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Environmental Surveillance at Los Alamos during 1991

8060

Los Alamos
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Aerial view looking westward toward the Valle Grande in the Jemez Mountains. Extending eastward from the mountains, the Pajarito Plateau is cut into numerous narrow mesas divided by southeast-trending canyons. The Los Alamos townsite is on the mesas in the right half of the photograph and Los Alamos National Laboratory is on those in the left. The Laboratory's main technical area (TA-3) is in the top center, at the foot of the mountains, and the Los Alamos Meson Physics Facility (LAMPF) is in the lower center.

LA-12572-ENV

UC-902
Issued: August 1993

Environmental Surveillance at Los Alamos during 1991

Environmental Protection Group

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Department of Energy
Albuquerque Operations
Los Alamos Area Office
Los Alamos, New Mexico 87544

APR 27 1993

To the Reader:

Enclosed is your copy of the Environmental Surveillance Report for the Los Alamos National Laboratory (the Laboratory). This report summarizes the Laboratory's 1991 environmental surveillance program. This program is carried out to assess compliance with environmental standards, to identify at early stages any undesirable environmental trends, and to inform the public about the Laboratory's impact on the environment.

The report was prepared by the Laboratory's Environmental Management Division and Health & Safety Division for the Department of Energy. Since this is an annual report for an ongoing program, we would appreciate your comments or suggestions for improving both the report and the program. My office will continue to work with you to improve the timeliness, quality, and usefulness of this report.

If you are not currently on the mailing list for this report, or if personnel changes in your organization have resulted in a need for us to update our mailing list for next year's report, please contact Joseph Vozella of the Environment, Safety, and Health Branch at the address provided above, or by telephone at (505) 665-5027. I hope you will find this document useful and informative.

Sincerely,

Jerry L. Bellows
Area Manager

Enclosure

ENVIRONMENTAL SURVEILLANCE AT LOS ALAMOS DURING 1991

ENVIRONMENTAL PROTECTION GROUP

ABSTRACT

This report describes the environmental surveillance program conducted by Los Alamos National Laboratory during 1991. Routine monitoring for radiation and for radioactive and chemical materials is conducted on the Laboratory site as well as in the surrounding region. Monitoring results are used to determine compliance with appropriate standards and to permit early identification of potentially undesirable trends. Results and interpretation of data for 1991 cover external penetrating radiation; quantities of airborne emissions and effluents; concentrations of chemicals and radionuclides in ambient air, surface waters and groundwaters, municipal water supply, soils and sediments, and foodstuffs; and environmental compliance. Comparisons with appropriate standards, regulations, and background levels provide the basis for concluding that environmental effects from Laboratory operations are small and do not pose a threat to the public, Laboratory employees, or the environment.

FOREWORD

Suggestions on How to Read This Report

This report is written for both the lay person and the scientist. Each reader may have limited or comprehensive interest in this report. We have tried to make it accessible to all without compromising its scientific integrity. Following are directions advising each audience on how best to use this document.

1. Lay Person with Limited Interest. Read Section I, the Executive Summary, which describes the Laboratory's environmental monitoring operations for this year. Emphasis is on the significance of findings and environmental regulatory compliance. A glossary and a list of acronyms and abbreviations in the back of the report describe pertinent terms and acronyms.

2. Lay Person with Comprehensive Interest. Follow directions for the "Lay Person with Limited Interest" given above. Also, summaries of each section of the report are in boldface type and precede the technical text. Read summaries of those sections that interest you. Further details are in the text following each summary. Appendix A, Standards for Environmental Contaminants; Appendix B, Units of Measurement; and Appendix C, Description of Technical Areas and Their Associated Programs, may also be helpful.

3. Scientists with Limited Interest. Read Section I, the Executive Summary, to determine the parts of the Laboratory's environmental program that interest you. You may then read summaries and technical details of these parts in the body of the report. 1991 publications and references are presented in Sections IX and X.

4. Scientists with Comprehensive Interest. Read Section I, the Executive Summary, which describes the Laboratory's environmental programs this year. Read each major subdivision of this report; detailed data tables are included in each section. Appendix D contains detailed environmental background data.

For further information about this report, contact the Los Alamos National Laboratory's Environmental Protection Group (EM-8):

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ACKNOWLEDGMENTS

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Belinda Harrigan did the editing and assembling of this report in a professional manner. Environmental data were provided by the following groups in the Laboratory's Environmental Management and Health & Safety Divisions: Waste Management (EM-7), Environmental Protection (EM-8), Environmental Chemistry (EM-9), Environmental Restoration (EM-13), Health Physics Measurements (HS-4), Risk Management Support (HS-3), and Health Physics Policy & Programs (HS-12).

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I. EXECUTIVE SUMMARY

A. Introduction

It is the policy of the Los Alamos National Laboratory (LANL or the Laboratory) to provide a safe and healthful working environment for its employees, the employees of its subcontractors, participating guests, and visitors and to prevent any harm to these individuals, the public, or the environment as a result of the Laboratory's activities. The Laboratory began as Project Y of the Manhattan Engineer District during World War II with the specific responsibility of developing the world's first nuclear weapon. The Laboratory is managed by the University of California for the Department of Energy (DOE).

The primary mission of the Laboratory today continues to be nuclear weapons research, development, and testing to help ensure the nation's nuclear deterrent. Programs include weapons development, nuclear fission and fusion research, nuclear safeguards and security, and verification and control technologies. Basic research in physics, chemistry, mathematics, engineering, and materials science is integral to Laboratory activities. Research on peaceful uses of nuclear energy has included space applications, power reactor programs, magnetic and inertial fusion, radiobiology, and medicine. Other programs ongoing at the Laboratory include astrophysics, earth sciences, lasers, computer sciences, solar energy, geothermal energy, biomedical and environmental research, and nuclear waste management research.

"Environmental Surveillance at Los Alamos during 1991" presents the annual summary of the ongoing environmental protection program conducted by the Laboratory. The report includes descriptions of the Laboratory and its mission and programs, the site and the surrounding area, the status of the Laboratory's compliance with environmental regulations and requirements, and the surveillance program of the ambient environment. Radiological and nonradiological constituents are routinely monitored in air, surface water, groundwater, soil, and sediments. The surveillance activities document compliance with appropriate standards and permit limits, identify trends, provide information to the public, and contribute to a better understanding of the Laboratory's impact on the environment.

The format of this year's report has been revised to more closely incorporate the guidance of DOE Order 5400.1 based on a 1991 Tiger Team finding. Readers who have read previous editions of the surveillance report may find the new organization different when attempting to compare analytical results from previous years. Please refer to the Contents and lists of Figures and Tables to locate items of specific interest.

Comprehensive information about compliance status and the monitoring activities is presented in the main body of the report, which includes detailed environmental tables of 1991 analytical results and trends. Methods and procedures for acquiring, analyzing, and recording data, as well as quality assurance procedures, are presented in Section VIII, Quality Assurance and Sampling Procedures. Environmental regulatory standards and background data are presented in Appendices A–D. A Glossary and lists of Acronyms and Scientific Symbols are also included.

B. Environmental Compliance Activities

1. Resource Conservation and Recovery Act.

This act regulates hazardous wastes from generation to ultimate disposal. The Environmental Protection Agency (EPA) has given full authority for administering the Resource Conservation and Recovery Act (RCRA), with the exception of the Hazardous and Solid Waste Amendments (HSWA) of 1984, to the New Mexico Environment Department (NMED). NMED conducted a hazardous waste compliance inspection at the Laboratory on April 29 through May 3, 1991. Nine violations were noted, and a Notice of Violation was issued by the NMED on May 14, 1991. The alleged violations consisted of failure to conduct or maintain adequate inspection records, to label containers properly, to use a satellite storage area properly, to exceed waste storage time limits, and to classify waste properly. These alleged violations presented no threat to human health or to the environment. All alleged violations were corrected within the 30 days allowed by

The Laboratory's response, sent to NMED in June 1991, was found adequate.

Laboratory hazardous waste operations, which will ultimately be closed under RCRA regulations, continued at Technical Area (TA) 35, Waste Oil Storage Pits; TA-40, Scrap Detonation Site; TA-54, Waste Oil Storage Tanks; and TA-16, Landfill at Area P. Six underground storage tanks in need of upgrades were removed during 1991. Laboratory policy is to remove underground storage tanks when user groups determine that the tanks are no longer needed and as funding permits.

The Laboratory's Environmental Restoration program submitted its first site-specific work plan under HWSA in May 1991 and updated the programmatic plan in November. The Laboratory is out of compliance with RCRA requirements related to storage of certain hazardous and mixed wastes subject to the land-disposal restrictions and is utilizing a National Capacity Variance to store mixed waste on site. DOE applied for another variance and worked on statutory changes to address the problems associated with the lack of available or adequate treatment capacity for LDR mixed waste.

2. Clean Water Act.

Regulations under the Clean Water Act (CWA) set water quality standards and effluent limitations. The two primary programs at the Laboratory established to comply with the CWA are the National Pollutant Discharge Elimination System (NPDES) program and the Spill Prevention Control and Countermeasure (SPCC) program.

The CWA, under the NPDES, requires permits for point-source discharges. A single NPDES permit for the Laboratory authorizes effluent discharges from 130 industrial outfalls and 9 sanitary sewage treatment outfalls. The Laboratory submitted a NPDES permit reapplication in September 1990; the existing permit is being administratively continued under 40 CFR 122.6, pending issuance of the new permit. The Laboratory was in compliance with the NPDES permit in 99.0% of the analyses done on samples at sanitary waste discharges and 98.8% at the industrial waste discharges in calendar year (CY) 91. Noncompliant discharges are being addressed under an EPA/DOE Federal Facilities Compliance Agreement (FFCA). For example, the Sanitary Wastewater Systems Consolidation project is designed to eliminate NPDES violations by construction of a new, centralized sanitary wastewater treatment plant at TA-46. In addition, NPDES corrective activities are listed in DOE's "Environmental Restoration and Waste Management Five-Year Plan."

Another NPDES permit authorizes liquid effluent discharge from the Fenton Hill Geothermal Project. The permit is for a single outfall and was issued to regulate the discharge of mineral-laden water from the recycle loop of the geothermal wells. No discharges occurred from this outfall in 1991.

The Laboratory has an SPCC Plan, as required by the CWA in 40 CFR 112. The plan is implemented by providing secondary containment for large tanks and other containers to control accidental oil spills and prevent them from entering a watercourse. The plan also provides for spill control and clean-up training. Approximately 32 major containment structures are presently in use at the Laboratory for spill control. During 1991, eight chemical storage lockers and two containment pallets were purchased.

3. National Environmental Policy Act.

In accordance with the National Environmental Policy Act (NEPA) of 1969, federal agencies must consider the potential environmental impacts of proposed activities during the planning stage so that decisions reflect environmental values, as well as cost and mission. Proposed activities at the Laboratory are reviewed by Environmental Protection Group (EM-8) staff to identify those that could adversely impact the human environment, including environmentally sensitive areas in need of special protection, such as archaeological resources, floodplains, wetlands, and the habitat of threatened or endangered species. The staff provides DOE with information on potential environmental impacts of proposed activities, including the results of surveys of environmentally sensitive areas. No action can go beyond the planning stage, nor can reasonable alternatives be precluded, until DOE approves the NEPA documentation for that action.

In 1991, EM-8 reviewed 614 actions proposed to be undertaken at the Laboratory for NEPA applicability. Seventy-eight DOE Environmental Checklists (DECs) were submitted to DOE on 90 of these projects. In addition to the 78 DECs submitted to DOE on 1991 projects, 21 DECs were submitted during 1991 on projects reviewed through the Environment, Safety, and

Health Questionnaire process during 1990, and decisions were still pending at DOE on 21 DECs submitted during 1990. Of the 120 DECs submitted to DOE for decisions, 62 were categorically excluded from additional NEPA documentation, Environmental Assessments (EAs) were required on 12, prior NEPA documentation covered 2, and no decision had been made on the remaining 44 by the end of 1991. EAs were written on five of the proposed projects.

4. Federal Clean Air Act and New Mexico Air Quality Control Act.

Regulations under these acts set ambient air quality standards, require the permitting of new sources, and set acceptable emission limits. During 1991, all of the Laboratory's existing operations remained in compliance with air quality regulations for nonradioactive emissions.

- Monitoring demonstrated compliance with all ambient air quality standards except the state ozone standard.
- All construction projects at the Laboratory were reviewed, and air emissions were estimated to determine whether air permits or construction approvals were required.
- One sample that exceeded the opacity limits was recorded.

The state ozone standard is exceeded in many areas of the state. The cause of these exceedences is unknown; they may result from transport from urban areas or may be generated by local sources. Because the New Mexico Air Quality Act does not specifically require compliance with state standards, there are no enforcement actions associated with these exceedences. Instead, the state uses these standards as guidelines in setting allowable emission limits for regulated sources, based on modeling results. At present, LANL is not affected by these emission limits.

During 1991, no Laboratory asbestos renovation or demolition operation produced visible asbestos emissions to the environment. Johnson Controls Inc. removed approximately 2,095 lin ft of friable asbestos, including 110 lin ft of potentially radioactive contaminated friable material from small jobs. Approximately 193 sq ft of friable insulation were removed from vessels and other facility components, and 330 sq ft of nonfriable vinyl-asbestos floor tile were removed. A total of 1,640 lin ft of friable asbestos was removed through large job work.

The Laboratory identified a beryllium cutting operation at TA-55-4 in August 1991 which may require a permit under the requirements of New Mexico Air Quality Control Regulation 702 - Permits. Following discussions with the NMED, DOE officially notified NMED on October 9, 1991, of the operations. Beryllium cutting operations were suspended and a commitment was made to file an air quality permit application with NMED. The NMED issued a Notice of Violation (NOV) for the beryllium cutting operation on October 16, 1991. Negotiations for settling this NOV are continuing between Laboratory, DOE, and NMED personnel.

The EPA regulates radioactive air emissions from DOE facilities under the Clean Air Act. During 1991, the Laboratory remained in compliance with the EPA standard that limits the effective dose equivalent to a member of the public from airborne radioactive emissions to less than 10 mrem/yr. However, the Laboratory cannot yet demonstrate compliance with all of EPA's radioactive emission monitoring requirements, and DOE received a Notice of Noncompliance from EPA on November 27, 1991. A draft FFCA to address bringing the emission monitoring program into compliance with the regulations was submitted by DOE to the EPA on March 12, 1992.

5. Safe Drinking Water Act.

The municipal and industrial water supplies for the Laboratory and community are from 16 deep wells owned by DOE and one gallery (collection system fed by a spring in Water Canyon). The wells range in depth from 265 to 942 m (869 to 3,090 ft). In 1991, the chemical quality of the water met federal and state primary and secondary drinking water standards.

6. Federal Insecticide, Fungicide, and Rodenticide Act.

This act regulates the manufacturing of pesticides, with requirements on registration, labeling, packaging, enforcement, recordkeeping, distribution, worker protection, certification, experimental use, and tolerances in foods and feeds. An annual inspection conducted in 1991 by the U.S. Department of Agriculture found no deficiencies in the Laboratory's pesticide application program or certified application equipment. In 1991,

approximately 27.5 lb of herbicides and 287.5 gal. of pesticides were applied at the Laboratory.

7. National Historic Preservation Act.

As required by Section 106 of the National Historic Preservation Act of 1966, which was implemented by 36 CFR 800, "Protection of Historic Properties," Laboratory activities are evaluated in consultation with the State Historic Preservation Officer for possible effects to cultural or historic resources. During 1991, Laboratory archaeologists evaluated 1,110 undertakings (an undertaking is an activity that has the potential to affect a cultural/historic resource), conducted 51 field surveys, recorded 161 new archaeological sites, and updated the site records for 20 previously recorded sites.

8. Endangered/Threatened/Protected Species.

The DOE and the Laboratory must comply with the Endangered Species Act of 1973, as amended. Compliance under NEPA requires review of projects for potential environmental impact on critical habitats. During 1991, EM-8 reviewed 614 actions proposed to be undertaken at the Laboratory and identified 40 projects as needing reconnaissance surveys, 15 proposed actions as needing quantitative surveys, and 8 projects as requiring intensive surveys to determine the presence or absence of a species at the project site.

9. Floodplain/Wetland Protection.

The Laboratory must comply with Executive Order (EO) 11988, "Floodplain Management," and EO 11990, "Protection of Wetlands." Compliance with NEPA also requires review of projects for potential environmental impact on floodplains and wetlands. During 1991, 416 proposed actions were reviewed for impact to floodplains and wetlands. All projects reviewed were outside floodplain/wetland boundaries.

10. Comprehensive Environmental Response, Compensation, and Liability Act/Superfund Amendments and Reauthorization Act.

Clean-up of toxic and hazardous contaminants at closed and abandoned hazardous waste sites was mandated by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The Superfund Amendments and Reauthorization Act (SARA) of 1986 extensively amended CERCLA. Investigations and any required remedial actions at Los Alamos will be completed as part of DOE's Environmental Restoration program in conjunction with RCRA corrective actions.

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

The University of California, as operator of the Laboratory, is required to report under Title III Section 313 of SARA if: (1) the Laboratory uses a listed toxic chemical above a specified threshold, and (2) the use of the chemical comes under the Standard Industrial Classification (SIC) Codes 20-39. All research operations at the Laboratory are exempt under other provisions of the regulation. Only pilot plants and specialty chemical production or manufacturing facilities at the Laboratory which fall under (1) above must report their releases.

The only facility of the Laboratory which could be considered to be within SIC codes 20-39 and therefore required to report under Section 313 is TA-55-4, the Plutonium Processing Facility. Reporting the chemical use and emissions for TA-55 has been the Laboratory's decision because of the special materials processing done at the facility. The only regulated chemical used at the Plutonium Processing Facility in amounts greater than the Section 313 reporting thresholds is nitric acid.

The Laboratory submitted its Section 313 report to EPA in July 1991. This report covered the releases of nitric acid during 1990. About 24,320 kg (53,500 lb) of nitric acid were used for plutonium processing with releases to the air of approximately 468.7 kg (1,031 lb). Atmospheric releases were calculated using data obtained from a study which measured the air emissions from the facility. All other nitric acid that was not consumed in chemical reactions was completely neutralized during wastewater treatment operations. Only the air releases required reporting in 1990. Data on releases for CY91 will be reported under Section 313 in July 1992.

12. Toxic Substances Control Act.

This act regulates the manufacture, processing, distribution, use, storage, and labeling of all chemical substances, including polychlorinated biphenyls (PCBs). The Laboratory has EPA authorization to dispose of PCB-contaminated equipment and soil at its low-level radioactive waste landfill (TA-54, Area G). However,

off site for disposal: 25,306 kg (55,673 lb) liquid PCB oil that included some 50-499 ppm PCB oil; 4,502 kg (9,904 lb) contaminated debris; 3,114 kg (6,851 lb) contaminated water; 64,621 kg (142,166 lb) from 39 transformers; and 6,622 kg (14,568 lb) from capacitors. In addition, 31,496 kg (69,291 lb) of PCB-contaminated soil, debris, and equipment were disposed of at TA-54, Area G. Of the 31 PCB transformers being retrofilled within the last two years, 11 were reclassified to non–PCB status at the end of 1991, and most of the rest were reclassified to PCB-contaminated status. The DOE Tiger Teams audited and inspected the Laboratory's PCB program in 1991. No audits or inspections of the Laboratory's PCB activities were conducted by the EPA or NMED in 1991.

C. Unplanned Releases

1. Airborne Radionuclide Releases.

On February 1, 1991, 2,800 Ci of elemental tritium were released at TA-41. Less than 0.1% of the tritium was present as tritiated water. The effective dose equivalent (50-yr dose commitment) to a member of the public was calculated to be 0.03 mrem. This dose occurred 7 km east of TA-41, where Los Alamos Canyon reaches State Road 4. The dose estimate conservatively assumed that 1% of the tritium was oxidized before reaching the receptor location. The dose is 0.03% of DOE's public dose limit (PDL) of 100 mrem/yr from all pathways and 0.3% of the EPA's 10 mrem/yr limit for the air pathway.

On March 28, 1991, 0.40 Ci of tritiated water vapor were released from TA-21 as tritium oxide. The effective dose equivalent to a member of the public was calculated to be 0.01 mrem. The dose is 0.01% of DOE's PDL from all pathways and 0.1% of the EPA's limit for the air pathway.

On April 17, 1991, 0.1550 Ci of tritiated water vapor were released from TA-3-16. A slow leak was discovered at the Van de Graaff accelerator. The effective dose equivalent to a member of the public was calculated to be 0.006 mrem. The dose is 0.006% of DOE's PDL and 0.06% of the EPA limit.

2. Airborne Nonradiological Releases.

No unplanned airborne nonradiological releases were reported during 1991.

3. Radioactive Liquid Releases.

On January 2, 1991, a discharge was discovered at TA-54, Area G. A plumbing joint on an eye wash/safety shower located inside Building 33 froze and burst sometime between December 21, 1990, and January 1, 1991, when the Laboratory was closed for the winter holidays. The amount of discharge was estimated to be 18,000 gal. Analyses were conducted on the frozen water and soil; gross alpha, beta, and gamma were found to be within background levels. Samples analyzed for tritium averaged 0.29 μCi/L, approximately 15% of the DOE Derived Concentration Guide for off-site tritium releases (2.0 μCi/L). Removal of the frozen water below Building 33 was not required because of the slow rate of melting during which the water either evaporates or enters the subsurface rather than producing a definitive runoff into Cañada del Buey.

On February 21, 1991, 0.2 μCi of plutonium and americium were released at TA-50 from a leaking pipe near the Size Reduction Facility. The spill was confined to a small area. The leak was repaired, and the spill was cleaned up to applicable standards.

4. Nonradioactive Liquid Releases.

On September 25, 1991, an underground diesel fuel transfer line broke during start-up of the TA-3 power plant's backup fuel system. Approximately 100-200 gal. of diesel fuel oil surfaced and was discharged across the ground to a storm water channel, where it drained into a tributary to Sandia Canyon. The discharge was immediately reported to EPA and NMED. Corrective actions included immediate shutdown of the fuel line. The diesel spill was contained in the water course within minutes using absorbent booms and pillows. Pools of diesel fuel and water were removed using a wet/dry vacuum and absorbents. The contaminated soil was sampled, removed, and disposed of at the Los Alamos County landfill.

During 1991, 56 other releases of nonradioactive liquids occurred at the Laboratory and were reported to the EPA and NMED. Each of these discharges was minor in nature and was contained on Laboratory property. None was found to be of any threat to health or to the environment. Sampling and clean-up were completed. Over 60% of these unplanned releases were either potable water or steam condensate originating from the Laboratory's utility system.

D. Monitoring Operations

1. Introduction.

The Laboratory supports an ongoing environmental surveillance program as required by DOE Orders 5400.1 and 5484.1. The surveillance program includes routine monitoring for radiation, radioactive materials, and hazardous chemical substances on the Laboratory site and in the surrounding region. These activities document compliance with appropriate standards, identify trends, provide information for the public, and contribute to general environmental knowledge. The environmental program also includes an assessment of the Laboratory's impact on the surrounding environment. Detailed, supplemental environmental studies also are carried out to determine the extent of potential problems, to provide a basis for any remedial actions, and to gather further information on the surrounding environment.

Monitoring and sampling locations for various types of environmental measurements are organized into three groups:

- Regional stations are located within the five counties surrounding Los Alamos County at distances up to 80 km (50 mi) from the Laboratory. They provide a basis for determining conditions beyond the range of potential influence from normal Laboratory operations.
- Perimeter stations are located within about 4 km (2.5 mi) of the Laboratory boundary, and many are in residential and community areas. They document conditions in areas regularly occupied by the public and potentially affected by Laboratory operations.
- On-site stations are within the Laboratory boundary, and most are in areas accessible only to employees during normal working hours.

They document environmental conditions at the Laboratory where public access is limited. Approximately 130,000 analyses for chemical and radiochemical constituents were carried out for more than 6,200 environmental samples during 1991.

2. External Penetrating Radiation.

Levels of external penetrating radiation (including x and gamma rays and charged particle contributions from cosmic, terrestrial, and manmade sources) around the Los Alamos area are monitored with thermoluminescent dosimeters (TLDs) at 150 locations.

Annual averages for the TLDs were generally the same in 1991 as in 1990, consistent with the variability in natural background observed at these stations. The network at Los Alamos Meson Physics Facility (LAMPF) did not record any radiation measurement above its 3.0 mrem/yr detection limit during 1991 because of reduced operations at the facility.

Radiation levels (including natural background radiation from cosmic and terrestrial sources) are also measured at regional, perimeter, and on-site locations in the environmental TLD network. Some measurements at on-site stations were above background levels, as expected, reflecting ongoing research activities at, or past releases from, Laboratory facilities.

3. Air Monitoring.

a. Radioactive. The sampling network for ambient airborne radioactivity consists of 36 continuously operating air sampling stations. Total radioactive airborne emissions decreased substantially from those in 1990. This was primarily due to a 48% decrease in releases of airborne activation products from LAMPF.

Ambient air is routinely sampled for tritium, uranium, plutonium, americium, and gross beta activity. Measurements of radioactivity in the air are compared with DOE's derived concentration guides.

Tritium was the primary radionuclide with air concentrations that showed levels indicating any measurable impact from radionuclide releases caused by Laboratory operations. Annual average concentrations of tritium continued to be much less than 0.1% of DOE's guides at all stations and posed no environmental or health problems in 1991. Annual average concentrations of all other radionuclides in air during 1991 were also much less than 0.1% of the guides.

b. Nonradioactive. The Laboratory operates monitors to routinely measure primary (or "criteria") pollutants, beryllium, acid precipitation, and visibility. In 1991, the Laboratory also monitored toxic air pollutants as part of a short-term study. Levels of pollutants in the ambient environment are extremely low and are in compliance with all applicable standards, except the state ozone standard.

4. Surface Water and Groundwater Monitoring.

Surface waters and groundwaters are monitored to detect potential dispersion of radionuclides and hazardous chemicals from Laboratory operations. Surface waters and shallow groundwaters in existing and former liquid effluent release areas contained radioactivity in concentrations that were above natural terrestrial and worldwide fallout levels. These waters are not a source of industrial or municipal water supplies. The quality of water from regional, perimeter, and on-site areas that have received no direct discharge showed no significant effects from Laboratory releases. Samples from deep test wells and water supply wells continued to show no radioactive or chemical contamination in the main aquifer. The top of the main aquifer occurs 180 to 360 m (600 to 1,200 ft) beneath the Pajarito Plateau. Liquid effluents containing low levels of radioactivity are routinely released from one waste treatment plant.

5. Soils and Sediments Monitoring.

Measurements of radioactivity and chemicals in samples of soils and sediments provide data on less direct pathways of exposure. These measurements are useful for understanding hydrological transport of radioactivity in intermittent stream channels near low-level radioactive waste management areas. Areas within Pueblo, Los Alamos, and Mortandad Canyons all had concentrations of radioactivity in sediments at levels higher than those attributable to natural terrestrial sources or worldwide fallout. Cesium, plutonium, and strontium in Mortandad Canyon result from effluents from a liquid waste treatment plant. No runoff or sediment transport has occurred beyond the Laboratory boundary in Mortandad Canyon since effluent release into the canyon started. However, some radioactivity in sediments in Pueblo Canyon (from pre-1964 effluents) and Los Alamos Canyon (from post-1952 treated effluents) has been transported to the Rio Grande. Theoretical estimates, confirmed by measurements, show that the incremental effect on Rio Grande sediments is a small percentage of the background concentrations attributable to worldwide fallout in soils and sediments.

Surface runoff has transported some low-level contamination from the active waste disposal area and several of the inactive areas into controlled-access canyons. Analyses of toxic metals in surface sediments indicate that no constituents in excess of EPA threshold criteria for determining hazardous waste are present in these canyons.

6. Monitoring of the Water Distribution System.

Samples are collected and analyzed from the Los Alamos County water distribution system on a routine basis in order to determine the levels of organic and inorganic chemical constituents and radioactive constituents in the local drinking water. During 1991, all water samples collected were found to be in compliance with the maximum contaminant levels established by federal regulation and New Mexico Water Supply Regulations.

7. Foodstuffs Monitoring.

Most fruit, vegetable, fish, bee, and honey samples from perimeter locations showed no radioactivity distinguishable from that attributable to natural sources or worldwide fallout. Some produce, bee, and honey samples from on-site locations had elevated tritium (H^3) concentrations at levels <1% of DOE's guides for tritium in water (there are no concentration guides for produce). The range in H^3 values in produce samples collected from Laboratory lands ranged in concentration from 0.7 to 8.1 pCi/mL. These values are higher than those in 1990 samples.

One fruit sample collected from the townsite area (the former TA-1 site) contained elevated levels of H^3 (16 pCi/mL) and $^{239,240}Pu$ (0.02 pCi/dry g). Plutonium levels, in particular, were about 100 times the levels found in fruit samples collected from other trees in the area. The amount of Pu in this fruit does not pose a health hazard; the total dose as a result of all radionuclides that could be obtained from ingesting all of the fruit from this tree (estimated to be about 50 lb) was only 0.3 mrem/yr.

E. Estimated Doses and Risks from Radiation Exposure

1. Radiation Doses.

Estimated individual radiation doses to the public attributable to Laboratory operations are compared with applicable standards in this report. Doses are expressed as percentages of DOE's public dose limit. The PDL excludes exposures from natural background, fallout, and radioactive consumer products. Estimated doses

are believed to be potential doses to individuals under realistic conditions of exposure.

In 1991, the estimated maximum individual effective dose was 4.4 mrem, or 4.4% of DOE's 100 mrem/yr standard for all pathways. It is 44% of EPA's 10 mrem/yr standard for the air pathway alone. This dose resulted mostly from external radiation from short-lived, airborne emissions from a linear particle accelerator at LAMPF. Another perspective is gained by comparing these estimated doses with the estimated effective dose attributable to background radiation. The estimated maximum effective dose from Laboratory operations is about 1.0% of the 339 mrem received from background radiation and radioactivity in Los Alamos during 1991. The average effective dose to residents in the Los Alamos townsite and to residents in White Rock are 0.05 mrem and 0.03 mrem, respectively.

2. Risk Estimates.

Estimates of the added risk of cancer were calculated to provide a perspective for comparing the significance of radiation exposures. Based on the average effective dose, incremental cancer risk to residents of Los Alamos townsite caused by 1991 Laboratory operations was estimated to be 1 chance in 47,000,000 and 1 chance in 68,000,000 for residents of White Rock. This risk is compared to the 1 chance in 8,000 for cancer from natural background radiation and the 1 chance in 43,000 for cancer from medical radiation.

The Laboratory's potential contribution to cancer risk is small when compared with overall cancer risks. The overall lifetime risk in the United States of contracting some form of cancer is 1 chance in 4. The lifetime risk of cancer mortality is 1 chance in 5.

II. INTRODUCTION

A. Los Alamos National Laboratory

In March 1943, a small group of scientists came to the Los Alamos Ranch School, located on a remote mesa high above the Rio Grande, northwest of Santa Fe. Project Y of the Manhattan Engineer District was charged with the specific responsibility of developing the world's first nuclear weapon. Originally, it was expected that the task could be completed by a hundred scientists. By 1945, when the first nuclear bomb was tested at Trinity Site in southern New Mexico, more than three thousand civilian and military personnel were working at Los Alamos National Laboratory (LANL or the Laboratory).

After the end of World War II, LANL became a permanent institution that is recognized as one of the finest scientific research laboratories in the world. A key factor in the Laboratory's excellence has been its management, since 1943, by the University of California. The University has maintained the tradition of free inquiry and debate that is essential to excellence in any scientific undertaking.

Today, the Laboratory is a vertically integrated research and development (R&D) institution of the Department of Energy (DOE). Vertical integration means the "research-to-retirement" responsibility that the weapons laboratories are assigned for nuclear warheads. The Laboratory works with the production plants to ensure that designs can be manufactured and with the armed services to ensure that the weapons are safe, secure, and reliable during their life cycle. The nuclear weapons program has provided challenge, flexibility, and a breadth of science and technology that has allowed LANL to contribute to many problems of national importance, developing expertise in solving large, complex technological problems for the nation and demonstrating that science makes a difference.

The overriding importance of the nuclear deterrence mission, plus the DOE's success in carrying it out, has encouraged the federal government over the years to invest resources in the Laboratory. The estimated operating cost of the Laboratory for fiscal year 1991 is $964 million, supported by close to $87 million in construction and capital equipment funds. Currently 57% of the operating budget supports broad DOE defense activities; 18% Department of Defense projects; and 25% civilian R&D, predominantly research and technology development and programs supported by the nondefense programs of DOE (Fig. II-1).

The Laboratory is the largest employer in northern New Mexico with about 7,550 full-time-equivalent employees. More than 3,000 of these employees are technical staff members, more than 2,000 are technicians, and the remainder are administrative and general support personnel.

In addition to University of California employees, over 2,000 more people are employed by contractors providing support services, protective force services, specialized scientific and technical services, and student researchers.

The primary mission of the Laboratory is nuclear weapons research, development, and testing to help ensure the nation's nuclear deterrence. As a multiprogram laboratory, it also serves the nation by using core competencies to make special contributions in such areas as

- technical assistance to the DOE weapons complex,
- energy and environmental technologies with an emphasis on working with U.S. industry,
- basic research to underpin the Laboratory's programs and support the DOE research mission, and
- work for other federal agencies, including defense and intelligence.

In performing its mission, the Laboratory has received a number of specific R&D assignments, including

- research, design, development, engineering, and testing of nuclear warhead concepts and new weapons capabilities, maintenance and enhancement of the technology base that is the

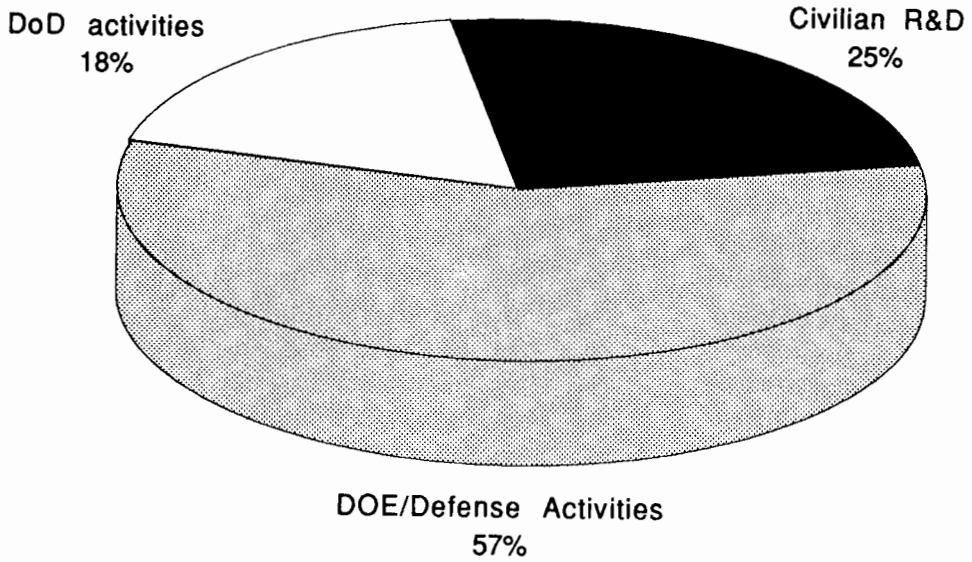


Fig. II-1. FY91 actual operating costs by percentage of allocation to programs.

foundation of the weapons program, and maintenance of the Laboratory's capabilities for nuclear tests and the execution of such tests;

- research, development, and testing support for advanced nuclear directed-energy concepts;
- R&D on inertial confinement fusion, including fusion target physics, laser-target interaction experiments, target design and fabrication, and high-energy laser development;
- nuclear materials R&D directly related to the nuclear weapons program, including research in materials science and materials development, process and fabrication development, and transfer of technology to the DOE production complex;
- non-nuclear materials R&D activities, including the neutral particle beam, free-electron laser, sensors, battle management, communication, command and control, high-velocity projectiles, advanced lasers, acquisition and tracking of targets, optics, beam propagation, and high-power microwaves;
- advanced conventional munitions, including computer code development and simulations, energetic and nonenergetic materials R&D, applications to armor/anti-armor, counter terrorism, and counter narcotics, and operations research and systems analysis;
- verification and safeguards R&D, including domestic and international safeguards, satellite- and earth-based detection and monitoring of nuclear tests, earth-based monitoring of nuclear weapons, and verification of chemical and biological warfare treaties;
- intelligence activities sponsored by national intelligence organizations involving the areas of hardware, analysis, international technology transfer and technology security, and Laboratory intelligence support;
- systems studies in the areas of strategic and tactical nuclear weapons, directed-energy weapons, non-nuclear weapons, energy technology, and supporting technologies;
- environmental R&D, including storing and managing radioactive waste, handling hazardous

waste, investigating new technologies to address problems associated with waste characterization and clean-up, environmental control technologies, global climate change, ozone depletion, clean air, and basic environmental science;

- non-nuclear energy activities, including renewable energy, conservation, and fossil energy;
- nondefense advanced technology that focuses on aerospace technology, biotechnology, artificial intelligence, and robotics;
- human genome studies, including informatics, research, and associated technology;
- research on the health consequences associated with the production and use of energy and national security materials, including radioisotope medicine, research on Acquired Immune Deficiency Syndrome, structural biology, and the use of lasers in medicine; and
- basic research in defense- and energy-related disciplines, including atomic and molecular physics, bioscience, chemistry, computational science and applied mathematics, geoscience, space science, astrophysics, materials science, nuclear and particle physics, plasma physics, fluids, particle beams, and applied science and engineering.

B. 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 100 km (60 mi) north-northeast of Albuquerque and 40 km (25 mi) northwest of Santa Fe (Fig. II-2). The 111 km^2 (43 mi^2) Laboratory site and adjacent communities are situated on Pajarito Plateau, which consists of a series of finger-like mesas separated by deep east-to-west oriented canyons cut by intermittent streams (Fig. II-3). Mesa tops range in elevation from approximately 2,400 m (7,800 ft) on the flanks of the Jemez Mountains to about 1,900 m (6,200 ft) at their eastern termination above the Rio Grande Valley.

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

Laboratory land is used for building sites, experimental areas, waste disposal locations, roads, and utility rights-of-way (see Fig. II-4 and Appendix C). However, these uses account for only a small part of the total land area. Most land provides isolation for security and safety and is a reserve for future structure locations.

The DOE controls the area within Laboratory boundaries and has the option to completely restrict access. Limited access by the public is allowed in certain areas of the Laboratory reservation. An area north of Ancho Canyon (Fig. II-5) between the Rio Grande and State Road 4 is open to hikers, rafters, and hunters, but woodcutting and vehicles are prohibited. Portions of Mortandad and Pueblo Canyons are also open to the public. An archaeological site (Otowi Tract), northwest of State Road 502 near the White Rock Y, and the cave kiva in Mortandad Canyon are open to the public subject to restrictions of cultural resource protection regulations.

In August 1977, the Laboratory site was dedicated as a National Environmental Research Park. The ultimate goal of programs associated with this regional facility is to encourage environmental research that will contribute to understanding how people can best live in balance with nature while enjoying the benefits of technology. Park resources are available to individuals and organizations outside of the Laboratory to facilitate self-supported research on these subjects deemed compatible with the Laboratory programmatic mission (DOE 1979).

A final Environmental Impact Statement (DOE 1979) that assessed potential cumulative environmental impacts associated with then, known future, and continuing activities at the Laboratory was completed in 1979. The report provided environmental input for decisions regarding continuing activities at the Laboratory. It also provided more detailed information on the environment of the Los Alamos area.

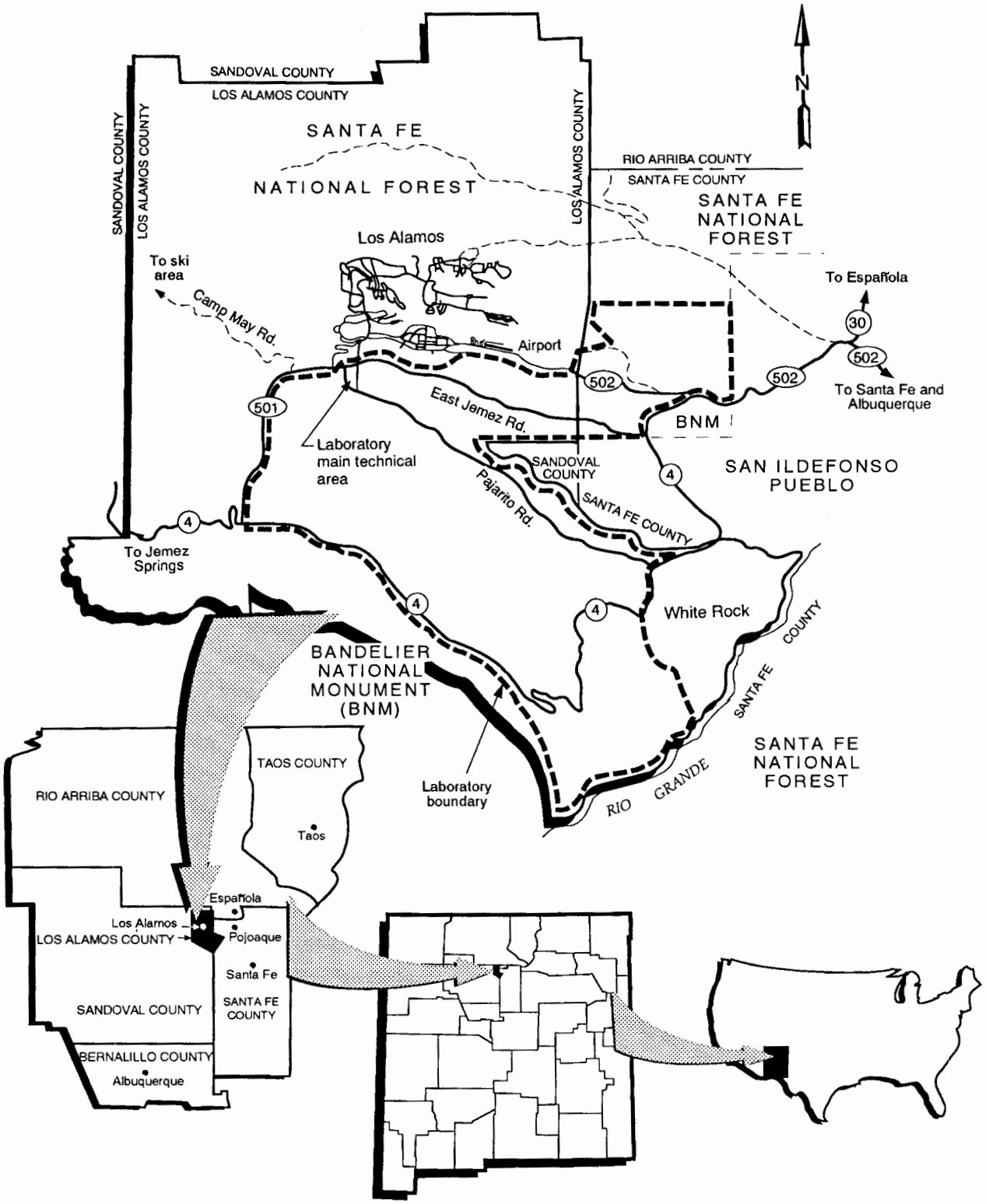


Fig II-2. Regional location of Los Alamos.

C. Geology-Hydrology

Most of the finger-like mesas in the Laboratory area are found in Bandelier Tuff (Fig. II-6). Ash fall, ash fall pumice, and rhyolite tuff form the surface of Pajarito Plateau. The tuff, ranging from nonwelded to welded, is over 300 m (1,000 ft) thick in the western part of the plateau and thins to about 80 m (260 ft) eastward above the Rio Grande. It was deposited as a result of a major eruption of a volcano in the Jemez Mountains about 1.1 to 1.4 million years ago.

The tuffs overlap 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 (Fig. II-6) in the central and eastern edge along the Rio Grande. Chino Mesa basalts interfinger with the conglomerate along the river. These formations overlay the sediments of the Tesuque Formation, which extends across the Rio Grande Valley and is in excess of 1,000 m (3,300 ft) thick. The Laboratory is bordered on the east by the Rio Grande, within the Rio Grande Rift. Because the rift is slowly widening, the area experiences frequent but minor seismic disturbances.

Los Alamos area surface water occurs primarily as intermittent streams. Springs on the flanks of the Jemez Mountains supply base flow into upper reaches of some canyons, but the amount is insufficient to maintain surface flows across the Laboratory site before it is depleted by evaporation, transpiration, and infiltration. Runoff from heavy thunderstorms or heavy snowmelt reaches the Rio Grande several times a year in some drainages. Effluents from sanitary sewage, industrial waste treatment plants, and cooling-tower blowdown are released into some canyons at rates sufficient to maintain surface flows for varying distances.

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

Intermittent stream flows in canyons of the plateau have deposited alluvium that ranges from less than 1 m

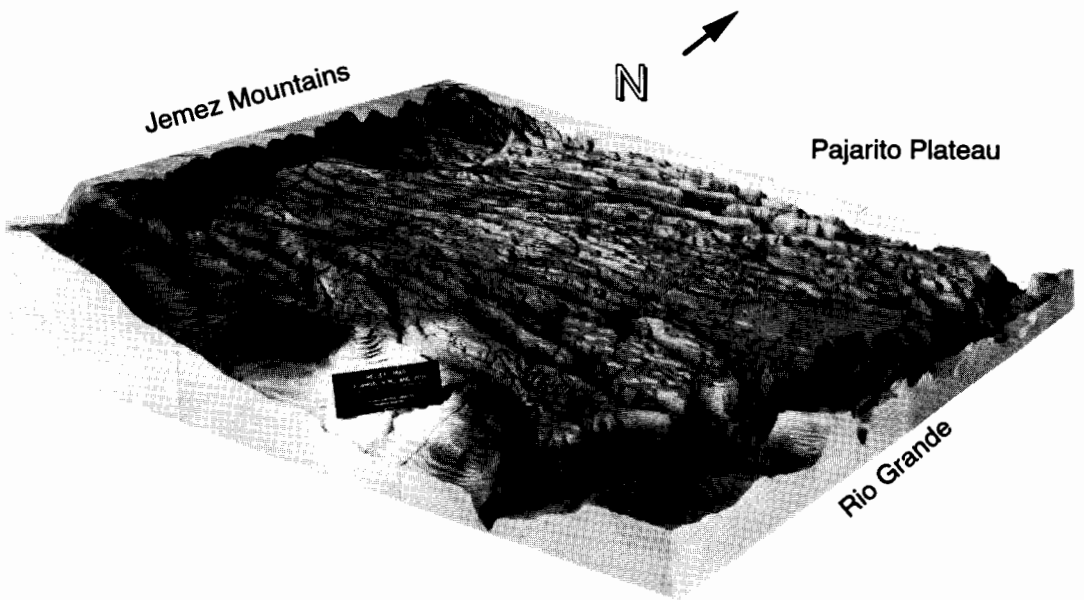


Fig. II-3. Topography of the Los Alamos area.

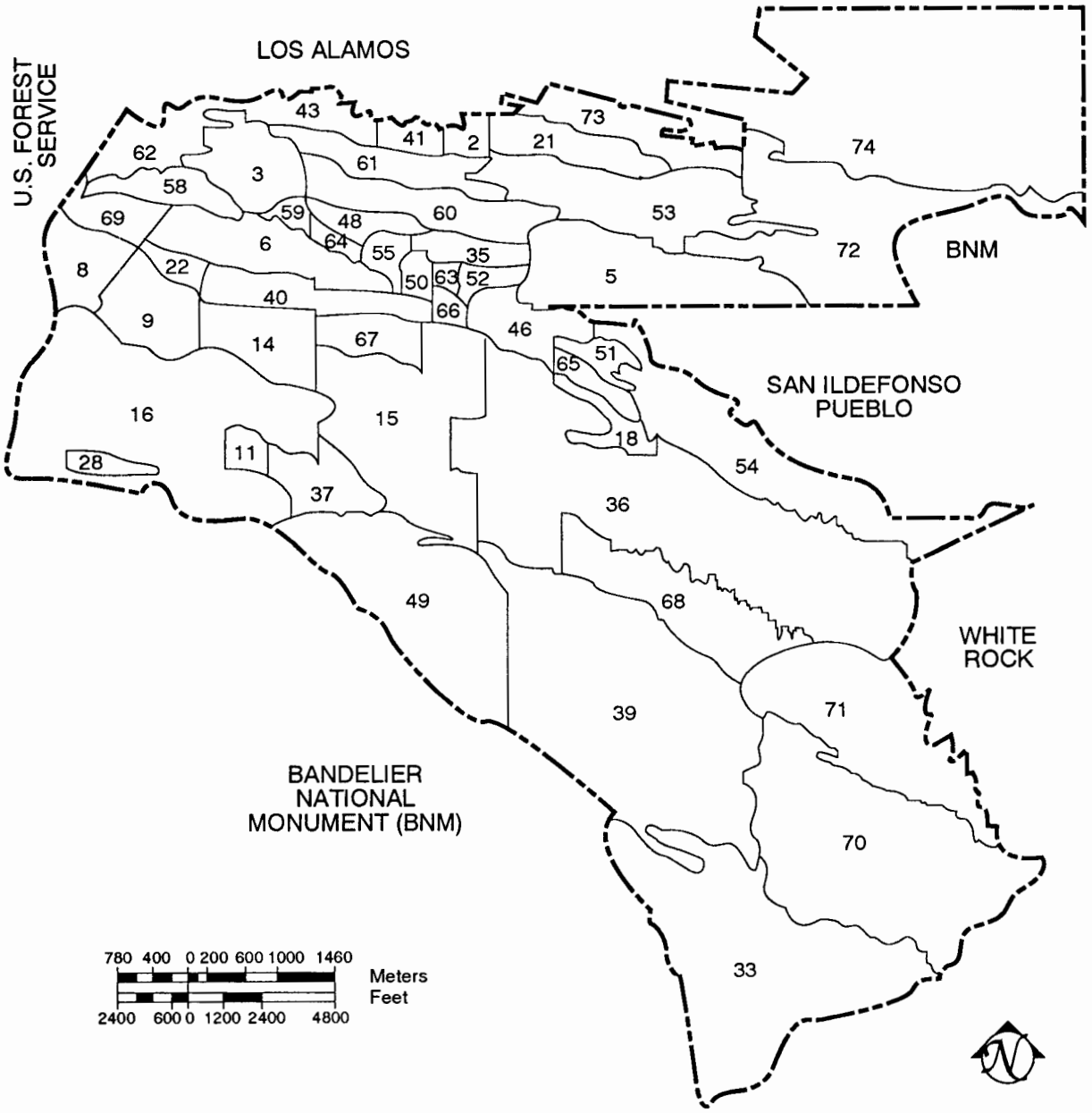
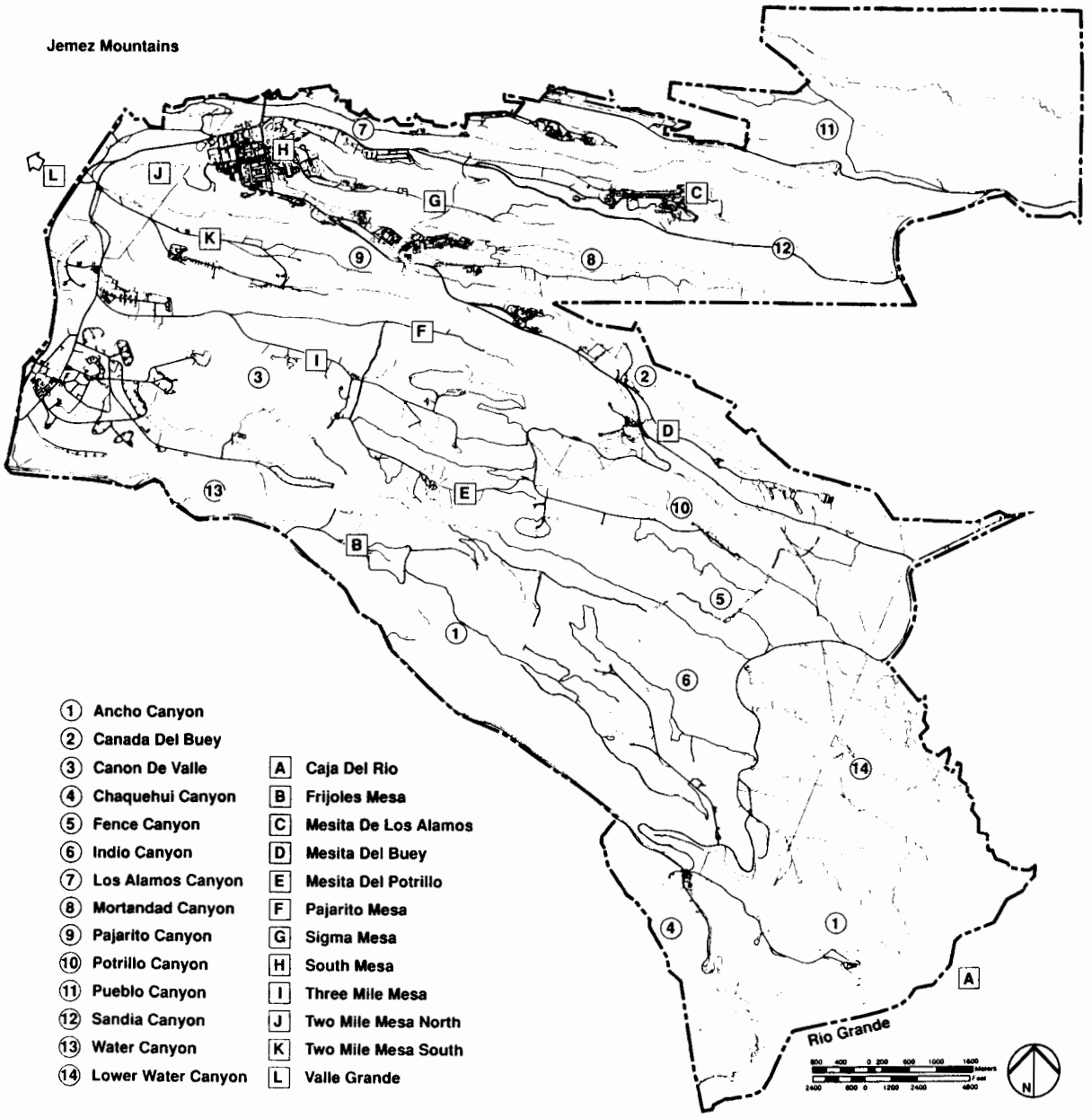


Fig. II-4. Technical areas (TAs) of Los Alamos National Laboratory in relation to surrounding landholdings.



General Site Description

1990 Los Alamos National Laboratory Site Development Plan

Fig. II-5. Major canyons and mesas.

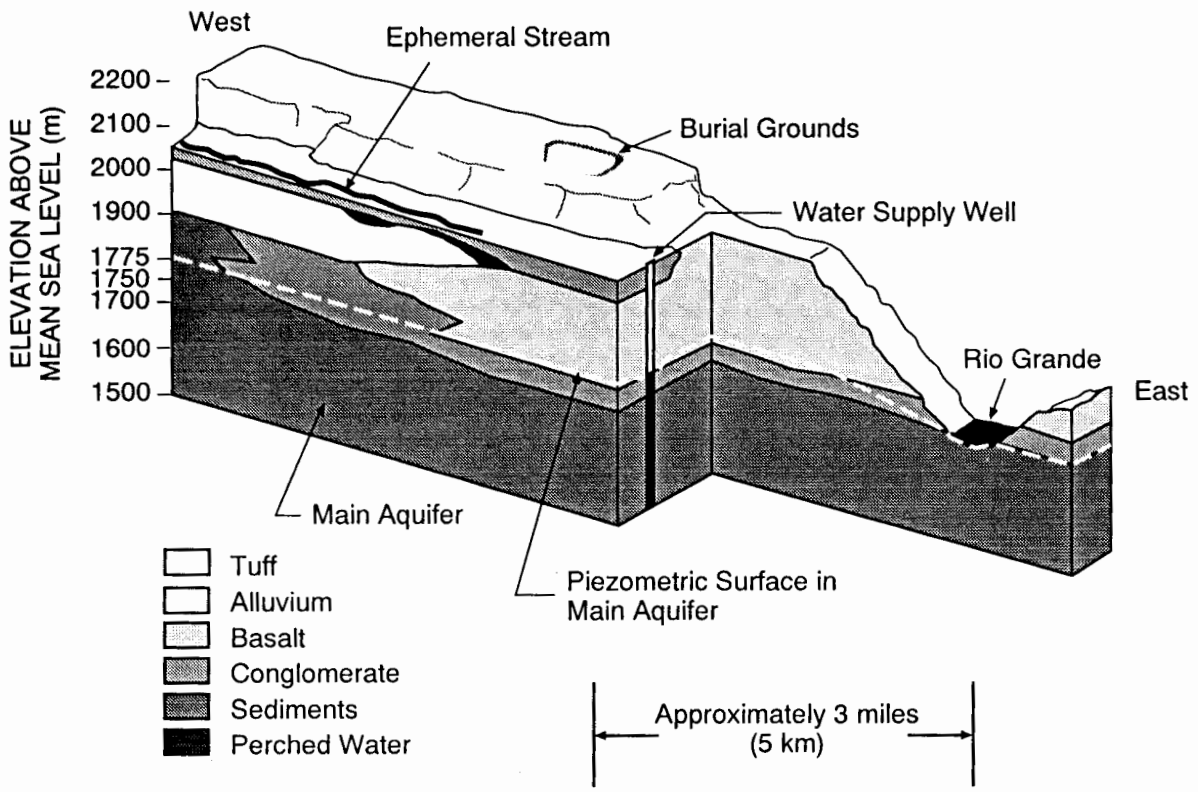


Fig. II-6. Conceptual illustration of geologic-hydrologic relationship in Los Alamos area.

(3 ft) to as much as 30 m (100 ft) in thickness. The alluvium is permeable, in contrast to the underlying volcanic tuff and sediments. Intermittent runoff in canyons infiltrates the alluvium until its downward movement is impeded by the less permeable tuff and volcanic sediment. This results in a shallow alluvial groundwater body that moves down gradient within the alluvium. As water in the alluvium moves down gradient, it is depleted by evapotranspiration and movement into underlying volcanics (Purtymun 1977).

Perched water occurs in conglomerate and basalts beneath the alluvium in portions of Pueblo, Los Alamos, and Sandia Canyons. It has been encountered at depths of about 37 m (120 ft) in the midreach of Pueblo Canyon, about 45 to 60 m (150 to 200 ft) beneath the surface in lower Pueblo and Los Alamos Canyons near their confluence, mainly in basalts in Los Alamos Canyon at 61-76 m (200-250 ft) (Fig. II-6), and in Sandia Canyon near the eastern Laboratory boundary at a depth of about 137 m (450 ft). Perched water has one discharge point at Basalt Spring in Los Alamos Canyon.

The main aquifer of the Los Alamos area is the only aquifer in the area capable of serving as a municipal water supply. The surface of the aquifer rises westward from the Rio Grande within the Tesuque Formation into the lower part of the Puye Formation beneath the central and western part of the plateau. Depth to the aquifer ranges from 360 m (1,200 ft) along the western margin of the plateau to about 180 m (600 ft) at the eastern margin. The main aquifer is isolated from alluvial and perched waters by about 110 to 190 m (350 to 620 ft) of dry tuff and volcanic sediments. Thus, there is little hydrologic connection or potential for recharge to the main aquifer from alluvial or perched water.

Water in the main aquifer is under artesian conditions in the eastern part and along the Rio Grande (Purtymun 1974b). Major recharge to the main aquifer is inferred to be from the west because of the slope of the piezometric surface. The main aquifer discharges into the Rio Grande through springs in White Rock

Canyon. The 18.5 km (11.5 mi) reach of the river in White Rock Canyon between Otowi Bridge and the mouth of Rito de Frijoles receives an estimated 5.3 to 6.8×10^6 m^3 (4,300 to 5,500 ac-ft) annually from the aquifer.

D. Climatology

Los Alamos has a semiarid, temperate mountain climate. Average annual precipitation is nearly 47 cm (19 in.). Thirty-six percent of the annual precipitation normally occurs during July and August from thundershowers. Winter precipitation falls primarily as snow, with accumulations of about 150 cm (59 in.) annually. Snowstorms with accumulations exceeding 10 cm (4 in.) are common in Los Alamos. Some storms can be associated with strong winds, frigid air, and dangerous wind chills.

Summers are generally sunny with moderate, warm days and cool nights. Maximum daily temperatures are usually below 32°C (90°F). Brief afternoon and evening thundershowers are common, especially in July and August. High altitude, light winds, clear skies, and dry atmosphere allow night temperatures to drop below 15°C (59°F) after even the warmest day. Winter temperatures typically range from about –9°C to –4°C (15°F to 25°F) during the night and from –1°C to 10°C (30°F to 50°F) during the day. Occasionally, temperatures drop to –18°C (0°F) or below. Many winter days are clear with light winds, so strong sunshine can make conditions comfortable even when air temperatures are cold.

Average wind speed and direction frequencies at four sites are plotted for daytime, night-time, and total time (Figs. II-7 to II-9). The frequencies are presented as wind roses, which are circles with lines extending from the center representing the direction *from* which the wind blows. The length of each line is proportional to the frequency at which the wind blows from the indicated direction. Each direction is 1 of 16 primary compass points (for example, N and NNE) and is centered on a 22.5° sector. Each spoke consists of different widths representing different wind speed classes. The frequency of calm winds (winds with speed less than 1 mph [0.5 m/s]) is given in the circle's center. Day and night are defined by sunrise and sunset times.

Because of complex terrain, surface winds in Los Alamos often vary greatly with time of day and location. With light, large-scale winds and clear skies, daytime winds are predominantly south to south-southwest as winds flow up the Rio Grande Valley. Thermally driven upslope winds from the southeast and east are also common toward the Jemez Mountains. At night, a shallow drainage wind often flows from the west and northwest high on the Pajarito Plateau. Night-time winds become more parallel to the Valley (south-southwest and north-northeast) both above the drainage winds over the Western Plateau (about 30-40 m [~100-130 ft] above ground level [AGL]) and at the surface toward the Valley. Predominant winds are west to west-northwesterly at the west end of the plateau to south-southwesterly at the east end.

Historically, no tornadoes have been reported to have touched down in Los Alamos County. Strong dust devils can produce winds up to 34 m/s (75 mph) at isolated spots in the County, especially at lower elevations.

Lightning is common over the Pajarito Plateau. There are 58 thunderstorm days during an average year, with most occurring during the summer. Lightning protection is an important design factor for most facilities at the Laboratory. Hail damage can also occur. Hailstones with diameters up to 0.64 cm (0.25 in.) are common; 1.3-cm- (0.5-in.-) diameter hailstones are less common.

The irregular terrain at Los Alamos affects the atmospheric turbulence and dispersion, sometimes favorably and sometimes unfavorably. Enhanced dispersion promotes greater dilution of contaminants released into the atmosphere. The complex terrain and forests create an aerodynamically rough surface, forcing increased horizontal and vertical dispersion. Dispersion generally decreases at lower elevations where the terrain becomes smoother and less vegetated. The frequent clear skies and light, large-scale winds cause good vertical, daytime dispersion, especially during the warm season. Strong daytime heating during the summer can force vertical mixing up to 1–2 km (3,000–6,000 ft) AGL, but the generally light winds are limited in diluting contaminants horizontally.

Clear skies and light winds have a negative effect on night-time dispersion, causing strong, shallow surface inversions to form. These inversions can severely restrict near-surface vertical and horizontal dispersion. Inversions are especially strong during the winter. Shallow drainage winds can fill lower areas with cold air, thereby creating deeper inversions, common toward the valley (White Rock) on clear nights with light

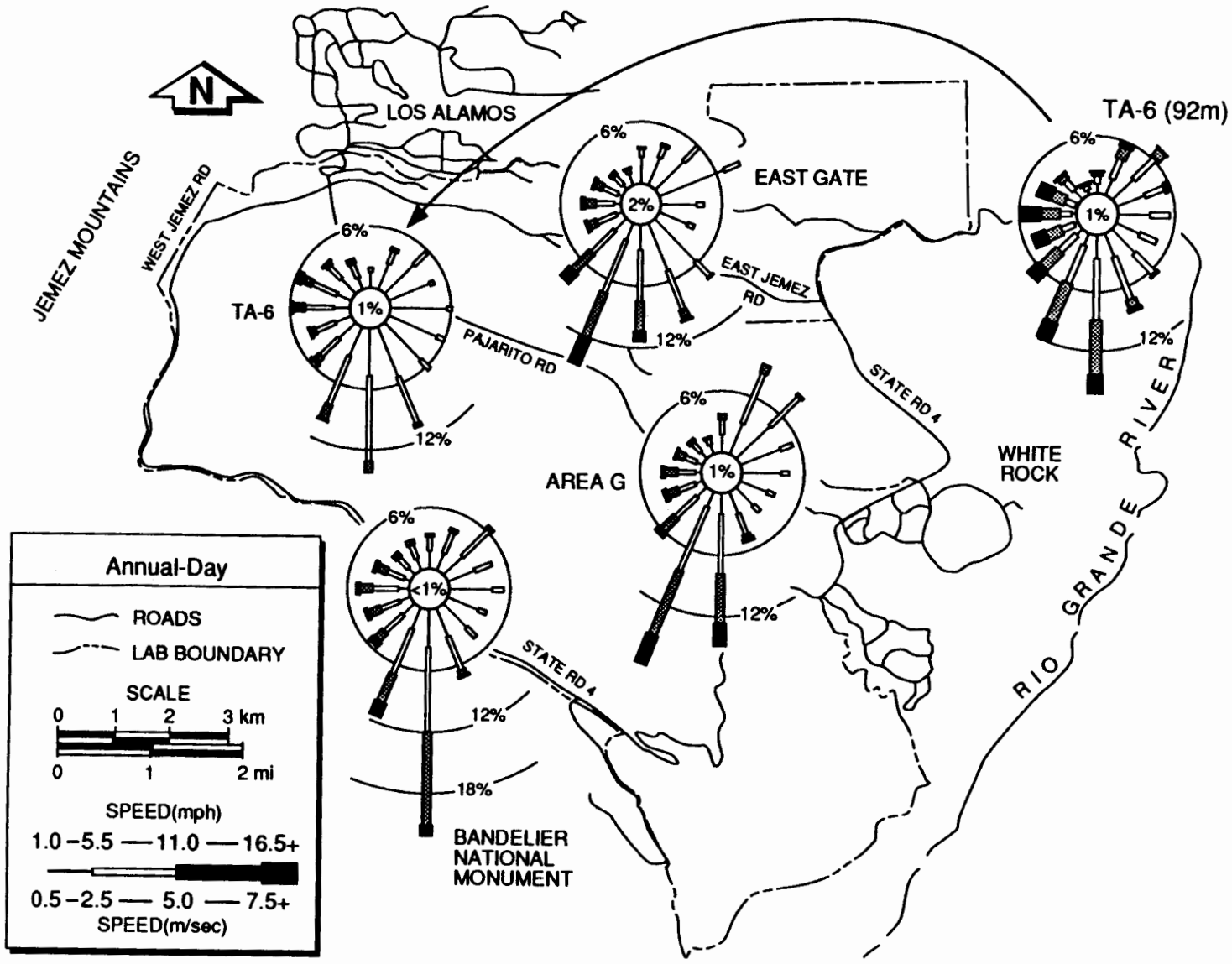


Fig. II-7. Average daytime wind roses at Laboratory stations. Surface winds are represented at TA-6 (upper left) clockwise to East Gate, Area G, and Bandelier. TA-6 winds at the 92 m (300 ft) level are also shown.

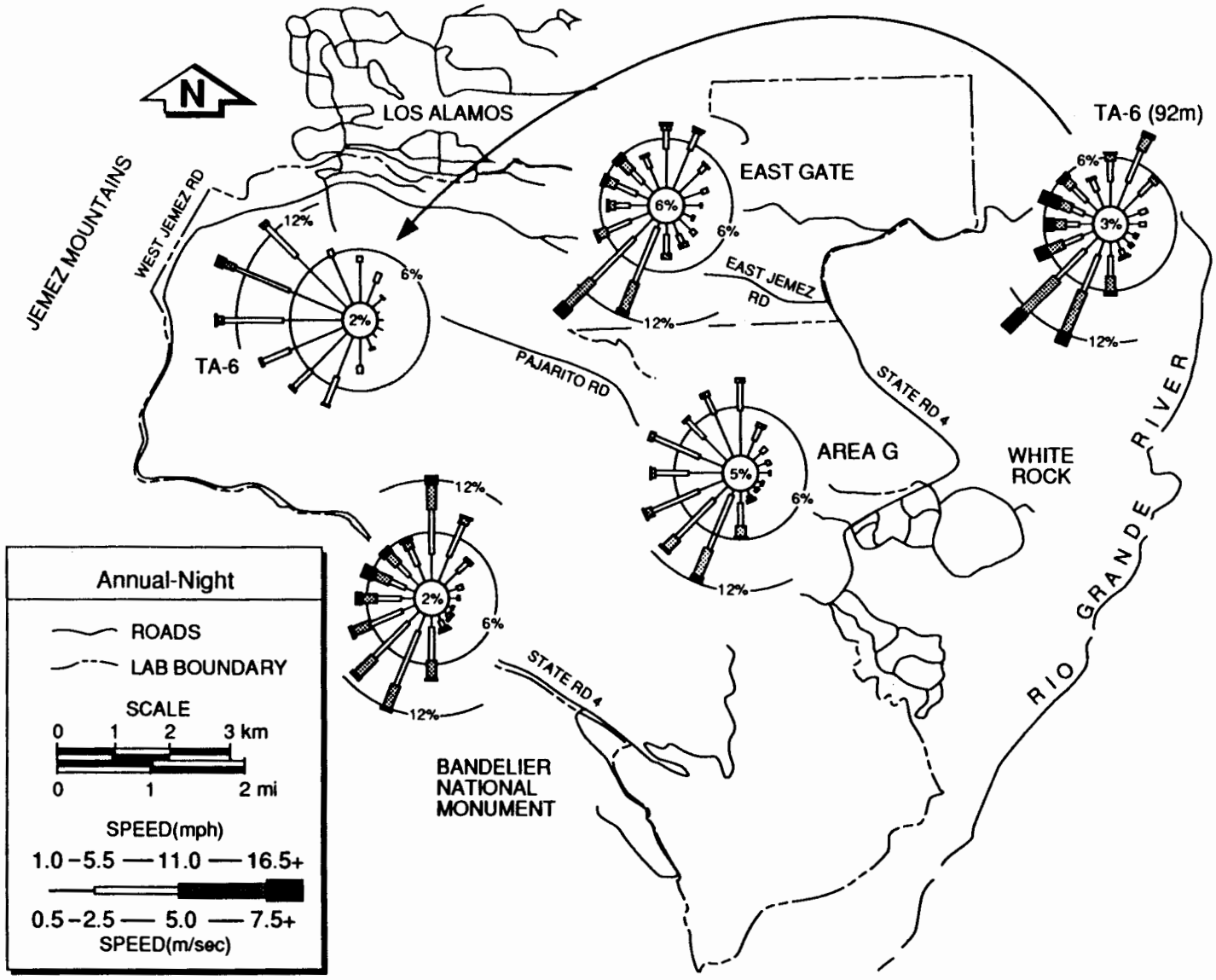


Fig. II-8. Average night-time wind roses at Laboratory stations. Surface winds are represented at TA-6 (upper left) clockwise to East Gate, Area G, and Bandelier. TA-6 winds at the 92 m (300 ft) level are also shown.

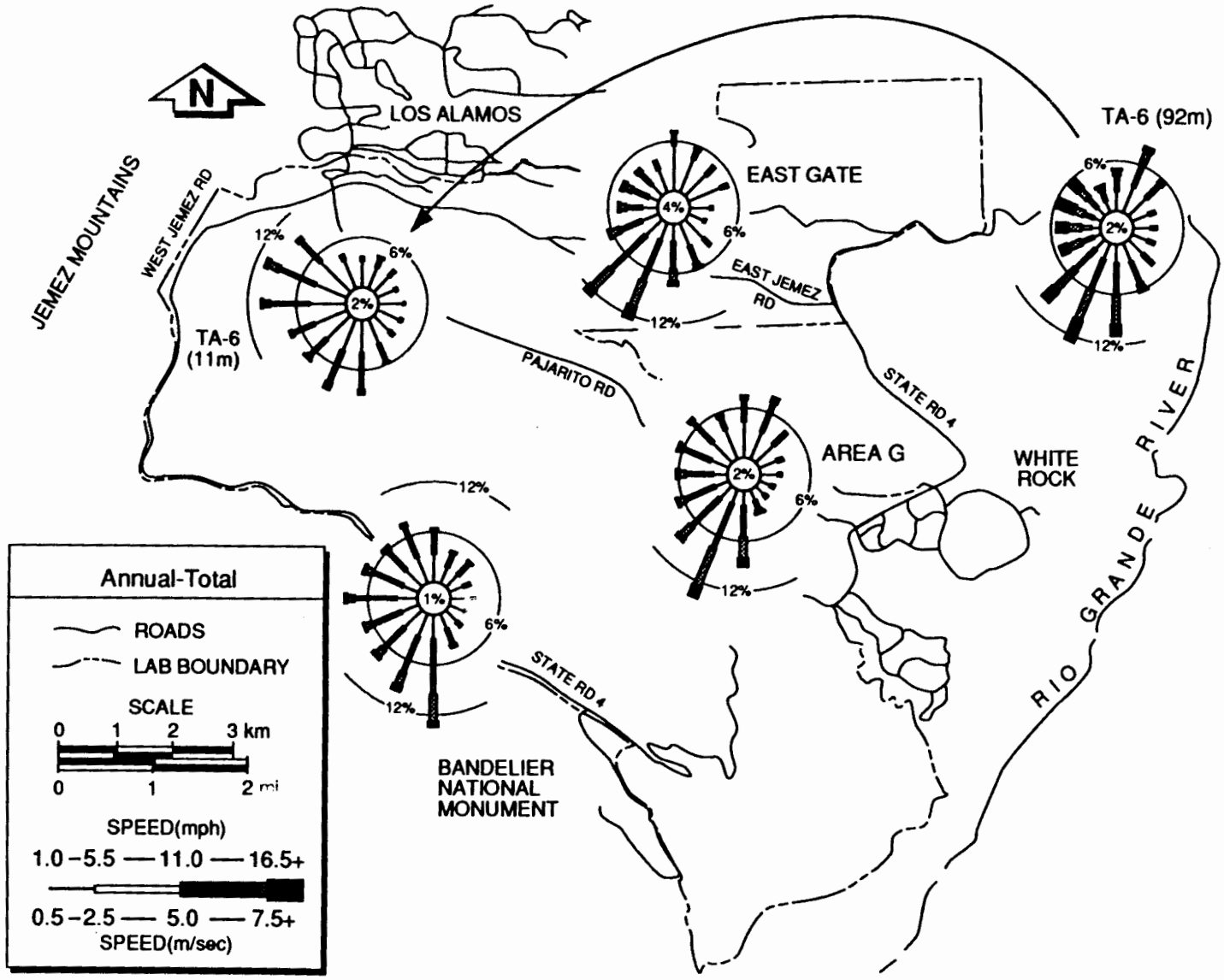


Fig. II-9. Average total wind roses at Laboratory stations. Surface winds are represented at TA-6 (upper left) clockwise to East Gate, Area G, and Bandelier. TA-6 winds at the 92 m (300 ft) level are also shown.

winds. Canyons can also limit dispersion by channeling air flow. Strong, large-scale inversions during the winter can limit vertical mixing to under 1 km (3,000 ft) AGL.

Dispersion is generally greatest during the spring when winds are strongest. However, deep vertical mixing is greatest during the summer. Low-level dispersion is generally the least during summer and autumn when winds are light. Even though low-level, winter dispersion is generally greater, intense surface inversions can cause the least dispersive conditions during the night and early morning.

The frequencies of atmospheric dispersive capability are 52% unstable (stability classes *A–C*), 21% neutral (*D*), and 27% stable (*E–F*) during the winter at TA-59. The frequencies are 44%, 22%, and 34%, respectively, during the summer. These stability category frequencies are based on measured vertical wind variations. Stability generally increases (becomes less dispersive) toward the valley.

E. Ecology

The diversity of ecosystems in the Los Alamos area is due partly to the dramatic 1,500 m (5,000 ft) elevation gradient from the Rio Grande on the east to the Jemez Mountains 20 km (12 mi) to the west and partly to the many canyons with abrupt surface slope changes that dissect the area. Six major vegetative complexes or community types are found in Los Alamos County. These are juniper-grassland, piñon-juniper, ponderosa pine, mixed conifer, spruce-fir, and subalpine grassland. The juniper-grassland is found along the Rio Grande on the eastern border of the plateau and extends upward on the south-facing sides of canyons, at 1,700 to 1,900 m (5,600–6,200 ft). The piñon-juniper, generally in the 1,900 to 2,100 m (6,200–6,900 ft) elevation range, includes large portions of the mesa tops and north-facing slopes at the lower elevations. Ponderosa pine is found in the western portion of the plateau in the 2,100 to 2,300 m (6,900–7,500 ft) elevation range. These three types predominate, each occupying about one-third of the Laboratory site. The mixed conifer, at an elevation of 2,300 to 2,900 m (7,500–9,500 ft), interfaces with the ponderosa pine in the deeper canyons and north slopes and extends to the west from the higher mesas on the slopes of the Jemez Mountains. The subalpine grasslands are mixed with the spruce-fir communities at higher elevations of 2,900 to 3,200 m (9,500–10,500 ft).

Because of the variety of complex interlocking ecotones in the Los Alamos area, there is no single ecological structure of food webs that can characterize the associations of flora and fauna in the area. Food web relations for the biota of the Laboratory environs have been studied only enough to provide general descriptions and expectations.

Generally, the larger mammals and the birds are wide-ranging and occupy commensurately large habitats, from the dry mesa-canyon country at lower elevations to the high mountain tops west of the Laboratory. The smaller mammals, reptiles, invertebrates, and vegetation are more sensitive to the variations in elevation and thus are confined to generally smaller habitats.

As a result of past and present human use of the Laboratory's environs, areas of vegetation are undergoing secondary succession. This process has had, and will continue to have, important consequences to the natural systems. Farming by prehistoric Indians and by Spanish and Anglo settlers before the Laboratory's establishment in 1943 created open grassy areas on the mesas that have not completely returned to climax plant communities. These areas afford suitable feeding areas for herbivores, especially the deer and elk, with adjacent timbered canyon slopes providing cover for these species. The food web relationships of the mesa areas are related to those of the canyons to some degree.

F. Cultural Resources

Approximately 60% of DOE land in Los Alamos County has been surveyed for prehistoric and historic cultural resources, and close to 1,000 have been recorded. Over 95% of these ruins date from the fourteenth and fifteenth centuries. Most of the sites are found in the piñon-juniper vegetation zone, with 80% lying between 5,800 and 7,100 ft in elevation. Almost three-quarters of all ruins are found on mesa tops, which are the preferred locations for development at the Laboratory today.

G. Population Distribution

Los Alamos County had an estimated 1991 population of approximately 18,200 (based on the 1990 U.S. Census, adjusted to July 1, 1991) (USBC 1991). Two residential and related commercial areas exist in the

County (Fig. II-2). The Los Alamos townsite (the original area of development, now including residential areas known as Eastern Area, Western Area, North Community, Barranca Mesa, and North Mesa) has an estimated population of 11,400. The White Rock area (including the residential areas of White Rock, La Senda, and Pajarito Acres) has about 6,800 residents. About 40% of the people employed in Los Alamos commute from other counties. Population estimates for 1991 place about 218,000 persons within an 80 km (50 mi) radius of Los Alamos (Table II-1).

Table II-1. 1991 Population within 80 km of Los Alamos[a,b]

	Distance from TA-53 (km)								
Direction	**1–2**	**2–4**	**4–8**	**8–15**	**15–20**	**20–30**	**30–40**	**40–60**	**60–80**
N	1	0	0	0	0	0	1,152	0	373
NNE	0	0	0	574	0	550	1,756	1,824	224
NE	1	0	0	0	322	15,606	1,024	1,153	3,905
ENE	0	0	0	1,985	1,586	2,780	2,778	1,205	2,241
E	0	0	85	26	569	1,172	712	0	1,412
ESE	0	0	0	0	0	299	23,695	1,079	1,493
SE	0	0	6,776	0	0	0	54,778	2,500	8
SSE	0	0	0	0	0	0	436	4,449	97
S	0	0	0	50	0	333	642	7,069	0
SSW	0	0	0	20	0	854	210	8,609	34,996
SW	0	0	0	0	0	0	329	4,345	0
WSW	0	0	0	0	0	329	327	2,660	216
W	0	0	0	0	0	0	0	171	138
WNW	0	1,439	6,553	0	0	0	0	0	3,220
NW	0	525	1,726	0	0	0	0	1,459	0
NNW	0	580	581	0	0	0	0	65	63
1991 Pop. Distribution	2	2,544	15,721	2,655	2,477	21,923	87,839	36,588	48,386

[a]Total population within 80 km of Los Alamos is 218,135.

[b]Please see Fig. II-2 for more information on the location of the population.

III. COMPLIANCE SUMMARY

Los Alamos National Laboratory (LANL or the Laboratory) operates under multiple federal and state environmental regulations and permits which mandate compliance standards for environmental qualities.

LANL had frequent interactions with federal and state Resource Conservation and Recovery Act (RCRA) personnel during 1991. Six underground storage tanks were removed during the year. The Laboratory is not able to comply with RCRA requirements related to storage of mixed waste and certain hazardous waste subject to the land-disposal restrictions because of the lack of adequate or available treatment capacity. A National Capacity Variance allows the storage of some of these wastes.

The Laboratory was in compliance with its liquid discharge permit in 99.0% of samples from its sanitary effluent outfalls and in 98.8% of its industrial effluent outfall samples in 1991. Under a Federal Facilities Compliance Agreement (FFCA) with the Environmental Protection Agency (EPA), sanitary waste treatment facilities are being upgraded to improve compliance.

During 1991, 614 actions proposed to be undertaken at the Laboratory were reviewed for National Environmental Policy Act (NEPA) applicability, and 78 Department of Energy (DOE) Environmental Checklists (DECs) were submitted to DOE on 90 of these projects.

The Laboratory is in compliance with all federal nonradiological ambient air quality standards. As a result of the review of nonradiological emissions from new and modified operations, one air quality permit and three source registrations will be submitted to the New Mexico Environment Department (NMED) in 1992. The Laboratory remained in compliance with EPA standards which limit the effective dose equivalent to members of the public from airborne radioactive emissions to less than 10 mrem/yr. The maximum off-site dose calculated for 1991 was 4.4 mrem with building shielding and occupancy being considered. DOE received a Notice of Noncompliance from EPA and is currently negotiating an FFCA on stack monitoring protocols.

Concentrations of constituents in the drinking water distribution system remained within federal and state water supply standards during 1991. An annual inspection conducted by the U.S. Department of Agriculture found no deficiencies in the Laboratory's pesticide application program.

During 1991, Laboratory archaeologists evaluated 1,110 proposed actions for possible effects on cultural resources which required 51 intensive field surveys. Laboratory biologists reviewed 614 proposed actions for potential impacts on threatened and endangered species; 63 actions required additional study. All of the proposed actions reviewed were outside floodplain/wetland boundaries.

A. Introduction

It is the policy of the Los Alamos National Laboratory to provide a safe and healthful working environment for its employees, the employees of its subcontractors, participating guests, and visitors and to prevent any harm to these individuals, the public, or the environment as a result of the Laboratory's activities.

Many of the activities and operations at the Laboratory involve or produce liquids, solids, and gases

that contain radioactive, nonradioactive but potentially hazardous materials, and combinations of the two. The Environmental Protection Program at the Laboratory monitors for contaminants and pollutants that may result from these operations. The program is under the jurisdiction of a variety of federal and state agencies to ensure that environmental regulations and standards are met. Federal agencies include the EPA and the DOE. The primary state agency involved is the NMED.

In accordance with the policy of the DOE, the Laboratory must comply with federal and state environmental requirements. These requirements address handling, transport, release, and disposal of contaminants and pollutants, as well as protection of ecological, archaeological, historic, atmospheric, and aquatic resources. Regulations specify generic requirements and standards to ensure maintenance of environmental qualities. Table III-1 presents a list of the major environmental legislation which governs the activities of the Laboratory. Environmental permits are issued under the auspices of specific legislation and are site and/or operation specific. A list of the environmental permits which applied to the Laboratory in 1991 is presented in Table III-2.

This summary presents the Laboratory's compliance status with environmental regulations and permits. A description of the applicable laws and/or permits, as well as the results of the monitoring program for 1991 and the first quarter of CY 1992, can be found in specific subsections which follow. The summary includes information on current issues and actions such as the status of the FFCAs, Notices of Violation (NOVs), significant accomplishments in achieving regulatory compliance, and DOE audits and appraisals.

B. Compliance Status

1. Resource Conservation and Recovery Act.

a. Introduction. The RCRA, as amended by the Hazardous and Solid Waste Amendments (HSWA) of 1984, mandates a comprehensive program to regulate hazardous wastes, from generation to ultimate disposal. A major emphasis of the amendments is to reduce hazardous waste volume and toxicity and to minimize land disposal of hazardous waste. EPA grants RCRA permits to specifically regulate hazardous waste and the hazardous component of radioactive mixed waste.

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. A facility that has submitted a RCRA Part A permit application is allowed to manage hazardous or mixed wastes under transitional regulations known as the Interim Status Requirements pending issuance of a RCRA Operating 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.

The EPA has granted RCRA authorization to New Mexico, transferring regulatory control of hazardous wastes to the NMED. State authority for hazardous waste regulation is the Hazardous Waste Act (HWA) and Hazardous Waste Management Regulation (HWMR). However, NMED has not yet obtained authorization for implementing the majority of the 1984 HSWA. HWMR adopted the federal codification for generating and managing hazardous waste. Although this adoption makes the state regulations more consistent with federal regulations and easier to interpret, some confusion will continue because only those federal regulations in effect on July 1, 1990, were adopted. The State of New Mexico's Hazardous Waste Program was delegated authority for mixed waste by the EPA in July 1990. A Part A Permit was submitted on January 25, 1991, within the required six month period for mixed waste storage and treatment units throughout the Laboratory. A schedule is being negotiated for submittal of the Part B application.

The Laboratory is currently out of compliance with RCRA requirements related to storage of certain hazardous and mixed waste subject to the land-disposal restrictions (LDRs). These include solvents; dioxins/furans; California list; and the first, second, and third groups of scheduled wastes. No treatment alternative has been available for these wastes. The National Capacity Variance on storage of scheduled mixed waste expires on May 8, 1992. DOE Headquarters (HQ) and EPA have been negotiating an extension of the Variance. The Laboratory will begin negotiating an FFCA with EPA Region 6 to develop a schedule to bring all waste subject to LDRs into compliance.

The Laboratory produces a wide variety of hazardous wastes. Small volumes of all chemicals listed under 40 CFR 261.33 could exist at the Laboratory as a result of ongoing research. Process

Table III-1. Major Environmental Regulations under which the Laboratory Operated in 1991

Regulation	Regulatory Citation	Responsible Agency	Related Legislation
Resource Conservation and Recovery Act	RCRA, 40 CFR 260-268, 270-272, 280, and 281	EPA/NMED	Hazardous Waste Facility Permit (RCRA Operating Permit) regulates treatment, storage, and disposal of hazardous wastes. Hazardous and Solid Waste Amendments (HSWA Permit) address releases of hazardous constituents. NM Hazardous Waste Act NM Hazardous Waste Management Regulations NM Solid Waste Regulations NM Underground Storage Tank Regulations
Clean Water Act	CWA 40 CFR 122	EPA/NMED	National Pollutant Discharge Elimination System (NPDES) (40 CFR 122): two permits mandate specific monitoring and reporting conditions along with setting standards for effluent quality for Laboratory discharges to the environment. NM Water Quality Control Commission Regulations NM Liquid Waste Disposal Regulations NM Oil Conservation Division - Groundwater discharge plan, Fenton Hill
National Environmental Policy Act	NEPA, 40 CFR 1500-1508, 10 CFR 1021	Council on Environmental Quality	
Federal Clean Air Act	CAA 40 CFR 50-99	EPA/NMED	National Emission Standards for Hazardous Air Pollutants (NESHAP) for **Radionuclides** (40 CFR 61, Subpart H) requires that no member of the public receive more than 10 mrem/yr (effective dose equivalent), **Asbestos** (40 CFR 61, Subpart M) requires no visible asbestos emissions to the environment, and **Beryllium** (40 CFR 61, Subpart C) requires notification, emission limits, and stack performance testing. Ambient Air Quality Standards NM Air Quality Control Regulations

Table III-1 (Cont.)

Regulation	Regulatory Citation	Responsible Agency	Related Legislation
Safe Drinking Water Act	SDWA 40 CFR 141-148	EPA/NMED	NM Water Supply Regulations
Federal Insecticide, Fungicide, and Rodenticide Act	FIFRA	U.S. Department of Agriculture	NM Pest Control Act
National Historic Preservation Act	NHPA Section 106	State Historic Preservation Officer	
Endangered Species Act	Public Law 93-205	U.S. Fish and Wildlife	
Floodplain Management	Executive Order 11988	U.S. Corps of Engineers	
Protection of Wetlands	Executive Order 11990	U.S. Corps of Engineers	
Comprehensive Environmental Response, Compensation, and Liability Act	CERCLA 40 CFR 300 and 302	EPA	Superfund Amendments and Reauthorization Act (SARA) – Title III Sec. 313: Emergency Planning and Community Right-to-Know Act.
Toxic Substances Control Act	TSCA 40 CFR 761, 762, and 792	EPA	Polychlorinated biphenyls (PCBs) (40 CFR 461)
Atomic Energy Act		Nuclear Regulatory Commission/DOE/EPA	

Table III-2. Environmental Permits under which the Laboratory Operated in 1991

Permit Type	Permitted Activity	Issue Date	Expiration Date	Administering Agency
RCRA hazardous waste facility	Hazardous waste storage, treatment, and disposal	November 1989	November 1999	NMED
	Postclosure care	Application submitted September 1988		EPA
	RCRA Mixed Waste	Part A application submitted January 1991		EPA
HSWA	RCRA Corrective Activities	March 1990	December 1999	EPA
NPDES,[a] Los Alamos	Discharge of industrial and sanitary liquid effluents	Modified permit January 30, 1990	March 1, 1991 [b]	EPA
NPDES, Fenton Hill	Discharge of industrial liquid effluents	October 15, 1979	June 30, 1983 [b]	EPA
NMLWD Regulations[c]	Discharge of sanitary effluents from septic tank systems into soil	[d]	—	NMED
Groundwater discharge plan, Fenton Hill	Discharge to groundwater	July 9, 1990	June 5, 1995	NMOCD [e]
Air Quality (NESHAP)[f]	Construction and operation of four beryllium facilities	December 26, 1985; March 19, 1986; September 8, 1987; April 26, 1989	—	NMED
Open Burning (AQCR 301)	Burning of jet fuel for ordnance testing, TA-11	August 30, 1991	After four tests	NMED
Open Burning (AQCR 301)	Burning of scrap wood from experiments, TA-36	October 10, 1991	October 10, 1992	NMED
PCBs[g]	Disposal of PCBs at TA-54, Area G	June 5, 1980	—	EPA
PCB oil	Incineration of PCB oils [h]	May 21, 1979	—	EPA

[a]National Pollutant Discharge Elimination System.
[b]Permit administratively extended while new permit is pending.
[c]New Mexico Liquid Waste Disposal Regulations.
[d]Dates vary depending on individual permits.
[e]New Mexico Oil Conservation Division.
[f]National Emission Standards for Hazardous Air Pollutants.
[g]Polychlorinated biphenyls.
[h]No incineration occurred during 1991 even though the activity was permitted.

wastes, such as liquid wastes from circuit board preparation and lithium hydride scrap from metal machining, are generated from ongoing manufacturing operations that support research. Although they occur in larger volumes than discarded laboratory chemicals, process wastes are few in number, are well defined, and are not acutely toxic. High-explosive (HE) wastes include small pieces of explosives and contaminated sludges and liquids that are thermally treated on site.

Table III-3 presents a list of the significant RCRA-related interactions the Laboratory had with EPA and NMED in 1991 and the first quarter of 1992.

Table III-3. Resource Conservation and Recovery Act Interactions among the Laboratory, the U.S. Environmental Protection Agency, and the New Mexico Environment Department[a] in 1991 and First Quarter of 1992

January 8, 1991	New Mexico Environmental Improvement Division (NMEID) issues letter withdrawing the 12/14/90 NOV agreeing there was some justification for misunderstanding; however, the required reports are to be submitted by the deadline in the NOV letter.
January 16, 1991	LANL submits the required reports (first three quarters) and a fourth as per Permit Attachment I.
January 25, 1991	LANL/DOE submits Part A application for continued operation of mixed waste units to NMEID.
February 26, 1991	LANL/DOE submits a 7-day notification to NMEID that soil contaminated by diesel fuel was discovered during the closure of Underground Storage Tanks (USTs) Technical Area (TA) 64-RC-73.
March 18, 1991	A letter dated March 6, 1991, is received from NMED informing LANL/DOE that no additional work is required at UST TA-3-36-3. This letter is NMED's version of a closure notification.
March 26, 1991	LANL/DOE submits a 30-day letter to NMED for UST TA-64-RC-73.
March 29, 1991	LANL/DOE submits a 7-day notification to NMED that soil contaminated by dielectric oil was discovered during the closure of two USTs (TA-35-TSL-188-1 & TA-35-TSL-188-2).
April 5, 1991	A letter dated March 26, 1991, is received from NMED informing LANL/DOE that no additional work is required at UST TA-55-15. This letter is NMED's version of a closure notification.
	A letter dated March 26, 1991, is received from NMED informing LANL/DOE that no additional work is required at UST site TA-55-16. This letter is NMED's version of a closure notification.
April 8, 1991	LANL/DOE submits a 45-day letter to NMED for UST TA-64-RC-73.
April 24, 1991	LANL/DOE submits a 30-day letter to NMED for USTs TA-35-188-1 & 2.
April 29, 1991	NMED conducts the annual RCRA compliance inspection from 4/29/91 through 5/3/91. Seven violations were noted in the close-out briefing on 5/3/91.
May 7, 1991	LANL/DOE submits a 45-day letter to NMED for USTs TA-35-TSL-188-1 & 2.
May 24, 1991	DOE/LANL receives NOV from NMED for violations of the New Mexico HWMRs. The letter reports nine violations (i.e., two were added after close-out).

Table III-3 (Cont.)

June 27, 1991	LANL notifies NMED that UST TA-3-191 was being removed on 6/28/91. However, the UST was removed by Johnson Controls (JCI) on 6/27/91.
June 28, 1991	DOE/LANL responds to NMED's RCRA notice of violation letter.
	Representatives from NMED and LANL meet to evaluate the UST TA-3-191 excavation. Soil contaminated with gasoline is discovered at this time. Representatives from LANL and the DOE Los Alamos Area Office (LAAO) meet with NMED to discuss findings at the TA-53 mixed waste lagoons (e.g., potential leakage) and plans of action.
July 11, 1991	LANL/DOE submits a 7-day notification to NMED that soil contaminated by gasoline was discovered during the closure of UST TA-3-191 located at TA-3 SM-16.
July 25, 1991	LANL delivers mixed waste Part B application for TA-53 surface impoundments to NMED.
July 29, 1991	Representatives of NMED's UST Bureau visit several UST sites at LANL. Sites visited include TA-64, TA-35, TA-54 Area J, TA-3 Building SM-16, TA-16 UST storage area. No problems are found.
August 13, 1991	LANL transmits the 7-day notification report for the petroleum release at the TA-60 Tank Farm to DOE for processing and submittal to the State.
August 21, 1991	LANL/DOE submits a 45-day letter to NMED for UST TA-3-191.
August 31, 1991	LANL/DOE submits a 30-day letter to NMED for a petroleum release at TA-60 Tank Farm, fuel loading station.
September 13, 1991	LANL submits draft Exposure Information Report to LAAO for review.
September 18, 1991	LANL/DOE submits a 45-day letter to NMED for a petroleum release at TA-60 Tank Farm, fuel loading station.
November 25, 1991	LANL makes the required 48-hour notification to NMED about a planned site investigation at TA-60 Tank Farm.
December 9, 1991	LANL receives information from NMED's UST Bureau that the state received authorization to implement and enforce the federal UST Program in October 1990.
December 10, 1991	LANL receives NMED close-out letter for UST site TA-64-RC-73. The close-out letter is dated December 9, 1991.
January 16, 1992	Meet with NMED and tour TA-55 Treatment, Storage, and Disposal (TSD) units and generating processes.
January 21, 1992	The Laboratory received approval from EPA of the RCRA Facility Investigation (RFI) Work Plan for TA-21.
March 3, 1992	Notice of Deficiency letter from NMED on TA-35-125 surface impoundment.
March 11, 1992	DOE and the Laboratory received a written request from EPA to initiate modifications to the HSWA Permit.
March 26, 1992	Meet with NMED about the closure of TA-35-125 and analytical parameters for TA-53 impoundments.

[a]NMEID became NMED in March 1991.

Solid Waste Disposal. On February 15, 1991, LANL submitted the annual solid waste management report to the State of New Mexico Solid Waste Bureau. By 1991, all nonradioactive asbestos was being shipped off site to an approved commercial disposal site. Suspect and radioactive asbestos continued to be disposed into a monofill constructed at TA-54, Area G.

In the spring of 1991, the Waste Management Group (EM-7) excavated two new cells within TA-54, Area J for disposal of administratively-controlled solid waste. This new activity was a continuation of activities identified in a 1989 Notice of Intent (NOI) to Continue to Operate to the State of New Mexico. In addition, LANL continued to dispose of sanitary solid wastes and rubble at the sanitary solid waste and rubble landfill on East Jemez Road. LANL contributed approximately 38% of the total volume disposed at this site during 1991 with the remainder contributed by Los Alamos County residents. Development of a proposed replacement of the East Jemez Road site has been delayed due to funding constraints.

In 1991, JCI salvaged 1,169,000 lb of scrap metal, 360 tons of paper, 4,000 lb of scrap nonhazardous photographic film, and a few thousand truck and automobile tires from the General Services Administration (GSA) motor pool.

No data for the first quarter 1992 are available.

b. RCRA Closure Activities. The status of Laboratory hazardous waste operations to be closed under RCRA regulations is given below:

TA-35, Waste Oil Storage Pits. Closure plans for the two waste oil pits associated with Buildings 85 and 125 at TA-35 were submitted in October 1988, and verbal approval to proceed with closure activities was subsequently received from the state. All contents of the pits and underlying soil were removed and disposed of as hazardous waste. Sampling to verify the removal of contaminants from the area was completed in October of 1989. Preliminary results of the sampling effort revealed that the criteria for clean closure had been met. The pits were backfilled and revegetated at that time. Upon receipt of the final analytical results, it was noted that the allowed sample holding times were exceeded. Because of this problem, it was determined that the data could not be defended as correct. The closure plan was modified to reflect the events of the field work that occurred and to include bore sampling to be used as the final verification of clean closure. Bore sampling was performed in December of 1990 to confirm the removal of all hazardous constituents from the area. It was determined that there were minimal amounts of contaminates left in place. The levels of contamination found to remain after this clean-up effort did not exceed the EPA's health risk based clean-up levels. By achieving these clean-up levels, the Laboratory could still achieve clean closure status for these two units and no post-closure care would be necessary. The NMED is currently reviewing the final closure reports for these units.

TA-40, Scrap Detonation Site. On September 13, 1991, the NMED notified the Laboratory that the closure plans for the TA-40 Scrap Detonation Site had been approved. The plans received no comments from the public. The start date of the closure plan was September 30, 1991. The closure plan called for a phased sampling approach including surface sampling, core sampling, and sampling of an old burn cage and disposal pit. Sampling was done during the week of January 20, 1992. Preliminary results of the sampling revealed no radiological activity, pesticides, herbicides, PCBs, organic compounds, or metals above background and/or RCRA hazardous waste action levels. The final closure report will be submitted to NMED upon receipt of the final analytical results.

TA-54, Waste Oil Storage Tanks. After discovering hazardous waste in six above ground waste oil storage tanks, the Laboratory pumped and disposed of the contents as hazardous waste. The tanks were moved to Area G to make room for needed facilities at Area L. In April of 1990 the Laboratory elected to proceed with the closure of these vessels before receiving an approved closure plan. After several cleanings of the tanks, the final decontamination was accomplished in August. A final closure plan/report that reflected the actual closure process of these units was submitted in June 1991. The process will have to be approved by the state before the disposal or salvaging of the tanks.

TA-16, Landfill at Area P. Closure and post-closure-care plans for the Area P landfill were submitted on November 25, 1985. In late 1987 these plans were modified to include standards that this unit would be subject to once the Laboratory received its RCRA permit. Since that time, the Environmental Restoration (ER) Program Office has come into existence and the

Laboratory has received the HSWA requirements of the RCRA permit. Currently negotiations with the state are under way to extend the closure deadlines for this and other units that appear within the HSWA Module of the RCRA permit. An extension of the closure window would allow the ER program to incorporate the results of the RFI/Corrective Measures Study into the closure process.

c. Underground Storage Tanks. Six USTs in need of upgrades were removed during 1991. A 3,000 gal. diesel fuel UST at TA-3 (TA-3-36-3) was removed and was not replaced. A 200 gal. gasoline tank (TA-3-191) was removed and will be replaced with another tank in FY92. Two USTs, which contained dielectric oil and had a 6,000 gal. fuel capacity each, were removed at TA-35 (TA-35-188 1 & 2). Replacements for these tanks are pending. A diesel fuel UST (TA-64-RC-73) with a 1,000 gal. fuel capacity was removed from the Central Guard Station. Replacement of this UST is scheduled for FY92. The final UST (TA-55-16) removed was a 560 gal. diesel tank, located at TA-55. Replacement of this tank is also scheduled for FY92.

No data for the first quarter of 1992 are available.

d. Other RCRA Activities. Areas L and G, located at TA-54 on Mesita del Buey, have been used for disposal of hazardous and mixed wastes and are subject to RCRA regulation. Information on a groundwater monitoring waiver for both Areas L and G has been submitted to NMED. Vadose zone (the subsurface above the main aquifer) monitoring is being conducted quarterly throughout Areas L and G to identify any releases from the disposal units. This type of monitoring is used to detect the presence of organic vapor in the vadose zone. A total of 27 monitoring systems have been emplaced, one during the past year.

Table D-1 lists hazardous waste management facilities at the Laboratory. In FY89, the TA-40 scrap detonation pit used for destroying HE scrap was closed to waste detonation. All scrap is now handled at other detonation and open-burning sites included in the Part B permit. A closure plan for the TA-40 facility was submitted to NMED and was approved in 1991.

A RCRA-permitted controlled air incinerator (CAI) for treating hazardous waste is located at TA-50-37. A trial burn was conducted in October 1986. The raw data were submitted to NMED in December 1986, and a final report for the test burn was submitted on March 5, 1987. These data and the report were used to support the Laboratory's application for a hazardous waste permit for this facility. The permit was issued in November 1989. The CAI is currently closed for upgrades and modifications to improve reliability to allow the burning of waste on a routine basis.

e. RCRA Compliance Inspection. NMED conducted a hazardous waste inspection at LANL on April 29 through May 3, 1991 (Table III-4). On May 24, 1991, NMED sent DOE an NOV letter alleging violations of the New Mexico Hazardous Waste Management Regulations (HWMR-6). The alleged violations consisted of failure to conduct or maintain adequate inspection records, to properly label containers, to use a satellite storage area properly to meet waste storage time limits, and to properly classify waste. These alleged violations presented no threat to human health or to the environment. All violations were corrected within the 30 days allowed by state statute. The Laboratory's response, sent to NMED in June 1991, was found adequate, as stated in a letter from NMED dated July 12, 1991.

f. RCRA Personnel Training. The Laboratory provides training to generators of hazardous waste and to workers assigned to support the permitted hazardous waste management facilities. This training is based on the general requirements of RCRA (40 CFR Parts 262.34 and 265.16) and Appendix C of the Part B Operating Permit.

The two-hour training covers the following topics:

- identification of factors that determine if a waste is hazardous,
- determination of the need for permits and controls,
- waste reduction,
- preparation of waste for transport,
- waste sampling protocols,
- waste disposal documentation, and
- emergency response.

By September 30, 1991, more than 4,400 LANL employees and contractors had attended a Waste Generator Training course required, by Laboratory policy, for anyone generating solid, hazardous, or radioactive waste. Training continued through

Table III-4. Environmental Inspections and Audits Conducted at the Laboratory in 1991 and the First Quarter of 1992

Date	Purpose	Performing Agency
January–June, 1991	Compliance Program	DOE/LAAO
January 23–24, 1991	Inspection of Permitted Beryllium Operations Machining	NMEID[a]
February 21, 1991	Site Visit & Meetings with Region II	NMEID
February 28–March 1, 1991	Site Visit & Meeting with NPDES Enforcement	EPA
April 28–May 3, 1991	RCRA Compliance Inspection of Hazardous Waste Management Activities	NMED
May 15, 1991	Inspection of Permitted Beryllium Operations Machining	NMED
May 31, 1991	Storm Water/Water Course Inspection	NMED
June 3, 1991	NPDES Quality Assurance Inspection	DOE/LAAO
June 4–6, 1991	Site Visit & Meeting with TSCA Permit Writer	EPA
August 29–30, 1991	O & M Inspection of Sanitary Waste Treatment Facilities	NMED
September 23–November 10, 1991	Tiger Team Audit	DOE
November 14, 1991	Site Visit & Meetings with NPDES Permit Writer	EPA
November 19–20, 1991	NPDES Compliance Evaluation Inspection	EPA
December 11, 1991	Sampling Inspection of TA-53 Sanitary Lagoons	NMED
January 29–30, 1992	Inspection of Permitted Beryllium Machining Operations	NMED
February 7, 1992	TA-53 Waste Stream Characterization Inspection	NMED
February 30, 1992	Inspection of Otowi Well #4 Construction Project	NMED
March 17, 1992	Spill Cleanup Inspection	DOE/LAAO
March 17, 1992	TSCA Inspection	EPA

[a]NMEID became NMED in March 1991.

December 31 and into 1992. Updates and continuing training will be offered in a video training program available in late 1992. This course discusses LANL waste management procedures, laws affecting management of wastes, proper identification of wastes, and how to fill out waste identification forms.

In addition, Waste Management Coordinators receive training designed for their specific job responsibilities. Each participant receives an eight-hour overview including sessions in waste minimization, waste management terms, and legal/regulatory authorities. Participants are encouraged to attend additional sessions dealing with specific kinds of waste.

Workers assigned to support hazardous waste management facilities listed in the Part B Operating Permit are required to attend various training courses or review on-the-job instructions including the annual eight-hour Occupational Safety and Health Administration (OSHA) refresher, spill prevention and control techniques, and site contingency plans.

No data for the first quarter of 1992 are available.

g. Waste Minimization. Subtitle A of RCRA states that the generation of hazardous waste is to be reduced or eliminated as soon as possible. All hazardous waste must be handled minimizing the present and future threat to human health and the environment. The act promotes recovery, recycling, and treatment as alternatives to land disposal of hazardous wastes.

Every two years the Laboratory submits a report on waste minimization by waste streams to NMED. In 1991, 13 streams reported minimized waste.

h. HSWA Compliance Activities. In January 1991, the Laboratory submitted Part A of the RCRA permit application for mixed waste to the NMED. A schedule is being negotiated for submittal of the Part B portion of the application.

The Laboratory submitted its first site-specific work plan under the HSWA requirements in May 1991. The work plan addresses characterization activities at TA-21, which will begin in 1992. This technical area is one of the oldest TAs still active and contains over 100 solid waste management units (SWMUs) regulated under HSWA. These units contain residual concentrations of radionuclides, organic chemicals, and metals released during nearly 50 years of operation. The Part B permit application for TA-53 Surface Impoundments was submitted on July 25, 1992, to NMED. The programmatic plan for environmental restoration at the Laboratory was updated in November 1991. During 1991, the Laboratory drafted new work plans to investigate eight new areas, including the Los Alamos townsite. These plans are due to EPA in May 1992.

Interim Action Assessments for Environmental Restoration. An interim action is the recourse taken to evaluate a SWMU or other area of concern before the normal RCRA corrective action. Most interim actions, therefore, are associated with institutional needs, i.e., construction projects, routine maintenance, and other activities that impact SWMUs.

The main objectives of an interim action are to determine (1) the impact on the health and safety of construction workers, (2) whether construction workers will be generating hazardous waste subject to the RCRA HWMRs, including land disposal restrictions or radioactive waste subject to DOE regulation, and (3) whether the project will have an adverse impact on the ER program's final remedy (corrective action) for the SWMU. A SWMU Interim Action Technical Team (the Waste Site Studies Section) was established in Group EM-8 to conduct reconnaissance sampling to determine the nature and extent of contamination, if any. During 1991 the Waste Site Studies Section completed approximately 30 interim action assessments. The Section completed seven interim action assessments during the first quarter of 1992.

One-hundred-year Floodplain Study. Under the existing HSWA permit requirements, the EPA stipulates that regulated hazardous waste treatment, storage, and disposal facilities must delineate all 100-year floodplain elevations within their boundaries. At the Laboratory, these floodplains are located within ungaged watersheds that drain approximately 43 square miles on the Pajarito Plateau. These floodplains were mapped in 1990 using a combined graphic information system and computer modeling (GIS-HEC) approach. These maps are maintained on file by the Facilities Engineering Planning Group (ENG-2) and satisfy the RCRA/HSWA permit condition requiring floodplain definition.

Wetland Characterization Studies. As part of the DOE/Laboratory RCRA permit's HSWA Module, in coordination with the United States Fish and Wildlife (USFW) Service, all wetlands greater than one acre within the Laboratory boundaries were mapped in 1990. The mapping was part of the USFW National

Wetland Inventory (NWI). The NWI mapping used aerial mapping and a hierarchical classification based on ecological, hydrological, and soil characteristics.

Field studies to characterize wetlands identified by NWI and to identify additional wetlands not identified by the NWI have been undertaken. During 1991 wetland studies in two palustrine (marsh) wetlands (Pajarito and Sandia Canyons) were initiated and springs and associated wetlands within Ancho, Chaquehui (Doe Springs) and White Rock Canyons (6A, 9, and 9A as noted on Fig. III-1) were characterized. The purpose of the study was fourfold:

- to define the presence of wetland indicators: hydrology, hydrophytic vegetation, and hydric soils;
- to characterize the use of the springs and associated wetlands by reptiles, amphibians, small mammals, and aquatic invertebrates;
- to determine present and future impacts and threats to these wetlands; and
- to determine the presence of threatened or endangered species.

Vegetative transects, capture/release studies for small mammals, trapping of ground dwelling insects, and sampling of aquatic invertebrates were done for the perennial stream originating with the spring in Ancho Canyon. Vegetative transects and sampling of aquatic invertebrates were done for springs in Chaquehui and White Rock Canyons.

Trespassing cattle were found to present the largest impact to the spring and perennial stream habitats within Ancho, Chaquehui, and White Rock Canyons. Considerable overgrazing and degradation of the stream have occurred because of the cattle. Additionally, a strip of land approximately 150 ft above the water level of the Rio Grande has been degraded by high water levels from Cochiti Lake in the mid-1980s. All trees within this zone are dead; the stream channel has become silted and channelized.

2. Clean Water Act.

a. National Pollutant Discharge Elimination System. 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 NPDES that requires permitting of all point-source effluent discharges to the nation's waters. The NPDES permits establish 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 DOE has two NPDES permits, one covering the effluent discharges at Los Alamos and one covering the hot dry rock geothermal facility located 50 km (30 mi) west of Los Alamos at Fenton Hill (Table III-2). The University of California (UC) is a co-permittee with DOE on the permit covering Los Alamos. Both permits are issued and enforced by EPA Region 6 in Dallas, Texas. However, through a joint federal and state agreement, NMED performs some compliance evaluation inspections and monitoring for EPA.

An NPDES application for a new permit was submitted by the Laboratory to EPA on September 4, 1990, in order to meet the 180 day submittal requirement before the old permit expired. The Laboratory's NPDES Permit No. NM0028355 expired on March 1, 1991, and is being administratively continued under 40 CFR 122.6. On May 11, 1991, EPA issued a public notice, fact sheet, and draft NPDES Permit to LANL. On August 8, 1991, the Laboratory submitted comments on the draft permit to EPA. On August 9, 1991, the NMED denied certification of the draft permit. On September 4, 1991, the NMED sent a letter to EPA Region 6 requesting that LANL be allowed to continue its discharge under administrative continuance of the expired permit. A revised draft permit is expected to be issued to LANL in May 1992.

At the present time, the Laboratory's NPDES permit for Los Alamos includes 9 sanitary wastewater treatment facilities and 130 industrial outfalls. A summary of these outfalls is included in Table D-2. The NPDES permit for the geothermal facility at Fenton Hill includes only one industrial outfall.

Under the Laboratory's existing NPDES Permit for Los Alamos, samples are collected for analysis on a weekly basis and results are reported each month to the EPA and NMED. During 1991 effluent limits were exceeded 3 times out of 297 samples collected from the sanitary wastewater facilities. Effluent limits were exceeded 21 times out of 1,799 samples collected from the industrial outfalls. As shown in Fig. III-2 and Tables D-3–D-6, overall compliance for the sanitary

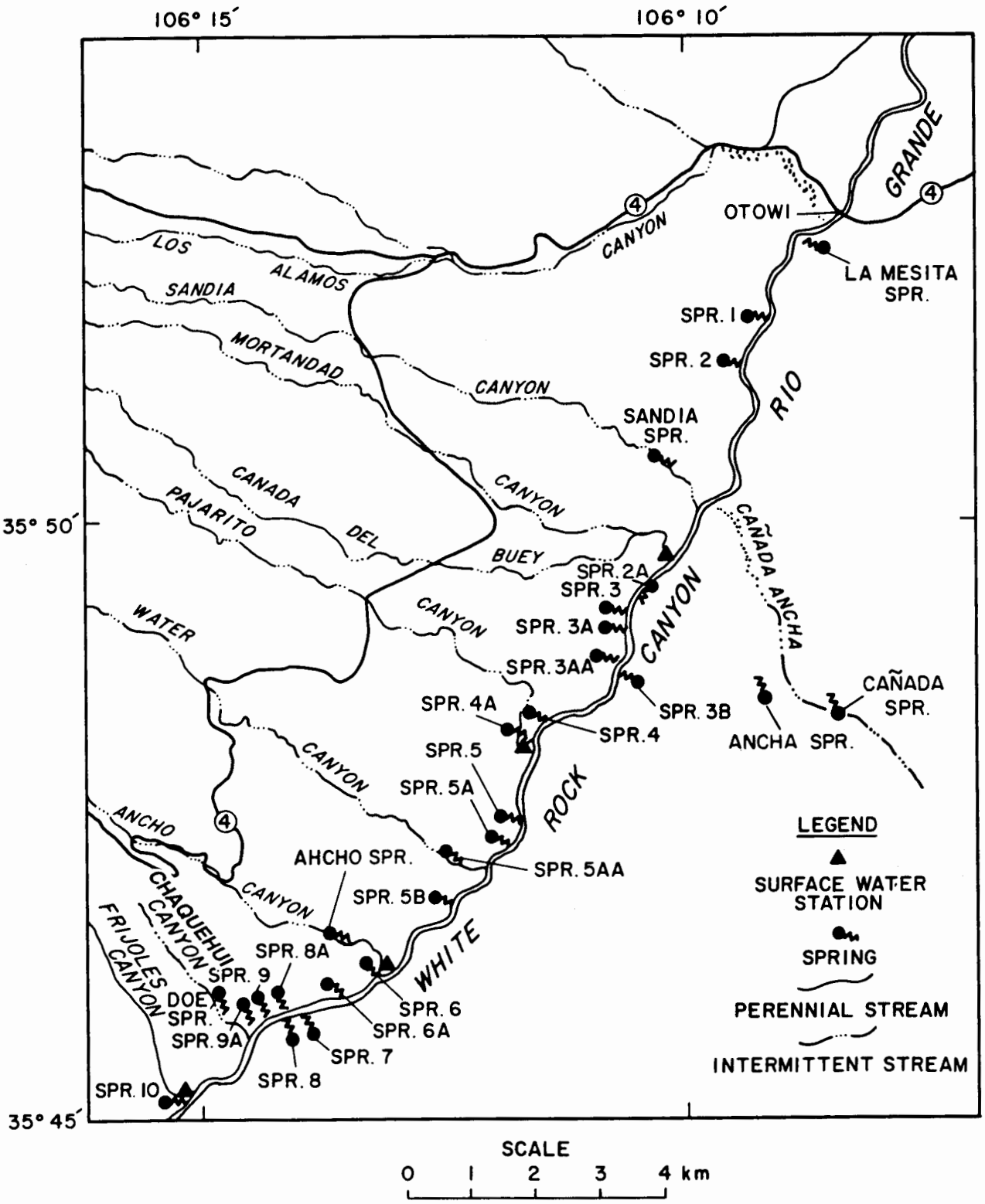


Figure III-1. Generalized location of springs in White Rock Canyon.

and industrial discharges during 1991 was 99.0% and 98.8% respectively. There was no discharge from the industrial outfall at the geothermal facility at Fenton Hill during 1991.

During the first quarter of 1992, none of the 56 samples collected from the sanitary wastewater facilities exceeded effluent limits. Effluent limits were exceeded two times out of 286 samples collected from the industrial outfalls. As shown in Fig. III-3, overall compliance for the sanitary and industrial discharges during the first quarter of 1992 was 100% and 99.3% respectively. There was no discharge for the industrial outfall at the geothermal facility at Fenton Hill during the first quarter of 1992.

Group EM-8 continued the waste stream identification and characterization program during 1991 and the first quarter of 1992 in order to verify that each waste stream is properly monitored under the outfall category in which it is permitted. These studies consist of dye testing, interviews with user groups, and coordination with other Laboratory organizations to determine sources, concentrations, and volumes of pollutants that enter waste streams, receive treatment, and are discharged to the environment.

b. Compliance Evaluation Inspection. On November 19 and 20, 1991, the EPA Region 6, Water Management Division's Enforcement Branch performed a Compliance Evaluation Inspection (CEI) on the Laboratory's NPDES self-monitoring program (Table III-4).

Following the inspection, EPA issued a Notice of Deficiency to UC and the DOE/LAAO for laboratory analytical procedures and recordkeeping for flow recorders. These items were corrected.

On February 19, 1992, EPA mailed a written report of the CEI findings to LANL and DOE. The Laboratory's written response to the CEI report was submitted to EPA on March 24, 1992.

c. Spill Prevention Control. The Laboratory has a Spill Prevention Control and Countermeasure (SPCC) Plan, as required by the CWA in accordance with 40 CFR 112. This plan requires that secondary containment be provided for all above ground storage tanks. There are approximately 40 major containment structures at the Laboratory. The plan also provides for spill control on drum and container storage, chemical storage, and equipment containing oil. Training is provided for the user group's designated Spill Coordinator on the requirements of the SPCC Plan and emergency response. The Spill Coordinator plays the major role in implementation of the SPCC Plan at the group level. During 1991, funding was allocated to various user groups for the purchase and installation of chemical storage lockers for drum storage. Eight chemical lockers and two containment pallets were purchased. The SPCC Plan is scheduled for its third revision, which will begin in early 1992.

d. Storm Water Discharges. On November 16, 1990, the EPA promulgated the final rule for NPDES Regulations for Storm Water Discharges and modified 40 CFR 122, 123, and 124. This rule was required to implement Section 402(p) of the CWA (added by Section 405 of the Water Quality Act of 1987).

Federal facilities are required to submit a permit application if they are engaged in a defined industrial activity. To date, LANL has identified approximately 100 outfalls that will require storm water permit applications. Additionally, the Laboratory will be required to submit storm water permit applications for SWMUs.

Regulations for NPDES General Permits and reporting requirements for storm water discharges associated with industrial activity are expected to be finalized in April 1992. LANL will submit NOIs for general permits for most of the outfalls requiring permitting.

Twenty-five sites were selected for storm water monitoring, and runoff from 18 of these sites was sampled during storm events during July through September 1991. Samples were collected and analyzed in accordance with EPA procedures for all required EPA Form 2F pollutants, all the priority pollutants, total alpha radioactivity, total beta radioactivity, radium 228, and radium 226. This data will be submitted to EPA with LANL storm water permit applications.

3. National Environmental Policy Act.

a. Introduction. NEPA mandates that federal agencies consider the environmental impact of their actions prior to final decision making. NEPA establishes the national policy of creating and maintaining conditions under which man and nature can exist in harmony and fulfill the social, economic, and other requirements of present and future generations.

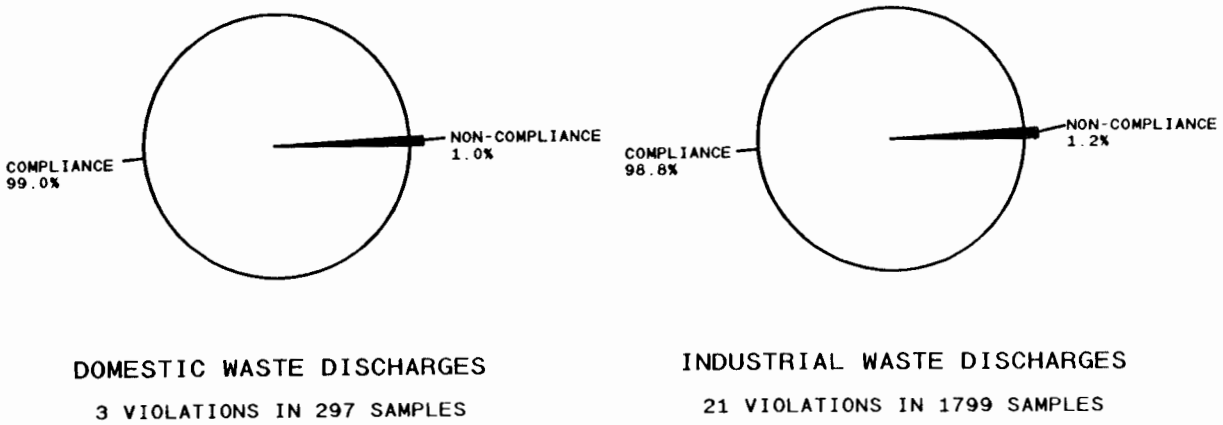


Fig. III-2. Summary of Clean Water Act Compliance in 1991, NPDES Permit NM0028355.

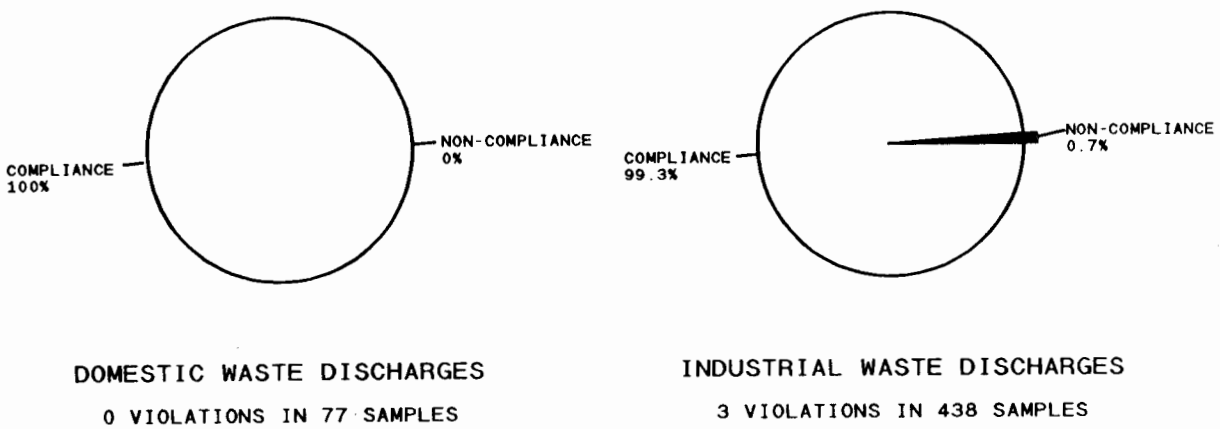


Fig. III-3. Summary of Clean Water Act Compliance in the first quarter of 1992, NPDES Permit NM0028355.

Proposed activities are evaluated to determine whether they have the potential to affect the environment. The sponsoring agency, DOE for LANL activities, is responsible for preparation of NEPA documents, which include the following:

- a categorical exclusion, applied to specific types of activities that have been determined to have no adverse environmental impacts;
- an Environmental Assessment (EA), evaluating environmental impacts, leading to either a finding of no significant impact (FONSI) if the impacts are indeed found to be not significant, or an Environmental Impact Statement (EIS) if the impacts are significant; and
- an EIS, in which impacts of proposed and alternative actions are evaluated and mitigation measures proposed, leading to a record of decision in which the agency discusses a decision on proceeding with the project.

NEPA provides specific protection to areas defined as unique resources (sensitive areas). Under NEPA review, proposed projects are evaluated for possible effects on cultural resources (archaeological sites or historic buildings) in accordance with the National Historic Preservation Act of 1966. In addition, proposed projects are evaluated for potential impact on threatened, endangered or sensitive species, in accordance with the Threatened and Endangered Species Act, and on floodplains or wetlands, in accordance with relevant executive orders (EOs). A proposed project, otherwise eligible for a categorical exclusion, cannot be approved for that NEPA determination if these sensitive areas would be adversely affected.

b. Compliance Actions. During 1991, the Environmental Protection Group (EM-8) reviewed 614 actions proposed to be undertaken at the Laboratory for NEPA applicability, including impacts on sensitive areas. Of these, about one-third were reviewed through the Environment, Safety, and Health (ES&H) Questionnaire system, which provides detailed descriptions of proposed activities. The remainder had no potential environmental, safety, or health issues, e.g., design studies, road signs, etc., and were not reviewed through the ES&H Questionnaire system. Seventy-eight DOE DECs were submitted to DOE on 90 of these projects; some DECs cover more than one related project.

In addition to the 78 DECs submitted to DOE on 1991 projects, 21 DECs were submitted during 1991 on projects reviewed through the ES&H Questionnaire process during 1990 and decisions were still pending at DOE on 21 DECs submitted during 1990. Of these 120 DECs submitted to DOE for decisions, 62 were categorically excluded from additional NEPA documentation, EAs were required on 12, two were covered by prior NEPA determinations, and no decision had been made on the remaining 44 by the end of 1991.

Based on submitted DECs, EAs were required on 12 proposed projects. Five of those EAs were prepared and submitted to DOE and were in review at the end of the year. An additional EA was required and submitted on a project for which no DEC had been prepared because the activity had been initiated at another DOE facility. A FONSI was signed in August for this project. Of the five EAs in review at the end of 1990, FONSIs were signed for three during 1991 and two were still in review at the end of 1991. This information is summarized in Tables III-5 and III-6. Copies of final EAs and FONSIs are available to the public through the Los Alamos Area Office of DOE.

During the first quarter of 1992 (January through March), EM-8 has reviewed 255 proposed actions for NEPA applicability. Of this group, 80 projects have been identified as having possible effects on the environment. Seventeen DECs were submitted covering seventeen proposed actions. Other DECs are in preparation. In addition, umbrella DECs, which cover groups of similar activities, were submitted on anticipated routine maintenance activities, minor modifications for increased workplace habitability, environmental and safety modifications, building and equipment instrumentation, and construction and operation of small support structures.

During the first quarter of 1992, DOE issued categorical exclusions on seven of the outstanding DECs and required EAs on three. Decisions on other submitted DECs are pending. A FONSI was signed January 31, 1992, for an EA on the Relocation of Superconducting Ceramics, Filament Winding, and Mechanical Characteristics Operations, which had been submitted to DOE in December 1990.

Table III-5. Environmental Assessments Submitted to DOE during 1991

Date Submitted	Title
February 4	General Purpose Heat Source Fabrication[a]
April 26	Sorbent Reactivity Study
May 24	Advanced Free Electron Laser
August 13	Transuranic (TRU) Waste Compactor[b]
August 13	Drum Storage Facility[b]
December 23	Expansion of Area G, TA-54

[a] Subsequently combined with an EA for project work at the Savannah River Plant and retitled Radioisotope Heat Source Fuel Processing and Fabrication.
[b] Subsequently combined into a single EA for the TRU Waste Compactor and Drum Storage Facility.

Table III-6. Environmental Assessments that Received Findings of No Significant Impact during 1991

Date Submitted	Title	FONSI Date
March 16, 1990	Weapons Engineering Tritium Facility	March 22, 1991
June 29, 1990	Material Science Laboratory	May 14, 1991
December 18, 1990	New Production Reactor-Modular High Temperature Gas-Cooled Reactor Experiments	October 10, 1991
February 4, 1991	General Purpose Heat Source Fabrication[a]	August 19, 1991

[a]Subsequently combined with an EA for Savannah River Plant and retitled Radioisotope Heat Source Fuel Processing and Fabrication.

c. Types of Activities Reviewed. The 78 DECs submitted during 1991 can be categorized by type of project as follows (some DECs include more than one activity):

- 22 addressed construction projects including transportables;
- 18 addressed waste management/environmental restoration projects;
- 6 addressed energy research projects;
- 11 addressed routine maintenance projects;
- 6 addressed PCB removal projects;
- 1 addressed a decontamination and decommissioning (D&D) project; and
- 14 addressed other research projects.

4. Federal Clean Air Act and the New Mexico Air Quality Control Act.

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

- NESHAP;
- National Ambient Air Quality Standards (NAAQS); and
- New Source Performance Standards (NSPS).

However, all of the above requirements, except the NESHAP for radionuclides and wood stoves, have been adopted by the State of New Mexico as part of its State Implementation Plan. Because the Laboratory does not operate wood stoves, the NESHAP for this source does not apply. Therefore, all of these regulations except the radionuclide NESHAP are discussed in Subsection b. State Regulations.

Radionuclide NESHAP. Under 40 CFR 61, Subpart H, the EPA limits the effective dose equivalent to any member of the public from radioactive airborne releases from DOE facilities, including LANL, to 10 mrem/yr. For 1991, the maximum dose to a member of the public from airborne releases was calculated using the EPA-approved computer program CAP-88 to be 4.4 mrem, or 44% of the EPA NESHAP. This dose is lower than the dose calculated for 1990 airborne emissions principally because beam line modifications and a reduced operating schedule at the Los Alamos Meson Physics Facility (LAMPF) lowered airborne radioactive emissions during 1991.

While the Laboratory is in compliance with the 10 mrem/yr dose standard, the Laboratory cannot yet demonstrate compliance with the radioactive air effluent monitoring requirements found in 40 CFR 61, Subpart H. The EPA has been notified by LAAO and the Laboratory of the status of LANL's airborne effluent monitoring system. Meetings were held with the EPA on August 21, 1991, and November 14, 1991, to discuss these issues and to propose remedial actions. On November 27, 1991, the EPA issued DOE a Notice of Noncompliance. A draft FFCA to address bringing the effluent monitoring program into compliance with the regulations was submitted by LAAO to the EPA on March 12, 1992 (see Section III.c.1.b for a discussion of the FFCA).

In October 1991 funding was received from the DOE to begin construction of a new stack for LAMPF. This stack will include a long delay line allowing increased radioactive decay of LAMPF effluent before it is released, consequently further reducing LAMPF emissions.

In addition to the existing federal programs, the Clean Air Act Amendments (CAAA) of 1990 mandate new programs which may affect the Laboratory. The new requirements include control technology for hazardous air pollutants, prevention of accidental releases, operating permits, and chlorofluorocarbon replacement. The Laboratory will track new regulations written to implement the act, determine their effects on Laboratory operations, and implement programs as needed.

b. State Regulations. The NMED preserves air quality through a series of Air Quality Control Regulations (AQCRs). Each AQCR relevant to Laboratory operations is discussed below.

AQCR 201 - National Ambient Air Quality Standards. As part of the federal Clean Air Act of 1977, the EPA established ambient air quality standards for certain types of pollutants, usually referred to as "criteria" pollutants, to protect human health and welfare. Compliance with these standards in areas of high pollutant emissions is determined through sampling the ambient air. States can adopt standards that are more restrictive than the federal ambient air quality standards but cannot adopt standards that are weaker. New Mexico has chosen to set more restrictive standards for

several pollutants, as well as setting ambient standards for some pollutants that are not addressed under the federal regulations. Both the federal and state standards are shown in Table A-3.

Criteria pollutants are measured at a background monitoring site on Laboratory property near Bandelier National Monument. Measurements are made of sulfur dioxide, nitrogen dioxide, ozone, and particulate matter. The data collected during 1991 are shown in Table III-7. As this table shows, air quality at the Laboratory site is much better than the ambient air quality standards. Measured ozone concentrations do not exceed the federal primary or secondary standard. However, the maximum hourly concentration exceeded the New Mexico ambient standard.

No data for the first quarter 1992 are available.

AQCR 301 - Regulation to Control Open Burning. AQCR 301 regulates the open burning of materials. Under this regulation, open burning of explosive materials is permitted when transport of these materials to other facilities may be dangerous. Provisions of this regulation allow DOE and the Laboratory to burn waste explosives and explosive-contaminated wastes. Civil defense-related research projects require open burning permits. In 1991, the Laboratory filed and received extensions on two open burning permits: one for the open burning of jet fuel for ordnance testing at TA-11, Site K, and the other for burning explosive-contaminated wood at TA-36 (Table III-2).

AQCR 401 - Regulations to Control Smoke and Visible Emissions. AQCR 401 regulates the visible emissions allowed from the Laboratory boilers to less than 20 percent 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 of this standard is unlikely. It may, however, occur during start up with oil, the backup fuel for the boilers. Although oil is used infrequently, the boilers must be periodically switched to oil to ensure that the backup system is operating properly. In 1991, the Laboratory recorded one incident where the opacity limit was exceeded. This occurred at the TA-16

Table III-7. Nonradiological Ambient Air Monitoring Results for 1991

Pollutant	Averaging Time	Unit	New Mexico Standard	Federal Standards Primary	Federal Standards Secondary	Measured Concentrations
Sulfur dioxide[a]	Annual arithmetic mean	ppm	0.02	0.03		0.001
	24 hours	ppm	0.10	0.14		
	3 hours	ppm			0.5	
	1 hour	ppm				0.008
PM_{10}[a]	Annual arithmetic mean	$\mu g/m^3$		50	50	7
	24 hours	$\mu g/m^3$		150	150	15
Ozone[a]	1 hour	ppm	0.06	0.12	0.12	0.087
Nitrogen dioxide[a]	Annual arithmetic mean	ppm	0.05	0.053	0.053	0.003
	24 hours	ppm	0.10			
	1 hour	ppm				0.01
Beryllium[b]	Calendar quarter	ng/m^3				0.06
	30 day	ng/m^3	10			

[a]Measurements made at Bandelier Monitoring Compound.

[b]Measurement made at TA-52.

incinerator when the secondary chamber encountered temperature control problems and shut down. Repairs to the incinerator restored normal operations and compliance.

AQCR 501 - Asphalt Process Equipment. Provisions of AQCR 501 set emission standards according to process rate and require the control of emissions from asphalt-processing equipment. The asphalt concrete plant operated by JCI is subject to this regulation. The plant, which has a 75,000 kg/h (75 ton/h) capacity, is required to meet an emission limit of 16 kg (35 lb) of particulate matter per hour. A stack test of the asphalt plant in 1977 indicated an average emission rate of 0.8 kg/h (1.8 lb/h) and a maximum rate of 1.0 kg/h (2.2 lb/h) over three tests (Kramer 1977). Although the plant is old and is not required to, it meets NSPS stack emission limits for asphalt plants (Kramer 1977).

AQCR 507 - Oil Burning Equipment - Particulate Matter. This regulation applies to an oil burning unit having a rated heat capacity greater than 250 million British Thermal Units (Btu) per hour. Oil burning equipment of this capacity must emit less than 0.03 lb per million Btu of particulate. Although the Laboratory boilers utilize oil as a backup fuel, all have maximum rated heat capacities below this level; consequently, this regulation does not apply. The TA-3 Cogeneration Facility operates the three highest heat capacity boilers, each having a maximum rated heat capacity of 188 million Btu per hour.

AQCR 604 - Gas Burning Equipment - Nitrogen Dioxide. Provisions of AQCR 604 require gas-burning equipment built before January 10, 1972, to meet an emission standard for NO_x of 0.3 lb/10^6 Btu when natural gas consumption exceeds 10^{12} Btu/yr/unit. The TA-3 power plant's boilers have the potential to operate at heat inputs that exceed the 10^{12} Btu/yr/unit, but they have not been operated beyond this limit. Therefore, these boilers have not been subject to this regulation. However, the TA-3 power plant meets the emission standard. The emission standard is equivalent to a flue gas concentration of 248 ppm; the measured flue gas concentrations of the TA-3 boilers ranged from 20 to 22 ppm in 1991.

AQCR 605 - Oil Burning Equipment - Sulfur Dioxide. This regulation applies to oil burning equipment having a heat input of greater than 1×10^{12} Btu/yr. Although the Laboratory utilizes oil as a backup fuel, none of the equipment utilizes it at this high a rate. Therefore, this regulation did not apply during 1991 to the Laboratory fuel burning equipment. Should such equipment operate above the heat input limit, emissions of sulfur dioxide would be required to be less than 0.34 lb per million Btu.

AQCR 606 - Oil Burning Equipment - Nitrogen Dioxide. This regulation applies to oil burning equipment having a heat input of greater than 1×10^{12} Btu/yr. None of the Laboratory boilers utilize oil (their backup fuel) at this rate. Therefore this regulation did not apply during 1991 to the Laboratory fuel burning equipment. Should such equipment operate above the heat input limit, emissions of nitrogen dioxide would be required to be less than 0.3 lb per million Btu.

AQCR 702 - Permits. Provisions of AQCR 702 require permitting of any new or modified sources of potentially harmful emissions if they exceed threshold emission rates. More than 500 toxic air pollutants are regulated, and each chemical's threshold hourly emission rate is based on its toxicity. The Laboratory reviews each new and modified source and makes conservative estimates of maximum hourly chemical usage and emissions. These estimates are compared with the applicable AQCR 702 limits to determine if additional permits are required. During 1991, over 200 source reviews were conducted. None of these sources required permits under AQCR 702.

AQCR 707 - Prevention of Significant Deterioration. These regulations have stringent requirements that must be addressed before the construction of any new, large stationary source can begin. Under this regulation, wildernesses, national parks, and national monuments receive special protection. For the Laboratory, this mainly impacts Bandelier National Monument's Wilderness Area. Each new or modified source at the Laboratory is reviewed to determine whether this regulation applies. However, due to the small size of air pollutant emissions at the Laboratory, DOE and the Laboratory have not yet been required to submit a permit under this regulation.

AQCR 751 - Emission Standards for Hazardous Air Pollutants. In this regulation, NMED adopts by reference all of the federal National Emission

Standards for Hazardous Air Pollutants, except for radionuclides and new residential wood heaters. The impact of each applicable NESHAP is discussed below.

Asbestos. Under the NESHAP for asbestos, the Laboratory must assure that no visible asbestos emissions to the atmosphere are produced by asbestos removal operations at the Laboratory. During 1991, no Laboratory operation produced visible asbestos emissions.

In addition, the Laboratory is required to notify the NMED of asbestos removal and disposal activities. Renovation projects removing less than 160 sq ft or 260 lin ft are covered by an annual small job notification to NMED. For projects removing greater than these amounts of asbestos, notification of NMED is required in advance of the work. The Laboratory received one Notice of Violation on October 17, 1991, related to asbestos notification, because LANL staff notified NMED of a delay in the start of a job on the day the job was supposed to start, rather than on the day before it was to start.

During 1991, JCI removed approximately 2,095 lin ft of friable asbestos, including 110 lin ft of potentially radioactively contaminated friable material, from small jobs covered by the annual notification. Approximately 193 sq ft of friable insulation was removed from vessels and other facility components, and 330 sq ft of nonfriable vinyl-asbestos floor tile was removed. Of the floor tile, approximately 48 sq ft was disposed of as potentially radioactively contaminated material. A total of 1,640 lin ft of friable asbestos material was removed through large, job specific notification work.

Asbestos wastes potentially contaminated with radionuclides are disposed on site at TA-54 in accordance with required disposal practices. Nonradioactive asbestos is disposed off site in a certified landfill.

The NMED is notified of the disposal of friable asbestos. Ten Hazard Waste Manifests documenting the off-site disposal of nonradioactively contaminated friable asbestos were reported to NMED during 1991. An additional 13 manifests were reported for radioactively contaminated friable asbestos disposed at TA-54. The Laboratory has 14 manifests for nonfriable asbestos disposal during 1991 (11 nonradioactive, 3 radioactive) for which NMED does not require documentation.

Beryllium. The beryllium NESHAP includes requirements for notification, emission limits, and stack performance testing for beryllium sources. The four beryllium facilities at the Laboratory operate under state air quality permits containing these requirements. The Laboratory obtained a permit for a fifth beryllium processing operation to be located in TA-3-35; this facility has not yet been constructed so the permit is not active.

Beryllium machining operations are located in Shop 4 at TA-3-39, in Shop 13 at TA-3-102, the beryllium Shop at TA-35-213, and the beryllium processing facility at TA-3-141. Exhaust air from each of these operations passes through air pollution control equipment before exiting from a stack. A fabric filter controls emissions from Shop 4. The other operations use high-efficiency particle-attenuation (HEPA) filters to control emissions, with a removal efficiency of more than 99.95%. Source tests have demonstrated that all beryllium operations meet the emission limits established by NESHAP and that emissions are so low that there is negligible impact on ambient air quality.

The Laboratory identified a beryllium cutting operation at TA-55-4 in August 1991 which may require a permit under the requirements of New Mexico Air Quality Control Regulation 702 - Permits. Following discussions with the NMED, DOE officially notified NMED on October 9, 1991, of the operations. Beryllium cutting operations were suspended and a commitment was made to file an air quality permit application with NMED. The NMED issued a Notice of Violation for the beryllium cutting operation on October 16, 1991. Negotiations for settling this NOV are continuing between Laboratory, DOE, and NMED personnel.

To support a new weapons program, additional beryllium machining operations will be located in TA-55-4. The Laboratory has prepared an air quality permit application to include the existing and modified sources, which will be submitted to the NMED in early 1992. The beryllium machining operations to be located in TA-55-4 will be controlled by a series of HEPA filters with removal efficiencies of at least 99.95% each.

During 1991, three existing beryllium machining operations (located at TA-3-66 and TA-16-450) were identified for which no records are available to confirm that they were registered with NMED or EPA. Because these operations were in existence prior to the adoption of the federal NESHAP, only registration is required.

Registration information for these operations will be submitted to NMED in April 1992.

AQCR 752 - Registration of Existing Toxic Air Pollution Sources. Provisions of this regulation required a one-time registration of all sources emitting toxic air pollutants in amounts in excess of a specified annual emission limit. Complying with this regulation required the Laboratory to estimate emissions on a building-by-building basis for more than 500 chemicals. To calculate these emissions, a computerized data base has been developed that includes usage, products, and wastes for each regulated chemical. In response to the anticipated requirements of the Environmental Oversight Agreement between DOE and New Mexico, this data base is being updated. In general, air emissions are very low because the Laboratory is primarily a research facility and chemical usage is small.

5. Safe Drinking Water Act, Municipal and Industrial Water Supplies.

This program includes sampling from various points in the Laboratory and County water distribution systems to ensure compliance with the Safe Drinking Water Act (SDWA) (40 CFR 141). The EPA has established maximum contaminant levels for microbiologic, organic, and inorganic constituents and radioactivity in drinking water. Most of these standards have been adopted by the State of New Mexico and are included in the New Mexico Water Supply Regulations. The NMED has been authorized by EPA to administer and enforce federal drinking water regulations and standards in New Mexico.

Compliance samples are analyzed for organic and inorganic constituents and for radioactivity at the New Mexico Health Department's Scientific Laboratory Division (SLD) in Albuquerque. The SLD reports the analytical results directly to NMED. The JCI Environmental Laboratory also collects samples throughout the Laboratory and County distribution systems and tests them for microbiological contamination, as required under the SDWA. The JCI Environmental Laboratory is certified by SLD for microbiological testing of drinking water.

During 1991, all water samples collected under the SDWA program at Los Alamos and tested by SLD in Albuquerque and by the JCI Laboratory were found to be in compliance with the maximum contaminant levels established by regulation. A summary of the results is presented in Tables III-8, III-9, III-10, and III-11. There were no violations nor any fines levied on the Laboratory's municipal and industrial water supplies during 1991.

Each month during 1991 an average of 46 samples was collected throughout the Laboratory and County water distribution systems to determine the free chlorine residual available for disinfection and the microbiological quality of the distribution systems. These samples were collected by JCI Environmental Section personnel and analyzed in the JCI-certified laboratory for the presence of coliform bacteria, which is an indicator used to determine if harmful bacteria could be present. During 1991, no coliform bacteria were found. Sixty-five of the microbiological samples (approximately 12%) collected were found to have some noncoliform bacteria present. Although the presence of noncoliform bacteria is not a violation of SDWA, it does indicate stagnant water or biofilm growth in the distribution lines. A summary of the analytical results is found in Table III-12.

Chemical and microbiological data are available for the first quarter of 1992 and indicate full compliance with standards (Tables III-9 and III-12).

6. Federal Insecticide, Fungicide, and Rodenticide Act.

This act regulates the manufacturing of pesticides, with requirements on registration, labeling, packaging, recordkeeping, distribution, worker protection, certification, experimental use, and tolerances in foods and feeds. Sections of this act that are applicable to the Laboratory include recommended procedures for storage and disposal, and requirements for certification of applicators. The Laboratory is also regulated by the New Mexico Pest Control Act. The application, storage, disposal, and certification of these chemicals are conducted in compliance with these regulations. The Laboratory's maintenance subcontractor, JCI, conducts the application of pesticides under the direction of the Laboratory's Pest Control Program Administrator. A Laboratory Pest Control Policy, which includes management programs for vegetation, insects, and small animals, was established in 1984 and is being revised by the Pest Control Oversight Committee (PCOC). This committee was established to review and recommend policy changes in the overall pest management program at the Laboratory.

Table III-8. Volatile Organic Constituents in the Water Distribution System in 1991 (μg/L)

Contaminant	Composite Samples A	B	C
VOC Group I			
63 Compounds	0.00 N	0.00 N	0.00 N
VOC Group II			
1,2-Dibromoethane (EDB)	0.00 N	0.00 N	0.00 N
1,2-Dibromo-3-chloropropane (DBCP)	0.00 N	0.00 N	0.00 N

MDL = (Minimal detection limit) 1.00 μg/L for VOC Group I.
MDL = 0.04 μg/L for VOC Group II.
N = None detected above detection limit.
*Composite Samples A = Guaje wells #1, 1A, 2
B = Guaje wells #4, 5, 6
C = Pajarito Mesa wells #1, 2, 3, 5

Table III-9. Total Trihalomethane Concentrations in the Water Distribution System (μg/L)

Sampling Location	1991 Quarters First	Second	Third	Fourth	1992 Quarters First
Los Alamos Airport	1.20	4.60	7.80	3.10	0.00
White Rock Fire Station	0.20	0.00	0.00	0.30	0.00
North Community Fire Station	1.40	1.20	1.00	0.00	0.00
S-Site Fire Station	0.50	0.00	2.00	0.50	0.00
Barranca School	1.60	0.00	0.50	0.50	0.00
TA-33, Bldg. 114	—	—	—	4.40	2.70

The maximum contaminant level is 100 μg/L under both the SDWA and the New Mexico Water Supply Regulations.

Table III-10. Inorganic Constituents in the Water Distribution System in 1991 (mg/L)

Sampling Location	As	Ba	Cd	Cr	F	Pb	Hg	Nitrate (as N)	Se	Ag
Los Alamos Airport	0.012	0.2	<0.001	0.01	0.49	<0.005	<0.0005	0.38	<0.005	<0.001
North Community Fire Station	0.015	0.1	<0.001	0.01	0.52	<0.005	<0.0005	0.37	<0.005	<0.001
Barranca School	0.014	0.1	<0.010	0.01	0.57	<0.005	<0.0005	0.36	<0.005	<0.001
MCL[a]	0.050	1.0	0.010	0.05	4.00	0.050	0.0020	10.00	0.010	0.05

[a]The maximum contaminant level under both the SDWA and the New Mexico Water Supply Regulations.

Table III-11. Radioactivity in the Water Distribution System

Analysis	Standard for Calibration	Radioactivity in Sample December 18, 1991 (pCi/L)	
Los Alamos Airport			
Gross alpha[a]	^{241}Am	1.00	(0.30)[b]
	Natural uranium	1.20	(0.40)
Gross beta[c]	^{137}Cs	3.10	(0.60)
	^{90}Sr, ^{90}Y	3.10	(0.60)
North Community Fire Station			
Gross alpha	^{241}Am	0.00	(0.30)
	Natural uranium	0.00	(0.40)
Gross beta	^{137}Cs	1.80	(0.70)
	^{90}Sr, ^{90}Y	1.80	(0.70)
Barranca School			
Gross alpha	^{241}Am	0.60	(0.30)
	Natural uranium	0.70	(0.40)
Gross beta	^{137}Cs	3.80	(0.70)
	^{90}Sr, ^{90}Y	3.90	(0.70)

[a]The gross alpha maximum contaminant level is 15 pCi/L under both the SDWA and the New Mexico Supply Regulations.

[b]Uncertainties are in parentheses.

[c]The gross beta maximum contaminant level is 50 pCi/L under both the SDWA and the New Mexico Supply Regulations.

An annual inspection conducted by the United States Department of Agriculture found no deficiencies in the Laboratory's pesticide application program and certified application equipment. In 1991, approximately 27.5 lb of herbicides and 287.5 gal. of pesticides were applied at the Laboratory. Data for the first quarter of 1992 are not available.

7. National Historic Preservation Act.

As required by Section 106 of the National Historic Preservation Act of 1966, Laboratory activities are evaluated in consultation with the State Historic Preservation Officer (SHPO) for possible effects on cultural resources. During 1991, Laboratory archaeologists evaluated 1,110 actions, which resulted in 51 intensive field surveys.

Although only 7 of the 51 field surveys were conducted for the ER program, these 7 surveys covered close to 3,000 acres on DOE, Forest Service, GSA, and Indian land. A total of 161 new archaeological sites were recorded, and the site records were updated for 20 previously recorded sites.

A data recovery plan for mitigation of adverse effects to seven Anasazi pueblos was approved by the SHPO. These ruins will be impacted by the proposed expansion of waste disposal facilities at TA-54. A copy of this plan was sent to San Ildefonso Pueblo for comments. At the Pueblo's request, the Pueblo Council was given a tour of these ruins and the nearby ruin of Tsirege, which is ancestral to San Ildefonso Pueblo. Discussions during this tour have resulted in an informal agreement to draft a Memorandum of Understanding between San Ildefonso, DOE, and LANL. This document will specify the procedures for avoiding sacred and traditional places as required by the American Indian Religious Freedom Act of 1978 and

Table III-12. Microbiological Testing of the Water Distribution System

Month	No. of Tests Conducted	No. of Tests with Bacteria Present	
		Coliform[a]	Noncoliform
1991			
January	49	0	0
February	44	0	1
March	54	0	5
April	48	0	2
May	46	0	2
June	41	0	4
July	49	0	12
August	43	0	9
September	40	0	6
October	46	0	9
November	47	0	9
December	47	0	6
Total 1991	554	0	65
1992			
January	49	1	3
February	47	0	3
March	47	0	6
Total 1992	143	1	12

[a]The EPA total coliform maximum contaminant level for a system which collects over 40 samples per month is no more than two samples with coliforms present per month.

the procedures for the return of Native American funerary remains and other sacred objects as required by the Native American Graves Protection and Repatriation Act of 1990.

In the first quarter of 1992, EM-8 reviewed 268 Laboratory actions for possible effects to cultural resources and continued ongoing field surveys for the ER program. Four cultural resource survey reports were submitted to the SHPO for review and concurrence.

8. Endangered/Threatened/Protected Species.

a. Threatened and Endangered Species. The DOE and the Laboratory must comply with the Endangered Species Act of 1973, as amended. During 1991, EM-8 reviewed 614 actions proposed to be undertaken at the Laboratory for potential impact on threatened and endangered species. Of these, 211 were reviewed through the ES&H Questionnaire system. The Biological Resource Evaluations Team (BRET) of EM-8 identified 40 projects as needing reconnaissance surveys. These surveys are designed to evaluate the amount of previous development or disturbance at the site and if any physical characteristics required by a threatened or endangered species are present. BRET also identified 15 projects as needing quantitative surveys to determine if the appropriate habitat types were present to support any threatened or endangered species. In addition, BRET identified eight projects (Table III-13) requiring an intensive survey which is designed to determine the presence or absence of a species at the project site. The Laboratory adhered to protocols and

permit requirements of the New Mexico State Game and Fish Department.

Of the surveys conducted, only the peregrine falcon (*Falco peregrinus*) and the bald eagle (*Haliaeetus leucocephalus*) were confirmed within a project site. Biological evaluations are being prepared for the projects and consultation with U.S. Fish and Wildlife will be undertaken. The meadow jumping mouse (*Zapus hudsonius*) and spotted bat (*Euderma maculatum*) were not found in any of the surveys.

An additional listed species, Jemez Mountain salamander (*Plethodon neomexicanus*), was encountered adjacent to an area of the Seismic Trench Study. The Jemez Mountain salamander was not found within the project impact area itself. The Seismic Trench Study was a Laboratory project that occurred partly on U.S. Forest Service property. The U.S. Forest Service conducted the appropriate consultation with New Mexico State Game and Fish.

During the first quarter of 1992, 98 proposed actions were reviewed for their potential impact on threatened and endangered species. Eight projects will require additional investigation.

b. Biological Surveys. Monitoring of selected biota and sensitive habitats to provide long-term data in accordance with NEPA, DOE Order 5400.1, Endangered Species Act and Floodplain/Wetland Executive Order was begun during 1990. Monitoring studies on raptors, reptiles and amphibians, small mammals and birds continued during 1991. Additionally, wetland and adjacent upland habitats within Pajarito and Sandia Canyons were monitored. A second year of data was collected for various trophic levels of biota within Cañada del Buey. Several new surveys were initiated to obtain inventory data on groups of organisms not previously studied.

Wildlife watering. A preliminary survey (conducted July through October 1991) of 135 of 140 NPDES outfalls indicated that approximately 50% of the outfalls are used or potentially can be used by macrofauna such as deer and elk. Additionally, one-third of the outfalls have potential wetland characteristics as evidenced by hydrophytic vegetation.

Observations indicated a number of aquatic invertebrates within effluent discharge waters. Cursory wildlife observations provided a list of 35 mammal, bird, amphibian, and reptile species (evidenced from visual sightings, scat, tracks, and bedding) in the vicinity of the outfalls. These and other nonmacrofaunal species could potentially use waters from the

Table III-13. Projects Requiring a Species Specific Survey in 1991.

Project Name	Species Surveyed
Emergency Gas Line Replacement	Meadow Jumping Mouse Jemez Mountain Salamander
Sanitary Waste Consolidation System	Jemez Mountain Salamander
Seismic Trench Study	Meadow Jumping Mouse Jemez Mountain Salamander
Site Characterization, OU 1106	Peregrine Falcon
Site Characterization, OU 1071	Meadow Jumping Mouse Peregrine Falcon
Site Characterization, OU 1078	Meadow Jumping Mouse Jemez Mountain Salamander
Site Characterization, OU 1079	Peregrine Falcon
Site Characterization, OU 1122	Meadow Jumping Mouse Spotted Bat Bald Eagle Peregrine Falcon

discharges. To determine the use and level of use of discharges by small and medium-sized mammals and amphibians, further studies will be conducted. Studies on the macroinvertebrate assemblages will continue.

9. Floodplain/Wetland Protection.

Los Alamos National Laboratory must comply with EO 11988, Floodplain Management and EO 11990, Protection of Wetlands (EPA 1989a). During 1991, 416 actions proposed to be undertaken at the Laboratory were reviewed for impact to floodplains and wetlands. All projects reviewed in 1991 were outside floodplain/wetland boundaries.

During the first quarter of 1992, 98 proposed actions were reviewed for impact to floodplains and wetlands. Seven projects may be within floodplain/wetland boundaries and will require further review.

10. Comprehensive Environmental Response, Compensation, and Liability Act.

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 and the Superfund Amendments and Reauthorization Act (SARA) of 1986 mandate cleanup of toxic and hazardous contaminants at closed and abandoned hazardous waste sites. The CERCLA/SARA-related actions for potential release sites at the Laboratory are being addressed under the DOE's Environmental Restoration Program (Section IV.I.6) in conjunction with RCRA corrective actions (Section III.B.1.h).

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

Title III Section 313 of SARA exempts DOE facilities from reporting requirements. However, it is DOE policy that this exemption not be exercised and that the Laboratory report its releases under the remaining provisions of Section 313. However, all research operations at the Laboratory are also exempt under other provisions of the regulation and only pilot plants and specialty chemical production facilities at the Laboratory must report their releases. As a result, the Plutonium Processing Facility is the only operation at the Laboratory that is covered by Section 313. The only regulated chemical that is used at the Plutonium Processing Facility in amounts greater than the Section 313 reporting thresholds is nitric acid.

The Laboratory submitted the required Section 313 report to EPA in July of 1991. This report covered the releases of nitric acid during 1990. About 24,320 kg (53,500 lb) of nitric acid were used for plutonium processing with releases to the air of approximately 468.7 kg (1,031 lb). The amount of nitric acid released to the atmosphere was calculated using data obtained from a study that measured the air emissions from the facility. The remaining nitric acid was either consumed in chemical reactions or was completely neutralized in the wastewater treatment operations. Only the air releases required reporting for 1990. Data on releases for CY91 will be reported under Section 313 in July 1992.

Data for the first quarter of 1992 are not available.

12. Toxic Substances Control Act

The Toxic Substances Control Act (TSCA 15 U.S.C. *et seq.*) is administered by the EPA which has authority to conduct premanufacture reviews of new chemicals prior to their introduction into the marketplace, require testing of chemicals which may present a significant risk to humans and the environment, and require recordkeeping and reporting requirements for new information regarding adverse health and environmental effects associated with chemicals. The EPA governs the manufacture, use, storage, handling, and disposal of PCB equipment and sets standards for PCB spill cleanups under TSCA. Because the Laboratory's activities are in the realm of research and development, the PCB regulations (40 CFR 761) have been the Laboratory's main concern under TSCA. Substances that are regulated by the PCB regulations include, but are not limited to, dielectric fluids, contaminated solvents, oils, waste oils, heat transfer fluids, hydraulic fluids, paints, slurries, dredge spoils, soils, and materials contaminated as a result of spills. Most of the provisions of the regulations apply to transformers and capacitors and PCB concentrations above a specified level. For example, the regulations regarding storage and disposal of PCBs generally apply to items whose concentrations are 50 ppm and above. At the Laboratory, equipment and materials containing greater than 500 ppm PCBs are transported off site for treatment and disposal, and those containing 50 to 500 ppm PCBs are incinerated off site or disposed of at TA-54, Area G. This area is approved by the EPA for disposal of PCB-contaminated solid materials.

Efforts continued toward the replacement, reclassification, and disposal of PCB equipment at the Laboratory. During 1991, the following PCB waste was sent off site for disposal: 25,306 kg (55,673 lb)

liquid PCB oil that included some 50-499 ppm oil; 4,502 kg (9,904 lb) contaminated debris; 3,114 kg (6,851 lb) contaminated water; 64,621 kg (142,166 lb) from 39 transformers; and 6,622 kg (14,568 lb) from capacitors. In addition, 31,496 kg (69,291 lb) of PCB-contaminated soil, debris, and equipment were disposed of at TA-54, Area G. Of the 31 PCB transformers that have been undergoing the retrofill process, 11 were reclassified to non–PCB status and most of the rest were reclassified to PCB-contaminated status. DOE Tiger Teams audited and inspected the Laboratory's PCB program in 1991. No other audits or inspections were conducted during 1991. In addition, a program to identify and recall PCB-contaminated equipment which was loaned to universities and other institutions prior to adoption of PCB regulations was initiated in 1991.

During the first quarter of 1992, a TSCA inspection was completed at the Laboratory by the EPA. Handling and storage of PCBs were found to be in substantial compliance with regulatory requirements. Replacement of PCB-contaminated equipment continued during the first quarter of 1992.

C. Current Issues and Actions

1. Compliance Agreements.

a. NPDES Federal Facilities Compliance Agreement and Administrative Orders. On May 31, 1991, EPA Region 6 served an Administrative Order (AO), Docket No. VI-91-273 on LANL. This AO listed 10 violations of the Laboratory's NPDES permit during November 1990 to March 1991. The AO also stated that the previous AO Docket No. VI-90-1263 was violated in that LANL had failed to comply with the specified construction schedule for Outfall 09S. The AO required the Laboratory to take corrective actions necessary to eliminate and prevent recurrence of the effluent violations cited. In addition, the Laboratory was required to submit a report detailing the specific corrective actions. For any corrective actions exceeding 30 days, EPA required LANL to submit a plan for the elimination and prevention of the listed violations. On July 8, 1991, the Laboratory submitted a response to EPA, including corrective actions taken and proposed schedules necessary to achieve compliance with the AO.

AO Docket No. VI-91-1329 was issued by the EPA to UC on August 29, 1991. Federal Facilities Compliance Agreement (FFCA) Docket No. VI-91-1328 was issued by EPA on August 29, 1991, and signed by LAAO on November 22, 1991. Included in the above AO and FFCA were interim effluent limits and compliance schedules for Outfalls 03A, 03A-023, 04S, 05S, 07S, 09S, 10S, and 12S. All sanitary discharges are scheduled to be in compliance with NPDES Permit limits by July 1992. A waste stream characterization schedule was also included in the AO and FFCA.

On December 24, 1991, the EPA issued an Order for Information, Docket No. VI-92-1130, to LANL. The Order for Information required the Laboratory to submit all information available from January 1989 to the present time concerning the radioactivity present in effluent and storm water discharges at the Laboratory. On January 29, 1992, LANL submitted a response to EPA for the Order for Information, providing all available information requested by EPA. The EPA is expected to include radioactivity limits in a draft NPDES permit to be issued in May 1992.

On February 10, 1992, the Laboratory requested that the final compliance schedules for the sanitary discharges in the AO and FFCA be revised due to delays in the construction schedules of collection lines and the TA-53 lagoon elimination project. The requested final compliance date is December 1992. The Laboratory also requested a revision to the waste stream characterization schedule and the addition of reporting procedures to provide regulatory coverage for potentially unpermitted outfalls or sources discovered while conducting the waste stream characterization to achieve compliance. The current and proposed schedules for completing projects required under the AO and FFCA are presented in Table D-7.

b. NESHAP Federal Facilities Compliance Agreement. The radioactive air emissions at the Laboratory have been evaluated against DOE/EH-0173T, Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance, and 40 CFR Part 61, Subpart H, National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities. Based on off-site environmental monitoring results and on doses calculated from measured stack emissions, the off-site doses are less than 10 mrem/yr, which is the standard given in 40 CFR 61.92.

On July 17, 1990, Los Alamos National Laboratory notified the DOE that the Laboratory met the 10 mrem/yr standard, but did not meet the monitoring

requirements (40 CFR 61.93) with its current sampling program. On November 27, 1991, EPA Region 6 issued DOE a Notice of Noncompliance with 40 CFR 61 Subpart H, specifically:

1. Every release source from an operation which used radionuclides has not been evaluated using the approved EPA computer model to determine a dose received by the public as required by 40 CFR 61.93(a).
2. DOE has failed to comply with 40 CFR 61.93(b)(4) because it has not determined each release point that has the potential to deliver more than 1% of the effective dose equivalent standard.
3. The facility currently has not installed stack monitoring equipment on all its regulated point sources in accordance with the above analysis and 40 CFR 61.93(b)(2)(ii) and (iii).
4. The facility has not conducted, and is not in compliance with, the appropriate quality assurance programs pursuant to 40 CFR 61.93(b)(2)(iv).
5. The facility is in violation of 40 CFR 61.94, Compliance and Reporting, because it has not calculated the highest effective dose equivalent in accordance with the regulations cited above.

As a result of the Notice of Noncompliance, the DOE is currently negotiating an FFCA with EPA Region 6. The FFCA will include schedules which the Laboratory will follow to come into compliance with the 1990 Clean Air Act. A draft FFCA was submitted by DOE/LAAO to the EPA on March 12, 1992.

c. Environmental Oversight and Monitoring Agreement. The Environmental Oversight and Monitoring Agreement between DOE and the State of New Mexico provides technical and financial support by DOE for state activities in environmental oversight, monitoring, access, and emergency response to ensure compliance with applicable federal, state, and local laws. The Agreement was signed in October 1990. The Agreement covers Los Alamos and Sandia National Laboratories, the Waste Isolation Pilot Project, and the Inhalation Toxicology Research Institute.

The Agreement requires the following actions on the part of DOE facilities.

- *Waste Minimization Plan:* a plan and schedule to describe how to reduce or eliminate the use and volume of existing solid, hazardous, mixed, and radioactive materials;
- *Source Reduction Study:* a study of available and appropriate methods to reduce or eliminate discharges and emissions of contaminants to the environment;
- *Waste Characterization Plan:* detailed information on the nature, quantities, and hazards associated with all hazardous, mixed, and radioactive waste produced, stored, or disposed at the facility or to be transported to the facility;
- *Site Characterization Studies:* studies to describe the background condition of surface water, groundwater, and soils on and around the facility;
- *Environmental Monitoring and Review Documents:* reports detailing environmental concerns, overviews, and monitoring at the facility;
- *Information on Environment Releases and Emissions:* information on known past releases of hazardous substances or radioactive materials above applicable standards which had not been previously reported to the state; 48-hour notification of any current releases that exceed applicable requirements or create a danger to human health or the environment; and a semiannual report on all hazardous, mixed, and radioactive waste emissions;
- *DOE Compliance Assessments:* comprehensive appraisals and audits of all activities at the site for compliance with regulatory requirements; access to all DOE Orders and Secretarial Notices on compliance assessments; and a description of all site activities that affect environmental quality, safety, and health that DOE regulates;
- *Incineration Data:* access to all information concerning the operation of any incinerator at the facility;
- *NEPA Documents:* a list of all NEPA documents submitted to DOE by the facility, to be

updated monthly; and copies of NEPA documents, as requested by the state;

- *Materials Reports:* access to the DOE Radioactive Waste Management Information System and the Industrial Waste Management Information System; identification of spent or irradiated reactor fuel, other radioactive, mixed, hazardous, or toxic wastes to be transported to the facility; and attendance by a state representative at off-site waste acceptance criteria committees;
- *Emergency Response:* notification to the state whenever there are any changes in facility operations which may have an impact on the state's emergency response program;
- *Access by State Representatives:* State representatives with the necessary security clearance will be granted access, without prior announcement and consistent with normal security procedures and safety precautions, to the facilities and facility records to carry out the provisions of the Agreement and other monitoring, inspections, and oversight activities that the state may conduct under its authority;
- *Security Clearance:* DOE will expedite the processing of security clearance applications for state representatives who will carry out the provisions of the Agreement and other monitoring, inspection, and oversight activities that the state may conduct under its authority;
- *Office for State Representatives:* Office space and telephone facilities will be provided for daily use by state representatives to carry out the provisions of the Agreement and other activities that the state may conduct under its authority; and
- *Public Participation:* provisions for public participation in the facility's Five-Year Planning Process.

Two meetings to discuss how each of these requirements affect each site were held in 1991. An addendum to the Agreement is being negotiated which will clarify requirements and schedules. Site-specific protocols are also being developed. The Laboratory expects that the Agreement will be implemented during 1992.

2. Corrective Activities.

The Corrective Activities (CA) Program is managed by EM-8 personnel under the overall DOE guidance of EM-30. Funding is provided through the Five-Year Plan. The CA Program includes those activities designed to bring active or standby facilities into compliance with ambient air, water, and solid waste regulations and/or agreements.

CA projects which demonstrate efforts toward regulatory compliance include the following:

- *Hazardous Waste Treatment Facility.* This facility, currently in the design phase, will consolidate all existing on-site hazardous waste treatment processes, upgrade existing waste treatment facilities to comply with regulations, and provide treatment for hazardous mixed wastes that are now being accumulated and stored. The facility, to be located at TA-50, is scheduled for completion in FY94 and will allow the Laboratory to achieve compliance with RCRA regulations and the RCRA Part B Operating Permit.
- *High-Explosive Wastewater Treatment System.* This project consists of two HE wastewater treatment facilities and a collection piping system to transfer HE-contaminated fluids from existing building sumps to treatment facilities. Conceptual design for the system is complete; construction is planned for FY96. This project will allow compliance with proposed toxicity (biomonitoring) requirements of the Laboratory's NPDES permit and RCRA regulations. It is anticipated that upgrading the HE wastewater facilities will be required under the Laboratory's NPDES AO and the FFCA.
- *Sanitary Wastewater Systems Consolidation.* This project consists of a new sanitary wastewater treatment plant and a new collection system which will replace 7 existing wastewater treatment plants and approximately 30 septic tanks. The project is under construction and will be fully operational during FY92. This project is required by the Laboratory's NPDES AO and the FFCA.
- *Stack Modifications at TA-53.* This project consists of modifications of the existing stack and the air quality treatment system at LAMPF at

TA-53. This stack will include a long delay line allowing increased radioactive decay of the effluent before it is released, consequently further reducing LAMPF emissions. Title I design for this project is scheduled to begin in the fourth quarter of FY92. Construction is scheduled to be completed in the fourth quarter of FY94. Funding for the continued operation of LAMPF has been allocated for FY92 and FY93. A study is now being completed concerning the decommissioning of LAMPF in FY94. If funding is not available for the continued operation of LAMPF in FY94, Title III construction will not be initiated.

- *PCB Transformers and Capacitors.* This project consists of replacing and retrofilling PCB-contaminated transformers and disposal of PCB-contaminated capacitors and other equipment. This is an ongoing activity and is required to insure compliance with the Toxic Substances Control Act.

Several other Corrective Activities projects are designed to achieve compliance with the CWA NPDES permit and the FFCA and AO requirements for effluent discharges. This work includes waste stream characterization to verify that waste streams are properly segregated and monitored, development of permits for storm water discharges and sludge disposal, implementation of toxicity testing (biomonitoring) of effluent discharges, improvements to prevent wastewater overflows and releases, upgrades to septic tank systems, and implementation of Spill Prevention Control & Countermeasures Plan requirements. In 1991 the last of 30 major secondary containment structures was completed. All major outdoor storage tanks are now equipped with secondary containment to prevent spills.

3. Unplanned Releases.

a. Airborne Radionuclide Releases. On February 1, 1991, 2,800 Ci of elemental tritium were released at TA-41. Less than 0.1% of the tritium was present as tritiated water. The effective dose equivalent (50-year dose commitment) to a member of the public was calculated to be 0.03 mrem. This dose occurred 7 km east of TA-41, where Los Alamos Canyon opens out onto State Road 4. The dose estimate conservatively assumed that 1% of the tritium was oxidized before reaching the receptor location. The dose is 0.03% of DOE's Public Dose Limit (PDL) of 100 mrem/yr from all pathways, and 0.3% of the EPA's 10 mrem/yr limit for the air pathway.

On March 28, 1991, 0.4 Ci of tritiated water vapor were released from TA-21 as tritium oxide. The effective dose equivalent (50-year dose commitment) to a member of the public was calculated to be 0.01 mrem. The dose is 0.01% of DOE's PDL of 100 mrem/yr from all pathways, and 0.1% of the EPA's 10 mrem/yr limit for the air pathway.

On April 17, 1991, 0.1550 Ci of tritiated water vapor were released from TA-3-16. A slow leak was discovered at the Van de Graaff accelerator. The effective dose equivalent (50-year dose commitment) to a member of the public was calculated to be 0.006 mrem. The dose is 0.006% of DOE's PDL of 100 mrem/yr from all pathways, and 0.06% of the EPA's 10 mrem/yr limit for the air pathway.

On March 25, 1992, 0.045 μCi of ^{242}Pu were released at TA-55. The effective dose equivalent (50-yr dose commitment) to a member of the public during passage of the puff was calculated to be 0.0001 mrem.

b. Airborne Nonradiological Releases. No unplanned airborne nonradiological releases were reported during 1991 or the first quarter of CY92.

c. Radioactive Liquid Releases. On January 2, 1991, a discharge was discovered at TA-54 Area G. A plumbing joint on an eye wash/safety shower located inside Building 33 froze and burst sometime between December 21, 1990, and January 1, 1991, when the Laboratory was closed for the winter holidays. The amount of discharge was estimated to be 18,000 gal. Analyses were conducted on the frozen water and soil; gross alpha, beta, and gamma were found to be within background levels. Samples analyzed for tritium averaged 0.29 μCi/L, approximately 15% of the DOE Derived Concentration Guide for off-site tritium releases (2.0 μCi/L). Removal of the frozen water below Building 33 was not required because of the slow rate of melting during which the water either evaporates or enters the subsurface rather than producing a definitive runoff in Cañada del Buey.

On February 21, 1991, 0.2 μCi of plutonium and americium were released at TA-50 from a leaking pipe near the Size Reduction Facility. The spill was confined to a small area. The leak was repaired, and the spill was cleaned up to applicable standards. The

contaminated soil was disposed of according to applicable standards.

d. Nonradioactive Liquid Releases. On September 25, 1991, an underground diesel fuel transfer line broke during start-up of the TA-3 Power Plant's back-up fuel system. Approximately 100-200 gal. of diesel fuel oil surfaced and was discharged across the ground to a storm water channel, where it drained into a tributary to Sandia Canyon. The discharge was immediately reported to EPA and NMED. Spill notifications were required pursuant to Paragraph G of the Laboratory's NPDES Permit and Section 1-203 of the Water Quality Control Commission Regulations, which require reporting, within 24 hours, of any discharge that may endanger health or the environment. Corrective actions included operators at the Power Plant shutting down the fuel line immediately upon discovery and clean-up of the diesel fuel. The diesel spill was contained in the water course within minutes using absorbent booms and pillows. Pools of diesel and water were removed using a wet/dry vacuum and absorbents. The contaminated soil was sampled, removed, and disposed of at the Los Alamos County Landfill.

During 1991 and the first quarter of 1992, 57 other releases of nonradioactive liquids occurred at the Laboratory and were reported to the EPA and NMED. The NMED Surface Water Bureau has requested that all liquid releases be reported regardless of any potential impact on the environment. Each of these discharges was minor in nature and was contained on Laboratory property. None was found to be of any threat to health or the environment. Sampling and clean-up were completed, as appropriate to confirm the presence or absence of pollutants and to prevent further migration. Over 60% of these unplanned releases were either potable water or steam condensate originating from the Laboratory's utility systems.

The following is a summary of these 57 unplanned releases:

- 23 releases of potable water which originated from water line breaks and other sources in the Los Alamos water supply system;
- 13 releases of steam condensate originating from condensate return line breaks and other sources in the Laboratory's steam system;
- 11 releases of sanitary sewage (less than 1,000 gal. each) from the Laboratory's wastewater treatment plant collection systems;
- 5 unplanned releases of cooling water or chiller water including: 2,000 gal. at TA-21, Bldg. 3 on November 10, 1991; 1,000 gal. at TA-21, Bldg. 149 on July 11, 1991; 30,000–40,000 gal. at TA-21, Bldg. 114 on February 15, 1991; 2,800 gal. at TA-21, Bldg. 144 on February 14, 1991; and 10 gal. per minute for an unknown period of time at TA-3, Bldg. 148 on September 4, 1991;
- 500–1,000 gal. of storm water and residual oil from fuel storage tanks at TA-60 Sigma Mesa on November 15, 1991;
- 3 gal. of ethylene glycol at TA-55, PF8 on May 19, 1991;
- residual oil in the parking lot caused a sheen in the storm drain near TA-3, Bldg. 105 on August 1, 1991;
- foam noted in storm drain near TA-3, Bldg. 105 on August 28, 1991, was a result of car washing activities in the area. Less than 1 quart of a detergent and water mixture was released into storm drain; and
- a discharge of hydraulic fluid (3-4 quarts) from a JCI street sweeper at TA-3, Bldg. 2001 ACI on February 11, 1992.

EM-8 prepared a generalized NOI to Discharge for the discharge of potable water from the Los Alamos water supply system, including production wells, transmission lines, storage tanks, booster pump stations, and other related facilities. The generalized NOI was submitted to NMED on October 31, 1991. The NOI provides the Laboratory with regulatory coverage for releases of potable water from the water supply system that are not considered hazardous to public health and are not covered under the NPDES permit. EM-8 also prepared a generalized NOI for the release of steam condensate from the Laboratory's steam distribution and condensate return systems.

4. Waiver or Variance Requests.

Groundwater monitoring is required for all RCRA surface impoundments, landfills, waste piles, and treatment units. This requirement may be waived if it

can be demonstrated that there is low or no potential for a release from the units to migrate to the uppermost aquifer. This demonstration has been developed for several units located at TA-16, TA-35, TA-53, and TA-54. All but the demonstration at TA-53 have been provided to the State of New Mexico's Hazardous Waste Program for review.

5. Significant Accomplishments.

On September 30, 1991, LANL became the first DOE site to have a DOE imposed waste shipment moratorium for hazardous and PCB wastes lifted. It was demonstrated that an effective program of waste characterization, waste management, and quality assurance exists on site, which prevents inadvertent shipment of radioactively contaminated waste off site.

LANL completed an extensive solid waste stream characterization study mandated by the hazardous waste permit. Although the permit deadline is March 1993, it was completed one year ahead of schedule. This study included site visits and personnel interviews throughout the Laboratory. More than 22,000 waste streams were identified.

The Water Quality and Toxics Section of EM-8 implemented a program in FY91 to identify all waste streams entering NPDES outfalls and to verify that each is included in the proper outfall category. Implementation of this program has allowed the Laboratory an opportunity to achieve compliance with its NPDES Permit under the current AO.

During 1991, a DEC was prepared to cover many routine maintenance activities at LANL. This DEC was given a categorical exclusion from the need for further NEPA documentation by DOE on October 1, 1991. The Laboratory was able to apply the categorical exclusion to 69 routine maintenance activities, without preparing further documentation on each one.

6. Significant Problems.

a. Lawsuits. In 1991 a lawsuit, Lujan v. Regents of the University of California, was filed against the Laboratory. Plaintiffs claim that they were injured by exposure to discharges and emissions of radioactive and hazardous materials from past operations of the Laboratory. Plaintiffs are seeking compensatory and punitive damages, as well as injunctive relief against certain ongoing operations of the Laboratory.

In February 1992, a lawsuit, Truelock v. Regents of the University of California, was filed against the Laboratory. Plaintiffs claim that they were injured by exposure to discharges and emissions of radioactive materials from past operations of the Laboratory. Plaintiffs are seeking compensatory and punitive damages, as well as injunctive relief against certain ongoing operations of the Laboratory.

On March 31, 1992, DOE and the University were notified that Concerned Citizens for Nuclear Safety intend to file a citizen suit pursuant to Section 7604 of the Clean Air Act. According to the notice letter, the suit will allege, among other things, that the Laboratory is not in compliance with the monitoring requirements for radionuclides found in 40 CFR, Part 61, Subpart H and will ask for an injunction against continued operation of all sources.

b. Notices of Violation. The Laboratory received a Notice of Violation from the NMED on January 18, 1991, concerning the discharge of potable water from a broken eye wash/safety shower at TA-54, Area G due to a frozen pipe. The NOV also addressed the discharge of steam condensate from a broken condensate return line from TA-43. The Laboratory completed a response to this NOV on February 7, 1991, including a corrective action plan. Corrective actions were completed and no further enforcement action was taken by the NMED.

The Laboratory received a Notice of Violation letter, dated May 24, 1991, citing nine violations noted during the April/May 1991 RCRA compliance inspection. The violations were corrected, and the NMED was notified within the 30 days required by state law. The Laboratory's response, sent to NMED in June 1991, was found adequate as stated in a letter from NMED dated July 12, 1991.

The Laboratory identified a site where asbestos-containing rubble waste piles had been placed in temporary storage. The site is adjacent to the sanitary landfill on East Jemez Road and was reported to state authorities in July 1991. Based on analysis of the rubble, the presence of asbestos was confined to nonfriable asbestos tiles and asbestos-embedded concrete. A Notice of Violation was received from the State of New Mexico on October 17, 1991, for failing to notify the state of a revised start-up date for clean-up prior to the originally scheduled date. This violation was a one-time occurrence, and the Laboratory's response to NMED included provisions for preventing similar occurrences in the future.

The Laboratory identified a beryllium cutting operation at TA-55-4 in August 1991 which may require a permit under the requirements of New Mexico Air Quality Control Regulation 702 - Permits. Following discussions with the New Mexico Environment Department (NMED), DOE officially notified NMED on October 9, 1991, of the operations. Beryllium cutting operations were suspended and a commitment was made to file an air quality permit application with NMED. The NMED issued a Notice of Violation for the beryllium cutting operation on October 16, 1991. The NMED proposed an out-of-court settlement on January 21, 1992. The Laboratory and DOE are negotiating the specific provisions of the agreement with NMED. The air quality permit application for beryllium cutting operations was submitted to NMED in April 1992.

7. Tiger Team Assessment.

The Tiger Team Assessment was conducted at LANL from September 23 to November 8, 1991, under the auspices of the Office of Special Projects, Office of the Assistant Secretary for Environment, Safety and Health, Headquarters, DOE. The objectives of the Environmental Subteam of the Tiger Team were to assess the effectiveness of environmental programs and program management at Los Alamos as well as to assess conformance with applicable regulations and best management practices within specific technical disciplines.

The Tiger Team did not identify any environmental deficiencies which could be considered an immediate danger to worker or public health and safety. The Tiger Team identified individual findings within nine technical disciplines. These individual findings were evaluated to determine four key findings–findings which summarize the most significant environmental program deficiencies. The key findings are

- inadequate site-wide programs for the management of wastes,
- inadequate identification, monitoring, and control of effluent releases,
- inadequate regulatory permit strategy and management, and
- lack of oversight of environmental activities.

The Tiger Team also identified some positive aspects of Laboratory environmental programs. In particular, the Tiger Team identified the high quality of environmental professionals at the Laboratory and their dedicated efforts to provide adequate and defensible programs and to meet regulatory requirements.

The Laboratory has prepared action plans to address all of the environmental deficiencies identified by the Tiger Team. These plans were submitted, as part of the Laboratory Draft Action Plan, for DOE review and approval on March 31, 1992. This Draft Action Plan, when fully executed, goes well beyond mere compliance. The Laboratory is committed to implement a comprehensive and coordinated environmental management program.

8. DOE/HQ Audits and Assessments.

The DOE Field Office, Albuquerque prepares an Annual Summary Appraisal Report of Los Alamos at the end of each fiscal year. The FY91 report concluded that LANL has made generally satisfactory progress in addressing environmental concerns and risks at LANL identified in the 1987 DOE Headquarters Environmental Survey (ES). A total of 46 of the 59 findings from this survey are now considered closed. LANL has completed corrective actions for specific findings and has programs in place to correct and track progress on long-term generic findings such as corrective actions for Inactive Waste Sites and contaminated areas.

LANL will continue to address open ES findings in a root cause/self-assessment mode to assure that all environmental risks identified in the 1987 ES are adequately incorporated into environmental programs at LANL, and that corrective actions are scheduled and tracked accordingly.

IV. ENVIRONMENTAL PROGRAM INFORMATION

The Los Alamos National Laboratory (LANL or the Laboratory) supports an ongoing environmental surveillance program which includes routine monitoring for radiation, radioactive materials, and hazardous chemical substances on the Laboratory site and in the surrounding area. Over 400 sampling locations are utilized for routine monitoring of the environment.

During 1991, the average levels of external penetrating radiation (including x and gamma rays and charged-particle contributions from cosmic, terrestrial, and manmade sources) were generally the same as in 1990, showing no statistically discernible increase in radiation levels attributable to Laboratory operations.

Airborne radioactive emissions were monitored at 88 Laboratory release points. The largest airborne release was 57,431 Ci of short-lived (8-s to 20-min half-lives) air activation products from the Los Alamos Meson Physics Facility (LAMPF). Airborne radioactive effluents decreased in 1991 from 1990 totals. Air is also sampled for tritium, uranium, and plutonium; the highest measured annual average concentrations all corresponded to less than 0.3% of the Department of Energy's (DOE's) public dose limits (PDLs).

Surface water, soils, and sediments were sampled and analyzed to monitor the impact of Laboratory operations. Surface waters and shallow alluvial groundwaters in present and former radioactive liquid effluent areas contain radioactivity in concentrations greater than natural terrestrial and worldwide fallout levels; nonradioactive constituents are also present in greater concentrations than natural waters. Radionuclides and chemical concentrations in waters from areas where there has been no direct release of treated effluents evidenced no observable effects caused by Laboratory operations. Most regional and perimeter soil and sediment stations contained radioactivity at or near background levels; concentrations of plutonium in sediments from regional reservoirs on the Rio Chama and Rio Grande reflected worldwide fallout. During 1991, all drinking water samples were in compliance with the maximum contaminant levels established by regulation.

Concentrations of radionuclides in foodstuffs (produce, honey, and fish) collected from Laboratory areas were compared to levels of radionuclides in samples collected from perimeter and regional (background) locations to determine the impact of Laboratory operations. With the exception of tritium, all other radionuclides in produce collected on site were within background concentrations. Fish from Cochiti Dam (downstream from the Laboratory) had slightly higher levels of uranium than fish from Abiquiu Dam (upstream from Laboratory operations). No radioactive contribution in foodstuffs posed a threat to the health or safety of the public.

In addition to environmental surveillance activities, the Laboratory carried out a number of special studies during 1991 which provide valuable supplementary environmental information.

A. Introduction

This section provides a summary of all of the Laboratory's environmental activities performed to comply with laws and regulations, to enhance environmental quality, and to improve understanding of the effects of environmental pollutants from site operations.

The Laboratory supports an ongoing environmental surveillance program as required by U.S. Department of Energy (DOE) Orders 5400.1 (DOE 1988a) and

5484.1 (DOE 1981a). The surveillance program includes routine monitoring for radiation, radioactive materials, and hazardous chemical substances on the Laboratory site and in the surrounding region. These activities document compliance with appropriate standards, identify trends, provide information for the public, and contribute to general environmental knowledge. Detailed, supplemental environmental studies also are carried out to determine the extent of potential problems, to provide a basis for any remedial actions, and to gather further information on the surrounding environment.

The monitoring program supports the Laboratory's policy to protect the public, employees, and environment from harm that could be caused by Laboratory activities and to reduce environmental impacts to the greatest degree practicable. Environmental monitoring information complements data on specific releases, such as those from radioactive liquid waste treatment plants and stacks at nuclear research facilities.

Monitoring and sampling locations for various types of environmental measurements are organized into three groups:

- Regional stations are located within the five counties surrounding Los Alamos County (Fig. II-2) at distances up to 80 km (50 mi) from the Laboratory. They provide a basis for determining conditions beyond the range of potential influence from normal Laboratory operations.
- Perimeter stations are located within about 4 km (2.5 mi) of the Laboratory boundary, and many are in residential and community areas. They document conditions in areas regularly occupied by the public and potentially affected by Laboratory operations.
- On-site stations are within the Laboratory boundary, and most are in areas accessible only to employees during normal working hours. They document environmental conditions at the Laboratory where public access is limited.

Samples of air particles and gases, water, soils, sediments, and foodstuffs are routinely collected at these stations for subsequent analyses. External penetrating radiation from cosmic, terrestrial, and Laboratory sources is also measured. Over 400 sampling locations are utilized for routine monitoring of the environment (Table IV-1).

Additional samples are collected and analyzed to gain information about particular events, such as major surface runoff events, nonroutine releases, or special studies. Approximately 130,000 analyses for chemical and radiochemical constituents were carried out for more than 6,200 environmental samples during 1991. Resulting data were used for dose calculations, for comparisons with standards and background levels, and for interpretation of the relative risks associated with Laboratory operations.

Methods and procedures for acquiring, analyzing, and recording data are presented in Section VIII, Quality Assurance and Sampling Procedures. Comprehensive information about environmental regulatory standards is presented in Appendix A. Detailed environmental data tables are given in Appendix D. Results are discussed in the body of the report.

Table IV-1. Number of Sampling Locations for Routine Monitoring of the Ambient Environment

Type of Monitoring	Regional	Perimeter	On-Site	Total
External radiation	3	12	135	150
Air	3	14	19	36
Surface waters[a]	6	10	12	28
Groundwaters[a]	0	48	29	77
Soils and sediments	18	28	36	82
Foodstuffs	10	8	11	29

[a]Samples from an additional 17 special surface water and groundwater stations related to the Fenton Hill Geothermal Program were also collected and analyzed as part of the monitoring program.

B. Measurement of External Penetrating Radiation

1. Introduction.

Natural external penetrating radiation comes from terrestrial and cosmic sources. The natural terrestrial component results primarily from the decay of ^{40}K and of radionuclides in the decay chains of ^{232}Th, ^{235}U, and ^{238}U. Natural terrestrial radiation in the Los Alamos area is highly variable with time and location. During any year, external radiation levels can vary from 15% to 25% at any location because of changes in soil moisture and snow cover (NCRP 1975b). There is also spatial variation because of different topographies and soil and rock types from area to area (ESG 1978).

The cosmic source of natural ionizing radiation increases with elevation because of reduced shielding by the atmosphere. At sea level, it produces measurements between 25 and 30 mrem/yr. Los Alamos, with a mean elevation of about 2.2 km (1.4 mi), receives about 60 mrem/yr from the cosmic component. However, regional locations range in elevation from about 1.7 km (1.1 mi) at Española to 2.7 km (1.7 mi) at Fenton Hill, resulting in a corresponding range between 45 and 90 mrem/yr for the cosmic component. This component can vary ±5% because of solar modulations (NCRP 1975b).

Fluctuations in natural background ionizing radiation make it difficult to detect an increase in radiation levels from manmade sources. This is especially true when the size of the increase is small relative to the magnitude of natural fluctuations. Therefore, to measure contributions to external radiation from the operation of LAMPF, arrays with 48 thermoluminescent dosimeters (TLDs) (12 stations, 4 TLDs per station) for each array have been deployed near LAMPF and in background areas.

2. Monitoring Network and Results.

Levels of external penetrating radiation (including X and gamma rays and charged-particle contributions from cosmic, terrestrial, and manmade sources) in the Los Alamos area are measured with TLDs in three independent networks. These networks are used to measure radiation levels (1) at the Laboratory and regional areas, (2) at the Laboratory boundary north of LAMPF, and (3) at low-level radioactive waste management areas.

a. Laboratory and Regional Areas. The environmental network consists of 38 stations divided into three groups. The regional group consists of three locations, 28 to 44 km (17 to 27 mi) from the Laboratory boundary in the neighboring communities of Española, Pojoaque, and Santa Fe. The Pojoaque station was removed during the fourth quarter of 1991. The off-site perimeter group consists of 12 stations within 4 km (2.5 mi) of the boundary and the on-site, or within the Laboratory, group is composed of 23 locations (Fig. IV-1, Table IV-2). Details of the sampling methodology for the TLD network are found in Section VIII.C.1.

Annual averages for the groups were generally the same in 1991 as in 1990 (Fig. IV-2), close to the averages observed in 1989, and consistent with the variability in natural background observed at these stations. An increase in the TLD reading during the second quarter of 1991 for four perimeter stations was noted and compared to independent dosimeters located at the same stations. The independent dosimeters did not reflect this increase, and it was attributed to the calibration/reading process. Data were reported as measured. Regional and perimeter stations showed no statistically discernible increase in radiation levels attributable to Laboratory operations (Table IV-2). Annual measurements at off-site stations ranged from 88 to 144 mrem.

Some comparisons provide a useful perspective for evaluating these measurements. For instance, the average person in the United States receives about 53 mrem/yr of radiation from medical diagnostic procedures (NCRP 1987a). The DOE's PDL is 100-mrem/yr effective dose received from all pathways, and the dose received by air is restricted by the Environmental Protection Agency's (EPA's) (effective dose) standard of 10 mrem/yr (Appendix A). These values are in addition to those from normal background, consumer products, and medical sources. The standards apply to locations of maximum probable exposure to an individual in an off-site, uncontrolled area.

b. TA-53 Network. This network monitors external radiation from airborne activation products (gases, particles, and vapors) released by LAMPF, Technical Area (TA) 53. The prevailing winds are from the south and southwest (Section II). Twelve TLD sites are located downwind at the Laboratory boundary north of LAMPF along 800 m (0.5 mi) of canyon rim. Twelve background TLD sites are about 9 km (5.5 mi) from the facility along a canyon rim near the southern boundary of the Laboratory (Fig. IV-1).

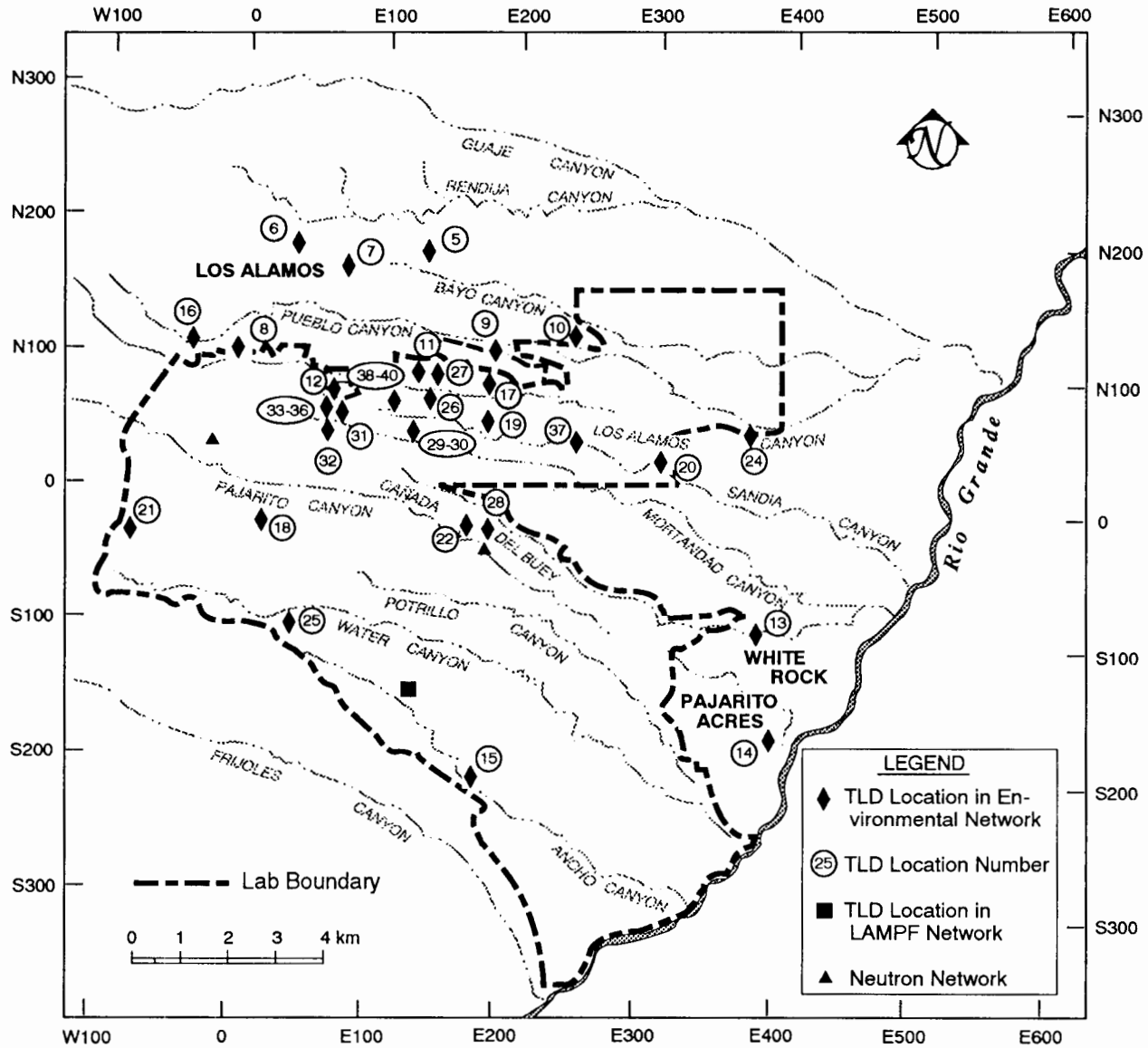


Fig. IV-1. Approximate thermoluminescent dosimeter (TLD) locations on or near the Laboratory site. Does not show Regional Stations.

This background location is not influenced by any Laboratory external radiation sources.

The TLDs at the 24 sites are changed each calendar quarter or more often if LAMPF's operating schedule indicates the need (start-up or shutdown of the accelerator for extended periods midway in a calendar quarter). No radiation measurement statistically above background was noted in this network during 1991 (Fig. IV-3). This conclusion was reached by subtracting the annual measurement taken at the background sites from the annual measurement taken at the Laboratory's boundary north of LAMPF (Section V.C.2.b). The difference was less than one mrem and within the errors of the two networks. The annual emissions of mixed activation products from LAMPF also decreased (Table IV-3) and is reflected in the boundary measurements.

No above-background increase in external radiation from Laboratory operations was measured above TLD detection limits in off-site areas by the TLD monitoring network during 1991. As a result, the effective dose to the maximum exposed individual from 1991 Laboratory operations was determined using the environmental model CAP-88, rather than by measurement as had been done in previous years. Please see Section V.C.3.b for discussion.

Table IV-2. Thermoluminescent Dosimeter Measurements

Station Location	Annual Measurement Coordinates		1991 Dose (mrem)
Uncontrolled Areas (Off Site)			
Regional Stations (28–44 km)			
1. Española	—		88[b]
2. Pojoaque	—		104[c]
3. Santa Fe	—		102
Perimeter Stations (0–4 km)[a]			
5. Barranca School	N180	E130	129
6. Arkansas Avenue	N170	E030	114
7. Cumbres School	N150	E090	102
8. 48th Street	N110	W010	107
9. Los Alamos Airport	N110	E170	121
10. Bayo Canyon	N120	E250	144
11. Shell Station	N090	E120	144
12. Royal Crest Trailer Court	N080	E080	118
13. White Rock	S080	E420	129
14. Pajarito Acres	S210	E380	104
15. Bandelier Lookout Station	S280	E200	111
16. Pajarito Ski Area	N150	W200	126
Controlled Areas (On Site)			
On-Site Stations[a]			
17. TA-21 (DP West)	N095	E140	111
18. TA-6 (Two Mile Mesa)	N025	E030	114
19. TA-53 (LAMPF)	N070	E090	118
20. Well PM-1	N030	E305	117
21. TA-16 (S Site)	S035	W025	127
22. Booster P-2	S030	E220	119
23. Discontinued	S075	E300	—
24. State Highway 4	N070	E350	138
25. Frijoles Mesa	S165	E085	109
26. TA-2 (Omega Stack)	N075	E120	123
27. TA-2 (Omega Canyon)	N085	E121	155
28. TA-18 (Pajarito Site)	S040	E205	139
29. TA-35 (Ten Site A)	N040	E105	137
30. TA-35 (Ten Site B)	N040	E110	124
31. TA-59 (Occupational Health Lab)	N050	E040	139
32. TA-3 (Van de Graaff)	N050	E020	133
33. TA-3 (Guard Station)	N050	E020	136
34. TA-3 (Alarm Building)	N050	E020	136
35. TA-3 (Guard Building)	N050	E020	125
36. TA-3 (Shop)	N050	E020	121
37. Pistol Range	N040	E240	101
38. TA-55 (Plutonium Facility South)	N040	E240	118
39. TA-55 (Plutonium Facility West)	N040	E080	132
40. TA-55 (Plutonium Facility North)	N040	E080	144

[a]See Fig. IV-1.

[b]Measurement (95% confidence increments).

[c]Station removed during fourth quarter and not replaced until 1992.

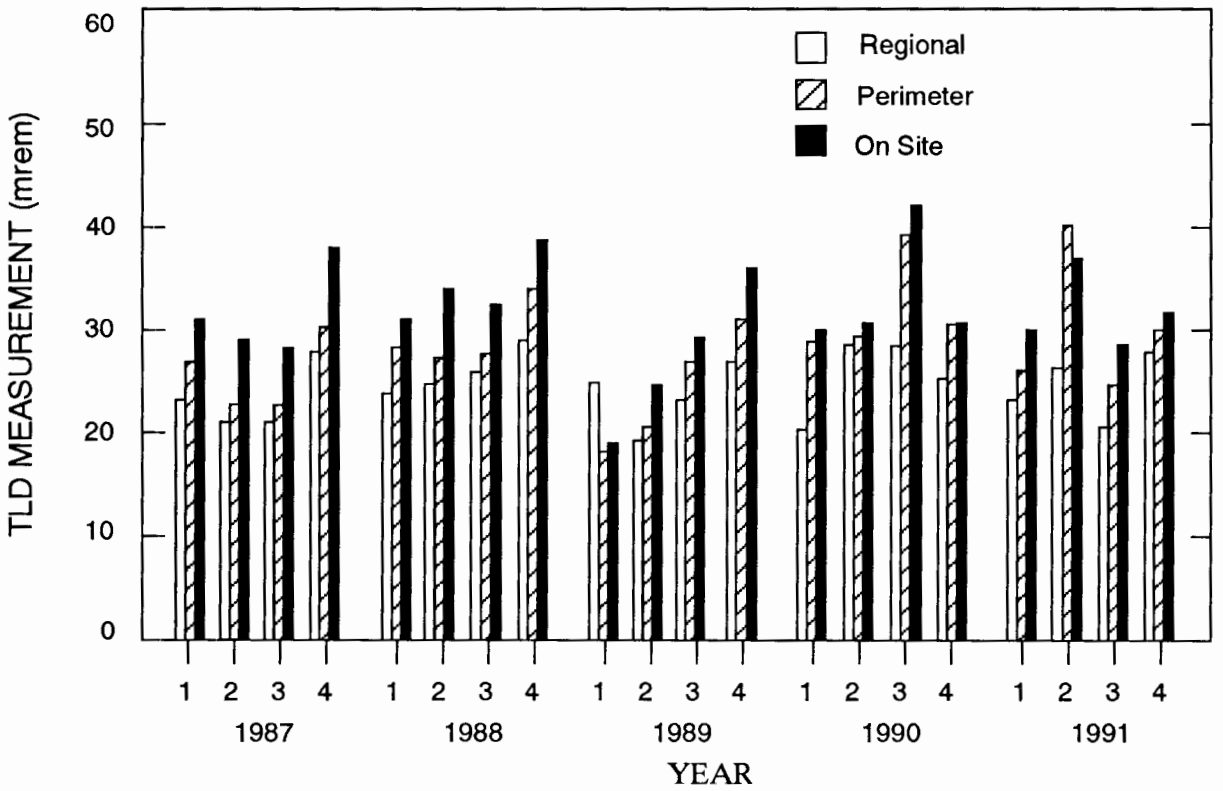


Fig. IV-2. Thermoluminescent dosimeter (TLD) measurements (including contributions from cosmic, terrestrial, and Laboratory radiation sources).

c. Low-Level Radioactive Waste Management Areas Network. This network of 88 locations monitors radiation levels at one active and nine inactive low-level radioactive waste management areas.

These waste management areas are controlled-access areas and thus are not accessible to the general public. Active and inactive waste areas are monitored for external penetrating radiation with arrays of TLDs (Table IV-4). Averages at all sites were higher than the average for the perimeter network. However, the range of values at most sites largely overlapped those found at perimeter and regional stations (Tables IV-2 and IV-4). The extremes at Area G (the active radioactive waste area) and Area T (an inactive waste area) have been noted in previous years. These data reflect the results of past and present radioactive waste management activities.

C. Air Monitoring

1. Airborne Radioactivity.

a. Introduction. Natural atmospheric and fallout radioactivity levels fluctuate and affect measurements made during the Laboratory's air sampling program. Worldwide background airborne radioactivity is largely composed of fallout from past atmospheric nuclear weapons tests, natural radioactive constituents from the decay chains of thorium and uranium attached to dust particles, and materials resulting from interactions with cosmic radiation (for example, natural tritiated water vapor produced by interactions of cosmic radiation and stable water). Background radioactivity concentrations in the atmosphere are summarized in Table IV-5 and are useful in interpreting air sampling data.

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

b. Monitoring Network. The sampling network for ambient airborne radioactivity consists of 36 continuously operating air sampling stations

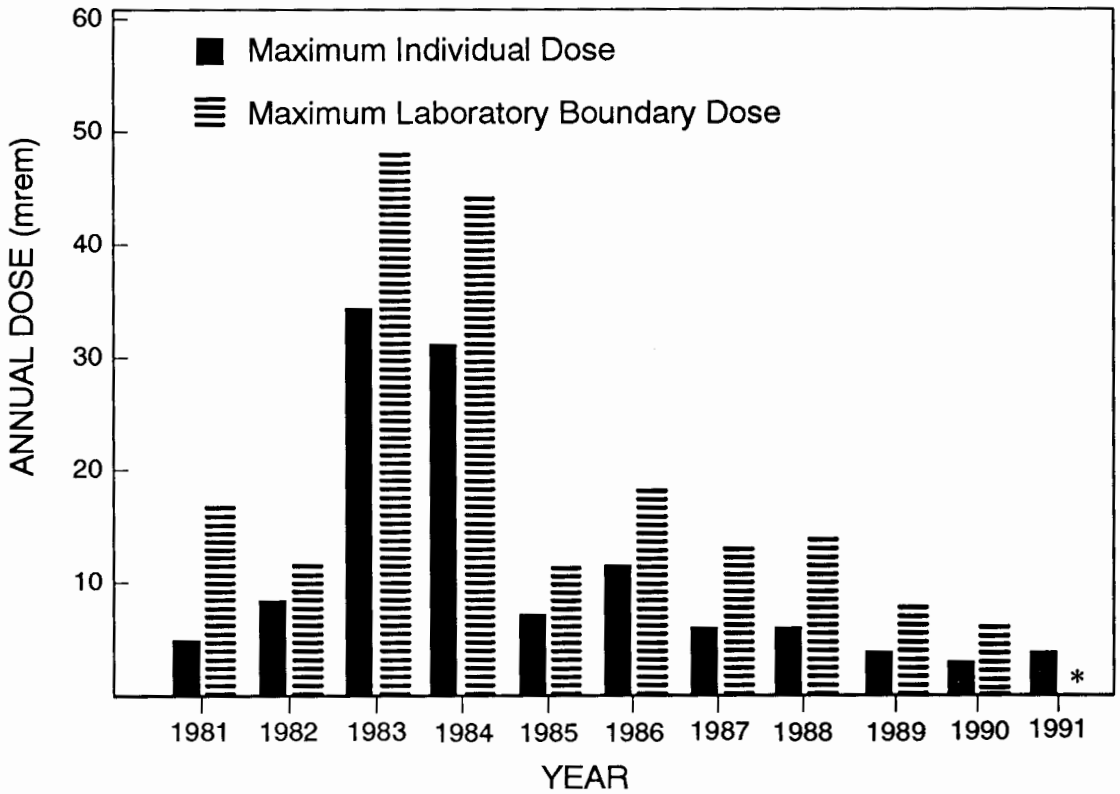


Fig. IV-3. Summary of estimated maximum individual and maximum Laboratory boundary doses from Laboratory operations (excluding contributions from cosmic, terrestrial, and medical diagnostic sources).

* No above-background Laboratory boundary doses, as measured by TLDs, were recorded during 1991. See Section IV.B.2 for discussion.

including 3 regional, 14 perimeter, 14 on site, and 5 waste site stations. In addition, two quality control stations are located next to existing locations. The regional monitoring stations, 28 to 44 km (18 to 28 mi) from the Laboratory, are located at Española, Pojoaque, and Santa Fe. The data from these stations are used as reference points for determining regional background levels of atmospheric radioactivity. The 14 perimeter stations are within 4 km (2.5 mi) of the Laboratory boundary. One perimeter station was added in 1991, and one station was changed from an on-site station in 1990 to a perimeter station in 1991. Fourteen on-site stations are within the Laboratory boundary (Fig. IV-4, Table D-8).

In addition to Station 27 at TA-54, which is part of the routine air sampling network, four additional stations are located at an active waste disposal site, Area G, TA-54, and one station at the inactive waste disposal site, Area AB, TA-49. In the past these additional stations were not identified as part of the airnet system, and the data collected from these stations were reported in a separate document (Soholt 1990).

The airnet monitoring network experienced approximately 15% station downtime during 1991. Samples were unavailable because of vacuum pump failures, power failures, and vandalism. The majority of these problems has been corrected.

c. Analytical Results.

Gross Beta Radioactivity. Gross beta analyses help in evaluating general radiological air quality. Beta activity for any single radionuclide cannot be present in greater quantity than the total gross beta concentration. If gross beta activity in a sample is consistent with past observations and background, special analysis for specific radionuclides is not required. If the sample analytical results appear to be elevated, then

Table IV-3. Comparison of 1990 and 1991 Releases of Radionuclides from Laboratory Operations[a]

Airborne Emissions

Radionuclide	Units	Activity Released 1990	Activity Released 1991	Ratio 1991:1990
H^3	Ci	6,400	4,716	0.7
^{32}P	µCi	9	17	1.9
Uranium	µCi	240	336	1.4
Plutonium	µCi	26	37	1.4
Gaseous mixed activation products	Ci	123,560	57,431	0.5
Mixed fission products	µCi	1,085	1,096	1.0
Particulate/vapor activation products	Ci	0.08	0.21	2.6
Spallation Products	Ci	2	<0.1	<0.1
Rounded Total	Ci	131,322	63,633	0.5

Liquid Effluents

Radionuclide	Activity Released (mCi) 1990	Activity Released (mCi) 1991	Ratio 1991:1990
H^3	12,000	10,600	0.9
$^{82,85,89,90}Sr$	253	124	0.5
^{137}Cs	21	67	3.2
^{234}U	0.07	0.07	1.0
$^{238,239,240}Pu$	0.8	1.3	1.6
^{241}Am	2.7	1.1	0.4
Other	574.6	52.5	0.09
Rounded Total	13,000	10,800	0.8

[a]Detailed data are presented in Tables V-1 and V-2 for airborne emissions and Table IV-26 for liquid effluents.

analysis for specific radionuclides is required to confirm or deny a problem such as an unplanned release.

Tritium. In 1991, the regional mean concentration of tritium as tritiated water in air (0.04[±0.9] × 10^{-12} µCi/mL) was lower than the perimeter annual mean (2.0 [±0.9] × 10^{-12} µCi/mL) and the on-site annual mean (4.6[±1.1] × 10^{-12} µCi/mL). The waste site's annual mean (97.0 [±160.0] × 10^{-12} µCi/mL was 21 times the on-site annual mean. The elevated concentrations observed in the waste sites are at TA-54, Area G, an area where tritium contaminated waste is disposed. The highest concentration observed in any month was also at TA-54, Area G (890.0 [±270.0] × 10^{-12} µCi/mL). These tritium concentrations are <0.1% of the concentration guide in air, based on DOE's derived air concentrations for uncontrolled areas. Table IV-6 presents complete monitoring data.

Tritium in rainwater was also analyzed by the Geology and Geochemistry Group (EES-1) of the Laboratory's Earth and Environmental Sciences Division, as reported in Section IV.I.2. The analytical results demonstrate elevated levels of tritium in rainwater in the Los Alamos area (>20 tritium units [TUs]) samples compared to the expected worldwide average concentration of 10 to 20 TUs. One tritium unit is equal to 3.2 pCi/L of water.

Plutonium and Americium. Of the 92 air sample analyses performed in 1991 for ^{238}Pu from locations outside of the waste sites, only two samples were above the minimum detectable limit of 4 × 10^{-18} µCi/mL. The highest concentration was observed at a perimeter station located at East Gate. Other sampling locations near this station did not indicate any elevations in sample results. No explanation

Table IV-4. Doses Measured by TLDs at On-Site Waste Disposal Areas during 1991

Area	Number of TLDs	Doses (mrem) Mean	Minimum	Maximum
A	5	122	119	125
B	14	128	111	144
C	10	125	115	145
E	4	126	123	130
F	4	123	112	133
G	26	162	119	569
T	7	141	115	251
U	4	124	121	130
V	4	138	127	145
AB	10	120	109	136

Table IV-5. Average Background Concentrations of Radioactivity in the Regional Atmosphere

Radioactive Constituent[a]	Units	EPA[b] 1987–1989	Laboratory[c] 1991	DOE Guide for Uncontrolled Area[d]
Gross beta	10^{-15} µCi/mL	10.0 (0.0)[e]	7.8 (2.7)	9,000
H^3	10^{-12} µCi/mL	—	1.0 (0.9)	200,000
Uranium (natural)	pg/m^3	33.0 (9.0)	96.6 (9.6)	100,000
^{238}Pu	10^{-18} µCi/mL	1.2 (0.1)	0.7 (0.6)	30,000
$^{239,240}Pu$	10^{-18} µCi/mL	0.7 (0.1)	0.9 (0.5)	20,000
^{241}Am	10^{-18} µCi/mL	—	2.9 (0.9)	20,000

[a]See Appendix D, Table D-38 for detection limits.

[b]EPA (1987–1989), Reports 49 through 58. Data are from the Santa Fe, New Mexico, sampling location and were taken from January 1987 through May 1989. Data for 1991 not available at time of publication.

[c]Data are annual averages from the regional stations (Española, Pojoaque, Santa Fe) and were taken during calendar year 1991

[d]See Appendix A. These values are presented for comparison.

[e]Uncertainties are in parentheses.

can be offered for this single anomalous observation of 3.25[±0.36] × 10^{-16} μCi/mL. However, all mean air concentrations of ^{238}Pu were less than 0.3% of the DOE's derived air concentration guide for uncontrolled area, 3 × 10^{-14} μ/Ci/mL.

Fifteen samples from the waste sites were analyzed for ^{238}Pu. The highest observation was 9.6 [±1.2] × 10^{-18} μCi/mL, which is less than 0.1% of the DOE's derived air concentration guide.

The 1991 annual means for ^{239,240}Pu air concentrations for the regional (0.8 [±0.5] × 10^{-18} μCi/mL), perimeter (0.7 [±0.6] × 10^{-18} μCi/mL), on site (2.4 [±0.7] × 10^{-18} μCi/mL) and waste site stations were all less than 0.1% of the DOE derived air concentration guide for controlled and uncontrolled areas. The maximum concentration observed was (31.4 [±2.6] × 10^{-18} μCi/mL) at the on site TA-54, Area G sampler. The sampler is located in a controlled area where contaminated waste is stored and disposed. Tables IV-7 and IV-8 present complete monitoring data.

Measured ^{241}Am concentrations were all less than 0.1% of the DOE's derived air concentration guides for

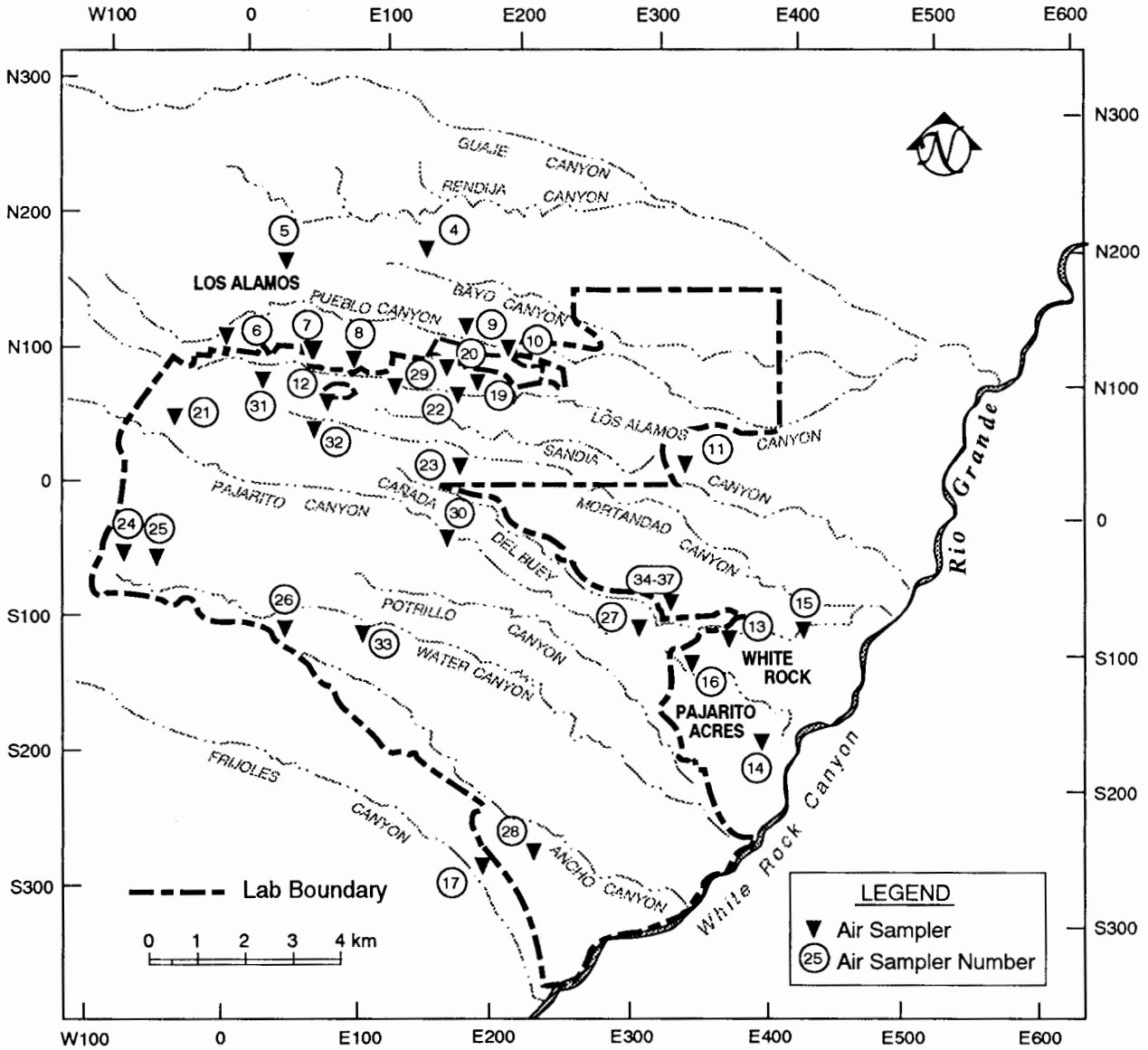


Fig. IV-4. Approximate locations on or near the Laboratory site for sampling airborne radionuclides. (Does not show Regional Stations; specific locations are presented in Table D-8.)

Table IV-6. Airborne Tritium as Tritiated Water Concentrations for 1991

Station Location[a]	Total Air Volume (m^3)	No. of Monthly Samples	No. of Samples <MDL[b]	Concentrations (pCi/m^3 [10^{-12} $\mu Ci/mL$]) Maximum[c]	Minimum[c]	Mean[c]	Mean as a Percentage of Guide[d]
Regional Stations (28–44 km), Uncontrolled Areas (Off Site)							
1. Española	119	10	10	2.8 (0.9)	−3.2 (1.7)	−0.1 (0.9)	<0.1
2. Pojoaque	34	4	2	6.3 (1.2)	−0.7 (1.3)	2.9 (1.0)	<0.1
3. Santa Fe	82	8	7	3.8 (1.5)	−3.5 (−2.0)	−0.3 (0.8)	<0.1
Group Summary		22	19	6.3 (1.2)	−3.5 (−2.0)	0.4 (0.9)	<0.1
Perimeter Stations (0–4 km), Uncontrolled Areas (Off Site)							
4. Barranca School	84	6	6	1.2 (0.6)	−0.7 (2.0)	0.1 (0.8)	<0.1
5. Arkansas Avenue	34	2	2	0.5 (0.4)	0.3 (0.4)	0.4 (0.4)	<0.1
6. 48th Street	107	10	8	28.6 (0.8)	−0.5 (1.1)	4.4 (2.8)	<0.1
7. Shell Station	63	7	6	4.9 (1.2)	−2.5 (−3.5)	1.0(−0.0)	<0.1
8. McDonald's	137	9	3	6.5 (1.3)	0.9 (0.2)	3.9 (0.7)	<0.1
9. Los Alamos Airport	61	5	5	0.8 (0.5)	−0.2 (0.3)	0.3 (0.2)	<0.1
10. East Gate	96	9	6	12.6 (1.7)	0.3 (1.2)	3.8 (1.0)	<0.1
11. Well PM-1	72	8	7	3.6 (1.0)	−0.5 (1.1)	1.0 (0.7)	<0.1
12. Royal Crest Trailer Park	182	9	5	3.9 (1.1)	0.2 (0.1)	2.3 (0.7)	<0.1
13. White Rock, Piñon School	34	5	3	6.8 (1.6)	−1.1 (1.5)	2.4 (1.2)	<0.1
14. Pajarito Acres	79	9	7	4.6 (1.2)	−1.7 (1.5)	1.0 (1.6)	<0.1
15. White Rock Fire Station	81	8	8	1.6 (0.8)	−0.4 (0.3)	0.4 (0.4)	<0.1
16. White Rock Nazarene	113	9	8	3.1 (0.6)	0.0 (0.9)	1.1 (0.5)	<0.1
17. Bandelier	64	9	8	21.4 (2.5)	−0.6 (0.6)	2.8 (0.7)	<0.1
Group Summary		105	82	28.6 (0.8)	−2.5 (−3.5)	2.0 (0.9)	<0.1
On-Site Stations, Controlled Areas							
19. TA-21, DP Site	100	9	1	20.6 (2.6)	2.6 (0.4)	11.9 (1.6)	<0.1
20. TA-21, Area B	27	4	1	8.1 (1.7)	3.0 (1.2)	5.0 (1.6)	<0.1
21. TA-6	104	9	8	9.2 (1.4)	−1.1 (1.0)	1.6 (0.9)	<0.1
22. TA-53 (LAMPF)	57	7	6	4.2 (1.0)	0.0 (2.3)	1.1 (0.8)	<0.1
23. TA-52, Beta Site	194	9	5	13.2 (2.0)	−0.4 (0.5)	3.7 (1.0)	<0.1
24. TA-16, S-Site	103	9	8	4.3 (1.2)	−2.3 (1.0)	0.4 (0.9)	<0.1
25. TA-16-450	68	5	5	2.2 (1.4)	−0.8 (1.2)	0.6 (0.9)	<0.1
26. TA-49	82	8	7	3.3 (0.7)	0.0 (0.1)	0.9 (0.3)	<0.1
27. TA-54	96	8	2	26.4 (2.8)	−0.2 (0.3)	11.5 (1.4)	<0.1
28. TA-33	34	4	2	5.4 (1.0)	0.2 (0.5)	3.2 (1.0)	<0.1
29. TA-2 (Omega)	62	6	1	10.3 (1.8)	0.8 (0.2)	5.2 (1.0)	<0.1
30. Booster P-2	86	8	6	8.7 (2.7)	−0.3 (0.4)	2.7 (1.3)	<0.1
31. TA-3	51	5	0	33.6 (5.8)	9.8 (1.5)	15.3 (2.4)	<0.1
32. TA-48	12	2	2	2.9 (2.6)	−2.7 (−1.6)	0.1 (0.5)	<0.1
Group Summary		93	54	33.6 (5.8)	−2.7 (−1.6)	4.6 (1.1)	<0.1

Table IV-6 (Cont.)

Station Location[a]	Total Air Volume (m^3)	No. of Monthly Samples	No. of Samples <MDL[b]	Concentrations (pCi/m^3 [10^{-12} μCi/mL]) Maximum[c]	Minimum[c]	Mean[c]	Mean as a Percentage of Guide[d]
Waste Site Stations, Controlled Areas							
33. Area AB	84	8	7	3.6 (0.9)	−0.4 (−0.1)	0.9 (1.0)	<0.1
34. Area G-1 NE Corner	75	8	3	52.0 (6.6)	0.4 (0.2)	22.7 (2.6)	<0.1
35. Area G-2 South Fence	93	10	4	890.0 (270.0)	16.0 (4.9)	360.0 (110.0)	<0.1
36. Area G-3 Gate	55	6	5	5.9 (1.7)	−1.2 (1.3)	1.3 (0.7)	<0.1
37. Area G-4 H_20 Tank	64	3	1	14.0 (1.8)	1.8 (0.2)	8.6 (1.2)	<0.1
Group Summary		34	20	890.0 (270.0)	−1.2 (1.3)	97.0 (160.0)	<0.1

[a]See Fig. IV-4 for map of local stations.

[b]Minimum detectable limit = 2×10^{-12} μCi/mL.

[c]Uncertainties are in parentheses.

[d]Controlled area DOE Derived Air Concentration = 2×10^{-5} μCi/mL; uncontrolled area Derived Concentration Guide = 1×10^{-7} μCi/mL.

controlled and uncontrolled areas. The perimeter mean (0.8 [±0.4] × 10^{-18} μCi/mL) and the on-site mean (2.2 [±0.6] × 10^{-18} μCi/mL) were not significantly greater than the regional mean (2.0[±0.9] × 10^{-18} μCi/mL). The station with the highest observed concentration (14.5[±1.5] × 10^{-18} μCi/mL) was the on-site location TA-54, Area G. Table IV-9 presents complete monitoring data for americium.

Uranium. Because uranium is a naturally occurring radionuclide in soil, it is found in airborne soil particles that have been resuspended by wind or mechanical forces (for example, vehicle or construction activity). As a result, uranium concentrations in air are heavily dependent on the immediate environment of the air sampling station. Stations with relatively higher annual averages or maximums are in dusty areas, such as Santa Fe, Pojoaque, and Española, where heavier accumulation of dust on filters results in increased amounts of natural uranium in the samples. This accounts for the larger uranium concentrations at regional stations.

The 1991 annual means for uranium concentrations in air for regional, perimeter, on site and waste sites were 108.8 (± 10.9) pg/m^3, 39.2 (± 3.9) pg/m^3, 50.5 (± 5.1) pg/m^3, and 45.8 (± 4.6) pg/m^3, respectively. All measured annual means were <0.1% of the DOE's concentration guides for uranium in air for controlled and uncontrolled areas. No effects attributable to Laboratory operations were observed. See Table IV-10 for 1991 uranium monitoring data.

d. Air Monitoring at Area G and Area AB.

In addition to the routine air monitoring performed for the environmental surveillance program, four additional air samplers are operated within the Area G controlled area at TA-54 as part of a program monitoring on-site conditions at radioactive waste management areas. A fifth air sampler is operated at Area AB at TA-49 as part of the same program.

These samplers measure air concentrations of H^3, total uranium, ^{238}Pu, $^{239,240}Pu$, and ^{241}Am. The Area G samplers are located near active waste disposal operations areas, and the measured air concentrations reflect these operations. The air sampling results for 1991 are given in Tables IV-6 to IV-10. All measured air concentrations are less than 0.1% of the DOE's

radioactivity concentration guides (Derived Air Concentrations) for on-site areas. Although the radioactivity concentration guides for off-site areas (Derived Concentration Guides [DCG]) do not apply to these on-site areas, the annual average air concentrations measured during 1991 also are less than 0.1% of these more restrictive DCGs.

Air concentrations measured by the samplers at Area G are slightly elevated above background but are less than 0.1% of the concentration guides. The ^{238}Pu air concentration at sampler G-1 was measured during 1991 to be 5.8 aCi/m^3 (5.8 × 10^{-18} μCi/mL), which is less than 0.1% of the DOE concentration guide for on-site areas. The highest annual average concentration observed at this location was 1.5 fCi/m^3, measured during 1988, also less than 0.1% of the DOE concentration guide for on-site areas. The highest single sample was 326 aCi/m^3. Measurements from the other air samplers at Area G indicated that the source of the increased concentration was a small localized area close to the G-1 air sampler. A small area that was

Table IV-7. Airborne ^{238}Pu Concentrations for 1991

Station Location[a]	Total Air Volume (m^3)	No. of Quarterly Samples	No. of Samples <MDL[b]	Concentrations (aCi/m^3 [10^{-18} μCi/mL]) Maximum[c]	Minimum[c]	Mean[c]	Mean as a Percentage of Guide[d]
Regional Stations (28–44 km), Uncontrolled Areas							
1. Española	68,005	3	3	0.0 (0.0)	−0.3 (0.4)	−0.1 (0.5)	<0.1
2. Pojoaque	16,685	1	1	0.7 (1.0)	0.7 (1.0)	0.7 (1.0)	<0.1
3. Santa Fe	80,627	4	4	1.3 (0.9)	−0.3 (0.3)	0.4 (0.6)	<0.1
Group Summary		8	8	1.3 (0.9)	−0.3 (0.4)	0.3 (0.6)	<0.1
Perimeter Stations (0–4 km), Uncontrolled Areas							
4. Barranca School	74,783	3	3	0.2 (0.2)	−0.6 (0.6)	−0.1 (0.4)	<0.1
5. Arkansas Avenue	29,241	1	1	0.0 (0.0)	−0.3 (0.2)	−0.3 (0.2)	<0.1
6. 48th Street	96,046	4	4	0.4 (0.6)	−0.4 (0.4)	0.1 (0.5)	<0.1
7. Shell Station	93,948	4	4	1.8 (1.1)	−0.2 (0.4)	0.8 (0.6)	<0.1
8. McDonald's	92,392	4	4	1.1 (1.2)	0.0 (0.4)	0.7 (0.7)	<0.1
9. Los Alamos Airport	43,065	2	2	0.7 (0.7)	0.4 (0.9)	0.6 (0.8)	<0.1
10. East Gate	100,833	4	3	325.9 (36.5)	−0.2 (0.4)	81.7 (9.5)	<0.3
11. Well PM-1	101,572	4	4	0.4 (0.5)	−0.4 (0.5)	−0.1 (0.4)	<0.1
12. Royal Crest Trailer Park	69,245	3	3	1.9 (0.8)	0.0 (0.4)	0.7 (0.6)	<0.1
13. White Rock, Piñon School	43,721	2	2	0.9 (0.9)	0.3 (0.3)	0.6 (0.6)	<0.1
14. Pajarito Acres	70,949	3	3	0.5 (0.3)	0.1 (0.1)	0.3 (0.4)	<0.1
15. White Rock Fire Station	71,810	3	3	0.5 (0.5)	0.0 (0.5)	0.2 (0.5)	<0.1
16. White Rock Nazarene	101,544	4	4	0.6 (0.6)	0.0 (0.4)	0.2 (0.4)	<0.1
17. Bandelier	63,776	3	3	1.5 (0.5)	0.2 (0.5)	0.8 (0.5)	<0.1
Group Summary		44	43	325.9 (36.5)	−0.6 (0.6)	7.8 (1.3)	<0.1

Table IV-7 (Cont.)

Station Location[a]	Total Air Volume (m^3)	No. of Monthly Samples	No. of Samples <MDL[b]	Concentrations (aCi/m^3 [10^{-18} μCi/mL]) Maximum[c]	Minimum[c]	Mean[c]	Mean as a Percentage of Guide[d]
On-Site Stations, Controlled Areas							
19. TA-21, DP Site	99,917	4	4	1.5 (0.6)	0.2 (0.6)	0.8 (0.5)	<0.1
20 TA-21, Area B	9,602	1	1	0.0 (0.0)	0.0 (1.0)	0.0 (1.0)	<0.1
21. TA-6	77,254	4	4	0.4 (0.7)	–0.8 (0.7)	0.0 (0.8)	<0.1
22. TA-53 (LAMPF)	69,279	3	3	0.6 (0.5)	0.2 (0.2)	0.4 (0.4)	<0.1
23. TA-52, Beta Site	98,083	4	4	1.0 (0.6)	–0.2 (0.4)	0.3 (0.5)	<0.1
24. TA-16, S-Site	101,140	4	4	1.4 (0.7)	–0.7 (0.7)	0.2 (0.5)	<0.1
25. TA-16-450	28,566	1	1	0.7 (0.6)	0.7 (0.6)	0.7 (0.6)	<0.1
26. TA-49	101,596	4	4	0.2 (0.5)	–0.3 (0.5)	–0.1 (0.5)	<0.1
27. TA-54	74,297	3	3	2.5 (0.9)	0.4 (0.5)	1.4 (0.6)	<0.1
28. TA-33	46,522	2	2	0.0 (0.0)	–1.2 (1.2)	–0.6 (0.8)	<0.1
29. TA-2 (Omega)	71,968	4	4	1.1 (1.5)	–0.4 (0.4)	0.3 (0.8)	<0.1
30. Booster P-2	65,812	3	3	1.1 (1.0)	0.3 (0.6)	0.7 (0.7)	<0.1
31. TA-3	39,586	2	1	3.7 (0.9)	1.7 (0.9)	2.7 (0.9)	<0.1
32. TA-48	16,175	1	1	0.0 (0.0)	0.0 (0.6)	0.0 (0.6)	<0.1
Group Summary		40	39	3.7 (0.9)	–1.2 (1.2)	0.5 (0.6)	<0.1
Waste Site Stations, Controlled Areas							
33. Area AB	103,066	4	4	0.6 (0.5)	–0.9 (1.1)	–0.0 (0.6)	<0.1
34. Area G-1 NE Corner	100,459	4	2	9.6 (1.2)	1.6 (0.5)	5.8 (1.2)	<0.1
35. Area G-2 South Fence	97,618	4	4	1.9 (1.0)	0.2 (0.5)	0.8 (0.6)	<0.1
36. Area G-3 Gate	24,100	1	1	1.0 (0.6)	1.0 (0.6)	1.0 (0.6)	<0.1
37. Area G-4 H_20 Tank	49,124	2	2	1.3 (0.6)	0.5 (0.6)	0.9 (0.56	<0.1
Group Summary		15	13	9.6(1.2)	–0.9 (1.1)	1.9 (0.7)	<0.1

[a]See Fig. IV-4 for map of on-site and perimeter stations.

[b]Minimum detectable limit = 4×10^{-18} μCi/mL.

[c]Uncertainties are in parentheses.

[d]Controlled area DOE Derived Air Concentration = 2×10^{-12} μCi/mL; uncontrolled area Derived Concentration Guide = 3×10^{-14} μCi/mL.

Table IV-8. Airborne $^{239,240}Pu$ Concentrations for 1991

Station Location[a]	Total Air Volume (m^3)	No. of Quarterly Samples	No. of Samples <MDL[b]	Concentrations (aCi/m^3 [10^{-18} $\mu Ci/mL$]) Maximum[c]	Minimum[c]	Mean[c]	Mean as a Percentage of Guide[d]
Regional Stations (28–44 km), Uncontrolled Areas							
1. Española	68,005	3	3	0.3 (0.4)	–0.2 (0.3)	0.1 (0.3)	<0.1
2. Pojoaque	16,685	1	1	2.6 (1.1)	2.6 (1.1)	2.6 (1.1)	<0.1
3. Santa Fe	80,627	4	4	1.6 (0.7)	0.2 (0.4)	0.9 (0.5)	<0.1
Group Summary		8	19	2.6 (1.1)	0.2 (0.3)	0.8 (0.5)	<0.1
Perimeter Stations (0–4 km), Uncontrolled Areas							
4. Barranca School	74,783	3	3	0.7 (0.6)	–0.2 (0.2)	0.3 (0.4)	<0.1
5. Arkansas Avenue	29,241	1	1	0.1 (0.3)	0.1 (0.3)	0.1 (0.3)	<0.1
6. 48th Street	96,046	4	4	0.2 (0.3)	–0.2 (0.4)	0.1 (0.4)	<0.1
7. Shell Station	93,948	4	4	1.8 (1.4)	0.2 (0.5)	1.0 (0.7)	<0.1
8. McDonald's	93,392	4	4	1.6 (0.8)	–0.4 (0.4)	0.8 (0.6)	<0.1
9. Los Alamos Airport	43,065	2	2	0.9 (0.5)	0.4 (0.4)	0.7 (0.5)	<0.1
10. East Gate	100,833	3	3	6.1 (5.4)	0.8 (0.4)	2.5 (1.8)	<0.1
11. Well PM-1	101,572	4	4	0.6 (0.4)	–0.2 (0.3)	0.2 (0.4)	<0.1
12. Royal Crest Trailer Park	69,245	3	3	0.8 (0.6)	0.0 (0.4)	0.3 (0.5)	<0.1
13. White Rock, Piñon School	43,721	2	2	1.3 (0.7)	1.2 (0.5)	1.3 (0.6)	<0.1
14. Pajarito Acres	70,949	3	3	0.2 (0.2)	0.0 (0.4)	0.1 (0.4)	<0.1
15. White Rock Fire Station	71,810	3	3	0.7 (0.3)	0.4 (0.5)	0.6 (0.4)	<0.1
16. White Rock Nazarene	101,544	4	4	1.3 (0.6)	0.0 (0.4)	0.7 (0.4)	<0.1
17. Bandelier	63,776	3	3	0.6 (0.4)	0.0 (0.6)	0.3 (0.5)	<0.1
Group Summary		44	43	6.1 (5.4)	-0.4 (0.4)	0.7 (0.6)	<0.1
On-Site Stations, Controlled Areas							
19. TA-21, DP Site	99,917	4	3	3.4 (0.8)	0.4 (0.3)	1.3 (0.5)	<0.1
20. TA-21, Area B	9,602	1	1	2.5 (1.0)	2.5 (1.0)	2.5 (1.0)	<0.1
21. TA-6	77,254	4	4	1.5 (0.5)	0.5 (0.4)	1.0 (0.6)	<0.1
22. TA-53 (LAMPF)	69,279	3	2	6.4 (1.2)	0.9 (0.4)	3.0 (0.7)	<0.1
23. TA-52, Beta Site	98,083	4	4	1.4 (0.5)	0.2 (0.5)	0.7 (0.4)	<0.1
24. TA-16, S Site	101,140	4	4	1.2 (0.4)	–0.5 (0.3)	0.7 (0.6)	<0.1
25. TA-16-450	28,566	1	1	1.3 (0.5)	1.3 (0.5)	1.3 (0.5)	<0.1
26. TA-49	101,596	4	3	4.3 (1.1)	0.8 (0.5)	1.7 (0.6)	<0.1
27. TA-54	74,297	3	1	31.4 (2.6)	1.6 (0.7)	18.2 (1.7)	<0.1
28. TA-33	46,522	2	2	1.2 (1.2)	0.2 (0.3)	0.7 (0.7)	<0.1
29. TA-2 (Omega)	71,968	4	4	1.5 (1.8)	–0.3 (0.3)	0.5 (0.8)	<0.1
30. Booster P-2	65,812	4	3	1.0 (0.7)	0.0 (0.6)	0.5 (0.6)	<0.1
31. TA-3	39,586	2	2	1.4 (0.6)	1.0 (0.5)	1.2 (0.6)	<0.1
32. TA-48	16,175	1	1	0.6 (0.9)	0.6 (0.9)	0.6 (0.9)	<0.1
Group Summary		40	35	31.4 (2.6)	–0.5 (0.3)	2.4 (0.7)	<0.1

Table IV-8 (Cont.)

Station Location[a]	Total Air Volume (m^3)	No. of Monthly Samples	No. of Samples <MDL[b]	Concentrations (aCi/m^3 [10^{-18} μCi/mL]) Maximum[c]	Minimum[c]	Mean[c]	Mean as a Percentage of Guide[d]
Waste Site Stations, Controlled Areas							
33. Area AB	103,066	4	4	0.7 (0.3)	−0.5 (0.1)	0.1 (0.3)	<0.1
34. Area G-1 NE Corner	100,459	4	2	13.4 (1.5)	1.3 (0.9)	5.0 (1.0)	<0.1
35. Area G-2 South Fence	97,618	4	4	1.3 (0.6)	0.3 (0.5)	0.8 (0.5)	<0.1
36. Area G-3 Gate	24,100	1	1	2.7 (0.7)	2.7 (0.7)	2.7 (0.7)	<0.1
37. Area G-4 H_20 Tank	49,124	2	2	1.5 (0.6)	0.7 (0.4)	1.1 (0.5)	<0.1
Group Summary		15	13	13.4 (1.5)	-0.5 (0.1)	1.9 (0.6)	<0.1

[a]See Fig. IV-4 for map of local stations.

[b]Minimum detectable limit = 3×10^{-18} μCi/mL.

[c]Uncertainties are in parentheses.

[d]Controlled area DOE Derived Air Concentration = 2×10^{-12} μCi/mL; uncontrolled area Derived Concentration Guide = 2×10^{-14} μCi/mL.

used for equipment storage located 40 m southwest of G-1; it had ^{238}Pu soil concentrations of up to 40 pCi/g. This area was remediated in 1990, and air concentrations at G-1 decreased to present levels. No increases in any of the off-site air concentrations were observed in the ambient air sampling network during this time period.

Air concentrations of H^3 were observed to be elevated at air sampler G-2. The 1991 average air concentration was measured to be 360.0 (± 110.0) pCi/m^3 (360.0 [± 110.0] × 10^{-12} μCi/mL). This concentration is less than 0.1% of the on-site concentration guide. All other air samplers at Area G measured H^3 concentrations within the range of those observed elsewhere. The G-2 air sampler is located from 7 to 50 m south of shafts used to dispose of higher level waste containing tritium and reflects the air concentrations close to these shafts.

Other radionuclide air concentrations were also small percentages of the concentration guides and reflected ongoing operations at Area G during 1991. The total effective dose to a member of the public from all Area G operations during 1991 was estimated using CAP-88 to be 0.009 mrem/yr (1991), or less than 1% of the EPA radiation limit. These doses are similar to doses estimated for operations in previous years. These estimates are confirmed by routine environmental monitoring in off-site areas. All measured air concentrations in off-site areas were less than 0.1% of the DOE concentration guides.

The measured air concentrations at the TA-49 air sampler showed no increase above background levels. TA-49 is an area along the southern boundary of the Laboratory where below ground experiments were performed with fissionable material (plutonium and enriched uranium) during 1959-1960.

2. Nonradioactive Air Quality.

a. Introduction. In addition to the radiological monitoring network, the Laboratory operates a network of nonradiological ambient air monitors. Because the Los Alamos area lies in a remote area far from large metropolitan areas and major sources of air pollution, extensive monitoring has not been conducted. The

Table IV-9. Airborne ^{241}Am Concentrations for 1991

Station Location[a]	Total Air Volume (m^3)	No. of Quarterly Samples	No. of Samples <MDL[b]	Concentrations (aCi/m^3 [10^{-18} μCi/mL]) Max[c]	Min[c]	Mean[c]	Mean as a Percentage of Guide[d]
Regional Station (44 km), Uncontrolled Area							
3. Santa Fe	80,627	4	2	2.9 (0.9)	1.4 (0.9)	2.0 (0.9)	<0.1
Group Summary		4	2	2.9 (0.9)	1.4 (0.9)	2.0 (0.9)	<0.1
Perimeter Stations (0–4 km), Uncontrolled Areas							
9. Los Alamos Airport	43,065	2	1	2.1 (1.0)	1.7 (0.7)	1.9 (0.8)	<0.1
10. East Gate	100,833	4	4	1.7 (0.8)	0.0 (0.4)	0.8 (0.5)	<0.1
13. White Rock, Piñon School	43,721	2	2	1.1 (0.5)	0.0 (0.0)	0.5 (1.3)	<0.1
15. White Rock Fire Station	71,810	3	3	1.1 (0.5)	0.0 (0.0)	0.6 (0.3)	<0.1
16. White Rock Nazarene	73,472	3	3	0.9 (0.4)	0.0 (0.0)	0.5 (0.3)	<0.1
Group Summary		14	13	2.1 (1.0)	0.0 (0.4)	0.8 (0.4)	<0.1
On-Site Stations, Controlled Areas							
20. TA-21, Area B	9,602	1	1	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	<0.1
21. TA-6	77,254	4	4	1.7 (0.8)	0.0 (0.0)	0.9 (0.5)	<0.1
22. TA-53 (LAMPF)	69,279	3	3	1.6 (0.7)	0.0 (0.0)	0.7 (0.4)	<0.1
24. TA-16, S Site	101,140	4	4	1.7 (0.7)	0.2 (0.3)	1.2 (0.6)	<0.1
26. TA-49	101,596	4	4	1.6 (0.7)	0.6 (0.6)	1.1 (0.6)	<0.1
27. TA-54, Area G	74,297	3	0	14.5 (1.5)	3.4 (1.0)	10.8 (1.4)	<0.1
30. Booster P-2	65,812	3	2	2.2 (0.9)	0.0 (0.4)	1.0 (0.7)	<0.1
31. TA 3	39,586	2	2	1.6 (0.8)	1.3 (0.5)	1.5 (0.7)	<0.1
Group Summary		24	20	14.5 (1.5)	0.0 (0.0)	2.2 (0.6)	<0.1
Waste Site Stations, Controlled Areas							
34. Area G-1 NE Corner	46,025	2	1	8.5 (1.5)	1.1 (0.8)	5.8 (1.2)	<0.1
35. Area G-2 South Fence	47,422	2	2	0.9 (0.8)	0.8 (0.5)	0.9 (0.6)	<0.1
36. Area G-3 Gate	24,100	1	1	2.0 (0.9)	2.0 (0.9)	2.0 (0.9)	<0.1
37. Area G-4 H_20 Tank	23,906	1	1	0.9 (0.7)	0.9 (0.7)	0.9 (0.7)	<0.1
Group Summary		6	5	8.5(1.5)	0.8 (0.5)	2.4 (0.9)	<0.1

[a]See Fig. IV-4 for map of station locations.
[b]Minimum detectable limit = 2×10^{-18} μCi/mL.
[c]Uncertainties are in parentheses.
[d]Controlled area DOE Derived Air Concentration = 2×10^{-12} μCi/mL; uncontrolled area Derived Concentration Guide = 2×10^{-14} μCi/mL.
NOTE: Only those Airnet stations listed in this table are sampled for ^{241}Am.

Table IV-10. Airborne Uranium Concentrations for 1991

Station Location[a]	Total Air Volume (m^3)	No. of Quarterly Samples	No. of Samples <MDL[b]	Concentrations (pg/m^3) Maximum[c]	Minimum[c]	Mean[c]	Mean as a Percentage of Guide[d]
Regional Stations (28–44 km), Uncontrolled Areas							
1. Española	68,005	3	0	98.7 (9.8)	35.5(3.5)	60.8(6.1)	<0.1
2. Pojoaque	16,685	1	0	157.4 (15.7)	157.4(15.7)	157.4(15.7)	<0.1
3. Santa Fe	80,627	4	0	116.3 (11.6)	103.7(10.4)	108.3(10.8)	<0.1
Group Summary		8	0	157.4 (15.7)	35.5(3.5)	108.8(10.9)	<0.1
Perimeter Stations (0–4 km), Uncontrolled Areas							
4. Barranca School	74,783	3	0	92.1 (9.2)	32.5(3.2)	58.9(5.9)	<0.1
5. Arkansas Avenue	29,241	1	0	39.5 (3.9)	39.5(3.9)	39.5(3.9)	<0.1
6. 48th Street	96,046	4	0	66.2 (6.6)	22.4(2.2)	36.6(3.7)	<0.1
7. Shell Station	93,948	4	0	86.6 (8.6)	24.9(2.5)	51.9(5.2)	<0.1
8. McDonald's	92,392	4	0	109.2 (11.0)	18.3(1.8)	53.5(5.3)	<0.1
9. Los Alamos Airport	43,065	2	0	89.5 (8.9)	81.1(8.1)	85.3(8.5)	<0.1
10. East Gate	100,833	4	0	61.5 (6.2)	26.7(2.7)	42.9(4.3)	<0.1
11. Well PM-1	101,572	4	0	58.2 (5.8)	13.3(1.3)	30.4(3.0)	<0.1
12. Royal Crest Trailer Park	69,245	3	0	38.5 (3.8)	19.9(1.9)	28.6(2.8)	<0.1
13. White Rock Piñon School	43,721	2	0	17.4 (1.8)	13.2(1.3)	15.3(1.6)	<0.1
14. Pajarito Acres	52,932	2	0	37.0 (3.7)	14.5(1.5)	25.8(2.6)	<0.1
15. White Rock Fire Station	71,810	3	0	45.7 (4.6)	17.6(1.7)	34.7(3.5)	<0.1
16. White Rock Nazarene	101,544	4	0	51.4 (5.1)	11.4(1.2)	25.3(2.5)	<0.1
17. Bandelier	63,776	3	0	25.3 (2.5)	14.1(1.4)	20.5(2.0)	<0.1
Group Summary		43	0	109.2 (11.0)	11.4(1.2)	39.2(3.9)	<0.1
On-Site Stations, Controlled Areas							
19. TA-21, DP Site	99,917	4	0	98.2 (9.9)	23.5(2.3)	64.5(6.5)	<0.1
20. TA-21, Area B	9,602	1	0	44.4 (4.4)	44.4(4.4)	44.4(4.4)	<0.1
21. TA-6	77,254	4	0	83.3 (8.4)	32.0(3.2)	53.5(5.4)	<0.1
22. TA-53 (LAMPF)	69,279	3	0	62.3 (6.3)	22.5(2.2)	39.1(3.9)	<0.1
23. TA-52, Beta Site	98,083	4	0	128.5 (12.8)	20.0(2.0)	55.5(5.5)	<0.1
24. TA-16, S Site	101,140	4	0	62.2 (6.3)	24.7(2.5)	44.0(4.4)	<0.1
25. TA-16-450	28,566	1	0	35.1 (3.5)	35.1(3.5)	35.1(3.5)	<0.1
26. TA-49	101,596	4	0	39.7 (4.0)	11.4(1.2)	23.3(2.3)	<0.1
27. TA-54	74,297	3	0	100.4 (10.0)	34.7(3.4)	61.2(6.1)	<0.1
28. TA-33	46,522	2	0	18.6 (1.8)	6.2(0.6)	12.4(1.2)	<0.1
29. TA-2 (Omega)	71,968	4	0	67.8 (6.8)	25.5(2.5)	48.1(4.8)	<0.1
30. Booster P-2	65,812	3	0	66.5 (6.7)	35.0(3.5)	51.8(5.2)	<0.1
31. TA-3	39,568	2	0	79.3 (7.9)	40.6(4.0)	59.9(6.0)	<0.1
32. TA-48	16,175	1	0	113.9 (11.4)	113.9(11.4)	113.9(11.4)	<0.1
Group Summary		40	0	128.5 (12.8)	6.2 (0.6)	50.5(5.1)	<0.1

Table IV-10 (Cont.)

Station Location[a]	Total Air Volume (m^3)	No. of Quarterly Samples	No. of Samples <MDL[b]	Concentrations (pg/m^3) Maximum[c]	Minimum[c]	Mean[c]	Mean as a Percentage of Guide[d]
Waste Site Stations, Controlled Areas							
33. Area AB	103,066	4	0	82.2 (8.2)	20.9(2.0)	50.7(5.1)	<0.1
34. Area G-1 NE Corner	100,459	4	0	83.8 (8.4)	27.8(2.8)	48.7(4.9)	<0.1
35. Area G-2 South Fence	97,618	4	0	83.2 (8.3)	30.3(3.0)	46.4(4.7)	<0.1
36. Area G-3 Gate	24,100	1	0	34.1 (3.4)	34.1(3.4)	34.1(3.4)	<0.1
37. Area G-4 H_20 Tank	49,124	2	0	88.2 (8.8)	10.3(1.0)	49.2(4.9)	<0.1
Group Summary		17	0	88.2(8.8)	10.3(1.0)	45.8(4.6)	<0.1

[a]See Fig. IV-4 for map of local stations.

[b]Minimum detectable limit = 1 pg/m^3.

[c]Uncertainties are in parentheses.

[d]Controlled area DOE Derived Air Concentration = 2×10^8 pg/m^3; uncontrolled area Derived Concentration Guide = 1×10^5 pg/m^3.

Laboratory operates monitors to routinely measure primary (or "criteria") pollutants, National Emission Standards for Hazardous Air Pollutants (NESHAP) for beryllium, acid precipitation, and visibility. In 1991, the Laboratory also monitored toxic air pollutants (TAPs) as part of a short-term study.

b. Monitoring Network. The nonradiological monitoring network consists of a variety of monitoring stations: one criteria pollutant monitor, nine beryllium monitors, one acid rain monitor, and one visibility monitoring station. For the 1991 TAP study, five additional monitoring sites were used.

c. Primary Pollutants. Although it is Laboratory owned, the New Mexico Environment Department (NMED) operates the criteria pollutant monitoring station south of TA-49, adjacent to Bandelier National Monument. This station, which began operation in the second quarter of 1990, continuously monitors air concentrations of nitrogen dioxide (NO_2), ozone (O_3), and sulfur dioxide (SO_2). Filters to trap small particulate matter (less than 10 microns in diameter – PM_{10}) are collected every 6 days and weighed. The NMED analyzes all results and provides the results to the Laboratory. Measured ozone concentrations do not exceed the federal primary or secondary standard. However, the maximum hourly concentration exceeded the New Mexico ambient standard.

d. NESHAP (Beryllium). The Laboratory conducts beryllium monitoring at nine monitoring stations; one regional station (28-44 km), four perimeter stations (0-4 km), and four on-site stations. Quarterly samples are taken and analyzed. Table IV-11 presents the results for 1991. All concentrations were well below the New Mexico ambient air standards.

e. Acid Precipitation. The Environmental Protection Group (EM-8) operates a wet deposition station that is part of the National Atmospheric Deposition Program (NADP) network. The station is located at the Bandelier National Monument. The corrected 1990 and 1991 annual and quarterly deposition rates are presented in Table IV-12.

Table IV-11. Airborne Beryllium Concentrations for 1991

Station Location[a]	Total Air Volume (m^3)	No. of Quarterly Samples	Concentrations (ng/m^3) Maximum[b]	Minimum[b]	Mean[b]
Regional Stations (28–44 km), Uncontrolled Areas					
Pojoaque	22,288	2	0.04 (0.02)	0.03 (0.02)	0.04 (0.02)
Group Summary		2	0.04 (0.02)	0.03 (0.02)	0.04 (0.02)
Perimeter Stations (0–4 km), Uncontrolled Areas					
Barranca School	60,004	3	0.02 (0.01)	0.02 (0.00)	0.02 (0.01)
Los Alamos, 48th Street	70,737	3	0.02 (0.01)	0.01 (0.00)	0.01 (0.01)
Shell Station	67,584	3	0.04 (0.00)	0.01 (0.00)	0.02 (0.00)
Pajarito Acres	70,949	3	0.02 (0.01)	0.01 (0.00)	0.01 (0.00)
Bandelier	37,528	2	0.01 (0.00)	0.01 (0.00)	0.01 (0.00)
Group Summary		14	0.04 (0.01)	0.01 (0.00)	0.02 (0.00)
On-Site Stations, Controlled Areas					
TA-52 Beta Site	69,689	3	0.06 (0.01)	0.01 (0.00)	0.03 (0.00)
TA-16 S-Site	74,668	3	0.02 (0.01)	0.02 (0.01)	0.02 (0.01)
TA-16-450	43,139	2	0.01 (0.00)	0.01 (0.01)	0.01 (0.00)
TA-54, Area G by QA	28,872	1	0.04 (0.01)	0.04 (0.01)	0.04 (0.01)
TA-3	39,586	2	0.01 (0.00)	0.01 (0.00)	0.01 (0.00)
Group Summary		11	0.06 (0.01)	0.01 (0.01)	0.02 (0.00)

[a]See Figure IV-4 for map of on-site and perimeter stations.
[b]Uncertainties are in parentheses.

Deposition rates for the various ionic species vary widely and are somewhat dependent on precipitation. The highest deposition rates usually coincide with high precipitation. The lowest rates normally occur in the winter, probably reflecting the decrease in wind-blown dust. The ions in the rainwater are from both nearby and distant anthropogenic and natural sources. High nitrate and sulfate deposition may be caused by anthropogenic sources, such as motor vehicles, copper smelters, and power plants.

The natural pH of rainfall, without anthropogenic contributions, is unknown. Because of the contribution from entrained alkaline soil particles in the southwest, natural pH may be higher than 5.6, the pH of rainwater in equilibrium with atmospheric carbon dioxide. Some studies indicate that there may be an inverse relationship between elevation and pH effect that lowers the pH of samples measured in the field.

f. Visibility. The Laboratory operates one transmissometer to measure visibility, adjacent to Bandelier National Monument. As shown in Table IV-13, typical visibility is high in the area, with median visibilities of almost 130 km (82 mi). Summers show the lowest visibility, due to high humidity associated with common afternoon thunderstorms. About 10% of the time the visibility exceeded 190 km (118 mi) with the maximum visibility exceeding 223 km (140 mi). These visibilities are characteristic of clean air areas in relatively arid climates. Visibility results also are provided to the National Park Service for publication.

g. Toxic Air Pollutants. During January 1991, the Laboratory conducted a short-term, intensive air monitoring program to estimate the impact of chemical emissions on the ambient air environment. Sampling and analysis of indicator chemicals required an

Table IV-12. Annual and Quarterly Wet Deposition Statistics for 1990 and 1991

1990[a]	Quarter				
	First	Second	Third	Fourth	Total
Field pH (standard units)					
Mean	4.9	4.9	4.9	5.2	4.9
Minimum	4.4	4.4	4.6	4.8	4.4
Maximum	6.0	5.6	5.6	5.6	6.0
Precipitation (in.)	2.2	1.8	4.8	3.3	12.1
Deposition (microequivalents per square meter)					
Ca	5,218	1,208	1,196	440	8,064
Mg	196	164	186	69	615
K	43	50	48	26	168
Na	363	202	209	131	905
NH_4	857	839	1,924	507	4,127
NO_3	862	998	2,439	675	4,975
Cl	215	243	394	125	976
SO_4	1,520	1,379	2,462	1,272	6,633
PO_4	44	51	112	25	233
H	720	650	1,430	910	3,710

1991	Quarter				
	First	Second	Third	Fourth	Total
Field pH (standard units)					
Mean	5.4	4.7	4.9	5.0	5.0
Minimum	4.7	4.5	4.7	4.8	4.5
Maximum	6.7	4.8	5.1	5.1	6.7
Precipitation (in.)	2.2	2.2	11.1	5.2	20.8
Deposition (microequivalents per square meter)					
Ca	1,494	2,010	1,619	529	5,653
Mg	160	364	257	90	872
K	47	129	91	24	291
Na	218	413	331	206	1,168
NH_4	317	1,542	1,718	463	4,039
NO_3	680	1,686	3,573	784	6,722
Cl	179	398	493	168	1,237
SO_4	576	2,501	3,353	1,692	8,121
PO_4	0	9	8	0	17
H	230	640	3,260	840	4,970

[a]Calendar year 1989 data were presented in the "Environmental Surveillance at Los Alamos during 1990," and were mistakenly identified as 1990 data.

Table IV-13. Median Visibility Measured at Bandelier National Monument in 1991

Season	Median Visibility km	(mi)
Winter (12/90–2/91)	160	(100)
Spring (3/91–5/91)	132	(82)
Summer (6/91–8/91)	120	(75)
Fall (9/91–11/91)	107	(66)

innovative and high-sensitivity strategy in order to detect chemicals at very low concentrations in the ambient air as well as to address the complex terrain and meteorology of the area and potential interferences from Los Alamos community emissions. The indicator chemicals were chosen from a list of more than 600 potential air contaminants regulated by the State of New Mexico. An inventory prepared in 1988 showed that the Laboratory emitted 50 of these regulated air contaminants in amounts greater than 10 lb/yr. Of these 50 compounds, certain compounds were identified as traceable only to Laboratory operations since no other nearby sources of these chemicals likely exist, for example, acetone and 2-butanone. Other chemicals were chosen that would be traceable to non-Laboratory sources. For instance, chemicals indicative of automobile emissions were targeted. Overall, 20 organic vapors, 6 metals, and 5 inorganic acid vapors were chosen as target compounds. These were measured at five sites around the Laboratory over seven consecutive days in January 1991. The sites were selected based on several criteria, including proximity to LANL's areas of highest emissions, historical wind direction patterns, utility in estimation, the impact of LANL emissions on the Los Alamos community, and (in some cases) proximity to electrical power.

The results of the sampling program are summarized in Tables IV-14–IV-16. All three target chemical groups were sampled at TA-3 (Sites A and B) and the background monitor located near Bandelier National Monument. The background monitor, located upwind of the Laboratory, was included to measure ambient chemical concentrations not associated with LANL. Acids were the only chemicals sampled by the monitors located at TA-55 and TA-59. These monitors were sited specifically to measure acid concentrations, because acids are the primary chemical emissions from each of these areas. These tables also show the occupational health standards (TLV-PEL) set by the National Institute for Occupational Safety and Health of the American Conference of Governmental Industrial Hygienists. These standards are set to protect healthy workers exposed during a 40-hour work week. To protect sensitive individuals potentially exposed more than 40 hours weekly, NMED divides these standards by 100. As the tables show, levels of these pollutants in the ambient air surrounding the Laboratory are so low that they are an order of magnitude lower than the TLV-PEL divided by 100.

D. Surface Water Monitoring

1. Introduction.

Surface waters from regional, perimeter, and on-site stations are monitored to provide routine surveillance of environmental effects of Laboratory operations. As described in Section II.C, Geology-Hydrology, there are no perennial surface water flows that extend completely across the Laboratory in any of the canyons. Spring-fed flow originating on the flanks of the Jemez Mountains in Los Alamos Canyon maintains a flow into the Los Alamos Reservoir that continues onto the western portion of the Laboratory. Two have spring-fed flows over short distances east of the Laboratory in White Rock Canyon. These are Pajarito Canyon (on Los Alamos County land) and Ancho Canyon (on DOE land). Periodic natural surface runoff occurs in two modes: 1) spring snowmelt runoff occurs over highly variable periods of time (days to weeks) at a low discharge rate and sediment load, and 2) summer runoff from thunderstorms occurs over a short period of time (hours) at a high discharge rate and sediment load. None of these surface waters within the Laboratory are a source of municipal, industrial, or irrigation water supply. The waters are utilized by wildlife.

Most canyons receive discharges from some of the approximately 140 National Pollutant Discharge Elimination System (NPDES) permitted industrial and sanitary effluent outfalls. These effluents support flows for varying distances in some of the canyons. The largest effluent-supported flow is in Sandia Canyon from the TA-3 Sanitary Sewage Plant. In 1991, treated radioactive liquid waste effluents containing residual radioactivity were released only from the central

Table IV-14. Summary of Acid Data for Seven-Day Sampling Period for All Five Sites for 1991

Station	Minimum µg/m³	Maximum µg/m³	TLV-PEL[a] µg/m³
TA-3 Site (A)			
Hydrochloric Acid	ND (<0.1)[b]	ND (<0.1)	7500[c]
Hydrofluoric Acid	ND (<0.07)	ND (<0.07)	2600[c]
Nitric Acid	0.29	0.47	5200[d]
Phosphoric Acid	ND (<0.5)	ND (<0.5)	1000
Sulfuric Acid	0.2	1.8	1000
TA-3 Site (B)			
Hydrochloric Acid	ND (<0.1)	0.2	7500[c]
Hydrofluoric Acid	ND (<0.07)	ND (<0.07)	2600[c]
Nitric Acid	0.34	0.67	5200[d]
Phosphoric Acid	ND (<0.5)	ND (<0.5)	1000
Sulfuric Acid	0.3	1.8	1000
TA-55			
Hydrochloric Acid	ND (<0.1)	0.2	7500[c]
Hydrofluoric Acid	ND (<0.07)	ND (<0.07)	2600[c]
Nitric Acid	0.34	0.71	5200[d]
Phosphoric Acid	ND (<0.5)	ND (<0.5)	1000
Sulfuric Acid	0.3	3.3	1000
TA-59			
Hydrochloric Acid	0.1	0.6	7500[c]
Hydrofluoric Acid	ND (<0.07)	ND (<0.07)	2600[c]
Nitric Acid	0.31	0.78	5200[d]
Phosphoric Acid	ND (<0.5)	ND (<0.5)	1000
Sulfuric Acid	0.5	2.7	1000
Background			
Hydrochloric Acid	ND (<0.1)	0.2	7500[c]
Hydrofluoric Acid	ND (<0.07)	ND (<0.07)	2600[c]
Nitric Acid	0.34	0.92	5200[d]
Phosphoric Acid	ND (<0.5)	ND (<0.5)	1000
Sulfuric Acid	ND (0.2)	0.2	1000

[a]This concentration is the occupational exposure standard.

[b]ND = None detected; number in parentheses is the detection level.

[c]This is a ceiling value, a concentration never to be exceeded.

[d]HNO_3 Limit of Detection (LOD) = 0.03 µg/m³; H_2SO_4 LOD = 0.2 µg/m³.

Table IV-15. Summary of Metals Data for Seven-Day Sampling Period for Three Sites for 1991

Station	Minimum $\mu g/m^3$	Maximum $\mu g/m^3$	TLV-PEL[a] $\mu g/m^3$
TA-3 Site (A)			
Beryllium	ND (<0.01)[b]	ND (<0.01)	2[c]
Cadmium	ND (<0.02)	ND (<0.02)	10[c]
Chromium	ND (<0.03)	ND (<0.03)	500
Lead	0.01	0.04	50[d]
Silver	ND (<0.05)	ND (<0.05)	10
Uranium	ND (<0.1)	ND (<0.1)	50
TA-3 Site (B)			
Beryllium	ND (<0.01)	ND (<0.01)	2[c]
Cadmium	ND (<0.02)	ND (<0.02)	10[c]
Chromium	ND (<0.03)	ND (<0.03)	500
Lead	0.01	0.03	50[d]
Silver	ND (<0.05)	ND (<0.05)	10
Uranium	ND (<0.1)	ND (<0.1)	50
Background			
Beryllium	ND (<0.01)	ND (<0.01)	2[c]
Cadmium	ND (<0.02)	ND (<0.02)	10[c]
Chromium	ND (<0.03)	ND (<0.03)	500
Lead	0.01	0.01	50[d]
Silver	ND (<0.05)	ND (<0.05)	10
Uranium	ND (<0.1)	ND (<0.1)	50

[a]This concentration is the occupational exposure standard.

[b]ND = None detected; number in parentheses is the detection level.

[c]Human carcinogen.

[d]Limit of detection (LOD) for lead = 0.01 $\mu g/m^3$

Table IV-16. Summary of Organics Data for Seven-Day Sampling Period for Three Sites for 1991

Station	Minimum µg/m³	Maximum µg/m³	TLV-PEL[a] µg/m³
TA-3 Site (A)			
Acetone	1.2	43.3	1,780,000
Benzene	0.8	5.8	32,000[b]
2-Butanone	ND (<1.5)[c]	5.3	590,000
Cyclohexane	ND (<1.0)	139.2	1,030,000
Ethylbenzene	ND (<0.4)	2.4	434,000
n-Hexane	1.1	3.6	176,000
Methanol	ND (<1.5)	12.7	262,000
Methylene chloride	ND (<0.2)	6.1	174,000[b]
Toluene	2.5	15.9	377,000
1,1,1-Trichloroethane	0.7	11.1	1,910,000
o,m,p-Xylenes	0.8	10.8	434,000
TNMHC[d]	69.9	393.0	
Halogenated TNMHC	3.7	19.0	
TA-3 Site (B)			
Acetone	1.8	30.0	1,780,000
Benzene	1.1	4.1	32,000[b]
2-Butanone	ND (<1.5)	10.7	590,000
Cyclohexane	ND (<1.0)	137.7	1,030,000
Ethylbenzene	ND (<0.4)	1.7	434,000
n-Hexane	1.0	2.9	176,000
Methanol	ND (<1.5)	92.0	262,000
Methylene chloride	ND (<0.2)	4.5	174,000[b]
Toluene	4.1	14.4	377,000
1,1,1-Trichloroethane	0.7	16.4	1,910,000
o,m,p-Xylenes	0.8	7.4	434,000
TNMHC[d]	94.2	482.0	
Halogenated TNMHC	3.6	15.6	
Background			
Acetone	ND (<0.7)	7.6	1,780,000
Benzene	ND (<0.4)	1.0	32,000[b]
2-Butanone	ND (<1.5)	2.5	590,000
Cyclohexane	ND (<3.4)	810.0	1,030,000
Ethylbenzene	ND (<0.4)	ND (<0.4)	434,000
n-Hexane	ND (<1.0)	1.5	176,000
Methanol	ND (<1.5)	21.0	262,000
Methylene chloride	ND (<0.2)	1.0	174,000[b]
Toluene	1.7	19.1	377,000
1,1,1-Trichloroethane	0.5	73.5	1,910,000
o,m,p-Xylenes	ND (<0.4)	1.4	434,000
TNMHC[d]	67.2	1,060.0	
Halogenated TNMHC	3.6	86.0	

[a]This concentration is the occupational exposure standard.
[b]Human carcinogen.
[c]ND = None detected; number in parentheses is the detection level.
[d]Total nonmethane hydrocarbons.

Radioactive Liquid Waste Treatment Plant at TA-50 into the Mortandad Canyon drainage. In the past, Pueblo and Los Alamos Canyons also received effluents containing radioactivity.

Concentrations of radionuclides in environmental water samples, whether within the DOE site boundary or off site, are compared with the ingested water derived concentration guides for members of the public. (See Section V.C.2, Methods for Dose Calculations for further explanation.) Routine chemical analyses of water samples have been carried out for many constituents over a number of years to monitor general water quality. For the stream channels that cross the DOE Laboratory lands, results of analyses of surface water samples from the on-site and downstream off-site locations for nonradioactive chemical quality analyses are compared with NMED Livestock and Wildlife Watering standards as these are the most likely potential water use (NMWQCC 1991). No attempt is made to evaluate water quality in the regional rivers or entirely off-site perennial streams.

2. Monitoring Network.

The locations of surface water monitoring stations are shown in Figs. IV-5 and IV-6 and are listed in Table D-9.

a. Regional Stations. Regional surface water samples were collected within 75 km (47 mi) of the Laboratory from six stations on the Rio Grande, the Rio Chama, and Jemez River. The six water sampling stations are located at current or former U.S. Geological Survey (USGS) gaging stations. These waters provide baseline data for radiochemical and chemical analyses in areas beyond the Laboratory boundary. Stations on the Rio Grande were at Embudo, Otowi, Cochiti, and Bernalillo (a former gaging station).

The Rio Grande at Otowi, just east of Los Alamos, has a drainage area of 37,000 km^2 (14,300 mi^2) in southern Colorado and northern New Mexico. Discharge for the periods of record (1895–1905 and 1909–1990) has ranged from a minimum of 1.7 m^3/s (60 ft^3/s) in 1902 to 691 m^3/s (24,400 ft^3/s) in 1920. The discharge for water year 1990 (October 1989 through September 1990) ranged from 15.7 m^3/s (555 ft^3/s) in October to 242 m^3/s (8,560 ft^3/s) in May (USGS 1992).

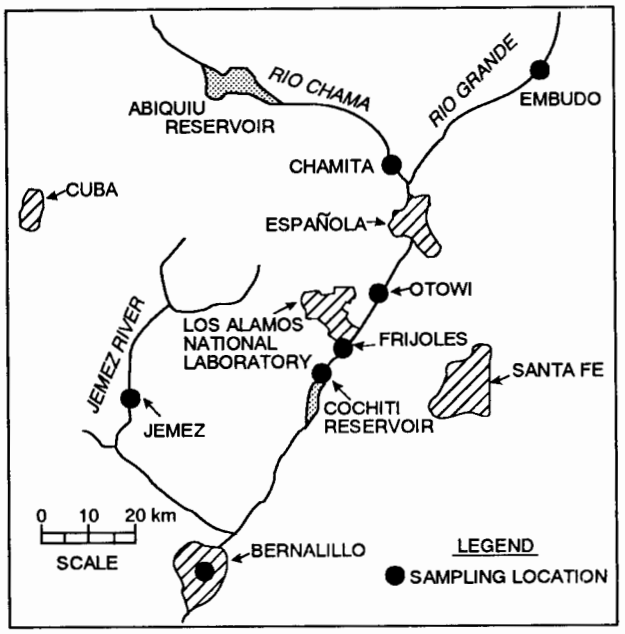


Fig. IV-5. Regional surface water, sediment, and soil sampling locations. (Map denotes general locations only; see Table D-9 for specific locations.)

The Rio Chama is a tributary to the Rio Grande upstream from Los Alamos. At Chamita on the Rio Chama, the drainage area above the station is 8,143 km^2 (3,143 mi^2) in northern New Mexico, together with a small area in southern Colorado. Since 1971, some flow has resulted from transmountain diversion water from the San Juan drainage. Flow at the Chamita gage is governed by release from several reservoirs. Discharge at Chamita during water year 1990 ranged from 1.4 m^3/s (51 ft^3/s) in January to 108 m^3/s (3,820 ft^3/s) in June.

The station at Jemez on the Jemez River drains an area of the Jemez Mountains west of Los Alamos. The Fenton Hill Hot Dry Rock Geothermal Facility (TA-57) is located within this drainage. The drainage area is small, about 1,220 km^2 (471 mi^2). During water year 1990, discharge ranged from 0.4 m^3/s (14 ft^3/s) in December to 30.3 m^3/s (1,070 ft^3/s) in April. The river is a tributary to the Rio Grande downstream from Los Alamos.

Surface waters from the Rio Grande, the Rio Chama, and Jemez River are used for irrigation of crops in the

valleys, both upstream and downstream from Los Alamos. These rivers run through recreational areas on state and federal lands.

b. Perimeter (Off-Site) Stations.

Radioactive Effluent Areas. Effluent-associated radionuclides occur off site in Pueblo and Los Alamos Canyons. The residual contaminants are from past discharges and are predominantly associated with sediments in the canyons. (See Section IV.E, Sediment and Soil Monitoring, for further information.) Some resuspension and redissolution occurs when surface flows move across these sediments, resulting in measurable concentrations in the surface waters.

Acid Canyon, a small tributary of Pueblo Canyon, is a former on-site release area for industrial effluents. Acid Canyon and the upper portion of Pueblo Canyon are now on Los Alamos County land about 1,190 m (3,900 ft) west of the Los Alamos-Santa Fe County Line. Acid-Pueblo Canyon received untreated and treated industrial effluent containing residual

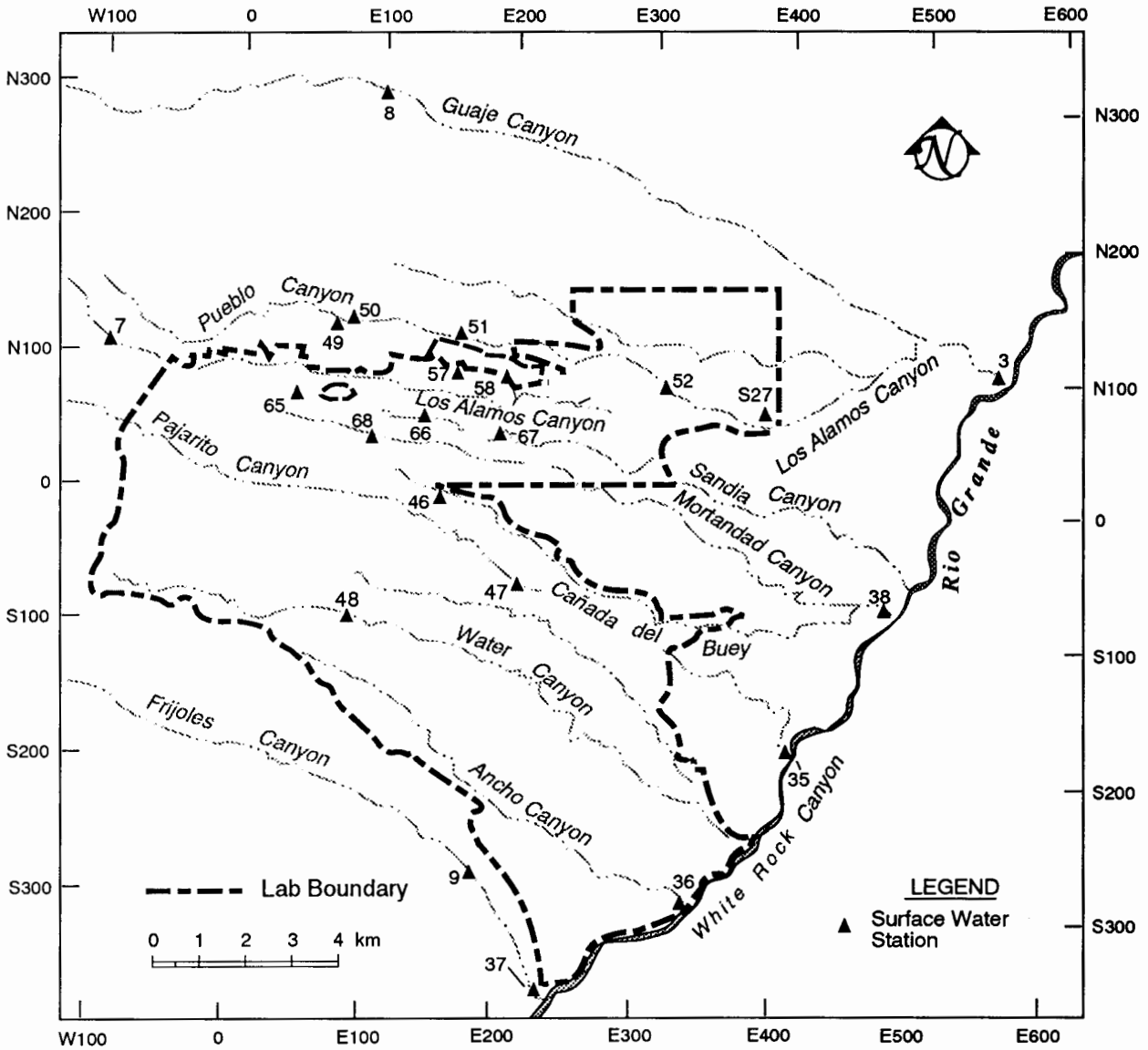


Fig. IV-6. Surface water sampling locations on and near the Laboratory site. (Map denotes general locations only; see Table D-9 for specific locations.)

radionuclides from 1944 to 1964 (ESG 1981). Most of the residual radioactivity from these historic releases are now associated with the sediments in Pueblo Canyon with an estimated total inventory of about 600 mCi of plutonium (ESG 1981). About two-thirds (400 mCi) of this total are on the DOE-owned portion of lower Pueblo Canyon. Pueblo Canyon presently receives treated sanitary effluent from the Los Alamos County Bayo sewage treatment plant in the middle reach of Pueblo Canyon. Increased discharge of sanitary effluent from the County treatment plant starting in 1990 resulted in nearly perennial flow during most days of all months except June and July in the lower reach of Pueblo Canyon, across the DOE land and into the off-site lower reach of Los Alamos Canyon on San Ildefonso Pueblo.

This effluent flow from Pueblo Canyon into Los Alamos Canyon typically extends to a location between Wells LA-6 and LA-2 in Los Alamos Canyon. During the peak irrigating season (mid-June through early August), the reduction in treatment plant discharge because of effluent diversion for golf course irrigation and higher evapotranspiration eliminates flow from Pueblo Canyon into Los Alamos Canyon.

The off-site surface water sampling stations are at Acid Weir (where Acid Canyon joins the main channel of Pueblo Canyon), Pueblo 1, and Pueblo 2. Flow is irregular at these locations, dependent mainly on snowmelt and thunderstorm runoff and return flow from the shallow alluvium. In the past, discharges from the Los Alamos County Pueblo sanitary sewage plant upstream from the confluence with Acid Canyon maintained more regular flow; however, operation of this plant has been discontinued except for short periods in the summer when it is operated primarily to provide irrigation water for the County golf course. In lower Los Alamos Canyon, off-site surface water samples are collected at its confluence with the Rio Grande.

Other Areas. Off-site perimeter stations within about 4 km (2.5 mi) of the Laboratory boundary include surface water stations at Los Alamos Reservoir, Guaje Canyon, and Frijoles Canyon. Los Alamos Reservoir, in upper Los Alamos Canyon on the flanks of the mountains west of Los Alamos, has a capacity of 51,000 m^3 (41 ac-ft) and a drainage area of 17 km^2 (6.4 mi^2) above the intake. The reservoir is used for recreation and storage for limited landscape irrigation in the townsite.

The station in Guaje Canyon is below Guaje Reservoir, which is located in upper Guaje Canyon and has a capacity of 900 m^3 (0.7 ac-ft) and a drainage area above the intake of about 14 km^2 (5.6 mi^2). Flow into the reservoir is maintained by perennial springs. The stream and reservoir are used for recreation and diversion of water for landscape irrigation in the townsite.

Surface water flow in Frijoles Canyon is sampled at Bandelier National Monument Headquarters. Flow in the canyon is from spring discharge in the upper reach of the canyon. The drainage area above the monument headquarters is about 45 km^2 (17 mi^2) (Purtymun 1980a). Surface flow in Frijoles Canyon is also sampled at the confluence with the Rio Grande.

There are four other perimeter stations in White Rock Canyon along the Rio Grande just east of the Laboratory; two are off site and two are on site. Included in this group are the streams in Pajarito (off site), Water, and Ancho Canyons (both on site), which are fed from Group I springs. (See Section VII, Groundwater Protection Management Program, for additional information.) Treated sanitary effluent from the community of White Rock is sampled in Mortandad Canyon (off site) at its confluence with the Rio Grande.

c. On-Site Stations.

Radioactive Effluent Areas. On-site effluent release areas are canyons that receive, or have received, effluents containing radioactivity, including Pueblo, DP, Los Alamos, and Mortandad Canyons.

As noted above in the section describing off-site radioactive effluent areas, the portion of lower Pueblo Canyon presently on DOE lands contains sediments contaminated with residuals from past discharges into Acid Canyon. (See Section IV.E for related information.) Surface flow is presently maintained across the DOE land in Pueblo Canyon by discharge of effluent from the Los Alamos County Bayo sanitary sewage treatment plant located just west of the County-DOE boundary. Some of this effluent flow infiltrates and maintains a shallow body of perched alluvial water. (See Section VII for further information.) Pueblo Canyon discharges into Los Alamos Canyon at State Road 502 near the eastern Laboratory boundary. Surface water is sampled at Pueblo 3 and at State Road 502 (Fig. IV-6).

DP Canyon, a small tributary of Los Alamos Canyon, received treated radioactive liquid waste

effluents between 1952 and 1984. Some residuals remain, primarily associated with sediments, that are subject to resuspension and redissolution in surface flow. DP Canyon presently receives some sanitary effluent from the treatment plant at TA-21. Sampling stations consist of two surface water stations in DP Canyon, DPS-1 and DPS-4.

In the upper reach of Los Alamos Canyon (above Station LAO-1), there were releases of treated and untreated radioactive effluents during the earliest years of operations at TA-1 (late 1940s) and some release of cooling water from the research reactor at TA-2. The Los Alamos Canyon drainage also received discharge containing some radioactivity in previous years from the sanitary sewage lagoon system at LAMPF (TA-53). In 1989, the low-level radioactive waste stream was separated from the sanitary system at TA-53 and directed into a total retention, evaporative lagoon. There is normally some surface flow in the westernmost portion of Los Alamos Canyon within the Laboratory which is maintained by discharge from the Los Alamos Reservoir. This flow generally infiltrates the shallow alluvium in the canyon and is depleted before reaching the eastern margin of the Laboratory at State Road 4. Water quality in this portion of Los Alamos Canyon is monitored by samples of the alluvial water. (See Section VII for further information.) Snowmelt will often saturate the alluvium sufficiently to result in some surface flow beyond State Road 4 for varying periods in the spring. In the fall of 1991, the USGS, under contract to the Laboratory, resumed continuous operation of a streamflow gaging station a short distance upstream from State Road 4.

Mortandad Canyon has a small drainage area that heads at TA-3. Industrial liquid wastes containing radionuclides are collected and processed at the industrial waste treatment plant at TA-50 which started operation in 1963. After treatment the effluents are released into Mortandad Canyon. Most of the residuals are now associated with the sediments in the canyon. The inventory of transuranic contaminants is about 400 mCi, entirely contained on site (Stoker 1991). Hydrologic studies in the canyon were initiated by the USGS in 1960. Since that time, there has been no surface water flow beyond the Laboratory's boundary because the small drainage area in the upper part of the canyon results in limited runoff and because a thick section of unsaturated alluvium in the lower canyon allows rapid infiltration and storage of runoff when it does occur. One surface water station, Gaging Station 1 (GS-1) is located a short distance downstream from the effluent release point. Most water quality observations in Mortandad Canyon are made on the alluvial water. (See Section VII for further information.) Three sediment traps are located about 3 km (2 mi) downstream from the effluent discharge in Mortandad Canyon to dissipate the energy of major thunderstorm runoff events and settle out transported sediments. It is approximately another 1.5 km (1 mi) to the Laboratory boundary with San Ildefonso Pueblo.

Other Areas. Sandia Canyon has a small drainage area that heads on Pajarito Plateau at TA-3. The canyon receives cooling tower blowdown from the TA-3 power plant and treated sanitary effluents from TA-3. Treated effluents from the TA-3 sanitary treatment plant form a perennial stream in a short reach of the upper canyon. Only during summer thundershowers does stream flow reach the Laboratory boundary at State Road 4. Only during periods of heavy thunderstorms or snowmelt does surface flow from Sandia Canyon extend beyond Laboratory boundaries or reach the Rio Grande. Three surface water sampling stations, SCS-1, SCS-2, and SCS-3, are located in the reach of the canyon containing perennial flow maintained by the effluents.

Surface water samples are collected in three other on-site canyons: Cañada del Buey, Pajarito, and Water (at Beta Hole). The flows at these locations are primarily maintained by effluents but do include some natural flows. Spring supported flows in Water and Ancho Canyons are sampled at the DOE boundary where these streams join the Rio Grande.

3. Analytical Results.

a. Radiochemical Analyses. The results of radiochemical analyses of surface water samples for 1991 are listed in Table IV-17. All results are below the DOE Derived Concentration Guides that limit potential exposure to the public from ingestion of water to levels below the DOE public dose limit (see Appendix A.). The majority of the results are near or below analytical method detection limits. Of the few at or above detection limits, most are from locations with previously known contamination: the Acid-Pueblo Canyon and the Mortandad Canyon locations. The plutonium analyses for the Jemez River and the Frijoles Stream at Bandelier National Monument Headquarters sample are just at the detection limit, but because they

Table IV-17. Radiochemical Analyses of Surface Waters

Location	H^3 (pCi/L)	^{90}S (nCi/L)	^{137}Cs (pCi/L)	Uranium (μg/L)	^{238}Pu (pCi/L)	^{239}Pu (pCi/L)	Gross Gamma (Counts/min/L)
REGIONAL STATIONS							
Rio Chama at Chamita	0.0 (0.3)[a]	N/A	114.00 (82.00)	1.3 (0.1)	0.000 (0.010)	0.004 (0.009)	20 (70)
Rio Grande at Embudo	0.3 (0.3)	N/A	96.00 (237.00)	1.1 (0.1)	0.012 (0.017)	0.000 (0.010)	-10 (70)
Rio Grande at Otowi	0.2 (0.3)	N/A	101.00 (88.00)	1.5 (0.2)	0.010 (0.020)	0.005 (0.011)	-10 (70)
Rio Grande at Cochiti	0.5 (0.3)	N/A	175.00 (135.00)	1.6 (0.1)	0.004 (0.004)	0.000 (0.010)	60 (80)
Rio Grande at Bernalillo	0.1 (0.3)	N/A	151.00 (126.00)	1.9 (0.1)	0.004 (0.004)	0.013 (0.007)	-30 (70)
Jemez River	0.3 (0.3)	N/A	74.00 (88.00)	0.6 (0.1)	0.022 (0.010)	0.022 (0.012)	-180 (80)
PERIMETER STATIONS (OFF SITE)							
Radioactive Effluent Release Areas							
Acid-Pueblo Canyons							
Acid Weir	0.4 (0.3)	N/A	186.00 (122.00)	0.2 (0.1)	-0.005 (0.009)	0.025 (0.013)	190 (80)
Pueblo 1	1.9 (0.3)	N/A	324.00 (131.00)	0.1 (0.1)	-0.005 (0.005)	0.014 (0.008)	140 (70)
Pueblo 2		Dry in 1991					
Los Alamos Canyon							
Los Alamos at Rio Grande		See Section IV.E.5.a[b]					
Other Areas							
Guaje at Rio Grande	0.3 (0.3)	N/A	103.00 (124.00)	0.1 (0.1)	0.020 (0.014)	0.008 (0.010)	20 (70)
Los Alamos Reservoir	0.2 (0.3)	N/A	-23.00 (74.30)	<0.1 (0.0)	0.012 (0.012)	0.004 (0.007)	-190 (70)
Mortandad at Rio Grande	0.4 (0.3)	0.5 (0.6)	89.70 (66.00)	0.8 (0.5)	0.013 (0.015)	0.008 (0.008)	
Pajarito at Rio Grande	0.0 (0.3)	0.1 (0.6)	11.50 (63.20)	<0.8 (0.5)	0.004 (0.007)	0.000 (0.010)	
Frijoles at Park Headquarters	1.7 (0.3)	N/A	93.30 (123.00)	0.3 (0.1)	0.024 (0.017)	0.006 (0.010)	
Frijoles at Rio Grande	0.1 (0.3)	0.5 (0.6)	94.80 (68.80)	<0.5 (0.0)	0.008 (0.008)	0.000 (0.010)	-80 (7)
ON-SITE STATIONS							
Radioactive Effluent Release Areas							
Acid-Pueblo Canyons							
Pueblo 3	1.5 (0.3)	N/A	6.53 (9.31)	0.8 (0.1)	0.015 (0.041)	0.046 (0.046)	110 (70)
Pueblo at SR 502		See Section IV.E.5.a[b]					

Table IV-17 (Cont.)

Location	H^3 (pCi/L)	^{90}S (nCi/L)	^{137}Cs (pCi/L)	Uranium (μg/L)	^{238}Pu (pCi/L)	^{239}Pu (pCi/L)	Gross Gamma (Counts/min/L)
DP--Los Alamos Canyons							
DPS-1		Dry in 1991					
DPS-4		Dry in 1991					
Mortandad Canyon							
GS-1		See Section VII.C.1[c]					
Other Areas							
Cañada del Buey	0.5 (0.3)	N/A	10.10 (85.00)	0.3 (0.1)	0.000 (0.010)	0.010 (0.010)	120 (70)
Pajarito Canyon	0.1 (0.3)	N/A	334.00 (131.00)	0.1 (0.0)	0.004 (0.007)	0.013 (0.007)	90 (70)
Water Canyon at Beta	0.3 (0.3)	N/A	53.60 (67.70)	0.3 (0.0)	-0.004 (0.004)	0.004 (0.004)	10 (80)
Ancho at Rio Grande	0.0 (0.3)	0.7 (0.6)	-3.82 (73.20)	0.6 (0.5)	0.004 (0.004)	0.004 (0.004)	
Sandia Canyon							
SCS-1	0.2 (0.3)	N/A	88.00 (93.00)	1.0 (0.1)	0.005 (0.008)	0.009 (0.007)	110 (70)
SCS-2	0.5 (0.3)	N/A	273.00 (121.00)	0.9 (0.1)	0.013 (0.009)	0.008 (0.010)	50 (70)
SCS-3	0.4 (0.3)	N/A	N/A	0.8 (0.1)	0.000 (0.010)	0.000 (0.010)	200 (80)
Limits of Detection[d]	0.4	3	40	1	0.02	0.02	50
DCG for Public Dose[e]	2000	1000	3000	800	40	60	—

[a]Radioactivity counting uncertainties (±1 standard deviation) are shown in parentheses.
[b]See special study on transport of radioactivity on sediments in Pueblo and Los Alamos Canyons in Section IV.E.5.a of the Sediments and Soils Monitoring for sampling results.
[c]Individual result not available this year, see radiochemical results discussion in Section VII.C.1 for range of values.
[d]See Section VIII.D.
[e]See Appendix A.

are not in the expected ratio for worldwide fallout ($^{239,240}Pu$ about 20 times ^{238}Pu), it is unlikely the ^{238}Pu values are representative. The tritium level in the sample of Frijoles Stream at Bandelier Headquarters is higher than seen previously or than expected for regional waters; however, the sample at Frijoles taken further downstream at the Rio Grande does not show any detectable tritium. Most of the cesium analyses appear to be above the detection limits, but even the largest is about 10% of the DOE guide. Because the individual measurement uncertainties are so large (most more than half of the reported value and ranging up to almost 20 times) and are generally inconsistent with the gross gamma measurements, it is not likely that they represent real values. Improvements are being made to the cesium counting procedure and equipment for 1992 that are expected to result in more confidence in the measurements.

Multiple measurements of radioactivity on sediments transported in Pueblo and Los Alamos Canyons are presented and discussed in Sediment and Soils, Section IV.E.5.a.

b. Nonradioactive Analyses. The results of major chemical parameters in surface water samples for 1991 are listed in Table IV-18. The results are consistent with those observed in previous years, showing some expected variability. The measurements in waters from areas receiving effluents show some effect from these effluents. None of the measurements exceed any limits for drinking water systems even though such standards are not applicable to these surface waters.

The results of metal analyses on surface water samples for 1991 are listed in Table IV-19. The levels are generally consistent with previous observations in the effluent release areas. Most of the measurements were made for the first time this year (Regional and Perimeter-Other) and will serve as a base for future comparisons. The only levels above the Livestock and Wildlife Watering standards include the aluminum and selenium levels at the GS-1 location in Mortandad Canyon. One other selenium level, the sample from Water Canyon, is just below the standard. However, this second level is only slightly above the analytical method detection limit, which is 80% of the standard. An effort will be made in 1992 to obtain a lower selenium detection limit for more confidence in comparisons with standards.

Analyses for organics were performed on some surface waters this year. The analyses included the volatile, semivolatile, and PCB analyses (see Section VIII.D for detailed listings of parameters). None of the analyses detected the presence of any of the compounds. The sources sampled included Acid Weir, Pueblo 1, Pueblo 2, and Pueblo 3 in the Pueblo Canyon; DPS-1 and DPS-4 in Los Alamos Canyon; and SCS-1, SCS-2, SCS-3 in Sandia Canyon.

4. Long-Term Trends.

Long-term trends of dissolved radionuclide concentrations in surface water in Pueblo Canyon (a former release area) are depicted in Fig. IV-7. These measurements were made on samples collected at Station Pueblo 3, which is a short distance upstream of the confluence of Pueblo and Los Alamos Canyons. This is representative of the surface water flow that moves off site into the lower reach of Los Alamos Canyon on San Ildefonso Pueblo. In general, there has been a decrease in combined ^{238}Pu and $^{239,240}Pu$ (in solution) over three and a half decades, to the point where most recent measurements are below detection limits. The tritium concentrations peaked in 1982 and have decreased over the last 10 years to values typically observed in regional surface waters and very near the detection limit of the methods of analysis. More transport of radioactivity occurs as sediments are suspended and moved by the surface water flow. This aspect of off-site transport from Pueblo Canyon into Los Alamos Canyon is described in the following section, Sediment and Soil Monitoring.

E. Sediment and Soil Monitoring

1. Introduction.

Sediments and soils from regional, perimeter, and on-site locations are monitored to provide routine surveillance of environmental effects of Laboratory operations. One major mechanism of transport of contaminants is the hydrologic cycle, principally in surface water, as sheet erosion of soil, and subsequently as suspended sediment or bedload in surface runoff in canyons. Many contaminants have an affinity for attachment to soil or sediment particles by adsorption or ion exchange. Thus contaminants from airborne deposition, effluent discharges, or unplanned releases usually become associated with soils or sediments.

Table IV-18. Chemical Quality of Surface Waters (mg/L)

Station	SiO_2	Ca	Mg	K	Na	Cl	F	CO_3	HCO_3	PO_4-P	SO_4	NO_3-N	CN	TDS[a]	Total Hardness	pH[b]	Conductivity (µmho/em)
REGIONAL STATIONS																	
Rio Chama at Chamita	15	51	9.4	2.3	19	3	0.2	<5	78	0.2	112	<0.04	<0.01	722	168	8.0	320
Rio Grande at Embudo	21	31	5.2	2.4	12	3	0.3	<5	70	0.2	33	0.5	<0.01	148	101	8.0	181
Rio Grande at Otowi	20	43	7.2	2.4	17	4	0.3	<5	81	0.2	69	0.1	<0.01	106	139	8.0	257
Rio Grande at Cochiti	19	45	7.1	2.8	18	4	0.3	<5	80	0.1	64	0.1	<0.01	197	142	8.0	225
Rio Grande at Bernalillo	19	45	7.3	3.2	25	12	0.4	<5	89	0.2	72	0.1	<0.01	86	143	7.9	284
Jemez River	27	33	3.2	4.3	18	19	0.4	<5	67	0.1	13	0.0	<0.01	192	96	7.9	207
PERIMETER STATIONS (OFF SITE)																	
Radioactive Effluent Release Areas																	
Acid-Pueblo Canyons																	
Acid Weir	17	29	3.2	7.0	81	212	0.3	<2	35	0.3	12	0.7	<0.01	362	95	6.8	631
Pueblo 1	24	31	5.2	8.7	65	162	0.3	<2	53	0.7	18	0.3	<0.01	322	99	7.3	562
Pueblo 2		Dry in 1991															
Other Areas																	
Guaje Canyon	55	10	2.4	2.9	10	1	0.3	<5	39	0.3	5	0.0	0.01	176	35	7.4	89
Los Alamos Reservoir	32	9	2.7	2.2	9	9	0.2	<5	24	0.1	4	0.0	0.01	66	35	7.2	80
Mortandad at Rio Grande	89	26	7.7	14.0	80	49	1.1	12	119	8.2	35	8.7	<0.01	432	96	8.6	569
Pajarito at Rio Grande	70	20	4.8	2.2	12	6	0.4	<5	83	0.3	5	0.7	<0.01	198	69	8.3	177
Frijoles at Park Headquarters	49	10	2.8	2.0	11	4	0.2	<5	33	0.3	5	0.0	0.01	90	37	7.5	89
Frijoles at Rio Grande	59	10	3.3	2.6	10	3	<0.2	<5	55	0.3	3	<0.04	<0.01	144	38	7.3	98
ON-SITE STATIONS																	
Radioactive Effluent Release Areas																	
Acid-Pueblo Canyons																	
Pueblo 3	72	24	3.3	14.9	79	51	0.9	<2	118	8.9	38	13.4	0.040	414	75	7.4	316
Mortandad Canyon																	
GS-1	39	190	33.0	43.0	180	7	0.3	<5	70	0.2	5	3.2	0.014	248	610	7.5	138
DP--Los Alamos Canyons																	
DPS-1			Dry in 1991														
DPS-4			Dry in 1991														

Table IV-18. (Cont.)

Station	SiO_2	Ca	Mg	K	Na	Cl	F	CO_3	HCO_3	PO_4-P	SO_4	NO_3-N	CN	TDS	Total Hardness	pH	Conductivity (µmho/em)
Other Areas																	
Cañada del Buey	33	16	3.3	3.3	34	57	0.6	<2	<2	0.2	62	6.0	<0.01	220	55	3.6	320
Pajarito Canyon	33	30	7.3	4.5	31	62	<0.2	<2	67	0.1	15	1.5	<0.01	218	105	8.0	286
Water Canyon at Beta	30	15	5.0	4.0	19	9	<0.2	<2	61	0.2	7	2.7	<0.01	168	58	6.8	172
Ancho at Rio Grande	75	13	3.4	2.4	11	2	0.4	<5	62	0.3	2	<0.04	<0.01	94	48	8.9	109
Sandia Canyon																	
SCS-1	73	32	5.0	13.0	91	62	0.8	2	126	3.2	99	0.8	0.010	494	101	8.3	636
SCS-2	74	32	4.9	12.8	88	63	0.8	2	122	3.2	109	0.8	0.010	484	100	8.3	665
SCS-3	74	32	4.9	12.8	86	62	0.8	2	123	16.0	98	0.8	0.023	492	122	8.3	650
Drinking Water System Limit						250[c]	4[d]				250[c]	10[d]		500[c]		6.8-8.5[c]	
Livestock and Wildlife Watering								None in this table[e]									

[a]Total dissolved solids.
[b]Standard Units.
[c]Maximum contaminent level for secondary constituents, applicable to drinking water system, given here for comparison only, see Appendix A.
[d]Maximum contaminent level for primary constituents, applicable to drinking water system, given here for comparison only, see Appendix A.
[e]New Mexico Water Quality Standards applicable to streams for designated uses, given here for comparison only, see Appendix A.

Table IV-19. Trace Metals in Surface Waters (mg/L)

Location	Ag	Al	As	B	Be	Cd	Cr	Co	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
REGIONAL STATIONS																						
Rio Chama at Chamita	<0.0005[a]	0.4	<0.01	0.03	<0.001	<0.01	<0.002	N/A	<0.02	0.37	<0.0002	0.120	<0.002	<0.01	0.002	<0.0001	<0.02	N/A	0.355	0.0002	0.012	0.007
Rio Grande at Embudo	<0.0005	0.5	<0.01	0.02	<0.001	<0.01	<0.002	N/A	<0.02	0.68	<0.0002	0.240	<0.002	<0.01	0.003	0.0002	<0.02	N/A	0.161	<0.0002	0.010	0.030
Rio Grande at Otowi	0.001	0.5	0.010	0.03	<0.001	<0.01	0.002	N/A	<0.02	0.51	<0.0002	0.180	<0.002	<0.01	0.004	<0.0001	<0.02	N/A	0.252	<0.0002	0.012	0.018
Rio Grande at Cochiti	<0.0005	0.2	<0.01	0.03	<0.001	<0.01	<0.002	N/A	<0.02	0.14	<0.0002	0.002	0.003	<0.01	0.001	0.0001	<0.02	N/A	0.239	<0.0002	0.010	<0.001
Rio Grande at Bernalillo	<0.0005	0.5	<0.01	0.07	<0.001	<0.01	<0.002	N/A	<0.02	0.51	<0.0002	0.100	0.003	<0.01	0.002	<0.0001	<0.02	N/A	0.299	<0.0002	0.011	0.009
Jemez River	<0.0005	0.4	0.020	0.15	<0.001	<0.01	<0.002	N/A	<0.02	0.41	<0.0002	0.070	<0.002	<0.01	0.001	<0.0001	<0.02	N/A	0.097	<0.0002	0.007	0.006
PERIMETER STATIONS (OFF SITE)																						
Effluent Release Areas																						
Acid-Pueblo Canyons																						
Acid Weir	<0.0005	<0.02	0.002	0.00	<0.0005	<0.0003	<0.001	<0.003	<0.001	<0.004	0.0004	0.002	<0.001	<0.02	0.000	0.0002	<0.03	<0.02	0.123	0.0001	0.004	<0.0033
Pueblo 1	<0.0005	<0.02	0.003	0.04	<0.0005	<0.0003	<0.001	<0.003	0.002	0.23	0.0004	0.220	0.002	<0.02	0.001	0.0002	<0.03	<0.02	0.135	<0.0001	0.006	0.004
Other Areas																						
Guaje Canyon	0.001	0.2	<0.02	0.01	<0.001	<0.005	0.0020	N/A	<0.007	0.11	<0.0002	0.007	<0.006	<0.01	0.001	<0.0005	<0.04	N/A	0.038	<0.0001	<0.003	0.008
Los Alamos Reservoir	0.001	0.1	<0.02	0.01	<0.001	<0.005	<0.002	N/A	<0.007	0.10	<0.0002	0.014	<0.006	<0.01	0.001	<0.0005	<0.04	N/A	0.045	<0.0001	0.004	0.006
Mortandad at Rio Grande	<0.0005	0.1	0.003	0.32	<0.0005	<0.004	<0.0005	N/A	0.031	0.70	<0.0002	0.005	N/A	0.010	0.001	<0.002	<0.03	N/A	0.125	<0.0005	0.011	0.019
Frijoles at Park Headquarters	<0.0005	0.3	<0.02	0.01	<0.001	<0.005	<0.002	N/A	<0.007	0.26	<0.0002	0.021	<0.006	<0.01	0.002	<0.0005	<0.04	N/A	0.062	<0.0001	0.005	0.009
Frijoles at Rio Grande	<0.0005	0.2	0.002	0.02	<0.0005	<0.001	0.0021	N/A	0.002	0.20	<0.0002	0.007	N/A	<0.006	0.001	<0.001	<0.03	N/A	0.062	<0.0005	0.005	0.014
ON-SITE STATIONS																						
Radioactive Effluent Release Areas																						
Acid-Pueblo Canyons																						
Pueblo 3	0.002	0.5	0.013	0.32	<0.0005	<0.0003	0.0032	<0.003	0.010	0.67	0.0004	0.017	0.004	<0.02	0.001	0.0004	<0.03	<0.02	0.108	<0.0001	0.026	0.033
Mortandad Canyon																						
GS-1	<0.0005	14.0	0.004	0.29	<0.0005	<0.0005	0.0063	0.060	0.006	11.00	0.0004	0.045	0.062	0.040	0.005	<0.0005	0.670	0.130	0.080	<0.0005	0.009	0.023
Other Areas																						
Cañada del Buey	0.002	0.3	<0.0017	0.07	<0.0005	<0.0003	0.0072	<0.008	0.006	0.77	<0.0002	0.518	0.101	0.010	0.002	0.0003	<0.04	<0.01	0.076	0.0002	0.003	0.054
Pajarito Canyon	0.001	0.1	<0.0015	0.04	<0.0005	<0.0003	0.0022	<0.008	<0.001	2.40	0.0002	0.064	0.001	<0.01	0.000	0.0003	<0.04	0.010	0.147	0.0002	0.001	0.005
Water Canyon at Beta	<0.002	2.5	<0.002	0.09	<0.0003	0.0021	<0.002	<0.008	<0.002	1.10	<0.0002	0.014	<0.002	<0.015	0.002	0.0003	0.048	0.026	0.090	<0.0005	<0.002	N/A
Ancho at Rio Grande	<0.0005	0.0	0.002	0.02	<0.0005	<0.0005	0.0034	N/A	<0.002	0.05	<0.0002	0.003	N/A	<0.006	<0.0005	<0.001	<0.03	N/A	0.071	<0.0005	0.009	<0.005

Table IV-19. (Cont.)

Location	Ag	Al	As	B	Be	Cd	Cr	Co	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
Sandia Canyon																						
SCS-1	0.001	0.1	N/A	0.11	<0.0005	N/A	0.0144	<0.008	0.012	0.36	<0.0002	0.015	0.179	0.010	0.003	0.0005	<0.04	0.020	0.115	0.0002	0.011	0.030
SCS-2	0.001	0.2	N/A	0.11	<0.0005	N/A	0.0131	<0.008	0.010	0.46	<0.0002	0.008	0.176	<0.01	0.012	0.0003	<0.04	0.020	0.114	0.0002	0.011	0.031
SCS-3	0.001	0.1	N/A	0.11	<0.0005	N/A	0.0130	<0.008	0.010	0.36	<0.0002	0.007	0.180	<0.01	0.003	0.0007	<0.04	0.020	0.113	0.0002	0.011	0.037
Drinking Water System Limit	0.05[b]		0.05[b]	0		.01[b]	0.05[b]		1.0[c]	0.3[c]	0.002[b]	0.05[c]			0.05[b]		0.01[b]					5.0[c]
Livestock and Wildlife Watering Limit[d]		5.0	0.02	5.0		0.05	1.0	1.0	0.5		0.01				0.1		0.05				0.1	25

[a]Less than symbol (<) means measurement was below the specified detection limit of the analytical method.
[b]Maximum contaminent level for primary constituents, applicable to drinking water system, given here for comparison only, see Appendix A.
[c]Maximum contaminent level for secondary constituents, applicable to drinking water system, given here for comparison only, see Appendix A.
[d]New Mexico Water Quality Standards applicable to streams for designated uses, given here for comparison only, see Appendix A.

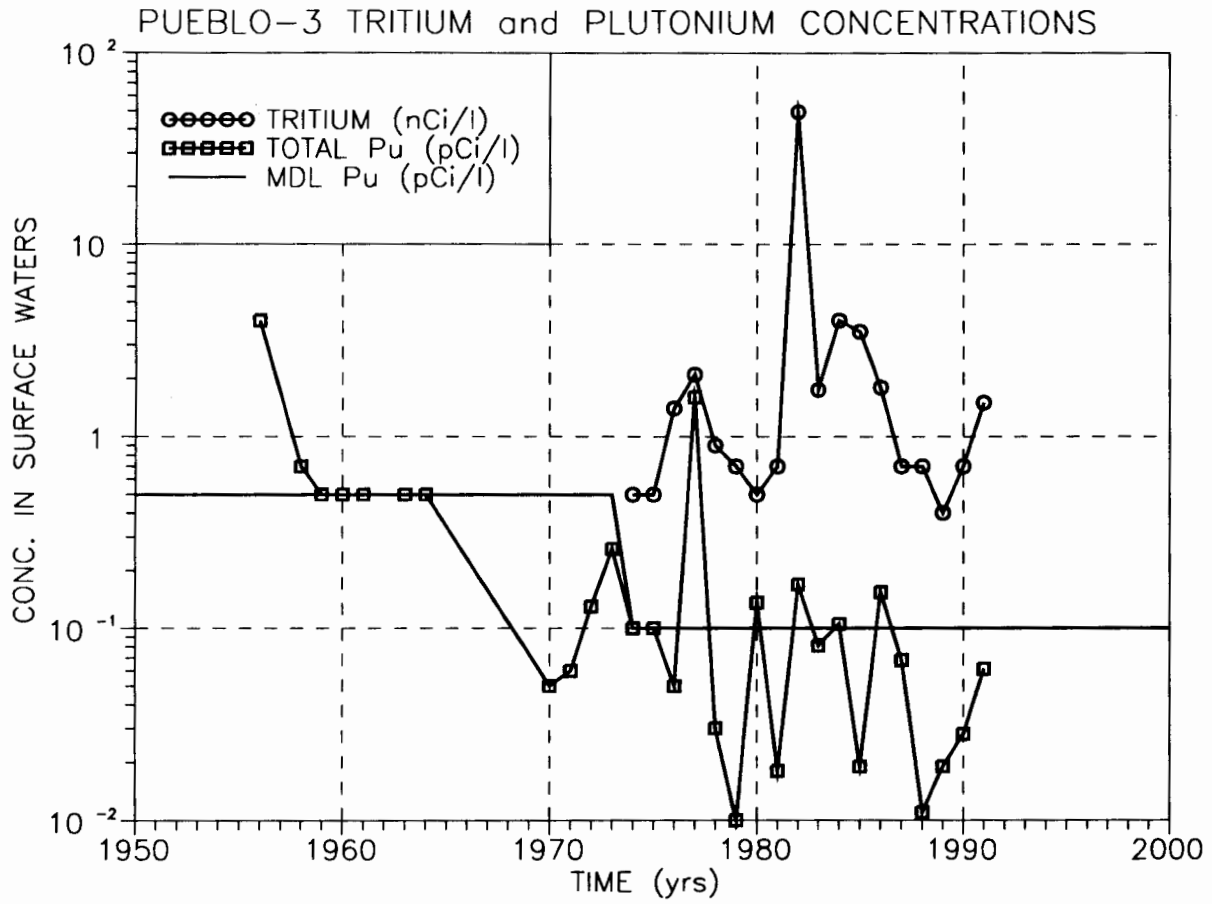


Fig. IV-7. Pueblo-3, tritium and plutonium concentrations.

Accordingly, soils are monitored at representative locations across the Laboratory, and sediments are sampled in all canyons, whether perennial or intermittent, that cross the Laboratory lands.

There are no standards directly applicable to radioactive contamination of soils or sediments; rather, the levels of contaminants on soils or sediments must be interpreted by means of pathway analyses that determine the consequences in terms of dose to humans if the contaminated particles are either ingested or inhaled. (See Section V.C.2, Methods of Dose Calculations, for further information.) As an indication of environmental contamination levels attributable to Los Alamos operations, the results of the annual sampling are compared to levels attributable to worldwide fallout or natural background. Results of analyses of radionuclides in soil and sediment samples from regional stations routinely collected from 1974 through 1986 were used to establish statistical limits for worldwide fallout levels of H^3, ^{90}Sr, ^{137}Cs, ^{238}Pu, and $^{239,240}Pu$ and natural background levels of total uranium in northern New Mexico soils and sediments (Purtymun 1987a). The average of the concentration levels in these samples plus twice the standard deviation of the mean was used to establish the upper limits of worldwide fallout or natural background concentrations.

2. Monitoring Network.

The sediment sampling locations are shown in Fig. IV-8 (Regional), Fig. IV-9 (Perimeter and On Site), and Fig. IV-10 (Solid Waste Management Areas) and are listed in Table D-10. The locations of the soil sampling locations are shown in Fig. IV-8 (Regional) and Fig. IV-11 (Perimeter and On Site), and listed in Table D-11. The sediment stations are organized in the same groupings as the surface water sampling locations discussed in the previous section, Surface Water Monitoring. That section contains the basic rationale for the groupings and related historic information. Some detail specific to sediment samples is included in the following paragraphs.

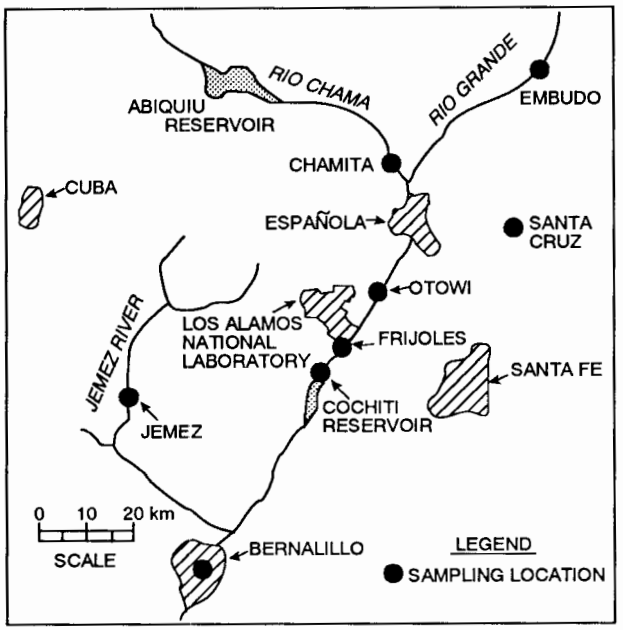


Fig. IV-8. Regional sampling locations for sediments and soil. (Four additional sediment samples are taken from the Rio Grande between Otowi and Frijoles, see Table D-10 and Fig. IV-9.)

a. Regional Stations. The regional stations for both soils and stream sediments are located in the three major drainages in northern New Mexico surrounding the Laboratory. One additional soil station is located near Santa Cruz Lake, across the Rio Grande valley to the northeast of the Laboratory.

Special samples of lake sediments are also collected from three locations in Abiquiu Reservoir on the Rio Chama upstream from Los Alamos, and three locations in Cochiti Reservoir on the Rio Grande downstream of Los Alamos. The two lakes are the nearest upstream and downstream lakes. These sediment samples are used to obtain better detection limits when analyzing for ^{238}Pu and ^{239,240}Pu by using 1 kg samples (100 times the mass usually used for analyses). Large samples increase the sensitivity of the plutonium analyses and are necessary to effectively evaluate plutonium concentrations due to worldwide fallout from atmospheric tests.

b. Perimeter (Off-Site) Stations. The Radioactive Effluent Release Area sediment stations are located to represent the off-site drainages affected by transport of residuals from past releases, as discussed in the previous section. The off-site Acid Canyon and Pueblo Canyon areas contain an estimated 150 mCi of plutonium from the 1944–1964 effluent releases into Acid Canyon (ESG 1981), the sampling station at Acid Weir at the confluence of Acid and Pueblo Canyons. The off-site portion of Los Alamos Canyon contains an estimated 30 mCi of plutonium; three stations are sampled routinely. Transport of contaminated sediments off site is discussed below. Other sediment locations are sampled in order to cover all the canyons including those without perennial flow. Several sediment samples are collected in the off-site portion of Mortandad Canyon on San Ildefonso Pueblo to document conditions downgradient from the on-site residual contamination as discussed in the previous section. Also, sediment samples are taken in the Rio Grande at confluences with major canyons that cross the Laboratory and adjacent public or San Ildefonso Pueblo lands.

The six perimeter soil stations within 4 km (2.5 mi) of the Laboratory perimeter are located to emphasize the inhabited areas to the north and east of the Laboratory.

c. On-Site Stations. The on-site sediment stations are grouped into Radioactive Effluent Release Areas, Solid Waste Management Areas, and Other Canyons.

The Radioactive Effluent Release Areas are the same as those used for the Surface Water Stations (see Section IV.D.2 for historic information). Transport of contaminated sediments off site from Pueblo Canyon is discussed below. Transport of contaminated sediments within the on-site portion of Mortandad Canyon and the sediment traps is discussed below. No off-site transport of contaminated sediments from Mortandad Canyon has occurred; no contaminated runoff has reached or extended past the Laboratory boundary since before the TA-50 treatment plant started operating in 1963.

Sediments from natural drainages around two Radioactive Solid Waste Management Areas are sampled to monitor transport of radioactivity from surface contamination. Nine sampling stations were established in 1982 outside the perimeter fence at TA-54, Area G (Fig. IV-10b), to monitor possible transport of radionuclides by sheet erosion from the active waste storage and disposal area. Some radionuclides are transported from the surface at Area G in suspended or bed sediments into channels that drain the area. This contamination is from the land surface and is not related to the buried wastes in the pits and shafts. It is

residual contamination in the land surface that occurred during earlier handling of the wastes.

From 1959 to 1961, hydronuclear experiments were conducted in underground shafts that ranged in depth from 15 to 36 m (50 to 120 ft) beneath the surface of the mesa at TA-49 (Purtymun 1987b, ESG 1988). The experiments involved a combination of conventional (chemical) high explosives, usually in a nuclear weapons configuration. The quantity of fissile material was kept far below the amount required for a nuclear explosion (Purtymun 1987b). The residuals of the experiments were confined in the shafts and left in place. The site is designated Solid Waste Management Area AB. A surface contamination incident occurred in 1960, and some erosional transport of radioactivity occurred (Purtymun 1987b, ESG 1988). Eleven sediment stations were established in 1972 to monitor surface sediments in natural drainage from the experimental area. Another station (AB-4A) was added in 1981 as the drainage changed (Fig. IV-10a).

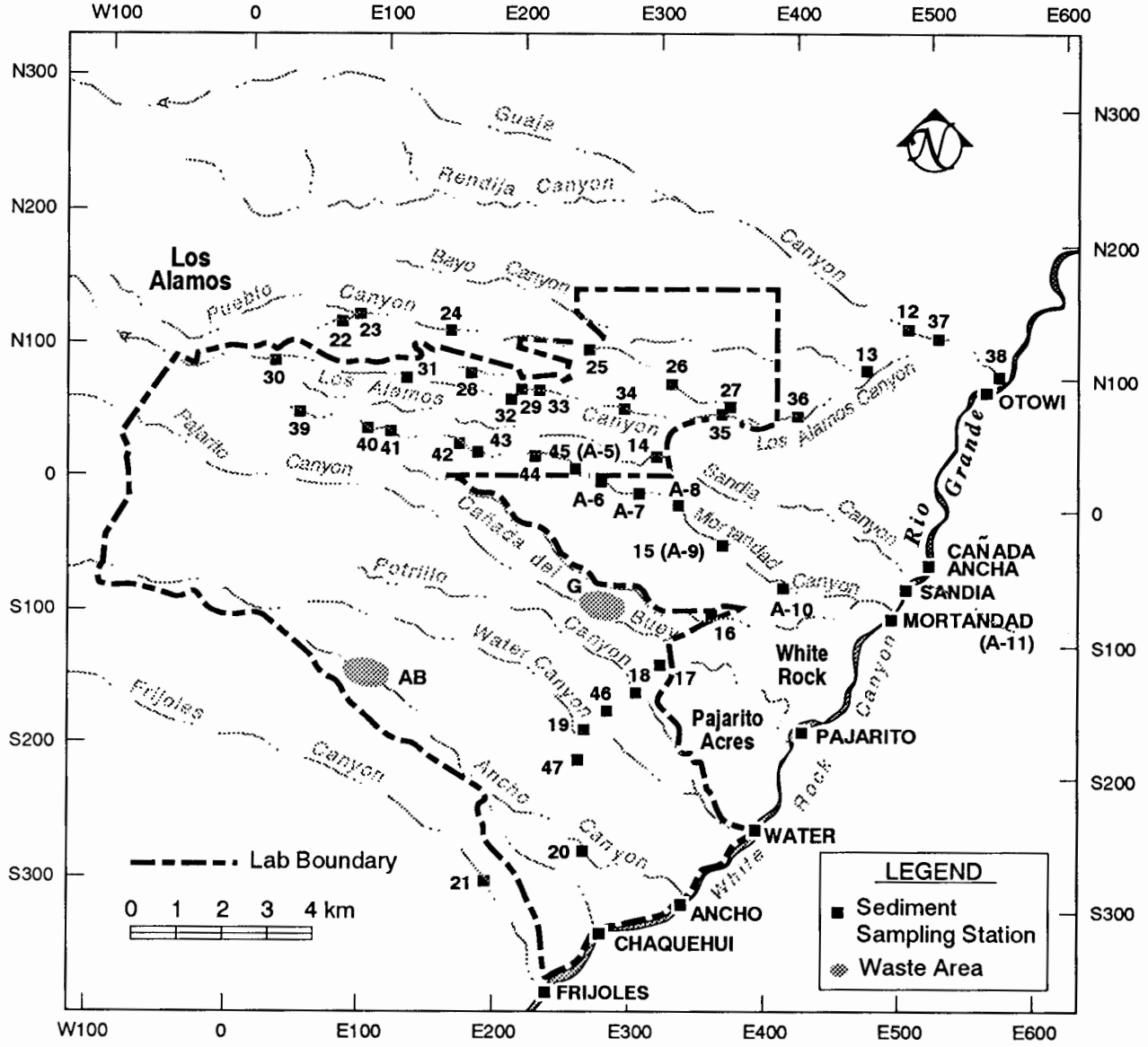
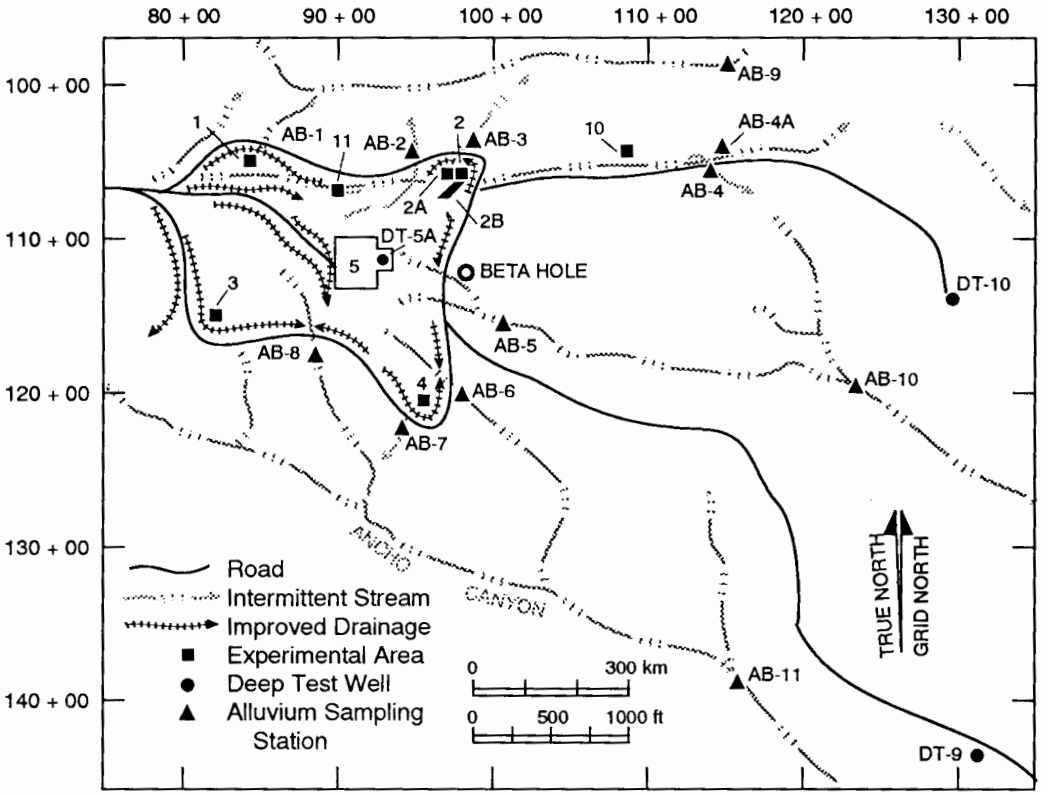


Fig. IV-9. Sediment sampling locations on and near the Laboratory site. Waste areas with multiple sampling locations are shown in Fig. IV-10. (Map denotes general locations only; see Table D-10 for specific locations.)



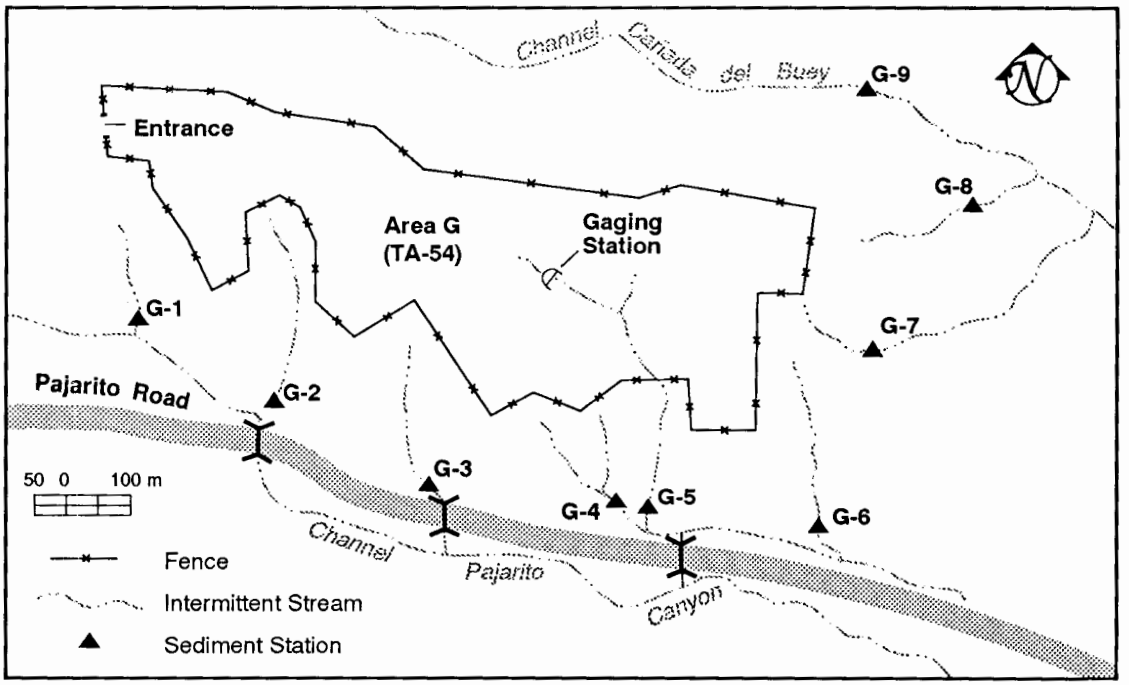


Fig. IV-10. Sediment sampling locations on and near solid waste management areas.
a. Upper map shows the location of experimental areas and sediment stations at TA-49, Area AB.
b. Bottom map shows the locations of alluvium sampling stations at TA-54, Area G.

Eight sediment sampling stations are in the Other Canyons group. These are located where the canyons intersect State Road 4 because all Laboratory facilities in or adjacent to those canyons are located upgradient of the state road.

The on-site soil sampling stations (Table D-10 and Fig. IV-11) are located near major Laboratory facilities that are principal sources of airborne emissions or could be potential contaminant sources.

3. Analytical Results.

a. Radiochemical Analyses. The results of radiochemical analyses of regional, perimeter, and on-site sediment samples for 1991 are listed in Table IV-20. The results of radiochemical analyses of radioactive solid waste area sediment samples for 1991 are listed in Table IV-21.

The results of radiochemical analyses of soil samples for 1991 are listed in Table IV-22.

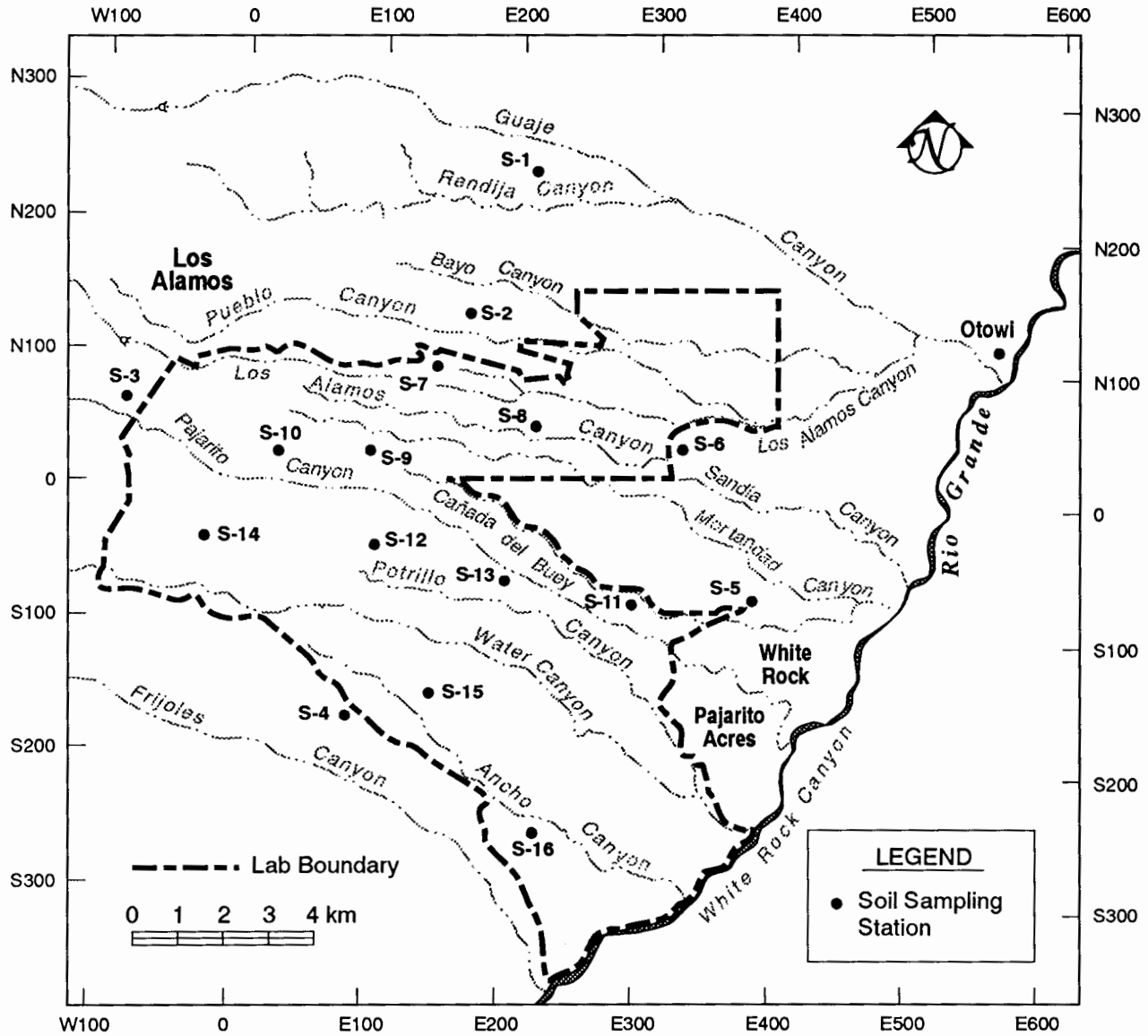


Fig. IV-11. Soil sampling locations on or near the Laboratory site. (Map denotes generalized locations only; refer to Table D-11 for specific locations.)

Table IV-20. Radiochemical Analyses of Sediments

Location	H^3 (nCi/L)[a]	^{90}Sr (pCi/g)	^{137}Cs (pCi/g)	Total Uranium (µg/g)	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)	^{241}Am (pCi/g)	Gross Alpha (pCi/g)	Gross Beta (pCi/g)	Gross Gamma (counts/min/g)
REGIONAL STATIONS										
Chamita	N/A[b]	0.100 (0.200)[c]	0.1 (0.1)	2.6 (0.3)	0.001 (0.001)	0.002 (0.001)	N/A	3 (1)	3 (0)	1 (0)
Embudo	N/A	0.100 (0.200)	0.0 (0.1)	3.0 (0.3)	0.011 (0.002)	0.004 (0.001)	N/A	2 (1)	3 (0)	-0 (0)
Rio Grande at Otowi	N/A	0.200 (0.200)	0.1 (0.1)	2.4 (0.2)	0.002 (0.001)	0.002 (0.001)	N/A	3 (1)	2 (0)	1 (0)
Rio Grande at Frijoles	-0.5 (0.3)	0.000 (0.200)	0.2 (0.1)	4.1 (0.4)	0.002 (0.001)	0.004 (0.001)	N/A	3 (1)	4 (0)	2 (0)
Rio Grande at Cochiti	Channel completely scoured, no sediment in 1991									
Rio Grande at Bernalillo	N/A	0.200 (0.200)	0.1 (0.1)	1.6 (0.2)	0.002 (0.001)	0.004 (0.001)	N/A	3 (1)	2 (0)	-0 (0)
Jemez River	N/A	0.200 (0.200)	0.0 (0.1)	2.4 (0.2)	0.001 (0.001)	0.002 (0.001)	N/A	4 (1)	3 (0)	0 (0)
Rio Grande in White Rock Canyon										
Rio Grande at Sandia	-0.6 (0.3)	0.200 (0.200)	0.2 (0.1)	3.2 (0.3)	0.001 (0.001)	0.004 (0.001)	N/A	3 (1)	3 (0)	2 (0)
Rio Grande at Pajarito	-0.5 (0.3)	0.100 (0.200)	0.2 (0.1)	2.6 (0.3)	0.008 (0.002)	0.001 (0.001)	N/A	2 (1)	2 (0)	1 (0)
Rio Grande at Water Canyon	-0.3 (0.3)	0.000 (0.200)	0.2 (0.1)	2.7 (0.3)	0.001 (0.001)	0.002 (0.001)	N/A	4 (1)	4 (1)	1 (0)
Rio Grande at Ancho	-0.6 (0.3)	0.200 (0.200)	0.3 (0.1)	2.2 (0.2)	0.002 (0.001)	0.001 (0.001)	N/A	2 (1)	2 (0)	1 (0)
Rio Grande at Chaquehui	-0.4 (0.3)	0.200 (0.200)	0.0 (0.1)	2.3 (0.2)	0.001 (0.000)	0.003 (0.001)	N/A	3 (1)	3 (0)	1 (0)
PERIMETER STATIONS (OFF SITE)										
Radioactive Effluent Release Areas										
Acid-Pueblo Canyon										
Acid Weir	N/A	0.600 (0.200)	0.5 (0.1)	2.2 (0.2)	0.036 (0.006)	7.280 (0.420)	N/A	8 (2)	2 (0)	0 (0)
Pueblo 1	N/A	0.200 (0.200)	0.1 (0.1)	2.3 (0.2)	0.002 (0.001)	0.055 (0.004)	N/A	4 (1)	2 (0)	1 (0)
Pueblo 2	N/A	0.200 (0.200)	0.1 (0.1)	2.1 (0.2)	0.000 (0.002)	0.008 (0.001)	N/A	3 (1)	2 (0)	1 (0)
DP–Los Alamos Canyon										
Los Alamos at Totavi	N/A	0.100 (0.200)	0.0 (0.1)	4.2 (0.4)	0.003 (0.001)	0.003 (0.001)	N/A	2 (0)	2 (0)	2 (0)
Los Alamos at LA-2	N/A	0.300 (0.200)	-0.1 (0.1)	2.6 (0.3)	0.004 (0.001)	0.002 (0.001)	N/A	2 (1)	1 (0)	1 (0)
Los Alamos at Otowi	N/A	0.200 (0.200)	0.0 (0.1)	2.1 (0.2)	0.002 (0.002)	0.059 (0.004)	N/A	1 (0)	1 (0)	-1 (0)
Other Areas										
Guaje at SR-4	N/A	0.200 (0.200)	0.1 (0.1)	2.4 (0.2)	0.001 (0.001)	0.001 (0.001)	N/A	2 (1)	1 (0)	1 (0)
Bayo at SR-4	N/A	0.500 (0.200)	0.0 (0.1)	2.8 (0.3)	0.002 (0.001)	0.005 (0.001)	N/A	2 (1)	2 (0)	1 (0)
Sandia at Rio Grande	-0.4 (0.8)	0.000 (0.200)	0.0 (0.1)	1.7 (0.2)	0.002 (0.001)	0.001 (0.001)	N/A	3 (1)	1 (0)	1 (0)
Cañada Ancha at Rio Grande	-1.7 (0.8)	0.000 (0.200)	0.1 (0.1)	1.7 (0.2)	0.002 (0.001)	0.002 (0.001)	N/A	3 (1)	28 (3)	0 (0)

Table IV-20. (Cont.)

Location	H^3 (nCi/L)	^{90}Sr (pCi/g)	^{137}Cs (pCi/g)	Total Uranium (µg/g)	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)	^{241}Am (pCi/g)	Gross Alpha (pCi/g)	Gross Beta (pCi/g)	Gross Gamma (counts/min/g)
Other Areas, Cont.										
Pajarito at Rio Grande	-0.8 (0.3)	0.200 (0.100)	0.1 (0.1)	3.2 (0.3)	0.004 (0.001)	0.010 (0.002)	N/A	4 (1)	4 (0)	1 (0)
Water Canyon at Rio Grande	-0.8 (0.3)	0.000 (0.300)	0.4 (0.1)	2.0 (0.2)	0.001 (0.001)	0.003 (0.001)	N/A	2 (1)	1 (0)	2 (0)
Ancho at Rio Grande	-0.4 (0.3)	0.200 (0.200)	0.1 (0.1)	1.3 (0.1)	0.004 (0.001)	0.003 (0.001)	N/A	2 (1)	1 (0)	0 (0)
Chaquehui at Rio Grande	28.0 (3.0)	0.200 (0.100)	0.4 (0.1)	2.4 (0.2)	0.000 (0.001)	0.004 (0.001)	N/A	3 (1)	2 (0)	1 (0)
Frijoles at National Monument Headquarters	N/A	0.000 (0.200)	0.3 (0.1)	2.3 (0.2)	0.002 (0.001)	0.004 (0.001)	N/A	2 (1)	1 (0)	1 (0)
Frijoles at Rio Grande	-0.2 (0.3)	0.100 (0.200)	0.3 (0.1)	2.8 (0.3)	0.000 (0.001)	0.002 (0.001)	N/A	2 (1)	2 (0)	2 (0)
Mortandad Canyon on San Ildefonso Lands										
Mortandad A-6	0.5 (0.3)	0.500 (0.200)	1.1 (0.2)	2.5 (0.2)	0.002 (0.001)	0.031 (0.003)	N/A	6 (1)	5 (1)	2 (0)
Mortandad A-7	0.4 (0.3)	0.300 (0.100)	0.2 (0.1)	5.4 (0.5)	0.002 (0.001)	0.020 (0.002)	N/A	5 (1)	5 (1)	4 (1)
Mortandad A-8	0.0 (0.3)	0.200 (0.200)	0.3 (0.1)	3.2 (0.3)	0.001 (0.001)	0.023 (0.002)	N/A	6 (1)	3 (0)	2 (0)
Mortandad at SR-4 (A-9)	N/A	0.200 (0.200)	-0.1 (0.1)	1.0 (0.1)	0.005 (0.004)	0.002 (0.001)	N/A	2 (1)	2 (0)	1 (0)
Mortandad A-10	0.6 (0.3)	0.000 (0.200)	0.2 (0.1)	2.3 (0.2)	0.006 (0.001)	0.003 (0.001)	N/A	3 (1)	2 (0)	2 (0)
Mortandad at Rio Grande	-0.4 (0.3)	0.300 (0.200)	0.1 (0.1)	2.8 (0.3)	0.008 (0.002)	0.001 (0.001)	N/A	3 (1)	4 (0)	2 (0)
ON SITE STATIONS										
Radioactive Effluent Release Areas										
Acid-Pueblo Canyon										
Hamilton Bend Spring	N/A	0.200 (0.200)	0.0 (0.1)	2.7 (0.3)	0.003 (0.003)	0.138 (0.007)	N/A	3 (1)	1 (0)	1 (0)
Pueblo 3	N/A	0.300 (0.200)	0.0 (0.1)	2.7 (0.3)	0.004 (0.002)	0.132 (0.006)	N/A	2 (1)	1 (0)	1 (0)
Pueblo at SR-4	N/A	0.200 (0.200)	0.2 (0.1)	1.2 (0.1)	0.003 (0.001)	0.424 (0.016)	N/A	2 (1)	1 (0)	0 (0)
DP–Los Alamos Canyon										
DPS-1	N/A	0.300 (0.200)	2.7 (0.4)	1.8 (0.2)	0.013 (0.002)	0.032 (0.003)	N/A	2 (1)	2 (0)	0 (0)
DPS-4	N/A	0.200 (0.200)	0.0 (0.1)	1.8 (0.2)	0.003 (0.001)	0.022 (0.002)	N/A	4 (1)	2 (0)	1 (0)
Los Alamos at Bridge	N/A	0.300 (0.200)	0.0 (0.1)	1.8 (0.2)	0.002 (0.001)	0.003 (0.001)	N/A	2 (1)	1 (0)	0 (0)
Los Alamos at LAO-1	N/A	0.300 (0.200)	0.0 (0.1)	2.1 (0.2)	0.001 (0.001)	0.001 (0.001)	N/A	4 (1)	2 (0)	-1 (0)
Los Alamos at GS-1	N/A	0.300 (0.200)	1.7 (0.3)	2.4 (0.2)	0.028 (0.002)	0.189 (0.008)	N/A	2 (0)	2 (0)	2 (0)
Los Alamos at LAO-3	N/A	0.200 (0.200)	1.3 (0.2)	2.0 (0.2)	0.040 (0.003)	0.148 (0.007)	N/A	2 (1)	3 (0)	1 (0)
Los Alamos at LAO4.5	N/A	0.100 (0.200)	1.5 (0.3)	1.7 (0.2)	0.028 (0.003)	0.154 (0.007)	N/A	1 (0)	2 (0)	1 (0)
Los Alamos at SR-4	N/A	0.200 (0.200)	0.6 (0.1)	2.1 (0.2)	0.016 (0.002)	0.074 (0.005)	N/A	2 (1)	2 (0)	0 (0)

Table IV-20. (Cont.)

Location	H^3 (nCi/L)	^{90}Sr (pCi/g)	^{137}Cs (pCi/g)	Total Uranium (µg/g)	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)	^{241}Am (pCi/g)	Gross Alpha (pCi/g)	Gross Beta (pCi/g)	Gross Gamma (counts/min/g)
Mortandad Canyon										
Mortandad near CMR	N/A	0.100 (0.200)	0.0 (0.1)	1.5 (0.1)	0.010 (0.002)	0.004 (0.001)	N/A	2 (0)	2 (0)	-2 (0)
Mortandad west of GS-1	N/A	0.400 (0.200)	0.3 (0.1)	3.0 (0.3)	0.015 (0.002)	0.011 (0.002)	N/A	3 (1)	4 (0)	1 (0)
Mortandad at GS-1	N/A	3.900 (0.400)	106.0 (15.9)	1.9 (0.2)	2.590 (0.090)	7.950 (0.260)	N/A	23 (5)	89 (9)	43 (4)
Mortandad at MCO-5	N/A	3.400 (0.300)	35.1 (5.3)	1.5 (0.1)	4.600 (0.300)	16.700 (1.000)	N/A	36 (7)	26 (3)	18 (2)
Mortandad at MCO-7	N/A	1.100 (0.200)	23.7 (3.6)	1.6 (0.1)	3.000 (0.200)	10.700 (0.600)	N/A	28 (6)	18 (2)	12 (1)
Mortandad at MCO-9	N/A	0.400 (0.200)	0.5 (0.1)	4.8 (0.5)	0.013 (0.002)	0.023 (0.002)	N/A	6 (1)	5 (1)	5 (1)
Mortandad at MCO-13 (A-5)	N/A	0.200 (0.200)	0.6 (0.1)	1.9 (0.2)	0.003 (0.001)	0.025 (0.002)	N/A	6 (1)	4 (1)	3 (1)
Other Canyons										
Sandia at SR-4	N/A	0.200 (0.200)	0.1 (0.1)	2.3 (0.2)	0.007 (0.003)	0.005 (0.002)	N/A	2 (1)	1 (0)	1 (0)
Cañada del Buey at SR-4	N/A	0.000 (0.200)	0.1 (0.1)	1.4 (0.1)	0.005 (0.003)	0.015 (0.004)	N/A	2 (1)	2 (0)	1 (0)
Pajarito at SR-4	Channel completely scoured, no sediment in 1991									
Potrillo at SR-4	N/A	0.200 (0.200)	0.0 (0.1)	2.5 (0.2)	0.007 (0.002)	0.010 (0.002)	N/A	3 (1)	2 (0)	1 (0)
Fence at SR-4	No sample in 1991									
Water at SR-4	N/A	0.100 (0.200)	0.1 (0.1)	1.8 (0.2)	0.001 (0.001)	0.005 (0.001)	N/A	2 (1)	1 (0)	1 (0)
Indio at SR-4	No sample in 1991									
Ancho at SR-4	N/A	0.100 (0.200)	0.1 (0.1)	3.8 (0.4)	0.006 (0.001)	0.003 (0.001)	N/A	3 (1)	3 (0)	2 (0)
Background Statistical Limit[d]	—	0.87	0.44	4.4	0.006	0.023	—	—	—	7.9

[a]Tritium as tritiated water in moisture distilled from sample.

[b]N/A means analysis not performed, lost in analysis, or not completed.

[c]Radioactivity counting uncertainties (±1 standard deviation) are shown in parentheses.

[d]Average plus 2 standard deviations of measurements in regional samples 1974–1986 (Purtymun 1987a).

Table IV-21. Radiochemical Analyses of Solid Waste Area Sediment Samples

Location	H^3 (nCi/L)[a]	^{90}Sr (pCi/g)	^{137}Cs (pCi/g)	Total Uranium (μg/g)	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)	^{241}Am (pCi/g)	Gross Alpha (pCi/g)	Gross Beta (pCi/g)	Gross Gamma (cpm/g)
TA-54, AREA G										
G-1	0.1 (0.3)[b]	0.1 (0.1)	0.1 (0.1)	2.3 (0.2)	0.005 (0.002)	0.005 (0.001)	N/A[c]	3 (1)	1 (0)	1 (1)
G-2	5.2 (0.6)	0.0 (0.1)	0.3 (0.1)	1.8 (0.2)	0.007 (0.003)	0.004 (0.001)	N/A	5 (1)	2 (0)	-0 (1)
G-3	6.5 (0.7)	0.3 (0.1)	0.3 (0.1)	2.3 (0.2)	0.005 (0.003)	0.012 (0.002)	N/A	6 (1)	3 (0)	2 (1)
G-4	2.8 (0.4)	0.2 (0.1)	0.4 (0.2)	3.1 (0.3)	0.002 (0.002)	0.011 (0.002)	N/A	5 (1)	3 (0)	3 (1)
G-5	2.1 (0.4)	0.1 (0.1)	0.3 (0.1)	2.4 (0.2)	0.008 (0.003)	0.089 (0.005)	N/A	13 (3)	2 (0)	3 (1)
G-6	3.2 (0.4)	0.2 (0.1)	0.2 (0.1)	2.2 (0.2)	0.002 (0.003)	0.040 (0.003)	N/A	6 (1)	2 (0)	5 (1)
G-7	0.0 (0.3)	0.1 (0.2)	0.2 (0.1)	4.0 (0.4)	0.009 (0.003)	0.022 (0.002)	N/A	5 (1)	3 (0)	7 (1)
G-8	0.3 (0.3)	0.2 (0.2)	0.5 (0.1)	3.8 (0.4)	0.014 (0.004)	0.027 (0.002)	N/A	10 (2)	3 (0)	8 (1)
G-9	-0.3 (0.3)	0.2 (0.1)	0.1 (0.1)	1.5 (0.2)	0.002 (0.003)	0.003 (0.001)	N/A	7 (1)	2 (0)	2 (1)
TA-49, AREA AB										
AB-1	0.1 (0.3)	N/A	0.4 (0.1)	4.2 (0.4)	0.002 (0.001)	0.008 (0.001)	N/A	5 (1)	6 (1)	3 (1)
AB-2	0.2 (0.3)	N/A	0.1 (0.1)	3.6 (0.4)	0.007 (0.001)	0.017 (0.002)	N/A	8 (2)	6 (1)	2 (0)
AB-3	0.1 (0.3)	N/A	0.3 (0.1)	3.3 (0.3)	0.014 (0.002)	0.594 (0.021)	N/A	4 (1)	5 (1)	3 (1)
AB-4	0.1 (0.3)	N/A	0.3 (0.1)	3.5 (0.3)	0.005 (0.001)	0.271 (0.012)	N/A	8 (2)	6 (1)	2 (0)
AB-4A	1.1 (0.3)	N/A	0.1 (0.1)	3.7 (0.4)	0.001 (0.001)	0.009 (0.001)	N/A	6 (1)	6 (1)	4 (1)
AB-5	0.2 (0.3)	N/A	0.0 (0.1)	2.2 (0.2)	0.002 (0.001)	0.002 (0.001)	N/A	4 (1)	3 (0)	3 (1)
AB-6	0.2 (0.3)	N/A	0.1 (0.1)	3.0 (0.3)	0.002 (0.001)	0.008 (0.001)	N/A	5 (1)	4 (1)	4 (1)
AB-7	0.3 (0.3)	N/A	0.9 (0.2)	3.7 (0.4)	0.002 (0.001)	0.027 (0.002)	N/A	7 (2)	7 (1)	1 (0)
AB-8	0.3 (0.3)	N/A	0.1 (0.1)	2.9 (0.3)	0.003 (0.001)	0.003 (0.001)	N/A	4 (1)	4 (1)	1 (0)
AB-9	-0.1 (0.3)	N/A	0.3 (0.1)	3.4 (0.3)	0.000 (0.001)	0.012 (0.002)	N/A	6 (1)	7 (1)	1 (0)
AB-10	0.2 (0.3)	N/A	0.0 (0.1)	2.4 (0.2)	0.001 (0.001)	0.004 (0.001)	N/A	5 (1)	3 (0)	-1 (0)
AB-11	0.1 (0.3)	N/A	0.1 (0.1)	4.2 (0.4)	0.002 (0.001)	0.006 (0.001)	N/A	6 (1)	5 (1)	1 (0)
Background Statistical Limit[d]	—	0.87	0.44	4.4	0.006	0.023	—	—	—	7.9

[a]Tritium as tritiated water in moisture distilled from sample.
[b]Radioactivity counting uncertainties (±1 standard deviation) are shown in parentheses.
[c]N/A means analysis not performed, lost in analysis, or not completed.
[d]Average plus 2 standard deviations of measurements in regional samples 1974–1986 (Purtymun 1987a).

Table IV-22. Radiochemical Analyses of Soils

Location	H^3 (nCi/L)[a]	^{90}Sr (pCi/g)	^{137}Cs (pCi/g)	Total Uranium (m g/g)	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)	^{241}Am (pCi/g)	Gross Alpha (pCi/g)	Gross Beta (pCi/g)	Gross Gamma (cpm/g)
Regional Soils										
Rio Chama	0.2 (0.3)[b]	N/A[c]	0.2 (0.1)	2.2 (0.2)	0.000 (0.002)	0.001 (0.001)	N/A	10 (2)	4 (1)	2 (1)
Embudo	-0.2 (0.3)	N/A	0.8 (0.2)	2.3 (0.2)	0.001 (0.002)	0.016 (0.002)	N/A	8 (2)	17 (2)	2 (0)
Otowi	0.5 (0.3)	N/A	0.5 (0.1)	2.7 (0.3)	0.002 (0.002)	0.064 (0.008)	N/A	4 (1)	3 (0)	3 (1)
Santa Cruz	-0.2 (0.3)	N/A	1.1 (0.2)	2.9 (0.3)	0.003 (0.002)	0.042 (0.003)	N/A	12 (3)	7 (1)	4 (1)
Cochiti	0.1 (0.3)	N/A	1.7 (0.3)	2.5 (0.3)	0.001 (0.002)	0.014 (0.002)	N/A	13 (3)	4 (1)	4 (1)
Bernalillo	-0.1 (0.3)	N/A	0.3 (0.1)	1.9 (0.2)	0.001 (0.001)	0.004 (0.002)	N/A	6 (1)	3 (0)	2 (0)
Jemez	-0.1 (0.3)	N/A	0.2 (0.1)	2.3 (0.2)	0.002 (0.002)	0.003 (0.001)	N/A	110 (20)	2 (0)	2 (0)
Perimeter Soils (off site)										
Sportsman Club	0.1 (0.3)	N/A	0.3 (0.1)	3.5 (0.4)	0.003 (0.002)	0.008 (0.003)	N/A	12 (3)	6 (1)	3 (1)
North Mesa	0.9 (0.3)	N/A	0.3 (0.1)	4.2 (0.4)	0.003 (0.001)	0.017 (0.002)	N/A	11 (2)	5 (1)	3 (1)
Near TA-8/GT Site	0.2 (0.3)	N/A	1.2 (0.3)	3.1 (0.3)	0.002 (0.002)	0.048 (0.004)	N/A	6 (1)	6 (1)	2 (1)
Near TA-49	-0.1 (0.3)	N/A	1.0 (0.2)	4.0 (0.4)	0.003 (0.002)	0.034 (0.003)	N/A	9 (2)	6 (1)	4 (1)
White Rock - East	0.1 (0.3)	N/A	0.7 (0.2)	3.5 (0.4)	0.007 (0.002)	0.020 (0.002)	N/A	12 (3)	6 (1)	4 (1)
Tsankawi	0.1 (0.3)	N/A	0.7 (0.2)	4.0 (0.4)	0.003 (0.002)	0.013 (0.002)	N/A	10 (2)	5 (1)	3 (1)
On-Site Soils										
TA-21 DP Site	1.4 (0.3)	N/A	1.9 (0.3)	3.8 (0.4)	0.002 (0.001)	0.002 (0.001)	N/A	12 (3)	5 (1)	3 (1)
East of TA-53	1.2 (0.3)	N/A	0.3 (0.1)	2.4 (0.2)	0.002 (0.003)	0.010 (0.002)	N/A	11 (2)	4 (1)	3 (1)
TA-50	1.2 (0.3)	N/A	0.1 (0.1)	3.9 (0.4)	0.001 (0.002)	0.043 (0.003)	N/A	15 (3)	10 (1)	4 (1)
2-Mile Mesa	0.8 (0.3)	N/A	0.2 (0.1)	3.7 (0.4)	0.006 (0.003)	0.012 (0.003)	N/A	11 (2)	4 (1)	3 (1)
East of TA 54	0.2 (0.3)	N/A	0.2 (0.1)	3.8 (0.4)	0.001 (0.001)	0.005 (0.001)	N/A	10 (2)	4 (1)	2 (0)
R-Site-RD-East	0.8 (0.3)	N/A	0.5 (0.1)	2.4 (0.2)	0.002 (0.001)	0.017 (0.002)	N/A	8 (2)	4 (0)	2 (1)
Potrillo Drive	0.3 (0.3)	N/A	0.3 (0.1)	4.0 (0.4)	0.001 (0.001)	0.005 (0.001)	N/A	10 (2)	4 (1)	4 (1)
S-Site TA-16	0.3 (0.3)	N/A	0.2 (0.1)	3.9 (0.4)	0.000 (0.001)	0.001 (0.001)	N/A	11 (2)	3 (0)	3 (1)
DT-9	-0.3 (0.3)	N/A	0.3 (0.2)	3.0 (0.3)	0.000 (0.000)	0.000 (0.000)	N/A	10 (2)	4 (0)	3 (1)
Near TA-33	2.0 (0.4)	N/A	0.3 (0.1)	2.8 (0.3)	0.006 (0.006)	0.005 (0.002)	N/A	26 (6)	6 (1)	3 (1)
Background Statistical Limit[d]	7.2	0.88	1.09	3.4	0.005	0.025	—	—	—	6.6

[a]Tritium as tritiated water in moisture distilled from sample.
[b]Radioactivity counting uncertainties (±1 standard deviation) are shown in parentheses.
[c]N/A means analysis not performed, lost in analysis, or not completed.
[d]Average plus 2 standard deviations of measurements in regional samples 1974–1986 (Purtymun 1987a).

The majority of the sediment samples outside known radioactive effluent release areas were within the statistically derived upper limit used as a comparison for activity attributable to worldwide fallout (Purtymun 1987a). These statistical limits give a level expected to be exceeded by about 1 in 40 samples taken from the same population. In the samples from the Rio Grande (Regional and White Rock Canyon groups), only the ^{238}Pu values for the Embudo and Pajarito samples exceeded the limit. Since they are not in the expected ratio with ^{239,240}Pu values for those stations, which themselves were below the statistical fallout limit, it is likely that they are analytical anomalies rather than real values. Samples taken on San Ildefonso land in Mortandad Canyon are discussed in Section IV.I.5.

Many sediment samples from the known radioactive effluent release areas, both off site and on site, including Acid-Pueblo, DP-Los Alamos, and Mortandad Canyons, exceeded worldwide fallout levels, as expected. The levels observed are consistent with previous data.

Two sediment samples from the On-Site Other Canyons group, from Sandia and Potrillo Canyons, showed ^{238}Pu levels that slightly exceeded the statistical fallout limit (0.007 compared to 0.006). Since they were not in the expected worldwide fallout ratio with ^{239,240}Pu values for those stations, which themselves were below the statistical fallout limit, it is likely that they are analytical anomalies rather than real values.

One sediment sample from the mouth of Chaquehui Canyon in White Rock Canyon contained significantly above background tritium in moisture distilled from the sediment. That sample contained 28 nCi/L. No other samples from canyons entering the Rio Grande contained any tritium above detection limits. Because of the unexpected anomaly, the location was resampled in February 1992, as soon as weather warmed sufficiently to melt snow and permit hiking into White Rock Canyon. That second sample also showed above background tritium, about 5.4 nCi/L. The lower level is possibly attributable to dilution from precipitation and snowmelt between October and February. Four additional samples were collected farther upstream in Chaquehui Canyon, below and above inflow from Spring 9A up to a point about 100 m upstream from where Doe Spring flow enters the channel. These four sediment samples had tritium contents ranging from about 0.5 to about 1.1 nCi/L, which, while lower, are still probably above background. No obvious source could be identified. Neither Doe Spring nor Spring 9A water samples from October 1991 showed tritium levels above the normal detection limits (see Table VII-2 and also some special low-detection limit analyses reported in Section VII.E.1). A potential source could be a known tritium-contaminated soil area in TA-33, which is located about 2 miles upgradient in a side drainage to Chaquehui Canyon. However, there is no obvious mechanism to move contaminated soil that far by a runoff event that would not also dilute the tritium in moisture significantly. This area will be investigated in detail in the future under the Environmental Restoration (ER) Program Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) that includes TA-33 (see Section III.B.1.h). The RFI Workplan encompassing TA-33, submitted to EPA in May 1992, includes field sampling tasks to help determine whether TA-33 could be the source.

The results for sediment samples from the solid radioactive waste areas (Table IV-21) were consistent with previous observations. Around Area G at TA-54, the statistical fallout levels for ^{238}Pu and/or ^{239,240}Pu were exceeded at Stations G-2, G-5, G-6, G-7, and G-8. The levels are generally in the same range as observed in previous years with the exception of station G-5, which may be the result of higher than typical runoff during the summer of 1991.

Tritium levels in the soil samples around Area G were within the general range observed in soils and did not repeat the anomalously high levels seen in 1990.

Subsequent to the water release from TA-54 (see Section V.B.3.b. for additional information), several special samples were collected along a small drainage leading from the north edge of TA-54 down into Cañada del Buey, joining the main channel slightly upstream of Location G-9. The first set collected on January 7, 1991, showed tritium concentrations in the water or soil moisture ranging up to 0.29 μCi/L. These samples extended from a point about 10 ft north of the TA-54 fence in the release path for about 800 ft, the apparent farthest point of flow as judged from the presence of ice. A subsequent set collected on March 27, 1991, showed a decline in concentration to about 0.053 μCi/L at the same point 10 ft north of the fence line. At the point where the drainage reached the Cañada del Buey channel, the concentration was about

0.004 μCi/L. Three samples 0.1, 0.3, and 0.7 miles farther downstream in Cañada del Buey had levels of only about 0.001 μCi/L down to analytical detection limits. Thus, it appears that the tritium in the release was substantially diluted or had mostly evaporated by the end of March.

Around Area AB at TA-49, worldwide fallout levels of ^{238}Pu and/or ^{239,240}Pu were exceeded at stations AB-2, AB-3, AB-4, and AB-7. These areas have shown elevated levels in previous years and are probably associated with known surface contamination incidents related to operation of the site in 1959–1961 (Purtymun, 1987b). The ^{137}Cs concentration in the sample from location AB-7 was about twice the statistical background limit for sediments but within the background limit for soils.

Four off-site soil samples (Otowi, Santa Cruz, near TA-8, and near TA-49) and one on-site sample (TA-50) had results for ^{239,240}Pu that were 2 to 3 times the statistical worldwide fallout limits for no apparent reason. Three soil samples (White Rock, 2-Mile Mesa, and TA-33) had results for ^{239}Pu (0.006 to 0.007 pCi/g) that were slightly above the statistical fallout limit (0.006). These locations were below the limits in 1990. Four soil samples (Santa Cruz, Cochiti, TA-8, and TA-21) had ^{137}Cs levels that were just at to about twice the statistical fallout limit. They are presumed to be normal variability as they did not exceed the limits in 1990, and are within the range of levels seen at other stations in 1991 that are below the limit this year. Uranium levels in the perimeter and on-site locations contain higher concentrations of natural uranium than other regional stations in northern New Mexico because the soils are derived from the Pajarito Plateau volcanic rocks that have higher than average natural uranium contents. The uranium levels are consistent with previous observations.

b. Nonradioactive Constituents. Sediments from the known radioactive effluent release areas were analyzed for metals using the EPA Toxicity Characteristic Leaching Procedure (TCLP) method for establishing whether solid wastes exceed the toxicity criteria (first section of Table IV-23). None of the criteria levels were exceeded or even approached. Sediments from the Perimeter group locations in White Rock Canyon were analyzed for total metals (second section of Table IV-23). These analyses were made to begin establishing a data base of results comparable to those reported by other agencies such as the USGS and are more meaningful for accounting for geochemical processes.

Soil samples were analyzed for metals using the EPA TCLP method for establishing whether solid wastes exceed the toxicity criteria (Table IV-24). None of the criteria levels were exceeded or even approached.

4. Long-Term Trends.

The concentrations of radioactivity on sediments in the Acid, Pueblo, and Los Alamos Canyon drainages that involve existing and potential off-site transport of radioactive contaminants are of considerable public interest. These were studied in extensive detail about 10 years ago under the Formerly Utilized Sites Remedial Action Program and are fully documented (ESG 1981). The routine monitoring program data from selected locations in these areas is an indication of changes. The total plutonium concentrations (^{238}Pu and ^{239,240}Pu) on sediments at four indicator locations observed since 1980 are shown in Fig. IV-12. The first location is Acid Weir, the location in Acid Canyon near its confluence with Pueblo Canyon where the highest concentrations are typically observed. This location is on Los Alamos County property and effectively integrates the mobile sediments from all of Acid Canyon. The second location is Pueblo at State Road 502 (State Road 4 in previous years), just upstream of the confluence with Los Alamos Canyon. This location is on DOE land and represents levels just prior to off-site transport. The third location is Los Alamos Canyon at Totavi, located on San Ildefonso Pueblo, and represents the first off-site point. The fourth location is Los Alamos Canyon at Otowi, also located on San Ildefonso Pueblo, and represents sediment concentrations at the point where they enter the Rio Grande. The basic observation is that the levels have been relatively constant at each location since 1980.

5. Transport of Radionuclides on Sediments in Surface Runoff.

The major transport of radionuclides from canyons that have received radioactive effluents (Acid-Pueblo, DP-Los Alamos, and Mortandad Canyons) is by surface runoff. Residual radionuclides in the effluents may become adsorbed or attached to sediment particles in the stream channels. Concentrations of radioactivity in

Table IV-23. Trace Metals in Sediments

Trace Metals in Solution Extracts from Sediment (mg/L)[a]

Stations	Ag	As	Ba	Cd	Cr	Hg	Pb	Se
REGIONAL STATIONS	Not all stations were sampled for metals in 1991; see next section of table for total recoverable metals in White Rock Canyon stations.							
PERIMETER STATIONS (OFF SITE)								
Radioactive Effluent Release Areas								
Acid-Pueblo Canyon								
Acid Weir	<0.023[b]	<0.02	0.47	<0.01	0.0	<0.0006	<0.05	0.020
Pueblo 1	<0.03	<0.02	0.55	<0.01	<0.01	<0.0006	<0.05	<0.02
Pueblo 2	<0.03	<0.02	0.48	<0.01	<0.01	<0.0006	<0.05	<0.02
DP – Los Alamos Canyon								
Los Alamos at Totavi	<0.03	<0.02	0.57	<0.01	<0.01	<0.0006	<0.05	0.028
Los Alamos at LA 2	<0.03	<0.02	0.51	<0.01	<0.01	<0.0006	<0.05	0.030
Los Alamos at Otowi	<0.03	<0.02	0.42	<0.01	<0.01	<0.0006	<0.05	0.023
Other Areas	See second section of table for total recoverable metals							
ON-SITE STATIONS								
Radioactive Effluent Release Areas								
Acid Pueblo Canyon								
Hamilton Bend Spring	<0.03	<0.02	0.46	<0.01	<0.01	<0.0006	<0.05	<0.02
Pueblo 3	<0.03	<0.02	0.46	<0.01	<0.01	<0.0006	<0.05	0.023
Pueblo at SR-4	<0.03	<0.02	0.28	<0.01	<0.01	<0.0006	<0.05	<0.02
DP–Los Alamos Canyon								
DPS-1	<0.03	<0.02	0.53	<0.01	<0.01	<0.0006	<0.05	0.034
DPS-4	<0.03	<0.02	0.76	<0.01	<0.01	0.0006	<0.05	0.022
Los Alamos at Bridge	<0.03	<0.02	0.55	<0.01	<0.01	0.0006	<0.05	0.034
Los Alamos at LAO-1	<0.03	<0.02	0.33	<0.01	<0.01	0.0006	<0.05	0.026
Los Alamos at GS-1	<0.023	<0.02	0.30	<0.01	<0.01	0.0006	<0.05	<0.02
Los Alamos at LAO-3	<0.03	<0.02	0.46	<0.01	<0.01	<0.0006	<0.05	0.030
Los Alamos at LAO4.5	<0.03	<0.02	0.48	<0.01	<0.01	<0.0006	<0.05	0.030
Los Alamos at SR-4	<0.03	<0.02	0.40	<0.01	<0.01	<0.0006	<0.05	0.025
Mortandad Canyon								
Mortandad near CMR	<0.03	<0.02	0.62	0.01	<0.01	<0.0002	<0.05	0.330
Mortandad W GS-1	<0.03	<0.02	0.98	<0.01	<0.01	<0.0006	<0.05	0.034
Mortandad at GS-1	<0.023	<0.02	0.56	<0.01	<0.01	<0.0006	<0.05	0.028
Mortandad at MCO-5	<0.03	<0.02	0.62	<0.01	<0.01	<0.0006	<0.5	0.025
Mortandad at MCO-7	<0.03	<0.02	0.53	<0.01	<0.01	<0.0006	<0.05	0.030
Mortandad at MCO-9	<0.03	<0.02	0.62	<0.01	<0.01	<0.0006	<0.05	0.030
Mortandad at MCO-13	<0.03	<0.02	0.66	<0.01	<0.01	<0.0006	<0.05	0.040
Limit for EPA Toxicity Criteria	5	5	100	1	5	0.2	5	1

Table IV-23. (Cont.)

Total Recoverable Trace Metals from Sediment (μg/g[c])

Stations	Ag	As	Ba	Cd	Cr	Hg	Pb	Se
REGIONAL STATIONS								
Rio Grande in White Rock Canyon								
Rio Grande at Sandia	<2	1.150	565	1.20	5.0	<21.5	1.4	<0.4
Rio Grande at Pajarito	<2	<0.4	553	0.77	3.0	<23	0.1	<0.4
Rio Grande at Water Canyon	5	1.400	619	1.40	4.6	97	3.1	<0.4
Rio Grande at Ancho	<2	0.900	578	1.00	3.7	23	0.5	<0.4
Rio Grande at Chaquehui	<2	1.500	637	1.30	4.7	<21	4.2	<0.4
Rio Grande at Frijoles	<2	1.000	550	1.70	7.3	<20	0.1	<0.4
PERIMETER STATIONS (OFF SITE)								
Other Canyons								
Sandia at Rio Grande	8	<0.4	299	1.20	3.6	<20	3.4	<0.4
Cañada Del Ancha	<2	<0.4	600	0.70	2.0	<20	5.9	<0.4
Pajarito at Rio Grande	<2	1.100	534	1.80	7.2	<20	1.2	<0.4
Frijoles at Rio Grande	27	0.400	207	0.54	2.8	<20	6.9	<0.4
Mortandad on San Ildefonso Lands								
Mortandad at Rio Grande	<2	<0.4	521	1.71	5.5	<23	1.5	<0.4
ON-SITE STATIONS								
Other Canyons								
Water Canyon at Rio Grande	<2	0.400	247	0.70	2.0	<22.5	1.5	<0.4
Ancho at Rio Grande	<2	<0.4	319	0.40	1.4	<22.5	3.4	<0.4
Chaquehui at Rio Grande	<2.1	<0.4	320	1.30	3.6	<20	3.8	<0.4

[a] Analysis by EPA TCLP method.
[b] Less than symbol (<) means measurement was below the specified detection limit of the analytical method.
[c] Analysis by EPA Method 3051 for total metals.

Table IV-24. Trace Metals In Soils

Trace Metals in Solution Extracted from Soil Sample (mg/L)[a]

Stations	Ag	As	Ba	Cd	Cr	Hg	Pb	Se
REGIONAL STATIONS								
Rio Chama	0.030	<0.02[b]	1.00	0.01	0.01	<0.0002	<0.05	0.03
Embudo	<0.03	<0.02	0.70	0.01	<0.01	<0.0002	<0.05	0.04
Otowi	<0.03	<0.02	0.50	0.01	<0.01	<0.0002	<0.05	0.02
Santa Cruz	0.027	<0.02	2.50	0.01	0.01	<0.0002	<0.05	0.05
Cochiti	<0.03	<0.02	0.74	0.01	<0.01	<0.0002	<0.05	0.02
Bernalillo	0.032	<0.02	1.00	0.01	0.01	<0.0002	<0.05	0.04
Jemez	0.0325	<0.02	1.70	0.02	0.01	<0.0002	<0.05	0.11
Perimeter Soils								
Sportsman Club	<0.03	<0.02	0.60	0.01	0.01	<0.0002	<0.05	0.03
North Mesa	<0.03	<0.02	0.70	0.01	<0.01	<0.0005	<0.05	0.04
TA-8	<0.03	<0.02	1.40	0.01	<0.01	<0.0005	<0.05	0.02
TA-49	<0.03	<0.02	1.20	0.01	<0.01	<0.0005	<0.05	0.02
White Rock	<0.03	<0.02	0.92	0.01	<0.01	<0.0002	<0.05	0.02
Tsankawi	<0.03	<0.02	0.60	<0.01	<0.01	<0.0002	<0.05	<0.02
On-Site Soils								
TA-21	<0.03	<0.02	0.70	0.01	<0.01	<0.0002	<0.05	0.02
East of TA-53	<0.023	<0.02	1.00	<0.01	<0.01	<0.0002	<0.05	0.02
TA-50	<0.03	<0.02	1.30	0.01	<0.01	<0.0002	<0.05	0.03
Two-Mile Mesa	<0.03	<0.02	0.90	0.01	<0.01	<0.0002	<0.05	0.02
East of TA-54	<0.03	<0.02	0.53	0.01	<0.01	<0.0002	<0.05	0.02
R-Site	<0.03	<0.02	0.90	<0.01	<0.01	<0.0002	<0.05	<0.0
Potrillo Drive	<0.03	<0.02	1.00	0.01	<0.01	<0.0002	<0.05	0.04
S-Site	<0.03	<0.02	0.51	<0.01	<0.01	<0.0002	<0.05	0.02
Near Well DT-9	<0.03	<0.02	2.10	0.01	<0.01	<0.0002	<0.05	0.03
Near TA-33	<0.03	<0.02	2.30	<0.01	<0.01	<0.0002	<0.05	0.03
Limit for EPA Toxicity Criteria	5	5	100	1	5	0.2	5	1

[a] Analysis by EPA TCLP method.
[b] The less than symbol (<) means the analysis was below the specified detection limit of the analytical method.

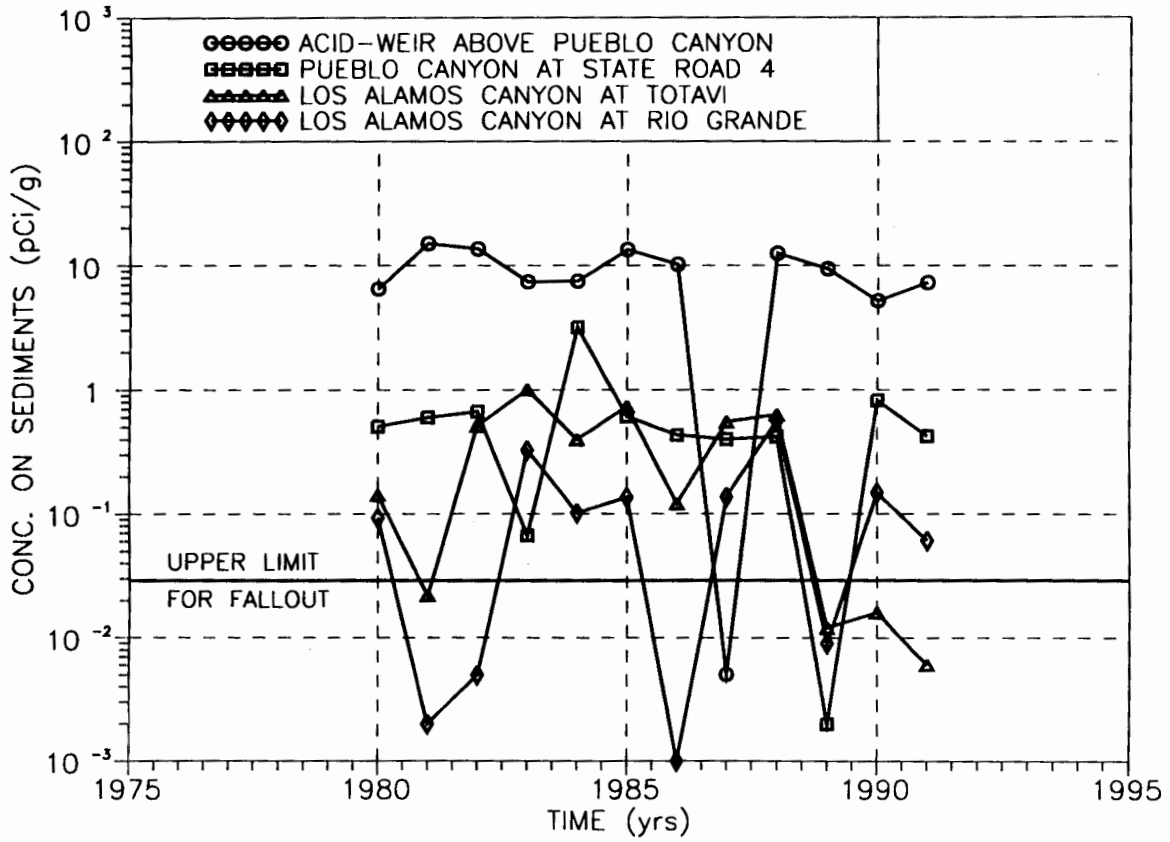


Fig. IV-12. Total plutonium concentrations on sediments.

the alluvium are generally highest near the effluent outfall and decrease downhill in the canyon as the sediments and radionuclides are transported and dispersed by other treated industrial effluents, sanitary effluents, and surface runoff.

a. Pueblo-Los Alamos Canyons. Residual radioactivity from past effluent releases into DP Canyon, upper Los Alamos Canyon, and Acid Canyon is present on sediments in those canyons and Pueblo Canyon downstream from Acid Canyon. (See Section IV.D.2 for more historic information.) Over the years some of that radioactivity has been transported off site into lower Los Alamos Canyon largely by snowmelt and thunderstorm runoff.

Starting in 1990, increased effluent flow from the Los Alamos County Bayo sanitary sewage treatment plant resulted in flow through the lower part of Pueblo Canyon and into Los Alamos Canyon during most of the year. This flow transported some of the contaminated sediments out of Pueblo Canyon and into the lower reach of Los Alamos Canyon. This effluent-induced flow from Pueblo Canyon entered Los Alamos Canyon on most days in 1991, except for the period from about mid-June to early August, and typically extended to a location between Wells LA-6 and LA-2 in Los Alamos Canyon.

Samples of effluent and runoff collected from Pueblo Canyon above the confluence with Los Alamos Canyon, near State Road 502, were analyzed for radioactivity in solution and suspended sediments. These runoff samples contained above-background amounts of cesium, strontium, and plutonium in solution, as expected from the residuals of historic releases into Pueblo Canyon. The plutonium results are shown in Table IV-25. Concentrations of plutonium on the suspended sediments were above background levels. Radioactivity in solution refers to the filtrate that passes through a 0.45-mm-pore-size filter; radioactivity in suspended sediments refers to the residue retained by the filter.

The current year measurements were combined with results of a special study, "Transport of Plutonium in

Table IV-25. Plutonium in Runoff in Pueblo and Los Alamos Canyons, 1991

Location and Date	Concentration in Solution		Concentration in Suspended Sediment		Suspended Sediment	Total in Solution and Suspended Sediment (pCi/L)		
	^{239}Pu (pCi/L)	^{238}Pu (pCi/L)	^{239}Pu (pCi/g)	^{238}Pu (pCi/g)	(gm/L)	^{239}Pu	^{238}Pu	% dissolved
Pueblo at SR 502								
2/25	0.022	0.004	4.030	0.011	0.05	0.23	0.00	11.1
3/12	0.000	0.000	4.290	0.042	0.02	0.07	0.00	0.0
8/7	0.352	0.008	14.700	0.071	3.51	51.93	0.26	0.7
8/12	0.027	0.000	1.620	0.048	1.45	2.38	0.07	1.1
8/19	0.012	0.004	0.050	0.005	14.68	0.75	0.08	1.9
9/6[a]	0.000	0.000	13.800	0.068	1.85	25.53	0.13	0.0
9/13[a]	0.023	0.054	5.650	0.062	0.44	2.53	0.08	2.9
11/26	0.049	0.000	2.380	0.120	3.84	9.19	0.46	0.5
12/19	0.082	0.017	0.948	0.006	3.50	3.40	0.04	2.9
Los Alamos at SR 4								
8/7	0.020	0.004	1.740	0.097	0.82	1.46	0.08	1.6
8/12	0.050	0.000	0.831	0.038	0.39	0.38	0.01	12.8
9/6[a]	0.027	0.014	2.930	0.465	0.52	1.54	0.25	2.3
9/13	0.017	0.000	2.070	0.094	0.06	0.15	0.01	10.9
Los Alamos at Totavi								
8/12	0.072	0.007	0.632	0.012	3.52	2.30	0.05	3.4
8/19	0.008	0.004	0.120	0.012	13.87	1.67	0.17	0.7
Los Alamos at LA-5								
9/6[a]	0.012	0.020	5.850	0.124	0.33	1.93	0.06	1.6
9/13	0.004	0.037	3.250	0.053	0.11	0.35	0.04	10.4
Los Alamos near LA-6								
2/25	0.009	0.000	1.740	0.014	6.92	12.05	0.10	0.1
3/12	0.009	0.017	1.070	0.007	10.07	10.78	0.09	0.2
Los Alamos at Rio Grande								
8/12	0.019	0.010	0.778	0.015	0.85	0.68	0.02	4.1
9/6[a]	0.029	0.000	6.900	0.170	1.36	9.38	0.23	0.3
9/13[a]	0.023	0.000	4.090	0.076	0.44	1.83	0.03	1.2
12/19	0.044	0.004	0.868	0.013	1.00	0.91	0.02	5.2
Rio Grande at Otowi								
9/6[a]	0.000	0.000	0.010	0.018	1.28	0.01	0.02	0.0
9/13	0.017	0.000	0.005	0.008	0.44	0.02	0.00	74.9

[a]Samples collected on 9/6 and 9/13 were also analyzed for plutonium on settleable solids as an estimate of bedload. These analyses showed that the total on bedload was 2 to 4 times the total in solution and suspended sediments.

Snowmelt Run-Off" (Purtymun 1990a), as the basis for estimating transport of plutonium into Los Alamos Canyon. The estimate of plutonium transported in solution and on suspended sediments from Pueblo Canyon into Los Alamos Canyon is about 1–2 mCi for 1991. By analogy with the snowmelt runoff, it is estimated that bedload sediments probably carried 2 to 3 times as much plutonium as the dissolved and suspended sediment components. Thus the total amount of plutonium transported from Pueblo Canyon into Los Alamos Canyon could be as much as 4–6 mCi.

The increased transport of contaminated sediments from Pueblo Canyon is not expected to have any significant effect on the concentrations of plutonium on sediments in lower Los Alamos Canyon (ESG 1981) which is supported by current measurements as given in Table IV-25 for locations in lower Los Alamos Canyon. Because there is an estimated inventory of about 400 mCi of plutonium in lower Pueblo Canyon, there may be periodic increases in the inventory in lower Los Alamos Canyon. Although summer thunderstorm runoff or long periods of snowmelt runoff periodically move accumulated sediments from lower Los Alamos Canyon into the Rio Grande (e.g., ESG 1981, Lane 1985), there is not likely to be any significant long-term change in the inventory in Lower Los Alamos Canyon.

The effluent-induced flow will slightly increase the rate at which contaminated sediments from historic discharges in Acid and Pueblo Canyons are moved into and through Los Alamos Canyon to the Rio Grande. Theoretical estimates (ESG 1981), confirmed by actual measurement (see Special Reservoir Sediment Studies below), show that the incremental contribution to radioactivity on sediments in Cochiti Reservoir is a small percentage (approximately 10%) of the contribution attributable to typical regional worldwide fallout levels. The resultant incremental doses through food pathways (see Section IV.G.3) are well below DOE's applicable PDLs.

b. Distribution of Radionuclides in Water and Sediment in and Adjacent to Sediment Traps in Mortandad Canyon. Residual radionuclides are released in effluent from the treatment plant at TA-50 into Mortandad Canyon (see Table IV-26). The liquid infiltrates and recharges a shallow body of groundwater in the alluvium. This shallow aquifer is of limited extent and lies completely within the Laboratory boundary (see Section IV.D.2 and Section VII.B for additional information). Most of the radionuclides in the effluent are adsorbed or bound to the sediments in the channel.

Table IV-26. Quality of Effluent Released from the TA-50 Radioactive Liquid Waste Treatment Plant in 1991

Radionuclide	Activity Released[a] (mCi)	Mean Concentration (μCi/mL)
^{3}H	10,600	4.8×10^{-4}
^{54}Mn	0	—
$^{56,57,58,60}Co$	1.0	4.6×10^{-8}
^{75}Se	6	2.7×10^{-7}
$^{83,84}Rb$	45	2.0×10^{-6}
$^{82,85,89,90}Sr$	124	5.7×10^{-6}
^{88}Y	0.6	2.9×10^{-8}
^{137}Cs	67	3.1×10^{-6}
^{234}U	0.07	3.0×10^{-9}
^{238}Pu	0.3	1.4×10^{-8}
$^{239,240}Pu$	1.0	4.4×10^{-8}
^{241}Am	1.1	4.9×10^{-8}
Total[b]	10,846	

[a]As reported on DOE Form F-5821.1.
[b]Total effluent volume 2.19×10^{7} liters.

The sediments and radionuclides in the stream channel alluvium are subject to transport when additional effluent releases or storm water runoff periodically enter the channel. The small drainage area of the canyon and the ability of the thick section of unsaturated alluvium to store runoff have prevented transport to the Laboratory boundary. To further assure containment of sediment transport by major runoff events within the Laboratory boundary, a series of canyon sediment traps was installed in the early 1970s. These traps are located in Mortandad Canyon approximately 2.3 km (1.4 mi) upstream of the eastern facility boundary. The traps are excavated below the prevailing grade of the stream channel, so runoff water flows in and is retained temporarily, letting the heavier sediments settle out. When one pond is filled up to the stream channel, the water then flows on into the next trap.

Several large thunderstorm runoff events occurred in late July and early August 1991 that filled all three sediment traps to capacity. Trap 3 overflowed on two separate occasions. An estimated 77 to 115 m^3 (20,000 to 30,000 gal.) of runoff flowed on downstream of the sediment traps during this time. The end of these flows terminated about 200 m (650 ft) east of the lowest trap.

Water samples were collected from water standing in each of the traps following the two overflows. The results of radiochemical analyses of the water and suspended sediments are presented in Table IV-27. The results are similar to values seen in previous years after major runoff events. The concentrations of suspended sediments are comparable to the maximums found on dry streambed sediments earlier in the year (see Table IV-20). The suspended sediments are predominantly smaller particles and thus exhibit somewhat higher concentrations.

After the water evaporated or infiltrated after the last runoff, sediment samples were collected from all three sediment traps (in depressions where fine grained sediments would tend to collect) and at an additional 27 locations spaced on a rectangular sample grid immediately downstream of Trap 3. This grid consisted of six channel transect lines located at approximately 30 m (100 ft) intervals below the outflow point from Trap 3. Sediment samples were collected along each transect at approximately 10 m (30 ft) intervals, with the end-point samples located outside of the visible water marks indicating where water had passed. These high-water marks consisted of sediment debris on plant leaves and plants deflected toward the direction of water flow. These water marks terminated approximately 150–250 m (500–650 ft) downstream of the outflow from Trap 3.

All sediment samples were initially scanned for gross gamma radiation. These analyses indicated that all samples contained detectable amounts of ^{241}Am, ^{137}Cs, and ^{60}Co, in addition to trace levels of other LAMPF activation products. Seven samples were selected from the 31 sample suite for quantitative gamma counting. These seven samples were selected from six locations near the outermost perimeter of the sampling grid and one location from within Trap 3. These sample results are summarized in Table IV-28. Radionuclide concentrations varied slightly above respective background values. There does not appear to be a decreasing trend in concentration levels with increasing distance downstream of the breach in Trap 3. Instead, these concentrations tend to reflect the maximum extent of sediment transport of the finest grained materials. A portion of these radionuclide concentrations is attributable to previous years when the traps were also overtopped by surface runoff. These analytical data are consistent with previous trap overflows that were reported in the 1987 and 1988 Environmental Surveillance Reports (ESG 1988, ESG 1989).

The three sediment traps will be excavated during 1992 to restore their original sediment retention volumes.

6. Special Reservoir Sediment Studies.

Results of the analyses of the special large samples collected in 1991 from Abiquiu and Cochiti Reservoirs are presented in Table IV-29. The results are similar to those from past years. The cesium concentration of 0.496 ± 0.119 pCi/g from the lower station in Abiquiu slightly exceeded the statistically established background level of 0.44 pCi/g (Purtymun 1987a). All other measurements were lower than statistical background limits.

The results are best interpreted in conjunction with information from a special study, "Plutonium Deposition and Distribution from Worldwide Fallout in Northern New Mexico and Southern Colorado," that provides a broader regional context for the reservoir sediment measurements (Purtymun 1990b). This study was based on the radiochemical analyses of large samples (1 kg) of soils and sediments collected between 1979 and 1987 from locations in northern New Mexico and southern Colorado. Data on sediments from Abiquiu and Cochiti previously published in the annual Environmental Surveillance at Los Alamos reports are included in the larger set of data. The conclusions of greatest significance to interpreting the current samples from Abiquiu and Cochiti Reservoirs are (1) the average total plutonium concentrations in Cochiti are almost identical to the concentrations found in the Rio Grande Reservoir in Colorado, (2) reservoirs on the Rio Chama exhibit slightly lower concentrations than those found in the Rio Grande Reservoir, and (3) the isotopic ratios of $^{239,240}Pu$ to ^{238}Pu are essentially the same, with nearly complete overlap of the statistical uncertainties for all of the soil and sediment samples. These findings are all consistent with the interpretation

Table IV-27. Radioactivity in Mortandad Canyon Sediment Traps

Concentrations in Solution

Location Date	H^3 (nCi/L)	^{137}Cs (pCi/L)	^{238}Pu (pCi/L)	^{239}Pu (pCi/L)	^{241}Am (pCi/L)	Gross Beta (pCi/L)
Trap 1						
7/24/91	7.2 (0.8)[a]	91 (61)	0.50 (0.05)	1.70 (0.10)	2.33 (0.12)	110 (10)
8/06/91	5.7 (0.7)	98 (66)	0.46 (0.07)	2.03 (0.28)	1.50 (0.10)	55 (5)
Trap 2						
7/24/91	7.6 (0.8)	155 (64)	0.76 (0.06)	2.08 (0.12)	3.87 (0.17)	88 (9)
8/06/91	2.0 (0.4)	80 (65)	0.35 (0.05)	1.19 (0.09)	1.21 (0.10)	51 (6)
Trap 3						
7/24/91	3.1 (0.4)	76 (56)	0.64 (0.06)	1.81 (0.11)	1.72 (0.10)	33 (3)
8/06/91	1.2 (0.3)	36 (60)	0.37 (0.08)	0.96 (0.25)	1.02 (0.09)	40 (4)

Concentrations on Suspended Sediment

	^{238}Pu (pCi/g)	^{239}Pu (pCi/g)	Suspended Sediment (g/L)
Trap 1			
7/24/91	20 (2)	61 (6)	0.80
8/06/91	37 (5)	120 (15)	0.28
Trap 2			
7/24/91	7 (3)	21 (10)	1.09
8/06/91	35 (5)	110 (15)	0.32
Trap 3			
7/24/91	12 (7)	36 (18)	1.18
8/06/91	33 (5)	102 (15)	0.41

[a]Radioactivity counting uncertainties (±1 standard deviation) are shown in parentheses.

Table IV-28. Radioactivity on Mortandad Canyon Sediments, October 18, 1991

	Analysis					
	^{241}Am (pCi/g)	^{75}Se (pCi/g)	^{137}Cs (pCi/g)	^{57}Co (pCi/g)	^{60}Co (pCi/g)	^{83}Rb (pCi/g)
Location[a]						
1	38.0 (5.72)[b]	10.9 (5.55)	282.0 (42.4)	0.232 (0.245)	3.640 (0.634)	0.714 (0.290)
2	32.2 (4.85)	3.68 (4.79)	138.0 (20.8)	0.092 (0.229)	0.319 (0.272)	0.058 (0.176)
3	28.9 (4.34)	4.06 (4.89)	173.0 (26.0)	0.007 (0.210)	0.877 (0.317)	0.043 (0.193)
4	19.4 (2.92)	11.30 (4.87)	98.0 (14.8)	0.914 (0.266)	0.120 (0.282)	0.176 (0.220)
5	36.6 (5.51)	4.58 (5.08)	225.0 (33.8)	0.681 (0.257)	0.665 (0.272)	0.041 (0.201)
6	9.2 (1.39)	8.90 (4.79)	101.0 (15.3)	0.601 (0.244)	0.050 (0.261)	0.317 (0.177)
7	10.2 (1.54)	2.29 (4.19)	11.9 (1.82)	0.172 (0.209)	0.316 (0.286)	0.247 (0.178)

[a]Sample Locations:
1 Eastern end of Trap 3; clay and fine sand.
2 Washout 120 m below outflow; 10 m north of channel.
3 Washout 120 m below outflow; 10 m south of channel.
4 Washout 150 m below outflow; 20 m north of channel.
5 Washout 150 m below outflow; in channel.
6 Washout 150 m below outflow; 20 m south of channel.
7 Washout 167 m below outflow; no channel apparent.

[b]Radioactivity counting uncertainties (±1 standard deviation) are shown in parentheses.

Table IV-29. Radiochemical Analyses of Sediments from Reservoirs on the Rio Chama and Rio Grande[a]

Location	H^3 (nCi/L)[b]	^{90}Sr (pCi/g)	^{137}Cs (pCi/g)	Total Uranium (µg/g)	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)	^{241}Am (pCi/g)	Gross Gamma (counts/min/g)
Abiquiu Reservoir								
Upper	0.0 (0.2)[c]	0.2 (0.2)	0.253 (0.092)	1.89 (0.2)	0.0003 (0.0001)	0.0054 (0.0004)	0.006 (0.003)	1.8 (0.4)
Middle	0.2 (0.3)	0.2 (0.1)	0.277 (0.141)	2.51 (0.2)	0.0003 (0.0001)	0.0060 (0.0003)	0.009 (0.003)	3.2 (0.5)
Lower	0.1 (0.3)	0.2 (0.2)	0.496 (0.119)	2.2 (0.2)	0.0004 (0.0001)	0.0102 (0.0004)	0.033 (0.007)	3.0 (0.5)
Cochiti Reservoir								
Upper	−0.5 (0.5)	0.17 (0.16)	0.402 (0.106)	—[d]	0.0003 (0.0001)	0.0072 (0.0003)	N/A	1.6 (0.4)
Middle	0.3 (0.3)	0.19 (0.16)	0.245 (0.0824)	—[d]	0.0002 (0.0001)	0.0045 (0.0002)	N/A	1.4 (0.4)
Lower	−0.1 (0.3)	0.11 (0.14)	0.305 (0.108)	—[d]	0.0001 (0.0001)	0.0005 (0.0001)	N/A	5.5 (0.7)
Background (1974-1986)[e]	—	0.87	0.44	4.4	0.006	0.023	—	—

[a]Samples were collected in June 1991 at Abiquiu and July 1991 at Cochiti; counting uncertainties are in parentheses.
[b]Tritium as tritiated water in moisture distilled from sample.
[c]Radioactivity counting uncertainties(±1 standard deviation) are shown in parentheses.
[d]Sample lost in analysis.
[e]Background, upper limit (Purtymun 1987a).

that the source of the plutonium at all locations is dominantly from worldwide fallout. The data from the 1991 samples fit the longer term pattern of concentrations and isotopic ratios, as tabulated in Table IV-30. The Cochiti samples are below the long-term means for concentration and very near the mean isotope ratio; the Abiquiu samples were near the average of the concentration range and the isotopic ratio mean.

Both the 1991 data and the special study support other observations and interpretations (ESG 1981) that the contribution of total plutonium carried into the Rio Grande by current runoff through Los Alamos Canyon is small, roughly estimated at no more than 10% of that attributable to worldwide fallout on sediments in the Rio Grande (ESG 1981). The levels of plutonium on sediments in the Rio Grande in the vicinity of Los Alamos represent a variable mixing of the generally higher concentrations and isotopic ratios observed on soils and sediments farther north in the Rio Grande drainage and the generally lower concentrations and

Table IV-30. Plutonium Analyses from Sediments in Reservoirs on the Rio Chama and Rio Grande[a]

		^{238}Pu (fCi/g)	^{239,240}Pu (fCi/g)	Ratio (^{239,240}Pu/^{238}Pu) (fCi/g)
Abiquiu Reservoir				
1984	$\bar{x}$ (*s*)	0.7 (0.4)	12.7 (6.3)	18
1985	$\bar{x}$ (*s*)	0.7 (0.5)	8.8 (0.9)	12
1986	$\bar{x}$ (*s*)	0.3 (0.1)	7.5 (1.7)	25
1987	$\bar{x}$ (*s*)	0.2 (0.1)	3.8 (3.1)	19
1988	$\bar{x}$ (*s*)	0.3 (0.2)	7.5 (2.6)	25
1989	$\bar{x}$ (*s*)	0.2 (0.6)	3.7 (0.4)	18
1990	$\bar{x}$ (*s*)	0.14 (0.1)	2.6 (1.6)	19
1991	Upper	0.3 (0.1)	5.4 (0.4)	18
	Middle	0.3 (0.1)	6.0 (0.3)	20
	Lower	0.4 (0.1)	10.2 (0.4)	26
	$\bar{x}$ (*s*)	0.33 (0.1)	7.2 (2.6)	22
Cochiti Reservoir				
1984	$\bar{x}$ (*s*)	0.7 (1.1)	19.7 (14.0)	28
1985	$\bar{x}$ (*s*)	1.6 (0.6)	24.1 (7.3)	15
1986	$\bar{x}$ (*s*)	1.2 (0.5)	21.2 (6.1)	18
1987	$\bar{x}$ (*s*)	0.8 (0.7)	17.5 (13.8)	22
1988	$\bar{x}$ (*s*)	1.7 (2.3)	21.1 (2.9)	7
1989	$\bar{x}$ (*s*)	2.5 (2.3)	49.3 (7.3)	20
1990	$\bar{x}$ (*s*)	1.1 (0.5)	20.9 (10.7)	19
1991	Upper	0.3 (0.1)	7.2 (0.3)	24
	Middle	0.2 (0.1)	4.5 (0.2)	23
	Lower	0.1 (0.1)	0.5 (0.1)	5
	$\bar{x}$ (*s*)	0.2 (0.1)	4.1 (3.4)	21
Background				
(1974–1986)[b]		6.0	23.0	

[a]Samples were collected in June 1991 at Abiquiu and July 1991 at Cochiti; counting uncertainties are in parentheses.

[b]Purtymun (1987a).

lower isotopic ratios found in the Chama system reservoirs and soils of northern New Mexico. Thus, the significant variability with time and the uncertainty in measurements of at least 5-10% in even the 1 kg samples (as much as 50% in normal size samples) at the low levels combine to make it generally impossible to distinguish the contribution from current Los Alamos Canyon sediments in the Rio Grande by measuring concentrations. For similar reasons there is no distinguishable increase in $^{239,240}Pu$ to ^{238}Pu isotopic ratio as would be expected if the higher concentration, higher ratio Los Alamos Canyon sediments were making a large contribution.

7. Special Rio Grande Sediment Study.

A geomorphologic study completed in 1991, "Geomorphology of Plutonium in the Northern Rio Grande System," (Graf 1991) provides an historic perspective to evaluate the contributions of plutonium from Los Alamos to the Rio Grande. That study utilized historic aerial photography and hydrologic data to study the movement and deposition of sediments over time. Among the study's conclusions regarding a regional plutonium budget for the 1948–1985 period accounting for both worldwide fallout and input from Los Alamos Canyon for the northern Rio Grande, three are particularly relevant to interpreting the surveillance data:

- Fallout accounts for more than 90% of the plutonium in the system; Los Alamos, for slightly less than 10%.
- About half of the total plutonium (fallout plus Los Alamos) is estimated to have been stored along the river, and the remainder moved into storage in Elephant Butte Reservoir.
- Most of the Los Alamos contributions remain in storage along the river between Otowi and Peña Blanca (just downstream from Cochiti Dam); since 1973 the downstream transport of the Los Alamos contributions has terminated in Cochiti Reservoir.

The study identified locations where sediments had been deposited during specific periods. A special sediment sample was collected from a floodplain near Buckman (just south of Cañada Ancha on Fig. IV-9) that was actively deposited during the 1941–1968 period. This sample was subject to a very sensitive analysis (detection limits as little as 0.0001 pCi/gm) of plutonium isotopes by the Isotope Geochemistry Group (INC-7) at the Laboratory. This analysis showed that plutonium found at Buckman had a ratio of ^{239}Pu to ^{240}Pu consistent with about an equal mix of worldwide fallout and plutonium from the Acid-Pueblo-Los Alamos Canyon system. The total levels of ^{239}Pu to ^{240}Pu in the sample (0.017 pCi/g) were within the statistically derived fallout level (0.023 pCi/g). Only the precise and costly analysis showed that the deposit had a substantial contribution from historic flows out of Los Alamos Canyon. Such techniques may be useful for other research into the sediment transport processes.

F. Monitoring of the Water Distribution Systems

1. Introduction.

The EPA has established maximum contaminant levels for organic and inorganic constituents and radioactivity in drinking water in the Safe Drinking Water Act (SDWA). These standards have been adopted by the State of New Mexico and are included in the New Mexico Water Supply Regulations (NMEIB 1991). NMED has been authorized by EPA to administer and enforce federal drinking water regulations and standards in New Mexico.

Compliance samples are analyzed for organic and inorganic constituents and for radioactivity at the State Scientific Laboratory Division (SLD) in Albuquerque. SLD reports the analytical results directly to NMED. The Johnson Controls Inc. Environmental (JENV) Laboratory also collects samples throughout the Laboratory and County distribution systems and tests them for microbiological contamination, as required under the SDWA. The JENV Laboratory is certified by SLD for microbiological testing of drinking water.

During 1991, all water samples collected under the SDWA program at Los Alamos and tested by SLD in Albuquerque and by the JENV Laboratory were found to be in compliance with the maximum contaminant levels established by regulation.

2. Monitoring Network.

The Laboratory and County water distribution systems were sampled at three locations for inorganic and volatile organic components (VOCs) during 1991 to determine compliance with SDWA parameters. Each location is representative of one of the well fields

supplying the distribution system: Los Alamos Airport is representative of water quality in the Los Alamos Well Field; White Rock Fire Station of the Pajarito Well Field; and Barranca Mesa School of the Guaje Well Field.

3. Analytical Results.

a. Radiological Analyses of the Water Distribution Systems. The water distribution systems were sampled for radioactivity at three locations during 1991. Samples were analyzed by SLD and the results showed concentrations below the maximum contaminant level for gross alpha and gross beta. These results are summarized in Table III-11.

b. Chemical Constituent Analyses of the Water Distribution Systems. All of these results were found to be in compliance with the standards. Inorganic analyses consist of the following parameters: arsenic, barium, cadmium, chromium, lead, mercury, selenium, silver, nitrate (as N), and fluoride. VOC analyses are divided into two classes. VOC Group I consists of aromatic and halogenated purgeables to determine the presence of benzene, carbon tetrachloride, 1,1-dichloroethylene, 1,2-dichloroethane, para-dichlorobenzene, trichloroethane, trichloroethylene, and vinyl chloride plus 49 unregulated contaminants. VOC Group II consists of ethylene dibromide (EDB) and 1,2-dibromo-3-chloropropane. A summary of analytical results is included in Table III-8.

Under the SDWA, testing for total trihalomethanes is required for the Los Alamos water supply once each quarter. During 1991, samples were collected by EM-8 at five locations within the Laboratory and County water distribution systems and delivered to SLD for analysis. Results showed concentrations below the maximum contaminant level of 0.10 mg/L for total trihalomethanes. A summary of these results is included in Table III-9.

c. Microbiological Analyses of the Water Distribution Systems. Each month during 1991 an average of 46 samples was collected throughout the Laboratory and County water distribution systems to determine the free chlorine residual available for disinfection and the microbiological quality of the distribution systems. These samples were collected by personnel at the JCI Environmental Section and analyzed in the JCI certified laboratory for the presence of coliform bacteria, which is an indicator used to determine if harmful bacteria could be present. During 1991, no coliform bacteria were found. Sixty-five of the microbiological samples (approximately 12%) collected were found to have some noncoliform bacteria present. Although the presence of noncoliform bacteria is not a violation of SDWA, it does indicate stagnant water or biofilm growth in the distribution lines. A summary of the analytical results is found in Table III-12.

d. Other Environmental Activities for Protection of the Water Supply Systems. Other programs conducted to protect the water supply system include the following:

Wellhead Inspection Program. A survey of water supply wells was conducted during 1991 by the JCI Environmental Section to detect any potential sources of contamination into the system. Daily inspections of the wells were also conducted by JCI Utilities to maintain pumping equipment and to identify any problem that might lead to a potential health hazard.

Disinfection Program for New Construction. Whenever new construction or repair work is required on the distribution or supply system, the pipe must be disinfected before it is put in service. This disinfection is accomplished by flushing the pipe and adding a high-strength chlorine solution to the piping. The chlorinated water is then removed, and a sample is taken during the flushing process by the JCI Environmental Section for the presence of coliform bacteria.

G. Foodstuffs Monitoring

1. Introduction.

Concentrations of radionuclides in foodstuffs collected from Laboratory areas were compared to levels of radionuclides in foodstuffs samples collected from perimeter and regional (background) locations in an effort to monitor Laboratory operations for potential radioactive contamination. In addition, radiation dose was calculated from the data collected and compared to the radiation protection standards recommended by the International Commission on Radiological Protection (ICRP 1979) and the National Council on Radiation Protection and Measurements (NCRP 1987a), as mandated by DOE Order 5400.5 (DOE 1990a).

2. Monitoring Network.

Produce (fruits, vegetables, and grains), bee, and honey samples are collected on a yearly basis from on site (within the Laboratory boundary), perimeter (Los Alamos townsite/White Rock), and regional (Española/San Ildefonso Pueblo) locations. Regional or background samples of foodstuffs are collected upstream from the confluence of the Rio Grande and intermittent streams that cross Laboratory lands. Similarly, levels of radionuclides are determined in catfish (bottom feeders) and crappie and/or trout (surface feeders) collected from Abiquiu (a reservoir upstream from the Laboratory) and are compared to fish collected from Cochiti (a reservoir downstream from the Laboratory). Locations of produce, fish, and beehives are shown in Figs. IV-13 and IV-14 and Table D-12.

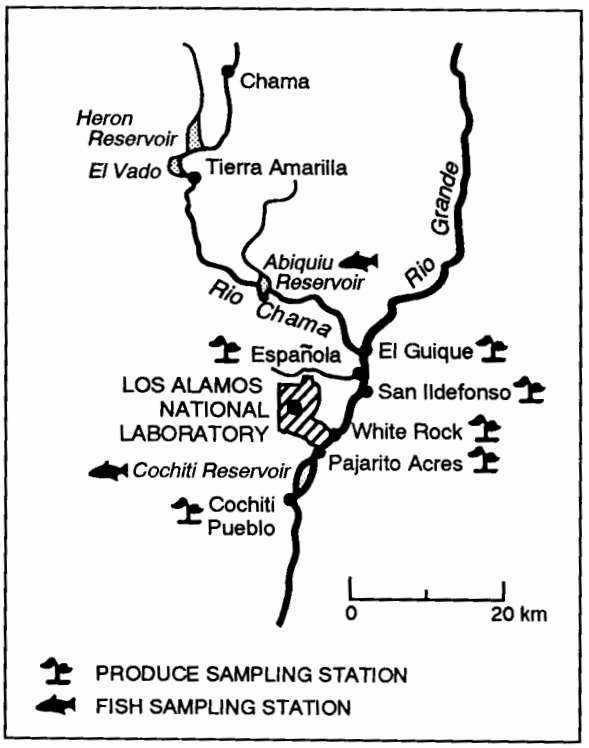


Fig. IV-13. Produce and fish sampling locations. (Map denotes general locations only.)

3. Analytical Results.

a. Produce. Concentrations of radionuclides in produce collected from on-site, perimeter and regional locations during the 1991 growing season can be found in Table IV-31. In general, most radionuclides in foodstuffs collected from on-site, perimeter, and regional locations were within a range of values reported for these areas in past years. With the exception of H^3, all radionuclides in produce collected from on-site areas were within background concentrations. The range in H^3 values in produce samples collected from on-site Laboratory lands ranged in concentration from 0.7 to 8.1 pCi/mL. These values are higher than last year's H^3 values and are probably the result of routine Laboratory operations.

With the exception of one perimeter location, no differences in H^3, ^{90}Sr, total U, $^{239,240}Pu$, and ^{137}Cs were detected between produce collected from regional areas (Española and San Ildefonso as a group mean) and produce samples collected from perimeter sampling locations.

One fruit sample collected from the former TA-1 site in the Los Alamos townsite contained elevated levels of H^3 (16 pCi/mL) and $^{239,240}Pu$ (0.02 pCi/dry g). Plutonium levels, in particular, were about 100 times the levels found in fruit samples collected from other trees in the area. The amount of Pu in this fruit does not pose a health hazard; the total dose as a result of all radionuclides that could be obtained from ingesting all of the fruit from this tree (estimated to be about 50 lb) was only 0.3 mrem/yr. This dose is less than 1% of the DOE's radiation protection standard of 100 mrem/yr for all pathways.

Subsequent sampling and analysis of air, plant branches, soil surface, and subsurface materials from around this tree and other fruit trees in the area showed that (1) the TA-1 fruit tree contained elevated levels of H^3 in fruit, branch, and subsurface soil samples as compared to plant and soil samples collected from other fruit trees growing in the area, suggesting that the TA-1 fruit tree may be transporting H^3 up through the roots to the fruit, and (2) $^{239,240}Pu$ was elevated in soil surface samples collected directly underneath the TA-1 fruit tree as compared to other soil surface samples in the area, suggesting that elevated levels of $^{239,240}Pu$ in fruit samples collected from the TA-1 tree may have been more a result of soil surface contamination (resuspension and/or sample contamination) rather than from root uptake. During the decommissioning and decontamination of the TA-1 area in the 1960s and 70s, the detection limits for clean-up activities was approximately 20 pCi/g gross alpha activity. All 1991 samples were below these limits.

Another study conducted in 1991 under the foodstuff monitoring program involved the collection

of produce samples from the Western Area community of Los Alamos. This study was initiated in response to a Los Alamos community concern about an apparently high brain cancer incidence rate in that area. Results of eight produce samples collected from the Western Area show that radionuclide contents were similar to the radionuclide contents in produce collected from the Española Valley. The total dose obtained from consuming 352 lb of Western Area produce was 0.4 mrem/yr. This dose was less than 1% of the DOE's radiation protection standard of 100 mrem/yr for all pathways for protecting members of the public. The slightly higher values of some radionuclides in produce samples collected from the Western Area as compared to background (i.e., ^{90}Sr) were believed to be a result of higher precipitation/fallout events. The total precipitation recorded in the Western Area during 1991 was twice that in Española.

In summary, Laboratory contributions to doses received from produce consumption, including that from H^3, pose no threat to the health and safety of the general public. Section V.C.3.f presents information on

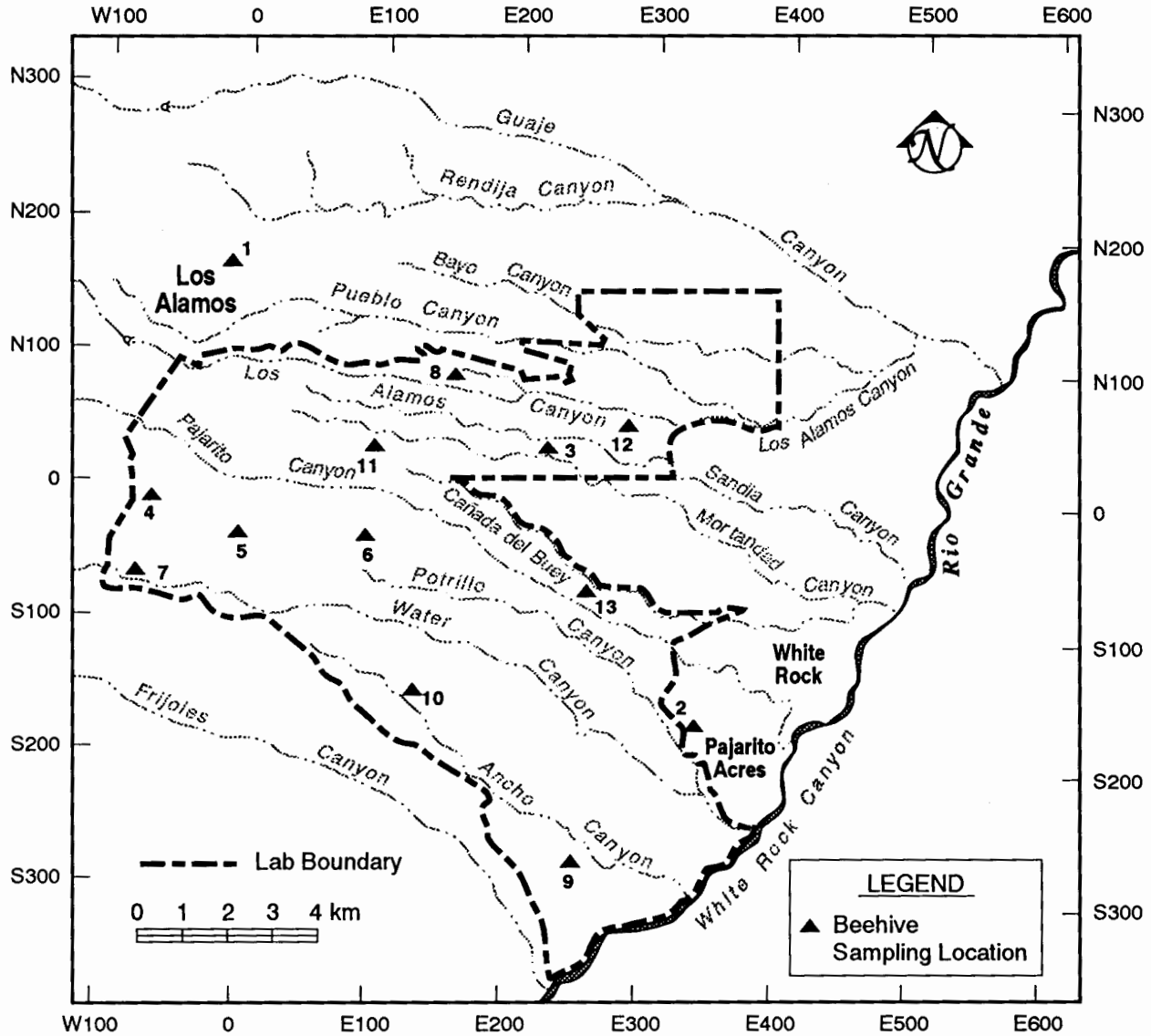


Fig. IV-14. Locations of beehives in the Los Alamos area. Regional stations are not shown. (Map denotes general locations; specific locations are presented in Table D-12.)

Table IV-31. Radionuclides in On-Site, Perimeter, and Regional Produce Collected during the 1991 Growing Season[a]

	H^3 (pCi/mL)	^{90}Sr (10^{-3} pCi/dry g)	Uranium (ng/dry g)	^{238}Pu (10^{-5} pCi/dry g)	$^{239,240}Pu$ (10^{-5} pCi/dry g)	^{137}Cs (10^{-3} pCi/dry g)
REGIONAL STATIONS						
Española						
N	10	10	10	10	10	10
Mean	0.4	45	23	−3.5	5	158
Std dev	0.2	57	15	13	15	141
Minimum	0.1 (0.3)[b]	−13.5 (−0.5)	1.5 (0.2)	−25 (1.5)	−15.1 (1.5)	−56 (61)
Maximum	0.5 (0.3)	159 (6.3)	50 (4.9)	14 (38.1)	38.0 (27)	350 (206)
San Ildefonso						
N	6	6	6	6	6	6
Mean	0.5	139	83	98	23	736
Std dev	0.4	89	103	94	44	984
Minimum	0.0 (0.3)	25 (4.2)	2 (0.2)	0.0 (3.6)	−33 (3.6)	14 (29)
Maximum	1.0 (0.3)	290 (10.5)	275 (27.5)	240 (144)	96 (93)	2,484 (1,150)
PERIMETER STATIONS (Los Alamos/White Rock)						
N	23	23	23	23	23	23
Mean	0.6	75	7	19	14	66
Std dev	0.6	173	5	28	19	287
Minimum	−0.3 (0.3)	6.6 (9.9)	1.0 (0.1)	−13.5 (3.3)	−30.8 (3.3)	−935 (62)
Maximum	2.7 (0.4)	855 (17.1)	20.8 (2.1)	123 (82.1)	60 (37)	643 (337)
ON-SITE STATIONS (Laboratory Lands)						
N	2	2	2	2	2	2
Mean	4.4	83	16	16	16	121
Std dev	5.2	14	2	9	9	172
Minimum	0.7 (0.3)	73 (9)	15 (1.5)	9.3 (9.3)	9.3 (9.3)	−0.7 (105)
Maximum	8.1 (0.5)	93 (12)	17 (1.7)	22 (14.6)	22 (15)	243 (145)

Table IV-31. (Cont.)

	H^3 (pCi/mL)	^{90}Sr (10^{-3} pCi/dry g)	Uranium (ng/dry g)	^{238}Pu (10^{-5} pCi/dry g)	$^{239,240}Pu$ (10^{-5} pCi/dry g)	^{137}Cs (10^{-3} pCi/dry g)
OTHER STATIONS (Cochiti/Santo Domingo)						
N	13	13	13	13	13	13
Mean	0.1	37	11	5	17	117
Std dev	0.4	25	9	14	19	101
Minimum	−0.6 (0.3)	5.1 (1.4)	1.5 (0.1)	−14.8 (8.6)	0.0 (5.1)	−0.6 (16)
Maximum	0.7 (0.3)	83 (14.0)	30.4 (3.1)	30.6 (30.5)	69 (43.0)	374 (189)

[a]There are no concentration guides for produce.
[b]Counting uncertainties are in parentheses.

the radiological health significance of these data (i.e., radiation dose assessments).

b. Fish. Radionuclides in fish collected from Abiquiu and Cochiti reservoirs are presented in Table IV-32. Heavy and trace metals in fish collected from these reservoirs can be found in Table IV-33. Similar types of feeders were compared using an unpaired student's t-test at the 0.05 confidence level. Concentrations of most radionuclides in bottom-feeding catfish collected from Cochiti were not statistically different than radionuclides in catfish collected from Abiquiu Dam. Total uranium was statistically different in catfish collected from Cochiti as compared to catfish collected from Abiquiu. The difference between total U in fish collected from these two reservoirs, however, was small (i.e., 4.1 ng/dry g).

Levels of ^{90}Sr, total U, and ^{238}Pu in crappie collected from Cochiti were statistically different from trout collected from Abiquiu. Although the levels of these radionuclides in fish from Cochiti were statistically higher in comparison to Abiquiu, they were within the variation exhibited by crappie in previous years. Also, the difference between the radionuclide contents detected in crappie collected from Cochiti as

Table IV-32. Radionuclides in Fish

	^{90}Sr (10^{-3} pCi/dry g)	^{137}Cs (10^{-3} pCi/dry g)	Uranium (ng/dry g)	^{238}Pu (10^{-5} pCi/dry g)	^{239}Pu (10^{-5} pCi/dry g)
BOTTOM FEEDERS (Catfish)					
Abiquiu					
N	12	12	12	12	12
Mean	26	21	5.1	1	3
Std dev	10	71	3.0	10	3
Minimum	4 (8)[a]	−17 (6)	0.7 (0.1)	−18 (2)	−5 (3)
Maximum	36 (36)	245 (36)	12.5 (1.2)	16 (18)	8 (18)
Cochiti					
N	11	11	11	11	11
Mean	17	1	9.2	4	2
Std dev	7	9	4.2	6	4
Minimum	6 (12)	−12 (9)	4.0 (0.4)	−8 (0)	−4 (3)
Maximum	27 (18)	13 (18)	16.5 (1.6)	14 (14)	7 (9)
SURFACE FEEDERS (Crappie or Trout)					
Abiquiu					
N	12	12	12	12	12
Mean	10	1	3.2	3	3
Std dev	3	16	1.0	4	4
Minimum	6 (12)	−37 (9)	1.7 (0.2)	0 (2)	−3 (2)
Maximum	16 (26)	24 (26)	5.2 (0.5)	8 (11)	10 (10)
Cochiti					
N	12	12	12	12	12
Mean	66	6	4.8	8	4
Std dev	14	21	1.0	7	8
Minimum	39 (26)	−24 (2)	3.6 (0.3)	0 (6)	−6 (3)
Maximum	90 (32)	55 (32)	6.4 (0.7)	16 (16)	16 (16)

[a]Counting uncertainties are in parentheses.

Table IV-33. Heavy and Trace Metals in Fish (μg/dry g)

	Abiquiu		Cochiti	
Element	Mean	Standard Deviation	Mean	Standard Deviation
Ag	<2.00	0.00	<2.00	0.00
Al	<2.00	0.00	<2.00	0.00
As	<0.10	0.00	<0.10	0.00
B	<2.00	0.00	<2.00	0.00
Ba	<2.00	0.00	<2.00	0.00
Be	<2.00	0.00	<2.00	0.00
Ca	85.50	20.60	378.28	440.72
Cd	<0.02	0.01	<0.02	0.00
Co	<1.00	0.00	<1.00	0.00
Cr	1.15	0.39	0.70	0.71
Cu	<2.00	0.00	<2.00	0.00
Fe	11.66	3.20	5.57	4.31
Hg	0.35	0.09	0.35	0.12
Mg	233.33	20.65	240.00	34.64
Mn	<1.00	0.00	<1.00	0.00
Mo	<2.00	0.00	<2.00	0.00
Ni	<2.00	0.00	<2.00	0.00
Pb	<0.10	0.00	<0.10	0.00
Se	0.38	0.27	0.46	0.23
Si	4.00	1.26	3.42	1.51
Sn	<2.00	0.00	<2.00	0.00
Sr	<2.00	0.00	<2.00	0.00
V	<2.00	0.00	<2.00	0.00
Zn	4.00	1.26	4.71	0.95

compared to trout collected from Abiquiu was small: ^{90}Sr was 0.056 pCi/dry g, total U was 1.6 ng/dry g, and ^{238}Pu was 0.00005 pCi/dry g. As in the past, body burdens in bottom-feeding catfish had higher levels of uranium (average was 7.1 ng/dry g) than those found in surface feeders such as crappie or trout (4.0 ng/dry g). None of the 24 heavy and trace metals analyzed, including Pb, Cd, and Hg, in fish collected from Cochiti Reservoir were significantly different from heavy and trace metal elements in fish collected from Abiquiu Reservoir.

Overall, the data indicate that Laboratory operations do not result in significant radiation doses to the general public from consuming fish from Cochiti Reservoir.

c. Bees and Honey. The most recent data (1990) for bees and honey are shown in Tables IV-34 through IV-37. In general, most radionuclide and trace metal elements were within the variation exhibited in previous years. Levels of H^3 in bees collected from Laboratory areas, in 1990, ranged in concentration from 2,400 (±400) to 760,000 (±80,000) pCi/L. The highest H^3 contents in bees collected from the Laboratory were from TA-54 (Area G) and TA-53 (LAMPF). Background levels of H^3 in bees range in concentration from 700 to 1500 (±300) pCi/L.

Tritium in honey collected from Laboratory lands in 1990 ranged from 500 (±600) to 420,000 (±40,000) pCi/L. The highest H^3 levels in honey at the Laboratory were those collected from TA-33 (HP-Site) and TA-53. Levels of H^3 in honey collected from background stations ranged in concentration from 300 (±200) to 2400 (±400) pCi/L. Honey produced by the hives on Laboratory lands is not available for consumption.

Table IV-34. Selected Radionuclides in Local and Regional Honey Collected during 1990

Station	H^3 (pCi/L)	^7Be (pCi/L)	^{22}Na (pCi/L)	^{54}Mn (pCi/L)	^{57}Co (pCi/L)	^{83}Rb (pCi/L)	^{137}Cs (pCi/L)
San Pedro	300 (200)[a]	650 (4,600)	2 (530)	9 (510)	14 (390)	18 (950)	14 (500)
Chimayo	2,400 (400)	1,900 (4,600)	–9 (530)	25 (510)	11 (390)	5 (950)	–2 (500)
San Juan	400 (200)	700 (4,600)	16 (530)	8 (510)	65 (390)	79 (950)	13 (500)
TA-5	4,900 (300)	–1,700 (4,600)	2 (530)	45 (510)	–19 (390)	11 (950)	19 (500)
TA-8	800 (300)	–2,100 (4,600)	10 (530)	7 (510)	11 (390)	110 (950)	–1 (500)
TA-9	800 (300)	2,900 (4,600)	–14 (530)	44 (510)	39 (390)	200 (950)	16 (500)
TA-15	1,000 (300)	1,700 (4,600)	204 (530)	4 (510)	4 (390)	60 (950)	–9 (500)
TA-16	500 (600)	2,500 (4,600)	60 (530)	33 (510)	–31 (390)	280 (950)	7 (500)
TA-21	110,000 (10,000)	–150 (4,600)	27 (530)	60 (510)	9 (390)	37 (950)	10 (500)
TA-33	240,000 (20,000)	–360 (4,600)	–5 (530)	35 (510)	7 (390)	–140 (950)	–30 (500)
TA-49	1,300 (300)	–900 (4,600)	2 (530)	37 (510)	13 (390)	90 (950)	55 (500)
TA-50	9,100 (1,000)	1,700 (4,600)	–3 (530)	3 (510)	–8 (390)	–6 (950)	6 (500)
TA-53	420,000 (40,000)	1,200 (4,600)	120 (530)	28 (510)	37 (390)	–24 (950)	10 (500)
TA-54	54,000 (5,000)	22 (4,600)	24 (530)	7 (510)	26 (390)	–150 (950)	49 (500)

[a]Counting uncertainties are in parentheses.

Table IV-35. Selected Trace Metals in Local and Regional Honey Collected during 1990[a]

Station	Arsenic (μg/g)	Beryllium (ng/g)	Boron (μg/g)	Cadmium (μg/g)	Chromium (μg/g)	Lead (μg/g)	Mercury (ng/g)	Selenium (μg/g)
San Pedro	0.76	<2.0	5.8	<0.01	0.03	<0.06	<25	0.90
Chimayo	0.87	<2.0	6.7	<0.01	0.04	<0.06	<25	0.85
San Juan	0.86	<2.0	6.9	<0.01	0.03	<0.06	<25	0.99
TA-5	1.10	<2.0	8.0	<0.01	0.04	0.08	<25	0.93
TA-8	0.93	<2.0	8.8	<0.01	0.04	0.06	<25	1.10
TA-9	0.97	<2.0	4.7	<0.01	0.04	<0.06	<25	0.88
TA-15	0.91	<2.0	5.2	0.02	0.04	<0.06	<25	1.20
TA-16	1.10	<2.0	7.0	<0.01	0.04	<0.06	<25	0.88
TA-21	1.00	<2.0	9.2	<0.01	0.04	<0.06	<25	1.10
TA-33	0.81	<2.0	7.5	<0.01	0.04	0.09	<25	0.92
TA-49	0.94	<2.0	5.1	<0.01	0.03	<0.06	<25	1.40
TA-50	0.82	<2.0	6.0	0.01	0.05	1.50	<25	0.90
TA-53	0.81	<2.0	5.2	<0.01	0.08	<0.06	<25	0.88
TA-54	0.94	<2.0	8.8	<0.01	0.03	<0.06	<25	1.30

[a]Uncertainty of the results is ±10%. The density of honey is about 1860 g/L.

Table IV-36. Selected Radionuclides in Local and Regional Bees Collected during 1990

Station	H^3 (pCi/L)	^7Be (pCi/g)	^{22}Na (pCi/g)	^{54}Mn (pCi/g)	^{57}Co (pCi/g)	^{83}Rb (pCi/g)	^{137}Cs (pCi/g)	Uranium (ng/g)
San Pedro	800	1.50	–0.03	0.10	0.03	0.17	0.02	288
	(300)[a]	(15.50)	(1.05)	(0.90)	(0.01)	(2.05)	(0.60)	(29)
Chimayo	1,500	1.50	–0.05	–0.05	0.05	0.10	0.03	286
	(300)	(15.50)	(1.05)	(0.90)	(0.01)	(2.05)	(0.60)	(29)
San Juan	700	2.25	0.04	–0.01	0.03	–0.07	0.00	253
	(300)	(1.00)	(1.05)	(0.90)	(0.01)	(2.05)	(0.60)	(25)
TA-5	7,200	4.06	0.04	0.02	0.00	0.00	0.00	138
	(800)	(1.15)	(1.05)	(0.90)	(0.25)	(2.05)	(0.60)	(14)
TA-8	3,500	2.45	0.02	–0.07	0.04	–0.05	–0.01	95
	(500)	(15.50)	(1.05)	(0.90)	(0.01)	(2.05)	(0.60)	(9)
TA-9	5,700	0.85	0.10	–0.04	0.06	0.11	0.02	161
	(700)	(15.50)	(1.05)	(0.90)	(0.25)	(2.05)	(0.60)	(16)
TA-15	2,400	0.65	0.03	–0.05	0.05	0.12	0.03	360
	(400)	(15.50)	(1.05)	(0.90)	(0.01)	(2.05)	(0.60)	(30)
TA-16	4,400	0.70	0.04	0.06	0.07	0.15	0.01	248
	(500)	(15.50)	(1.05)	(0.90)	(0.01)	(2.05)	(0.60)	(25)
TA-21	19,000	1.20	–0.04	–0.04	0.11	0.07	0.03	132
	(2,000)	(15.20)	(1.05)	(0.90)	(0.25)	(2.05)	(0.01)	(13)
TA-33	47,000	1.25	0.07	0.09	0.03	0.15	0.02	509
	(5,000)	(15.50)	(1.05)	(0.90)	(0.01)	(2.05)	(0.60)	(51)
TA-49	5,600	1.99	0.04	0.03	0.02	0.00	0.01	159
	(700)	(0.90)	(1.05)	(0.90)	(0.25)	(2.05)	(0.60)	(16)
TA-50	25,000	0.07	0.08	0.05	0.03	–0.09	0.03	109
	(3,000)	(15.50)	(0.03)	(0.90)	(0.01)	(2.05)	(0.60)	(11)
TA-53	55,000	0.47	1.01	0.16	0.18	0.04	0.04	147
	(6,000)	(15.50)	(0.10)	(0.90)	(0.02)	(2.05)	(0.60)	(15)
TA-54	760,000	1.77	–0.05	0.07	0.07	–0.02	0.06	81
	(80,000)	(0.80)	(1.05)	(0.90)	(0.25)	(2.05)	(0.60)	(8)

[a]Counting uncertainties are in parentheses.

Table IV-37. Selected Trace Metals in Local and Regional Bees Collected during 1990[a]

Station	Arsenic (µg/g)	Beryllium (ng/g)	Boron (µg/g)	Cadmium (µg/g)	Chromium (µg/g)	Lead (µg/g)	Mercury (ng/g)	Selenium (µg/g)
San Pedro	<0.03	8.0	7.8	0.02	0.22	0.25	<25	1.60
Chimayo	<0.03	8.0	6.0	<0.01	3.80	4.30	<25	1.70
San Juan	<0.03	20.0	6.9	0.03	0.23	0.68	<25	1.10
TA-5	<0.03	2.0	7.2	<0.01	4.00	0.16	<25	0.66
TA-8	<0.03	<2.0	4.0	0.02	0.17	0.37	<25	0.47
TA-9	<0.03	<2.0	3.9	<0.01	0.16	0.51	<25	0.68
TA-15	<0.03	<2.0	6.1	<0.01	0.26	0.52	<25	0.60
TA-16	<0.03	<2.0	3.5	0.02	0.53	0.68	<25	2.50
TA-21	<0.03	10.0	4.6	0.04	0.18	0.31	<25	0.62
TA-33	<0.03	5.0	3.9	0.04	0.33	0.85	<25	1.90
TA-49	<0.03	23.0	6.3	0.04	0.20	0.77	<25	0.51
TA-50	0.14	<2.0	3.0	0.03	0.15	0.48	<25	0.48
TA-53	0.74	<2.0	6.2	<0.01	0.46	0.21	<25	1.10
TA-54	<0.03	<2.0	0.7	<0.01	0.14	0.02	<25	<0.07

[a]Uncertainty of the results is ±10%.

H. Environmental Assessments

The National Environmental Policy Act (NEPA) mandates that federal agencies consider the environmental impact of their actions prior to final decision making. NEPA establishes the national policy of creating and maintaining conditions under which man and nature can exist in harmony and fulfill the social, economic, and other requirements of present and future generations.

NEPA documents include the following:

- a categorical exclusion, applied to specific types of activities that have been determined to have no adverse environmental impacts;
- an Environmental Assessment (EA), evaluating environmental impacts, leading to either a finding of no significant impact (FONSI) if the impacts are indeed found to be not significant, or preparation of an Environmental Impact Statement (EIS) if the impacts could be significant; and
- an EIS, in which impacts of proposed and alternative actions are evaluated and mitigation measures proposed, leading to a record of decision in which the agency discusses a decision on proceeding with the project.

The proposed activities documented in the EAs submitted to DOE during 1991 are summarized below. The DOE reviews the analysis of environmental impacts for the proposed action presented in each EA and either issues a FONSI or prepares an EIS.

Radioisotope Heat Source Fuel Processing and Fabrication. The proposed action is for the DOE to renovate and operate existing ^{238}Pu processing facilities at the Savannah River Site (SRS) and to fabricate a limited quantity of ^{238}Pu heat source units at an existing ^{238}Pu research and development facility in Building PF-4, TA-55 at LANL. The proposed action includes facilities used in ^{238}Pu fuel processing and fabrication from the point at which existing inventories of ^{238}Pu oxide can be dissolved and reblended at SRS to the point at which the fabricated ^{238}Pu fuel forms are shipped from LANL for final integration into end-use system components.

The purpose of the proposed action is to enable DOE to provide the required supplies of ^{238}Pu fuel in a fabricated form to support the National Aeronautics and Space Administration's near-term Comet Rendezvous Asteroid Flyby and Cassini missions. DOE issued a FONSI on this proposed action on August 19, 1991.

Sorbent Radioactivity Study. The proposed action is to study the adsorption and decomposition of toxic gases in contact with activated carbon filter material; theoretical studies would be conducted concurrently. The research is needed to test and improve the effectiveness of carbon sorbents used to clean toxic gases from air. One application of this research is in the design of improved respiratory protection for individuals exposed to chemical warfare agents. To date, DOE has not made a determination on this EA.

Advanced Free-Electron Laser. The proposed project is to assemble and test a laser capable of producing laser light with wavelengths in the range of 100-0.1 micrometer and to conduct experiments using the laser light. Support activities such as construction of the shielded vault, temperature controlled rooms, equipment temperature control systems, and ventilation systems also would be necessary.

Goals of the proposed program include the development of advanced components for the free-electron laser, in particular electron beam accelerators, optical systems, resonators, and wiggler magnets. DOE has issued a draft FONSI on this proposed action.

Transuranic Waste Compactor and Drum Storage Building. The proposed action consists of two activities: (1) installing a 20-ton hydraulic press in an existing laboratory area to compact approximately 500 lb/wk of TRU waste; and (2) using a prefabricated, concrete-floored, metal building for the temporary storage of drums of solid TRU waste as they await certification and transport to a longer term storage area. The proposed action would increase the efficiency of waste volume minimization and waste storage while increasing safety in process and storage areas. At DOE's request, LANL combined separate EAs for the TRU Waste Compactor and the Drum Storage Building into this EA. The combined EA was submitted to DOE, but, to date, DOE has not made a determination on these proposed activities.

Expansion of Area G. Routine activities at the Laboratory generate solid low-level wastes (LLWs) which are disposed of or stored at Area G, TA-54. For some waste types, burial is the only feasible disposal

method that is consistent with all regulations. The useful lifetime of the existing Area G 63-acre site, which is limited by the area suitable for pit construction, is estimated to be 1993. The proposed action is to expand Area G, TA-54 onto nearby acreage on Mesita del Buey in order to provide adequate area and facilities to accommodate the disposal of solid LLW after the currently active part of Area G has been filled. The Laboratory site-wide EIS (DOE 1979) designated Mesita del Buey as a dedicated waste disposal site. The EA has been revised following DOE Field Office, Albuquerque, and DOE Headquarters (HQ) comments and is currently at DOE/HQ awaiting a determination.

I. Other Significant Environmental Activities at Los Alamos

1. External Radiation Measurement Study.

In addition to the Laboratory's routine TLD monitoring of external penetrating radiation in 1991, which is described in Section IV.B, a special study was conducted from August 1990 through July 1991 to evaluate TLD measurements. This is part of a continuing study consisting of an intercomparison of Laboratory TLDs with TLDs obtained from a commercial contractor.

One phase of the study involved colocating environmental dosimeters obtained from the contractor next to Laboratory dosimeters at 29 locations in the routine environmental monitoring network. Two contractor TLDs were placed at five of these locations.

The study began in August 1990. Contractor TLDs were colocated with the Laboratory TLDs for two months of the third quarter of 1990. Both the Laboratory TLDs and the contractor TLDs were exposed for the same time period, one calendar quarter, for the fourth quarter of 1990 and the first and second quarters of 1991.

The intercomparison was a "blind" study as far as the contractor was concerned. The contractor's TLDs were set out and collected following the contractor's instructions. No information was given to the contractor concerning the nature of study. The TLDs provided to LANL were processed by the contractor as would be those from any other customer.

The preliminary measured annual average external radiation levels for the 22 stations for which data for all four quarters is available is shown in Fig. IV-15. Please note that the contractor data for the third quarter of 1990 was corrected for its shorter exposure time by scaling the measurements to a full quarter exposure.

Figure IV-15 also shows the two-standard deviation acceptance band above and below the contractor's measurements. The LANL TLD measurements appear slightly but not significantly higher than those obtained from the contractor. In general, good agreement was found between the contractor's and LANL's measurements.

2. Tritium in Precipitation in the Los Alamos Region of New Mexico. (Andrew Adams and Fraser Goff [EES-1])

In February of 1990 EES-1 commenced a study to determine the background levels of tritium in precipitation in the Los Alamos region of New Mexico. This study is part of the framework studies in support of the ER program at Los Alamos.

In Figs. IV-16–IV-18 all the collection locations and elevations are plotted with the results of the tritium analyses shown in small boxes. A Tritium Unit is about 3.2 pCi/L of water. From examination of the tritium data of this study, plus cold spring and creek data from other studies in the Jemez Mountains, it appears that any rainwater with greater than 20 TUs must be contaminated to some degree by Laboratory activities. Assuming that the maximum value of background tritium in precipitation is 20 TU, a 20 TU contour was drawn through the data points for each sampling period. The exact position of the contour is approximate, but the results are clear; activities at the Laboratory release tritium into the atmosphere. However, over the 3- to 4-month time periods represented by these samples, the average concentration is almost 2 orders of magnitude below EPA limits set for tritium in drinking water (20,000 pCi/L, which is about 6,200 TU).

Figure IV-16 shows the results of the December 1990–April 1991 collection period. Inside the Laboratory boundary, the range is from 25.5 TU at S-Site to 117 TU at the White Rock "Y". Outside the Laboratory, the tritium values range from 8.2 TU at VC-2B to 14.6 TU at the Santa Fe Ski Basin.

Figure IV-17 shows the results of the April 1991–August 1991 collection period now with 14 collectors in place. During this time period, higher than average rainfall was recorded. As a result of this, the

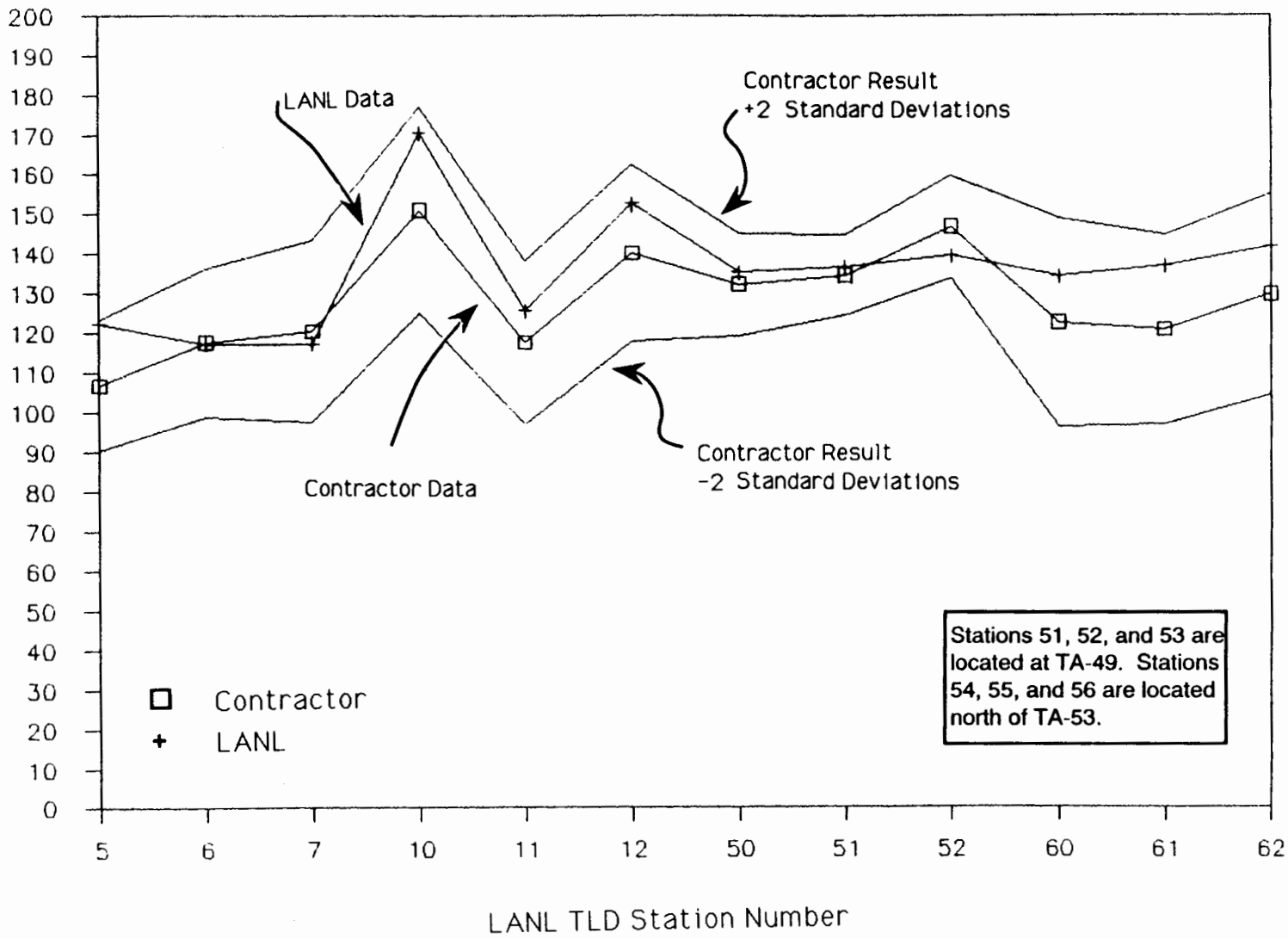


Fig. IV-15. Los Alamos National Laboratory/Contractor TLD intercomparison, July 1990 through June 1991. Please note that these data are for the period of July 1990 through June 1991 and so do not correspond to the January 1990 through December 1990 annual TLD results presented elsewhere in this report. These data are given to indicate the preliminary results of the intercomparison study.

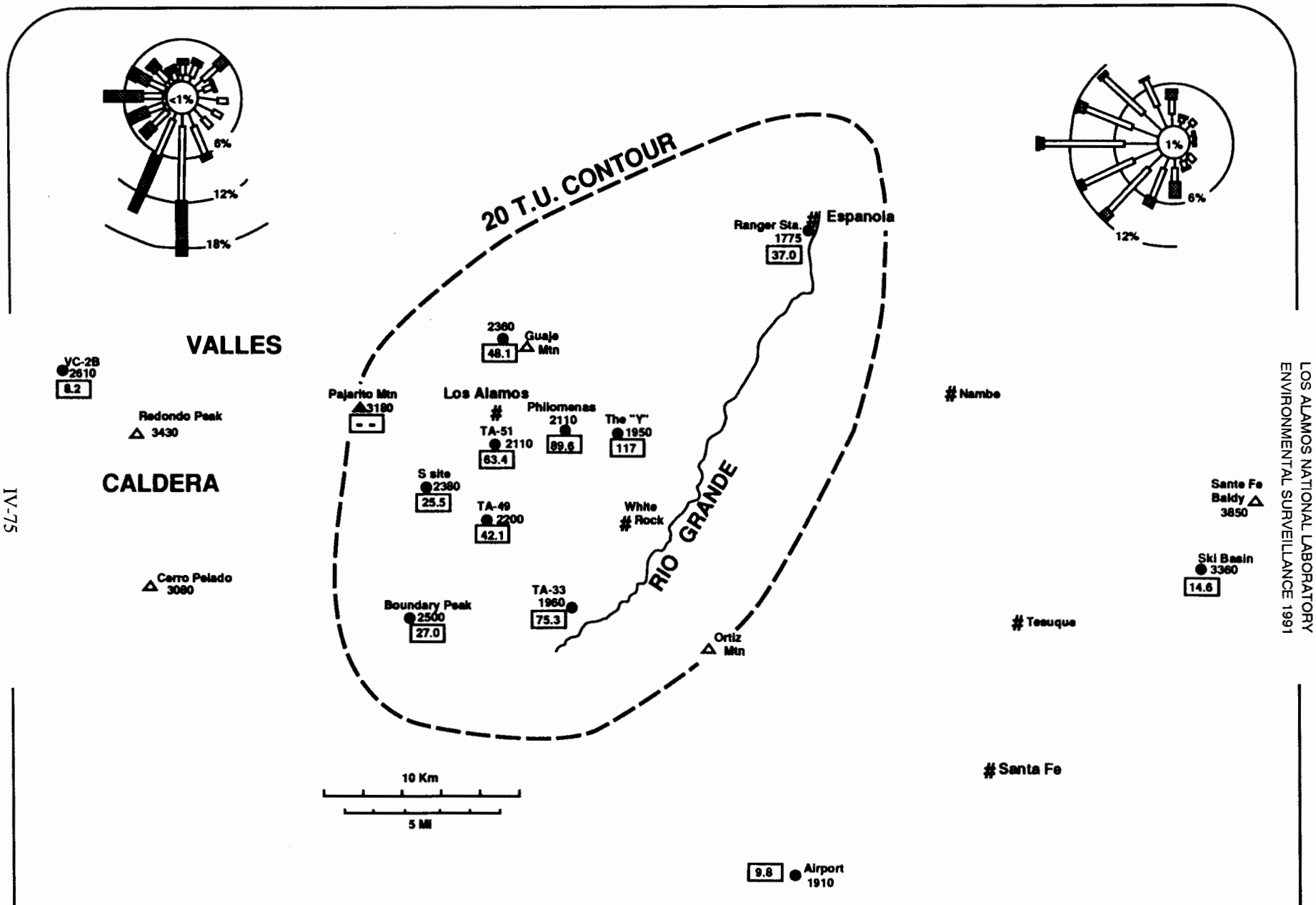


Fig. IV-16. Tritium in rainwater (collected during December 1990 - April 1991).

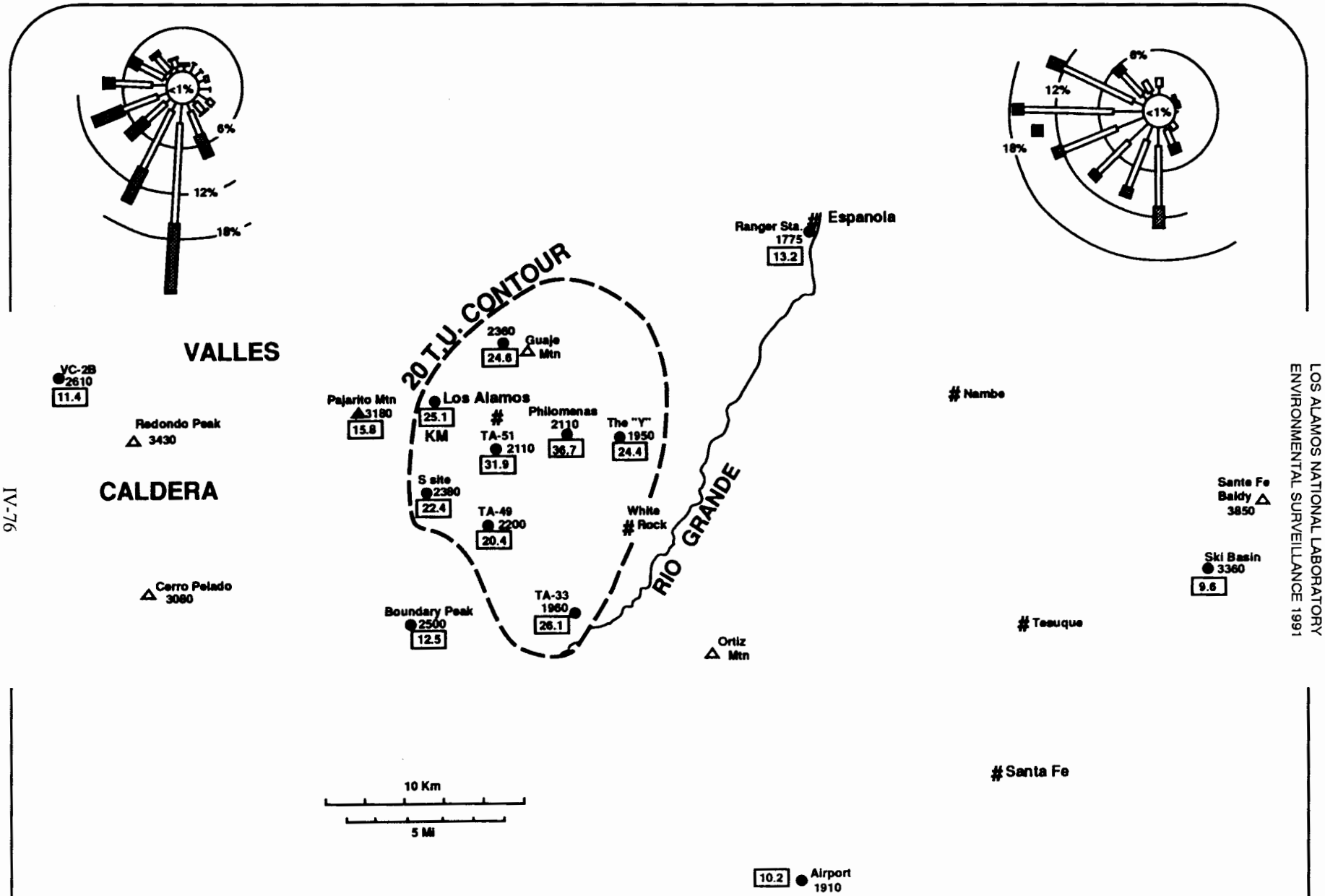


Fig. IV-17. Tritium in rainwater (collected during April 1991 - August 1991).

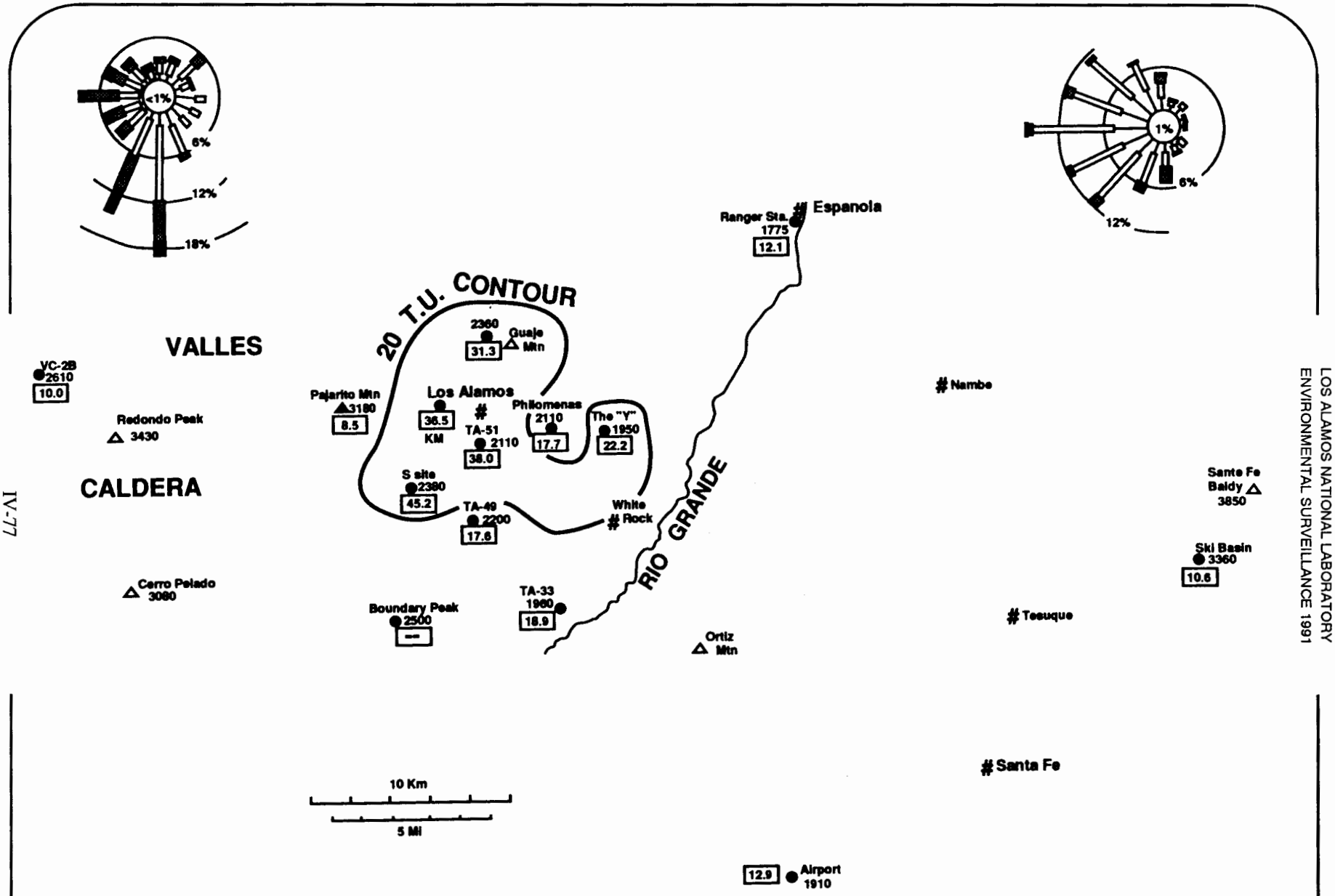


Fig. IV-18. Tritium in rainwater (collected during August 1991 - December 1991).

area within the contour shrinks due to dilution of Laboratory tritium releases by increased rain. The values inside the Laboratory range from 20.4 TU at TA-49 to 36.7 TU at East Gate. The range outside the Laboratory is 9.6 TU at the Santa Fe Ski Basin to 15.8 TU at Pajarito Mountain.

Figure IV-18 shows the results of the August 1991–December 1991 collection period. Inside the Laboratory the range is from 17.6 TU at TA-49 to 45.2 TU at S-Site. Outside the Laboratory the tritium values range from 8.2 TU at VC-2B to 14.6 TU at the Santa Fe Ski Basin.

3. Meteorological Monitoring. (Brent Bowen, Greg Stone, Bill Olsen, and Susan Kreiner)

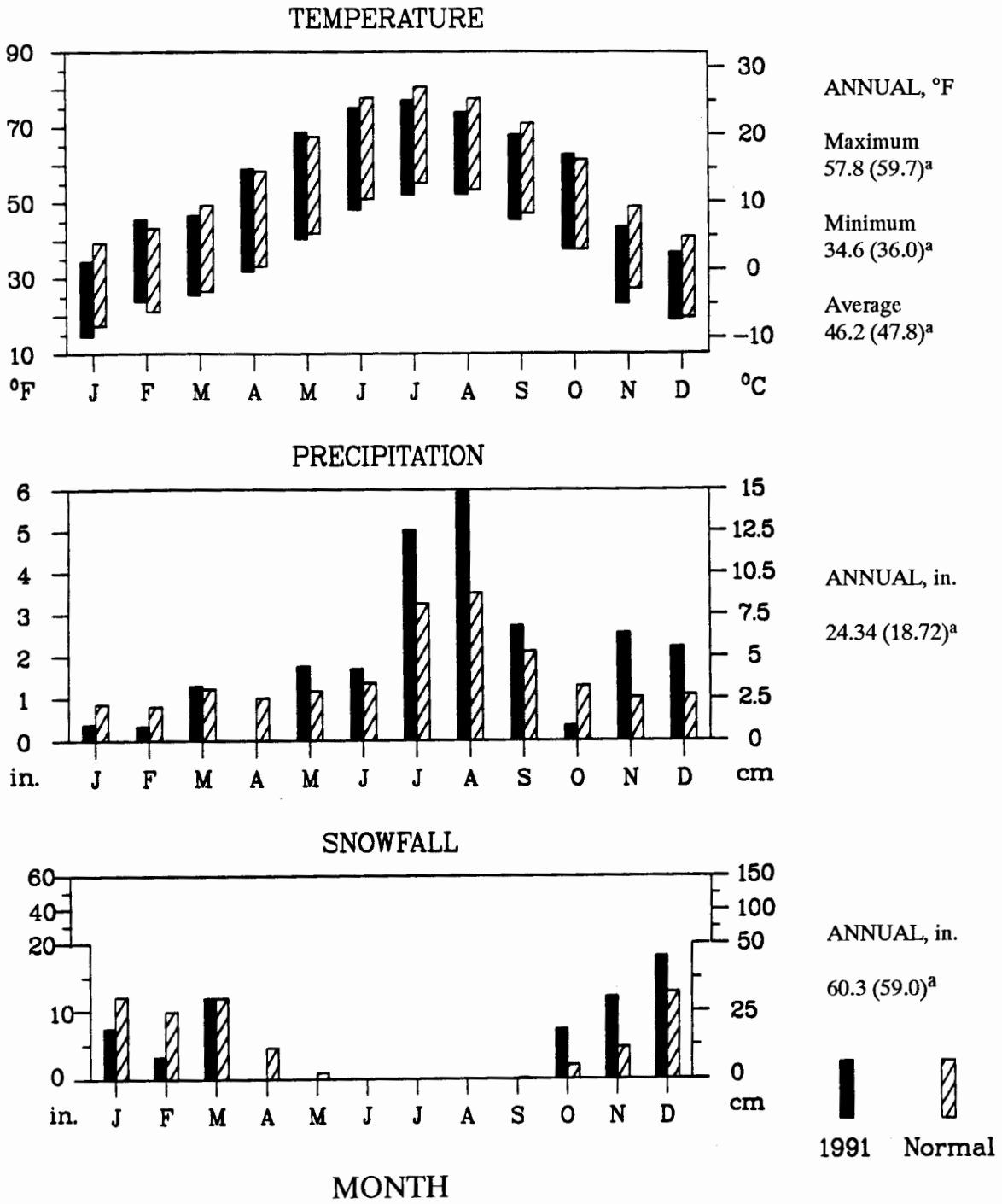
a. Weather Summary. Precipitation was heavy in Los Alamos during 1991, totaling 61.8 cm (24.34 in.), about 30% above normal. Snowfall was near normal at 153 cm (60.3 in.). Temperatures were well below normal; it was the coldest year since 1941. Unusually heavy summer rains caused some local flooding along with record cold temperatures. Unprecedented, early-season Arctic air chilled Los Alamos in late October. Heavy snowfall also fell from late October through December. The annual summary is shown in Fig. IV-19; other data are shown in Tables IV-38 and IV-39 and Tables D-13 and D-14.

The year started with dry weather in January and February. Precipitation was less than half of normal; 1.9 cm (0.73 in.) over the two months. Temperatures were quite cold in January and warm in February. Strong storms caused windier than normal conditions in March. Strong winds with peak gusts exceeding 22 m/s (50 mph) occurred on three days, with the East Gate site recording a 33 m/s (73 mph) gust on the 19th. Dry weather returned in April, with only a trace of precipitation measured during the entire month. It was the sixth April on record to report no measurable precipitation. A peak wind gust of 32 m/s (72 mph) was measured at the East Gate site on the 11th. A small rainfall on May 15 finally broke a consecutive string of 45 days without measurable precipitation.

The summer began with cool weather in June. A strong dust devil on the 18th caused considerable damage to the Los Alamos Catholic Church roof. The monsoon season began in July with heavier than normal rainfall. It was the wettest July since 1968. While official rainfall (TA-6) was over 50% above normal with 12.8 cm (5.03 in.), rainfall was even heavier at other County locations. The East Gate station recorded the greatest rainfall of 17.2 cm (6.76 in.), the second largest amount of precipitation to fall during July in Los Alamos County on record. The frequent rainfall also kept temperatures cool; it was the third coldest July on record.

Heavy thundershowers continued through August, especially at sites near the Jemez Mountains. Official rainfall was even higher in August, totaling 15.1 cm (5.93 in.), 68% above normal. It was the wettest August since 1968. The North Community site recorded 20.3 cm (7.98 in.) for the greatest rainfall in Los Alamos County. It was the highest recorded monthly precipitation to fall in Los Alamos County since the record high of 28.4 cm (11.18 in.) which fell in August of 1952. A thunderstorm on the 2nd caused local flash flooding in the SW Laboratory area with 4.5 cm (1.76 in.) falling at the Bandelier tower site. An even heavier thunderstorm occurred on the 4th, with 6.1 cm (2.40 in.) falling at the North Community rain gauge site, including 3.8 cm (1.50 in.) during a one-hour period. The heavy rains on this day falling on already saturated soil caused Los Alamos County sewer lines to be washed out in Pueblo Canyon. Widespread street and basement flooding also occurred over much of the Los Alamos townsite. More thunderstorms caused additional local flash flooding on the 6th with 4.9 cm (1.91 in.) and 4.1 cm (1.61 in.) falling at the S-Site and North Community sites, respectively. Additional heavy rains fell on the 13th and 19th. The storm on the 19th dropped 2.9 cm (1.15 in.) during a 15-minute period at the TA-6 site. The frequent and heavy rainfall made the summer the coldest on record edging out the previous coldest of 1929.

Cool and wet weather continued in September. The month became the fourth coldest September on record. Dry and mild weather prevailed through most of October. Record high temperatures were set or tied on three days in the middle of the month, including 75°F on the 17th. A record-breaking Arctic air mass descended on New Mexico at the end of the month, along with heavy snow. The low temperature reached 16°F on the 29th, setting a record for the date. The low temperature of 15°F on the 30th not only set a daily record, but also tied the record low for the entire month of October. The high temperature reached only 28°F on that day, setting a record low for the month of



[a]Normals are in parentheses.

Fig IV-19. 1991 weather summary, Los Alamos, NM.

October. Snowfall totaled 7.3 in. during the day, also a record for the date. Temperatures plunged even further, reaching a low of 9°F on the 31st which broke the record low set the previous day. While the month's precipitation was only 0.9 cm (0.35 in.), or 27% of normal, snowfall was more than 3-1/2 times the normal, totaling 18.5 cm (7.3 in.).

The cold, wet, and snowy weather from the end of October continued through much of November. Temperatures averaged 0.7°C (33.3°F) during the month or 2.6°C (4.7°F) below normal. Precipitation was 2-1/2 times the normal, totaling 6.5 cm (2.56 in.). The month became the fourth coldest and fourth wettest November on record. Record low temperatures were set on three of the four days of the month, resulting from the Arctic air mass remaining from the last few days of October. A slow-moving storm produced much of the month's precipitation, 5.1 cm (2.00 in.) on the 14–16th, including 3.5 cm (1.39 in.) on the 15th. The precipitation started out as rain; however, the rain changed to wet snow late on the 15th. Snowfall totaled about 25 cm (10 in.) by noon on the 16th. The weight of the heavy snow on the abundant amount of leaves left on deciduous trees caused wide-spread damage to trees and limbs. The month's snowfall totaled 30.7 cm (12.1 in.), or more than 2-1/2 times normal. The cold, wet, and snowy weather continued through December. Precipitation was more than twice the normal, totaling 5.7 cm (2.23 in.). Snowfall was 40% above normal at 46.0 cm (18.1 in.). Record low temperatures were set or equaled on the first three days of the month. A storm dropped 2.6 cm (1.03 in.) of precipitation on the 11th. Temperatures hovering just above freezing limited snow accumulation to 8.1 cm (3.2 in.). Another storm caused heavy snow of 27.4 cm (10.8 in.) on the 18–19th, with most falling on the 18th forcing an early shutdown of the Laboratory and other local businesses and schools.

b. Precipitation Summary. Precipitation ranged from near normal over the western parts of Los Alamos County to several inches above normal in the northeast and east. Figure IV-20 shows precipitation analyses for the summer monsoon season (July-September) and the entire year. Monthly precipitation totals are also listed in Table IV-38.

Table IV-38. Los Alamos Climatological Summary for 1991

	Temperature (°F)[a]						
	Means			Extremes			
Month	Mean Maximum	Mean Minimum	Average	High	Date	Low	Date
January	34.6	14.7	24.7	45	31	2	22
February	45.8	23.9	34.8	54	21,23	12	19
March	46.9	25.5	36.2	59	24	14	8
April	59.1	31.9	45.5	72	6	19	14
May	68.8	40.6	54.7	78	18	28	1,5
June	75.2	48.3	61.7	88	26	37	1
July	77.2	52.2	64.7	88	7	46	26
August	74.0	52.3	63.2	80	21	48	7
September	68.0	45.5	56.7	78	2	37	23
October	62.9	37.6	50.3	75	11,17	9	31
November	43.4	23.2	33.3	59	6	9	1
December	36.6	18.8	27.7	46	6,8, 9,16	5	1,2
Annual	57.8	34.6	46.2	88	6/27,7/7	2	1/22

Table IV-38. (Cont.)

Month	Precipitation (in.)[a] Water Equivalent Total	Water Equivalent Daily Maximum	Water Equivalent Date	Snow Total	Snow Daily Maximum	Snow Date	Number of Days Precip. ≥0.10 in.	Max. Temp. ≥90°F	Min. Temp. ≤32°F
January	0.39	0.21	21	7.5	5.2	21	2	0	31
February	0.34	0.20	18	3.3	2.8	18	2	0	28
March	1.30	0.37	1	12.0	4.5	16	5	0	28
April	0.00	0.00	—	0.0	0.0	—	0	0	14
May	1.77	0.97	20	0.0	0.0	—	3	0	4
June	1.71	1.00	11	0.0	0.0	—	5	0	0
July	5.03	1.52	22	0.0	0.0	—	9	0	0
August	5.93	1.20	19	0.0	0.0	—	12	0	0
September	2.73	0.71	6	0.0	0.0	—	8	0	0
October	0.35	0.33	30	7.3	7.3	30	1	0	5
November	2.56	1.39	15	12.1	6.0	16	4	0	27
December	2.23	1.03	11	18.1	8.8	18	5	0	31
Annual	24.34	1.52	7/22	60.3	8.8	12/18	56	0	168

[a]Metric conversions: 1 in. = 2.5 cm; °F = 9/5 °C + 32.

Table IV-39. Los Alamos Precipitation for 1991[a]
(in.)

	North Community (Site 1)	S-Site (Site 2)	TA-6 (Site 3)	Bandelier (Site 4)	East Gate (Site 5)	TA-54 (Area G) (Site 6)	White Rock Y (Site 7)	White Rock (Site 8)
January	0.36	0.35	0.39	0.42	0.19	0.13	0.12	0.18
February	0.34	0.51	0.34	0.54	0.21	0.27	0.27	0.56
March	1.72	1.55	1.30	1.11	0.97	0.95	1.04	1.01
April	0.01	0.01	0.00	0.00	0.00	0.01	0.00	0.02
May	2.18	2.07	1.77	1.88	1.62	1.61	1.15	1.79
June	1.34	1.61	1.71	1.98	1.25	1.09	0.96	1.66
July	4.91	5.25	5.03	5.09	6.76	4.14	5.88	4.54
August	7.89	5.10	5.93	6.57	2.70	3.44	2.90	2.53
September	2.83	4.42	2.73	2.66	2.26	2.46	1.64	1.83
October	0.57	0.42	0.35	0.27	0.23	0.20	0.28	0.58
November	3.04	3.29	2.56	2.54	2.26	2.13	2.29	2.20
December	2.19	2.27	2.23	2.17	1.75	1.68	1.55	1.75
Annual	27.38	26.85	24.34	25.23	20.20	18.11	18.08	18.65

[a]Metric conversion: 1 in. = 2.5 cm. See Fig. IV-20 for site locations.

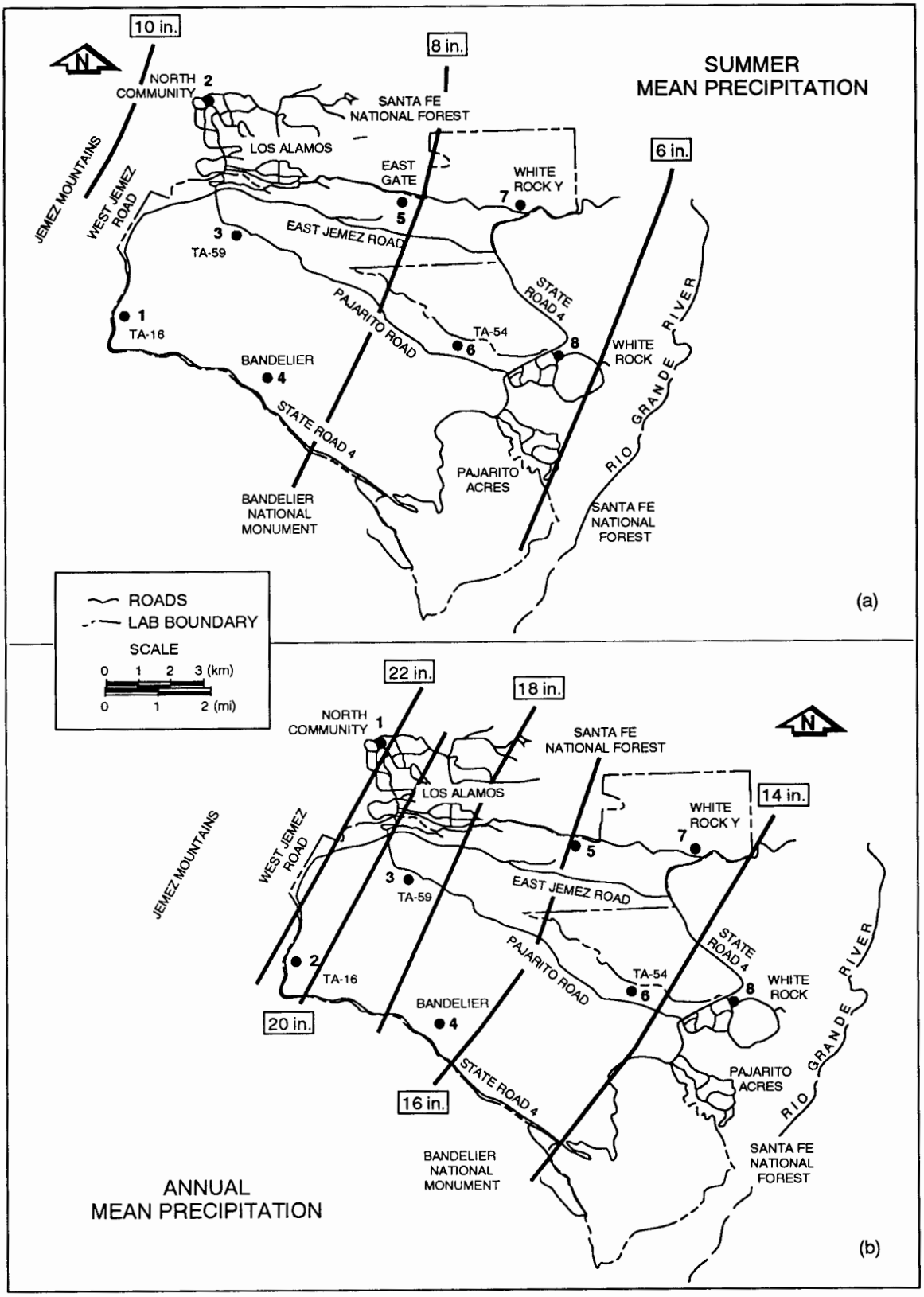


Fig. IV-20. (a) Summer monsoon (July - September) mean precipitation and (b) annual mean precipitation at Los Alamos. Isolines of precipitation are based on the eight sites shown on the maps.

Precipitation is generally greatest over and near the Jemez Mountains and decreases east-southeastward over Los Alamos County toward the Rio Grande Valley. Typically, nearly half of the annual precipitation falls during the monsoon season. The combination of a large-scale moist wind flow from the tropical Pacific Ocean and Gulf of Mexico into New Mexico, strong sunshine, warm temperatures, and elevated terrain are responsible for frequent afternoon and early evening showers and thundershowers. Monsoon rainfall was especially heavy during 1991, with rainfall ranging from 50% above normal in western locations to nearly 100% above normal at eastern locations. Precipitation also averaged above-normal during the other months, resulting in annual precipitation exceeding normal by 30-40% across the County.

4. Environmental Monitoring at the Fenton Hill Site. (Alan Stoker, Steve McLin, Max Maes, and William Purtymun).

The Laboratory operates a program to evaluate the feasibility of extracting thermal energy from the hot dry rock geothermal reservoir at the Fenton Hill Geothermal Site (TA-57), which is located about 45 km (28 mi) west of Los Alamos on the southern edge of the Valles Caldera. The hot dry rock energy concept involves drilling two deep holes, connecting these holes by hydraulic fracturing, and bringing geothermal energy to the surface by circulating water through the system. Environmental monitoring is performed adjacent to the site to assess any impacts from the geothermal operations.

The chemical quality of surface water and groundwaters in the vicinity of TA-57 (Fig. IV-21) has been monitored for use in geohydrologic and environmental studies. These water quality studies began before the construction and testing of the hot dry rock system (Purtymun 1974d).

Water samples for Fenton Hill monitoring have routinely been collected during periods of base flow (low surface water discharge) in late November or early December; in 1991 the samples were collected on December 9. The results of the general chemical parameter analyses are presented in Table IV-40, and the results of trace metal analyses and uranium tests are presented in Table IV-41. Slight variations were found in the chemical quality of surface waters and groundwaters among the individual stations when the analyses were compared with those from previous years; however, these variations are within typical seasonal fluctuations observed in the past (Purtymun 1988a). There were no significant changes in the chemical quality of surface water and groundwater at the individual stations from previous years (Purtymun 1988a).

5. Environmental Studies at the Pueblo de San Ildefonso. (Alan Stoker, Max Maes, and John Sorrell [Bureau of Indian Affairs])

To document the potential impacts of Laboratory operations on lands belonging to San Ildefonso Pueblo, the DOE entered into a memorandum of understanding (MOU) with the Pueblo and the Bureau of Indian Affairs (BIA) to conduct environmental sampling on Pueblo land. The agreement, entitled "Memorandum of Understanding Among the Bureau of Indian Affairs, the Department of Energy, and the Pueblo of San Ildefonso Regarding Testing for Radioactive and Chemical Contamination of Lands and Natural Resources Belonging to the Pueblo of San Ildefonso," No. DE-GM32-87AL37160, was concluded in June 1987. The agreement calls for both hydrologic pathway sampling (including water, soils, and sediments) and foodstuff sampling. This section deals with the hydrologic pathway. The foodstuff sampling is covered in Section IV.G of this report. During 1987, 1988, and 1989, water, soil, and sediment samples were collected in accord with the agreement (Purtymun 1988b, ESG 1989, EPG 1990).

In 1991, the formal sampling plan (Appendix A to the MOU) called for the Laboratory to collect and analyze special water samples from two stations east and two stations west of the Rio Grande (West: Station 3, Pajarito Well [both pumps]; Station 8, Halladay Well; East: Station 17 [new], Don Juan Playhouse Well; and Station 9 Eastside Artesian Well). Special sediment samples were to be collected from four locations on San Ildefonso lands in Mortandad Canyon, designated A-6, A-7, A-8, and A-10 on Fig. IV-22. Because of scheduling conflicts and postponements caused by weather, these samples were collected by Laboratory personnel on February 5, 1992, in the company of personnel from the San Ildefonso Pueblo Governor's Office and the BIA. Because of pump problems, it was not possible to sample the Pajarito Well, Pump 2, and instead, a sample was collected from the Westside Artesian Well (Station 10). The plan also specifies

collection and analysis of 9 other water samples and 11 other sediment samples that have long been included in the routine environmental sampling program, as well as special sampling of storm runoff in Los Alamos Canyon, as part of the Laboratory's routine monitoring. These locations are identified in Table IV-42 to permit cross-referencing to other sections of this report. Instead of storm runoff sampling this year, a special sampling of runoff fed by treated effluent from the Los Alamos County sewage treatment plant was conducted. Results and interpretation of this sampling are described in Section IV.E of this report.

a. Groundwater. Radiochemical analyses in 1991 of groundwater from Stations 3, 8, and 9 indicated no significant change from the analyses that were performed on wells at those locations in 1990 (Table IV-43) for all radioactive constituents except ^{137}Cs. The ^{137}Cs measurements were lower for all the

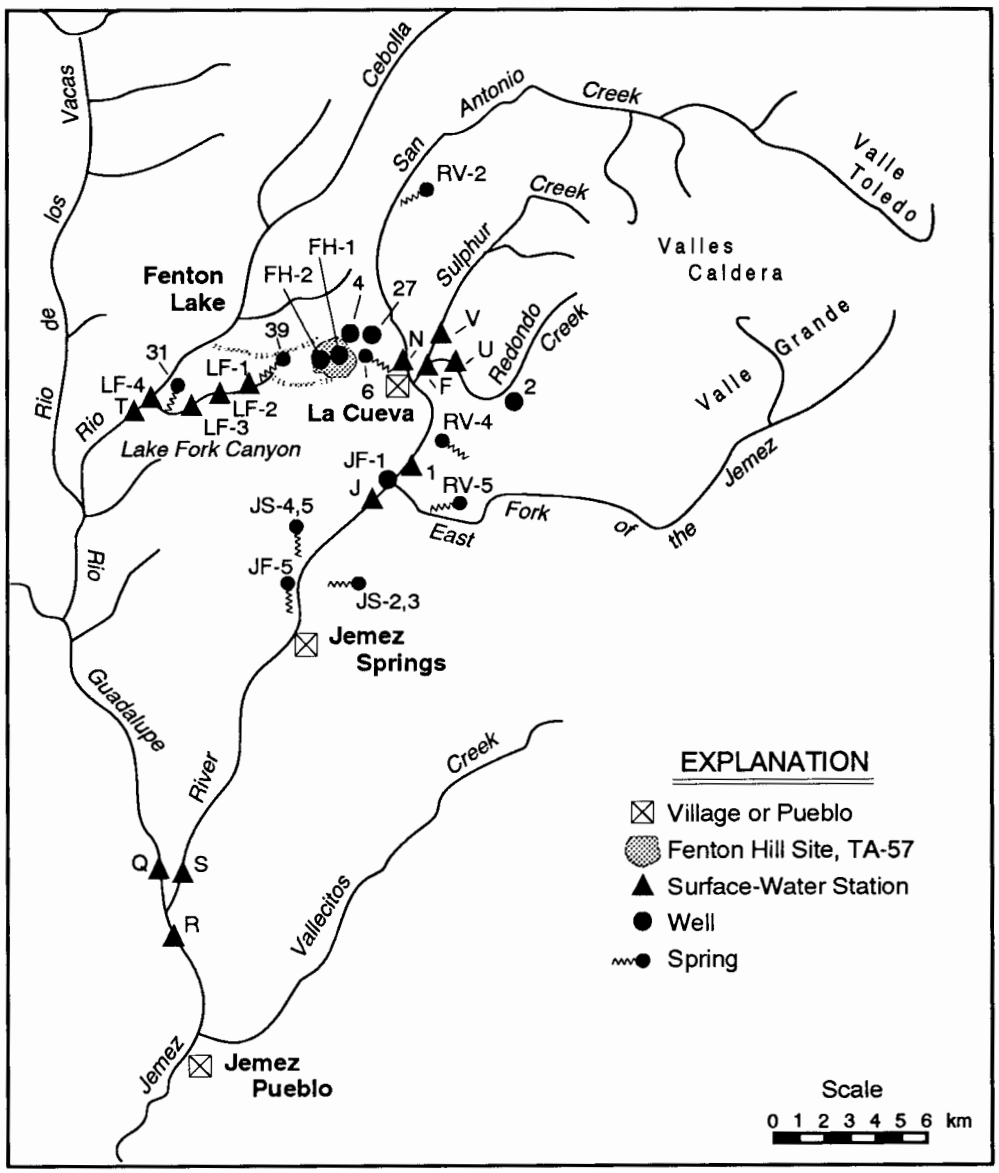


Fig. IV-21. Sampling stations for surface water and groundwater near the Fenton Hill Site (TA-57). (Map denotes general locations only.)

Table IV-40. Analyses of Surface Water and Groundwater Quality, Fenton Hill, December 9, 1991 (mg/L)

Station	Location	SiO_2	Ca	Mg	K	Na	Cl	F	CO_3	HCO_3	PO_4-P	SO_4	NO_3-N	Cn	TDS[a]	Total Hardness	PH[b]	Specific Conductance µmho/cm
Surface Water																		
J	Jemez at Gage	54	13	2.5	2.0	3	4	0.7	<5	51	0.2	10	0.1	<0.01	28	42	7.9	117
N	San Antonio	38	13	2.1	2.0	12	2	0.9	<5	51	0.2	7	<0.04	<0.01	06	42	7.8	183
Q	Rio Guadalupe	25	50	5.1	1.0	11	5	0.4	<5	120	0.1	5	<0.04	<0.01	198	146	8.3	296
S	Jemez River	51	35	4.4	9.0	60	57	0.8	<5	114	0.2	68	3.2	<0.01	352	106	7.3	171
LF-1	LakeFork-1	29	29	3.9	3.0	8	3	0.4	<5	29	1.8	10	2.3	<0.01	92	88	6.2	77
LF-2	LakeFork-2	37	22	3.7	4.0	12	3	0.7	<5	13	0.2	32	0.5	<0.01	180	70	5.9	182
LF-3	LakeFork-3	66	13	2.0	2.0	12	3	1.0	<5	48	0.2	3	0.3	<0.01	86	42	7.5	112
LF-4	LakeFork-4	52	16	2.6	3.0	13	3	1.0	<5	72	0.2	4	0.1	<0.01	154	52	7.8	143
Groundwaters																		
JS-4,5	Jemez Village (spring)	86	29	4.9	4.0	50	25	1.0	<5	165	0.3	10	0.2	<0.01	290	93	7.9	399
FH-1	Fenton Hill Well	77	90	9.4	6.0	22	9	<0.2	<5	215	0.3	9	0.3	<0.01	346	264	7.8	612
JF-1	Jemez Canyon (hot spring)	49	73	18.8	50.0	468	807	1.9	<5	650	0.2	33	0.3	<0.01	1900	509	7.5	2770
JF-5	Soda Dam (hot spring)	49	29	22.6	150.0	1000	1870	2.3	<5	688	0.2	34	<0.04	<0.01	2	914	6.6	5506
Loc.4	Hofheins (well)	91	10	2.5	2.0	17	3	0.2	<5	57	0.4	3	0.3	<0.01	162	36	7.8	87
Loc.5	La Cueva (well)	77	27	6.5	3.0	18	4	0.4	<5	42	1.2	54	0.5	<0.01	182	96	6.3	233
Rv-4	Spence Spring	55	6	1.6	1.0	50	8	0.7	<5	83	0.3	28	5.6	<0.01	160	21	7.3	282
Loc.3	Cold Spring	54	20	2.7	4.0	12	3	0.9	<5	61	0.2	4	0.3	<0.01	78	61	8.0	126
Loc.39	Lf Tank	24	15	2.8	3.0	6	2	<0.2	<5	47	0.1	15	0.2	<0.01	20	50	6.7	103

[a]Total Dissolved Solids
[b]Standard Units

Table IV-41. Trace Metals in Surface Waters and Groundwaters, Fenton Hill, December 9, 1991 (mg/L)

		Ag	Al	As	B	Be	Cd	Cr	Co	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
Surface Water																							
J	Jemez River	<0.0005[a]	0.466	0.002	0.026	<0.0005	0.0101	<0.0005	<0.0005	0.003	0.410	<0.0001	0.008	0.007	<0.003	N/A	<0.0005	<0.03	<0.02	0.067	<0.0005	0.003	0.007
N	San Antonio	<0.0005	0.310	0.002	0.027	<0.0005	0.0005	<0.001	<0.0005	0.003	0.375	<0.0001	0.009	0.004	<0.003	N/A	0.001	<0.03	<0.02	0.062	<0.0005	0.003	0.010
Q	Rio Guadalupe	<0.0005	0.180	0.001	0.037	<0.0005	<0.0005	<0.0005	<0.0005	0.002	0.224	<0.0001	0.008	0.001	0.003	N/A	<0.0005	0.040	<0.02	0.179	<0.0005	0.001	0.003
S	Jemez River	<0.0005	0.390	0.058	0.656	<0.0005	<0.0005	<0.0005	<0.0005	0.002	0.390	<0.0001	0.015	0.005	0.004	N/A	0.0008	0.030	<0.02	0.155	<0.0005	0.006	0.010
LF-1	Lake Fork-1	<0.0005	5.690	0.010	0.052	0.0030	<0.0005	0.0144	0.0200	0.032	81.000	<0.0001	1.660	0.006	0.014	N/A	<0.0005	0.180	<0.02	0.186	<0.0005	0.037	0.274
LF-2	Lake Fork-2	<0.0005	0.090	<0.0005	0.018	<0.0005	<0.0005	<0.0005	0.0006	0.001	5.200	<0.0001	0.085	0.001	0.003	N/A	<0.0005	0.030	<0.02	0.095	<0.0005	0.001	0.008
LF-3	Lake Fork-3	<0.0005	<0.030	0.002	0.016	<0.0005	<0.0005	<0.0005	0.0010	0.002	0.040	<0.0001	0.002	0.002	<0.003	N/A	<0.0005	0.030	<0.02	0.061	<0.0005	0.001	0.011
LF-4	Lake Fork-4	<0.0005	0.120	0.003	0.018	<0.0005	<0.0005	0.0007	0.0010	0.003	0.250	<0.0001	0.004	0.003	<0.003	N/A	<0.0005	0.030	<0.02	0.081	<0.0005	0.001	0.007
Groundwater																							
JS-4,5	Jemez Village (spring)	<0.0005	<0.030	0.017	0.226	<0.0005	0.0011	<0.0005	<0.0005	0.006	0.010	<0.0001	0.001	0.026	<0.003	N/A	0.001	<0.03	<0.02	0.184	<0.0005	0.007	0.216
FH-1	Fenton Hill (well)	<0.0005	<0.030	0.002	0.772	<0.0005	<0.0005	0.0014	0.0010	0.006	0.200	<0.0001	0.033	0.001	0.053	N/A	<0.0005	0.050	<0.02	0.317	<0.0005	0.004	1.250
JF-1	Jemez Canyon (hot spring)	<0.0005	<0.030	<0.0005	5.480	<0.0005	<0.0005	0.0024	<0.0005	<0.001	0.161	<0.0001	<0.003	<0.0005	<0.005	N/A	0.001	0.140	<0.02	0.002	0.0015	0.003	<0.005
JF-5	Soda Dam (hot spring)	<0.0005	<0.030	1.840	13.300	<0.0005	0.0006	0.0028	0.0008	0.022	0.090	<0.0001	0.634	<0.0005	0.008	N/A	0.001	0.270	0.040	1.500	0.0015	0.036	0.013
Loc. 4	LaCueva (well)	<0.0005	0.040	0.002	0.015	<0.0005	<0.0005	<0.0005	<0.0005	0.002	0.035	<0.0001	0.001	0.003	<0.003	N/A	<0.0005	0.040	<0.02	0.063	<0.0005	0.004	0.050
Loc. 5	La Cueva (well)	<0.0005	1.090	0.001	0.031	<0.0005	<0.0005	0.0041	0.0010	0.007	7.430	<0.0001	0.054	0.002	<0.003	N/A	<0.0005	0.040	<0.02	0.112	<0.0005	0.013	0.039
RV-4	Spence Spring	<0.0005	0.040	0.049	0.110	< 0.0005	<0.0005	<0.0005	0.0010	0.001	<0.003	<0.0001	<0.001	0.054	<0.003	N/A	<0.0005	<0.03	<0.02	0.028	<0.0005	0.003	0.005
Loc. 3	Cold Springs	<0.0005	1.220	0.004	0.023	<0.0005	0.0021	<0.0005	<0.0005	0.005	2.200	<0.0001	0.024	0.001	<0.003	N/A	<0.0005	0.040	<0.02	0.076	<0.0005	0.001	0.007
Loc. 39	LF Tank	<0.0005	0.050	0.004	0.017	<0.0005	<0.0005	<0.0005	<0.0005	0.001	0.035	<0.0001	<0.001	0.001	<0.003	N/A	<0.0005	0.050	<0.02	0.080	<0.0005	0.001	0.003

[a] Less than symbol (<) means measurement was below the specified detection limit of the analytical method.

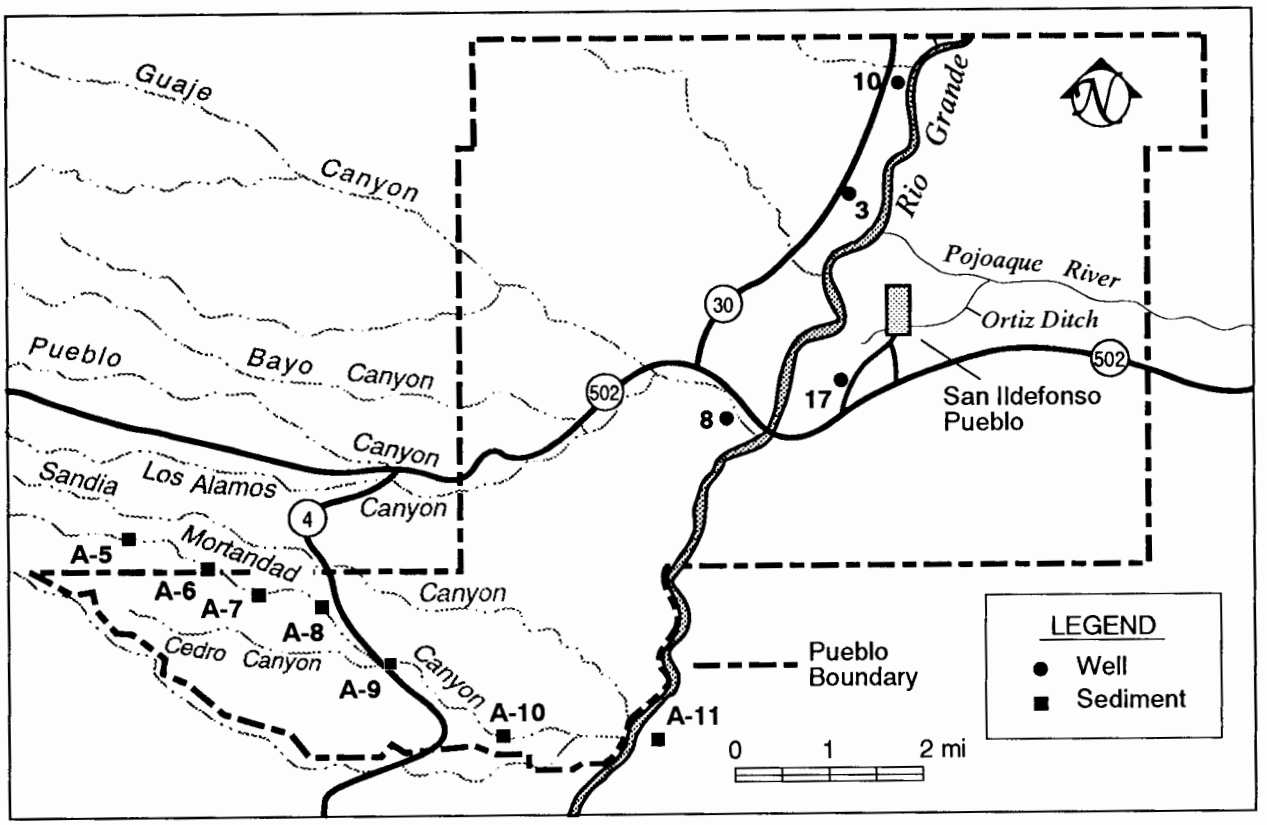


Fig. IV-22. Groundwater and sediment stations on Pueblo de San Ildefonso land. (Map denotes general locations only; see Table IV-42 for cross-referencing to specific locations.)

1991 samples, with two measurements (Stations 8 and 17) above the limit of detection by a factor of about 2, but the uncertainty in those measurements is quite high because of analytical background. It is unlikely that there is any significant cesium present. None of the measured values exceed the DOE DCG.

The maximum gross alpha activity in water was for Station 10 with 17 pCi/L. As detailed in Purtymun 1988b, the gross alpha activity in this area is due to natural uranium and not radium. The activity attributable to uranium (21.8 µg/L is equivalent to about 15 pCi/L) more than accounts for the gross alpha activity. The same pattern is true for the other wells, with natural uranium accounting for the gross alpha activity. Thus, the NMED drinking water gross alpha screening level of 5 pCi/L for radium (used for comparison only), which excludes activity from radon and uranium, is not exceeded by any of the samples. The Station 3 well showed a similar, relatively high concentration of uranium when previously sampled (Purtymun 1988b). The plutonium measurements were all below the limits of detection.

The chemical quality of the groundwater is consistent with previous observations except that standards were exceeded, as expected, for waters with such high natural dissolved solids (Table IV-44). Initial analyses of the samples showed the cadmium and lead standards were exceeded at Station 3, but analytical laboratory quality control data indicated the values were not reliable and probably high by a factor of 2 to 3. Subsequent reanalysis showed all cadmium and lead measurements to be less than the analytical detection limits. The chloride standard was exceeded slightly at Station 3 and by about a factor of 2 at Station 10. The total dissolved solids standard (500 mg/L) was exceeded, with a concentration of 1,042 mg/L at

Table IV-42. Locations on San Ildefonso Lands for Water and Sediment Sampling Included in Routine Monitoring Program

Station Identification	Map Designation	See this Table for Results
Water Sampling Locations		
Rio Grande		
Otowi	Fig. IV-6, No. 3	IV-17, -18, -19
Springs in Los Alamos Canyon		
Basalt Spring	Fig. VII-1, No. 56	VII-1, -2, -3
Indian Spring	Fig. VII-1, No. 12	VII-1, -2, -3
Spring in Canyon North of Los Alamos Canyon		
Sacred Spring	Fig. VII-1, No. 11	VII-1, -2, -3
Spring in Sandia Canyon		
Sandia Spring	Fig. VII-1, No. 13	VII-1, -2, -3
Springs in White Rock Canyon		
La Mesita Spring	Fig. VII-1, No. 10	VII-1, -2, -3
Spring 1	Fig. VII-1, No. 32	VII-1, -2, -3
Spring 2	Fig. VII-1, No. 33	VII-1, -2, -3
Sanitary Effluent Flow in Mortandad Canyon		
Mortandad at Rio Grande	Fig. VII-6, No. 38	IV-17, 18, 19
Sediment Sampling Locations		
Guaje at SR-502	Fig. IV-9, No. 12	IV-20, IV-23
Bayo at SR-502	Fig. IV-9, No. 13	IV-20, IV-23
Los Alamos Canyon		
Los Alamos at SR-4	Fig. IV-9, No. 35	IV-20, IV-23
Los Alamos at Totavi[a]	Fig. IV-9, No. 36	IV-20, IV-23
Los Alamos at LA-2[a]	Fig. IV-9, No. 37	IV-20, IV-23
Los Alamos at Otowi	Fig. IV-9, No. 38	IV-20, IV-23
Sandia Canyon		
Sandia at SR-4	Fig. IV-9, No. 38	IV-20, IV-23
Sandia at Rio Grande	Fig. IV-9, SANDIA	IV-20, IV-23
Mortandad Canyon		
Mortandad at MCO-13	Fig. IV-9, No. 45 and Fig. IV-22, A-5	IV-20, IV-23
Mortandad at SR-4	Fig. IV-9, No. 15 and Fig. IV-22, A-9	IV-20, IV-23
Mortandad at Rio Grande	Fig. IV-9, MORTANDAD	IV-20, IV-23

[a]Not required by MOU but routinely sampled and reported.

Table IV-43. Radiochemical Quality of Groundwater from Wells, Pueblo de San Ildefonso

Station Number and Well Identification	H^3 (nCi/L)	^{137}Cs (pCi/L)	Total Uranium (μg/L)	^{238}Pu (pCi/L)	$^{239,240}Pu$ (pCi/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)
3. Pajarito Well (pump 1)	0.3 (0.3)[a]	35 (43)	24 (5)	0.000 (0.010)	0.000 (0.010)	13.0 (4.0)	3.2 (5.0)
8. Halladay Well	0.5 (0.3)	80 (44)	22 (4)	0.004 (0.005)	0.000 (0.010)	1.2. (0.6)	1.2 (0.4)
9. Eastside Artesian Well	0.7 (0.3)	19 (47)	20 (4)	0.014 (0.014)	0.009 (0.013)	1.5. (0.9)	1.2 (0.4)
10. Westside Artesian Well	0.4 (0.3)	32 (47)	33 (6)	0.008 (0.012)	0.000 (0.010)	17.0 (4.0)	0.8 (0.3)
17. Don Juan Playhouse Well	–0.2 (0.3)	90 (48)	27 (5)	0.005 (0.016)	0.005 (0.005)	7.0 (2.0)	2.0 (0.4)
Summary							
Maximum concentration	0.7	90	33	0.014	0.009	17.0	3.2
Standard[b]	20[b]	120[c]	30[c]	1.6[c]	1.2[c]	15[b]	50[b]
Maximum as a percentage of standard	3.5	75	110	0.9	<0.1	113	6.4
Limits of detection	0.7	40	1	0.1	0.1	3	3

[a]Radioactivity counting uncertainties (±1 standard deviation) are shown in parentheses.

[b]Maximum contaminant level-MCL, used for comparison only (NMEIB 1991, EPA 1989b).

[c]Derived concentration guide applicable to DOE drinking water systems – used for comparison only (see Appendix A).

Table IV-44. Chemical Quality of Groundwater from Wells, Pueblo de San Ildefonso (mg/L)[a]

	Standard[b,c]	Station 3 Pajarito Well (pump 1)	Station 8 Halladay Well	Station 9 Eastside Artesian Well	Station 10 Westside Artesian Well	Station 17 Don Juan Playhouse Well	Summary: Maximum Concen-tration	Summary: Maximum Concentration as a Percentage of Standard
Chemical Constituents								
Primary[b]								
Ag	0.05	0.007	<0.005	<0.005	<0.005	<0.005	<0.007	14
As	0.05	0.005	0.006	<0.002	0.006	0.005	0.006	12
Ba	1.0	0.103	0.04	0.016	0.037	<0.005	0.103	10
Cd	0.01	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<10
Cr	0.05	<0.005	0.01	<0.005	<0.005	0.012	0.012	24
F	4.0	0.5	0.6	0.88	5.6	0.65	5.6	140
Hg	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<50
NO_3-N	10	0.1	0.5	<0.04	<0.1	1.8	1.8	18
Pb	0.05	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<2
Se	0.01	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<20
Secondary[c]								
Cl	250	268	4.4	4.1	446	3.8	446	178
Cu	1.0	0.008	<0.003	0.005	<0.005	<0.005	0.008	<1
Fe	0.3	0.2	0.1	0.1	0.3	<0.1	0.3	100
Mn	0.05	<0.005	0.002	0.01	0.010	<0.005	0.01	20
SO_4	250	52	12	11	82	14	82	33
Zn	5.0	0.036	0.013	0.023	<0.005	0.011	0.036	<1
TDS[d]	500	1,042	164	280	1,186	236	1,186	237

Table IV-44. (Cont.)

	Standard[b,c]	Station 3 Pajarito Wells (pump 1)	Station 8 Halladay Well	Station 9 Eastside Artesian Well	Station 10 Westside Artesian Well	Station 17 Don Juan Playhouse Well	Summary: Maximum Concen-tration	Summary: Maximum Concentration as a Percentage of Standard
Miscellaneous								
SiO_2	—	40	30	<5	26	27	40	—
Be	—	0.017	0.009	<0.005	<0.005	<0.005	0.017	—
Ca	—	69	4.8	2.8	15	7.2	69	—
Mg	—	6.5	0.4	0.2	0.9	0.5	6.5	—
K	—	3.9	1.4	1.2	1.9	1.4	3.9	—
Na	—	354	44	89	410	69	410	—
CO_3	—	<5	<5	34	<5	<5	34	—
HCO_3	—	553	84	185	329	137	553	—
PO_4-P	—	0.13	<0.1	<0.1	<0.1	<0.1	0.13	—
Total hardness	—	200	20	8	41	12	200	
Conductivity (μmho/cm)	—	1,436	173	385	1,540	313	1,540	—
pH (standard units)	6.8-8.5	7.3	9.1	9.7	8.1	8.9	9.7	114

[a]Units are milligrams per liter, except as noted for conductivity and pH.

[b]Maximum contaminant level for primary constituents, applicable to drinking water system, given here for camparison only, see Appendix A.

[c]New Mexico Water Quality Standards applicable to streams for designated uses, given here for comparison only, see Appendix A.

[d]Total dissolved solids.

Station 3 and 1,186 mg/L at Station 10. Other chemical constituents in water from Stations 3 and 10 and from the other three stations were at or below the standards. All these constituents are naturally occurring, and the levels are within ranges expected for the area.

Station 9 showed some significant differences in chemical quality because of recompletion of the well during 1991 by the BIA. The well was lined with new screen and casing with pressure grouting restricting the producing zone to between 115–206 m (380–680 ft) below surface to prevent uncontrolled artesian flow that had been occurring for years. Major decreases in the levels of chloride (165 in 1990, 4 this year) and silica (27 in 1990, less than 5 this year) and increases in total dissolved solids (184 in 1990, 280 this year) were noted. The chemical analyses agreed well with measurements made by the BIA immediately following the reconstruction of the well.

Special sampling and analyses were conducted during 1989 at Station 3, known as the Pajarito Wells site, to investigate what appeared to be anomalous changes in the chemical quality of water that were noted between samples collected in 1987 and those collected in 1988 (ESG 1989). This sampling determined that the difference in quality is natural and is attributable to the different location and depth of the two separate wells operated at alternate times by a controller, with no indication of a contamination problem (EPG 1990). Samples collected for 1991 from Pump 1 indicated the quality of water was within the range of values found previously.

b. Sediments. The industrial waste treatment plant at TA-50 releases treated effluent into the upper reaches of Mortandad Canyon. The effluent, containing traces of radionuclides and other chemicals, infiltrates into the underlying alluvium, forming an aquifer of limited extent perched on the underlying tuff in the upper- and midreaches of the canyon within Laboratory boundaries. A large proportion of the radionuclides in the effluent when it is first released as surface flow is adsorbed or attached to the sediments in the stream channel; thus, the principal means of transport is in surface runoff. Mortandad Canyon heads on the Pajarito Plateau at TA-3 and has a small drainage area. The alluvium thickens in the middle and lower reaches of the canyon. The small drainage area and the thick section of unsaturated alluvium in the middle reach of the canyon have retained all the runoff since 1960 when hydrologic studies began in the canyon.

During 1991, Mortandad Canyon sediments were collected and analyzed for radionuclides from seven sediment stations, one west of the Laboratory and Pueblo boundary and six within the Pueblo (Fig. IV-22). The analytical results for samples from the stations were compared with results from regional soil and sediment samples collected over many years to establish background levels for northern New Mexico (Purtymun 1987a).

Plutonium concentrations in Mortandad Canyon sediment samples taken in 1991 at and east of the Laboratory boundary to State Road 4 were near the upper end of the statistical range attributable to worldwide fallout in northern New Mexico (Table IV-45). The highest value for ^{239}Pu in 1991 was obtained at Station A-6 (on San Ildefonso property adjacent to the boundary with the Pueblo) and was slightly above the statistically derived comparison value for fallout. The levels are consistent with the range of values obtained during the last several years and do not indicate any apparent change in general conditions. In 1989 and 1990 both A-6 and A-7 had levels exceeding the statistical background limit. Samples from Station A-9 (at State Road 4) and further east had even lower levels.

The measurements are consistent with observation of the physical appearance of the stream channel at the time of collection, which gave no indication of any water runoff or transport of sediments across the Laboratory boundary. Observations during the thunderstorm season noted that no runoff from the contaminated portion of Mortandad Canyon extended near the Laboratory boundary (see related discussion in Section IV.E.5). No runoff has been observed to reach the Laboratory boundary in Mortandad Canyon since 1960 when the USGS initiated special studies there. For samples dominated by worldwide fallout at these low levels, considerable variability is expected because of different particle-size distributions in grab samples (Purtymun 1990b). Samples with a large percentage of small particles typically exhibit higher mass concentrations of plutonium because of their high adsorption capacity. The sediments in this part of Mortandad Canyon are more like soils because there has been no runoff to separate out silt and clay-size particles that typically show higher concentrations of plutonium.

Table IV-45. Radiochemical Analyses of Sediments from Mortandad Canyon

Station	Location	H^3 (nCi/L)[a]	^{137}Cs (pCi/g)	Total Uranium (µg/g)	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)	Gross Gamma (counts/min/g)	^{90}Sr (pCi/g)
Sediments[b]								
(MCO-13) A-5	Laboratory	N/A[c]	0.60 (0.13)[d]	1.9 (0.2)	0.003 (0.001)	0.025 (0.002)	2.6 (0.5)	0.2(0.2)
A-6	San Ildefonso	0.5 (0.3)	1.13 (0.21)	2.5 (0.2)	0.002 (0.001)	0.031 (0.003)	1.7 (0.4)	0.5(0.2)
A-7	San Ildefonso	0.4 (0.3)	0.18 (0.06)	5.4 (0.5)	0.002 (0.001)	0.020 (0.002)	3.8 (0.5)	0.3(0.1)
A-8	San Ildefonso	0.0 (0.3)	0.29 (0.09)	3.2 (0.3)	0.001 (0.001)	0.023 (0.002)	2.3 (0.5)	0.2(0.2)
A-9	San Ildefonso	N/A	–0.07 (0.09)	1.0 (0.1)	0.005 (0.004)	0.002 (0.001)	1.3 (0.4)	0.2(0.2)
A-10	San Ildefonso	0.6 (0.3)	0.22 (0.10)	2.3 (0.2)	0.006 (0.001)	0.003 (0.001)	1.6 (0.4)	0.0(0.2)
A-11	San Ildefonso	–0.4 (0.3)	0.10 (0.10)	2.8 (0.3)	0.008 (0.002)	0.001 (0.001)	1.8 (0.4)	0.3(0.2)
Background[e]								
Sediments (1974–1986)		—	0.44	4.4	0.006	0.023	7.9	0.87
Soils (1974–1986)		7.2	1.09	3.4	0.005	0.025	6.6	0.88

[a]Tritium as tritiated water in moisture distilled from sample.

[b]Samples in Mortandad Canyon were collected from Stations A-6, A-7, A-8, and A-10 in February 1992; A-5 in June 1991; A-9 at State Road 4 in July 1991; and A-11 at the Rio Grande in October 1991.

[c]N/A means analysis not performed.

[d]Radioactivity counting uncertainities (±1 standard deviation) are in parentheses.

[e]Average plus 2 standard deviations of measurements in regional samples 1974-1986 (Purtymun 1987a).

Cesium concentrations from samples at Stations A-5, A-6, and A-7 showed minor differences from previous results. The level at A-5 was lower (by about a factor of 3), at A-6 higher (about the same as seen in 1989), and at A-7 lower (by a factor of about 2). The values overlapped the range of the statistical background comparison values for regional soils and sediments (0.44 to 1.09 pCi/g [Purtymun 1987a]).

c. Monitoring Well. A monitoring well (SIMO-1) was installed in Mortandad Canyon just east of sediment sampling station A-6 on San Ildefonso land in 1990 by BIA and Laboratory personnel under the general terms of the MOU (EPG 1992). The purpose of the monitoring well was to confirm the absence of any perched water in the alluvium of Mortandad Canyon.

No evidence of perched water was found, confirming previous inferences that no water could be moving from the Laboratory onto San Ildefonso beneath the surface. Even though the hole penetrated no saturated zones, it was completed by installing a polyvinyl chloride casing with screened sections located in two intervals that would be geologically likely locations for water to accumulate. When inspected in February 1992, the well was found to be dry.

The radiochemical analyses of the cores showed no evidence of any contaminants from the Laboratory (Tables D-15 and D-16). The plutonium measurements were all at or below detection limits. Tritium in water vapor extracted from the cores from the surface down to 4.27 m (14 ft) was all at levels within the range attributable to background expected in northern New Mexico soils (Purtymun 1987a); below 4.27 m (14 ft) the tritium measurements were all below the limits of detection. Gross gamma and ^{137}Cs in all cores were at levels within the range attributable to background expected in northern New Mexico soils (Purtymun 1987a). Uranium was measured at levels well within the ranges for naturally occurring uranium expected for the Tshirege, Tsankawi, and Otowi formations penetrated by the hole (Becker 1985 and Crowe 1978).

6. Environmental Restoration Program at Los Alamos National Laboratory.

In 1989, DOE created the Office of Environmental Restoration and Waste Management (DOE/EM). The goal of the office is to implement the DOE's policy to ensure that its past, present, and future operations do not threaten human or environmental health and safety (DOE 1990b). The DOE/EM Office implements procedures to meet these goals through three associate directorates: ER, Waste Operations, and Technology Development. The ER Program in DOE/EM is responsible for assessing, cleaning up, decontaminating, and decommissioning sites at DOE facilities and sites formerly used by DOE.

Two primary laws govern ER activities within the DOE complex: RCRA and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA [Superfund]). At the Laboratory only RCRA currently governs ER activities. The hazardous waste management provisions of RCRA, as enacted in 1976, govern the day-to-day operations of hazardous waste treatment, storage, and disposal (TSD) facilities. The law established standards for generators of hazardous waste and requires permits for TSD facilities. The Laboratory's hazardous waste treatment and storage facilities must be permitted. Section 3004(u) of RCRA as amended by the Hazardous and Solid Waste Amendments (HSWA) mandates that permits for TSD facilities include provisions for corrective action to mitigate releases from facilities currently in operation and to clean up contamination in areas designated as solid waste management units (SWMUs).

Congress conceived and passed CERCLA to clean up the nation's most hazardous abandoned waste sites. Under CERCLA, EPA ranks abandoned facilities that have hazardous waste sites according to their potential threat to human health and the environment. The high-scoring sites are listed on the National Priorities List (NPL) and are cleaned up in accordance with CERCLA regulations. When EPA ranked the Laboratory, the agency determined that current environmental conditions do not pose an imminent threat to human health. Hence, the Laboratory is not listed on the NPL and is not a Superfund site. The DOE/University of California (UC) RCRA permit includes a section called the HSWA Module, which prescribes a specific corrective action program for the Laboratory. Because the Laboratory has not been listed on the NPL, the HSWA Module provides the primary guidance for the Laboratory's ER program. The HSWA Module specifies a three-step corrective action process (Fig. IV-23):

The RCRA Facility Investigation. The goal of this step is to identify the extent of contamination at source points and environmental pathways for the

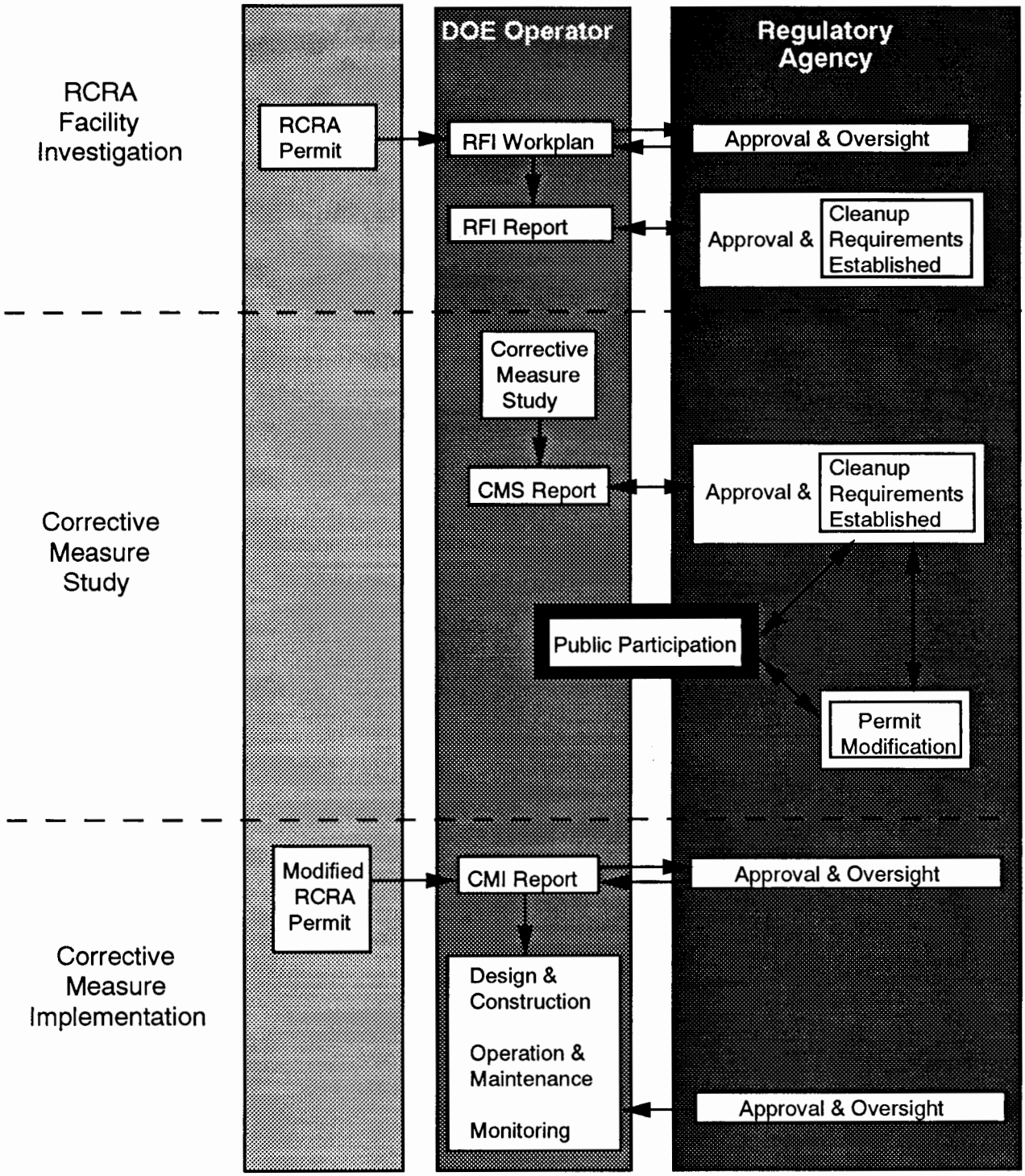


Fig. IV-23. Resource Conservation and Recovery Act corrective action process.

exposure of potential human and environmental receptors. This step will be implemented by characterizing the extent of contamination in the detail necessary to determine what corrective measures, if any, need to be taken. This approach will focus on answering only those questions relevant to deciding further actions in a cost-effective manner.

Corrective Measures Study. If characterization indicates that corrective measures may be needed, a corrective measures study (CMS) will evaluate alternatives that might be reasonably implemented. These measures will be evaluated based on their projected efficacy in reducing risks to human and environmental health and safety in a cost-effective manner.

Corrective Measures Implementation. This step implements the chosen remedy, verifies its effectiveness, and establishes ongoing control and monitoring requirements.

An ER program plan has been prepared in accordance with the HWSA Module and with proposed Subpart S, Corrective Action for Solid Waste Management Units, of 40 CFR 264 (EPA 1990a) in the regulations promulgated by EPA to implement HSWA. EPA proposed Subpart S in July 1990 to implement the clean-up program mandated in Section 3004(u) of RCRA. The plan describes how each of the three corrective action steps described above will be implemented at the Laboratory. DOE and UC propose to use the operable unit approach defined in CERCLA for organizing and managing the various SWMUs. Operable units are aggregates of SWMUs that will be addressed together. The details for each step required under the corrective action process will be presented individually for each operable unit.

The HSWA Module provides a schedule for addressing 603 SWMUs that the EPA has selected from those identified by DOE/UC. The schedule requires that all 603 SWMUs be addressed in RFI work plans by May 23, 1994, and that CMSs be complete by May 23, 2000. The work plan requirement will be met by completing work plans for 24 operable units at the Laboratory. These work plans will describe the general approach that will be applied to each operable unit. Current risks from known SWMUs are low; hence, no operable unit or set of SWMUs has a priority for action based on health or environmental concerns. The order in which operable units will be addressed is therefore designed to meet the requirements of the HSWA Module. However, DOE and UC propose to extend the RFI schedule so that the CMS process is not complete until May 23, 2002. This is necessary because of the increased number of SWMUs identified at the Laboratory and will allow effort to be spread over a period that is compatible with the availability of national resources, including funding.

Major components of the program that address the requirements of the HSWA Module are

- a technical decision making approach which identifies appropriate corrective actions and meets the requirements of the EPA;
- a strategy for the conduct of interim remedial measures;
- program management that organizes and manages the Laboratory's ER effort, including projecting schedules and costs;
- a quality assurance program that ensures a technically defensible and valid program;
- a health and safety program that ensures adequate health and safety protection during implementation of the Laboratory's ER program;
- a records management program that tracks and stores information and data throughout the ER program; and
- a community relations program that provides information to and receives recommendations from the public throughout the life of the ER program.

The HSWA Module of the RCRA permit defines the principal requirements with which DOE/UC must comply in implementing the ER Program at the Laboratory. However, RCRA does not address several issues of concern at Los Alamos. For example, source material, by-product, and special nuclear material are exempt from the RCRA definition of solid waste and are not subject to the provisions of the HSWA Module. DOE and UC recognize that these radioactive constituents are of major concern and cannot be separated from concerns about hazardous wastes. Thus, the DOE and UC ER program addresses radioactive as well as other hazardous substances not regulated by RCRA. This approach is intended to maintain a technically comprehensive program that covers

potential liabilities associated with other environmental laws, such as CERCLA.

The Laboratory submitted its first site-specific work plan under the HSWA requirements in May 1991. The work plan addresses characterization activities at TA-21, which will begin in 1992. This technical area is one of the oldest TAs still active and contains over 100 SWMUs regulated under HSWA. These units contain residual concentrations of radionuclides, organic chemicals, and metals released during nearly 50 years of operation. The programmatic plan for environmental restoration at the Laboratory was updated in November 1991. During 1991, the Laboratory drafted new work plans to investigate eight operable units, including the Los Alamos townsite. These plans are due to EPA in May 1992.

7. Performance Assessment for TA-54, Area G.

DOE Order 5820.2A, Radioactive Waste Management, became effective in September 1988. Section III of this order established policies, guidelines, minimum requirements, and performance criteria for LLW and mixed waste (LLW that also contains nonradioactive hazardous waste components) management at DOE facilities. The order applies only to LLW disposed after the order became effective. The order requires that a performance assessment (PA) of the LLW site be made to demonstrate compliance with specific performance objectives stated in the order.

A draft PA document is in preparation. It reports the results of preliminary calculations to assess the projected performance of TA-54, Area G. Area G disposes of only LLW; mixed waste is stored at the site for future disposition. Such disposition, to be determined in the future, may be on site treatment of the hazardous waste component and disposal of the resulting material as LLW on site or shipment of the mixed waste off site for treatment and subsequent disposal. The PA evaluates only the Laboratory's LLW stream; it does not consider transuranic wastes, which are not covered under Chapter III of the order.

An exposure scenario is a conceptual model that describes patterns of human activity, events, and processes that result in radiation exposure to people. Two classes of scenarios are considered in the PA: intruder scenarios and undisturbed site scenarios. Intrusion is assumed to occur after loss of institutional control at the waste site after periods of several hundreds of years. At this time, one or a few individuals are assumed to disturb the waste site, unaware of the presence of radioactive waste. Undisturbed scenarios assume that future inhabitants of the area are exposed to radioactive components of the waste that have been released from the waste site through normal environmental processes. These include possible impacts to groundwater from leaching and to surface water from erosion after long periods of time.

A variety of intruder scenarios have been defined. Inadvertent intrusion is a hypothetical event that may not occur at all. It is not possible to identify, let alone consider in the PA, all of the possible intrusion scenarios. Three hypothetical scenarios were chosen for analysis:

- Intruder-construction. A construction crew digs a pit for a basement and constructs a house at the waste site.
- Intruder-agriculture. The site is used by a farmer/gardener for the production of foodstuffs.
- Intruder-drilling. In this scenario, drilling for water, natural resources, or perhaps for site characterization causes a limited amount of deeper (shaft-disposed) wastes to be brought to the surface.

The major exposure pathways are direct exposure and inhalation. Dose limits for intruders are established in DOE Order 5820.2A, Ch. III. The annual effective dose equivalent to inadvertent intruders (after the loss of institutional control) shall not exceed 100 mrem for continuous exposure or 500 mrem for a single acute exposure.

Under current waste-stream concentrations, none of the intruder scenarios produces doses that exceed the applicable dose criteria. In the intruder-construction scenario, ^{239}Pu, ^{241}Am, and ^{238}Pu account for 44%, 25%, and 15%, respectively, of the dose to an intruder. In the intruder-agriculture scenario, ^{239}Pu, ^{241}Am, and ^{238}Pu account for 41%, 30%, and 14%, respectively, of the dose to an intruder. In the analyses to date, the only radioactive materials treated as shaft-disposed radioactive wastes are ^{90}Sr/^{90}Y and ^{137}Cs. In this scenario, 98% of the dose is from ^{137}Cs by external exposure. Other, minor components account for the remainder of the dose.

Although dose assessment for undisturbed site scenarios has not been completed, the depth to groundwater and the dryness of the climate are likely to reduce doses from these scenarios to insignificant levels. The migration of radionuclides by subsurface aqueous transport is always viewed as one of the critical components in assessing any waste site. Area G has the advantage of a large unsaturated zone (average distance to the saturated zone of 260 m) and low water content in the intervening material. These advantages result in delaying radionuclide migration. These advantages will be discussed in more detail in the final PA.

Waste management strategies involve maximizing distances from the source to the saturated zone while minimizing the potential for exposure by surface erosion of the mesa tops and lateral erosion of the canyon walls. The large unsaturated zone in conjunction with a retardation mechanism will allow this strategy to be effectively implemented.

8. Preoperational Studies.

Preoperational studies are required under DOE Order 5400.1 (DOE 1988a). This order requires that chemical, physical, and biological characteristics be assessed before an area is disturbed. One preoperational study was continued during 1991. Detailed results may be obtained by referring to individual preoperational reports available through EM-8.

Sanitary Wastewater Systems Consolidation (Cañada del Buey). A preoperational appraisal of the site of the Sanitary Wastewater Consolidation System (SWCS) plant has been conducted for two years. The biotic diversity of Cañada del Buey, below the SWCS site and the location of future discharges of up to 600,000 gal. of water a day, has been studied.

Activities included habitat evaluation; capture/release surveys for small mammals; point counts for birds; pellet counts for large mammals; and tracking of small, medium-sized, and large mammals. Mapping of vegetation below the plant site and monitoring of the animal populations within the canyon will be continued prior to and after the onset of discharge of water from the plant.

9. Biological Resource Evaluations.

a. Biological Surveys/Monitoring. Monitoring of selected biota and sensitive habitats to provide long-term data in accordance with NEPA, DOE Order 5400.1 (DOE 1988a), the Endangered Species Act, and the Floodplain/Wetland Executive Order was begun during 1990. Monitoring studies on raptors, reptiles and amphibians, small mammals, and birds continued during 1991. Additionally, wetland and adjacent upland habitats within Pajarito and Sandia Canyons were monitored. A second year of data was collected for various trophic levels of biota within Cañada del Buey. Several new surveys were initiated to obtain inventory data on groups of organisms not previously studied. No fish were encountered in Laboratory waters.

Raptors. Evaluation of raptor populations and raptor nest sites within Laboratory boundaries continued during 1991. Birds of concern included the zone-tail hawk (*Buteo albonotautus*), Cooper's hawk (*Accipiter cooperii*), and Northern goshawk (*Accipiter gentilis*).

Breeding birds. Breeding bird surveys were conducted by members of the Pajarito Ornithological Survey in cooperation with the Biological Resource Evaluations program for a period of five years. Data analysis and manuscript preparation was completed. Approximately 112 species of birds were found to breed within Laboratory boundaries or within Los Alamos County.

Bats. During the summer of 1991, a survey for bat species found on Laboratory land was begun by the Biological Resource Evaluations Team. The purpose of the study was two-fold: (1) to identify species of bats inhabiting Laboratory lands, and (2) to determine if the spotted bat (*Euderma maculatum*), a state endangered species, was utilizing Laboratory lands for foraging or roosting. Species identified are included in Table IV-46. No spotted bats were identified. Additional bat studies will be conducted to further define the presence or absence of this species on Laboratory lands and to further inventory the bat species using Laboratory lands for breeding, roosting, and foraging.

Table IV-46. Bat Species Found on Los Alamos National Laboratory Lands

Myotis evotis	Long-eared myotis
Myotis volans	Long-legged myotis
Lasiurus cinereus	Hoary bat
Lasionycteris noctivagans	Silver-haired bat
Eptesicus fuscus	Big brown bat
Pipistrellus hesperus	Western pipistrelle

Snails. No information on mollusk species found on the Pajarito Plateau has been compiled. Cursory surveys for land dwelling and aquatic mollusk species were conducted during the summer of 1991 in conjunction with Dr. Richard Smartt, New Mexico Museum of Natural History. Surveys were carried out in Pajarito, Los Alamos, Ancho, and Chaquehui Canyons. This preliminary survey identified 12 species of snails and bivalves on Laboratory and adjacent lands (Table IV-47). Surveys will be continued to further inventory mollusk species.

Insects. Few studies of insects or arachnids have been conducted on Laboratory lands. Two studies done prior to 1991 inventoried ants and land dwelling spiders. Trapping studies for land dwelling insects were initiated in Pajarito Canyon and in Ancho Canyon during the summer of 1991. Identification of the specimens collected is being done by various entomologists with expertise within each Order. Results have not yet been compiled.

Elk/Deer. Studies evaluating population numbers of elk and deer have not been conducted since the late 1970s. In cooperation with the New Mexico Game and Fish Department, aerial game counts were initiated in August to determine resident populations and in January 1992 for wintering populations. Counts were not successful because of altitude limitations mandated by the DOE for purposes of safety. The altitude was too high to successfully count numbers or cow/bull ratios. Other techniques are being investigated to determine the population numbers consistently from year to year.

b. Wildlife Watering. In July through October 1991, a preliminary survey of 135 of 140 NPDES outfalls was conducted to determine wildlife use. The results of the survey indicated that approximately 50% of the outfalls are used or potentially can be used by macrofauna such as deer and elk. Additionally, one-third of the outfalls have potential wetland characteristics as evidenced by hydrophytic vegetation.

Observations indicated a number of aquatic invertebrates within effluent discharge waters. Cursory wildlife observations provided a list of 35 mammal, bird, amphibian, and reptile species (evidenced from visual sightings, scat, tracts, and bedding) in the vicinity of the outfalls. These and other nonmacrofaunal species could potentially use waters from the discharges. To determine the level of use of these discharge outfalls by small and medium-sized mammals and amphibians, further studies will be conducted. Studies on the macroinvertebrate assemblages will continue.

Table IV-47. Land and Aquatic Mollusks Found on Los Alamos National Laboratory Land

Canyon	Location	Species
SNAILS		
Upper Pajarito	T19N,R6E,NW1/4, Sec. 19	*Zonitoides arboreus* *Glyphyalinia indentata* *Euconulus fulvus*
Middle Pajarito	T19N,R7E, unplatted	*Gyraulus spp.*
Lower Pajarito	T19N,47E,NE1/4,NW1/4, Sec. 10	*Physa virgata* *Oreohelix subrudis*
Los Alamos	T19N,R6E,SE1/4,NW1/4, Sec. 17	*Euconulus fulvus*
Ancho	T18N,R7E, unplatted	*Cochilicopa lubrica* *Lymnea palva* *Physa virgata*
Chaquehui	T18N,R7E, unplatted	*Physa virgata*
BIVALVES		
Ancho	T18N,R7E, unplatted	*Pisidium casertanum*

c. Wetland monitoring.

Pajarito Canyon. Monitoring of reptile, amphibian, and small mammal populations within the palustrine wetlands and adjacent uplands within Pajarito Canyon continued for a second year. Water levels within the wetlands were substantially higher due to heavy seasonal rains. Many areas that had been dry during the summer of 1990 were inundated for a period of time greater than 21 days during 1991.

Amphibian species found breeding within the wetlands included the Spadefoot toad (*Scaphlopus multiplicatus*), Red spotted toad (*Bufo punctatus*), Woodhouse's toad (*Bufo woodhousei*), Chorus frog (*Pseudacris triseriata*), and Tiger salamander (*Ambystoma tigrinum*). Tadpoles from two species were observed during the summer of 1991 that were not observed during the drier summer of 1990, the Spadefoot toad and Red spotted toad. During August, large numbers of spadefoot toads metamorphosed and were observed moving from the wetlands into the uplands.

A capture/release study of small mammals was conducted for a second year within the study area. The two most commonly captured species were the Western harvest mouse (*Reithrodontomys mealotis*) and the Deer mouse (*Peromyscus maniculatus*). Each species comprised 31.9% of the total organisms caught. Other species included Piñon mouse (*Peromyscus truei*), Brush mouse (*Peromyscus boylei*), Least chipmunk (*Eutamium minimus*), Colorado chipmunk (*Eutamius quadrivittatus*), and White throated woodrat (*Neotoma albiqua*).

Additionally, pellet transects were established in Pajarito Canyon to determine large mammal use of the wetland areas as compared to a drier canyon, Cañada del Buey. Preliminary information indicated a heavier use of the Pajarito wetland by elk and deer than the drier Cañada del Buey. These transects are monitored on a monthly basis. Pellet groups identified in Pajarito and Cañada del Buey include coyote (*Canis latrans*), elk (*Cervus canadensis*), deer (*Odocoileus hemionus*), rabbits (*Sylvilagus* spp.), and black bear (*Ursus americanus*).

Sandia Canyon. Water quality as related to the diversity and types of aquatic invertebrate assemblages has been monitored in Sandia Canyon. Water sources to the stream in Sandia Canyon include steam plant blowdown, sanitary treatment plant effluent, and other industrial waste. From the literature, there is evidence that the kinds and types of aquatic invertebrates within a stream are directly related to the quality of the waters in that stream. Initial limited data collected from Sandia Canyon suggest that aquatic assemblages do represent an ecological indication of water quality. Three sampling stations have been set up in the canyon (Fig. IV-24). The first two stations are just below industrial waste discharge points. The effluent discharges consist of sanitary waste and steam plant blowdown. The third station is approximately 0.5 m downstream from any effluent discharge. Water quality parameters such as pH, temperature, dissolved oxygen, and conductivity are measured on a monthly basis at each station. Aquatic invertebrates are also sampled. The first two stations have a limited diversity of aquatic invertebrates and tend to have those invertebrates commonly found in low oxygen environments. Water quality measurements indicate that Station 2 consistently has the lowest dissolved oxygen content (due to sanitary waste effluent). However, the third station consistently has a dissolved oxygen content near saturation and a higher degree of invertebrate diversity. The aquatic invertebrates found within Station 3 are those species thought to be sensitive to contamination and low oxygen environments. The third station appears to be in the stream recovery zone. Table IV-48 summarizes the aquatic invertebrates that have been found in Sandia Canyon.

d. Special Accomplishments.

Wildlife Observation Database. A Wildlife Observation Database was established within the Environmental Assessments and Resource Evaluations Section of EM-8. The purpose of the database is to record observations on wildlife made by Laboratory employees and field personnel. Observations are used to determine distribution and presence of species on Laboratory lands, Bandelier National Monument, and adjacent Forest Service lands. Animals observed by employees included bear, deer, elk, raccoon, fox, bald eagle, golden eagle, bobcat, coyote, peregrine falcon, chorus frogs, and a variety of birds.

Biota Databases. The Biological Resource Evaluations Program has established databases for mammals, birds, reptiles, amphibians, mollusks, insects, vascular plants, fungi, and threatened and endangered species. Historic information about species found on Laboratory and adjacent lands is being

compiled. These databases will provide information on species diversity and distribution.

10. Community Relations Program.

In 1991, community relations continued to be an important facet of LANL environmental programs. As part of the ER program, several community relations activities were accomplished. These included

- developing and distributing townsite operable unit fact sheets to the public,
- holding ER Installation Work Plan Public Information Workshops in Taos, Española, Santa Fe, and Los Alamos,
- in cooperation with DOE, mailing notifications to 350 property owners of land classified as SWMUs, and holding a public information meeting to discuss the notifications,
- holding a DOE/LANL ER and Waste Management Site-Specific Plan Public meeting, and

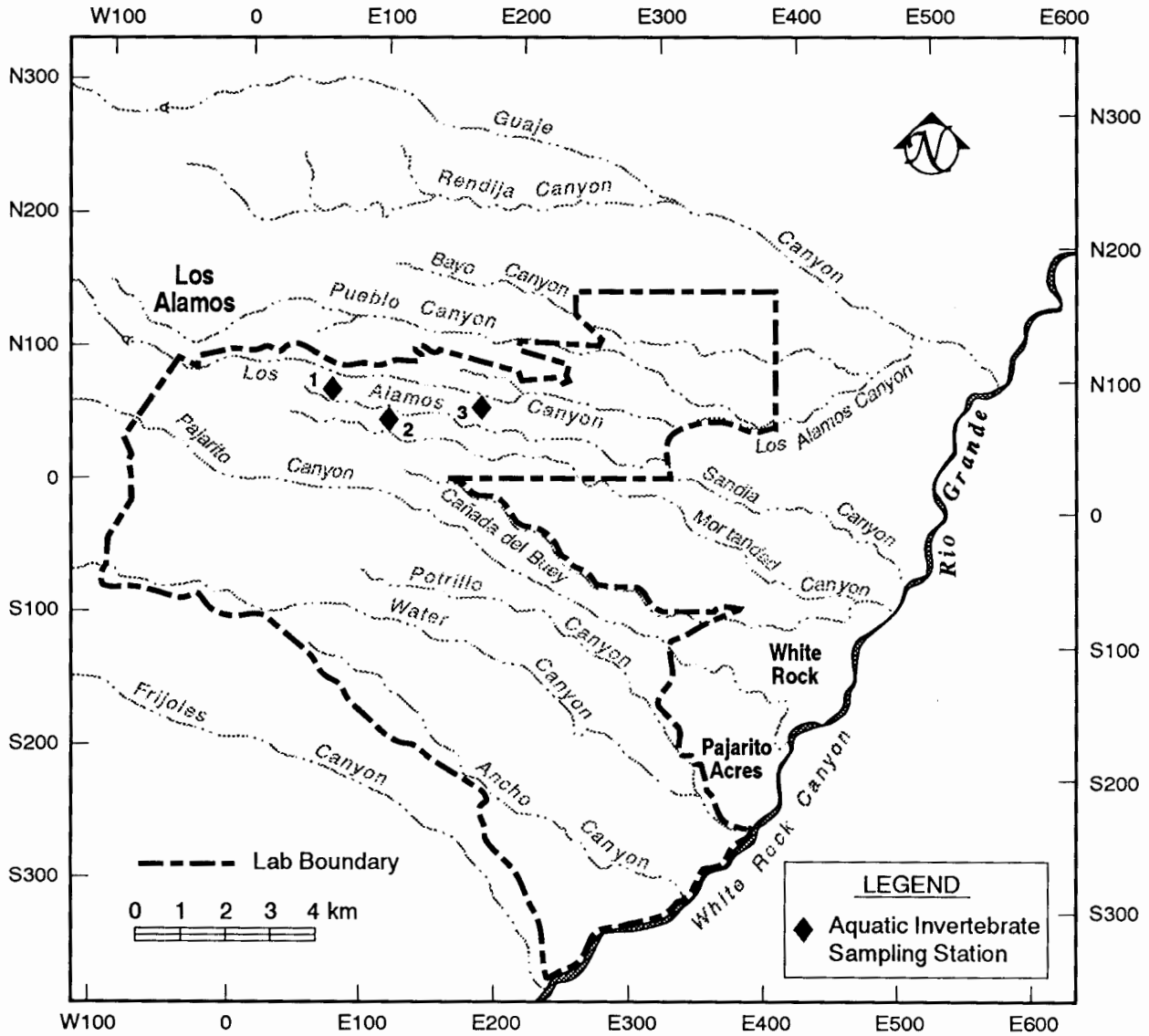


Fig. IV-24. Locations of aquatic invertebrate sampling stations in Sandia Canyon. (Map denotes general location only.)

Table IV-48. Aquatic Invertebrates Found in Sandia Canyon at Three Sampling Stations

Aquatic Invertebrate	Present at Station 1[a]	Present at Station 2[b]	Present at Station 3[c]
Order Diptera (Flies, Midges, and Mosquitoes)	Yes	Yes	Yes
Order Coleoptera (Beetles)	No	Yes	Yes
Order Ephemeroptera (Mayflies)	No	No	Yes
Order Trichoptera (Caddis Flies)	No	No	Yes
Order Hemiptera (True Bugs)	No	No	Yes
Order Plecoptera (Stoneflies)	No	No	Yes
Class Odonata (Damselfiles and Dragonflies)	No	No	Yes
Class Oligocheata (Aquatic Earthworms)	No	No	Yes
Class Gordiacea (Hairworms)	No	No	Yes
Class Nematoda (Roundworms)	Yes	Yes	No

[a]Station 1 = Immediately below steam plant effluent discharge point.
[b]Station 2 = Immediately below the sanitary waste discharge point.
[c]Station 3 = 1/2 mile down from any discharge point.

- meeting with several local neighborhood associations and the County Council to update them on current ER program activities.

In an attempt to communicate more effectively with interested and affected parties on environment, safety, and health (ES&H) issues, the Community Relations Group (PA-3) recently subscribed to Northern New Mexico Environmental Information Exchange (NENIX). NENIX is a newly initiated multiline computer bulletin board and environmental information bank.

PA-3 sponsored several events to foster dialogue between Laboratory senior management and staff and local public interest groups. Among these events were:

- Presentation to LANL staff about the Nuclear Guardianship Project by Charlotte Cook.
- Colloquium by Dr. Isadore Rosenthal and luncheon discussion among public interest groups and Laboratory representatives. Laboratory staff included members of Senior Management, Common Ground, Environmental Management Division staff, and Community Relations staff. Public interest groups included Citizens for Clean Air and Water, Trinity Forum for International Security, Concerned Citizens for Nuclear Safety, Nuclear Guardianship Project, Physicians for Social Responsibility, New Mexico Alliance, and Southwest Research and Information Center.

- Nuclear testing round table discussions among Laboratory representatives and members of Concerned Citizens for Nuclear Safety and public interest group representatives from the Livermore area.
- Seminar entitled "Public Acceptance of Science: Chernobyl and Sellafield as Competing Causes of an Environmental Emergency in England," by British scientist, Brian Wynne.
- Round table dialogue with public interest group representatives including Concerned Citizens for Nuclear Safety and People for Peace, Laboratory senior managers and John Zysman/Michael Borrus (Berkeley Round Table for the International Economy) to discuss economic conversion issues.
- Round table dialogue among public interest group representatives including People for Peace and Citizens for Clean Air and Water; Laboratory Community Relations staff; and Dixie Lee Ray, former Director of the National Regulatory Commission.

11. Waste Minimization and Pollution Prevention.

LANL's Waste Minimization and Pollution Prevention Awareness Program is a comprehensive and continual effort to systematically reduce waste generation. This program is designed to eliminate or minimize pollutant releases to the environment from all aspects of the Laboratory's operations. Included are methods of reducing hazardous chemical waste, TRU waste, low-level radioactive waste, radioactive liquid waste, mixed waste, and sanitary/industrial waste. The oversight and planning of the Waste Minimization Program is done through the LANL Waste Minimization Program Office.

The Laboratory Waste Minimization and Pollution Prevention Awareness Program is reinforced through senior management commitment. This commitment is addressed in the Laboratory Director's Policy (DP 105) which emphasizes reduction or elimination of waste whenever or wherever possible. In addition, the program uses a number of waste minimization and pollution prevention techniques to actively minimize waste and prevent pollution. These techniques include process waste assessments; site specific plans; an upper management level Waste Minimization Steering committee to facilitate waste minimization actions within the Laboratory; and an employee awareness program encompassing training, campaigns, and incentives.

The Laboratory is committed to waste minimization and pollution prevention. The program follows all applicable federal, state, and DOE requirements for waste minimization.

12. Environmental Training.

The Laboratory maintains an extensive personnel training program for ES&H courses coordinated by the Policy and Guidance Section of the Risk Management Support Group (HS-3) of the Health and Safety Division. All Laboratory employees must take the following training: General Employee Training (GET), Radiation Protection for Occupational Workers (every other year), Lockout/Tagout for Affected Workers (available in July 1992), Occupational Safety and Health Act (OSHA) Rights and Regulations, and Employee Participation Packet (yearly). The following courses are suggested for all employees: Introduction to Hazard Communication and Waste Generator Training.

All new employees, contractors, affiliates, long-term visitors, and co-op students must take the GET sessions which consist of 16 training modules:

- Facilities
- Policies
- Quality Assurance
- Security
- Safeguard Awareness
- ES&H Policy
- Employee Participation Packet
- OSHA Rights and Regulations
- Industrial Safety
- Fire Protection
- Emergency Management

- Industrial Hygiene
- Occupational Medicine
- Radiation Protection for the Occupational Worker
- Lockout/Tagout
- Environment

The Laboratory also offers specific environment-related courses for employees who work with hazardous and toxic wastes. A variety of classes designed to meet site-/job-/operation-specific training needs includes classes on Hazardous Waste Generation; Hazardous Waste Operations (which meets the OSHA training requirements as described in 29 CFR 1910.120); Packaging and Transportation of Hazardous Materials; Procedures to Implement the Spill Prevention, Control, and Countermeasures Plan; and Waste Management Coordination.

V. ENVIRONMENTAL RADIOLOGICAL PROGRAM INFORMATION

A major component of the Laboratory's Environmental Surveillance Program includes monitoring for potential exposures to the public from Laboratory-related radiation sources and assessing the risk associated with that exposure. Air is routinely sampled at locations on Laboratory property, along the Laboratory perimeter, and in more distant areas that serve as regional background stations. Atmospheric concentrations of tritium, uranium, plutonium, americium, and gross beta are measured. In 1991, total radioactive air emissions decreased by approximately 50% with gaseous mixed activation products and tritium showing the largest declines. Water effluent from the liquid waste treatment plant is sampled to determine the release of radionuclides. Total releases continued to decline in 1991. The maximum effective dose to a member of the public from 1991 Laboratory operations was 4.4 mrem. The average doses to individuals in Los Alamos and White Rock because of 1991 Laboratory activities were 0.05 and 0.03 mrem, respectively. These doses are estimated to add lifetime risks of about 1 chance in 47,000,000 in Los Alamos and 1 chance in 68,000,000 in White Rock to an individual's risk of cancer mortality.

A. Introduction

Many of the activities that take place at the Los Alamos National Laboratory (LANL or the Laboratory) involve handling radioactive materials and operating radiation-producing equipment. A major component of the Laboratory's Environmental Surveillance Program includes monitoring for potential exposures to the public from Laboratory-related radiation sources.

Radiation from radioactive materials and radiation-producing equipment is called ionizing radiation. Common types of ionizing radiation include alpha, beta, and gamma. Each type of ionizing radiation has a unique ability to penetrate or pass through materials and thereby be absorbed in living tissues causing damage from the ionization process. Alpha radiation penetrates poorly; a piece of paper or outer skin tissue can stop it. Beta radiation has low to moderate penetrating ability. X-rays and gamma radiation have much greater penetrating ability.

Radiation is released by both naturally occurring materials and by artificially produced or enhanced sources. Naturally occurring sources are called background radiation and include naturally occurring gases such as radon and naturally occurring elements such as uranium in regional rocks and soils. Ionizing radiation is also produced by medical diagnosis and treatment equipment such as x-rays, nuclear medicine procedures, and linear accelerators. Medical diagnosis and treatment account for the largest radiation dose to the American public from artificially produced sources of radiation. Tobacco products, smoke detectors, and television sets have ionizing radiation associated with them.

Other sources of ionizing radiation include occupational exposures, residual fallout from past atmospheric weapons testing, the nuclear fuel cycle, and research and scientific activities at facilities such as the Laboratory.

B. Radioactive Emissions

1. Air.

The radiological air sampling network at the Laboratory is designed to measure environmental levels of airborne radionuclides that may be released from Laboratory operations. Plutonium, americium, and uranium are released in microcurie amounts as a result of Laboratory operations. Tritium is released in curie amounts. Radioiodine and noble gases are released from facilities performing fission product chemistry, medical isotope preparation, and research reactors. The Laboratory also releases radionuclides that emit beta

and gamma radiation from the Los Alamos Meson Physics Facility (LAMPF) at TA-53 and the Omega West Reactor at TA-2.

Radioactive airborne emissions are monitored at 88 Laboratory discharge locations. These emissions consist primarily of filtered exhausts from glove boxes, experimental facilities, operational facilities (such as liquid waste treatment plants), a nuclear research reactor, and a linear particle accelerator at LAMPF. Some emissions receive appropriate treatment before discharge, such as filtration for particulate matter and catalytic conversion and adsorption for activation gases. The quantities of airborne radioactivity released depend on the type of research activities and can vary markedly from year to year (Figs. V-1 to V-3). During 1991, the most significant releases were from LAMPF. The amount released for the entire year was 57,431 Ci (2,117,029 GBq) of air activation products (gases, particles, and vapors) (Tables V-1 and V-2). This emission was about half of that in 1990 (Fig. V-3). The principal airborne activation products (half-lives in parentheses) were ^{10}C (19.5 s), ^{11}C (20 min), ^{13}N (10 min), ^{16}N (7.14 s), ^{14}O (71 s), ^{15}O (123 s), and ^{41}Ar (1.83 h). Most of the radioactivity was from these radioisotopes, whose radioactivity declines very rapidly over time. A list of selected nuclides and their half-lives is given in Table D-17.

Airborne tritium emissions continued to decrease from the 6,400 Ci (236,800 GBq) released in 1990 to 4,716 Ci (174,492 GBq) released in 1991 (Table IV-3). Release of mixed fission products remained constant in 1991, equaling levels observed prior to the 1989 unplanned release from TA-48 (1,150 μCi [42 MBq] in 1988, 435,000 μCi [16 GBq] in 1989, 1,085 μCi [40 MBq] in 1990, and 1,096 μCi [40.4 MBq] in 1991). Spallation products were observed at TA-53 and TA-48. Total activity was less than 0.1 Ci.

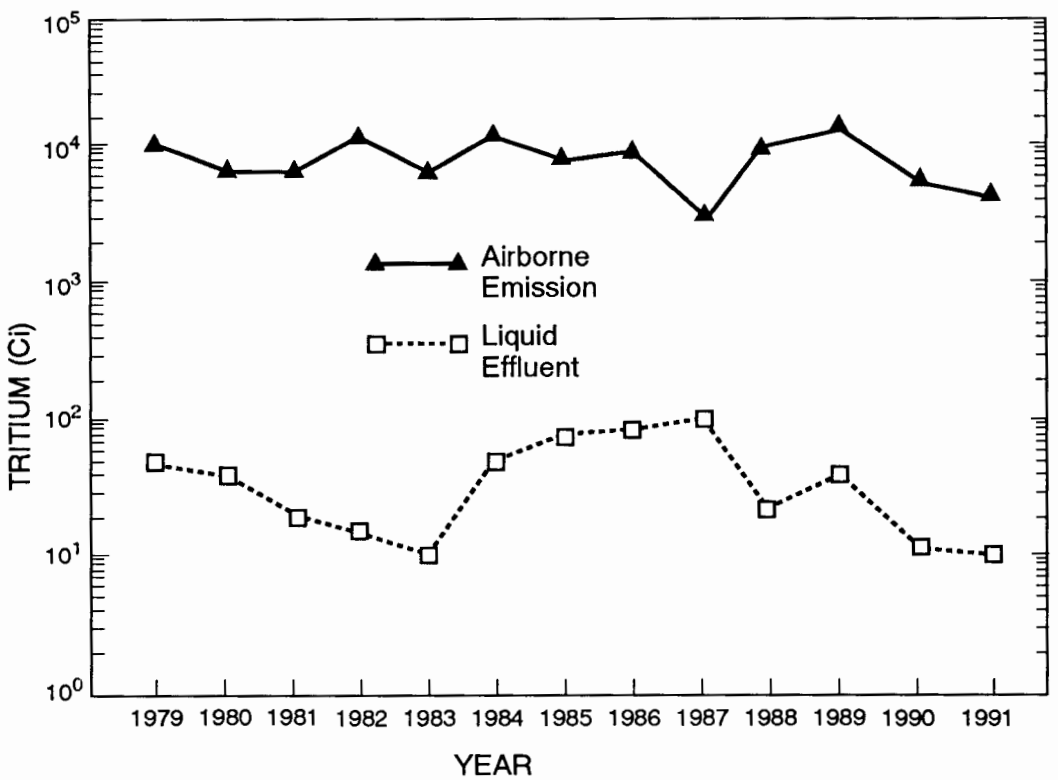


Fig. V-1. Summary of tritium releases (airborne emissions and liquid effluents).

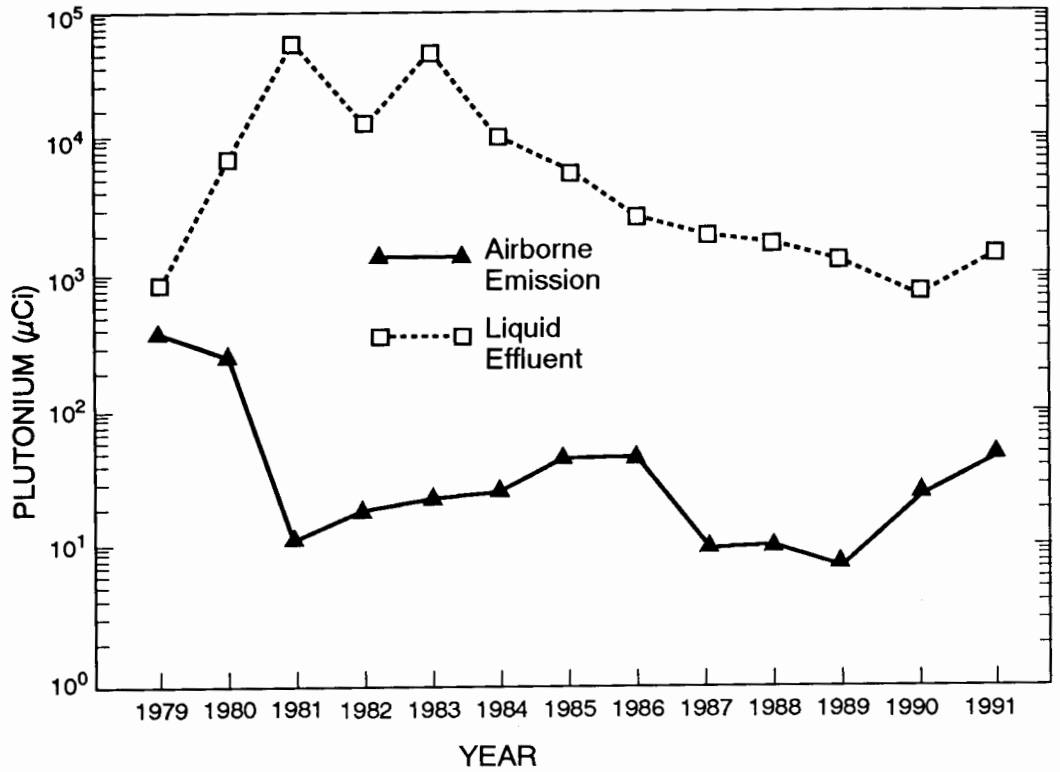


Fig. V-2. Summary of plutonium releases (airborne emissions and liquid effluents).

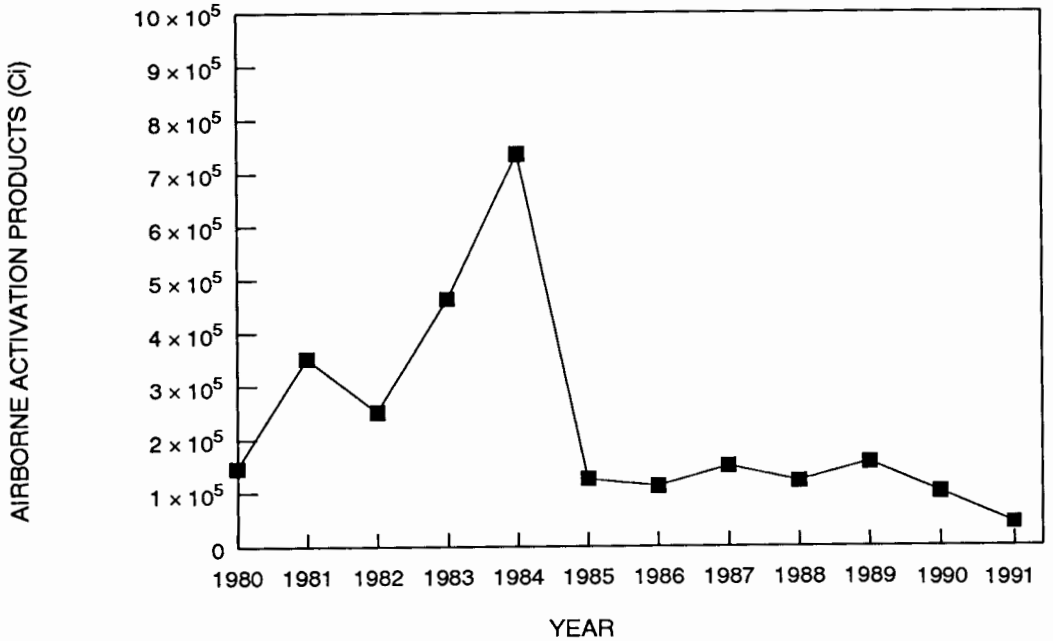


Fig. V-3. Airborne activation product emissions (principally ^{10}C, ^{11}C, ^{12}N, ^{16}N, ^{14}O, ^{15}O, ^{41}Ar) from the Los Alamos Meson Physics Facility (TA-53).

Table V-1. Airborne Radioactive Emissions from Laboratory Operations in 1991[a]

Location	H^{3b} (Ci)	Mixed Fission Products (μCi)	$^{235}U^{c}$ (μCi)	^{238}U (μCi)	$^{238/239/240}Pu^{d}$ (μCi)	^{32}P (μCi)	Summary of Activation Products (See detailed list in Table V-2) Gaseous[e] (Ci)	Particle/Vapor[f] (Ci)
TA-2	—	—	—	—	—	—	203.3	—
TA-3	205.2	14.1	164.3	79.9	30.8	—	—	—
TA-21	323.3	<0.1	92.0	—	0.8	—	—	—
TA-33	254.0	—	—	—	—	—	—	—
TA-35	—	—	—	—	1.2	—	—	—
TA-41	3,841.0	—	—	—	—	—	—	—
TA-43	—	—	—	—	—	17.0	—	—
TA-46	—	—	—	—	—	—	—	—
TA-48	—	1,078.8	—	—	0.6	—	—	<0.1
TA-50	—	3.1	—	—	1.4	—	—	—
TA-53	0.9	—	—	—	—	—	57,228.0	0.2
TA-54	—	—	—	—	<0.1	—	—	—
TA-55	91.2	—	—	—	2.0	—	—	—
Rounded Total	4,715.6	1,096.0	256.3	79.9	36.8	17.0	57,431.3	0.2

[a]As reported on DOE form F-5821.1.
[b]Includes 99.2% as H^3 (gas) and 0.2% as tritium vapor in the HTO form.
[c]Does not include aerosolized uranium from explosives testing (Table V-3).
[d]Plutonium values contain indeterminate traces of ^{241}Am, a transformation product of ^{241}Pu.
[e]Includes the following constituents: ^{16}N, ^{10}C, ^{14}O, ^{15}O, ^{13}N, ^{11}C, ^{41}Ar, (see Table V-2 for details).
[f]Includes 26 nuclides (see Table V-2 for details).

In addition to releases from facilities, some depleted uranium (uranium consisting primarily of ^{238}U) is dispersed by experiments that use conventional high explosives. About 309.2 kg (680 lb) of depleted uranium was used in such experiments in 1991 (Table V-3). This mass contains about 0.12 Ci (4,440 MBq) of radioactivity. Most of the debris from these experiments is deposited on the ground in the vicinity of the firing sites. Limited experimental data show that no more than about 10% of the depleted uranium becomes airborne (Dahl 1977). Dispersion calculations indicate that resulting airborne concentrations are in the same range as that for concentrations attributable to the natural abundance of uranium

Table V-2. Airborne Radioactive Emissions from Laboratory Operation in 1991 Detailed Listing of Mixed Activation Products: Particulate, Vapor, and Gases

Mixed Activation Products	Radionuclide	Activity in Curies		
		Location: TA-2	Location: TA-53	Location: TA-48
Particle/Vapor (P/VAP)	As-72			8.72×10^{-2}
	As-73			7.23×10^{-4}
	As-74			6.83×10^{-4}
	Be-7		1.94×10^{-2}	
	Br-76		2.00×10^{-3}	
	Br-77			2.56×10^{-3}
	Br-82		$6.01 \cdot 10^{-3}$	9.00×10^{-5}
	Cd-109			2.49×10^{-3}
	Co-57		1.13×10^{-6}	
	Co-58		7.69×10^{-6}	
	Cr-51		3.56×10^{-4}	
	Ir-192		9.67×10^{-7}	
	Mn-52		4.45×10^{-4}	
	Mn-54		1.12×10^{-5}	
	Na-22		3.11×10^{-6}	
	Na-24		5.85×10^{-3}	
	Os-185		2.83×10^{-6}	
	Rb-83		2.74×10^{-4}	
	Rb-105			1.29×10^{-3}
	Sc-46		1.95×10^{-5}	
	Sc-47		6.30×10^{-4}	
	Se-75		7.63×10^{-5}	8.30×10^{-2}
	Ta-182		1.09×10^{-4}	
	Te-132			1.08×10^{-4}
	Tl-202		5.56×10^{-5}	
	V-48		2.05×10^{-4}	
Gaseous (G/MAP)	AR-41	2.03×10^{2}	2.58×10^{2}	
	C-10		2.57×10^{3}	
	C-11		9.59×10^{3}	
	N-13		8.52×10^{3}	
	N-16		1.02×10^{3}	
	O-14		1.17×10^{3}	
	O-15		3.41×10^{4}	

Table V-3. Estimated Concentrations of Radioactive Elements Aerosolized by Dynamic Experiments

Element	1991 Total Usage (kg)	Fraction Aerosolized (%)	Annual Average Concentration ($\mu g/m^3$) (4 km)[a]	Annual Average Concentration ($\mu g/m^3$) (8 km)[a]	Applicable Standard ($\mu g/m^3$)
Uranium	309.2	10	3.0×10^{-5}	1.2×10^{-5}	9[b]

[a]Distance downwind.

[b]DOE (1981a).

that is resuspended in dust particles originating from the earth's crust.

Radioactive air emissions at the Laboratory are monitored according to DOE/EH-0173T "Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance" (DOE 1991) and 40 CFR Part 61, Subpart H, "National Emission Standards for Emissions of Radionuclides Other than Radon from Department of Energy Facilities" (EPA 1989c). Based on off-site environmental monitoring results and on doses calculated from measured stack emissions, the off-site doses are less than the 10 mrem/year standard given in 40 CFR 61.92.

On July 17, 1990, LANL notified the Department of Energy (DOE) that the Laboratory met the 10 mrem/yr standard but did not meet the monitoring requirements (40 CFR 61.93) with its existing sampling program. On November 27, 1991, Environmental Protection Agency (EPA) Region 6 issued the DOE a Notice of Noncompliance with 40 CFR 61, Subpart H, specifically:

1. Every release source from an operation which uses radionuclides has not been evaluated using the approved Environmental Protection Agency (EPA) computer model to determine a dose received by the public, as required by 40 CFR 61.93(a).
2. DOE has failed to comply with 40 CFR 61.93(b)(4) because it has not determined each release point that has the potential to deliver more than 1% of the effective dose equivalent standard.
3. The facility currently has not installed stack monitoring equipment on all its regulated point sources in accordance with the above analysis and 40 CFR 61.93 (b)(2)(ii) and (iii).
4. The facility has not conducted, and is not in compliance with, the appropriate quality assurance programs pursuant to 40 CFR 61.93 (b)(2)(iv).
5. The facility is in violation of 40 CFR 61.94 "Compliance and Reporting" because it has not calculated the highest effective dose equivalent in accordance with the regulations cited above.

As a result of the Notice of Noncompliance, the DOE is currently negotiating a Federal Facilities Compliance Agreement (FFCA) with EPA Region 6. The FFCA will include schedules which the Laboratory will follow to come into compliance with the Clean Air Act. A draft FFCA was submitted by DOE Los Alamos Area Office (LAAO) to the EPA on March 12, 1992.

2. Water.

In recent years, treated effluents containing low levels of radioactivity have been released from the central liquid waste treatment plant (TA-50), a smaller plant serving laboratories at TA-21, and a sanitary sewage lagoon system serving LAMPF at TA-53 (Tables IV-3 and IV-26 and Figs. V-1, V-2, and V-4). In 1989, the low-level radioactive waste stream was separated from the sanitary system at TA-53 and directed into a total retention, evaporative lagoon. In 1991, there were no releases from the TA-21 plant or the TA-53 total retention lagoons.

Total activity released in 1991 (about 11 Ci) was slightly less than that released in 1990 (about 13 Ci) (Table IV-3). The decrease resulted because of

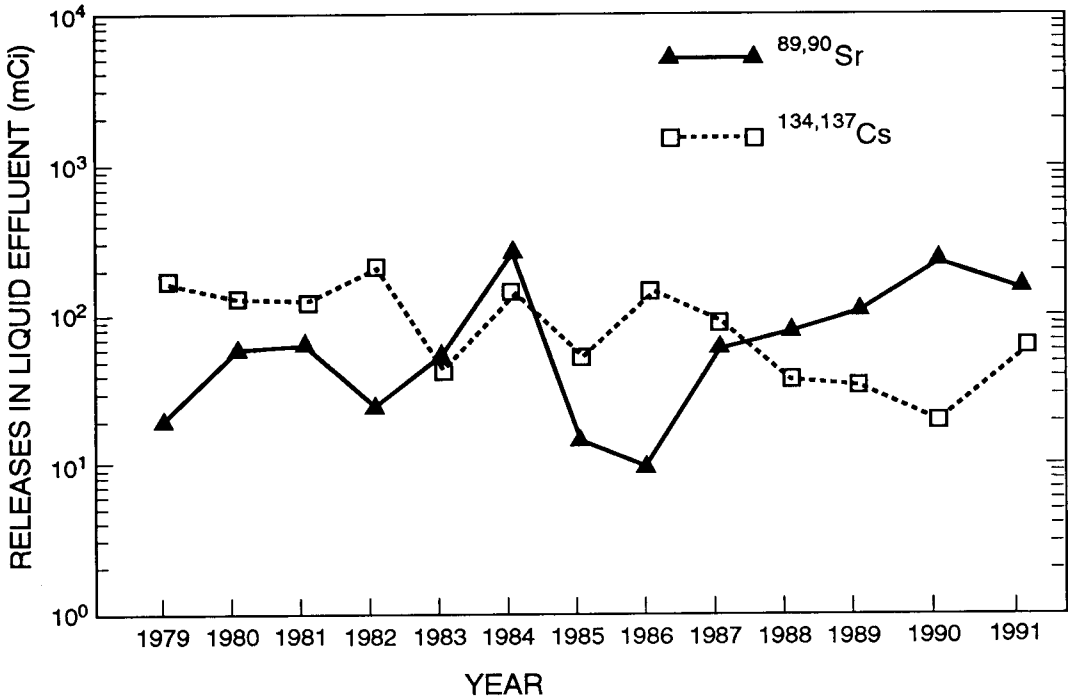


Fig. V-4. Summary of strontium and cesium liquid effluent releases.

improved treatment of the radioactive liquid waste stream. Effluents from TA-50 are discharged into the normally dry stream channel in Mortandad Canyon, where surface flow has not passed beyond the Laboratory's boundary since the plant began operation in 1963.

3. Unplanned Releases.

a. Airborne Radionuclide Releases. On February 1, 1991, 2,800 Ci of elemental tritium were released at TA-41. Less than 0.1% of the tritium was present as tritiated water. The effective dose equivalent (50-yr dose commitment) to a member of the public was calculated to be 0.03 mrem. This dose occurred 7 km (5.8 mi) east of TA-41, where Los Alamos Canyon opens out onto State Road 4. The dose estimate conservatively assumed that 1% of the tritium was oxidized before reaching the receptor location. The dose is 0.03% of DOE's Public Dose Limit (PDL) of 100 mrem/year from all pathways, and 0.3% of the EPA's 10 mrem/year limit for the air pathway. (See Appendix A for standards.)

On March 28, 1991, 0.4 Ci of tritiated water vapor were released from TA-21 as tritium oxide. The effective dose equivalent (50-yr dose commitment) to a member of the public was calculated to be 0.01 mrem. The dose is 0.01% of DOE's PDL of 100 mrem/yr (1 mSv/yr) from all pathways, and 0.1% of the EPA's 10 mrem/yr (0.1 mSv/yr) limit for the air pathway.

On April 17, 1991, 0.1550 Ci of tritiated water vapor were released from TA-3-16. A slow leak was discovered at the Van de Graaff accelerator. The effective dose equivalent (50-year dose commitment) to a member of the public was calculated to be 0.006 mrem. The dose is 0.006% of DOE's PDL of 100 mrem/yr from all pathways and 0.06% of the EPA's 10 mrem/yr limit for the air pathway.

b. Radioactive Liquid Releases. On January 2, 1991, a discharge was discovered at TA-54, Area G. A plumbing joint on an eye wash/safety shower located inside Building 33 froze and burst sometime between December 21, 1990, and January 1, 1991, when the Laboratory was closed for the winter holidays. The

amount of discharge was estimated to be 18,000 gallons. Analyses were conducted on the frozen water and soil; gross alpha, beta, and gamma were found to be within background levels. Samples analyzed for tritium averaged 0.29 μCi/L, approximately 15% of the DOE Derived Concentration Guide for off-site tritium releases (2.0 μCi/L). Removal of the frozen water below Building 33 was not required because of the slow rate of melting during which the water either evaporates or enters the subsurface, rather than producing a definitive runoff in Cañada del Buey. (See Section IV.6.3.a for data on measurements of tritiated water in sediments in Cañada del Buey.)

On February 21, 1991, 0.2 mCi of plutonium and americium isotopes were released at TA-50 from a leaking pipe near the Size Reduction Facility. The leak was repaired, and the spill was cleaned up to applicable standards.

C. Radiological Doses

1. Introduction.

Radiological doses are calculated in order to measure the health impacts of any releases of radioactivity to the public. Radiation dose refers to the quantity of radiation energy absorbed per unit mass, multiplied by adjustment factors for type of radiation. Effective dose equivalent (or simply "effective dose") is the principal measurement used in radiation protection. This term means the hypothetical whole-body dose that would give the same risk of cancer mortality and serious genetic disorder as a given exposure 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 × 0.12) = 12 mrem.

Standards exist which limit the maximum effective dose to the public. DOE applies a PDL of 100 mrem/yr for all pathways. EPA limits the effective dose to a member of the public to 10 mrem/yr for the air pathway only.

2. Methods for Dose Calculations.

a. Introduction. Annual radiation doses are evaluated for three principal exposure pathways: external exposure (which includes exposure from immersion in air containing photon-emitting radionuclides and direct and scattered penetrating radiation), inhalation, and ingestion. Estimates are made of the following exposures:

- Maximum individual organ doses and effective dose equivalent to an individual at or outside the Laboratory boundary where the highest dose rate occurs and a person actually is present. It takes into account occupancy (the fraction of time that a person actually occupies that location), shielding by buildings, and self-shielding.
- Average organ doses and effective dose equivalents to nearby residents.
- Collective effective dose equivalent for the population living within an 80 km (50 mi) radius of the Laboratory.

Results of environmental measurements are used as much as possible in assessing doses to individual members of the public. Calculations based on these measurements follow procedures recommended by federal agencies to determine radiation doses (DOE 1991, NRC 1977).

If the impact of Laboratory operations is not detectable by environmental measurements, individual and population doses attributable to Laboratory activities are estimated through modeling of releases.

Dose conversion factors used for inhalation and ingestion calculations are given in Table D-18. These factors are taken from the DOE (1988b) and are based on factors in Publication 30 of the International Commission on Radiological Protection (ICRP 1979).

Dose conversion factors for inhalation assume a 1-μm activity median aerodynamic diameter, as well as the lung solubility category that will maximize the effective dose equivalent (for comparison with DOE's 100-mrem/yr PDL) if more than one category is given. Similarly, the ingestion dose conversion factors are chosen to maximize the effective dose if more than one gastrointestinal tract uptake is given (for comparison with DOE's 100-mrem/yr PDL for all pathways).

These dose conversion factors give the 50-year dose commitment for internal exposure. The 50-year dose commitment is the total dose received by an organ during the 50-year period following the intake of a radionuclide that is attributable to that intake.

External doses are calculated using the dose-rate conversion factors published by DOE (1988c) (Table D-19). These factors give the photon dose rate

in millirems per year per unit radionuclide air concentration in microcuries per cubic meter. If these factors are not available in DOE 1988c, they are calculated with the computer program DOSFACTOR II (Kocher 1981).

Annual effective dose equivalents are estimated with the CAP-88 collection of computer codes published by the EPA if impacts from Laboratory operations are so small that they are less than measurement detection limits. CAP-88 uses dose conversion factors generated by the computer program RADRISK. The 50-year dose commitment conversion factors from RADRISK were compared with the ICRP/DOE dose conversion factors and found to agree to within 5%. This agreement was judged more than adequate to justify RADRISK dose factors when CAP-88 is being used.

b. External Radiation. Environmental thermoluminescent dosimeter (TLD) measurements are used to estimate external radiation doses.

The TLD measurements are corrected for background to determine the contribution to the external radiation field from Laboratory operations. Background estimates at each site, which are based on historical data, consideration of possible nonbackground contributions, and, if possible, values measured at locations of similar geology and topography, are subtracted from each measured value. This net dose is assumed to represent the dose from Laboratory activities that would be received by an individual who spent 100% of his or her time during an entire year at the monitoring location.

The individual dose is estimated from these measurements by taking into account occupancy and shielding. At off-site locations where residences are present, an occupancy factor of 1.0 is used. Two types of shielding are considered: (1) shielding by buildings and (2) self-shielding. Each shielding type is estimated to reduce the external radiation dose by 30%.

Neutron doses from the critical assemblies at TA-18 were based on field measurements. Neutron fields were monitored principally with TLDs placed in cadmium-hooded, 23 cm (9 in.) polyethylene spheres. At on-site locations at which above background doses were measured, but at which public access is limited, dose estimates are based on a more realistic estimate of exposure time.

c. Inhalation Dose. Annual average air concentrations of H^3, total uranium, ^{238}Pu, $^{239,240}Pu$, and ^{241}Am, determined by the Laboratory's air monitoring network, are corrected for background by subtracting the average concentrations measured at regional stations. These net concentrations are then multiplied by a standard breathing rate of 8,400 m^3/yr (ICRP 1975) to determine total adjusted intake via inhalation, in microcuries per year, for each radionuclide. Each intake is multiplied by appropriate dose conversion factors to convert radionuclide intake into 50-year dose commitments. Following ICRP methods, doses are calculated for all organs that contribute more than 10% of the total effective dose equivalent for each radionuclide. The dose calculated for inhalation of H^3 is increased by 50% to account for absorption through the skin.

This procedure for dose calculation conservatively assumes that a hypothetical individual is exposed to the measured air concentration continuously throughout the entire year (8,760 hours). This assumption is made for the boundary dose, dose to the maximum exposed individual, and dose to the population living within 80 km of the site.

Organ doses and effective dose equivalent are determined at all sampling sites for each radionuclide. A final calculation estimates the total inhalation organ doses and effective dose equivalent by summing over all radionuclides.

d. Ingestion Dose. Results from foodstuffs sampling are used to calculate organ doses and effective dose equivalents from ingestion for individual members of the public. The procedure is similar to that used in the previous section. Corrections for background are made by subtracting the average concentrations from sampling stations not affected by Laboratory operations. The radionuclide concentration in a particular foodstuff is multiplied by the annual consumption rate (NRC 1977) to obtain total adjusted intake of that radionuclide. Multiplication of the adjusted intake by the radionuclide's ingestion dose conversion factor for a particular organ gives the estimated dose to the organ. Similarly, effective dose equivalent is calculated using the effective dose equivalent conversion factor (Table D-18).

Doses are evaluated for ingestion of H^3, ^{90}Sr, ^{137}Cs, total uranium, ^{238}Pu, and $^{239,240}Pu$ in fruits and

vegetables; H^3, ^7Be, ^{22}Na, ^{54}Mn, ^{57}Co, ^{83}Rb, ^{134}Cs, ^{137}Cs, and total uranium in honey; and ^{90}Sr, ^{137}Cs, total uranium, ^{238}Pu, and $^{239,240}Pu$ in fish.

3. Estimation of Radiation Doses.

a. Doses from Natural Background. Effective dose equivalents from natural background and from medical and dental uses of radiation are estimated to provide a comparison with doses resulting from Laboratory operations. Doses from global fallout are only a small fraction of total background doses (<0.3%, NCRP 1987a) and are not considered further here. Exposure to natural background radiation results principally in whole-body doses and in localized doses to the lung and other organs. These doses are divided into those resulting from exposure to radon and its decay products that mainly affect the lung and those from nonradon sources that mainly affect the whole body.

Estimates of background radiation are based on a comprehensive report by the National Council on Radiation Protection and Measurements (NCRP 1987b). The 1987 NCRP report uses 20% shielding by structures for high-energy cosmic radiation and 30% self-shielding by the body for terrestrial radiation.

Whole-body external dose is incurred from exposure to cosmic rays and to external terrestrial radiation from naturally occurring radioactivity in the earth's surface and from global fallout. Effective dose equivalents from internal radiation are due to radionuclides deposited in the body through inhalation or ingestion.

Nonradon effective dose equivalents from background radiation vary each year depending on factors such as snow cover and the solar cycle (NCRP 1975b). Estimates of background radiation in 1991 from nonradon sources are based on measured external radiation background levels of 119 mrem (1.19 mSv) in Los Alamos and 117 mrem (1.17 mSv) in White Rock caused by irradiation from charged particles, x-rays, and gamma rays. These uncorrected measured doses were adjusted for shielding by reducing the cosmic ray component (60 mrem [0.6 mSv] at Los Alamos and 52 mrem [0.52 mSv] at White Rock) by 20% to allow for shielding by structures and by reducing the terrestrial component (59 mrem [0.59 mSv] at Los Alamos and 65 mrem [0.65 mSv] at White Rock) by 30% to allow for self-shielding by the body (NCRP 1987a). To these estimates, based on measurements, were added 10 mrem (0.1 mSv) at Los Alamos and 8 mrem (0.08 mSv) at White Rock from neutron cosmic radiation (20% shielding assumed) and 40 mrem (0.4 mSv) from internal radiation (NCRP 1987a). The estimated whole body dose from background, nonradon radiation is 139 mrem (1.39 mSv) at Los Alamos and 135 mrem (1.35 mSv at White Rock.

In addition to these nonradon doses, a second component of background radiation is dose to the lung from inhalation of ^{222}Rn and its decay products. The ^{222}Rn is produced by decay of ^{226}Ra, a member of the uranium series, which is naturally present in construction materials in buildings and in the underlying soil. The effective dose equivalent from exposure to background ^{222}Rn and its decay products is taken to be equal to the national average, 200 mrem/yr (2 mSv/yr) (NCRP 1987a). This background estimate may be revised if a nationwide study of background levels of ^{222}Rn and its decay products in homes is undertaken, as recommended by the NCRP (1984, 1987a).

The total effective dose equivalent to residents is 339 mrem/yr (3.39 mSv/yr) at Los Alamos and 335 mrem (3.35 mSv) at White Rock (Table V-4), or 139 mrem/yr (1.39 mSv/yr) from nonradon sources and 200 mrem/yr (2 mSv/yr) from radon at Los Alamos and 135 mrem/yr (1.35 mSv/yr) from nonradon sources and 200 mrem/yr (2 mSv/yr) from radon at White Rock.

Medical and dental radiation in the United States accounts for an average effective dose equivalent, per person, of 53 mrem/yr (0.53 mSv/yr) (NCRP 1987a). This estimate includes doses from both x-rays and radiopharmaceuticals.

b. Doses to Individuals from External Penetrating Radiation from Airborne Emissions. The major source of external penetrating radiation from LANL operations has been airborne emissions from LAMPF. Nuclear reactions with air in the target areas at LAMPF (TA-53) cause the formation of air activation products, principally ^{11}C, ^{13}N, ^{14}O, and ^{15}O. These isotopes are all positron emitters and have 20.4-minute, 10-minute, 71-second, and 122-second half-lives, respectively. Neutron reactions with air at the Omega West Reactor (TA-2) and LAMPF also form ^{41}Ar, which has a 1.8-hour half-life.

The radioisotopes ^{11}C, ^{13}N, ^{14}O, and ^{15}O are sources of photon radiation because of the formation of two 0.511-MeV (million-electron-volt) photons through positron-electron annihilation. The ^{14}O also emits a 2.3-MeV gamma with 99% yield. The ^{41}Ar emits a 1.29-MeV gamma with 99% yield.

Table V-4. Summary of Annual Effective Dose Equivalents Attributable to 1991 Laboratory Operations

	Maximum Dose to an Individual[a]	Average Dose to Nearby Residents		Collective Dose to Population within 80 km of the Laboratory
		Los Alamos	White Rock	
Dose	4.4 mrem	0.05 mrem	0.03 mrem	1.1 person-rem
Location	Residence north of TA-53	Los Alamos	White Rock	Area within 80 km of Laboratory
DOE Public Dose Limit	100 mrem	100 mrem	100 mrem	—
Percentage of Public Dose Limit	4.4%	0.05%	0.03%	—
Background	339 mrem	339 mrem	335 mrem	71,000 person-rem
Percentage of Background	1%	0.02%	0.01%	0.002%

[a]Maximum individual dose is the dose to any individual at or outside the Laboratory where the highest dose rate occurs. Calculations take into account occupancy (the fraction of time a person is actually at that location), self-shielding, and shielding by buildings.

This dose is routinely monitored with a special TLD network in the off-site location which receives the maximum dose from LAMPF operations. During the past 5 years, this annual dose has varied between 11 mrem in 1986 to 3.1 mrem in 1990.

LAMPF airborne emissions in 1991 were 48% of the emissions in 1990. This reduction occurred primarily because of the shorter LAMPF operating schedule in 1991. As a result, the measured off-site dose during 1991 was less than the 3 mrem/yr (0.03 mSv/yr) detection limit of the LAMPF monitoring network. The maximum off-site dose was estimated using the computer model AIRDOS (CAP-88 version), which uses measured stack emissions and meteorological data to calculate off-site air concentrations and radiation doses, rather than environmental measurements. The computer model has been found in the past (see below) to slightly overestimate the dose at Los Alamos sites, principally because of the increased atmospheric mixing at Los Alamos compared to the relatively flat terrain where the model was developed. The maximum off-site effective dose from external penetrating radiation LAMPF emissions was calculated by AIRDOS to be 3.8 mrem (0.038 mSv) during 1991. This dose is 38% of the EPA's air pathway standard of 10 mrem/yr (0.1 mSv/yr), and 3.8% of the DOE's PDL of 100 mrem/yr (1 mSv/yr).

Over the past five years, the maximum annual dose calculated by AIRDOS has averaged 9.9 mrem (0.099 mSv), whereas the measured dose has averaged 6.1 mrem (0.061mSv) during the same time period. Using these averages to scale the 3.8 mrem (0.038 mSv) calculated dose to estimate what the measured dose would be yields 2.4 mrem (0.024 mSv), which is below the TLD detection limit.

c. Doses to Individuals from Direct Penetrating Radiation. No direct penetrating radiation from Laboratory operations was detected by TLD monitoring in off-site areas. On-site TLD measurements of external penetrating radiation reflected Laboratory operations and did not represent potential exposure to the public. During previous years, a potential 2- to 4-mrem/yr (0.02-to 0.04-mSv/yr) dose occurred to members of the public using the DOE-controlled road passing by TA-18. This potential dose has not occurred since 1989 because of curtailed operations at TA-18. Several programs at TA-18 restarted limited operations in the summer of 1991, but these did not include the facility with the potential for the 2- to 4-mrem (0.02- to 0.04-mSv) dose.

The on-site TLD station (Station 24, Fig. IV-1) near the northeastern Laboratory boundary recorded an above-background dose of about 139 mrem (1.39 mSv). This dose reflects direct radiation from a localized accumulation of ^{137}Cs on sediments transported from TA-21 before 1964. No one resides near this location at this time.

d. Doses to Individuals from Inhalation of Airborne Emissions. The maximum individual effective doses attributable to inhalation of airborne emissions (Table V-5) are below the EPA air pathway standard of 10 mrem/yr (1 mSv/yr).

Exposure to airborne H^3 (as tritiated water vapor), uranium, ^{238}Pu, $^{239,240}Pu$, and ^{241}Am was determined by measurement. Correction for background was made by assuming that natural radioactivity and worldwide fallout were represented by data from the three regional sampling stations at Española, Pojoaque, and Santa Fe. The highest effective dose equivalent for ^{238}Pu, $^{239,240}Pu$, and ^{241}Am was 0.3 mrem (0.003 mSv), or 0.3% of the DOE's PDL of 100 mrem/yr (1 mSv/yr), and 3% of the EPA's 10 mrem/yr (0.1 mSv/yr) standard for dose from the air pathway at the East Gate Station. Emissions of air activation products from LAMPF resulted in negligible inhalation exposures.

Exposure from all other atmospheric releases of radioactivity (Table V-2) was also evaluated by theoretical calculations of airborne dispersion. All inhalation potential doses from these releases were less than 0.5% of the DOE's PDL of 100 mrem/yr (1 mSv/yr).

e. Doses to Individuals from Treated Effluents. At this time, discharged treated effluents do not flow beyond the Laboratory boundary but are retained in the alluvium of the receiving canyons. These treated effluents are monitored at point of discharge; their behavior in the alluvium of the canyons below outfalls has been studied and is monitored annually (Hakonson 1976a, 1976b; Purtymun 1971, 1974a).

Small quantities of radioactive contaminants transported during periods of heavy runoff have been measured in canyon sediments beyond the Laboratory boundary in Los Alamos Canyon (Fig. II-5). Increased discharge from the Bayo Canyon sanitary sewage treatment plant has resulted in additional flow in Los Alamos Canyon, typically to a location between wells LA-6 and LA-2. Calculations made with radiological

Table V-5. Estimated Maximum Individual 50-Year Dose Commitments from 1991 Airborne Radioactivity[a]

Isotope	Location[b]	Estimated Dose (mrem/yr)	Percentage of Public Dose Limit
H^3	White Rock	0.004	<0.1
^{11}C, ^{13}N, ^{14}O, ^{15}O, ^{41}Ar	East Gate (Station 6)	3.8	3.8%
U, ^{238}Pu, $^{239,240}Pu$, ^{241}Am	East Gate	0.3	0.3%

[a]Estimated maximum individual dose is the dose from Laboratory operations (excluding dose contributions from cosmic, terrestrial, medical diagnostics, and other non-Laboratory sources) to an individual at or outside the Laboratory boundary where the highest dose rate occurs and where a person actually resides. It takes into account shielding and occupancy factors.

[b]See Fig. IV-4 for station locations.

data from Acid-Pueblo and Los Alamos Canyons (ESG 1981) indicate a minor exposure pathway to man from these canyon sediments. Obtaining 50% of an annual consumption of meat from a steer that drinks water from or grazes in lower Los Alamos Canyon could potentially result in a maximum committed effective dose equivalent of 0.8 mrem (0.008 mSv).

f. Doses to Individuals from Ingestion of Foodstuffs. Data from sampling of produce, fish, and honey during 1991 were used to estimate doses received from eating these foodstuffs. All calculated effective dose equivalents are <2% of DOE's 100 mrem/yr standard.

Fruit and vegetable samples were analyzed for six radionuclides (H^3, ^{137}Cs, total uranium, ^{238}Pu, and $^{239,240}Pu$). The maximum committed effective dose equivalent that would result from ingesting one-fourth of a typical annual consumption of fruits and vegetables (160 kg) with averaged radionuclide concentrations from off-site locations was 0.2 mrem (0.002 mSv). This dose, which is based on the samples collected in Los Alamos and White Rock, is 0.2% of the DOE's PDL for protecting members of the public (see Appendix A for standards). The dose calculated from the eight samples (out of the total Los Alamos County samples) collected in the Western Area of Los Alamos was 0.4 mrem (0.004 mSv). This dose was statistically indistinguishable from the dose calculated for all Los Alamos County produce samples.

Fruit from a tree in the area previously occupied by the original Los Alamos laboratory site (TA-1) was found to have elevated levels of tritium and ^{239}Pu. The estimated effective dose from consuming 5 kg (11 lbs) of fruit from this tree is 0.06 mrem, or 0.06% of the DOE's 100 mrem/yr standard. Consuming the entire 23 kg (50 lbs) annual yield from this tree corresponds to 0.3 mrem, or 0.3% of the DOE standard.

Ingestion of produce collected on site is not a significant exposure pathway because of the small amount of edible material, low radionuclide concentrations, and limited access to these foodstuffs.

Produce collected at San Ildefonso Pueblo during 1991 was found to have slightly elevated concentrations of several radionuclides. As discussed in Section IV, the produce samples were collected in an area more than 10 km beyond Laboratory facilities and upstream from the point of past Laboratory discharges into the Rio Grande. As a result, this location is not believed to be impacted by Laboratory operations. The cause of the slightly elevated radionuclide concentrations is not known, but in any case, the resulting radiation dose is low. The effective dose equivalent is calculated to be 1.5 mrem/yr (0.015 mSv/yr), which is 1.5% of the DOE's PDL of 100/mrem/yr (1 mSv/yr).

Fish samples were analyzed for ^{90}Sr, ^{137}Cs, natural uranium, ^{238}Pu, and $^{239,240}Pu$. Radionuclide concentrations in fish from Cochiti Reservoir, the sampling location downstream from the Laboratory, are compared with concentrations in fish taken from Abiquiu Reservoir upstream. The maximum effective dose equivalent to an individual eating 21 kg of fish from

Cochiti Reservoir is 0.04 mrem (0.0004 mSv), which is 0.04% of DOE's 100 mrem/yr standard (DOE 1990a).

Trace amounts of radionuclides were found on site in honey. The maximum effective dose equivalent one would get from eating 5 kg of this honey, if it were made available for consumption, would be 0.08 mrem (0.0008 mSv), which is 0.08% of DOE's 100 mrem/yr standard.

4. Total Maximum Individual Dose to a Member of the Public from 1991 Laboratory Operations.

a. Maximum Individual Dose. The maximum individual effective dose equivalent to a member of the public from 1991 Laboratory operations is estimated to be 4.4 mrem/yr (0.044 mSv/yr). This is the total effective dose equivalent from all pathways. This dose is 4.4% of the DOE's PDL of 100 mrem/yr (1 mSv/yr) effective dose equivalent from all pathways (Table V-4).

The dose occurred at East Gate (the Laboratory boundary northeast of LAMPF) and was primarily due to external penetrating radiation from air activation products released by the LAMPF accelerator. In contrast to previous years, this 1991 dose estimate is based on computer modeling rather than environmental measurements for doses from external radiation from airborne radioactivity. This is because reduced emissions from LAMPF during 1991 resulted in no measurable above-background external radiation dose in off site-areas (see Section V.C.3.b.).

The computer model CAP-88, which is discussed in more detail in the following section, was used to make the dose estimate for external radiation from airborne radioactivity. Doses from other exposure pathways were estimated using environmental monitoring results (see Sections V.C.3.d and V.C.3.f). Doses from liquid releases and direct radiation from LANL facilities did not impact this location. The maximum effective dose for external radiation from airborne emissions was estimated by CAP-88 using all measured releases from LANL facilities (Tables V-1 and V-3) and 1991 meteorological data. The dose estimate took into account shielding by buildings (30% reduction) and occupancy (100% for residences, 25% for businesses).

The average effective dose to residents in Los Alamos townsite attributable to Laboratory operation in 1991 was 0.05 mrem (0.0005 mSv). The corresponding dose to White Rock residents was 0.03 mrem (0.0003 mSv). The doses are approximately 0.05 and 0.03% of DOE's PDL of 100 mrem/yr (1.0 mSv/yr).

b. Estimate of Maximum Individual Dose from Airborne Emissions for Compliance with 40 CFR Part 61, Subpart H. As required by the EPA, compliance with regulation 40 CFR 61, Subpart H must be demonstrated with the CAP-88 version of the computer codes PREPAR2, AIRDOS2, DARTAB2, and RADRISK (EPA 1990b). These codes use measured radionuclide release rates and meteorological information to calculate transport and airborne concentrations of radionuclides released to the atmosphere. The programs estimate radiation exposures from inhalation of radioactive materials; external exposure to the radionuclides present in the atmosphere and deposited on the ground; and ingestion of radionuclides in produce, meat, and dairy products.

Calculations for Laboratory airborne releases use the radionuclide emissions given in Tables V-1 and V-3. Wind speed, wind direction, and stability class are continually measured at meteorology towers located at TA-54, TA-49, TA-6, and East Gate. Emissions were modeled with the wind information most representative of the release point.

To account for shielding by buildings, doses from external penetrating radiation were reduced by 30%, as recommended by the DOE (1988c) and the Nuclear Regulatory Commission (NRC 1977) and based on data in Report 94 of the National Council on Radiation Protection and Measurements (NCRP 1987a) for photon radiation with energies equivalent to those found in terrestrial penetrating radiation.

The maximum individual effective dose equivalent, as determined by CAP-88, was 4.0 mrem (0.040 mSv), corrected to include shielding by buildings (30% reduction) and occupancy. As expected, more than 98% of the maximum individual dose resulted from external exposure to air activation products from LAMPF. The 4.0 mrem (0.040 mSv) maximum dose, which would occur in the area just northeast of LAMPF, is 40% of the EPA's air pathway standard of 10 mrem/yr (0.1 mSv/yr) effective dose equivalent.

5. Collective Dose Equivalents.

The collective effective dose equivalent from 1991 Laboratory operations was evaluated for the area within

80 km of the Laboratory. Over 99% of this dose is expected to have resulted from airborne radioactive

the results of the 1990 Census (USBC 1991). The population dose was calculated for the population residing

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The estimated national average radon effective dose that was given by the NCRP is 200 mrem/yr. The NCRP derived this dose from an estimated national average radon exposure of 0.2 WLM/yr. Because the risk factors are derived in terms of WLM, for the purposes of risk calculation it is more convenient to use the radon exposure of 0.2 WLM/yr than to use the radon dose of 200 mrem/yr. Both the 0.2 WLM/yr and the 200 mrem/yr effective dose, however, correspond to the same radiation exposure.

Risks from radon were estimated using a risk factor of 350×10^{-6}/WLM. This risk factor was taken from the BEIR IV report (BEIR IV 1988).

4. Risk from Natural Background Radiation and Medical and Dental Radiation.

During 1991, persons living in Los Alamos and White Rock received an average effective dose equivalent of 139 mrem (1.39 mSv) and 135 mrem (1.35 mSv), respectively, of nonradon radiation (principally to the whole body) from natural sources (including cosmic, terrestrial, and self-irradiation sources, with allowances for shielding and cosmic neutron exposure). Thus, the added cancer mortality risk attributable to natural, whole-body radiation in 1991 was 1 chance in 16,000 in Los Alamos and 1 chance in 17,000 in White Rock.

Natural background radiation also includes exposure to the lung from ^{222}Rn and its decay products (see above) in addition to exposure to whole-body radiation. This exposure to the lung also carries a chance of cancer mortality because of natural radiation sources that were not included in the estimate for whole-body radiation. For the background effective dose equivalent of 200 mrem/yr (2 mSv/yr), the added risk because of exposure to natural ^{222}Rn and its decay products is 1 chance in 14,000.

The total cancer mortality risk from natural background radiation is 1 chance in 8,000 for Los Alamos and White Rock residents (Table V-7). The additional risk of cancer mortality from exposure to medical and dental radiation is 1 chance in 43,000.

Table V-7. Added Individual Lifetime Cancer Mortality Risks Attributable to 1991 Radiation Exposure

Exposure Source	Incremental Effective Dose Equivalent Used in Risk Estimate (mrem)	Added Risk to an Individual of Cancer Mortality (chance)
Average Exposure from Laboratory Operations		
Los Alamos townsite	0.05	1 in 47,000,000
White Rock area	0.03	1 in 68,000,000
Natural Radiation		
Cosmic, terrestrial, self irradiation, and radon exposure[a]		
Los Alamos	339	1 in 8,000[b]
White Rock	335	1 in 8,000
Medical X Rays (Diagnostic Procedures)		
Average whole-body exposure	53	1 in 43,000

[a]An effective dose equivalent of 200 mrem was used to estimate the risk from inhaling ^{222}Rn and its transformation products.

[b]The risks from natural radiation from nonradon sources were estimated to be 1 chance in 16,000 in Los Alamos and 1 chance in 17,000 for White Rock. The risk of lung cancer from radon exposure was estimated to be 1 chance in 14,000 for both locations. Risk estimates are derived from the NRC BEIR IV and BEIR V reports and the NCRP Report 93 (BEIR IV 1988, BEIR V 1990, NCRP 1987a).

5. Risk from Laboratory Operations.

The risks calculated above 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 1991 Laboratory activities were 0.05 and 0.03 mrem (0.0005 and 0.0003 mSv), respectively. These doses are estimated to add lifetime risks of about 1 chance in 47,000,000 in Los Alamos and 1 chance in 68,000,000 in White Rock to an individual's risk of cancer mortality (Table V-7). These risks are <0.1% of the risk attributed to exposure to natural background radiation or to medical and dental radiation.

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). The Los Alamos incremental risk attributable to Laboratory operations is equivalent to the additional exposure from cosmic rays a person would get from flying in a commercial jet aircraft for 27 minutes at an altitude of 9,100 m (30,000 ft) (NCRP 1987b). The exposure from Laboratory operations to Los Alamos County residents is well within variations in exposure of these people to natural cosmic and terrestrial sources and global fallout. For example, the amount of snow cover and variability of the solar sunspot cycle can explain a 10 mrem (0.1 mSv) difference from year to year (NCRP 1975b).

VI. ENVIRONMENTAL NONRADIOLOGICAL PROGRAM INFORMATION

The Laboratory quantifies and assesses nonradioactive pollutant releases to the environment by calculating and monitoring nonradioactive emissions and effluents, evaluating unplanned releases, and conducting environmental sampling. Air emissions were determined for lead pouring operations, steam and power plants, the asphalt plant, explosives detonation, removal of asbestos, and beryllium operations. All nonradioactive air emissions remained within federal and state limits during 1991. Surface water and groundwaters are monitored to determine the Los Alamos National Laboratory's (LANL's or the Laboratory's) impact on the environment; no observable effects are caused by Laboratory operations. Municipal and industrial water quality met federal and state standards during 1991.

A. Nonradioactive Emissions and Effluents Monitoring

1. Air.

a. 1990 Air Pollutant Emissions Inventory. During 1991, as part of the Environmental Oversight and Monitoring Agreement between the Department of Energy (DOE) and the New Mexico Environment Department (NMED), the Laboratory undertook an intensive effort to create a comprehensive, Laboratory-wide air pollutant emissions inventory based on 1990 chemical usages and operations. The goal of this effort was to update and expand the original emissions inventory prepared in 1987. The original inventory was performed to evaluate emissions under NMED-regulated toxic air pollutants and determine whether source registration under Air Quality Control Regulation (AQCR) 752 was required. The 1990 inventory expanded upon the 1987 work to include criteria pollutants, as well as hazardous air pollutants not currently regulated under AQCR 702 but listed in the Federal Clean Air Act.

During the 1987 survey, the Laboratory identified approximately 500 sources (specific rooms within buildings) in 44 operating groups as having the potential to emit air pollutants. For the 1990 inventory, the Laboratory evaluated approximately 1,100 emissions sources, chemical usages, and air pollutant emissions. Each emission source was described using maximum 1-hour and annual chemical usage estimates based on conservative assumptions about the operation's schedule, usage, disposal, and evaporation. Environmental Protection Agency (EPA)-published air pollutant emission factors found in AP-42: Compilation of Air Pollutant Emission Factors (EPA 1986a) or emission factors provided on the EPA Clearinghouse Inventory of Emission Factors (CHIEF) bulletin board were used to estimate emission rates. For operations containing no emission factor, material balance equations were used. The Laboratory developed an electronic database, the Regulated Air Pollutants System (RAPS), to compile, document, and store final emission estimates. Results of this study will be presented in the "Environmental Surveillance at Los Alamos during 1992" report.

b. Lead Pouring Operations. A lead pouring facility for casting lead is located at Technical Area (TA) 3-38. This facility emits particulate matter containing lead. Both federal and state ambient air quality standards for lead are 1.5 $\mu g/m^3$, averaged over a calendar quarter. Approximately 457 kg (1,000 lb) of lead were poured during 1991. The EPA emissions factors for total suspended particulate (TSP) emissions range from 0.87 lb to 0.04 lb of TSP matter and 0.01 lb of lead per ton of lead poured. There are considerable differences between the two, so both were used to provide a range of possible emissions, as shown in Table VI-1.

Table VI-1. Maximum Lead Emissions from the Lead-Pouring Facility per Quarter in 1991

	Maximum Quarterly Emissions	
Pollutant	**Emissions (lb)**	**Concentrations ($\mu g/m^3$)**
TSP matter	0.02–0.44	0.001–0.03
Lead	0.01	0.0001

The maximum quarterly ambient air quality concentrations for 1991 are also shown in the table. Air dispersion procedures recommended by the EPA (EPA 1986b) were used to estimate these concentrations on the basis of quarterly emissions from the lead pouring facility. Impacts were estimated by assuming that all of the TSP matter was lead. This approach provides a worst-case estimate of ambient lead concentration of 0.03 $\mu g/m^3$, or about 2% of the standard. If the lower lead emission factors for secondary lead processing were used, the estimated air concentrations would be only 0.0001 $\mu g/m^3$, or about 0.005% of the standard.

c. Steam Plants and Power Plant. Fuel consumption and emission estimates for the steam plants located throughout the Laboratory and the TA-3 power plant are reported in Table VI-2. The plants are sources of particulate matter, oxides of nitrogen (NO_x), carbon monoxide, and hydrocarbons. The NO_x emissions from the TA-3 power plant were estimated on the basis of boiler exhaust gas measurements. Exhaust gas measurements also indicated that sulfur oxides (SO_x) in the exhaust gases were below minimum detection levels. EPA emission factors were used in making the other emission estimates (EPA 1986a). The emissions from these plants are low, posing no threat of violating ambient air quality standards. The Western Area steam plant used as a standby plant was not operated during 1991.

d. Asphalt Plant. In addition to the power plant and steam plants at TA-3, Johnson Controls Inc. (JCI) operates an asphalt plant at TA-3. As part of its contract with the Laboratory, JCI provides annual records summarizing operations at the asphalt concrete plant. The records presented in Table VI-3 show 1991 production figures and estimates of emissions. Asphalt production has decreased steadily since 1986 because most of the asphalt used at the Laboratory has been purchased from an outside vendor. Although it is not required to, the plant meets the New Source Performance Standards stack emission limits for asphalt plants.

e. Detonation of Explosives. The Laboratory conducts explosive testing by detonating explosives at Dynamic Testing Division firing sites. The Laboratory maintains monthly shot records, including the type of explosive and weight fired at each mound to tract

Table VI-2. Emissions and Fuel Consumption during 1991 from the Steam Plants and TA-3 Power Plant

Pollutant	TA-3	TA-16	TA-21	Western Area	Total
Emissions (ton/yr)					
Particulate Matter	0.8	0.6	0.2	0.0	1.6
Oxides of Nitrogen	6.9	17.2	5.4	0.0	29.5
Carbon Monoxide	10.2	4.3	1.3	0.0	15.8
Hydrocarbons	0.4	0.7	0.2	0.0	1.3
Fuel Consumption (10^9 Btu/yr)	535	270	84	0	889

Table VI-3. Asphalt Plant Emissions in 1991

Production (ton/yr)	Particulate Matter Emissions (lb/yr)	Sulfur Dioxide Emissions (lb/yr)	Nitrogen Dioxide (lb/yr)	Carbon Monoxide (lb/yr)	Nonmethane Hydrocarbons (lb/yr)	Formaldehyde (lb/yr)
4,147	138	1,210	149	153	116	0.6

emissions from this activity. Emission rates from 1990 operations were included in the 1990 air pollutant emission inventory. Table VI-4 summarizes the explosives detonation conducted at the Laboratory during 1991.

f. Asbestos. During 1991, JCI removed approximately 2,095 lin ft of friable asbestos, including 110 lin ft of potentially radioactively contaminated friable material, from small jobs covered by the annual notification to NMED. Approximately 193 sq ft of friable insulation was removed from vessels and other facility components, and 330 sq ft of nonfriable vinyl-asbestos floor tile was removed. Of the floor tile, approximately 48 sq ft was disposed of as potentially radioactively contaminated material. A total of 1,640 lin ft of friable asbestos material was removed through large jobs.

g. Beryllium. Beryllium machining operations are located in Shop 4 at TA-3-39, in Shop 13 at TA-3-102, the beryllium shop at TA-35-213, and the beryllium processing facility at TA-3-141. Exhaust air from each of these operations passes through air pollution control equipment before exiting from a stack. Source tests have demonstrated that all beryllium operations meet the emission limits established by National Emission Standards for Hazardous Air Pollutants and that emissions are so low that there is negligible impact on ambient air quality.

2. Water.

a. Surface Water and Groundwater Monitoring. Surface waters and groundwaters are sampled and analyzed to monitor dispersion of chemicals from Laboratory operations. Chemical concentrations in water from areas where there has been no direct release of treated effluents show no observable effects caused by Laboratory operations. The chemical quality of surface waters from areas with no effluent release varied with seasonal fluctuations. The quality of off-site water in and downstream from the release areas reflects some impact from Laboratory operations, but these waters are not a source of municipal or industrial water supply. Water in Los Alamos Canyon is used by livestock.

Groundwater resource management and protection at Los Alamos is focused on the main aquifer underlying the region (see Section II.C, Geology-Hydrology). Groundwater resource monitoring routinely documents conditions of the water supply wells and the main aquifer. The long and comprehensive record of data indicates that DOE operations at the Laboratory have not resulted in any contamination of the main aquifer.

b. National Pollutant Discharge Elimination System. The DOE has two National Pollutant Discharge Elimination System (NPDES) permits. One permit covers the effluent discharges for nine sanitary wastewater treatment facilities and 130 industrial outfalls at the Laboratory. A summary of these outfalls is presented in Table D-2. The other permit covers one industrial outfall at the hot dry rock geothermal facility located 50 km (30 mi) west at Fenton Hill. Both permits are issued and enforced by EPA Region 6 in Dallas, Texas. Through a joint federal/state agreement, NMED performs some compliance evaluation inspections and monitoring for EPA.

The NPDES permit for the Laboratory expired on March 1, 1991, and is being administratively continued under 40 CFR 122.6. A revised draft permit was issued to LANL on May 16, 1992.

During 1991, effluent limits were exceeded 3 times out of 297 samples collected from the sanitary wastewater facilities. Effluent limits were exceeded 21 times out of 1,799 samples collected from the industrial outfalls. As shown in Fig. III-2, overall compliance for the sanitary and industrial discharges during 1991 was 99% and 98.8%, respectively. There was no discharge from the industrial outfall at the geothermal facility at Fenton Hill during 1991.

Table VI-4. Estimated Concentrations of Toxic Elements Aerosolized by Dynamic Experiments

Element	1991 Total Usage (kg)	Fraction Aerosolized (%)	Annual Average Concentration ($\mu g/m^3$) (4 km)[a]	Annual Average Concentration ($\mu g/m^3$) (8 km)[a]	Applicable Standard ($\mu g/m^3$)
Beryllium	2.2	2	3.0×10^{-8}	1.2×10^{-8}	0.01[b]
Lead	30.5	100[c]	3.2×10^{-5}	1.3×10^{-8}	1.5[d]
Heavy metals	113.4	100[c]	1.2×10^{-4}	4.7×10^{-5}	10[d]

[a]Distance downwind.

[b]Standard for 30-day average, New Mexico AQCR 201.

[c]No data are available; estimate was done assuming worst-case percentage was aerosolized.

[d]Standard for 3-month average (40 CFR 50.12).

The Environmental Protection Group (EM-8) continued the waste stream identification and characterization program during 1991 in order to verify that each waste stream is properly monitored under the outfall category in which it is permitted. These studies consist of dye testing; interviews with user groups; and coordination with other Laboratory organizations to determine sources, concentrations, and volumes of pollutants that enter waste streams, receive treatment, and are discharged to the environment.

TA-50 Liquid Waste Treatment Plant. In recent years, treated effluents containing constituents regulated by the NPDES permit have been released from the central liquid waste treatment plant at TA-50. Table VI-5 presents information on the quality of that effluent for 1990 and 1991. The total effluent volume increased in 1991 while the constituent levels generally decreased (see Section V.B.2 for information on radioactive constituents released from the plant). Effluents from TA-50 are discharged into the normally dry stream channel in Mortandad Canyon where surface flow has not passed beyond the Laboratory's boundary since the plant began operation in 1963.

c. Safe Drinking Water Act, Municipal and Industrial Water Supplies. This program includes sampling from various points in the Laboratory and County water distribution systems to ensure compliance with the Safe Drinking Water Act (SDWA) (40 CFR 141). The EPA has established maximum contaminant levels for microbiologic, organic, and inorganic constituents in drinking water. These standards have been adopted by the State of New Mexico and are included in the New Mexico Water Supply Regulations (NMEIB 1991). The NMED has been authorized by EPA to administer and enforce federal drinking water regulations and standards in New Mexico.

During 1991, all water samples collected under the SDWA program at Los Alamos were found to be in compliance with the maximum contaminant levels established by regulation. Summaries of the results are presented in Tables III-8, III-9, and III-10. There were no violations or fines levied on the Laboratory's municipal and industrial water supplies during 1991.

Each month during 1991, an average of 46 samples was collected throughout the Laboratory and County water distribution systems to determine the free chlorine residual available for disinfection and the microbiological quality of the distribution systems. During 1991, no coliform bacteria were found. Sixty-five of the microbiological samples (approximately 12%) collected were found to have some noncoliform bacteria present. Although the presence of noncoliform bacteria is not a violation of the SDWA, it does indicate stagnant water or biofilm growth in the distribution lines. A summary of the analytical results is found in Table III-12.

3. Superfund Amendments and Reauthorization Act: Title III Reporting.

The University of California, as operator of the Laboratory, is required to report under Title III Section 313 of SARA if: (1) the Laboratory uses a listed toxic chemical above a specified threshold, and (2) the use of the chemical comes under the Standard Industrial Classification (SIC) Codes 20-39. All research operations at the Laboratory are exempt under other provisions of the regulation. Only pilot plants and specialty chemical production or manufacturing facilities at the Laboratory which fall under (1) above must report their releases.

The only facility of the Laboratory which could be considered to be within SIC codes 20-39 and therefore required to report under Section 313 is TA-55-4, the Plutonium Processing Facility. Reporting the chemical use and emissions for TA-55 has been the Laboratory's decision because of the special materials processing done at the facility. The only regulated chemical used at the Plutonium Processing Facility in amounts greater than the Section 313 reporting thresholds is nitric acid.

The Laboratory submitted the required Section 313 report to EPA in July of 1991. This report covered the releases of nitric acid during 1990. About 24,320 kg (53,500 lb) of nitric acid were used for plutonium processing with releases to the air of approximately 468.7 kg (1,031 lb). Atmospheric releases were calculated using data obtained from a study which measured the air emissions from the facility. All other nitric acid that was not consumed in chemical reactions was completely neutralized during wastewater treatment operations. For this reason only the air releases required reporting for 1990. Data on releases for CY91 will be reported under Section 313 in July 1992.

Table VI-5. Quality of Nonradioactive Effluent Released from the TA-50 Radioactive Liquid Waste Treatment Plant in 1990 and 1991

Nonradioactive Constituents	Mean Concentration (mg/L)	
	1990	1991
Cd[a]	4.3×10^{-4}	3.3×10^{-4}
Ca	241	290
Cl	97	82
Total Cr[a]	2.5×10^{-2}	4.0×10^{-3}
Cu[a]	0.2	0.2
F	11	3.3
Hg[a]	3.6×10^{-4}	1.6×10^{-4}
Mg	6.3	0.2
Na	591	397
Pb[a]	2.1×10^{-2}	7.1×10^{-3}
Zn[a]	0.1	0.08
CN	0.2	0.2
COD[a]	33	29
NO_3-N	297	164
PO_4	0.2	0.9
TDS[b]	2,550	1,810
pH[a]	7.1–7.8	7.16–7.7
Total Effluent Volume	2.11×10^7 Liters	2.19×10^7 Liters

[a]Constituents regulated by NPDES permit.
[b]Total dissolved solids.

4. Toxic Substances Control Act.

The Toxic Substances Control Act (TSCA) (15 U.S.C. *et seq.*) is administered by EPA which has authority to conduct premanufacture reviews of new chemicals prior to their introduction into the marketplace; require testing of chemicals which may present a significant risk to humans and the environment; and require recordkeeping and reporting requirements for new information regarding adverse health and environmental effects associated with chemicals. Because the Laboratory's activities are in the realm of research and development, the PCB regulations (40 CFR 761) have been the Laboratory's main concern under TSCA which governs the manufacture, use, storage, handling, and disposal of PCB equipment and sets standards for PCB spill clean-ups.

Efforts continued toward the replacement, reclassification, and disposal of PCB equipment at the Laboratory. During 1991, the following PCB waste was sent off site for disposal: 25,306 kg (55,673 lb) liquid PCB oil that included 50-499 ppm PCB oil; 4,502 kg (9,904 lb) contaminated debris; 3,114 kg (6,851 lb) contaminated water; 64,621 kg (142,166 lb) from 39 transformers; and 6,622 kg (14,568 lb) from capacitors. In addition, 31,496 kg (69,291 lb) of PCB-contaminated soil, debris, and equipment were disposed of at TA-54, Area G, an EPA-approved area for the disposal of PCB-contaminated solid materials. Of the 31 PCB transformers that have been undergoing the retrofill process, 11 were reclassified to non-PCB status, and most of the rest were reclassified to PCB-contaminated status. DOE Tiger Teams audited and inspected the Laboratory's PCB program in 1991; no other audits or inspections were conducted in 1991. In addition, a program to identify and recall PCB equipment which was loaned to universities and other institutions prior to adoption of PCB regulations was initiated in 1991.

B. Unplanned Releases of Nonradiological Materials

1. Airborne Releases.

No airborne nonradiological unplanned releases were reported during 1991.

2. Liquid Releases.

On September 25, 1991, an underground diesel fuel transfer line broke during start-up of the TA-3 power plant's back-up fuel system. Approximately 100-200 gal. of diesel fuel oil surfaced and were discharged across the ground to a storm water channel where it drained into a tributary to Sandia Canyon. The discharge was immediately reported to EPA and NMED. Corrective actions included shutting down the fuel line immediately upon discovery and cleaning up the diesel fuel. The diesel spill was contained in the water course within minutes using absorbent booms and pillows. Pools of diesel and water were removed using a wet/dry vacuum and absorbents. The contaminated soil was sampled, removed, and disposed of at the Los Alamos County landfill.

During 1991, 56 other releases of nonradioactive liquids occurred at the Laboratory and were reported to the EPA and NMED. The NMED Surface Water Bureau has requested that all liquid releases be reported, regardless of any potential impact on the environment. Each of these discharges was minor in nature and was contained on DOE property. None were found to be of any threat to health or the environment. Sampling and clean-up were completed, as appropriate, to confirm the presence or absence of pollutants and to prevent further migration. Over 60% of these unplanned releases were either potable water or steam condensate originating from the Laboratory's utility systems.

The following is a summary of these 56 unplanned releases:

- 23 releases of potable water which originated from water line breaks and other sources in the Los Alamos water supply system;
- 13 releases of steam condensate originating from condensate return line breaks and other sources in the Laboratory's steam system;
- 11 releases of sanitary sewage (less than 1,000 gal. each) from the Laboratory's wastewater treatment plant collection system;
- 5 unplanned releases of cooling water or chiller water;

- 500-1,000 gal. of storm water and residual oil from fuel storage tanks at TA-60 Sigma Mesa, on November 15, 1991;
- 3 gal. of ethylene glycol at TA-55 PF8, on May 19, 1991;
- residual oil in the parking lot caused a sheen in the storm drain near TA-3-105 on August 1, 1991; and
- foam noted in storm drain near TA-3-105 on August 28, 1991, a result of car washing activities in the area. Less than 1 qt of a detergent and water mixture was released into the storm drain.

EM-8 prepared a generalized Notice of Intent (NOI) to Discharge for the discharge of potable water from the Los Alamos water supply system, including production wells, transmission lines, storage tanks, booster pump stations, and other related facilities. The generalized NOI was submitted to NMED on October 31, 1991. The NOI provides the Laboratory with regulatory coverage for releases of potable water from the water supply system that are not considered hazardous to public health and are not covered under the NPDES permit. EM-8 also prepared a generalized NOI for the release of steam condensate from the Laboratory's steam condensate distribution and condensate return systems.

C. Environmental Sampling for the Nonradioactive Effluent Program

1. Air.

a. Ambient Air Monitoring. The nonradiological monitoring network consists of one criteria pollutant station, nine samplers where beryllium is monitored, one acid precipitation monitoring station, and one visibility monitoring station. For the 1991 toxic air pollutant (TAP) study, five additional monitoring stations were used. Results of the 1991 ambient air monitoring program are described fully in Section IV.C.2. The special air sampling program conducted in 1991 is described below.

b. Toxic Air Pollutant Sampling Program. During January 1991, the Laboratory conducted a short-term, intensive air monitoring program to estimate the impact of chemical emissions on the ambient air environment. Sampling and analysis of indicator chemicals required an innovative and high-sensitivity strategy in order to detect chemicals at very low concentrations in the ambient air, as well as to address the complex terrain and meteorology of the area and potential interferences from Los Alamos community emissions. The indicator chemicals were chosen from a list of more than 600 potential air contaminants regulated by the State of New Mexico. An inventory prepared in 1987 showed that the Laboratory emitted 50 of these regulated air contaminants in amounts greater than 10 lb/yr. Of these 50 compounds, certain compounds were identified as traceable only to Laboratory operations since no other nearby sources of these chemicals were likely to exist (for example, acetone and 2-butanone). Other chemicals were chosen that would be traceable to non-Laboratory sources. For instance, chemicals indicative of automobile emissions were targeted. Overall, 20 organic vapors, 6 metals, and 5 inorganic acid vapors were chosen as target compounds. These were measured at five sites around the Laboratory over seven consecutive days in January 1991. Results of this sampling program are summarized in Tables IV-14 through IV-16.

2. Water.

The Laboratory maintains three separate programs which monitor water quality: the surface and groundwater monitoring programs, NPDES compliance, and SDWA compliance.

The first program includes sampling of water supply wells and special monitoring wells under the long-term environmental surveillance program. The samples are collected by EM-8 personnel and are analyzed by the Environmental Chemistry Group (EM-9) laboratory. Routine chemical analyses of water samples have been carried out for many constituents over a number of years. Although surface water and shallow groundwater are not sources of municipal or industrial water supplies, results of these analyses are compared with NMED and EPA drinking water standards (maximum concentration levels). The chemical quality of surface waters is compared to N.M. Livestock and Wildlife Watering Standards. The results of these programs are reported for nonradioactive constituents in Sections IV.D and VII of this report. A detailed description of procedures for sampling surface water and groundwater is presented in Section VIII.C.3.

Under the Laboratory's existing NPDES permit for Los Alamos, samples are collected on a weekly basis and analyzed for those chemicals listed in the permit. Results are reported each month to the EPA and NMED. See Section VIII.C.3 for more information on the NPDES compliance sampling program.

Samples collected by the Laboratory to ensure compliance with SDWA standards are analyzed for organic, inorganic, and radioactive constituents at the New Mexico Health Department's Scientific Laboratory Division (SLD) in Albuquerque. The SLD reports the analytical results directly to NMED. The JCI Environmental Laboratory (JENV) also collects samples throughout the Laboratory and County water distribution systems and tests them for microbiological contamination, as required by the SDWA. The JENV is certified by SLD for microbiological testing of drinking water. See Section VIII.C.3 for more information on the sampling program.

VII. GROUNDWATER PROTECTION MANAGEMENT PROGRAM

Efforts to monitor and protect groundwater quality in the Los Alamos area began in 1949. The long and comprehensive record of data indicates that Department of Energy (DOE) operations at Los Alamos National Laboratory (LANL or the Laboratory) have not resulted in any measurable contamination of the main aquifer. In addition, there has been no significant depletion of the main aquifer groundwater resource.

A. Introduction

Groundwater resource management and protection at the Laboratory are focused on the main aquifer underlying the region (see Section II.C of this report: Geology-Hydrology). The aquifer has been of paramount importance to Los Alamos since the days of the post-World War II Manhattan Engineer District when the Atomic Energy Commission (AEC) needed to develop a reliable water supply. The U.S. Geological Survey (USGS) was extensively involved in overseeing and conducting various studies for development of groundwater supplies starting in 1945–46. Studies specifically aimed at protecting and monitoring groundwater quality were initiated as joint efforts between the AEC, the Los Alamos Scientific Laboratory, and the USGS in about 1949.

The long and comprehensive record of data indicates that DOE operations at the Laboratory have not resulted in any measurable contamination of the main aquifer. The development and production of the water supply have not resulted in any significant depletion of the resource as there is no widespread major decline of the piezometric surface of the aquifer. Drawdowns are localized in the vicinity of the production wells; nearly complete recoveries are observed when wells are shut down for routine maintenance.

The early groundwater management efforts evolved with the growth of the Laboratory's current Groundwater Protection Management Program that addresses environmental monitoring, resource management, aquifer protection, and geohydrologic investigations. Essentially all of the action elements required by DOE Order 5400.1 (DOE 1988a) as part of the Groundwater Protection Management Program have been functioning at the Laboratory for varying lengths of time prior to issuance of the DOE order. Formal documentation for the program, the "Groundwater Protection Management Program Plan," was issued in April 1990. Several hundred reports and articles document studies and data germane to groundwater and the related Los Alamos environmental setting (Bennett 1990).

Groundwater resource monitoring routinely documents conditions of the water supply wells and the hydrologic conditions of the main aquifer as part of the overall Groundwater Protection Management Program. This information is documented in an annual series of reports providing detailed records of pumping and water level measurements. The most recent report in this series is entitled "Water Supply at Los Alamos During 1989" (Stoker 1992).

The groundwater quality monitoring described in this report is the current evolution of the program that was initiated by the USGS for the AEC in 1949. Groundwater quality monitoring addresses the main aquifer at Los Alamos; shallow alluvial groundwaters in canyons; the deeper perched systems in the basalt; the Puye conglomerate beneath parts of Pueblo, Los Alamos, and Sandia Canyons; and special studies on the vadose zone. See Section II.C for a general description of hydrogeological relationships.

Concentrations of radionuclides in environmental water samples from the main aquifer, the alluvial canyon aquifers, and the perched systems, whether

collected within the DOE site boundary or off site, may be evaluated by comparison with derived concentration guides (DCGs) for ingested water calculated from DOE's public dose limits (see Section V.C.2). Concentrations of radioactivity in samples of water from the water supply wells completed in the Los Alamos main aquifer are also compared to New Mexico Environment Department (NMED) and Environmental Protection Agency (EPA) drinking water standards or to the DOE derived concentration guides 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 NMED and EPA drinking water standards (maximum concentration levels [MCLs]), even though these standards are only directly applicable to public water supply. The supply wells in the main aquifer are the source of the Los Alamos public water supply. Although not a source of municipal or industrial water supply, the shallow alluvial groundwaters that result in return flow to surface water and the various springs are used by livestock and wildlife and may be compared to the Livestock and Wildlife Watering Standards established by the New Mexico Water Quality Control Commission (NMWQCC 1991).

B. Monitoring Network

There are three principal groups of groundwater sampling locations: main aquifer, alluvial canyon aquifers, and the localized perched systems. The sampling locations are shown in Fig. VII-1 and referenced by map number in Table D-20.

Water for drinking and industrial use is also obtained from a well at the Laboratory's experimental geothermal site (Fenton Hill, Technical Area [TA] 57) about 45 km (28 mi) west of Los Alamos on Forest Service land. The well is about 133 m (436 ft) deep, completed in volcanics. Information about groundwater and other environmental monitoring at this remote technical area is presented in Section IV.J.5.

1. Main Aquifer.

Sampling locations for the main aquifer include test wells, supply wells, and springs. Seven deep test wells, completed into the main aquifer, are routinely sampled. One of the test wells is off site; the other six are within the Laboratory boundary. The off-site well, Test Well 2, drilled in 1949, is in the middle reach of Pueblo Canyon downstream from the confluence with Acid Canyon on Los Alamos County land. Depth to the top of the main aquifer in 1990 was 241 m (789 ft). Test Well 1, drilled in 1950, is in the lower reach of Pueblo Canyon near the DOE boundary with San Ildefonso Pueblo. Depth to the top of the main aquifer in 1991 was 155 m (507 ft).

Test Well 3, drilled in 1949, is in the midreach of Los Alamos Canyon just upstream from the confluence with DP Canyon. Depth to the top of the main aquifer in 1990 was 236 m (774 ft).

Test Well 8, drilled in 1960, is in the midreach of Mortandad Canyon. Depth to the top of the main aquifer in 1961 was about 295 m (968 ft).

Test Wells DT-5A, DT-9, and DT-10 (all three were drilled in 1960) are at the southern edge of the Laboratory in TA-49. Depths to the top of the main aquifer were 359 m (1.180 ft) in 1960, 332 m (1,090 ft) in 1967, and 306 m (1,006 ft) in 1982. When drilled, no perched water was observed between the surface of the mesa and the top of the main aquifer.

Samples are collected from 16 deep wells in 3 well fields that produce water for the Laboratory and community. The well fields include the Los Alamos and Guaje fields located off site in canyons east of the Laboratory and the on-site Pajarito field.

The Los Alamos Well Field is located on San Ildefonso Pueblo lands east of the Laboratory in Los Alamos Canyon. In 1991, the Los Alamos Well Field had four producing wells, including LA-1B, LA-2, LA-3, and LA-5. Wells LA-1, LA-4, and LA-6 were entirely out of service; their pump houses were demolished in 1990 as the initial steps in phasing out the Los Alamos Well Field. Most of the wells in that field have reached the limit of economically useful production (Purtymun 1988c), and reconstruction of State Road 502, which started in 1991, required discontinuance of the transmission line. The last production of water for the distribution system was in September 1991. Wells in the field range in depth from 265 m to 610 m (870 ft to 2,000 ft). Movement of water in the upper 411 m (1,350 ft) of the main aquifer in this area is eastward at about 6 m/yr (20 ft/yr) (Purtymun 1984).

The Guaje Well Field is located northeast of the Laboratory on U.S. Forest Service lands in Guaje Canyon. The Guaje Well Field contains seven wells, six in production during 1991. Wells in this field

range in depth from 463 m to 610 m (1,520 ft to 2,000 ft). Movement of water in the upper 430 m (1,410 ft) of the aquifer is southeastward at about 11 m/yr (36 ft/yr) (Purtymun 1984).

The Pajarito Well Field is located in Sandia and Pajarito Canyons and on mesa tops between those canyons. The Pajarito Well Field comprises five wells ranging in depth from 701 m to 942 m (2,300 ft to 3,090 ft). Movement of water in the upper 535 m (1,750 ft) of the aquifer is eastward at 29 m/yr (95 ft/yr) (Purtymun 1984).

Two new water supply wells were completed in 1990. These are the first wells in a new field designated as the Otowi Well Field, and the wells were designated Otowi-1 and Otowi-4. No production from these wells occurred in 1991; Otowi-4 is expected to be equipped with a pump and connected to the distribution system during 1992.

Additional wells in the aquifer in the Santa Fe Group sedimentary deposits included five San Ildefonso Pueblo wells located near the Rio Grande. These included two wells that are used for water

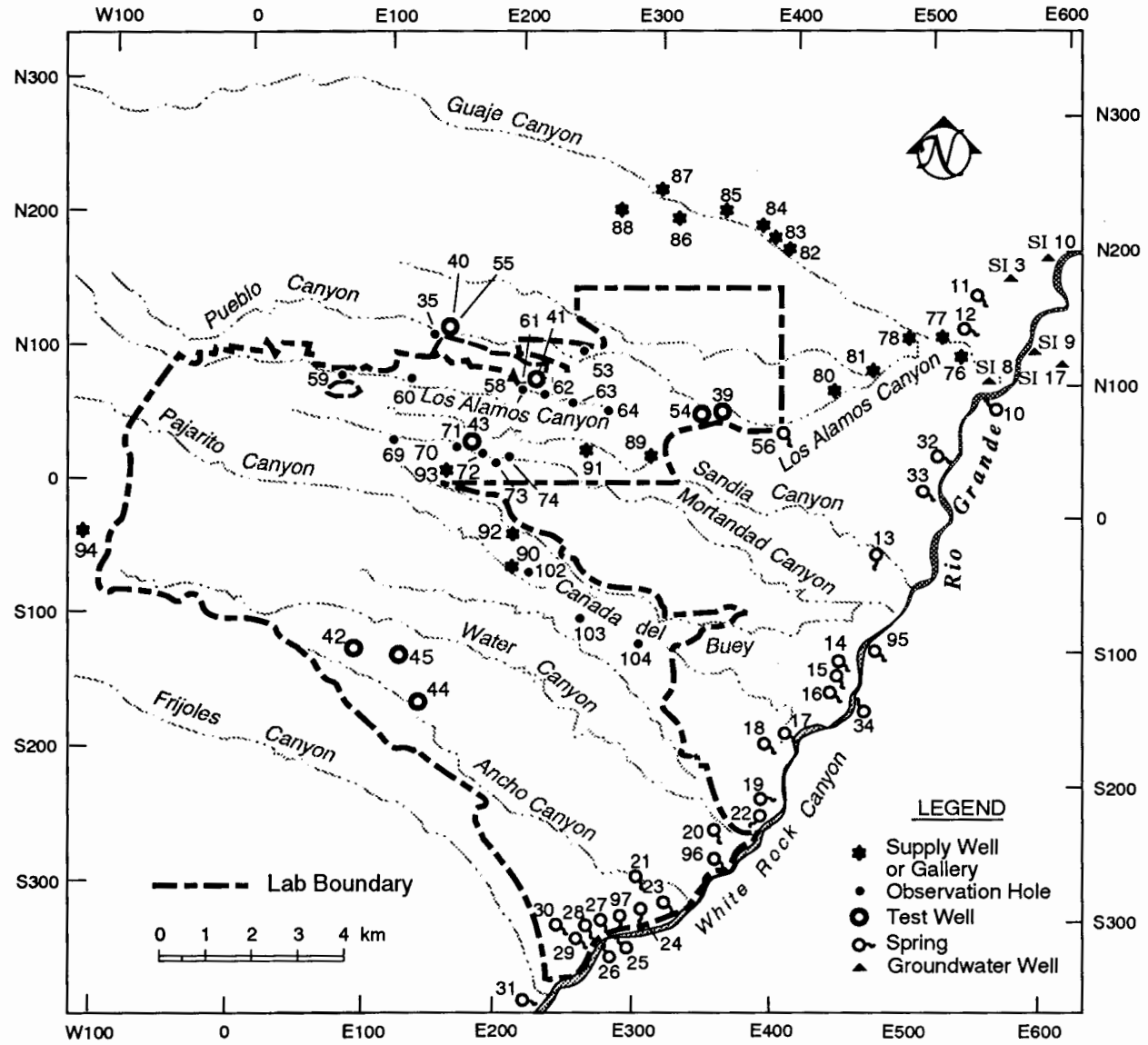

Fig. VII-1. Groundwater sampling locations on and near the Laboratory site.

supply, Pajarito Well (Pump 1) and the Halladay House Well; one that is used for irrigation, Don Juan Playhouse Well; and two artesian wells presently unused, the Eastside and Westside Artesian wells. See Section IV.I.5 for information on the Memorandum of Understanding between DOE, the Bureau of Indian Affairs, and Pueblo de San Ildefonso.

Numerous springs near the Rio Grande are sampled because they are representative of natural discharge from the main aquifer (Purtymun 1980b). See Section II.C. for information on discharge into the Rio Grande. In White Rock Canyon four groups of springs discharge from the main aquifer. Three groups (I, II, and III) have similar, aquifer-related chemical quality. Chemical quality of springs in Group IV reflect local conditions in the aquifer, probably discharging through faults in volcanics. Indian and Sacred Springs are west of the river in lower Los Alamos Canyon. These two springs discharge from faults in the siltstones and sandstones of the Tesuque Formation.

2. Alluvial Canyon Aquifers.

The alluvial canyon aquifers in four canyons are sampled by means of shallow observation wells as part of the routine monitoring program. Three of these canyons are radioactive effluent release areas: Pueblo, Los Alamos, and Mortandad Canyons. The fourth is Pajarito Canyon, immediately south of the existing solid waste management areas in TA-54 on Mesita del Buey. All of the alluvial aquifer sampling locations are on site.

Acid Canyon, a small tributary of Pueblo Canyon, received untreated and treated industrial effluent that contained residual radionuclides from 1944 to 1964 (ESG 1981). Pueblo Canyon currently receives treated sanitary effluent from 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. One sampling point, 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, almost abandoned Los Alamos County Pueblo sewage treatment plant. Further east, at the location of well APCO-1, the alluvium is continuously saturated, mainly because of infiltration of effluent from the Los Alamos County Bayo sanitary sewage treatment plant. At APCO-1, the alluvium is about 3.4 m (11 ft) thick and depth to water is about 1.8 m (6 ft).

The on-site reach of Los Alamos Canyon presently carries inflow from the Los Alamos Reservoir to the west of the Laboratory, as well as National Pollutant Discharge Elimination System (NPDES)-permitted effluents from TA-2, TA-53, and TA-21. In the past, the reservoir received treated and untreated industrial effluents containing some radionuclides. See Section IV.D, Surface Water Monitoring, for more information on historic releases. Infiltration of NPDES-permitted effluents and natural runoff from the stream channel maintains a shallow body of water in the alluvium of Los Alamos Canyon. Water 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 storm runoff is at a minimum. Sampling stations consist of six observation wells completed into the alluvium in Los Alamos Canyon. The wells range in depth from about 6 m to about 9 m (20–30 ft). Depth to water is typically in the range of 1.5 m to 3 m (5–10 ft).

Mortandad Canyon has a small drainage area that also heads at TA-3. Its drainage area presently receives inflow from natural precipitation and a number of NPDES-permitted effluents including those from the current radioactive liquid waste treatment plant at TA-50. See Section IV.D for more information. These infiltrate the stream channel and maintain a saturated zone in the alluvium extending about 3.5 km (2.2 mi) downstream from the TA-50 outfall location. The easternmost extent of saturation is on site, about 1.6 km (1 mi) west of the Laboratory boundary with San Ildefonso Pueblo. The alluvium is less than 1.5 m (5 ft) thick in the upper reach of Mortandad Canyon and thickens to about 23 m (75 ft) 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 (10 ft) thick. There is considerable seasonal variation depending on the amount of runoff experienced in any given year (Stoker 1991). Velocity of water movement in the perched aquifer ranges from 18 m/day (59 ft/day) in the upper reach to about 2 m/day (7 ft/day) in the lower reach of the canyon (Purtymun 1974c, 1983). The top of the main aquifer is about 290 m (950 ft) below the perched aquifer. Monitoring wells that are sampled as part of

the routine monitoring program consist of six observation wells in the shallow alluvial aquifer. These wells range in depth from about 3.7 m to about 21 m (12–69 ft) with depths to water ranging from about 0.9 m to about 14 m (3–45 ft). Additional wells that have been installed in the lower reach of the canyon are dry.

In Pajarito Canyon, water in the alluvium is perched on the underlying tuff and is recharged mainly through snowmelt and thunderstorm runoff and some NPDES-permitted effluents. Three shallow observation wells were constructed in 1985 as part of a compliance agreement with the State of New Mexico to determine if technical areas in the canyon or solid waste disposal activities on the adjacent mesa were affecting the quality of shallow groundwater.

3. Perched Systems.

Perched water systems of limited extent occur in the conglomerates and basalts beneath the alluvium in portions of Pueblo, Los Alamos, and Sandia Canyons. Samples are obtained from two test wells and one spring. Test Well 2A is located in the off-site middle reach of Pueblo Canyon. Test Well 2A (drilled in 1949 to a depth of 40.5 m [133 ft]) penetrates the alluvium and Bandelier Tuff and is completed into the Puye Conglomerate. Aquifer tests indicated that the perched aquifer in the conglomerate is of limited extent. Depth to water was about 27 m (89 ft) in 1990.

Test Well 1A is located in the on-site lower reach of Pueblo Canyon. Test Well 1A (drilled in 1950 to a depth of 69 m [225 ft]) penetrates the alluvium, Puye Conglomerate, and basalt and is completed in basalts. Depth to water was about 53 m (173 ft) in 1991. Perched water in the basaltic rocks is also sampled from Basalt Spring, which is off site in lower Los Alamos Canyon on San Ildefonso Pueblo. Measurements of water levels over a period of time indicate that the perched aquifer is hydrologically connected to the stream in Pueblo Canyon. Perched water in similar stratigraphy was observed during the drilling of water supply wells Otowi-4 in Los Alamos Canyon (depth about 61 to 76 m [200–250 ft]), Otowi-1 in Pueblo Canyon (depth about 69 to 76 m [225–250 ft]), and PM-1 in Sandia Canyon (depth about 137 m [450 ft]).

Some recharge to the perched aquifer in the basalt occurs near Hamilton Bend Spring. The time for water from the recharge area near Hamilton Bend Spring to reach Test Well 1A is estimated to be 1 to 2 months, with another 2 to 3 months required to reach Basalt Spring. Recharge probably also occurs in Los Alamos Canyon.

Some perched water occurs in volcanics on the flanks of the Jemez mountains off site to the west of the Laboratory. This discharges into several springs (Armistead and American Springs) and a significant flow from the Water Canyon gallery in Water Canyon. The gallery contributed to the Los Alamos water supply for 41 years, producing 23 to 96 million gallons annually. Since 1988 it has only been used for makeup water for the steam plant at TA-16, producing about 12 million gallons in 1991.

4. Vadose Zone.

The occurrence and movement of water in unsaturated conditions has been studied in numerous locations within the Laboratory starting with special USGS studies in the 1950s (Purtymun 1990c). Knowledge of vadose zone processes is relevant to understanding the potential for downward movement of water that could constitute recharge to the main aquifer or provide a mechanism for downward migration of contaminants.

In general, the vadose zone studies show that there is consistently low moisture content (less than 10% by volume) in the tuff beneath mesa tops at depths greater than a few tens of feet, the zone affected by seasonal inputs of moisture and evapotranspiration. This carries the implication that very little, if any, recharge from the mesas is able to reach the main aquifer, which is about 305 m (1,000 ft) deep.

The canyons with alluvial aquifers are presumed to represent a greater potential for downward water movement because there is a constant driving force. Since the mid-1980s several investigations have been performed under various Resource Conservation and Recovery Act compliance requirements that have installed monitoring facilities in canyons to further define the occurrence of alluvial water or to help understand the potential for movement of water or contaminants.

In 1985, observation wells were installed in canyons adjacent to the operating solid waste management and disposal areas in TA-54. These included the three in Pajarito Canyon (south of TA-54) already described in

Section B.2 of this chapter, and four in the Cañada del Buey drainage (north of TA-54). Three of the wells were located in a side drainage of the main Cañada del Buey, west and north of Area L and penetrated to 2.4 to 3.7 m (8–12 ft) of dry alluvium. One in the main channel north of the eastern end of Area G penetrated 2.7 m (9 ft) of dry alluvium. These have remained dry on subsequent observation indicating the absence of any saturation in this reach of Cañada del Buey (Devaurs 1985).

In 1989 boreholes or monitoring wells were installed in four canyons to determine whether saturated conditions occurred in the alluvium. Two holes in Sandia Canyon, SCO-1 (near supply well PM-2) drilled to 24 m (79 ft) and SCO-2 (near supply well PM-1) drilled to 9 m (29 ft), penetrated the alluvium without encountering any saturated zone. These were completed as observation holes and have remained dry. One hole in Potrillo Canyon, PCTH-1 (about 0.3 km [1/2 mi] west of State Road 4) was drilled to 23 m (74 ft). It penetrated only dry weathered and unweathered tuff indicating no presence of past water. This hole was plugged. One hole in Fence Canyon, FCO-1 (within 0.2 km [1/4 mi] of State Road 4) was drilled to 9 m (29 ft) and completed as an observation well. It penetrated only dry weathered and unweathered tuff, indicating no past saturation. Three holes in Water Canyon, WCO-1 (about 3.2 km [2 mi] west of State Road 4) drilled 11 m (37 ft), WCO-2 (about 0.6 km [1 mi] west of State Road 4) drilled to 12 m (38 ft), and WCO-3 (within about 0.2 km [1/4 m] of State Road 4) all penetrated the alluvium without encountering saturated conditions. They were all completed as observation wells for future monitoring of potential occurrence of saturation (Purtymun 1990c).

In 1987 nine observation wells were installed in Cañon del Valle adjacent to inactive Waste Disposal Area P in TA-16. These wells, drilled on the toe of the landfill above the channel alluvium, encountered no saturation and showed no evidence of leachate or seepage from the landfill.

C. Analytical Results

1. Radiochemical Constituents.

The results of the radiochemical analyses of groundwater samples for 1991 are listed in Table VII-1. Discussion of the results will address first the main aquifer and second, the alluvial canyon aquifers.

For samples from wells or springs in the main aquifer, all results for ^{3}H, ^{90}Sr, U, ^{238}Pu, $^{239,240}Pu$, and gross beta were below the DOE Derived Concentration Guides or New Mexico Standards that would be applicable to a DOE drinking water system. Most of the results were at or below the detection limits for the analytical methods.

A few samples from wells (TW-1, PM-2, PM-4, TW-2, G-1, and LA-5) and springs (Sandia, SP-4, SP-5A, SP-9, SP-2, and Indian) had plutonium results slightly above method detection limits (up to about a factor of two). Because of inconsistency between the two types of analyses, (i.e., apparent ^{238}Pu without any corresponding $^{239,240}Pu$ or vice versa), the large counting uncertainties in the measurements (often 50% or more of the value) at the low levels near average detection limits, and, in the case of springs, the fact that such samples often must be collected in contact with surface rocks or channel sediments, none of these are believed to represent any indication of contamination in the main aquifer. Two samples from Wells G-4 and G-6 showed apparently measurable ^{239}Pu at levels of 0.669 and 0.4 pCi/L, respectively. Reanalysis of the G-6 sample was below detection limits with a value of 0.008 ± 0.006; however, there was insufficient sample from G-4 for reanalysis. The G-4 result is suspected to have been contaminated during sampling or analysis because there is no corresponding ^{238}Pu, there has never been previous confirmed contamination in the well, and none of the other wells in the field show any contamination.

One gross alpha analysis, for Well LA-1B, is above the limit that would be applicable to a drinking water distribution system. The water from that well (and Wells LA-2 and LA-3) has always contained natural uranium.

Several ^{137}Cs measurements from wells (TW-3, PM-2, PM-3, PM-4, TW-2, G-1, G-1A, G-2, G-5, LA-1B, and LA-3) and springs (SP-5A, SP-7, and SP-1) appear to be above the Derived Concentration Guide applicable to DOE Drinking Water Systems (though they are no more than 14% of the Derived Concentration Guide for Public Dose for Ingestion of Environmental Water). All of these measurements are believed to be suspect because of the large counting uncertainties (generally more than 50% of the result),

Table VII-1. Radiochemical Analyses of Groundwater Samples for 1991

Location	H^3 (nCi/L)	^{90}Sr (pCi/L)	^{137}Cs (pCi/L)	U (µg/L)	^{238}Pu (pCi/L)	$^{239,240}Pu$ (pCi/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Gross Gamma (cpm/L)
MAIN AQUIFER ON SITE									
Test Wells									
Test Well 1	1.1 (0.3)[a]	0.5 (0.6)	−169 (74)	0.0 (0.0)	0.030 (0.013)	0.004 (0.006)	0 (1)	6 (1)	−90.0 (80.0)
Test Well 3	−0.3 (0.3)	N/A[b]	158 (124)	0.8 (0.1)	0.009 (0.015)	0.000 (0.010)	−0 (1)	3 (0)	90.0 (70.0)
Test Well 8	0.0 (0.3)	0.2 (0.6)	−57 (99)	0.0 (0.0)	0.004 (0.004)	0.000 (0.010)	−0 (1)	3 (0)	−220.0 (80.0)
Test Well DT-5A	0.0 (0.3)	3.0 (0.9)	−260 (84)	0.6 (0.5)	−0.008 (0.006)	0.004 (0.007)	2 (1)	2 (0)	−130.0 (80.0)
Test Well DT-9	−0.1 (0.3)	0.7 (0.6)	19 (92)	0.0 (0.0)	−0.004 (0.010)	0.007 (0.010)	1 (1)	3 (0)	−30.0 (80.0)
Test Well DT-10	−0.2 (0.3)	0.9 (0.6)	−90 (76)	0.0 (0.0)	0.000 (0.010)	0.008 (0.006)	1 (1)	3 (0)	−100.0 (80.0)
Water Supply Wells									
Pajarito Well Field									
Well PM-1	N/A	N/A	N/A	2.2 (0.5)	N/A	N/A	N/A	N/A	N/A
Well PM-2	−0.2 (0.3)	N/A	197 (91)	0.7 (0.3)	0.017 (0.017)	0.021 (0.014)	2 (1)	2 (0)	50.0 (70.0)
Well PM-3	−0.2 (0.3)	N/A	431 (138)	1.3 (0.3)	0.005 (0.017)	0.000 (0.010)	3 (1)	4 (1)	140.0 (70.0)
Well PM-4	0.9 (0.3)	N/A	189 (120)	0.9 (0.3)	0.000 (0.010)	0.022 (0.010)	2 (1)	3 (1)	20.0 (70.0)
Well PM-5	N/A	N/A	N/A	0.9 (0.5)	N/A	N/A	N/A	N/A	N/A
MAIN AQUIFER OFF SITE									
Test Wells									
Test Well 2	1.8 (0.3)	N/A	138 (80)	0.4 (0.1)	0.031 (0.018)	0.021 (0.015)	2 (1)	4 (1)	−10.0 (70.0)
Water Supply Wells									
Guaje Well Field									
Well G-1	0.4 (0.3)	N/A	284 (121)	0.9 (0.3)	0.026 (0.014)	0.018 (0.011)	2 (1)	4 (1)	230.0 (80.0)
Well G-1A	0.4 (0.3)	N/A	188 (89)	0.9 (0.3)	−0.008 (0.008)	0.004 (0.009)	2 (1)	4 (1)	160.0 (80.0)
Well G-2	1.1 (0.3)	N/A	118 (117)	1.1 (0.3)	−0.009 (0.009)	−0.004 (0.004)	1 (1)	4 (1)	160.0 (80.0)
Well G-4	0.2 (0.3)	N/A	40 (88)	1.1 (0.3)	0.000 (0.010)	0.669 (0.069)	2 (1)	4 (1)	90.0 (70.0)
Well G-5	0.6 (0.3)	N/A	191 (118)	1.5 (0.3)	0.011 (0.017)	−0.011 (0.008)	2 (1)	3 (1)	180.0 (80.0)
Well G-6	0.0 (0.3)	N/A	−21 (86)	1.0 (0.3)	0.006 (0.009)	0.008 (0.006)	0 (1)	3 (0)	−20.0 (70.0)

Table VII-1 (Cont)

Location	H^3 (nCi/L)	^{90}Sr (pCi/L)	^{137}Cs (pCi/L)	U (µg/L)	^{238}Pu (pCi/L)	$^{239,240}Pu$ (pCi/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Gross Gamma (cpm/L)
Los Alamos Well Field									
Well LA-1B	0.2 (0.3)	N/A	229 (120)	6.0 (0.6)	0.008 (0.012)	0.008 (0.010)	30 (7)	3 (1)	-0.0 (70.0)
Well LA-2	0.1 (0.3)	N/A	40 (92)	6.1 (0.6)	0.000 (0.010)	-0.005 (0.009)	6 (2)	2 (0)	0.0 (70.0)
Well LA-3	0.3 (0.3)	N/A	223 (119)	4.2 (0.4)	0.014 (0.008)	0.019 (0.012)	3 (1)	2 (0)	-10.0 (70.0)
Well LA-5	0.2 (0.3)	N/A	74 (81)	1.0 (0.3)	0.038 (0.014)	0.010 (0.010)	0 (1)	2 (0)	80.0 (70.0)
MAIN AQUIFER SPRINGS									
White Rock Canyon Springs (Perimeter and Off Site)									
Group I									
Sandia Spring	-0.3 (0.3)	0.0 (0.6)	-40 (55)	1.6 (0.5)	0.028 (0.017)	0.004 (0.007)	1 (1)	4 (1)	-380.0 (80.0)
Spring 3	0.0 (0.3)	0.2 (0.6)	132 (66)	1.6 (0.5)	0.008 (0.008)	0.000 (0.010)	3 (1)	6 (1)	-40.0 (70.0)
Spring 3A	-0.3 (0.3)	-0.1 (0.5)	84 (61)	1.2 (0.5)	0.000 (0.010)	-0.008 (0.006)	3 (1)	5 (1)	-60.0 (70.0)
Spring 3AA	0.1 (0.3)	1.0 (0.6)	-4 (64)	2.0 (0.5)	0.004 (0.012)	0.000 (0.010)	1 (1)	5 (1)	-40.0 (70.0)
Spring 4	0.1 (0.3)	0.6 (0.6)	85 (65)	0.9 (0.5)	0.022 (0.015)	0.000 (0.010)	2 (1)	4 (1)	10.0 (70.0)
Spring 4A	0.0 (0.3)	0.0 (0.6)	64 (64)	0.7 (0.5)	0.000 (0.010)	0.008 (0.010)	1 (1)	3 (1)	-40.0 (70.0)
Spring 5	0.0 (0.3)	0.5 (0.6)	-20 (59)	0.5 (0.0)	0.008 (0.010)	0.000 (0.010)	1 (1)	3 (1)	-80.0 (70.0)
Spring 5AA	0.2 (0.3)	0.7 (0.6)	110 (69)	0.5 (0.0)	-0.004 (0.004)	0.008 (0.008)	1 (1)	4 (1)	-110.0 (70.0)
Ancho Spring	-0.1 (0.3)	0.8 (0.7)	-0 (64)	0.5 (0.0)	0.004 (0.013)	0.012 (0.007)	1 (1)	3 (0)	30.0 (70.0)
Group II									
Spring 5A	0.2 (0.3)	0.6 (0.6)	103 (68)	1.9 (0.5)	0.021 (0.011)	0.021 (0.011)	2 (1)	3 (1)	-70.0 (70.0)
Spring 6	-0.1 (0.3)	0.6 (0.6)	-1 (67)	0.5 (0.5)	0.004 (0.006)	0.004 (0.004)	1 (1)	2 (0)	-70.0 (70.0)
Spring 6A	-0.1 (0.3)	0.3 (0.6)	37 (64)	0.5 (0.0)	0.004 (0.010)	0.000 (0.010)	1 (1)	2 (0)	30.0 (70.0)
Spring 7	0.3 (0.3)	0.4 (0.6)	131 (70)	0.5 (0.5)	0.009 (0.007)	0.005 (0.008)	1 (1)	3 (0)	-20.0 (70.0)
Spring 8	0.1 (0.3)	0.4 (0.5)	71 (70)	2.1 (0.5)	0.004 (0.007)	0.000 (0.010)	2 (1)	5 (1)	10.0 (70.0)
Spring 8A	0.1 (0.3)	0.6 (0.6)	35 (60)	0.5 (0.0)	0.012 (0.013)	0.008 (0.011)	2 (1)	3 (0)	-0.0 (70.0)
Spring 9	-0.3 (0.3)	0.4 (0.6)	63 (64)	0.5 (0.0)	0.025 (0.014)	0.000 (0.010)	1 (0)	2 (0)	40.0 (70.0)
Spring 9A	0.1 (0.3)	0.3 (0.6)	65 (65)	0.5 (0.0)	0.004 (0.012)	-0.008 (0.012)	0 (0)	62 (0)	-90.0 (70.0)
Doe Spring	-0.1 (0.3)	0.5 (0.6)	-47 (65)	0.5 (0.0)	0.004 (0.007)	0.004 (0.004)	0 (0)	2 (0)	-70.0 (70.0)

Table VII-1 (Cont)

Location	H^3 (nCi/L)	^{90}Sr (pCi/L)	^{137}Cs (pCi/L)	U (µg/L)	^{238}Pu (pCi/L)	$^{239,240}Pu$ (pCi/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Gross Gamma (cpm/L)
Group III									
Spring 1	-0.1 (0.3)	0.3 (0.6)	142 (63)	3.0 (0.5)	-0.014 (0.008)	0.000 (0.010)	4 (1)	5 (1)	150.0 (70.0)
Spring 2	-0.1 (0.4)	0.8 (0.6)	-77 (57)	3.9 (0.5)	0.042 (0.017)	0.023 (0.012)	2 (1)	3 (1)	-40.0 (70.0)
Group IV									
La Mesita	-0.3 (0.3)	N/A	92 (92)	11.0 (0.6)	0.004 (0.009)	0.004 (0.004)	4 (1)	5 (1)	-100 (70.0)
Spring 3B	0.8 (0.3)	0.7 (0.6)	57 (60)	18.3 (1.8)	0.000 (0.010)	0.004 (0.010)	18 (4)	11 (1)	-30 (70.0)
Other Off-Site Springs									
Sacred Spring	0.7 (0.3)	N/A	57 (115)	1.2 (0.1)	0.009 (0.012)	0.004 (0.007)	3 (1)	4 (1)	-40 (70.0)
Indian Spring	-0.2 (0.3)	N/A	118 (88)	20.2 (1.0)	0.026 (0.017)	0.000 (0.010)	13 (4)	14 (1)	20 (70.0)
ALLUVIAL CANYON AQUIFERS									
Radioactive Effluent Release Areas									
DP-Los Alamos Canyon									
LAO-C	0.1 (0.2)	0.6 (0.6)	258 (127)	1.6 (0.3)	-0.020 (0.024)	0.010 (0.022)	8 (2)	6 (1)	0 (70.0)
LAO-1	6.2 (0.7)	14.0 (1.0)	80 (124)	0.3 (0.0)	-0.028 (0.021)	0.009 (0.016)	4 (1)	28 (3)	100 (70.0)
LAO-2	3.1 (0.4)	42.0 (2.0)	3 (9)	0.3 (0.3)	-0.011 (0.011)	0.021 (0.015)	5 (2)	74 (8)	-00 (70.0)
LAO-3	2.4 (0.4)	55.0 (2.0)	13 (9)	2.2 (0.3)	0.004 (0.011)	0.016 (0.010)	5 (2)	120 (10)	120 (70.0)
LAO-4	3.0 (0.4)	5.6 (0.8)	3 (9)	0.3 (0.0)	-0.005 (0.014)	0.005 (0.009)	3 (1)	20 (2)	160 (70.0)
LAO-4.5	2.3 (0.4)	0.5 (0.6)	234 (113)	0.3 (0.0)	0.008 (0.017)	0.230 (0.044)	3 (1)	8 (1)	50 (70.0)
Mortandad Canyon									
MCO-3	See text for discussion.[c]								
MCO-4	See text for discussion.[c]								
MCO-5	See text for discussion.[c]								
MCO-6.0	See text for discussion.[c]								
MCO-7	See text for discussion.[c]								
MCO-7.5	See text for discussion.[c]								

Table VII-1 (Cont)

Location	H^3 (nCi/L)	^{90}Sr (pCi/L)	^{137}Cs (pCi/L)	U (µg/L)	^{238}Pu (pCi/L)	$^{239,240}Pu$ (pCi/L)	Gross Alpha (pCi/L)	Gross Beta (pCi/L)	Gross Gamma (cpm/L)
Other Areas									
Pajarito Canyon									
PCO-1	0.4 (0.3)	N/A	25 (86)	0.3 (0.3)	0.000 (0.010)	0.024 (0.017)	2 (1)	5 (1)	140.0 (70.0)
PCO-2	0.3 (0.3)	N/A	237 (135)	1.8 (0.3)	–0.011 (0.011)	0.000 (0.010)	3 (1)	6 (1)	70.0 (70.0)
PCO-3	0.8 (0.3)	N/A	140 (87)	0.3 (0.3)	0.026 (0.014)	0.005 (0.009)	6 (3)	7 (1)	60.0 (70.0)
PERCHED SYSTEM CONGLOMERATES AND BASALT									
(Pueblo/Los Alamos/Sandia Canyon Area)									
Test Well 1A	0.2 (0.3)	N/A	56 (92)	0.5 (0.1)	0.000 (0.010)	0.027 (0.018)	1 (1)	7 (1)	100.0 (70.0)
Test Well 2A	0.2 (0.3)	N/A	–10 (124)	0.2 (0.1)	0.000 (0.010)	–0.004 (0.004)	0 (1)	3 (0)	50.0 (70.0)
Basalt Spring	0.2 (0.3)	N/A	2 (9)	0.7 (0.1)	0.000 (0.010)	0.000 (0.010)	4 (2)	10 (1)	80 (70.0)
PERCHED AQUIFER IN VOLCANICS									
Water Canyon Gallery	1.0 (0.3)	N/A	151 (79)	0.4 (0.3)	0.004 (0.011)	0.004 (0.009)	1 (0)	2 (0)	340.0 (80.0)
Limits of Detection[d]	0.4	3	40	1	0.02	0.02	3	3	50
DCG for Public Dose[e]	2000	1000	3000	800	40	60	—	—	—
Drinking Water System	20[f]	8[g]	120[g]	30[g]	1.6[g]	1.2[g]	15[f]	50[f]	—

[a]Radioactivity counting uncertainties (±1 Standard Deviation) are shown in parentheses.

[b]N/A symbol means analysis not performed, lost in analysis, or not completed.

[c]Due to laboratory error in labeling, individual well sample results are not available. Range of results for Mortandad Canyon samples in 1991 were: 4.2 to 40 nCi/L for H^3, nondetectable to 25 pCi/L for ^{90}Sr, 0.004 to 0.907 pCi/L for ^{238}Pu, 0.024 to 2.43 pCi/L for $^{239,240}Pu$, and 0.462 to 45 pCi/L for ^{241}Am.

[d]Limit of valid quantification based on radioactivity counting statistics for analytical method.

[e]DOE Derived Concentration Guide to meet the Public Dose Limit applicable to water ingested, see Appendix A.

[f]Maximum Contaminant Level (MCL), See Appendix A; (NMEIB 1991 and EPA 1989b).

[g]DOE Derived Concentration Guide applicable to DOE Drinking Water System, see Appendix A.

NOTE: See Table IV-43 for radiochemical quality of groundwater from wells, Pueblo de San Ildefonso.

the lack of consistency with the gross gamma results, and the lack of consistency for groups of samples that should have similar characteristics. Accordingly the measurements are not believed to represent any real contamination. The reason for the large uncertainties is that the present counting system and procedure has a detection limit that is about one-third the DOE Derived Concentration Guide that went into effect in 1990. Good measurements would preferably have a detection limit about one-tenth of the Guide. New procedures are to be implemented for 1992 and should permit better discrimination.

The samples from the alluvial aquifer in Los Alamos Canyon show residual contamination as has been seen since the earliest days of operation at Los Alamos. None of the concentrations are above the DOE Derived Concentration Guides for Public Dose for Ingestion of Environmental Water. Tritium; ^{137}Cs; Uranium; ^{238}Pu; $^{239,240}Pu$; and gross alpha, beta, and gamma results are all within the range of values observed in recent years. Measurements of ^{90}Sr serve as a basis for observing future changes.

The Mortandad Canyon water samples (six shallow alluvial groundwaters and one surface water) were analyzed as a single batch, but an apparent error in analytical laboratory labeling resulted in the loss of individual sample identity. Many years of data have shown a consistent distinct decline in concentrations of plutonium (in particular) with distance downstream from the TA-50 liquid waste treatment plant outfall. The analytical results as reported more or less inverted that pattern, which is very unlikely from a physical process standpoint. The range of values in the data set as a group, however, is completely consistent with the ranges of values observed in previous years. Thus, there is no reason to believe that any real change in overall concentrations or physical distribution has occurred. Accordingly, the individual results are not being reported this year. The ranges of values for the principal radioactive analyses were 0.024 to 2.43 pCi/L for $^{239,240}Pu$, 0.004 to 0.907 pCi/L for ^{238}Pu, 4.2 to 40 nCi/L for H^3, 0.462 to 45 pCi/L for ^{241}Am, nondetectable to 1,730 pCi/L for ^{137}Cs, and nondetectable to 25 pCi/L for ^{90}Sr. All stations will be sampled in 1992.

The samples from Test Wells 1A and 2A in the perched zones in Pueblo Canyon were consistent with previous observations. The levels are all at or below limits of detection and indicate no measurable radioactive contamination even though the waters are known to be influenced by contaminated surface water in the canyon based on major inorganic ion measurements.

The sample from the Water Canyon Gallery was consistent with previous results, showing no evidence of contamination from Los Alamos operations.

2. Nonradioactive Constituents.

The results of major general chemical parameter analyses of groundwater samples for 1991 are listed in Table VII-2. The results are consistent with values observed in previous years, showing some expected variability.

Values for all parameters measured in the water supply wells were within drinking water limits with the exception of two pH values. These measurements at Wells G-2 and LA-5 were both 8.6, only slightly above the standard of 8.5; blending of waters in the distribution system results in compliance with standards. Alluvial canyon aquifer waters in the areas receiving effluents show levels of some parameters higher than water supply values as expected.

The results of metal analyses of groundwater samples for 1991 are listed in Table VII-3. The results are generally consistent with values observed in previous years. A few parameters from analyses of samples from the water supply wells were above drinking water limits applicable to the distribution system. Two wells in the Guaje field, G-1 and G-5, exhibited lead levels of 0.049 and 0.095, compared to the limit of 0.05. Neither well has shown excessive lead before; if the values are not due to inadvertent sample contamination and excessive levels appear in the 1992 samples, an attempt will be made to isolate the source. Blending of waters in the distribution system results in overall water system compliance.

Test Wells TW-2, TW-1A, and TW-2A had lead levels slightly above drinking water limits as has been observed previously, probably attributable to the original well construction which included lead swedging in the casings. Iron and manganese levels in several test wells exceed the EPA secondary limit, to be expected because of the steel casings.

Table VII-2. Chemical Quality of Groundwaters (mg/L)[a]

Station	SiO_2	Ca	Mg	K	Na	Cl	F	CO_3	HCO_3	PO^4-P	SO_4	NO_3-N	Cn	TDS[b]	Total Hard-ness	pH[c]	Conduc-tivity (µmho/cm)
MAIN AQUIFER ON SITE																	
Test Wells																	
Test Well 1	40	45	9.3	3.8	16	39	0.4	<2[d]	99	0.2	22	5.3	<0.01	216	150	8.0	366
Test Well 3	82	23	5.9	2.4	15	4	0.5	<2	80	0.3	3	0.6	<0.01	150	82	7.9	170
Test Well 8	11	10	2.5	1.6	12	2	0.3	<1	50	0.1	1	<0.04	<0.01	36	35	8.3	80
Test Well DT-5A	73	8	2.5	1.6	11	1	0.3	<5	49	0.3	1	0.3	<0.01	138	31	7.9	74
Test Well DT-9	11	7	1.9	1.1	9	2	0.3	<2	48	0.1	1	<0.04	<0.01	20	26	8.4	91
Test Well DT-10	11	9	2.4	1.6	12	2	0.3	3	50	0.1	1	<0.04	<0.01	12	34	8.4	92
Water Supply Wells																	
Pajarito Well Field																	
Well PM-1	83	24	6.2	3.6	21	6	0.3	<5	116	0.3	4	0.4	N/A[e]	122	85	8.2	234
Well PM-2	82	13	3.4	2.2	14	2	0.3	<2	50	0.3	2	0.3	<0.01	156	46	8.0	87
Well PM-3	90	32	9.4	4.4	23	8	0.3	<2	112	0.3	5	0.4	<0.01	238	119	7.8	232
Well PM-4	89	17	5.3	2.9	19	3	0.3	<2	62	0.3	3	0.3	<0.01	188	43	7.9	115
Well PM-5	95	9	3.7	1.9	13	2	0.3	<5	65	0.3	2	0.3	N/A	240	39	8.1	91
MAIN AQUIFER OFF SITE																	
Test Wells																	
Test Well 2	17	42	7.7	4.7	28	51	0.2	<2	83	0.4	20	<0.04	<0.01	236	138	8.0	318
Water Supply Wells																	
Guaje Well Field																	
Well G-1	81	18	0.7	3.3	32	<0.5	0.6	<2	75	0.3	<1	0.4	<0.01	198	47	8.5	120
Well G-1A	72	15	0.6	3.0	41	5	0.6	<2	82	0.2	5	0.4	<0.01	196	39	8.5	172
Well G-2	30	17	0.7	3.2	45	3	0.8	<2	90	0.2	4	0.4	<0.01	190	45	8.6	184
Well G-4	58	25	4.1	2.2	18	3	0.4	<2	75	0.2	4	0.6	<0.01	168	80	8.2	149
Well G-5	59	24	4.4	2.3	17	4	0.4	<2	74	0.2	4	0.6	<0.01	144	80	8.3	140
Well G-6	52	21	2.4	2.4	24	3	0.4	<2	69	0.2	4	0.4	<0.01	162	62	8.4	138
Los Alamos Well Field																	
Well LA-1B	39	14	<0.5	3.4	192	21	2.9	11	278	0.2	41	0.5	<0.01	456	35	8.4	652
Well LA-2	33	12	<0.5	1.7	103	21	2.1	<2	132	0.1	16	0.6	<0.01	264	31	8.5	349
Well LA-3	33	20	<0.5	2.2	55	5	0.9	<2	99	0.1	8	0.5	<0.01	164	52	8.5	207
Well LA-5	40	18	<0.5	2.0	34	3	0.5	<2	70	0.1	4	0.4	<0.01	148	46	8.6	128

Table VII-2 (Cont)

Station	SiO_2	Ca	Mg	K	Na	Cl	F	CO_3	HCO_3	PO^4-P	SO_4	NO_3-N	Cn	TDS[b]	Total Hard-ness	pH[c]	Conduc-tivity (µmho/cm)
MAIN AQUIFER SPRINGS																	
White Rock Canyon Springs (Perimeter and Off Site)																	
Group I																	
Sandia Spring	47	43	3.8	3.2	17	4	0.6	<5	143	0.2	4	0.1	<0.01	172	123	8.1	287
Spring 3	52	21	1.8	3.2	16	4	0.5	<5	81	0.2	4	0.8	<0.01	160	61	8.2	141
Spring 3A	53	20	1.8	3.2	15	3	0.5	<5	79	0.2	4	0.7	<0.01	162	57	8.2	161
Spring 3AA	43	19	0.4	3.3	18	3	0.4	<5	82	0.2	3	0.7	<0.01	128	49	7.9	153
Spring 4	55	<0.003	<0.02	0.2	<0.008	7	0.5	<5	85	0.2	9	1.1	<0.01	114	<1	7.6	152
Spring 4A	54	23	4.6	2.7	14	5	0.5	<5	72	0.3	5	0.8	<0.01	186	76	8.1	150
Spring 5	69	21	4.7	2.7	14	4	0.5	<5	74	0.3	4	0.5	<0.01	158	71	7.9	155
Spring 5AA	66	39	7.8	2.9	17	6	0.6	<5	147	0.3	3	<0.04	<0.01	256	129	7.0	296
Ancho Spring	78	14	3.5	2.3	10	2	0.4	<5	62	0.3	2	0.5	<0.07	134	49	7.5	120
Group II																	
Spring 5A	60	19	5.0	2.2	12	5	0.4	<5	97	0.4	7	0.5	<0.01	160	68	8.0	194
Spring 6	76	13	3.9	2.3	11	2	0.4	<5	57	0.3	2	0.4	<0.01	114	48	7.2	115
Spring 6A	79	10	2.8	2.2	10	1	0.3	<5	47	0.3	1	0.4	<0.01	126	37	8.1	89
Spring 7	80	12	3.2	2.6	14	2	0.3	<5	64	0.3	3	0.5	<0.01	154	44	7.2	121
Spring 8	79	22	4.8	3.4	25	4	0.4	<5	100	0.4	10	0.7	<0.01	204	74	6.9	235
Spring 8A	61	11	2.9	2.5	12	2	0.4	<5	59	0.3	1	<0.04	<0.01	170	39	8.4	100
Spring 9	74	11	3.3	1.8	12	2	0.5	<5	61	0.3	2	<0.04	<0.01	148	41	8.0	103
Spring 9A	79	11	3.2	1.8	11	2	0.5	<5	63	0.3	1	0.4	<0.01	168	40	8.0	90
Doe Spring	79	13	3.5	1.8	12	2	0.5	<5	59	0.4	1	0.1	<0.01	64	46	7.9	112
Group III																	
Spring 1	29	24	1.9	3.2	33	4	0.6	<5	110	0.3	7	0.2	<0.01	106	13	8.0	186
Spring 2	42	22	1.3	1.5	66	6	1.4	<5	187	0.2	11	<0.04	<0.01	292	61	8.4	356
Group IV																	
La Mesita	30	49	1.0	3.2	37	8	0.3	<5	117	0.2	18	1.4	0.010	188	128	8.2	281
Spring 3B	47	20	1.9	4.5	121	4	0.7	<5	280	0.7	16	2.4	<0.01	346	57	7.6	592
Other Off-Site Springs																	
Sacred Spring	34	31	0.5	2.7	31	2	0.6	<5	83	0.1	13	1.5	0.010	6	79	7.3	209
Indian Spring	46	109	5.0	7.7	34	14	0.6	<5	129	3.9	19	0.5	0.120	366	294	7.2	488

Table VII-2 (Cont)

Station	SiO_2	Ca	Mg	K	Na	Cl	F	CO_3	HCO_3	PO^4-P	SO_4	NO_3-N	Cn	TDS[b]	Total Hard-ness	pH[c]	Conduc-tivity (µmho/cm)
ALLUVIAL CANYON AQUIFERS																	
Radioactive Effluent Release Areas																	
DP-Los Alamos Canyon																	
LAO-C	36	13	2.5	3.0	28	45	<0.2	<2	38	1.4	4	0.4	<0.01	204	43	7.1	195
LAO-1	39	19	3.2	3.6	59	105	0.5	<2	62	0.3	8	0.1	<0.01	290	62	7.1	369
LAO-2	50	24	4.8	8.9	40	69	0.9	<2	78	0.4	11	0.5	<0.01	264	81	6.9	346
LAO-3	46	23	4.2	8.3	44	70	1.0	<2	74	0.5	11	0.4	<0.01	268	77	6.9	341
LAO-4	39	18	4.7	5.7	43	68	0.8	<2	64	0.2	13	0.0	<0.01	224	65	7.1	312
LAO-4.5	40	18	4.2	7.5	42	77	0.9	<2	5[illegible]	0.2	8	0.1	<0.01	234	63	7.0	305
Mortandad Canyon																	
MCO-3	39	19	3.2	4.2	18	7	0.3	<5	59	0.2	5	4.8	0.017	250	60	7.5	166
MCO-4	46	38	8.6	11.0	130	29	1.4	<5	140	0.5	30	34.7	0.034	500	130	7.0	566
MCO-5	47	35	7.5	11.0	120	31	1.4	<5	111	0.5	31	35.8	0.033	488	118	7.0	748
MCO-6.0	49	39	6.5	8.8	98	23	1.3	<1	<1	0.6	30	28.5	0.011	584	124	2.2	665
MCO-7	46	35	6.1	8.3	95	23	1.7	<1	152	0.6	30	26.0	0.011	444	112	6.9	621
MCO-7.5	45	33	5.7	7.3	94	23	1.2	<5	153	0.6	29	27.0	0.011	446	105	7.1	627
Other Areas																	
Pajarito Canyon																	
PCO-1	35	24	6.3	4.0	25	56	<0.2	<2	59	0.3	11	0.3	<0.01	194	146	6.9	279
PCO-2	30	26	6.8	3.1	22	59	<0.2	<2	58	0.1	15	0.0	<0.01	204	175	6.9	275
PCO-3	43	118	17.2	5.8	66	245	<0.2	<2	81	0.3	151	0.1	<0.01	622	782	6.5	999
PERCHED SYSTEM IN CONGLOMERATES AND BASALT																	
(Pueblo/Los Alamos/Sandia Canyon Area)																	
Test Well 1A	55	34	8.2	9.6	88	60	0.7	<2	157	4.1	29	2.9	<0.01	334	120	8.2	502
Test Well 2A	7	10	1.8	2.7	52	8	0.8	<2	101	0.1	10	<0.04	<0.01	184	33	8.5	210
Basalt Spring	64	26	4.2	12.3	67	45	0.8	<2	121	6.9	34	10.9	0.023	358	82	8.3	489

Table VII-2 (Cont)

Station	SiO_2	Ca	Mg	K	Na	Cl	F	CO_3	HCO_3	PO^4-P	SO_4	NO_3-N	Cn	TDS[b]	Total Hard-ness	pH[c]	Conduc-tivity (µmho/cm)
PERCHED AQUIFER IN VOLCANICS																	
Water Canyon Gallery	38	8	3.1	1.6	7	1	<0.2	<5	37	0.2	2	0.2	<0.01	100	32	7.7	83
Drinking Water System Limit						250[f]	4[g]				250[f]	10[g]		500[f]		6.8-8.5[f]	
Livestock and Wildlife Watering[h]		None in this table															

[a]Except where noted.
[b]Total dissolved solids.
[c]Standard units.
[d]Less than symbol (<) means measurement was below the specified detection limit of the analytical method.
[e]N/A means analysis not performed, lost in analysis, or not completed.
[f]Maximum contaminant level, secondary standard (EPA 1989b), see Appendix A.
[g]Maximum contaminant level, primary standard (NMEIB 1991, EPA 1989b), see Appendix A.
[h]New Mexico Stream Standards for Livestock and Wildlife Watering (NMWQCC 1991), see Appendix A.

Table VII-3. Trace Metals in Groundwaters (mg/L)

Station	Ag	Al	As	B	Be	Cd	Cr	Co	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
MAIN AQUIFER ON SITE																						
Test Wells																						
Test Well 1	<0.001[a]	0.03	0.0026	0.07	<0.0005	<0.0005	0.0012	<0.006	<0.0005	1.80	<0.0002	0.071	<0.003	<0.008	0.022	0.0085	<0.040	<0.03	0.256	<0.0005	0.002	0.691
Test Well 3	<0.0003	<0.03	0.001	0.04	<0.0005	0.0001	0.0029	<0.008	0.003	0.07	0.0002	0.005	0.003	<0.01	0.001	<0.0005	<0.04	0.020	0.076	<0.0001	0.010	0.019
Test Well 8	<0.001	0.04	0.0041	0.10	<0.0005	<0.0005	0.0086	<0.006	0.270	0.40	<0.0002	0.023	<0.003	<0.008	0.036	<0.0005	0.040	<0.03	0.045	<0.0005	0.002	1.100
Test Well DT-5A	<0.001	0.03	0.0037	0.10	<0.0005	0.0005	0.0100	<0.006	0.243	0.33	<0.0002	0.022	0.003	<0.008	0.033	<0.0005	<0.040	<0.03	0.045	<0.0005	0.001	1.050
Test Well DT-9	<0.001	<0.02	0.0038	0.08	<0.0005	<0.0005	0.0018	<0.006	0.155	0.24	<0.0002	0.020	<0.003	<0.008	0.026	0.0006	<0.040	<0.03	0.046	<0.0005	0.001	0.895
Test Well DT-10	<0.001	0.03	0.0039	0.10	<0.0005	0.0006	0.0016	<0.006	0.181	0.33	<0.0002	0.019	<0.003	<0.008	0.028	0.0010	0.040	<0.03	0.044	<0.0005	0.002	1.010
Water Supply Wells																						
Pajarito Well Field																						
Well PM-1	<0.001	<0.02	<0.0005	0.05	<0.0005	<0.0005	0.0055	N/A[b]	0.009	0.01	N/A	<0.001	<0.002	<0.008	0.002	<0.0005	<0.04	N/A	0.136	<0.0005	0.012	0.025
Well PM-2	<0.002	<0.03	<0.0015	<0.01	<0.0015	<0.002	0.0046	<0.008	<0.001	<0.003	0.0002	<0.001	0.001	<0.01	<0.001	<0.0005	<0.04	0.020	0.038	<0.0003	0.007	<0.003
Well PM-3	<0.002	0.12	<0.0015	0.05	<0.0015	<0.002	0.0044	<0.008	<0.001	<0.003	<0.0002	<0.001	<0.001	<0.01	0.002	<0.0005	<0.04	0.020	0.126	<0.0003	0.016	0.008
Well PM-4	<0.002	0.03	0.003	0.01	<0.0015	<0.002	0.0064	<0.008	<0.01	<0.003	0.0002	<0.001	0.001	<0.01	<0.001	<0.0005	<0.04	0.010	0.050	<0.0003	0.012	0.005
Well PM-5	<0.001	<0.02	<0.0005	0.01	<0.0005	<0.0005	0.0098	N/A	0.024	0.00	N/A	<0.001	0.002	<0.008	0.003	<0.0005	<0.04	N/A	0.046	<0.0005	0.008	0.030
MAIN AQUIFER OFF SITE																						
Test Wells																						
Test Well 2	<0.0003	0.04	<0.001	0.16	<0.0005	0.0079	0.0010	<0.008	0.006	1.30	0.0002	0.174	0.003	<0.01	0.053	<0.0005	<0.04	0.010	0.168	<0.0005	0.001	4.280
Water Supply Wells																						
Guaje Well Field																						
Well G-1	<0.002	<0.03	0.005	0.02	<0.0015	<0.002	0.0054	<0.008	0.006	<0.003	<0.0002	<0.001	0.002	<0.01	0.049	<0.0005	<0.04	<0.01	0.095	<0.0003	0.028	0.015
Well G-1A	<0.002	<0.03	0.013	0.03	<0.001	<0.002	0.0077	<0.008	0.002	<0.003	<0.0002	<0.001	0.004	<0.01	0.001	<0.0005	<0.04	<0.01	0.071	<0.0003	0.046	0.012
Well G-2	<0.002	<0.03	0.033	0.04	<0.0015	<0.0015	0.0087	<0.008	0.001	<0.003	<0.0002	<0.001	0.001	<0.01	<0.001	<0.0005	<0.04	<0.01	0.078	<0.0003	0.080	0.007
Well G-4	<0.002	<0.03	0.002	0.02	<0.0015	<0.0015	0.0042	<0.008	0.002	<0.003	<0.0002	0.001	0.001	<0.01	<0.001	<0.0005	<0.04	0.010	0.100	<0.0003	0.019	0.015
Well G-5	<0.002	<0.03	<0.0015	0.02	<0.0015	0.0018	0.0035	<0.008	0.051	<0.003	<0.0002	<0.001	0.001	<0.01	0.095	<0.0005	<0.04	<0.01	0.083	0.0003	0.012	0.022
Well G-6	<0.002	<0.03	0.002	0.02	<0.0015	<0.002	0.0041	<0.008	0.002	<0.003	<0.0002	0.001	0.001	<0.01	0.007	<0.0005	<0.04	<0.01	0.065	<0.0003	0.021	0.010
Los Alamos Field																						
Well LA-1B	<0.002	<0.03	0.0308	0.35	<0.0015	<0.002	0.0255	<0.008	0.0256	<0.003	<0.0002	<0.001	0.0193	<0.01	0.0011	<0.0005	<0.04	<0.01	0.164	<0.0003	0.0482	0.0044
Well LA-2	<0.002	<0.03	0.0098	0.24	<0.0015	0.0037	0.0221	<0.008	<0.001	<0.003	<0.0002	<0.001	0.0119	<0.01	0.0011	<0.0005	<0.04	0.01	0.146	<0.0003	0.0284	0.0137
Well LA-3	<0.002	<0.03	0.0042	0.06	<0.0015	<0.002	0.0085	<0.008	0.0356	<0.003	<0.0002	<0.001	0.0026	<0.01	0.01	<0.0005	<0.04	<0.01	0.191	<0.0003	0.0192	0.0399
Well LA-5	<0.002	<0.03	0.002	0.02	<0.0015	<0.002	0.0048	<0.008	<0.001	<0.003	<0.0002	<0.001	0.0017	<0.01	<0.001	<0.0005	<0.04	0.01	0.16	<0.0003	0.0206	0.0039
MAIN AQUIFER SPRINGS																						
White Rock Canyon Springs (Perimeter and Off Site)																						
Group I																						
Sandia Spring	<0.0005	0.2	0.002	0.03	<0.0005	0.0051	<0.0005	N/A	0.005	0.40	<0.0002	0.155	N/A	0.006	0.001	<0.002	<0.03	N/A	0.426	<0.0005	0.005	0.003
Spring 3	<0.0005	0.02	0.002	0.03	<0.0005	0.0050	0.0057	N/A	<0.005	0.05	<0.0002	0.003	N/A	<0.006	0.001	<0.002	<0.03	N/A	0.227	<0.0005	0.015	0.005
Spring 3A	<0.0005	0.01	0.002	0.03	<0.0005	0.0051	0.0055	N/A	<0.005	0.01	<0.0002	0.001	N/A	<0.006	0.001	<0.002	<0.03	N/A	0.220	<0.0005	0.014	0.002
Spring 3AA	<0.0005	0.08	0.001	0.03	<0.0005	<0.002	0.0044	N/A	0.005	0.12	<0.0002	0.007	N/A	<0.006	0.001	<0.002	<0.03	N/A	0.166	<0.0005	0.017	0.008
Spring 4	<0.0005	<0.008	0.002	0.00	<0.0005	<0.002	0.0055	N/A	<0.005	0.00	<0.0002	<0.0005	N/A	0.830	0.001	<0.002	<0.03	N/A	0.132	<0.0005	0.010	0.003
Spring 4A	<0.0005	0.01	0.001	0.02	<0.0005	0.0138	0.0058	N/A	<0.003	0.02	<0.0002	<0.0005	N/A	<0.006	0.001	<0.002	<0.03	N/A	0.100	<0.0005	0.008	0.042
Spring 5	<0.0005	0.03	0.003	0.03	0.0005	0.0089	0.0058	N/A	<0.006	0.03	<0.0008	0.013	N/A	<0.006	0.001	<.002	<0.03	N/A	0.093	<0.0005	<0.0092	0.005
Spring 5AA	<0.0005	0.02	0.002	0.04	<0.0005	0.0007	<0.0005	N/A	0.003	1.20	<0.0002	0.295	N/A	<0.006	<0.0005	<0.001	<0.03	N/A	0.227	<0.0005	0.001	<0.005
Ancho Spring	<0.0005	0.2	0.001	0.02	<0.0005	<0.0005	0.0033	N/A	0.004	0.11	<0.0002	0.008	N/A	<0.006	0.001	<0.001	<0.03	N/A	0.068	<0.0005	0.008	<0.005

Table VII-3 (Cont)

Station	Ag	Al	As	B	Be	Cd	Cr	Co	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
Group II																						
Spring 5A	<0.0005	0.10	0.002	0.03	<0.0005	<0.0005	0.0206	N/A	0.004	0.14	<0.0002	0.004	N/A	<0.006	0.002	<0.001	<0.03	N/A	0.189	<0.0005	0.014	<0.005
Spring 6	<0.0005	0.02	0.001	0.02	<0.0005	<0.0005	0.0049	N/A	<0.002	0.01	0.0006	0.002	N/A	0.006	0.001	<0.001	<0.03	N/A	0.063	<0.0005	0.008	0.009
Spring 6A	<0.0005	0.03	0.002	0.02	<0.0005	<0.0005	0.0030	N/A	<0.002	0.02	<0.0002	0.001	N/A	<0.006	<0.0005	<0.001	<0.03	N/A	0.049	<0.0005	0.008	<0.005
Spring 7	<0.0005	0.1	0.002	0.02	<0.0005	<0.0005	0.0025	N/A	<0.002	0.07	<0.0002	<0.001	N/A	<0.006	0.001	<0.001	<0.03	N/A	0.086	<0.0005	0.010	<0.005
Spring 8	<0.0005	<0.008	0.003	0.04	<0.0005	0.0006	0.0026	N/A	<0.002	0.01	<0.0002	<0.002	N/A	0.008	0.001	<0.001	<0.03	N/A	0.142	<0.0005	0.014	<0.005
Spring 8A	<0.0005	0.03	0.002	0.01	<0.0005	0.0005	0.0011	N/A	<0.002	0.05	<0.0002	<0.001	N/A	<0.006	<0.0005	<0.001	<0.03	N/A	0.053	<0.0005	0.011	<0.005
Spring 9	<0.0005	0.06	<0.001	0.01	<0.0005	0.0019	0.0024	N/A	<0.002	0.17	<0.0002	0.005	N/A	0.006	0.001	<0.001	<0.03	N/A	0.052	0.0005	0.009	<0.005
Spring 9A	<0.0005	0.02	0.001	0.03	<0.0005	<0.0005	0.0014	N/A	<0.002	0.02	<0.0002	<0.001	N/A	0.010	<0.0005	<0.001	<0.03	N/A	0.050	<0.0005	0.009	0.005
Doe Spring	<0.0005	0.1	0.002	0.02	<0.0005	0.0020	0.1150	N/A	<0.002	0.09	<0.0002	0.022	N/A	<0.006	0.001	<0.001	0.030	N/A	0.056	<0.0005	0.009	<0.005
Group III																						
Spring 1	<0.0005	0.6	0.003	0.05	<0.0005	0.0059	0.0094	N/A	0.024	0.90	<0.0002	0.107	N/A	0.007	0.003	<0.002	<0.03	N/A	0.240	<0.0005	0.020	0.009
Spring 2	<0.0005	0.1	0.022	0.08	<0.0005	0.0061	0.0047	N/A	0.010	0.06	<0.0002	0.006	N/A	<0.006	0.001	<0.002	<0.03	N/A	0.256	<0.0005	0.031	0.006
Group IV																						
La Mesita	<0.0005	0.03	<0.02	0.05	<0.001	<0.005	0.0020	N/A	<0.007	0.06	<0.0002	0.002	<0.006	<0.01	0.000	<0.0005	<0.04	N/A	0.734	<0.0001	0.006	0.006
Spring 3B	<0.0005	0.7	0.011	0.20	<0.0005	<0.002	0.0304	N/A	0.012	1.10	<0.0002	0.013	N/A	0.007	0.002	<0.002	<0.03	N/A	0.220	<0.0005	0.039	0.006
Other Off-Site Springs																						
Sacred Spring	<0.0005	0.1	<0.02	0.04	<0.001	<0.005	0.0050	N/A	<0.007	0.25	<0.0002	0.036	<0.006	<0.01	0.001	<0.0005	<0.04	N/A	0.450	<0.0001	0.014	0.006
Indian Spring	0.001	3.8	0.070	0.08	0.0020	0.0060	0.0260	N/A	<0.007	10.00	<0.0002	1.300	<0.006	<0.01	0.199	<0.0005	0.070	N/A	1.430	0.0012	0.150	6.500
ALLUVIAL CANYON AQUIFERS																						
Radioactive Effluent Release Areas																						
DP-Los Alamos Canyons																						
LAO-C	<0.0003	2.1	0.011	<0.02	0.0017	<0.002	0.0079	<0.003	0.013	35.00	0.0003	2.060	0.003	<0.0200	0.050	0.0010	<0.03	<0.02	0.078	0.0004	0.032	0.048
LAO-1	<0.0001	0.8	0.002	<0.02	0.0004	<0.002	0.0145	<0.003	0.005	0.82	0.0002	0.067	0.156	<0.0200	0.003	<0.0005	<0.03	<0.02	0.103	0.0003	0.006	0.262
LAO-2	<0.0003	0.7	0.002	0.27	0.0003	<0.002	0.0039	<0.003	0.011	0.69	<0.0002	0.101	0.026	<0.0200	0.005	0.0007	<0.03	<0.02	0.129	<0.0003	0.006	0.020
LAO-3	<0.0003	1.4	0.002	0.22	0.0007	<0.002	0.0057	<0.003	0.009	1.00	0.0002	0.192	0.018	<0.0200	0.011	<0.0005	<0.03	<0.02	0.109	0.0004	0.007	0.019
LAO-4	<0.0003	0.3	0.001	0.12	0.0003	0.002	0.0021	<0.003	0.003	0.28	<0.0002	0.013	0.012	<0.0200	0.001	<0.0005	<0.03	<0.02	0.097	<0.0003	0.003	0.014
LAO-4.5	0.0004	0.6	0.001	0.23	0.0004	0.002	0.0058	<0.003	0.021	0.35	<0.0002	0.064	0.002	<0.0200	0.012	<0.0005	<0.03	<0.02	0.092	<0.0003	0.004	0.037
Mortandad Canyon																						
MCO-3	<0.0005	1.0	0.002	0.03	<0.0005	<0.0005	0.0064	<0.03	0.006	0.89	<0.0002	0.044	0.059	<0.01	0.004	0.0016	0.050	<0.04	0.080	<0.0005	0.009	0.032
MCO-4	<0.0005	2.4	0.006	0.11	0.0013	0.0006	0.0122	<0.03	0.051	1.30	<0.0008	0.268	0.010	<0.01	0.016	<0.0005	0.090	<0.04	0.186	0.0005	0.022	0.070
MCO-5	<0.0005	0.2	0.006	0.10	0.0015	<0.0005	0.0122	<0.03	0.037	0.04	0.0009	0.309	0.011	<0.01	0.020	<0.0005	0.080	<0.04	0.190	<0.0007	0.023	0.063
MCO-6.0	<0.0005	3.7	0.005	0.11	0.0012	<0.002	0.0110	<0.03	0.068	3.10	0.0009	0.293	0.015	0.030	0.016	<0.0005	0.070	<0.04	0.145	<0.0005	0.018	0.089
MCO-7	0.001	3.2	0.006	0.11	0.0020	<0.002	0.0184	<0.03	0.041	2.60	0.0019	0.687	0.015	0.030	0.029	0.0021	0.070	<0.04	0.149	<0.0005	0.027	0.078
MCO-7.5	0.001	3.0	0.006	0.10	0.0015	<0.002	0.0177	<0.03	0.025	2.40	0.0010	0.290	0.014	0.030	0.017	0.0005	0.080	<0.04	0.151	<0.0005	0.023	0.058
Other Areas																						
Pajarito Canyon																						
PCO-1	0.005	0.1	0.004	0.04	N/A	0.0018	N/A	<0.008	0.004	9.50	0.0006	2.340	0.002	<0.01	0.002	<0.0005	<0.04	0.020	0.150	<0.0001	N/A	0.020
PCO-2	0.003	1.5	0.003	0.04	N/A	0.0012	N/A	<0.008	0.017	14.00	0.0005	0.707	0.004	0.010	0.032	0.0005	<0.04	0.010	0.181	0.0002	N/A	0.066
PCO-3	0.001	0.2	0.004	0.05	N/A	0.0019	N/A	<0.008	0.008	2.50	0.0003	0.632	0.002	<0.01	0.004	0.0005	<0.04	0.020	0.659	<0.0001	N/A	0.022

Table VII-3 (Cont)

Station	Ag	Al	As	B	Be	Cd	Cr	Co	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Sb	Se	Sn	Sr	Tl	V	Zn
PERCHED SYSTEM IN CONGLOMERATES AND BASALT																						
(Pueblo/Los Alamos/Sandia Canyon)																						
TW-1A	<0.0003	0.04	0.007	0.22	<0.0005	0.0004	0.0016	<0.008	0.047	4.00	0.0002	0.056	0.005	<0.01	0.090	0.1320	<0.04	0.070	0.127	<0.0001	0.005	0.140
TW-2A	<0.0003	0.04	<0.001	0.03	<0.0005	0.0103	0.0064	<0.008	0.055	0.45	0.0002	0.072	0.007	<0.01	0.089	<0.0005	<0.04	<0.01	0.033	0.0001	0.002	0.000
Basalt Spring	0.001	<0.02	0.013	0.27	<0.0005	<0.0003	0.0015	<0.003	0.004	0.12	0.0004	0.017	0.004	<0.02	0.001	0.0004	<0.03	<0.02	0.113	<0.0001	0.018	0.010
PERCHED AQUIFER IN VOLCANICS																						
Water Canyon Gallery	<0.002	0.09	0.0015	<0.01	<0.0015	<0.002	0.0053	<0.008	0.003	0.04	<0.0002	<0.001	<0.001	<0.01	<0.001	<0.0005	<0.04	<0.01	0.042	<0.0003	0.004	0.030
Drinking Water System Limit	0.05[c]		0.05[c]			0.01[c]	0.05[c]		1.0[d]	0.3[d]	0.002[c]	0.05[d]			0.5[c]		0.01[c]					5.0[d]
Livestock and Wildlife Watering Limit[e]		5.0	0.02	5.0		0.05	1.0	1.0	0.5		0.01				0.1		0.05				0.1	25

[a] Less than symbol (<) means measurement was below the specified detection limit of the analytical method.

[b] N/A means analysis not performed, lost in analysis, or not completed.

[c] Maximum contaminant level, primary standard (NMEIB 1991 EPA 1989b), see Appendix A.

[d] Maximum contaminant level, secondary standard (EPA, 1989b), see Appendix A.

[e] New Mexico Stream Standard for Livestock and Wildlife Watering (NMWQCC 1991), see Appendix A.

Samples from some of the springs in White Rock Canyon showed levels of iron and manganese that would exceed drinking water system secondary standards, but are naturally occurring levels generally consistent with those observed previously. One sample, from Doe Spring, showed a level of chromium that exceeded the drinking water system standard; this level is inconsistent with the level seen last year and is suspected of being inadvertent sample contamination. Selenium level in one spring, Indian Spring, exceeds the livestock and wildlife watering limit; however, the analytical detection limit for selenium this year is itself above the standard, and the value is less than twice the detection limit. The source will be sampled again in 1992.

Analyses for organics were performed on some groundwaters this year. The analyses included the volatile, semivolatile, and PCB analyses (see Table D-21 for detailed listings of parameters). None of the analyses detected the presence of any of the compounds. The sources sampled included Water Supply Wells G-1, G-1A, G-2, G-3, G-4, G-5, G-6, PM-2, PM-3, PM-4, LA-1B, LA-2, LA-3, and LA-5; Test Wells TW-1A and TW-2A; Basalt Spring; and the shallow alluvial groundwater observation wells in Los Alamos Canyon (LAO-1 through LAO-4.5) and Mortandad Canyon (MCO-3 through MCO-7.5).

D. Long-Term Trends

1. Main Aquifer.

The long-term trends of the water quality in the main aquifer are simple to summarize: no concentrations of radionuclides above detection limits (other than an occasional analytical statistical outlier) have been measured on water samples from the production wells or test wells that reach the main aquifer. There is no indication that any contamination of the main aquifer has occurred as a result of Laboratory operations.

In 1990 a special large volume sample (approximately 200 L) was collected for analysis of plutonium isotopes by unique extra-low-level mass spectrometric measurement facilities available in the Isotope Geochemistry Group (INC-7) at LANL. The sample was collected from one of the newly drilled production wells, Otowi-4, near the end of the aquifer pumping test in April 1990. The results showed less than 0.00008 pCi/L of ^{239}Pu, with the limit being constrained by the value of the analytical method blanks rather than any inferred actual presence of plutonium. This detection limit is about 1,000 times smaller than levels detected in routine radiochemical methods at LANL, which have a detection limit of about 0.1 pCi/L for ^{239,240}Pu. These results further confirm that operation of the Laboratory over the years has had no measurable effect on the main aquifer.

The long-term trends of water levels in the water supply and test wells in the main aquifer indicate that there is no major depletion of the resource as a result of pumping for the Los Alamos water supply. In the central part of the plateau, water levels in Test Wells 2 and 3 have declined about 1.6 to 12 m (25–40 ft) in slightly more than 50 years or less than a 0.25 m/yr. Test Well 3 is located about 1.6 km (1 mi) from the nearest supply wells (PM-5 and PM-3); Test Well 2 is about 3.0 km (2 m). Nonpumping levels in Supply Well PM-5 have declined about 10 m (32 ft) in 10 years and in PM-3 have declined about 8 m (26 ft) in 26 years. PM-3, the largest producer of all the wells, provided about 220 million gallons a year or 16% of the total water supply in the last several years. Near the southern boundary of the Laboratory, water levels were monitored in Test Well DT-9 from 1960 to 1982, when a pump was installed. The water level declined a total of about 1 m (3 ft) in the 22 years. The initial years of this decline occurred before any of the Pajarito field wells were drilled and must be attributed to a general regional trend unaffected by pumpage. Thus, the decline observed in the test wells to the north and in the pumping wells is probably partly attributable to a general trend in the regional aquifer.

In the Guaje Well Field northeast of the Laboratory, the average 1991 nonpumping water levels in the well field remained about the same when compared to the 1990 water levels. Increased or decreased pumpage in individual wells during the year resulted in slight declines or increases in water levels in that particular well. The overall nonpumping levels have declined an average of about 19 m (62 ft) for the entire field in the past 40 years.

The Los Alamos Well Field will be retired from service after 1991. The production during 1991 was from wells LA-1B, LA-2, LA-3, and LA-5. The production decreased about 62 million gallons from 187 million gallons in 1990 to 125 million gallons in 1991. The well field contributed about 9% of the total 1991

production. From 1952 to 1964 the production was high, varying from 350 million gallons in 1957 to 627 million gallons in 1964 as the Pajarito field was added to the system. The average water level in the field declined about 17 m (61 ft) from 37 m (121 ft) in 1951 to 55 m (182 ft) in 1964. Since 1965 the production from the field has generally decreased. As a result of the reduced pumpage, the water level in the field has recovered. The average water level has recovered about 21 m (68 ft) from 55 m (182 ft) in 1964 to 35 m (114 ft) in 1991. With end of production from the field there should be a general water recovery in the field.

2. Alluvial Canyon Aquifers.

Long-term trends of radionuclide concentrations in shallow alluvial groundwater in Mortandad Canyon (the current radioactive effluent release area for the waste treatment plant at TA-50) are depicted in Fig. VII-2. The samples are from Observation Well MCO-6, in the midreach of the canyon. The combined total of ^{238}Pu and ^{239,240}Pu concentrations (in solution) are relatively constant, fluctuating up and down in response to variations in the treatment plant effluent and storm runoff water that cause some dilution in the shallow alluvial water. The tritium concentration has fluctuated almost in direct response to the average annual concentration of tritium in the TA-50 effluent, with a time lag of about 1 year. Because of the analytical problem discussed in Section VII.C.1 and Table VII-1, the 1991 data are not shown in Fig. VII-2.

E. Special Studies

1. Main Aquifer.

a. Age of the Water. In an effort to better understand the nature of recharge to the main aquifer in the Los Alamos area, a series of special measurements has been initiated on selected water samples. This cooperative effort, involving researchers in the

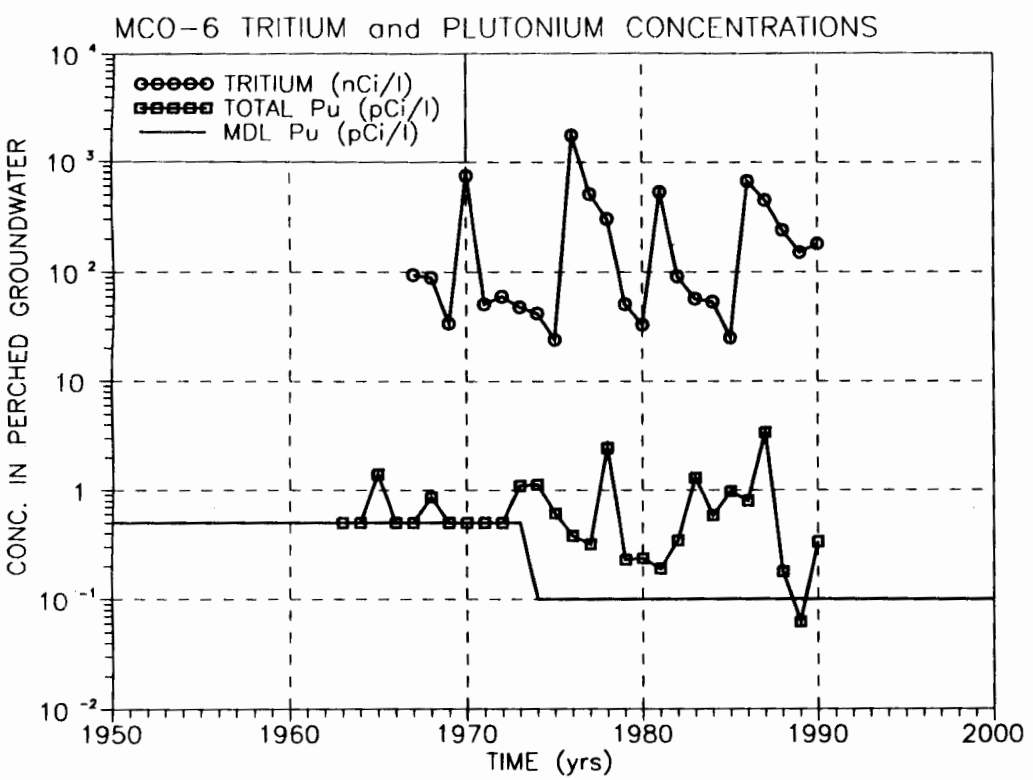

Fig. VII-2. Observation Well, MCO-6 tritium and plutonium concentrations, through 1990. (Graph does not include 1991 data because of analytical problems.)

Laboratory's Earth and Environmental Sciences and Isotope and Nuclear Chemistry Divisions and staff from another DOE installation, is attempting to apply a range of geochemical techniques based on measurements of both radioactive and stable isotopes to help identify specific sources and estimate the age of water in the main aquifer. To date, low-detection limit tritium analyses have been completed on 12 samples from springs in White Rock Canyon and 5 samples from wells into the main aquifer (Goff 1991). These data are summarized in Table VII-4.

The values for tritium in the water range from less than detectable to about 7 pCi/L, with one value about 18 pCi/L. The highest value, for Doe Spring in Chaquehui Canyon, is a sample that must be collected in a pool in the stream channel after it has flowed over a rock face for some distance and thus is subject to mixing with some contemporary precipitation or contamination in the sediments. (See also Section IV.E.3 for information on tritium in sediments in Chaquehui Canyon.) The values are all less than values for tritium in contemporary precipitation (about 30 to 60 pCi/L) and much less than the roughly 700 pCi/L that would be present now in water precipitated in northern New Mexico during the 1962–1963 period when tritium from atmospheric nuclear weapons testing was at its maximum. The conclusion is that there cannot be any significant component of recharge from

Table VII-4. Low-Level Tritium Measurements in Groundwater Samples [a]

Sample Location	Date of Sample	Tritium (as HTO)
Springs in White Rock Canyon		
Spring 2	Oct. 91	4.21 ± (0.36)
Spring 3	Oct. 91	1.65 ± (0.39)
	Sept. 90	3.40 ± (0.29)
Spring 3B	Oct. 91	0.13 ± (0.29)
	Sept. 90	0.91 ± (0.29)
Spring 4A	Oct. 91	2.40 ± (0.39)
Spring 6	Oct. 91	1.78 ± (0.32)
Spring 6A	Oct. 91	0.03 ± (0.29)
	Sept. 90	0.06 ± (0.29)
Spring 7	Oct. 91	2.10 ± (0.29)
	Sept. 90	1.46 ± (0.29)
Spring 8	Oct. 91	7.09 ± (0.55)
	Sept. 90	5.83 ± (0.29)
Spring 8B	Sept. 90	4.66 ± (0.29)
Spring 9A	Oct. 91	1.78 ± (0.29)
Ancho Spring	Oct. 91	4.21 ± (0.36)
	Sept. 90	3.40 ± (0.29)
Doe Spring	Sept. 90	17.71 ± (0.58)
Wells In Main Aquifer		
Well LA-1B	Oct. 91	0.26 ± (0.29)
Well G-5	Oct. 91	0.06 ± (0.29)
Well PM-1	Oct. 91	1.65 ± (0.32)
Well PM-5	Oct. 91	0.29 ± (0.29)
Test Well DT-5A	Oct. 91	-0.23 ± (0.29)

[a]Counting uncertainties are in parenthesis.

water precipitated during the last several decades in the water from the main aquifer. The inference is that the water is considerably older.

Preliminary interpretation of carbon-14 data for samples from the same five deep wells indicates that the water ranges in age from several thousand years to more than 10,000 years (Spangler 1992). It is anticipated that results from all the analyses will be complete in 1992, and a full interpretation will be included in "Environmental Surveillance at Los Alamos during 1992."

b. Potential Communication between Test Well 1 and Test Well 1A. A special study was initiated in 1991 to investigate the potential for communication between two test wells adjacent to each other in lower Pueblo Canyon. Test Wells TW-1 and TW-1A are located in Pueblo Canyon upstream from the Los Alamos Canyon confluence. These wells were drilled by cable tool and completed in 1949 as observation wells (Purtymun 1987a). TW-1A penetrates to a total depth of 68 m (225 ft) below land surface; this entire length is cased and the bottom 3 m (10 ft) is screened in the top of the main aquifer in the Puye Conglomerate. Two separate layers of dense basalt are located between the screened intervals in these two test wells. Between 1951 and 1991, the water levels in TW-1A have fluctuated between about 52 to 64 m (170–210 ft) below land surface. These fluctuations were in response to stream channel percolation losses, which have fluctuated widely during this period in response to variable storm water and snowmelt runoff, evapotranspiration losses, and historic (i.e., prior to 1964) Laboratory effluent releases into Pueblo Canyon.

The water levels in TW-1 have fluctuated between about 178 to 180 m (587–593 ft) below land surface between 1951 and 1966. Since 1966, however, the water levels in TW-1 have risen to approximately 153 m (506 ft) below land surface. The reason for this change is currently under investigation; however, such increases could be associated with either a leaky well casing or natural percolation through the formations surrounding the wellbore.

During late September and early October 1991, TW-1 and TW-1A were tested as follows. A recording pressure transducer was placed in TW-1A to monitor water level fluctuations while TW-1 was pump tested. TW-1 began pumping on September 23, 1991, at a constant rate of 2.35 gpm. Within several hours, the water level in TW-1 had declined by approximately 23 m (75 ft) below its static level. This pumping rate continued for approximately 15 days; however, the drawdown levels in TW-1 gradually approached a constant 24 m (80 ft). During this period, the water levels in TW-1A only responded to atmospheric pressure fluctuations; these TW-1A water level fluctuations were less than 0.3 m (1 ft) and are directly correlated with corresponding atmospheric pressure fluctuations. Eleven water samples were collected from TW-1 during this period for chemical analyses; these data are summarized in Table VII-5. When the pump at TW-1 was turned off, the water level recovered back to previous static levels within 24 hours. TW-1A was then pump tested at approximately 0.5 gpm for several days, and water levels were simultaneously recorded in TW-1. Approximately 2 m (7 ft) of total drawdown were observed in TW-1A during this period; however, no corresponding water level changes were observed in TW-1. Three water samples were collected from TW-1A for laboratory analyses during this second pump test period. Throughout the pump test periods at TW-1 and TW-1A, additional water samples were also collected at TW-2, TW-2A, APCO-1, and Basalt Springs; these data are summarized in Table VII-5.

Major ion water quality data from TW-1 and TW-1A were compared to major ion water quality data from Pueblo Canyon surface waters and shallow alluvial waters (i.e., from Observation Well APCO-1 located near the Pueblo-3 sample station). These analyses suggest that the water quality in TW-1A is practically identical to that in the surface stream (Pueblo-3 surface sample station) and in the shallow alluvium (APCO-1 sample at about 3 to 4 m [10–12 ft] below land surface) as expected. Furthermore, the relative proportions of major ions (i.e., Ca, Mg, Na, K, ^{3}CO, ^{3}HCO, Cl, and ^{4}SO) have not significantly changed over the years. However, the water quality in TW-1, as characterized by major ion concentrations, is distinctly different from TW-1A, APCO-1, or Pueblo-3 samples, as seen in the Stiff pattern diagrams shown in Fig. VII-3. The Stiff patterns for TW-1A, APCO-1, and Pueblo-3 surface waters are very similar because major ion concentrations are similar. It is apparent that TW-1A is in hydraulic communication with surface and near surface waters in Pueblo Canyon as expected. Furthermore, these Stiff pattern similarities have

Table VII-5. Water Quality in Pueblo Canyon Average Water Quality Values (conc in mg/l)[a]

Location	TW-1	TW-1A	TW-2	TW-2A	APCO-1	Basalt Springs
No. of Samples	10	3	3	3	2	2
Analysis						
Ca	45.9	24.7	6.5	33.7	21.5	22.0
K	3.4	6.9	2.0	3.4	12.0	5.0
Mg	9.7	6.9	1.7	7.1	3.7	4.9
Na	16.0	68.0	39.0	22.3	73.0	36.0
HCO^3	99.6	137.3	98.0	83.0	140.5	57.5
CO^3	4.1	5.0	5.0	5.0	5.0	5.0
Cl	40.1	52.8	4.8	47.5	45.1	31.6
NO^3-N	6.1	2.2	0.0	2.3	1.1	7.3
SO^4	23.6	28.3	1.8	22.5	29.9	45.2
PO^4-P	0.2	3.3	0.1	1.4	7.0	11.2
F	0.4	0.6	0.8	0.2	0.7	0.6
SiO^2	46.5	35.0	14.7	47.3	62.5	49.0
TDS	176.6	202.0	55.3	182.0	139.0	215.0
pH[b]	6.7	6.3	6.8	6.8	6.3	7.07
Temperature[c]	15.1	13.0	16.0	14.6	16.6	17.9
Conductivity[d]	268.7	306.0	183.7	166.7	355.0	254.0

[a]Samples collected September 23 to October 10, 1991.
[b]Standard units.
[c]Degrees Celsius.
[d]Units of μmho/cm.

remained relatively constant since at least 1981. The major ion pattern for TW-1 is distinctly different from the other samples and has maintained its current pattern over the past decade. These data suggest that TW-1 is basically isolated from surface and near surface waters in Pueblo Canyon and has been for at least the past decade.

The Stiff diagrams for TW-1 may also be showing subtle changes in water quality over the past decade (note the increases in chloride and sulfate concentrations over time) possibly reflecting slow percolation from the stream channel over decades, or they may be reflecting normal temporal variability. However, current and historical water quality data do not conclusively answer this question.

If TW-1A and TW-1 were in relatively direct hydraulic communication via a leaky wellbore, then one would also expect that rapid water level fluctuations in these wells would be correlated over time. Indeed, one might logically expect these water levels to also be in equilibrium during nonpumping periods. On the other hand, if there is a natural hydraulic communication through the formations separating the respective well screens, then one might expect lower frequency nonpumping water levels to be correlated. If these water levels are not correlated, then one would likely conclude that TW-1A and TW-1 are not in hydraulic communication. In addition, water level fluctuation data should also corroborate findings implied by major ion water quality data. Long-term, high-frequency water level fluctuations must be monitored to answer these questions conclusively. Additional study will be necessary to completely determine the significance of the higher water levels and chemical quality changes in TW-1.

c. Water Production Records. Monthly water production records are provided to the State Engineer's Office under the water rights permit held by the DOE

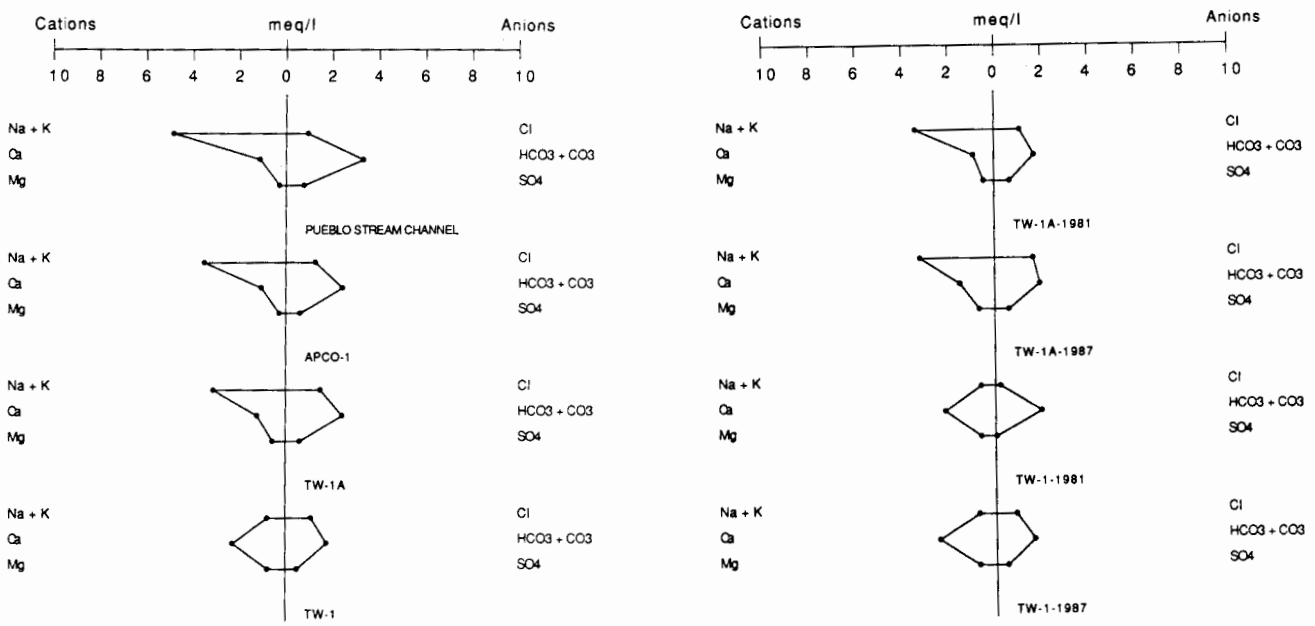

Fig. VII-3. Pueblo Canyon water quality.

for the Los Alamos water system. During 1991, total production from the wells and gallery for potable and nonpotable use was 5.55×10^6 m^3 (4,493 ac-ft). This production amounts to 81% of the total diversion right of 6.8×10^6 m^3 (5,541 ac-ft) that is available to the DOE under its permit. Details of the performance of the water supply wells (pumpage, water levels, drawdown, and specific yield) and their operation are published in a series of separate reports, the most recent of which is "Water Supply at Los Alamos During 1989" (Stoker 1992).

2. Vadose Zone.

A special study, "Extent of Saturation in Mortandad Canyon" (Stoker 1991), provides some important information on the movement of moisture and contaminants in the unsaturated tuff beneath the alluvial aquifer in that canyon. Measurements of moisture content from several core holes that penetrated the saturated portion of the alluvium all exhibited the same pattern. Data from one of the holes (MCM-5.9) are shown in Fig. VII-4 as an example. Most values for gravimetric moisture content in the Tshirege tuff beneath the alluvial aquifer ranged from 10 to 30%, corresponding to about 20 to 60% of saturation. There were one or more peaks at higher values, approaching 90% of saturation near the contact with or in the Tsankawi tuff and the fluvial Cerro Toledo rhyolite deposits on the top of the Otowi member of the tuff, at depths around 30 m (100 ft). In the Otowi tuff, the gravimetric moisture content decreased and leveled off at about 12 to 18%, which corresponds to 20 to 40% of saturation.

A similar pattern occurred in a core hole (SIMO-1) further downstream in Mortandad Canyon on San Ildefonso lands past the end of the alluvial aquifer (EPG 1992). The gravimetric moisture content was somewhat lower in the Tshirege tuff but still with some higher peaks in the vicinity of the Tsankawi, and then gradually increasing in the Otowi tuff to 10 to 20%, which corresponds to about 20 to 40% of saturation.

In other canyons the basic pattern of moisture distribution appears to be repeated. One core hole was drilled in Sandia Canyon south of TA-53 in June 1991 as part of a special investigation regarding potential leakage from the lagoons at TA-53. The hole was located in a side drainage that flows only occasionally

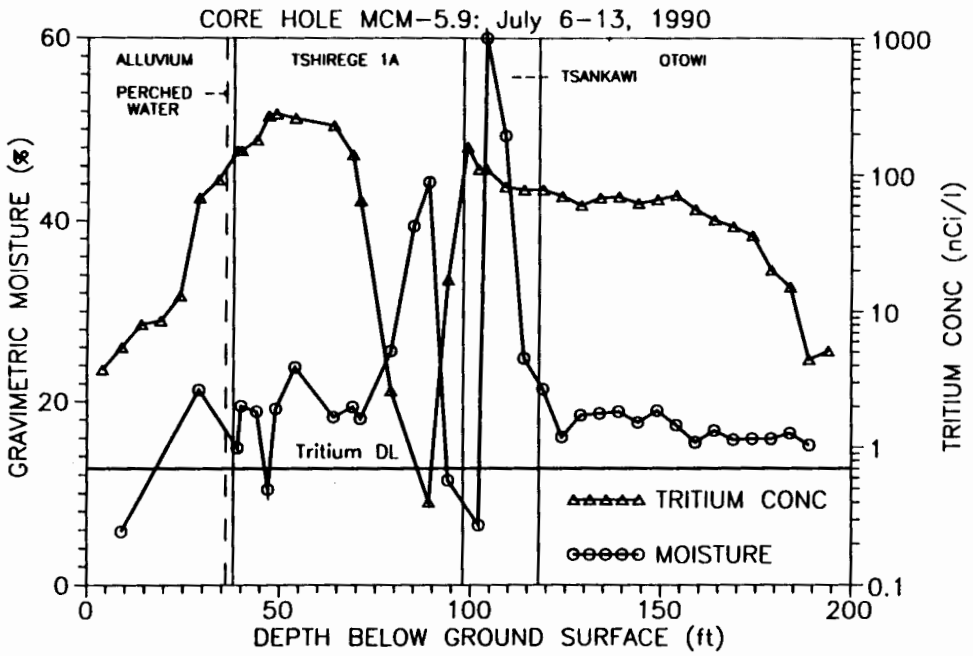

Fig. VII-4. Mortandad Canyon moisture and tritium profiles.

with natural runoff and did not penetrate any saturated zone. Data from that hole are shown in Fig. VII-5. As in Hole SIMO-1, there are peaks of moisture just above and in the Tsankawi, and then gravimetric moisture increases and levels off between 15 and 20%, which corresponds to 25 to 30% of saturation.

A core hole was drilled in Potrillo Canyon in November 1991 as part of a special uranium transport study. The hole was drilled in an area where significant volumes of natural runoff infiltrate during the rainy season but no saturation was encountered. Data from that hole is shown in Fig. VII-6. The gravimetric moisture content in the Tshirege tuff is relatively high, between 15 and 25%. In the Tsankawi the moisture content dips and peaks sharply; once into the Otowi tuff, the moisture content levels off at 10 to 11%.

The data suggest there are some complex variations in hydrologic properties in the layers from the base of the Tshirege through to the top of the Otowi tuff that significantly affect the movement of moisture in the unsaturated zone. These data also indicate that moisture conditions in the Otowi tuff become very uniform with only moderate differences in magnitude depending on whether there are saturated conditions in overlying layers. Additional field data and theoretical interpretation will be required to confirm the patterns and quantify movement.

The basic conclusions of the Mortandad study regarding the movement of radioactive contaminants below the alluvial aquifer are (1) soluble or particulate radioactive constituents have moved less than about 3 m (10 ft) into the unsaturated zone beneath the alluvial aquifer, and (2) tritium, as tritiated water (HTO), has moved at least 46 m (150 ft) below the alluvial aquifer, to a total depth of about 59 m (195 ft). The tritium data for cores from hole MCM-5.9 (the deepest corehole drilled to date in Mortandad Canyon) are shown in Fig. VII-4. Tritium concentrations decrease by a factor of about 100 between 46 and 59 m (150 and 195 ft), suggesting the possibility that tritium may not have moved much deeper in the almost 30 years since effluents were first released from the TA-50 treatment plant. However, this possible conclusion must be considered tentative until additional, deeper core holes can confirm the pattern.

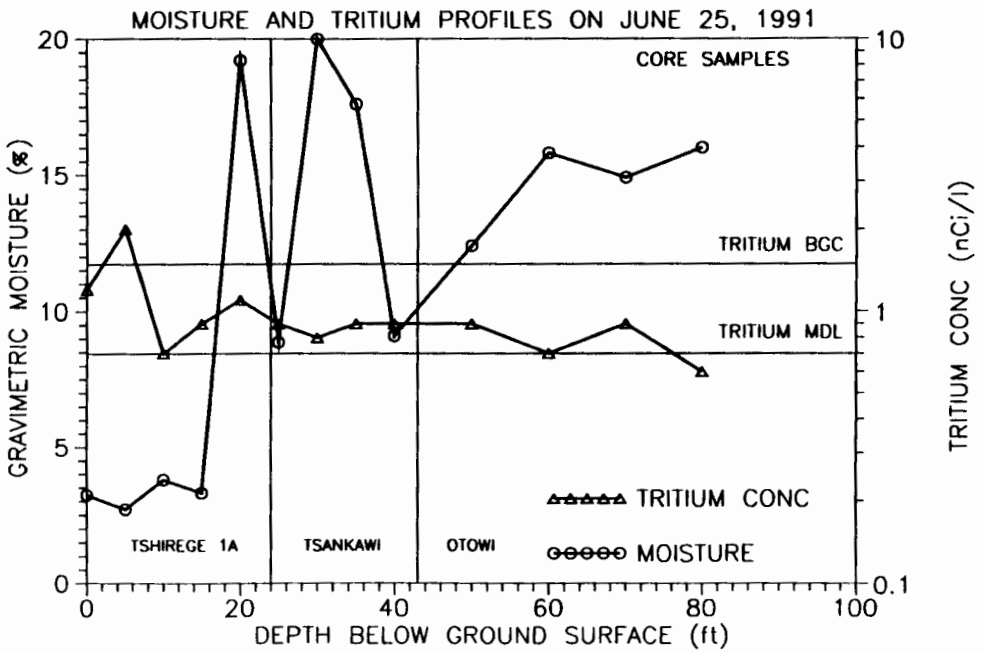

Fig. VII-5. TA-53 Surface Impoundments: Core Hole No. 7 moisture and tritium profiles on June 25, 1991.

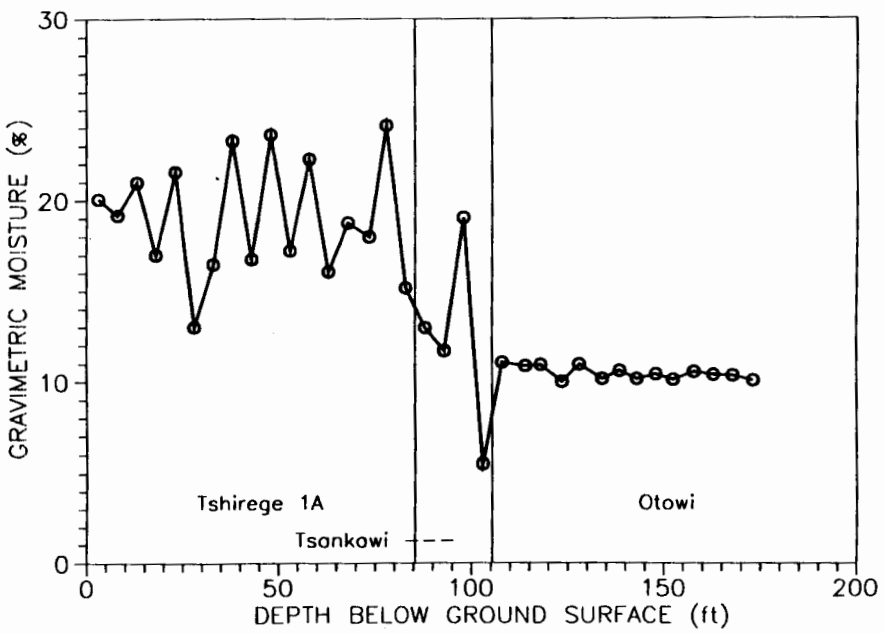

Fig. VII-6. Potrillo Canyon Core Hole No. 1 on December 12, 1991.

VIII. QUALITY ASSURANCE AND SAMPLING PROCEDURES

Quality assurance includes all of the planned and systematic actions and activities necessary to provide adequate confidence that a system or process will perform satisfactorily. Every monitoring and compliance activity sponsored by the Laboratory's Environmental Protection Group (EM-8) has its own quality assurance program with documented sampling procedures. The Environmental Chemistry Group (EM-9) also has a documented quality assurance program for sample analysis and data verification.

A. Organization

The Laboratory is managed by the University of California (UC) for the Department of Energy (DOE) and is obligated to report both to the UC and to the DOE. The Laboratory contract is administered through the DOE Los Alamos Area Office (LAAO) and the Albuquerque Operations Office (AL). The Laboratory Director is ultimately responsible for all Laboratory activities. However, technical and administrative responsibility and authority are delegated to directorates and support offices.

The Director is supported by a Deputy Director, an Executive Staff Director, eight Associate Directors, two Associate Directors at Large, the Controller, Laboratory Counsel, the Director of Human Resources, and the Office of Public Affairs.

The Environmental Management (EM) Division is the primary Laboratory support program in all environmental activities. The Division initiates and promotes a comprehensive Laboratory program for environmental protection and has primary responsibility for environmental surveillance and regulatory compliance; manages the Laboratory's waste management, corrective action, environmental chemistry, environmental protection, and environmental restoration programs; and maintains a record of Laboratory documents related to environmental matters and provides data to Laboratory managers for trend and root cause analysis. Although the Laboratory Director has primary responsibility for environment, safety, and health (ES&H) management, EM 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 Resource Conservation and Recovery Act (RCRA). With assistance from Laboratory Counsel, EM Division helps to define and recommend Laboratory policies with regard to applicable federal and state environmental regulations and laws and DOE orders and directives.

The EM Division organization and groups within the Division are shown in Fig. VIII-1. EM-8 assists operating groups in complying with federal, state, local, and DOE environmental requirements. This group also bears primary responsibility for monitoring the ambient environment and evaluating past, present, and future environmental impacts from Laboratory operations. EM-8 bears principal responsibility for obtaining permits and approvals from applicable environmental regulatory authorities and oversees corrective actions required in compliance orders and interagency agreements with regulators.

EM-9 provides analytical services to the Laboratory's environmental, waste management, radiation protection, and industrial hygiene operations. EM-9 is responsible for quality assurance for the health and environmental analytical work. EM-9 currently participates in the following Interlaboratory Quality Assurance Programs:

- National Institute for Occupational Safety and Health, Proficiency Analytical Testing Program;
- Environmental Monitoring and Support Laboratory, Cincinnati (EMSL-CI) Drinking Water Program;
- EMSL-CI Water Pollution Study;

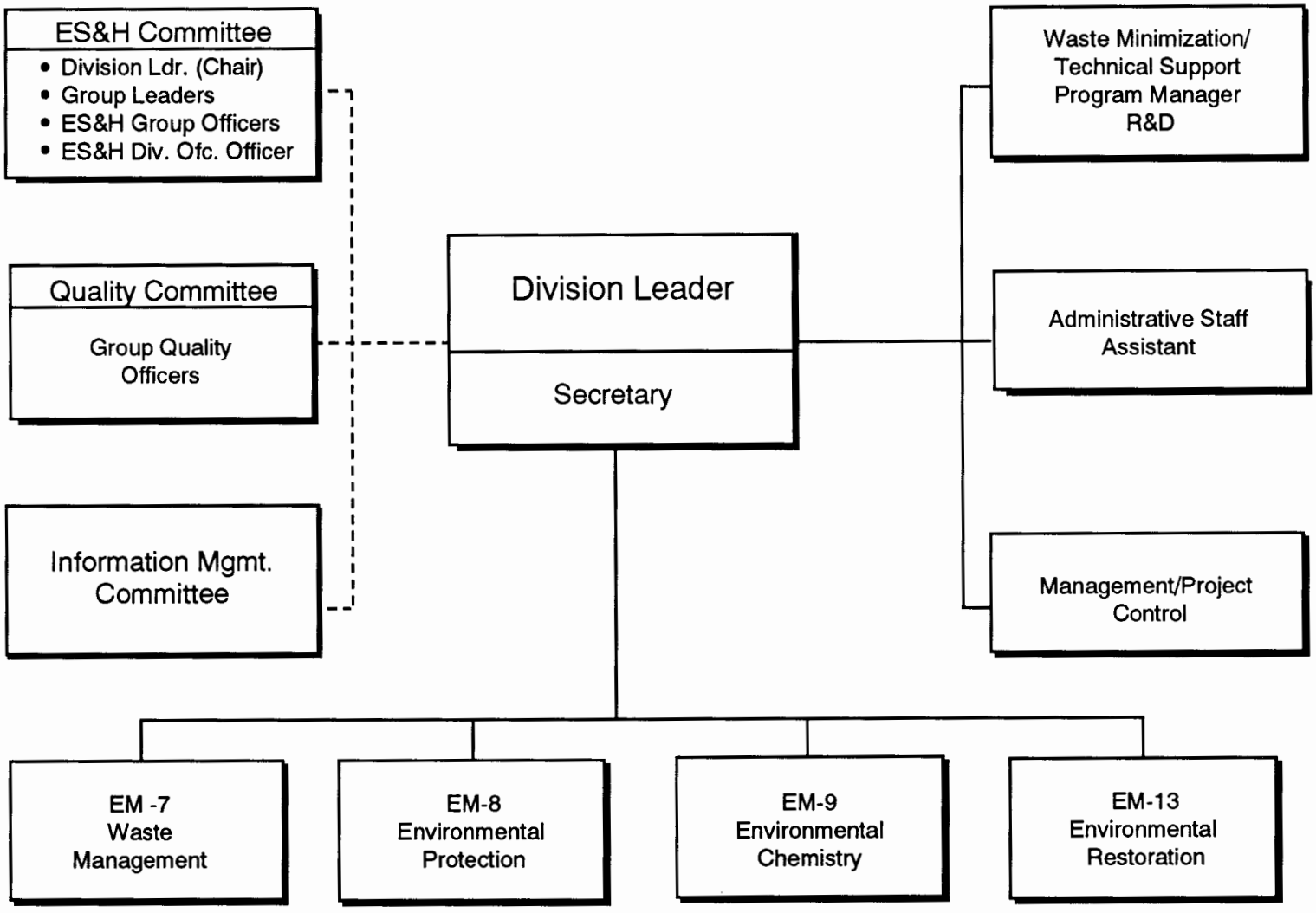

Fig. VIII-1. Organizational chart for the Environmental Management Division.

- Environmental Protection Agency (EPA) Environmental Monitoring Systems Laboratory-Las Vegas;
- Environmental Measurements Laboratory;
- National Pollutant Discharge Elimination System (NPDES); and
- DOE Beryllium Intercomparison Study.

The Waste Management Group (EM-7) manages Laboratory-generated liquid and solid wastes to reduce the impact of the release of radioactive and hazardous materials to the environment while ensuring that requirements for regulatory compliance are maintained. The group also maintains the program for monitoring the constituents of the radioactive liquid waste streams at the Laboratory. The Environmental Restoration Group (EM-13) is responsible for compliance with the Hazardous and Solid Waste Amendments (HSWAs) and Module VIII of the RCRA Operating Permit and coordinates any Comprehensive Environmental Response, Compensation, and Liability Act activities at the Laboratory. The primary objective of EM-13 is to implement assessment and remediation activities as required for potential release sites and contaminated facilities at the Laboratory.

The Health and Safety Division (HS) is also key in implementing the Laboratory's environmental program. The Health Physics Measurement Group (HS-4) and the Health Physics Policy & Programs Group (HS-12) are responsible for monitoring radiological airborne emissions from stacks around the Laboratory, for maintaining stack emission plans and quality assurance documentation, and for preparing annual reports. The Risk Management Support Group (HS-3) helps communicate environmental policies to Laboratory employees and ensures that appropriate environmental training programs are available.

Several committees provide environmental concurrence and review functions for Laboratory operations. The Laboratory's ES&H Questionnaire Review Committee provides reviews of proposed projects to ensure that appropriate environmental, as well as health and safety, issues are properly addressed. In 1991, the committee reviewed 211 questionnaires. The day-to-day questionnaire and review process is managed by HS-3. The Laboratory Environmental Review Committee reviews and concurs with NEPA documentation for projects prior to submittal to DOE. The ES&H Council provides senior management level oversight of environmental activities and policy development.

The Laboratory Assessment Office is an independent environmental appraisal and auditing program which verifies appropriate implementation of environmental requirements. The Quality Operations Office performs quality assurance (QA) and quality control (QC) audits and surveillance of Laboratory and subcontractor activities in accordance with the Quality Assurance Plan for the Laboratory and for the specific activity, if one is required. The Emergency Management Office is responsible for the Laboratory's Emergency Response Plan, which is designed for prompt mitigation of all incidents, including those with environmental impact, and provides the means for coordinating all Laboratory resources in the mitigation effort.

B. Quality Assurance Program

Quality is the extent to which an item or activity meets or exceeds requirements. QA is all of the planned and systematic actions and activities necessary to provide adequate confidence that a facility, structure, system, component, or process will perform satisfactorily in service. Each monitoring activity sponsored by EM-8 maintains its own QA program (QAP) for its activities. Programs 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 1988a) and 5700.6B (DOE 1989b), by the following criteria:

- Organization
- QA program
- Design control
- Procurement document control
- Plans, procedures, and drawings
- Document control
- Control of purchased items and services
- Identification and control of data, samples, and items
- Control of processes
- Inspection
- Test control
- Control of measuring and test equipment
- Handling, storage, and shipping

- Status of inspection, test, and operations
- Control of nonconforming items and activities
- Corrective action
- QA records
- Audits and surveillances

QAPs for each environmental monitoring program performed by EM-8 have been drafted for inclusion in the Environmental Monitoring Program, currently being revised. The QAPs will be revised under DOE Order 5700.6C (August 21, 1991) within three years. The Laboratory's Quality Operations Office has recently distributed guidelines for revision which indicate that the existing 18-point program used by DOE Order 5700.6B will be replaced by a 10-point program.

C. Sampling Procedures

1. Thermoluminescent Dosimeters.

Thermoluminescent dosimeters (TLDs) used at the Laboratory are lithium fluoride (LiF) chips, 6.4 mm square by 0.9 mm thick. The TLDs, after being exposed to radiation, emit light upon being heated. The amount of light is proportional to the amount of radiation to which the TLD was exposed. The TLDs used in the Laboratory's environmental monitoring program are insensitive to neutrons, so the contribution of cosmic neutrons to natural background radiation is not measured.

The chips are annealed to 400°C (752°F) for 1 hour and then cooled rapidly to room temperature. This is followed by annealing at 100°C (212°F) for 1 hour and again cooling rapidly to room temperature. For the annealing conditions to be repeatable, chips are put into rectangular borosilicate glass vials that hold 48 LiF chips each. These vials are slipped into a borosilicate glass rack so they can be placed all at once into ovens maintained at 400°C and 100°C.

Four LiF chips constitute a dosimeter. The LiF chips are contained in a two-part threaded assembly made of an opaque yellow acetate plastic. A calibration set is prepared each time chips are annealed. The calibration set is read at the start of the dosimetry cycle. The number of dosimeters and exposure levels are determined for each calibration in order to efficiently use available TLD chips and personnel. Each set contains from 20 to 50 dosimeters, which are irradiated at levels between 0 and 80 mR using an 8.5-mCi ^{137}Cs source calibrated by the National Bureau of Standards.

A factor of 1 mrem (tissue) = 1.050 mR is used in evaluating the dosimeter data. This factor is the reciprocal of the product of the roentgen-to-rad conversion factor of 0.958 for muscle for ^{137}Cs and of 0.994, which corrects for attenuation of the primary radiation beam at electronic equilibrium thickness. A rad-to-rem conversion factor of 1.0 for gamma rays is used, as recommended by the International Commission on Radiation Protection (John 1974, ICRP 1970). A method of weighted least-squares linear regression is used to determine the relationship between TLD reader response and dose (the weighting factor is the variance) (Bevington 1969).

The TLD chips used were all from the same production batch and were selected by the manufacturer so that the measured standard deviation in thermoluminescent sensitivity is 2.0% to 4.0% of the mean at a 10-R exposure. At the end of each field cycle, whether a calendar quarter or the Los Alamos Meson Physics Facility (LAMPF) operation cycle, the dose at each network location is estimated from the regression along with the regression's upper and lower 95% confidence limits at the estimated value (Natrella 1963). At the end of the calendar year, individual field cycle doses are summed for each location. Uncertainty is calculated as the summation in quadrature of the individual uncertainties (Bevington 1969).

2. Air Sampling.

a. Ambient Air. Samples are collected monthly at all but one of the 37 continuously operating stations. Samples are collected weekly from a station located on the top of the Occupational Health Laboratory (OHL) building at TA-59.

Airborne particulates are collected from the atmosphere using vacuum pumps with flow rates of 3 liters per second (approximately 6 cubic feet per minute [cfm]). The flow rates at the start and the finish of the sampling period are measured with a calibrated rotameter to determine average flow rate and are multiplied by the total run time to determine the volume of air sampled. The particulates are collected on 79 mm diameter polystyrene filters (Microsorban). Each filter is mounted on a charcoal cartridge. The charcoal cartridge is used as a quantitative determination for gaseous gamma emitters should an unplanned release occur.

The particulate filters are analyzed monthly for gross alpha and gross beta activity. Particulate filters and charcoal cartridges are also analyzed monthly using gamma ray spectrometry. The filter and cartridge collected from the OHL building at TA-59 are analyzed by the process described above on a weekly basis. Particulate filters are then composited for a quarter and analyzed for plutonium, americium, and uranium.

Part of the total airflow (1.5 to 4.0 cc/sec) from the above system is passed through a cartridge containing 200 to 300 grams of indicating silica gel. The silica gel adsorbs atmospheric water vapor to tritium analysis. Indicating silica gel is used to determine if moisture was absorbed through the entire sample during the collection period. If the sample indicates "breakthrough" has occurred, then the sample is discarded.

A calibrated rotameter is used to determine initial and final air flow to find average air flow. The total time of operation is multiplied by the average flow rate to determine the volume of air sampled. The silica gel collected monthly is heated to drive off the moisture collected from the atmosphere. The moisture is then analyzed for tritium using liquid scintillation counting.

A specific radioiodine sampling program is being developed in anticipation of the Laboratory's future participation in additional medical isotope production projects. The program was started in August with six sampling stations. The system will be modified for optimum detection as the projects near start-up. The system uses vacuum pumps with constant airflow regulators that sample at 1 cfm. Cartridges that contain activated TEDA treated charcoal are used to collect radioiodine as gas. A 47 mm micro glass borosilicate particulate filter is placed in front of the charcoal cartridge to collect any iodine in particulate form. Air volumes are determined by multiplying the constant flow rate (1 cfm) by the total time sampled. Samples are collected weekly. Filters and cartridges are qualitatively analyzed by gamma spectroscopy before being sent to the analytical laboratory for quantitative analysis. No radioiodine was detected in 1991.

Measurement of tritium in rainwater is included in this year's monitoring results. This sampling program was initiated to support the Laboratory's Environmental Restoration program and was conducted by the Geology and Geochemistry Group (ESS-1). In the laboratory, measurement of tritium in rainwater is accomplished through ultra low-level beta counting in gas proportional counters. The tritium content of the rainwater sample is enriched through electrolysis, then reduced to hydrogen gas, which is injected into the counter and measured. The sample measurement value is statistically scrutinized according to background and standards before release to the investigator. Values of tritium are given in tritium units: one TU is 3.2 pCi/L of water.

b. Radioactive Air Emissions Monitoring. Samples are collected at weekly intervals from 88 monitors. Sample collection and analysis are performed by personnel from HS-12 and HS-4.

The typical system for monitoring particulate radioactivity in stack emissions consists of one or more sampling or monitoring probes that continuously extract a representative sample from the stack exhaust stream by the use of an air sampling pump that passes the sample through a filter on which the particles are trapped. The pumps typically sample at a rate of 2 cfm. The filter with its trapped particles is analyzed for radioactivity. The filters are counted for either gross alpha or gross beta activity depending on the respective isotope(s) that are emitted from the stack. To determine the total activity released, the radioactivity on the sample filter is multiplied by the ratio of the total stack flow (in the sampling time) to the volume of air sampled by the pump during the sampling period. This total activity is expressed in microcuries or curies. The radioisotopes of plutonium are not listed separately because the analysis of the air sample filters by gross alpha count does not distinguish between the individual isotopes of plutonium. Likewise, the analysis of the air sample filters by gross beta counts does not distinguish between the individual radioisotopes in the group called "mixed fission products."

The typical system for monitoring an effluent or exhaust stream for airborne tritium in the gaseous form (HT, DT, T^2) is basically an in-line system in which one or more sampling or monitoring probes continuously extract a representative sample from the stream and direct it to remotely located tritium (H^3) measuring instruments through metal tubing (or "lines"). The instruments measure the tritium concentration and, in conjunction with the effluent exhaust rate, the total H^3 activity (in curies) released to the environment over a period of time. At LAMPF, the tritium in the form of water (HTO) is captured on silica gel, which is changed monthly to count for the H^3 activity. At other facilities such as the Tritium Systems Test Assembly (TSTA) the

effluent containing H^3 activity is captured in a bubbler system which enables analysts to distinguish between the quantity of tritium activity that is in the form of HT or HTO.

At LAMPF, the particulate/vapor activation products are captured on paper filters in the case of particulates or on charcoal filters in the case of vapor products, and total radioactivity is counted. Gaseous activation products (G/MAP) are counted in a flow-through air ionization chamber to determine total radioactivity. Isotopic ratios are measured using high purity germanium detectors. Stack flow rates are measured by Johnson Controls Inc. (JCI) using flowmeters that are calibrated at least quarterly using magnehelic gauges that are traceable to National Institute of Standards and Technology (NIST) (formerly the National Bureau of Standards) standards.

The following procedures have been documented and approved by HS-12:

- the calibration of flowmeters used in stack effluent sampling;
- traverse flow measurements;
- Sutorbilt maintenance procedures;
- assembly and service of Sutorbilt air sampling system (air sampling pumps used to collect stack air samples);
- calibration procedures of magnehelic gauges (to calibrate the flowmeters); and
- special monitoring instructions for air sampling.

The following procedures have been documented and approved by HS-4:

- instrumentation and calibration;
- instrument recall and issue;
- calibration of fixed tritium instrumentation at TSTA, TA-3-16, TA-21-209, TA-33-86, TA-35-TSL 213, TA-55-PF4, TA-16-205;
- calibration procedures for the TSTA stack bubbler;
- calibration and maintenance of the TA-55 CAM facility, TA-3-40-RM E28;
- gamma spectroscopy of LAMPF stack filters and water samples;
- operation of the IMPULSE alpha analyses system (used to transfer data from HS-4 to databank on OF-VAX computer); and
- liquid scintillation analysis.

c. Nonradioactive Air. The criteria pollutant monitoring station owned by the Laboratory is located south of TA-49, adjacent to Bandelier National Monument. This station, which began operation in the second quarter of 1990, continuously monitors air concentrations of nitrogen dioxide (NO_2), ozone (O_3), and sulfur dioxide (SO_2). Filters to trap small particulate matter (less than 10 microns in diameter - PM_{10}) are collected every 6 days and weighed. Once each month, the New Mexico Environment Department (NMED) audits the flow rate of the instrumentation.

Atmospheric visibility is also analyzed using a transmissometer. A 10-minute measurement is taken every hour, on a 24-hour per day basis. The visibility is measured between TA-49 and TA-33, a distance of 4.58 km (2.84 mi). Air Resources of Fort Collins, Colorado, is responsible for data quality.

Acid deposition from precipitation is measured once per week. Water samples are examined in the field for visible contamination, pH factor, and electrical conductivity. Samples are sent to Colorado State University (CSU) to be further analyzed for inorganic content and pH values. Blind samples are audited by CSU twice per year, and equipment checks are made once every three years.

Beryllium is monitored on the Continuous Ambient Air Monitors that are operated as part of the ambient radionuclide monitoring system. The samples are taken using a flow rate of 6 cfm. The flow rate is calibrated to a dry gas flow meter which is calibrated to a National Bureau of Standards spirometer. The equipment operates continuously, and samples are collected monthly. A composite of the monthly samples is generated quarterly by combining the samples into one and then analyzing it.

3. Water Sampling.

a. Surface Water and Groundwater. Surface water and groundwater sampling stations are grouped by location (regional, perimeter, on site) and hydrologic similarity. Water samples are taken once a year. Samples from wells are collected after sufficient water has been pumped or bailed to ensure that the sample is representative of the aquifer. Spring samples (groundwater) are collected at the discharge point.

The water samples are collected in 4-L polyethylene bottles for radiochemical analyses. The 4-L bottles are acidified in the field with 5 mL of concentrated nitric acid and then are returned to the laboratory within a

few hours of sample collection for filtration through a 0.45-μm membrane filter. The samples are routinely analyzed radiochemically for H^3, ^{137}Cs, total uranium, ^{238}Pu, and $^{239,240}Pu$, as well as for gross alpha, beta, and gamma activities. Selected samples are also analyzed for ^{241}Am, ^{90}Sr, and accelerator-induced activation products. Analytical methodology and its quality assurance program are discussed in Section VIII.D. Detailed container and preservation requirements of EM-9 are documented in a handbook (Williams 1990).

Water samples for inorganic and organic chemical analyses are collected at the same time. For most samples for inorganic analyses, three 1-L polyethylene bottles are collected, one with no additives, one with sulfuric acid, and one with nitric acid to provide the proper range of preservatives for the standard list of constituents. When necessary, additional containers with appropriate preservatives are collected for mercury, cyanide, and sulfide analyses. For selected samples additional glass containers are collected for organic analyses. Details of container and preservation requirements, and identification of EPA methodology for each analysis are contained in the EM-9 Handbook (Williams 1990).

Runoff samples are analyzed for radionuclides in solution and suspended sediments. The samples are filtered through a 0.45-μm filter. Solution is defined as filtrate passing through the filter; suspended sediment is defined as the residue on the filter.

b. National Pollutant Discharge Elimination System. Personnel from EM-8 complete sample collection, preservation, and field analysis of the Laboratory's National Pollutant Discharge Elimination System (NPDES) permitted industrial outfall discharges. Industrial effluent samples are collected for specific parameters at the monitoring frequencies and locations specified in the NPDES Permit. Monitoring is conducted according to EPA-approved methods documented in 40 CFR Part 136 and NPDES Permit Nos. NM0028355 and NM0028576. Chain-of-custody (COC) procedures for sample collection and analysis are conducted during NPDES industrial compliance sampling.

EM-9 performs analysis of industrial discharges for pollutants listed in the NPDES permits. Samples are tested according to EPA-approved methods documented in 40 CFR Part 136, "Guidelines Establishing Test Procedures for Analysis of Pollutants under the Clean Water Act; Final Rule and Technical Amendments" (EPA 1991) or otherwise specified in the NPDES permits.

Treated effluent samples are collected from the sanitary treatment plants by JCI Environmental (JENV) laboratory in accordance with the monitoring conditions specified in NPDES Permit NM0028355. Representative samples are collected from the monitoring points designated by the permit for each outfall. Sample collection and preservation are conducted according to test procedures approved under 40 CFR 136. Chain-of-custody procedures are used by JENV for sample collection and analysis. JENV conducts the sanitary wastewater testing for pollutants listed in the NPDES permit. Testing procedures are conducted according to the seventeenth edition of Standard Methods for the Examination of Water and Wastewater (APHA 1989) and other conditions specified by the NPDES permit.

All instruments used for sanitary and industrial field and laboratory analysis are routinely serviced and calibrated; records are properly maintained. Measurements are made in accordance with the NPDES permit quality assurance requirements, 40 CFR Section 122.41. Quality assurance procedures include the use of duplicate, replicate, and spike analyses; sample splits; outside reference samples; blanks; reagent blanks to check for sources of error; and method verification. Both JENV and the EM-9 laboratories participate in the National Discharge Monitoring Report Quality Assurance Program. EM-9 also participates in the EPA Water Pollution Study for blind spike analyses. The Laboratory's NPDES program is subject to Compliance Evaluation Inspections by EPA and NMED on an annual basis.

c. Safe Drinking Water Act. The sampling program for drinking water quality is designed to meet or exceed regulatory requirements under the Federal Safe Drinking Water Act (SDWA) and the New Mexico Environmental Improvement Act. Sampling locations, frequencies, preservation, handling, and analysis follow the requirements specified in federal and state regulations. Samples are drawn from the individual water supply well heads for volatile organic compounds and microbiology. All other types of regulatory compliance samples are drawn from the taps in the water distribution system.

Samples are drawn at taps on the individual water supply well heads for volatile organic constituents (VOCs) at least once every year. Samples are collected in 40 ml glass septum vials. Travel blanks are submitted with the well head VOC samples.

Well head samples are drawn on a monthly basis for microbiological quality including total coliforms, noncoliforms, and heterotrophic plate counts. Autoclaved 100 ml polyethylene bottles are used to collect microbiological samples.

Samples for inorganic chemicals and radiochemistry are collected annually from locations in the distribution system representative of the two currently operating well fields. The White Rock Fire Station location is representative of water originating from the Pajarito Well Field. The Barranca Mesa School and the North Community Fire Station are representative of the Guaje Well Field. Samples are collected in 1 liter polyethylene containers.

Trihalomethane (THM) samples are collected on a quarterly basis from six sampling locations which are spread throughout the distribution system. These are Barranca Mesa School, North Community Fire Station, Los Alamos Airport, White Rock Fire Station, S-Site Fire Station, and TA-33, Building 114. The sample containers are 40 ml glass septum vials. Travel blanks are submitted with the distribution system THM samples.

Microbiological samples are also collected at a network of approximately 80 locations throughout the distribution system. The sampling sites are rotated such that at least 40 samples from throughout the system are taken each month. Samples are analyzed for total coliforms, fecal coliforms, and noncoliform bacteria. Autoclaved 100 ml polyethylene bottles are used to collect microbiological samples.

Microbiological sampling and analysis are performed by personnel of the JENV which is certified by the State of New Mexico for microbiological compliance analysis. Certification requirements include proficiency samples, maintenance of an approved QA/QC program, and periodic audit by the State Scientific Laboratory Division (SLD).

Chemical and radiochemical sampling is performed by LANL staff certified by the NMED to do drinking water compliance sampling. These samples are sent to SLD in Albuquerque for analysis. The SLD QA/QC program is certified by the EPA.

4. Soil and Sediment Sampling.

The soil sampling procedure involves taking five plugs, 75 mm (3.0 in.) in diameter and 50 mm (2.0 in.) deep, at the center and corners of a 10 m (33 ft) square area. The five plugs are combined to form a single composite sample for radiochemical analysis.

Sediment samples are collected from dune buildup behind boulders in the main channels of perennially flowing streams. Samples from the beds of intermittently flowing streams are collected by scooping a line of uniform depth across the main channel. Reservoir sediments are collected from a boat, using an Eckman dredge. Bottom reservoir sediments are collected from an area 10 cm by 15 cm (4 in. by 6 in.) to a depth of 5 cm (2 in.).

Depending on the reason for taking a particular soil or sediment sample, it may be analyzed to detect any of the following: gross alpha and gross beta activities, ^{90}Sr, total uranium, ^{137}Cs, ^{238}Pu, $^{239,240}Pu$, ^{241}Am, and possibly selected accelerator-induced activation products. Moisture distilled from soil samples may be analyzed for H^3.

5. Foodstuffs Sampling.

Local and regional produce are sampled annually. Fish are sampled annually from reservoirs upstream and downstream from the Laboratory.

Produce and soil samples are collected from local gardens in the fall of each year (Salazar 1984). Each produce or soil sample is sealed in a labeled plastic bag. Samples are refrigerated until prepared for chemical analysis. Produce samples are washed, as if prepared for consumption, and quantitative wet, dry, and ash weights are determined. Soils are split and dried at 100°C (212°F) before analysis. A complete sample bank is kept until all radiochemical analyses are completed. Water is distilled from samples and submitted for tritium analysis. Produce ash and dry soil are submitted for analyses of ^{90}Sr, ^{137}Cs, total uranium, ^{238}Pu, and $^{239,240}Pu$.

At each reservoir, hook and line, trot line, or gill nets are used to capture fish (Salazar 1984). Fish, sediment, and water samples are transported under ice to the Laboratory for preparation. Sediment and water samples are submitted directly for radiochemical analysis. Fish are individually washed, as if for consumption, and dissected. Wet, dry, and ash weights are

determined, and ash is submitted for analysis of ^{90}Sr, ^{137}Cs, total uranium, ^{238}Pu, and $^{239,240}Pu$.

6. Meteorological Monitoring.

Meteorological data were continuously gathered at four instrumented towers during 1991. Data taken include wind speed and direction, standard deviations of wind speed and direction, vertical wind speed and its standard deviation, air and soil temperature, relative humidity, solar and terrestrial radiation, precipitation, and sensible and evaporative heat fluxes (vertical transport). Each variable is measured every three seconds. A Dopper Acoustic Sodar is also located at a tower site. This instrument measures wind direction and speed, vertical wind speed, horizontal and vertical wind standard deviations, and inversion information at 30 m (99 ft) levels up to 750 m (2,475 ft). Finally, four additional sites monitor precipitation; one of these sites also measures temperature and relative humidity.

The tower and sodar data are averaged or summed over 15-minute intervals. Data are transmitted by phone line to a microcomputer at the OHL at TA-59. Charts from the four precipitation stations are picked up every week. Data validation of 15-minute data is accomplished with automated and manual screening techniques. Computer codes screen incoming data for reasonableness and consistency. Invalid data are discarded. Other codes produce daily plots for each tower and the sodar. These graphics are reviewed to provide an additional check of the data. This screening helps to detect problems with the instrumentation that might develop between calibrations. Most instruments are calibrated semiannually, including a thorough audit by an outside contractor once a year. The outside audit was performed in June 1991 (META 1991).

D. Analytical Chemistry

1. Methodology.

a. Introduction. Most analytical chemistry services are provided by the Laboratory's EM-9 Group. The EM-9 Sample Management Section functions as a working interface between the group and its customers. This section provides the sample collector with pre-sampling information in the areas of sample containers, sample volumes, and sample preservation techniques. Collection of samples for chemical and radiochemical analyses follows a set procedure to ensure proper sample collection, documentation, submittal for chemical analysis, and posting of analytical results.

Before sample collection, the Sample Management Section discusses the schedule and procedures to be followed with the sample collector. The discussion includes

- number and type of samples;
- type of analyses and required limits of detection;
- proper sample containers;
- preparation of sample containers with preservative, if needed; and
- sample schedule to ensure minimum holding time of analyses to comply with EPA criteria.

All samples are delivered to Sample Management personnel and are then scheduled and processed for proper distribution and analysis. EM-9 assigns sample numbers to samples when submitted. Each number, representing a single sample, is assigned to a particular station and is entered into the collector's log book. The processing of samples includes (1) validating all samples for sampling correctness and integrity, (2) scheduling and labeling all samples for analysis, (3) initiating internal COC procedures for all samples, and (4) arranging for the proper disposal of any unused portions of samples.

After a sample is collected, it is delivered to the EM-9 Sample Management Section, where the pertinent information is entered into the EM-9 Laboratory Information Management System and the request is given a form number. The request form number is also entered in the collector's log book opposite sample numbers submitted, along with the date the sample was delivered to EM-9. EM-9 provides COC forms for the samples once they are received if COC was not started in the field. The date, time, temperature (if water), other pertinent information, and remarks are entered opposite the sample number and station previously listed in the log book. The sample container is labeled with station name, sample number, date, and preservative, if added.

The analytical request form contains the following information related to ownership and the sample program submitted: (1) requester, i.e., sample collector; (2) program code; (3) sample owner, i.e., program manager; (4) date; and (5) total number of samples. The second part of the request form contains (1) sample

number or numbers; (2) matrix, e.g., water; (3) types of analyses, i.e., specific radionuclide and/or chemical constituents; (4) technique, i.e., analytical method to be used for individual constituents; (5) analyst, i.e., chemist to perform analyses; (6) priority of sample or samples; and (7) remarks. One copy of the form goes to the collector for filing, and the other copies follow the sample.

The analytical results are returned to the sample collector, who posts data according to sample and station taken from the log book. These data sheets are included in the report and are used to interpret data for the report.

b. Radioactive Constituents. Environmental samples are routinely analyzed for the following radioactive constituents: gross alpha, beta, and gamma; isotopic plutonium; americium; uranium; cesium; tritium; and strontium. Detailed procedures have been published in this report in previous years (EPG 1990) and in the EM-9 Analytical Methods Manual (Gautier 1986). Occasionally, other radionuclides from specific sources are determined: ^{7}Be, ^{22}Na, ^{40}K, ^{51}Cr, ^{60}Co, ^{65}Zn, ^{83}Rb, ^{106}Ru, ^{134}Cs, ^{140}Ba, ^{152}Eu, ^{154}Eu, and ^{226}Ra. All but ^{226}Ra are determined by gamma-ray spectrometry on large germanium lithide detectors. Depending on the concentration and matrix, ^{226}Ra is measured by emanation or by gamma-ray spectrometry of its ^{214}Bi decay product. Uranium isotopic ratios ($^{235}U/^{238}U$) are measured by neutron activation analysis where precisions of ±5% are adequate. More precise work requires mass spectrometry. Uranium isotopic ratios are readily determined in environmental materials with precisions of 1%–2% relative standard deviation, at considerably reduced cost relative to neutron activations by inductively coupled plasma mass spectrometry (ICPMS).

c. Stable Constituents. A number of analytical methods are used for various stable isotopes. The choice of method is based on many criteria, including the operational state of the instruments, time limitations, expected concentrations in samples, quantity of sample available, sample matrix, and EPA regulations. Instrumental techniques available include neutron activation, atomic absorption, ion chromatography, color spectrophotometry (manual and automated), potentiometry, combustion analysis, ICPMS, and inductively coupled plasma atomic emission spectrometry. Standard chemical methods are also used for many of the common water quality tests. Atomic absorption capabilities include flame, furnace, cold vapor, and hydride generation, as well as flame emission spectrophotometry. The methods used and references for determination of various chemical constituents are presented elsewhere (Gautier 1986). In 1986, the EPA Region 6 administration granted EM-9 limited approval for alternative test procedures for uranium in drinking water (delayed neutron assay) and for chloride in drinking water and wastewater (flow injection without distillation). EPA approval for other modified methods is actively being sought. EM-9 is participating in the EPA-sponsored study to evaluate ICPMS for acceptance as an EPA-approved methodology.

d. Organic Constituents. Environmental soil and water samples are analyzed using EPA procedures outlined in EPA SW-846 (EPA 1989d) or modified procedures (Gautier 1986) that meet QA criteria outlined in Chapter One of SW-846, as shown in Table VIII-1. Methods used are supported by documented spike/recovery studies, method and field blanks, matrix spikes, surrogate spikes, and blind quality control samples. Volatile organics are analyzed using method 8260, SW-846. Tables D-21 and D-22 list volatile organics on the target list for water and soil samples, respectively. Semivolatile organics are analyzed using method 8270, SW-846. Table D-23 is the target list for semivolatile organics in water. Soil-gas (pore-gas) monitoring is performed by collecting organic vapors on charcoal, extracting the charcoal with CS_2 and analyzing the CS_2 extracts using gas chromatography/mass spectrometry (GC/MS). Soil-gas target compounds are listed in Table D-24, and the Toxicity Characteristics Leaching Procedure (TCLP) target compounds are listed in Table D-25.

Instrumentation available for organic analysis includes GC/flame ionization detector, GC/electron capture detector, GC/MS, high performance liquid with ultraviolet (UV) and refractive index detectors, a Fourier transform infrared spectrometer, and a UV/visible spectrophotometer. Sample preparation methods include: Soxhlet extraction, ultrasonic extraction, continuous liquid/liquid extraction, Kuderna Danish concentration, evaporative blowdown, and gel permeation chromatography clean-up of sample extracts.

Organic mixed waste analyses are performed for samples up to 100 nCi/g (solids/sludges) or 100 nCi/L (solutions) alpha, beta, or gamma. Higher level

Table VIII-1. Method Summary (Organic Compounds)

Analyte	Matrix	Method[a]	Technique[b]
Volatile organic compounds	Air	—	GC/MS
	Soil	8,240	PAT/GC/MS
	Water	8,240	PAT/GC/MS
TCLP[c] toxicity	Soil	1,311, 8,080 8,150,8240,8270	GC/ECD
PCBs	Water	608	GC/ECD
	Soil	8,270	GC/ECD
	Oil	IH 320	GC/ECD
Semivolatile organic compounds	Soil and waste	8270	GC/MS

[a]Industrial hygiene (IH).

[b]Gas chromatography (GC), purge and trap (PAT), electron capture detection (ECD), and mass spectrometry (MS).

[c]Toxicity Characteristic Leaching Procedure (TCLP).

samples are analyzed on a case-by-case basis. New methods are being developed for routine analysis of mixed waste greater than 100 nCi/g (or nCi/L). The Laboratory's capacity for mixed waste analyses will increase in the summer of 1992 when mixed waste analytical operations move to a dedicated facility.

2. Quality Evaluation Program.

a. Introduction. Control samples are analyzed in conjunction with the normal analytical chemistry workload. Such samples consist of several general types: calibration standards, reagent blanks, process blanks, matrix blanks, duplicates, spikes, and reference materials. Analysis of control samples fills two needs in analytical work: (1) it provides quality control over analytical procedures so that problems that might occur can be identified and corrected, and (2) data obtained from analysis of control samples permit evaluation of the capabilities of a particular analytical technique to determine a given element or constituent under a certain set of circumstances.

Blind QC samples are disguised and numbered to resemble unknown samples in a set, and no attempt is made to conceal the identity of the open QC samples from the analyst. In neither case are the concentrations of the analytes of interest revealed until after the data have been formally reported.

These samples are submitted to the laboratory at regular intervals and are analyzed in association with other samples; that is, they are not handled as a unique set of samples. At least 10% of stable constituent, organic, and selected radioactive constituent analyses are run as quality control samples using the materials described above. A detailed description of EM-9's QAP and a complete listing of results have been published annually since 1976 (Gautier 1991).

b. Radioactive Constituents. In addition to those that are prepared internally, QC and QA samples for radioactive constituents are obtained from outside agencies. The Quality Assurance Division of the Environmental Monitoring Systems Laboratory (EPA, Las Vegas) provides water, milk, and air filter samples for analysis of gross alpha, gross beta, H^3, ^{40}K, ^{60}Co, ^{65}Zn, ^{90}Sr, ^{106}Ru, ^{131}I, ^{134}Cs, ^{137}Cs, ^{226}Ra, and $^{239,240}Pu$ as part of an ongoing laboratory intercomparison program. NIST provides several soil and sediment standard reference materials (SRMs) for environmental radioactivity. These SRMs are certified for ^{60}Co, ^{90}Sr, ^{137}Cs, ^{226}Ra, ^{238}Pu, ^{239}Pu, ^{241}Am, and several other

nuclides. The DOE's Environmental Measurements Laboratory also provides quality assurance samples.

Soil, rock, and ore samples obtained from the Canadian Geological Survey (CGS) are used for quality assurance of uranium and thorium determinations in silicate matrices. EM-9's own in-house standards are prepared by adding known quantities of liquid NIST radioactivity SRMs to blank matrix materials.

c. Stable Constituents. Quality assurance for the stable constituent analysis program is maintained by analysis of certified or well-characterized environmental materials. The NIST has a large set of silicate, water, and biological SRMs. The EPA distributes mineral analysis and trace analysis water standards. Rock and soil reference materials have been obtained from the CGS and the United States Geological Survey. Details of this program have been published elsewhere (Gautier 1991). Stock solutions of inorganic analytes are prepared and spiked on blank matrices by the Quality Assurance Section.

The analytical quality control program for a specific batch of samples is the combination of many factors. These include the "fit of the calibration," instrument drift, calibration of the instrument and/or reagents, recovery for SRMs, and precision of results.

d. Organic Constituents. Soil samples are received for the analysis of volatile and semivolatile organic compounds, pesticides, and herbicides for compliance work done under RCRA. Certified matrix-based reference materials were not available for these analyses, so stock solutions of the analytes were prepared and spiked directly on blank soil by the Quality Assurance Section. Because homogeneity of the sample could not be ensured, the entire sample was analyzed. Volatile organic compounds are analyzed by GC/MS and are spiked in the microgram-per-kilogram range.

The majority of water samples submitted during 1991 were environmental compliance samples for the analysis of pesticides, herbicides, volatile and semivolatile organic compounds, and PCBs. Methods were developed and refined for in-house preparation of quality control samples for volatile and semivolatile organic compounds in water.

Oil samples were received for the analysis of PCBs and organic solvents. Quality control samples for PCBs were prepared by diluting EPA standards or by preparing standards in hexane from the neat analyte. In the United States, the only PCBs that have been found in transformers have been PCBs 1242, 1254, and 1260. Samples submitted for analysis have contained only these PCBs, so they have been used to spike quality control samples. Vacuum pump oil was chosen for the oil base blank after an experiment with various brands of motor oil showed excessive matrix interferences.

3. Data Handling of Radiochemical Samples.

Measurements of radiochemical samples require that analytical or instrumental backgrounds be subtracted to obtain net values. Thus, net values that are lower than the minimum detection limit of an analytical technique are sometimes obtained. 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 the standard deviation. These values are associated with the estimated variance of counting and indicate the precision of the counts.

Standard deviations for the station and group (regional, 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 the uncertainty for the station and group means.

4. Indicators of Accuracy and Precision of Radiochemical Samples.

Accuracy is the degree of difference between average test results and true results when the latter are known or assumed. Precision is the degree of mutual agreement among replicate measurements (frequently assessed by calculating the standard deviation of a set of data points). Accuracy and precision are evaluated from results of analysis of reference materials. These results (r) are normalized to the known quality in the reference material to permit comparison among reference materials of a similar matrix containing different concentrations of the analyte:

$$r = \frac{\text{Reported quantity}}{\text{Known quantity}}.$$

A mean value R for all normalized analyses of a given type is calculated as follows for a given matrix type (N is total number of analytical determinations):

$$R = \frac{\sum_i r_i}{N}.$$

Standard deviations of R are calculated assuming a normal distribution of the population of analytical determinations (N):

$$s = \sqrt{\frac{\sum_i \left(R - r_i\right)^2}{(N-1)}}.$$

These calculated values are presented as the EM-9 "Ratio – Std Dev" in Tables D-26 to D-36. The mean value of R is a measure of the accuracy of a procedure. Values of R greater than unity indicate a positive bias in the analysis; values less than unity, a negative bias. The standard deviation is a measure of precision. Precision is a function of the concentration of analyte; that is, as the absolute concentration approaches the limit of detection, precision deteriorates. For instance, the precision for some determinations is quite good because many standards approach the limits of detection of a measurement. We address this issue by calculating a new quality assurance parameter,

$$\left|\overline{X}_E - \overline{X}_C\right|,$$

where X_E is the experimentally determined mean elemental concentration based on N measurements, and X_c is the certified or consensus mean elemental concentration. The total standard deviation, S_T, of X_E - X_c is given by

$$S_r \sqrt{\left(S_E^2\right)\sqrt{N} + \left(S_C^2\right)},$$

where S_E is the standard deviation of a single experimentally determined measurement, and S_c is the standard deviation of the certified or consensus mean elemental concentration.

Analyses are considered under control if the absolute value of the difference between our result ($\overline{X}_E$) and the certified or consensus mean ($\overline{X}_c$) is within the propagated standard deviation of the experimental uncertainty (U_E) and of the certified mean (S_c). N is equal to the number of measurements on a sample and in our case is equal to 1. This concept is formulated in the following equation and is an adaptation of Dixon and Massey (Dixon 1969) to include the experimental uncertainty:

$$z = \frac{\left|\overline{X}_E - \overline{X}_c\right|}{\sqrt{\left(U_E\right)^2\sqrt{N} + \left(S_c\right)^2}}.$$

The test statistics used in this document are based on 5% and 0.2% levels of significance. The respective critical regions are defined using the z statistics 2 and 3. Data having a calculated z value ≤2 are accepted as in control at the 5% level of significance. Data that have a calculated z value >2 and ≤3.0 are considered at the warning level, or the 0.2% level of significance. Data

with a z value >3.0 are considered out of control. This criterion is also incorporated in the QACHECK computer program.

The percentage of the tests for each parameter where X_E - X_C fell within ≤2 S_T (under control), between $2S_T$ and $3S_T$ (warning level), or outside $>3S_T$ (out of control) is shown in Tables D-26 to D-36. A summary of the overall state of statistical control for analytical work done by EM-9 is also provided in Table VIII-2.

Table VIII-3 summarizes recovery information on organic surrogate compounds required for use in the EPA-Contract Laboratory Program protocol. Table VIII-4 summarizes EM-9's overall record of meeting EPA SW-846 holding times for EM-9 samples during 1991. The data include all samples where holding times were missed and the customer elected to either resample or accept the data as usable.

Table D-37 reports the incidence of false positive results for blank QC samples and false negative results for spiked QC samples at the 95% confidence level.

For most radiochemical and inorganic analyses, more than 90% are within <2 propagated standard deviations of the certified/consensus mean values (under control). EM-9's performance on most classes of inorganic matrices remained virtually unchanged since 1990, while improvement in radiochemical determinations in soils was observed. Unfortunately, the overall control of radiochemical analyses in biological materials declined over the 1990 record as did that of stable elements in soils. These areas will be the focus of increased QA/QC efforts in the future. Overall control on organic measurements in all materials remained at over 90% with all organic determinations being under control. Data on analytical detection limits are given in Table D-38.

Table VIII-2. Overall Summary of EM-9 Quality Assurance Tests for 1991

Analysis	No. QC with CV[a]	Under Control <2z (%)	Warning 2–3z (%)	Out of Control >3z (%)
Stable Elements				
Biological Materials	4	75	25	—
Filters	13	100	—	—
Bulk Materials	18	100	—	—
Soil	1,263	82	8	10
Water	3,400	97	2	1
Radiochemical Elements				
Biologicals	67	76	11	13
Filters	168	97	2	1
Soils	475	89	8	3
Water	988	95	4	1
Organic Compounds				
Filters	268	92	6	2
Bulk Materials	284	98	1	1
Soil	4,621	95	1	4
Charcoal Tube	897	97	1	2
Water	3,008	96	1	3

[a]Quality control tests with certified values.

Table VIII-3. Summary of EM-9 Organic Surrogate Compliance with EPA SW-846 Criteria for 1991

Analysis	EPA SW-846 Range Low	EPA SW-846 Range High	Number of Surrogates In-Range	Number of Surrogates Total	% In-Range	% of Samples Run with Surrogate
Volatile Organic Compounds						
In Soil						
1,2-Dichloroethane d4	70	121	464	536	86.6	99.1
Toluene d8	81	117	501	536	93.5	99.1
4-Bromofluorobenzene	74	121	411	536	76.7	99.1
In Water						
1,2-Dichloroethane d4	76	114	178	213	83.6	100.0
Toluene d8	88	110	180	213	84.5	100.0
4-Bromofluorobenzene	86	115	171	213	80.3	100.0
Semivolatile Organic Compounds						
In Soil						
2-Fluorophenol	25	121	331	353	93.8	97.2
Phenol d6	24	113	346	362	95.6	99.7
Nitrobenzene d5	23	120	352	362	97.2	99.7
2-Fluorobiphenyl	30	115	351	362	97.0	99.7
2,4,6-Tribromophenol	19	122	346	362	95.6	99.7
p-Terphenyl d14	18	137	324	362	89.5	99.7
In Water						
2-Fluorophenol	21	100	145	173	83.8	95.1
Phenol d6	10	94	152	173	87.9	95.1
Nitrobenzene d5	35	114	147	173	85.0	95.1
2-Fluorobiphenyl	43	116	150	173	86.7	95.1
2,4,6-Tribromophenol	10	123	161	173	93.1	95.1
p-Terphenyl d14	33	141	141	173	81.5	95.1

Table VIII-4. EPA SW-846 Holding Time Summary for 1991

Organic Analysis Type	Number Meeting EPA Criteria	Total Number Performed	% Within EPA Criteria
Extraction holding times			
Volatiles in soils	363	419	86.6
Volatiles in waters	125	141	88.7
Semivolatiles in soils	274	282	97.2
Semivolatiles in waters	111	133	83.5
Pesticides in soils	29	35	82.9
Pesticides in waters	3	3	100.0
Herbicides in waters	3	3	100.0
PCBs in soils	134	221	60.6
PCBs in waters	35	72	48.6
Instrument analysis holding times			
Volatiles in soils	419	419	100.0
Volatiles in waters	141	141	100.0
Semivolatiles in soils	282	282	100.0
Semivolatiles in waters	133	133	100.0
Pesticides in soils	35	35	100.0
Pesticides in waters	3	3	100.0
Herbicides in waters	3	3	100.0
PCBs in soils	147	221	66.5
PCBs in waters	72	72	100.0

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APPENDIX A

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, and 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;" and 5484.1, "Environmental Radiation Protection, Safety, and Health Protection Information Reporting Requirements," Chap. III, "Effluent and Environmental Monitoring Program Requirements."

DOE regulates radiation exposure to the public and the worker by limiting the radiation dose that can be received during routine Laboratory operation. 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-year dose commitments were calculated using dose factors from Refs. A1 and A2. The dose factors adopted by DOE are based on the recommendations of Publication 30 of the International Commission on Radiological Protection (ICRP).[A3]

In 1990, DOE issued Order 5400.5 which finalized the interim radiation protection standard (RPS) for the public.[A4] 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 that a member of the public can receive from DOE operations to 100 mrem/yr. The PDLs and the information in Refs. A1 and A2 are based on recommendations of the ICRP and the National Council on Radiation Protection and Measurements.[A3,A4]

The effective dose equivalent 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. The effective dose 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 effective dose equivalent includes doses from both internal and external exposure.

Radionuclide concentrations in air and water in uncontrolled areas measured by the Laboratory's surveillance program are compared with DOE's derived concentration guides (DCGs) in this report (Table A-2).[A5] These DCGs represent the smallest estimated concentrations in water or air, taken in continuously for a period of 50 years, that will result in annual effective dose equivalents equal to the PDL of 100 mrem in the 50th year of exposure.

In addition to the 100 mrem/yr effective dose PDL, exposures from the air pathway are also limited by the Environmental Protection Agency's (EPA's) 1989 standard of 10 mrem/yr (effective dose equivalent).[A6] To demonstrate compliance with these standards, doses from the air pathway are compared directly with the EPA dose limits. This dose limit of 10 mrem/yr replaced the previous EPA limits of 25 mrem/yr (whole body) and 75 mrem/yr (any organ).[A7]

Federal and state ambient air quality standards for nonradioactive pollutants are shown in Table A-3. New Mexico nonradiological standards are generally more stringent than national standards.

For chemical constituents in drinking water, standards have been promulgated by the EPA and adopted by the New Mexico Environment Department (NMED) (Table A-4).[A8] The EPA's primary maximum contaminant level (MCL) is the maximum permissible level of a contaminant in water that is delivered to the ultimate user of a public water system.[A9] The EPA's secondary water standards, which are not included in

Table A-1. DOE Public Dose Limits and Radiation Protection Standards for External and Internal Exposures

Exposure of Any Member of the Public [a]

	Effective Dose Equivalent[b] at Point of Maximum Probable Exposure
All Pathways	100 mrem/yr[c]

	Effective Dose Equivalent at Point of Maximum Probable Exposure
Air Pathway Only [d]	10 mrem/yr
Drinking Water	4 mrem/yr

Occupational Exposure [a]

Stochastic Effects	5 rem (annual effective dose equivalent[e])
Nonstochastic Effects	
Lens of eye	15 rem (annual dose equivalent[e])
Extremity	50 rem (annual dose equivalent[e])
Skin of the whole body	50 rem (annual dose equivalent[e])
Organ or tissue	50 rem (annual dose equivalent[e])
Unborn Child	
Entire gestation period	0.5 rem (annual effective dose equivalent[e])

[a]In keeping with DOE policy, exposures shall be limited to as small a fraction of the respective annual dose limits as practicable. DOE's RPS 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 Ref. A4. Limits for occupational exposure are taken from DOE Order 5480.11.

[b]As used by DOE, effective dose equivalent includes both the effective dose equivalent from external radiation and the committed effective dose equivalent to individual tissues from ingestion and inhalation during the calendar year.

[c]Under special circumstances and subject to approval by the DOE, this effective dose equivalent limit may be temporarily increased up to 500 mrem/yr, provided the dose averaged over a lifetime does not exceed the principal limit of 100 mrem/yr.

[d]This level is from EPA's regulations promulgated under the Clean Air Act (40 CFR 61, Subpart H).

[e]Annual effective dose equivalent is the effective dose equivalent received in a year.

Table A-2. DOE's Derived Concentration Guides (DCG) for Public Dose and Derived Air Concentrations (DAC) for Controlled Areas[a]

Nuclide	DCGs for Uncontrolled Areas (μCi/mL) Air	DCGs for Uncontrolled Areas (μCi/mL) Water	Calculated Guides for Drinking Water Systems (μCi/mL)	DACs for Controlled Areas (μCi/mL)
H^3	1×10^{-7}	2×10^{-3}	8×10^{-5}	2×10^{-5}
^7Be	4×10^{-8}	1×10^{-3}	4×10^{-5}	8×10^{-6}
^{89}Sr	3×10^{-10}	2×10^{-5}	8×10^{-7}	6×10^{-8}
^{90}Sr[b]	9×10^{-12}	1×10^{-6}	4×10^{-8}	2×10^{-9}
^{137}Cs	4×10^{-10}	3×10^{-6}	1.2×10^{-7}	7×10^{-8}
^{234}U	9×10^{-14}	5×10^{-7}	2×10^{-8}	2×10^{-11}
^{235}U	1×10^{-13}	6×10^{-7}	2.4×10^{-8}	2×10^{-11}
^{238}U	1×10^{-13}	6×10^{-7}	2.4×10^{-8}	2×10^{-11}
^{238}Pu	3×10^{-14}	4×10^{-8}	1.6×10^{-9}	3×10^{-12}
^{239}Pu[b]	2×10^{-14}	3×10^{-8}	1.2×10^{-9}	2×10^{-12}
^{240}Pu	2×10^{-14}	3×10^{-8}	1.2×10^{-9}	2×10^{-12}
^{241}Am	2×10^{-14}	3×10^{-8}	1.2×10^{-9}	2×10^{-12}
	(pg/m³)	(mg/L)	(mg/L)	(pg/m³)
Natural Uranium	1×10^{5}	8×10^{-1}	3×10^{-2}	3×10^{7}

[a]Guides for uncontrolled areas are based on DOE's Public Dose Limit (PDL) for the general public;[A4] those for controlled areas are based on occupational Radiation Protection Standards (RPSs) for DOE Order 5480.11 ("Radiation Protection for Occupational Workers," December 21, 1988). Guides apply to concentrations in excess of those occurring naturally or that are due to fallout.

[b]Guides for ^{239}Pu and ^{90}Sr are the most appropriate to use for gross alpha and gross beta, respectively.

the NMED Water Supply Regulations and are not enforceable, relate to contaminants in drinking water that primarily affect aesthetic qualities associated with public acceptance of drinking water.[A9] At considerably higher concentrations of these contaminants, health implications may arise.

Radioactivity in drinking water is regulated by EPA regulations contained in 40 CFR 141[A9] and New Mexico Water Supplies Regulations, Sections 206 and 207.[A8] These regulations provide that combined ^{226}Ra and ^{228}Ra may not exceed 5×10^{-9} μCi/mL. Gross alpha activity (including ^{226}Ra, but excluding radon and uranium) may not exceed 15×10^{-9} μCi/mL.

A screening level of 5×10^{-9} μCi/mL 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-4) and the DOE guides calculated for the DCGs applicable to drinking water (Table A-2).

For manmade beta- and photon-emitting radionuclides, EPA drinking water standards are limited to concentrations that would result in doses not exceeding 4 mrem/yr, calculated according to a specified procedure. In addition, DOE Order 5400.5 requires that DOE-operated public water supplies not cause persons consuming the water to receive an effective dose equivalent exceeding 4 mrem/yr. Drinking water concentration guides based on this requirement are in Table A-2.

In its regulations, the EPA has established minimum concentrations of certain contaminants in water extracted from wastes that will cause the waste to be designated as hazardous by reason of toxicity.[A10] The toxicity characteristic leaching procedure (TCLP) must

follow steps outlined by the EPA in 40 CFR 261, Appendix II. In this report, the TCLP minimum concentrations (Table A-5) are used for comparison with concentrations of selected constituents in extracts from the Laboratory's active waste areas.

The NMED is now using numeric Livestock and Wildlife Watering Standards (Table A-6)[A11] to evaluate requirements for National Pollutant Discharge Elimination System (NPDES) discharges into normally dry canyons where the attainable use is only livestock and wildlife watering. In this report, surface waters and shallow alluvial water sample analyses are compared to these values as a potential actual use of the water regardless of whether the water is directly from an NPDES outfall.

Table A-3. National and New Mexico Ambient Air Quality Standards

Pollutant	Averaging Time	Unit	New Mexico Standard	Federal Standards Primary	Federal Standards Secondary
Sulfur dioxide	Annual arithmetic mean	ppm	0.02	0.03	
	24 hours[a]	ppm	0.10	0.14	
	3 hours[a]	ppm			0.5
Total suspended particulate matter	Annual geometric mean	μg/m³	60		
	30 days	μg/m³	90		
	7 days	μg/m³	110		
	24 hours[a]	μg/m³	150		
PM_{10}[b]	Annual arithmetic mean	μg/m³		50	50
	24 hours	μg/m³		150	150
Carbon monoxide	8 hours[a]	ppm	8.7	9	
	1 hour[a]	ppm	13.1	35	
Ozone	1 hour[c]	ppm	0.06	0.12	0.12
Nitrogen dioxide	Annual arithmetic mean	ppm	0.05	0.053	0.053
	24 hours[a]	ppm	0.10		
Lead	Calendar quarter	μg/m³		1.5	1.5
Beryllium	30 days	μg/m³	0.01		
Asbestos	30 days	μg/m³	0.01		
Heavy metals (total combined)	30 days	μg/m³	10		
Nonmethane hydrocarbons	3 hours	ppm	0.19		

[a]Maximum concentration, not to be exceeded more than once per year.

[b]Particles measured at an effective diameter of <10 μm.

[c]The standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above the limit is ≤1.

Table A-4. Maximum Contaminant Level in the Water Supply for Inorganic Chemicals, Organic Chemicals, and Radiochemicals[a]

Inorganic Chemical Contaminant	MCL (mg/L)
Primary Standards	
Ag	0.05
As	0.05
Ba	1
Cd	0.010
Cr	0.05
F	4.0
Hg	0.002
NO_3 (as N)	10
Pb	0.05
Se	0.01
Secondary Standards	
Cl	250
Cu	1
Fe	0.3
Mn	0.05
SO_4	250
Zn	5.0
TDS[c]	500
pH	6.5–8.5

Radiochemical Contaminant	MCL
Gross alpha[b]	15×10^{-9} µCi/mL
Gross beta & photon[c]	4 mrem/yr
H^3	$20{,}000 \times 10^{-9}$ µCi/mL
^{90}Sr	8×10^{-9} µCi/mL

Organic Chemical Contaminant	MCL (mg/L)
Insecticides:	
Endrin (1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4,4a,5,6,7,8a-octa hydro-1,4-endo, endo-5, 8-dimethano napthalene)	0.0002
Lindane (1,2,3,4,5,6-hexachlorocyclohexane, gamma isomer)	0.004
Methoxychlor (1,1,1-Trichloro-2, 2-bis[p-methoxyphenyl] ethane)	0.1
Toxaphene ($C_{10}H_{10}C_{l8}$ - technical chlorinated camphene, 67-69 percent chlorine)	0.005
Herbicides:	
2,4-D, (2,4-Dichlorophenoxyacetic acid)	0.1
2,4,5-TP Silvex (2,4,5-Trichlorophenoxy-propionic acid)	0.01
Total trihalomethanes (TTHM)	0.10

Table A-4 (Cont.)

Other Organic Contaminants:	
Benzene	0.005
Vinyl Chloride	0.002
Carbon tetrachloride	0.005
1,2-Dichloroethane	0.005
Trichloroethylene	0.005
1,1-Dichloroethylene	0.007
1,1,1-Trichloroethane	0.20
para-Dichlorobenzene	0.075

Microbiological Contaminant	**MCL**
Total coliforms - presence	5% of samples/month
Fecal coliform or E. Coli - presence	0 sample/month

[a]Refs. A8 and A9.

[b]See text for discussion of application of gross alpha MCL and gross alpha screening level of 5×10^{-9} μCi/mL.

[c]Screening limit for gross beta activity is 50×10^{-9} μCi/mL.[A8]

[d]Ref. A8.

Table A-5. Toxicity Characteristic Leaching Procedure Levels[a,b]

Contaminant	(mg/L)
Arsenic	5.0
Barium	100.0
Benzene	0.5
Cadmium	1.0
Carbon tetrachloride	0.5
Chlordane	0.03
Chlorobenzene	100.0
Chloroform	6.0
Chromium	5.0
o-Cresol	200.0
m-Cresol	200.0
p-Cresol	200.0
Cresol	200.0
2,4-D	10.0
1,4-Dichlorobenzene	7.5
1,2-Dichloroethane	0.5
1,1-Dichloroethylene	0.7
2,4-Dinitrotoluene	0.13
Endrin	0.02
Heptachlor (and its epoxide)	0.008
Hexachlorobenzene	0.13
Hexachlorobutadiene	0.5
Hexachloroethane	3.0
Lead	5.0
Lindane	0.4
Mercury	0.2
Methoxychlor	10.0
Methyl ethyl ketone	200.0
Nitrobenzene	2.0
Pentachlorophenol	100.0
Pyridine	5.0
Selenium	1.0
Silver	5.0
Tetrachloroethylene	0.7
Toxaphene	0.5
Trichloroethylene	0.5
2,4,5-Trichlorophenol	400.0
2,4,6-Trichlorophenol	2.0
2,4,5-TP (Silvex)	1.0
Vinyl chloride	0.2

[a]Concentrations of inorganic contaminants that constitute hazardous waste.
[b]Ref. A10.

Table A-6. Wildlife Watering Standards[a]

Livestock Contaminant	Concentration (mg/L)
Dissolved Al	5.0
Dissolved As	0.02
Dissolved B	5.0
Dissolved Cd	0.05
Dissolved $Cr^{(+3, +6)}$	1.0
Dissolved Co	1.0
Dissolved Cu	0.5
Dissolved Pb	0.1
Total Hg	0.01
Dissolved Se	0.05
Dissolved V	0.1
Dissolved Zn	25.0
^{226}Ra, ^{228}Ra	30 pCi/L

[a] Ref. All

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A1. U.S. Department of Energy, "Internal Dose Conversion Factors for Calculation of Dose to the Public," U.S. Department of Energy report DOE/EH-0071 (July 1988).

A2. U.S. Department of Energy, "External Dose-Rate Conversion Factors for Calculation of Dose to the Public," U.S. Department of Energy report DOE/EH-0070 (July 1988).

A3. 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).

A4. National Council on Radiation Protection and Measurements, "Recommendations on Limits for Exposure to Ionizing Radiation," NCRP report No. 91 (June 1987).

A5. U.S. Department of Energy, "Radiation Protection of the Public and the Environment," U.S. Department of Energy Order 5400.5 (February 8, 1990).

A6. U.S. Environmental Protection Agency, "40 CFR 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).

A7. U.S. Environmental Protection Agency, "National Emission Standard for Radionuclide Emissions from Department of Energy Facilities," *Code of Federal Regulations,* Title 40, Part 61, Subpart H (1985).

A8. Environmental Improvement Board, State of New Mexico, "New Mexico Water Supply Regulations," (as amended through April 16, 1991).

A9. U.S. Environmental Protection Agency, "National Primary Drinking Water Regulations," *Code of Federal Regulations,* Title 40, Parts 141 and 142 (1989), and "National Secondary Drinking Water Regulations," Part 143 (1989).

A10. U.S. Environmental Protection Agency, "Title 40, Part 261, Identification and Listing of Hazardous Waste. Table I. Maximum Concentration of Contaminants for the Toxicity Concentrations," (July 1, 1990 edition).

A11. New Mexico Water Quality Control Commission, "Water Quality Standards for Interstate and Intrastate Streams in New Mexico," Section 3-101.K (as amended through October 8, 1991; effective November 12, 1991).

APPENDIX B

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, U.S. Customary Units (that is, curie [Ci], roentgen [R], rad, and rem) are retained 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. Table B-2 presents conversion factors for converting from SI units to U.S. Customary Units. Table B-3 presents common measurement abbreviations.

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 U.S. Customary Unit
Celsius (°C)	9/5 + 32	Fahrenheit (°F)
Centimeters (cm)	0.39	Inches (in.)
Cubic meters (m^3)	35	Cubic feet (ft^3)
Hectares (ha)	2.5	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)	3.3	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)	0.39	Square miles (mi^2)

Table B-3. Common Measurement Abbreviations

aCi	attocurie
Btu/yr	British thermal unit per year
cc/sec	cubic centimeters per second
cfm	cubic feet per minute
cfs	cubic feet per second
Ci	curie
cpm/L	counts per minute per liter
fCi/g	femtocurie per gram
ft	foot
ft^3/s	cubic feet per second
gal.	gallon
in.	inch
kg	kilogram
kg/h	kilogram per hour
L or l	liter
lb	pound
lb/h	pound per hour
lin ft	linear feet
m^3/s	cubic meter per second
µCi/L	microcurie per liter
µCi/mL	microcurie per milliliter
µg/g	microgram per gram
$\mu g/m^3$	microgram per cubic meter
mL or ml	milliliter
mm	millimeter
µm	micrometer
µmho/cm	micro mho per centimeter (mho is the reciprocal of ohm)
mCi	millicurie
mR	milliroentgen
mrem	millirem
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 microns in diameter)
sq ft (ft^2)	square feet
TU	tritium unit

APPENDIX C

DESCRIPTIONS OF TECHNICAL AREAS AND THEIR ASSOCIATED PROGRAMS

Locations of the technical areas (TAs) operated by the Laboratory in Los Alamos County are shown in Sec. II, Fig. II-4. The main programs conducted at each of the areas are listed in this Appendix.

TA-2, Omega Site: Omega West Reactor, an 8-MW nuclear research reactor, is located here. It serves as a research tool by providing a source of neutrons for fundamental studies in nuclear physics and associated fields.

TA-3, Core Area: In this main technical area of the Laboratory is the Administration Building that contains the Director's office and administrative offices and laboratories for several divisions. Other buildings house the central computing facility, materials division, science museum, chemistry and materials science laboratories, physics laboratories, technical shops, cryogenics laboratories, a Van de Graaff accelerator, the main cafeteria, and the Study Center.

TA-5, Beta Site: This site contains some physical support functions, several archaeological sites, and environmental monitoring and buffer areas.

TA-6, Two-Mile Mesa 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-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 to 1,000,000 V and a 24-MeV betatron), radioactive-isotope 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 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 and for fragment impact tests.

TA-15, R Site: This is the home of PHERMEX, a multiple-cavity electron accelerator capable of producing a very large flux of x rays for certain weapons development problems and tests. This site is also used for the investigation of weapons functioning and systems behavior in non-nuclear tests, principally by electronic recording means.

TA-16, S Site: Investigations at this site include development, engineering design, prototype manufacture, and environmental testing of nuclear weapons warhead systems. 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: The fundamental behavior of nuclear chain reactions with simple,

low-power reactors called critical assemblies is studied here. Experiments are operated by remote control and observed by closed-circuit television. 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 materials. This is done to study the effects of various shapes, sizes, and configurations. These machines are also used as a source of fission neutrons in large quantities for experimental purposes.

TA-21, DP Site: This site has two primary research areas: DP West and DP East. DP West is concerned with chemistry research; DP East is the high-temperature chemistry and tritium research site. Currently, several structures are undergoing decontamination and decommissioning. The future use of TA-21 is being studied.

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. The National Radio Astronomy Observatory's Very Large Baseline Array Telescope is located at this site.

TA-35, Ten Site: Nuclear safeguards research and development, which are conducted here, are concerned with techniques for nondestructive detection, identification, and analysis of fissionable isotopes. Research in reactor safety and laser fusion is also done here.

TA-36, Kappa Site: Various explosives phenomena, such as detonation velocity, are investigated at this dynamic testing site.

TA-37, Magazine Area C: This is an explosives storage site.

TA-39, Ancho Canyon Site: Non-nuclear weapons behavior is studied here, primarily by photographic techniques. Investigations are also made into various phenomenological aspects of explosives, interactions of explosives, and explosions involving other materials.

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 initiating high explosives and research in rapid shock-induced reactions.

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: Research performed at this site includes cellular radiobiology, biophysics, mammalian radiobiology, and mammalian metabolism. A large medical library; special counters used to measure radioactivity in humans and animals; and animal quarters for dogs, mice, and monkeys are also located in this building.

TA-46, WA Site: Applied photochemistry, which includes development of technology for laser isotope separation and laser enhancement of chemical processes, is investigated here. Solar energy research, particularly in the area of passive solar heating for residences, is also done at this site.

TA-48, Radiochemistry Site: Laboratory scientists and technicians at this site study nuclear properties of radioactive materials by using analytical and physical chemistry. Measurements of radioactive substances are made, and "hot cells" are used for remote handling of radioactive materials.

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.

TA-50, Waste Management Site: Personnel at this site have responsibility for treating and disposing of most industrial liquid and radioactive liquid waste received from Laboratory technical areas, for development of improved methods of solid waste treatment, and for containment of radioactivity removed by treatment.

TA-51, Animal Exposure Facility: At this site, animals are exposed to nonradioactive toxic materials to determine biological effects of high and low exposures.

TA-52, Reactor Development Site: A wide variety of activities related to nuclear reactor performance and safety is done at this site.

TA-53, Meson Physics Facility: The Los Alamos Meson Physics Facility, a linear particle accelerator, is used to conduct research in areas of basic physics, cancer treatment, materials studies, and isotope production. The Los Alamos Neutron Scattering Center and the Proton Storage Ring are also located at this TA.

TA-54, Waste Disposal Site: The primary function of this site is radioactive solid and hazardous chemical waste management and disposal.

TA-55, Plutonium Facility Site: Processing of plutonium and research in plutonium metallurgy are done at this site.

TA-57, Fenton Hill Site: This is the location of the Laboratory's Hot Dry Rock geothermal project. Scientists at this site are studying the possibility of producing energy by circulating water through hot, dry rock located hundreds of meters below the earth's surface. The water is heated and then brought to the surface to drive electric generators.

TA-59, Occupational Health Site: Occupational health and environmental science activities are conducted at this site.

TA-60, Sigma Mesa: This area contains physical support and infrastructure facilities, including the Test Fabrication Facility.

TA-61, East Jemez Road: This site is used for physical support and infrastructure facilities, including the sanitary landfill.

TA-63: This area contains physical support facilities operated by Johnson Controls Inc.

TA-64: This is the site of the Central Guard Facility.

TA-66: This site is used for public and corporate interface functions.

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 San Ildefonso Pueblo on the east, is isolated from most of the Laboratory and contains significant concentrations of archaeological sites and an endangered species breeding area.

APPENDIX D

ENVIRONMENTAL BACKGROUND INFORMATION

Table D-1. Hazardous Waste Management Facilities at Los Alamos National Laboratory.

Technical Area	Facility Type	Inclusion in Part B Permit Application or Interim Status[a]
3-29[b]	Container (2 Units)	Interim S
3-102-118A	Container	Closed
14-35	OB/OD (2 Units)[c]	Interim T
15-184[b]	OB/OD	Interim T
16, Area-P	Landfill	Under Closure
16	OB/OD (6 Units)	Interim T
16	Surface Impoundment	Under Closure
16-88[b]	Container	Interim S
16-1150	Incinerator	Interim T
21-61[b]	Container	Interim S
22-24	Container	Closed
35-85	Surface Impoundment	Under Closure
35-125	Surface Impoundment	Under Closure
36-8[b]	OB/OD	Interim T
39-6	OB/OD	Interim T
39-57	OB/OD	Interim T
40, SDS	OB/OD	Under Closure
40-2	Container	Closed
50-1-60A[b]	Container	Interim TS
50-1-60D[b]	Container	Interim S
50-1-BWTP	Above Ground Tank	Permitted TS
50-37-115[b]	Above Ground Tank (2 Units)	Interim S
50-37-115[b]	Container	Interim S
50-37-117	Container	Permitted S
50-37-117[b]	Container	Interim S
50-37-118[b]	Container	Interim S
50-37-CAI[b]	Incinerator	Interim T
50-37-CAI	Incinerator	Permitted T
50-69[b]	Container	Interim S
50-69[b]	Container	Interim S
50-114	Container	Permitted S
50-114[b]	Container	Interim S
50-137[d]	Container	Permitted S
50-138[d]	Container	Permitted S
50-139[d]	Container	Permitted S
50-140[d]	Container	Permitted S
53-166[b]	NE Surface Impoundment	Interim S
53-166[b]	NW Surface Impoundment	Interim S
53-166[b]	S Surface Impoundment	Interim S
54, Area-G Over Pit 33[b]	Container	Interim S
54, Area-G	Landfill	Under Closure

Table D-1. (Cont.)

Technical Area	Facility Type	Inclusion in Part B Permit Application or Interim Status[a]
54, Area-G Pad 1[b]	Container	Interim S
54, Area-G Pad 2[b]	Container	Interim S
54, Area-G Pad 4[b]	Container	Interim S
54, Area-H	Landfill	Under Closure
54, Area-G Over Pit 30[b]	Container	Interim S
54, Area-G Shaft 145[b]	Container	Interim S
54, Area-G Shaft 146[b]	Container	Interim S
54, Area-G Shaft 148[b]	Container	Interim S
54, Area-L Shaft 36[b]	Container	Interim S
54, Area-L Shaft 37[b]	Container	Interim S
54, Area-G Shaft 147[b]	Container	Interim S
54, Area-G Shaft 149[b]	Container	Interim S
54, Area L	Above Ground Tank (4 Tanks)	Permitted T
54, Area L Gas Cyl[b]	Container	Interim S
54, Area L Gas Cyl	Container	Permitted S
54-8[b]	Container	Interim S
54-31	Container	Permitted S
54-32	Container	Permitted S
54-33[b]	Container	Interim S
54-48[b]	Container	Interim S
54-49[b]	Container	Interim S
54-68	Container	Permitted S
54-69	Container	Permitted S
55, Near Bldg 4[b]	Container	Interim S
55-4[b]	Container (3 Units)	Interim S
55-4[b]	Tank (13 Tanks)	Interim TS
55-4[b]	Container	Interim S
55-4[b]	Container	Interim S
55-4[b]	Container	Interim TS
55-4[b]	Container	Interim S

[a]S = Storage; T = Treatment.
[b]Designates mixed waste units.
[c]OB/OD = open burning/open detonation.
[d]These units have not yet been constructed.

Table D-2. Types of Discharges and Parameters Monitored at the Laboratory under its NPDES Permit NM0028355

EPA Identification No.	Type of Discharge	Number of Outfalls	Monitoring Required	Sampling Frequency
01A	Power plant	1	Total suspended solids, free available chlorine, pH, flow	Monthly
02A	Boiler blowdown	2	pH, total suspended solids, flow, copper, iron, phosphorus, sulfite, total chromium	Weekly
03A	Treated cooling water	38	Total suspended solids, free available chlorine, phosphorus, pH, flow	Weekly
04A	Noncontact cooling water	52	pH, flow	Weekly
050 051	Radioactive waste treatment plant (TA-21 & TA-50)	2	Ammonia, chemical oxygen demand, total suspended solids, cadmium, chromium, copper, iron, lead, mercury, zinc, pH, flow	Weekly
05A	High explosives wastewater	21	Chemical oxygen demand, pH, flow, total suspended solids	Weekly
06A	Photo wastewater	13	Cyanide, silver, pH, flow	Weekly
128	Printed circuit board	1	pH, chemical oxygen demand, total suspended solids, iron, copper, silver, flow	Weekly
S	Sanitary wastewater	9	Biochemical oxygen demand, flow, pH, total suspended solids, fecal coliform bacteria	Variable frequency, from three per month to once quarterly

Table D-3. Limits Established by NPDES Permit NM0028355 for Sanitary Outfall Discharges

Discharge Category	Permit Parameter	Daily Average	Daily Maximum	Unit of Measurement
01S TA-3 Treatment Plant	BOD[a]	30.0	45.0	mg/l
		225.2	N/A	lb/day
	TSS[b]	30.0	45.0	mg/l
		225.2	N/A	lb/day
	Fecal coliform bacteria	1,000.0	2,000.0	org/100 ml
	pH	6–9	6–9	standard unit
02S TA-9 Lagoon and Sand Filters	BOD	30.0	45.0	mg/l
		0.3	N/A	lb/day
	TSS	30.0	45.0	mg/l
		0.3	N/A	lb/day
	pH	6–9	6–9	standard unit
03S TA-16 Treatment Plant	BOD	30.0	45.0	mg/l
		25.0	N/A	lb/day
	TSS	30.0	45.0	mg/l
		25.0	N/A	lb/day
	pH	6–9	6–9	standard unit
04S TA-18 Lagoons	BOD	100.0[c]	175.0[c]	mg/l
		2.5[c]	N/A	lb/day
	TSS	100.0[c]	200.0[c]	mg/l
		2.5[c]	N/A	lb/day
	pH	5.5–11.5[c]	5.5–11.5[c]	standard unit
05S TA-21 Package Plant	BOD	100.0[c]	175.0[c]	mg/l
		12.5[c]	N/A	lb/day
	TSS	150.0[c]	200.0[c]	mg/l
		12.5[c]	N/A	lb/day
	pH	5.5–11.5[c]	5.5–11.5[c]	standard unit

Table D-3. (Cont.)

Discharge Category	Permit Parameter	Daily Average	Daily Maximum	Unit of Measurement
07S TA-46N Lagoons & Sand Filters	BOD	30.0	45.0	mg/l
		1.3	N/A	lb/d
	TSS	30.0	45.0	mg/l
		1.3	N/A	lb/d
	pH	6–9	6–9	standard unit
09S TA-53 Lagoons	BOD	100.0[c]	175.0[c]	mg/l
		94.0[c]	N/A	lb/day
	TSS	150.0[c]	200.0[c]	mg/l
		94.0[c]	N/A	lb/day
	pH	5.5–11.5[c]	5.5–11.5[c]	standard unit
10S TA-35 Lagoons & Sand Filters	BOD	100.0[c]	175.0[c]	mg/l
		94.0[c]	N/A	lb/d
	TSS	150.0[c]	200.0[c]	mg/l
		94.0[c]	N/A	lb/d
	pH	5.5[c]	11.5[c]	standard unit
12S TA-46S Lagoons	BOD	100.0[c]	175.0[c]	mg/l
		2.5[c]	N/A	lb/d
	TSS	100.0[c]	200.0[c]	mg/l
		2.5[c]	N/A	lb/d
	pH	5.5–11.5[c]	5.5–11.5[c]	standard unit

[a]Biochemical oxygen demand.
[b]Total suspended solids.
[c]Interim effluent limitations in effect pursuant to FFCA dated November 22, 1991.

Table D-4. NPDES Permit Monitoring of Effluent Quality at Sanitary Sewage Treatment Outfalls

Discharge Location (Outfall)	Permit Parameters	Number of Deviations	Range of Deviation
TA-3 (01S)	BOD[a]	0	—
	TSS[b]	0	—
	Fecal coliform bacteria[c]	1	21,400
	pH[d]	0	—
	Foam	1	present/trace
	Foam	1	present/trace
TA-9 (02S)	BOD	0	—
	TSS	0	—
	pH	0	—
TA-16 (03S)	BOD	0	—
	TSS	0	—
	pH	0	—
TA-18 (04S)	BOD	0	—
	TSS (90)	0	—
	pH	0	—
TA-21 (05S)	BOD	0	—
	TSS	0	—
	pH	0	—
TA-35 (10S)	BOD	0	—
	TSS (90)	0	—
	pH	0	—
TA-41 (06S)	BOD	0	—
	TSS	0	—
	Fecal coliform bacteria	0	—
	pH	0	—
TA-46 (07S)	BOD	0	—
	TSS	0	—
	pH	0	—
TA-46 (12S)	BOD	0	—
	TSS	0	—
	pH	0	—
TA-53 (09S)	BOD	0	—
	TSS (90)	0	—
	pH	0	—

[a]Biochemical oxygen demand (BOD) permit limits are 30 mg/L (30-day average) and 45 mg/L (7-day average).

[b]Total suspended solids (TSS) permit limits are 30 mg/L (30-day average) and 45 mg/L or 90 mg/L (7-day average), dependent on the specific outfall.

[c]Fecal coliform bacteria limits are 1,000 organisms/100 mL (30-day average) and 2,000 organisms/100 mL (7-day average).

[d]Range of permit pH limits is between 6.0 and 9.0 standard units.

Table D-5. Limits Established by NPDES Permit NM0028355 for Industrial Outfall Discharges

Discharge Category	Permit Parameter	Daily Average	Daily Maximum	Unit of Measurement
01A Power plant	TSS[a]	30.0	100.0	mg/L
	Free Cl	0.2	0.5	mg/L
	pH	6–9	6–9	standard unit
02A Boiler blowdown	TSS	30	100	mg/L
	Fe	10	40	mg/L
	Cu	1	1	mg/L
	P	20	40	mg/L
	SO_3	35	70	mg/L
	Cr	Report	Report	mg/L
	pH	6–9	6–9	standard unit
03A Treated cooling water	TSS	30.0	100.0	mg/L
	Free Cl	0.2	0.5	mg/L
	P	20.0[b]	40.0[b]	mg/L
04A Noncontact cooling water	pH	6–9	6–9	standard unit
050 Radioactive waste	COD[c]	18.8	37.5	lb/day
051 treatment plants	COD[d]	94.0	156.0	lb/day
	TSS[c]	3.8	12.5	lb/day
	TSS[d]	18.8	62.6	lb/day
	Cd[c]	0.01	0.06	lb/day
	Cd[d]	0.06	0.3	lb/day
	Cr[c]	0.02	0.08	lb/day
	Cr[d]	0.19	0.38	lb/day
	Cu[c]	0.13	0.13	lb/day
	Cu[d]	0.63	0.63	lb/day
	Fe[c]	0.13	0.13	lb/day
	Fe[d]	1.0	2.0	lb/day
	Pb[c]	0.01	0.03	lb/day
	Pb[d]	0.06	0.15	lb/day
	Hg[c]	0.007	0.02	lb/day
	Hg[d]	0.003	0.09	lb/day
	Zn[c]	0.13	0.37	lb/day
	Zn[d]	0.62	1.83	lb/day
	pH[c]	6–9	6–9	standard unit
	pH[d]	6–9	6–9	standard unit

Table D-5. (Cont.)

Discharge Category	Permit Parameter	Daily Average	Daily Maximum	Unit of Measurement
05A High explosive	COD	150.0	250.0	mg/L
	TSS	30.0	45.0	mg/L
	pH	6–9	6–9	standard unit
06A Photo waste	CN	0.2	0.2	mg/L
	Ag	0.5	1.0	mg/L
	pH	6–9	6–9	standard unit
128 Printed circuit board	COD	1.9	3.8	lb/day
	TSS	1.25	2.5	lb/day
	Fe	0.05	0.1	lb/day
	Cu	0.05	0.1	lb/day
	Ag	Report	Report	lb/day
	pH	6–9	6–9	standard unit

[a]Total suspendid solids.

[b]Interim effluent limitations in effect pursuant to FFCA dated November 22, 1991.

[c]Limitations for outfall 050 located at TA-21-257; COD = chemical oxygen demand.

[d]Limitations for outfall 051 located at TA-50-1.

Table D-6. NPDES Permit Monitoring of Effluent Quality at Industrial Outfalls[a]

Discharge Category	Outfall No.	Number of Outfalls	Permit Parameter	Number of Deviations	Range of Deviations	Number of Outfalls with Deviations
Power plant	01A	1	TSS[b]	0	—	0
			Free Cl	0	—	0
			pH	2	10.4–10.9	2
Boiler blowdown	02A	2	pH	1	9.8	1
			TSS	3	451.0–1,694.0	1
			Cu	0	—	0
			Fe	0	—	0
			P	3	62.0–384.0	1
			SO_3	0	—	0
			Cr	0	—	0
			Foam	1	—	1
			Foam	1	—	1
			Floating Solids	1	present/trace	1
Treated cooling water	03A	38	TSS	2	818.0–2,072.0	1
			Free Cl	1	1.4	1
			P	1	7.26	1
			pH	1	5.4	1
			Foam	1	present/trace	1
Noncontact cooling water	04A	52	pH	0	—	0
Radioactive waste treatment plant	051 and 050	2	COD[c]	0	—	0
			TSS	0	—	0
			Cd	0	—	0
			Cr	0	—	0
			Cu	0	—	0
			Fe	0	—	0
			Pb	0	—	0
			Hg	0	—	0
			Zn	0	—	0
			pH	0	—	0
High explosive	05A	21	COD	1	1,010.0	1
			TSS	0	—	0
			pH	0	—	0

Table D-6. (Cont.)

Discharge Category	Outfall No.	Number of Outfalls	Permit Parameter	Number of Deviations	Range of Deviations	Number of Outfalls with Deviations
Photo waste	06A	13	CN	0	—	0
			Ag	0	—	0
			TSS	0	—	0
			pH	0	—	0
Printed circuit board	128	1	pH	1	9.7	1
			COD	1	3.9	1
			Ag	0	—	0
			Fe	0	—	0
			Cu	0	—	0
			TSS	0	—	0
		130				

[a]Limits set by the NPDES permit are presented in Table D-3.

[b]Total suspended solids.

[c]Chemical oxygen demand.

Table D-7. Federal Facility Compliance Agreement: Schedule for Upgrading the Laboratory's Wastewater Outfalls

Outfalls	Date	Status or Target Date
Outfall 02A (Boiler Blowdown)		
Final design complete	December 1988	Completed
Advertisement of construction contract	February 1989	Completed
Award of construction contract	April 1989	Completed
Construction completion	September 1989	Completed
In compliance with final limits	October 1989	Completed
Outfall 02A-007 (TA-16 Steam Plant)		
Final design complete	April 1991	Completed
Construction complete	September 1991	September 1992
In compliance with final limits	October 1991	October 1992
Outfall 05A (HE Wastewater Discharge)		
Final design complete	December 1988	Completed
Advertisement of construction contract	February 1989	Completed
Award of construction contract	April 1989	Completed
Construction completion	August 1989	Completed
In compliance with final limits	October 1989	Completed
Outfall 04S (TA-18 Sanitary Treatment Plant)		
Outfall 10S (TA-35 Sanitary Lagoons)		
Outfall 12S (TA-46 Sanitary Lagoons)		
Final design complete	June 1990	Completed
Advertisement of construction contract	September 1990	Completed
Award of construction contract	December 1989	Completed
Construction completion	January 1992	September 1992
Special facilities completion and facility startup	September 1992	October 1992
In compliance with final limits	October 1992	October 1992
Outfall 05S (TA-21 Sanitary Package Plant)[a]		
Final design complete	August 1990	Completed
Advertisement of construction contract	September 1990	Completed
Award of construction contract	December 1990	Completed
Construction completion	January 1992	Completed
Special facilities completion and facility startup	June 1992	Completed
In compliance with final limits	July 1992	Completed
Outfall 03A (Treated Cooling Water)		
Study complete	September 1991	Completed
Corrective actions complete	March 1992	Completed
In compliance with final limits	July 1992	Completed

Table D-7. (Cont.)

Outfalls	Date	Status or Target Date
Outfall 03A-023 (Treated Cooling Water)		
Complete waste stream characterization of storm drainage system	October 1991	Completed
Complete other corrective actions	October 1991	Completed
In compliance with final limits	January 1992	Completed
Outfall 09S (TA-53 Sanitary Lagoons)		
Final design complete	March 1991	Completed
Advertisement of construction contract	January 1992	Completed
Award of construction contract	March 1992	June 1992
Construction completion	July 1992	December 1992
Special facilities completion and facilities startup	July 1992	December 1992
In compliance with final limits	August 1992	December 1992
Waste Stream Characterization		
Start Survey	October 1991	Completed
Complete Survey	July 1993	July 1993

[a]Schedule based on Phase I (Sand Filter Addition) of the TA-21 Plant Upgrades.

Table D-8. Locations of Air Sampling Stations[a]

Station	Latitude or North-South Coordinate	Longitude or East-West Coordinate
Regional (28–44 km)		
1. Española	36°00′	106°06′
2. Pojoaque	35°52′	106°02′
3. Santa Fe	35°40′	106°56′
Perimeter (0–4 km)		
4. Barranca School	35°54′09″	106°16′55″
5. Arkansas Avenue	35°54′06″	106°19′10″
6. 48th Street	35°52′58″	106°19′43″
7. Shell Station	35°52′51″	106°18′21″
8. McDonald's	35°52′42″	106°17′57″
9. Los Alamos Airport	35°52ó55″	106°16′33″
10. East Gate	35°52′32″	106°15′19″
11. Well PM-1	35°51′36″	106°13′31″
12. Royal Crest Trailer Park	35°52′21″	106°18′01″
13. White Rock- Piñon School	35°49′22″	106°12′46″
14. Pajarito Acres	35°47′35″	106°12′31″
15. White Rock Fire Station	35°49′44″	106°12′20″
16. White Rock Church of the Nazarene	35°49′20″	106°13′18″
17. Bandelier National Monument	35°46′52″	106°15′57″
18. North Rim	—	(non-active)
On Site Stations, Controlled Areas		
19. TA-21 DP Site	35°52′30″	106°16′04″
20. TA-21 Area B	35°52′41″	106°16′40″
21. TA-6	35°51′	106°20′
22. TA-53 (LAMPF)	35°52′12″	106°16′00″
23. TA-52 Beta Site	35°51′30″	106°16′35″
24. TA-16 S Site	35°50′57″	106°21′28″
25. TA-16-450	35°50′46″	106°21′19″
26. TA-49	35°49′35″	106°19′08″
27. TA-54 Area G	35°49′53″	106°14′13″
28. TA-33 HP Site	35°47′02″	106°15′26″
29. TA-2 Omega Site	35°52′	106°16′
30. Booster P-2	35°50′43″	106°15′51″
31. TA-3	35°52′24″	106°19′22″
32. TA-48	35°52′42″	106°19′1.6″
Waste Site Stations, Controlled Areas		
33. Area AB	35°49′27″	106°17′55″
34. Area G-1 NE Corner	35°49′48″	106°14′13.8″
35. Area G-2 Back Fence	35°49′46″	106°14′22″
36. Area G-3 Old Office	35°50′6″	106°14′42″
37. Area G-4 H_2O Tank	35°49′49″	106°14′21″

[a]See Fig. IV-4 for station locations.

Table D-9. Locations of Surface Water Sampling Stations

Station	Latitude or North-South Coordinate	Longitude or East-West Coordinate	Map Designation[a]
REGIONAL STATIONS			
Rio Chama at Chamita	30°05″	106°07″	Chamita
Rio Grande at Embudo	36°12″	105°58″	Embudo
Rio Grande at Otowi	35°52″	106°08″	Otowi
Rio Grande at Frijoles	S375	E235	Frijoles
Rio Grande at Cochiti	35°37″	106°19″	Cochiti
Rio Grande at Bernalillo	35°17″	106°36″	Bernalillo
Jemez River	35°40″	106°44″	Jemez
PERIMETER STATIONS (OFF SITE)			
Radioactive Effluent Release Areas			
Acid-Pueblo Canyons			
Acid Weir	N125	E070	49
Pueblo 1	N130	E080	50
Pueblo 2	N120	E155	51
Los Alamos Canyon			
Los Alamos at Rio Grande	35°52″	106°08″	3
Other Areas			
Guaje Canyon	N300	E100	8
Los Alamos Reservoir	N105	W090	7
Mortandad at Rio Grande	S070	E480	38
Pajarito at Rio Grande	S180	E410	35
Frijoles at Park Headquarters	S280	E180	9
Frijoles at Rio Grande	S375	E235	37
ON-SITE STATIONS			
Radioactive Effluent Release Areas			
Acid-Pueblo Canyons			
Pueblo 3	N085	E315	52
Pueblo at SR 502	N070	E350	S27[b]
DP–Los Alamos Canyons			
DPS-1	N090	E160	57
DPS-4	N080	E200	58
Mortandad Canyon			
GS-1	N040	E100	68
Other Areas			
Cañada del Buey	N010	E150	46
Pajarito Canyon	S060	E215	47
Water Canyon at Beta	S090	E090	48
Sandia Canyon			
SCS-1	N080	E040	65
SCS-2	N060	E140	66
SCS-3	N050	E185	67
Ancho at Rio Grande	S295	E340	36

[a]Regional surface water sampling locations are given in Fig. IV-5; perimeter and on site sampling locations are given in Fig. IV-6.
[b]Same location as sediment station 27 (map designation) in Table D-10.

Table D-10. Locations of Sediment Sampling Stations

Station	Latitude or North-South Coordinate	Longitude or East-West Coordinate	Map Designation[a]
REGIONAL STATIONS			
Chamita	36°05″	106°07″	Chamita
Embudo	36°12″	106°58″	Embudo
Rio Grande at Otowi	35°52″	106°08″	Otowi
Rio Grande at Sandia	S060	E490	Sandia
Rio Grande at Pajarito	S185	E410	Pajarito
Rio Grande at Water	S237	E388	Water
Rio Grande at Ancho	S305	E335	Ancho
Rio Grande at Frijoles	S375	E235	Frijoles
Rio Grande at Cochiti	35°37″	106°19″	Cochiti
Rio Grande at Bernalillo	35°17″	106°36″	Bernalillo
Jemez River	35°40″	106°44″	Jemez
PERIMETER STATIONS (OFF-SITE)			
Radioactive Effluent Release Area			
Acid-Pueblo Canyon			
Acid Weir	N125	E070	22
Pueblo 1	N130	E085	23
Pueblo 2	N120	E145	24
DP–Los Alamos Canyon			
Los Alamos at Totavi	N065	E405	36
Los Alamos at LA-2	N125	E510	37
Los Alamos at Otowi	N100	E560	38
Other Canyons			
Guaje at SR-502	N135	E480	12
Bayo at SR-502	N100	E455	13
Sandia at Rio Grande	S060	E490	Sandia
Cañada Ancha at Rio Grande	S140	E510	Cañada Ancha
Pajarito at Rio Grande	S185	E410	Pajarito
Frijoles at National Monument Headquarters	S280	E185	21
Frijoles at Rio Grande	S375	E235	Frijoles
Mortandad Canyon on San Ildefonso Lands			
Mortandad A-6	N015	E250	A-6
Mortandad A-7	N005	E280	A-7
Mortandad A-8	N000	E320	A-8
Mortandad at SR-4 (A-9)	S030	E350	15
Mortandad A-10	S060	E430	A-10
Mortandad at Rio Grande (A-11)	S070	E480	Mortandad (A-11)

Table D-10 (Cont)

Station	Latitude or North-South Coordinate	Longitude or East-West Coordinate	Map Designation[a]
ON SITE STATIONS			
Radioactive Effluent Release Areas			
Acid-Pueblo Canyon			
Hamilton Bend Spring	N105	E255	25
Pueblo 3	N090	E315	26
Pueblo at SR-502	N070	E350	27
DP–Los Alamos Canyon			
DPS-1	N090	E160	28
DPS-4	N075	E205	29
Los Alamos at Bridge	N095	E020	30
Los Alamos at LAO-1	N080	E120	31
Los Alamos at GS-1	N075	E200	32
Los Alamos at LAO-3	N075	E215	33
Los Alamos at LAO-4.5	N065	E270	34
Los Alamos at SR-4	N065	E355	35
Mortandad Canyon			
Mortandad near CMR Building	N060	E036	39
Mortandad west of GS-1	N045	E095	40
Mortandad at GS-1	N040	E105	41
Mortandad at MCO-5	N035	E155	42
Mortandad at MCO-7	N025	E190	43
Mortandad at MCO-9	N030	E215	44
Mortandad at MCO-13 (A-5)	N015	E250	45
Other Canyons			
Sandia at SR-4[b]	N025	E315	14
Cañada del Buey at SR-4[b]	S090	E360	16
Pajarito at SR-4[b]	S105	E320	17
Potrillo at SR-4[b]	S136	E285	18
Fence at SR-4[b]	S139	E280	46
Water at SR-4[b]	S170	E260	19
Indio at SR-4[b]	S200	E260	47
Ancho at SR-4[b]	S255	E250	20
Water at Rio Grande	S237	E388	Water
Ancho at Rio Crande	S305	E335	Ancho
Chaquehiu at Rio Grande	S330	E275	Chaquehui

[a]Sediment sampling locations in Figs. IV-8 and IV-9.

[b]These sediment stations located at State Road 4 are the first points of public access as all Laboratory facilities in or adjacent to these canyons are located west of State Road 4.

Table D-11. Location and Description of Soil Sampling Stations[a]

Station	Location[b]	Map Designation[c]	Description of Nearby LANL Contaminant Sources
Regional Soils			
Rio Chama	36°05' 106°07'	Chamita	
Embudo	36°12' 105°58'	Embudo	
Otowi	35°52' 106°08'	Otowi	
Near Santa Cruz	35°59' 105°54'	Santa Cruz	
Cochiti	35°37' 106°19'	Cochiti	
Bernalillo	35°17' 106°36'	Bernalillo	
Jemez	35°40' 106°44'	Jemez	
Perimeter Soils			
L.A. Sportsman Club	N240 E215	S1	
North Mesa	N134 E168	S2	
Near TA-8 (GT Site)	N060 W075	S3	
Near TA-49	S165 E085	S4	Inactive Waste Site
White Rock (east)	S055 E385	S5	
Tsankawi	N020 E310	S6	
On-Site Soils			
TA-21 (DP Site)	N095 E140	S7	Pu/Chem. Research
East of TA-53	N051 E218	S8	LAMPF Accelerator
TA-50	N035 E095	S9	Rad. Water Treatment
Two-Mile Mesa	N025 E030	S10	Main Technical Area
East of TA-54	S080 E295	S11	Rad. Disposal Site
R-Site Road East	S042 E103	S12	PHERMEX Accelerator
Potrillo Drive	S065 E195	S13	HE Detonation
S-Site (TA-16)	S035 W025	S14	HE Res.; H^3 Facility
Near Test Well DT-9	S150 E140	S15	Inactive Waste Site
Near TA-33	S245 E225	S16	Ex H^3 Facility

[a]Soil sampling locations are given in Figs. IV-8 and IV-11.
[b]Latitude/Longitude or LANL N-S/E-W coordinates.

Table D-12. Locations of Beehives[a]

Station	North-South Coordinate	East-West Coordinate
Regional Stations (28–44 km), Uncontrolled Areas		
San Pedro	—	—
Chimayo	—	—
San Juan	—	—
Perimeter Stations (0–4 km), Uncontrolled Areas		
1. Northern Los Alamos County	N180	W020
2. White Rock/Pajarito Acres	—	—
On-Site Stations, Controlled Areas		
3. TA-5 (Lower Mortandad Canyon)	N020	E185
4. TA-8 (Anchor Site W)	S020	W065
5. TA-9 (Anchor Site E)	S005	W040
6. TA-15 (R-Site)	S020	E065
7. TA-16 (S-Site)	S055	W080
8. TA-21 (DP Canyon)	N095	E180
9. TA-33 (HP-Site)	S260	E265
10. TA-49 (Frijoles Mesa)	S160	E105
11. TA-50 (Upper Mortandad Canyon)	N040	E095
12. TA-53 (LAMPF)	N050	E220
13. TA-54 (Area G)	—	—

[a]Approximate beehive locations are presented in Fig. IV-14.

Table D-13. Los Alamos, New Mexico,[a] Climatological Summary (1911–1991), Temperature and Precipitation Means[b] and Extremes

	Temperature (°F)[c]										
	Normals			Extremes							
Month	Mean Maximum	Mean Minimum	Average	High Average	Year	Low Average	Year	High Daily Maximum	Date	Low Daily Minimum	Date
January	39.5	17.4	28.4	37.6	1986	20.9	1930	64	1/12/81	–18	1/13/63
February	43.5	21.1	32.3	37.4	1934	23.0	1939	69	2/25/86	–14	2/01/51
March	49.6	26.5	38.0	45.8	1972	32.1	1948	73	3/11/89	–3	3/11/48
April	58.4	33.3	45.8	54.3	1954	39.7	1973	80	4/23/50	5	4/09/28
May	67.6	42.0	54.8	60.5	1956	50.1	1957	89	5/29/35	24	5/01/76[d]
June	77.8	51.1	64.5	69.6	1990	60.4	1965	95	6/22/81	28	6/03/19
July	80.6	55.3	68.0	71.4	1980	63.3	1926	95	7/11/35	37	7/07/24
August	77.5	53.5	65.5	70.3	1936	60.9	1929	92	8/10/37	40	8/16/47
September	71.1	47.2	59.1	65.8	1956	56.2	1965	94	9/11/34	23	9/29/36
October	61.5	37.6	49.2	54.7	1963	42.8	1984	84	10/01/80	9	10/31/91
November	48.9	27.1	38.0	44.4	1949	30.5	1972	72	11/01/50	–14	11/28/76
December	40.8	19.4	30.1	38.4	1980	24.0	1990	64	12/27/80	–13	12/09/78
Annual	59.7	36.0	47.8	52.0	1954	46.2	1932	95	6/22/81[d]	–18	1/13/63

Table D-13. (Cont.)

Month	Precipitation (in.)[c]										Mean Number of Days Per Year		
	Precipitation[e]					Snow							
	Mean	Maximum	Year	Daily Maximum	Date	Mean	Maximum	Year	Daily Maximum	Date	Precip. ≥0.10 in.	Max. Temp. ≥90°F	Min. Temp. ≤32°F
January	0.86	6.75	1916	2.45	1/12/16	12.1	64.8	1987	22.0	1/15/87	2	0	29
February	0.80	2.78	1987	1.05	2/20/15	9.9	48.5	1987	20.0	2/19/87	2	0	27
March	1.22	4.11	1973	2.25	3/30/16	12.0	36.0	1973	18.0	3/30/16	3	0	24
April	1.01	4.64	1915	2.00	4/12/75	4.6	33.6	1958	20.0	4/12/75	3	0	14
May	1.17	4.47	1929	1.80	5/21/29	0.9	17.0	1917	12.0	5/02/78	3	0	3
June	1.36	5.67	1986	2.51	6/10/13	—	—	—	—	—	3	1	0
July	3.26	7.98	1919	2.47	7/31/68	—	—	—	—	—	8	1	—
August	3.52	11.18	1952	2.26	8/01/51	—	—	—	—	—	8	0	—
September	2.12	5.79	1941	2.21	9/22/29	0.1	6.0	1913	6.0	9/25/13	5	0	0
October	1.30	6.77	1957	3.48	10/05/11	2.0	20.0	1984	9.0	10/31/72	3	0	7
November	1.02	6.60	1978	1.77	11/25/78	4.6	34.5	1957	14.0	11/22/31	2	0	22
December	1.08	3.21	1984	1.60	12/06/78	12.8	41.3	1967	22.0	12/06/78	3	0	30
Annual	18.72	30.34	1941	3.48	10/05/11	59.0	178.4	1987	22.0	1/15/87	46	3	156
Season							153.2	1986–87		12/06/78			

[a]Latitude 35°52′ north, longitude 106°19′ west; elevation 2263 m.

[b]Means are based on standard 30-year period: 1961–1990.

[c]Metric conversions: 1 in. = 2.5 cm; °F = 9/5°C + 32.

[d]Most recent occurrence.

[e]Includes water equivalent of frozen precipitation.

Table D-14. 1991 Weather Highlights

Key for Abbreviations:

SMDH: Set maximum daily high-temperature record.
TMDH: Tied maximum daily high-temperature record.
SMDL: Set minimum daily low-temperature record.
TMDL: Tied minimum daily low-temperature record.
SMDP: Set maximum daily precipitation record.
SMDS: Set maximum daily snowfall record.

January

Cold and dry.
Mean temperature = 24.7°F (normal = 28.4°F).
Precipitation = 0.39 in. (normal = 0.86 in.).
SMDS on the 21st: 5.2 in.

February

Warm and dry.
Mean temperature = 34.8°F (normal = 32.3°F).
Precipitation = 0.34 in. (normal = 0.80 in.).
Snowfall = 3.3 in. (normal = 9.9 in.).
Strong winds with peak gust of 51 mph on the 13th.

March

Windy.
Strong winds with peak gusts of 54, 57, and 55 mph on the 11th, 26th, and 27th, respectively.
Peak gust of 73 mph at the East Gate Station on the 19th.

April

Dry - only trace of precipitation entire month.
Precipitation = 0.00 in. (normal = 1.01 in.).
Tied record for driest April; 5 previous Aprils with no precipitation; most recent: 1967.
TMDH on the 6th: 72°F.
TMDL on the 28th: 22°F.
Strong winds with peak gusts of 51 and 55 mph on the 1st and 11th, respectively.
Peak gust of 72 mph at the East Gate Station on the 11th.

May

TMDL on the 5th: 28°F.
Precipitation of 0.02 in. on the 15th ended a consecutive string of 45 days with no measurable precipitation.
SMDP on the 20th: 0.71 in.

June

Cool.
Mean temperature = 61.7°F (normal = 64.5°F).
Strong dust devil damages Los Alamos Catholic Church roof on the 18th.

July

Wet and cool.
Rainfall = 5.03 in. (normal = 3.26 in.).
Wettest July since 1968 when 6.60 in. fell.

Table D-14. (Cont.)

July (cont.)

The rainfall of 6.76 in. at the East Gate Station was second largest July precipitation ever recorded in Los Alamos County; highest was 7.98 in. during 1919.
Mean temperature = 64.7°F (normal = 68.0°F).
3rd coldest July on record and coldest since 1941.
SMDP on the 22nd: 1.52 in.
SMDL on the 26th: 46°F.
SMDL on the 27th: 47°F.

August

Wet and cool.
Rainfall = 5.93 in. (normal = 3.52 in.).
Wettest August since 1968 when 6.39 in. fell.
The rainfall of 7.98 in. at the North Community site was the largest monthly precipitation recorded in Los Alamos County since the record highest 11.18 in. fell in August of 1952.
Mean temperature = 63.2°F (normal = 65.5°F).
Rainfall of 1.76 in. at Bandelier site on the 2nd.
Flooding on the 4th with 2.40 in. at North Community, including 1.50 in. during one hour.
Los Alamos County sewer lines washed out in Pueblo Canyon; widespread street and basement flooding in Los Alamos.
Heavy thunderstorms on the 6th caused more local flooding with 1.91 in. at S-Site, 1.61 in. at North Community, and 1.11 in. at TA-6 (official station).
Heavy rainfall of 1.09 in. at Bandelier on the 13th.
Heavy rainfall of 1.20 in. at both TA-6 and North Community on the 19th; 1.15 in. fell in 15 minutes at TA-6.

Summer (June - August)

Coldest summer on record.
Mean temperature = 63.2°F (normal = 66.0°F).
Previous coldest summer: 1929, 63.3°F.
2nd coldest July-August period on record.
Mean temperature (July-August) = 63.9°F (normal = 66.7°F).
Coldest July-August period: 1929, 63.1°F.
Wettest July-August period (11.96 in.) since 1968 when 12.99 in. fell.

September

Cool and wet.
Mean temperature = 56.7°F (normal = 59.1°F).
4th coldest September on record.
Rainfall = 2.73 in. (normal = 2.12 in.).
Rainfall = 4.42 in. at S-Site.

October

Dry but snowy.
Precipitation = 0.35 in. (normal = 1.30 in.).
Snowfall = 7.3 in. (normal = 2.0 in.).
TMDH on the 15th: 72°F.
SMDH on the 17th: 75°F.

Table D-14. (Cont.)

October (cont.)

TMDH on the 18th: 74°F.
SMDL on the 29th: 16°F.
SMDL on the 30th: 15°F.
Tied record low temperature during month of October: 10/19/76.
Record lowest high temperature of 28°F on the 30th.
Tied record lowest high temperature for month of October.
SMDS on the 30th: 7.3 in.
SMDL on the 31st: 9°F.
Record lowest for month of October: previous record = 15°F on 10/30/91 and 10/19/76.
Record lowest high temperature of 25°F on the 31st.
Record lowest high temperature for month of October: previous record = 28°F on 10/30/91 and 10/12/86.

November

Cold, wet, and snowy.
Mean temperature = 33.3°F (normal = 38.0°F).
Precipitation = 2.56 in. (normal = 1.03 in.).
4th coldest and 4th wettest November on record.
Snowfall = 12.1 in. (normal = 4.6 in.).
SMDL on the 1st: 9°F.
TMDL on the 3rd: 10°F.
SMDL on the 4th: 16°F.
SMDP on the 15th: 1.39 in.
SMDS on the 15th: 4.0 in.
Extensive damage to trees and limbs early morning on the 16th resulting from wet snow accumulation.
Strong winds with peak gust = 50 mph on the 18th.

December

Cold, wet, and snowy.
Mean temperature = 27.7°F (normal = 30.1°F).
Precipitation = 2.23 in. (normal = 1.08 in.).
Snowfall = 18.1 in. (normal = 12.8 in.).
SMDL on the 1st: 5°F.
SMDL on the 2nd: 5°F.
TMDL on the 3rd: 6°F.
SMDP on the 11th: 1.03 in.
SMDP on the 18th: 0.76 in.
SMDS on the 18th: 8.8 in.

Annual

1991 mean temperature = 46.2°F (normal = 47.8°F).
5th coldest year on record and coldest since 1941.
1991 precipitation = 24.34 in. (normal = 18.72 in.).
Wettest year since 1985.
1991 snowfall = 60.3 in. (normal = 59.0 in.).
1990-1991 winter snowfall = 38.8 in.
Least seasonal snowfall since 1977-1978 when 31.8 in. fell.

Table D-15. Moisture (gravimetric) and TritiumConcentration in Moisture Extracted from Core Samples from Hole SIMO-1

Depth[a] (ft)	Moisture (% by mass)	H^{3}[b] (nCi/L)
4	4.5	1.6
9	4.0	1.4
14	8.0	1.1
19	7.7	0.4
24	5.7	0.2
29	6.1	0.6
33	5.3	0.0
39	7.0	-0.1
44	8.1	0.3
49	2.8	0.2
54	8.8	0.2
59	3.9	0.1
64	4.1	0.0
69	2.3	-0.2
74	7.9	0.1
79	7.3	-0.2
84	11.2	-0.4
89	10.3	-0.1
94	19.2	-0.2
99	9.3	0.3
104	9.4	0.0

[a] depth below surface.
[b] Detection limit 0.7 nCi/L.

Table D-16. Radiochemical Analyses of Core Samples from Hole SIMO-1

Sample depth (ft)	H^3 (nCi/L)	^{137}CS (pCi/g)	Gross Alpha (cpm/g)	^{238}PU (pCi/g)	$^{239,240}PU$ (pCi/g)	Total Uranium (ug/g)	Gross Beta (pCi/g)	Gross Gamma (pCi/g)
4	1.6 (0.3)[a]	0.043 (0.077)	2.7 (0.5)	0.001 (0.001)	0.002 (0.001)	2.2 (0.2)	3.7 (0.8)	1.4 (0.2)
9	1.4 (0.3)	0.347 (0.135)	4.0 (0.6)	0.008 (0.001)	0.003 (0.001)	2.9 (0.3)	6.0 (1.0)	2.1 (0.3)
14	1.1 (0.3)	0.124 (0.079)	4.0 (0.6)	0.000 (0.000)	0.002 (0.001)	4.6 (0.5)	14.0 (3.0)	5.5 (0.6)
19	0.4 (0.3)	0.185 (0.126)	4.4 (0.6)	0.002 (0.002)	0.001 (0.001)	4.6 (0.4)	14.0 (3.0)	5.9 (0.7)
24	0.2 (0.3)	0.161 (0.081)	4.0 (0.6)	0.000 (0.000)	0.002 (0.001)	4.1 (0.4)	10.0 (2.0)	5.4 (0.6)
29	0.6 (0.3)	0.243 (0.133)	4.0 (0.6)	0.002 (0.001)	0.003 (0.002)	3.6 (0.4)	13.0 (3.0)	5.0 (0.6)
33.5	0.0 (0.3)	0.128 (0.081)	4.8 (0.6)	0.000 (0.001)	0.006 (0.006)	3.9 (0.4)	9.0 (2.0)	4.0 (0.5)
39	–0.1 (0.3)	0.043 (0.116)	2.9 (0.5)	0.000 (0.001)	0.002 (0.001)	3.9 (0.4)	9.0 (2.0)	2.9 (0.4)
44	0.3 (0.3)	0.032 (0.085)	3.9 (0.6)	0.006 (0.006)	0.001 (0.001)	4.0 (0.4)	8.0 (2.0)	3.3 (0.4)
49	0.2 (0.3)	0.150 (0.126)	2.4 (0.5)	0.000 (0.000)	0.000 (0.001)	1.6 (0.2)	2.7 (0.6)	2.0 (0.3)
54	0.2 (0.3)	0.057 (0.079)	6.7 (0.8)	0.001 (0.000)	0.001 (0.001)	5.4 (0.5)	7.0 (2.0)	3.1 (0.4)
59	0.1 (0.3)	0.119 (0.119)	4.0 (0.6)	0.001 (0.000)	0.002 (0.001)	2.8 (0.3)	4.1 (0.9)	1.5 (0.2)
64	0.0 (0.3)	0.094 (0.078)	3.7 (0.5)	0.003 (0.001)	0.002 (0.001)	2.8 (0.3)	5.0 (1.0)	1.7 (0.2)
69	–0.2 (0.3)	0.147 (0.117)	1.8 (0.4)	0.000 (0.000)	0.001 (0.001)	1.5 (0.2)	3.0 (0.7)	1.2 (0.2)
74	0.1 (0.3)	0.107 (0.081)	7.0 (0.8)	0.001 (0.001)	0.001 (0.001)	6.7 (0.7)	8.0 (2.0)	2.7 (0.3)
79	–0.2 (0.3)	0.202 (0.132)	5.6 (0.7)	0.001 (0.000)	0.001 (0.001)	5.9 (0.6)	7.0 (1.0)	2.2 (0.3)
84	–0.4 (0.3)	–0.077 (0.080)	7.1 (0.8)	0.001 (0.000)	0.001 (0.001)	6.3 (0.6)	8.0 (2.0)	3.5 (0.4)
89	–0.1 (0.3)	0.189 (0.120)	4.1 (0.6)	0.000 (0.000)	0.001 (0.000)	3.9 (0.4)	9.0 (2.0)	3.1 (0.4)
94	–0.2 (0.3)	0.102 (0.079)	5.0 (0.6)	0.000 (0.000)	0.004 (0.001)	5.6 (0.6)	3.7 (0.8)	1.8 (0.2)
99	0.3 (0.3)	0.090 (0.118)	3.9 (0.6)	0.000 (0.010)	0.003 (0.001)	5.6 (0.6)	3.1 (0.7)	1.6 (0.2)
104	0.0 (0.3)	0.004 (0.086)	5.3 (0.7)	0.000 (0.010)	0.001 (0.001)	5.5 (0.5)	2.4 (0.6)	1.6 (0.2)

[a]Counting uncertainties are in parentheses.

Table D-17. Summary of Selected Radionuclides Half-Life Information

Nuclide	Symbol	Half-Life (years)
Tritium	H^3	12
Beryllium-7	^{7}Be	0.15
Phosphorus-32	^{32}P	0.04
Potassium-40	^{40}K	1,260,000,000
Argon-41	^{41}Ar	0.00008
Cobalt-60	^{60}Co	5.2
Strontium-85	^{85}Sr	0.18
Strontium-89	^{89}Sr	0.14
Strontium-90	^{90}Sr	27.7
Iodine-131	^{131}I	0.02
Cesium-134	^{134}Cs	2.05
Cesium-137	^{137}Cs	30
Uranium-234	^{234}U	247,000
Uranium-235	^{235}U	710,000,000
Uranium-238	^{238}U	4,510,000,000
Plutonium-238	^{238}Pu	86
Plutonium-239	^{239}Pu	24,390
Plutonium-240	^{240}Pu	6,580
Americium-241	^{241}Am	458

NOTE: For the half-life of the principal airborne activation products, see discussion on page V-2.

Table D-18. Dose Conversion Factors for Calculating Internal Doses[a] (rem/μCi Intake)

Inhalation

Radionuclide	Effective Dose
H^3	6.3×10^{-5}
^{234}U	1.3×10^{2}
^{235}U	1.2×10^{2}
^{238}U	1.2×10^{2}
^{238}Pu	4.6×10^{2}
$^{239,240}Pu$	5.1×10^{2}
^{241}Am	5.2×10^{2}

Ingestion

Radionuclide	Effective Dose
H^3	6.3×10^{-5}
^{7}Be	1.1×10^{-4}
^{90}Sr	1.3×10^{-1}
^{137}Cs	5.0×10^{-2}
^{234}U	2.6×10^{-1}
^{235}U	2.5×10^{-1}
^{238}U	2.3×10^{-1}
^{238}Pu	3.8
$^{239,240}Pu$	4.3
^{241}Am	4.5

[a]Dose conversion factors taken from DOE 1988b.

Table D-19. Dose Conversion Factors for Calculating External Doses ([mrem/yr]/[μCi/m³])

Radionuclide[a]	Effective Dose
^{10}C[b]	8,830
^{11}C	5,110
^{13}N	5,110
^{16}N	29,300
^{14}O[b]	18,900
^{15}O	5,120
^{41}A	6,630

[a]Dose conversion factors taken from DOE 1988c.

[b]Dose conversion factors for ^{10}C and ^{14}O were not given in DOE 1988c and were calculated with the computer program DOSFACTER II (Kocher 1981).

Table D-20. Locations of Groundwater Sampling Stations

Station	North-South Coordinate	East-West Coordinate	Map Designation[a]
MAIN AQUIFER ON SITE			
Test Wells			
Test Well 1	N070	E345	39
Test Well 3	N080	E215	41
Test Well 8	N035	E170	43
Test Well DT-5A	S110	E090	42
Test Well DT-9	S155	E140	44
Test Well DT-10	S120	E125	45
Water Supply Wells			
Pajarito Well Field			
Well PM-1	N030	E305	89
Well PM-2	S055	E202	90
Well PM-3	N040	E255	91
Well PM-4	S030	E205	92
Well PM-5	N015	E155	93
MAIN AQUIFER OFF SITE			
Test Wells			
Test Well 2	N120	E150	40
Water Supply Wells			
Guaje Well Field			
Well G-1	N190	E385	82
Well G-1A	N197	E380	83
Well G-2	N205	E365	84
Well G-3	N215	E350	85
Well G-4	N213	E315	86
Well G-5	N228	E295	87
Well G-6	N215	E270	88
Los Alamos Well Field			
Well LA-1B	N115	E530	76
Well LA-2	N125	E505	77
Well LA-3	N130	E490	78
Well LA-5	N076	E435	80
Well LA-6	N105	E465	81
San Ildefonso Wells			
Westside Artesian Well			SI 10
Halladay Well			SI 8
Pajarito Well (Pump 1)			SI 3
Eastside Artesian Well			SI 9
Don Juan Playhouse Well			SI 17

Table D-20. (Cont.)

Station	North-South Coordinate	East-West Coordinate	Map Designation[a]
MAIN AQUIFER SPRINGS			
White Rock Canyon Springs (Perimeter and Off-Site)			
Group I			
Sandia Spring	S030	E470	13
Spring 3	S110	E450	14
Spring 3A	S120	E445	15
Spring 3AA	S140	E440	16
Spring 4	S170	E410	17
Spring 4A	S150	E395	18
Spring 5	S220	E390	19
Spring 5AA	S240	E360	20
Ancho Spring	S280	E305	21
Group II			
Spring 5A	S230	E390	22
Spring 5B	S275	E355	96
Spring 6	S300	E330	23
Spring 6A	S310	E310	24
Spring 7	S330	E295	25
Spring 8	S335	E285	26
Spring 8A	S315	E280	27
Spring 8B	S310	E285	97
Spring 9	S320	E270	28
Spring 9A	S325	E265	29
Doe Spring	S320	E250	30
Spring 10	S370	E230	31
Group III			
Spring 1	N040	E520	32
Spring 2	N015	E505	33
Group IV			
La Mesita Spring	N080	E550	10
Spring 2A	S105	E475	95
Spring 3B	S150	E465	34
Other Off-Site Springs			
Sacred Spring	N170	E540	11
Indian Spring	N140	E530	12

Table D-20. (Cont.)

Station	North-South Coordinate	East-West Coordinate	Map Designation[a]
ALLUVIAL CANYON AQUIFERS			
Radioactive Effluent Release Areas			
Acid-Pueblo Canyons			
Hamilton Bend Spring	N110	E250	53
DP-Los Alamos Canyons			
LAO-C	N085	E070	59
LAO-1	N080	E120	60
LAO-2	N080	E210	61
LAO-3	N080	E220	62
LAO-4	N070	E245	63
LAO-4.5	N065	E270	64
Mortandad Canyon			
MCO-3	N040	E110	69
MCO-4	N035	E150	70
MCO-5	N030	E160	71
MCO-6	N030	E175	72
MCO-7	N025	E180	73
MCO-7.5	N030	E190	74
Other Areas			
Pajarito Canyon			
PCO-1	S054	E212	102
PCO-2	S081	E255	103
PCO-3	S098	E293	104
PERCHED SYSTEM IN CONGLOMERATES AND BASALT			
(Pueblo/LosAlamos/Sandia Canyon Area)			
Test Well 1A	N070	E335	54
Test Well 2A	N120	E140	55
Basalt Spring	N065	E395	56
PERCHED AQUIFER IN VOLCANICS			
Water Canyon Gallery	S040	W125	94

[a]See Fig. VII-1 for perimeter and on-site groundwater sampling locations.

Table D-21. Volatile Organic Compounds Determined in Water by PAT Analyses

Compound	CAS #	Representative Limit of Quantification[a] (µg/L)
Chloromethane	74-87-3	10
Vinyl chloride	75-01-4	10
Bromomethane	74-83-9	10
Chloroethane	75-00-3	10
Acetone	67-64-1	20
Trichlorofluoromethane	75-69-4	5
1,1-Dichloroethene	75-35-4	5
Methylene chloride	75-09-2	5
Carbon disulfide	75-15-0	5
t-1,2-Dichloroethene	156-60-5	5
1,1-Dichloroethane	75-34-3	5
c-1,2-Dichloroethene	156-59-2	5
Bromochloromethane	74-97-5	5
Chloroform	67-66-3	5
1,2-Dichloroethane	107-06-2	5
1,1-Dichloropropene	563-58-6	5
Vinyl acetate	108-05-4	10
2-Butanone	78-93-3	20
2,2-Dichloropropane	590-20-7	5
1,1,1-Trichloroethane	71-55-6	5
Carbon tetrachloride	56-23-5	5
Benzene	71-43-2	5
1,2-Dichloropropane	78-87-5	5
Trichloroethene	79-01-6	5
Dibromomethane	74-95-3	5
Bromodichloromethane	75-27-4	5
t-1,3-Dichloropropene	1006-10-26	5
c-1,3-Dichloropropene	1006-10-15	5
1,1,2-Trichloroethane	79-00-5	5
1,3-Dichloropropane	142-28-9	5
Chlorodibromomethane	124-48-1	5
Bromoform	75-25-2	5
4-Methyl-2-pentanone	10-81-1	20
Toluene	108-88-3	5
2-Hexanone	59-17-86	20
1,2-Dibromomethane	74-95-3	5
Tetrachloroethene	127-18-4	5
Chlorobenzene	108-90-7	5
1,1,1,2-Tetrachloroethane	630-20-6	5
1-Chlorohexane	544-10-5	5
Ethylbenzene	100-41-4	5
m,p-Xylene (total)	108-38-3 + 106-42-3	5
o-Xylene	95-47-6	5
Styrene	100-42-5	5

Table D-21. (Cont.)

Compound	CAS #	Representative Limit of Quantification[a] (µg/L)
1,1,2,2-Tetrachloroethane	79-34-5	5
1,2,3-Trichloropropane	96-18-4	5
Isopropylbenzene	98-82-8	5
Bromobenzene	108-86-1	5
n-Propylbenzene	103-65-1	5
2-Chlorotoluene	95-49-8	5
4-Chlorotoluene	106-43-4	5
1,3,5-Trimethylbenzene	108-67-8	5
tert-Butylbenzene	98-06-6	5
1,2,4-Trimethylbenzene	95-63-6	5
sec-Butylbenzene	135-98-8	5
1,3-Dichlorobenzene	541-73-1	5
1,4-Dichlorobenzene	106-46-7	5
p–Isopropyltoluene	99-87-6	5
1,2-Dichlorobenzene	95-50-1	5
n-Butylbenzene	104-51-8	5
1,2-Dibromo-3-chloropropane	96-12-8	10
1,2,4-Trichlorobenzene	120-82-1	N/A
Naphthalene	91-20-3	N/A
1,2,3-Trichlorobenzene	87-61-6	N/A
Hexachlorobutadiene	87-68-3	N/A
Dichlorodifluoromethane	75-71-8	10
Trichlorotrifluoroethane	76-13-1	5
Iodomethane	74-88-4	5
2-Chloroethylvinylether	110-75-8	50
Acrylonitrile	107-13-1	100
Acrolein	107-02-8	100

[a]Column: Supelco SPB-5 60 m × 0.25 mm × 1.0 µm. Limits of detection estimated by minimum signal required to yield identifiable mass spectral scan.

Table D-22. Volatile Organic Compounds Determined in Solids by SW-846 Method 8260

Compound	CAS #	Limit of Quantification[a] (mg/kg)
Chloromethane	74-87-3	10
Vinyl chloride	75-01-4	10
Bromomethane	74-83-9	10
Chloroethane	75-00-3	10
Acetone	67-64-1	20
Trichlorofluoromethane	75-69-4	5
1,1-Dichloroethene	75-35-4	5
Methylene chloride	75-09-2	5
Carbon disulfide	75-15-0	5
t-1,5-Dichloroethene	156-60-5	5
1,1-Dichloroethane	75-34-3	5
c-1,2-Dichloroethene	156-59-4	5
Bromochloromethane	74-97-5	5
Chloroform	67-66-3	5
1,2-Dichloroethane	107-06-2	5
1,1-Dichloropropene	563-58-6	5
Vinyl acetate	108-05-4	10
2-Butanone (MEK)	78-93-3	20
2,2-Dichloropropane	590-20-7	5
1,1,1-Trichloroethane	71-55-6	5
Carbon tetrachloride	56-23-5	5
Benzene	71-43-2	5
1,2-Dichloropropane	78-87-5	5
Trichloroethene	79-01-6	5
Dibromomethane	74-95-3	5
Bromodichloromethane	75-27-4	5
t-1,3-Dichloropropene	1006-10-26	5
c-1,3-Dichloropropene	1006-10-15	5
1,1,2-Trichloroethane	79-00-5	5
1,3-Dichloropropane	142-28-9	5
Chlorodibromomethane	124-48-1	5
Bromoform	75-25-2	5
4-Methyl-2-pentanone (MIK)	10-81-1	20
Toluene	108-88-3	5
2-Hexanone	59-17-86	20
1,2-Dibromomethane	74-95-3	5
Tetrachloroethene	127-18-4	5
Chlorobenzene	108-90-7	5
1,1,1,2-Tetrachloroethane	630-20-6	5
1-Chlorohexane	544-10-5	5
Ethylbenzene	100-41-4	5
Mixed Xylene (total)	1330-20-7	5
Styrene	100-42-5	5
1,1,2,2-Tetrachloroethane	79-34-5	5

Table D-22. (Cont.)

Compound	CAS #	Limit of Quantification[a] (mg/kg)
1,2,3-Trichloropropane	96-18-4	5
Isopropylbenzene	98-82-8	5
Bromobenzene	108-86-1	5
n-Propylbenzene	103-65-1	5
2-Chlorotoluene	95-49-8	5
4-Chlorotoluene	106-43-4	5
1,3,5-Trimethylbenzene	108-67-8	5
tert-Butylbenzene	98-06-6	5
1,2,4-Trimethylbenzene	98-63-6	5
sec-Butylbenzene	135-98-8	5
1,3-Dichlorobenzene	541-73-1	5
1,4-Dichlorobenzene	106-46-7	5
p-Isopropyltoluene	99-87-6	5
1,2-Dichlorobenzene	95-50-1	5
n-Butylbenzene	104-51-8	5
1,2-Dibromo-3-chloropropane	96-12-8	10
1,2,4-Trichlorobenzene	120-82-1	N/A
Naphthalene	91-20-3	N/A
1,2,3-Trichlorobenzene	87-61-6	N/A
Hexachlorobutadiene	87-68-3	N/A
Dichlorodifluoromethane	75-71-8	10
Trichlorotrifluoroethane	76-13-1	5
Iodomethane	74-88-4	5
2-Chloroethylvinylether	110-75-8	50
Acrylonitrile	107-13-1	100
Acrolein	107-02-8	100

[a]Column: 60 m × 0.32 mm SPB-5 fused silica capillary, using a methanolic partition with purge and trap. Limits of quantification are calculated from the intercept of the external calibration curve using a flame-ionization detector.

Table D-23. Semivolatile Organics in Water

Compound	CAS #	Limit of Quantification (mg/L)
N-Nitrosodimethylamine	62-75-9	10
Aniline	62-55-3	10
Phenol	108-95-2	10
bis(-2-Chloroethyl)ether	111-44-4	10
2-Chlorophenol	95-57-8	10
1,3-Dichlorobenzene	541-73-1	10
1,4-Dichlorobenzene	106-46-7	10
Benzyl alcohol	100-51-6	10
1,2-Dichlorobenzene	95-50-1	10
2-Methylphenol	95-48-7	10
bis(2-Chloroisopropyl)ether	39638-32-9	10
4-Methylphenol	106-44-5	10
N-Nitroso-di-*n*-propylamine	621-64-7	10
Hexachloroethane	67-72-1	10
Nitrobenzene	98-95-3	10
Isophorone	78-59-1	10
2-Nitrophenol	88-75-5	10
2,4-Dimethylphenol	105-67-9	10
Benzoic acid	65-85-0	10
bis(-2-Chloroethoxy)methane	111-91-1	10
2,4-Dichlorophenol	120-83-2	10
1,2,4-Trichlorobenzene	120-82-1	10
Naphthalene	91-20-3	10
4-Chloroaniline	106-47-8	10
Hexachlorobutadiene	87-68-3	10
4-Chloro-3-methylphenol	59-50-7	10
2-Methylnaphthalene	91-57-6	10
Hexachlorocyclopentadiene	77-47-4	10
2,4,6-Trichlorophenol	88-06-2	10
2,4,5-Trichlorophenol	95-95-4	10
2-Chloronaphthalene	91-58-7	10
2-Nitroaniline	88-74-4	10
Dimethyl phthalate	131-11-3	10
Acenaphthylene	208-96-8	10
3-Nitroaniline	99-09-2	10
Acenaphthene	83-32-9	10
2,4-Dinitrophenol	51-28-5	10
4-Nitrophenol	100-02-7	10
Dibenzofuran	132-64-9	10
2,4-Dinitrotoluene	121-14-2	10
2,6-Dinitrotoluene	606-20-2	10
Diethylphthalate	84-66-2	10
4-Chlorophenyl-phenylether	7005-72-3	10
Fluorene	86-73-7	10
4-Nitroaniline	100-01-6	10
4,6-Dinitro-2-methylphenol	534-52-1	10
N-Nitrosodiphenylamine	86-30-6	10

Table D-23. (Cont.)

Compound	CAS #	Limit of Quantification (mg/L)
Azobenzene	103-33-3	10
4-Bromophenyl-phenylether	101-55-3	10
Hexachlorobenzene	118-74-1	10
Pentachlorophenol	87-86-5	10
Phenanthrene	85-01-8	10
Anthracene	120-12-7	10
Di-*n*-butylphthalate	84-74-2	10
Fluoranthene	206-44-0	10
Benzidine	92-87-5	10
Pyrene	129-00-0	10
Butylbenzylphthalate	85-68-7	10
3,3ó-Dichlorobenzidine	91-94-1	10
Benzo(*a*)anthracene	56-55-3	10
bis(2-Ethylhexyl)phthalate	117-81-7	10
Chrysene	218-01-9	10
Di-*n*-octyl phthalate	117-84-0	10
Benzo(*b*)fluoranthene	205-99-2	10
Benzo(*k*)fluoranthene	207-08-9	10
Benzo(*a*)pyrene	50-32-8	10
Indeno(1,2,3-*cd*)pyrene	193-39-5	10
Dibenzo(*a,h*)anthracene	53-70-3	10
Benzo(*g,h,i*)perylene	191-24-2	10

Table D-24. Volatiles Determined in Air (Pore Gas)

Compound	CAS #	Limit of Quantification (mg/tube)
Chloroform	67-66-3	8.0
1,1,1-Trichloroethane	71-56-6	8.0
Benzene	71-43-2	8.0
Carbon tetrachloride	56-23-5	8.0
Trichloroethene	79-01-6	8.0
Toluene	108-88-3	8.0
Tetrachloroethene	127-18-4	8.0
Chlorobenzene	108-90-7	8.0
Ethylbenzene	100-41-4	8.0
o-Xylene	95-47-6	8.0
m,p-Xylene (total)	108-38-3 + 106-42-3	8.0
1,2,4-Trimethylbenzene	95-63-6	8.0
Bromobenzene	108-86-1	8.0

Table D-25. Toxicity Characteristic Leaching Procedure for Target Organic Contaminants

Contaminant	Regulatory Level (mg/L)
Compound	
Acrylonitrile	5.0
Benzene	0.07
Carbon disulfide	14.4
Carbon tetachloride	0.07
Chlorobenzene	1.4
Chloroform	0.07
1,2-Dichloroethane	0.04
1,1-Dichlorethylene	0.1
Isobutanol	25
Methylene chloride	8.6
Methy ethyl ketone	7.2
1,1,1,2-Tetrachloroethane	10.0
1,1,2,2-Tetrachloroethane	1.3
Tetachloroethylene	0.1
Toluene	14.4
1,1,1-Trichloroethane	25
1,1,2-Trichloroethane	1.2
Trichloroethylene	0.07
Vinyl chloride	0.05
o-Cresol	10.0
m-Cresol	10.0
p-Cresol	10.0
Pentachlorophenol	3.6
Phenol	14.4
2,3,4,6-Tetrachlorophenol	1.5
2,4,5-Trichlorophenol	5.8
2,4,6-Trichlorophenol	0.30
Bis(2-chloroethyl)ether	0.05
1,2-Dichlorobenzene	4.3
1,4-Dichlorobenzene	10.8
2,4-Dinitrotoluene	0.13
Hexachlorobenzene	0.13
Hexachlorobutadiene	0.72
Hexachloroethane	4.3
Nitrobenzene	0.13
Pyridine	5.0
Heptachlor	0.001
Insecticides	
Endrin	0.003
Lindane(γ-BHC)	0.06
Methoxychlor	1.4
Toxaphene	0.07
Herbicides	
2,4-D	1.4
2,3,5-TP (Silvex)	0.14

Table D-26. Summary of EM-9 Quality Assurance Tests for 1991 (Stable Element Analyses in Biologicals)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2–3σ (%)	Out of Control >3σ (%)	EM-9 Ratio ± Std Dev
B	2	100	—	—	0.98
Pb	2	50	50	—	0.83

Table D-27. Summary of EM-9 Quality Assurance Tests for 1991 (Stable Element Analyses in Filters)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2–3σ (%)	Out of Control >3σ (%)	EM-9 Ratio ± Std Dev
Be	9	100	—	—	0.87 ± 0.05
Pb	4	100	—	—	1.12 ± 0.11

Table D-28. Summary of EM-9 Quality Assurance Tests for 1991 (Stable Element Analyses in Bulk Materials)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2–3σ (%)	Out of Control >3σ (%)	EM-9 Ratio ± Std Dev
Ag	3	100	—	—	0.90 ± 0.08
As	2	100	—	—	0.80
Ba	2	100	—	—	0.83
Cd	2	100	—	—	0.85
Cr	1	100	—	—	0.96
Flashpoint	4	100	—	—	1.01 ± 0.01
Hg	1	100	—	—	1.03
Pb	1	100	—	—	0.76
Se	2	100	—	—	0.93

Table D-29. Summary of EM-9 Quality Assurance Tests for 1991 (Stable Element Analyses in Soil)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2–3σ (%)	Out of Control >3σ (%)	EM-9 Ratio ± Std Dev
Ag	17	100	—	—	1.03 ± 0.24
Al	40	73	10	18	0.91 ± 0.26
As	30	80	13	7	1.40 ± 2.04
Au	17	100	—	—	0.94 ± 0.11
Ba	29	90	7	3	0.98 ± 0.17
Be	12	67	17	17	0.71 ± 0.22
Br	19	74	5	21	1.64 ± 2.38
Ca	40	60	15	25	0.95 ± 0.25
Cd	7	57	29	14	0.59
Ce	27	74	7	19	0.99 ± 0.14
Cl	21	90	5	5	1.04 ± 0.32
Co	35	74	17	9	1.16 ± 0.78
Cr	38	66	5	29	0.97 ± 0.35
Cs	22	95	5	—	0.93 ± 0.07
Cu	24	100	—	—	1.07
Dy	25	84	12	4	0.97 ± 0.20
Eu	25	80	8	12	0.93 ± 0.13
Fe	40	83	15	3	0.95 ± 0.14
Ga	23	96	4	—	1.12 ± 0.19
H^2O	24	100	—	—	0.93 ± 0.05
Hf	26	88	12	—	0.92 ± 0.13
Hg	24	100	—	—	1.19 ± 0.14
I	18	100	—	—	0.91
In	19	100	—	—	0.91 ± 0.07
K	40	80	3	18	0.85 ± 0.36
La	25	88	12	—	1.03 ± 0.08
Lu	24	67	29	4	1.02 ± 0.18
Mg	39	74	18	8	0.96 ± 0.54
Mn	40	78	15	8	1.01 ± 0.17
Na	40	68	10	23	0.89 ± 0.35
Nd	24	79	4	17	1.01 ± 0.28
Ni	7	71	29	—	0.68 ± 0.15

Table D-29. (Cont.)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2–3σ (%)	Out of Control >3σ (%)	EM-9 Ratio ± Std Dev
Pb	7	71	14	14	0.66 ± 0.21
Rb	22	91	9	—	0.99 ± 0.07
Sb	29	76	10	14	0.94 ± 0.21
Sc	26	88	8	4	0.98 ± 0.06
Se	25	76	—	24	18.23 ± 78.62
Sm	25	72	—	28	0.97 ± 0.18
Sr	31	97	3	—	1.04 ± 0.22
Ta	21	76	14	10	0.89 ± 0.11
Tb	24	92	4	4	0.93 ± 0.16
Th	26	96	—	4	1.00 ± 0.12
Ti	34	97	3	—	1.07 ± 0.47
Tl	7	—	—	100	35.33 ± 49.16
V	33	76	3	21	0.90 ± 0.20
W	20	90	5	5	1.31 ± 0.39
Yb	25	72	24	4	1.04 ± 0.16
Zn	40	80	5	15	1.03 ± 0.22
Zr	27	93	7	—	1.16 ± 0.31

Table D-30. Summary of EM-9 Quality Assurance Tests for 1991 (Stable Element Analyses in Water)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2–3σ (%)	Out of Control >3σ (%)	EM-9 Ratio ± Std Dev
Ag	299	98	2	—	1.01 ± 0.09
Al	42	100	—	—	1.03 ± 0.08
As	230	99	—	—	1.04 ± 0.17
Au	3	100	—	—	—
B	46	100	—	—	1.02 ± 0.05
Ba	208	98	1	—	1.02 ± 0.08
Be	94	98	2	—	0.93 ± 0.12
Bi	3	100	—	—	—
Br	2	100	—	—	—
Ca	49	90	10	—	1.10 ± 0.12
Cd	219	99	1	—	1.02 ± 0.08
Ce	3	100	—	—	—
Cl	44	82	18	—	1.09 ± 0.17
CN	52	94	6	—	0.85 ± 0.09
Co	32	97	3	—	1.05 ± 0.09
COD	3	100	—	—	0.98 ± 0.02
Conductivity	36	92	6	3	0.92 ± 0.09
Cr	211	98	1	—	1.04 ± 0.20
Cs	3	100	—	—	—
Cu	67	93	4	3	0.97 ± 0.10
Dy	3	100	—	—	—
Er	3	100	—	—	—
Eu	3	100	—	—	—
F	31	100	—	—	1.07 ± 0.08
Fe	54	100	—	—	1.02 ± 0.08
Ga	3	100	—	—	—
Gd	3	100	—	—	—
Ge	3	100	—	—	—
Hardness	29	93	7	—	1.15 ± 0.11
Hf	3	100	—	—	—
Hg	112	93	4	4	0.97 ± 0.15
Ho	3	100	—	—	—
In	3	100	—	—	—
Ir	3	100	—	—	—
K	47	100	—	—	1.03 ± 0.08
La	3	100	—	—	—
Li	5	80	20	—	1.39
Lu	3	100	—	—	—
Mg	54	100	—	—	1.06 ± 0.06
Mn	55	96	2	2	1.08 ± 0.18
Mo	59	95	5	—	1.09 ± 0.12

Table D-30. (Cont.)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2–3σ (%)	Out of Control >3σ (%)	EM-9 Ratio ± Std Dev
Na	47	96	4	—	1.08 ± 0.08
Nb	3	100	—	—	—
Nd	3	100	—	—	—
NH_3-N	2	50	—	50	1.02
Ni	57	100	—	—	1.03 ± 0.06
NO_3-N	55	100	—	—	0.98 ± 0.07
Oil/grease	1	100	—	—	0.90
P	8	63	38	—	1.34 ± 0.46
Pb	236	99	—	1	1.02 ± 0.06
Pd	3	100	—	—	—
pH	37	100	—	—	1.00 ± 0.01
PO_4-P	48	100	5	—	0.99 ± 0.21
Pr	3	100	—	—	—
Pt	3	100	—	—	—
Rb	3	100	—	—	—
Rh	3	100	—	—	—
Ru	3	100	—	—	—
Sb	66	97	3	—	.95 ± 0.08
Se	206	100	—	—	1.00 ± 0.09
SiO2	56	100	—	—	1.00 ± 0.05
Sm	3	100	—	5	—
Sn	19	95	—	—	0.92 ± 0.10
SO_4	45	96	4	—	1.02 ± 0.17
Sr	59	100	1	—	1.02 ± 0.07
Ta	3	100	—	—	—
Total alkalinity	33	97	3	—	1.09 ± 0.10
Tb	3	100	—	—	—
TDS (total dissolved solids)	38	84	16	—	0.95 ± 0.15
Tc	3	100	—	—	—
Th	8	100	—	—	1.01 ± 0.09
Ti	9	100	—	—	0.95 ± 0.06
Tl	75	99	1	—	1.01 ± 0.08
Tm	3	100	—	—	—
TDS (total suspended solids)	3	100	—	—	0.97 ± 0.02
V	51	96	4	—	1.01 ± 0.08
W	3	100	—	—	—
Y	4	75	—	25	—
Yb	3	100	—	—	—
Zn	61	84	16	—	0.92 ± 0.15
Zr	3	100	—	—	—

Table D-31. Summary of EM-9 Quality Assurance Tests for 1991 (Radiochemical Analyses)

Matrix	Analysis	No. QC with CV	Under Control <2σ (%)	Warning 2-3σ (%)	Out of Control >3σ (%)	EM-9 CV Ratio ± Std Dev
Biologicals						
	^{241}Am	1	100	—	—	—
	^{137}Cs	17	82	6	12	0.94 ± 0.72
	^{238}Pu	12	75	17	8	1.04 ± 0.09
	^{239}Pu	12	83	17	—	1.06 ± 0.03
	^{90}Sr	10	40	—	60	0.84 ± 0.22
	U	15	87	13	—	1.15 ± 0.09
Filters						
	Alpha	60	100	—	—	0.92 ± 0.10
	^{241}Am	9	89	11	—	0.94 ± 0.04
	Beta	60	100	—	—	0.82 ± 0.02
	^{238}Pu	9	100	—	—	1.00 ± 0.07
	^{239}Pu	9	67	22	11	0.91 ± 0.07
	U	21	100	—	—	1.09 ± 0.09
Soil						
	Alpha	8	75	25	—	0.95 ± 0.41
	^{241}Am	25	80	16	4	1.09 ± 0.25
	Beta	8	88	13	—	0.93 ± 0.17
	^{137}Cs	57	95	4	2	0.98 ± 0.22
	Gamma	43	100	—	—	0.89 ± 0.02
	^{3}H	48	73	23	4	1.03 ± 0.12
	^{238}Pu	38	92	3	5	0.99 ± 0.07
	^{239}Pu	38	87	5	8	1.08 ± 0.24
	^{90}Sr	27	67	26	7	0.89 ± 0.15
	U	155	92	6	2	0.97 ± 0.09
	$^{235/238}U$	28	96	4	—	1.03 ± 0.17
Water						
	Alpha	165	98	1	1	0.96 ± 0.35
	^{241}Am	3	100	—	—	0.90
	Beta	165	95	3	2	3.86 ±29.70
	^{137}Cs	59	100	—	—	1.10 ± 0.14
	Gamma	26	88	12	—	0.99 ± 0.19
	^{3}H	219	91	8	—	1.03 ± 0.10
	^{238}Pu	17	100	—	—	1.03 ± 0.07
	^{239}Pu	17	94	—	6	1.09 ± 0.12
	^{226}Ra	4	100	—	—	1.13 ± 0.02
	^{90}Sr	9	78	22	—	0.95 ± 0.08
	^{232}Th	1	100	—	—	1.00
	U	201	93	4	3	0.97 ± 0.10
	$^{235/238}U$	101	100	—	—	1.10 ± 0.38

Table D-32. Summary of EM-9 Quality Assurance Tests for 1991 (Organic Analyses in Filters)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2–3σ (%)	Out of Control >3σ (%)	EM-9 Ratio ± Std Dev
Mixed-Aroclor	67	84	12	4	1.48 ± 1.63
Aroclor 1242	67	91	6	3	1.63 ± 1.66
Aroclor 1254	67	99	—	1	1.04 ± 0.31
Aroclor 1260	67	94	6	—	1.68 ± 2.11

Table D-33. Summary of EM-9 Quality Assurance Tests for 1991 (Organic Analyses in Bulk Materials)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2–3σ (%)	Out of Control >3σ (%)	EM-9 Ratio ± Std Dev
Mixed-Aroclor	71	96	1	3	1.07 ± 0.29
Aroclor 1242	71	99	—	1	1.11 ± 0.30
Aroclor 1254	71	100	—	—	—
Aroclor 1260	71	97	1	1	1.04 ± 0.27

Table D-34. Summary of EM-9 Quality Assurance Tests for 1991 (Organic Analyses in Soil)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2–3σ (%)	Out of Control >3σ (%)	EM-9 CV Ratio ± Std Dev
Acenaphthene	25	96	4	—	0.62 ± 0.04
Acenaphthylene	25	100	—	—	—
Acetone	41	41	15	44	0.51 ± 0.21
Acrolein	38	100	—	—	—
Acrylonitrile	38	100	—	—	—
Aldrin	4	100	—	—	—
Aniline	25	92	—	8	0.14
Anthracene	25	100	—	—	0.86 ± 0.10
Mixed-Aroclor	43	91	7	2	1.01 ± 0.34
Aroclor 1242	41	98	2	—	0.88 ± 0.19
Aroclor 1254	41	93	5	2	0.95 ± 0.47
Aroclor 1260	41	100	—	—	1.11 ± 0.28
Azobenzene	25	100	—	—	—
alpha-BHC	4	100	—	—	0.91
beta-BHC	4	100	—	—	—
delta-BHC	4	100	—	—	—
Benzene	41	98		2	0.35
m-Benzidine	25	100	—	—	—
Benzo[*a*]anthracene	25	96	—	4	—
Benzo[*a*]pyrene	25	100	—	—	0.66
Benzo[*b*]fluoranthene	25	100	—	—	0.78 ± 0.07
Benzo[*g,h,i*]perylene	25	100	—	—	—
Benzo[*k*]fluoranthene	25	100	—	—	0.75
Benzoic acid	25	68	—	32	0.21 ± 0.05
Benzyl alcohol	25	92	—	8	0.76 ± 0.36
Bis(2-chloroethoxy)methane	25	100	—	—	—
Bis(2-chloroethyl)ether	25	100	—	—	0.76 ± 0.10
Bis(2-chloroisopropyl)ether	25	100	—	—	—
Bis(2-ethylhexyl)phthalate	25	96	—	4	—
Bromobenzene	41	98	2	—	0.92 ± 0.17
Bromochloromethane	41	100	—	—	—
Bromodichloromethane	41	98	—	2	1.03 ± 0.24
Bromoform	41	95	—	5	1.02 ± 0.28
Bromomethane	41	100	—	—	—
4-Bromophenylphenyl ether	25	96	4	—	0.67
2-Butanone	41	56	7	37	0.54 ± 0.21
Butyl benzyl phthalate	25	100	—	—	—
tert-Butylbenzene	41	100	—	—	0.71
n-Butylbenzene	41	100	—	—	—
sec-Butylbenzene	41	100	—	—	0.73
Carbon disulfide	41	80	—	20	0.37
Carbon tetrachloride	41	93	—	7	1.01 ± 0.42

Table D-34. (Cont.)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2–3σ (%)	Out of Control >3σ (%)	EM-9 CV Ratio ± Std Dev
Chlordane	4	100	—	—	—
4-Chloro-3-methylphenol	25	96	4	—	0.75 ± 0.13
4-Chloroaniline	25	96	—	4	0.16
Chlorobenzene	41	98	—	2	0.89 ± 0.14
Chlorodibromomethane	41	93	2	5	0.97 ± 0.21
Chloroethane	41	100	—	—	—
2-Chloroethylvinyl ether	38	100	—	—	—
Chloroform	41	98	2	—	0.87 ± 0.17
Chloromethane	41	100	—	—	—
2-Chloronaphthalene	25	84	12	4	0.59 ± 0.11
o-Chlorophenol	25	96	4	—	0.60 ± 0.08
4-Chlorophenylphenyl ether	25	100	—	—	—
p-Chlorotoluene	41	100	—	—	0.65
o-Chlorotoluene	41	93	5	2	0.79 ± 0.28
Chrysene	25	100	—	—	1.35 ± 0.52
p,p'-DDD	4	100	—	—	0.81 ± 0.20
p,p'-DDE	4	100	—	—	0.63
p,p'-DDT	4	100	—	—	0.76 ± 0.26
Di-*n*-butyl phthalate	25	92	4	4	0.67 ± 0.04
Di-*n*-octyl phthalate	25	100	—	—	1.26 ± 0.55
Dibenzo[*a*,*h*]anthracene	25	100	—	—	—
Dibenzofuran	25	100	—	—	—
1,2-Dibromo-3-chloropropane	41	100	—	—	—
1,2-Dibromoethane	41	100	—	—	—
Dibromomethane	41	100	—	—	0.88 ± 0.16
o-Dichlorobenzene (1,2)	66	100	—	—	0.95 ± 0.11
m-Dichlorobenzene (1,3)	66	100	—	—	—
p-Dichlorobenzene (1,4)	66	95	5	—	0.71 ± 0.13
3,3'-Dichlorobenzidine	25	100	—	—	—
Dichlorodifluoromethane	41	100	—	—	—
1,1-Dichloroethane	41	83	2	15	0.33 ± 0.17
1,2-Dichloroethane	41	85	—	15	0.97 ± 0.40
trans-1,2-Dichloroethene	41	100	—	—	—
1,1-Dichloroethene	41	98	—	2	—
cis-1,2-Dichloroethylene	41	100	—	—	—
2,4-Dichlorophenol	25	84	16	—	0.62 ± 0.13
1,2-Dichloropropane	41	80	—	20	0.68 ± 0.36
2,2-Dichloropropane	41	100	—	—	—
1,3-Dichloropropane	41	100	—	—	—
1,1-Dichloropropene	41	100	—	—	—
trans-1,3-Dichloropropene	41	100	—	—	—
cis-1,3-Dichloropropene	41	100	—	—	—
Dieldrin	4	100	—	—	—

Table D-34. (Cont.)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2–3σ (%)	Out of Control >3σ (%)	EM-9 CV Ratio ± Std Dev
Diethyl phthalate	25	96	4	—	0.65 ± 0.06
Dimethyl phthalate	25	100	—	—	—
2,4-Dimethylphenol	25	80	16	4	0.59 ± 0.09
2,4-Dinitrophenol	25	100	—	—	—
2,6-Dinitrotoluene	25	100	—	—	0.68 ± 0.02
2,4-Dinitrotoluene	25	100	—	—	—
Endosulfan I	1	100	—	—	—
Endosulfan II	1	100	—	—	—
Endosulfan sulfate	4	100	—	—	—
Endrin	4	100	—	—	0.87 ± 0.30
Endrin aldehyde	4	100	—	—	—
Esters	—	—	—	—	—
Ethylbenzene	41	83	2	15	0.71 ± 0.33
Fluoranthene	25	96	—	4	0.94 ± 0.10
Fluorene	25	100	—	—	—
Heptachlor	4	100	—	—	—
Heptachlor epoxide	4	100	—	—	0.77
Hexachlorobenzene	25	100	—	—	—
Hexachlorobutadiene	26	96	—	4	0.70 ± 0.14
Hexachlorocyclopentadiene	25	96	—	4	0.60
Hexachloroethane	25	80	4	16	0.51 ± 0.23
2-Hexanone	41	80	7	12	0.72 ± 0.18
Hexyl petyl ether	—	—	—	—	—
Indeno[1,2,3-*cd*]pyrene	25	100	—	—	—
Isophorone	25	100	—	—	—
Isopropylbenzene	41	100	—	—	—
4-Isopropyltoluene	41	100	—	—	—
Lindane	4	100	—	—	0.83 ± 0.25
Methoxychlor	4	100	—	—	0.66 ± 0.16
Methyl acetate	—	—	—	—	—
Methyl iodide	41	100	—	—	—
4-Methyl-2-pentanone	41	100	—	—	0.96 ± 0.17
2-Methyl-4,6-dinitrophenol	25	100	—	—	—
Methylene chloride	41	66	5	29	0.83 ± 0.48
2-Methylnaphthalene	25	100	—	—	—
4-Methylphenol	25	100	—	—	—
2-Methylphenol	25	100	—	—	—
Naphthalene	26	92	8	—	0.55 ± 0.04
2-Nitroaniline	25	100	—	—	—
3-Nitroaniline	25	76	—	24	0.23 ± 0.09
4-Nitroaniline	25	80	8	12	0.36 ± 0.14
Nitrobenzene	25	100	—	—	—

Table D-34. (Cont.)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2–3σ (%)	Out of Control >3σ (%)	EM-9 CV Ratio ± Std Dev
2-Nitrophenol	25	100	—	—	—
4-Nitrophenol	25	96	4	—	0.76 ± 0.15
N-Nitrosodi-*n*-propylamine	25	100	—		—
N-Nitrosodimethylamine	25	100	—		—
N-Nitrosodiphenylamine	25	100	—		0.71 ± 0.06
Pentachlorophenol	25	100	—	—	—
Phenanthrene	25	100	—	—	0.72
Phenol	25	100	—	—	—
Propylbenzene	41	95	2	2	0.67 ± 0.18
Pyrene	25	100	—	—	—
Saturated Hydrocarbons	—	—	—	—	—
Styrene	41	90	—	10	0.84 ± 0.21
1,1,1,2-Tetrachloroethane	41	98	2	—	0.89 ± 0.15
1,1,2,2-Tetrachloroethane	41	100	—	—	1.04 ± 0.16
Tetrachloroethylene	41	93	5	2	0.80 ± 0.26
Toluene	41	95	2	2	0.77 ± 0.21
Toxaphene	4	100	—	—	—
1,1,2-Trichloro-1,2,2-trifluorethane	41	100	—	—	—
1,2,3-Trichlorobenzene	1	100	—	—	—
1,2,4-Trichlorobenzene	26	100	—	—	—
1,1,1-Trichloroethane	41	85	—	15	0.93 ± 0.48
1,1,2-Trichloroethane	41	88	7	5	0.87 ± 0.20
Trichloroethene	41	90	2	7	0.77 ± 0.20
Trichlorofluoromethane	41	100	—	—	—
2,4,5-Trichlorophenol	25	100	—	—	—
2,4,6-Trichlorophenol	25	100	—	—	—
1,2,3-Trichloropropane	41	100	—	—	0.81 ± 0.16
1,2,4-Trimethylbenzene	41	98	2	—	0.88 ± 0.13
1,3,5-Trimethylbenzene	41	100	—	—	—
n-Undecane	—	—	—	—	—
Unknown Polynuclear Aromatic Hydrocarbons	—	—	—	—	—
Unknown organic acid	—	—	—	—	—
Unknown organic compound	—	—	—	—	—
Unsaturated Hydrocarbons	—	—	—	—	—
Vinyl acetate	41	93	—	7	0.72 ± 0.05
Vinyl chloride	41	100	—	—	—
Mixed-Xylenes ($o + m + p$)	41	98	2	—	0.86 ± 0.17

Table D-35. Summary of EM-9 Quality Assurance Tests for 1991 (Organic Analyses in Charcoal Tubes)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2–3σ (%)	Out of Control >3σ (%)	EM-9 Ratio ± Std Dev
Benzene	69	100	—	—	0.84 ± 0.20
Bromobenzene	69	97	3	—	0.71 ± 0.17
Carbon tetrachloride	69	99	—	1	0.90 ± 0.21
Chlorobenzene	69	100	—	—	0.82 ± 0.14
Chloroform	69	100	—	—	0.94 ± 0.29
Ethylbenzene	69	90	—	10	0.85 ± 0.16
Tetrachloroethylene	69	100	—	—	0.94 ± 0.18
Toluene	69	100	—	—	0.86 ± 0.16
1,1,1-Trichloroethane	69	100	—	—	0.87 ± 0.16
Trichloroethene	69	100	—	—	0.97 ± 0.15
1,2,4-Trimethylbenzene	69	99	—	1	0.76 ± 0.16
o-Xylene	69	100	—	—	0.95 ± 0.13
Mixed-Xylenes (*o* + *m* + *p*)	69	83	7	10	0.81 ± 0.21

Table D-36. Summary of EM-9 Quality Assurance Tests for 1991 (Organic Analyses in Water)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2–3σ (%)	Out of Control >3σ (%)	HSE-9 Ratio ± Std Dev
Acenaphthene	20	85	—	15	0.27 ± 0.10
Acenaphthylene	20	100	—	—	—
Acetone	24	46	13	42	0.54 ± 0.19
Acrolein	22	100	—	—	—
Acrylonitrile	22	100	—	—	—
Aldrin	1	100	—	—	—
Aniline	20	85	—	15	0.44
Anthracene	20	95	5	—	0.71 ± 0.07
Mixed-Aroclor	12	83	8	8	0.95 ± 0.50
Aroclor 1242	12	100	—	—	1.54 ± 0.34
Aroclor 1254	12	83	8	8	0.75 ± 0.37
Aroclor 1260	12	100	—	—	—
Azobenzene	20	100	—	—	—
alpha-BHC	1	100	—	—	—
beta-BHC	1	100	—	—	—
delta-BHC	1	100	—	—	—
Benzene	24	100	—	—	0.88
Benzenes, substituted	—	—	—	—	—
m-Benzidine	20	100	—	—	—
Benzo[*a*]anthracene	20	100	—	—	—
Benzo[*a*]pyrene	20	95	—	5	0.40
Benzo[*b*]fluoranthene	20	100	—	—	0.85
Benzo[*g,h,i*]perylene	20	100	—	—	—
Benzo[*k*]fluoranthene	20	90	—	10	0.20
Benzoic acid	20	90	—	10	0.78
Benzyl alcohol	20	100	—	—	0.85 ± 0.20
Bis(2-chloroethoxy)methane	20	100	—	—	—
Bis(2-chloroethyl)ether	20	80	10	10	0.58 ± 0.17
Bis(2-chloroisopropyl)ether	20	100	—	—	—
Bis(2-ethylhexyl)phthalate	21	90	—	10	—
Bromobenzene	24	100	—	—	0.99 ± 0.07
Bromochloromethane	24	100	—	—	—
Bromodichloromethane	24	100	—	—	1.19 ± 0.37
Bromoform	24	100	—	—	0.99 ± 0.09
Bromomethane	24	100	—	—	—
4-Bromophenylphenyl ether	20	100	—	—	0.60
2-Butanone	24	54	29	17	0.50 ± 0.11
Butyl benzyl phthalate	20	100	—	—	—
n-Butylbenzene	24	100	—	—	—
sec-Butylbenzene	24	100	—	—	—
tert-Butylbenzene	24	100	—	—	0.71 ± 0.06
Carbon disulfide	24	96	4	—	0.85 ± 0.18

Table D-36. (Cont.)
(Organic Analyses in Water)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2–3σ (%)	Out of Control >3σ (%)	HSE-9 Ratio ± Std Dev
Carbon tetrachloride	24	100	—	—	0.86 ± 0.15
Chlordane	1	100	—	—	—
4-Chloro-3-methylphenol	20	90	5	5	0.67 ± 0.25
4-Chloroaniline	20	90	—	10	0.14
Chlorobenzene	24	100	—	—	0.86 ± 0.05
Chlorodibromomethane	24	100	—	—	0.97 ± 0.09
Chloroethane	24	100	—	—	—
2-Chloroethylvinyl ether	22	100	—	—	—
Chloroform	24	100	—	—	0.93 ± 0.10
Chloromethane	24	100	—	—	—
2-Chloronaphthalene	20	100	—	—	0.63
o-Chlorophenol	20	90	5	5	0.60 ± 0.13
4-Chlorophenylphenyl ether	20	100	—	—	—
o-Chlorotoluene	24	100	—	—	0.74 ± 0.10
p-Chorotoluene	24	100	—	—	—
Chrysene	20	90	—	10	0.15
2,4-D	1	100	—	—	2.07
p,p'-DDD	1	100	—	—	—
p,p'-DDE	1	—	100	—	0.46
p,p'-DDT	1	100	—	—	—
Di-*n*-butyl phthalate	20	95	—	5	0.32
Di-*n*-octyl phthalate	20	80	—	20	0.50 ± 0.26
Dibenzo[*a,h*]anthracene	20	100	—	—	—
Dibenzofuran	20	100	—	—	—
1,2-dibromo-3-Chloropropane	24	100	—	—	—
1,2-Dibromoethane	24	100	—	—	—
Dibromomethane	24	100	—	—	1.02 ± 0.11
o-Dichlorobenzene (1,2)	44	100	—	—	0.74 ± 0.06
m-Dichlorobenzene (1,3)	44	100	—	—	—
p-Dichlorobenzene (1,4)	44	95	—	5	0.69 ± 0.21
3,3'-Dichlorobenzidine	20	100	—	—	—
Dichlorodifluoromethane	24	100	—	—	—
1,2-Dichloroethane	24	100	—	—	1.18 ± 0.34
1,1-Dichloroethane	24	100	—	—	0.87 ± 0.09
1,1-Dichloroethene	24	100	—	—	—
trans-1,2-Dichloroethylene	24	100	—	—	—
cis-1,2-Dichloroethylene	24	100	—	—	—
2,4-Dichlorophenol	20	100	—	—	0.70
2,2-Dichloropropane	24	100	—	—	—
1,3-Dichloropropane	24	100	—	—	—
1,2-Dichloropropane	24	100	—	—	0.86 ± 0.13

Table D-36. (Cont.)
(Organic Analyses in Water)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2–3σ (%)	Out of Control >3σ (%)	HSE-9 Ratio ± Std Dev
1,1-Dichloropropene	24	100	—	—	—
cis-1,3-Dichloropropene	24	100	—	—	—
trans-1,3-Dichloropropene	24	100	—	—	—
Dieldrin	1	100	—	—	0.71
Diethyl phthalate	20	75	—	25	0.13 ± 0.01
Dimethyl phthalate	20	100	—	—	—
N,N-Dimethylformamide	—	—	—	—	—
2,4-Dimethylphenol	20	85	5	10	0.59 ± 0.24
2,4-Dinitrophenol	20	100	—	—	—
2,4-Dinitrotoluene	20	100	—	—	—
2,6-Dinitrotoluene	20	85	5	10	0.33 ± 0.18
Endosulfan I	1	100	—	—	—
Endosulfan II	1	100	—	—	—
Endosulfan sulfate	1	100	—	—	—
Endrin	1	100	—	—	—
Endrin aldehyde	1	100	—	—	—
Ethylbenzene	24	100	—	—	0.74 ± 0.10
Fluoranthene	20	95	—	5	0.75 ± 0.19
Fluorene	20	100	—	—	—
Heptachlor	1	100	—	—	—
Heptachlor epoxide	1	100	—	—	0.85
Hexachlorobenzene	20	100	—	—	—
Hexachlorobutadiene	21	86	10	5	0.50 ± 0.06
Hexachlorocyclopentadiene	20	90	5	5	0.51 ± 0.07
Hexachloroethane	20	90	—	10	0.35
2-Hexanone	24	67	17	17	0.65 ± 0.18
Indeno[1,2,3-*cd*]pyrene	20	100	—	—	—
Isophorone	20	100	—	—	—
Isopropylbenzene	24	100	—	—	—
4-Isopropyltoluene	24	100	—	—	—
Lindane	1	100	—	—	—
Methoxychlor	1	100	—	—	1.00
Methyl iodide	24	100	—	—	—
4-methyl-2-pentanone	24	96	—	4	0.90 ± 0.15
1-Methyl-2-pyrrolidinone	—	—	—	—	—
2-Methyl-4,6-dinitrophenol	20	100	—	—	—
Methylene chloride	24	100	—	—	0.85 ± 0.17
2-Methylnaphthalene	20	100	—	—	—
2-Methylphenol	20	100	—	—	—
4-Methylphenol	20	100	—	—	—
Naphthalene	21	95	5	—	0.58
4-Nitroaniline	20	95	5	—	0.80 ± 0.15

Table D-36. (Cont.)
(Organic Analyses in Water)

Analysis	Number of QC Tests	Under Control <2σ (%)	Warning 2–3σ (%)	Out of Control >3σ (%)	HSE-9 Ratio ± Std Dev
2-Nitroaniline	20	100	—	—	—
3-Nitroaniline	20	100	—	—	0.77
Nitrobenzene	20	100	—	—	—
2-Nitrophenol	20	100	—	—	—
4-Nitrohenol	20	90	5	5	0.61 ± 0.19
N-Nitrosodi-*n*-propylamine	20	100	—	—	—
N-Nitrosodimethylamine	20	100	—	—	—
N-Nitrosodiphenylamine	20	85	5	10	0.31 ± 0.16
Pentachlorophenol	20	100	—	—	—
Phenanthrene	20	95	—	5	0.54
Phenol	20	100	—	—	0.88
Propylbenzene	24	92	—	8	0.53 ± 0.14
Pyrene	20	100	—	—	—
Styrene	24	100	—	—	0.74 ± 0.07
2,4,5-TP	1	100	—	—	1.70
1,1,1,2-Tetrachloroethane	24	100	—	—	0.91 ± 0.06
1,1,2,2-Tetrachloroethane	24	100	—	—	0.95 ± 0.03
Tetrachloroethylene	24	100	—	—	0.73 ± 0.08
2,2,4,4-Tetramethyl-3-Pentanone	—	—	—	—	—
Toluene	24	100	—	—	0.74 ± 0.05
Toxaphene	1	100	—	—	—
1,1,2-Trichloro-1,2,2-Trifluoroethane	24	100	—	—	—
1,2,4-Trichlorobenzene	21	95	—	5	0.48
1,2,3-Trichlorobenzene	1	100	—	—	—
1,1,1-Trichloroethane	24	96	—	4	0.86 ± 0.15
1,1,2-Trichloroethane	24	100	—	—	0.93 ± 0.07
Trichloroethene	24	100	—	—	0.81 ± 0.05
Trichlorofluoromethane	24	96	—	4	—
2,4,6-Trichlorophenol	20	100	—	—	—
2,4,5-Trichlorophenol	20	100	—	—	—
1,2,3-Trichloropropane	24	100	—	—	0.96 ± 0.15
1,2,4-Trimethylbenzene	24	92	—	8	0.52 ± 0.20
1,3,5-Trimethylbenzene	24	100	—	—	—
Unknown Alcohol	—	—	—	—	—
Unknown Sulfur compounds	—	—	—	—	—
Unsaturated Hydrocarbons	—	—	—	—	—
Vinyl acetate	24	88	4	8	2.35
Vinyl chloride	24	100	—	—	—
Mixed-Xylenes($o + m + p$)	24	92	8	—	0.75 ± 0.16

Table D-37. Summary of EM-9 False Positive/False Negative Occurrences for EM-8 Quality Control Samples Run in 1991

Matrix Analyte	False Positive	False Negative	Total Quality Occurrence
INORGANIC ANALYSES			
Biologicals			
B	—	—	2
Pb	—	—	2
U	—	—	15
Bulk Materials			
Ag	—	—	1
As	—	—	1
Ba	—	—	1
Cd	—	—	1
Cr	—	—	1
Flashpoint	—	—	4
Hg	—	—	1
Pb	—	—	1
Se	—	—	1
Filters			
Be	—	—	6
Pb	—	—	4
U	—	—	21
Soils			
Ag	—	—	17
Al	—	—	40
As	—	2	30
Au	—	1	17
Ba	—	2	29
Be	—	—	12
Br	—	—	19
Ca	—	1	40
Cd	—	2	7
Ce	—	1	27
Cl	1	—	21
Co	—	3	35
Cr	—	—	38
Cs	—	—	22
Cu	—	—	24
Dy	—	—	25
Eu	—	—	25
Fe	—	—	40
Ga	—	—	23
H_2O-(Unbound Water)	—	24	
Hf	—	—	26

Table D-37. (Cont.)

Matrix Analyte	False Positive	False Negative	Total Quality Occurrence
INORGANIC ANALYSES (Cont.)			
Soils (Cont.)			
Hg	—	—	24
I	—	—	18
In	—	—	19
K	—	—	40
La	—	—	25
Lu	—	—	24
Mg	—	—	39
Mn	—	—	40
Na	—	1	40
Nd	—	1	24
Ni	—	—	7
Pb	—	—	7
Rb	—	—	22
Sb	—	3	29
Sc	—	—	26
Se	—	1	25
Sm	—	—	25
Sr	—	3	31
Ta	—	—	21
Tb	—	—	24
Th	—	—	26
Ti	—	—	34
Tl	—	1	7
U	—	—	155
V	—	2	33
W	—	—	20
Yb	—	—	25
Zn	—	5	40
Zr	—	2	27
Waters			
Ag	—	—	287
Al	—	—	42
As	—	—	226
Au	—	—	3
B	—	—	46
Ba	—	2	208
Be	—	—	94
Bi	—	—	3
Br	—	—	2
Ca	—	—	49
Cd	2	1	219

Table D-37. (Cont.)

Matrix Analyte	False Positive	False Negative	Total Quality Occurrence
INORGANIC ANALYSES (Cont.)			
Waters (Cont.)			
Ce	—	—	3
Cl	—	—	44
Cn	—	—	41
Co	—	—	32
Chemical Oxygen Demand	—	3	
Conductivity	—	—	34
Cr	—	—	211
Cs	—	—	3
Cu	—	—	67
Dy	—	—	3
Er	—	—	3
Eu	—	—	3
F	—	—	31
Fe	—	—	54
Ga	—	—	3
Gd	—	—	3
Ge	—	—	3
Hardness	—	—	28
Hf	—	—	3
Hg	—	—	110
Ho	—	—	3
In	—	—	3
Ir	—	—	3
K	—	—	47
La	—	—	47
Li	—	—	5
Lu	—	—	3
Mg	—	—	54
Mn	—	—	55
Mo	—	—	59
Na	—	—	47
Nb	—	—	3
Nd	—	—	3
NH_3-N	—	1	2
Ni	—	—	57
NO_3-N	—	—	52
Oil/grease	—	—	1
P	—	—	5
Pb	2	1	236
Pd	—	—	3
Ph	—	—	37
PO_4-P	—	—	48

Table D-37. (Cont.)

Matrix Analyte	False Positive	False Negative	Total Quality Occurrence
INORGANIC ANALYSES (Cont.)			
Waters (Cont.)			
Pr	—	—	3
Pt	—	—	3
Rb	—	—	3
Rh	—	—	3
Ru	—	—	3
Sb	—	—	66
Se	—	—	202
Si	—	—	51
Sm	—	—	3
Sn	—	—	19
SO_4	—	—	45
Sr	—	—	59
Ta	—	—	3
Total Alkalinity	—	33	
Tb	—	—	3
Total Dissolved Solids	—	38	
Te	—	—	3
Th	—	—	8
Ti	—	—	9
Tl	—	—	75
Tm	—	—	3
Total Suspended Solids	—	3	
U	—	—	196
V	—	—	51
W	—	—	3
Y	—	—	4
Yb	—	—	3
Zn	—	—	61
Zr	—	—	3
ORGANIC ANALYSES			
Bulk Materials			
Mixed-Aroclor	—	—	71
Aroclor 1242	—	—	71
Aroclor 1254	—	—	71
Aroclor 1260	—	—	71
Filters			
Mixed-Aroclor	—	1	67
Aroclor 1242	—	1	67
Aroclor 1254	—	—	67
Aroclor 1260	—	—	67

Table D-37. (Cont.)

Matrix Analyte	False Positive	False Negative	Total Quality Occurrence
ORGANIC ANALYSES (Cont.)			
Soils			
Acenaphthene	—	—	54
Acenaphthylene	—	—	54
Acetone	1	1	130
Acrolein	—	—	117
Acrylonitrile	—	—	117
Aldrin	—	—	4
Aniline	—	1	54
Anthracene	—	—	54
Mixed-Aroclor	—	—	42
Aroclor 1242	—	—	41
Aroclor 1254	—	—	41
Aroclor 1260	—	—	41
Azobenzene	—	—	54
Alpha-BHC	—	—	4
Beta-BHC	—	—	4
Delta-BHC	—	—	4
Benzene	—	—	130
m-Benzidine	—	—	54
Benzo[*a*]anthracene	1	—	54
Benzo[*a*]pyrene	—	—	54
Benzo[*b*]fluoranthene	—	—	54
Benzo[*g,h,i*]perylene	—	—	54
Benzo[*k*]fluoranthene	—	—	54
Benzoic acid	2	3	54
Benzyl alcohol	—	—	54
Bis(2-chloroethoxy)methane	—	—	54
Bis(2-chloroethyl)ether	—	—	54
Bis(2-chloroisopropyl)ether	—	—	54
Bis(2-ethylhexyl)phthalate	2	—	54
Bromobenzene	—	—	130
Bromochloromethane	—	—	130
Bromodichloromethane	—	—	130
Bromoform	—	2	130
Bromomethane	—	—	130
4-Bromophenylphenyl ether	—	—	54
2-Butanone	4	2	130
Butyl benzyl phthalate	—	—	54
n-Butylbenzene	—	—	129
sec-Butylbenzene	—	—	129
tert-Butylbenzene	—	—	130
Carbon disulfide	6	4	130
Carbon tetrachloride	—	1	130
Chlordane	—	—	4

Table D-37. (Cont.)

Matrix Analyte	False Positive	False Negative	Total Quality Occurrence
ORGANIC ANALYSES (Cont.)			
Soils (Cont.)			
4-Chloro-3-methylphenol	—	—	54
4-Chloroaniline	—	—	54
Chlorobenzene	—	—	130
Chlorodibromomethane	—	2	130
Chloroethane	—	—	130
2-Chloroethylvinyl ether	—	—	118
Chloroform	—	—	130
Chloromethane	—	—	130
2-Chloronaphthalene	—	—	54
o-chlorophenol	—	—	54
4-Chlorophenylphenyl ether	—	—	54
o-Chlorotoluene	—	—	130
p-Chlorotoluene	—	—	130
Chrysene	—	—	54
p,p'-DDD	—	—	4
p,p'-DDE	—	—	4
p,p'-DDT	—	—	4
Di-*n*-butyl phthalate	2	—	54
Di-*n*-octyl phthalate	—	—	54
Dibenzo[*a,h*]anthracene	—	—	54
Dibenzofuran	—	—	54
1,2-Dibromo-3-Chloropropane	—	129	
1,2-Dibromoethane	—	—	130
Dibromomethane	—	—	130
o-Dichlorobenzene(1,2)	1	—	183
m-Dichlorobenzene(1,3)	—	—	183
p-Dichlorobenzene(1,4)	—	—	183
3,3'-Dichlorobenzidine	—	—	54
Dichlorodifluoromethane	—	—	130
1,1-Dichloroethane	—	3	130
1,2-Dichloroethane	—	3	130
1,1-Dichloroethene	1	—	130
trans-1,2-Dichloroethene	—	—	130
cis-1,2-Dichloroethylene	—	—	130
2,4-Dichlorophenol	—	—	54
1,2-Dichloropropane	—	4	130
1,3-Dichloropropane	—	—	130
2,2-Dichloropropane	—	—	130
1,1-Dichloropropene	—	—	130
cis-1,3-Dichloropropene	—	—	130
trans-1,3-Dichloropropene	—	—	130
Dieldrin	—	—	4
Diethyl phthalate	—	—	54

Table D-37. (Cont.)

Matrix Analyte	False Positive	False Negative	Total Quality Occurrence
ORGANIC ANALYSES (Cont.)			
Soils (Cont.)			
Dimethyl phthalate	—	—	54
2,4-Dimethylphenol	—	1	54
2,4-Dinitrophenol	—	—	54
2,4-Dinitrotoluene	—	—	54
2,6-Dinitrotoluene	—	—	54
Endosulfan I	—	—	1
Endosulfan II	—	—	1
Endosulfan sulfate	—	—	4
Endrin	—	—	4
Endrin aldehyde	—	—	4
Ethylbenzene	—	3	130
1,2-Dibromoethane	—	—	130
Fluoranthene	—	1	54
Fluorene	—	—	54
Heptachlor	—	—	4
Heptachlor epoxide	—	—	4
Hexachlorobenzene	—	—	54
Hexachlorobutadiene	—	—	59
Hexachlorocyclopentadiene	—	1	54
Hexachloroethane	—	2	54
2-Hexanone	—	4	130
Indeno[1,2,3-*cd*]pyrene	—	—	54
Isophorone	—	—	54
Isopropylbenzene	—	—	130
4-Isopropyltoluene	—	—	129
Lindane	—	—	4
Methoxychlor	—	—	4
Methyl iodide	—	—	130
4-Methyl-2-pentanone	—	—	130
2-Methyl-4,6-Dinitrophenol	—	—	54
Methylene chloride	13	1	130
2-Methylnaphthalene	—	—	54
2-Methylphenol	—	—	54
4-Methylphenol	—	—	54
Naphthalene	—	—	59
2-Nitroaniline	—	—	54
3-Nitroaniline	—	3	54
4-Nitroaniline	—	—	54
Nitrobenzene	—	—	54
2-Nitrophenol	—	—	54
4-Nitrophenol	—	—	54
N-Nitrosodi-*n*-propylamine	—	—	54

Table D-37. (Cont.)

Matrix Analyte	False Positive	False Negative	Total Quality Occurrence
Organic Analyses (Cont.)			
Soils (Cont.)			
N-Nitrosodimethylamine	—	—	54
N-Nitrosodiphenylamine	—	—	54
Pentachlorophenol	—	—	54
Phenanthrene	—	—	54
Phenol	—	—	54
Propylbenzene	—	—	130
Pyrene	—	—	54
Styrene	—	2	130
1,1,1,2-Tetrachloroethane	—	—	130
1,1,2,2-Tetrachloroethane	—	—	130
Tetrachloroethylene	—	—	130
Toluene	—	—	130
Toxaphene	—	—	4
1,1,2-Trichloro-1,2,2-Trifluoroethane	1	—	130
1,2,3-Trichlorobenzene	—	—	5
1,2,4-Trichlorobenzene	—	—	59
1,1,1-Trichloroethane	2	—	130
1,1,2-Trichloroethane	—	2	130
Trichloroethene	2	—	130
Trichlorofluoromethane	1	—	130
2,4,5-Trichlorophenol	—	—	54
2,4,6-Trichlorophenol	—	—	54
1,2,3-Trichloropropane	—	—	130
1,2,4-Trimethylbenzene	—	—	130
1,3,5-Trimethylbenzene	—	—	130
Vinyl acetate	—	3	130
Vinyl chloride	—	—	130
Mixed-Xylenes ($o + m + p$)	—	—	130
Charcoal Tubes			
Benzene	—	—	98
Bromobenzene	—	—	98
Carbon tetrachloride	—	1	98
Chlorobenzene	—	—	98
Chloroform	—	—	98
Ethylbenzene	4	3	98
Tetrachloroethylene	—	—	98
Toluene	—	—	98
1,1,1-Trichloroethane	—	—	98
Trichloroethene	—	—	98
1,2,4-Trimethylbenzene	—	—	98

Table D-37. (Cont.)

Matrix Analyte	False Positive	False Negative	Total Quality Occurrence
INORGANIC ANALYSES (Cont.)			
Charcoal Tubes (Cont.)			
o-Xylene	—	—	98
Mixed-Xylenes (*o* + *m* + *p*)	3	4	98
Waters			
Acenaphthene	3	—	67
Acenaphthylene	—	—	47
Acetone	1	—	63
Acrolein	—	—	56
Acrylonitrile	—	—	56
Aldrin	—	—	1
Aniline	—	2	47
Anthracene	—	1	47
Mixed-Aroclor	—	—	12
Aroclor 1242	—	—	12
Aroclor 1254	—	—	12
Aroclor 1260	—	—	12
Azobenzene	—	—	47
alpha-BHC	—	—	1
beta-BHC	—	—	1
delta-BHC	—	—	1
Benzene	—	—	63
m-Benzidine	—	—	47
Benzo[*a*]anthracene	—	—	47
Benzo[*a*]pyrene	—	—	47
Benzo[*b*]fluoranthene	—	—	47
Benzo[*g,h,i*]perylene	—	—	47
Benzo[k]fluoranthene	—	—	47
Benzoic acid	1	—	47
Benzyl alcohol	—	—	47
Bis(2-chloroethoxy)methane	—	—	47
Bis(2-chloroethyl)ether	—	1	47
Bis(2-chloroisopropyl)ether	—	—	47
Bis(2-ethylhexyl)phthalate	4	—	48
Bromobenzene	—	—	63
Bromochloromethane	—	—	63
Bromodichloromethane	—	—	63
Bromoform	—	—	63
Bromomethane	—	—	63
4-Bromophenylphenyl ether	—	—	47
2-Butanone	2	2	63
Butyl benzyl phthalate	—	—	47
n-Butylbenzene	—	—	63
sec-Butylbenzene	—	—	63

Table D-37. (Cont.)

Matrix Analyte	False Positive	False Negative	Total Quality Occurrence
ORGANIC ANALYSES (Cont.)			
Waters (Cont.)			
tert-Butylbenzene	—	—	63
Carbon disulfide	1	—	63
Carbon tetrachloride	—	—	63
Chlordane	—	—	1
4-Chloro-3-methylphenol	2	—	67
4-Chloroaniline	—	1	47
Chlorobenzene	—	—	63
Chlorodibromomethane	—	—	63
Chloroethane	—	—	63
2-Chloroethylvinyl ether	—	—	56
Chloroform	—	—	63
Chloromethane	—	—	63
2-Chloronaphthalene	—	—	47
o-Chlorophenol	9	—	67
4-Chlorophenylphenyl ether	—	—	47
o-Chlorotoluene	—	—	63
p-Chlorotoluene	—	—	63
Chrysene	—	1	47
2,4-D	—	—	1
p,p'-DDD	—	—	1
p,p'-DDE	—	—	1
p,p'-DDT	—	—	1
Di-*n*-butyl phthalate	—	—	47
Di-*n*-octyl phthalate	—	—	47
Dibenzo[*a,h*]anthracene	—	—	47
Dibenzofuran	—	—	47
1,2-Dibromo-3-chloropropane	—	63	
1,2-Dibromoethane	—	—	63
Dibromomethane	—	—	63
o-Dichlorobenzene(1,2)	—	—	110
m-Dichlorobenzene(1,3)	—	—	110
p-Dichlorobenzene(1,4)	5	—	130
3,3'-Dichlorobenzidine	—	—	47
Dichlorodifluoromethane	—	—	63
1,1-Dichloroethane	—	—	63
1,2-Dichloroethane	—	—	63
1,1-Dichloroethene	—	—	63
trans-1,2-Dichloroethene	—	—	63
cis-1,2-Dichloroethylene	—	—	63
2,4-Dichlorophenol	—	—	47
1,2-Dichloropropane	—	—	63
1,3-Dichloropropane	—	—	63
2,2-Dichloropropane	—	—	63

Table D-37. (Cont.)

Matrix Analyte	False Positive	False Negative	Total Quality Occurrence
ORGANIC ANALYSES (Cont.)			
Waters (Cont.)			
1,1-Dichloropropene	—	—	63
cis-1,3-Dichloropropene	—	—	63
trans-1,3-Dichloropropene	—	—	63
Dieldrin	—	—	1
Diethyl phthalate	—	2	47
Dimethyl phthalate	—	—	47
2,4-Dinethylphenol	—	—	47
2,4-Dinitrophenol	—	—	47
2,4-Dinitrotoluene	3	—	67
2,6-Dinitrotoluene	—	—	47
Endosulfan I	—	—	1
Endosulfan II	—	—	1
Endosulfan sulfate	—	—	1
Endrin	—	—	1
Endrin aldehyde	—	—	1
Ethylbenzene	—	—	63
1,2-Dibromoethane	—	—	63
Fluoranthene	—	—	47
Fluorene	—	—	47
Heptachlor	—	—	1
Heptachlor epoxide	—	—	1
Hexachlorobenzene	—	—	47
Hexachlorobutadiene	—	—	49
Hexachlorocyclopentadiene	—	—	47
Hexachloroethane	—	—	47
2-Hexanone	1	2	63
Indeno[1,2,3-*cd*]pyrene	—	—	47
Isophorone	—	—	47
Isopropylbenzene	—	—	63
4-Isopropyltoluene	—	—	63
Lindane	—	—	1
Methoxychlor	—	—	1
Methyl iodide	—	—	63
4-Methyl-2-pentanone	2	—	63
2-Methyl-4,6-dinitrophenol	—	—	47
Methylene chloride	2	—	63
2-Methylnaphthalene	—	—	47
2-Methylphenol	—	—	47
4-Methylphenol	—	—	47
Naphthalene	—	—	49
2-Nitroaniline	—	—	47
3-Nitroaniline	—	—	47
4-Nitroaniline	—	—	47

Table D-37. (Cont.)

Matrix Analyte	False Positive	False Negative	Total Quality Occurrence
ORGANIC ANALYSES (Cont.)			
Waters (Cont.)			
4-Nitrophenol	3	—	67
N-Nitrosodi-*n*-propylamine	7	—	67
N-Nitrosodimethylamine	—	—	47
N-Nitrosodiphenylamine	—	—	47
Pentachlorophenol	2	—	67
Phenanthrene	—	—	47
Phenol	9	—	67
Propylbenzene	—	—	63
Pyrene	1	—	67
Styrene	—	—	63
2,4,5-TP	—	—	1
1,1,1,2-Tetrachloroethane	—	—	63
1,1,2,2-Tetrachloroethane	—	—	63
Tetrachloroethylene	—	—	63
Toluene	—	—	63
Toxaphene	—	—	1
1,1,2-Trichloro-1,2,2-Trifluoroethane	—	—	63
1,2,3-Trichlorobenzene	—	—	2
1,2,4-Trichlorobenzene	8	—	69
1,1,1-Trichloroethane	1	—	63
1,1,2-Trichloroethane	—	—	63
Trichloroethene	—	—	63
Trichlorofluoromethane	1	—	63
2,4,5-Trichlorophenol	—	—	47
2,4,6-Trichlorophenol	—	—	47
1,2,3-Trichloropropane	—	—	63
1,2,4-Trimethylbenzene	—	—	63
1,3,5-Trimethylbenzene	—	—	63
Vinyl acetate	—	2	63
Vinyl chloride	—	—	63
Mixed-Xylenes (*o* + *m* + *p*)	—	—	63

Table D-37. (Cont.)

Matrix Analyte	False Positive	False Negative	Total Quality Occurrence
RADIOCHEMICAL ANALYSES			
Biologicals			
Nitrobenzene	—	—	47
2-Nitrophenol	—	—	47
^{137}Cs	—	—	17
^{238}Pu	2	—	12
^{239}Pu	2	—	12
^{90}Sr	6	—	10
Filters			
Alpha	—	—	60
^{241}Am	—	—	9
Beta	—	—	60
^{238}Pu	—	—	9
^{239}Pu	—	—	9
Soils			
Alpha	—	—	8
^{241}Am	3	—	25
Beta	—	—	8
^{137}Cs	1	—	57
Gamma	—	—	43
^{3}H	9	—	48
^{238}Pu	3	—	38
^{239}Pu	3	—	38
^{90}Sr	1	—	27
$^{235/238}U$	—	—	28
Waters			
Alpha	1	—	165
^{241}Am	—	—	3
Beta	2	—	165
^{137}Cs	—	—	59
Gamma	—	—	26
^{3}H	9	3	219
^{238}Pu	—	—	17
^{239}Pu	1	—	17
^{226}Ra	—	—	4
^{90}Sr	—	—	9
^{232}Th	—	—	1
$^{235/238}U$	—	—	100

Table D-38. Radiochemical Detection Limits for Analyses of Typical Environmental Samples

Parameter	Approximate Sample Volume or Weight	Count Time	Detection Limit Concentration	
Air Sample				
Tritium	3 m^3	30 min	1×10^{-10}	$\mu Ci/m^3$
^{238}Pu	2.0×10^4 m^3	8×10^4 s	2×10^{-18}	$\mu Ci/m^3$
$^{239,240}Pu$	2.0×10^4 m^3	8×10^4 s	2×10^{-18}	$\mu Ci/m^3$
^{241}Am	2.0×10^4 m^3	8×10^4 s	2×10^{-18}	$\mu Ci/m^3$
Gross alpha	6.5×10^3 m^3	100 min	4×10^{-16}	$\mu Ci/m^3$
Gross beta	6.5×10^3 m^3	100 min	4×10^{-16}	$\mu Ci/m^3$
Uranium (delayed neutron)	2.0×10^4 m^3	60 s	1	pg/m^3
Water Sample				
Tritium	0.005 L	30 min	4×10^{-7}	µCi/mL
^{90}Sr	0.5 L	200 min	3×10^{-9}	µCi/mL
^{137}Cs	0.5 L	5×10^4 s	4×10^{-8}	µCi/mL
^{238}Pu	0.5 L	8×10^4 s	2×10^{-11}	µCi/mL
$^{239,240}Pu$	0.5 L	8×10^4 s	2×10^{-11}	µCi/mL
^{241}Am	0.5 L	8×10^4 s	2×10^{-11}	µCi/mL
Gross alpha	0.9 L	100 min	3×10^{-9}	µCi/mL
Gross beta	0.9 L	100 min	3×10^{-9}	µCi/mL
Soil Sample				
Tritium	1 kg	30 min	0.003	pCi/g
^{90}Sr	2 g	200 min	2	pCi/g
^{137}Cs	100 g	5×10^4 s	0.1	pCi/g
^{238}Pu	10 g	8×10^4 s	0.002	pCi/g
$^{239,240}Pu$	10 g	8×10^4 s	0.002	pCi/g
^{241}Am	10 g	8×10^4 s	0.002	pCi/g
Gross alpha	2 g	100 min	3	pCi/g
Gross beta	2 g	100 min	3	pCi/g
Uranium (delayed neutron)	2 g	20 s	0.2	µg/g

GLOSSARY OF TERMS

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.

ALARA — As low as reasonably achievable. The term that describes an approach to radiation exposure control or management whereby the exposures and resulting doses are maintained as far below the limits specified for the appropriate circumstances as economic, technical, and practical considerations permit.

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.

AEC — Atomic Energy Commission. A federal agency created in 1946 to manage the development, use, and control of nuclear energy for military and civilian applications. It was abolished by the Energy Reorganization Act of 1974 and was succeeded by the Energy Research and Development Administration (now part of the U.S. Department of Energy and the U.S. Nuclear Regulatory Commission).

atom — Smallest particle of an element capable of entering into a chemical reaction.

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; 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.

blank sample A control sample that is identical, in principal, 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 government 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 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.

DCG — Derived Concentration Guide. The concentration of a radionuclide in air or water that, under conditions of continuous exposure for one year by one exposure mode (i.e., ingestion of water, submersion in air, or inhalation), would result in either an effective dose equivalent of 0.1 rem (1 mSv) or a dose equivalent of 5 rem (50 mSv) to any tissue, including skin and lens of the eye. The standards for radionuclides in air and water are given in DOE Order 5400.5.

DOE — U.S. Department of Energy. The federal agency that sponsors energy research and regulates nuclear materials used for weapons production.

dose — A term denoting the quantity of radiation energy absorbed.

- ***dose, absorbed*** — The energy imparted to matter by ionizing radiation per unit mass of irradiated material. (The unit of absorbed dose is the rad.)
- ***dose, effective*** — 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.
- ***dose, equivalent*** — A term used in radiation protection that expresses all types of radiation (alpha, beta, and so on) on a common scale for calculating the effective absorbed dose. It is the product of the absorbed dose in rads and certain modifying factors. (The unit of dose equivalent is the rem.)
- ***dose, maximum boundary*** — The greatest dose commitment, considering all potential routes of exposure from a facility's operation, to a hypothetical individual who is in an uncontrolled area where the highest dose rate occurs. It assumes that the hypothetical individual is present 100% of the time (full occupancy), and it does not take into account shielding (for example, by buildings).
- ***dose, maximum individual*** — 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.

dose, population — 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.)

dose, whole body — 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).

dosimeter — A portable detection device for measuring the total accumulated exposure to ionizing radiation.

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 or gaseous waste discharge 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.

environmental surveillance — The collection and analysis of samples of air, water, soil, foodstuffs, biota, and other media to determine environmental quality of an industry or community. It is commonly performed at sites containing nuclear facilities.

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 or gamma radiation. (The unit of exposure is the roentgen).

external radiation — Radiation originating from a source outside the body.

fission products — Atoms created by the splitting of larger atoms into smaller ones accompanied by release of energy.

friable asbestos — Asbestos that is brittle or readily crumbled.

gallery — An underground collection basin for spring discharges.

gamma radiation — Short-wavelength electromagnetic radiation of nuclear origin that has no mass or charge. Because of its short wavelength (high energy), gamma radiation can cause ionization. Other electromagnetic radiation (such as microwaves, visible light, and radiowaves) has longer wavelengths (lower energy) and cannot cause ionization.

gross alpha — The total amount of measured alpha activity without identification of specific radionuclides.

gross beta — The total amount of measured beta activity without identification of specific radionuclides.

groundwater — A subsurface body of water in the zone of saturation.

H^3 — Tritium. A radionuclide of hydrogen with a half-life of 12.3 years. The very low energy of its radioactivity decay makes it one of the least hazardous radionuclides.

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 EP-toxicity (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 more 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.

ion — An atom or compound that carries an electrical charge.

isotopes — Forms of an element having the same number of protons in their nuclei but differing in the number of neutrons.

- 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).

J — Joule. The unit for work and energy equal to one newton along a distance of one meter.

LDR — Land Disposal Restrictions (land ban). A regulatory program that identifies hazardous wastes that are restricted from land disposal. The regulations incorporate a phasing-in of restrictions in three stages.

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-4). The MCLs are specified by the EPA.

Mixed waste — Waste which 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 (10^{-3} rem). See rem definition. 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 Clean Air Act; they set limits for such pollutants as beryllium and radionuclides.

nonpoint source — Any nonconfined area from which pollutants are discharged into a body of water (e.g., agricultural runoff, construction runoff, and parking lot drainage).

NPDES — National Pollutant Discharge Elimination System. This federal regulation, 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.

part B permit — The second narrative section submitted by treaters, storers, or disposers of hazardous wastes in the RCRA permitting process. It covers in detail the procedures followed at a facility to protect human health and the environment.

PCBs — Polychlorinated biphenyls. A family of organic compounds used since 1926 in electric transformers as insulators and coolants, in lubricants, carbonless copy paper, adhesives, and caulking compounds. They are also produced in certain combustion processes. PCBs are extremely persistent in the environment because they do not break down into new and less harmful chemicals. PCBs are stored in the fatty tissues of humans and animals through the bioaccumulation process. EPA banned the use of PCBs, with limited exceptions, in 1976. In general, PCBs are not as toxic in acute short-term doses as some other chemicals, although acute and chronic exposure can cause liver damage. PCBs have also caused cancer in laboratory animals. When tested, most people show traces of PCBs in their blood and fatty tissues.

PDL — Public Dose Limit. The new term for RPS, a standard for external and internal exposure to radioactivity as defined in DOE Order 5400.5 (see Appendix A and Table A-1).

perched water — A groundwater body above an impermeable layer that is separated from an underlying main body of groundwater by an unsaturated zone.

person-rem — The unit of population dose that expresses the sum of radiation exposures received by a population. For example,

two persons, each with a 0.5 rem exposure, receive 1 person-rem, and 500 people, each with an exposure of 0.002 rem, also receive 1 person-rem.

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.

point source — Any confined and discrete conveyance from which pollutants are discharged into a body of water (e.g., pipe, ditch, well, or stack).

ppb — Part per billion. A unit measure of concentration equivalent to the weight/volume ratio expressed as μg/L or ng/mL.

ppm — Part per million. A unit measure of concentration equivalent to the weight/volume ratio expressed as mg/L.

QA — Quality assurance. Any action in environmental monitoring to assure 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.

R — Roentgen. A unit of radiation exposure that expresses exposure in terms of the amount of ionization produced by x rays in a volume of air. One roentgen (R) is 2.58×10^{-4} coulombs per kilogram of air.

rad — A unit of absorbed dose from ionizing radiation. A dose of 1 rad equals the absorption of 100 ergs of radiation energy per gram of absorbing material.

radiation — The emission of particles or energy as a result of an atomic or nuclear process.

radionuclide — An unstable nuclide capable of spontaneous transformation into other nuclides by changing its nuclear configuration or energy level. This transformation is accompanied by the emission of photons or particles.

RCRA — Resource Conservation and Recovery Act of 1976. RCRA is an amendment to the first federal solid waste legislation, the

Solid Waste Disposal Act of 1965. In RCRA, Congress established initial directives and guidelines for EPA to regulate hazardous wastes.

reagent — Any substance used in a chemical reaction to detect or measure another substance or to convert one substance into another by means of the reaction that it causes.

release — Any discharge to the environment. Environment is broadly defined as any water, land, or ambient air.

rem — The unit of radiation dose equivalent that takes into account different kinds of ionizing radiation and permits them to be expressed on a common basis. The dose equivalent in rems is numerically equal to the absorbed dose in rads multiplied by the necessary modifying factors.

RPS — Radiation Protection Standards. See PDL.

SARA — Superfund Amendments and Reauthorization Act of 1986. This act modifies and reauthorizes CERCLA. Title III of this act is also known as the Emergency Planning and Community Right-to-Know Act of 1986.

SWMU — Solid Waste Management Unit. Any discernible unit at which solid wastes have been placed at any time, irrespective 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. Potential release sites include, for example, waste tanks, septic tanks, firing sites, burn pits, sumps, landfills (material disposal areas), outfall areas, LANL canyons, and contaminated areas resulting from leaking product storage tanks (including petroleum).

TCLP — Toxicity Characteristic Leaching Procedure. An analytical method designed to determine the mobility of both organic and inorganic compounds present in liquid, solid, and multiphase wastes. It is used to determine applicability of the LDR to a waste.

TDS — Total Dissolved Solids. The portion of solid material in a waste stream that is dissolved and passed through a filter.

terrestrial radiation — Radiation emitted by naturally occurring radionuclides such as ^{40}K; the natural decay chains of ^{235}U, ^{238}U, or ^{232}Th; or cosmic-ray-induced radionuclides in the soil.

TLD — Thermoluminescent dosimeter. A material (the Laboratory uses lithium fluoride) that, after being exposed to radiation,

luminesces upon being heated. The amount of light the material emits is proportional to the amount of radiation (dose) to which it was exposed.

TRU — Transuranic waste. Waste contaminated with long-lived transuranic elements in concentrations within a specified range established by DOE, EPA, and NRC. These are elements shown above uranium on the chemistry periodic table, such as plutonium, americium, and neptunium.

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 and to the environment.

TSP — Total suspended particulates. Refers to the concentration of particulates in suspension in the air irrespective of the nature, source, or size of the particulates.

tuff — Rock of compacted volcanic ash and dust.

uncontrolled area — An area beyond the boundaries of a controlled area (see controlled area in this glossary).

uranium, depleted — Uranium consisting primarily of ^{238}U and having less than 0.72 wt % ^{235}U. Except in rare cases, depleted uranium is manmade.

uranium, total — The amount of uranium in a sample, assuming that the uranium has the isotopic content of uranium in nature (99.27 wt % ^{238}U, 0.72 wt % ^{235}U, and 0.0057 wt % ^{234}U).

UST — Underground storage tank. A stationary device designed to contain petroleum products or hazardous materials. A tank is constructed primarily of nonearthen material and 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 to wells.

VOC — Volatile organic compound. Liquid or solid organic compounds that have a tendency to spontaneously pass into the vapor state.

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, river system, or 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.

WLM — Working level month. A unit of exposure to ^{222}Rn and its decay products. Working level (WL) is any combination of the short-lived ^{222}Rn decay products in 1 L of air that will result in the emission of 1.3×10^5 MeV potential alpha energy. At equilibrium, 100 pCi/L of ^{222}Rn corresponds to 1 WL. Cumulative exposure is measured in working level months, which is 170 WL-h.

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.

ACRONYMS AND ABBREVIATIONS

ADO	Associate Director for Operations
AEA	Atomic Energy Act of 1954
AEC	Atomic Energy Commission
AGL	above ground level
AIP	Agreement in Principle
AL	Albuquerque Operations Office (DOE)
ALARA	as low as reasonably achievable
ANSI	American National Standards Institute
AO	Administrative Order
AQCA	Air Quality Control Act (New Mexico)
AQCR	Air Quality Control Regulation (New Mexico)
ASL	above sea level
BIA	Bureau of Indian Affairs
BOD	biochemical oxygen demand
BRET	Biological Resource Evaluation Team (EM-8)
Btu	British thermal unit
CA	corrective activities
CAA	Clean Air Act
CAAA	Clean Air Act Amendments
CAI	controlled-air incinerator
CEARP	Comprehensive Environmental Assessment and Response Program
CEI	Comprehensive Evaluation Inspection
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CGS	Canadian Geologic Survey
CHIEF	Clearinghouse Inventory of Emission Factors
CMI	corrective measures implementation
CMR	Chemistry-Metallurgical Research (LANL building)
CMS	corrective measures study
COC	chain-of-custody
COD	chemical oxygen demand

CSU	Colorado State University
CWA	Clean Water Act
CY	calendar year
D&D	decontamination and decommissioning
DAC	Derived Air Concentration Guide for Controlled Areas (DOE)
DCG	Derived Air Concentration Guide for Uncontrolled Areas (DOE)
DEC	DOE Environmental Checklist
DoD	Department of Defense
DOE	Department of Energy
DOE/AL	DOE/Albuquerque Operations Office
DOE/HQ	DOE Headquarters
DOE/HQ-EH	DOE Headquarters, Environment & Health
DOE/HQ-EM	DOE Headquarters, Environmental Management
DOE/LAAO	DOE/Los Alamos Area Office
DOT	Department of Transportation
DREF	dose rate effectiveness factor
EA	Environmental Assessment
EES	Earth and Environmental Sciences (LANL Division)
EES-1	Geology and Geochemistry Group
EES-3	Geophysics Group
EIS	Environmental Impact Statement
EM	Environmental Management (LANL Division)
EM-DO	Environmental Management Division Office
EM-7	Waste Management Group
EM-8	Environmental Protection Group
EM-9	Environmental Chemistry Group
EM-13	Environmental Restoration Group
EMSL-CI	Environmental Monitoring and Support Laboratory - Cincinnati
ENG	Facilities Engineering (LANL Division)
ENG-2	Facilities Engineering Planning Group
ENG-6	Engineering Maintenance Group
EO	Executive Order
EPA	Environmental Protection Agency
ER	Environmental Restoration Program

ERDA	Energy, Research, and Development Administration
ES	environmental survey
ES&H	Environment, Safety, and Health
FFCA	Federal Facilities Compliance Agreement
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FONSI	Finding of No Significant Impact
FS	feasibility study
FUSRAP	Formerly Utilized Sites Remedial Action Program
FY	fiscal year
GC	gas chromatography
GC/MS	gas chromatography/mass spectrometry
GET	General Employee Training
GIS/HEC	Geographic Information System and computer modeling
GSA	General Services Administration
HE	high-explosive
HEPA	high-efficiency particulate air (filter)
HQ	DOE Headquarters
HS	Health and Safety (LANL Division)
HS-DO	Health Safety Division Office
HS-3	Risk Management Support Group
HS-4	Health Physics Measurements Group
HS-5	Industrial Hygiene and Safety Group
HS-12	Health Physics Policy and Programs Group
HSWA	Hazardous and Solid Waste Amendments
HW	hazardous waste
HWA	Hazardous Waste Act (New Mexico)
HWMR	Hazardous Waste Management Regulations (New Mexico)
ICPMS	inductively coupled plasma mass spectrometry
ICRP	International Commission on Radiological Protection
IH	Industrial Hygiene
INC-7	Isotope Geochemistry Group (LANL)
JCI	Johnson Controls Inc.
JENV	JCI Environmental

LAAO	Los Alamos Area Office
LAMPF	Los Alamos Meson Physics Facility (a.k.a. Clinton P. Anderson Meson Physics Facility - LANL building)
LANL	Los Alamos National Laboratory (or the Laboratory)
LDR	land disposal restrictions
LERC	Laboratory Environmental Review Committee
LET	linear-energy-transfer
LLW	low-level waste
LOD	limit of detection
LOQ	limit of quantification
MAP	mixed activation product
MCL	maximum contaminant level
MDA	minimum detectable amount (activity)
MDL	minimum detection limit
MOU	Memorandum of Understanding
MS	mass spectrometry
NAAQS	National Ambient Air Quality Standard
NADP	National Atmospheric Deposition Program
NBS	National Bureau of Standards
NCRP	National Council on Radiation Protection and Measurements
NENIX	Northern New Mexico Information Exchange
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NHPA	National Historic Preservation Act
NIOSH	National Institute of Occupational Safety and Health
NIST	National Institute of Standards and Technology
NMED	New Mexico Environment Department
NMEIB	New Mexico Environmental Improvement Board
NMEID	New Mexico Environmental Improvement Division (See NMED)
NMHWA	New Mexico Hazardous Waste Act
NMOCD	New Mexico Oil Conservation Division
NMWQCA	New Mexico Water Quality Control Act
NMWQCC	New Mexico Water Quality Control Commission
NMWQCCR	New Mexico Water Quality Control Commission Regulations

NOI	Notice of Intent
NOV	Notice of Violation
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NRC	Nuclear Regulatory Commission
NSPS	New Source Performance Standards
NWI	National Wetland Inventory
OHL	Occupational Health Laboratory (LANL building)
OSHA	Occupational Safety and Health Act
OU	operable unit
PA	performance assessment
PA-3	Community Relations Group (LANL)
PA/SI	preliminary assessment/site inspection
PAT	purge-and-trap gas chromatography/mass spectrometry
PCB	polychlorinated biphenyl
PCOC	Pest Control Oversight Committee (LANL Committee)
PDL	public dose limit
ppb	parts per billion
ppm	parts per million
PSD	Prevention of Significant Deterioration
QA	quality assurance
QAP	Quality Assurance Program
QAPP	Quality Assurance Program Plan
QC	quality control
R&D	research and development
RA	remedial action
RAPS	Regulated Air Pollutants System
RCG	Radioactivity Concentration Guide
RCRA	Resource Conservation and Recovery Act
RFA	RCRA facility assessment
RFI	RCRA facility investigation
RFP	Request for Proposal
RI	remedial investigation
RI/FS	remedial investigation/feasibility study

ROD	Record of Decision
RPS	Radiation Protection Standard
SARA	Superfund Amendments and Reauthorization Act
SDWA	Safe Drinking Water Act
SEN	Secretary of Energy Notice
SHPO	State Historic Preservation Officer (New Mexico)
SLD	Scientific Laboratory Division (New Mexico)
SOP	standard operating procedure
SPCC	Spill Prevention Control and Countermeasures
SRF	Size Reduction Facility
SRM	standard reference material
SRS	Savannah River Site
SUPERFUND	See CERCLA and SARA
SWSC	Sanitary Wastewater Systems Consolidation
SWDA	Solid Waste Disposal Act
SWMU	solid waste management unit
TA	Technical Area
TAP	toxic air pollutant
TCE	trichlorethylene
TCLP	Toxicity Characteristic Leaching Procedure
TDS	total dissolved solids
THM	trihalomethane
TLD	thermoluminescent dosimeter
TOC	total organic carbon
TOX	total organic halides (or halogens)
TRU	transuranic waste
TSCA	Toxic Substances Control Act
TSD	treatment, storage, and disposal
TSP	total suspended particulate matter
TSS	total suspended solids
TSTA	Tritium Systems Test Assembly
TU	tritium unit
UC	University of California
USC	United States Code

USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UST	underground storage tank
UV	ultraviolet
VOC	volatile organic compound
WL	working level
WLM	Working Level Month
WM	Waste Minimization
WM	Waste Management

Symbols for the Chemical Elements and Compounds

Actinium	Ac
Aluminum	Al
Americium	Am
Antimony	Sb
Argon	Ar
Arsenic	As
Astatine	At
Barium	Ba
Berkelium	Bk
Beryllium	Be
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
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
Nitrogen	N
Nitrogen dioxide	N0
Nobelium	No
Osmium	Os
Oxygen	O
Palladium	Pd
Phosphorus	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
Strontium	Sr
Sulfur	S
Tantalum	Ta
Technetium	Te
Tellurium	Te
Terbium	Tb
Thallium	Tl
Thorium	Th
Thulium	Tm
Tin	Sn
Titanium	Ti
Tritiated water	HT0
Tritium	H^3
Tungsten	W
Uranium	U
Vanadium	V
Xenon	Xe
Ytterbium	Yb
Yttrium	Y
Zinc	Zn
Zirconium	Zr

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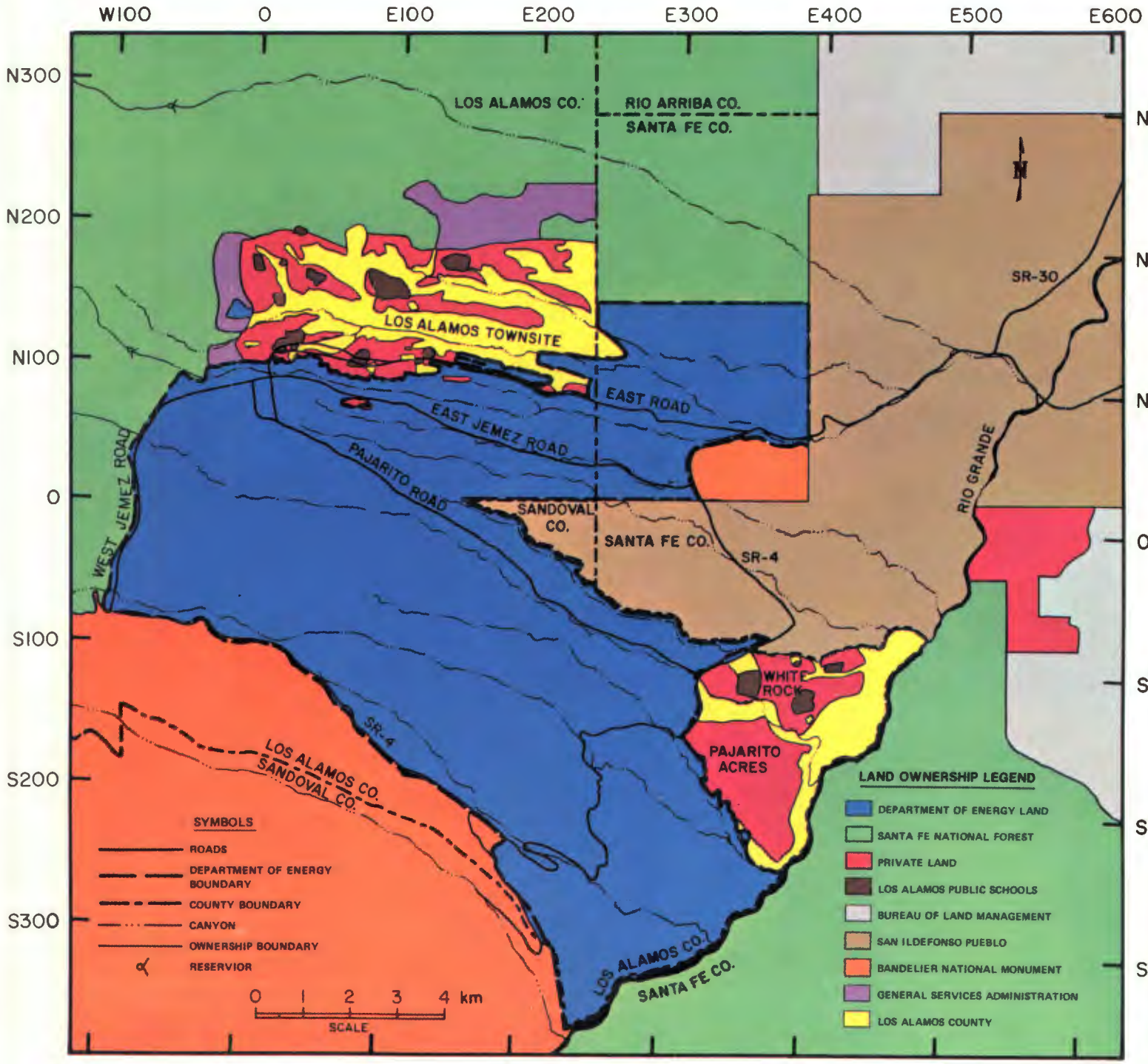

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