Environmental Surveillance at Los Alamos during 1997

LA-13487-ENV

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Los Alamos
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Los Alamos, New Mexico 87545

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Los Alamos National Laboratory is operated by the University of California for the United States Department of Energy under contract W-7405-ENG-36

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Previous reports in this series are LA-12973-ENV, LA-13047-ENV, LA-13210-ENV, and LA-13343-ENV.

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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 1997. 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 and foodstuffs) 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 1997* that briefly explains important concepts, such as radiation, and provides a summary of the environmental programs, monitoring results, and regulatory compliance.

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1. Introduction

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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 1997. 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. Data were collected in 1997 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, and foodstuffs. Using comparisons with standards and regulations, this report concludes that environmental effects from Laboratory operations are small and do not pose a demonstrable threat to the public, Laboratory employees, or the environment. Laboratory operations were in compliance with all major 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); the contract is administered through the Department of Energy (DOE) Los Alamos Area Office 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 laboratory with the central mission of reducing the global nuclear danger by utilizing five major elements:

- stockpile stewardship activities ensure that the United States has safe, secure, and reliable nuclear weapons;
- stockpile management projects provide capabilities ranging from the dismantlement to the remanufacture of existing nuclear weapons;
- nuclear materials management ensures the availability or safe disposal of plutonium, highly enriched uranium, and tritium;
- effective nonproliferation and counterproliferation technologies help to deter, detect, and respond to the proliferation of weapons of mass destruction; and
- environmental stewardship projects provide for the remediation and reduction of wastes from the nuclear weapons complex.

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) and perform industrial collaborations (LANL 1997).

1. Introduction

2. Geographic Setting

The Laboratory and the associated residential 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. Mesa tops range in elevation from approximately 7,800 feet on the flanks of the Jemez Mountains to about 6,200 feet at their eastern termination 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

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 1,400 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.

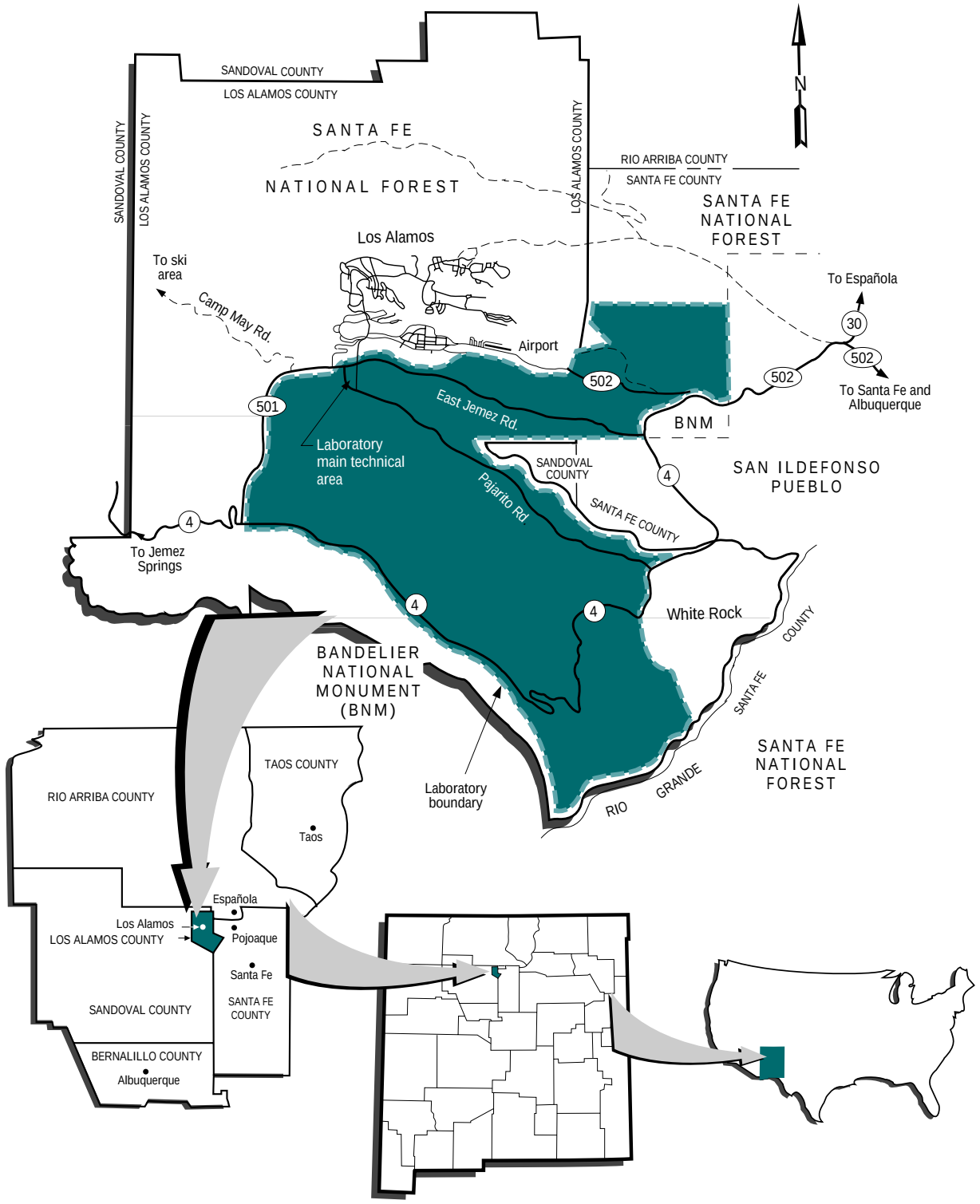


Figure 1-1. Regional location of Los Alamos National Laboratory.

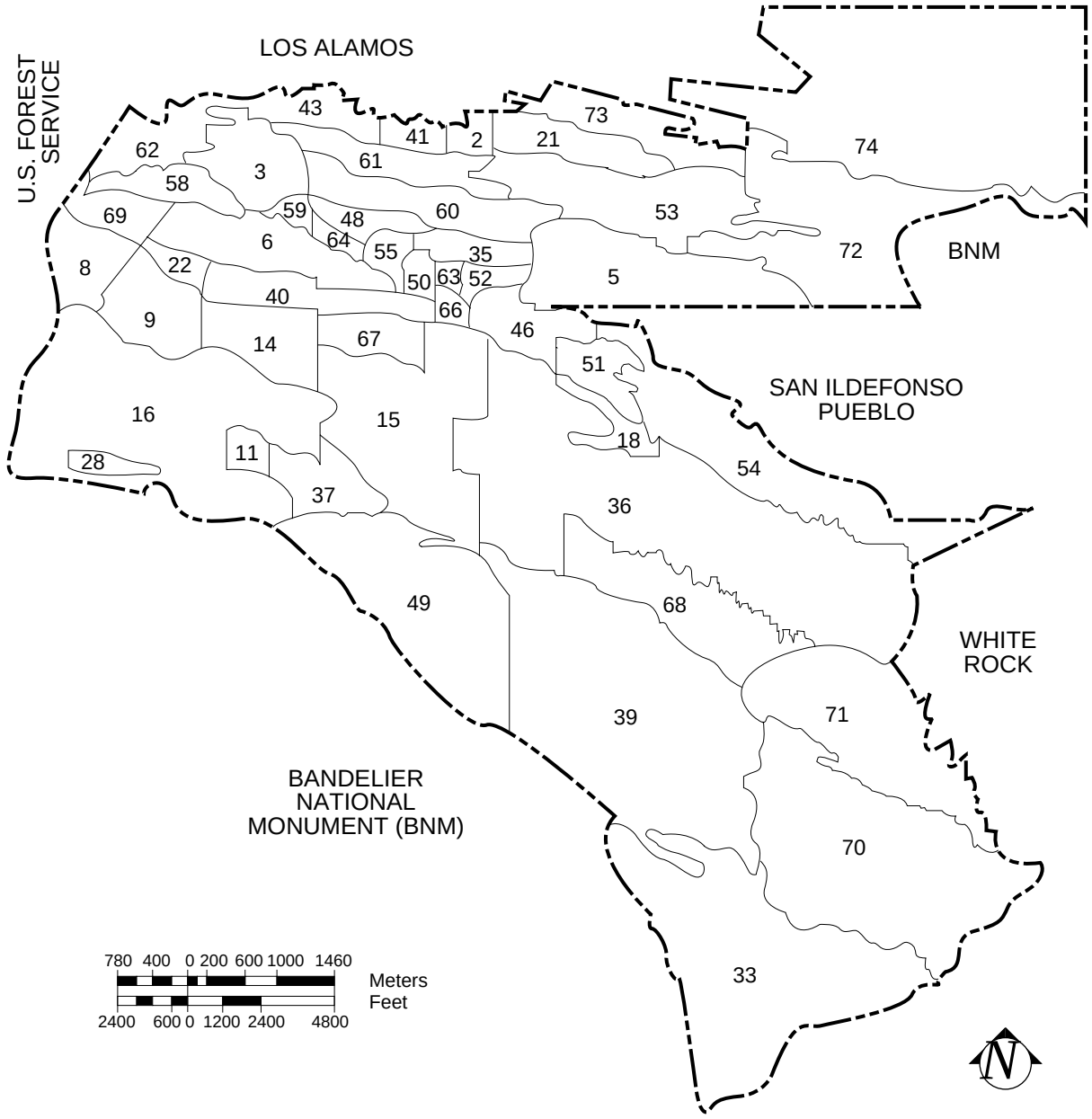
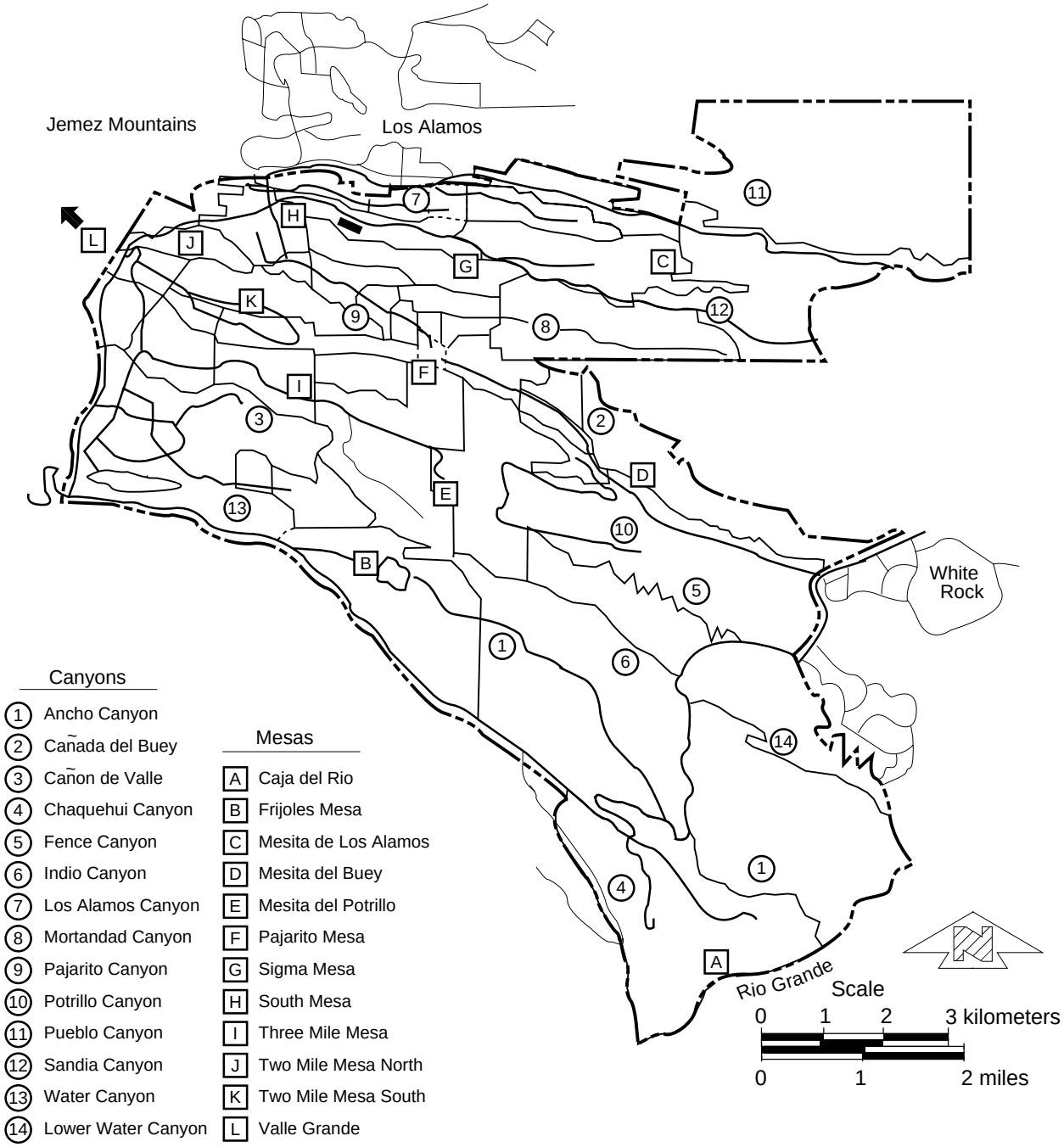


Figure 1-2. Technical areas of Los Alamos National Laboratory in relation to surrounding landholdings.



1990 Los Alamos National Laboratory Site Development Plan

Figure 1-3. Major canyons and mesas.

Approximately 500 buildings and structures are being evaluated for eligibility to be placed on the National Historic Register.

B. Environmental Management Systems

1. Introduction

The Laboratory Director is ultimately responsible for all Laboratory activities, including all environmental protection activities. Technical and administrative responsibility and authority have been delegated to the Environment, Safety, and Health (ESH) Division for environmental monitoring, surveillance, and compliance and to the Environmental Management (EM) Program for environmental restoration and waste management responsibilities.

2. Environmental Protection Program

The ESH Division is in charge of performing environmental monitoring, surveillance, and compliance activities to help ensure that Laboratory operations do not adversely affect public health 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 consists of 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 1997, 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, and foodstuffs are routinely collected at the 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 1997. 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 1997 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); 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 includes an update of the NPDES Federal Facilities Compliance Agreement. Chapter 5 presents results of the data collected and analyzed by ESH-18 personnel from surveillance 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, including updates on the status of federal facility compliance orders and agreements on mixed waste and storage of radioactively contaminated PCB wastes.

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 and foodstuffs. Chapter 2 documents the 1997 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 at the Laboratory.

3. Waste Management Program

a. Waste Management Activities. 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 waste, mixed waste, hazardous waste, and nonhazardous waste.

b. Pollution Prevention. The Laboratory's Environmental Stewardship Office coordinates the integrated Laboratory pollution prevention program. Specific amounts of source material reduction and recycling are provided in Section 2.B.1.h. Other waste management activities that reduce waste generation include the following:

- continuing financial incentives for waste reduction and innovative pollution prevention ideas,
- developing databases and automated procedures for purchases that could minimize waste or use recycled materials, and
- providing pollution prevention expertise to Laboratory organizations in construction projects, site remediation, and decontamination and decommissioning projects.

The *1997 Annual Report on Waste Generation and Waste Minimization Progress as Required by DOE Order 5400.1* and additional information concerning waste minimization are located at *http://twilight.saic.com/WasteMin/default.asp* on the World Wide Web.

4. Environmental Restoration Project

The Environmental Restoration (ER) Project within the DOE Office of Environmental Management is responsible for assessing, cleaning up, decontaminating, and decommissioning sites at DOE facilities and sites formerly used by DOE. The 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 for decontamination and decommissioning of surplus facilities at the Laboratory.

The ER Project at the Laboratory responds to two primary laws: RCRA, which is the statutory basis for the 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 (HSWA) 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. The DOE has oversight for those sites not subject to RCRA and for the decommissioning program. A summary of ER Project activities completed in 1997 is presented in Section 2.B.1.j of this report.

C. 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 Involvement Office (CIO) 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 regarding the Laboratory's potential impact on local safety, health, and the environment.

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

Public Meetings

DOE is required to have public meetings and comment periods when it undertakes an activity that could have a significant impact on the environment. It is the Laboratory's responsibility to assist DOE in activities that relate to the LANL site. During 1997, the DOE and the Laboratory Director entered into a Consent Decree and Settlement Agreement with the Concerned Citizens for Nuclear Safety in conjunction with the Laboratory's air monitoring program (see Section 2.D.1). Part of the consent decree stipulated that LANL begin quarterly public meetings on environmental issues. The first of these meetings took place on June 17, 1997, and three more were held during 1997. The meetings covered the topics of air and water quality, the latest statistics on brain tumor and thyroid cancers in Los Alamos, and environmental restoration and waste management. In addition, the Laboratory held other public meetings including a meeting on the environmental surveillance report on May 7, 1997.

Outreach Centers

During 1997, CIO operated three outreach centers located in Los Alamos, Española, and Taos. Approximately 250 people visited the centers each month. Access to environmental information is available at all the outreach centers.

Tribal Interactions

During 1997, 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. In the fall of 1997, the new Laboratory Director, John Browne, signed Reaffirmations of Cooperative Agreements with governors from the Pueblos of Cochiti, Jemez, Santa Clara, and San Ildefonso. An amendment to the cooperative agreements calls for Laboratory-Pueblo development of educational initiatives with the UC. Meetings with Cochiti Pueblo and the Pueblo of San Ildefonso were also held to discuss radiological analyses about Cochiti Reservoir sediment studies using new Laboratory technologies.

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 1997, the museum hosted approximately 115,000 visitors.

The World Wide Web

In response to the ever-growing interest in using electronic communications media, the Laboratory has made information available at *http://www.lanl.gov/external/* on the World Wide Web. Search engines for Laboratory environmental information (as well as for other topics) are available through the community pages.

Inquiries

In 1997, CIO—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 CIO by letter, phone, fax, e-mail, and personal visits. Addresses and phone/fax numbers for the various CIO facilities are listed below.

Community Involvement & Outreach Office
Los Alamos National Laboratory
P. O. Box 1663, Mail Stop A117
Los Alamos, NM 87545
Phone: (505) 665-4400 or 1-800-508-4400;
Fax: (505) 665-4411
cio@lanl.gov

Española Outreach Center
1002 N. Oñate
Española, NM 87532
Phone: (505) 753-3682; Fax: (505) 753-4679

Los Alamos Outreach Center
1350 Central, Suite 101
Los Alamos, NM 87544
Phone: (505) 665-2127 or 1-800-985-7232;
Fax: (505) 667-3111

Santa Fe Outreach Center (Scheduled to open June 1998)
1640 Old Pecos Trail
Santa Fe, NM 87505
Phone: (505) 982-3761; Fax: (505) 982-9743

Bradbury Science Museum
1350 Central Avenue
Los Alamos, NM 87544
Phone: (505) 667-4444; Fax: (505) 665-6932

D. Assessment Programs

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

Quality is the extent to which an item or activity meets or exceeds requirements. Quality assurance (QA) 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 QA functions at the Laboratory. ESH-14 personnel perform QA and quality control audits and surveillance of Laboratory and subcontractor activities in accordance with the Quality Assurance Plan (QAP) 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 appropriate implementation of environmental requirements. The Quality and Planning Program Office manages and coordinates the effort to become a customer-focused, unified Laboratory.

Each monitoring activity sponsored by the ESH Division has its own QAP 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 QAP must address the criteria for management, performance, and assessments. Monitoring activities for each environmental program performed by groups in ESH Division have been included in the LANL Environmental Monitoring Plan for 1996–1998 (EARE 1995).

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

During 1997, the Laboratory was evaluated by the UC and DOE based on mutually negotiated performance measures. The performance measure rating periods are from July to June. The environmental components of these performance measures include the following categories:

- radiation protection of workers;
- radiation protection of the public;
- release incidents;
- permit exceedances;
- environmental violations, fines, and penalties;
- status of regulatory commitments and milestones; and
- waste minimization and pollution prevention.

Specific information on the categories and the assessment scoring can be obtained at *http://labs.ucop.edu/library.html* on the World Wide Web.

3. Department of Energy Audits and Assessments

The DOE Office of Oversight, Environment, Safety, and Health, published a "Profile of Los Alamos National Laboratory" in October 1997. The profile documents how effectively DOE and Laboratory line management have implemented safety

management and environment, safety, and health programs. Numerous aspects of ESH were evaluated, including portions of the environmental programs. The environmental programs covered by external regulations were determined to be effective. This profile can be accessed at *http://www.tis.eh.doe.gov/web/eh2/profiles/index.html* through the World Wide Web.

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

4. Cooperative and Independent Monitoring

DOE 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.
- **Accords** between the individual Pueblos of San Ildefonso, Cochiti, Jemez, and Santa Clara and DOE.
- **Cooperative Agreements** between the individual Pueblos of San Ildefonso, Cochiti, Jemez, and Santa Clara and UC.

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 have allowed access to monitoring locations and encouraged cooperative sampling activities, improved data sharing, and enhanced communications on technical subjects. The agreements also provide frameworks for grant support that allow development of independent monitoring programs. In addition, environmental monitoring at and near the Laboratory involves other state and federal agencies such as the NMED's DOE Oversight Bureau (see Section 2.C.2 for more information), the Defense Nuclear Facilities Safety Board, the Agency for Toxic Substances and Disease Registry, the Bureau of Indian Affairs, and the US Geological Survey.

The Laboratory also works directly with residents on cooperative and independent monitoring programs. Part of the Consent Decree and Settlement Agreement to resolve a lawsuit filed by Concerned Citizens for Nuclear Safety (CCNS) stipulated that the Laboratory present a five-day course on radiation exposure and protection to representatives of CCNS, the Four Accord Pueblos, and regional city/county government officials. The Laboratory purchased radiation monitoring equipment that is available to the course trainees for independent monitoring in their communities.

In addition, DOE calibrated the Neighborhood Environmental Watch Network (NEWNET) stations located in northern New Mexico in 1997 (see Section 2.D.1). Data from NEWNET monitors are recorded every 15 minutes and can be accessed through the World Wide Web.

E. References

Blake et al., 1995: W. D. Blake, F. Goff, A. Adams, and D. Counce, "Environmental Geochemistry for Surface and Subsurface Waters in the Pajarito Plateau and Outlying Areas, New Mexico," Los Alamos National Laboratory report LA-12912-MS (May 1995).

DOE 1988: US Department of Energy, "General Environmental Protection Program," US Department of Energy Order 5400.1 (November 1988).

DOE 1990: US Department of Energy, "Radiation Protection of the Public and the Environment," US Department of Energy Order 5400.5 (February 1990).

DOE 1991: US Department of Energy, "Quality Assurance," US Department of Energy Order 5700.6C (August 1991).

DOE 1995: US Department of Energy, "Environmental Safety and Health Reporting," US Department of Energy Order 231.1 (September 1995).

EARE 1995: Environmental Assessments and Resource Evaluations Group, "Environmental Monitoring Plan," Los Alamos National Laboratory document LA-UR-95-3770 (1995).

LANL 1997: "Institutional Plan FY 1998–FY 2003," Los Alamos National Laboratory report LALP 97-130 (October 1997).

Purtymun and Johansen 1974: W. D. Purtymun and S. Johansen, "General Geohydrology of the Pajarito Plateau," New Mexico Geological Society Guidebook, 25th Field Conference, Ghost Ranch, New Mexico (1974).

2. Compliance Summary

primary authors:

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Highlights from 1997

Los Alamos National Laboratory (LANL or the Laboratory) staff frequently interacted with regulatory personnel during 1997 regarding Resource Conservation and Recovery Act and New Mexico Hazardous Waste Act requirements and compliance activities. The New Mexico Environment Department (NMED) conducted its annual inspection intermittently between July and December and noted 52 apparent findings of noncompliance during its inspection of the Laboratory's hazardous waste storage areas and walkthroughs of approximately 95% of perimeter areas. NMED has not yet issued a formal Compliance Order; based on knowledge of apparent findings, the Laboratory believes it has taken appropriate corrective actions.

Laboratory operations were in compliance with all federal and state nonradiological air quality requirements. Radioactive emissions generated at the Laboratory during 1997 were in compliance with 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. The EDE is calculated to be 3.51 mrem using EPA-approved methods. During 1997, the Department of Energy (DOE) and the Director of the Laboratory entered into a Consent Decree and a Settlement Agreement to resolve the lawsuit filed by the Concerned Citizens for Nuclear Safety that alleged that LANL was not in full compliance with the National Emission Standards for Radionuclides under the Clean Air Act.

In 1997, the Laboratory was in compliance with its on-site liquid discharge requirements in 99.4% of the samples from its sanitary effluent outfalls and in 99.5% of the samples from its industrial effluent outfalls. The Laboratory was in compliance with its on-site liquid discharge requirements in 99.9% of the water quality parameter samples collected at sanitary and industrial outfalls (August 1, 1996 through July 31, 1997). Concentrations of chemical, microbiological, and radioactive constituents in the drinking water system remained within federal and state drinking water supply standards.

In 1997, Laboratory staff reviewed 254 proposed projects for compliance with the National Environmental Policy Act (NEPA) and sent 137 NEPA Environmental Review Forms to DOE. In addition, Laboratory archaeologists evaluated 751 proposed actions for possible effects on cultural resources, which required 28 intensive field surveys. Laboratory biologists reviewed more than 750 proposed actions for potential impacts to threatened and endangered species; 75 of the actions required additional study.

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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 contain radioactive and/or nonradioactive hazardous 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. The environmental permits issued by these organizations and the specific operations and/or sites affected are presented in Table 2-1.

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. 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 specifically 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 DOE and the University of California (UC) were issued the current Hazardous Waste Facility Permit on November 8, 1989, from the State of New Mexico.

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 to be renewed. The 10-year permit expires in November 1999, and NMED has asked the Laboratory to submit the application for renewal by the end of 1998. The extensive permit application development process was initiated in late 1997.

The Hazardous and Solid Waste Group (ESH-19) submitted permit applications for the waste management organizations during 1997 to support compliance-related activities, to continue converting existing mixed waste management units to RCRA-permitted status, and to obtain new unit permits for ongoing project expansions. These permit applications and modifications were submitted using the permitting approach proposed in 1995 under which NMED intends to issue permits for the individual TAs where hazardous or mixed waste management activities are conducted. By late 1997, ESH-19 was discussing a modified approach with NMED that involved separate modules of the facility permit for each TA.

LANL proposed that the permitting process could be facilitated by the availability of a LANL General Part B information submittal, subject to approval by NMED, which would provide common references for Laboratory documents that could be incorporated into permit modification packages without requiring repetitive NMED reviews. Final approval of the General Part B application is expected to occur as part of the 1998 permit renewal process.

By the end of 1997, some permit modification approvals related to the December 10, 1993, Consent Agreement for Compliance Orders New Mexico Hazardous Waste Act (HWA) 93-01, 93-02, 93-03, and 93-04 had been received from NMED. Waste characterization temporary storage areas at the TA-50 Waste Characterization, Reduction, and Repackaging Facility and the TA-54 Radioassay and Nondestructive Testing Facility were approved in February 1997. Two other

Table 2-1. Environmental Permits or Approvals under which the Laboratory Operated during 1997

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 October 1993	– – –	NMED
	RD&D application-Electrochemical Treatment Unit	submitted September 6, 1996	– – –	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	EPA
	Storm water associated with industrial activity	September 29, 1992	September 9, 1997[c]	EPA
	DP Storage Area	April 26, 1996	September 4, 1997	EPA
	Tar Remnant Remediation	May 26, 1995	September 27, 1997	EPA
	TA-32	March 11, 1996	September 4, 1997	EPA
	Hot Shots	May 23, 1996	August 27, 1997	EPA
	Storm water associated with construction activity			
	TRU Dome/TWISP Facility	January 2, 1995	January 8, 1997	EPA
	TA-53 Sanitary Pipeline	October 1, 1992	September 5, 1997	EPA
	US West Communications Ductbank	October 1, 1992	September 5, 1997	EPA
	DARHT Facility	May 20, 1994	September 5, 1997[c]	EPA
	Small Arms Firing Range	August 18, 1994	August 27, 1997	EPA
	TA-9 and 16 Steam System Upgrade	September 1, 1995	September 5, 1997[c]	EPA
	RLW Cross Country Line	July 25, 1996	September 5, 1997[c]	EPA
	Guaje Well Field	June 5, 1997	September 5, 1997[c]	EPA
	Wildlands Fire Management	September 5, 1996	September 5, 1997[c]	EPA
CWA/NPDES, Fenton Hill	Discharge of industrial liquid effluents	October 15, 1979	December 29, 1997[d]	EPA

Table 2-1. Environmental Permits or Approvals under which the Laboratory Operated during 1997 (Cont.)

Category	Approved Activity	Issue Date	Expiration Date	Administering Agency
CWA Sections 404/401 Permits	Guaje Canyon/Utility Line Discharges	September 9, 1997	September 9, 1999	COE[e]/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/Utility Line Discharges	November 14, 1997	November 14, 1999	COE/NMED
Groundwater Discharge Plan, Fenton Hill	Discharge to groundwater	June 5, 1995	June 5, 2000	NMOCD[f]
Groundwater Discharge Plan, TA-46 SWSC Plant[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 Application (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	September 8, 1987	None	NMED
	Beryllium machining at TA-35-213	April 26, 1989	None	NMED
	Beryllium machining at TA-55-4	July 28, 1994	None	NMED

Table 2-1. Environmental Permits or Approvals under which the Laboratory Operated during 1997 (Cont.)

Category	Approved Activity	Issue Date	Expiration Date	Administering Agency
Open Burning (20 NMAC 2.60) Operational Burning	Burning of jet fuel and wood for ordnance testing, TA-11 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	August 18, 1997	None	NMED
Open Burning (20 NMAC 2.60) Prescribed Burning	Prescribed Open Burning TA-15, TA-36	October 22, 1996	April 3, 1997	NMED

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

related permit modifications, including an application for the retrieval of mixed transuranic (TRU) waste at TA-54, Area G (pads 1, 2, and 4, and storage at domes 229, 230, 231, and 232) and for waste characterization staging areas at the TA-50 Radioactive Materials Research, Operations, and Demonstration Facility were pending at the end of 1997.

A permit modification to allow mixed waste treatment residuals for wastes generated at LANL to be allowed back onto the LANL facility, if necessary for treatment to support Site Treatment Plan (STP) requirements, was approved on May 19, 1997. Approval of two additional mixed waste storage areas at TA-54, structures/pads 36 and 58, used to support related mixed waste segregation activities, was received in January 1997.

The Laboratory submitted permit modifications to NMED for existing hazardous and mixed waste management facilities. Part B permit applications for two TRU mixed waste container storage areas in TA-3, Building 29, were submitted in May 1997.

NMED requested a revision for TRU mixed waste characterization to the LANL hazardous waste analysis plan as a condition for approval of the Transuranic Waste Inspectable Storage Project (TWISP). The revised TRU mixed waste analysis plan was submitted to NMED on March 31, 1995. NMED issued a notice of deficiency (NOD) on May 24, 1996, requesting more information on specific waste characterization and certification procedures, which were provided by the Laboratory on July 12, 1996. LANL had not received word from NMED on this revision by the end of 1997.

The Laboratory responded to an NOD with regard to the technical adequacy of the Part B permit application submitted in September 1996 for open burning/open detonation units at TA-14. The NOD was issued on June 10, 1997, and the Laboratory responded within the 30-day deadline.

An application for the proposed LANL Electrochemical Treatment Unit, a RCRA Research, Development, and Demonstration (RD&D) project, was submitted to NMED on September 6, 1996. LANL had not received word from NMED on this application by the end of 1997. The research objective of the work to be conducted under this permit was to experimentally define waste streams amenable for an electrochemical treatment process developed at LANL, to determine treatment conditions for these waste streams, and to assess the feasibility of processing batch waste quantities larger than those allowed under RCRA treatability studies.

c. Resource Conservation and Recovery Act Closure Activities. Closure activities for container storage areas at TA-21, Building 61 continued during 1997. Closure certifications were submitted in 1997 for RCRA RD&D permits for the TA-9 Hydrothermal Processing Unit and the TA-35 Packed Bed Reactor/Silent Discharge Plasma Unit, which were never operational for hazardous or mixed waste studies. A closure certification report for the TA-50 Controlled Air Incinerator was submitted to NMED in 1997.

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 environmental surveillance reports (ESP 1997, ESP 1996). The 1997 status of these sites is given below.

- TA-35 surface impoundments—An amended closure plan was approved by NMED on September 19, 1996. The Laboratory completed Phase VI verification sampling at TA-35, TSL-85 during July 1996. At the end of 1997, the Laboratory had not received a response from NMED on the amended closure certification report that LANL submitted on September 30, 1996.
- TA-16, landfill at MDA-P—NMED approved the closure plan for MDA-P on February 18, 1997. Storm water collection trenches were constructed as part of premobilization activities. The remediation contractor excavated a series of pits into the landfill to better characterize it. Detonable high explosives and high barium concentrations were found in some of the pits. Excavation of the landfill will begin in 1998.
- TA-53 surface impoundments—On July 21, 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 units to corrective action units under HSWA had been approved. A closure plan for the impoundments is no longer necessary. A RCRA Facility Investigation (RFI) work plan for the impoundments was submitted on January 21, 1998.

d. Other Resource Conservation and Recovery Act Activities. 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. The findings of the assessment 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. In 1997, ESH-19 completed 1,070 quarterly assessments.

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

e. Resource Conservation and Recovery Act Compliance Inspection. NMED conducted its annual hazardous waste compliance inspection from July intermittently through December 1997 (Table 2-2). In addition to visiting approximately 680 hazardous and mixed waste satellite accumulation areas, less-than-90 day storage areas, and permitted or interim status storage and treatment facilities located throughout the Laboratory, NMED inspectors walked through 95% of the Laboratory visiting general storage areas, laboratories, and perimeter spaces. Although a formal Compliance Order has not yet been issued, NMED noted 52 apparent findings of noncompliance, the majority which were found in perimeter areas rather than in the Laboratory's permitted storage areas. The majority of the findings were administrative in nature, involving training and paperwork documentation. Fourteen of the apparent findings were related to the lack of a proper waste determination, and 10 of the findings cited abandonment of waste, i.e., waste illegally stored in lieu of disposal or proper storage. The Laboratory has taken corrective actions where appropriate.

f. Underground Storage Tanks. The Laboratory's underground storage tanks (USTs) are regulated under the New Mexico Administrative Code, Title 20, Chapter 5 (20 NMAC 5). At the end of calendar year (CY) 97, the Laboratory had six USTs in use. The Laboratory plans to close five of those six USTs by the end of CY98.

Seven USTs were removed in CY97. On August 20, 1997, UST TA-3-36-2 was removed; this UST at one time held 5,038 gal. of unleaded gasoline. UST-TA-3-36-1, removed on August 21, 1997, previously held 10,152 gal. of unleaded gasoline. On August 17, 1997, minor petroleum contamination was discovered as soil staining at or near the east fuel dispenser

Table 2-2. Environmental Inspections and Audits Conducted at the Laboratory during 1997

Date	Purpose	Performing Agency
January 31, 1997	Open Burn Permit Inspection	NMED
March 31, 1997	DOE Audit	DOE/IG Office
April 10, 1997	Beryllium Inspection	NMED
May 16–17, 1997	Compliance Evaluation Inspection (NPDES)	NMED/SWQB[a]
June 23, 1997	FFCA Compliance Audit	RAC[b]
June 24, 1997	Asbestos Inspection	NMED
July–December 1997	Hazardous Waste Facility Inspection	NMED
July 9, 1997	Open Burn Permit Inspection	NMED
July 15, 1997	TA-54 Area J Commercial/Special Waste Landfill	NMED
September 22, 1997	Burns Swale Spill Site, Fenton Hill	NMOCD[c]
November 12, 1997	Asbestos Inspection	NMED

[a] New Mexico Environment Department/Surface Water Quality Bureau.
[b] Radiological Assessments Corporation.
[c] New Mexico Oil Conservation Division.

island. Elevated total recoverable petroleum hydrocarbon (TRPH) concentrations of 370 ppm and total aromatic hydrocarbon (BTEX) concentrations of 0.22 ppm were detected. Soil samples collected beneath the two USTs show no petroleum contamination. Analytical data collected from the October 1997 subsurface drilling campaign to determine the extent of petroleum contamination found no detectable petroleum in the subsurface. The surface soil that showed elevated petroleum levels was excavated and is being land farmed at TA-60.

Five USTs located at the TA-60 tank farm were removed in CY97. On October 20, 1997, USTs TA-3-TF-1 and TA-3-TF-2, which held 10,152 gal. of kerosene and 25,560 gal. of diesel fuel respectively, were removed. UST TA-3-TF-3, which held 15,228 gal. of unleaded gasoline, was removed on October 21, 1997. On October 27, 1997, USTs TA-3-TF-4 and TA-3-TF-5, both of which held 25,560 gal. of unleaded gasoline, were removed. A total of 14 soil samples was collected from the bottom of the 5 UST excavations. Soil samples were analyzed for TRPH and BTEX using EPA SW-846 modified method 8015 and method 8020 respectively. The analytical results indicate no TRPH or BTEX contamination.

NMED did not conduct a UST inspection during 1997.

g. Solid Waste Disposal. The Laboratory has a commercial/special waste landfill located at TA-54, Area J, that is subject to New Mexico Solid Waste Act (SWA) regulations. In CY97, the TA-54, Area J landfill received and disposed 127 yd^3 of solid waste. On July 15, 1997, the NMED Solid Waste Bureau conducted an inspection at the Laboratory's commercial/special waste landfill. No violations of the management regulations were found during the inspection. In CY97, LANL completed and delivered the required Solid Waste Facility annual report for the previous year (CY96) to DOE.

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. NMED has not requested a permit to be filed for this facility but is expected to do so in the next two to five years. LANL contributed 10.5% (2,497 tons) of the total volume of trash landfilled at this site during CY97, with the remainder contributed by Los Alamos County and the City of Española. LANL also sent 5,296 tons of concrete/rubble, 636 tons of construction and demolition debris, 136 tons of brush for composting, and 77 tons of metal for recycling to the landfill.

h. Waste Minimization. In order to comply with the HSWA Module of the RCRA, RCRA Subtitle A, DOE Order 5400.1, and other regulations, the Laboratory must have a waste minimization and pollution prevention program.

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 act promotes process substitution; materials recovery, recycling, and reuse; and treatment as alternatives to land disposal of hazardous waste.

The amounts of routine, nonroutine, and total RCRA-hazardous, low-level, and mixed low-level wastes generated by Laboratory operations during CY97 are provided in *1997 Annual Report on Waste Generation and Waste Minimization Progress as Required by DOE Order 5400.1* (Wilburn 1998). A copy of this report and additional information concerning waste minimization can be found at *http://twilight.saic.com/WasteMin/default.asp* on the World Wide Web.

In CY97, source reduction and recycling activities reduced the following amounts of waste or pollutants:

Criteria Air Pollutants	95 tons
TRU waste	32.2 m^3
Low-level waste	1,415.5 m^3
Mixed low-level waste	63.4 m^3
RCRA-hazardous waste (chemicals, lead, solvents, etc.)	225.5 m^3
Sanitary waste (paper, phone books, construction materials, rubble, metals, etc.)	10,209.8 mt
State-regulated waste (used tires, waste oil, etc.)	2,684.9 mt
Toxic Substances Control Act (TSCA) waste	12.9 mt

i. Resource Conservation and Recovery Act Training. The RCRA training program, as described in the RCRA Hazardous Waste Facility Permit, is complete and only experienced minor modifications

and revisions in 1997 to reflect regulatory, organizational, and/or programmatic changes.

During 1997, 131 workers completed RCRA Personnel Training, 303 workers completed RCRA Refresher Training, and 565 workers completed Waste Generation Overview. RCRA Refresher Training for treatment, storage, and disposal workers and for less-than-90-day storage workers had previously been incorporated into Hazardous Waste Operations (HAZWOPER) Refresher Training. Of the 303 workers who required RCRA Refresher Training during 1997, approximately 234 met this requirement through completing the combined course.

The following RCRA courses were revised by the Environment, Safety, and Health Training Group (ESH-13) during 1997:

RCRA Refresher Training

HAZWOPER: Refresher for Environmental Restoration Workers

HAZWOPER: Refresher for Treatment, Storage, and Disposal Workers

Waste Documentation Forms

j. Hazardous and Solid Waste Amendments Compliance Activities. In 1997, the Environmental Restoration (ER) Project remained in compliance with Module VIII of the RCRA permit. The Laboratory's ER Project originally consisted of approximately 2,100 potential release sites (PRSs). At the end of FY97, there were approximately 756 PRSs remaining that require investigation and/or remediation and 118 buildings awaiting decontamination and decommissioning (D&D). The Laboratory's ER Project is scheduled for completion in 2006.

In FY97, 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 24 RFI reports to NMED and RFI field work on numerous sites. Remedial activities conducted in FY97 included cleanup of seven sites including a surface disposal area, septic systems, an abandoned manhole, a lead storage area, and a firing site. In addition, during the evaluation of other potential remedial sites, 151 sites were determined by human health risk assessments not to require remedial action. Seven contaminated facilities were demolished, including radioactively contaminated facilities from TA-21 DP West and Phases II and III at the TA-35 Phase Separator Pit.

2. Comprehensive Environmental Response, Compensation, and Liability Act

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 as amended by the 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 Executive Order (EO) 12856, the Federal Compliance with Right-to-Know Laws and Pollution Prevention Requirements.

b. Compliance Activities. In 1997, 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, as modified by EO 12856, requires all federal facilities to prepare emergency plans for more than 360 extremely hazardous substances when they are stored in amounts above threshold limits. The Laboratory is required to notify state and local emergency planning committees if the Laboratory's emergency planning coordinator changes and/or if the Emergency Response Plan has changed. During 1997, there were no changes at the Laboratory requiring notification of 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 into the environment over a specified reporting quantity. Releases are to be reported immediately to the state and local emergency planning committees and to the National Response Center. In 1997, there were no leaks, spills, or other releases of specific chemicals into the environment that required reporting.

Material Safety Data Sheet/Chemical Inventory Reporting. Title III, Sections 311-312, of EPRCA, requires facilities to provide an annual inventory on the quantity and location of hazardous chemicals present at the facility above specified

Table 2-3. Compliance with Emergency Planning and Community Right-to-Know Act during 1997

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	×		

thresholds; the inventory includes the material safety data sheet for each chemical. In 1997, the Laboratory submitted a report to the state emergency response commission, the local emergency planning committee, and the Los Alamos County Fire Department; the report listed 39 chemicals and explosives present in quantities exceeding threshold limits.

Toxic Release Inventory Reporting. Title III, Section 313, of EPRCA, as modified by EO 12856, requires all federal facilities to submit an annual Toxic Chemical Release Inventory report every July for the preceding calendar year. Nitric acid was the only chemical used in 1996 that met the reportable threshold limit of 10,000 lb. The 1996 Toxic Chemical Release Inventory reported that approximately 41,741 lb of nitric acid were used in plutonium metal processing, which resulted in air emissions of 573 lb of nitric acid, 72 lb of nitrogen oxide, and 214 lb of nitrogen dioxide.

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 the provision of DOE Order 151.1 is scheduled for completion in February 1998 and is currently being reviewed by applicable Laboratory senior management for final approval. 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 1997, 567 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. Substances that are governed by the PCB regulations include but are 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 Consolidation (SWSC) Plant, and materials contaminated as a result of spills. Most of the provisions of the regulations apply to transformers, capacitors, and other PCB items with concentrations above 50 ppm.

In 1997, the Laboratory had 25 off-site shipments of PCB waste. The total weight of PCB in those shipments was 21,029 kg. PCB wastes are sent to EPA-permitted disposal and treatment facilities. The quantities of waste types disposed were 3 containers of capacitors, 41 containers of light ballast, 3 containers of water, 10 kg of PCB-contaminated soil, and 2,265 kg of PCB oil. All wastes are managed in accordance with 40 CFR 761 manifesting, record keeping, and disposal requirements. Light ballast is sent off-site for recycling. Section 2.B.8.b describes the status of sanitary sewer sludge from the TA-46 SWSC Plant in which low-level PCB (less than 5 ppm) have been detected.

The Laboratory generates radioactively contaminated PCB in three forms: in 1997, a total of 6,197 kg of liquids, 93 kg of media (mixtures of liquid and solid materials), and 1,108 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 1997. 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 Federal Facility Compliance Agreement for Stored Polychlorinated Biphenyls (PCB FFCAgreement) (see Section 2.C.1.b for a full discussion of the agreement).

The primary compliance documents related to 40 CFR 761.180 are the annual PCB report submitted to EPA, Region 6 and an annual report submitted to DOE required by the PCB FFCAgreement. EPA did not conduct an audit of the Laboratory's PCB management program during 1997.

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 did not conduct an annual inspection of the Laboratory's pesticide application program during 1997.

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,
- New Source Performance Standards,
- 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) mandate new programs that may affect the Laboratory. The new requirements include control technology for hazardous air pollutants, enhanced 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 to any member of the public from radioactive airborne releases from a DOE facility, including LANL, to 10 mrem per year. The 1997 effective dose equivalent (as calculated using EPA-approved methods) was 3.51 mrem per year, primarily from the Los Alamos Neutron Science Center (LANSCE) operations. Any new construction or modifications undertaken at LANL that will increase airborne radioactive emissions causing a potential increase in the dose of 0.1 mrem per year must be approved by EPA. In 1997, approximately 60 projects were reviewed by the Air Quality Group (ESH-17) 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) for which LANL has to comply. The sections 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, operation, service, repair, or disposal of air conditioning or refrigeration equipment; Section 609, Servicing of Motor Vehicle Air Conditioners, implemented by 40 CFR 82 Subpart B, which includes standards and requirements for recycling equipment used to service motor vehicle air conditioners and for training and certification of maintenance and repair technicians; 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 while maintaining, servicing, repairing, and disposing of air conditioning and refrigeration equipment; by contracting automotive repair work to 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 Environmental Improvement Board (NMEIB), as provided by the New Mexico Air Quality Control Act, regulates air quality through a series of air quality control regulations in the NMAC. These regulations are administered by NMED. The NMACs relevant to Laboratory operations are discussed below.

b. Compliance Summary.

20 NMAC 2.07—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 1997.

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 emissions from asphalt-processing equipment. The asphalt plant operated by JCNNM is subject to this regulation. The plant is in compliance with an emission limit of 34 lb of particulate matter per hour.

20 NMAC 2.33—Gas Burning Equipment, Nitrogen Dioxide. Provisions of 20 NMAC 2.33 require gas burning equipment built before January 10, 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/power plants have the capacity to operate at this level, although they never have. The Operating Permit Application proposed compliance by setting a voluntary federal enforceable term that limits the operation of the 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 built before January 10, 1972, 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/power plants have the capacity to operate at this level, although they never have. The Operating Permit Application proposed a voluntary federally enforceable term that limits 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 require open burn permits. On August 17, 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 the first part of 1997.

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. If the Laboratory exceeds the opacity standard during the switch over, 20 NMAC 2.07 notification procedures are then followed. There were no exceedances of these standards during 1997.

20 NMAC 2.70—Operating Permits. This regulation requires major sources of air pollution to obtain an operating permit from NMED. Because of LANL's large potential to emit regulated air pollutants (primarily nitrogen dioxide from the steam/power plants), LANL is considered 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 1996, paid in 1997, totaled $14,165.50.

20 NMAC 2.72—Construction Permits. Provisions of 20 NMAC 2.72 require permits for any new or modified source 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 are required. During 1997, over 150 source reviews were conducted. None of these sources required permits under 20 NMAC 2.72.

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 1 ton of lead per year. In addition, the provisions of 20 NMAC 2.73 specify requirements for annual emission inventories for regulated contaminants. The 1997 inventory will be submitted to NMED on April 30, 1998. Emissions data are presented in Section 4.D.4.

20 NMAC 2.74—Permits, Prevention of Significant Deterioration (PSD). This regulation has stringent requirements that must be addressed before the construction of any new, large stationary emission source can begin. Wilderness areas, national parks, and national monuments receive special protection under this regulation. This affects 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 with this regulation and compared to overall emissions from the Laboratory as documented in the Operating Permit application. None of the new or modified sources in 1997 have resulted in emission increases that would cause the Laboratory to exceed the PSD emission threshold limits.

20 NMAC 2.78—Emission Standards for Hazardous Air Pollutants. In this regulation, NMEIB adopted by reference all of the federal NESHAPs, except those for radionuclides. The impact of each applicable NESHAP is discussed below.

Asbestos. Under the NESHAP for asbestos, the Laboratory must ensure that no visible asbestos emissions to the atmosphere are produced by asbestos removal operations at the Laboratory. During 1997, no Laboratory operation produced visible asbestos emissions. The Laboratory is also required to notify NMED of asbestos removal activities and disposal quantities. Such activities involving less than 15 m^2 or 80 lin m 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 1997, small-job activity accounted for 133 m^3 of asbestos waste. Several large demolition jobs accounted for 109 m^3 of asbestos waste. From the large and small jobs combined, 12 m^3 of radioactively contaminated asbestos waste were disposed of on-site.

Beryllium. The beryllium NESHAP includes requirements for notification, emission limits, and stack performance testing for beryllium sources. The Laboratory has previously received five beryllium permits from 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 set by NMED.

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. 446 *et seq*.) is to restore and maintain the chemical, physical, and biological integrity of the nation's waters. The act established the National Pollutant Discharge Elimination System (NPDES) that requires permitting 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.

The UC and DOE are copermittees of the NPDES permits covering Laboratory operations. The permits are issued and enforced by EPA Region 6 in Dallas, Texas. However, NMED performs some compliance evaluation inspections and monitoring for EPA through a Section 106 water quality grant.

In January 1997, the Laboratory's NPDES outfall permit for Los Alamos included 2 sanitary wastewater treatment facilities and 86 industrial outfalls. By the end of 1997, the Laboratory had eliminated the outfall for the sanitary treatment plant at TA-21 and 22 permitted industrial outfalls from the NPDES permit. The NPDES permit for the geothermal facility at

Fenton Hill includes only one industrial outfall. This outfall did not discharge during 1997, and at the request of the DOE and the Laboratory, the permit was discontinued by EPA on December 29, 1997 (Table 2-1).

Under the Laboratory's NPDES outfall permit, samples are collected for analysis weekly, monthly, quarterly, and annually depending upon the outfall, and results are reported to EPA and NMED at the end of the monitoring period for each respective outfall category. During 1997, effluent limits were exceeded once in the 166 samples collected from the sanitary wastewater outfalls and 6 times in the 1,115 samples collected from the industrial outfalls (see Table 2-4). Overall compliance for the sanitary and industrial wastewater discharges during 1997 was 99.4% and 99.5%, respectively. The water quality parameter for vanadium was exceeded once out of 822 samples collected (99.9% compliance) in 1997 (see Table 2-4). A summary of these outfalls and a listing of the permit's monitoring limits are presented in Table A-4. The annual water quality parameters for sanitary and industrial outfalls are presented in Table A-5.

The following is a summary of the corrective actions taken by the Laboratory during 1997 to address permit noncompliances.

TA-53, Cooling Towers 62 and 64 (NPDES Outfalls 03A048 and 03A049). There were two arsenic exceedances (daily maximum) at TA-53 cooling towers 62 and 64 on January 16, 1997. The operating division is currently monitoring the arsenic levels in the cooling tower basins. Short-term corrective actions include using untreated redwood in cooling tower repair, operational sampling, controlling the cycles of concentration (reducing the number of times water is cycled through the cooling tower), and/or routing the wastewater through an ion-exchange treatment system for further treatment if needed. The

Table 2-4. National Pollutant Discharge Elimination System Permit Monitoring of Effluent Quality and Water Quality Parameters at Industrial and Sanitary Outfalls: Exceedances during 1997[a]

EPA ID	Outfall Type	Technical Area	Date	Parameter		Results/Limits	
January							
03A048	Industrial	TA-53-62	01/16/97	As[b]	(daily max)	0.05/0.04	mg/L
03A049	Industrial	TA-53-64	01/16/97	As	(daily max)	0.05/0.04	mg/L
February							
03A113	Industrial	TA-53-293	02/20/97	Cl_2[c]	(daily max)	2.5/0.5	mg/L
03A113	Industrial	TA-53-293	02/20/97	Cl_2	(daily avg)	0.6/0.2	mg/L
March							
13S	Sanitary	TA-46 SWSC	03/20/97	BOD[d]	(daily max)	73/45	mg/L
April							
051	Industrial	TA-50-1	04/08/97	pH	(min)	5.9/6.0	s. u.
October							
03A181	Industrial	TA-55-6	10/30/97	pH	(daily max)	9.3/9.0	s. u.
03A181	Industrial	TA-55-6	10/30/97	V[e]	(daily max)	0.28/0.10	mg/L

Note: During May, June, July, August, September, November, and December there were no exceedances.

[a]Effluent quality limits are presented in Table A-4; water quality parameters are presented in Table A-5.
[b]Arsenic.
[c]Chlorine.
[d]Biochemical oxygen demand.
[e]Vanadium, a water quality parameter.

long-term corrective action is to replace the two wooden cooling towers with new units constructed of steel, fiberglass, and plastic pipe.

TA-53, Cooling Towers 293, 365, 1032 (NPDES Outfall 03A113). There were two chlorine exceedances (daily average/daily maximum) at NPDES Outfall 03A113 on February 20, 1997. Upon discovery of the elevated chlorine levels, the operating group immediately shut off and locked out the blow-down valves. The cooling tower basin (structure #293) that was overchlorinated was treated with a neutralizing agent and returned to service on February 24, 1997. The facility returned to the original treatment method of placing a mesh bag containing bromine/chlorine tablets in the cooling tower basin, which allows for slow dissolution.

TA-46, Sanitary Wastewater Systems Consolidation (SWSC) Plant (NPDES Outfall 13S). There was one biochemical oxygen demand (BOD) exceedance at the TA-46 SWSC Plant on March 20, 1997. Initial operational data suggested that the problem was due to the MIOX™ system (an on-site mixed oxidants generator used to disinfect effluent) increasing BOD at the outfall. The MIOX™ system was pilot tested in February 1997 and permanently installed in March 1997 to replace the existing chlorine gas system. The SWSC Plant operating engineer believed that the exceedance was caused by factors other than the MIOX™ system and conducted a separate investigation. The exact cause of the noncompliance has not been identified.

TA-50, Building 1 (NPDES Outfall 051). There was one pH noncompliance (minimum) at NPDES Outfall 051 on April 8, 1997. The exact cause of the noncompliance was not identified. The operating group suspects the compliance meter malfunctioned, although no problems with the meter were found. An operator failed to follow established procedures by not being present in the control room to respond to the pH alarm. The low pH of 5.9 s.u. occurred for approximately two minutes. The operating group installed a computerized system programmed to automatically stop the effluent discharge pump when the system's alarm is activated.

TA-55, Cooling Tower at Building 6 (NPDES Outfall 03A181). There was one pH exceedance (maximum) and one vanadium noncompliance (daily maximum) at NPDES Outfall 03A181 on October 30, 1997. Upon discovery of the noncompliant condition, the discharge was stopped. Because of safety and equipment damage concerns, the discharge was resumed after the pH was adjusted within permit limits using hydrochloric acid. Operators at the site indicated that the cooling tower monitoring equipment was not operating correctly and was not properly calibrated or maintained. The operating group has repaired the monitoring equipment, which has reduced the number of cycles of concentration in the cooling tower operations to lower pH and reduce vanadium concentrations in the cooling tower basin.

b. National Pollutant Discharge Elimination System Sanitary Sewage Sludge Management Program. On July 31, 1997, the Laboratory requested approval from the EPA Region 6 to formally change its sewage sludge disposal practices from land application under 40 CFR Part 503 regulations to landfill disposal as a PCB-contaminated waste. This change was necessary because of the repeated detection of low-level PCB (less than 5 ppm) in the SWSC Plant sewage sludge. The EPA approved the Laboratory's request and in September 1997 the Laboratory disposed of approximately 67 dry tons of sewage sludge as PCB-contaminated waste at a TSCA-permitted landfill in California. In November 1997, the Laboratory formally adopted the following interim management practice: All sewage sludge generated at the SWSC Plant will, until further notice, be handled, sampled, and disposed of in accordance with TSCA regulations for 50-499 ppm PCB-contaminated waste.

c. National Pollutant Discharge Elimination System Compliance Inspection. On May 15 and 16, 1997, the NMED Surface Water Quality Bureau conducted a Compliance Evaluation Inspection (CEI) at the SWSC Plant (NPDES Outfall 13S). NMED submitted the CEI report to the EPA and the Laboratory on January 23, 1998.

The CEI report documented the following concerns. Most deficiencies noted are administrative in nature and all concerns have been addressed by the Laboratory. Final resolution of the CEI had not been received from NMED by the end of 1997.

(1) Sludge management and disposal problems. The Laboratory disagrees with NMED's findings concerning record keeping and reporting, sampling, storage, and disposal under 40 CFR Part 503. The last time the Laboratory disposed of sludge by land application under 40 CFR Part 503 was November 1995. In September 1997, EPA approved LANL's request to manage and dispose of SWSC Plant sludge as PCB-contaminated waste.

(2) Issues concerning NPDES Outfall 001 and deleted Outfall 01S (both located in Sandia Canyon), and Outfall 13S (the SWSC Plant). The Laboratory also disagrees with these findings. NMED raised concerns that the deleted Outfall 01S has not been sampled. The NPDES permit does not require monitoring at the outfall. The Laboratory collects the NPDES compliance samples at the end of the chlorine contact chamber, as required by the NPDES permit for Outfall 13S. Outfall 13S effluent is then reused in cooling operations and discharges to Outfall 001 or through the deleted Outfall 01S to Sandia Canyon. The Laboratory's NPDES permit requires the Laboratory to utilize best management practices in such a manner as to enhance and maintain wetland areas in Sandia Canyon and Cañada del Buey. During 1997, Outfall 13S did not discharge into Cañada del Buey. The Laboratory is addressing wetlands maintenance below NPDES Outfall 001 through physical improvements to be installed by the Laboratory in 1998 designed to slow the water down.

(3) Deficiency in sample collection for fecal coliform. The Laboratory has changed its NPDES sampling procedures and sampling techniques for fecal coliform collection.

(4) Illegal discharge into a drainage located next to the SWSC Plant. The Laboratory has completed corrective actions to eliminate the discharge of treated effluent used in irrigation at the SWSC Plant from entering Cañada del Buey.

(5) Discharge of grease balls from the TA-46 SWSC Plant discharge (13S). The Laboratory has developed a waste acceptance criteria (WAC) for the discharge of oil and grease. SWSC operators conduct weekly inspections and cleaning of the chlorine contact chamber.

(6) Incorrect EPA method cited on the laboratory benchsheet. The analytical laboratory benchsheets have been updated to reference the currently approved EPA method.

d. National Pollutant Discharge Elimination System: Waste Stream Characterization Program and Corrections Project. The Water Quality and Hydrology Group (ESH-18) implemented the Waste Stream Corrections project to correct Laboratory-wide noncomplying waste streams and potential unpermitted outfalls that discharge to the environment, as identified by the Waste Stream Characterization (WSC) survey conducted from 1991 to 1994. The Waste Stream Corrections Project was completed on March 31, 1997. Each of the 7,602 deficiencies identified in the WSC Final Reports was addressed by construction of physical improvements, by implementation of administrative controls, or by three modified permit applications submitted to the EPA on March 13, 1997.

During the Waste Stream Corrections project, operational safety reviews of completed construction were conducted by the Laboratory's Industrial Hygiene and Safety Group. As a result of these reviews, approximately 50 drains that were previously plugged to prevent noncomplying discharges from entering the environment were opened or rerouted in order to mitigate potential safety hazards.

On April 1, 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 AO Docket No. VI-96-1236. All completed corrective actions have been tracked and verified by use of a database developed by the Laboratory. Information collected in this database will be used for preparation of the Laboratory's NPDES permit reapplication, which is due for submittal to the EPA in May 1998.

e. National Pollutant Discharge Elimination System Storm Water Program. NPDES permits are also required for storm water discharges. During 1997, the Laboratory had 14 NPDES permits for its storm water discharges (see Table 2-1). One permit is for the Laboratory site and includes storm water discharges related to industrial activity such as 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; and steam and electric power generating facilities. Five NPDES storm water permits are for the remediation of ER Project sites off of DOE property. The other eight permits are for construction activities that disturb more than five acres. The NPDES storm water permits expired on September 9, 1997, and under EPA guidance, the Laboratory applied for and received an administrative extension.

The NPDES permit requires the development and implementation of a Storm Water Pollution Prevention (SWPP) Plan. During 1997, the Laboratory developed and implemented over 70 SWPP Plans.

Under the NPDES storm water permit, monitoring activities are required at landfills and EPCRA, Section 313 facilities. In 1997, 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, 1997, for landfills and on January 27, 1998, 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 1997, there were 19 stations on watercourses at the Laboratory. The discharge information for 1997 is reported in "Surface Water Data at Los Alamos National Laboratory: 1997 Water Year" (Shaull et al., 1998).

f. Spill Prevention Control and Countermeasures Program. The Laboratory's Spill Prevention Control and Countermeasures (SPCC) Plan, as required by the CWA, was developed in accordance with 40 CFR 112 and is a comprehensive plan developed to meet the requirements of EPA and NMED that regulate water pollution from oil spills. The purpose of the SPCC Plan is to ensure that adequate prevention and response measures are provided to prevent oil spills from reaching a watercourse. Prevention measures include maintenance and inspection of facilities to ensure the integrity of the oil and chemical handling equipment and proper operator training.

A triennial review of the SPCC Plan was completed by the Laboratory in March 1997. From this review, only oil storage tanks greater than 660 gal. are required to have a site-specific SPCC Plan. In keeping with the site-specific SPCC Implementation Plan approach, the operating conditions for each location are addressed and, as these change, only the individual site-specific SPCC Implementation Plan is revised.

g. Dredge and Fill Permit Program. Under Section 404 of the CWA, the Laboratory is required to obtain permits from the Army Corps of Engineers (COE) 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 that must be met by the permittee 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 has six nationwide permits under the Sections 404/401 program; 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, Los Alamos County, 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 DOE provides drinking water to Los Alamos County and Bandelier National Monument. The EPA has established maximum contaminant levels (MCLs) for microbiological organisms, organic and inorganic constituents, and radioactivity in drinking water. These standards have been adopted by the state and are included in the New Mexico Drinking Water Regulations (NMEIB 1995). The NMED has been given authority by EPA to administer and enforce federal drinking water regulations and standards in New Mexico.

The particular locations within the water system where SDWA compliance samples are collected are specified in the regulations for each contaminant or group of contaminants. In 1997, the monitoring network for SDWA compliance sampling consisted of the following 4 location groups within the water system:

(1) wellhead sampling from the water supply wells in operation at the time of sampling (Guaje wells G-1, G-1A, G-2, G-4, G-5, 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-6) and the New Mexico Environmental Improvement Act. Sampling locations, frequencies, preservation, handling, and analyses follow the requirements specified in federal and state regulations. Chemical and radiological sampling is performed by Laboratory staff and submitted for analysis to the New Mexico Health Department's Scientific Laboratory Division (SLD) in Albuquerque. Dioxin analyses are performed by Triangle Laboratories, Inc., of Durham, NC. Microbiological sampling and analysis are performed by the JCNNM Environmental (JENV) laboratory. The JENV laboratory is certified by NMED for microbiological compliance analysis. Certification requirements include proficiency samples, maintenance of an approved quality assurance/quality control program, and periodic audits by NMED. Laboratory and JENV staff are certified by NMED 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 JENV laboratory report their analytical results directly to NMED. ESH-18 maintains both electronic and hard-copy files of all data collected from SDWA compliance testing.

b. Radiochemical Analytical Results. As required by the SDWA, in 1997, 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 2-5, the concentrations of gross alpha and gross beta activity were less than the screening limits. When gross alpha and beta activity measurements are below the screening limits, the Laboratory does not need to perform further isotopic analyses or perform dose calculations under the SDWA program. However, it should be noted that comprehensive monitoring of the water supply wells for radiochemical constituents is conducted annually by ESH-18 (see Table 5-22).

In 1997, the Laboratory conducted baseline sampling on the new Otowi well O-1. Baseline sampling is conducted for four consecutive quarters and is required by the SWDA for all new sources of water in a drinking water supply system. The three quarters of baseline sampling conducted in 1997 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 1997, radon sampling was performed at the 13 operating water supply wellheads and the 5 entry points into the distribution system. This sampling was done to collect information before the issuance of final EPA regulations governing radon in drinking water. As shown in Table 2-6, the concentrations ranged from 109 to 647 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 1997, TTHM samples were collected during each quarter from six locations in the Laboratory and Los Alamos County water distribution systems. As shown in Table 2-7, the annual average for samples in 1997 was 6.3 µg of TTHM per liter of water, less than the SDWA MCL of 100 µg of TTHM per liter of water.

In 1997, inorganic constituents in drinking water were sampled at the 13 operating water supply wellheads. As shown in Table 2-8, all locations and all inorganic constituents were less than the MCLs.

In 1997, VOC samples were collected at the 13 operating water supply wellheads. No VOCs were detected at any of the sampling locations with the exception of 13.3 µg of chloroform per liter of water at Otowi well O-1 on April 18, 1997. The SWDA MCL for chloroform is 80 µg of chloroform per liter of water. Chloroform is a byproduct of chlorine disinfection. It is believed that the source of chloroform found in the sample was the chlorine used in disinfecting the well in the weeks before sampling. Chloroform was not detected during repeat sampling at Otowi well O-1 conducted on September 8 and November 14, 1997.

In 1997, synthetic organic compound (SOC) samples were collected at the 13 operating water supply wellheads. Baseline sampling at Otowi well O-1 for SOCs was conducted during the last three quarters of 1997. No SOCs were detected at any of the sampling locations.

In 1997, sampling for the presence of lead and copper from residential taps was not required by the SDWA. Sampling for lead and copper will resume in 1999.

Table 2-5. Radioactivity in Drinking Water (pCi/L) during 1997

	Gross Alpha			Gross Beta		
Sample Location	**Calibration Std.**	**Value**	**(Uncertainty)**	**Calibration Std.**	**Value**	**(Uncertainty)**
Wellheads:						
Otowi Well O-1	^{241}Am	2.6	(0.6)	^{137}Cs	2.4	(1.0)
(2nd Qtr 1997)	Natural U	2.9	(0.6)	^{90}Sr, ^{90}Y	2.3	(0.9)
Otowi Well O-1	^{241}Am	2.7	(0.7)	^{137}Cs	1.3	(0.8)
(3rd Qtr 1997)	Natural U	3.1	(0.8)	^{90}Sr, ^{90}Y	1.3	(0.8)
Otowi Well O-1	^{241}Am	2.6	(0.6)	^{137}Cs	1.9	(0.8)
(4th Qtr 1997)	Natural U	2.9	(0.7)	^{90}Sr, ^{90}Y	1.8	(0.8)
Entry Points:						
Pajarito Booster #2	^{241}Am	0.2	(0.3)	^{137}Cs	3.4	(0.9)
	Natural U	0.2	(0.3)	^{90}Sr, ^{90}Y	3.4	(0.9)
Guaje Booster #2	^{241}Am	1.1	(0.5)	^{137}Cs	2.9	(0.9)
	Natural U	1.3	(0.6)	^{90}Sr, ^{90}Y	2.8	(0.9)
Pajarito Well PM-1	^{241}Am	2.3	(0.6)	^{137}Cs	3.6	(0.9)
	Natural U	2.7	(0.6)	^{90}Sr, ^{90}Y	3.4	(0.8)
Pajarito Well PM-3	^{241}Am	1.3	(0.5)	^{137}Cs	3.6	(0.8)
	Natural U	1.6	(0.6)	^{90}Sr, ^{90}Y	3.4	(0.7)
Otowi Booster #2	^{241}Am	1.0	(0.6)	^{137}Cs	5.5	(1.3)
(formerly LA Booster #4)	Natural U	1.2	(0.7)	^{90}Sr, ^{90}Y	5.3	(1.2)
EPA Maximum Contaminant Level		15			none	
EPA Screening Level		5			50	

d. Microbiological Analyses of Drinking Water. Each month during 1997, an average of 46 samples was collected from the Laboratory, Los Alamos County, 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 552 samples analyzed during 1997, 2 indicated the presence of total coliforms. None of the samples indicated the presence of fecal coliforms. Noncoliform bacteria were present in 29 of the microbiological samples. Noncoliform bacteria are not regulated, but their presence in repeated samples may serve as indicators of stagnation and biofilm growth in water pipes. A summary of the monthly analytical data is presented in Table 2-9.

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 proposed SDWA MCLs for arsenic and radon because of their natural occurrence in the main aquifer. Violations of the SDWA MCL for microbiological constituents occurred in 1993 and 1994. Both of these violations were attributed to localized contamination in the distribution system and not microbiological contamination of 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 1997.

Table 2-6. Radon in Drinking Water (pCi/L) during 1997

Sample Location	Value	(Uncertainty)
Entry Points:		
Pajarito Booster #2	472	(28)
Guaje Booster #2	194	(17)
Pajarito Well-PM1	263	(18)
Pajarito Well-PM3	338	(22)
Otowi Booster #2	322	(21)
Wellheads:		
Pajarito Well-PM1	263	(18)
Pajarito Well-PM2	647	(36)
Pajarito Well-PM3	338	(22)
Pajarito Well-PM4	490	(29)
Pajarito Well-PM5	452	(27)
Guaje Well-G1A	377	(25)
Guaje Well-G1	398	(25)
Guaje Well-G2	392	(25)
Guaje Well-G4	398	(26)
Guaje Well-G5	338	(23)
Guaje Well-G6	423	(27)
Otowi Well-O4	440	(26)
Otowi Well-O1	109	(10)

Table 2-7. Total Trihalomethanes in Drinking Water (μg/L) during 1997

	1997 Quarters			
Sample Location	**First**	**Second**	**Third**	**Fourth**
Distribution Sites:				
Los Alamos Airport	2.9	10.1	17.5	10.0
White Rock Fire Station	<0.5	<0.5	<0.5	<0.5
North Community Fire Station	0.7	5.4	5.7	4.9
S-Site Fire Station	<0.5	5.7	10.7	5.5
Barranca Mesa School	<0.5	2.3	12.5	1.3
TA-39, Bldg. 02	8.9	13.7	15.6	15.1
1997 Average of 6.3 μg/L				
EPA Maximum Contaminant Level			100.0	
Sample Detection Limit			0.5	

Table 2-8. Inorganic Constituents in Drinking Water (mg/L) during 1997

Sample Location	As	Ba	Be	Cd	Cr	F	CN	Hg	Ni	NO_3 (as N)	Se	Sb	Tl
Wellheads:													
Pajarito Well-PM1	0.002	<0.1	<0.001	<0.001	0.003	<0.40	<0.005	<0.0002	<0.01	0.50	<0.005	<0.001	<0.001
Pajarito Well-PM2	0.001	<0.1	<0.001	<0.001	0.003	<0.40	<0.005	<0.0002	<0.01	0.30	<0.005	<0.001	<0.001
Pajarito Well-PM3	0.002	<0.1	<0.001	<0.001	0.003	<0.40	<0.005	<0.0002	<0.01	0.50	<0.005	<0.001	<0.001
Pajarito Well-PM4	0.002	<0.1	<0.001	<0.001	0.005	<0.40	<0.005	<0.0002	<0.01	0.30	<0.005	<0.001	<0.001
Pajarito Well-PM5	0.001	<0.1	<0.001	<0.001	0.005	<0.40	<0.005	<0.0002	<0.01	0.30	<0.005	<0.001	<0.001
Guaje Well-G1A	0.015	<0.1	<0.001	<0.001	0.007	0.70	<0.005	<0.0002	<0.01	0.40	<0.005	<0.001	<0.001
Guaje Well-G1	0.007	<0.1	<0.001	<0.001	0.005	0.40	<0.005	<0.0002	<0.01	0.40	<0.005	<0.001	<0.001
Guaje Well-G2	0.038	<0.1	<0.001	<0.001	0.008	0.80	<0.005	<0.0002	<0.01	0.40	<0.005	<0.001	<0.001
Guaje Well-G4	0.003	<0.1	<0.001	<0.001	0.002	<0.40	<0.005	<0.0002	<0.01	0.60	<0.005	<0.001	<0.001
Guaje Well-G5	0.003	<0.1	<0.001	<0.001	0.002	<0.40	<0.005	<0.0002	<0.01	0.60	<0.005	<0.001	<0.001
Guaje Well-G6	0.003	<0.1	<0.001	<0.001	0.002	<0.40	<0.005	<0.0002	<0.01	0.50	<0.005	<0.001	<0.001
Otowi Well-O4	0.002	<0.1	<0.001	<0.001	0.003	<0.40	<0.005	<0.0002	<0.01	0.30	<0.005	<0.001	<0.001
Otowi Well-O1 (4/97)	0.005	<0.1	<0.001	<0.001	0.010	<0.40	<0.005	<0.0002	<0.01	1.00	<0.005	<0.001	<0.001
Otowi Well-O1 (11/97)										0.44			
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.

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 (GWPMPP) 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. Under Task III, Section A.1, the Laboratory is required to conduct a program to evaluate hydrogeologic conditions. Under Task III, Section C.1, the Laboratory is required to conduct a groundwater investigation to characterize any plumes of contamination at the facility.

New Mexico Water Quality Control Commission (NMWQCC) 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 the 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 NMWQCC regulations (Table 2-1): one for TA-57 (Fenton Hill); one for the SWSC Plant; and one for the land application of dried sanitary sewage sludge from the SWSC Plant. On April 10, 1997, the Laboratory submitted an application to renew the SWSC Plant groundwater discharge plan that was scheduled to expire on July 20, 1997. On January 7, 1998, the NMED approved the renewal application for a period of five years. At the request of NMED, on August 20, 1996, the

Table 2-9. Bacteria in Drinking Water at Distribution System Taps during 1997

Month	No. of Samples Collected	No. of Positive Tests		
		Coliform	Fecal Coliform	Noncoliform
January	50	1	0	4
February	45	0	0	1
March	46	0	0	1
April	45	0	0	0
May	49	1	0	3
June	46	0	0	0
July	45	0	0	6
August	44	0	0	1
September	46	0	0	1
October	45	0	0	5
November	46	0	0	3
December	45	0	0	4
Total 1997	552	2	0	29
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.

Laboratory submitted a groundwater discharge plan application for the Radioactive Liquid Waste Treatment Facility at TA-50. As of December 31, 1997, approval of the plan by NMED was still pending.

b. Compliance Activities. The Laboratory's revised GWPMPP was approved by DOE in March 1996. The plan provides general management goals and direction to activities pertaining to groundwater quality and quantity.

In March 1997, the NMED approved a proposed comprehensive hydrogeologic characterization and groundwater monitoring plan for the Laboratory. The plan was developed in response to NMED's denial of the Laboratory's RCRA groundwater monitoring waiver demonstrations. The plan proposes a major long-term drilling and hydrologic analysis program to broadly characterize the hydrogeology of the Pajarito Plateau and to assess in detail the potential for groundwater contamination to occur from individual waste disposal operations. The plan contains a prioritized list of activities and studies addressing the above.

The Laboratory continued an ongoing study of the hydrogeology and stratigraphy of the region, as required by the HSWA Module of the RCRA permit and DOE Order 5400.1. Studies by various Laboratory programs are integrated by the GWPMPP administered by ESH-18. Some key 1997 activities are listed below.

(1) The "Performance Assessment and Composite Analysis for Los Alamos National Laboratory Material Disposal Area G" was completed in March by the Waste Management Program. This report includes several studies reflecting our understanding of groundwater flow and transport beneath mesa top settings at the Laboratory. The report estimates dose to the public for a 1,000-yr period beginning after assumed facility closure in 2044. The analysis showed that TA-54, Area G is expected to meet these and other required performance objectives. The calculated dose for all pathways was 0.0001 mrem per year (compared to a 25 mrem per year limit). The calculated dose for groundwater was 0.000035 mrem per year (compared to a 4 mrem per year limit).

(2) In September 1997, the ER Project began drilling the first deep characterization borehole, as required by the Hydrogeologic Workplan. The borehole is located at the Laboratory's eastern boundary in Los Alamos Canyon. When completed, it will be the first main aquifer characterization well drilled at the Laboratory since 1961.

(3) Environmental surveillance program and ER Project investigations at TA-54 and TA-49 indicate that the portion of the mesa at an elevation above the neighboring canyon bottom is subjected to a naturally occurring evaporation and drying mechanism. This evaporation apparently occurs by air movement along fractures and higher permeability zones. The consistency in results at the two sites, one on the eastern edge of the Laboratory and the other on the south central edge, indicates that this phenomenon may occur at most mesa settings. This drying process results in very low infiltration rates within the mesa.

11. National Environmental Policy Act

a. Introduction. The National Environmental Policy Act (NEPA) of 1969 (42 U.S.C. 4331 *et seq.*) mandates that federal agencies consider whether proposed major actions will significantly affect the environment and allow public input before making a final decision on what actions to take. The DOE is the sponsoring agency for most LANL activities, and it is DOE's responsibility to follow the letter and spirit of NEPA. 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 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,
- 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, the 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 requiring an EIS (e.g., the LANL Site-Wide EIS or a programmatic EIS done at the nationwide level), it may be included in the EIS analyzing 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, which form the basis of a DOE NEPA environmental review form formerly known as a DOE Environmental Checklist. These forms are written by the LANL Ecology Group (ESH-20) using the streamlined format known as a NEPA Environmental Review form, specified by the DOE/Los Alamos Area Office (LAAO).

b. Compliance Activities. In 1997, LANL sent 137 NEPA environmental review forms to DOE for review. DOE categorically excluded 129 actions and made a determination for 6 other actions. Two actions were unresolved in 1997. Pursuant to authority delegated by DOE, LANL applied "umbrella" categorical exclusion determinations for 117 actions. DOE completed three EAs and issued three FONSIs in 1997.

c. Site-Wide Environmental Impact Statement. Under DOE's compliance strategy for NEPA, a Site-Wide Environmental Impact Statement (SWEIS) is prepared to examine the environmental impacts of operations at a multiprogram site. A SWEIS was prepared for the operation of LANL in 1979. That document and subsequent NEPA reviews for specific project or program activities have served as the NEPA basis for operations at LANL since 1979. DOE is now preparing an updated SWEIS to replace the 1979 SWEIS, and future NEPA documents at LANL will be tiered from or reference this SWEIS. This SWEIS addresses operation of LANL (from 1997 through 2006) across the approximately 43 square miles of government land under the administrative control of DOE. DOE is the lead agency and Los Alamos County is a cooperating agency (due to the interdependence of county and DOE planning) in the preparation of this SWEIS.

The process for the preparation of this SWEIS was designed to enhance the participation of members of the public. The SWEIS Advance Notice of Intent, published in the *Federal Register* (FR) on August 10, 1994 (59 FR 40889), identified possible issues and alternatives to be analyzed. It was followed by a series of public meetings intended to both provide information on LANL and the plans for the SWEIS and to obtain public input regarding the scope of the SWEIS. Based on the input received during this "prescoping" period, DOE prepared and published the Notice of Intent to prepare the SWEIS on May 12, 1995 (60 FR 25697). This publication was also followed by a series of public meetings to provide opportunities for stakeholders to identify the issues, environmental concerns, and alternatives that should be analyzed in the SWEIS. Nearly 1,300 comments from 215 commentors were recorded. DOE began preparing the draft SWEIS document in late 1996 and continued this effort during 1997.

Two of the Laboratory's projects were previously considered EA-level and during 1997, these projects were instead included in the SWEIS. The project descriptions follow.

Expansion of TA-54, Area G. Routine activities at the Laboratory generate solid low-level radioactive wastes (LLWs) that are disposed of or stored at TA-54, Area G, which is currently a 63-acre site. For some types of waste, burial in pits or shafts is the only feasible disposal method that complies with all regulations. The analysis for this project considers five alternatives for the management of LLWs: (1) using the active disposal area at Area G until it is full, (2) developing Zone 4 at TA-54, west of the active disposal area, (3) developing Zone 6 at TA-54, west of Area L and extending to Area J, (4) developing the North Site at TA-54, north of Zone 6, and (5) developing another location within the Laboratory, with TA-67 used as a representative undeveloped mesa site. Potential environmental, safety, and health issues include land use, air quality, ecological resources, soil, surface water, threatened and endangered species, cultural resources, and environmental restoration.

Enhancement of Pit Manufacturing Operations. The proposed action is to relocate or upgrade certain existing operations and to construct an access road to support plutonium pit (the central core of a nuclear weapon typically composed of plutonium-239 and/or highly enriched uranium) manufacturing operations at LANL. Essential operations at TA-55 and the Chemistry and Metallurgy Research (CMR) Building would be expanded and relocated between TA-55 and the CMR Building or upgraded in place. A new controlled access road would be constructed between TA-55 and the CMR Building. As a result of these upgrades and construction activities, LANL would be able to manufacture each type of pit required to support the existing nuclear weapons stockpile. In addition, the Laboratory would be able to produce a maximum of up to 80 pits per year if required. Alternatives to the proposed action include configuration for

expanding existing facilities as well as the construction of a new facility. Potential environmental, safety, and health issues include worker exposure to construction hazards as well as interruption to existing traffic patterns and minor increases in traffic volumes.

d. Environmental Assessments. The status of the Laboratory's EA-level NEPA documentation and project descriptions follow.

Chemical and Metallurgy Research Building Upgrades. The CMR Building was constructed as a major chemical research and analysis laboratory facility for radioactive materials in 1952. Despite some repairs and upgrades since that time, the CMR Building does not meet current DOE regulations governing construction of a new nonreactor nuclear facility. The DOE needs to maintain the capability to continue to perform uninterrupted interim and ongoing radioactive chemical and metallurgical research activities in a safe, secure and environmentally sound manner at LANL. DOE proposes to extend the life of the building 20 years by performing seismic upgrades, ventilation system replacements and confinement zone separations, acid vents and drain lines replacements, and electrical system upgrades. The alternative action is not to upgrade the facility. Potential environmental, safety, and health issues include worker safety while the work is performed and LLW disposal. The EA for this proposed action was completed, and a FONSI was issued in February 1997.

Transfer of the DP Road Tract to the County of Los Alamos. Under the proposed action, DOE intends to transfer ownership of a 28-acre tract of land located along DP Road, currently part of TA-21, to the County of Los Alamos. The transfer of this tract of land would result in a permanent change to the existing DOE property boundaries for TA-21. The county proposes to construct a new office building to house county employees, a new warehouse, garages, and a support building in order to transfer its equipment maintenance, school bus yard, and school supplies warehousing activities to the site. The alternative action is not to transfer the land and to continue to maintain government ownership of the tract. Potential environmental, safety, and health issues include worker and public exposure to construction hazards and nonradioactive air emissions from operations and from increased vehicular traffic. The proposed action could create approximately 450 new direct jobs and 585 indirect jobs. The EA for this action was completed, and a FONSI was issued in January 1997.

Lease of Land for the Development of a Research Park at LANL. DOE proposes to lease to the County of Los Alamos approximately 60 acres of land located in TA-3. This tract of land is bordered on the east by Diamond Drive, West Jemez Road on the south, West Road on the west, and Los Alamos Canyon on the north. The existing DOE property site boundary would not change under the proposed action. The county would be responsible for construction, development, and operation of the research park. The county or future tenants would be prohibited from developing the tract for residential uses, heavy industrial uses, or any other uses that would not be consistent with LANL mission operations. Approximately 10 variably sized office buildings and supporting infrastructure are to be built on this tract. Approximately 300,000 ft^2 of floor space is planned for the site with parking for up to 1,400 cars. Up to 1,500 employees are anticipated to occupy the research park after its completion. Roadway improvements would be necessary for West Road, West Jemez Road, and Diamond Drive. Traffic signals would need to be modified on West Jemez Road at Casa Grande and Pajarito Roads. Alternatives that were considered but dismissed include the following: (1) lease of the tract to a nongovenment entity, (2) lease of the tract to another federal agency or Indian tribe, (3) transfer ownership of the proposed research park land to the county, (4) transfer of the land to entities other than the county, and (5) lease of a tract at another LANL location. Potential environmental, safety, and health issues include worker exposure to construction hazards as well as interruption of existing traffic patterns and minor increases in traffic volumes. The EA for this proposed action was completed, and a FONSI was issued in October 1997.

e. Mitigation Action Plans. Mitigation Action Plans (MAPs) are designed to (1) document potentially adverse environmental impacts of a proposed action, (2) identify commitments made in the final NEPA documents, and (3) establish action plans to carry out each commitment. The status of the Laboratory's MAPs follows.

Dual Axis Radiographic Hydrodynamic Test Facility Mitigation Action Plan. In August 1995, DOE published a final EIS on the Dual Axis Radiographic Hydrodynamic Test (DARHT) facility at LANL. DOE published a ROD on this final EIS in the Federal Register (60 FR 53588) on October 16, 1995. The DARHT ROD states that DOE has decided to complete and operate the DARHT facility while implementing a 10-yr phased-containment program to conduct most tests inside steel containment vessels.

The ROD further states that DOE must develop several mitigation measures to protect workers, soils, water, and biotic and cultural resources in and around the DARHT facility. The DOE has published the first official DARHT MAP Annual Report, which identified potential impacts associated with the course of action selected in the ROD and commitments and action plans that DOE considers necessary to mitigate these potential impacts.

Low-Energy Demonstration Accelerator Mitigation Action Plan. In conjunction with the Low-Energy Demonstration Accelerator (LEDA) EA and FONSI, approved in April 1996, DOE issued a MAP that defined a scope of activities that would be implemented to mitigate some of the potential environmental impacts associated with the LEDA project. The LEDA MAP is being implemented by LEDA project management and overseen by DOE/LAAO and ESH-20.

The MAP requires a written annual report to provide the status of the LEDA schedule and the action taken on the identified mitigation measures. 1997 was the second year of LEDA project development. The LEDA project was scaled back and will now only proceed to Stage III as described in the EA and allowed by the current safety analysis document. Because Stages IV and V development have been removed from the LEDA project schedule, the large quantities of water and power use estimated in the final LEDA EA will no longer be required and generated. This affects the LEDA MAP because the land disturbance issue for utility line installation is removed and the quantity of water released into Sandia Canyon will be much less. For example, no erosion is expected at the drainage channel of NPDES Outfall 03A113, and it is unlikely that a wetland will be created in Sandia Canyon. Thus, potential environmental impacts mentioned in the final EA and MAP will be eliminated or much reduced due to the changes in the project.

During early FY97, planning was completed for the remediation of a potential release site containing lead shot (pellets) near Outfall 03A113 and the LEDA site. All of the necessary documentation and approvals for the cleanup by the LANL ER Project were conducted and completed as required before a remediation. The lead-shot site was successfully cleaned up in FY97. Laboratory samples showed no traces of lead in the soil afterwards.

Lease of Land for the Development of a Research Park at LANL Mitigation Action Plan. DOE issued this MAP in October 1997. The EA indicates that potential adverse effects of the proposed action under normal conditions would be minimal. However, the EA includes provisions concerning the analysis of the environmental effects of the proposed site development and subsequent occupation to mitigate any potential adverse effects that could result from future construction activities on the site. DOE's commitment to mitigate possible adverse effects related to potential habitat or cultural resources will be included in appropriate final lease documents. Temporary site exclusion zones will be established to protect ongoing Mexican spotted owl and cultural resource surveys, evaluations, and data recovery activities located on and near the site. Additionally, the mitigations include the establishment of a site buffer zone next to Los Alamos Canyon where construction will be excluded.

The DOE has overall responsibility for insuring the adequate and timely completion of all actions associated with this MAP. ESH-20 is responsible for conducting the mitigation measures, data collection, and monitoring activities.

12. Cultural Resources

a. Introduction. The Cultural Resources Team in ESH-20 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 and to consult with the State Historic Preservation Officer (SHPO) and/or National Advisory Council on Historic Preservation concerning possible effects to identified resources.

During 1997, Laboratory archaeologists evaluated 751 Laboratory proposed actions; 28 new field surveys were conducted to identify cultural resources. The results of 12 surveys were sent by DOE to the SHPO for concurrence in findings of effects and

determinations of eligibility for National Register inclusion of any cultural resources located during the survey. Copies were also sent to the governors of the Pueblos of San Ildefonso, Santa Clara, Cochiti, Jemez, and to the President of the Mescalero Apache tribe for comment and identification of any traditional cultural properties which may be affected by a proposed action. No adverse effects to prehistoric cultural resources were identified in 1997.

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. No inadvertent discoveries of burials or cultural objects were made during 1997.

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 1997.

13. Biological Resources including Floodplain and Wetland Protection

a. Introduction. The DOE and the Laboratory must comply with the Endangered Species Act, the Migratory Bird Treaty Act; the Bald Eagle Protection Act; EO 11988, Floodplain Management; EO 11990, Protection of Wetlands (EPA 1989); and Section 404 of the CWA. The Laboratory also considers plant and animal species listed under the New Mexico Conservation Act and the Endangered Species Act.

b. Compliance Activities. During 1997, ESH-20 reviewed approximately 750 proposed Laboratory actions for potential impact on threatened and endangered species. The Biology Team of ESH-20 reviewed 210 proposed Laboratory projects for their impact on biological resources. These surveys are designed to evaluate the amount of previous development or disturbance at the site and to determine the presence of any surface water or floodplains in the project area. The Biology Team also identified approximately 60 projects that required habitat evaluation surveys to assess if the appropriate habitat types and habitat parameters were present to support any threatened or endangered species. In addition, the Biology Team identified 15 projects that required a species-specific survey designed to determine the presence or absence of a threatened or endangered species at the project site. As a result of species-specific surveys, five biological assessments were prepared and submitted to the US Fish and Wildlife Service. The Laboratory adhered to protocols set by the US Fish and Wildlife Service and permit requirements of the New Mexico State Game and Fish Department.

c. Biological Assessments. The Biology Team is currently preparing a threatened and endangered species habitat management plan on behalf of the DOE as part of the DARHT MAP commitments by DOE. The site plan should be completed in October 1998 and will be used to further evaluate and manage the threatened and endangered species occupying DOE/Laboratory property.

C. Current Issues and Actions

1. Compliance Agreements

a. Mixed Waste Federal Facility Compliance Order. DOE and the Laboratory are required by the Federal Facility Compliance Act of 1992 (section 3021[b] of RCRA) to prepare a Site Treatment Plan (STP) describing the development of treatment capacities and technologies for treating mixed waste generated at LANL that is being stored beyond the one-year time frame provided for in the land disposal restrictions (Section 3004(j) of RCRA and 40 CFR Section 268.50). On October 4, 1995, the State of New Mexico issued the Federal Facility Compliance Order to both DOE and UC requiring compliance with the STP and thereby terminating the Federal Facility Compliance Agreement that had previously been in effect (ESP 1996). The Laboratory met all 1997 STP deadlines and milestones.

b. Federal Facility Compliance Agreement on Storage of Polychlorinated Biphenyls. On August 8, 1996, DOE, the Naval Nuclear Propulsion Program, and EPA entered into a PCB Federal Facility Compliance Agreement pertaining specifically to radioactive PCB and PCB waste containing RCRA wastes. The Agreement is intended to be a compliance bridge from now until EPA's December 6, 1994, proposed rule updating the PCB regulations is final. The Agreement also contains provisions to address the discrepancy created in the TSCA PCB regulations when the Department of Transportation changed its container specifications. The PCB

Agreement incorporates the proposed rule and provides regulatory relief for facilities now. When EPA makes the final decision, it will supersede the PCB Federal Facility Compliance Agreement.

The PCB Federal Facility Compliance Agreement requires an annual report to be prepared by DOE and submitted to EPA. LANL met that requirement in 1997.

c. National Pollutant Discharge Elimination System Federal Facility Compliance Agreement and Administrative Order. AO Docket No. VI-96-1236, issued to the Laboratory on September 16, 1996, incorporated the revised High-Explosive Wastewater Treatment Plant (HEWTP) schedule and the new schedule for completion of the remaining corrective actions for the WSC project. The Laboratory met the March 31, 1997, deadline to complete 100% of the WSC corrective actions, as specified in the AO and corresponding Federal Facilities Compliance Agreement (Docket No. VI-96-1237).

The new TA-16 HEWTP (NPDES Outfall 05A055) is also covered under AO Docket No. VI-96-1236. The AO required construction of the new HEWTP to be completed by September 1997 and in compliance with effluent limits by October 1997. Construction, initial testing, and startup of the new facility has been completed. New WAC have been developed based on RCRA universal treatment standards, New Mexico Stream Standards, and NPDES permit requirements. All HE wastewater is characterized through the Laboratory's Waste Profile Form process. Wastewater that does not meet the WAC is evaluated against the NPDES limits and may be sent to the existing HEWTP, which will remain on-line and serve as a backup treatment facility until all HE waste streams are characterized and are confirmed to meet the WAC for the new HEWTP. Both the new and the backup HEWTP are currently meeting NPDES permit requirements.

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 period for the current AIP is effective through September 30, 2000.

During 1997, the NMED/DOE Oversight Bureau staff focused most of their resources on environmental surveillance activities. 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 (NMED 1998).

Air particulate and water vapor monitoring: The DOE Oversight Bureau maintains five air particulate samplers co-located with the Laboratory's Air Monitoring Network (AIRNET) samplers. Overall, the Bureau's data for 1997 were similar to data reported by the Laboratory.

Environmental radiation dosimetry: The DOE Oversight Bureau maintains a network of 12 thermoluminescent dosimeters (TLDs) for measuring the levels of gamma radiation and any Laboratory-related gamma radiation anomalies. Levels of gamma radiation measured by the Bureau were consistently lower than the levels measured by the Laboratory, and none of the TLD measurements were above natural background radiation levels.

Environmental radiation ambient monitoring system: The Bureau maintains an air monitoring station in Santa Fe that is part of a national EPA-sponsored network designed to collect air and water samples for analysis of radioactivity. Data from this station is available at *http://www.epa.gov/narel/erdonline.html* on the World Wide Web.

Surface water and groundwater: In 1997, the DOE Oversight Bureau began evaluating the influence of the Pajarito fault zone on surface water infiltration in Pajarito Canyon, Cañon de Valle, and Water Canyon. The study found contaminants in Cañon de Valle surface water and indications of perennial flows in both Pajarito Canyon and Cañon de Valle. Field data were also collected to better understand perennial surface water in Sandia Canyon.

The Bureau also performed a study of water and sediment quality at two locations on the Rio Grande—one upstream of the Laboratory and one downstream. Preliminary data indicate that the water quality was similar at both locations.

During 1997, Bureau staff conducted eight informal inspections at the Laboratory for liquid release notifications, the NPDES outfall reduction program, and construction activities.

Sediments, soils, vegetation, and foodstuffs: Preliminary comparisons of the analysis of split samples from selected locations indicate Laboratory data are consistent with the Bureau's data and tract historical radiological trends.

Environmental Restoration Project: The NMED formed a 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 in the prioritization of cleanup projects based on health or environmental risks versus prioritization of interim measures based on the potential for contaminant migration. Bureau staff continued to work with regulatory agencies and the ER Project to develop consensus on technical approaches in order to facilitate the review of requests for no further action.

The Bureau continues to work with the Laboratory to identify ER Project sites with the potential for erosion and to determine what measures are needed to prevent the migration of contaminants into watercourses. Staff reviewed stabilization measures at TA-21 and TA-9, Area M.

***NEPA*:** The DOE Oversight Bureau reviewed and commented on three draft DOE NEPA documents for proposed activities at the Laboratory.

D. Significant Events

1. 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 initiated in 1997 and are as follows:

- $150,000 payment to the US Treasury. Per the Consent Decree, the DOE submitted the paperwork for payment to the US Treasury Department in April 1997.
- Independent technical audits of the Laboratory's Radionuclide NESHAP program. Per the provisions of the decree and agreement, an independent team was selected and began the technical audit in June 1997. The audit is expected to be completed in fall 1998. The audit report will be submitted to DOE, which will provide copies to EPA Region 6, CCNS, and to the Laboratory's public reading room. Additional audits will be performed in future years as required.
- AIRNET stations. Per the Consent Decree, four AIRNET stations in the proximity of TA-54, Area G are operating and will continue to be operated for the next five years. In addition, AIRNET stations were installed and are operating at TA-33 and in the Santa Fe area. The quarterly raw data and analyses have been provided to the Laboratory's Reading Room and to CCNS.
- Additional thermoluminescent dosimeters (TLDs). Per the Consent Decree, in May 1997 approximately 50 new TLDs were added to the existing TLD monitoring network. The new TLDs were placed at the 17 AIRNET compliance stations, as well as at TA-53, TA-50, TA-54, TA-16, and TA-15. Seven TLDs specific to neutron detection were installed at TA-18. Duplicate TLDs were installed for quality assurance measurements. An independent laboratory is currently under contract to analyze the duplicate quality assurance TLDs. The quarterly raw data and analyses have been provided to the Laboratory's reading room and to CCNS.
- Operation of northern New Mexico NEWNET stations. Per the Consent Decree, the DOE calibrated the NEWNET stations located in northern New Mexico, and the stations are fully operational. The NEWNET data is available at *http://newnet.jdola.lanl.gov/* on the World Wide Web.
- Meetings on environmental, safety, and health issues. Per the Consent Decree, the UC's ESH Panel (a group whose purpose is to provide advice and consultation to the UC President's Council on National Laboratories) met on July 17, 1997, to hear the public's concerns on environmental issues specific to LANL. The Laboratory Director met with CCNS representatives in July 1997 to discuss protection of employees from retaliation or harassment for voicing environmental concerns, as well as to discuss CCNS's environmental concerns. Four public meetings were held in 1997 dealing with environmental issues specific to LANL's processes and programs.
- Payment to the University of New Mexico (UNM) School of Medicine. Per the Settlement Agreement, in April 1997, DOE allocated $150,000 to the UNM School of Medicine to fund development of curriculum in the Masters of Public Health degree program on environmental health issues.
- Five-day course in radiation education. Per the Settlement Agreement, in September 1997, a five-day training course on radiation exposure

and radiation protection was presented to representatives of CCNS, the Four Accord Pueblos, and regional city/county government officials in Española, NM.

- Radiation detection equipment loan program. Per the Settlement Agreement, radiation monitoring equipment was purchased in 1997 for use by individuals who attended the five-day training course. The equipment will be available through December 31, 2002. Additional equipment is continuing to be evaluated and tested for use in this program.

2. Lummis Fire.

On June 27, 1997, a wildland fire was ignited by a lightning strike in the Lummis Canyon area of Bandelier National Monument. This fire, the Lummis Wildland Fire, was managed as a prescribed natural fire. It was allowed to burn on the mesas, but handlines were constructed and backlines were secured to prevent the fire from entering nearby canyons. On July 9, it was determined that the Lummis Wildland Fire did not pose a threat to life and property, and the prescribed fire teams were demobilized. The fire burned 1,660 acres all within Bandelier National Monument.

3. Interagency Wildfire Management Team.

In the wake of the Dome Fire (Balice 1996), LANL formed the Interim Fire Management Team at the request of DOE in May 1996. After the Lummis Wildland Fire, it became evident that a more permanent organization was needed. In July 1997, the Laboratory formed the Interagency Wildfire Management Team (IWMT), which includes representatives of the following Laboratory groups: ESH-20, Emergency Management Response, Fire Protection, the ER Project, ESH-18, ESH-17, and Utilities and Infrastructure. ESH-20 chairs the IWMT. External participants include representatives from the DOE/LAAO, the Los Alamos County Fire Department, US Forest Service, Bandelier National Monument, Pueblo of San Ildefonso, NM State Forester's Office, and NM DOE Oversight Bureau. The IWMT operates under an agreement in principle.

The IWMT has worked to reestablish fire roads and fire breaks, as well as thinning trees to reduce fire fuel. In addition, a permanent logistical support center that includes a helibase for fire suppression operations was established at TA-49, allowing for rapid response by both Bandelier National Monument and LANL during the Lummis wildfire. The lines of communication and coordination between all agencies have also been strengthened.

4. National Resources Trustee Council

During 1997, DOE began to establish a Natural Resources Trustee Council in order to provide for the restoration of natural resources injured and services lost as a result of unpermitted releases of hazardous substances or discharge of oil from LANL in accordance with applicable federal laws and regulations (including sections 101, 104, 107, and 120 of CERCLA; and the Natural Resource Damage Assessment Regulations, 43 CFR Part 11 and 15 CFR Part 990). The Council provides a framework for coordination and cooperation between the trustees in order to meet this goal. Participating trustee organizations include the United States Departments of Energy, Interior, and Agriculture; the State of New Mexico; and the Pueblos of Cochiti, Jemez, San Ildefonso, and Santa Clara.

5. Lawsuit Filed

In May 1997, a national coalition of 39 citizen interest groups filed a motion with the U.S. District Court in Washington D.C. asking for a preliminary injunction to force DOE to stop work on 13 facilities at LANL, Lawrence Livermore National Laboratory and Pacific National Laboratory. The suit also charged that the 1996 Stockpile Stewardship and Management (SSM) Programmatic Environmental Impact Statement (PEIS) was inadequate and asked the Court to enforce a 1990 order for the DOE to prepare a PEIS on its Environmental Restoration Program. The DOE's SSM Program oversees the safety, security and reliability of the nation's nuclear weapons stockpile, and is a key mission at LANL. In August, the Court denied the motion for preliminary injunction. Subsequently, in January 1998, the coalition filed an amended complaint; in August 1998, the Court dismissed the portion of the plaintiff's case on the adequacy of the SSM PEIS.

E. Awards

1. Water Quality

Members of the SDWA/Engineering and NPDES Outfall Teams, at ESH-18 received awards during 1997: the 1997 Pollution Prevention Award (EM Division) for NPDES Outfall Reduction, the 1997 Distinguished Performance Award (ESH-Division) for

NPDES Outfall Reduction, and the 1997 Albuquerque Field Office Team Quality, Silver Award, was issued by DOE Albuquerque Operations Office for dedication and excellence by the High Explosives Wastewater Treatment Facility Team.

2. Air Quality

In late 1997, ESH-17 applied for and won the annual Donald Summers Quality Excellence Award for 1997. This award recognizes the organization with an outstanding quality program and adherence to quality management practices. The award was established in recognition of the late group leader of the Quality Management Group who was a strong advocate for quality within the Laboratory.

3. Air Emissions and Pollutants

a. Fuelwood Removal. LANL, through the efforts of the IWMT, won the 1997 Innovative Pollution Prevention Award" for their alternative fire control efforts at the State Road 501 fuel break." This award was presented by the New Mexico Facility Managers Network and the City of Albuquerque. Instead of conducting a prescribed burn of 110 acres at LANL, the IWMT determined that cutting and removing trees was the best approach. Trees were marked by Laboratory workers, cut by the United States Forest Service (USFS) Hot Shot Crew, then the USFS/DOE issued permits to local citizens who gathered the cut wood. By using the tree-cutting method in place of a controlled burn, the amount of air emissions were minimized, avoiding emitting 76 tons of carbon dioxide, 6 tons of VOCs, 12 tons of particulate matter, 1 ton of nitrogen oxides, and 0.1 ton of sulfur dioxides. The project also avoided sanitary waste generation in that the chipped product was used by the Laboratory for landscaping mulch and erosion control.

b. Protective Coating. During 1997, Laboratory researchers developed a method that produces highly adherent coatings of metal oxides, nitrides, carbides, and diamond-like carbon for use as coatings on metals, ceramics, and plastics that need to be protected from corrosion, erosion, friction, and stress. The new technique uses a plasma to create a graded coating that has "roots" in the substrate of the material. The gradation eliminates the problems of a sharp interface between substrate and coating and so provides excellent resistance against delimitation. In addition to improved adhesion and reduced thickness of the coating, the new technique is less expensive and more environmentally friendly than previously used methods.

c. Dry Cleaning Process. The Laboratory received a Research & Development 100 Award for a drywash system that replaces harsh dry cleaning chemicals with a liquid carbon dioxide cleaning process.

d. Nitrogen Oxide Emissions. A LANL research team won an award from the Partnership for the Next Generation of Vehicles, commonly called the Green Car Project. The LANL team won the award for its work in reducing nitrogen oxide emissions from diesel and gasoline engines.

4. Environment Reports

a. Report for Our Communities. ESH Division published and distributed 20,000 copies of a new annual report, "Environment, Safety, and Health at Los Alamos National Laboratory: A Report to Our Communities." This report gives the Laboratory, its neighbors, and other stakeholders a snapshot of some of the ESH programs. This first-time publication received several awards including an international award for technical excellence from the Society for Technical Communication and a Los Alamos Achievement Award.

b. Environmental Surveillance Reports. In August 1997, the Laboratory team that produces the annual report, "Environmental Surveillance at Los Alamos" received a Los Alamos Achievement Award. This team developed new processes and a proactive network of subject matter experts who now publish this report on schedule gaining credibility for the Laboratory in its ability to assure timely and effective reporting.

c. Habitat Management. The Laboratory's Threatened and Endangered Species Habitat Management Plan Annual Review document received a regional award from the Society for Technical Communication.

E. References

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EPA 1989: US Environmental Protection Agency, US Army Corps of Engineers, US Fish and Wildlife Service, and USDA Soil Conservation Service, Federal Manual for Identifying and Delineating Jurisdiction Wetlands, US Government Printing Office, Washington, DC (1989).

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3. Environmental Radiological Dose Assessment

primary author:

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Highlights from 1997

The calculated maximum off-site radiation exposure to a member of the public from Los Alamos National Laboratory sources is near East Gate, north of the Los Alamos Neutron Science Center; this dose of 2.2 mrem per year is below the applicable dose limits. This dose is calculated using all exposure pathways to satisfy Department of Energy requirements and is different than the air-pathway dose presented in Chapter 2, which is calculated for compliance with National Emission Standards for Hazardous Air Pollutants. The calculated maximum on-site individual exposure to a member of the public is 6.1 mrem. This member of the public is considered to be an individual who passes along Pajarito Road, near the Technical Area 18 criticality facility during multiple 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 (DOE 1990).

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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 for 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 varying degrees of effectiveness. 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. 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 1997. The doses reported below include the contributions from internally deposited radionuclides (CEDE) and from radiation exposures received from sources outside the body (EDE).

Federal government standards limit the dose that the public may receive from Laboratory operations. The Department of Energy (DOE 1990) public dose limit (PDL) 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 are presented in Chapter 2 and are based on different pathways and use different modeling programs than those for DOE requirements, which are presented in Chapter 3.

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 is a modeled dose that 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 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 that 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 very different 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 property but not necessarily employed by LANL. DOE-owned roads pass through LANL property but are generally open to public travel. Doses are calculated for a hypothetical member of the public traveling these roads.

(4) An "average" resident of Los Alamos and White Rock. These 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 gathered (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)

Ingestion of Wild Fruits and Vegetables from Mortandad Canyon

Exposure to Sediments in Mortandad Canyon

Exposure to Soils in the Vicinity of Los Alamos and White Rock

Hiking up Los Alamos Canyon from State Road 4 to DP Canyon

Jogging near TA-21.

2. General Methodology

Our 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 and described the methods we used. The general process for calculating dose from ingestion is to multiply the concentration of radionuclides in the food product or in air by the amount of food ingested or air breathed to calculate the total amount of radioactivity taken in to the body of each radionuclide. Then, this amount is multiplied by factors specific for each radionuclide (DOE 1988) to give the dose from each radionuclide. These are summed to give the total dose from ingestion of a food type or 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, the doses at receptor locations can be calculated by using a model. The model combines source term information with meteorological data to estimate where the radioactivity 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 radioactivity finds its way into nearby vegetation and animal material. We use the Generation II (GENII) model (Napier et al., 1988) because this is the accepted DOE model for dose calculation. Some of the specifics of the modeling are provided in following sections.

C. Dose Calculations and Results

Explanation of Reported Doses Including Negative Values. 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 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 past annual site surveillance reports, we have carried these negative concentrations through all calculations but then, if the calculated dose was less than zero, it was reported as zero. This year, doses are reported 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 more closely calculate actual 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 and 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 and we can have more confidence that a dose really occurred.

1. Dose to the Population Within 80 km

The population distribution is used to calculate the collective dose resulting from 1997 Laboratory operations. In 1997, the estimated population of 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 in mid-1997 (Table 3-1).

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. The population distribution given in Table 3-1 was used in the dose calculation.

The collective dose was calculated using the GENII collection of computer programs (Napier et al., 1988). Airborne radioactive emissions from all types of releases were included in the analysis. 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 9 AIRNET stations at Area G were used to calculate the diffuse emission source term from Area G. All of these source terms were put into GENII to evaluate public doses. 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 1997 collective population dose attributable to Laboratory operations to persons living within 80 km of the Laboratory was calculated to be 0.9 person-rem**.** This is comparable to the population dose of 1.2 person rem reported for 1996 (ESP 1997). 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 75% to the calculated population dose. Diffuse emissions of uranium, plutonium, and tritium from Area G and tritium from stack sources are about 25% of the dose. Plutonium, uranium, and americium from stack sources cause less 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 is at East Gate, along State Road 502 entering the east side of Los Alamos County. This has traditionally been the site of

Table 3-1. Estimated 1997 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**
N	3	3	0	0	21	0	15	127	381	2,962
NNE	3	3	0	0	31	1	711	1,244	6,463	49,597
NE	3	11	0	0	4	1	0	0	2,037	164
ENE	1	16	29	0	7	0	26	355	2,340	4
E	0	3	83	216	0	6	61	267	57	68
ESE	2	15	969	6,155	0	0	24	28	58	2,427
SE	5	31	887	1,407	0	2	23	47	418	553
SSE	7	63	639	288	0	5	19	253	154	284
S	7	68	240	129	0	13	87	917	786	566
SSW	7	61	83	16	2	10	2,311	386	646	296
SW	4	7	0	0	1	1,185	14,165	2,436	2,363	3,483
WSW	0	0	0	0	540	1,456	4,282	3,426	1,369	1,493
W	0	0	0	1	313	1,291	3,852	362	21	401
WNW	0	0	0	0	7	11	652	7,408	679	2,108
NW	0	1	0	4,552	496	0	947	69,214	7,129	640
NNW	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.

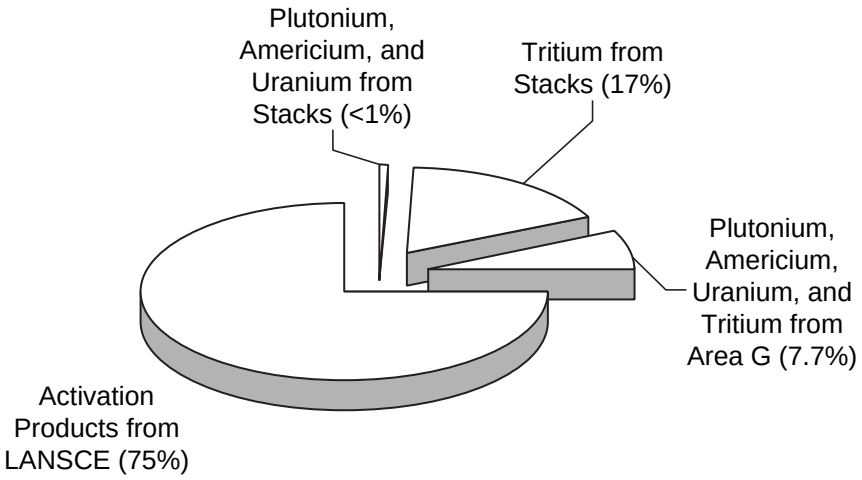

Figure 3-1. Contributions to population air pathway dose from Los Alamos National Laboratory sources.

Note: Total population air pathway dose = 0.9 person-rem.

the highest exposure to a member of the public 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.

For 1997, the off-site MEI is located at the businesses across from the old guard tower on SR 502. The dose for the off-site MEI is calculated by modeling the releases from LANSCE using the GENII computer code. The GENII computer code has been 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), located very nearby. 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 1997 MEI air pathway dose calculated using GENII for all LANSCE sources is 1.16 mrem (Figure 3-2 and 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, at East Gate. The total net dose calculated from the AIRNET data is 0.031 mrem. Airborne tritium, which gave a dose of 0.022 mrem is the major dose contributor.

The dose contribution from food grown or gathered in the area was calculated for all food products that were gathered around Los Alamos. These studies indicate contributions from produce (fruits and vegetables), piñon, milk, honey, Navajo tea, eggs, deer, and elk (Table 3-3). The total calculated dose is 0.31 mrem.

For 1997, strontium-90 was the only radionuclide detected in Los Alamos water supply wells, and it was detected only in well G-1, which serves primarily North and Barranca Mesas. Assuming that the MEI only consumed water from that well, at a rate of 2 liters per day, the dose would be 0.49 (0.27) mrem.

Soils were collected from a number of sites near or within Los Alamos (1996 Table 6-1). Using the data from sites in or near Los Alamos as input to the RESRAD computer code (Version 5.70), the dose from living on these soils was calculated to be 0.16 (0.63) mrem for 1997. The dose calculation includes subtraction of the dose from living on "background" soils, away from the Los Alamos area and considers

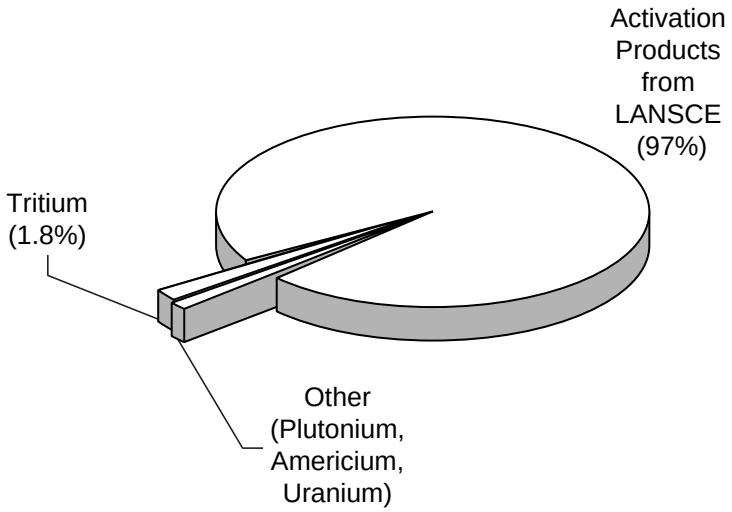

Figure 3-2. Contributions to air pathway dose at East Gate.

Note: Total air pathway dose = 1.2 mrem.

Table 3-2. Compiled Doses during 1997[a]

Sources	Receptors			
	Off-Site MEI Eastgate (mrem)	On-Site MEI Pajarito Road (mrem)	LA Average Resident (mrem)	WR Average Resident (mrem)
LANSCE[b]	1.2	0.14	0.011	0.025
TA-18	0.0000076	5	0.0000076	0.000046
AIRNET[c]	0.031	0.021	0.023	0.015
Food Stuffs Ingestion[d]	0.31	0.31	0.31	0.28
Well Water Ingestion[e]	0.49	0.49	0.49	0
Soils Exposure[f]	0.16	0.16	0.16	0.16
Total	2.2	6.1	1.0	0.5

[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 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]Calculated based on detected levels of strontium-90 in Well G-1. We include this dose for Los Alamos but not in White Rock because Well G-1 does not serve White Rock.
[f]These doses are modeled with the RESDRAD Code 5.70 using radionuclide data from local soil concentrations.

direct exposure to soil, and inhalation and ingestion of the soil.

Figure 3-3 shows the combination of the AIRNET calculated dose of 0.031 mrem (which includes the contributions from all stacks and diffuse sources at LANL), the GENII modeled dose of 1.16 mrem (which includes the contributions from LANSCE sources only), the food ingestion dose of 0.31 mrem, the water ingestion dose of 0.49 mrem, and the soils dose of 0.16 mrem gives a total off-site MEI dose of 2.2 mrem (Table 3-2). This is far below applicable standards and no adverse effects are expected.

This dose is not comparable directly to the 3.51 mrem dose reported in Chapter 2, which is calculated for compliance with 40 CFR 61. That dose assumes dose through the air pathway only and is modeled using CAP88, as required by 40 CFR 61. The dose presented here is for all pathways and uses the GENII computer code, which is the DOE code for dose assessment. We believe that the main difference in the Chapter 2 and 3 calculated air pathway doses are caused by differences in the two codes used to model the doses. In this case, CAP88 gives a more conservative but probably less realistic calculation.

3. Maximally Exposed On-Site Member of the Public (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, 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, public access is restricted by closing Pajarito Road from White Rock to TA-51. Although exposure to a member of the public would be negligible during road closures, we calculated the potential dose to a member

Table 3-3. Ingestion Doses from Foods Gathered or Grown in the Area during 1997

	Dose per Unit Consumed in 1997 (mrem)	Average Consumption[a] Dose[b] (mrem)		Maximum Consumption[a] Dose[b] (mrem)	
Produce					
Regional Background (see text)	0.00060/lb	0.078	(0.20)	0.21	(0.55)
LANL On-Site Stations	0.00022/lb	0.028	(0.23)	0.077	(0.61)
Los Alamos Townsite	–0.00019/lb[c]	–0.025	(0.23)	–0.068	(0.63)
White Rock & Pajarito Acres	–0.00032/lb	–0.041	(0.21)	–0.11	(0.56)
San Ildefonso Pueblo	–0.00067/lb	–0.088	(0.21)	–0.24	(0.58)
Cochiti Pueblo	–0.00027/lb	–0.035	(0.22)	–0.094	(0.59)
Piñon					
Regional Background (see text)	–0.0023/lb	–0.0068	(0.37)	–0.023	(1.2)
Los Alamos	–0.00021/lb	–0.00062	(0.54)	–0.0021	(1.8)
White Rock	–0.00021/lb	–0.00063	(0.57)	–0.0021	(1.9)
San Ildefonso Pueblo	0.011/lb	0.033	(0.52)	0.11	(1.7)
Milk					
Regional Background (Albuquerque)	0.0021/gal.	**0.065**	**(0.064)**	**0.16**	**(0.16)**
Los Alamos	0.0069/gal.	0.22	(0.26)	0.54	(0.64)
Pojoaque	0.0048/gal.	0.15	(0.31)	0.38	(0.77)
Honey					
Regional Background (Jemez Pueblo)	0.00042/lb	0.0014	(0.0028)	0.0047	(0.0093)
Los Alamos	–0.0000012/lb	–0.000018	(0.0034)	–0.000058	(0.011)
White Rock	–0.00036/lb	–0.0012	(0.0029)	–0.0040	(0.0097)
Navajo Tea (Cota)					
Regional Background (Española)	0.0012/L (~quart)	0.46	(1.1)	0.63	(1.5)
Los Alamos	–0.00015/L (~quart)	–0.059	(1.2)	–0.081	(1.7)
White Rock	–0.00017/L (~quart)	–0.069	(1.7)	–0.094	(2.3)
San Ildefonso Pueblo	0.00044/L (~quart)	0.18	(1.5)	0.24	(2.0)
Egg					
Regional Background (Española)	0.000018/2 eggs	0.0041	(0.0069)	0.0066	(0.011)
Los Alamos	–0.000021/2 eggs	–0.0048	(0.023)	–0.0077	(0.037)
San Ildefonso Pueblo	–0.0000050/2 eggs	–0.0011	(0.011)	–0.0018	(0.017)
Steer					
Regional Background (see text)	–0.017/lb muscle 0.054/lb bone	**2.9**	**(1.6)[d]**	**3.3**	**(1.9)[d]**
San Ildefonso	0.015/lb muscle 0.013/lb bone	0.80	(1.9)[d]	0.92	(2.2)[d]
Deer					
Regional Background (Dulce, NM)	0.0052/lb muscle 0.035/lb bone	0.17	(0.024)[e]	0.42	(0.056)[e]
Los Alamos Area Roads	–0.00066/lb muscle 0.00073/lb bone	–0.011	(0.14)[e]	–0.025	(0.33)[e]

Table 3-3. Ingestion Doses from Foods Gathered or Grown in the Area during 1997 (Cont.)

	Dose per Unit Consumed in 1997 (mrem)	Average Consumption[a] Dose[b] (mrem)		Maximum Consumption[a] Dose[b] (mrem)	
Elk					
Regional Background (Coyote, NM)	0.00021/lb muscle 0.019/lb bone	**0.11**	**(0.039)[d]**	**0.25**	**(0.088)[d]**
Los Alamos Area Roads	0.00041/lb muscle 0.031/lb bone	**0.18**	**(0.15)[d]**	**0.41**	**(0.34)[d]**
Game Fish					
Regional Background (upstream)	0.00022/lb	0.0028	(0.018)	0.010	(0.066)
Cochiti (downstream)	0.00025/lb	0.0031	(0.019)	0.012	(0.070)
Nongame Fish					
Regional Background (upstream)	0.00086/lb	0.011	(0.019)	0.040	(0.071)
Cochiti (downstream)	0.00068/lb	0.0085	(0.039)	0.031	(0.14)

[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. Those that appear to be statistically meaningful, i.e., the 2s range around the mean is greater than or equal to zero.
[e] Consumption of 0.21 lb of bone included for every pound of muscle. Those that appear to be statistically meaningful, i.e., the 2s range around the mean is greater than or equal to zero.
Note—doses presented in this table are based on foodstuffs and biota data included in Chapter 6.

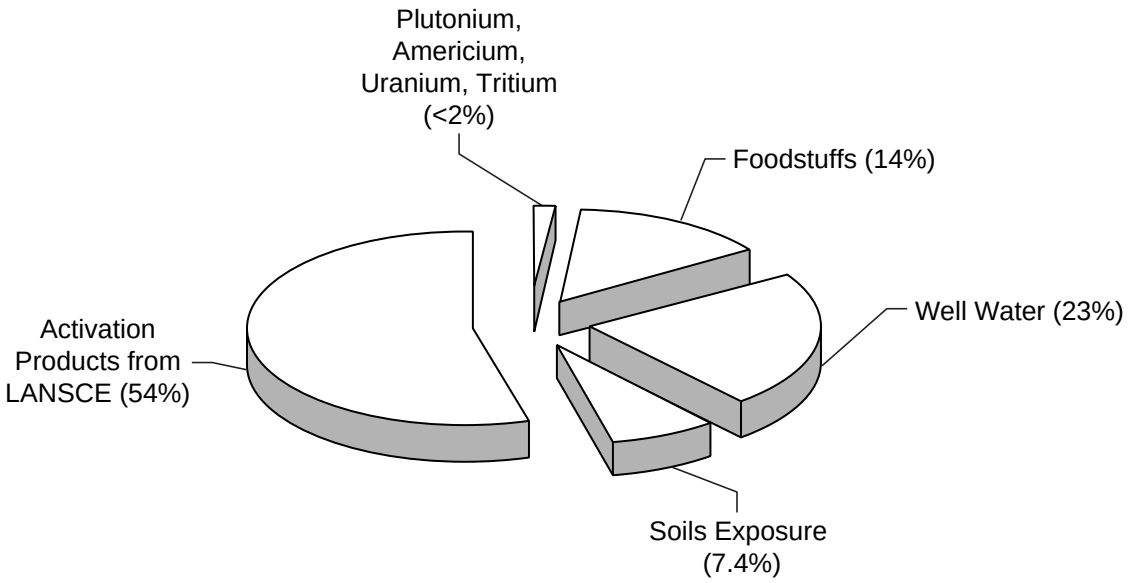

Figure 3-3. Contributions to total dose of 2.2 mrem at East Gate.

of the public who passes by TA-18 repeatedly throughout the year and thus could be subjected to multiple small exposures.

Two scenarios were evaluated: a driver in a car that passes the facility 10 times per day, 250 days per year, traveling 40 miles per hour; and 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 of an exposure occurring while the driver or jogger was within the 0.5-mile stretch of roadway passing by TA-18.

The calculations predicted that the driver of the car would receive a dose of 4 mrem and the jogger would receive 5 mrem. These are conservative calculations that assume if an exposure occurred, it would be at the maximum possible level. Furthermore, fractional probabilities of exposure are rounded up so that 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 1997, dose from food and water ingestion, from LANSCE operation, and from exposure to contaminated soils and air would add to the dose from TA-18. These additional doses are shown in Table 3-2 and in Figure 3-4. The total calculated dose to this hypothetical resident of Los Alamos would be 6.1 mrem. This dose is 6% of the DOE PDL of 100 mrem [DOE Order 5400.5 (DOE 1990)].

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

Doses to the average residents of Los Alamos and White Rock are calculated based on average air concentrations (from AIRNET) 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 previous years, the Laboratory's annual environmental surveillance report has not included 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 to dose to an average member of Los Alamos during 1997 was 1.0 mrem from all pathways (Table 3-2). Figure 3-5 shows the various Laboratory contributions to this dose. The remainder of this section explains what contributes to this 1.0 mrem dose calculation.

Air concentration data for uranium, plutonium, americium, and tritium were compiled from stations #4 (Barranca School), #5 (Urban Park), #6 (48th Street), #7 (Shell Station), #8 (McDonalds), #9 (Los

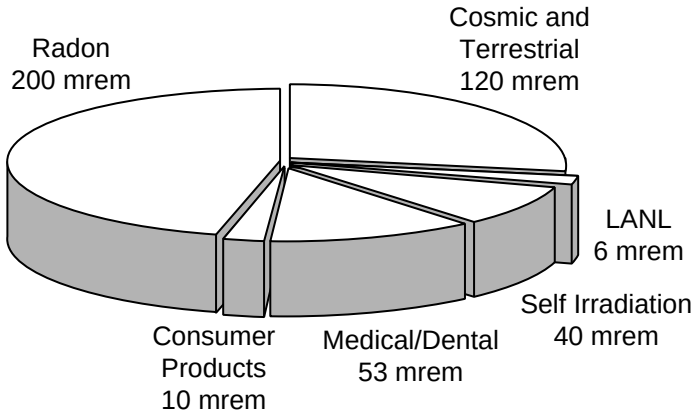

Figure 3-4. All contributions to the 1997 radiation dose for the Laboratory's maximum exposed individual.

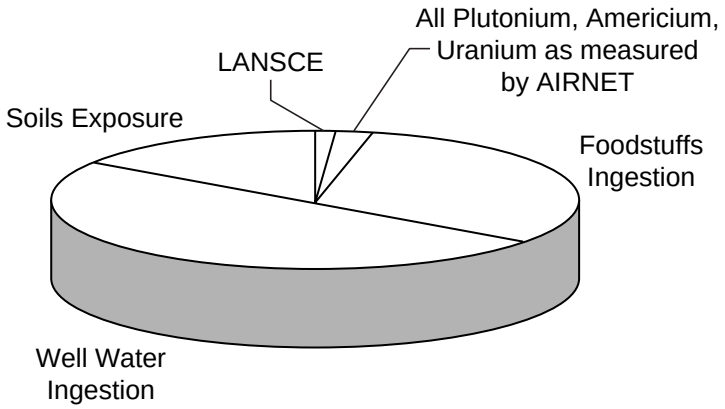

Figure 3-5. Laboratory contributions to dose (1.0 mrem) to an average Los Alamos resident.

Alamos Airport), #10 (East Gate), #12 (Royal Crest Trailer Court), #60 (Los Alamos Canyon), #61 (Los Alamos Hospital), and #62 (Trinity Bible Church). The modeling to calculate doses from the AIRNET data includes the dose a person would receive from inhalation and contaminated food and soil from the immediate area. The total dose calculated from the Los Alamos AIRNET data is 0.023 (0.0093) mrem.

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 by GENII to be 0.011 mrem from LANSCE and 0.0000076 mrem from TA-18 (Table 3-2).

As discussed earlier, the dose calculated (with two standard deviations in parentheses) from exposure to contaminated soil in Los Alamos is 0.16 (0.63) 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 could give a dose of 0.31 (1.4) mrem, including consumption of fish caught in Cochiti Reservoir (Table 3-2).

Ingestion of water from local wells is another exposure source for residents of Los Alamos. For 1997, only one of the Los Alamos water supply wells (G-1) showed any radionuclides above the detection limit. Strontium-90 in this well showed a concentration of 5.19 (1.39) pCi per liter (see Table 5-18 and Section 5.D.3.c). Assuming consumption of 2 L of water per day (considered to be the maximum reasonable consumption), the dose from this well water, uncorrected for background strontium-90, would be 0.49 mrem. This is quite conservative because most of the water consumed in Los Alamos would be from a combination of the wells and the average concentration of strontium would be near zero.

b. White Rock Dose. The total dose from all pathways to an average member of White Rock from Laboratory operations was 0.5 mrem in 1997. The methodology for calculating the White Rock dose was identical to that used for Los Alamos. The AIRNET stations used to calculate average White Rock air concentrations were #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 dose calculated from these data is 0.015 (0.012) mrem. The dose contribution from LANSCE operations in 1997 was 0.025 mrem, and the contribution from TA-18 was negligible (Table 3-2).

Because none of the water from well G-1 reached White Rock residents in 1997, 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; the dose would be 0.16 (0.63) mrem from exposure to soils. Ingestion of locally grown or gathered food products would provide a dose of 0.28 mrem (Table 3-3).

5. Ingestion Doses for Various Locations in Northern New Mexico

Many different types of potential food products are collected and analyzed for their radionuclide content. The following section presents the details of calculat-

ing food ingestion doses for various potential receptors 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, i.e., potential 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.

Three calculations are performed: one assuming average consumption rates, one assuming maximum hypothetical consumption rates, and one for dose-per-unit of food consumed. The consumption rates 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.

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 is 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 are shown in Table 6-3. For 1997, the average American consumed an average of 130 lb per year and a maximum of 352 lb per year of fruits and vegetables (NRC 1977). The highest doses were calculated to have occurred from ingestion of food products in regional background locations. The average consumption net dose at Los Alamos on-site location of 0.028 mrem has an associated two standard deviation value of 0.23, indicating the large uncertainty in this low value.

b. Ingestion of Piñon. Doses for ingestion of piñon are calculated and presented separately from other produce because of the traditional importance of piñon in the native diet. Because piñon nuts were not available for collection, piñon shoot tips were collected and analyzed and are reported in (Table 3-3). The dose calculated from hypothetical ingestion of shoot tips is greater than that from nuts because radionuclides tend to collect in higher concentrations in the tips than in the nuts (Salazar 1979). The highest (and only positive) unit dose of 0.011 mrem per pound of piñon was seen at the Pueblo of San Ildefonso. We assumed that the average annual consumption was about 3 lb and that the maximum annual consumption was 10 lb. The average consumption dose at the Pueblo of San Ildefonso for 1997 was calculated to be 0.033 (0.52) mrem.

Piñon tree nuts are produced irregularly in nonannual cycles about every seven to 10 years and there was no crop produced in 1997. Although it is not known whether the use of piñon tree foliage to estimate the dose for the ingestion of pine nuts is an acceptable surrogate for nuts, most literature suggests that the nonedible portions of plants tend to have higher concentrations of radionuclides than the edible portions of plants. Therefore, the use of piñon tree foliage to estimate doses for the ingestion of pine nuts is probably an over (conservative) estimation of risk.

c. Ingestion of Milk. Milk from Los Alamos, Pojoaque, and Albuquerque (as background) was collected and analyzed (Table 6-7). The largest net doses from milk ingestion were seen in the Los Alamos area where consumption of each gallon of milk would yield a dose of 0.0069 mrem (Table 3-3). Average annual consumption of 31.3 gal. of milk would have resulted in a dose of 0.22 (0.26) mrem and consumption of 78.4 gal. of milk, considered a maximum amount, would have yielded a dose of about 0.54 (0.64) mrem. Cesium-137 and iodine-131 are the largest contributors to dose.

d. Ingestion of Honey. Honey was collected and analyzed from two locations in Los Alamos and two locations in White Rock, and from Jemez Pueblo, which was used as the background location. Average annual consumption of honey was assumed to be 3.3 lb and maximum annual consumption was assumed to be 11 lb. The highest (and only positive) consumption dose was calculated for the background location (Jemez Pueblo) (Table 3-3) and was 0.0014 (0.0028) mrem for average consumption in 1997.

e. Ingestion of Navajo Tea (Cota). Navajo tea (Cota) leaves were collected from Los Alamos, White Rock/Pajarito Acres, the Pueblo of San Ildefonso and Española (as the background location). The largest doses were calculated from the background location (Española) and were 0.0012 mrem per liter of tea consumed (Table 3-3). The largest (and only positive) net dose was determined for the Pueblo of San Ildefonso, where an average annual consumption of 402 L per year would have resulted in a net dose of 0.18 (1.5) mrem, and a maximum annual consumption of 548 L would have given a dose of 0.24 (2.0) mrem.

f. Ingestion of Chicken Eggs. Chicken eggs were collected and analyzed from Los Alamos, the Pueblo of San Ildefonso, and from Española (as a background location). All of the doses calculated from egg consumption were extremely small; none were statistically different than zero. The only positive doses were calculated for the background location in Española, where the unit dose from eating two eggs was 0.000018 mrem (Table 3-3). An annual dose from an average consumption of about 1.25 eggs per day would be 0.0041 (0.0069) mrem, and a maximum consumption of about 2 eggs per day would be 0.0066 (0.011) mrem.

g. Ingestion of Steer Meat and Bone. A free-range steer was collected from Pueblo of San Ildefonso lands and a regional background steer was collected from El Rito (Table 6-12). Doses for consumption of meat and bone from the background steer and for consumption of the steer from the Pueblo of San Ildefonso, after subtracting the background dose are presented in Table 3-3. The background dose (with two standard deviations shown in parentheses) 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 3.3 (1.9) mrem. The net dose from average consumption at the Pueblo of San Ildefonso is 0.80 (1.9) mrem, and the dose from maximum consumption is 0.92 (2.2) mrem. Consuming muscle or bone would give doses 0.015 and 0.013 per pound, respectively.

h. Ingestion of Deer Meat and Bone. Deer killed along roadways around Los Alamos were collected, and their meat and bone tissue were analyzed, and compared to regional background samples. The dose from the background deer was calculated to be 0.0052 mrem per pound of muscle consumed and 0.035 mrem per pound of bone consumed. At an average consumption rate of 20.9 lb of muscle and 4.4 lb of bone, the 1997 background dose was 0.17 (0.024) mrem. Maximum consumption of 50 lb of muscle and 11 lb of bone would have given a dose of 0.42 (0.056) mrem. Calculated net dose for the deer roadkills near Los Alamos was negative; the average consumption dose calculated as –0.011 (0.14) mrem.

We can probably never say that on a definitive basis that the elk or deer collected on LANL lands as road kill lived or fed on LANL property for any given length of time. However, we now have strong evidence, based on a two year radio collaring study, that elk that have spent an average of 50% of their time on LANL lands contain similar radionuclide concentrations in muscle and bone as those that have been collected as road kill as part of the environmental surveillance program. These data are scheduled for publication at the end of 1998.

i. Ingestion of Elk Meat and Bone. Elk were collected around Los Alamos and their meat and bone tissue was analyzed and compared to a regional background elk samples. The dose from the background elk was calculated to be 0.00021 mrem per pound of muscle consumed and 0.019 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 1997, the background dose was 0.11 (0.039) mrem. The maximum consumption rate of 50 lb of muscle and 13 lb of bone would have given a dose of 0.25 (0.088) mrem. Calculated net dose for consumption of the Los Alamos elk was 0.00041 mrem per pound of muscle and 0.031 mrem per pound of bone consumed. At an average consumption rate the calculated dose is 0.18 (0.15) mrem, and at maximum consumption rate, the dose would be 0.41 (0.34) mrem (Table 3-3).

j. Ingestion of Fish. Surface feeding fish (referred to as game fish), including trout, walleye, and bass, were collected from reservoirs upstream of LANL (Abiquiu, Heron, and El Vado) and compared to game fish collected from Cochiti Reservoir, downstream of LANL. The calculated net dose from downstream game fish was slightly higher than the 0.0028 (0.018) mrem dose for upstream fish although the uncertainties indicate the doses are statistically not different from each other (Table 3-3). At an average annual consumption of 12 lb of fish, the net downstream dose would be 0.0031 (0.019) mrem, and it would be 0.012 (0.070) at maximum consumption of 46 lb.

Bottom-feeding fish (referred to as nongame fish), including carp, catfish, and sucker, were collected 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 used for game fish.

k. 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 these analyses were used 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 3-4. The total dose from consumption at average rates (as defined in the text of Section 3.C.5) was calculated to be 1.1 (2.5) mrem. The large uncertainty indicates that the actual dose may be zero. The largest contributor to this reported dose was from consumption of steer meat from a steer that was collected on Pueblo of San Ildefonso lands.

Table 3-4. Dose from Foodstuff Grown or Gathered Near Pueblo of San Ildefonso Lands

Food Product	Dose[a] (mrem)	
Produce	–0.088[b]	(0.21)
Piñon	0.0333	(0.52)
Navajo Tea	0.18	(1.5)
Eggs	–0.0011	(0.011)
Steer	0.80	(1.9)
Deer	–0.011	(0.14)
Elk	0.18	(0.15)
Total Annual	1.1	(2.5)

[a] Dose assumes average consumption rates as defined in the text. Two standard deviation values are shown in parentheses.

[b] See Section 3.C for an explanation of negative numbers.

Sampling from wells in and around the Pueblo of San Ildefonso revealed four cases where uranium in the groundwater exceeded about 25% of the EPA-proposed drinking water MCL of 20 µg of uranium per liter of water. The dose from ingesting this groundwater was calculated assuming 2 liters per day were consumed of this water. The ratio of the uranium isotopes was assumed to be the same as natural isotopic ratios. The dose from drinking the uranium in these well waters is shown in Table 3-5. The highest calculated dose was from the New Community Well with a dose of 2.8 (0.56) mrem. 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.

l. Conclusions. Potentially significant doses were seen for consumption of milk, steer, deer, and elk from background areas in the Los Alamos area. By significant, we mean that the uncertainty in the measurements (which are shown in parentheses) are 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 statistically different that zero.

Table 3-5. Dose from Ingestion of Two Liters of Water per Day from Wells Near San Ildefonso

Well Name	Committed Dose[a] (mrem)	
Pajarito Well	1.37	(.27)
Don Juan Playhouse Well	0.87	(0.17)
New Community Well	2.81	(0.56)
Sanchez House Well	1.64	(0.33)

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

The largest statistically significant dose is from ingestion of steer collected in El Rito, NM. This totaled 2.9 (1.6) mrem for average consumption rates. Consumption of an average quantity of elk from the Los Alamos area would give a dose of 0.18 (0.15) mrem.

6. Special Scenarios

a. Ingestion of Radioactive Effluent from the Technical Area 50 Outfall. TA-50 discharges residual radioactive effluent to Mortandad Canyon. During 1997, the effluent included tritium; sodium-22; 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 the area below the outfall is not closed to the public, it is possible 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 of effluent consumed is calculated to be 1.2 mrem per liter. Last year, the dose was also reported as 1.2 mrem per liter (ESP 1997). The plutonium isotopes (238, 239, and 240) and americium-241 contribute the majority of this calculated dose.

b. Ingestion of Wild Fruits and Vegetables from Mortandad Canyon. Fruits and vegetables were collected from LANL/DOE property in areas where members of the public, including Native Americans, would be unlikely to gather fruits or vegetable to ingest. However, because access to the areas is not closed, we cannot discount the possibility that an individual might consume small quantities of the edible materials. Dose calculations are shown in Table 3-6 and are based on the concentrations shown in Table 6-3. Strawberries provide the largest dose, at 0.12 mrem per pound consumed.

Table 3-6. Mortandad Ingestion during 1997

	Gross Dose Total[a] (mrem/lb)
LANL (Mortandad Canyon):	
Raspberries	0.00243
Currants	0.00287
Acorns	0.0280
Wild Rhubarb	0.0947
Rose Hips	0.00389
Piñon (shoot tips)	0.00300
Strawberries	0.120

[a]These doses do not include a subtraction for background concentrations.

c. Exposure to Sediments in Mortandad Canyon. In previous annual environmental surveillance reports (ESP 1996, 1997), we modeled potential doses from contaminated sediments in Mortandad Canyon. We performed a similar residual radioactive material computer code (RESRAD) analysis this year for comparison with earlier reports but have also included a more realistic assessment of potential doses without using RESRAD. Both analyses are presented below.

Radioanalytical results for sediments collected from Mortandad Canyon in 1996 were modeled using the RESRAD model, version 5.70. The pathways evaluated included external gamma exposure from radioactive material deposited in the sediments, inhalation of materials resuspended by winds, and soil ingestion. Because water in the canyon is not generally used for drinking water or irrigation and there are no cattle grazing in the canyon or gardens in the canyon, the drinking water, meat ingestion, and fruit/vegetable ingestion pathways were not considered.

The RESRAD model was run for each of 11 sampled locations for any radionuclides detected. Locations include the Chemistry and Metallurgy Research (CMR) Building, west of GS-1, GS-1, MCO-5, MCO-7, MCO-9, MCO-13 [A-5], A-6, A-7, SR-4 [A-9], and A-11 and are shown in Figure 5-5**.** A background was determined for each radionuclide by averaging values for river and lake (reservoir) sediments distant from LANL. These background values were subtracted from the concentrations reported for Mortandad Canyon and were used to calculate potential net doses from exposure to these sediments. The input parameters for the RESRAD model are summarized in Table 3-7.

The total dose at each sampling location is presented in Table 3-8. For comparison, the 1996 dose for each monitoring location is also shown. In 1997, the maximum dose was 23 mrem at the GS-1 sampling location. Figure 3-6 shows the dose contributions from each radionuclide at each location. Direct exposure to cesium-137 is the largest contributor to dose. For monitoring locations away from GS-1 (i.e., near the CMR building, MCO-13 (A-5, A-6, A-7, A-9, and A-11), the naturally occurring radionuclides of uranium, strontium-90, and cesium-137 from nuclear atmospheric testing contributed more than 5% of the dose.

The dose calculated by RESRAD is quite unrealistic and overly conservative because the sediment channel is generally rocky and choked with brush, and it is extremely unlikely that a person would spend much time in the actual stream bottom. Rather than walk through the stream bed, visitors generally walk or jog or ride bikes along the road/trail nearby. This road/trail crosses the stream channel above GS-1, but generally lies 40 to 120 m from the channel for the 1.8 km below GS-1. We recalculated a more likely dose rate from walking along this road in the vicinity of the most contaminated sediments at GS-1. The following assumptions were made:

- The entire stream channel for approximately one mile is contaminated at the highest measured concentration of 15.5 pCi per gram.
- The contaminated volume is 1 m deep, 1 m wide, and 1,760 m long.
- All the dose is from direct exposure to cesium-137 (no inhalation or ingestion).
- The visitor is an average distance of 50 m from the stream channel.
- No shielding is assumed between the sediments and the visitor.

Table 3-7. RESRAD[a] Input Parameters for Mortandad Canyon Sediments Collected in 1997

Parameter	Value	Comments
Area of contaminated zone	100 m^2 [,b]	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 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 top most unit being sand (Purtyman 1983) and Table 13.1 in the data handbook [Yu 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)
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]

[a]RESRAD is a computer modeling code designed to model radionuclide transport to the environment.
[b]For each sampling location, the area of the contaminated zone was assumed to be 100 m^2.

Table 3-8. Total Effective Dose Equivalent[a] (mrem) for Mortandad Canyon

Location	1997		1996	
Near CMR Building	0.16	(± 0.058)[b]	0.16	(± 0.032)[b]
West of GS-1	0.022	(± 0.082)[b]	3.3	(± 0.60)[b]
GS-1	23	(± 2.8)[b]	24	(± 3.4)[b]
MCO-5	19	(± 3.4)[b]	21	(± 3.2)[b]
MCO-7	5.9	(± 0.91)[b]	8.8	(± 1.4)[b]
MCO-9	0.041	(± 0.076)[b]	0.78	(± 0.21)[b]
MCO-13 (A-5)	0.0041	(± 0.016)[b]	0.65	(± 0.19)[b]
A-6	3.3	(± 0.69)[b]	0.41	(± 0.097)[b]
A-7	0.038	(± 0.053)[b]	0.36	(± 0.072)[b]
SR 4 (A-9)	0.011	(± 0.061)[b]	0.19	(± 0.057)[b]
Rio Grande (A-11)	0.0051	(± 0.17)[b]	0.16	(± 0.12)[b]

[a]Based on results from RESRAD version 5.70.
[b]±2 sigma in parenthesis; to convert to μSv multiply by 10.

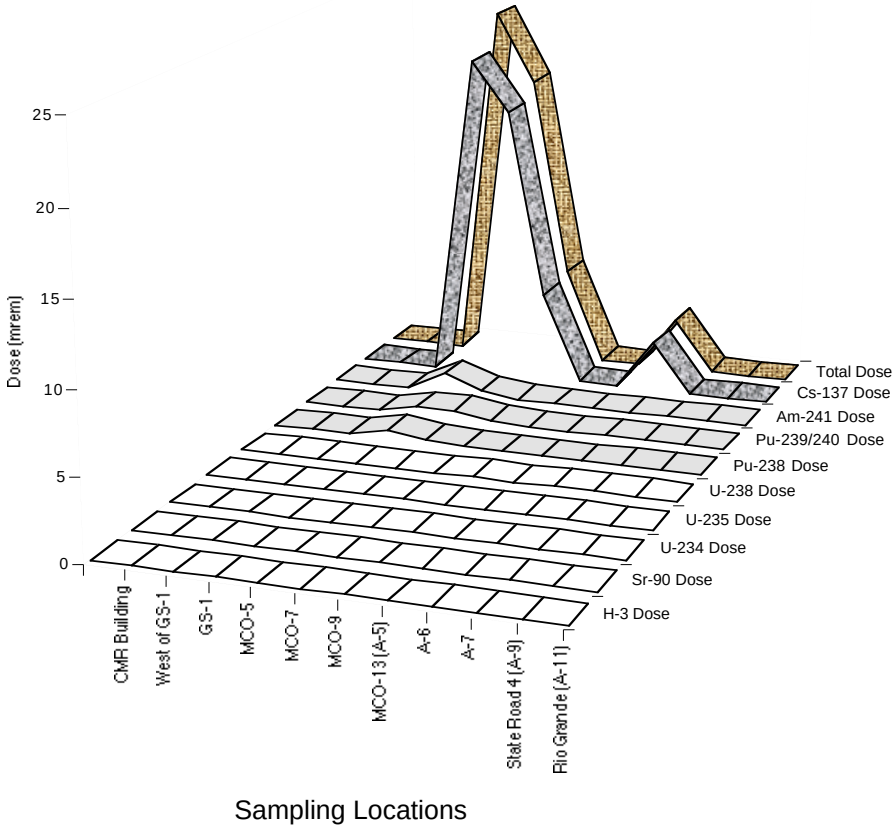

Figure 3-6. RESRAD calculated dose in 1997 from exposure to contaminated sediments in Mortandad Canyon.

- The visitor is in the area about an hour each day, 200 days per year.

The dose calculated for this scenario is 0.22 mrem. This number is about 1/100th or 1% of that calculated using RESRAD and represents a much more realistic estimate of potential dose received by visitors to this area. This is our best (but still conservative) estimate of the dose someone would receive walking along this road 200 times per year. Inhalation of cesium-137 and americium-241 would add an extremely small increment to this dose.

d. Exposure to Soils in the Vicinity of Los Alamos and White Rock. A simplified version of the residential scenario originally developed by Fresquez and others (1996a) was used in a computer model, RESRAD (version 5.70), to estimate the EDE from external radiation and the CEDE from internally deposited radiation (Yu et al., 1995). The primary simplification was that the modeling performed here did not consider horizons other than the contaminated zone. The rationale behind this simplification is that we are not including the plant or drinking water ingestion pathways here because they are evaluated through direct measurement of these media. With these pathways we have included direct exposure to, inhalation of, and ingestion of, contaminated soil. Inclusion of zones other than the contaminated soil horizon 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.

The net dose and two standard deviations for Los Alamos/White Rock area were found to be 0.16 (0.63) mrem. The background dose was 0.50 (0.25) 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.

e. Hiking up Los Alamos Canyon from State Road 4 to DP Canyon. Over a period of about 50 years, a number of LANL operations, primarily at TA-21, released contaminants into DP Canyon, which drains into Los Alamos Canyon about 2.5 mi west of State Road 4. The main source for the contaminants is believed to be an outfall (#21-011[k]) that discharged radionuclides including americium-241, cesium-137, plutonium-238, plutonium-239, and strontium-90 (Reneau and McDonald 1996).

Data were collected to assess radionuclide concentrations in Los Alamos Canyon Sediments**.** These stream channel and overbank deposits were analyzed down to depths of more than a meter to determine concentrations of radionuclides. Most of the contamination appears to have deposited within about 80 m of DP Canyon although slightly elevated levels of contaminants continue down Los Alamos Canyon. We used these data to evaluate potential exposures a visitor to this area might receive.

The scenario for exposure is as follows:

A casual hiker walks up the Los Alamos Canyon stream channel every day of the year and takes 4 hours for the approximately 8 km walk from State Road 4 to DP Canyon confluence and back. This assumption is quite conservative in that most hikers would likely follow the road, which parallels the stream bed and is quite a bit farther from the contamination. The hiker is assumed to be about 5 m, on average, from the overbank deposits and is assumed to be directly in contact with the channel deposits. No background subtraction was made for the sediment concentrations. Therefore, the reported doses are "gross" doses. Calculations based on net concentrations would reduce these doses.

Based on the scenario described above, the hiker would receive a dose of about 2.7 mrem for the entire year. It is probably unreasonable to assume that any one person would do this particular hike every day. The dose received per hike is estimated to be 0.0074 mrem. Individuals who mainly stay on the road as they walk through the canyon would receive a much smaller dose.

f. Walking Near the Northeast Corner of Technical Area 21. The thermoluminescent dosimeter (TLD) at TA-21, Area T indicated an annual dose at that site of 307 (17) mrem for 1997. This is approximately double the annual dose seen on TLDs, and the extra dose, is attributed to residual cesium-137 ground contamination. Because this is an area that workers walk or jog by frequently, we calculated a potential dose to a hypothetical walker. Assuming that about half of the 307 mrem is attributable to the cesium-137 ground contamination, then the annual dose above background is about 160 mrem. This dose would occur if an individual spent 24 hours per day, 365 days per year at the TLD site. Assuming that a person walked by the site once per day, 200 days per year, spending about 10 minutes per trip near this

location, their total time at this location would be about 33 hours per year. This is about 0.4% of the total time in a year and would result in a dose from the ground contamination of about 0.61 mrem. An individual who spent more or less time in this area would receive a correspondingly larger or smaller dose.

D. Estimation of Radiation Dose Equivalents for Naturally Occurring Radiation

Operations at LANL contribute radiation and radioactive materials to the environment. To understand the Laboratory's impact, 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 in the 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 and terrestrial 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 1975a).

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. This estimate may be revised 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 of total environmental doses (<0.3% [NCRP 1987a]). Naturally occurring radiation dose is due primarily to exposure to the lungs from radon decay products and exposures from non-radon sources that affect the whole body.

Finally, 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 3-4. 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

1. Estimating Risk

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 radiation dose, a sizable body of research indicates that the calculation will over estimate the actual risk.

2. Risk from Laboratory Operations

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 1997 Laboratory activities were 1.0 and 0.5 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 1975a).

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.

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4. Air Surveillance

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Highlights from 1997

Three instances of elevated air concentrations were investigated in 1997: plutonium and americium at one location within Technical Area (TA) 54, Area G; plutonium and americium at TA-21; and gross alpha and beta at the Los Alamos county landfill. At TA-54, Area G, elevated levels of plutonium and americium were measured by two air sampling network (AIRNET) samplers (see Section 4.A). A nearby area of contamination, which had been brought to the surface by trenching activities and was being resuspended by construction and use of a rerouted dirt road, was covered with a mixture of sand and gravel to isolate the contamination and greatly reduced ambient concentrations. However, the concentrations have not dropped to pre-1995 levels. Additional mitigation is possible. The elevated gross alpha and beta measurements at the Los Alamos County landfill appear to be caused by radon decay products, but the evidence is not conclusive. Elevated concentrations of plutonium and americium were measured at TA-21 and may have been related to soil disturbances or to past decontamination and decommissioning activities.

In early 1998, we found that the silica gel collection media used to collect tritiated water was not capable of removing all of the moisture from air samples. 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 Air Quality Group began routine publication of AIRNET data on the World Wide Web during 1997, and data are now available on the World Wide Web within two to three months following the sampling period. The web site at http://www.air-quality.lanl.gov/ also includes followup information on investigations of higher than normal values.

In January 1997, the DOE and the Laboratory reached an agreement with the Concerned Citizen's for Nuclear Safety, which settled a lawsuit concerning violations of the Clean Air Act. As part of the agreement, additional air monitoring and penetrating radiation stations were added to the existing AIRNET and the thermoluminescent network (TLDNET) programs, respectively. Two AIRNET stations were added at TA-33 and in Santa Fe, and over 50 TLDNET stations, primarily located on Laboratory property, were established. In addition, seven neutron monitoring stations were established in the vicinity of TA-18, the Los Alamos Critical Assemblies Facility.

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4. Air Surveillance

A. Ambient Air Sampling

1. Introduction

The radiological air sampling network at Los Alamos National Laboratory (LANL or the Laboratory) is designed to measure environmental levels of airborne radionuclides that may be released from Laboratory operations. Laboratory emissions include plutonium, americium, uranium, tritium, and activation products. Each 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). Regional levels of radioactivity in the atmosphere, which are useful in interpreting air sampling data, are summarized in Table 4-1.

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 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 1997, the Laboratory operated more than 50 environmental air samplers to sample radionuclides by collecting water vapor and particulate matter. This air sampling network is referred to as AIRNET (Figures 4-1 through 4-3). Sampling locations are categorized as regional, pueblo, perimeter, quality assurance (QA), Technical Area (TA) 21, TA-15, TA-54 (Area G) or other on-site locations. There are four regional sampling stations for determining regional background and fallout levels of atmospheric radioactivity. These regional stations are located in Española, El Rancho (this station replaced the Pojoaque station in early 1997), and at two locations in Santa Fe. The pueblo monitoring stations are located at the Pueblos of San Ildefonso, Taos, and Jemez. In 1997, there were more than 20 perimeter stations 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, there is a backup station located at East Gate. Stations can also be classified as being inside or outside a controlled area. A controlled area is defined as having possibly radioactive materials or elevated radiation fields and are clearly posted as such (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 is equipped with a filter to collect a particulate matter sample for gross alpha/beta and radiochemical determinations and a silica gel cartridge to collect water vapor for tritium determination. 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 gross alpha and beta analysis. 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 1997) and in the numerous procedures through which the plan is implemented.

b. Data Management. The 1997 field data, including timer readings, readings for the flow in the sampling trains 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. These data were later transferred to a table format within the ESH-17 AIRNET Microsoft Access database.

c. Analytical Chemistry. One-half of each 1997 particulate matter filter was analyzed biweekly by a commercial laboratory for gross alpha and gross beta. A composite for isotopic analyses was prepared quarterly for each station by combining the remaining half filters from the six or seven sampling periods

during the quarter. Every two weeks, Air Quality Group (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 1997, ESH-17 maintained a program of blank, spike, duplicate, and replicate analyses. This program was designed to provide information on the quality of the data received from analytical chemistry suppliers. The chemistry met 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 generally 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 standard deviation values in the tables represent one standard deviation calculated from the sample data. In past surveillance reports, two standard deviations were generally reported. 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. When the true value does reach zero, the measured value is equal to the total random errors. Because the random errors are normally distributed with a mean of zero, half of the measured values are expected to be negative and half are expected to be positive. Arbitrarily discarding negative values when the true value is equal to zero, will result in expected mean values being overestimated by approximately 0.67 standard deviations.

b. Gross Alpha and Beta Radioactivity. Gross alpha and gross beta analyses are used 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 exhibit considerable environmental variability, and for alpha measurements analytical variability. The 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 1997 and analyzed for gross alpha and gross beta activity. As shown in Table 4-2, the annual mean for all of the stations are 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. 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 1997, Laboratory operations released 420 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 1998). 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.

These sampling results for tritiated water concentrations are presented in Table 4-4. Average annual concentrations for 1997 at all of the on-site stations are higher than all of the regional and pueblo stations. Most of the perimeter stations were also higher than the regional and pueblo stations. These data clearly indicate that the Laboratory is a measurable source of tritium based on ambient measurements.

The highest off-site annual concentration of 3.8 pCi per cubic meter was at station #8 in Los Alamos. This represents only about 0.25% 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. Station #35 is located in a radiological control area, near shafts where tritium-contaminated waste has been disposed. However, the annual mean concentration, 605 pCi per cubic meter, is only about 0.003% of the Department of Energy (DOE) derived air concentration (DAC) for worker exposure (20×10^6 pCi per cubic meter).

Elevated mean air concentrations were also seen at other Area G 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 of tritium from some used glove boxes that are stored nearby. Annual mean concentrations at all sampling sites were well below the applicable EPA and DOE guidelines.

If the tritium concentrations for this report had been calculated using the amount of water vapor collected by the silica gel as the atmospheric water vapor measurements, the concentrations would generally be from 30% to 70% of the reported values. The high on-site concentration (#35) would drop by 68% to 195 pCi per cubic meter and the highest off-site concentration (#8) would drop by half to 1.9 pCi per cubic meter.

d. Plutonium. While plutonium occurs naturally at extremely low concentrations, it is not naturally present in measurable quantities in the ambient air. All measurable sources are from nuclear explosions, 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 concentrations in ambient air (Eisenbud and Gesell 1997). Four isotopes of concern can be present in the atmosphere: plutonium-238, plutonium-239, plutonium-240, and plutonium-241. However, plutonium-241 is not measured because it is an insignificant alpha emitter that decays by beta emission to americium-241. This beta decay in not only hard to measure, but the dose is insignificant 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-54, Area G stations, with an annual mean of 3.0 aCi per cubic meter. This corresponds to approximately 0.15% of the EPA public dose limit. The highest annual mean for an individual station, which was in a controlled access area, was at station #27 on the north perimeter of TA-54, Area G, with an annual mean activity of 19 aCi per cubic meter. This corresponds to approximately 0.9% of the EPA's public dose limit, or about 0.09 mrem. The data from this station indicate continued elevated concentrations of plutonium, americium, and uranium as originally described in the 1996 environmental surveillance report (ESP 1997) and in a recent paper (Kraig et al., 1998). Additional details concerning these higher concentrations are provided in Section 4.A.5 of this chapter.

Sampling results for plutonium-239 are presented in Table 4-6. As with the plutonium-238 analyses, most of the analytical results were below the MDA. Only TA-54 concentrations were above the MDA for more than 50% of the samples. The regional, pueblo, and perimeter station group summaries all indicate annual means near zero. The highest annual mean at any off-site station occurred at three locations and was

1.4 aCi per cubic meter of plutonium-239, -240. This annual mean concentration corresponds to approximately 0.1% of the EPA's public dose limit, or about 0.01 mrem. The stations at TA-21 have an annual group mean that is higher than the other groups, with the exception of the TA-54, Area G stations discussed below. The somewhat elevated concentrations at TA-21 may have resulted from increased ground-level emissions associated with resuspension of soil containing elevated plutonium concentrations.

The maximum on-site station mean for plutonium-239 (679 aCi per cubic meter) was recorded at station #27, TA-54, Area G. This concentration is equivalent to a dose of 4.5 mrem, or .03% of the DOE DAC limit for worker exposure. There has been a significant increase in the air concentration of plutonium-239 at station #27 beginning during the second quarter of 1995 and continuing at least through the final quarter of 1997 with reductions due to mitigation (see Section 4.A.5).

e. Americium. The americium-241 concentrations are the primary source of dose caused by the release of plutonium-241. As a decay product of plutonium-241, measurable sources are from nuclear explosions, the nuclear fuel cycle, and other related activities.

Americium results are presented in Table 4-7. As described for plutonium-238 and -239, americium is present in very low concentrations in the environment, and this is indicated by the low annual mean concentrations seen at the regional, pueblo, and perimeter station summaries. Most of the off-site measurements are below the MDA. The slightly elevated americium concentrations at the TA-21 stations 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 100 times higher than the next highest annual concentration. This concentration, 469 aCi per cubic meter, is equivalent to a dose of 2.5 mrem, only 0.02% of the applicable DOE DAC.

f. Uranium. Three isotopes of uranium are naturally present in the ambient air: 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 outside this range (Eisenbud and Gesell 1997). Uranium results are given in Tables 4-8 through 4-10.

All annual mean concentrations of the three uranium isotopes were well below the applicable EPA and DOE guidelines. The highest on- or off-site annual mean concentrations for all three uranium isotopes were at station #27, where, as noted previously, there are elevated concentrations of other radionuclides. However, the proportional increases in uranium isotopic measurements at this site are not nearly as dramatic as the increases for plutonium and americium. The relative abundance of the three isotopes indicate that the concentrations are attributable to natural uranium. Therefore, the higher concentrations of uranium at this site are apparently caused by the higher levels of suspended particulate matter from unpaved roads and surface soil disturbances.

Most of the uranium-235 measurements, both on - and off-site, were below the MDA (97%) whereas only about 20% of the uranium-234 and uranium-238 concentrations were below the MDA. Both the regional and pueblo groupings had higher average concentrations of uranium-234 and uranium-235 than all of the other groupings except for the TA-54, Area G stations. The regional and pueblo groups were also higher than the perimeter group for uranium-238, but on-site concentrations were generally higher probably because of various Laboratory sources of uranium-238 as discussed in the following paragraph. These higher off-site concentrations indicate that the high background levels of particulate matter and natural uranium in the soils usually predominate when compared to Laboratory contributions.

In addition to releases of uranium from some Laboratory facilities, depleted uranium, consisting primarily of uranium-238, is dispersed by experiments that use conventional high explosives. About 99 kg of depleted uranium containing approximately 40 millicuries of radioactivity was used in such experiments in 1997. 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 airborne in a high-explosive test (Dahl and Johnson 1977). Elevated concentrations of uranium-238 were generally not detected near the firing sites with the possible exception of station #77 at TA-15 where isotopic ratios indicate a higher-than-natural abundance of uranium-238 (three to five times higher than the natural ratio of uranium-238 to uranium-234). The

annual concentration at this site was 46 aCi of uranium-238 per cubic meter with a high quarterly concentration of 109 aCi of uranium-238 per cubic meter. This annual high concentration is equivalent to a dose of .05 mrem or 0.5% of the EPA public dose limit.

5. Investigation of Elevated Air Concentrations

In 1997, a number of air sampling values exceeded investigation levels established by ESH-17. A discussion of how investigation levels are determined can be found in the AIRNET project plan (ESH-17 1997). 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. The following sections identify three incidents of elevated air concentrations that warrant further discussion.

a. Technical Area 54, Area G. An increasing trend in plutonium and americium levels has been occurring at two stations (#27 and #38) (Kraig et al., 1998). The stations are co-located for QA purposes and both stations show about the same results. No other stations at Area G or stations in White Rock show elevated results. The upward trend began in 1995, with the majority of the increase occurring in 1996 and early 1997. Personnel from Area G, ESH-17, and the Hazardous and Solid Waste Group (ESH-19) worked together to investigate the cause of this trend.

During the week of May 19, 1997, a survey of the area was performed using a direct reading radiological survey instrument that indicated an area of americium surface contamination near stations #27 and #38. Discussion with Area G personnel revealed that in 1995, when the elevated readings first appeared, some trenching work had been performed within several meters of the two stations. Additionally, the dirt access road in the vicinity of the stations was relocated in the spring of 1996, coincident with a very significant increase in air concentration. A second trenching operation was also completed at about this time. It appears that contaminated material was brought to the surface during the trenching and that local traffic transported some of the material toward the air monitoring stations.

Although the elevated results did not indicate either a compliance issue or a health and safety concern, a mitigation plan was developed. The mitigation plan included covering the surface contamination with a mix of gravel and sand in order to isolate the contamination. Relevant air sampling data were analyzed at an increased frequency (biweekly instead of quarterly) to evaluate the effectiveness of the remediation. Results are now available and show a large decrease in air concentrations since the remediation.

During the approximately nine months following the remediation, air concentrations of plutonium-239 have decreased from about 1,600 to 47 aCi of plutonium-239 per cubic meter and levels have dropped from approximately 1,000 to 44 aCi of americium per cubic meter. Although these are major reductions, the concentrations do not appear to have dropped to pre-1995 levels. TA-54, Area G personnel have been informed of this situation and are considering what additional mitigation efforts may be necessary. ESH-17 personnel will continue their follow-up evaluations, and updates will be posted on the ESH-17 home page (*http://www.air-quality.lanl.gov/*), as they become available.

b. First Quarter 1997 Investigation at Technical Area 21. The first quarter of 1997 showed three stations within TA-21 boundaries with values exceeding the investigation level. In order to determine the cause of the elevated levels, personnel involved in the ER Project and decontamination and decommissioning (D&D) program were contacted. Basically, two operations were underway during the first quarter of 1997 that could have had potential air quality impacts. The first was a drilling operation at Area T. We don't believe the drilling operation is the likely cause because Area T is located significantly toward the west, away from stations #73 and #74. In addition, a high-efficiency particulate air filtration device was attached to the drill rig and would have captured essentially all of the particulate matter before it was released to the atmosphere.

Minimal activities were occurring in association with the TA-21 D&D program shutdown. Soil moving operations were conducted on the south side of Buildings 4 and 5 on February 8, 1997. On February 19, 1997, bulk waste shipments were being made out of the Buildings 4 and 5 south areas. However, the bulk waste shipments contained minimal levels of radioactive materials. The investigation to determine the cause of the elevated readings is inconclusive. Second quarter data did not exceed action levels.

c. Los Alamos County Landfill. Air concentration values for gross alpha exceeded action levels for sample periods November and December in 1997

at the county landfill AIRNET station (#32). Because of these exceedances, the samples were reanalyzed for gross alpha and gross beta. Isotopic analyses were also performed to provide information as to which radionuclides were causing the gross alpha and beta increases.

From these data, we concluded that polonium-210, a radionuclide within the natural radon-222 decay chain was responsible for the increased gross alpha values at the time of the reanalysis, but not necessarily at the time of the original analysis. Plutonium, uranium, and americium from LANL operations were not elevated and did not cause the elevated gross alpha for either the original analysis or the reanalysis.

Large, short-term fluctuations in atmospheric levels of radon and radon decay products are very common, but we cannot conclude that these natural fluctuations caused the gross alpha and gross beta increases in late 1997. We do not have a method (either by analytical chemistry or by calculations) that will allow us to make a definitive judgment as to whether or not the polonium-210 was the cause of the high alpha and beta concentrations measured by the original analysis in late 1997. Since naturally occurring radon decay products are constantly being deposited on the surface of materials exposed to the atmosphere, it is likely that handling any material will resuspend these decay products, such as lead-210 and polonium-210, to some extent. Such resuspensions will occur with regularity at a landfill. Therefore, nearby samplers such as this AIRNET sampler will occasionally collect elevated concentrations of these naturally occurring radioactive materials.

For complying with the Clean Air Act, this elevated value will be considered a release of polonium-210 when calculating the annual dose to a member of the public for compliance with 40 CFR 61 Subpart H.

6. Long-Term Trends

As noted in the tritium section above, we discovered that the silica gel collection medium was not collecting all of the water vapor present in the air samples. This underestimate appears to have been going on for many years, but to date, we have recalculated tritium concentrations for the past five years. These recalculated concentrations are generally two to three times higher than previously published values, but since the sampling stations collection efficiencies varied together, historical comparisons *between* sites will, in most cases, still be valid. Figure 4-4 shows time-series data from three stations: Santa Fe, a background site (#3); East Gate (#10), the maximum exposed individual (MEI) site, located in the eastern part of Los Alamos near the LANL perimeter; and a site within TA-54, Area G (#35), an active radioactive waste disposal site. This figure shows the same data on different scales. Figure 4-4a clearly shows that tritium concentrations are several orders of magnitude greater at the TA-54, Area G waste disposal site than at the other two sites. The cause of these high tritium concentrations is the tritium from buried radioactive waste diffusing from the ground into the ambient air. This graph also shows that the diffusion rate dramatically increases during the summer months because of higher temperatures and increased evaporation and transpiration. There is clearly an on-site impact in the controlled area, but the average concentrations at the TA-54, Area G site are less than 0.01% of the DAC for worker exposure.

Figure 4-4b is a plot of the same data, but the scale has been reduced by a factor of 50. A few low winter tritium values at TA-54, Area G show on this scale and are comparable to the highest values recorded for Santa Fe and East Gate. Even though both the Santa Fe and East Gate stations have very low concentrations of tritium (normally less than 10 pCi of tritium per cubic meter), the East Gate station is still significantly higher than the Santa Fe station, which indicates a LANL impact at the East Gate location. In addition, most of the measurements of tritium at the East Gate site are above the MDA whereas most of the measurements at the Santa Fe site are below the MDA. This qualitatively indicates that there are measurable concentrations at East Gate, but not at Santa Fe.

B. Stack Air Sampling for Radionuclides

1. Introduction

Radioactive materials are an integral part of many activities at the Laboratory. Some operations involving these materials may be vented to the environment through a stack. These operations are evaluated 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 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 1997, 28 stacks met this criterion. An additional three sampling systems were in place to meet DOE requirements for

nuclear facilities prescribed in their respective technical or operational safety requirements. Where sampling is not required, emissions are estimated using engineering calculations and radionuclide inventory information.

2. Sampling Methodology

As of the end of 1997, LANL was continuously sampling 31 stacks for the emission of radioactive material to the ambient air. LANL has identified four types of radioactive stack emissions: (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.

Emissions of radioactive particulate matter, generated by operations at facilities such as the Chemistry and Metallurgy Research Building (CMR) and TA-55, are sampled 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 to be shipped to an off-site commercial laboratory. These composited samples are analyzed to determine the total activity of materials such as uranium-234; uranium-235; uranium-238; plutonium-238; plutonium-239, -240; and americium-241. These data are then used to calculate emissions.

VAP emissions, generated by Los Alamos Neutron Science Center (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. The amount and identity of the radionuclide(s) present on the filter are determined through the use of gamma spectroscopy.

Tritium emissions from the Laboratory's tritium facilities are measured 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 (HT) or oxide (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). After "bubbling" through these three vials, essentially all HTO is removed 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 amount of HTO and HT is 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. Since the primary source for tritium is activated water, sampling for only HTO is appropriate.

G/MAP emissions, resulting from activities at LANSCE, are calculated 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. Specific radioisotopes are identified through the use of gamma spectroscopy and decay curves. Gaseous air activation products are also generated as nonpoint or diffuse sources at TA-53 and at TA-18. The diffuse source contributions from TA-53 are determined by measurements using an ionization chamber while the diffuse source contributions at TA-18 are determined through Monte Carlo modeling.

3. Sampling Procedure and Data Management

a. Sampling and Analysis. Analytical methods were chosen for compliance with EPA requirements (40 CFR 61, Appendix B, [EPA 19] Method 114). These methods were derived during 1995, as part of the development of QA 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, used to sample facilities with significant 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 were used to ensure 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. Since the energy of decay is specific to a given radioactive isotope, the HPAL could determine the identity of any isotopes detected by the gamma spectroscopy. 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.

Since 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 1997, a change to the sample analyses for these composites was implemented. Rather than using isotopic data only to identify radionuclides as was done in the past, the data were also used to quantify these emissions. This method is considered an improvement in sample analysis and in emissions determination. To further ensure that the analyses requested identify any significant activity in the composites, ESH-17 compares the results of the isotopics to gross activity measurements.

VAP Emissions. Charcoal canisters, used to sample 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, was used to identify and quantify the presence of vaporous radioactive isotopes.

Tritium Emissions. Tritium bubbler samples, used to sample 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 were used to sample 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. Continuous monitoring was used 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 offline. 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 composition of these G/MAP emissions was analyzed using the gamma spectroscopy system. 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. Diffuse sources of activated air at LANSCE are calculated by performing several individual measurements and calculations. First, the concentration of radioactive air in the room is measured using flow through air ionization chambers. Next, the outflow of the building is determined through measurements and engineering calculations. The measured concentration is then multiplied by the building outflow to determine the amount of radioactive air released into the environment.

Diffuse sources of activated air at TA-18 are calculated based on data from Monte Carol modeling. The modeling results identify the number of argon-41 atoms that are produced from a single neutron released from a criticality experiment. Using this information along with the number of neutrons released during the year, the total amount of activated air (argon-41) is determined.

b. Laboratory Quality Control Performance. Groups of discrete samples were submitted to commercial laboratories for radiochemical analyses. For these analyses, the Laboratory maintained a program of blanks and spikes consistent with EPA guidelines (EPA 1991). These EPA guidelines call for a frequency of 1 blank and 1 duplicate for every 20 samples. For the tritium analyses for the stack program, the Health Physics Analytical Laboratory (HPAL) maintained a program of blanks and duplicates analyses that was more frequent than EPA guidelines.

4. Analytical Results

Measurements of Laboratory stack emissions during 1997 totaled 20,000 Ci. Of this total, tritium emissions comprised 420 Ci, and air activation products from LANSCE contributed 19,600 Ci. Combined airborne emissions of materials such as plutonium, uranium, americium, and particulate/vapor activation products were less than 1 Ci. Detailed emissions data for Laboratory buildings with sampled stacks are provided in Table 4-11. Table 4-12 provides a detailed listing of the constituent radionuclides in the groupings of G/MAP and particulate/vapor activation products (P/VAP). The half-lives of the radionuclides emitted by the Laboratory are presented in Table 4-13. Diffuse sources of activated air from TA-53 totaled 830 Ci of carbon-11 and 35 Ci of argon-41 while the TA-18 contribution was 1.4 Ci of argon-41.

As in 1995 and 1996, radioactive particulate source terms were developed using radionuclide-specific analyses rather than process knowledge. In an effort to provide better data, the identities of radionuclides emitted from Laboratory stacks were determined through the use of radioanalytical chemistry. For this reason, emissions of americium-241 are now presented separately from emissions of plutonium.

5. Long-Term Trends

Radioactive emissions from sampled Laboratory stacks are presented in Figures 4-5 through 4-8. These figures illustrate trends in measured emissions for plutonium, uranium, tritium, and G/MAP emissions, respectively. As the figures demonstrate, only emissions from TA-53, LANSCE increased from 1996 to 1997. This increase was a result of an increase in run-time for the accelerator.

Figure 4-9 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 comprise the vast majority of radioactive stack emissions.

Because G/MAP emissions account for most of the airborne radioactivity, and because 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 is passed through a 1,200-m tube, allowing approximately 100 minutes of additional decay time (Fuehne 1996). Because of the short half-lives of the G/MAP isotopes, carbon-10 (19.3 s), carbon-11 (20.5 min), nitrogen-13 (10 min), nitrogen-16 (7.13 s), oxygen-14 (70.6 s), oxygen-15 (122.2 s), and argon-41 (1.83 h), 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 to 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 and Gamma Radiation Monitoring Program

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 with the exception of the heavy nuclei. To evaluate natural and man-made radiation, the Laboratory's environmental monitoring program uses thermoluminescent dosimeters (TLDs) and a high-pressure ion chamber (HPIC) which is part of the Neighborhood Environmental Watch Network (NEWNET) community monitoring network operated by the Laboratory's Instrumentation and Control group. Because the natural background from terrestrial and cosmic sources is much larger than those from man-made sources, it is extremely difficult to distinguish man-made sources from the natural background. There are several environmental mechanisms that contribute to this difficulty.

The terrestrial component results primarily from naturally occurring potassium-40, the thorium and uranium decay chains, and radionuclides deposited as a result of fallout from nuclear atmospheric testing (e.g., 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). There is also spatial variation that is a result of 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 (ESP 1978).

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 per year. Los Alamos, with a mean elevation of about 2.2 km receives about 75 mrem per year from cosmic sources. However, different locations in the region range in elevation from about 1.7 km at Española to 2.7 km at Fenton Hill, resulting in a corresponding range of 45 to 90 mrem per year 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, 93 TLD stations are placed around the Laboratory and in the surrounding communities. This network of dosimeters is divided into three groups: off-site regional, off-site perimeter, and on-site locations.

The off-site regional group has four locations ranging from approximately 7 to 117 km from the Laboratory boundary. These regional stations are located in the neighboring communities of Española, El Rancho, Santa Fe, and the Pueblo of San Ildefonso. Jemez Pueblo and Fenton Hill were part of this network in 1996 but were discontinued in 1997 because of repeated loss of measurements. The Pojoaque station was moved to El Rancho in 1997.

The off-site perimeter group has 28 locations within 4 km of the Laboratory boundary (see Figure 4-10). These stations are placed in residential areas surrounding the Laboratory and in locations where people work. Five perimeter stations were added, and two stations were removed in 1997.

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 TA-53, LANSCE lagoons, TA-50 locations, Mortandad Canyon, and TA-15 Phermex. Other locations include TA-16, TA-36 Kappa Site, TA-33, and the Fitness Trail near TA-8, Building 24.

b. Technical Area 53, Los Alamos Neutron Science Center Network. To monitor external penetrating radiation from airborne gases, particles, and vapors resulting from LANSCE operations at TA-53, a network of 24 TLD stations is used. Twelve of these monitoring locations are approximately 800 m north of and downwind from the LANSCE stack. The other 12 TLD stations are located about 9 km from LANSCE, near the southern boundary of the Laboratory and are used as a background measurement. 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 1 active (TA-54, Area G) low-level radioactive waste management areas. To monitor any external penetrating radiation from these areas, 97 dosimeters are placed around the perimeter of these waste management areas. This total represents an increase over the number of 1996 locations, with the number of strategic monitoring locations at TA-54, Area G increasing from 25 to 32. All waste management areas are controlled-access areas and are not accessible to the general public. The average annual dose at each waste area is calculated from a set of TLDs located around each site.

d. Technical Area 18 Albedo Dosimeters. To monitor potential neutron doses from activities at TA-18, seven albedo TLD stations were maintained on the north, south, and east sides of TA-18. Albedo dosimeters are used to measure neutrons around TA-18. Albedo dosimeters are sensitive to neutrons and uses a polyethylene phantom. The phantom is used to capture neutron backscatter and simulates the human body. Since the human body has many hydrogen atoms, a significant fraction of intermediate energy and fast neutrons can be slowed down to epithermal energies and backscattered, and thus can interact with neutron sensitive thermoluminescent material.

The albedo dosimeters were sited early in the second quarter of 1997 at locations where public access is possible. The dosimeters were placed to simulate backscatter from the human body. Two albedo TLDs were placed at each monitoring station. In the event of a road closure during special operations, the second of the dosimeters was removed and stored at a control location until the road was reopened. The measurement results from albedo dosimeters should not be compared to results of measurements using other geometries. Two background stations were located at Santa Fe and TA-49, respectively. Neutron background is essentially zero. Because of dosimeter loss, only one quarter of data was available from the Santa Fe monitoring station.

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

Environmental TLDs used at the Laboratory are composed of natural lithium fluoride crystals containing 7.4% lithium-6 in the form of 3.2-mm^2 by 0.9-mm-thick chips, referred to as TLD-100. After exposure to x- and gamma radiation, the TLD chips are collected and heated in a laboratory setting 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 absorbed by the TLD. 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 they can be measured by TLD-100 chips.

A newly designed dosimeter was introduced for field monitoring in 1996 and was used for all monitoring locations in 1997. This new dosimeter uses the same type of "acorn" holder as the old dosimeter, but utilizes five, 1/8 in. TLD-100 chips, instead of the four, 1/4 in. TLD-100 chips used in the old dosimeter. (For a complete description of this dosimeter, see Archuleta 1997.) American National Standards Institute (ANSI) N545 performance testing of this newly designed dosimeter was completed in 1996, and the dosimeter passed all performance tests (ANSI 1966).

Procedures that outline the QA/quality control (QC) protocols; placement and retrieval of the dosimeters; reading of the dosimeters; and data handling, validation and tabulation can be found in operating procedures maintained by ESH-17. A QA project plan was updated in 1997 (ESH-17 1997b).

4. Analytical Results

The dose equivalent ranges observed in 1997 are consistent with natural background radiation or the 1996 measurements.

a. Laboratory and Regional Areas. Results from these locations are presented in Table 4-14. Some of the TLD stations are lacking one or more quarters of data. Reasons for these omissions include dosimeter loss, animal damage to stations, processing error, removal requests by the public, and new station installation after the beginning of the monitoring year.

Only one off-site regional station, El Rancho (station #53), had a complete set of data in 1997 (i.e., data for each quarterly monitoring period). Station #53 shows an annual dose equivalent of 109 mrem without any background subtraction. The average quarterly dose equivalents at the other off-site regional stations ranged from 30 to 36 mrem, corresponding to an approximate annual dose equivalent of 120 to 144 mrem. The annual measurements at off-site perimeter stations having complete data sets ranged from 107 to 164 mrem. Annual measurements at on-site stations reporting 100% data ranged from 135 to 178 mrem. Five new monitoring locations near the LANSCE lagoons and stacks indicated doses ranging from 222 to 934 mrem for nine months of monitoring. These results are not representative of potential doses to a member of the public because they include operational exposures at areas where public access is 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 observed in the vicinity of the LANSCE. The average dose at the 12 site stations was 164 ± 10 mrem, while the background was 165 ± 10 mrem.

c. Low-Level Radioactive Waste Management Areas (WASTENET). Results from monitoring the waste disposal management areas are presented in Table 4-15. Among the sites with a complete data set, the annual average doses at all inactive waste management areas during 1997 ranged from 132 to 307 mrem. The 1997 annual doses for two stations at TA-50, Area C, are incomplete because of lost dosimeters. Six monitoring stations at TA-54, Area G, did not have complete data for 1997. Five of these were initialized in the second quarter of 1997 while the last station lost one quarter due to equipment malfunction.

The highest waste management area annual average dose for 1997 was measured at TA-54, Area G, LANL's only active low-level radioactive waste area. During the second half of 1997, 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 removing transuranic waste from storage for further characterization and ultimate shipment to the Waste Isolation Pilot Plant. The radiological constituents of these drums varies greatly, and the drum inventory near the TLDs is changing constantly. As the TWISP project progresses, changes in external penetrating radiation doses near the project are expected to vary. These TLD locations are on-site and not in an area that can be routinely accessed by members of the public. 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 operations that occur at the facility. Evaluation of this 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.

One of the monitoring sites at TA-21, Area T had an elevated reading of 307 ± 17 mrem in 1997. 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. Discussions on potential dose equivalent to a member of the public from this location are discussed in Chapter 3.

d. Technical Area 18 Albedo Dosimeters. Table 4-16 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 the second through fourth quarters of 1997; only the second quarter of data is available for the Santa Fe station because of dosimeter loss. Neutron doses are presented for TLDs undergoing continuous exposure and for those removed during road closure. Members of the general public could only be exposed at times when the road in front of TA-18 was open. The average neutron dose at the seven stations is 6.2 mrem over three quarters of 1997 during road open conditions, while the maximum dose of 18 mrem occurred at the TA-18 personnel gate near the parking lot. This high result is expected because of multiple operations at TA-18 capable of generating neutron exposure. The neutron dose results from the background monitoring stations are, as expected, essentially zero accounting for analytical uncertainty.

D. Nonradioactive Emissions Monitoring

1. Introduction

Emissions from industrial-type sources are calculated annually because these sources are responsible for 90% of all the nonradiological air pollutant emissions at the Laboratory. 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.

2. Particulate Matter Sampling

Particulate matter (PM-10) samples (particles less than 10 μm in aerodynamic diameter) were not collected during 1997.

3. Detonation and Burning of Explosives

The Laboratory conducts explosive testing by detonating explosives 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 mound. Table 4-17 summarizes estimated toxic releases from the explosives detonations conducted at the Laboratory during 1997. The Laboratory also burns scrap and waste explosives because of treatment requirements and safety concerns. In 1997, the Laboratory burned 3.7 tons of high explosives.

4. Emissions Calculations

The 1997 calculated actual emissions for the criteria pollutants from industrial-type sources are shown in Table 4-18. Following is an explanation of the different industrial-type sources at LANL. The power plants produce steam for heating and electricity when sufficient power from outside sources is not available. The water pump is used to pump 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 power plant can use fuel oil as a backup. These sources and emissions estimates will be reported to NMED under 20 NMAC 2.73-Notice of Intent and Emissions Inventory Requirements.

Various methods and resources were used to estimate source emissions. Emissions from the asphalt plant are based on the 1,306 tons of asphalt produced in 1997. 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 Power 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 were calculated using data provided by the manufacturer. Emission factors for NO_X, CO, and volatile organic compound (VOC) emissions from the water pump were obtained from the manufacturer. All other criteria emissions were estimated using EPA guidance documents.

In addition to the industrial type sources, VOC emissions from research and development activities will be reported to NMED under 20 NMAC 2.73.

VOCs are any compound of carbon, with the exception of specific chemicals, which participate in atmospheric photochemical reactions. VOCs include commonly used chemicals such as ethanol, methanol, and isopropyl alcohol. In 1997, ten tons of VOC emissions were estimated based on chemical procurement records. For this estimate, it was conservatively assumed that air releases were equivalent to the quantity purchased.

E. Meteorological Monitoring

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 available through the World Wide Web at *http://weather.lanl.gov/* and 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, which are 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 well below freezing. 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 often causes a wide range of daily temperature (the average diurnal temperature range is 13˚C).

Winter temperatures range from –1˚C to 10˚C (30˚F to 50˚F) during the daytime, to –9˚C to –4˚C (15˚F to 25˚F) during the nighttime. The record low temperature recorded is –28˚C (–18˚F). Winter is usually not particularly windy, so extreme wind chills are uncommon.

Summer temperatures range from 21˚C to 31˚C (70˚F to 88˚F) during the daytime, to 10˚C to 15˚C (50˚F to 59˚F) during the nighttime. Temperatures occasionally will break 32˚C (90˚F). The highest temperature ever recorded is 35˚C (95˚F).

The average annual precipitation (including both rain and water equivalent of frozen precipitation) is 47.57 cm (18.73 in.). The average snowfall for a year is 149.6 cm (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.

Winds in Los Alamos are also affected by the complex topography, 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 4-12). During the nighttime, as the mountain slopes and plateau cool,

the flow becomes downslope, causing light westerly and northwesterly flow (Figure 4-13). 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.

3. Monitoring Network

A meteorological network of five towers was used to gather data at the Laboratory during 1997 (see Fig. 13.1 in the Meteorological Monitoring Plan [Baars et al., 1998] or access through the World Wide Web at *http://weather.lanl.gov/*). A sodar (sonic detection and ranging) and three precipitation measurement sites also supplemented the data collected. The towers are located at TA-6 (the official measurement site of the Laboratory), TA-49, TA-53, TA-54, and TA-41 (located in Los Alamos Canyon). 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 where there is 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 longwave 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 do 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.

Most of the meteorological variables are sampled every 3 s, and the results are averaged every 15 min to give a sample size of 300 (for each of the 15-min periods). The data are stored by data loggers located at the tower sites and then fed to a Hewlett Packard workstation through telephone lines. At the workstation, automatic range checking is performed on the data, and data edits are automatically performed on variables falling outside of preset ranges. Next, time-series plots are constructed. These plots are used by a meteorologist 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 calibration inspections twice a year. An external audit is performed every two to three years and takes the place of one of the internal calibration inspections. All instrument calibrations are traceable to the National Institute of Standards and Technology standards. In 1997, a calibration inspection and external audit were performed, and no significant problems were found (Sandstrom 1997).

5. Analytical Results

A graphical summary of the weather at Los Alamos (TA-6) for 1997 is presented in Figure 4-11. This figure shows the average temperature range and precipitation by month, compared with the normals, which are averages based on a 30-yr record (1961 to 1990). Significant departures from normal include below average temperatures in January, February, April, November, and December, and above average temperatures in May. For the year, temperatures were below normal.

Precipitation exceeded normal monthly totals for eight months of the year. January, February, April, and August were particularly wet, and precipitation in those months was near or above twice the normal precipitation amounts. May and October were unusually dry with precipitation less than half the normal amounts. The total precipitation for the year was 136% of normal. The annual snowfall for 1997 was 162% of normal. The months of February, April, November, and December saw over double the normal snowfall amounts. Precipitation data for 1997 for all recording sites are listed in Table 4-19.

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 4-12 through 4-14. 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-53 (Figure 4-12), the most frequent wind direction is southerly, which occurs 14% 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 0.5 to 2.5 m/s category, the 5.0 to 7.5 m/s category, and the 7.5+ m/s category. Winds were calm 1.0% of the time at TA-53 during the daytime in 1997.

During the daytime (Figure 4-12), winds were predominately southerly at all four towers. Looking at the nighttime wind roses (Figure 4-13), it can be seen that the winds were more westerly and northwesterly, and that the winds are generally weaker. Wind roses for all times are given in Figure 4-14.

F. Quality Assurance Program in the Air Quality Group

1. Quality Assurance Program Development

During 1997, the Air Quality Group continued to maintain and to improve upon the QA program developed in recent years. This program includes a group quality management plan, project plans, and implementing procedures. QA plans for sampling systems follow the EPA QA-R/5 data quality objective process. Required elements of DOE QA programs are incorporated. 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 1997, biweekly gross alpha, gross beta, and isotopic gamma analytical services were provided by Wastren-Grand Junction analytical laboratory associated with the DOE's Grand Junction Project Office. 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 DQOs. These DQOs were summarized as purchase requirements in statements of work used for procurement of 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 1997.

Both Paragon and the Grand Junction analytical laboratories participated in national performance evaluation studies during 1997. Two federal agencies, EPA and DOE, sponsor intercomparison studies: the EPA Environmental Monitoring Systems Laboratory in Las Vegas, Nevada, and the DOE Environmental Measurements Laboratory in New York, New York. The DOE laboratory sends spiked air filters twice a year to the participating laboratories. The EPA laboratory sends one type of spiked media from one to three times a year that is of interest to the ESH-17 QA program.

G. Unplanned Releases

There were no unplanned radioactive or nonradioactive air releases during 1997.

H. Special Studies

1. Neighborhood Environmental Watch Network Community Monitoring Stations

Neighborhood Environmental Watch Network (NEWNET) is a LANL Dynamic Experiment Division program focused on establishing a partnership with communities, state and tribal governments, and the DOE to address concerns about 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.

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, and stored in a public access database. The data from all the stations are available to the public with, at most, a 24-h delay. Methods to decrease this period to near real-time are being developed.

Station measurements include wind speed and wind direction, ambient temperature, relative humidity, barometric pressure, and gross gamma radiation using a pressurized ion chamber. The radiation sensors are sampled at 5-s intervals and averaged every 15 min. These values are transmitted every 4 h.

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] 1997	EPA Concentration Limit[b]
Gross Alpha	fCi/m^3	0.7	NA[c]
Gross Beta	fCi/m^3	14.1	NA
^{234}U	aCi/m^3	16.3	7,700
^{235}U	aCi/m^3	1.2	7,100
^{238}U	aCi/m^3	14.2	8,300
^{238}Pu	aCi/m^3	0.1	2,100
$^{239,240}Pu$	aCi/m^3	0.3	2,000
Tritium	pCi/m^3	0.3	1,500
^{241}Am	aCi/m^3	2.3	1,900

[a] Data from regional air sampling stations operated by LANL at Santa Fe, Pojoaque, 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 1997

Station Location	Number of Results	Number of Results <MDA	Maximum (fCi/m^3)	Minimum (fCi/m^3)	Mean (fCi/m^3)	1 *s*
Regional Stations						
01 Española	27	1	1.16	0.14	0.61	0.24
02 Pojoaque	2	0	0.70	0.41	0.55	0.21
03 Santa Fe	27	0	2.19	0.33	0.79	0.40
55 Santa Fe West (Buckman Booster #4)	11	0	1.03	0.36	0.64	0.20
56 El Rancho	18	1	1.05	0.22	0.64	0.24
Pueblo Stations						
41 San Ildefonso Pueblo	27	1	1.28	0.16	0.71	0.22
42 Taos Pueblo	15	0	1.23	0.35	0.74	0.28
53 Jemez Pueblo-tribal office	25	2	1.28	0.18	0.80	0.31
Perimeter Stations						
04 Barranca School	27	2	1.08	0.06	0.50	0.23
05 Urban Park	27	6	0.85	0.10	0.43	0.20
06 48th Street	26	7	0.90	0.04	0.40	0.24
07 Gulf/Exxon/Shell Station	27	1	1.15	0.12	0.65	0.25
08 McDonalds Restaurant	27	1	1.38	–0.05[a]	0.52	0.28
09 Los Alamos Airport	27	2	1.33	0.20	0.61	0.28
10 East Gate	23	1	1.13	0.18	0.51	0.23
11 Well PM-1 (E. Jemez Road)	27	4	0.98	0.04	0.51	0.24
12 Royal Crest Trailer Court	27	0	1.25	0.25	0.54	0.26
13 Piñon School	27	2	0.88	0.21	0.55	0.20
14 Pajarito Acres	27	4	1.14	0.10	0.49	0.23
15 White Rock Fire Station	27	2	1.18	0.14	0.51	0.24
16 White Rock Nazarene Church	27	1	0.92	0.25	0.51	0.18
17 Bandelier Entrance	27	2	1.46	0.12	0.50	0.25
60 LA Canyon	27	3	1.06	–0.02	0.43	0.21
61 LA Hospital	27	2	0.96	0.18	0.58	0.23
62 Trinity Bible Church	27	2	1.04	0.13	0.50	0.20
63 Monte Rey South	27	2	0.89	0.04	0.44	0.18
90 East Gate-Backup	4	0	0.57	0.33	0.43	0.11
TA-15 Stations						
76 TA-15-61	27	1	1.88	0.16	0.59	0.37
77 TA-15-IJ Site	27	2	14.47	0.10	1.21	2.68
78 TA-15-N	27	5	1.27	0.12	0.48	0.24
TA-21 Stations						
20 TA-21 Area B	27	0	2.99	0.25	0.61	0.56
71 TA-21.01 (NW Bldg 344)	27	1	0.97	0.21	0.54	0.21
72 TA-21.02 (N Bldg 344)	27	2	0.89	0.16	0.55	0.22
73 TA-21.03 (NE Bldg 344)	26	2	1.03	0.23	0.65	0.23
74 TA-21.04 (SE Bldg 344)	27	1	2.59	0.12	0.56	0.44
75 TA-21.05 (S Bldg 344)	27	3	1.01	0.11	0.53	0.24

Table 4-2. Airborne Long-Lived Gross Alpha Concentrations for 1997 (Cont.)

Station Location	Number of Results	Number of Results <MDA	Maximum (fCi/m^3)	Minimum (fCi/m^3)	Mean (fCi/m^3)	1 *s*
TA-54 Area G Stations						
27 TA-54 Area G (by QA)	27	0	7.44	0.64	1.88	1.62
34 TA-54 Area G-1 (behind trailer)	27	2	0.95	0.20	0.56	0.22
35 TA-54 Area G-2 (back fence)	27	3	0.99	0.13	0.52	0.21
36 TA-54 Area G-3 (by office)	27	3	1.60	0.12	0.68	0.37
45 TA-54 Area G (SE Perimeter)	26	0	2.39	0.23	0.91	0.63
47 TA-54 Area G (N Perimeter)	27	2	0.95	0.14	0.55	0.21
50 TA-54 Area G-expansion	26	0	1.92	0.24	0.85	0.39
51 TA-54 Area G-expansion pit	27	0	1.41	0.32	0.66	0.27
Other On-Site Stations						
23 TA-52 Beta Site	27	3	1.45	0.16	0.49	0.27
25 TA-16-450	26	4	1.30	0.12	0.51	0.28
26 TA-49	26	3	0.99	0.22	0.45	0.20
30 Pajarito Booster 2 (P-2)	27	2	0.94	0.12	0.51	0.23
31 TA-3	27	1	0.92	0.17	0.54	0.18
32 County Landfill (alias TA-48)	29	0	7.84	0.25	1.48	1.58
49 Pajarito Road (TA-36)	27	4	0.97	0.16	0.51	0.22
54 TA-33 East	18	1	1.09	0.16	0.59	0.24
QA Stations						
38 TA-54 Area G (adjacent to station 27)	27	0	7.90	0.40	1.78	1.68
39 TA-49 (adjacent to station 26)	26	3	1.04	0.15	0.51	0.24

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]	1 *s*
Regional	85	2	2.19	0.14	0.68	±0.07	0.30
Pueblo	67	3	1.28	0.16	0.75	±0.07	0.27
Perimeter	485	44	1.46	–0.05[a]	0.51	±0.02	0.23
TA-15	81	8	14.47	0.10	0.76	±0.35	1.58
TA-21	161	9	2.99	0.11	0.57	±0.05	0.34
TA-54 Area G	214	10	7.44	0.12	0.83	±0.10	0.78
Other On-Site	207	18	7.84	0.12	0.65	±0.10	0.71

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 1997

Station Location	Number of Results	Number of Results <MDA	Maximum (fCi/m^3)	Minimum (fCi/m^3)	Mean (fCi/m^3)	1 *s*
Regional Stations						
01 Española	27	0	20.9	10.3	14.4	3.2
02 Pojoaque	2	0	15.4	8.5	12.0	4.9
03 Santa Fe	27	0	20.0	9.0	13.1	2.8
55 Santa Fe West (Buckman Booster #4)	11	0	27.0	11.8	16.2	4.5
56 El Rancho	18	0	21.6	8.3	14.3	3.7
Pueblo Stations						
41 San Ildefonso Pueblo	27	0	20.8	7.9	13.6	3.5
42 Taos Pueblo	15	0	19.8	8.6	12.6	2.4
53 Jemez Pueblo-tribal office	25	0	19.4	8.3	13.5	2.8
Perimeter Stations						
04 Barranca School	27	0	19.4	7.1	13.0	3.1
05 Urban Park	27	0	18.3	4.8	12.0	3.2
06 48th Street	26	0	18.3	6.7	12.3	2.7
07 Gulf/Exxon/Shell Station	27	0	20.4	7.0	12.8	2.8
08 McDonalds Restaurant	27	0	20.5	7.5	13.2	2.6
09 Los Alamos Airport	27	0	20.5	8.2	14.1	3.0
10 East Gate	23	0	25.0	7.8	13.4	3.6
11 Well PM-1 (E. Jemez Road)	27	0	20.8	7.4	12.9	3.0
12 Royal Crest Trailer Court	27	0	22.3	7.2	13.6	3.2
13 Piñon School	27	0	20.1	8.3	14.1	3.1
14 Pajarito Acres	27	0	20.2	7.2	13.8	2.8
15 White Rock Fire Station	27	0	20.1	9.6	13.1	2.8
16 White Rock Nazarene Church	27	0	19.0	8.7	13.3	2.7
17 Bandelier Entrance	27	0	19.2	7.8	14.1	3.0
60 LA Canyon	27	0	26.2	8.1	13.0	3.3
61 LA Hospital	27	0	19.4	8.4	13.2	2.5
62 Trinity Bible Church	27	0	18.2	6.7	13.2	2.9
63 Monte Rey South	27	0	20.3	6.4	12.7	3.5
90 East Gate-Backup	4	0	18.2	10.2	14.3	3.3
TA-15 Stations						
76 TA-15-61	27	0	29.0	7.6	15.1	4.4
77 TA-15-IJ Site	27	0	21.7	8.5	13.8	3.4
78 TA-15-N	27	0	22.5	7.9	13.6	3.3
TA-21 Stations						
20 TA-21 Area B	27	0	20.3	8.7	13.3	2.8
71 TA-21.01 (NW Bldg 344)	27	0	20.3	7.7	13.1	3.0
72 TA-21.02 (N Bldg 344)	27	0	26.2	7.3	14.5	4.0
73 TA-21.03 (NE Bldg 344)	26	0	21.8	7.9	14.2	3.2
74 TA-21.04 (SE Bldg 344)	27	0	25.6	7.8	13.8	3.8
75 TA-21.05 (S Bldg 344)	27	0	22.8	7.7	13.6	3.5

Table 4-3. Airborne Long-Lived Gross Beta Concentrations for 1997 (Cont.)

Station Location	Number of Results	Number of Results <MDA	Maximum (fCi/m^3)	Minimum (fCi/m^3)	Mean (fCi/m^3)	1 *s*
TA-54 Area G Stations						
27 TA-54 Area G (by QA)	27	0	26.2	7.8	15.3	4.5
34 TA-54 Area G-1 (behind trailer)	27	0	24.2	8.2	14.4	4.2
35 TA-54 Area G-2 (back fence)	27	0	19.8	8.2	12.7	2.8
36 TA-54 Area G-3 (by office)	27	0	20.9	8.0	12.4	3.0
45 TA-54 Area G (SE Perimeter)	26	0	20.8	7.6	14.0	2.9
47 TA-54 Area G (N Perimeter)	27	0	20.4	8.3	13.4	3.1
50 TA-54 Area G-expansion	26	0	23.2	6.4	14.6	3.6
51 TA-54 Area G-expansion pit	27	0	20.0	7.8	13.6	3.1
Other On-Site Stations						
23 TA-52 Beta Site	27	0	21.7	9.2	14.8	3.1
25 TA-16-450	26	0	21.3	7.7	13.2	3.1
26 TA-49	26	0	17.5	7.3	11.6	2.3
30 Pajarito Booster 2 (P-2)	27	0	22.2	8.2	12.9	3.1
31 TA-3	27	0	18.0	8.1	12.6	2.3
32 County Landfill (for TA-48)	29	0	21.9	5.8	12.1	3.4
49 Pajarito Road (TA-36)	27	0	22.0	9.7	14.0	3.0
54 TA-33 East	18	0	23.4	10.4	15.6	3.2
QA Stations						
38 TA-54 Area G (adjacent to station 27)	27	0	19.6	5.0	12.4	3.3
39 TA-49 (adjacent to station 26)	26	0	18.7	7.3	12.6	2.6

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]	1 *s*
Regional	85	0	27.0	8.3	14.1	±0.8	3.5
Pueblo	67	0	20.8	7.9	13.3	±0.7	3.0
Perimeter	485	0	26.2	4.8	13.2	±0.3	3.0
TA-15	81	0	29.0	7.6	14.2	±0.8	3.7
TA-21	161	0	26.2	7.3	13.7	±0.5	3.4
TA-54 Area G	214	0	26.2	6.4	13.8	±0.5	3.5
Other On-Site	207	0	23.4	5.8	13.3	±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 1997

Station Location	Number of Results	Number of Results <MDA	Maximum (pCi/m^3)	Minimum (pCi/m^3)	Mean (pCi/m^3)	1 *s*
Regional Stations						
01 Española	27	26	2.8	–1.4[a]	0.3	0.9
02 Pojoaque	2	1	2.5	–0.4	1.0	2.0
03 Santa Fe	27	27	2.4	–1.1	0.1	0.7
55 Santa Fe West (Buckman Booster #4)	11	10	2.8	–1.2	0.4	1.0
56 El Rancho	18	17	3.5	–1.6	0.4	1.2
Pueblo Stations						
41 San Ildefonso Pueblo	27	25	4.7	–1.2	0.3	1.1
42 Taos Pueblo	15	13	2.0	–1.0	0.3	0.8
53 Jemez Pueblo-tribal office	26	25	3.6	–1.4	0.2	1.0
Perimeter Stations						
04 Barranca School	27	21	2.4	–1.0	0.8	0.7
05 Urban Park	27	20	3.1	–1.0	0.9	0.9
06 48th Street	27	18	7.0	–0.3	1.3	1.6
07 Gulf/Exxon/Shell Station	27	11	5.2	–0.4	1.6	1.4
08 McDonalds Restaurant	27	2	10.7	0.5	3.8	2.2
09 Los Alamos Airport	27	5	5.8	0.3	2.6	1.3
10 East Gate	21	3	11.7	0.6	3.7	3.3
11 Well PM-1 (E. Jemez Road)	27	10	10.0	–0.3	2.5	2.7
12 Royal Crest Trailer Court	27	8	4.8	0.1	1.8	1.2
13 Piñon School	27	8	7.0	–0.1	2.5	1.8
14 Pajarito Acres	27	16	6.1	0.0	1.4	1.4
15 White Rock Fire Station	26	12	13.9	–0.2	1.9	2.7
16 White Rock Nazarene Church	27	5	11.6	0.2	3.2	2.5
17 Bandelier Entrance	27	14	12.4	–1.2	1.7	2.5
60 LA Canyon	27	4	4.7	1.0	2.4	1.1
61 LA Hospital	27	16	4.9	–0.9	1.1	1.1
62 Trinity Bible Church	27	6	5.6	–0.2	2.0	1.3
63 Monte Rey South	27	18	3.5	–0.3	1.1	1.0
90 East Gate-Backup	6	3	9.0	0.6	3.7	3.7
TA-15 Stations						
76 TA-15-61	27	17	9.6	–0.5	1.6	1.8
77 TA-15-IJ Site	27	15	5.1	–0.5	1.4	1.0
78 TA-15-N	27	8	10.1	0.4	2.2	2.0
TA-21 Stations						
20 TA-21 Area B	27	0	14.9	0.9	4.6	3.6
71 TA-21.01 (NW Bldg 344)	27	1	10.3	0.3	3.2	2.2
72 TA-21.02 (N Bldg 344)	26	0	12.7	1.5	3.6	2.4
73 TA-21.03 (NE Bldg 344)	27	0	19.4	1.7	6.3	4.9
74 TA-21.04 (SE Bldg 344)	27	0	14.6	2.0	5.2	3.0
75 TA-21.05 (S Bldg 344)	27	0	14.1	2.1	5.7	3.2

Table 4-4. Airborne Tritium as Tritiated Water Concentrations for 1997 (Cont.)

Station Location	Number of Results	Number of Results <MDA	Maximum (pCi/m^3)	Minimum (pCi/m^3)	Mean (pCi/m^3)	1 *s*
TA-54 Area G Stations						
27 TA-54 Area G (by QA)	27	0	60.7	2.3	24.6	20.2
34 TA-54 Area G-1 (behind trailer)	27	0	68.2	2.6	22.8	18.6
35 TA-54 Area G-2 (back fence)	27	0	2,673.4	10.2	604.6	717.9
36 TA-54 Area G-3 (by office)	27	2	190.6	–0.1	32.4	51.8
45 TA-54 Area G (SE Perimeter)	26	0	32.7	1.7	13.5	9.4
47 TA-54 Area G (N Perimeter)	26	0	44.6	1.9	17.1	13.5
50 TA-54 Area G-expansion	27	1	21.6	0.7	7.2	5.5
51 TA-54 Area G-expansion pit	26	2	20.4	0.3	5.7	4.9
Other On-Site Stations						
23 TA-52 Beta Site	26	3	15.7	0.6	5.5	5.0
25 TA-16-450	27	0	132.0	2.0	62.4	28.7
26 TA-49	27	2	9.2	–0.1	3.6	2.3
30 Pajarito Booster 2 (P-2)	27	7	6.9	0.4	2.4	1.8
31 TA-3	27	6	17.2	0.4	3.6	4.4
32 County Landfill (alias TA-48)	27	11	4.3	–0.5	1.5	1.1
49 Pajarito Road (TA-36)	27	17	4.5	0.0	1.3	1.1
54 TA-33 East	18	17	2.4	0.2	0.9	0.5
QA Stations						
38 TA-54 Area G (adjacent to station 27)	26	0	65.5	2.9	23.7	19.2
39 TA-49 (adjacent to station 26)	27	8	7.6	0.1	3.4	2.4

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]	1 *s*
Regional	85	81	3.5	–1.6	0.3	±0.2	0.9
Pueblo	68	63	4.7	–1.4	0.3	±0.2	1.0
Perimeter	485	200	13.9	–1.2	2.0	±0.2	2.0
TA-15	81	40	10.1	–0.5	1.7	±0.4	1.7
TA-21	161	1	19.4	0.3	4.8	±0.5	3.5
TA-54 Area G	213	5	2,673.4	–0.1	92.1	±43.8	319.4
Other On-Site	206	63	132.0	–0.5	10.6	±3.2	22.8

Concentration Guidelines

DOE Derived Air Concentration (DAC) Guide for work place 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 1997

Station Location	Number of Results	Number of Results <MDA	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	1 *s*
Regional Stations						
01 Española	4	3	1.0	–0.3[a]	0.2	0.6
02 Pojoaque	1	1	0.3	0.3	0.3	
03 Santa Fe	4	4	0.1	0.0	0.1	0.1
55 Santa Fe West (Buckman Booster #4)	2	2	0.8	–0.4	0.2	0.9
56 El Rancho	3	3	0.1	–0.1	0.0	0.1
Pueblo Stations						
41 San Ildefonso Pueblo	4	4	0.1	0.0	0.1	0.1
42 Taos Pueblo	3	3	0.0	0.0	0.0	0.0
53 Jemez Pueblo-tribal office	4	3	0.6	–0.7	0.1	0.6
Perimeter Stations						
04 Barranca School	4	4	1.1	0.1	0.4	0.5
05 Urban Park	4	3	0.4	–0.4	–0.1	0.3
06 48th Street	4	4	0.6	–0.1	0.1	0.4
07 Gulf/Exxon/Shell Station	4	4	0.3	–0.2	0.1	0.2
08 McDonalds Restaurant	4	3	0.0	–0.3	–0.1	0.1
09 Los Alamos Airport	4	3	0.5	–0.4	0.1	0.4
10 East Gate	4	4	0.5	–0.1	0.1	0.3
11 Well PM-1 (E. Jemez Road)	4	3	0.7	–0.5	0.1	0.5
12 Royal Crest Trailer Court	4	3	0.6	–0.4	0.1	0.4
13 Piñon School	4	4	2.6	–0.2	0.6	1.4
14 Pajarito Acres	4	3	0.1	–0.3	–0.1	0.2
15 White Rock Fire Station	4	4	0.4	–0.1	0.1	0.2
16 White Rock Nazarene Church	4	4	0.6	–0.1	0.1	0.3
17 Bandelier Entrance	4	4	0.3	0.0	0.1	0.1
60 LA Canyon	4	4	0.6	–0.1	0.2	0.3
61 LA Hospital	4	3	0.1	–1.2	–0.3	0.6
62 Trinity Bible Church	4	4	0.6	0.0	0.3	0.3
63 Monte Rey South	4	3	0.1	–0.2	0.0	0.2
TA-15 Stations						
76 TA-15-61	4	3	0.1	–0.3	0.0	0.2
77 TA-15-IJ Site	4	3	0.6	–0.3	0.2	0.4
78 TA-15-N	4	4	0.2	–0.1	0.1	0.2
TA-21 Stations						
20 TA-21 Area B	4	3	5.1	–0.5	1.4	2.6
71 TA-21.01 (NW Bldg 344)	4	3	0.1	–0.1	0.0	0.1
72 TA-21.02 (N Bldg 344)	4	3	3.6	0.1	1.5	1.5
73 TA-21.03 (NE Bldg 344)	4	2	3.8	0.4	2.2	1.7
74 TA-21.04 (SE Bldg 344)	4	3	2.0	0.3	0.8	0.8
75 TA-21.05 (S Bldg 344)	4	4	0.6	–0.1	0.3	0.3

Table 4-5. Airborne Plutonium-238 Concentrations for 1997 (Cont.)

Station Location	Number of Results	Number of Results <MDA	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	1 *s*
TA-54 Area G Stations						
27 TA-54 Area G (by QA)	4	2	42.6	2.1	19.0	19.7
34 TA-54 Area G-1 (behind trailer)	4	4	2.1	0.5	1.5	0.7
35 TA-54 Area G-2 (back fence)	4	4	0.9	0.0	0.3	0.4
36 TA-54 Area G-3 (by office)	4	4	1.1	–0.1	0.5	0.5
45 TA-54 Area G (SE Perimeter)	4	4	3.7	0.2	1.5	1.5
47 TA-54 Area G (N Perimeter)	4	4	0.7	0.3	0.5	0.2
50 TA-54 Area G-expansion	4	4	1.4	0.2	0.6	0.6
51 TA-54 Area G-expansion pit	4	3	0.6	–0.3	0.2	0.4
Other On-Site Stations						
23 TA-52 Beta Site	4	4	0.5	–0.1	0.1	0.3
25 TA-16-450	4	3	0.6	–0.4	0.0	0.4
26 TA-49	4	3	0.1	–0.3	0.0	0.2
30 Pajarito Booster 2 (P-2)	4	4	2.2	–0.1	0.6	1.1
31 TA-3	4	4	0.9	–0.1	0.3	0.4
32 County Landfill (alias TA-48)	4	4	0.6	–0.1	0.3	0.3
49 Pajarito Road (TA-36)	4	4	0.6	–0.1	0.2	0.4
54 TA-33 East	3	2	0.7	–0.3	0.3	0.5
QA Stations						
38 TA-54 Area G (adjacent to station 27)	4	2	35.6	2.2	15.2	15.7
39 TA-49 (adjacent to station 26)	4	4	0.6	–0.1	0.2	0.3

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]	1 *s*
Regional	14	13	1.0	–0.4	0.13	±0.22	0.4
Pueblo	11	10	0.6	–0.7	0.05	±0.23	0.3
Perimeter	72	64	2.6	–1.2	0.09	±0.11	0.4
TA-15	12	10	0.6	–0.3	0.10	±0.16	0.3
TA-21	24	18	5.1	–0.5	1.01	±0.62	1.5
TA-54 Area G	32	29	42.6	–0.3	3.0	±3.15	8.7
Other On-Site	31	28	2.2	–0.4	0.21	±0.18	0.5

Concentration Guidelines

DOE Derived Air Concentration (DAC) Guide for work place 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 1997

Station Location	Number of Results	Number of Results <MDA	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	1 *s*
Regional Stations						
01 Española	4	4	0.4	–0.2[a]	0.1	0.3
02 Pojoaque	1	1	1.0	1.0	1.0	
03 Santa Fe	4	4	1.1	–0.1	0.4	0.5
55 Santa Fe West (Buckman Booster #4)	2	2	0.7	0.1	0.4	0.4
56 El Rancho	3	3	0.6	–0.4	0.1	0.5
Pueblo Stations						
41 San Ildefonso Pueblo	4	3	0.8	–0.5	0.4	0.6
42 Taos Pueblo	3	3	0.3	–1.3	–0.3	0.9
53 Jemez Pueblo-tribal office	4	3	1.1	–0.5	0.4	0.7
Perimeter Stations						
04 Barranca School	4	3	1.7	–0.4	0.3	1.0
05 Urban Park	4	3	1.2	–0.2	0.4	0.7
06 48th Street	4	4	0.7	0.2	0.6	0.2
07 Gulf/Exxon/Shell Station	4	4	0.6	0.1	0.4	0.2
08 McDonalds Restaurant	4	4	1.3	–0.2	0.5	0.6
09 Los Alamos Airport	4	4	1.9	0.0	1.1	0.9
10 East Gate	4	4	2.5	0.3	1.4	0.9
11 Well PM-1 (E. Jemez Road)	4	3	2.0	–0.3	0.5	1.0
12 Royal Crest Trailer Court	4	3	1.3	–0.3	0.4	0.7
13 Piñon School	4	4	2.5	0.1	1.1	1.2
14 Pajarito Acres	4	4	0.7	0.0	0.3	0.3
15 White Rock Fire Station	4	4	1.2	–0.1	0.5	0.7
16 White Rock Nazarene Church	4	4	0.5	–0.5	0.2	0.5
17 Bandelier Entrance	4	4	1.1	–0.3	0.4	0.6
60 LA Canyon	4	4	2.2	0.6	1.4	0.7
61 LA Hospital	4	4	1.9	–0.9	0.4	1.1
62 Trinity Bible Church	4	4	4.4	–0.1	1.4	2.0
63 Monte Rey South	4	4	1.0	0.0	0.4	0.5
TA-15 Stations						
76 TA-15-61	4	3	2.2	–0.9	0.6	1.3
77 TA-15-IJ Site	4	3	1.0	–0.6	0.4	0.7
78 TA-15-N	4	4	1.4	–0.1	0.6	0.7
TA-21 Stations						
20 TA-21 Area B	4	4	1.4	1.0	1.2	0.1
71 TA-21.01 (NW Bldg 344)	4	4	2.3	0.5	1.6	0.8
72 TA-21.02 (N Bldg 344)	4	1	33.1	2.0	15.9	12.9
73 TA-21.03 (NE Bldg 344)	4	2	37.0	6.3	18.0	14.5
74 TA-21.04 (SE Bldg 344)	4	1	165.3	7.4	49.1	77.5
75 TA-21.05 (S Bldg 344)	4	2	13.4	1.6	7.5	6.3

Table 4.6. Airborne Plutonium-239 Concentrations for 1997 (Cont.)

Station Location	Number of Results	Number of Results <MDA	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	1 *s*
TA-54 Area G Stations						
27 TA-54 Area G (by QA)	4	0	1,584.5	72.1	679.8	723.6
34 TA-54 Area G-1 (behind trailer)	4	1	12.1	1.8	6.8	4.3
35 TA-54 Area G-2 (back fence)	4	3	4.0	0.4	2.2	1.5
36 TA-54 Area G-3 (by office)	4	1	11.6	–0.6	5.6	5.3
45 TA-54 Area G (SE Perimeter)	4	0	34.9	7.7	18.0	13.0
47 TA-54 Area G (N Perimeter)	4	2	18.4	2.8	10.6	8.9
50 TA-54 Area G-expansion	4	2	12.2	2.4	6.2	4.2
51 TA-54 Area G-expansion pit	4	2	4.7	2.2	3.3	1.2
Other On-Site Stations						
23 TA-52 Beta Site	4	4	1.4	–0.1	0.4	0.7
25 TA-16-450	4	4	2.0	0.0	0.8	0.9
26 TA-49	4	4	0.8	–0.1	0.3	0.4
30 Pajarito Booster 2 (P-2)	4	3	4.2	0.3	1.5	1.9
31 TA-3	4	3	6.3	0.2	2.4	2.8
32 County Landfill (alias TA-48)	4	2	4.8	2.2	3.5	1.4
49 Pajarito Road (TA-36)	4	3	1.6	–0.6	0.5	0.9
54 TA-33 East	3	3	2.3	0.1	1.1	1.1
QA Stations						
38 TA-54 Area G (adjacent to station 27)	4	0	1,369.5	41.4	550.8	629.0
39 TA-49 (adjacent to station 26)	4	4	1.3	0.1	0.7	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]	1 *s*
Regional	14	14	1.1	–0.4	0.3	±0.25	0.4
Pueblo	11	9	1.1	–1.3	0.2	±0.47	0.7
Perimeter	72	68	4.4	–0.9	0.6	±0.20	0.9
TA-15	12	10	2.2	–0.9	0.5	±0.55	0.9
TA-21	24	14	165.3	0.5	15.5	±14.11	33.4
TA-54 Area G	32	11	1,584.5	–0.6	91.6	±115.14	319.0
Other On-Site	31	26	6.3	–0.6	1.3	±0.61	1.7

Concentration Guidelines

DOE Derived Air Concentration (DAC) Guide for work place 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 1997

Station Location	Number of Results	Number of Results <MDA	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	1 *s*
Regional Stations						
01 Española	4	4	2.7	0.4	1.5	0.9
02 Pojoaque	1	1	4.2	4.2	4.2	
03 Santa Fe	4	2	4.3	1.6	2.5	1.3
55 Santa Fe West	2	2	3.7	0.3	2.0	2.4
(Buckman Booster #4)	2	2	3.7	0.3	2.0	2.4
56 El Rancho	3	3	3.8	1.7	2.8	1.1
Pueblo Stations						
41 San Ildefonso Pueblo	4	4	2.6	1.1	1.6	0.7
42 Taos Pueblo	3	3	5.6	1.4	3.2	2.2
53 Jemez Pueblo-tribal office	4	3	3.3	0.3	2.0	1.3
Perimeter Stations						
04 Barranca School	4	3	3.9	1.3	2.4	1.1
05 Urban Park	4	3	3.9	0.6	2.1	1.4
06 48th Street	4	3	3.6	1.2	2.0	1.1
07 Gulf/Exxon/Shell Station	4	3	3.9	1.1	1.9	1.3
08 McDonalds Restaurant	4	4	2.6	1.3	1.9	0.6
09 Los Alamos Airport	4	4	3.8	0.3	1.5	1.6
10 East Gate	4	3	2.9	1.4	2.1	0.7
11 Well PM-1 (E. Jemez Road)	4	3	3.6	0.3	1.9	1.5
12 Royal Crest Trailer Court	4	4	2.8	0.8	1.8	1.0
13 Piñon School	4	3	2.9	1.4	2.0	0.7
14 Pajarito Acres	4	3	4.2	0.7	2.0	1.5
15 White Rock Fire Station	4	3	4.5	0.7	1.9	1.7
16 White Rock Nazarene Church	4	3	4.1	1.4	2.6	1.2
17 Bandelier Entrance	4	3	3.9	1.5	2.5	1.1
60 LA Canyon	4	4	1.8	0.0	1.1	0.8
61 LA Hospital	4	4	2.3	0.6	1.7	0.8
62 Trinity Bible Church	4	4	1.9	0.8	1.3	0.5
63 Monte Rey South	4	4	3.1	0.1	1.8	1.3
90 East Gate-Backup						
TA-15 Stations						
76 TA-15-61	4	4	2.1	1.4	1.9	0.3
77 TA-15-IJ Site	4	4	3.2	1.0	1.8	1.0
78 TA-15-N	4	4	3.5	0.4	2.0	1.3
TA-21 Stations						
20 TA-21 Area B	4	4	3.1	0.3	2.0	1.2
71 TA-21.01 (NW Bldg 344)	4	3	4.1	1.0	2.4	1.5
72 TA-21.02 (N Bldg 344)	4	2	5.9	2.3	3.9	1.5
73 TA-21.03 (NE Bldg 344)	4	2	20.2	3.8	10.1	7.2
74 TA-21.04 (SE Bldg 344)	4	2	11.8	1.1	4.7	4.8
75 TA-21.05 (S Bldg 344)	4	3	3.8	2.0	2.7	0.8

Table 4-7. Airborne Americium-241 Concentrations for 1997 (Cont.)

Station Location	Number of Results	Number of Results <MDA	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	1 *s*
TA-54 Area G Stations						
27 TA-54 Area G (by QA)	4	0	1,033.9	43.6	468.9	487.2
34 TA-54 Area G-1 (behind trailer)	4	2	11.6	0.9	5.9	4.9
35 TA-54 Area G-2 (back fence)	4	2	4.5	0.8	2.8	1.5
36 TA-54 Area G-3 (by office)	4	2	7.9	2.5	4.9	2.2
45 TA-54 Area G (SE Perimeter)	4	1	13.5	3.6	7.8	4.7
47 TA-54 Area G (N Perimeter)	4	2	15.4	2.4	8.4	6.5
50 TA-54 Area G-expansion	4	2	8.2	0.6	5.0	3.2
51 TA-54 Area G-expansion pit	4	1	5.8	1.6	3.5	1.8
Other On-Site Stations						
23 TA-52 Beta Site	4	2	4.2	1.1	2.4	1.3
25 TA-16-450	4	3	3.7	0.9	2.2	1.2
26 TA-49	4	3	4.2	0.4	1.9	1.6
30 Pajarito Booster 2 (P-2)	4	3	6.1	0.6	2.7	2.4
31 TA-3	4	3	5.0	0.6	2.5	1.9
32 County Landfill (alias TA-48)	4	2	3.8	1.4	2.5	1.0
49 Pajarito Road (TA-36)	4	4	2.9	1.0	2.2	0.8
54 TA-33 East	3	3	4.8	0.1	3.1	2.6
QA Stations						
38 TA-54 Area G (adjacent to station 27)	4	0	900.0	30.8	367.8	413.6
39 TA-49 (adjacent to station 26)	4	4	3.1	1.4	2.2	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]	1 *s*
Regional	14	12	4.3	0.3	2.3	±0.8	1.3
Pueblo	11	10	5.6	0.3	2.2	±1.0	1.4
Perimeter	72	61	4.5	0.0	1.9	±0.3	1.1
TA-15	12	12	3.5	0.4	1.9	±0.6	0.9
TA-21	24	16	20.2	0.3	4.3	±1.8	4.3
TA-54 Area G	32	12	1,033.9	0.6	63.4	±78.5	217.3
Other On-Site	31	23	6.1	0.1	2.4	±0.5	1.5

Concentration Guidelines
DOE Derived Air Concentration (DAC) Guide for work place 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 1997

Station Location	Number of Results	Number of Results <MDA	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	1 *s*
Regional Stations						
01 Española	4	0	21.0	11.2	15.8	4.3
02 Pojoaque	1	0	21.4	21.4	21.4	
03 Santa Fe	4	0	41.5	13.7	23.0	12.5
55 Santa Fe West (Buckman Booster #4)	2	1	6.7	5.7	6.2	0.7
56 El Rancho	3	0	19.5	8.3	12.8	5.9
Pueblo Stations						
41 San Ildefonso Pueblo	4	0	22.0	14.2	17.2	3.4
42 Taos Pueblo	3	0	26.5	17.6	23.1	4.8
53 Jemez Pueblo-tribal office	4	0	23.3	12.2	16.2	4.9
Perimeter Stations						
04 Barranca School	4	0	12.9	4.5	8.1	3.5
05 Urban Park	4	3	6.8	3.0	4.6	1.7
06 48th Street	4	4	6.1	2.0	3.7	1.9
07 Gulf/Exxon/Shell Station	4	0	18.4	8.6	11.9	4.5
08 McDonalds Restaurant	4	1	11.2	3.6	7.3	3.4
09 Los Alamos Airport	4	0	10.7	5.4	7.3	2.3
10 East Gate	4	1	11.1	3.7	6.6	3.2
11 Well PM-1 (E. Jemez Road)	4	3	8.8	2.8	5.2	2.7
12 Royal Crest Trailer Court	4	3	10.7	3.8	6.5	3.0
13 Piñon School	4	3	8.1	2.2	5.3	2.6
14 Pajarito Acres	4	3	10.1	3.2	5.9	2.9
15 White Rock Fire Station	4	1	15.0	3.8	7.7	5.0
16 White Rock Nazarene Church	4	2	8.2	4.2	6.5	1.9
17 Bandelier Entrance	4	3	7.2	3.7	5.5	1.7
60 LA Canyon	4	0	12.0	5.8	9.0	2.6
61 LA Hospital	4	0	22.3	7.6	13.5	6.9
62 Trinity Bible Church	4	0	10.4	5.2	7.9	2.5
63 Monte Rey South	4	2	9.3	3.2	5.8	2.8
TA-15 Stations						
76 TA-15-61	4	1	11.2	3.9	8.4	3.5
77 TA-15-IJ Site	4	0	21.5	4.8	11.9	7.1
78 TA-15-N	4	2	98.1	2.3	27.9	46.9
TA-21 Stations						
20 TA-21 Area B	4	1	11.0	4.5	7.3	2.9
71 TA-21.01 (NW Bldg 344)	4	1	16.0	3.8	8.9	5.9
72 TA-21.02 (N Bldg 344)	4	0	13.8	5.1	9.9	4.0
73 TA-21.03 (NE Bldg 344)	4	0	17.2	4.0	11.7	6.6
74 TA-21.04 (SE Bldg 344)	4	1	20.9	6.0	11.6	6.8
75 TA-21.05 (S Bldg 344)	4	0	17.9	4.5	11.5	7.2

Table 4-8. Airborne Uranium-234 Concentrations for 1997 (Cont.)

Station Location	Number of Results	Number of Results <MDA	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	1 *s*
TA-54 Area G Stations						
27 TA-54 Area G (by QA)	4	0	111.9	33.4	56.6	37.1
34 TA-54 Area G-1 (behind trailer)	4	0	26.1	10.9	16.3	6.8
35 TA-54 Area G-2 (back fence)	4	0	14.5	5.4	11.5	4.1
36 TA-54 Area G-3 (by office)	4	0	30.1	10.4	17.9	8.8
45 TA-54 Area G (SE Perimeter)	4	0	56.8	15.0	40.4	20.4
47 TA-54 Area G (N Perimeter)	4	0	16.1	7.9	10.9	3.7
50 TA-54 Area G-expansion	4	0	67.9	24.9	39.0	19.6
51 TA-54 Area G-expansion pit	4	0	57.8	17.0	31.0	18.3
Other On-Site Stations						
23 TA-52 Beta Site	4	0	15.5	6.0	10.1	4.2
25 TA-16-450	4	0	12.0	7.5	9.7	1.9
26 TA-49	4	4	4.6	2.8	3.8	0.7
30 Pajarito Booster 2 (P-2)	4	1	10.8	3.6	6.4	3.3
31 TA-3	4	0	11.9	5.7	8.1	2.9
32 County Landfill (alias TA-48)	4	0	46.9	25.2	34.9	9.0
49 Pajarito Road (TA-36)	4	1	14.0	4.0	8.6	4.6
54 TA-33 East	3	0	10.7	3.6	7.4	3.6
QA Stations						
38 TA-54 Area G (adjacent to station 27)	4	0	83.5	26.0	43.3	27.0
39 TA-49 (adjacent to station 26)	4	3	5.0	1.8	3.6	1.6

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[a]	1 *s*
Regional	14	1	41.5	5.7	16.3	±5.17	9.0
Pueblo	11	0	26.5	12.2	18.4	±3.31	4.9
Perimeter	72	29	22.3	2.0	7.1	±0.88	3.7
TA-15	12	3	98.1	2.3	16.0	±16.74	26.4
TA-21	24	3	20.9	3.8	10.2	±2.27	5.4
TA-54 Area G	32	0	111.9	5.4	28.0	±8.10	22.4
Other On-Site	31	6	46.9	2.8	11.2	±3.73	10.2

Concentration Guidelines

DOE Derived Air Concentration (DAC) Guide for work place 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 1997

Station Location	Number of Results	Number of Results <MDA	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	1 *s*
Regional Stations						
01 Española	4	4	1.9	0.2	0.9	0.7
02 Pojoaque	1	1	0.3	0.3	0.3	
03 Santa Fe	4	4	3.5	1.0	2.3	1.0
55 Santa Fe West (Buckman Booster #4)	2	2	1.3	0.5	0.9	0.6
56 El Rancho	3	3	1.1	–0.2[a]	0.6	0.7
Pueblo Stations						
41 San Ildefonso Pueblo	4	4	2.2	0.0	1.0	0.9
42 Taos Pueblo	3	3	1.4	0.9	1.2	0.3
53 Jemez Pueblo-tribal office	4	4	1.5	0.4	1.2	0.5
Perimeter Stations						
04 Barranca School	4	4	1.6	–0.1	0.8	0.7
05 Urban Park	4	4	1.5	0.0	0.8	0.6
06 48th Street	4	4	1.2	–1.0	0.4	1.0
07 Gulf/Exxon/Shell Station	4	4	1.5	0.5	1.0	0.5
08 McDonalds Restaurant	4	4	3.1	–0.1	1.2	1.4
09 Los Alamos Airport	4	4	1.9	–0.1	1.0	0.9
10 East Gate	4	4	1.3	–0.1	0.6	0.6
11 Well PM-1 (E. Jemez Road)	4	4	1.0	–0.7	0.4	0.8
12 Royal Crest Trailer Court	4	4	2.2	0.4	1.2	0.8
13 Piñon School	4	4	2.1	–0.4	0.7	1.2
14 Pajarito Acres	4	4	1.2	0.2	0.7	0.4
15 White Rock Fire Station	4	4	3.4	0.0	1.1	1.6
16 White Rock Nazarene Church	4	4	1.2	0.1	0.7	0.5
17 Bandelier Entrance	4	3	2.2	–0.4	0.5	1.2
60 LA Canyon	4	4	1.5	–0.1	0.9	0.7
61 LA Hospital	4	4	2.5	0.4	1.3	0.9
62 Trinity Bible Church	4	4	1.3	0.7	1.0	0.3
63 Monte Rey South	4	4	1.6	–0.2	0.5	0.9
TA-15 Stations						
76 TA-15-61	4	4	0.9	0.2	0.6	0.3
77 TA-15-IJ Site	4	4	2.1	–0.6	0.8	1.2
78 TA-15-N	4	4	2.9	–1.3	0.8	1.7
TA-21 Stations						
20 TA-21 Area B	4	4	0.9	0.1	0.6	0.4
71 TA-21.01 (NW Bldg 344)	4	4	1.0	0.0	0.4	0.5
72 TA-21.02 (N Bldg 344)	4	4	1.5	0.7	1.0	0.4
73 TA-21.03 (NE Bldg 344)	4	4	1.6	–0.2	0.5	0.8
74 TA-21.04 (SE Bldg 344)	4	3	1.6	–0.1	0.8	0.7
75 TA-21.05 (S Bldg 344)	4	4	2.3	–0.1	0.6	1.2

Table 4-9. Airborne Uranium-235 Concentrations for 1997 (Cont.)

Station Location	Number of Results	Number of Results <MDA	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	1 *s*
TA-54 Area G Stations						
27 TA-54 Area G (by QA)	4	3	8.6	2.8	4.8	2.7
34 TA-54 Area G-1 (behind trailer)	4	4	3.4	0.7	1.5	1.3
35 TA-54 Area G-2 (back fence)	4	4	1.7	0.1	0.7	0.7
36 TA-54 Area G-3 (by office)	4	4	3.0	0.6	1.7	1.0
45 TA-54 Area G (SE Perimeter)	4	4	3.4	2.0	2.7	0.7
47 TA-54 Area G (N Perimeter)	4	4	1.8	0.4	1.0	0.7
50 TA-54 Area G-expansion	4	4	3.4	1.5	2.4	0.8
51 TA-54 Area G-expansion pit	4	3	5.0	0.4	2.2	2.0
Other On-Site Stations						
23 TA-52 Beta Site	4	4	2.4	0.6	1.2	0.8
25 TA-16-450	4	4	1.8	0.6	1.0	0.6
26 TA-49	4	4	0.4	0.0	0.3	0.2
30 Pajarito Booster 2 (P-2)	4	4	2.0	–1.0	0.7	1.3
31 TA-3	4	4	1.0	–0.1	0.5	0.5
32 County Landfill (alias TA-48)	4	4	2.5	0.4	1.5	0.9
49 Pajarito Road (TA-36)	4	3	0.2	–0.5	–0.2	0.3
54 TA-33 East	3	3	1.1	–0.9	0.4	1.1
QA Stations						
38 TA-54 Area G (adjacent to station 27)	4	4	2.7	1.3	1.8	0.6
39 TA-49 (adjacent to station 26)	4	4	1.0	–0.4	0.5	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]	1 *s*
Regional	14	14	3.5	–0.2	1.2	±0.57	1.0
Pueblo	11	11	2.2	0.0	1.1	±0.39	0.6
Perimeter	72	71	3.4	–1.0	0.8	±0.19	0.8
TA-15	12	12	2.9	–1.3	0.7	±0.70	1.1
TA-21	24	23	2.3	–0.2	0.7	±0.28	0.7
TA-54 Area G	32	30	8.6	0.1	2.1	±0.63	1.7
Other On-Site	31	30	2.5	–1.0	0.7	±0.32	0.9

Concentration Guidelines

DOE Derived Air Concentration (DAC) Guide for work place 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 1997

Station Location	Number of Results	Number of Results <MDA	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	1 *s*
Regional Stations						
01 Española	4	0	16.9	8.8	13.0	4.5
02 Pojoaque	1	0	19.5	19.5	19.5	
03 Santa Fe	4	0	36.6	12.3	21.2	10.6
55 Santa Fe West (Buckman Booster #4)	2	1	5.8	5.5	5.6	0.2
56 El Rancho	3	0	15.0	7.9	10.3	4.1
Pueblo Stations						
41 San Ildefonso Pueblo	4	0	23.8	11.8	17.3	5.0
42 Taos Pueblo	3	0	26.5	19.2	23.2	3.7
53 Jemez Pueblo-tribal office	4	0	25.5	7.6	16.2	7.3
Perimeter Stations						
04 Barranca School	4	0	27.2	5.9	12.7	9.9
05 Urban Park	4	3	10.4	4.1	6.2	2.8
06 48th Street	4	3	11.6	2.0	5.2	4.3
07 Gulf/Exxon/Shell Station	4	0	34.3	7.3	16.2	12.4
08 McDonalds Restaurant	4	1	41.5	5.1	15.0	17.7
09 Los Alamos Airport	4	1	18.8	3.3	8.9	7.1
10 East Gate	4	2	10.3	2.5	6.3	3.2
11 Well PM-1 (E. Jemez Road)	4	2	11.8	3.7	6.2	3.8
12 Royal Crest Trailer Court	4	2	39.1	3.6	14.2	16.7
13 Piñon School	4	2	8.6	4.1	5.7	2.1
14 Pajarito Acres	4	3	10.9	3.1	5.8	3.5
15 White Rock Fire Station	4	1	9.0	5.5	6.7	1.7
16 White Rock Nazarene Church	4	2	7.8	3.6	5.6	1.7
17 Bandelier Entrance	4	2	9.0	3.1	5.5	2.8
60 LA Canyon	4	0	13.0	6.8	10.2	2.7
61 LA Hospital	4	0	19.2	6.9	12.0	5.7
62 Trinity Bible Church	4	0	28.8	6.0	14.0	10.5
63 Monte Rey South	4	2	9.8	3.7	6.3	2.9
TA-15 Stations						
76 TA-15-61	4	1	18.9	3.8	12.6	6.5
77 TA-15-IJ Site	4	0	108.6	12.4	45.5	43.1
78 TA-15-N	4	1	13.8	3.2	8.2	4.7
TA-21 Stations						
20 TA–21 Area B	4	3	20.5	3.7	8.8	7.9
71 TA-21.01 (NW Bldg 344)	4	1	20.6	2.0	9.9	8.0
72 TA-21.02 (N Bldg 344)	4	0	23.0	4.0	10.8	8.5
73 TA-21.03 (NE Bldg 344)	4	0	26.0	4.3	13.6	9.5
74 TA-21.04 (SE Bldg 344)	4	1	21.9	5.2	9.9	8.0
75 TA-21.05 (S Bldg 344)	4	0	21.5	3.4	10.9	8.2

Table 4-10. Airborne Uranium-238 Concentrations for 1997 (Cont.)

Station Location	Number of Results	Number of Results <MDA	Maximum (aCi/m^3)	Minimum (aCi/m^3)	Mean (aCi/m^3)	1 *s*
TA-54 Area G Stations						
27 TA-54 Area G (by QA)	4	0	109.7	32.6	55.7	36.2
34 TA-54 Area G-1 (behind trailer)	4	0	18.0	7.2	13.7	4.6
35 TA-54 Area G-2 (back fence)	4	0	16.9	5.9	12.6	4.8
36 TA-54 Area G-3 (by office)	4	0	36.0	7.3	19.6	12.2
45 TA-54 Area G (SE Perimeter)	4	0	57.9	16.8	38.5	18.5
47 TA-54 Area G (N Perimeter)	4	0	16.6	7.7	11.8	3.8
50 TA-54 Area G-expansion	4	0	61.7	24.2	40.7	16.2
51 TA-54 Area G-expansion pit	4	0	55.6	14.7	31.2	17.4
Other On-Site Stations						
23 TA-52 Beta Site	4	0	24.3	4.3	13.0	8.7
25 TA-16-450	4	0	13.7	5.8	8.6	3.5
26 TA-49	4	1	6.9	2.8	4.5	1.8
30 Pajarito Booster 2 (P-2)	4	1	17.6	3.9	8.5	6.2
31 TA-3	4	0	13.1	5.3	7.9	3.7
32 County Landfill (alias TA-48)	4	0	54.1	32.1	39.0	10.2
49 Pajarito Road (TA-36)	4	0	12.8	6.6	9.9	3.1
54 TA-33 East	3	2	7.5	3.4	5.6	2.0
QA Stations						
38 TA-54 Area G (adjacent to station 27)	4	0	84.2	27.3	44.9	26.3
39 TA-49 (adjacent to station 26)	4	2	6.7	2.2	4.4	2.3

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]	1 *s*
Regional	14	1	36.6	5.5	14.2	±4.67	8.1
Pueblo	11	0	26.5	7.6	18.5	±3.99	5.9
Perimeter	72	26	41.5	2.0	9.0	±1.86	7.9
TA-15	12	2	108.6	3.2	22.1	±18.24	28.7
TA-21	24	5	26.0	2.0	10.7	±3.20	7.6
TA-54 Area G	32	0	109.7	5.9	28.0	±7.82	21.7
Other On-Site	31	4	54.1	2.8	12.3	±4.33	11.9

Concentration Guidelines
DOE Derived Air Concentration (DAC) Guide for work place 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 Radioactive Emissions from Laboratory Buildings with Sampled Stacks in 1997 (Ci)

TA-Building	^{3}H[a]	^{241}Am	Pu[b]	U[c]	Th	^{90}Sr	P/VAP[d]	G/MAP[e]
TA-03-029		0.00000037	0.0000035	0.000021	0.00000037	0.000000078		
TA-03-035		0.0000000014	0.0000000026	0.00000017				
TA-03-102		0.00000000053	0.0000000014	0.00000082	0.000000011			
TA-16-205	98.							
TA-21-155	38.							
TA-21-209	170.							
TA-33-086	43.							
TA-41-004	42.							
TA-48-001		0.00000000036	0.0000000025			0.0000000015	0.0018	
TA-50-001		0.0000000084	0.000000054			0.00000010		
TA-50-037				0.0000000013		0.000000015		
TA-50-069			0.00000000015			0.00000000020		
TA-53-003	15.						0.52	19000.
TA-53-007	1.8						0.41	570.
TA-55-004	12.		0.00000011	0.000000028	0.000000044			

[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 4-12. Detailed Listing of Activation Products Released from Sampled Laboratory Stacks in 1997 (Ci)

TA-Building	Radionuclide	Emission
TA-48-001	^{72}As	0.000029
	^{73}As	0.000012
	^{74}As	0.00000064
	^{77}Br	0.0016
	^{191}Os	0.0000092
	^{75}Se	0.00012
TA-53-003	^{41}Ar	190.
	^{7}B	0.000081
	^{76}Br	0.12
	^{77}Br	0.22
	^{82}Br	0.17
	^{10}C	190.
	^{11}C	12000.
	^{60}Co	0.00024
	^{195}Hg	0.0041
	^{197}Hg	0.0095
	^{13}N	2000.
	^{16}N	130.
	^{24}Na	0.0021
	^{14}O	91.
	^{15}O	4400.
	^{183}Os	0.0037
	^{185}Os	0.0013
	^{182}Ta	0.0013
TA-53-007	^{41}Ar	8.0
	^{192}Au	0.012
	^{76}Br	0.0013
	^{82}Br	0.35
	^{10}C	0.13
	^{11}C	430
	^{193}Hg	0.0043
	^{195}Hg	0.015
	^{195m}Hg	0.00077
	^{197}Hg	0.017
	^{197m}Hg	0.0024
	^{13}N	60.
	^{14}O	0.58
	^{15}O	67.

Table 4-13. 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 4-14. Thermoluminescent Dosimeter (TLD) Measurements of External Radiation 1996–1997

	TLD Station ID #	Location	1997 Annual Dose (mrem)[a,b]	1997 Quarters Monitored	1996 Annual Dose (mrem)
Regional	01	Española	30 ± 5	1[d]	98 ± 11[d]
	03	Santa Fe	98 ± 6	1, 4[d]	105 ± 9[d]
	53	El Rancho	109 ± 6	1–4	82 ± 16[d]
	95	Pueblo of San Ildefonso[c]	71 ± 7	3–4[d]	– – –
Perimeter	05	Barranca School, Los Alamos	139 ± 9	1–4	104 ± 10[d]
	07	Cumbres School, Los Alamos	136 ± 8	1–4	130 ± 12
	08	48th Street, Los Alamos	138 ± 8	1–4	144 ± 11
	09	Los Alamos Airport	130 ± 8	1–4	131 ± 11
	10	Bayo Canyon, Los Alamos	182 ± 10	1–4	170 ± 12
	11	Shell Station, Los Alamos	109 ± 8	1–4	142 ± 11
	12	Royal Crest Trailer Court, Los Alamos	143 ± 8	1–4	140 ± 11
	13	White Rock	141 ± 8	1–4	134 ± 11
	14	Pajarito Acres, White Rock	138 ± 8	1–4	130 ± 11
	15	Bandelier National Monument Lookout Station	152 ± 9	1–4	149 ± 12
	16	Pajarito Ski Area	139 ± 9	1–4	114 ± 10[d]
	41	McDonald's Restaurant, Los Alamos	126 ± 8	1, 2, 4[d]	78 ± 8[d]
	42	Los Alamos Airport-South	154 ± 10	1–4	147 ± 11
	43	East Gate Business Park, Los Alamos	141 ± 8	1–4	145 ± 11
	44	Big Rock Loop, Los Alamos	137 ± 11	1–4	176 ± 12
	45	Cheyenne Street, Los Alamos	156 ± 9	1–4	165 ± 12
	46	Los Pueblos Street, Los Alamos	157 ± 9	1–4	161 ± 12
	47	Urban Park, Los Alamos	149 ± 9	1–4	144 ± 12
	49	Piñon School, White Rock	129 ± 8	1–4	103 ± 10[d]
	50	White Rock Church of the Nazarene	107 ± 7	1–4	95 ± 10
	51	Bayo Canyon Well, Los Alamos	164 ± 10	1–4	162 ± 12
	55	Monte Rey South, White Rock	136 ± 8	1–4	128 ± 11
	56	East Gate (mid station)	159 ± 10	1–4	– – –
	60	Piedra Drive, White Rock[c]	138 ± 8	1–4	– – –
	67	Los Alamos Hospital	75 ± 7	2–3[d]	– – –
	68	Trinity Church[c]	83 ± 7	2, 4[d]	– – –
	80	TA-16 SR4 Back Gate[c]	111 ± 8	2–4	– – –
	81	TA-16 SR4 Ponderosa Camp[c]	149 ± 11	2–4	– – –
On-Site	17	TA-21 (DP West)	166 ± 10	1–4	155 ± 12
	18	TA-6 (Two Mile Mesa)	148 ± 9	1–4	142 ± 11
	19	TA-53 (LANSCE)	173 ± 10	1–4	159 ± 12
	20	Well PM-1 (SR4 and Truck Rt.)	163 ± 9	1–4	167 ± 12
	21	TA-16 (S-Site)	151 ± 9	1–4	141 ± 11
	22	Booster P-2	147 ± 10	1–4	179 ± 12
	23	TA-3 East Gate of SM 43	135 ± 8	1–4	125 ± 11
	24	State Highway 4	178 ± 11	1–4	178 ± 13
	25	TA-49 (Frijoles Mesa)	148 ± 10	1–4	135 ± 11
	26	TA-2 (Omega Stack)	154 ± 9	1–4	148 ± 12
	27	TA-2 (Omega Canyon)[e]	37 ± 4	1[d]	173 ± 13
	28	TA-18 (Pajarito Site)	166 ± 10	1–4	241 ± 13
	29	TA-35 (Ten Site A)	145 ± 9	1–4	92 ± 10

Table 4-14. Thermoluminescent Dosimeter (TLD) Measurements of External Radiation 1996–1997 (Cont.)

	TLD Station ID #	Location	1997 Annual Dose (mrem)[a,b]	1997 Quarters Monitored	1996 Annual Dose (mrem)
On-Site (Cont.)	30	TA-35 (Ten Site B)	137 ± 8	1–4	140 ± 12
	31	TA-59 (Occupational Health Lab)	146 ± 9	1–4	144 ± 12
	32	TA-3-16 (Van de Graaff)	148 ± 9	1–4	153 ± 11
	33	TA-3-316 (Ion Beam Bldg.)	150 ± 9	1–4	144 ± 12
	34	TA-3-440 (CAS)	147 ± 9	1–4	113 ± 13
	35	TA-3-420 (CMR Bldg. West Fence)	136 ± 8	1–4	111 ± 11
	36	TA-3-102 (Shop)	146 ± 9	1–4	115 ± 11
	37	TA-72 (Pistol Range)	172 ± 11	1–4	142 ± 12
	38	TA-55 (Plutonium Facility South)	153 ± 10	1–4	132 ± 14
	39	TA-55 (Plutonium Facility West)	165 ± 10	1–4	181 ± 12
	40	TA-55 (Plutonium Facility North)	148 ± 9	1–4	154 ± 11
	48	Los Alamos County Landfill	136 ± 8	1–4	135 ± 11
	56	East Gate Mid Station			119 ± 10[d]
	57	TA-54 West (TLD Lab)	157 ± 9	1–4	129 ± 11[d]
	58	TA-54 Lagoon	159 ± 9	1–4	89 ± 9[d]
	59	Los Alamos Canyon	167 ± 10	1–4	52 ± 8[d]
	61	S. LANSCE Lagoons[c]	934 ± 75	2–4	– – –
	62	N. LANSCE Lagoons[c]	332 ± 24	2–4	– – –
	63	E. LANSCE Lagoons[c]	741 ± 57	2–4	– – –
	64	NE LANSCE Area A Stack[c]	369 ± 27	2–4	– – –
	65	NW LANSCE Area A Stack[c]	222 ± 16	2–4	– – –
	69	TA-50 Old Outfall[c]	82 ± 7	3–4[d]	– – –
	70	TA-50 Dirt Road to Outfall[c]	96 ± 9	3–4[d]	– – –
	71	TA-50 Dirt Road Turnoff[c]	123 ± 10	2–4	– – –
	72	TA-50 East Fence[c]	116 ± 8	2–4	– – –
	73	TA-50 South Corner[c]	113 ± 8	2–4	– – –
	74	TA-50 Pecos Drive[c]	107 ± 8	2–4	– – –
	75	TA-50-37 West[c]	118 ± 8	2–4	– – –
	76	TA-16 WETF[c]	111 ± 8	2–4	– – –
	77	TA-16 Guard Station[c]	82 ± 8	2, 4[d]	– – –
	78	Fitness Trail SW TA-8-24[c]	116 ± 8	2–4	– – –
	79	Fitness Trail SE TA-8-24[c]	115 ± 8	2–4	– – –
	82	TA-15 Phermex N TA-15-185[c]	111 ± 8	2–4	– – –
	83	TA-15 Phermex Entrance[c]	100 ± 7	2–4	– – –
	84	TA-15 Phermex NNE Entrance[c]	105 ± 8	2–4	– – –
	85	TA-15 Phermex N DAHRT[c]	100 ± 7	2–4	– – –
	86	TA-15-312 DAHRT Entrance[c]	96 ± 8	2–4	– – –
	87	TA-15-183 Access Control[c]	114 ± 9	2–4	– – –
	88	TA-15 R-Site Road[c]	107 ± 8	2–4	– – –
	89	TA-15-45 SW[c]	110 ± 8	2–4	– – –
	90	TA-15-306 North[c]	105 ± 8	2–4	– – –
	91	TA-15, IJ Firing Pit[c]	63 ± 5	3–4[d]	– – –
	92	TA-36 Kappa Site[c]	111 ± 8	2–4	– – –
	93	TA-15 Ridge Road Gate[c]	25 ± 3	3[d]	– – –
	94	TA-33 VLBA Dish[c]	60 ± 5	3–4	– – –
	97	TA-50, GS-1-1, Mortandad Canyon[c]	74 ± 6	3–4	– – –
	98	TA-50, GS-1-2, Mortandad Canyon[c]	160 ± 14	3–4	– – –
	99	Mortandad Canyon, MCO-5[c]	170 ± 149	3–4	– – –
	100	Mortandad Canyon, MCO-13[c]	63 ± 5	3–4	– – –

Table 4-14. Thermoluminescent Dosimeter (TLD) Measurements of External Radiation 1996–1997 (Cont.)

TLD Station ID #	Location	1997 Annual Dose (mrem)[a,b]	1997 Quarters Monitored	1996 Annual Dose (mrem)

[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 1997.
[d]One or more quarters of data not reported due to loss of TLDs or analytical problems.
[e]Station ceased operation in 1997.

Table 4-15. Thermoluminescent Dosimeter (TLD) Measurements of External Radiation at Waste Disposal Areas during 1997

	TLD Station ID #	Location	1997 Annual Dose (mrem)[a,b]	1997 Quarters Monitored
Area W	381	TA-35 Area W-1	156 ± 10	1–4
	382	TA-35 Area W-2	153 ± 10	1–4
	383	TA-35 Area X	132 ± 10	1–4
Area V	361	TA-21 Area V-1	141 ± 11	1–4
	362	TA-21 Area V-2	156 ± 16	1–4
	363	TA-21 Area V-3	159 ± 12	1–4
	364	TA-21 Area V-4	145 ± 12	1–4
Area U	341	TA-21 Area U-1	142 ± 11	1–4
	342	TA-21 Area U-2	149 ± 11	1–4
	343	TA-21 Area U-3	157 ± 13	1–4
	344	TA-21 Area U-4	145 ± 11	1–4
Area T	321	TA-21 Area T-1	161 ± 12	1–4
	322	TA-21 Area T-2	157 ± 12	1–4
	323	TA-21 Area T-3	307 ± 17	1–4
	324	TA-21 Area T-4	151 ± 11	1–4
	325	TA-21 Area T-5	143 ± 11	1–4
	326	TA-21 Area T-6	148 ± 11	1–4
	327	TA-21 Area T-7	152 ± 11	1–4
Area G	601	TA-54 Area G, 1	169 ± 10	1–4
	602	TA-54 Area G, 2	219 ± 13	1–4
	603	TA-54 Area G, 3	152 ± 9	1–4
	604	TA-54 Area G, 4	158 ± 9	1–4
	605	TA-54 Area G, 5	165 ± 10	1–4
	606	TA-54 Area G, 6	160 ± 9	1–4
	607	TA-54 Area G, 7	207 ± 12	1–4
	608	TA-54 Area G, 8	195 ± 11	1–4
	610	TA-54 Area G, 10	179 ± 11	1–4
	611	TA-54 Area G, 11	160 ± 11	2–4[d]
	613	TA-54 Area G, 13	220 ± 13	1–4
	614	TA-54 Area G, 14	205 ± 13	1–4
	615	TA-54 Area G, 15	175 ± 11	1–4
	616	TA-54 Area G, 16	166 ± 9	1–4
	617	TA-54 Area G, 17	168 ± 10	1–4
	618	TA-54 Area G, 18	187 ± 11	1–4
	619	TA-54 Area G, 19	211 ± 12	1–4
	620	TA-54 Area G, 20	172 ± 10	1–4
	622	TA-54 Area G, 22	223 ± 13	1–4
	623	TA-54 Area G, 23	278 ± 16	1–4
	624	TA-54 Area G, 24	174 ± 10	1–4
	625	TA-54 Area G, 25	189 ± 11	1–4
	626	TA-54 Area G, 26	166 ± 10	1–4

Table 4-15. Thermoluminescent Dosimeter (TLD) Measurements of External Radiation at Waste Disposal Areas during 1997 (Cont.)

	TLD Station ID #	Location	1997 Annual Dose (mrem)[a,b]	1997 Quarters Monitored
Area G (Cont.)	628	TA-54 Area G, 28	201 ± 11	1–4
	629	TA-54 Area G, 29	250 ± 16	1–4
	630	TA-54 Area G, 30	209 ± 12	1–4
	631	TA-54 Area G, 31	183 ± 11	1–4
	634	TA-54 Area G, 34[c]	166 ± 11	2–4
	635	TA-54 Area G, 35[c]	158 ± 11	2–4
	636	TA-54 Area G, 36[c]	83 ± 7	2, 4[d]
	637	TA-54 Area G, 37[c]	117 ± 8	2–4
	638	TA-54 Area G, 38[c]	117 ± 9	2–4
Area F	301	TA-6 Area F-1	153 ± 11	1–4
	302	TA-6 Area F-2	150 ± 11	1–4
	303	TA-6 Area F-3	146 ± 11	1–4
	304	TA-6 Area F-4	150 ± 11	1–4
Area E	281	TA-33 Area E-1	115 ± 11	1 - 3[d]
	282	TA-33 Area E-2	159 ± 12	1–4
	283	TA-33 Area E-3	162 ± 12	1–4
	284	TA-33 Area E-4	157 ± 13	1–4
Area C	261	TA-50 N Area (C-1) SW Bldg 37	141 ± 11	1–4
	262	TA-50 N Area (C-2) Bldg 1	162 ± 12	1–4
	263	TA-50 Area C-3	44 ± 5	4[d]
	264	TA-50 Area C-4	172 ± 12	1–4
	265	TA-50 SE Area (C-5)	161 ± 12	1–4
	266	TA-50 Area C-6	161 ± 12	1–4
	267	TA-50 Area C-7	150 ± 11	1–4
	268	TA-50 S Area (C-8)	150 ± 11	1–4
	269	TA-50 Area C-9	118 ± 11	2, 4[d]
	270	TA-50 W Area (C-10)	152 ± 11	1–4
Area B	241	TA-21 Area B-1	100 ± 9	2–3[d]
	242	TA-21 Area B-2	141 ± 11	1–4
	243	TA-21 Area B-3	116 ± 9	2–3[d]
	244	TA-21 Area B-4	138 ± 10	1–4
	245	TA-21 Area B-5	126 ± 10	1–4
	246	TA-21 Area B-6	149 ± 10	1–4
	247	TA-21 Area B-7	155 ± 11	1–4
	248	TA-21 Area B-8	163 ± 10	1–4
	249	TA-21 Area B-9	146 ± 10	1–4
	250	TA-21 Area B-10	158 ± 11	1–4
	251	TA-21 Area B-11	155 ± 11	1–4
	252	TA-21 Area B-12	163 ± 11	1–4
	253	TA-21 Area B-13	159 ± 10	1–4
	254	TA-21 Area (B-14) S AirNet#20	153 ± 11	1–4

Table 4-15. Thermoluminescent Dosimeter (TLD) Measurements of External Radiation at Waste Disposal Areas during 1997 (Cont.)

	TLD Station ID #	Location	1997 Annual Dose (mrem)[a,b]	1997 Quarters Monitored
Area AB	221	TA-49 (AB-1)	145 ± 11	1–4
	222	TA-49 (AB-2)	146 ± 11	1–4
	223	TA-49 (AB-3)	146 ± 11	1–4
	224	TA-49 (AB-4)	143 ± 12	1–4
	225	TA-49 (AB-5)	149 ± 11	1–4
	226	TA-49 (AB-6)	149 ± 11	1–4
	227	TA-49 (AB-7)	145 ± 11	1–4
	228	TA-49 NW (AB-8)	145 ± 11	1–4
	229	TA-49 W (AB-9, near gate)	140 ± 12	1–4
	230	TA-49 SW (AB-10)	148 ± 12	1–4
Area A	201	TA-21 Area A-1	143 ± 12	1–4
	202	TA-21 Area A-2	145 ± 11	1–4
	203	TA-21 Area A-3	146 ± 12	1–4
	204	TA-21 Area A-4	144 ± 11	1–4
	205	TA-21 Area A-5	142 ± 11	1–4

[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 1997.
[d]One or more quarters of data not reported due to loss of TLDs or analytical problems.

Table 4-16. TA-18 Albedo Dosimeter Network

Location ID #	Location	Dosimeter Reading (mrem) Continuous[a]	Dosimeter Reading (mrem) Road Open[a]
1	NEWNET Kappa Site	15	4.8
2	TA-36 Entrance	5.2	4.5
3	TA-18 Personnel Gate at Parking Lot	50	18
4	P2 Booster Station at TA-54 Entrance	3.9	3.6
5	TA-51 Entrance	1.1	1.4
6	Pajarito Hill West of TA-18 Entrance	18	6.1
7	TA-18 Entrance at Pajarito Road	24	5.0
8	Santa Fe Background	0.3	NA[b]
8	TA-49 Background	0.33	NA[b]
9	Vault Control	0.07	NA[b]

[a]Reported dose is the sum of results from quarters 2–4. Only quarter 2 data available for Santa Fe.
[b]Not Applicable—background or control location with continuous exposure.

Table 4-17. Estimated Concentrations of Materials[a] Released by Dynamic Experiments

	Total Usage (kg)	Respirable Release (%)	Amount Released (kg)	Maximum Impact (2,767 m) ($\mu g/m^3$)	Nearest Public Access Point (1,500 m) ($\mu g/m^3$)	Nearest Off-Site Receptor (3,800 m) ($\mu g/m^3$)
Beryllium	0.1	2	0.002	2×10^{-7}	1×10^{-7}	9×10^{-7}
Molybdenum	0.4	10	0.04	2×10^{-5}	2×10^{-5}	2×10^{-5}
Tin	1.085	10	0.11	8×10^{-5}	5×10^{-5}	7×10^{-5}
Iron	4.4	10	0.44	4×10^{-4}	2×10^{-4}	3×10^{-4}
Lithium Hydride	7	10	0.70	6×10^{-4}	4×10^{-4}	5×10^{-4}
Lead	7.096	10	0.71	6×10^{-4}	4×10^{-4}	5×10^{-4}
Tantalum	7.103	10	0.71	6×10^{-4}	4×10^{-4}	5×10^{-4}
Brass	156.6	10	15.66	2×10^{-3}	1×10^{-3}	2×10^{-3}
Copper	276.34	10	27.63	3×10^{-3}	1×10^{-3}	2×10^{-3}
Steel	323.85	10	32.39	3×10^{-3}	2×10^{-3}	2×10^{-3}
Aluminum	889.05	10	88.91	9×10^{-3}	4×10^{-3}	7×10^{-3}

[a]Materials that exceeded 70 kg, that are toxic air pollutants as listed in 20 NMAC 2.72 (Construction Permits), and/or that have national ambient air quality standards.

Table 4-18. Calculated Actual Emissions for Criteria Pollutants (Tons)

Source	PM	CO	NO_X	SO_X	VOC
Asphalt Plant	0.05	0.22	0.02	0.00	0.01
TA-3 Power Plant	1.74	13.90	56.65	0.21	0.49
TA-16 Power Plant	0.43	1.32	1.32	0.02	0.19
TA-21 Power Plant	0.41	1.02	4.10	0.02	0.08
Water Pump	0.01	6.61	20.64	0.01	0.41
Large Boilers[a]	0.53	0.92	4.40	0.03	0.23
Total	3.16	23.99	87.13	0.29	1.42

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

Table 4-19. 1997 Precipitation (in.)

	North Community	TA-16	TA-6	TA-49	TA-53	TA-54	TA-74
January	1.54	1.77	1.68	1.51	1.12	1.05	1.16
February	1.67	2.26	2.18	2.48	2.29	1.56	1.71
March	0.07	0.19	0.09	0.18	0.09	0.17	0.08
April	1.79	2.16	2.04	1.95	1.79	1.74	1.72
May	2.50	1.81	1.55	1.50	0.81	0.96	1.31
June	2.29	2.18	1.91	1.87	1.71	1.72	1.55
July	2.75	2.25	2.63	2.01	1.99	1.64	1.87
August	6.69	6.47	6.44	3.44	4.48	3.98	5.16
September	2.88	4.96	3.40	3.75	1.70	2.06	1.58
October	0.98	0.80	0.59	0.49	0.82	0.85	0.61
November	0.71	1.17	1.16	1.40	0.83	0.88	0.66
December	1.01	2.11	1.83	1.69	1.39	1.17	1.13
Total	24.88	28.13	25.50	22.27	19.02	17.78	18.54

J. Figures

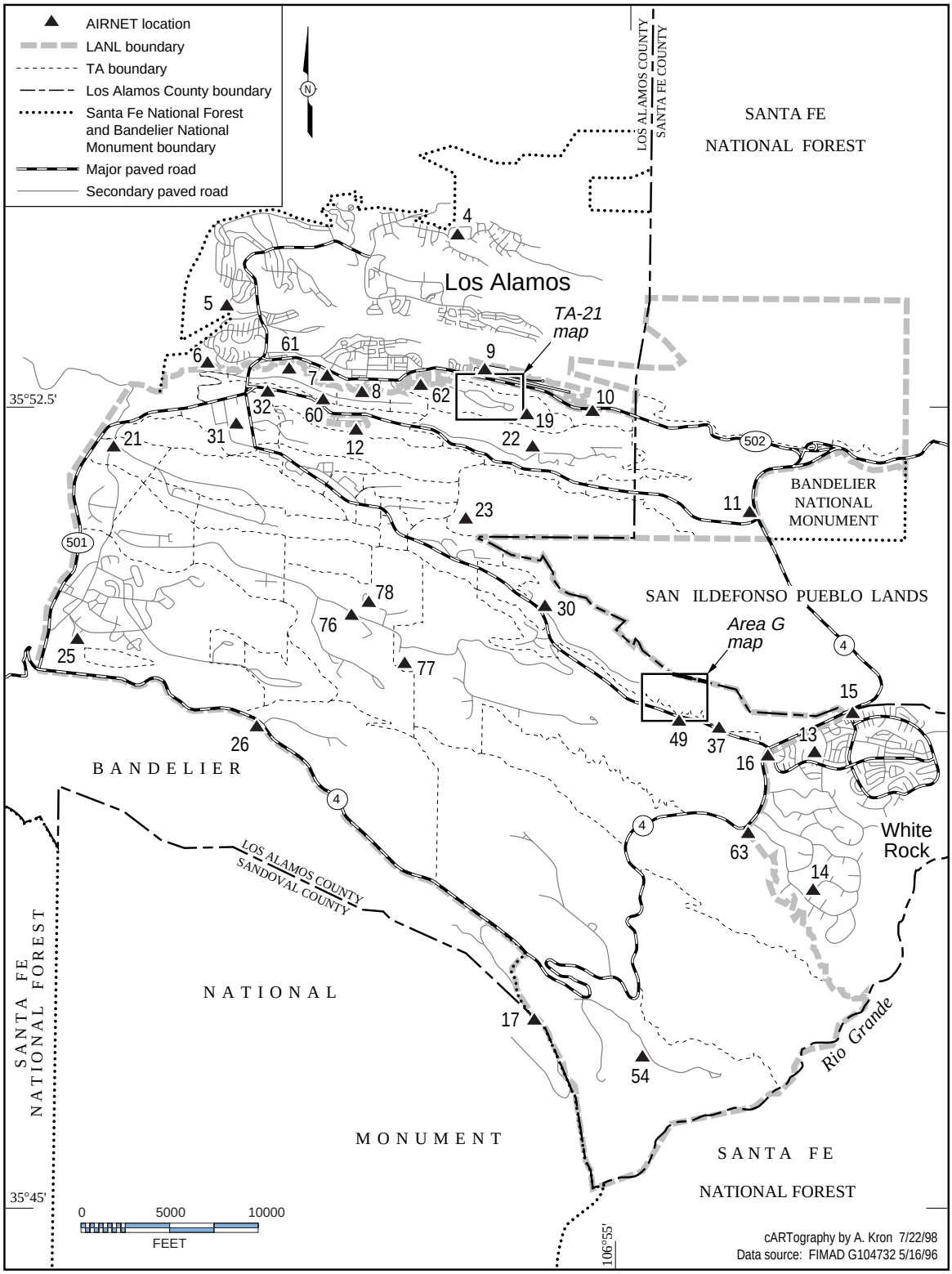


Figure 4-1. Off-site perimeter and on-site Laboratory AIRNET locations.

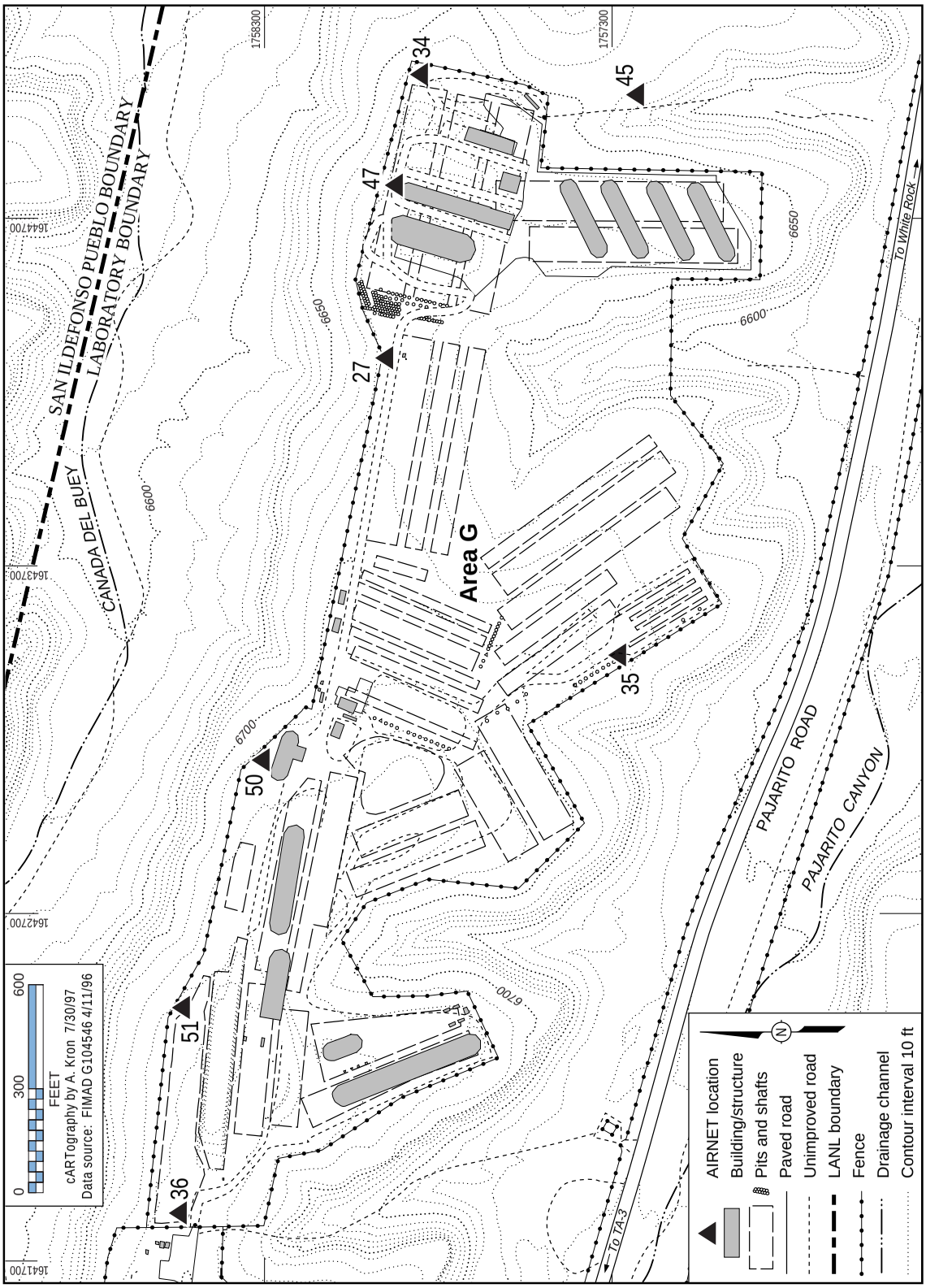


Figure 4-2. Technical Area 54, Area G map of AIRNET locations.

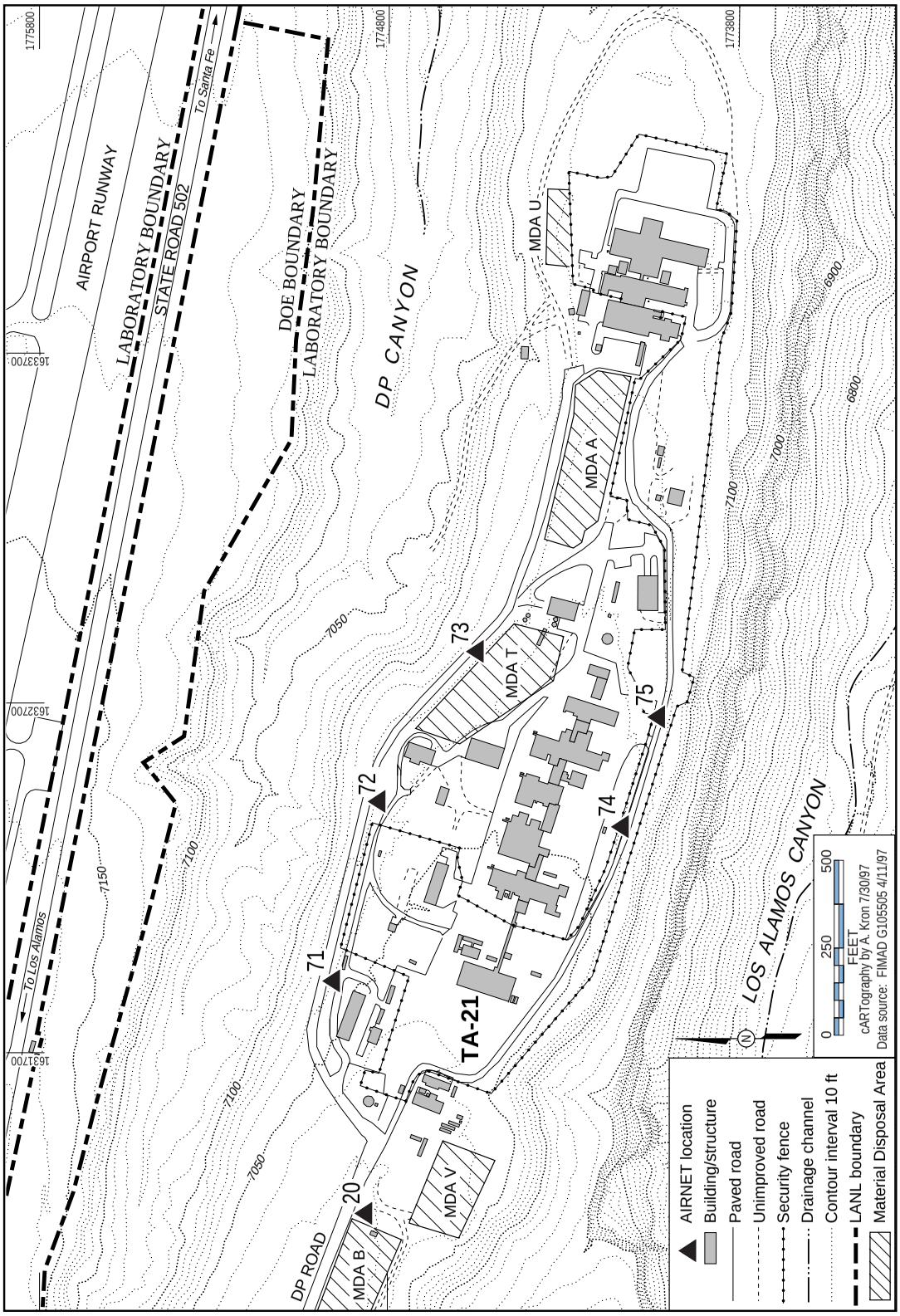
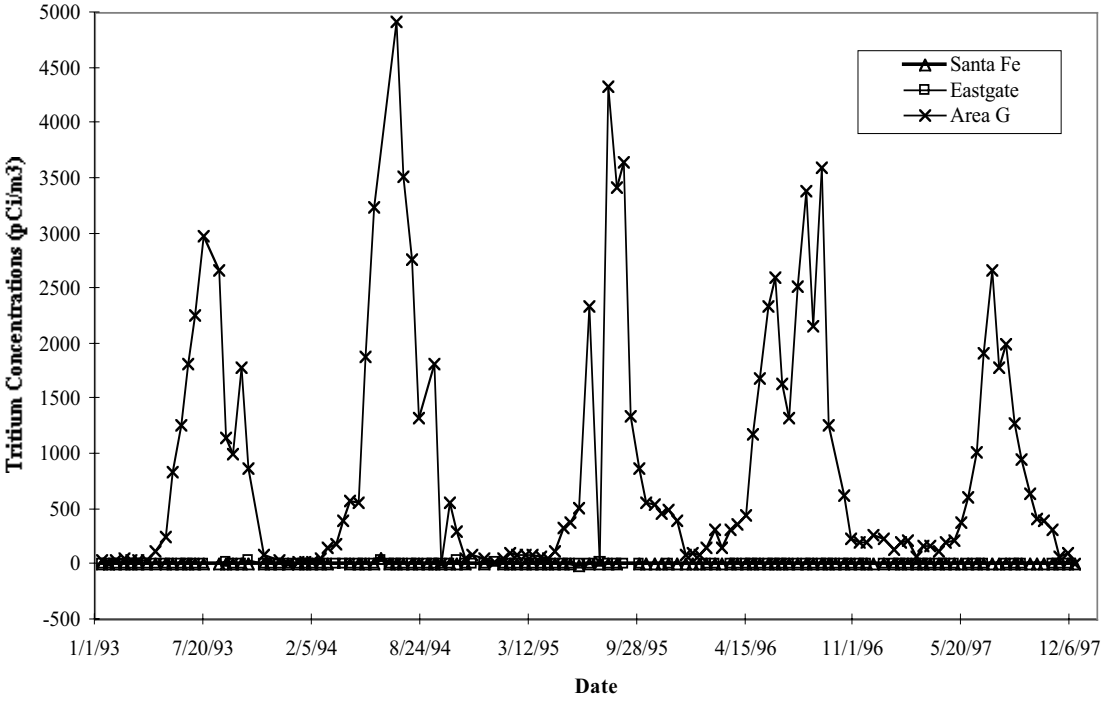


Figure 4-3. Technical Area 21 map of AIRNET locations.

4-4a.



4-4b.

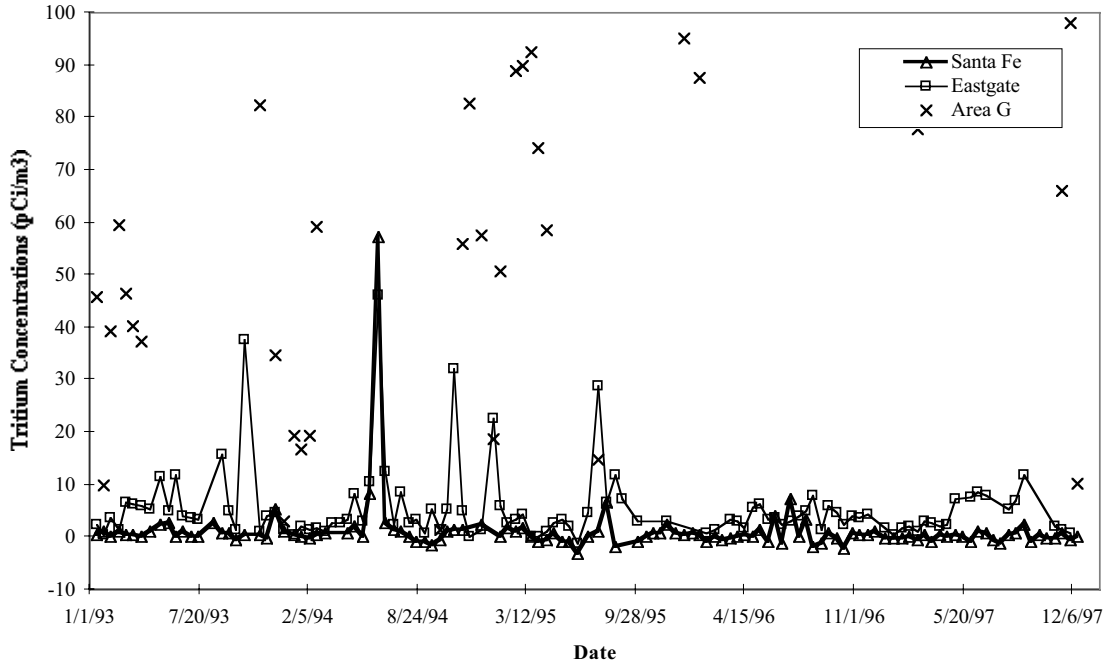


Figure 4-4. Two week tritium concentrations at three selected AIRNET sampling sites.

Note: The bottom graph (4-4b) is a magnified view of the tritium concentration range from 0 to 100 pCi/m^3 that is shown in the top graph (4-4a).

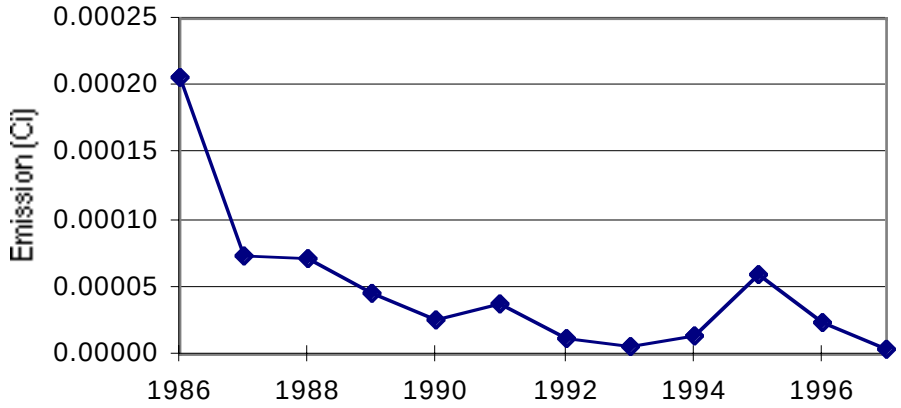


Figure 4-5. Plutonium emissions from sampled Laboratory stacks since 1986.

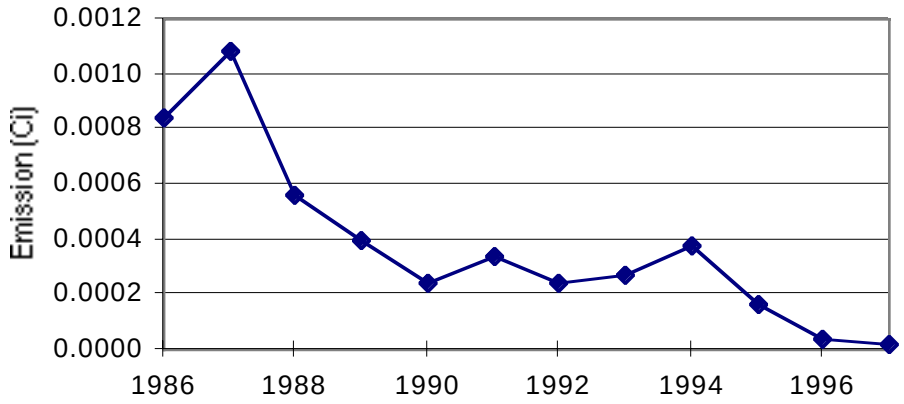


Figure 4-6. Uranium emissions from sampled Laboratory stacks since 1986.

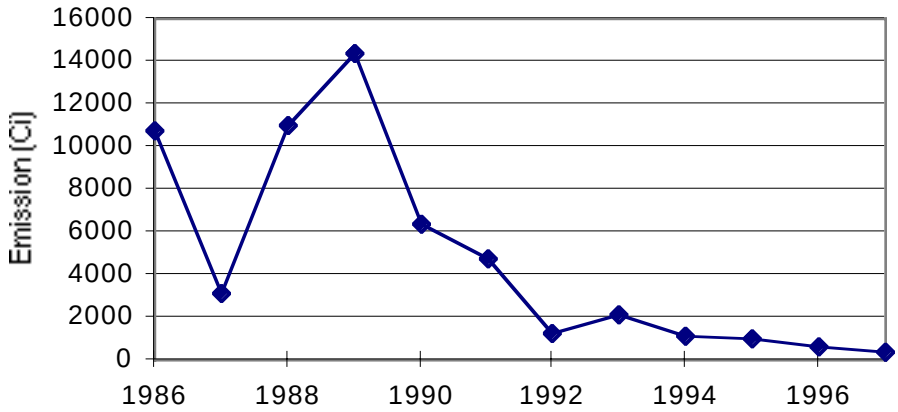


Figure 4-7. Tritium emissions from sampled Laboratory stacks since 1986.

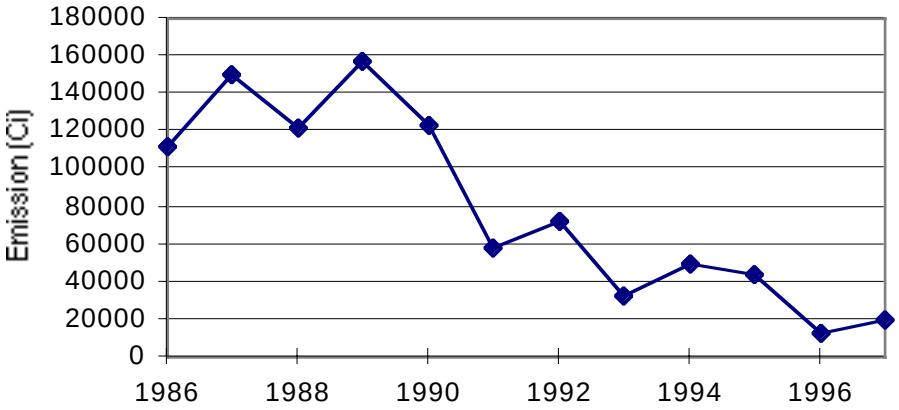


Figure 4-8. G/MAP emissions from sampled Laboratory stacks since 1986.

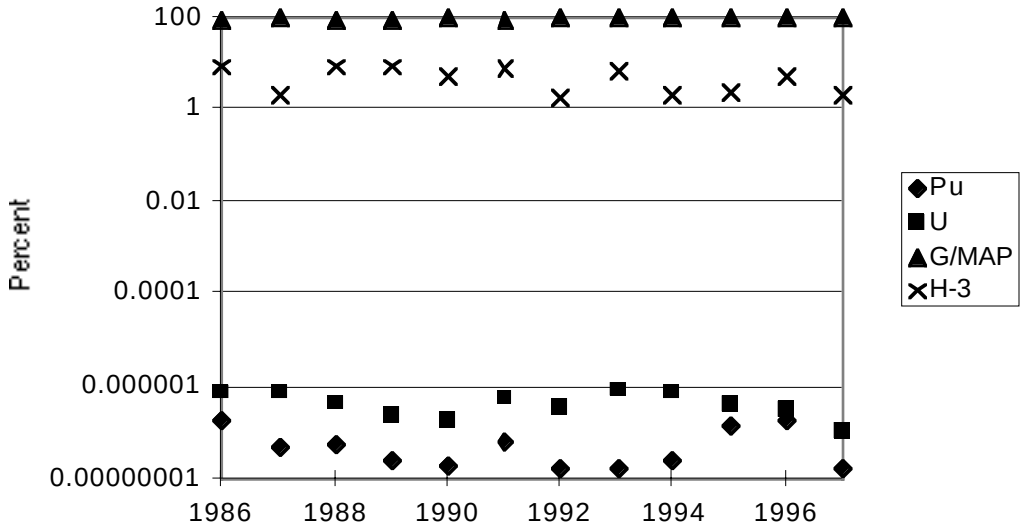


Figure 4-9. Percentage of total emissions resulting from plutonium, uranium, tritium, and G/MAP.

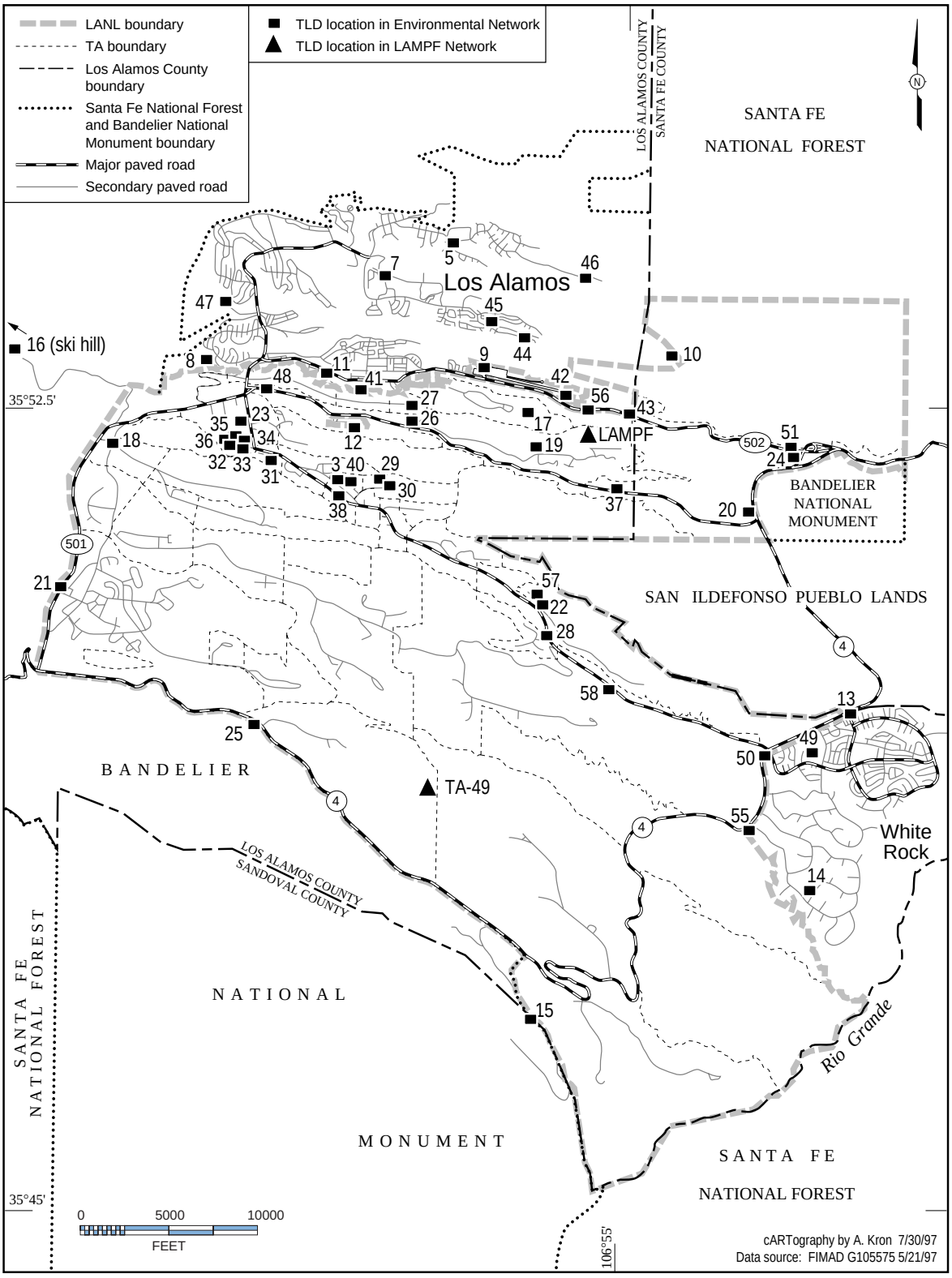
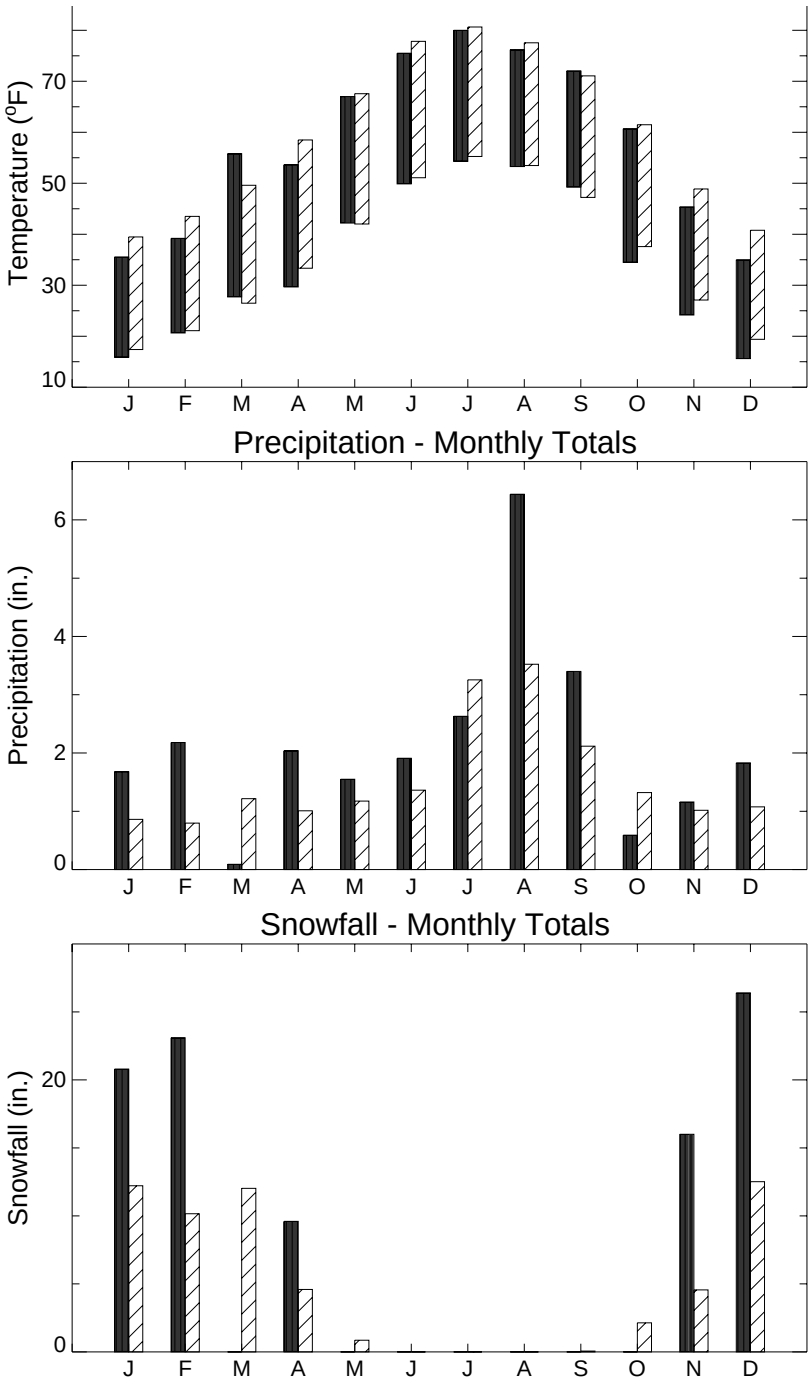


Figure 4-10. Off-site perimeter and on-site Laboratory TLD locations..



Annual Averages (°F)
Maximum
58.1 [59.8]
Minimum
34.8 [36.0]
Average
46.5 [47.9]

Annual Total (in.)
25.50 [18.73]

Annual Total (in.)
95.9 [59.1]

Figure 4-11. 1997 weather summary for Los Alamos.

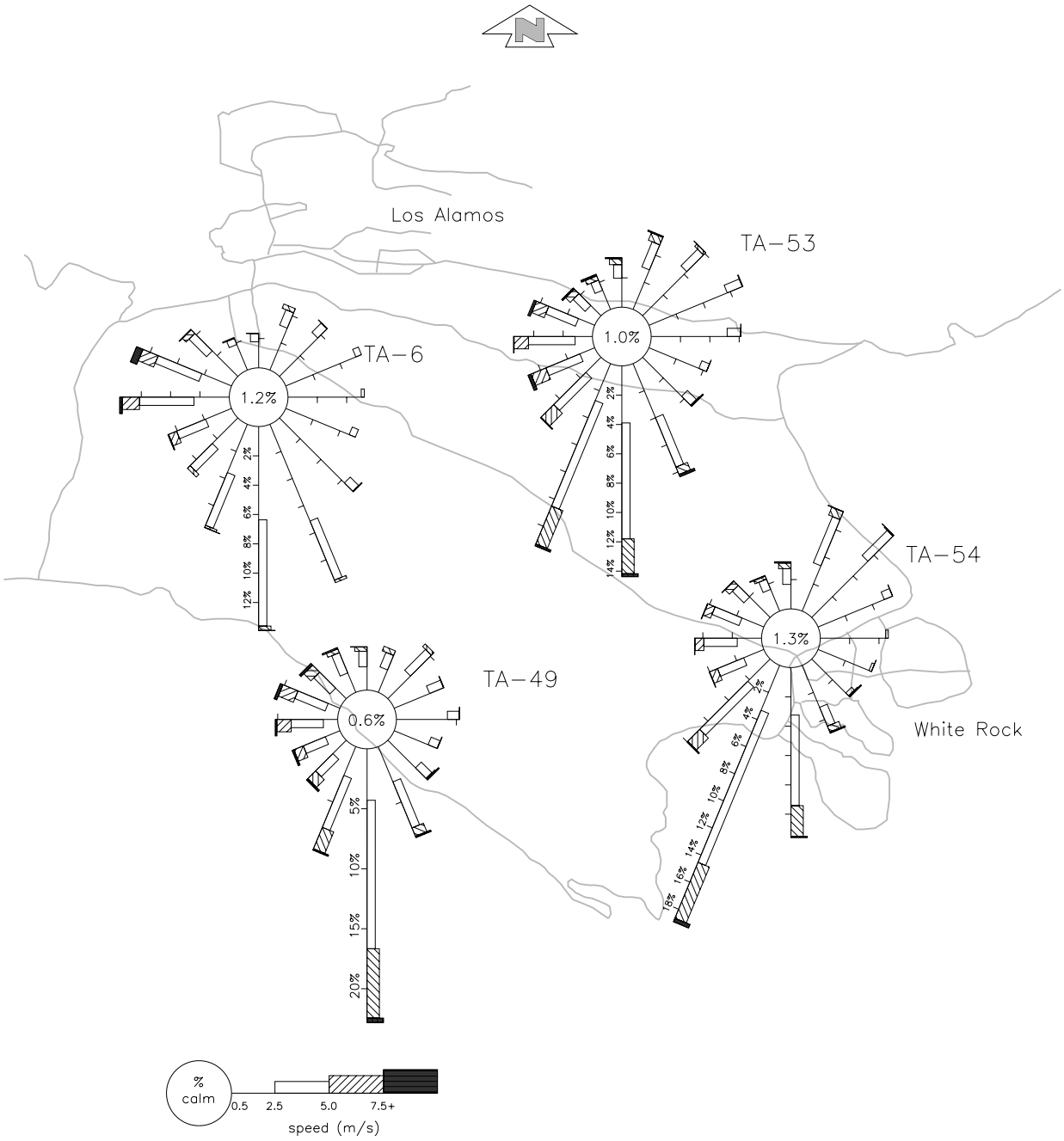


Figure 4-12. Daytime wind roses.

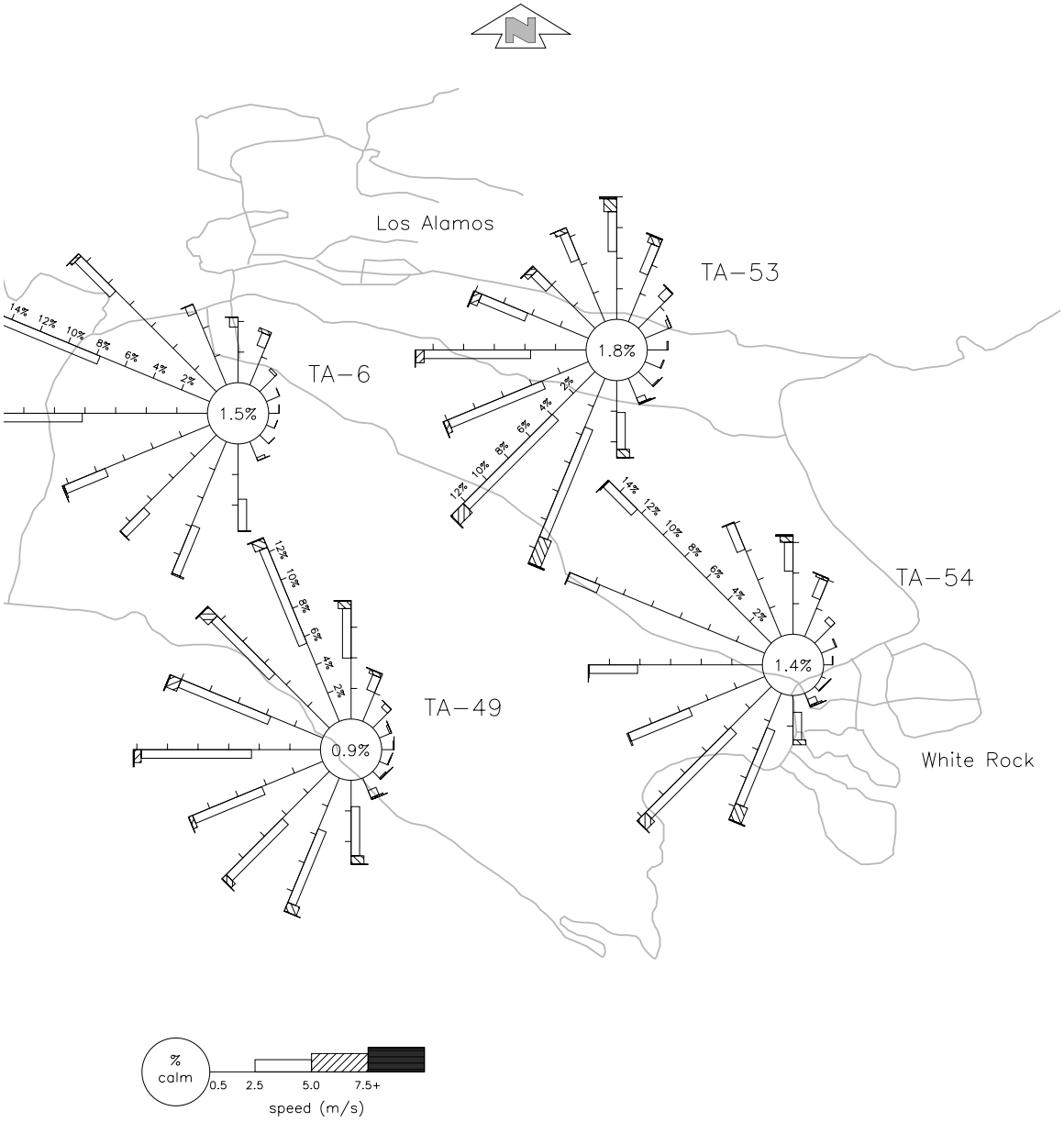


Figure 4-13. Nighttime wind roses.

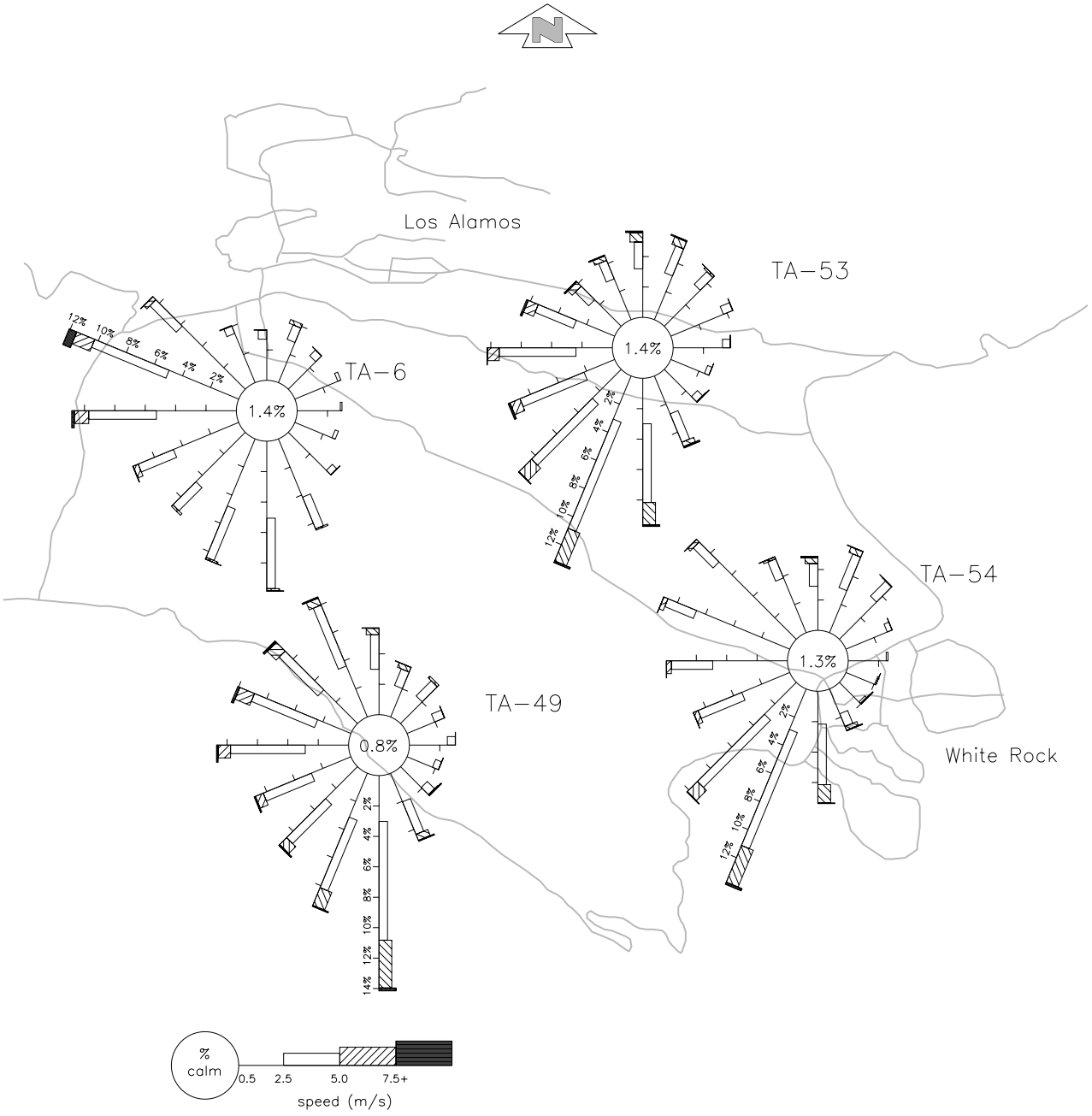


Figure 4-14. Total wind roses.

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5. Surface Water, Groundwater, and Sediments

primary authors:

Stephen G. McLin, Ken Mullen, and David B. Rogers

Highlights from 1997

The 1997 surface water analysis results are consistent with past findings. Environmental surveillance runoff samples are collected using automated samplers; the samplers are actuated when a significant precipitation event causes flow in a drainage crossing the Laboratory's eastern or western boundaries. Ten gross alpha and gross beta values exceeded the DOE Derived Concentration Guide (DCG) values in surface water or runoff samples in 1997. No radionuclides exceeded the DCG, however.

Groundwater sample analysis results from the regional aquifer were consistent with previous years' results. Trace levels of tritium are present in the regional aquifer in a few areas where former or present liquid waste discharges occurred, notably beneath Los Alamos, Pueblo, and Mortandad Canyons. The highest regional aquifer tritium level found in a test well is about 2% of the drinking water standard and poses no health risk according to the US Public Health Service. In 1994, possible strontium-90 detections occurred in a sampling of test wells. However, continued testing shows no detectable levels, suggesting that the 1994 values were not true detections. Nitrate (as nitrogen) levels in a test well beneath Pueblo Canyon continue to be high, but in 1997, were only about half the drinking water standard.

Analytical results for alluvial and intermediate depth groundwater are similar to those of past years. Waters near former or present effluent discharge also show the effects of these discharges; however, radionuclide activities are below DOE dose concentration guidelines for public exposure. Only three measured values (americium-241, plutonium-238, and plutonium-239, -240) exceeded DOE dose concentration guidelines for a DOE-operated drinking water system: these were measured in a shallow canyon bottom well just downstream from the TA-50 Radioactive Liquid Waste Treatment Facility permitted outfall in Mortandad Canyon.

Analytical results from the 1997 sediment samples are consistent with historical data. Radiochemical measurements for the majority of sediment samples collected at locations other than radioactive effluent release areas and waste management areas reflect worldwide fallout levels. As expected, sediment samples from radioactive effluent release areas and waste management areas exceeded worldwide fallout levels for tritium, cesium-137, plutonium, and americium-241, and gross alpha, gross beta, and gross gamma activities. Sediments from three Mortandad Canyon sampling stations continue to show cesium-137 values that exceed screening action levels. Radiochemical analyses of the large 1-kg samples collected in 1997 from Heron, El Vado, Abiquiu, Cochiti, and Rio Grande Reservoirs are similar to those from previous years. These sample results were below atmospheric fallout levels except for some of the Cochiti and Rio Grande Reservoir samples, which showed slightly above-background concentrations for cesium-137 and total uranium.

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5. Surface Water, Groundwater, and Sediments

A. Description of Monitoring Program

Studies related to development of groundwater supplies began at Los Alamos under the direction of the US Geological Survey (USGS). Studies specifically aimed at environmental monitoring and at 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 evaluate the background quantities of radionuclides and radioactivity derived from natural rock-forming 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.

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 discharged treated effluents that contained residual radionuclides. Most of the residual radioactivity from these releases is now associated with the sediments in Pueblo Canyon.

Based on analysis of radiological sediment survey data using arithmetic means, the estimated total plutonium inventory in Acid Canyon, Pueblo Canyon, and Lower Los Alamos Canyon is about 630 ± 300 mCi; using geometric means, the value is 246 mCi (ESP 1981). The use of different means reflect different methods of averaging discrete data collected over a large area. The estimated plutonium releases were about 177 mCi, in satisfactory agreement with the plutonium 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. Several studies (ESP 1981, Ferenbaugh et al., 1994) have concluded that the plutonium does not present a health risk to the public.

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 groundwater (at depths of 37 to 58 m [120 to 190 ft]) and 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.

Increased discharge of sanitary effluent from the county treatment plant, starting in 1990, 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 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 (late 1940s) and some release of water and radionuclides from the research reactors at TA-2. 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. 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.

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-2, TA-53, and TA-21. Infiltration of NPDES-permitted effluents and natural runoff from the stream channel maintains 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. Alluvial perched groundwater also occurs in the lower portion of Los Alamos Canyon on the Pueblo of San Ildefonso lands. This alluvium is not continuous with the alluvium within the Laboratory.

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 and treated effluents from the TA-46 Sanitary Wastewater Systems Consolidation (SWSC) Plant. These effluents support a continuous flow in a short reach of the upper part of the canyon. Only during summer thundershowers does stream flow reach 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 presently receives inflow from natural precipitation and a number of NPDES-permitted effluents, including one from the Radioactive Liquid Waste Treatment Facility (RLWTF) at TA-50. The TA-50 facility began operations in 1963. The TA-50 effluents infiltrate into the stream channel and maintain a saturated zone in the alluvium extending about 3.5 km downstream from the outfall. The easternmost extent of saturation is onsite, about 1.6 km west of the Laboratory boundary with the Pueblo of San Ildefonso. In addition to residual radionuclides, the effluent contains nitrate that often causes alluvial groundwater concentrations to exceed the New Mexico groundwater standard of 10 mg per liter (nitrate as nitrogen). The groundwater standard applies because the TA-50 effluent infiltrates into the alluvium in the canyon. In order to address these problems, the Laboratory is working to upgrade the TA-50 treatment process.

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 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 another 2.3 km 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 is generally no more than 3 m thick. 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 perched alluvial groundwater ranges from 18 m per day in the upper reach to about 2 m per day in the lower reach of the canyon (Purtymun 1974 and 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 perched alluvial groundwater.

5. Pajarito Canyon

In Pajarito Canyon, water in the alluvium is perched on the underlying tuff and is recharged mainly through snowmelt, thunderstorm runoff, and some NPDES-permitted effluents. 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 TAs 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 perched groundwater was found to be contained in the canyon bottom and did 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). The apparent source of the saturation is purge water from nearby municipal water supply well PM-4, as the alluvium is dry upstream of the purge water entry point. Because treated effluent from the Laboratory's SWSC Plant may at some time be discharged into the Cañada del Buey drainage system, a network of five shallow groundwater monitoring wells and two moisture monitoring holes was installed during the early summer of 1992 within the upper and middle reaches of the drainage (ESP 1994). Construction of the SWSC Plant 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 of the canyons. 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. Concentrations of radionuclides in surface water samples may be compared to either the DOE Derived Concentration Guides (DCGs) or the New Mexico Water Quality Control Commission (NMWQCC) stream standards, which reference the New Mexico Health and Environment Department Environmental Improvement Division's New Mexico Radiation Protection Regulations (part 4, Appendix A). However, New Mexico radiation protection levels are in general two orders of magnitude greater than the DOE DCGs for public dose, so only the DCGs will be discussed 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

Surface water samples are collected from regional stations and Pajarito Plateau stations surrounding the Laboratory. Surface water grab samples are collected annually from regional stations and from Laboratory locations where effluent discharges or natural runoff maintain stream flow. Runoff samples have historically been collected as grab samples during or shortly after precipitation events. As of 1996, runoff samples have been collected using gaging stations, some with automated samplers (Shaull et al., 1996). Samples are collected when a significant rainfall event causes flow in a drainage crossing the Laboratory's eastern or western boundaries.

Regional surface water samples (Figure 5-1) are collected from stations on the Rio Grande, Chama, and the Jemez Rivers. These waters provide background data from areas beyond the Laboratory boundary. Historically, samples have been collected at stations on the Rio Grande at Embudo, Otowi, Frijoles Canyon, Cochiti, and Bernalillo. In 1997, the station on the Rio Grande at Bernalillo was not sampled.

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

3. Radiochemical Analytical Results

The results of radiochemical analyses for surface water samples for 1997 are listed in Tables 5-1 and 5-2. Tables 5-3 and 5-4 contain lists of radionuclides detected in surface water and runoff samples and of possible detections, according to criteria discussed in Section 5.F.4. Because uranium, gross alpha, and gross beta are widespread at detectable levels, only occurrences of these measurements above significant levels (chosen to be below the EPA MCLs or screening levels) are reported. The specific values are 5 µg per liter for uranium, 5 pCi per liter for gross alpha, and 20 pCi per liter for gross beta.

Radiochemical values 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 shown in Table 5-5. Gross alpha and gross beta values in this table are greater than their respective EPA drinking water limits, which are higher than the DCG. Note that the DCG value for gross beta is actually the strontium-90 DCG, and the DCG for gross alpha is the plutonium-239, -240 DCG. Ten gross alpha and gross beta values exceeded the DOE public dose DCG values in surface water or runoff samples in 1997. These samples were the surface water samples from Mortandad Canyon at GS-1 and runoff samples from Los Alamos Canyon near Los Alamos, Area G stations G-SWMS-5 and G-SWMS-6, Potrillo Canyon near White Rock, and Cañada del Buey at White Rock. Half of these values are possible detections, owing to their high uncertainty (see Section 5.F.4).

Most of the measurements at or above detection limits are from locations with previously known contamination: the perimeter of Area G, Acid/Pueblo Canyon, DP/Los Alamos Canyon, and Mortandad Canyon. Otherwise, the remainder of the results are near or below the detection limits of the analytical methods used and are 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, Area G and in Pueblo, DP/Los Alamos, and Mortandad Canyons are discussed below.

a. Radiochemical Analytical Results for Surface Water. The 1997 samples from the Rio Grande at Otowi and the Rio Grande at Frijoles were collected from the bank; no width-integrated samples were collected. The 1995 and 1996 bank samples from Rio Grande at Otowi showed possible detections of americium-241, and the 1996 sample had possible plutonium-238 and gross beta detections. An additional station (Rio Grande at Otowi Upper) was located farther upstream from the previous station, 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. None of these stations had any radionuclide detections in 1997.

The samples from the Rio Grande at Cochiti and the Jemez River had gross alpha detections at relatively small values. A second sample from Rio Grande at Cochiti had a much lower gross alpha value. Other than low levels of uranium, which are probably of natural origin, no other radionuclides were detected at these two stations so the source of the gross alpha readings is unclear.

Americium-241 was detected in surface water at Cañada del Buey in 1995. No sample was collected at this location in 1996 because there was no water at the station. The 1997 sample had no radionuclide detections, except for a low level of uranium.

A possible detection of americium-241 occurred at the station Los Alamos at State Road 4. In 1995, there was a possible detection of americium-241 at this location. Plutonium-239, -240 was detected at the stations Los Alamos at State Road 4 and Pueblo at State Road 502. Results are consistent with past detections of plutonium-239, 240 at these locations.

Americium-241 was detected at Water Canyon at Beta below TA-16. There have been no detections of americium-241 at this location in the past**.**

b. Radiochemical Analytical Results for Runoff. Automated samplers were used to collect runoff samples whenever rainfall events caused significant runoff at the Laboratory boundaries. See Section 5.F.1 for a description of the runoff samplers and sampling protocols. In addition to measured data, Table 5-2 gives calculated activities associated with the suspended sediments for cases where both filtered and unfiltered samples were obtained for runoff samples. (See Section 5.F.1 for discussion of filtered and unfiltered samples.) The values were determined by subtracting the filtered results from the unfiltered results, using the total suspended solids measured for the samples. The associated uncertainties were calculated using propagation of errors. This is a method for determining how measurement errors affect the results of a calculation using these measurements. Two samples were snowmelt rather than thunderstorm runoff and have much lower total suspended solids: Los Alamos Canyon at Los Alamos and Pajarito at SR 501. The values for these samples have high uncertainties reflecting the small total suspended solids.

Comparison of the results for filtered and unfiltered samples collected at Los Alamos Canyon near Los Alamos on August 5, 1997, show questionable results. The quantities of strontium-90, uranium, plutonium, and americium-241 are quite large in both the filtered and unfiltered samples. In some cases, the filtered values are higher, as shown by negative values in the calculated suspended sediments activities on Table 5-2. The results for the September 20, 1997, sample from this station are more in line with usual measurements, with unfiltered radionuclide activities greatly exceeding those for the filtered sample. Americium-241; cesium-137; plutonium-238; plutonium-239, -240; strontium-90; and gross alpha and gross beta were detected or possibly detected in

most of the runoff samples at this station. Sediment screening action levels (see discussion in 5.C.1) in two samples were exceeded by calculated suspended sediment activities for strontium-90 and cesium-137. These observations were consistent with earlier findings for this station.

The DP Canyon near Los Alamos station showed detections of gross beta; americium-241; and plutonium-239, -240. No runoff sample was collected at Ancho Canyon near Bandelier in 1997. This station had high strontium-90 in 1995, and in 1996 high uranium and possible cesium-137.

The runoff sample collected at Cañada del Buey near White Rock had detectable gross beta, and possible detections of gross alpha and plutonium-239, -240. This station had high uranium levels in 1996.

The largest concentrations of uranium in the runoff samples collected in 1997 was 10.8 µg per liter for a TA-54, Area G runoff sample (G-SWMS-5). Americium-241; plutonium-238; plutonium-239, -240; strontium-90; and gross alpha and gross beta were detected or possibly detected in the runoff samples at TA-54, Area G. These radionuclides have previously been detected in sediment samples surrounding TA-54, Area G.

The samples from Potrillo Canyon near White Rock had detections of gross beta and cesium-137, and possible detections of gross alpha and plutonium-239, -240. No previous data are available for this station.

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 1995 through 1997 are given in Table 5-6. In addition to total annual activity released for 1995 through 1997, Table 5-6 also shows mean annual activities in effluent for each radionuclide, and the ratio of this activity to the DCG. In 1997, the DCG was exceeded for americium-241, plutonium-238, and plutonium-239, -240. For 1997, the effluent nitrate concentration (average value of 69.6 mg per liter, nitrate as nitrogen) exceeded the New Mexico groundwater standard of 10 mg of nitrate as nitrogen per liter of water.

4. Nonradiochemical Analytical Results

a. Major Chemical Constituents. The results of major chemical constituents analyses in surface water and runoff samples for 1997 are listed in Table 5-7. The results are generally consistent with those observed in previous years, with some variability. The measurements in waters from areas receiving effluents show the effects of these effluents. None of the results exceeds standards except for some pH measurements below 6.8 and above 8.5. Fluoride values in samples from the Jemez River, DPS-4, SCS-3, Mortandad at GS-1, and Mortandad at Rio Grande were between 50% and 100% of the NMWQCC Groundwater Standard. The nitrate (as nitrogen) value for Mortandad at Rio Grande was about 75% of the NMWQCC Groundwater Standard.

b. Trace Metals. The results of trace metal analyses on surface water and runoff samples for 1997 are listed in Table 5-8. 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 metals content. The levels of trace metals in samples for 1997 are generally consistent with previous observations.

The sample from the middle of Cochiti Reservoir showed levels of beryllium, cadmium, cobalt, and chromium that exceeded drinking water or NMWQCC groundwater limits. The other two reservoirs did not contain these metals. The sample from the Jemez River had arsenic and boron values 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 discharging 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).

In 1995, a barium concentration of 520 µg per liter was measured in the sample collected at Water Canyon at Beta, compared to a NMWQCC groundwater limit of 1,000 µg per liter. This sample also had an elevated level of nitrate. The sample collected at Water Canyon at Beta in 1996 also contained about 400 µg per liter of barium, higher than normally observed in surface water on the Pajarito Plateau. For 1997, the barium concentration was 322 µg per liter. Analyses confirmed the presence of high explosives (HE) for the Water Canyon at Beta sample in 1996. No HE was detected at Water Canyon at Beta in 1997. In 1997, runoff samples collected at Los Alamos Canyon near Los Alamos contained similarly high levels of barium (242 to 416 µg of barium per liter of water).

The analytical detection limit used for mercury (0.2 µg per liter) is not adequate to determine whether it is present in excess of the New Mexico Wildlife Habitat

stream standard of 0.012 µg per liter. In 1997, mercury was not observed above the detection limit at any location with the exception of Mortandad at Rio Grande and Cañada del Buey.

Aluminum, iron, and manganese concentrations exceed EPA secondary drinking water standards at many locations. These results reflect the presence of suspended solids in the water samples. Some of these cases occur with filtered samples. Some of the water samples were unfiltered, so the results are due to naturally occurring constituents (e.g., aluminum, iron, and manganese) of minerals in the suspended solids.

Lead values (80 to 130 µg per liter) above the EPA drinking water action level (15 µg per liter) and the New Mexico Livestock Watering Standard (100 µg per liter) were again found in the runoff samples collected at Los Alamos Canyon near Los Alamos. This station is upstream of State Road 4 in Los Alamos Canyon. Surprisingly, these results came from analyses that were performed on both filtered and unfiltered samples. These samples also showed levels of beryllium, chromium, and vanadium in the range of 50% to 100% of drinking water or NMWQCC groundwater limits. The sample from DP Canyon near Los Alamos had an unfiltered lead concentration of 18 µg per liter.

Measurable selenium concentrations were reported for surface waters in 1997. Typically, selenium has not been detected in surface waters on the Pajarito Plateau. Selenium values exceeded the New Mexico Wildlife Habitat Stream Standard (2 µg per liter) at Guaje Canyon and Frijoles at Monument HQ.

c. Organics. The locations where organics samples were collected in 1997 are summarized in Table 5-9. (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 HE constituents. In 1996, two HE compounds, 2, 4, 6-trinitrotoluene and 2, 4-dinitrotoluene were detected at Frijoles Canyon at Monument Headquarters in Bandelier National Monument. In 1996, two HE compounds were also detected at the stations Water Canyon at Beta. No HE compounds were detected at any stations in 1997.

5. Long-Term Trends

Long-term trends of the activity of tritium and total plutonium in surface water in Mortandad Canyon are depicted in Figure 5-4. These measurements were performed on samples collected at the station Mortandad at GS-1, which is a short distance downstream of the TA-50 effluent discharge into Mortandad Canyon. If more than one sample was collected in a year, the average value for the year is plotted. Samples collected before 1996 were preserved in the field and filtered through a 0.45-micron filter in the laboratory. Subsequent measurements represented the total (unfiltered) activity. Plutonium values for 1962 to 1966 are for plutonium-239, -240 only. Plutonium-238 was not measured for those years. In general, there has been a decrease in the combined levels of plutonium-238 and plutonium-239, -240 during the period. All plutonium values exceed the detection limit of 0.04 pCi per liter; all tritium activities exceed the detection limit of 700 pCi per liter except for a sample collected in April 1988. As discussed in Section 5.B.3 and shown on Table 5-5, the 1997 plutonium values from this station exceeded the DOE drinking water DCG but were below the public dose DCG. Tritium values were about half the EPA drinking water MCL in 1997.

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. Accordingly, sediments are sampled in all canyons that cross the Laboratory, including those with either perennial or ephemeral flows. Sediments from five regional reservoirs and five stream channels are also sampled annually.

There are no federal or state regulatory standards for soil or sediment contaminants that can be used for comparison with the Laboratory's surveillance data. Instead, contaminant levels in sediments may be interpreted in terms of toxicity to humans, assuming the contaminated particles are either ingested or inhaled. The data can also be compared to levels attributable to worldwide fallout or natural background levels. Results of radionuclide analyses of sediment samples from regional stations collected annually from 1974 through 1986 were used to establish limits for worldwide fallout and for natural background levels of total uranium (Purtymun et al., 1987). McLin and Lyons (1998) developed provisional fallout levels of radioactivity in sediments for tritium, strontium-90, cesium-137, uranium, plutonium, americium-241, and for gross alpha, gross beta, and gross gamma activity for the period 1974 to 1996. The average activity level for each analyte in these samples, plus twice its standard deviation, is an indicator of the approximate

upper limit for worldwide fallout or natural background activity. If an individual sample analysis exceeds a background level, we assume that Laboratory contamination is a possible source.

Screening action levels (SALs) are used by the Laboratory's Environmental Restoration Project to identify the presence of contaminants at levels of concern. SALs are screening levels below a level of human health risk. SAL values are derived from toxicity values and exposure parameters using data from the EPA. Both background activity and SAL values for sediments are listed in tables summarizing analytical results.

2. Monitoring Network

Sediment samples are collected from regional stations and from Pajarito Plateau stations near the Laboratory. The information gathered from these stations document conditions in areas potentially affected by Laboratory operations. 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 determining background radionuclide concentrations resulting from fallout. Stations on the Pajarito Plateau (Figures 5-5, 5-3, and 5-6) are located within about 4 km from the Laboratory boundary. The majority of the Pajarito Plateau stations are located within the Laboratory boundary.

During 1997, sediment samples were collected from 22 regional and 68 Pajarito Plateau stations. Of the 22 regional samples, 7 are from rivers and 15 are from the upper, middle, and lower portions of 5 regional reservoirs: El Vado, Heron, and Abiquiu Reservoirs on the Rio Chama; Cochiti Reservoir on the Rio Grande; and Rio Grande Reservoir on the Rio Grande in southern Colorado.

Of the 68 Pajarito Plateau samples, 21 are specifically related to waste management areas. Many of the sediment sampling stations on the Pajarito Plateau are located within canyons to monitor sediment transport that is possibly related to past or present effluent release sites. Twelve plateau samples were collected on or adjacent to Pueblo of San Ildefonso Pueblo lands.

Sediments from drainages around two radioactive solid waste management areas are sampled. Nine sampling stations were established in 1982 outside the perimeter fence at TA 54, Area G (Figure 5-3) to monitor possible transport of radionuclides by sheet erosion from the active waste storage and disposal area. From 1959 to 1961, hydronuclear experiments were conducted in underground shafts beneath the surface of the mesa at TA-49, designated Area AB (Purtymun and Stoker 1987, ESP 1988). Eleven stations were established in 1972 to monitor surface sediments in drainages surrounding the experimental area at TA-49 (Figure 5-6). Another station (AB-4A) was added in 1981 as the surface drainage changed.

3. Radiochemical Analytical Results for Sediments

a. Radiochemical Analytical Results. The results of radiochemical analyses of sediment samples collected during 1997 are listed in Table 5-10. Individual analytes that meet detection criteria and are above background levels are also summarized in Tables 5-11 and 5-12. Results from the 1997 sediment samples are consistent with those from previous years. The majority of the sediment samples collected at locations other than at known radioactive effluent release areas and waste management areas were within background levels that reflect worldwide fallout. All sediments from the regional stream channel stations showed below-background concentrations for sampled radionuclides.

Many sediment samples from known radioactive effluent release areas, including Acid/Pueblo, DP/Los Alamos, and Mortandad Canyons, exceeded worldwide fallout levels for tritium, cesium-137, plutonium, americium-241, gross alpha, gross beta, and gross gamma activities. These levels are consistent with historical data. Within both Los Alamos and Pueblo Canyons, above-background levels of plutonium in sediments are evident for distances greater than 16 km downstream from the major historical sources in Acid and DP Canyons. The contamination extends off site across Pueblo of San Ildefonso lands and reaches the Rio Grande near the Otowi Bridge. Near the sources, plutonium concentrations are 5 to nearly 300 times background (fallout) levels; levels decline downstream by several orders of magnitude. These patterns have been documented for several decades in Laboratory reports.

Within Mortandad Canyon, the largest plutonium concentrations in sediments (more than 100 times background) are found between the point where TA-50 RLWTF effluent enters the drainage (GS-1) and the sediment traps (MCO-7), an approximately 3-km distance. Radionuclide levels near or slightly exceeding fallout levels are found downstream of the sediment traps, extending to the Laboratory/Pueblo of San Ildefonso boundary station A-6.

In 1997, 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 at TA-50. During 1997, no other sediment samples showed any values that exceeded respective SAL values, although reported values from stations GS-1, MCO-5, and MCO-7 were between 31% and 94% of the SAL values for tritium, plutonium, and americium-241. These radionuclide levels decrease rapidly in the downstream direction. The levels are consistent with historical data that reflect TA-50 effluent discharges into Mortandad Canyon since 1963.

At TA-54, Area G, a number of stations exceeded background levels for cesium-137 and plutonium. At TA-49, Area AB, a number of sediment stations showed above-background values for tritium, cesium-137, plutonium, and americium-241. The reported values are consistent with earlier observations from these stations.

Several of the Pajarito Plateau stations that are outside radioactive effluent and solid waste management areas showed slightly above-background radioactivity values. These stations included Chaquehui at Rio Grande (tritium), Fence at State Road 4 (plutonium-238), Frijoles at Monument Headquarters (uranium), and Pajarito at State Road 4 (plutonium-239, -240 and uranium). These 1997 values are within the range of historical results obtained for these sites during the 1980s and 1990s. The sources of the above-background levels have not been determined. At the Chaquehui at Rio Grande station, however, it appears that Laboratory activities may be responsible for anomalous levels of tritium found in moisture distilled from the sediment. Similar tritium levels were detected near this station in the early 1990s during sampling by both the Environmental Surveillance Program and the ER Project. The pattern and persistence of the higher-than-background levels of tritium support a hypothesis of a subsurface source of tritium at this location, possibly arising from tritium disposal activities at nearby TA-33.

Results of the radiochemical analyses of the 1-kg samples collected in 1997 from Heron, El Vado, Abiquiu, Cochiti, and Rio Grande Reservoirs are similar to those from previous years. All of these sample results were below background levels except for some samples from Cochiti and Rio Grande Reservoirs. The samples from the Rio Grande Upper, Rio Grande Middle, and Cochiti Lower stations showed above-background levels for cesium-137. Sediments from the Cochiti Middle and Cochiti Lower stations showed above-background values for total uranium. Historical values for cesium and uranium at these stations have exceeded reported background levels on several occasions. The Rio Grande Reservoir results reflect natural variations in fallout and background concentration levels for radionuclides in sediments, as it is far removed from Laboratory influences. The elevated levels of cesium-137 and uranium from Cochiti Reservoir may reflect a combination of atmospheric fallout contributions or natural conditions and Laboratory activities. There is a known abundance of natural uranium in soils and rocks near the reservoir. In previous studies, the isotopic atom ratio of uranium-235 to uranium-238 in Cochiti Reservoir bottom-feeding fish and in lake sediments were consistent with naturally occurring uranium (that is, 0.0072) (Fresquez et al., 1995, Gallaher 1997). There was no indication of the refined forms of uranium (enriched or depleted in uranium-235) used in Laboratory research.

Plutonium deposition by atmospheric fallout in the Rio Grande Basin is not uniform but varies with differences in weather, altitude, erosion, and sediment transport conditions. Summary data from reservoir sediment plutonium analyses are shown in a long-term context in Table 5-13. Abiquiu Reservoir historically has had some of the lowest plutonium concentration ranges and isotopic ratios observed, while Cochiti and Rio Grande Reservoirs have had some of the highest. The other sampled reservoirs tend to fall between these two extremes. The data show that mean plutonium concentration levels are higher in Cochiti Reservoir than in Abiquiu Reservoir. The results of the reservoir analyses may be interpreted in conjunction with previous studies (Purtymun et al., 1990; Graf, 1993; Fresquez et al., 1994, 1995; Gallaher, 1997; and McLin and Lyons, 1998), which provide a regional context for reservoir sediments. Before 1963, between 2 and 12 grams of plutonium were released from the Laboratory into the Acid/Pueblo/Los Alamos Canyon watershed. A small but unquantified portion of this plutonium, along with trace amounts of strontium-90 and cesium-137, has been carried across Pueblo of San Ildefonso lands into the Rio Grande. These Laboratory-contaminated sediments have commingled with fallout-contaminated sediments carried by the Rio Grande and have accumulated in Cochiti Reservoir since its construction in 1973. Between 50% and 90% of the plutonium in Cochiti Reservoir sediments probably has originated from atmospheric fallout, while the remainder may be associated with Laboratory sources. However, strontium-90,

cesium-137, plutonium-238, and plutonium-239, -240 in Cochiti Reservoir sediments have not entered the food chain (nongame fish) at levels significantly higher than in Heron, El Vado, or Abiquiu Reservoirs.

4. Nonradiochemical Analytical Results

a. Trace Metals. Beginning in 1992, sediments were analyzed for trace metals. Trace metal results for the sediment samples collected in 1997 are presented in Table 5-14. Sediments from the Mortandad A-10 and G-8 stations showed elevated mercury levels at 4.0 and 4.3 mg per kilogram, respectively. The reason for these elevated mercury levels is not understood. Historically, mercury levels much above the detection limit have not been found in sediment samples collected at A-10 and G-8 nor in general for the Environmental Surveillance Program's Pajarito Plateau stations. However, some Environmental Restoration Project samples have shown higher mercury levels, so a Laboratory source is possible. None of the other results show any significant accumulations of metals, and results are comparable to previously collected data.

b. Organic Analyses. Beginning in 1993, sediments have been analyzed for VOCs, SVOCs, and PCB. No samples were analyzed for VOCs in 1997. Some sediment samples also have been analyzed for HE constituents since 1995. Samples from only a portion of the sediment stations are analyzed each year for organics; in 1997 only about one-seventh of the stations were analyzed. The sampled stations are listed in Table 5-15. The analytical results showed that there were no SVOCs, PCBs, or HE constituents detected above the limit of quantitation (LOQ) in any of the sediment samples collected during 1997.

5. Long-Term Trends

The concentrations of radionuclides in sediments from Acid, Pueblo, and lower Los Alamos Canyons have been relatively constant at each station since 1980, with some yearly variability. The total plutonium concentrations (plutonium-238 plus plutonium-239, -240) observed since 1980 in sediments at four indicator locations are shown in Figure 5-7.

Figure 5-7 also depicts total plutonium concentrations at four stations in Mortandad Canyon from 1980 to 1997. MCO-5 and MCO-7 are located downstream of the TA-50 discharge point and upstream of the sediment traps. MCO-9 and MCO-13 are between the sediment traps and the Pueblo of San Ildefonso boundary. The plutonium concentrations upstream of the sediment traps have declined by approximately a factor of 10 since the 1980s, presumably due to decreased radioactivity in the RLWTF discharges. Below the sediment traps, plutonium concentrations have remained relatively constant: the levels are more than 100 times lower than above the traps, and are close to atmospheric fallout levels.

Available data indicate that a small but measurable amount of Laboratory-derived plutonium is present in Mortandad Canyon sediments at the Pueblo of San Ildefonso boundary, possibly extending downstream to near State Road 4. Analysis of sediments collected at the boundary station Mortandad A-6 in 1997 showed cesium-137; total uranium; plutonium-239, -240; and gross beta activity that exceed background levels. Above-background plutonium-239, -240 concentrations also were detected at this station in 4 of the previous 10 years.

A special study that utilized low-detection-limit thermal ionization mass spectrometry to analyze plutonium and uranium in sediments (Gallaher et al., 1997) indicates that off-site migration of Laboratory-derived plutonium has occurred in Mortandad Canyon. Evidence of Laboratory-derived plutonium extends for a distance of approximately 1.5 miles beyond the Laboratory boundary to near State Road 4. There remains considerable uncertainty, however, about the timing and means of contaminant movement in this part of the canyon. There has been no observed stream flow at the boundary since hydrologic studies began in Mortandad Canyon in 1961. Moreover, there have been no recorded flows at the boundary since continuous stream gaging measurements began in 1995 (Shaull et al., 1996a, 1996b, 1998). These observations suggest that if any contaminants have reached Pueblo of San Ildefonso lands, transport by storm water was probably before 1960 and thus before the initial discharges from the TA-50 RLWTF-permitted outfall. Wind, vehicles, or foot traffic could also have carried contaminated dust, soils, and sediments downstream.

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 above the regional aquifer at intermediate depths.

The early groundwater management efforts by the USGS evolved with 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 geohydrologic 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 to the New Mexico Environment Department (NMED) (LANL 1996b).

Concentrations of radionuclides in environmental water samples from the regional aquifer, the alluvial perched 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 established standards for groundwater quality (NMWQCC 1993). Concentrations of radioactivity in samples of water from the water supply wells completed in the Los Alamos regional aquifer are also 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. The supply wells in the regional aquifer are the source of the Los Alamos public water supply. Although it is not a source of municipal or industrial water, shallow alluvial groundwater results in 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 Stream Standards and Wildlife Habitat Stream Standards established by the NMWQCC (NMWQCC 1993, NMWQCC 1995). These standards are for the most part based on dissolved concentrations, but many of the results reported here include both dissolved and suspended solids concentrations, which may be higher.

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, perched 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 5-8. The sampling locations for the canyon alluvial perched groundwater systems are shown in Figure 5-9. The springs and wells are described by Purtymun (1995).

Sampling locations for the regional aquifer include test wells, supply wells, and springs. Eight deep test wells, completed within the regional aquifer, are routinely sampled. The Laboratory located the test wells to detect possible infiltration of contaminants from effluent disposal operations. These test wells were drilled by the USGS between 1949 and 1960 using the cable tool method. The 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 3 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 1997. The five wells of the Pajarito Well Field are located in Sandia and Pajarito Canyons and on mesa tops between those canyons. Two wells comprise the Otowi Well Field, located in Los Alamos and Pueblo Canyons; no production from Otowi-1 occurred in 1997. 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 contaminated groundwater from beneath the Laboratory into the Rio Grande. Based on their chemistry, the springs in White Rock Canyon are divided into groups, three of which (I, II, and III) have similar, aquifer-related chemical quality. The chemical quality of springs in Group IV 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.

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.

The perched alluvial groundwater in five canyons (Pueblo, Los Alamos, Mortandad, and Pajarito Canyons, and Cañada del Buey) is sampled by means of 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 HSWA permit, the Laboratory installed several alluvial wells (or, in some cases, boreholes). This work was completed in 1990 according to EPA's RCRA guidelines (Purtymun and Stoker 1990, Stoker 1990, ESP 1992). Some of the wells were drilled near existing wells in order 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),
- 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. Samples are obtained 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.

3. Radiochemical Analytical Results for Groundwater

The results of radiochemical analyses of groundwater samples for 1997 are listed in Table 5-16. Tables 5-17 and 5-18 contain lists of radionuclides detected in water samples and of possible radionuclide detections, according to criteria discussed in Section 5.F. Because uranium, gross alpha, and gross beta are common at detectable levels, occurrences of these measurements above significant levels (chosen to be below the EPA MCLs or screening levels) are reported. The specific values are 5µg per liter for uranium, 5µg per liter for gross alpha, and 20 pCi per liter for gross beta. Discussion of the results will address the regional aquifer, the canyon alluvial groundwater, and the intermediate perched groundwater system.

Radiochemical values 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 shown in Table 5-19. Gross alpha and gross beta values in this table are greater than their respective EPA drinking water limits. Note that the DCG value for gross beta is actually the strontium-90 DCG, and the DCG for gross alpha is the plutonium-239, -240 DCG. Two gross alpha values exceeded half the DOE public dose DCG values, at CDBO-7 and MCO-7.5 (the CDBO-7 value was 168% of the DCG). These values are possible detections rather than detections, owing to their high uncertainties. Aside from CDBO-7 and LAO-3A, values on the table are from alluvial wells in Mortandad Canyon. MCO-3 results for plutonium-238; plutonium-239, -240; and americium-241 were more than 40% of the DCG. The gross beta results for all wells in Mortandad Canyon were about 10% of the DCG except MCO-7A, which was lower.

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 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. Since dissolved uranium is a common constituent of groundwater (Hem 1989), only occurrences close to the proposed EPA MCL of 20 µg per liter are discussed here.

The 1994 surveillance sampling of three test wells, TW-3, TW-4, and TW-8 showed unexpected levels of strontium-90 (ESP 1996a). Several of the sampling results were suspect because there were no corroborating measurements such as correspondingly elevated gross beta measurements in some of the samples. The chemical analysis of strontium-90 is difficult, and the sensitivity of the method is near to the EPA MCL. Special time-series sampling was carried out in 1995 to evaluate possible aquifer contamination near these wells, during which no strontium-90 was detected (ESP 1996b). The wells were sampled four times during 1996, with no radionuclides detected, except naturally occurring uranium and trace levels of tritium. TW-8 was not sampled in 1997 because of a

pump problem. No strontium-90 was detected in the other two wells during 1997.

Water supply well G-1 showed a possible strontium detection in 1997. No other radiological or nonradiological parameters were elevated. The value of 5.19 ± 1.39 pCi per liter was slightly larger than the detection limit of 3 pCi per liter but the uncertainty is sufficiently large to make detection uncertain. In 1995, water supply well G-1A had a strontium-90 detection of 3.9 ± 0.7 pCi per liter. This value is just above the strontium-90 detection limit of 3 pCi per liter. Another 1995 analysis of the same sample gave a result of 7.4 ± 3.5 pCi per liter. Due to the very high uncertainty for that analysis, that result did not qualify as a detection or as a possible detection. Analysis of the 1996 and 1997 samples indicate no trace of strontium-90 in samples from G-1A.

Strontium-90 was detected in Sandia Spring during 1996, but none was apparent in 1997.

La Mesita Spring has a significant uranium concentration of 12.1 µg per liter. 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 still below the proposed EPA primary drinking water MCL of 20 µg per liter. The spring also has a high gross alpha value of about 12.8 pCi per liter, near the EPA primary drinking water standard of 15 pCi per liter. The EPA standard applies to gross alpha not arising from radon and uranium, however.

b. Tritium Sampling of Test Wells. Three test wells, DT-5A, DT-9, and DT-10, were sampled for trace levels of tritium in 1997. This section discusses the trace-level tritium analyses done by the University of Miami Tritium Laboratory.

Tritium is a naturally occurring isotope of hydrogen. Tritium is produced in the atmosphere by cosmic rays and in rocks by decay of naturally occurring radioactive elements. Tritium is also produced by nuclear reactors and as part of the development and testing of nuclear weapons. Because tritium is an isotope of hydrogen, tritium commonly occurs in nature as part of a water molecule. Before atmospheric testing of nuclear weapons began, tritium levels in northern New Mexico precipitation were about 20 pCi per liter (Adams 1995). This is 5 to 10 times higher than the tritium level detected in the Los Alamos public water supply wells. By the mid-1960s, tritium in atmospheric water in northern New Mexico reached a peak level of about 6,500 pCi per liter. At present, atmospheric levels in northern New Mexico are about 30 pCi per liter, and those in the Los Alamos vicinity range from 20 to 450 pCi per liter (Adams 1995).

Because tritium often occurs as part of a water molecule, the rate of infiltration of tritium into the earth is the same as the infiltration rate of water. Other radionuclides such as plutonium-238 or strontium-90 infiltrate at a much slower rate, if at all; the progress of these radionuclides is either halted or significantly slowed by the chemical processes of adsorption (adherence to the surfaces of soil particles, for example) or precipitation (the formation of solid chemical phases).

Tritium has a half-life of 12.43 years. This relatively short half-life combined with low naturally occurring levels of tritium means that groundwater isolated from the surface should have a very low tritium activity. Groundwater that contains between 16 and 65 pCi per liter of tritium most likely shows the effects of recent recharge, that is, recharge within the last four decades (Blake 1995). Groundwater with a tritium activity below about 1.6 pCi per liter is probably old and isolated from surface recharge. The age of such groundwater is more than 3,000 years, but there may be large dating uncertainties associated with small tritium activities. Groundwater with a tritium activity greater than 1,000 pCi per liter and collected after 1990 can only be the result of contamination (Blake 1995).

All of the tritium results determined by the trace-level method for the regional aquifer wells at TA-49 are shown in Table 5-20. These low tritium levels suggest that the regional aquifer water tapped by these wells is isolated from surface recharge.

c. Radiochemical Constituents in Alluvial Groundwater. Except for a possible detection of gross alpha activity in CDBO-7, none of the radionuclide activities in alluvial groundwater are above the DOE DCGs for Public Dose for Ingestion of Environmental Water. Except for americium-241; plutonium-238; and plutonium-239, -240, values in samples from MCO-3 in Mortandad Canyon and gross alpha and gross beta values in Table 5-19, none of the radionuclide activities exceeds 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.

The samples of the alluvial groundwater in Los Alamos Canyon show residual contamination, as has been seen since the original installation of the monitoring wells in the 1960s. In particular, for LAO-2 and LAO-3A, the activity of strontium-90

exceeds the EPA Primary Drinking Water Standard MCL of 8 pCi per liter. Plutonium-239, -240 was detected in LAO-0.7 (and has been every year since 1993) and was possibly detected at LAO-1. Strontium-90 was possibly detected at LAO-1 and LAO-4. LAO-2 and LAO-3A showed gross beta activities approaching or exceeding the drinking water screening level of 50 pCi per liter.

The alluvial groundwater samples from Mortandad Canyon showed levels of radionuclides within the ranges observed previously. Tritium; strontium-90; cesium-137; plutonium-238; plutonium-239, -240; americium-241; gross alpha; gross beta; and gross gamma are either detected or possibly 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 are lower further down the canyon. Values in MCO-3 are similar to those in surface water station Mortandad at GS-1 located a short distance upstream. 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. There are no EPA 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, except at MCO-3.

Cañada del Buey well CDBO-7 had possible detections of gross alpha, gross beta, and strontium-90. The uncertainties for all of these measurements were quite high, however. Pueblo Canyon well APCO-1 had a plutonium-239, -240 level above the detection limit from 1994 through 1996. No plutonium-239, -240 was detected in this well in 1997. Only one well in Pajarito Canyon (PCO-1) was sampled in 1997 because wells PCO-2 and PCO-3 were dry, or their pumps were inoperable.

d. Radiochemical Constituents in Intermediate-Depth Perched Groundwater. Taken over time, the radionuclide activity measurements in samples from TW-1A, 2A, and Basalt Spring in the intermediate-depth perched zones in Pueblo Canyon indicate a connection with surface water and alluvial groundwater in Pueblo Canyon. Intermediate-depth perched zone waters have long been known to be influenced by contaminated surface water in the canyon based on measurements of major inorganic ions. TW-2A, furthest upstream and closest to the historical discharge area in Acid Canyon, has shown the highest levels. Tritium was not detected in TW-2A in 1997, for the first year since 1991. Tritium levels in that well have averaged at about 2,590 pCi per liter from 1992 through 1996. Neither TW-1A nor TW-2A had detectable plutonium-239, -240 levels, in contrast to 1995. Basalt Spring again 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 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 1997 are listed in Table 5-21, and results of total recoverable metal analyses are listed in Table 5-22.

a. Nonradiochemical Constituents in the Regional Aquifer. With the following exceptions, values for all parameters measured in the water supply wells were within drinking water limits. Note that separate samples are collected to determine regulatory compliance for the public water supply system, and that these samples were all in compliance for 1997.

The pH values in wells G-2 and Otowi-1 were above the EPA secondary standard limit of 8.5. Well Otowi-1 was being tested during this sample collection period and had not been connected to the water supply system. The analytical laboratory reported values in PM-1 for pH of 1.7 and electrical conductance of 12,000 µS per centimeter. These values are clearly in error and compare with field values for PM-1 of 7.8 for pH and 270 µS per centimeter for electrical conductance.

Otowi-1 had high aluminum, iron, and manganese values. These values probably reflect the high total suspended solids in the well, which had not been completely prepared as a water supply well.

The lead level in PM-2 was 19 µg per liter, compared to the EPA action level of 15 µg per liter. For well G-2, the arsenic level was about 70% of the standard of 50 µg per liter and was similar to previous measurements. The vanadium levels in wells G-1A and G-2 are just below the EPA health advisory range of 80 to 110 µg per liter.

The test wells in the regional aquifer showed levels of several constituents that approach or exceed standards for drinking water distribution systems. However, the test wells are used for monitoring purposes

only and are not part of the water supply system. TW-1 again had a nitrate value of 5.5 mg per liter, below the EPA primary drinking water standard of 10 mg per liter (nitrate as nitrogen). This test well has shown nitrate levels in the range of about 5 to 20 mg per liter (nitrate as nitrogen) since the early 1980s. The source of the nitrate might be infiltration from sewage treatment effluent discharged 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.

In 1996, the sample from TW-2 had values of sodium, chloride, sulfate, arsenic, and boron that were about 10 times the usual ranges for these values. Results for these analytes from the 1997 sample were in line with values previously found for this well.

Levels of trace metals that approach water quality standards in some of the test wells are believed to be associated with turbidity of samples or with the more than 40-yr-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. Several of the test wells have occasionally had elevated lead levels in previous years. In 1995 and 1997, lead levels exceeded the EPA action level in TW-1, 2, 3, and 4. In 1996, TW-1 and TW-4 had lead levels above the 15 μg per liter EPA action level. The lead levels appear to be due to 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 commonly extremely low (Hem 1989).

Samples collected for metals analysis from most of the White Rock Canyon springs were filtered in 1997. In recent years, samples from a few springs in White Rock Canyon showed aluminum, iron, and manganese levels that exceed NMWQCC Livestock Watering and Wildlife Watering Standards or EPA drinking water standards. These levels were total rather than dissolved concentrations and reflect the composition of suspended sediments. Many of the springs have very low flow rates, and samples are collected in small pools in contact with the surrounding soils. The 1997 samples from Sandia Spring were unfiltered and showed levels of aluminum, iron, and manganese that approached standards for drinking water systems. Of the filtered spring samples, Springs 5 and 7 had silver levels two to three times above the drinking water MCL. Such silver values have never been observed at these locations and may be an analytical artifact.

b. Nonradiochemical Constituents in Alluvial Groundwater. The groundwater in Pueblo, Los Alamos, and Mortandad Canyons receives effluents. The canyon bottom alluvial groundwater showed the effects of those effluents in that values of some constituents were elevated above natural levels. Mortandad Canyon alluvial groundwater samples exceeded or approached the NMWQCC Groundwater Standards for fluoride and nitrate (nitrate as nitrogen). The nitrate source is nitric acid used in plutonium processing at TA-55 that enters the TA-50 waste stream. Improvements to the TA-50, RLWTF treatment process are planned during 1998, so that the effluent will not exceed water quality standards in the future. Mortandad Canyon alluvial groundwater is also high in sodium. Nitrate in Pueblo Canyon well APCO-1 was about 60% of the EPA primary drinking water standard of 10 mg per liter (nitrate as nitrogen).

Overall, trace metal levels in alluvial groundwater samples were much lower than for 1993 and 1994. As with past samples from the White Rock Canyon Springs, 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. Notable 1997 metals values were lead in CDBO-6 and MCO-3, and of molybdenum in LAO-2 and LAO-3A.

c. Nonradiochemical Constituents in Intermediate-Depth Perched Groundwater. In 1997, the nitrate values for TW-1A, 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.

TW-1A had levels of iron, manganese, and zinc approaching or exceeding water quality standards. Again, the detection of these metals in TW-1A 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. TW-1A had a fluoride concentration that was about 60% of the NMWQCC Groundwater Standard. The pH in TW-1A was above the EPA secondary drinking water range of 8.5. Otherwise, the intermediate perched groundwater and the Water Canyon gallery did not show any concentrations of trace metals that are of concern.

d. Organic Constituents in Groundwater. Analyses for organic constituents were performed on selected springs and test wells in 1997. The stations sampled are listed in Table 5-23. Samples were analyzed for VOCs, SVOCs, and PCBs. Test wells at TA-49 and most springs were analyzed for HE constituents.

HE constituents were detected in Ancho Spring during 1995 sampling, but not in 1996 or 1997 samples. This spring is below the explosives testing sites in the southern portion of the Laboratory. Most of the possible organic detections reported by the Organic Analysis Group were rejected because the compounds were either detected in method blanks (introduced during laboratory analysis) or detected in trip blanks.

The only organic detection not rejected was a PCB, Arochlor 1260, found at 0.77 µg per liter in TW-4. The limit of quantitation for this PCB is 0.5 µg per liter. PCBs have not previously been found in this well, and no source is immediately apparent.

5. Long-Term Trends

a. Regional Aquifer. The long-term trends of the water quality in the regional aquifer have shown little impact resulting from Laboratory operations. Except for low levels of tritium contamination found at four locations in Los Alamos and Pueblo Canyons and one location in Mortandad Canyon, no concentrations of radionuclides above detection limits have been measured on water samples from the production wells or test wells that reach the regional aquifer other than an occasional analytical outlier not confirmed by analysis of subsequent samples. The apparent detection of strontium-90 in TW-3 in 1994 (ESP 1996a) presently appears to be due to analytical error because the gross beta measurement does not support the strontium result. The apparent detection of strontium-90 in TW-4 in 1994 (ESP 1996a) has not been substantiated by previous or subsequent measurements.

Measurements of tritium by extremely 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 wells into the regional aquifer at Los Alamos. The levels measured range from less than 2% to less than a 0.01% of current drinking water standards and are all less than levels that could be detected by the EPA-specified analytical methods normally used to determine compliance with drinking water regulations. Detection of lead in the 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 long-term trends of water levels in the water supply and test wells in the regional aquifer indicate that there is no major depletion of the resource as a result of pumping for the Los Alamos water supply (McLin et al., 1998).

b. Alluvial Perched Groundwater in Mortandad Canyon. Long-term trends of radionuclide concentrations in shallow alluvial perched groundwater in Mortandad Canyon (downstream from the NPDES-permitted outfall for the RLWTF at TA-50) are depicted in Figure 5-10. The samples are from observation well MCO-6 in the middle reach of the canyon. The combined total of plutonium-238 and plutonium-239, -240 activities has been relatively constant, fluctuating up and down in response to variations in the treatment plant effluent and storm runoff that causes some dilution in the shallow alluvial water. Note that the current plutonium detection limit of 0.04 pCi per liter applies to the separate analyses of plutonium-238 and plutonium-239, -240, and might be doubled for the addition of these values because results are often at or near the detection limit. The tritium concentration has fluctuated almost in direct response (with a time lag of about one year) to the average annual concentration of tritium in the TA-50 outfall effluent.

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 5-11 and 5-12. Aside from stations listed in the accompanying tables, the MOU also specifies collection and analysis of additional water and sediment samples from sites that have long been included in the routine environmental sampling program, as well as special sampling of storm runoff in Los Alamos Canyon. These locations are shown in Figures 5-1, 5-2, 5-5, and 5-8, and the results of analyses are discussed in previous sections.

1. Groundwater

Radiochemical analyses of the 1997 groundwater samples are shown in Table 5-16. Tables 5-17 and 5-18 contain lists of radionuclides detected in water samples and of possible detections, according to criteria discussed in Section 5.F.4. Because uranium, gross alpha, and gross beta are common at detectable levels, occurrences of these measurements above significant levels (chosen to be below the EPA MCLs or screening levels) are reported. The specific values are 5 µg per liter for uranium, 5 pCi per liter for gross alpha, and 20 pCi per liter for gross beta.

Most of the groundwater stations (wells and springs) listed in the MOU are discussed in Section 5.D. The present section focuses on the Pueblo of San Ildefonso water supply wells.

As in previous years, the groundwater data 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 much greater than the proposed MCL of 20 µg per liter are prevalent in well water throughout the Pojoaque area, which includes the Pueblo of San Ildefonso. The high gross alpha readings for these wells are related to uranium occurrence.

In 1997, 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 or not detection has occurred. At these measurement levels, precise quantification of the amount detected is not possible. For 1995, detection limits for plutonium-238 and americium-241 were exceeded in several wells. The possibility that these were detections is in doubt for two reasons: there was also a high value for americium-241 in the trip blank, and values for plutonium-238 and americium-241 in the New Community well sample and a duplicate sample differed widely. These two observations emphasize the limits of precision of the laboratory analyses at these extremely low measurement levels. For 1996 sampling, the only possible detection of radionuclides in the Pueblo of San Ildefonso water supply wells, other than uranium, was for plutonium-239, -240 in the Sanchez House well, at a value only slightly above the detection limit. Again, in 1997 there were no detections of radionuclides other than uranium in any Pueblo of San Ildefonso water supply wells.

The New Community well had a uranium concentration exceeding the proposed EPA primary drinking water standard of 20 µg per liter. Uranium concentrations at the Pajarito Pump 1, Don Juan Playhouse, and Sanchez House wells were about half of the proposed EPA standard. These measurements are consistent with the levels in previous samples and with relatively high levels of naturally occurring uranium in other wells and springs in the area.

The gross alpha level in samples from the Don Juan Playhouse, Otowi House, and New Community wells were below the EPA primary drinking water standard of 15 pCi per liter. This standard applies to gross alpha from radionuclides other than radon and uranium. Except for the Otowi House well, the gross alpha levels are apparently attributable to the presence of uranium.

The chemical quality of the groundwater, shown in Table 5-21, 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.

The fluoride values for some wells are near (Eastside Artesian and Sanchez House) or greatly exceed (LA-1B) the NMWQCC Groundwater Standard of 1.6 mg per liter, again similar to previous values. Several of the wells (Eastside Artesian, Halladay House, LA-1B, and Don Juan Playhouse) have alkaline pH values, above the EPA secondary standard range of 6.8 to 8.5; again, these values do not represent a change from those previously observed in the area. None of the sampled wells had nitrate values approaching drinking water limits of 10 mg per liter (nitrate as nitrogen).

Many of the wells have sodium values significantly above the EPA health advisory limit of 20 mg per liter. The values from Pajarito Pump 1, LA-1B, Sanchez House, and Eastside Artesian wells are especially high.

Trace metal analyses are shown in Table 5-22. The boron value in Pajarito Pump 1 was nearly twice the NMWQCC groundwater limit of 750 µg per liter. This value was similar to those of past years. The only other trace metal occurrence of note was antimony that was detected in the Pajarito Pump 1 well. The uncertainty for this measurement was almost as large as the reported values, so the result is questionable.

2. Sediments

Sediments from Pueblo of San Ildefonso lands in Mortandad Canyon were collected in 1997 from five permanent sampling stations, shown in Figure 5-12.

The results of these and other sediment analyses are shown in Tables 5-10 through 5-12 and Table 5-14. Related information is presented in Section 5.C. 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 1997 showed cesium-137; total uranium; plutonium-239, -240; and gross beta activity levels that exceeded background. However, samples from other sediment stations downstream of Mortandad A-6 showed only atmospheric fallout levels for all radionuclides.

Sediments from sampling stations located on the Pueblo of San Ildefonso lands in Los Alamos Canyon at Los Alamos at State Road 502, Los Alamos at Totavi, and Los Alamos at Otowi showed levels of cesium-137, plutonium, and americium-241 above background. These levels are consistent with previous samples collected from these stations (see Section 5.C).

Analytical results from the sediment sampling locations in Guaje, Bayo, and Sandia Canyons are within the range of values expected from worldwide fallout. These findings are consistent with previous measurements. Sediment samples collected from the Pueblo of San Ildefonso in 1997 were also analyzed for trace metals, as reported in Table 5-14. These results, which are all within the general ranges found in geologic materials from Pajarito Plateau, suggest natural origins for all trace metals (Longmire et al., 1996).

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). More focused guidance is provided in formal procedures developed to address sampling for each sample matrix (Mullen and Naranjo 1996, 1997). 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. Samples are submitted to the Chemical Science and Technology (CST) analytical laboratory. Detailed analytical methods are published in Gautier (1995). Samples are submitted using blind sample numbers to prevent possible bias that might occur if the analyst knows the sampled location.

Beginning in 1996, samples collected for radionuclide and metals analyses at the White Rock Canyon Springs were filtered in the field. The White Rock Canyon Springs samples are collected to represent groundwater surfacing at the springs. These samples were filtered in the field to minimize the effects of surface soils. 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.

Beginning May 30, 1997, surface water samples collected for metals analyses were filtered in the field. This procedural change was initiated to make the analytical results comparable with the NMWQCC standards. These standards are typically for dissolved concentrations, except for mercury and selenium, for which New Mexico standards are based on total concentrations. Mercury and selenium were not filtered in the field and were analyzed to determine total concentration.

Runoff was collected using automated samplers located at recently installed gaging stations (Shaull et al., 1998). 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, while 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 laboratory and digestion methods have changed over time. Before 1993, water samples were preserved in the field and filtered in the lab 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; 1,000-g samples are analyzed from reservoirs. With larger sample volumes, there is 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. Beginning in 1997 a separate, unpreserved sample was collected for tritium analysis. 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.

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 the values are less than the detection limit and the negative values are included in the analytical results.

c. Organics. Organics are analyzed using SW-846 methods as shown on Table A-9. 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-10 through A-13. All organic samples are collected in glass bottles, and the VOC samples are preserved with hydrochloric acid. A trip blank always accompanies the VOC sample.

3. Data Management and Quality Assurance

a. Data Management. CST transfers the data to ESH-18 both electronically and as a hard copy. Samples submitted to CST for analyses before April 11, 1997, went through the Datatrieve System. The electronic data were transferred weekly to the Facility for Information Management, Analysis, and Display (FIMAD). The data were screened by FIMAD and stored in an Oracle database table. Data were extracted from the FIMAD Oracle table and transferred to ESH-18 through a Microsoft Access interface using ODBC drivers.

In April of 1997, CST installed a new SQL Laboratory Information Management System. Samples submitted after April 11, 1997, went through this system. A data retrieval query was created to generate a table of ESH-18 data every week. The complete data set is recreated and downloaded to ESH-18 personal computers every week. The sample location name, the sample barcode number, and the field data are stored in a separate table on ESH-18 personal computers. This table provides the link for associating a blind sample barcode number with a location name.

b. Quality Assurance. Each analytical batch (20 samples or less) contains at least one blank, one matrix spike, and a duplicate as dictated by SW-846 protocols. These 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 5-24 and 5-25. The analytical results for the duplicates are presented on the analytical result tables.

Deionized water (DI) blanks and spiked samples are submitted as regular samples, without any indication that they are QC samples. They go through the same analysis 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. The DI blank sample values are used to 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 5-24 to the values reported in the analytical result tables.

Results in Table 5-24 suggest a high bias in the americium-241 analyses. The average concentration of americium-241 in the DI blanks (0.051 pCi per liter) was above the detection limit. The likely cause for higher than expected concentrations for americium-241 is the plutonium-242 tracer that is added to the sample to determine plutonium recovery. There is a small amount of plutonium-241 in this tracer. Plutonium-241 decays to americium-241 by beta decay, resulting in additional americium-241 in the samples.

A high analytical bias is also suggested for several other analytes. Last year CST analysts believed that the high bias in tritium might be due to the nitric acid preservative. All tritium samples were submitted unpreserved in 1997 and a similar high bias is still suggested.

A high bias, on the order of one-half of the detection limit, is also apparent in the plutonium-238 and plutonium-239, 240 DI blank results. Ideally, these values should be zero.

The concentrations reported in Table 5-24 for the spiked samples are the concentrations after subtraction of the average blank values. There is good agreement between the analytical results and the spiked concentrations after blank correction.

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. Results of this analysis are presented in the last line on Table 5-24. Detection limits calculated using this method are at least twice the values that the analytical laboratory reports.

The ratio of the standard deviation of the blank values and the laboratory detection limit is calculated in Table 5-24. Since the detection limits are based on 4.66 times the uncertainty, the standard deviation should be about 22% of the detection limits. The relatively higher standard deviations reported suggest that sample values near the detection limit are not very precise. Both these points emphasize that detection limits are subject to uncertainty and should not be considered an absolute indicator of the presence or absence of an analyte.

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. There was generally good agreement between spike concentrations and the analytical results. Standard deviations associated with the average values for the DI blanks and spiked samples are generally significantly less than the reported concentrations, suggesting relatively precise measurements. Mercury concentrations were consistently low at about 40% of the spiked value; we are investigating potential solutions.

4. Determination of Radiochemical Detections

Analytical uncertainties are reported in the tables presenting radiochemical analytical results. The CST analyst for each radiological measurement reports these uncertainties, which are specific to each sample measurement. One standard deviation (one sigma) counting uncertainty is typically reported. Through 1995, the uncertainties reported for tritium in the tables were described in surveillance reports as representing one standard deviation (one sigma). Communications with CST show that this value was reported incorrectly. For tritium results, the value reported as the one-sigma uncertainty through 1995 should have been labeled a three-sigma uncertainty. Since 1996, one-sigma uncertainties have been reported for tritium.

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.

To identify Laboratory impacts as early as possible, it is important to determine when a contaminant is present in an area where it has not previously been identified. There are two approaches to determining when an analyte is detected in a sample. For the purpose of this discussion, a 95% confidence level is assumed. The lower level is often called either the limit of detection (LOD) (Keith 1991 and Taylor 1987) or the critical level, L_C (Currie 1968). This is the lowest level that is statistically different from a blank. When the LOD is used as a decision point, 5% of the analytical results will be falsely identified as containing the analyte of interest when it is not present.

The reliable detection limit (RDL) (Keith 1991) (or the L_D [Currie 1968]) is the level at which there is little chance of failing to detect an analyte that is present at or above this concentration. When the RDL is used as a decision point, an analyte that is present at a concentration equal to the RDL will not be detected 5% of the time.

For radiological analyses, a background measurement is subtracted from the instrument reading generated by the sample. This corrects for background radiation such as that originating from cosmic rays or from bedrock. The uncertainty in the background measurement must be included in the uncertainty for the sample measurement. For background corrected radiological measurements, for one-tailed, paired observations at the 95% confidence level, the LOD (or L_C) is 2.33 times the uncertainty (sigma) and the RDL or L_D is 4.66 sigma.

The limit of quantification or LOQ (or L_Q) is the level where the concentration of an analyte can be quantified with significant confidence. Using the same criteria as above (95% confidence level, one-tailed, paired observations) the LOQ for radiological measurements is 14.1 sigma. The importance of this number is demonstrated when analytical results are compared against standards; the analytical result should be greater than 14.1 sigma for the comparison to be meaningful.

The Surface Water, Sediments, and Groundwater sections of this chapter contain tables identifying two groups of radionuclide detections. Possible detections are defined as being above the detection limit and greater than 2.33 times the uncertainty (sigma) but less than 4.66 sigma. This defines the set of measurements above the critical level but below the RDL. A large data set of values near the detection limit will contain about 1 false positive for every 20 observations. Detections are defined as being above the detection limit and greater than 4.66 sigma, that is, the RDL. These tables are presented to focus on cases where radionuclides were detected. For sediments, detections in either category are also above background levels determined for fallout, or natural background levels in the case of uranium.

G. Unplanned Releases

All unplanned releases were of radioactive and nonradioactive liquid and were investigated by ESH-18. Upon cleanup, personnel from NMED-DOE/OB (Oversight Bureau) inspected the unplanned release site to ensure adequate cleanup. NMED-DOE/OB administratively closed 9 of the 18 unplanned releases that occurred in 1997. It is anticipated that the rest of the unplanned release investigations will be closed when NMED-DOE/OB personnel become available for inspections.

1. Radioactive Liquid Materials

There were no unplanned radioactive liquid releases in 1997.

2. Nonradioactive Liquid Materials

There were 18 unplanned releases of nonradioactive liquid in 1997. The following is a summary of these discharges.

- Five unplanned releases of noncontact cooling water and treated cooling water.
- Four releases of sanitary sewage from the Laboratory's TA-46, SWSC Plant's collection system.
- Four releases of diesel from vehicles, equipment, and an old underground storage tank being removed for salvage.
- One release of dielectric oil which occurred while moving an old transformer.
- Three releases of potable water which impacted ER Project solid waste management unit sites.
- One release of drilling water/mud to a watercourse.

H. Special Studies

1. Main Aquifer Hydrologic Properties Study: Water Production Records

Monthly water production records are provided to the State Engineer Office under State of New Mexico requirements specified in the water rights permit held by DOE for the Los Alamos municipal water supply system. During 1997, total water production from 14 wells in the Guaje, Pajarito, and Otowi municipal well fields and Los Alamos Reservoir was 4.88 million m^3. This total production amounts to 71.3% of the total water right of 6.84 million m^3 that is available to DOE under its permit. The Otowi-1 well did not contribute to water supply during 1997 because of operational NPDES discharge restrictions. The drilling of four new replacement wells in the Guaje well field began during 1997. Details of the performance of the water supply wells and their operation 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. Main Aquifer Hydraulic Properties Study: Measurement of Main Aquifer Water Levels

In October 1992, the Laboratory began measuring and recording water level fluctuations in test wells completed into the main 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: 1997 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: 1997 Water Year" (Shaull et al., 1998), show less runoff than do data for the 1996 water year. Water chemistry data from larger storm events occurring at some stations are also published in that report.

The annual 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.

Group ESH-18 developed and installed the stream-gaging network; the USGS Water Resources Division designed and installed the necessary data collection structures. The network is operated by the Storm Water Team of ESH-18.

4. Hydrogeologic Investigations at Los Alamos National Laboratory

Groundwater contained within the regional aquifer beneath LANL is used for both public water supply by Los Alamos County and for industrial applications by the Laboratory. Recently, the Laboratory issued the "Hydrogeologic Workplan," (LANL 1996b) which describes activities proposed to be performed to further characterize the hydrogeologic setting and to enhance the Laboratory's groundwater monitoring program. The workplan was issued as a result of the Laboratory's own commitment to the protection of the groundwater resource and to issues raised by the NMED. The DOE Oversight Bureau reviewed a draft version of the workplan and submitted written recommendations regarding well location, well design, and scheduling.

During the fall of 1997, the Laboratory began implementation of the workplan by drilling test well R-9, a regional-aquifer well located in Los Alamos Canyon near the Laboratory's eastern boundary at State Road 4. Well R-9 is designed to provide geologic, hydrogeologic, and water quality data from shallow and intermediate saturated zones, as well as the regional aquifer. Before drilling R-9, the last regional aquifer test well was drilled in 1960.

Laboratory investigators expected R-9 to encounter an intermediate perched aquifer at approximately 238 ft within the basalt. However, as work progressed, three intermediate saturated zones were encountered: one at approximately 180 ft, another at 270 ft, and a third at 579 ft. Samples from each groundwater zone were collected by the Laboratory and the DOE Oversight Bureau. Preliminary Laboratory analyses showed tritium slightly above background levels in both the 180-ft and 270-ft intermediate saturated zones. Following several attempts, the intermediate saturated zones were successfully sealed off from the lower regional aquifer to prevent cross-contamination between saturated zones. The occurrence of the third saturated zone at 579 ft was an additional, unexpected event. This deep saturated zone was originally assumed to be the upper portion of the regional aquifer. After discovering only 2 ft of saturation, drilling continued for another 100 ft, to a depth of 680 ft, resulting only in dry bedrock and no regional water table. Currently, the drilling is expected to continue until the regional water table is encountered. Water quality and hydrogeologic data collected from all the intermediate saturated zones will be evaluated to decide if additional intermediate saturated zone wells are needed in the vicinity of R-9.

Currently, R-9 is projected to penetrate the regional water table in gravels of the Puye Formation, somewhere deeper than 680 ft below land surface, where it will be completed and developed. Following well completion, the upper 50 ft of saturation within the regional aquifer will be monitored and sampled by the Laboratory and the DOE Oversight Bureau.

Table 5-1. Radiochemical Analysis of Surface Waters for 1997 (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 Stations																						
Rio Chama at Chamita	10/07	1 UF	138	–670[c,d]	0.7	1.5	–0.71	0.17	1.43	0.15	–0.015	0.006	0.007	0.012	0.030	0.019	1.7	0.4	3.1	0.3	52	48
Rio Grande at Embudo	10/07	1 UF	–212	640	0.1	1.6	–0.36	0.17	1.43	0.15	–0.019	0.010	–0.016	0.009	–0.048	0.010	1.0	0.3	2.7	0.3	14	48
Rio Grande at Otowi Upper (bank)	12/01	1 UF	298	690	0.1	1.1	–0.15	1.00	2.24	0.23	0.010	0.013	–0.004	0.011	0.017	0.020	1.3	1.7	2.6	1.8	79	49
Rio Grande at Otowi (bank)	12/01	1 UF	–22	670	0.1	1.2	0.59	0.42	2.36	0.24	0.000	0.011	0.017	0.013	0.029	0.021	0.9	1.7	2.5	1.8	24	49
Rio Grande at Frijoles (bank)	09/30	1 UF	–162	660	–1.3	2.5	–0.43	0.59	0.97	0.10	–0.031	0.005	–0.006	0.012	–0.035	0.014	3.1	4.5	5.5	2.1	15	49
Rio Grande at Cochiti	10/07	1 UF	248	670	1.8	2.2	0.59	0.32	1.69	0.17	0.043	0.020	0.005	0.015	–0.043	0.011	10.9	1.7	16.9	1.2	47	48
Rio Grande at Cochiti	10/07	1 UF	–22	660	0.3	2.0	–0.44	0.18	0.97	0.10	–0.018	0.011	–0.008	0.010	–0.029	0.011	3.8	0.6	3.9	0.4	19	48
Cochiti Lower	10/29	1 UF	288	690	0.7	1.3	–0.44	0.57	1.35	0.14	–0.024	0.007	–0.009	0.010	–0.001	0.013	1.6	3.1	4.0	1.9	5	48
Cochiti Middle	10/29	1 UF	188	690	1.1	1.2	–0.38	0.67	1.21	0.12	–0.029	0.005	–0.012	0.010	–0.012	0.027	2.0	6.5	2.8	1.8	–8	48
Cochiti Upper	10/29	1 UF	48	680	1.6	1.8	–0.76	0.09	1.33	0.14	–0.019	0.011	–0.007	0.013	–0.028	0.011	1.0	3.1	2.1	1.7	–14	48
Jemez River	10/07	1 UF	–52	650	2.9	2.1	1.20	0.42	0.94	0.10	0.007	0.014	–0.002	0.012	–0.036	0.014	7.0	1.2	14.1	1.1	18	48
Pajarito Plateau																						
Guaje Canyon:																						
Guaje Canyon	11/18	1 UF	–72	650	–0.2	1.4	–0.49	0.50	0.09	0.01	–0.014	0.006	0.016	0.011	–0.018	0.010	1.0	4.8	2.1	1.7	17	49
Pueblo Canyon:																						
Acid Weir	06/02	1 UF	130	190	7.9	3.8	0.85	2.50	0.32	0.04	0.089	0.023	2.585	0.157	0.207	0.035	4.4	1.3	27.0	4.0	20	48
Pueblo 1	06/02	1 UF	264	214	0.3	1.5	–0.55	0.40	0.03	0.01	0.002	0.015	–0.021	0.013	–0.042	0.014	0.8	0.4	1.9	0.7	–14	48
Pueblo 3	06/12	1 UF	–130	156	1.5	1.5	–0.96	0.80	0.42	0.05	–0.009	0.009	0.063	0.019	0.022	0.020	–0.4	0.3	13.6	1.9	–49	47
Pueblo at SR 502	06/12	1 UF	–281	652	0.5	1.5	–0.78	0.07	0.20	0.02	–0.015	0.007	0.179	0.028	0.049	0.024	0.9	3.1	14.1	5.1	–21	48
DP/Los Alamos Canyon:																						
Los Alamos Canyon Reservoir	12/01	1 UF	–172	670	0.0	1.4	0.90	0.39	0.14	0.02	–0.027	0.005	–0.012	0.008	0.005	0.025	–0.3	0.9	1.4	1.6	5	49
DPS-1	06/02	1 UF	–97	90	142.1	9.5	–0.75	0.10	0.39	0.04	–0.034	0.018	0.026	0.020	–0.010	0.015	–3.4	0.7	285.0	38.0	–6	48
DPS-4	06/10	1 UF	29	202	41.9	4.1	1.04	0.41	0.15	0.02	–0.006	0.009	0.056	0.017	0.087	0.028	0.8	0.2	81.0	11.0	–4	48
Los Alamos at Upper GS	12/18	1 UF	178	670	0.6	1.5	–0.70	0.18	0.28	0.03	–0.035	0.007	0.011	0.012	–0.028	0.013	0.4	2.1	5.9	2.1	–28	48
Los Alamos at SR 4	04/29	1 UF	54	199	1.9	1.6	0.24	0.26	0.11	0.01	0.000	0.014	0.159	0.031	0.119	0.033	1.9	0.8	3.4	0.9	20	48
Los Alamos at Rio Grande	05/19	1 UF	–192	–198	0.9	1.7	1.31	0.48	1.58	0.16	–0.001	0.012	0.022	0.015	0.002	0.024	–0.6	2.4	1.1	0.6	36	47
Sandia Canyon:																						
SCS-1	06/12	1 UF	356	216	0.7	2.0	–1.05	0.80	0.24	0.03	0.000	0.010	–0.003	0.011	–0.036	0.017	0.3	1.2	13.0	5.0	–40	48
SCS-2	06/12	1 UF	–27	207	0.4	1.9	–0.64	0.27	0.47	0.05	–0.021	0.008	–0.024	0.009	–0.022	0.017	3.2	3.2	6.7	3.7	–50	47
SCS-3	06/03	1 UF	–59	148	–0.1	1.2	–1.24	0.80	0.55	0.06	–0.027	0.008	0.013	0.014	–0.003	0.015	0.2	0.3	15.0	3.0	–24	48
Mortandad Canyon:																						
Mortandad at GS-1	06/03	1 UF	9,095	424	9.5	3.5	33.28	3.80	0.50	0.05	5.984	0.306	4.705	0.249	11.219	0.554	49.8	9.0	69.0	10.0	–6	48
Mortandad at GS-1	06/03	1 UF	8,797	417	10.5	2.2	32.58	3.70	0.53	0.06	7.011	0.355	6.167	0.318	12.101	0.589	39.8	8.0	69.0	10.0	–4	48
Mortandad at Rio Grande (A-11)	09/11	1 UF	–192	660	1.4	1.6	0.40	1.83	0.53	0.06	0.006	0.013	0.004	0.012	–0.007	0.018	0.4	2.0	5.9	2.1	19	48
Cañada del Buey:																						
Cañada del Buey	05/22	1 UF	–168	194	0.9	1.4	–0.51	0.47	0.53	0.06	0.016	0.020	0.002	0.015	–0.029	0.020	–0.7	1.1	2.7	0.8	42	47
Pajarito Canyon:																						
Pajarito at Rio Grande	09/29	1 UF	–372	650	–0.9	2.4	–0.43	0.59	1.02	0.11	–0.007	0.010	–0.005	0.012	0.028	0.020	1.5	3.1	2.0	1.7	–26	48

Table 5-1. Radiochemical Analysis of Surface Waters for 1997 (pCi/L[a]) (Cont.)

Station Name	Date	Code[a]	^{3}H	^{90}Sr	^{137}Cs	U (μg/L)	^{238}Pu	$^{239,240}Pu$	^{241}Am	Gross Alpha	Gross Beta	Gross Gamma
Water Canyon:												
Water Canyon at Beta	06/23	1 UF	–93 182	–0.3 2.3	–0.11 1.07	0.12 0.02	–0.017 0.021	0.002 0.018	0.289 0.045	0.3 1.4	4.4 1.9	–9 48
Ancho Canyon:												
Ancho at Rio Grande	09/29	1 UF	28 680	–0.6 1.2	–0.48 0.19	0.20 0.02	–0.012 0.011	0.017 0.014	0.019 0.021	0.5 2.8	1.3 1.6	6 49
Frijoles Canyon:												
Frijoles at Monument HQ	11/18	1 UF	–232 640	0.7 1.2	0.62 2.17	0.10 0.01	0.011 0.011	–0.006 0.009	–0.007 0.010	0.9 5.9	1.4 1.6	46 49
Frijoles at Rio Grande	09/30	1 UF	–342 650	–0.2 1.1	–0.61 0.32	0.13 0.02	–0.015 0.011	0.012 0.015	–0.051 0.012	0.2 0.9	1.7 1.7	–4 49
Detection Limits			700	3	4	0.1	0.04	0.04	0.04	3	3	120
Water Quality Standards[e]												
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.
[b] Codes: UF–unfiltered, F–filtered, 1–primary analysis, 2–secondary analysis, R1–lab replicate, D1–lab duplicate.
[c] 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.
[d] See Appendix B for an explanation of negative numbers.
[e] Standards given here for comparison only, see Appendix A.

Table 5-2. Radiochemical Analysis of Runoff Water Samples in 1997

Station Name	Date	Codes[b]	Flow (cfs)	^{3}H		^{90}Sr		^{137}Cs		U (µg/L)		^{238}Pu		^{239,240}Pu		^{241}Am		Gross Alpha		Gross Beta		Gross Gamma	
Water Samples (pCi/L[a])																							
DP Canyon near LA	08/05	1 UF	5	338	690	–0.2[d]	1.1	1.51	0.50	0.51	0.05	0.023	0.014	0.210	0.033	0.671	0.064	2.6	1.5	49.0	4.0	–69	47
LA Canyon near LA	06/07	1 UF	36	–71	178	8.1	2.0	5.29	0.97	4.16	0.42	0.255	0.043	2.387	0.159	2.702	0.205	258.8	86.0	247.0	37.0	–39	47
LA Canyon near LA	06/07	1 UF	36	–77	167	7.6	1.8	9.58	1.30	4.54	0.46	0.223	0.029	2.208	0.106	5.016	0.308	113.8	52.0	147.0	38.0	–57	47
LA Canyon near LA	08/05	1 F	5.2			12.8	2.6	2.07	4.33	0.25	0.03	0.105	0.027	0.990	0.083	1.309	0.110	16.8	5.0	40.0	4.0	40	48
LA Canyon near LA	08/05	1 UF	5.2	–432	640	25.0	2.7	–0.32	0.76	1.29	0.13	0.140	0.031	1.684	0.122	2.081	0.141	13.8	5.0	33.0	4.0	–27	47
LA Canyon near LA	08/22	1 UF	171	168	680	3.1	0.8	42.28	4.70	6.58	0.66	0.151	0.045	1.285	0.123	10.288	0.503	640.8	168.0	1,637.0	289.0	66	48
LA Canyon near LA	09/20	1 F	40			5.1	2.0	–0.93	0.36	0.01	0.01	–0.006	0.009	0.028	0.014	0.034	0.020	0.1	3.0	12.0	2.0	6	48
LA Canyon near LA	09/20	1 UF	40	–22	660	7.2	1.8	18.88	2.40	4.34	0.44	0.541	0.077	5.459	0.336	7.570	0.443	175.8	5.0	336.0	5.0	12	48
Los Alamos Canyon at LA	03/26	1 F	1.6	127	203	0.7	0.6	–0.32	0.76	0.04	0.01	–0.008	0.010	–0.016	0.009	–0.016	0.016	0.6	0.4	1.1	0.6	6	48
Los Alamos Canyon at LA	03/26	1 UF	1.6	20	190	0.5	0.7	–0.39	0.64	0.10	0.01	–0.043	0.002	–0.028	0.008	–0.005	0.044	1.2	0.6	2.3	0.7	–26	47
Cañada del Buey at WR	08/02	1 UF	3.2	–52	670	2.7	0.8	3.24	0.74	4.30	0.43	0.015	0.019	0.108	0.034	0.017	0.024	233.8	76.0	616.0	105.0	48	48
Pajarito at SR 501	03/25	1 F	0.28	328	219	0.6	0.4	–0.19	0.33	0.13	0.02	–0.015	0.009	–0.008	0.012	0.022	0.021	2.3	0.8	1.7	0.6	–29	47
Pajarito at SR 501	03/25	1 UF	0.28	–93	145	0.8	0.5	3.18	6.00	0.10	0.01	–0.027	0.005	–0.014	0.008	–0.024	0.030	2.1	0.8	1.6	0.6	–45	47
Potrillo Canyon near WR	08/17	1 UF	3.3			2.7	0.9	5.11	0.97	4.64	0.47	–0.027	0.020	0.218	0.049	0.038	0.030	187.8	45.0	343.0	46.0	66	48
Area G Runoff																							
G-SWMS-4	07/21	1 UF	0.12	–111	182	2.1	1.6	0.74	2.33	2.35	0.24	0.143	0.036	2.994	0.199	–0.034	0.020	0.3	1.8	5.9	2.1	25	48
G-SWMS-4	07/21	1 UF	0.12	86	196	0.5	1.6	–1.19	0.36	0.42	0.05	0.060	0.028	0.653	0.071	–0.026	0.014	6.8	2.8	21.0	3.0	–46	47
G-SWMS-5	08/04	1 UF	4.6	498	700	11.5	4.1	–0.25	0.27	10.78	1.08	0.297	0.040	0.704	0.065	0.379	0.120	131.8	4.4	120.0	4.2	118	48
G-SWMS-6	10/21	1 UF	0.36	–152	670	1.8	0.9	1.47	0.49	3.87	0.39	0.325	0.047	2.094	0.142	0.933	0.089	336.8	87.0	425.0	60.0	9	48
Detection Limits				700		3		4		0.1		0.04		0.04		0.04		3		3		120	
Water Quality Standards[e]																							
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 5-2. Radiochemical Analysis of Runoff Water Samples in 1997 (Cont.)

Station Name	Date	Codes[b]	TSS (mg/L)	Flows (cfs)	^{90}Sr		^{137}Cs		U (mg/kg)		^{238}Pu		^{239,240}Pu		^{241}Am		Gross Alpha		Gross Beta		Gross Gamma	
Calculated activities and uncertainties for suspended sediments in water samples (pCi/g[a])																						
LA Canyon near LA	08/05	1	1,233	5.2	9.9	3.1	–1.94	3.58	0.84	0.11	0.028	0.034	0.563	0.120	0.626	0.145	–2.4	5.7	–5.7	4.6	–54	55
LA Canyon near LA	09/20	1	3,794	40	0.6	0.7	5.22	0.64	1.14	0.12	0.144	0.020	1.431	0.089	1.986	0.118	46.3	1.5	85.4	1.4	2	18
LA Canyon at LA	03/26	1	21	1.6	–7.6	45.1	–3.33	47.32	2.86	0.67	–1.638	0.477	–0.600	0.570	0.510	2.230	31.0	35.7	57.1	43.9	–1,510	3,199
Pajarito at SR 501	03/25	1	4	0.28	47.5	160	842.5	1,661.1	–7.50	5.73	–2.95	2.71	–1.58	3.76	–11.35	9.19	–50.0	282.8	–25.0	212.1	–3,800	16,741
Sediment Comparisons																						
Background (x + 2s)[f]					0.9		0.44		4.40		0.006		0.023		0.090[g]		14.8[g]		12.0[g]		8.2[g]	
SAL[h]					5.9		4.0		95		20		18		17							

[a] Except where noted.
[b] Codes: UF–unfiltered, F–filtered, 1–primary analysis, 2–secondary analysis, R1–lab replicate, D1–lab duplicate.
[c] 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.
[d] See Appendix B for an explanation of negative numbers.
[e] Standards given here for comparison only; see Appendix A.
[f] Purtymun, 1987a; upper limit for background.
[g] Preliminary background value for channel sediments from 1974–1996 (McLin 1997).
[h] Screening Action Level; Environmental Restoration, 1997; see text for details.

Table 5-3. Detections of Radionuclides in Surface Waters and Runoff Samples for 1997[a]

Station Name	Date	Code[b]	Analyte	Lab Value	Uncertainty	Units	Detection Limit
Runoff							
Cañada del Buey at WR	08/02	1 UF	Beta	616.0	105.0	pCi/L	3
DP Canyon near LA	08/05	1 UF	^{241}Am	0.671	0.064	pCi/L	0.04
DP Canyon near LA	08/05	1 UF	Beta	49.0	4.0	pCi/L	3
DP Canyon near LA	08/05	1 UF	^{239,240}Pu	0.210	0.033	pCi/L	0.04
G-SWMS-4	07/21	1 UF	Beta	21.0	3.0	pCi/L	3
G-SWMS-4	07/21	1 UF	^{239,240}Pu	0.653	0.071	pCi/L	0.04
G-SWMS-4	07/21	1 UF	^{239,240}Pu	2.994	0.199	pCi/L	0.04
G-SWMS-5	08/04	1 UF	Alpha	131.8	4.4	pCi/L	3
G-SWMS-5	08/04	1 UF	Beta	120.0	4.2	pCi/L	3
G-SWMS-5	08/04	1 UF	^{238}Pu	0.297	0.040	pCi/L	0.04
G-SWMS-5	08/04	1 UF	^{239,240}Pu	0.704	0.065	pCi/L	0.04
G-SWMS-5	08/04	1 UF	U	10.78	1.08	µg/L	0.1
G-SWMS-6	10/21	1 UF	^{241}Am	0.933	0.089	pCi/L	0.04
G-SWMS-6	10/21	1 UF	Beta	425.0	60.0	pCi/L	3
G-SWMS-6	10/21	1 UF	^{238}Pu	0.325	0.047	pCi/L	0.04
G-SWMS-6	10/21	1 UF	^{239,240}Pu	2.094	0.142	pCi/L	0.04
LA Canyon near LA	06/07	1 F	^{241}Am	2.702	0.205	pCi/L	0.04
LA Canyon near LA	06/07	1 F	Beta	247.0	37.0	pCi/L	3
LA Canyon near LA	06/07	1 F	^{137}Cs	5.29	0.97	pCi/L	4
LA Canyon near LA	06/07	1 F	^{238}Pu	0.255	0.043	pCi/L	0.04
LA Canyon near LA	06/07	1 F	^{239,240}Pu	2.387	0.159	pCi/L	0.04
LA Canyon near LA	06/07	1 UF	^{241}Am	5.016	0.308	pCi/L	0.04
LA Canyon near LA	06/07	1 UF	^{137}Cs	9.58	1.30	pCi/L	4
LA Canyon near LA	06/07	1 UF	^{238}Pu	0.223	0.029	pCi/L	0.04
LA Canyon near LA	06/07	1 UF	^{239,240}Pu	2.208	0.106	pCi/L	0.04
LA Canyon near LA	08/05	1 F	^{241}Am	1.309	0.110	pCi/L	0.04
LA Canyon near LA	08/05	1 F	Beta	40.0	4.0	pCi/L	3
LA Canyon near LA	08/05	1 F	^{239,240}Pu	0.990	0.083	pCi/L	0.04
LA Canyon near LA	08/05	1 F	^{90}Sr	12.8	2.6	pCi/L	3
LA Canyon near LA	08/05	1 UF	^{241}Am	2.081	0.141	pCi/L	0.04
LA Canyon near LA	08/05	1 UF	Beta	33.0	4.0	pCi/L	3
LA Canyon near LA	08/05	1 UF	^{239,240}Pu	1.684	0.122	pCi/L	0.04
LA Canyon near LA	08/05	1 UF	^{90}Sr	25.0	2.73	pCi/L	3
LA Canyon near LA	08/22	1 UF	^{241}Am	10.288	0.503	pCi/L	0.04
LA Canyon near LA	08/22	1 UF	Beta	1,637.0	289.0	pCi/L	3
LA Canyon near LA	08/22	1 UF	^{137}Cs	42.28	4.70	pCi/L	4
LA Canyon near LA	08/22	1 UF	^{239,240}Pu	1.285	0.123	pCi/L	0.04
LA Canyon near LA	08/22	1 UF	U	6.58	0.66	µg/L	0.1
LA Canyon near LA	09/20	1 UF	Alpha	175.8	5.0	pCi/L	3
LA Canyon near LA	09/20	1 UF	^{241}Am	7.570	0.443	pCi/L	0.04
LA Canyon near LA	09/20	1 UF	Beta	336.0	5.0	pCi/L	3
LA Canyon near LA	09/20	1 UF	^{137}Cs	18.88	2.40	pCi/L	4
LA Canyon near LA	09/20	1 UF	^{238}Pu	0.541	0.077	pCi/L	0.04
LA Canyon near LA	09/20	1 UF	^{239,240}Pu	5.459	0.336	pCi/L	0.04
Potrillo Canyon near WR	08/17	1 UF	Beta	343.0	46.0	pCi/L	3
Potrillo Canyon near WR	08/17	1 UF	^{137}Cs	5.11	0.97	pCi/L	4
Surface Water							
Acid Weir	06/02	1 UF	^{241}Am	0.207	0.035	pCi/L	0.04
Acid Weir	06/02	1 UF	Beta	27.0	4.0	pCi/L	3
Acid Weir	06/02	1 UF	^{239,240}Pu	2.585	0.157	pCi/L	0.04
DPS-1	06/02	1 UF	Beta	285.0	38.0	pCi/L	3
DPS-1	06/02	1 UF	^{90}Sr	142.1	9.5	pCi/L	3
DPS-4	06/10	1 UF	Beta	81.0	11.0	pCi/L	3
DPS-4	06/10	1 UF	^{90}Sr	41.9	4.1	pCi/L	3
Jemez River	10/07	1 UF	Alpha	7.0	1.2	pCi/L	3
Los Alamos at SR 4	04/29	1 UF	^{239,240}Pu	0.159	0.031	pCi/L	0.04

Table 5-3. Detections of Radionuclides in Surface Waters and Runoff Samples for 1997[a] (Cont.)

Station Name	Date	Code[b]	Analyte	Lab Value	Uncertainty	Units	Detection Limit
Surface Water (Cont.)							
Mortandad at GS-1	06/03	1 UF	Alpha	49.8	9.0	pCi/L	3
Mortandad at GS-1	06/03	1 UF	Alpha	39.8	8.0	pCi/L	3
Mortandad at GS-1	06/03	1 UF	^{241}Am	12.101	0.589	pCi/L	0.04
Mortandad at GS-1	06/03	1 UF	^{241}Am	11.219	0.554	pCi/L	0.04
Mortandad at GS-1	06/03	1 UF	Beta	69.0	10.0	pCi/L	3
Mortandad at GS-1	06/03	1 UF	Beta	69.0	10.0	pCi/L	3
Mortandad at GS-1	06/03	1 UF	^{137}Cs	33.28	3.80	pCi/L	4
Mortandad at GS-1	06/03	1 UF	^{137}Cs	32.58	3.70	pCi/L	4
Mortandad at GS-1	06/03	1 UF	^{3}H	9095	424	pCi/L	700
Mortandad at GS-1	06/03	1 UF	^{3}H	8797	417	pCi/L	700
Mortandad at GS-1	06/03	1 UF	^{238}Pu	7.011	0.355	pCi/L	0.04
Mortandad at GS-1	06/03	1 UF	^{238}Pu	5.984	0.306	pCi/L	0.04
Mortandad at GS-1	06/03	1 UF	^{239,240}Pu	4.705	0.249	pCi/L	0.04
Mortandad at GS-1	06/03	1 UF	^{239,240}Pu	6.167	0.318	pCi/L	0.04
Mortandad at GS-1	06/03	1 UF	^{90}Sr	10.5	2.2	pCi/L	3
Pueblo at SR-502	06/12	1 UF	^{239,240}Pu	0.179	0.028	pCi/L	0.04
Rio Grande at Cochiti	10/07	1 UF	Alpha	10.9	1.7	pCi/L	3
Water Canyon at Beta	06/23	1 UF	^{241}Am	0.289	0.045	pCi/L	0.04

[a] Detection defined as sample value–average blank > 4.66 uncertainty and > detection limit, except values for uranium > 5 µg/L, for gross beta > 20 pCi/L, and for gross alpha > 5 pCi/L.

[b] Codes: UF–unfiltered, F–filtered, T–total as calculated on Table 5-2, 1–primary analysis, R1–lab replicate, D1–lab duplicate.

Table 5-4. Possible Detections of Radionuclides in Surface Waters and Runoff Samples for 1997[a]

Station Name	Date	Code[b]	Analyte	Lab Value	Uncertainty	Units	Detection Limit
Runoff							
Cañada Del Buey at WR	08/02	1 UF	Alpha	233.8	76.0	pCi/L	3
Cañada Del Buey at WR	08/02	1 UF	^{239,240}Pu	0.108	0.034	pCi/L	0.04
G-SWMS-4	07/21	1 UF	Alpha	6.8	2.8	pCi/L	3
G-SWMS-4	07/21	1 UF	^{238}Pu	0.143	0.036	pCi/L	0.04
G-SWMS-5	08/04	1 UF	^{241}Am	0.379	0.120	pCi/L	0.04
G-SWMS-5	08/04	1 UF	^{90}Sr	11.47	4.05	pCi/L	3
G-SWMS-6	10/21	1 UF	Alpha	336.8	87.0	pCi/L	3
LA Canyon near LA	06/07	1 F	Alpha	258.8	86.0	pCi/L	3
LA Canyon near LA	06/07	1 F	^{90}Sr	8.08	1.97	pCi/L	3
LA Canyon near LA	06/07	1 UF	Beta	147.0	38.0	pCi/L	3
LA Canyon near LA	06/07	1 UF	^{90}Sr	7.56	1.77	pCi/L	3
LA Canyon near LA	08/05	1 F	Alpha	16.8	5.0	pCi/L	3
LA Canyon near LA	08/05	1 F	^{238}Pu	0.105	0.027	pCi/L	0.04
LA Canyon near LA	08/05	1 UF	Alpha	13.8	5.0	pCi/L	3
LA Canyon near LA	08/05	1 UF	^{238}Pu	0.140	0.031	pCi/L	0.04
LA Canyon near LA	08/22	1 UF	Alpha	640.8	168.0	pCi/L	3
LA Canyon near LA	08/22	1 UF	^{238}Pu	0.151	0.045	pCi/L	0.04
LA Canyon near LA	08/22	1 UF	^{90}Sr	3.07	0.83	pCi/L	3
LA Canyon near LA	09/20	1 F	^{90}Sr	5.13	1.97	pCi/L	3
LA Canyon near LA	09/20	1 UF	^{90}Sr	7.22	1.83	pCi/L	3
Potrillo Canyon near WR	08/17	1 UF	Alpha	187.8	45.0	pCi/L	3
Potrillo Canyon near WR	08/17	1 UF	^{239,240}Pu	0.218	0.049	pCi/L	0.04
Surface Water							
Acid Weir	06/02	1 UF	^{238}Pu	0.089	0.023	pCi/L	0.04
DPS-4	06/10	1 UF	^{241}Am	0.087	0.028	pCi/L	0.04
DPS-4	06/10	1 UF	^{239,240}Pu	0.056	0.017	pCi/L	0.04
Los Alamos at SR-4	04/29	1 UF	^{241}Am	0.119	0.033	pCi/L	0.04
Mortandad at GS-1	06/03	1 UF	^{90}Sr	9.48	3.50	pCi/L	3
Pueblo 3	06/12	1 UF	^{239,240}Pu	0.063	0.019	pCi/L	0.04

[a] Possible detection defined as 2.33 uncertainty < (sample value–average blank) < 4.66 uncertainty and sample value–average blank > detection limit, except values for uranium > 5 µg/L, for gross beta > 20 pCi/L, and for gross alpha > 5 pCi/L.

[b] Codes: UF–unfiltered, F–filtered, T–total as calculated on Table 5-2, 1–primary analysis, R1–lab replicate, D1–lab duplicate.

Table 5-5. Radionuclides near Department of Energy Derived Concentration Guides in Surface Waters for 1997[a]

Station Name	Date	Code	Analyte	Lab Value	Uncertainty	Units	DOE DCG	Ratio of Value to DCG	Min Std	Detection or Possible Detection[b]
Surface Water										
Acid Weir	06/02	1 UF	^{239,240}Pu	2.585	0.157	pCi/L	30	0.09	1.2	Detect
DPS-1	06/02	1 UF	Beta	285.0	38.0	pCi/L	1,000	0.28	50	Detect
DPS-1	06/02	1 UF	^{90}Sr	142.1	9.5	pCi/L	1,000	0.14	8	Detect
DPS-4	06/10	1 UF	Beta	81.0	11.0	pCi/L	1,000	0.08	50	Detect
DPS-4	06/10	1 UF	^{90}Sr	41.9	4.1	pCi/L	1,000	0.04	8	Detect
Mortandad at GS-1	06/03	1 UF	Alpha	49.8	9.0	pCi/L	30	1.66	15	Detect
Mortandad at GS-1	06/03	1 UF	Alpha	39.8	8.0	pCi/L	30	1.33	15	Detect
Mortandad at GS-1	06/03	1 UF	^{241}Am	11.219	0.554	pCi/L	30	0.37	1.2	Detect
Mortandad at GS-1	06/03	1 UF	^{241}Am	12.101	0.589	pCi/L	30	0.40	1.2	Detect
Mortandad at GS-1	06/03	1 UF	Beta	69.0	10.0	pCi/L	1,000	0.07	50	Detect
Mortandad at GS-1	06/03	1 UF	Beta	69.0	10.0	pCi/L	1,000	0.07	50	Detect
Mortandad at GS-1	06/03	1 UF	^{238}Pu	5.984	0.306	pCi/L	40	0.15	1.6	Detect
Mortandad at GS-1	06/03	1 UF	^{238}Pu	7.011	0.355	pCi/L	40	0.18	1.6	Detect
Mortandad at GS-1	06/03	1 UF	^{239,240}Pu	6.167	0.318	pCi/L	30	0.21	1.2	Detect
Mortandad at GS-1	06/03	1 UF	^{239,240}Pu	4.705	0.249	pCi/L	30	0.16	1.2	Detect
Runoff										
LA Canyon near LA	06/07	1 F	Alpha	258.8	86.0	pCi/L	30	8.63	15	Poss Detect
LA Canyon near LA	06/07	1 F	^{241}Am	2.702	0.205	pCi/L	30	0.09	1.2	Detect
LA Canyon near LA	06/07	1 UF	^{241}Am	5.016	0.308	pCi/L	30	0.17	1.2	Detect
LA Canyon near LA	06/07	1 F	Beta	247.0	37.0	pCi/L	1,000	0.25	50	Detect
LA Canyon near LA	06/07	1 UF	Beta	147.0	38.0	pCi/L	1,000	0.15	50	Poss Detect
LA Canyon near LA	06/07	1 F	^{239,240}Pu	2.387	0.159	pCi/L	30	0.08	1.2	Detect
LA Canyon near LA	06/07	1 UF	^{239,240}Pu	2.208	0.106	pCi/L	30	0.07	1.2	Detect
LA Canyon near LA	08/05	1 F	Alpha	16.8	5.0	pCi/L	30	0.56	15	Poss Detect
LA Canyon near LA	08/05	1 UF	^{241}Am	2.081	0.141	pCi/L	30	0.07	1.2	Detect
LA Canyon near LA	08/05	1 F	^{241}Am	1.309	0.110	pCi/L	30	0.04	1.2	Detect
LA Canyon near LA	08/05	1 UF	^{239,240}Pu	1.684	0.122	pCi/L	30	0.06	1.2	Detect
LA Canyon near LA	08/22	1 UF	Alpha	640.8	168.0	pCi/L	30	21.36	15	Poss Detect
LA Canyon near LA	08/22	1 UF	^{241}Am	10.288	0.503	pCi/L	30	0.34	1.2	Detect
LA Canyon near LA	08/22	1 UF	Beta	1,637.0	289.0	pCi/L	1,000	1.64	50	Detect
LA Canyon near LA	08/22	1 UF	^{239,240}Pu	1.285	0.123	pCi/L	30	0.04	1.2	Detect
LA Canyon near LA	09/20	1 UF	Alpha	175.8	5.0	pCi/L	30	5.86	15	Detect
LA Canyon near LA	09/20	1 UF	^{241}Am	7.570	0.443	pCi/L	30	0.25	1.2	Detect
LA Canyon near LA	09/20	1 UF	Beta	336.0	5.0	pCi/L	1,000	0.34	50	Detect
LA Canyon near LA	09/20	1 UF	^{239,240}Pu	5.459	0.336	pCi/L	30	0.18	1.2	Detect
Cañada Del Buey at WR	08/02	1 UF	Alpha	233.8	76.0	pCi/L	30	7.79	15	Poss Detect
Cañada Del Buey at WR	08/02	1 UF	Beta	616.0	105.0	pCi/L	1,000	0.62	50	Detect

Table 5-5. Radionuclides near Department of Energy Derived Concentration Guides in Surface Waters for 1997[a] (Cont.)

Station Name	Date	Code	Analyte	Lab Value	Uncertainty	Units	DOE DCG	Ratio of Value to DCG	Min Std	Detection or Possible Detection[b]
Runoff (Cont.)										
Potrillo Canyon near WR	08/17	1 UF	Alpha	187.8	45.0	pCi/L	30	6.26	15	Poss Detect
Potrillo Canyon near WR	08/17	1 UF	Beta	343.0	46.0	pCi/L	1,000	0.34	50	Detect
G-SWMS-4	07/21	1 UF	^{239,240}Pu	2.994	0.199	pCi/L	30	0.10	1.2	Detect
G-SWMS-5	08/04	1 UF	Alpha	131.8	4.4	pCi/L	30	4.39	15	Detect
G-SWMS-5	08/04	1 UF	Beta	120.0	4.2	pCi/L	1,000	0.12	50	Detect
G-SWMS-6	10/21	1 UF	Alpha	336.8	87.0	pCi/L	30	11.23	15	Poss Detect
G-SWMS-6	10/21	1 UF	Beta	425.0	60.0	pCi/L	1,000	0.42	50	Detect
G-SWMS-6	10/21	1 UF	^{239,240}Pu	2.094	0.142	pCi/L	30	0.07	1.2	Detect

[a] Values shown 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.
[b] Detection or possible detection determined according to criteria described in text.

Table 5-6. Summary of TA-50 Radionuclide and Nitrate Discharges[a]

	1963–1977	1995			1996			1997		
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	731	41,400	0.02	1,020	61,700	0.03	1,330	76,300	0.04
^{241}Am	7	1.4	79.4	2.65	1.99	120	4.00	2.56	147	4.90
^{137}Cs	848	6.6	375	0.13	2.20	133	0.04	2.48	142	0.05
^{238}Pu	51	3.4	195	4.88	2.25	136	3.40	1.34	76.7	1.92
$^{239,240}Pu$	39	0.6	35.6	1.19	0.39	23.8	0.79	0.80	45.9	1.53
^{89}Sr	<1	0.1	6.9	0.0003	0.66	40.2	0.002	0.83	47.7	0.002
^{90}Sr	295	0.6	36.9	0.04	0.60	36.1	0.04	0.50	28.5	0.03
^{234}U	NA	0.2	14.3	0.03	0.19	11.7	0.02	0.08	4.88	0.01
^{235}U	2	.009	0.53	0.0009	0.003	0.18	0.0003	0.007	0.44	0.0007
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		718	35.6	3.5	1,260	76.4	7.6	1,220	69.6	7.0
Total effluent volume ($\times 10^7$ liters)		1.76			1.65			1.75		

[a]Compiled from Radioactive Liquid Waste Group (EM-RLW) Annual Reports. Data for 1997 are preliminary.
[b]DOE 1979; decay corrected through 12/77.
[c]Public dose limit.

Table 5-7. Chemical Quality of Surface Waters and Runoff Samples for 1997 (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 Stations																				
Rio Chama at Chamita	10/07	1 UF															13			
Rio Chama at Chamita	10/07	1 F	19	29.8	4.9	1.4	12.5	4.5	33.9	<5[f]	79	0.27	<0.02	0.20	0.01	114		95	8.3	240
Rio Grande at Embudo	10/07	1 F	18	28.5	4.7	1.6	11.9	4.6	35.0	<5	79	0.25	<0.02	0.17	0.01	156		91	8.3	239
Rio Grande at Embudo	10/07	1 UF															13			
Rio Grande at Otowi Upper (bank)	12/01	1 F	24	1.3	0.2	<1.0	0.7	6.3	30.0	<5	93	0.12	0.02	0.11	<0.01	194		4	8.4	268
Rio Grande at Otowi Upper (bank)	12/01	1 UF															15			
Rio Grande at Otowi (bank)	12/01	1 F	24	23.9	4.7	2.3	15.0	6.6	29.0	<5	98	0.36	0.03	0.16	<0.01	162		79	8.2	271
Rio Grande at Otowi (bank)	12/01	1 UF															4			
Rio Grande at Frijoles (bank)	09/30	1 F	25	18.4	3.3	2.2	9.7	3.7	20.4	<5	65	0.21	0.03	0.14	0.01	141		60	8.5	171
Rio Grande at Frijoles (bank)	09/30	1 UF															118			
Rio Grande at Cochiti	10/07	1 F	23	21.0	4.1	2.2	11.4	4.2	19.8	<5	69	0.27	<0.02	0.22	0.01	106		69	7.7	189
Rio Grande at Cochiti	10/07	1 UF															32			
Rio Grande at Cochiti	10/07	1 F	15	33.6	5.8	<1.0	12.4	3.7	57.4	<5	77	0.13	<0.02	0.22	0.01	170		108	7.9	263
Rio Grande at Cochiti	10/07	1 UF															95			
Cochiti Lower	10/29	1 F	21	22.3	4.1	2.0	10.4	4.5	25.0	<5	78	0.22	0.02	0.46	0.01	240		73	7.8	217
Cochiti Lower	10/29	1 UF															15			
Cochiti Middle	10/29	1 UF															11			
Cochiti Middle	10/29	1 F	20	22.5	4.2	2.4	10.5	4.5	26.0	<5	73	0.21	0.03	0.33	0.01	220		74	7.7	215
Cochiti Upper	10/29	1 F	21	22.1	4.1	1.8	10.8	4.7	25.0	<5	77	0.21	0.04	0.12	0.01	250		72	7.8	211
Cochiti Upper	10/29	1 UF															11			
Jemez River	10/07	1 F	45	44.3	4.6	9.9	67.6	104.0	11.4	13	158	1.07	<0.02	0.05	0.01	356		130	8.8	638
Jemez River	10/07	1 UF															3			
Pajarito Plateau																				
Guaje Canyon:																				
Guaje Canyon	11/18	1 UF															12			
Guaje Canyon	11/18	1 F	64	7.3	2.7	1.7	9.3	4.8	3.2	<5	52	0.14	0.05	<0.02	<0.01	160		29	7.6	113
Pueblo Canyon:																				
Acid Weir	06/02	1 UF															<1			
Acid Weir	06/02	1 F	18	15.9	1.7	5.0	60.1	86.8	7.7	<5	44	0.25	0.20	0.69	<0.01	262		47	7.0	405
Pueblo 1	06/02	1 F	20	14.3	2.4	3.5	41.7	52.3	7.8	<5	50	0.16	0.28	0.09	<0.01	236		46	7.6	308
Pueblo 1	06/02	1 UF															2			
Pueblo 3	06/12	1 UF															<1			
Pueblo 3	06/12	1 F	86	19.8	5.5	12.9	59.9	37.0	22.8	<5	181	0.44	4.78	0.88	0.01	374		72	7.1	532
Pueblo at SR 502	06/12	1 F	77	18.1	4.4	12.6	64.6	37.2	19.6	<5	142	0.62	5.57	0.83	<0.01	342		63	7.8	477
Pueblo at SR 502	06/12	1 UF															1			

Table 5-7. Chemical Quality of Surface Waters and Runoff Samples for 1997 (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)
Pajarito Plateau (Cont.)																				
DP/Los Alamos Canyon:																				
Los Alamos Canyon Reservoir	12/01	1 F	37	7.8	2.9	2.5	7.2	7.2	4.0	<5	40	0.05	0.07	0.25	<0.01	84		31	7.5	109
Los Alamos Canyon Reservoir	12/01	1 UF															1			
DPS-1	06/02	1 F		53.3	3.6	8.4	110.9											148		
DPS-4	06/10	1 UF															2			
DPS-4	06/10	1 F	19	17.0	1.6	6.7	31.6	35.1	7.0	<5	65	0.86	0.09	0.37	<0.01	108		49	7.7	292
Los Alamos at Upper GS	12/18	1 F		11.7	3.1	3.4	28.1													
Los Alamos at Upper GS	12/18	1 UF															<1			
Los Alamos at SR-4	04/29	1 UF	36	10.2	3.0	2.2	20.7	32.0	7.0	<5	39	0.26	0.06	0.09	<0.01	156		38	7.9	203
Los Alamos at Rio Grande	05/19	1 UF	54	44.0	5.1	3.9	34.6	27.8	19.0	<5	151	0.49	0.31	1.10	<0.01	308	80	131	8.5	428
Sandia Canyon:																				
SCS-1	06/12	1 F	92	18.6	5.2	11.7	94.3	58.3	61.7	<5	138	0.45	2.96	2.11	0.01	462		68	8.3	619
SCS-1	06/12	1 UF															<1			
SCS-2	06/12	1 F	80	18.5	4.2	10.8	90.9	59.6	44.2	<5	142	0.75	2.91	0.50	0.01	424		63	8.6	577
SCS-2	06/12	1 UF															<1			
SCS-3	06/03	1 F	83	21.2	4.6	12.7	109.6	77.9	60.9	<5	145	1.05	3.16	0.26	<0.01	510		72	8.6	680
SCS-3	06/03	1 UF															<1			
Mortandad Canyon:																				
Mortandad at GS-1	06/03	1 F	80	30.4	2.5	5.6	29.8	9.8	9.6	<5	123	0.95	0.27	4.69	<0.01	298		86	8.0	325
Mortandad at GS-1	06/03	1 UF															<1			
Mortandad at GS-1	06/03	1 F		31.4	2.5	5.9	31.0											89		
Mortandad at Rio Grande (A-11)	09/11	1 UF															160			
Mortandad at Rio Grande (A-11)	09/11	1 F	90	19.8	5.7	14.1	64.9	48.1	25.7	<5	119	0.82	5.86	7.47	0.01	380		73	8.1	530
Cañada del Buey:																				
Cañada del Buey	05/22	1 UF	26	10.3	3.0	3.2	15.2	21.5	5.7	<5	32	0.31	<0.02	0.06	<0.01	154	14	38	6.4	163
Pajarito Canyon:																				
Pajarito at Rio Grande	09/29	1 F	75	19.1	4.1	2.4	13.0	6.2	7.0	<5	81	0.46	<0.02	0.74	0.01	195		65	8.6	198
Pajarito at Rio Grande	09/29	1 UF															<1			
Water Canyon:																				
Water Canyon at Beta	06/23	1 UF															<1			
Water Canyon at Beta	06/23	1 F	42	14.1	4.2	4.2	20.7	21.3	5.9	<5	55	0.17	0.07	<0.02	<0.01	190		52	7.7	200
Ancho Canyon:																				
Ancho at Rio Grande	09/29	1 F	74	12.1	2.7	1.7	9.8	3.4	3.4	24	61	0.42	0.04	0.17	0.01	145		41	9.4	130
Ancho at Rio Grande	09/29	1 UF															20			

Table 5-7. Chemical Quality of Surface Waters and Runoff Samples for 1997 (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)
Pajarito Plateau (Cont.)																				
Frijoles Canyon:																				
Frijoles at Monument HQ	11/18	1 F	64	7.6	2.8	1.9	10.0	4.9	3.3	<5	49	0.16	0.03	0.07	<0.01	136		30	7.7	113
Frijoles at Monument HQ	11/18	1 UF															2			
Frijoles at Rio Grande	09/30	1 UF															20			
Frijoles at Rio Grande	09/30	1 F	66	8.7	2.9	1.6	9.6	5.2	3.9	<5	49	0.16	0.14	0.09	0.01	141		34	8.4	122
Runoff Stations																				
DP Canyon near LA	08/05	1 UF		19.2	2.5	7.1	21.8										244	58		
LA Canyon near LA	06/07	1 UF	25	16.4	7.3	10.8	21.2	20.5	6.1	<5	51	0.34	0.81	0.44	0.01	95	2,810	71	7.2	188
LA Canyon near LA	06/07	1 UF		20.4	9.6	10.9	21.3											91		
LA Canyon near LA	08/05	1 UF		16.8	5.4	6.5	16.1										1,233	64		
LA Canyon near LA	08/22	1 UF															6,641			
LA Canyon near LA	09/20	1 UF															3,794			
Los Alamos Canyon at LA	03/26	1 F	31	7.4	2.5	1.5	6.3	9.8	5.5	<5	29	0.08	0.03	0.24	<0.01	96	3	29	7.6	101
Los Alamos Canyon at LA	03/26	1 UF	31	6.9	2.5	1.6	6.1	9.8	5.6	<5	35	0.08	0.03	0.04	<0.01	128	24	28	7.6	96
Cañada del Buey at WR	08/02	1 UF															22,015			
Pajarito at SR 501	03/25	1 F	33	5.1	2.1	<1.0	4.1	4.8	6.8	<5	30	0.07	0.09	0.11	<0.01	116	<1	21	7.6	82
Pajarito at SR 501	03/25	1 UF	33	6.8	2.9	1.6	4.6	4.8	6.9	<5	34	0.07	0.09	0.05	<0.01	112	4	29	7.7	75
Potrillo Canyon near WR	08/17	1 UF															6,362			
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, 1–primary analysis, R1–lab replicate, D1–lab duplicate.
[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 5-8. Total Recoverable Trace Metals in Surface Waters and Runoff Samples for 1997 (µg/L)

Station Name	Date	Code[a]		Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg
Regional Stations															
Rio Chama at Chamita	10/07	1	F	<10[b]	<50	<2	30	59	<3	<7	<8	<7	<10	<40	<0.2
Rio Grande at Embudo	10/07	1	F	<10	<50	<2	36	58	<3	<7	<8	<7	<10	<40	<0.2
Rio Grande at Otowi Upper (bank)	12/01	1	F	<10	<50	<2	<20	1	<3	<7	<8	<7	<10	<40	<0.2
Rio Grande at Otowi (bank)	12/01	1	F	<10	53	<2	32	36	<3	<7	<8	<7	<10	<40	<0.2
Rio Grande at Frijoles (bank)	10/30	1	UF												<0.2
Rio Grande at Frijoles (bank)	09/30	1	F	<10	134	<2	28	33	<3	<7	<8	<7	<10	136	
Rio Grande at Cochiti	10/07	1	F	<10	<50	<2	73	56	<3	<7	<8	<7	<10	<40	
Rio Grande at Cochiti	10/07	1	F	<10	<50	<2	54	25	<3	<7	16	<7	<10	65	
Cochiti Lower	10/29	1	F	<10	<50	<2	41	44	<3	<7	<8	<7	<10	<40	<0.2
Cochiti Middle	10/29	1	F	15	983	<2	191	58	6	45	54	49	39	<40	<0.2
Cochiti Upper	10/29	1	F	<10	<50	<2	36	42	<3	<7	<8	<7	<10	<40	<0.2
Jemez River	10/07	1	F	<10	<50	92	832	72	<3	<7	<8	<7	<10	44	
Pajarito Plateau															
Guaje Canyon:															
Guaje Canyon	11/18	1	F	<10	84	<6	23	12	<3	<7	<8	<7	<10	106	<0.2
Pueblo Canyon:															
Acid Weir	06/02	1	F	<10	<50	<2	26	35	<3	<7	<8	<7	<10	<40	<0.2
Pueblo 1	06/02	1	F	<10	<50	<2	23	28	<3	<7	<8	<7	<10	<40	<0.2
Pueblo 3	06/12	1	F	<10	114	9	256	13	<3	<7	<8	<7	<10	203	<0.2
Pueblo at SR 502	06/12	1	F	<10	<50	13	267	22	<3	<7	<8	<7	<10	897	<0.2
DP/Los Alamos Canyon:															
Los Alamos Canyon Reservoir	12/01	1	F	<10	389	<2	<20	23	<3	<7	<8	<7	22	218	<0.2
DPS-1	06/02	1	F	<10	<50	<2	48	168	<3	<7	<8	<7	<10	75	<0.2
DPS-4	06/10	1	F	<10	750	2	46	61	<3	<9	<8	<7	<10	342	<0.2
Los Alamos at Upper GS	12/18	1	UF												<0.2
Los Alamos at Upper GS	12/15	1	F	<10	<50	<2	<20	32	<3	<7	<8	9	<10	<40	
Los Alamos at SR 4	04/29	1	UF	<10	1,216	<2	23	43	<3	<7	<8	<7	<10	848	<0.2
Los Alamos at Rio Grande	05/19	1	UF	<10	1,556	4	100	132	<3	<7	<8	<7	<10	941	<0.3

Table 5-8. Total Recoverable Trace Metals in Surface Waters and Runoff Samples for 1997 (μg/L) (Cont.)

Station Name	Date	Code[a]		Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg
Pajarito Plateau (Cont.)															
Sandia Canyon:															
SCS-1	06/12	1	F	<10	<50	5	78	27	<3	<7	<8	<7	<10	93	
SCS-2	06/12	1	F	<10	58	6	80	21	<3	<7	<8	8	<10	129	<0.2
SCS-3	06/03	1	F	<10	61	5	85	26	<3	<7	<8	<7	11	196	
Mortandad Canyon:															
Mortandad at GS-1	06/03	1	F	<10	160	4	61	23	<3	<7	<8	<7	16	216	<0.2
Mortandad at GS-1	06/03	1	F	<10	<50	3	66	22	<3	<7	<8	<11	16	116	<0.2
Mortandad at Rio Grande (A-11)	09/11	1	F	<10	226	<2	268	42	<3	<7	<8	<7	28	118	0.2
Cañada del Buey:															
Cañada del Buey	05/22	1	UF	22	6,632	2	33	87	<3	<7	<8	<7	17	3,605	0.3
Pajarito Canyon:															
Pajarito at Rio Grande	09/29	1	F	<10	<50	<2	26	39	<3	<7	<8	<7	<10	<40	<0.2
Water Canyon:															
Water Canyon at Beta	06/23	1	F	<10	1,179	<2	38	322	<3	<7	<8	<7	<10	529	<0.2
Ancho Canyon:															
Ancho at Rio Grande	09/29	1	F	<10	<50	<2	23	24	<3	<7	<8	<7	<10	<40	<0.2
Frijoles Canyon:															
Frijoles at Monument HQ	11/18	1	F	<10	116	<6	<20	12	<3	<7	<8	<7	<10	96	<0.2
Frijoles at Rio Grande	09/30	1	F	<10	122	<2	<20	15	<3	<7	<8	<7	<10	98	<0.2
Runoff Stations															
DP Canyon near Los Alamos	08/05	1	UF	<10	7,765	2	27	112	<3	<7	<8	<7	18	4,309	<0.2
LA Canyon near LA	06/07	1	UF	<10	35,937	15	22	287	<3	<7	<13	26	33	20,632	<0.3
LA Canyon near LA	06/07	1	UF	<10	46,753	15	42	416	4	<9	13	39	50	30,136	<0.3
LA Canyon near LA	08/05	1	UF	<10	22,894	5	27	242	<3	<7	10	16	35	14,571	<0.2
Los Alamos Canyon at LA	03/26	1	F	<10	208	<2	<20	24	<3	<7	<8	<7	<10	146	<0.2
Los Alamos Canyon at LA	03/26	1	UF	<10	3,525	<2	<20	35	<3	<7	<8	<7	<10	1,465	<0.2
Pajarito at SR 501	03/25	1	F	<10	2,222	<2	<20	50	<3	<7	<8	<7	<10	906	<0.2
Pajarito at SR 501	03/25	1	UF	<10	5,046	<2	<20	48	<3	<7	<8	<7	<10	1,950	<0.2

Table 5-8. Total Recoverable Trace Metals in Surface Waters and Runoff Samples for 1997 (μg/L) (Cont.)

Station Name	Date	Code[a]	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg
Water Quality Standards[c]														
EPA Primary Drinking Water Standard					50		2,000	4	5		100			2.0
EPA Secondary Drinking Water Standard				50–200									300	
EPA Action Level												1,300		
EPA Health Advisory														
NM Livestock Watering Standard				5,000	200	5,000			50	1,000	1,000	500		10.0
NMWQCC Groundwater Limit			50	5,000	100	750	1,000		10	50	50	1,000	1,000	2.0
NM Wildlife Habitat Stream Standard														0.012

Table 5-8. Total Recoverable Trace Metals in Surface Waters and Runoff Samples for 1997 (μg/L) (Cont.)

Station Name	Date	Code[a]		Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
Regional Stations														
Rio Chama at Chamita	10/07	1	F	2	<30	<20	<3	<3	<4	<30	230	<3	<8	<50
Rio Grande at Embudo	10/07	1	F	<2	<30	<20	<3	<3	<4	<30	217	<3	<8	<50
Rio Grande at Otowi Upper (bank)	12/01	1	F	<2	<30	<20	<3	<3	<3	<30	10	<3	<8	<50
Rio Grande at Otowi (bank)	12/01	1	F	9	<30	<20	<3	<3	<3	<30	203	<3	<8	<50
Rio Grande at Frijoles (bank)	10/30	1	UF						<3					
Rio Grande at Frijoles (bank)	09/30	1	F	12	<30	<20	<3	<3		<30	150	<3	<8	<50
Rio Grande at Cochiti	10/07	1	F	<2	<30	<20	<3	<3		<30	281	<3	<8	<50
Rio Grande at Cochiti	10/07	1	F	<2	<30	<20	<3	<3		<30	168	<3	<8	<50
Cochiti Lower	10/29	1	F	<2	<30	<20	<3	<3	<3	<30	189	<3	8	<50
Cochiti Middle	10/29	1	F	56	58	45	<3	3	<3	<56	253	<3	23	<50
Cochiti Upper	10/29	1	F	6	<30	<20	<3	<3	<3	<31	189	<3	<9	<50
Jemez River	10/07	1	F	9	<30	<20	<3	<3		<30	175	<3	<8	<50
Pajarito Plateau														
Guaje Canyon:														
Guaje Canyon	11/18	1	F	7	<30	<20	<3	<3	7	<30	49	<3	<8	<50
Pueblo Canyon:														
Acid Weir	06/02	1	F	11	<30	<20	<3	<3	<3	<30	89	<3	<8	<50
Pueblo 1	06/02	1	F	14	<30	<20	<3	<3	<3	<30	79	<3	<8	<50
Pueblo 3	06/12	1	F	39	<30	<20	<3	<3	<3	<30	96	<3	11	<50
Pueblo at SR 502	06/12	1	F	655	<30	<20	<3	<3	<3	<30	88	<3	<8	<50
DP/Los Alamos Canyon:														
Los Alamos Canyon Reservoir	12/01	1	F	48	<30	<20	<3	<3	<3	<30	68	<3	<8	<50
DPS-1	06/02	1	F	872	<30	<20	<3	<3	<3	<30	253	<3	<8	<50
DPS-4	06/10	1	F	5	<30	<20	<3	<3	<5	<30	95	<3	<8	<50
Los Alamos at Upper GS	12/18	1	UF						<2					
Los Alamos at Upper GS	12/15	1	F	<2	<30	<20	<3	<3		<30	81	<3	<8	<50
Los Alamos at SR 4	04/29	1	UF	36	41	<20	4	<3	<3	<30	73	<3	<8	<50
Los Alamos at Rio Grande	05/19	1	UF	37	<30	<20	<3	<3	<3	<34	318	<3	13	<50

Table 5-8. Total Recoverable Trace Metals in Surface Waters and Runoff Samples for 1997 (μg/L) (Cont.)

Station Name	Date	Code[a]		Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
Pajarito Plateau (Cont.)														
Sandia Canyon:														
SCS-1	06/12	1	F	25	<30	<20	<3	<3		<42	90	<3	9	78
SCS-2	06/12	1	F	5	67	<23	<3	<3	<3	<30	91	<3	<8	<50
SCS-3	06/03	1	F	2	94	<20	<3	<3		<30	103	<3	<8	<50
Mortandad Canyon:														
Mortandad at GS-1	06/03	1	F	6	406	<20	<3	<3	<3	<30	64	<3	<8	<50
Mortandad at GS-1	06/03	1	F	5	431	<20	<3	<3	<3	<30	68	<3	<8	<50
Mortandad at Rio Grande (A-11)	09/11	1	F	16	<39	<20	<3	<3	<3	<30	89	<3	<12	<50
Cañada del Buey:														
Cañada del Buey	05/22	1	UF	234	120	<20	<3	<3	<3	<30	70	<3	<8	<50
Pajarito Canyon:														
Pajarito at Rio Grande	09/29	1	F	2	<30	<20	<3	<3	<3	<30	117	<3	<26	<50
Water Canyon:														
Water Canyon at Beta	06/23	1	F	5	<30	<20	<3	<3	<3	<30	97	<3	<8	<50
Ancho Canyon:														
Ancho at Rio Grande	09/29	1	F	2	<30	<20	<3	<3	<3	<30	61	<3	<8	<50
Frijoles Canyon:														
Frijoles at Monument HQ	11/18	1	F	7	<30	<20	<3	<3	4	<30	51	<3	<8	<50
Frijoles at Rio Grande	09/30	1	F	3	<30	<22	<3	<3	<3	<30	59	<3	<8	<50
Runoff Stations														
DP Canyon near Los Alamos	08/05	1	UF	157	<30	<20	18	<3	<2	<30	112	<3	9	55
LA Canyon near LA	06/07	1	UF	884	60	<33	80	3	<3	<30	129	<3	32	194
LA Canyon near LA	06/07	1	UF	1,490	65	24	130	<3	<3	<30	158	<3	47	328
LA Canyon near LA	08/05	1	UF	708	41	<20	90	3	<2	<55	113	<3	27	187
Los Alamos Canyon at LA	03/26	1	F	3	<30	<20	<3	<3	<3	<30	56	<3	<8	<50
Los Alamos Canyon at LA	03/26	1	UF	45	<30	<20	<3	<3	<3	<30	57	<3	<8	<50
Pajarito at SR 501	03/25	1	F	7	<30	<20	<3	<3	<3	<30	51	<3	<8	<50
Pajarito at SR 501	03/25	1	UF	18	<30	<20	<3	<3	<3	<30	59	<3	<8	<50

Table 5-8. Total Recoverable Trace Metals in Surface Waters and Runoff Samples for 1997 (μg/L) (Cont.)

Station Name	Date	Code[a]	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
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	
NM Livestock Watering Standard						100		50				100	25,000
NMWQCC Groundwater Limit			200	1,000	200	50		50					10,000
NM Wildlife Habitat Stream Standard								2					

[a] Codes: UF–unfiltered, F–filtered, 1–primary analysis, R1–lab replicate, D1–lab duplicate. Note that all Hg and Se samples are unfiltered.

[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 5-9. Number of Results above the Analytical Limit of Quantitation for Organic Compounds in Surface Waters in 1997

		Type of Organic Compound			
Station Name	**Date**	**Volatile**	**Semivolatile**	**PCB**	**High Explosives**
Number of compounds analyzed		66	71	8	13
Acid Weir	06/02	0	0	0	
Pueblo 3	06/12	0	0	0	
Pueblo at SR-502	06/12	0	0	0	
Los Alamos Canyon Reservoir	12/01	0	0	0	
DPS-1	06/02	0	0	0	
DPS-4	06/10	0	0	0	
Los Alamos at Rio Grande	05/19		0	0	
SCS-1	06/12	0	0	0	
SCS-2	06/12	0	0	0	
SCS-3	06/03	0	0	0	
Mortandad at GS-1	06/03	0	0	0	
Mortandad at GS-1	06/03	0	0	0	
Cañada del Buey	05/22	0	0	0	0
Pajarito at Rio Grande	09/29	0	0	0	
Water Canyon at Beta	06/23	0	0	0	0
Ancho at Rio Grande	09/29	0	0	0	0
Frijoles at Monument HQ	11/18	0	0	0	0
Frijoles at Rio Grande	09/30	0	0	0	0

Table 5-10. Radiochemical Analysis for Sediments in 1997 (pCi/g)[a]

Station Name[b]	Date	Code[c]	^{3}H	^{90}Sr	^{137}Cs	U (mg/kg)	^{238}Pu	$^{239,240}Pu$	^{241}Am	Gross Alpha	Gross Beta	Gross Gamma
Regional Stations												
Rio Chama at Chamita	05/12	1	–17[d] 838[e]	–0.09 1.03	0.09 0.01	1.71 0.17	0.002 0.001	0.003 0.001	0.006 0.001	1.0 9.5	1.3 0.8	2.2 0.2
Rio Grande at Embudo	05/12	1	–262 660	0.67 0.59	0.11 0.02	1.86 0.19	0.001 0.001	0.003 0.001	0.002 0.001	2.8 2.1	2.1 1.0	2.4 0.2
Rio Grande at Frijoles (bank)	09/30	1	–112 720	0.73 1.26	0.06 0.01	2.61 0.26	0.001 0.001	0.002 0.001	0.004 0.001	3.8 2.0	3.6 0.9	2.1 0.2
Rio Grande at Bernalillo	05/09	1	–331 193	–0.57 0.84	<0.01[f]	0.92 0.09	0.001 0.001	0.002 0.001	0.002 0.002	1.1 2.5	0.9 0.7	1.8 0.2
Jemez River	05/09	1	–52 670	2.57 1.99	0.04 0.01	1.66 0.17	0.001 0.001	0.003 0.001	0.003 0.001	2.9 2.7	2.0 1.0	3.1 0.3
Reservoirs on Rio Chama (New Mexico)												
Heron Upper	07/22	1	8 660	0.18 1.35	0.19 0.03	3.02 0.30	0.0002 0.0001	0.0060 0.0003	0.003 0.001	6.9 2.9	6.7 0.7	2.8 0.3
Heron Middle	07/22	1	–272 640	0.93 0.95	0.19 0.03	3.24 0.32	0.0002 0.0001	0.0042 0.0003	0.005 0.001	13.7 3.8	8.6 1.7	3.5 0.4
Heron Middle	07/22	D1	–22 650	0.63 0.71	0.17 0.03	3.81 0.38	0.0007 0.0001	0.0051 0.0003	0.004 0.001	13.4 4.0	10.3 2.0	3.6 0.4
Heron Lower	07/22	1	–122 650	0.60 1.11	0.22 0.03	3.65 0.37	0.0003 0.0003	0.0072 0.0022	0.008 0.002	15.6 4.5	11.7 2.1	3.5 0.3
El Vado Upper	07/22	1	188 670	1.43 1.67	0.07 0.02	3.15 0.32	0.0002 0.0000	0.0040 0.0002	0.001 0.002	8.5 4.0	6.0 1.7	2.4 0.2
El Vado Middle	07/22	1	–282 640	1.04 0.96	0.20 0.03	3.90 0.39	0.0003 0.0001	0.0063 0.0003	0.005 0.004	7.9 2.1	7.8 1.2	2.7 0.3
El Vado Lower	07/22	1	–2 660	8.43 3.66	0.30 0.04	4.11 0.41	0.0008 0.0001	0.0074 0.0004	0.004 0.001	11.8 3.0	8.3 1.2	3.4 0.3
Abiquiu Middle	07/21	1	–152 640	–0.08 1.46	0.21 0.03	2.44 0.24	0.0004 0.0001	0.0068 0.0007	0.005 0.001	9.0 3.0	7.0 2.0	2.4 0.2
Abiquiu Lower	07/21	1	38 660	0.72 0.94	0.19 0.03	3.20 0.32	0.0004 0.0001	0.0054 0.0004	0.002 0.001	8.0 2.0	6.0 1.0	0.2 0.2
Reservoirs on Rio Grande (Colorado)												
Rio Grande Upper	07/24	1	–492 620	0.72 1.01	0.53 0.05	3.62 0.36	0.0007 0.0002	0.0204 0.0032	0.011 0.002	9.9 2.6	7.0 1.1	3.3 0.3
Rio Grande Middle	07/24	1	198 670	0.70 0.71	0.51 0.06	3.51 0.35	0.0008 0.0001	0.0196 0.0010	0.009 0.002	6.9 1.7	5.3 1.0	3.2 0.3
Rio Grande Lower	07/24	1	–242 640	0.62 0.92	0.39 0.04	3.24 0.32	0.0008 0.0001	0.0177 0.0009	0.006 0.002	7.3 1.8	5.8 1.0	3.0 0.3
Reservoirs on Rio Grande (New Mexico)												
Cochiti Upper	10/29	1	148 680	0.90 0.65	0.23 0.03	3.56 0.36	0.0005 0.0001	0.0082 0.0002	0.004 0.001	4.0 3.3	4.9 2.1	2.6 0.3
Cochiti Upper	10/29	D1	–42 670	1.49 0.80	0.22 0.03	3.95 0.40	0.0003 0.0001	0.0075 0.0002	0.011 0.002	5.5 3.6	5.7 2.1	3.3 0.3
Cochiti Middle	10/29	1	–172 660	2.69 1.95	0.40 0.04	5.05 0.51	0.0007 0.0001	0.0134 0.0004	0.006 0.002	15.0 5.7	14.0 3.3	3.5 0.4
Cochiti Lower	10/29	1	108 680	1.84 2.29	0.55 0.05	4.43 0.44	0.0009 0.0001	0.0179 0.0005	0.014 0.005	12.0 5.8	12.0 3.6	3.7 0.4
Pajarito Plateau Stations												
Guaje Canyon:												
Guaje at SR 502	03/17	1		0.76 0.57	0.10 0.02	2.11 0.21	0.003 0.001	0.006 0.002	0.009 0.007	2.2 1.9	1.2 0.4	2.8 0.3
Guaje at SR 502	03/17	R1		0.73 0.33	0.07 0.01	2.33 0.23	0.003 0.001	0.004 0.001		3.2 1.5	1.0 0.7	3.0 0.3
Guaje at SR 502	03/17	D1		0.99 0.82	0.03 0.01	1.98 0.20	–0.001 0.000	0.002 0.001	0.004 0.001	1.9 1.5	1.3 0.8	2.8 0.3
Bayo Canyon:												
Bayo at SR 502	03/17	1		0.86 0.77	0.09 0.02	2.49 0.25	0.000 0.001	0.002 0.001	0.003 0.001	2.9 1.8	1.5 0.9	2.7 0.3
Bayo at SR 502	03/17	D1	2,063 435	0.99 0.68	0.12 0.02	2.05 0.21	0.001 0.001	0.016 0.002	0.008 0.002	2.7 1.8	2.0 0.9	2.7 0.3

Table 5-10. Radiochemical Analysis for Sediments in 1997 (pCi/g)[a] (Cont.)

Station Name[b]	Date	Code[c]	^{3}H	^{90}Sr	^{137}Cs	U (mg/kg)	^{238}Pu	$^{239,240}Pu$	^{241}Am	Gross Alpha	Gross Beta	Gross Gamma
Pajarito Plateau Stations (Cont.)												
Acid/Pueblo Canyons:												
Acid Weir	05/06	1	298 690	0.75 0.72	0.24 0.03	1.48 0.15	0.040 0.003	6.418 0.134	0.294 0.012	15.5 2.4	11.9 2.1	2.4 0.2
Pueblo 1	05/06	1	86 736	0.67 1.13	0.08 0.01	1.44 0.14	0.002 0.001	0.003 0.001	0.005 0.001	4.0 1.6	2.0 0.5	2.5 0.3
Pueblo 2	05/07	1		0.59 1.16	0.07 0.01	1.10 0.11	0.005 0.001	0.617 0.015	0.023 0.002	1.3 1.1	0.7 0.6	2.0 0.2
Hamilton Bend Spring	05/07	1		0.19 0.61	<0.03	2.42 0.24	0.001 0.001	0.428 0.011	0.021 0.003	2.8 1.5	1.5 0.8	2.5 0.2
Pueblo 3	05/07	1	551 504	1.03 0.80	0.12 0.02		0.006 0.001	1.103 0.030	0.061 0.005	5.5 2.8	4.0 1.2	3.7 0.4
Pueblo at SR 502	05/04	1	–72 670	0.90 0.78	<0.02	1.11 0.11	0.003 0.001	0.520 0.014	0.030 0.009	1.6 0.7	1.2 0.8	3.0 0.3
DP/Los Alamos Canyons:												
Los Alamos at Bridge	05/07	1	508 710	1.37 0.85	<0.02	2.13 0.21	–0.001 0.001	0.002 0.001	0.007 0.002	2.2 0.9	1.6 0.8	2.2 0.2
Los Alamos at LAO-1	05/07	1	–256 128	0.41 1.15	0.03 0.01	3.31 0.33	0.005 0.001	0.621 0.016	0.012 0.002	4.4 1.9	2.7 1.0	3.2 0.3
Los Alamos at LAO-1	05/07	D1	14 459	0.82 0.77	0.15 0.02	3.40 0.34	0.005 0.001	1.225 0.023	0.030 0.004	6.6 2.1	2.9 1.1	3.7 0.4
Los Alamos at GS-1	05/07	1	–250 98	0.51 0.83	0.14 0.02	2.12 0.21	0.004 0.002	0.449 0.019	0.010 0.004	4.5 1.8	2.2 1.0	2.7 0.3
DPS-1	05/12	1	–22 670	1.87 1.18	0.04 0.01	1.13 0.11	0.000 0.000	0.005 0.001	0.004 0.001	1.7 0.7	3.3 1.1	2.7 0.3
DPS-1	05/12	D1	238 690	1.46 0.88	0.07 0.01	1.09 0.11	0.002 0.001	0.006 0.002	0.009 0.002	1.2 0.6	2.7 1.0	2.1 0.2
DPS-4	05/07	1	1,051 319	0.41 0.62	2.15 0.16	1.29 0.13	0.017 0.002	0.109 0.005	0.194 0.009	2.0 1.2	3.9 1.2	4.0 0.4
Los Alamos at LAO-3	05/07	1	–314 249	0.08 0.53	2.17 0.16	1.84 0.18	0.033 0.003	0.215 0.008	0.260 0.011	3.2 1.5	3.3 1.1	4.6 0.5
Los Alamos at LAO-4.5	05/07	1	–253 235	0.53 0.99	2.64 0.19	2.93 0.29	0.208 0.007	0.479 0.013	0.000 0.000	4.6 1.7	4.7 1.3	5.5 0.6
Los Alamos at SR 4	03/17	1		1.04 1.62	0.64 0.08	1.47 0.15	0.009 0.002	0.092 0.005	0.090 0.005	3.6 1.5	2.5 1.0	2.7 0.3
Los Alamos at Totavi	05/12	1	–982 610	2.06 1.99	0.10 0.02	1.19 0.12	0.000 0.001	0.091 0.005	0.013 0.002	1.3 0.7	1.2 0.8	3.0 0.3
Los Alamos at Otowi	05/12	1	–902 610	0.86 1.54	0.08 0.01	1.20 0.12			0.009 0.002	0.7 0.7	0.9 0.7	2.2 0.2
Sandia Canyon:												
Sandia at SR 4	03/17	1	–58 171	1.57 1.08	0.11 0.02	3.32 0.33	0.002 0.001	0.007 0.001	0.003 0.001	4.2 1.8	3.1 1.1	3.5 0.4
Sandia at SR 4	03/17	R1	478 92									
Mortandad Canyon:												
Mortandad near CMR Building	05/08	1	178 690	1.39 2.30	0.04 0.01	1.00 0.10	0.014 0.002	0.009 0.002	0.007 0.002	2.2 0.8	1.7 0.9	2.5 0.2
Mortandad west of GS-1	05/08	1	158 690	1.35 1.28	0.11 0.02	2.73 0.27	0.003 0.001	0.009 0.001	0.007 0.002	4.2 1.3	4.0 1.2	2.7 0.3
Mortandad at GS-1	05/07	1	18,728 1,500	0.94 0.78	15.70 1.00	0.85 0.08	6.124 0.121	5.696 0.113	11.522 0.329	8.7 1.6	2.7 0.9	14.8 1.5
Mortandad at MCO-5	05/07	1		0.41 0.88	12.40 0.80	1.00 0.10	2.200 0.100	6.090 0.240	5.980 0.230	25.5 4.2	17.3 2.9	13.3 1.3
Mortandad at MCO-5	05/07	D1		1.07 0.82	14.20 0.90	1.78 0.18	2.480 0.100	6.530 0.240	0.000 0.000	27.9 4.5	16.4 2.8	15.6 1.6
Mortandad at MCO-7	05/07	1	6,178 379	0.43 1.61	4.46 0.30	0.82 0.08	0.666 0.016	2.062 0.041	0.000 0.000	7.7 1.9	5.0 1.3	6.7 0.7
Mortandad at MCO-9	05/07	1	–252 156	0.82 0.80	0.24 0.03	3.37 0.34	0.003 0.001	0.013 0.003	0.012 0.004	4.4 1.6	3.6 1.1	5.3 0.5
Mortandad at MCO-13 (A-5)	08/14	1	508 710	0.51 0.60	0.23 0.03	1.93 0.19	0.003 0.001	0.011 0.002	0.004 0.002	3.1 0.7	3.0 0.9	2.5 0.2
Mortandad A-6	08/14	1	188 690	0.89 0.68	2.58 0.19	4.99 0.50	0.005 0.001	0.094 0.005	0.030 0.090	11.8 2.1	13.5 1.5	5.7 0.6
Mortandad A-7	08/14	1	18 670	0.12 0.58	0.23 0.03	3.49 0.35	0.002 0.001	0.008 0.001	0.005 0.002	2.9 0.6	3.1 0.9	3.1 0.3
Mortandad at SR 4 (A-9)	08/14	1	358 700	0.37 0.44	0.13 0.02	2.78 0.28	0.001 0.001	0.001 0.001	0.002 0.003	2.2 0.6	2.0 0.8	2.7 0.3
Mortandad at Rio Grande (A-11)	09/11	1	338 750	0.64 0.69	0.03 0.01	2.01 0.20	0.002 0.001	0.003 0.001	0.002 0.001	1.9 0.9	2.2 0.8	2.1 0.2

Table 5-10. Radiochemical Analysis for Sediments in 1997 (pCi/g)[a] (Cont.)

Station Name[b]	Date	Code[c]	^{3}H	^{90}Sr	^{137}Cs	U (mg/kg)	^{238}Pu	$^{239,240}Pu$	^{241}Am	Gross Alpha	Gross Beta	Gross Gamma
Pajarito Plateau Stations (Cont.)												
Cañada del Buey:												
Cañada del Buey at SR 4	03/17	1		0.62 0.57	0.04 0.01	1.62 0.16	0.006 0.002	0.005 0.002	0.003 0.001	3.0 1.6	1.6 0.9	2.5 0.3
TA-54 Area G:												
G-1	04/11	1	–2 680	0.72 0.60	0.06 0.01	1.51 0.15	0.001 0.001	0.004 0.009	0.009 0.003	1.7 0.2	0.8 0.1	2.5 0.2
G-1	04/11	D1	308 700	1.04 1.07	0.01 0.01	1.70 0.17	–0.001 0.000	0.002 0.001	0.004 0.001	3.3 0.3	1.5 0.1	2.7 0.3
G-2	04/11	1	808 730	0.92 0.58	0.09 0.02	1.59 0.16	0.001 0.001	0.004 0.001	0.007 0.002	4.2 0.4	1.7 0.1	2.4 0.2
G-3	04/11	1	118 690	0.89 0.74	0.05 0.01	2.59 0.26	0.000 0.000	0.002 0.001	0.003 0.001	6.8 0.5	2.8 0.2	1.8 0.2
G-4	04/11	1	918 740	1.11 0.54	0.25 0.03	2.95 0.30	0.003 0.001	0.014 0.002	0.008 0.004	7.2 0.5	3.3 0.2	3.7 0.4
G-5	04/11	1	1,518 770	1.47 0.61	0.18 0.02	2.95 0.30	0.011 0.002	0.665 0.005	0.033 0.008	7.0 0.5	3.5 0.2	3.4 0.3
G-6	04/11	1	878 740	1.57 0.85	0.18 0.02	1.36 0.14	0.017 0.002	0.162 0.007	0.038 0.008	5.6 0.5	2.9 0.2	3.6 0.4
G-7	04/11	1	1,548 780	0.81 0.73	0.13 0.02	2.42 0.24	0.116 0.007	0.156 0.009	0.032 0.003	2.8 0.3	1.3 0.1	3.1 0.3
G-8	04/11	1	1,508 770	0.98 0.62	0.47 0.04	1.01 0.10	0.056 0.035	0.049 0.003	0.017 0.002	8.5 0.5	4.7 0.2	3.2 0.3
G-9	04/11	1	178 690	0.61 0.67	0.04 0.01	1.52 0.15	0.013 0.002	0.016 0.002	0.007 0.002	2.0 0.2	0.9 0.1	2.8 0.3
Pajarito Canyon:												
Two Mile at SR 501	05/08	1	–92 670	1.29 1.28	<0.02	1.77 0.18	0.003 0.001	0.002 0.001	0.001 0.001	2.3 0.9	2.1 0.5	3.1 0.3
Pajarito at SR 501	05/08	1	–39 223	–0.09 0.82	0.03 0.01	1.52 0.15	0.002 0.001	0.004 0.001	0.002 0.001	3.3 1.9	1.9 0.9	2.4 0.2
Pajarito at SR 4	12/16	1	738 800	3.66 1.99	0.37 0.04	4.43 0.44	0.004 0.001	0.030 0.002	0.014 0.002	13.0 3.0	11.0 1.0	4.4 0.4
Potrillo Canyon:												
Potrillo at SR 4	03/17	1		0.88 0.63	0.13 0.03	1.71 0.17	0.000 0.001	0.002 0.001	0.003 0.001	2.5 1.4	1.5 0.9	2.7 0.3
Fence Canyon:												
Fence at SR 4	03/17	1	91 61	0.66 0.63	0.33 0.04	2.49 0.25	0.014 0.002	0.017 0.002	0.008 0.004	6.6 2.1	4.1 1.2	3.8 0.4
Cañon de Valle:												
Cañon de Valle at SR 501	03/17	1	199 101	0.39 1.44	0.12 0.02	1.19 0.12	0.002 0.001	0.002 0.001	0.003 0.001	2.9 1.5	1.3 0.8	0.5 0.2
Water Canyon:												
Water at SR 501	03/17	1	197 100	0.94 0.73	0.19 0.03	1.98 0.20	0.000 0.001	0.004 0.001	0.007 0.001	6.5 2.0	3.1 1.1	2.9 0.3
Water at SR 501	03/17	R1	–82 122									
Water at SR 4	03/17	1	850 110	0.84 0.66	0.27 0.04	2.31 0.23	0.001 0.001	0.006 0.001	0.003 0.001	4.9 1.7	3.5 1.1	3.3 0.4
Indio Canyon:												
Indio at SR 4	03/17	1	177 68	0.71 0.77	0.20 0.03	1.52 0.15	0.000 0.001	0.005 0.001	0.006 0.001	2.5 1.3	1.7 0.9	2.6 0.3
Ancho Canyon:												
Ancho at SR 4	03/17	1		1.12 0.69	0.22 0.04	4.08 0.41	0.001 0.001	0.008 0.001	0.012 0.002	4.0 1.7	3.4 1.1	3.2 0.4
Ancho at Rio Grande	09/29	1	78 740	0.67 1.02	0.10 0.02	1.75 0.18	0.001 0.001	0.004 0.001	0.002 0.001	1.6 0.9	2.2 0.8	2.5 0.2
Ancho at Rio Grande	09/29	D1	178 740	1.15 0.92	0.13 0.02	2.27 0.23	0.001 0.000	0.005 0.001	0.008 0.002	2.1 1.1	2.6 0.8	2.3 0.2

Table 5-10. Radiochemical Analysis for Sediments in 1997 (pCi/g)[a] (Cont.)

Station Name[b]	Date	Code[c]	^{3}H	^{90}Sr	^{137}Cs	U (mg/kg)	^{238}Pu	$^{239,240}Pu$	^{241}Am	Gross Alpha	Gross Beta	Gross Gamma
Pajarito Plateau Stations (Cont.)												
Chaquehui Canyon:												
Chaquehui at Rio Grande	09/30	1	4,288 970	0.80 1.12	0.16 0.02	2.19 0.22	0.002 0.001	0.004 0.001	0.002 0.001	1.9 0.9	2.4 0.8	2.3 0.2
TA-49, Area AB:												
AB-1	04/23	1	194 196	0.59 1.00	0.38 0.04	2.22 0.22	0.002 0.001	0.111 0.001	0.011 0.002	9.0 1.7	5.5 0.9	3.8 0.4
AB-1	04/24	D1	–112 64	0.94 1.16	0.25 0.03	3.14 0.31	0.002 0.001	0.010 0.001	0.009 0.002	10.1 1.9	4.9 0.8	3.6 0.4
AB-2	04/23	1	–20 133	0.36 1.09	0.31 0.04	2.23 0.22	0.001 0.001	0.052 0.003	0.018 0.002	9.6 1.8	6.0 0.9	3.3 0.3
AB-3	04/23	1	58 170	0.56 1.04	0.18 0.03	2.90 0.29	0.014 0.002	0.621 0.014	0.160 0.009	6.4 1.2	3.3 0.6	3.3 0.3
AB-4	04/23	1	–2 148	0.49 0.97	0.21 0.03	3.19 0.32	0.001 0.001	0.009 0.001	0.005 0.002	9.8 1.8	5.4 0.9	3.7 0.4
AB-4A	04/23	1	–13 117	0.95 0.92	0.32 0.04	2.93 0.29	0.003 0.001	0.017 0.002	0.008 0.002	8.7 1.6	6.2 1.0	3.6 0.4
AB-5	04/23	1	–13 117	0.67 0.69	1.26 0.10	2.61 0.26	0.001 0.001	0.052 0.004	0.020 0.002	10.5 1.9	7.2 1.1	3.7 0.4
AB-6	04/23	1	13 139	0.73 0.74	0.22 0.03	2.60 0.26	0.002 0.001	0.012 0.002	0.008 0.002	9.0 1.6	4.8 0.8	3.1 0.3
AB-7	04/23	1	3,937 349	0.69 0.82	0.09 0.02	1.27 0.13	0.002 0.001	0.004 0.001	0.002 0.002	4.4 0.9	2.6 0.5	3.5 0.4
AB-8	04/23	1	–206 53	1.20 1.20	0.08 0.02	2.03 0.20	0.000 0.000	0.002 0.001	0.003 0.002	7.5 1.4	3.4 0.6	3.2 0.3
AB-9	04/23	1	169 138	0.60 0.77	0.11 0.02	1.41 0.14	0.000 0.000	0.004 0.001	0.006 0.002	3.8 0.7	2.1 0.4	2.6 0.3
AB-10	04/24	1	–83 93	1.33 0.92	0.63 0.06	2.22 0.22	0.001 0.001	0.052 0.004	0.014 0.005	8.5 1.6	6.4 1.0	3.4 0.3
AB-11	04/24	1	–351 –1,000	–0.82 1.35	0.05 0.01	0.97 0.10	0.007 0.002	0.543 0.018	0.003 0.001	2.7 0.6	2.0 0.4	2.6 0.3
Frijoles Canyon:												
Frijoles at Monument HQ	05/08	1	–485 282	0.61 0.58	0.11 0.02	4.80 0.48	0.002 0.001	0.002 0.001	0.004 0.001	3.0 1.6	2.2 0.9	3.8 0.4
Frijoles at Rio Grande	09/30	1	278 750	1.88 1.73	0.05 0.01	1.98 0.20	0.000 0.000	0.004 0.001	0.004 0.001	1.5 0.7	1.5 0.7	2.7 0.3
Standardized Comparisons												
Average Detection Limits			700	1.00	0.05	0.25	0.005[g]	0.005[g]	0.005	1.5	1.5	0.8
Background			3,200[i]	0.87[h]	0.44[h]	4.40[h]	0.006[h]	0.023[h]	0.090[i]	14.8[i]	12.0[i]	8.2[i]
SAL[j]			2,0000	5.9	4.0	95.0	20.0	18.0	17.0			

[a] Except where noted.
[b] Sample sizes: stream channels–100 g; reservoirs–1000 g.
[c] Codes: 1–primary analysis, D–field duplicate, R–lab replicate.
[d] See Appendix B for an explanation of negative numbers.
[e] Two columns are listed: the first is the value; the second is the counting uncertainty (1 std dev).
[f] Value is below detection limit.
[g] Limits of Detection for ^{238}Pu and $^{239,240}Pu$ reservoir analyses are 0.0001 pCi/g.
[h] Purtymun et al. (1987a); upper limit for background for sediment samples from 1974–1986.
[i] Preliminary upper limit for background values for channel sediments from 1974–1996 (McLin and Lyons, 1998).
[j] Screening Action Level, Environmental Restoration Project, 1997; see text for details.

Table 5-11. Detections of Above-Background Radionuclides in Sediments for 1997[a]

Station Name	Date	Codes[b]	Analyte	Value	Uncertainty[c]	Detection Limit	Background	Units
Pajarito Plateau Stations								
AB-1	04/23	1	^{239,240}Pu	0.111	0.001	0.005	0.023	pCi/g
AB-2	04/23	1	^{239,240}Pu	0.052	0.003	0.005	0.023	pCi/g
AB-3	04/23	1	^{241}Am	0.160	0.009	0.005	0.090	pCi/g
AB-3	04/23	1	^{238}Pu	0.014	0.002	0.005	0.006	pCi/g
AB-3	04/23	1	^{239,240}Pu	0.621	0.014	0.005	0.023	pCi/g
AB-5	04/23	1	^{137}Cs	1.26	0.10	0.05	0.44	pCi/g
AB-5	04/23	1	^{239,240}Pu	0.052	0.004	0.005	0.023	pCi/g
AB-7	04/23	1	^{3}H	3,937	349	700	3,200	pCi/L
AB-10	04/24	1	^{137}Cs	0.63	0.06	0.05	0.44	pCi/g
AB-10	04/24	1	^{239,240}Pu	0.052	0.004	0.005	0.023	pCi/g
AB-11	04/24	1	^{239,240}Pu	0.543	0.018	0.005	0.023	pCi/g
Acid Weir	05/06	1	Gross Alpha	15.5	2.4	1.5	14.8	pCi/g
Acid Weir	05/06	1	^{241}Am	0.294	0.012	0.005	0.090	pCi/g
Acid Weir	05/06	1	^{238}Pu	0.040	0.003	0.005	0.006	pCi/g
Acid Weir	05/06	1	^{239,240}Pu	6.418	0.134	0.005	0.023	pCi/g
Chaquehui at Rio Grande	09/30	1	^{3}H	4,288	970	700	3,200	pCi/L
DPS-4	05/07	1	^{241}Am	0.194	0.009	0.005	0.090	pCi/g
DPS-4	05/07	1	^{137}Cs	2.15	0.16	0.05	0.44	pCi/g
DPS-4	05/07	1	^{238}Pu	0.017	0.002	0.005	0.006	pCi/g
DPS-4	05/07	1	^{239,240}Pu	0.109	0.005	0.005	0.023	pCi/g
Fence at SR 4	03/17	1	^{238}Pu	0.014	0.002	0.005	0.006	pCi/g
Frijoles at Monument HQ	05/08	1	Total U	4.80	0.48	0.25	4.40	mg/kg
G-5	04/11	1	^{238}Pu	0.011	0.002	0.005	0.006	pCi/g
G-5	04/11	1	^{239,240}Pu	0.665	0.005	0.005	0.023	pCi/g
G-6	04/11	1	^{238}Pu	0.017	0.002	0.005	0.006	pCi/g
G-6	04/11	1	^{239,240}Pu	0.162	0.007	0.005	0.023	pCi/g
G-7	04/11	1	^{238}Pu	0.116	0.007	0.005	0.006	pCi/g
G-7	04/11	1	^{239,240}Pu	0.156	0.009	0.005	0.023	pCi/g
G-8	04/11	1	^{137}Cs	0.47	0.04	0.05	0.44	pCi/g
G-8	04/11	1	^{238}Pu	0.056	0.035	0.005	0.006	pCi/g
G-8	04/11	1	^{239,240}Pu	0.049	0.003	0.005	0.023	pCi/g
G-9	04/11	1	^{238}Pu	0.013	0.002	0.005	0.006	pCi/g

Table 5-11. Detections of Above-Background Radionuclides in Sediments for 1997[a] (Cont.)

Station Name	Date	Codes[b]	Analyte	Value	Uncertainty[c]	Detection Limit	Background	Units
Pajarito Plateau Stations (Cont.)								
Hamilton Bend Spring	05/07	1	^{239,240}Pu	0.428	0.011	0.005	0.023	pCi/g
Los Alamos at GS-1	05/07	1	^{239,240}Pu	0.449	0.019	0.005	0.023	pCi/g
Los Alamos at LAO-1	05/07	1	^{239,240}Pu	0.621	0.016	0.005	0.023	pCi/g
Los Alamos at LAO-1	05/07	1	^{239,240}Pu	1.225	0.023	0.005	0.023	pCi/g
Los Alamos at LAO-3	05/07	1	^{241}Am	0.260	0.011	0.005	0.090	pCi/g
Los Alamos at LAO-3	05/07	1	^{137}Cs	2.17	0.16	0.05	0.44	pCi/g
Los Alamos at LAO-3	05/07	1	^{238}Pu	0.333	0.003	0.005	0.006	pCi/g
Los Alamos at LAO-3	05/07	1	^{239,240}Pu	0.215	0.008	0.005	0.023	pCi/g
Los Alamos at LAO-4.5	05/07	1	^{137}Cs	2.64	0.19	0.05	0.44	pCi/g
Los Alamos at LAO-4.5	05/07	1	^{238}Pu	0.208	0.007	0.005	0.006	pCi/g
Los Alamos at LAO-4.5	05/07	1	^{239,240}Pu	0.479	0.013	0.005	0.023	pCi/g
Los Alamos at SR 4	03/17	1	^{137}Cs	0.64	0.08	0.05	0.44	pCi/g
Los Alamos at SR 4	03/17	1	^{238}Pu	0.009	0.002	0.005	0.006	pCi/g
Los Alamos at SR 4	03/17	1	^{239,240}Pu	0.092	0.005	0.005	0.023	pCi/g
Los Alamos at SR 4	03/17	1	^{241}Am	0.090	0.005	0.005	0.090	pCi/g
Los Alamos at Totavi	05/12	1	^{239,240}Pu	0.091	0.005	0.005	0.023	pCi/g
Los Alamos at Upper GS	12/18	1	^{239,240}Pu	0.468	0.013	0.005	0.023	pCi/g
Mortandad A-6	08/14	1	Gross Beta	13.5	1.5	1.5	12.0	pCi/g
Mortandad A-6	08/14	1	^{137}Cs	2.58	0.19	0.05	0.44	pCi/g
Mortandad A-6	08/14	1	^{239,240}Pu	0.094	0.005	0.005	0.023	pCi/g
Mortandad A-6	08/14	1	Total U	4.99	0.50	0.25	4.40	mg/kg
Mortandad at GS-1	05/07	1	^{241}Am	11.522	0.329	0.005	0.090	pCi/g
Mortandad at GS-1	05/07	1	^{137}Cs	15.70	1.00	0.05	0.44	pCi/g
Mortandad at GS-1	05/07	1	Gross Gamma	14.8	1.5	0.8	8.2	pCi/g
Mortandad at GS-1	05/07	1	^{3}H	18,728	1,500	700	3,200	pCi/L
Mortandad at GS-1	05/07	1	^{238}Pu	6.124	0.121	0.005	0.006	pCi/g
Mortandad at GS-1	05/07	1	^{239,240}Pu	5.696	0.113	0.005	0.023	pCi/g
Mortandad at MCO-5	05/07	D	Gross Alpha	27.9	4.5	1.5	14.8	pCi/g
Mortandad at MCO-5	05/07	1	Gross Alpha	25.5	4.2	1.5	14.8	pCi/g
Mortandad at MCO-5	05/07	1	^{241}Am	5.980	0.230	0.005	0.090	pCi/g
Mortandad at MCO-5	05/07	D	Gross Beta	16.4	2.8	1.5	12.0	pCi/g
Mortandad at MCO-5	05/07	1	Gross Beta	17.3	2.9	1.5	12.0	pCi/g
Mortandad at MCO-5	05/07	D	^{137}Cs	14.20	0.90	0.05	0.44	pCi/g

Table 5-11. Detections of Above-Background Radionuclides in Sediments for 1997[a] (Cont.)

Station Name	Date	Codes[b]	Analyte	Value	Uncertainty[c]	Detection Limit	Background	Units
Pajarito Plateau Stations (Cont.)								
Mortandad at MCO-5	05/07	1	^{137}Cs	12.40	0.80	0.05	0.44	pCi/g
Mortandad at MCO-5	05/07	D	Gross Gamma	15.6	1.6	0.8	8.2	pCi/g
Mortandad at MCO-5	05/07	1	Gross Gamma	13.3	1.3	0.8	8.2	pCi/g
Mortandad at MCO-5	05/07	1	^{238}Pu	2.200	0.100	0.005	0.006	pCi/g
Mortandad at MCO-5	05/07	D	^{238}Pu	2.480	0.100	0.005	0.006	pCi/g
Mortandad at MCO-5	05/07	1	^{239,240}Pu	6.090	0.240	0.005	0.023	pCi/g
Mortandad at MCO-5	05/07	D	^{239,240}Pu	6.530	0.240	0.005	0.023	pCi/g
Mortandad at MCO-7	05/07	1	^{137}Cs	4.46	0.30	0.05	0.44	pCi/g
Mortandad at MCO-7	05/07	1	^{3}H	6,178	379	700	3,200	pCi/L
Mortandad at MCO-7	05/07	1	^{238}Pu	0.666	0.016	0.005	0.006	pCi/g
Mortandad at MCO-7	05/07	1	^{239,240}Pu	2.062	0.041	0.005	0.023	pCi/g
Mortandad near CMR Bldg	05/08	1	^{238}Pu	0.014	0.002	0.005	0.006	pCi/g
Pajarito at SR 4	12/16	1	^{239,240}Pu	0.030	0.002	0.005	0.023	pCi/g
Pajarito at SR 4	12/16	1	Total U	4.43	0.44	0.25	4.40	mg/kg
Pueblo 2	05/07	1	^{239,240}Pu	0.617	0.015	0.005	0.023	pCi/g
Pueblo 3	05/07	1	^{238}Pu	0.006	0.001	0.005	0.006	pCi/g
Pueblo 3	05/07	1	^{239,240}Pu	1.103	0.030	0.005	0.023	pCi/g
Pueblo at SR 502	05/04	1	^{239,240}Pu	0.520	0.014	0.005	0.023	pCi/g
Reservoirs								
Cochiti Middle	10/29	1	Total U	5.05	0.51	0.25	4.40	mg/kg
Cochiti Lower	10/29	1	Total U	4.43	0.44	0.25	4.40	mg/kg
Cochiti Lower	10/29	1	^{137}Cs	0.55	0.05	0.05	0.44	pCi/g
Rio Grande Middle	07/24	1	^{137}Cs	0.51	0.05	0.05	0.44	pCi/g
Rio Grande Upper	07/24	1	^{137}Cs	0.53	0.05	0.05	0.44	pCi/g

[a] Detection defined as value ≥ 4.66*uncertainty and ≥ detection limit and ≥ background.
[b] Codes: 1–primary analysis, D–field duplicate, R–lab replicate.
[c] Radioactivity counting uncertainty (1 std dev).

Table 5-12. Possible Detections of Above-Background Radionuclides in Sediments for 1997[a]

Station Name	Date	Codes[b]	Analyte	Value	Uncertainty[c]	Detection Limit	Background	Units
Pajarito Plateau Stations								
AB-11	04/24	1	^{238}Pu	0.007	0.002	0.005	0.006	pCi/g
Cañada del Buey at SR 4	03/17	1	^{238}Pu	0.006	0.002	0.005	0.006	pCi/g
G-5	04/11	1	^{90}Sr	1.47	0.61	1.00	0.87	pCi/g
Pueblo 3	05/07	1	^{238}Pu	0.006	0.001	0.005	0.006	pCi/g
Reservoirs								
Heron Lower	07/22	1	Gross Alpha	15.6	4.5	1.5	14.8	pCi/g
Cochiti Lower	10/29	1	Gross Beta	12.0	3.6	1.5	12.0	pCi/g
Cochiti Middle	10/29	1	Gross Alpha	15.0	5.7	1.5	14.8	pCi/g
Cochiti Middle	10/29	1	Gross Beta	14.0	3.3	1.5	12.0	pCi/g

[a] Possible detection defined as 2.33* ≤ value ≤ 4.66* and value ≥ detection limit and value ≥ background.
[b] Codes: 1–primary analysis, D–field duplicate R–lab replicate.
[c] Radioactivity counting uncertainty (1 std dev).

Table 5-13. Plutonium Analysis of Reservoir Sediments from the Rio Chama and Rio Grande (fCi/g)

Year	Location[a]	^{238}Pu	Uncertainty[b]	^{239,240}Pu	Uncertainty[b]	Ratio (^{239,240}Pu/^{238}Pu)
Abiquiu Reservoir (Rio Chama)						
1984	Mean	0.7	0.2	12.7	1.1	18.1
1985	Mean	0.7	0.2	8.8	0.8	12.6
1986	Mean	0.3	0.1	7.5	0.3	25.0
1987	Mean	0.2	0.0	3.7	0.2	18.5
1988	Mean	0.3	0.1	7.4	0.3	24.7
1989	Mean	0.4	0.1	3.7	0.2	9.3
1990	Mean	0.1	0.1	2.6	0.2	26.0
1991	Mean	0.3	0.2	7.2	0.4	24.0
1992	Mean	0.1	0.0	0.8	0.0	8.0
1993	Mean	0.2	0.1	5.1	0.4	25.5
1994	Mean	0.2	0.1	0.5	0.2	2.5
1995[c]	Mean	13.7	1.7	8.0	1.3	0.6
1996	Mean	0.2	0.0	4.6	0.4	23.0
1997	Upper	No sample collected in 1997				
1997	Middle	0.4	0.1	6.8	0.7	17.0
1997	Lower	0.4	0.1	5.4	0.4	13.5
1997	Mean	0.4	0.1	6.1	0.6	15.3
1984–97	Mean	0.3	0.1	5.4	0.4	17.9
1984–97	Std Dev	0.2	0.1	3.4	0.3	7.8
1984–97	Count	13	13	13	13	13
Cochiti Reservoir (Rio Grande)						
1984	Mean	0.7	0.1	19.7	1.1	28.1
1985	Mean	1.6	0.3	24.1	0.8	15.1
1986	Mean	1.3	0.1	21.6	0.3	16.6
1987	Mean	0.8	0.1	17.5	0.2	21.9
1988	Mean	1.7	0.2	12.1	0.3	7.1
1989	Mean	2.5	0.2	49.3	0.2	19.7
1990	Mean	3.2	0.1	17.6	0.2	5.5
1991	Mean	0.2	0.1	4.1	0.4	20.5
1992	Mean	1.9	0.2	13.4	0.0	7.1
1993	Mean	4.1	0.4	30.5	0.4	7.4
1994	Mean	0.4	0.1	9.3	0.4	23.3
1995[c]	Mean	7.6	1.4	12.5	1.8	1.6
1996	Mean	0.9	0.1	18.1	0.8	20.1
1997	Upper	0.4	0.1	7.9	0.2	19.8
1997	Middle	0.7	0.1	13.4	0.4	19.1
1997	Lower	0.9	0.1	17.9	0.5	19.9
1997	Mean	0.7	0.1	13.1	0.4	19.6
1984–97	Mean	1.5	0.2	19.3	0.4	16.3
1984–97	Std Dev	1.2	0.1	11.2	0.3	7.6
1984–97	Count	13	13	13	13	13

[a] Reservoir sample locations: Upper, Middle, or Lower end; or mean of all three sample locations.
[b] Analytical counting uncertainity (1 std dev).
[c] Uncertainties for 1995 were not within quality control specifications; data not used for long-term statistics.

Table 5-14. Total Recoverable Trace Metals in Sediments for 1997 (mg/kg)[a,b]

Station Name	Date	Code[c]	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg
Regional Stations														
Rio Chama at Chamita	05/12	1	<2[d]	3,691	4.9	<3	61.0	0.3	<0.9	2.7	6.7	4.1	6,301	<0.05
Rio Grande at Embudo	05/12	1	<2	4,267	3.2	<3	64.0	0.3	<0.9	2.9	6.5	4.7	6,632	<0.05
Rio Grande at Otowi (bank)	12/16	1	<10	2,422	1.2	<15	31.5	1.0	<4.5	<5.0	<9.0	<5.0	6,221	<0.05
Rio Grande at Bernalillo	05/01	1	<2	2,329	<0.6	<3	26.5	<0.2	<0.9	<1.0	1.9	<1.0	2,795	<0.05
Jemez River	05/09	1	<2	1,648	4.1	<3	22.6	0.2	<0.9	1.4	2.7	1.3	2,659	<0.05
Reservoirs on Rio Chama (New Mexico)														
El Vado Upper	07/22	1	<2	9,084	7.3	<3	107.4	0.5	<0.9	5.9	11.1	11.0	15,756	<0.05
El Vado Middle	07/22	1	<2	22,916	11.6	<3	183.6	1.3	<0.9	11.2	26.8	22.7	25,750	<0.05
El Vado Lower	07/22	1	<2	25,689	10.6	<3	215.1	1.4	<0.9	10.7	26.1	22.7	26,008	<0.05
Reservoirs on Rio Grande (Colorado)														
Rio Grande Upper	07/24	1	<2	15,023	4.8	<3	215.8	0.9	<0.9	7.5	8.3	12.7	21,113	<0.05
Rio Grande Middle	07/24	1	<2	15,350	4.6	<3	238.6	0.9	<0.9	9.0	6.7	16.7	22,509	<0.05
Rio Grande Lower	07/24	1	<2	10,048	4.7	<3	166.3	0.5	<0.9	7.5	4.4	9.7	19,192	<0.05
Pajarito Plateau Stations														
Guaje Canyon:														
Guaje at SR 502	03/17	1	<2	3,111	0.3	<3	60.3	0.2	<0.9	1.7	2.7	2.2	4,194	<0.05
Guaje at SR 502	03/17	D1	<2	2,274	<0.2	<3	27.5	0.2	<0.9	1.2	1.7	1.9	3,209	<0.05
Guaje at SR 502	03/17	D2	<2	2,275	<0.2	<3	47.3	0.3	<0.9	3.8	8.0	1.6	14,261	<0.05
Guaje at SR 502	03/17	R1												<0.05
Bayo Canyon:														
Bayo at SR 502	03/17	1	<2	4,593	0.9	<3	71.8	0.4	<0.9	3.0	5.4	3.2	7,461	<0.05
Bayo at SR 502	03/17	D1	<2	2,550	<0.2	<3	30.1	0.2	<0.9	1.9	3.3	2.1	4,967	<0.05
Bayo at SR 502	03/17	R1												<0.05
DP/Los Alamos Canyons:														
Los Alamos at Totavi	05/12	1	<2	2,334	<0.2	<3	30.5	0.3	<0.9	1.2	2.1	1.7	2,591	<0.05
Los Alamos at Otowi	05/12	1	<2	1,671	<0.2	<3	19.4	<0.2	<0.9	1.0	2.3	1.7	2,613	<0.05
Sandia Canyon:														
Sandia at Rio Grande	09/29	1	<2	1,245	<0.2	<3	18.8	<0.2	<0.9	<1.0	1.1	2.4	2,352	<0.05

Table 5-14. Total Recoverable Trace Metals in Sediments for 1997 (mg/kg)[a,b] (Cont.)

Station Name	Date	Code[c]	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg
Pajarito Plateau Stations (Cont.)														
Cañada Ancha:														
Cañada Ancha at Rio Grande	09/29	1	<2	2,022	1.2	<3	34.8	<0.2	<0.9	1.1	1.9	13.3	3,327	<0.05
Mortandad Canyon:														
Mortandad A-8	08/14	1	<2	3,031	0.5	<3	33.3	0.4	<0.9	1.3	2.0	2.7	3,970	<0.05
Mortandad A-10	08/14	1	<2	2,409	0.5	<3	33.2	0.3	<0.9	1.5	2.3	2.0	4,238	4.00
TA-54 Area G:														
G-1	04/11	1	<2	1,476	0.4	<3	19.9	<0.2	<0.9	<1.0	<0.9	1.2	1,992	<0.05
G-1	04/11	D1	<2	1,916	0.5	<3	16.8	<0.2	<0.9	<1.0	1.2	1.4	2,917	<0.05
G-2	04/10	1	<2	2,630	0.8	<3	30.6	0.2	<0.9	1.8	2.7	2.0	5,759	<0.05
G-3	04/11	1	<2	1,288	0.6	<3	18.2	<0.2	<0.9	1.2	3.8	4.2	3,068	<0.05
G-4	04/11	1	<2	6,299	1.1	<3	57.4	0.5	<0.9	2.3	4.1	3.2	7,456	<0.05
G-5	04/11	1	<2	5,651	1.2	<3	52.1	0.5	<0.9	2.2	3.6	2.5	6,418	<0.05
G-6	04/11	1	<2	7,978	1.6	<3	69.3	0.5	<0.9	2.9	5.5	3.5	8,542	0.06
G-7	04/11	1	<2	2,784	0.8	<3	21.9	<0.2	<0.9	<1.0	1.4	1.5	3,169	0.05
G-8	04/11	1	<2	5,951	1.3	<3	38.2	0.3	<0.9	2.1	4.6	2.6	7,771	4.26
G-9	04/11	1	<2	2,750	0.6	<3	21.4	<0.2	<0.9	<1.0	1.7	1.3	2,840	0.05
Cañon de Valle:														
Cañon de Valle at SR 501	03/17	1	<2	2,037	0.8	<3	20.2	0.2	<0.9	1.5	4.8	2.4	4,486	<0.05
Cañon de Valle at SR 501	03/17	R1												<0.05
Water Canyon:														
Water at SR 501	03/17	1	<2	7,201	1.0	<3	76.7	0.6	<0.9	3.1	5.6	3.8	7,811	<0.05
Water at SR 501	03/17	R1												<0.05
Ancho Canyon:														
Ancho at Rio Grande	09/29	1	<2	3,977	0.5	<3	35.0	0.2	<0.9	1.7	4.2	6.1	5,988	<0.05
Ancho at Rio Grande	09/29	D1	<2	10,470	1.9	<3	99.6	0.7	<0.9	3.3	7.8	7.1	9,804	<0.05
Chaquehui Canyon:														
Chaquehui at Rio Grande	09/30	1	<2	7,539	1.4	<3	85.3	0.5	<0.9	4.2	7.4	8.8	11,441	<0.05

Table 5-14. Total Recoverable Trace Metals in Sediments for 1997 (mg/kg)[a,b] (Cont.)

Station Name	Date	Code[c]	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg
Pajarito Plateau Stations (Cont.)														
TA-49 Area AB:														
AB-1	04/24	1	<2	8,973	2.2	<3	70.7	0.5	<0.9	3.3	5.1	1.5	8,318	<0.05
AB-1	04/23	D1	<2	9,891	2.5	<3	74.9	0.6	<0.9	3.3	6.1	1.5	8,752	<0.05
AB-2	04/23	1	<2	15,448	4.6	<3	189.7	0.9	<0.9	7.5	9.9	8.3	12,702	<0.05
AB-3	04/23	1	<2	6,505	1.1	<3	53.7	0.3	<0.9	2.0	3.9	1.8	5,411	<0.05
AB-4	04/23	1	<2	15,352	1.4	<3	164.4	0.9	<0.9	5.5	10.5	7.6	11,297	<0.05
AB-4A	04/23	1	<2	9,919	2.4	<3	95.1	0.6	<0.9	3.1	5.1	1.8	6,585	<0.05
AB-5	04/23	1	<2	12,310	2.2	<3	111.6	0.8	<0.9	4.4	9.1	7.0	11,949	<0.05
AB-6	04/23	1	<2	11,398	2.3	<3	116.2	0.7	<0.9	4.4	8.3	5.5	9,957	<0.05
AB-7	04/23	1	<2	5,992	0.8	<3	41.9	0.3	<0.9	1.3	3.0	1.8	5,044	<0.05
AB-8	04/23	1	<2	9,400	3.4	<3	78.4	0.7	<0.9	2.8	6.5	1.4	9,359	<0.05
AB-9	04/23	1	<2	6,042	2.1	<3	39.6	0.3	<0.9	<1.0	3.0	1.6	4,438	<0.05
AB-10	04/24	1	<2	2,036	0.5	<3	20.9	<0.2	<0.9	<1.0	1.8	<1.0	5,135	<0.05
AB-11	04/24	1	<2	13,157	<0.2	<3	66.7	0.6	<0.9	1.6	6.2	2.5	7,399	<0.05
Frijoles Canyon:														
Frijoles at Monument HQ	05/08	1	<2	7,233	<1.4	<3	48.0	0.6	<0.9	<1.0	4.1	<1.0	6,269	<0.05
Frijoles at Rio Grande	09/30	1	<2	862	0.6	<3	15.3	<0.2	<0.9	<1.0	2.4	2.4	1,067	<0.05
Standardized Comparisons														
Detection Limits			2	7	0.2	3	0.2	0.2	0.9	1.0	0.9	1.0	1	0.05
Background–Stream Channels[e]			3	6,934	5.3	64	3,39.2	0.7	1.0	10.5	13.9	9.3	13,250	0.11
Background–Reservoirs[e]			4	24,290	18.9	7	269.6	1.3	1.3	12.3	22.5	24.2	29,257	0.06
SAL[f]			380	78,000		5,900	5,300		38	4,600	30[g]	2,800		23

Table 5-14. Total Recoverable Trace Metals in Sediments for 1997 (mg/kg)[a,b] (Cont.)

Station Name	Date	Code[c]	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
Regional Stations													
Rio Chama at Chamita	05/12	1	138.5	<5	<4.0	11.6	<0.3	<1.20	<5	18.6	<0.3	11.6	22.1
Rio Grande at Embudo	05/12	1	184.0	<5	5.4	7.8	<0.3	<0.33	<5	21.8	<0.3	11.4	24.9
Rio Grande at Otowi (bank)	12/16	1	99.2	<25	<20.0	<5.0	<0.3	<0.50	<25	13.4	0.4	18.6	17.6
Rio Grande at Bernalillo	05/01	1	53.5	<5	<4.0	1.0	<0.3	<0.50	<5	14.8	<0.3	6.0	8.5
Jemez River	05/09	1	171.0	<5	<4.0	2.3	<0.3	<0.33	<5	15.9	<0.3	5.4	8.4
Reservoirs on Rio Chama (New Mexico)													
El Vado Upper	07/22	1	269.3	<5	10.2	10.0	<1.5	0.65	<5	99.0	0.4	26.8	43.3
El Vado Middle	07/22	1	729.6	<5	22.1	20.0	<1.5	1.18	<5	72.8	0.8	56.7	80.1
El Vado Lower	07/22	1	889.3	<5	23.6	29.0	3.0	1.15	<5	72.5	1.1	58.9	91.7
Reservoirs on Rio Grande (Colorado)													
Rio Grande Upper	07/24	1	356.4	<5	4.4	15.0	<1.5	0.37	<5	64.6	0.4	39.6	75.5
Rio Grande Middle	07/24	1	501.8	<5	8.4	17.0	<1.5	0.55	<5	74.4	0.4	40.7	85.1
Rio Grande Lower	07/24	1	386.8	<5	<4.0	11.0	<1.5	<0.35	<5	51.0	<0.3	29.1	60.5
Pajarito Plateau Stations													
Guaje Canyon:													
Guaje at SR 502	03/17	1	269.0	<5	<4.0	3.8	<0.3	<0.30	<5	8.3	<0.3	6.5	12.1
Guaje at SR 502	03/17	D1	112.0	<5	<4.0	3.3	<0.3	<0.30	<5	6.4	<0.3	4.6	9.8
Guaje at SR 502	03/17	D2	545.0	<5	4.4	4.5	<0.3	<0.30	<5	5.6	<0.3	20.3	37.1
Guaje at SR 502	03/17	R1											
Bayo Canyon:													
Bayo at SR 502	03/17	1	221.0	<5	<4.0	7.3	<0.3	<0.30	<5	16.2	<0.3	12.7	18.3
Bayo at SR 502	03/17	D1	128.0	<5	<4.8	3.3	<0.3	<0.30	<5	8.1	<0.3	7.6	13.9
Bayo at SR 502	03/17	R1											
DP/Los Alamos Canyons:													
Los Alamos at Totavi	05/12	1	93.1	<5	<4.0	2.6	<0.3	<0.33	<5	8.4	<0.3	3.9	19.0
Los Alamos at Otowi	05/12	1	60.0	<5	<4.0	2.6	<0.3	<0.33	<5	5.9	<0.3	3.6	13.0
Sandia Canyon:													
Sandia at Rio Grande	09/29	1	60.2	<5	<4.0	1.5	<0.3	<0.38	<5	6.2	<0.3	3.9	8.1

Table 5-14. Total Recoverable Trace Metals in Sediments for 1997 (mg/kg)[a,b] (Cont.)

Station Name	Date	Code[c]	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
Pajarito Plateau Stations (Cont.)													
Cañada Ancha:													
Cañada Ancha at Rio Grande	09/29	1	79.0	<5	<4.0	2.3	<0.3	<0.38	<5	13.7	<0.3	6.4	12.3
Mortandad Canyon:													
Mortandad A-8	08/14	1	185.2	<5	<4.0	7.2	<0.3	<0.37	<5	4.5	<0.3	4.2	23.2
Mortandad A-10	08/14	1	180.4	<5	<4.0	6.9	<0.3	<0.37	<5	5.3	<0.3	5.6	17.0
TA-54 Area G:													
G-1	04/11	1	75.9	<5	<4.0	2.2	<0.3	<0.38	<5	3.8	<0.3	1.8	22.3
G-1	04/11	D1	94.0	<5	<4.0	4.4	<0.3	<0.38	<5	2.9	<0.3	2.2	23.9
G-2	04/10	1	183.1	<5	<4.0	5.6	0.4	<0.38	<5	6.2	<0.3	5.6	38.0
G-3	04/11	1	61.8	<5	<4.0	10.8	<0.3	<0.38	<5	12.9	<0.3	5.2	42.1
G-4	04/11	1	311.8	<5	<4.0	9.0	<0.3	<0.38	<5	8.8	<0.3	7.2	51.7
G-5	04/11	1	235.3	<5	<4.0	7.3	<0.3	<0.38	<5	9.2	<0.3	6.7	39.7
G-6	04/11	1	274.4	<5	5.9	9.1	<0.3	<0.38	<5	13.6	<0.3	10.3	51.2
G-7	04/11	1	118.8	<5	<4.0	3.6	<0.3	<0.38	<5	3.5	<0.3	2.8	23.4
G-8	04/11	1	227.6	<5	<4.0	8.7	<0.3	<0.38	<5	7.5	<0.3	9.5	55.0
G-9	04/11	1	97.0	<5	<4.0	3.8	<0.3	<0.38	<5	4.1	<0.3	3.7	24.0
Cañon de Valle:													
Cañon de Valle at SR 501	03/17	1	88.9	<5	<4.0	13.0	<0.3	<0.30	<5	6.2	<0.3	6.1	19.4
Cañon de Valle at SR 501	03/17	R1											
Water Canyon:													
Water at SR 501	03/17	1	381.0	<5	<4.0	10.5	<0.3	<0.30	<5	22.0	<0.3	12.0	33.3
Water at SR 501	03/17	R1											
Ancho Canyon:													
Ancho at Rio Grande	09/29	1	116.0	<5	4.2	4.6	0.3	<0.38	<5	10.0	<0.3	8.1	31.7
Ancho at Rio Grande	09/29	D1	231.7	<5	5.3	18.0	<0.3	0.51	<5	24.2	0.3	13.7	32.3
Chaquehui Canyon:													
Chaquehui at Rio Grande	09/30	1	285.6	<5	10.3	9.8	<0.3	<0.38	<5	19.5	<0.3	14.3	33.4

Table 5-14. Total Recoverable Trace Metals in Sediments for 1997 (mg/kg)[a,b] (Cont.)

Station Name	Date	Code[c]	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
Pajarito Plateau Stations (Cont.)													
TA-49 Area AB:													
AB-1	04/24	1	273.3	<5	<4.0	13.3	<0.4	<0.70	<5	12.9	<0.3	11.3	322.8
AB-1	04/23	D1	269.0	<5	5.6	17.7	<0.4	<0.70	<5	14.3	<0.3	12.0	321.2
AB-2	04/23	1	594.4	<5	8.0	15.3	0.5	<0.70	<5	47.2	<0.3	20.8	176.8
AB-3	04/23	1	155.5	<5	<4.0	6.8	<0.4	<0.70	<5	9.5	<0.3	6.4	45.4
AB-4	04/23	1	340.3	<5	8.3	15.4	<0.4	<0.70	<5	28.2	0.3	17.8	31.7
AB-4A	04/23	1	226.9	<5	4.4	14.0	<0.4	<0.70	<5	15.0	<0.3	7.7	17.6
AB-5	04/23	1	386.6	<5	6.7	19.9	<0.4	<0.70	<5	22.6	0.3	15.1	55.2
AB-6	04/23	1	293.2	<5	5.2	12.4	<0.4	<0.70	<5	21.8	0.3	14.6	26.6
AB-7	04/23	1	127.2	<5	<4.0	5.0	<0.4	<0.70	<5	7.5	<0.3	5.0	20.0
AB-8	04/23	1	251.1	<5	<4.0	21.2	<0.4	<0.70	<5	15.7	0.6	12.8	22.4
AB-9	04/23	1	105.5	<5	<4.0	4.3	<0.4	<0.70	<5	7.3	<0.3	4.5	18.8
AB-10	04/24	1	128.8	<5	<4.0	4.6	<0.4	<0.70	<5	3.9	<0.3	5.6	19.2
AB-11	04/24	1	151.9	<5	4.4	7.4	<0.4	<0.70	<5	12.9	<0.3	6.8	26.9
Frijoles Canyon:													
Frijoles at Monument HQ	05/08	1	217.0	<5	<4.0	5.8	<0.3	<0.50	<5	12.3	<0.3	6.0	52.4
Frijoles at Rio Grande	09/30	1	19.4	<5	4.1	0.6	<0.3	<0.38	<5	4.1	<0.3	2.6	3.9
Standardized Comparisons													
Detection Limits			0.3	5	4.0	0.3	0.3	0.24	5	0.2	0.3	1.3	0.8
Background–Stream Channels[e]			416.0	3	11.6	8.7	2.9	0.30	20	76.8	6.8	32.4	47.9
Background–Reservoirs[e]			836.0	1	25.1	19.1	0.3	1.20	9	99.8	34.8	45.0	105.1
SAL[f]			390	380	1,500	400	31	380	46,000	46,000	6.4	540	23,000

[a] Sample Sizes: stream channels and reservoirs—100 g.
[b] Analytical uncertainities are approximately 10% of reported values.
[c] Codes: 1–primary analysis, D–field duplicate, R–lab replicate.
[d] Less than symbol (<) means measurement was below the specified limit of detection of the analytical method.
[e] Upper limit for background based on 1993–96 surveillance data (McLin and Lyons, 1998).
[f] Screening Action level from ER Project, March 1997; see text for details. All units in mg/kg.
[g] SAL value for hexavalent chromium is listed; SAL value for trivalent or total chromium is 210 mg/kg.

Table 5-15. Number of Analyses Above Analytical Limit of Quantitation for Organic Compounds in Sediment Samples for 1997

Station Name	Date	Code[a]	Semivolatile[b]	PCB[c]	HE[d]
Number of Compounds Analyzed			69	4	14
TA-49 Area AB					
AB-1	04/23	1	0	0	
AB-1	04/24	D	0	0	
AB-2	04/23	1	0	0	
AB-3	04/23	1	0	0	
AB-4	04/23	1	0	0	
AB-4A	04/23	1	0	0	
AB-5	04/23	1	0	0	
AB-6	04/23	1	0	0	
AB-7	04/23	1	0	0	
AB-8	04/23	1	0	0	
AB-9	04/23	1	0	0	
AB-10	04/24	1	0	0	
AB-11	04/24	1	0	0	
Frijoles Canyon					
Frijoles at Monument HQ	05/08	1	0	0	
Frijoles at Monument HQ	05/30	1			0

[a] Codes: 1–primary analysis, 2–secondary analysis, D–field duplicate, R–lab replicate.
[b] Semivolatile organic compounds (SVOC).
[c] Polychlorinated biphenyl compounds (PCB).
[d] High-explosive compounds.

Table 5-16. Radiochemical Analyses of Groundwater for 1997 (pCi/L[a])

Station Name	Date	Codes[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	08/11	1 UF	468 690[c]	0.1 0.9	0.26 0.29	1.90 0.19	0.008 0.012	0.012 0.012	–0.015[d] 0.013	0.5 1.6	3.0 2.9	–40 47
Test Well 2	12/11	1 UF	–162 670	0.8 1.0	0.74 2.33	0.00 0.01	–0.012 0.017	–0.016 0.023	–0.047 0.017	0.2 0.8	0.7 1.5	52 49
Test Well 3	08/11	1 UF	–2,052 500	1.0 1.3	–0.92 0.36	0.73 0.08	–0.023 0.004	0.009 0.012	0.002 0.029	0.1 0.7	2.2 1.7	–59 47
Test Well 4	08/11	1 UF	–302 640	1.3 1.7	0.21 0.24	0.45 0.05	–0.008 0.009	0.010 0.011	–0.001 0.014	0.2 0.9	1.6 1.6	–11 47
Test Well DT-5A	03/07	1 UF	104 216	–0.07 0.4	0.35 0.53	0.45 0.05	0.001 0.020	–0.009 0.004	–0.016 0.012	0.4 0.6	1.3 0.5	–28 50
Test Well DT-5A	03/07	2 UF	69 188									
Test Well DT-5A	03/07	R1 UF										160 50
Test Well DT-5A	05/13	1 UF	185 201	0.8 1.8	0.96 2.67	0.08 0.01	–0.007 0.009	–0.010 0.009	–0.019 0.014	0.4 0.4	–0.2 0.4	–52 47
Test Well DT-5A	10/16	1 UF	–222 700	–1.1 1.3	0.10 1.39	0.49 0.05	0.011 0.013	0.012 0.012	–0.006 0.013	0.3 1.1	0.7 0.5	–115 48
Test Well DT-9	05/13	1 UF	1 166	0.9 1.6	1.10 0.42	0.43 0.05	0.003 0.010	0.000 0.010	–0.014 0.016	0.0 0.2	0.2 0.4	–31 47
Test Well DT-9	10/15	1 UF	–172 700	–1.6 1.5	–0.82 0.80	0.61 0.06	–0.007 0.011	0.004 0.012	–0.015 0.011	0.1 0.7	0.3 1.4	–123 48
Test Well DT-10	05/14	1 UF	–59 148	–0.6 1.2	0.02 0.24	0.46 0.05	–0.025 0.007	–0.020 0.010	–0.005 0.018	–0.2 0.2	–1.3 0.3	–27 47
Test Well DT-10	10/16	1 UF	–232 700	–3.4 2.2	–0.91 0.80	0.74 0.08	0.021 0.014	–0.002 0.010	0.019 0.030	0.9 3.1	1.7 1.6	–28 49
Water Supply Wells:												
O-1	01/08	1 UF	169 136	0.1 0.4	0.31 0.48	1.72 0.17	0.005 0.018	–0.012 0.011	–0.033 0.014	2.8 1.0	0.6 0.5	62 50
O-1	01/08	D1 UF			0.13 0.18					2.8 1.0	0.3 0.4	
O-1	01/08	R1 UF	–144 133				–0.018 0.010	–0.016 0.009	0.025 0.027			
O-1	04/17	1 UF		0.0 0.3								
O-1	04/19	1 UF		0.0 0.3								
O-1	04/19	D1 UF		0.6 0.3								
O-4	06/25	1 UF	288 710	0.2 2.0	–0.85 0.80	0.85 0.09	–0.014 0.022	–0.014 0.017	0.022 0.021	0.5 4.0	2.5 1.8	–10 47
PM-1	06/25	1 UF	88 700	–0.9 1.8	–0.74 0.12	1.87 0.19	0.018 0.015	0.029 0.019	–0.045 0.022	2.5 6.1	3.8 1.9	1 47
PM-2	06/25	1 UF	368 720	–1.2 1.8	–0.76 0.08	0.47 0.05	–0.006 0.019	–0.005 0.020	–0.003 0.019	0.0 0.7	1.5 0.6	–9 47
PM-3	06/25	1 UF	658 730	0.1 2.2	–0.88 0.80	1.03 0.11	–0.035 0.007	–0.017 0.010	0.000 0.016	–0.3 0.3	2.3 1.8	17 47
PM-4	06/25	1 UF	58 700	–1.2 2.2	–1.08 0.80	0.35 0.04	–0.007 0.011	0.019 0.016	–0.035 0.026	0.5 4.5	1.4 1.6	8 47
PM-5	06/25	1 UF	–2 690	–0.5 2.5	–0.72 0.16	0.55 0.06	–0.026 0.008	0.001 0.014	0.004 0.017	0.1 0.9	1.2 1.6	–6 47
G-1	12/08	1 UF	198 720	5.2 1.4	–0.13 1.03	0.64 0.07	0.005 0.010	0.015 0.012	–0.008 0.020	–0.2 0.1	2.1 1.7	29 49
G-1A	06/25	1 UF	–82 690	–1.1 2.7	–1.00 0.80	0.43 0.05	–0.023 0.007	0.011 0.015	–0.001 0.034	0.0 0.4	1.7 1.7	15 47
G-2	06/25	1 UF	388 720	0.0 1.3	–0.93 0.80	0.92 0.09	–0.029 0.005	0.010 0.013	–0.004 0.017	–0.3 0.2	1.5 1.6	21 47
G-4	06/25	1 UF	–52 690	–0.2 1.0	–0.59 0.36	0.91 0.09	–0.032 0.010	0.006 0.012	–0.015 0.015	0.2 1.5	1.5 1.6	–16 47
G-5	06/25	1 UF	458 720	–0.7 1.4	–0.70 0.18	0.98 0.10	–0.005 0.010	–0.001 0.011	–0.015 0.014	0.5 2.9	0.9 1.5	9 47
G-6	06/25	1 UF	158 700	–4.4 2.7	–1.01 0.80	0.59 0.06	–0.014 0.011	0.012 0.015	–0.003 0.044	–0.4 0.4	1.4 1.6	4 47

Table 5-16. Radiochemical Analyses of Groundwater for 1997 (pCi/L[a]) (Cont.)

Station Name	Date	Codes[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												
White Rock Canyon Group I:												
Sandia Spring	08/19	1 UF	118 720	1.8 1.6	–0.82 0.36	1.02 0.11	–0.018 0.053	–0.001 0.011	0.023 0.021	2.8 3.2	3.5 1.8	–39 47
Spring 3	11/18	1 UF	48 710	0.3 1.2	1.06 0.38	1.57 0.16	–0.003 0.009	0.009 0.011	0.029 0.040	1.7 8.3	2.6 1.8	2 49
Spring 3AA	11/18	1 UF	98 710	0.7 1.1	0.40 1.83	1.34 0.14	–0.023 0.002	–0.003 0.008	–0.020 0.012	0.4 2.5	2.7 1.8	21 49
Spring 4A	11/18	1 UF	–292 680	0.4 1.0	–1.69 0.36	1.20 0.12	–0.008 0.008	–0.007 0.008	–0.035 0.011	0.3 2.7	0.3 1.4	–20 48
Spring 5	09/29	1 UF	–432 650	–0.4 1.1	–0.36 0.22	0.55 0.06	–0.008 0.012	0.024 0.014	–0.038 0.014	0.3 1.2	1.1 1.6	–4 49
Ancho Spring	11/19	1 UF	–282 690	1.2 1.2	–0.28 0.81	0.29 0.03	0.029 0.014	0.007 0.012	–0.001 0.030	0.5 2.1	2.5 1.8	17 49
White Rock Canyon Group II:												
Spring 6A	09/29	1 UF	–52 670	–0.3 1.1	0.29 0.32	0.28 0.03	–0.016 0.012	0.006 0.015	0.002 0.019	0.5 2.7	1.6 1.6	–6 49
Spring 7	09/29	1 UF	108 680	–0.1 1.1	–0.50 0.48	1.13 0.12	–0.018 0.004	0.002 0.010	–0.024 0.013	0.8 5.8	1.4 1.6	–26 48
Spring 7	09/29	1 UF	218 690	0.0 1.0	–0.48 0.52	1.15 0.12	0.002 0.010	–0.011 0.008	0.008 0.017	0.8 5.8	1.4 1.6	23 49
Spring 8B	09/30	1 UF	–2 680	–0.6 1.3	–1.24 0.36	0.09 0.01	–0.029 0.002	–0.003 0.009	–0.023 0.014	0.4 2.3	0.6 1.4	–19 49
Spring 9	09/30	1 UF	98 680	–0.2 1.3	–0.92 0.36	0.21 0.02	–0.018 0.006	0.009 0.012	0.020 0.022	0.2 1.0	0.3 1.3	9 49
White Rock Canyon Group III:												
Spring 1	08/19	1 UF	68 720	1.0 1.3	–1.14 0.36	2.59 0.26	0.009 0.011	–0.005 0.008	0.004 0.018	1.4 3.1	2.7 1.7	–24 47
Spring 2	08/19	1 UF	8 710	2.3 1.6	0.19 1.51	2.61 0.26	–0.032 0.013	0.035 0.029	–0.009 0.030	3.0 5.6	4.3 0.8	–29 47
White Rock Canyon Group IV:												
La Mesita Spring	12/08	1 UF	–312 680	0.2 0.9	1.96 0.53	12.13 1.22	–0.025 0.002	0.025 0.014	–0.023 0.013	12.8 3.0	14.0 5.0	–30 48
Other Springs:												
Sacred Spring	07/08	1 UF	–372 750	0.0 2.0	0.48 1.95	0.32 0.04	–0.024 0.002	–0.006 0.008	0.000 0.020	0.8 40.3	1.6 0.6	13 47
Canyon Alluvial Groundwater Systems												
Acid/Pueblo Canyons:												
APCO-1	12/10	1 UF	288 690	2.3 2.5	0.00 0.23	0.59 0.06	–0.008 0.013	0.036 0.016	0.030 0.026	0.1 0.8	15.0 5.0	–1 48
Cañada del Buey:												
CDBO-6	06/16	1 UF	98 710	1.1 1.1	–0.34 0.71	0.65 0.07	–0.026 0.011	0.012 0.016	0.004 0.020	16.6 7.3	18.4 5.8	30 47
CDBO-7	06/16	1 UF	–112 700	5.2 1.8	–0.22 0.27	2.11 0.21	–0.014 0.010	–0.012 0.010	0.011 0.023	50.4 20.5	57.1 21.2	3 47

Table 5-16. Radiochemical Analyses of Groundwater for 1997 (pCi/L[a]) (Cont.)

Station Name	Date	Codes[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	06/17	1 UF	168	710	0.8	1.0	–0.54	0.42	0.07	0.01	–0.026	0.009	0.005	0.013	–0.010	0.016	1.4	10.2	2.2	1.7	–4	47
LAO-0.7	06/18	1 UF	–142	690	0.5	1.4	–0.38	0.67	0.23	0.03	–0.023	0.007	0.261	0.038	0.002	0.021	4.2	4.4	5.3	2.0	–5	47
LAO-1	06/18	1 UF	468	730	7.1	1.8	0.16	1.47	0.13	0.02	–0.026	0.006	0.105	0.024	–0.043	0.015	0.3	0.7	13.9	2.5	–16	47
LAO-2	08/04	1 UF	98	680	15.6	2.5	–0.78	0.07	0.24	0.03	–0.006	0.012	0.002	0.013	0.015	0.017	–1.6	1.5	33.0	4.0	–11	47
LAO-3A	08/04	1 UF	188	680	34.8	3.5	–0.02	0.30	0.20	0.02	–0.004	0.010	0.028	0.015	0.002	0.021	–2.1	0.4	83.0	6.0	–32	47
LAO-4	08/04	1 UF	378	690	4.4	1.4	2.36	0.66	0.11	0.01	–0.001	0.010	0.006	0.011	0.048	0.023	–0.8	3.2	12.8	1.5	283	49
LAO-4.5C	08/04	1 UF	88	670	3.2	1.7	–0.21	0.92	–0.03	0.01	–0.004	0.009	0.001	0.011	0.005	0.016	0.2	9.7	6.8	2.1	639	69
LAO-6A	08/04	1 UF	248	680	1.7	1.3	–0.44	0.57	0.09	0.01	–0.008	0.010	0.013	0.014	–0.053	0.012	0.3	5.3	5.6	2.0	34	47
Mortandad Canyon:																						
MCO-3	08/07	1 UF	11,428	1,300	20.2	3.4	0.55	0.36	1.85	0.19	16.202	0.756	12.522	0.594	14.093	0.697	18.8	12.0	136.0	22.0	140	48
MCO-4B	08/05	1 UF	20,128	1,600	38.3	4.3	7.65	1.14	1.96	0.20	–0.012	0.010	0.013	0.015	0.591	0.054	5.8	4.9	131.0	11.0	–5	47
MCO-5	08/05	1 UF	17,728	1,500	32.3	3.2	0.88	0.39	1.78	0.18	0.019	0.013	0.076	0.021	0.485	0.050	7.6	10.0	131.0	16.0	–19	47
MCO-6	08/05	1 UF	18,328	1,500	32.4	3.5	0.54	0.36	2.45	0.25	0.008	0.014	0.014	0.013	0.416	0.045	5.9	7.8	132.9	13.8	1	48
MCO-7A	06/13	1 UF	15,928	1,500	1.4	1.6	–0.39	0.19	2.81	0.28	–0.017	0.006	0.002	0.011	0.053	0.029	10.8	7.8	48.9	10.1	19	47
MCO-7.5	06/13	1 UF	18,428	1,600	1.1	1.8	–0.33	0.73	1.86	0.19	0.007	0.012	–0.009	0.012	0.185	0.037	26.5	10.4	80.5	12.0	25	47
Pajarito Canyon:																						
PCO-1	06/16	1 UF	318	720	0.9	1.2	0.67	0.33	0.07	0.01	0.002	0.011	0.007	0.014	–0.082	0.021	0.6	4.6	2.1	0.7	21	47
Intermediate Perched Groundwater Systems																						
Pueblo/Los Alamos Canyon Area:																						
Test Well 1A	08/11	1 UF	–272	640	1.2	1.3	0.61	0.33	0.24	0.03	0.001	0.010	0.003	0.011	–0.014	0.013	–0.7	0.7	3.2	3.0	–75	47
Test Well 2A	12/11	1 UF	1,778	790	0.4	1.0	1.33	0.48	0.00	0.01	–0.009	0.007	0.013	0.011	–0.004	0.013	0.0	0.3	1.0	1.5	74	49
Basalt Spring	08/14	1 UF	18	710	2.6	2.4	–0.83	0.36	2.22	0.23	–0.014	0.006	0.476	0.050	–0.007	0.015	8.4	7.6	22.1	4.1	–55	47

Table 5-16. Radiochemical Analyses of Groundwater for 1997 (pCi/L[a]) (Cont.)

Station Name	Date	Codes[b]	^{3}H	^{90}Sr	^{137}Cs	U (μg/L)	^{238}Pu	$^{239,240}Pu$	^{241}Am	Gross Alpha	Gross Beta	Gross Gamma
Perched Groundwater System in Volcanics:												
Water Canyon Gallery	12/01	1 UF	38 670	–0.2 1.0	–0.75 0.10	0.19 0.02	–0.025 0.007	–0.017 0.009	0.039 0.029	–0.3 0.2	0.7 1.5	–7 48
Pueblo of San Ildefonso												
LA-1B	10/06	1 UF	408 680	–0.2 1.0	1.29 0.42	0.00 0.01	–0.020 0.007	–0.014 0.008	–0.046 0.013	4.6 1.0	6.1 0.7	22 48
LA-5	07/07	1 UF	–492 740	–0.2 1.7	–0.63 0.29	1.10 0.11	–0.006 0.009	–0.009 0.007	0.015 0.045	1.2 3.2	2.3 1.7	–8 47
Eastside Artesian Well	10/06	1 UF	248 670	–0.4 1.0	–0.10 0.28	–0.01 0.01	–0.025 0.006	–0.012 0.010	–0.011 0.014	1.0 0.4	0.2 0.1	54 48
Halladay House Well	08/13	1 UF	–292 690	0.8 1.5	–1.21 0.36	1.48 0.15	0.025 0.014	–0.002 0.009	–0.016 0.015	1.2 3.4	0.8 1.5	–60 47
Pajarito Well (Pump 1)	07/08	1 UF	–142 770	0.7 1.9	–0.36 0.69	11.01 1.10	–0.020 0.001	0.001 0.010	–0.006 0.044	1.3 1.4	2.6 1.7	45 47
Don Juan Playhouse Well	10/06	1 UF	778 710	0.3 1.0	–0.31 0.21	6.97 0.70	–0.001 0.009	0.012 0.012	–0.001 0.015	6.5 1.0	2.4 0.3	46 48
Otowi House Well	10/06	1 UF	288 680	0.2 0.9	0.88 0.40	1.41 0.14	–0.001 0.014	0.006 0.014	–0.025 0.016	5.5 1.1	2.2 0.3	12 48
New Community Well	07/07	1 UF	368 800	0.0 1.5	–0.28 0.18	22.49 2.25	–0.012 0.006	0.029 0.013	–0.002 0.018	11.6 4.0	10.3 2.2	16 47
Sanchez House Well	07/08	1 UF	–242 760	–0.3 2.1	–0.28 0.81	13.18 1.32	–0.018 0.006	0.019 0.014	–0.022 0.014	1.7 1.3	6.4 1.9	–34 47
Limits of Detection			700	3	4	0.1	0.04	0.04	0.04	3	3	120
Water Quality Standards[e]												
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.
[b] Codes: UF–unfiltered, F–filtered, 1–primary analysis, 2–second analysis, R1–lab replicate, D1–lab duplicate.
[c] Two columns are listed: the first is the value; the second is the radioactive counting uncertainty (1 std dev). Radioactivity counting uncertainties may be less than analytical method uncertainties.
[d] See Appendix B for an explanation of negative numbers.
[e] Standards given here for comparison only, see Appendix A.

Table 5-17. Detections of Radionuclides in Groundwater for 1997[a]

Station Name	Date	Code[b]	Analyte	Lab Value	Uncertainty	Units	Detection Limit
La Mesita Spring	12/08	1 UF	U	12.13	1.22	µg/L	0.1
LAO-0.7	06/18	1 UF	^{239,240}Pu	0.261	0.038	pCi/L	0.04
LAO-2	08/04	1 UF	Beta	33	4	pCi/L	3
LAO-2	08/04	1 UF	^{90}Sr	15.6	2.5	pCi/L	3
LAO-3A	08/04	1 UF	Beta	83	6	pCi/L	3
LAO-3A	08/04	1 UF	^{90}Sr	34.8	3.5	pCi/L	3
LAO-4	08/04	1 UF	Gamma	283	49	pCi/L	120
LAO-4.5C	08/04	1 UF	Gamma	639	69	pCi/L	120
MCO-3	08/07	1 UF	^{241}Am	14.093	0.697	pCi/L	0.04
MCO-3	08/07	1 UF	Beta	136	22	pCi/L	3
MCO-3	08/07	1 UF	^{3}H	11,428	1,300	pCi/L	700
MCO-3	08/07	1 UF	^{238}Pu	16.202	0.756	pCi/L	0.04
MCO-3	08/07	1 UF	^{239,240}Pu	12.522	0.594	pCi/L	0.04
MCO-3	08/07	1 UF	^{90}Sr	20.2	3.4	pCi/L	3
MCO-4B	08/05	1 UF	^{241}Am	0.591	0.054	pCi/L	0.04
MCO-4B	08/05	1 UF	Beta	131	11	pCi/L	3
MCO-4B	08/05	1 UF	^{137}Cs	7.65	1.14	pCi/L	4
MCO-4B	08/05	1 UF	^{3}H	20,128	1,600	pCi/L	700
MCO-4B	08/05	1 UF	^{90}Sr	38.3	4.3	pCi/L	3
MCO-5	08/05	1 UF	^{241}Am	0.485	0.050	pCi/L	0.04
MCO-5	08/05	1 UF	Beta	131	16	pCi/L	3
MCO-5	08/05	1 UF	^{3}H	17,728	1,500	pCi/L	700
MCO-5	08/05	1 UF	^{90}Sr	32.3	3.2	pCi/L	3
MCO-6	08/05	1 UF	^{241}Am	0.416	0.045	pCi/L	0.04
MCO-6	08/05	1 UF	Beta	133	14	pCi/L	3
MCO-6	08/05	1 UF	^{3}H	18,328	1,500	pCi/L	700
MCO-6	08/05	1 UF	^{90}Sr	32.4	3.5	pCi/L	3
MCO-7A	06/13	1 UF	Beta	49	10	pCi/L	3
MCO-7A	06/13	1 UF	^{3}H	15,928	1,500	pCi/L	700
MCO-7.5	06/13	1 UF	^{241}Am	0.185	0.037	pCi/L	0.04
MCO-7.5	06/13	1 UF	Beta	80	12	pCi/L	3
MCO-7.5	06/13	1 UF	H-3	18,428	1,600	pCi/L	700
Basalt Spring	08/14	1 UF	Beta	22	4	pCi/L	3
Basalt Spring	08/14	1 UF	^{239,240}Pu	0.476	0.050	pCi/L	0.04
Pajarito Well (Pump 1)	07/08	1 UF	U	11.01	1.10	µg/L	0.1
Don Juan Playhouse Well	10/06	1 UF	Alpha	6.5	1.0	pCi/L	3
Don Juan Playhouse Well	10/06	1 UF	U	6.97	0.70	µg/L	0.1
Otowi House Well	10/06	1 UF	Alpha	5.5	1.1	pCi/L	3
New Community Well	07/07	1 UF	U	22.49	2.25	µg/L	0.1
Sanchez House Well	07/08	1 UF	U	13.18	1.32	µg/L	0.1

[a] Detection defined as sample value–average blank > 4.66* 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] Codes: UF–unfiltered, F–filtered, 1–primary analysis, 2–second analysis, R1–lab replicate, D1–lab duplicate.

Table 5-18. Possible Detections of Radionuclides in Groundwater for 1997[a]

Station Name	Date	Code[b]	Analyte	Lab Value	Uncertainty	Units	Detection Limit
G-1	12/08	1 UF	^{90}Sr	5.19	1.39	pCi/L	3
La Mesita Spring	12/08	1 UF	Alpha	12.8	3.0	pCi/L	3
CDBO-7	06/16	1 UF	Alpha	50.4	20.5	pCi/L	3
CDBO-7	06/16	1 UF	^{90}Sr	5.22	1.75	pCi/L	3
CDBO-7	06/16	1 UF	Beta	57.1	21.2	pCi/L	3
LAO-1	06/18	1 UF	^{90}Sr	7.1	1.82	pCi/L	3
LAO-1	06/18	1 UF	^{239,240}Pu	0.105	0.024	pCi/L	0.04
LAO-4	08/04	1 UF	^{90}Sr	4.44	1.42	pCi/L	3
MCO-3	08/07	1 UF	Gamma	140	48	pCi/L	120
MCO-5	08/05	1 UF	^{239,240}Pu	0.076	0.021	pCi/L	0.04
MCO-7.5	06/13	1 UF	Alpha	26.5	10.4	pCi/L	3
New Community Well	07/07	1 UF	Alpha	11.6	4.0	pCi/L	3
DI Blank	06/17	1 UF	^{239,240}Pu	0.079	0.025	pCi/L	0.04
DI Blank	06/17	1 UF	^{238}Pu	0.065	0.024	pCi/L	0.04
DI Blank	05/15	1 UF	^{241}Am	0.101	0.025	pCi/L	0.04
DI Blank	07/09	1 UF	^{241}Am	0.109	0.025	pCi/L	0.04
DI Blank	12/10	1 UF	^{241}Am	0.082	0.022	pCi/L	0.04

[a] Possible detection defined as 2.33 × uncertainty ≤ sample value-average blank ≤ 4.66 × uncertainty and sample value-average blank > detection limit, except values shown for uranium > 5 µg/L, for gross alpha > 5 pCi/L, and for gross beta > 20 pCi/L.

[b] Codes: UF–unfiltered, F–filtered, 1–primary analysis, 2–second analysis, R1–lab replicate, D1–lab duplicate.

Table 5-19. Radionuclides near Department of Energy Derived Concentration Guides in Groundwater for 1997[a]

Station Name	Date	Code	Analyte	Lab Value	Uncertainty	Units	DOE DCG	Ratio of Value to DCG	Minimum Standard	Detect or Possible Detection[b]
CDBO-7	06/16	1 UF	Alpha	50.4	20.5	pCi/L	30	1.68	15	Possible Detect
CDBO-7	06/16	1 UF	Beta	57.1	21.2	pCi/L	1,000	0.06	50	Possible Detect
LAO-3A	08/04	1 UF	Beta	83.0	6.0	pCi/L	1,000	0.08	50	Detect
MCO-3	08/07	1 UF	^{241}Am	14.093	0.697	pCi/L	30	0.47	1.2	Detect
MCO-3	08/07	1 UF	Beta	136.0	22.0	pCi/L	1,000	0.14	50	Detect
MCO-3	08/07	1 UF	^{238}Pu	16.202	0.756	pCi/L	40	0.41	1.6	Detect
MCO-3	08/07	1 UF	^{239,240}Pu	12.522	0.594	pCi/L	30	0.42	1.2	Detect
MCO-4B	08/05	1 UF	Beta	131.0	11.0	pCi/L	1,000	0.13	50	Detect
MCO-5	08/05	1 UF	Beta	131.0	16.0	pCi/L	1,000	0.13	50	Detect
MCO-6	08/05	1 UF	Beta	132.9	13.8	pCi/L	1,000	0.13	50	Detect
MCO-7.5	06/13	1 UF	Alpha	26.5	10.4	pCi/L	30	0.88	15	Possible Detect
MCO-7.5	06/13	1 UF	Beta	80.5	12.0	pCi/L	1,000	0.08	50	Detect

[a]Values shown 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.
[b]Detection or possible detection determined according to criteria described in text.

Table 5-20. Tritium Data for Regional Aquifer Test Wells at Technical Area 49

Station	Date	TU[a]	ΔTU[b]	pCi/L	ΔpCi/L
DT-10	05/20/93	0.41	0.09	1.31	0.29
DT-10	05/30/95	0.99	0.09	3.16	0.29
DT-10	09/19/96	0.25	0.09	0.80	0.29
DT-10	12/05/96	0.01	0.09	0.03	0.29
DT-10	05/13/97	0.10	0.09	0.32	0.29
DT-10	10/16/97	–0.02[c]	0.09	–0.06	0.29
Mean		0.29	0.09	0.93	0.29
DT-5A	10/23/91	–0.07	0.09	–0.22	0.29
DT-5A	05/20/93	0.07	0.09	0.22	0.29
DT-5A	11/27/96	0.08	0.09	0.26	0.29
DT-5A	03/07/97	0.15	0.09	0.48	0.29
DT-5A	10/16/97	–0.08	0.09	–0.26	0.29
Mean		0.03	0.09	0.10	0.29
DT-9	05/20/93	0.14	0.09	0.45	0.29
DT-9	05/31/95	0.47	0.09	1.50	0.29
DT-9	09/18/96	0.09	0.09	0.29	0.29
DT-9	12/05/96	0.02	0.09	0.06	0.29
DT-9	05/13/97	0.12	0.09	0.38	0.29
DT-9	10/15/97	0.04	0.09	0.13	0.29
Mean		0.15	0.09	0.47	0.29

[a] The University of Miami detection limit for this set of samples is about 0.3 pCi/L (0.1 TU). 1 TU = 3.193 pCi/L.

[b] The Δ values represent one standard deviation of the uncertainty of measurement.

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

Table 5-21. Chemical Quality of Groundwater for 1997 (mg/L[a])

Station Name	Date	Codes[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	08/11	1 UF	44	43.3	9.0	2.4	15.2	31.8	21.0	<5[f]	110	0.45	<0.02	5.52	<0.01	253		145	8.0	405
Test Well 2	12/11	1 UF	6	7.4	1.9	1.6	20.7	3.8	1.4	<5	89	0.45	0.02	<0.02	<0.01	64	<1	26	7.9	139
Test Well 3	08/11	1 UF	80	14.9	4.8	1.3	10.5	4.6	4.0	<5	84	0.48	<0.02	0.69	<0.01	159		57	7.6	173
Test Well 4	08/11	1 UF	36	9.9	5.4	1.5	9.4	3.6	2.0	<5	72	0.25	<0.02	0.16	<0.01	108		47	8.1	144
Test Well DT-5A	03/07	1 UF	73	7.2	2.2	1.0	9.8	3.5	3.0	<5	52	0.22	<0.02	0.33	<0.01	130	<1	27	7.9	113
Test Well DT-5A	03/07	R1 UF		7.2	2.2	1.2	9.8	3.6	2.8		53		<0.02	0.34	<0.01	144		27		
Test Well DT-5A	05/13	1 UF	48	7.0	2.2	<1.0	10.2	4.0	3.0	<5	47	0.24	<0.02	<0.02	<0.01	100	2	26	7.9	102
Test Well DT-5A	10/16	1 UF	67	6.6	1.9	1.6	8.5	2.7	2.7	<5	59	0.22	<0.02	0.12	0.01	162	<1	25	8.0	110
Test Well DT-9	05/13	1 UF	72	9.1	2.6	<1.0	10.0	4.1	3.3	<5	56	0.31	0.05	0.37	<0.01	142	1	34	8.2	115
Test Well DT-9	10/15	1 UF	77	11.8	3.4	<1.0	10.3	2.7	2.7	<5	53	0.29	<0.02	0.37	0.01	175	<1	44	7.6	116
Test Well DT-10	05/14	1 UF	72	8.6	2.5	<1.0	9.3	4.0	3.0	<5	53	0.31	0.02	0.41	<0.01	108	3	32	8.2	115
Test Well DT-10	10/16	1 UF	70	11.3	3.5	1.3	11.1	2.7	2.6	<5	64	0.26	<0.02	0.23	0.01	176	<1	43	7.4	131
Water Supply Wells:																				
O-1	01/08	1 UF	38	3.5	0.8	<1.0	63.8	6.0	6.0	5	144	0.35			<0.01	224	17	12	8.7	285
O-1	01/08	R1 UF	39	3.0	0.3	<1.0	63.9					0.37			<0.01	218	19	9		
O-4	06/25	1 UF	97	21.4	8.1	3.8	19.5	8.1	6.2	<5	113	0.30	0.08	0.72	<0.01	190		87	7.9	256
PM-1	06/25	1 UF	79	26.3	6.4	3.9	19.7	8.8	9.0	<5	<5	0.23	0.04	0.48	<0.01	280		92	1.7	12,000
PM-2	06/25	1 UF	83	9.0	2.7	1.5	9.4	3.4	2.8	<5	49	0.22	0.05	0.32	<0.01	84		34	8.0	111
PM-3	06/25	1 UF	92	23.9	7.7	3.6	16.9	7.5	5.9	<5	116	0.34	0.04	0.45	<0.01	138		91	8.3	254
PM-4	06/25	1 UF	90	11.4	3.9	2.9	12.5	3.9	3.5	<5	66	0.29	0.06	0.34	<0.01	72		45	8.1	143
PM-5	06/25	1 UF	94	11.1	3.6	2.7	12.5	3.6	3.1	<5	61	0.26	0.04	0.35	<0.01	64		42	8.1	131
G-1	12/08	1 UF	79	12.5	0.5	2.5	20.9	3.6	4.4	<5	74	0.40	<0.02	0.48	<0.01	136	<1	33	7.3	164
G-1A	06/25	1 UF	75	9.9	0.4	2.9	30.8	4.8	5.3	<5	84	0.63	0.04	0.45	<0.01	74		27	8.5	188
G-2	06/25	1 UF	76	10.3	0.5	3.0	34.0	4.2	4.9	<5	92	0.81	0.02	0.46	<0.01	150		28	8.5	205
G-4	06/25	1 UF	63	18.2	3.7	2.3	11.5	4.2	4.4	<5	76	0.28	<0.02	0.63	<0.01	84		61	8.3	168
G-5	06/25	1 UF	63	17.2	3.7	2.9	11.3	4.2	4.5	<5	75	0.31	<0.02	0.64	<0.01	86		58	8.3	164
G-6	06/25	1 UF	62	17.5	2.9	2.7	14.8	4.0	4.2	<5	68	0.27	<0.02	0.47	<0.01	110		56	8.3	162

Table 5-21. Chemical Quality of Groundwater for 1997 (mg/L[a]) (Cont.)

Station Name	Date	Codes[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																				
White Rock Canyon Group I:																				
Sandia Spring	08/19	1 UF	49	27.6	1.7	2.1	16.3	4.5	5.7	<5	108	0.63	<0.02	0.11	<0.01	316	<1	76	7.7	229
Spring 3	11/18	1 F	53	22.2	1.8	<1.0	15.1	5.5	6.0	<5	85	0.45	<0.02	1.35	<0.01	132		63	7.9	199
Spring 3	11/18	1 UF															1			
Spring 3AA	11/18	1 F	44	16.9	0.3	1.6	14.3	4.1	4.0	<5	82	0.44	<0.02	0.61	<0.01	60		43	8.2	167
Spring 3AA	11/18	1 UF															121			
Spring 4A	11/18	1 F	70	21.2	4.5	<1.0	11.1	6.2	6.0	<5	81	0.53	<0.02	1.01	<0.01	170		71	8.1	193
Spring 4A	11/18	1 UF															1			
Spring 5	09/29	1 F	73	16.4	4.3	1.8	11.2	5.3	6.0	<5	76	0.42	<0.02	0.77	0.01	178		59	8.4	176
Spring 5	09/29	1 UF															5			
Ancho Spring	11/19	1 F	77	12.1	2.8	<1.4	9.2	3.9	3.0	<5	57	0.30	0.10	0.40	<0.01	162		42	7.8	130
Ancho Spring	11/19	1 UF															5			
White Rock Canyon Group II:																				
Spring 6A	09/29	1 F	77	11.3	3.3	1.5	9.8	3.4	3.8	<5	63	0.35	0.02	1.76	0.01	164		42	7.8	141
Spring 6A	09/29	1 UF															3			
Spring 7	09/29	1 F	81	15.8	3.4	2.4	18.8	3.8	7.7	<5	98	0.38	<0.02	0.46	0.01	212		53	7.6	691
Spring 7	09/29	1 F	81	16.1	3.3	2.4	18.6	3.9	7.8	<5	85	0.38	0.06	0.48	0.01	183		54	7.9	197
Spring 7	09/29	1 UF															59			
Spring 7	09/29	1 UF															39			
Spring 8B	09/30	1 F	89	10.9	3.0	1.8	11.7	3.2	4.0	<5	63	0.43	0.03	0.02	0.01	158		39	8.2	139
Spring 8B	09/30	1 UF															<1			
Spring 9	09/30	1 F	80	9.5	2.7	1.3	10.9	3.3	3.5	<5	61	0.44	<0.02	0.12	0.01	151		35	8.2	444
Spring 9	09/30	1 UF															18			
White Rock Canyon Group III:																				
Spring 1	08/19	1 UF	34	14.4	1.0	2.0	29.7	4.4	8.2	<5	98	0.53	<0.02	0.41	<0.01	54	3	40	8.1	224
Spring 2	08/19	1 UF	33	13.0	0.6	1.3	35.8	4.3	5.6	<5	104	0.59	<0.02	0.04	<0.01	1,214	<1	35	8.2	229
White Rock Canyon Group IV:																				
La Mesita Spring	12/08	1 F	30	35.8	0.9	2.3	26.3	7.4	13.6	5	123	0.22	0.11	1.96	<0.01	204		93	8.2	313
La Mesita Spring	12/08	1 UF															222			
Other Springs:																				
Sacred Spring	07/08	1 UF	28	20.2	0.5	<1.0	21.0	3.5	5.9	<5	101	0.50	0.03	0.39	<0.01	182		52	7.5	213

Table 5-21. Chemical Quality of Groundwater for 1997 (mg/L[a]) (Cont.)

Station Name	Date	Codes[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																				
Acid/Pueblo Canyons:																				
APCO-1	12/10	1 UF	76	22.7	5.9	13.3	60.5	42.3	22.3	6	93	0.98	4.14	6.29	<0.01	376	8	81	7.1	556
Cañada del Buey:																				
CDBO-6	06/16	1 UF	60	16.5	4.2	3.2	19.9	11.6	8.8	<5	61	0.15	0.45	0.08	<0.01	322	660	59	7.2	186
CDBO-6	06/16	1 UF												0.12						
CDBO-6	09/13	1 UF												0.11						
CDBO-6	12/03	1 UF												0.23						
CDBO-7	06/16	1 UF	69	17.9	4.1	3.1	20.9	8.7	7.4	<5	81	0.12	0.32	0.02	<0.01	220	742	62	7.3	195
CDBO-7	06/16	1 UF												0.04						
CDBO-7	09/13	1 UF												0.11						
CDBO-7	12/03	1 UF												0.10						
DP/Los Alamos Canyons:																				
LAO-C	06/17	1 UF	37	11.3	2.8	3.4	23.6	26.6	6.1	<5	41	0.10	0.10	0.05	<0.01	170	<1	40	7.4	194
LAO-0.7	06/18	1 UF	36	12.6	2.6	3.7	31.0	38.1	6.6	<5	37	0.17	0.09	0.08	<0.01	182	14	42	7.0	237
LAO-1	06/18	1 UF	38	11.9	2.5	3.1	32.4	37.5	6.7	<5	44	0.25	0.08	0.04	<0.01	182	2	40	7.1	242
LAO-2	08/04	1 UF	61	21.2	6.1	4.5	31.5	32.0	10.0	<5	104	0.59	0.10	0.46	<0.01	186		78	7.1	340
LAO-3A	08/04	1 UF	55	17.7	3.9	6.0	30.0	24.0	14.0	<5	93	0.88	<0.02	0.66	<0.01	223		60	7.4	303
LAO-4	08/04	1 UF	45	14.1	4.1	4.4	27.4	26.0	10.0	<5	80	0.64	<0.02	0.03	<0.01	168		52	6.9	269
LAO-4.5C	08/04	1 UF	43	12.2	3.9	3.6	27.6	32.0	9.0	<5	67	0.72	0.10	0.03	<0.01	167		46	7.0	260
LAO-6A	08/04	1 UF	46	13.0	4.4	2.6	29.6	40.0	9.0	<5	66	0.47	<0.02	0.07	<0.01	202		50	6.9	279
Mortandad Canyon:																				
MCO-3	08/07	1 UF	46	22.1	2.8	7.9	40.0	8.0	12.0	<5	105	1.08	0.22	3.86	<0.01	274		67	7.5	288
MCO-4B	08/05	1 UF	34	27.3	2.5	14.3	79.1	19.5	14.0	<5	172	1.49	<0.02	19.10	<0.01	429		78	7.4	583
MCO-5	08/05	1 UF	35	26.6	2.8	15.4	75.3	20.1	15.0	<5	167	1.54	0.02	19.90	<0.01	441		78	7.4	584
MCO-6	08/05	1 UF	36	29.4	3.1	18.8	83.6	22.0	15.0	<5	184	1.69	0.06	23.50	<0.01	443		86	7.3	641
MCO-7A	06/13	1 UF	37	24.8	6.1	19.9	89.7	19.5	19.2	<5	165	1.74	0.34	22.00	<0.01	412	2	87	7.3	599
MCO-7.5	06/13	1 UF	40	25.6	6.2	13.7	99.9	18.2	19.0	<5	166	1.71	0.08	24.10	<0.01	460	4	89	7.8	619
Pajarito Canyon:																				
PCO-1	06/16	1 UF	38	16.5	4.6	3.9	26.1	26.1	12.4	<5	61	0.14	0.05	0.17	<0.01	212	2	60	7.2	237

Table 5-21. Chemical Quality of Groundwater for 1997 (mg/L[a]) (Cont.)

Station Name	Date	Codes[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)
Intermediate Perched Groundwater Systems																				
Pueblo/Los Alamos Canyon Area:																				
Test Well 1A	08/11	1 UF	1	11.0	3.2	3.6	40.4	66.6	5.0	<5	50	0.98	0.42	<0.02	<0.01	196		40	8.8	330
Test Well 2A	12/11	1 UF	16	2.1	0.4	<1.0	1.1	45.8	10.9	<5	82	0.19	0.07	<0.02	<0.01	196	<1	7	8.0	337
Basalt Spring	08/14	1 UF	65	16.0	4.0	8.1	44.6	27.7	22.0	<5	92	0.47	<0.02	2.36	<0.01	306	<1	57	7.3	353
Perched Groundwater System in Volcanics:																				
Water Canyon Gallery	12/01	1 UF	47	6.7	3.1	<1.0	5.4	3.4	2.0	<5	43	0.06	<0.02	0.24	<0.01	70	<1	30	7.6	89
Pueblo of San Ildefonso:																				
LA-1B	10/06	1 UF	2	2.3	<0.1	1.6	134.7	23.4	29.2	50	278	3.24	<0.02	0.05	0.01	354		6	9.5	650
LA-5	07/07	1 UF	42	18.6	0.8	1.1	14.4	4.2	6.2	<5	79	0.35	<0.02	0.60	<0.01	162		50	8.3	175
Eastside Artesian Well	10/06	1 UF	1	3.0	0.1	<1.0	83.6	4.6	18.4	27	191	0.81	<0.02	0.02	0.01	228		8	9.5	405
Halladay House Well	08/13	1 UF	28	4.0	<0.1	<1.0	42.6	5.4	13.1	<5	88	0.56	<0.02	0.54	<0.01	160	<1	10	8.9	201
Pajarito Well (Pump 1)	07/08	1 UF	39	53.3	5.6	3.2	306.1	197.0	51.5	<5	554	0.34	<0.02	0.22	<0.01	1,082		156	7.7	1,710
Don Juan Playhouse Well	10/06	1 UF	24	6.4	0.4	<1.0	62.5	4.5	17.8	12	122	0.60	<0.02	2.06	0.01	184		18	8.8	325
Otowi House Well	10/06	1 UF	62	77.2	5.6	2.7	40.4	56.3	33.5	<5	204	0.37	<0.02	1.20	0.01	344		216	7.1	607
New Community Well	07/07	1 UF	27	15.3	1.0	<1.0	74.7	8.8	33.6	<5	166	0.14	<0.02	1.47	<0.01	296		42	8.4	437
Sanchez House Well	07/08	1 UF	42	31.6	2.3	<1.0	97.4	52.5	47.5	<5	194	1.18	0.02	1.76	<0.01	440		88	7.9	636
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, 1–primary analysis, R1–lab replicate, D1–lab duplicate.
[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 5-22. Total Recoverable Trace Metals in Groundwater for 1997 (μg/L)

Station Name	Date	Codes[a]		Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg
Regional Aquifer Wells															
Test Wells:															
Test Well 1	08/11	1	UF	<10[b]	243	<2	51	84	<3	<7	<8	<7	11	1,340	<0.2
Test Well 2	12/11	1	UF	<10	96	<2	<20	16	<3	<7	<8	<7	<10	4,783	<0.2
Test Well 3	08/11	1	UF	<10	107	2	41	28	<3	<7	<8	<7	15	708	<0.2
Test Well 4	08/11	1	UF	<10	163	<2	<20	79	<3	<7	<8	12	73	9,120	<0.2
Test Well DT-5A	03/07	1	UF	<10	<50	<5	<20	21	<3	<7	<8	<7	13	293	<0.4
Test Well DT-5A	03/07	R1	UF	<10	<50	<4	<20	21	<3	<7	<8	<7	13	67	<0.4
Test Well DT-5A	05/13	1	UF	<10	103	<2	21	16	<3	<7	<8	<7	<10	1,437	<0.3
Test Well DT-5A	10/16	1	UF	<10	<50	<6	26	16	<3	<7	<8	<7	<10	52	<0.2
Test Well DT-9	05/13	1	UF	<10	<50	<2	<20	15	<3	<7	<8	<7	<10	206	<0.3
Test Well DT-9	10/15	1	UF	<10	<50	<6	<20	6	<3	<7	<8	<7	<10	207	<0.2
Test Well DT-10	05/14	1	UF	<10	<50	<2	<20	14	<3	<7	<8	<7	<10	55	<0.3
Test Well DT-10	10/16	1	UF	<10	<50	<2	34	8	<3	<7	<8	<7	<10	502	<0.2
Water Supply Wells:															
O-1	01/08	1	UF	<10	1,000	6	71	34	<3	<7	<8	16	<10	4,483	<0.3
O-1	01/08	R1	UF	<10	<500	6	71	30	<3	<7	<8	15	<10	4,104	<0.3
O-4	06/25	1	UF	<10	61	<2	55	48	<3	<7	<8	<8	<10	<40	<0.2
PM-1	06/25	1	UF	<10	101	<2	63	78	<3	<7	<8	<7	<10	<40	<0.2
PM-2	06/25	1	UF	<10	<50	<2	<20	32	<3	<7	<8	10	313	7,418	<0.2
PM-3	06/25	1	UF	11	131	2	47	53	<3	<7	<8	<7	<10	57	<0.2
PM-4	06/25	1	UF	<10	<50	2	<20	31	<3	<7	<8	7	<10	<40	<0.2
PM-5	06/25	1	UF	<10	359	<2	46	33	<3	<7	<10	28	<10	252	<0.2
G-1A	06/25	1	UF	<10	<50	14	32	40	<3	<7	<8	9	<10	<40	<0.2
G-2	06/25	1	UF	<10	<50	35	36	68	<3	<7	<8	10	<10	<40	<0.2
G-4	06/25	1	UF	<10	<50	2	<33	20	<3	<7	<8	<7	<10	<40	<0.2
G-5	06/25	1	UF	<10	<50	2	<20	15	<3	<7	<8	<7	<10	<40	<0.2
G-6	06/25	1	UF	<10	59	3	<34	14	<3	<7	<8	<7	<10	58	<0.2
Regional Aquifer Springs															
White Rock Canyon Group I:															
Sandia Spring	08/19	1	UF	<10	137	<6	50	91	<3	<7	<8	<7	<10	170	<0.2
Spring 5	09/29	1	F	113	<50	<2	29	45	<3	<7	<11	<7	<10	<40	

Table 5-22. Total Recoverable Trace Metals in Groundwater for 1997 (μg/L) (Cont.)

Station Name	Date	Codes[a]		Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg
Regional Aquifer Springs (Cont.)															
White Rock Canyon Group II:															
Spring 6A	09/29	1	F	<10	<50	<2	26	25	<3	<9	<8	<7	<10	<40	
Spring 7	09/29	1	F	<10	<50	<2	32	51	<3	<7	<8	<7	<10	<40	
Spring 7	09/29	1	F	174	<50	<2	35	40	<3	<7	<8	<7	<10	40	
Spring 8B	09/30	1	F	<10	<50	<2	29	25	<3	<7	<8	<7	<10	<40	
Spring 9	09/30	1	F	<10	<50	<2	30	16	<3	<7	<8	<7	<10	<40	
White Rock Canyon Group III:															
Spring 1	08/19	1	UF	<10	<50	<6	46	22	<3	<7	<8	<7	<10	<40	<0.2
Spring 2	08/19	1	UF	<10	<50	<6	51	20	<3	<7	<8	<7	<10	<40	<0.2
White Rock Canyon Group IV:															
La Mesita Spring	12/08	1	F	<10	<50		80	127	<3	<7	<20	<7	<10	112	
Other Springs:															
Sacred Spring	07/08	1	UF	<10	<50	<2	42	96	<3	<7	<8	<7	<10	104	<0.2
Canyon Alluvial Groundwater Systems															
Acid/Pueblo Canyons:															
APCO-1	12/10	1	UF	<10	832	7	233	19	<3	<7	<8	<7	<10	579	<0.2
Cañada del Buey:															
CDBO-6	06/16	1	UF	<10	8,157	2	38	134	<3	<7	<8	<7	<10	4,571	<0.2
CDBO-7	06/16	1	UF	<10	5,432	2	41	182	<3	<7	<8	<7	<10	2,377	<0.2
DP/Los Alamos Canyons:															
LAO-C	06/17	1	UF	<10	1,896	<2	<20	45	<3	<7	<8	<7	<10	838	<0.2
LAO-0.7	06/18	1	UF	<10	3,466	2	<20	58	<3	<7	<8	<7	<10	1,478	<0.2
LAO-1	06/18	1	UF	<10	2,272	2	<28	36	<3	<7	<8	11	<10	964	<0.2
LAO-2	08/04	1	UF	<10	356	<2	42	56	<3	<7	<8	<7	<10	179	<0.2
LAO-3A	08/04	1	UF	<10	444	<2	34	56	<3	<7	<8	<7	<10	177	<0.2
LAO-4	08/04	1	UF	<10	292	<3	27	52	<3	<7	<8	<7	<10	119	<0.2
LAO-4.5C	08/04	1	UF	<10	386	<2	26	42	<3	<7	<8	<7	<10	193	<0.2
LAO-6A	08/04	1	UF	<10	228	<2	38	36	<3	<7	<8	<7	<10	100	<0.2

Table 5-22. Total Recoverable Trace Metals in Groundwater for 1997 (μg/L) (Cont.)

Station Name	Date	Codes[a]		Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg
Canyon Alluvial Groundwater Systems (Cont.)															
Mortandad Canyon:															
MCO-3	08/07	1	UF	<10	14,662	2	88	81	<3	<7	<8	19	44	8,471	<0.2
MCO-4B	08/05	1	UF	<10	423	<2	62	85	<3	<7	<8	<7	14	234	<0.2
MCO-5	08/05	1	UF	<10	248	<2	57	91	<3	<7	<8	<7	11	98	<0.2
MCO-6	08/05	1	UF	<10	76	<2	62	99	<3	<7	<8	<7	11	<40	<0.2
MCO-7A	06/13	1	UF	<10	399	<2	76	221	<3	<7	<8	<7	<10	219	<0.2
MCO-7.5	06/13	1	UF	<10	183	<2	78	209	<3	<7	<8	<7	<10	104	<0.2
Pajarito Canyon:															
PCO-1	06/16	1	UF	<10	990	<2	34	93	<3	<11	<8	<7	<10	501	<0.2
Intermediate Perched Groundwater Systems															
Pueblo/Los Alamos Canyon Area:															
Test Well 1A	08/11	1	UF	<10	<50	<2	140	68	<3	<7	<8	<7	10	3,032	<0.2
Test Well 2A	12/11	1	UF	<10	<50	<2	<20	2	<3	<7	<8	<7	<10	54	<0.2
Basalt Spring	08/14	1	UF	<10	<50	<6	186	61	<3	<7	<8	<7	<10	42	<0.2
Perched Groundwater System in Volcanics:															
Water Canyon Gallery	12/01	1	UF	<10	100	<6	<20	11	<3	<7	<8	<7	<10	51	<0.2
Pueblo of San Ildefonso:															
LA-1B	10/06	1	UF	<10	<50	7	272	23	<3	<7	<8	<7	<10	103	<0.2
LA-5	07/07	1	UF	<10	<50	<2	<20	65	<3	<7	<8	<7	<10	119	<0.2
Eastside Artesian Well	10/06	1	UF	<10	<50	<2	152	2	<3	<7	<8	<7	<10	107	0.2
Halladay House Well	08/13	1	UF	105	63	6	67	41	<3	<7	<8	10	<10	148	<0.2
Pajarito Well (Pump 1)	07/08	1	UF	<10	<50	5	1,388	94	<3	<7	<8	<7	<11	188	<0.2
Don Juan Playhouse Well	10/06	1	UF	<10	<50	6	98	2	<3	<7	<8	9	<10	<40	<0.2
Otowi House Well	10/06	1	UF	<10	<50	<2	99	336	<3	<7	<8	<7	12	<40	<0.2
New Community Well	07/07	1	UF	<10	<50	<2	39	16	<3	<7	<8	<7	<10	<40	<0.2
Sanchez House Well	07/08	1	UF	<10	<50	10	244	111	<3	<7	<8	<7	15	<40	<0.2

Table 5-22. Total Recoverable Trace Metals in Groundwater for 1997 (μg/L) (Cont.)

Station Name	Date	Codes[a]	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg
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

[a] Codes: UF–unfiltered, F–filtered, 1–primary analysis, R1–lab replicate, D1–lab duplicate.

[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 5-22. Total Recoverable Trace Metals in Groundwater for 1997 (μg/L) (Cont.)

Station Name	Date	Codes[a]	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
Regional Aquifer Wells													
Test Wells:													
Test Well 1	08/11	1 UF	63	<30	<20	88	9	<3	<50	269	<3	<8	1,167
Test Well 2	12/11	1 UF	83	<30	<20	45	<3	<2		35	<3	<8	1,111
Test Well 3	08/11	1 UF	23	<30	<20	15	<6	<3	<30	71	<3	10	126
Test Well 4	08/11	1 UF	81	<30	<20	101	<6	<3	53	53	<3	<8	2,825
Test Well DT-5A	03/07	1 UF	<2	<30	30	4	<3	<2	37	41	<3	14	193
Test Well DT-5A	03/07	R1 UF	<2	<30	<20	<3	<3	<2	<30	42	<3	12	191
Test Well DT-5A	05/13	1 UF	55	<30	<20	4	4	<3	<31	38	<3	<8	573
Test Well DT-5A	10/16	1 UF	<2	<30	<20	<3	<3	<3	38	36	<3	12	1,537
Test Well DT-9	05/13	1 UF	<2	<30	<20	5	<3	<3	<32	47	<3	<8	204
Test Well DT-9	10/15	1 UF	4	<30	<20	3	<3	<3	<37	49	<3	<8	93
Test Well DT-10	05/14	1 UF	<2	<30	<20	3	<3	<3	<30	44	<3	<8	188
Test Well DT-10	10/16	1 UF	5	<30	<20	3	<3	<3	<30	49	<3	<8	99
Water Supply Wells:													
O-1	01/08	1 UF	300	<30	<20	3	<3	14	<30	26	<3	37	172
O-1	01/08	R1 UF	277	<30	<20	<3	<3	5	<30	24	<3	43	135
O-4	06/25	1 UF	<2	<30	<20	3	<3	<3	<30	112	<3	14	76
PM-1	06/25	1 UF	<2	<30	<20	<3	<3	<3	<30	142	<3	11	<50
PM-2	06/25	1 UF	25	<30	<20	19	<3	<3	<43	40	<3	<8	173
PM-3	06/25	1 UF	<2	<30	<20	<3	<3	<3	<30	123	<3	<14	<50
PM-4	06/25	1 UF	<2	<30	<20	<3	<3	<3	<30	53	<3	<12	<50
PM-5	06/25	1 UF	<2	<34	<29	4	<3	<3	<30	47	<3	<8	<50
G-1A	06/25	1 UF	<2	<30	<20	<3	<3	<3	<30	74	<3	42	<50
G-2	06/25	1 UF	<2	<30	<20	<3	<3	<3	<65	80	<3	71	<50
G-4	06/25	1 UF	<2	<30	<20	<3	<3	<3	<30	102	<3	15	<50
G-5	06/25	1 UF	<2	<30	<20	<3	<3	<3	<30	80	<3	15	<50
G-6	06/25	1 UF	<2	<30	<20	<3	<3	<3	<30	79	<3	15	<50
Regional Aquifer Springs													
White Rock Canyon Group I:													
Sandia Spring	08/19	1 UF	38	<30	<20	<3	<3	<4	<30	313	<3	<8	<50
Spring 5	09/29	1 F	2	<30	<20	<3	<3		<30	87	<3	<11	<50

Table 5-22. Total Recoverable Trace Metals in Groundwater for 1997 (μg/L) (Cont.)

Station Name	Date	Codes[a]		Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
Regional Aquifer Springs (Cont.)														
White Rock Canyon Group II:														
Spring 6A	09/29	1	F	2	<30	<20	<3	<3		<52	58	<3	<8	<50
Spring 7	09/29	1	F	12	<30	<20	<3	<3		<30	100	<3	<8	<50
Spring 7	09/29	1	F	12	<30	<20	<3	<3		<77	104	<3	<8	<50
Spring 8B	09/30	1	F	7	<30	<44	<3	<3		<40	55	<3	<8	<50
Spring 9	09/30	1	F	<2	<30	<20	<3	<3		<113	49	<3	<8	<50
White Rock Canyon Group III:														
Spring 1	08/19	1	UF	<2	<30	<20	<3	<3	<4	<41	203	<3	12	<50
Spring 2	08/19	1	UF	4	<30	<20	<3	<3	<4	<30	175	<3	<8	<50
White Rock Canyon Group IV:														
La Mesita Spring	12/08	1	F	<2	<30	<20				<30	817		9	<50
Other Springs:														
Sacred Spring	07/08	1	UF	17	<30	<20	<3	<5	<3	<30	465	<3	<8	<50
Canyon Alluvial Groundwater Systems														
Acid/Pueblo Canyons:														
APCO-1	12/10	1	UF	37	<30	<20	<3	<3	<4	<30	101	<3	10	<50
Cañada del Buey:														
CDBO-6	06/16	1	UF	64	<30	<23	8	<3	<3	<30	111	<3	<8	<50
CDBO-7	06/16	1	UF	123	<30	<20	5	<3	<3	<30	122	<3	<8	<50
DP/Los Alamos Canyons:														
LAO-C	06/17	1	UF	<8	<30	<20	<3	<3	<3	<30	76	<3	<8	<50
LAO-0.7	06/18	1	UF	406	<30	<20	3	<3	<3	<30	89	<3	<8	<50
LAO-1	06/18	1	UF	9	<33	<20	<3	<3	<3	<30	85	<3	<8	<50
LAO-2	08/04	1	UF	2	624	<20	<3	3	<3	32	153	<3	<8	<50
LAO-3A	08/04	1	UF	2	643	<20	<3	<3	<3	<102	121	<3	<8	<50
LAO-4	08/04	1	UF	<2	174	<20	<3	<3	<3	35	106	<3	<8	<50
LAO-4.5C	08/04	1	UF	<2	<30	<20	<3	4	<3	<44	92	<3	<8	<50
LAO-6A	08/04	1	UF	<2	<30	<20	<3	<3	<3	40	105	<3	<8	<50

Table 5-22. Total Recoverable Trace Metals in Groundwater for 1997 (μg/L) (Cont.)

Station Name	Date	Codes[a]		Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
Canyon Alluvial Groundwater Systems (Cont.)														
Mortandad Canyon:														
MCO-3	08/07	1	UF	408	224	<20	9	<5	<3	47	55	<3	14	82
MCO-4B	08/05	1	UF	6	183	<20	<3	<6	<3	<30	114	<3	<8	<50
MCO-5	08/05	1	UF	<2	161	<20	<3	7	<3	<30	126	<3	<8	<50
MCO-6	08/05	1	UF	<2	172	<39	<3	<6	<3	<30	140	<3	<8	<50
MCO-7A	06/13	1	UF	<5	109	<26	<3	<3	<3	<30	165	<3	<8	<50
MCO-7.5	06/13	1	UF	<9	60	<20	<3	<3	<3	<30	165	<3	<8	<50
Pajarito Canyon:														
PCO-1	06/16	1	UF	8	<30	<20	<3	6	<3	<30	117	<3	<8	<50
Intermediate Perched Groundwater Systems														
Pueblo/Los Alamos Canyon Area:														
Test Well 1A	08/11	1	UF	70	<30	<20	5	<6	<3	<45	87	<3	<8	8,136
Test Well 2A	12/11	1	UF	6	<30	<20	<3	<3	<2	11	<3	<8	229	
Basalt Spring	08/14	1	UF	<2	<30	<34	<3	<3	<4	<30	98	<3	<8	<50
Perched Groundwater System in Volcanics:														
Water Canyon Gallery	12/01	1	UF	<2	<30	<20	<3	<3	<3	<30	49	<3	<8	<50
Pueblo of San Ildefonso:														
LA-1B	10/06	1	UF	12	<30	<33	<3	<3	<3	<30	64	<3	<8	<50
LA-5	07/07	1	UF	4	<30	<20	<3	<5	<3	<30	222	<3	12	<50
Eastside Artesian Well	10/06	1	UF	9	<30	<48	<3	<3	<3	<30	54	<3	<8	<50
Halladay House Well	08/13	1	UF	<3	<30	<20	<3	<3	5	<36	128	<3	18	<50
Pajarito Well (Pump 1)	07/08	1	UF	<2	<30	<20	<3	<8	<3	30	1,360	<3	16	<50
Don Juan Playhouse Well	10/06	1	UF	<2	<30	<20	<3	<3	<3	<30	88	<3	18	<50
Otowi House Well	10/06	1	UF	<2	<30	<41	<3	<3	<3	<34	873	<3	<8	251
New Community Well	07/07	1	UF	<2	<30	<20	<3	<5	<3	<30	201	<3	<8	<50
Sanchez House Well	07/08	1	UF	<2	<30	<20	<3	<5	<3	<30	346	<3	14	<50

Table 5-22. Total Recoverable Trace Metals in Groundwater for 1997 (μg/L) (Cont.)

Station Name	Date	Codes[a]	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
Water Quality Standards[c]													
EPA Primary Drinking Water Standard					100		6	50			2		
EPA Secondary DrinkingWater 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, 1–primary analysis, R1–lab replicate, D1–lab duplicate.

[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 5-23. Number of Results above the Analytical Limit of Quantitation for Organic Compounds in Groundwater for 1997

		Type of Organic Compound[a]			
Station Name	**Date**	**Volatile**	**Semivolatile**	**PCB**	**HE**
Number of Compounds Analyzed		66	71	8	13
Test Well 1	08/11	0	0	0	
Test Well 3	08/11	0	0	0	
Test Well 4	08/11	0	0	1	
Test Well DT-5A	03/07	0	0	0	0
Test Well DT-5A	05/13	0	0	0	0
Test Well DT-5A	10/16	0	0	0	0
Test Well DT-9	05/13	0	0	0	0
Test Well DT-9	10/15	0	0	0	0
Test Well DT-10	05/14	0	0	0	0
Test Well DT-10	10/16	0	0	0	0
Spring 3	11/18	0	0	0	
Spring 3AA	11/18	0	0	0	0
Spring 4A	11/18				0
Spring 5	09/29	0	0	0	0
Ancho Spring	11/19				0
Ancho Spring	11/19				0
Spring 6A	09/29	0	0	0	0
Spring 7	09/29	0	0	0	0
Spring 7	09/29	0	0	0	0
Spring 8B	09/30	0	0	0	0
Spring 9	09/30	0	0	0	0
APCO-1	12/10	0	0	0	
CDBO-6	06/16	0	0	0	
CDBO-7	06/16	0	0	0	
LAO-C	06/17	0	0	0	
LAO-0.7	06/18	0	0	0	
LAO-1	06/18	0	0	0	
LAO-2	08/04	0	0	0	
LAO-3A	08/04	0	0	0	
LAO-4	08/04	0	0	0	
LAO-4.5C	08/04	0	0	0	
LAO-6A	08/04	0	0	0	
MCO-3	08/07	0	0	0	
PCO-1	06/16	0	0	0	
Test Well 1A	08/11	0	0	0	
Test Well 2A	12/11	0	0	0	
Basalt Spring	08/14	0	0	0	
Water Canyon Gallery	12/01	0	0	0	

[a] Volatiles, semivolatiles, polychlorinated biphenyls, and high explosives.

Table 5–24. Quality Assurance Sample Results for Radiochemical Analysis in 1997 (pCi/L[a])

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	05/15	331	196[b]	–0.1[c]	1.0	1.4	0.3	0.03	0.01	0.019	0.011	0.008	0.009	0.101	0.025	1.1	0.3	8.4	1.4	27	47
DI Blank	06/12	–116	264	–0.2	0.9	0.9	1.3	0.06	0.01	0.003	0.010	0.003	0.010	0.020	0.017	0.0	0.0	0.2	0.6	28	48
DI Blank	06/17	240	710	0.6	1.2	1.1	1.6	0.08	0.01	0.065	0.024	0.079	0.025	0.035	0.022	0.2	0.6	0.4	0.9	62	47
DI Blank	06/25	470	710	–1.1	1.2	0.6	0.9	0.08	0.01	0.027	0.017	0.012	0.013	0.032	0.013	–0.1	0.2	0.1	0.4	48	47
DI Blank	07/09	110	770	–0.1	1.4	0.0	0.0	0.00	0.01	0.028	0.011	0.025	0.010	0.109	0.025	0.4	2.0	0.5	1.0	65	47
DI Blank	08/06	550	690	0.2	0.8	1.5	0.4	0.00	0.01					0.039	0.016	–0.1	0.2	–0.2	1.5	70	47
DI Blank	09/29	210	680																		
DI Blank	10/29			–0.3	0.9			0.00	0.01	–0.005	0.009	0.007	0.007	0.004	0.013	0.1	0.1	–0.2	0.7	–26	48
DI Blank	12/10	190	670	0.3	1.0	0.0	0.0	0.00	0.01	0.011	0.020	0.025	0.028	0.082	0.022	–0.1	0.1	0.1	0.2	71	49
DI Blank	12/12	–440	630	–0.4	0.9	1.1	1.7	0.00	0.01	0.007	0.007	0.009	0.008	0.036	0.012	0.1	0.2	–0.3	1.9	86	49
Analytical Detection Limit		700		3.0		4.0		0.10		0.040		0.040		0.040		3.0		3.0		120	
Average of Blank Value		172		–0.1		0.8		0.03		0.019		0.021		0.051		0.2		1.0		48	
Standard Deviation of Blank Value		301		0.5		0.6		0.04		0.022		0.025		0.037		0.4		2.8		34	
Std Dev of Blank/Detection Limit (should be <0.22)		0.43		0.17		0.14		0.36		0.54		0.62		0.93		0.13		0.93		0.28	
Spiked Sample	06/16			5.3	1.6	0.2	0.3	0.03	0.01	0.109	0.024	0.112	0.025	0.077	0.032	0.5	0.7	10.4	2.2	14	47
Spiked Sample	06/25			2.2	1.3	–0.8	0.0	0.03	0.01	0.056	0.029	0.109	0.030	0.039	0.022	0.5	0.9	9.0	2.1	–11	47
Spiked Sample	07/09			4.9	1.7	–0.7	0.2	–0.03	0.01	0.062	0.017	0.130	0.023	0.099	0.031	1.1	1.0	10.6	2.2	–39	47
Spiked Sample	08/12			5.4	1.4	–0.3	0.8	0.22	0.03	0.116	0.026	0.078	0.023	0.119	0.027	0.2	13.1	8.9	2.1	–65	47
Spiked Sample	10/01			8.2	2.5	1.0	2.7	–0.03	0.01	0.118	0.025	0.074	0.022	0.062	0.023	0.4	1.5	9.8	2.2	19	49
Spiked Sample	10/08	168	670	4.3	1.3	–0.2	0.2	0.00	0.01	0.076	0.021	0.123	0.025	0.087	0.028	11.6	1.5	12.3	0.8	1	48
Spiked Sample	11/25	238	720	5.9	1.3	–0.8	0.4	–0.03	0.01	0.122	0.027	0.106	0.025	0.094	0.029	0.8	1.0	11.0	2.0	53	49
Spiked Sample	12/03			4.5	1.3	2.0	0.5	–0.03	0.01	0.141	0.028	0.096	0.023	0.093	0.026	0.5	1.3	10.0	2.2	2	49
Average of Spiked Values		203		5.1		0.0		0.02		0.100		0.104		0.084		2.0		10.2		–3	
Standard Deviation of Spiked Values		49		1.7		1.0		0.09		0.031		0.020		0.024		3.9		1.1		36	
Spiked Concentration		0		5.0		0.0		0.00		0.100		0.100		0.100							
Calculated Detection Limit (Standard Deviation of Spikes × 4.66)				7.9						0.145		0.093		0.113							

[a] Except where noted.

[b] 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.

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

Table 5-25. Quality Assurance Sample Results for Metals Analysis in 1997 (μg/L)

Station Name	Date	Codes[a]	Ag	Al	As	B	Ba	Be	Cd	Co	Cr	Cu	Fe	Hg
DI Blank	05/15	UF	<10	<50	<2	<20	<1	<3	<7	<8	<7	<10	315	<0.3
DI Blank	06/12	UF	<10	<50	<2	<20	<1	<3	<7	<8	<7	<10	<40	<0.2
DI Blank	06/17	UF	<10	<50	<2	<28	<6	<3	<7	<8	<7	<10	<40	<0.2
DI Blank	06/25	UF	11	<50	<2	<20	<1	<3	<7	<13	<7	<10	<40	<0.2
DI Blank	07/09	UF	<10	<50	<2	<20	<1	<3	<7	<8	<7	11	<40	<0.2
DI Blank	08/06	UF	<10	<50	<2	<20	<1	<3	<7	<8	<7	<10	<40	<0.2
DI Blank	09/29	UF	<10	<50	<2	<20	<1	<3	<7	<8	<7	<10	<40	
DI Blank	12/10	UF	<10	<50	<2	26	1	<3	<7	<8	20	<10	155	<0.2
DI Blank	12/12	UF	<10	<50	<2	<20	<1	<3	<7	<8	<7	<10	<40	<0.2
Spiked Sample	06/16	UF	26	79	<2	<20	512	<3	<7	<8	<7	<10	44	2.3
Spiked Sample	06/25	UF	30	<50	<2	<20	493	<3	<7	<8	<7	<10	<40	3.1
Spiked Sample	07/09	UF	23	<50	<2	<20	510	<3	<7	<8	<7	11	53	2.8
Spiked Sample	08/12	UF	22	<50	<2	<20	498	<3	<7	<8	<7	<10	<40	3.2
Spiked Sample	10/01	UF	21	<50	<2	<20	490	<3	<7	<8	<7	<10	59	
Spiked Sample	10/08	UF	22	<50	<2	50	526	<3	<7	<8	<7	<10	67	<0.2
Spiked Sample	11/25	UF	41	727	<2	118	480	3	44	49	42	33	41	3.1
Spiked Sample	12/03	UF	13	<50	<2	<20	492	<3	<7	<8	<7	<10	<40	
Average of Spiked Values			25				500							2
Standard Deviation of Spiked Values			8				15							1
Spiked Concentration			25				500							5.0

Table 5-25. Quality Assurance Sample Results for Metals Analysis in 1997 (μg/L) (Cont.)

Station Name	Date	Codes[a]	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
DI Blank	05/15	UF	<2	<30	<20	<3	<3	<3	<30	<2	<3	<8	<50
DI Blank	06/12	UF	<2	<30	<20	<3	<3	<3	<30	<2	<3	<8	<50
DI Blank	06/17	UF	<2	<30	<20	<3	<3	<3	<30	5	<3	<8	<50
DI Blank	06/25	UF	<2	<30	<20	<3	<3	<3	<30	<2	<3	<8	<50
DI Blank	07/09	UF	<2	<30	<20	<3	<5	<3	<30	2	<3	<8	<50
DI Blank	08/06	UF	<2	<30	<20	<3	<3	<3	<45	<2	<3	<8	<50
DI Blank	09/29	UF	<2	<30	<20	<3	<3		43	<2	<3	<8	<50
DI Blank	12/10	UF	<2	<30	<40	<3	<3	<4	<30	<2	<3	<8	<50
DI Blank	12/12	UF	<2	<30	<20	<3	3	<2	<30	3	<3	<8	63
Spiked Sample	06/16	UF	<2	<30	<20	8	<3	<3	<30	3	<3	<8	<50
Spiked Sample	06/25	UF	<2	<30	<20	7	<3	<3	<30	<2	<3	<8	<50
Spiked Sample	07/09	UF	3	<30	<20	9	<3	<3	<49	6	<3	<8	<50
Spiked Sample	08/12	UF	<2	<30	<20	7	<6	<3	<30	<2	<3	<8	<50
Spiked Sample	10/01	UF	<2	<30	<34	9	<3		35	<2	<3	<8	<50
Spiked Sample	10/08	UF	<2	<30	<20	8	<3	<4	<30	<2	<3	<8	<50
Spiked Sample	11/25	UF	50	50	<32	10	<3	<3	<30	55	<3	19	<50
Spiked Sample	12/03	UF	<2	<30	<20	8	<3		<30	<2	<3	<8	<50
Average of Spiked Values						8							
Standard Deviation of Spiked Values						1							
Spiked Concentration						7.5							

J. Figures

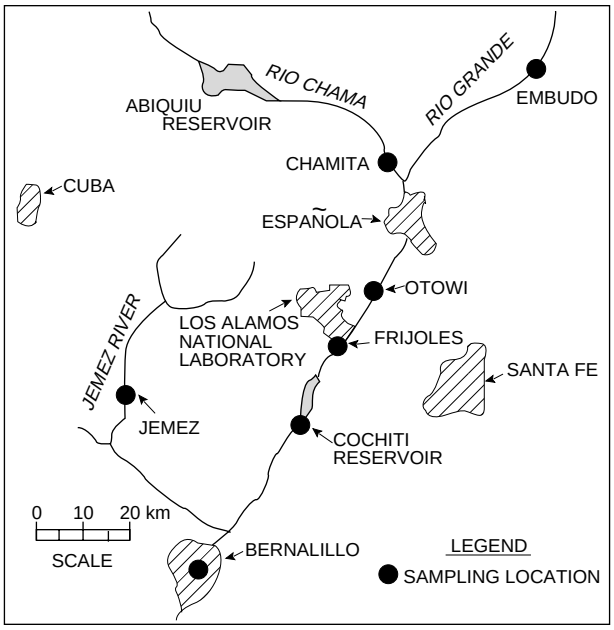

Figure 5-1. Regional surface water and sediment sampling locations.

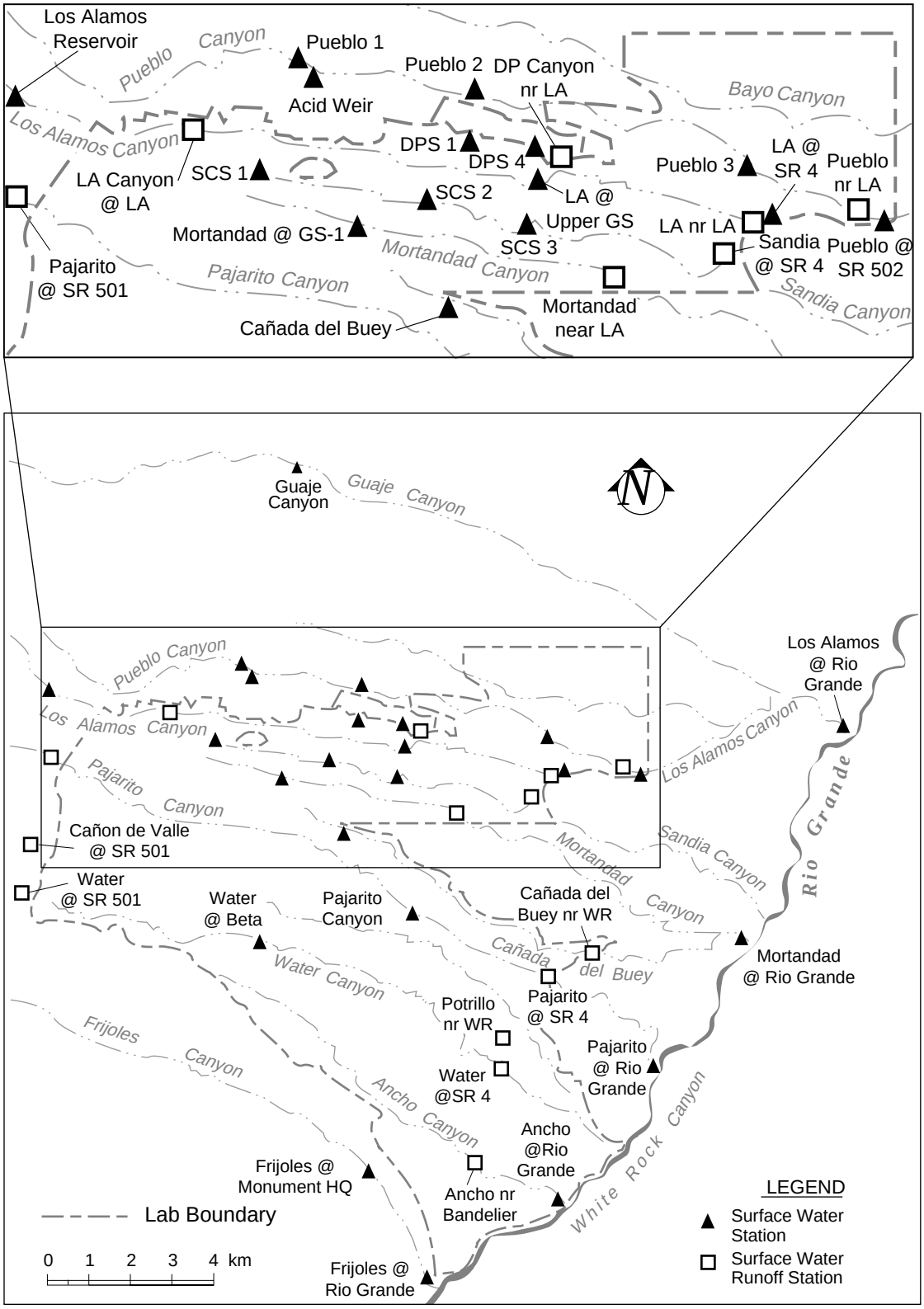

Figure 5-2. Surface water sampling locations in the vicinity of Los Alamos National Laboratory.

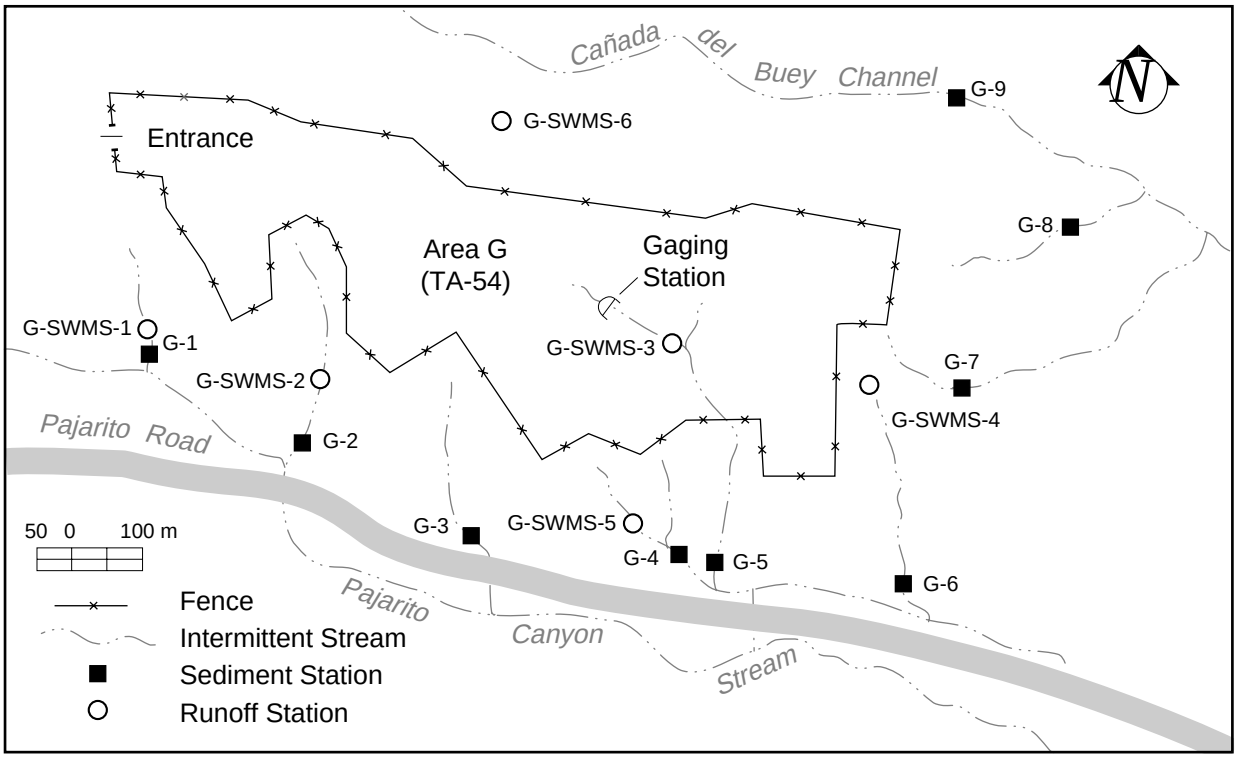

Figure 5-3. Sediment and runoff sampling stations at TA-54, Area G.

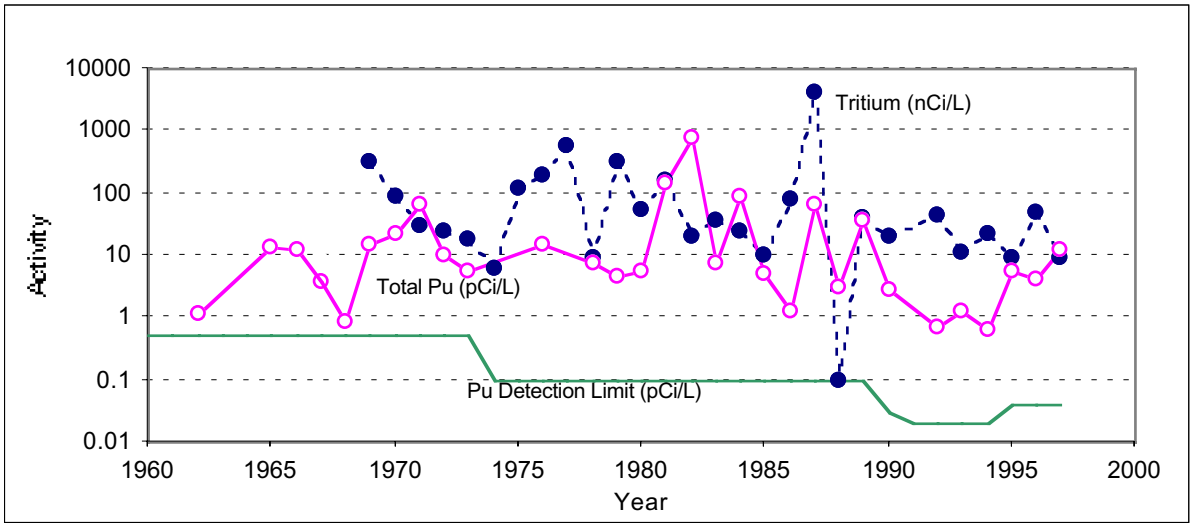

Figure 5-4. Tritium and plutonium activity at Mortandad Canyon at Gaging Station 1.

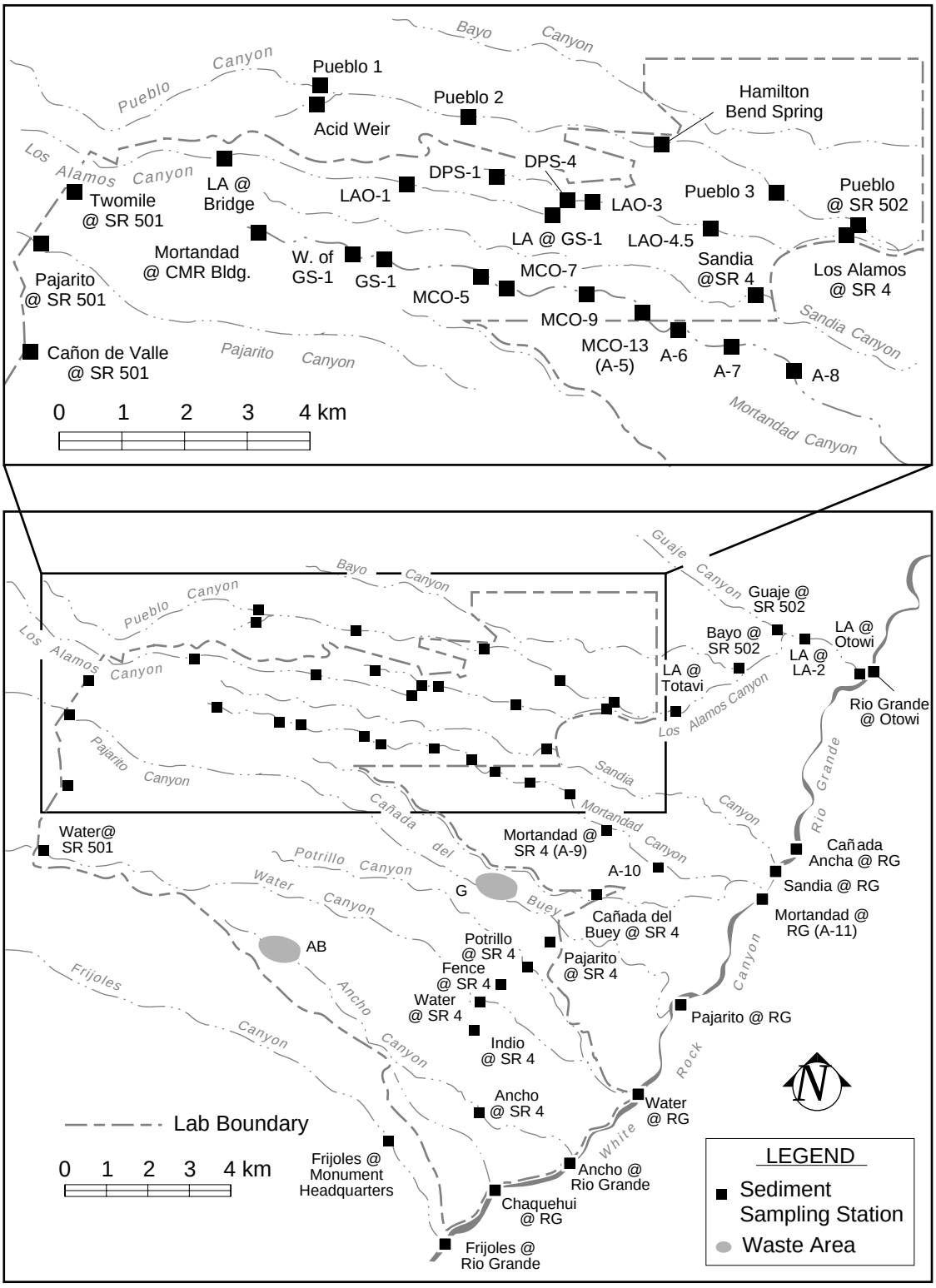

Figure 5-5. Sediment sampling stations on the Pajarito Plateau near Los Alamos National Laboratory. Solid waste management areas with multiple sampling locations are shown in Figures 5-3 and 5-6.

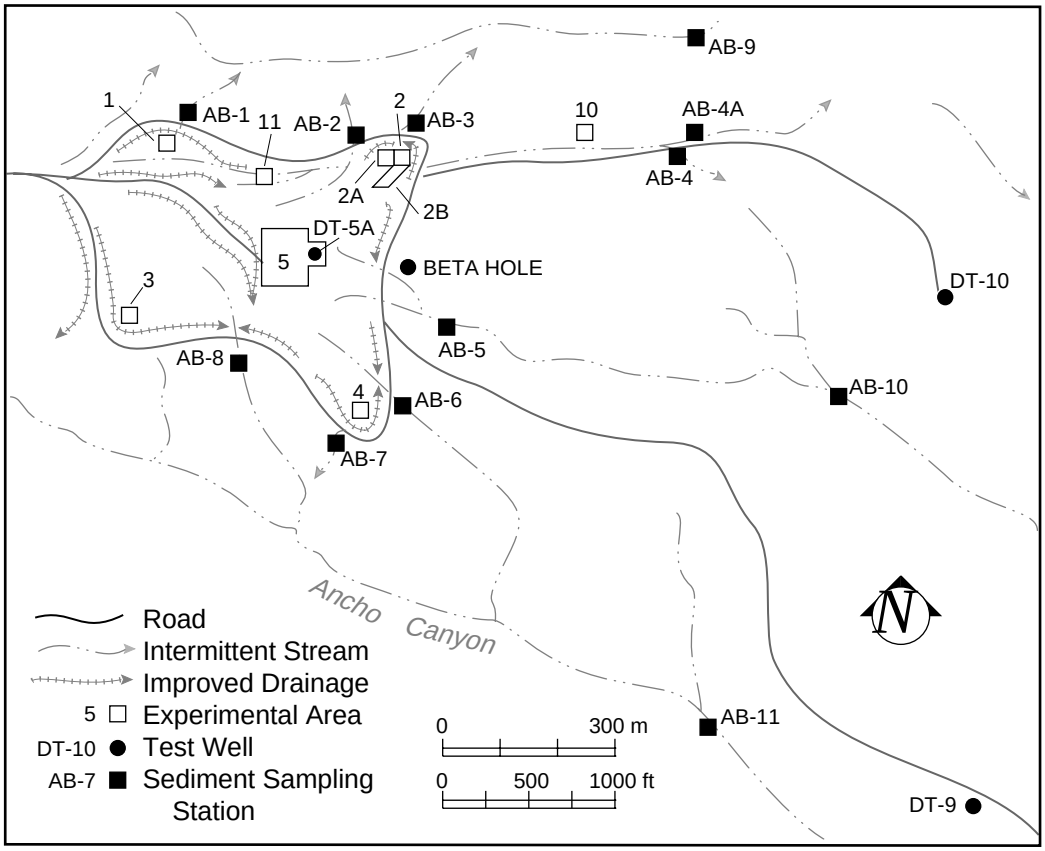

Figure 5-6. Sediment sampling stations at TA-49, Area AB.

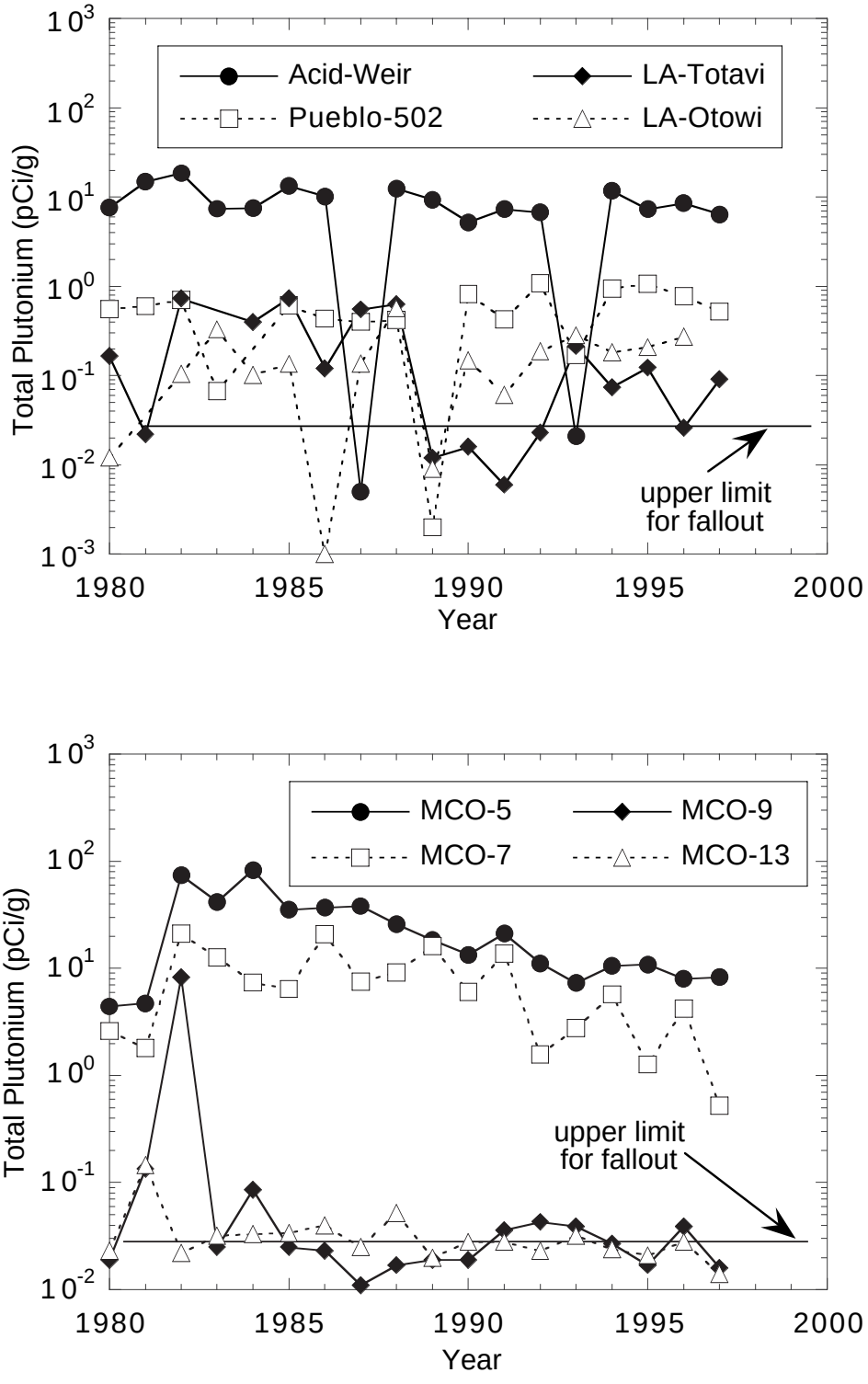

Figure 5-7. Total plutonium activity in Pueblo (top) and Mortandad (bottom) Canyons channel sediments.

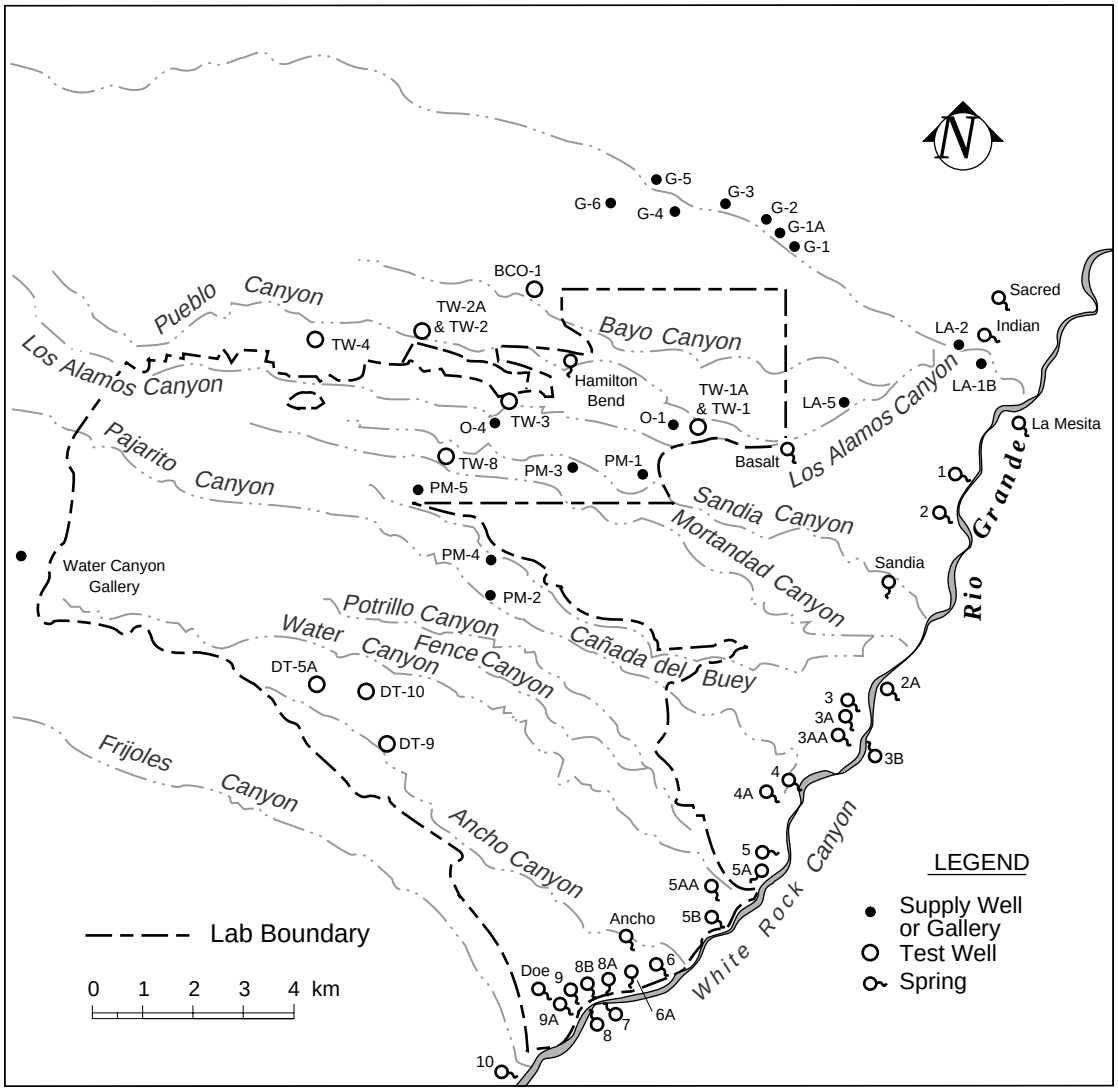

Figure 5-8. Springs and deep and intermediate wells used for groundwater sampling.

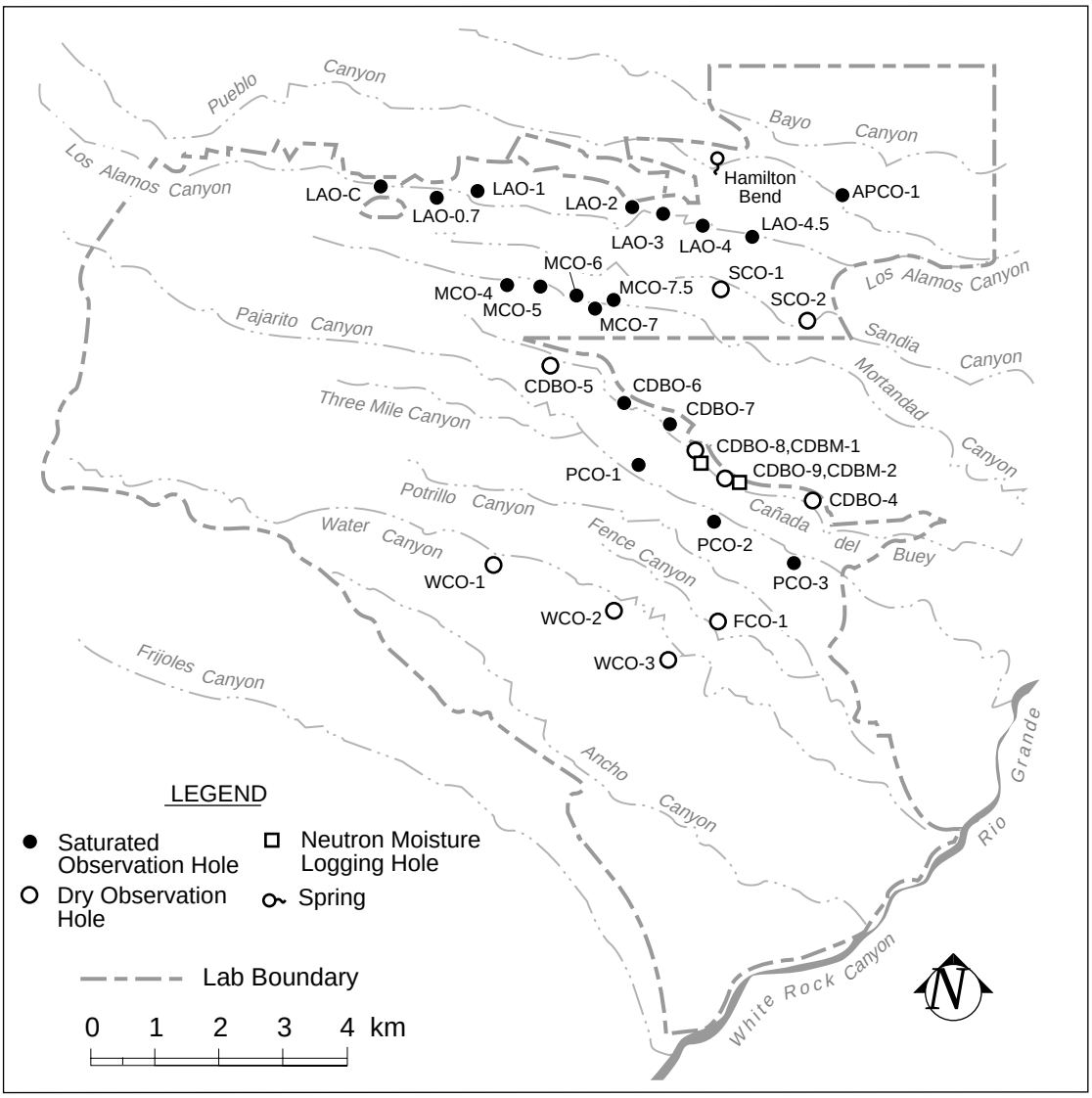

Figure 5-9. Observation wells and springs used for alluvial groundwater sampling and shallow neutron moisture holes.

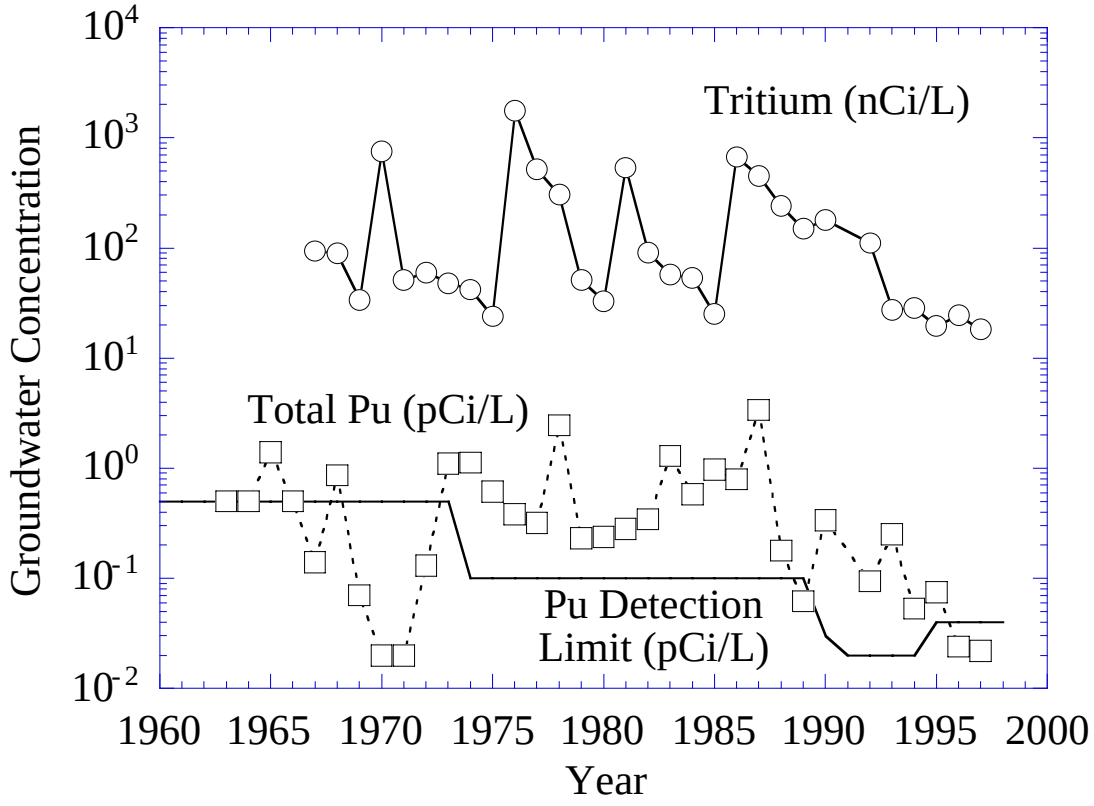

Figure 5-10. Tritium and plutonium concentrations in water samples from Mortandad Canyon Alluvial Observation Well MCO-6.

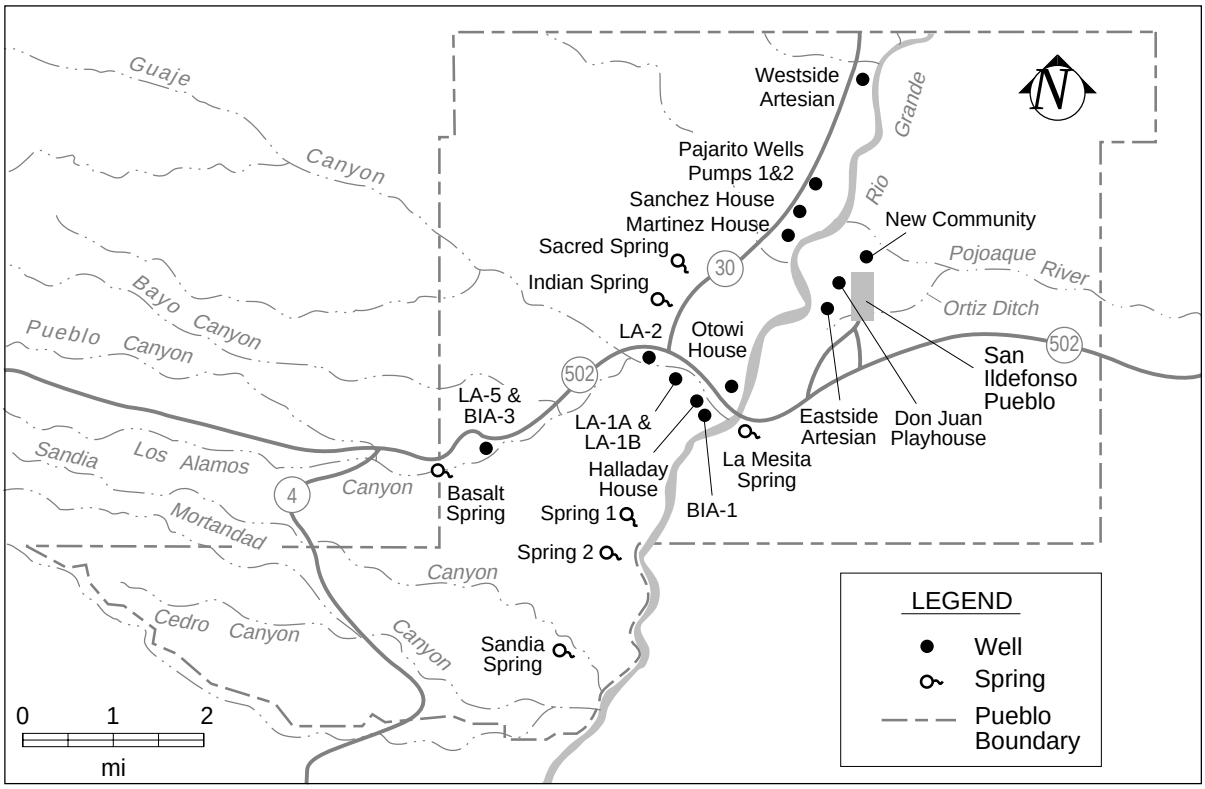

Figure 5-11. Springs and groundwater stations on or adjacent to Pueblo of San Ildefonso land.

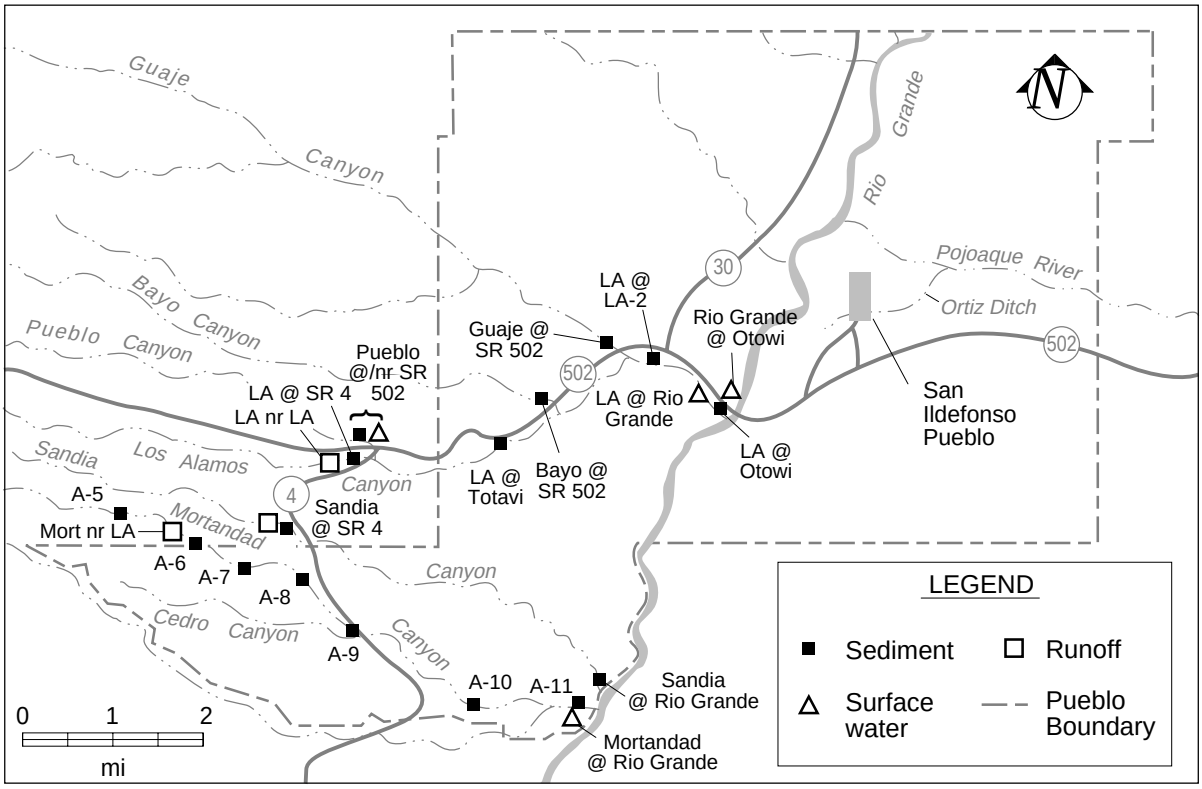

Figure 5-12. Sediment and surface water stations on or adjacent to Pueblo of San Ildefonso land.

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6. Soil, Foodstuffs, and Associated Biota

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Highlights from 1997

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 to regional background locations in northern New Mexico. Radionuclides in soils collected from regional background areas are from natural sources and/or worldwide fallout. Most radionuclide concentrations in soils collected from on-site and perimeter areas were within or just above the range of background concentrations and were far below LANL screening action levels (SALs). Trend analysis show that most radionuclides, with the exception of plutonium-238, in soils from on-site and perimeter areas significantly decreased over time so that by 1997 most radionuclides in soils from on-site and, especially from perimeter areas, have values similar to soils collected from regional background locations. These trends were especially apparent for tritium and uranium in soils from on-site areas. Soils were also analyzed for trace and heavy metals, and most metals were within the range of background concentrations and well below LANL SALs.

Foodstuffs and biota samples (milk, eggs, fruits, vegetables, honey, elk, deer, fish, herbal tea, piñon, and beef cows) were collected either 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. Foodstuffs and biota samples from the Laboratory, with the exception of wild edible plants and fruits from Mortandad Canyon, and perimeter locations showed no radioactivity that could be distinguished from regional background levels. Wild edible plants and fruits collected along the length of Mortandad Canyon contained concentrations of strontium-90; cesium-137; plutonium-238; plutonium-239, -240; and americium-241 above background concentrations. Also, some radionuclides in bone of elk and deer tended to be just above upper limit background levels. Most heavy metal elements in produce collected from Laboratory and perimeter areas were within background concentrations.

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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 and proposed 10 CFR 834. Soil provides an integrating medium that can account for contaminants released to the atmosphere, either directly in gaseous effluents (e.g., air stack emissions) or indirectly from resuspension of on-site contamination (e.g., firing sites), or through liquid effluents released to a stream that is subsequently used for irrigation. The knowledge gained from a soil radiological sampling program is critical for providing information about potential pathways (e.g., 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., 1998). This program evaluates radionuclides, radioactivity, and nonradionuclides (heavy metals) in soils collected from regional (background) locations, around the perimeter of the Laboratory, and on-site (Los Alamos National Laboratory—LANL or the Laboratory). On-site and perimeter areas are compared to regional background areas—these background areas are distant from the Laboratory, and their radionuclide and nonradionuclide contents are 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 background locations (3 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)—any discernible site at which solid and/or liquid wastes have been routinely and systematically released (e.g., waste tanks, septic tanks, sumps, firing sites, burn pits, sumps, material disposal areas (such as Technical Area [TA] 54, Area G). Instead, the majority of on-site soil-sampling stations are located close to, and downwind from if possible, major facilities and/or operations at LANL in an effort to assess radionuclides, radioactivity, and heavy metals in soils that may have been contaminated as a result of air stack emissions and fugitive dust (e.g., the resuspension of dust from SWMUs and active firing sites). The ten perimeter stations are located on the north (four), east (four), west (one) and southwest (one) side of the Laboratory. All areas are compared to soils collected from background locations in northern NM where radionuclides, radioactivity, and heavy metals are from natural and/or worldwide fallout events; these areas are located around the Embudo, Cochiti, and Jemez areas.

a. Regional Background Stations. The regional background stations for soils are located in northern New Mexico surrounding the Laboratory: Embudo to the north, Cochiti to the south; and Jemez to the west. All are more than 32 km from the Laboratory and are beyond the range of potential influence from normal Laboratory operations (DOE 1991).

b. Perimeter Stations. Ten soil sampling stations are located within 4 km of the Laboratory. These stations are located 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.

c. On-Site Stations. Soil samples are collected from 12 on-site stations; they are mostly located near and downwind from Laboratory facilities that are the principal sources of airborne emissions or fugitive dust at LANL.

3. Sampling Procedures, Data Management, and Quality Assurance

Collection of samples for chemical and radiochemical analyses follows a set procedure to ensure proper sample collection, processing, submittal for chemical analyses, and posting of analytical results. Stations and samples are assigned a unique identifier to provide chain-of-custody control during the transfer of samples 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, RO, 1997.

4. Radiochemical Analytical Results

Table 6-1 shows data from soils collected in 1997. Most radionuclide concentrations and radioactivity in soils collected from on-site and perimeter stations were within regional statistical reference levels (RSRLs). The RSRL is the (95%) upper limit background concentration (mean plus two standard deviations from data collected from Embudo, Cochiti, and Jemez from 1993 through 1997) for worldwide fallout of tritium; strontium-90; cesium-137; americium-241; plutonium-238; and plutonium-239, -240; total uranium; and gross alpha, beta, and gamma radioactivity. The average concentrations of strontium-90; total uranium; plutonium-239, -240; and americium-241 in on-site and perimeter soils were just above RSRLs. These values, however, were low and they were far below LANL screening action levels (SALs). LANL SALs, developed by the Environmental Restoration Project at the Laboratory, are used to identify the presence of contaminants of concern and are derived from a risk assessment pathway using a 10-mrem per year dose.

The slightly higher radionuclide concentrations of strontium-90; total uranium; plutonium-239, -240; and americium-241 in soils collected from on-site and perimeter areas as compared to regional background locations may be, in part, due to Laboratory operations, but probably more to worldwide fallout from nuclear weapons testing, the burn up of a satellite power source in the atmosphere, and reactor accidents (e.g., Chernobyl). In the case of uranium, the slightly higher concentrations ar probably due to naturally occurring minerals in the earth's crust. Radionuclides due to fallout vary from one area to

another depending on wind patterns, elevation, and precipitation (Whicker and Schulz, 1982). Usually, higher amounts of radionuclides from fallout occur at higher elevations that receive greater amounts of precipitation than in areas at lower elevations that receive lower amounts of precipitation. Most of the regional areas, for example, ranged from 5,600 ft to 6,300 ft above sea level and have an average rainfall of approximately 10 in. per year (Bowen 1990). By contrast, the on-site and perimeter areas were located above 7,200 ft above sea level and receive about 19 in. of rainfall on average per year. The higher levels of uranium detected in the soils collected from the on-site and perimeter areas as compared with background areas may be a result of differences in the geology or mineralogy of the soils between the two sites. Soils in the Los Alamos area are derived from Bandelier (volcanic) tuff and have higher-than-average natural uranium contents, ranging from 3 to 11 µg of uranium per gram of soil (Crowe et al., 1978).

5. Nonradiochemical Analytical Results

Soils were also analyzed for trace and heavy metals. These data will be used to establish a database and are meaningful from a Laboratory operation/effects standpoint. The results of the 1997 soil sampling program can be found in Table 6-2.

All concentrations of heavy metals measured in soils collected from perimeter and on-site 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). Results of cadmium, mercury, and antimony were not reported this year (see Table 6-2) because the minimum detection levels (MDLs) reported for these metals were higher than what has been normally employed in the past and, therefore, could not be compared to past results. All cadmium, mercury, and antimony results from soils collected from perimeter and on-site areas, however, were similar to background.

6. Long-Term Trends

All soils collected from on-site and perimeter stations from 1974 through 1996 were subjected to a Mann-Kendal test for trend analysis (Fresquez et al., 1998). Although some radionuclide and radioactivity levels were generally higher in perimeter and on-site soils as compared with background, 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 time 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 (e.g., 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 radionuclides and radioactivity 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

There is a high diversity of wild and domestic edible plant, fruit, and animal products that are grown and/or are 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, piñon, domestic animals, and elk and deer bone and meat are collected annually from Laboratory property. This Foodstuffs and Biota Monitoring program is mandated by DOE Orders 5400.1 and 5400.5, and proposed 10 CFR 834. The two main objectives of the program are to (1) determine and compare radioactive and heavy metals constituents in foodstuffs and biota between on-site LANL and perimeter areas with regional background area; and (2) calculate a committed effective dose equivalent (CEDE) to surrounding area residents (e.g., Los Alamos townsite, White Rock/Pajarito Acres

townsite, the Pueblo of San Ildefonso, and Cochiti Pueblo). Potential radiation doses to individuals from the ingestion of foodstuffs are presented in Chapter 3.

2. Produce

a. Monitoring Network. Fruits, vegetables, and grains are collected each year from on-site (Laboratory), perimeter (Los Alamos townsite and White Rock/Pajarito Acres), 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 are compared to 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 the 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 (Salazar 1984). All QA/QC protocols, chemical analysis, 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, RO, 1997.

c. Radiochemical Analytical Results. Concentrations of radionuclides in produce collected from on-site, perimeter, and regional background locations during the 1997 growing season can be found in Table 6-3. Most radionuclide concentrations in fruits and vegetables collected from on-site (mesa tops) and perimeter areas were less than the RSRL, defined as the upper (95%) limit background concentration (mean plus two standard deviations) for worldwide fallout of tritium; strontium-90; cesium-137; americium-241; plutonium-238; and plutonium-239, -240; and total uranium compiled from 1993 to 1997. Only a few radionuclide values at a few sites, from the Los Alamos townsite (tritium; plutonium-238; and plutonium-239, -240) and White Rock/Pajarito Acres (plutonium-239, -240 and americium-241) townsites, were higher than the RSRL (see Table 6-3). In most instances, however, they were just above the RSRL, and the higher concentrations are probably a reflection of incomplete washing procedures rather than contamination effects from the Laboratory. Also, as in past years, tritium appears to be higher in on-site and Los Alamos townsite produce samples than in regional background samples.

In contrast to produce samples collected from the mesa-top areas, concentrations of most radionuclides, with the exception of tritium and total uranium, in wild edible plants and fruits collected along the length of Mortandad Canyon were above the RSRLs. Almost all of the radionuclides in these edible wild plants and fruits were elevated above produce commonly collected from regional background locations. Cesium-137 ranged from 0.02 pCi per gram dry in currants to a high of 2.7 pCi per gram dry in acorns; strontium-90 ranged from 0.05 to a high of 9.4 pCi per gram dry in strawberries; and, wild rhubarb contained the highest concentrations of total uranium (36 ng per gram dry); plutonium-238 (9.9 pCi per gram dry); plutonium-239, -240 (10.6 pCi per gram dry); and americium-241 (24.0 pCi per gram dry). These results are similar to a study conducted in Los Alamos Canyon in 1996 (Fresquez et al., 1998), in that the concentrations of most radionuclides measured in most produce samples collected from both canyons were far above background concentrations. In general, levels of strontium-90 and cesium-137 in produce from Mortandad Canyon were lower in concentration than levels detected in pinto beans, zucchini squash, and sweet corn grown in Los Alamos Canyon, whereas total uranium; plutonium-238; plutonium-239, -240; and americium-241 concentrations in wild edible plants and fruits, particularly wild rhubarb, collected in Mortandad Canyon were generally higher than concentrations in produce grown in Los Alamos Canyon.

d. Nonradiochemical Analytical Results. Most trace and heavy metal elements, particularly silver, arsenic, beryllium, cadmium, mercury, antimony, selenium, and thallium in produce from on-site, perimeter, and regional locations were below the limit of detection (Table 6-4). In those cases where produce samples contained some metals above the limit of detection (e.g., barium, chromium, nickel, and lead), only a few samples exceeded the RSRL. However, none of the means for barium, chromium, nickel, and lead in produce from any of the sites were higher than the RSRL.

3. Honey

a. Monitoring Network. Beehives located within perimeter areas—Los Alamos townsite and White Rock/Pajarito Acres—are sampled on an annual basis for honey (Figure 6-2). Honey from these hives is compared to honey collected from regional background hives located in northern New Mexico.

b. Sampling Procedures, Data Management, and Quality Assurance. Honey is collected directly from the beekeepers. The honey samples in glass quart jars are submitted under full chain-of-custody to CST-9 for radiochemical analyses of tritium, total uranium, strontium-90, plutonium-238, plutonium-239, -240, americium-241, and cesium-137. All QA/QC protocols, chemical analysis, 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.

c. Radiochemical Analytical Results. Results of the analysis of honey collected during the 1997 season are presented in Table 6-5. Most radionuclide concentrations in honey collected from perimeter hives were below RSRLs, with the exception of strontium-90 from Los Alamos. The strontium-90 value in honey collected from Los Alamos, however, was not a detectable value (i.e., where the result is greater than two times the counting uncertainty).

4. Eggs

a. Monitoring Network. Fresh eggs are collected from free-range chickens from the Los Alamos townsite area and from the Pueblo of San Ildefonso. These eggs are compared to eggs produced from free-range chickens located in the Española area (background).

b. Sampling Procedures, Data Management, and Quality Assurance. Approximately 24 medium-sized eggs from Los Alamos townsite, Pueblo of San Ildefonso, and Española (background) were collected directly from the farmer, transported in Styrofoam containers to the Laboratory, and submitted under chain-of-custody to CST-9 for the analysis of tritium; total uranium; strontium-90; plutonium-238; plutonium-239, -240; americium-241; and cesium-137. All QA/QC protocols, chemical analysis, 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, RO, 1997.

c. Radiochemical Analytical Results. Results of radionuclide concentrations detected in eggs collected from Los Alamos townsite, the Pueblo of San Ildefonso, and Española area can be found in Table 6-6. All radionuclide values in eggs collected from Los Alamos townsite and the Pueblo of San Ildefonso were less than the RSRLs.

5. Milk

a. Monitoring Network. Goat's milk was collected from the Los Alamos townsite and cow's milk was collected from the closest working dairy—approximately 40 km away—from the Laboratory. Milk from these areas was compared to milk collected from a dairy located in Albuquerque, NM.

b. Sampling Procedures, Data Management, and Quality Assurance. Milk is collected directly from the dairies in the Pojoaque Valley and from Albuquerque and submitted to CST-9 in the original containers for the analysis of tritium; uranium; strontium-90; plutonium-238; plutonium-239, -240; iodine-131; and cesium-137. Goat milk was collected directly from the producer in Los Alamos (this milk is for family use and is not sold to the public). All QA/QC protocols, chemical analysis, data handling, validation, and tabulation can be found in the ESH-20 OP entitled, "Milk/Tea Sampling and Processing for the Foodstuffs Monitoring Program," LANL-ESH-20-SF-OP-005, RO, 1997.

c. Radiochemical Analytical Results. The results of the radiochemical analysis performed on milk collected from the Pojoaque Valley and Albuquerque (background) during 1997 are summarized in Table 6-7. Concentrations of plutonium-239, -240; tritium; cesium-137; and iodine-131 in goat's milk collected from the Los Alamos townsite were just above RSRLs determined for cow's milk. However, of these radionuclides, only plutonium-239, -240 was a detectable value (a concentration where the result is greater than two times its counting uncertainty) and should be viewed with caution because these results were compared to cow's milk and not to goat's milk; and goats tend to forage on a wider diversity of plants than dairy cows and the milk would be expected to have a different chemistry makeup. Most radionuclide concentrations in milk collected from the Pojoaque Valley, with the exception of tritium, although the value was not considered a detectable value, were within RSRLs. Results were similar to those obtained in previous years, neither increasing nor decreasing trends are evident. Tritium and strontium-90 levels, in

particular, compare well with tritium and strontium-90 levels in milk from other background states around the Country (Black et al., 1994).

6. Fish

a. Monitoring Network. Fish are collected 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 Laboratory. Radionuclides in fish collected from Cochiti Reservoir are compared to fish collected from background reservoirs. Abiquiu, Heron, and El Vado reservoirs 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 are collected by gill nets (Salazar 1984) and transported under ice to the laboratory for preparation. At the laboratory fish are gutted, head and tails removed, and washed. Muscle (plus associated bone) tissue is processed; wet, dry, and ash weights are determined, and ash is submitted for analysis. Concentrations of tritium; total uranium; strontium-90; plutonium-238; plutonium-239, -240; americium-241; and cesium-137 are determined. All results are reported on an oven-dry-weight basis (dry g). Heavy and trace metals in fish were also analyzed (this year only mercury was determined). The complete fish are submitted under full chain of custody directly to CST-9 for metals analysis. Results are reported on a wet basis. All QA/QC protocols, chemical analysis, 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, RO, 1997.

c. Radiochemical Analytical Results. Concentration of radionuclides in game and nongame fish collected upstream and downstream of the Laboratory in 1997 are presented in Table 6-8. In general, the concentrations of most radionuclides in game and nongame fish collected from Cochiti reservoir were not higher than RSRLs from similar fish collected from Abiquiu reservoir. These results compare well with radionuclide contents in crappie, trout, and salmon from comparable (background) reservoirs and lakes in Colorado (Whicker et al., 1972, Nelson and Whicker 1969).

The only radionuclide that was found to be higher in fish from Cochiti Reservoir as compared to background fish from Abuiquiu reservoir was uranium in nongame fish. Past studies on uranium in fish from Cochiti reservoir have shown that the uranium is of natural origin. The isotopic ratio of uranium-235 to uranium-238 in Cochiti bottom-feeding fish collected during 1993 (1.25×10^{13} atoms uranium-235/ash g to 1.74×10^{15} atoms uranium-238/ash g) and 1994 (1.20×10^{13} atoms uranium-235/ash g to 1.65×10^{15} atoms uranium-238/ash g) were consistent with naturally occurring uranium (i.e., 0.0072 ratio). In other words, there was no evidence of depleted uranium—a by-product of uranium enrichment processes—in fish samples collected from Cochiti Reservoir in past years, although depleted uranium has been used in dynamic weapons testing at LANL firing sites since the mid-1940s (Becker 1992). Also, there was no evidence of uranium-236; this isotope does not occur in nature and is indicative of the presence of anthropogenic (man-made) uranium. The higher concentrations of uranium in nongame fish from Cochiti can be attributed to one or more of the following: (1) Cochiti receives greater amounts of sediments than the other reservoirs (ESP 1995), (2) there are more uranium-bearing minerals around the Cochiti area (e.g., uranium in Bandelier Tuff around the Los Alamos area ranges in concentration from 4.0 to 11.4 µg per gram [Crowe et al., 1978]) than in areas upstream of Cochiti (e.g., uranium in soils from northern New Mexico ranges in concentration from 1.3 to 4.05 µg per gram [Purtymun et al., 1987; Fresquez et al., 1996]), and (3) some uranium may be entering Cochiti Reservoir via the Santa Fe River as this river flows past the edge of an abandoned 25-acre uranium mine site (La Bajada Uranium Mine) approximately 9.7 km upstream and northeast of Cochiti Reservoir (Fresquez and Armstrong 1996).

As expected, the nongame fish from both downstream and upstream reservoirs from LANL contained higher average uranium contents (17.2 ng per dry gram) than the surface-feeders (2.6 ng per dry gram).

The higher concentration of uranium in bottom-feeders as compared to surface-feeders is attributed to the ingestion of sediments on the bottom of the lake (Gallegos et al., 1971). Sediments represent the accumulation or sink compartment for most radionuclides (Whicker and Schultz 1982).

d. Long-Term Trends. Fresquez et al., (1994a) 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 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 as compared to 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. Based on the average concentration of radionuclides over the years, the net positive CEDE from consuming 21 kg per year (46 lb per year) of game fish and nongame fish from Cochiti reservoir after natural background has been subtracted was 0.005 and 0.009 mrem per year, respectively. The highest dose was <0.01% of the International Commission on Radiological Protection (ICRP) permissible dose limit for protecting members of the public.

e. Nonradiological Analytical Results. The results of the heavy metal 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. For this reason, mercury was the only element analyzed in fish in 1997. Results can be found in Table 6-9. All concentrations of mercury in fish from Cochiti Reservoir were within the RSRL (<0.41 µg per gram wet). Mercury concentrations in fish occurring in lakes and reservoirs in the State of New Mexico have been of significant concern to the public for several years. However, based on six years of data, mercury concentrations in fish upstream of LANL, have been consistently higher, albeit slightly, than mercury concentrations downstream of the Laboratory. Also, mercury levels in all fish collected from Cochiti and Abiquiu Reservoirs were lower than 0.50 µg per gram wet which is typical of nonpolluted fresh water systems (Abernathy and Cumbie 1977).

7. Game Animals (Elk and Deer)

a. Monitoring Network. Samples of elk and deer are collected as road kill on an annual basis from Laboratory areas and the meat and bone is analyzed for a host of radionuclides. These data, from meat and bone samples, were compared to 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 are collected (1,000 g each) from fresh road kills around and within the Laboratory. Background samples are collected from the New Mexico Department of Game and Fish during this same period of time. Samples are submitted to CST-9 for the determination of tritium; total uranium; strontium-90; plutonium-238; plutonium-239, -240; cesium-137; and americium-241. All results are reported on an oven-dry-weight basis (dry per gram). All QA/QC protocols, chemical analysis, 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. Results of road kill elk and deer collected during 1996 and 1997 can be found in Tables 6-10 and 6-11.

Most radionuclides, with the exception of strontium-90 and plutonium-239, -240, found in muscle tissue of elk collected from LANL lands were within RSRLs (Table 6-10). Of the strontium-90 and plutonium-239, -240 concentrations that were in higher concentrations in muscle of elk from LANL lands as compared to the RSRLs, only the strontium-90 values were at detectable levels (i.e., where the analytical result was higher than two times the counting uncertainty). Most of the plutonium-239, -240 levels in muscle from LANL elk that were higher than the RSRL's, on the other hand, were nondetectable values. Although the levels of strontium-90 in bone tissues of elk from on-site areas were higher in concentration than the current year's regional background mean concentration, they were still well within the upper limit background concentration (e.g. the RSRL). Another radionuclide that appears to be in higher concentrations in bone tissue of elk collected from LANL lands as compared

to regional background was uranium, although only two of the five uranium values in elk bone from LANL elk (that were higher than the RSRL) were detectable values.

Most radionuclides in muscle tissue of deer collected from LANL lands were within RSRLs (Table 6-11). With regard to bone tissue of deer on LANL lands, some radionuclides, particularly plutonium-238 and plutonium-239, -240, were in higher concentrations than the RSRL; most of these values, however, were not at detectable levels (i.e., the values were less than two times the counting uncertainty). Nevertheless one of these animals (TA-53, LANSCE Road) had three out of seven radionuclides higher than the RSRL's in the bone tissue samples.

8. Domestic Animals.

a. Monitoring Network. Cattle owned by the Pueblo of San Ildefonso graze the boundaries of LANL on a regular basis and are offered by the Pueblo for sampling and analysis. Meat and bone tissue collected from the beef cattle from the Pueblo of San Ildefonso are compared to 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 the Pueblo of San Ildefonso lands during the 1997 year can be found in Table 6-12. In general, most radionuclides, with the exception of plutonium-239, -240 in muscle and total uranium in bone, of a domestic steer collected from the Pueblo of San Ildefonso were within RSRLs. Of these two elements, only total uranium, was a detectable value (the analytical result was greater that two times the counting uncertainty).

9. Herbs/Tea

a. Monitoring Network. Navajo Tea (Cota) was collected 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 area and used as a background value.

b. Sampling Procedures, Data Management, and Quality Assurance. Tap water is added to the vegetative portion of Navajo Tea and brought to a boil. After the tea is cooled it is poured into a suitable container and submitted to chemistry as a liquid. All QA/QC protocols, chemical analysis, and data handling, validation and tabulation can be found in the ESH-20 OP entitled, "Milk/Tea Sampling and Processing for the Foodstuffs Monitoring Program," LANL-ESH-20-SF-OP-005, RO, 1997.

c. Radiochemical Analytical Results. Results of the liquid tea analysis collected during the 1997 year can be found in Table 6-13. Most radionuclides in tea collected from the perimeter areas around LANL were within RSRLs, with the following exceptions: tea from Los Alamos, White Rock/Pajarito Acres and the Pueblo of San Ildefonso contained concentrations slightly higher than the RSRL of plutonium-239, -240; tea from Los Alamos townsite and White Rock/Pajarito Acres contained concentrations higher than the RSRL of tritium; and tea from San Ildefonso contained concentrations higher than the RSRL of strontium-90.

10. Piñon

a. Monitoring Network. Because piñon nuts are produced every 7 to 10 years by piñon pine trees in the semiarid Southwest, the collection of piñon shoot tips, a more conservative medium, will be harvested on an annual basis to determine the dose from the ingestion of this very popular product. Piñon tree shoot tips were collected from three perimeter areas surrounding the Laboratory: Los Alamos townsite on the north, White Rock/Pajarito Acres on the south east, and Pueblo of San Ildefonso lands on the east. Piñon tree shoot tips were collected from the Jemez area to provide background measurements.

b. Sampling Procedures, Data Management, and Quality Assurance. All QA/QC protocols, chemical analysis, 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, RO, 1997.

c. Radiochemical Analytical Results. Results of the piñon tree shoot tips collected during 1997 can be found in Table 6-14. Most radionuclides in piñon tree shoot tips from the perimeter areas of LANL were within the RSRLs. However, piñon tree shoot tips collected from the White Rock/Pajarito Acres area

and, especially from the Pueblo of San Ildefonso, contained higher (and detectable) concentrations of total uranium than the RSRL.

C. Other Environmental Surveillance Program Activities around Los Alamos National Laboratory, Special Studies, and Long-Term Data Evaluations

1. Tritium Concentrations in Bees and Honey at Los Alamos National Laboratory: 1979–1996

Honeybees are effective monitors of environmental pollution. The objective of this study was to summarize tritium concentrations in bees and honey collected from within and around LANL over an 18-year period. Based on the long-term average, bees from 9 out of 11 hives and honey from 6 out of 11 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 per milliliter) collected over the years was from TA-54—a low-level radioactive waste disposal site (Area G). Similarly, the highest average concentration of tritium in honey (709 pCi per milliliter) was collected from a hive located near three tritium storage ponds at LANL TA-53. The average concentration of tritium in bees and honey from background hives was 1.0 pCi per milliliter and 1.5 pCi per milliliter, 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 (Fresquez et al., 1996).

2. Baseline Concentrations of Radionuclides and Heavy Metals in Soils and Vegetation around the Dual Axis Radiographic Hydrodynamic Test Facility: Construction Phase (1996)

As part of the Department of Energy's Mitigation Action Plan for the Dual Axis Radiographic Hydrodynamic Test (DARHT) Facility at LANL, baseline concentrations of radionuclides (tritium, cesium-137, strontium-90, plutonium-238, plutonium-239, americium-241, and total uranium) and heavy metals (silver, arsenic, barium, beryllium, cadmium, chromium, copper, mercury, nickel, lead, antimony, selenium and thallium) in soil, sediment, and vegetation (overstory and understory) around the DARHT facility during the construction phase in 1996. Also, uranium and beryllium concentrations in soil samples collected in 1993 from within the proposed DARHT facility area are reported. Most radionuclides in soils, sediments, and vegetation were within current background and/or long-term RSRLs (Fresquez et al., 1997a).

3. Radionuclides in Soils Collected from within and around Los Alamos National Laboratory: 1974–1996

A soil sampling program is the most direct means of determining the types, concentration/activity, and distribution of radionuclides within and around nuclear facilities. LANL, for example, has had a soil surveillance program since the early 1970s, and the purpose of this paper was to (1) evaluate this 20+ year data set to determine if there are any statistical differences in radionuclides (tritium; cesium-137; plutonium-238; plutonium-239, -240; americium-241; strontium-90; and total uranium) and radioactivity (gross alpha, beta, and gamma), as a function of air emissions and fugitive dust, in surface soils (0–5 cm depth) collected from LANL, perimeter and background sites, and (2) determine if radionuclide concentrations are increasing or decreasing over time. Also, the total effective dose equivalent (TEDE) and the corresponding risk of excess cancer fatalities (RECF) to a perimeter community were estimated. Based on the long-term average, 9 out of the 10 radionuclide parameters measured in LANL soils were significantly ($p < 0.05$) higher in concentration than background ($n = 6$). Perimeter soils showed less differences with only 4 out of the 10 parameters being statistically higher in concentration than regional background. Most radionuclides in LANL and perimeter areas, with the exception of plutonium-238 in soils from perimeter areas, significantly decrease in concentration over time, so that by 1996 most radionuclides were approaching values similar to regional background. The maximum net positive TEDE (i.e., the TEDE + two sigma for each radioisotope minus background and then only the positive doses summed) for a resident living around the perimeter of LANL, as modeled by the residual radioactive (RESRAD) code using a residential scenario for soils collected from 1974–1996, 1993–1996, and 1996 was 2.9 mrem per year (29 μSv per year), 2.3 mrem per year (23 μSv per year), and 0.8 mrem per year (8 μSv per year), respectively. All upper bound TEDEs were far below the ICRP permissible dose limit of 100 mrem per year (1,000 μSv per year) for all pathways, and the highest TEDE corresponds to a RECF of 1.5×10^{-6}—an esti-

mate far below the Environmental Protection Agency guideline of 10^{-4} (Fresquez et al., 1998).

4. Radionuclide Concentrations in Soils and Vegetation at Radioactive-Waste Disposal Technical Area 54, Area G during the 1997 Growing Season

Soil and overstory and understory vegetation (washed and unwashed) collected at eight locations within and around TA-54, Area G—a low-level radioactive solid-waste disposal facility at LANL—were analyzed for tritium, strontium-90, plutonium-238, plutonium-239, cesium-137, uranium-234, uranium-235, uranium-238, total uranium, americium-241, actinium-228, bismuth-214, cobalt-60, potassium-40, manganese-54, sodium-22, lead-214, and thallium-208. Also, heavy metals (silver, arsenic, barium, beryllium, cadmium, chromium, mercury, nickel, lead, antimony, selenium and thallium) in soil and vegetation were determined. In general, most radionuclide concentrations, with the exception of tritium and plutonium-239, in soils and washed and unwashed overstory and understory vegetation collected from within and around TA-54, Area G were within upper limit background concentrations. Tritium was detected as high as 14,744 pCi per milliliter in understory vegetation collected from transuranic (TRU) waste pad #4, and the TRU waste pad area contained the highest levels of plutonium-239 in soils and in understory vegetation when compared to other areas at TA-54, Area G (Fresquez et al., 1997b).

5. The Distributions and Diversity of Fungal Species in and adjacent to the Los Alamos National Laboratory

Previously archived information representing 43 sample locations was used to perform a preliminary evaluation of the distributions and diversity of fungal species at LANL and in adjacent environments. Presence-absence data for 71 species of fungi in 5 habitats: piñon-juniper, canyon-bottom ponderosa pine, ponderosa pine, canyon-bottom mixed conifer, and mixed conifer were analyzed. The results indicate that even though fungi occur in each of the habitats, fungal species are not distributed evenly among these habitats. The richness of fungal species is greater in the canyon-bottom mixed conifer and mixed conifer habitats than in the piñon-juniper, canyon-bottom ponderosa pine, or ponderosa pine habitats. All but three of the fungal species were recorded in either the canyon-bottom mixed conifer or the mixed conifer habitats, and all but seven of the fungal species were found in the mixed conifer habitat. In addition, species fidelity increases from the piñon-juniper to the mixed conifer. Five of the species have a high fidelity to the mixed conifer, and 13 species have a high fidelity to either the canyon-bottom mixed conifer or the mixed conifer habitats. In contrast, only eight fungal species were found in the piñon-juniper habitat, and none of these were found with high fidelity or in high abundance. Finally, only two species of fungi were collected in all five of the habitats (Balice et al., 1997a).

6. A Survey of Macromycete Diversity at Los Alamos National Laboratory, Bandelier National Monument, and Los Alamos County

A 5-year survey (1991 to 1995) was completed of macromycetes found in Los Alamos County, Los Alamos National Laboratory, and Bandelier National Monument. A database of 1,048 collections has been compiled, including their characteristics and identifications. The database represents 123 (98%) genera and 175 (73%) species reliably identified. Issues of habitat loss, species extinction, and ecological relationships are addressed, and comparisons with other surveys are made (Jarmie and Rogers 1997).

7. Preliminary Vegetation and Land Cover Classification for the Los Alamos Region

The major vegetation and land cover types in the Los Alamos region were classified according to a hierarchical scheme. Ten Level I cover types were identified, and each of these was subdivided into two or more Level II cover types. For identification purposes, a dichotomous key was developed. The Level I classes reflect major physiognomic and floristic groupings and correspond to the categories that arose during supervised and unsupervised classifications of Thematic mapper imagery. The Level II divisions are based on the dominant or codominant species and the characteristics of the physical environment. The implications of these land cover classes to management of vegetation and wildlife, particularly threatened and endangered species, are discussed where appropriate (Balice et al., 1997b).

8. Development of a Land Cover Map for Los Alamos National Laboratory and Vicinity

LANL's Threatened and Endangered Species Habitat Management Plan calls for identifying areas on LANL property that are suitable or potentially

suitable habitat for federally listed species. The production of a land cover map was the first step toward meeting this goal. A 1992 Landsat thematic mapper image was sorted into 30 classes using the Iterative Self-Organizing Data Analysis Technique. These 30 classes were aggregated into 10 land cover types through field surveys, aerial photo interpretation, and the incorporation of topographic information. The resulting cover types include major vegetational zones and physiognomic types that are important to the distribution and abundance of several threatened and endangered species. The final land cover map has been integrated into an ARC/INFO geographic information system, along with habitat criteria and other environmental and biological data (Koch et al., 1997).

9. Honey Bees as Indicators of Radionuclide Contamination: Exploring Colony Variability and Temporal Contaminant Accumulation

Two aspects of using honey bees, (*Apis mellifera*), as indicators of environmental radionuclide contamination were investigated: colony variability and temporal contaminant accumulation. Two separate field experiments were conducted in areas with bioavailable radionuclide contamination. Bees were collected from colonies, analyzed for concentrations of radionuclides, and the results were compared using graphical and statistical methods. The first experiment indicates that generally a low variability exists between samples collected within the same colony. A higher variability exists between samples collected from adjacent colonies. Levels of tritium and sodium-22 found in samples taken from similar colonies were inconsistent, while levels of cobalt-57, cobalt-60, and manganese-54 were consistent. A second experiment investigated the accumulation of radionuclides over time by comparing colonies that had been in the study area for different periods of time. This experiment demonstrated that there is indeed a significant accumulation of radionuclides within colonies (Haarmann 1997).

10. Radionuclide Concentrations in Honey Bees from Technical Area 54, Area G during 1997

Honey bees were collected from two colonies located at TA-54, Area G and from one control background colony located near Jemez Springs. Samples were analyzed for the following: cesium-137; americium-241; plutonium-238; plutonium-239, -240; tritium; total uranium; and gross gamma activity. TA-54, Area G sample results from both colonies were higher than the upper (95%) level background concentration for plutonium-238 and tritium (Haarmann and Fresquez 1998).

11. A Spatially-Dynamic Preliminary Risk Assessment of the Bald Eagle at the Los Alamos National Laboratory

The Endangered Species Act of 1973 and the Record of Decision on DARHT at the Laboratory require that DOE protect the bald eagle (*Haliaeetus leucocephalus*), a state and federally listed species, from stressors such as contaminants. A preliminary risk assessment of the bald eagle was performed. Estimated exposure doses to the eagle for radionuclide, inorganic metal, and organic contaminants were derived for varying ratios of aquatic fish vs. terrestrial simulated diet and compared against toxicity reference values to generate hazard indices. Results indicate that no appreciable impact to the bald eagle is expected from contaminants at LANL from soil ingestion and food consumption pathways. This includes a measure of cumulative effects from multiple contaminants that assumes linear additive toxicity. Improving model realism by weighting simulated eagle foraging based on distance from potential roost sites increased the hazard indices by 76% but still to inconsequential levels. Information on risk by specific geographical location was generated, and can be used to manage contaminated areas, eagle habitat, facility siting, and/or facility operations in order to maintain risk from contaminants at low levels (Gonzales et al., 1998).

12. Radionuclide Contaminant Analysis of Small Mammals at Technical Area 54, Area G, 1996 (with cumulative summary for 1994–96)

Small mammals which live in the vicinity of two waste burial sites at TA-54, Area G and a control site were sampled to (1) identify radionuclides that are present within rodent tissues at waste burial sites, (2) to compare the amount of radionuclide uptake by small mammals at waste burial sites to a control site, and (3) to identify the primary mode of contamination to small mammals, either through surface contact or ingestion/inhalation. Three composite samples of approximately five animals per sample were collected at each site. Pelts and carcasses of each animal were separated and analyzed independently. Samples were analyzed for americium-241, strontium-90, plutonium-238, plutonium-239, total uranium, cesium-137, and tritium. Higher levels of total

uranium, americium-241, plutonium-238, and plutonium-239 were detected in pelts as compared to the carcasses of small mammals at TA-54. Concentrations of other measured radionuclides in carcasses were nearly equal to or exceeded the mean concentrations in the pelts. Due to low sample sizes of the total number of animals captured, statistical analysis to compare site to site could not be conducted. However, mean concentrations of total uranium, plutonium-238, plutonium-239, and cesium-137 in rodent carcasses were higher at Site 1 than Site 2 or the Control Site and americium-241was higher at Site 2 than Site 1 or the Control Site (Biggs et al., 1997a).

13. Evaluation of Habitat Use by Rocky Mountain Elk in North-Central New Mexico Using Global Positioning System Radio Collars

In 1996, LANL initiated a study to identify habitat use in north-central New Mexico by Rocky Mountain elk (*Cervus elaphus nelsoni*) using global positioning system (GPS) radio collars. We collared 6 elk (5 cows/1 bull) in the spring of 1996 with GPS radio collars programmed to obtain locational fixes every 23 h. Between April 1, 1996, and January 7, 1997, we collected more than 1,200 fixes with an approximately 70% observation rate. GPS locational fixes of elk were interfaced with detailed vegetation maps using the Geographic Information System (GIS) to provide seasonal (calving, late summer, fall, winter) habitat use within mountainous regions of north-central New Mexico. Based on habitat use and availability analysis, use of grass/shrub and piñon-juniper habitats was generally higher than expected during most seasons and use of forested habitats (ponderosa pine, mixed conifer) was lower than expected. Most of the collared elk remained on LANL property year-round. The application of GPS collars to elk studies in north-central New Mexico is believed to be a more efficient and effective method than the use of very high-frequency radio collars (Biggs et al., 1997b).

14. Estimation of Home Range and Water Resource Use of Elk at Los Alamos National Laboratory

LANL estimated yearly and seasonal home ranges of six GPS-collared elk that occupied Laboratory land at least partially between February 1996 and September 1997, using the Program CALHOME. Seasonal home ranges varied from 903 ha to 5,004 ha during winter, 1,218 ha to 6,157 ha in spring, 2,138 ha to 7,907 ha during calving, 1,957 ha to 3,306 ha in summer, and 3021 ha to 10,160 ha in fall. Seasonal core activity areas (50%) were generally less than 500 ha. for most animals. We evaluated relative percent seasonal and yearly water source use by overlaying permanent water sources on to the GIS and calculating the number of locational fixes within a set of five distances from that source: 0.25 mi., 0.50 mi., 0.75 mi., 1.0 mi., and 2.0 miles. Cumulated use was 17%, 35%, 49%, 61%, and 90%, respectively (Biggs et al., 1997c).

15. Determination of Locational Error Associated with Global Positioning System Radio Collars in Relation to Vegetation and Topography in North-Central New Mexico

In 1996, LANL initiated a study to assess seasonal habitat use and movement patterns of Rocky Mountain elk (*Cervus elaphus nelsoni*) using GPS radio collars. As part of this study, LANL attempted to assess the accuracies of GPS (nondifferentially corrected) positions under various vegetation canopies and terrain conditions with the use of a GPS test collar. The test collar was activated every 20 min to obtain a position location and continuously uplinked to Argos satellites to transfer position data files. A Telonics, Inc. uplink receiver was used to intercept the transmission and view the results of the collar in real time. The collar was placed on a stand equivalent to the neck height of an adult elk and then the stand was placed within three different treatment categories: topographical influence (canyon and mesa tops), canopy influence (open and closed canopy), and vegetation type influence (ponderosa pine and piñon pine-juniper). The collar was kept at each location for one hour (usually obtaining three fixes). In addition, we used a hand-held GPS to obtain a position of the test collar at the same time and location. The hand-held unit was differentially corrected. Previous tests of the hand-held unit indicated that the accuracy was within two meters of an actual position. To determine locational error of the test collar within the different treatments, we made comparisons between the test collar and the hand-held GPS following correction. The overall mean locational error was 106 ± 16 m (354 ± 53 ft). There were no statistical differences in locational errors between ponderosa pine and piñon pine-juniper vegetation types, open and closed canopies, or canyons and mesa tops. Observation rate was also calculated for each treatment category. There were no statistical differences between observation rates of the three treatments (Bennett et al., 1997).

Table 6-1. Radiochemical Analyses of Soils Collected during 1997

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	–0.16 (0.36)[a,b]	0.61 (0.75)	0.22 (0.03)	1.54 (0.15)	0.001 (0.001)	0.012 (0.002)	0.003 (0.002)	3.4 (2.0)	2.4 (0.6)	2.2 (0.3)
Cochiti	–0.21 (0.39)	0.67 (0.63)	0.32 (0.04)	1.77 (0.18)	–0.000 (0.001)	0.013 (0.002)	0.005 (0.001)	2.0 (1.2)	2.8 (1.1)	2.2 (0.3)
Jemez	–0.10 (0.49)	1.08 (0.76)	0.22 (0.04)	2.77 (0.28)	0.000 (0.001)	0.011 (0.002)	0.010 (0.018)	2.5 (1.8)	2.4 (1.0)	3.1 (0.4)
Mean (std dev)	–0.16 (0.06)	0.79 (0.26)	0.25 (0.06)	2.03 (0.65)	0.000 (0.001)	0.012 (0.001)	0.006 (0.004)	2.6 (0.7)	2.5 (0.2)	2.5 (0.5)
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	–0.29 (0.30)	0.25 (1.13)	0.31 (0.04)	3.26 (0.33)	0.002 (0.001)	0.052 (0.003)	0.023 (0.002)	2.2 (1.5)	2.8 (1.1)	NA[f]
TA-8 (GT Site)	0.28 (0.37)	1.07 (0.78)	0.89 (0.10)	2.93 (0.29)	0.003 (0.001)	0.038 (0.003)	0.060 (0.011)	7.1 (2.0)	6.1 (1.5)	3.9 (0.4)
Near TA-49 (BNP)	0.03 (0.87)	1.16 (0.59)	0.57 (0.07)	5.17 (0.52)	0.002 (0.001)	0.021 (0.002)	0.012 (0.002)	2.5 (0.8)	5.1 (1.4)	3.6 (0.4)
East Airport	0.06 (0.21)	0.93 (0.70)	0.29 (0.04)	3.41 (0.34)	0.001 (0.001)	0.042 (0.003)	0.008 (0.001)	4.7 (1.5)	3.5 (1.1)	3.5 (0.4)
West Airport	0.09 (0.33)	0.86 (0.72)	0.17 (0.03)	3.43 (0.34)	0.001 (0.001)	0.049 (0.004)	0.007 (0.002)	5.2 (1.8)	3.8 (1.2)	3.3 (0.4)
North Mesa	0.64 (0.32)	1.24 (0.75)	0.35 (0.05)	3.69 (0.37)	0.001 (0.001)	0.020 (0.002)	0.005 (0.001)	8.8 (2.9)	4.6 (1.3)	3.5 (0.4)
Sportsman's Club	0.25 (0.48)	1.11 (0.80)	0.44 (0.06)	3.93 (0.39)	0.001 (0.001)	0.036 (0.003)	0.010 (0.002)	9.1 (2.8)	4.9 (0.9)	3.6 (0.4)
Tsankawi/PM-1	–0.40 (0.34)	0.93 (0.82)	0.16 (0.03)	5.15 (0.52)	0.001 (0.001)	0.005 (0.001)	0.005 (0.001)	7.1 (2.4)	2.8 (1.1)	3.9 (0.4)
White Rock (East)	0.06 (0.30)	0.99 (0.75)	0.31 (0.04)	3.15 (0.32)	–0.002 (0.001)	0.014 (0.003)	0.010 (0.002)	4.5 (1.7)	3.7 (1.2)	3.6 (0.4)
San Ildefonso	0.04 (0.30)	1.05 (0.76)	0.29 (0.04)	2.77 (0.28)	0.002 (0.001)	0.014 (0.002)	0.007 (0.001)	4.8 (1.8)	2.7 (1.0)	3.3 (0.4)
Mean (std dev)	0.08 (0.29)	0.96 (0.27)	0.38 (0.22)	3.69 (0.84)	0.001 (0.001)	0.029 (0.016)	0.015 (0.017)	5.6 (2.4)	4.0 (1.1)	3.6 (0.2)
On-Site Stations:										
TA-16 (S-Site)	–0.05 (0.24)	0.79 (0.17)	0.82 (0.07)	6.17 (0.62)	0.002 (0.001)	0.041 (0.003)	0.016 (0.002)	10.5 (2.9)	6.1 (1.5)	4.5 (0.5)
TA-21 (DP-Site)	0.19 (0.24)	0.67 (0.20)	0.14 (0.02)	3.01 (0.30)	0.010 (0.002)	0.868 (0.020)	0.065 (0.005)	10.0 (2.8)	4.5 (0.8)	2.8 (0.3)
Near TA-33	–0.12 (0.28)	0.64 (0.51)	0.30 (0.04)	2.98 (0.30)	0.000 (0.001)	0.015 (0.002)	0.007 (0.002)	3.2 (1.4)	3.3 (1.1)	3.5 (0.4)
TA-50	–0.06 (0.19)	0.51 (0.17)	0.11 (0.02)	2.75 (0.28)	0.002 (0.001)	0.032 (0.003)	0.008 (0.002)	6.1 (2.0)	4.2 (1.2)	3.2 (0.4)
TA-51	0.37 (0.21)	0.46 (0.22)	0.18 (0.02)	3.08 (0.31)	0.001 (0.001)	0.011 (0.002)	0.003 (0.001)	6.9 (2.1)	3.5 (1.1)	3.2 (0.4)
West of TA-53	0.10 (0.22)	0.69 (0.17)	0.14 (0.02)	3.06 (0.31)	0.001 (0.001)	0.016 (0.003)	0.005 (0.001)	5.2 (1.9)	7.4 (1.7)	3.4 (0.4)
East of TA-53	0.49 (0.28)	0.70 (0.13)	0.94 (0.08)	3.02 (0.30)	0.002 (0.001)	0.053 (0.003)	0.015 (0.002)	5.6 (1.9)	3.6 (1.2)	3.2 (0.4)
East of TA-54	0.46 (0.20)	0.49 (0.33)	0.43 (0.04)	2.83 (0.28)	0.004 (0.001)	0.043 (0.003)	0.014 (0.002)	6.0 (1.9)	3.6 (1.2)	3.5 (0.4)
Potrillo Drive/TA-36	0.09 (0.13)	0.76 (0.21)	0.31 (0.04)	3.05 (0.31)	–0.001 (0.001)	0.014 (0.002)	0.005 (0.001)	6.2 (2.1)	3.5 (1.2)	3.5 (0.4)
Near Test Well DT-9	0.06 (0.17)	0.70 (0.15)	0.35 (0.04)	2.53 (0.25)	0.001 (0.000)	0.010 (0.002)	0.006 (0.002)	8.2 (2.2)	4.4 (1.3)	3.2 (0.4)
R-Site Road East	–0.03 (0.15)	0.87 (0.22)	0.46 (0.05)	5.35 (0.54)	0.002 (0.001)	0.020 (0.002)	0.012 (0.002)	6.6 (2.2)	3.9 (1.2)	3.2 (0.4)
Two-Mile Mesa	0.28 (0.23)	0.49 (0.23)	0.35 (0.04)	3.23 (0.32)	–0.000 (0.000)	0.009 (0.002)	0.005 (0.001)	8.5 (2.4)	3.9 (1.2)	3.1 (0.4)
Mean (std dev)	0.15 (0.21)	0.65 (0.13)	0.38 (0.26)	3.42 (1.12)	0.002 (0.003)	0.094 (0.244)	0.013 (0.017)	6.9 (2.1)	4.3 (1.2)	3.4 (0.4)

[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 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] Not analyzed, lost in analysis, or outlier omitted.

Table 6-2. Total Recoverable Trace and Heavy Metals (µg/g dry) in Soils Collected during 1997[a]

Location	Ag	As	Ba	Be	Cd	Cr	Hg	Ni	Pb	Sb	Se	Tl[c]
Regional Background Stations:												
Embudo	0.50[b]	0.40	64.0	0.20	NA[c]	1.90	NA	2.50[b]	5.20	NA	0.50[b]	0.03[b]
Cochiti	0.50[b]	0.50	64.0	0.10		1.10		2.50[b]	6.30		0.50[b]	0.03[b]
Jemez	0.50[b]	1.80	48.0	0.20		1.20		2.50[b]	6.80		0.50[b]	0.03[b]
Mean	0.50	0.90	58.7	0.17		1.40		2.50	6.10		0.50	0.03
(std dev)	(0.00)	(0.78)	(9.2)	(0.06)		(0.44)		(0.00)	(0.82)		(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	0.50[b]	0.30	38.0	0.20		1.00		2.50[b]	5.0		0.50[b]	0.03[b]
TA-8 (GT Site)	0.50[b]	0.90	74.0	0.20		1.50		2.50[b]	11.3		0.50[b]	0.03[b]
TA-49 (BNP)	0.50[b]	1.10	111.0	0.40		1.70		2.50[b]	14.0		0.50[b]	0.06
East Airport	0.50[b]	0.70	52.0	0.30		1.10		2.50[b]	13.9		0.50[b]	0.03[b]
West Airport	0.50[b]	1.10	93.0	0.30		2.10		2.50[b]	18.7		0.50[b]	0.03[b]
North Mesa	0.50[b]	1.00	81.0	0.30		2.10		2.50[b]	9.9		0.50[b]	0.03[b]
Sportsman's Club	0.50[b]	1.50	106.0	0.40		2.10		2.50[b]	14.8		0.50[b]	0.03[b]
Tsankawi/PM-1	0.50[b]	0.15[b]	23.0	0.30		1.00		2.50[b]	11.5		0.50[b]	0.03[b]
White Rock (East)	0.50[b]	0.60	86.0	0.50		1.30		2.50[b]	14.1		0.50[b]	0.03[b]
San Ildefonso	0.50[b]	0.50	33.0	0.20		1.00		2.50[b]	6.8		0.50[b]	0.03[b]
Mean	0.50	0.79	69.7	0.31		1.49		2.50	12.0		0.50	0.03
(std dev)	(0.00)	(0.41)	(31.3)	(0.10)		(0.48)		(0.00)	(4.0)		(0.00)	(0.01)
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-21 (DP-Site)	0.50[b]	1.10	106.0	0.40		3.20		2.50[b]	26.5		0.50[b]	0.09
Near TA-33	0.50[b]	0.60	128.0	0.50		2.60		2.50[b]	10.7		0.50[b]	0.10
TA-50	0.50[b]	1.00	109.0	0.40		3.30		2.50[b]	11.5		0.50[b]	0.11
TA-51	0.50[b]	0.90	106.0	0.30		3.10		2.50[b]	12.6		0.50[b]	0.11
West of TA-53	0.50[b]	1.00	100.0	0.40		3.30		2.50[b]	11.1		0.50[b]	0.10
East of TA-53	0.50[b]	0.80	48.0	0.40		1.80		2.50[b]	12.9		0.50[b]	0.05
East of TA-54	0.50[b]	0.50	49.0	0.30		1.40		2.50[b]	8.7		0.50[b]	0.03
Potrillo Drive/TA-36	0.50[b]	1.00	71.0	0.30		2.70		2.50[b]	10.6		0.50[b]	0.07
Near Test Well DT-9	0.50[b]	0.70	97.0	0.40		2.30		2.50[b]	10.4		0.50[b]	0.09
R-Site Road	0.50[b]	1.30	102.0	0.40		2.70		2.50[b]	12.8		0.50[b]	0.08
Two-Mile Mesa	0.50[b]	1.40	102.0	0.40		3.80		2.50[b]	12.5		0.50[b]	0.11
Mean	0.50	0.93	98.2	0.39		2.63		2.50	12.6		0.50	0.08
(std dev)	(0.00)	(0.27)	(31.1)	(0.07)		(0.78)		(0.00)	(4.5)		(0.00)	(0.03)

[a] Analysis by EPA Method 3051 for total recoverable metals.
[b] All less-than values were converted to one-half the concentration (Gilbert 1987).
[c] Not analyzed, lost in analysis, or an outlier that was omitted; and in the case of Cd (<1 µg/g), Hg (<20 µg/g), and Sb (<1 µg/g) results, these data were not reported because the minimum detection levels were higher than what was employed in the past.
[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 Off-Site, Perimeter, and On-Site Areas during the 1997 Growing Season[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	–0.29	(0.62)[b,c]	40.61	(61.57)	1.3	(19.7)	NA[d]		–1.3	(2.6)	10.5	(3.9)	10.5	(3.9)
Tomato	0.25	(0.66)	6.00	(24.00)	35.0	(85.0)	NA		2.0	(2.0)	4.0	(3.0)	–5.0	(21.0)
Cucumber	–0.06	(0.64)	136.99	(206.15)	234.1	(385.7)	2.66	(1.33)	–4.0	(6.7)	13.3	(12.0)	66.5	(25.3)
Apple	0.10	(0.65)	2.52	(3.60)	2.2	(10.4)	0.36	(0.36)	3.2	(2.2)	4.0	(2.2)	2.5	(1.4)
Corn	–0.11	(0.64)	NA		127.4	(210.6)	0.64	(0.64)	–21.8	(9.0)	6.4	(14.1)	16.6	(14.1)
Collard	–0.17	(0.63)	70.0	(102.5)	15.0	(165.0)	NA		–1.3	(4.0)	6.7	(5.3)	18.6	(10.6)
Mean (std dev)	–0.05	(0.19)	51.22	(55.31)	69.2	(93.6)	1.22	(1.25)	–3.9	(9.2)	7.5	(3.7)	18.3	(25.2)
RSRL[e]	0.39		73.8		81.6		17.4		11.2		16.2		20.5	
Perimeter Stations														
Los Alamos:														
Corn	1.60	(0.74)	34.56	(51.84)	23.0	(53.8)	0.64	(0.64)	21.1	(25.0)	8.3	(23.7)	–5.1	(6.4)
Tomato	–0.13	(0.72)	39.00	(7.00)	–1.0	(18.0)	0.00	(1.00)	11.0	(10.0)	26.0	(14.0)	–50.0	(22.0)
Squash	–0.13	(0.72)	102.18	(24.89)	260.7	(203.1)	1.31	(1.31)	–5.2	(39.3)	–11.8	(43.2)	10.5	(44.5)
Peach	0.24	(0.74)	12.16	(2.28)	–6.8	(26.6)	1.52	(0.76)	62.3	(22.8)	122.4	(31.2)	13.7	(5.3)
Nectarine	0.02	(0.73)	–2.34	(18.72)	–7.0	(14.0)	0.78	(0.78)	15.6	(57.7)	73.3	(48.4)	0.0	(2.3)
Cherry	0.05	(0.73)	16.66	(3.92)	–23.5	(26.5)	0.98	(0.98)	–8.8	(8.8)	–5.9	(13.7)	–10.8	(2.9)
Apple	0.16	(0.74)	37.44	(7.92)	–9.4	(37.4)	1.44	(0.36)	9.7	(12.2)	0.7	(16.2)	–2.5	(10.8)
Peach	1.22	(0.80)	6.84	(9.88)	–19.0	(16.7)	1.52	(0.76)	4.6	(3.8)	3.8	(3.8)	20.5	(7.6)
Lettuce	3.60	(0.74)	–87.50	(60.00)	157.5	(292.5)	27.50	(2.50)	7.5	(37.5)	65.0	(47.5)	177.5	(162.5)
Mean (std dev)	0.74	(1.24)	17.67	(49.85)	41.6	(99.3)	3.97	(8.84)	13.1	(20.7)	31.3	(45.7)	17.1	(63.5)
White Rock/Pajarito Acres:														
Bean	0.00	(0.68)	–3.12	(18.72)	24.2	(29.6)	17.94	(1.56)	–5.5	(6.2)	40.6	(12.5)	52.3	(16.4)
Lettuce	–0.26	(0.66)	0.00	(60.00)	52.5	(87.5)	12.50	(2.50)	–10.0	(22.5)	117.5	(42.5)	27.5	(32.5)
Cucumber	–0.34	(0.66)	–7.98	(31.9)	53.2	(49.2)	5.32	(1.33)	–17.3	(6.7)	42.6	(18.6)	85.1	(27.9)
Squash	0.04	(0.68)	11.79	(18.34)	68.1	(51.1)	5.24	(1.31)	0.0	(3.9)	22.3	(7.9)	41.9	(26.2)
Corn	–0.40	(0.65)	3.84	(5.76)	–3.8	(21.8)	0.64	(0.64)	–1.9	(6.4)	–5.8	(9.0)	0.6	(5.1)
Tomato	0.35	(0.70)	–3.00	(24.00)	–17.0	(51.0)	2.00	(1.00)	37.0	(22.0)	21.0	(32.0)	22.0	(14.0)
Apple	0.13	(0.69)	11.16	(16.92)	6.1	(14.0)	1.44	(0.36)	3.6	(5.8)	9.7	(7.9)	13.3	(6.5)
Mean (std dev)	–0.07	(0.27)	1.81	(7.50)	26.2	(35.5)	6.44	(6.46)	–9.7	(13.9)	35.4	(39.9)	34.7	(28.1)

Table 6-3. Radionuclides in Produce Collected from Off-Site, Perimeter, and On-Site Areas during the 1997 Growing Season[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	–0.03	(0.66)	73.36	(110.04)	85.2	(187.3)	6.55	(1.31)	–17.0	(13.1)	–7.9	(17.0)	40.6	(14.4)
Cucumber	–0.07	(0.66)	15.96	(22.61)	238.1	(295.3)	2.66	(1.33)	–21.3	(21.3)	–5.3	(14.6)	53.2	(25.3)
Tomato	0.38	(0.69)	–10.00	(24.00)	0.0	(167.0)	1.00	(1.00)	–5.0	(6.0)	–2.0	(6.0)	24.0	(9.0)
Bell pepper	0.22	(0.68)	–21.17	(17.52)	–8.0	(172.3)	8.76	(0.73)	8.8	(13.9)	25.6	(20.4)	75.9	(101.5)
Apple	0.47	(0.69)	8.64	(2.16)	–3.2	(17.3)	0.36	(0.36)	0.0	(1.4)	1.1	(2.2)	1.1	(2.2)
Lettuce	–0.11	(0.66)	105.00	(155.00)	30.0	(317.5)	25.00	(2.50)	12.5	(20.0)	20.0	(25.0)	17.5	(52.5)
Mean (std dev)	0.14	(0.25)	28.63	(49.73)	57.0	(95.3)	7.39	(9.22)	–3.7	(13.6)	5.3	(14.0)	35.4	(26.9)
Pueblo of San Ildefonso:														
Apple	–0.30	(0.66)	0.72	(0.72)	5.8	(22.3)	1.08	(0.36)	–2.9	(3.6)	1.8	(3.6)	–4.3	(11.9)
Apple	–0.62	(0.64)	0.00	(8.64)	–7.9	(13.7)	0.72	(0.36)	9.7	(6.8)	–5.8	(4.7)	17.6	(13.0)
Squash	–0.30	(0.66)	7.86	(13.10)	–27.5	(159.8)	14.41	(1.31)	1.3	(7.9)	–2.6	(3.9)	–1.3	(9.2)
Corn	–0.34	(0.66)	6.40	(9.60)	–42.2	(80.0)	1.28	(0.64)	–1.3	(3.8)	–0.6	(3.8)	10.2	(8.3)
Cucumber	0.11	(0.69)	1.33	(2.66)	14.6	(155.6)	3.99	(1.33)	–31.9	(10.6)	–29.3	(22.6)	38.6	(13.3)
Tomato	0.33	(0.70)	10.00	(4.00)	–11.0	(60.0)	2.00	(1.00)	11.0	(7.0)	24.0	(9.0)	4.0	(6.0)
Mean (std dev)	–0.19	(0.34)	4.39	(4.23)	–11.4	(20.9)	3.91	(5.27)	–2.4	(15.6)	–2.1	(17.0)	10.8	(15.8)
On-Site Stations														
LANL (Mesa):														
Peach	1.63	(0.78)	20.52	(30.40)	48.6	(58.5)	0.76	(0.76)	–6.8	(8.4)	–0.8	(10.6)	32.7	(22.0)
Apple	0.31	(0.70)	66.24	(10.44)	68.4	(53.3)	2.16	(0.36)	–5.4	(11.5)	5.4	(9.0)	–32.0	(24.5)
Peach	–0.03	(0.68)	44.84	(10.64)	120.1	(69.2)	3.04	(0.76)	–11.4	(6.8)	38.8	(16.0)	29.6	(11.4)
Peach	14.60	(1.40)	26.60	(5.32)	29.6	(55.5)	2.28	(0.76)	16.0	(9.9)	12.9	(10.6)	113.2	(43.3)
Nectarine	0.12	(0.69)	–7.80	(140.40)	NA		1.56	(0.78)	–13.3	(5.5)	6.2	(12.5)	–70.2	(14.8)
Apple	0.74	(0.73)	32.76	(7.20)	46.1	(47.2)	0.72	(0.36)	4.3	(6.5)	4.3	(7.9)	51.1	(18.0)
Mean (std dev)	2.90	(5.77)	30.53	(24.78)	62.6	(35.0)	1.75	(0.92)	–2.8	(11.1)	11.1	(14.2)	20.7	(64.4)

Table 6-3. Radionuclides in Produce Collected from Off-Site, Perimeter, and On-Site Areas during the 1997 Growing Season[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)	
On-Site Stations														
LANL (Mortandad Canyon):														
Raspberries	0.005	(0.021)	12.3	(18.3)	105.6	(85.8)	12.6	(1.2)	84.9	(24.6)	77.7	(25.2)	54.9	(33.0)
Currants	–0.005	(0.034)	21.5	(5.0)	192.5	(58.5)	3.5	(0.5)	17.0	(5.5)	35.0	(7.5)	100.5	(27.5)
Acorns	0.174	(0.030)	2,763.0	(204.0)	460.2	(97.5)	0.6	(0.3)	5.7	(3.9)	5.1	(4.2)	15.6	(9.6)
Wild Rhubarb	0.154	(0.173)	554.4	(67.2)	2,901.6	(441.6)	36.0	(4.8)	9,866.4	(266.4)	10,603.2	(280.8)	23,992.8	(1,027.2)
Rose Hips	0.082	(0.032)	30.4	(45.6)	149.6	(63.6)	2.4	(0.4)	0.4	(4.8)	–4.0	(6.4)	5.2	(8.8)
Pinon (shoot tips)	0.001	(0.054)	34.4	(51.2)	51.2	(38.4)	20.8	(2.4)	16.0	(16.0)	18.4	(16.8)	53.6	(28.8)
Strawberries	0.092	(0.047)	492.0	(738.0)	9,421.8	(878.4)	7.8	(0.6)	764.4	(156.0)	307.8	(124.2)	654.0	(285.0)
Mean (std dev)	0.072	(0.074)	558.3	(1,000.4)	1,897.5	(3,470.6)	12.0	(12.7)	1,536.4	(3,683.6)	1,577.6	(3,981.4)	3,553.8	(9,015.7)

[a] There are no concentration guides for produce.
[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] Not analyzed, lost in analyses, or outlier omitted.
[e] 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 and Heavy Metals (μg/g dry) in Produce Collected during 1997[a]

Location	Ag	As	Ba	Be	Cd	Cr	Hg	Ni	Pb	Sb	Se	Tl
Regional Background Stations												
Española/Santa Fe/Jemez:												
Squash	0.50[b]	0.10	8.95	0.05[b]	0.08	0.80	0.05[b]	0.01[b]	1.1	0.50[b]	0.10[b]	0.03[b]
Tomato	0.50[b]	0.10	3.67	0.05[b]	0.03[b]	1.34	0.05[b]	6.48	3.7	0.50[b]	0.20	0.03[b]
Cucumber	0.50[b]	1.00	47.50	0.05[b]	0.10	0.78	0.05[b]	28.10	25.9	0.50[b]	0.20	0.03[b]
Apple	0.50[b]	0.05[b]	3.70	0.05[b]	0.13	0.40	0.05[b]	70.81	21.2	0.50[b]	0.10[b]	0.03[b]
Corn	0.50[b]	0.10	8.80	0.05[b]	0.03[b]	0.64	0.05[b]	3.48	5.6	0.50[b]	0.20	0.03[b]
Collard	0.50[b]	2.00	23.37	0.05[b]	0.24	1.02	0.05[b]	4.69	3.9	0.50[b]	1.30	0.61
Mean	0.50	0.56	16.00	0.05	0.10	0.83	0.05	18.93	10.2	0.50	0.35	0.13
(std dev)	(0.00)	(0.80)	(17.04)	(0.00)	(0.08)	(0.32)	(0.00)	(27.31)	(10.5)	(0.00)	(0.47)	(0.24)
RSRL[c]	1.38	0.66	27.43	0.53	0.46	3.98	0.06	23.50	22.0	0.18	0.3	0.20
Perimeter Stations												
Los Alamos:												
Corn	0.50[b]	0.05[b]	1.21	0.05[b]	0.03[b]	0.49	0.05[b]	6.51	16.4	0.50[b]	0.10[b]	0.03[b]
Tomato	0.50[b]	0.05[b]	6.11	0.05[b]	0.05	1.75	0.05[b]	10.11	4.5	0.50[b]	0.20	0.03[b]
Squash	0.50[b]	0.10	19.77	0.05[b]	0.03[b]	0.73	0.05[b]	1.91	3.0	0.50[b]	0.10[b]	0.03[b]
Peach	0.50[b]	0.10	4.62	0.05[b]	0.03[b]	0.74	0.05[b]	4.36	6.7	0.50[b]	0.10[b]	0.03[b]
Nectarine	0.50[b]	0.05[b]	4.45	0.05[b]	0.03[b]	1.24	0.05[b]	6.15	5.6	0.50[b]	0.10[b]	0.03[b]
Cherry	0.50[b]	0.05[b]	15.04	0.05[b]	0.03[b]	0.57	0.10	1.82	3.6	0.50[b]	0.10[b]	0.03[b]
Apple	0.50[b]	0.05[b]	5.22	0.05[b]	0.03[b]	0.29	0.05[b]	0.57	2.9	0.50[b]	0.10[b]	0.03[b]
Peach	0.50[b]	0.05[b]	1.63	0.05[b]	0.03[b]	1.51	0.05[b]	9.47	4.1	0.50[b]	0.10[b]	0.03[b]
Lettuce	0.50[b]	0.20	31.05	0.05[b]	0.19	1.63	0.05[b]	2.28	1.2	0.50[b]	0.30	0.03[b]
Mean	0.50	0.08	9.90	0.05	0.05	1.00	0.06	4.80	5.3	0.50	0.13	0.03
(std dev)	(0.00)	(0.05)	(10.06)	(0.00)	(0.05)	(0.54)	(0.02)	(3.47)	(4.5)	(0.00)	(0.07)	(0.00)
White Rock /Pajarito Acres:												
Bean	0.50[b]	0.05[b]	13.50	0.05[b]	0.05	0.55	0.05[b]	1.87	1.5	0.50[b]	0.20	0.03[b]
Lettuce	0.50[b]	0.20	62.68	0.05[b]	0.22	1.20	0.05[b]	1.16	1.9	0.50[b]	0.20	0.03[b]
Cucumber	0.50[b]	0.20	6.16	0.05[b]	0.15	0.96	0.05[b]	2.74	2.3	0.50[b]	0.40	0.03[b]
Squash	0.50[b]	0.05[b]	19.81	0.05[b]	0.03[b]	0.60	0.05[b]	3.31	1.6	0.50[b]	0.20	0.03[b]
Corn	0.50[b]	0.05[b]	1.04	0.05[b]	0.03[b]	0.47	0.05[b]	2.24	28.9	0.50[b]	0.10[b]	0.03[b]
Tomato	0.50[b]	0.05[b]	4.76	0.05[b]	0.09	3.01	0.05[b]	24.68	1.8	0.50[b]	0.20	0.03[b]
Apple	0.50[b]	0.05[b]	3.68	0.05[b]	0.03[b]	0.30	0.05[b]	1.16	7.6	0.50[b]	0.10[b]	0.03[b]
Mean	0.50	0.09	15.95	0.05	0.09	1.01	0.05	5.31	6.5	0.50	0.20	0.03
(std dev)	(0.00)	(0.07)	(21.60)	(0.00)	(0.07)	(0.93)	(0.00)	(8.58)	(10.1)	(0.00)	(0.10)	(0.00)

Table 6-4. Total Recoverable Trace and Heavy Metals (μg/g dry) in Produce Collected during 1997[a] (Cont.)

Location	Ag	As	Ba	Be	Cd	Cr	Hg	Ni	Pb	Sb	Se	Tl
Cochiti/Peña Blanca/Santo Domingo:												
Squash	0.50[b]	0.05[b]	11.59	0.05[b]	0.03[b]	0.80	0.05[b]	4.20	2.6	0.50[b]	0.10[b]	0.03[b]
Cucumber	0.50[b]	0.20	7.71	0.05[b]	0.06	0.70	0.05[b]	4.11	1.6	0.50[b]	0.20	0.03[b]
Tomato	0.50[b]	0.05[b]	5.06	0.05[b]	0.12	0.70	0.05[b]	1.22	3.9	0.50[b]	0.20	0.03[b]
Bell pepper	0.50[b]	0.05[b]	2.91	0.05[b]	0.12	0.56	0.05[b]	2.21	23.6	0.50[b]	0.10[b]	0.03[b]
Apple	0.50[b]	0.05[b]	2.30	0.05[b]	0.03[b]	0.32	0.05[b]	0.47	2.5	0.50[b]	0.10[b]	0.03[b]
Lettuce	0.50[b]	0.20	27.10	0.05[b]	0.25	1.07	0.05[b]	32.65	7.9	0.50[b]	0.40	0.03[b]
Mean	0.50	0.10	9.45	0.05	0.10	0.69	0.05	7.48	7.0	0.50	0.18	0.03
(std dev)	(0.00)	(0.08)	(9.30)	(0.00)	(0.08)	(0.25)	(0.00)	(12.42)	(8.4)	(0.00)	(0.12)	(0.00)
Pueblo of San Ildefonso:												
Apple	0.50[b]	0.05[b]	1.60	0.05[b]	0.03[b]	0.59	0.05[b]	0.61	3.0	0.50[b]	0.10[b]	0.03[b]
Apple	0.50[b]	0.05[b]	22.18	0.05[b]	0.03[b]	0.83	0.05[b]	5.03	3.2	0.50[b]	0.10[b]	0.03[b]
Squash	0.50[b]	0.05[b]	14.39	0.05[b]	0.06	0.87	0.05[b]	11.63	3.6	0.50[b]	0.10[b]	0.03[b]
Corn	0.50[b]	0.05[b]	2.37	0.05[b]	0.03[b]	0.68	0.05[b]	4.59	12.2	0.50[b]	0.10[b]	0.03[b]
Cucumber	0.50[b]	0.10	9.86	0.05[b]	0.03[b]	0.78	0.05[b]	2.21	2.0	0.50[b]	0.10[b]	0.03[b]
Tomato	0.50[b]	0.10	6.90	0.05[b]	0.06	1.81	0.05[b]	5.69	13.7	0.50[b]	0.40	0.03[b]
Mean	0.50	0.07	9.55	0.05	0.04	0.93	0.05	4.96	6.3	0.50	0.15	0.03
(std dev)	(0.00)	(0.03)	(7.81)	(0.00)	(0.02)	(0.44)	(0.00)	(3.79)	(5.2)	(0.00)	(0.12)	(0.00)
On-Site Stations												
LANL:												
Peach	0.50[b]	0.05[b]	3.49	0.05[b]	0.03[b]	0.49	0.05[b]	5.65	6.2	0.50[b]	0.20	0.03[b]
Apple	0.50[b]	0.05[b]	3.84	0.05[b]	0.03[b]	0.75	0.05[b]	4.10	1.6	0.50[b]	0.20	0.16
Peach	0.50[b]	0.05[b]	3.94	0.05[b]	0.03[b]	0.49	0.10	3.97	1.9	0.50[b]	0.10[b]	0.03[b]
Peach	0.50[b]	0.05[b]	6.84	0.05[b]	0.07	0.45	0.05[b]	7.28	1.9	0.50[b]	0.10[b]	0.03[b]
Nectarine	0.50[b]	0.05[b]	5.79	0.05[b]	0.05	0.47	0.05[b]	1.85	4.5	0.50[b]	0.10[b]	0.03[b]
Apple	0.50[b]	0.05[b]	4.85	0.05[b]	0.03[b]	0.41	0.10	0.39	2.4	0.50[b]	0.10[b]	0.03[b]
Mean	0.50	0.05	4.79	0.05	0.04	0.51	0.07	3.87	3.1	0.50	0.13	0.05
(std dev)	(0.00)	(0.00)	(1.31)	(0.00)	(0.02)	(0.12)	(0.03)	(2.49)	(1.9)	(0.00)	(0.05)	(0.06

[a] Analysis by EPA Method 3051 for total recoverable metals.
[b] Less-than values were converted to one-half the concentration (Gilbert 1987).
[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 Off-Site Perimeter and Regional (Background) Beehives 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., 1997.

Table 6-6. Radionuclides in Eggs Collected during 1997[a]

Radionuclide	Perimeter: Pueblo of San Ildefonso	Perimeter: Los Alamos Townsite	Regional Background: Española	RSRL[d]
^{238}Pu (pCi/L)[c]	–0.008 (0.004)[b,c]	–0.000 (0.001)	–0.002 (0.001)	0.059
^{239}Pu (pCi/L)	–0.001 (0.004)	–0.001 (0.001)	0.005 (0.002)	0.052
^{90}Sr (pCi/L)	–0.02 (0.81)	0.91 (0.90)	0.69 (0.98)	2.43
Total U (µg/L)	0.04 (0.01)	0.12 (0.01)	0.22 (0.02)	0.31
Tritium (pCi/mL)	0.29 (0.31)	0.32 (0.31)	0.25 (0.25)	0.61
^{137}Cs (pCi/L)	4.6 (6.9)	–5.6 (19.5)	3.8 (5.7)	9.1
^{241}Am (pCi/L)	0.011 (0.003)	0.013 (0.003)	0.005 (0.002)	0.045

[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 1997.

Table 6-7. Radionuclides in Milk Collected during 1997

Radionuclide	Perimeter: Los Alamos[a]	Perimeter: Pojoaque Valley[b]	Regional Background: Albuquerque	RSRL[c]
^{238}Pu (pCi/L)	0.007 (0.003)[d]	0.002 (0.002)	–0.005 (0.003)[e]	0.011
^{239}Pu (pCi/L)	0.083 (0.010)	0.005 (0.002)	0.014 (0.007)	0.020
^{90}Sr (pCi/L)	0.04 (1.62)	–0.16 (0.88)	0.70 (1.65)	6.95
Total U (µg/L)	0.04 (0.01)	0.42 (0.04)	0.03 (0.1)	0.85
Tritium (pCi/mL)	0.31 (0.28)	0.18 (0.36)	–0.10 (0.36)	0.07
^{137}Cs (pCi/L)	20.0 (30.0)	19.8 (29.7)	6.4 (9.6)	19.0
^{131}I (pCi/L)	19.0 (28.5)	14.5 (2.4)	2.0 (3.0)	15.4

[a] Goat's milk.
[b] Cow's milk.
[c] Regional Statistical Reference Level; this is the upper (95%) limit background (mean + 2 std dev) based on data from 1994 to 1997.
[d] (±1 counting uncertainty); values are the uncertainty of the analytical results at the 65% confidence level.
[e] 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 1997

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	–0.14 (0.64)[b,c]	3.85 (12.94)	2.62 (0.46)	2.31 (0.77)	–2.31 (3.08)	26.95 (6.16)	–0.77 (2.31)
Walleye	0.06 (0.66)	0.94 (14.99)	2.36 (0.35)	1.18 (1.18)	NA[d]	NA	20.06 (10.62)
Walleye	0.09 (0.66)	–7.08 (17.46)	0.59 (0.24)	1.18 (1.18)	0.00 (2.36)	10.62 (4.72)	NA
Bass	–0.24 (0.64)	0.48 (1.20)	2.04 (0.24)	2.40 (1.20)	0.00 (3.60)	16.80 (6.00)	12.00 (4.80)
Mean (std dev)	–0.06 (0.16)	–0.45 (4.66)	1.90 (0.91)	1.77 (0.68)	–0.77 (1.33)	18.2 (8.25)	10.43 (10.50)
RSRL[e]	0.20	17.00	27.70	6.50	23.6	28.3	28.90
Downstream (Cochiti):							
Blue Gill	0.10 (0.66)	0.91 (2.57)	0.91 (1.36)	NA	–1.51 (1.51)	3.02 (3.02)	12.08 (12.08)
Crappie	0.15 (0.66)	4.68 (3.78)	1.81 (0.45)	4.53 (1.51)	–3.02 (3.02)	3.02 (3.02)	12.08 (12.08)
Bass	0.07 (0.66)	1.68 (1.56)	2.04 (0.48)	4.80 (1.20)	0.00 (1.20)	7.20 (2.40)	–2.40 (4.80)
Pike	0.09 (0.66)	0.66 (1.32)	1.54 (2.31)	1.10 (1.10)	2.20 (1.10)	6.60 (2.20)	7.70 (9.90)
Pike	0.00 (0.65)	0.66 (1.43)	0.33 (0.55)	3.30 (1.10)	0.00 (1.10)	5.50 (2.20)	5.50 (3.30)
Mean (std dev)	0.08 (0.05)	1.72 (1.71)	1.33 (0.70)	3.43 (1.69)	–0.47 (1.95)	5.07 (1.97)	6.99 (5.97)
Nongame Fish							
Upstream (Abiquiu, Heron, and El Vado):							
Catfish	0.00 (0.65)	0.82 (9.02)	1.07 (0.33)	9.84 (0.82)	6.56 (2.46)	5.74 (3.28)	2.46 (4.10)
Carp	0.24 (0.67)	–0.58 (9.28)	0.93 (0.35)	22.04 (2.32)	3.48 (3.48)	11.60 (5.80)	11.60 (8.12)
Catfish	0.26 (0.67)	10.09 (14.02)	0.74 (1.15)	9.84 (0.82)	6.56 (4.92)	–0.82 (3.28)	9.84 (5.74)
Carp	0.15 (0.66)	–0.46 (7.54)	0.46 (0.58)	6.96 (1.16)	33.64 (9.28)	NA	3.48 (4.64)
Sucker	–0.02 (0.65)	2.52 (14.36)	1.01 (0.38)	3.78 (1.26)	NA	NA	15.12 (8.82)
Mean (std dev)	0.13 (0.13)	2.48 (4.43)	0.84 (0.25)	10.49 (6.92)	12.56(14.13)	5.51 (6.21)	8.50 (5.41)
RSRL[e]	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 1997 (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):							
Sucker	0.06 (0.66)	2.65 (1.76)	2.02 (0.50)	6.30 (1.26)	0.00 (1.26)	6.30 (2.52)	11.34 (3.78)
Catfish	0.20 (0.67)	0.00 (0.90)	1.64 (0.41)	11.48 (0.82)	–1.64 (0.82)	5.74 (1.64)	2.46 (3.28)
Carp	0.14 (0.66)	0.81 (1.39)	0.46 (0.12)	30.16 (3.48)	1.16 (1.16)	4.64 (2.32)	–53.36 (10.44)
Carp	0.07 (0.66)	4.76 (6.61)	0.93 (0.23)	32.48 (3.48)	2.32 (1.16)	2.32 (2.32)	8.12 (2.32)
Carp	0.13 (0.66)	18.68 (13.46)	0.93 (0.23)	39.44 (3.48)	NA	NA	5.80 (6.96)
Mean (std dev)	0.12 (0.06)	5.38 (7.66)	1.20 (0.62)	23.97 (14.30)	0.46 (1.69)	4.75 (1.76)	–5.13 (27.16)

[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] Not analyzed, lost in analysis, or outlier omitted.
[e] 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 Nongame Fish (μg/g wet) Collected during 1997

Upstream Abiquiu Reservoir		Downstream 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] Less-than values were converted to one-half the concentration (Gilbert 1987).
[b] The average (std dev) of five nongame 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, Perimeter, and Regional Background Areas during 1996 and 1997

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							
TA-62/Ski Hill Road/9-13-96/Bull	0.32 (0.14)[b]	0.44 (0.44)	29.3 (6.8)	51.9 (6.6)	12.6 (3.2)	1.4 (1.4)	9.2 (2.7)
TA-18/Pajarito Road/12-2-96/Cow	0.41 (0.14)	0.44 (0.44)	15.8 (3.1)	24.2 (2.6)	0.2 (0.9)	0.4 (1.3)	2.6 (1.3)
TA-54/Pajarito Road/12-9-96/Cow	0.24 (0.14)	0.18 (0.18)	9.7 (14.5)	51.9 (5.3)	–1.8 (0.9)[c]	4.4 (2.2)	0.9 (1.3)
TA-36/Pajarito Road/1-9-97/Bull	0.22 (0.14)	0.44 (0.44)	28.2 (42.3)	100.8 (6.2)	0.2 (0.5)	2.2 (1.3)	4.4 (1.3)
San Ildefonso/Sacred Area/1-19-97/Cow	0.24 (0.14)	5.72 (0.44)	8.4 (12.3)	–8.4 (12.3)	–1.3 (1.8)	4.8 (2.2)	11.4 (5.7)
San Ildefonso/State Road 4/1-24-97/Cow	1.09 (0.14)	1.76 (0.44)	11.9 (18.1)	16.7 (12.0)	2.6 (2.7)	4.0 (2.7)	0.9 (6.6)
TA-49/State Road 4/1-27-97/Cow	0.01 (0.13)	1.76 (0.44)	4.0 (1.3)	–29.9 (18.5)	2.2 (2.7)	0.2 (2.7)	8.4 (7.5)
TA-54/Pajarito Road/3-12-97/Cow	NA[d]	NA	NA	NA	NA	NA	NA
Mean (std dev)	0.36 (0.34)	1.53 (1.96)	15.3 (9.8)	29.6 (43.3)	2.1 (4.9)	2.5 (1.9)	5.4 (4.3)
Regional Background Elk							
Coyote, NM/11-19-96/Cow	0.12 (0.14)	0.44 (0.44)	16.3 (24.7)	0.0 (2.2)	–0.4 (0.9)	–0.4 (0.2)	–0.4 (2.2)
Coyote, NM/11-20-96/Cow	0.03 (0.14)	0.88 (0.44)	48.8 (8.8)	0.0 (4.4)	–6.2 (0.9)	–2.6 (2.7)	11.4 (4.9)
Mean (std dev)	0.08 (0.06)	0.66 (0.31)	32.6 (23.0)	0.0 (0.0)	–3.3 (4.1)	–1.5 (1.6)	5.5 (8.3)
RSRL[e]	0.43	2.71	71.15	3.3	3.5	1.4	17.0
Leg Bone:							
LANL Elk							
TA-62/Ski Hill Road/9-13-96/Bull	0.23 (0.14)	5.00 (5.00)	25.0 (4.0)	1,280.0 (105.0)	45.0 (15.0)	90.0 (20.0)	75.0 (30.0)
TA-18/Pajarito Road/12-2-96/Cow	–0.06 (0.13)	5.00 (5.00)	270.0 (405.0)	1,260.0 (105.0)	–20.0 (20.0)	–20.0 (10.0)	10.0 (25.0)
TA-54/Pajarito Road/12-9-96/Cow	0.42 (0.14)	2.00 (2.00)	–40.0 (15.0)	1,090.0 (110.0)	2.0 (10.0)	80.0 (20.0)	15.0 (25.0)
TA-36/Pajarito Road/1-9-97/Bull	1.54 (0.15)	2.00 (2.00)	–15.0 (120.0)	625.0 (35.0)	–5.0 (10.0)	15.0 (10.0)	40.0 (20.0)
San Ildefonso/Sacred Area/1-19-97/Cow	–0.01 (0.13)	2.00 (2.00)	2.00 (15.0)	955.0 (130.0)	30.0 (35.0)	35.0 (35.0)	65.0 (60.0)
San Ildefonso/State Road 4/1-24-97/Cow	–0.08 (0.13)	15.0 (5.00)	2.0 (15.0)	1,375.0 (165.0)	25.0 (35.0)	25.0 (25.0)	50.0 (80.0)
TA-49/State Road 4/1-27-97/Cow	0.14 (0.14)	50.0 (5.00)	10.0 (5.0)	715.0 (110.0)	–25.0 (10.0)	10.0 (20.0)	40.0 (40.0)
TA-54/Pajarito Road/3-12-97/Cow	0.66 (0.15)	10.0 (5.00)	2.0 (120.0)	885.0 (90.0)	15.0 (20.0)	10.0 (20.0)	–25.0 (25.0)
Mean (std dev)	0.36 (0.54)	11.38(16.27)	32.0 (98.0)	1,023.0 (274.5)	8.4 (24.7)	30.6 (37.2)	33.8 (32.5)

Table 6-10. Radionuclides in Muscle and Bone Tissues of Elk Collected from On-Site, Perimeter, and Regional Background Areas during 1996 and 1997 (Cont.)

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)
Leg Bone:							
Regional Background Elk							
Coyote, NM/11-19-96/Cow	0.14 (0.14)	2.00 (2.00)	30.0 (45.0)	350.0 (40.0)	–45.0 (10.0)	–15.0 (20.0)	35.0 (20.0)
Coyote, NM/11-20-96/Cow	0.06 (0.13)	2.00 (2.00)	–25.0 (120.0)	450.0 (45.0)	35.0 (25.0)	–15.0 (15.0)	45.0 (20.0)
Mean (std dev)	0.10 (0.06)	2.00 (0.00)	2.5 (38.9)	400.0 (70.7)	–5.0 (56.6)	–15.0 (0.0)	40.0 (7.1)
RSRL[e]	0.51	4.32	54.6	2,281.7	114.8	64.7	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] Regional Statistical Reference Level; this is the upper (95%) limit background concentration (mean + 2 std dev) based on data from 1991 to 1997.

Table 6-11. Radionuclides in Muscle and Bone Tissues of Deer Collected from On-Site, Perimeter, and Regional Background Areas during 1996 and 1997

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							
San Ildefonso/State Road 502/11-25-96/Buck	0.14 (0.13)[b]	0.45 (0.45)	21.2 (4.5)	0.9 (2.7)	–2.3 (0.9)[c]	0.2 (2.3)	7.2 (2.7)
TA-73/State Road 502/11-25-96/Buck	0.27 (0.14)	0.18 (0.18)	15.3 (3.6)	49.5 (4.1)	0.2 (0.9)	–0.9 (0.9)	2.3 (1.8)
TA-73/State Road 502/12-4-96/Doe	0.03 (0.13)	0.45 (0.45)	19.4 (3.6)	3.6 (1.4)	–1.8 (0.9)	3.2 (1.4)	1.8 (1.8)
TA-53/LANSCE Road/2-10-97/Buck	0.28 (0.14)	0.18 (0.18)	6.8 (10.0)	–19.8 (12.2)	5.9 (2.7)	6.3 (3.2)	1.6 (0.7)
Mean (std dev)	0.18 (0.12)	0.32 (0.16)	15.7 (6.4)	8.6 (29.2)	0.5 (3.8)	2.2 (3.2)	3.2 (2.6)
Regional Background Deer							
Dulce, NM/10-31-96	0.15 (0.35)	1.80 (0.45)	6.8 (2.3)	22.5 (2.7)	–0.5 (0.9)	0.5 (1.4)	18.5 (10.4)
Mean (counting uncertainty)	0.15 (0.35)	1.80 (0.45)	6.8 (2.3)	22.5 (2.7)	–0.5 (0.9)	0.5 (1.4)	18.5 (10.4)
RSRL[d]	0.86	2.42	29.0	38.3	3.72	14.8	27.5
Leg Bone:							
LANL Deer							
San Ildefonso/State Road 502/11-25-96/Buck	0.52 (0.14)	8.80 (4.40)	22.0 (35.2)	NA[e]	–4.4 (8.8)	35.2 (17.6)	22.0 (17.6)
TA-73/State Road 502/11-25-96/Buck	0.45 (0.14)	1.76 (1.75)	35.2 (52.8)	651.2 (48.4)	–66.0 (30.8)	–35.2 (4.4)	30.8 (17.6)
TA-73/State Road 502/12-4-96/Doe	0.12 (0.14)	1.76 (1.75)	88.0 (132.0)	541.2 (111.0)	26.4 (26.4)	17.6 (22.0)	61.6 (22.0)
TA-53/LANSCE Road/2-10-97/Buck	0.53 (0.13)	1.76 (1.76)	1.8 (13.2)	1,227.6 (136.0)	30.8 (17.6)	22.0 (17.6)	18.5 (7.5)
Mean (std dev)	0.41 (0.19)	3.52 (3.52)	36.8 (36.8)	806.7 (368.7)	–3.3 (44.6)	9.9 (31.0)	33.2 (19.6)
Regional Background Deer							
Dulce, NM/10-31-96	0.12 (0.13)	4.40 (4.40)	39.6 (57.2)	787.6 (57.2)	–17.6 (30.8)	1.8 (17.6)	92.4 (30.8)
Mean (counting uncertainty)	0.12 (0.13)	4.40 (4.40)	39.6 (57.2)	787.6 (57.2)	–17.6 (30.8)	1.8 (17.6)	92.4 (30.8)
RSRL[d]	0.57	6.23	61.8	1,028.3	14.5	2.68	116.5

[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 1997.
[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 San Ildefonso Lands during 1997

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:							
San Ildefonso	0.11 (0.14)[b]	1.48 (0.37)	8.9 (2.6)	31.5 (11.1)	–2.2 (1.5)[c]	2.6 (1.5)	5.9 (4.8)
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:							
San Ildefonso	–0.09 (0.13)	35.00 (5.00)	0.0 (15.0)	1,530.0 (210.0)	0.0 (20.0)	15.0 (20.0)	0.0 (80.0)
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 1997

	^{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	–0.08 (0.33)[a,b]	–1.26 (6.04)	0.008 (0.009)	0.022 (0.012)	15.4 (23.1)	0.82 (0.08)	0.063 (0.019)
RSRL[c]	0.05	1.73	0.015	0.043	17.1	1.28	0.287
Perimeter:							
San Ildefonso	–0.36 (0.22)	2.49 (5.85)	0.048 (0.017)	0.037 (0.016)	12.2 (18.3)	0.71 (0.07)	0.049 (0.017)
Los Alamos Townsite	0.07 (0.13)	0.60 (2.98)	0.018 (0.012)	0.031 (0.013)	6.2 (9.3)	0.86 (0.09)	0.058 (0.019)
White Rock/ Pajarito Acres	0.14 (0.15)	–2.63 (6.65)	0.027 (0.017)	0.018 (0.014)	17.8 (26.7)	0.94 (0.09)	0.018 (0.011)
On-Site:							
LANL (Mortandad Canyon)		7.05 (4.63)	0.039 (0.017)	0.041 (0.018)	8.6 (12.9)	0.68 (0.07)	0.033 (0.012)

[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 1997.

Table 6-14. Radionuclides in Piñon Shoot Tips (Vegetation) Collected from Regional Background, Perimeter, and On-Site Areas during the 1997 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	0.00 (0.66)	3.2 (0.8)	–4.8 (144.0)[b]	–116.8 (2,472.8)	15.2 (11.2)	37.6 (14.4)	16.8 (19.2)
RSRL[c]	1.32	4.8	283.2	4,828.8	37.6	66.4	55.2
Perimeter:							
Los Alamos Townsite	0.70 (0.70)	0.0 (0.8)	18.4 (28.0)	–124.0 (2,632.0)	–5.6 (6.4)	16.8 (10.4)	36.0 (18.4)
White Rock/Pajarito Acres	0.38 (0.68)	12.8 (1.6)	20.8 (31.2)	–157.6 (2,905.6)	6.4 (11.2)	32.0 (12.8)	56.8 (17.6)
Pueblo of San Ildefonso	0.26 (0.67)	177.6 (17.6)	2.4 (4.0)	86.4 (2,489.6)	10.4 (7.2)	32.0 (10.4)	34.4 (16.8)

[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 present data.

E. Figures

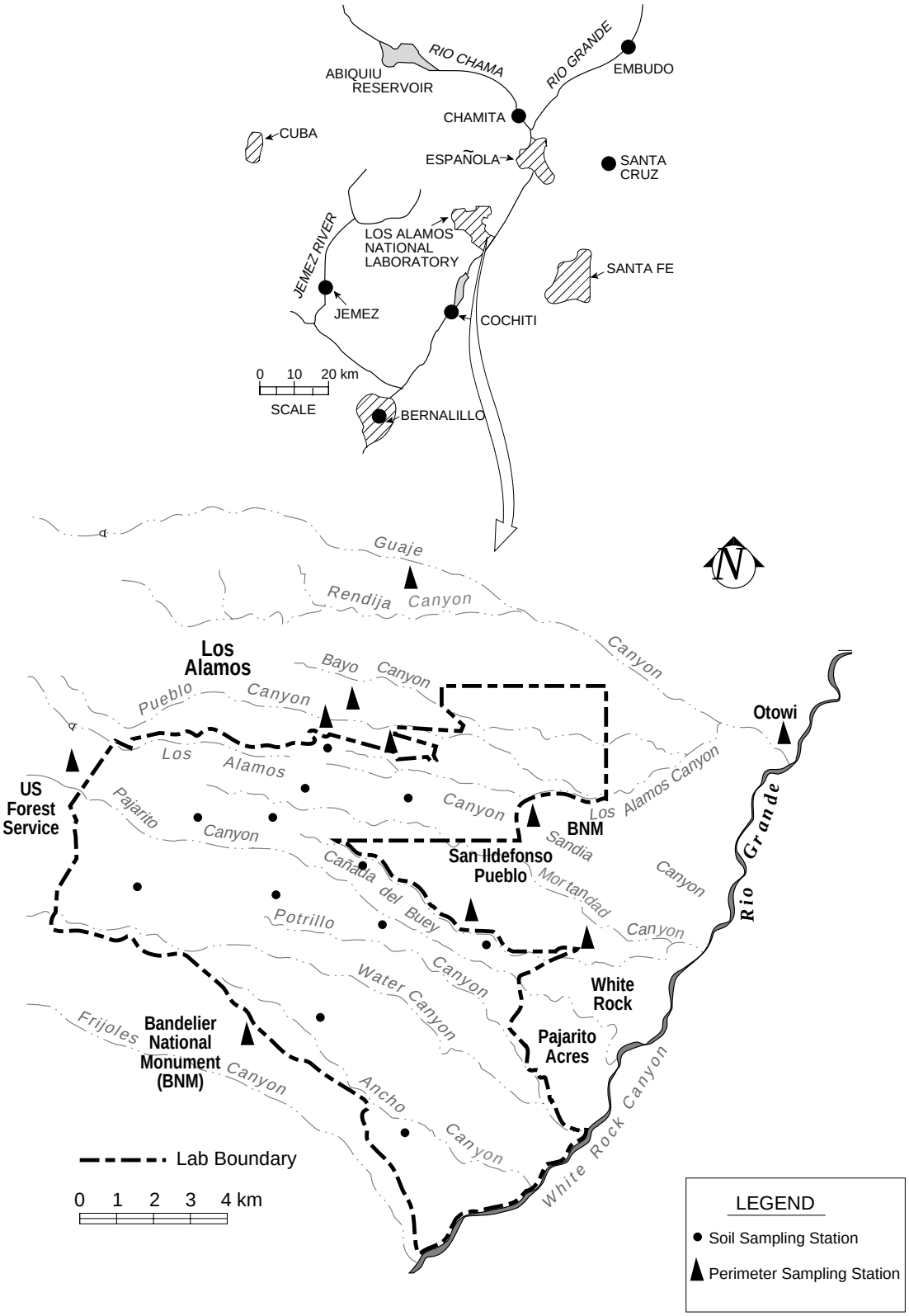

Figure 6-1. Off-site regional (top) and perimeter and on-site (bottom) Laboratory soil sampling locations.

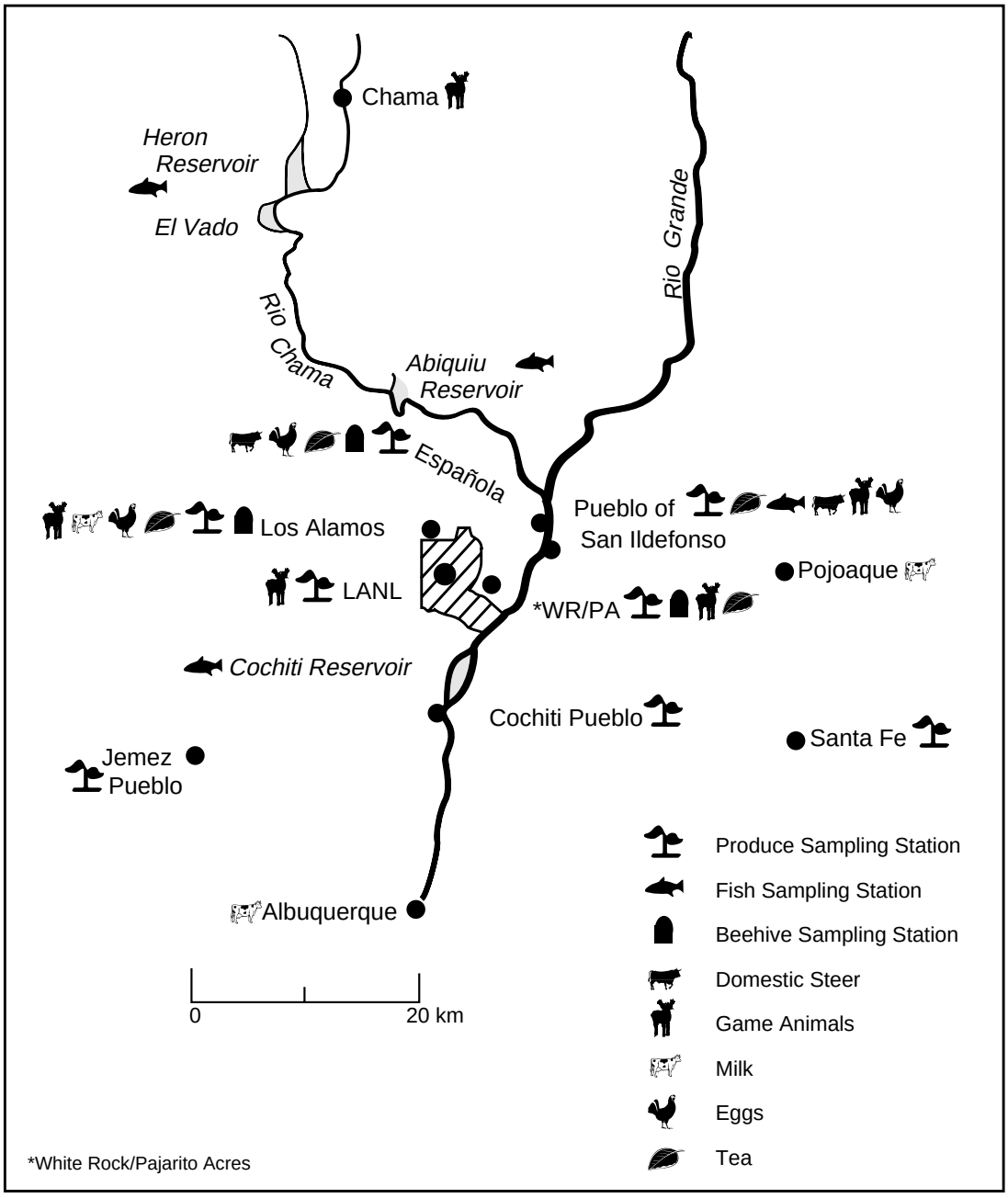

Figure 6-2. Produce, fish, milk, eggs, tea, domestic and game animals, and beehive sampling locations. (Map denotes general locations only.)

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Standards for Environmental Contaminants

Throughout this report, concentrations of radioactive and chemical constituents in air and water samples are compared with pertinent standards and guidelines in regulations of federal and state agencies. 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.

National Pollutant Discharge Elimination System. Table A-4 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-5 presents NPDES annual water quality parameters for all outfalls.

Drinking Water Standards. For chemical constituents in drinking water, regulations and standards are issued by EPA and adopted by the New Mexico Environment Department (NMED) as part of the New Mexico Drinking Water Regulations (Table A-6) (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 acceptance of drinking water (EPA 1989b). There may be health effects associated with considerably higher concentrations of these contaminants.

Appendix A

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-6) 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-7 and A-8.) 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-9. This table shows the number of analytes included in each analytical suite. The specific compounds analyzed in each suite are listed in Tables A-10 through A-13.

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 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 per year, 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) (EPS 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 2.03) 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		
	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 hours	$\mu g/m^3$		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	0.12
	8 hours	ppm		0.08	0.08
Nitrogen dioxide	Annual	ppm	0.05	0.053	0.053
	24 hours	ppm	0.10		
Lead and its 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.

Table A-4. Limits Established by National Pollutant Discharge Elimination System Permit No. NM0028355 for Sanitary and Industrial Outfall Discharges for 1997

Discharge Category	Permit Parameter	Daily Average			Daily Maximum	
Sanitary						
13S TA-46 SWSC Plant	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-4. (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-5. Annual Water Quality Parameters Established by National Pollutant Discharge Elimination System Permit No. NM0028355 for Sanitary and Industrial Outfall Discharges for 1997

Discharge Category	Number of Outfalls	Sampling Frequency	Permit Parameter	Daily Average	Daily Maximum	Unit of Measurement
All Outfall Categories: Annual Water Quality Parameters	65	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-6. Safe Drinking Water Act Maximum Contaminant Levels in the Water Supply for Radiochemicals, Inorganic Chemicals, and Microbiological Constituents

ContaminantsLevel	
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[a]
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, 1997.

Table A-7. 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-8. 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 which 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-9. 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-10. 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
Dichloroethene [1,1-]	5
Dichloroethene [trans-1,2-]	5

Table A-10. Volatile Organic Compounds (Cont.)

Analytes	Limit of Quantitation Water (μg/L)
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-11. 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-11. Semivolatile Organic Compounds (Cont.)

	Limit of Quantitation	
Analytes	**Water (μg/L)**	**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-12. Polychlorinated Biphenyls

	Detection Limits	
Analytes	**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-13. High-Explosives Analytes

	Limit of Quantitation	
Analytes	**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:

$$s = \sqrt{\frac{\sum_{i=1}^{N} \left(\bar{c} - c_i\right)^2}{(N-1)}},$$

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 (1*s*) 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
$µg/m^3$	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, and 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 Consolidation project 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 studied 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 managing 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 chemicals, 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.

^{3}H 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 Maximum 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 prior to 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 due to 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) due to the different types of radiation.

rem = rad x 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, which 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
Aluminum	Al
Americium	Am
Argon	Ar
Antimony	Sb
Arsenic	As
Astatine	At
Barium	Ba
Berkelium	Bk
Beryllium	Be
Bicarbonate	HCO_3
Bismuth	Bi
Boron	B
Bromine	Br
Cadmium	Cd
Calcium	Ca
Californium	Cf
Carbon	C
Cerium	Ce
Cesium	Cs
Chlorine	Cl
Chromium	Cr
Cobalt	Co
Copper	Cu
Curium	Cm
Cyanide	CN
Carbonate	CO_3
Dysprosium	Dy
Einsteinium	Es
Erbium	Er
Europium	Eu
Fermium	Fm
Fluorine	F
Francium	Fr
Gadolinium	Gd
Gallium	Ga
Germanium	Ge
Gold	Au
Hafnium	Hf
Helium	He
Holmium	Ho
Hydrogen	H
Hydrogen oxide	H_2O
Indium	In
Iodine	I
Iridium	Ir
Iron	Fe
Krypton	Kr
Lanthanum	La
Lawrencium	Lr (Lw)
Lead	Pb
Lithium	Li
Lithium fluoride	LiF
Lutetium	Lu
Magnesium	Mg
Manganese	Mn
Mendelevium	Md
Mercury	Hg
Molybdenum	Mo
Neodymium	Nd
Neon	Ne
Neptunium	Np
Nickel	Ni
Niobium	Nb
Nitrate (as Nitrogen)	NO_3-N
Nitrite (as Nitrogen)	NO_2-N
Nitrogen	N
Nitrogen dioxide	NO_2
Nobelium	No
Osmium	Os
Oxygen	O
Palladium	Pd
Phosphaeus	P
Phosphate (as Phosphous)	PO_4-P
Platinum	Pt
Plutonium	Pu
Polonium	Po
Potassium	K
Praseodymium	Pr
Promethium	Pm
Protactinium	Pa
Radium	Ra
Radon	Rn
Rhenium	Re
Rhodium	Rh
Rubidium	Rb
Ruthenium	Ru
Samarium	Sm
Scandium	Sc
Selenium	Se
Silicon	Si
Silver	Ag
Sodium	Na
Stronium	Sr
Sulfate	SO_4
Sulfite	SO_3
Sulfur	S
Tantalum	Ta
Technetium	Tc
Tellurium	Te
Terbium	Tb
Thallium	Tl
Thorium	Th
Thulium	Tm
Tin	Sn
Titanium	Ti
Tritiated water	HTO
Tritium	^3H
Tungsten	W
Uranium	U
Vanadium	V
Xenon	Xe
Ytterbium	Yb
Yttrium	Y
Zinc	Zn
Zirconium	Zr

Standard UC-902 (Environmental Sciences) and UC-707 (Health and Safety) Distribution

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