0.0136 0.0017	0.0070 0.0016	3.54 0.68	2.74 0.19	3.1 0.3
G-2	03/20	831 750	1.89 0.85	0.37 0.04	2.65 0.27	0.0054 0.0011	0.0238 0.0022	0.0106 0.0018	4.00 0.77	3.36 0.22	3.5 0.3
G-3	03/20	1 700	2.39 0.85	0.11 0.02	2.67 0.27	0.0007 0.0005	0.0119 0.0017	0.0065 0.0015	3.39 0.64	3.25 0.22	3.4 0.3
G-4	03/20	401 730	1.23 0.72	0.24 0.03	2.89 0.29	0.0012 0.0006	0.0153 0.0019	0.0049 0.0012	5.29 0.95	3.36 0.22	3.5 0.3
G-5	03/20	521 730	1.06 0.56	0.08 0.01	2.05 0.21	0.0072 0.0017	0.0246 0.0029	0.0069 0.0017	3.37 0.61	2.03 0.15	2.8 0.3
G-6	03/20	1,881 810	2.97 0.83	0.12 0.02	3.90 0.39	0.0183 0.0020	0.2522 0.0085	0.0758 0.0049	4.83 0.95	3.43 0.23	4.0 0.4
G-7	03/20	511 730	1.51 0.85	0.21 0.03	1.72 0.17	0.1113 0.0054	0.0749 0.0043	0.0135 0.0021	4.19 0.78	3.11 0.21	3.4 0.3
G-8	03/20	161 710	2.55 0.68	0.05 0.01	2.35 0.24	0.0058 0.0012	0.0083 0.0013	0.0013 0.0011	3.91 0.73	2.87 0.20	3.6 0.4
G-9	03/20	21 700	1.00 0.64	0.08 0.02	1.70 0.17	0.0088 0.0016	0.0091 0.0016	0.0058 0.0019	1.97 0.36	1.22 0.12	2.3 0.2
TA-49, Area AB:											
AB-1	07/14	–19 690	1.96 0.86	0.39 0.05	2.67 0.27	0.0013 0.0006	0.0277 0.0023	0.0303 0.0032	7.41 2.04	5.76 0.41	3.2 0.3
AB-1	07/14	71 690	1.06 0.88	0.49 0.05	4.78 0.48	0.0026 0.0009	0.0298 0.0025	0.0097 0.0013	5.40 1.35	4.22 0.31	3.3 0.3
AB-2	07/14	141 700	1.99 0.88	0.43 0.05	2.69 0.27	0.0013 0.0007	0.0432 0.0031	0.0391 0.0039	6.59 1.62	4.78 0.34	3.3 0.3
AB-3	07/14	–9 690	2.26 1.00	0.35 0.04	3.38 0.34	0.0166 0.0019	1.0809 0.0253	0.2400 0.0200	4.54 1.09	3.49 0.27	3.7 0.4
AB-4	07/14	–309 670	2.39 1.10	0.49 0.06	3.18 0.32	0.0022 0.0009	0.0129 0.0019	0.0322 0.0030	4.64 1.13	4.10 0.30	4.2 0.4
AB-4A	07/14	61 690	2.61 1.09	0.46 0.06	2.77 0.28	0.0007 0.0005	0.0127 0.0016	0.0080 0.0014	5.45 1.26	5.47 0.37	4.1 0.4
AB-5	07/14	–59 680	2.34 0.97	0.96 0.10	3.18 0.32	0.0037 0.0009	0.0325 0.0026	0.0335 0.0034	5.68 1.30	5.57 0.38	4.1 0.4
AB-6	07/14	–119 680	1.15 0.65	0.31 0.04	2.67 0.27	0.0008 0.0006	0.0072 0.0012	0.0326 0.0036	3.42 0.77	2.83 0.23	3.3 0.3
AB-7	07/14	81 690	1.68 0.94	0.21 0.03	1.72 0.17	0.0011 0.0005	0.0030 0.0008	0.0203 0.0024	3.22 0.66	2.58 0.21	3.4 0.3
AB-8	07/14	–229 670	0.35 0.76	0.20 0.03	2.24 0.22	0.0013 0.0005	0.0054 0.0010	0.0057 0.0013	4.19 1.00	3.35 0.27	3.4 0.3
AB-9	07/14	51 690	1.06 2.08	0.26 0.04	1.66 0.17	0.0004 0.0004	0.0039 0.0010	0.0035 0.0008	3.35 0.80	2.40 0.21	3.4 0.3
AB-10	07/14	141 700	1.65 1.21	0.19 0.03	1.49 0.15	0.0025 0.0009	0.0030 0.0010	0.0020 0.0020	2.82 0.71	2.31 0.21	2.6 0.3
AB-11	07/14	–49 680	1.64 0.94	0.27 0.04	1.38 0.14	0.0003 0.0003	0.0066 0.0012	0.0090 0.0030	3.29 0.75	2.16 0.20	2.8 0.3
Standardized Comparisons											
Average Detection Limits		700	2.00	0.05	0.25	0.0050[c]	0.0050[c]	0.0050	1.50	1.50	0.8
Background			0.87[d]	0.44[d]	4.4[d]	0.006[d]	0.023[d]	0.09[e]	14.8[e]	12[e]	8.2[e]
SAL[f]		20,000	5.9	4.4	29	27	24	22			

[a] Except where noted. Two columns are listed; the first is the value, the second is the counting uncertainty (1 std dev).
[b] See Appendix B for an explanation of negative numbers.
[c] Sample sizes for plutonium ^{238}Pu and $^{239,240}Pu$ analysis: stream channels 100 g; reservoirs 1,000 g. Limits of detection for plutonium ^{238}Pu and $^{239,240}Pu$ in reservoir samples are 0.0001 pCi/g.
[d] Purtymun et al. (1987a), upper limit for background for sediment samples from 1974–1986.
[e] Preliminary upper limit for background values for channel sediments from 1974–1996 (McLin et al., in preparation).
[f] Screening Action Level, LANL Environmental Restoration Project, 1998, see text for details.

Table 5-9. Detections of Greater-Than-Background Radionuclides in Sediments for 1998[a]

Station Name	Date	Analyte	Value	Uncertainty[b]	Detection Limit	Background	SAL[c]	Units	Ratio of Value to Background[d]	Ratio of Value to Sal
Reservoirs on Rio Grande (Colorado)										
Rio Grande Upper	06/24	^{137}Cs	0.64	0.08	0.05	0.44		pCi/g	1.5	
Rio Grande Upper	06/24	Gross Alpha	15.1	4.3	1.5	14.8		pCi/g	1.0	
Rio Grande Middle	06/24	^{137}Cs	0.75	0.09	0.05	0.44		pCi/g	1.7	
Rio Grande Middle	06/24	$^{239,240}Pu$	0.024	0.001	0.005	0.023		pCi/g	1.0	
Rio Grande Middle	06/24	Gross Alpha	16.6	4.6	1.5	14.8		pCi/g	1.1	
Rio Grande Lower	06/24	^{137}Cs	0.53	0.07	0.05	0.44		pCi/g	1.2	
Rio Grande Lower	06/24	^{137}Cs	0.72	0.09	0.05	0.44		pCi/g	1.6	
Rio Grande Lower	06/24	Gross Alpha	21.5	6.4	1.5	14.8		pCi/g	1.5	
Rio Grande Lower	06/24	Gross Alpha	20.2	6.0	1.5	14.8		pCi/g	1.4	
Reservoirs on Rio Chama (New Mexico)										
Abiquiu Middle	06/22	Gross Alpha	15.3	3.8	1.5	14.8		pCi/g	1.0	
Reservoirs on Rio Grande (New Mexico)										
Cochiti Middle	09/24	Gross Alpha	16.5	4.2	1.5	14.8		pCi/g	1.1	
Regional Stations										
Rio Chama at Chamita	10/28	^{137}Cs	0.45	0.05	0.05	0.44		pCi/g	1.0	
Rio Chama at Chamita	10/28	^{90}Sr	2.00	0.43	2.00	0.87		pCi/g	2.3	
Rio Grande at Frijoles (bank)	09/30	^{3}H	10,411	1,200	700			pCi/L		
Rio Grande at Bernalillo	10/28	^{90}Sr	2.00	0.44	2.00	0.87		pCi/g	2.3	
Jemez River	11/20	^{90}Sr	3.65	0.48	2.00	0.87		pCi/g	4.2	
Acid/Pueblo Canyons										
Acid Weir	11/05	^{241}Am	0.400	0.030	0.005	0.090		pCi/g	4.4	
Acid Weir	11/05	^{238}Pu	0.041	0.005	0.005	0.006		pCi/g	6.8	
Acid Weir	11/05	$^{239,240}Pu$	8.900	0.400	0.005	0.023	18	pCi/g	387.0	0.5
Acid Weir	11/05	Gross Alpha	15.1	2.7	1.5	14.8		pCi/g	1.0	
Pueblo 1	11/05	$^{239,240}Pu$	0.170	0.008	0.005	0.023		pCi/g	7.4	
Pueblo 3	05/05	^{137}Cs	21.54	1.63	0.05	0.44	5.1	pCi/g	49.0	4.2
Pueblo at SR-502	08/05	$^{239,240}Pu$	0.945	0.022	0.005	0.023		pCi/g	41.1	

Table 5-9. Detections of Greater-Than-Background Radionuclides in Sediments for 1998[a] (Cont.)

Station Name	Date	Analyte	Value	Uncertainty[b]	Detection Limit	Background	SAL[c]	Units	Ratio of Value to Background[d]	Ratio of Value to Sal
DP/Los Alamos Canyons										
DPS-4	07/22	$^{239,240}Pu$	0.187	0.007	0.005	0.023		pCi/g	8.1	
Los Alamos at Upper GS	07/21	$^{239,240}Pu$	0.229	0.008	0.005	0.023		pCi/g	10.0	
Los Alamos at Upper GS	07/21	$^{239,240}Pu$	0.214	0.008	0.005	0.023		pCi/g	9.3	
Los Alamos at GS-1	07/21	^{241}Am	0.106	0.008	0.005	0.090		pCi/g	1.2	
Los Alamos at GS-1	07/21	^{241}Am	0.092	0.006	0.005	0.090		pCi/g	1.0	
Los Alamos at GS-1	07/21	^{137}Cs	0.77	0.08	0.05	0.44		pCi/g	1.8	
Los Alamos at GS-1	07/21	^{137}Cs	0.86	0.09	0.05	0.44		pCi/g	2.0	
Los Alamos at GS-1	07/21	^{238}Pu	0.016	0.002	0.005	0.006		pCi/g	2.6	
Los Alamos at GS-1	07/21	^{238}Pu	0.013	0.002	0.005	0.006		pCi/g	2.2	
Los Alamos at GS-1	07/21	$^{239,240}Pu$	0.116	0.005	0.005	0.023		pCi/g	5.0	
Los Alamos at GS-1	07/21	$^{239,240}Pu$	0.083	0.005	0.005	0.023		pCi/g	3.6	
Los Alamos at LAO-1	07/21	$^{239,240}Pu$	0.342	0.010	0.005	0.023		pCi/g	14.9	
Los Alamos at LAO-1	07/21	$^{239,240}Pu$	0.183	0.008	0.005	0.023		pCi/g	8.0	
Los Alamos at LAO-3	07/21	^{137}Cs	0.93	0.09	0.05	0.44		pCi/g	2.1	
Los Alamos at LAO-3	07/21	^{238}Pu	0.019	0.002	0.005	0.006		pCi/g	3.1	
Los Alamos at LAO-3	07/21	$^{239,240}Pu$	0.114	0.006	0.005	0.023		pCi/g	5.0	
Los Alamos at LAO-4.5	07/21	^{137}Cs	0.88	0.09	0.05	0.44		pCi/g	2.0	
Los Alamos at LAO-4.5	07/21	^{238}Pu	0.020	0.002	0.005	0.006		pCi/g	3.3	
Los Alamos at LAO-4.5	07/21	$^{239,240}Pu$	0.096	0.005	0.005	0.023		pCi/g	4.2	
Los Alamos at SR-4	07/21	^{137}Cs	0.81	0.08	0.05	0.44		pCi/g	1.8	
Los Alamos at SR-4	07/21	^{238}Pu	0.010	0.002	0.005	0.006		pCi/g	1.7	
Los Alamos at SR-4	07/21	$^{239,240}Pu$	0.078	0.004	0.005	0.023		pCi/g	3.4	
Los Alamos at Otowi	11/10	$^{239,240}Pu$	0.052	0.006	0.005	0.023		pCi/g	2.2	
Mortandad Canyon										
Mortandad near CMR Building	07/22	^{238}Pu	0.011	0.002	0.005	0.006		pCi/g	1.8	
Mortandad west of GS-1	07/21	^{238}Pu	0.015	0.002	0.005	0.006		pCi/g	2.4	
Mortandad at GS-1	07/22	^{241}Am	10.582	0.299	0.005	0.090	24	pCi/g	117.6	0.4
Mortandad at GS-1	07/22	^{3}H	3,491	890	700.			pCi/L		
Mortandad at GS-1	07/22	^{137}Cs	17.8	1.37	0.05	0.44	5.1	pCi/g	40.5	3.5
Mortandad at GS-1	07/22	^{238}Pu	6.451	0.129	0.005	0.006	27	pCi/g	1075.1	0.2
Mortandad at GS-1	07/22	$^{239,240}Pu$	7.193	0.144	0.005	0.023	24	pCi/g	312.7	0.3

Table 5-9. Detections of Greater-Than-Background Radionuclides in Sediments for 1998[a] (Cont.)

Station Name	Date	Analyte	Value	Uncertainty[b]	Detection Limit	Background	SAL[c]	Units	Ratio of Value to Background[d]	Ratio of Value to Sal
Mortandad Canyon (Cont.)										
Mortandad at GS-1	07/22	Gross Alpha	33.1	6.1	1.5	14.8		pCi/g	2.2	
Mortandad at GS-1	07/22	Gross Beta	24.0	1.4	1.5	12.0		pCi/g	2.0	
Mortandad at GS-1	07/22	Gross Gamma	18.8	1.9	0.2	8.2		pCi/g	2.3	
Mortandad at MCO-5	07/22	^{241}Am	7.393	0.187	0.005	0.090	22	pCi/g	82.1	0.3
Mortandad at MCO-5	07/22	^{3}H	8,611	1,100	700	20,000		pCi/L	0.4	
Mortandad at MCO-5	07/22	^{137}Cs	20.38	1.55	0.05	0.44	5.1	pCi/g	46.3	4.0
Mortandad at MCO-5	07/22	^{90}Sr	2.17	0.29	2.00	0.87	5.1	pCi/g	2.5	0.4
Mortandad at MCO-5	07/22	^{238}Pu	2.510	0.054	0.005	0.006		pCi/g	418.3	
Mortandad at MCO-5	07/22	^{239,240}Pu	6.302	0.128	0.005	0.023		pCi/g	274.0	
Mortandad at MCO-5	07/22	Gross Alpha	17.4	3.2	1.5	14.8		pCi/g	1.2	
Mortandad at MCO-5	07/22	Gross Beta	19.0	1.1	1.5	12.0		pCi/g	1.6	
Mortandad at MCO-5	07/22	Gross Gamma	24.1	2.4	0.2	8.2		pCi/g	2.9	
Mortandad at MCO-7	07/22	^{241}Am	1.557	0.046	0.005	0.090		pCi/g	17.3	
Mortandad at MCO-7	07/22	^{137}Cs	3.64	0.31	0.05	0.44		pCi/g	8.3	
Mortandad at MCO-7	07/22	^{238}Pu	0.654	0.017	0.005	0.006		pCi/g	109.1	
Mortandad at MCO-7	07/22	^{239,240}Pu	2.041	0.044	0.005	0.023		pCi/g	88.7	
Mortandad at MCO-9	07/22	^{90}Sr	2.86	0.39	2.00	0.87		pCi/g	3.3	
Mortandad A-6	08/05	^{137}Cs	0.46	0.05	0.05	0.44		pCi/g	1.0	
Mortandad A-6	08/05	^{239,240}Pu	0.028	0.002	0.005	0.023		pCi/g	1.2	
Mortandad A-7	08/05	U	5.19	0.52	0.25	4.4		mg/kg	1.2	
Pajarito Canyon										
Pajarito at SR-4	05/04	^{137}Cs	0.51	0.06	0.05	0.44		pCi/g	1.2	
Pajarito at SR-4	05/04	^{90}Sr	2.39	0.74	2.00	0.87		pCi/g	2.7	
Pajarito at SR-4	05/04	^{238}Pu	0.007	0.001	0.005	0.006		pCi/g	1.2	
Fence Canyon										
Fence at SR-4	05/04	^{90}Sr	2.07	0.59	2.00	0.87		pCi/g	2.4	
Ancho Canyon										
Ancho at Rio Grande	09/29	^{90}Sr	2.20	0.38	2.00	0.87		pCi/g	2.5	

Table 5-9. Detections of Greater-Than-Background Radionuclides in Sediments for 1998[a] (Cont.)

Station Name	Date	Analyte	Value	Uncertainty[b]	Detection Limit	Background	SAL[c]	Units	Ratio of Value to Background[d]	Ratio of Value to Sal
Chaquehui Canyon										
Chaquehui at Rio Grande	09/30	^{137}Cs	0.51	0.06	0.05	0.44		pCi/g	1.2	
Chaquehui at Rio Grande	09/30	^{90}Sr	2.37	0.34	2.00	0.87		pCi/g	2.7	
Frijoles Canyon										
Frijoles at Rio Grande	09/30	^{90}Sr	3.32	0.73	2.00	0.87		pCi/g	3.8	
TA-54 Area G										
G-2	03/20	$^{239,240}Pu$	0.024	0.002	0.005	0.023		pCi/g	1.0	
G-5	03/20	^{238}Pu	0.007	0.002	0.005	0.006		pCi/g	1.2	
G-5	03/20	$^{239,240}Pu$	0.025	0.003	0.005	0.023		pCi/g	1.1	
G-6	03/20	^{90}Sr	2.97	0.83	2.00	0.87		pCi/g	3.4	
G-6	03/20	^{238}Pu	0.018	0.002	0.005	0.006		pCi/g	3.1	
G-6	03/20	$^{239,240}Pu$	0.252	0.009	0.005	0.023		pCi/g	11.0	
G-7	03/20	^{238}Pu	0.111	0.005	0.005	0.006		pCi/g	18.6	
G-7	03/20	$^{239,240}Pu$	0.075	0.004	0.005	0.023		pCi/g	3.3	
G-8	03/20	^{90}Sr	2.55	0.68	2.00	0.87		pCi/g	2.9	
G-9	03/20	^{238}Pu	0.009	0.002	0.005	0.006		pCi/g	1.5	
TA-49, Area AB										
AB-1	07/14	^{137}Cs	0.49	0.05	0.05	0.44		pCi/g	1.1	
AB-1	07/14	U	4.78	0.48	0.25	4.40		mg/kg	1.1	
AB-1	07/14	$^{239,240}Pu$	0.030	0.003	0.005	0.023		pCi/g	1.3	
AB-1	07/14	$^{239,240}Pu$	0.028	0.002	0.005	0.023		pCi/g	1.2	
AB-2	07/14	$^{239,240}Pu$	0.043	0.003	0.005	0.023		pCi/g	1.9	
AB-3	07/14	$^{239,240}Pu$	1.081	0.025	0.005	0.023		pCi/g	47.0	
AB-3	07/14	^{241}Am	0.240	0.020	0.005	0.090		pCi/g	2.7	
AB-3	07/14	^{238}Pu	0.017	0.002	0.005	0.006		pCi/g	2.8	
AB-4	07/14	^{137}Cs	0.49	0.06	0.05	0.44		pCi/g	1.1	
AB-4A	07/14	^{137}Cs	0.46	0.06	0.05	0.44		pCi/g	1.0	
AB-5	07/14	^{137}Cs	0.96	0.10	0.05	0.44		pCi/g	2.2	
AB-5	07/14	$^{239,240}Pu$	0.033	0.003	0.005	0.023		pCi/g	1.4	

Table 5-9. Detections of Greater-Than-Background Radionuclides in Sediments for 1998[a] (Cont.)

Station Name	Date	Analyte	Value	Uncertainty[b]	Detection Limit	Background	SAL[c]	Units	Ratio of Value to Background[d]	Ratio of Value to Sal

[a]Above background detection defined as ≥ 3× uncertainty and ≥ detection limit and ≥ background. Values indicated by entries in SAL column are greater than 20 percent of the SAL.
[b]Radioactivity counting uncertainty (1 std dev).
[c]Screening Action Level, LANL Environmental Restoration Project, 1998, see text for details.
[d]Purtymun et al. (1987a), upper limit for background for sediment samples from 1974–1986. Preliminary upper limit for background values for channel sediments from 1974–1996 (McLin et al., in preparation).

Table 5-10. Total Recoverable Trace Metals in Sediments for 1998 (mg/kg)

Station Name	Date	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg
Pajarito Plateau Stations													
DP/Los Alamos Canyons:													
Los Alamos at Upper GS	07/21	7	3,140	0.6	<3[a]	24.3	0.3	<0.9	1.2	5.1	3.2	7,426	0.043
Los Alamos at Upper GS	07/21	<2	30	<0.2	<3	0.7	<0.2	<0.9	<1.0	<0.9	1.3	32	<0.030
Mortandad Canyon:													
Mortandad A-6	08/05	<2	6,068	2.3	<3	48.0	0.4	<0.9	2.1	5.2	4.4	5,581	0.037
Mortandad A-7	08/05	<2	3,090	0.5	<3	21.9	0.2	<0.9	<1.0	2.1	2.3	4,137	<0.030
TA-54 Area G:													
G-1	11/09												<0.025
G-2	11/09												<0.025
G-3	11/09												<0.025
G-4A	11/09												0.034
G-4B	11/09												0.033
G-5	11/09												0.027
G-6R	11/09												<0.025
G-7	11/09												<0.025
G-8	11/09												<0.025
G-9	11/09												<0.025
G-10	11/09												<0.025
Standardized Comparisons													
Detection Limits		2	7	0.2	3	0.2	0.2	0.9	1.0	0.9	1.0	1	0.050
SAL[b]		380	78,000	19	5,900	270		38	4,600	30[c]	28,000		23

Table 5-10. Total Recoverable Trace Metals in Sediments for 1998 (mg/kg) (Cont.)

Station Name	Date	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
Pajarito Plateau Stations												
DP/Los Alamos Canyons:												
Los Alamos at Upper GS	07/21	187.3	<5	<4	11.2	<0.3	<1	<5	6.2	<0.3	6.5	42.4
Los Alamos at Upper GS	07/21	0.5	<5	<4	0.3	<0.3	<0.2	<5	0.4	<0.3	<1.3	5.9
Mortandad Canyon:												
Mortandad A-6	08/05	191.2	<5	<4	18.6	<0.3	0.3	<5	9.8	<0.3	7.2	42.7
Mortandad A-7	08/05	151.2	<5	<4	7.0	<0.3	<0.2	<5	4.0	<0.3	3.8	25.1
TA-54 Area G:												
G-1	11/09						1.0					
G-2	11/09						0.7					
G-3	11/09						0.6					
G-4A	11/09						0.4					
G-4B	11/09						0.4					
G-5	11/09						0.5					
G-6 R	11/09						0.8					
G-7	11/09						0.5					
G-8	11/09						0.4					
G-9	11/09						0.5					
G-10	11/09						1.0					
Standardized Comparisons												
Average Detection Limits		0.3	5	4	0.3	0.30	0.2	5	0.2	0.3	1.3	0.8
SAL[b]		390	380	1,500	400	31	380		46,000	6	540	23,000

[a] Less than symbol (<) means measurement was below the specified limit of detection of the analytical method.
[b] Screening Action Level, Environmental Restoration Project, 1997, see text for details.
[c] SAL value for hexavalent chromium is listed; SAL value for trivalent or total chromium is 210 mg/kg.

Table 5-11. Number of Samples Collected for Each Suite of Organic Compounds in Sediments for 1998

		Organic Suite[a]		
Station Name	Date	HE	PCB	Semivolatile
Above Ancho Spring	09/29	1		
Ancho at Rio Grande	09/29	1		
Ancho at SR-4	05/04	1		
Cañada del Buey at SR-4	05/04	2		
Fence at SR-4	05/04	2		
Frijoles at Monument HQ	05/05	1		
Frijoles at Rio Grande	09/30	1		
Indio at SR-4	05/04	1		
Pajarito at SR-4	05/04	1		
Potrillo at SR-4	05/04	1		
Rio Grande at Frijoles (wdth intgrt)	09/30		1	1
Rio Grande at Otowi Upper (bank)	08/05		1	1
Sandia at SR-4	08/05	1		
Water at SR-4	05/04	1		

[a] High explosives, polychlorinated biphenyls, and semivolatiles.

Table 5-12. Radiochemical Analyses of Groundwater for 1998 (pCi/L[a])

Station Name	Date	Code[b]	^{3}H		^{90}Sr	^{137}Cs	U (µg/L)	^{238}Pu	$^{239,240}Pu$	^{241}Am	Gross Alpha		Gross Beta		Gross Gamma	
Regional Aquifer Wells																
Test Wells:																
Test Well 1	05/28	UF	11	670	0.0	0.7	–0.12	1.30	1.68	0.17	–0.002	0.011	–0.001	0.010	–0.001	0.016
Test Well 3	09/01	UF	441	770	0.5	0.4	–0.24	0.29	0.44	0.05	–0.014	0.015	–0.018	0.010	–0.014	0.017
Test Well 4	09/01	UF	231	750	0.1	0.5	–0.08	1.37	0.30	0.04	0.001	0.008	0.000	0.008	0.024	0.021
Test Well 8	09/02	UF	311	760	0.6	0.4	–0.37	0.23	0.53	0.06	–0.029	0.011	–0.006	0.011	0.022	0.024
Test Well 8	09/02	UF	201	750	0.1	0.4	–0.12	0.34	0.41	0.05	–0.002	0.016	–0.014	0.010	0.001	0.024
Test Well DT-5A	11/05	UF	–39	670	0.3	0.3	1.12	3.17	0.42	0.05	–0.013	0.004	–0.018	0.006	–0.023	0.011
Test Well DT-9	11/05	UF	–89	670	0.1	0.3	1.90	4.33	0.43	0.05	–0.011	0.005	–0.010	0.008	0.029	0.050
Test Well DT-10	11/06	UF	–79	670	0.4	0.3	–1.91	0.90	0.61	0.07	0.012	0.010	0.012	0.011	0.024	0.019
Water Supply Wells:																
O-1	06/08	UF	121	640	0.5	0.7	2.12	4.67	1.97	0.20	–0.009	0.020	0.010	0.020	–0.008	0.015
O-1	11/12	UF	141	680	–0.1	0.4	1.00	0.41	1.40	0.15	–0.006	0.012	0.001	0.014	0.056	0.080
O-4	11/12	UF	51	680	–0.4	0.9	0.10	1.64	0.51	0.06	–0.008	0.007	0.017	0.015	0.010	0.019
PM-1	06/08	UF	291	650	0.3	0.8	2.13	4.67	1.75	0.18	0.006	0.010	0.012	0.010	–0.018	0.015
PM-2	06/08	UF	–69	630	0.2	0.8	0.79	2.67	–0.06	0.01	–0.014	0.007	0.009	0.012	–0.015	0.013
PM-3	06/08	UF	81	640	0.1	0.8	0.34	2.00	0.41	0.05	–0.018	0.005	–0.013	0.011	–0.015	0.013
PM-4	07/27	UF	–139	630	0.3	0.8	0.92	0.43	0.32	0.04	–0.010	0.000	0.048	0.017	0.024	0.015
PM-5	06/08	UF	–109	630	0.4	0.6	–0.41	0.87	–0.06	0.01	–0.007	0.013	–0.023	0.011	0.007	0.018
G-1	11/11	UF	–289	650	0.2	0.4	0.63	0.46	0.84	0.09	–0.022	0.008	–0.005	0.009	0.015	0.018
G-1A	06/08	UF	–69	630	0.4	0.8	0.05	1.57	–0.06	0.01	–0.021	0.006	–0.016	0.010	0.012	0.020
G-1A	06/08	UF	–29	630	0.2	0.7	0.57	2.33	–0.06	0.01	0.010	0.011	0.004	0.012	–0.031	0.012
G-2	06/08	UF	41	640	0.3	0.8	–0.12	1.30	0.48	0.05	–0.011	0.009	0.004	0.011	0.000	0.032
G-5	11/11	UF	–359	650	0.3	0.3	–0.50	0.73	5.85	0.59	0.004	0.011	–0.011	0.011	–0.006	0.016
G-6	06/08	UF	41	640	0.3	0.6	–0.98	0.72	–0.06	0.01	–0.006	0.010	–0.005	0.009	0.006	0.016
Regional Aquifer Springs																
White Rock Canyon Group I:																
Sandia Spring	09/28	F			0.3	0.4	–1.43	0.81	0.53	0.06	0.006	0.011	–0.006	0.012	0.046	0.022
Sandia Spring	09/28	UF	31	650												
Spring 3A	09/28	F			0.7	0.4	0.57	2.33	1.14	0.12	–0.008	0.009	0.001	0.011	0.004	0.022
Spring 3A	09/28	UF	41	650												
Spring 4	09/28	F			0.3	0.4	–1.15	0.36	0.87	0.09	–0.003	0.011	–0.005	0.011	0.018	0.019
Spring 4	09/28	UF	–49	640												
Spring 4A	09/29	F			0.3	0.4	–1.41	0.36	1.03	0.11	–0.003	0.005	–0.001	0.008	0.125	0.050
Spring 4A	09/29	UF	81	650												
Ancho Spring	09/29	F			0.4	0.3	–1.00	0.36	0.24	0.03	–0.004	0.009	0.001	0.011	–0.005	0.040
Ancho Spring	09/29	UF	171	660												

Station Name	Gross Alpha		Gross Beta		Gross Gamma	
Test Well 1	2.0	2.2	4.3	2.2	–37	48
Test Well 3	0.1	0.4	2.1	0.3	46	49
Test Well 4	0.3	0.4	2.0	0.3	16	48
Test Well 8	0.6	0.4	1.7	0.8	63	49
Test Well 8	0.0	1.4	5.1	0.5	–12	48
Test Well DT-5A	–0.1	0.2	1.2	0.3	–28	49
Test Well DT-9	0.4	0.3	1.2	0.3	–22	49
Test Well DT-10	–0.1	0.2	1.2	0.3	–13	49
O-1	1.7	0.8	1.8	0.3	–7	48
O-1	1.5	0.8	3.4	0.4	–20	49
O-4	0.1	0.7	3.3	0.5	–16	49
PM-1	0.8	0.8	2.9	0.4	44	48
PM-2	0.1	0.3	1.8	0.3	16	48
PM-3	0.7	0.8	3.3	0.4	–19	47
PM-4	0.1	0.3	1.8	0.3	78	49
PM-5	0.1	0.3	1.7	0.3	–5	48
G-1	0.9	0.5	2.0	0.3	–12	49
G-1A	–0.1	0.5	2.5	0.3	14	48
G-1A	–0.2	0.4	2.0	0.3	–10	48
G-2	0.6	0.6	1.9	0.3	15	48
G-5	6.0	2.0	3.6	1.0	–39	48
G-6	–0.1	0.4	1.6	0.3	30	48
Sandia Spring	0.0	0.6	2.6	0.6	27	49
Spring 3A	0.2	0.6	2.8	0.3	14	49
Spring 4	0.4	0.7	4.1	0.4	–13	48
Spring 4A	0.5	0.6	2.8	0.3	29	49
Ancho Spring	0.1	0.3	2.0	0.3	89	49

Table 5-12. Radiochemical Analyses of Groundwater for 1998 (pCi/L[a]) (Cont.)

Station Name	Date	Code[b]	^{3}H	^{90}Sr	^{137}Cs	U (µg/L)	^{238}Pu	$^{239,240}Pu$	^{241}Am	Gross Alpha	Gross Beta	Gross Gamma
Regional Aquifer Springs (Cont.)												
White Rock Canyon Group II:												
Spring 5A	09/29	F		0.3 0.3	1.52 0.49	1.62 0.17	–0.006 0.005	–0.001 0.009	0.048 0.022	0.7 0.9	3.0 0.4	55 49
Spring 5A	09/29	UF	241 660									
Spring 6	09/29	F		0.4 0.4	–0.13 0.23	0.33 0.04	–0.008 0.005	0.020 0.012	0.057 0.026	0.1 0.2	1.9 0.3	20 49
Spring 6	09/29	UF	51 650									
Spring 6	09/29	F		0.5 0.4	0.51 2.26	1.13 0.12	–0.010 0.000	–0.002 0.008	–0.019 0.014	1.1 0.6	2.7 0.3	36 49
Spring 6	09/29	UF	–79 640									
Spring 8A	09/29	F		0.6 0.3	–0.62 0.54	0.17 0.02	–0.001 0.010	–0.011 0.007	–0.001 0.016	0.1 0.3	1.9 0.3	87 49
Spring 8A	09/29	UF	181 660									
Spring 9A	09/30	F		0.3 0.5	–0.37 0.93	0.16 0.02	0.006 0.009	0.005 0.010	–0.023 0.017	–0.2 0.3	2.0 0.3	20 49
Spring 9A	09/30	UF	–79 640									
Spring 9B	09/30	F		–0.6 0.5	–0.03 0.26	0.13 0.02	–0.008 0.005	–0.002 0.007	–0.020 0.017	0.0 0.3	1.5 0.3	–7 48
Spring 9B	09/30	UF	–129 630									
Doe Spring	09/30	F		0.0 0.4	–1.37 0.36	0.26 0.03	0.009 0.010	0.007 0.011	0.015 0.019	–0.3 0.3	1.4 0.3	1 49
Doe Spring	09/30	UF	101 650									
Spring 10	09/30	F		0.4 0.3	–0.80 0.29	0.71 0.08	–0.011 0.009	–0.012 0.010	–0.020 0.010	0.8 0.4	1.5 0.3	6 49
Spring 10	09/30	UF	131 650									
White Rock Canyon Group III:												
Spring 1	09/28	F		–0.3 0.4	0.93 0.40	2.17 0.22	–0.005 0.014	0.019 0.012	0.004 0.017	2.3 1.1	3.2 0.4	–19 48
Spring 1	09/28	UF	61 650									
Spring 2	09/28	F		–0.6 0.5	–1.97 0.36	1.56 0.16	–0.006 0.004	0.003 0.008	0.030 0.020	1.3 0.8	2.2 0.7	–16 48
Spring 2	09/28	UF	–29 640									
White Rock Canyon Group IV:												
La Mesita Spring	09/08	F		0.5 0.4	–0.98 0.02	10.56 1.06	0.016 0.009	0.011 0.010	0.005 0.017	10.2 2.6	6.1 0.7	–32 49
La Mesita Spring	09/08	UF	21 640									
Other Springs:												
Sacred Spring	09/08	F		0.3 0.4	–0.27 0.29	1.76 0.18	–0.011 0.001	–0.010 0.006	0.034 0.020	1.8 1.0	2.8 0.3	19 49
Sacred Spring	09/08	UF	–99 630									
Canyon Alluvial Groundwater Systems												
Acid/Pueblo Canyons:												
APCO-1	09/03	UF	521 770	0.1 0.4	–0.92 0.10	0.50 0.06	–0.011 0.006	0.083 0.018	0.141 0.026	0.7 1.4	9.0 1.3	39 49
Cañada del Buey:												
CDBO-6	05/26	UF	61 670	0.9 1.1	0.57 2.33	0.84 0.09	0.019 0.023	0.004 0.019	–0.002 0.020	43.1 11.8	45.5 3.7	–20 48

Table 5-12. Radiochemical Analyses of Groundwater for 1998 (pCi/L[a]) (Cont.)

Station Name	Date	Code[b]	^{3}H	^{90}Sr	^{137}Cs	U (µg/L)	^{238}Pu	$^{239,240}Pu$	^{241}Am	Gross Alpha	Gross Beta	Gross Gamma
Canyon Alluvial Groundwater Systems (Cont.)												
DP/Los Alamos Canyons:												
LAO-C	11/09	UF	1 670	0.4 0.5	1.12 3.17	0.04 0.01	0.010 0.021	0.002 0.018	0.081 0.037	0.3 0.3	2.0 0.3	17 49
LAO-0.7	11/09	UF	1 670	0.7 0.4	0.02 1.51	0.13 0.02	0.014 0.021	0.148 0.032	-0.027 0.025	2.3 1.0	4.2 5.3	-2 49
LAO-1	11/09	UF	-209 660	5.4 0.7	-0.67 0.48	0.09 0.02	-0.007 0.016	0.013 0.015	-0.044 0.023	-30.0 3.3	12.9 0.9	58 49
DP Spring	09/02	F		68.8 4.0	-0.32 1.00	0.32 0.04	0.007 0.011	0.008 0.014	0.043 0.023	-2.2 32.0	113.3 7.7	103 49
DP Spring	09/02	UF	361 760									
LAO-2	08/31	UF	461 770	13.6 1.1	-0.25 1.12	0.10 0.02	-0.004 0.010	0.020 0.015	0.011 0.020	-0.3 3.2	30.5 2.0	18 48
LAO-3A	08/31	UF	351 760	33.9 2.2	0.29 0.33	0.12 0.02	-0.005 0.008	0.011 0.013	0.004 0.017	-0.7 8.0	72.5 4.4	27 48
LAO-4	11/09	UF	-149 660	3.6 0.6	0.57 2.33	0.06 0.01	-0.017 0.006	0.001 0.011	-0.017 0.025	0.2 2.4	11.0 0.8	98 49
LAO-4.5C	05/14	UF	221 670	2.0 0.9	-1.51 0.72	0.68 0.07	-0.018 0.011	0.042 0.019	0.002 0.012	0.6 1.3	5.8 0.5	-16 48
LAO-6A	05/14	UF	171 670	2.0 0.9	-1.21 0.72	0.22 0.03	0.010 0.012	0.025 0.013	0.001 0.013	1.1 0.7	4.2 0.4	-4 48
LAO-6A	05/14	UF	291 680	2.0 0.8	-1.28 0.72	0.16 0.02	-0.011 0.008	0.007 0.015	-0.003 0.012	-0.2 1.0	5.0 0.4	-9 48
Otowi Spring	09/08	F		0.1 0.5	0.08 1.60	1.54 0.16	-0.008 0.005	0.001 0.009	0.018 0.018	0.5 1.1	3.5 0.6	14 49
Otowi Spring	09/08	UF	311 660									
Mortandad Canyon:												
MCO-3	08/20	UF	19,211 1,600	45.9 2.7	2.97 0.67	5.99 0.61	0.848 0.049	0.205 0.024	0.498 0.050	8.1 8.8	89.4 6.1	19 49
MCO-4B	05/27	UF	12,711 1,300	48.4 3.6	0.57 2.33	0.99 0.11	0.014 0.016	0.037 0.015	1.038 0.074	-5.0 52.6	264.3 17.1	-35 48
MCO-5	05/27	UF	14,011 1,400	36.0 3.0	0.09 1.61	0.85 0.09	0.023 0.013	0.017 0.013	0.907 0.068	-1.6 19.3	162.3 10.3	-13 48
MCO-5	05/27	UF	16,111 1,400	31.2 2.7	0.43 0.38	0.85 0.09	0.025 0.013	0.011 0.013	0.896 0.066	-3.8 27.8	191.4 12.1	-43 48
MCO-6B	05/27	UF	18,011 1,500	11.1 1.4	-0.21 1.17	2.54 0.26	0.021 0.014	0.039 0.019	0.727 0.061	6.9 17.7	107.3 7.3	7 48
MCO-7A	05/28	UF	18,311 1,500	1.8 0.9	-0.61 0.57	2.01 0.21	0.008 0.015	-0.005 0.013	0.517 0.061	-2.0 13.1	63.1 4.7	-13 48
MCO-7.5	05/28	UF	17,211 1,500	0.7 0.8	-0.51 0.71	1.55 0.16	0.005 0.012	-0.005 0.012	0.280 0.040	3.1 11.8	59.9 4.4	-38 48
MT-3	09/04	UF	18,511 1,600	0.5 0.4	-0.92 0.10	1.92 0.20	0.005 0.014	-0.001 0.012	0.482 0.050	1.5 3.5	27.2 2.1	4 48
MT-4	05/14	UF	17,811 1,500	0.4 0.8	-1.16 0.72	2.81 0.29	0.002 0.014	0.009 0.012	0.290 0.034	-0.7 5.7	25.6 2.0	-31 48
Pajarito Canyon:												
PCO-1	04/30	F		0.7 0.7	-0.25 1.12	0.06 0.01	-0.009 0.013	-0.003 0.013	-0.025 0.009	-0.5 0.6	3.4 0.3	-30 48
PCO-1	04/30	UF	341 710									
PCO-3	05/13	UF	331 680	1.9 1.2	-1.16 0.72	4.55 0.46	0.013 0.016	0.012 0.015	-0.016 0.010	-0.7 1.2	-1.7 1.3	-39 48
Intermediate Perched Groundwater Systems												
Pueblo/Los Alamos/Sandia Canyon Area Perched System in Conglomerates and Basalt:												
Test Well 1A	05/29	UF	-119 660	0.4 0.8	0.31 0.29	0.05 0.01	0.014 0.012	0.001 0.010	-0.008 0.014	1.2 3.2	12.3 1.9	-43 48
Test Well 2A	09/01	UF	3,301 920	0.3 0.4	-0.25 0.26	-0.06 0.01	-0.034 0.024	-0.010 0.020	0.043 0.031	-0.8 0.5	1.3 0.6	-42 48
Basalt Spring	06/04	F		0.1 0.9	-0.91 0.12	0.26 0.03	-0.002 0.013	0.038 0.015	0.015 0.020	0.0 1.8	6.2 0.6	7 48
Basalt Spring	06/04	UF	21 630									

Table 5-12. Radiochemical Analyses of Groundwater for 1998 (pCi/L[a]) (Cont.)

Station Name	Date	Code[b]	^{3}H		^{90}Sr		^{137}Cs		U (µg/L)		^{238}Pu		$^{239,240}Pu$		^{241}Am		Gross Alpha		Gross Beta		Gross Gamma	
Intermediate Perched Groundwater Systems (Cont.)																						
Perched Groundwater System in Volcanics:																						
Water Canyon Gallery	07/27	UF	–249	630	0.8	0.7	–0.12	1.30	0.34	0.04	0.000	0.011	0.003	0.013	–0.012	0.012	0.2	0.3	1.7	0.3	28	49
San Ildefonso Pueblo:																						
LA-5	08/05	UF	–209	650	0.2	0.3	0.34	2.00	1.05	0.11	–0.009	0.004	0.013	0.017	–0.003	0.018	1.2	0.8	2.4	0.3	13	48
Eastside Artesian Well	08/05	UF	–29	660	–0.3	0.4	0.23	1.83	–0.06	0.01	–0.002	0.008	–0.006	0.007	0.011	0.021	–0.6	0.6	1.0	0.4	9	48
Pajarito Well (Pump 1)	06/04	UF	71	640	0.1	1.1	–0.75	0.72	10.05	1.01	–0.011	0.008	–0.005	0.013	0.015	0.019	–0.3	0.8	–0.9	0.8	–9	48
Don Juan Playhouse Well	08/05	UF	121	670	–0.2	0.6	0.57	0.34	16.31	1.64	0.005	0.010	–0.008	0.007	0.017	0.018	12.1	3.3	6.8	0.7	32	48
Otowi House Well	08/05	UF	231	680	0.2	0.3	1.12	3.17	3.70	0.38	–0.001	0.005	0.000	0.008	0.032	0.023	1.8	1.3	3.1	1.1	–23	48
New Community Well	06/04	UF	41	640	0.1	0.7	–0.95	0.06	22.99	2.31	0.028	0.014	–0.008	0.007	0.026	0.024	26.6	7.4	12.4	1.1	–1	48
Sanchez House Well	08/05	UF	–119	650	0.6	0.3	0.34	2.00	14.76	1.48	0.007	0.013	0.006	0.013	0.024	0.026	13.0	3.7	6.5	1.3	21	48
Limits of Detection			700		3.0		4		0.1		0.04		0.04		0.04		3		3		120	
Water Quality Standards[c]																						
DOE DCG for Public Dose			2,000,000		1,000		3,000		800		40		30		30		30		1,000			
DOE Drinking Water System DCG			80,000		40		120		30		1.6		1.2		1.2		1.2		40			
EPA Primary Drinking Water Standard			20,000		8				20								15					
EPA Screening Level																			50			
NMWQCC Groundwater Limit									5,000													

[a]Except where noted. Two columns are listed: the first is the analytical result; the second is the radioactive counting uncertainty (1 std dev). Radioactivity couning uncertainties may be less than analytical method uncertainties.

[b]Codes: UF–unfiltered; F–filtered.

[c]Standards given here for comparison only, see Appendix A.

Table 5-13. Detections of Radionuclides[a] and Comparison to Derived Concentration Guides[b] in Groundwater for 1998

Station Name	Date	Code[c]	Analyte	Value	Uncertainty[d]	Units	Detection Limit	DOE DCG	Ratio of Value to DCG	Minimum Standard	Minimum Standard Type
APCO-1	09/03	UF	^{241}Am	0.141	0.026	pCi/L	0.04				
APCO-1	09/03	UF	^{239,240}Pu	0.083	0.018	pCi/L	0.04				
CDBO-6	05/26	UF	Alpha	43.1	11.8	pCi/L	3	30	1.44	15	EPA Primary Drinking Water Standard
CDBO-6	05/26	UF	Beta	45.5	3.7	pCi/L	3				
Don Juan Playhouse Well	08/05	UF	Alpha	12.1	3.3	pCi/L	3				
Don Juan Playhouse Well	08/05	UF	U	16.31	1.64	µg/L	0.1				
DP Spring	09/02	F	Beta	113.3	7.7	pCi/L	3	1,000	0.11	50	EPA Screening Level
DP Spring	09/02	F	^{90}Sr	68.8	4.0	pCi/L	3	1,000	0.07	8	EPA Primary Drinking Water Standard
La Mesita Spring	09/08	F	Alpha	10.2	2.6	pCi/L	3				
La Mesita Spring	09/08	F	U	10.56	1.06	µg/L	0.1				
LAO-0.7	11/09	UF	^{239,240}Pu	0.148	0.032	pCi/L	0.04				
LAO-1	11/09	UF	^{90}Sr	5.4	0.7	pCi/L	3				
LAO-2	08/31	UF	Beta	30.5	2.0	pCi/L	3				
LAO-2	08/31	UF	^{90}Sr	13.6	1.1	pCi/L	3				
LAO-3A	08/31	UF	Beta	72.5	4.4	pCi/L	3	1,000	0.07	50	EPA Screening Level
LAO-3A	08/31	UF	^{90}Sr	33.9	2.2	pCi/L	3				
LAO-4	11/09	UF	^{90}Sr	3.6	0.6	pCi/L	3				
MCO-3	08/20	UF	^{241}Am	0.498	0.050	pCi/L	0.04				
MCO-3	08/20	UF	Beta	89.4	6.1	pCi/L	3	1,000	0.09	50	EPA Screening Level
MCO-3	08/20	UF	^{3}H	19,211	1,600	pCi/L	700				
MCO-3	08/20	UF	^{238}Pu	0.848	0.049	pCi/L	0.04				
MCO-3	08/20	UF	^{239,240}Pu	0.205	0.024	pCi/L	0.04				
MCO-3	08/20	UF	^{90}Sr	45.9	2.7	pCi/L	3	1,000	0.05	8	EPA Primary Drinking Water Standard
MCO-3	08/20	UF	U	5.99	0.61	µg/L	0.1				
MCO-4B	05/27	UF	^{241}Am	1.038	0.074	pCi/L	0.04				
MCO-4B	05/27	UF	Beta	264.3	17.1	pCi/L	3	1,000	0.26	50	EPA Screening Level
MCO-4B	05/27	UF	^{3}H	12,711	1,300	pCi/L	700				
MCO-4B	05/27	UF	^{90}Sr	48.4	3.6	pCi/L	3	1,000	0.05	8	EPA Primary Drinking Water Standard
MCO-5	05/27	UF	^{241}Am	0.907	0.068	pCi/L	0.04				
MCO-5	05/27	UF	^{241}Am	0.896	0.066	pCi/L	0.04				
MCO-5	05/27	UF	Beta	162.3	10.3	pCi/L	3	1,000	0.16	50	EPA Screening Level
MCO-5	05/27	UF	Beta	191.4	12.1	pCi/L	3	1,000	0.19	50	EPA Screening Level
MCO-5	05/27	UF	^{3}H	16,111	1,400	pCi/L	700				
MCO-5	05/27	UF	^{3}H	14,011	1,400	pCi/L	700				
MCO-5	05/27	UF	^{90}Sr	36.0	3.0	pCi/L	3				

Table 5-13. Detections of Radionuclides[a] and Comparison to Derived Concentration Guides[b] in Groundwater for 1998 (Cont.)

Station Name	Date	Code[c]	Analyte	Value	Uncertainty[d]	Units	Detection Limit	DOE DCG	Ratio of Value to DCG	Minimum Standard	Minimum Standard Type
MCO-5	05/27	UF	^{90}Sr	31.2	2.7	pCi/L	3				
MCO-6B	05/27	UF	^{241}Am	0.727	0.061	pCi/L	0.04				
MCO-6B	05/27	UF	Beta	107.3	7.3	pCi/L	3	1,000	0.11	50	EPA Screening Level
MCO-6B	05/27	UF	^{3}H	18,011	1,500	pCi/L	700				
MCO-6B	05/27	UF	^{90}Sr	11.1	1.4	pCi/L	3				
MCO-7.5	05/28	UF	^{241}Am	0.280	0.040	pCi/L	0.04				
MCO-7.5	05/28	UF	Beta	59.9	4.4	pCi/L	3	1,000	0.06	50	EPA Screening Level
MCO-7.5	05/28	UF	^{3}H	17,211	1,500	pCi/L	700				
MCO-7A	05/28	UF	^{241}Am	0.517	0.061	pCi/L	0.04				
MCO-7A	05/28	UF	Beta	63.1	4.7	pCi/L	3	1,000	0.06	50	EPA Screening Level
MCO-7A	05/28	UF	^{3}H	18,311	1,500	pCi/L	700				
MT-3	09/04	UF	^{241}Am	0.482	0.050	pCi/L	0.04				
MT-3	09/04	UF	Beta	27.2	2.1	pCi/L	3				
MT-3	09/04	UF	^{3}H	18,511	1,600	pCi/L	700				
MT-4	05/14	UF	^{241}Am	0.290	0.034	pCi/L	0.04				
MT-4	05/14	UF	Beta	25.6	2.0	pCi/L	3				
MT-4	05/14	UF	^{3}H	17,811	1,500	pCi/L	700				
New Community Well	06/04	UF	Alpha	26.6	7.5	pCi/L	3	30	0.89	15	EPA Primary Drinking Water Standard
New Community Well	06/04	UF	U	22.99	2.31	µg/L	0.1				
Pajarito Well (Pump 1)	06/04	UF	U	10.05	1.01	µg/L	0.1				
Sanchez House Well	08/05	UF	Alpha	13.0	3.7	pCi/L	3				
Sanchez House Well	08/05	UF	U	14.76	1.48	µg/L	0.1				
Test Well 2A	09/01	UF	^{3}H	3,301	920	pCi/L	700				
G-5	11/11	UF	U	5.85	0.59	µg/L	0.1				

[a] Detection defined as value ≥ 3× uncertainty and ≥ detection limit, except values shown for uranium ≥ 5 µg/L, for gross alpha ≥ 5 pCi/L, and for gross beta ≥ 20 pCi/L.
[b] Values indicated by entries in right-hand columns are greater than 1/25 of the DOE public dose DCG and greater than the minimum standard shown. The minimum standard is either a DOE DCG for DOE-administered drinking water systems or an EPA drinking water standard.
[c] Codes: UF-unfiltered; F–filtered.
[d] One standard deviation radioactivity counting uncertainty.

Table 5-14. Chemical Quality of Groundwater for 1998 (mg/L[a])

Station Name	Date	Code[b]	SiO_2	Ca	Mg	K	Na	Cl	SO_4	CO_3 Alkalinity	Total Alkalinity	F	PO_4-P	NO_3-N	CN	TDS[c]	TSS[d]	Hardness as $CaCO_3$	pH[e]	Conductance (µS/cm)
Regional Aquifer Wells																				
Test Wells:																				
Test Well 1	05/28	UF	44	47.4	9.2	2.2	16.2	34.0	22	<5	109	0.42	<0.02	5.27		304	150	156.4	7.7	406
Test Well 1	05/29	UF													0.01					
Test Well 3	09/01	UF	82	16.9	5.2	1.9	11.9	3.9	4	<5	80	0.36	0.02	0.65	<0.01	238	<1	63.5	6.1	175
Test Well 4	09/01	UF	65	10.5	5.6	2.0	9.9	3.1	3	<5	64	0.18	0.02	0.32	<0.01	202	5	49.4	7.6	141
Test Well 8	09/02	UF	71	11.6	3.9	1.5	10.6	3.6	3	<5	65	0.15	<0.02	0.28	<0.01	144	<1	45.2	7.4	132
Test Well 8	09/02	UF	70	10.7	3.7	<1.0	10.2	3.5	3	<5	61	0.15	0.02	0.26	<0.01	140	<1	41.9	7.5	132
Test Well DT-5A	11/05	UF	70	8.2	2.2	<1.0	10.1	3.6	3	<5	50	0.20	0.03	0.31	<0.01	120	<1	29.6	7.8	111
Test Well DT-9	11/05	UF	69	9.0	2.4	<1.0	9.4	3.7	3	<5	57	0.24	0.02	0.33	<0.01	140	<1	32.6	7.9	116
Test Well DT-10	11/06	UF	64	11.3	3.3	<1.0	10.3	3.6	3	<5	73	0.21	0.02	0.23	<0.01	138	<1	42.0	8.0	131
Water Supply Wells:																				
O-1	06/08	UF	62	10.9	1.5	<1.1	38.5	6.0	7	<5	108	0.30	0.03	1.12	<0.01	221	<1	33.6	8.7	240
O-1	11/12	UF	69	16.1	2.3	2.9	21.7	6.7	7	<5	97	0.33	<0.02	1.11	<0.01	194	<1	49.8	8.3	211
O-4	11/12	UF	95	18.9	6.7	3.0	15.8	9.1	6	<5	126	0.27	0.02	0.33	<0.01	224	1	74.6	7.7	260
PM-1	06/08	UF	83	25.9	7.0	2.7	20.1	6.0	6	<5	108	0.21	0.03	0.49	<0.01	228	<1	93.3	8.3	252
PM-2	06/08	UF	92	9.9	3.4	1.5	11.1	3.0	3	<5	65	0.25	0.03	0.33	<0.01	167	<1	38.8	8.1	126
PM-3	06/08	UF	95	23.4	7.7	2.6	17.3	7.0	6	<5	109	0.25	0.03	0.47	<0.01	234	<1	90.1	7.9	254
PM-4	07/27	UF	90	8.3	2.9	<1.0	9.6	3.9	3	<5	65	0.26	0.05	0.35	<0.01	150	<1	10.3	7.8	140
PM-5	06/08	UF	91	12.6	5.2	1.3	12.1	3.0	3	<5	72	0.24	0.03	0.30	<0.01	176	<1	52.8	8.0	148
G-1	11/11	UF	63	16.3	3.5	2.2	10.3	4.7	5	<5	80	0.22	<0.02	0.67	<0.01	120	<1	55.2	8.1	169
G-1A	06/08	UF	76					3.0	5	<5	79	0.47	0.03	0.44	<0.01	191	<1		8.6	168
G-1A	06/08	UF	77	11.1	1.1	1.9	25.0	3.0	5	<5	75	0.46	0.03	0.43	<0.01	229	<1	32.4	8.6	168
G-1A	06/08	UF		11.0	1.4	1.9	23.8											33.1		
G-2	06/08	UF	60	13.0	0.9	2.3	34.0	3.0	6	<5	96	0.91	0.03	0.43	<0.01	201	<1	36.3	8.3	222
G-5	11/11	UF	63	16.2	3.5	2.5	10.5	4.8	5	<5	75	0.22	<0.02	0.68	<0.01	126	<1	54.9	8.1	169
G-6	06/08	UF	59	13.7	2.2	1.4	16.5	3.0	4	<5	72	0.27	0.03	0.44	<0.01	148	<1	43.3	8.5	158
Regional Aquifer Springs																				
White Rock Canyon Group I:																				
Sandia Spring	09/28	F	50	35.2	2.2	2.1	15.3	5.1	5	<5	130	0.45	<0.02	0.04		200		97.2	7.7	264
Sandia Spring	09/28	U													<0.01					
Spring 3A	09/28	F	53	16.6	1.4	2.7	12.7	4.6	5	<5	66	0.34	<0.02	0.84		142		47.1	7.9	182
Spring 3A	09/28	UF													<0.01					
Spring 4	09/28	F	69	19.4	4.2	2.9	12.7	7.4	6	<5	87	0.36	0.03	0.74		192		65.6	7.9	202
Spring 4	09/28	UF													<0.01					
Spring 4A	09/29	F	70	19.8	4.3	<2.0	13.0	6.0	6	<5	86	0.38	0.06	0.72		198		67.3	7.8	190
Spring 4A	09/29	UF													<0.01		<1			
Ancho Spring	09/29	F	77	0.9	0.2	<1.0	0.8	3.7	3	<5	54	0.29	0.03	0.38		162		3.0	7.5	125
Ancho Spring	09/29	UF													<0.01		2			

Table 5-14. Chemical Quality of Groundwater for 1998 (mg/L[a]) (Cont.)

Station Name	Date	Code[b]	SiO_2	Ca	Mg	K	Na	Cl	SO_4	CO_3 Alkalinity	Total Alkalinity	F	PO_4-P	NO_3-N	CN	TDS[c]	TSS[d]	Hardness as $CaCO_3$	pH[e]	Conductance (µS/cm)
Regional Aquifer Springs (Cont.)																				
White Rock Canyon Group II:																				
Spring 5A	09/29	F	56	22.9	2.4	2.5	24.7	5.5	8	<5	110	0.31	0.02	0.30		188		67.3	7.5	234
Spring 5A	09/29	UF													<0.01		44			
Spring 6	09/29	F	74	11.9	3.4	1.5	10.0	3.8	4	<5	63	0.29	0.03	0.37		170		43.8	7.2	135
Spring 6	09/29	F	54	20.2	2.6	2.0	13.5	4.8	6	<5	83	0.31	<0.02	0.48		170		60.9	7.7	182
Spring 6	09/29	UF													<0.01		9			
Spring 6	09/29	UF													<0.01		1,180			
Spring 8A	09/29	F	81	8.3	2.5	<1.6	10.9	3.6	3	<5	53	0.30	0.04	0.24		146		31.0	7.4	112
Spring 8A	09/29	UF													<0.01		<1			
Spring 9A	09/30	F	75	10.6	3.0	1.7	10.9	4.4	3	<5	59	0.40	0.03	0.11		150		38.6	7.7	127
Spring 9A	09/30	UF													<0.01		110			
Spring 9B	09/30	F	74	1.0	0.2	<1.0	1.0	4.0	3	<5	58	0.39	0.04	0.14		164		3.5	7.2	125
Spring 9B	09/30	UF													<0.01		97			
Doe Spring	09/30	F	74	10.6	2.9	<1.3	10.7	3.9	3	<5	57	0.39	<0.02	0.04		144		38.7	8.0	125
Doe Spring	09/30	UF													<0.01		4			
Spring 10	09/30	F	72	14.0	2.7	1.3	10.4	3.7	3	<5	68	0.39	0.05	0.43		166		45.9	7.9	152
Spring 10	09/30	UF													<0.01		86			
White Rock Canyon Group III:																				
Spring 1	09/28	F	34	16.4	1.0	1.8	29.5	4.8	7	<5	102	0.45	<0.02	0.39		166		45.1	7.8	219
Spring 1	09/28	UF													<0.01		191			
Spring 2	09/28	F	35	18.5	0.9	1.2	48.7	4.6	6	<5	148	1.11	<0.02	0.04		226		49.8	8.2	289
Spring 2	09/28	UF													<0.01		8			
White Rock Canyon Group IV:																				
La Mesita Spring	09/08	F	30	31.7	0.9	<4.7	26.1	7.4	13	<5	125	0.21	<0.02	2.22		198		82.9	8.1	297
La Mesita Spring	09/08	UF													<0.01		49			
Other Springs:																				
Sacred Spring	09/08	F	46	26.4	1.4	2.4	19.4	3.9	7	<5	107	0.38	<0.02	0.28		178		71.5	7.9	236
Sacred Spring	09/08	UF													<0.01		5			
Canyon Alluvial Groundwater Systems																				
Acid/Pueblo Canyons:																				
APCO-1	09/03	F	81	19.5	5.2	11.7	68.4	39.0	13	<5	155	0.43	6.32	0.69		354		70.4	6.9	474
APCO-1	09/03	UF		20.0	5.4	12.0	71.7								<0.01		2			
Cañada del Buey:																				
CDBO-6	03/02	UF												0.05						
CDBO-6	05/26	F	56	15.1	3.3	<1.0	19.6	16.0	8	<5	72	0.22	0.18	0.17		224		51.3	7.3	198
CDBO-6	05/26	UF													0.01		361			
CDBO-7	03/02	UF												0.08						
CDBO-7	05/26	F		17.8	3.7	2.1	19.9											59.8		

Table 5-14. Chemical Quality of Groundwater for 1998 (mg/L[a]) (Cont.)

Station Name	Date	Code[b]	SiO_2	Ca	Mg	K	Na	Cl	SO_4	CO_3 Alkalinity	Total Alkalinity	F	PO_4-P	NO_3-N	CN	TDS[c]	TSS[d]	Hardness as $CaCO_3$	pH[e]	Conductance (µS/cm)
Canyon Alluvial Groundwater Systems (Cont.)																				
DP/Los Alamos Canyons:																				
LAO-C	11/09	F	39	10.9	2.7	3.2	25.7	36.0	6	<5	51	0.12	0.04	0.03		140			7.3	227
LAO-C	11/09	UF		10.8	2.7	3.3	25.1								<0.01		5			
LAO-0.7	11/09	F	36	12.6	2.7	3.0	34.0	54.0	6	<5	45	0.16	0.09	0.10		204			7.4	279
LAO-0.7	11/09	UF		12.5	2.5	3.4	32.0								<0.01		22			
LAO-1	11/09	F	39	12.1	2.9	4.1	25.7	36.0	6	<5	62	0.19	0.06	<0.02		166				
LAO-1	11/09	UF		11.9	2.6	3.2	28.7								<0.01		<1			
DP Spring	09/02	F	18	14.6	1.7	9.4	33.4	28.0	7	<5	74	1.04	0.12	0.34		160		43.3	7.9	260
DP Spring	09/02	UF													<0.01		<1			
LAO-2	08/31	F	44	18.1	4.8	5.8	30.1	19.0	8	<5	91	0.51	0.12	0.65		360		65.0	6.6	278
LAO-2	08/31	UF		18.4	5.0	6.4	30.5								<0.01		<1			
LAO-3A	08/31	F	57	17.9	3.8	5.9	27.4	19.0	9	<5	82	0.62	0.15	0.63		318		60.5	7.0	265
LAO-3A	08/31	UF													<0.01		<1			
LAO-4	11/09	F	44	12.1	2.9	3.9	25.3	20.7	10	<5	65	0.49	0.06	<0.02		168			7.2	223
LAO-4	11/09	UF		12.7	3.4	4.8	22.8								<0.01		<1			
LAO-4.5C	05/14	F	43	11.0	3.1	2.0	26.0	35.0	7	<5	46	0.67	<0.02	<0.02		128		40.2	6.9	230
LAO-4.5C	05/14	UF													<0.01		9			
LAO-6A	05/14	F	44	10.0	3.2	1.3	27.0	31.0	8	<5	45	0.50	<0.02	0.04		136		38.1	7.0	222
LAO-6A	05/14	F	44	10.0	3.2	1.3	27.0	31.0	7	<5	51	0.45	0.04	<0.02		144		38.1	7.1	218
LAO-6A	05/14	UF													<0.01		2			
LAO-6A	05/14	UF													<0.01		1			
Otowi Spring	09/08	F	58	49.4	4.6	2.6	33.1	32.9	21	<5	167	0.41	0.08	1.15		310		142.6	7.3	471
Otowi Spring	09/08	UF													<0.01		5			
Mortandad Canyon:																				
MCO-3	08/20	F	51	64.6	3.2	11.8	101.8	22.9	25	<5	218	1.08	0.13	35.00		962		176.0	7.4	815
MCO-3	08/20	UF													<0.01		<1			
MCO-4B	05/27	F	40	29.7	2.4	13.3	68.2	19.0	16	<5	152	1.40	0.06	16.20		410		84.1	7.5	528
MCO-4B	05/27	UF													0.01		8			
MCO-5	05/27	F	40	25.3	2.6	15.7	68.7	18.0	15	<5	159	1.47	0.08	15.50		418		74.1	7.4	513
MCO-5	05/27	F	43	25.3	2.7	15.5	69.2	18.0	15	<5	148	1.49	0.08	15.50		368		74.0	7.1	510
MCO-5	05/27	UF													0.01		1			
MCO-5	05/27	UF													0.01		1			
MCO-6B	05/27	F	38	23.5	3.9	17.4	81.4	18.0	16	<5	176	1.64	0.13	18.20		366		74.9	7.3	574
MCO-6B	05/27	UF													0.01		14			
MCO-7A	05/28	F	41	21.1	5.1	15.9	78.8	14.0	17	<5	<5	1.40	0.33	19.30		514		73.7	1.6	11,140
MCO-7A	05/28	UF													0.01		19			
MCO-7.5	05/28	F	40	20.8	5.0	7.2	87.7	18.0	16	<5	164	1.52	0.05	18.70		450		72.7	6.9	555
MCO-7.5	05/25	UF													0.01					

Table 5-14. Chemical Quality of Groundwater for 1998 (mg/L[a]) (Cont.)

Station Name	Date	Code[b]	SiO_2	Ca	Mg	K	Na	Cl	SO_4	CO_3 Alkalinity	Total Alkalinity	F	PO_4-P	NO_3-N	CN	TDS[c]	TSS[d]	Hardness as $CaCO_3$	pH[e]	Conductance (µS/cm)
Canyon Alluvial Groundwater Systems (Cont.)																				
Mortandad Canyon: (Cont.)																				
MT-3	09/04	F	37	20.5	5.1	8.1	91.1	18.0	16	<5	169	1.66	0.10	20.00		404		72.2	7.5	561
MT-3	09/04	UF		21.0	5.2	8.7	94.4								<0.01					
MT-4	05/14	F	43	18.0	4.2	2.6	98.0	18.0	16	<5	160	0.95	0.09	19.30		202		62.2	7.2	565
MT-4	05/14	UF													<0.01		4			
Pajarito Canyon:																				
PCO-1	04/30	F	35	13.0	3.8	3.1	17.0	24.0	8	<5	58	0.09	0.04	0.08		130		48.1	6.7	216
PCO-1	04/30	UF													<0.01		2			
PCO-3	05/13	F	43	210.0	44.0	2.0	210.0	382.0	11	11	640	0.38	<0.02	0.03		1,450		705.6	7.4	2,250
PCO-3	05/13	UF													<0.01		6			
Intermediate Perched Groundwater Systems																				
Pueblo/Los Alamos/Sandia Canyon Area Perched System in Conglomerates and Basalt:																				
Test Well 1A	05/29	UF	4	15.9	5.2	3.8	48.8	53.0	7	<5	91	0.63	0.46	<0.02	0.01	170	9	60.9	8.0	372
Test Well 2A	09/01	UF	27	31.8	5.7	2.3	16.9	60.0	7	<5	57	0.20	0.08	0.40	<0.01	740	45	102.8	5.7	341
Basalt Spring	06/04	F	61	23.7	5.8	7.4	52.2	46.0	30	<5	121	0.40	2.67	4.78		312		83.0	7.2	450
Basalt Spring	06/04	UF													<0.01		9			
Perched Groundwater System in Volcanics:																				
Water Canyon Gallery	07/27	UF	90	2.6	0.9	<1.3	2.9	3.9	3	<5	64	0.25	0.03	0.33	<0.01	160	<1	32.6	7.6	138
San Ildefonso Pueblo:																				
LA-5	08/05	F	43	19.3	0.8	<2.2	15.2	4.0	6	<5	71	0.44	0.02	0.60		139		51.0	7.3	170
LA-5	08/05	UF													<0.01		<1			
Eastside Artesian Well	08/05	F	1	2.8	0.2	<1.0	89.9	4.7	14	35	194	0.82	0.02	0.02		221		7.8	9.1	386
Eastside Artesian Well	08/05	UF													<0.01		<1			
Pajarito Well (Pump 1)	06/04	F	42	53.9	5.2	4.1	303.8	199.0	49	<5	544	0.41	<0.02	0.43		984		156.2	7.7	1,690
Pajarito Well (Pump 1)	06/04	UF													<0.01		17			
Don Juan Playhouse Well	08/05	F	26	23.2	2.3	1.8	49.6	6.8	18	<5	149	0.51	0.02	1.16		228		67.0	8.6	339
Don Juan Playhouse Well	08/05	UF													<0.01		1			
Otowi House Well	08/05	F	58	72.0	5.5	<4.1	46.3	53.4	32	<5	212	0.34	0.03	1.95		409		202.0	7.3	608
Otowi House Well	08/05	UF													<0.01		<1			
New Community Well	06/04	F	30	15.9	0.9	<8.0	79.2	10.0	41	<5	181	0.74	0.03	3.07		286		43.6	8.7	446
New Community Well	06/04	UF													<0.01		3			
Sanchez House Well	08/05	F	42	37.9	2.6	2.2	109.9	59.0	61	<5	206	1.08	0.03	1.12		1,275		105.0	8.0	695
Sanchez House Well	08/05	UF													<0.01		<1			

Table 5-14. Chemical Quality of Groundwater for 1998 (mg/L[a]) (Cont.)

Station Name	Date	Code[b]	SiO_2	Ca	Mg	K	Na	Cl	SO_4	CO_3 Alkalinity	Total Alkalinity	F	PO_4-P	NO_3-N	CN	TDS[c]	TSS[d]	Hardness as $CaCO_3$	pH[e]	Conductance (µS/cm)
Water Quality Standards[g]																				
EPA Primary Drinking Water Standard									500			4		10	0.2					
EPA Secondary Drinking Water Standard								250	250							500		6.8–8.5		
EPA Health Advisory							20													
NMWQCC Groundwater Limit								250	600			1.6		10	0.2	1,000		6–9		

[a] Except where noted.
[b] Codes: UF–unfiltered: F–filtered.
[c] Total dissolved solids.
[d] Total suspended solids.
[e] Standard units.
[f] Less than symbol (<) means measurement was below the specified limit of detection of the analytical method.
[g] Standards given here for comparison only, see Appendix A.

Table 5-15. Trace Metals in Groundwater for 1998 (µg/L)

Station Name	Date	F/UF[a]	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg
Regional Aquifer Wells														
Test Wells:														
Test Well 1	05/28	UF	<10[b]	612	<2	62	87	<3	<7	<8	<7	<10	1,902	<0.2
Test Well 3	09/01	UF	<10	<50	2	47	26	<3	<7	<8	<7	<10	384	<0.2
Test Well 4	09/01	UF	<10	85	<2	<20	63	<3	<7	<8	<7	31	1,520	<0.2
Test Well 8	09/02	UF	<10	<50	<2	33	8	<3	<7	<8	<7	<10	117	<0.2
Test Well 8	09/02	UF	<10	<50	<2	25	8	<3	<7	<8	<7	<10	135	<0.2
Test Well DT-5A	11/05	UF	<10	<50	2	29	22	<3	<7	<8	<7	<10	<40	<0.2
Test Well DT-9	11/05	UF	<10	<50	<2	<20	15	<3	<7	<8	<7	<10	<40	<0.2
Test Well DT-10	11/06	UF	25	<50	<2	20	7	<3	<7	<8	<7	<10	<40	<0.2
Water Supply Wells:														
O-1	06/08	UF	<10	<50	<2	42	20	<3	<7	<8	7	<10	55	<0.2
O-1	11/12	UF	<10	<50		<20	34	<3	<7	<8	<7	27	<40	
O-4	11/12	UF	<10	<50		<20	38	<3	<7	<8	<7	144	63	
PM-1	06/08	UF	<10	54	<2	42	79	<3	<7	<8	<7	<10	<40	<0.2
PM-2	06/08	UF	<10	74	<2	<20	32	<3	<7	<8	7	<10	<40	<0.2
PM-3	06/08	UF	<10	<50	<2	49	50	<3	<7	<8	<7	<10	<40	<0.2
PM-4	07/27	UF	<10	<50		<20	21	<3	<7	<8	<7	<10	<40	
PM-5	06/08	UF	<10	<50	<2	20	31	<3	<7	<8	<7	<10	<40	<0.2
G-1	11/11	UF	<10	<50		<20	13	<3	<7	<8	<7	<10	<40	
G-1A	06/08	UF	<10	<50	8	29	37	<3	<7	<8	8	<10	<40	<0.2
G-1A	06/08	UF	<10	<50	8	28	36	<3	<7	<8	9	<10	<40	<0.2
G-2	06/08	UF	<10	<50	52	44	28	<3	<7	<8	16	<10	<40	<0.2
G-5	11/11	UF	<10	<50		<20	14	<3	<3	<30	<7	<10	<40	
G-6	06/08	UF	<10	<50	3	<20	10	<3	<7	<8	<7	<10	<40	<0.2
Regional Aquifer Springs														
White Rock Canyon Group I:														
Sandia Spring	09/28	F	<10	<50		41	126	<3	<7	<8	<7	<10	<40	
Spring 3A	09/28	F	<10	<50	<2	33	30	<3	<7	<8	<7	<10	102	
Spring 3A	09/28	UF												<0.2
Spring 4	09/28	F	<10	<50	<2	28	45	<3	<7	<8	<7	<10	<40	
Spring 4	09/28	UF												<0.2
Spring 4A	09/29	F	<10	<50		28	40	<3	<7	<8	<7	<10	<40	
Ancho Spring	09/29	F	<10	<50		<20	1	<3	<7	<8	<7	<10	<40	
White Rock Canyon Group II:														
Spring 5A	09/29	F	<10	<50		39	35	<3	<7	<8	<7	<10	<40	
Spring 6	09/29	F	<10	<50		21	25	<3	<7	<8	<7	<10	<40	
Spring 6	09/29	F	<10	<50		22	41	<3	<7	<8	<7	<10	<40	
Spring 8A	09/29	F	<10	<50		22	17	<3	<7	<8	<7	<10	<40	

Table 5-15. Trace Metals in Groundwater for 1998 (µg/L) (Cont.)

Station Name	Date	F/UF[a]	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg
Regional Aquifer Springs (Cont.)														
White Rock Canyon Group I: (Cont.)														
Spring 9A	09/30	F	<10	<50		27	12	<3	<7	<8	<7	<10	<40	
Spring 9B	09/30	F	<10	<50		<20	<1	<3	<7	<8	<7	<10	<40	
Doe Spring	09/30	F	<10	<50		23	12	<3	<7	<8	<7	<10	<40	
Spring 10	09/30	F	<10	<50		28	17	<3	<7	<8	<7	<10	<40	
White Rock Canyon Group III:														
Spring 1	09/28	F	<10	<50		41	32	<3	<7	<8	<7	<10	<40	
Spring 2	09/28	F	<10	79	28	66	32	<3	<7	<8	<7	<10	53	
Spring 2	09/28	UF												<0.2
White Rock Canyon Group IV:														
La Mesita Spring	09/08	F												
Other Springs:														
Sacred Spring	09/08	F												
Canyon Alluvial Groundwater Systems														
Acid/Pueblo Canyons:														
APCO-1	09/03	F	<10	<50	7	273	45	<3	<7	<8	<7	<10	455	
APCO-1	09/03	UF	<10	<50	7	290	57	<3	<7	<8	<7	<10	735	<0.2
Cañada del Buey:														
CDBO-6	05/26	F	<10	1,201	<2	48	89	<3	<7	<8	<7	<10	677	
CDBO-6	05/26	UF	<10	24,145	6	47	208	4	<7	<8	12	<10	11,483	<0.2
CDBO-7	05/26	F	<10	76	<2	50	123	<3	<7	<8	<7	<10	1,465	
CDBO-7	05/26	UF	<10	93,840	28	55	3,132	18	<7	21	39	24	62,970	<0.2
DP/Los Alamos Canyons:														
LAO-C	11/09	F	<10	1,906	<2	<20	44	<3	<7	<8	<7	<10	557	
LAO-C	11/09	UF	<10	2,308	2	<20	45	<3	<7	<8	<7	<10	783	<0.2
LAO-0.7	11/09	F	<10	1,627	2	<20	49	<3	<7	<8	<7	13	318	
LAO-0.7	11/09	UF	<10	<50	2	<20	31	<3	<7	<8	<7	<10	<40	<0.2
LAO-1	11/09	F	<10	1,346	<2	<20	39	<3	<7	<8	8	<10	223	
LAO-1	11/09	UF	<10	1,630	<2	<20	34	<3	<7	<8	12	<10	303	<0.2
DP Spring	09/02	F	<10	272	2	43	41	<3	<7	<8	<7	<10	177	
DP Spring	09/02	UF												<0.2
LAO-2	08/31	F	<10	495	<2	59	53	<3	<7	<8	<7	<10	250	
LAO-2	08/31	UF	<10	423	2	58	56	<3	<7	<8	<7	<10	282	<0.2
LAO-3A	08/31	F	<10	250	2	60	49	<3	<7	<8	<7	<10	112	
LAO-3A	08/31	UF	<10	394	2	47	54	<3	<7	<8	<7	<10	187	<0.2

Table 5-15. Trace Metals in Groundwater for 1998 (µg/L) (Cont.)

Station Name	Date	F/UF[a]	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg
Canyon Alluvial Groundwater Systems (Cont.)														
DP/Los Alamos Canyons: (Cont.)														
LAO-4	11/09	F	<10	1,276	2	<20	41	<3	<7	<8	8	<10	181	
LAO-4	11/09	UF	<10	600	<2	<20	41	<3	<7	<8	<7	<10	<40	<0.2
LAO-4.5C	05/14	F	<10	270	<2	<20	35	<3	<7	<8	8	<10	54	
LAO-4.5C	05/14	UF	<10	1,200	<2	<20	39	<3	<7	<8	12	<10	420	<0.2
LAO-6A	05/14	F	<10	1,400	<2	35	31	<3	<7	<8	7	<10	530	
LAO-6A	05/14	F	<10	1,400	<2	35	31	<3	<7	<8	7	<10	530	
LAO-6A	05/14	UF	<10	1,800	<2	24	33	<3	<7	<8	9	<10	690	<0.2
LAO-6A	05/14	UF	<10	1,900	<2	30	32	<3	<7	<8	9	<10	710	<0.2
Otowi Spring	09/08	F	<10	<50	3	57	144	<3	<7	<8	<7	<10	<40	
Otowi Spring	09/08	UF												<0.2
Mortandad Canyon:														
MCO-3	08/20	F	<10	387	<2	170	65	<3	<7	<8	<7	15	<40	
MCO-3	08/20	UF	<10	359	<2	173	65	<3	<7	<8	<7	18	<40	<0.2
MCO-4B	05/27	F	<10	<50	<2	64	87	<3	<7	<8	<7	<10	<40	
MCO-4B	05/27	UF	<10	305	<2	69	88	<3	<7	<8	<7	<10	176	<0.2
MCO-5	05/27	F	<10	61	<2	77	87	<3	<7	<8	<7	<10	<40	
MCO-5	05/27	F	<10	56	<2	66	88	<3	<7	<8	<7	<10	<40	
MCO-5	05/27	UF	<10	180	<2	73	90	<3	<7	<8	21	<10	92	<0.2
MCO-5	05/27	UF	<10	145	<2	71	90	<3	<7	<8	<7	<10	47	<0.2
MCO-6B	05/27	F	<10	375	<2	73	176	<3	<7	<8	<7	<10	183	
MCO-6B	05/27	UF	<10	2,365	<2	71	193	<3	<7	<8	<7	<10	936	<0.2
MCO-7A	05/28	F	<10	181	<2	63	189	<3	<7	<8	<7	<10	58	
MCO-7A	05/28	UF	<10	1,422	<2	72	198	<3	<7	<8	<7	<10	665	<0.2
MCO-7.5	05/28	F	<10	174	<2	70	156	<3	<7	<8	<7	<10	57	
MCO-7.5	05/28	UF	<10	437	<2	73	157	<3	<7	<8	<7	<10	204	<0.2
MT-3	09/04	F	<10	66	<2	86	148	<3	<7	<8	<7	<10	250	
MT-3	09/04	UF	<10	<50	<2	82	150	<3	<7	<8	<7	<10	<40	<0.2
MT-4	05/14	F	<10	250	<2	81	110	<3	<7	<8	<7	<10	74	
MT-4	05/14	UF	<10	330	<2	57	110	<3	<7	<8	9	<10	73	<0.2
Pajarito Canyon:														
PCO-1	04/30	F	<10	290	<2	23	70	<3	<7	<8	<7	<10	210	
PCO-1	04/30	UF	<10	590	<2	26	71	<3	<7	<8	<7	<10	440	<0.2
PCO-3	05/13	F	<10	210	2	<20	480	<3	<7	15	<7	<10	2,000	
PCO-3	05/13	UF	<10	270	2	<20	470	<3	<7	11	<7	<10	1,200	<0.2

Table 5-15. Trace Metals in Groundwater for 1998 (µg/L) (Cont.)

Station Name	Date	F/UF[a]	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg
Intermediate Perched Groundwater Systems														
Pueblo/Los Alamos/Sandia Canyon Area Perched System in Conglomerates and Basalt:														
Test Well 1A	05/29	UF	<10	125	<2	179	71	<3	<7	<8	<7	<10	2,249	<0.2
Test Well 2A	09/01	UF	<10	<50	<2	85	42	<3	<7	<8	<7	<10	21,405	<0.2
Basalt Spring	06/04	F	<10	<50	4	228	70	<3	<7	<8	<7	<10	130	
Basalt Spring	06/04	UF												<0.2
Perched Groundwater System in Volcanics:														
Water Canyon Gallery	07/27	UF	11	<50		<20	7	<3	<7	<8	<7	<10	<40	
San Ildefonso Pueblo:														
LA-5	08/05	F	<10	<50	2	<20	66	<3	<7	<8	<7	<10	<40	
LA-5	08/05	UF	<10	<50	<2	<20	70	<3	<7	<8	<7	<10	61	<0.2
Eastside Artesian Well	08/05	F	<10	<50	<2	100	27	<3	<7	<8	<7	<10	42	
Eastside Artesian Well	08/05	UF	<10	<50	<2	105	6	<3	<7	<8	<7	<10	61	<0.2
Pajarito Well (Pump 1)	06/04	F	<10	<50	6	1,398	88	<3	<7	<8	<7	<10	102	
Pajarito Well (Pump 1)	06/04	UF	13	<50	7	1,455	86	<3	<7	<8	<7	<10	156	<0.2
Don Juan Playhouse Well	08/05	F	<10	<50	4	58	64	<3	<7	<8	<9	<10	<40	
Don Juan Playhouse Well	08/05	UF	<10	<50	4	68	66	<3	<7	<8	<7	<10	<40	<0.2
Otowi House Well	08/05	F	<10	<50	2	72	346	<3	<7	<8	<7	<10	<40	
Otowi House Well	08/05	UF	<10	<50	3	65	336	<3	<7	<8	<7	<10	68	<0.2
New Community Well	06/04	F	<10	<50	<2	48	19	<3	<7	<8	<7	13	49	
New Community Well	06/04	UF	15	<50	<2	46	17	<3	<7	<8	<7	<10	<40	<0.2
Sanchez House Well	08/05	F	<10	<50	9	285	118	<3	<7	<8	<7	<10	<40	
Sanchez House Well	08/05	UF	<10	<50	8	292	117	<3	<7	<8	<7	<10	<40	<0.2
Water Quality Standards[c]														
EPA Primary Drinking Water Standard					50		2,000	4	5		100			2
EPA Secondary Drinking Water Standard				50–200									300	
EPA Action Level												1,300		
EPA Health Advisory														
NMWQCC Livestock Watering Standard				5,000	200	5,000			50	1,000	1,000	500		10
NMWQCC Groundwater Limit			50	5,000	100	750	1,000		10	50	50	1,000	1,000	2

Table 5-15. Trace Metals in Groundwater for 1998 (µg/L) (Cont.)

Station Name	Date	F/UF[a]	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Ti	V	Zn
Regional Aquifer Wells													
Test Wells:													
Test Well 1	05/28	UF	65	<30	<20	97	9	<2	<30	268	<3	<8	1,176
Test Well 3	09/01	UF	13	<30	<20	3	<3	<2	<30	77	<3	<12	151
Test Well 4	09/01	UF	45	<30	<20	46	<3	<2	<30	51	<3	<8	1,807
Test Well 8	09/02	UF	4	<30	<20	5	<3	<2	<30	51	<3	<8	709
Test Well 8	09/02	UF	5	<30	<20	5	6	<2	<30	50	<3	<8	665
Test Well DT-5A	11/05	UF	3	<30	<20	<3	<3	3	<30	43	<3	<8	203
Test Well DT-9	11/05	UF	<3	<30	<20	<3	<3	3	<30	45	<3	<8	111
Test Well DT-10	11/06	UF	<2	<30	<20	<3	<3	3	<30	48	<3	<8	72
Water Supply Wells:													
O-1	06/08	UF	<2	<30	<20	<3	<3	<2	<49	67	<3	16	<50
O-1	11/12	UF	<2	<30	<20	6	<3		<30	102	<3	14	70
O-4	11/12	UF	17	<30	<20	<3	<3		<30	95	<3	14	<50
PM-1	06/08	UF	<2	<30	<20	<3	<3	<2	<49	136	<3	11	<50
PM-2	06/08	UF	<2	<30	<20	<3	<3	<2	<49	48	<3	9	<50
PM-3	06/08	UF	<2	<30	<20	<3	<3	<2	<49	121	<3	14	<50
PM-4	07/27	UF	2	<30	<20	<3	<3		<30	40	<3	9	<50
PM-5	06/08	UF	<2	<30	<20	<3	<3	<2	<49	55	<3	9	<50
G-1	11/11	UF	<2	<30	<20	<3	<3		<30	78	<3	11	<50
G-1A	06/08	UF	<2	<30	<20	<3	<3	<2	<49	75	<3	34	<50
G-1A	06/08	UF	<2	<30	<20	<3	<3	<2	<49	72	<3	34	<50
G-2	06/08	UF	<2	<30	22	<3	<3	<2	<49	75	<3	118	<50
G-5	11/11	UF	<2	<30	<20	<3	<3		<30	78	<3	14	<50
G-6	06/08	UF	<2	<30	<20	<3	<3	<2	<49	65	<3	19	<50
Regional Aquifer Springs													
White Rock Canyon Group I:													
Sandia Spring	09/28	F	75	<30	<20				<30	336		<8	<50
Spring 3A	09/28	F	<2	<30	<20	<10	<3		<30	192	<3	14	<50
Spring 3A	09/28	UF						<4					
Spring 4	09/28	F	<2	<30	<20	<10	<3		<30	118	<3	9	<50
Spring 4	09/28	UF						<2					
Spring 4A	09/29	F	<2	<30	<20				<30	116		9	<50
Ancho Spring	09/29	F	<2	<30	<20				<30	4		<8	<50
White Rock Canyon Group II:													
Spring 5A	09/29	F	13	<30	<20				<30	175		9	<50
Spring 6	09/29	F	<2	<30	<20				<30	61		9	<50
Spring 6	09/29	F	29	<30	<20				<30	178		12	<50
Spring 8A	09/29	F	<2	<30	<20				<30	42		9	<50

Table 5-15. Trace Metals in Groundwater for 1998 (µg/L) (Cont.)

Station Name	Date	F/UF[a]	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Ti	V	Zn
Regional Aquifer Springs (Cont.)													
White Rock Canyon Group I: (Cont.)													
Spring 9A	09/30	F	<2	<30	<20				<30	51		8	<50
Spring 9B	09/30	F	<2	<30	<20				<30	5		<8	<50
Doe Spring	09/30	F	<2	<30	<20				<30	51		9	<50
Spring 10	09/30	F	6	<30	<20				<30	64		9	<50
White Rock Canyon Group III:													
Spring 1	09/28	F	<2	<30	<20				<30	208		18	<50
Spring 2	09/28	F	7	<30	<20	<10	<3		<30	225	<3	20	<50
Spring 2	09/28	UF						<2					
White Rock Canyon Group IV:													
La Mesita Spring	09/08	F				<3	<3				<3		
Other Springs:													
Sacred Spring	09/08	F				<3	<3				<3		
Canyon Alluvial Groundwater Systems													
Acid/Pueblo Canyons:													
APCO-1	09/03	F	967	<30	<20	<3	<3		<57	91	<3	<8	<50
APCO-1	09/03	UF	1,008	<30	<24	<3	<3	<2	<92	96	<3	<8	<50
Cañada del Buey:													
CDBO-6	05/26	F	6	<30	<20	<3	<3		<30	98	<3	<8	<50
CDBO-6	05/26	UF	155	<30	<20	16	<3	<2	<30	115	<3	22	51
CDBO-7	05/26	F	609	<30	<20	<3	<3		<30	123	<3	<8	<50
CDBO-7	05/26	UF	3,618	<30	43	107	<3	<2	<30	356	<3	108	440
DP/Los Alamos Canyons:													
LAO-C	11/09	F	<2	<30	<20	<3	<4		<30	73	<3	<8	<50
LAO-C	11/09	UF	<2	<30	<20	3	<3	3	<30	72	<3	<8	<50
LAO-0.7	11/09	F	285	<30	<20	<3	<3		<30	92	<3	8	<50
LAO-0.7	11/09	UF	61	<30	<20	<3	<3	3	<30	87	<3	<8	<50
LAO-1	11/09	F	<2	107	<20	<3	<3		<30	84	<3	<8	<50
LAO-1	11/09	UF	<2	<30	<20	3	<3	3	<30	86	<3	<8	<50
DP Spring	09/02	F	5	<30	<20	<3	<3		<30	97	<3	<8	<50
DP Spring	09/02	UF						<2					
LAO-2	08/31	F	<2	153	<20	<3	<3		<76	123	<3	<8	<50
LAO-2	08/31	UF	2	166	<20	<3	<3	<2	<30	128	<3	<8	<50
LAO-3A	08/31	F	<3	328	<20	61	<3		<42	111	<3	<8	<50
LAO-3A	08/31	UF	<2	335	<20	16	<3	<2	<30	114	<3	<8	<50

Table 5-15. Trace Metals in Groundwater for 1998 (µg/L) (Cont.)

Station Name	Date	F/UF[a]	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Ti	V	Zn
Canyon Alluvial Groundwater Systems (Cont.)													
DP/Los Alamos Canyons: (Cont.)													
LAO-4	11/09	F	<2	104	<20	<3	<3		<30	83	<3	<8	<50
LAO-4	11/09	UF	<2	198	<20	<3	<3	<3	<30	86	<3	<8	<50
LAO-4.5C	05/14	F	<2	<30	<20	<3	<3		<30	74	<3	<8	<50
LAO-4.5C	05/14	UF	3	<30	<20	<3	<3	<2	<30	79	<3	<8	<50
LAO-6A	05/14	F	4	<30	<20	<3	<3		<30	75	<3	<8	<50
LAO-6A	05/14	F	4	<30	<20	<3	<3		<30	76	<3	<8	<50
LAO-6A	05/14	UF	4	<30	<20	<3	<3	<2	<30	78	<3	<8	<50
LAO-6A	05/14	UF	4	<30	<20	<3	<3	<2	<30	76	<3	<8	<50
Otowi Spring	09/08	F	<2	<30	<20	<3	<3		<30	387	<3	10	<50
Otowi Spring	09/08	UF						2					
								2					
Mortandad Canyon:													
MCO-3	08/20	F	<2	157	<20	<3	<3		<30	123	<3	<8	<50
MCO-3	08/20	UF	<2	158	<20	<3	<3	<2	<30	123	<3	<8	<50
MCO-4B	05/27	F	<2	122	<20	<3	<3		<30	110	<3	<8	<50
MCO-4B	05/27	UF	2	121	<20	<3	<3	<2	<30	110	<3	<8	<50
MCO-5	05/27	F	<2	129	<20	<3	<3		<30	111	<3	<8	<50
MCO-5	05/27	F	<2	127	<20	<3	<3		<30	112	<3	<8	<50
MCO-5	05/27	UF	<2	127	<20	<3	<3	<2	<30	114	<3	<8	<50
MCO-5	05/27	UF	<2	128	<20	<3	<3	<2	<30	114	<3	<8	<50
MCO-6B	05/27	F	2	119	<20	<3	<3		<30	130	<3	<8	<50
MCO-6B	05/27	UF	21	117	<20	<3	<3	<2	<30	135	<3	<8	<50
MCO-7A	05/28	F	<2	110	<20	<3	<3		<30	139	<3	<8	<50
MCO-7A	05/28	UF	11	108	<20	<3	<3	<2	<30	141	<3	<8	<50
MCO-7.5	05/28	F	<2	68	<20	<3	<3		<30	134	<3	<8	<50
MCO-7.5	05/28	UF	4	72	<20	<3	<3	<2	<30	134	<3	<8	<50
MT-3	09/04	F	12	68	<20	<3	<3		<128	137	<3	<8	<50
MT-3	09/04	UF	<2	67	<20	<3	<3	<2	<30	140	<3	<8	<50
MT-4	05/14	F	3	<30	<20	<3	<3		<30	120	<3	<8	<50
MT-4	05/14	UF	3	<30	<20	<3	<3	<2	<30	120	<3	<8	<50
Pajarito Canyon:													
PCO-1	04/30	F	46	<30	<20	<3	<3		<30	95	<3	<8	<50
PCO-1	04/30	UF	47	<30	<20	<3	<3	<2	<30	94	<3	<8	<50
PCO-3	05/13	F	12,000	<30	<20	<3	<3		<30	1,200	<3	<8	<50
PCO-3	05/13	UF	12,000	<30	<20	<3	<3	<2	<30	1,100	<3	<8	<50

Table 5-15. Trace Metals in Groundwater for 1998 (µg/L) (Cont.)

Station Name	Date	F/UF[a]	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Ti	V	Zn
Intermediate Perched Groundwater Systems													
Pueblo/Los Alamos/Sandia Canyon Area Perched System in Conglomerates and Basalt:													
Test Well 1A	05/29	UF	84	<30	20	5	<3	<2	<30	103	<3	<8	2,416
Test Well 2A	09/01	UF	370	<30	<20	53	<3	<2	<30	175	<3	<8	9,193
Basalt Spring	06/04	F	4	<30	<20	<3	<3		<30	132	<3	<8	<50
Basalt Spring	06/04	UF						<2					
Perched Groundwater System in Volcanics:													
Water Canyon Gallery	07/27	UF	<2	<30	<20	<3	<3		<30	13	<3	<8	<50
San Ildefonso Pueblo:													
LA-5	08/05	F	3	<30	<20	<3	<3		<30	219	<3	14	<50
LA-5	08/05	UF	<6	<30	<20	<3	<3	<4	<30	218	<3	18	<50
Eastside Artesian Well	08/05	F	6	<30	<20	<3	<3		<30	56	<3	<8	<50
Eastside Artesian Well	08/05	UF	5	<30	<20	<3	<3	<4	<30	55	<3	<8	<50
Pajarito Well (Pump 1)	06/04	F	4	<30	<20	<3	<3		<30	1,240	<3	12	<50
Pajarito Well (Pump 1)	06/04	UF	4	<30	<20	<3	<3	<2	<30	1,237	<3	13	<50
Don Juan Playhouse Well	08/05	F	<5	<30	<20	<3	<3		<30	241	<3	16	<50
Don Juan Playhouse Well	08/05	F	3	<30	<20	<3	<3	<4	<30	242	<3	15	<50
Otowi House Well	08/05	F	<3	<30	<20	<3	<3		<30	911	<3	<15	195
Otowi House Well	08/05	UF	3	<30	<20	<3	<3	<4	<30	894	<3	13	168
New Community Well	06/04	F	<5	<30	<20	<3	<3		<30	190	<3	<8	<50
New Community Well	06/04	UF	<2	<30	<20	<3	<3	<2	<30	196	<3	<8	<50
Sanchez House Well	08/05	F	<2	<30	<20	<3	<3		<30	387	<3	22	<50
Sanchez House Well	08/05	UF	3	<30	<20	<3	<3	<4	<30	386	<3	20	<50
Water Quality Standards[c]													
EPA Primary Drinking Water Standard					100		6	50			2		
EPA Secondary Drinking Water Standard			50										5,000
EPA Action Level						15							
EPA Health Advisory									25,000–90,000			80–110	
NMWQCC Livestock Watering Standard						100		50				100	25,000
NMWQCC Groundwater Limit			200	1,000	200	50		50					10,000

[a] Codes: UF–unfiltered; F–filtered.

[b] Less than symbol (<) means measurement was below the specified limit of detection of the analytical method.

[c] Standards given here for comparison only, see Appendix A. Note that New Mexico Livestock Watering and Groundwater limits are based on dissolved concentrations, while many of these analyses are of unfiltered samples—thus concentrations may include suspended sediment quantities.

Table 5-16. Number of Samples Collected for Each Suite of Organic Compounds in Groundwater for 1998

		Organic Suite[a]			
Station Name	Date	HE	PCB	Semivolatile	Volatile
Ancho Spring	09/29	1			
APCO-1	09/03		1	1	2
Basalt Spring	06/04		3	3	2
CDBO-6	05/26		3	3	2
DOE Spring	09/30	1			
LA Mesita Spring	09/08	1			
LAO-4.5C	09/08		3	3	2
MCO-3	08/20		1	1	2
MCO-4B	05/27		3	3	2
MCO-5	05/27		6	6	4
MCO-6B	05/27		3	3	2
MCO-7.5	05/28		3	3	2
MCO-7A	05/28		3	3	2
O-1	11/03	3			
O-4	10/03	1			
O-4	11/03	2			
PCO-1	04/30	1			
PCO-3	05/13	1	3	3	2
PM-1	10/03	1			
PM-1	11/03	2			
PM-2	10/03	1			
PM-2	11/02	2			
PM-3	10/02	1			
PM-3	11/03	2			
PM-5	10/02	1			
PM-5	11/02	2			
Sacred Spring	09/08	1			
Sanchez House Well	08/05		3	3	2
Sandia Spring	09/28	1			
Spring 1	09/28	1			
Spring 10	09/30	1			
Spring 2	09/28	1	1	1	2
Spring 3A	09/28	1	1	1	2
Spring 4	09/28	1	3	3	2
Spring 4A	09/29	1			
Spring 5A	09/29	1			
Spring 6	09/29	2			
Spring 8A	09/29	1			
Spring 9A	09/30	1			
Spring 9B	09/30	1			
Test Well 8	09/02		2	2	4
Test Well DT-10	11/05	3			
Test Well DT-10	11/06	3			
Test Well DT-5A	11/04	3			
Test Well DT-5A	11/05	3			
Test Well DT-9	11/04	3			
Test Well DT-9	11/05	3			
Well GR-2	03/12		1	1	2
Well GR-2	04/09		1	1	2

[a] High explosives, polychlorinated biphenyls, semivolatiles, and volatiles.

Table 5–17. Quality Assurance Sample Results for Radiochemical Analysis of Water Samples in 1998[a,b] (pCi/L[c])

Station Name	Date	^{3}H	^{90}Sr	^{137}Cs	U (µg/L)	^{238}Pu	$^{239,240}Pu$	^{241}Am	Gross Alpha	Gross Beta	Gross Gamma
DI Blank	05/28	–170 660	–0.13 0.82	1.47 0.33	0.00 0.01	0.003 0.010	0.015 0.011	0.011 0.014	0.01 0.02	–1.55 0.36	–4.10 47.80
DI Blank	06/08	–200 630	0.03 0.80	2.00 3.00	0.00 0.01	0.014 0.011	0.016 0.010	0.021 0.009	–0.09 0.11	–0.32 0.21	93.00 47.60
DI Blank	06/08	–100 630	–0.36 0.67	0.93 1.40	0.00 0.01	0.006 0.008	0.012 0.009	0.050 0.040	0.00 0.13	–0.77 0.20	79.20 47.60
DI Blank	07/07	10 660	–0.78 0.79	0.57 0.86	0.00 0.01	0.052 0.013	0.036 0.011	0.026 0.011	–0.01 0.12	–0.36 0.19	82.10 48.40
DI Blank	08/05	–180 660	–0.49 0.30	–0.11 0.36	0.00 0.01	0.000 0.000	0.018 0.010	0.079 0.022	–0.18 0.11	0.10 0.22	81.10 48.20
DI Blank	09/08	150 660	–0.58 0.36	1.33 2.00	0.00 0.01	–0.001 0.010	0.015 0.010	0.065 0.018	0.46 0.23	1.18 0.26	146.70 49.30
DI Blank	10/01	–180 640	–0.56 0.36	1.89 2.83	0.47 0.05	–0.004 0.006	0.010 0.010	0.033 0.014	–0.14 0.11	–0.55 0.21	52.80 48.30
DI Blank	11/13	–220 670	0.03 0.37	–0.16 0.36	0.00 0.01	0.010 0.014	0.015 0.010	0.033 0.025	–0.15 0.11	–0.27 0.21	80.20 48.70
Analytical Detection Limit		700	3.00	4.00	0.10	0.040	0.040	0.040	3.00	3.00	120.00
Average of Blank Values		–111	–0.35 0.56	0.99 1.39	0.06 0.01	0.010 0.009	0.017 0.010	0.040 0.019	–0.01 0.12	–0.32 0.23	76.37 48.24
Standard Deviation of Blank Values		129	0.30	0.84	0.17	0.018	0.008	0.023	0.20	0.77	41.97
Spiked Sample[d]	06/03	111 640	6.32 1.03	–1.13 0.72	–0.06 0.01	0.064 0.022	0.111 0.025	0.067 0.026	0.02 0.56	9.67 0.64	–5.28 47.50
Spiked Sample	06/09	11 630	4.80 0.93	0.57 2.33	–0.06 0.01	0.071 0.018	0.077 0.019	–0.026 0.026	0.04 0.58	10.00 0.66	–5.28 47.50
Spiked Sample	07/22	–199 630	4.28 0.95	–1.15 0.36	–0.06 0.01	0.066 0.019	0.166 0.027	0.080 0.050	0.23 0.55	9.65 0.64	0.03 48.40
Spiked Sample	08/05	–109 650	3.71 0.49	0.57 2.33	–0.06 0.01	0.064 0.017	0.103 0.022	0.106 0.029	0.29 0.48	1.12 0.57	9.43 48.20
Spiked Sample	09/01	391 760	2.80 0.49		–0.06 0.01	0.088 0.021	0.089 0.022	0.147 0.032			–1.27 48.20
Spiked Sample	09/28	31 650	4.87 0.57	0.23 1.83	–0.06 0.01	0.060 0.017	0.121 0.023	0.108 0.025	0.15 0.61	10.72 0.70	–56.08 48.10
Spiked Sample	09/28	–19 640	5.16 0.63	1.92 0.62	–0.06 0.01	0.017 0.010	0.110 0.021	0.153 0.030	0.44 0.57	9.90 0.65	–34.38 48.20
Spiked Sample	11/13	–189 660	5.78 0.67	0.57 2.33	–0.06 0.01	0.082 0.023	0.112 0.028	0.030 0.060	0.48 0.61	10.20 0.67	20.13 48.80
Average of Result		4 658	4.72 0.72	0.23 1.50	–0.06 0.01	0.064 0.018	0.111 0.023	0.083 0.035	0.24 0.57	8.75 0.65	–9.09 48.11
Standard Deviation of Result		190	1.12	1.08	0.00	0.021	0.026	0.060	0.18	3.38	24.54
Spiked Value		0	5.00 0.50	0.00	0.00	0.100 0.010	0.100 0.010	0.100 0.010			
Ratio of Result/Spiked Value			0.94			0.64	1.11	0.83			
Calculated Detection Limit (Standard Deviation of Spikes × 3)			3.37	3.23		0.064	0.079	0.179			
Calculated Detection Limit / Analytical Detection Limit (Should be ≤1.00)		0.00	1.12	0.81		1.588	1.979	4.481			

[a]Two columns are listed: the first is the value; the second is the radioactive counting uncertainties (1 std dev). Radioactivity counting uncertainties may be less than analytical method uncertainties.
[b]See Appendix B for an explanation of negative numbers.
[c]Except where noted.
[d]Spiked results corrected by subtracting average of blanks.

Table 5-18. Quality Assurance Sample Results for Metals Analysis of Water Samples in 1998 (µg/L)

Station Name	Date	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg
DI Blank	05/27	<10	86	<2	<20	3	<3	<7	<8	<7	<10	<40	
DI Blank	05/28	<10	120	<2	<20	4	<3	<7	<8	<7	<10	47	<0.2
DI Blank	06/08	12	<50	<2	<20	3	<3	<7	<8	<7	<10	65	<0.2
DI Blank	06/08	<10	<50	<2	<20	<5	<3	<7	<8	<7	<10	<40	<0.2
DI Blank	07/07	<10	<50	<2	<20	1	<3	<7	<8	<7	<10	<40	<0.2
DI Blank	08/05	<16	<50	<2	<20	2	<3	<7	<8	<7	<10	<40	
DI Blank	08/05	<10	<50	<2	<20	<4	<3	<7	<8	26	<10	61	<0.2
DI Blank	09/08	<10	<50	<2	<20	3	<3	<7	<8	<7	<10	<40	<0.2
DI Blank	10/01	<10	<50	<2	<20	<1	<3	<7	<8	<7	<10	<40	<0.2
DI Blank	11/13	<10	<50	<2	<20	1	<3	<7	<8	<7	<10	<40	<0.2
Spiked Sample[a]	06/03	41	<50	<2	<20	457	<3	<7	<8	<7	<10	<40	3.9
Spiked Sample	06/09	20	<50	<2	<20	490	<3	<7	<8	<7	<10	<40	1.7
Spiked Sample	07/22	34	<50	<2	<20	310	<3	<7	<8	<7	<10	<40	2.6
Spiked Sample	08/05		<50	<2	<20	478	<3	<7	<8	<7	<10	<40	4.1
Spiked Sample	09/01		<50	<2	<20	489	<3	<7	<8	<7	<10	<40	0.5
Spiked Sample	09/28		<50	<2	<20	472	<3	<7	<8	<7	<10	<40	4.2
Spiked Sample	09/28	14	<50	<2	<20	491	<3	<7	<8	<7	<10	<40	4.2
Spiked Sample	11/13	17	<50	<2	<20	447	<3	<7	<8	<7	<10	<40	<0.2
Average of Results		25				454							3.0
Standard Deviation of Results		12				60							1.5
Spiked Concentration		25				500							5.0
Ratio of Result/Spiked Value		1.01				0.91							0.61

Table 5-18. Quality Assurance Sample Results for Metals Analysis of Water Samples in 1998 (µg/L) (Cont.)

Station Name	Date	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
DI Blank	05/27	<2	<30	<20	5	<3		<30	<2	<3	<8	<50
DI Blank	05/28	<2	<30	<20	<3	<3	<2	<30	<2	<3	<8	<50
DI Blank	06/08	<2	<30	<20	<3	<3	<2	<30	2	<3	<8	<50
DI Blank	06/08	<2	<30	<20	<3	<3	<2	<49	<2	<3	<8	<50
DI Blank	07/07	<2	<30	<20	<3	<3	<2	<30	<2	<3	<8	<50
DI Blank	08/05	<2	<30	<20	<3	<3		<30	4	<3	<8	<50
DI Blank	08/05	40	<30	<20	<3	<3	<4	<30	7	<3	<21	<50
DI Blank	09/08	<2	<30	<20	<3	<3	<2	<30	2	<3	<8	<50
DI Blank	10/01	<2	<30	<20	<10	<3	<2	<30	<2	<3	<8	<50
DI Blank	11/13	<2	<30	<20	<3	<3	<3	<30	<2	<3	<8	<50
Spiked Sample[a]	06/03	2	<30	<20	8	<3	<2	<30	8	<3	<8	<50
Spiked Sample	06/09	<2	<30	<20	7	<3	<2	<49	<2	<3	<8	<50
Spiked Sample	07/22	<2	<30	<20	4	<3	<2	<30	<2	<3	<8	<50
Spiked Sample	08/05	<2	<30	<20	5	<3	<4	<30	<2	<3	<8	<50
Spiked Sample	09/01	<2	<30	<20	9	<3	<2	<30	<2	<3	<8	60
Spiked Sample	09/28	<2	<30	<20	<10	<3	4	<30	<2	<3	<8	<50
Spiked Sample	09/28	<2	<30	<20	<10	<3	<2	<30	<2	<3	<8	<50
Spiked Sample	11/13	<2	<30	<20	8	<3	<3	<30	<2	<3	<8	<50
Average of Results					6.8							
Standard Deviation of Results					1.9							
Spiked Concentration					7.5							
Ratio of Result/Spiked Value					0.91							

[a] Spiked results corrected by subtracting average of blanks.

J. Figures

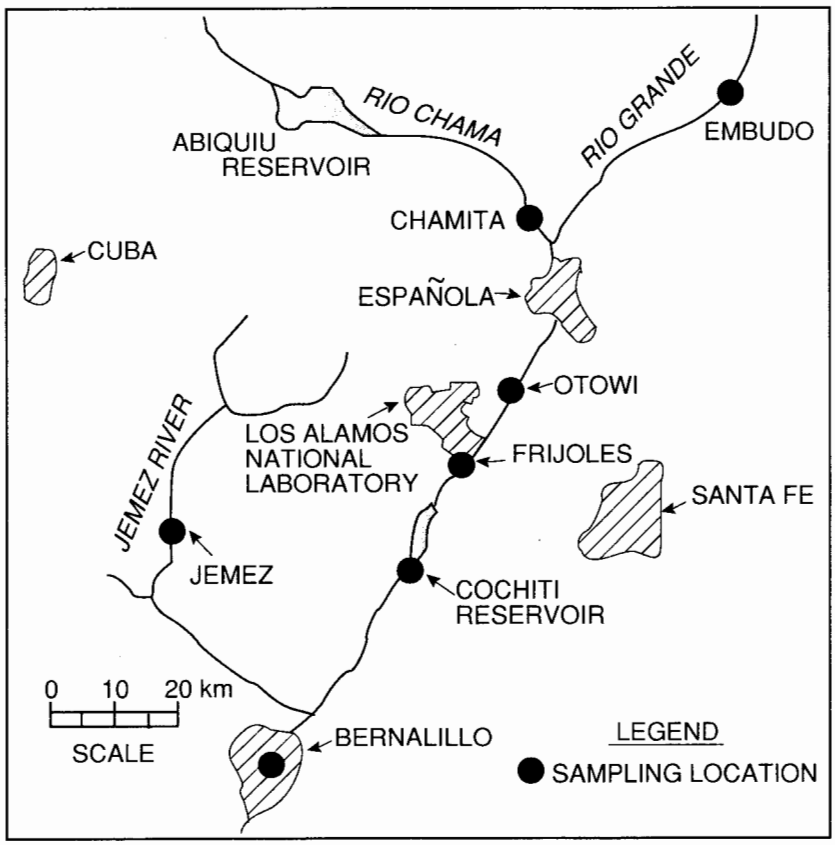


Figure 5-1. Regional surface water and sediment sampling locations.

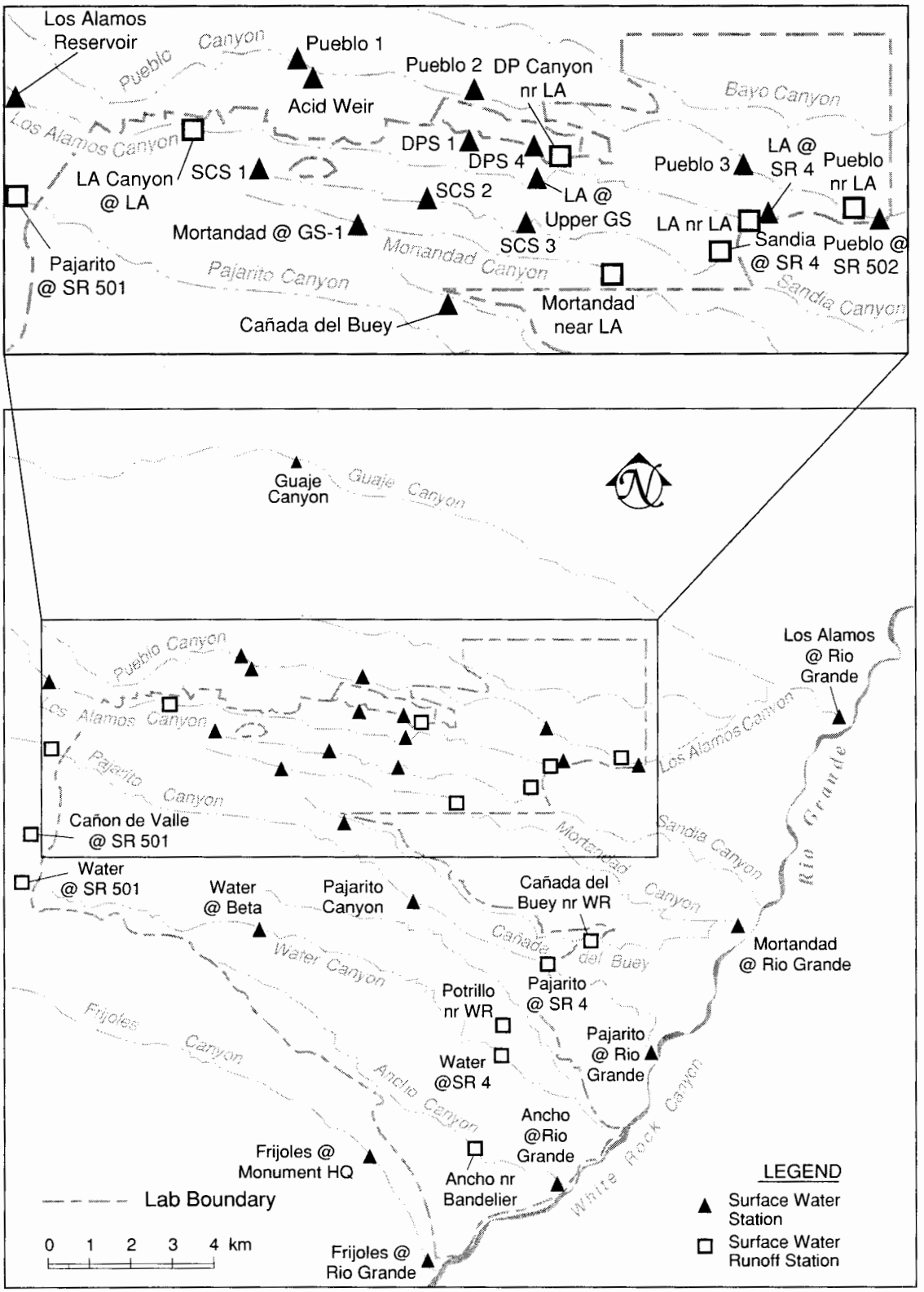


Figure 5-2. Surface water sampling locations in the vicinity of Los Alamos National Laboratory.

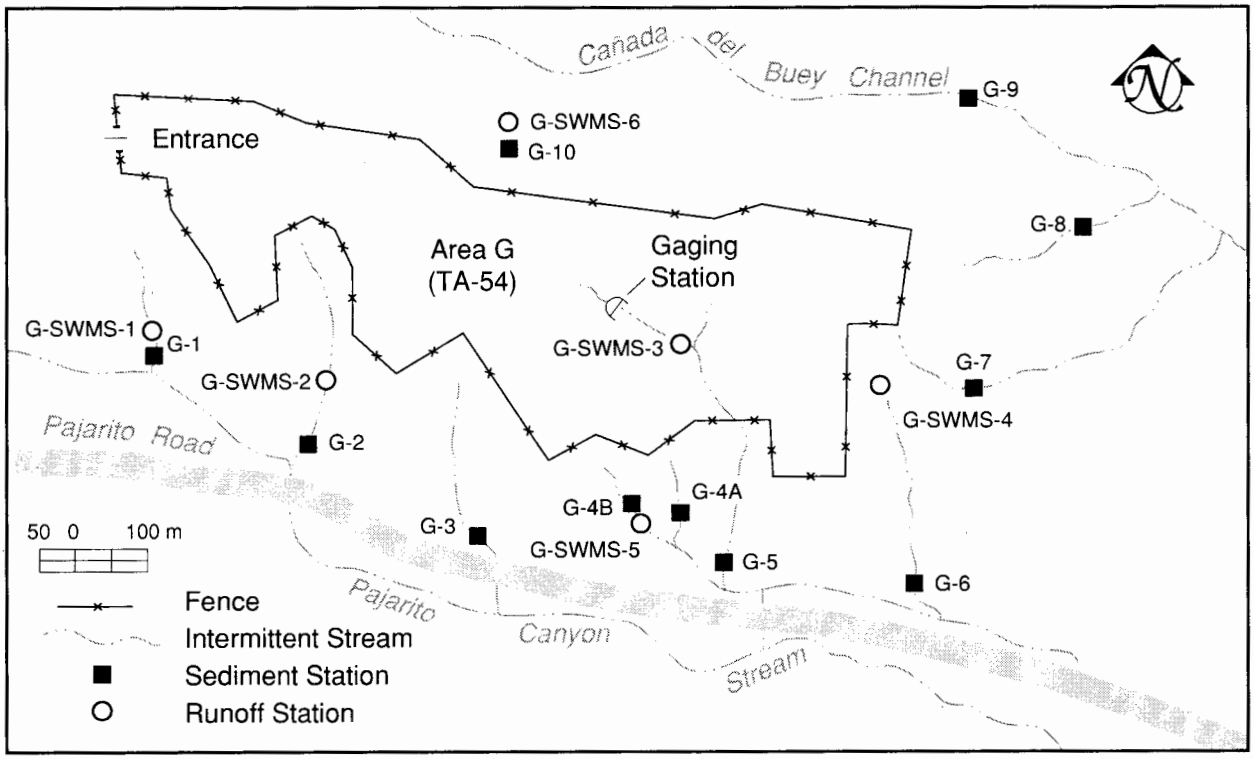


Figure 5-3. Sediment and runoff sampling stations at TA-54, MDA G.

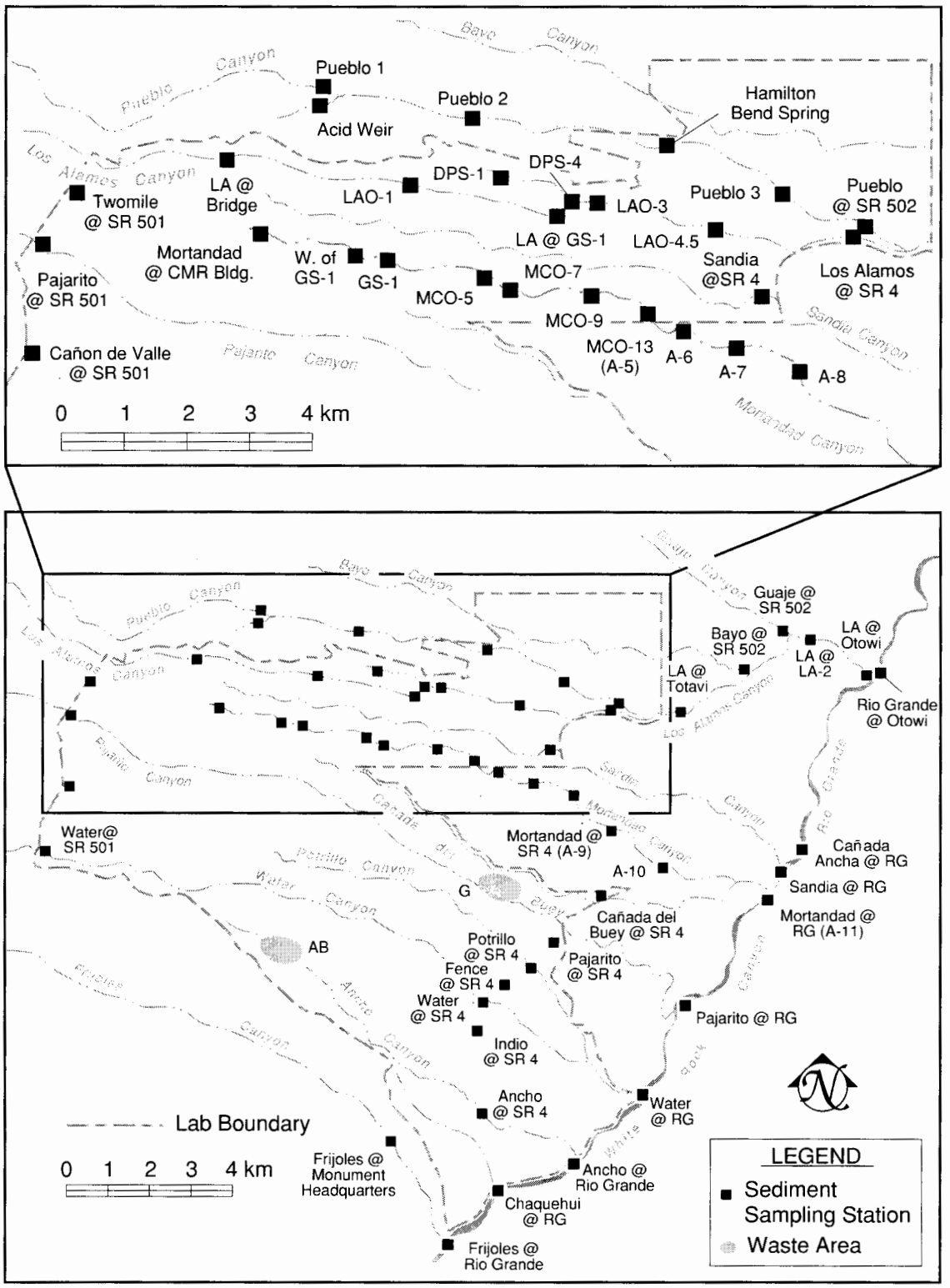


Figure 5-4. Sediment sampling stations on the Pajarito Plateau near Los Alamos National Laboratory. (Solid waste management areas with multiple sampling locations are shown in Figures 5-3 and 5-5.)

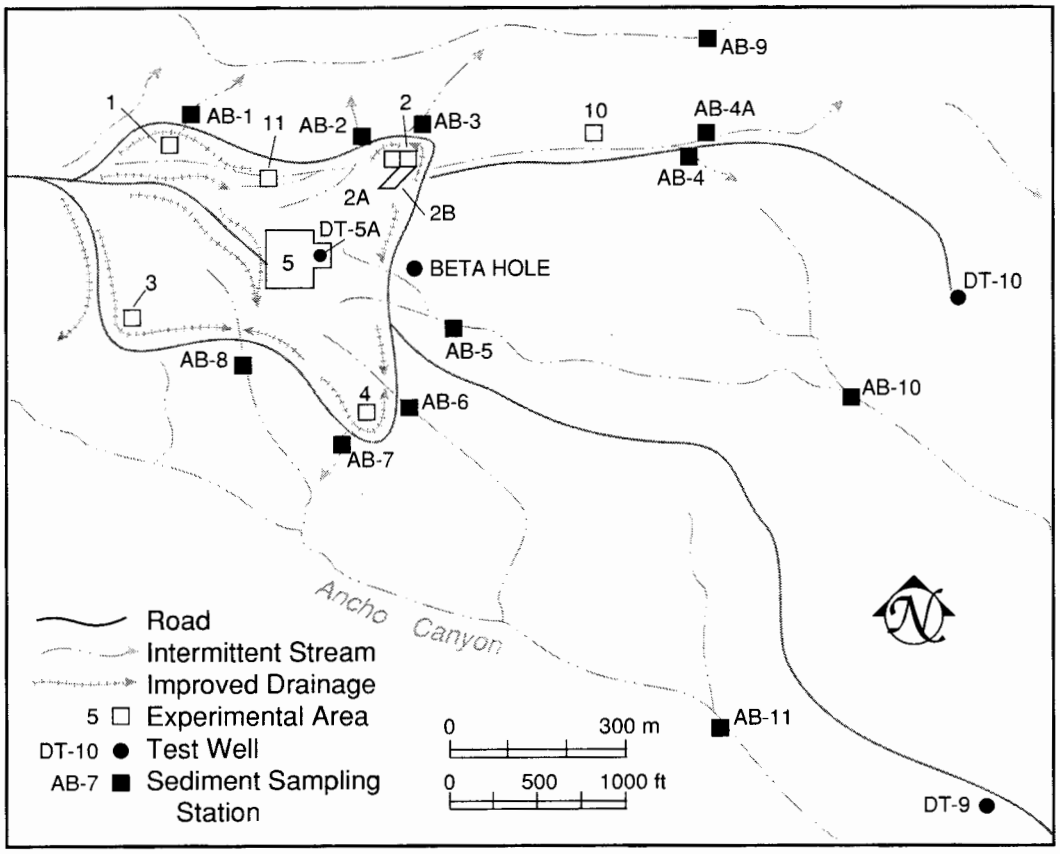
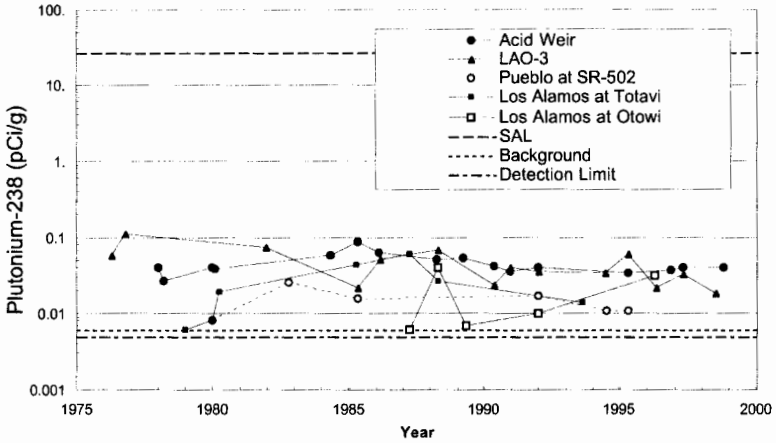
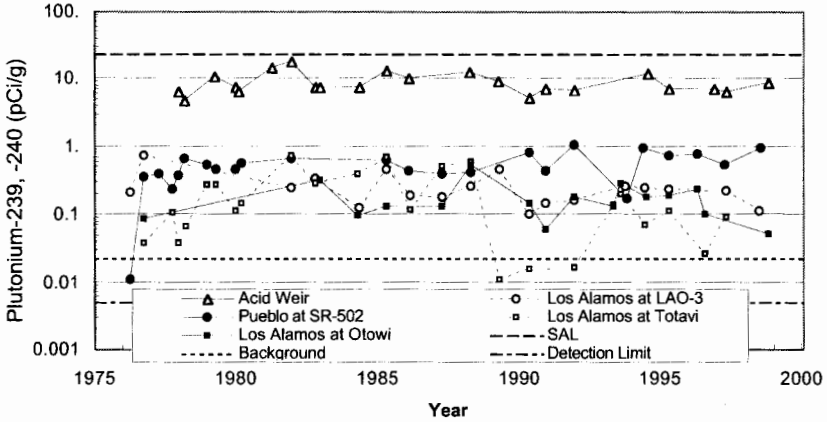


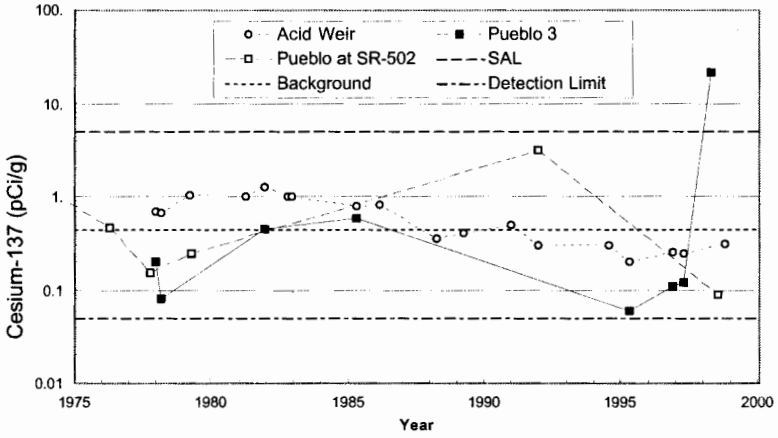
Figure 5-5. Sediment sampling stations at Technical Area 49, MDA AB.



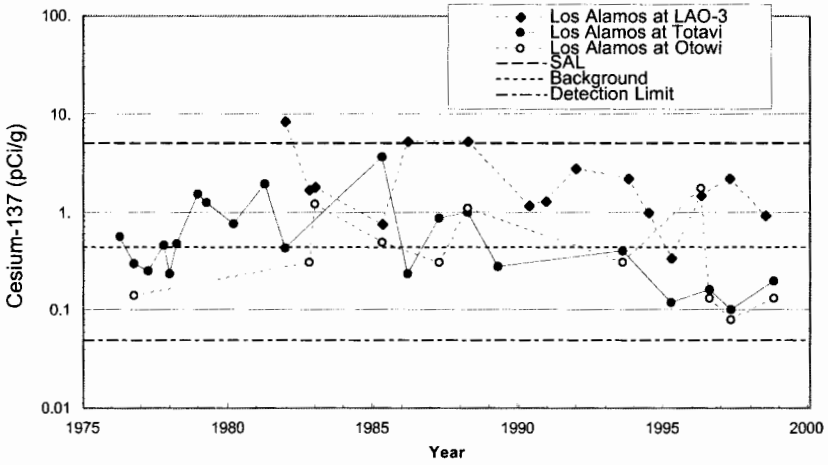
a. Plutonium-238 in Pueblo/Los Alamos Canyons.



b. Plutonium-239, -240 in Pueblo/Los Alamos Canyons.

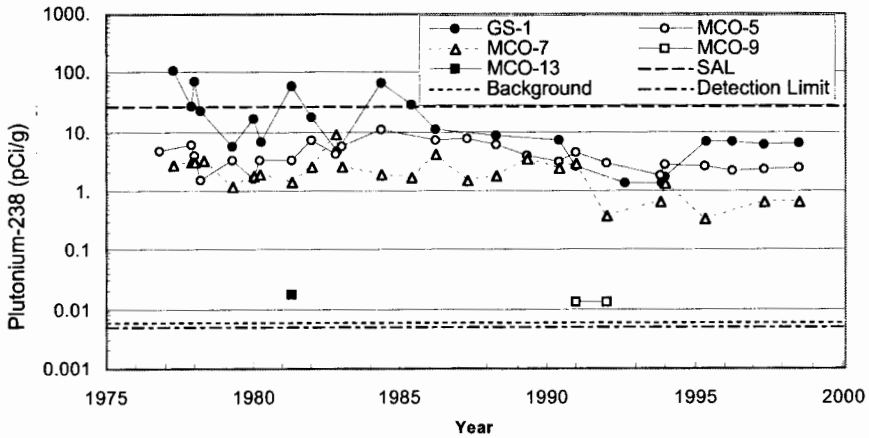


c. Cesium-137 in Pueblo Canyon.

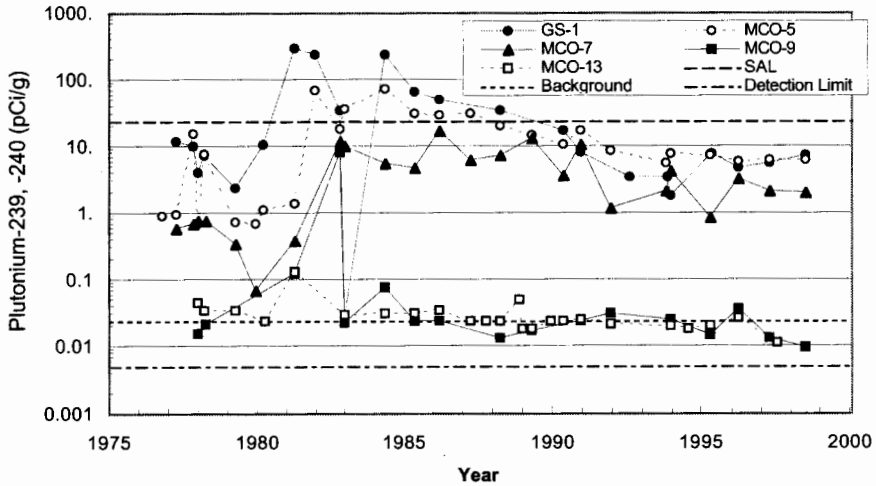


d. Cesium-137 in Los Alamos Canyon.

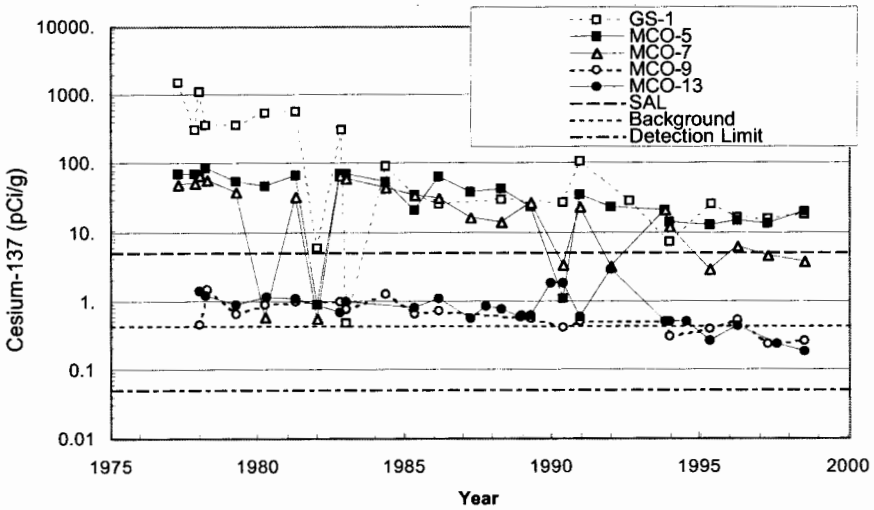
Figure 5-6. Sediment radioactivity histories for stations in Pueblo and Los Alamos Canyons. Only detections are shown although data are available for most years.



a. Plutonium-238 on Laboratory lands in Mortandad Canyon.

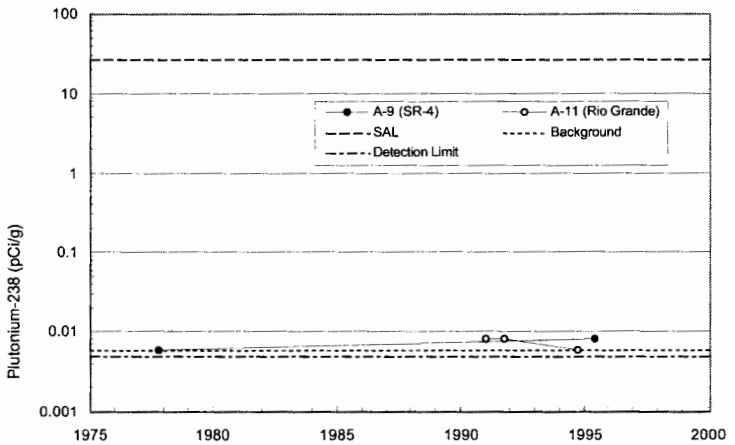


b. Plutonium-239, -240 on Laboratory lands in Mortandad Canyon.

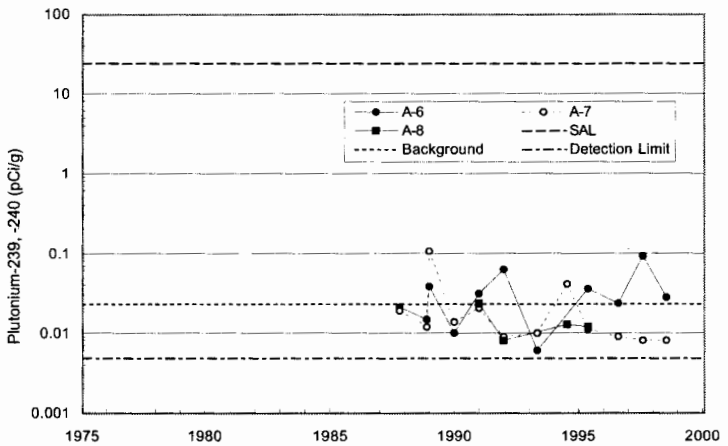


c. Cesium-137 on Laboratory lands in Mortandad Canyon.

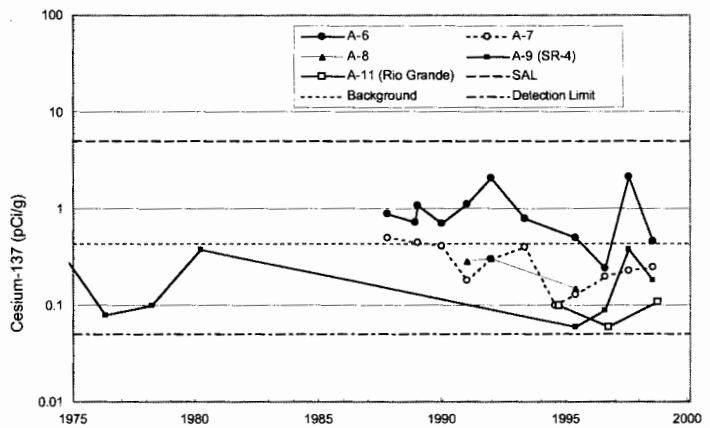
Figure 5-7. Sediment radioactivity histories for stations located on Laboratory lands in Mortandad Canyon. Only detections are shown, although data are available for most years.



a. Plutonium-238 on Pueblo of San Ildefonso lands in Mortandad Canyon.



b. Plutonium-239, -240 on Pueblo of San Ildefonso lands in Mortandad Canyon.



c. Cesium-137 on Pueblo of San Ildefonso lands in Mortandad Canyon.

Figure 5-8. Sediment radioactivity histories for stations located on Pueblo of San Ildefonso lands in Mortandad Canyon. Only detections are shown, although data are available for most years.

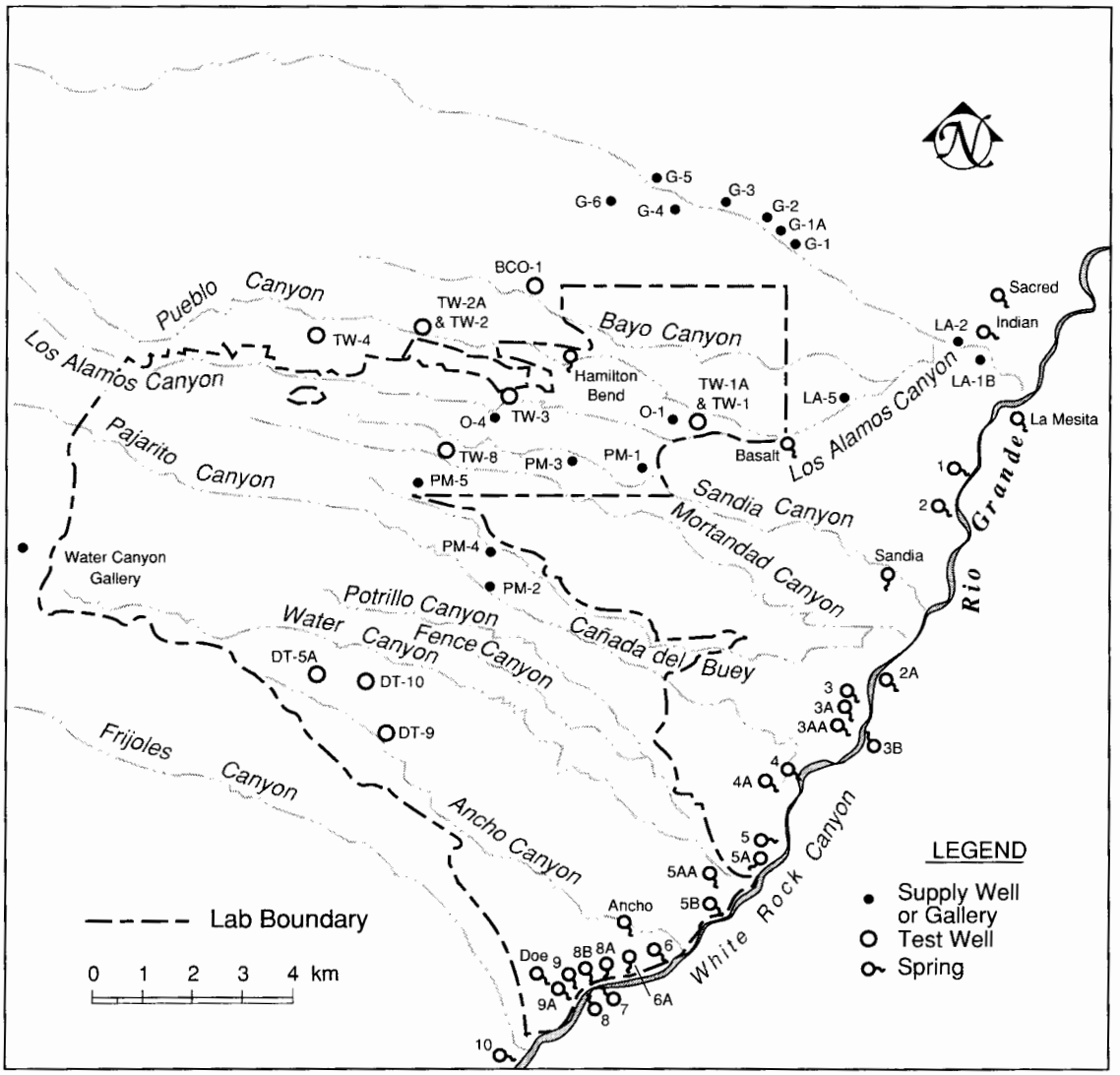


Figure 5-9. Springs and deep and intermediate wells used for groundwater sampling.

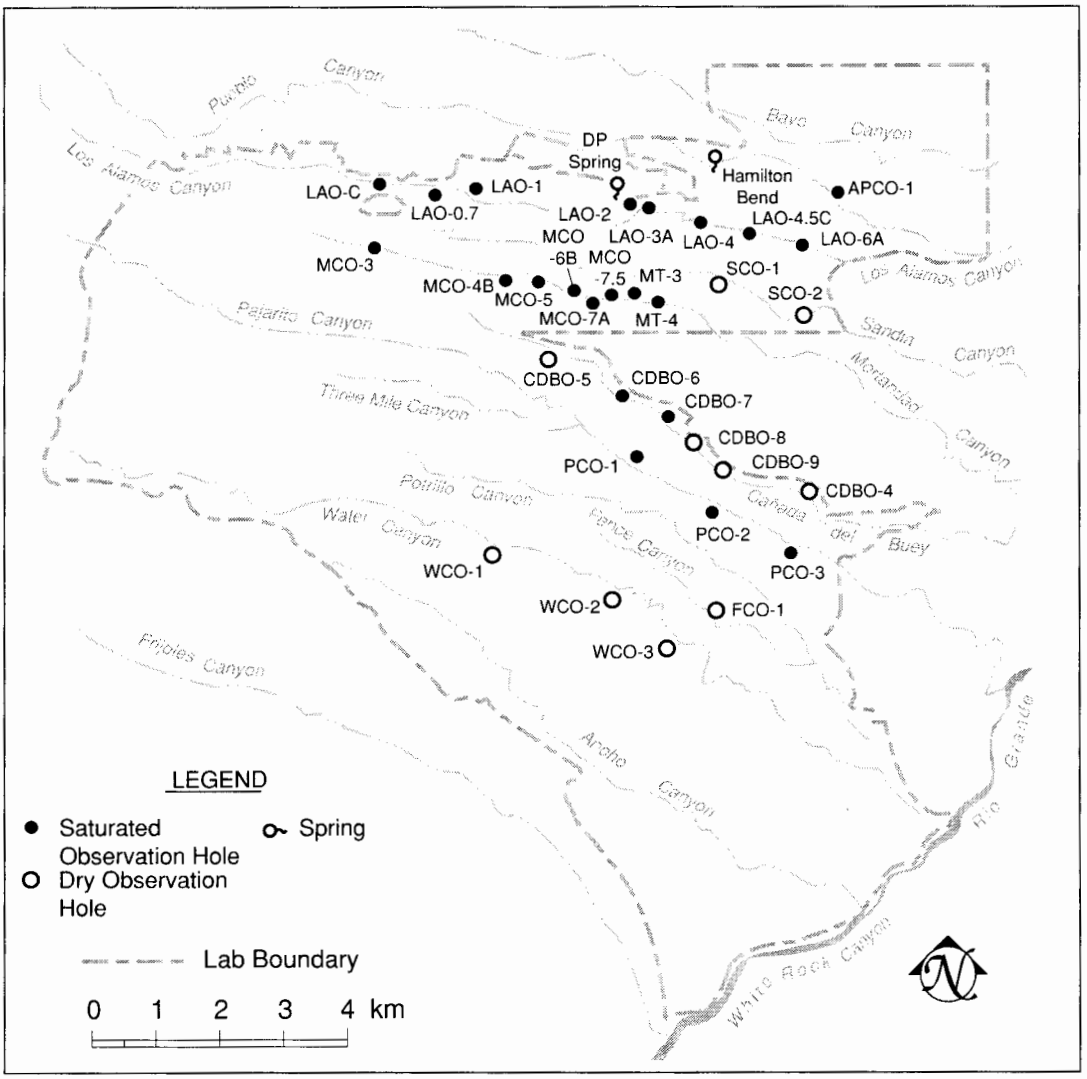
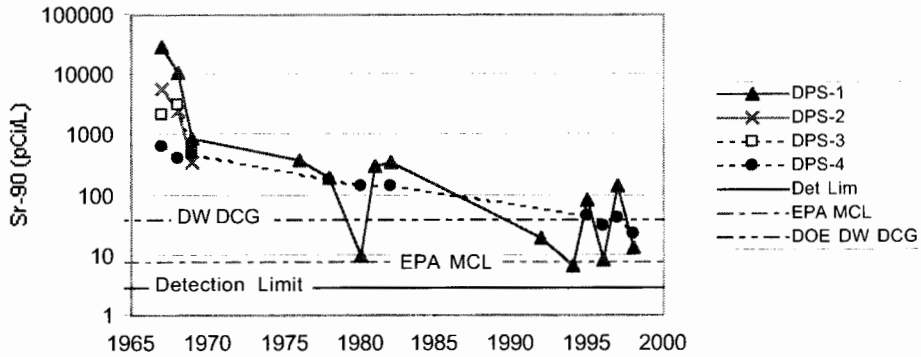
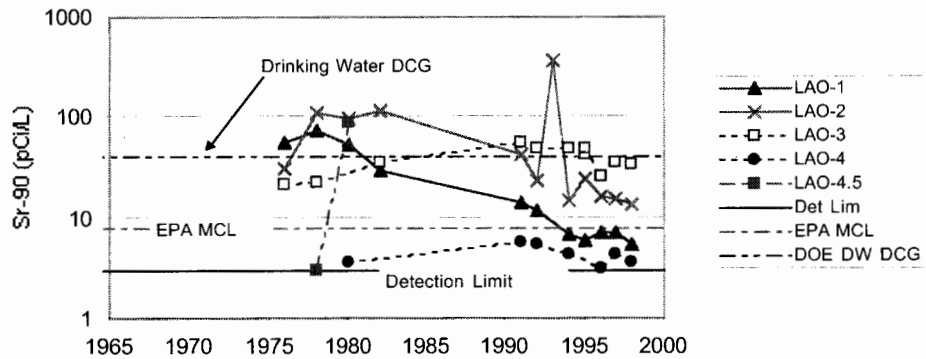


Figure 5-10. Observation wells and springs used for alluvial groundwater sampling.

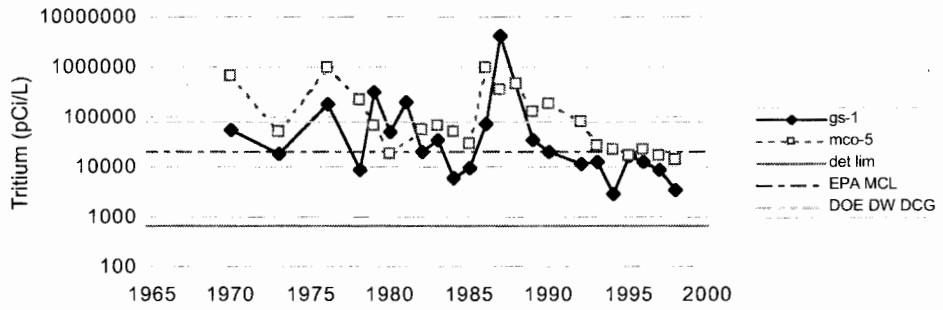


a. DP Canyon surface water strontium-90.

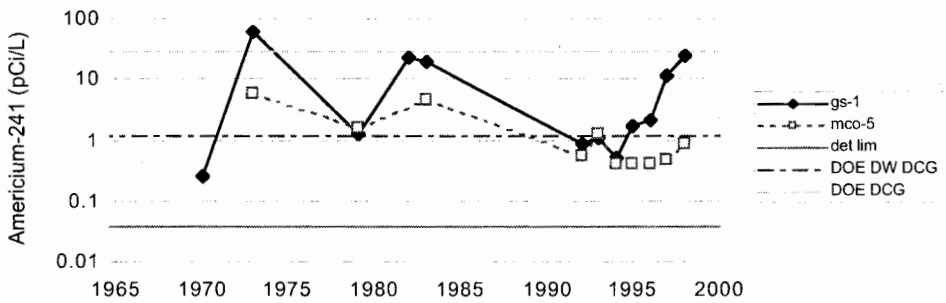


b. Los Alamos Canyon alluvial groundwater strontium-90.

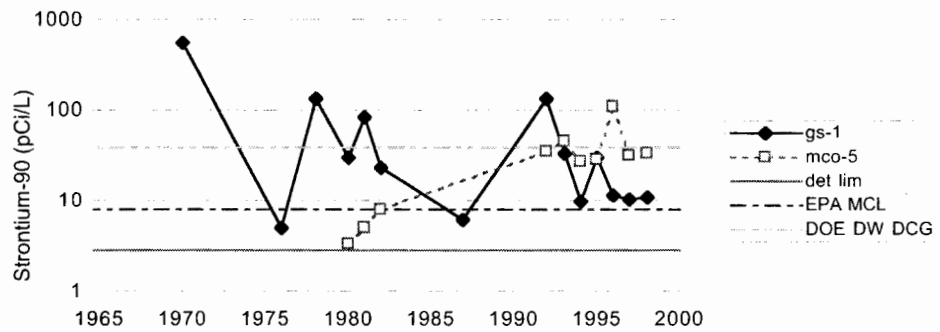
Figure 5-11. Annual average surface water and groundwater strontium-90 activity in DP and Los Alamos Canyons. (Only samples with strontium-90 detections are shown.)



a. Mortandad Canyon tritium.

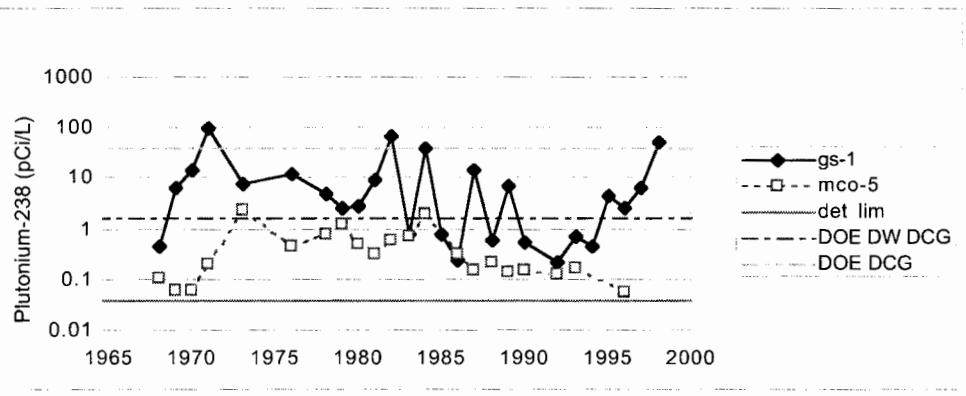


b. Mortandad Canyon americium-241.

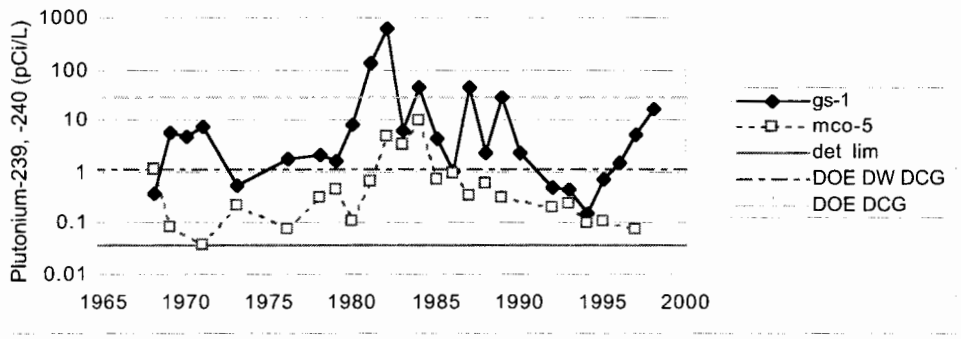


c. Mortandad Canyon strontium-90.

Figure 5-12. Annual average radioactivity in surface water and groundwater from Mortandad Canyon. (Only samples with radionuclide detections are shown.)



d. Mortandad Canyon plutonium-238.



e. Mortandad Canyon plutonium-239, -240

Figure 5-12 (Cont.). Annual average radioactivity in surface water and groundwater from Mortandad Canyon. (Only samples with radionuclide detections are shown.)

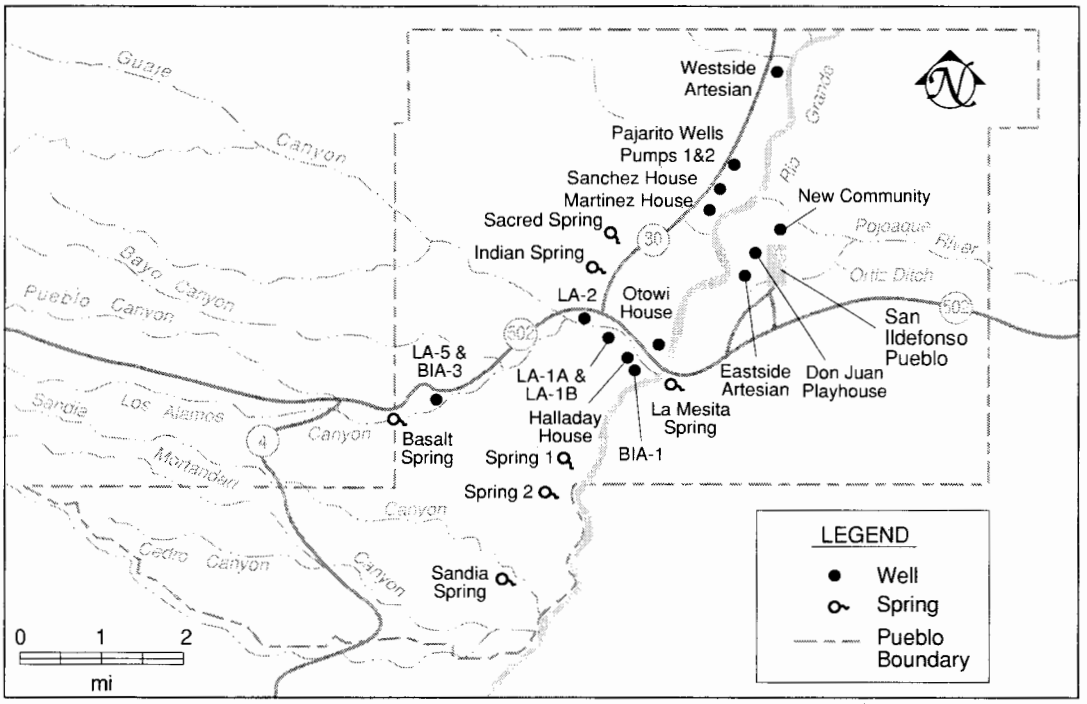


Figure 5-13. Springs and groundwater stations on or adjacent to Pueblo of San Ildefonso land.

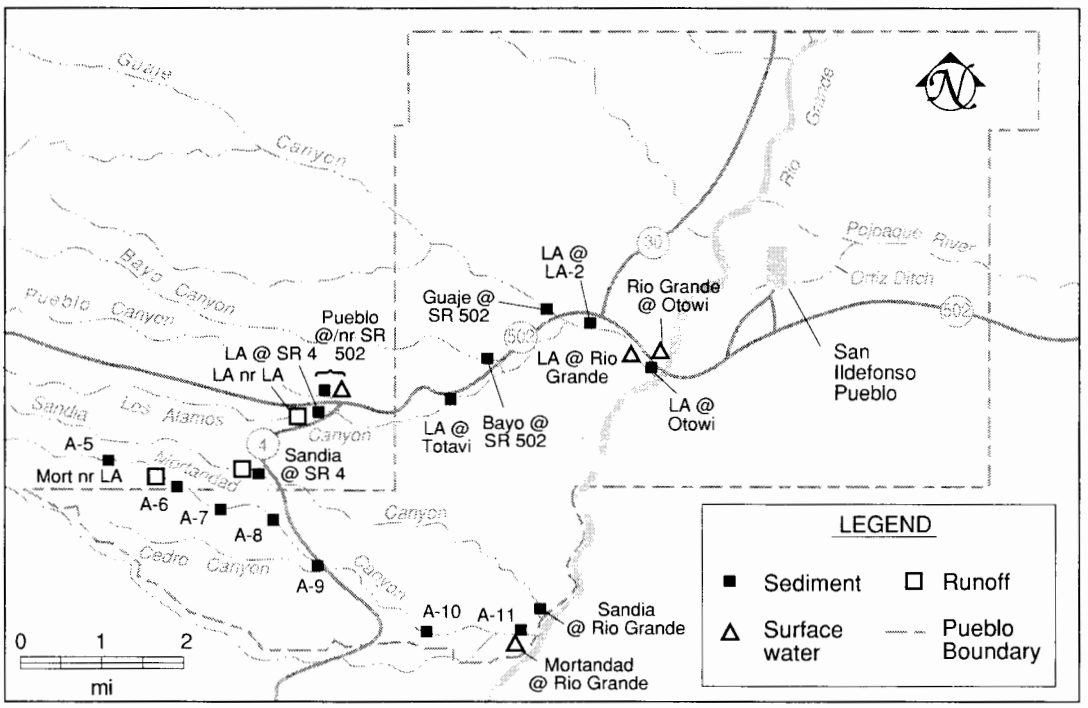


Figure 5-14. Sediment and surface water stations on or adjacent to Pueblo of San Ildefonso land.

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6. Soil, Foodstuffs, and Associated Biota

primary author:

Phillip Fresquez

Highlights from 1998

Soil samples were collected from 12 on-site (Los Alamos National Laboratory [LANL or the Laboratory]) and 10 perimeter areas around the Laboratory, analyzed for radiological and nonradiological constituents, and compared with soils collected from regional background locations in northern New Mexico. Radionuclides in soils collected from regional background areas are from natural sources and/or worldwide fallout. All radionuclide concentrations in soils collected from on-site and perimeter areas were low, and most were nondetectable (where the analytical results were less than two counting uncertainties) and/or within the upper range of background concentrations. Trend analyses show that most radionuclides in soils from on-site and perimeter areas have significantly decreased over time; they are currently at concentrations very similar to concentrations commonly detected in regional background soils. Soils were also analyzed for trace elements, and most constituents, with the exception of beryllium and lead, were within background mean concentrations; all, however, were well below LANL screening action levels.

Foodstuffs and biota samples (milk, eggs, fruits, vegetables, mushrooms, honey, elk, deer, squirrels, fish, herbal tea, piñon, and beef cows) were collected from Laboratory and/or surrounding perimeter areas (including several Native American Pueblo communities) to determine the impact of LANL operations on the human food chain. All radionuclides in foodstuffs and biota collected from the Laboratory and perimeter locations were low and, for the most part, were indistinguishable from worldwide fallout and/or natural sources. Similarily, all trace elements, including beryllium and lead, in produce collected from Laboratory and perimeter areas were within background concentrations.

Other environmental surveillance activities associated with the soils, foodstuffs, and biota programs included the determination of radionuclides and trace elements in soil, bees, vegetation, and small and large game mammals within and around Area G (the Laboratory's primary low-level radioactive waste disposal area) and DARHT (Dual Axis Radiographic Hydrodynamic Test). Special contaminant studies included a preoperational survey for tritium at Technical Area (TA)-54, a survey of contaminants in fish within lakes in Santa Clara Canyon and along the length of the Rio Grande from Colorado to Texas, an estimate of risk among threatened and endangered species, an investigation of bees as indicators of radionuclide contamination, and an evaluation of squirrels around a radioactive liquid waste site at TA-53 for contaminants. We also monitored threatened and endangered species (Mexican spotted owl, bald eagle, willow flycatcher, peregrine falcon), bats, reptiles, amphibians, hantavirus, forest fuel loads, vascular plants, and elk and deer.

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A. Soil Monitoring

1. Introduction

A soil sampling and analysis program provides the most direct means of determining the concentration/activity, inventory, and distribution of radionuclides and radioactivity around nuclear facilities (DOE 1991). This program is mandated by Department of Energy (DOE) Orders 5400.1 and 5400.5. Soil provides an integrating medium that can account for contaminants released to the atmosphere, either directly in gaseous effluents (such as air stack emissions) or indirectly from resuspension of on-site contamination (such as firing

sites) or through liquid effluents released to a stream that is subsequently used for irrigation (Purtymun et al., 1987). The knowledge gained from a soil radiological sampling program is critical for providing information about potential pathways (such as soil ingestion, food crops, resuspension into the air, and contamination of groundwater) that may result in a radiation dose to a person (Fresquez et al., 1998a). The main objectives of this program include an evaluation of (1) radionuclides, radioactivity, and nonradionuclides (light, heavy, and nonmetal trace elements) in soils collected from regional (background) locations, around the perimeter of the Laboratory, and on-site; (2) trends over time (that is, are radionuclides and nonradionuclides increasing or decreasing over time); and (3) committed effective dose equivalent (CEDE) to surrounding area residents. We compare on-site and perimeter areas with regional background areas located at such a distance from the Laboratory that their radionuclide and nonradionuclide contents are mostly due to naturally occurring elements and/or to worldwide fallout. Potential radiation doses to individuals from exposure to soils are presented in Chapter 3.

2. Monitoring Network

Soil surface samples (0- to 2-in. depth) are collected from relatively level, open, and undisturbed areas at regional background locations (three sites), LANL's perimeter (10 sites), and at LANL (12 sites) (see Figure 6-1). Areas sampled at LANL are not from solid waste management units (SWMUs). Instead, the majority of on-site soil-sampling stations are located close to and downwind from major facilities and/or operations at LANL in an effort to assess radionuclides, radioactivity, and trace elements (light, heavy, and nonmetal) in soils that may have been contaminated as a result of air stack emissions and fugitive dust (the resuspension of dust from SWMUs and active firing sites).

The ten perimeter stations are located within 4 km (2.5 mi) of the Laboratory. These stations were chosen to reflect the soil conditions of the inhabited areas to the north (Los Alamos townsite area—four stations) and east (White Rock area and Pueblo of San Ildefonso lands—four stations) of the Laboratory. The other two stations, one located on Forest Service land to the west and the other located on Park Service land (Bandelier) to the southwest, provide additional coverage. Soil samples from all these areas are compared with soils collected from regional background locations in northern New Mexico surrounding the Laboratory where radionuclides, radioactivity, and trace elements are from natural and/or worldwide fallout events; these areas are located around Embudo to the north, Cochiti to the south, and Jemez to the southwest. All are more than 32 km (20 mi) from the Laboratory and are beyond the range of potential influence from normal Laboratory operations (DOE 1991).

3. Sampling Procedures, Data Management, and Quality Assurance

Collection of samples for chemical analyses follows a set procedure to ensure proper collection, processing, submittal, and posting of analytical results. Stations and samples are assigned unique identifiers to provide chain-of-custody control from the time of collection through analysis and reporting. All quality assurance/quality control (QA/QC) protocols, chemical analysis, data handling, validation, and tabulation can be found in the ESH-20 operating procedure (OP) entitled "Soil Sampling for the Soil Monitoring Program," LANL-ESH-20-SF-OP-007, R0, 1997.

4. Radiochemical Analytical Results

Table 6-1 shows data from soils collected in 1998. All radionuclide concentrations and radioactivity in soils collected from on-site and perimeter stations were low, and most were nondetectable (where the analytical result was lower than two times the counting uncertainty) (Corely et al., 1981) and/or within regional statistical reference levels (RSRLs). The RSRL is the upper-limit background concentration (mean plus two standard deviations) (Purtymun et al., 1987) from data collected from regional background areas from 1993 through 1997 for worldwide fallout and natural sources of tritium; strontium-90; cesium-137; americium-241; plutonium-238; and plutonium-239, -240; total uranium; and gross alpha, beta, and gamma radioactivity.

As a group, the average concentrations of total uranium and gross alpha, beta, and gamma activity in on-site and perimeter soils were significantly higher ($p<0.05$=the 95% confidence level) than concentrations detected in background locations. All of these mean concentrations, however, were low and were far below LANL screening action levels (SALs). LANL SALs, developed by the Environmental Restoration Project at the Laboratory, identify the presence of

contaminants of concern and are derived from a risk assessment pathway based on a 10 mrem/y dose.

Slightly higher concentrations of uranium and gross alpha, beta, and gamma activity were found in soils collected from on-site and perimeter areas, as compared with regional background locations. Although these slightly elevated levels may be due in part to Laboratory operations, radionuclides caused by fallout vary from one area to another depending on wind patterns, elevation, and precipitation (Whicker and Schulz 1982). Thus, it is likely that fallout is more concentrated in the area of the Laboratory because it lies at a higher elevation and receives more precipitation. Most of the regional background areas lie at elevations of 5,600 to 6,300 ft and receive approximately 10 in. of precipitation per year (Bowen 1990), whereas the on-site and perimeter areas lie at elevations of 6,500 to 7,500 ft and receive 14 to 19 in. of precipitation per year. On the other hand, the higher levels of uranium detected in the soil samples collected from the on-site and perimeter areas may be a result of differences in the geology or mineralogy of the soils between the areas. Soils in the Los Alamos area are derived from Bandelier (volcanic) tuff and have higher-than-average natural uranium concentrations, ranging from 3 to 11 μg of uranium per gram of soil (Crowe et al., 1978).

5. Nonradiochemical Analytical Results

We analyzed soils for light, heavy, and nonmetal trace elements. The results of the 1998 soil-sampling program can be found in Table 6-2.

Five out of the twelve trace elements measured in surface soils collected from regional background, perimeter, and on-site stations were below the limits of detection (LOD). Of those elements that were above the LOD, most of these trace elements measured in soils collected from on-site and perimeter areas were within RSRLs and were within the range of metals normally encountered in the Los Alamos area (Ferenbaugh et al., 1990) and the continental United States (Shacklette and Boerngen 1984). The RSRLs (mean plus two standard deviations) were derived from regional background locations averaged over four years (1994–1997). As a group, only beryllium and lead concentrations in soils from on-site and perimeter areas were significantly higher ($p<0.05$) than background. The differences in beryllium and lead in soils between the sites, however, were very low, and they were far below SALs.

6. Long-Term Trends

We subjected radionuclides and radioactivity in soils collected from on-site and perimeter stations from 1974 through 1996 to a Mann-Kendal test for trend analysis (Fresquez et al., 1998a). Although some radionuclide and radioactivity levels were generally higher in on-site and perimeter soils when compared with background levels, most radionuclides, with the exception of plutonium-238 in soils from perimeter areas, exhibited decreasing concentrations over time. The statistically significant (but very small) increase of plutonium-238 in perimeter soils over this interval may be related to the resuspension and redistribution of global fallout and/or to past LANL operations. Plutonium-238 and plutonium-239, -240 in soils from background areas also exhibited statistically increasing trends, but in this case, the small increase in plutonium levels in soils from background areas was probably a reflection of the redistribution of fallout. The plutonium levels in background soils, for example, were still well within worldwide fallout concentrations.

The decreasing concentrations of the other isotopes in soils collected from perimeter and on-site areas over time may be a result of (1) cessation of above-ground nuclear weapons testing in the early 1960s, (2) weathering (water and wind erosion and leaching), (3) radioactive decay (half-life), and (4) reductions in operations and/or better engineering controls employed by LANL. Tritium, which has a half-life of about 12 years, exhibited the greatest decrease in activity over the 20-plus-year period of this study at all three sites: background, perimeter, and on-site. Indeed, by 1996, the majority of radionuclide and radioactivity values in soils collected from both perimeter and on-site areas were statistically similar to values detected in regional background locations.

B. Foodstuffs and Associated Biota Monitoring

1. Introduction

A wide variety of wild and domestic edible plant, fruit, and animal products are grown and/or harvested in the area surrounding the Laboratory. Ingestion of foodstuffs constitutes a critical pathway by which radionuclides can be transferred to humans (Whicker and Schultz 1982). For this reason, samples of milk, eggs, produce (wild and domestic fruits, vegetables, and grains), fish, honey, herbal teas, mushrooms,

piñon, domestic animals, and large and small game animals are collected annually from Laboratory property from the surrounding communities. This Foodstuffs and Biota Monitoring program is mandated by DOE Orders 5400.1 and 5400.5. The three main objectives of the program are to determine (1) radioactive and nonradioactive (light, heavy, and nonmetal trace elements) constituents in foodstuffs and biota at on-site LANL and perimeter areas compared with regional background; (2) trends; and (3) dose. Potential radiation doses to individuals from the ingestion of foodstuffs are presented in Chapter 3.

2. Produce

a. Monitoring Network. We collect fruits, vegetables, and grains each year from on-site, perimeter, and regional background locations (Figure 6-2). Samples of produce are also collected from the Pueblos of Cochiti and San Ildefonso, which are located in the general vicinity of LANL. Produce from areas within and around the perimeter of LANL is compared with produce collected from regional background gardens in northern New Mexico; these gardens are located in the Española, Santa Fe, and Jemez areas. The regional sampling locations are far enough away from the Laboratory that they are unaffected by Laboratory airborne emissions.

b. Sampling Procedures, Data Management, and Quality Assurance. Produce samples are collected from local gardens within and around the perimeter of the Laboratory in the summer and fall of each year. All QA/QC protocols, chemical analyses, data handling, validation, and tabulation can be found in the ESH-20 OP entitled, "Produce Sampling and Processing for the Foodstuffs Monitoring Program," LANL-ESH-20-SF-OP-001, R0, 1997.

c. Radiochemical Analytical Results. Concentrations of radionuclides in produce collected from on-site, perimeter, and regional background locations during the 1998 growing season can be found in Table 6-3. All radionuclide concentrations in fruits and vegetables collected from on-site and perimeter areas were very low, and most were nondetectable and/or within RSRLs. Radionuclides in produce collected from the Pueblo communities around LANL were also low, showing concentrations similar to past years (Fresquez et al., 1995a). Moreover, as a group, radionuclides in almost all perimeter and on-site areas, with the exception of tritium in produce collected from on-site areas, were not significantly higher ($p<0.05$) than produce collected from regional background locations. Although tritium in produce from on-site areas was significantly higher than background, as in past years, the difference between the two sites was very low (0.63 pCi/mL).

d. Nonradiochemical Analytical Results. The trace elements silver, arsenic, beryllium, cadmium, chromium, mercury, nickel, selenium (for the most part), and thallium in produce from on-site, perimeter, and regional locations were below the LOD (Table 6-4). In those cases where produce samples contained trace elements above the LOD (for barium, lead, and zinc), very few individual samples exceeded RSRLs. As a group, the levels of barium, lead, or zinc in produce from on-site and perimeter areas were not significantly higher ($p<0.05$) than in produce collected from regional background areas.

3. Honey

a. Monitoring Network, Sampling Procedures, Data Management, Quality Assurance, and Radiochemical Analytical Results. Beehives located within perimeter areas—Los Alamos townsite and White Rock/Pajarito Acres—are sampled on a biannual basis for honey and were last sampled during the 1997 year (Figure 6-2). We compared honey from those hives with honey collected from regional background hives located in northern New Mexico. We collected honey directly from the beekeepers. All QA/QC protocols, chemical analyses, data handling, validation and tabulation can be found in the ESH-20 OP entitled, "Honey Sampling and Processing for the Foodstuffs Monitoring Program," LANL-ESH-20-SF-OP-004, RO, 1997. All radionuclide concentrations in honey collected from perimeter hives in 1997 were in nondetectable and/or within upper-level background concentrations (ESP 1998) and were in concentrations similar to past years (Fresquez et al., 1997a; Fresquez et al., 1997b).

b. Long-Term Trends. There have been several recent long-term data evaluations on radionuclide concentrations, particularly tritium, in bees and honey within the LANL environs. In the first study, a host of radionuclides (tritium; cobalt-57; cobalt-60; europium-152; potassium-40; beryllium-7; sodium-22; manganese-54; rubidium-83; cesium-137; plutonium-238 and -239, -240; strontium-90; americium-241; and uranium) in honey collected from hives located around the perimeter of LANL (Los Alamos and White Rock/Pajarito Acres) over a 17-year period was evaluated (Fresquez et al., 1997a). All radionuclides,

with the exception of tritium, in honey collected from perimeter hives around LANL were not significantly different ($p<0.05$) from background. Overall, the maximum total net positive CEDE—based on the average concentration plus two standard deviations of all the radionuclides measured over the years after the subtraction of background—from consuming 11 lb of honey (maximum consumption rate) collected from Los Alamos and White Rock/Pajarito Acres was 0.031 mrem/y and 0.006 mrem/y, respectively. The highest CEDE was <0.04% of the International Commission on Radiological Protection (ICRP) permissible dose limit of 100 mrem/y from all pathways.

In the second study, tritium concentrations in bees and honey collected from within and around LANL over an 18-year period were evaluated (Fresquez et al., 1997b). Based on the long-term average, bees from nine out of eleven hives and honey from six out of eleven hives on LANL lands contained tritium that was significantly higher ($p <0.05$) than background. The highest average concentration of tritium in bees (435 pCi/mL) collected over the years was from LANL's TA-54—a low-level radioactive waste disposal site (Area G). Similarly, the highest average concentration of tritium in honey (709 pCi/mL) was collected from a hive located near three tritium-contaminated storage ponds at LANL TA-53. The average concentrations of tritium in bees and honey from background hives were 1.0 pCi/mL and 1.5 pCi/mL, respectively. Although the concentrations of tritium in bees and honey from most LANL and perimeter (White Rock/Pajarito Acres) areas were significantly higher than background, most areas, with the exception of TA-53 and TA-54, generally exhibited decreasing tritium concentrations over time (Table 6-5).

4. Eggs

a. Monitoring Network. We collected fresh eggs from free-ranging chickens from the Los Alamos townsite, the White Rock/Pajarito Acres townsite and the Pueblo of San Ildefonso. We compared these eggs with eggs produced from free-range chickens located in the Española area (background).

b. Sampling Procedures, Data Management, and Quality Assurance. We collected twenty-four medium-sized eggs from Los Alamos townsite, White Rock/Pajarito Acres townsite, Pueblo of San Ildefonso, and Española (background) directly from the farmer. All QA/QC protocols, chemical analyses, data handling, validation, and tabulation can be found in the ESH-20 OP entitled, "Egg Sampling and Processing for the Foodstuffs Monitoring Program," LANL-ESH-20-SF-OP-006, R0, 1997.

c. Radiochemical Analytical Results. Results of radionuclide concentrations detected in eggs collected from Los Alamos townsite, White Rock/Pajarito Acres townsite, the Pueblo of San Ildefonso, and Española (background) area can be found in Table 6-6. All radionuclide concentrations in eggs collected from all locations were low, and most were nondetectable and/or within upper-level background concentrations. Only strontium-90 and total uranium concentrations in eggs from the Los Alamos townsite were above RSRLs. The differences in strontium-90 and total uranium concentrations between the Los Alamos townsite and background areas, however, were very low—a difference of 7 pCi/L for strontium-90 and 0.34 µg/L for total uranium.

5. Milk

a. Monitoring Network. We collected goat milk from Los Alamos and White Rock/Pajarito Acres townsite areas and compared it with goat milk collected from a dairy located near Albuquerque, NM.

b. Sampling Procedures, Data Management, and Quality Assurance. We collected milk directly from the farmers. All QA/QC protocols, chemical analyses, data handling, validation, and tabulation can be found in the ESH-20 OP entitled, "Milk and Tea Sampling and Processing for the Foodstuffs Monitoring Program," LANL-ESH-20-SF-OP-005, R0, 1997.

c. Radiochemical Analytical Results. The results of the radiochemical analysis performed on goat milk collected from the perimeter areas and Albuquerque (background) are summarized in Table 6-7. All radionuclides, including iodine-131, in goat milk from the perimeter areas were low and were nondetectable and/or within upper-level background concentrations. Tritium and strontium-90 levels, in particular, are similar to tritium and strontium-90 levels in milk from other states around the country (Black et al., 1994).

6. Fish

a. Monitoring Network. We collect fish annually upstream and downstream of the Laboratory (Figure 6-2). Cochiti Reservoir, a 10,690-acre flood and sediment control project, is located on the Rio Grande approximately five miles downstream from the Labo-

ratory. Radionuclides and nonradionuclides (trace elements) in fish collected from Cochiti Reservoir are compared with fish collected from background reservoirs. These background reservoirs are the Abiquiu, Heron, and El Vado reservoirs, which are located on the Rio Chama, upstream from the confluence of the Rio Grande and intermittent streams that cross Laboratory lands (Fresquez et al., 1994).

Two types of fish are collected: game (surface-feeders) and nongame (bottom-feeders). Game fish include rainbow trout (*Salmo gairdneri*), brown trout (*Salmo trutta*), kokanee salmon (*Oncorhynchus nerka*), largemouth bass (*Micropterus salmoides*), smallmouth bass (*Micropterus dolomieui*), white crappie (*Pomixis annularis*), and walleye (*Stizostedion vitreum*). Nongame fish include the white sucker (*Catostomus commersone*), channel catfish (*Ictalurus penctatus*), carp (*Cyprinus carpio*), and carp sucker (*Carpiodes carpio*).

b. Sampling Procedures, Data Management, and Quality Assurance. Fish were collected by gill nets and transported under ice to the laboratory for preparation. At the laboratory, fish were gutted, had head and tail removed, and were washed. Muscle (plus associated bone) tissue was processed; wet, dry, and ash weights were determined, and the ash was submitted for analysis. All QA/QC protocols, chemical analyses, data handling, validation and tabulation can be found in the ESH-20 OP entitled, "Fish Sampling and Processing for the Foodstuffs Monitoring Program," LANL-ESH-20-SF-OP-002, R0, 1997.

c. Radiochemical Analytical Results. Concentrations of radionuclides in game and nongame fish collected upstream and downstream of the Laboratory in 1998 are presented in Table 6-8. In general, the concentrations of all radionuclides in game and nongame fish collected from Cochiti reservoir were low and were nondetectable and/or within upper-level background concentrations. These results were similar to radionuclide contents in crappie, trout, and salmon from comparable (background) reservoirs and lakes in Colorado (Whicker et al., 1972; Nelson and Whicker 1969) and, more recently, in fish collected along the length of the Rio Grande from Colorado to Texas (Booher et al., 1998).

As a group, both game and nongame fish collected downstream of LANL at Cochiti reservoir were significantly higher ($p<0.05$) in tritium concentrations than fish collected upstream of LANL at Abiquiu reservoir. Also, bottom-feeding fish at Cochiti reservoir were significantly higher in strontium-90 concentrations than fish from Abiquiu reservoir, although the differences were very low and were similar to past years' results (Fresquez et al., 1999a).

As expected, the nongame fish from both downstream and upstream reservoirs from LANL contained higher average uranium contents (11.6 ng per dry gram) than the surface-feeders (2.6 ng per dry gram). The higher concentration of uranium in bottom-feeding fish compared with surface-feeding fish is attributed to the ingestion of sediments on the bottom of the lake (Gallegos et al., 1971). Radionuclides readily bind to sediments (Whicker and Schultz 1982).

d. Long-Term Trends. Fresquez et al. (1994) conducted a summary and trend analysis of radionuclides in game and nongame fish collected from reservoirs upstream (Abiquiu, Heron, and El Vado Reservoirs) and downstream (Cochiti Reservoir) of LANL from 1981 to 1993. In general, the average levels of strontium-90; cesium-137; plutonium-238; and plutonium-239, -240 in game and nongame fish collected from Cochiti Reservoir were not significantly different from concentratons in fish collected from reservoirs upstream of the Laboratory. Total uranium was the only radionuclide that was found to be significantly higher in both game and nongame fish from Cochiti Reservoir when compared with fish from Abiquiu, Heron, and El Vado Reservoirs. Uranium concentrations in fish collected from Cochiti Reservoir, however, significantly ($p<0.05$) decreased from 1981 to 1993, and no evidence of depleted uranium was found in fish samples collected from Cochiti Reservoir in 1993 (Fresquez and Armstrong 1996).

e. Nonradiological Analytical Results. The results of the trace element analysis in fish samples from Cochiti and Abiquiu reservoirs in past years showed that mercury was the only element to be detected above the minimum level of detection (Table 6-9). All concentrations of mercury in fish from Cochiti Reservoir collected in 1997 were within the RSRL (<0.41µg mercury per gram wet) (ESR 1998).

7. Game Animals (Elk and Deer)

a. Monitoring Network. Mule deer and Rocky Mountain elk are common inhabitants of LANL; resident populations of deer number from 50 to 100, whereas elk number from 100 to 200 and increase to as many as 2000 animals during the winter months (Fresquez et al., 1999b). Samples of elk and deer are collected as road kill on an annual basis from Laboratory areas, and the meat and bone are analyzed for a

host of radionuclides. These data from meat and bone samples were compared with radionuclide concentration in meat and bone samples from elk and deer collected from regional background locations.

b. Sampling Procedures, Data Management, and Quality Assurance. Samples of elk and deer meat and bone tissue were collected (1000 g each) from fresh road kills around and within the Laboratory. Background samples were collected by the New Mexico Department of Game and Fish. All QA/QC protocols, chemical analyses, data handling, validation, and tabulation can be found in the ESH-20 OP entitled, "Game Animal Sampling and Processing for the Foodstuffs Monitoring Program," LANL-ESH-20-SF-OP-003, R0, 1997.

c. Radiochemical Analytical Results. Most radionuclide concentrations in muscle and bone tissue of elk collected from LANL lands were nondetectable and/or below upper-level background concentrations (Tables 6-10 and 6-11). Very few elk contained radionuclide concentrations above regional upper-level background concentrations. One, however, contained radioisotopes associated with a known contaminated site at LANL; this cow elk spent over 55% of its time within LANL technical areas associated with firing site activities (TA-15) (Fresquez et al., 1998b) and, in fact, was collected within 328 ft (100 m) of EF site—a nonactive firing site heavily contaminated with natural and depleted uranium (Hanson and Miera, 1976; Hanson and Miera, 1978). Its muscle contained over 50 times more uranium than the muscle tissue of elk collected from background locations. Although the ultimate deposition site of uranium is the bone (Whicker and Schultz 1982), the uptake of uranium by this particular elk may have been recent because the levels of uranium in the bone (11.6 ng g^{-1} dry) were relatively low and just slightly higher than uranium concentrations in bone (2.3 ng g^{-1} dry) from background elk. As a group, none of the radionuclides in muscle and bone tissue in elk collected from LANL lands, with the exception of total uranium in bone, was significantly higher ($p<0.05$) than radionuclides in tissues of elk collected from background regions. The difference between the mean concentration of total uranium in bone from LANL elk as compared with total uranium in bone of background elk, however, was very low—a difference of only 8 ng/g dry.

Most radionuclide concentrations in muscle and bone tissue of deer collected from LANL lands were nondetectable and/or within RSRLs. As we found with the elk, very few deer (samples) contained radionuclide concentrations above regional background concentrations, but one, however, contained radioisotopes associated with a known contaminated site at LANL. This deer, collected from a mesa top located between two canyons at LANL that have a known history of cesium-137 and strontium-90 contamination (Fresquez et al., 1995b; Fresquez et al., 1998c), contained higher concentrations of cesium-137 and strontium-90 in muscle and bone tissue than similar tissue collected from deer at regional background locations. As a group, none of the radionuclides in either deer muscle or bone was significantly higher ($p<0.05$) than similar tissue from deer collected from background regions.

d. Long-Term Trends. Radionuclide concentrations (tritium; strontium-90; cesium-137; plutonium-238 and -239, -240; americium-241; and uranium) determined in muscle and bone tissue of deer and elk collected from LANL lands from 1991 through 1998 were summarized (Fresquez et al., 1998b). Also, we estimated the CEDE to people who ingest muscle and bone from deer and elk collected from LANL lands. Most radionuclide concentrations in muscle and bone from individual deer and elk collected from LANL lands were at less than detectable quantities and/or within upper-level background concentrations. As a group, most radionuclides in muscle and bone of deer and elk from LANL lands were not significantly higher ($p<0.10$=at the 90% confidence level) than in similar tissues from deer and elk collected from background locations. Also, elk that had been radio collared and tracked for two years and spent an average time of 50% on LANL lands were not significantly different in most radionuclide levels from those in road-kill elk that have been collected on LANL lands as part of the environmental surveillance program. All CEDEs were far below the ICRP guideline of 100 mrem/y.

8. Domestic Animals

a. Monitoring Network. Beef cattle owned by the various Pueblos around LANL graze the boundaries of LANL on a regular basis and are offered by the Pueblo for sampling and analysis. We compared meat and bone tissue collected from these cattle sampled from the Pueblos with similar tissues from beef cattle collected from regional background locations.

b. Sampling Procedures, Data Management, and Quality Assurance. All QA/QC protocols, chemical analyses, data handling, validation, and

tabulation can be found in the ESH-20 OP entitled, "Game Animal Sampling and Processing for the Foodstuffs Monitoring Program," LANL-ESH-20-SF-OP-003, RO, 1997.

c. Radiochemical Analytical Results. Radionuclide concentrations in muscle and bone tissue of a domestic free-range steer collected from Pueblo of Cochiti lands can be found in Table 6-12. All radionuclides in muscle and bone tissue from a domestic steer we collected from the Pueblo of Cochiti were low and were nondetectable and/or within upper-limit background concentrations. The only radionuclide we detected in higher concentrations than the RSRL was americium-241. The differences between the concentrations of americium-241 in the steer from Pueblo of Cochiti and the background steer, however, were low.

9. Herbs/Tea

a. Monitoring Network. We collected Navajo Tea (also known as Cota) from three perimeter areas surrounding the Laboratory: Los Alamos townsite on the north, White Rock on the southeast, and Pueblo of San Ildefonso lands on the east. Tea was collected from the Española/Santa Fe/Jemez area(s) as a background comparison.

b. Sampling Procedures, Data Management, and Quality Assurance. Tap water was added to the vegetative portion (stems) of Navajo Tea and brought to a boil. After the tea was cooled, it was filtered and poured into a suitable container and submitted to chemistry as a liquid. All QA/QC protocols, chemical analyses, and data handling, validation, and tabulation can be found in the ESH-20 OP entitled, "Milk and Tea Sampling and Processing for the Foodstuffs Monitoring Program," LANL-ESH-20-SF-OP-005, R0, 1997.

c. Radiochemical Analytical Results. Results of the liquid tea analysis can be found in Table 6-13. Most radionuclides in tea collected from the perimeter areas around LANL were nondetectable and/or within upper-limit background concentrations. Total uranium in Navajo Tea from all of the perimeter locations was detected in higher concentrations than the RSRL; however, the concentrations were still within or close to the current year's background concentration of 4.2 μg/L. The higher uranium concentrations in tea collected from perimeter areas were probably a function of analysis, as all of the values, including the control, were about four times higher than last year's results. In contrast, all of the other radionuclides, particularly plutonium in teas from the perimeter locations, were in lower quantities than last year's results.

10. Piñon

a. Monitoring Network. Because piñon nuts are produced only every seven to ten years by piñon pine trees in the semiarid Southwest, piñon shoot tips (a more conservative medium) have been harvested on an annual basis since 1996 in an effort to estimate the dose from the ingestion of this very popular native product. We collected piñon tree shoot tips from three perimeter areas surrounding the Laboratory: Los Alamos townsite on the north, White Rock/Pajarito Acres on the southeast, and Pueblo of San Ildefonso lands on the east. Piñon tree shoot tips collected from the Jemez area provided background comparisons.

b. Sampling Procedures, Data Management, and Quality Assurance. All QA/QC protocols, chemical analyses, data handling, validation, and tabulation can be found in the ESH-20 OP entitled, "Produce Sampling and Processing for the Foodstuffs Monitoring Program," LANL-ESH-20-SF-OP-001, R0, 1997.

c. Radiochemical Analytical Results. Analytical results of the piñon tree shoot tips collected during 1998 can be found in Table 6-14. Most radionuclides in piñon tree shoot tips from the perimeter areas of LANL were present in very low concentrations and were nondetectable and/or within the RSRLs. Of piñon pine shoots in which the radionuclides (plutonium-238 from San Ildefonso Pueblo and plutonium-239 in all of the perimeter areas) exceeded regional background concentrations, the differences between these shoots and background shoots were very low.

11. Small Game Animals (Squirrels)

a. Monitoring Network. Samples of squirrels were collected from Laboratory and perimeter areas, and the meat and bone were analyzed for a host of radionuclides. We compared these data with radionuclide concentrations in meat and bone samples from squirrels collected from regional background locations.

b. Sampling Procedures, Data Management, and Quality Assurance. All QA/QC protocols, chemical analyses, data handling, validation, and tabulation can be found in the ESH-20 OP entitled, "Game Animal Sampling and Processing for the Foodstuffs Monitoring Program," LANL-ESH-20-SF-OP-003, R0, 1997.

c. Radiochemical Analytical Results. Analytical results of squirrel muscle and bone collected during 1997–1998 can be found in Table 6-15. Most radionuclide concentrations, particularly tritium, total uranium, and cesium-137, in muscle tissue of the composited squirrel sample collected from LANL TA-53 were higher than radionuclides in squirrel tissues collected from perimeter and background locations (Table 6-15). In contrast, most radionuclide concentrations, with the exception of total uranium, in muscle and bone tissue of squirrels collected from perimeter areas were similar to concentrations in muscle and bone tissues of squirrels collected from background locations. Bone tissue in squirrels collected from LANL had higher concentrations of tritium and cesium-137 and, to a greater degree, uranium and strontium-90. The strontium-90 concentration in bone tissue of squirrel, however, was not a detectable value (see note on Table 6-15) and should be viewed with caution. Total uranium in squirrel bone from TA-53, on the other hand, was over 600 times higher than bone tissue collected from squirrels at regional locations.

12. Mushrooms

a. Monitoring Network. We collected wild mushrooms from LANL (six species were collected) and three perimeter areas: Los Alamos townsite on the north (12 species), White Rock/Pajarito Acres on the southeast (10 species), and Pueblo of San Ildefonso lands on the east (seven species). We also collected mushrooms from the Española/Santa Fe/Jemez area as a background comparison (six species).

b. Sampling Procedures, Data Management, and Quality Assurance. All QA/QC protocols, chemical analyses, data handling, validation, and tabulation can be found in the ESH-20 OP entitled, "Produce Sampling and Processing for the Foodstuffs Monitoring Program," LANL-ESH-20-SF-OP-001, R0, 1997.

c. Radiochemical Analytical Results. Analytical results of the mushrooms collected during 1998 can be found in Table 6-16. Although low, many radionuclide concentrations were detectable and/or above upper-limit background concentrations, particularly uranium and plutonium-239, especially in mushrooms collected from the perimeter sites—Los Alamos, White Rock/Pajarito Acres, and Pueblo of San Ildefonso. In contrast, only one value, plutonium-239, was a detectable value in mushrooms collected from LANL lands, but it was far below background concentrations. Because this was the first time that mushrooms have been collected within and around the LANL environs, it is not certain whether the higher radionuclide concentrations in mushrooms collected from the perimeter areas as compared to background sources were from LANL sources or simply a result of incomplete washing procedures before analysis. These samples, for example, were composites and contained many small species of fungi that were difficult to wash. On the other hand, it is known that certain fungal species can sequester radionuclides, particularly cesium, strontium, and plutonium (Hoshi et al., 1994). For this reason, we will collect wild and larger species of mushrooms in future seasons in the same general locations and reevaluate them to determine with greater confidence the radionuclide uptake by mushrooms in the area.

C. Other Environmental Surveillance Program Activities or Special Studies around Los Alamos National Laboratory

1. Radionuclide Concentrations in Bed Sediment and Fish Tissue Within the Rio Grande Drainage Basin

In 1992–93, Los Alamos National Laboratory collaborated with the US Geological Survey in an effort to characterize radionuclide concentrations in bed sediment and fish tissue within the Rio Grande drainage basin from Colorado to Texas. Bed sediment was sampled from 18 locations and fish tissue was sampled from 12 locations for various radionuclides (Booher et al., 1998).

2. Moisture Conversion Ratios for the Foodstuffs and Biota Environmental Surveillance Programs

A study was conducted to determine the mean ash to dry weight and dry to wet weight moisture ratios for a variety of foodstuffs and biota commonly collected as part of the Environmental Surveillance Program at Los Alamos National Laboratory (Fresquez and Ferenbaugh 1998).

3. Radionuclides and Heavy Metals in Rainbow Trout from Tsichomo, Nana Ka, Wen Povi, and Pin De Lakes in Santa Clara Canyon

Radionuclide and heavy metal concentrations were determined in rainbow trout collected from Tsichomo, Nana Ka, Wen Povi, and Pin De lakes in Santa Clara Canyon in 1997. Most radionuclide and heavy metal

concentrations in fish collected from these four lakes were within or just above upper limit background concentrations (Abiquiu reservoir) and, as a group, were statistically ($p < 0.05$) similar in most parameters to background. Consequently, the CEDE from the ingestion of 46 lb of fish from Santa Clara Canyon (0.028 mrem/y) was within the CEDE from the ingestion of fish from Abiquiu reservoir (0.037 mrem/y). Moreover, the upper-level (95%) net positive total CEDE—a dose that could potentially be attributed to Laboratory operations—was only 0.042 mrem/y. This dose was far below the ICRP permissible dose level (Fresquez et al., 1998d).

4. Human Health Risk Assessment Related to the Consumption of Elk and Deer That Forage Around the Perimeter of a Low-Level Radioactive Waste Disposal Site

Material Disposal Area G (MDA G) is the primary low-level radioactive waste disposal site at LANL and occupies 26 ha on the eastern side of LANL adjacent to Pueblo of San Ildefonso lands. Analyses of soil and vegetation collected from the perimeter of MDA G show concentrations of radionuclides greater than background concentrations established for northern New Mexico. As a result, Pueblo residents have become concerned that contaminants from TA-54, MDA G could enter tribal lands through various pathways. The residents have specifically questioned the safety of consuming meat from elk and deer that forage near MDA G and then migrate on to tribal lands. In this study, we used the RESRAD code to estimate the CEDE to a resident who ingests elk and deer meat. Radionuclide concentrations measured in the soils from the perimeter of MDA G and from nearby water sources were used as inputs. Preliminary results suggest that a human who consumes 23 kg of elk meat or deer meat yearly would receive a maximum net positive CEDE of <0.8 μSv/y and <0.3 μSv/y, respectively. The estimates collected from LANL lands are slightly greater than values obtained from analyses of elk tissue collected from roadkills (0.3 μSv/y) but less than deer tissue collected from roadkills (1.82 μSv/y) (Ferenbaugh et al., 1998).

5. Baseline Tritium Concentrations in Soils and Vegetation: The Tshirege Woodland Site at Technical Area 54

A preoperational environmental survey was conducted for the Tshirege woodland site—an experimental area managed by the Earth and Environmental Science Group (EES-15)—where radioactive tritium was injected ten cm deep in and around the base of piñon (*Pinus edulis*) and one-seeded juniper (*Juniperus monosperma*) trees. The site is located at the lower end of Cañada del Buey close to the intersection of Pajarito Road and State Road 4. We measured baseline values of tritium in soil and plant samples from five locations immediately surrounding the study area (Fresquez 1998).

6. Baseline Concentrations of Radionuclides and Heavy Metals in Soils and Vegetation Around the DARHT Facility: Construction Phase (1997)

As part of the Department of Energy's Mitigation Action Plan for the DARHT facility at LANL, we determined baseline concentrations of radionuclides and heavy metals in soil, sediment, and vegetation around the DARHT facility during the construction phase. Most radionuclides and heavy metals in soils, sediments, and vegetation, with the exception of strontium-90 in soils and sediments, were within upper-limit background concentrations. Although the levels of strontium-90 in soils and sediments around the DARHT facility were higher than background, they were below LANL screening action levels (Fresquez et al., 1998e).

7. Radionuclide Concentrations in Soils and Vegetation at Radioactive-Waste Disposal MDA G during the 1997 Growing Season

Soil and overstory and understory vegetation (washed and unwashed) collected at eight locations within and around MDA G were analyzed for various radionuclides. In general, most radionuclide concentrations, with the exception of tritium and plutonium-239, -240, were within upper-level (95%) background concentrations. Although tritium concentrations in vegetation from most sites were significantly higher than background (>2 pCi/mL), concentrations decreased markedly in comparison with last year's results. The highest tritium concentration in vegetation was detected from a juniper tree that was growing over tritium shaft #150; it contained 530,000 pCi tritium/mL. Also, as in the past, the transuranic (TRU) waste pad area contained the highest levels of plutonium-239 in soils and in understory vegetation when compared with other areas at MDA G (Fresquez et al., 1998f).

8. Sampling of Perimeter Surface Soils at Technical Area 54, MDA G

During fiscal year (FY) 1998, 39 surface soil samples were collected from the perimeter of TA-54, MDA G. The locations sampled depended on historical data collected at MDA G between 1993 and 1997. We chose the locations for the FY98 surface soil samples to best indicate whether contaminants, under the influence of surface water runoff, were moving outside the TA-54, MDA G perimeter. Each sampling point was located in obvious (but small) drainage channels just outside the perimeter fence. These sampling locations were thus biased to best determine movement of contaminated soil being carried by surface water runoff from within the confines of MDA G to beyond the MDA G fence. The radioactive constituents measured in these surface soil samples included americium-214, cesium-137, isotopic plutonium, and tritium.

The analytical results of the surface soil sampling indicate that some perimeter soils at MDA G continue to be elevated above background levels for tritium and plutonium. The most elevated concentrations of tritium in soils are prevalent in locations that are adjacent to the active tritium disposal shafts and next to a series of inactive tritium shafts and the TRU waste storage pads. Isotopic plutonium and americium-241 activity are slightly elevated in perimeter surface soils located adjacent to the TRU pads. Cesium-137 is uniformly distributed in the perimeter soils. The perimeter soil samples were not analyzed for total uranium, but previous years' uranium data have shown a uniform distribution in surface soils with no evidence of elevated levels over background. No gross changes in radioactivity in surface soil samples were observed, and the samples collected in FY98 contain radioactivity similar to samples collected in previous years. Our sampling did not define any new locations where surface soils were elevated with radioactivity. These findings are consistent with analogous measurements taken in FY93 through FY97. The MDA G perimeter surface soil data indicate that very little radioactivity moves outside of MDA G under the influence of surface water runoff (Childs 1999).

9. Radionuclide Contaminant Analysis of Small Mammals at MDA G

In 1997, small mammals were sampled at four locations: LANL MDA G, TA-54, a control site within the proposed MDA G expansion area, and a background site on Frijoles Mesa. The three purposes of the sampling were to identify radionuclides present within rodent tissues at waste burial sites, to compare the amount of radionuclide uptake by small mammals at waste burial sites with such uptake at a control site, and to identify the primary mode of contamination to small mammals (surface contact or ingestion/inhalation). Three composite samples of approximately five animals per sample were collected at each site. We analyzed samples for various radionuclides. Higher levels of total uranium and cesium-137 were detected in pelts than in the carcasses of small mammals, and strontium-90 was found to be higher in carcasses. Concentrations of other measured radionuclides in carcasses were not found to be statistically different from those measured in pelts. However, pelts generally had higher concentrations than carcasses, indicating surface contamination may be the primary contamination mode. Low sample sizes in total number of animals captured during 1997 prevented statistical analysis to compare site-to-site for all but four sites. Mean concentrations of americium-241, plutonium-238 and -239, and tritium in small mammal carcasses were found to be statistically greater at the transuranic waste pad #2. In addition, mean concentrations of total uranium, americium-241, and tritium in pelts of small mammals were also statistically greater. The control site and background site consistently had the lowest mean concentrations of radionuclides. We conducted year-to-year comparison of mean radionuclide concentrations where sufficient sample size existed. We found americium-241, plutonium-238 and -239, and tritium mean concentrations in carcasses statistically greater in 1997 than previous years at transuranic waste pad #2. However, mean concentrations of cesium-137 in small mammal carcasses were higher at the transuranic waste pad #2 and Pits 17 and 18 during 1996 (Bennett et al., 1998a).

10. Honey Bees as Indicators of Radionuclide Contamination: Comparative Studies of Contaminant Levels in Forager and Nurse Bees

We conducted two separate field experiments as part of ongoing research using honey bees (*Apis mellifera*) as indicators of environmental radionuclide contamination. The experiments were conducted within a study site containing radionuclide contamination above background levels. The first experiment compared levels of radionuclides found in forager

bees with those levels found in nurse bees. Bees were collected from colonies and analyzed for concentrations of radionuclides, and we compared the results using graphical and statistical methods. Results indicate no significant difference between the contaminant levels in forager and nurse bees. A second experiment compared the levels of radionuclides found in the flowers of three plant species growing in the study site: salt cedar (*Tamarix ramosissima*), white sweet clover (*Melilotus albus*), and rabbit brush (*Chrysothamnus nauseosus*). Results indicate no significant difference in the amounts of radionuclides found in the flowers of these three plants (Haarmann 1998a).

11. Honey Bees as Indicators of Radionuclide Contamination: Investigating Contaminant Redistribution Using Concentrations in Water, Flowers, and Honey Bees

As part of ongoing research using honey bees (*Apis mellifera*) as indicators of environmental radionuclide contamination, samples of water, flowers, and honey bees were collected for two consecutive years. We collected the samples within a study site containing radionuclide contamination above background levels. The samples were analyzed for concentrations of radionuclides, and we compared the results using rank sum, correlation, and trend analysis. Results were then used to assess the redistribution pathway of radionuclides within the study site. Results indicate that honey bees receive the majority of their contamination directly from the source, a radioactive waste lagoon. The amount of contamination the honey bees receive from flowers during nectar collection appears to be insignificant compared with the amount received during water collection. Results did not demonstrate significant patterns of correlation or trend between the lagoon, bees, or flowers. Sample results showed a significant bioaccumulation of cobalt-60 and sodium-22 within the honey bees but no significant bioaccumulation within the flowers (Haarmann 1998b).

12. Contaminants in Medium-Sized Mammals Around a Radioactive Liquid Waste Lagoon

Animals may be exposed to radioactive and nonradioactive contamination from wastes produced by historic and current operations at LANL. Understanding the potential for uptake and transport of contaminants by wildlife is an important component of environmental monitoring. We trapped, marked, and sampled medium-sized mammals (rock squirrel, raccoon, striped skunk, and bobcat) around a radioactive liquid waste lagoon at LANL during 1997 and 1998. We used radio-frequency identification tags to permanently mark animals and to monitor their movements into and out of the lagoon area. Urine from captured animals was sampled for tritium, and hair was sampled for levels of various metals. Results from mammals at the lagoon site were compared with results from mammals captured north of LANL. Rock squirrels captured at the lagoon had significantly higher levels of tritium than animals captured off the LANL site in both 1997 and 1998 ($P = 0.024$ in 1997 and $P < 0.0005$ in 1998). Rock squirrels captured farther from the lagoon tended to have lower tritium levels. Metal levels were not significantly elevated in rock squirrels at the lagoon area compared with rock squirrels at the control area. Although marked animals were recorded moving into the lagoon area, not all animals with elevated tritium levels were detected at the lagoon. Therefore, indirect routes are probably important in the uptake of tritium around the lagoon area (Hansen et al., 1998).

13. Relationship of Ecological Variables to Sin Nombre Virus Antibody Seroprevalence in Deer Mouse Populations

Seroprevalence of Sin Nombre hantavirus in rodents varies greatly in different geographic regions. We evaluated deer mouse (*Peromyscus maniculatus*) population density, plant cover and biomass, and terrestrial arthropod biomass to identify factors correlated with prevalence of antibody to Sin Nombre virus. Prior year insect biomass and present year rodent population density were positively correlated with Sin Nombre virus antibody prevalence ($\underline{P} = 0.04$ and 0.05, respectively), and a significant interaction occurred between deer mouse density, arthropod biomass, and plant cover with seroprevalence ($\underline{R}^2 = 0.50$, $\underline{P} = 0.05$). Our data suggest that, as food availability decreases, rodent population density becomes a more important factor in the hantavirus seroprevalence of a rodent population. Evaluating changes in habitat quality and incorporating the measurement of local ecological variables with studies of rodent population density fluctuations may aid in predicting human outbreaks of hantavirus disease (Biggs et al., 1998a).

14. Estimation of Observation Rates of Global Positioning Collars Deployed on Elk

A new and innovative form of satellite tracking involves the deployment of global positioning system (GPS) radio collars on animals. From 1996 to 1997, we conducted a study on Rocky Mountain elk (*Cervus elaphus nelsoni*) using GPS collars to evaluate the collar effectiveness, including the observation rate (the ability of the GPS collar to acquire a satellite locational position) in various terrain and plant cover types. GPS radio collars were attached to six elk; these collars were programmed to receive a locational position every 23 hours. Observation rate differences were estimated between cover types and terrain by interfacing home range polygons of the collared elk with vegetation cover types and terrain using the geographical information system. The overall mean observation rate was 75% for all elk collared. Preliminary results indicate observation rates were lower in mixed conifer and ponderosa pine forests compared with piñon-juniper woodlands, both in canyons and on mesas. Some differences in observation rates were observed between canyons and mesas based on predicted movement patterns in multiterrain home range polygons. Cloud cover did not appear to influence GPS collar observation rates. Observation rates estimated for GPS collars deployed on elk in montane forests of the southwestern US appear to be within an acceptable range for use in determining resource use patterns (Biggs et al., 1998b).

15. Development and Application of a Movement Predictive Model for Elk

We are continuing the development of an ArcView application to predict travel corridors of Rocky Mountain elk (*Cervus elaphus*) in and around LANL. We are using GPS radio collar data from eight elk to aid in predicting elk movement patterns. GPS locations are collected from collared elk every 23 hours. A "least cost surface" (cartographical surface depicting friction of movement) analysis was developed using the Spatial Analyst extension of ArcView and GRID of ARC/INFO to model movement pathways. Model variables include land cover type, slope, aspect, mean daily distance traveled, and human-induced variables such as fences, roads, and permanent structures. We are using a Chi Square Goodness of Fit analysis to evaluate elk locational data to each variable. All locational data are pooled for this analysis as well as analyzed by each season separately. Variables are weighed and assigned relative values based on their attractiveness to elk. An accumulated cost surface is then developed for the LANL area. We are using simulation data with barriers to look at the modeled movement predictions. Once completed, this model can be a management tool for evaluating the siting of new structures, roads, or fences. Elk travel routes and daily movement patterns can be modeled to determine potential effects of various types of human impact (Bennett et al., 1998b).

16. A Preliminary Survey of Terrestrial Plant Communities in the Sierra de los Valles

To more fully understand the species compositions and environmental relationships of high-elevation terrestrial plant communities in the Los Alamos region, we sampled 30 plots in randomly selected, upland locations for vegetation, topographic, and soils characteristics. All plots were more than 2,134 m above sea level. The field results were summarized, analyzed, and incorporated into a previously developed classification of vegetation and land cover types. The revised and updated discussions of the environmental relationships at these sites and their associated species compositions are included in a report (Balice 1998). A previously developed key to the major land cover types in the Los Alamos region was also revised in accordance with the new information and included in its entirety.

17. Levels of Forest Fuels and Their Relationships to Vegetation Types and Fire History at LANL

Understory and overstory fuels were quantitatively inventoried in 54 sample plots located throughout the Los Alamos region. Sample data were collected in piñon-juniper woodlands, ponderosa pine forests, and mixed conifer forests. Analyses of these data indicate that the fuel levels in the piñon-juniper woodlands are moderate to low, and these fuels are structured such that catastrophic fires would not be expected in piñon-juniper woodlands except under extreme weather conditions. In contrast, understory fuels were greatest in mixed-conifer forests. Overstory fuels were greatest in the ponderosa pine forests, although the overstory fuels were also high in the mixed conifer forests. These results have implications for fire behavior. Fires that ignite in mixed conifer forests have the potential to burn at low levels until hot, windy weather conditions elevate these fires into the

forest crowns. Then catastrophic crown fires can occur, especially in the ponderosa pine forests where the overstory fuels are the greatest. This scenario is consistent with the behavior of three recent wildfires that have occurred in the Los Alamos region (Oswald and Balice 1998).

18. An Analysis of Background Noise in Selected Canyons of Los Alamos County

We recorded background noise levels in six canyons within Los Alamos County to establish a baseline for future comparisons and to discover what noises animals are exposed to. Noise level measurements were taken within each canyon, beginning at an established starting point and at one-mile intervals up to four miles. The primary source of noise above 55 dBA was vehicular traffic. One clap of thunder provided the highest recorded noise level (76 dBA). In general, the level of noise, once away from highways and parking lots, was well below 60 dBA (Huchton et al., 1998).

19. Annotated Checklist and Database of Vascular Plants of the Jemez Mountains

Studies done in the last 40 years have provided information to construct a checklist of plants of the Jemez Mountains. The present database and checklist build on the basic list compiled by Teralene Foxx and Gail Tierney in the early 1980s. The checklist is annotated with taxonomic information, geographic and biological information, economic uses, wildlife cover, revegetation potential, and ethnographic uses. Nearly 1000 species have been observed in the Jemez Mountains. This list is cross-referenced with the US Department of Agriculture Natural Resource Conservation Service PLANTS Data base species names and acronyms. This information is available on the World Wide Web (*http://plants.usda.gov/plantproj/plants/project_databases.html*) (Foxx et al., 1998).

20. Threatened and Endangered Species Habitat Management Plan Overview

The relative isolation and undisturbed natural setting of much of LANL make this facility ideally suited for its defense-related mission. These factors, combined with limited public access, also have resulted in the preservation of habitat that can sustain a number of species receiving federal protection under the Endangered Species Act. The Threatened and Endangered Species Habitat Management Plan (HMP) at LANL—which covers all of the lands within LANL's boundaries—was developed over a three-year period with the dual intent of providing protection for threatened or endangered species that may reside on or use LANL property as well as facilitating the implementation of DOE's mission at LANL. The HMP's procedures and strategies provide the basis for the sound management of these species while allowing LANL's programs to proceed in an efficient and cost-effective manner. A report (Ecology Group, 1998) provides an overview of the HMP, including

- Regulatory requirements and reviews that led to its development;
- Existing conditions at LANL that gave rise to the need for an HMP;
- Goals, objectives, and implementing strategies;
- HMP components;
- A summary of roles and responsibilities of key organizations involved in implementing the HMP;
- Long-term activities required to implement the HMP;
- Methods for modifying the HMP; and
- Methods for tracking the success of the plan and for implementing corrective actions where needed.

21. Preliminary Risk Assessment of the Southwestern Willow Flycatcher

The southwestern willow flycatcher (*Empidonax traillii extimus*) is the fourth threatened or endangered species to undergo a preliminary assessment for estimating potential risk from environmental contaminants at LANL. For the preliminary assessment, estimated doses were compared against toxicity reference values to generate hazard indices. This assessment included a measure of cumulative effects from multiple contaminants (radionuclides, metals, and organic chemicals) to 100 simulated nest sites located within flycatcher potential habitat. Sources of contaminant values were 10,000-ft^2 grid cells within an Ecological Exposure Unit. This Ecological Exposure Unit was estimated around the potential habitat and was based on the maximum home range for the flycatcher as identified in scientific literature. We modeled foraging scenarios for both the breeding and nonbreeding season. Food consumption and soil ingestion contaminant pathways were addressed in the

assessment. Using a four-category risk evaluation, hazard indices results indicated the southwestern willow flycatcher will not experience any appreciable impact (Gonzales et al., 1998a). Information on risk by specific geographical location was generated, which can be used to manage contaminated areas, flycatcher habitat, facility siting, and/or facility operations to maintain low levels of risk from contaminants.

22. Threatened and Endangered Bird Surveys: Mexican Spotted Owl

During the 1994–1998 field seasons, we surveyed five primary areas at LANL for the Mexican spotted owl (*Strix occidentalis lucida*). The surveys revealed a nesting pair of owls that subsequently fledged a pair of young for four consecutive years (Keller 1998a).

23. Threatened and Endangered Bird Surveys at Los Alamos National Laboratory: Southwestern Willow Flycatcher

During the 1995–1998 field seasons, we surveyed two primary areas for the southwestern willow flycatcher (*Empidonax traillii extimus*): Pajarito Canyon and the Rio Grande near Buckman Crossing. The southwestern willow flycatcher was found for the first time during the 1998 spring migration (Keller 1998b).

24. Bald Eagle Habitat Management and Monitoring

Bald eagles (*Haliaeetus leucocephalus*) winter along the Rio Grande but are not known to nest in the area. Most wintering bald eagles congregate downstream from LANL, but LANL contains winter foraging, and roosting habitat, and potential nesting habitat. Numbers of wintering bald eagles in White Rock Canyon have generally increased but were notably lower in 1997 and 1998. As bald eagles become more numerous and the river delta above Cochiti Lake expands, bald eagle use of LANL is expected to increase. Interagency coordination will increase the effectiveness of bald eagle habitat management in the area. Potential nest and roost trees in White Rock Canyon and sensitive zones have been mapped to trigger assessments of potentially disturbing activities. We monitor potential nest trees, roost trees, and foraging perches in LANL annually for signs of use. Most bald eagle use in 1998 occurred near foraging perches (Johnson and Keller 1998).

25. Peregrine Falcon Habitat Management and Monitoring

Suitable breeding habitat for the American peregrine falcon (*Falco peregrinus anatum*) is located in and around the Los Alamos National Environmental Research Park; the entire area is foraging habitat. Statewide, the peregrine population has been increasing; however, reproduction has been declining for a decade, which threatens to reverse this population trend. If peregrine falcons continue to increase in New Mexico, peregrine use of LANL areas is expected to increase. Four suitable nesting areas in and around LANL have been identified, and sensitive zones have been mapped to trigger assessments of activities that could potentially disturb them. Site management plans will guide planning of LANL activities within the sensitive zones, but management of the suitable habitat involves several other entities and will require interagency cooperation to be successful (Johnson 1998).

26. Songbird Survey

In 1997, a roadside songbird survey was initiated on LANL land to provide data about bird species that are not listed as threatened or endangered. This survey provides an opportunity to detect LANL impacts on local populations over time and the presence of species listed as sensitive or as species of concern. Our three objectives in this study were to determine what species are present, to determine if any species of concern are on LANL property, and to monitor trends in populations. Piñon-juniper woodland and ponderosa pine forest were the most often surveyed land-cover types with 23 stations and 20 stations in each type, respectively (Koch 1998).

27. Literature Review of the Site Nonspecific Habitat Use and Feeding Habits of Threatened and Endangered Species Concerning the Los Alamos National Laboratory

We conducted a systematic search of published and unpublished literature for information about biological species that are federally or state-listed as threatened, endangered, or species of concern that have the potential to inhabit, use, or migrate through the 43 square miles of Los Alamos National Laboratory or adjacent lands. To date, we have entered 456 references related to these species in a bibliographic database called ProCite. We have developed habitat

use and feeding habits tables for 21 species (Gonzales et al., 1998b).

28. Annual and Seasonal Variations in Four Species of Reptiles and Amphibians

Baseline studies of reptiles and amphibians of the Pajarito wetlands at LANL have been conducted since 1990. With the data gathered from 1990–1997, we examined the annual and seasonal population changes of four species of reptiles and amphibians over seven years. The four species studied are the Woodhouse toad (*Bufo woodhousii*), the western chorus frog (*Pseudacris triseriata*), the many-lined skink (Eumeces multivirgatus), and the plateau striped whiptail lizard (*Cnemidophorus velox*). Statistical analyses indicate a significant change on a seasonal basis for the western chorus frog and the many-lined skink. Results indicate a significant difference in the annual population of the Woodhouse toad (Nelson et al., 1998).

29. Bat Populations at Los Alamos National Laboratory and Bandelier National Monument

The status and trends of bat populations in the Jemez Mountains are not well known. In 1995, a three-year study was initiated to assess the current status of bat species of concern, elucidate distribution and relative abundance, and obtain information on roosting sites of bats. (Bogan et al., 1998a).

30. Continued Studies of Bat Species of Concern in the Jemez Mountains, New Mexico

A three-year study we initiated in 1995 has added considerably to our understanding of bats in the Jemez Mountains. In 1998, LANL funded an additional year to obtain more information on bat species of concern, especially the spotted bat (*Euderma maculatum*) and the big free-tailed bat (*Nyctinomops macrotis*). Work in 1998 helped refine our understanding of bat distributions in the Jemez Mountains, provided important information on site and roost fidelity, and enhanced the amount of available baseline information on status and trends of eight bat species of concern in the area (Bogan et al., 1998b).

31. Reptiles and Amphibians Monitoring

We have conducted baseline studies of reptiles and amphibians of the Pajarito wetlands at LANL since 1990. The LANL Ecology Group continued a pioneer mark-recapture study in 1998, using a passive integrated transponder (PIT) and toe clipping. When animals are over eight grams in mass, PIT tagging is utilized, and when less than eight grams, toe clipping is used. The study investigates the feasibility for using permanent marking methods. With the gathered data, we will develop a monitoring plan and then use the information to interpret population dynamics over time (Haarmann et al., 1998).

Table 6-1. Radionuclides in Surface Soils Collected from Regional Background, Perimeter, and On-Site Locations during 1998

Location	^{3}H (pCi/mL)	^{90}Sr (pCi/g dry)	^{137}Cs (pCi/g dry)	^{tot}U (µg/g dry)	^{238}Pu (pCi/g dry)	$^{239,240}Pu$ (pCi/g dry)	^{241}Am (pCi/g dry)	Gross Alpha (pCi/g dry)	Gross Beta (pCi/g dry)	Gross Gamma (pCi/g dry)
Regional Background Stations:										
Embudo	0.22 (0.70)[a]	1.56 (0.70)	0.29 (0.04)	1.57 (0.16)	0.000 (0.001)	0.013 (0.002)	0.006 (0.002)	3.4 (2.0)	2.4 (0.6)	2.2 (0.3)
Cochiti	0.11 (0.70)	1.10 (0.58)	0.28 (0.03)	1.79 (0.18)	0.001 (0.001)	0.008 (0.001)	0.006 (0.001)	2.0 (1.2)	2.8 (1.1)	2.2 (0.3)
Jemez	0.41 (0.71)	1.11 (0.60)	0.29 (0.04)	2.41 (0.24)	0.002 (0.001)	0.012 (0.002)	0.006 (0.001)	2.5 (1.8)	2.4 (1.0)	3.1 (0.4)
Mean (std dev)	0.25 (0.15)A[b]	1.26 (0.26)A	0.28 (0.01)A	1.92 (0.44)B	0.001 (0.001)A	0.011 (0.003)A	0.006 (0.000)B	2.6 (0.7)A	2.5 (0.2)A	2.5 (0.5)A
RSRL[c]	1.06	0.71	0.60	3.16	0.010	0.021	0.011	6.1	6.2	4.1
SAL[d]	1,900.00[e]	4.40	5.10	29.00	27.000	24.000	22.000	---	---	---
Perimeter Stations:										
Otowi	0.14 (0.70)	1.98 (0.88)	0.27 (0.03)	3.55 (0.36)	0.003 (0.001)	0.141 (0.007)	0.014 (0.002)	2.2 (1.5)	2.8 (1.1)	NA[f]
TA-8 (GT Site)	0.24 (0.71)	1.89 (0.72)	0.38 (0.04)	3.06 (0.31)	0.001 (0.001)	0.014 (0.002)	0.008 (0.002)	7.1 (2.0)	6.1 (1.5)	3.9 (0.4)
Near TA-49 (BNP)	0.19 (0.70)	2.31 (0.78)	0.32 (0.04)	3.46 (0.35)	0.002 (0.001)	0.014 (0.002)	0.006 (0.001)	2.5 (0.8)	5.1 (1.4)	3.6 (0.4)
East Airport	0.33 (0.71)	1.52 (0.66)	0.30 (0.04)	3.08 (0.31)	0.003 (0.001)	0.067 (0.004)	0.010 (0.004)	4.7 (1.5)	3.5 (1.1)	3.5 (0.4)
West Airport	0.38 (0.72)	1.34 (0.67)	0.22 (0.03)	3.35 (0.34)	0.001 (0.001)	0.044 (0.003)	0.007 (0.002)	5.2 (1.8)	3.8 (1.2)	3.3 (0.4)
North Mesa	0.42 (0.72)	1.04 (0.62)	0.48 (0.05)	3.80 (0.38)	0.003 (0.001)	0.023 (0.002)	0.007 (0.003)	8.8 (2.9)	4.6 (1.3)	3.5 (0.4)
Sportsman's Club	0.43 (0.72)	0.62 (2.17)	0.41 (0.05)	3.72 (0.37)	0.003 (0.001)	0.028 (0.003)	0.014 (0.006)	9.1 (2.8)	4.9 (0.9)	3.6 (0.4)
Tsankawi/PM-1	0.49 (0.72)	2.36 (0.74)	0.28 (0.04)	5.59 (0.56)	0.003 (0.001)	0.008 (0.002)	0.005 (0.001)	7.1 (2.4)	2.8 (1.1)	3.9 (0.4)
White Rock (East)	0.58 (0.73)	2.27 (0.81)	0.09 (0.02)	2.55 (0.26)	0.001 (0.001)	0.003 (0.001)	0.004 (0.001)	4.5 (1.7)	3.7 (1.2)	3.6 (0.4)
San Ildefonso	0.43 (0.72)	2.03 (0.69)	0.26 (0.03)	2.10 (0.21)	0.007 (0.001)	0.014 (0.002)	0.007 (0.002)	4.8 (1.8)	2.7 (1.0)	3.3 (0.4)
Mean (std dev)	0.36 (0.14)A	1.74 (0.59)A	0.30 (0.11)A	3.42 (0.93)A	0.003 (0.001)A	0.044 (0.054)A	0.008 (0.003)A,B	5.6 (2.4)A	4.0 (1.1)A	3.6 (0.2)A
On-Site Stations:										
TA-16 (S-Site)	–0.38 (0.67)[e]	1.61 (0.62)	0.82 (0.09)	5.68 (0.57)	0.000 (0.001)	0.027 (0.002)	0.010 (0.002)	10.5 (2.9)	6.1 (1.5)	4.5 (0.5)
TA-21 (DP-Site)	0.57 (0.73)	1.23 (0.78)	0.22 (0.03)	2.30 (0.23)	0.005 (0.001)	0.067 (0.005)	0.014 (0.002)	10.0 (2.8)	4.5 (0.8)	2.8 (0.3)
Near TA-33	0.12 (0.70)	1.22 (0.67)	0.41 (0.05)	3.61 (0.36)	0.003 (0.001)	0.024 (0.002)	0.010 (0.002)	3.2 (1.4)	3.3 (1.1)	3.5 (0.4)
TA-50	0.06 (0.70)	1.55 (0.79)	0.18 (0.03)	3.32 (0.33)	0.000 (0.001)	0.032 (0.003)	0.007 (0.002)	6.1 (2.0)	4.2 (1.2)	3.2 (0.4)
TA-51	0.15 (0.71)	0.88 (0.52)	0.34 (0.04)	3.32 (0.33)	0.000 (0.000)	0.036 (0.003)	0.008 (0.002)	6.9 (2.1)	3.5 (1.1)	3.2 (0.4)
West of TA-53	0.30 (0.71)	1.24 (0.74)	0.19 (0.03)	2.95 (0.30)	0.002 (0.001)	0.009 (0.002)	0.006 (0.004)	5.2 (1.9)	7.4 (1.7)	3.4 (0.4)
East of TA-53	0.28 (0.71)	1.30 (0.61)	0.37 (0.05)	2.81 (0.28)	0.001 (0.001)	0.021 (0.003)	0.008 (0.002)	5.6 (1.9)	3.6 (1.2)	3.2 (0.4)
East of TA-54	0.34 (0.72)	0.93 (0.57)	0.32 (0.05)	2.72 (0.27)	0.001 (0.001)	0.016 (0.002)	0.012 (0.002)	6.0 (1.9)	3.6 (1.2)	3.5 (0.4)
Potrillo Drive/TA-36	–0.20 (0.69)	1.51 (0.74)	0.42 (0.05)	2.85 (0.29)	0.002 (0.001)	0.016 (0.002)	0.008 (0.004)	6.2 (2.1)	3.5 (1.2)	3.5 (0.4)
Near Test Well DT-9	–0.41 (0.67)	1.21 (0.63)	0.29 (0.04)	2.93 (0.29)	0.001 (0.001)	0.013 (0.002)	0.009 (0.002)	8.2 (2.2)	4.4 (1.3)	3.2 (0.4)
R-Site Road East	–0.30 (0.68)	1.72 (0.67)	0.39 (0.05)	4.20 (0.42)	–0.000 (0.000)	0.010 (0.002)	0.005 (0.003)	6.6 (2.2)	3.9 (1.2)	3.2 (0.4)
Two-Mile Mesa	0.33 (0.72)	1.07 (0.62)	0.42 (0.05)	3.51 (0.35)	0.003 (0.001)	0.009 (0.002)	0.006 (0.002)	8.5 (2.4)	3.9 (1.2)	3.1 (0.4)
Mean (std dev)	0.07 (0.32)B	1.29 (0.26)A	0.36 (0.17)A	3.35 (0.89)A	0.002 (0.002)A	0.023 (0.016)A	0.009 (0.003)A	6.9 (2.1)A	4.3 (1.2)A	3.4 (0.4)A

[a] (±1 counting uncertainty); values are the uncertainty of the analytical results at the 65% confidence level.

[b] Means within the same column followed by the same upper-case letter are not significantly different from one another using a Wilcoxon Rank Sum Test at the 0.05 probability level.

[c] Regional Statistical Reference Level; this is the upper (95%) limit background concentration (mean + 2 std dev) based on data from 1993 to 1997 for Embudo, Cochiti, and Jemez.

[d] Los Alamos National Laboratory Screening Action Level from Fresquez et al. (1996a).

[e] Equivalent to the SAL of 260 pCi/g dry soil at 12% moisture.

[f] See Appendix B for an explanation of the presence of negative values.

Table 6-2. Total Recoverable Light, Heavy and Nonmetal Trace Elements (µg/g dry) in Surface Soils Collected from Regional Background, Perimeter, and On-Site Locations during 1998[a]

Location	Ag	As	Ba	Be	Cd	Cr	Hg	Ni	Pb	Sb	Se	Tl[c]
Regional Background Stations:												
Embudo	1.00[b]	2.00	65.8	0.20	0.20[b]	9.05	0.02	4.93	8.90	0.10[b]	0.20[b]	0.10[b]
Cochiti	1.00[b]	3.40	125.6	0.10	0.20[b]	8.80	0.01	5.65	10.80	0.10[b]	0.20[b]	0.10[b]
Jemez	1.00[b]	3.20	90.2	0.20	0.20[b]	19.61	0.02	12.09	12.00	0.10[b]	0.20[b]	
Mean	1.00	2.87A[c]	98.9A	0.17B	0.20	12.49A	0.02A	7.56A	10.57B	0.10	0.20	0.10
(std dev)	(0.00)	(0.76)	(30.1)	(0.06)	(0.00)	(6.17)	(0.01)	(3.94)	(1.56)	(0.00)	(0.00)	(0.00)
RSRL[d]	2.09	6.05	194.0	0.74	0.20	14.78	0.02	10.96	14.42	0.20	0.62	0.84
SAL[e]	400.00	6.00	5,600.0	0.90	80.00	400.00	24.00	1,600.00	500.00		400.0	
Perimeter Stations:												
Otowi	1.00[b]	1.00	53.9	0.20	0.20[b]	5.72	0.05[b]	3.37	7.00	0.10[b]	0.20[b]	0.10[b]
TA-8 (GT Site)	1.00[b]	1.90	120.0	0.20	0.20[b]	5.91	0.01	4.92	16.30	0.10[b]	0.20[b]	0.10[b]
TA-49 (BNP)	1.00[b]	3.00	131.0	0.40	0.20[b]	10.77	0.01	7.03	15.90	0.10[b]	0.20[b]	0.30
East Airport	18.63	2.10	82.3	0.30	0.20[b]	8.14	0.03	27.13	21.20	0.10[b]	0.20[b]	0.20
West Airport	1.00[b]	3.00	113.6	0.30	0.20[b]	10.80	0.03	12.17	30.10	0.10[b]	0.20[b]	0.20
North Mesa	1.00[b]	2.80	106.0	0.30	0.20[b]	9.27	0.05[b]	5.83	14.40	0.10[b]	0.20[b]	0.20
Sportsman's Club	1.00[b]	2.90	108.3	0.40	0.20[b]	10.13	0.02	6.71	17.00	0.10[b]	0.20[b]	0.20
Tsankawi/PM-1	1.00[b]	0.80	23.9	0.30	0.20[b]	3.56	0.01	1.91	9.10	0.10[b]	0.20[b]	0.10[b]
White Rock (East)	1.00[b]	2.70	124.8	0.50	0.20[b]	11.88	0.02	8.42	14.00	0.10[b]	0.50	0.20
San Ildefonso	1.00[b]	2.20	62.5	0.20	0.20[b]	7.90	0.02	5.49	12.50	0.30	0.20[b]	
Mean	2.76	2.24A	92.6A	0.31A	0.20	8.41A	0.03A	8.30A	15.75A	0.12	0.23	0.17
(std dev)	(5.58)	(0.81)	(35.5)	(0.10)	(0.00)	(2.67)	(0.02)	(7.18)	(6.44)	(0.06)	(0.09)	(0.07)
On-Site Stations:												
TA-16 (S-Site)	0.50[b]	0.80	160.0	0.50		1.40		2.50[b]	11.0		0.50[b]	0.07
TA-16 (S-Site)	1.00[b]	5.00	223.9	0.50	0.20[b]	7.87	0.02	5.79	16.70	0.10[b]	0.60	0.20
TA-21 (DP-Site)	1.00[b]	2.60	75.5	0.40	0.20[b]	7.08	0.03	5.14	21.00	0.10[b]	0.20[b]	0.20
Near TA-33	1.00[b]	2.00	129.0	0.50	0.20[b]	8.08	0.03	5.67	14.00	0.10[b]	0.60	0.30
TA-50	1.00[b]	2.50	94.2	0.40	0.20[b]	6.59	0.02	4.83	14.60	0.10[b]	0.20[b]	0.20
TA-51	1.00[b]	2.70	125.3	0.30	0.20[b]	10.93	0.02	5.60	16.40	0.10[b]	0.20[b]	0.20
West of TA-53	1.00[b]	2.80	95.4	0.40	0.20[b]	9.12	0.05[b]	6.14	14.20	0.10[b]	0.20[b]	0.20
East of TA-53	1.00[b]	1.60	41.8	0.40	0.20[b]	4.27	0.02	2.07	10.00	0.10[b]	0.20[b]	0.10[b]
East of TA-54	1.00[b]	1.20	53.2	0.30	0.20[b]	4.58	0.05[b]	2.64	8.80	0.10[b]	0.20[b]	0.10[b]
Potrillo Drive/TA-36	1.00[b]	2.40	78.9	0.30	0.20[b]	8.22	0.02	5.89	11.90	0.10[b]	0.20[b]	0.10[b]
Near Test Well DT-9	1.00[b]	1.80	101.5	0.40	0.20[b]	7.50	0.02	5.50	11.40	0.20	0.90	0.20
R-Site Road	1.00[b]	3.80	157.0	0.40	0.51	14.23	0.03	8.14	18.40	0.10[b]	0.60	0.30
Two-Mile Mesa	1.00	4.00	115.9	0.40	0.20[b]	9.91	0.02	6.81	30.00	0.10[b]	0.50	0.50
Mean	1.00	2.70A	107.6A	0.39A	0.23	8.20A	0.03A	5.35A	15.61A	0.11	0.38	0.22
(std dev)	(0.00)	(1.04)	(48.9)	(0.07)	(0.09)	(2.71)	(0.01)	(1.64)	(5.73)	(0.03)	(0.24)	(0.11)

[a] Analysis by EPA Method 3051 for total recoverable metals.

[b] All less-than values were converted to one-half the concentration.

[c] Means within the same column followed by the same upper-case letter are not significantly different from one another using a Wilcoxon Rank Sum Test at the 0.05 probability level.

[d] Regional Statistical Reference Level; this is the upper (95%) limit background concentration (mean + 2 std dev) based on data from 1994 to 1997.

[e] Los Alamos National Laboratory Screening Action Level.

Table 6-3. Radionuclides in Produce Collected from Regional Background, Perimeter, and On-Site Locations during 1998[a]

Location	^{3}H (pCi/mL)		^{137}Cs (10^{-3} pCi/g dry)		^{90}Sr (10^{-3} pCi/g dry)		^{tot}U (ng/g dry)		^{238}Pu (10^{-5} pCi/g dry)		$^{239,240}Pu$ (10^{-5} pCi/g dry)		^{241}Am (10^{-5} pCi/g dry)	
Regional Background Stations														
Española/Santa Fe/Jemez:														
Squash	–0.55	(0.60)[b,c]	66.81	(100.87)	283.0	(95.6)	2.62	(1.31)	14.4	(11.8)	91.7	(23.6)	32.8	(22.3)
Cucumber	–0.23	(0.63)	59.85	(89.11)	307.2	(230.1)	2.66	(1.33)	13.3	(25.3)	21.3	(26.6)	61.2	(39.9)
Pumpkin	–0.30	(0.62)	34.80	(51.60)	42.0	(69.6)	1.20	(1.20)	4.8	(13.2)	10.8	(18.0)	34.8	(18.0)
Apricot	–0.42	(0.61)	14.76	(22.96)	423.1	(277.2)	4.92	(1.64)	–27.9	(41.0)	9.8	(39.4)	101.7	(45.9)
Cherry	–0.45	(0.61)	44.10	(65.66)	204.8	(48.2)	17.64	(1.96)	–16.7	(21.6)	6.9	(22.5)	12.7	(21.6)
Mean (std dev)	–0.39	(0.13)	44.06	(20.68)	252.0	(141.1)	5.81	(6.75)	–2.4	(18.9)	28.1	(36.0)	48.6	(34.3)
RSRL[d]	0.39		73.8		81.6		17.4		11.2		16.2		20.5	
Perimeter Stations														
Los Alamos:														
Plum	–0.35	(0.62)	4.92	(7.38)	12.3	(28.3)	1.23	(1.23)	11.1	(11.1)	6.2	(13.5)	55.4	(19.7)
Peach	–0.27	(0.63)	4.56	(6.08)	26.6	(24.3)	2.28	(0.76)	8.4	(14.4)	25.8	(21.3)	47.1	(12.2)
Apricot	–0.25	(0.63)	0.00	(18.04)	154.2	(78.7)	6.56	(1.64)	1.6	(9.8)	18.0	(24.6)	75.4	(26.2)
Squash	–0.23	(0.63)	17.03	(26.20)	199.1	(148.0)	2.62	(1.31)	1.3	(7.9)	7.9	(10.5)	13.1	(24.9)
Apple	–0.32	(0.62)	10.44	(15.84)	52.2	(37.1)	1.08	(0.36)	–4.7	(9.7)	–23.0	(12.6)	7.2	(11.2)
Cherry	–0.04	(0.64)	30.38	(46.06)	185.2	(88.2)	3.92	(0.98)	–28.4	(29.4)	–84.3	(36.3)	18.6	(7.8)
Mean (std dev)	–0.24	(0.11)	11.22	(11.06)	104.9	(83.9)	2.95	(2.05)	–1.8	(14.2)	–8.2	(40.8)	36.1	(27.2)
White Rock/Pajarito Acres:														
Apricot	–0.33	(0.63)	255.84	(383.76)	80.4	(65.6)	3.28	(1.64)	–8.2	(13.1)	13.1	(16.4)	85.3	(29.5)
Tomato	–0.52	(0.62)	13.00	(19.00)	35.0	(96.0)	2.00	(1.00)	–16.0	(13.0)	–14.0	(15.0)	33.0	(27.0)
Green bean	–0.63	(0.61)	–17.94	(26.52)	266.8	(134.2)	3.12	(0.78)	–7.0	(10.1)	–5.5	(16.4)	53.8	(20.3)
Cherry	–0.52	(0.62)	106.82	(159.74)	65.7	(149.0)	6.86	(0.98)	–21.6	(14.7)	–5.9	(35.3)	58.8	(26.5)
Apple	–0.29	(0.64)	6.12	(9.00)	11.9	(23.4)	0.36	(0.36)	–7.9	(8.6)	–8.3	(7.2)	12.6	(5.8)
Corn	–0.46	(0.63)	80.00	(120.32)	307.8	(156.8)	1.92	(0.64)	6.4	(18.6)	7.0	(30.1)	18.6	(34.6)
Rhubarb	–0.52	(0.62)	73.32	(15.60)	516.4	(134.9)	7.02	(0.78)	–4.7	(7.8)	–1.6	(14.0)	30.4	(17.2)
Mean (std dev)	–0.47	(0.12)	73.88	(92.16)	183.4	(186.7)	3.51	(2.53)	–8.4	(8.8)	–2.2	(9.3)	41.8	(25.6)

Table 6-3. Radionuclides in Produce Collected from Regional Background, Perimeter, and On-Site Locations during 1998[a] (Cont.)

Location	^{3}H (pCi/mL)		^{137}Cs (10^{-3} pCi/g dry)		^{90}Sr (10^{-3} pCi/g dry)		^{tot}U (ng/g dry)		^{238}Pu (10^{-5} pCi/g dry)		$^{239,240}Pu$ (10^{-5} pCi/g dry)		^{241}Am (10^{-5} pCi/g dry)	
Cochiti:														
Squash	–0.31	(0.62)	36.68	(7.86)	390.4	(167.7)	2.62	(1.31)	3.9	(10.5)	–5.2	(13.1)	70.7	(40.6)
Lettuce	–0.51	(0.61)	25.00	(35.00)	790.0	(227.5)	72.50	(7.50)	2.5	(27.5)	15.0	(37.5)	262.5	(192.5)
Apricot	–0.38	(0.62)	–8.20	(16.40)	90.2	(50.8)	6.56	(1.64)	–1.6	(14.8)	–1.6	(36.1)	18.0	(32.8)
Cherry	–0.48	(0.61)	48.02	(9.80)	123.5	(83.3)	5.88	(0.98)	0.98	(4.9)	11.8	(7.8)	18.6	(24.5)
Corn	–0.17	(0.63)	53.12	(8.96)	45.4	(47.4)	0.64	(0.64)	2.6	(9.6)	11.5	(12.2)	28.2	(13.4)
Mean (std dev)	–0.37	(0.14)	30.92	(24.41)	287.9	(311.3)	17.64	(30.76)	1.7	(2.1)	6.3	(9.1)	79.6	(104.5)
Pueblo of San Ildefonso:														
Apricot	–0.39	(0.63)	–3.28	(16.40)	178.8	(119.7)	9.84	(1.64)	18.0	(34.4)	8.2	(36.1)	67.2	(31.2)
Squash	–0.77	(0.60)	94.32	(34.06)	250.2	(124.5)	2.62	(1.31)	–10.5	(14.4)	–14.4	(21.0)	47.2	(41.9)
Plum	–0.63	(0.61)	22.94	(34.72)	60.5	(36.9)	1.55	(0.31)	–2.2	(1.9)	6.5	(3.4)	17.4	(9.9)
Peach	–0.69	(0.61)	42.56	(12.92)	46.4	(40.3)	4.56	(0.76)	6.1	(16.0)	11.4	(17.5)	5.3	(15.2)
Corn	–0.64	(0.61)	42.88	(64.00)	58.9	(39.0)	0.64	(0.64)	5.1	(10.2)	1.9	(15.4)	32.0	(11.5)
Mean (std dev)	–0.62	(0.14)	39.88	(35.81)	119.0	(91.0)	3.84	(3.66)	3.3	(10.6)	2.7	(10.2)	33.8	(24.4)
On-Site Stations														
LANL (Mesa):														
Apple	1.02	(0.71)	20.52	(5.40)	13.0	(21.2)	1.08	(0.36)	–7.6	(6.1)	–6.5	(6.8)	10.8	(6.1)
Apricot	1.11	(0.72)	27.88	(41.00)	47.6	(101.7)	3.28	(1.64)	–31.2	(21.3)	24.6	(42.6)	23.0	(44.3)
Peach	–0.19	(0.63)	14.44	(21.28)	7.6	(42.6)	2.28	(0.76)	–3.0	(12.9)	–20.5	(25.1)	18.2	(17.5)
Crab Apple	–0.28	(0.62)	27.60	(6.40)	142.0	(42.8)	1.20	(0.40)	2.0	(8.8)	–2.0	(7.2)	8.0	(6.4)
Nectarine	–0.12	(0.64)	24.18	(5.46)	84.2	(53.8)	2.34	(0.78)	4.7	(12.5)	–20.3	(19.5)	37.4	(13.3)
Apple	–0.01	(0.64)	89.64	(16.20)	197.6	(86.4)	2.88	(0.36)	24.8	(7.9)	3.6	(9.4)	10.1	(27.0)
Mean (std dev)	0.26	(0.63)	34.04	(27.69)	82.0	(75.4)	2.18	(0.88)	–1.7	(18.2)	–3.5	(16.9)	17.9	(10.0)

[a] There are no concentration guides for produce, and with the exception of tritium, there were no statistical differences in any of the mean values from perimeter and on-site locations when compared with regional background at the 0.05 probability level using a Wilcoxon Rank Sum Test.

[b] See Appendix B for an explanation of the presence of negative values.

[c] (±1 counting uncertainty); values are the uncertainty of the analytical results at the 65% confidence level.

[d] Regional Statistical Reference Level; this is the upper (95%) limit background concentration (mean + 2 std dev) based on worldwide fallout data from 1993 to 1997.

Table 6-4. Total Recoverable Trace Elements (µg/g dry) in Produce Collected from Regional Background, Perimeter, and On-Site Locations during 1998[a]

Location	Ag	As	Ba	Be	Cd	Cr	Hg	Ni	Pb	Se	Tl	Zn
Regional Background Stations												
Española/Santa Fe/Jemez:												
Squash	1.00[b]	0.25[b]	15.00	0.10[b]	0.50[b]	0.50[b]	0.03[b]	1.00[b]	1.8	0.60	0.20[b]	17.0
Cucumber	1.00[b]	0.50	31.00	0.10[b]	0.50[b]	0.50[b]	0.03[b]	1.00[b]	1.5	0.60	0.20[b]	22.0
Pumpkin	1.00[b]	0.25[b]	8.00	0.10[b]	0.50[b]	0.50[b]	0.03[b]	1.00[b]	2.0	0.60	0.20[b]	20.0
Apricot	1.00[b]	0.25[b]	3.70	0.10[b]	0.50[b]	0.50[b]	0.03[b]	1.00[b]	3.1	0.60	0.20[b]	6.2
Mean	1.00	0.31	14.43	0.10	0.50	0.50	0.03	1.00	2.1	0.60	0.20	16.3
(std dev)	(0.00)	(0.13)	(11.99)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.7)	(0.00)	(0.00)	(7.0)
RSRL[c]	1.38	0.66	27.43	0.53	0.46	3.98	0.06	23.50	22.0	0.3	0.20	30.3
Perimeter Stations												
Los Alamos:												
Plum	1.00[b]	0.25[b]	2.50	0.10[b]	0.50[b]	0.50[b]	0.03[b]	1.00[b]	1.7	0.20[b]	0.20[b]	4.9
Peach	1.00[b]	0.25[b]	2.90	0.10[b]	0.50[b]	0.50[b]	0.03[b]	1.00[b]	1.4	0.20[b]	0.20[b]	8.2
Apricot	1.00[b]	0.25[b]	9.80	0.10[b]	0.50[b]	0.50[b]	0.03[b]	1.00[b]	3.9	0.20[b]	0.20[b]	7.8
Squash	1.00[b]	0.25[b]	7.30	0.10[b]	0.50[b]	0.50[b]	0.03[b]	1.00[b]	0.2[b]	0.20[b]	0.20[b]	31.0
Apple	1.00[b]	0.25[b]	3.90	0.10[b]	0.50[b]	0.50[b]	0.03[b]	1.00[b]	1.2	0.20[b]	0.20[b]	2.1
Cherry	1.00[b]	0.25[b]	12.00	0.10[b]	0.50[b]	0.50[b]	0.03[b]	1.00[b]	1.1	0.20[b]	0.20[b]	13.0
Mean	1.00	0.25	6.40	0.10	0.50	0.50	0.03	1.00	1.6	0.20	0.20	11.2
(std dev)	(0.00)	(0.00)	(3.94)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(1.2)	(0.00)	(0.00)	(10.4)
White Rock /Pajarito Acres:												
Apricot	1.00[b]	0.25[b]	9.50	0.10[b]	0.50[b]	0.50[b]	0.03[b]	13.00	7.0	0.50	0.20[b]	10.0
Tomato	1.00[b]	0.25[b]	13.00	0.10[b]	0.50[b]	0.50[b]	0.03[b]	1.00[b]	8.0	0.50	0.20[b]	15.0
Green bean	1.00[b]	0.25[b]	17.00	0.10[b]	0.50[b]	0.50[b]	0.03[b]	1.00[b]	0.7	0.60	0.20[b]	29.0
Cherry	1.00[b]	0.25[b]	5.90	0.10[b]	0.50[b]	0.50[b]	0.03[b]	1.00[b]	2.9	0.40	0.20[b]	6.1
Apple	1.00[b]	0.25[b]	3.10	0.10[b]	0.50[b]	0.50[b]	0.03[b]	1.00[b]	2.7	0.50	0.20[b]	1.5
Corn	1.00[b]	0.25[b]	0.74	0.10[b]	0.50[b]	0.50[b]	0.03[b]	1.00[b]	7.0	0.60	0.20[b]	21.0
Rhubard	1.00[b]	0.25[b]	36.00	0.10[b]	0.50[b]	0.50[b]	0.03[b]	1.00[b]	1.6	0.50	0.20[b]	11.0
Mean	1.00	0.25	12.18	0.10	0.50	0.50	0.03	2.71	4.3	0.51	0.20	13.4
(std dev)	(0.00)	(0.00)	(11.91)	(0.00)	(0.00)	(0.00)	(0.00)	(4.54)	(3.0)	(0.07)	(0.00)	(9.3)

Table 6-4. Total Recoverable Trace Elements (µg/g dry) in Produce Collected from Regional Background, Perimeter, and On-Site Locations during 1998[a] (Cont.)

Location	Ag	As	Ba	Be	Cd	Cr	Hg	Ni	Pb	Se	Tl	Zn
Cochiti/Peña Blanca/Santo Domingo:												
Squash	1.00[b]	0.25[b]	4.50	0.10[b]	0.50[b]	0.50[b]	0.03[b]	1.00[b]	4.6	0.60	0.20[b]	24.0
Lettuce	1.00[b]	0.25[b]	35.00	0.10[b]	0.50[b]	0.50[b]	0.03[b]	1.00[b]	1.5	0.40	0.20[b]	26.0
Apricot	1.00[b]	0.25[b]	3.40	0.10[b]	0.50[b]	0.50[b]	0.03[b]	1.00[b]	8.0	0.50	0.20[b]	6.3
Cherry	1.00[b]	0.25[b]	3.00	0.10[b]	0.50[b]	0.50[b]	0.03[b]	3.80	1.6	0.60	0.20[b]	4.1
Corn	1.00[b]	0.25[b]	0.58	0.10[b]	0.50[b]	0.50[b]	0.03[b]	1.00[b]	18.7	0.60	0.20[b]	
Mean	1.00	0.25	9.30	0.10	0.50	0.50	0.03	1.56	6.9	0.54	0.20	17.9
(std dev)	(0.00)	(0.00)	(14.44)	(0.00	(0.00)	(0.00)	(0.00)	(1.25)	(7.1)	(0.09)	(0.00)	(11.7)
Pueblo of San Ildefonso:												
Apricot	1.00[b]	0.25[b]	4.10	0.10[b]	0.50[b]	0.50[b]	0.03[b]	1.00[b]	2.9	0.20[b]	0.20[b]	6.4
Squash	1.00[b]	0.25[b]	8.30	0.10[b]	0.50[b]	0.50[b]	0.03[b]	1.00[b]	1.7	0.20[b]	0.20[b]	25.0
Plum	1.00[b]	0.25[b]	1.30	0.10[b]	0.50[b]	0.50[b]	0.03[b]	1.00[b]	3.5	0.20[b]	0.20[b]	3.1
Peach	1.00[b]	0.25[b]	2.70	0.10[b]	0.50[b]	0.50[b]	0.03[b]	1.00[b]	2.9	0.20[b]	0.20[b]	5.6
Corn	1.00[b]	0.25[b]	0.50	0.10[b]	0.50[b]	0.50[b]	0.03[b]	1.00[b]	15.0	0.20[b]	0.20[b]	21.0
Mean	1.00	0.25	3.38	0.10	0.50	0.50	0.03	1.00	5.2	0.20	0.20	12.2
(std dev)	(0.00)	(0.00)	(3.07)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(5.5)	(0.00)	(0.00)	(10.0)
On-Site Stations												
LANL:												
Apple	1.00[b]	0.25[b]	3.10	0.10[b]	0.50[b]	0.50[b]	0.03[b]	1.00[b]	3.7	0.40	0.20[b]	2.5
Apricot	1.00[b]	0.25[b]	41.00	0.10[b]	0.50[b]	0.50[b]	0.03[b]	1.00[b]	4.3	0.50	0.20[b]	6.8
Peach	1.00[b]	0.25[b]	8.80	0.10[b]	0.50[b]	0.50[b]	0.03[b]	1.00[b]	1.9	0.50	0.20[b]	8.0
Crab apple	1.00[b]	0.25[b]	8.90	0.10[b]	0.50[b]	0.50[b]	0.03[b]	22.00	9.0	0.50	0.20[b]	3.1
Nectarine	1.00[b]	0.25[b]	4.20	0.10[b]	0.50[b]	0.50[b]	0.03[b]	1.00[b]	5.0	0.50	0.20[b]	5.6
Apple	1.00[b]	0.25[b]	2.70	0.10[b]	0.50[b]	0.50[b]	0.03[b]	1.00[b]	1.3	0.50	0.20[b]	1.8
Mean	1.00	0.25	11.45	0.10	0.50	0.50	0.03	4.50	4.2	0.48	0.20	4.6
(std dev)	(0.00)	(0.00)	(14.73)	(0.00)	(0.00)	(0.00)	(0.00)	(8.57)	(2.7)	(0.04)	(0.00)	(2.5)

[a]Analysis by EPA Method 3051 for total recoverable metals and there were no statistical differences in any of the mean concentrations form perimeter and on-site locations as compared to regional background at the 0.5 probability level using a Wilcoxon Rank Sum Test.

[b]Less-than values were converted to one-half the concentration.

[c]Regional Statistical Reference Level; this is the upper (95%) limit background concentration (mean + 2 std dev) based on data from 1994 to 1996.

Table 6-5. Radionuclides in Honey Collected from Regional Background and Perimeter Locations during 1997

Radioisotope		Perimeter: Los Alamos Venado St.		Perimeter: Los Alamos 43rd St.		Perimeter: White Rock Monte Rey St.		Perimeter: White Rock Piedra Loop St.		Regional Background: Jemez		Regional Background: RSRL[d]
^{3}H	(pCi/mL)[a]	1.82	(0.80)[b]	0.35	(0.71)	1.21	(0.76)	0.60	(0.72)	0.19	(0.70)	5.25
^{137}Cs	(pCi/L)	13.2	(19.8)	10.2	(15.3)	–0.98	(19.5)[c]	11.8	(17.7)	22.0	(33.0)	305.28
^{238}Pu	(pCi/L)	0.002	(0.007)	0.001	(0.007)	–0.020	(0.020)	–0.008	(0.005)	–0.011	(0.009)	0.07
^{239}Pu	(pCi/L)	0.005	(0.009)	0.030	(0.016)	–0.035	(0.007)	0.017	(0.010)	0.047	(0.019)	0.12
^{241}Am	(pCi/L)	0.002	(0.004)	0.013	(0.006)	0.015	(0.009)	0.0062	(0.014)	0.033	(0.010)	0.05
^{90}Sr	(pCi/L)	14.00	(14.62)	1.04	(4.26)	0.10	(3.79)	–0.06	(4.58)	2.23	(3.95)	5.04
^{tot}U	(µg/L)	0.11	(0.01)	0.19	(0.02)	0.13	(0.01)	0.12	(0.01)	0.21	(0.02)	4.99

[a]pCi/mL of honey moisture; honey contains approximately 18% water and has a density of 1,860 g/L.
[b](±1 counting uncertainty); values are the uncertainty of the analytical results at the 65% confidence level.
[c]See Appendix B for an explanation of the presence of negative values.
[d]Regional Statistical Reference Level; this is the upper (95%) limit background concentration (mean + 2 std dev) based on data from Fresquez et al., 1998.

Table 6-6. Radionuclides in Eggs Collected from Regional Background and Perimeter Locations during 1998[a]

Radionuclide	Perimeter: Pueblo of San Ildefonso	Perimeter: Los Alamos Townsite	Perimeter: White Rock Pajarito Acres	Regional Background: Española	Regional Background: RSRL[d]
^{238}Pu (pCi/L)	–0.0025 (0.0014)[b,c]	–0.0018 (0.0031)	–0.0019 (0.0014)	–0.0009 (0.0013)	0.050
^{239}Pu (pCi/L)	0.0041 (0.0029)	0.0104 (0.0038)	0.0088 (0.0040)	0.0036 (0.0026)	0.177
^{90}Sr (pCi/L)	5.72 (1.01)	15.11 (1.86)	5.57 (0.70)	6.77 (0.79)	8.44
Total U (µg/L)	0.79 (0.08)	0.87 (0.09)	1.12 (0.11)	0.62 (0.06)	0.78
Tritium (pCi/mL)	0.03 (0.65)	0.04 (0.65)	0.13 (0.66)	–0.03 (0.64)	0.51
^{137}Cs (pCi/L)	–0.06 (19.50)	14.60 (21.90)	3.00 (4.50)	17.80 (26.70)	23.18
^{241}Am (pCi/L)	–0.0091 (0.0256)	0.0153 (0.0303)	0.0079 (0.0394)	0.0137 (0.0073)	0.037

[a] 1L is equal to approximately 24 eggs, and the density of eggs is approximately 1,135 g/L.
[b] See Appendix B for an explanation of the presence of negative values.
[c] (±1 counting uncertainty); values are the uncertainty of the analytical results at the 65% confidence level.
[d] Regional Statistical Reference Level; this is the upper (95%) limit background concentration (mean + 2 std dev) based on data from 1995 to 1998.

Table 6-7. Radionuclides in Goat's Milk Collected from Regional Background and Perimeter Locations during 1998

Radionuclide	Perimeter: Los Alamos	Perimeter: White Rock/Pajarito Acres	Regional Background: Albuquerque	Regional Background: RSRL[a]
^{238}Pu (pCi/L)[b]	–0.0074[c] (0.0031)	–0.0051 (0.0056)	–0.0125 (0.0075)	0.011
^{239}Pu (pCi/L)	–0.0010 (0.0039)	0.0010 (0.0077)	–0.0057 (0.0085)	0.020
^{90}Sr (pCi/L)	3.31 (4.56)	3.56 (6.09)	2.16 (3.62)	6.95
Total U (µg/L)	0.56 (0.06)	0.37 (0.04)	0.70 (0.07)	0.85
Tritium (pCi/mL)	–0.31 (0.62)	–0.22 (0.63)	–0.25 (0.63)	0.07
^{137}Cs (pCi/L)	10.20 (19.50)	16.80 (19.50)	44.0 (66.0)	19.0
^{131}I (pCi/L)	6.60 (9.90)	13.4 (20.1)	3.40 (5.10)	15.4

[a] Regional Statistical Reference Level; this is the upper (95%) limit background (mean + 2 std dev) based on data from 1994 to 1998.
[b] (±1 counting uncertainty); values are the uncertainty of the analytical results at the 65% confidence level.
[c] See Appendix B for an explanation of the presence of negative values.

Table 6-8. Radionuclides in Game and Nongame Fish Upstream and Downstream of Los Alamos National Laboratory during 1998

Location	^{3}H[a] (pCi/mL)	^{90}Sr (10^{-2} pCi/g dry)	^{137}Cs (10^{-2} pCi/g dry)	^{tot}U (ng/g dry)	^{238}Pu (10^{-5} pCi/g dry)	^{239}Pu (10^{-5} pCi/g dry)	^{241}Am (10^{-5} pCi/g dry)
Game Fish							
Upstream (Abiquiu, Heron, and El Vado):							
Trout	–0.18 (0.65)[b,c]	–5.93 (6.66)	3.63 (0.73)	3.63 (1.21)	–7.26 (12.10)	–9.68 (19.36)	66.55 (30.25)
Trout	–0.08 (0.66)	–6.05 (4.84)	–0.00 (1.33)	2.42 (1.21)	–9.68 (21.78)	–4.84 (19.36)	0.00 (0.00)
Walleye	–0.32 (0.64)	–4.24 (6.17)	2.78 (0.48)	2.42 (1.21)	10.89 (9.68)	–3.63 (21.10)	27.83 (25.41
Walleye	–0.28 (0.64)	–9.80 (4.84)	–0.24 (1.33)	2.42 (1.21)	–8.47 (7.26)	3.63 (14.52)	84.70 (49.61)
Crappie	–0.38 (0.64)	–0.24 (6.53)	1.33 (0.36)	3.63 (1.21)	–16.94 (18.15)	–15.73 (29.04)	52.03 (20.57)
Crappie	–0.32 (0.64)	9.44 (5.57)	1.33 (0.36)	2.42 (1.21)	–14.52 (12.10)	24.20 (18.15)	52.03 (32.67)
Mean (std dev)	–0.26 (0.11)	–2.80 (6.75)	1.47 (1.52)	2.82 (0.62)	–7.66 (9.82)	–1.01 (13.93)	47.19 (29.77)
RSRL[d]	0.20	17.00	27.70	6.50	23.6	28.3	28.90
Downstream (Cochiti):							
Crappie	0.60 (0.71)	1.45 (3.51)	3.63 (5.32)	4.84 (1.21)	–13.31 (13.31)	36.30 (16.94)	88.33 (43.56)
Crappie	0.55 (0.71)	7.87 (5.20)	4.48 (0.73)	3.63 (1.21)	2.42 (15.73)	–6.05 (16.94)	179.08 (55.66)
White Bass	0.66 (0.71)	4.60 (5.45)	2.42 (0.48)	3.63 (1.21)	12.10 (30.25)	8.47 (27.83)	457.38 (104.06)
Pike	0.68 (0.71)	–1.33 (3.51)	1.45 (0.24)	0.00 (1.21)	–19.36 (20.57)	13.31 (22.99)	127.05 (29.04)
Pike	1.63 (0.77)	–1.09 (3.99)	2.78 (0.48)	0.00 (1.21)	–7.26 (15.73)	–12.10 (30.25)	83.49 (29.04)
Mean (std dev)	0.82 (0.45)	2.30 (3.93)	2.95 (1.16)	2.42 (2.26)	–5.08 (12.53)	7.99 (18.91)	187.07 (155.89)
Nongame Fish							
Upstream (Abiquiu, Heron, and El Vado):							
Catfish	–0.49 (0.63)	–3.61 (3.14)	0.10 (0.19)	10.45 (0.95)	–1.90 (9.50)	–4.75 (15.20)	–3.80 (24.70)
Catfish	–0.25 (0.64)	–2.85 (3.33)	0.95 (0.29)	5.70 (0.95)	7.60 (8.55)	–15.20 (19.95)	–5.70 (20.90)
Sucker	–0.30 (0.64)	–2.57 (3.71)	–0.48 (1.05)	2.85 (0.95)	7.60 (9.50)	7.60 (12.35)	44.65 (19.00)
Carp	–0.20 (0.65)	–1.24 (4.85)	0.76 (1.24)	18.05 (1.90)	7.60 (8.55)	17.10 (11.40)	78.85 (40.85)
Mean (std dev)	–0.31 (0.13)	–2.57 (0.99)	0.33 (0.65)	9.26 (6.64)	5.23 (4.75)	1.19 (14.12)	28.50 (40.86)
RSRL[d]	0.20	13.20	26.90	16.20	9.80	19.20	16.14

Table 6-8. Radionuclides in Game and Nongame Fish Upstream and Downstream of Los Alamos National Laboratory during 1998 (Cont.)

Location	^{3}H[a] (pCi/mL)	^{90}Sr (10^{-2} pCi/g dry)	^{137}Cs (10^{-2} pCi/g dry)	^{tot}U (ng/g dry)	^{238}Pu (10^{-5} pCi/g dry)	^{239}Pu (10^{-5} pCi/g dry)	^{241}Am (10^{-5} pCi/g dry)
Downstream (Cochiti):							
Catfish	0.76 (0.72)	4.94 (2.95)	1.62 (0.38)	9.50 (0.95)	–33.25 (33.25)	11.40 (37.05)	76.00 (22.80)
Catfish	0.68 (0.71)	1.33 (4.56)	2.66 (0.57)	4.75 (0.95)	–2.85 (26.60)	0.95 (20.90)	58.90 (26.60)
Sucker	1.36 (0.76)	2.19 (3.23)	–0.86 (4.18)	4.75 (0.95)	–8.55 (16.15)	–14.25 (14.25)	94.05 (24.70)
Carp	1.54 (0.77)	8.17 (3.71)	–0.00 (4.28)	37.05 (3.80)	6.65 (26.60)	41.80 (38.00)	81.70 (19.00)
Mean (std dev)	1.09 (0.43)	4.16 (3.09)	0.86 (1.58)	14.01 (15.52)	–9.50 (17.03)	9.98 (23.69)	77.66 (14.60)

[a]pCi/mL of tissue moisture.

[b]See Appendix B for an explanation of the presence of negative values.

[c](±1 counting uncertainty); values are the uncertainty of the analytical results at the 65% confidence level.

[d]Regional Statistical Reference Level; this is the upper (95%) limit background concentration (mean + 2 std dev) based on data from Fresquez et al. (1994c).

Table 6-9. Total Recoverable Mercury in Bottom-Feeding Fish (µg/g wet) Collected Upstream and Downstream of Los Alamos in 1998

Abiquiu Reservoir (Background)	Cochiti Reservoir	RSRL[c]
0.03 (sucker)*[a]	0.06 (sucker)	
0.10 (catfish)	0.10 (catfish)	
0.15 (catfish)*[a]	0.30 (carp)	
0.30 (carp)	0.20 (carp)	
0.20 (carp)	0.10 (carp)	
0.16 (0.10)[b]	0.15 (0.10)[b]	0.41

[a]Values denoted with an * were less-than values that were reduced by one-half their concentration.
[b]The average (std dev) of five bottom-feeding fish.
[c]Regional Statistical Reference Level; this is the upper (95%) limit background concentration (mean + 2 std dev) based on data from 1991 to 1996.

Table 6-10. Radionuclides in Muscle and Bone Tissues of Elk Collected from On-Site and Regional Background Areas during 1997 and 1998

Location/Date/Sample	^{3}H[a] (pCi/mL)	^{tot}U (ng/g dry)	^{137}Cs (10^{-3} pCi/g dry)	^{90}Sr (10^{-3} pCi/g dry)	^{238}Pu (10^{-5} pCi/g dry)	^{239}Pu (10^{-5} pCi/g dry)	^{241}Am (10^{-5} pCi/g dry)
Muscle:							
LANL Elk							
USFS/Ski Hill Road/9-14-97/Cow	–0.29 (0.66)[b,c]	0.88 (0.44)	10.1 (15.0)	63.4 (48.8)	20.7 (10.1)	0.0 (8.8)	d
TA-15/Firing Site 306/11-19-97/Cow	0.57 (0.69)	2.20 (0.44)	92.4 (138.6)	141.7 (109.6)	–48.8 (17.2)	–62.9 (29.0)	d
TA-15/EF Firing Site/11-26-97/Cow	0.18 (0.67)	44.40 (4.40)	15.8 (23.8)	119.2 (149.2)	–2.6 (5.7)	–7.9 (6.2)	d
TA-16/K-Site Road/3-30-98/Cow	0.46 (0.71)	0.88 (0.44)	54.6 (81.8)	–0.9 (36.0)	–11.8 (5.7)	7.9 (7.0)	d
TA-55/Pajarito Road/4-8-98/Cow	0.10 (0.68)	1.32 (0.44)	–0.9 (4.8)	–18.0 (89.3)	–11.4 (16.7)	1.3 (9.2)	26.0 (13.2)
TA-72/East Jemez Road/4-28-98/Cow	0.55 (0.70)	2.64 (0.44)	–0.4 (4.8)	6.2 (38.3)	–16.3 (11.4)	–5.7 (16.3)	51.0 (13.2)
Mean (std dev)	0.26 (0.33)	8.72(17.49)	28.6 (37.3)	51.9 (67.1)	–11.7 (22.5)	–11.2 (25.9)	38.5 (17.7)
Regional Background Elk							
Mean (std dev)[e]	0.21 (0.16)	0.83 (0.68)	95.1 (113.1)	0.7 (1.6)	–1.1 (2.5)	–0.5 (1.0)	4.4 (5.1)
RSRL[e]	0.53	2.19	321.4	3.9	3.9	1.6	14.5
Leg Bone:							
LANL Elk							
USFS/Ski Hill Road/9-14-97/Cow	0.05 (0.68)	0.00 (5.80)	34.8 (52.2)	2488.2 (661.2)	139.2 (110.2)	150.8 (116.0)	d
TA-15/Firing Site 306/11-19-97/Cow	1.07 (0.72)	5.80 (5.80)	–17.4 (1044.0)	1270.2 (400.0)	133.4 (133.4)	–162.4 (92.8)	d
TA-15/EF Firing Site/11-26-97/Cow	1.27 (0.74)	11.60 (5.80)	0.0 (1044.0)	2070.6 (632.2)	307.4 (1716.8)	–307.4 (2070.6)	d
TA-16/K-Site Road/3-30-98/Cow	0.23 (0.69)	11.60 (5.80)	46.4 (69.6)	2575.2 (597.4)	–162.4 (133.4)	–92.8 (133.4)	d
TA-55/Pajarito Road/4-8-98/Cow	–0.08 (0.67)	17.40 (5.80)	11.6 (17.4)	1693.6 (475.6)	–110.2 (110.2)	–29.0 (58.0)	d
TA-72/East Jemez Road/4-28-98/Cow	0.20 (0.67)	17.40 (5.80)	11.6 (17.4)	2186.6 (701.8)	–150.8 (133.4)	–104.4 (162.4)	d
Mean (std dev)	0.46 (0.57)	10.63 (6.78)	14.5 (23.1)	2047.4 (494.4)	26.1 (194.3)	–90.9 (151.3)	
Regional Background Elk							
Mean (std dev)[e]	–0.01 (0.26)	2.29 (1.96)	43.1 (77.5)	1300.7 (882.5)	13.7 (47.5)	–6.0 (8.2)	41.0 (5.3)
RSRL[e]	0.51	6.21	198.2	3065.7	108.8	10.4	51.6

[a]pCi/mL of tissue moisture.

[b](±1 counting uncertainty); values are the uncertainty of the analytical results at the 65% confidence level.

[c]See Appendix B for an explanation of the presence of negative values.

[d]Not analyzed, lost in analysis, or outlier omitted.

[e]The mean (std dev) and the Regional Statistical Reference Level (the upper [95%] limit background concentration [mean + 2 std dev]) is based from 1991 to 1998 (Fresquez et al. 1998).

Table 6-11. Radionuclides in Muscle and Bone Tissues of Deer Collected from On-Site Locations and Regional Background Areas during 1997 and 1998

Location/Date/Sample	^{3}H[a] (pCi/mL)	^{tot}U (ng/g dry)	^{137}Cs (10^{-3} pCi/g dry)	^{90}Sr (10^{-3} pCi/g dry)	^{238}Pu (10^{-5} pCi/g dry)	^{239}Pu (10^{-5} pCi/g dry)	^{241}Am (10^{-5} pCi/g dry)
Muscle:							
LANL Deer							
TA-21/DP Road/10-02-97/Buck	0.81 (0.81)[b]	0.90 (0.45)	156.2 (15.8)	307.8 (115.7)	13.1 (9.0)	23.0 (8.6)	4.5 (2.2)
Los Alamos/Diamond Drive/10-29-97/Buck	0.25 (0.67)	1.35 (0.45)	–1.8 (81.0)[c]	210.6 (137.7)	47.7 (10.8)	35.6 (9.9)	3.0 (0.8)
Los Alamos/Trinity Drive/5-6-98/Doe	0.31 (0.68)	0.45 (0.45)	–3.6 (5.0)	–34.7 (45.5)	5.0 (8.6)	–0.5 (12.2)	22.1 (19.8)
Mean (std dev)	0.46 (0.31)	0.90 (0.45)	50.3 (91.7)	161.2 (176.5)	21.9 (22.7)	19.4 (18.3)	9.9 (10.6)
Regional Background Deer							
Mean (std dev)[d]	0.15 (0.25)	1.10 (0.66)	14.5 (7.3)	14.2 (12.3)	–1.8 (2.8)	3.5 (5.7)	6.2 (10.7)
RSRL[d]	0.65	2.42	29.0	38.8	3.7	14.8	27.5
Leg Bone:							
LANL Deer							
TA-21/DP Road/10-02-97/Buck	0.92 (0.74)	0.00 (4.40)	39.6 (8.8)	4831.2 (963.6)	83.6 (57.2)	61.6 (61.6)	12.8 (15.8)
Los Alamos/Diamond Drive/10-29-97/Buck	0.04 (0.66)	0.00 (4.40)	22.0 (4.4)	2195.6 (440.0)	–268.4 (70.4)	–17.6 (123.2)	42.7 (10.1)
Los Alamos/Trinity Drive/5-6-98/Doe	0.60 (0.70)	0.00 (4.40)	52.8 (26.4)	1166.0 (365.2)	70.4 (61.6)	–22.0 (74.8)	[e]
Mean (std dev)	0.52 (0.45)	0.00 (0.00)	38.1 (15.5)	2730.9 (1890.3)	–38.1 (199.5)	7.3 (47.1)	27.8 (21.1)
Regional Background Deer							
Mean (std dev)[d]	0.07 (0.25)	2.03 (2.10)	10.3 (25.7)	907.5 (106.1)	–5.9 (10.2)	0.6 (1.0)	59.5 (28.5)
RSRL[d]	0.57	6.23	61.8	1119.7	14.5		

[a]pCi/mL of tissue moisture.

[b](±1 counting uncertainty); values are the uncertainty of the analytical results at the 65% confidence level.

[c]See Appendix B for an explanation of the presence of negative values.

[d]Regional Statistical Reference Level; this is (the upper [95%] limit background concentration [mean + 2 std dev]) based on data from 1991 to 1998 (Fresquez et al., 1998).

[e]Not analyzed, lost in analysis, or outlier omitted.

Table 6-12. Radionuclides in Muscle and Bone of a Free-Range Steer Collected from the Pueblo of Cochiti and Regional Background during 1998

Tissue/Location	^{3}H[a] (pCi/mL)	^{tot}U (ng/g dry)	^{137}Cs (10^{-3} pCi/g dry)	^{90}Sr (10^{-3} pCi/g dry)	^{238}Pu (10^{-5} pCi/g dry)	^{239}Pu (10^{-5} pCi/g dry)	^{241}Am (10^{-5} pCi/g dry)
Muscle:							
Cochiti	-0.25 (0.70)[b,c]	1.11 (0.37)	4.4 (6.7)	–0.7 (28.9)	–8.1 (8.9)	1.9 (8.1)	31.1 (12.6)
Regional Background[d]	0.32 (0.72)	1.11 (0.37)	30.7 (46.3)	–8.9 (23.7)	3.0 (7.0)	–12.2 (4.8)	11.5 (3.7)
RSRL[e]	1.76	1.85	123.3	38.5	17.0	–2.6	18.9
Leg Bone:							
Cochiti	–0.31 (0.70)	10.00 (5.00)	–10.0 (55.0)	765.0 (485.0)	–280.0 (160.0)	–255.0 (220.0)	495.0 (190.0)
Regional Background	–0.52 (0.69)	5.00 (5.00)	25.0 (35.0)	1,250.0 (350.0)	–35.0 (160.0)	–75.0 (95.0)	125.0 (95.0)
RSRL[e]	0.86	15.00	95.0	1,950.0	285.0	115.0	315.0

[a]pCi/mL of tissue moisture.
[b](±1 one counting uncertainty); values are the uncertainty of the analytical results at the 65% confidence level.
[c]See Appendix B for an explanation of the presence of negative values.
[d]Background from El Rito, NM.
[e]Regional Statistical Reference Level; this is the upper (95%) limit background concentration (mean + 2 std dev) based on data from current year.

Table 6-13. Radionuclides in Navajo Tea (Cota) Collected from Regional and Perimeter Locations during 1998

	^{3}H (pCi/mL)	^{90}Sr (pCi/L)	^{238}Pu (pCi/L)	^{239}Pu (pCi/L)	^{137}Cs (pCi/L)	^{tot}U (µg/L)	^{241}Am (pCi/L)
Regional Background:							
Española/Santa Fe/Jemez	–0.41 (0.62)[a,b]	1.18 (0.84)	–0.001 (0.004)	0.004 (0.003)	0.1 (19.5)	4.20 (0.42)	0.016 (0.004)
RSRL[c]	0.05	1.73	0.015	0.043	17.1	1.28	0.287
Off-Site Perimeter:							
San Ildefonso	–0.45 (0.62)	–0.15 (0.84)	–0.003 (0.003)	–0.002 (0.004)	12.4 (18.6)	1.72 (0.17)	0.013 (0.005)
Los Alamos Townsite	–0.28 (0.63)	0.83 (0.50)	–0.003 (0.002)	–0.000 (0.002)	1.1 (1.6)	4.14 (0.41)	0.014 (0.005)
White Rock/Pajarito Acres	–0.17 (0.64)	0.58 (0.72)	–0.002 (0.004)	–0.005 (0.004)	–1.2 (19.5)	4.95 (0.50)	0.018 (0.007)

[a]See Appendix B for an explanation of the presence of negative values.

[b](±1 counting uncertainty); values are the uncertainty of the analytical results at the 65% confidence level.

[c]Regional Statistical Reference Level; this is the upper (95%) limit background concentration (mean + 2 std dev) based on data from 1994 to 1998.

Table 6-14. Radionuclides in Piñon Shoot Tips (Vegetation) Collected from Regional Background and Perimeter Areas during the 1998 Growing Season[a]

Location	^{3}H (pCi/mL)	^{tot}U (ng/g dry)	^{137}Cs (10^{-3} pCi/g dry)	^{90}Sr (10^{-3} pCi/g dry)	^{238}Pu (10^{-5} pCi/g dry)	^{239}Pu (10^{-5} pCi/g dry)	^{241}Am (10^{-5} pCi/g dry)
Regional Background:							
Española/Santa Fe/Jemez	–0.450 (0.68)[b,c]	71.2 (7.2)	–12.8 (8.8)	200.0 (68.0)	25.6 (24.8)	20.8 (16.0)	144.0 (58.4)
RSRL[d]	0.41	133.4	2.5	489.6	35.1 53.0	260.3	
Off-Site Perimeter:							
Los Alamos Townsite	0.070 (0.71)	48.8 (4.8)	4.8 (7.2)	128.8 (59.2)	16.8 (13.6)	55.2 (21.6)	45.6 (27.2)
White Rock/Pajarito Acres	–0.180 (0.69)	28.8 (3.2)	14.4 (21.6)	148.0 (64.8)	7.2 (13.6)	64.8 (24.8)	83.2 (34.4)
Pueblo of San Ildefonso	–0.210 (0.69)	28.0 (3.2)	18.4 (27.2)	169.6 (65.6)	54.4 (24.8)	67.2 (25.6)	128.0 (72.0)

[a]These are the shoot tips of the piñon tree and are not piñon nuts.

[b](±1 counting uncertainty); values are the uncertainty of the analytical results at the 65% confidence level.

[c]See Appendix B for an explanation of the presence of negative values.

[d]Regional Statistical Reference Level; this is the upper (95%) limit background concentration (mean + 2 std dev) based on 1997 and 1998 data.

Table 6-15. Radionuclides in Muscle and Bone of Squirrels Collected from On-Site, Perimeter, and Regional Background Locations during 1998

Tissue/Location	^{3}H (pCi/mL)	^{tot}U (ng/g dry)	^{137}Cs (10^{-3} pCi/g dry)	^{90}Sr (10^{-3} pCi/g dry)	^{238}Pu (10^{-5} pCi/g dry)	^{239}Pu (10^{-5} pCi/g dry)	^{241}Am (10^{-5} pCi/g dry)
Muscle:							
LANL							
TA-53	15.50	11.60	88.8	–1954.0	30.8	3.6	54.8
	(1.40)[a]	(1.20)	(15.2)	(4729.2)[b]	(14.0)	(8.8)	(18.8)
Off-Site Perimeter							
Los Alamos	–0.13	1.60	4.8	–49.2	–80.0	–6.4	42.8
	(0.63)	(0.40)	(7.2)	(48.0)	(46.0)	(48.4)	(16.4)
Rendija	–0.18	2.00	27.6	–78.8	–77.2	–72.8	88.4
Canyon	(0.63)	(0.40)	(41.6)	(82.0)	(40.4)	(57.6)	(29.2)
Mean (SD)	–0.16	1.80	16.2	–64.0	–78.6	–39.6	65.6
	(0.04)	(0.28)	(16.1)	(20.9)	(2.0)	(47.0)	(32.2)
Regional Background							
Española	–0.27	0.00	49.2	–74.8	–88.0	–10.8	54.4
	(0.63)	(0.40)	(74.0)	(66.0)	(45.6)	(104.0)	(22.8)
Española	–0.11	0.00	58.8	–129.6	39.6	–38.0	70.8
	(0.64)	(0.40)	(88.0)	(61.2)	(14.8)	(127.6)	(28.8)
Mean (SD)	–0.19	0.00	54.0	–102.2	–24.2	–24.4	62.6
	(0.11)	(0.00)	(6.8)	(38.8)	(90.2)	(19.2)	(11.6)
Bone:							
LANL							
TA-53	16.20	2053.60	98.6	2002.6	47.6	30.6	98.6
	(1.40)	(204.00)	(17.0)	(9292.2)	(20.4)	(20.4)	(34.0)
Off-Site Perimeter							
Los Alamos	–0.17	3.40	163.2	608.6	34.0	–972.4	295.8
	(0.63)	(3.40)	(244.8)	(156.4)	(652.8)	(856.8)	(136.0)
Rendija	–0.29	3.40	23.8	761.6	163.2	71.4	156.4
Canyon	(0.62)	(3.40)	(34.0)	(153.0)	(44.2)	(40.8)	(64.6)
Mean (SD)	–0.23	3.40	93.5	685.1	98.6	–450.5	226.1
	(0.08)	(0.00)	(98.6)	(108.2)	(91.4)	(738.1)	(98.6)

Table 6-15. Radionuclides in Muscle and Bone of Squirrels Collected from On-Site, Perimeter, and Regional Background Locations during 1998 (Cont.)

Tissue/Location	^{3}H (pCi/mL)	^{tot}U (ng/g dry)	^{137}Cs (10^{-3} pCi/g dry)	^{90}Sr (10^{-3} pCi/g dry)	^{238}Pu (10^{-5} pCi/g dry)	^{239}Pu (10^{-5} pCi/g dry)	^{241}Am (10^{-5} pCi/g dry)
Regional Background							
Española	–0.17	3.40	–17.0	122.4	680.0	391.0	397.8
	(0.63)	(3.40)	(37.4)	(145.2)	(268.6)	(319.6)	(81.6)
Española	–0.21	3.40	34.0	136.0	30.6	125.8	136.0
	(0.63)	(3.40)	(51.0)	(98.6)	(125.8)	(306.0)	(61.2)
Mean (SD)	–0.19	3.40	8.5	129.2	355.3	258.4	266.9
	(0.03)	(0.00)	(36.1)	(9.6)	(459.2)	(187.5)	(185.1)

[a] (±1 counting uncertainty); values are the uncertainty of the analytical results at the 65% confidence level.

[b] See Appendix B for an explanation of the presence of negative values.

Table 6-16. Radionuclides in Mushrooms Collected from Regional Background, Perimeter, and On-Site Locations duing 1998

Tissue/Location	^{3}H (pCi/mL)	^{tot}U (ng/g dry)	^{137}Cs (10^{-3} pCi/g dry)	^{90}Sr (10^{-3} pCi/g dry)	^{238}Pu (10^{-5} pCi/g dry)	^{239}Pu (10^{-5} pCi/g dry)	^{241}Am (10^{-5} pCi/g dry)
Regional Background							
Española/Santa Fe/Jemez	–0.66 (0.61)[a,b]	44.5 (4.2)	–5.0 (8.4)	69.7 (89.0)	–17.6 (30.2)	119.3 (43.7)	73.9 (33.6)
RSRL[c]	0.56	52.9	11.8	247.7	42.8	206.7	14.1
Off-Site Perimeter:							
Los Alamos Townsite	–0.43 (0.63)	83.2 (8.4)	70.6 (13.4)	104.2 (84.0)	–9.2 (10.1)	88.2 (10.3)	20.2 (16.8)
White Rock/Pajario Acres	–0.50 (0.62)	118.4 (11.8)	95.8 (143.6)	270.5 (95.8)	–36.1 (53.8)	1234.0 (141.1)	223.4 (75.6)
San Idefonso (Sacred Area)	–0.13 (0.65)	121.8 (12.6)	4.2 (5.9)	158.8 (93.2)	23.5 (35.3)	292.3 (56.3)	20.2 (68.0)
On-Site:							
LANL (TA-59)	–0.43 (0.63)	52.1 (5.0)	6.7 (10.1)	64.7 (70.6)	–2.5 (10.9)	68.0 (19.3)	22.7 (12.6)

[a] (±1 counting uncertainty); values are the uncertainty of the analytical results at the 65% confidence level.

[b] See Appendix B for an explanation of the presence of negative values.

c Regional Statistical Reference Level; this is the upper (95%) limit background concentration (mean + 2 std dev) based on 1998 data.

E. Figures

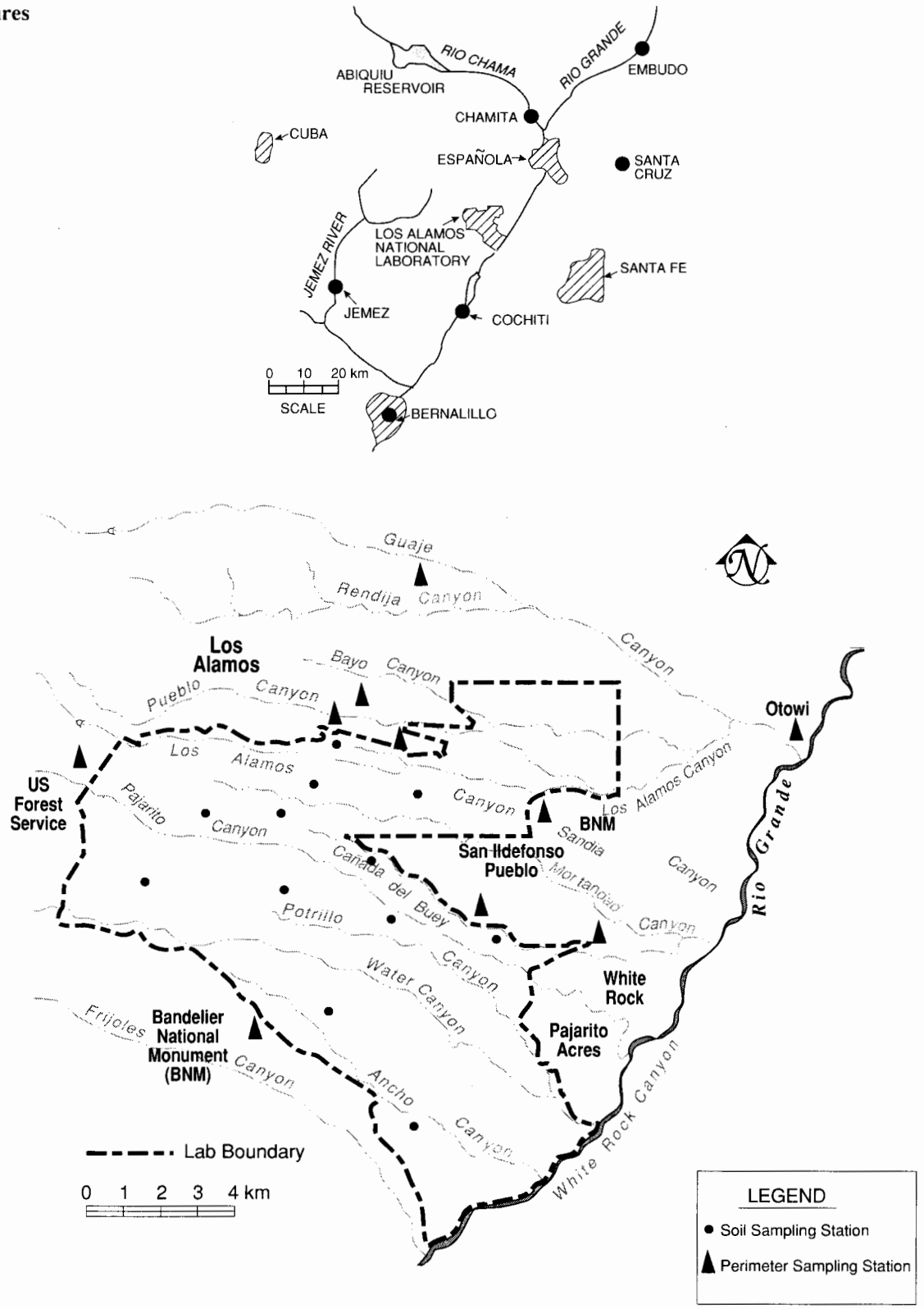

Figure 6-1. Off-site regional (top) and perimeter and on-site (bottom) Laboratory soil sampling locations.

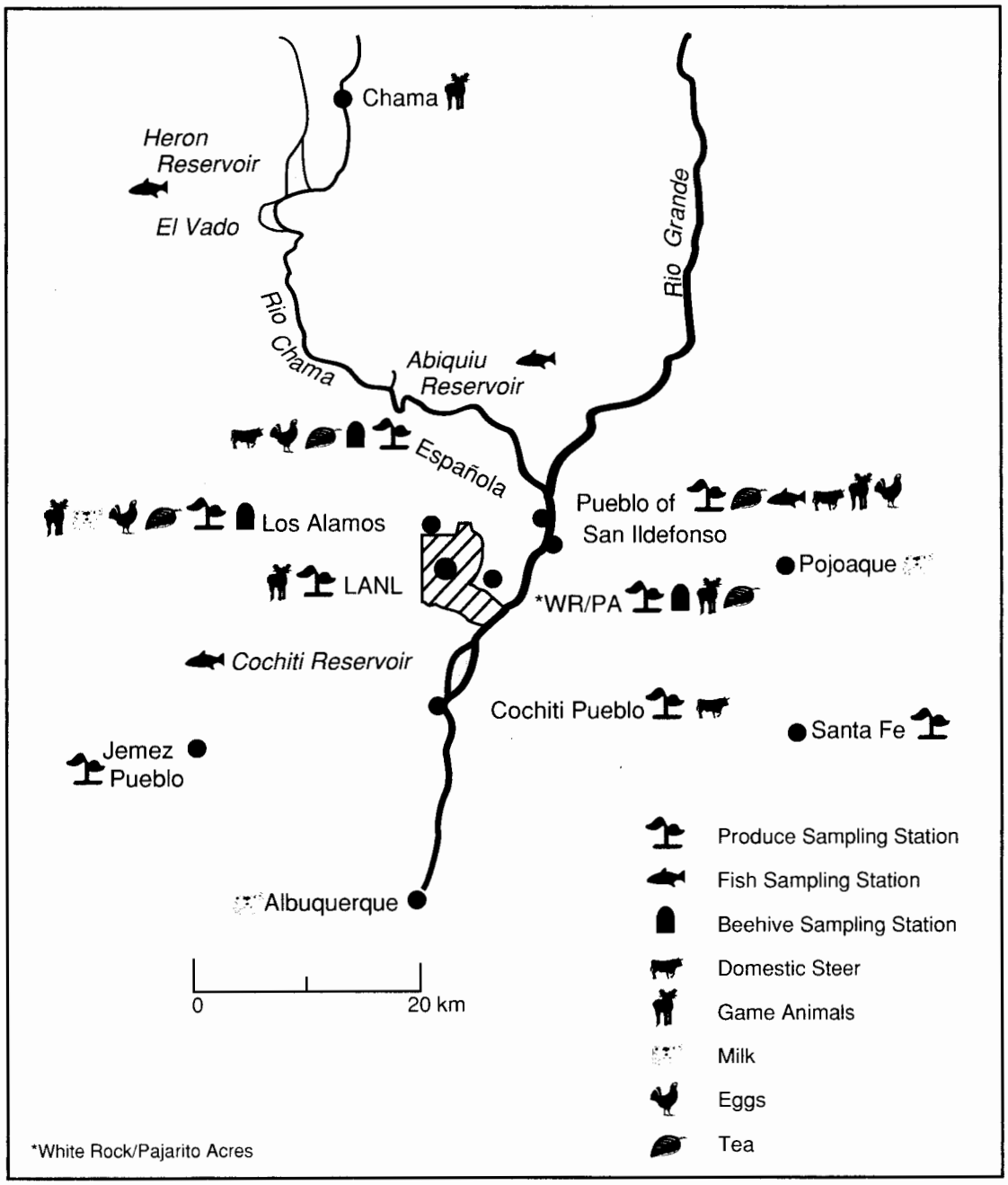

Figure 6-2. Produce, fish, milk, eggs, tea, domestic and game animals, and beehive sampling locations. (Map denotes general locations only.)

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Standards for Environmental Contaminants

Throughout this report, we compare concentrations of radioactive and chemical constituents in air and water samples with pertinent standards and guidelines in regulations of federal and state agencies. No comparable standards for soils, sediments, or foodstuffs are available. Los Alamos National Laboratory (LANL or the Laboratory) operations are conducted in accordance with directives for compliance with environmental standards. These directives are contained in Department of Energy (DOE) Orders 5400.1, "General Environmental Program;" 5400.5, "Radiation Protection of the Public and the Environment;" 5480.1, "Environmental Protection, Safety, and Health Protection Standards;" 5480.11, "Requirements for Radiation Protection for Occupational Workers;" 5484.1, "Environmental Radiation Protection, Safety, and Health Protection Information Reporting Requirements," Chap. III, "Effluent and Environmental Monitoring Program Requirements," and 231.1, "Environmental Safety and Health Reporting."

Radiation Standards. DOE regulates radiation exposure to the public and the worker by limiting the radiation dose that can be received during routine Laboratory operations. Because some radionuclides remain in the body and result in exposure long after intake, DOE requires consideration of the dose commitment caused by inhalation, ingestion, or absorption of such radionuclides. This evaluation involves integrating the dose received from radionuclides over a standard period of time. For this report, 50-yr dose commitments were calculated using the DOE dose factors from DOE 1988a and DOE 1988b. The dose factors adopted by DOE are based on the recommendations of Publication 30 of the International Commission on Radiological Protection (ICRP 1988).

In 1990, DOE issued Order 5400.5, which finalized the interim radiation protection standard (RPS) for the public (NCRP 1987). Table A-1 lists currently applicable RPSs, now referred to as public dose limits (PDLs), for operations at the Laboratory. DOE's comprehensive PDL for radiation exposure limits the effective dose equivalent (EDE) that a member of the public can receive from DOE operations to 100 mrem per year. The PDLs and the DOE dose factors are based on recommendations in ICRP (1988) and the National Council on Radiation Protection and Measurements (NCRP 1987).

The EDE is the hypothetical whole-body dose that would result in the same risk of radiation-induced cancer or genetic disorder as a given exposure to an individual organ. It is the sum of the individual organ doses, weighted to account for the sensitivity of each organ to radiation-induced damage. The weighting factors are taken from the recommendations of the ICRP. The EDE includes doses from both internal and external exposure.

Radionuclide concentrations in air or water are compared to DOE's Derived Concentration Guides (DCGs) to evaluate potential impacts to members of the public. The DCGs for air are the radionuclide concentrations in air, which, if inhaled continuously for an entire year would give a dose of 100 mrem. Similarly, the DCGs for water are those concentrations in water, which if consumed at a maximum rate of 730 liters per year would give a dose of 100 mrem per year. Derived air concentrations (DACs) were developed for protection of workers and are the air concentrations, which, if inhaled throughout a "work year" would give the limiting allowed dose to the worker. The DCGs and DACs are shown in Table A-2.

Nonradioactive Air Quality Standards. Federal and state ambient air quality standards for nonradioactive pollutants are shown in Table A-3. Beryllium emission limits for regulated Laboratory sources are shown in Table A-4.

National Pollutant Discharge Elimination System. Table A-5 presents a summary of the outfalls, the types of monitoring required under National Pollutant Discharge Elimination System (NPDES), and the limits established for sanitary and industrial outfalls. Table A-6 presents NPDES annual water quality parameters for all outfalls.

Drinking Water Standards. For chemical constituents in drinking water, regulations and standards are issued by the Environmental Protection Agency (EPA) and adopted by the New Mexico Environment Department (NMED) as part of the New Mexico Drinking Water Regulations (Table A-7) (NMEIB 1995). EPA's secondary drinking water standards, which are not included in the New Mexico Drinking Water Regulations and are not enforceable, relate to contaminants in drinking water that primarily affect aesthetic qualities associated with public accep-

tance of drinking water (EPA 1989b). There may be health effects associated with considerably higher concentrations of these contaminants.

Radioactivity in drinking water is regulated by EPA regulations contained in 40 CFR 141 (EPA 1989b) and New Mexico Drinking Water Regulations, Sections 206 and 207 (NMEIB 1995). These regulations provide that combined radium-226 and radium-228 may not exceed 5 pCi per liter. Gross alpha activity (including radium-226, but excluding radon and uranium) may not exceed 15 pCi per liter.

A screening level of 5 pCi per liter for gross alpha is established to determine when analysis specifically for radium isotopes is necessary. In this report, plutonium concentrations are compared with both the EPA gross alpha standard for drinking water (Table A-7) and the DOE guides calculated for the DCGs applicable to drinking water (Table A-2).

For man-made beta- and photon-emitting radionuclides, EPA drinking water standards are limited to concentrations that would result in doses not exceeding 4 mrem per year, calculated according to a specified procedure. In addition, DOE Order 5400.5 requires that persons consuming water from DOE-operated public water supplies do not receive an EDE greater than 4 mrem per year. DCGs for drinking water systems based on this requirement are in Table A-2.

Surface Water Standards. Concentrations of radionuclides in surface water samples may be compared to either the DOE DCGs (Table A-2) or the New Mexico Water Quality Control Commission (NMWQCC) stream standard, which references the state's radiation protection regulations. However, New Mexico radiation levels are in general two orders of magnitude greater than DOE's DCGs for public dose, so only the DCGs will be discussed here. The concentrations of nonradioactive constituents may be compared with the NMWQCC Livestock Watering and Wildlife Habitat stream standards (NMWQCC 1995). (See Tables A-8 and A-9.) The NMWQCC groundwater standards can also be applied in cases where discharges may affect groundwater.

Organic Analysis of Surface and Groundwaters: Methods and Analytes. Organic analyses of surface waters, groundwaters, and sediments are made using SW-846 methods as shown in Table A-10. This table shows the number of analytes included in each analytical suite. The specific compounds analyzed in each suite are listed in Tables A-11 through A-14.

Table A-1. Department of Energy Public Dose Limits for External and Internal Exposures

	Effective Dose Equivalent[a] at Point of Maximum Probable Exposure
Exposure of Any Member of the Public[b]	
All Pathways	100 mrem/yr[c]
Air Pathway Only[d]	10 mrem/yr
Drinking Water	4 mrem/yr
Occupational Exposure[b]	
Stochastic Effects	5 rem (annual EDE[e])
Nonstochastic Effects	
Lens of eye	15 rem (annual EDE[e])
Extremity	50 rem (annual EDE[e])
Skin of the whole body	50 rem (annual EDE[e])
Organ or tissue	50 rem (annual EDE[e])
Unborn Child	
Entire gestation period	0.5 rem (annual EDE[e])

[a]As used by DOE, effective dose equivalent (EDE) includes both the EDE from external radiation and the committed EDE to individual tissues from ingestion and inhalation during the calendar year.

[b]In keeping with DOE policy, exposures must be limited to as small a fraction of the respective annual dose limits as practicable. DOE's public dose limit (PDL) applies to exposures from routine Laboratory operation, excluding contributions from cosmic, terrestrial, and global fallout; self-irradiation; and medical diagnostic sources of radiation. Routine operation means normal, planned operation and does not include actual or potential accidental or unplanned releases. Exposure limits for any member of the general public are taken from DOE Order 5400.5 (DOE 1990). Limits for occupational exposure are taken from 10 CFR 835 Occupational Radiation Protection.

[c]Under special circumstances and subject to approval by DOE, this limit on the EDE may be temporarily increased to 500 mrem/yr, provided the dose averaged over a lifetime does not exceed the principal limit of 100 mrem per year.

[d]This level is from EPA's regulations issued under the Clean Air Act, (40 CFR 61, Subpart H) (EPA 1989a).

[e]Annual EDE is the EDE received in a year.

Table A-2. Department of Energy's Derived Concentration Guides for Water and Derived Air Concentrations[a]

Nuclide	f_1[b]	DCGs for Water Ingestion in Uncontrolled Areas (pCi/L)	DCGs for Drinking Water Systems (pCi/L)	DCGs for Air Inhalation by the Public (μCi/mL)	Class[b]	DACs for Occupational Exposure (μCi/mL)
^{3}H	—	2,000,000	80,000	1×10^{-7}[c]	—	2×10^{-5}[c]
^{7}Be	5×10^{-3}	1,000,000	40,000	4×10^{-8}	Y	8×10^{-6}
^{89}Sr	2×10^{-5}	20,000	800	3×10^{-10}	Y	6×10^{-8}
^{90}Sr[b]	1×10^{-6}	1,000	40	9×10^{-12}	Y	2×10^{-9}
^{137}Cs	1×10^{0}	3,000	120	4×10^{-10}	D	7×10^{-8}
^{234}U	5×10^{-2}	500	20	9×10^{-14}	Y	2×10^{-11}
^{235}U	5×10^{-2}	600	24	1×10^{-13}	Y	2×10^{-11}
^{238}U	5×10^{-2}	600	24	1×10^{-13}	Y	2×10^{-11}
^{238}Pu	1×10^{-3}	40	1.6	3×10^{-14}	W	3×10^{-12}
^{239}Pu[b]	1×10^{-3}	30	1.2	2×10^{-14}	W	2×10^{-12}
^{240}Pu	1×10^{-3}	30	1.2	2×10^{-14}	W	2×10^{-12}
^{241}Am	1×10^{-3}	30	1.2	2×10^{-14}	W	2×10^{-12}

[a]Guides for uncontrolled areas are based on DOE's public dose limit for the general public (DOE 1990); those for occupational exposure are based on radiation protection standards in 10 CFR 835. Guides apply to concentrations in excess of those occurring naturally or that are due to worldwide fallout.
[b]Gastrointestinal tract absorption factors (f_1) and lung retention classes (Class) are taken from ICRP30 (ICRP 1988). Codes: Y = year, D = day, W = week.
[c]Tritium in the HTO form.

Table A-3. National (40 CFR 50) and New Mexico (20 NMAC 2.3) Ambient Air Quality Standards

Pollutant	Averaging Time	Unit	New Mexico Standard	Federal Standards Primary	Federal Standards Secondary
Sulfur dioxide	Annual	ppm	0.02	0.030[a]	
	24 hours	ppm	0.10	0.14[b]	
	3 hours	ppm			0.5[b]
Hydrogen sulfide	1 hour	ppm	0.010[b]		
Total reduced sulfur	1/2 hour	ppm	0.003[b]		
Total Suspended Particulates	Annual	$\mu g/m^3$	60	50	50
	30 days	$\mu g/m^3$	90		
	7 days	$\mu g/m^3$	110		
	24 hours	$\mu g/m^3$	150		
PM_{10}[c]	Annual	$\mu g/m^3$		50	50
	24 days	$\mu g/m^3$		150	150
$PM_{2.5}$[d]	Annual	$\mu g/m^3$		15[e]	15[e]
	24 hours	$\mu g/m^3$		65[e]	65[e]
Carbon monoxide	8 hours	ppm	8.7	9[b]	
	1 hour	ppm	13.1	35[b]	
Ozone	1 hour	ppm		0.12[f]	0.12[f]
	8 hours	ppm		0.08	0.08
Nitrogen dioxide	Annual	ppm	0.05	0.053	0.053
	24 hours	ppm	0.10		
Lead and lead compounds	Calendar quarter	$\mu g/m^3$		1.5	1.5

[a]Not to be exceeded in a calendar year.
[b]Not to be exceeded more than once in a calendar year.
[c]Particles ≤10 μm in diameter.
[d]Particles ≤2.5 μm in diameter.
[e]Applicable when the changes to the NM State Implementation Plan are approved by EPA.
[f]EPA has determined that the one-hour ozone standard no longer applies to Los Alamos County. The only ozone standard now applicable to Los Alamos County is the eight-hour standard (63 CFR 31014, June 5, 1998).

Table A-4. Beryllium Limits during 1999

20 NMAC 2.72 Permits–Allowable Emissions (lb/yr)		
Facility	**Al**	**Be**
BE Shop, TA-3, Bldg. 39	NR	0.008
BE Machining, TA-35, Bldg. 213	NR	0.0008
BE Machining, TA-3, Bldg. 141	NR	0.0004
BE Machining, TA-3, Bldg. 102	NR	0.00014
BE Cutting and Bead Dressing	0.5	0.0041
Metallography	NR	0.0030

Table A-5. Limits Established by National Pollutant Discharge Elimination System Permit No. NM0028355 for Sanitary and Industrial Outfall Discharges for 1998

Discharge Category	Permit Parameter	Daily Average			Daily Maximum	
Sanitary						
13S TA-46 SWS Facility	BOD[a]	concentration	30	mg/L	45	mg/L
		loading limit	100	lb/day	N/A[b]	
	TSS[c]	concentration	30	mg/L	45	mg/L
		loading limit	100	lb/day	N/A	
	Fecal coliform bacteria[d]		500	colonies/100 mL	500	colonies/100 mL
	pH		6.0–9.0 s.u.		6.0–9.0 s.u.	
	Flow[e]		Report			Report

Discharge Category	Number of Outfalls	Sampling Frequency	Permit Parameter	Daily Average	Daily Maximum	Unit of Measurement
Industrial						
001 Power Plant	1	Monthly	TSS	30	100	mg/L
			Free available CL_2	0.2	0.5	mg/L
			pH	6.0–9.0	6.0–9.0	s.u.
02A Boiler Blowdown	2	Every 3 months	TSS	30	100	mg/L
			Total Fe	10	40	mg/L
			Total Cu	1.0	1.0	mg/L
			Total P	20	40	mg/L
			Sulfite	35	70	mg/L
			Total Cr	1.0	1.0	mg/L
			pH	6.0–9.0	6.0–9.0	s.u.
03A Treated Cooling Water	20	Every 3 months	TSS	30	100	mg/L
			Free available Cl	0.2	0.5	mg/L
			Total P	20	40	mg/L
			Total As	0.04	0.04	mg/L
			pH	6.0–9.0	6.0–9.0	s.u.
04A Noncontact Cooling Water	19	Every 3 months	pH	6.0–9.0	6.0–9.0	s.u.
			Total residual CL_2	Report[f]	Report	mg/L
051 Radioactive Liquid Waste Treatment Facility (TA-50)	1	Variable: weekly to monthly	COD[g]	94	156	lb/day
			TSS	18.8	62.6	lb/day
			Total Cd	0.06	0.30	lb/day
			Total Cr	0.19	0.38	lb/day
			Total Cu	0.63	0.63	lb/day
			Total Fe	1.0	2.0	lb/day
			Total Pb	0.06	0.15	lb/day
			Total Hg	0.003	0.09	lb/day
			Total Zn	0.62	1.83	lb/day
			TTO[h]	1.0	1.0	mg/L
			Total Ni	Report	Report	mg/L
			Total N	Report	Report	mg/L
			NO_3-NO_2	Report	Report	mg/L
			Ammonia (as N)[f]	Report	Report	mg/L

Table A-5. (Cont.)

Discharge Category	Number of Outfalls	Sampling Frequency	Permit Parameter	Daily Average	Daily Maximum	Unit of Measurement
051 (Cont.)			pH	6.0–9.0	6.0–9.0	s.u.
			COD	125	125	mg/L
			^{226}Ra and ^{228}Ra	30.0	30.0	pCi/L
05A High Explosive Wastewater	11	Every 3 months	Oil & Grease	15	15	mg/L
			COD	125	125	mg/L
			TSS	30.0	45.0	mg/L
			pH	6.0–9.0	6.0–9.0	s.u.
06A Photo Wastewater	10	Every 3 months	Total Ag	0.5	1.0	mg/L
			pH	6.0–9.0	6.0–9.0	s.u.

[a]Biochemical oxygen demand.
[b]Not applicable.
[c]Total suspended solids.
[d]Logarithmic mean.
[e]Discharge volumes are reported to EPA but are not subject to limits.
[f]Concentrations are reported to EPA but are not subject to limits.
[g]Chemical oxygen demand.
[h]Total toxic organics.

Note: Sampling frequency for sanitary outfall varies from once a week to once every 3 months, depending on the parameter.

Table A-6. Annual Water Quality Parameters Established by National Pollutant Discharge Elimination System Permit No. NM0028355 for Sanitary and Industrial Outfall Discharges for 1998

Discharge Category	Number of Outfalls	Sampling Frequency	Permit Parameter	Daily Average	Daily Maximum	Unit of Measurement
All Outfall Categories: Annual Water Quality Parameters	66	Annually	Total Al	5.0	5.0	mg/L
			Total As	0.04	0.04	mg/L
			Total B	5.0	5.0	mg/L
			Total Cd	0.2	0.2	mg/L
			Total Cr	5.1	5.1	mg/L
			Total Co	1.0	1.0	mg/L
			Total Cu	1.6	1.6	mg/L
			Total Pb	0.4	0.4	mg/L
			Total Hg	0.01	0.01	mg/L
			Total Se	0.05	0.05	mg/L
			Total V	0.1	0.1	mg/L
			Total Zn	95.4	95.4	mg/L
			^{226}Ra and ^{228}Ra	30.0	30.0	pCi/L
			^{3}H[a]	3,000,000	3,000,000	pCi/L

[a]When accelerator produced.

Table A-7. Safe Drinking Water Act Maximum Contaminant Levels in the Water Supply for Radiochemicals, Inorganic Chemicals, and Microbiological Constituents

Contaminants	Level
Radiochemical:	**Maximum Contaminant Level**
Gross alpha	15 pCi/L[a]
Gross beta & photon	4 mrem/yr[a]
^{226}Ra & ^{228}Ra	5 pCi/L[a]
U	20 µg/L[a]
Radon	300 pCi/L[b]
	Screening Level
Gross alpha	5 pCi/L[a]
Gross beta	50 pCi/L[a]
Inorganic Chemical:	
Primary Standards	**Maximum Contaminant Level (mg/L)**
Asbestos	7 million fibers/L (longer than 10 µm)
As	0.05[a]
Ba	2
Be	0.004
Cd	0.005
CN	0.2
Cr	0.1
F	4
Hg	0.002
Ni	0.1
NO_3 (as N)	10
NO_2 (as N)	1
SO_4	500[c]
Se	0.05
Sb	0.006
Tl	0.002
	Action Levels (mg/L)
Pb	0.015
Cu	1.3
Secondary Standards	**(mg/L)**
Cl	250
Cu	1
Fe	0.3
Mn	0.05
Zn	5
Total Dissolved Solids	500
pH	6.5–8.5
Microbiological:	**Maximum Contaminant Level**
Presence of total coliforms	5% of samples/month
Presence of fecal coliforms or Escherichia coli	No coliform-positive repeat samples following a fecal coliform-positive sample

[a]Proposed.
[b]The proposed MCL for radon was withdrawn by the EPA on August 6, 1996.
[c]The proposed MCL for sulfate was suspended by the EPA on August 6, 1996.

Table A-8. Livestock Watering Standards[a]

Livestock Contaminant	Concentration	
Dissolved Al	5	mg/L
Dissolved As	0.2	mg/L
Dissolved B	5	mg/L
Dissolved Cd	0.05	mg/L
Dissolved Cr	1	mg/L
Dissolved Co	1	mg/L
Dissolved Cu	0.5	mg/L
Dissolved Pb	0.1	mg/L
Total Hg	0.01	mg/L
Dissolved Se	0.05	mg/L
Dissolved V	0.1	mg/L
Dissolved Zn	25	mg/L
^{226}Ra and ^{228}Ra	30	pCi/L
^{3}H	20,000	pCi/L
Gross alpha	15	pCi/L

[a]NMWQCC 1995.

Table A-9. Wildlife Habitat Stream Standards[a]

The following narrative standard shall apply:

1. Except as provided below in Paragraph 2 of this section, no discharge shall contain any substance, including, but not limited to selenium, DDT, PCBs, and dioxin, at a level which, when added to background concentrations, can lead to bioaccumulation to toxic levels in any animal species. In the absence of site-specific information, this requirement shall be interpreted as establishing a stream standard of 2 µg per liter for total recoverable selenium and of 0.012 µg per liter for total mercury.

2. The discharge of substances that bioaccumulate in excess of levels specified above in Paragraph 1 is allowed if, and only to the extent that, the substances are present in the intake waters which are diverted and utilized prior to discharge, and then only if the discharger utilizes best available treatment technology to reduce the amount of bioaccumulating substances which are discharged.

3. Discharges to waters which are designated for wildlife habitat uses, but not for fisheries uses, shall not contain levels of ammonia or chlorine in amounts which reduce biological productivity and/or species diversity to levels below those which occur naturally and in no case shall contain chlorine in excess of 1 mg per liter nor ammonia in excess of levels that can be accomplished through best reasonable operating practices at existing treatment facilities.

4. A discharge which contains any heavy metal at concentrations in excess of the concentrations set forth in Section 3101.J.1 of these standards shall not be permitted in an amount, measured by total mass, which exceeds by more than 5% the amount present in the intake waters which are diverted and utilized prior to the discharge, unless the discharger has taken steps (an approved program to require industrial pretreatment or a corrosion program) appropriate to reduce influent concentration to the extent practicable.

[a]NMWQCC 1995.

Table A-10. Organic Analytical Methods

Test	SW-846 Method	Extraction Water	Extraction Sediments	Number of Analytes
Volatiles	8260A	E0730	E0720	59
Semivolatiles	8270B[a]	E0530	E0510	69
PCB[b]	8080A, 8081	E0430	E0410	4
HE[c]	8330			14

[a]Direct injection used for method 8270B.
[b]Polychlorinated biphenyls.
[c]High-explosive.

Table A-11. Volatile Organic Compounds

Analytes	Limit of Quantitation Water (µg/L)
Acetone	20
Benzene	5
Bromobenzene	5
Bromochloromethane	5
Bromodichloromethane	5
Bromoform	5
Bromomethane	10
Butanone [2-]	20
Butylbenzene [n-]	5
Butylbenzene [sec-]	5
Butylbenzene [tert-]	5
Carbon disulfide	5
Carbon tetrachloride	5
Chlorobenzene	5
Chlorodibromomethane	5
Chloroethane	10
Chloroform	5
Chloromethane	10
Chlorotoluene [o-]	5
Chlorotoluene [p-]	5
Dibromo-3-chloropropane [1,2]	10
Dibromoethane [1,2-]	5
Dibromomethane	5
Dichlorobenzene [m-] (1,3)	5
Dichlorobenzene [o-] (1,2)	5
Dichlorobenzene [p-] (1,4)	5
Dichlorodifluoromethane	10
Dichloroethane [1,1-]	5
Dichloroethane [1,2-]	5

Table A-11. Volatile Organic Compounds (Cont.)

Analytes	Limit of Quantitation Water (µg/L)
Dichloroethene [1,1-]	5
Dichloroethene [trans-1,2-]	5
Dichloropropane [1,2-]	5
Dichloropropane [1,3-]	5
Dichloropropane [2,2-]	5
Dichloropropene [1,1-]	5
Dichloropropene [cis-1,3-]	5
Dichloropropene [trans-1,3-]	5
Ethylbenzene	5
Hexachlorobutadiene	10
Hexanone [2-]	20
Isopropylbenzene	5
Isopropyltoluene [4-]	5
Methyl iodide	5
Methyl-2-pentanone [4-]	20
Methylene chloride	5
Naphthalene	10
Propylbenzene	5
Styrene	5
Tetrachloroethane [1,1,1,2-]	5
Tetrachloroethane [1,1,2,2-]	5
Tetrachloroethylene	5
Toluene	5
Trichloro-1,2,2-trifloroethane [1,1,2-]	5
Trichlorobutadiene [1,2,3-]	10
Trichlorobutadiene [1,2,4-]	10
Trichloroethane [1,1,1-]	5
Trichloroethane [1,1,2-]	5
Trichloroethene	5
Trichlorofluoromethane	5
Trichloropropane [1,2,3-]	5
Trimethylbenzene [1,2,4-]	5
Trimethylbenzene [1,3,5-]	5
Vinyl chloride	10
Xylene (o)	5
Xylene (x+p)	5
Xylenes (o + m + p) [Mixed-]	5

Table A-12. Semivolatile Organic Compounds

Analytes	Limit of Quantitation Water (µg/L)	Sediments (mg/kg-avg)
Acenaphthene	10	0.38
Acenaphthylene	10	0.38
Aniline	10	0.38
Anthracene	10	0.38
Azobenzene	10	0.38
Benzidine [m-]	50	1.95
Benzo[a]anthracene	10	0.38
Benzo[a]pyrene	10	0.38
Benzo[b]fluoranthene	10	0.38
Benzo[g,h,i]perylene	10	0.38
Benzo[k]fluoranthene	10	0.38
Benzoic acid	50	1.95
Benzyl alcohol	10	0.38
Bis(2-chloroethoxy)methane	10	0.38
Bis(2-chloroethyl)ether	10	0.38
Bis(2-chloroisopropyl)ether	10	0.38
Bis(2-ethylhexyl)phthalate	10	0.38
Bromophenylphenyl ether [4-]	10	0.38
Butyl benzyl phthalate	10	0.38
Chloro-3-methylphenol [4-]	10	0.38
Chloroaniline [4-]	10	0.38
Chloronaphthalene [2-]	10	0.38
Chlorophenol [o-]	10	0.38
Chlorophenylphenyl ether [4-]	10	0.38
Chrysene	10	0.38
Di-n-butyl phthalate	10	0.38
Di-n-octyl phthalate	10	0.38
Dibenzo[a,h]anthracene	10	0.38
Dibenzofuran	10	0.38
Dichlorobenzene (1,2) [o-]	10	0.38
Dichlorobenzene (1,3) [m-]	10	0.38
Dichlorobenzene (1,4) [p-]	10	0.38
Dichlorobenzidine [3,3'-]	20	0.66
Dichlorophenol [2,4-]	10	0.38
Diethyl phthalate	10	0.38
Dimethyl phthalate	10	0.38
Dimethylphenol [2,4-]	10	0.38
Dinitrophenol [2,4-]	50	1.95
Dinitrotoluene [2,4-]	10	0.38
Dinitrotoluene [2,6-]	10	0.38
Fluoranthene	10	0.38
Fluorene	10	0.38
Hexachlorobenzene	10	0.38
Hexachlorobutadiene	50	1.95

Table A-12. Semivolatile Organic Compounds (Cont.)

Analytes	Limit of Quantitation Water (µg/L)	Limit of Quantitation Sediments (mg/kg-avg)
Hexachlorocyclopentadiene	10	0.38
Hexachloroethane	10	0.38
Indeno[1,2,3-cd]pyrene	10	0.38
Isophorone	10	0.38
Methyl-4,6-dinitrophenol [2-]	50	1.95
Methylnaphthalene [2-]	10	0.38
Methylphenol [2-]	10	0.38
Methylphenol [4-]	10	0.38
Naphthalene	10	0.38
Nitroaniline [2-]	20	0.66
Nitroaniline [3-]	20	0.66
Nitroaniline [4-]	20	0.66
Nitrobenzene	10	0.38
Nitrophenol [2-]	10	0.38
Nitrophenol [4-]	50	1.95
Nitrosodi-n-propylamine [N-]	10	0.38
Nitrosodimethylamine [N-]	10	0.38
Nitrosodiphenylamine [N-]	10	0.38
Pentachlorophenol	50	1.95
Phenanthrene	10	0.38
Phenol	10	0.38
Picoline [2-]	10	0.38
Pyrene	10	1.95
Pyridine	10	0.38
Trichlorobenzene [1,2,4-]	10	0.38
Trichlorophenol [2,4,5-]	10	0.38
Trichlorophenol [2,4,6-]	10	0.38

Table A-13. Polychlorinated Biphenyls

Analytes	Detection Limits Water (µg/L)	Sediments (mg/kg)
Aroclor 1016	0.5	0.25
Aroclor 1221	0.5	0.25
Aroclor 1232	0.5	0.25
Aroclor 1242	0.5	0.25
Aroclor 1248	0.5	0.25
Aroclor 1254	0.5	0.25
Aroclor 1260	0.5	0.25
Aroclor 1262	0.5	0.25

Table A-14. High-Explosives Analytes

Analytes	Limit of Quantitation Water (µg/L	Sediments (mg/kg)
HMX	0.5	0.5
RDX	0.5	0.5
1,3,5-TNB	0.5	0.5
1,3-DNB	0.5	0.5
Tetryl	0.5	0.5
Nitrobenzene	0.5	0.5
2,4,6-TNT	0.5	0.5
4-A-2,6-DNT	0.5	0.5
2,6-DNT	0.5	0.5
2,4-DNT	0.5	0.5
2-NT	0.5	0.5
4-NT	0.5	0.5
3-NT	0.5	0.5

References

DOE 1988a: US Department of Energy, "Internal Dose Conversion Factors for Calculation of Dose to the Public," US Department of Energy report DOE/EH-0071 (July 1988).

DOE 1988b: US Department of Energy, "External Dose-Rate Conversion Factors for Calculation of Dose to the Public," US Department of Energy report DOE/EH-0070 (July 1988).

DOE 1990: US Department of Energy, "Radiation Protection of the Public and the Environment," US Department of Energy Order 5400.5 (February 8, 1990).

EPA 1989a: US Environmental Protection Agency, "40CFR 61, National Emission Standards for Hazardous Air Pollutants, Radionuclides; Final Rule and Notice of Reconsideration," Federal Register 54, 51 653-51 715 (December 15, 1989).

EPA 1989b: US Environmental Protection Agency, "National Interim Primary Drinking Water Regulations," Code of Federal Regulations, Title 40, Parts 141 and 142 (1989), and "National Secondary Drinking Water Regulations," Part 143 (1989).

ICRP 1988: International Commission on Radiological Protection, "Limits for Intakes of Radionuclides by Workers," ICRP Publication 30, Parts 1, 2, and 3, and their supplements, Annals of the ICRP 2(3/4) -8(4) (1979-1982), and Publication 30, Part 4, 19(4) (1988).

NCRP 1987: National Council on Radiation Protection and Measurements, "Recommendations on Limits for Exposure to Ionizing Radiation," NCRP report No. 91 (June 1987).

NMEIB 1995: New Mexico Environmental Improvement Board, "New Mexico Drinking Water Regulations," (as amended through January 1995).

NMWQCC 1995: New Mexico Water Quality Control Commission, "State of New Mexico Water Quality Standards for Interstate and Intrastate Streams," Section 3-101.K (as amended through January 23, 1995).

Units of Measurement

Throughout this report the International System of Units (SI) or metric system of measurements has been used, with some exceptions. For units of radiation activity, exposure, and dose, US Customary Units (that is, curie [Ci], roentgen [R], rad, and rem) are retained as the primary measurement because current standards are written in terms of these units. The equivalent SI units are the becquerel (Bq), coulomb per kilogram (C/kg), gray (Gy), and sievert (Sv), respectively.

Table B-1 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 2,000. 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 presents conversion factors for converting SI units into US Customary Units. Table B-3 presents abbreviations for common measurements.

Data Handling of Radiochemical Samples

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

For individual measurements, uncertainties are reported as one standard deviation. The standard deviation is estimated from the propagated sources of analytical error.

Standard deviations for the station and group (off-site regional, off-site perimeter, and on-site) means are calculated using the following equation:

$$s = \sqrt{\frac{\sum_{i=1}^{N} (\bar{c} - c_i)^2}{(N-1)}},$$

where

c_i = sample i,

$\bar{c}$ = mean of samples from a given station or group, and

N = number of samples comprising a station or group.

This value is reported as one standard deviation ($1s$) for the station and group means.

Tables

Table B-1. Prefixes Used with SI (Metric) Units

Prefix	Factor	Symbol
mega	1 000 000 or 10^6	M
kilo	1 000 or 10^3	k
centi	0.01 or 10^{-2}	c
milli	0.001 or 10^{-3}	m
micro	0.000001 or 10^{-6}	μ
nano	0.000000001 or 10^{-9}	n
pico	0.000000000001 or 10^{-12}	p
femto	0.000000000000001 or 10^{-15}	f
atto	0.000000000000000001 or 10^{-18}	a

Table B-2. Approximate Conversion Factors for Selected SI (Metric) Units

Multiply SI (Metric) Unit	by	to Obtain US Customary Unit
celsius (°C)	9/5 + 32	fahrenheit (°F)
centimeters (cm)	0.39	inches (in.)
cubic meters (m^3)	35.3	cubic feet (ft^3)
hectares (ha)	2.47	acres
grams (g)	0.035	ounces (oz)
kilograms (kg)	2.2	pounds (lb)
kilometers (km)	0.62	miles (mi)
liters (L)	0.26	gallons (gal.)
meters (m)	3.28	feet (ft)
micrograms per gram (µg/g)	1	parts per million (ppm)
milligrams per liter (mg/L)	1	parts per million (ppm)
square kilometers (km^2)	0.386	square miles (mi^2)

Table B-3. Common Measurement Abbreviations and Measurement Symbols

aCi	attocurie
Bq	becquerel
Btu/yr	British thermal unit per year
Ci	curie
cm^3/s	cubic centimeters per second
cpm/L	counts per minute per liter
fCi/g	femtocurie per gram
ft	foot
ft^3/min	cubic feet per minute
ft^3/s	cubic feet per second
kg	kilogram
kg/h	kilogram per hour
lb/h	pound per hour
lin ft	linear feet
m^3/s	cubic meter per second
µCi/L	microcurie per liter
µCi/mL	microcurie per milliliter
µg/g	microgram per gram
$\mu g/m^3$	microgram per cubic meter
mL	milliliter
mm	millimeter
µm	micrometer
µmho/cm	micro mho per centimeter
mCi	millicurie
mg	milligram
mR	milliroentgen

Table B-3. Common Measurement Abbreviations and Measurement Symbols (Cont.)

m/s	meters per second
mrad	millirad
mrem	millirem
mSv	millisievert
nCi	nanocurie
nCi/dry g	nanocurie per dry gram
nCi/L	nanocurie per liter
ng/m^3	nanogram per cubic meter
pCi/dry g	picocurie per dry gram
pCi/g	picocurie per gram
pCi/L	picocurie per liter
pCi/m^3	picocurie per cubic meter
pCi/mL	picocurie per milliliter
pg/g	picogram per gram
pg/m^3	picogram per cubic meter
PM_{10}	small particulate matter (less than 10 µm diameter)
$PM_{2.5}$	small particulate matter (less than 2.5 µm diameter)
R	roentgen
s, ST or σ	standard deviation
s.u.	standard unit
sq ft (ft^2)	square feet
TU	tritium unit
>	greater than
<	less than
≥	greater than or equal to
≤	less than or equal to
±	plus or minus
~	approximately

Reference

Gilbert 1975: R. O. Gilbert, "Recommendations Concerning the Computation and Reporting of Counting Statistics for the Nevada Applied Ecology Group," Batelle Pacific Northwest Laboratories report BNWL-B-368 (September 1975).

Description of Technical Areas and Their Associated Programs

Locations of the technical areas (TAs) operated by the Laboratory in Los Alamos County are shown in Figure 1-2. The main programs conducted at each of the areas are listed in this Appendix.

TA-0: The Laboratory has about 180,000 sq ft of leased space for training, support, architectural engineering design, and unclassified research and development in the Los Alamos townsite and White Rock. The publicly accessible Community Reading Room and the Bradbury Science Museum are also located in the Los Alamos townsite.

TA-2, Omega Site: Omega West Reactor, an 8-MW nuclear research reactor, is located here. It was placed into a safe shutdown condition in 1993 and was removed from the nuclear facilities list. The reactor will be transferred to the institution for placement into the decontamination and decommissioning (D&D) program beginning in 2006.

TA-3, Core Area: The Administration Complex contains the Director's office, administrative offices, and support facilities. Laboratories for several divisions are in this main TA of the Laboratory. Other buildings house central computing facilities, chemistry and materials science laboratories, earth and space science laboratories, physics laboratories, technical shops, cryogenics laboratories, the main cafeteria, and the Study Center. TA-3 contains about 50% of the Laboratory's employees and floor space.

TA-5, Beta Site: This site contains some physical support facilities such as an electrical substation, test wells, several archaeological sites, and environmental monitoring and buffer areas.

TA-6, Two-Mile Mesa Site: The site is mostly undeveloped and contains gas cylinder staging and vacant buildings pending disposal.

TA-8, GT Site (or Anchor Site West): This is a dynamic testing site operated as a service facility for the entire Laboratory. It maintains capability in all modern nondestructive testing techniques for ensuring quality of material, ranging from test weapons components to high-pressure dies and molds. Principal tools include radiographic techniques (x-ray machines with potentials up to 1,000,000 V and a 24-MeV betatron), radioisotope techniques, ultrasonic and penetrant testing, and electromagnetic test methods.

TA-9, Anchor Site East: At this site, fabrication feasibility and physical properties of explosives are explored. New organic compounds are investigated for possible use as explosives. Storage and stability problems are also studied.

TA-11, K Site: Facilities are located here for testing explosives components and systems, including vibration testing and drop testing, under a variety of extreme physical environments. The facilities are arranged so that testing may be controlled and observed remotely and so that devices containing explosives or radioactive materials, as well as those containing nonhazardous materials, may be tested.

TA-14, Q Site: This dynamic testing site is used for running various tests on relatively small explosive charges for fragment impact tests, explosives sensitivities, and thermal responses.

TA-15, R Site: This is the home of PHERMEX (the pulsed high-energy radiographic machine emitting x-rays) a multiple-cavity electron accelerator capable of producing a very large flux of x-rays for weapons development testing. It is also the site where DARHT (the dual-axis radiographic hydrotest facility) is being constructed. This site is also used for the investigation of weapons functioning and systems behavior in nonnuclear tests, principally through electronic recordings.

TA-16, S Site: Investigations at this site include development, engineering design, prototype manufacture, and environmental testing of nuclear weapons warhead systems. TA-16 is the site of the Weapons Engineering Tritium Facility for tritium handled in gloveboxes. Development and testing of high explosives, plastics, and adhesives and research on process development for manufacture of items using these and other materials are accomplished in extensive facilities.

TA-18, Pajarito Laboratory Site: This is a nuclear facility that studies both static and dynamic behavior of multiplying assemblies of nuclear materials. The Category I quantities of special nuclear materials (SNM) are used to support a wide variety of programs such as Stockpile Management, Stockpile Stewardship, Emergency Response, Nonproliferation, Safeguards, etc. Experiments near critical are operated by remote control using low-power reactors called criti-

cal assemblies. The machines are housed in buildings known as kivas and are used primarily to provide a controlled means of assembling a critical amount of fissionable material so that the effects of various shapes, sizes, and configurations can be studied. These machines are also used as a large-quantity source of fission neutrons for experimental purposes. In addition, this facility provides the capability to perform hands-on training and experiments with SNM in various configurations below critical.

TA-21, DP Site: This site has two primary research areas: DP West and DP East. DP West has been in the D&D program since 1992, and six buildings have been demolished. The programs conducted at DP West, primarily in inorganic and biochemistry, were relocated during 1997, and the remainder of the site was scheduled for D&D in future years. DP East is a tritium research site.

TA-22, TD Site: This site is used in the development of special detonators to initiate high-explosive systems. Fundamental and applied research in support of this activity includes investigating phenomena associated with initiating high explosives and research in rapid shock-induced reactions.

TA-28, Magazine Area A: This is an explosives storage area.

TA-33, HP Site: An old, high-pressure, tritium-handling facility located here is being phased out. An intelligence technology group and the National Radio Astronomy Observatory's Very Large Baseline Array Telescope are located at this site.

TA-35, Ten Site: This site is divided into five facility management units. Work here includes nuclear safeguards research and development that are concerned with techniques for nondestructive detection, identification, and analysis of fissionable isotopes. Research is also done on reactor safety, laser fusion, optical sciences, pulsed-power systems, high-energy physics, tritium fabrication, metallurgy, ceramic technology, and chemical plating.

TA-36, Kappa Site: Phenomena of explosives, such as detonation velocity, are investigated at this dynamic testing site.

TA-37, Magazine Area C: This is an explosives storage area.

TA-39, Ancho Canyon Site: The behavior of nonnuclear weapons is studied here, primarily by photographic techniques. Investigations are also made into various phenomenological aspects of explosives, interactions of explosives, explosions involving other materials, shock wave physics, equation state measurements, and pulsed-power systems design.

TA-40, DF Site: This site is used in the development of special detonators to initiate high-explosive systems. Fundamental and applied research in support of this activity includes investigating phenomena associated with the physics of explosives.

TA-41, W Site: Personnel at this site engage primarily in engineering design and development of nuclear components, including fabrication and evaluation of test materials for weapons.

TA-43, Health Research Laboratory: This site is adjacent to the Los Alamos Medical Center in the townsite. Research performed at this site includes structural, molecular, and cellular radiobiology, biophysics, mammalian radiobiology, mammalian metabolism, biochemistry, and genetics. The Department of Energy Los Alamos Area Office is also located within TA-43.

TA-46, WA Site: This TA contains two facility management units. Activities include applied photochemistry research including the development of technology for laser isotope separation and laser enhancement of chemical processes. A new facility completed during 1996 houses research in inorganic and materials chemistry. The Sanitary Wastewater System Facility is located at the east end of this site. Environmental management operations are also located here.

TA-48, Radiochemistry Site: Laboratory scientists and technicians perform research and development (R&D) activities at this site on a wide range of chemical processes including nuclear and radiochemistry, geochemistry, biochemistry, actinide chemistry, and separations chemistry. Hot cells are used to produce medical radioisotopes.

TA-49, Frijoles Mesa Site: This site is currently restricted to carefully selected functions because of its location near Bandelier National Monument and past use in high-explosive and radioactive materials experiments. The Hazardous Devices Team Training Facility is located here.

TA-50, Waste Management Site: This site is divided into two facility management units, which include managing the industrial liquid and radioactive liquid

waste received from Laboratory technical areas and activities that are part of the waste treatment technology effort.

TA-51, Environmental Research Site: Research and experimental studies on the long-term impact of radioactive waste on the environment and types of waste storage and coverings are performed at this site.

TA-52, Reactor Development Site: A wide variety of theoretical and computational activities related to nuclear reactor performance and safety are done at this site.

TA-53, Los Alamos Neutron Science Center: The Los Alamos Neutron Science Center, including the linear proton accelerator, the Manuel Lujan Jr. Neutron Scattering Center, and a medical isotope production facility are located at this TA. Also located at TA-53 are the Accelerator Production of Tritium Project Office, including the Low-Energy Demonstration Accelerator, and R&D activities in accelerator technology and high-power microwaves.

TA-54, Waste Disposal Site: This site is divided into two facility management units for the radioactive solid and hazardous chemical waste management and disposal operations and activities that are part of the waste treatment technology effort.

TA-55, Plutonium Facility Site: Processing of plutonium and research on plutonium metallurgy are done at this site.

TA-57, Fenton Hill Site: This site is located about 28 miles west of Los Alamos on the southern edge of the Valles Caldera in the Jemez Mountains and was the location of the Laboratory's now decommissioned Hot Dry Rock geothermal project. The site is used for the testing and development of downhole well-logging instruments and other technologies of interest to the energy industry. The high elevation and remoteness of the site make Fenton Hill a choice location for astrophysics experiments. A gamma ray observatory is located at the site.

TA-58: This site is reserved for multiuse experimental sciences requiring close functional ties to programs currently located at TA-3.

TA-59, Occupational Health Site: Occupational health and safety and environmental management activities are conducted at this site. Emergency management offices are also located here.

TA-60, Sigma Mesa: This area contains physical support and infrastructure facilities, including the Test Fabrication Facility and Rack Assembly and the Alignment Complex.

TA-61, East Jemez Road: This site is used for physical support and infrastructure facilities, including the Los Alamos County sanitary landfill.

TA-62: This site is reserved for multiuse experimental science, public and corporate interface, and environmental research and buffer zones.

TA-63: This is a major growth area at the Laboratory with expanding environmental and waste management functions and facilities. This area contains physical support facilities operated by Johnson Controls Northern New Mexico.

TA-64: This is the site of the Central Guard Facility and headquarters for the Laboratory Hazardous Materials Response Team.

TA-66: This site is used for industrial partnership activities.

TA-67: This is a dynamic testing area that contains significant archeological sites.

TA-68: This is a dynamic testing area that contains archeological and environmental study areas.

TA-69: This undeveloped TA serves as an environmental buffer for the dynamic testing area.

TA-70: This undeveloped TA serves as an environmental buffer for the high-explosives test area.

TA-71: This undeveloped TA serves as an environmental buffer for the high-explosives test area.

TA-72: This is the site of the Protective Forces Training Facility.

TA-73: This area is the Los Alamos Airport.

TA-74, Otowi Tract: This large area, bordering the Pueblo of San Ildefonso on the east, is isolated from most of the Laboratory and contains significant concentrations of archeological sites and an endangered species breeding area. This site also contains Laboratory water wells and future well fields.

activation mixed fission — Activation products are formed when a substance is struck by protons or neutrons. The atoms of the original substance are converted to another element that is unstable and, therefore, radioactive.

activation products — Radioactive products generated as a result of neutrons and other subatomic particles interacting with materials such as air, construction materials, or impurities in cooling water. These activation products are usually distinguished, for reporting purposes, from fission products.

albedo dosimeters — Albedo dosimeters are used to measure neutrons around TA-18. They use a neutron-sensitive polyethylene phantom that is used to capture neutron backscatter to simulate the human body.

alpha particle — A positively charged particle (identical to the helium nucleus) composed of two protons and two neutrons that are emitted during decay of certain radioactive atoms. Alpha particles are stopped by several centimeters of air or a sheet of paper.

ambient air — The surrounding atmosphere as it exists around people, plants, and structures. It is not considered to include the air immediately adjacent to emission sources.

aquifer — A saturated layer of rock or soil below the ground surface that can supply usable quantities of groundwater to wells and springs. Aquifers can be a source of water for domestic, agricultural, and industrial uses.

artesian well — A well in which the water rises above the top of the water-bearing bed.

background radiation — Ionizing radiation from sources other than the Laboratory. This radiation may include cosmic radiation; external radiation from naturally occurring radioactivity in the earth (terrestrial radiation), air, and water; internal radiation from naturally occurring radioactive elements in the human body; worldwide fallout; and radiation from medical diagnostic procedures.

beta particle — A negatively charged particle (identical to the electron) that is emitted during decay of certain radioactive atoms. Most beta particles are stopped by 0.6 cm of aluminum.

biota — The types of animal and plant life found in an area.

blank sample — A control sample that is identical, in principle, to the sample of interest, except that the substance being analyzed is absent. The measured value or signals in blanks for the analyte is believed to be caused by artifacts and should be subtracted from the measured value. This process yields a net amount of the substance in the sample.

blind sample — A control sample of known concentration in which the expected values of the constituent are unknown to the analyst.

BOD — Biochemical (biological) oxygen demand. A measure of the amount of oxygen in biological processes that breaks down organic matter in water; a measure of the organic pollutant load. It is used as an indicator of water quality.

CAA	Clean Air Act. The federal law that authorizes the Environmental Protection Agency (EPA) to set air quality standards and to assist state and local governments to develop and execute air pollution prevention and control programs.
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980. Also known as Superfund, this law authorizes the federal government to respond directly to releases of hazardous substances that may endanger health or the environment. The EPA is responsible for managing Superfund.
CFR	Code of Federal Regulations. A codification of all regulations developed and finalized by federal agencies in the *Federal Register*.
COC	Chain-of-Custody. A method for documenting the history and possession of a sample from the time of collection, through analysis and data reporting, to its final disposition.
contamination	(1) Substances introduced into the environment as a result of people's activities, regardless of whether the concentration is a threat to health (see pollution). (2) The deposition of unwanted radioactive material on the surfaces of structures, areas, objects, or personnel.
controlled area	Any Laboratory area to which access is controlled to protect individuals from exposure to radiation and radioactive materials.
Ci	Curie. Unit of radioactivity. One Ci equals 3.70×10^{10} nuclear transformations per second.
cosmic radiation	High-energy particulate and electromagnetic radiations that originate outside the earth's atmosphere. Cosmic radiation is part of natural background radiation.
CWA	Clean Water Act. The federal law that authorizes the EPA to set standards designed to restore and maintain the chemical, physical, and biological integrity of the nation's waters.
DOE	US Department of Energy. The federal agency that sponsors energy research and regulates nuclear materials used for weapons production.
dose	A term denoting the quantity of radiation energy absorbed.
EDE	Effective dose equivalent. The hypothetical whole-body dose that would give the same risk of cancer mortality and serious genetic disorder as a given exposure but that may be limited to a few organs. The effective dose equivalent is equal to the sum of individual organ doses, each weighted by degree of risk that the organ dose carries. For example, a 100 mrem dose to the lung, which has a weighting factor of 0.12, gives an effective dose that is equivalent to $100 \times 0.12 = 12$ mrem. CEDE: committed effective dose equivalent TEDE: total effective dose equivalent

maximum individual dose The greatest dose commitment, considering all potential routes of exposure from a facility's operation, to an individual at or outside the Laboratory boundary where the highest dose rate occurs. It takes into account shielding and occupancy factors that would apply to a real individual.

population dose The sum of the radiation doses to individuals of a population. It is expressed in units of person-rem. (For example, if 1,000 people each received a radiation dose of 1 rem, their population dose would be 1,000 person-rem.)

whole body dose A radiation dose commitment that involves exposure of the entire body (as opposed to an organ dose that involves exposure to a single organ or set of organs).

EA Environmental Assessment. A report that identifies potentially significant environmental impacts from any federally approved or funded project that may change the physical environment. If an EA shows significant impact, an Environmental Impact Statement is required.

effluent A liquid waste discharged to the environment.

EIS Environmental Impact Statement. A detailed report, required by federal law, on the significant environmental impacts that a proposed major federal action would have on the environment. An EIS must be prepared by a government agency when a major federal action that will have significant environmental impacts is planned.

emission A gaseous waste discharged to the environment.

environmental compliance The documentation that the Laboratory complies with the multiple federal and state environmental statutes, regulations, and permits that are designed to ensure environmental protection. This documentation is based on the results of the Laboratory's environmental monitoring and surveillance programs.

environmental monitoring The sampling of contaminants in liquid effluents and gaseous emissions from Laboratory facilities, either by directly measuring or by collecting and analyzing samples in a laboratory.

environmental surveillance The sampling of contaminants in air, water, sediments, soils, food-stuffs, and plants and animals, either by directly measuring or by collecting and analyzing samples in a laboratory.

EPA Environmental Protection Agency. The federal agency responsible for enforcing environmental laws. Although state regulatory agencies may be authorized to administer some of this responsibility, EPA retains oversight authority to ensure protection of human health and the environment.

exposure A measure of the ionization produced in air by x-ray or gamma ray radiation. (The unit of exposure is the roentgen.)

external radiation	Radiation originating from a source outside the body.
gallery	An underground collection basin for spring discharges.
gamma radiation	Short-wavelength electromagnetic radiation of nuclear origin that has no mass or charge. Because of its short wavelength (high energy), gamma radiation can cause ionization. Other electromagnetic radiation (such as microwaves, visible light, and radiowaves) has longer wavelengths (lower energy) and cannot cause ionization.
GENII	Computer code used to calculate doses from all pathways (air, water, foodstuffs, and soil).
gross alpha	The total amount of measured alpha activity without identification of specific radionuclides.
gross beta	The total amount of measured beta activity without identification of specific radionuclides.
groundwater	Water found beneath the surface of the ground. Groundwater usually refers to a zone of complete water saturation containing no air.
^3H	Tritium.
half-life, radioactive	The time required for the activity of a radioactive substance to decrease to half its value by inherent radioactive decay. After two half-lives, one-fourth of the original activity remains ($1/2 \times 1/2$), after three half-lives, one-eighth ($1/2 \times 1/2 \times 1/2$), and so on.
hazardous waste	Wastes exhibiting any of the following characteristics: ignitability, corrosivity, reactivity, or yielding toxic constituents in a leaching test. In addition, EPA has listed as hazardous other wastes that do not necessarily exhibit these characteristics. Although the legal definition of hazardous waste is complex, the term generally refers to any waste that EPA believes could pose a threat to human health and the environment if managed improperly. Resource Conservation and Recovery Act (RCRA) regulations set strict controls on the management of hazardous wastes.
hazardous waste constituent	The specific substance in a hazardous waste that makes it hazardous and therefore subject to regulation under Subtitle C of RCRA.
HSWA	Hazardous and Solid Waste Amendments of 1984 to RCRA. These amendments to RCRA greatly expanded the scope of hazardous waste regulation. In HSWA, Congress directed EPA to take measures to further reduce the risks to human health and the environment caused by hazardous wastes.
hydrology	The science dealing with the properties, distribution, and circulation of natural water systems.
internal radiation	Radiation from a source within the body as a result of deposition of radionuclides in body tissues by processes such as ingestion, inhalation, or implantation. Potassium-40, a naturally occurring radionuclide, is a major source of internal radiation in living organisms. Also called self-irradiation.

ionizing radiation Radiation possessing enough energy to remove electrons from the substances through which it passes. The primary contributors to ionizing radiation are radon, cosmic and terrestrial sources, and medical sources such as x-rays and other diagnostic exposures.

isotopes Forms of an element having the same number of protons in their nuclei but differing in the number of neutrons. Isotopes of an element have similar chemical behaviors but can have different nuclear behaviors.

- ~~long-lived isotope~~ - A radionuclide that decays at such a slow rate that a quantity of it will exist for an extended period (half-life is greater than three years).
- ~~short-lived isotope~~ - A radionuclide that decays so rapidly that a given quantity is transformed almost completely into decay products within a short period (half-life is two days or less).

LLW Low-level waste. The level of radioactive contamination in LLW is not strictly defined. Rather, LLW is defined by what it is not. It does not include nuclear fuel rods, wastes from processing nuclear fuels, transuranic (TRU) waste, or uranium mill tailings.

MCL Maximum contaminant level. Maximum permissible level of a contaminant in water that is delivered to the free-flowing outlet of the ultimate user of a public water system (see Appendix A and Table A-6). The MCLs are specified by the EPA.

MEI Maximally exposed individual. The average exposure to the population in general will always be less than to one person or subset of persons because of where they live, what they do, and their individual habits. To try to estimate the dose to the MEI, one tries to find that population subgroup (and more specifically, the one individual) that potentially has the highest exposure, intake, etc. This becomes the MEI.

mixed waste Waste that contains a hazardous waste component regulated under Subtitle C of the RCRA and a radioactive component consisting of source, special nuclear, or byproduct material regulated under the federal Atomic Energy Act (AEA).

mrem Millirem. See definition of rem. The dose equivalent that is one-thousandth of a rem.

NEPA National Environmental Policy Act. This federal legislation, passed in 1969, requires federal agencies to evaluate the impacts of their proposed actions on the environment before decision making. One provision of NEPA requires the preparation of an EIS by federal agencies when major actions significantly affecting the quality of the human environment are proposed.

NESHAP National Emission Standards for Hazardous Air Pollutants. These standards are found in the CAA; they set limits for such pollutants as beryllium and radionuclides.

nonhazardous waste Chemical waste regulated under the Solid Waste Act, Toxic Substances Control Act, and other regulations, including asbestos, PCB, infectious wastes, and other materials that are controlled for reasons of health, safety, and security.

NPDES National Pollutant Discharge Elimination System. This federal program, under the Clean Water Act, requires permits for discharges into surface waterways.

nuclide A species of atom characterized by the constitution of its nucleus. The nuclear constitution is specified by the number of protons, number of neutrons, and energy content; or alternately, by the atomic number, mass number, and atomic mass. To be a distinct nuclide, the atom must be capable of existing for a measurable length of time.

outfall The location where wastewater is released from a point source into a receiving body of water.

PCB Polychlorinated biphenyls. A family of organic compounds used since 1926 in electric transformers, lubricants, carbonless copy paper, adhesives, and caulking compounds. PCB are extremely persistent in the environment because they do not break down into new and less harmful chemicals. PCB are stored in the fatty tissues of humans and animals through the bioaccumulation process. EPA banned the use of PCB, with limited exceptions, in 1976.

PDL Public Dose Limit. The new term for Radiation Protection Standards, a standard for external and internal exposure to radioactivity as defined in DOE Order 5400.5 (see Appendix A and Table A-1).

perched groundwater A groundwater body above a slow-permeablity rock or soil layer that is separated from an underlying main body of groundwater by a vadose zone.

pH A measure of the hydrogen ion concentration in an aqueous solution. Acidic solutions have a pH less than 7, basic solutions have a pH greater than 7, and neutral solutions have a pH of 7.

pollution Levels of contamination that may be objectionable (perhaps because of a threat to health [see contamination]).

point source An identifiable and confined discharge point for one or more water pollutants, such as a pipe, channel, vessel, or ditch.

ppb Parts per billion. A unit measure of concentration equivalent to the weight/volume ratio expressed as μg/L or ng/mL. Also used to express the weight/weight ratio as ng/g or μg/kg.

ppm Parts per million. A unit measure of concentration equivalent to the weight/volume ratio expressed as mg/L. Also used to express the weight/weight ratio as μg/g or mg/kg.

QA — Quality assurance. Any action in environmental monitoring to ensure the reliability of monitoring and measurement data. Aspects of quality assurance include procedures, interlaboratory comparison studies, evaluations, and documentation.

QC — Quality control. The routine application of procedures within environmental monitoring to obtain the required standards of performance in monitoring and measurement processes. QC procedures include calibration of instruments, control charts, and analysis of replicate and duplicate samples.

rad — Radiation absorbed dose. The rad is a unit for measuring energy absorbed in any material. Absorbed dose results from energy being deposited by the radiation. It is defined for any material. It applies to all types of radiation and does not take into account the potential effect that different types of radiation have on the body.

1 rad = 1,000 millirad (mrad)

radionuclide — An unstable nuclide capable of spontaneous transformation into other nuclides through changes in its nuclear configuration or energy level. This transformation is accompanied by the emission of photons or particles.

RESRAD — A computer modeling code designed to model radionuclide transport in the environment.

RCRA — Resource Conservation and Recovery Act of 1976. RCRA is an amendment to the first federal solid waste legislation, the Solid Waste Disposal Act of 1965. In RCRA, Congress established initial directives and guidelines for EPA to regulate hazardous wastes.

release — Any discharge to the environment. Environment is broadly defined as water, land, or ambient air.

rem — Roentgen equivalent man. The rem is a unit for measuring dose equivalence. It is the most commonly used unit and pertains only to people. The rem takes into account the energy absorbed (dose) and the biological effect on the body (quality factor) from the different types of radiation.

rem = rad × quality factor
1 rem = 1,000 millirem (mrem)

SAL — Screening Action Limit. A defined contaminant level that if exceeded in a sample requires further action.

SARA — Superfund Amendments and Reauthorization Act of 1986. This act modifies and reauthorizes CERCLA. Title III of this act is known as the Emergency Planning and Community Right-to-Know Act of 1986.

saturated zone — Rock or soil where the pores are completely filled with water, and no air is present.

SWMU	Solid waste management unit. Any discernible site at which solid wastes have been placed at any time, regardless of whether the unit was intended for the management of solid or hazardous waste. Such units include any area at or around a facility at which solid wastes have been routinely and systematically released, such as waste tanks, septic tanks, firing sites, burn pits, sumps, landfills (material disposal areas), outfall areas, canyons around LANL, and contaminated areas resulting from leaking product storage tanks (including petroleum).
terrestrial radiation	Radiation emitted by naturally occurring radionuclides such as internal radiation source; the natural decay chains of uranium-235, uranium-238, or thorium-232; or cosmic-ray-induced radionuclides in the soil.
TLD	Thermoluminescent dosimeter. A material (the Laboratory uses lithium fluoride) that emits a light signal when heated to approximately 300°C. This light is proportional to the amount of radiation (dose) to which the dosimeter was exposed.
TRU	Transuranic waste. Waste contaminated with long-lived transuranic elements in concentrations within a specified range established by DOE, EPA, and Nuclear Regulatory Agency. These are elements shown above uranium on the chemistry periodic table, such as plutonium, americium, and neptunium, that have activities greater than 100 nanocuries per gram.
TSCA	Toxic Substances Control Act. TSCA is intended to provide protection from substances manufactured, processed, distributed, or used in the United States. A mechanism is required by the act for screening new substances before they enter the marketplace and for testing existing substances that are suspected of creating health hazards. Specific regulations may also be promulgated under this act for controlling substances found to be detrimental to human health or to the environment.
tuff	Rock formed from compacted volcanic ash fragments.
uncontrolled area	An area beyond the boundaries of a controlled area (see controlled area in this glossary).
unsaturated zone	See vadose zone in this glossary.
UST	Underground storage tank. A stationary device, constructed primarily of nonearthen material, designed to contain petroleum products or hazardous materials. In a UST, 10% or more of the volume of the tank system is below the surface of the ground.
vadose zone	The partially saturated or unsaturated region above the water table that does not yield water for wells. Water in the vadose zone is held to rock or soil particles by capillary forces and much of the pore space is filled with air.

water table	The water level surface below the ground at which the unsaturated zone ends and the saturated zone begins. It is the level to which a well that is screened in the unconfined aquifer would fill with water.
water year	October through September.
watershed	The region draining into a river, a river system, or a body of water.
wetland	A lowland area, such as a marsh or swamp, that is inundated or saturated by surface water or groundwater sufficient to support hydrophytic vegetation typically adapted for life in saturated soils.
wind rose	A diagram that shows the frequency and intensity of wind from different directions at a particular place.
worldwide fallout	Radioactive debris from atmospheric weapons tests that has been deposited on the earth's surface after being airborne and cycling around the earth.

AA-2	Internal Assessment Group (LANL)
AEC	Atomic Energy Commission
AIP	Agreement in Principle
AIRFA	American Indian Religious Freedom Act
AIRNET	Air Monitoring Network
AL	Albuquerque Operations Office (DOE)
AO	Administrative Order
AQCR	Air Quality Control Regulation (New Mexico)
ARPA	Archeological Resources Protection Act
BEIR	biological effects of ionizing radiation
BOD	biochemical/biological oxygen demand
BTEX	total aromatic hydrocarbon
Btu	British thermal unit
CAA	Clean Air Act
CAS	Connected Action Statement
CCNS	Concerned Citizens for Nuclear Safety
CEDE	committed effective dose equivalent
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CIO	Community Involvement Office (LANL)
CMR	Chemistry and Metallurgy Research (LANL building)
CO	compliance order
COC	chain-of-custody
COD	chemical oxygen demand
COE	Army Corps of Engineers
CST	Chemical Sciences and Technology (LANL division)
CST-3	Analytical Services Group (LANL)
CST-13	Radioisotopes and Industrial Wastewater Science Group (LANL)
CWA	Clean Water Act
CY	calendar year
DAC	derived air concentration (DOE)
DARHT	Dual Axis Radiographic Hydrotest facility
DCG	Derived Concentration Guide (DOE)
D&D	decontamination and decommissioning
DEC	DOE Environmental Checklist
DOE	Department of Energy
DOE-EM	DOE, Environmental Management
DOU	Document of Understanding
EA	Environmental Assessment
EDE	effective dose equivalent
EIS	Environmental Impact Statement
EML	Environmental Measurements Laboratory
EO	Executive Order
EPA	Environmental Protection Agency
EPCRA	Emergency Planning and Community Right-to-Know Act

ER	Environmental Restoration
ESH	Environment, Safety, & Health
ESH-4	Health Physics Measurements Group (LANL)
ESH-13	ESH Training Group (LANL)
ESH-14	Quality Assurance Support Group (LANL)
ESH-17	Air Quality Group (LANL)
ESH-18	Water Quality & Hydrology Group (LANL)
ESH-19	Hazardous & Solid Waste Group (LANL)
ESH-20	Ecology Group (LANL)
ESO	Environmental Stewardship Office (LANL)
EST	Ecological Studies Team (ESH-20)
FFCA	Federal Facilities Compliance Agreement
FFCAct	Federal Facilities Compliance Act
FFCAgreement	RCRA Federal Facility Compliance Agreement
FFCO	Federal Facility Compliance Order
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FIMAD	Facility for Information Management, Analysis, and Display
FONSI	Finding of No Significant Impact
FY	fiscal year
GENII	Generation II
GIS	geographic information system
G/MAP	gaseous/mixed air activation products
GPS	global positioning system
GWPMPP	Groundwater Protection Management Program Plan
HAZWOPER	hazardous waste operations (training class)
HE	high-explosive
HEWTP	High-Explosive Wastewater Treatment Plant
HMPT	Hazardous Materials Packaging and Transportation
HPAL	Health Physics Analytical Laboratory
HSWA	Hazardous and Solid Waste Amendments
HWA	Hazardous Waste Act (New Mexico)
HWMR	Hazardous Waste Management Regulations (New Mexico)
ICRP	International Commission on Radiological Protection
JCNNM	Johnson Controls Northern New Mexico
JENV	JCNM Environmental Laboratory
LAAO	Los Alamos Area Office (DOE)
LANSCE	Los Alamos Neutron Science Center
LANL	Los Alamos National Laboratory (or the Laboratory)
LEDA	Low-Energy Demonstration Accelerator
LLW	low-level radioactive waste
LLMW	low-level mixed waste
LOQ	limit of quantitation
MAP	Mitigation Action Plan
MCL	maximum contaminant level
MDA	minimum detectable amount

MEI	maximum exposed individual
NAGPRA	Native American Grave Protection and Repatriation Act
NCRP	National Council on Radiation Protection and Measurements
NEPA	National Environmental Policy Act
NERF	NEPA Review Form
NESHAP	National Emission Standards for Hazardous Air Pollutants
NEWNET	Neighborhood Environmental Watch Network
NHPA	National Historic Preservation Act
NMDA	New Mexico Department of Agriculture
NMED	New Mexico Environment Department
NMEIB	New Mexico Environmental Improvement Board
NMWQCA	New Mexico Water Quality Control Act
NMWQCC	New Mexico Water Quality Control Commission
NPDES	National Pollutant Discharge Elimination System
NRC	US Nuclear Regulatory Commission
OB/OD	open burning/open detonation
ODS	ozone depleting substance
O&G	oil and grease
OHL	Occupational Health Laboratory (LANL)
OSHA	Occupational Safety and Health Act/Administration
PCB	polychlorinated biphenyls
PDL	public dose limit
PHERMEX	Pulsed high-energy radiographic machine emitting x-rays
ppb	parts per billion
ppm	parts per million
QA	quality assurance
QAP	Quality Assurance Program
QC	quality control
RCRA	Resource Conservation and Recovery Act
RD&D	research, development, and demonstration
RESRAD	residual radioactive material computer code
RLWTF	Radioactive Liquid Waste Treatment Facility (LANL)
RSRL	regional statistical reference level
SAL	screening action level
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SHPO	State Historic Preservation Officer (New Mexico)
SLD	Scientific Laboratory Division (New Mexico)
SOC	synthetic organic compound
SPCC	Spill Prevention Control and Countermeasures
SVOC	semivolatile organic compound
SWA	Solid Waste Act
SWPP	Storm Water Prevention Plan
SWMR	solid waste management regulations
SWMU	solid waste management unit

SWSC	Sanitary Wastewater Systems Consolidation Plant (LANL)
TA	Technical Area
TDS	total dissolved solids
TEDE	total effective dose equivalent
TLD	thermoluminescent dosimeter
TLDNET	thermoluminescent dosimeter network
TRI	toxic chemical release inventory
TRU	transuranic waste
TRPH	total recoverable petroleum hydrocarbon
TSCA	Toxic Substances Control Act
TSS	total suspended solids
TTHM	trihalomethane
TWISP	Transuranic Waste Inspectable Storage Project (LANL)
UC	University of California
USFS	United States Forest Service
USGS	United States Geological Survey
UST	underground storage tank
VAP	vaporous activation products
VOC	volatile organic compound
WASTENET	Waste Management Areas Network (for air monitoring)
WM	Waste Management (LANL)
WSC	Waste Stream Characterization
WWW	World Wide Web

Elemental and Chemical Nomenclature

Actinium	Ac	Molybdenum	Mo
Aluminum	Al	Neodymium	Nd
Americium	Am	Neon	Ne
Argon	Ar	Neptunium	Np
Antimony	Sb	Nickel	Ni
Arsenic	As	Niobium	Nb
Astatine	At	Nitrate (as Nitrogen)	NO_3-N
Barium	Ba	Nitrite (as Nitrogen)	NO_2-N
Berkelium	Bk	Nitrogen	N
Beryllium	Be	Nitrogen dioxide	NO_2
Bicarbonate	HCO_3	Nobelium	No
Bismuth	Bi	Osmium	Os
Boron	B	Oxygen	O
Bromine	Br	Palladium	Pd
Cadmium	Cd	Phosphaeus	P
Calcium	Ca	Phosphate (as Phosphous)	PO_4-P
Californium	Cf	Platinum	Pt
Carbon	C	Plutonium	Pu
Cerium	Ce	Polonium	Po
Cesium	Cs	Potassium	K
Chlorine	Cl	Praseodymium	Pr
Chromium	Cr	Promethium	Pm
Cobalt	Co	Protactinium	Pa
Copper	Cu	Radium	Ra
Curium	Cm	Radon	Rn
Cyanide	CN	Rhenium	Re
Carbonate	CO_3	Rhodium	Rh
Dysprosium	Dy	Rubidium	Rb
Einsteinium	Es	Ruthenium	Ru
Erbium	Er	Samarium	Sm
Europium	Eu	Scandium	Sc
Fermium	Fm	Selenium	Se
Fluorine	F	Silicon	Si
Francium	Fr	Silver	Ag
Gadolinium	Gd	Sodium	Na
Gallium	Ga	Stronium	Sr
Germanium	Ge	Sulfate	SO_4
Gold	Au	Sulfite	SO_3
Hafnium	Hf	Sulfur	S
Helium	He	Tantalum	Ta
Holmium	Ho	Technetium	Tc
Hydrogen	H	Tellurium	Te
Hydrogen oxide	H_2O	Terbium	Tb
Indium	In	Thallium	Tl
Iodine	I	Thorium	Th
Iridium	Ir	Thulium	Tm
Iron	Fe	Tin	Sn
Krypton	Kr	Titanium	Ti
Lanthanum	La	Tritiated water	HTO
Lawrencium	Lr (Lw)	Tritium	^3H
Lead	Pb	Tungsten	W
Lithium	Li	Uranium	U
Lithium fluoride	LiF	Vanadium	V
Lutetium	Lu	Xenon	Xe
Magnesium	Mg	Ytterbium	Yb
Manganese	Mn	Yttrium	Y
Mendelevium	Md	Zinc	Zn
Mercury	Hg	Zirconium	Zr

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