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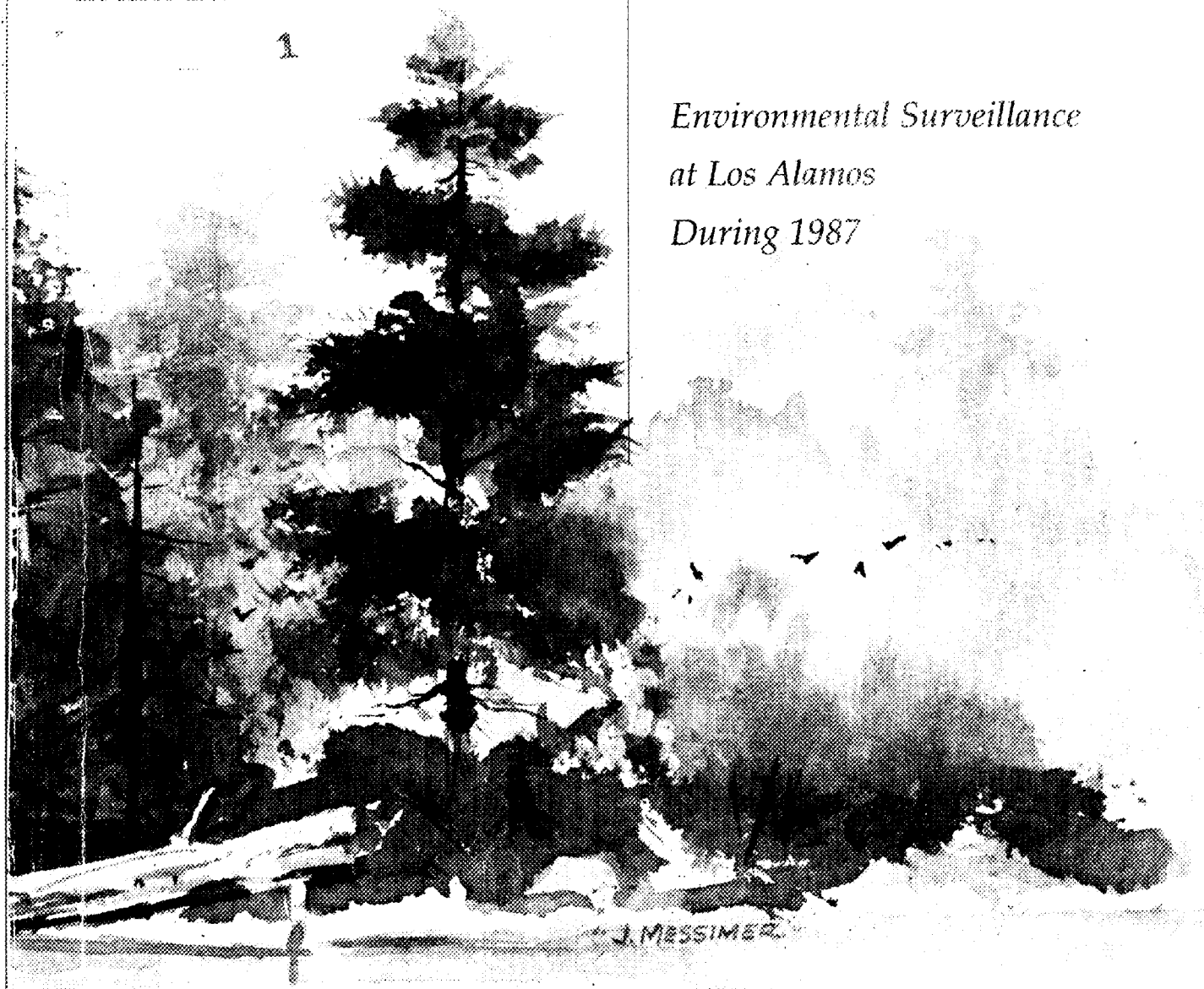

Environmental Surveillance at Los Alamos During 1987

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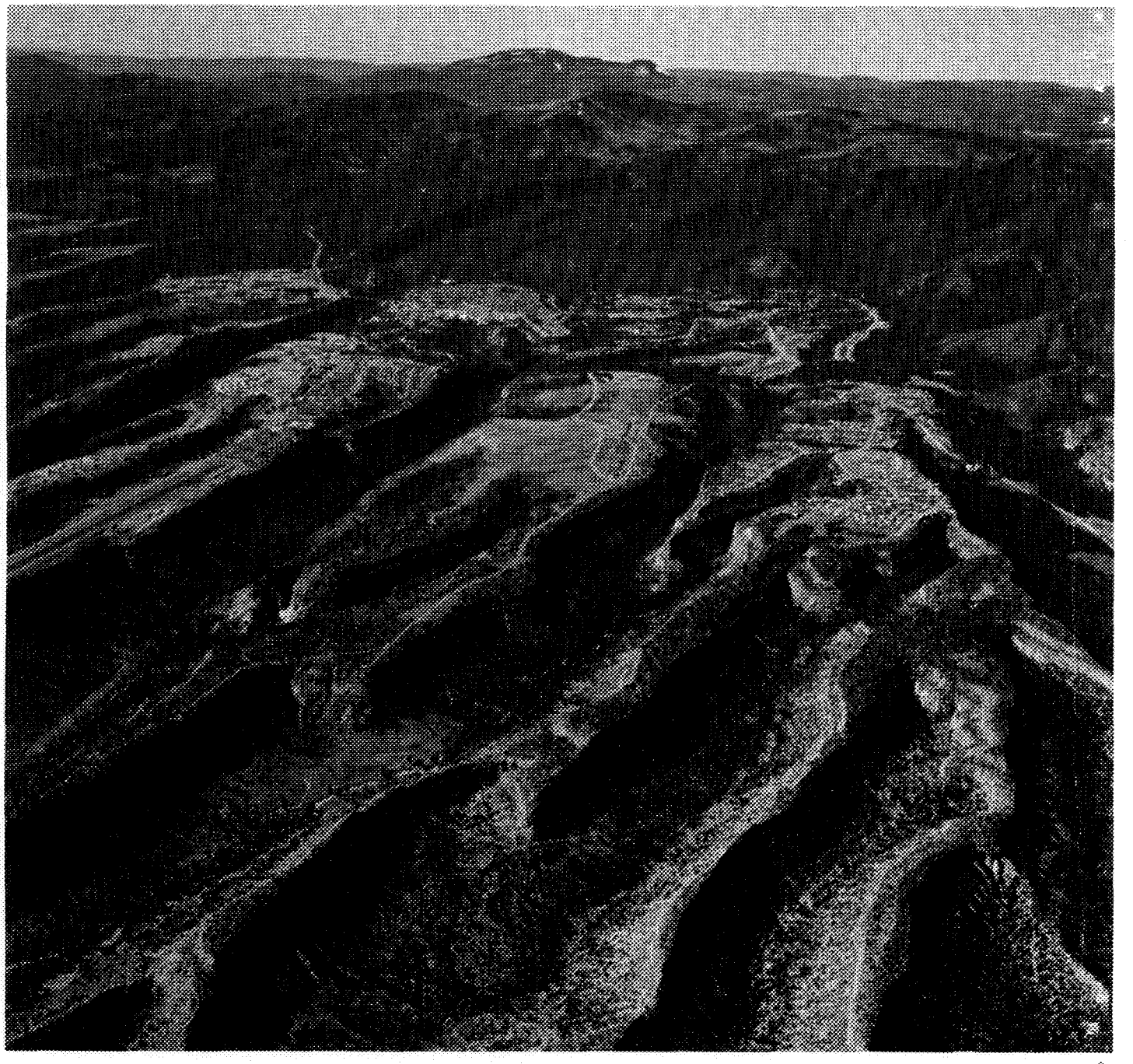

Aerial view looking west toward the Jemez Mountains across the Pajarito Plateau, which is cut into numerous narrow mesas by southeast-trending canyons. The Los Alamos townsite is in the center of the photo, the main Laboratory technical area (TA-3) is in the upper left, and the airport is at left center.

Los Alamos
Los Alamos National Laboratory
Los Alamos, New Mexico 87545

DATE: April 25, 1988
IN REPLY REFER TO: HSE8-88-246
MAIL STOP: K490
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To the Reader:

Enclosed is a copy of the Laboratory's annual Environmental Surveillance Report. The report summarizes the results of routine environmental monitoring and compliance activities at Los Alamos National Laboratory during 1987. If you have any questions about the report, if you would like extra copies of the report, or if you have changes in your mailing address, contact me at the above address or at (505) 667-2256 or -5021. Thank you for your continued interest in the Laboratory's environmental programs.

Sincerely,

Lars F. Soholt, Ph.D.
Environmental Surveillance Group

Enclosure: a/s

LFS:bjh

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ERRATA

This errata sheet corrects the following pages of LA-11306, "Environmental Surveillance at Los Alamos During 1987."

Page 6. The units have been corrected for the following radionuclides: ^{32}P, ^{131}I, Uranium, Plutonium, and Mixed Fission Products.

Page 30. Figure 8 has been replaced with the correct figure.

LA-11306-ENV

UC-41
Issued: May 1988

Environmental Surveillance at Los Alamos During 1987

Environmental Surveillance Group

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Los Alamos National Laboratory
Los Alamos, New Mexico 87545

FOREWORD

Suggestions on How to Read this Report

This report addresses 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 Part I, the Executive Summary, which describes the Laboratory's environmental monitoring operations and summarizes environmental data for this year. Emphasis is on the significance of findings and environmental regulatory compliance. A glossary is in the back.

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) and Appendix F (Description of Technical Areas and Their Associated Programs) may also be helpful.

3. **Scientists with Limited Interest.** Read Part 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. Detailed data tables are in Appendix G.

4. **Scientists with Comprehensive Interest.** Read Part I, the Executive Summary, which describes the Laboratory's environmental programs and summarizes environmental data for this year. Read the boldface summaries that head each major subdivision of this report. Further details are in the text and appendixes.

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

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ENVIRONMENTAL SURVEILLANCE AT

LOS ALAMOS DURING 1987

by

ENVIRONMENTAL SURVEILLANCE GROUP

ABSTRACT

This report describes the environmental surveillance program conducted by Los Alamos National Laboratory during 1987. Routine monitoring for radiation and radioactive or 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 1987 cover: external penetrating radiation; quantities of airborne emissions and liquid effluents; concentrations of chemicals and radionuclides in ambient air, surface and ground waters, 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 insignificant and do not pose a threat to the public, Laboratory employees, or the environment.

I. EXECUTIVE SUMMARY

A. Monitoring Operations

The Laboratory maintains an ongoing environmental surveillance program as required by US Department of Energy (DOE) Orders 5480.1A ("Environmental Protection, Safety, and Health Protection Programs," August 1981) and 5484.1 ("Environmental Protection, Safety, and Health Protection Information Reporting Requirements," February 1981). The surveillance program maintains routine monitoring for radiation, radioactive materials, and 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. More detailed, supplemental environmental studies are carried out to determine the extent of the potential problems, to provide the basis for any remedial actions, and to provide further information on surrounding environments. The monitoring program also 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 measurements are organized into three groups: (1) Regional stations are located within the five counties surrounding Los Alamos County (Fig. 1) 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. (2) 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. (3) 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 the public has limited access.

Samples of air particulates and gases, waters, soils, sediments, and foodstuffs are routinely collected at these stations for subsequent analyses (Table 1). External penetrating radiation from cosmic, terrestrial, and Laboratory sources is also measured.

Additional samples are collected and analyzed to gain information about particular events, such as major surface run-off events, nonroutine releases, or special studies. More than 25 000 analyses for chemical and radiochemical constituents were carried out for environmental surveillance during 1987. 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.

B. 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 a percentage of DOE's Radiation Protection Standard (RPS). The RPS is for doses from exposures excluding contributions from natural background, fallout, and radioactive consumer products. Estimated doses are those believed to be potential doses to individuals under realistic conditions of exposure.

Historically, estimated doses from Laboratory operations have been less than 7% of the 500 mrem/yr standard that was in effect prior to 1985 (Fig. 2). These doses have principally resulted from external radiation from the Laboratory's airborne releases. In 1985, DOE issued interim guidelines that lowered its RPS to 100 mrem/yr (effective dose equivalent) from all exposure pathways. In addition, exposure via the air pathway is further limited to 25 mrem/yr (whole body) in accordance with requirements of the US Environmental Protection Agency (EPA) (Appendix A). In 1987 the estimated maximum individual dose was 6.1 mrem, 24% of the EPA's 25-mrem standard. This dose resulted mostly from external radiation from short-lived airborne emissions from a linear particle accelerator, the Los Alamos Meson Physics Facility (LAMPF).

Another perspective is gained by comparing these estimated doses with the estimated whole-body dose attributable to background radiation. The highest estimated dose caused from Laboratory operations was about 2% of the 327 mrem received from background radioactivity in Los Alamos during 1987.

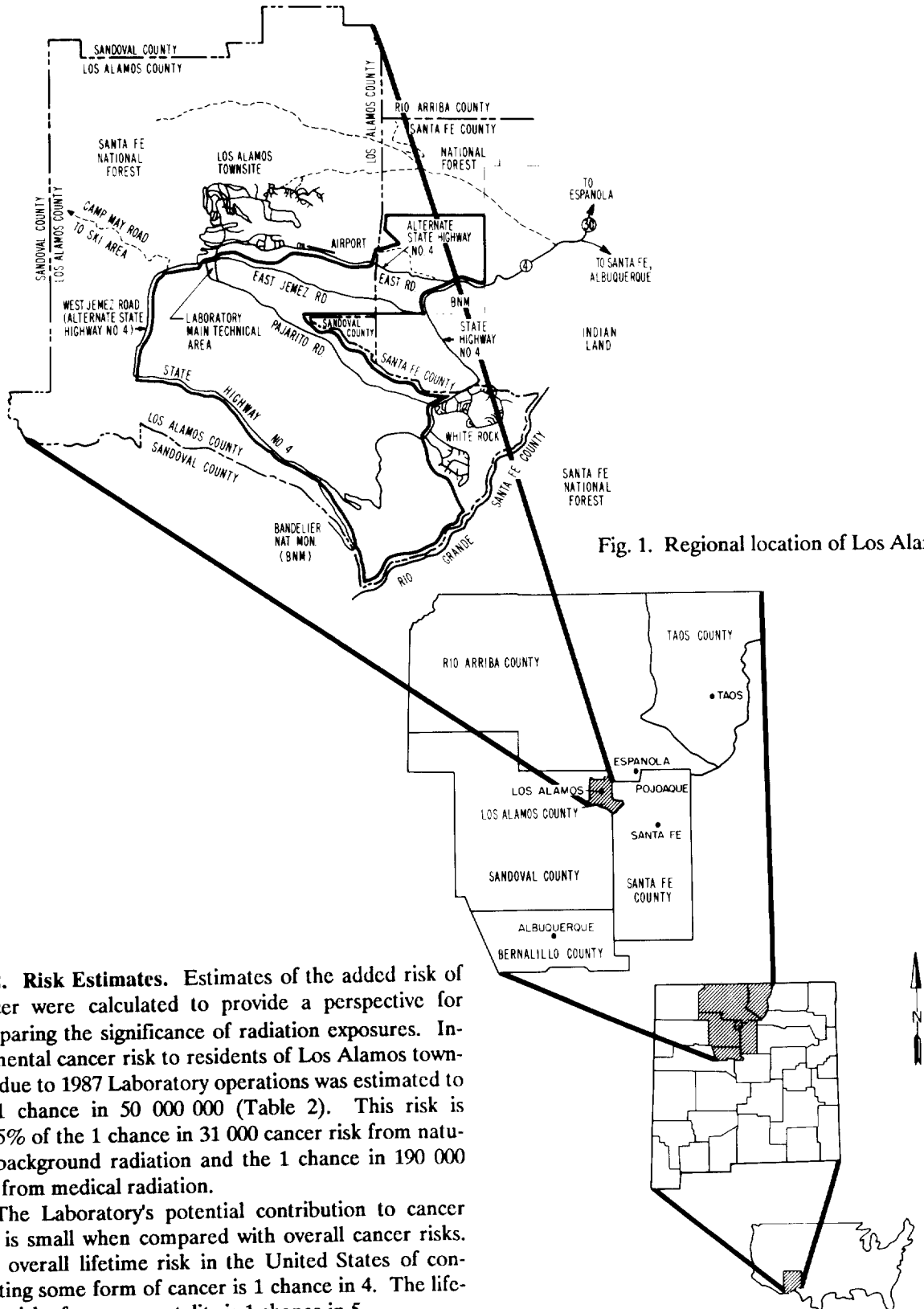

Fig. 1. Regional location of Los Alamos.

2. Risk Estimates. Estimates of the added risk of cancer were calculated to provide a perspective for comparing the significance of radiation exposures. Incremental cancer risk to residents of Los Alamos townsite due to 1987 Laboratory operations was estimated to be 1 chance in 50 000 000 (Table 2). This risk is <0.5% of the 1 chance in 31 000 cancer risk from natural background radiation and the 1 chance in 190 000 risk 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.

Table 1. Number of Sampling Locations

Typing of Monitoring	Regional	Perimeter	Onsite
External radiation	4	12	139
Air	3	11	12
Surface and ground waters[a]	6	32	37
Soils and sediments	16	16	34
Foodstuffs	10	8	11

[a]An additional 22 stations for the water supply and 33 special surface and ground water stations related to the Fenton Hill Geothermal Program were also sampled and analyzed as part of the monitoring program.

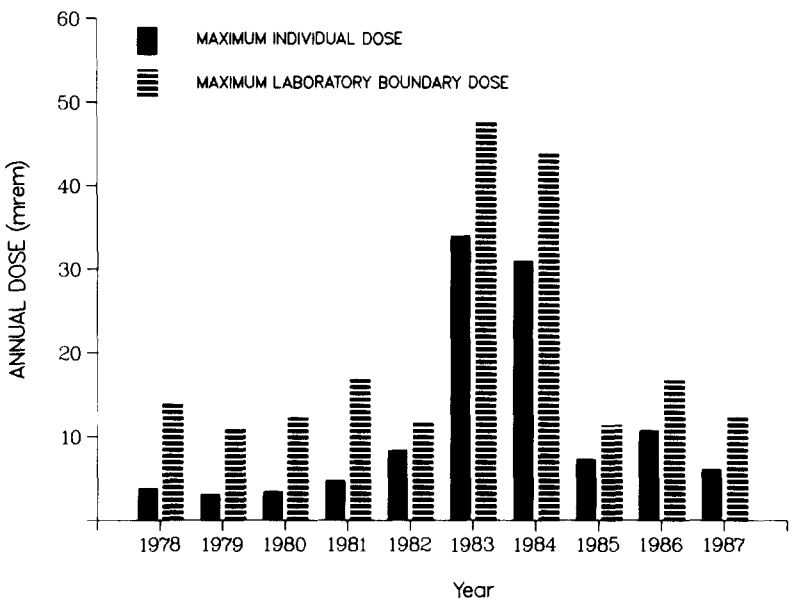

Fig. 2. Summary of estimated maximum individual and Laboratory boundary doses (excluding contributions from cosmic, terrestrial, and medical diagnostic sources) from Laboratory operations.

C. External Penetrating Radiation

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 monitored with thermoluminescent dosimeters (TLDs) at 147 locations.

The TLD network monitoring radiation from airborne activation products released by the LAMPF measured about 12 $\pm$ 5 mrem/yr (excludes background radiation from cosmic and terrestrial sources). This measured external radiation level was used to calculate radiation dose by taking into account shielding by buildings and self-shielding by the body. The value

Table 2. Added Individual Lifetime Cancer Mortality Risks Attributable to 1987 Radiation Exposure

Exposure Source	Incremental Effective Dose Equivalent (mrem) Used in Risk Estimate	Added Risk (Chance) to an Individual of Cancer Mortality
Average exposure from Laboratory Operations		
Los Alamos Townsite	0.21	1 in 50 000 000
White Rock Area	0.17	1 in 60 000 000
Natural Radiation		
Cosmic, Terrestrial, Self-Irradiation and Radon Exposure[a]		
Los Alamos and White Rock	327[a]	1 in 31 000[b]
Medical X-Rays (Diagnostic Procedures)		
Average Whole Body Exposure	53	1 in 190 000

[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 non-radon sources were estimated to be 1 chance in 79,000 in Los Alamos and in White Rock. The risk of lung cancer from radon exposure was estimated to be 1 chance in 50,000 for both locations. Risk estimates are derived from ICRP Publication 26 and NCRP Report 93.

measured in 1987 is lower than the measured 18 ± 2 mrem/yr obtained in 1986 (Fig. 2). The difference is probably caused by variation in weather patterns between the two years rather than differences in LAMPF operations, because the estimate of airborne activity emitted from LAMPF increased in 1987 (Table 3).

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 historical releases from Laboratory facilities.

D. Air Monitoring

Airborne radioactive emissions were monitored at 87 release points at the Laboratory. Total airborne 26 sampling stations. Measurements of radioactivity in the air are compared with concentration guides based upon DOE's RPS. These guides are concentrations of radioactivity in air breathed continuously throughout the year that result in effective doses equal to DOE's RPS of 100 mrem/yr for off-site areas (Derived Concentration Guides for Uncontrolled Areas) and to the occupational RPS (see Appendix A) for on-site areas (Concentration Guides for Controlled Areas). Hereafter they are called guides for on-site and off-site areas.

Only the on-site tritium air concentrations showed any measurable impact due to Laboratory operations. Annual average concentrations of tritium remained <0.1% of DOE's guides at all stations and posed no environmental or health problems in 1987. Annual average concentrations of longer-lived radionuclides in air were also <0.1% of the guides during 1987.

Table 3. Comparison of 1986 and 1987 Radioactive Releases from the Laboratory

Airborne Emissions

Radionuclide	Units	Activity Released 1986	Activity Released 1987	Ratio 1987:1986
^{3}H	Ci	10 700	3 180	0.3
^{32}P	µCi	70	48	0.7
^{41}Ar	Ci	276	232	0.8
^{131}I	µCi	38	0	0
Uranium	µCi	847	1 080	1.3
Plutonium	µCi	207	73	0.4
Gaseous Mixed Activation Products	Ci	112 000	150 000	1.3
Mixed Fission Products	µCi	2 570	1 290	0.5
Particulate/Vapor Activation Products	Ci	0.1	0.2	2.0
Total	Ci	122 976	153 412	1.2

Liquid Effluents

Radionuclide	Activity Released (mCi) 1986	Activity Released (mCi) 1987	Ratio 1987:1986
^{3}H	89 710	110 000	1.2
$^{89,90}Sr$	9.9	65	6.6
^{137}Cs	18	8.1	0.4
^{234}U	2.4	1.6	0.7
$^{238,239,240}Pu$	5.1	4.6	0.9
^{241}Am	3.2	3.6	1.1
Other	1 166.7	610.5	0.5
Total	90 915.3	110 693.4	1.2

E. Water, Soil, and Sediment Monitoring

Liquid effluents containing low levels of radioactivity were routinely released from one waste treatment plant and one sanitary sewage lagoon system. Concentrations at all discharge points were well below the DOE's concentration guides for on-site areas. The dominant change was an increase in tritium discharge from TA-50's radioactive liquid-waste treatment facility due to increased concentrations in the released waters (Table 3).

Surface and ground waters are monitored to detect potential dispersion of radionuclides from Laboratory operations. Only the surface and shallow ground waters in on-site liquid effluent release areas contained radioactivity in concentrations that are above natural terrestrial and worldwide fallout levels. These concentrations are minute fractions (<0.1%) of DOE's guides for on-site areas. These on-site waters are not a source of industrial, agricultural, or municipal water supplies. The radiochemical quality of water from regional, perimeter, and on-site areas that have received no direct discharge showed no significant effects from Laboratory releases.

The potable water supply met all applicable EPA radiochemical and chemical standards. Lack of a hydrologic connection to the deep aquifer was confirmed by lack of radioactive or chemical contamination in municipal water supply sources.

Measurements of radioactivity 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. On-site areas within Pueblo, Los Alamos, and Mortandad canyons all had concentrations of radioactivity on sediments at levels slightly higher than attributable to natural terrestrial sources or worldwide fallout. The low levels of cesium, plutonium, and strontium in Mortandad Canyon are due to liquid effluents from a waste treatment plant. No above-background radioactivity on sediments or in water has been measured in locations beyond the Laboratory boundary in Mortandad Canyon. However, small amounts of radioactivity on sediments in Pueblo Canyon (from pre-1964 effluents) and Los Alamos Canyon (from 1952 to current treated effluents) have been transported to the Rio Grande. Theoretical estimates, confirmed by measurements, show the incremental effect on Rio Grande sediments is insignificant when compared with background concentrations in soils and sediments.

Environmental monitoring is done at 1 active and 11 inactive waste management areas at the Laboratory. The general public is excluded from these controlled-access sites. Surface run-off has transported some low-level contamination from the active disposal area and several of the inactive areas into controlled-access canyons. Leachate extracts (following EPA guidelines) from the surface contamination indicate the presence of no constituents in excess of EPA criteria for hazardous waste determination.

F. Foodstuffs Monitoring

Most fruit, vegetable, fish, bee, and honey samples from regional and perimeter locations showed no radioactivity distinguishable from that attributable to natural sources or worldwide fallout. Some produce samples from on-site locations had slightly elevated tritium concentrations at levels $\leq$2% of DOE's guides for tritium in water (there are no concentration guides for produce).

G. Unplanned Releases

During 1987, there were two unplanned releases of radioactive or hazardous materials. Both involved release of tritium. The quantities of tritium released were small and resulted in radiation doses that were fractions of the Radiation Protection Standard.

1. March 18 Tritium Release at the Van de Graaff Facility at TA-3. On March 18, 1987, 375 Ci of tritium (as elemental tritium gas) were released from the Van de Graaff facility at TA-3. Air samples collected from four downwind air samplers were within normal ranges for tritium at these locations. All measured concentrations were <0.1% of the DOE's Derived Concentration Guide for tritium in off-site areas. Calculations from meteorological modeling estimated a dose to the maximum exposed individual of 0.003 mrem to the lung, <0.1% of the EPA's air emission standard of 75 mrem/yr (any organ) to a member of the public.

2. December 11-12 Tritium Release at TA-33. Approximately 165 Ci of elemental tritium gas were inadvertently released from TA-33 on December 11-12, 1987. Air samples were collected at five downwind locations. All measured air concentrations were found to

be within their normal range and <0.1% of the DOE's Derived Concentration Guide for tritium. The highest estimated dose to a member of the public was 0.001 mrem to the lung, <0.1% of the 75 mrem/yr EPA air emission standard.

H. Environmental Compliance Activities

1. Resource Conservation and Recovery Act. The Resource Conservation and Recovery Act (RCRA) regulates hazardous wastes from generation to ultimate disposal. The EPA has transferred full authority (with the exception of the Hazardous and Solid Waste Amendment of 1984) for administering RCRA to New Mexico's Environmental Improvement Division (EID). In 1987, the Laboratory had numerous interactions with EID and prepared documentation to comply with RCRA requirements. The Laboratory has revised RCRA Parts A and B permit applications, originally submitted in 1985. The latest revisions were submitted November 1987.

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

The NPDES requires permits for nonradioactive constituents at all point source discharges. A single NPDES permit for the Laboratory authorizes liquid effluent discharges from 98 industrial outfalls and 10 sanitary sewage treatment outfalls; the permit expires in March 1991. The Laboratory was in compliance with the NPDES permit in about 96% and 99% of the analyses done on samples collected for compliance monitoring at sanitary and industrial waste discharges, respectively. Chronically noncompliant discharges are being upgraded under an EPA/DOE Federal Facility Compliance Agreement.

Another NPDES permit authorizes liquid effluent discharge from the Fenton Hill Geothermal Project. The permit for a single outfall was issued to regulate the discharge of mineral-laden water from the recycle loop of the geothermal wells.

The SPCC program provides for cleanup of spills and requires preparation of a SPCC Plan. The Laboratory has many elements that are required in a SPCC plan and has assembled a Laboratory-wide formal SPCC Plan that was adopted and implemented in 1987.

3. National Environmental Policy Act. The Laboratory Environmental Review Committee reviews environmental documentation required by National Environmental Policy Act legislation as well as identifies other environmental items of concern to the Laboratory. An Environmental Evaluations Coordinator helps prepare required DOE documentation and identify other items requiring committee attention. Documentation usually consists of Action Description Memorandums (brief environmental evaluations) or Environmental Assessments (more detailed evaluations). During 1987, the committee approved 20 Action Description Memorandums and 1 Environmental Assessment and forwarded this documentation to DOE.

4. Clean Air Act. During 1987, the Laboratory's operations remained in compliance with all federal and state air quality regulations. State regulations are required to be as stringent as federal regulations, and many state standards are more stringent. Over 180 asbestos removal jobs involved the disposal of 270 m^3 (9500 ft^3) of asbestos. All beryllium shops met emissions performance requirements. The Laboratory applied to EPA for approval to construct the Independent Management Activity facility. This program will emit depleted uranium similar to other dynamic testing projects at the Laboratory. Approval was obtained from EPA in January, 1988.

5. Safe Drinking Water Act. Municipal and industrial water supply for the Laboratory and community is from 16 deep wells and 1 gallery (collection system fed by springs). The wells range in depth from 265 to 942 m (869 to 3090 ft). The chemical quality of the water easily met EPA's National Interim Primary Drinking Water Standards (40 CFR 141) in 1987.

6. Federal Insecticide, Fungicide, and Rodenticide Act. The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) requires registration of all pesticides, restricts use of certain pesticides, recommends standards for pesticide applicators, and regulates disposal and transportation of pesticides. The Laboratory stores, uses, and discards pesticides in compliance with this act.

7. Archaeological and Historical Protection. The Laboratory's Environmental Evaluation Coordination and Quality Assurance programs provide protection as mandated by law for the hundreds of archaeological

and historical resources located on Laboratory land. Pursuant to federal regulations implementing Section 106 of the National Historic Preservation Act of 1966, as amended, clearance for construction where no resource will be affected and mitigation of unavoidable adverse effects from Laboratory activity is determined in consultation with New Mexico's State Historical Preservation Office. During 1987, archaeologists performed 28 cultural resource surveys, monitored 7 projects, fenced 1 site, and undertook adverse impact mitigation at 2 sites.

8. Threatened/Endangered Species and Floodplains/Wetlands Protection. The DOE and Laboratory must comply with the Endangered Species Act of 1973, as amended, and with Executive orders 11988, Floodplain Management, and 11990, Protection of Wetlands Environmental Review Requirements. Three Floodplains/Wetlands notifications were prepared for publication in the Federal Register. Laboratory biologists surveyed 17 proposed construction sites for potential impact. They identified no endangered or rare species at these sites.

9. Comprehensive Environmental Response, Compensation, and Liability Act. The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 mandated cleanup of toxic and hazardous contaminants at closed and abandoned hazardous waste sites. The Superfund Amendments and Reauthorization Act (SARA) of 1986 extensively amended CERCLA. Laboratory compliance activities at hazardous waste sites are part of DOE's Albuquerque Operations Office's Comprehensive Environmental Restoration Program (CERP). The program is evaluating all areas at the Laboratory for possible contamination.

10. Toxic Substances Control Act. The Toxic Substances Control Act (TSCA) regulates the manufacture, processing, distribution, use, storage, and labeling of chemical substances, including polychlorinated biphenyls (PCBs). The Laboratory has EPA authorization to dispose of PCB wastes at its chemical waste landfill (Area L) and burn PCB contaminated wastes at its Controlled Air Incinerator (99.9999% combustion efficiency). The Laboratory is in compliance with EPA's permit conditions for authorizing on-site disposal of PCB contaminated wastes.

11. Emergency Planning and Community Right-to-Know Act. Title III of SARA, also known as the Emergency Planning and Community Right-to-Know Act (EPCRA), is the centerpiece of federal policy on chemical disaster prevention and response. In response to this legislation, the state of New Mexico has established an Emergency Response Commission (ERC) within the State Police Department's Hazardous Materials Emergency Response Division; the commission has designated Los Alamos County as the local Emergency Planning District, and the Laboratory's Emergency Management Office will continue to develop and coordinate a comprehensive laboratory-wide, all-hazards emergency response plan that is compatible with the county's overall plan.

The Industrial Hygiene (HSE-5) and Environmental Surveillance (HSE-8) groups provided a preliminary list of 137 chemical substances used on-site to the Emergency Management Office. In addition, individual Materials Safety Data Sheets for each of these 137 chemicals have also been provided to the Emergency Management Office to facilitate county planning.

II. INTRODUCTION TO THE LOS ALAMOS AREA

A. Geographic Setting

Los Alamos National Laboratory and the associated residential areas of Los Alamos and White Rock are located in Los Alamos County, northcentral New Mexico, approximately 100 km (60 mi) NNE of Albuquerque and 40 km (25 mi) NW of Santa Fe (Fig. 1). The 111 km^2 (43 mi^2) Laboratory site and adjacent communities are situated on Pajarito Plateau. The plateau consists of a series of finger-like mesas separated by deep eastwest oriented canyons cut by intermittent streams (Fig. 3). Mesa tops range in elevation from approximately 2400 m (7800 ft) on the flank of the Jemez Mountains to about 1800 m (6200 ft) at their eastern termination above the Rio Grande valley.

All Los Alamos County and vicinity locations referenced in this report are identified by the Laboratory Cartesian coordinate system, which is based upon US Customary units of measurement. This system is standard throughout the Laboratory, but is independent of the US Geological Survey and New Mexico State Survey coordinate systems. The major coordinate markers shown on the maps are at 3 km (10 000 ft) intervals, and for the purpose of this report, locations are reported to the nearest 0.03 km (100 ft).

The DOE controls the area within the Laboratory boundary and has the option to completely restrict access. This control can be instituted if necessary.

B. Land Use

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 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). The San Ildefonso Pueblo borders the Laboratory to the east.

Laboratory land is used for building sites, test areas, waste disposal locations, roads, and utility rights-of-way (Fig. 4 and Appendix F). However, these account for only a small fraction of the total land area. Most land provides isolation for security and safety and is a reserve for future structure locations. The Long Range Site Development Plan (Engineering 1982) assures adequate planning for the best possible future uses of available Laboratory lands.

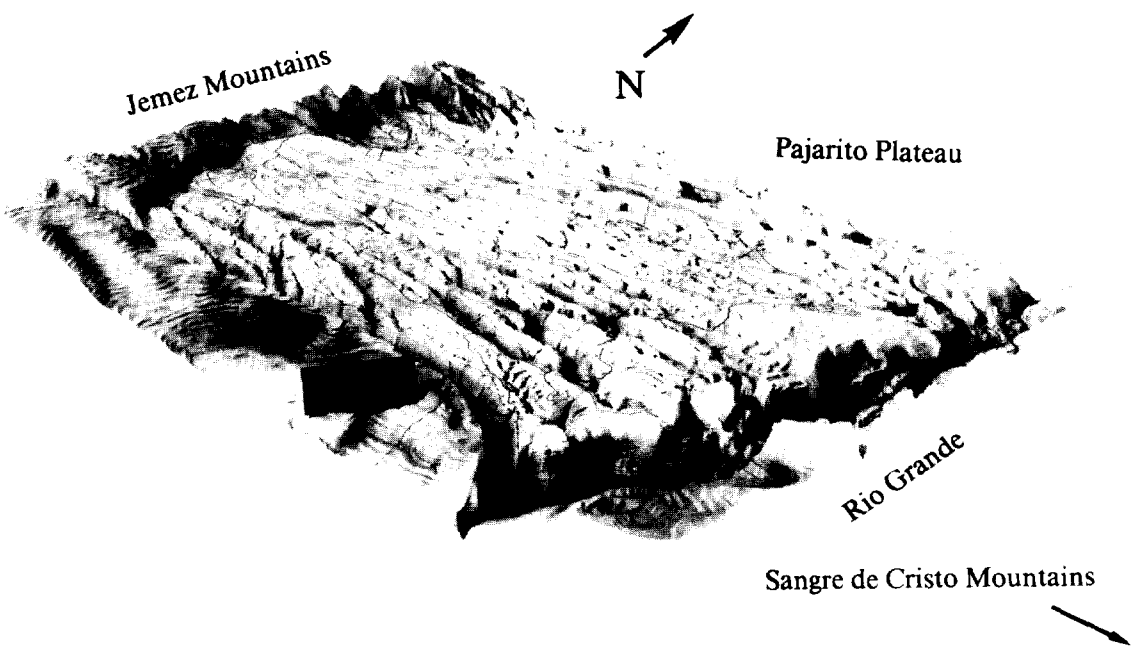

Fig. 3. Topography of the Los Alamos area.

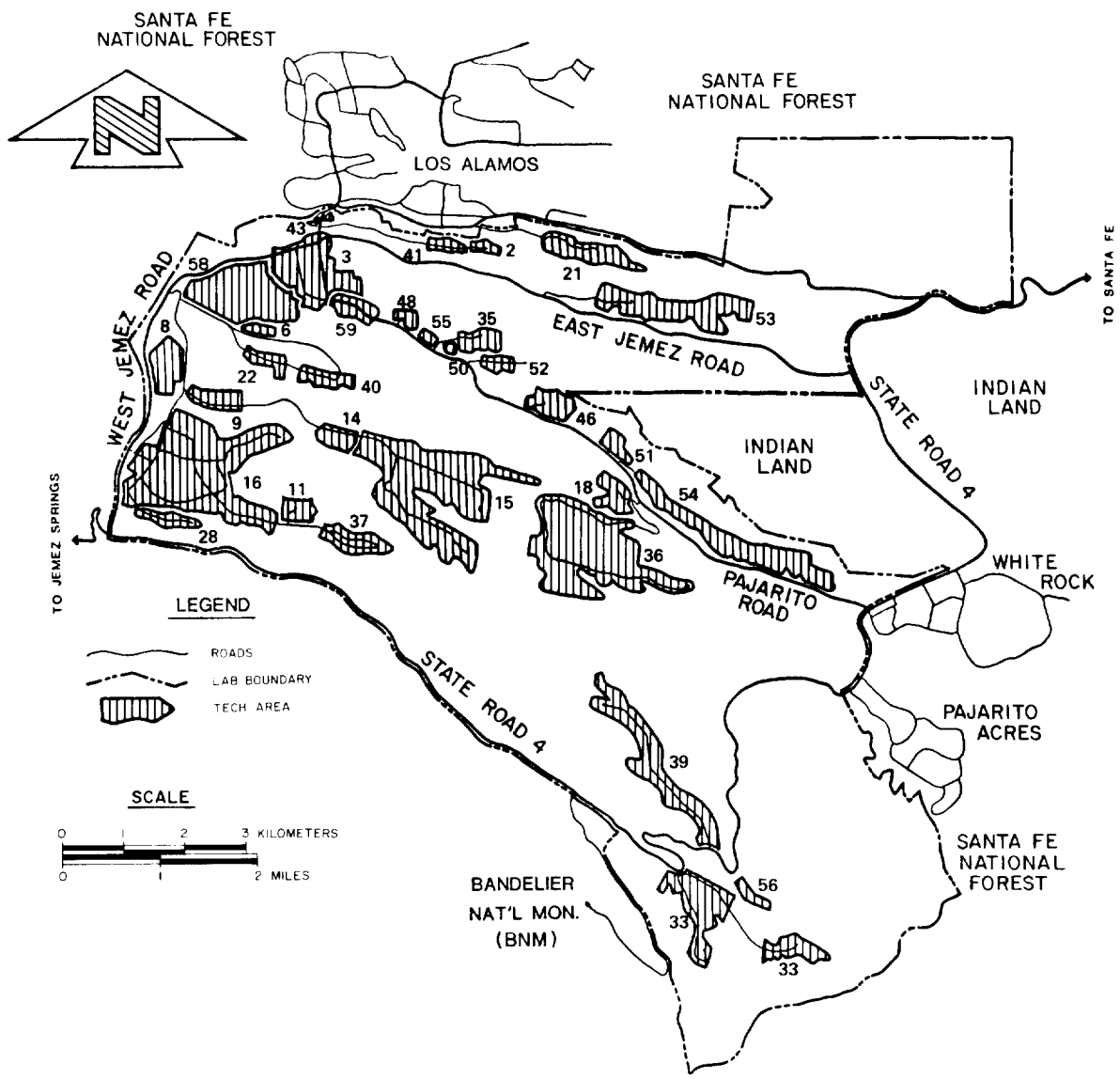

Fig. 4. Technical areas (TAs) of Los Alamos National Laboratory in relation to surrounding landholdings.

Limited access by the public is allowed in certain areas of the Laboratory reservation. An area north of Ancho Canyon 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 4, near the White Rock Y, is open to the public subject to restrictions of cultural resource protection regulations.

C. Geology-Hydrology

Most of the finger-like mesas in the Laboratory area are found in Bandelier Tuff (Fig. 5). Ashfall, ashfall pumice, and rhyolite tuff form the surface of

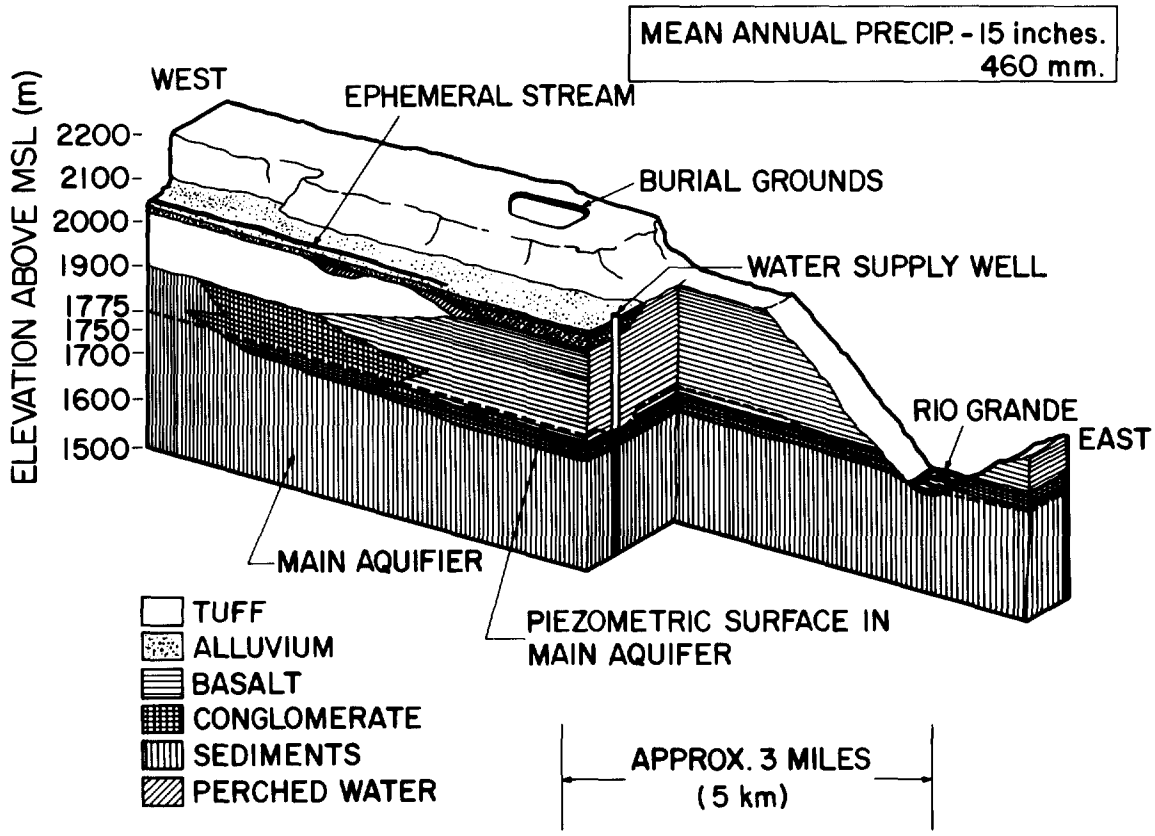

Fig. 5. Conceptual illustration of geologic-hydrologic relationships in Los Alamos area.

Pajarito Plateau. The tuff ranges from nonwelded to welded and is in excess of 300 m (1000 ft) thick in the western part of the plateau and thins to about 80 m (260 ft) eastward above the Rio Grande. It is deposited as the 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 older volcanics of the Tschicoma Formation, which form the Jemez Mountains. They are underlain by the conglomerate of the Puye Formation (Fig. 5) in the central and eastern edge along the Rio Grande. Chino Mesa basalts (Fig. 5) interfinger with the conglomerate along the river. These formations overlay the sediments of the Tesuque Formation (Fig. 5), which extends across the Rio Grande valley and is in excess of 1000 m (3300 ft) thick.

Los Alamos area surface water is primarily in intermittent streams. Springs on 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. Run-off 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 to some canyons at rates sufficient to maintain surface flows for about 1.5 km (1 mi).

Ground water occurs in three modes in the Los Alamos area: (1) water in shallow alluvium in canyons, (2) perched water (a ground water body above an impermeable layer that is separated from the underlying main body of ground water by an unsaturated zone), and (3) the main aquifer of the Los Alamos area (Fig. 5).

Intermittent stream flows in canyons of the plateau have deposited alluvium that ranges from less than 1 m (3 ft) to as much as 30 m (100 ft) in thickness.

The alluvium is quite permeable, in contrast to the underlying volcanic tuff and sediments. Intermittent run-off 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 ground water body that moves downgradient in the alluvium. As water in the alluvium moves downgradient, it is depleted by evapotranspiration and movement into underlying volcanics (Purtymun 1977).

Perched water occurs in comglomerate and basalts beneath the alluvium in a limited area about 40 m (120 ft) in the mid-reach of Pueblo Canyon and in a second area about 50 to 70 m (150 to 200 ft) beneath the surface in lower Pueblo and Los Alamos canyons near their confluence. The second area is mainly in basalts (Fig. 5) and has one discharge point at Basalt Springs 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 of the aquifer decreases from 360 m (1200 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 water table conditions in the western and central part of the plateau and under artesian conditions in the eastern part and along the Rio Grande (Purtymun 1974B). The major recharge to the main aquifer is from the intermountain basin of the Valles Caldera in the Jemez Mountains west of Los Alamos. The water table in the caldera is near land surface. The underlying lake sediment and volcanics are highly permeable and recharge the aquifer through Tschicoma Formation interflow breccias (rock consisting of sharp fragments embedded in a fine-grained matrix) and the Tesuque Formation. The Rio Grande receives ground water discharge from springs fed by the main aquifer. The 18.4 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 x 10^3 m^3 (4300 to 5500 acre-feet) annually from the aquifer.

D. Climatology

Los Alamos has a semiarid, temperate mountain climate. Average, annual precipitation is nearly 45 cm (18 in). Precipitation was heavy during 1987, totalling 60 cm (23.6 in.). It was the third consecutive year with precipitation at least 130% of normal. Forty per cent of the annual precipitation normally occurs during July and August due to thundershowers. Officially, at TA-59, rainfall was normal during the summer of 1987. However, other areas in Los Alamos were below normal for the summer. Winter precipitation falls primarily as snow, with accumulations of about 130 cm (51 in.) annually. Record snowfalls in January and February and heavy snow in December of 1987 helped produce a record annual snowfall of 453 cm (178 in.).

Summers are generally sunny with moderate warm days and cool nights. Maximum 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 to -4°C (15 to 25°F) during the night and from -11 to 10°C (30 to 50°F) during the day. Occasionally, temperatures drop to near -18°C (0°F) or below. Many winter days are clear with light winds, so strong sunshine can make conditions quite comfortable even when air temperatures are cold.

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. Several severe storms occurred during the year. One storm dumped 122 cm (48 in.) officially with up to 152 cm (60 in.) along the mountains during January 15-17, 1987. It was the heaviest snowfall on record in Los Alamos for one storm. Another severe storm dropped nearly 66 cm (26 in.) of snow during February 18-19.

Surface winds in Los Alamos often vary dramatically with time-of-day and with location because of complex terrain. With light, large-scale winds and clear skies, a distinct daily wind cycle often exists: a light southeasterly to southerly upslope wind during the day and a light westerly to northwesterly drainage wind during the night. However, several miles to the east toward the edge of Pajarito Plateau, near the Rio Grande Valley, a different daily wind cycle is common: a moderate southwesterly up-valley wind during the

day and either a light northwesterly to northerly drainage wind or moderate southwesterly wind at night. On the whole, the predominant winds are southerly to northwesterly over western Los Alamos County and southwesterly and northeasterly toward the Rio Grande Valley. The year 1987 followed normal patterns in wind.

Historically, no tornadoes have been reported to have touched down in Los Alamos County. Numerous funnel clouds were reported near Santa Fe on August 24-25, 1987. Strong dust devils can produce winds up to 35 m/sec (75 mph) at isolated spots in the county, especially at lower elevations. Strong winds with gusts exceeding 27 m/sec (60 mph) are common and widespread during the spring. Lightning is very common over 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, whereas 1.3-cm (0.5-in.) diameter hailstones are rare.

Atmospheric mixing or dispersion characteristics affect the transport of contaminants released into the air. Good mixing conditions result in greater dilution of released contaminants. Under poorer mixing conditions, the potential increases for exposure to higher concentrations of released contaminants.

Frequent clear skies and light winds promote good daytime atmospheric dispersion at Los Alamos. Complex terrain and forested vegetation also enhance vertical and horizontal mixing of the atmosphere and contaminants released into the air. During the night, light winds and clear skies favor the formation of temperature inversions, restricting vertical atmospheric dispersion. Air flow channeling by terrain features also reduces nighttime dispersion. Poor atmospheric dispersion conditions frequently exist in canyon bottoms. The frequency of atmospheric stability, an estimate of the dispersion capability of the atmosphere, is approximately 40% unstable (good mixing), 35% neutral (fair mixing), and 25% stable (poor mixing) on the mesa tops of the Los Alamos area.

E. Population Distribution

Los Alamos County has an estimated 1987 population of approximately 18 370 (based on the 1980 census adjusted for 1987). Two residential and related commercial areas exist in the county (Fig. 4). The Los Alamos townsite, the original area of development (and now including residential areas known as the Eastern Area, the Western Area, North Community, Barranca Mesa, and North Mesa), has an estimated population of 11 480. The White Rock area (including the residential areas of White Rock, La Senda, and Pajarito Acres) has about 6820 residents. About one-third of those employed in Los Alamos commute from other counties. Population estimates for 1987 place about 193 000 people within an 80 km (50 mi) radius of Los Alamos (Table 4).

F. Programs at Los Alamos National Laboratory

The Laboratory is administered by the University of California for the Department of Energy. The Laboratory's environmental program, conducted by the Environmental Surveillance Group, is part of a continuing investigation and documentation program.

Since its inception in 1943, the Laboratory's primary mission has been nuclear weapons research and development. Programs include weapons development, magnetic and inertial fusion, nuclear fission, nuclear safeguards and security, and laser isotope separation. There is also basic research in the areas of physics, chemistry, and engineering that supports such programs. Research on peaceful uses of nuclear energy has included space applications, power reactor programs, radiobiology, and medicine. Major research programs in elementary particle physics are carried out at the Laboratory's linear proton accelerator. Other programs include applied photochemistry, astrophysics, earth sciences, energy resources, nuclear fuel safeguards, lasers, computer sciences, solar energy, geothermal energy, biomedical and environmental research, and nuclear waste management research. Appendix F summarizes activities at the Laboratory's 32 active Technical Areas (TAs).

In August 1977, the Laboratory site, encompassing 111 km^2 (43 mi^2), 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 understanding of 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).

Table 4. 1987 Population Within 80 km of Los Alamos[a,b]

Direction	1-2	2-4	4-8	8-15	15-20	20-30	30-40	40-60	60-80
N	1	---	---	---	---	---	1 114	---	360
NNE	---	---	---	554	---	531	1 697	1 761	216
NE	1	---	---	---	311	14 798	990	1 104	3 730
ENE	---	---	---	1 745	1 533	2 443	2 592	1 164	2 216
E	---	---	75	23	500	1 030	626	---	1 455
ESE	---	---	---	---	---	263	20 829	1 062	1 470
SE	---	---	6 820	---	---	---	48 152	2 198	7
SSE	---	---	---	---	---	---	383	3 911	85
S	---	---	---	50	---	267	516	5 720	---
SSW	---	---	---	20	---	686	169	6 917	28 115
SW	---	---	---	---	---	---	264	3 490	---
WSW	---	---	---	---	---	264	263	2 137	174
W	---	---	---	---	---	---	---	138	111
WNW	---	1 448	6 595	---	---	---	---	---	2 587
NW	---	528	1 737	---	---	---	---	1 410	---
NNW	---	583	584	---	---	---	---	62	61

[a]This distribution represents the resident, nonworkforce population with respect to the Los Alamos Meson Physics Facility's stack at TA-53. A slightly different distribution for Los Alamos County townsites was used to model releases from the TA-2 stack, which is located closer to Los Alamos.
[b]Total population within 80 km of Los Alamos is 192 649.

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

III. RADIATION DOSES

Some incremental radiation doses--above those received from natural background, resuspended fallout, and medical and dental diagnostic procedures--are received by Los Alamos County residents as a result of Laboratory operations. The largest estimated dose at an occupied location was about 6 mrem to the whole body or 24% of EPA's air emission standard of 25 mrem/yr. This dose estimate is principally due to airborne radiation from the linear particle accelerator at the Los Alamos Meson Physics Facility. The effective dose equivalent to the maximum exposed individual from all pathways was also approximately 6 mrem. This is 6% of the DOE Radiation Protection Standard of 100 mrem/yr.

No significant exposure pathways are believed to exist for radioactivity released in treated liquid waste discharges. Most released radionuclides are retained in alluvial sediments within Laboratory boundaries. A small fraction is transported off-site in stream channel sediments during heavy run-off. Radionuclide concentrations in these sediments, however, are only slightly above background levels. Other minor pathways include direct radiation and foodstuffs.

The cumulative effective dose equivalent attributable to Laboratory operations received by the population living within 80 km (50 mi) of the Laboratory was conservatively estimated to be 3.5 person-rem during 1987. This is <0.01% of the 61 000 person-rem cumulative effective dose equivalent received by the same population from natural radiation sources and 0.03% of the 10 000 person-rem cumulative effective dose equivalent received from diagnostic medical procedures. About 90% of this dose, 3.0 person-rem, was received by persons living in Los Alamos County. This dose is 0.05% of the 6000 person-rem received by the population of Los Alamos County from background radiation and 0.3% of the 970 person-rem from diagnostic medical and dental procedures.

In 1987, the average, added risk of cancer mortality to Los Alamos townsite residents was 1 chance in 50 000 000 due to radiation from this year's Laboratory operations; this is much less than 1 chance in 31 000 from background radiation. The EPA has estimated average lifetime risk for overall cancer incidence as 1 chance in 4 and for cancer mortality as 1 chance in 5.

A. Background

The impact of environmental releases of radioactivity is evaluated by estimating doses received by the public from exposure to these releases. These doses are then compared with applicable standards and with doses from background radiation and medical and dental radiation.

The DOE's Radiation Protection Standard (RPS) limits the effective dose equivalent to 100 mrem/yr for all pathways of exposure (DOE 1985). The effective dose equivalent is the hypothetical whole-body dose that carries the same risk of cancer or genetic disorders as a given dose to a particular organ (see Glossary). Using this dose, which was introduced by the International Commission on Radiological Protection (ICRP 1977), allows direct comparison of exposures to different organs.

In accordance with federal EPA regulations (40 CFR 61), whole-body doses received via the air pathway only are limited to 25 mrem/yr and individual organ doses are limited to 75 mrem/yr via this pathway. The principal pathway of exposure at Los Alamos has been via release of radionuclides into the air resulting in external radiation doses to the whole body. Other pathways contribute finite but negligible doses. Detailed discussion of standards is presented in Appendix A.

The exposure pathways considered for the Los Alamos area are atmospheric transport of airborne radioactive emissions, hydrologic transport of treated liquid effluents, food chains, and direct exposure to external penetrating radiation. Exposure to radioactive materials or radiation in the environment was determined by direct measurements of airborne and

waterborne contaminants, of contaminants in foodstuffs, and of external penetrating radiation. Theoretical dose calculations based on atmospheric dispersion modeling were made for other airborne emissions present at levels too low for measurement.

Doses were calculated from measured or derived exposures using models based on the recommendations of the International Commission of Radiological Protection (Appendix D). These doses are summarized in Table 5 for the most important exposure categories, as defined in DOE Order 5484.1 (DOE 1981) as:

1. *Maximum Boundary Dose, or "Fence-Post" Dose Rate:* Maximum dose at the Laboratory boundary where the highest dose rate occurs. This dose does not take into account shielding or occupancy and does not require that an individual actually receive this dose.
2. *Maximum Individual Dose:* Maximum dose to an individual in the off-site location where the highest dose rate occurs and where there is a person present. It includes corrections for shielding (for example, for being inside a building) and occupancy (what fraction of the year the person is in the area).
3. *Average Dose:* Average doses to residents of Los Alamos and White Rock.
4. *Whole-Body Cumulative Dose:* The whole-body cumulative dose for the population within an 80-km (50-mi) radius of the Laboratory. The cumulative effective dose equivalent for the 80 km area is also given in accordance with the DOE Radiation Protection Standard (DOE 1985).

The maximum boundary and the individual doses over the past 9 years are summarized in Fig. 2. Over 95% of each of these doses resulted from airborne emissions of activation products from the Los Alamos Meson Physics Facility (LAMPF).

The effective dose equivalent is taken to be the same as the whole-body dose equivalent for whole-body external radiation. The effective dose equivalent for internal radiation is the weighed sum of the doses to individual organs (see Glossary).

All internal radiation doses (via inhalation or ingestion) are 50-year dose commitments (Appendix D). This is the total dose received from intake of a radionuclide for 50 years following intake.

In addition to compliance with dose standards, which define an upper limit for doses to the public, there is a concurrent commitment to maintain radiation exposure to individuals and population groups to levels as low as reasonably achievable (ALARA). This policy is followed at the Laboratory by applying strict controls on airborne emissions, liquid effluents, and operations to minimize doses to the public and to limit releases of radioactive materials to the environment. Ambient monitoring described in this report documents the effectiveness of these controls.

B. Estimate of Radiation Doses

1. Doses from Natural Background Radiation and Medical and Dental Radiation. 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 these doses (<1%) 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. For convenience, 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 recent comprehensive report by the National Council on Radiation Protection and Measurements (NCRP 1987). This document contains some minor differences from a 1975 NCRP report that had been used in previous environmental surveillance reports. These differences include using 20% (instead of 10%) shielding by structures for cosmic radiation and 30% (instead of 20%) self-shielding by the body for terrestrial radiation. The 1987 NCRP document also gives an effective dose equivalent for radon exposure. These changes were incorporated into this report to obtain the most current estimates of background radiation. This resulted in some small differences from the procedure used in previous reports for determining background doses.

Whole-body external dose is incurred from exposure to cosmic rays, 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 (Sec. IV). Estimates of background from nonradon sources are

Table 5. Summary of Annual, Effective Dose Equivalents Due to 1987 Laboratory Operations

	Maximum Dose at Laboratory Boundary[a]	Maximum Dose to an Individual[b]	Average Dose to Nearby Residents		Cumulative Dose to Population Within 80 km of the Laboratory
			Los Alamos	White Rock	
Dose	12 ± 5 mrem	6.1 mrem	0.21 mrem	0.17 mrem	3.5 person-rem
Location	Boundary N. of TA-53	Residence N. of TA-53	Los Alamos	White Rock	Area within 80 km of Laboratory
DOE Radiation Protection Standard	--	100 mrem	100 mrem	100 mrem	--
% of Radiation Protection Standard	--	6%	0.2%	0.2%	--
Background	327 mrem	327 mrem	327 mrem	327 mrem	61 000 person-rem
% of Background	4%	2%	0.06%	0.05%	0.006%

[a]Maximum boundary dose is the dose to a hypothetical individual at the Laboratory boundary where the highest dose rate occurs with no correction for shielding. It assumes that the hypothetical individual is at the Laboratory boundary continuously (24 hours a day, 365 days a year).

[b]Maximum individual dose is the dose to an individual at or outside the Laboratory where the highest dose rate occurs and where there is a person. It takes into account occupancy (the fraction of time a person is actually at that location), self-shielding, and shielding by buildings.

based on measured external radiation background levels of 102 mrem (Los Alamos) and 106 mrem (White Rock) due to 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 at Los Alamos, 52 mrem at White Rock) by 20% to allow for shielding by structures, and the terrestrial component (42 mrem at Los Alamos and 54 mrem at White Rock) by 30% to allow for self-shielding by the body (NCRP 1987). To these estimates, based on measurements, were added 10 mrem at Los Alamos and 8 mrem at White Rock from neutron cosmic radiation (20% shielding assumed) and 40 mrem from internal radiation (NCRP 1987). The estimated whole-body dose from background, nonradon radiation is 127 mrem at Los Alamos and 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 the construction materials in a building and in its underlying soil. The effective dose equivalent from exposure to background ^{222}Rn and its decay products is taken to be 200 mrem/year (NCRP 1987). 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 (1984A, 1987).

The total effective dose equivalent to residents at Los Alamos and White Rock is 327 mrem/yr (Table 5), or 127 mrem/yr from nonradon sources and 200 mrem/yr from radon.

The use of medical and dental radiation in the United States accounts for an annual average, per capita, effective dose equivalent of 53 mrem (NCRP 1987). This estimate includes doses from both X rays and radiopharmaceuticals.

2. Dose to Individuals from External Penetrating Radiation from Airborne Emissions. The thermoluminescent dosimeter network at the Laboratory boundary north of LAMPF indicated a 12.4 mrem increment above cosmic and terrestrial background radiation during 1987 (Sec. IV). This increment is attributed to emission of air activation products from LAMPF. Based on 30% shielding from being inside buildings (NRC 1977), 30% self-shielding (NCRP 1987), and 100% occupancy, this 12.4 mrem increment translates to an estimated 6.1 mrem whole-body dose to an individual living along State Road 4 north of LAMPF (Table G-1). The 6.1 mrem is 24% of EPA's air emission standard of 25 mrem/yr for a member of the public (Appendix A). This location north of LAMPF has been the area where the highest boundary and individual doses have been measured since the dosimeter monitoring began.

Because these doses are from external penetrating radiation, all whole-body doses reported in this section are numerically equal to effective dose equivalents. Consequently, the doses are not only less than EPA's air emission standard of 25 mrem/yr (whole body), but also less than DOE's Radiation Protection Standard of 100 mrem/yr (effective dose equivalent).

A maximum on-site dose to a member of the public from external penetrating radiation from all Laboratory airborne emissions was estimated using a Gaussian dispersion meteorological model (Slade 1968). The estimated maximum on-site dose was 0.001 mrem (whole body) for 1987. This is <0.005% of the EPA's 25 mrem air emission standard for protection of a member of the public (Appendix A). This dose was calculated (using credible worst-case conditions) for a person spending 4 hours at the Laboratory's science museum, an area readily accessible to the public.

Average dose to residents in Los Alamos townsite attributable to Laboratory operations was 0.21 mrem to the whole body. The corresponding dose to White Rock residents was 0.17 mrem to the whole body. The doses are 0.8% and 0.7%, respectively, of EPA's 25 mrem air emission standard. They were estimated using an air dispersion model, measured stack releases (Table G-2), and 1987 meteorological data. These doses were dominated by external radiation from airborne releases at LAMPF.

3. Doses to Individuals from Inhalation of Airborne Emissions. The maximum individual doses attributable to inhalation of airborne emissions are summarized in Table G-1 and are below the EPA air emission standards for whole-body doses, 25 mrem/yr, and the limit for organ doses, 75 mrem/yr (Appendix A).

Exposure to airborne ^{3}H (as tritiated water vapor), uranium, ^{238}Pu, ^{239,240}Pu, and ^{241}Am were determined by measurement (Sec. V). Correction for background was made assuming that natural radioactivity and worldwide fallout were represented by data from the three regional sampling stations at Espanola, Pojoaque, and Santa Fe. Doses were calculated using the procedures described in Appendix D.

The inhalation dose that was the highest percentage of the EPA's air emission standard was 0.11 mrem to the bone surface; this is 0.1% of the 75 mrem/yr standard for dose to any organ from the air pathway.

Emissions of air activation products from LAMPF resulted in negligible inhalation exposures.

All other atmospheric releases of radioactivity (Table G-2) were evaluated by theoretical calculations. All potential doses from these other releases were less than the smallest ones presented in this section and were thus considered insignificant.

4. Modeled Doses from Airborne Emissions. For compliance with 40 CFR Part 61, Subpart H, the federal EPA requires that radiation doses be determined with the computer code AIRDOS-EPA (EPA 1985A). The AIRDOS-EPA code was run with 1987 meteorology data and radioactive emissions data given in Table G-2. As expected, over 98% of the maximum individual dose resulted from external exposure to the air activation products from LAMPF. The maximum individual whole-body dose as determined by AIRDOS-EPA was 10.9 mrem corrected to include shielding due to buildings (30% reduction). This dose, which would occur in the area just north of LAMPF, is 44% of the EPA's air emission standard of 25 mrem/yr (whole body).

The maximum organ dose was calculated by AIRDOS-EPA to be 12.8 mrem to the lung, or 17% of EPA's air emission standard of 75 mrem/yr to any organ. This dose would also occur in the area just north of LAMPF. Of the 12.8 mrem, approximately 95% is due to external penetrating radiation from LAMPF air emissions and 5% from other Laboratory emissions.

5. Doses from Direct Penetrating Radiation. No direct penetrating radiation from Laboratory operations was detected by TLD monitoring in off-site areas. The only off-site TLD measurements showing any effect from Laboratory operations were those taken north of LAMPF. These were due to airborne emissions and are discussed above. On-site TLD measurements of external penetrating radiation reflected Laboratory operations and do not represent potential exposure to the public except in the vicinity of TA-18 on Pajarito Road. Members of the public using the DOE-controlled road passing by TA-18 would likely receive no more than 2 mrem/yr of direct gamma and neutron radiation, which is 2% of the DOE's 100 mrem/yr standard for protection from exposure by all pathways (Appendix A). This value was based on 1987 field measurements of gamma plus neutron dose rates using thermoluminescent dosimeters.

The on-site thermoluminescent dosimeter station (Station 24, Fig. 6) near the northeastern Laboratory boundary recorded an above-background dose of about 70 mrem. This reflects direct radiation from a localized accumulation of ^{137}Cs on sediments transported from treated effluent released from TA-21 prior to 1964. No one resides near this location.

6. Doses to Individuals from Treated Liquid Effluents. Treated, liquid effluents do not flow beyond the Laboratory boundary but are retained in alluvium of the receiving canyons (Sec. VI). These treated effluents are monitored at their point of discharge and their behavior in the alluvium of the canyons below outfalls has been studied (Hakonson 1976A, 1976B, and Purtymun 1971, 1974A).

Small quantities of radioactive contaminants transported during periods of heavy run-off have been measured in canyon sediments beyond the Laboratory boundary in Los Alamos Canyon. Calculations made with radiological data from Acid, Pueblo, and Los Alamos canyons (ESG 1981) indicate a minor exposure pathway (eating liver from a steer that drinks water from and grazes in lower Los Alamos Canyon) to man from these canyon sediments. This pathway could potentially result in a maximum 50-year dose commitment of 0.0013 mrem to bone.

7. Doses to Individuals from Ingestion of Foodstuffs. Data from sampling of produce, fish, and honey during 1987 (Section VII) were used to estimate doses received from eating these foodstuffs. All calculated effective dose equivalents are 0.1% or less of the DOE's 100 mrem/yr standard (Appendix A).

Fruit and vegetable samples were analyzed for six radionuclides (^{3}H, ^{137}Cs, total uranium, ^{238}Pu, and $^{239,240}Pu$). Maximum committed effective dose equivalent that would result from ingesting one quarter of an annual consumption of fruits and vegetables (160 kg) from the off-site locations was 0.07 mrem. This dose is 0.07% of the DOE's Radiation Protection Standards for protecting members of the public (Appendix A).

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.

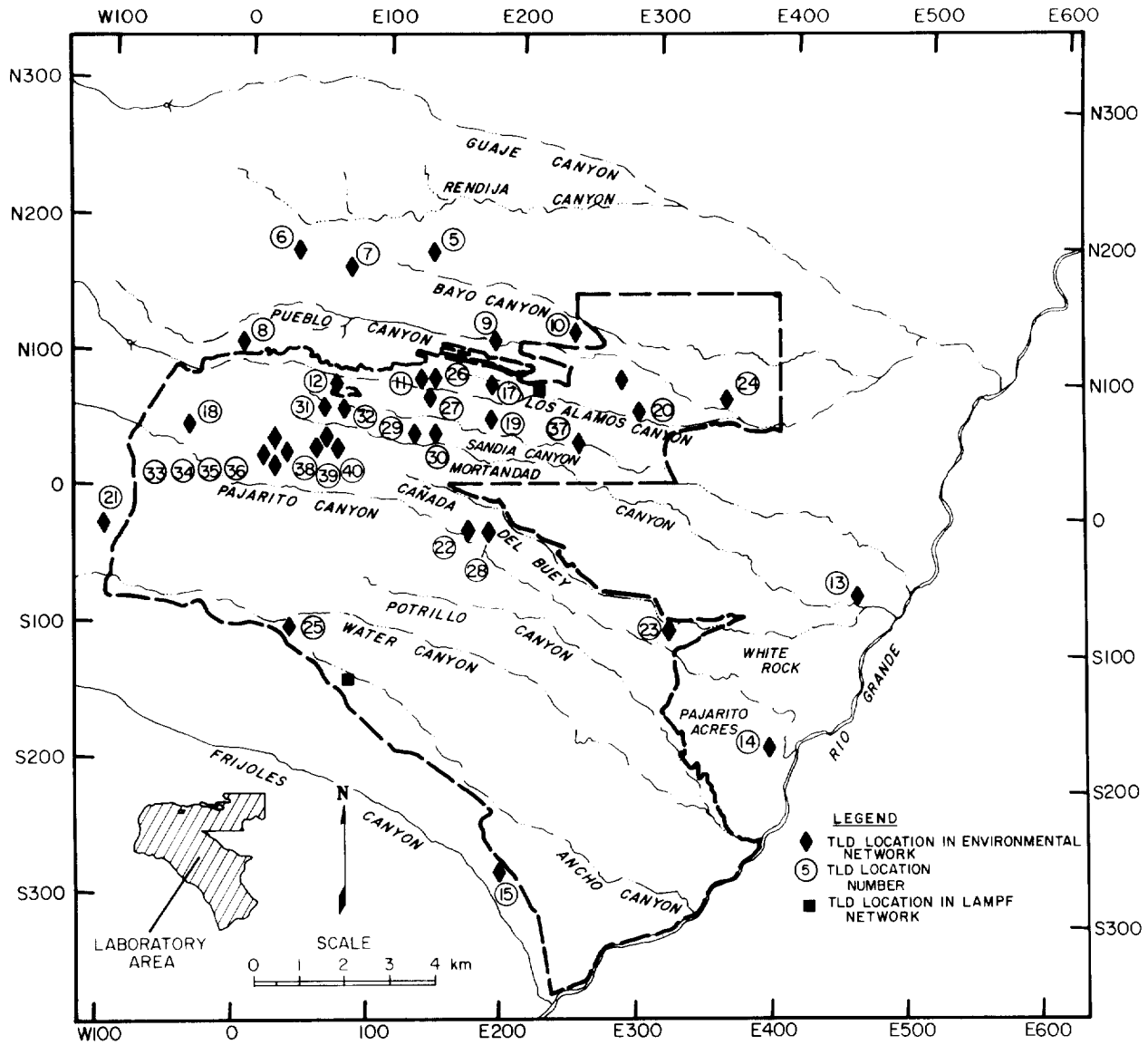

Fig. 6. Thermoluminescent dosimeter (TLD) locations on or near the Laboratory site.

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 upstream. The maximum effective dose equivalent to an individual eating 21 kg of fish from Cochiti Reservoir is 0.03 mrem, which is 0.03% of DOE's 100 mrem standard (DOE 1985). Maximum organ dose is 0.3 mrem to bone surface.

Trace amounts of radionuclides were found 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 0.02 mrem, which is 0.02% of DOE's 100 mrem standard.

8. Cumulative Effective Dose Equivalents. The 1987 population cumulative effective dose equivalents attributable to Laboratory operations to persons living within 80 km (50 mi) of the Laboratory was calculated

to be 3.5 person-rem. This dose is <0.01% of the 61 000 person-rem exposure from natural background radiation and 0.03% of the 10 000 person-rem exposure from medical radiation (Table 6). The 1987 population whole-body dose equivalent is also 3.5 person-rem. This is because the dose is dominated by external whole-body radiation from LAMPF emissions. Whole-body doses received from external radiation equal total effective doses.

The population dose from Laboratory operations was calculated from measured radionuclide emission rates (Table G-2), atmospheric modeling using measured meteorological data for 1987, and population data based on the 1980 Bureau of Census count adjusted to 1987 (Table 4 and Appendix D).

The population dose from natural background radiation was calculated using the background radiation levels given above. The dose to the 80-km population from medical and dental radiation was calculated using a mean annual dose of 53 mrem per capita. The population distribution in Table 4 was used in both these calculations to obtain the total population dose.

Also shown in Table 6 is the population effective dose equivalent in Los Alamos County from Laboratory operations, natural background radiation, and medical and dental radiation. Approximately 90% of the total population dose from Laboratory operations is to Los Alamos County residents. This dose is 0.05% of the population effective dose equivalent from background and 0.3% of the population dose from medical and dental radiation, respectively.

Population centers outside of Los Alamos County are farther away, so dispersion, dilution, and decay in transit (particularly for ^{11}C, ^{13}N, ^{14}O, ^{15}O, and ^{41}Ar) reduce their dose to less than 10% of the total. The population dose to residents outside of Los Alamos County and within 80 km (50 mi) of the Laboratory is 0.001% of the dose from natural background radiation and 0.004% of the dose from medical and dental radiation.

C. Risk to an Individual from Laboratory Releases

1. Estimating Risk. Risk estimates of possible health effects from radiation doses to the public

Table 6. Estimated Population Effective Dose Equivalents (person-rem) During 1987

Exposure Mechanism	Los Alamos County (18 400 persons)	80-km Region (193 000 persons)[a]
Total Due to Laboratory Releases	3.1[b]	3.5
Natural Background		
Non-Radon	2300	22 000
Radon	3700	39 000
Total Due to Natural Sources of Radiation	6000	61 000
Diagnostic Medical Exposure [~53 mrem/yr per person (NCRP 1987)]	970	10 000

[a]Includes doses reported for Los Alamos County.
[b]Calculations are based on thermoluminescent dosimeter measurements. They include a 30% reduction in cosmic radiation from shielding by structures and a 30% reduction in terrestial radiation from self-shielding by the body.

resulting from Laboratory operations have been made to provide perspective in interpreting these radiation doses. These calculations, however, may overestimate actual risk for low-LET (linear energy transfer) radiation. The National Council on Radiation Protection and Measurements (NCRP 1975A) has warned "risk estimates for radiogenic cancers at low doses and low dose rates derived on the basis of linear (proportional) extrapolation from the rising portions of the dose incidence curve at high doses and high dose rates...cannot be expected to provide realistic estimates of the actual risks from low level, low-LET radiation, and have such a high probability of overestimating the actual risk as to be of only marginal value, if any, for purposes of realistic risk-benefit evaluation."

Low-LET radiation, which includes gamma rays, is the principal type of environmental radiation resulting from Laboratory operations. Estimated doses from high-LET radiation, such as neutron or alpha particle radiation, are less than 3% of estimated low-LET radiation doses. Consequently, risk estimates in this report may overestimate the true risks.

The International Commission on Radiological Protection (ICRP 1977) estimated that the total risk of cancer mortality from uniform, whole-body radiation for individuals is 0.0001 per rem, that is, there is 1 chance in 10 000 that an individual exposed to 1000 mrem (1 rem) of whole-body radiation would develop a fatal cancer during his lifetime due to that exposure. This same risk factor applies to the risk of cancer mortality per rem of effective dose equivalent. In developing risk estimates, the International Commission on Radiological Protection has warned "radiation risk estimates should be used only with great caution and with explicit recognition of the possibility that the actual risk at low doses may be lower than that implied by a deliberately cautious assumption of proportionality" (ICRP 1977).

2. Risk from Natural Background Radiation and Medical and Dental Radiation. During 1987, persons living in Los Alamos and White Rock received an average effective dose equivalent of 127 mrem of non-radon (principally to the whole body) radiation 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 1987 was 1 chance in 79 000 in Los Alamos and White Rock (Table 2).

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 due to natural radiation sources that was not included in the estimate for whole body radiation. For the background effective dose equivalent of 200 mrem/yr, the added risk due to exposure to natural ^{222}Rn and its decay products is 1 chance in 50 000.

The total cancer mortality risk from natural background radiation is 1 chance in 31 000 for Los Alamos and White Rock. The additional risk of cancer mortality from exposure to medical and dental radiations is 1 chance in 190 000.

3. Risk from Laboratory Operations. The risks calculated above from natural background radiation and medical and dental radiation can be compared with the incremental risk due to radiation from Laboratory operations. The average doses to individuals in Los Alamos and White Rock because of 1987 Laboratory activities were 0.21 mrem and 0.17 mrem, respectively. These doses are estimated to add lifetime risks of about 1 chance in 50 000 000 in Los Alamos and White Rock to an individual's risk of cancer mortality (Table 2). 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 a cancer and a 1 in 5 chance of dying of cancer (EPA 1979A). The Los Alamos incremental dose 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 57 min.

The exposure from Laboratory operations to Los Alamos County residents is well within variations in exposure to these people from natural cosmic and terrestrial sources and global fallout. For example, amount of snow cover and position in the solar sunspot cycle can account for a 10 mrem variation from year to year. Energy conservation measures, such as sealing and insulating houses and installing passive solar systems, are likely to contribute more to the total risk to Los Alamos County residents than Laboratory operations because of increased ^{222}Rn levels inside homes.

IV. MEASUREMENT OF EXTERNAL PENETRATING RADIATION

Levels of external penetrating radiation--including X and gamma rays and charged particle contributions from cosmic, terrestrial, and manmade sources--are monitored in the Los Alamos area with thermoluminescent dosimeters. Measurements for regional locations showed a statistically discernible decrease in radiation levels for 1987. The only boundary or perimeter measurements showing an effect attributable to laboratory operations were those from dosimeters located north of the Los Alamos Meson Physics Facility (a linear particle accelerator). They showed an above-background radiation measurement of about 12 $\pm$ 5 mrem in 1987. This is a decrease from the 1986 measurement of 18 $\pm$ 3 mrem, although not statistically significant. Some on-site measurements were above background levels, as expected, reflecting research activities and waste management operations at the Laboratory.

A. Background

Natural external penetrating radiation comes from terrestrial and cosmic sources. The natural terrestrial component results from decay of ^{40}K and of radioactive nuclides 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 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 soil and rock types in the 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, the regional locations range in elevation from about 1.7 km (1.1 mi) at Espanola 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. The cosmic component can vary about $\pm$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, in order to measure contributions to external radiation from operation of the Los Alamos Meson Physics Facility (LAMPF), arrays of 48 thermoluminescent dosimeters (TLDs) each have been deployed near LAMPF and in background areas.

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 deployed in three independent networks. These networks are used to measure radiation levels at: (1) the Laboratory and regional areas, (2) the Laboratory boundary north of LAMPF, and (3) low-level radioactive waste management areas.

B. Environmental TLD Network

The environmental network consists of 40 stations divided into three groups. The regional group consists of four locations, 28 to 44 km (17 to 27 mi) from the Laboratory boundary in the neighboring communities of Espanola, Pojoaque, and Santa Fe as well as the Fenton Hill Site 30 km (19 mi) west of Los Alamos. The off-site perimeter group consists of 12 stations within 4 km (2.5 mi) of the boundary. Within the Laboratory boundary, 24 locations comprise the on-site group (Fig. 6). Details of methodology for this network are found in Appendix B.

Annual averages for the groups were significantly lower in 1987 than 1986 ($p < 0.05$, 2-way analysis of variance) (Fig. 7). Regional and perimeter stations showed no statistically discernible increase in radiation levels attributable to Laboratory operations (Table G-3). Annual measurements at off-site stations ranged from 70 to 124 mrem.

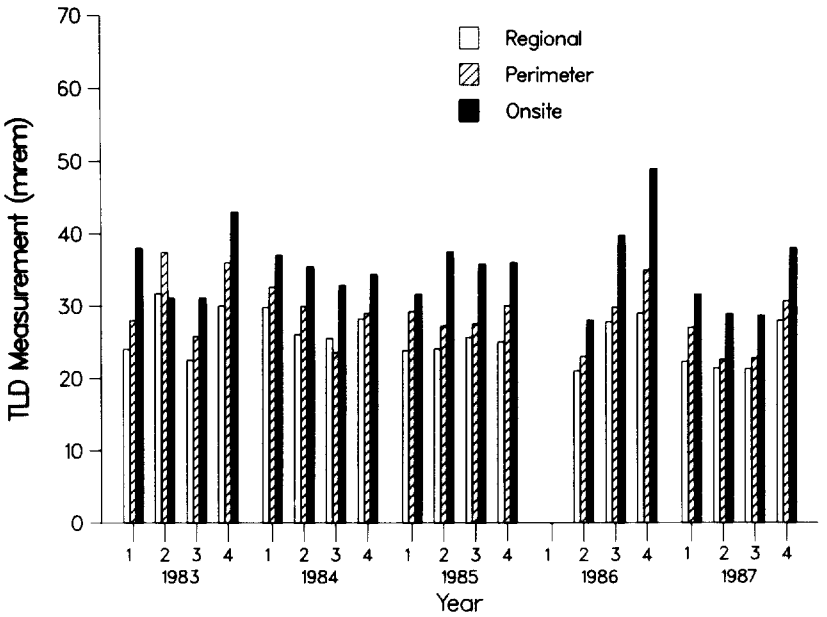

Fig. 7. Thermoluminescent dosimeter (TLD) measurements (includes contributions from cosmic, terrestrial, and Laboratory radiation sources).

Some comparisons provide a useful perspective for evaluating these measurements. For instance, the average person in the United States receives about 53 mrem/yr for medical diagnostic procedures (NCRP 1987). The DOE's RPS is 100 mrem/yr, effective dose received from all pathways, and the dose received via air is restricted by EPA's standard of 25 mrem/yr (whole body) (Appendix A). These values are in addition to 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.

C. Los Alamos Meson Physics Facility (LAMPF) TLD Network

This network monitors external radiation from airborne activation products (gases, particles, and vapors) released by LAMPF, TA-53. The prevailing winds are from the south and southwest (Sec. 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. 6). This background location is not influenced by any Laboratory external radiation sources.

The TLDs at the 24 sites are changed each calendar quarter or sooner, if LAMPF's operating schedule dictates (start-up or shut-down of the accelerator for extended periods midway in a calendar quarter). The radiation measurement (above background) for this network was about 12 $\pm$ 5 mrem for 1987. This value is obtained by subtracting the annual measurement at the background sites from the annual measurement at the Laboratory's boundary north of LAMPF (Appendix B). This year's measurement is about two-thirds of the value measured in 1986 (Fig. 2) even though estimated emissions from LAMPF increased in 1987 (Table 3).

D. TLD Network for Low-Level Radioactive Waste Management Areas

This network of 92 locations monitors radiation levels at 1 active and 11 inactive low-level radioactive waste management areas. These waste management areas are controlled-access areas and are not accessible to the general public. Active and inactive waste areas are monitored for external penetrating radiation with arrays of TLDs (Table 7). Averages at all sites but Area X were higher than average perimeter values. However, the ranges at most sites largely overlapped the range of values found at perimeter and

regional stations (Tables 7 and G-3). The extremes at Area G, the active radioactive waste area, and Area T, an inactive waste area, have been noted in previous years. These are the results of past and present radioactive waste management activities.

Table 7. Doses (mrem) Measured by TLDs at On-site Waste Areas During 1987

Area	Number of TLDs	Mean	Minimum	Maximum
A	5	118	112	121
B	14	118	107	126
C	10	116	104	149
E	4	119	113	125
F	4	108	102	111
G	27	132	111	174
T	7	133	109	198
U	4	115	112	119
V	4	117	111	122
W	2	110	107	113
X	1	91	---	---
AB	10	106	96	114

V. AIR MONITORING

Airborne radioactive emissions were released from 87 points at the Laboratory during 1987. The largest airborne release was 150 000 Ci of short-lived (2 to 20 minute half-lives) air activation products from the Los Alamos Meson Physics Facility (LAMPF). Ambient air is routinely sampled at several locations on-site, along the Laboratory perimeter, and in distant areas which serve as regional background stations. Concentrations of airborne tritium, uranium, plutonium, americium, and gross beta activity are measured. The highest measured and annual average activity concentrations of these radioactive materials were much less than 0.1% of levels that exceed DOE's Radiation Protection Standards. Nonradiological airborne emissions from the Laboratory remained below federal and state limits.

A. Radionuclides in Ambient Air

1. Background. The ambient air sampling network for radioactivity consists of 26 continuously operating stations (see Appendix B for a complete description of sampling procedures). The regional monitoring stations, 28 to 44 km (18 to 28 mi) from the Laboratory, are located at Espanola, Pojoaque, and Santa Fe (Fig. 8). The results from these stations are used as reference points for determining regional background levels of airborne radioactivity. The 11 perimeter stations are within 4 km (2.5 mi) of the Laboratory boundary; 12 stations are located within the Laboratory boundary (Fig. 8, Table G-4).

Natural fallout radioactivity levels in air fluctuate and affect measurements made by the Laboratory's air sampling program. Worldwide background airborne radioactivity is largely composed of fallout from past above-ground nuclear weapon tests, natural radionuclides from the transformation products of thorium and uranium attached to dust particles, and materials resulting from interactions with cosmic radiation (e.g., tritiated water vapor produced by interactions of cosmic radiation and stable water). Background, airborne radioactivity concentrations are summarized in Table G-5.

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

2. Airborne Emissions. Radioactive airborne emissions are discharged at the Laboratory from 87 stacks. These emissions consist primarily of filtered exhausts from gloveboxes, experimental facilities, operational facilities (such as liquid waste treatment plants), a nuclear research reactor, and a linear particle accelerator at LAMPF. The emissions receive appropriate treatment prior to discharge, such as filtration for particulates as well as catalytic conversion and adsorption for activation gases. Quantities of airborne radioactivity released depend on the nature of ongoing research activities and vary significantly from year to year (Figs. 9-11).

During 1987, as in previous years, the most significant releases were from LAMPF (Fig. 11 and Table G-2). The amount released for the year was 150 000 Ci of air activation products (gases, particulates, and vapors). These emissions were about 30% above 1986 amounts. The principal airborne activation products (half-lives in parentheses) were ^{11}C (20 min), ^{13}N (10 min), ^{14}O (71 sec), ^{15}O (123 sec), and ^{41}Ar (1.83 h). Over 95% of the radioactivity was from ^{11}C, ^{13}N, ^{14}O, and ^{15}O. However, the radioactivity from these radionuclides declines rapidly because of the short half-lives.

Airborne tritium emissions decreased by 70% from 10 700 Ci in 1986 to 3180 Ci in 1987 (Table 3). This was principally due to decreases in tritium releases from facilities at TA-3, TA-33, and TA-41.

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 98 kg (220 lb) of depleted uranium was used in such experiments in 1987 (Table G-6). This mass contains about 46 mCi of radioactivity.

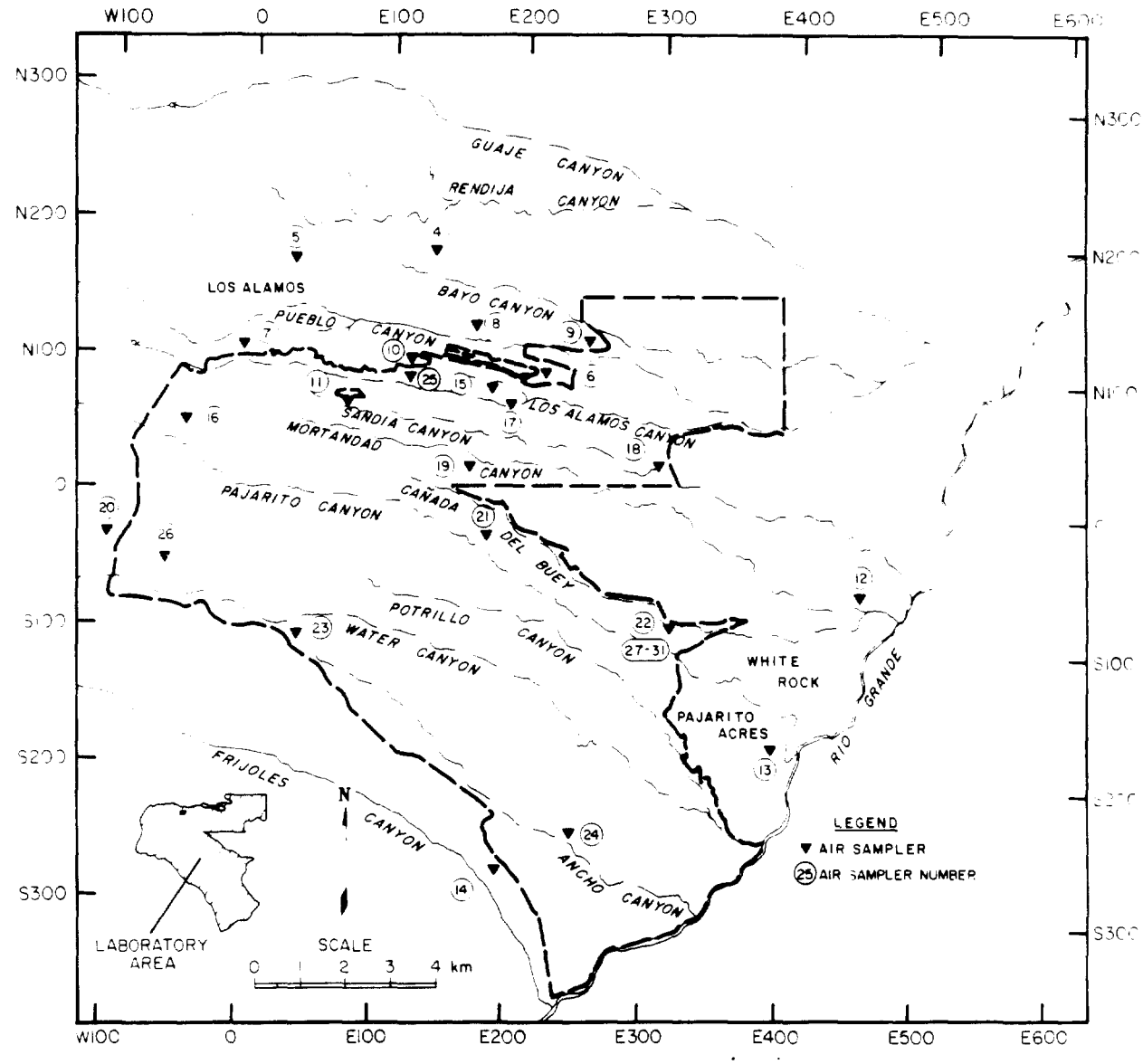

Fig. 8. Air sampler locations on or near the Laboratory site.

Most of the debris from these experiments is deposited on the ground in the vicinity of the firing sites. Limited experimental data indicate that about 10% of the depleted uranium becomes airborne. Dispersion calculations indicate that resulting airborne concentrations are in the same range as attributable to the natural abundance of uranium resuspended in dust particles originating from the earth's crust. This is confirmed by monitoring of airborne uranium concentrations (see below).

3. Gross Beta Radioactivity. Gross beta analyses help in evaluating general radiological air quality. Figure 12 shows gross beta concentrations at a regional sampling location (Espanola), about 30 km (20 mi) from the Laboratory, and at an on-site sampling location (TA-59).

4. Tritium. In 1987, the regional mean (4.1 x 10^{-12} μCi/mL) and the perimeter annual mean (11.0 x 10^{-12} μCi/mL) were slightly but statistically

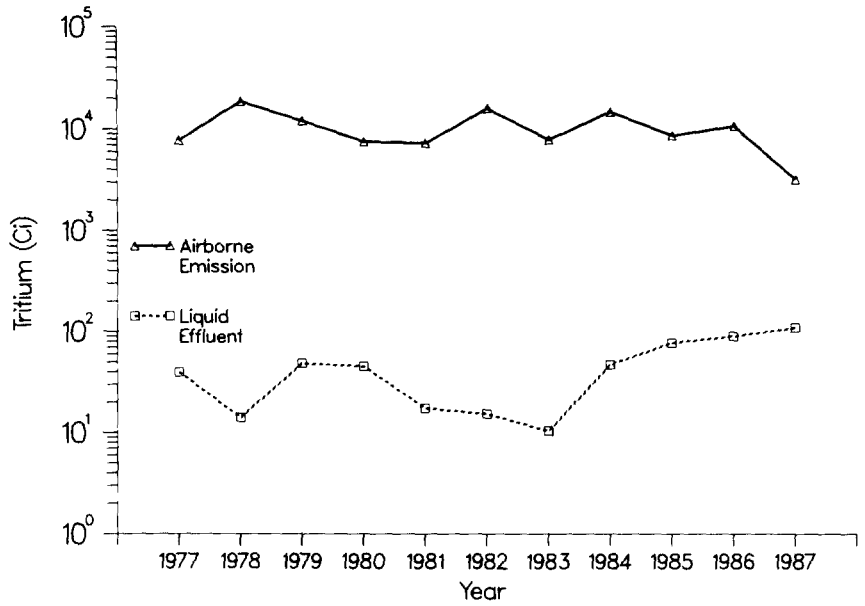

Fig. 9. Summary of tritium releases (airborne emissions and liquid effluents).

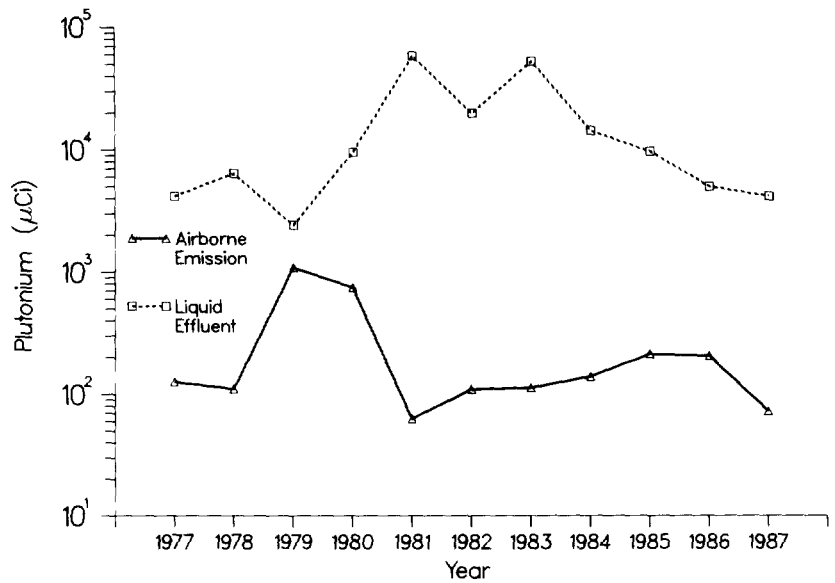

Fig. 10. Summary of plutonium releases (airborne emissions and liquid effluents).

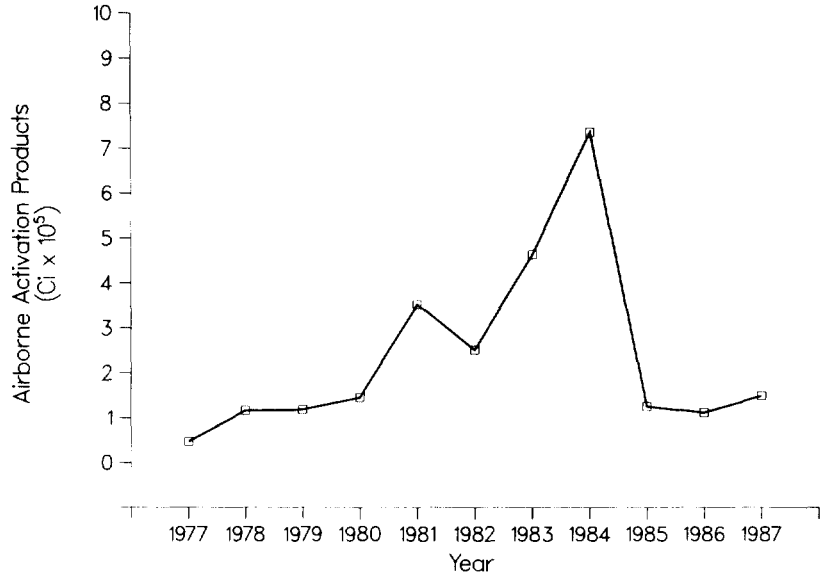

Fig. 11. Airborne activation product emissions (principally ^{11}C, ^{10}C, ^{13}N, ^{16}N, ^{14}O, ^{15}O, ^{41}Ar) from the Los Alamos Meson Physics Facility (TA-53).

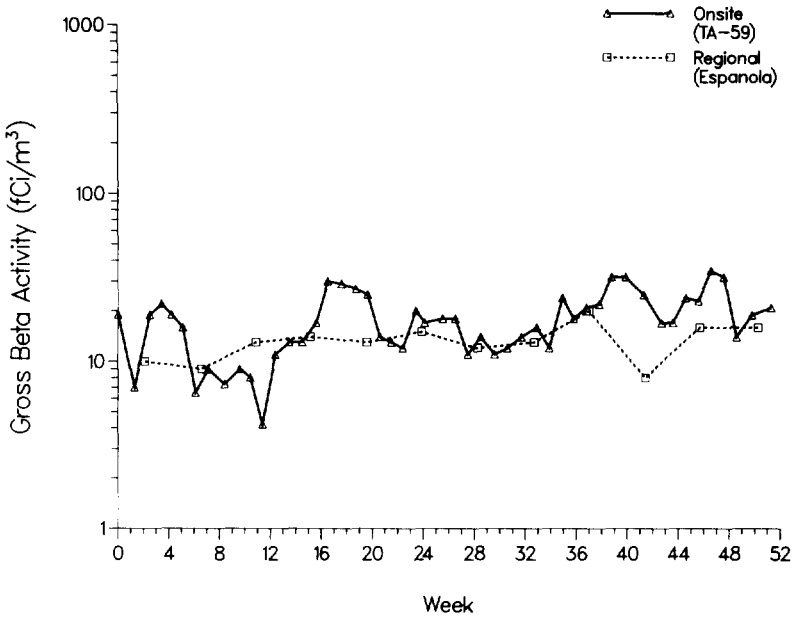

Fig. 12. Atmospheric gross beta activity at a regional (background) station and an on-site station during 1987.

significantly lower than the on-site annual mean (21.7 x 10^{-12} μCi/mL) (Table G-7). This reflects the slight impact of Laboratory operations. The TA-21 (Station 15) and TA-54 (Station 22) annual means of 51.8 x 10^{-12} and 32.3 x 10^{-12} μCi/mL, respectively, were the two highest means measured in 1987. Both of these stations are located within the Laboratory boundary near areas where tritium is disposed of or used in operations. These tritium concentrations are <0.1% of the concentration guide for tritium in air based on DOE's RPS for Controlled Areas (Appendix A).

5. Plutonium and Americium. Of the 101 air sample analyses performed in 1987 for ^{238}Pu, only three were above the minimum detectable limit of 2 x 10^{-18} μCi/mL. The highest concentration occurred at TA-54 (6.3 ± 1.4 x 10^{-18} μCi/mL) and represents <0.1% of the DOE's Derived Concentration Guide for ^{238}Pu in off-site areas, 2 x 10^{-12} μCi/mL (Appendix A). The results of the ^{238}Pu analyses are not tabulated in this report because of the large number of results below the minimum detectable activity.

The 1987 annual means for ^{239,240}Pu concentrations in air for the regional (0.7 x 10^{-18} μCi/mL), perimeter (0.9 x 10^{-18} μCi/mL), and on-site (1.8 x 10^{-18} μCi/mL) stations were all <0.1% of concentration guides.

Measured concentrations of ^{241}Am were also <0.1% of the concentration guides for Controlled and Uncontrolled Areas (Appendix A).

The detailed results are in Tables G-8 and G-9.

6. 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, vehicles or construction activity). As a result, uranium concentrations in air are heavily dependent on the immediate environment of the air sampling station. Those stations with relatively higher annual averages or maximums are in dusty areas, where a higher filter dust loading accounts for collection of more natural uranium from resuspended soil particles.

The 1987 means were: regional, 74 pg/m^3; perimeter, 33 pg/m^3; and on-site, 31 pg/m^3 (Table G-10). All measured annual means were less than 0.1% of the concentration guides for uranium in off-site and on-site areas (Appendix A). No effects attributable to Laboratory operations were observed.

B. Nonradioactive Chemicals in Ambient Air

1. Air Quality

a. Bandelier National Atmospheric Deposition Program Station. The Laboratory operates a wet deposition station located at the Bandelier National Monument. The station is part of the National Atmospheric Deposition Program Network. The sampling results are presented in Section IX.

b. Particulate Air Quality Measurements. Measurements of total suspended particulates (TSP) in Los Alamos and White Rock and applicable state and federal standards are reported in Table 8. The measurements are made once every 6 days at a site on West Road in Los Alamos and at the sewage treatment plant in White Rock by the NMEID. The 24-hour average standards are not to be exceeded more than once per year. There is both a primary and a secondary standard for TSP. The primary standard is to protect human health and the secondary standard is to protect general welfare, such as the prevention of soiling and material damage. The state 24-hour standard is as stringent as the federal secondary standard.

The state and federal ambient air quality standards were met in both Los Alamos and White Rock. The seasonally averaged TSP concentrations are shown in Table 9.

2. Beryllium Operations. Beryllium machining operations are located in shop 4 at TA-3-39, in shop 13 at TA-3-102, and the beryllium shop at TA-35-213. Beryllium machining takes place intermittently, a few days per year. A new beryllium processing facility located at TA-3-141 began operation in 1987. Exhaust air from each of these operations passes through air pollution control equipment before exiting from a stack. A baghouse type filter is used to control emissions from shop 4. The other operations use HEPA filters to control emissions. The air pollution control systems have >99.9% particulate removal efficiencies.

3. Steam Plants and Power Plant. Fuel consumption and emissions estimates for the three steam plants and the TA-3 power plant are reported in Table G-12. The NO_x emissions from the TA-3 power plant

Table 8. Particulate Air Quality ($\mu g/m^3$)

Federal and State Ambient Air Quality Standards		Measurements	
Type	Concentration	Los Alamos	White Rock
24-hour average[a]		70.2[b] (150.8)[c]	46.2[b] (53.3)[c]
State[c]	150		
Federal			
Primary	260		
Secondary	150		
7-day average[d]	110		
30-day average[d]	90		
Annual Geometric Mean		23.8	29.7
Primary	75		
Secondary	60		

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[a]Not to be exceeded more than once per year.
[b]Second highest
[c]Highest.
[d]New Mexico state standard only.

Table 9. Particulate Air Quality, Seasonal Averages ($\mu g/m^3$)

	Winter	Spring	Summer	Fall
Los Alamos	22.5	26.4	24.0	17.8
White Rock	19.6	34.7	29.0	45.9

were estimated based upon boiler exhaust gas measurements. Exhaust gas measurements indicated that SO_x levels exhaust gases were below minimum detectable levels. Emission factors from EPA were used in making the other emission estimates (EPA 1984). The change in emissions from 1986 to 1987 reflects the change in fuel consumption. The Western Area steam plant, used as a standby plant, was operated only one month during 1987.

4. Motor Vehicle Emissions. Estimates of air pollutant emissions associated with the operation of the motor vehicle fleet are reported in Table 10. Emissions increased due to increases in mileage and fuel use. Direct emissions from the vehicles as well as emissions caused by evaporative losses from fuel storage tanks were estimated. Hydrocarbons, carbon monoxide, nitrogen oxides, sulfur oxides, and particulate emissions were estimated based upon motor

Table 10. Estimate of Air Pollutant Emissions Associated With the Operation of the Vehicle Fleet (metric tons)

	1986	1987	Incremental % Change
Fuel Storage Evaporative Losses	4.8	6.7	39.8
Hydrocarbons	10.4	12.4	18.9
Carbon Monoxide	120.2	133.6	11.2
Nitrogen Oxides	11.9	13.3	11.4
Sulfur Oxides	1.4	1.8	30.6
Particulates			
Exhaust	0.6	0.8	32.7
Tire Wear	1.3	1.7	30.1

Table 11. Asphalt Plant Particulate Emissions

Year	Production (tons/yer)	Emissions (lb/year)	Incremental % Change from 1986
1986	6 980	232	---
1987	8 083	269	15.8

vehicle class, age, and the vehicle miles traveled (EPA 1981, EPA 1984). Fuel storage evaporative losses were estimated based upon the fuel usage.

5. Asphalt Plant. Annual production figures and estimates of particulate emissions from the asphalt concrete plant are found in Table 11. The particulate emissions from the plant are low, but have increased from 1986 to 1987 because of an increase in production. There has been a substantial decrease in production since 1985 because of the purchase of the asphalt from outside vendors. A multicyclone and a wet scrubber are used to clean the exhaust gas stream before it is released into the atmosphere. The particulate emission estimate was based upon stack testing data (Kramer 1977) and production data.

6. Burning and Detonation of Explosives. During 1987, a total of 18 400 kg (20 tons) of high-explosive wastes were disposed of by open burning at the TA-16 burn ground. Estimates of emissions resulting from this burning are reported in Table 12. The emissions were 7.7% lower than those for 1986. These estimates were made by using data from experimental work carried out by Mason and Hanger - Silas Co., Inc. (MHSM 1976).

Dynamic experiments employing conventional explosives are routinely conducted in certain test areas at the Laboratory. In some experiments these explosives contain toxic metals including uranium, beryllium, and lead. Through November 1987, uranium emissions had decreased 51.3%, lead emissions

Table 12. Estimated Air Pollutant Emissions from the Open Burning of Waste Explosives (kg)

Pollutant	1986	1987
Oxides of Nitrogen	602.1	555.7
Particulates	358.9	331.2
Carbon Monoxide	155.5	143.5
Hydrocarbons	2.0	1.8

decreased 26.9%, and beryllium emissions decreased 4.8% from 1986 levels.

Estimates of average concentrations of these toxic metals downwind from the detonations are reported in Table G-6. Applicable standards are also presented in this table. Estimated concentrations were <0.01% of applicable standards. These estimates are based upon information concerning the proportion of material aerosolized provided from limited field experiments involving aircraft sampling and the amounts of toxic metals used in the experiments through November 1987.

7. Lead Pouring Facility. Pan Am World Services operates a lead pouring facility for producing lead castings that is located at TA-3-38. Approximately 11 700 kg (25 800 lb) of lead were estimated to have been poured during 1987. The estimated 1987 annual lead emissions from this facility were 5.1 kg (11.2 lb); maximum quarterly emissions were 1.8 kg (3.9 lb). The emission estimates were based upon the amounts of lead poured and an EPA emission factor for lead casting operations (EPA 1984).

Both federal and state ambient air quality standards for lead are 1.5 g/m^3 averaged over a calendar quarter. Air dispersion procedures recommended by the EPA (EPA 1977, 1986) were used to estimate the maximum quarterly average lead concentrations caused by emissions from the lead pouring facility. These procedures provide conservative concentration estimates. The maximum quarterly concentration for 1987 was estimated to be 0.11 $\mu g/m^3$, 7% of the standard.

VI. WATER, SOILS, AND SEDIMENTS MONITORING

Surface and ground waters, soils, and sediments were sampled and analyzed to monitor dispersion of radionuclides and chemicals from Laboratory operations. Radionuclide and chemical concentrations of water from areas where there has been no direct release of treated effluents evidenced no observable effects due to Laboratory operations. The chemical quality of surface waters from areas with no effluent release varied with seasonal fluctuations. Water in on-site areas where treated effluent has been released contained radionuclides below DOE's concentration guides. The quality of water in these release areas reflected some impact of Laboratory operations, but these waters are confined within the Laboratory and are not a source of municipal, industrial, or agricultural water supply.

Most regional and perimeter soil and sediment stations contained radioactivity at or near background levels. Concentrations that did exceed background were low and not considered significant. Sediments from areas where treated discharges have been released contained radionuclides in excess of background. Concentrations of plutonium in sediments from regional reservoirs on the Rio Chama and Rio Grande reflected worldwide fallout.

A. Effluent Quality

In the past, treated liquid 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 (TA-53) (Tables 3, G-12, G-13, and Figs. 9, 10, and 13). In 1987, there were no releases from TA-21.

Radionuclide concentrations in treated effluents from the larger radioactive liquid waste-treatment plant (TA-50) were well below DOE's concentration guides for on-site areas (Table G-12). The total activity released in 1987 (ca. 110 Ci) was 120% of that

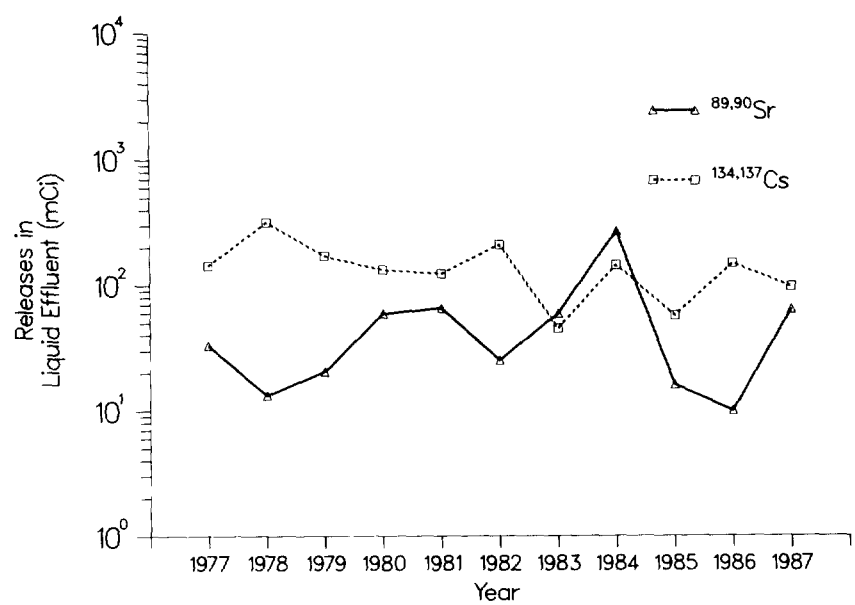

Fig. 13. Summary of strontium and cesium liquid effluent releases.

released in 1986 (ca. 91 Ci) (Table 3). Release of ^{89}Sr increased six-fold because of additional processing of LAMPF isotopes at the TA-48 hot cells. 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 before the plant began operation in 1963.

Concentrations found in the TA-53 lagoon effluent in 1987 were higher than in 1986 for some radionuclides and lower for others (Table G-13). The source of the radioactivity was activated nuclides in water from the beam-stop cooling systems. The volume discharged from the lagoons decreased slightly in 1987. There was no discharge after April 8, 1987. All radionuclide concentrations were well below DOE's concentration guides for on-site areas (Table G-13). The discharge from the lagoons sinks into the alluvium of Los Alamos Canyon within the Laboratory's boundary.

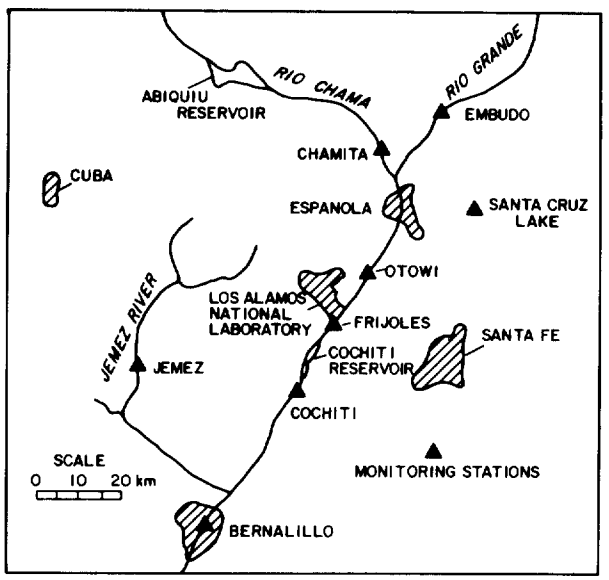

Fig. 14. Regional surface water, sediment, and soil sampling locations.

B. Radiochemical and Chemical Quality of Surface and Ground Waters

1. Background. Surface and ground waters from regional, perimeter, and on-site stations are monitored to provide routine surveillance of Laboratory operations (Figs. 14 and 15, Table G-14). If a sample from a particular station was not taken this year, it was because the station was dry or a water pump was broken. Concentrations of radionuclides in water samples are compared with guides derived from DOE's Radiation Protection Standard (RPS) (Appendix A). Concentration guides do not account for concentrating mechanisms that may exist in environmental media. Consequently, other media such as sediments, soils, and foodstuffs are also monitored (see subsequent sections).

Routine chemical analyses of water samples have been carried out for many constituents over a number of years. Although surface and shallow ground waters are not a source of municipal or industrial water supply, results of these analyses are compared with EPA drinking water standards as these are the most restrictive related to water use.

2. Regional Stations. Regional surface water samples were collected within 75 km (47 mi) of the Laboratory from 6 stations on the Rio Grande, Rio Chama, and Jemez River (Fig. 14). The six sampling stations were located at U.S. Geological Survey Gaging Stations. These waters provided baseline data for radiochemical and chemical analyses in areas beyond the Laboratory boundary. Stations on the Rio Grande were: Embudo, Otowi, Cochiti, and Bernalillo. 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 period of record (1895-1905, 1909-1986) has ranged from a minimum of 1.7 m^3/sec (60 ft^3/sec) in 1902 to 691 m^3/sec (24 400 ft^3/sec) in 1920. The discharge for water year 1986 (October 1985 to September 1986) ranged from 12 m^3/sec (408 ft^3/sec) in September to 220 m^3/sec (7900 ft^3/sec) in June (USGS 1987).

The Rio Chama is tributary to the Rio Grande upstream from Los Alamos (Fig. 14). At Chamita on the Rio Chama, the drainage area above the station is 8143 km^2 (3143 mi^2) in northern New Mexico 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 gage is governed by release from several reservoirs. Discharge at Chamita during water year 1986 ranged from 1.8 m^3/sec (65 ft^3/sec) in December to 98 m^3/sec (3460 ft^3/sec) in May.

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

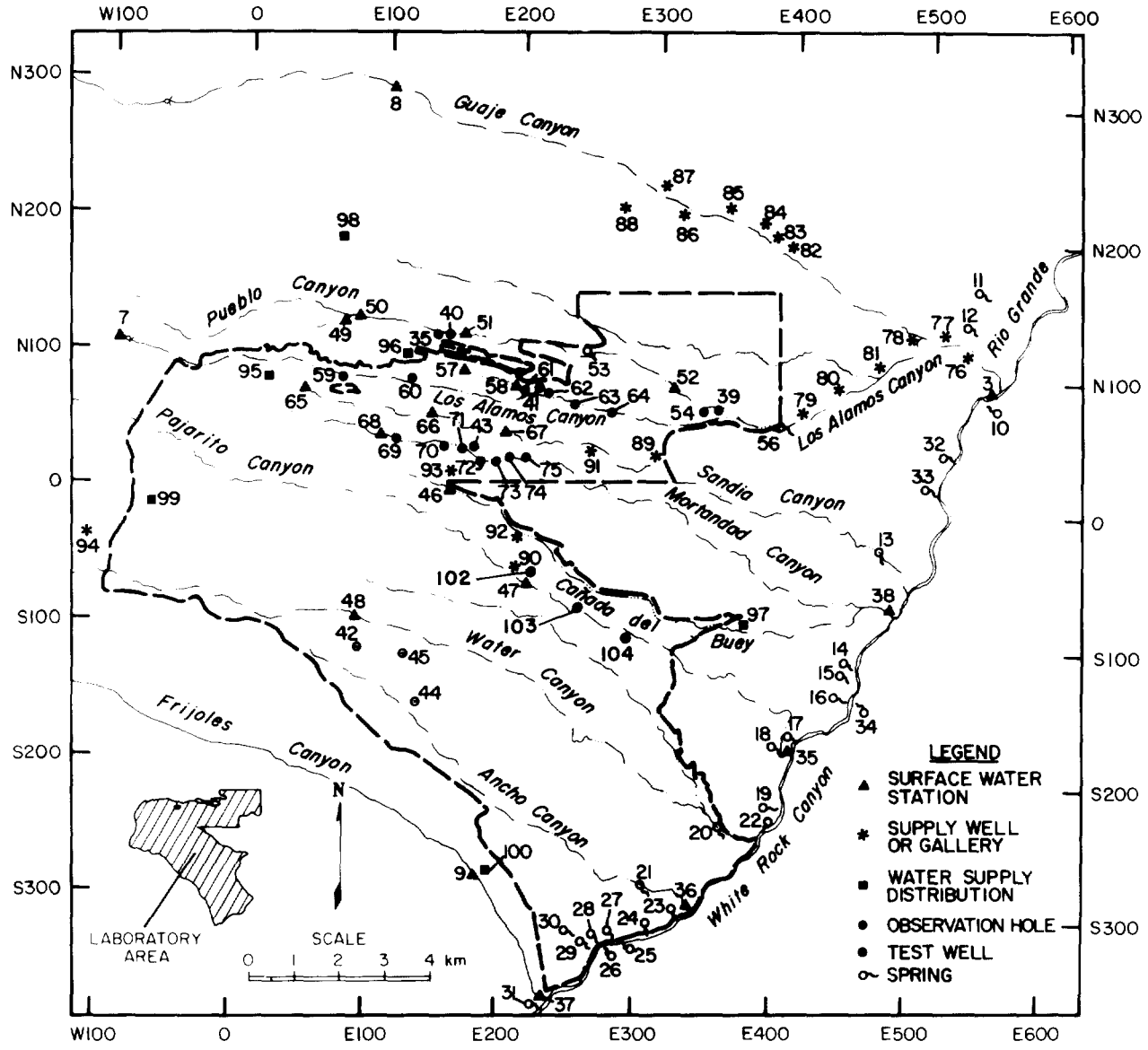

Fig. 15. Surface and ground water sampling locations on and near the Laboratory site.

(TA-57) is located within this drainage. The drainage area is small, about 1220 km^2 (471 mi^2). During water year 1986, discharge ranged from 0.34 m^3/sec (12 ft^3/sec) in February to 54 m^3/sec (1900 ft^3/sec) in July. The river is tributary to the Rio Grande downstream from Los Alamos.

Surface waters from the Rio Grande, Rio Chama, and Jemez River are used for irrigation of crops in the valleys both upstream and downstream from Los Alamos. Water from these rivers is part of recreational areas on state and federal lands.

a. Radiochemical Analyses. Surface water samples from regional stations were collected in February and September 1987. Cesium, plutonium, tritium, and total uranium activity levels in these waters were low (Tables 13 and G-15). Samples collected downgradient from the Laboratory showed no

Table 13. Maximum Concentrations of Radioactivity in Surface and Ground Waters from Off-site and On-site Stations

	Number of Stations[a]	^{137}Cs (10^{-9} µCi/mL)	^{238}Pu (10^{-9} µCi/mL)	$^{239,240}Pu$ (10^{-9} µCi/mL)	^{3}H (10^{-6} µCi/mL)	Total U (µg/L)
Analytical Limits of Detection		40	0.009	0.03	0.7	1.0
Off-site Stations (Uncontrolled Areas)						
Derived Concentration Guide (DCG) for Uncontrolled Areas[b]		3000	400	300	2000	800
Regional	6	1200 (414)	0.011 (0.012)	0.025 (0.014)	0.2 (0.3)	3.0 (1.0)
Perimeter						
Adjacent	6	98 (62)	0.036 (0.016)	0.037 (0.041)	0.4 (0.3)	12.5 (1.3)
White Rock	20	149 (71)	0.027 (0.015)	0.009 (0.006)	13 (1.0)	22 (2.4)
Off-site Station Group Summary:						
Maximum Concentration		1200	0.036	0.037	13	22
Maximum Concentration as % DCG for Uncontrolled Areas		40	<1	<1	<1	3
On-site Stations (Controlled Areas)						
Concentration Guide (CG) for Controlled Areas[b]		400 000	100 000	100 000	100 000	60 000
Noneffluent Areas						
Groundwater (Main Aquifer)	7	136 (63)	0.035 (0.037)	0.022 (0.016)	0.5 (0.3)	0.0 (0.1)
Surface Water	3	44 (55)	0.010 (0.023)	0.006 (0.018)	0.6 (0.3)	7.0 (1.0)
Pajarito Canyon	3	111 (68)	0.035 (0.016)	0.015(0.015)	0.7 (0.3)	1.0 (1.0)

Table 13 (cont)

	Number of Stations[a]	^{137}Cs (10^{-9} µCi/mL)	^{238}Pu (10^{-9} µCi/mL)	$^{239,240}Pu$ (10^{-9} µCi/mL)	^{3}H (10^{-6} µCi/mL)	Total U (µg/L)
Effluent Areas						
Acid-Pueblo Canyon	8	167 (71)	0.010 (0.015)	2.38 (0.126)	1.4 (0.4)	
DP-Los Alamos Canyon	8	188 (86)	0.028 (0.015)	0.124 (0.024)	19 (2.0)	1.0 (1.0)
Sandia Canyon	3	135 (58)	0.002 (0.004)	0.012 (0.032)	0.8 (0.3)	1.8 (0.1)
Mortandad Canyon	7	213 (84)	30.0 (3.00)	90.0 (5.00)	12000 (1000)	5.7 (0.6)
On-site Group Summary:						
Maximum Concentration		213	30.0	90.0	12000	5.7
Maximum Concentration as % CG for Controlled Areas		<1	<1	<1	1	<1

effect from the Laboratory's operation. Results from 1987 exhibited no significant differences from 1986. Maximum concentrations of radioactivity in regional surface water samples were well below DOE's concentration guides for off-site areas.

b. Chemical Analyses. Surface water samples from regional stations were collected in February 1987. Maximum concentrations in regional water samples were well below drinking water standards (Tables 14 and G-16). There were some variations from previous years' results. These fluctuations result from chemical changes that occur with variations in discharges at the sampling stations. This is normal and no inference can be made that the water quality at these stations is deteriorating.

3. Perimeter Stations. Perimeter stations within 4 km (2.5 mi) of Los Alamos included surface water stations at Los Alamos Reservoir, Guaje Canyon, Frijoles Canyon, and three springs (La Mesita, Indian, and Sacred springs). Other perimeter stations were in White Rock Canyon along the Rio Grande just east of the Laboratory. Included in this group were stations at 23 springs, 3 streams, and a sanitary effluent release (Fig. 15 and Table G-14).

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 acre-ft) and a drainage area of 16.6 km^2 (6.4 mi^2) above the intake. The reservoir is used for storage and recreation. Water flows by gravity through about 10.2 km (6.4 mi) of water lines for irrigation of lawns and shrubs at the Laboratory's Health Research Laboratory (TA-43), the Los Alamos High School, and University of New Mexico's Los Alamos Branch.

The station in Guaje Canyon is below Guaje Reservoir. Guaje Reservoir in upper Guaje Canyon has a capacity of 0.9 x 10^3 m^3 (0.7 acre-ft) and a drainage area above the intake of about 14.5 km^2 (5.6 mi^2). The reservoir is used for diversion rather than storage as flow in the canyon is maintained by perennial springs. Water flows by gravity through 9.0 km (5.6 mi) of water lines for irrigation of lawns and shrubs at Los Alamos Middle School and Guaje Pines Cemetery. The stream and reservoir are also used for recreation.

The water lines from Guaje and Los Alamos reservoirs are not a part of the municipal or industrial water supply at Los Alamos. They are owned by DOE and operated by Pan Am World Services. Diversion for irrigation is usually from May through October.

Surface flow in Frijoles Canyon was sampled at Bandelier National Monument Headquarters. Flow in the canyon is from spring discharge in the upper reach of the canyon. Flow decreases as the stream crosses Pajarito Plateau because of seepage and evapotranspiration losses. The drainage area above the monument headquarters is about 45 km^2 (17 mi^2) (Purtymun 1980A).

La Mesita Spring is east of the Rio Grande, whereas Indian and Sacred springs are west of the river in lower Los Alamos Canyon. These springs discharge from faults in the siltstones and sandstones of the Tesuque Formation and from small seep areas. Total discharge at each spring is probably less than 1 L/sec (0.3 gal/sec).

Perimeter stations in White Rock Canyon are composed of four groups of springs. The springs discharge from the main aquifer. Three groups (Group I, II, and III) have similar, aquifer-related, chemical quality. Water from these springs is from the main aquifer beneath the Pajarito Plateau (Purtymun 1980B). Chemical quality of Spring 3B (Group IV) reflects local conditions in the aquifer discharging through a fault in volcanics.

Part of the heavy run-off in the Rio Grande in 1987 was stored in Cochiti Reservoir. In October, when the springs were sampled, seven springs were below the reservoir level and could not be sampled.

Three streams that flow to the Rio Grande were also sampled. Streams in Pajarito and Ancho canyons are fed from Group I springs. The stream in Frijoles Canyon at the Rio Grande is fed by a spring on the flanks of the mountains west of Pajarito Plateau and flows through Bandelier National Monument to the Rio Grande.

Treated sanitary effluent from the community of White Rock was also sampled in Mortandad Canyon at its confluence with the Rio Grande.

Detailed results of radiochemical and chemical analyses of samples collected from the perimeter stations are shown in Tables G-17 through G-22.

a. Radiochemical Analyses. Cesium, plutonium, tritium, and total uranium activity for samples collected at perimeter stations were low and well below DOE's concentration guides for off-site areas (Table 13).

Table 14. Maximum Chemical Concentrations in Surface and Ground Waters

	Number of Stations	mg/L				
		Cl	F	NO_3 (as N)	TDS	pH
EPA Drinking Water Standard[a]	--	250	2.0	10	500	6.5-8.5
Off-site Stations						
Regional Stations	6	47	0.8	<1	174	8.3
Perimeter Stations						
Adjacent	6	32	0.5	2	208	8.1
White Rock Canyon	20	43	1.5	12	467	8.6
Summary: Off-site Stations						
Maximum Concentration		47	1.5	12	208	8.6
Maximum Concentration as Per Cent of Standard		19	75	120	42	101
On-site Stations						
Noneffluent Areas						
Ground Water	7	32	0.5	7	253	8.4
Surface Water	3	36	9.3	<1	188	7.8
Pajarito Canyon	3	73	0.6	0.4	462	7.5
Effluent Release Areas						
Acid-Pueblo Canyon	8	86	0.9	6.0	343	8.0
DP-Los Alamos Canyon	8	101	2.5	1.4	306	8.1
Sandia Canyon	3	159	1.0	1.8	1129	7.9
Mortandad Canyon	7	39	3.9	118	1011	9.9
Summary: On-site Stations						
Maximum Concentration		159	9.3	118	1129	9.9
Maximum Concentration as Per Cent of Standard		80	465	1180	225	116

[a]EPA (1976, 1979B).

b. Chemical Analyses. Maximum chemical concentrations in samples from the perimeter stations were within drinking water standards except for nitrate (as N) in waters (sanitary effluent) from Mortandad Canyon at the Rio Grande (Tables 15 and G-20). The effluent also exceeded secondary standards for copper, iron, and pH at the Rio Grande (Table G-21). Table G-22 presents miscellaneous data for chemical quality of water in White Rock Canyon. Concentrations in water samples from the 16 springs and 3 streams in White Rock Canyon were also within drinking water standards.

4. On-site Stations. On-site sampling stations are grouped as those that are not located in effluent release areas and those that are located in areas receiving or that have received treated industrial effluents (Fig. 15, Table G-14).

a. Noneffluent Release Areas. On-site, noneffluent sampling stations consist of seven deep test wells, three surface water sources, and three new, shallow observation wells. The deep test wells are completed into the main aquifer.

Test Wells 1 and 2 are in the lower and middle reaches of Pueblo Canyon. Depths to the top of the main aquifer are 181 to 231 m (594 and 758 ft), respectively. Test Well 3 is in the midreach of Los Alamos Canyon with a depth of 228 m (748 ft) to the top of the main aquifer. These wells are in canyons that have received (Pueblo Canyon) or are now receiving (Los Alamos Canyon) industrial effluents. Test Wells DT-5A, DT-9, and DT-10 are at the southern edge of the laboratory. Depths to the top of the main aquifer are 359, 306, and 332 m (1180, 1006, and 1090 ft), respectively. Test Well 8 is in the midreach of Mortandad Canyon, an area that receives industrial effluents. The top of the aquifer here lies at about 295 m (968 ft) below the surface. These test wells are constructed to seal out all water above the main aquifer. The wells monitor any possible effects that the Laboratory's operation may have on water quality in the main aquifer.

Surface water samples are collected in Canada del Buey and Pajarito and Water canyons downstream from technical areas to monitor the quality of run-off from these sites.

Three shallow observation wells were drilled in 1985 and cased through the alluvium (thickness about 4 m [12 ft]) in Pajarito Canyon (Fig. 15 and Table G-14). Water in the alluvium is perched on the underlying tuff and is recharged through storm run-off. The observation wells were constructed to determine if technical areas in the canyon or adjacent mesas were affecting the quality of shallow ground water (Tables 13, 14, and G-23).

Radiochemical concentrations from surface and ground water sources showed no effects of laboratory operations (Tables 13, G-23, and G-24). Concentrations of tritium, cesium, and plutonium were at or below limits of detection. Concentrations of all radionuclides were well below DOE's concentration guides for on-site areas.

Chemical quality of ground water from the test wells into the main aquifer reflected local conditions of the aquifer around the well. Quality of surface water and of observation wells in Pajarito Canyon varied slightly. The effect, if any, was small, probably as the result of seasonal fluctuations. Maximum concentrations of five chemical constituents in the on-site surface and ground water samples were within drinking water standards, except for fluoride (9.3 mg/L) in water from Canada del Buey (Tables 14, G-25, and G-26).

b. On-site Effluent Release Areas. On-site effluent release areas are canyons that receive or have received treated industrial or sanitary effluents. These include DP-Los Alamos, Sandia, and Mortandad canyons. Also included is Acid-Pueblo Canyon, which is a former release area for industrial effluents. Acid-Pueblo Canyon received untreated and treated industrial effluents, which contained residual radionuclides from 1944 to 1964 (ESG 1981). The canyon also receives treated sanitary effluents from the Los Alamos County treatment plants in the upper and middle reaches of Pueblo Canyon. Sanitary effluents form some perennial flow in the canyon, but do not reach State Road 4.

Water occurs seasonally in the alluvium dependent on the volume of surface flow from sanitary effluents and storm run-off. Hamilton Bend Springs discharges from alluvium in the lower reach of Pueblo Canyon and is dry part of the year. The primary sampling stations are surface water stations at Acid Weir, Pueblo 1, Pueblo 2, and Pueblo 3 (Table G-14). Other sampling stations are Test Well T-2A [drilled to a depth of 40.5 m (133 ft)], which penetrates the alluvium and Bandelier Tuff and is completed into the Puye conglomerate. Aquifer tests indicated the perched aquifer is of limited extent. Water level measurements over a period of time indicate that the perched

Table 15. Average Plutonium Concentrations in Snowmelt Run-off in Canyons Draining the Laboratory

Location	Number of Analyses	Solution		Suspended Sediments	
		^{238}Pu (10^{-9} µCi/mL)	$^{239,240}Pu$ (10^{-9} µCi/mL)	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)
Water Canyon at SR-4	8	0.004 (0.011)	0.005 (0.017)	0.056 (0.118)	0.115 (0.268)
Pajarito Canyon at SR-4	14	−0.002 (0.016)	0.013 (0.037)	0.068 (0.138)	0.128 (0.242)
Los Alamos Canyon at SR-4	14	0.006 (0.026)	0.015 (0.015)	0.093 (0.093)	1.96 (1.01)
Pueblo Canyon at SR-4	7	−0.002 (0.016)	0.007 (0.010)	0.016 (0.016)	2.86 (2.38)
Los Alamos Canyon at Otowi	11	0.004 (0.022)	0.007 (0.009)	0.216 (0.561)	0.827 (0.829)
Rio Grande at Otowi	1	−0.016 (0.011)	−0.024 (0.014)	0.001 (0.004)	0.001 (0.002)
Background[a]		0.030	0.026	0.135	0.830

[a] $\bar{x}$ + 2s from Table G-35.

aquifer is hydrologically connected to the stream in Pueblo Canyon.

Perched water in the basaltic rocks is sampled from Test Well 1A, in lower Pueblo Canyon, and Basalt Springs, further eastward in lower Los Alamos Canyon. Recharge to the perched aquifer in the basalt occurs near Hamilton Bend Springs. Travel time from the recharge area near Hamilton Bend Spring to Test Well 1A is estimated to be 1 to 2 months with another 2 to 3 months to reach Basalt Springs.

DP-Los Alamos Canyon has received treated industrial effluents, which contain some radionuclides and some sanitary effluents from treatment plants at TA-21. Treated industrial effluents have been released into the canyon since 1952. During 1987, there were no liquid discharges from TA-21. In the upper reaches of Los Alamos Canyon (above Station LAO-1), there are occasional releases of cooling water from the research reactor at TA-2. Los Alamos Canyon also receives discharge from the lagoons at LAMPF (TA-53). On the flanks of the mountains, Los Alamos Reservoir impounds run-off from snowmelt and rainfall. Stream flow from this impoundment into the canyon is intermittent, dependent on precipitation to cause run-off to reach the laboratory boundary at State Road 4.

Infiltration of treated effluents and natural run-off maintains a shallow body of water in the alluvium of Los Alamos Canyon. Water levels are highest in late spring from snowmelt run-off and late summer from thundershowers. Water levels decline during the winter and early summer as storm run-off is at a minimum. Sampling stations consist of two surface water stations in DP Canyon and six observation wells completed into alluvium (about 66 m [20 ft] thick) in Los Alamos Canyon (Table G-14).

Sandia Canyon has a small drainage area that heads on Pajarito Plateau in TA-3. The canyon receives cooling tower blowdown from the TA-3 power plant and treated sanitary effluents from TA-3. Treated effluents from a sanitary treatment plant form a perennial stream in a short reach of the upper canyon. Only during heavy summer thundershowers in the drainage area does stream flow reach the Laboratory boundary at State Road 4. Two monitoring wells in the lower canyon just west of State Road 4 indicated no perched water in the alluvium in this area. There are three surface water sampling stations in the reach of the canyon that contains perennial flow (Table G-14).

Mortandad Canyon has a small drainage area that heads in TA-3. Industrial liquid wastes containing radionuclides are collected and processed at the Industrial Waste Treatment Plant at TA-50. After treatment that removes most of the radioactivity, the effluents are released into Mortandad Canyon. 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 (Purtymun 1974C, 1983). The top of the main aquifer is about 290 m (950 ft) below the perched aquifer. Hydrologic studies in the canyon began in 1960. Since that time, there has been no surface flow beyond the Laboratory's boundary because the small drainage area in the upper part of the canyon results in limited run-off and a thick section of unsaturated alluvium in the lower canyon allows rapid infiltration and storage of run-off when it does occur. Monitoring stations in the canyon are one surface water station (Gaging Station 1, GS-1) and six observation wells completed into the shallow alluvial aquifer. At times, wells in the lower reach of the canyon are dry.

Acid-Pueblo (Table G-27), DP-Los Alamos (Table G-28), Mortandad (Table G-29), and Sandia (Table G-30) canyons all contained surface and shallow ground waters with measurable amounts of radioactivity. Radioactivity is well below DOE's concentration guides for on-site areas (Table 13). Radionuclide concentrations from treated effluents decreased downgradient in the canyon due to dilution and adsorption of radionuclides on alluvial sediments. Surface and shallow ground waters in these canyons are not a source of municipal, industrial, or agricultural supply. Only during periods of heavy precipitation or snowmelt would waters from Acid-Pueblo, DP-Los Alamos, or Sandia canyons extend beyond Laboratory boundaries and reach the Rio Grande. In Mortandad Canyon there has been no surface run-off to the Laboratory's boundary since hydrologic studies were initiated in 1960. This was 3 years before the treatment plant at TA-50 began releasing treated effluents into the canyon (Purtymun 1983).

Relatively high concentrations of chlorides, nitrates, fluorides, and total dissolved solids have resulted from effluents released into some of the canyons (Tables G-31 through G-34). Relatively high fluoride and nitrate concentrations were found in waters from Mortandad Canyon, which receives the largest volume of industrial effluents (Purtymun 1977). Though the concentrations of some chemical constituents in the waters of these canyons were high

when compared with drinking water standards (Table 14), these on-site waters are not a source of municipal, industrial, or agricultural supply.

Maximum chemical concentrations occurred in water samples taken near treated effluent outfalls (Table G-31 through G-34). Chemical quality of the water improved downgradient from the outfalls. Surface flows in Acid-Pueblo and DP-Los Alamos canyons reach the Rio Grande only during spring snowmelt or heavy summer thunderstorms. There has been no surface run-off to Laboratory boundaries recorded in Mortandad Canyon since 1960, when observations began.

5. Transport of Radionuclides in Surface Run-Off. The major transport of radionuclides from canyons that have received treated, low-level radioactive effluents is by surface run-off. Radionuclides in the effluents may become adsorbed or attached to sediment particles in the stream channels. Concentrations of radioactivity in the alluvium is highest near the treated effluent outfall and decreases in concentration downgradient in the canyon as the sediments and radionuclides are transported and dispersed by other treated industrial effluents, sanitary effluents, and surface run-off.

Surface run-off occurs in two modes. Spring snowmelt run-off occurs over a long period of time (days) at a low discharge rate and sediment load. Summer run-off from thunderstorms occurs over a short period of time (hours) at a high discharge rate and sediment load. During 1987, no summer run-off samples were collected.

Spring snowmelt samples of run-off from 13 stations (Fig. 16) were analyzed for radionuclides in solution and suspended sediments. Radioactivity in solution is defined as the filtrate passing through a 0.45 μm pore-size filter, whereas radioactivity in suspended sediments is defined as a residue on the filter. For background samples, the solution was analyzed for ^{3}H, ^{137}Cs, total U, ^{238}Pu, $^{239,240}Pu$, and gross gamma, whereas suspended sediments were analyzed for ^{238}Pu and $^{239,240}Pu$. Only plutonium was analyzed in samples from the other stations.

Background values are presented in Table G-35. Plutonium levels at the six sampling stations were below background (Tables 15 and G-36). Suspended sediments collected in Los Alamos Canyon at SR-4 contained ^{238}Pu above background levels; $^{239,240}Pu$ in sediments from Los Alamos and Pueblo Canyon at SR-4 were above background. Los Alamos Canyon and Pueblo Canyon west of SR-4 have received treated effluents containing plutonium. The plutonium in the suspended sediments in these canyons are dispersed and diluted by storm run-off before reaching the Rio Grande. The plutonium in suspended sediments from Los Alamos Canyon was below background in the Rio Grande (Table 15).

In lower Mortandad Canyon just below Well MCO-7 (Fig. 15 and Table G-14), three sediment traps were constructed. The upper part of the canyon receives treated, low-level radioactive effluents from the treatment plant at TA-50. A run-off event into the upper sediment trap in June was sampled for radionuclides. Transuranics in solution and in suspended sediments was above background indicating run-off transport from the upper canyon (Table G-37).

C. Radioactivity in Soils and Sediments

1. Background Levels of Radioactivity in Soils and Sediments. Samples were routinely collected and analyzed for radionuclides from regional stations from 1974 through 1985 (Purtymun 1987A). They were used to establish background levels of ^{137}Cs, ^{238}Pu, $^{239,240}Pu$, ^{90}Sr, total U, ^{3}H, and gross gamma radioactivity in soils and sediments (Table 16). Average concentrations plus twice the standard deviation were used to establish the upper limits of the background concentrations. The number of analyses used to establish background levels ranged from 29 (^{90}Sr) to 76 (^{238}Pu, $^{239,240}Pu$) for soils and 36 (^{90}Sr) to 113 (^{238}Pu, $^{239,240}Pu$) for sediments. Samples were collected from 5 regional soil stations and 10 regional sediments stations. Background concentrations may be exceeded slightly by 1987 surveillance results due to changes in instrument background or a modification of analytical procedures. See Appendix B for description of methods for collection of soil and sediment samples.

2. Regional Soils and Sediments. Regional soil and sediment samples were collected in the same general locations as the regional water samples (Fig. 14). Additional regional sediment samples were collected along the Rio Grande from Otowi Bridge to Cochiti Reservoir. The locations are listed in Table G-38 and the detailed results of radiochemical analyses of the regional soils and sediments are in Table G-39.

In 1987, soil and sediment samples were collected from seven stations and analyzed for six types of radioactivity (Table 16). Radioactivity ranged within background as reported by Purtymun (1987A).

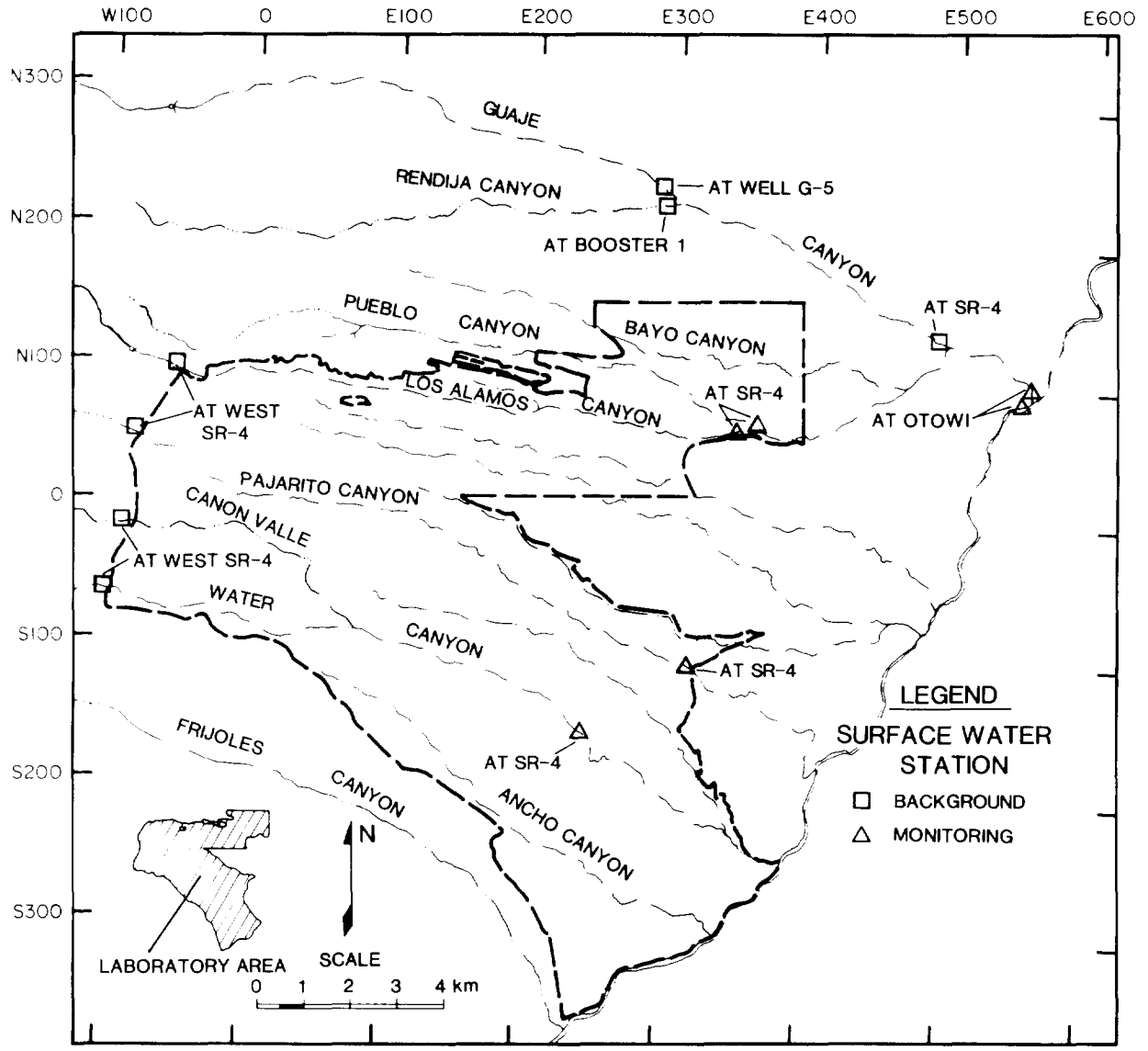

Fig. 16. Locations of surface run-off sampling stations at the Laboratory.

3. Perimeter Soil and Sediments. Six perimeter soil stations were sampled within 4 km (2.5 mi) of the Laboratory. Seventeen sediment stations near the Laboratory boundary and in intermittent streams that cross the Pajarito Plateau were also sampled (Figs. 17 and 18). The perimeter soil and sediment sampling stations are listed in Table G-38 and detailed analytical results are found in Table G-40.

Analyses of the perimeter soil samples indicated that background concentrations were slightly exceeded in 1987 for ^{238}Pu (one sample), ^{239,240}Pu (one sample), and ^{137}Cs (one sample). Uranium and gross gamma levels result from naturally occurring radiation in soil and sediments (Table 16).

Analyses of sediments from the 17 perimeter stations indicated that concentrations of most radionuclides were below background levels with the exception of total uranium, which exceeded background in one sample (Table 16).

Table 16. Maximum Concentrations of Radioactivity in Soils and Sediments from Regional, Perimeter, and On-site Stations

	Number of Stations	^{3}H (10^{-6} µCi/mL)	^{137}Cs (pCi/g)	Total U (µg/g)
Analytical Limits of Detection	--	0.7	0.1	0.03
Soil				
Background (1974-1986)[a]	--	7.2	1.09	3.4
Regional Stations	7	13	0.60	5.4
Perimeter Stations	6	2.8 (0)[c]	1.3 (1)	5.3 (5)
On-site Stations	10	10 (1)	0.79 (0)	4.6 (7)
Sediments				
Background (1974-1986)[a]	--	13	0.44	4.4
Regional Stations[b]	7	0.7	0.38	8.5
Perimeter Stations	17	0.5 (0)	0.39 (0)	3.2 (0)
On-site Station, Effluent Release Areas				
Acid-Pueblo Canyon	6	---	0.27 (0)	3.4 (0)
DP-Los Alamos Canyon	11	---	10.7 (6)	5.0 (1)
Mortandad Canyon	7	---	38 (3)	4.8 (1)

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[a] $\bar{x}$ + 2s of a number of background analyses for soils and bed sediments (Purtymun 1987).
[b] Regional background 1987.
[c] Number in parentheses indicates number of stations exceeding background concentrations.

Table 16 (cont)

	Number of Stations	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)	Gross Gamma (Counts/min/g)
Analytical Limits of Detection	--	0.003	0.002	0.1
Soil				
Background (1974-1986)[a]	--	0.005	0.025	6.6
Regional Stations[b]	7	0.002	0.016	6.4
Perimeter Stations	6	0.029 (1)	0.026 (1)	9.0 (4)
On-site Stations	10	0.005 (0)	0.038 (1)	7.5 (3)
Sediments				
Background (1974-1986)[a]	--	0.006	0.023	7.9
Regional Stations[b]	7	0.001	0.007	3.8
Perimeter Stations	17	0.002 (0)	0.006 (0)	2.5 (0)
On-site Station, Effluent Release Areas				
Acid-Pueblo Canyon	6	0.026 (1)	0.612 (3)	0.8 (0)
DP-Los Alamos Canyon	11	0.196 (8)	0.615 (10)	5.8 (0)
Mortandad Canyon	7	7.59 (2)	30.7 (2)	54 (2)

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[a] $\bar{x}$ + 2s of a number of background analyses for soils and bed sediments (Purtymun 1987).
[b] Regional background 1987.
[c] Number in parentheses indicates number of stations exceeding background concentrations.

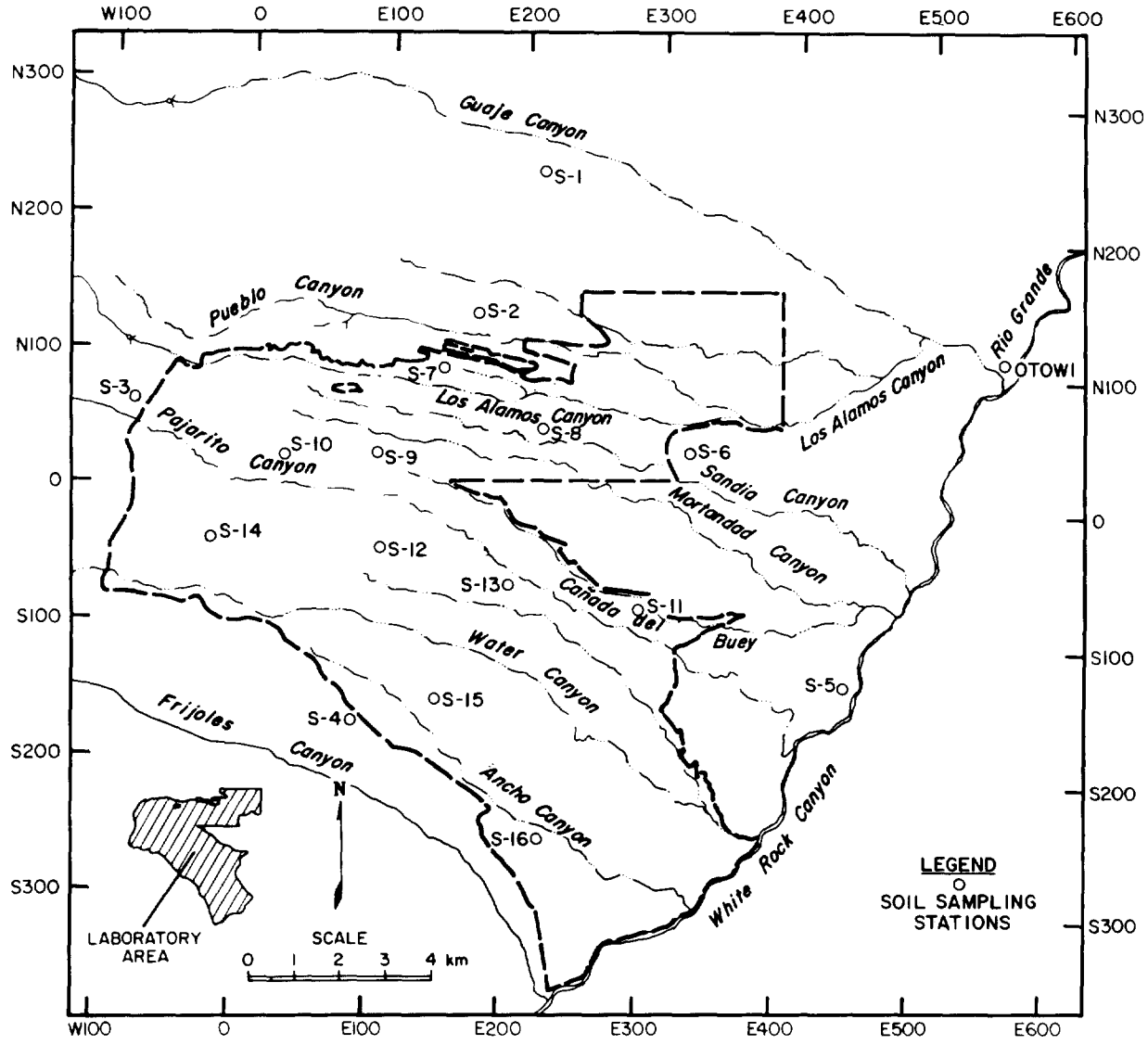


Fig. 17. Soil sampling on an near the Laboratory site.

4. On-site Soils and Sediments. On-site soil samples were collected from 10 stations within the Laboratory boundaries. On-site sediments were collected from 24 stations within areas that have received treated liquid effluent (Table G-38, Figs. 17 and 18).

The maximum ^{137}Cs and ^{238}Pu concentrations in the 10 soil samples were below regional background levels (Tables 16, G-41, and G-42). The concentrations of $^{239,240}Pu$ at two stations (near TA-55, Plutonium Facility) were above background (Tables 16 and G-42). The ^{3}H concentrations from soil at two stations (one near TA-33, Tritium Facility) were above background. The uranium background concentration was exceeded at seven stations, and gross gamma background activity was exceeded at three stations. Uranium and gross gamma are low and do not reflect contamination from Laboratory operations but rather variation in natural radioactivity in the soil minerals.

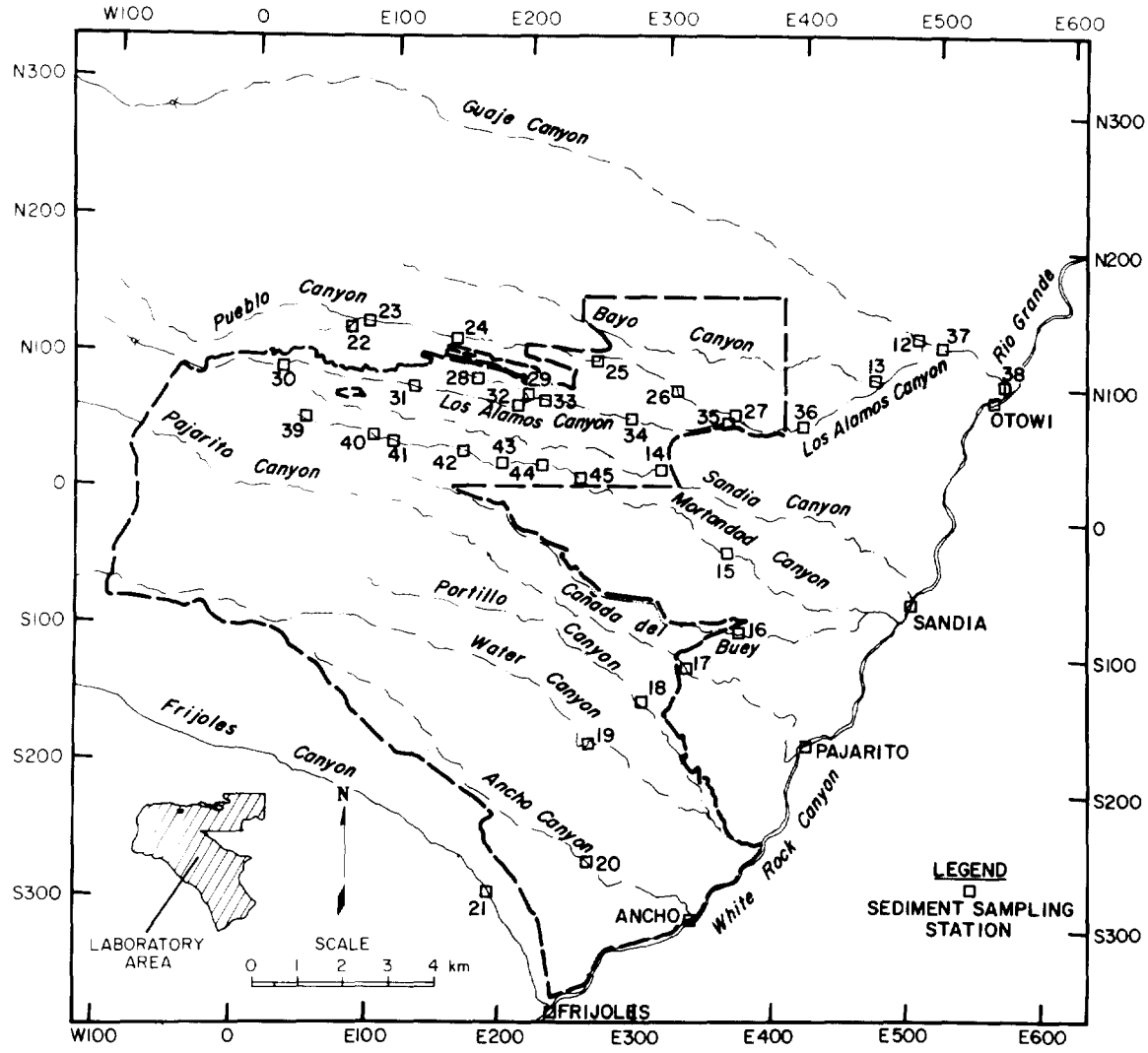


Fig. 18. Sediment sampling locations on and near the Laboratory site.

Three canyons received or are receiving treated, low-level radioactive effluents: Acid-Pueblo, DP-Los Alamos, and Mortandad canyons. The concentrations of radionuclides in these canyons exceeded regional background levels (Table 16). The concentrations in sediments of Pueblo and DP-Los Alamos canyons decrease downgradient as the radionuclides are dispersed and mixed with uncontaminated sediments (Tables G-41 and G-42). The concentrations in Mortandad also decrease downgradient in the canyon; however, the concentrations at the Laboratory boundary do not indicate any transport to this point or beyond. The radionuclides in these canyons are derived from low-level radioactive effluents released from the treatment plants. The concentrations are low and pose no health or environmental problems.

5. Sediments in Regional Reservoirs. Reservoir sediments were collected from three stations in Abiquiu Reservoir on the Rio Chama and three stations in Cochiti Reservoir on the Rio Grande south of Los Alamos (Fig. 19). The samples were analyzed for ^{238}Pu and ^{239,240}Pu using 1 kg (2 lb, dry weight) samples (100 times the usual mass used for analyses)

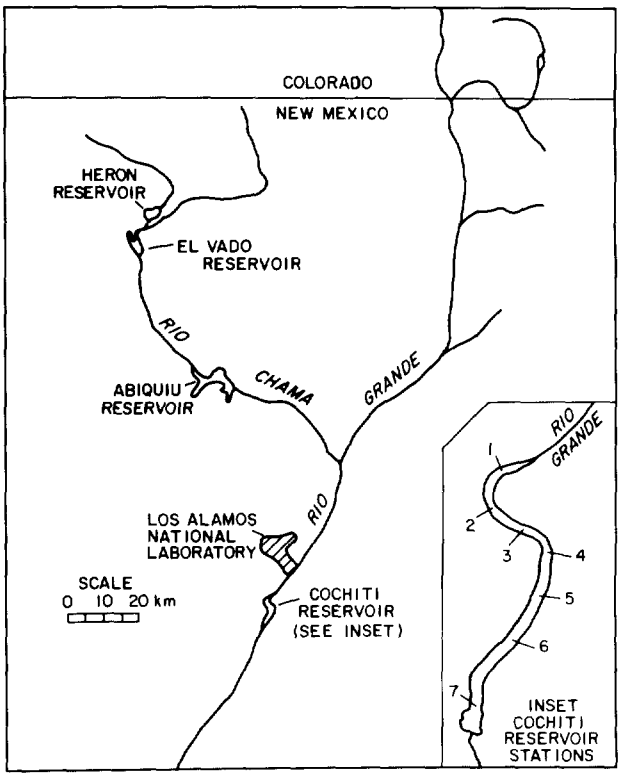


Fig. 19. Special regional sediment sampling locations.

of regular sediments. These large samples increase the sensitivity of the plutonium analyses, which is necessary to effectively evaluate background plutonium concentrations in fallout from atmospheric tests.

Average ^{238}Pu concentrations ranged from 0.00003 pCi/g to 0.00135 pCi/g; ^{239,240}Pu concentrations were slightly higher, ranging from 0.00020 pCi/g to 0.02910 pCi/g (Table 17). The distribution of plutonium was similar to samples collected in previous years (1979, 1982, 1984, 1985, and 1986). Analyses of the current and previous years' data revealed significantly higher levels ($p<0.05$) of plutonium in Cochiti than in Abiquiu reservoir. Sediments in Cochiti reservoirs contained a higher fraction of finer particles and organic materials than sediments from Abiquiu. These features enhance the capacity of the sediment to adsorb plutonium and other metal ions. The difference does not appear to be attributable to Laboratory operations. The ratios of ^{239,240}Pu to ^{238}Pu in the Cochiti sediments do not differ significantly from the ratio characteristic of worldwide fallout, about the same as found in sediment at Abiquiu Reservoir. The plutonium concentrations in sediments from the two reservoirs are low, within the range of worldwide fallout and are not a health or environmental concern.

6. Transport in Sediments and Run-Off from an Active Waste Management Area (Area TA-54). Radionuclides transported by surface run-off have an affinity for attachment to sediment particles by ion exchange or adsorption. Thus, radionuclides in surface run-off tend to concentrate in sediments. Nine sampling stations were established in 1982 outside the perimeter fence at Area G (TA-54) to monitor possible transport of radionuclides by storm run-off from the waste storage and disposal area (Fig. 20). The samples collected in September 1987 for radiochemical analyses were lost, and another set collected in February 1988 will be reported with 1988 monitoring data.

All surface run-off from Area L is into Canada del Buey. Sediment samples were analyzed for a number of inorganics (Table G-43). Eight constituents have EPA criteria set for toxic concentrations. The inorganics analyzed for EPA's Extraction Procedure (EP) toxicity criteria were well below criteria concentrations and below limits of detection. The other five were at or below limits of detection. The pH was slightly alkaline, ranging from 7.0 to 8.0.

Table 17. Radiochemical Analyses of Sediments from Reservoirs on the Rio Chama and Rio Grande[a]

Reservoir	^{137}Cs (pCi/g)	Total U (μg/g)	^{90}Sr (pCi/g)	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)	Ratio of $^{239,240}Pu$ to ^{238}Pu
Rio Chama						
Abiquiu Reservoir						
Upper	0.10 (0.08)	3.3 (0.3)	0.00 (0.10)	0.00009 (0.00002)	0.00020 (0.00011)	--
Middle	0.21 (0.09)	3.8 (0.4)	−0.03 (0.10)	0.00020 (0.00004)	0.00502 (0.00026)	--
Lower	0.35 (0.11)	3.6 (0.4)	−0.10 (0.20)	0.00024 (0.00003)	0.00602 (0.00026)	--
$\bar{x}$ (s)	0.22 (0.13)	3.6 (0.25)	−0.04 (0.5)	0.00018 (0.00008)	0.00375 (0.00311)	21
Rio Grande						
Cochiti Reservoir						
Upper	0.26 (0.11)	3.8 (0.4)	0.07 (0.05)	0.00003 (0.00001)	0.00256 (0.00011)	--
Middle	0.15 (0.09)	3.8 (0.4)	0.03 (0.06)	0.00110 (0.00006)	0.02970 (0.00107)	--
Lower	0.51 (0.12)	3.8 (0.4)	0.08 (0.09)	0.00135 (0.00010)	0.02020 (0.00089)	--
$\bar{x}$ (s)	0.31 (0.18)	3.8 (0.0)	0.06 (0.03)	0.00083 (0.00070)	0.01749 (0.01377)	21

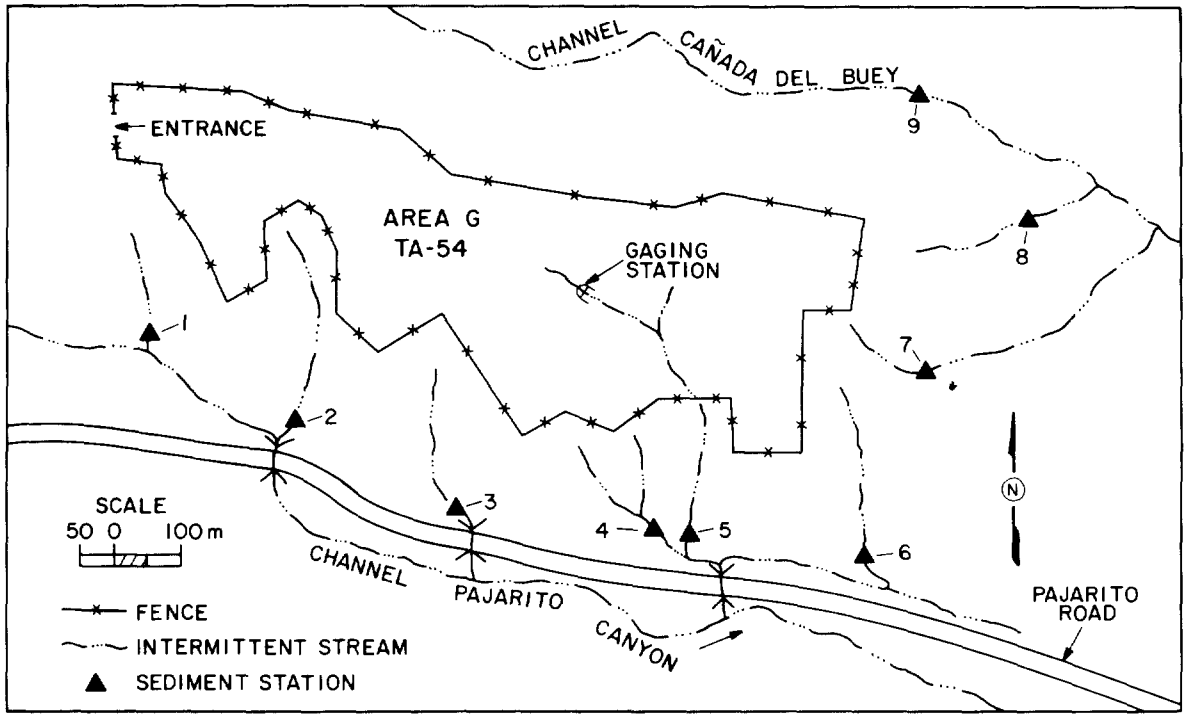


Fig. 20. Surface water gaging station in Area G (TA-54) and sediment sampling stations adjacent to Area G.

VII. FOODSTUFFS MONITORING

Most produce, fish, and honey samples collected near the Laboratory showed no influence from Laboratory operations. Some on-site samples contained slightly elevated levels of tritium and uranium. Concentrations of radionuclides in foodstuffs contributed only a minute fraction of the Laboratory's contribution to individual and population doses received by the public.

A. Background

Produce, garden soil, fish, and honey have been routinely sampled to monitor for potential radioactivity from Laboratory operations. Produce and honey collected in the Espanola Valley and fish collected at Abiquiu Reservoir are not affected by Laboratory operations (Fig. 21). These regional sampling locations are upstream from the confluence of the Rio Grande and intermittent streams that cross the Laboratory. They are also sufficiently distant from the Laboratory as to be unaffected by airborne emissions (Sec. V). Consequently, these regional areas are used as background sampling locations for the foodstuffs sampling program.

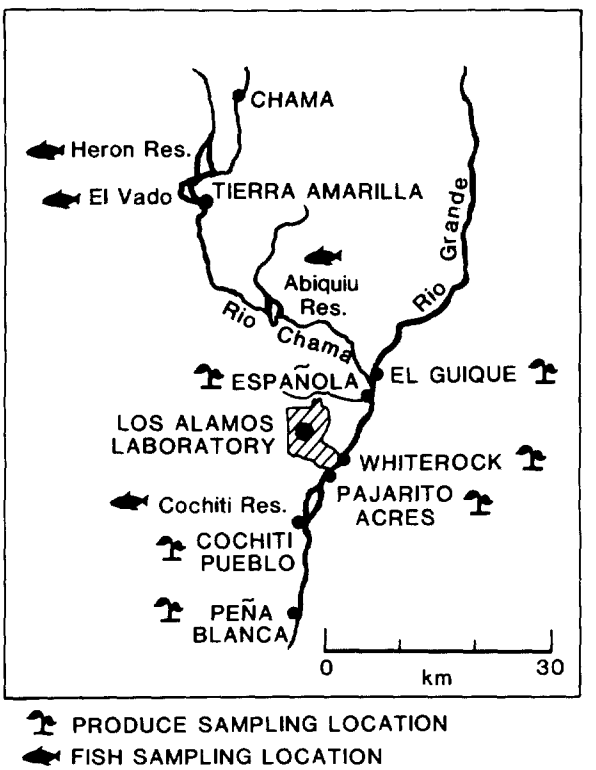


Fig. 21. Fish and produce sampling locations.

B. Produce

Data in Table G-44 summarize produce sample results for ^{3}H (in tissue water), ^{90}Sr, ^{137}Cs, ^{238}Pu, $^{239,240}Pu$, and total uranium. Sampling and preparation methods are described in Appendix B.

Concentrations of ^{137}Cs, ^{238}Pu, and $^{239,240}Pu$ in produce from regional, perimeter, and on-site sampling locations were statistically indistinguishable (one-way analysis of variance at the 95% confidence level). Significantly higher levels of ^{3}H ^{90}Sr, and uranium were found in on-site produce than in produce from some other sites.

Elevated radionuclide levels in on-site samples are probably the result of Laboratory operations. However, on-site produce is not a regular component of the diet of either Laboratory employees or the general public. The Laboratory contributions to doses received in produce consumption pose no threat to the health and safety of the general public (Sec. III).

C. Fish

Fish were sampled in two reservoirs (Fig. 21). Abiquiu Reservoir is upstream from the Laboratory on the Rio Chama and serves as a background sampling location. Cochiti Reservoir could potentially be affected by Laboratory effluents because it is downstream from the Laboratory on the Rio Grande. Sampling procedures are described in Appendix B. Edible tissue was radiochemically analyzed within fish species for ^{90}Sr, ^{137}Cs, ^{238}Pu, $^{239,240}Pu$, and total uranium.

Results for fish are presented in Table G-45. For ^{137}Cs, ^{238}Pu, and $^{239,240}Pu$, no differences were apparent (two-factor analysis of variance, 95% confidence level) between the upstream and downstream samples.

Thus, significantly higher concentrations of plutonium in Cochiti sediments (Table 17) were not reflected in the food chain. In some previous years, higher levels of ^{137}Cs had been observed in fish upstream. As in previous years, uranium levels within species exhibited distinct patterns. Body burdens in bottom-feeding catfish tended to be higher than those found in crappie. Uranium levels were significantly higher in Cochiti fish, although the difference remained low (6 $\mu g/g$). Levels of ^{90}Sr in crappie were significantly higher in upstream samples, reflecting increased global fallout at higher elevations.

The data indicate that Laboratory operations do not result in significant doses received by the general public consuming fish from Cochiti Reservoir (Sec. III).

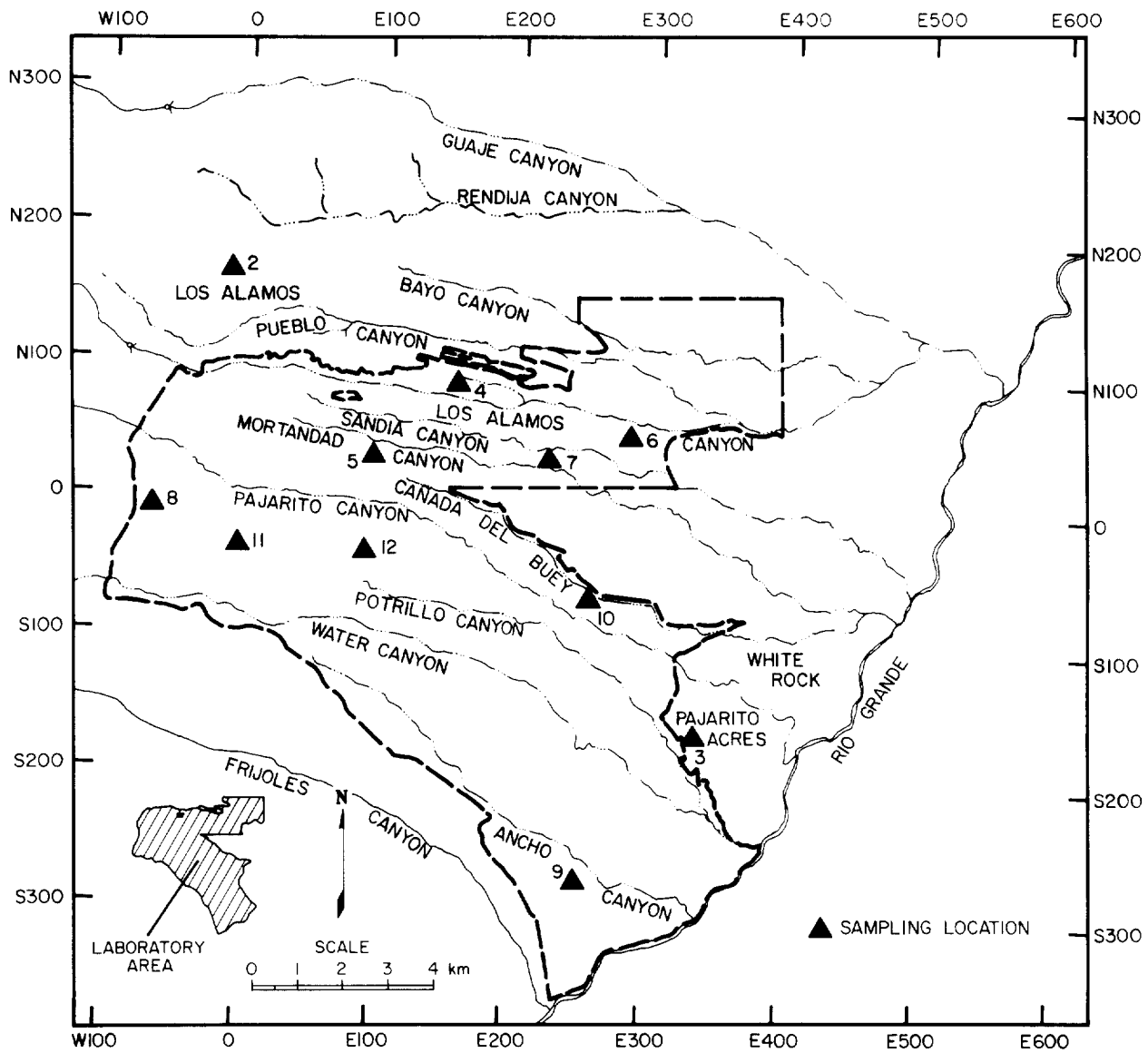


Fig. 22. Locations of beehives.

VIII. ENVIRONMENTAL COMPLIANCE

In accordance with the policy of the Department of Energy, the Laboratory complies with federal and state environmental requirements. These requirements address handling, transport, release, and disposal of hazardous materials as well as protection of ecological, archaeological, historical, atmospheric, and aquatic resources. The Laboratory is currently applying for federal and state permits for operating hazardous waste storage areas as well as renewing a permit for discharge of liquid effluents. The Laboratory was in compliance with treated liquid discharge permit limits in 96% and 99% of monitoring analyses from sanitary and industrial effluent outfalls, respectively. Sanitary waste treatment facilities are currently being upgraded to improve compliance. All airborne releases were well within regulatory limits during 1987. A total of 180 asbestos removal jobs were carried out during the year, and appropriate notification was provided to state regulators. Concentrations of constituents in the drinking water distribution system remained within federal water supply standards, although a few constituents exceeded limits at the wellhead. The Laboratory carried out two mitigation actions at cultural sites. During 1987, 21 documents were prepared to ensure environmental compliance by new Laboratory activities.

A. Resource Conservation and Recovery Act (RCRA)

1. Background. The Resource Conservation and Recovery Act (RCRA) (as amended by the Hazardous and Solid Waste Amendments of 1984 [HSWA]) mandates a comprehensive program to regulate hazardous wastes from generation to ultimate disposal. Major emphasis of the amendments is to reduce hazardous waste volume and toxicity and to minimize land disposal of hazardous waste. Major requirements under HSWA that impact waste handling at the Laboratory are presented in Table 18.

The EPA has granted New Mexico interim RCRA authorization transferring regulatory control of hazardous wastes to the state's Environmental Improvement Division (NMEID). State authority for hazardous waste regulation is the New Mexico State Hazardous Waste Act and Hazardous Waste Management Regulation (HWMR). However, NMEID has not yet obtained authorization for implementing all of the 1984 RCRA amendments.

The Laboratory produces a wide variety of hazardous wastes. Small volumes of all chemicals listed under 40 CFR 261.33 could occur at the Laboratory as a result of ongoing research. Process wastes are generated from ongoing manufacturing operations that support research, such as liquid wastes from circuit board preparation and lithium hydride scrap from metal machining. Although they occur in larger volumes than discarded laboratory chemicals, process wastes are few in number, well defined, and not acutely toxic. High-explosive wastes include small pieces of explosives and contaminated sludges that are thermally treated on-site.

2. Permit Application. The Los Alamos Area Office of DOE has submitted both Part A and Part B applications under RCRA and the New Mexico Hazardous Waste Act for the Laboratory (Table 19). In response to changes in waste handling, comments from NMEID, and changes in regulations, DOE submitted revised applications in November 1987.

Landfilling of hazardous wastes was discontinued in 1985, and existing landfills will be closed under interim authority after the NMEID approves closure plans. Storage facilities holding wastes for less than 90 days need not obtain a Part B permit. All facilities listed in Table G-49 as having interim status, but not included in the Part B application, must be closed before the application is approved.

3. Area P Landfill and Lagoons. The Area P landfill and surface impoundment are located in a remote area of the northeastern section of TA-16, adjacent to burning pads. The landfill was used from the

Table 18. Major Regulatory Requirements of the Hazardous and Solid Waste Amendments of 1984 Impacting Waste Management at Los Alamos National Laboratory

The Hazardous and Solid Waste Amendments of 1984:

- o prohibit placement of bulk liquids, containerized liquid hazardous waste, or free bulk or free liquids, even with adsorbents, in landfills.
- o prohibit landfill disposal of certain waste and require that the EPA review all listed wastes to determine their suitability for land disposal.
- o establish minimum technology requirements for landfills to include double liners and leak detection.
- o require EPA to establish minimum technology requirements for underground tanks.
- o require that generators of manifested wastes certify that they have minimized the volume and toxicity of wastes to the degree economically feasible.
- o require that the operators of landfills or surface impoundments certify that a ground water monitoring program is in place or a waiver demonstrated by November 8, 1985, with failure to do so resulting in loss of interim status on November 23, 1985.
- o require that federal installations submit an inventory of hazardous waste facilities by January 31, 1986.
- o require the preparation by August 8, 1985, of a health assessment for landfills and surface impoundments seeking a Part B permit.

early 1950s until about 1982 to dispose of high-explosive (HE) contaminated materials. The surface impoundment received filtered liquid extract from HE contaminated wastewater associated with activities at Buildings 401 and 406. Both sites received soluble barium nitrate in excess of EPA's criteria for defining toxic materials and are considered to contain hazardous wastes under RCRA. Neither site was included in the Laboratory's original or updated RCRA permit applications. The Laboratory chose to separately close each of these sites under 40 CFR 265 interim status standards. Appropriate closure and post-closure plans were submitted to New Mexico's EID in 1985, and both plans are awaiting final approval.

A modified landfill closure and post-closure plan was prepared for submittal to the NMEID in late 1987. Modifications were necessary because the landfill will eventually be subject to permitted standards under 40 CFR 264 once the NMEID issues the Laboratory its RCRA permit. Furthermore, HSE-8 desired to establish a 30-year post-closure ground water monitoring plan that would be consistent with regard to monitoring parameters and would fulfill requirements under both interim and permitted standards. To this end, HSE-8 personnel constructed nine ground water monitoring wells and five neutron moisture access monitoring wells. To date no recoverable amounts of ground water have been observed; average unsaturated gravimetric borehole moisture contents range from 2% to 24%. Based on these and other hydrogeologic data, a ground water monitoring waiver was requested from the NMEID in December 1987. If this waiver is eventually approved, then the 30-year,

Table 19. Enviromental Permits Under Which the Laboratory Operated in 1987

Type	Permitted Activity	Issue Date	Expiration Date	Administering Agency
RCRA Hazardous Waste Facility	Hazardous Waste Handling	Revised Application Submitted November 1987	--	NMEID[a]
PCB	Disposal of PCBs	June 5, 1980	--	EPA[b]
PCB Oil	Incineration of PCB Oils	May 21, 1984	--	EPA
NPDES-Los Alamos	Discharge of Industrial and Sanitary Liquid Effluents	Modified Permit May 29, 1987	March 1, 1991	EPA
NPDES-Fenton Hill	Discharge of Industrial and Sanitary Liquid Effluents	October 15, 1983[c]	--	EPA
Ground Water Discharge Plan-Fenton Hill	Discharge to Ground Water	June 5, 1985	June 1990	NMOCD[d]
NESHAPS	Construction and Operation of Four Beryllium Facilities	December 26, 1985 and March 19, 1986	--	NMEID
Open Burning	Burning at TA-16-412	May 26, 1987	May 26, 1988	NMEID

[a]New Mexico Enviromental Improvement Division.
[b]US Enviromental Protection Agency.
[c]Renewal pending.
[d]New Mexico Oil Conservation Division.

post-closure ground water monitoring requirements at the landfill will be terminated.

Closure and post-closure plans for the lagoon did not require modification because all of the impoundment's wastewater was completely removed in 1987 and shipped off-site for final treatment and disposal. In addition, the lagoon's synthetic membrane underliner was completely removed along with all contaminated subbase soils. This "clean" closure approach dictates interim status standards be followed rather than permitted standards since it occurred prior to the issuance of a RCRA permit. Furthermore, this lagoon closure plan does not require the typical 30-year, post-closure care requirements for in situ closure. The same process could not be used for the landfill because explosion hazards preclude landfill excavations.

4. Other RCRA Activities. Areas L and G are located at TA-54 on Mesita del Buey and have been used for disposal of hazardous wastes and are subject to RCRA regulation. A ground water monitoring waiver application for both Area L and Area G has been submitted to the NMEID. Vadose zone (partially saturated zone above the water table) monitoring beneath the landfills and perched water monitoring in the adjacent canyons is being conducted to support this application (Sec. IX). Quarterly reports of the pore gas sampling and perched water analysis have been submitted to the NMEID.

Table G-49 lists several storage areas and one thermal treatment area currently under interim status but for which a Part B permit is not being sought. Area TA-3-102, used to store drummed lithium hydride scrap, will be closed under interim authority in 1988 and reopened as a <90-day storage area. Areas TA-22-24 and TA-40-2 are magazines used for storage of high-explosive wastes. These will be closed to waste storage in 1988 and replaced by other satellite storage units. The TA-40 scrap detonation pit used for destroying scrap high explosives has been closed to waste detonation. All scrap generated will be handled at other detonation sites included in the Part B application. Closure plans for these facilities have been submitted to NMEID.

A controlled air incinerator with interim status for treating hazardous waste is located at TA-50-37. A trial burn was conducted in October 1986. The raw data were submitted to the NMEID in December 1986 and a final report for the test burn was submitted on March 5, 1987. These data and report will support the laboratory's application for a hazardous waste permit for this facility.

An inventory of underground storage tanks (UST) was submitted to the NMEID on May 5, 1986, in accordance with the Hazardous and Solid Waste Amendments. A revised inventory has been completed. Some tanks have been removed and others added including one at the Life Sciences Division's facility at Kirtland Air Force Base. A total of 104 tanks are now identified for the underground storage of regulated substances under Subtitle I of RCRA. Nine unused USTs were removed during 1987 and disposed of along with any contaminated soil.

In July 1987, EPA/NMEID conducted a joint hazardous waste compliance inspection (Table G-50). Violations were noted and a notice of violations will be issued in January 1988. Corrective actions will have to take place addressing these violations. The EPA was the lead agency for this inspection.

B. Clean Water Act

1. Laboratory Liquid Waste Discharge Permits. The primary goal of the Clean Water Act (33 U.S.C. 446 et seq.) is to restore and maintain the chemical, physical, and biological integrity of the nation's waters. The act established the National Pollutant Discharge Elimination System (NPDES) that requires permitting all point-source effluent discharges to the nation's waters. The permit establishes specific chemical, physical, and biological criteria that an effluent must meet prior to discharge. The DOE has two NPDES permits, one for Laboratory facilities in Los Alamos and one for the Fenton Hill Geothermal Project facility, located 50 km (30 mi) west of Los Alamos in the Jemez Mountains (Table 19). Both permits are issued and enforced by EPA's Region VI, Dallas, Texas. However, through a federal/state agreement and grant, NMEID performs compliance monitoring and reporting as agents for EPA.

The NPDES permit in effect for the Laboratory in 1987 (NM0028355) was reissued May 29, 1987, and will expire on March 1, 1991. As of December 31, 1987, the permit regulates 98 industrial outfalls and 10 sanitary outfalls (Table G-51). Each outfall represents a sampling station for permit compliance monitoring.

The Laboratory forwarded three NPDES permit modification requests to DOE for transmittal to EPA during 1987. The first requested addition of two new outfalls: outfall No. 128, which discharges effluent from a printed circuit board discharge at TA-22-91;

and outfall No. 129, which discharges effluent from boiler blowdown at TA-21-357. The second modification request addressed elimination of 22 outfalls that are no longer discharging; reactivation of outfall No. 007 at the TA-16 steam plant; combination of outfalls at three locations within the Laboratory; correction of outfall descriptions at four locations; and addition of three new outfalls (outfall No. 130 discharges effluent from a cooling tower located at TA-11-30, outfall No. 131 discharges effluent from once-through cooling water at TA-48-1, and outfall No. 132 discharges photographic waste effluent from TA 35-87. The third request contained information regarding 16 new wastewater outfalls consisting of eleven noncontact cooling water discharges, four treated cooling water discharges, and one sanitary wastewater discharge. The modification request also contained information about modifying six existing outfalls and eliminating two existing outfalls because wastewater has been diverted to other permitted outfalls.

Weekly sampling results are tabulated in a Discharge Monitoring Report (DMR) and submitted through DOE to EPA and NMEID on a monthly basis. Deviations from NPDES permit limits are explained separately to EPA and NMEID with the monthly submittal (Tables G-52 through G-54). During 1987, 96.3% and 98.7% of monitoring analyses complied with NPDES limits at sanitary and industrial outfalls, respectively (Fig. 23).

2. Federal Facility Compliance Agreement. On July 18, 1986, the Federal Facility Compliance Agreement (FFCA) between DOE's Los Alamos Area Office (LAAO) and EPA became effective. The FFCA contains interim effluent limitations and a schedule of compliance for several outfalls and outfall categories that had experienced frequent noncompliance with the NPDES permit limitations (Tables G-55 and G-56). Throughout 1987, required FFCA quarterly progress reports indicated that the Laboratory was well ahead of schedule in meeting final compliance milestones, with the exception of corrective actions on outfall 06S (TA-41). The completion of these corrections was delayed until November due to contract negotiations. At the end of December 1987, completion of only one project was needed to meet the FFCA schedule of compliance.

3. Clean Water Act Audits. The EPA conducted one audit under the Clean Water Act in 1987 (Table 20). An EPA Compliance Evaluation Inspection (CEI) was conducted on April 23, 1987. The CEI report received from EPA indicated that the permit deficiencies previously noted during the CEI had been corrected, and that the permittee was in compliance with permit requirements. The report stated that, "overall, this is a well run, well managed facility."

4. Administrative Order. On August 6, 1987, EPA's Region VI issued an Administrative Order (AO) to DOE regarding NPDES Permit NM0028355. The AO was based on self-monitoring reports submitted by the Laboratory that identified a number of individual parameter violations occurring at outfalls during 1986 and 1987, as well as alleged reporting violations. DOE responded to the AO in a submittal to EPA dated September 3, 1987.

5. Fenton Hill Geothermal Project NPDES Permit. The NPDES permit for the Fenton Hill

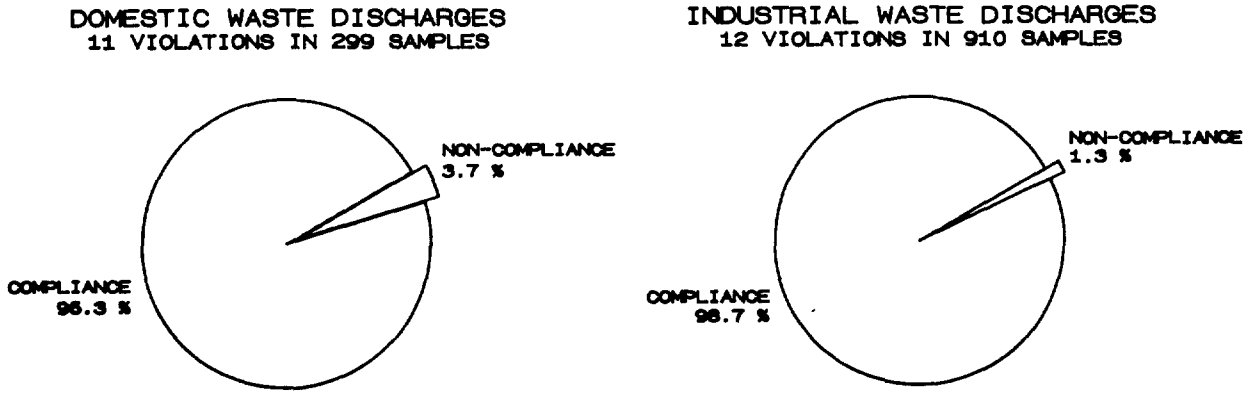


Fig. 23. 1987 Summary of Clean Water Act Compliance, NPDES Permit NM0028353

Table 20. Environmental Appraisals Conducted at the Laboratory in 1987

Day	Purpose	Performing Agency
January 28-29	Hazardous Waste Management Inspection	New Mexico's Environmental Improvement Division (EID) and U.S. Environmental Protection Agency (EPA)
January 27-31	Review of Environmental Monitoring Program	Albuquerque Operations Office U.S. Department of Energy (ALO/DOE)
January 27-29	Reconnaissance Survey of Zia Motor Pool	Laboratory's Environmental Surveillance Group, HSE-8
March 30-April 17	Environmental Survey	DOE Headquarters
April 23	NPDES Compliance Evaluation Inspection - Main Technical Area	EPA
May 1	Inspection of Air Pollution Compliance	EPA and EID
June 19	Compliance Inspection Federal Facility Compliance Agreement	EPA
June 24	Groundwater Discharge Plan Inspection - Fenton Hill	OCD
August 11	NPDES Compliance Evaluation Inspection - Fenton Hill	EID
October 27	Evaluation of RCRA Permit	EID
November 9	NPDES Site Inspection - Fenton Hill	EID and OCD

Geothermal Project was issued to regulate the discharge of mineral-laden water from the recycle loop of the geothermal wells (Table 19). NPDES permit NM0028576 was issued October 15, 1979, with an expiration date of June 30, 1983. Although the Laboratory applied for permit renewal more than 180 days prior to the expiration date, until April 1987 EPA Region VI had not acted upon the application. The existing permit has been administratively continued until supplanted by a new permit.

On April 15, 1987, EPA requested an updated application for the permit in order to reflect present conditions at the site, and DOE submitted an application package on May 20. Subsequently, EPA issued a proposed permit for comment and state certification (pursuant to Section 401, 33 U.S.C. 466 et seq.). The proposed permit included effluent monitoring and reporting requirements for flow, pH, and phenols.

Because proposed NPDES permits are subject to state review and certification, a meeting was held with

the NMEID and New Mexico Oil Conservation Division (NMOCD) to discuss the proposed permit and the environmental concerns of the state agencies. Subsequent to the meeting, a site inspection was held at Fenton Hill on November 9, 1987, to review the discharge location(s), inspect treatment systems, sample the wastewater, and survey the drainage system affected by the discharge. In December an information package containing a description of all water and wastewater piping and storage at the site was mailed by DOE/LAAO to the state agencies. State certification was granted by NMEID on January 8, 1988, with no additional state-imposed permit conditions. Issuance of the final NPDES permit is anticipated during the first quarter of 1988.

The original Fenton Hill NPDES permit regulates a single outfall. The daily monitoring requirements for the outfall during discharge include: arsenic, boron, cadmium, fluoride, lithium, pH, and flow. Concentrations for each of these parameters are to be reported. However, only the parameter pH has a limit, i.e., it must be within the range of 6.0 to 9.0 standard units.

The proposed Fenton Hill NPDES permit also will regulate the same single outfall. The daily monitoring requirements for the outfall during discharge will include: flow, pH, and phenols.

On August 11, 1987 the NMEID conducted a CEI at the Fenton Hill Geothermal Site. The results of the inspection were transmitted to DOE/LAAO on September 11, 1987. The inspection report indicated some deficiencies in flow measurement, pH monitoring, and analytical reporting, and record-keeping. All deficiencies were corrected.

A discharge plan for the Fenton Hill Geothermal Project was submitted to the NMOCD in June 1984 and approved in June 1985 (Table 19). The discharge plan approval is for a period of 5 years. The discharge plan approval letter states that there will be no routine monitoring or reporting requirements other than those mentioned above.

On April 27, 1987, DOE/LAAO submitted to NMOCD a request to modify the ground water discharge plan (GW-31) by using chemical tracers in various experiments conducted to evaluate the geothermal reservoir. In order to fully evaluate the discharge plan modification, NMOCD conducted a site inspection at Fenton Hill on June 24, 1987. After considering all of the information available to them, NMOCD approved the discharge plan modification on September 8, 1987.

6. Spill Prevention Control and Countermeasure (SPCC) Plan. During 1987 technical and administrative reviews of the Laboratory's Spill Prevention Control and Countermeasure (SPCC) Plan were completed. The SPCC Plan was distributed to the Senior Management Group and to divisional environmental coordinators during October 1987. The plan was accompanied by a VHS video cassette that included a 15-minute overview of the plan, as well as two short videos on safe drum handling and polychlorinated biphenyls (PCBs) at the Laboratory, topics related to the SPCC plan.

The SPCC plan addresses facilities improvements (e.g., dikes, berms, or other secondary spill containment measures), operational procedures, and mechanisms for reporting of hazardous substances and oil spills to the appropriate managerial and regulatory authorities. The plan complements existing Administrative Requirements in the Laboratory's Health and Safety Manual for accidental oil and chemical spills and environmental protection. Its goal is to minimize off-site oil and hazardous chemical discharges and to provide a spill response system.

7. Sanitary Wastewater Systems Consolidation. Many of the existing sanitary wastewater treatment facilities at the Laboratory are over 30 years old and do not consistently meet NPDES permit requirements. The cost of operation of these facilities has increased over the years due to maintenance and replacement of old equipment and other factors. In 1985, the Laboratory initiated the Sanitary Wastewater Systems Consolidation (SWSC) project to replace most of these facilities and to provide an area-wide wastewater treatment system.

The proposed SWSC project will be designed to meet current and anticipated future discharge requirements and reduce operation and maintenance costs. The new wastewater treatment plant will be located near TA-46 and will utilize the extended aeration process. The proposed plant will include preliminary treatment works, flow equalization basins, an oxidation ditch, a secondary clarifier and facilities for disinfection of effluent. Effluent from the plant will be reused for cooling water at the TA-3 power plant and for other nonpotable uses. Excess effluent will be discharged to Canada del Buey under a new NPDES permit. Upon completion, the proposed SWSC project will replace 8 wastewater treatment plants and 32 septic tank systems currently maintained by the Laboratory.

During 1987, the final design criteria for the SWSC project were approved, and construction is scheduled to be completed in 1992. When complete, the SWSC project will eliminate noncomplying discharges. The project will reduce operation and maintenance costs associated with the existing treatment plants and septic tank systems. Also, the number of discharge points requiring sampling, analyses and reporting will be reduced.

8. Interim Improvements at TA-3 Sanitary Wastewater Treatment Plant. The TA-3 Wastewater Treatment Plant is presently the largest sanitary wastewater facility at the Laboratory and provides treatment for about 1.15×10^6 liter (0.3×10^6 gal.) of wastewater per day. The TA-3 plant is a trickling filter plant with two parallel trains of treatment units. Effluent from the plant exceeds biochemical oxygen demand (BOD) standards at times during the winter months. During cold periods, biological activity in the trickling filters is reduced and removal of dissolved organic matter from the wastewater declines. Installation of a steam injection system was selected from several alternatives considered to improve BOD removal at the plant. No discharge violations for BOD have occurred since completion of the system. Additional testing is being conducted in order to fine-tune the temperature setting and to determine the optimum amount of steam for meeting permit requirements.

In addition to the steam injection system, a new chlorination system was installed at the plant to prevent occasional violations of the fecal coliform limit. Since installation of this system, no violations of fecal coliform requirements have occurred.

9. Interim Improvements At Other Sanitary Wastewater Treatment Plants. The wastewater treatment facilities serving TA-18 include two lined lagoons that are operated in parallel. Effluent from these lagoons has contained total suspended solids in excess of NPDES limits. A conceptual design was completed for the construction of two sand filters to be located below the lagoons for removal of suspended solids. The old wastewater treatment facilities that served TA-41 were replaced by a high-pressure system, which now carries wastewater to the TA-3 plant. This new pumping system has eliminated all effluent discharges at TA-41.

10. Septic Tank System Survey And Registration. During 1987, a survey of all septic tank systems at the Laboratory found a total of 61 systems receiving <2,000 gal./day that required registration under New Mexico's Liquid Waste Disposal Regulations. Each septic tank system was registered with the Health, Safety, and Environment Section of Los Alamos County. In addition, a manual for selecting on-site wastewater disposal systems was completed. The manual provides Laboratory design engineers and project reviewers with information on the alternatives available for treatment and disposal of sanitary wastewater and on meeting state regulations when connection to the central collection system is not possible.

11. Treatment of Chemical Oxygen Demands at TA-16. The industrial wastewater at TA-16 originates from explosives processing and includes several organic wastes. Effluent from industrial outfall No. 055 at TA-16 has exceeded the chemical oxygen demand (COD) NPDES limit of 150 mg/L. In order to consistently meet COD permit limitations, a new treatment unit was combined with the existing facilities in 1987.

The new treatment unit includes two activated carbon tanks designed to reduce organics contributing to COD. Preliminary results indicate that adsorption by activated carbon is selective and that some organics remain in the effluent. Additional testing is needed to determine the most effective types of activated carbon or other filter media available for the organics present.

C. National Environmental Policy Act (NEPA)

The National Environmental Policy Act of 1969 (NEPA) requires that proposed federal actions be evaluated for their potential environmental impacts. The DOE's compliance with NEPA generally takes the form of an Action Description Memorandum (ADM). The ADM provides a brief description of the proposed action and serves as a basis for determining the required level of any further NEPA documentation. Further documentation is carried out at the request of DOE and may consist of either an Environmental Assessment (EA) or an Environmental Impact Statement (EIS). The Laboratory Environmental

Review Committee (LERC) reviews NEPA documentation. A Laboratory Environmental Evaluation Coordinator assists project personnel to prepare the appropriate documentation and present it to the committee.

The LERC approved 18 ADMs, 2 revised ADMs, and 1 EA in 1987 (Table G-57). The Laboratory instituted a new procedure for identifying project environmental, health, and safety requirements which has reduced the volume of paperwork required for NEPA documentation.

D. Clean Air Act

1. Federal Regulations

a. National Emissions Standards for Hazardous Air Pollutants (NESHAPS). This regulation sets reporting, emissions control, disposal, stack testing, and other requirements for specified operations involving hazardous air pollutants. New Mexico's EID has responsibility for administering these regulations. Laboratory operations that are regulated by NESHAPS include radionclide handling, asbestos disposal and removal, and beryllium machining.

The EPA has promulgated regulations for control of airborne radionuclide releases from DOE facilities (40 CFR 61, Subpart H). Since 1985, DOE and its contractors have been subject to EPA's radionuclide air emissions limits for exposure of the general public via the air pathway (DOE 1985). Laboratory operations are in compliance with these standards (Sec. III). Further discussion is presented in Appendix A. During 1987, the DOE and the Laboratory submitted an application to construct facilities for the Independent Management Activity program, as required under 40 CFR 61, Subpart A. This application was approved by EPA in January 1988.

Notification, emissions control, and disposal requirements for operations involving the removal of friable asbestos are specified under the NESHAPS regulations. The NMEID requires asbestos disposal certification forms be filled out and sent to them for each large asbestos removal job and an annual one for all small renovation jobs. Four certification forms, including the annual notification for the small disposal jobs, were sent to NMEID. Nearly 270 m^3 (9500 ft^3) of asbestos contaminated wastes were disposed at TA-54 in 1987.

During 1987, 180 asbestos jobs involved the removal of 2080 m (6825 ft) of asbestos materials on pipe and 96 m^2 (1032 ft^2) on other facility components. Six notifications of asbestos removal were sent to NMEID in 1987, including the notification for small removal jobs. Ninety-seven percent of the asbestos removed, including 53.5% of the length of asbestos removed from pipe, involved small renovation jobs that required no job-specific notification to the state.

The NESHAPS includes notification, emission limit, and stack performance testing requirements for beryllium machine shops. A modification to an existing permit was issued by NMEID during 1987 for one processing operation (Table 19).

b. National Ambient Air Quality Standards. Federal and state Ambient Air Quality Standards are shown in Table 21. Based upon available monitoring data and modeling, Laboratory emissions have not exceeded federal or state standards (Sec. V). Pollutants emitted by Laboratory sources include: sulfur dioxide, particulates, carbon monoxide, nitrogen dioxide, lead, beryllium, heavy metals, and nonmethane hydrocarbons. Laboratory sources that emit these pollutants include beryllium machining and processing, the TA-3 power plant, the steam plants, the motor vehicle fleet, the asphalt plant, the lead pouring facility, the burning and detonation of high explosives, and the burning of potentially high-explosive contaminated wastes (Sec. V).

A new federal particulate standard (the PM_{10} standard) for particles less than 10 microns in diameter went into effect this year.

c. Prevention of Significant Deterioration (PSD). The PSD regulations have stringent requirements (preconstruction review, permitting, best available control technology for emissions, air quality increments not to be exceeded, visibility protection requirements and air quality monitoring) for the construction of any new major stationary source or major modification located near a Class I Area, such as Bandelier National Monument's Wilderness Area. To date, the DOE and Laboratory have not been subject to PSD.

d. New Source Performance Standards (NSPS). The NSPS applies to 72 source categories. Its provisions include emission standards, notification, and emission testing procedures and reporting and emission monitoring requirements. The DOE and Laboratory have not been subject to NSPS. A proposed

Table 21. National and New Mexico Ambient Air Quality Standards

Pollutant	Averaging Time	Units	New Mexico	Federal Primary	Federal Secondary
Sulfur Dioxide	Annual Arithmetic Mean	ppm	0.02	0.03	---
	24 hour[a]	ppm	0.10	0.14	---
	3 hour[a]	ppm	---	---	0.5
Total Suspended Particulates	Annual Geometric Mean	g/m^3	60	75	60
	30 days	$\mu g/m^3$	90	---	---
	7 days	$\mu g/m^3$	110	---	---
	24 hour[a]	$\mu g/m^3$	150	260	150
PM_{10}[c]	Annual Arithmetic Mean	$\mu g/m^3$	50	50	50
	24 hour	$\mu g/m^3$	150	150	150
Carbon Monoxide	8 hour[a]	ppm	8.7	9	---
	1 hour[a]	ppm	13.1	35	---
Ozone	1 hour[b]	ppm	0.06	0.12	0.12
Nitrogen Dioxide	Annual Arithmetic Mean	ppm	0.05	0.053	0.053
	24 hour[a]	ppm	0.10	---	---
Lead	Calendar Quarter	$\mu g/m^3$	1.5	1.5	1.5
Beryllium	30 days	$\mu g/m^3$	0.01	---	---

Table 21 (cont)

Pollutant	Averaging Time	Units	New Mexico	Federal Primary	Federal Secondary
Asbestos	30 days	$\mu g/m^3$	0.01	---	---
Heavy Metals (Total Combined)	30 days	$\mu g/m^3$	10	---	---
Non-Methane Hydrocarbons	3 hour	ppm	0.19	---	---

[a]Maximum concentration not to be exceeded more than once per year.
[b]The standard is attained when the expected number of days per calendar year with maximum hourly average concentrations above the limit is equal to or less than one.
[c]PM_{10} covers particles less than 10 microns in diameter.

solid-waste-fired-boiler would easily meet NSPS limits for incinerators.

2. State Regulations

a. New Mexico Air Quality Control Regulation (NMAQCR) 301. Under this regulation, open burning of explosive materials is permitted where transport to other facilities may be dangerous. The DOE and Laboratory are permitted to burn waste explosives and explosive-contaminated wastes. Burning of waste explosives is done at the TA-16 burn ground, whereas burning of potentially high-explosive contaminated wastes is done at the TA-16 open incinerator.

The open incinerator is in the process of being replaced by an enclosed incinerator, with two-stage combustion. Complete combustion would occur within the two-stage incinerator, and an open burning permit is not required. An air pollution review of the planned incinerator estimated ambient air pollutant concentrations that were not of concern. The estimated emissions were too low to require either a permit or registration.

b. NMAQCR 501. The NMAQCR 501 sets emission standards according to process rate and requires the control of fugitive emissions from asphalt processing equipment. The asphalt concrete plant operated by Pan Am World Services is subject to this regulation. This plant is old, subject to leaking, and is inspected annually. During the annual inspection, leaks causing fugitive emissions were discovered and repaired.

The asphalt plant meets the stack emission standard for particulates as specified in 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) particulates 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 3 tests (Kramer 1977). Although the plant is old and not required to meet NSPS stack-emission limits for asphalt plants, it meets these standards (Kramer 1977).

c. NMAQCR 604. The NMAQCR 604 requires gas burning equipment built prior to January 10, 1973, 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 have not operated beyond this limit.

Thus, these boilers have not been subject to this regulation. The TA-3 power plant meets the emission standard, although it is not required to do so. The emission standard is equivalent to a flue gas concentration of 248 ppm. The TA-3 boilers meet the standard with measured flue gas concentrations of 15 to 22 ppm.

d. NMAQCR 702. The NMAQCR 702 requires the permitting of any new or modified source if it exceeds a given emissions rate and is not addressed by other regulations. When new Laboratory emission sources or modifications to existing sources are planned, an air pollution regulatory compliance review is carried out. This review evaluates the steps to be followed to comply with state and federal air pollution regulations. As part of the permitting process, NMEID reviews new or modified sources for compliance with all state and federal air pollution regulations. Under this regulation, the NMEID issued the modification to the permit for the beryllium processing operation at TA-3-141.

Group HSE-8 is assisting Facilities Engineering (ENG) Division in obtaining an air quality construction permit for a steam production facility consisting of two solid-waste-fired boilers (SWFB) and two gas-fired auxiliary boilers. This facility is proposed to replace the TA-16 steam plant. The facility will burn county and Laboratory refuse as well as natural gas and generate steam for TA-16. The permit application has been submitted and has been ruled complete by the NMEID. Meteorological air-dispersion modeling of emitted substances has demonstrated that impact on the local air quality, including impacts at the Bandelier Wilderness Area, will be negligible.

The NMEID has proposed amendments to this regulation that would require the permitting of an additional 600-700 substances. The NMEID has called this new class of substances "toxic air pollutants." If adopted, the proposed amendments would have a major impact on Laboratory operations and would be expensive to comply with. The Laboratory has hundreds of laboratories and shops that use these substances. Reconstruction of existing facilities and the construction of new facilities would be impacted by the proposed amendments.

e. Other Regulations. The NMEID proposed new regulations requiring one-time registration of all sources that have emissions of toxic air pollutants that exceed specified levels. The New Mexico Environmental Improvement Board (NMEIB) adopted these regulations on June 12, 1987, and they went into effect on September 17, 1987. The Laboratory is required to comply with these regulations by September 17, 1988. The Laboratory, with the assistance of a subcontractor, has completed a survey to obtain the necessary information and is in the process of using this information to develop an emission inventory for all of the Laboratory sources. A computerized data base system is being developed to process the large amount of information that has been collected. The data base will also be used to meet future permitting and internal requirements.

E. Safe Drinking Water Act (Municipal and Industrial Water Supplies)

1. Background. The federal Safe Drinking Water Act (42 U.S.C. 300f et seq.), as amended, requires the adoption of national drinking water regulations as part of the effort to protect the quality of drinking water in the United States. The U.S. Environmental Protection Agency (EPA) is responsible for the administration of the act and has promulgated National Interim Primary Drinking Water regulations. Although EPA is designated by law as the administrator of the Act, assignment of responsibilities to a state is permitted, and primacy for administration and enforcement of federal drinking water regulations has been approved for New Mexico.

The state of New Mexico administers and enforces the drinking water requirements through regulations adopted by New Mexico's EIB and implemented by NMEID. During 1987, reports on trihalomethane, radiological, microbiological, and inorganic chemical concentrations in the Laboratory's water supply were prepared for the NMEID pursuant to NMEIB regulations. Municipal and industrial water supplies for the Laboratory and community easily met the regulations.

The main aquifer is the only aquifer in the area capable of municipal and industrial water supply (Sec. II). Water for the Laboratory and community is supplied from 17 deep wells in 3 well fields and 1 gallery. The well fields are on Pajarito Plateau and in canyons east of the Laboratory (Fig. 24). The gallery is west of the Laboratory on the flanks of the mountains. Production from the wells and gallery for 1987 was 6.1 x 10^9 L (1.6 x 10^9 gal).

The Los Alamos well field is composed of five producing wells and one standby well. Well LA-6 is on

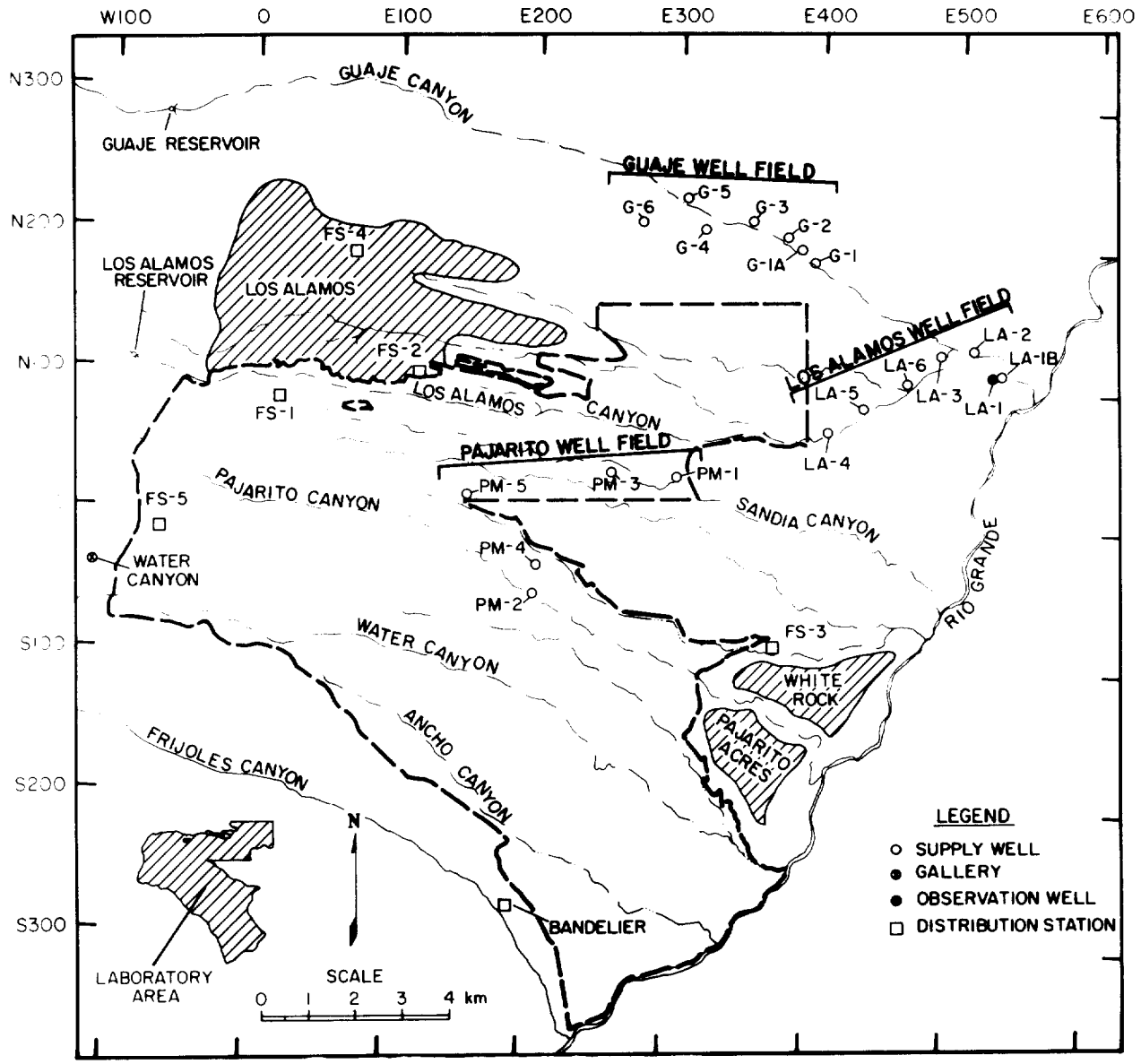


Fig. 24. Locations of reservoirs, well fields, supply wells, and gallery water supply

standby status, to be used only in case of emergency. Water from Well LA-6 contains excessive amounts of natural arsenic (up to 0.200 mg/L) that cannot be reduced to acceptable limits by mixing in the distribution system (Purtymun 1977). Well LA-4 was down for repairs and was not sampled. Wells in the field range in depth from 265 to 600 m (870 to 2000 ft). Movement of water in the upper 411 m (1350 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 composed of seven producing wells. During 1987, Well G-3 was down for repairs and was not sampled. Wells in the field range in depth from 463 to 610 m (1520 to 2000 ft). Movement in water in the upper 430 m (1410 ft) of the aquifer is southeastward at about 11 m/yr (36 ft/yr) (Purtymun 1984).

The Pajarito well field is composed of five wells that range in depth from 701 to 942 m (2300 to 3090

ft). Movement of water in the upper 535 m (1750 ft) of the aquifer is eastward at 29 m/yr (85 ft/yr).

The Water Canyon gallery collects spring discharge from a perched water zone in the volcanics on the flanks of the mountains west of Los Alamos and Pajarito Plateau (Fig. 24). The canyon supplies a small but important part of the production with use of little energy.

Water for drinking and industrial use is also obtained from a well at the Laboratory's experimental geothermal site (Fenton Hill, TA-57) about 45 km (28 mi) west of Los Alamos. The well is about 133 m (436 ft) deep completed in volcanics. During 1987, the well produced about 20 x 10^6 L (5.4 x 10^6 gal). The TA-57 water is not a part of the Los Alamos supply.

All water comprising the municipal and industrial supply is pumped from wells, piped through transmission lines, and lifted by booster pumps into reservoirs for distribution to the community and Laboratory. Water from the gallery flows by gravity through a microfilter station and is pumped into one of the reservoirs for distribution. All supply water is chlorinated prior to entering the distribution system.

Water in the distribution systems was sampled at five community and Laboratory locations (fire stations), Bandelier National Monument, and Fenton Hill (Fig. 24, Table G-14). Although federal and state standards (Appendix A) require analyses every 3 years, the Laboratory performs the analyses annually.

2. Radioactivity in Municipal and Industrial Water Supply. The maximum radioactivity concentrations found in the supply (wells and gallery) and distribution (including Fenton Hill) systems are in compliance with the EPA's National Interim Primary Drinking Water Standards (Tables 22, G-58, and G-59).

3. Chemical Quality of Municipal and Industrial Water Supply. Water from most wells and the distribution systems complied with EPA's primary and secondary standards (Tables 23 and G-60 through G-62). The concentration of fluoride from Well LA-1B was above primary standards (Table G-60). This is consistent with previous years. Mixing in the distribution system reduced concentrations to acceptable levels (Table 23). The concentration of lead from Well PM-5 also exceeded the primary standard (Table G-60). Well PM-5 was resampled and lead (<0.001 mg/L) was well below the primary standard.

The quality of water from the wells varied with local conditions within the same aquifer (Tables G-60 through G-62). Water quality depends on well depth, lithology of aquifer adjacent to well, and yield from beds within the aquifer.

F. Federal Insecticide, Fungicide, and Rodenticide Act

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) requires registration of all pesticides, restricts use of certain pesticides, recommends standards for pesticide applicators, and regulates disposal and transportation of pesticides. A pesticide is defined as any substance intended to prevent, destroy, repel, or mitigate pests. The Laboratory stores, uses, and discards pesticides in compliance with the provisions of FIFRA. A Laboratory pest control policy was established in June 1984 to establish procedures and identify suitable pesticides for control of plant and animal pests. Anything outside the scope of the policy must be approved by the Pest Control Oversight Committee. No unusual events associated with compliance occurred during 1987.

G. Archaeological and Historical Protection

Laboratory lands contain about 900 known archaeological and historical sites. Protection of cultural resources is mandated by numerous laws and regulations, including the National Historic Preservation Act of 1966, as implemented by 36 CFR Part 800 Protection of Historic and Cultural Properties, and the New Mexico Cultural Properties Act of 1969, as amended. The Laboratory's Environmental Evaluation Coordinator oversees management and protection of cultural resources.

Laboratory archaeologists survey project sites in advance of construction to determine the presence or absence of cultural resources. During 1987, the Laboratory conducted 28 cultural resource surveys, monitored construction at 7 sites, had permanent protective fencing erected at 1 site, and undertook adverse impact mitigation at 2 sites. During surveys of one project in Mortandad Canyon, archaeologists discovered a pit house site that indicates earlier prehistoric occupation of the area than heretofore thought.

The DOE granted an Archaeological Resource Protection Act permit to the Museum of New Mexico, Laboratory of Anthropology, for archaeological testing at the White Rock Y Intersection, site of a proposed new highway interchange.

Table 22. Maximum Concentrations of Radioactivity in Municipal Water Supply, Well and Distribution System

	Number of Stations	^{3}H (10^{-6} µCi/mL)	^{137}Cs (10^{-9} µCi/mL)	Total U (µg/L)	^{238}Pu (10^{-9} µCi/mL)
Analytical Limits of Detection	--	0.7	40	1.0	0.009
Maximum Contamination Level (MCL)[a]	--	20	200	1800[b]	15
Wells	16	0.3 (0.7)	42 (48)	6.0 (1.0)	0.011 (0.009)
	--	(2%)[c]	(21%)	(<1%)	(<1%)
Distribution System (Los Alamos)	6	2.1 (0.7)	71 (42)	2.0 (1.0)	0.012 (0.012)
	--	(11%)	(36%)	(<1%)	(<1%)
Distribution System (Fenton Hill)	1	0.1 (0.3)	113 (50)	1.0 (1.0)	0.000 (0.010)
	--	(<1%)	(57%)	(<1%)	(<1%)

Table 22 (cont)

	Number of Stations	$^{239,240}Pu$ (10^{-9} µCi/mL)	Gross Alpha (10^{-9} µCi/mL)	Gross Beta (10^{-9} µCi/mL)	Gross Gamma (Counts/min/L)
Analytical Limits of Detection	--	0.03	3	3	50
Maximum Contamination Level (MCL)[a]	--	15	15[d]	--	--
Wells	16	0.044 (0.007)	-5.0 (2.0)	3.2 (0.5)	-40 (100)
	--	(<1%)	(<1%)	--	--
Distribution System (Los Alamos)	6	0.037 (0.017)	2.4 (0.9)	42 (4.0)	500 (90)
	--	(<1%)	(16%)	--	--
Distribution System (Fenton Hill)	1	0.004 (0.004)	-0.2 (0.8)	6.1 (0.8)	350 (90)
	--	(<1%)	(<1%)	--	--

---

[a]EPA (1976).
[b]Level recommended by International Commission on Radiological Protection.
[c]Percentage of EPA's MCL is shown in parentheses.
[d]Environmental Protection Agency's Maximum Contaminant Level (MCL) for gross alpha is 15 x 10^{-9} µCi/mL. However, if gross alpha results exceed EPA's limit of 5 x 10^{-9} Ci/mL, isotopic analysis to determine radium content is required.

Table 23. Maximum Chemical Concentrations in Water Supply and Distribution Systems (results in mg/L)

Inorganic Chemical Contaminant	Standards	Supply: Well and Gallery	Supply: Per Cent of Standard	Distribution: Los Alamos Bandelier TA-57	Distribution: Per Cent of Standard
Primary[a]					
Ag	0.05	<0.001	<2	<0.001	<2
As	0.05	0.044	88	0.017	34
Ba	1.0	0.084	8	0.107	11
Cd	0.01	<0.0005	<5	<0.0005	<5
Cr	0.05	0.022	44	0.011	22
F	2.0	3.2	160	1.0	50
Hg	0.002	0.0003	15	<0.0002	10
NO_3(N)	10	<1	<10	<1	<10
Pb	0.05	0.092	184	0.031	62
Se	0.01	<0.002	<20	<0.002	<20
Secondary[b]					
Cl	250	17	7	45	18
Cu	1.0	0.266	27	0.024	2
Fe	0.3	0.095	32	0.110	37
Mn	0.05	0.009	18	<0.001	<2
SO_4	250	39	16	10	4
Zn	5.0	0.250	5	0.096	<2
TDS	500	430	86	276	55
pH	6.5 - 8.5	8.6	101	8.4	99

[a]EPA (1976).
[b]EPA (1979B).

Pursuant to federal regulations implementing Section 106 of the National Historic Preservation Act of 1966, as amended, clearance for construction and mitigation of unavoidable adverse impact to cultural resources is determined in consultation with the New Mexico State Historic Preservation Office (SHPO) and, if necessary, with the Advisory Council on Historic Preservation. The SHPO was consulted concerning potential impact to surveyed project areas.

The SHPO and Advisory Council approved stabilization and restoration work on the historic Pond Cabin at TA-18. The Laboratory completed work on this project during 1987. The cabin will be nominated for inclusion on the State Register of Cultural Properties. Surveys of prehistoric Indian cavates along the south slope of Mesita del Buey using volunteer Laboratory staff supervised by Laboratory archaeologists were completed, and a report was submitted to the Laboratory. Analysis of archaeological and botanical data recovered from the Romero Cabin homesteading site was completed and draft reports prepared.

The DOE and the Museum of New Mexico established a curatorial Programmatic Memorandum of Agreement (PMOA). Archaeological and historical artifacts from Laboratory projects will be curated professionally at the Museum's Laboratory of Anthropology. A draft procedural PMOA among DOE, SHPO, and the Advisory Council for Historic Preservation was prepared and is under DOE review. The PMOA will streamline Section 106 consultation requirements of the National Historic Preservation Act of 1966.

H. Threatened/Endangered Species and Floodplains/Wetlands Protection

The DOE and Laboratory must comply with the Endangered Species Act of 1973, as amended, and with Executive orders 11988, Floodplain Management, and 11990, Protection of Wetlands Environmental Review Requirements. Three Floodplain/Wetland notifications were prepared for publication in the Federal Register: Live Firing Range Extension, Sandia Canyon; Pulsed Power Assembly Building, TA-39, Ancho Canyon; and White Rock Y Interchange, Pueblo and Los Alamos canyons. Laboratory biologists surveyed 17 proposed construction sites for potential impact. They identified no endangered or rare animal or plant species at these sites.

A draft management plan for the endangered peregrine falcon was prepared and is under review. Computer mapping and analysis of raptor aeries and prey habitat in Los Alamos and Water canyons were initiated.

I. Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)

The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980 and 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 action at hazardous waste sites at the Laboratory are being addressed under the DOE Albuquerque Operations Office's Environmental Restoration (ER) Program.

J. Toxic Substances Control Act (TSCA)

The TSCA (15 U.S.C. et seq.) establishes a list of toxic chemicals for which the manufacture, use, storage, handling, and disposal are regulated. This is accomplished by requiring premanufacturing notification for new chemicals, testing of new or existing chemicals suspected of presenting unreasonable risk to human health or the environment, and control of chemicals found to pose an unreasonable risk.

Part 761 of TSCA contains the regulations applicable to polychlorinated biphenyls (PCBs). This part applies to all persons who manufacture, process, distribute in commerce, use, or dispose of PCBs or PCB items. Substances that are regulated by this rule include, but are not limited to, dielectric fluids, contaminated solvents, oils, waste oils, heat transfer fluids, hydraulic fluids, paints, sludges, slurries, dredge spoils, soils, and materials contaminated as a result of spills. Most of the provisions of the regulations apply to PCBs only if they are present in concentrations above a specified level. For example, the regulations regarding storage and disposal of PCBs generally apply to materials at PCB concentrations of 50 parts per million (ppm) and above. At the Laboratory, materials with >500 ppm PCBs are transported off-site for disposal.

During 1987, the Laboratory continued to inventory and mark PCB articles such as transformers and capacitors. The Laboratory's inventory of in-service PCB transformers >500 ppm, PCB transformers >50 but <500 ppm, and PCB capacitors includes 136, 137, and 2,777 units, respectively, as of July 1, 1987. Visual inspection of PCB transformers was conducted at least quarterly during 1987, and inspection records maintained pursuant to regulations. An annual report summarizing PCB disposal, transportation, storage, and in-service use for the time period July 1, 1986, through June 30, 1987, is available pursuant to federal regulation. During September 1987, HSE-8 prepared a 15-minute video film summarizing PCB use and regulation at the Laboratory. The video film will be used as a training aid to acquaint Laboratory personnel with PCBs and familiarize them with the federal regulations governing their use and disposal.

The Laboratory has EPA approval (Region VI) to dispose of PCB-contaminated articles, oils, and materials in the chemical waste landfill located at TA-54, Area G (Table 19). The approval requires semiannual reporting to EPA regarding the type and weight of PCB articles disposed of, and monitoring information regarding chemical quality of storm water run-off and natural springs in the area. The cumulative weights of specific types of PCB articles which were disposed at TA-54 during 1987 are listed in Table 24.

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

Title III of SARA, also known as the Emergency Planning and Community Right-to-Know Act (EPCRA), became effective on May 17, 1987. The EPCRA is the centerpiece of federal policy on chemical disaster prevention and response. The act is intended to encourage and support emergency planning

Table 24. Quantities (kg) of PCB Contaminated Articles Discarded at TA-54 in 1987[a]

PCB Article(s)	Shaft C11	Shaft C12	Pit 29	Pit 32
Transformer Carcases		907		522
Absorbed PCB Oil (<500 ppm)				
Rags/Dirt (drummed)				
Empty Drums				
Asphalt/dirt (noncontainerized)		9 616		1 361
Capacitors				
Generators				
Power Supply				
PCB Clean-Up Drum	722		41	
PCB Contaminated Equipment			175	2 359
Misc				
Total	722	10 523	216	4 242
Grand Total	15 703			

[a]PCB article and oils that contain ≥500 ppm PCB are shipped out-of-state for disposal.

efforts at state and local levels. Its implementation provides the public and local governments with information concerning potential toxic and chemical hazards present in their communities. The act is organized into three subtitles; the Laboratory will only be directly affected by Subtitle B, which provides the mechanism for community awareness of hazardous chemicals present in a given facility. However, it has voluntarily taken an active role in coordinating local community emergency response planning activities under Subtitle A.

The Laboratory is required to report its hazardous chemical substance inventory and safety handling procedures to the newly-created Los Alamos District Emergency Planning Commission, the state Emergency Response Commission, and the Los Alamos County Fire Department. The Laboratory's Emergency Management Office (EMO) coordinates all reporting, planning, and response efforts with the preexisting Los Alamos County Office of Emergency Preparedness, which acts as the district emergency planning group. Groups HSE-5 and HSE-8 provided a preliminary list of 137 on-site chemical substances that are on either the EPA's Chemical Emergency Preparedness Program (CEPP) list of 369 chemicals that are considered to be extremely hazardous (40 CFR 355, Appendices A and B) or on the list of 717 hazardous substances that are subject to CERCLA reportable quantity provisions (40 CFR 302, Table 302.4). In addition, individual Materials Safety Data Sheets (MSDS) for each of these substances have been provided to the EMO. These sheets, which were organized according to health and physical hazards, were originally developed in response to the Occupational Health and Safety Administration's (OSHA) Hazard Communication Standard (29 CFR 1910.1200). They are designed to inform individuals of specific chemical dangers and methods to avoid potential hazards.

In order for a listed chemical substance to qualify for EPCRA reporting requirements, the Laboratory must have a combined total amount of that chemical substance in excess of either its threshold planning quantity or its reportable quantity. For those chemical substances with no established reportable quantities, the Laboratory must have at least 0.45 kg (1 lb) of that substance before it qualifies for reporting requirements. Once a given listed chemical substance has been determined to be reportable, future annual reporting requirements dictate that the Laboratory must disclose individual building storage locations and the average annual quantity on-hand at each location where that substance is located. Once reported, this information becomes public property. These requirements may conflict with national security guidelines enforced by DOE and may require future DOE reporting directives if conflicting requirements are to be fully satisfied.

L. DOE Headquarters' Environmental Survey

The DOE Headquarters conducted an environmental survey of the Laboratory during March 30 through April 17, 1987. The purpose of the survey was to provide a no-fault identification, inventory, prioritization, and review of environmental issues and practices at the Laboratory. Similar surveys have been conducted at other DOE facilities, and evaluation of findings from all the surveys will lead to a DOE-wide prioritization of environmental problems (due in October 1989).

Findings of the survey were separated into four categories based upon potential for environmental impact:

> Category I: Finding addresses situations that pose an immediate threat to employees, public, or environment. Immediate action required.
>
> Category II: Finding addresses situations that cannot wait for action to be taken until the final report of the survey is published in approximately 3 years. The Laboratory should start new programs or continue existing programs, as appropriate, to address this finding before the 3-year period expires.
>
> Category III: Finding addresses situations that hold a "potential" for contamination from existing operations. The Laboratory is encouraged to continue existing programs or start new programs to address this finding as appropriate.
>
> Category IV: Finding is an observation only.

The findings were further subdivided into eight topical areas (Table 25). The majority (87%) of the findings were in categories III and IV. Most (63%) addressed hazardous materials handling and storage.

A preliminary report that will list the findings at Los Alamos from the survey will be published by DOE in March 1988. The DOE Survey Team will conduct environmental sampling at the Laboratory in the summer of 1988 and results of this sampling may affect the findings.

The Laboratory has drafted an implementation plan based on the tentative findings and has started to implement appropriate remedial actions.

M. Health, Safety, and Environmental Appraisal of Laboratory Operations and Facilities

Laboratory policy requires line management to establish an effective health, safety, and environmental (HSE) protection program. These programs must be appraised periodically to evaluate their effectiveness. The HSE Division began an appraisal program in November 1987, and over the next three years will perform operational and facility appraisals of the HSE programs of all Divisions. Appraisal teams are comprised of one representative each from the Safety (HSE-3), Industrial Hygiene (HSE-5), Waste Management (HSE-7), and Environmental Surveillance (HSE-8) groups. The responsibility of HSE-8 is to determine the effectiveness of divisional and facilities programs for ensuring compliance with applicable Laboratory policy, DOE orders and guidelines, federal and state regulations, and prudent management practices for protection of the environment and the general public.

Group HSE-8's appraisal includes evaluations of air emissions, liquid effluents, toxic substances use, waste management practices, and archaeological/cultural resources protection as applicable. The

Table 25. Tentative Findings by Topical Area and Category from the DOE Headquarters' Environmental Survey of Los Alamos National Laboratory 1987

Topical Area	Category I	Category II	Category III	Category IV
Air	0	0	0	2
Surface Water	0	2	3	3
Ground Water	0	0	1	2
Active Waste Disposal Areas	0	1	5	1
Chemical Handling	0	1	5	2
Hazardous Materials	0	1	2	1
Inactive Waste Disposal Areas	0	0	5	0
Quality Assurance	0	0	1	0

Group also evaluates whether the operation or facility is in accord with applicable environmental documentation such as an EIS, EA, ADM, or completed HSE Preliminary Project Questionnaire. The Group takes the opportunity during the appraisal to inform operations and facilities of potential environmental problems and of the availability of support from the Group for addressing these problems.

The HSE programs of Life Sciences and Facilities Engineering divisions were appraised in the last quarter of 1987.

N. Engineering Quality Assurance

The Laboratory has a Quality Assurance program (Facilities 1983) for engineering, construction, modification, installation, and maintenance of DOE facilities. The purpose of the program is to minimize the chance of deficiencies in construction; to improve the cost effectiveness of facility design, construction, and operation; and to protect the environment. A major goal of engineering quality assurance is to ensure operational compliance with all applicable environmental regulations. The quality assurance program is implemented from inception of design through completion of construction by a project team approach. The project team consists of individuals from the DOE's program division, the DOE's Albuquerque Operations, and Los Alamos Area Offices, the Laboratory's operating group(s), the Laboratory's Facility Engineering Division, design contractor, inspection organization, and construction contractor. Each proposed project is reviewed by personnel from the Environmental Surveillance Group (HSE-8) to ensure environmental integrity is maintained.

IX. ENVIRONMENTAL SUPPORT ACTIVITIES

In addition to environmental surveillance and compliance activities, the Laboratory carried out a number of related environmental activities. Selected studies are briefly described below. Many of these are ongoing and provide information for surveillance and compliance activities at the Laboratory.

A. Meteorological Monitoring (Brent Bowen, Jean Dewart, William Olsen, I-li Chen, and Margaret Salazar)

1. Weather Summary. Los Alamos received heavy precipitation for the third consecutive year, with 60 cm (23.6 in.) of water equivalent falling during 1987. Much of the precipitation was from record snowfall in January and February and from heavy rainfall in May and June. Snowfall totaled a record 453 cm (178.4 in.) for the year, over 3.5 times normal. Record snow fell in both January and February, including a record 122 cm (48 in.) from one storm during January. Heavy rains fell during May and locally (TA-59) during June. Temperatures were quite warm during October. Arctic air and several storms gave Los Alamos a cold December with near-record snowfall. The year as a whole had slightly cooler than normal temperatures. The annual summary is shown in Fig. 25 and other data are shown in Table G-63 through G-66.

A stormy pattern became established over the southwestern United States during January. One storm dropped nearly 25 cm (10 in.) on Los Alamos during the 7-8th and the record snowfall from one storm fell during the 15-17th. Even larger accumulations of 152-178 cm (60-70 in.) were reported in northern Los Alamos. The storm closed the Laboratory and the townsite. The locally large snowfall resulted from a stationary storm in Arizona forcing relatively warm air northward over the Pajarito Plateau and an arctic air mass. Only several inches fell in the Rio Grande Valley and Santa Fe. The snowfall helped give Los Alamos its snowiest month on record of nearly 165 cm (65 in.), exceeding the old record by nearly 61 cm (2 ft). Also, the 102 cm (40 in.) of snow on the ground on the 16th and 17th set a record. After 5 cm (2 in.) of snowfall two days later, temperatures rose dramatically, reaching 12.2°C (54°F) on the 27th. Except for another 10 cm (4 in.) of snow on January 31st, temperatures remained warm through the middle of February, with the snow cover shrinking to 2.5 cm (1 in.) by the 14th. The stormy pattern returned, however, with a 11.4 cm (4.5 in.) snowfall on the 16th. Then, an intense storm dropped nearly 68 cm (27 in.) of snow during the 18-20th, including 51 cm (20 in.) on the 19th. This snowfall became the largest for February on record. A week later, another storm dropped 43 cm (17 in.) of snow during the 24-26th. Some of the snow was accompanied by thunder and lightning. The total snow of 123 cm (48.5 in.) was the largest on record for February and second only to the previous month for all months. In addition, this month became the wettest February on record with 7.1 cm (2.78 in.) of water equivalent precipitation.

Winter weather moderated during March, with near-normal weather. Except for a storm that dropped 30 cm (12 in.) of wet snow on April 4-5th, warm weather prevailed during April. Frequent thundershowers produced 7.2 cm (2.83 in.) of rain during May, nearly 2-1/2 times the normal. One thunderstorm produced up to 7.6 cm (3 in.) of hail on the 23rd.

The summer began with a downpour at TA-59 on June 7th. A local thunderstorm dropped 5.5 cm (2.16 in.) of rain, with 5.4 cm (2.11 in.) falling in two hours. The two hour rainfall represented a near 50 year rainfall. Very little or no rain fell at other sites. Rainfall was scant in July with 3.5 cm (1.37 in.), less than half of normal. Rainfall was normal during August with 10.9 cm (4.29 in.). Thunderstorms produced a funnel cloud on the 24th and numerous funnel clouds on the 25th near Santa Fe.

Near-normal weather conditions prevailed during September. A strong high-pressure system centered over the Western United States gave Los Alamos a warm and dry October. High temperatures for the month averaged (19.1°C) (66.4°F), nearly 2°C (4°F) above normal. Rainfall was light at 1.2 cm (0.49 in.), less than one-third of normal. Near-record snows fell during December, with a total of over 91 cm (36 in.). The biggest snowfall of 48 cm (19 in.) on the 24-25th gave Los Alamos its whitest Christmas on record, with 41 cm (16 in.) of snow on the ground. The year ended with 453 cm (178.4 in.) of snow, exceeding the previous record of 287 cm (112.8 in.) set in 1984.

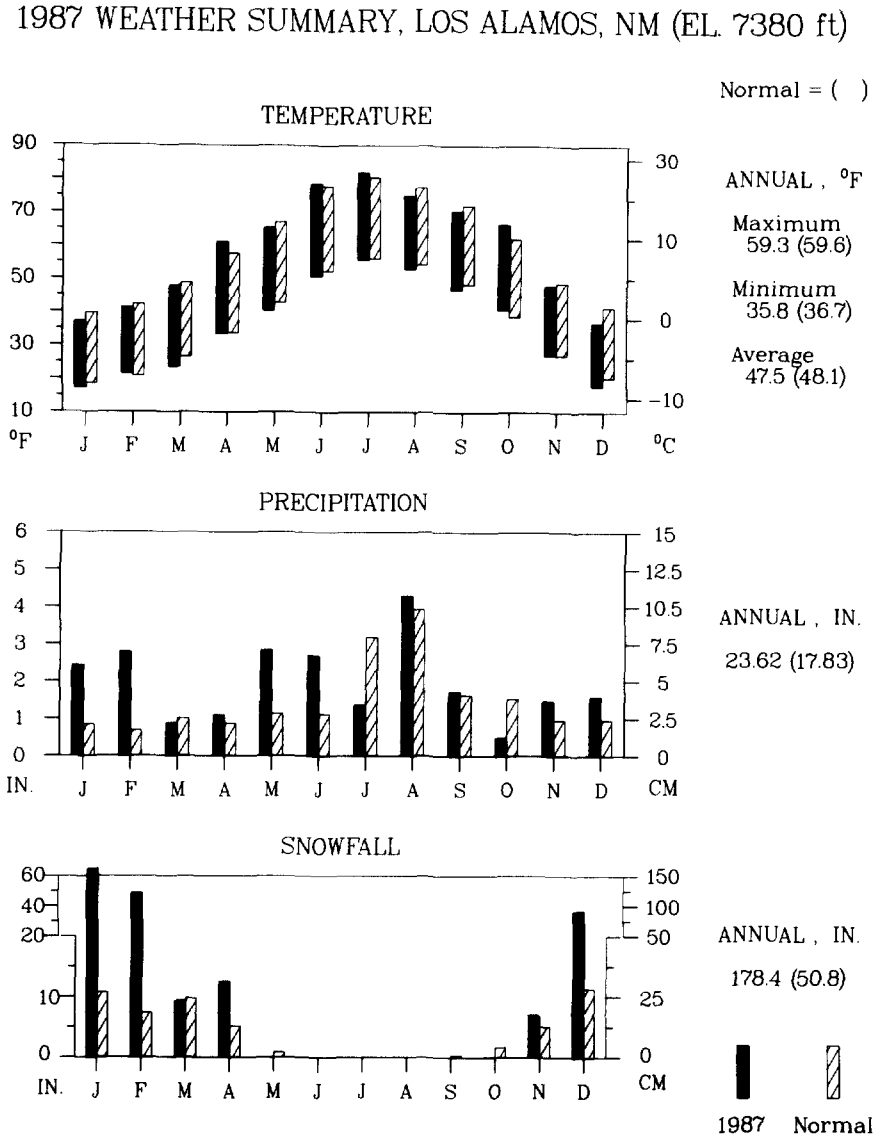


Fig. 25. Summary of 1987 weather in Los Alamos (data from Occupational Health Laboratory, OHL, TA-59.

2. Wind Roses. The 1987 surface wind speed and direction measured from three sites at Los Alamos are plotted in wind roses for day, night, and total hours (Figs. 26 through 28). A wind rose is a circle with lines extending from the center representing the direction *from* which the wind blows. The length of each line is proportional to the frequency of the wind speed interval from that particular direction. Each direction is one of 16 primary compass points (N, NNE, etc.) and is centered on a 22.5 sector of the circle. The frequency of the calm winds, defined as those having speeds less than 0.5 m/s (1.1 mph), is given in the circle's center. Day and night are defined by the times of sunrise and sunset.

The wind roses represent winds at TA-50 (2216 m above sea level or MSL [7019 ft]), East Gate (2140 m MSL [7019 ft]), and Area-G (2039 m MSL [6688 ft]). Surface winds were measured at a height of about

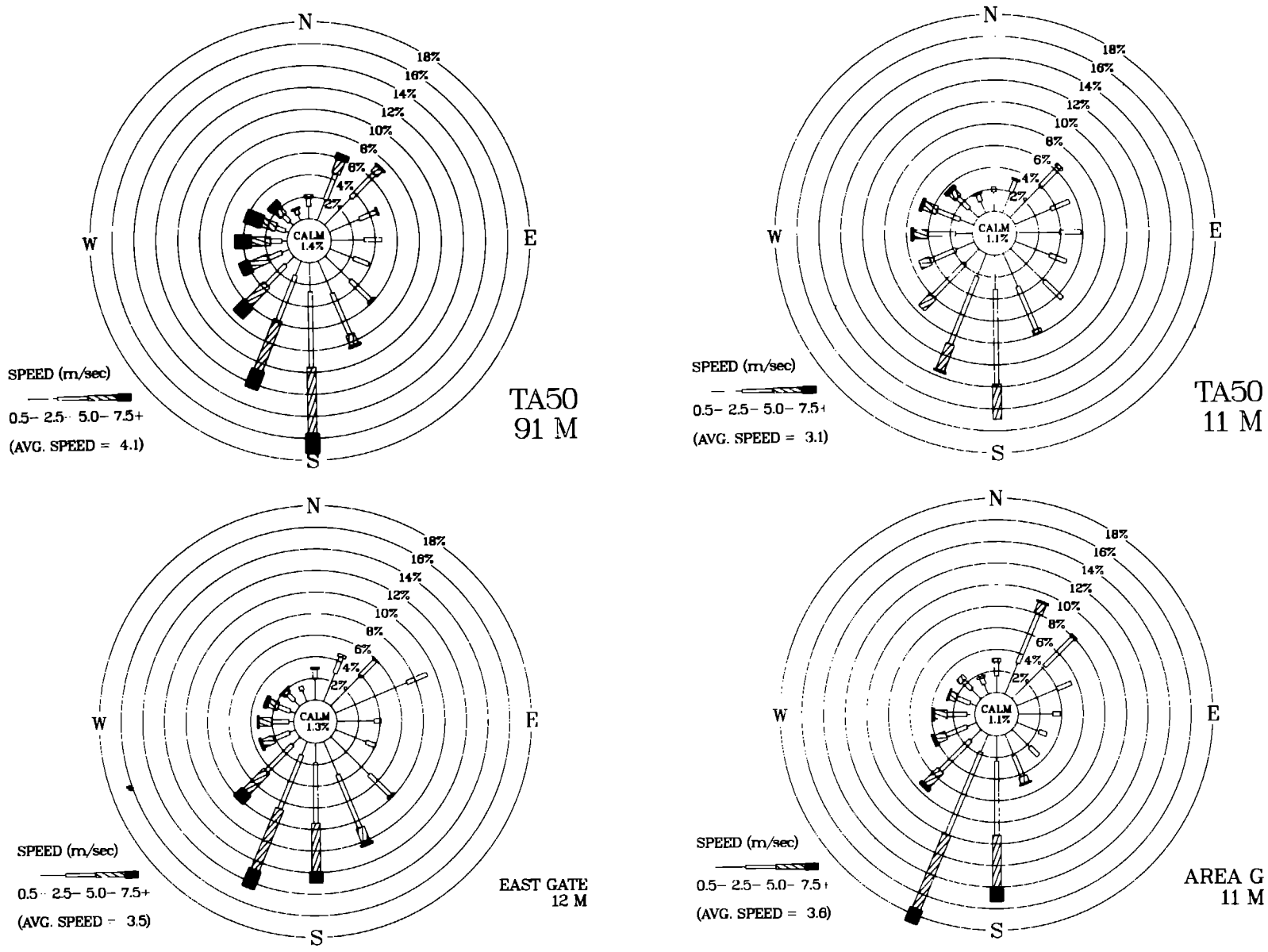


Fig. 26. Daytime wind roses at Laboratory stations during 1987.

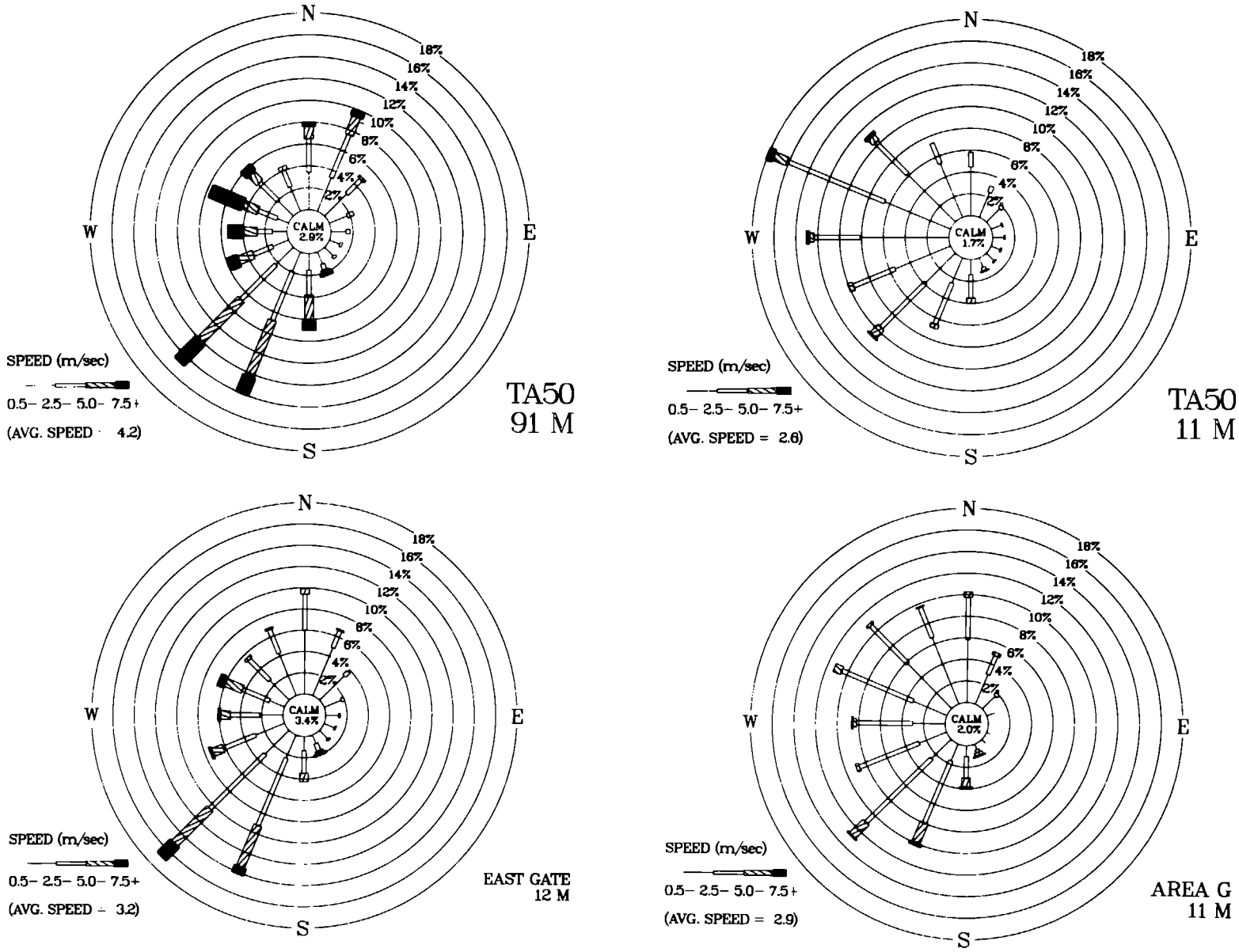


Fig. 27. Nighttime wind roses at Laboratory stations during 1987.

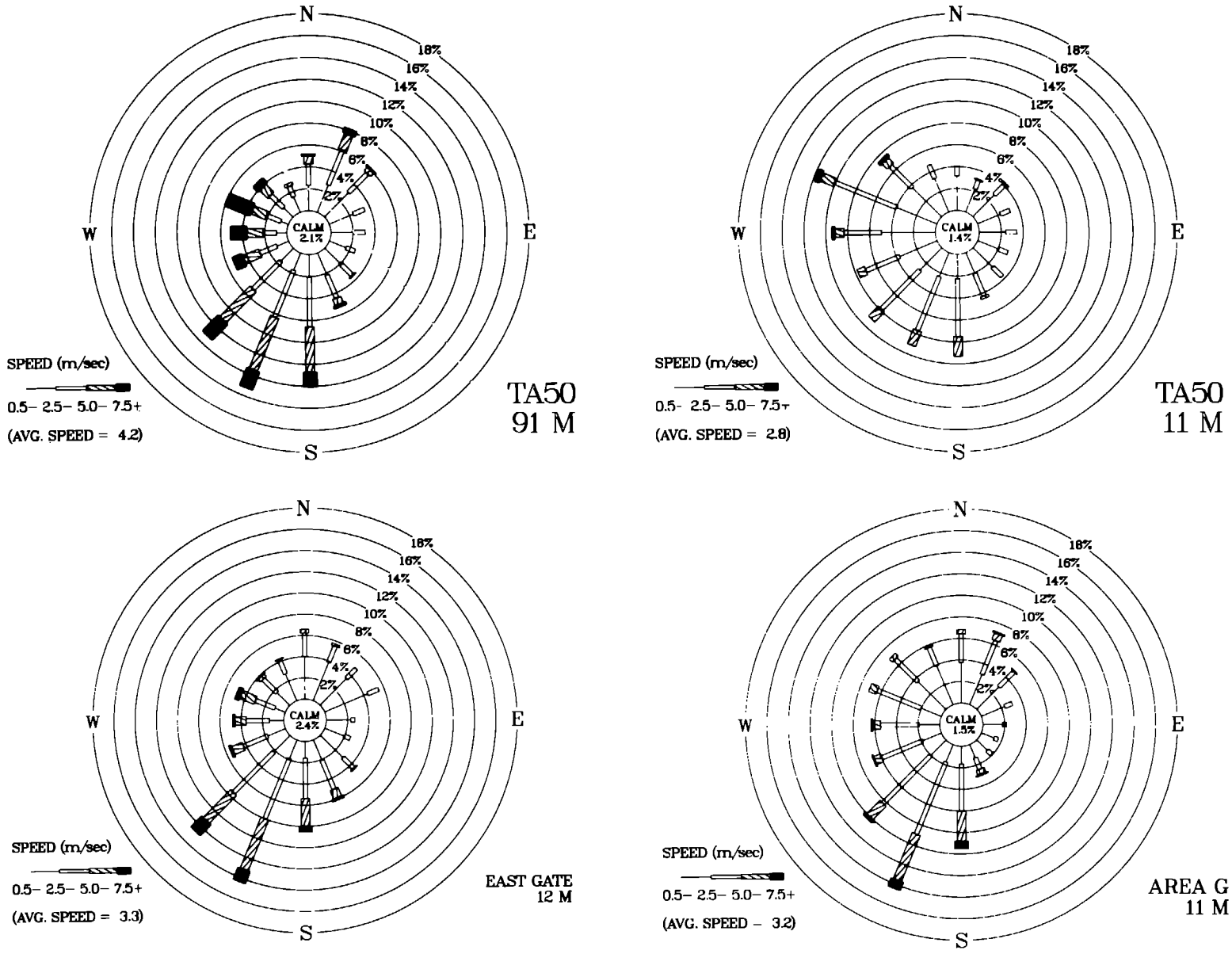


Fig. 28. Cumulative wind roses at Laboratory stations in 1987.

11 m (36 ft) at the three sites and an upper level wind rose is shown for the 91 m (300 ft) level at TA-50. Data recovery exceeded 96% at all sites.

Surface winds at Los Alamos are generally light with the average speed of nearly 3 m/s (7 mph). Wind speeds greater than 5 m/s (11 mph) occurred with frequencies ranging from 10% at TA-50 to 21% at East Gate. Many of the strong winds occurred during the spring. Over 40% of surface winds at all sites were less than 2.5 m/s (5.5 mph). The average wind speed increases to over 4 m/s (9 mph) at 91 m (300 ft). Wind speeds greater than 5 m/s (11 mph) occurred 34% of the time while speeds less than 2.5 m/s (5.5 mph) occurred 29% of the time at the higher level.

Distribution of winds varies with site, height above ground, and time of day primarily because of the terrain features found at Los Alamos. On days with sunshine and light large-scale winds, a deep, thermally driven upslope wind develops over the Pajarito Plateau. Note the high frequency of SE through S winds during the day at TA-50 (both levels) and East Gate (Fig. 26). Upslope winds are generally light, less than 2.5 m/s (5.5 mph). Winds become more SSW and S at Area G (i.e., at lower elevations). The winds here are more affected by the Rio Grande Valley than the plateau. Channeling of regional-scale winds by the valley contributes to the high frequency of SSW and NNE or NE winds. In addition, a thermally driven up-valley wind probably causes some of the SSW winds under 2.5 m/s (5.5 mph) at Area G.

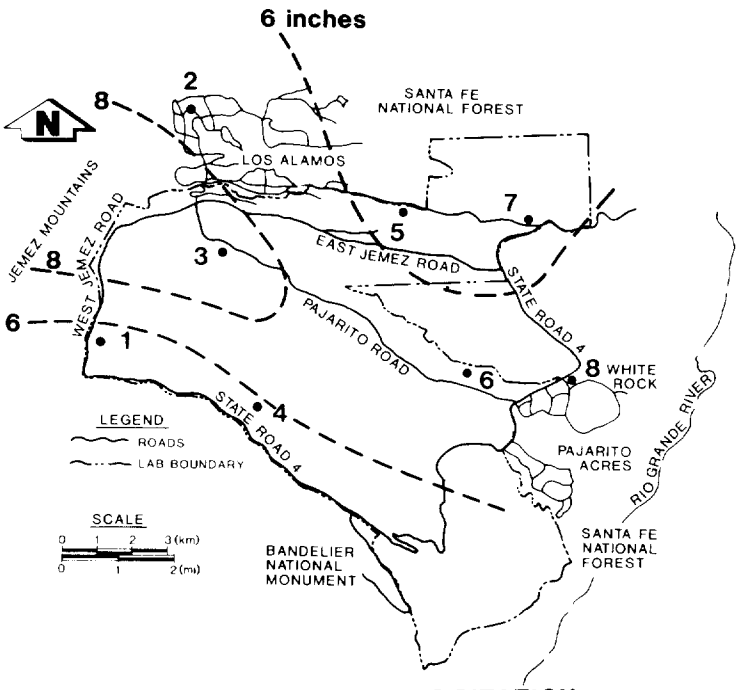
Winds display a reversal during the night. A shallow drainage wind often forms and flows down the plateau on clear nights with light, large-scale winds. These winds are generally less than 2.5 m/s (5.5 mph). Surface wind peaks from the NW through W are evident at TA-50, whereas the drainage wind at Area G is evenly distributed from the WNW through the N. Downslope winds are much less frequent at East Gate. The TA-50 wind rose at 91 m (300 ft) shows dramatically different winds from those at the surface, with valley-channeled winds dominating. A high frequency of winds are up-valley (SW and SSW) and down-valley (N through NE). Note that less frequent channeled winds also occur at the lower sites, East Gate and Area G, during the night.

3. Precipitation Summary. Precipitation in Los Alamos County was heavy during 1987, with as much as 61 cm (24 in.) falling in the North Community and at TA-59. Figure 29 shows analyses of rainfall for the summer season (June-August) and the entire year. Monthly precipitation totals are presented in Table G-64. Record January and February and near-record December snowfalls helped to push 1987 precipitation to about 30% above normal at the western sites near the Jemez Mountains. Summer rainfall was generally below normal. The maximum area of summer rainfall included TA-59. A thunderstorm dumped 5 cm (2 in.) of rain locally at TA-59 during a single day in June. Precipitation was generally the highest in the northwestern part of the area, near the mountains and where the highest terrain is. Precipitation decreased with decreasing elevation and distance from mountains.

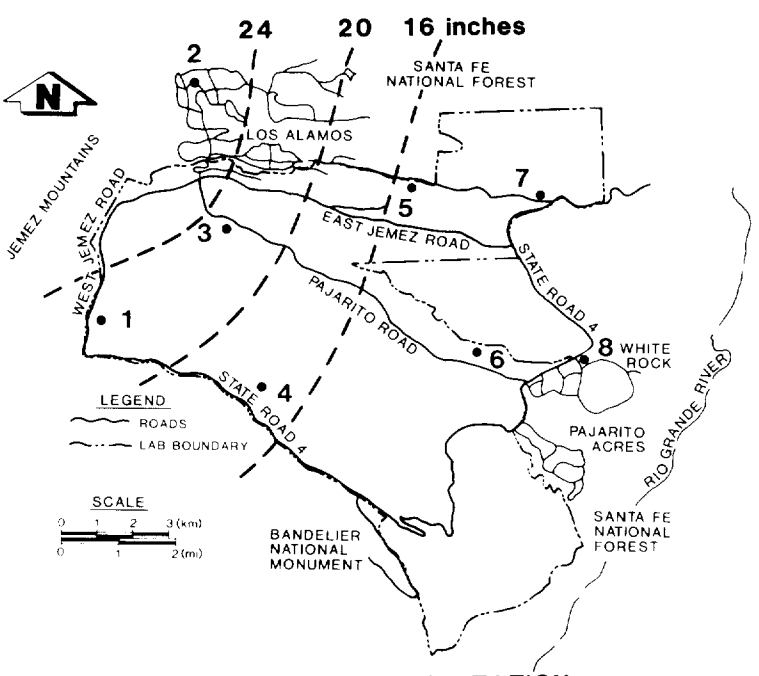
B. Environmental Restoration (ER) Program (Kenneth Rea, Robert Vocke, Roger Ferenbaugh, Robert Gonzales, Marjorie Martz-Emerson, Betty Perkins, and Alan Stoker)

The DOE facilities operate under a policy of full compliance with applicable environmental regulations. The DOE's Albuquerque Operations Office (AL) Environmental Restoration (ER) Program is being implemented to help fulfill that commitment at installations within the AL complex, including facilities in California, Colorado, Florida, Missouri, New Mexico, Ohio, and Texas. The program assists DOE in setting environmental priorities and in justifying funding enhancements of existing programs or remedial actions. Implementation of the ER Program is being accomplished through the combined efforts of the AL complex. The Laboratory is providing programmatic guidance/management and technical support to AL for ER implementation.

The program is designed to identify, assess, and correct existing or potential environmental concerns. The scope includes the review of major environmental regulations, with emphasis on CERCLA/SARA and RCRA. The program includes evaluation of management practices for hazardous substances. Additionally, assessment of pollution control of and monitoring programs for hazardous substances emphasizes both adequate understanding of environmental pathways and regulatory compliance. Implementation of the ER Program is intended to help fulfill DOE's obligations for federal facilities under the EPA's CERCLA/SARA. The program was initially implemented in five phases (i.e., Installation Assessment, Remedial Investigation, Feasibility Study, Remedial Action, and Compliance and Verification).



1987 SUMMER PRECIPITATION



1987 TOTAL PRECIPITATION

Fig. 29. Summer (June-August) and annual rainfall during 1987 (inches).

During 1987, the Phase I reports for Pinellas, Sandia National Laboratories-Livermore and Los Alamos National Laboratory were released to the EPA and appropriate states. The Phase I reports for the other major AL installations were released in 1986.

Remedial investigation plan (RIP) development and remedial investigations proceeded at all eight AL installations during 1987. The installation generic monitoring plans (IGMPs) that have been prepared for each DOE/AL installation are being tiered to the DOE/AL CERP generic monitoring plan (CGMP), which was prepared during 1986. Remedial investigation plans that will be prepared for each AL installation will be tiered to the appropriate IGMP.

The draft Phase I report for Los Alamos was released to the state of New Mexico and the EPA during October 1987. The Laboratory's IGMP will be ready for internal review during early 1988. Several site-specific RIPs will be prepared for the Laboratory during 1988.

Remedial investigations at Los Alamos during 1987 consisted of the White Rock Y and the Potrillo Canyon studies. Reconnaissance geophysics studies were also conducted at TA-21. Additionally, substantial information was acquired for preparing site-specific RIPs at TA-21, TA-33, and TA-49.

C. Vadose Zone Characterization at Areas L and G (Alice Barr, Anthony Grieggs, and David McInroy)

The Resource Conservation and Recovery Act (RCRA) requires that hazardous waste disposal facilities such as the Laboratory either (1) perform ground water monitoring, or (2) obtain a waiver of ground water monitoring requirements, provided there is a low potential for migration of hazardous waste or constituents from the disposal areas to water supply wells via the uppermost aquifer. A vadose zone (unsaturated zone above the main aquifer) characterization program was initiated to substantiate the Laboratory's request for a ground water monitoring waiver.

At Areas L and G (TA-54), the uppermost aquifer is approximately 300 m (1000 ft) below the surface. The zone above the aquifer (the vadose zone) was studied to characterize its hydrogeology and evaluate the potential for contaminant migration. Data were collected to determine intrinsic permeability, moisture characteristic curves, unsaturated hydraulic conductivity, pore gas distribution, and actual contaminant presence in the vadose zone. Several conclusions were reached from this study, including the following: (1) the dominant mechanism of subsurface transport is through vapor phase migration--aqueous transport of contaminants is highly unlikely; (2) perched water is confined to the alluvium in the adjacent canyon and does not extend beneath the mesa or connect hydraulically to the main aquifer; (3) some metal contamination exists at shallow depths in Area L; (4) organic vapor contamination exists in Areas L and G; (5) no contamination was evident in the perched canyon water; and (6) vertical cooling fractures are present in the disposal areas but their ability to transport contaminants and water has not been determined. A final report presenting these findings and the data collected was submitted to the NMEID's Hazardous Waste Program on March 31, 1987.

The analytical results of this study indicated the presence of organic vapor contamination at depths up to 30 m (100 ft). As a result, the Laboratory has initiated a program to determine the vertical and horizontal extent of this contamination and appropriate remediation, if deemed necessary. The program consists of four phases: (1) an initial experimental effort to determine the most effective method for monitoring hole completion and sampling; (2) an expanded sampling and analytical program to delineate the extent of contamination; (3) interpretation of results and proposal of any necessary remedial action; and (4) the remediation itself.

The first phase is now in progress. Four different (1 existing, 3 new) borehole completions have been sampled. Initial analytical results indicate the new sampling technique is more effective in determining a concentration gradient. Also, the three new completion methods surpass the existing borehole in sensitivity, ease of installation and cost. Additional sampling will be performed to substantiate these findings before proceeding to the second phase.

D. Remedial Investigations at the Proposed White Rock Y Interchange (Lars Soholt, Richard Romero Eddie Lujan, John Salazar and Thomas Buhl)

The state of New Mexico is proposing to construct an interchange to improve the intersection of State Road 4 (SR 4) and the Main Hill Road (Alternate SR 4) into the Los Alamos townsite. The DOE intends to grant an easement to the state for construction and maintenance of the interchange on DOE-managed lands. The easement area would include

parts of Los Alamos and Lower Pueblo canyons that are known to have residual radioactivity at levels above background. This residual radioactivity is the result of liquid discharges from TA-2, TA-21, and TA-45. As part of DOE's ER Program, the Environmental Surveillance Group (HSE-8) carried out an investigation to determine if the lands were suitable for release to the state without remedial action to lower levels of residual radioactivity. The results of this remedial investigation indicate that the lands in Los Alamos and Lower Pueblo canyons are suitable for construction of the White Rock Y interchange without need for remedial action.

Above-background, residual radioactivity in Los Alamos Canyon is dominated by cesium-137 (up to 50 pCi/g) and strontium-90 (up to 13 pCi/g). Uranium and transuranics are also present at above-background levels, but activity concentrations are lower. These radionuclides have deposited in the alluvial accumulation of sediment where the canyon's stream intersects State Road 4. Within Lower Pueblo Canyon, plutonium-239 is the dominant residual radionuclide (up to 15 pCi/g), and uranium is also present at above-background levels. These radionuclides have deposited where the canyon's stream widens, upstream from its confluence with Los Alamos Canyon.

Transport pathways analyses were carried out using conservative scenarios to determine if the levels of residual radioactivity indicated that remedial action was necessary prior to granting an easement to the state. The two scenarios that were considered were:

- Construction activity in Los Alamos and Lower Pueblo canyons; and
- Removal of soil material for use in a home garden.

Potential pathways of exposure within the construction scenario include worker inhalation of dust suspended during earth-moving activities and direct exposure to gamma radiation from residual cesium-137. Within the home garden scenario, it was assumed that material was removed from the construction site for use as garden soil. Potential pathways for exposure of a home gardener include direct gamma radiation from cesium-137, inhalation of dust suspended during gardening activities, ingestion of produce grown in the garden, and ingestion of water from a nearby well which has received radionuclides leached from garden soils.

For residual radioactivity in Los Alamos Canyon, the pathways analyses resulted in a calculated commitment of 9 mrem/yr effective dose equivalent within the construction scenario and 29 mrem/yr effective dose equivalent within the home-garden scenario. For residual radioactivity in Lower Pueblo Canyon, the pathways analyses resulted in a calculated commitment of 4 mrem/yr effective dose equivalent within the construction scenario and 9 mrem/yr effective dose equivalent within the home-garden scenario. All of these doses are less than the 100 mrem/yr effective dose equivalent commitment that serves as DOE's radiation protection standard for protection of the general public. Maximum concentrations of airborne radionuclides during construction would be less than 15% of DOE's limits for exposure of the general public.

E. Environmental Monitoring at the Fenton Hill Site [William Purtymun, Roger Ferenbaugh, (HSE-9), Max Maes and Mary Williams (HSE-9)]

The Laboratory is currently evaluating the feasibility of extracting thermal energy from the hot dry rock geothermal reservoir at the Fenton Hill Geothermal Site (TA-57). The site 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 thermal 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 and ground waters in the vicinity of TA-57 (Fig. 30) has been determined for use in geohydrologic and environmental studies. These water quality studies began before construction and testing of the hot dry rock system (Purtymun 1974D). The most recent samples were collected in November 1987.

Surface water stations (13 on the Jemez River, the Rio Guadalupe, and their tributaries) are divided into four general groups based on the predominate ions and TDS (Table 26). The predominate ions are (1) sodium and chloride, (2) calcium and bicarbonate, (3) calcium and sulfate, and (4) sodium and bicarbonate. Ground water stations (five mineral and hot springs, one well, and five springs) are also grouped according to predominate ions. These ions are (1) sodium and chloride, (2) calcium and bicarbonate, and (3) sodium and bicarbonate (Table 26).

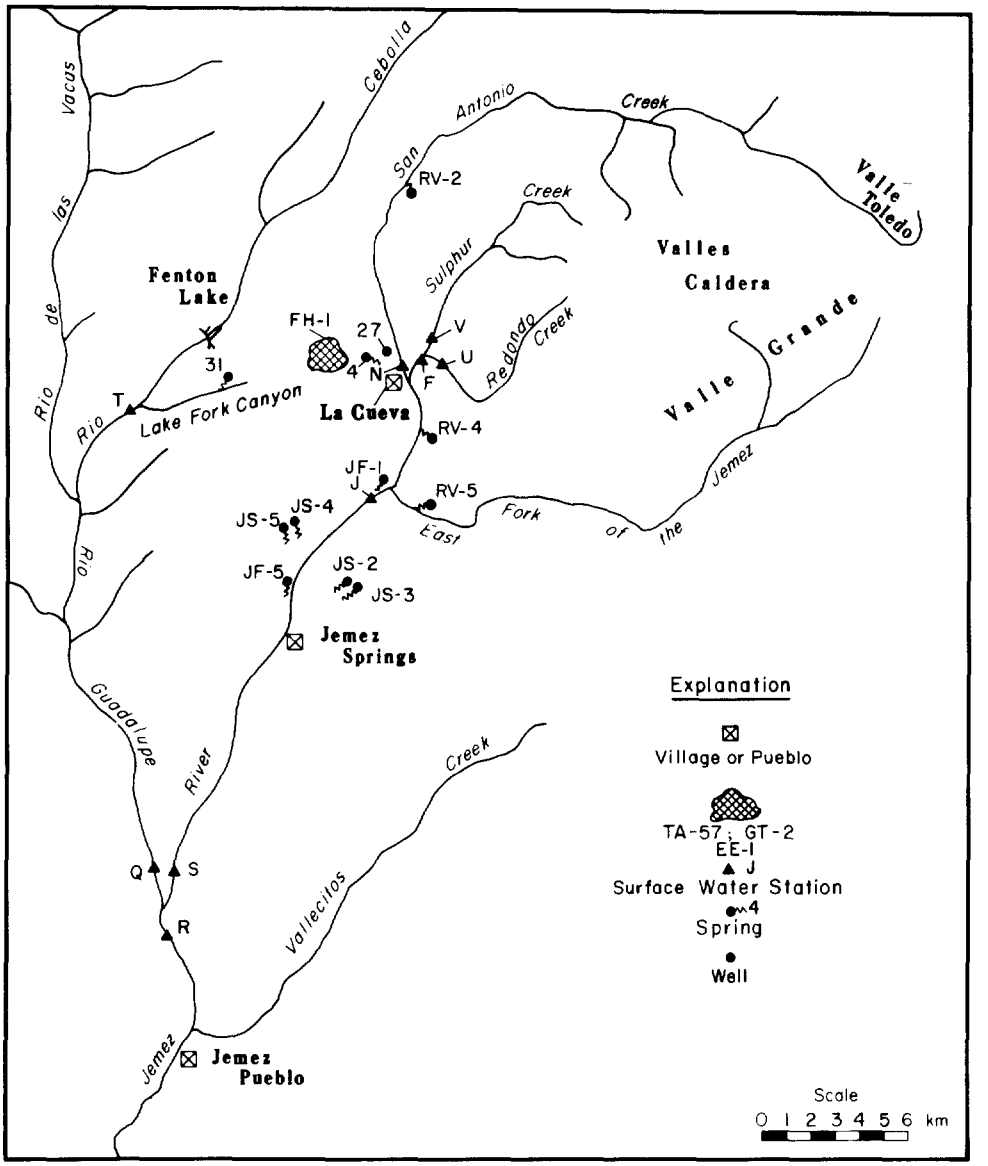


Fig. 30. Sampling stations for surface and ground water near the Fenton Hill Site (TA-57).

There were no significant changes in the chemical quality of surface and ground water at the individual stations from previous years (Purtymun 1988A).

F. Distribution of Radionuclides in Channel Alluvium of Mortandad Canyon [Donald VanEtten, William Purtymun, Max Maes, and Richard Peters (HSE-9)]

Trace amounts of radionuclides remaining in effluent are released from the treatment plant at TA-50 into the adjacent Mortandad Canyon (Table G-12). The effluent recharges a shallow body of ground water in the alluvium. The radionuclides in the effluent are adsorbed or bound to the sediments in the channel, reducing the amount found in the water of the shallow aquifer. This shallow aquifer is of limited extent and lies within the Laboratory boundary.

The sediments and radionuclides in the stream channel alluvium are subject to transport by additional releases of effluent or by storm run-off. The small drainage area of the canyon and the ability of the thick

Table 26. Quality of Surface and Groundwaters at Fenton Hill Geothermal Site
(concentrations in mg/L)
November

Surface Water

	Na	Cl	TDS
Sodium Chloride			
Redondo Creek (U)	10	15	126
Jemez River (R)	75	97	436
Jemez River (S)	85	132	388

	Na	HCO_3	TDS
Calcium Bicarbonate			
San Antonio Creek (N)	16	62	141
Rio Cebolla (T)	10	88	118
Rio Guadalupe (Q)	15	170	228
Lake Fork 1 (LF-1)	10	54	132
Lake Fork 2 (LF-2)	17	71	168
Lake Fork 3 (LF-3)	13	50	220
Lake Fork 4 (LF-4)	15	72	284

	Ca	SO_4	TDS
Calcium Sulfate			
Sulphur Creek (V)	52	305	456
Sulphur Creek (F)	28	66	150

	Na	HCO_3	TDS
Sodium Bicarbonate			
Jemez River (J)	16	59	104

Groundwater

	Na	Cl	TDS
Sodium Chloride			
Loc. JF-1 (Hot Spr)	460	1000	1940
Loc. JF-5 (Hot Spr)	960	2300	3830

	Ca	HCO_3	TDS
Calcium Bicarbonate			
FH-1 (Supply Well)	48	117	280
Loc. 39 (Spr)	13	41	52

	Na	HCO_3	TDS
Sodium Bicarbonate			
JS-2, 3 (Spr)	17	80	160
JS-4, 5 (Spr)	17	72	154
Loc. 4 (Spr)	16	55	92
Loc. 31 (Spr)	11	62	110
RV-2 (Hot Spr)	22	45	114
RV-4 (Hot Spr)	52	123	168
RV-5 (Hot Spr)	20	83	78

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[a]See Fig. 30 for sampling locations. One sample taken at each location.

section of unsaturated alluvium to store the run-off has prevented transport to the Laboratory boundary. To confine the surface run-off and contaminants within the Laboratory, there has been a series of sediment traps installed in the canyon since early 1970. The traps range from gravel-filled galleries to stilling basins that contain suspended solids as well as bed sediment (alluvium).

A storm on June 7, 1987, produced a record 50-year, 2-hr rainfall of 5.5 cm (2.16 in.). The rainfall resulted in the largest run-off event in Mortandad Canyon since hydrologic studies began in 1960. The peak discharge in the upper canyon at gaging station GS-1 was estimated to be 4.5 m^3/s (160 ft^3/s [cfs]). Two other large run-off events occurred in August 1968 (3.2 m^3/s [115 cfs]) and November 1987 (2.9 m^3/s [102 cfs]). The peak discharge at the sediment traps of the June 1987 event was about 3 m^3/s (100 cfs). The run-off filled the two sediment traps and overflowed into the third. The estimated volume of run-off was 3500 m^3 (930 000 gal.).

A set of sediment samples were collected in the canyon on June 16 and analyzed for transuranics and gamma emitting radionuclides (Fig. 31). The concentrations of plutonium and americium above the effluent outfall from TA-50 (stations 1, 2, and A) were background (Table 27). The ^{238}Pu concentrations between gaging station GS-1 to station 7 just above the sediment trap ranged from 3.3 to 11.7 pCi/g, and the $^{239,240}Pu$ in the same reach of canyon ranged from 12.2 to 39.3 pCi/g. The ^{241}Am for this same sampling area ranged from 11.72 to 33.81 pCi/g. The largest concentrations of transuranics in sediments were in sediment trap 1 with 18 pCi/g of ^{238}Pu, 58.9 pCi/g of $^{239,240}Pu$, and 79.50 pCi/g of ^{241}Am. The concentrations decreased in trap 2 and decreased further in trap 3. All of the bed sediments and most of the suspended sediments were retained in trap 1, resulting in higher concentrations here than in traps 2 and 3.

Gamma-emitting radionuclides followed the same trends as transuranics (Table 28). The concentrations above the effluent outfall were background. The highest concentrations were for ^{137}Cs with a range from 15.3 to 62.9 pCi/g in the channel above the traps and 96.7 pCi/g in trap 1. Trace amounts of ^{134}Cs, $^{59,60}Co$, and ^{75}Se were found in the channel sediment samples with the highest concentrations in the sediment traps.

The sediments from traps 1 and 2 were analyzed using EPA's toxic characteristic leach procedure (TCLP) to identify hazardous wastes. Analyses were carried out for pesticides (8 compounds), extractable organics (15 compounds), volatile organics (18 compounds), and metal (8 elements). None of these were detected.

Previous run-off events have not been contained in the area of the sediment traps. The analyses of sediments below the traps indicated that run-off events had carried radionuclides to station 10. Below station 10 and still within the Laboratory, the concentrations of radionuclides were at or below background. The

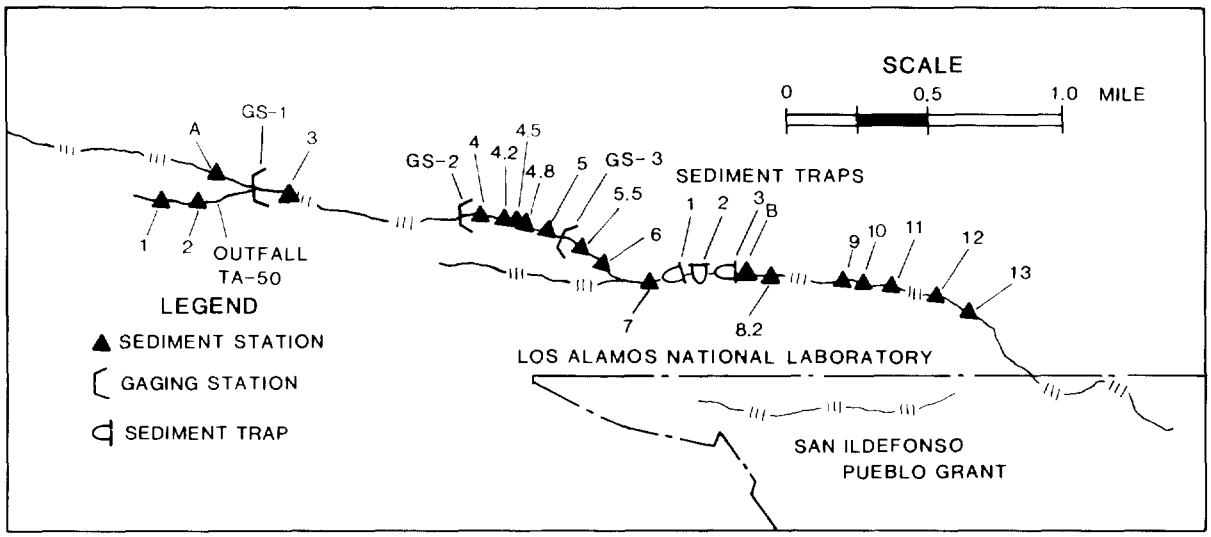

Fig. 31. Sediment sampling stations in Mortandad Canyon.

Table 27. Transuranics in Mortandad Canyon Channel Alluvium, June 16, 1987[a]

Station	^{238}Pu (pCi/g)		$^{239,240}Pu$ (pCi/g)		^{241}Am (pCi/g)	
Effluent Canyon						
1	0.012	(0.007)	0.024	(0.011)	-0.008	(0.002)
2	0.011	(0.006)	0.033	(0.011)	0.130	(0.050)
TA-50 Outfall	0.712	(0.058)	1.81	(0.107)	0.970	(0.050)
Mortandad Canyon						
A	0.005	(0.009)	0.033	(0.010)	0.02	(0.002)
GS-1	3.91	(0.330)	16.2	(1.20)	11.72	(0.14)
3	7.69	(0.580)	17.6	(1.30)	16.79	(0.17)
GS-2	7.00	(0.560)	24.6	(1.80)	31.96	(0.24)
4	7.27	(0.550)	26.2	(1.80)	33.81	(0.24)
4.2	11.7	(0.070)	39.3	(2.30)	22.08	(0.20)
4.5	4.69	(0.37)	18.9	(1.30)	19.85	(0.20)
4.8	4.26	(0.390)	18.1	(1.40)	28.76	(0.22)
5	7.11	(0.690)	29.7	(2.20)	20.51	(0.19)
GS-3	4.67	(0.450)	20.1	(1.60)	22.60	(0.19)
5.5	5.67	(0.430)	24.5	(1.60)	27.71	(0.22)
6	6.29	(0.610)	16.2	(1.40)	14.60	(0.16)
7	3.30	(0.171)	12.2	(0.519)	16.53	(0.17)
Sediment Trap 1	18.2	(1.30)	58.9	(3.90)	79.50	(0.40)
Sediment Trap 2	9.71	(0.750)	35.8	(2.60)	51.42	(0.31)
Sediment Trap 3	2.06	(0.126)	7.06	(0.329)	10.11	(0.13)
3	2.13	(0.24)	7.17	(0.64)	12.53	(0.15)
8.2	0.105	(0.018)	0.399	(0.037)	0.56	(0.03)
10	0.09	(0.02)	0.33	(0.04)	0.31	(0.03)
11	0.095	(0.024)	0.330	(0.042)	0.01	(0.002)
12	-0.025	(0.017)	0.010	(0.012)	0.1	(0.01)
13	-0.010	(0.011)	0.089	(0.020)	0.8	(0.002)

[a]Location of sediment stations shown on Fig. 31; counting uncertainty in parentheses.

maintenance of the sediment traps is essential to contain residual radioactivity within the Laboratory boundaries.

G. Underground Storage Tanks (James White, Alice Barr, David McInroy, and Steven McLin)

Subtitle I of the Hazardous and Solid Waste Amendments to the Resource Conservation and Recovery Act has broadened the scope of underground tank regulations. Previously, only Subtitle C of RCRA regulated those underground tanks that contained hazardous waste. Subtitle I now brings underground tanks that contain regulated substances under RCRA regulation. Along with the requirement for EPA to promulgate specific regulations, several major provisions have been included in this new program. Among them are: the requirement to notify of existing tanks; the provision granting EPA authority to inspect the test tanks and to enforce regulatory requirements through the use of administrative orders, injunctions or civil penalties; the provision subjecting tanks controlled by the federal government to Subtitle I; and the requirement to satisfy statutory standards for new tanks.

Table 28. Radionuclides in Mortandad Canyon Channel Alluvium, June 16, 1987[a]

Station	^{137}Cs (pCi/g)	^{134}Cs (pCi/g)	^{60}Co (pCi/g)	^{57}Co (pCi/g)	^{75}Se (pCi/g)
Effluent Canyon					
1	0.24 (0.10)	0.11 (0.09)	0.07 (0.14)	0.39 (0.21)	-0.11 (0.14)
2	0.005 (0.07)	-0.12 (0.09)	-0.07 (0.12)	0.02 (0.14)	-0.03 (0.09)
TA-50 Outfall	0.69 (0.14)	0.28 (0.12)	0.16 (0.13)	1.56 (0.33)	0.71 (0.17)
Mortandad Canyon					
A	0.13 (0.09)	0.03 (0.08)	-0.10 (0.11)	0.09 (0.014)	0.003 (0.008)
GS-1	15.30 (2.31)	0.83 (0.17)	1.73 (0.30)	15.60 (2.36)	2.82 (0.44)
3	30.20 (4.55)	0.25 (0.18)	0.73 (0.20)	8.23 (1.26)	2.13 (0.36)
GS-2	48.90 (7.36)	0.10 (0.09)	0.40 (0.16)	4.30 (0.69)	2.00 (0.34)
4	62.90 (9.46)	0.97 (0.18)	0.35 (0.14)	3.52 (0.55)	1.92 (0.31)
4.2	31.60 (4.76)	0.34 (0.11)	0.23 (0.17)	3.00 (0.53)	1.27 (0.24)
4.5	37.30 (5.63)	0.56 (0.16)	0.18 (0.17)	1.80 (0.35)	0.73 (0.17)
4.8	43.20 (6.50)	0.78 (0.15)	0.12 (0.12)	1.99 (0.33)	1.33 (0.23)
5	23.50 (3.55)	0.29 (0.12)	0.02 (0.15)	1.75 (0.36)	0.79 (0.18)
GS-3	39.50 (5.95)	0.84 (0.16)	0.20 (0.12)	1.45 (0.25)	0.76 (0.15)
5.5	55.40 (8.33)	0.98 (0.19)	0.24 (0.12)	2.08 (0.35)	1.24 (0.23)
6	53.30 (8.01)	0.16 (0.11)	0.11 (0.16)	1.02 (0.29)	0.21 (0.12)
7	29.70 (4.48)	0.34 (0.10)	-0.18 (0.12)	0.85 (0.21)	0.34 (0.12)
Sediment Trap 1	96.70 (19.5)	0.24 (0.12)	1.36 (0.26)	11.70 (1.79)	7.64 (1.17)
Sediment Trap 2	96.50 (14.5)	1.68 (0.28)	0.71 (0.18)	5.52 (0.85)	3.41 (0.52)
Sediment Trap 3	15.10 (2.29)	0.16 (0.10)	-0.19 (0.14)	1.37 (0.36)	0.61 (0.17)
B	27.40 (4.13)	0.37 (0.16)	0.21 (0.19)	0.70 (0.32)	0.38 (0.19)
8.2	3.12 (0.48)	0.29 (0.10)	-0.14 (0.13)	0.48 (0.21)	0.07 (0.14)
10	1.60 (0.26)	0.23 (0.11)	-0.09 (0.14)	0.66 (0.22)	0.16 (0.14)
11	0.46 (0.13)	0.02 (0.08)	-0.27 (0.14)	-0.06 (0.12)	0.09 (0.09)
12	0.63 (0.15)	0.19 (0.11)	-0.20 (0.14)	0.66 (0.24)	0.01 (0.12)
13	0.23 (0.08)	-0.08 (0.09)	-0.05 (0.12)	-0.16 (0.14)	0.09 (0.09)

[a]Location of sediment stations shown in Fig. 31; counting uncertainty in parentheses.

In response to these requirements, underground storage tanks at the Laboratory were inventoried and the results submitted to New Mexico's EID. Leak testing was conducted on 27 of the 105 tanks subject to Subtitle I, and several leaking tanks were found. The major leaks were corrected. Further mitigation will be implemented as the need is identified in development of a tank management plan. An underground storage tank management program is currently being developed that will provide background information, descriptions of the tank population and associated regulatory requirements, a leak detection program, and a software package to facilitate data manipulation.

For new USTs installed after 1988, there is little difference between the newly proposed and existing regulations regardless of the substance stored. These requirements basically mandate design and construction standards, secondary containment provisions, corrosion protection, leak detection monitoring, and spill and overfill control. However, for existing USTs that hold regulated substances under Subtitle I of RCRA, there are some important differences: (1) a ten-year transition period during which existing USTs must be upgraded to new UST standards or removed from service; (2) a three to five year period during which existing USTs must be retrofitted with corrosion protection and spill prevention safeguards; and (3) a regulatory exemption for all USTs that are contained within an underground vault, or otherwise having complete secondary containment. This last provision in the proposed rules was the main driving force behind the development of a vault design concept for all new USTs at the Laboratory below.

During 1987, 32 inactive USTs that were used to store petroleum products were identified at the laboratory. The majority of these tanks were installed in the mid-1940s. These tanks were prioritized for removal according to age, tank size, and overall environmental concerns. Residual fuels in these tanks were removed by pumping and sold to a recycling firm in Albuquerque after being tested to verify their chemical composition. Complete removal of the first nine of these tanks began in August 1987 and included the removal of the tank, all associated piping, and any contaminated soils which might have been affected by leaking hydrocarbons. These excavated materials were then decontaminated before final off-site landfill disposal. Two leaded gasoline and seven diesel fuel tanks were completely removed by late October. A summary of these tanks is shown in Table 29.

During the remainder of 1987, the other twenty-three abandoned USTs were emptied of their contents. Pan Am World Services has estimated the costs of removing these twenty-three USTs at approximately $10,000 per tank; during FY 1988 Pan Am will continue removal operations as funding permits.

H. PCB Inventory at the Laboratory (Roy Bohn)

In order to comply with federal, state, and Laboratory environmental regulations, the Laboratory's Environmental Surveillance Group (HSE-8) coordinated a Laboratory-wide program to inventory and label polychlorinated biphenyls (PCBs).

A PCB hotline was installed and operated by HSE-8 personnel to record any messages or questions regarding PCB contaminated items owned or operated by any user group throughout the Laboratory. Each division appointed a PCB representative whose responsibilities included notifying HSE-8, through the PCB hotline, of any equipment owned or operated by the division that contained or was suspected to contain PCBs.

Once notified of equipment containing or suspected of containing PCBs, HSE-8 sampled the equipment and submitted the samples to the Laboratory's Health and Environmental Chemistry Group (HSE-9) for PCB analysis. The analytical results along with other information on sample origin (i.e., location and type of equipment) are entered into the HSE-8 computer data base. The equipment is then labeled either as containing PCBs (in concentrations found present) or as containing no PCBs.

The HSE-8 computer data base contains data on 931 samples analyzed for PCBs in 1987.

I. Biomonitoring of the Laboratory's Liquid Effluents (Roy Bohn and Charles Nylander)

HSE-8 has initiated a biomonitoring program at the Laboratory in support of its NPDES program. Biomonitoring is used as a strategy to evaluate the overall toxic impact of effluents without specifically identifying individual contaminants.

With over 100 NPDES permitted outfalls at the Laboratory, consistent monitoring of each effluent is not feasible. Outfalls were segregated into nine basic categories according to wastewater source. Biomonitoring samples are collected from one representative outfall of each category. Biomonitoring assays using

Table 29. Summary of Underground Petroleum Storage Tanks Removed in 1987

Tank Structure Number	Size (gallons)	Substance Stored
TA-3-318	5,000	Diesel
TA-6-47	2,000	Diesel
TA-8-60	2,000	Diesel
TA-8-61	2,000	Diesel
TA-15-52	6,000	Diesel
TA-15-274	218	Leaded Gasoline
TA-16-16	1,000	Diesel
TA-16-196	4,000	Leaded Gasoline
TA-52-12	400	Diesel

Daphnia pulex as a test organism are conducted for each representative effluent and LC50 values are calculated. To date each outfall has been sampled three times and preliminary results indicate that overall water quality of effluents is good. Biomonitoring sampling will continue in 1988.

J. National Atmospheric Deposition Program (NADP) Network Station (David Nochumson and Michael Trujillo)

Group HSE-8 operates a wet deposition station that is part of the NADP Network. The station is located at the Bandelier National Monument. Composition precipitation samples are collected on a weekly basis. The samples are initially weighed and analyzed for pH and conductivity before being sent out for the analysis of the composition of ionic species. The samples are sent out for analysis to a laboratory located at Colorado State University. Summary statistics of the data for the four latest completed quarters are presented in Table G-67.

The magnitude of the ionic species deposition was generally highest in the third quarter of 1987 and lowest during the second quarter of 1987. The amount of precipitation was also lowest during the second quarter of 1987. The amount of deposition is quite variable. This variation reflects the variability in the cleanliness of the atmosphere that the storm clouds have contacted. The ions in the rainwater are from nearby and distant as well as manmade and natural sources. High nitrate and sulfate deposition are most likely from manmade sources (motor vehicles, copper smelters, and power plants).

The natural pH of the rainfall, without manmade contribution, is unknown. The natural pH is most likely higher than 5.6, for rainwater in equilibrium with atmospheric carbon dioxide because of the contribution from alkaline soils. For the latest 4 quarters, all but two of the weekly samples had pHs below 5.6, which indicates contributions from acidic species other than carbon dioxide.

K. Vadose Zone Characterization at TA-16, Area P (Steven McLin, David McInroy, and Anthony Grieggs)

The hydrologic transmitting characteristics of the vadose zone in Area P are presently under detailed investigation. These efforts will support the ground water monitoring waiver that was requested in December 1987 as required under 40 CFR 265, Subpart F. This waiver must demonstrate that there is low potential for migration of hazardous wastes or their components from the landfill via the uppermost aquifer to water supply wells or to surface water in Canon de Valle. Based on currently available information, major potential migratory pathways from the landfill include (in decreasing order of importance): (1) surface erosion into Canon de Valle waters and subsequent sediment transport; (2) shallow percolation into the underlying unsaturated tuff with hydraulic interconnection to the surface stream; and (3) deep percolation to the major freshwater aquifer. Soluble barium nitrate is the major contaminant of concern, although other substances may also be present in the landfill. During a December 1987 survey of locations adjacent to the landfill, barium concentrations did not exceed 3 mg/L; in the

past, barium concentrations have occasionally exceeded 100 mg/L.

Five neutron moisture access wells and nine ground water monitoring wells were installed around the landfill in 1987. Additional boreholes were also located approximately 240 m (800 ft) south to verify suspected stratigraphic unit correlations within the unsaturated Bandelier Tuff and to obtain continuous core samples from a third borehole for laboratory testing. A thin veneer of alluvium (i.e., locally less than 1.5 m (5 ft) has been deposited on the floor of Canyon de Valle; however, the entire landfill site is underlaid by the Bandelier Tuff. Two major lithologic subunits were identified at Area P, based on degree of welding. The uppermost subunit varies in thickness from about 40 to 60 m (140 to over 200 ft) and consists of unsaturated, friable to moderately welded, yellowish-brown tuff. The lower subunit is also unsaturated, and consists of a densely welded, grey tuff. The top of the major freshwater aquifer is estimated to be between 240 and 370 m (800 and 1200 ft) below the surface of Area P.

Continuous core samples were recovered from well P-16A, located immediately south of the western portion of the Area P landfill. Total borehole depth was about 25 m (80 ft); this test hole was converted to a neutron moisture access well when 2.5-in. aluminum casing was set. Laboratory testing on selected core segments included a determination of saturated hydraulic conductivity utilizing both a constant and falling head procedure, moisture retention characteristics using the hanging column and pressure plate apparatuses, initial gravimetric and volumetric moisture contents, bulk density, porosity, and unsaturated hydraulic conductivity as a function of both negative pore pressure head and volumetric moisture content. This information will be utilized in a numerical simulation of potential barium migration from the landfill through these upper Bandelier Tuff units in order to evaluate the likelihood deep ground water contamination. A detailed water balance computation and sediment erosion characterization study for Canon de Valle will complete the efforts required under the waiver request.

L. Environmental Studies of TA-49 (William Purtymun, Alan Stoker, and Max Maes)

From 1959 to 1961, hydronuclear experiments were conducted in underground shafts at the Laboratory's TA-49. Area TA-49 is located on Frijoles Mesa in the southwest corner of the Laboratory between TA-28 and TA-33 (Fig. 4). These experiments involved a combination of conventional (chemical) high explosives, usually in a nuclear weapon configuration, and fissile material whose quantity was reduced far below the amount required for a nuclear explosion. A total of 35 hydronuclear experiments and 9 related equation-of-state and criticality experiments, all involving some fissile material, were conducted. Other experiments involving high explosives, but no fissile materials, were conducted through the same period.

A total of about 41 kg (90 lb) of plutonium, 93 kg (200 lb) of enriched uranium, 82 kg (180 lb) of depleted uranium, and 15 kg (33 lb) of beryllium was utilized. These materials were dispersed in the bottoms of the shafts by detonation of the conventional (chemical) high explosives.

Some plutonium contamination was measured at the surface in one experimental area in December 1960 and was traced to cuttings from a shaft drilled during October and November. Plutonium had apparently been dispersed through fractures in the tuff by the detonation of an experiment in an adjacent, experimental shaft. All surface soil contamination ascertainable by standard procedures and instruments of the time was cleaned up and placed back in the shaft from which it originated (Purtymun 1987B).

Three deep test wells (DT-5A, DT-9, and DT-10) are drilled from the surface of the mesa at TA-49 into the main aquifer of the Los Alamos area (Fig. 23). The depth to the main aquifer is about 360 m (1200 ft). There is no water perched in beds between the surface of the mesa and top of main aquifer. The chemical and radiochemical quality of water from these wells indicated no contamination from activities at TA-49 (Sec. VI).

Eleven sediment surface stations were established in 1972 in natural drainage from the experimental areas. A twelfth station was added in 1981 as the drainage was changed (Fig. 32). Samples collected in 1986 and 1987 indicated sediments at Station A-3 contained plutonium concentrations in excess of background (Table G-68). The concentrations are below cleanup levels (100 pCi/g) and are from the chemistry building (removed) at Area 11. The ^{3}H, ^{137}Cs, total U and gross gamma analytical results were at or near background levels.

Sediments from the twelve stations were analyzed for chemical constituents extracted from sediments downgradient from the experimental area (Fig. 31). The results of the analyses indicated constituents were

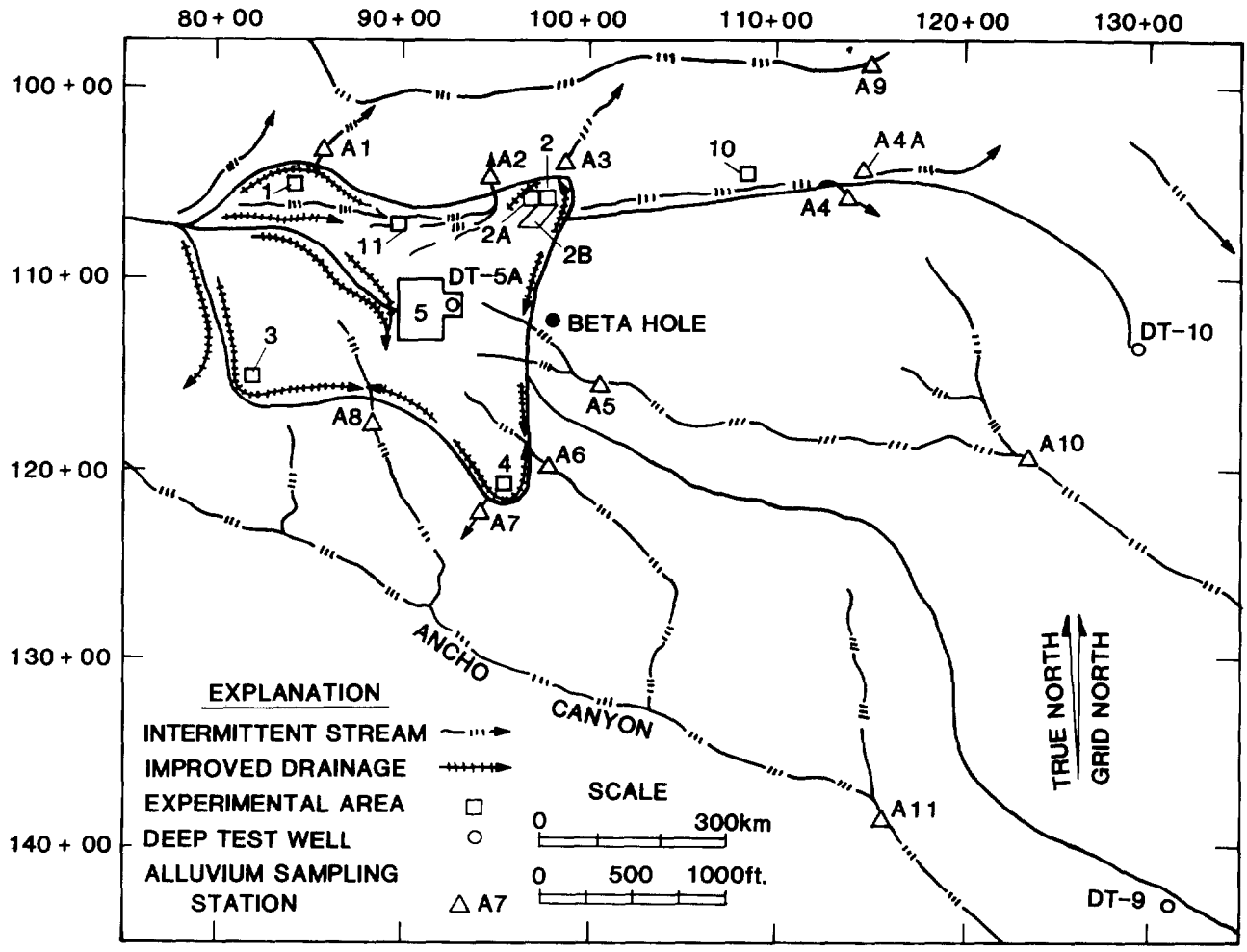

Fig. 32. Location of experimental areas and test wells at TA-49.

below limits of detection or EP toxic criteria concentrations where applicable (Table G-69).

Storm run-off samples were taken from four stations in late August and early September. The ^{137}Cs and plutonium in solution and plutonium in suspended sediments were at or below background indicating no detectable transport in storm run-off (Table G-70).

The chemical quality of the run-off contained only naturally occurring constituents (Table G-71).

M. Quality of Surface and Ground Water Adjacent to the Los Alamos National Laboratory: Organic Compounds (William Purtymun, Roger Ferenbaugh, and Max Maes)

Surface and ground water samples were collected from 43 stations representing the major occurrences of natural and municipal water and industrial and sanitary effluents in the Los Alamos area (Fig. 33). The

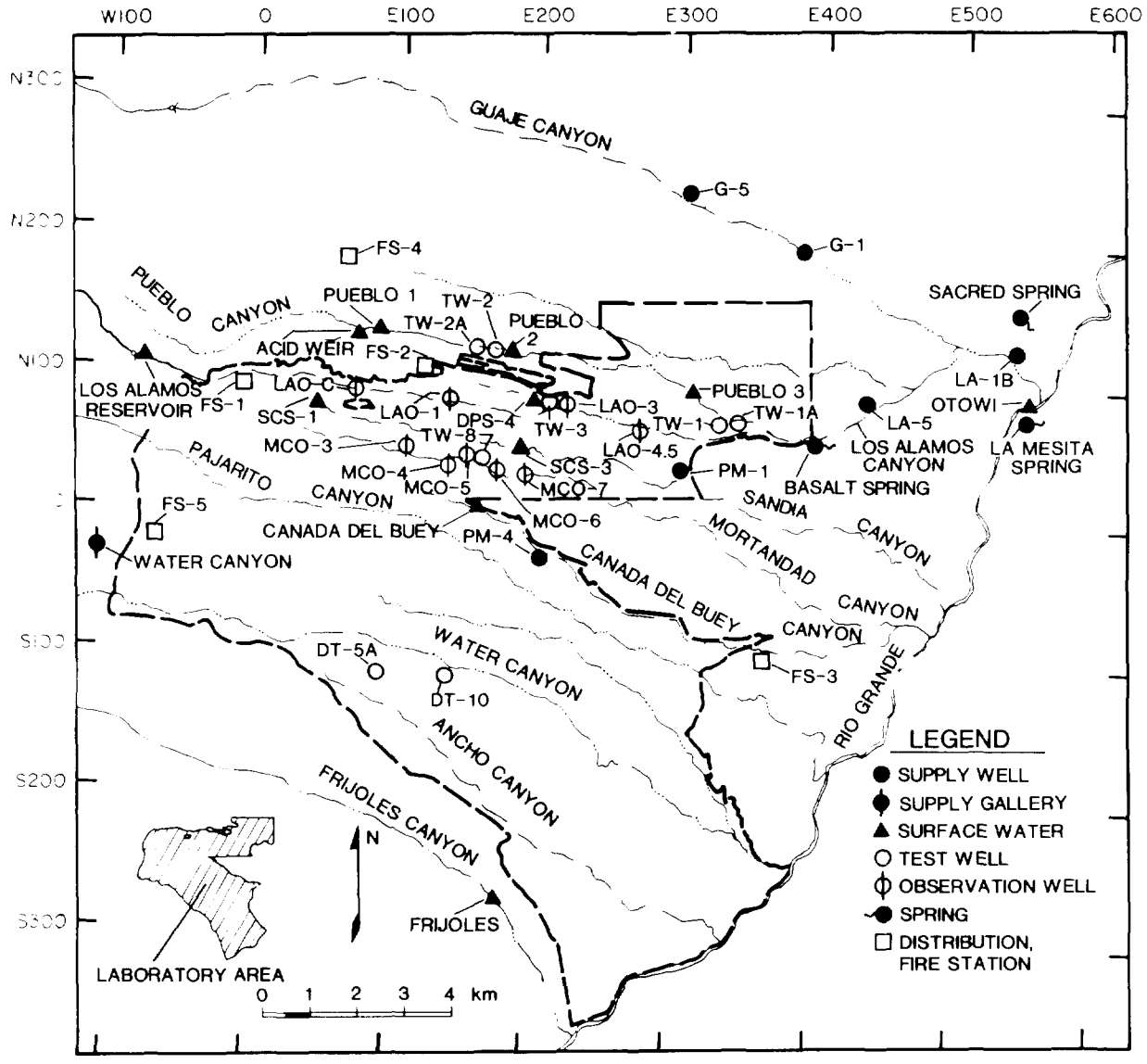

Fig. 33. Surface and ground water locations sampled for organic analyses.

samples were analyzed for volatile organics (35 compounds), semi-volatile organics (65 compounds), BNA fraction, pesticides (20 compounds), herbicides (3 compounds), polychlorinated biphenyls (7 compounds), and cyanides. The investigation was made to investigate possible areas of organic contamination for further study; however, the impact of organic contamination in surface and ground water is minimal. A limited program of organic monitoring will be incorporated into the annual surveillance of surface and ground water in and adjacent to the Laboratory at Los Alamos (Purtymun 1988).

N. Radiation Levels from LAMPF Emissions (Brent Bowen, William Olsen, I-li Chen, and Donald VanEtten)

The monitoring network of high-pressure ionization chambers (HPICs) used to measure external radiation from LAMPF emissions was expanded to seven

units during 1987. Three HPICs continued to monitor external radiation levels north, north-northeast, and northeast of LAMPF, across the Los Alamos Canyon during most of the LAMPF operating cycle, June through November. The other four units were placed at various locations for shorter periods of time. Locations included Kwage Mesa (2.0 km [1.2 mi] north of LAMPF), Bayo sewage treatment plant (2.3 km [1.4 mi] northeast of LAMPF in Bayo Canyon), locations north-northwest and east-northeast of LAMPF across Los Alamos Canyon, 0.8 km (0.5 mi) east of LAMPF, 0.5 km (0.3 mi) northwest of LAMPF in Los Alamos Canyon, sites 1.2-2.6 km (0.7-1.6 mi) south to southwest of LAMPF on mesas, and a site west-southwest of LAMPF in Mortandad Canyon. Most of the siting took advantage of the high frequency of south to southwesterly and north to northeasterly winds caused by Rio Grande Valley channeling.

Results to date confirm that the highest external radiation levels are transported toward the northeast and north-northeast. However, the highest short-term (an hour or so) levels of over 100 μR/hour were found east of LAMPF, with over the mesa transport. Higher short-term levels were also found north of LAMPF. External radiation dropped off by 50% or so with increases in downwind distance of 0.8-2.0 km (0.5-1.2 mi). Above-background external radiation was detected at all canyon sites, especially in Los Alamos Canyon, at 0.5 km (0.3 mi) downwind. Radiation levels occasionally exceeded 50-60 μR/h at this site. Much of these levels may be a result of shine of the LAMPF plume traveling overhead. Predicted external radiation levels using on-site meteorological data and release data agree well with measured concentrations at all sites.

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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. Laboratory operations are conducted in accordance with directives and procedures regarding compliance with environmental standards. These directives are contained in DOE Orders 5480.1B (Environmental Protection, Safety, and Health Protection Program for DOE Operations), 5480.1 (Environmental Protection, Safety, and Health Protection Standards) and 5480.11 (Requirements for Radiation Protection); and DOE Order 5484.1 (Environmental Radiation Protection, Safety, and Health Protection Information Reporting Requirements), Chapter III (Effluent and Environmental Monitoring Program Requirements). All of these DOE orders are being revised.

The DOE regulates radiation exposure to the public and the worker by limiting the radiation dose that can be received. 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 involves integrating the dose received from radionuclides over a standard period of time. For this report, 50-yr dose commitments were calculated using dose factors from Reference A1. The dose factors adopted by DOE are based on the recommendations of Publication 30 of the International Commission on Radiological Protection (ICRP).[A2] Those factors used in this report are presented in Appendix D.

In 1985, DOE adopted interim limits that lowered its Radiation Protection Standard (RPS) for members of the general public.[A3] Table A-1 lists currently applicable RPS for operations at the Laboratory. Concentrations of radionuclides that are measured at on-site stations are compared with DOE's Concentration Guides (CGs) for Controlled Areas as listed in DOE Order 5480.1, Chapt. 11 (Table A-2). Off-site measurements are compared with DOE's Derived Concentration Guides (DCGs) for Uncontrolled Areas, based upon a revised RPS for the general public of 100 mrem/yr effective dose equivalent.[A4] These DCGs represent the smallest estimated concentrations in water or air, taken in continuously for a period of 50 yr, that will result in annual effective dose equivalents equal to the RPS of 100 mrem. The new RPSs and the information in Reference A1 are based on recommendations of the ICRP and of the National Commission on Radiation Protection and Measurements (NCRP).[A2,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 dose from both internal and external exposure.

Radionuclide concentrations in air and water in uncontrolled areas measured by the Laboratory's surveillance program are compared to DCGs in this report. In addition to the 100 mrem/yr effective dose RPS, exposures from the air pathway are also limited by the EPA's standard of 25 mrem/yr (whole body) and 75 mrem/yr (any organ) (Table A-1). To demonstrate compliance with these standards, doses from the air pathway are compared directly with the EPA dose limits.

For chemical constituents in drinking water, standards have been promulgated by the EPA and adopted by the New Mexico Environmental Improvement Division (Table A-3). The EPA's primary Maximum Contaminant Level (MCL) is the maximum permissible level of a contaminant in water that is delivered to the outlet of the ultimate user of a public water system.[A7] The EPA's secondary water standards control contaminants in drinking water that primarily affect esthetic qualities associated with public acceptance of drinking water.[A8] 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.[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.

Table A-1. DOE Radiation Protection Standards for External and Internal Exposures

Exposure of Any Member of the Public[a]

1. All Pathways

	Annual Effective Dose Equivalent[b] at Point of Maximum Probable Exposure
Occasional annual[c] exposure	500 mrem
Prolonged annual[c] exposure	100 mrem

No individual organ shall receive an annual dose equivalent in excess of 5000 mrem.

2. Air pathway only[d]

	Annual Dose Equivalent at Point of Maximum Probable Exposure
Whole body dose	25 mrem
Any organ	75 mrem

Occupational Exposures[a]

Type of Exposure	Exposure Period	Dose Equivalent
Whole body, head and trunk, gonads, lens of the eye[e], red bone marrow, active blood forming organs	Year	5 000 mrem
	Calendar Quarter	3 000 mrem
Unlimited area of the skin (except hands and forearms); other organs, tissues, and organ systems (except bone)	Year	15 000 mrem
	Calendar Quarter	5 000 mrem
Bone	Year	30 000 mrem
	Calendar Quarter	10 000 mrem
Forearms[f]	Year	30 000 mrem
	Calendar Quarter	10 000 mrem
Hands and feet[f]	Year	75 000 mrem
	Calendar Quarter	25 000 mrem

Table A-1 (cont)

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[a]In keeping with DOE policy, exposures shall be limited to as small a fraction of the respective annual dose limits as practicable. These Radiation Protection Standards apply to exposures from routine Laboratory operation, excluding contributions from cosmic, terrestrial, 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 Reference A3. 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]For the purposes of DOE's Radiation Protection Standard, a prolonged exposure will be one that lasts, or is predicted to last, longer than 5 years.

[d]These levels are from EPA's regulations promulgated under the Clean Air Act(40 CFR 61, Subpart H).

[e]Beta exposure below 700 keV will not penetrate the lens of the eye; therefore, the applicable limit for beta radiation of these energies would be that for skin, 15 000 mrem/year.

[f]All reasonable effort should be made to keep exposure of forearms and hands within the general limit for skin.

Table A-2. DOE's Derived Concentration Guides (DCG) for Uncontrolled Areas and Concentration Guides (CG) for Controlled Areas (μCi/mL)[a]

Nuclide	DCGs for Uncontrolled Areas		CGs for Controll Areas	
	Air	Water	Air	Water
^{3}H	1×10^{-7}	2×10^{-3}	5×10^{-6}	1×10^{-1}
^{7}Be	5×10^{-8}	1×10^{-3}	1×10^{-6}	5×10^{-2}
^{89}Sr	3×10^{-10}	2×10^{-5}	3×10^{-8}	3×10^{-4}
^{90}Sr[b]	9×10^{-12}	1×10^{-6}	1×10^{-9}	1×10^{-5}
^{137}Cs	4×10^{-10}	3×10^{-6}	1×10^{-8}	4×10^{-4}
^{234}U	9×10^{-14}	5×10^{-7}	1×10^{-10}	1×10^{-4}
^{235}U	1×10^{-13}	6×10^{-7}	1×10^{-10}	1×10^{-4}
^{238}U	1×10^{-13}	6×10^{-7}	7×10^{-11}	2×10^{-5}
^{238}Pu	3×10^{-14}	4×10^{-7}	2×10^{-12}	1×10^{-4}
^{239}Pu[b]	2×10^{-14}	3×10^{-7}	2×10^{-12}	1×10^{-4}
^{240}Pu	2×10^{-14}	3×10^{-7}	2×10^{-12}	1×10^{-4}
^{241}Am	2×10^{-14}	6×10^{-7}	6×10^{-12}	1×10^{-4}
	(pg/m^3)	(mg/L)	(pg/m^3)	(mg/L)
U, natural[c]	$1 \times 10^{+5}$	8×10^{-1}	$2 \times 10^{+8}$	$6 \times 10^{+1}$

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[a]Guides for uncontrolled areas are based upon DOE's Radiation Protection Standard (RPS) for the general public;[A5] those for controlled areas are based upon occupational RPSs for DOE Order 5480.11. Guides apply to concentrations in excess of those occurring naturally or due to fallout.

[b]Guides for ^{239}Pu and ^{90}Sr are the most appropriate to use for gross alpha and gross beta, respectively.

[c]One curie of natural uranium is equivalent to 3000 kg of natural uranium. Therefore, uranium masses may be converted to DOE's "uranium special curie" by multiplying by 3.3×10^{-13} μCi/pg.

Table A-3. Maximum Contaminant Level (MCL) in Water Supply for Inorganic Chemicals and Radiochemicals[a]

Inorganic Chemical Contaminant	MCL (mg/L)	Radiochemical Contaminant	MCL (µCi/mL)
Primary Standard			
Ag	0.05		
As	0.05	Gross alpha[b]	15×10^{-9}
Ba	1	^{3}H	20×10^{-6}
Cd	0.010	^{238}Pu	15×10^{-9}
Cr	0.05	^{239}Pu	15×10^{-9}
F[c]	2.0		
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	500		
pH	6.5 - 8.5		

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[a]Source: References A7 and A8.
[b]See text for duscussion of application of gross alpha MCL and gross beta screening level of 5×10^{-9} µCi/mL.
[c]Based on annual average of the maximum daily air temperature of 14.7 to 17.6°C.

A screening level of 5 x 10^{-9} Ci/mL is established to determine when analysis specifically for radium isotopes is necessary. In this report, plutonium concentrations are compared with the gross alpha standard for drinking water (Table A-3). For manmade beta and photon emitting radionuclides, drinking water concentrations are limited to concentrations that would result in doses not exceeding 4 mrem/yr, calculated according to a specified procedure.

The EPA established minimum concentrations of certain contaminants in a water extract from wastes for designation of these wastes as hazardous by reason of toxicity.[A9] The Extraction Procedure (EP) must follow steps outlined by EPA in 40 CFR 261, Appendix II. In this report, the EP toxicity minimum concentrations (Table A-4) are used to compare to concentrations of selected constituents in extracts from the Laboratory's active waste areas.

Table A-4. Minimum Concentrations of Inorganic Contaminants for Meeting EPA's Extraction Procedure (EP) Toxicity Characteristic for Hazardous Waste[a]

Contaminant	Criteria Concentration (mg/L)
Arsenic	5.0
Barium	100.0
Cadmium	1.0
Chromium	1.0
Lead	5.0
Mercury	0.2
Selenium	1.0
Silver	5.0

[a]Source: Reference A9.

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APPENDIX B

PROCEDURES FOR SAMPLING, DATA HANDLING, AND QUALITY ASSURANCE

A. Thermoluminescent Dosimeters

The 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 h and then cooled rapidly to room temperature. This followed by annealing at 100°C (212°F) for 1 h and again cooling rapidly to room temperature. In order 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 at once into the 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. These are irradiated at levels between 0 mR and 80 mR using an 8.5 mCi ^{137}Cs source calibrated by the National Bureau of Standards.

A factor of 1 rem (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 factors of 0.958 for muscle ^{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.[B1,B2] A method of weighted least squares linear regression is used to determine the relationship between TLD reader response and dose (weighting factor is the variance).[B3]

The TLD chips used are 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 calendar quarter or the Los Alamos Meson Physics Facility 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.[B4] At the end of the calendar year, individual field cycle doses are summed for each location. Uncertainty is calculated as summation in quadrature of the individual uncertainties.[B3]

Further details are provided in the TLD quality assurance project plan.[B5]

B. Air Sampling

Samples are collected monthly at 26 continuously operating stations.[B6] Air pumps with flow rates of about 3 L/sec are used. Airborne aerosols are collected on 79 mm diameter polystyrene filters. Each filter is mounted on a cartridge that contains charcoal. This charcoal is not routinely analyzed for radioactivity. However, if an unplanned release occurs, the charcoal can be analyzed for any ^{131}I it may have collected. Part of the total air flow is passed through a cartridge containing silica get to absorb atmospheric water vapor for tritium analyses. Air flow rates through both sampling cartridges are measured with rotameters and sampling times recorded. The entire air sampling train at each station is cleaned, repaired, and calibrated as-needed.

Two clean, control filters are used to detect any possible contamination of the 26 sampling filters while they are in transit. The control filters accompany the 26 sampling filters when they are placed in the air samplers and when they are retrieved. The control filters are analyzed for radioactivity along with the 26 sampling filters. Analytical results for the control filters are subtracted from the appropriate gross results to obtain net data.

At one on-site location (N050 E040), airborne radioactivity samples are collected weekly. Airborne

particulate matter on each filter is counted for gross alpha and gross beta activities, which help trace temporal variations in radionuclide concentrations in ambient air. The same measurements are made monthly on a filter from the Espanola (Station 1) regional air sampler.

On a quarterly basis, the monthly filters for each station are cut in half. The filter halves are combined to produce two quarterly composite samples for each station. The first group is analyzed for ^{238}Pu, $^{239,240}Pu$, and ^{241}Am (on selected filters). The second group of filter halves is saved for uranium analysis.

Filters from the first composite group are ignited in platinum dishes, treated with $HF\text{-}HNO_3$ to dissolve silica, wet ashed with $HNO_3\text{-}H_2O_2$ to decompose organic residue, and treated with HNO_3-HC1 to ensure isotopic equilibrium. Plutonium is separated from the resulting solution by anion exchange. For 11 selected stations, americium is separated by cation exchange from the eluant solutions resulting from the plutonium separation process. The purified plutonium and americium samples are separated, electrodeposited, and measured for alpha-particle emission with a solid state alpha detection system. Alpha particle energy groups associated with decay of ^{238}Pu, $^{239,240}Pu$, and ^{241}Am are integrated and the concentration of each radionuclide in its respective filter sample calculated. This technique does not differentiate between ^{239}Pu and ^{240}Pu. Uranium analyses by neutron activation analysis (see Appendix C) are done on the second group of filter halves.

Silica gel cartridges from the 26 air sampling stations are analyzed monthly for tritiated water. The cartridges contain blue "indicating" gel to indicate the degree of desiccant saturation. During cold months of low absolute humidity, sampling flow rates are increased to ensure collection of enough water vapor for analysis. Water is distilled from each silica get cartridge and an aliquot of the distillate is analyzed for tritium by liquid scintillation counting. The amount of water absorbed by the silica get is determined by the difference between weights of the gel before and after sampling.

Analytical quality control for analyses done in the air sampling program are described in Appendix C. In brief, both blanks and standards are analyzed in conjunction with normal analytical procedures. About 10% of the analyses are devoted to quality control.

Further details may be found in the air sampling quality assurance project plan. [B7]

C. Water Sampling

Surface and ground water sampling stations are grouped by location (regional, perimeter, onsite) and hydrologic similarity. Water samples are taken once or twice a year. Samples from wells are collected after sufficient pumpage or bailing to ensure that the sample is representative of the aquifer. Spring samples (ground water) are collected at the discharge point.

The water samples are collected in 4 L (for radiochemical) and 1 L (for chemical) polyethylene bottles. The 4-L bottles are acidified in the field with 5 mL of concentrated nitric acid and returned to the laboratory within a few hours of sample collection for filtration through a 0.45-μm pore membrane filter. The samples are analyzed radiochemically for ^{3}H, ^{137}Cs, total U, ^{238}Pu and $^{239,240}Pu$, and as well as for gross alpha, beta, and gamma activities. Water samples for chemical analyses are handled similarly.

Storm run-off samples are analyzed for radionuclides in solution and suspended sediments. The samples are filtered through a 0.45- m filter. Solution is defined as filtrate passing through the filter, while suspended sediment is defined as the residue on the filter.

Further details may be found in the water sampling quality assurance project plan.[B8]

D. Soil and Sediment Sampling

Two soil sampling procedures are used. The first procedure is used to take surface composite samples. Soiled samples are collected by taking 5 plugs, 75 mm (3.0 in.) in diameter and 50 mm (2.0 in.) deep, at the center and corners of a square area 10 m (33 ft) on a side. The five plugs are combined to form a composite sample for radiochemical analysis

The second procedure is used to take surface and subsurface samples at one sampling location. Samples are collected from three layers in the top 30 cm (12 in.) of soil. A steel ring is placed on the surface of the soil at the sampling point. The soil enclosed by the ring is then collected by undercutting the ring with a metal spatula. A second spatula is then placed on top of the ring and the sample is transferred into a plastic bag and labelled.

All three layers are preserved by freezing. All equipment used for collection of these samples is washed with a soap and water solution and dried with paper towels. This is done before each sample is taken to reduce the potential for cross contamination.

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 in the main channel.

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 beta activities, ^{90}Sr, total uranium, ^{137}Cs, ^{238}Pu, and $^{239,240}Pu$. Moisture distilled from soiled samples may be analyzed for ^{3}H.

Further details may be found in the soil and sediment sampling quality assurance plan.[B8]

E. 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.[B9] Each produce or soil sample is sealed in a labeled, plastic bag. Samples are refrigerated until preparation 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.[B9] 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, dissected, and wet, dry, and ash weights determined. Ash is submitted for analysis of ^{90}Sr, ^{137}Cs, total uranium, ^{238}Pu, and $^{239,240}Pu$.

Further information may be found in the foodstuffs sampling quality assurance project plan.[B10]

F. Meteorological Monitoring

Meteorological data are continuously monitored on instrumented towers at five Laboratory locations. Measurements include wind speed and direction, standard deviations of wind speed and direction, vertical wind speed and its standard deviation, air temperature, dewpoint temperature, relative humidity, solar radiation, and precipitation.

These parameters are measured at discrete levels on the towers at heights ranging from ground level to 91 m (300 ft). Each parameter is measured every 3 to 5 sec and averaged or summed over 15 minute intervals. Data are recorded on digital cassette tape or transmitted by phone line to a microcomputer at the Occupational Health Laboratory at TA-59.

Data validation is accomplished with automated and manual screening techniques. One computer code compares measured data with expected ranges and make comparisons based on known meteorological relationships. Another code produces daily plots of data from each tower. These graphics are reviewed to provide another check of the data. This screening also helps to detect problems with the instrumentation that might develop between the annual or semi-annual (depending upon the instrument) calibrations.

Further details may be found in the meteorological monitoring quality assurance project plan.[B11]

G. Data Handling

Measurements of the 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 (see Appendix C) are sometimes obtained. Consequently, individual measurements can result in values of zero and 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.[B12]

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 (s) for the station and group (regional, perimeter, onsite) means are calculated using the following equation:

$$s = \sqrt{\frac{\sum_{i=1}^{N} (\bar{c}-c_i)^2}{(N-1)}}$$

where,

c_i = concentration for sample i,
$\bar{c}$ = means of samples from a given station or group, and
N = number of samples comprising a station or a group.

This value is reported as the uncertainty for the station and group means.

H. Quality Assurance

Collection of samples for chemical and radiochemical analyses follow a set procedure to ensure proper sample collection, documentation, submittal for chemical analysis, and posting of analytical results.

Before sample collection, the schedule and procedures to be followed are discussed with the chemist or chemists involved with doing the analyses. The discussion includes:

1. Number and type of samples.
2. Type of analyses and required limits of detection.
3. Proper sample containers.
4. Preparation of sample containers with preservative, if needed.
5. Sample schedule to ensure minimum holding time of analyses to comply with EPA criteria.

The Health and Environmental Chemistry Group (HSE-9) issues to the collector a block of sample numbers (e.g., 86.0071) with individual numbers assigned by the collector to individual station. These sample numbers follow the sample from collection through analyses and posting of individual results.

Each number, a single sample, is assigned to a particular station and is entered into the collector's log book. After the sample is collected, the date, time, temperature (if water), other pertinent information, and remarks are entered opposite 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.

After the sample is collected, it is delivered to the Group HSE-9 section leader. The section leader makes out a numbered request form entitled "HSE-9 Analytical Chemical Request." The request form number is entered in the collector's log book opposite sample numbers submitted along with the date delivered to chemist. The analytical request form serves as "chain-of-custody" for the samples.

The analytical request form contains the following information related to ownership and sample program submitted as (1) requestor (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 constituent), (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 his file and the other copies follow the sample.

Quality control, analytical methods and procedures, and limits of detection related to Group HSE-9's analytical work are presented in Appendix C.

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.

Further details may be found in the quality assurance project plan for each program.[B5,B7,B8,B10,B11]

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B10. L. Soholt, "Quality Assurance project Plan--Foodstuffs Monitoring at Los Alamos National Laboratory," in *Environmental Surveillance Group*, "Quality Assurance Project Plans," Los Alamos National Laboratory report LA-UR-87-1075 (February 1987).

B11. W. Olsen and J. Dewart, "Meteorological Quality Assurance Program of the Los Alamos National Laboratory's Environmental Surveillance Group, HSE-8," in *Environmental Surveillance Group*, "Quality Assurance Project Plans," Los Alamos National Laboratory report LA-UR-87-1076 (February 1987).

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APPENDIX C

ANALYTICAL CHEMISTRY METHODOLOGY

Most analytical chemistry is provided by the Environmental and Health Chemistry Group (HSE-9). Overflow work is contracted to several commercial laboratories.

A. 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. The detailed procedures have been published in this appendix in previous years.[C1,C2] 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 Ge(Li) detectors. Depending upon the concentration and matrix, ^{226}Ra is measured by emanation[C3] or by gamma-ray spectrometry of its ^{214}Bi decay product.[C4] Uranium isotopic ratios ($^{235}U/^{238}U$) are measured by neutron activation analysis where precisions of $\pm 5\%$ are adequate.[C5] More precise work require mass spectrometry. Group HSE-9 acquired a VG-Instruments PLASMAQUAD Inductively Coupled Plasma Mass Spectrometer (ICPMS) in early 1986. Uranium isotopic ratios can be readily determined in environmental materials with precisions of 1-2% RSD at considerably reduced cost relative to neutron activation.

B. 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 Environmental Protection Agency (EPA) regulations.

Instrumental techniques available include neutron activation, atomic absorption, ion chromatography, color spectrophotometry (manual and automated), potentiometry, combustion analysis, and ICPMS. Standard chemical methods are also used for many of the common water quality tests. Atomic absorption capacities include flame, furnace, mercury cold vapor, and hydride generation, as well as flame emission spectrophotometry. The methods used and references for determination of various chemical constituents are summarized in Table C-1. In 1986 the EPA Region-6 administration granted HSE-9 limited approval for alternative test procedures for uranium in drinking water (delayed neutron assay) and for flow injection (without distillation) for chloride in drinking water and waste water. EPA approved for other modified methods is being actively sought.

C. Organic Constituents

Environmental water samples are analyzed by EPA or modified EPA methodology. Methods in use are supported by the use of documented spike/recovery studies, method and field blanks, matrix spikes, surrogate spikes, and blind quality control samples. EPA procedures are modified in order to take advantages of recent advances in analytical separation and analysis techniques. Volatile organics are analyzed by a modification of EPA 624 [purge and trap/gas chromatography/mass spectrometry (PT/GC/MS)]. Semivolatile organics are analyzed by a variety of methods including 604 (phenols), 606 (phthalate esters), 608 (organochlorine pesticides and PBCs), 609 (nitroaromatics), 610 (polynuclear aromatic hydrocarbons), 612 (chlorinated hydrocarbons), and 625 (semivolatiles by GC/MS). For samples in a solid matrix, comparable methods found within EPA's document SW-846 are used with suitable modifications as needed. Manual and automated methods have been developed using neutron activation to screen oil samples for potential PCB contamination via total chlorine determination.

Instrumentation available for organic analysis includes gas chromatographs with a variety of detector systems including mass spectrometry, flame ionization, and electron capture. Also available is a high pressure liquid chromatograph equipped with a UV and refractive index detection system, an infrared spectrophotometer, and a UV/visible spectrophotometer for colorimetric analyses. Methods used for sample preparation include solvent extraction, soxhlet extraction, liquid/liquid extraction, kuderna danish concentration,

Table C-1. Analytical Methods for Various Stable Constituents

Technique	Stable Constituents Measured	References
Standard Chemical Methods	Total Alkalinity, Hardness, SO_3^{-2}, SO_4^{-2}, TDS, Conductivity, COD	C6, C65
Color Spectrophotometry	NO_3^-, PO_4^{-3}, Si, Pb, Ti, B	C6, C65
Neutron Activation		
Instrumental Thermal	Al, Sb, As, Ba, Br, Ca, Ce, Cs, Cl, Cr, Co, Dy, Eu, Au, Hf, In, I, Fe, La, Lu, Mg, Mn, K, Rb, Sm, Sc, Se, Na, Sr, S, Ta, Tb, Th, Ti, W, V, Yb, Zn	C7, C12, C13, C14, C15 C65
Instrumental Epithermal	Al, Sb, As, Ba, Br, Cs, Cr, F, Ga, Au, In, I, La, Mg, Mn, Mo, Ni, K, Sm, Se, Si, Na, Sr, Th, Ti, W, U, Zn, Zr	C7, C9, C16, C17, C18, C19, C20, C21, C65
Thermal Neutron Capture Gamma Ray	Al, B, Ca, Cd, C, Gd, H, Fe, Mg, N, P, K, Si, Na, S, Ti	C7, C22, C23, C24, C25, C26, C27, C29, C65
Radiochemical	Sb, As, Cu, Au, Ir, Hg, Mo, Os, Pd, Pt, Ru, Se, Ag, Te, Th, W, U, La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Yb, Lu, $^{235}U/^{238}U$, ^{238}Pu, ^{239}Pu	C5, C6, C7, C30, C31, C32, C33, C34, C35, C36, C37, C38, C51, C65
Delayed Neutron Assay	U	C7, C8, C10, C11, C39, C40, C65
Atomic Absorption	Sb, As, Ba, Be, Bi, Cd, Ca, Cr, Co, Cu, Ga, In, Fe, Pb, Li, Mg, Mn, Hg, Mo, Ni, K, Se, Ag, Na, Sr, Tc, Tl, Sn, Ti, V, Zn, Al	C6, C41, C43, C44, C45, C46, C47, C48, C52, C53, C54, C65

Table C-1 (cont)

Technique	Stable Constituents Measured	References
Inductively Coupled Plasma Mass Spectrometry	Sb, As, Ba, Be, B, Bi, Cd, Cr, Co, Cu, Ga, In, Pb, Li, Mn, Hg, Mo, Ni, Sc, Br, Ag, Sr, Te, Ti, Sn, Ti, V, Zn	C65
Ion Chromatograpy	F^-, Cl^-, Br^-, NO_2^-, NO_3^- SO_4^{-2}, PO_4^{-3}	C49, C65
Potentiometric	F^-, NH_4^+, pH, Br^-, Cl_2 (total) Cl_2 (free)	C50, C55, C65
Combustion	C, N, H, S, Total Organic Carbon	C29, C62, C63, C65
Corrosivity	--	C56, C57
Ignitability (Flash point)	--	C56, C58
Automated Colorimetry	CN^-, NH_4^-, PO_4^{-3}, NO_3^- NO_2^-, Cl^-, COD, TKN Si, B, SO_4^{-2}, Cr^{+6}	C6, C59, C60, C62, C65

column separation, headspace, and purge and trap. The methods used for analyses in 1987 along with references are shown in Table C-2. Tables C-3 through C-7 show compounds determined by these methods and representative detection limits.

D. Analytical Chemistry Quality Evaluation Program

1. Introduction. Control samples are analyzed in conjunction with normal analytical chemistry workload. Such samples consist of several general types: calibration standards, reagent blanks, process blanks, matrix blanks, duplicates, and standard reference materials. Analysis of control samples fills two needs in the analytical work. First, it provides quality control over analytical procedures so that problems that might occur can be identified and corrected. Secondly, data obtained from analysis of control samples permit evaluation of the capabilities of a particular analytical technique for determination of a given element or constituent under a certain set of circumstances. The former function is analytical quality control; the latter is quality assurance.

No attempt is made to conceal the identity of control samples from the analyst. They are submitted to the laboratory at regular intervals and analyzed in association with other samples; that is, they are not handled as a unique set of samples. We feel it would be difficult for analysts to give the samples special attention, even if they are so inclined. We endeavor to run at least 10% of stable constituent analyses and

Table C-2. Method Summary (Organics)

Analyte	Matrix	Method	Technique[a]	Reference
Volatiles	air	---	GC/MS	C65
Volatiles	soil	8010	PT/GC/MS	C64 C65
		8020		C66
Volatiles	water	625	PT/GC/MS	C64
EP Toxicity	soil	1310, 8080 8150	GC/ECD	C66
PCBs	water	606	GC/ECD	C64
	soil	8080	GC/ECD	C66
	oil	IH 320	GC/ECD	C65

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[a]GC - gas chromatography, PT - purge and trap, ECD - electron capture detection, and MS - mass spectrometry.

selected radioactive constituent analyses as quality assurance samples using the materials described above. A detailed description of our Quality Assurance program and a complete listing of our annual results have been published annually.[C67-C76]

2. Radioactive Constituents. Quality control and quality assurance samples for radioactive constituents are obtained from outside agencies as well as prepared internally. The Quality Assurance Division of the Environmental Monitoring Systems Laboratory (EPA-Las Vegas) provides water, foodstuff, and air filter samples for analysis of gross alpha, gross beta, ^{3}H, ^{40}K, ^{60}Co, ^{65}Zn, ^{90}Sr, ^{106}Ru, ^{134}Cs, ^{137}Cs, ^{226}Ra, and $^{239,240}Pu$ as part of an ongoing laboratory intercomparison program. The National Bureau of Standards (NBS) provides several soil and sediment Standard Reference Materials (SRM) for environmental radioactivity. These SRMs are certified for ^{60}Co, ^{90}Sr, ^{137}Cs, ^{226}Ra, ^{238}Pu, $^{239,240}Pu$, ^{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. Our own "inhouse" standards are prepared by adding known quantities of liquid NBS radioactivity SRMs to blank matrix materials.

3. Stable Constituents. Quality assurance for the stable constituent analysis program is maintained by analysis of certified or well-characterized environmental materials. The NBS 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 (USGS and NBS), Details of this program have also been published elsewhere.[C76]

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. In addition, there is a program for evaluation of the quality of results for an individual water sample.[C77] These individual water sample quality ratios are the sum of the milliequivalent (meq) cations to the sum of meq anions, the meq hardness of the sum of meq

Table C-3. Volatiles Determined by Purge and Trap

Compound	Representative Detection Limits (μg/L)
Methylene chloride	1.0
1,1-Dichloroethane	1.0
1,1-Dichloroethene	1.0
cis-1,2-Dichloroethene	1.0
1,2-Dichloroethane	1.0
Chloroform	1.0
Bromoform	1.0
Carbon tetrachloride	1.0
Bromodichloromethane	1.0
Dibromochloromethane	1.0
Dibromomethane	1.0
4-Methyl-2-pentanone	1.0
1,1,1-Trichloroethane	1.0
1,1,2-Trichloroethane	1.0
1,2-Dichloropropane	1.0
cis-1,3-Dichloropropene	5.0
trans-1,3-Dichloropropene	5.0
1,2-Dibromo-3-chloropropane	1.0
Trichloroethene	1.0
2-chloroethylvinyl ether	5.0
1,1,2,2-Tetrachloroethane	1.0
Tetrachloroethene	1.0
Chlorobenzene	1.0
1,2-Dichlorobenzene	1.0
1,3-Dichlorobenzene	1.0
1,4-Dichlorobenzene	1.0
Benzene	1.0
Acetone	5.0
Carbon disulfide	5.0
Toluene	1.0
Ethyl benzene	1.0
Styrene	5.0
o-xylene	1.0
m-xylene/p-xylene	1.0

Column: Supelco SPB-5 60 m x 0.25 mm x 1.0 μm. Limits of detection estimated by minimum signal required to yield identifiable mass spectral scan.

Ca^{+2} and Mg^{+2}, the observed total dissolved solids (TDS) to the sum of solids, the observed conductivity to the sum of contributing conductivities, as well as the two ratios obtained by multiplying (0.01) x (conductivity) and dividing by the meq cations and the meq anions.

4. Indicators of Accuracy and Precision. 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

Table C-4. Volatiles Determined by SW-846 Method 8010

Compound	Detection Limits (µg/kg)[a]
Bis (2-chloroethoxy) methane	--
Bis (2-chlorisopropy) ether	--
Bromobenzene	2300
Bromodichloromethane	1000
Bromoform	1000
Carbon tetrachloride	2100
Chloracetaldehyde	--
Chlorobenzene	1200
Chloroethane	--
Chloroform	1000
1-Chlorohexane	--
2-Chloroethyl vinyl ether	--
Chloromethane	--
Chlorotoluene	--
Dibromochloromethane	1000
Dibromomethane	--
1,2-Dichlorobenzene	500
1,3-Dichlorobenzene	500
1,4-Dichlorobenzene	500
Dichlorodifluoromethane	--
1,1-Dichloroethane	1000
1,2-Dichloroethane	800
1,1-Dichloroethylene	--
trans-1,2-Dichloroethylene	500
Dichloromethane	500
1,2-Dichloropropane	500
trans- 1,3-Dichloropropylene	--
1,1,2,2-Tetrachloroethane	2100
1,1,1,2-Tetrachloroethane	--
Tetrachloroethylene	2100
1,1,1-Trichloroethane	1600
1,1,2-Trichloroethane	1500
Trichloroethylene	500
Trichlorofluoromethane	--
Trichloropropane	--
Vinyl chloride	--

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[a]Column: 60 m x 0.32 mm SPB-5 fused silica capillary, using methanolic partition with purge-and-trap. Detection limits is calculated from intercept of external calibration curve using a Flame Ionization Detector.

Table C-5. Volatiles Determined by SW-846 Method 8020

Compound	Detection Limits (μg/kg)[a]
Benzene	500
Chlorobenzene	1200
1,4-Dichlorobenzene	500
1,3-Dichlorobenzene	500
1,2-Dichlorobenzene	500
Toluene	500
Ethyl Benzene	800
Xylenes	--

[a]Column: 60 m x 0.32 mm SPB-5 fused silica capillary, using methanolic partition with purge-and-trap. Detection limits is calculated from intercept of external calibration curve using a Flame Ionization Detector.

points). Accuracy and precision are evaluated from results of analysis of reference materials. These results are normalized to the known quality in the reference material to permit comparison among reference materials of 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):

$$R = \frac{\Sigma_i r_i}{N} .$$

The standard deviation(s) of R is calculated assuming a normal distribution of the population of analytical determinations (N):

$$s = \sqrt{\frac{\Sigma_i (R - r_i)^2}{(N - 1)}}$$

These calculated values are presented in Table C-8 through C-12. The mean value of R is a measure of the accuracy of a procedure. Values of R greater than unity indicate a positive bias and values less than unity a negative bias in the analysis.

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 instances, the precision for some determinations is quite large because many standards approached the limits of detection of a measurement. We are attempting to address this issue by calculating a new quality assurance parameter:

$$|\bar{X}_E - \bar{X}_c| < 1.96 \quad (S_E)^2 + (S_c)^2$$

where X_E and X_c are the experimentally determined and certified or consensus mean elemental concentrations, respectively. The S_E and S_c parameters are the standard deviations associated with $\bar{X}_E$ and $\bar{X}_c$, respectively. An analysis will be considered under control when this condition is satisfied for a certain element in a given matrix. Details on this approach are presented elsewhere.[C76]

Data on analytical detection limits are in Table C-13.

Table C-6. Volatiles Determined in Air

Compound	Representative Detection Limits (μg/tube)
1,1-Dichloroethane	3.0
1,1-Dichloroethene	3.0
cis-1,2-Dichloroethene	3.0
Chloroform	3.0
Bromoform	3.0
Bromodichloromethane	3.0
Dibromochloromethane	3.0
Dibromomethane	3.0
1,1,1-Trichloroethane	3.0
1,1,2-Trichloroethane	3.0
1,2-Dichloropropane	3.0
cis-1,3-Dichloropropene	5.0
trans-1,3-Dichloroprepene	5.0
1,2-Dibromo-3-chloropropane	3.0
Trichlorethene	3.0
2-chloroethylvinyl ether	5.0
1,1,2,2-Tetrachloroethane	3.0
Tetrachloroethene	3.0
Chlorobenzene	3.0
1,2-Dichlorobenzene	3.0
1,3-Dichlorobenzene	3.0
1,4-Dichlorobenzene	3.0
Trichlorofluoromethane	5.0
Toluene	3.0
Ethyl benzene	3.0
o-xylene	3.0
m-xylene/p-xylene	3.0

Column: Supelco SPB-5 60 m x 0.25 mm x 1.0 μm.
Method: Carbon disulfide desorbtion of charcoal tubes followed by GC/MS analysis.

Table C-7. EP Toxicity Organic Contaminants

Contaminant	Maximum Concentration (mg/L)	Representative Detection Limits (mg/L)[a]
Endrin (1,2,3,4,10,10-Hexachloro-1 7-epoxy-1,4,4a,5,6,7,8,8a-octahydro-1 4-endo, endo-5, 8-dimethanoaphthalene)	0.02	0.006
Lindane (1,2,3,4,5,6- Hexachlorocyclohexane, gamma isomer)	0.4	0.0002
Methoxychlor (1,1,1-Trichloro-2,2-bis (p-methoxphenyl)ethane)	10.0	0.004
Toxaphene ($C_{10}H_{10}Cl_8$ Technical chlorinated camphene, 67-69% chlorine)	0.5	0.020
2,4-D (2,4-Dichlorophenoxyacetic acid)	10.0	0.016
2,4,5-TP (Silvex) (2,4,5- Trichlorophenoxypropionic acid)	1.0	0.005

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[a]Column: 30 m x 0.32 mm SPB-5 fused silica capillary. Detection limit is calculated from GC response being equal to four times the GC background noise using an electron capture detector.

Table C-8. Summary of HSE-9 Quality Assurance Tests for Data from January 1, 1987 to December 31, 1987 (Stable Element Analyses Performed by HSE-9)

ELE	BIOLOGICAL Mean ± SD (n)	SLUDGE Mean ± SD (n)	EP-TOX Mean ± SD (n)	FILTER Mean ± SD (n)	BULK Mean ± SD (n)	SILICATE Mean ± SD (n)	WATER Mean ± SD (n)
Ag	---	---	1.07 ± 0.06 (31)	---	1.17 ± 0.01 (3)	---	1.02 ± 0.07 (130)
Al	---	---	---	1.04 ± 0.02 (3)	---	---	1.01 ± 0.11 (19)
As	0.96 ± 0.22 (12)	0.92 ± 0.09 (9)	1.05 ± 0.05 (51)	1.01 ± 0.07 (27)	---	1.33 ± 0.39 (6)	1.05 ± 0.10 (92)
B	0.99 ± 0.10 (7)	---	---	1.08 (1)	---	---	1.02 ± 0.06 (42)
Ba	---	---	1.03 ± 0.08 (35)	---	0.91 ± 0.02 (3)	1.15 (2)	1.02 ± 0.11 (93)
Be	---	---	1.02 ± 0.07 (9)	0.95 ± 0.09 (93)	---	1.42 ± 0.37 (9)	1.04 ± 0.06 (35)
Bi	---	---	---	1.05 ± 0.11 (10)	---	---	---
Br	0.93 ± 0.18 (14)	---	---	---	---	0.98 (1)	0.91 ± 0.07 (26)
C	0.99 ± 0.02 (25)	---	---	---	---	---	---
Ca	0.78 (1)	---	---	---	---	---	0.99 ± 0.04 (39)
Cd	---	0.94 ± 0.08 (15)	1.05 ± 0.08 (78)	0.96 ± 0.11 (32)	1.08 ± 0.04 (3)	1.00 (1)	0.98 ± 0.08 (127)
Ce	---	---	---	---	---	1.13 (2)	---
Cl	0.93 (1)	---	---	---	---	---	1.00 ± 0.05 (89)
Cl2	---	---	---	---	---	---	0.96 ± 0.16 (13)
CN	---	---	---	---	---	---	0.87 ± 0.09 (175)
Co	---	---	0.94 (2)	---	---	2.88 ± 2.77 (10)	1.00 ± 0.08 (4)
COD	---	---	---	---	---	---	1.02 ± 0.06 (54)
COND	---	---	---	---	---	---	1.01 ± 0.04 (52)
Cr	---	---	1.02 ± 0.06 (60)	---	0.96 ± 0.08 (4)	0.89 (2)	1.01 ± 0.16 (115)
Cr(+6)	---	---	---	---	---	---	0.92 ± 0.06 (109)
Cs	1.65 ± 0.08 (7)	---	---	---	---	0.97 (2)	---
Cu	1.06 (1)	---	0.97 ± 0.05 (13)	1.03 ± 0.03 (6)	---	1.09 (1)	1.01 ± 0.08 (108)
Eu	---	---	---	---	---	1.02 ± 0.08 (8)	---
F	---	---	---	---	---	---	1.02 ± 0.11 (104)
Fe	---	---	---	---	---	0.98 ± 0.04 (9)	1.03 ± 0.07 (102)
FLASH PT.	---	---	---	---	1.01 ± 0.02 (27)	---	---
Ga	---	---	---	1.04 ± 0.06 (13)	---	1.08 ± 0.38 (7)	---
Gd	---	---	---	0.97 ± 0.06 (4)	---	---	---
H	0.99 ± 0.04 (31)	---	---	---	---	---	---
HARD	---	---	---	---	---	---	1.00 ± 0.05 (17)
HEATCAP	---	---	---	---	1.06 ± 0.14 (8)	---	---
Hf	---	---	---	---	---	0.99 (2)	---
Hg	---	---	0.85 ± 0.26 (21)	---	---	1.09 ± 0.21 (135)	1.00 ± 0.10 (70)
I	---	---	---	---	---	---	0.94 ± 0.02 (6)
K	0.95 (1)	---	---	---	---	1.13 ± 0.16 (4)	1.02 ± 0.09 (26)

Table C-8 (cont)

ELE	BIOLOGICAL Mean ± SD (n)	SLUDGE Mean ± SD (n)	EP-TOX Mean ± SD (n)	FILTER Mean ± SD (n)	BULK Mean ± SD (n)	SILICATE Mean ± SD (n)	WATER Mean ± SD (n)
La	---	---	---	---	---	0.95 ± 0.08 (12)	---
Li	---	---	0.99 (2)	1.20 ± 0.01 (3)	---	---	1.01 ± 0.05 (40)
Lu	---	---	---	---	---	1.16 (1)	---
Mg	---	---	---	---	---	---	0.96 ± 0.12 (40)
Mn	1.04 (1)	---	0.89 ± 0.03 (3)	1.01 ± 0.01 (3)	---	---	1.07 ± 0.12 (41)
Mo	1.00 ± 0.02 (4)	---	---	---	---	---	1.13 ± 0.08 (7)
N	0.95 ± 0.06 (65)	---	---	---	---	---	---
Na	1.00 (1)	---	---	---	---	0.97 ± 0.02 (4)	1.03 ± 0.04 (29)
NH3-N	---	---	---	---	---	---	0.98 ± 0.06 (138)
Ni	---	---	1.02 ± 0.07 (22)	---	---	0.90 (1)	1.00 ± 0.08 (61)
NO3-N	---	---	---	---	---	---	1.00 ± 0.05 (77)
P	---	---	---	---	---	---	0.95 ± 0.11 (86)
Pb	---	1.03 ± 0.04 (17)	1.06 ± 0.08 (73)	1.01 ± 0.12 (49)	1.02 (2)	---	1.01 ± 0.11 (144)
pH	---	---	---	---	---	---	1.00 ± 0.01 (474)
Rb	---	---	---	---	---	0.95 ± 0.05 (8)	---
S	0.97 ± 0.06 (138)	---	---	---	---	0.69 ± 0.09 (99)	---
Sb	---	---	---	---	---	1.18 (2)	---
Sc	0.97 ± 0.02 (4)	---	---	1.00 ± 0.11 (19)	---	1.00 ± 0.06 (8)	---
Se	---	---	0.97 ± 0.14 (42)	---	---	1.12 (2)	1.05 ± 0.14 (73)
Si	---	---	---	---	---	---	0.99 ± 0.06 (85)
Sm	---	---	---	---	---	0.96 ± 0.05 (4)	---
SO4	---	---	---	---	---	---	0.97 ± 0.06 (80)
Ta	---	---	---	---	---	0.86 (2)	---
TALK	---	---	---	---	---	---	0.98 ± 0.03 (47)
Tb	---	---	---	---	---	1.11 (1)	---
TDS	---	---	---	---	1.04 (1)	---	0.98 ± 0.12 (34)
Th	---	---	---	---	---	1.03 ± 0.20 (20)	1.00 ± 0.10 (6)
Ti	---	1.32 ± 0.25 (10)	---	1.01 ± 0.01 (3)	---	---	---
Tl	---	---	---	---	---	---	1.04 ± 0.12 (8)
TOX	---	---	---	---	1.08 ± 0.10 (9)	---	---
TSS	---	---	---	---	---	---	0.66 (1)
U	1.08 ± 0.08 (25)	---	---	0.99 ± 0.07 (29)	---	0.98 ± 0.03 (81)	1.02 ± 0.06 (62)
V	1.29 (1)	1.92 ± 0.15 (32)	0.99 (2)	1.02 ± 0.01 (3)	---	1.09 ± 0.13 (3)	1.03 ± 0.08 (4)
W	0.79 ± 0.06 (4)	---	---	---	---	---	---
Yb	---	---	---	---	---	0.95 ± 0.11 (10)	---
Zn	---	1.05 ± 0.07 (58)	1.01 ± 0.06 (5)	0.98 ± 0.10 (32)	---	---	1.00 ± 0.09 (93)

Table C-9. Summary of HSE-9 Quality Assurance Tests for Data from January 1, 1987 to December 31, 1987 (Stable Element Analyses Performed by Contractors)

ELEMENT	BULK Mean ± SD (n)	SILICATE Mean ± SD (n)	WATER Mean ± SD (n)
Ag	---	---	1.43 (1)
Al	---	0.93 ± 0.06 (20)	1.11 (1)
As	---	---	0.92 (1)
Ba	---	---	0.98 (1)
Br	0.98 ± 0.12 (11)	---	---
Ca	---	0.96 ± 0.06 (20)	---
Cd	---	---	1.00 (1)
Cl	0.91 ± 0.22 (13)	0.96 ± 0.20 (20)	1.06 ± 0.04 (7)
Cr	---	---	1.06 (1)
Dy	---	0.97 ± 0.16 (20)	---
F	1.85 ± 1.16 (11)	---	---
Fe	---	---	1.23 (2)
I	1.02 ± 0.09 (11)	---	---
Mg	---	0.83 ± 0.12 (20)	---
Mn	---	1.01 ± 0.03 (20)	---
Na	---	0.97 ± 0.03 (20)	---
Pb	---	---	1.81 (1)
Ti	---	0.95 ± 0.06 (20)	---
V	---	1.03 ± 0.04 (20)	---

Table C-10. Summary of HSE-9 Quality Assurance Tests for Data from January 1, 1987 to December 31, 1987 (Organic Analyses Performed by HSE-9)

COMPOUND	FILTER		BULK		SILICATE		TUBE		WATER	
	Mean ± SD	(n)	Mean ± SD	(n)	Mean ± SD	(n)	Mean ± SD	(n)	Mean ± SD	(n)
Acetone	---		---		---		---		0.07	(1)
Aldrin	---		---		---		---		1.16	(2)
Aroclor 1221	---		---		---		---		1.03	(2)
Aroclor 1242	1.04 ± 0.06	(5)	0.97 ± 0.11	(64)	0.66 ± 0.24	(8)	---		0.99 ± 0.19	(3)
Aroclor 1254	1.15	(1)	0.90 ± 0.10	(6)	0.67	(2)	---		---	
Aroclor 1260	1.00	(2)	0.92 ± 0.11	(56)	0.93	(2)	---		0.88	(2)
Benzene	---		0.89	(1)	0.48	(1)	0.92 ± 0.27	(16)	1.00 ± 0.28	(4)
Benzo-k-fluoranthene	---		---		---		---		0.83	(1)
Bis(2-chloroethoxy)methane	---		---		---		---		0.82	(1)
Bromodichloromethane	---		---		0.55	(1)	0.87	(2)	0.83 ± 0.05	(8)
Bromoform	---		---		0.68	(1)	---		0.97 ± 0.16	(6)
2-Butanone	---		0.75	(1)						
Camphene, chlorinated	---		---		---		---		3.10	(2)
Carbon tetrachloride	---		---		---		1.07 ± 0.15	(18)	0.68 ± 0.23	(11)
Cellosolve acetate	---		---		---		1.02 ± 0.04	(3)	---	
Chlorobenzene	---		---		0.60	(2)	0.85	(2)	0.85	(2)
Chlorodibromomethane	---		---		---		0.76	(2)	0.93 ± 0.15	(5)
Chloroform	---		---		0.47	(1)	1.01 ± 0.22	(18)	0.85 ± 0.21	(8)
2-Chloronaphthalene	---		---		---		---		1.03	(1)
2,4-D	---		---		1.74	(1)	---		1.18 ± 0.44	(7)
Dibromochloromethane	---		---		---		0.76	(2)	0.93 ± 0.15	(5)
Dibromomethane	---		---		---		---		0.99	(1)
o-Dichlorobenzene (1,2)	---		---		---		1.01	(1)	0.99	(1)
m-Dichlorobenzene (1,3)	---		---		---		---		0.98	(2)
p-Dichlorobenzene (1,4)	---		---		---		---		1.06	(2)
Dichlorobromomethane	---		---		0.55	(1)	0.87	(2)	0.83 ± 0.05	(8)
1,1-Dichloroethane	---		---		0.47	(2)	1.03 ± 0.08	(16)	0.92 ± 0.20	(3)
1,1-Dichloroethane	0.96	(2)								
1,1-Dichloroethene	---		---		---		---		1.64 ± 0.69	(4)
2,4-Dichlorophenol	---		---		---		---		1.14	(1)
1,4-Dioxane	---		---		---		1.26	(1)	---	

Table C-10 (cont)

COMPOUND	FILTER Mean ± SD	(n)	BULK Mean ± SD	(n)	SILICATE Mean ± SD	(n)	TUBE Mean ± SD	(n)	WATER Mean ± SD	(n)
Endrin	---		---		---		---		0.95	(2)
Ethyl acetate	---		---		---		1.09	(1)	---	
Ethylbenzene	---		0.88	(1)	---		1.47 ± 0.05	(4)	0.72 ± 0.09	(4)
Ethylene chloride	---		---		---		1.03 ± 0.08	(16)	0.92 ± 0.20	(3)
Hexachloro-1,3-butadiene	---		---		---		---		0.96	(1)
Hexane	---		---		---		0.82	(1)	---	
Lindane	---		---		2.75	(1)	---		1.23 ± 0.36	(6)
Methoxychlor	---		---		---		---		1.79 ± 0.39	(3)
Methylchloroform	---		---		---		---		0.68 ± 0.16	(7)
Methylene chloride	---		---		---		---		1.68 ± 0.76	(4)
Methylethyl ketone	---		0.75	(1)	---		---		---	
Naphthalene	---		---		---		0.45	(2)	---	
Phenol	---		---		---		---		0.92	(1)
Silvex	---		---		---		---		0.96 ± 0.24	(7)
Styrene	---		---		---		1.00	(1)	---	
1,1,2,2-Tetrachloroethane	---		---		---		---		1.05	(2)
Tetrachloroethylene	---		---		---		0.40	(1)	0.81	(1)
Tetrahydrofuran	---		---		---		0.31	(4)	---	
Toluene	---		---		0.21 ± 0.08	(5)	0.97 ± 0.06	(18)	0.82	(2)
Toxaphene	---		---		---		---		3.10	(2)
Tribromomethane	---		---		0.68	(1)	---		0.97 ± 0.16	(6)
1,1,2-Trichloroethane	---		---		---		---		1.35 ± 0.60	(3)
1,1,1-Trichloroethane	---		---		---		---		0.68 ± 0.16	(7)
Trichloroethylene	---		---		---		0.97 ± 0.15	(13)	1.14 ± 0.42	(3)
Vinyl acetate	---		---		---		---		1.29	(1)
Vinylidene chloride	---		---		---		---		1.64 ± 0.69	(4)
o-Xylene	---		---		---		1.09 ± 0.30	(15)	---	
p-Xylene	---		---		---		1.30	(2)	0.77	(1)

Table C-11. Summary of HSE-9 Quality Assurance Tests for Data from January 1, 1987 to December 31, 1987 (Organic Analyses Performed by Contractors)

COMPOUND	WATER Mean ± SD	(n)	BULK Mean ± SD	(n)	SILICATE Mean ± SD	(n)	TUBE Mean ± SD	(n)
Acenaphthene	0.87	(1)	---		---		---	
Anthracene	0.35	(1)	---		---		---	
Aroclor 1242	---		0.74 ± 0.14	(10)	---		---	
Aroclor 1254	---		0.71 ± 0.22	(5)	---		---	
Aroclor 1260	---		0.78 ± 0.46	(9)	---		---	
1,2-Benzanthracene	0.62	(2)	---		---		---	
1,2-Benzanthracene (d12)	0.62	(2)	---		---		---	
Benzo-a-pyrene	0.63	(1)	---		---		---	
Benzo-b-fluoranthene	1.11	(1)	---		---		---	
Benzo-k-fluoranthene	0.53	(2)	---		---		---	
Bis(2-chloroethoxy)methane	0.66	(2)	---		---		---	
Bis(2-chloroethyl)ether	0.56	(2)	---		---		---	
Bis(2-chloroisopropyl)ether	0.66	(1)	---		---		---	
Bis(2-ethylhexyl)phthalate	0.48 ± 0.47	(3)	---		---		---	
Bromodichloromethane	0.62	(2)	---		---		---	
Bromoform	0.70	(2)	---		---		---	
4-Bromophenylphenyl ether	0.76	(1)	---		---		---	
Butylbenzyl phthalate	0.67	(1)	---		---		---	
Carbon tetrachloride	0.99 ± 0.58	(6)	0.87	(1)	---		0.77 ± 0.43	(5)
Chlorobenzene	---		---		0.07 ± 0.04	(4)	---	
Chlorodibromomethane	0.69	(2)	---		---		---	
Chloroform	0.64	(2)	---		---		---	
2-Chloronaphthalene	0.23	(2)	---		---		---	
4-Chlorophenylphenyl ether	0.62	(1)	---		---		---	
Chrysene	0.70	(1)	---		---		---	
Di-n-butyl phthalate	1.59	(2)	---		---		---	
Dibromochloromethane	0.69	(2)	---		---		---	
Dibutyl phthalate	1.59	(2)	---		---		---	
o-Dichlorobenzene (1,2)	0.42	(2)	---		---		---	
m-Dichlorobenzene (1,3)	0.54	(2)	---		---		---	
p-Dichlorobenzene (1,4)	0.59	(1)	---		---		---	
Dichlorobromomethane	0.62	(2)	---		---		---	
1,2-Dichloroethane	0.89	(2)	---		---		---	
Diethyl phthalate	0.92	(2)	---		---		---	
Dimethyl phthalate	0.46	(1)	---		---		---	
2,4-Dinitrotoluene	0.76	(2)	---		---		---	
2,6-Dinitrotoluene	0.76	(2)	---		---		---	
Ethylbenzene	---		---		0.13 ± 0.07	(5)	---	
Ethylene chloride	0.89	(2)	---		---		---	
Fluoranthene	0.78	(1)	---		---		---	
Fluorene	1.67	(1)	---		---		---	
HCB	0.41	(2)	---		---		---	
Hexachloro-1,3-butadiene	0.30	(2)	---		---		---	
Hexachlorobenzene	0.41	(2)	---		---		---	
Hexachlorobutadiene	0.30	(2)	---		---		---	
Hexachloroethane	0.46	(1)	---		---		---	
Isophorone	0.57	(2)	---		---		---	
Methylchloroform	0.73	(2)	---		---		---	
Methylene chloride	---		---		0.36	(2)	---	
Nitrobenzene	0.57	(1)	---		---		---	
N-Nitrosodi-n-propylamine	0.24	(2)	---		---		---	
Phenanthrene	0.72	(2)	---		---		---	
Phenanthrene (d10)	0.72	(2)	---		---		---	
Tetrachloroethylene	0.41	(2)	---		---		---	
Tribromomethane	0.70	(2)	---		---		---	
1,1,1-Trichloroethane	0.73	(2)	---		---		---	
Trichloroethylene	0.59 ± 0.17	(4)	---		200.	(2)	0.05	(2)
o-Xylene	---		---		0.16 ± 0.04	(5)	---	

Table C-12. Summary of HSE-9 Quality Assurance Tests for Data from January 1, 1987 to December 31, 1987 (Radiochemical Analyses Performed by HSE-9)

NUCLIDE	BIOLOGICAL Mean ± SD	(n)	FILTER Mean ± SD	(n)	SILICATE Mean ± SD	(n)	WATER Mean ± SD	(n)
Alpha	---		0.93 ± 0.06	(72)	---		1.07 ± 0.13	(546)
Am-241	1.23 ± 0.09	(3)	1.12 ± 0.10	(7)	1.00 ± 0.16	(6)	1.04 ± 0.08	(66)
Be-7	---		1.80 ± 0.31	(6)	---		---	
Beta	---		0.94 ± 0.04	(72)	---		1.03 ± 0.47	(549)
Co-57	---		---		---		1.15 ± 0.09	(53)
Co-60	1.19 ± 0.10	(4)	0.92 ± 0.01	(3)	---		0.91 ± 0.41	(72)
Cs-134	---		---		---		1.03 ± 0.24	(66)
Cs-137	1.13 ± 0.66	(35)	1.34 ± 0.32	(6)	0.92 ± 0.11	(43)	1.00 ± 0.11	(108)
Gamma	---		---		0.93 ± 0.04	(5)	0.92 ± 0.11	(21)
H-3	---		---		---		1.07 ± 0.23	(307)
I-131	1.11 ± 0.13	(9)	---		---		---	
K-40	---		---		3.29 ± 0.02	(3)	---	
Mn-54	---		1.05 ± 0.03	(3)	---		1.07 ± 0.07	(56)
Na-22	---		---		---		1.01 ± 0.03	(49)
Pu-238	0.95 ± 0.21	(22)	---		1.09 ± 0.44	(18)	1.05 ± 0.10	(58)
Pu-239	1.15 ± 0.37	(34)	1.33 ± 0.60	(9)	1.20 ± 0.62	(25)	1.00 ± 0.17	(81)
Ra-226	---		---		---		0.94 ± 0.06	(15)
Ru-106	---		1.49 ± 0.07	(3)	---		1.07 ± 0.36	(10)
Sr-90	0.98 ± 0.13	(23)	1.01 ± 0.07	(4)	1.16 ± 0.46	(7)	0.94 ± 0.05	(18)
U-234	---		---		---		0.93 ± 0.10	(26)
U-235	---		---		---		0.89 ± 0.13	(23)
U-235/238	---		---		---		0.95	(2)

Table C-13. 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	50 min	1×10^{-10} µCi/m^3
^{238}Pu	2.0×10^4 m^3	8×10^4 sec	2×10^{-18} µCi/m^3
$^{239,240}Pu$	2.0×10^4 m^3	8×10^4 sec	3×10^{-18} µCi/m^3
^{241}Am	2.0×10^4 m^3	8×10^4 sec	2×10^{-18} µCi/m^3
Gross alpha	6.5×10^3 m^3	100 min	4×10^{-16} µCi/m^3
Gross beta	6.5×10^3 m^3	100 min	4×10^{-16} µCi/m^3
Uranium (delayed neutron)	2.0×10^4 m^3	60 sec	1 pg/m^3
Water Sample			
Tritium	0.005 L	50 min	7×10^{-7} µCi/mL
^{137}Cs	0.5 L	5×10^4 sec	4×10^{-8} µCi/mL
^{238}Pu	0.5 L	8×10^4 sec	9×10^{-12} µCi/mL
$^{239,240}Pu$	0.5 L	8×10^4 sec	3×10^{-11} µCi/mL
^{241}Am	0.5 L	8×10^4 sec	2×10^{-10} 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
Uranium (delayed neutron)	0.025 L	50 sec	1 µg/L
Soil Sample			
Tritium	1 kg	50 min	0.003 pCi/g
^{137}Cs	100 g	5×10^4 sec	10^{-1} pCi/g
^{238}Pu	10 g	8×10^4 sec	0.003 pCi/g
$^{239,240}Pu$	10 g	8×10^4 sec	0.002 pCi/g
^{241}Am	10 g	8×10^4 sec	0.01 pCi/g
Gross alpha	2 g	100 min	1.4 pCi/g
Gross beta	2 g	100 min	1.3 pCi/g
Uranium (delayed neutron)	2 g	20 sec	0.03 µg/g

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APPENDIX D

METHODS FOR DOSE CALCULATIONS

A. Introduction

Annual radiation doses are evaluated for three principal exposure pathways: inhalation, ingestion, and external exposure (which includes exposure from immersion in air containing photon-emitting radionuclides and direct and scattered penetrating radiation). Estimates are made of:

(1) Maximum boundary organ doses and effective dose equivalents to a hypothetical individual at the laboratory boundary where the highest dose rate occurs. It assumes the individual is outdoors at the Laboratory boundary continuously (24 hours a day, 365 days a year).

(2) Maximum individual organ doses and effective dose equivalents 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.

(3) Average organ by body tissues and effective dose equivalents to nearby residents.

(4) 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.[D1,D2]

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-1. These adose conversion factors are taken from the DOE[D3] and are based on factors in Publication 30 of the International Commission on Radiological Protection (ICRP).[D4]

The dose conversion factors for inhalation assume a 1 um 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 Radiation Protection Standard [RPS]) if more than one category is given. Similarly, the ingestion dose conversion factors are chosen to maximize the effective dose or organ dose if more than one gastrointestinal tract uptake is given (for comparison with DOE's 100 mrem/yr RPS for all pathways).

These dose conversion factors calculate the 50-yr dose commitment for internal exposure. The 50-yr dose commitment is the total dose received by an organ during the 50-yr 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 Kocher.[D5] These factors, which are given in Table D-2, give the photon dose rate in mrem/yr per unit radionuclide air concentration in uCi/mL. The factors are used in the calculation of the population effective dose equivalent from external radiation for the 80-km (50-mi) area.

B. Inhalation Dose

Annual average air concentrations of ^{3}H, total U, ^{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 8400 m^3/yr[D6] to determine total annual intake via inhalation, in uCi/yr, for each radionuclide. Each intake is multiplied by appropriate dose conversion factors to convert radionuclide intake into 50-yr dose commitments. Following ICRP methods, doses are calculated for all organs that contribute over 10% of the total effective dose equivalent for each radionuclide (see Appendix A for definition of effective dose equivalent).

The dose calculated for inhalation of ^{3}H 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 (8760 h). This assumption is made for the boundary dose, dose to the maximum exposed individual, and dose to the population living within 80 km (50 mi) of the site.

Table D-1. Dose Conversion Factors (rem/uCi Intake) for Calculating Internal Doses

INHALATION

Radionuclide	Target Organ: Soft Tissue	Lung	Bone Surface	Red Marrow	Liver	Gonads	Effective Dose
^{3}H	6.3×10^{-5}						6.3×10^{-5}
^{234}U		$1.1 \times 10^{+3}$					$1.3 \times 10^{+2}$
^{235}U		$1.0 \times 10^{+3}$					$1.2 \times 10^{+2}$
^{238}U		$1.0 \times 10^{+3}$					$1.2 \times 10^{+2}$
^{238}Pu			$8.1 \times 10^{+3}$	$6.7 \times 10^{+2}$	$1.8 \times 10^{+3}$	$1.0 \times 10^{+2}$	$4.6 \times 10^{+2}$
$^{239,240}Pu$			$9.3 \times 10^{+3}$	$7.4 \times 10^{+2}$	$2.0 \times 10^{+3}$	$1.2 \times 10^{+2}$	$5.1 \times 10^{+2}$
^{241}Am			$9.3 \times 10^{+3}$	$7.4 \times 10^{+2}$	$2.0 \times 10^{+3}$	$1.2 \times 10^{+2}$	$5.2 \times 10^{+2}$

INGESTION

Radionuclide	Bone Surface	Red Marrow	Liver	Gonads	Kidney	Lungs	Breast	Thyroid
^{3}H								
^{7}Be		4.4×10^{-3}		2.1×10^{-4}				
^{90}Sr	1.6	7.0×10^{-1}						
^{137}Cs	4.8×10^{-2}	4.8×10^{-2}		5.2×10^{-2}		4.8×10^{-3}	4.4×10^{-3}	4.8 x 10
^{234}U	4.1	2.7×10^{-1}			1.7			
^{235}U	3.7	2.5×10^{-1}			1.6			
^{238}U	3.7	2.5×10^{-1}			1.5			
^{238}Pu	6.7	5.5×10^{-1}	1.5	8.5×10^{-2}				
$^{239,240}Pu$	7.8	5.9×10^{-1}	1.6	9.6×10^{-2}				
^{241}Am	$4.1 \times 10^{+1}$	3.1	8.5	5.2×10^{-1}				

Table D-1 (cont)

Radionuclide	Target Organ: Soft Tissue	LLI[a] Wall	SI[a] Wall	ULI[a] Wall	Remainder	Effective Dose
^{3}H	6.3×10^{-5}					6.3×10^{-5}
^{7}Be		4.4×10^{-4}	2.0×10^{-4}	2.7×10^{-4}		1.1×10^{-4}
^{90}Sr						1.3×10^{-1}
^{137}Cs		5.2×10^{-2}	5.2×10^{-2}		5.5×1^{-2}	5.0×10^{-2}
^{234}U						2.6×10^{-1}
^{235}U		2.0×10^{-1}				2.5×10^{-1}
^{238}U						2.3×10^{-1}
^{238}Pu						3.8×10^{-1}
$^{239,240}Pu$						4.3×10^{-1}
^{241}Am						2.2

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[a]LLI = lower lower-intestine; SI = small intestine; ULI = upper-intestine.

Table D-2. Dose Conversion Factors [(mrem/yr)/(μCi/mL)] for Calculating External Doses[a]

^{10}C	$9.8 \times 10^{+9}$
^{11}C	$5.6 \times 10^{+9}$
^{13}N	$5.6 \times 10^{+9}$
^{16}N	$2.5 \times 10^{+10}$
^{14}O	$1.8 \times 10^{+10}$
^{15}O	$5.6 \times 10^{+9}$
^{41}Ar	$7.5 \times 10^{+9}$

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[a]Dose conversion factors for ^{11}C, ^{13}N, ^{15}O, and ^{41}Ar were taken from Kocher.[D5] Dose conversion factors for the remaining radionuclides, which were not presented by Krocher, were calculated from:

$$\text{DCF } [(\text{mrem/yr})/(\mu\text{Ci/mL})] = 0.25 \times E \times 3.2 \times 10^{+10}$$

where E is the average gamma ray energy in MeV. The calculated factors were reduced by 30% to account for self-shielding by the body, so that they would be directly comparable with the factors from Kocher.

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.

C. Ingestion Dose

Results from foodstuff sampling (Sec. VII) 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[D2] to obtain total annual intake of that radionuclide. Multiplication of the annual 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-1).

Doses are evaluated for ingestion of ^{3}H, ^{137}Cs, total U, ^{238}Pu, and $^{239,240}Pu$ in fruits and vegetables; ^{3}H, ^{7}Be, ^{22}Na, ^{54}Mn, ^{57}Co, ^{83}Rb, ^{134}Cs, ^{137}Cs, and total U in honey; and ^{90}Sr, ^{137}Cs, total U, ^{238}Pu, and $^{239,240}Pu$ in fish.

D. External Radiation

Environmental thermoluminescent dosimeter (TLD) measurements are used to estimate external radiation doses.

Nuclear reactions with air in the target areas at the Los Alamos Meson Physics Facility (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 min, 10 min, 71 sec, and 122 sec half-lives, respectively. Neutron reactions with air at the Omega West Reactor (TA-2) and the LAMPF also form ^{41}Ar, which has a 1.8 h half-life.

The radioisotopes ^{11}C, ^{13}N, ^{14}O, and ^{15}O are sources of photon radiation because of formation of two 0.511 MeV photons through positron-electron annihilation. The ^{14}O emits a 2.3 MeV gamma with 99% yield. The ^{41}Ar emits a 1.29 MeV gamma with 99% yield.

The TLD measurements are corrected for background to determine the contribution to the external radiation field from Laboratory operations. Background estimates at each site, based on historical data, consideration of possible nonbackground contributions, and, if possible, values measured at locations of similar geology and topography, are then subtracted from each measured value. This net dose is assumed to represent the dose from Laboratory activities that an individual would receive if he or she were to spend 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 offsite locations where residences are present, an occupancy factor of 1.0 was used.

Two types of shielding are considered: shielding by buildings and self-shielding. Each shielding type is estimated to reduce the external radiation dose by 30%.[D9,D10]

Boundary and maximum individual doses from ^{41}Ar releases from the Omega West Reactor are estimated using a standard Gaussian dispersion model and measured stack releases (from Table G-2). Procedures used in making the calculations are described in the following section.

Neutron doses from the critical assemblies at TA-18 were based on 1987 measurements. Neutron fields were monitored principally with TLDs placed in cadmium-hooded 23-cm (9-in.) polyethylene spheres.

At onsite locations at which above-background doses were measured, but at which public access is limited, doses based on a more realistic estimate of exposure time are also presented. Assumptions used in these estimates are in the text.

E. Population Dose

Calculation of collective effective dose equivalent estimates (in person-rem) are based on measured data to the extent possible. For background radiation, average measured background doses for Los Alamos, White Rock, and regional stations are multiplied by the appropriate population number. Tritium average doses are calculated from average measured concentrations in Los Alamos and White Rock above background (as measured by the regional stations).

These doses are multiplied by population data incorporating results of the 1980 census (Sec. II.E). The population data have been slightly modified (increased from 155 077 in 1980 to 192 649 persons in 1987 within 80 km [50 mi] of the boundary) to account for population changes between 1980 and 1987. These changes are extrapolated from an estimate of the 1986 New Mexico population, by county, that was made by the U.S. Bureau of the Census.[D7]

Radionuclides emitted by the LAMPF and, to a lesser extent, by the Omega West Reactor, contribute over 95% of the population dose.

For ^{41}Ar, ^{11}C, ^{13}N, ^{14}O, and ^{15}O, atmospheric dispersion models are used to calculate an average dose to individuals living in the area in question. The air concentration of the isotope ($\chi[r,\theta]$) at a location (r,θ) due to its emission from a particular source is found using the annual average meteorological dispersion coefficient ($\chi[r,\theta]/Q$) (based on Gaussian plume dispersion models[D8]) and the source term Q. Source terms, obtained by stack measurements, are in Table G-2.

The dispersion factors were calculated from 1987 meteorological data collected near LAMPF during the actual time periods when radionuclides were being released from the stacks. Dispersion coefficients used to calculate the χ/Q's were determined from measurements of the standard deviations of wind direction. The χ/Q includes the reduction of the source term due to radioactive decay.

The gamma dose rate in a semi-infinite cloud at time t, $\gamma_\infty(r,\theta,t)$, can be represented by the equation

$$\gamma_\infty(r,\theta,t) = (DCF)\,(r,\theta,t)$$

where

$\gamma_\infty(r,\theta,t)$ = gamma dose rate in mrem/yr at time t, at a distance r, and angle θ,

DCF = dose rate conversion factor from Kocher[D5] or calculated from Slade[D8]

$\chi(r,\theta,t)$ = plume concentration in μCi/mL.

The annual dose is multiplied by the appropriate population figure to give the estimated population dose.

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APPENDIX E

UNITS OF MEASUREMENT

Throughout this report the International (SI) or Metric system of measurements has been used, with some exceptions. For units of radiation activity, exposure, and dose, customary units [i.e., 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 E-1 presents prefixes used in this report to define fractions or multiples of the base units of measurements. Table E-2 presents conversion factors for converting from SI units to U.S. Customary Units.

Table E-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 E-2. Approximate Conversion Factors for Selected SI (Metric) Units

Multiply SI (Metric) Unit	By	To Obtain US Customary Unit
Celsius (°C)	9/5, +32	Fahrenheit (°F)
Centimeters (cm)	0.39	Inches (in.)
Cubic Meters (m^3)	35	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 (g/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)

APPENDIX F

DESCRIPTIONS OF TECHNICAL AREAS AND THEIR ASSOCIATED PROGRAMS

Locations of the 32 active technical areas (TA) operated by the Laboratory are shown in Fig. 4. The main programs conducted at each are listed in this appendix.

TA-2, Omega Site: Omega West Reactor, an 8 megawatt nuclear research reactor, is located here. It serves as a research tool in providing a source of neutrons for fundamental studies in nuclear physics and associated fields.

TA-3, South Mesa Site: 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, Administration offices, Materials Department, the science museum, Chemistry and Materials Science Laboratories, Physics Laboratories, technical shops, cryogenics laboratories, a Van de Graaff accelerator, and cafeteria.

TA-6, Two Mile Mesa Site: This is one of three sites (TA-22 and TA-40 are the other two sites) used in development of special detonators for initiation of high explosive systems. Fundamental and applied research in support of this activity includes investigation of phenomena associated with initiation of high explosives, and research in rapid shock-induced reactions with shock tubes.

TA-8, GT Site (or Anchor Site West): This is a nondestructive 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 weapon components to checking of high pressure dies and molds. Principal tools include radiographic techniques (X ray machines to 1 million volts, a 24-MeV betatron), radioactive isotopes, ultrasonic testing, penetrant testing, and electromagnetic 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 explosive components and systems under a variety of extreme physical environments. The facilities are arranged so 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 firing 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 weapon functioning and weapon system behavior in nonnuclear tests, principally by electronic recording means.

TA-16, S-Site: Investigations at this site include development, engineering design, pilot manufacture, environmental testing, and stockpile production liaison for nuclear weapon warhead systems. Development and testing of high explosives, plastics and adhesives, and 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 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 site.

TA-22, TD Site: See TA-6.

TA-28, Magazine Area "A": Explosives storage area.

TA-33, HP-Site: A major high-pressure tritium handling facility is located here. Laboratory and office space for Geosciences Division related to the Hot Dry Rock Geothermal Project are also here.

TA-35, Ten Site: Nuclear safeguards research and development, which is conducted here, is 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 explosive phenomena, such as detonation velocity, are investigated here.

TA-37, Magazine Area "C": Explosives storage area.

TA-39, Ancho Canyon Site: Nonnuclear weapon behavior is studied here, primarily by photographic techniques. Investigations are also made into various phenomenological aspects of explosives, interactions of explosives, and explosions with other materials.

TA-40, DF-Site: See TA-6.

TA-41, W-Site: Personnel in this site are engaged primarily in engineering design and development of nuclear components, including fabrications and evaluation of test materials for weapons.

TA-43, Health Research Laboratory: The Biomedical Research Group does research here in 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: Here, applied photochemistry, which includes development of technology for laser isotope separation and laser-enhancement of chemical processes, is investigated. Solar energy research, particularly in the area of passive solar heating for residences, is done.

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-50, Waste Management Site: Personnel at this site have responsibility for treating and disposing of most industrial liquid waste received from Laboratory technical areas, for development of improved methods of solid waste treatment, and for containment of radioactivity removed by treatment. Radioactive liquid waste is piped to this site for treatment from most technical areas.

TA-51, Animal Exposure Facility: Here, 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 are done here.

TA-53, Meson Physics Facility: The Los Alamos Meson Physics Facility (LAMPF), a linear particle accelerator, is used to conduct research in the areas of basic physics, cancer treatment, material studies, and isotope production.

TA-54, Waste Disposal Site: This is a disposal area for solid radioactive and toxic wastes.

TA-55, Plutonium Processing Facilities: Processing of plutonium and research in plutonium metallurgy are done here.

TA-57, Fenton Hill Site: This is the location of the Laboratory's Hot Dry Rock geothermal project. Here scientists 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-58, Two Mile Mesa: Undeveloped technical area.

TA-59, Occupational Health Site: Occupational health and environmental science activities are conducted here.

APPENDIX G

ENVIRONMENTAL DATA TABLES

Table G-1. Estimated Maximum Individual 50-Year Dose Commitments from 1987 Airborne Radioactivity[a]

Isotope	Critical Organ	Location	Estimated Dose (mrem/yr)	Percentage of Radiation Protection Standard
^{3}H	Whole Body	Royal Crest (Station 11)[b]	0.02	<0.1%
$^{11}C, ^{13}N, ^{14}O, ^{15}O, ^{41}Ar$	Whole Body	East Gate (Station 6)[b]	6.1	24%
$U, ^{238}Pu, ^{239,240}Pu, ^{241}Am$	Bone Surface	Exxon Station (Station 10)[b]	0.11	0.1%

[a]Estimated maximum individual dose is the dose from Laboratory operations (excluding dose contributions from cosmic, terrestial, medical diagnostics, and other non-Laboratory sources) to an individual at or outside the Laboratory boundary where the highest dose rate occurs and where there is a person. It takes into account occupancy factors.
[b]See Fig. 8 for station locations.

Table G-2. Airborne Radioactive Emissions Totals[a]

Location	$^{238,239,240}Pu$[b] (μCi)	$^{235,238}U$[c] (μCi)	Mixed Fission Products (μCi)	^{41}Ar[d] (Ci)	^{32}P (μCi)	^{3}H (Ci)	Activation Products: Gaseous[e] (Ci)	Activation Products: Particulate/Vapor[f] (Ci)
TA-2				232				
TA-3	64.9	868	21.6			851		
TA-21	1.4	207	0.2			596		
TA-33						1000		
TA-35	0.6					155		
TA-41						470		
TA-43	0.5				48.4			
TA-46								
TA-48	0.6	1.6	1250					
TA-50	4.5		21.6					
TA-53						15.2	150 000	0.2
TA-54	<0.1							
TA-55	0.2					85.4		
Totals	72.8	1080	1290	232	48.4	3180	150 000	0.2

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[a] As reported on DOE Forms F-5821.1

[b] Plutonium values contain indeterminant traces of ^{241}Am, a transformation product of ^{241}Pu.

[c] Does not include aerosolized uranium from explosives testing (Table G-6).

[d] Does not include 600 Ci of ^{41}Ar present in gaseous, mixed activation products.

[e] Includes the following constituents: ^{16}N - 3.7%; ^{10}C - 1.4%; ^{14}O - 0.6%; ^{15}O - 43.7%; ^{13}N - 15.1%; ^{11}C - 35.1%; ^{41}Ar - 0.4%.

[f] Includes 37 nuclides, dominated by ^{183}Os and ^{7}Be.

Table G-3. Thermoluminescent Dosimeter Measurements

Station Location	Coordinates	Annual[a] Measurement (mrem)
Regional Stations (28-44 km)--Uncontrolled Areas		
1. Espanola	--	70 (8)[a]
2. Pojoaque	--	88 (8)
3. Santa Fe	--	90 (8)
4. Fenton Hill	--	124 (8)
Perimeter Stations (0-4 km)--Uncontrolled Areas		
5. Barranca School	N180 E130	98 (8)
6. Arkansas Avenue	N170 E030	85 (8)
7. Cumbres School	N150 E090	103 (8)
8. 48th Street	N110 W010	107 (8)
9. LA Airport	N110 E170	98 (8)
10. Bayo Canyon	N120 E250	106 (10)
11. Exxon Station	N090 E120	115 (8)
12. Royal Crest Trailer Court	N080 E080	108 (8)
13. White Rock	S080 E420	122 (8)
14. Pajarito Acres	S210 E380	90 (8)
15. Bandelier Lookout Station	S280 E200	95 (8)
16. Pajarito Ski Area	N150 W200	112 (8)
Onsite Stations--Controlled Areas		
17. TA-21 (DP West)	N095 E140	83 (8)
18. TA-6 (Two-Mile Mesa)	N025 E030	97 (8)
19. TA-53 (LAMPF)	N070 E090	115 (8)
20. Well PM-1	N030 E305	115 (8)
21. TA-16 (S-Site)	S035 W025	113 (7)
22. Booster P-2	S030 E220	112 (8)
23. TA-54 (Area G)	S080 E290	93 (8)
24. State Hwy 4	N070 E350	176 (8)
25. Frijoles Mesa	S165 E085	102 (8)
26. TA-2 (Omega Stack)	N075 E120	117 (8)
27. TA-2 (Omega Canyon)	N085 E1210	149 (7)
28. TA-18 (Pajarito Site)	S040 E205	153 (8)
29. TA-35 (Ten Site A)	N040 E105	116 (8)
30. TA-35 (Ten Site B)	N040 E110	122 (8)
31. TA-59 (Occupational Health Lab)	N050 E040	111 (8)
32. TA-3 (Van de Graaff)	N050 E020	121 (8)
33. TA-3 (Guard Station)	N050 E020	219 (8)
34. TA-3 (Alarm Building)	N050 E020	211 (8)
35. TA-3 (Guard Building)	N050 E020	165 (8)
36. TA-3 (Shop)	N050 E020	112 (8)
37. Pistol Range	N040 E240	110 (8)
38. TA-55 (Plutonium Facility South)	N040 E240	106 (8)
39. TA-55 (Plutonium Facility West)	N040 E080	117 (8)
40. TA-55 (Plutonium Facility North)	N040 E080	118 (8)

[a]Measurement (95% confidence increments).

Table G-4. Location of Air Sampling Stations

Station	Latitude or N-S Coord	Longitude or E-W Coord
Regional (28-44 km)		
1. Espanola	36°00'	106°06'
2. Pojoaque	35°52'	106°02'
3. Santa Fe	35°40'	106°56'
Perimeter (0-4 km)		
4. Barranca School	N180	E130
5. Arkansas Avenue	N170	E030
6. East Gate	N090	E210
7. 48th Street	N110	W010
8. LA Airport	N110	E170
9. Bayo Canyon	N120	E250
10. Exxon Station	N090	E120
11. Royal Crest	N080	E080
12. White Rock	S080	E420
13. Pajarito Acres	S210	E380
14. Bandelier	S280	E200
Onsite		
15. TA-21	N095	E140
16. TA-6	N025	E030
17. TA-53 (LAMPF)	N070	E090
18. Well PM-1	N030	E305
19. TA-52	N020	E155
20. TA-16	S035	W025
21. Booster P-2	S030	E180
22. TA-54	S080	E290
23. TA-49	S165	E085
24. TA-33	S245	E225
25. TA-2	N082	E110
26. TA-16-450	S055	W070

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

Radioactive Constituent	Units	EPA[a] 1983-1986	Laboratory[b] 1987	Uncontrolled Area Guide[c]
Gross beta	10^{-15} μCi/mL	10 ± 20	13 ± 3	9000
^{3}H	10^{-12} μCi/mL	Not reported	4.1 ± 17.0	200 000
U(natural)	pg/m^3	68 ± 25	74 ± 35	100 000
^{238}Pu	10^{-18} μCi/mL	0.3 ± 0.4	0.4 ± 0.3[d]	30 000
$^{239,240}Pu$	10^{-18} μCi/mL	0.8 ± 0.9	0.7 ± 0.4[e]	20 000
^{241}Am	10^{-18} μCi/mL	Not reported	1.4 ± 0.4[d]	20 000

[a]Environmental Protection Agency, "Environmental Radiation Data," Reports 33 through 45. Data are from Santa Fe, New Mexico sampling location and were taken from January 1983 through June 1986, excluding the periods from May 1983 through February 1984 and January 1985 through February 1985 for which data were not available.
[b]Data are annual averages from the regional stations (Espanola, Pojoaque, Santa Fe) and were taken during calendar year 1987.
[c]See Appendix A. These values are presented for comparison.
[d]Minimum detectable limit is 2 x 10^{-18} μCi/mL.
[e]Minimum detectable limit is 3 x 10^{-18} μCi/mL.

Table G-6. Estimated Aerial Concentrations of Toxic Elements Aerosolized by Dynamic Experiments[a]

Element	1987 Total Usage (kg)	Fraction Aerosolized (%)	Annual Average Concentration (ng/m^3) (4 km)	Annual Average Concentration (ng/m^3) (8 km)	Applicable Standard (ng/m^3)
Uranium	97.6	10	9.5×10^{-3}	3.8×10^{-3}	9000[b]
Beryllium	2.0	2	5.5×10^{-5}	1.6×10^{-5}	10[c]
Lead	70.8	100[d]	7.6×20^{-2}	3.0×10^{-2}	1500[e]

[a]Through November.
[b]DOE 1981.
[c]Thirty day average. New Mexico Air Quality Control Regulation 201.
[d]Assumed percentage aerosolized.
[e]Three-month average, 40 CFR 50.12.

Table G-7. Airborne Tritiated Water Concentrations for 1987

Station Location[a]	Total Air Volume (m^3)	Number of Monthly Samples	Number of Samples <MDL[b]	Concentrations--pCi/m^3 (10^{-12} µCi/mL) Max[c]	Min[c]	Mean[c]	Mean as % Guide[d]
Regional Stations (24-44 km)--Uncontrolled Areas							
1. Espanola	111.31	11	7	31.0 (6.0)	-8.0 (2.0)	3.1 (10.0)	<0.1
2. Pojoaque	104.96	11	7	90.0 (20.0)	-7.0 (2.0)	9.1 (27.6)	<0.1
3. Santa Fe	111.66	11	8	5.0 (2.0)	-7.0 (2.0)	0.0 (3.7)	<0.1
Regional Group Summary	326.93	33	22	90.0 (20.0)	-8.0 (2.0)	4.1 (17.0)	<0.1
Perimeter Stations (0-4 km)--Uncontrolled Areas							
4. Barranca School	122.26	12	2	60.0 (10.0)	-3.0 (1.0)	11.7 (16.8)	<0.1
5. Arkansas Avenue	116.71	12	5	30.0 (6.0)	-2.5 (0.6)	9.4 (10.9)	<0.1
6. East Gate	121.19	12	1	28.0 (5.0)	0.7 (0.6)	9.0 (6.9)	<0.1
7. 48th Street	119.99	12	4	120.0 (20.0)	-3.6 (1.0)	27.0 (41.6)	<0.1
8. LA Airport	118.14	12	0	37.0 (7.0)	3.5 (0.8)	11.5 (9.0)	<0.1
9. Bayo STP	113.21	11	5	7.0 (1.0)	-1.3 (0.4)	2.9 (2.8)	<0.1
10. Exxon Station	123.49	12	2	25.0 (5.0)	-1.8 (0.6)	8.9 (8.2)	<0.1
11. Royal Crest	108.75	12	0	140.0 (30.0)	3.0 (1.0)	27.3 (39.0)	<0.1
12. White Rock	106.36	12	7	49.0 (9.0)	-6.0 (2.0)	7.7 (15.2)	<0.1
13. Pajarito Acres	120.93	12	9	7.0 (1.0)	-4.0 (1.0)	0.6 (3.0)	<0.1
14. Bandelier	105.59	12	4	13.0 (3.0)	-0.8 (0.6)	4.4 (3.8)	<0.1
Perimeter Group Summary	1276.62	131	39	140.0 (30.0)	-6.0 (2.0)	11.0 (20.4)	<0.1

Table G-7 (cont)

Station Location[a]	Total Air Volume (m^3)	Number of Monthly Samples	Number of Samples <MDL[b]	Concentrations--pCi/m^3 (10^{-12} µCi/mL) Max[c]	Min[c]	Mean[c]	Mean as % Guide[d]
On-site Stations--Controlled Areas							
15. TA-21	94.84	11	0	460.0 (90.0)	2.5 (0.8)	51.8 (135.6)	<0.1
16. TA-6	116.66	12	5	90.0 (20.0)	-2.9 (0.9)	10.9 (25.6)	<0.1
17. TA-53 (LAMPF)	106.20	12	2	70.0 (10.0)	-4.0 (1.0)	15.1 (21.3)	<0.1
18. Well PM-1	107.70	12	2	51.0 (10.0)	-5.0 (1.0)	12.3 (15.8)	<0.1
19. TA-52	105.85	12	2	130.0 (30.0)	-3.6 (1.0)	19.2 (37.4)	<0.1
20. TA-16	121.59	12	6	39.0 (8.0)	-6.0 (1.0)	3.9 (11.5)	<0.1
21. Booster P-2	95.73	12	3	140.0 (30.0)	-5.0 (1.0)	19.6 (41.2)	<0.1
22. TA-54	114.93	12	1	100.0 (20.0)	-2.0 (2.0)	32.3 (35.7)	<0.1
23. TA-49	99.71	12	8	160.0 (30.0)	-7.0 (2.0)	17.9 (46.8)	<0.1
24. TA-33	120.35	12	0	32.0 (6.0)	7.0 (1.0)	19.5 (7.5)	<0.1
25. Ta-2	90.70	12	0	120.0 (20.0)	3.0 (1.0)	27.4 (33.9)	<0.1
26. TA-16-450	79.03	12	7	180.0 (30.0)	-12.0 (3.0)	15.8 (52.1)	<0.1
On-site Group Summary	1253.29	143	36	460.0 (90.0)	-12.0 (3.0)	21.7 (51.5)	<0.1

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[a]See Fig. 8 for map of station locations.
[b]Minimum detectable limit = 2×10^{-12} µCi/mL.
[c]Uncertainties are in parentheses (see Appendix B).
[d]Controlled Area DOE Concentration Guide = 5×10^{-6} µCi/mL;
uncontrolled Area Derived Concentration Guide = 1×10^{-7} µCi/mL.

Table G-8. Airborne $^{239,240}Pu$ Concentrations for 1987

Station Location[a]	Total Air Volume (m^3)	Number of Quarterly Samples	Number of Samples <MDL[b]	Concentrations--aCi/m^3 (10^{-18} µCi/mL) Max[c]	Min[c]	Mean[c]	Mean as % Guide[d]
Regional Stations (28-44 km)--Uncontrolled Areas							
1. Espanola	91 077	4	4	1.0 (1.5)	0.5 (0.5)	0.8 (0.2)	<0.1
2. Pojoaque	84 739	4	4	1.3 (0.6)	0.0 (0.5)	0.5 (0.6)	<0.1
3. Santa Fe	96 114	4	4	1.2 (0.6)	0.3 (0.7)	0.7 (0.4)	<0.1
Regional Group Summary	271 930	12	12	1.3 (0.6)	0.0 (0.5)	0.7 (0.4)	<0.1
Perimeter Stations (0-49 km)--Uncontrolled Areas							
4. Barranca School	72 961	3	3	1.4 (2.3)	0.2 (0.3)	0.6 (0.6)	<0.1
5. Arkansas Avenue	74 296	3	3	0.8 (0.7)	0.5 (0.4)	0.7 (0.2)	<0.1
6. East Gate	73 328	4	4	3.8 (3.0)	0.2 (0.5)	1.5 (1.6)	<0.1
7. 48th Street	59 630	3	3	0.5 (0.5)	0.0 (0.5)	0.3 (0.3)	<0.1
8. LA Airport	93 632	4	3	2.1 (0.6)	0.6 (0.4)	1.2 (0.7)	<0.1
9. Bayo STP	88 374	4	3	2.1 (0.9)	0.7 (1.3)	1.2 (0.6)	<0.1
10. Exxon Station	87 022	4	2	3.1 (0.8)	0.6 (0.6)	2.1 (1.0)	<0.1
11. Royal Crest	86 622	4	4	1.4 (4.2)	0.0 (0.5)	0.6 (0.6)	<0.1
12. White Rock	92 885	4	4	1.1 (0.5)	0.0 (0.6)	0.7 (0.5)	<0.1
13. Pajarito Acres	105 964	4	4	1.1 (0.5)	0.2 (0.2)	0.5 (0.4)	<0.1
14. Bandelier	88 466	4	4	0.6 (0.4)	0.1 (0.4)	0.3 (0.2)	<0.1
Perimeter Group Summary	923 180	41	37	3.8 (3.0)	0.0 (0.5)	0.9 (0.9)	<0.1

Table G-8 (cont)

Station Location[a]	Total Air Volume (m^3)	Number of Quarterly Samples	Number of Samples <MDL[b]	Concentrations--aCi/m^3 (10^{-18} µCi/mL) Max[c]	Min[c]	Mean[c]	Mean as % Guide[d]
On-site Stations--Controlled Areas							
15. TA-21	94 118	4	4	1.8 (0.5)	0.4 (0.4)	1.1 (0.6)	<0.1
16. TA-6	87 428	4	4	1.0 (0.5)	0.4 (0.4)	0.6 (0.3)	<0.1
17. TA-53 (LAMPF)	104 546	4	4	0.8 (0.6)	0.0 (0.4)	0.4 (0.4)	<0.1
18. Well PM-1	110 612	4	4	0.3 (0.2)	0.1 (0.1)	0.2 (0.1)	<0.1
19. TA-52	94 263	4	4	0.3 (0.4)	0.0 (0.5)	0.2 (0.1)	<0.1
20. TA-16	103 821	4	4	0.9 (0.4)	0.5 (0.4)	0.7 (0.2)	<0.1
21. Booster P-2	91 987	4	3	3.8 (1.0)	0.0 (0.4)	1.6 (1.6)	<0.1
22. TA-54	91 599	4	0	36.8 (3.6)	2.8 (0.7)	13.5 (15.7)	<0.1
23. TA-49	77 741	4	4	0.7 (0.8)	0.4 (0.2)	0.6 (0.1)	<0.1
24. TA-33	105 211	4	4	1.7 (0.6)	0.1 (0.4)	0.8 (0.7)	<0.1
25. TA-2	89 097	4	3	3.2 (1.0)	0.2 (0.4)	1.0 (1.5)	<0.1
26. TA-16-450	67 011	4	4	1.6 (0.9)	0.3 (0.6)	0.8 (0.6)	<0.1
On-site Group Summary	1 117 434	48	42	36.8 (3.6)	0.0 (0.4)	1.8 (5.4)	<0.1

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[a]See Fig. 8 for map of station locations.
[b]Minimum detectable limit = 3×10^{-18} µCi/mL.
[c]Uncertainties are in parentheses (see Appendix B).
[d]Controlled Area DOE Concentration Guide = 2×10^{-12} µCi/mL.
Uncontrolled Area Derived Concentration Guide = 2×10^{-14} µCi/mL.

Table G-9. Airborne ^{241}Am Concentrations for 1987

Station Location[a]	Total Air Volume (m^3)	Number of Quarterly Samples	Number of Samples <MDL[b]	Concentrations--aCi/m^3 (10^{-18} µCi/mL) Max[c]	Min[c]	Mean[c]	Mean as % Guide[d]
Regional Stations (28-44 km)--Uncontrolled Areas							
3. Santa Fe	71 629	3	3	1.8 (0.8)	1.0 (0.8)	1.4 ± 0.4	<0.1
Perimeter Stations (0-40 km)--Uncontrolled Areas							
6. East Gate	55 655	3	3	1.7 (0.7)	0.3 (0.7)	1.1 (0.7)	<0.1
8. LA Airport	24 931	1	1	1.7 (0.8)	1.7 (0.8)	1.7 (0.8)	<0.1
9. Bayo STP	66 204	3	3	1.7 (0.7)	0.3 (0.4)	1.0 (0.7)	<0.1
12. White Rock	92 885	4	4	1.3 (0.8)	0.5 (0.7)	0.8 (0.3)	<0.1
Perimeter Group Summary	239 675	11	11	1.7 (0.8)	0.3 (0.7)	1.0 (0.5)	<0.1
On-site Stations--Controlled Areas							
16. TA-6	87 428	4	4	1.9 (0.9)	0.8 (0.5)	1.5 (0.5)	<0.1
17. TA-53 (LAMPF)	104 546	4	4	1.0 (0.5)	0.5 (0.4)	0.8 (0.2)	<0.1
20. TA-16	103 821	4	4	1.6 (0.8)	0.6 (0.5)	1.0 (0.4)	<0.1
21. Booster P-2	91 987	4	4	1.9 (0.9)	0.8 (0.6)	1.3 (0.5)	<0.1
22. TA-54	91 599	4	0	26.3 (2.4)	3.3 (1.0)	9.5 (11.2)	<0.1
23. TA-49	77 741	4	4	2.5 (1.5)	0.4 (0.7)	1.2 (0.9)	<0.1
On-site Group Summary	557 122	24	20	26.3 (2.4)	0.4 (0.7)	2.5 (5.2)	<0.1

[a]See Fig. 8 for map of station locations.
[b]Minimum detectable limit = 2×10^{-18} µCi/mL.
[c]Uncertainties are in parentheses (see Appendix B).
[d]Controlled Area DOE Concentration Guide = 6×10^{-12} µCi/mL.
Uncontrolled Area Derived Concentration Guide = 2×10^{-14} µCi/mL.

Table G-10. Airborne Uranium Concentrations for 1987

Station Location[a]	Total Air Volume (m^3)	Number of Quarterly Samples	Number of Samples <MDL[b]	Concentrations--pg/m^3 Max[c]	Min[c]	Mean[c]	Mean as % Guide[d]
Regional Stations (28-44 km)--Uncontrolled Areas							
1. Espanola	91 077	4	0	118.9 (11.9)	28.1 (2.8)	78.9 (40.5)	<0.1
2. Pojoaque	84 739	4	0	124.8 (12.5)	88.0 (8.8)	103.0 (15.6)	<0.1
3. Santa Fe	96 114	4	0	48.5 (4.9)	31.6 (3.2)	40.4 (7.0)	<0.1
Regional Group Summary	271 930	12	0	124.8 (12.5)	28.1 (2.8)	74.1 (35.4)	<0.1
Perimeter Stations (0-4 km)--Uncontrolled Areas							
4. Barranca School	96 881	4	0	49.0 (4.9)	29.7 (3.0)	36.2 (8.9)	<0.1
5. Arkansas Avenue	97 921	4	0	27.1 (2.7)	14.9 (1.5)	21.4 (5.0)	<0.1
6. East Gate	73 328	4	0	47.9 (4.8)	28.0 (2.8)	36.9 (8.4)	<0.1
7. 48th Street	77 435	4	0	34.0 (3.4)	24.4 (2.4)	28.5 (4.5)	<0.1
8. LA Airport	93 632	4	0	69.8 (7.0)	35.4 (3.5)	50.1 (16.6)	<0.1
9. Bayo STP	88 374	4	0	39.2 (3.9)	18.0 (1.8)	28.0 (10.9)	<0.1
10. Exxon Station	87 022	4	0	66.8 (6.7)	38.3 (3.8)	52.4 (13.2)	<0.1
11. Royal Crest	86 622	4	0	68.1 (6.8)	24.2 (2.4)	41.6 (18.8)	<0.1
12. White Rock	92 885	4	0	31.5 (3.1)	24.1 (2.4)	27.6 (3.7)	<0.1
13. Pajarito Acres	105 964	4	0	25.5 (2.5)	11.3 (1.1)	19.8 (6.0)	<0.1
14. Bandelier	88 466	4	0	33.6 (3.4)	11.6 (1.2)	21.8 (11.3)	<0.1
Perimeter Group Summary	988 530	44	0	69.8 (7.0)	11.3 (1.1)	33.1 (14.5)	<0.1

Table G-10 (cont)

Station Location[a]	Total Air Volume (m^3)	Number of Quarterly Samples	Number of Samples <MDL[b]	Concentrations--pg/m^3 Max[c]	Min[c]	Mean[c]	Mean as % Guide[d]
On-site Stations--Controlled Areas							
15. TA-21	94 118	4	0	42.5 (4.3)	24.9 (2.5)	34.6 (7.9)	<0.1
16. TA-6	87 428	4	0	74.4 (7.4)	18.2 (1.8)	39.8 (24.4)	<0.1
17. TA-53 (LAMPF)	104 546	4	0	34.5 (3.4)	26.8 (2.7)	30.3 (3.2)	<0.1
18. Well PM-1	110 612	4	0	20.9 (2.1)	15.4 (1.5)	19.0 (2.6)	<0.1
19. TA-52	94 263	4	0	50.9 (5.1)	21.0 (2.1)	39.1 (13.4)	<0.1
20. TA-16	103 821	4	0	27.5 (2.7)	15.6 (1.6)	20.7 (5.4)	<0.1
21. Booster P-2	91 987	4	0	37.0 (3.7)	28.1 (2.8)	30.5 (4.4)	<0.1
22. TA-54	91 599	4	0	88.6 (8.9)	35.0 (3.5)	53.8 (24.0)	<0.1
23. TA-49	77 741	4	0	28.3 (2.8)	13.2 (1.3)	20.2 (6.8)	<0.1
24. TA-33	105 211	4	0	70.2 (7.0)	15.3 (1.5)	32.8 (25.2)	<0.1
25. TA-2	89 097	4	0	56.4 (5.6)	23.1 (2.3)	34.1 (15.3)	<0.1
26. TA-16-450	67 011	4	0	18.6 (1.9)	12.8 (1.3)	16.5 (2.6)	<0.1
On-site Group Summary	1 117 434	48	0	88.6 (8.9)	12.8 (1.3)	30.9 (16.2)	<0.1

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[a]See Fig. 8 for map of station locations.
[b]Minimum detectable limit = 1 pg/m^3.
[c]Uncertainties are in parentheses (see Appendix B).
[d]Controlled Area DOE Concentration Guide = 2×10^8 pg/m^3.
Uncontrolled Area Derived Concentration Guide = 1×10^5 pg/m^3.

Note: One curie of natural uranium is equivalent to 3000 kg of natural uranium. Hence, uranium masses can be converted to the DOE "uranium special curie" by using the factor 3.3×10^{-13} $\mu Ci/pg$.

Table G-11. Emissions (tons/yr) and Fuel Consumption (10^9 Btu/yr) from the TA-3 Power Plant and Steam Plants

		Location				
Parameter	Year	TA-3	TA-16	TA-21	Western Area	Total
Particulates	1986	1.8	0.4	0.1	0.00	2.3
	1987	1.5	0.5	0.1	0.00	2.1
	% Change	-14.9	11.6	-1.7	--	-9.3
Oxides of Nitrogen	1986	15.1	19.6	5.5	0.00	40.2
	1987	12.8	21.8	5.4	0.07	40.1
	% Change	-15.3	11.4	-1.2	--	-0.2
Carbon Monoxide	1986	23.6	4.9	1.4	0.00	29.9
	1987	20.1	5.5	1.4	0.02	26.9
	% Change	-15.0	11.6	-1.2	--	-10.0
Hydrocarbons	1986	1.0	0.8	0.2	0.00	2.0
	1987	0.9	0.9	0.2	0.00	2.0
	% Change	-14.6	11.6	-1.2	--	-2.5
Fuel Consumption	1986	1313	310	87	0	1710.0
	1987	1098	341	85	1	1525.0
	% Change	-16.3	10.0	-2.8	--	-10.8

Table G-12. Quality of Effluent from the TA-50 Liquid Radioactive Waste Treatment Plan for 1987[a]

Radionuclide	Activity Released (mCi)	Mean Concentration (μCi/mL)	Mean as % DOE's CG[b]
^{3}H	100 000	3.8×10^{-3}	3.8
^{89}Sr	64	2.4×10^{-6}	0.8
^{90}Sr	1.0	3.9×10^{-8}	0.4
^{137}Cs	8.1	3.0×10^{-7}	0.1
^{234}U	1.6	6.0×10^{-8}	<0.1
^{238}Pu	1.4	5.3×10^{-8}	<0.1
$^{239,230}Pu$	3.2	1.2×10^{-7}	0.1
^{241}Am	3.6	1.3×10^{-7}	0.1

Nonradioactive Constituents	Mean Concentration (mg/L)
Cd[c]	1.1×10^{-3}
Ca	170
Cl	150
Total Cr[c]	2.4×10^{-2}
Cu[c]	0.33
F	12
Hg[c]	4.9×10^{-4}
Mg	1.1
Na	920
Pb[c]	5.1×10^{-2}
Zn[c]	0.32
CN	0.3
COD	100
NO_3-N	476
PO_4	1.5
TDS	4150
pH[c]	6.98 - 7.77

Total Effluent Volume = 2.66×10^{7} L

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[a]As reported on DOE forms F-5821.1.
[b]Department of Energy's Concentration Guide for Controlled Areas (Appendix A).
[c]Constituents regulated by National Pollutant Discharge Elimination System permit.

Table G-13. Quality of Effluent from the Los Alamos Meson Physics Facilities (TA-53) Lagoons for 1987[a]

Radionuclide	Activity Released (mCi)	Mean Concentration (μCi/mL)	Mean as % DOE's CG[b]
^{3}H	10 900	2.7×10^{-3}	2.7
^{7}Be	330	8.0×10^{-5}	0.2
^{22}Na	89	2.2×10^{-5}	2.2
^{54}Mn	23	5.6×10^{-6}	0.1
^{57}Co	81	2.0×10^{-5}	<0.1
^{60}Co	8.5	2.1×10^{-6}	0.2
^{134}Cs	79	1.9×10^{-5}	6.4

Total Effluent Volume = 4.109×10^{6} L

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[a]As reported on DOE forms F-5821.1.
[b]Department of Energy's Concentration Guide for Controlled Areas (Appendix A).

Table G-14. Location of Surface and Ground Water Sampling Stations

Station	Latitude or N-S Coordinate	Longitude or E-W Coordinate	Map Designation[a]	Type[b]
Regional Surface Water				
Rio Chama at Chamita	30°05'	106°07'	---	SW
Rio Grande at Embudo	36°12'	105°58'	---	SW
Rio Grande at Otowi	35°52'	106°08'	---	SW
Rio Grande at Cochiti	35°37'	106°19'	---	SW
Rio Grande at Bernalillo	35°17'	106°36'	---	SW
Jemez River	35°40'	106°44'	---	SW
Perimeter Stations				
Los Alamos Reservoir	N105	W090	7	SW
Guaje Canyon	N300	E100	8	SW
Frijoles	S280	E180	9	SW
La Mesita Spring	N080	E550	10	GWD
Sacred Spring	N170	E540	11	GWD
Indian Spring	N140	E530	12	GWD
White Rock Canyon				
Group I				
Sandia Spring	S030	E470	13	SWR
Spring 3	S110	E450	14	SWR
Spring 3A	S120	E445	15	SWR
Spring 3AA	S140	E440	16	SWR
Spring 4	S170	E110	17	SWR
Spring 4A	S150	E395	18	SWR
Spring 5	S220	E390	19	SWR
Sprng 5A	S240	E360	20	SWR
Ancho Spring	S280	E305	21	SWR
Group II				
Spring 5A	S230	E390	22	SWR
Spring 6	S300	E330	23	SWR
Spring 6A	S310	E310	24	SWR
Spring 7	S330	E295	25	SWR
Spring 8	S335	E285	26	SWR
Spring 8A	S315	E280	27	SWR
Spring 9	S270	E270	28	SWR
Spring 9A	S325	E265	29	SWR
Doe Spring	S320	E250	30	SWR
Spring 10	S370	E230	31	SWR
Group III				
Spring 1	N040	E520	32	SWR
Spring 2	N015	E505	33	SWR

Table G-14 (cont)

Station	Latitude or N-S Coordinate	Longitude or E-W Coordinate	Map Designation[a]	Type[b]
White Rock Canyon				
Group IV				
Spring 3B	S150	E465	34	SWR
Streams				
Pajarito	S180	E410	35	SWR
Ancho	S295	E340	36	SWR
Frijoles	S365	E235	37	SWR
Sanitary Effluent				
Mortandad	S070	E480	38	SWR
Onsite Stations				
Test Well 1	N070	E345	39	GWD
Test Well 2	N120	E150	40	GWD
Test Well 3	N080	E215	41	GWD
Test Well DT-5A	S110	E090	42	GWD
Test Well 8	N035	E170	43	GWD
Test Well DT-9	S155	E140	44	GWD
Test Well DT-10	S120	E125	45	GWD
Canada del Buey	N010	E150	46	SW
Pajarito	S060	E215	47	SW
Water Canyon at Beta	S090	E090	48	SW
Pajarito Canyon (Onsite)				
PCO-1	S054	E212	102	GWS
PCO-2	S081	E255	103	GWS
PCO-3	S098	E293	104	GWS
Effluent Release Areas				
Acid-Pueblo Canyon				
Acid Weir	N125	E070	49	SW
Pueblo 1	N130	E080	50	SW
Pueblo 2	N120	E155	51	SW
Pueblo 3	N085	E315	52	SW
Hamilton Bend Springs	N110	E250	53	S
Test Well 1A	N070	E335	54	GWS
Test Well 2A	N120	E140	55	GWS
Basalt Spring	N065	E395	56	S

Table G-14 (cont)

Station	Latitude or N-S Coordinate	Longitude or E-W Coordinate	Map Designation[a]	Type[b]
DP-Los Alamos Canyon				
DPS-1	N090	E160	57	SW
DPS-4	N080	E200	58	SW
LAO-C	N085	E070	59	GWS
LAO-1	N080	E120	60	GWS
LAO-2	N080	E210	61	GWS
LAO-3	N080	E220	62	GWS
LAO-4	N070	E245	63	GWS
LAO-4.5	N065	E270	64	GWS
Sandia Canyon				
SCS-1	N080	E040	65	SW
SCS-2	N060	E140	66	SW
SCS-3	N050	E185	67	SW
Mortandad Canyon				
GS-1	N040	E100	68	SW
MCO-3	N040	E110	69	GWS
MCO-4	N035	E150	70	GWS
MCO-5	N030	E160	71	GWS
MCO-6	N030	E175	72	GWS
MCO-7	N025	E180	73	GWS
MCO-7.5	N030	E190	74	GWS
MCO-8				
Water Supply and Distribution				
Los Alamos Well Field				
Well LA-1B	N115	E530	76	GWD
Well LA-2	N125	E505	77	GWD
Well LA-3	N130	E490	78	GWD
Well LA-4	N070	E405	79	GWD
Well LA-5	N076	E435	80	GWD
Well LA-6	N105	E465	81	GWD
Guaje Well Field				
Well G-1	N190	E385	82	GWD
Well G-1A	N197	E380	83	GWD
Well G-2	N205	E365	84	GWD
Well G-3	N215	E350	85	GWD
Well G-4	N213	E315	86	GWD
Well G-5	N228	E295	87	GWD
Well G-6	N215	E270	88	GWD

Table G-14 (cont)

Station	Latitude or N-S Coordinate	Longitude or E-W Coordinate	Map Designation[a]	Type[b]
Pajarito Well Field				
Well PM-1	N030	E305	89	GWD
Well PM-2	S055	E202	90	GWD
Well PM-3	N040	E255	91	GWD
Well PM-4	S030	E205	92	GWD
Well PM-5	N015	E155	93	GWD
Water Canyon Gallery	S040	W125	94	GWD
Fire Station 1	N080	E015	95	D
Fire Station 2	N100	E120	96	D
Fire Station 3	S085	E375	97	D
Fire Station 4	N185	E070	98	D
Fire Station 5	S010	W065	99	D
Bandelier National Monument Headquarters	S270	E190	100	D
Fenton Hill (TA-57)	35°53'	106°40'	101	D

[a]Regional surface water sampling locations in Fig. 15; Perimeter, White Rock Canyon, On-site, and Effluent Release Area sampling locations in Fig. 16.
[b]SW = surface water, GWD = deep or main aquifer, GWS = shallow or alluvial aquifer, SWR = spring at White Rock Canyon, and D = water supply distribution system.

Table G-15. Radiochemical Quality of Surface Water from Regional Stations[a]

Station	^{3}H (10^{-6} µCi/mL)	^{137}Cs (10^{-9} µCi/mL)	Total U (µg/L)	^{238}Pu (10^{-9} µCi/mL)	$^{239,240}Pu$ (10^{-9} µCi/mL)	Gross Gamma (Counts/min/L)
Rio Chama at Chamita	-0.7 (0.7)	32 (44)	1.3 (1.0)	0.008 (0.012)	0.017 (0.012)	-70 (100)
Rio Chama at Chamita	0.2 (0.3)	95 (62)	2.0 (1.0)	0.011 (0.012)	-0.004 (0.004)	260 (80)
Rio Grande at Embudo	-1.6 (0.7)	80 (57)	2.2 (1.0)	0.000 (0.010)	0.006 (0.010)	30 (100)
Rio Grande at Embudo	-0.2 (0.3)	21 (53)	2.0 (1.0)	-0.008 (0.008)	-0.008 (0.006)	460 (90)
Rio Grande at Otowi	-0.9 (0.7)	8 (44)	2.1 (1.0)	0.000 (0.010)	-0.004 (0.010)	-150 (100)
Rio Grande at Otowi	0.2 (0.3)	1200 (414)	2.0 (1.0)	0.018 (0.018)	-0.004 (0.012)	260 (80)
Rio Grande at Cochiti	-0.7 (0.7)	38 (55)	2.3 (1.0)	0.000 (0.010)	0.000 (0.010)	20 (100)
Rio Grande at Cochiti	0.1 (0.3)	--	2.0 (1.0)	-0.005 (0.005)	0.000 (0.010)	360 (90)
Rio Grande at Bernalillo	-0.4 (0.7)	41 (45)	2.4 (1.0)	-0.012 (0.018)	-0.025 (0.013)	-300 (100)
Rio Grande at Bernalillo	0.2 (0.3)	139 (65)	3.0 (1.0)	0.000 (0.010)	-0.008 (0.008)	380 (90)
Jemez River at Jemez	-1.4 (0.7)	108 (58)	1.6 (1.0)	-0.004 (0.009)	0.025 (0.014)	-180 (100)
Jemez River at Jemez	-0.1 (0.3)	58 (58)	2.0 (1.0)	0.004 (0.008)	-0.004 (0.004)	400 (90)
No. of Analyses	12	11	12	12	12	12
Average	-0.4	165	2.1	0.001	-0.001	122
S	0.6	345	0.4	0.008	0.013	261
Minimum	-1.6 (0.7)	8 (44)	1.3 (1.0)	-0.012 (0.018)	-0.025 (0.013)	-300 (100)
Maximum	0.2 (0.3)	1200 (414)	3.0 (1.0)	0.011 (0.012)	0.025 (0.014)	460 (90)
Limits of Detection	0.7	40	1	0.009	0.03	50

[a]Samples collected in February and September; counting uncertainty in parentheses.

Table G-16. Chemical Quality of Surface Water from Regional Stations (mg/L)[a]

Station	SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	P	SO_4	Cl	F	N	TDS	Total Hardness	pH	Conductivity (mS/m)
Rio Chama at Chamita	11	32	8.2	1.8	17	0	89	<0.2	80	3	0.2	<1	174	217	8.2	34
Rio Grande at Embudo	24	30	6.0	2.3	15	0	92	<0.2	34	5	0.5	<1	103	177	8.0	26
Rio Grande at Otowi	26	30	6.1	2.2	15	0	93	<0.2	34	5	0.5	<1	101	175	8.2	26
Rio Grande at Cochiti	17	38	7.1	1.9	16	0	96	<0.2	56	4	0.3	<1	127	195	8.1	30
Rio Grande at Bernalillo	18	39	7.3	2.0	18	0	95	<0.2	62	5	0.3	<1	126	203	8.0	32
Jemez River at Jemez	38	37	5.5	5.9	44	2	141	<0.2	17	47	0.8	<1	123	279	8.3	45
Summary																
No. of Analyses	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Average	22	34	6.7	2.6	20	<1	101	--	47	11	0.4	--	126	208	8.1	32
S	9	4	1.0	1.6	11	1	20	--	23	17	0.2	--	26	38	0.1	7
Minimum	11	30	5.5	1.8	15	0	89	--	17	3	0.2	--	101	175	8.0	26
Maximum	38	39	8.2	5.9	44	2	141	<0.2	80	47	0.8	<1	174	279	8.3	45

[a]Samples collected in February.

Table G-17. Radiochemical Quality of Surface and Ground Waters from Perimeter Stations

Station	^{3}H (10^{-6} µCi/mL)	^{137}Cs (10^{-9} µCi/mL)	Total U (µg /L)[a]	^{238}Pu (10^{-9} µCi/mL)	$^{239,240}Pu$ (10^{-9} µCi/mL)	Gross Gamma (Counts/min/L)
Los Alamos Reservoir	-0.7 (0.3)	8 (54)	1.0 (1.0)	0.021 (0.015)	-0.004 (0.011)	---
Los Alamos Reservoir	0.0 (0.3)	42 (62)	1.0 (1.0)	-0.002 (0.006)	-0.004 (0.006)	-70 (80)
Guaje Reservoir	-2.7 (0.7)	-24 (55)	0.2 (0.1)	0.036 (0.016)	0.011 (0.010)	-400 (100)
Frijoles Canyon	-2.0 (0.7)	88 (51)	0.2 (0.1)	0.016 (0.018)	0.016 (0.014)	160 (100)
Frijoles Canyon	0.4 (0.3)	98 (62)	1.0 (1.0)	0.008 (0.006)	0.008 (0.005)	-20 (80)
La Mesita Spring	-1.5 (0.7)	59 (44)	12.5 (1.3)	-0.014 (0.014)	-0.014 (0.012)	-180 (100)
La Mesita Spring	0.0 (0.3)	24 (53)	--	0.002 (0.006)	-0.002 (0.005)	-80 (80)
Indian Spring	-1.1 (0.7)	80 (56)	9.6 (1.0)	-0.007 (0.019)	0.029 (0.023)	-30 (100)
Indian Spring	0.0 (0.3)	59 (68)	6.0 (1.0)	-0.005 (0.008)	0.000 (0.005)	80 (80)
Sacred Spring	-1.7 (0.7)	13 (38)	2.1 (1.0)	0.001 (0.010)	0.037 (0.041)	-50 (100)
Sacred Spring	-0.1 (0.3)	-2 (60)	4.0 (1.0)	0.010 (0.009)	0.002 (0.005)	160 (80)
Summary						
No. of Analyses	11	11	10	11	11	10
Average	-0.8	40	3.8	0.006	0.007	-43
S	1.0	40	4.3	0.014	0.015	166
Minimum	-2.7 (0.7)	-24 (55)	0.2 (0.1)	-0.014 (0.012)	-0.014 (0.012)	-400 (100)
Maximum	0.4 (0.3)	98 (62)	12.5 (1.3)	0.036 (0.016)	0.037 (0.041)	160 (100)
Limits of Detection	0.7	40	1	0.009	0.03	50

[a]Samples collected in March and September; counting uncertainty in parentheses.

Table G-18. Radiochemical Quality of Surface Waters from White Rock Canyon, October 1987

Station	^{3}H (10^{-6} µCi/mL)	^{137}Cs (10^{-9} µCi/mL)	Total U (µg/L)	^{238}Pu (10^{-9} µCi/mL)	$^{239,240}Pu$ (10^{-9} µCi/mL)	Gross Gamma (Counts/min/L)
Group I						
Sandia Spring	-0.8 (0.3)	122 (64)	1.0 (1.0)	0.020 (0.014)	-0.004 (0.004)	100 (80)
Spring 3	-0.8 (0.3)	-6 (65)	1.0 (1.0)	0.000 (0.010)	0.004 (0.008)	0 (80)
Spring 3A	-1.2 (0.3)	94 (62)	1.0 (1.0)	-0.019 (0.010)	0.000 (0.010)	0 (80)
Spring 3AA	-0.9 (0.3)	40 (62)	1.0 (1.0)	0.004 (0.004)	0.000 (0.010)	60 (80)
Spring 4	0.7 (0.3)	103 (64)	1.0 (1.0)	0.012 (0.013)	-0.008 (0.008)	-110 (80)
Spring 4A	-0.1 (0.3)	87 (60)	1.0 (1.0)	0.022 (0.011)	-0.004 (0.004)	0 (80)
Spring 5	-0.1 (0.3)	99 (63)	1.0 (1.0)	0.009 (0.009)	0.005 (0.008)	10 (80)
Spring 5AA	-0.2 (0.3)	74 (61)	1.0 (1.0)	0.004 (0.008)	-0.004 (0.004)	10 (80)
Ancho Spring	-0.7 (0.3)	38 (69)	1.0 (1.0)	-0.008 (0.010)	0.000 (0.010)	190 (80)
Group II						
Spring 8A	-0.9 (0.3)	100 (62)	1.0 (1.0)	0.013 (0.013)	0.000 (0.010)	160 (80)
Spring 9	-0.6 (0.3)	-49 (62)	1.0 (1.0)	-0.004 (0.007)	0.000 (0.010)	90 (80)
Spring 9A	-1.0 (0.3)	13 (61)	1.0 (1.0)	0.004 (0.011)	0.008 (0.012)	170 (80)
Doe Spring	-0.8 (0.3)	149 (71)	1.0 (1.0)	0.008 (0.005)	0.000 (0.010)	130 (80)
Group III						
Spring 1	-1.1 (0.3)	103 (61)	1.0 (1.0)	0.004 (0.010)	-0.013 (0.008)	30 (80)
Spring 2	-0.8 (0.3)	24 (67)	3.9 (1.0)	0.004 (0.008)	0.009 (0.006)	220 (80)
Group IV						
Spring 3B	-0.2 (0.3)	29 (60)	2.2 (2.4)	0.000 (0.010)	0.004 (0.004)	60 (80)
Streams						
Pajarito	13 (1.0)	64 (68)	1.3 (1.0)	0.027 (0.015)	-0.004 (0.004)	10 (80)
Ancho	-0.7 (0.3)	-2 (60)	1.0 (1.0)	-0.008 (0.008)	0.000 (0.010)	160 (80)
Frijoles	-0.8 (0.3)	-45 (61)	1.0 (1.10)	0.020 (0.018)	-0.004 (0.009)	190 (80)

Table G-18 (cont)

Station	^{3}H (10^{-6} µCi/mL)	^{137}Cs (10^{-9} µCi/mL)	Total U (µg/L)	^{238}Pu (10^{-9} µCi/mL)	$^{239,240}Pu$ (10^{-9} µCi/mL)	Gross Gamma (Counts/min/L)
Sanitary Effluent						
Mortandad	-0.2 (0.3)	-39 (68)	1.0 (1.0)	0.000 (0.010)	0.000 (0.010)	70 (80)
No. of Analyses	20	20	20	20	20	20
Maximum	13 (1.0)	149 (71)	22 (2.4)	0.027 (0.015)	0.009 (0.006)	
Limits of Detection	0.7	40	1	0.009	0.03	50

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[a]Counting uncertainty in parentheses; Springs 5A, 5B, 6, 6A, 7, 8, and 10 covered by Cochiti Reservoir.

Table G-19. Chemical Quality of Surface and Ground Waters from Perimeter Stations (mg/L)[a]

Station	SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	P	SO_4	Cl	F	N	TDS	Total Hardness	pH	Conductivity mS/m
Los Alamos Reservoir	28	7	0.9	2.5	3	0	27	<0.2	7	2	<0.2	<1	78	24	7.8	7
Guaje Canyon	49	10	3.1	1.7	6	0	37	<0.2	8	2	0.2	<1	106	37	7.7	10
Frijoles at Nat. Mon.	54	9	3.1	2.1	8	0	42	<0.2	6	3	<0.2	<1	111	33	7.8	11
La Mesita Spring	27	33	0.8	2.4	30	0	118	<0.2	14	8	0.3	2	174	90	8.1	30
Indian Spring	42	27	2.7	2.7	27	0	110	<0.2	7	32	0.5	<1	208	95	7.5	32
Sacred Spring	32	22	0.4	2.9	23	0	99	<0.2	7	3	0.5	<1	135	56	7.7	20
Summary																
No. of Analyses	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Average	37	18	1.8	2.4	16	--	72	--	8	8	<0.3	<1	135	56	7.8	18
S	11	11	1.3	0.4	12	--	41	--	3	12	0 .1	0.4	48	30	0.2	11
Minimum	27	7	0.8	1.7	3	--	27	--	6	2	<0.2	<1	78	24	7.7	7
Maximum	54	33	3.1	2.9	30	0	118	<0.2	14	32	0.5	2	208	90	8.1	32

[a]Samples collected in February and March.

Table G-20. Primary Chemical Quality of Surface and Ground Waters from White Rock Canyon, October 1987 (mg/L)

Stations	Ag	As	Ba	Cd	Cr	F	Hg	N	Pd	Se
Group I										
Sandia Spring	<0.001	0.002	0.132	<0.001	0.003	0.6	0.002	0.2	0.003	<0.002
Spring 3	<0.001	0.002	0.035	<0.001	0.005	0.5	0.001	0.8	<0.001	<0.002
Spring 3A	<0.001	0.003	0.031	<0.001	0.005	0.5	<0.001	0.5	<0.001	<0.002
Spring 3AA	<0.001	0.003	0.021	<0.001	0.011	0.5	<0.001	0.5	0.001	<0.002
Spring 4	<0.001	0.002	0.039	<0.001	0.005	0.6	<0.001	1.0	<0.001	<0.002
Spring 4A	<0.001	<0.001	0.043	<0.001	0.005	0.6	<0.001	1.1	<0.001	<0.002
Spring 5	<0.001	0.002	0.031	<0.001	0.005	0.5	<0.001	0.4	<0.001	<0.002
Spring 5AA	<0.001	0.002	0.194	<0.001	0.002	0.5	<0.001	<0.2	0.001	<0.002
Ancho Spring	<0.001	0.001	0.028	<0.001	0.004	0.4	<0.001	<0.2	<0.001	<0.002
Group II										
Spring 8A	<0.001	0.001	0.024	<0.001	0.001	0.5	<0.001	<0.2	<0.001	<0.002
Spring 9	<0.001	0.001	0.016	<0.001	0.003	0.5	0.002	<0.2	<0.001	<0.002
Spring 9A	<0.001	0.001	0.013	<0.001	0.007	0.5	0.001	<0.2	<0.001	<0.002
Doe Spring	<0.001	0.001	0.022	<0.001	0.002	0.6	<0.001	<0.2	<0.001	<0.002
Group III										
Spring 1	<0.001	0.004	0.061	<0.001	0.003	0.7	<0.001	<0.2	0.001	<0.002
Spring 2	<0.001	0.024	0.081	<0.001	0.001	1.5	<0.001	<0.2	0.001	<0.002
Group IV										
Spring 3B	<0.001	0.011	0.044	<0.001	0.008	0.9	<0.001	2.1	<0.001	<0.002
Streams										
Pajarito	<0.001	0.002	0.038	<0.001	0.004	0.5	<0.001	0.7	<0.001	<0.002
Ancho	<0.001	<0.001	0.026	<0.001	0.004	0.4	<0.001	<0.2	<0.001	<0.002
Frijoles	<0.001	<0.001	0.017	<0.001	0.001	0.2	<0.001	<0.2	<0.001	<0.002

Table G-20 (cont)

Stations	Ag	As	Ba	Cd	Cr	F	Hg	N	Pd	Se
Sanitary Effluent										
Mortandad	<0.001	0.005	0.053	0.005	0.003	0.9	<0.001	12	<0.001	<0.002
Summary										
No. of Analyses										
Maximum Concentration	<0.001	0.024	0.194	0.005	0.011	1.5	0.002	12	0.003	<0.002
USEPA and NMEID										
Primary Maximum Concentrations[a]	0.05	0.05	1.0	0.01	0.05	2.0	0.002	10	0.05	0.01
Maximum Concentrations as % of primary maximum	<2	48	19	50	22	75	100	120	6	<20

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[a]Reference (USEPA 1976); comparison of primary and secondary maximum concentration to spring and stream maximum concentrations for comparison only, spring and stream not a source of water supply.

Table G-21. Secondary Chemical Quality of Surface and Ground Waters from White Rock Canyon, October 1987 (mg/L)

Stations	Cl	Cu	Fe	Mn	SO_4	Zn	TDS	pH
Group I								
Sandia Spring	4	<0.001	0.137	0.042	5	<0.001	195	8.1
Spring 3	4	<0.001	0.145	<0.001	5	<0.001	145	8.1
Spring 3A	3	0.002	0.114	<0.001	5	0.001	140	7.9
Spring 3AA	3	0.002	1.71	<0.001	4	0.006	131	7.8
Spring 4	7	<0.001	0.070	<0.001	10	0.001	168	7.6
Spring 4A	6	<0.001	0.010	<0.001	7	<0.001	170	7.8
Spring 5	5	0.001	0.540	<0.001	6	<0.001	160	7.9
Spring 5AA	8	0.001	1.99	0.179	10	0.003	214	7.6
Ancho Spring	2	<0.001	0.020	0.002	3	0.001	140	7.4
Group II								
Spring 8A	2	<0.001	0.127	0.002	2	<0.001	146	7.8
Spring 9	2	<0.001	0.101	0.003	2	<0.001	142	7.7
Spring 9A	2	<0.001	0.817	0.003	2	<0.001	134	7.7
Doe Spring	2	<0.001	0.174	<0.001	2	<0.001	143	7.8
Group III								
Spring 1	4	<0.001	2.90	0.056	8	0.005	153	7.9
Spring 2	4	0.001	1.57	0.120	7	0.003	224	8.1
Group IV								
Spring 3B	4	<0.001	0.054	0.010	17	<0.001	403	8.0
Streams								
Pajarito	6	<0.001	0.049	0.002	6	<0.001	175	8.1
Ancho	3	<0.001	0.174	0.004	3	<0.001	143	8.6
Frijoles	4	<0.001	0.240	0.005	5	<0.001	133	7.9
Sanitary Effluent								
Mortandad	43	33	0.627	0.021	32	0.027	467	7.3

Table 21 (cont)

Stations	Cl	Cu	Fe	Mn	SO_4	Zn	TDS	pH
Summary								
No. of Analyses	20	20	20	20	20	20	20	20
Maximum Concentration	43	33	2.90	0.042	32	0.027	467	8.6
USEPA and NMEID								
Secondary Maximum Concentration[a]	250	1.0	0.3	0.5	250	5.0	500	6.5-8.5
Maximum Concentration as % of Secondary Maximum Concentration	17	3300	967	8	6	<1	93	101

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[a]Reference (USEPA 1976); comparison of primary and secondary maximum concentration to spring and stream maximum concentrations for comparison only, spring and stream not a source of water supply.

Table G-22. Chemical Quality of Surface and Ground Waters from White Rock Canyon, October 1987 (mg/L)

Station	SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	Mo	Ni	Total Hard-ness	Cond (mS/M)
Group I											
Sandia Spring	42	38	2.7	2.9	17	0	131	<0.001	0.002	108	26
Sandia 3	49	21	1.6	2.9	17	0	81	<0.001	<0.001	59	17
Spring 3A	49	21	1.7	2.9	16	0	81	<0.001	<0.001	58	17
Spring 3AA	41	18	<0.5	2.9	18	0	77	<0.001	<0.001	45	16
Spring 4	52	23	3.7	2.7	15	0	85	<0.001	<0.001	77	21
Spring 4A	67	22	4.6	2.2	13	0	81	<0.001	0.002	73	19
Spring 5	66	18	4.8	2.0	12	0	79	<0.001	<0.001	65	18
Spring 5AA	59	32	6.0	3.5	14	0	122	<0.001	0.001	112	28
Ancho Spring	72	12	3.1	2.0	11	0	60	<0.001	0.001	42	13
Group II											
Spring 8A	76	12	3.2	2.1	12	0	62	<0.001	0.001	39	14
Spring 9	72	11	3.1	1.5	11	0	61	<0.001	0.001	39	12
Spring 9A	70	11	3.1	1.4	10	0	58	<0.001	0.001	39	12
Doe Spring	72	12	3.3	1.5	2	0	64	<0.001	0.001	43	13
Group III											
Spring 1	32	19	1.2	2.2	34	0	109	0.002	0.002	57	24
Spring 2	32	21	1.0	1.4	61	0	172	0.002	<0.001	58	34
Group IV											
Spring 3B	44	22	1.9	4.8	127	0	316	0.004	<0.001	66	64
Streams											
Pajario	68	20	4.4	2.5	14	0	86	<0.001	<0.001	70	19
Ancho	76	12	3.2	1.9	11	4	64	<0.001	<0.001	47	13
Frijoles	59	9	2.4	2.2	10	0	53	<0.001	<0.001	39	12

Table G-22 (cont)

Station	SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	Mo	Ni	Total Hard-ness	Cond (mS/M)
Sanitary Effluent											
Mortandad	93	26	7.7	16	85	0	132	<0.001	0.029	110	64
Summary											
No. of Analyses	20	20	20	20	20	20	20	20	20	20	20
Maximum Concentration	93	38	7.7	16	127	20	316	0.004	0.027	108	64

NOTE: Springs 5A, 5B, 6, 6A, 7, 8, and 10 covered by Cochito Reservoir: The 20 locations also analyzed for following constituents: CN <0.01 mg/L; P <0.2 mg/L, except Mortandad 12 mg/L; Sb <0.001 mg/L; Th <0.001 mg/L; Tl <0.001 mg/L;

Table G-23. Radiochemical Quality of Surface and Ground Waters from On-site Stations[a]

Station	^{3}H (10^{-6} µCi/mL)	^{137}Cs (10^{-9} µCi/mL)	Total U (µg/L)	^{238}Pu (10^{-9} µCi/mL)	$^{239,240}Pu$ (10^{-9} µCi/mL)	Gross Gamma (Counts/min/L)
Test Well 1	-2.4 (0.7)	77 (58)	2.9 (1.0)	-0.005 (0.008)	0.005 (0.013)	-400 (100)
Test Well 1						
Test Well 2	-2.1 (0.7)	90 (52)	0.3 (0.1)	0.000 (0.010)	0.000 (0.010)	-200 (100)
Test Well 2						
Test Well 3	-1.4 (0.7)	8 (61)	0.6 (0.1)	0.022 (0.027)	0.022 (0.016)	-200 (100)
Test Well 3	0.3 (0.3)	65 (60)	1.0 (1.0)	0.021 (0.019)	0.011 (0.011)	10 (80)
Test Well DT-5A	-2.0 (0.7)	-37 (55)	0.3 (0.1)	-0.009 (0.009)	0.005 (0.011)	-300 (100)
Test Well DT-5A	0.1 (0.3)	58 (52)	1.0 (1.0)	0.002 (0.005)	0.002 (0.006)	130 (80)
Test Well 8	-2.1 (0.7)	86 (50)	0.0 (0.1)	0.035 (0.037)	0.000 (0.010)	-300 (100)
Test Well 8	0.5 (0.3)	38 (67)	1.0 (1.0)	-0.010 (0.010)	0.010 (0.010)	190 (80)
Test Well DT-9	0.0 (0.3)	-13 (58)	1.0 (1.0)	-0.002 (0.006)	0.008 (0.007)	-60 (80)
Test Well DT-10	-1.6 (0.7)	-93 (50)	0.3 (0.1)	0.005 (0.012)	0.000 (0.010)	-40 (100)
Test Well DT-10	0.2 (0.3)	136 (63)	0.3 (0.1)	0.002 (0.008)	0.002 (0.004)	-10 (80)
Canada del Buey	-0.6 (0.7)	44 (55)	0.4 (0.1)	0.010 (0.023)	0.005 (0.014)	-500 (100)
Canada del Buey	0.3 (0.3)	-25 (60)	1.0 (1.0)	-0.002 (0.003)	0.002 (0.003)	-70 (80)
Pajarito Canyon	-1.2 (0.7)	29 (54)	0.3 (0.1)	0.000 (0.010)	0.006 (0.018)	110 (100)
Pajarito Canyon	0.6 (0.3)	33 (58)	1.0 (1.0)	0.004 (0.007)	0.002 (0.004)	-280 (80)
Water Canyon at Beta Hole	-2.0 (0.7)	21 (55)	0.0 (0.1)	-0.004 (0.004)	0.000 (0.010)	-400 (100)
Water Canyon at Beta Hole	0.1 (0.3)	67 (60)	1.0 (1.0)	-0.004 (0.008)	0.000 (0.010)	80 (80)

Table G-23 (cont)

Station	^{3}H (10^{-6} µCi/mL)	^{137}Cs (10^{-9} µCi/mL)	Total U (µg/L)	^{238}Pu (10^{-9} µCi/mL)	$^{239,240}Pu$ (10^{-9} µCi/mL)	Gross Gamma (Counts/min/L)
Summary						
No. of Analyses	17	17	17	17	17	17
Average	−0.8	34	0.7	0.004	0.005	−132
S	1.1	55	0.7	0.012	0.007	208
Minimum	−2.4 (0.7)	−93 (50)	0.0 (0.1)	−0.010 (0.010)	0.000 (0.010)	−500 (100)
Maximum	0.6 (0.3)	−136 (63)	22.9 (1.0)	0.035 (0.037)	0.022 (0.016)	190 (80)
Limits of Detection	0.7	40	1	0.009	0.03	50

[a]Samples collected in March and September; counting uncertainty in parentheses.

Table G-24. Radiochemical Quality of Shallow Ground Water in Pajarito Canyon

Station	^{3}H (10^{-6} µCi/mL)	^{137}Cs (10^{-9} µCi/mL)	Total U (µg/L)	^{238}Pu (10^{-9} µCi/mL)	$^{239,240}Pu$ (10^{-9} µCi/mL)	Gross Gamma (Counts/min/L)
Well PCO-1	0.4 (0.3)	111 (68)	1.0 (1.0)	0.005 (0.018)	0.015 (0.015)	130 (80)
Well PCO-2	0.7 (0.3)	89 (69)	1.0 (1.0)	0.035 (0.016)	-0.004 (0.004)	210 (80)
Well PCO-3	0.3 (0.3)	-3 (67)	1.0 (1.0)	-0.004 (0.010)	0.004 (0.010)	110 (80)
Summary						
No. of Analyses	3	3	3	3	3	3
Average	0.5	66	1.0	0.012	0.005	150
S	0.2	60	0.020	0.010	0.010	53
Minimum	0.3 (0.3)	-3 (67)	--	-0.004 (0.010)	-0.004 (0.004)	110 (80)
Maximum	0.7 (0.3)	111 (68)	1.0 (1.0)	0.035 (0.016)	0.015 (0.015)	210 (80)

Table G-25. Chemical Quality of Surface and Ground Waters from On-site Stations (mg/L)[a]

Station	SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	P	SO_4	Cl	F	N	TDS	Total Hardness	pH	Conductivity (mS/m)
Test Well 1	50	49	9.1	4.1	14	0	102	<0.2	24	32	0.5	7	253	164	8.0	40
Test Well 2	65	16	4.0	1.1	9	0	66	<0.2	2	2	0.5	<1	136	52	7.9	14
Test Well 3	72	19	5.7	2.2	12	0	80	<0.2	3	4	0.4	<1	165	67	7.8	18
Test Well DT-5A	67	9	2.6	1.6	11	0	52	<0.2	2	2	0.3	<1	123	30	7.9	11
Test Well 8	5	4	1.1	1.3	11	3	38	<0.2	<1	2	0.3	<1	27	12	8.7	8
Test Well DT-10	56	14	3.8	1.2	11	0	63	<0.2	6	2	0.3	<1	107	48	8.4	13
Canada del Buey	21	6	1.5	1.4	12	0	27	<0.2	4	8	9.3	<1	77	18	7.1	9
Pajarito Canyon	22	28	7.1	2.9	26	0	87	<0.2	7	36	0.3	<1	188	98	7.7	31
Water at Beta Hole	37	13	4.6	3.4	18	0	42	<0.2	11	19	0.3	<1	148	55	7.8	17
Summary																
No. of Analyses	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
Average	44	18	4.4	2.1	14	<1	62	--	<7	12	1.4	<2	136	60	7.9	18
S	24	14	2.6	1.1	5	<1	25	--	7	14	3.0	2	65	47	0.4	11
Minimum	5	4	1.1	1.1	9	0	27	--	<1	2	0.3	<1	27	18	7.1	9
Maximum	72	49	9.1	4.1	26	3	102	<0.2	24	36	9.3	7	253	164	8.0	40

[a]Samples collected in February and March.

Table G-26. Chemical Quality of Shallow Ground Water in Pajarito Canyon (mg/L)

Station	SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	P	SO_4	Cl	F	N	TDS	Total Hardness	pH	Conductivity (mS/m)
Well PCO-1	49	76	13	4.9	52	0	250	<0.2	8	70	0.6	0.2	462	269	7.3	70
Well PCO-2	49	74	13	4.0	52	0	247	<0.2	8	71	0.6	0.4	434	263	7.5	71
Well PCO-3	48	77	12	4.0	105	0	249	<0.2	8	73	0.6	0.3	447	262	7.5	72
Summary																
No. of Analyses	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Average	49	76	12.7	4.3	70	0	249	<0.2	8	71	0.6	0.3	448	265	7.5	71
S	1	2	0.6	0.5	30	0	2	0	0	2	0	0.1	14	4	0.2	1
Minimum	48	74	12	4.0	52	--	247	--	--	70	--	0.2	434	262	7.3	70
Maximum	49	77	13	4.9	105	0	250	<0.2	8	73	0.6	0.4	462	269	7.5	72

Table G-27. Radiochemical Quality of Surface and Ground Waters from Acid-Pueblo Canyon[a]

Station	^{3}H (10^{-6} µCi/mL)	^{137}Cs (10^{-9} µCi/mL)	Total U (µg/L)	^{238}Pu (10^{-9} µCi/mL)	$^{239,240}Pu$ (10^{-9} µCi/mL)	Gross Gamma (Counts/min/L)
Acid Weir	-2.2 (0.7)	2 (43)	0.6 (0.1)	0.010 (0.015)	0.068 (0.018)	300 (100)
Acid Weir	0.0 (0.3)	-58 (50)	2.0 (1.0)	0.017 (0.015)	2.38 (0.126)	130 (80)
Pueblo 1	-1.7 (0.7)	-16 (42)	0.6 (0.1)	0.007 (0.015)	0.083 (0.028)	200 (100)
Pueblo 1	-0.2 (0.4)	44 (60)	1.0 (1.0)	-0.009 (0.009)	0.006 (0.010)	-10 (80)
Pueblo 2	-1.5 (0.7)	-8 (43)	0.6 (0.1)	-0.062 (0.055)	0.062 (0.069)	-2500 (300)
Pueblo 2	0.1 (0.3)	82 (70)	1.0 (1.0)	-0.010 (0.012)	0.031 (0.014)	700 (100)
Pueblo 3	-1.8 (0.7)	41 (43)	0.9 (0.1)	0.012 (0.034)	0.092 (0.043)	-90 (100)
Pueblo 3	-0.3 (0.3)	118 (63)	1.0 (1.0)	0.000 (0.010)	0.031 (0.015)	580 (100)
Hamilton Bend Springs	-2.3 (0.7)	46 (21)	0.6 (0.1)	-0.009 (0.011)	-0.004 (0.008)	100 (100)
Hamilton Bend Springs (Dry)	--	--	--	--	--	--
Test Well 1A	-1.7 (0.7)	24 (48)	0.0 (1.0)	0.010 (0.017)	-0.010 (0.012)	-300 (100)
Test Well 1A	0.3 (0.3)	13 (59)	1.0 (1.0)	0.005 (0.004)	-0.002 (0.005)	-270 (80)
Test Well 2A	0.5 (0.7)	--	0.0 (1.0)	0.000 (0.010)	0.032 (0.018)	-500 (100)
Test Well 2A	1.4 (0.4)	167 (71)	1.0 (1.0)	-0.005 (0.005)	0.005 (0.005)	580 (100)
Basalt Spring	-0.9 (0.7)	131 (65)	1.3 (1.0)	-0.011 (0.012)	0.000 (0.010)	-300 (100)
Basalt Spring	-0.4 (0.3)	40 (62)	1.0 (1.0)	0.002 (0.003)	0.002 (0.002)	420 (90)
Summary						
No. of Analyses	15	14	15	15	15	15
Average	-0.7	45	0.8	-0.003	0.180	-64
S	1.1	62	0.5	0.019	0.610	765
Minimum	-2.3 (0.7)	-58 (50)	0.0 (1.0)	-0.062 (0.055)	-0.004 (0.008)	-2500 (300)
Maximum	1.4 (0.4)	167 (71)	2.0 (1.0)	0.010 (0.015)	2.38 (0.012)	700 (100)
Limits of Detection	0.7	50	1	0.009	0.03	50

[a]Samples collected in March and September; counting uncertainty in parentheses.

Table G-28. Radiochemical Quality of Surface and Ground Waters from DP-Los Alamos Canyon[a]

Station	^{3}H (10^{-6} µCi/mL)	^{137}Cs (10^{-9} µCi/mL)	Total U (µg/L)	^{238}Pu (10^{-9} µCi/mL)	$^{239,240}Pu$ (10^{-9} µCi/mL)	Gross Gamma (Counts/min/L)
DPS-1	-1.5 (0.7)	27 (44)	1.0 (0.1)	0.021 (0.016)	0.114 (0.024)	300 (100)
DPS-1	0.5 (0.3)	16 (75)	1.0 (1.0)	-0.005 (0.012)	0.014 (0.013)	700 (100)
DPS-4	-0.6 (0.7)	33 (44)	0.8 (0.1)	0.008 (0.018)	0.041 (0.027)	200 (100)
DPS-4	1.2 (0.4)	188 (80)	1.0 (1.0)	0.019 (0.012)	0.034 (0.013)	530 (100)
LAO-C	-0.3 (0.8)	56 (48)	0.1 (0.1)	0.000 (0.010)	0.005 (0.015)	-400 (100)
LAO-C	0.6 (0.3)	89 (69)	1.0 (1.0)	0.015 (0.015)	0.015 (0.016)	580 (100)
LAO-1	-0.4 (0.7)	-20 (48)	0.2 (0.1)	-0.006 (0.010)	-0.017 (0.010)	40 (100)
LAO-1	19 (2.0)	68 (67)	1.0 (1.0)	-0.017 (0.013)	0.008 (0.008)	700 (100)
LAO-2	-1.6 (0.7)	7 (42)	0.2 (0.1)	0.000 (0.010)	0.029 (0.023)	-60 (100)
LAO-2	1.3 (0.4)	116 (71)	1.0 (1.0)	0.009 (0.019)	0.009 (0.015)	350 (90)
LAO-3	-0.8 (0.7)	-56 (38)	0.3 (0.1)	0.015 (0.018)	0.015 (0.021)	-100 (100)
LAO-3	1.5 (0.4)	13 (58)	1.0 (1.0)	0.015 (0.011)	-0.004 (0.010)	240 (80)
LAO-4	-0.5 (0.7)	78 (50)	0.3 (0.1)	0.028 (0.015)	0.124 (0.024)	0 (100)
LAO-4	1.3 (0.4)	155 (79)	1.0 (1.0)	0.004 (0.013)	0.004 (0.015)	90 (80)
LAO-4.5	0.0 (0.7)	-39 (43)	0.3 (0.1)	0.000 (0.010)	0.021 (0.018)	-200 (100)
LAO-4.5	1.7 (0.4)	128 (77)	1.0 (1.0)	0.017 (0.017)	0.000 (0.010)	120 (80)
Summary						
No. of Analyses	16	16	16	16	16	16
Average	1.3	54	0.7	0.008	0.026	193
S	4.8	79	0.4	0.012	0.039	321
Minimum	-1.6 (0.7)	-56 (38)	0.1 (0.1)	-0.017 (0.013)	-0.017 (0.010)	-400 (100)
Maximum	19 (2.0)	188 (86)	1.0 (1.0)	0.028 (0.015)	0.124 (0.008)	700 (100)
Limits of Detection	0.7	40	1	0.009	0.03	50

[a]Samples collected in March and November; counting uncertainty in parentheses.

Table G-29. Radiochemical Quality of Surface and Shallow Ground Waters from Mortandad Canyon[a]

Station	^{3}H (10^{-6} µCi/mL)	^{90}Sr (10^{-9} µCi/mL)	^{137}Cs (10^{-9} µCi/mL)	Total U (µg/L)	^{238}Pu (10^{-9} µCi/mL)	$^{239,240}Pu$ (10^{-9} µCi/mL)	Gross Gamma (Counts/min/L)
GS-1	8400 (800)	6.2 (0.3)	-29 (55)	3.3 (0.3)	30.0 (3.00)	90.0 (5.00)	8500 (900)
GS-1	120 (10)	--	213 (84)	1.0 (1.0)	0.677 (0.033)	4.51 (0.185)	9700 (1000)
MCO-3	12 000 (1000)	9.5 (0.7)	66 (51)	3.8 (0.4)	24.2 (1.50)	68.0 (4.00)	10 000 (1000)
MCO-3	140 (10)	--	-2 (68)	1.0 (1.0)	0.921 (0.066)	5.23 (0.219)	11 000 (1000)
MCO-4	210 (20)	0.4 (0.4)	18 (56)	2.4 (0.2)	0.165 (0.034)	0.278 (0.044)	-300 (100)
MCO-4	480 (50)	--	-62 (75)	4.0 (1.0)	0.093 (0.023)	0.097 (0.021)	210 (80)
MCO-5	210 (20)	-0.6 (0.5)	73 (56)	1.7 (0.2)	0.053 (0.025)	0.337 (0.052)	-500 (100)
MCO-5	490 (50)	--	-20 (59)	4.0 (1.0)	0.150 (0.025)	0.382 (0.041)	270 (80)
MCO-6	400 (40)	56 (1.0)	95 (56)	2.7 (0.3)	0.941 (0.142)	3.35 (0.281)	1200 (200)
MCO-6	500 (50)	--	22 (68)	4.0 (1.0)	0.138 (0.026)	0.333 (0.039)	270 (80)
MCO-7	480 (50)	--	68 (60)	5.6 (0.6)	0.037 (0.044)	0.037 (0.040)	60 (100)
MCO-7	470 (50)	--	7 (62)	3.0 (1.0)	0.038 (0.018)	0.021 (0.015)	190 (80)
MCO-7.5	406 (40)	--	68 (49)	5.7 (0.6)	0.075 (0.026)	0.091 (0.026)	-300 (100)
MCO-7.5	490 (50)	--	53 (69)	3.0 (1.0)	0.030 (0.018)	0.066 (0.020)	180 (80)
Summary							
No. of Analyses	14	5	14	14	14	14	14
Average	1770	14	41	3.2	4.11	12.3	2891
S	3643	24	67	1.4	9.81	28.6	4578
Minimum	120 (10)	-0.6 (0.5)	-62 (75)	1.0 (1.0)	0.036 (0.018)	0.021 (0.015)	-500 (100)
Maximum	12 000 (1000)	56 (1.0)	213 (84)	5.7 (0.6)	30.0 (3.00)	90.0 (5.00)	11 000 (1000)
Limits of Detection	0.7	0.01	40	1	0.009	0.03	50

[a]Samples collected in March and November; counting uncertainty in parentheses.

Table G-30. Radiochemical Quality of Surface Waters from Sandia Canyon[a]

Station	^{3}H (10^{-6} µCi/mL)	^{137}Cs (10^{-9} µCi/mL)	Total U (µg/L)	^{238}Pu (10^{-9} µCi/mL)	$^{239,240}Pu$ (10^{-9} µCi/mL)	Gross Gamma (Counts/min/L)
SCS-1	−0.9 (0.7)	−47 (44)	1.8 (0.1)	0.000 (0.010)	0.012 (0.032)	40 (100)
SCS-1	0.7 (0.3)	29 (61)	1.0 (1.0)	0.002 (0.004)	0.000 (0.005)	30 (80)
SCS-2	−0.1 (0.7)	83 (57)	0.5 (0.1)	−0.076 (0.039)	−0.019 (0.033)	−130 (100)
SCS-2	0.8 (0.3)	36 (61)	1.0 (1.0)	0.000 (0.005)	0.002 (0.002)	160 (80)
SCS-3	−0.3 (0.7)	32 (48)	0.5 (0.1)	−0.054 (0.033)	−0.027 (0.019)	−40 (100)
SCS-3	0.0 (0.3)	135 (58)	1.0 (1.0)	−0.002 (0.007)	0.000 (0.005)	0 (80)
Summary						
No. of Analyses	6	6	6	6	6	6
Average	0.3	45	0.9	−0.022	−0.005	56
S	0.6	60	0.5	0.034	0.015	155
Minimum	−0.9 (0.7)	−47 (44)	0.5 (0.1)	−0.076 (0.039)	−0.027 (0.019)	−130 (100)
Maximum	0.8 (0.3)	135 (58)	1.8 (0.1)	0.002 (0.004)	0.012 (0.032)	306 (80)
Limits of Detection	0.7	40	1	0.009	0.03	50

[a]Samples collected in March and September; counting uncertainty in parentheses.

Table G-31. Chemical Quality of Surface and Shallow Ground Waters in Acid-Pueblo Canyon (mg/L)[a]

Station	SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	P	SO_4	Cl	F	N	TDS	Total Hardness	pH	Conductivity (mS/m)
Acid Weir	25	18	3.6	5.0	70	0	56	1.7	19	85	0.5	2	265	59	7.4	45
Pueblo 1	26	18	3.7	5.3	69	0	56	1.7	20	86	0.5	2	277	60	7.3	44
Pueblo 2	26	18	3.5	4.9	68	0	56	1.7	20	85	0.5	2	274	58	7.5	45
Pueblo 3	32	19	3.5	6.8	76	0	75	3.7	23	74	0.8	6	302	60	7.7	48
Hamilton Bend Spring	55	15	4.3	9.2	74	0	110	6.5	23	47	0.9	2	287	51	8.0	44
Test Well 1A	50	30	8.2	8.2	69	0	119	4.3	30	60	0.7	9	343	114	7.9	55
Test Well 2A	35	34	6.8	3.5	22	0	79	<0.2	23	54	0.4	<1	211	109	7.0	36
Basalt Spring	40	24	6.7	3.8	17	0	80	<0.2	17	16	0.6	2	173	89	7.7	26
Summary																
No. of Analyses	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Average	36	22	5.0	5.8	58	0	79	<2.5	22	64	0.6	<3	266	75	7.6	43
S	11	7	1.9	2.0	24	--	24	2.2	4	24	0.2	3	53	25	0.3	9
Minimum	25	15	3.5	3.5	17	--	56	<0.2	17	16	0.4	<1	173	51	7.0	26
Maximum	55	34	8.2	9.2	76	--	119	6.5	30	86	0.9	6	343	114	8.0	55

[a]Samples collected in March.

Table G-32. Chemical Quality of Surface and Shallow Ground Waters in DP-Los Alamos Canyon (mg/L)[a]

Station	SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	P	SO_4	Cl	F	N	TDS	Total Hardness	pH	Conductivity (mS/m)
DPS-1	17	26	2.2	4.9	78	0	84	<0.2	18	101	0.6	1.2	306	75	7.8	51
	19	16	1.0	3.5	32	0	77	<0.2	9	13	0.7	<0.2	152	44	7.5	23
DPS-4	21	15	1.7	10.5	90	0	90	0.4	26	94	2.5	1.2	306	44	8.1	52
	44	18	3.4	4.5	46	0	89	<0.2	13	34	0.6	1.0	216	57	7.0	32
LAO-C	27	8	2.6	2.2	7	0	21	<0.2	9	10	<0.2	<0.2	96	28	7.5	9
	32	10	2.1	2.7	34	0	57	<0.2	7	31	0.3	<0.2	157	32	7.0	23
LAO-1	29	12	3.5	2.5	22	0	26	<0.2	9	39	<0.2	<1	142	42	7.6	20
	23	13	1.1	10.5	65	0	129	0.4	16	21	2.4	0.7	228	39	7.8	37
LAO-2	30	13	3.7	2.8	29	0	32	<0.2	9	49	0.3	<1	165	52	7.4	25
	40	18	3.9	8.6	35	0	95	<0.2	14	21	1.1	0.5	186	58	7.0	30
LAO-3	33	14	4.0	3.1	30	0	32	<0.2	10	56	0.3	<1	184	54	7.6	25
	41	18	3.9	8.5	35	0	93	<0.2	14	21	1.1	0.4	184	57	7.0	27
LAO-4	31	13	3.7	3.3	30	0	34	<0.2	10	52	0.3	<1	169	49	7.4	26
	41	16	2.8	12.4	59	0	126	0.3	17	23	2.0	0.8	231	47	7.1	38
LAO-4.5	33	15	4.0	3.5	31	0	33	<0.2	10	57	0.3	1.4	183	58	7.6	26
	42	16	2.8	12.1	59	0	125	0.3	17	24	2.0	0.7	229	44	7.1	37
Summary																
No. of Analyses	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16
Average	31	15	2.9	5.9	42	0	71	0.2	13	40	0.9	<0.8	196	49	7.4	30
S	8	4	1.0	3.7	22	0	38	0.0	5	27	0.8	<0.4	55	11	0.3	11
Minimum	17	8	1.0	2.2	7	0	21	<0.2	7	13	<0.2	<0.2	96	28	7.0	9
Maximum	44	26	4.0	12.4	90	0	129	0.4	26	101	2.5	1.4	306	75	8.1	52

[a]Samples collected in March and April.

Table G-33. Chemical Quality of Surface and Shallow Ground Waters in Mortandad Canyon (mg/L)[a]

Station	SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	P	SO_4	Cl	F	N	TDS	Total Hardness	pH	Conductivity (mS/m)
GS-1	44	109	2.7	54.9	54	0	257	<0.2	81	35	6.0	45	780	256	7.9	130
	57	38	3.1	20.0	85	0	124	<0.2	24	4	1.1	37	492	110	7.8	71
MCO-3	44	130	2.9	66.8	132	0	306	<0.2	102	40	7.7	56	963	315	7.9	160
	62	39	3.3	21.4	92	0	124	<0.2	25	28	1.2	42	426	112	7.8	73
MCO-4	33	37	2.8	35.1	74	2	142	<0.2	24	30	2.4	31	492	97	8.4	76
	65	9	<0.5	18.9	165	66	133	<0.2	60	38	3.9	44	601	24	9.9	91
MCO-5	30	20	4.7	7.3	220	0	176	<0.2	21	28	1.9	37	551	76	7.7	85
	27	39	5.7	34.2	228	0	164	<0.2	48	37	3.0	118	1010	107	7.5	145
MCO-6	29	18	4.1	8.2	155	0	176	<0.2	29	29	2.3	37	548	63	7.6	85
	42	21	2.8	26.2	190	19	150	<0.2	53	39	3.3	75	751	61	9.0	115
MCO-7	30	17	4.2	4.9	223	0	214	<0.2	37	30	2.4	62	775	61	8.3	118
	31	12	2.4	4.0	178	0	182	<0.2	40	35	3.3	46	622	37	7.6	92
MCO-7.5	30	17	4.2	4.9	229	0	215	<0.2	38	30	2.5	62	777	62	8.3	120
	31	13	2.5	4.1	178	0	183	<0.2	40	35	3.2	47	592	43	7.7	92
Summary																
No. of Analyses	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
Average	40	37	3.2	22.2	157	6	182	<0.2	45	31	3.2	53	677	102	8.1	104
S	13	37	1.2	19.7	61	18	52	0.0	23	9	1.8	22	168	83	0.5	28
Minimum	29	9	<0.5	4.0	74	0	124	<0.2	24	4	1.1	37	492	24	7.5	72
Maximum	65	130	5.7	66.8	229	66	306	<0.2	102	39	3.9	118	1010	315	9.9	160

[a]Samples collected in March.

Table G-34. Chemical Quality of Surface Water from Sandia Canyon (mg/L)[a]

Station	SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	P	SO_4	Cl	F	N	TDS	Total Hardness	pH	Conductivity (mS/m)
SCS-1	96	34	4.7	8.1	215	--	--	1.4	768	83	1.0	1.3	1129	100	--	300
SCS-2	46	22	3.8	8.5	126	0	68	1.5	40	157	0.8	1.8	465	71	7.8	80
SCS-3	46	19	3.7	8.6	130	0	62	1.5	40	159	0.8	1.8	468	66	7.9	81
Summary																
No. of Analyses	3	3	3	3	3	2	2	3	3	3	3	3	3	3	2	3
Average	63	25	4.1	8.4	157	0	65	1.5	283	133	0.9	1.6	687	79	7.8	153
S	29	8	0.6	0.3	50	--	4	0.1	420	43	0.1	0.3	382	18	0.1	127
Minimum	46	19	3.8	8.1	126	--	62	1.4	40	83	0.8	1.3	465	66	7.8	80
Maximum	96	34	4.7	8.6	215	0	68	1.5	768	159	1.0	1.8	1129	100	7.9	300

[a]Samples collected in March.

Table G-35. Background Radiochemical Quality of Run-off (Solution and Suspended Sediments) in the Los Alamos Area[a]

Station	1987 Date	In Solution: ^{3}H (10^{-6} µCi/mL)	In Solution: ^{137}Cs (10^{-9} µCi/mL)	In Solution: Total U (µg/L)	In Solution: Gross Gamma (counts/min/L)
West SR-4 at Water Canyon	4/29	0.4 (0.3)	69 (60)	1.0 (1.0)	20 (80)
West SR-4 at Canon Valle	4/29	0.5 (0.3)	117 (62)	1.0 (1.0)	120 (80)
West SR-4 at Pajarito Canyon	4/29	0.7 (0.3)	138 (71)	1.0 (1.0)	130 (80)
West SR-4 at Los Alamos Canyon	4/29	0.4 (0.3)	−91 (50)	1.0 (1.0)	150 (80)
Guaje Canyon at Well G-5	4/29	0.5 (0.3)	13 (75)	1.0 (1.0)	170 (80)
$\bar{x}$ (s)		0.5 (0.1)	64 (67)	1.0 (1.0)	118 (58)

Station	1987 Date	In Solution: ^{238}Pu (10^{-9} µCi/mL)	In Solution: $^{239,240}Pu$ (10^{-9} µCi/mL)	Suspended Sediments: ^{238}Pu (pCi/g)	Suspended Sediments: $^{239,240}Pu$ (pCi/g)
West SR-4 at Water Canyon	4/29	0.000 (0.010)	0.009 (0.027)	0.077 (0.045)	0.033 (0.037)
West SR-4 at Canon Valle	4/29	0.031 (0.015)	0.010 (0.010)	0.000 (0.019)	0.034 (0.034)
West SR-4 at Pajarito Canyon	4/29	0.000 (0.010)	0.004 (0.010)	0.034 (0.075)	0.006 (0.045)
West SR-4 at Los Alamos Canyon	4/29	0.013 (0.017)	0.004 (0.008)	0.064 (0.013)	1.32 (0.071)
Rendija Canyon at Booster 1	3/12	0.013 (0.012)	−0.004 (0.010)	−0.010 (0.001)	0.020 (0.012)
Guaje Canyon at Well G-5	4/29	−0.004 (0.012)	0.014 (0.013)	−0.004 (0.004)	0.011 (0.005)
	5/4-7	0.007 (0.012)	0.014 (0.010)	−0.016 (0.016)	0.056 (0.027)
	5/11-14	0.015 (0.009)	0.011 (0.008)	0.066 (0.050)	0.089 (0.054)
	5/26-28	−0.009 (0.014)	0.000 (0.010)	0.020 (0.061)	−0.020 (0.035)
	6/4	−0.019 (0.014)	0.000 (0.010)	0.176 (0.117)	0.106 (0.093)
	6/8-11	0.010 (0.010)	0.010 (0.010)	0.022 (0.071)	0.000 (0.039)
Guaje Canyon at SR-4	4/20	0.004 (0.011)	−0.004 (0.007)	0.001 (0.001)	0.012 (0.002)
	4/30	0.010 (0.010)	0.029 (0.014)	0.011 (0.003)	0.233 (0.014)
	5/18-21	0.009 (0.016)	−0.009 (0.013)	−0.032 (0.045)	0.032 (0.051)
$\bar{x}$ (s)		0.006 (0.012)	0.006 (0.010)	0.029 (0.053)	0.138 (0.346)

[a]Location of stations shown in Fig. 16; counting uncertainty in parentheses.

Table G-36. Plutonium in Spring Run-off in Solution and Suspended Sediments

Station	1987 Date	Solution ^{238}Pu (10^{-9} µCi/mL)	Solution $^{239,240}Pu$ (10^{-9} µCi/mL)	Suspended Sediments ^{238}Pu (pCi/g)	Suspended Sediments $^{239,240}Pu$ (pCi/g)
Water Canyon at SR-4	4/14	−0.017 (0.020)	0.033 (0.026)	0.000 (0.140)	0.000 (0.140)
	4/20	0.000 (0.010)	0.024 (0.016)	0.018 (0.060)	−0.062 (0.038)
	4/30	0.010 (0.019)	−0.010 (0.013)	−0.012 (0.032)	0.024 (0.042)
	5/4-7	0.018 (0.014)	0.004 (0.004)	0.004 (0.006)	0.004 (0.004)
	5/11-14	0.000 (0.010)	−0.004 (0.011)	0.342 (0.343)	0.770 (0.356)
	5/18-21	0.004 (0.008)	−0.004 (0.004)	0.000 (0.132)	0.058 (0.101)
	5/26-28	0.000 (0.001)	0.009 (0.009)	0.066 (0.066)	0.066 (0.081)
	6/4	0.015 (0.015)	−0.015 (0.008)	0.028 (0.048)	0.056 (0.040)
$\bar{x}$ (s)		0.004 (0.011)	0.005 (0.017)	0.056 (0.118)	0.115 (0.268)
Pajarito Canyon at SR-4	3/5	0.035 (0.019)	0.004 (0.010)	−0.134 (0.164)	0.067 (0.178)
	3/2-5	−0.010 (0.007)	0.014 (0.008)	0.945 (0.069)	0.942 (0.131)
	3/6-19	−0.004 (0.015)	−0.004 (0.004)	0.021 (0.044)	0.000 (0.022)
	3/23-26	−0.018 (0.022)	−0.018 (0.018)	−0.026 (0.070)	0.079 (0.087)
	3/30-4/2	0.004 (0.012)	0.000 (0.010)	0.150 (0.011)	0.060 (0.110)
	4/6-9	−0.005 (0.012)	0.017 (0.017)	0.020 (0.040)	0.066 (0.052)
	4/20	0.000 (0.010)	0.000 (0.000)	0.030 (0.030)	0.000 (0.030)
	4/30	0.000 (0.010)	0.134 (0.010)	0.116 (0.084)	0.093 (0.080)
	5/4-7	−0.120 (0.009)	−0.004 (0.009)	−0.034 (0.034)	0.034 (0.059)
	5/11-14	−0.011 (0.012)	0.007 (0.007)	0.161 (0.105)	0.095 (0.056)
	5/18-21	−0.024 (0.016)	0.034 (0.016)	0.172 (0.150)	0.000 (0.079)
	5/26-28	0.016 (0.014)	0.004 (0.011)	0.040 (0.069)	0.120 (0.090)
	6/4	−0.022 (0.011)	0.000 (0.010)	0.000 (0.227)	0.218 (0.218)
	6/8-11	−0.012 (0.013)	0.000 (0.010)	−0.014 (0.024)	0.014 (0.014)
$\bar{x}$ (s)		−0.002 (0.016)	0.013 (0.037)	0.068 (0.138)	0.128 (0.242)

Table G-36 (cont)

Station	1987 Date	Solution ^{238}Pu (10^{-9} µCi/mL)	Solution $^{239,240}Pu$ (10^{-9} µCi/mL)	Suspended Sediments ^{238}Pu (pCi/g)	Suspended Sediments $^{239,240}Pu$ (pCi/g)
Los Alamos Canyon at SR-4	3/2-5	-0.011 (0.019)	0.011 (0.024)	0.190 (0.061)	2.84 (0.219)
	3/16-19	0.030 (0.016)	0.035 (0.015)	0.105 (0.014)	0.770 (0.048)
	3/23-26	0.012 (0.013)	0.020 (0.012)	0.026 (0.004)	0.426 (0.024)
	3/30-31,4/1-2	0.000 (0.010)	-0.004 (0.004)	0.033 (0.023)	3.50 (0.400)
	4/6-9	-0.059 (0.066)	0.040 (0.040)	-0.040 (0.040)	0.230 (0.110)
	4/14-17	0.054 (0.020)	0.010 (0.012)	0.018 (0.018)	2.20 (0.160)
	4/20	0.021 (0.016)	0.036 (0.006)	0.118 (0.024)	1.65 (0.110)
	4/30	0.008 (0.011)	0.008 (0.011)	0.074 (0.019)	2.08 (0.121)
	5/4-7	0.029 (0.018)	0.000 (0.010)	0.055 (0.021)	1.63 (0.128)
	5/11-14	-0.004 (0.009)	0.014 (0.012)	0.023 (0.069)	1.59 (0.209)
	5/18-21	0.009 (0.013)	0.014 (0.014)	0.117 (0.060)	2.52 (0.228)
	5/26-27	0.000 (0.010)	0.000 (0.010)	0.212 (0.071)	3.32 (0.304)
	6/4	0.004 (0.004)	0.031 (0.013)	0.314 (0.105)	2.79 (0.328)
	6/8-11	-0.009 (0.011)	-0.004 (0.010)	0.051 (0.102)	1.94 (0.241)
$\bar{x}$ (s)		0.006 (0.026)	0.015 (0.015)	0.093 (0.093)	1.96 (1.01)
Pueblo Canyon at SR-4	3/5	-0.014 (0.025)	0.014 (0.032)	0.021 (0.010)	4.63 (0.232)
	3/2-5	-0.026 (0.015)	0.000 (0.010)	0.036 (0.008)	0.742 (0.047)
	3/16-19	-0.008 (0.010)	0.023 (0.014)	0.011 (0.005)	1.60 (0.095)
	3/23-26	0.000 (0.010)	-0.007 (0.007)	0.015 (0.004)	1.17 (0.050)
	3/30-31,4/1-2	0.021 (0.014)	0.000 (0.010)	0.005 (0.002)	1.35 (0.058)
	4/6-9	0.012 (0.015)	0.012 (0.013)	0.034 (0.014)	7.27 (0.310)
	4/14-17	0.000 (0.010)	0.010 (0.010)	-0.009 (0.009)	3.27 (0.210)
$\bar{x}$ (s)		-0.002 (0.016)	0.007 (0.010)	0.016 (0.016)	2.86 (2.38)

Table G-36 (cont)

Station	1987 Date	Solution ^{238}Pu (10^{-9} µCi/mL)	Solution $^{239,240}Pu$ (10^{-9} µCi/mL)	Suspended Sediments ^{238}Pu (pCi/g)	Suspended Sediments $^{239,240}Pu$ (pCi/g)
Los Alamos Canyon at Otowi	3/2-5	−0.033 (0.025)	0.011 (0.019)	0.181 (0.012)	0.401 (0.022)
	3/16-19	0.008 (0.012)	0.011 (0.011)	0.059 (0.008)	1.40 (0.069)
	4/20	0.000 (0.010)	0.000 (0.010)	0.036 (0.006)	0.930 (0.047)
	4/30	0.000 (0.010)	0.008 (0.013)	0.004 (0.002)	0.121 (0.010)
	5/4-7	0.004 (0.004)	−0.004 (0.004)	0.019 (0.005)	0.264 (0.021)
	5/11-14	0.000 (0.010)	0.018 (0.018)	0.009 (0.005)	0.167 (0.97)
	5/18-21	0.000 (0.010)	0.021 (0.018)	0.029 (0.011)	0.228 (0.029)
	5/26-28	0.054 (0.021)	0.009 (0.009)	0.018 (0.009)	0.268 (0.036)
	6/4	0.027 (0.017)	0.013 (0.012)	0.058 (0.041)	0.878 (0.164)
	6/8-11	−0.005 (0.013)	0.005 (0.015)	0.064 (0.034)	2.74 (0.202)
	6/14-17	−0.011 (0.017)	−0.011 (0.011)	1.90 (0.060)	1.70 (0.160)
$\bar{x}$ (s)		0.004 (0.022)	0.007 (0.009)	0.216 (0.561)	0.827 (0.829)
Rio Grande at Otowi	3/12	−0.016 (0.011)	−0.024 (0.014)	0.001 (0.004)	0.001 (0.002)

Table G-37. Radiochemistry of Storm Run-off in Sediment Traps, Mortandad Canyon

Uranium and Plutonium Analyses

Station	Solution: Total U (µg/L)	Solution: ^{238}Pu (10^{-9} µCi/mL)	Solution: $^{239,240}Pu$ (10^{-9} µCi/mL)	Suspended Sediments: ^{238}Pu (pCi/g)	Suspended Sediments: $^{239,240}Pu$ (pCi/g)
Sediment Trap 1	2.0 (1.0)	0.225 (0.225)	1.24 (0.331)	39.2 (1.72)	137 (5.17)
Sediment Trap 2	1.0 (1.0)	0.767 (0.334)	1.34 (0.363)	31.1 (1.43)	107 (4.13)
Sediment Trap 3	1.0 (1.0)	−0.212 (0.150)	0.265 (0.206)	21.5 (1.04)	75.3 (2.97)

Tritium, Cesium, and Gross Radioactivity Analyses

Station	Solution: ^{3}H (10^{-6} µCi/mL)	Solution: ^{137}Cs (10^{-9} µCi/mL)	Solution: Gross Alpha (10^{-9} µCi/mL)	Solution: Gross Beta (10^{-9} µCi/mL)	Solution: Gross Gamma (counts/min/L)
Sediment Trap 1	9.0 (1.0)	−18 (59)	5.0 (1.0)	35 (4.0)	---
Sediment Trap 2	4.7 (0.6)	26 (40)	1.5 (0.7)	26 (3.0)	---
Sediment Trap 3	5.9 (0.7)	3 (59)	2.4 (0.9)	17 (2.0)	---

Table G-38. Locations of Soil and Sediment Sampling Stations

Station	Latitude or N-S Coord	Longitude or E-W Coord	Map Designation[a]
Regional Sediments			
Chamita	36°05'	106°07'	--
Embudo	36°12'	105°58'	--
Otowi	35°52'	106°08'	--
Sandia	S060	E490	--
Pajarito	S185	E410	--
Ancho	S305	E335	--
Frijoles	S375	E235	--
Cochiti	35°37'	106°19'	--
Bernalillo	35°17'	106°36'	--
Jemez River	35°40'	106°44'	--
Perimeter Sediments			
Guaje at SR-4	N135	E480	12
Bayo at SR-4	N100	E455	13
Sandia at SR-4	N025	E315	14
Mortandad at SR-4	S030	E350	15
Canada del Buey at SR-4	S090	E360	16
Pajarito at SR-4	S105	E320	17
Potrillo at SR-4	S145	E295	18
Water at SR-4	S170	E260	19
Ancho at SR-4	S255	E250	20
Frijoles at National Monument Headquarters	S280	E185	21
Effluent Release Area Sediments			
Acid Pueblo Canyon			
Acid Weir	N125	E070	22
Pueblo 1	N130	E085	23
Pueblo 2	N120	E145	24
Hamilton Bend Spring	N105	E255	25
Pueblo 3	N090	E315	26
Pueblo at SR-4	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
Los Alamos at Totavi	N065	E405	36
Los Alamos at LA-2	N125	E510	37
Los Alamos at Otowi	N100	E560	38

Table G-38 (cont)

Station	Latitude or N-S Coord	Longitude or E-W Coord	Map Designation[a]
Mortandad Canyon			
Mortandad near CMR	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	N015	E250	45
Regional Soils			
Rio Chama	36°05'	106°07'	--
Embudo	36°12'	105°58'	--
Otowi	35°52'	106°08'	--
Near Santa Cruz	35°59'	105°54'	--
Cochiti	35°37'	106°19'	--
Bernalillo	35°17'	106°36'	--
Jemez	35°40'	106°44'	--
Perimeter Soils			
Sportsman's Club	N240	E215	S1
North Mesa	N134	E168	S2
TA-8	N060	W075	S3
TA-49	S165	E085	S4
White Rock (east)	S055	E385	S5
Tsankawi	N020	E310	S6
Onsite Soils			
TA-21	N095	E140	S7
East of TA-53	N051	E218	S8
TA-50	N035	E095	S9
Two Mile Mesa	N025	E030	S10
East of TA-54	S080	E295	S11
R-Site Road East	S042	E103	S12
Potrillo Drive	S065	E195	S13
S-Site	S035	W025	S14
Near Test Well DT-9	S150	E140	S115
Near TA-33	S245	E225	S16

[a]Soil sampling locations in Figs. 14 and 17; sediment sampling locations in Figs. 14 and 18.

Table G-39. Radiochemical Analyses of Regional Soils and Sediments[a]

Location	^{3}H (10^{-6} µCi/mL)	^{137}Cs (pCi/g)	Total U (µg/g)	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)	^{241}Am (pCi/g)	Gross Gamma (counts/min/g)
Soils							
Chamita	0.2 (0.5)	0.24 (0.07)	5.4 (0.5)	0.002 (0.001)	0.008 (0.002)	--	6.4 (0.8)
Embudo	0.1 (0.5)	0.25 (0.10)	4.8 (0.5)	0.000 (0.001)	0.007 (0.002)	--	6.0 (0.8)
Otowi	-0.8 (0.5)	0.02 (0.06)	5.0 (0.5)	0.000 (0.001)	0.008 (0.002)	--	6.1 (0.8)
Near Santa Cruz Lake	--	0.41 (0.10)	3.1 (0.3)	0.000 (0.001)	0.007 (0.002)	--	4.6 (0.7)
Cochiti	4.7 (0.7)	0.43 (0.09)	3.0 (0.3)	0.000 (0.001)	0.016 (0.003)	--	4.1 (0.7)
Bernalillo	13 (1.0)	0.60 (0.13)	1.9 (0.2)	0.002 (0.001)	0.013 (0.003)	--	3.7 (0.7)
Jemez	4.3 (0.7)	0.23 (0.08)	2.1 (0.2)	0.001 (0.001)	0.010 (0.003)	--	1.7 (0.6)
Summary							
No. of Analyses	6	7	7	7	7	--	7
Average	3.6	0.31	3.6	0.001	0.010	--	4.7
S	5.2	0.19	1.4	0.001	0.003	--	1.7
Minimum	-0.8 (0.5)	0.02 (0.06)	1.9 (0.2)	0.000 (0.001)	0.007 (0.002)	--	1.7 (0.6)
Maximum	13 (1.0)	0.60 (0.13)	5.4 (0.5)	0.002 (0.001)	0.016 (0.003)	--	6.4 (0.8)
Sediments							
Rio Chama at Chamita	--	0.00 (0.06)	1.9 (0.2)	-0.001 (0.001)	-0.002 (0.001)	-0.160 (0.081)	-3.5 (0.7)
Rio Grande at Embudo	--	0.14 (0.10)	2.3 (0.2)	0.000 (0.001)	0.000 (0.001)	-0.146 (0.177)	-4.1 (0.7)
Rio Grande at Otowi	--	0.06 (0.06)	2.0 (0.2)	0.001 (0.002)	0.000 (0.001)	-0.078 (0.081)	-5.5 (0.8)
Rio Grande at Sandia	0.7 (0.4)	0.38 (0.11)	8.5 (0.9)	0.001 (0.002)	0.002 (0.001)	--	3.8 (0.7)
Rio Grande at Pajarito	0.2 (0.4)	0.12 (0.10)	3.4 (0.4)	0.000 (0.001)	0.007 (0.002)	--	1.8 (0.6)
Rio Grande at Ancho[b]	--	--		--	--	--	--
Rio Grande at Frijoles[b]	--	--	--	--	--	--	--
Rio Grande at Bernalillo	--	0.13 (0.09)	2.8 (0.3)	0.000 (0.001)	0.004 (0.002)	-3.26 (0.520)	-1.6 (0.6)
Jemez River at Jemez	--	0.09 (0.08)	1.1 (0.2)	0.000 (0.002)	0.001 (0.001)	--	--

Table G-39 (cont)

Location	^{3}H (10^{-6} µCi/mL)	^{137}Cs (pCi/g)	Total U (µg/g)	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)	^{241}Am (pCi/g)	Gross Gamma (counts/min/g)
Summary							
No. of Analyses	2	7	7	7	7	4	6
Average	0.4	0.13	3.1	0.000	0.002	-0.911	-1.5
S	0.3	0.12	2.5	0.001	0.003	1.57	3.6
Minimum	0.2 (0.4)	0.00 (0.06)	1.1 (0.2)	-0.001 (0.001)	-0.002 (0.001)	-3.26 (0.520)	-3.5 (0.7)
Maximum	0.7 (0.4)	0.38 (0.11)	8.5 (0.9)	0.001 (0.002)	0.007 (0.002)	-0.078 (0.081)	3.8 (0.7)
Limits of Detection	0.7	0.1	0.3	0.003	0.002	0.01	0.1

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[a]Samples collected in April; counting uncertainty in parentheses.

[b]Sampling station covered by reservoir.

Table G-40. Radiochemical Analyses of Perimeter Soils and Sediments

Location	^{3}H (10^{-6} µCi/mL)	^{137}Cs (pCi/g)	Total U (µg/g)	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)	^{241}Am (pCi/g)	Gross Gamma (counts/min/g)
Perimeter Soils							
Sportmens Club	1.1 (0.5)	0.29 (0.09)	4.2 (0.4)	0.001 (0.001)	0.018 (0.003)	--	4.4 (0.7)
North Mesa	0.4 (0.5)	0.25 (0.08)	3.8 (0.4)	0.001 (0.001)	0.008 (0.002)	--	6.3 (0.8)
TA-8	0.6 (0.5)	1.3 (0.22)	3.1 (0.3)	0.002 (0.001)	0.026 (0.004)	--	7.3 (0.9)
TA-49	-0.1 (0.5)	0.34 (0.09)	4.8 (0.5)	0.000 (0.001)	0.004 (0.002)	--	7.1 (0.9)
White Rock	2.8 (0.6)	0.24 (0.08)	4.0 (0.4)	0.001 (0.001)	0.010 (0.002)	--	7.5 (0.9)
Tsankawi	1.5 (0.5)	0.27 (0.07)	5.3 (0.5)	0.029 (0.004)	0.009 (0.002)	--	9.0 (1.0)
Summary							
No. of Analyses	6	6	6	6	6		6
Average	1.0	0.44	4.2	0.006	0.013	--	6.9
S	1.0	0.42	0.8	0.011	0.008	--	1.5
Minimum	-0.1 (0.5)	0.24 (0.08)	3.1 (0.3)	0.000 (0.001)	0.004 (0.002)	--	4.4 (0.7)
Maximum	2.8 (0.6)	1.3 (0.22)	5.3 (0.5)	0.029 (0.004)	0.026 (0.004)	--	9.0 (1.0)
Perimeter Sediments							
Guaje at SR-4	--	0.06 (0.06)	2.8 (0.3)	0.000 (0.001)	0.002 (0.001)	-0.016 (0.068)	-2.4 (0.6)
Bayo at SR-4	--	0.34 (0.11)	3.2 (0.3)	-0.001 (0.002)	0.002 (0.002)	0.028 (0.202)	-0.8 (0.6)
Sandia at SR-4	--	0.06 (0.06)	1.8 (0.2)	0.001 (0.001)	0.001 (0.001)	0.010 (0.081)	-2.1 (0.6)
Mortandad at SR-4	--	0.00 (0.07)	1.7 (0.2)	-0.000 (0.001)	0.002 (0.001)	--	-1.2 (0.6)
Canada del Buey at SR-4	--	0.13 (0.09)	2.1 (0.2)	0.002 (0.002)	0.001 (0.002)	0.054 (0.179)	-23 (2.0)
Pajarito at SR-4	--	0.10 (0.06)	2.6 (0.3)	-0.001 (0.002)	0.005 (0.003)	0.043 (0.096)	0.2 (0.6)
Potrillo at SR-4	--	0.04 (0.09)	2.5 (0.3)	0.001 (0.001)	0.002 (0.001)	0.311 (0.188)	-1.6 (0.6)
Water at SR-4	--	0.15 (0.08)	1.7 (0.2)	0.000 (0.001)	0.002 (0.001)	--	-2.6 (0.6)
Ancho at SR-4	--	0.12 (0.07)	2.3 (0.3)	0.000 (0.001)	0.006 (0.002)	0.110 (0.097)	-1.2 (0.6)
Frijoles at Bandelier	--	0.24 (0.10)	3.2 (0.3)	-0.001 (0.001)	0.001 (0.001)	0.230 (0.185)	-0.9 (0.6)
Sandia at Rio Grande	--	0.39 (0.12)	2.0 (0.2)	0.000 (0.001)	0.001 (0.002)	--	-1.5 (0.6)
Canada del Ancha at Rio Grande	--	0.14 (0.09)	1.3 (0.2)	-0.001 (0.001)	0.001 (0.001)	--	-0.8 (0.6)

Table G-40 (cont)

Location	^{3}H (10^{-6} µCi/mL)	^{137}Cs (pCi/g)	Total U (µg/g)	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)	^{241}Am (pCi/g)	Gross Gamma (counts/min/g)
Mortandad At Rio Grande	0.3 (0.4)	0.03 (0.10)	1.7 (0.2)	0.000 (0.000)	0.002 (0.001)	--	-0.7 (0.6)
Pajarito at Rio Grande	0.5 (0.4)	0.36 (0.11)	2.9 (0.3)	0.000 (0.001)	0.003 (0.002)	--	-0.0 (0.6)
Water at Rio Grande	--	0.09 (0.09)	1.8 (0.2)	0.001 (0.001)	0.001 (0.001)	--	-2.9 (0.6)
Ancho at Rio Grande	0.2 (0.4)	0.08 (0.08)	1.2 (0.2)	0.000 (0.001)	0.000 (0.001)	--	-4.8 (0.7)
Frijoles at Rio Grande	0.4 (0.4)	0.13 (0.10)	2.8 (0.3)	-0.001 (0.001)	0.002 (0.001)	--	2.5 (0.6)
Summary							
No. of Analyses	4	17	17	17	17	8	17
Average	0.3	0.14	2.2	0.000	0.002	0.096	-2.6
Std. Dev.	0.1	0.12	0.6	0.001	0.002	0.116	5.5
Minimum	0.2 (0.4)	0.00 (0.07)	1.2 (0.2)	-0.001 (0.002)	0.000 (0.001)	-0.016 (0.068)	-2.3 (2.0)
Maximum	0.5 (0.4)	0.39 (0.12)	3.2 (0.3)	0.002 (0.002)	0.006 (0.002)	0.311 (0.188)	2.5 (0.6)
Limits of Detection	0.7	0.1	0.3	0.003	0.002	0.002	0.1

[a]Samples collected in April; counting uncertainty in parentheses.

Table G-41. Suburanic and Gross Gamma Analyses of On-site Soils and Sediments[a]

Location	^{3}H (10^{-6} µCi/mL)	^{137}Cs (pCi/g)	Gross Gamma (counts/min/g)
On-site Soils			
TA-21	1.9 (0.5)	−0.01 (0.08)	6.6 (0.9)
East of TA-53	1.0 (0.5)	0.17 (0.08)	7.5 (0.9)
TA-50	2.3 (0.5)	0.11 (0.08)	6.8 (0.9)
Two-Mile Mesa	0.7 (0.5)	0.51 (0.11)	4.7 (0.7)
East of TA-54	−0.5 (0.5)	0.14 (0.07)	6.0 (0.8)
R-Site Road East	0.4 (0.5)	0.05 (0.05)	6.4 (0.8)
Potrillo Drive	2.4 (0.6)	0.25 (0.09)	5.2 (0.8)
S-Site	0.7 (0.5)	0.12 (0.06)	5.8 (0.8)
Near DT-9	−0.2 (0.5)	0.79 (0.15)	5.1 (0.7)
Near TA-33	10 (1.0)	0.25 (0.07)	7.2 (0.9)
Summary			
No. of Analyses	10	10	10
Average	1.9	0.24	6.1
S	3.0	0.24	0.9
Minimum	−0.5 (0.5)	−0.01 (0.08)	4.7 (0.7)
Maximum	10 (1.0)	0.79 (0.15)	7.5 (0.9)
Sediments: Effluents			
Release Areas			
Pueblo Canyon			
Acid Weir	---	0.18 (0.10)	0.8 (0.6)
Pueblo 1	---	0.20 (0.10)	−2.2 (0.6)
Pueblo 2	---	−0.02 (0.06)	−0.8 (0.6)
Hamilton Bend Spring	---	0.27 (0.09)	−0.3 (0.6)
Pueblo 3	---	0.02 (0.07)	−1.3 (0.6)
Pueblo at SR-4	---	−0.01 (0.09)	−3.4 (0.7)

Table G-41 (cont)

Location	^{3}H (10^{-6} µCi/mL)	^{137}Cs (pCi/g)	Gross Gamma (counts/min/g)
Summary			
No. of Analyses	---	6	6
Average	---	0.11	-1.2
S	---	0.12	1.5
Minimum	---	-0.02 (0.06)	-3.4 (0.7)
Maximum	---	0.27 (0.09)	0.8 (0.6)
Los Alamos Canyon			
DP Canyon at DPS-1	---	7.2 (1.1)	5.4 (0.8)
DP Canyon at DPS-4	---	10.7 (1.6)	---
Los Alamos at Bridge	---	0.30 (0.10)	-3.9 (0.7)
Los Alamos at LAO-1	---	1.1 (0.19)	1.1 (0.6)
Los Alamos at GS-1	---	0.20 (0.09)	3.6 (0.7)
Los Alamos at LAO-3	---	0.20 (0.07)	-0.9 (0.6)
Los Alamos at LAO-4.5	---	0.62 (0.14)	0.9 (0.6)
Los Alamos at SR-4	---	1.8 (0.28)	3.5 (0.7)
Los Alamos at Totavi	---	0.85 (0.16)	3.4 (0.7)
Los Alamos at LA-2	---	0.31 (0.09)	3.6 (0.7)
Los Alamos at Otowi	---	0.30 (0.10)	0.8 (0.6)
Summary			
No. of Analyses	---	11	10
Average	---	2.1	1.8
S	---	3.5	2.7
Minimum	---	0.20 (0.09)	-3.9 (0.7)
Maximum	---	10.7 (1.6)	5.4 (0.8)

Table G-41 (cont)

Location	^{3}H (10^{-6} µCi/mL)	^{137}Cs (pCi/g)	Gross Gamma (counts/min/g)
Mortandad Canyon			
Mortandad at CMR	---	0.08 (0.06)	-1.4 (0.6)
Mortandad West of GS-1	---	0.11 (0.09)	-2.1 (0.6)
Mortandad at GS-1	---	-0.06 (0.06)	0.2 (0.6)
Mortandad at MCO-5	---	38 (5.7)	54 (5.0)
Mortandad at MCO-7	---	16 (2.4)	17 (2.0)
Mortandad at MCO-9	---	0.28 (0.10)	4.9 (0.8)
Mortandad at MCO-13	---	0.56 (0.13)	--
Summary			
No. of Analyses	---	7	16
Average	---	7.85	12
S	---	14.5	22
Minimum	---	-0.06 (0.06)	-2.1 (0.6)
Maximum	---	38 (5.7)	54 (5.0)
Limits of Detection	0.7	0.1	0.1

[a]Samples collected in April and May; counting uncertainty in parentheses.

Table G-42. Uranium and Transuranic Radiochemical Analyses of On-site Soils and Sediments[a]

Location	Total U (µg/g)	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)	^{241}Am (pCi/g)
On-site Soils				
TA-21	3.8 (0.4)	0.005 (0.004)	0.002 (0.002)	---
East of TA-53	4.6 (0.5)	0.000 (0.002)	0.012 (0.001)	--
TA-50	4.2 (0.5)	0.002 (0.001)	0.038 (0.003)	--
Two-Mile Mesa	2.9 (0.3)	0.002 (0.002)	0.020 (0.005)	--
East of TA-54	3.4 (0.3)	0.002 (0.002)	0.008 (0.004)	--
R-Site Road East	3.9 (0.4)	0.003 (0.001)	0.002 (0.002)	--
Potrillo Drive	3.9 (0.4)	0.000 (0.001)	0.000 (0.001)	--
S-Site	4.1 (0.4)	0.001 (0.002)	0.000 (0.001)	--
Near DT-9	3.1 (0.4)	0.000 (0.001)	0.016 (0.003)	--
Near TA-33	3.6 (0.4)	0.001 (0.001)	0.009 (0.002)	--
Summary				
No. of Analyses	10	10	10	--
Average	3.7	0.002	0.011	--
S	0.5	0.002	0.012	--
Minimum	2.9 (0.3)	0.000 (0.002)	0.000 (0.001)	--
Maximum	4.6 (0.5)	0.005 (0.004)	0.038 (0.003)	--
Sediments: Effluent Release Area				
Pueblo Canyon				
Acid Weir	3.2 (0.3)	0.001 (0.002)	0.004 (0.002)	1.28 (0.251)
Pueblo 1	2.4 (0.2)	-0.036 (0.018)	0.009 (0.027)	-1.83 (0.330)
Pueblo 2	2.9 (0.3)	0.026 (0.014)	0.612 (0.062)	2.51 (0.401)
Hamilton Bend Spring	3.4 (0.3)	0.001 (0.008)	0.167 (0.010)	2.29 (0.373)
Pueblo 3	3.2 (0.3)	0.000 (0.001)	0.004 (0.002)	1.31 (0.254)
Pueblo at SR-4	2.7 (0.3)	0.002 (0.001)	0.399 (0.021)	2.37 (0.382)

Table G-42 (cont)

Location	Total U (µg/g)	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)	^{241}Am (pCi/g)
Summary				
No. of Analyses	6	6	6	6
Average	2.9	−0.001	0.199	1.93
S	0.4	0.020	0.254	0.54
Minimum	2.4 (0.2)	−0.036 (0.018)	0.004 (0.002)	1.28 (0.251)
Maximum	3.4 (0.3)	0.026 (0.014)	0.612 (0.062)	2.51 (0.401)
Sediments: Effluent Release Area				
Los Alamos Canyon				
DP Canyon at DPS-1	2.5 (0.3)	0.067 (0.019)	0.139 (0.026)	2.88 (0.457)
DP Canyon at DPS-4	5.0 (0.5)	0.196 (0.012)	0.609 (0.029)	--
Los Alamos at Bridge	2.8 (0.3)	−0.001 (0.001)	0.002 (0.011)	−1.27 (0.223)
Los Alamos at LAO-1	3.4 (0.3)	0.021 (0.004)	0.239 (0.014)	1.65 (0.301)
Los Alamos at GS-1	4.4 (0.4)	0.002 (0.001)	0.516 (0.026)	1.38 (0.291)
Los Alamos at LAO-3	3.0 (0.3)	0.005 (0.002)	0.183 (0.011)	1.37 (0.260)
Los Alamos at LAO-4.5	3.2 (0.3)	0.008 (0.002)	0.267 (0.015)	−1.48 (0.278)
Los Alamos at SR-4	4.2 (0.4)	0.029 (0.004)	0.414 (0.023)	1.24 (0.246)
Los Alamos at Totavi	4.4 (0.4)	0.062 (0.006)	0.493 (0.025)	−2.71 (0.442)
Los Alamos at LA-2	4.3 (0.4)	0.006 (0.002)	0.615 (0.030)	2.43 (0.390)
Los Alamos at Otowi	3.6 (0.4)	0.006 (0.002)	0.131 (0.010)	−2.43 (0.391)
Summary				
No. of Analyses	11	11	11	10
Average	3.7	0.036	0.328	0.306
S	0.8	0.058	0.211	2.06
Minimum	2.5 (0.3)	−0.001 (0.001)	0.002 (0.011)	−2.43 (0.391)
Maximum	5.0 (0.5)	0.196 (0.012)	0.615 (0.030)	2.88 (0.457)

Table G-42 (cont)

Location	Total U (µg/g)	^{238}Pu (pCi/g)	$^{239,240}Pu$ (pCi/g)	^{241}Am (pCi/g)
Sediments: Effluent Release Area, Mortandad Canyon				
Mortandad at CMR	1.8 (0.2)	0.021 (0.003)	0.006 (0.002)	1.16 (0.225)
Mortandad West of GS-1	1.5 (0.2)	0.008 (0.017)	0.000 (0.001)	1.39 (0.290)
Mortandad at GS-1	2.3 (0.2)	-0.028 (0.013)	-0.005 (0.012)	3.99 (0.613)
Mortandad at MCO-5	2.9 (0.3)	7.59 (0.520)	30.7 (1.90)	24.6 (3.71)
Mortandad at MCO-7	1.7 (0.2)	1.52 (0.082)	6.02 (0.246)	4.22 (0.649)
Mortandad at MCO-9	4.8 (0.5)	-0.035 (0.013)	0.005 (0.011)	1.50 (0.304)
Mortandad at MCO-13	2.4 (0.2)	0.002 (0.001)	0.023 (0.003)	--
Summary				
No. of Analyses	7	7	7	6
Average	2.5	1.30	5.25	6.14
S	1.1	2.83	11.4	9.14
Minimum	1.5 (0.2)	-0.035 (0.013)	-0.005 (0.012)	1.16 (0.225)
Maximum	4.8 (0.5)	7.59 (0.520)	30.7 (1.90)	24.6 (3.71)
Limits of Detection	1	0.003	0.002	0.001

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[a]Samples collected in April and May; counting uncertainty in parentheses.

Table G-43. Inorganic Chemical Parameters in Solution Extracted from Sediments Downgradient from Areas G and L, TA-54

Parameters[b]	Maximum EP Toxic Concentration[c]	Limits of Detection	Station Numbers[a]								
			1	2	3	4	5	6	7	8	9
Arsenic	5.0	0.05	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Barium	100	0.5	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Cadmium	1.0	0.01	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Chromium	5.0	0.05	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Lead	5.0	0.05	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Mercury	2.0	0.001	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Selenium	1.0	0.01	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Silver	5.0	0.05	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Nickel	--	0.01	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Beryllium[d]	--	0.005	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Sulfate	--	0.2	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Nitrate	--	0.2	0.3	BLD	0.7	0.2	BLD	0.3	BLD	BLD	BLD
Cyanide	--	0.01	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
pH[e]	--	--	8.0	7.4	7.5	7.3	7.2	7.0	7.9	7.2	7.0

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[a]Samples collected in September; station number location in Figure 20.

[b]Concentrations in mg/L except as noted; BLD = Below Detection Limit.

[c]New Mexico Hazardous Waste Management Regulations (HWMR) 201 B.5.; Extraction procedure.

[d]Units are μg/g.

[e]Standard units.

Table G-44. Radionuclides in Local and Regional Produce

	^{3}H (pCi/mL)	^{90}Sr (10^{-3} pCi/dry g)	^{137}Cs (10^{-3} pCi/dry g)	U (ng/dry g)	^{238}Pu (10^{-5} pCi/dry g)	$^{239,240}Pu$ (10^{-5} pCi/dry g)
Cochiti/Santo Domingo						
N	7	7	7	7	7	7
Mean	0.8	4.6	96	4.1	0.7	1.8
Std. Dev.	0.4	5.4	52	3.5	1.9	3.6
Minimum	0.0 (0.4)	0.6 (0.6)	-99 (130)	0.8 (0.8)	-2.8 (5.0)	-1.7 (1.7)
Maximum	1.2 (0.4)	12.6 (2.4)	180 (130)	8.0 (0.8)	3.2 (5.5)	8.7 (5.5)
Espanola						
N	7	7	7	7	7	7
Mean	1.1	6.9	45	6.3	3.5	7.7
Std. Dev.	0.8	6.0	98	7.3	4.1	4.8
Minimum	-0.3 (0.4)	0.5 (1.5)	36 (65)	0.5 (0.05)	0.0 (6.7)	0.0 (1.9)
Maximum	1.5 (0.4)	14.2 (1.8)	180 (120)	21 (2.1)	10.7 (8.0)	15 (8.5)
San Ildefonso						
N	2	2	2	2	2	2
Mean	1.0	0.6	24	0.5	0.2	0.7
Std. Dev.	0.5	0.4	52	0.1	1.4	2.2
Minimum	0.7 (0.4)	0.9 (0.6)	-13 (22)	0.5 (0.05)	-0.8 (0.8)	-0.8 (0.8)
Maximum	1.4 (0.4)	0.3 (0.5)	61 (32)	0.6 (0.06)	1.2 (1.2)	2.3 (1.2)
Los Alamos/White Rock						
N	8	8	8	8	8	8
Mean	2.3	13	45	4.4	0.5	13
Std. Dev.	0.7	12	41	4.6	1.3	29
Minimum	1.4 (0.4)	1.8 (1.2)	-18 (46)	1.0 (0.1)	-1.4 (1.4)	-15 (15)
Maximum	3.4 (0.5)	33.2 (1.6)	100 (71)	13 (1.3)	2.5 (3.3)	78 (13)

Table G-44 (cont)

	^{3}H (pCi/mL)	^{90}Sr (10^{-3} pCi/dry g)	^{137}Cs (10^{-3} pCi/dry g)	U (ng/dry g)	^{238}Pu (10^{-5} pCi/dry g)	$^{239,240}Pu$ (10^{-5} pCi/dry g)
On-site						
N	17	17	17	17	17	17
Mean	24	20	54	19	20	15
Std. Dev.	50	16	60	26	42	32
Minimum	1.0 (0.4)	2.5 (1.4)	-30 (81)	1.0 (0.1)	-13 (36)	-18 (33)
Maximum	200 (20)	51.8 (1.2)	240 (100)	97 (9.7)	170 (21)	120 (16)
Minimum Detectable Limit	0.7	0.5 (1.5)	100	2	20	10

[a]Counting uncertainties within parentheses.

Table G-45. Radionuclides in Fish

	^{90}Sr (10^{-3} pCi/dry g)	^{137}Cs (10^{-3} pCi/dry g)	U (ng/dry g)	^{238}Pu (10^{-5} pCi/dry g)	^{239}Pu (10^{-5} pCi/dry g)
CATFISH					
Abiquiu					
N	10	10	10	5	5
Mean	42	130	5.2	3	3
Std. Dev.	36	90	2.0	4	3
Minimum	14 (2)[a]	-35 (78)	1.4 (0.1)	0 (4)	0 (6)
Maximum	140 (8)	290 (99)	9.3 (0.9)	10 (10)	7 (4)
Cochiti					
N	10	10	10	5	5
Mean	52	100	11.5	5	1
Std. Dev.	72	120	5.0	8	6
Minimum	12 (2)	-140 (100)	6.2 (0.6)	-5 (5)	-5 (4)
Maximum	240 (26)	270 (100)	19 (1.9)	14 (1)	8 (6)
CRAPPIE					
Abiquiu					
N	10	10	10	5	5
Mean	190	60	1.4	-3	6
Std. Dev.	150	130	0.42	8	1
Minimum	26 (2)	-210 (120)	0.45 (0.1)	-14 (11)	5 (8)
Maximum	500 (25)	240 (170)	1.9 (0.2)	5 (6)	8 (8)

Table G-45 (cont)

	^{90}Sr (10^{-3} pCi/dry g)	^{137}Cs (10^{-3} pCi/dry g)	U (ng/dry g)	^{238}Pu (10^{-5} pCi/dry g)	^{239}Pu (10^{-5} pCi/dry g)
Cochiti					
N	10	10	10	5	5
Mean	53	120	2.4	5	5
Std. Dev.	42	93	0.58	10	6
Minimum	15 (1)	-70 (120)	1.2 (0.1)	-8 (7)	-3 (3)
Maximum	120 (13)	245 (130)	2.6 (0.3)	17 (10)	12 (5)
Minimum Detectable Limit	--	10	3	30	20

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[a]Counting uncertainties in parentheses.

Table G-46. Locations of Beehives

Stations	N-S Coordinate	E-W Coordinate
Regional Stations (28-44 km)--Uncontrolled Area		
1. Chimayo	--	--
13. San Pedro	--	--
Perimeter Stations (0-4 km)--Uncontrolled Areas		
2. Northern Los Alamos County	N180	W020
3. Pajarito Acres	S210	E380
On-site Stations--Controlled Areas		
4. TA-21 (DP Canyon)	N095	E180
5. TA-50 (Upper Mortandad Canyon)	N040	E095
6. TA-53 (LAMPF)	N050	E220
7. Lower Mortandad Canyon	N020	E185
8. TA-8 (Anchor Site W)	S020	W065
9. TA-33 (HP-Site)	S260	E265
10. TA-54 (Area G)	N050	E220
11. TA-9 (Anchor Site E)	S005	W040
12. TA-15 (R-Site)	S020	E065
14. Frijoles Mesa	S160	E105
15. TA-16 (S-Site)	S055	W080

Table G-47. Selected Radionuclides in Local and Regional Honey[a]

	Chimayo	San Pedro	Pajarito Acres	Lower Mortandad	TA-8	TA-9	TA-15	TA-21	TA-33	TA-35	TA-53
^{3}H (pCi/L)	300 (400)[b]	1400 (400)	2300 (400)	8400 (1000)	400 (400)	4500 (400)	4300 (600)	7500 (900)	33 000 (3000)	8400 (1000)	120 (10)
^{7}Be (pCi/L)	1430 (1190)	-550 (1330)	-140 (568)	41 (1000)	1830 (1270)	130 (461)	1920 (996)	1130 (564)	1710 (1250)	-422 (1210)	1040 (1110)
^{57}Co (pCi/L)	69 (64)	65 (60)	217 (70)	101 (48)	13 (69)	69 (47)	107 (50)	160 (58)	60 (71)	16 (79)	92 (49)
^{137}Cs (pCi/L)	488 (94)	509 (102)	4 (40)	88 (51)	24 (52)	61 (45)	5 (36)	24 (43)	-52 (52)	73 (56)	62 (48)
^{54}Mn (pCi/L)	76 (56)	72 (53)	99 (42)	93 (47)	54 (52)	73 (41)	77 (41)	53 (40)	118 (56)	52 (51)	3 (38)
^{22}Na (pCi/L)	62 (55)	-32 (58)	43 (46)	40 (43)	20 (57)	609 (111)	105 (47)	82 (49)	481 (106)	70 (64)	30 (49)
^{83}Rb (pCi/L)	330 (215)	216 (197)	48 (139)	145 (146)	55 (187)	36 (132)	52 (180)	-50 (115)	145 (194)	62 (192)	138 (207)

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[a]Density of honey was about 1860 g/L; data from 1986.
[b]Counting uncertainty in parentheses.

Table G-48. Selected Radionuclides in Local and Regional Bees[a]

	Chimayo	San Pedro	Pajarito Acres	Lower Mortandad	TA-8	TA-9	TA-15	TA-33	TA-35	TA-53
^{3}H (pCi/L)	2400 (500)[b]	5000 (700)	4600 (600)	14 000 (2000)	7700 (900)	12 000 (1000)	5300 (700)	8700 (1000)	21 000 (2000)	6100 (800)
^{7}Be (pCi/g)	1.7 (1.1)	4.1 (2.3)	0.0 (2.1)	0.9 (2.2)	6.6 (2.4)	5.4 (2.4)	2.6 (1.3)	1.2 (1.3)	1.2 (1.3)	1.6 (1.1)
^{57}Co (pCi/g)	0.44 (0.13)	0.14 (0.094)	0.30 (0.12)	0.26 (0.14)	0.18 (0.15)	0.26 (0.11)	0.27 (0.13)	0.24 (0.11)	0.31 (0.12)	0.16 (0.11)
^{137}Cs (pCi/g)	0.020 (0.069)	0.009 (0.072)	-0.041 (0.060)	0.022 (0.11)	-0.066 (0.10)	0.14 (0.063)	0.002 (0.079)	0.11 (0.074)	0.079 (0.071)	-0.041 (0.070)
^{54}Mn (pCi/g)	0.20 (0.096)	0.024 (0.088)	0.18 (0.11)	0.25 (0.11)	0.006 (0.098)	0.17 (0.099)	0.14 (0.082)	0.086 (0.081)	0.084 (0.092)	0.21 (0.11)
^{22}Na (pCi/g)	-0.11 (0.086)	-0.042 (0.083)	0.082 (0.099)	1.2 (0.22)	0.008 (0.087)	0.077 (0.086)	0.079 (0.087)	--	0.11 (0.088)	0.22 (0.10)
^{83}Rb (pCi/g)	0.31 (0.27)	0.13 (0.28)	0.28 (0.32)	-0.25 (0.28)	0.31 (0.33)	0.24 (0.29)	-0.19 (0.23)	0.012 (0.23)	0.083 (0.17)	-0.086 (0.20)
Uranium (ng/g)[b]	63 (6.3)	200 (19)	57 (5.7)	62 (6.2)	57 (5.7)	73 (7.3)	88 (8.8)	160 (16)	75 (7.50)	89 (9.0)

[a]Data from 1986.
[b]Counting uncertainty in parentheses.

Table G-49. Hazardous Waste Management Facilities at Los Alamos National Laboratory

Technical Area	Facility Type	Interim Status or <90-Day Storage	Part B Permit Application
TA-54 Area L	Tank Treatment	Yes	Yes
	Container Storage	Yes	Yes
	Landfill[a]	No	No
TA-54 Area G	Landfill[a]	No	No
TA-50-1	Batch Treatment	Yes	Yes
	Container Storage	Yes	Yes
TA-50-37	Controlled Air Incinerator	Yes	Yes
	Container Storage	<90-day	Yes
TA-3-102	Container Storage	<90-day	No
TA-3-40	Container Storage	<90-day	No
TA-14	Thermal Treatment	Yes	Yes
TA-15	Thermal Treatment	Yes	Yes
TA-36	Thermal Treatment	Yes	Yes
TA-39	Thermal Treatment	Yes	Yes
TA-22-24	Container Storage	Yes	No[b]
TA-53-2	Container Storage	<90-day	No
TA-40-2	Container Storage	Yes	No[b]
TA-40 SDS	Thermal Treatment	Yes	No
TA-16	Thermal Treatment	Yes	Yes
TA-16 Area P	Landfill[a]	No	No
TA-46	Tank Storage	<90-day	No

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[a]Interim status was terminated in November 1985. These landfills are in the process of being closed in accordance with New Mexico Hazardous Waste Regulations.
[b]To be closed under interim status.

Table G-50. 1987 RCRA Interactions Among the Laboratory, Environmental Protection Agency (EPA), and New Mexico's Environmental Improvement Division (EID)

January 30, 1987	EID affirms LANL's RCRA permit application is complete and that they are proceeding with the technical review.
March 5, 1987	Trial burn report for the TA-50 controlled air incinerator submitted to the EID.
July 14, 1987	EPA/EID hazardous waste inspection.
August 17, 1987	Submit revised Part A including mixed wastes. DOE dirrective.
September 9, 1987	EID denies LANL request to modify the Part A. Inadequate justification and no authority to regulate mixed waste.
October 16, 1987	Request from the EID for the post-closure care permit application for hazardous waste landfills. Due by 9/30/88.
October, 1987	Respond to EID Part A denial.
October 23, 1987	EPA National Survey of Hazardous Waste Treatment, Storage, Disposal and Recycling Facilities submitted.
November 12, 1987	Received Notice of Violation letter (November 10) as result of July 14, 1987 EPA/EID inspection.
November 20, 1987	EID informs LANL that no comments were received on the closure plans for TA-40-2, TA-3-102, and TA-22-24.
November 24, 1987	Letter for EID rescinding the November 10 NOV.
November 25, 1987	Submitted revised permit application (Parts A and B) to the EID.
December 8, 1987	Submitted post-closure care permit application to the EID. See 10/16/87 above.
December 22, 1987	Request to the EID for a ground water monitoring waiver for Area P.

Table G-51. Types of Discharges and Parameters Monitored at the Laboratory Under its NPDES Permit NM0028355

EPA ID #	Type of Discharge	Number Outfalls	Monitoring Required and Sample Frequency
01A	Power Plant	1	Total Suspended Solids, Free Available Chlorine, pH, Flow (monthly)
02A	Boiler Blowdown	1	pH, Total Suspended Solids, Flow Copper, Iron, Phosphorous, Sulfite, Total Chromium (weekly)
03A	Treated Cooling Water	35	Total Suspended Solids, Free Available Chlorine, Phosphorous, pH, Flow (weekly)
04A	Noncontact Cooling Water	28	pH, Flow (weekly)
050 051	Radioactive Waste Treatment Plants	2	Ammonia, Chemical Oxygen Demand, Total Suspended Solids, Cadmium, Chromium, Copper, Iron Lead, Mercury, Zinc, pH, Flow (weekly)
05A	High Explosive Discharge	18	Chemical Oxygen Demand, pH, Flow, Total Suspended Solids (weekly)
06A	Photo Wastes	12	Cyanide, Silver, pH, Flow (weekly)
128	Printed Circuit Board	1	pH, Chemical Oxygen Demand, Total Suspended Solids, Iron, Copper, Silver, Flow (weekly)
SS	Sanitary Wastes	10	Biochemical Oxygen Demand, Flow, pH, Total Suspended Solids, Fecal Coliform Bacteria, (variable frequency, from 3 per month to quarterly)

Table G-52. NPDES Permit Effluent Quality Monitoring of Sanitary Sewage Treatment Outfalls

Discharge Location	Permit Parameters	Number of Deviations	Range of Deviation
TA-3	BOD[a]	0	--
	TSS[b]	1	51.3
	Fecal Coliforms[c]	3	3500.0 to 227,200
	pH[d]	0	--
TA-8	BOD	0	--
	TSS (90)	0	--
	pH	0	--
TA-9	BOD	0	--
	TSS	0	--
	pH	0	--
TA-16	BOD	0	--
	TSS	1	165.5
	pH	0	--
TA-18	BOD	0	--
	TSS (90)	0	--
	pH	2	9.4 to 10.1
TA-21	BOD	0	--
	TSS	0	--
	pH	1	10.6
TA-35	BOD	0	--
	TSS (90)	0	--
	pH	0	--
TA-41	BOD	0	--
	TSS	0	--
	Fecal Coliforms	1	4800.0
	pH	0	--
TA-46	BOD	0	--
	TSS	0	--
	pH	1	5.7
TA-48	BOD	0	--
	TSS	0	--
	pH	0	--

Table G-52 (cont)

Discharge Location	Permit Parameters	Number of Deviations	Range of Deviation
TA-53	BOD	0	--
	TSS (90)	0	--
	pH	1	10.2

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[a]Biochemical oxygen demand (BOD) permit limits are 30 mg/L (20-day average) and 45 mg/L (7-day average).
[b]Total suspended solids (TSS) permit limits are 30 mg/L (20-day average) and 45 mg/L or 90 mg/L (7-day average).
[c]Fecal coliform limits are 1000 organisms/100 mL (20-day average) and 2000 organisms/100 mL (7-day average).
[d]Range of permit pH limits is >6.0 and <9.0 standard units.

Table G-53. Limits Established by NPDES Permit NM0028355 for Industrial Outfall Discharges

Discharge Category	Parameter Limited	Daily Average	Daily Maximum	Units of Measurement
Power Plant	TSS	30.0	100.0	mg/L
	Free Cl	0.2	0.5	mg/L
	pH	6-9	6-9	standard units
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 units
Treated Cooling Water	TSS	30.0	100.0	mg/L
	Free Cl	0.2	0.5	mg/L
	P	5.0	5.0	mg/L
Noncontact Cooling Water	pH	6-9	6-9	standard units
Radioactive Waste Treatment Plants	COD[a]	18.8	37.5	lb/day
	COD[b]	94.0	156.0	lb/day
	TSS[a]	3.8	12.5	lb/day
	TSS[b]	18.8	62.6	lb/day
	Cd[a]	0.01	0.06	lb/day
	Cd[b]	0.06	0.3	lb/day
	Cr[a]	0.02	0.08	lb/day
	Cr[b]	0.19	0.38	lb/day
	Cu[a]	0.13	0.13	lb/day
	Cu[b]	0.63	0.63	lb/day
	Fe[a]	0.13	0.13	lb/day
	Fe[b]	1.0	2.0	lb/day
	Pb[a]	0.01	0.03	lb/day
	Pb[b]	0.06	0.15	lb/day
	Hg[a]	0.007	0.02	lb/day
	Hg[b]	0.003	0.09	lb/day
	Zn[a]	0.13	0.37	lb/day
	Zn[b]	0.62	1.83	lb/day
	pH[a]	6-9	6-9	standard units
	pH[b]	6-9	6-9	standard units
High Explosives	COD	150.0	250.0	mg/L
	TSS	30.0	45.0	mg/L
	pH	6-9	6-9	standard units

Table G-53 (cont)

Discharge Category	Parameter Limited	Daily Average	Daily Maximum	Units of Measurement
Photo Wastes	CN	0.2	0.2	mg/L
	Ag	0.5	1.0	mg/L
	pH	6-9	6-9	standard units
Printed Circuit Board	COD	1.9,	3.8	lb/dy
	TSS	1.25	2.5	lb/dy
	Fe	0.05	0.1	lb/dy
	Cu	0.05	0.1	lb/dy
	Ag	Report	Report	lb/dy
	pH	6-9	6-9	standard units

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[a]Limitations for outfall 050 located at TA-21-257.
[b]Limitations for outfall 051 located at TA-50-1.

Table G-54. NPDES Permit Effluent Quality Monitoring of Industrial Outfalls[a]

Discharge Category	Number of Outfalls	Permit Parameter	Number of Deviations	Range of Deviations	Number of Outfalls With Deviations
Power Plant	1	TSS[b]	0	---	0
		Free Cl	1	2.0	1
		pH	0	---	0
Boiler Blowdown	1	pH	0	---	0
		TSS	0	---	0
		Cu	0	---	0
		Fe	0	---	0
		P	0	---	0
		SO_3	0	---	0
		Cr	0	---	0
Treated Cooling Water	35	TSS	0	---	0
		Free Cl	3	0.60 to 1.5	3
		P	0	---	0
		pH	3	9.2 to 9.3	2
Noncontact Cooling Water	28	pH	0	---	0
Radioactive Waste Treatment Plant	2	COD[c]	0	180.2 to 787.33	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	1	4.9	1
High Explosives	18	COD	2	360.0 to 410.0	2
		TSS	0	---	0
		pH	0	---	0

Table G-54 (cont)

Discharge Category	Number of Outfalls	Permit Parameter	Number of Deviations	Range of Deviations	Number of Outfalls With Deviations
Photo Wastes	12	CN	0	---	0
		Ag	0	---	0
		TSS	0	---	0
		pH	1	9.9	1
Printed Circuit Board	1	pH	1	9.4	1
		COD	0	---	0
		Ag			
		Fe	0	---	0
		Cu	0	---	0
		TSS	0	---	0

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[a]Limits set by the NPDES permit are presented in Table G-40.

[b]Total suspended solids.

[c]Chemical oxygen demand.

Table G-55. Schedule and Status of Upgrading the Laboratory's Waste Water Outfalls

Outfalls	Date	Status
01A		
Final design complete	August 1986	Completed
Advertisement of construction contract	September 1986	Completed
Award of construction contract	October 1986	Completed
Construction completion	December 1986	Completed
In compliance with final limits	January 1987	Completed
03A		
Final design complete	August 1986	Completed
Advertisement of construction contract	September 1986	Completed
Award of construction contract	October 1986	Completed
Construction completion	December 1986	Completed
In compliance with final limits	January 1987	Completed
05A		
Final design complete	September 1986	Completed
Advertisement of construction contract	October	Completed
Award of construction contract	November 1986	Completed
Construction completion	May 1987	Completed
In compliance with final limits	June 1987	Completed
01S		
Final design complete	Completed	Completed
Advertisement of construction contract	Completed	Completed
Award of construction contract	July 1986	Completed
Construction completion	May 1987	Completed
In compliance with final limits	August 1987	Completed
04S		
Final design complete	January 1987	Completed
Advertisement of construction contract	February 1987	Completed
Award of construction contract	March 1987	Completed
Construction complete	December 1987	Completed
In compliance with final limits	January 1988	Completed
05S		
Final design complete	Completed	Completed
Advertisement of construction contract	Completed	Completed
Award of construction contract	July 1986	Completed
Construction completion	January 1988	Completed
In compliance with final limits	May 1988	--

Table G-55 (cont)

Outfalls	Date	Status
06S		
Final design complete	Completed	Completed
Advertisement of construction contract	July 1986	Completed
Award of construction contract	August 1986	Completed
Construction completion	August 1987	Completed
In compliance with final limits	September 1987	Completed
10S		
Final design complete	Completed	Completed
Advertisement of construction contract	Completed	Completed
Award of construction contract	Completed	Completed
Construction completion	Completed	Completed
In compliance with final limits	September 1986	Completed
11S		
Final design complete	Completed	Completed
Advertisement of construction contract	Completed	Completed
Award of construction contract	July 1986	Completed
Construction complete	November 1986	Completed
In compliance with final limits	January 1987	Completed

Table G-56. Federal Facility Compliance Agreement Interim Compliance Limits and Compliance Schedule

Effluent Characteristic	Discharge Limitation		
	Daily Avg. (lb/day)	Daily Avg. (mg/L)	7-Day Avg. (mg/L)
Industrial Outfalls			
Outfall 01A (Power Plant)			
Flow[a]	N/A	N/A	N/A
Total suspended solids	N/A	30	100
Free available chlorine	N/A	1.0	5.0
Outfall 03A (Treated Cooling Water)			
Flow	N/A	N/A	N/A
Total suspended solids	N/A	30	100
Free available chlorine	N/A	1.0	5.0
Total phosphorous	N/A	5	5
Outfall 05A (High Explosive)			
Flow	N/A	N/A	N/A
Chemical oxygen demand	N/A	1000	2000
Total suspended solids	N/A	60	90
Sanitary Waste Water Outfalls			
Outfall 01S (Located at TA-3)			
Flow	N/A	N/A	N/A
Biochemical oxygen demand	225.2	70	105
Total suspended solids	225.2	55	105
Fecal coliform	N/A	10,000	200,000
Outfall 04S (Located at TA-18)			
Flow	N/A	N/A	N/A
Biochemical oxygen demand	10	60	95
Total suspended solids	10	70	125
Outfall 05S (Located at TA-21)			
Flow	N/A	N/A	N/A
Biochemical oxygen demand	6.8	60	95
Total suspended solids	7.3	60	100

Table G-56 (cont)

Effluent Characteristic	Discharge Limitation Daily Avg. (lb/day)	Daily Avg. (mg/L)	7-Day Avg. (mg/L)
Outfall 06S (Located at TA-41)			
Flow	N/A	N/A	N/A
Biochemical oxygen demand	11.4	55	60
Total suspended solids	6.2	30	45
Fecal coliform bacteria	N/A	20,000	100,000
Outfall 10S (Located at TA-35)			
Flow	N/A	N/A	N/A
Biochemical oxygen demand	23.2	115	185
Total suspended solids	26.1	130	170
Outfall 11S (Located at TA-8)			
Flow	N/A	N/A	N/A
Biochemical oxygen demand	N/A	60	95
Total suspended solids	N/A	70	125

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[a]Flow must be monitored and reported in millions of gallons per day.
NOTE: The pH shall not be less than 6.0 nor greater than 9.0.

Table G-57. Environmental Documentation Approved by the Laboratory Environmental Review Committee in 1987

Action Description Memorandums

Laboratory-Wide

- Core Hole, Valles Caldera (VC-2B), Sulphur Springs, Document No. 87-15
- Dwarf Mistletoe Control with Ethrel, A Growth Regulator, Document No. 87-10
- Live Firing Range Extension, Sandia Canyon, Document 87-9
- Seismic Trench, Cabra Canyon, Document No. 87-4

TA-3

- Beryllium Facility, TA-3-141, Document No. 87-8
- Lethality Test System, TA-3-253, -322, 218, Document No. 87-2
- Remote Handled Transuranic Waste Close-out, Document No. 87-16

TA-15

- Dual Axis Radiography Hydrotest Facility, Document No. 87-14

TA-16

- New Tritium Processing Facility, Document No. 87-6

TA-35

- Confinement Physics Research Facility, TA-35/52, Document No. 87-5
- Confinement Physics Research Facility, Revised TA-35/52, Document No. 87-5 rev
- Plutonium Gas Gun Facility, Document No. 87-7

TA-50

- Combustible Chemical and Radioactive Waste Storage/Staging Facility, TA 50-37, Document No. 87-11

Table G-57 (cont)

TA-52

- High density Z-Pinch (ZEBRA), Document No. 87-19

TA-53

- Neutron Time of Flight Program, Document No. 87-3
- Neutron Time of Flight Program, Revised, Document No. 87-3 rev

TA-54

- Polychlorinated Biphenyl (PCB) Storage Facility, LJ 8002 Document No. 87-1

TA-55

- Accelerated Residue Recovery Project, Document No. 87-20
- Special Nuclear Materials (SNM) Research and Development Laboratory, Document No. 87-13

TA-59

- Organic Chemistry Standards Preparation Facility, TA-59-1, Rm B4, Document No. 87-17

Environmental Assessments

Transuranic (TRU) Waste Inventory Work-Off Plan

Other

An additional document, a CEARP/CERCLA Remedial Investigation Plan, was processed as the functional equivalent to the ADM for compliance with the requirements of NEPA:

- Comprehensive Environmental Assessment and Response Program, White Rock Y Interchange Remedial Investigation Plan, Synopsis

Table G-58. Radiochemical Analyses of Water from Municipal Supply and Distribution System[a]

Stations	^{3}H (10^{-6} µCi/mL)	^{137}Cs (10^{-9} µCi/mL)	Total U (µg/L)	^{238}Pu (10^{-9} µCi/mL)	$^{249,240}Pu$ (10^{-9} µCi/mL)
Los Alamos Field					
Well LA-1B	-1.4 (0.7)	-31 (49)	6.0 (1.0)	0.011 (0.009)	-0.003 (0.009)
Well LA-2	-1.4 (0.7)	42 (48)	6.0 (1.0)	-0.007 (0.005)	0.000 (0.010)
Well LA-3	-0.6 (0.7)	42 (43)	2.0 (1.0)	0.000 (0.010)	0.024 (0.016)
Well LA-4	--	--	--	--	--
Well LA-5	-1.1 (0.7)	33 (42)	5.0 (1.0)	0.000 (0.010)	0.000 (0.010)
Guaje Field					
Well G-1	-1.0 (0.7)	40 (44)	1.0 (1.0)	-0.013 (0.010)	0.044 (0.010)
Well G-1A	-0.9 (0.7)	-33 (44)	1.0 (1.0)	0.004 (0.010)	-0.004 (0.007)
Well G-2	-0.7 (0.7)	-16 (36)	1.0 (1.0)	-0.039 (0.012)	-0.008 (0.010)
Well G-3	--	--	--	--	--
Well G-4	-0.6 (0.7)	9 (44)	1.0 (1.0)	-0.024 (0.011)	0.000 (0.010)
Well G-5	-0.9 (0.7)	-7 (36)	1.0 (1.0)	0.000 (0.010)	0.004 (0.010)
Well G-6	-1.4 (0.7)	19 (43)	1.0 (1.0)	-0.018 (0.013)	-0.004 (0.008)
Pajarito Field					
Well PM-1	0.0 (0.7)	-6 (37)	2.0 (1.0)	-0.004 (0.007)	-0.021 (0.011)
Well PM-2	0.0 (0.7)	3 (44)	0.0 (1.0)	-0.011 (0.013)	-0.011 (0.008)
Well PM-3	-0.8 (0.7)	42 (42)	1.0 (1.0)	-0.013 (0.010)	-0.004 (0.008)
Well PM-4	0.3 (0.7)	-77 (44)	0.0 (1.0)	0.000 (0.010)	0.012 (0.012)
Well PM-5	0.2 (0.7)	-22 (38)	0.0 (1.0)	-0.012 (0.009)	0.000 (0.010)

Table G-58 (cont)

Stations	^{3}H (10^{-6} µCi/mL)	^{137}Cs (10^{-9} µCi/mL)	Total U (µg/L)	^{238}Pu (10^{-9} µCi/mL)	$^{249,240}Pu$ (10^{-9} µCi/mL)
Gallery (Water Canyon)	-1.2 (0.7)	10 (50)	1.0 (1.0)	-0.005 (0.008)	-0.014 (0.011)
Supply Summary					
No. of Analyses	16	16	16	16	16
Average	-0.7	5.7	2	-0.002	0.001
S	0.6	33.5	2	0.015	0.015
Minimum	-1.4 (0.7)	-77 (44)	0.0 (1.0)	-0.039 (0.012)	-0.021 (0.011)
Maximum	0.3 (0.7)	42 (48)	6.0 (1.0)	0.011 (0.009)	0.044 (0.007)
Distribution					
Fire Station 1	0.5 (0.7)	-5 (42)	1.0 (1.0)	0.006 (0.016)	0.037 (0.017)
Fire Station 1	-0.3 (0.3)	71 (56)	1.0 (1.0)	-0.012 (0.009)	-0.006 (0.006)
Fire Station 2	-0.1 (0.7)	-32 (43)	2.0 (1.0)	0.000 (0.010)	0.005 (0.009)
Fire Station 2	-0.4 (0.3)	2 (58)	1.0 (1.0)	0.000 (0.010)	0.000 (0.010)
Fire Station 3	0.9 (0.7)	18 (44)	1.0 (1.0)	0.000 (0.010)	-0.008 (0.008)
Fire Station 3	0.5 (0.3)	17 (61)	1.0 (1.0)	0.004 (0.012)	0.019 (0.013)
Fire Station 4	2.1 (0.7)	47 (44)	1.0 (1.0)	0.000 (0.010)	0.019 (0.010)
Fire Station 4	-0.2 (0.3)	62 (59)	1.0 (1.0)	0.009 (0.011)	0.000 (0.010)
Fire Station 5	-1.9 (0.7)	65 (45)	1.0 (1.0)	0.008 (0.018)	0.000 (0.010)
Fire Station 5	0.2 (0.3)	-48 (64)	1.0 (1.0)	0.012 (0.012)	0.000 (0.010)
Bandelier Nat. Mon.	-2.4 (0.7)	-24 (45)	1.0 (1.0)	0.000 (0.010)	0.025 (0.018)
Bandelier Nat. Mon.	0.2 (0.3)	-12 (61)	1.0 (1.0)	-0.004 (0.011)	0.004 (0.010)

Table G-58 (cont)

Stations	^{3}H (10^{-6} µCi/mL)	^{137}Cs (10^{-9} µCi/mL)	Total U (µg/L)	^{238}Pu (10^{-9} µCi/mL)	$^{249,240}Pu$ (10^{-9} µCi/mL)
Distribution Summary					
No. of Analyses	12	12	12	12	12
Average	−0.1	13	1	0.002	0.008
S	1.2	40	0	0.006	0.014
Minimum	−2.4 (0.7)	−48 (64)	1.0 (1.0)	−0.012 (0.009)	−0.008 (0.008)
Maximum	2.1 (0.7)	71 (56)	2.0 (1.0)	0.012 (0.012)	0.037 (0.017)
Fenton Hill (TA-57)	−0.9 (0.7)	113 (50)	1.0 (1.0)	0.000 (0.010)	0.004 (0.008)
Fenton Hill (TA-57)	0.1 (0.3)	−42 (60)	1.0 (1.0)	0.000 (0.010)	0.004 (0.004)
Standby Well (not part of Water Supply) Well LA-6	−1.6 (0.7)	50 (43)	4.0 (1.0)	0.000 (0.010)	0.012 (0.012)
USEPA Maximum Concentration[b]	20	200	1800[c]	15	15
Limits of Detection	0.7	40	1	0.009	0.03

[a]Well samples collected in February; distribution samples collected in February and September; counting uncertainty in parentheses.
[b]Reference (EPA 1976).
[c]Levels recommended by International Commission on Radiological Protection.

Table G-59. Gross Radioactivity in Water from Municipal Supply and Distribution Systems[a]

Stations	Gross Alpha (10^{-9} µCi/mL)	Gross Beta (10^{-9} µCi/mL)	Gross Gamma (Counts/min/L)
Los Alamos Field			
Well LA-1B	-6.0 (4.0)	7.2 (0.8)	-40 (100)
Well LA-2	-7.0 (2.0)	1.7 (0.4)	-160 (100)
Well LA-3	6.0 (2.0)	2.5 (0.5)	-300 (100)
Well LA-4	--	--	--
Well LA-5	-5.0 (2.0)	1.7 (0.4)	-400 (100)
Guaje Field			
Well G-1	-6.0 (2.0)	2.8 (0.5)	-300 (100)
Well G-1A	-5.0 (1.0)	1.8 (0.4)	-140 (100)
Well G-2	-8.0 (2.0)	3.1 (0.5)	-300 (100)
Well G-3	--	--	--
Well G-4	-7.0 (2.0)	1.2 (0.4)	-220 (100)
Well G-5	-6.0 (2.0)	3.0 (0.5)	-300 (100)
Well G-6	-6.0 (2.0)	2.9 (0.5)	-120 (100)
Pajarito Field			
Well PM-1	-8.0 (2.0)	4.3 (0.6)	-170 (100)
Well PM-2	-6.0 (2.0)	1.8 (0.4)	-140 (100)
Well PM-3	-9.0 (2.0)	3.2 (0.5)	-110 (100)
Well PM-4	-7.0 (2.0)	1.9 (0.4)	-140 (100)
Well PM-5	-6.0 (2.0)	2.3 (0.4)	-190 (100)

Table G-59 (cont)

Stations	Gross Alpha (10^{-9} µCi/mL)	Gross Beta (10^{-9} µCi/mL)	Gross Gamma (Counts/min/L)
Gallery (Water Canyon)	-6.0 (2.0)	2.2 (0.4)	70 (100)
Supply Summary			
No. of Analyses	16	16	16
Average	-6.5	2.7	-185
S	1.1	1.4	116
Minimum	-9.0 (2.0)	1.2 (0.4)	-400 (100)
Maximum	-5.0 (2.0)	3.2 (0.5)	-40 (100)
Distribution			
Fire Station 1	-7.0 (2.0)	1.7 (0.4)	-120 (100)
Fire Station 1	2.4 (0.9)	3.0 (0.5)	310 (80)
Fire Station 2	-7.0 (2.0)	42 (4.0)	-40 (100)
Fire Station 2	2.1 (1.0)	3.5 (0.5)	500 (90)
Fire Station 3	-7.0 (2.0)	8.3 (1.0)	90 (100)
Fire Station 3	2.0 (0.9)	4.7 (0.6)	330 (90)
Fire Station 4	-7.0 (2.0)	2.3 (0.4)	90 (100)
Fire Station 4	1.5 (0.9)	4.1 (0.6)	420 (90)
Fire Station 5	-6.0 (2.0)	2.5 (0.4)	-80 (100)
Fire Station 5	1.9 (0.9)	2.7 (0.5)	340 (90)
Bandelier Nat. Mon.	-7.0 (2.0)	1.7 (0.4)	60 (100)
Bandelier Nat. Mon.	2.0 (1.0)	5.3 (0.7)	270 (90)

Table G-59 (cont)

Stations	Gross Alpha (10^{-9} µCi/mL)	Gross Beta (10^{-9} µCi/mL)	Gross Gamma (Counts/min/L)
Distribution Summary			
No. of Analyses	12	12	12
Average	-2.4	6.8	180
S	4.6	11	207
Minimum	-0.7 (2.0)	1.7 (0.4)	-120 (100)
Maximum	2.4 (0.9)	42 (4.0)	500 (90)
Fenton Hill (TA-57)	-11 (3.0)	4.9 (0.6)	20 (100)
Fenton Hill (TA-57)	-0.2 (0.8)	6.1 (0.8)	350 (90)
Standby Well (not part of Water Supply) Well LA-6	-6.0 (2.0)	1.0 (0.4)	-150 (100)
USEPA Maximum Concentration Limits[b]	15	--	--
Limits of Detection	3	3	50

[a]Well samples collected in February; distribution samples collected in February and September; counting uncertainty in parentheses.

[b]The Environmental Protection Agency MCL for gross alpha is 15 x 10^{-9} µCi/mL; however, if gross alpha in the system exceeds 5 x 10^{-9} µCi/mL, isotopic analyses of radium content is required.

Table G-60. Primary Chemical Quality for Water Supply and Distribution Systems (mg/L)[a]

Stations	Ag	As	Ba	Cd	Cr
Supply					
Los Alamos Field					
Well 1B	<0.001	0.034	0.032	<0.0005	0.022
Well 2	<0.001	0.013	0.084	<0.0005	0.021
Well 3	<0.001	0.006	0.053	<0.0005	0.008
Well 4	--	--	--	--	--
Well 5	<0.001	0.017	0.075	<0.0005	0.007
Guaje Field					
Well G-1	<0.001	0.003	0.062	<0.0005	0.007
Well G-1A	<0.001	0.012	0.037	<0.0005	0.008
Well G-2	<0.001	0.044	0.064	<0.0005	0.013
Well G-3	--	--	--	--	--
Well G-4	<0.001	0.002	0.017	<0.0005	0.005
Well G-5	<0.001	0.002	0.013	<0.0005	0.004
Well G-6	<0.001	0.003	0.007	<0.0005	0.007
Pajarito Field					
Well PM-1	<0.001	0.001	0.075	<0.0005	0.006
Well PM-2	<0.001	0.001	0.028	<0.0005	0.008
Well PM-3	<0.001	0.002	0.047	<0.0005	0.008
Well PM-4	<0.001	<0.001	0.026	<0.0005	0.007
Well PM-5	<0.001	<0.001	0.027	<0.0005	0.007
Gallery (Water Canyon)	<0.001	<0.001	0.018	<0.0005	<0.004
Supply Summary					
No. of Analyses	16	16	16	16	16
Maximum	<0.001	0.044	0.084	<0.0005	0.022

Table G-60 (cont)

Stations	Ag	As	Ba	Cd	Cr
Distribution					
Fire Station 1	<0.001	0.002	0.025	<0.0005	0.008
Fire Station 2	<0.001	0.017	0.043	<0.0005	0.010
Fire Station 3	<0.001	0.001	0.051	<0.0005	0.008
Fire Station 4	<0.001	0.016	0.030	<0.0005	0.011
Fire Station 5	<0.001	0.013	0.030	<0.0005	0.007
Bandelier National Monument	<0.001	0.012	0.027	<0.0005	0.001
Distribution Summary					
No. of Analyses	6	6	6	6	6
Maximum	<0.001	0.017	0.051	<0.0005	0.011
Fenton Hill (TA-57)	<0.001	<0.001	0.107	<0.0005	<0.001
Standby Well (not part of Water Supply) Well LA-6	<0.001	0.142	0.072	<0.0005	0.024
EPA and NMEID Primary Maximum Concentration Levels [b]	0.05	0.05	1.0	0.01	0.05

Table G-60 (cont)

Stations	F	Hg	N	Pb	Se
Supply					
Los Alamos Field					
Well 1B	3.2	<0.0002	<1	0.008	<0.002
Well 2	2.2	<0.0002	<1	0.006	<0.002
Well 3	0.7	0.0003	<1	0.002	<0.002
Well 4	--	--	--	--	--
Well 5	0.9	<0.0002	<1	0.041	<0.002
Guaje Field					
Well G-1	0.4	<0.0002	<1	0.002	<0.002
Well G-1A	0.6	<0.0002	<1	0.008	<0.002
Well G-2	0.9	<0.0002	<1	0.011	<0.002
Well G-3	--	--	--	--	--
Well G-4	0.3	<0.0002	<1	0.005	<0.002
Well G-5	0.4	0.0003	<1	0.003	<0.002
Well G-6	0.3	<0.0002	<1	0.001	<0.002
Pajarito Field					
Well PM-1	0.3	0.0003	<1	0.004	<0.002
Well PM-2	0.3	0.0002	<1	0.034	<0.002
Well PM-3	0.4	0.0003	<1	0.012	<0.002
Well PM-4	0.3	0.0003	<1	0.020	<0.002
Well PM-5	0.3	0.0003	<1	0.092	<0.002
Gallery (Water Canyon)	0.2	0.0002	<1	<0.001	<0.002
Supply Summary					
No. of Analyses	16	16	16	16	16
Maximum	3.2	0.0003	<1	0.092	<0.002

Table G-60 (cont)

Stations	F	Hg	N	Pb	Se
Distribution					
Fire Station 1	0.3	<0.0002	<1	<0.001	<0.002
Fire Station 2	0.1	<0.0002	<1	0.031	<0.002
Fire Station 3	0.6	<0.0002	<1	<0.001	<0.002
Fire Station 4	0.6	<0.0002	<1	<0.001	<0.002
Fire Station 5	0.8	<0.0002	<1	0.004	<0.002
Bandelier National Monument	0.8	<0.0002	<1	0.003	<0.002
Distribution Summary					
No. of Analyses	6	6	6	6	6
Maximum	1.0	<0.0002	<1	0.031	<0.002
Fenton Hill (TA-57)	<0.2	<0.0002	<1	0.001	<0.002
Standby Well (not part of Water Supply) Well LA-6	--	0.0002	<1	0.007	<0.002
EPA and NMEID Primary Maximum Concentration Levels[b]	2.0	0.002	10	0.05	0.01

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[a]Samples collected in February.
[b]Reference (EPA 1976).

Table G-61. Secondary Chemical Quality for Water Supply (mg/L)[a]

Stations	Cl	Cu	Fe	Mn	SO_4	Zn	TDS	pH
Supply								
Los Alamos Field								
Well 1B	17	0.090	0.014	0.009	39	0.030	430	8.6
Well 2	17	0.024	0.015	<0.001	17	0.015	244	8.4
Well 3	4	0.005	0.071	0.001	7	0.006	155	8.2
Well 4	--	--	--	--	--	--	--	--
Well 5	2	0.266	0.065	0.004	5	0.250	155	8.5
Guaje Field								
Well G-1	3	0.008	0.061	0.001	5	0.006	193	8.3
Well G-1A	3	0.014	0.022	<0.001	4	0.009	173	8.4
Well G-2	3	0.004	0.021	0.001	4	0.005	203	8.4
Well G-3	--	--	--	--	--	--	--	--
Well G-4	3	0.035	0.017	0.007	4	0.013	167	8.2
Well G-5	3	0.008	0.008	<0.001	4	0.011	169	8.0
Well G-6	3	0.008	0.008	<0.001	3	0.008	152	8.2
Pajarito Field								
Well PM-1	8	0.037	0.019	0.001	6	0.019	201	8.1
Well PM-2	2	0.018	0.017	0.005	2	0.011	150	8.1
Well PM-3	8	0.036	0.010	0.002	6	0.011	203	8.4
Well PM-4	2	0.013	0.024	<0.001	2	0.010	174	8.0
Well PM-5	2	0.032	0.030	0.008	2	0.043	155	8.0
Gallery (Water Canyon)	1	0.001	0.095	0.004	4	0.002	111	7.7
Supply Summary								
No. of Analyses	16	16	16	16	16	16	16	16
Maximum	17	0.266	0.095	0.009	39	0.250	430	8.6

Table G-61 (cont)

Stations	Cl	Cu	Fe	Mn	SO_4	Zn	TDS	pH
Distribution								
Fire Station 1	3	0.001	0.010	<0.001	3	0.030	150	8.0
Fire Station 2	6	0.006	0.020	<0.001	10	0.002	184	8.4
Fire Station 3	8	0.024	0.007	<0.001	6	0.002	217	8.1
Fire Station 4	4	0.006	0.022	<0.001	5	0.002	163	8.3
Fire Station 5	5	0.003	0.110	<0.001	8	0.046	193	8.3
Bandelier Nat. Mon.	5	0.014	0.084	<0.001	8	0.096	187	8.3
Distribution Summary								
No. of Analyses	6	6	6	6	6	6	6	6
Maximum	8	0.024	0.110	<0.001	10	0.096	217	8.4
Fenton Hill (TA-57)	45	0.002	0.048	<0.001	10	0.015	276	8.0
Standby Well (not part of Water Supply) Well LA-6	4	0.024	0.100	0.167	6	0.664	230	8.8
EPA Secondary Maximum Concentration Levels[b]	250	1.0	0.3	0.05	250	5.0	500	6.5-8.5

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[a]Standard units.
[b]Reference: EPA 1979.

Table G-62. Miscellaneous Chemical Analyses (mg/L)[a]

Stations	SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	P	Total Hard-ness	Conduc-tivity (mS/m)
Los Alamos Field										
Well LA-1B	38	8	0.4	2.4	166	7	316	<0.2	18	68
Well LA-2	31	7	0.1	1.1	77	3	141	<0.2	15	36
Well LA-3	34	13	0.3	1.6	35	0	86	<0.2	31	20
Well LA-4	--	--	--	--	--	--	--	--	--	--
Well LA-5	37	9	0.1	1.4	45	3	101	<0.2	23	22
Guaje Field										
Well G-1	88	13	0.5	3.1	22	0	75	<0.2	32	16
Well G-1A	70	10	0.4	2.7	32	0	84	<0.2	24	18
Well G-2	69	11	0.5	2.7	38	2	100	<0.2	27	22
Well G-3	--	--	--	--	--	--	--	--	--	--
Well G-4	52	18	3.6	2.0	13	0	72	<0.2	58	16
Well G-5	56	18	3.8	2.0	12	0	76	<0.2	58	16
Well G-6	51	13	2.1	2.2	19	0	73	<0.2	43	16
Pajarito Field										
Well PM-1	72	27	6.4	3.6	20	0	117	<0.2	91	26
Well PM-2	87	9	3.3	2.0	13	0	57	<0.2	36	12
Well PM-3	82	25	7.7	3.6	19	3	112	<0.2	97	26
Well PM-4	83	11	3.9	2.3	13	0	61	<0.2	43	14
Well PM-5	73	9	3.3	2.0	13	0	60	<0.2	36	12
Gallery (Water Canyon)	34	7	3.3	2.0	7	0	39	<0.2	43	9
Supply Summary										
No. of Analyses	16	16	16	16	16	16	16	16	16	16
Maximum	88	27	7.7	3.6	166	7	316	<0.2	97	68

Table G-62 (cont)

Stations	SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	P	Total Hard-ness	Conduc-tivity (mS/m)
Distribution										
Fire Station 1	82	11	3.3	2.1	14	0	65	<0.2	41	14
Fire Station 2	54	11	1.0	2.1	50	0	112	<0.2	31	26
Fire Station 3	82	25	7.0	3.6	20	0	118	<0.2	94	26
Fire Station 4	60	13	1.6	2.8	27	0	87	<0.2	38	18
Fire Station 5	52	11	1.7	2.2	38	0	91	<0.2	31	22
Bandelier Nat. Mon.	48	12	1.8	2.1	38	1.2	101	<0.2	35	24
Distribution Summary										
No. of Analyses	6	6	6	6	6	6	6	6	6	6
Maximum	82	25	7.0	3.6	50	1.2	118	<0.2	94	26
Fenton Hill (TA-57)	67	53	5.0	5.2	17	0	127	<0.2	160	40
Standby Well (not part of Water Supply) Well LA-6	30	3	<0.1	0.9	70	8	144	<0.2	8	30

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[a]Supply samples collected in February; distribution samples collected in February and September.

Table G-63. Los Alamos, New Mexico,[a] Climatological Survey (1911-1987)
Temperature and Precipitation Means[b] and Extremes

Temperature(°F)[c]

	Normals			Extremes							
Month	Mean Max	Mean Min	Avg	High Avg	Year	Low Avg	Year	High Daily Max	Date	Low Daily Min	Date
Jan	39.7	18.5	29.1	37.6	1986	20.9	1930	64	1/12/81	-18	1/13/63
Feb	43.0	21.5	32.2	37.4	1934	23.0	1939	69	2/25/86	-14	2/1/51
Mar	48.7	26.5	37.6	45.8	1972	32.1	1948	71	3/27/86[d]	-3	3/11/48
Apr	57.6	33.7	45.6	54.3	1954	39.7	1973	79	4/23/38	5	4/9/28
May	67.0	42.8	54.9	60.5	1956	50.1	1957	89	5/29/35	24	5/1/76[d]
Jun	77.8	52.4	65.1	69.4	1980	60.4	1965	95	6/22/81	28	6/3/19
Jul	80.4	56.1	68.2	71.4	1980	63.3	1926	95	7/11/35	37	7/7/24
Aug	77.4	54.3	65.8	70.3	1936	60.9	1929	92	8/10/37	40	8/16/47
Sept	72.1	48.4	60.2	65.8	1956	56.2	1965	94	9/11/34	23	9/29/36
Oct	62.0	38.7	50.3	54.7	1963	42.8	1984	84	10/1/80	15	10/19/76
Nov	48.7	27.1	37.9	44.4	1949	30.5	1972	72	11/1/50	-14	1/28/76
Dec	41.4	20.3	30.8	38.4	1980	24.6	1931	64	12/27/80	-13	12/9/78
Annual	59.6	36.7	48.1	52.0	1954	46.2	1932	95	6/22/81[d]	-18	1/13/63

Table G-63 (cont)

	Precipitation (in.)[c]										Mean Number of Days Per Year		
	Precipitation[e]					Snow							
Month	Mean	Max	Year	Daily Max	Date	Mean	Max	Year	Daily Max	Date	Precip >0.10 in.	Max Temp >90°F	Min Temp <32°F
Jan	0.85	6.75	1916	2.45	1/12/76	10.7	64.8	1987	22.0	1/15/87	2	0	30
Feb	0.68	2.78	1987	1.05	2/20/15	7.3	48.5	1987	20.0	2/19/87	2	0	26
Mar	1.01	4.11	1973	2.25	3/30/16	9.7	36.0	1973	18.0	3/30/16	3	0	24
Apr	0.86	4.64	1915	2.00	4/12/75	5.1	33.6	1958	20.0	4/12/75	2	0	13
May	1.13	4.47	1929	1.80	5/21/29	0.8	17.0	1917	12.0	5/2/78	3	0	2
Jun	1.12	5.67	1986	2.51	6/10/13	0	---	---	---	---	3	0	0
Jul	3.18	7.98	1919	2.47	7/31/68	0	---	---	---	---	8	1	0
Aug	3.93	11.18	1952	2.26	8/1/51	0	---	---	---	---	9	0	0
Sept	1.63	5.79	1941	2.21	9/22/29	0.1	6.0	1913	6.0	9/25/13	4	0	0
Oct	1.52	6.77	1957	3.48	10/5/11	1.7	20.0	1984	9.0	10/31/72	3	0	7
Nov	0.96	6.60	1978	1.77	11/25/78	5.0	34.5	1957	14.0	11/22/31	2	0	22
Dec	0.96	3.21	1984	1.60	12/6/78	11.4	41.3	1967	22.0	12/6/78	3	0	30
Annual	17.83	30.34	1941	3.48	10/5/11	50.8	178.4	1987	22.0	1/15/87	43	2	154
Season							153.2	1986-1987		12/6/78			

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[a]Latitude 35° 32′ north, longitude 106° 19′ west; elevation 2249 m.
[b]Means based on standard 30-year period: 1951-1980.
[c]Metric conversions: 1 in. = 2.5 cm; °F = 9/5 °C + 32.
[d]Most recent occurrence.
[e]Includes liquid water equivalent of frozen precipitation.

Table G-64. Los Alamos Precipitation (inches) for 1987[a]

	S-Site (1)	North Community (2)	TA-59 (3)	Bandelier (4)	East Gate (5)	Area G (6)	White Rock Y (7)	White Rock (8)
January	2.60	3.43	2.43	1.67	1.72	0.94	1.39	0.94
February	3.39	3.44	2.78	2.11	1.71	1.37	1.43	1.26
March	0.75	0.90	0.88	0.43	0.34	0.30	0.30	0.38
April	1.12	1.24	1.09	0.66	0.57	0.43	0.43	0.49
May	2.25	1.75	2.83	2.29	2.15	1.54	3.13	2.35
June	1.88	1.22	2.69	0.68	0.64	0.64	0.95	0.52
July	1.02	0.76	1.37	1.29	1.03	1.38	0.85	1.28
August	4.48	4.97	4.29	3.67	2.92	4.76	3.79	4.83
September	1.00	2.24	1.72	0.76	1.19	0.62	1.00	0.96
October	0.74	0.58	0.49	0.41	0.45	0.43	0.47	0.49
November	1.66	1.79	1.47	0.99	1.17	0.94	0.59	0.75
December	1.79	2.20	1.58	1.71	1.34	1.04	1.34	1.19
Annual	22.68	24.52	23.62	16.67	15.23	14.39	15.67	15.44

[a]See Figure 29 for site locations.

Table G-65. Los Alamos Climatological Summary for 1987

	Temperature (^{0}F)[a]						
	Means			Extremes			
Month	Mean Max	Mean Min	Avg	High	Date	Low	Date
Jan	37.1	17.2	27.2	54	12,27	-3	18
Feb	41.3	21.6	31.4	54	11	7	21,28
Mar	47.9	23.5	35.7	61	6	7	30
Apr	61.0	33.5	47.3	76	17	21	7
May	65.4	40.5	52.9	76	31	31	3
Jun	78.6	50.9	64.7	88	24	42	5
Jul	81.9	55.8	68.8	87	5 dates	51	14,17
Aug	75.3	53.3	64.0	87	1	43	27
Sept	70.5	46.9	58.7	77	1	40	15
Oct	66.4	40.8	53.6	77	4	28	20
Nov	48.0	27.2	37.6	63	4	15	28
Dec	36.7	17.8	27.3	60	4	1	27
Annual	59.3	35.8	47.5	88	6/24	-3	1/18

Table G-65 (cont)

	Precipitation (in.)[a]						Number of Days		
	Water Equivalent			Snow					
Month	Total	Daily Max	Date	Total	Daily Max	Date	Precip >0.10 in.	Max Temp >90°F	Min Temp <32°F
Jan	2.43	0.68	15	64.8	22.0	15	6	0	31
Feb	2.78	0.97	19	48.5	20.0	19	6	0	28
Mar	0.88	0.34	10	9.3	5.3	28	2	0	31
Apr	1.09	0.58	4	12.5	7.5	4	3	0	15
May	2.83	0.59	23	0	0	--	9	0	1
Jun	2.69	2.16	7	0	0	--	3	0	0
Jul	1.37	0.63	16	0	0	--	3	0	0
Aug	4.29	1.00	26	0	0	--	10	0	0
Sept	1.72	0.73	6	0	0	--	5	0	0
Oct	0.49	0.22	14	0	0	--	2	0	1
Nov	1.47	0.57	1	7.0	4.5	26	4	0	24
Dec	1.58	0.47	18,24	36.3	12.0	24	6	0	29
Annual	23.62	2.16	6/7	178.4	22.0	1/15	59	0	160

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

Table G-66. Weather Highlights of 1987

January	Record snowfall: 64.8 in. Snowiest January on record (previous: 39.3 in. in 1949). Snowiest month on record (previous: 41.3 in. in December 1967). Precip = 2.43 in. (normal = 0.85 in.). Storm dropped 48.0 in. during 15-17th with 60-70 in. reported in North Community - LANL closed and townsite paralyzed. Record snowfall from one storm, 48.0 in. (previous: 34.5 in. during 12/12 to 12/15/84). Set daily record snowfall for January with 22.0 in. on 15th (previous: 15.0 in. on 1/5/13). Tied daily record snowfall for any month with 22.0 in. on 15th (also 12/6/78). Set record for most snow on ground in January with 40 in. on 16th and 17th (previous: 27 in., 1/30-1/31/79). Set record for most snow on ground in any month (previous: 28 in., 3/4 to 3/5/15). Strong winds with gusts = 59 mph on 5th. SMDP on the 7th: 0.41 in. SMDS on the 15th: 22.0 in. SMDS on the 16th: 21.0 in. SMDS on the 17th: 5.0 in.
February	Record snowfall and precip. Record February snowfall: 48.5 in. (previous: 36.4 in., 1982). 2nd snowiest month (most: 64.8 in., January 1987). Record February precip.: 2.78 in. (previous: 2.44 in., 1948). Storm drops 26.7 in. of snow 18th-20th. Record snowfall from one storm in February (previous: 21.5 in., 2/3 to 2/5/82). Strong winds with gusts = 56 mph on 14th. SMDP on the 16th: 0.27 in. SMDS on the 16th: 4.5 in. SMDP on the 18th: 0.30 in. SMDP on the 19th: 0.97 in. (Also record for most daily precip. in February - previous: 0.96 in., 2/15/75). SMDS on the 19th: 20.0 in. (Also record for most daily snow in February - previous: 19.0 in., 2/4/82). SMDP on the 26th: 0.63 in. SMDS on the 26th: 9.0 in.
March	Cooler than normal. Strong winds with gusts = 50 mph on 20th.

Table G-66 (cont)

April	Mild and above normal snow. Average maximum temperature = 61.0°F (Normal = 57.6°F) Snowfall = 12.5 in. (Normal = 5.1 in.).
May	Wet and cool. Precipitation = 2.83 in. (Normal = 1.13 in.). SMDP on the 16th: 0.41 in. SMDP on the 23rd: 0.59 in. Hail accumulation of 3 in. on 23rd.
June	Wet. Precipitation = 2.69 in. (Normal = 1.12 in.). SMDP on the 7th: 2.16 in. Thunderstorm on 7th gives near 50-year rainfall for 2 hours: 2.11 in. Strong winds with gusts = 58 mph on 18th, some windows blown out in townsite.
July	Dry. Precipitation = 1.37 in. (Normal = 3.18 in.). Some one-inch diameter hail, but little accumulation on 13th.
August	Funnel clouds reported near Santa Fe on 24-25th. SMDP on the 26th: 1.00 in. SMDL on the 29th: 44°F.
September	Hazy 4th-10th from Western U.S. forest fires. SMDP on the 6th: 0.73 in.
October	Warm and dry. Mean temperature = 53.6°F (Normal = 50.3). Mean max temperature = 66.4°F (Normal = 62.0°F). Precipitation = 0.49 in. (Normal = 1.52 in.). TMDH on the 4th: 77°F.
November	SMDP on the 1st: 0.57 in.

Table G-66 (cont)

December	Snowy and cold. Snowfall = 36.3 in. (Normal = 11.4 in.). 3rd snowiest December on record. Storm drops 19.0 in. snow with up to 26 in. in North Community during 24-25th. Mean temperature = 27.3°F (Normal = 30.8°F). Mean max temperature = 36.7°F (Normal = 41.4°F). TMDH on the 4th: 60°F. SMDS on the 12th: 4.5 in. SMDL on the 15th: 3°F. SMDP on the 18th: 0.47 in. SMDS on the 18th: 6.0 in. SMDP on the 24th: 0.47 in. SMDS on the 24th: 12.0 in. SMDS on the 25th: 7.0 in. Record snow on ground for Christmas: 16.0 in. High temperatures only 19, 14, and 17°F, respectively, on 25, 26, and 27th.
Annual	1987 mean temperature = 47.5°F (Normal = 48.1°F). 1987 precipitation = 23.62 in. (Normal = 17.83 in.). 3rd consecutive year with precipitation >30% above normal. 1987 snowfall = 178.4 in. or 14.9 ft. (Normal = 50.8 in.). Snowiest year on record (previous: 112.8 in., 1984). 1986-1987 winter season snowfall = 153.2 in. Snowiest winter season on record (previous: 123.6 in., 1957-1958).

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

Table G-67. Wet Deposition Measurements ($\mu eq/m^2$ unless specified)[a]

Parameter	Fourth Quarter 1986	First Quarter 1987	Second Quarter 1987	Third Quarter 1987
Precipitation (in.)	0.45 (0.0-2.0)	0.27 (0.0-.83)	0.17 (0.0-.77)	0.40 (0.0-1.49)
Field pH	4.8 (4.6-5.1)	4.8 (4.0-5.8)	4.7 (4.6-4.9)	4.7 (4.1-5.5)
Calcium	68 (0.5-470)	92 (1.5-290)	66 (0.5-200)	180 (1.0-580)
Magnesium	9.4 (0.0-48)	14 (1.6-29	12 (0.0-31)	29 (0.0-86)
Potassium	4.2 (0.0-25)	3.4 (0.0-6.6)	7.8 (0.0-37)	9.8 (0.0-32)
Sodium	31 (0.0-90)	34 (1.7-90)	15 (0.0-43.9)	39 (1.3-84)
Ammonium	110 (1.1-47)	63 (1.1-270)	79 (0.55-270)	110 (4.4-300)
Nitrate	130 (0.8-450)	133 (16-310)	120 (0.58-300)	300 (32-60)
Chloride	19 (3.4-51)	26 (2.0-64)	15 (0.84-63)	41 (1.1-100)
Sulfate	280 (2.1-1000)	150 (21-430)	140 (1.5-390)	280 (31-590)
Phosphate	-- --	-- --	6.9 --	2.2 --

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[a]Mean; range in parentheses.

Table G-68. Radiochemical Analyses of Sediments at TA-49

Station No.	Date	^{3}H (10^{-6} pCi/g)	^{137}Cs (10^{-9} pCi/g)	Total U (µg/g)	^{238}Pu (10^{-9} pCi/g)	$^{239,240}Pu$ (10^{-9} pCi/g)	Gross Gamma (Counts/min/g)
A-1	8-6-86	2.4 (0.5)	0.11 (0.05)	3.0 (0.3)	0.000 (0.001)	0.004 (0.002)	4.0 (0.7)
A-1	4-13-87	--	0.08 (0.07)	2.3 (0.2)	0.004 (0.002)	0.003 (0.002)	7.3 (0.9)
A-2	8-6-86	5.4 (0.7)	0.35 (0.10)	4.2 (0.4)	0.005 (0.002)	0.022 (0.004)	5.2 (0.7)
A-2	4-13-87	--	0.22 (0.08)	3.7 (0.4)	0.001 (0.001)	0.004 (0.005)	9.0 (1.0)
A-3	8-6-86	3.4 (0.5)	1.2 (0.21)	5.3 (0.5)	0.216 (0.013)	10.7 (0.425)	6.5 (0.7)
A-3	4-13-87	--	0.29 (0.08)	4.7 (0.5)	0.001 (0.000)	0.083 (0.010)	10 (1.0)
A-4	8-6-87	5.7 (0.7)	-0.20 (0.05)	4.2 (0.4)	0.000 (0.001)	0.004 (0.002)	5.5 (0.8)
A-4	4-13-87	--	0.16 (0.09)	3.4 (0.3)	0.001 (0.002)	0.006 (0.002)	9.0 (1.0)
A-4A	8-6-86	3.1 (0.5)	0.70 (0.15)	4.0 (0.4)	0.001 (0.001)	0.000 (0.001)	6.5 (0.8)
A-4A	4-13-87	--	0.23 (0.09)	3.4 (0.3)	0.001 (0.001)	0.008 (0.002)	9.0 (1.0)
A-5	8-6-86	3.0 (0.5)	-0.08 (0.02)	3.8 (0.4)	0.001 (0.002)	0.042 (0.006)	5.8 (0.8)
A-5	4-13-87	--	0.39 (0.11)	3.4 (0.3)	0.000 (0.001)	0.016 (0.004)	9.0 (1.0)
A-6	8-6-86	4.7 (0.6)	0.49 (0.10)	4.2 (0.4)	0.002 (0.001)	0.012 (0.002)	6.3 (0.8)
A-6	4-13-87	--	0.14 (0.08)	3.5 (0.4)	0.000 (0.001)	0.001 (0.001)	9.0 (1.0)
A-7	8-6-86	4.1 (0.6)	0.48 (0.10)	4.1 (0.4)	0.003 (0.002)	0.016 (0.003)	6.3 (0.8)
A-7	4-13-87	--	0.37 (0.11)	3.9 (0.4)	0.002 (0.001)	0.016 (0.003)	8.0 (1.0)
A-8	8-6-86	3.8 (0.6)	0.20 (0.06)	2.6 (0.3)	0.001 (0.001)	0.001 (0.002)	4.4 (0.7)
A-8	4-13-87	--	0.17 (0.09)	3.4 (0.3)	-0.001 (0.002)	0.004 (0.002)	7.8 (0.9)
A-9	8-6-86	6.4 (0.8)	0.10 (0.06)	3.9 (0.4)	0.000 (0.001)	0.003 (0.002)	6.1 (0.8)
A-9	4-13-87	--	0.09 (0.09)	2.9 (0.3)	0.000 (0.001)	0.002 (0.002)	6.3 (0.8)
A-10	8-6-86	8.0 (0.9)	0.10 (0.07)	2.6 (0.3)	0.000 (0.001)	0.004 (0.002)	4.8 (0.7)
A-10	4-13-87	--	0.45 (0.11)	3.7 (0.4)	0.005 (0.001)	0.014 (0.003)	9.0 (1.0)

Table G-68 (cont)

Station No.	Date	^{3}H (10^{-6} pCi/g)	^{137}Cs (10^{-9} pCi/g)	Total U (µg/g)	^{238}Pu (10^{-9} pCi/g)	$^{239,240}Pu$ (10^{-9} pCi/g)	Gross Gamma (Counts/min/g)
A-11	8-6-86	2.9 (0.5)	0.03 (0.06)	3.2 (0.3)	0.000 (0.001)	0.003 (0.002)	5.9 (0.8)
A-11	4-13-87	--	0.57 (0.13)	2.6 (0.3)	0.002 (0.002)	0.010 (0.002)	7.0 (0.9)
A Background	4-13-87	--	0.20 (0.09)	3.4 (0.3)	0.000 (0.001)	0.005 (0.002)	5.7 (0.8)
B Background	4-13-87	--	0.05 (0.08)	2.9 (0.3)	0.004 (0.003)	0.001 (0.003)	3.1 (0.6)
Limits of Detection		0.3	0.1	0.1	0.002	0.002	0.1
Maximum Concentration		8.0	1.2 (0.21)	5.3 (0.5)	0.216 (0.013)	10.7 (0.425)	10 (1.0)
Regional Background		7.2	0.44	4.4	0.006	0.023	7.9
Maximum as % of Regional Background		111	272	120	3600	4652	126

Note: Station number shown in Fig. 33; counting uncertainty in parentheses.

Table G-69. Chemical Concentrations in Solution Extracted from Sediments Downgradient from Experimental Areas at TA-49

Chemical[b]	Maximum EP Toxic Concentration[c]	Limit of Detection	Stations Numbers[a]												Background[a]	
			A-1	A-2	A-3	A-4	A-4A	A-5	A-6	A-7	A-8	A-9	A-10	A-11	A	B
Arsenic	5.0	0.05	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Barium	100	0.5	0.6	BLD	0.6	BLD	0.8	0.5	0.7	BLD	0.6	BLD	BLD	BLD	0.5	1.3
Cadmium	1.0	0.01	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Chromium	5.0	0.05	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Lead	5.0	0.05	BLD	0.06	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Mercury	2.0	0.005	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Selenium	1.0	0.01	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Silver	---	0.05	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Nickel	---	0.01	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Beryllium[d]	---	0.001	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Sulfate	---	0.2	BLD	BLD	BLD	0.4	BLD	BLD	0.3	BLD	1.1	BLD	BLD	BLD	BLD	0.5
Nitrate	---	0.2	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD
Uranium[d]	---	1.0	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	BLD	7.9

[a]Station number shown in Figure 31; background stations are Bandelier National Monument, entrance (A) and small canyon north of supply well PM-1 (B).

[b]Concentrations in mg/L except as noted; BLD = Below Limit of Detection.

[c]New Mexico Hazardous Waste Management Regulations (HWMR) 201 B.5.; Extraction procedure.

[d]Units are μg/g.

Table G-70. Storm Run-off from TA-49

Station	Date 1987	Solution ^{137}Cs (10^{-9} µCi/ml)	Solution ^{238}Pu (10^{-9} µCi/ml)	Solution $^{239,240}Pu$ (10^{-9} µCi/ml)	Suspended Sediments ^{238}Pu (pCi/g)	Suspended Sediments $^{239,240}Pu$ (pCi/g)
A-1	8-24	152 (65)	0.007 (0.011)	0.010 (0.008)	0.000 (0.001)	0.027 (0.006)
A-1	8-24	15 (60)	−0.008 (0.011)	0.000 (0.010)	−0.004 (0.008)	0.048 (0.013)
A-2	8-24	38 (60)	−0.057 (0.033)	0.000 (0.010)	0.001 (0.001)	0.002 (0.001)
A-5	8-24	−13 (60)	−0.009 (0.015)	0.033 (0.018)	0.000 (0.001)	0.007 (0.033)
A-5	8-28	67 (61)	0.008 (0.008)	0.025 (0.010)	0.000 (0.001)	0.006 (0.002)
A-5	9-10	82 (61)	0.011 (0.014)	−0.004 (0.004)	0.004 (0.002	0.024 (0.004)
A-8	8-24	45 (53)	0.000 (0.010)	0.000 (0.010)	0.001 (0.001)	0.001 (0.001)
A-8	8-28	−27 (60)	0.021 (0.017)	0.005 (0.014)	0.000 (0.001)	0.028 (0.004)

Table G-71. Chemical Quality of Storm Run-off from TA-49

Station	Date 1987	mg/L As	Cr	N	SO_4	pH
A-1	8-24	0.002	0.02	1.2	2	6.0
A-1	8-24	0.002	0.03	0.3	3	7.8
A-2	8-24	0.003	0.02	0.2	2	7.7
A-5	8-24	0.003	0.03	0.2	2	7.6
A-5	8-28	0.002	0.04	1.0	2	7.1
A-5	9-10	0.003	0.03	0.2	2	7.0
A-8	8-24	0.003	0.04	0.7	4	8.1
A-8	8-28	0.008	0.04	0.7	2	7.0
Standard[a]		0.05	0.05	10	250	

Constituent[b]	Concentration (mg/L)	Standards[a] (mg/L)
Ag	<0.05	0.05
Ba	<0.1	1.0
Be	<0.01	--
CN	<0.01	--
Cd	<0.01	0.01
Hg	<0.002	0.002
Ni	<0.01	--
Pb	<0.01	0.05
Se	<0.02	0.01

---

[a]Primary or secondary drinking water standards (EPA 1976, 1979).
[b]Analyzed from stations for each run-off event.

GLOSSARY

alpha particle	A charged particle (identical to the helium nucleus) composed of two protons and two neutrons that is emitted during decay of certain radioactive atoms. Alpha particles are stopped by several centimeters of air or a sheet of paper.
activation products	In nuclear reactors and some high energy research facilities, neutrons and other subatomic particles that are being generated can produce radioactive species through interaction with materials such as air, construction materials, or impurities in cooling water. These "activation products" are usually distinguished, for reporting purposes, from "fission products."
background radiation	Ionizing radiation from sources other than the laboratory. It 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 diagostic procedures.
beta particle	A charged particle (identical to the electron) that is emitted during decay of certain radioactivity atoms. Most beta particles are stopped by 0.6 cm of aluminum or less.
Concentration Guide (CG)	The concentration of a radionuclide in air or water that results in a whole body or organ dose in the 50th year of exposure equal to the Department of Energy's Radiation Protection Standard for external and internal exposures. This dose is calculated assuming the air is continuously inhaled or the water is the sole source of liquid nourishment for 50 years.
Controlled Area	Any Laboratory area to which access is controlled to protect individuals from exposure to radiation and radioactive materials.

cosmic radiation	High-energy particulate and electromagnetic radiations that originate outside the earth's atmosphere. Cosmic radiation is part of natural background radiation.
curie (Ci)	A special unit of radioactivity. One curie equals 3.70×10^{10} nuclear transformations per second.
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/or serious genetic disorder as a given exposure, that may be limited to just 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 0.112, gives an effective dose equivalent to (100 x 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 for 100% of the time (full occupancy) and 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 1000 people each received a radiation dose of 1 rem, their population dose would be 1000 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).
exposure	A measure of the ionization produced in air by x or gamma radiation. (The unit of exposure is the reontgen).
external radiation	Radiation originating from a source outside the body.
fission products	Those atoms created through the splitting of larger atoms into smaller ones, accompanied by release of energy.
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 (microwaves, visible light, radiowaves, etc.) have 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.
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 x 1/2), after three half-lives, one-eighth (1/2 x 1/2 x 1/2), and so on.
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.
Laboratory	Los Alamos National Laboratory.

Maximum Contaminant Level (MCL)	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-III). The MCLs are specified by the Environmental Protection Agency.
mrem	Millirem (10^{-3} rem). See rem definition.
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, it expresses the sum of radiation exposures received by a population. For example, two persons each with a 0.5 rem exposure have received 1 person-rem. Also, 500 people each with an exposure of 0.002 rem have received 1 person-rem.
rad	A special unit of absorbed dose from ionizing radiation. A dose of 1 rad equals the absorption of 100 years of radiation energy per gram of absorbing material.
radiation	The emission of particles or energy as a result of an atomic or nuclear process.
Radiation Protection Standard	A standard for external and internal exposure to radioactivity as defined in Department of Energy Order 5480.1A, Chapter XI (see Appendix A and Table A-II in this report).
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.
roentgen (R)	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.
terrestrial radiation	Radiation emitted by naturally occurring radionuclides, such as ^{40}K, the natural decay chains ^{235}U, ^{238}U, or ^{232}Th, or from cosmic-ray induced radionuclides in the soil.

thermoluminescent dosimeter (TLD)	A material (the Laboratory users 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.
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.
tuff	Rock of compacted volcanic ash and dust.
Uncontrolled Area	An area beyond the boundaries of a Controlled Area (see definition of "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 occurring in nature, depleted uranium is manmade.
uranium, total	The amount of uranium in a sample assuming the uranium has the isotopic content of uranium in nature (99.27 wt% ^{238}U 0.72 wt% ^{235}U, 0.0057 wt% ^{234}U).
Working Level Month (WLM)	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 liter 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 one WL. Cumulative exposure is measured in Working Level Months, which is 170 WL-hours.

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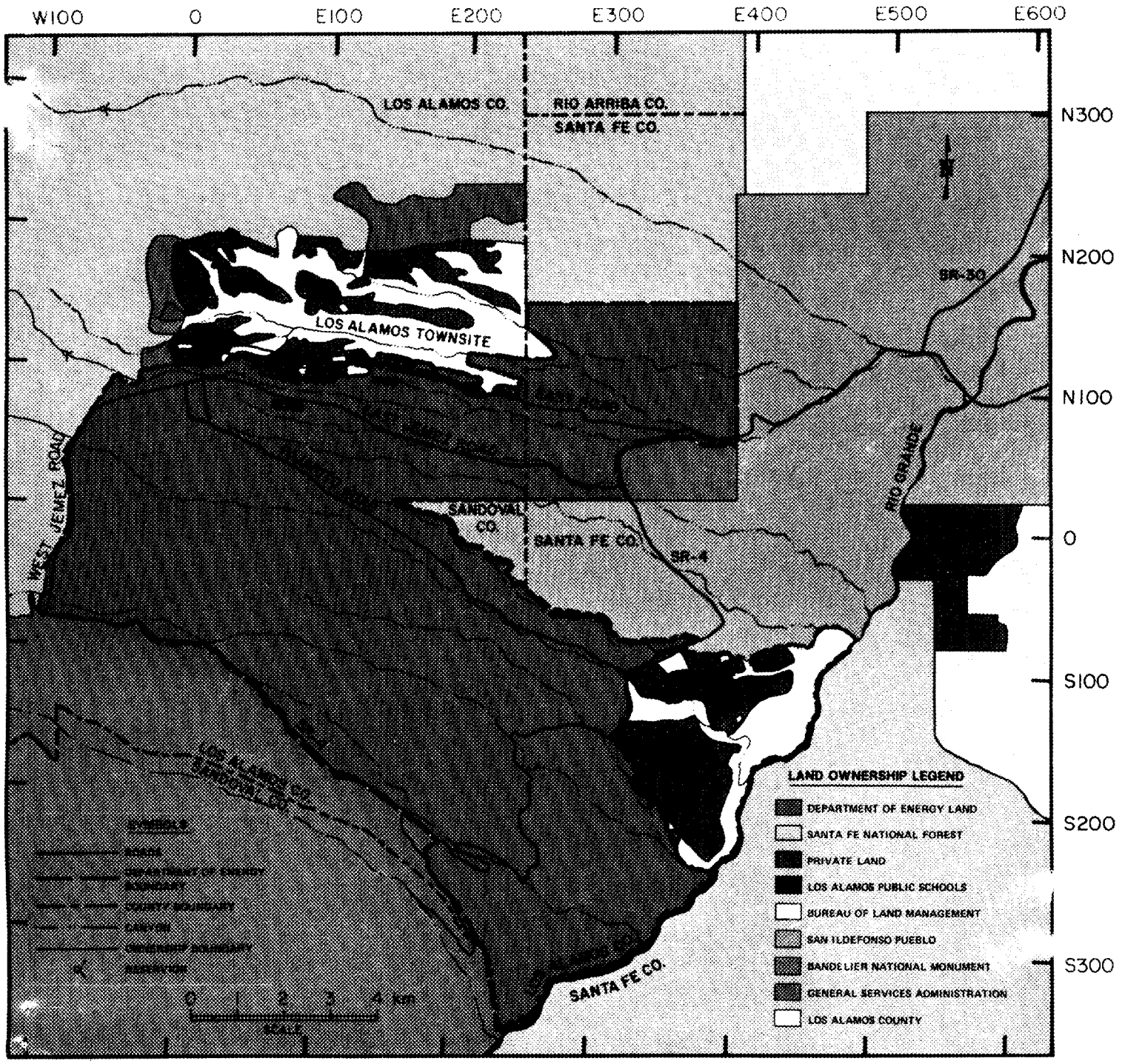

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