LA-8810-ENV

ENVIRONMENTAL SURVEILLANCE AT LOS ALAMOS DURING 1980

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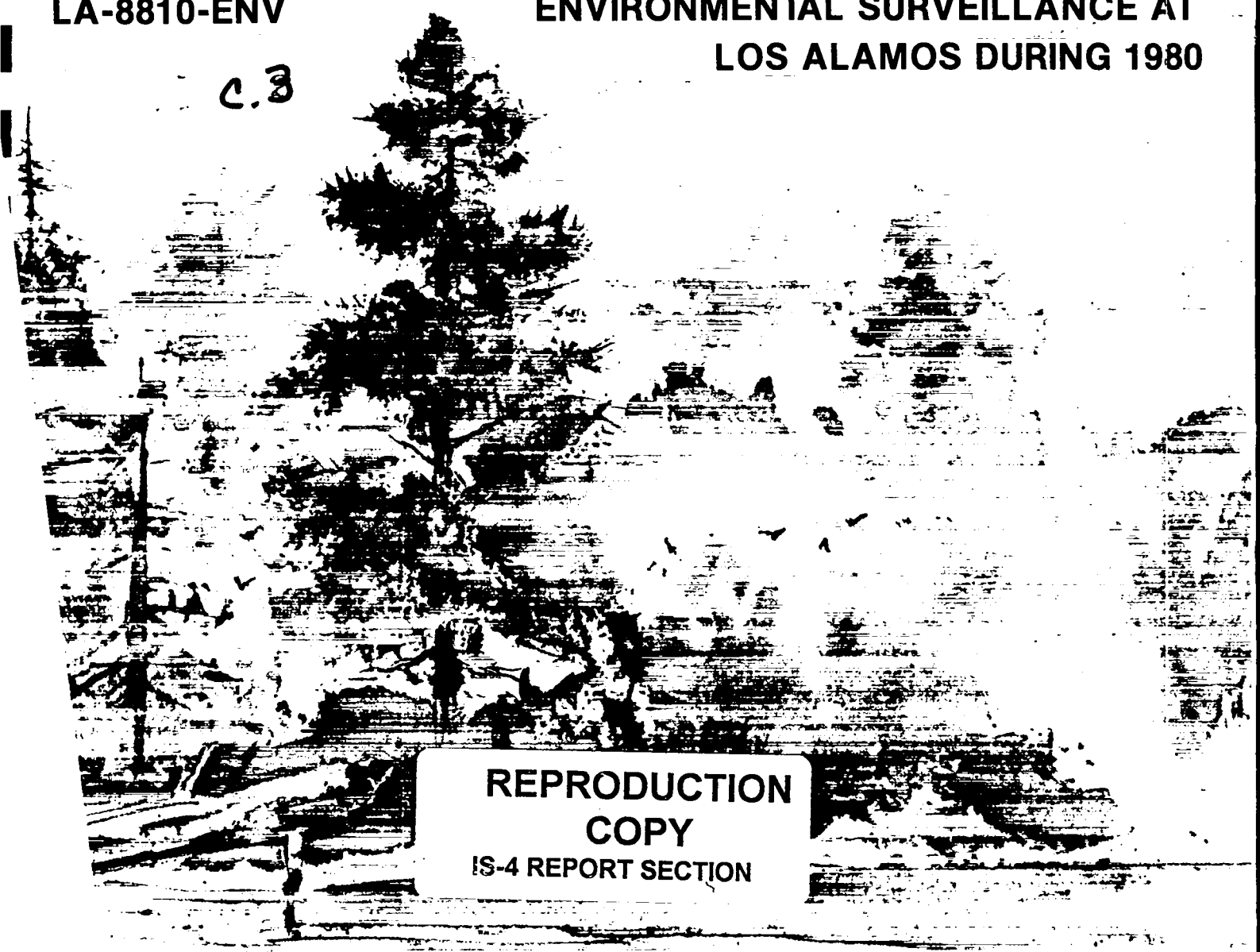

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Aerial view looking west toward the Jemez Mountains across the Pajarito Plateau, which is cut into numerous narrow mesas by southeast-trending canyons. The Los Alamos townsite is in the center of the photo, the main LASL technical area (TA-3) is in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

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Environmental Surveillance Group

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UNITED STATES
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ACRONYMS AND ABBREVIATIONS

BOD_5	5-day biochemical oxygen demand
COD	chemical oxygen demand
CG	concentration guide
DOE	Department of Energy
EA	environmental assessment
EEC	Environmental Evaluations Coordinator
EPA	Environmental Protection Agency
ERDA	Energy Research and Development Administration
FEIS	final environmental impact statement
H-7	Waste Management Group at the Laboratory
H-8	Environmental Surveillance Group at the Laboratory
HDR	hot dry rock
HT	tritium gas
HTO	tritiated water
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
LAMPF	Los Alamos Meson Physics Facility
LERC	Laboratory Environmental Review Committee
LS-6	Environmental Sciences Group at the Laboratory
MAP	mixed activation products
MCL	maximum contaminant level
MFP	mixed fission products
N	normal (chemical term)
NBS	National Bureau of Standards
NEPA	National Environmental Policy Act
NERP	National Environmental Research Park
NIPDWR	National Interim Primary Drinking Water Regulations
NMEID	New Mexico Environmental Improvement Division
NPDES	National Pollutant Discharge Elimination System
QA	quality assurance
RPS	Radiation Protection Standard
SRM	standard reference material
TA	technical area
TDS	total dissolved solids
TLD	thermoluminescent dosimeter
TRU	transuranic wastes
TSS	total suspended solids
USGS	United States Geological Survey

α	alpha
β	beta
γ	gamma
s	standard deviation
$\bar{x}$	mean

SYSTEM INTERNATIONAL PREFIXES

Exponent	Prefix	Symbol
10^{6}	mega	M
10^{3}	kilo	k
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f
10^{-18}	atto	a

UNITS

Abbreviation	Unit
c	count
aCi	attocurie (10^{-18} curies)
Btu	British thermal unit
°C	Celsius degree
Ci	curie (unit of radioactivity)
cm	centimeter
fCi	femtocurie (10^{-15} curies)
ft	foot
g	gram
h	hour
ha	hectare
in	inch
keV	kiloelectron volt
kg	kilogram
km	kilometer
km^2	square kilometer
ℓ	liter
m	meter
m^3	cubic meter
mCi	millicurie (10^{-3} curies)
MeV	megaelectron volt
mg	milligram (10^{-3} grams)
min	minute
mℓ	milliliter (10^{-3} liters)
mm	millimeter (10^{-3} meters)
mR	milliroentgen (10^{-3} roentgen)
mrem	millirem (10^{-3} rem)
mS/m	milliSiemens/meter (1 mS/m = 10 μmho/cm)
MGD	million gallons per day
MT	megaton (10^6 tons)
μCi	microcurie (10^{-6} curies)
μg	microgram (10^{-6} grams)
μm	micrometer (10^{-6} meters)
nCi	nanocurie (10^{-9} curies)
ng	nanogram (10^{-9} grams)
pCi	picocurie (10^{-12} curies)
pg	picogram (10^{-12} grams)
ppb	parts per billion (1 in 1 000 000 000)
ppm	parts per million (1 in 1 000 000)
rad	62.5 × 10^6 MeV/g (unit of absorbed dose)
rem	roentgen equivalent man (unit of dose equivalence)
R	roentgen
sec	second
yr	year

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.
beta particle	A charged particle (identical to the electron) that is emitted during decay of certain radioactive atoms. Most beta particles are stopped by 0.6 cm of aluminum or less.
CG (Concentration Guide)	The concentration of radioactivity in air or water that is determined to result in whole body or organ doses equal to ERDA's Radiation Protection Standards for external and internal exposures if the air is continuously inhaled or the water is the sole source of liquid nourishment throughout the year.
Curie	A special unit of radioactivity. One curie equals 3.70×10^{10} nuclear transformations per second (abbreviated Ci).
gamma radiation	Short-wavelength electromagnetic radiation of nuclear origin which has no mass or charge. Because of its short wavelength, gamma radiation can cause ionization. Other electromagnetic radiation (microwaves, visible light, radio waves, etc.) have longer wavelengths (lower energy) and cannot cause ionization.
gross alpha	The total amount of measured alpha activity.
gross beta	The total amount of measured beta activity.
MCL (Maximum Contaminant Level)	Maximum permissible level of a contaminant in water specified by the EPA that is delivered to the free flowing outlet of the ultimate user of a public water system (see Appendix A and Table A-III).
person-rem	The sum of radiation exposures received by a population. For example, two persons each with a 0.5 rem exposure have received one person-rem. Also, 500 people each with an exposure of 0.002 rem have received one person-rem.

rem	The unit of radiation dose equivalence which takes into account difference effects on humans of various kinds of ionizing radiation and permits them to be expressed on a common basis.
roentgen	A unit of radiation exposure that expresses exposure in terms of the amount of ionization produced by x-rays in a volume of air. One roentgen (R) is 2.58×10^{-4} coulombs/kg air.
RPS (Radiation Protection Standard)	Standards for external and internal exposure to radioactivity as defined in ERDA Manual Chapter 0524 (see Appendix A and Table A-II in this report).
total uranium	Uranium having the isotopic content of uranium in nature (99.27% ^{238}U, 0.72% ^{235}U, 0.0057% ^{234}U).
tuff	Rock of compacted volcanic ash and dust.

ENVIRONMENTAL SURVEILLANCE AT LOS ALAMOS DURING 1980

by

Environmental Surveillance Group

ABSTRACT

This report documents the environmental surveillance program conducted by the Los Alamos National Laboratory during 1980. Routine monitoring for radiation and radioactive or chemical substances is conducted on the Laboratory site and in the surrounding region to determine compliance with appropriate standards and permit early identification of possible undesirable trends. Results and interpretation of the data for 1980 on penetrating radiation, chemical and radiochemical quality of ambient air, surface and ground water, municipal water supply, soils and sediments, food, and airborne and liquid effluents are included. Comparisons with appropriate standards and regulations or with background levels from natural or other non-Laboratory sources provide a basis for concluding that environmental effects attributable to Laboratory operations are minor and cannot be considered likely to result in any hazard to the population of the area. Results of several special studies describe some unique environmental conditions in the Laboratory environs.

I. ENVIRONMENTAL MONITORING SUMMARY

Los Alamos National Laboratory policy emphasizes protection of the general public and environment from any harm that could arise from Laboratory activities and mitigation of environmental impacts to the greatest degree practicable. In keeping with this policy and Department of Energy (DOE) requirements to assess and document possible influences of operations on the environment, this report provides data and interpretation of environmental conditions in the vicinity of the Laboratory during 1980.

A. Monitoring Operations

Routine monitoring for radiation, radioactive materials, and chemical substances is conducted on the Laboratory site and in the surrounding region to document compliance with appropriate standards, identify possible undesirable trends, provide information for the public, and contribute to general environmental knowledge. This monitoring in the environment is a backup to data on specific effluent releases, such as those from radioactive waste treatment plants and various stacks at nuclear research facilities.

Monitoring and sampling locations for various types of measurements are organized into three main groups. Regional stations are located within the five counties surrounding Los Alamos County (see Fig. 1) at distances up to 80 km (50 mi) from the Laboratory. They provide a basis for determining natural conditions beyond the range for potential influence of Laboratory operations. Perimeter stations are located primarily within about 4 km (2.5 mi) of the Laboratory boundary (see Fig. 1) and emphasize locations in the adjacent residential and community areas. They document conditions in areas regularly occupied by the general public and likely to be

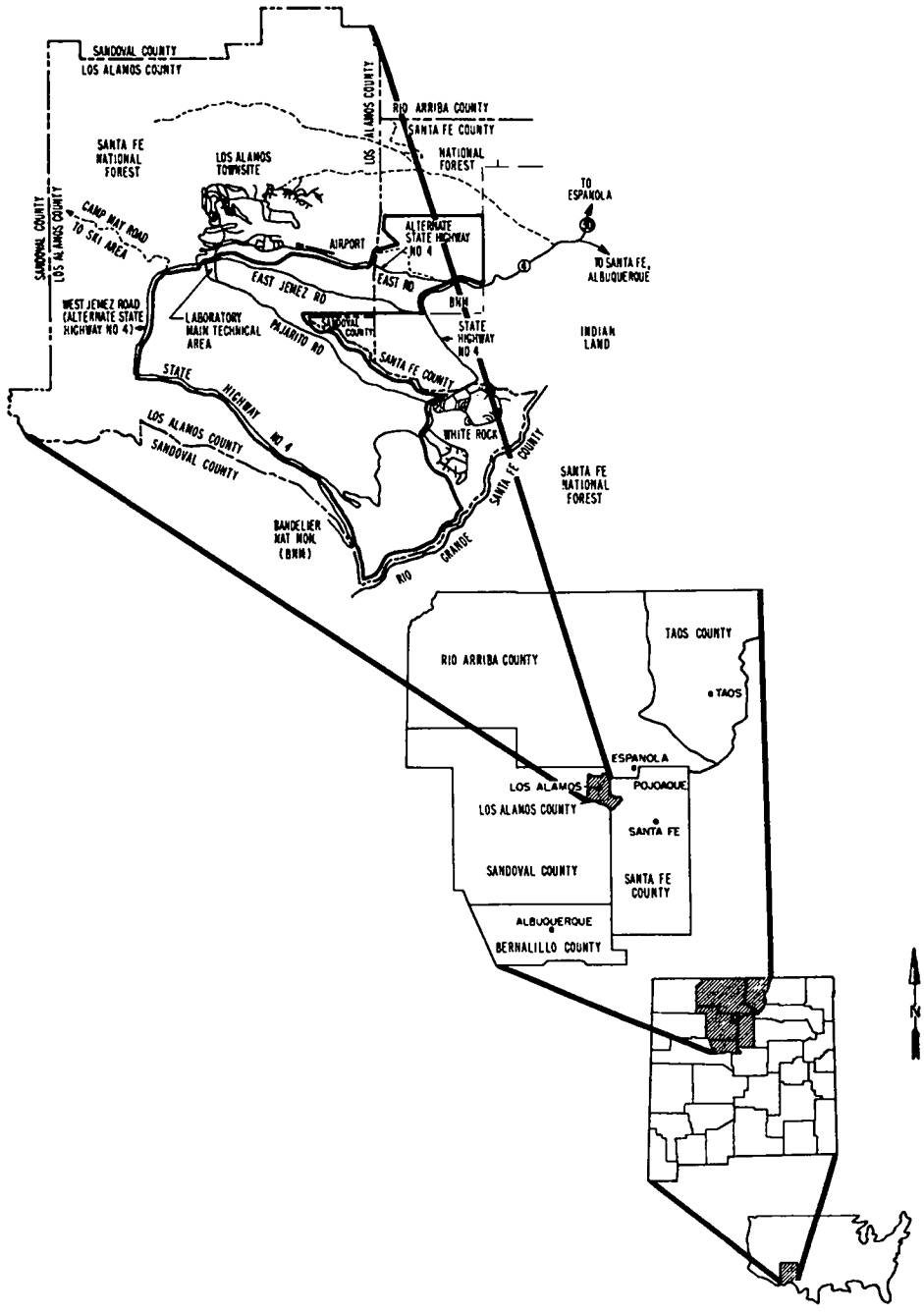


Fig. 1.
Regional location of Los Alamos.

influenced by Laboratory operations. Onsite stations are within the Laboratory boundary and most are in areas accessible only to employees during nominal working hours. Their data are useful for continuity of interpretation and for documentation of conditions in parts of the Laboratory site where the public has limited access (for example, commuters on cross-site roads or near some boundaries). The number of stations in each group is shown in Table I.

TABLE I

NUMBER OF SAMPLING LOCATIONS

Type of Monitoring	Number of Sampling Stations in Group		
	Regional	Perimeter	Onsite
External Radiation	3	12	41
Air	3	11	11
Surface and Ground Water[a]	6	36	36
Soils and Sediments	15	27	51
Foodstuffs	8	7	9

[a]An additional 24 stations for the water supply and 20 special stations related to the Fenton Hill Geothermal Program were also sampled.

The types of routine monitoring conducted at these stations include measurements of radiation and collection of samples of air particulates, water, soils, and foodstuffs for subsequent analysis. External penetrating radiation (the x and gamma ray contributions from natural, cosmic, and terrestrial sources, plus any Laboratory contributions) was measured at 56 locations by thermoluminescent dosimeters. Airborne radioactivity samples were accumulated during monthly intervals by continuously operating samplers at 25 locations. Surface and groundwater samples were collected periodically at 122 locations: 78 of which are indicated in Table I, 24 for the DOE water supply wells and distribution system, and 20 related to the Hot Dry Rock Geothermal Project at Fenton Hill.

Samples of foodstuffs, principally vegetables, fruit, and fish, were collected at 24 locations. Soil and sediment samples were collected periodically from 93 locations. Additional samples were collected at various times and locations to gain information about particular events, such as for major runoff events in intermittent streams, nonroutine releases, or special studies. During 1980, more than 16 800 analyses for chemical and radiochemical constituents were performed on these environmental samples. Resulting data were used for comparison with standards and natural background, dose calculations, and other interpretations.

B. Summary of 1980 Results

The large number of samples and wide range of purposes for which they are collected makes a brief summary difficult without leading to possible misinterpretation. Consequently, this summary presents an overview of monitoring results with selected highlights, emphasizing comparisons with standards or other bases for indicating significance. Full details of the results, their contexts, and interpretive methodology are explained in the body of the report and appendixes.

1. Penetrating Radiation

Levels of penetrating radiation, including x and gamma rays from cosmic, terrestrial, and man-made sources in the Los Alamos area, are monitored with thermoluminescent dosimeters (TLDs) at 56 locations divided into regional, perimeter, and onsite groups. No measurements at regional or perimeter locations in the environmental network for any calendar quarter showed any statistically distinguishable increase in radiation levels that could be attributed to Laboratory operations (see Table II). Apparent differences between the regional and perimeter groups are attributable to differences in the natural radioactivity content of geologic formations.

TABLE II

EXTERNAL PENETRATING RADIATION DURING 1980

Group	Dose (mrem)		
	Minimum	Maximum	Average
Regional	90	99	96
Perimeter	108	149	124
Onsite	118	303	161

Quarterly measurements at the 17 onsite stations in the routine environmental network were expectably above background levels, reflecting ongoing research activities at the Laboratory. Twenty-four of the 41 onsite TLD stations are specially located to monitor radioactivity from the Los Alamos Meson Physics Facility (LAMPF).

2. Radioactivity in Air and Water

Measurements of radioactivity in air and water are compared to standards, known as Concentration Guides (CGs) that are applicable to all federal agencies (see Appendix A). CGs are concentrations of radioactivity in air breathed continuously or water constituting all that is ingested during a year that are determined to result in whole body or organ doses equal to the Radiation Protection Standards [standards for exernal or internal exposure to radioactivity (see Appendix A)]. The 1980 results for the principal isotopes (including amounts present from worldwide fallout) potentially influenced by Laboratory operations are shown in Table III as ranges of percentages of the CGs. The values shown represent a statistical range (from two standard deviations below to two standard deviations above the mean) that encompasses 90-95% of the individual results. All comparisons in Table III are with CGs applicable to individuals in the general public, even though many onsite locations are not accessible to the public.

During 1980, atmospheric concentrations of gross alpha, gross beta, americium, plutonium, and uranium were measured at onsite, perimeter, and regional sampling locations. For all analyses except gross beta and uranium, the regional annual means were slightly lower than the perimeter and onsite group means. This indicates Laboratory contributions to concentrations of these radionuclides were greater than local variability in background levels. Tritiated water vapor concentrations at four stations were four to seven times higher than regional background levels, and are attributable to Laboratory operations. The data in Table III show that tritium (^{3}H), plutonium (^{239}Pu), and uranium (U) atmospheric concentrations were small fractions of their

TABLE III

RADIONUCLIDE CONCENTRATIONS IN AIR AND WATER AS PERCENTAGES OF CONCENTRATION GUIDES

	% CG[a]		
	Regional	Perimeter	Onsite
Air			
^{3}H (as HTO)	0.001-0.007	0.003-0.007	0.006-0.01
^{239}Pu	0.0003-0.003	0.00-0.03	0.003-0.02
U	0.0004-0.0009	0.0004-0.0007	0.0004-0.0007
Water			
^{3}H (as HTO)	0.1-0.2	0.00-0.05	0.00-0.06
^{239}Pu	0.0000-0.0002	0.0000-0.0002	0.0000-0.0001
^{137}Cs	0.0-0.4	0.0-0.4	0.0-0.4

[a]Values in table are $(\bar{x} - 2\ s)$ to $(\bar{x} + 2\ s)$ as % CG.

respective CGs. Results from only 1 of 100 ^{238}Pu samples and 2 of 44 ^{241}Am samples were above their respective analytical detection limits and were not included in Table III.

Atmospheric gross alpha and beta analyses serve as crude indicators of overall radioactivity levels. The highest gross alpha and beta concentrations were 17% and 0.05%, respectively, of the most relevant CGs.

On October 16, 1980, the People's Republic of China tested a nuclear device in the atmosphere that injected fission products into the troposphere and stratosphere over the mid-latitudes of the northern hemisphere. This resulted in elevated levels of fresh fission products for a time.

Surface and ground waters are monitored to provide routine surveillance of potential dispersion of radionuclides from Laboratory operations. Results of analyses are compared to CGs (see Table III) as an indication of the low concentrations of radionuclides in the environment. Other radioactivities measured but not listed in this table are ^{238}Pu (most analyses were at or below analytical detection limits), gross alpha and beta (used only as gross indicators of radioactivity), and uranium (concentrations low and generally indistinguishable from levels naturally in the environment). Results of the 1980 radiochemical quality analyses of water from regional, perimeter, water supply, and onsite noneffluent release areas indicate no significant effect from effluent releases from the Laboratory. Waters in the onsite liquid effluent release areas contain measurably higher concentrations of radioactivity, but at levels that are still small fractions of CGs. These onsite waters are not a source of industrial, agricultural, or municipal water supplies.

The water supply met all applicable U.S. Environmental Protection Agency and New Mexico Environmental Improvement Division chemical quality and radioactivity standards. Integrity of geological formations protecting the deep groundwater aquifer was confirmed by lack of any measurements indicative of nonnatural radioactivity or chemical contamination in municipal water supply sources.

3. Radioactivity in Other Media

Measurements of radioactivity in samples of soils, sediments, and a variety of foodstuffs are made to provide information on less direct natural mechanisms that could result in exposures to people. Estimated doses potentially resulting from these mechanisms, or pathways, such as wind resuspension of dust and incorporation into food chains, are summarized in the next section and compared to Radiation Protection Standards as an interpretation of their significance.

Measurements of radioactivity in soils and sediments are also useful for monitoring and understanding hydrologic transport of some radioactivity that occurs in intermittent stream channels in and adjacent to the Laboratory site and is from past and current liquid waste disposal operations. Pueblo, Los Alamos, and Mortandad Canyons all have concentrations of radioactivity on sediments at levels higher than those attributable to worldwide fallout. Some radioactivity on sediments in Pueblo Canyon (from pre-1964 effluent disposal) and upper Los Alamos Canyon (from 1952 to current treated effluent disposal) has been transported during runoff events to the Rio Grande. Theoretical estimates, confirmed by measurements, show the incremental effect on Rio Grande sediments is small in comparison with levels of activity on soils and sediments attributable to worldwide fallout and to variability in such measurements. No radioactivity on sediments has been transported past the Laboratory boundary in Mortandad Canyon. Measurements of above-background but low level radioactivity on soils from a few locations indicate probable deposition of some airborne emissions from Laboratory facilities. Most such locations are near facilities known to have had higher emission rates in the past, especially prior to 1974.

Fruit, vegetable, fish, and honey samples analyzed in 1980 show no increments of radioactivity distinguishable from that attributable to natural sources or worldwide fallout at any offsite location. At onsite locations near facilities emitting tritium, some elevated levels of tritiated water were found in fruit and in honey from an experimental hive.

4. Radiation Doses

Individual whole-body radiation doses to members of the public attributable to Laboratory operations are compared to applicable Radiation Protection Standards (RPSs) in Table IV. Radiation doses for various mechanisms of exposure are expressed as a percentage of the 500 mrem/yr RPS. This RPS is only for doses from exposures above natural background and medical exposures. Doses presented here are those calculated to be possible doses to individuals under realistic conditions of exposure and do not include some of the maximum

TABLE IV

COMPARISON OF INDIVIDUAL WHOLE BODY RADIATION DOSES WITH RADIATION PROTECTION STANDARDS
(Values are percent of RPS. For Individual in Public: 500 mrem/yr)

Calculated Doses Attributable to Laboratory Operations From:	% RPS		
	Regional	Perimeter	Onsite
Direct external radiation	<0.001	<0.001	0.2
Airborne radioactivity	<0.001	0.7	<0.001
Food pathways	<0.001	0.004	0.8

hypothetical exposures discussed in the body of this report that have minimal likelihood of occurring.

Another perspective is provided by comparing these estimated doses with the estimated whole body dose attributable to worldwide fallout (from inhalation, ingestion of food, and external radiation) in the United States, which is about 0.9% of the RPS.

The estimated maximum regional doses shown in Table IV for direct external radiation and airborne radioactivity are both based on exposure to theoretically calculated concentrations of emissions from the LAMPF and Omega West research reactor. The maximum estimated regional dose based on a food pathway assumes consumption of liver from a steer that grazed in Los Alamos Canyon and drank water containing some radioactivity on suspended sediments during a long spring runoff.

Estimated perimeter doses from direct external radiation and airborne radioactivity occur at a commercial establishment near the boundary north of the LAMPF and are attributable to its operation. The perimeter food pathway is based on consumption of honey from an experimental hive located onsite but near the Laboratory boundary.

The onsite external radiation dose is that estimated for a commuter regularly travelling past a Laboratory facility on one of the DOE roads normally open to public travel. The onsite airborne pathway was calculated for a half-day visit to the science museum-personnel building area. The onsite food pathway could occur from consumption of venison from a deer frequenting a canyon where treated liquid effluents are discharged.

5. Interpretation of Significance

To provide a perspective for comparing the significance of radiation exposures, estimates of the added risk of cancer were calculated. The increases in risk estimated for average individual exposures to ionizing radiation from 1980 Laboratory operations are presented in Table V, along with estimated incremental risks from natural and diagnostic medical radiation.

The maximum potential Laboratory contribution to the cancer risk is extremely small when compared to overall cancer risks. Further perspective is gained by noting the overall United States lifetime risk of contracting some form of cancer from all causes is 1 chance in 4. The lifetime risk of cancer mortality is 1 chance in 5.

The factors for risk estimation are those given by the International Commission on Radiological Protection (ICRP) based on observed radiation damage at high doses and linearly extrapolated to effects at low doses and dose rates (that is, the injury is assumed to be directly proportional to dose). The ICRP warns that these radiation risk estimates should be used only with great caution because the factors may overestimate actual risk. The National Council on Radiation Protection and Measurements (NCRP) has also taken the official position that linear extrapolation methods "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." Thus, one must keep in mind that the radiation risks are likely to be less than stated in Table V.

TABLE V

ADDED INDIVIDUAL LIFETIME CANCER MORTALITY RISKS ATTRIBUTABLE TO 1980 RADIATION EXPOSURE

Exposure Source	Added Risk (Chance) of Cancer Mortality	Dose (mrem) Used in Risk Estimate
Average Exposure from Laboratory Operations		
Los Alamos Townsite	1 in 7 000 000	1.42
White Rock Area	1 in 70 000 000	0.14
Natural Radiation		
Cosmic and Terrestrial		
Los Alamos Townsite	1 in 97 000	103[a]
White Rock Area	1 in 105 000	95[a]
Self Irradiation	1 in 420 000	24
Medical x-rays (Diagnostic Procedures)		
Average Whole Body Exposure	1 in 97 000	103

[a]Based on measured dose rates with reductions made for structural and self-shielding.

6. Other Monitoring Results

Airborne radioactive emissions were monitored as released from 89 points at the Laboratory and were typical of releases during the past several years. The greatest increase in radioactivity released during 1980 was a 23% (26 800 Ci more) increase in emissions of short-lived (20 min half-life or lower) activation products (^{11}C, ^{13}N, ^{15}O) at the LAMPF. Plutonium, uranium, iodine, thorium, tritium, and phosphorus emissions were all lower than last year, while released quantities of americium, mixed fission products, argon, and beryllium were all higher. Liquid effluents from two radioactive waste treatment plants and one sanitary sewage lagoon contained some radioactivity, all at levels well within CGs.

Nonradioactive effluents include airborne and liquid discharges. Airborne effluents from the beryllium fabrication shop, gasoline storage and combustion, power plant, gases and volatile chemicals, waste explosive burning, and dynamic testing did not result in any measurable or theoretically calculable degradation of air quality. A single National Pollutant Discharge Elimination System (NPDES) permit covers 113 industrial discharge points and 10 sanitary sewage treatment facilities. This year 8 of the 10 sanitary sewage treatment facilities exceeded one or more of the NPDES limits (excluding flow rate limitations) in one or more months, and less than 1% of all samples from the 113 industrial outfalls exceeded NPDES limits.

Some special environmental research programs were conducted this year to gain a better understanding of the ecosystems at Los Alamos. Among these projects were the study of water quality, elk migration, transuranic wase management methods, hydrologic transport of sediments, and retention of soil particles on plants.

II. BACKGROUND ON LOS ALAMOS

A. Description of the Area

1. Geographic Setting

The Los Alamos National Laboratory and associated residential areas of Los Alamos and White Rock are

located in Los Alamos County in 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 (27 500 acres) Laboratory site and adjacent communities are situated on Pajarito Plateau. The Plateau consists of a series of finger-like mesas separated by deep east-west oriented canyons cut by intermittent streams. The mesa tops range in elevation from approximately 2400 m (7800 ft) at the flank of the Jemez Mountains to about 1800 m (6200 ft) on their eastern margin terminating above the Rio Grande valley.

Most Laboratory and community developments are confined to mesa tops (see Fig. 2 and 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 U.S. Forest Service and U.S. Park Service (see land ownership map inside back cover). The Pueblo de San Ildefonso borders the Laboratory to the east.

All Los Alamos County and vicinity locations referenced in this report are identified by the Laboratory cartesian coordinate system, which is based on English units of measurement. This system is standard throughout the Laboratory, but is independent of the U.S. Geological Survey and New Mexico State Survey coordinate systems. The major coordinate markers shown on the maps are at 3.048 km (10 000 ft) intervals, but for the purpose of this report are identified to the nearest 0.30 km (1000 ft). The area within the Laboratory boundary is controlled by the DOE, which has the option to completely restrict access. This control can be instituted when necessary.

2. Geology-Hydrology

Canyons and mesas in the Laboratory area are generally formed by Bandelier Tuff (see Fig. 3, tuff) composed of ashfall and ashflow pumice and rhyolite tuff that form the surface of Pajarito Plateau. The tuff ranges from nonwelded to welded and is in excess of 300 m (1000 ft) thick in the western part of Pajarito Plateau and thins to about 80 m (260 ft) toward the east above the Rio Grande. It was deposited as a result of a major eruption of a volcano in the Jemez Mountains to the west about 1.1 to 1.4 million years ago.

The tuffs lap onto older volcanics of the Tschicoma Formation, which form the Jemez Mountains along the western edge of the Plateau and are underlain by the conglomerate of the Puye Formation (see Fig. 3, conglomerate) in the central and eastern edge along the Rio Grande. Chino Mesa basalts (see Fig. 3, basalt) interfinger with the conglomerate along the river. These formations overlie the siltstone/sandstone Tesuque Formation (see Fig. 3, sediments), which extends across the Rio Grande valley and is in excess of 1000 m (3300 ft) thick.

Los Alamos area surface water is primarily intermittent stream flow. Springs on flanks of the Jemez Mountains supply base flow to upper reaches of some canyons, but the amount is insufficient to maintain surface flows across Laboratory area before it is depleted by evaporation, transpiration, and infiltration. Runoff from heavy thunderstorms or heavy snowmelt reaches the Rio Grande several times a year. 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 as long as 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 (perched water bodies are formed by water infiltrating from canyon alluvium into underlying volcanics until it reaches an impermeable layer that prevents further downward movement), and (3) the main aquifer of the Los Alamos area (see Fig. 3, alluvium, perched water, and main aquifer, respectively).

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 runoff in canyons infiltrates 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.[1]

Perched water occurs in one limited area about 40 m (120 ft) beneath 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 the basalts (see Fig. 3, perched water and basalt) 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

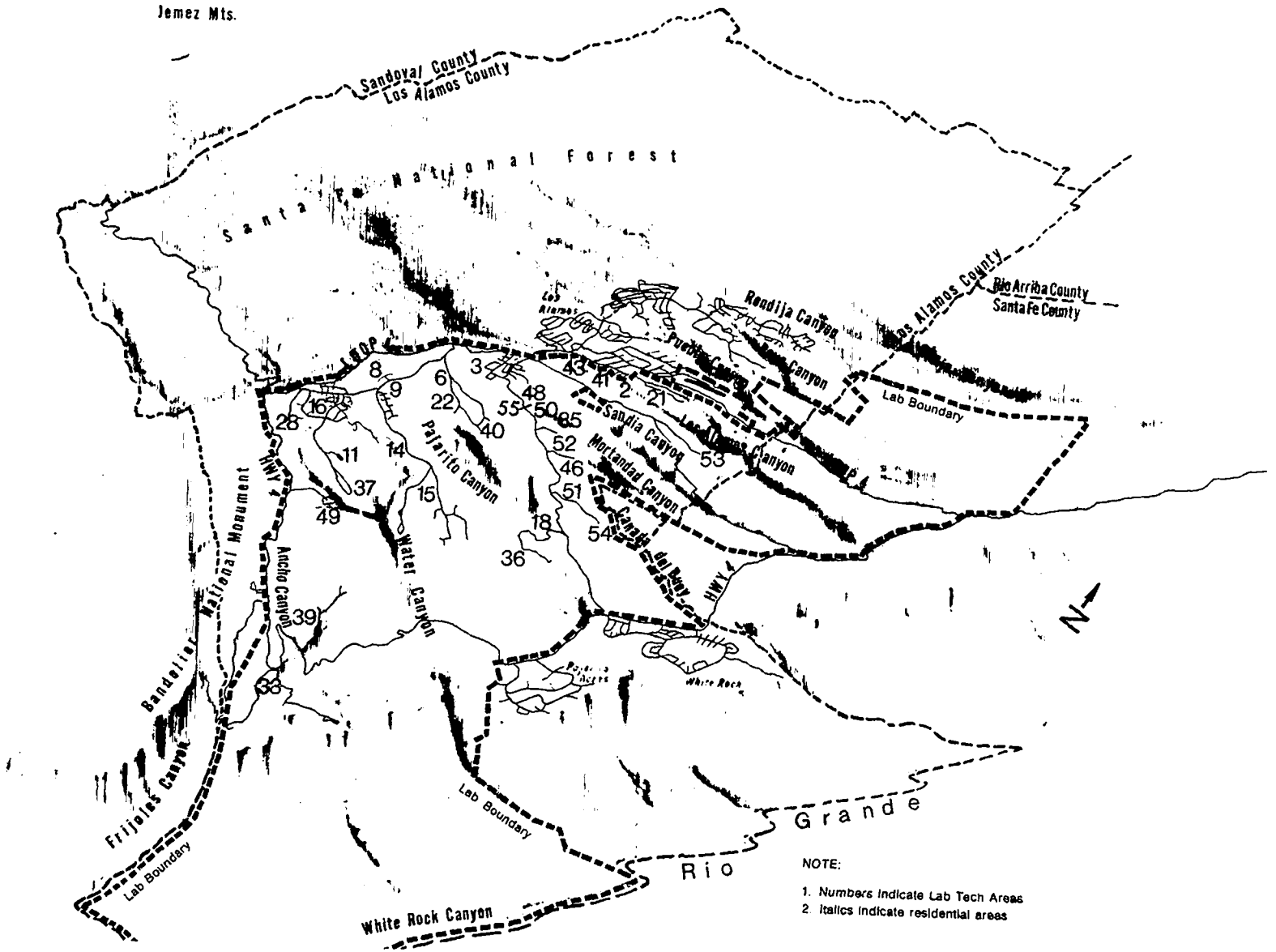


Fig. 2.
Topography of the Los Alamos, New Mexico, area.

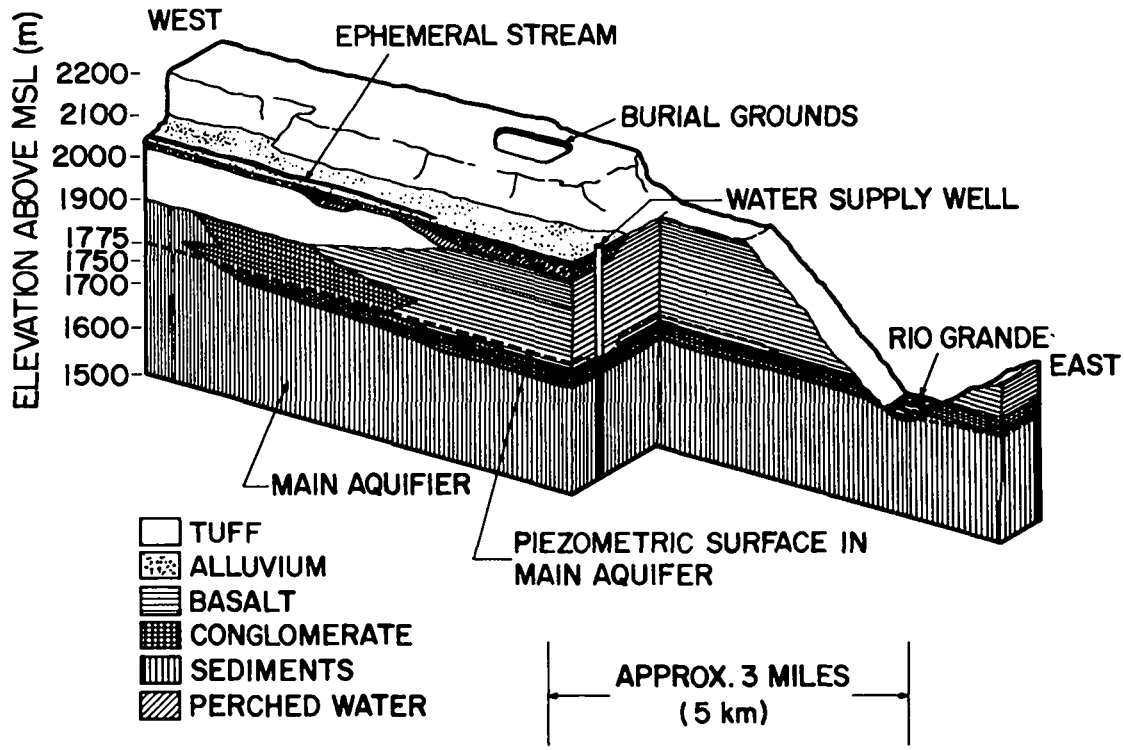


Fig. 3.
Conceptual illustration of geologic-hydrologic relationships in the Los Alamos area.

and western part of the Plateau. Depth to 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 water and perched water by about 110 to 190 m (350 to 620 ft) of dry tuff and volcanic sediments. Thus there is no hydrologic connection or potential for recharge to the main aquifer from alluvial or perched water.

Water in the main aquifer is under table conditions in the western and central part of the Plateau and under artesian conditions in the eastern part and along the Rio Grande.[2] The major recharge area to the main aquifer is the intermountain basin of the Valles Caldera in the Jemez Mountains west of Los Alamos (see Fig. 1 and inside front cover). 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 extimated 5.3 to 6.8×10^6 m^3 (4300 to 5500 acre-feet) annually from the aquifer.

3. Climatology

Los Alamos has a semiarid, continental mountain climate. The average annual precipitation of 45 cm (18 in) is accounted for by warm-season convective rain showers and cold-season migratory storms. Forty percent of the annual moisture total falls during July and August, primarily from afternoon thundershowers. Winter precipitation primarily falls as snow, with heavy annual accumulations of about 130 cm (51 in).

Summers are generally cool and pleasant. Maximum temperatures are usually below 32°C (90°F). The high altitude, light winds, clear skies, and dry atmosphere allow night temperatures to drop into the 12 to 15°C (54 to 59°F) range. Winter temperatures are typically in the range from −10°C to 5°C (14 to 41°F). Many winter days are clear with light winds, so strong solar radiation

makes conditions quite comfortable even when air temperatures are cold. A summary of 1980 weather data is in Section III.C and Tables E-I and E-II.

Major spatial and diurnal variations of surface winds in Los Alamos are caused by the complex terrain. Under moderate and strong atmospheric pressure differences, flow is channeled by the major terrain features. Under weak pressure differences, a distinct daily wind cycle exists: a light westerly drainage wind during nighttime hours and a light easterly upslope wind during daytime hours. Interaction of the strong and weak pressure patterns gives rise to westerly flow predominance over the Laboratory and a more southerly predominance at the east end of the mesas.

Historically, no tornadoes have been reported in Los Alamos County. Lightning, however, is very common in the vicinity of Pajarito Plateau. Local climatological records indicate an average of 58 thunderstorm-days per year. Lightning protection is an important consideration applied to each facility at the Laboratory.

4. Population Distribution

Los Alamos County has a population estimated by the preliminary 1980 census count at 17 586. Two residential and related commercial areas exist in the couny (see Fig. 4 and inside back cover). 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 1 038. The White Rock Area (including residential areas known as White Rock, La Senda, and Pajarito Acres) has about 6 548 residents. About one-third of those employed in Los Alamos commute from other counties. Population estimates for 1980 place 112 000 people within an 80 km (50 mi) radius of Los Alamos.

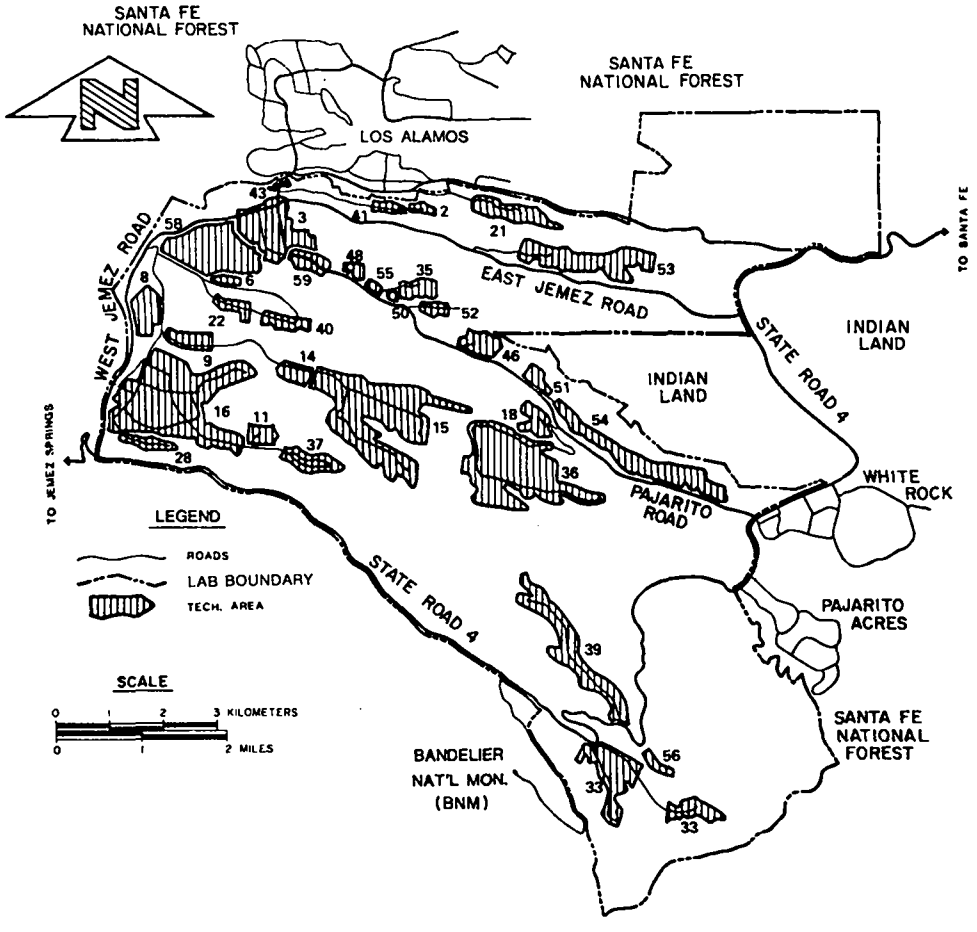


Fig. 4.
Los Alamos National Laboratory's technical areas and adjacent communities.

B. Los Alamos National Laboratory

1. Programs and Facilities

Since its inception in 1943, the Laboratory's primary mission has been nuclear weapons research and development. National security programs include weapons development, laser fusion, nuclear materials research, and laser isotope separation, as well as basic research in the areas of physics, chemistry, and engineering that support such programs. Research on peaceful uses of nuclear energy has included space applications, power reactor programs, radiobiology, medicine, and laser and magnetic fusion. In more recent years, other programs have been added in applied photochemistry, astrophysics, earth sciences, energy resources, nuclear fuel safeguards, lasers, computers, solar energy, geothermal energy, biomedical and environmental research, and nuclear waste management research.

A unique combination of facilities which contribute to the various research programs exists at Los Alamos. These facilities include an 800 MeV protron accelerator, a tandem Van de Graaff accelerator, a High Energy Gas Laser Facility, a Magentic Fusion Laboratory, a flash radiographic facility, and an 8 megawatt research reactor. Some of these facilities encourage participation and joint projects by researchers from other laboratories and research facilities.

In August 1977, the Laboratory site, encompassing 111 km^2 (27 500 acres), was dedicated as a National Environmental Research Park. The ultimate goal of the programs associated with this regional facility is to encourage environmental research that will contribute understanding of how man can best live in balance with nature while enjoying the benefits of technology. Park resources are made available to individuals and organizations outside of the Laboratory for the purpose of facilitating self-supported research on these subjects deemed compatible with the Laboratory programmatic mission.

A final environmental impact statement (FEIS)[3] which assesses potential cumulative environmental impacts associated with current, known future, and continuing activities at the Laboratory was completed this year. The FEIS provides environmental input for decisions regarding continuing activities at the Laboratory. It also provides much more detailed information on the environment of Los Alamos area.

The Laboratory is administered by the University of California for DOE, under contract W-7405-ENG-36. The Laboratory's environmental program, conducted by the Environmental Surveillance Group, is part of a continuing investigation and documentation program.

2. Waste Management

The Laboratory's activities are conducted in 33 active technical areas (TAs) distributed over the site (see Fig. 4 and Appendix F for descriptions of activities at the TAs). Wastes requiring disposal are generated at virtually all these locations. Sanitary sewage is handled by a number of plants employing conventional secondary treatment processes or by septic tanks. Uncontaminated solid waste is disposed in the County-operated landfill located within the Laboratory boundary. Nonradioactive airborne effluents include combustion products from the power and steam plants, vapors or fumes from numerous local exhaust systems (such as chemistry laboratory hoods), and burning of high explosives wastes.

Most liquid radioactive or chemical laboratory waste is routed to one of two waste treatment facilities by a collection system that is independent from the sanitary sewage system. The balance of such wastes from remote locations is accumulated in holding tanks and periodically collected and transported to the treatment plants for processing. Radioactivity is removed at the treatment plants by physiochemical processes that produce a concentrated sludge subsequently handled as solid radioactive waste. The treated effluents are released to canyons.

Between 90% and 95% of the total volume of radioactively contaminated solid waste from the Laboratory is disposed of by burial at the waste disposal area (TA-54). The remaining 5-10% is classed as transuranic waste and stored retrievably. Environmental containment is provided by the dry geologic formation of the burial ground.

Airborne radioactive effluents are discharged from a number of facilities after receiving appropriate treatment, such as filtration for particulates, catalytic conversion and adsorption of tritium, or storage to permit decay of short-lived activation gases.

III. MONITORING RESULTS

A. Radiation and Radioactivity

1. Penetrating Radiation

Levels of penetrating radiation—including x and gamma rays from cosmic, terrestrial, and man-made sources—in the Los Alamos area are monitored with thermoluminescent dosimeters deployed in two independent networks. Data from the environmental network at regional and perimeter locations for each calendar quarter did not show any statistically discernible increase in radiation levels attributable to Laboratory operations. Onsite measurements were slightly above background levels, reflecting research activities at the Laboratory. The second network, which monitors radioactivity of gaseous effluents from the Los Alamos Meson Physics Facility (LAMPF), showed a small increase in radiation levels due to operation of the LAMPF.

Natural penetrating radiation has two components. The natural terrestrial component results from the decay of ^{40}K and of the radioactive daughters from the decay chains of ^{232}Th and ^{238}U. The cosmic component includes both photon radiation and neutrons. Thermoluminescent dosimeters (TLDs) used in the Laboratory monitoring program are insensitive to neutrons, so neutron contribution to natural background radiation is not measured. The cosmic ionizing radiation level increases with elevation because of reduction in the shielding effect of the atmosphere. At sea level it averages between 25 and 30 mrem/yr. Los Alamos, with a mean elevation of about 2.2 km, receives about 60 mrem/yr from the cosmic component. The regional monitoring locations, ranging from about 1.7 km elevation at Pojoaque to about 2.1 km at Santa Fe, receive from 50-60 mrem/yr.[4]

In contrast to this fairly constant cosmic component, the dose from the natural terrestrial component in the Los Alamos area is highly variable. Temporal variation at any particular location (Fig. 5) is about 15-25% because of variations in soil moisture content and snow cover.[4] Figure 5, which compares all TLD locations that have been unchanged during the last 5 years, shows this temporal variation in the regional and perimeter averages. The variation in onsite averages is more influenced by changes in research programs at particular Laboratory sites than by changes in soil moisture or snow cover. There is also spatial variation because of different soil and rock types in the area.[5] These natural sources of variation make it difficult to detect any increases in the radiation level from man-made sources, especially if the magnitude of such an increase is small compared to natural fluctuations.

Levels of penetration radiation—including x and gamma rays from cosmic, terrestrial, and man-made sources—in the Los Alamos area are monitored with TLDs deployed in two independent networks. The environmental network consists of 32 locations divided into three groups (Fig. 6). Three of these locations are 28 to 44 km from the Laboratory boundary at air sampling stations in the neighboring communities of Española, Pojoaque, and Santa Fe, and form the regional group (Fig. 7). The perimeter group consists of 12 dosimeters placed within 4 km of the boundary. Seventeen locations within the Laboratory boundary comprise the onsite group. The dosimeters are changed each calendar quarter (see Appendix B for more information on handling of the TLDs).

Tables II and E-III summarize the annual total doses by the regional, perimeter, and onsite groups for 1980. Figure 5 shows a comparison of dose averages for the last 5 years. No measurements at regional or perimeter locations in the environmental network for any calendar quarter showed any statistically discernible increase in radiation levels attributable to Laboratory operations. Onsite measurements were slightly above background levels, reflecting research activities at the Laboratory.

The second network monitors radioactivity of gaseous effluents from the LAMPF. The dose contribution from the LAMPF operations is very small. Therefore, to improve the accuracy and decrease the uncertainty of this measurement, 12 TLD sites are located at the Laboratory boundary north of the LAMPF along 800 m of canyon rim. Twelve background TLD sites are

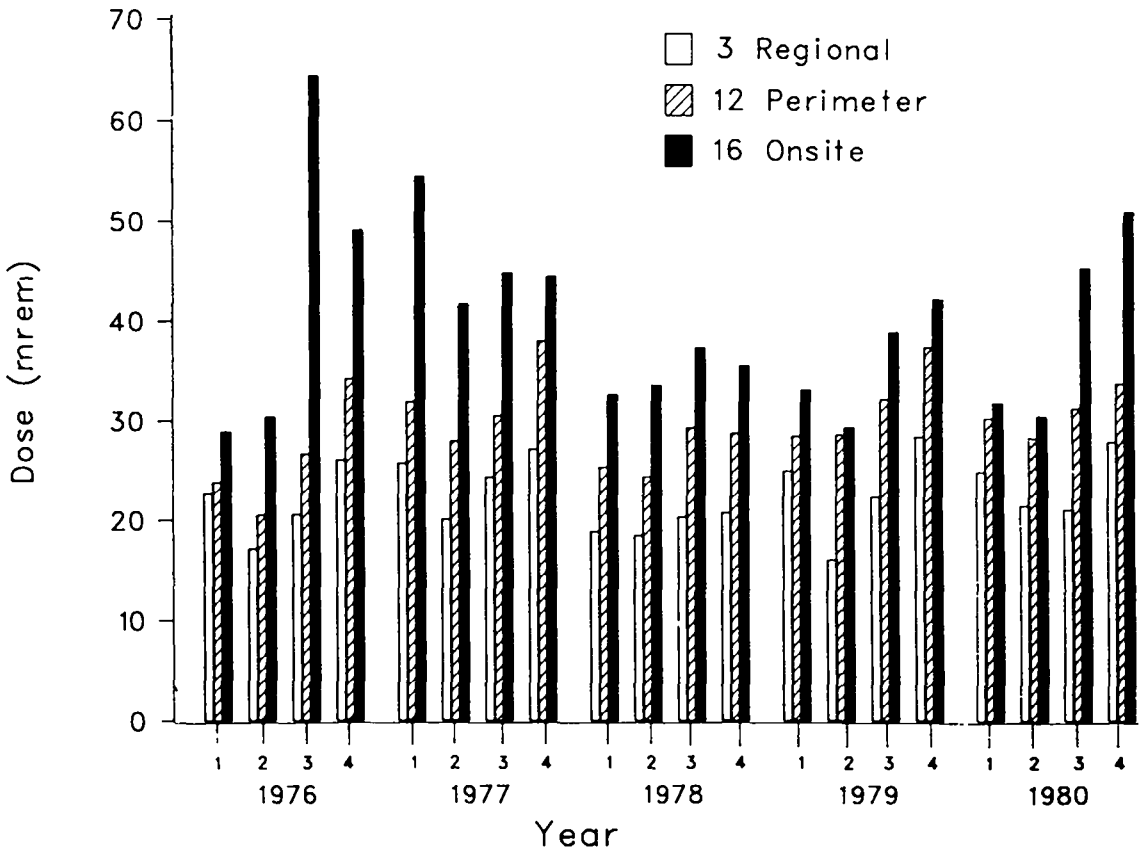


Fig. 5.
Quarterly dose averages for three station groups during the last five years.

similarly located about 9 km from the LAMPF along a canyon rim near the southern boundary of the Laboratory (see Fig. 6). This background location is not influenced by any Laboratory radiation sources. These 24 TLDs are changed in accordance with the operational schedule of the LAMPF. The difference between the average of the dosimeters at the north and south boundaries is the contribution to the dose from LAMPF operations and is plotted in Fig. 8. The LAMPF network showed an increase of 12.3 ± 1.1 mrem/yr at the Laboratory boundary north of the LAMPF due to its operation.

2. Atmospheric Radioactivity

Worldwide background atmospheric radioactivity is composed of fallout from atmospheric nuclear weapon tests, natural radioactive constituents in dust from the earth's surface, and radioactive materials resulting from interactions with cosmic radiation. Air is routinely sampled at several locations on Laboratory land, along the Laboratory perimeter, and in distant areas to determine the existence and composition of any contributions to radionuclide levels from Laboratory operations. Atmospheric concentrations of gross alpha, gross beta, americium, plutonium, and uranium were measured and statistically analyzed. There were some small but statistically significant differences among the regional, perimeter, and onsite groups and among stations within

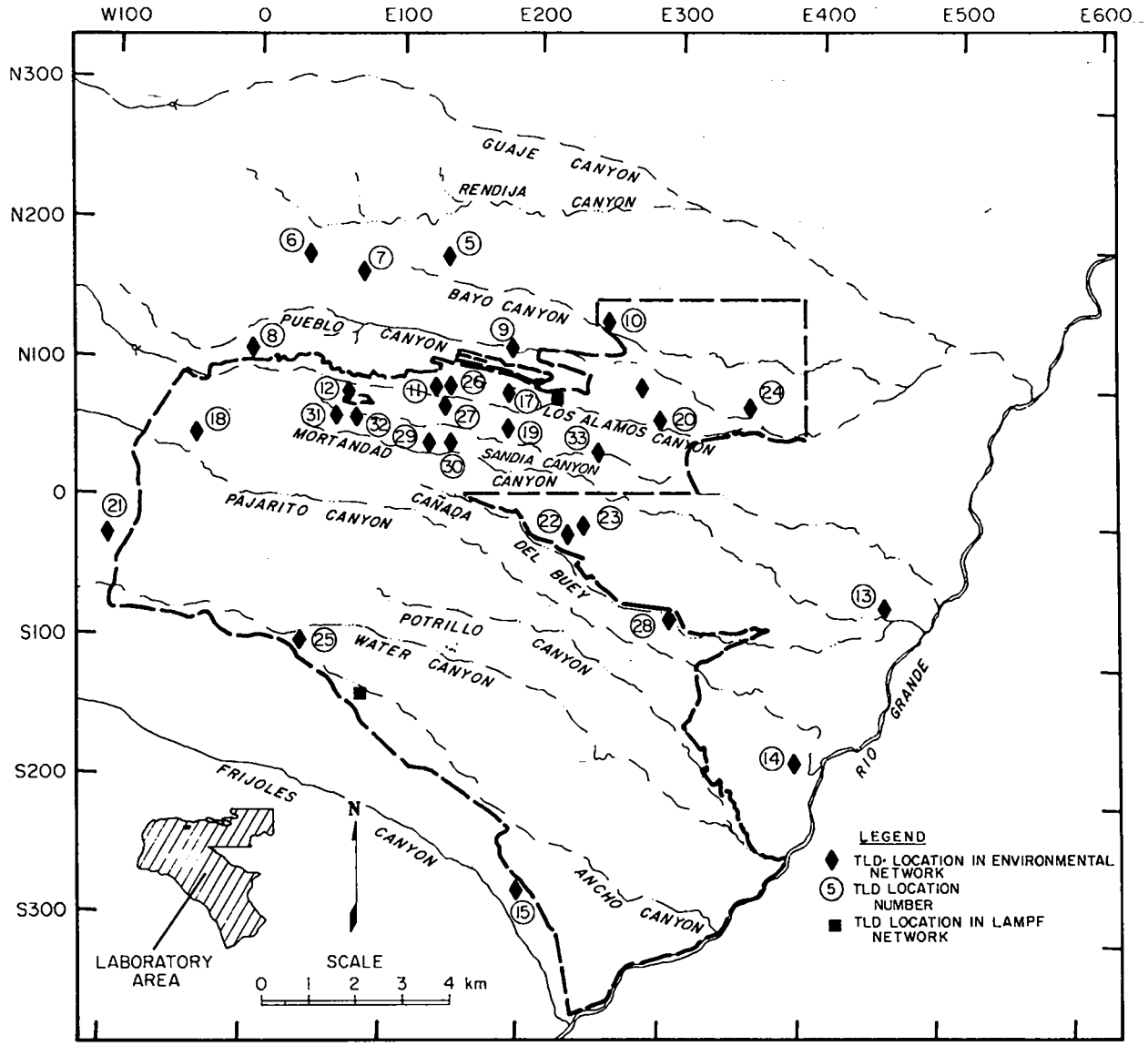


Fig. 6.
TLD locations on or near the Laboratory.

groups for some of these analyses. On October 16, 1980, the People's Republic of China tested a nuclear device in the atmosphere that injected fission products into the troposphere and stratosphere over the mid-latitudes of the northern hemisphere. This test was responsible for small increases in measured atmospheric concentrations of radioactivity.

a. Introduction. Atmospheric radioactivity samples were collected at 25 continuously operating air sampling stations in Los Alamos County and vicinity. Onsite and perimeter station locations are shown in Fig. 9 and identified by map coordinates in Table E-IV. Perimeter stations are within 4 km of the Laboratory boundary. The regional monitoring stations, located 28 to 44 km from the Laboratory at Española, Pojoaque, and Santa Fe

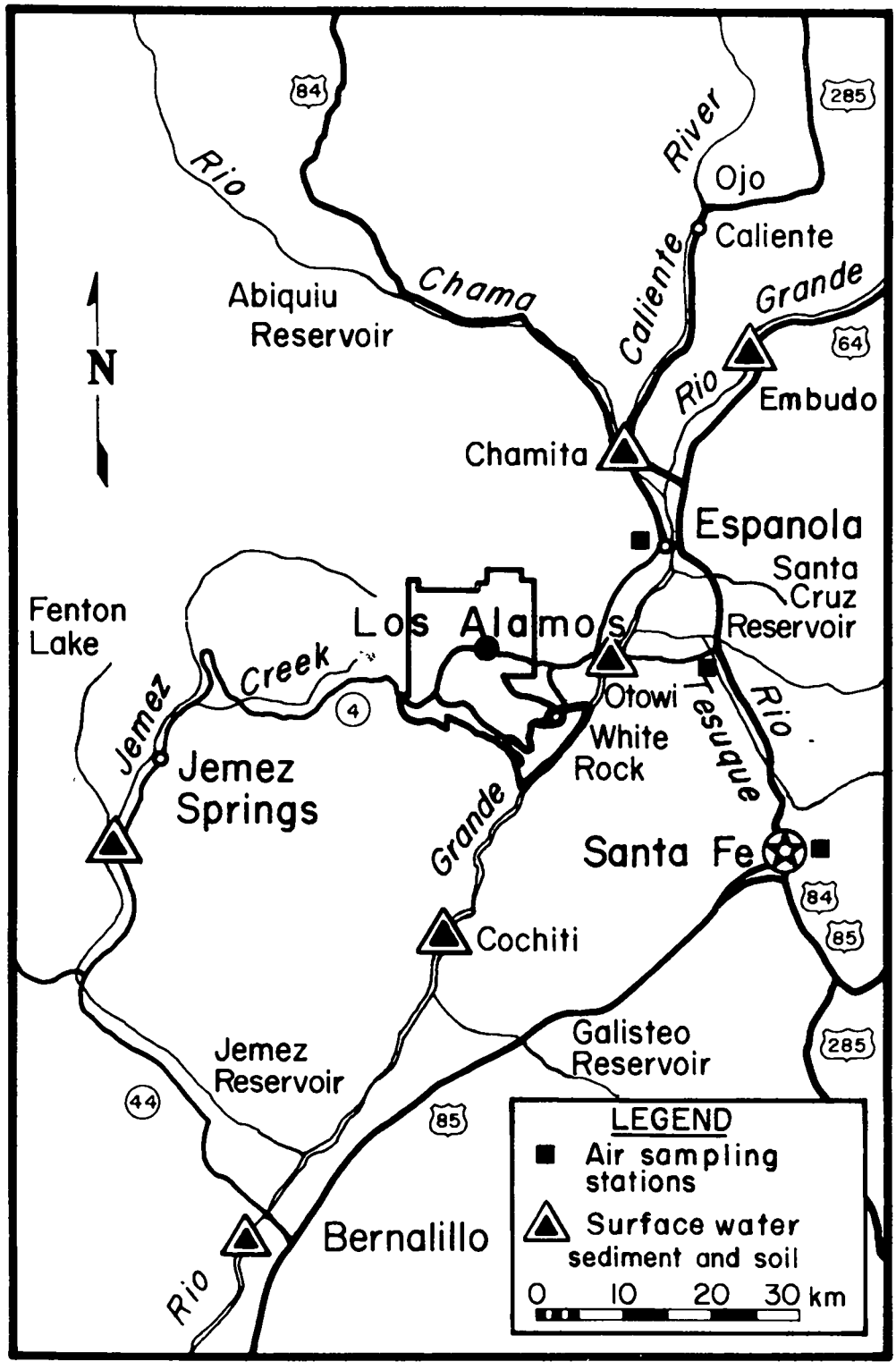


Fig. 7.
Regional surface water, sediment, soil, and air sampling locations.

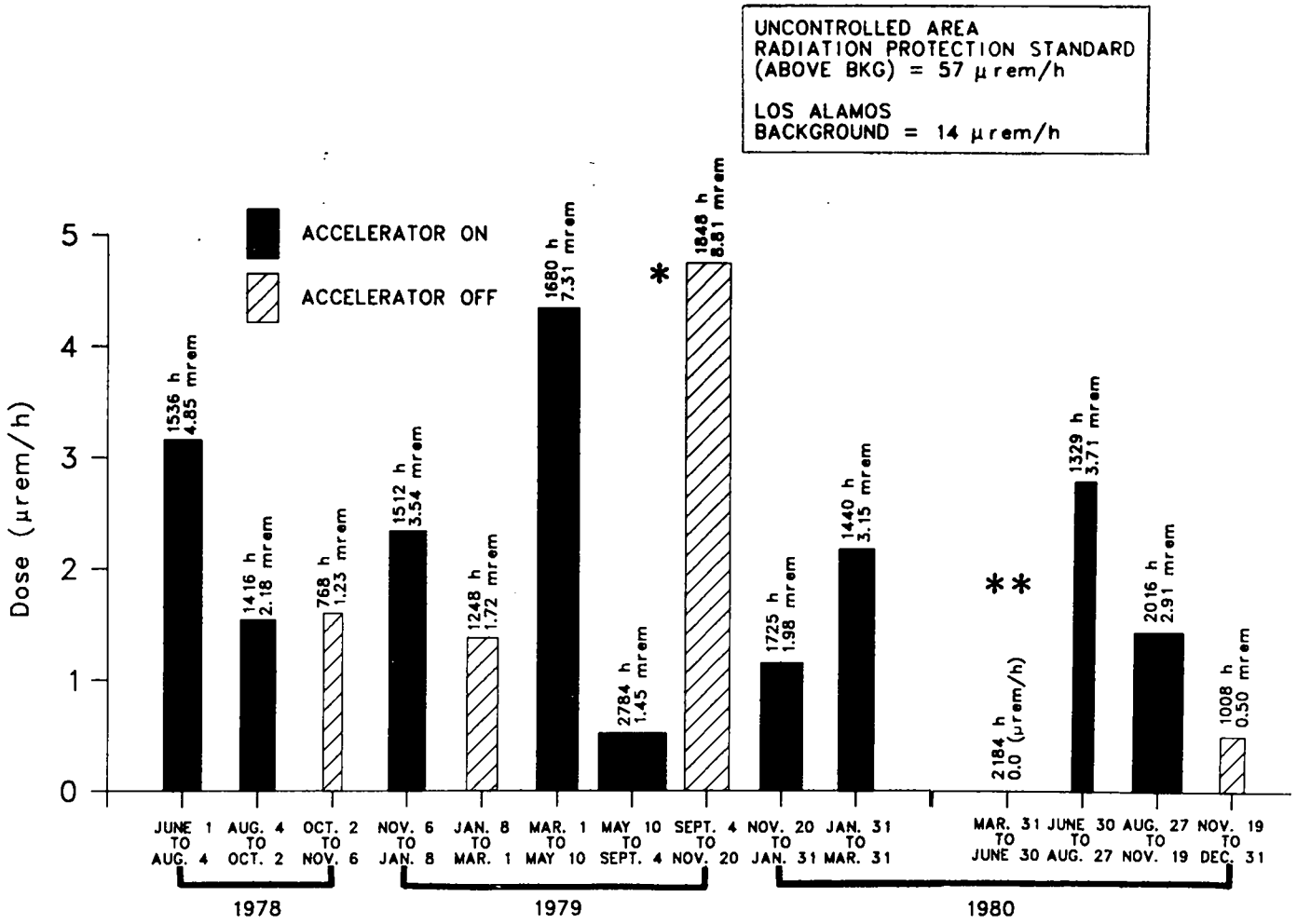


Fig. 8.
Above background dose rate due to operation of the LAMPF.

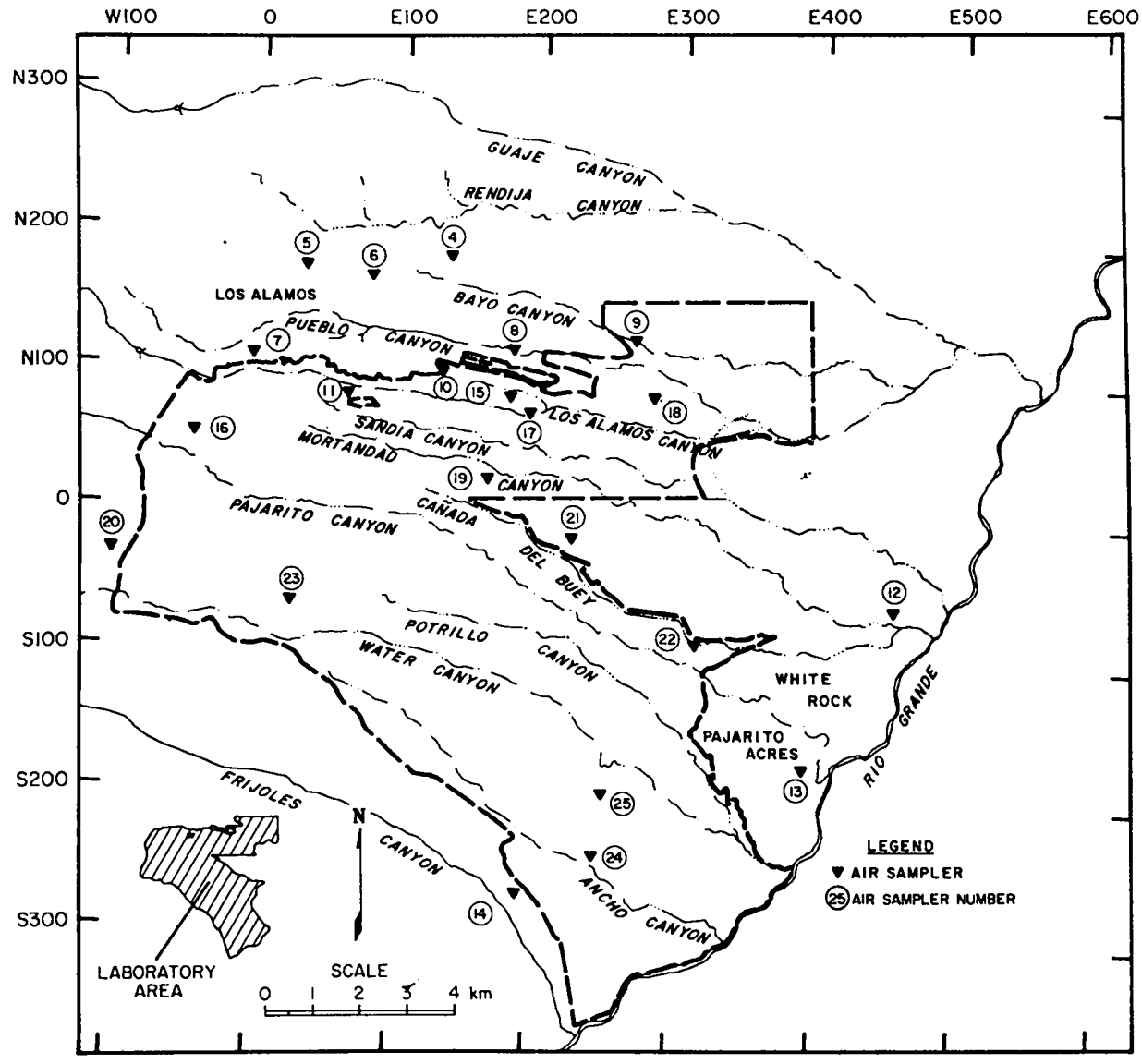


Fig. 9.
Air sampler locations on or near the Laboratory.

(Fig. 7), serve as reference points in determining the regional background for atmospheric radioactivity. A complete description of sampling procedures and statistical treatment of data is given in Appendix B.

When interpreting data from this air sampling program, one must first be aware of natural and fallout radioactivity levels and their fluctuations. Worldwide background atmospheric radioactivity is largely composed of fallout from atmospheric nuclear weapons tests, natural radioactive constituents in dust from the decay chains of ^{232}Th, ^{238}U, and materials resulting from interactions with cosmic radiation, such as tritiated water vapor. Because suspended particulates are mostly from soil resuspension, there are large temporal fluctuations in radioactivity concentrations as a result of changing meteorological conditions. Periods of high winds, resulting in relatively high suspended particulate concentrations, contrast with periods of heavy precipitation, which remove much of the suspended mass. Spatial variations may be dependent on these same factors.

Measurements of background atmospheric radioactivity concentrations are summarized in Table E-V and are useful in interpreting the air sampling data.

b. Chinese Fallout Monitoring. An atmospheric nuclear test by the People's Republic of China was conducted at their Lop Nor testing area in northwest China on October 16, 1980. Estimated yield of the nuclear device was 0.2 to 1.0 megatons (1 megaton is equivalent to 1 million tons of TNT). Radioactive materials were injected into the troposphere and stratosphere over the mid-latitudes of the northern hemisphere by this above-ground detonation. Prevailing air currents then carried the airborne radioactive materials to the North American continent where radioactive debris continued dropping slowly to the earth's surface as fallout.

After this test, supplementary air sampling was initiated to measure fallout. Daily particulate samples were taken at the onsite Occupational Health Laboratory (OHL) and at the offsite station at Española, 28 km distant from the Laboratory (see Fig. 7). The highest observed long-lived (counted after 7 to 10 days), gross beta concentration measured was 250×10^{-15} μCi/mℓ at the OHL and 290×10^{-15} μCi/mℓ at Española. These concentrations are 0.25% and 0.29%, respectively, of the uncontrolled area CG for ^{131}I. Qualitative gamma spectral analyses of the atmospheric particulate samples showed the presence of ^{235}U from the detonation. Table E-VI contains all data collected during the special Chinese fallout monitoring program.

c. Annual Gross Alpha and Gross Beta Radioactivity. Gross alpha and beta analyses serve as crude indicators of overall radioactivity levels. The annual average 4-wk gross alpha and beta concentrations are summarized in Table VI and described in detail in Table E-VII. There was no increase in long-lived gross beta concentrations (see Fig. 10) during the spring. Normally, elevated activity is observed in the spring when mixing of the stratosphere with the troposphere causes increased fallout of radioactive particles.

The gross alpha data showed that the regional annual mean (1.8×10^{-15} μCi/mℓ) was statistically significantly lower (with P=0.05, which means there is a 5% probability of concluding there is a significant difference when none exists) than both the perimeter annual mean (3.1×10^{-15} μCi/mℓ) and the onsite annual mean (2.8×10^{-15} μCi/mℓ). This would be expected, since the regional stations are 28 to 40 km distant from the Laboratory and, therefore, are not influenced by its operation. The perimeter-onsite comparison of annual means showed no significant differences. Gross alpha annual means for Pajarito Acres (station 13) and Bandelier (station 14) were slightly lower than the other stations in the perimeter group.

The gross beta data showed that the regional annual mean (18×10^{-15} μCi/mℓ) was statistically significantly lower (P = 0.05) than the perimeter annual mean (25×10^{-15} μCi/mℓ). The regional-onsite and perimeter-onsite comparisons of annual means showed no significant differences. There were some statistically significant differences in the comparison of annual means of stations within the same group, but these differences were environmentally unimportant.

d. Tritium. Atmospheric tritiated water concentrations for each station for 1980 are summarized in Table VI, detailed in Table E-VIII, and plotted in Fig. 11. The regional annual mean (7.7×10^{-12} μCi/mℓ) was statistically significantly lower (P = 0.05) than the onsite annual mean (18×10^{-12} μCi/mℓ), and the perimeter annual mean (10×10^{-12} μCi/mℓ) was significantly lower than the onsite annual mean. The regional-perimeter comparison evidenced no significant differences. These findings reflect the fact that quantities of tritium (see Table E-XXVI) are routinely released onsite at the Laboratory.

The annual mean (34×10^{-12} μCi/mℓ) for the Bandelier perimeter station (station 14) was much higher than the annual means for stations in the perimeter group. This reflects Bandelier's location, which is near (see Figs. 4 and 9) a facility (TA-33) that routinely releases tritium. The annual mean (53×10^{-12} μCi/mℓ) for the station (22) located at the solid waste disposal area (TA-54) was significantly higher than means for the other onsite stations and resulted from evapotranspiration from buried tritium-contaminated wastes at this site. Also, tritium effluents from stacks near sampling stations at TA-33 (station 24) and at TA-39 (station 25) caused the annual means of these two stations to be significantly higher (P=0.05) than the other stations in the onsite group.

e. Plutonium. Annual average ^{238}Pu and ^{239}Pu concentrations are summarized in Table VI and detailed in Table E-IX. There was just one ^{238}Pu concentration that had a detectable value (i.e., where the 2s measurement

TABLE VI

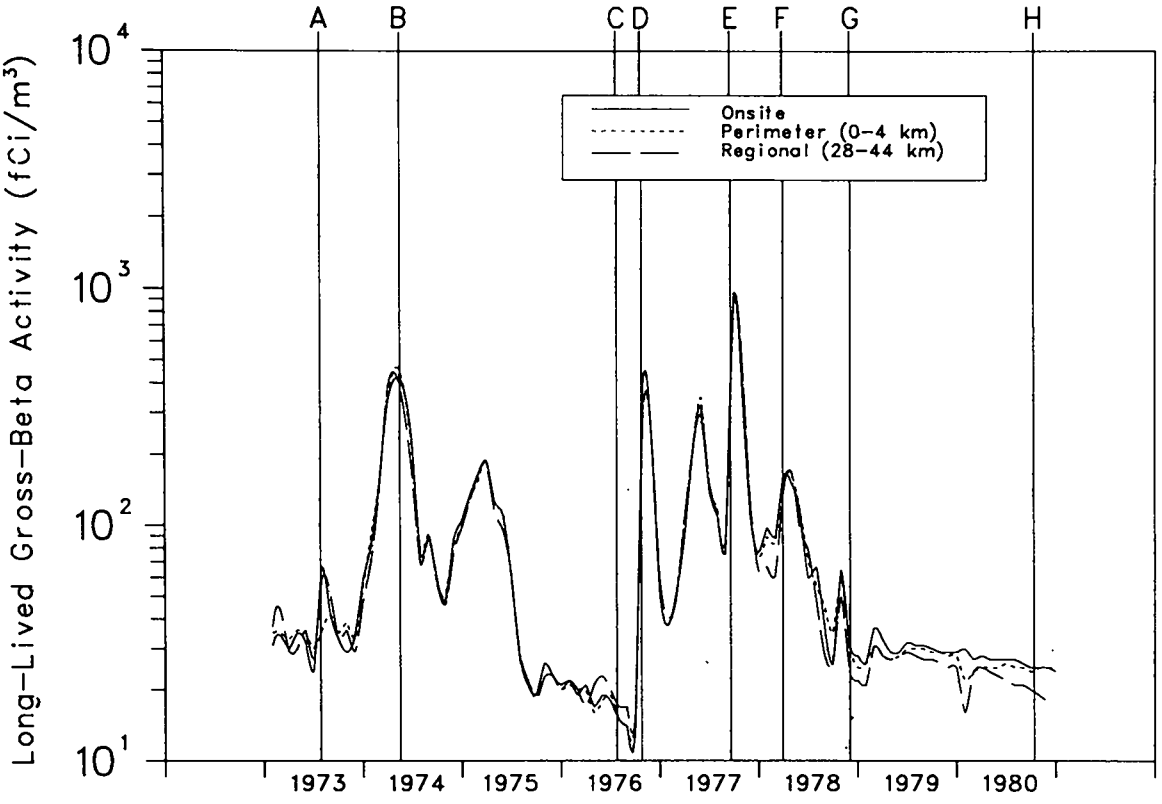
SUMMARY OF ANNUAL ATMOSPHERIC RADIOACTIVITY MONITORING FOR 1980

Analysis	Group	Units	Maximum Observed	Minimum Observed	Annual Mean	Mean As % CG
Gross alpha	Regional	10^{-15} μCi/mℓ	4.3 ± 1.8	0.3 ± 0.1	1.8 ± 0.3	3.0
	Perimeter	10^{-15} μCi/mℓ	10 ± 4	0.0 ± 0.1	3.1 ± 0.3	5.2
	Onsite	10^{-15} μCi/mℓ	7.4 ± 3.2	0.3 ± 0.2	2.8 ± 0.3	0.2
Gross beta	Regional	10^{-15} μCi/mℓ	37 ± 10	1.2 ± 0.3	18 ± 4	0.02
	Perimeter	10^{-15} μCi/mℓ	52 ± 14	4.0 ± 1.0	25 ± 2	0.03
	Onsite	10^{-15} μCi/mℓ	46 ± 12	1.7 ± 0.4	24 ± 2	0.0006
Tritiated water vapor	Regional	10^{-12} μCi/mℓ	88 ± 28	−2.2 ± 1.6	7.7 ± 5.8	0.004
	perimeter	10^{-12} μCi/mℓ	170 ± 60	0.1 ± 1.0	10 ± 4	0.005
	Onsite	10^{-12} μCi/mℓ	160 ± 60	0.1 ± 1.2	18 ± 5	0.0003
^{238}Pu	Regional	10^{-18} μCi/mℓ	−1.0 ± 2.1	−3.4 ± 2.7	−2.1 ± 0.4	0.0
	Perimeter	10^{-18} μCi/mℓ	1.9 ± 2.6	−4.6 ± 2.2	−1.9 ± 0.3	0.0
	Onsite	10^{-18} μCi/mℓ	4.2 ± 3.1	−3.9 ± 5.2	−1.6 ± 0.4	0.0
^{239}Pu	Regional	10^{-18} μCi/mℓ	4.7 ± 2.9	−1.0 ± 2.0	1.1 ± 0.9	0.002
	Perimeter	10^{-18} μCi/mℓ	182 ± 19	−1.6 ± 2.9	8.1 ± 8.3	0.013
	Onsite	10^{-18} μCi/mℓ	109 ± 11	−2.4 ± 1.3	6.7 ± 5.2	0.0003
^{241}Am	Regional	10^{-18} μCi/mℓ	−0.0 ± 4.4	−1.0 ± 4.4	−0.4 ± 0.5	0.0
	Perimeter	10^{-18} μCi/mℓ	48 ± 8	−1.8 ± 4.9	3.3 ± 6.0	0.002
	Onsite	10^{-18} μCi/mℓ	23 ± 5	−2.8 ± 6.9	2.5 ± 2.2	0.00004
Total U	Regional	pg/m^3	140 ± 20	18 ± 4	60 ± 21	0.0007
	Perimeter	pg/m^3	221 ± 37	−1.4 ± 14	49 ± 11	0.0005
	Onsite	pg/m^3	203 ± 37	−1.7 ± 35	50 ± 13	0.00002

uncertainty was less than the measured value); this concentration was at the solid waste disposal area (station 22, 4.2×10^{-18} μCi/mℓ). For ^{239}Pu, the regional annual mean (1.1×10^{-18} μCi/mℓ) was statistically significantly lower (P=0.05) than both the perimeter annual mean (8.1×10^{-18} μCi/mℓ) and the onsite annual mean (6.7×10^{-18} μCi/mℓ). The perimeter-onsite comparison showed those two annual means to be statistically indistinguishable.

Two samples, one at Barranca School (station 4, 182×10^{-18} μCi/mℓ) and the other at TA-21 (station 15, 109×10^{-18} μCi/mℓ) were more than an order of magnitude higher than the annual means for their respective groups. These concentrations were 0.3% and 0.2%, respectively, of the uncontrolled area CG, so did not pose a threat to public health.

f. Uranium and Americium. The 1980 atmospheric uranium concentrations are summarized in Table VI and listed in Table E-X. Uranium concentrations are heavily dependent on the immediate environment of the sampling station. Those stations with higher annual averages and



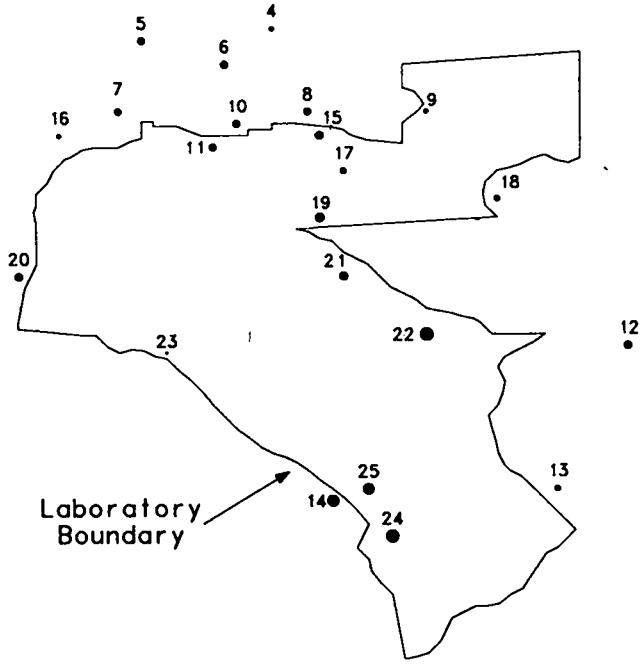
Chinese Nuclear Atmospheric Tests

A.	26 June 1973	2-3 MT
B.	17 June 1974	0.2-1 MT
C.	26 September 1976	0.2 MT
D.	17 November 1976	4 MT
E.	17 September 1977	0.02 MT
F.	14 March 1978	0.02 MT
G.	14 December 1978	0.02 MT
H.	16 October 1980	0.2-1 MT

Fig. 10.
Monthly average long-lived gross beta activity in air, 1973 through 1980, by sampling station groups.

maximums were all located in dusty areas, where historically a higher filter dust loading has accounted for collection of more natural uranium. Annual station averages are typical of regional background atmospheric uranium concentrations (see Table E-V). This year the uranium data was very uniform. There were no statistically significant differences (P = 0.05) among the groups or stations.

The 1980 atmospheric ^{241}Am concentrations are summarized in Table VI and listed in Table E-XI. Analyses for ^{241}Am are done because it is a daughter of ^{241}Pu and is much easier to detect than ^{241}Pu. Weapon-grade plutonium contains ^{241}Pu, so fallout from atmospheric nuclear tests usually contains ^{241}Pu and ^{241}Am. This year there were only 6 of the 44 analyses done for ^{241}Am that had detectable levels. The highest of these six concentrations was 48×10^{-18} μCi/mℓ at Los Alamos Airport (station 8) and was 0.006% of the uncontrolled area CG for ^{241}Am.



Legend

Each circle is located at a sampling station and is proportional to tritium concentration.

X
• – Represents 10 pCi/m³ at station X

Y
● – Represents 100 pCi/m³ at station Y

Fig. 11.
Annual mean atmospheric tritiated water vapor concentrations on or near the Laboratory.

3. Radioactivity in Surface and Ground Waters

Surface and ground waters are monitored to provide routine surveillance of potential dispersion of radionuclides from Laboratory operations. Results of these analyses are compared to CGs for water. Regional background concentrations are an indication of the small amounts of radionuclides (natural and fallout) in the environment. The 1980 radiochemical quality analyses of water from regional, perimeter, water supply, and on-site noneffluent release areas indicate no significant effect from effluent releases from the Laboratory. Waters in onsite liquid effluent release areas contain trace amounts of radioactivity. These onsite waters are not a source of industrial, agricultural, or municipal water supplies.

a. Regional and Perimeter Waters. Analyses of surface and ground waters from regional and perimeter stations reflect baseline levels of radioactivity in areas outside the Laboratory boundary. Regional surface waters were collected within 75 km of the Laboratory from six stations on the Rio Grande, Rio Chama, and Jemez River (Fig. 7, Table E-XII). Samples were also collected from five perimeter stations located within about 4 km of

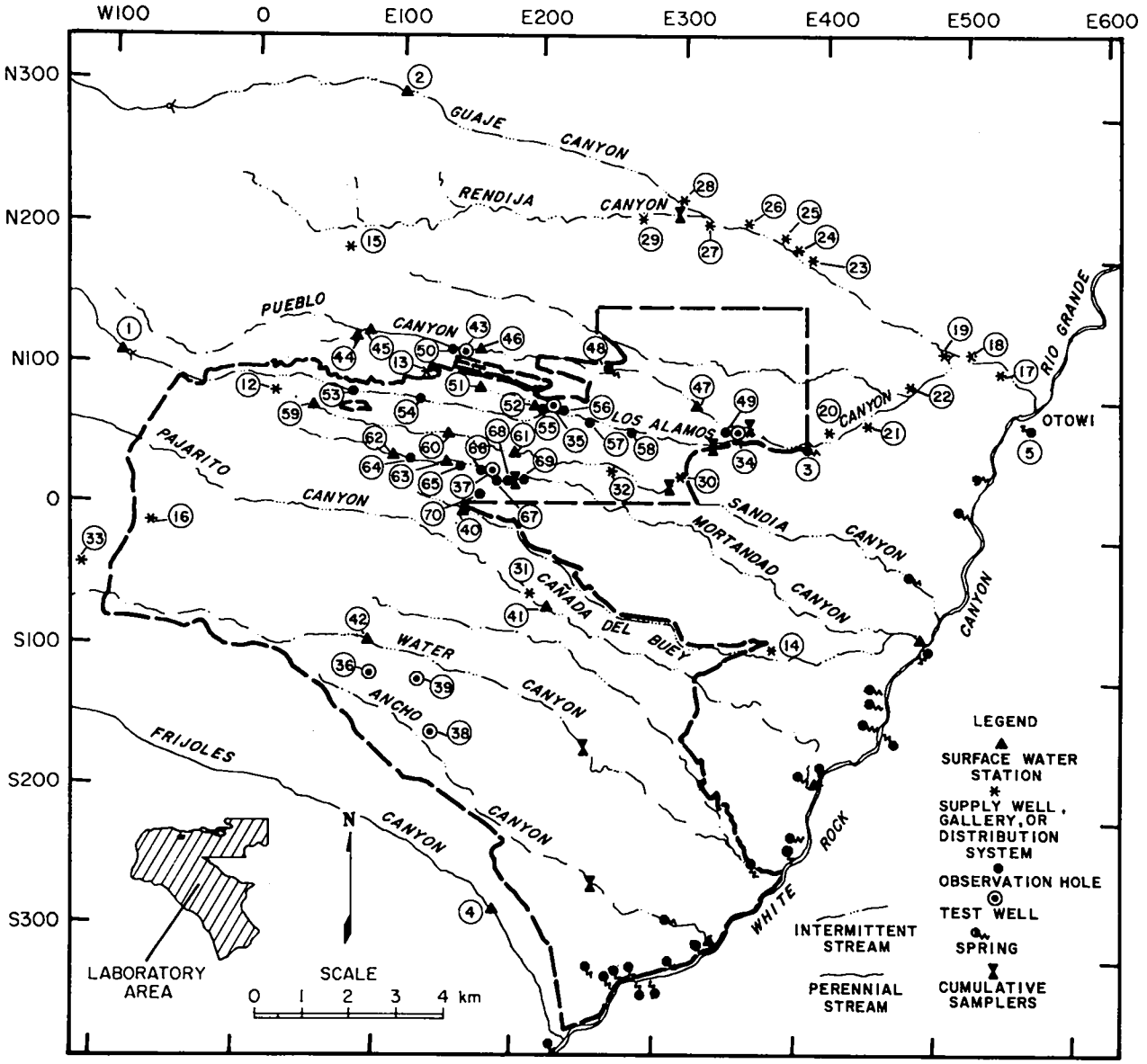


Fig. 12.
Surface and ground water sampling locations on or near the Laboratory.

the Laboratory boundaries and from 28 stations in White Rock Canyon of the Rio Grande (Figs. 12 and 13, Table E-XII). Excluded from this discussion is Acid-Pueblo Canyon, a former release area for industrial liquid waste, which has four offsite stations and three onsite stations (Fig. 12). As a known release area and for hydrologic continuity, all monitoring results from Acid-Pueblo Canyon are discussed in the following section concerning onsite surface and ground waters. Detailed data from regional, perimeter, and White Rock stations are in Tables E-XIII, E-XIV, and E-XV, respectively (see Appendix B.3 for methods of collection, analyses, and reporting of water data). A comparison of the maximum concentrations found in these waters with CGs (see Appendix A) for uncontrolled areas are given in Table VII. However, the CGs do not account for concentration mechanisms that may exist in environmental media. Consequently, other media such as sediments, soils, and foods are monitored (as discussed in subsequent sections).

Radionuclide concentrations in surface and ground waters from the six regional and five perimeter stations

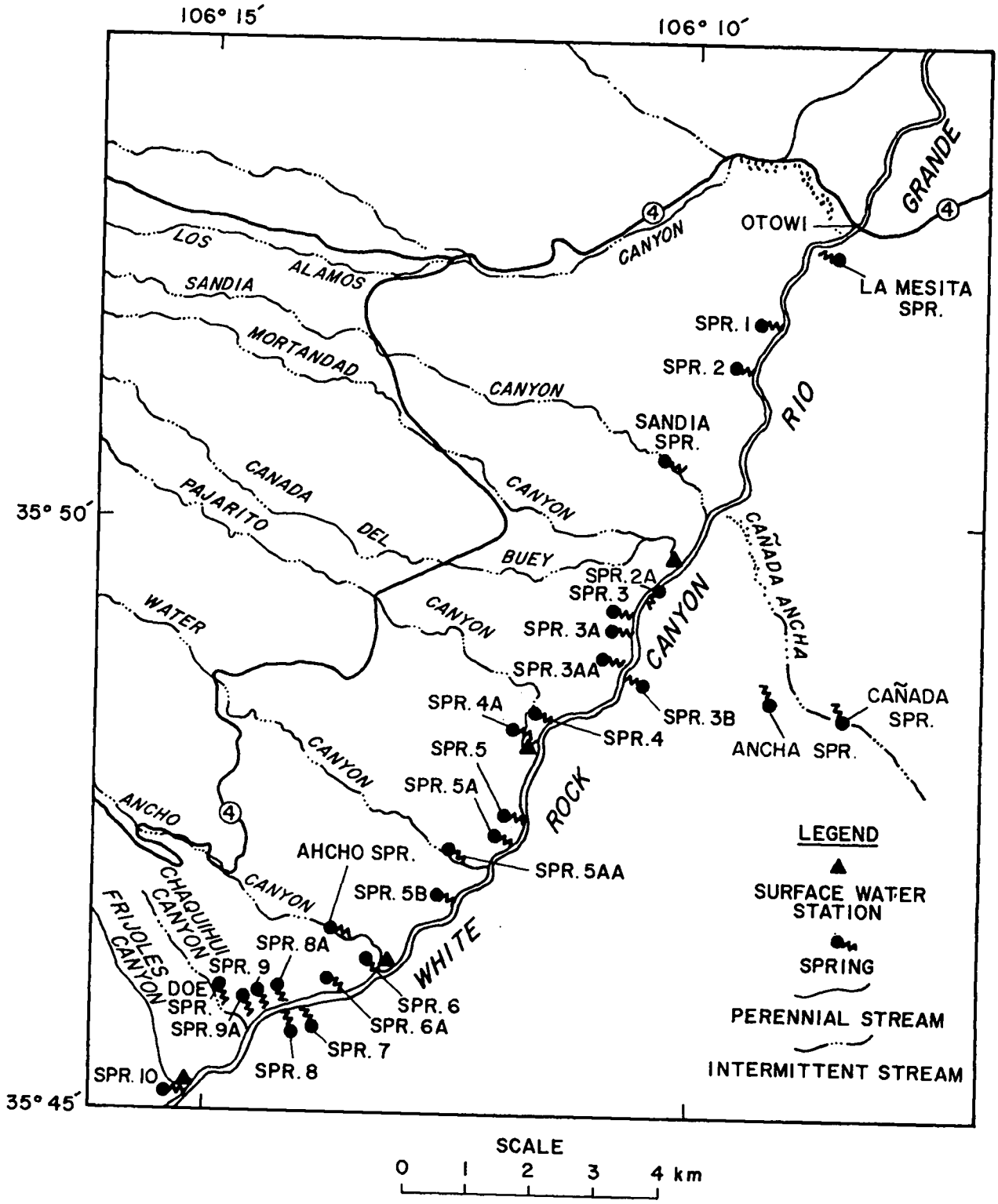


Fig. 13.
Surface water sampling locations in White Rock Canyon.

were low and showed no effect from release of liquid effluents at the Laboratory. Plutonium concentrations were near minimum detection levels and were well below CGs for uncontrolled areas.

Stations in White Rock Canyon are divided into four groups. Three groups are of similar aquifer-related chemical quality, while the fourth group reflects localized conditions in the aquifer. Radionuclide concentrations in water from the 28 stations reflect natural occurring radionuclides (Table E-XV).

b. Onsite Surface and Ground Waters. Onsite sampling stations are grouped according to areas that are not located in effluent release areas and those located in areas that receive or have received industrial liquid effluents. Sampling locations in onsite noneffluent release areas consist of seven test wells completed into the main aquifer, and three surface water sources (Fig. 12, Table E-XII). Detailed radiochemical analyses are shown in Table E-XVI. Maximum concentrations of radioactivity at the ten stations is in Table VII. The concentrations were low, near or below detection limits, and well below CGs for controlled areas.

Canyons that receive or have received industrial effluents are Acid-Pueblo, DP-Los Alamos, Sandia, and Mortandad. Samples were collected from surface water stations or shallow observation holes completed in the alluvium (Fig. 12, Tables E-XVII through E-XX). Maximum concentrations of radioactivity in each of the four canyons is given in Table VII. Radioactivity observed (Table E-XVII) in Acid-Pueblo Canyon results from residuals of treated and untreated radioactive liquid waste effluents released into the canyon before 1964. Radionuclides that were adsorbed by channel sediments are now being resuspended by runoff and municipal sanitary effluents.

Sandia Canyon receives cooling tower blowdown from the TA-3 power plant and some sanitary effluent from the TA-3 areas (Table E-XVIII). DP-Los Alamos Canyon receives industrial effluents that contain low levels of radionuclides and some sanitary effluents from TA-21 (Table E-XIX). Mortandad Canyon receives treated industrial effluent containing radionuclides (Table E-XX). Water in these canyons contain radionuclides as the result of effluent from the treatment plants.

Acid-Pueblo, DP-Los Alamos, and Mortandad Canyons all contain surface and ground water with measurable amounts of radioactivity that are well below CGs for controlled areas. Surface and ground waters of these canyons are not a source of municipal, industrial, or agricultural supply. Surface waters in these canyons normally infiltrate into alluvium of stream channels within the Laboratory's boundaries. Only during periods of heavy precipitation or snowmelt does water from Acid-Pueblo and DP-Los Alamos Canyons reach the Rio Grande. In Mortandad Canyon, there has been no surface water runoff past the Laboratory's boundary since hydrologic studies in the canyon began in 1960, three years before release of any industrial effluents.

c. Water Supply. The municipal and industrial water supply for the Laboratory and community is from 15 deep wells (in 3 well fields) and 1 gallery (underground collection basin for spring discharge). The wells are located on Pajarito Plateau and in canyons east of the Laboratory (Fig. 12). Water is pumped from the main aquifer, which lies about 350 m below the surface of the Plateau. The gallery discharges from a perched water zone in the volcanics west of the Plateau. During 1980, production from the wells and gallery was about 6.1×10^6 m^3, with the wells furnighing about 97% of the total production and the gallery about 3%. Water samples were collected from the wells and gallery and at 6 stations on the distribution system. The 5 stations on the distribution system are located within the Laboratory and community, while the sixth is located at Bandelier (Fig. 12, Table E-XII). The water supply distribution system at TA-57, the Fenton Hill Geothermal Site, was also sampled.

Detailed radiochemical analyses of water from the wells, gallery, and distribution system (including Fenton Hill) are presented in Table E-XXI. A comparison of maximum concentrations found in these waters with the EPA's National Interim Primary Drinking Water Standards[6] is given in Table VII.

Radioactivity occurring in the water supply is low and naturally occurring. One ^{239}Pu analyses from well LA-1B contained a detectable amount ($0.125 \pm 0.060 \times 10^{-9}$ μCi/mℓ) of plutonium that is attributed to contamination of the sample during collection or processing during analysis. Water from the well has shown no previous detectable levels of plutonium. Other plutonium analyses were at or below limits of detection.

Samples from the water distribution system showed gross alpha activity lower than the EPA screening limit (see Appendix A). One well (LA-1B, Los Alamos field) contained natural alpha activity about 80% greater than

TABLE VII

MAXIMUM RADIOACTIVITY IN SURFACE AND GROUND WATER FROM OFFSITE, ONSITE, AND WATER SUPPLY STATIONS

	No. of Stations	^{137}Cs (10^{-9} μCi/mℓ)	^{241}Am (10^{-9} μCi/mℓ)	^{90}Sr (10^{-9} μCi/mℓ)	^{238}Pu (10^{-9} μCi/mℓ)	^{239}Pu (10^{-9} μCi/mℓ)	Gross Alpha (10^{-9} μCi/mℓ)	Gross Beta (10^{-9} μCi/mℓ)	^{3}H (10^{-6} μCi/mℓ)	Total U (μg/ℓ)
Offsite Stations (Uncontrolled Areas)										
Concentration Guides for Uncontrolled Areas[a]		20 000	4 000	300	5 000	5 000	5 000	300	3 000	1 800
Regional	6	90	---	1.6	<0.045	0.050	18	22	1.5	3.7
Perimeter	8	<140	---	0.9	<0.110	<0.110	29	30	0.9	31
White Rock Canyon										
Group I Springs	9	<154	---	0.9	<0.050	<0.060	<3.3	6.3	0.6	1.8
Group II Springs	11	<208	---	<2.2	<0.035	<0.050	1.5	26	0.6	2.2
Group III Springs	2	<125	---	0.9	<0.110	<0.080	1.6	4.7	<0.4	18
Group IV Springs	3	<134	---	<1.8	<0.036	<0.042	14	11	<1.1	18
Streams	3	<174	---	<1.0	<0.043	<0.050	1.5	19	<1.1	1.4
Onsite Stations (Controlled Areas)										
Concentration Guides for Controlled Areas[a]		400 000	100 000	10 000	100 000	100 000	100 000	10 000	100 000	60 000
Noneffluent Areas	10	<136	0.14	1.3	<0.070	<0.057	6.2	7.9	1.8	1.2
Effluent Areas										
Acid—Pueblo	7	<110	0.23	61	<0.072	2.58	69	260	19	12
DP—Los Alamos	8	<219	4.7	137	0.620	1.61	520	320	24	63
Sandia	3	43	<0.12	1.3	<0.049	<0.045	5.3	31	24	1.7
Mortandad	8	1.63	62	58	5.60	11.5	106	320	103	6.8
Water Supply										
Maximum Contaminant Levels[b]		200	---	8	7.5	7.5	15[c]	---	20	1 800[d]
Wells and Gallery	17	<130	---	1.1	<0.047	0.125	10	5.6	0.9	6.4
Distribution	7	<140	---	1.2	<0.029	0.060	<4.2	3.4	0.6	3.2

[a]DOE Manual Chapter 0524, Annex A.

[b]EPA's National Interim Primary Drinking Water Regulations.

[c]The EPA's MCL for gross alpha is 15×10^{-9} μCi/mℓ. However, exceeding EPA's screening limit of 5×10^{-9} μCi/mℓ gross alpha in the distribution system requires isotopic analyses to determine radium content.

[d]Level recommended by the International Commission on Radiological Protection.

Note: The < value represents analytical value plus twice the uncertainty term for that analysis.

the screening limit. Dilution by water from the other wells results in concentrations at points of use (distribution system) that meet the EPA's criteria for municipal supply.

4. Radioactivity in Soils and Sediments

Soil samples were collected from 33 stations and sediment samples from 60 stations in and adjacent to the Los Alamos area. Concentrations of ^{137}Cs from one regional soil station and ^{90}Sr from one regional sediment station were slightly above worldwide fallout levels. Five soil and seven sediment perimeter stations, and thirteen soil and sixteen sediment onsite stations contained concentrations of radioactivity in excess of normal or fallout levels. Concentrations of radioactivity from these stations are less than twice the normal or fallout levels, except in areas where treated radioactive effluents are released.

a. Regional Soil and Sediments. Regional soils are collected in the same general locations as regional waters (Fig. 7). Regional sediments are also collected at the same general locations with additional samples collected from Otowi to Cochiti from the Rio Grande. The exact locations are presented in Table E-XXII (see Appendix B.3 for methods of collection, analysis, and reporting of soil and sediment data) and detailed results are in Table E-XXIII.

Regional and perimeter soil and sediment radiochemical data collected from 1974 through 1978 are used to distinguish background radioactivity (from natural and worldwide fallout) from atmospheric nuclear weapons tests.[7] These criteria are used for comparison using the mean plus twice the standard deviation for a number of analyses for a certain radionuclide from 1974 through 1977 (Table VIII). The mean plus twice the standard deviation includes approximately 95% of the population of the samples.

Maximum concentrations of radionuclides in regional samples were near or below concentrations for natural and worldwide fallout levels, except for one soil sample analyzed for ^{137}Cs from Otowi (7% above fallout levels) and for one sediment sample analyzed for ^{90}Sr from the Jemez River near Jemez Pueblo (39% above fallout levels). These concentrations are low and are probably due to variability in worldwide fallout.

b. Perimeter Soils and Sediments. Eight perimeter soil stations were sampled in areas within 4 km of the Laboratory. Nineteen sediment samples were collected from major intermittent streams that cross Pajarito Plateau. Locations of the stations are described in Table E-XXII and are shown in Fig. 14. Detailed analyses are shown in Table E-XXIV.

Soil analyses from perimeter stations indicated that ^{137}Cs concentrations from five stations, a ^{90}Sr concentration from one station, and ^{239}Pu concentrations from two stations were above natural background and fallout concentrations, but were low. The ^{239}Pu concentrations may be the result of airborne emissions from the Laboratory. Similar concentrations were reported during a study in 1970.[8] At a few stations, gross alpha (one station), gross beta (five stations), and total U (one station) slightly exceed background activity (Tables E-XXIV and VIII).

Sediment analyses indicated that ^{137}Cs from two stations, ^{90}Sr from two stations, ^{238}Pu from four stations, ^{239}Pu from six stations, and gross alpha from two stations were above background in Acid-Pueblo and lower Los Alamos Canyons. Industrial effluents were released into Acid-Pueblo Canyon before 1964 and residual radionuclides remain there. Concentrations in lower Los Alamos Canyon (Totavi to the Rio Grande) reflect transport by intermittent storm runoff from Acid-Pueblo Canyon and from onsite release of industrial effluents into DP-Los Alamos Canyon. The concentrations decrease downgradient in the canyons (Table E-XXIV).

c. Onsite Soil and Sediments. Onsite soil samples were collected from 19 stations within Laboratory boundaries. Sediment samples were collected from 32 stations within the boundaries (Fig. 13, Table E-XXII). Analytical results are shown in Table E-XXV and maximum concentrations in Table VIII.

Soil analyses indicated that concentrations of ^{137}Cs from seven stations, ^{90}Sr from three stations, ^{238}Pu from

TABLE VIII

MAXIMUM RADIOACTIVITY IN SOILS AND SEDIMENTS
FROM REGIONAL, PERIMETER, AND ONSITE STATIONS

	No. of Stations	^{137}Cs (pCi/g)	^{90}Sr (pCi/g)	^{238}Pu (pCi/g)	^{239}Pu (pCi/g)	Gross Alpha (pCi/g)	Gross Beta (pCi/g)	Total U (μg/g)	^{3}H (10^{-6} μCi/mℓ)
Maximum Natural and Worldwide Fallout for New Mexico[a]		0.92	0.79	0.008	0.028	11	11	4.4	27[b]
Regional Station									
Soil	6	1.04 (1)	0.63	<0.005	0.017	7.3	8.9	3.1	2.5
Sediments	9	0.40	1.1 (1)	<0.003	0.009	11	11	4.6	---
Perimeter Stations									
Soils	8	1.29 (5)	2.9 (1)	<0.005	0.169 (2)	14 (1)	21 (5)	4.9 (1)	14.
Sediments	19	1.74 (2)	1.23 (2)	0.060 (4)	13.5 (6)	17 (2)	9.2	3.1	---
Onsite Stations									
Soils	19	3.50 (7)	1.10 (3)	2.59 (2)	0.610 (4)	18 (10)	26 (13)	8.2 (7)	25.5
Sediments	32	1850 (10)	23.5 (7)	14.6 (11)	46.3 (16)	100 (5)	1020 (9)	7.5 (2)	---

[a]Maximum value ($\bar{x}$ + 2s) for soils and sediments 1974-77 (Ref. 7).

[b]($\bar{x}$ + 2s) for regional soils 1978.

Note: Numbers in parentheses indicate number of station exceeding maximum natural and worldwide fallout concentrations for northern New Mexico. The < value represents analytical value plus twice the uncertainty term for that analysis.

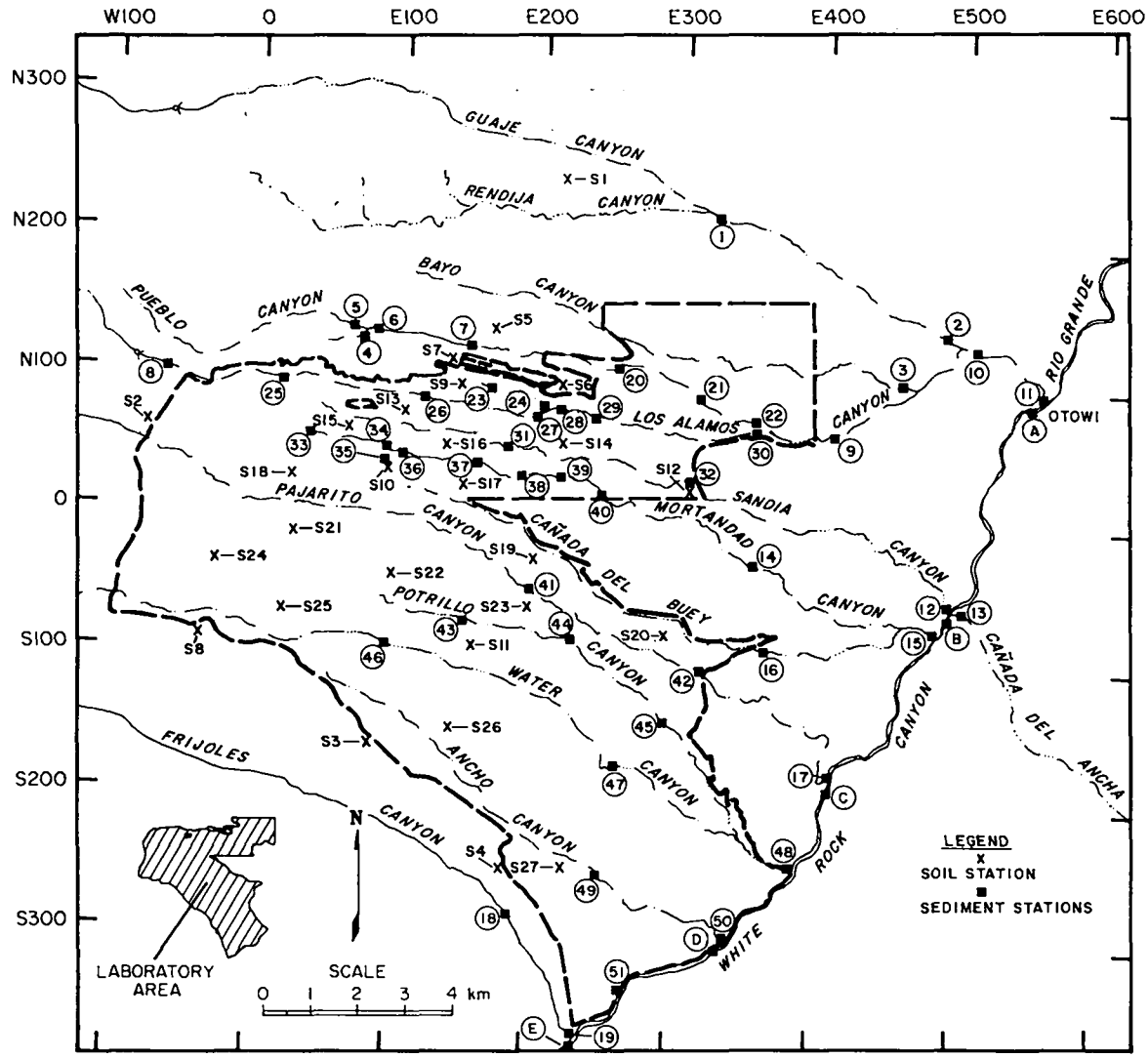


Fig. 14.
Soil and sediment sampling locations on or near the Laboratory.

two stations, ^{239}Pu from four stations, gross alpha from ten stations, gross beta from thirteen stations, and total U from seven stations were above normal or worldwide fallout levels.

Sediment stations in Acid-Pueblo, DP-Los Alamos, and Mortandad Canyons contained radionuclides above background levels (Table E-XXV). These canyons have or are now receiving treated industrial liquid effluents. Radionuclides in effluents are adsorbed or attached to sediment particles in the alluvium and their concentrations are highest near effluent outfalls. They decrease in concentration downgradient in the canyon as sediments and radionuclides are transported and dispersed by other industrial effluents, sanitary effluents, and periodic storm runoff.

d. Radionuclide Transport in Snowmelt Runoff, Spring 1980. The major transport of radionuclides from canyons receiving treated liquid radioactive effluents is in storm runoff (solution and suspended sediments). During the spring of 1980, snowmelt runoff samples were collected in Los Alamos Canyon at State Road 4 (SR-4, Laboratory boundary) and Totavi. Control samples were

TABLE IX

PLUTONIUM CONCENTRATIONS IN SOLUTION AND SUSPENDED SEDIMENTS IN SNOWMELT RUNOFF IN LOS ALAMOS CANYON

	No. of Analyses	^{238}Pu	^{239}Pu
Solution (10^{-9} μCi/mℓ)			
Control—Guaje Canyon	2	0.013 ± 0.030	−0.002 ± 0.012
Los Alamos Canyon at SR-4	7	−0.002 ± 0.029	0.013 ± 0.022
Los Alamos Canyon at Totavi	1	0.000 ± 0.040	0.017 ± 0.032
Suspended Sediments (pCi/g)			
Control—Guaje Canyon	2	−0.04 ± 0.13	0.10 ± 0.28
Los Alamos Canyon at SR-4	7	0.27 ± 0.23	5.1 ± 5.4
Los Alamos Canyon at Totavi	1	0.12 ± 0.14	3.3 ± 1.6

collected in Guaje Canyon. Snowmelt runoff at the gaging station near SR-4 lasted 30 days at a mean discharge of 43 ℓ/sec. About 1.01×10^5 m^3 of water passed through the station. The flow extended down the canyon to Totavi. Flow loss into the alluvium precluded any water reaching the Rio Grande.

Samples of runoff were collected and analyzed for plutonium in solution and suspended sediments (Table IX). There was little, if any, plutonium transported in solution compared to that transported in suspended sediments. It is apparent that plutonium in suspended sediments is Los Alamos Canyon is being transported in snowmelt runoff.

5. Radioactivity in Foodstuffs

Fruit, vegetable, fish, and honey samples collected in the vicinity of the Laboratory showed no apparent influence from Laboratory operations, except for apples, honey from experimental hives, and peaches collected onsite near facilities that emit tritium.

a. **Introduction.** Fruit, vegetable, fish, and honey samples were collected during the fall to monitor foodstuffs for possible radioactive contamination from Laboratory operations. Fruits and vegetables were collected in the Los Alamos area and in the Rio Grande valley above and below confluences of intermittent streams that cross the Laboratory and flow into the Rio Grande (see Fig. 7). Fish were collected from locations above (Abiquiu and El Vado reservoirs that are on the Rio Chama, a tributary of the Rio Grande) and below (Cochiti) confluences of these intermittent streams. Fish samples from the Pecos area, about 25 km east of the Laboratory, were also analyzed. Fish samples were taken from bottom feeders, such as catfish and suckers, which have a

greater probability than higher tropic orders of ingesting any activity that might be associated with sediments, as well as higher level feeders. Honey was collected from hives established in 1978 at several locations within the Laboratory boundary near waste stream outfalls and a tritium facility. Background samples came from other Laboratory locations, Barranca Mesa (in Los Alamos), Pajarito Acres, and Chimayo, New Mexico.

Fruit and vegetable samples were analyzed for tritiated water (HTO), ^{90}Sr, ^{238}Pu, ^{239}Pu, and total U. Fish sample analyses included ^{238}Pu, ^{239}Pu, ^{137}Cs, and total U. Honey samples were analyzed for HTO , ^{7}Be, ^{22}Na, ^{137}Cs, and total U.

b. Fruits and Vegetables. Data presented in Tables X, XI, and XII summarize fruit and vegetable sample results for tritium, strontium, uranium, and plutonium according to different water supplies. Sample moisture ranged from 61% to 98% of total sample weight. With the exception of onsite samples (TA-35 and TA-21) there was no significant difference in HTO content among any of the batches of samples analyzed. Observed concentrations are within the range of values measured in local surface water and atmospheric water vapor. Thus, there is no indication of any measurable offsite contribution from Laboratory operations.

The tritium content of peaches at TA-35 was similar to previously reported relatively higher values at that location.[9,10] TA-35 releases tritium at the Laboratory (see Table E-XXVI). Elevated HTO concentrations were also measured in apples and peaches from trees located near a facility in TA-21, where tritium operations are conducted and where tritium is released. These few peaches and apples do not represent a significant pathway to man because they are within a Laboratory fence, represent a very small volume of edible material, and have considerably less tritium than the uncontrolled area CG for water (3000×10^{-6} μCi/mℓ).

None of the samples collected had measurable ^{238}Pu (i.e., where the 2s measurement uncertainty was less than the measured value). Only one sample, a peach from a fenced area of TA-21, had detectable ^{239}Pu activity. Foodstuffs from this area, as discussed above, are not a significant source of exposure to man. Ingestion of 395 kg (wet weight)/yr (consumption rate for the maximum exposed individual[10]) of fruits and vegetables having the highest average ^{239}Pu concentration measured offsite at 0.8×10^{-3} pCi/g (0.1×10^{-3} pCi/g wet weight) gives a 50-yr dose commitment to bone of 0.065 mrem, 0.004% of the RPS. The magnitude of these offsite concentrations and doses indicate that they are due to fallout or

TABLE X

TRITIATED WATER CONTENT OF FRUITS AND VEGETABLES

Location	Water Source	No. of Samples	Tritiated Water Concentration (10^{-6} μCi/mℓ) Average (±1s)	Range	Average Moisture (%)
Española	Rio Grande[a]	5	−0.30 ± 0.42	−0.9 to 0.2	89 ± 12
Española	Rio Chama[a]	5	−0.40 ± 0.31	−0.8 to 0.0	85 ± 15
Cochiti	Rio Grande[b]	5	−0.34 ± 0.32	−0.6 to 0.1	91 ± 8
Los Alamos	Community System	3	0.37 ± 0.12	0.3 to 0.5	80 ± 5
Pajarito Acres	Community System	5	−0.30 ± 0.12	−0.4 to −0.1	87 ± 10
White Rock	Community System	2	−0.50 ± 0.0	---	94 ± 1
TA-35	Community System	1	21.5	---	86
TA-21	Precipitation	2	3.1 ± 1.5	2.0 to 4.1	80 ± 2
TA-46	Community System	2	0.35 ± 0.21	0.2 to 0.5	86 ± 9

[a]Upstream from Laboratory stream confluence.
[b]Downstream from Laboratory stream confluence.

TABLE XI

PLUTONIUM CONTENT OF FRUITS AND VEGETABLES

Location	Water Source	No. of Samples	^{238}Pu (10^{-3} pCi/g)[c] Average (±1s)	^{238}Pu (10^{-3} pCi/g)[c] Range	^{239}Pu (10^{-3} pCi/g)[c] Average (±1s)	^{239}Pu (10^{-3} pCi/g)[c] Range
Española	Rio Grande[a]	5	0.7 ± 2.6	−1.6 to 5.3	−3.1 ± 5.2	−12 to −0.19
Española	Rio Chama[a]	5	−0.03 ± 0.95	−1.1 to 1.3	0.8 ± 1.3	−0.5 to 2.7
Cochiti	Rio Grande[b]	5	1.0 ± 2.9	−1.5 to 6.0	0.20 ± 1.4	−1.5 to 2.0
Los Alamos	Community System	3	−0.33 ± 0.38	−0.5 to 0.1	−0.13 ± 0.75	−0.9 to 0.60
Pajarito Acres	Community System	5	0.29 ± 0.72	−0.6 to 1.0	−0.33 ± 0.65	−1.0 to 0.60
White Rock	Community System	2	−2.05 ± 0.92	−2.7 to −1.4	−1.3 ± 1.1	−2.1 to −0.50
TA-35	Community System	1	−0.50	---	−0.40	---
TA-21	Precipitation	2	−0.02 ± 0.17	−0.14 to 0.10	32 ± 45	−0.10 to 64
TA-46	Community System	1	1.0	---	−4.0	---

[a]Upstream from Laboratory stream confluence.
[b]Downstream from Laboratory stream confluence.
[c]Dry weight.

TABLE XII

URANIUM AND ^{90}Sr CONTENT OF FRUITS AND VEGETABLES

Location	Water Source	No. of Samples	Uranium (ng/g)[c] Range	^{90}Sr (pCi/g)[c] Average (±1s)	^{90}Sr (pCi/g)[c] Range
Española	Rio Grande[a]	5	0.0 to 15.8	0.060 ± 0.060	−0.002 to 0.15
Española	Rio Chama[a]	5	<70	0.076 ± 0.13	−0.027 to 0.29
Cochiti	Rio Grande[b]	5	<70	0.027 ± 0.062	−0.036 to 0.13
Los Alamos	Community System	3	0.0 to 4.3	0.035 ± 0.014	0.020 to 0.048
Pajarito Acres	Community System	5	<48	0.038 ± 0.076	−0.021 to 0.16
White Rock	Community System	2	<30	0.011 ± 0.059	−0.031 to 0.053
TA-35	Community System	1	18.7	−0.005	---
TA-21	Precipitation	2	0.0 to 8.4	0.000 ± 0.007	−0.005 to 0.005
TA-46	Community System	2	<20	−0.004 ± 0.006	−0.008 to 0.0

[a]Upstream from Laboratory stream confluence.
[b]Downstream from Laboratory stream confluence.
[c]Dry weight.

soil contamination on plant surfaces, and not due to Laboratory effluents.

The ^{90}Sr concentrations are low and vary widely. Both the highest single value and highest mean value were obtained at a regional location, upstream from the Laboratory and beyond the influence of airborne material. These levels are apparently due to fallout and not related to Laboratory operations.

Most uranium values were at less than detectable levels. The highest measured value, found in peaches at TA-35, was 18.7 parts per billion (ppb), and does not represent a significant pathway to man. The highest offsite value was 15.8 ppb, measured in a chili sample at a background location. Eating 20 kg (wet weight) of chili at 15.8 ppb (1.9 ppb wet weight) of uranium would result in a 50-yr dose commitment to bone, the critical organ, of 0.09 mrem, or 0.01% of the RPS for bone.

c. Fish. Data on radioactivity in fish are presented in Table XIII. For all determinations, the fish were analyzed on samples containing both flesh and bone.

Low levels of ^{137}Cs were detected in 13 of the 30 samples analyzed; levels in the remaining 17 samples were less than the minimum level of detection. Results were

TABLE XIII

RADIOACTIVITY IN FISH

Location	Type of Sample	No. of Samples	Data Range[d] Total Uranium (ng/g)	^{238}Pu (10^{-3} pCi/g)	^{239}Pu (10^{-3} pCi/g)	^{137}Cs (pCi/g)
Cochiti[a]	Walleye guts	1	<52 (0)[e]	0.48 (1)	22.5 (1)	0.2 (0)
	Channel guts	1	<66 (0)	−0.19 (0)	0.52 (0)	0.2 (0)
	Bullhead guts	1	115 (1)	0.20 (0)	3.1 (1)	0.6 (0)
	Bottom feeders	4	<86 (0)	−0.04 to 0.05 (0)	−0.10 to 0.05 (0)	0.0 to 1.0 (1)
	Higher level	2	<78 (0)	−0.09 to 0.03 (0)	0.74 to 14.5 (2)	0.06 to 0.07 (0)
Abiquiu[b]	Trout guts	1	<52 (0)	−0.03 (0)	0.01 (0)	2.2 (1)
	Bass guts	1	<54 (0)	−0.17 (0)	−0.04 (0)	0.5 (0)
	Channel guts	2	0.0 to 50 (1)	−0.3 to 0.1 (0)	0.15 to 0.40 (0)	0.9 to 3.7 (2)
	Bottom feeders	4	<94 (0)	−0.12 to 0.1 (0)	−0.14 to 0.11 (0)	0.4 to 0.9 (4)
	Higher level	4	<74 (0)	−0.09 to 0.03 (0)	−0.06 to 0.03 (0)	0.03 to 1.5 (2)
El Vado[b]	Trout guts	2	0.0 to 86 (1)	−0.2 to −0.1 (0)	−0.1 to 0.3 (0)	0.3 to 0.4 (0)
	Sucker guts	1	<72 (0)	0.1 (0)	6.3 (1)	0.0 (0)
	Bottom feeders	2	<86 (0)	−0.17 to −0.04 (0)	−0.11 to 0.06 (0)	0.0 (0)
	Higher level	2	<72 (0)	−0.03 to 0.02 (0)	−0.07 to −0.04 (0)	0.0 to 1.0 (1)
Pecos[c]	Trout guts	1	<62 (0)	−1.8 (0)	9.9 (1)	3.7 (1)
	Trout	1	<74 (0)	0.04 (0)	0.11 (0)	0.4 (1)

[a]Below confluence of the Rio Grande with intermittent Laboratory streams.
[b]Above confluence of the Rio Grande with intermittent Laboratory streams.
[c]Located in Pecos River drainage area.
[d]Concentrations are based on tissue weight after oven drying.
[e]Number in parentheses indicates number of samples >MDL.

scattered, with mean values from areas not influenced by Laboratory operations being slightly higher than those downstream from the Laboratory.

One sample had a detectable level of ^{238}Pu, found in a walleye gut sample from Cochiti, which indicates ingestion of sediments. Six samples had low but detectable levels of ^{239}Pu (four from Cochiti, one from El Vado, and one from Pecos). Four of these six samples were from the gut. Though these ^{239}Pu levels were detectable, statistical tests showed no significant difference between ^{239}Pu concentrations in samples in background areas and those downstream from the Laboratory. Whatever the cause, any dose associated with these concentrations is small. Consumption of 21 kg (wet weight) of fish at the highest ^{239}Pu level found in edible muscle at 14.5×10^{-3} pCi/g (3.7×10^{-3} pCi/g wet weight) would give a 50-yr dose commitment to bone of 0.062 mrem, or 0.004% of the RPS.

Three uranium values were above detection limits. All three values were found in gut samples, indicating ingestion of sediment. The difference between the one sample at detectable levels at Cochiti, and the two at background locations, is within the limits of analytical variability.

In summary, no statistically significant differences between mean concentrations in fish from background areas and from Cochiti were found for any of the radionuclides monitored by the sampling program.

d. Honey. Honey samples were analyzed for HTO, ^{7}Be, ^{22}Na, ^{137}Cs, and total U. Results are shown in Table XXIV. With the exception of HTO analyses, one ^{22}Na and one U result, all samples had less than detectable levels (i.e,, the 2s measurement uncertainty was less than the measured value) for the monitored radionuclides. If a person ate 5 kg of honey from the hive with the maximum HTO concentration (found at TA-33), the whole body dose would be 0.019 mrem, which is 0.004% of the RPS for members of the public. Doses due to ^{22}Na and total U were smaller, amounting to 0.00008% and 0.00001% of the respective RPSs.

6. Radioactive Effluents

Quantities of airborne radioactive effluents released from Laboratory operations in 1980 were lower for all radionuclides, except argon, beryllium, americium, and other activation products when compared to 1979. These increases are primarily due to programmatic activities at the LAMPF. Liquid effluents from three waste treatment plants contained radioactivity at levels well below controlled area CGs.

Effluents containing radioactivity are discharged at the Laboratory as airborne materials in stack exhausts at 12 of the technical areas and as liquid discharges from 2 industrial waste treatment plants and 1 sanitary sewage lagoon system. The airborne effluents consist principally of filtered ventilation exhausts from gloveboxes, other experimental facilities, some process facilities such as the liquid waste treatment plants, exhausts from the research reactor, and exhausts from the linear accelerator at the LAMPF. Releases of various isotopes from the technical areas are detailed in Table E-XXVI. Quantities of radioactivity released depend on research programs conducted, so vary significantly from year-to-year (see Figs. 15-17).

Routine airborne releases of tritium (7506 Ci lower, 50% lower) and plutonium (341 μCi lower, 31% lower) were both lower when compared to quantities released during 1979 (see Figs. 15 and 16). The plutonium releases were lower due to improved filtration of the effluent from one wing of an experimental building in the main technical area (TA-3). Americium releases (0.042 μCi higher, 221% higher) were somewhat higher, but represent a miniscule amount of the total radioactivity annually released at the Laboratory.

Routine airborne releases of ^{41}Ar (243 Ci higher, 34% higher), ^{7}Be (9.6 μCi higher, 369% higher), and other activation products (^{11}C, ^{13}N, ^{15}O; 26 800 Ci higher, 23% higher) were higher when compared to quantities released during 1979 (see Fig. 16). These increases are due to increased programmatic activities at the LAMPF. The half-lives of ^{11}C, ^{13}N, and ^{15}O range from 2 to 20 minutes, so they decay very rapidly. The half-life of ^{41}Ar is 1.83 hours, so it too decays quickly. The half-life of ^{7}Be is 54 days, so persists longer in the environment.

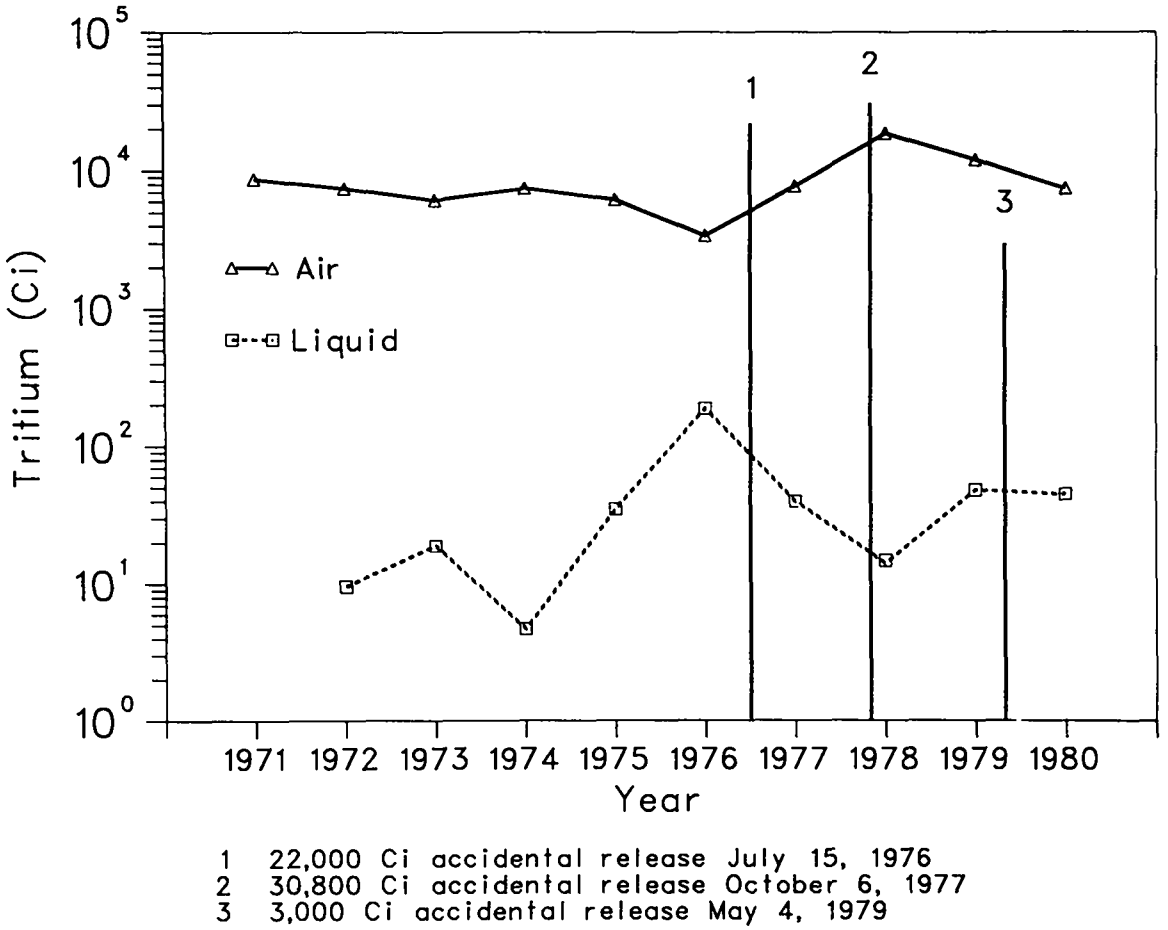


Fig. 15.
Summary of tritium effluents (air and liquid).

In addition to airborne releases from stacks, some depleted uranium (uranium consisting almost entirely of ^{238}U) is dispersed by experiments employing conventional high explosives. In 1980, about 881 kg of depleted uranium were used in such experiments. Based on known isotopic composition, this mass is estimated to contain approximately 0.31 Ci of activity. Most debris from these experiments is deposited on the ground in the vicinity of the firing point. Limited experimental information indicates that no more than about 10% of the depleted uranium becomes airborne. Approximate dispersion calculations indicate that resulting airborne concentrations would be in the same range as attributable to natural crustal-abundance uranium in resuspended dust. This theoretical evaluation is compatible with the concentrations of atmsopheric uranium measured by the routine air sampling network (see Section III.A.2). Estimates of nonradioactive releases from these experiments are discussed in Section III.B.3.

Treated liquid effluents containing low levels of radioactivity are released from the Central Liquid Waste Treatment Plant (TA-50), a smaller plant serving the old plutonium processing facility (TA-21), and two sanitary sewage lagoons serving the LAMPF. Detailed results of the effluent radioactivity monitoring are in Table E-XXVII and Figs. 15, 17, and 18. Changes in total releases in 1980 compared to 1979 were as follows: plutonium (7.15 mCi higher, 298% higher), americium (0.485 mCi higher, 9% higher), strontium (38.754 mCi, 191% higher), tritium (11 838 mCi higher, 36% higher), cesium (38.496 mCi lower, 77% lower), and uranium (1.72 mCi lower, 66% lower). These increases were due mostly to higher quantities of radioactivity in process wastes from the Plutonium Processing Facility (TA-55)

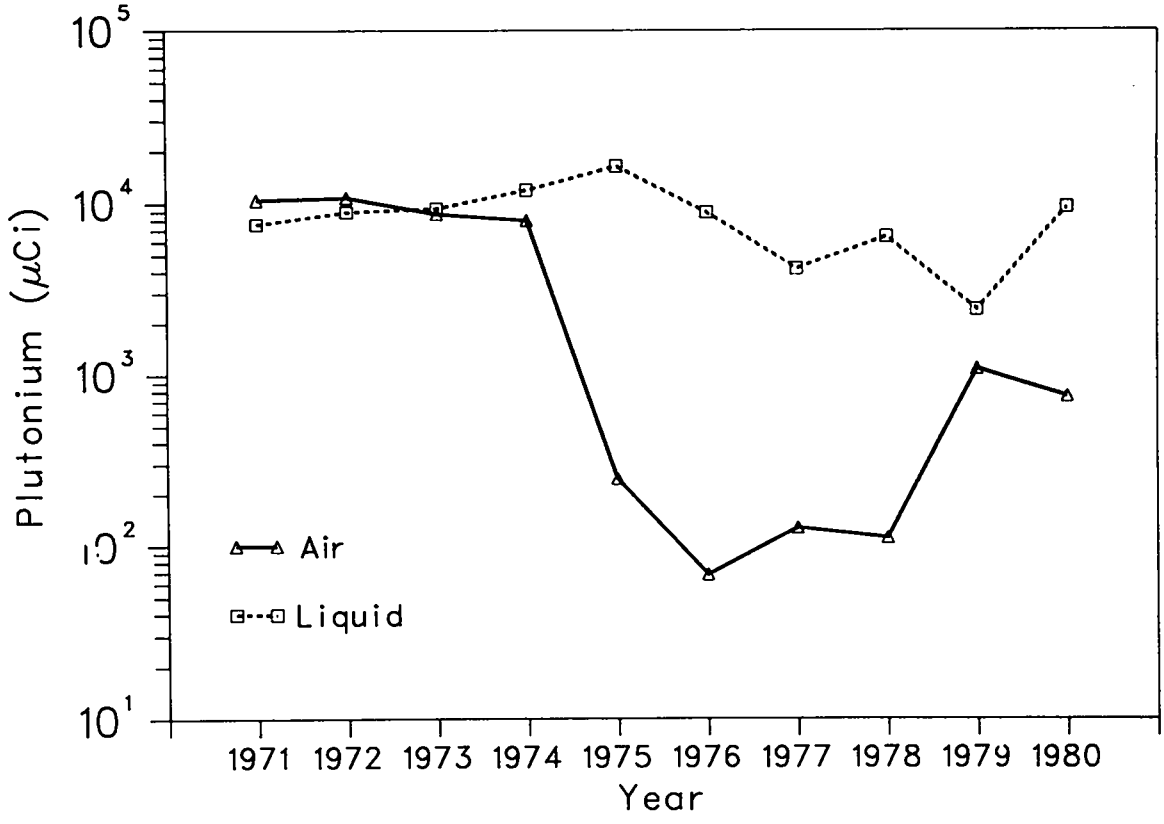


Fig. 16.
Summary of plutonium effluents (air and liquid).

and were treated at the TA-50 Liquid Waste Treatment Plant. Design work is underway for upgrading TA-50, which will reduce the amount of contaminants in its effluent.

A total of 1.985×10^7 ℓ of effluent was discharged from the TA-53 sanitary lagoons containing 0.12 Ci of ^{22}Na, 2.4 Ci of ^{7}Be, and 16.6 Ci of ^{3}H. The source of the radioactivity was activated water from beam-stop cooling systems. None of the concentrations were at concentrations higher than about 0.9% of CGs for water in controlled areas. Samples of water, sediments, and transpirate from trees adjacent to the discharge from the lagoons have been collected this year and the results of this sampling program are discussed in Section IV.C.3.

Releases from the larger plant (TA-50) are discharged into a normally dry stream channel (Mortandad Canyon) in which surface flow has not passed beyond the Laboratory boundary since before the plant began operation. Discharges from the smaller plant (TA-21) are into DP Canyon, a tributary of Los Alamos Canyon where runoff does at times flow past the boundary and transports some residual activity adsorbed on sediments. Effluent from the LAMPF lagoons sinks into alluvium within the Laboratory boundary.

7. Unplanned Releases

The first unplanned release occurred on December 12, 1979, but was not in last year's report because analytical results were not completed in time for inclusion in that report. This release was of about 950 ℓ of primary coolant water from the Omega West Reactor at TA-2. The water spilled while piping was removed from a deionizer and it drained into nearby Los Alamos Creek, which was dry at the time. The water seeped into the creek bed completely within the TA-2 compound. Gamma spectral results from collected sediment and water samples showed the presence of ^{3}H, ^{24}Na, ^{51}Cr, ^{54}Mn, ^{58}Co, ^{59}Fe, ^{60}Co, ^{65}Zn, ^{99m}Tc, ^{110m}Ag, ^{137}Cs, ^{140}Ba-^{140}La, ^{40}K, and ^{91}Sr. The highest concentrations in any of

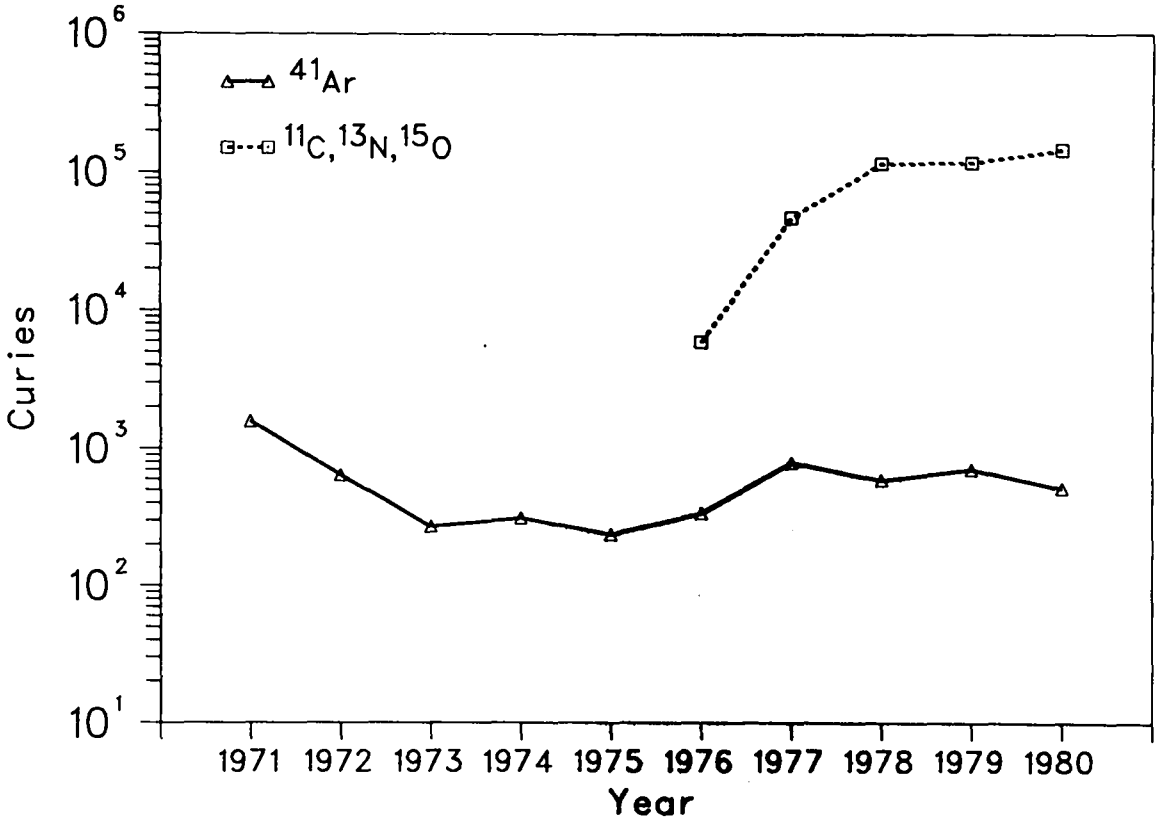


Fig. 17.
Summary of atmospheric releases of ^{41}Ar, ^{11}C, ^{13}N, and ^{15}O.

the sediment samples was 695 pCi/g of ^{24}Na (15 h half-life). The highest concentration found in water released to Los Alamos Creek was 289 × 10^{-6} mCi/mℓ of ^{3}H (12.3 yr half-life), which is 0.3% of the controlled area CG.

The second unplanned release was on April 11, 1980, and was a tritium leak to the atmosphere at TA-35-2. The leak could not be stopped easily, was composed of ~75% tritiated water vapor (HTO) and ~25% tritium gas (HT), was slow (initially ~0.67 Ci/h), and eventualy released 20 to 25 Ci. The leak rate slowly diminished until ending on April 18. On April 21, pressure in a surge tank was bled to the atmosphere, causing an additional release of ~150 mCi. Tritium sampling cartridges at six air sampling stations in the routine air sampling network and near the release were analyzed for HTO. Measured HTO concentrations at all six stations were well within the expected range of values typically seen throughout the year. Using the highest HTO concentration measured of 22 × 10^{-6} μCi/mℓ, the dose from the release to residents living near the station where this concentration was measured was estimated to be <0.001 mrem.

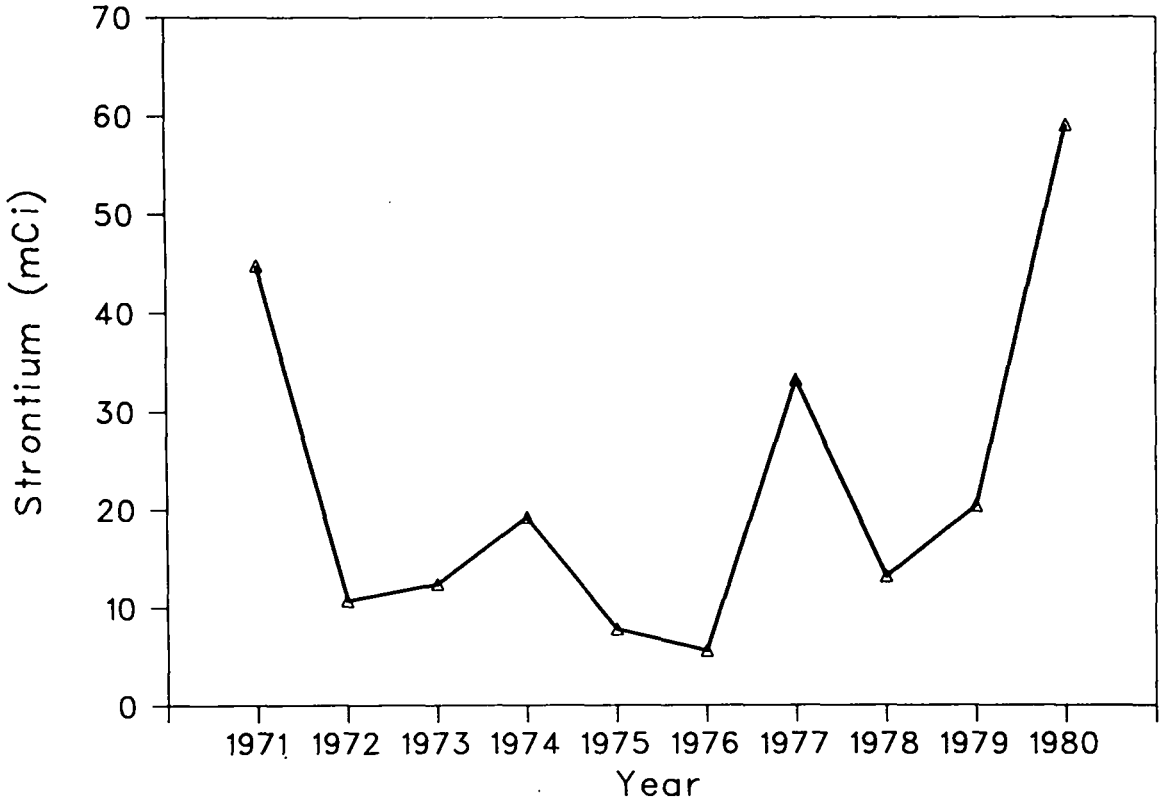


Fig. 18.
Summary of strontium liquid effluents.

B. Chemical Constituents

1. Chemical Quality of Surface Waters, Ground Waters, and Water Supply

Chemical analyses of surface and ground waters from regional, perimeter, and onsite noneffluent release areas varied slightly from previous years; however, these variations in concentrations were within the normal range of seasonal fluctuations. Chemical quality of water from the municipal supply for the Laboratory and community meets the standards set by the EPA and New Mexico Environmental Improvement Division. Analyses from onsite effluent release areas indicated that some constituents were higher than in naturally-occurring waters; however, these waters are not a source of municipal, industrial, or agricultural supply. The federally-owned well field produced water for the Laboratory and County. Water samples from the distribution system met all applicable EPA standards.

a. Regional and Perimeter Surface and Ground Waters. Regional and perimeter surface and ground waters were sampled at the same locations as were used for radioactivity monitoring (Table E-XII). The regional surface waters were sampled at 6 stations, with perimeter waters sampled at 8 stations plus 28 stations in White Rock Canyon (Figs. 7, 12, and 13). Detailed analyses from the regional, perimeter, and White Rock stations are presented in Tables E-XIII, E-XIV, and E-XV,

TABLE XIV

MAXIMUM CHEMICAL CONCENTRATIONS IN SURFACE AND GROUND WATERS

	No. of Stations	mg/ℓ						
		Ca	Mg	Na	Cl	F	NO_3	TDS
Standard or Criteria[a]	---	---	---	250	250	2.0	45	1000
Regional Stations	6	39	8	61	68	1.3	1.7	300
Perimeter Stations	8	29	6	23	15	0.5	13	534
White Rock Stations								
Group I	9	34	4	19	7	0.7	5.6	240
Group II	11	17	3	23	5	0.6	3.8	220
Group III	2	19	1	61	5	1.2	1.5	380
Group IV	3	81	23	143	5	1.6	32	540
Streams	3	12	4	45	49	1.3	11	540
Onsite Stations	10	35	6	21	19	0.8	2.9	188
Effluent Release Stations								
Acid-Pueblo Canyon	7	44	6	110	220	1.3	43	516
DP—Los Alamos Canyon	8	23	5	112	124	6.7	60	474
Sandia Canyon	3	43	8	200	182	2.2	25	934
Mortandad Canyon	8	34	5	272	30	2.4	374	1160
Water Supply								
Supply Wells and Gallery	16	20	6	50	15	2.5	2.9	514
Distribution								
Los Alamos	5	20	7	33	7	0.7	2.3	200
Bandelier	1	9	2	21	3	0.4	1.8	94
Fenton Hill	1	31	4	12	15	0.1	1.3	236

[a]EPA's National Interim Primary Drinking Water Standards and New Mexico's Environmental Improvement Division maximum contaminant levels.

respectively. (See Appendix B.3 for methods of collection, analyses, and reporting of water data.) The maximum concentrations for seven parameters are in Table XIV.

The chemical quality of surface water varies at given stations during a year because of dilution of base flow with runoff from precipitation. There has been no significant change in the quality of water from previous analyses.

b. Onsite Surface and Ground Waters. Water samples were collected from three surface water stations and seven wells completed in the main aquifer (Table E-XII). They are located in onsite areas that do not receive industrial effluents (Fig. 12). Detailed results of analyses are given in Table E-XVI. The maximum concentrations for selected constituents are in Table XIV. Water quality at the surface water stations varies slightly as base flow is diluted with varying amounts of storm runoff. The quality of surface and ground waters has not changed significantly from previous analyses.

Tables E-XVII through E-XX detail chemical quality analyses of surface and ground water from 25 stations located in canyons that receive sanitary and/or industrial effluent (Fig. 12, Table XII). Maximum concentrations

TABLE XV

MAXIMUM METAL ION CONCENTRATIONS IN WATER FROM EFFLUENT RELEASE AREAS

	mg/ℓ							
	Zn	Pb	Hg	B	Cd	Cu	Cr	Li
Standard or Criteria[a]	---	0.05	0.002	---	0.010	---	0.05	---
Effluent Release Areas								
Acid-Pueblo Canyon	25	0.592	0.0013	0.31	0.0032	0.093	0.073	0.077
DP—Los Alamos Canyon	0.368	0.090	0.0015	0.11	0.0041	3.88	0.220	0.022
Sandia Canyon	0.418	0.032	0.0017	0.60	0.0040	0.387	0.250	0.093
Mortandad Canyon	2.89	0.246	0.0009	0.08	0.0043	2.08	0.103	0.067

[a]EPA's National Interim Primary Drinking Water Regulations and New Mexico's Environmental Improvement Division Maximum contaminant levels.

of selected constituents found in each canyon are summarized in Table XIV. Metal ions analyses from effluent release areas are summarized in Table XV, while individual analyses are shown in Tables E-XVII to E-XX.

Acid-Pueblo Canyon received industrial effluents from 1943 to 1964 and currently is receiving treated sanitary effluents, which are now the major part of the flow. Sandia Canyon receives cooling tower blowdown and some treated sanitary effluents. DP-Los Alamos and Mortandad Canyons receive treated industrial effluents that contain some radionuclides and residual chemicals used in the waste treatment process. The high TDS and chlorides reflect effluents released into the canyons. Fluorides and nitrates in DP-Los Alamos and Mortandad canyons were above drinking water standards;[6] however, these onsite waters are not a source of municipal, industrial, or agricultural supply. Maximum concentrations occurred near effluent outfalls. The chemical quality of the water improves downgradient from the outfalls. There is no surface flow to the Rio Grande in these canyons except during periods of heavy precipitation.

General chenical quality of water comprising the water supply is also shown in Table XIV for comparison with the quality from regional, perimeter, White Rock Canyon, onsite, and effluent release stations.

c. **Water Supply.** Municipal and industrial water supplies for the Laboratory and community were sampled at 15 deep wells, 1 gallery, 5 stations on the distribution system, and at Bandelier National Monument (Table E-XII, Fig. 12). Maximum concentrations of chemical constituents from wells, gallery, and distribution system stations are compared to criteria in Table XVI. Detailed analyses are in Table E-XXI. Also, shown in Table E-XXXIII is the chemical quality of water used from a supply at Fenton Hill (TA-57). This site is located about 30 km west of Los Alamos. Appendix A gives the federal and state standards and criteria for municipal water supplies.

Concentrations of arsenic (mg/ℓ) and fluoride (mg/ℓ) in water from well LA-1B were above standards for drinking water;[6] however, mixing with water from other wells reduces the concentrations to levels well within standards at points of use. Arsenic and fluoride in water from well LA-1B is naturally occurring in the aquifer. Comparison of quality of water in the distribution systems at Los Alamos, Bandelier, and Fenton Hill with EPA standards shows that all three systems are in compliance.

TABLE XVI

MAXIMUM CHEMICAL CONCENTRATIONS IN WATER SUPPLY

	No. of Samples	mg/ℓ									
		Ag	As	Ba	Cd	Cr	F	Hg	NO_3	Pb	Se
Standard or Criteria[a]	---	0.05	0.05	1.0	0.010	0.05	2.0	0.002	45	0.05	0.01
Supply Well and Gallery	16	0.004	0.045	0.103	0.0002	0.023	2.5	<0.00005	2.9	0.005	<0.005
Distribution											
Los Alamos	5	<0.0003	0.012	0.096	0.0001	0.007	0.7	<0.00005	2.3	<0.002	<0.005
Bandelier	1	<0.0003	0.004	0.034	0.0007	0.004	0.4	<0.00005	1.8	<0.002	<0.005
Fenton Hill—TA-57	1	<0.0003	0.002	0.086	0.0003	<0.002	0.1	<0.00005	1.3	0.003	<0.005

[a]EPA's National Interim Primary Drinking Water Regulations and New Mexico's Environmental Improvement Division maximum contaminant levels.

2. Nonradioactive Effluents

Nonradioactive effluents include airborne and liquid discharges. Airborne effluents from the beryllium fabrication shop, gasoline storage and combustion, power plant, gases and volatile chemicals, waste explosive burning, and dynamic testing did not result in any measurable or theoretically calculable degradation of air quality. Particulate concentrations in the Los Alamos area did not exceed state standards. A single NPDES permit covers liquid effluents from 113 industrial discharge points and 10 sanitary treatment facilities. This year 8 to the 10 sanitary sewage treatment facilities exceeded one or more of the NPDES limits (excluding flow rate limitations) in one or more months and less than 1% of all samples from the industrial outfalls exceeded NPDES limits.

a. Airborne Discharges. Airborne particulate concentrations in the Los Alamos and White Rock areas are routinely measured by the New Mexico State Environmental Improvement Division. The highest 24 h averages and annual averages are compared to the New Mexico Ambient Air Quality Standards for particulates in Table XVII. Table E-XXVIII summarizes these data for 1980. Both the 24 h averages and annual geometric means are well within state standards. Although true 7 day and 30 day averages cannot be calculated, there is no indication that they would exceed state standards.

Airborne emission sources at the Laboratory that are routinely assayed include the beryllium shop, gasoline storage and combustion, the TA-3 power plant, gas and volatile chemical usage, waste explosive burning, and dynamic testing operations. These sources are discussed separately in the following paragraphs.

Beryllium concentrations in stack gases from the beryllium shop are monitored by the Industrial Hygiene Group. Measured stack gas concentrations during 1980 ranged from 0.0008 to 0.1 $\mu g/m^3$. The anomolously high concentration of 0.1 $\mu g/m^3$ during the month of August exceeded all other concentrations measured during the year by at least a factor of 15. The state ambient air quality standard for beryllium is 0.01 $\mu g/m^3$, as a 30-day average. Although the beryllium concentration in the stack gas exceeded 0.01 $\mu g/m^3$ during the month of August, the dilution of the gas upon emission from the stack undoubtedly reduced the ambient concentration to below 0.01 $\mu g/m^3$. Total beryllium emissions for the year were about 3.5 mg, which is considerably less than the normal annual emission of 15-20 mg.

A large fleet of cars and trucks is maintained for the Laboratory complex by the Zia Company. During fiscal year 1980, a total of 2.3×10^6 ℓ of gasoline were used by this fleet to cover 9.4×10^6 km. These figures represent reductions of 6.4% and 4.0%, respectively, from the previous year. This indicates both a slightly increased

TABLE XVII

SUMMARY OF ATMOSPHERIC PARTICULATE CONCENTRATIONS IN LOS ALAMOS AND WHITE ROCK DURING 1980

	New Mexico Ambient Air Quality Standards for Particulates ($\mu g/m^3$)	Los Alamos ($\mu g/m^3$)	White Rock ($\mu g/m^3$)
Maximum 24 h average	150	92	113
Maximum 7 day average	110	---	---
Maximum 30 day average	90	---	---
Annual geometric mean	60	38	33

fuel economy and a decreased use of the vehicle fleet with respect to 1979.

Carbon monoxide, hydrocarbons, nitrogen oxides, sulfur oxides, and particulates are emitted during automobile operation. There are also gasoline evaporative losses associated with gasoline storage and vehicle refueling. By breaking down total gasoline usage among the size classes of vehicles and by applying the most appropriate EPA emissions factors[11] to these data, air emissions associated with maintenance and operation of the vehicle fleet (Table XVIII) were estimated.

The TA-3 power plant is fueled with natural gas and thus comes under state regulations for gas burning equipment. These regulations specify maximum allowable nitrogen oxide emissions but also contain a provision exempting facilities that have a heat input of less than 1×10^{12} Btu/yr/unit. Heat input for the TA-3 power plant individual boilers during 1980 were 0.80×10^{12} Btu, 0.56×10^{12} Btu, and 0.55×10^{12} Btu. Total heat input for the power plant was 1.95×10^{12} Btu (about 7.7% less than last year), but inputs for the individual boilers were below the 1×10^{12} Btu/yr exemption threshold.

Measured NO_x (nitrogen oxides) concentrations in the power plant stack gas ranged from 21 to 48 ppm, which is about 20% of the standard that would apply if the heat input threshold were exceeded. Sulfur dioxide (SO_2) analyses of the stack gas are not performed routinely, but the sulfur content of the natural gas fed to the boilers is so low that it precludes any significant WO_2 emissions. Table XIX shows estimated total power plant emissions for 1980, based on EPA emission factors[11] for natural gas burning facilities.

TABLE XVIII

ESTIMATES OF AIR POLLUTANT EMISSIONS ASSOCIATED WITH MAINTENANCE AND OPERATION OF THE VEHICLE FLEET

Pollutant	Estimated Amount (metric tons)	Change From 1979 (%)
Gasoline evaporative losses	27.7	−3.9
Carbon monoxide	106	−1.9
Hydrocarbons	8.6	−2.9
Nitrogen oxides	16.6	−3.0
Sulfur oxides	1.1	−3.6
Particulates, exhaust	0.7	−2.0
Particulates, tires	1.3	−4.8

The Laboratory complex uses large quantities of various volatile chemicals and gases, some of which are released into the atmosphere by evaporation or exhaust. Using data from stock records, a table of patterns of chemical usage has been compiled (Table E-XXIX).

During 1980 a total of 19 415 kg of high explosives wastes were disposed by open burning at the Laboratory. Estimates of emissions (Table XX) were made by using

TABLE XIX

ESTIMATES OF STACK GAS EMISSIONS FROM THE TA-3 POWER PLANT

Pollutant	Estimated Amount (metric tons)
Sulfur oxides	0.50
Hydrocarbons	0.84
Carbon monoxide	14.2
Particulates	8.4
Nitrogen oxides	282

TABLE XX

ESTIMATED EMISSIONS FROM BURNING OF EXPLOSIVE WASTES

Pollutant	Estimated Amount (kg)
Carbon monoxide	152
Particulates	349
Nitrogen oxides	586

data from experimental work carried out by Mason & Hangar-Silas Mason Co., Inc.[12] Open buring of high explosives wastes is permitted by the New Mexico Air Quality Control regulations.

Dynamic experiments employing conventional explosives are routinely conducted in certain test areas at the Laboratory and may contain quantities of potentially toxic metals, including beryllium, lead, and uranium. Some limited field experiments, based on aircraft sampling of debris clouds, provided information on the proportion of such materials aerosolized. This information was employed to prepare estimates of concentrations at the Laboratory boundary based on the curent year's utilization of the elements of interest. The results are presented in Table XXX along with comparisons to applicable air quality regulations. The average concentrations are all less than 0.003% of applicable standards.

b. Liquid Discharges. Nonradioactive liquid wastes are released from 113 industrial discharge points and 10 sanitary sewage treatment facilities subject to National Pollutant Discharge Elimination System (NPDES) requirements. The single NPDES permit for the Laboratory issued by the EPA places specific effluent limits on 10 categories of industrial waste outfalls and 10 sanitary sewage treatment facilities. Tables E-XXXI and E-XXXII summarize the effluent quality and compliance status of the sanitary and industrial waste outfalls, respectively.

This year one of the sanitary sewage outfalls met all limits, and one lagoon exceeded only flow rate limits during winter months when they were frozen. The industrial outfalls exceeded one or more limits during 1980 less than 7% of the time. Six of those responsible for the largest number of deviations are scheduled for corrective measures to be carried out in 1981-82.

The two radioactive waste treatment plants have the largest number of limits with which to comply, and those plants exceeded one or more limits in less than 1% of the samples taken. Details of the effluent quality from these two plants are given in Table E-XXVII for nonradioactive (including several not regulated by the NPDES permit) and radioactive constituents.

C. Meteorology

Weather during 1980 was unusually dry and warm for Los Alamos. It was the warmest year since 1956 and the driest since 1964. It was marked by unusually warm temperatures in January, February, June, July, August, and December. Dry conditions prevailed from June to December causing one of the most severe droughts on record.

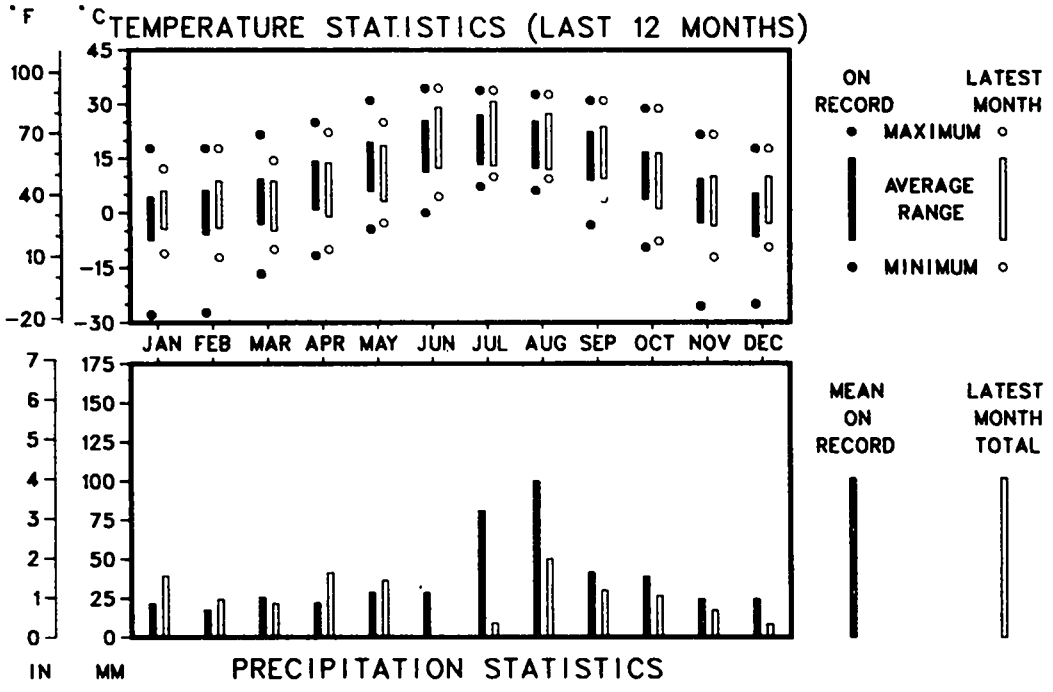


Fig. 19.
Summary of 1980 weather in Los Alamos.

1. Summary of 1980 Weather

Los Alamos had a very dry and warm 1980. This extreme weather continued the trend of extreme weather of the late 1970s. The 1980 weather is summarized in Fig. 19, Table E-I, and Table E-II. The year started mild and dry, with January and February of 1980 and December of 1979 constituting the warmest winter on record with an average temperature of 1.5°C (34.7°F). A slightly cool and wet spring followed. The most striking weather of the year occurred in the summer (June, July, and August). Unusually hot and dry conditions occurred due to an intense high pressure system extending over the southern United States. Los Alamos had its warmest and driest summer, breaking records previously set in the "Dust Bowl" years of the 1930's and in the warm and dry summers of the early 1950's. There were 22 days with maximum temperatures over 32°C (90°F), compared with the average of 2 days. Until 1980, there had been only 74 days (in records dating back to 1919) exceeding 32°C (90°F).

Suppression of monsoon thundershowers by the strong high pressure system limited summer precipitation to a scant 59 mm (2.32 in). Dry weather continued through the rest of the year, although temperatures fell to near seasonal normals through November. Another strong high pressure ridge formed over the western states in December, giving Los Alamos its warmest December in history (average = 3.6°C or 38.4°F). The temperature climbed to 17.8°C (64°F) on the 27th, setting the all time high temperature for December.

2. Wind Roses for 1980

The 1980 wind speed and direction data measured at the Occupational Health Laboratory (OHL, TA-59) are plotted in wind roses (see Fig. 20). A description of how to read a wind rose follows to help in interpreting them. A wind rose is a circle from the center of which emanates lines 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 the 16 major compass points (N, NNE, etc.) and is centered on a 22.5° sector of the circle. The frequency of calm winds defined as those having a <1 m/sec wind speed and no direction, is given in the circle's center.

The OHL wind data were measured at a height of 23 m with over 99% data recovery for 1980. The wind roses

in Fig. 20 include an annual summary for 1980 and summaries for daytime and nighttime hours. Daylight hours were defined as the hours when measured solar insolation was >0.01 langleys/min. Los Alamos is a generally light wind site with an annual average wind speed of 3.3 m/sec. Only 17% of wind speeds in 1980 were >5 m/sec, while almost 40% were <2.5 m/sec. The distribution of wind direction reflects (1) the location of Los Alamos on the southern side of the midlatitude westerlies, and (2) the northwest-southeast slope of the Jemez Mountains and Pajarito Plateau. Predominance of winds from NW to SW is produced by "westerlies," which are often located as far south as New Mexico. Slope of the terrain also produces a distinct diurnal pattern under weak atmospheric pressure gradients. At night, drainage winds (<2.5 m/sec) flow down from the Jemez Mountains out of the NW and WNW. During the daytime light upslope winds come up out of the SE to SSE.

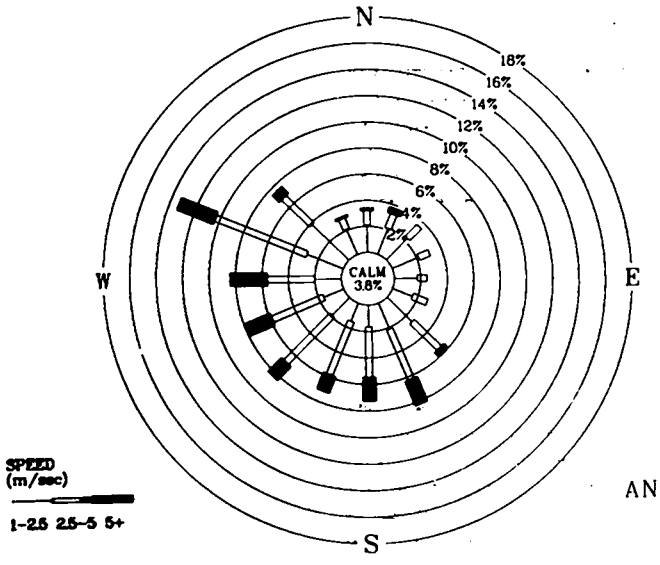
IV. ENVIRONMENTAL EVALUATION

A. Radiation Doses

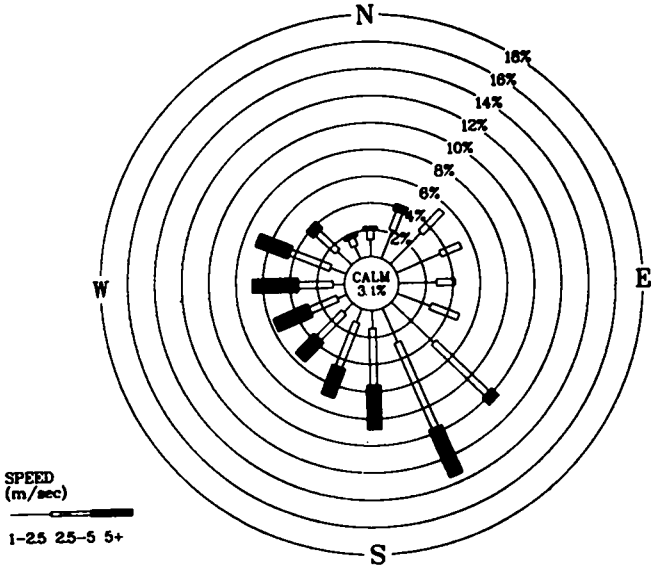
Small incremental radiation doses above those received from natural and worldwide fallout background are received by Los Alamos County residents as a result of Laboratory operations. The largest estimated dose at an occupied location was 3.4 mrem or 0.7% of the Radiation Protection Standard. This estimate is based on boundary dose measurements of airborne and scattered radiation from the accelerator at TA-53. Other minor exposure pathways, direct radiation from TA-18 and two unlikely food pathways may result in several mrem/yr in isolated cases. No significant exposure pathways are believed to exist for radioactivity released in treated liquid waste effluents. The radioactivity is absorbed in alluvium before leaving the Laboratory boundaries and some is transported offsite in stream channel sediments during heavy runoff. The total population dose received by residents of Los Alamos County was conservatively estimated to be 16.62 person-rem, or about 0.8% of the 2187 person-rem received by the same population from natural radiation sources, and 0.9% of the population dose due to diagnostic medical exposure. As no significant pathways could be identified outside the County, the 16.62 person-rem dose also represents the population dose to inhabitants living within an 80 km radius of the Laboratory who receive an estimated 12 600 person-rem from background radiation. The average added risk of cancer mortality to Los Alamos townsite residents from radiation from this year's Laboratory operations is 1 chance in 7 000 000. This risk is much less than the 1 chance in 79 000 from background radiation. The EPA has estimated average lifetime risk for cancer incidence as 1 chance in 4, and for cancer mortality as 1 chance in 5.

One means of evaluating the significance of environmental releases of radioactivity is to interpret the exposures received by the public in terms of doses that can be compared to appropriate standards and naturally present background. The critical exposure pathways considered for the Los Alamos area were atmospheric transport of airborne radioactive effluents, hydrologic transport of liquid effluents, food chains, and direct exposure to penetrating radiation. Exposures to radioactive materials or radiation in the environment were determined by direct measurements for some airborne and waterborne contaminants and external penetrating radiation, and by theoretical calculation based on atmospheric dispersion for other airborne contaminants. Doses were calculated from measured or derived exposures utilizing models based on recommendations of the International Commission on Radiological Protection (ICRP, see Appendix D for details) for each of the following categories:

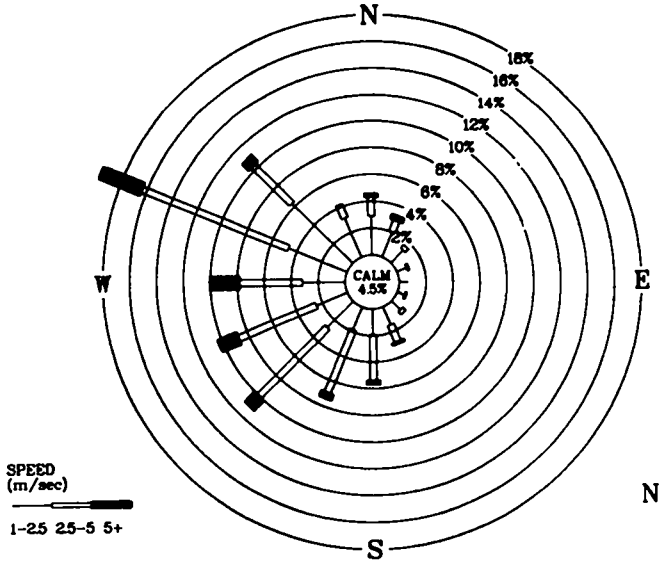
1. Maximum dose at a site boundary,
2. Dose to individual or population groups where highest dose rates occur, and
3. The whole body cumulative dose for the population within and 80 km radius of the site.



ANNUAL



DAY



NIGHT

Fig. 20.
Annual, day, and night wind roses for Los Alamos for 1980.

Exposure to airborne ^{3}H (as HTO) was determined by actual measurements with background correction based on the assumption that natural and worldwide fallout activity was represented by the average data from the three regional sampling locations at Española, Pojoaque, and Santa Fe.

Exposures to ^{11}C, ^{13}N, ^{15}O, and ^{41}Ar from the LAMPF were inferred from direct radiation measurements (see Sec. III.A.1). Exposure from ^{41}Ar released from the TA-2 stack was theoretically calculated from measured stack releases and standard atmospheric dispersion models.

Estimates of a maximum exposure to plutonium, americium, and uranium were calculated by subtracting the average concentration at the regional stations from the average concentration from the perimeter station with the highest measured concentration (Table XXI) for each of these radionuclides.

The maximum boundary and individual doses attributable to these exposures are summarized in Table XXI with a comparison to the Radiation Protection Standards (RPSs) for individual doses (see Appendix A).

All other atmospheric releases of radioactivity (see Table E-XXVI) were evaluated by theoretical calculations. All potential doses were found to be less than the smallest ones presented above and were thus considered insignificant.

Liquid effluents do not flow beyond the Laboratory boundary but are absorbed in alluvium of the receiving canyons. These effluents are monitored at their point of discharge and their behavior in the alluvium of the canyons below outfalls has been studied.[13-16] Small quantities of radioactive contaminants transported during periods of heavy runoff have been measured in canyon sediments beyond the Laboratory boundary. Calculations made for the Final Environmental Impact Statement[3] indicate a maximum exposure pathway (eating liver from a steer that drinks water from and grazes in lower Los Alamos Canyon) to man from these canyon sediments results in a maximum 50-yr dose commitment of 0.0013 mrem to the bone.

There are no known significant aquatic pathways or food chains to humans in the local area. Fruit, vegetable,

TABLE XXI

BOUNDARY AND MAXIMUM INDIVIDUAL DOSES FROM AIRBORNE RADIOACTIVITY

		Maximum Boundary Dose		Maximum Individual Dose		
Isotope	Critical Organ	Location	Dose (mrem/yr)	Location	Dose (mrem/yr)	% RPS
^{3}H (HTO)	Whole Body	TA-54	0.058	White Rock	0.0036	0.0007
^{11}C, ^{13}N, ^{15}O	Whole Body	Restaurant N. of TA-53	12.3	Restaurant N. of TA-53	3.4	0.69
^{41}Ar	Whole Body	Boundary N. of TA-2 Stack	2.2	Apts. N. of TA-2 Stack	1.2	0.2
^{239}Pu[a]	Lung	TA-21	0.020	Barranca School	0.030[a]	0.002

[a]For a 50-yr dose commitment, bone is the critical organ. A maximum individual would receive a 50-yr bone dose commitment of 1.19 mrem, which is 0.08% of RPS.

honey, and fish sampling (see Sec. III.A.5) has documented that any exposure attributable to Laboratory operations via those pathways is insignificant. A possible minor exposure pathway exists by eating venison from deer that cross into Laboratory property to graze and drink. The maximum dose calculated via this pathway is 3.9 mrem/yr and is unlikely to occur.

As was stated in Sec. III.A.1, no measurements of external penetrating radiation at regional and perimeter stations in the environmental network indicated any discernable increase in radiation levels that could be attributed to Laboratory opertions except those along State Road 4 north of the LAMPF. The special TLD network at the Laboratory boundary north of the LAMPF indicated a 12.3 mrem increase above natural background. This increase is attributed to the emission of air activation products from the LAMPF.

Based on occupancy and shielding, this would contribute a 3.4 mrem dose to an individual working at the restaurant north of the LAMPF. This dose represents 0.7% of the RPS for a member of the public.

Onsite measurements of above background doses were expected and do not represent potential exposure to the public except in the vicinity of TA-18 on Pajarito Road. Members of the public regularly utilizing the DOE-controlled road passing by TA-18 would likely receive no more than 0.75 mrem/yr of direct gamma and neutron radiation. This value was derived from 1975 data[17] on total dose rates using 1980 gamma doses measured by TLDs and estimating exposure time by assuming a person made 15 round trips per week at an average speed of 65 km/h past TA-18 while tests were being conducted. The onsite station near the Laboratory boundary at State Road 4 recorded a dose of 195 mrem/yr. This is caused by a localized accumulation of ^{137}Cs on sediments transported from a treated effluent release point upstream. A maximum onsite dose to a member of the public from airborne effluents of 0.00078 mrem was estimated for a person spending 4 h at the Laboratory Museum while ^{41}Ar effluent dispersed from TA-2 and TA-53 could result in a theoretically calculated annual regional (at Española) dose of 0.005 mrem.

Cumulative 1980 whole body doses to Los Alamos County residents attributable to Laboratory operations are compared to exposure from natural radiation and medical radiation in Table XXII. Population data are based on the preliminary U.S. Bureau of Census estimate of 11 038 residents in Los Alamos townsite and 6548 in White Rock.

The calculated 16.62 person-rem from atmospheric ^{11}C, ^{13}N, and ^{15}O is probably high because it is subject to many of the same uncertainties that caused boundary dose calculations to overestimate actual doses. The whole-body population dose to the estimated 112 000 inhabitants[19] of the 80 km circle around Los Alamos because of Laboratory operations is estimated to be 16.62 person-rem, which is the population dose to Los Alamos County inhabitants. That is because other population centers are far enough away that dispersion, dilution, and decay in transit (particularly for ^{11}C, ^{13}N, ^{15}O, and ^{41}Ar) make exposure undetectable and theoretically a very small fraction of the estimated 16.62 person-rem. By contrast, natural radiation exposure to the inhabitants within the 80 km circle is 12 600 person-rem.

Thus, doses potentially attributable to releases of effluents contribute about 0.76% of the total dose received by Los Alamos County residents from natural radiation, about 0.92% to the same population from diagnostic medical radiation, and about 0.13% of the dose from natural radiation received by the population within an 80 km of the Laboratory.

Since there is considerable interest in possible health effects from radiation doses to the public resulting from Laboratory operations, several risk estimates have been made. However, these calculations may overestimate actual risk. The NCRP[20] 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 (linear energy transfer) radiations, 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."

The ICRP[21] estimates that the total stochastic risk of cancer mortality from uniform whole body irradiation for individuals is 1×10^{-4} per rem, i.e., there is 1 chance in 10 000 that an individual exposed to 1000 mrem of whole body radiation would develop a cancer. In developing risk estimates the ICRP[21] has warned "radiation risk estimates should be used ohly with great caution and with explicit recognition of the possibility that the actual risk at low doses may be lower than that implied

TABLE XXII

WHOLE BODY POPULATION DOSES TO RESIDENTS OF LOS ALAMOS COUNTY DURING 1980

Exposure Mechanism	Whole-Body Population Dose (person-rem)
Atmospheric Tritium (as HTO)	0.01
Atmospheric ^{11}C, ^{13}N, ^{15}O	13.96
Atmospheric ^{41}Ar	2.65
Total Due to Laboratory Atmospheric Releases	16.62
Cosmic and Terrestrial External Radiation[a]	1563
Cosmic Neutron Radiation (~11 mrem/yr per person[4])	187
Self Irradiation from Natural Isotopes in the Body (~24 mrem/yr per person[4])	422
Average Due to Airline Travel (~0.22 mrem/h at 9 km[4])	15
Total Due to Natural Sources of Radiation	2187
Diagnostic Medical Exposure (~103 mrem/yr per person[18])	1811

[a]Calculations are based on measured TLD data. They include a 10% reduction in cosmic radiation due to shielding by structures and a 40% reduction in terrestrial radiation due to shielding by structures and self-shielding by the body.

by a deliberately cautious assumption of proportionality."

During 1980, persons living in Los Alamos and White Rock received an average of 127 mrem and 118 mrem, respectively, of whole body radiation from natural sources (including cosmic and terrestrial radiation with allowances for shielding, self-irradiation and cosmic neutron exposure, but excluding that radiation received from airline travel, liminous dial watches, building materials, etc.). Thus, the added cancer mortality risk due to natural radiationin 1980 was 1 chance in 79 000 in Los Alamos and 1 chance in 85 000 in White Rock. Laboratory operations contributed an average dose of 1.42 mrem to individuals in Los Alamos and 0.14 mrem to individuals in White Rock. These added lifetime risks amount to a conservative 1 chance in 7 000 000 in Los Alamos and 1 chance in 70 000 000 in White Rock of a cancer mortality due to 1980 Laboratory activities.

For Americans the average lifetime risk is a 1 in 4 chance of contracting a cancer from all causes and a 1 in 5 chance of dying from the disease.[22,23] The Los Alamos and White Rock additional doses attributable to Laboratory operations are equivalent to the additional exposure a person would get from riding in a jet aircraft for 6.5 and 0.64 h, respectively.

The additional exposure (which is likely overestimated) and subsequent risk to Los Alamos County residents are well within variations in natural exposure and risks in life that are accepted routinely by

most people. For example, one study[24] showed the annual dose rate on the second floor of single-family frame dwellings was 14 mrem/yr less than the dose rate on the first floor. Energy conservation measures, such as sealing and insulating houses and installing passive solar systems, are likely to contribute much larger doses to Los Alamos County residents than Laboratory operations because of increased radon levels inside the homes. The EPA has estimated the annual whole body dose to individuals from global fallout to be 4.4 mrem.[25]

B. Environmental Protection Programs at Los Alamos

1. LERC/EEC Program

In order to assist DOE to comply with requirements of the National Environmental Policy Act (NEPA), the Laboratory has a Laboratory Environmental Review Committee (LERC). Membership consists or representatives from several Associate Directors offices, Financial Management, the Engineering Department, and the Health Division. The LERC has responsibility to review environmental assessments (EAs) and other environmental documents prepared for DOE by the Laboratory. Additionally, LERC identifies and reviews items of environmental interest that are generated by Laboratory activities or that affect the Laboratory programs and property. An Environmental Evaluations Coordinator (EEC), based in the Environmental Surveillance Group (H-8), assists LERC by coordinating with user groups, Health Division and the Engineering Department on development of environmental documents and providing input to project design at the earliest stage for appropriate environmental decision making.

Projects that may require an EA or EIS are screened by the EEC to determine what form of environmental documentation is necessary. When needed, various resource persons are identified by the EEC to assist in preparation of the draft environmental document for the proposed construction or programmatic project.

The EEC also coordinates input on environmental matters for other official documents and the Quality Assurance (QA) program (see next section). The EEC and the Environmental Surveillance Group representative to the QA program work with those responsible for construction and/or programmatic activities to assure that proper environmental considerations are made during the assessment and that they are implemented in the QA program.

2. Quality Assurance Program

The Laboratory has a Quality Assurance (QA) program[26] for engineering, construction, modification, and maintenance of DOE-owned facilities and installations. The purpose of the program is not only to minimize chance of deficiencies in construction, but also to improve cost effectiveness of facilities' design, construction, and operation, and to protect the environment. QA is implemented from inception of design through completion of construction by a project team approach. The project team consists of individuals from the DOE program division, DOE Albuquerque Operations and Los Alamos Area Offices, Laboratory operating group(s), Laboratory Engineering Department, design contractor, inspection organization, and construction contractor. Under the project team approach, each organization having responsibility for some facet of the project is likewise responsible for its respective aspects of the overall QA program. For example, it is the inspection organization's responsibility to provide assurance that the structures, systems, and components have been constructed or fabricated in accordance with the approved drawings and specifications.

Laboratory representatives are responsible for coordinating reviews and comments from all groups with a vested interest in the project. In particular, the Environmental Surveillance Group reviews proposed new construction, maintenance activities, and modifications to existing facilities to minimize any environmental degradation. Consideration is given to the present condition of the site (soils, geology, ground water, surface water, air quality, archeology, flora, fauna, drainage features, archeological resources, etc.), environmental consequences of the proposed project (airborne effluents, liquid effluents, industrial waste, solid waste, noise levels, traffic patterns, etc.), and environmental impact assessment (air, water, land, visual, noise, odor, biota, etc.).

3. Archeology

Protection of archeological sites at the Laboratory (mandated by several Congressional acts and Executive Order 11593) is also part of the QA program. A

proposed location for a new facility is checked to determine if there are any archeological sites in the area. If there is one, then an attempt is made to adjust siting so as to preserve the site. If alternative siting is not feasible, then the site is excavated to gain knowledge about it and recover artifacts before it is destroyed. The decision as to which course to follow is based on the value of the archeological site, on availability of alternative locations for the new facility, and on the programmatic impact if the new facility were not built at that location.

A survey of more than 450 archeological sites at the Laboratory was made between March 1973 and July 1975. This survey of the pre-Columbian Indian ruins is summarized in a report,[27] which is used during construction planning to avoid damage to such sites if possible, or to provide the lead time necessary to conduct required salvage archeology. Several unique sites were recommended for registration as national historic sites and formal nomination procedures are underway. This will ensure their preservation for future generations by establishing formal responsibility and authority to protect the sites. Eleven new sites, both pre-Columbian and historic, were located this year and added to the inventory of sites.

Two public tours of archeological sites within the Laboratory's boundary were conducted in 1980 (see Fig. 21). These tours allow the public to see archeological sites that are normally inaccessible to them due to security restrictions. This year the tours included Mortandad Cave Kiva, which contains some of the finest petroglyphs in the Southwest, and a Tewa Indian site, which has a unique configuration of a plaza village and stone shrine. These tours have proved extremely popular, with over 500 Laboratory employees and visitors participating in each one.

C. Related Environmental Studies

The Environmental Sciences Group (LS-6) at the Laboratory conducts research and experimental studies under auspices of the DOE. Some of the research programs conducted by LS-6 complement routine

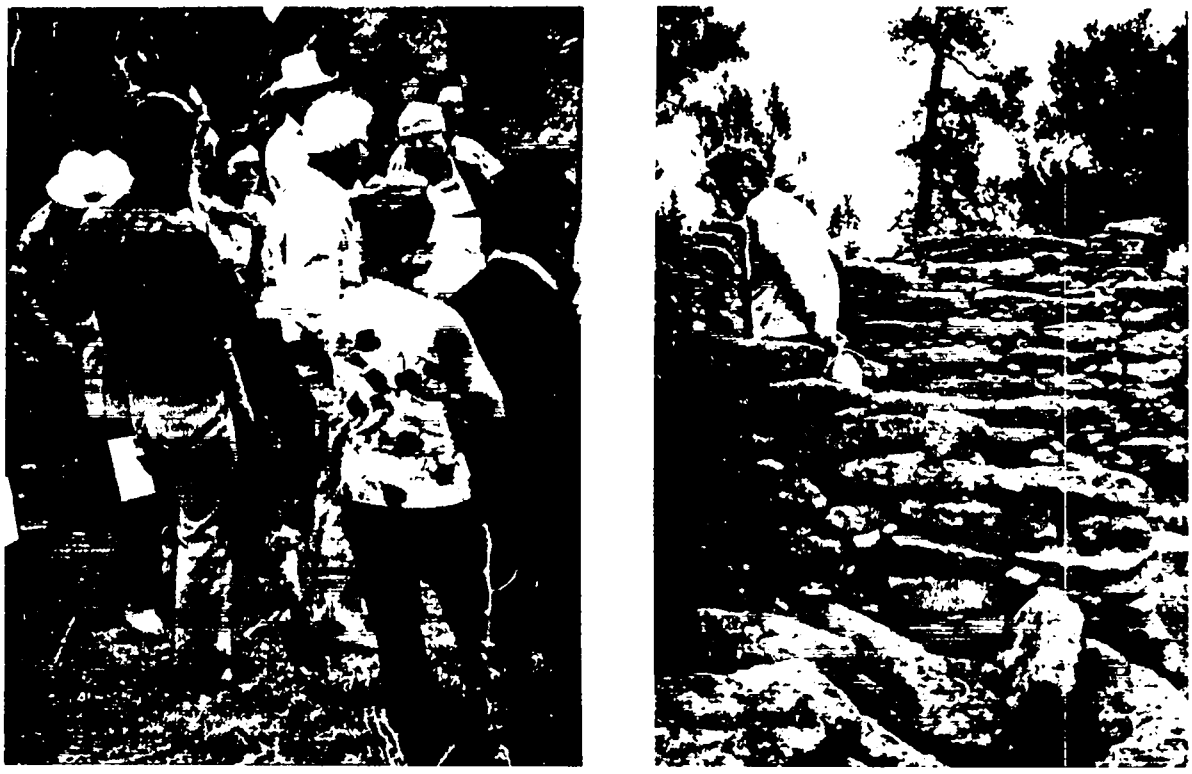


Fig. 21.
A public tour of an archeological site at the Laboratory.

monitoring and research (see Appendix G for list of publications) conducted by the Environmental Surveillance Group (H-8) by providing a better understanding of the ecosystem surrounding the Laboratory in relation to its operations. Following are highlights of several of these research programs.

1. Fenton Hill Site (TA-57) Surface and Ground Water Quality. [W. D. Purtymun and R. W. Ferenbaugh (H-8)]

Los Alamos National Laboratory is currently evaluating the feasibility of extracting thermal energy from hot dry rock (HDR) geothermal reservoirs at its Fenton Hill Site (TA-57). The concept involves drilling two deep holes into HDR, connecting these holes by hydraulic fracture, and bringing thermal energy to the surface by circulating water through the system.

The chemical quality of surface and ground waters in the vicinity of TA-57, which is about 30 km west of Los Alamos (Fig. 22), has been determined for use in geohydrologic and environmental studies. Results of past studies and detail data have been reported elsewhere.[28-36] Table E-XXXIII summarizes the chemical quality of water for nine surface water stations, four water supply locations, two springs along the Jemez Fault, one spring discharging from recent volcanics, and one abandoned well. Water quality has varied slightly; however, the variations in quality are normal due to seasonal fluctuations.

Ponds at the site contain water used in drilling operations and water used in the experimental loop in the dry hot rocks about 3000 m below land surface. The water in the ponds is highly mineralized (1870 mg/ℓ of TDS). Certain elements present in the ponds are of interest because of monitoring requirements specified in the National Pollutant Discharge Elimination System permit. These are arsenic, boron, cadmium, fluoride, and lithium.

Discharges from the ponds into the canyon began about 1974. Samples of vegetation and soil from the canyon bottom and bank of the channel have been collected semiannually since 1978. These samples are analyzed for the five elements previously mentioned. Sample locations are about 100, 200, 400, and 1000 m down canyon, plus an additional sample at the lower end of the canyon, far beyond the section of the canyon reached by the holding pond discharges. These sample collections are designed to give some indication of whether there is any accumulation of the elements of interest with time and with progression down the canyon. Results obtained to data are shown in Table E-XXXIV. Although these data are scanty, there is some indication in the lithium and boron data that there might be elevated concentrations in vegetation in the stream channel in the upper part of the canyon. This is consistent with the preliminary conclusion, using chloride as a tracer, that the discharge from the holding ponds sinks into the canyon alluvium before it reaches 400 m down the canyon.

2. Radiological Survey of the Site of a Former Radioactive Liquid Waste Treatment Plant and the Effluent Receiving Areas of Acid, Pueblo, and Los Alamos Canyons [A. K. Stoker and D. A. Mayfield (H-8)]

This summary of an evaluation of current radiological conditions at the site of a former radioactive liquid waste treatment plant and the interconnected canyons that received treated and untreated effluents is based on extensive field measurements and sampling, followed by interpretation of the resulting data. The study was completed as part of the Formerly Utilized Sites Remedial Action Program sponsored by the U.S. Department of Energy (DOE). It will be used by the DOE to determine whether any remedial measures are desirable to further reduce any residual effects from previous use of this site. A final report on the study will be published in 1981.

Liquid radioactive wastes were generated by research with nuclear materials at Los Alamos, New Mexico, for the World War II Manhattan Engineer District atomic bomb project starting in 1943, and subsequently by work conducted for the Atomic Energy Commission. Untreated effluents were discharged into Acid Canyon from 1944 until 1951. A treatment plant was constructed on the rim of Acid Canyon and discharged treated effluents from 1951 until 1964. Following decommissioning of the plant and decontamination of the site and part of Acid Canyon, ownership of the property was transferred to Los Alamos County by the federal government in 1967.

Acid Canyon is a small branch of Pueblo Canyon, which, in turn, joins Lower Los Alamos Canyon. Acid Canyon and part of Pueblo Canyon are currently controlled by the County of Los Alamos. The federal government has an easement across the County land, generally following the course of the normally dry channel from the discharge point at the head of Acid Canyon, for collecting samples and maintaining test wells.

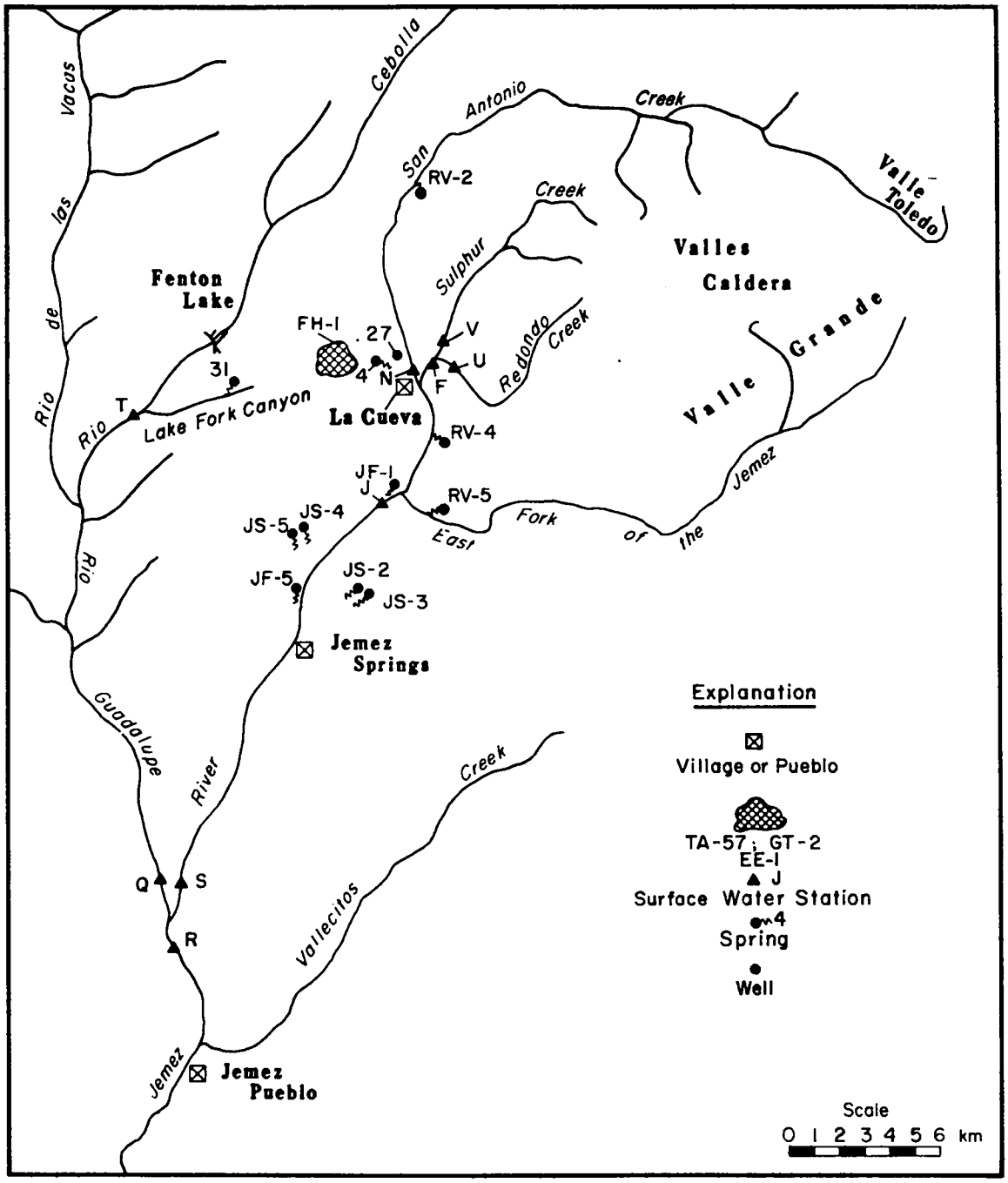


Fig. 22.
Water sampling locations in vicinity of Fenton Hill Geothermal Site (TA-57).

The remainder of Pueblo Canyon and a small part of Lower Los Alamos Canyon are currently controlled by the DOE. Most of Lower Los Alamos Canyon, down to where it joins the Rio Grande, is controlled by the San Ildefonso Indian Pueblo. Some residual radioactivity attributable to the effluents is found on soils and sediments in the channels of each of these canyons. Intermittent runoff events transport and redistribute the sediments periodically.

The study considered all available relevant information. Records provided the history of the treatment plant and data on types and amounts of contaminants discharged. Environmental monitoring and hydrogeologic studies, some extending back to the mid-1940's, were reviewed for information on trends and patterns. Data from these and special radioecology research studies were compiled to provide points of comparison and a basis for planning the acquisition of new data. Most of the new data consisted of multiple analyses of several hundred sediment and soil samples from the affected areas. Field measurements included documentation of radiation conditions and surveys to assure no significant areas of contamination had been overlooked.

The findings, based on interpretation of the data, are expressed as potential maximum increments of risk to individuals exposed to the conditions. Specifically, individual risks of cancer from exposure to radiation were calculated from factors recommended by the International Commission on Radiological Protection (ICRP). Potential exposures to radiation for various possible mechanisms were generally calculated as 50-yr dose commitments resulting from 1-yr exposures to account for cumulative doses from those radioactive materials retained in the body for varying periods after the initial exposure. Exposure to radiation from natural background results in exactly the same kinds of risks. The ICRP risk estimating factors were applied to natural background radiation to provide one context for judging the significance of other risks. People living in Los Alamos County incur an estimated incremental risk of cancer mortality of 8 chances in 10 000, from a 50-yr exposure to the natural radiation background. The natural radiation background dose, about 150 mrem each year, includes contributions from cosmic radiation, natural terrestrial radioactivity, and natural radioactivity incorporated in the body. A larger perspective is that the overall U.S. population lifetime risk of mortality from cancers induced by all causes is currently about 2 chances in 10.

The maximum likely incremental risks from all mechanisms of potential exposure in the areas having residual radioactivity attributable to liquid effluent disposal range from about 6 chances in 1 000 000 down to 1 chance in 10 000 000 000 under current conditions of land use. The pathways include direct exposure to penetrating radiation and inhalation of resuspended dust. Current land use includes occasional recreational use of Acid and Pueblo Canyons, commuter traffic on State Road 4 in Lower Los Alamos Canyon, several households, a commercial sand and gravel operation, and cattle grazing in Lower Los Alamos Canyon.

The 50-yr dose commitments for whole body, lung, and bone were calculated. All dose commitment values are considered overstated to some degree, because assumptions used in their derivation were made to maximize estimates of potential effects. All dose commitments are small fractions of those permitted above natural background and medical exposure by the DOE Radiation Protection Standards (RPSs). The highest one, from the unlikely circumstance of a full year occupancy of a small portion of the former waste treatment plant site, is about 12% of the RPS. All of the others are less than 2% of the RPS.

Measurements of conditions over many years in the Los Alamos County community and residential areas adjacent to the canyons have documented the absence of any doses in those locations attributable to the residual radioactivity from liquid effluent disposal. Measurements of food pathways (fish in Cochiti Lake on the Rio Grande and food crops irrigated with the water) show that no doses are attributable to the transport of contaminated sediments from Los Alamos Canyon.

Theoretical analysis shows two other pathways could result in doses to a limited number of individuals. One is uptake of some contamination through an abrasion wound caused by rocks in the vicinity of the untreated waste outfall location. The other is consumption of meat from a beef steer grazed in Lower Los Alamos Canyon. Potential risks from these pathways are in the same range as estimated for the other mechanisms.

Possible future changes in land use could result in other types of exposures. Pueblo Canyon has been discussed as a potential area for residential development to ease housing pressures in Los Alamos County. Most of the land amenable to development is in Lower Pueblo Canyon, now under DOE control. The potential for chronic exposure over many years from residential occupancy was evaluated. Calculated doses after 70 yrs of

continuous exposure to resuspended dust were no more than about 1.3% of the proposed Environmental Protection Agency (EPA) guidance on dose limits for persons exposed to transuranium elements in the general environment. Potential exposures for hypothetical home gardeners and construction workers in Lower Pueblo Canyon were the highest estimated (1.5% and 6% of RPS) with maximum incremental bone cancer risks of about 1 and 5 chances in 10 000 000, respectively. Potential exposure to a construction worker at the County-owned site of the former waste treatment plant could result in risks of about the same size.

Some highlights of the occurrence and distribution of radioactivity on the sediments and soils affected by the liquid effluents may be useful in evaluating future management alternatives and describing possible future changes from natural hydrologic processes. Transuranium elements (plutonium and americium) are present in all affected areas at levels with statistical significance above those normally observed as background from worldwide fallout in northern New Mexico. The highest concentrations occur in small areas at the County-owned site of the former waste treatment plant (affected area ~3500 m^2, to depths of ~2 m) and a natural drainage course that carried the untreated effluent (affected area ~500 m^2, to depths of ~1/2 m).

Within the canyons most contaminated material is near-surface (<1/2 m). The largest average concentrations and about 16% of the total inventory occur in County-owned Acid Canyon (affected area ~1750 m^2). Intermediate average concentrations and about 12% of the inventory occur in County-owned Middle Pueblo Canyon (affected area ~50 000m^2). Similar concentrations, but about 67% of the inventory, occur in DOE-controlled Lower Pueblo Canyon (affected area ~200 000 m^2). The lowest average concentrations, and about 6% of the inventory, occur in Lower Los Alamos Canyon on San Ildefonso Indian Pueblo land (affected area ~260 000 m^2).

Other radioactive contaminants including fission products are present at low, but statistically significant, levels above background in some, but not all, areas. Their major contribution to estimated risks is from external penetrating radiation that would be experienced only in the immediate vicinity of the contamination, for example, the channels and banks.

Some differences in future conditions will result from radioactive decay processes. Estimated total doses from transuranics will change by no more than about ±4% in 70 years, the approximate time required for maximum ingrowth to one daughter product (^{241}Am). The estimated doses from fission products will decline to about 1/5 the present values in the same time period. The fission products are largely responsible for the estimated external doses in Lower Los Alamos Canyon, Acid Canyon, and at the treatment plant site.

Major future runoff events in Pueblo Canyon could result in movement of the large proportion of the transuranic inventory, now accumulated in the broad channel of Lower Pueblo Canyon, further downstream and into Lower Los Alamos Canyon. Should such major movement occur, estimated potential risks and doses now calculated for bone and lung in Lower Pueblo Canyon would be applicable as upper limits for Lower Los Alamos Canyon. Concentrations in Lower Los Alamos Canyon would be increased by factors of as much as 10, which would be no more than the levels presently occurring in Lower Pueblo Canyon, with the resultant changes in risk noted.

During the year of such an event, it is possible that the average concentration of plutonium on suspended sediments in the Rio Grande in White Rock canyon down to Cochiti Dam (about 20 km downstream from the junction with Los Alamos Canyon) would be higher than that typically observed in the river due to worldwide fallout. Maximum levels would be about the same as the concentration considered by the EPA to be average for soils throughout the United States.

3. Transport of Radionuclides From the LAMPF Lagoons [R. W. Ferenbaugh and W. D. Purtymun (H-8)]

Cooling system leaks at the Los Alamos Meson Physics Facility (LAMPF) discharge water with activation product radionuclides, primarily ^{3}H, ^{7}Be, and ^{22}Na, into lagoons below the facility. Samples of water, sediments, and transpirate from trees adjacent to the effluent stream from the lagoons have been collected approximately every two months since the effluent began flowing in the spring of 1979. The purpose of this sampling program is to ascertain the extent to which radionuclides are dispersed from the lagoons. Figure 23 shows locations of the sampling sites relative to the lagoons and Los Alamos Canyon. Between sites 2 and 3, the discharge stream drops from the plateau, on which the lagoons are located, into a side canyon that eventually enters Los Alamos Canyon between sites 6 and 7. Surface water is

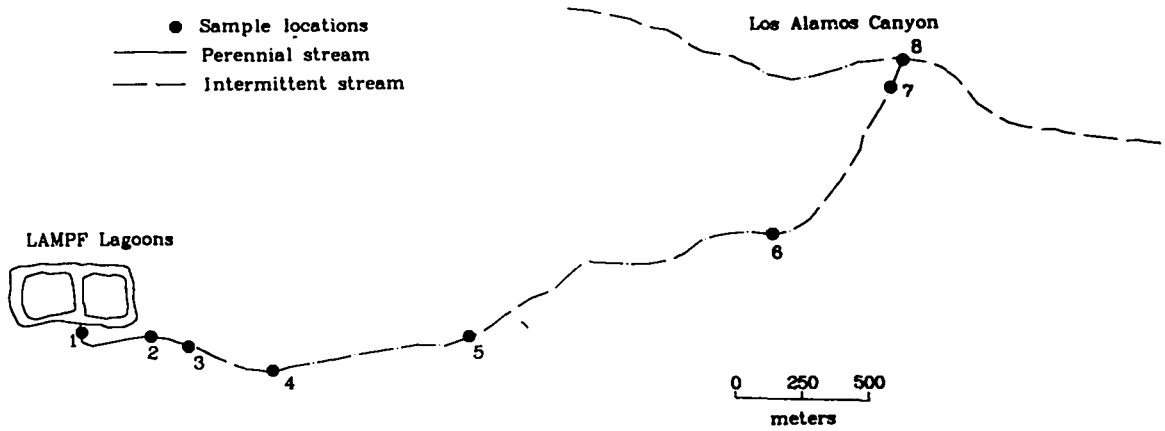


Fig. 23.
Sampling locations in vicinity of the LAMPF lagoons.

found in the side canyon below site 4 only during heavy runoff events.

A summary of the sampling results from 1979 and 1980 is shown in Table XXIII. These data show that radionuclide concentrations decrease with progression down the canyon and fall off sharply past sampling site 4. Tranpirates from piñon and juniper trees located immediately adjacent to the stream show elevated tritium concentrations (as HTO) above site 4. Tritium in transpirates collected below site 4 also are lower.

Given the uncertainty associated with the analytical results (approaching 100% in many cases), the data in Table XXIII are difficult to interpret in terms of accumulation in the environment. The ^{22}Na concentrations for 1980 do seem to be higher than the 1979 values. This may be because of the 2.6 yr half-life of ^{22}Na, compared with a half-life of only 53 days for ^{7}Be. Tritium has a half-life of 12.3 yr, but the 1979 and 1980 tritium profiles in water and sediment are very similar. However, transpirate samples for 1980 appear to have higher tritium levels than 1979 samples, indicating possible accumulation in the trees adjacent to the stream.

In general, the data continue to show that, while there has been some dispersal of radionuclides down the canyon receiving the discharge, there has been no detectable dispersion beyond where the discharge stream sinks into the alluvium.

4. Honeybees as Biological Monitors [R. W. Ferenbaugh and A. J. Ahlquist (H-8)]

Several studies[37-39] have demonstrated that honeybees can be used as indicators of environmental pollution. Use of honeybees for biological monitoring is presently being investigated by the U.S. Environmental Protection Agency. This investigation is based on the premise that honeybees pick up any contaminants present in the environment and concentrate them in their bodies and/or honey.

At the Los Alamos National Laboratory, use of honeybees as environmental biomonitors for radionuclides was first investigated by Dr. T. E. Hakonson[40] in the early 1970s. This work showed that honeybees could be used for this purpose, particularly for detection of tritium in the environment. More recently, a network of beehives has been established near waste disposal sites and waste stream outfalls throughout the Laboratory reservation. Bee and honey samples are collected each fall from these hives and from control hives at various locations away from the Laboratory. These samples are analyzed for both radioactive and nonradioactive constituents. Honey has proved to be rather intractable to most analytical techniques, but the analytical problems are slowly being resolved. Table XXIV shows analytical results that have been obtained

TABLE XXIII

ANALYTICAL RESULTS OF SAMPLES TAKEN BELOW LAMPF LAGOONS

	^{3}H		^{7}Be		^{22}Na	
	1979 ($\times 10^5$)	1980 ($\times 10^5$)	1979	1980	1979	1980
Water (pCi/ℓ)						
1	7.93 (5)	7.51 (4)	152 000 (5)	191 000 (4)	2310 (4)	4290 (4)
2	7.73 (5)	7.17 (4)	357 000 (5)	317 000 (4)	2290 (4)	4330 (4)
3	7.23 (4)	7.50 (4)	33 000 (4)	156 000 (4)	2070 (3)	4530 (4)
4	6.15 (3)	7.36 (4)	39 300 (2)	136 000 (4)	1400 (2)	4050 (4)
8	0.02 (2)	0.04 (3)	75 (2)	341 (3)	3 (1)	33 (3)
Sediment (pCi/g)						
1	7.91 (3)	7.47 (5)	2580 (3)	2120 (5)	2.2 (3)	6.3 (5)
2	8.27 (4)	6.54 (5)	5010 (5)	3570 (5)	5.9 (4)	12.5 (5)
3	7.32 (4)	6.66 (5)	2770 (5)	3850 (5)	1.9 (4)	4.2 (5)
4	4.55 (4)	6.61 (5)	439 (5)	2320 (5)	1.5 (4)	4.9 (5)
5	0.90 (4)	0.06 (5)	148 (5)	0.5 (5)	0.5 (4)	0.05 (5)
6	0.03 (4)	0.03 (5)	0.7 (5)	0.6 (5)	0.01 (4)	0.02 (5)
7	0.01 (3)	0.03 (5)	0.6 (3)	0.6 (5)	0.01 (3)	0.02 (5)
8	0.05 (3)	0.04 (3)	0.7 (4)	1.1 (5)	0.03 (3)	0.05 (5)
Transpirate (pCi/ℓ)						
2	3.47 (3)	5.73 (4)	483 (3)	1010 (3)	29 (3)	187 (3)
3	2.70 (4)	4.01 (3)	708 (4)	<416 (3)	129 (4)	28 (3)
4	0.97 (7)	2.42 (7)	30 (7)	<1330 (5)	5 (7)	110 (5)
5	0.00 (5)	0.04 (3)	914 (5)	350 (2)	8 (5)	15 (2)
6	0.01 (4)	0.01 (2)	250 (4)	<150 (1)	<31 (4)	40 (1)
8	0.00 (3)	0.03 (4)	667 (3)	<300 (1)	0 (3)	60 (1)

Note: Numbers in parentheses represent number of samples taken throughout the year.

to date. In addition to the data shown in Table XXIV, analyses of the 1980 honey samples showed no detectable quantities of mercury, ^{238}Pu, or ^{239}Pu. As further data are accumulated, they will provide monitoring information and possibly information on movement of pollutants in the environment and food chains.

5. Evaluation of Transuranic Waste Management Methods [L. J. Walker and W. R. Hansen (H-8)]

The project evaluating alternative transuranic (TRU) waste management strategies at Los Alamos National Laboratory is nearing completion, as a part of the

TABLE XXIV

ELEMENTAL ANALYSES OF BEES AND HONEY

Sample Location	Honey Analyses							
	^{7}Be (pCi/ℓ)	^{137}Cs (pCi/ℓ)		^{3}H (pCi/mℓ)		^{22}Na (pCi/ℓ)	U (ppb)	
	1980	1979	1980	1979	1980	1980	1979	1980
Area G	136	<43	<28	9.6	21.4	24	0	0
DP Canyon	<266	<29	16	5.8	5.6	<34	0	0
Effluent Canyon	<156	10	14	26.7	17.9	26	0	0
Mortandad Canyon	206	<29	4	11.8	27.4	<16	0	0.9
TA-33	<94	<26	30	579	207	4	0	0
TA-16	<196	1	62	2.8	5.2	28	0	0
Pajarito Acres	<176	0	6	10.5	7.9	<20	0	0
Barranca Mesa	<266	<9	6	3.6	4.0	12	0	0
Chimayo	92	<11	<42	0.6	3.0	82	0	0

Sample Location	Bee Analyses			
	U (ppb)		B (ppm)	
	1979	1980	1979	1980
Area G	23	14	25	20
DP Canyon	57	99	20	15
Effluent Canyon	15	47	11	13
Mortandad Canyon	36	96	24	17
TA-33	7	44	15	17
TA-16	18	31	11	11
Pajarito Acres	---	0	---	18
Barranca Mesa	---	59	---	14
Chimayo	---	20	---	19

Laboratory's ongoing waste management programs. The study considered several possible strategies for long-term management of TRU wastes currently buried and stored at Los Alamos. Several strategies were identified and the list narrowed to 14 alternatives and combinations selected for in-depth evaluation.

The alternative strategies selected for the study include:

- Continue present practices, that is, continue surveillance and maintenance of the six waste disposal sites where TRU wastes are thought to be located at Los Alamos, for an assumed 100 yr period of institutional control.
- Engineered improvements, that is, increase the depth of cover over the existing TRU waste sites and add an additional rip-rap cover.
- Exhumation of the buried wastes and retrieval of the stored wastes.
- Segregation of the wastes into TRU and non-TRU factions, with reburial of the non-TRU wastes.

- Resizing and packaging of the TRU wastes into standard-sized containers.
- Processing of the TRU wastes, that is, such as incineration of combustibles, decontamination of metallics, and immobilization of unprocessed materials and the residuals.
- Disposal by burial in a deep pit at Los Alamos.
- Disposal by entombment in a federally-owned deep geological repository.

Comparisons resulting from the study indicate the least amount of short-term (100 yr) commitment of dollars and other resources is the continue present practices alternative. Dollar costs for the other alternatives range up to a high of about seven times this base.

Results of the radiological dose assessment in general follow the cost pattern with one exception. The smallest radiation dose to workers and the public is with the Engineered Improvements option. For this option, additional cover would be added to enhance protection against possible intrusion. During this operation the wastes would not be contacted or uncovered. The radiological doses ranged from a low for the Engineered Improvements option, to a high of about 95 times higher for the most complex strategy relative to the base case of continue present practices. Dose estimates were made under both normal working conditions and under various accident scenarios, including estimated possible doses to occupationally exposed workers and the general public to a distance of 80 km, including the Albuquerque population.

Several groups at the Laboratory contributed to this study. Engineering and cost estimating efforts were performed by personnel from the Engineering Design Division (WX-4), while radiation dose estimates and assessment work was done by personnel from the Health Physics Group (H-1). Personnel from the Waste Management Group (H-7) contributed data on the waste inventory and source term definition. Environmental transport methodology and modelling were the responsibility of personnel from the Environmental Sciences Group (LS-6). Overall management, coordination, and the nonradiological assessments were provided by personnel from the Environmental Surveillance Group (H-8).

6. Environmental Surveillance of Radioactive Waste Disposal Areas. [D. L. Mayfield (H-8)]

In 1980, an environmental surveillance plan[41] tailored to specific radioactive waste disposal sites was developed to supplement the Laboratory's general environmental surveillance effort. The plan, which is for both active and retired disposal areas, specifies a brief annual survey for most disposal areas and a comprehensive survey for each disposal area every fifth year. The annual surveys are designed to monitor changes on the surface of each disposal area. Fifth year comprehensive surveys will disclose more subtle trends, both on and below the surface.

The survey plan also provides guidance in designing sampling grids and transects, using field instruments for radioactivity measurements, taking soil and biota sample, and applying laboratory analytical techniques to soil and biota specimens. Several areas were surveyed during the annual survey in 1980, and the results will be reported in 1981. The remaining areas will be surveyed in 1981.

7. Accumulation and Retention of Soil Particles on Plants [M. K. Wallwork-Barber (H-8) and T. E. Hakonson (LS-6)]

A study was conducted to measure accumulation and retention of soil particles on tomato plant surfaces as a function of soil particle size, surface of deposition, height of foliage above ground, rainfall characteristics, and time. Accumulation and retention of soil particles on plant surfaces are simultaneously occurring processes that require separate treatment to clarify experimental results. This was accomplished by conducting two studies, one involving accumulation of particles on foliage by rain splash-up of soil from the ground surface, and the other involving retention of particles that were applied directly to the foliage surfaces. A burlap covering over the ground surface prevented rain splash-up of soil from occurring in the retention plot. The number and size of particles per unit area of leaf surface were measured with a scanning electron microscope (SEM).

Results based on SEM analysis indicated that no particles greater than 200 μm in diameter were accumulated or retained by tomato plant surfaces. Particles smaller than 200 μm were divided into three size fractions, 4-16 μm (clays), 17-55 μm (silts), and 56-200 μm (fine sands). The number of particles in each size fraction was significantly different ($P < 0.05$). Clay particles accounted for 85 (~385 particles/mm^2) of the number of particles present on the plant surfaces, while the fine sand size accounted for less than 1% of the particles observed.

The number of particles present on plant surfaces decreased with an increase in height of foliage above

ground surface for all three particle sizes. Samples collected from the zone 0-40 cm above the ground surface contained 1.4 times more particles than the zone greater than 40 cm above the ground surface.

Distribution of particles on the plant as a function of location (upper leaf surface, lower leaf surface, stem) was uniform for all particle sizes with the exception of the clays. Clay particles (4-16 μm) were most abundant on upper leaf surfaces.

Accumulation of particles increased by a factor of 2, and retention of particles decreased by a factor of 1.5 as a function of time. Assuming that, after the fourth rainfall, the amount of soil on the plants was approaching equilibrium, an estimate can be made of the soil accumulation rate constant for plants under field conditions. Assuming a simple linear model [(amount of soil available for resuspension) × (accumulation rate constant) = (amount of soil on plant)], the accumulation rate constant was estimated to be about 9×10^{-5}/day. This estimate has been incorporated into the DOE-funded pathway analysis for the study "Human Radiation Exposures Near the Nevada Test Site."

This study confirmed that small, mobile particles are the major component of the soil that is accumulated and retained by plants, that clay particles preferentially accumulate on the upper leaf surfaces and lower heights of the plant, and that particle accumulation is influenced by rainfall intensity. Since silt-clay particles contain as much as 10 times higher contamination concentrations than the larger particles, this study could account for the relatively high radionuclide plant/soil concentration ratios observed in the field. It is also likely that as time progresses, an equilibrium is established between retention and accumulation processes, and this assumption can be used to estimate accumulation rate constants for plants under field conditions.

8. Hydrological Transport of Sediments [T. E. Hakonson (LS-6)]

During 1979, three runoff events occurred in Mortandad Canyon at the Los Alamos National Laboratory after placement of labeled soil in the stream channel. Two of the events (storms 1 and 2) were small and resulted in peak flows at the labeling location of 11.3 and 8.5 liters per second (*l*ps). The third event (storm 3) was substantially larger, although still a relatively small flow, and resulted in a peak flow of 241 *l*ps. Flows in excess of 2800 *l*ps have been recorded in Mortandad Canyon.

Data on runoff and particle transport distance as a function of accumulative number of runoff events demonstrate that particle sorting by runoff occurs and that smaller particles are transported further downstream than larger particles during a given runoff event. For example, labeled silt-clay (<53 μm) particles were transported at least 10 times further downstream than were the medium to coarse sands (106-495 μm and >495 μm, respectively) during a given runoff event. The highly mobile nature of the silt-clay particles is further indicated by their presence in the stream channel at locations where surface water runoff from a given event ceased.

Depletion of labeled soil from the label location was most rapid for silt-clay particles, being consistent with the high mobility of this size fraction. Following the first runoff event, maximum concentrations of ^{182}Ta (<53 μm particles) in the label location were only 13% of the initial concentrations, whereas from 65% to 100% of the initial concentrations of the tracers ^{141}Ce, ^{124}Sb, and ^{46}Sc could still be detected at the label location after the first runoff event. However, after three runoff events less than 3% of the initial concentrations of any of the tracers were detected at the label location.

The implication of these data are that a point source of contamination in the intermittent stream channel in Mortandad Canyon is rapidly diluted and/or transported downstream. The rate of depletion, initially, is more rapid for the highly mobile silt-clay size fraction; however, this depletion is nearly complete for all size fractions after as few as three relatively small runoff events.

In summary, particle sorting by rainstorm runoff does occur and is characterized by large downstream movement of silt-clay particles with relatively smaller movement of coarser particle sizes. Furthermore, the maximum transport distance of silt-clay particles coincides with the maximum distance downstream that surface water runoff occurs. Transport of labeled soil particles from a point source is most rapid for silt-clay particles; however, after as few as three relatively small runoff events, less than 3% of any of the labeled particles remained at the label location. Thus, contaminants, particularly those associated with silt-clay size fractions, that are released to an intermittent stream channel would be rapidly transported downstream during rainstorm runoff events.

9. A Reference Elk Model for Calculating Contaminant Doses to Rocky Mountain Elk [Susan Meadows (LS-6)]

Most toxic substances are unevenly distributed throughout the body.[42] For instance, iodine is used primarily by the thyroid, and the radioactive isotope ^{131}I will accumulate in that gland. Total body weight alone provides insufficient information to calculate the body burden, or dose, of a particular contaminant. However, if the ratio of a target tissue, such as thyroid, to total body weight is known, total weight can be used to estimate dosage. A model for the Reference Man was developed in 1949 to calculate radiation doses to human beings[42] and was updated in 1975.[43] During studies on radionuclide metabolism in mule deer (*Odocoileus hemionus hemionus*), Hakonson and Whicker[44] developed a similar model for that species.

The objective of this study was to devise a Reference Elk model for use in radioactive and stable contaminant dose assessments in elk (*Cervus elaphus nelsoni*). It was conducted at the Los Alamos National Environmental Research Park, which is located on the eastern slope of the Jemez Mountains in north-central New Mexico, and encompasses the Los Alamos National Laboratory. A large population of elk winter in a ponderosa pine habitat on and near Laboratory technical areas. These animals could potentially obtain radioactive and stable contaminants from areas contaminated by Laboratory activities.[9]

Between 18 March and 16 April 1980, five elk were collected in an abandoned Laboratory technical area. Each carcass was dissected and all tissues weighed. Information obtained from the dissections was used to calculate the Reference Elk model presented in Table XXV. Boyd[45] offers similar data for Rocky Mountain elk, but only for five major organs. A complete Reference Elk model was not available before completion of this study.

Certain tissue percentages are similar for man and elk, such as muscle tissue and lungs. Differences occur with the proportionally larger brain of man, and larger gastrointestinal tract characteristic of ruminant elk. Mule deer and elk have similar proportions of muscle tissue and whole skeleton, but show important differences in proportions of lung, liver, and heart mass. The latter is possibly related to differences in metabolism and total body size. The Reference Elk, like the Reference Man and Reference Mule Deer, is expected to provide reliable baseline data for studies of environmental contaminants and their effects on mammalian systems.

10. Los Alamos National Environmental Research Park Biotelemetry Studies on Elk [G. C. White (LS-6)]

Elk biotelemetry studies were continued during the past year in Los Alamos National Environmental Research Park through cooperative research with Bandelier National Monument, U.S. Forest Service (Santa Fe National Forest), Baca Land and Cattle Company, New Mexico Game and Fish Department, and Los Alamos National Laboratory. A total of 36 elk have been live-trapped, marked, and released over the past 2 yr, with 30 of these animals radio collared. Objectives of this study are to (1) determine areas on Laboratory and adjacent lands that are heavily used by elk, (2) determine habitat use and seasonal migration pathways, and (3) develop effective methodologies for the study of large herbivore populations.

Biotelemetry data have shown that the elk favored a wintering habitat created by the June 1977 La Mesa Forest Fire. Several 10 yr old clear cuts were used for calving and nursing areas. In general, radio- collared elk tended to use areas in an early successional state and where there was little human activity.

The rate of poaching in areas frequented by the radio-collared elk appears to be fairly low. Only 2 animals are assumed to have been poached in over 45 elk-years. Thus, the probability of an individual elk being killed by poachers during a year appears to be about 0.044 (95% confidence interval is 0 to 0.106). This result does not imply that numerous elk are not poached, but rather than for any one individual, there is only a of 44 in 1000 chance that it will be illegally taken by a poacher during the coming year. Stated differently, the radio-collar data suggest that 4.4% of the population is taken illegally each year. Note that this figure is based on a very small sample of two elk poached in 45 elk-years, so interpretation must be carefully made. Also, the survival rate of 2-1/2-yr old bulls through their first legal hunting season is estimated to be 60% (95% confidence interval is 14% to 95%), based on a very limited sample size of two kills.

Two new techniques have been published by personnel associated with this study. Hayes[46] developed a method to detect when an elk has been caught in a trap utilizing radio transmitters. White[47] developed a method of

TABLE XXV

PERCENTAGE OF TOTAL WEIGHT FOR TISSUES OF MAN, MULE DEER, AND ROCKY MOUNTAIN ELK

Tissue	% of Total Weight		
	Man[a]	Mule Deer[b]	Elk[c]
Pelt	---	---	5.8 ± 0.94[d]
G.I. tract	1.7	---	5.4 ± 0.56
Diaphragm	---	0.36	0.59 ± 0.13
Kidneys	0.44	0.26	0.19 ± 0.022
Spleen	0.26	0.26	0.34 ± 0.20
Reproductive tract	---	---	2.7 ± 0.65
Liver	2.6	1.90	1.1 ± 0.058
Lungs	1.4	1.80	1.4 ± 0.24
Esophagus	0.06	0.080	0.10 ± 0.033
Heart	0.47	0.85	0.62 ± 0.041
Adrenals	0.020	0.010	0.0039 ± 0.00026
Pancreas	0.14	0.10	0.079 ± 0.014
Thyroid	0.029	0.009	0.0061 ± 0.0014
Pituitary	0.00086	0.002	0.0011 ± 0.00029
Brain	2.0	0.30	0.15 ± 0.019
Eyes	0.02	0.066	0.031 ± 0.0049
Tongue	0.10	0.25	0.27 ± 0.066
Skeletal muscle	40	46.9	44 ± 0.55
Whole skeleton[e]	14	10.3	11 ± 0.8
Long bones	---	---	4.8 ± 0.58
Marrow[f]	2.1	---	0.35 ± 0.019

[a]From ref. 43. Man weighs 70 kg.
[b]From ref. 44. Mule deer weighs 63 kg.
[c]Elk weighs 233 kg.
[d]±1s.
[e]Reference man weighed with marrow; reference elk and mule deer weighed without long bone marrow.
[f]Reference man: all yellow marrow; reference elk: yellow marrow iron long bones only.

presenting biotelemetry data utilizing computer generated movies. Movies of the data allow the time dimension to be emphasized and illustrate interactions among the individual animals.

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APPENDIX A

STANDARDS FOR ENVIRONMENTAL CONTAMINANTS

The concentrations of radioactive and chemical contaminants in air and water samples collected throughout the environment are compared with pertinent standards contained in the regulations of several federal and state agencies in order to verify the Laboratory's compliance with these standards. Because many DOE orders, manuals, and directives are still being promulated and were not considered final at the time this report was being written, numerous references have been made to Energy Research and Development Administration (ERDA) Manual Chapters which continue to serve as guidelines until superseded by the final DOE orders and manuals. Laboratory operations pertaining to environmental quality control are conducted in accordance with the directives and procedures contained in ERDA's Health and Safety Manual, Chapters 0510, 0511, 0513, 0524, and 0550.

In the case of radioactive materials in the environment, the guides contained in Manual Chapter 0524 are used as a basis for evaluation. However, the ERDA standard for uranium in water (1500 and 60 mg/ℓ for controlled and uncontrolled areas, respectively) does not consider chemical toxicity. Therefore, for the purposes of this report, the more restrictive standards[A1] of the International Commission on Radiological Protection (ICRP) for uranium in water (60 mg/ℓ for an occupational 40-h week) are used as a point of comparison. For atmospheric uranium, the ERDA and ICRP standards are in agreement. The standards are listed in Table A-I in the form of a Radioactivity Concentration Guide (CG). A CG is the concentration of radioactivity in air breathed continuously or water constituting all that ingested during a year that is determined to result in whole body or organ doses equal to the Radiation Protection Standards (RPSs, listed in Table A-II) for internal and external exposures. Obviously, there are uncertainties in relating CGs to RPSs. Uncontrolled area CGs correspond to RPSs for the general public, whereas controlled area CGs correspond to RPSs for workers. Thus, common practice and stated ERDA policy in Manual Chapter 0524 are that operations shall be "conducted in a manner to assure that radiation exposure to individuals and population groups is limited to the lowest levels technically and exonomically practicable."

Because some radioisotopes remain in the body and cause exposure long after intake has occurred, the RPSs require consideration of the dose commitment caused by inhalation, ingestion, or absorption of such isotopes. For purposes of this report, 50-yr dose commitments were calculated where appropriate using dose factors from reference A-2.

For chemical pollutants in water supply, the controlling standards are those promulgated by either the Environmental Protection Agency (EPA) or the New Mexico Environmental Improvement Division (NMEID, see Table A-III). EPA's maximum contaminant level (MCL) is the maximum permissible level of a contaminant in water which is delivered to the free flowing outlet of the ultimate user of a public water system.[A2]

Radioactivity in public water supply is governed by EPA regulations contained in 40CFR141. These regulations provide that combined ^{226}Ra and ^{228}Ra shall not exceed 5×10^{-9} μCi/mℓ (5 pCi/ℓ) and gross alpha activity (including ^{226}Ra, but excluding radon and uranium) shall not exceed 15×10^{-9} μCi/mℓ (15 pCi/ℓ). A screening level of 5×10^{-9} μCi/mℓ (5 pCi/ℓ) is established as part of the monitoring requirements to determine whether specific radium analyses must be performed. Plutonium concentrations are compared to the EPA gross alpha MCL of 15×10^{-9} μCi/mℓ (15 pCi/ℓ).[A3]

For man-made beta and photon emitting radionuclides, the EPA drinking water regulations specify that a concentration be limited to a level that would result in a dose of 4 mrem/yr calculated according to a specified procedure. The EPA calculated value for tritium (^{3}H) is 20×10^{-6} μCi/mℓ and for cesium (^{137}Cs) is 200×10^{-9} μCi/mℓ.[A3]

TABLE A-I

ERDA RADIOACTIVITY CONCENTRATION GUIDES (CGs)

Concentration Guides for Uncontrolled Areas[a,b]

Nuclide	CG for Air (μCi/mℓ)	CG for Water (μCi/mℓ)	CG for Water (nCi/ℓ)
^{3}H	2×10^{-7}	3×10^{-3}	3000
^{7}Be	---	2×10^{-3}	2000
$^{11}C, ^{13}N, ^{15}O$	3×10^{-8}	---	---
^{41}Ar	4×10^{-8}	---	---
^{89}Sr	3×10^{-10}	3×10^{-6}	3
^{90}Sr[d]	3×10^{-11}	3×10^{-7}	0.3
^{131}I[d]	1×10^{-10}	3×10^{-7}	0.3
^{137}Cs	5×10^{-10}	2×10^{-5}	20
^{238}Pu	7×10^{-14}	5×10^{-6}	5
^{239}Pu[d]	6×10^{-14}	5×10^{-6}	5
^{241}Am	2×10^{-13}	4×10^{-6}	4
	(pg/m^3)[c]		(mg/ℓ)
U, natural[c]	9×10^{6}	2×10^{-5}	60
			1.8 (ICRP[e])

Concentration Guides for Controlled Areas[a,b]

Nuclide	CG for Air (μCi/mℓ)	CG for Water (μCi/mℓ)	CG for Water (nCi/ℓ)
^{3}H	5×10^{-6}	1×10^{-1}	1×10^{5}
^{7}Be	---	5×10^{-2}	5×10^{4}
$^{11}C, ^{13}N, ^{15}O$	1×10^{-6}	---	---
^{41}Ar	2×10^{-6}	---	---
^{89}Sr	3×10^{-8}	3×10^{-4}	300
^{90}Sr	1×10^{-9}	1×10^{-5}	10
^{131}I[d]	4×10^{-9}	3×10^{-5}	30
^{137}Cs	1×10^{-8}	4×10^{-4}	400
^{238}Pu	2×10^{-12}	1×10^{-4}	100
^{239}Pu[d]	2×10^{-12}	1×10^{-4}	100
^{241}Am	6×10^{-12}	1×10^{-4}	100
	(pg/m^3)[c]		(mg/ℓ)
U, natural[c]	2.1×10^{8}	5×10^{-4}	1500
			60 (ICRP[e])

[a]This table contains the most restrictive CGs for nuclides of major interest at the Laboratory (ERDA Manual Chap. 0524, Annex A).

[b]CGs apply to radionuclide concentrations in excess of that occurring naturally or due to fallout.

[c]One curie of natural uranium is equivalent to 3000 kg of natural uranium. Hence, uranium masses may be converted to the ERDA "uranium special curie" by using the factor 3.3×10^{-13} μCi/pg.

[d]Of the possible alpha and beta emitting radionuclides released at the Laboratory, ^{239}Pu and ^{131}I, respectively, have the most restrictive CGs. The CGs for this species are used for the gross alpha and gross beta CGs, respectively.

[e]For purposes of this report, concentrations of total uranium in water are compared to the ICRP recommended values which consider chemical toxicity.

TABLE A-II

ERDA RADIATION PROTECTION STANDARDS FOR EXTERNAL AND INTERNAL EXPOSURES

Individuals and Population Groups in Uncontrolled Areas

Type of Exposure	Annual Dose Equivalent or Dose Commitment (rem)[a]	
	Based on Dose to Individuals at Points of Maximum Probable Exposure	Based on an Average Dose to a Suitable Sample of the Exposed Population
Whole body, gonads, or bone marrow	0.5	0.17
Other organs	1.5	0.5

Individuals in Controlled Areas

Type of Exposure	Exposure Period	Dose Equivalent [Dose or Dose Commitment[a] (rem)]
Whole body, head and trunk, gonads, lens of the eys,[b] red bone marrow, active blood forming organs.	Year	5[c]
	Calendar Quarter	3
Unlimited areas of the skin (except hands and forearms). Other organs, tissues, and organ systems (except bone).	Year	15
	Calendar Quarter	5
Bone	Year	30
	Calendar Quarter	10
Forearms[d]	Year	30
	Calendar Year	10
Hands[d] and feet	Year	75
	Calendar Quarter	25

[a]To meet the above dose commitment standards, operations must be conducted in such a manner that it would be unlikely that an individual would assimilate in a critical organ, by inhalation, ingestion, or absorption, a quantity of a radionuclide(s) that would commit the individual to an organ dose which exceeds the limits specified in the above table.

[b]A beta exposure below a maximum energy of 700 keV will not penetrate the lens of the eye; therefore, the applicable limit for these energies would be that for the skin (15 rem/year).

[c]In special cases with the approval of the Director, Division of Safety, Standards, and Compliance, a worker may exceed 5 rem/year provided his/her average exposure per year since age 18 will not exceed 5 rem/year.

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

TABLE A-III

MAXIMUM CONTAMINANT LEVEL (MCL) IN WATER SUPPLY FOR INORGANIC CHEMICALS AND RADIOCHEMICALS[a]

Inorganic Chemical Contaminant	MCL (mg/ℓ)
As	0.05
Ba	1.0
Cd	0.010
Cl	250
Cr	0.05
F[b]	2.0
Pb	0.05
Hg	0.002
Na	250
NO_3	45
Se	0.01
Ag	0.05
TDS	1000

Radiochemical Contaminant	MCL (μCi/mℓ)
^{137}Cs	200×10^{-9}
Gross alpha[c]	5×10^{-9}
^{3}H	20×10^{-6}
^{238}Pu	15×10^{-9}
^{239}Pu	15×10^{-9}

[a]EPA's National Interim Primary Drinking Water Regulations (EPA-570/9-76-003), EPA, Office of Water Supply (1976) and NMEID Water Supply Regulations (Regulations Governing Water Supply, N.M. Environmental Improvement Agency, Santa Fe, N.M., Dec. 9, 1977).
[b]Based on annual average of the maximum daily air temperature of 14.6 to 17.7°C.
[c]See text for discussion of application of gross alpha MCL and gross alpha screening level of 5×10^{-9} μCi/mℓ.

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APPENDIX B

SAMPLING PROCEDURES AND STATISTICAL TREATMENT OF DATA

A. Thermoluminescent Dosimeters

Lithium fluoride (LiF) chips, 6.4 mm square by 0.9 mm thick, are used in the environmental and Los Alamos Meson Physics Facility (LAMPF) networks. The chips are annealed at 400°C for 1 h and then cooled rapidly to room temperature. This is followed by annealing at 100°C for 1 h and again cooling rapidly to room temperature. In order for the annealing conditions to be repeatable, the chips are put into rectangular borosilicate glass vials that hold 48 LiF chips each. These vials are slipped into rectangular holes formed by stacking machined stainless steel blocks inside the ovens maintained at 400°C and 100°C. After 1 h the vials are removed from the ovens and placed between massive copper blocks at room temperature.

Incandescent lighting is used exclusively during all phases of annealing, dosimeter preparation, and readout to prevent ultraviolet-induced spurious thermoluminescence (TL). Four chips are placed in a molded nylon acorn nut, size 3/8-16, then closed with a 3/8-16 × 1/4 inch nylon set screw. This assembly constitutes one dosimeter. A calibration set is prepared each time chips are annealed. Some unexposed chips from this annealed batch are read at the start of the dosimetry cycle. The calibration set is read at some convenient time during the dosimetry cycle. Exposure received during storage is determined using readings from the unexposed chips, and the calibration set is normalized to the start of the 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 in the range between 0 mR and 160 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 factor of 0.958 for muscle for ^{137}Cs and the factor 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] 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).[B2]

The TLD chips used are all from the same production batch and were selected by the manufacturer so that the measured standard deviation in TL 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 LAMPF operation cycle, the dose at each network location is calculated along with the upper and lower limits at the 95% confidence level.[B3] 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.

B. Air Sampling

1. Sampling Procedures

Samples are collected monthly at 25 continuously operating station. Positive displacement air pumps with flow rates of approximately 3 ℓ/sec are used. Atmospheric aerosols are collected on 79 mm diameter polystyrene filters. Part of the total air flow (2.4 — 3.1 mℓ/sec) is passed through a cartridge containing silica gel to adsorb atmospheric water vapor for tritium analyses. Air flow rates through both sampling cartridges are measured with variable-area flow meters, and sampling times recorded.

Gross alpha and gross beta activities on the monthly air filters are measured with a gas-flow proportional counter on collection day and again 7 to 10 days after collection. The first count is used to screen samples for inordinate activity levels. The second count (made after absorbed, naturally-occurring, radon-thoron daughters had reached equilibrium with their long-lived parents) provides a record of long-lived atmospheric radioactivity.

At one location (N050-E040) atmospheric radioactivity samples are collected daily (Monday through Friday). Atmospheric particulate matter on each daily filter

is counted for gross alpha and gross beta activities on collection day and again 7 to 10 days after collection. The first measurement provides an early indication of any major change in atmospheric radioactivity. The second measurements are used to observe temporal variations in long-lived atmospheric radioactivity.

After being measured for gross alpha and gross beta activities, the monthly filters for each station are cut in half. The first group of filter halves is then combined and dissolved to produce quarterly composite samples for each station. The second group of filter halves is saved for uranium analysis.

Plutonium is separated from the solution by anion exchange. For 11 selected stations, americium is separated by cation exchange from the eluent solutions from the plutonium separation process. The purified plutonium and americium samples are separately electrodeposited and measured for alpha-particle emission with a solid-state alpha detection system. Alpha-particle energy groups associated with the decay of ^{238}Pu, ^{239}Pu, and ^{241}Am are integrated, and the concentration of each radionuclide in its respective air 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 25 air sampling stations are analyzed monthly for tritiated water. The cartridges contain a small amount of blue "indicating" gel at each end to indicate a desiccant over-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 frrm each silica gel sample, yielding a monthly average atmospheric water vapor sample. An aliquot of the distillate is then analyzed for tritium by liquid scintillation counting.

2. Statistical Analysis

Measurements of the air particulate samples require that chemical or instrumental backgrounds be subtracted to obtain net values. Thus, net values lower than the minimum detection limit (MDL, Table C-IV) of an analytical technique are sometimes obtained. Consequently, individual measurements result in values of zero or negative numbers because of statistical fluctuations in the measurements. 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[B4] are included in the population.

Uncertainties reported for maximum and minimum concentrations reflect uncertainties introduced both in the field (flow rate and time determinations), and laboratory (counting, pipetting, etc.). These values indicate the precision of the maximums and minimums and represent twice the propagated measurement uncertainties.

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

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

where

s_c = standard deviation of $\bar{c}$
$\bar{c}$ = annual mean of a station or group of stations
c_i = concentration for station i
N = number of concentrations (sampling periods).

An analysis of variance is done with groups (regional, perimeter, onsite) and sampling period (month or quarter) as sources of variation. A commercially available software package[B5] is used for this analysis. The purpose of the analysis is to detect significant differences among regional, perimeter, and onsite means. Differences are declared significant at $P < 0.05$. This means there is a 5% probability of concluding a difference exists when there is none.

Next, all radioactive constituents that exhibit significant differences among regional, perimeter, and onsite annual means are analyzed using a modified t-test for unpaired observations and unequal variances.[B6] The t-test is used to compare regional-perimeter, onsite-perimeter, and regional-onsite group annual means and specifically determine if a particular group differed from the other two groups.

Finally for each radioactive constituent, the Student-Newman-Keul procedure[B6] is used to determine within a group which stations are significantly different. This procedure was chosen because it mitigates a problem that arises with multiple comparisons. Namely, there is

almost a certainty that some differences will be falsely declared significant. The 5% test level used in this procedure means that 5% of the comparisons will give false significant differenes.

C. Water, Soil, and Sediment Sampling

Surface and ground water sampling points are grouped (regional, perimeter, and onsite) according to location and hydrologic similarity. Surface and ground water grab samples are taken one to two times annually. Samples from wells are collected after sufficient pumpage or bailing to ensure that the sample is representative of the water in the aquifer. Spring samples (ground water) are collected at point of discharge.

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 for filtration through a 0.45 μm pore membrane filter. The samples are analyzed radiochemically for dissolved cesium (^{137}Cs), plutonium (^{238}Pu and ^{239}Pu), and tritium (as HTO), as well as for total dissolved gross alpha, beta, and gamma activities. Total uranium is measured using the neutron activation method (see Appendix C).

Water is collected for chemical analyses at the same time as for radiochemical analysis and returned to the laboratory for filtration. Samples for trace constituents in the water supply are collected and acidified in the field and returned immediately to the laboratory for filtration.

Soil samples are collected by taking five plugs, 75 mm in diameter and 50 mm deep, at the center and corners of a square area 10 m on a side. The five plugs are combined to form a composite sample for radiochemical analyses. 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 across the main channel. The soil and sediment samples are analyzed for gross alpha and gross beta activities, ^{137}Cs and ^{238}Pu and ^{239}Pu. Moisture distilled from soil samples is analyzed for ^{3}H. A few select samples are analyzed for ^{90}Sr.

Samples of snowmelt runoff are filtered through a 0.45 μm filter. The radioactivity and chemical composition of the solution is defined as filtrate passing through the filter, while the radioactivity in suspended sediments is defined as the residue on the filter.

The average concentrations of radionuclides and chemical constituents are reported for a number of individual analyses in Tables E-XIII through E-XXI and Tables E-XXIII and E-XXV. The minimum and maximum values reported are individual analyses in the groups, while the average is computed from all of the individual analyses in the group. The uncertainty following the primary value represents twice the standard deviation of the distribution of observed values, or the analytical variation for individual results.

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APPENDIX C

ANALYTICAL CHEMISTRY METHODS

1. Procedures

a. **Plutonium and Americium.** Soil and sediment samples are dried, sieved through a No. 12 screen (<1.7 mm), and split into 10 g aliquots. Each aliquot is leached with HF-HNO_3.

Waters are acidified to ~1% HNO_3 in the field. Immediately upon arrival in the laboratory, they are filtered through 0.45 μm pore membrane filters, split into 500 mℓ aliquots, and evaporated to dryness with HNO_3. The residue is treated with HF to dissolve silica.

Air filters are ignited in platinum dishes, treated with HF-HNO_3 to dissolve silica, wet ashed with HNO_3-H_2O_2 to decomose the organic residue and treated with HNO_3HCl to ensure isotopic equilibrium.

Vegetation samples are ashed in a high temperature oven and then treated with soil samples. All samples are spiked with standardized ^{242}Pu and ^{243}Am during dissolution to serve as a chemical recovery tracer.

Dissolved samples are thoroughly digested in 7.2 M HNO_3, and 1M $NaNO_2$ is added to ensure that Pu is in the tetravalent state. The solution is passed through a preconditioned anion exchange column. The initial eluate and the first 20 mℓ of a 7.2 M HNO_3 wash is saved for ^{241}Am analysis. The column is then washed with 7.2 M HNO_3 and 8 M HCl. Plutonium is eluted with a freshly prepared solution of 1 g/ℓ NHI in 1M HCl. The eluate is appropriately conditioned and Pu is electrodeposited from a 4% solution of $(NH_4)_2C_2O_4$. The plated Pu is counted on an alpha spectrometer. Values reported for ^{239}Pu are the sum of ^{239}Pu and ^{240}Pu, since both have identical alpha energies.

For water and air filter samples, the eluate from the Pu column is conditioned to ensure removal of HNO_3 and adjusted to 0.5 M HCl. This solution is loaded on a cation exchange column, rinsed with 0.5 M HCl followed by 2.0 M HCl, and Am is eluted with 4 M HCl. The eluate is converted to the nitrate, made 6 M with HNO_3, then mixed with ethanol in the proportion 40% 6 M HNO_3-60% ethanol, and loaded on a preconditioned anion exchange column. The column is washed with 75% methanol-25% 6 M HNO_3, and 60% methanol-40% 6 M HNO_3. Americium is eluted with 60% methanol-40% 2.5 M HNO_3. This nonaqueous solvent-anion exchange step separates the rare earth elements, other actinides, and Ra from Am.

For soil and vegetation samples the eluate from the Pu column is converted to 6 M HCl. Americium is extracted into 0.015 M DEHPP and then back extracted with $(NH_4)_2CO_3$. The back extract is decomposed with HCl, HNO_3, and $HClO_4$, dissolved in 3 M HCl. The solution is brought in 3 M in HF and Am is coprecipitated with YF_3. The YF_3 is dissolved with H_3BO_3 in 6 HNO_3, then mixed with ethanol in the proportion 40% 6 M HNO_3-60% ethanol, and loaded on a preconditioned anion exchange column. The column is washed with 75% methanol-25% 6 M HNO_3 and 60% methanol-40% 6 M HNO_3. Americium is eluted with 60% methanol-40% 2.5 M HNO_3. This nonaqueous solvent-anion exchange step separates the rare earth elements, other actinides, and Ra from Am.

Air filter, water, soil, and vegetation sample eluates from the methanol-HNO_3 column are coprecipitated with a 50 μg Nd carrier. The precipitate is filtered onto 0.05 μm Millipore MF filters. Values of ^{241}Am are determined by alpha spectrometry.

b. **Gross Alpha and Beta.** Two grams of soil or sediment are leached in hot HNO_3-HCl, and the supernate is transferred to a stainless steel planchet and dried for counting.

Nine hundred mℓ of water are acidified with 5 mℓ of HNO_3 and evaporated to dryness. The residue is treated with HF-HNO_3 to dissolve silica, and H_2O_2 and HNO_3 to destroy organics. Residue is dissolved in 7.2 M HNO_3, and then transferred to a counting planchet.

Air filters are mounted directly on counting planchets.

Samples appropriately loaded on the planchets are counted on a thin window, dual channel, gas proportional counter. Activity is calculated with appropriate corrections for cross talk between the two channels and the effect of mass loading on the counting efficiency.

c. **Tritium.** Soils are heated to evaporate the soil moisture, the condensate is trapped, and 5 mℓ aliquots are transferred to scintillation vials.

Water samples are acidified to ~1% HNO_3 in the field and filtered through 0.45 μm pore membrane filters immediately upon arrival in the laboratory. Five mℓ of the water are transferred into a scintillation counting vial.

Atmospheric water is trapped in a desiccator in the field. Moisture is removed from desiccant in the laboratory, and appropriate aliquots taken for scintillation counting. Fifteen mℓ of scintillation liquid are added to each sample, which is then vigorously shaken.

Samples are counted in a liquid scintillation counter for 50 min or 10 000 counts, whichever comes first. Standards and blanks are counted in conjunction with each set of samples.

d. **^{137}Cs and Gross Gamma.** Soils and sediments are sieved through a No. 12 (<1.7 mm) screen. One hungred grams of the sieved soils are weighed into polyethylene bottles.

Water samples are acidified in the field to ~1% HNO_3 and filtered through 0.45 μm pore membrane filters. Five hundred mℓ of each sample are transferred to a standard 500 mℓ polyethylene bottle for counting.

The amount of ^{137}Cs is determined by counting on a Ge(Li) detector coupled to a multichannel analyzer. The activity is calculated by direct comparison with standards prepared in the same geometrical configuration as the samples. Gross gamma is measured by counting in an NaI(Tl) well counter, which accommodates the 500 mℓ bottles. A single channel analyzer adjusted to register gamma radiation between 0 and 2 MeV is interfaced to the detector. Gross gamma determinations are reported as net counts per unit time and unit weight.

e. **^{90}Sr.** Sample preparation and dissolutions are similar to those described in the section on Pu. After dissolution, the residue is dissolved in HCl, the pH is adjusted to 2, and Y is separated from Sr by extraction into 20% HDEHP in toluene. The isolated ^{90}Sr is left undisturbed for two weeks to allow the daughter ^{90}Y to attain radioactive equilibrium. After that period, inactive Y carrier is added and ^{90}Y is again extracted from ^{90}Sr by solvent extraction into 5% HDEHP in toluene. Yttrium is back extracted into 3 M HNO_3 and precipitated as the hydroxide. Yttrium hydroxide is redissolved and the oxalate is precipitated. This precipitate is oven fired to the oxide which is filtered and weighed to determine the chemical yield. Yttrium oxide precipitate is counted on a gas proportional counter to measure the activity. Samples are recounted after three days to verify the separation of ^{90}Y from other beta-emitting nuclides.

f. **Uranium.** Analyses for U are performed in one of two ways—instrumental epithermal neutron activation analysis or delayed neutron activation analysis. In the first method, two gram samples are irradiated in the epithermal neutron port at the Los Alamos Omega West Reactor. A period of two to four days is allowed to pass after the irradiation, and the samples are counted on a Ge(Li) gamma-ray spectrometer. The 228 and 278 keV transitions from ^{239}Np are used for the quantitative determination. The nuclear reaction is $^{238}U\ (n,\gamma) \rightarrow {}^{239}Np + \beta$. Obviously the ratio measures the major isotope of U and calculates total U assuming ^{238} is >99% of the total U. This assumed value will probably not vary significantly in environmental samples.

For samples with U concentrations greater than 100 ppm, another epithermal irradiation may be used. Following a 5 min irradiation and 10 min decay, the 75 keV gamma ray from ^{239}U may be observed directly rather than waiting for the total decay to ^{239}Np. Results from both epithermal methods have been reported in the literature.[C1-C3]

In the second method, samples are irradiated in a thermal neutron port and pneumatically transferred to a neutron counter where the delayed neutrons produced by the fission of ^{235}U are measured.[C4] The technique is very manpower efficient and has a lower limit of detection than does the epithermal irradiation method. However, total U is calculated assuming a $^{235}U/^{238}U$ ratio of 0.0072. Variations in this ratio will produce inaccuracies in the result, hence samples likely to contain depleted U were not analyzed by this method because of the lower limits of detection. Most of our U analyses are done by this method because it is the more sensitive.

An advantage to having both U techniques available is that samples containing enriched U may be measured. The ^{235}U content may be determined by delayed neutrons and the ^{238}U content by epithermal activation. Total U is the sum of these, and a rough indication of the isotope ratio may also be given.

A comparison of these methods with the more traditional fluorometric technique for U analysis in soils has been published.[C5]

2. Stable Elements

Six instrumental methods are used for a wide variety of stable element determinations. Neutron activation and atomic absorption are the principal techniques with inductively coupled argon plasma emission spectrometry,

ion chromatography, ion selective electrodes, and combustion analysis used in a supplementary role. Elements and anions determined by the various methods are summarized in Table C-I. In addition, standard chemical methods are used for HCO_3^{-2}, total dissolved solids (TDS), and total hardness. It should be noted that our Hg method of choice is cold vapor atomic absorption using the standard Perkin-Elmer technique.

3. Analytical Chemistry Quality Evaluation Program

Control samples are analyzed in conjunction with the normal analytical chemistry workload. Such samples consist of two general types. Blanks are matrix materials containing quantities of analyte below the detection limit

TABLE C-I

ANALYTICAL METHODS FOR VARIOUS ELEMENTS AND ANIONS

Technique	Elements/Anions Measured	References
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	C1,6,7,8,9
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	C1,3,10,11,12,13,14,15
Thermal Neutron Capture Gamma Ray	Al,B,Ca,Cd,C,Gd,H,Fe,Mg N,P,K,Si,Na,S,Ti	C1,16,17,18,19,20,21,22,23
Radiochemical	Sb,As,Cu,Au,Ir,Hg,Mo,Os,Pd Pt,Ru,Se,Ag,Te,Th,W,U	C1,24,25,26,27,28,29,30,31,32
Delayed Neutron Assay	U,Th	C1,2,4,5,33,34
Atomic Absorption	Sb,As,Ba,Be,Bi,Cd,Ca,Cr,Co,Cu F,Ga,In,Fe,Pb,Li,Mg,Mn,Hg,Mo, Ni,K,Se,Si,Ag,Na,Sr,Te,Tl,Sn, Ti,V,Zn	C35,36,37,38,39,40,41,42
Ion Chromatography	F^-,Cl^-,Br^-,NO_2^-, NO_3^-,SO_3^{-2},SO_4^{-2}, PO_4^{-3}	C43
Ion Selective Electrodes	F^-,NH_4^+	C44
Combustion	C,N,H	C23

of the analytical procedure. Standards are materials containing known quantities of the analyte. Analyses of control samples fill two needs in the analytical work. First, they provide quality control over the analytical procedures so that problems that might occur can be identified and corrected. Secondly, data obtained from the analysis of control samples permits the evaluation of the capabilities of a particular analytical technique under a certain set of circumstances. The former function is one of analytical control, the latter is called quality assurance.

Quality control samples are obtained from outside agencies and prepared internally. The EPA provides water, foodstuff, and air filter standards 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, ^{239}Pu, and ^{241}Am as part of the ongoing laboratory intercomparison program. The Environmental Measurements Laboratory (EML) provides soil, water, bone, tissue, vegetation, and air filter samples each containing many of the same radionuclides. These are part of a laboratory intercomparison of DOE-supported facilities. Uranium standards obtained from the Canadian Geological Survey (CGS) and the International Atomic Energy Agency (IAEA) are used to evaluate the uranium analysis procedures. Internal standards are prepared by adding known quantities of analyte to blank matrix materials.

Quality assurance for the stable element analysis program is maintained by the analysis of certified or well-characterized environmental materials. The National Bureau of Standards (NBS) has a large set of silicate, water, and biological Standard Reference Materials (SRM). The EPA distributes mineral analysis and trace analysis water standards. Rock and soil certified standards have been obtained frrm the CGS and the United States Geological Survey (USGS). Other trace elemental standards have been purchases from a private company.

No attempt is made to make control samples unknown to the analyst. However, they are submitted to the laboratory at regular intervals and analyzed in association with other samples; that is, they are not normally handled as a unique set of samples. We feel that it would be difficult for the analyst to give the samples special attention even if they were so inclined. We endeavor to run at least 10% of the stable element analyses as quality assurance samples using the materials described above. A more detailed description of our Quality Assurance Program using SRM is in preparation.[C45]

The capabilities of the analytical procedures are evaluated from the quality control samples. Accuracy and precision are evaluated from results of analysis of standards. These results are normalized to the known quantity in the standard to permit comparison between standards containing different quantities 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 by weighting each normalized value (r_i) by the uncertainty associated with it (s_i).

$$R = \frac{\Sigma_i \, (r_i/s_i^2)}{\Sigma_i \, (1/s_i^2)}$$

The standard deviation (s) of R is calculated assuming a normal distribution.

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

These calculated values are presented in Tables C-II and C-III. The weighted mean of the R is a measure of the accuracy of the procedure. Values of R greater than unity indicate a positive bias and values less unity, a negative bias in the analysis. The standard deviation is a measure of the precision. The precision is a function of the quantity of analyte; that is, as the absolute quantity approaches the limit of detection, the precision increases. For instance, the precision for ^{137}Cs determinations is quite large because many of the standards approached the limits of detection of the measurement. Conversely, the precision fo the uranium analyses is unrealistically small because the standards contained quantities of uranium significantly above detection limits.

Analysis of blanks provides a criterion to judge the probability that samples were contaminated during the analysis. Table C-IV presented weighted means and standard deviations of the absolute quantity of analyte reported in blank materials analyzed during 1980.

TABLE C II

ANALYTICAL QUALITY ASSURANCE STANDARDS FOR STABLE ELEMENT ANALYSES AND SELECTED RADIOCHEMICAL ANALYSES

Analysis	Soil (R ± s[a])	Water (R ± s)	Biological (R ± s)	Analysis	Soil (R ± s)	Water (R ± s)	Biological (R ± s)
Ag	1.00 ± 0.05 (12)[b]	0.88 ± 0.18 (4)		Mg		1.03 ± 0.25 (12)	
Al	0.99 ± 0.04 (46)			Mn	1.07 ± 0.19 (43)	1.03 (2)	0.99 ± 0.04 (6)
As	1.01 ± 0.13 (42)	1.00 ± 0.11 (73)		Mo	1.08 ± 0.08 (3)	1.16 (1)	
B	1.02 ± 0.07 (12)		1.03 ± 0.08 (13)	Na	1.01 ± 0.09 (54)	1.04 ± 0.06 (10)	1.06 ± 0.07 (4)
Ba	1.07 ± 0.12 (58)	1.17 ± 0.11 (5)		^{22}Na	1.15 ± 0.08 (9)	1.06 ± 0.10 (12)	
Be		1.00 ± 0.09 (18)		Nd	0.94 (2)		
Br	0.90 ± 0.14 (5)			Ni	0.95 ± 0.16 (5)		
Ca		1.09 ± 0.20 (12)	0.85 ± 0.19 (3)	NO_3		1.00 ± 0.01 (3)	
Cd	0.90 ± 0.39 (8)	0.97 ± 0.20 (90)		Pb		0.92 ± 0.25 (12)	
Ce	0.99 ± 0.06 (57)			^{226}Ra	1.06 ± 0.07 (10)		
Cl	1.10 ± 0.11 (14)	1.02 ± 0.07 (56)	0.99 ± 0.08 (8)	Rb	1.02 ± 0.10 (72)		
Co	1.01 ± 0.07 (84)	1.00 (1)		Sb	1.05 ± 0.05 (25)		
Cond		0.99 ± 0.08 (5)		Sc	1.01 ± 0.08 (52)		
Cr	1.00 ± 0.09 (79)	1.02 ± 0.18 (24)		Se	0.97 ± 0.09 (24)	1.12 ± 0.11 (10)	
Cs	1.02 ± 0.14 (49)			Sm	1.01 ± 0.13 (49)		
^{137}Cs	1.13 ± 0.12 (9)	1.00 ± 0.06 (19)		SO_4		0.99 ± 0.10 (29)	
Cu		1.03 ± 0.09 (5)		Sr	0.92 ± 0.06 (11)		
Dy	1.07 ± 0.17 (6)			Ta	0.86 ± 0.15 (45)		
Eu	0.97 ± 0.08 (59)			Tb	1.02 ± 0.17 (9)		
F		1.03 ± 0.32 (49)		TDS		0.99 ± 0.04 (6)	
Fe	0.99 ± 0.05 (94)			Th	1.01 ± 0.05 (102)		
Ga	0.96 ± 0.11 (9)			Ti	1.01 ± 0.06 (14)		
Hf	0.98 ± 0.12 (46)			U	1.00 ± 0.08 (248)	0.98 ± 0.04 (45)	1.02 ± 0.09 (6)
Hg	0.93 ± 0.10 (9)	0.98 ± 0.05 (4)	1.06 ± 0.04 (3)	V	1.09 ± 0.21 (40)	1.02 (1)	
^{3}H		1.16 ± 0.19 (100)		W	0.98 ± 0.11 (11)		
K	1.02 ± 0.10 (26)	1.03 ± 0.20 (12)	0.98 ± 0.13 (4)	Yb	1.00 ± 0.22 (19)		
La	1.06 ± 0.13 (53)			Zn	1.02 ± 0.23 (6)	1.06 ± 0.16 (6)	
Li	0.91 ± 0.28 (8)			Zr	0.95 ± 0.02 (3)		
Lu	1.64 (2)						

[a]Three or more samples required to calculate s.
[b]Number of determinations are in parentheses.

4. Limits of Detection

Data from the analysis of blanks also provide a means of calculating limits of detection for the various procedures. Table C-V presents detection limits for analyses of various constituents in several environmental matrices. The limits for $^{238,239}Pu$, ^{241}Am, ^{137}Cs, and U are calculated from the weighted mean plus two standard deviations of the analysis of blanks (Table C-IV). For tritium, the detection limit is merely 2s of repetitive determinations of the instrumental blank. Gross alpha and gross beta are measured simultaneously by counting on a gas proportional counter and electronically discriminating the output pulses. As there is crosstalk generated by the detection of the two types of emissions, the detection limit of one is a function of the counting rate of the other. Detection limits in Table C-V are calculated assuming that counting rates for both alpha and beta are at background levels. The detection limit for alpha increases 10% above the limit for every count per minute (cpm) of beta activity emitted by the sample. Similarly, the detection limit for beta increases 40% for every 10 cpm of alpha.

Results greater than the defined detection limits indicate the presence of the constituent at the 95% confidence level. However, results less than the detection limit do not necessarily indicate its absence.

TABLE C-III

RADIOCHEMICAL QUALITY ASSURANCE ON EPA AND EML PROGRAMS

Analysis[a]	No. of Samples	R ± s
Alpha	22	1.12 ± 0.09
Beta	21	1.22 ± 0.15
^{3}H	12	0.94 ± 0.17
^{90}Sr	9	1.11 ± 0.29
^{131}I	3	0.96 ± 0.15
^{137}Cs	7	1.18 ± 0.07
^{239}Pu	10	0.83 ± 0.10
U, natural	7	0.99 ± 0.08

[a]All results for ^{51}Cr, ^{60}Co, ^{65}Zn, ^{140}Ba, ^{106}Ru, and ^{134}Cs were below our detection limits.

TABLE C-IV

QUANTITY OF CONSTITUENT REPORTED IN BLANKS

Analysis	No. of Samples	Quantity $(\bar{x} \pm s)$ [a]	Units
^{90}Sr	10	0.01 ± 0.05	pCi
^{238}Pu	11	0.003 ± 0.004	pCi
^{239}Pu	11	0.0003 ± 0.0064	pCi
^{241}Am	6	0.019 ± 0.013	pCi
Uranium (Delayed neutron)	12	13 ± 8	ng
Uranium (Epithermal activation)	24	13 ± 12	ng

[a]Mean is calculated by weighting each value (x_i) by its variance (s_i^2).

TABLE C-V

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	100 min	1×10^{-12} μCi/mℓ
^{238}Pu	2.0×10^4 m^3	8×10^4 sec	2×10^{-18} μCi/mℓ
^{239}Pu	$2.0 \times 10^4 mm^3$	8×10^4 sec	3×10^{-18} μCi/mℓ
^{241}Am	$2.0 \times 10^4 mm^3$	8×10^4 sec	2×10^{-18} μCi/mℓ
Gross alpha	6.5×10^3 m^3	100 min	3×10^{-16} μCi/mℓ
Gross beta	6.5×10^3 m^3	100 min	3×10^{-16} μCi/mℓ
Uranium (Delayed neutron)	2.0×10^4 m^3	60 sec	1 pg/m^3
Water Sample			
Tritium	0.005 ℓ	100 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}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	1×10^{-9} μCi/mℓ
Gross beta	0.9 ℓ	100 min	5×10^{-9} μCi/mℓ
Uranium (Delayed neutron)	0.025 ℓ	50 sec	1 μg/ℓ
Soil Sample			
Tritium	1 kg	100 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}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	0.8 pCi/g
Gross beta	2 g	100 min	0.003 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 radionuclides and direct and scattered penetrating radiation). Results of environmental measurements are used as much as possible. Calculations based on these measurements follow procedures recommended by federal agencies to determine radiation doses.[D1,D2]

Estimates are made of (1) the dose at the site boundary where maximum dose rates are expected to exist, (2) the dose for maximum exposed individuals and population groups, and (3) the whole body person-rem dose for the population living within an 80-km radius of the site. Four age groups are considered: infant, child, teen, and adult. Dose calculations utilize parameters such as annual food consumption and breathing rates specific to each age group. The values[D2,D3] provided for these and other parameters used in the calculations are given in Table D-I.

Age specific dose conversion factors[D4] used in the inhalation and ingestion calculations are listed in Table D-II. These factors give the total dose received (in mrem) by an organ during the 50-yr period following intake of a radionuclide (the 50-yr dose commitment) per amount of radionuclide (in pCi) either inhaled or ingested.[D5]

Table D-III also list a second set of dose conversion factors based on the dose (in mrem) received in the first year, rather than the 50-yr dose commitment. Procedures for calculating doses using these two sets of dose conversion factors are identical. The first set gives the total dose incurred during the 50-yr following intake, the second gives dose received in the first year. The dose estimates given in the text are identified as to which type of dose they represent.

B. Inhalation Dose

Annual average air concentrations of ^{3}H, ^{238}Pu, ^{239}Pu, ^{241}Am, and total U, determined by H-8's air monitoring network, are corrected for background by subtracting the average concentrations measured at the regional stations. These net concentrations are then multiplied by standard breathing rates for the four age groups to determine the total annual intake via inhalation, in pCi/yr, for each radionuclide. Each intake is multiplied by appropriate dose conversion factors to convert intake into the 50-yr dose commitments for bone, liver, total body, thyroid, kidney, lung, and gastrointestinal (GI) tract. First year dose is estimated for bone, total body, thyroid, lung, and GI tract. Organs chosen for dose calculations include those expected to receive the largest dose from the radionuclides being considered. Parameters used in the calculations are given in Tables D-I, D-II, and D-III. As noted in Tables D-II and D-III, the dose conversion factors for ^{3}H include an increase of 1.5 over inhalation intake to account for skin absorption.

This procedure for dose calculation conservatively assumes that an individual is exposed to the measured air concentration continuously throughout the entire year (8736 h). This assumption is made for the boundary dose, dose to the maximum exposed individual, and dose to the population living within 80 km of the site.

Organ doses are determined at sampling sites for each radionuclide. A final calculation estimates the total inhalation dose to an organ by summing the doses to that organ from each radionuclide.

C. Ingestion Dose

Results from foodstuff sampling, described in Section III.A.5, are used to calculate doses to the same organs as considered for the inhalation dose. The procedure is similar to that used in the previous section. The radionuclide concentration in a particular foodstuff is multiplied by the annual consumption rate[D2] to obtain the 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 50-yr dose commitment and first year dose to the organ. Consumption rates and dose conversion factors used in the calculations are listed in Tables D-I, D-II, and D-III.

TABLE D-I

PARAMETERS USED IN DOSE ASSESSMENT

Parameter	Infant	Child	Teenager	Adult
Annual breathing rate (m^3/yr)	1400	3700	8000	8000
Food consumption rate				
Fish (kg/yr)	---	6.9	16	21
Fruits (kg/yr)	---	114	139	114
Vegetables (kg/yr)	---	281	340	281
Grain (kg/yr)	---	125	151	125
Meat and poultry (kg/yr)	---	41	65	110
Milk (ℓ/yr)	330	330	400	310
Honey (kg/yr)	---	3	5	5
Shielding factor for residential structures				0.7
Occupancy Factor				
Restaurant north of TA-53				0.4
All other locations, except where noted				1.0
Solubility of inhaled radionuclides				
^{3}H				Soluble
Total U				Insoluble
^{238}Pu				Insoluble
$^{239,240}Pu$				Insoluble
^{241}Am				Insoluble
Number of trips, longer than one day, taken by Laboratory personnel in 1980				15 977

Doses are evaluated for ingestion of ^{3}H, ^{90}Sr, total U, ^{238}Pu, and ^{239}Pu in fruits and vegetables; ^{3}H, ^{7}Be, ^{22}Na, ^{137}Cs, and total U in honey; and ^{137}Cs, total U, ^{238}Pu, and ^{239}Pu in fish.

Consumption rates given in Table D-I correspond to values recommended by the Nuclear Regulatory Commission[D2] for calculation of dose to the maximum exposed individual. The single exception is the honey consumption rate, which, since it has no recommended value, was based on professional judgment.

D. External Radiation

Nuclear reactions with air in the target areas at the Los Alamos Meson Physics Facility (LAMPF, TA-53) cause the air activation products ^{11}C, ^{13}N, and ^{15}O to be formed. These isotopes are all positron emitters and have 20.4-min, 10-min, and 122-sec half-lives, respectively. Neutron reactions with air at the Omega West Reactor (TA-2) and the LAMPF form ^{41}Ar (1.8 h half-life).

TABLE D-II

AGE SPECIFIC DOSE CONVERSION FACTORS FOR 50-YR DOSE COMMITMENT

Infant Dose Conversion Factors
(mrem/50-yr per pCi intake in first year)

Radionuclide	Pathway	Organ						
		Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI[b]
^{3}H	Inhalation[a]	0.0	4.62×10^{-7}	4.62×10^{-7}	4.62×10^{-7}	4.62×10^{-7}	4.62×10^{-7}	4.62×10^{-7}
	Ingestion	0.0	3.08×10^{-7}	3.08×10^{-7}	3.08×10^{-7}	3.08×10^{-7}	3.08×10^{-7}	3.08×10^{-7}
^{137}Cs	Ingestion	5.22×10^{-4}	6.11×10^{-4}	4.33×10^{-5}	0.0	1.64×10^{-4}	6.64×10^{-5}	1.91×10^{-6}
Total U	Inhalation	5.00×10^{-2}	0.0	3.52×10^{-3}	0.0	1.00×10^{-2}	3.27×10^{-1}	3.77×10^{-5}
	Ingestion	4.67×10^{-3}	0.0	3.56×10^{-4}	0.0	9.93×10^{-4}	0.0	6.08×10^{-5}
^{238}Pu	Inhalation	5.02	6.33×10^{-1}	1.27×10^{-1}	0.0	4.64×10^{-1}	9.03×10^{-1}	4.69×10^{-5}
	Ingestion	1.34×10^{-3}	1.69×10^{-4}	3.40×10^{-5}	0.0	1.21×10^{-4}	0.0	7.57×10^{-5}
^{239}Pu	Inhalation	5.50	6.72×10^{-1}	1.34×10^{-1}	0.0	4.95×10^{-1}	8.47×10^{-1}	4.28×10^{-5}
	Ingestion	1.45×10^{-3}	1.77×10^{-4}	3.54×10^{-5}	0.0	1.28×10^{-4}	0.0	6.91×10^{-5}
^{241}Am	Inhalation	1.84	8.44×10^{-1}	1.31×10^{-1}	0.0	7.94×10^{-1}	4.06×10^{-1}	4.78×10^{-5}
	Ingestion	1.53×10^{-3}	7.18×10^{-4}	1.09×10^{-4}	0.0	6.55×10^{-4}	0.0	7.70×10^{-5}

Child Dose Conversion Factors
(mrem/50-yr per pCi intake in first year)

^{3}H	Inhalation[a]	0.0	3.04×10^{-7}	3.04×10^{-7}	3.04×10^{-7}	3.04×10^{-7}	3.04×10^{-7}	3.04×10^{-7}
	Ingestion	0.0	2.03×10^{-7}	2.03×10^{-7}	2.03×10^{-7}	2.03×10^{-7}	2.03×10^{-7}	2.03×10^{-7}
^{137}Cs	Ingestion	3.27×10^{-4}	3.13×10^{-4}	4.62×10^{-5}	0.0	1.02×10^{-4}	3.67×10^{-5}	1.96×10^{-6}
Total U	Inhalation	4.27×10^{-2}	0.0	2.59×10^{-3}	0.0	7.00×10^{-3}	1.63×10^{-1}	3.74×10^{-5}
	Ingestion	3.42×10^{-3}	0.0	2.07×10^{-4}	0.0	5.60×10^{-4}	0.0	6.03×10^{-5}
^{238}Pu	Inhalation	4.74	6.05×10^{-1}	1.21×10^{-1}	0.0	4.47×10^{-1}	6.08×10^{-1}	4.65×10^{-5}
	Ingestion	1.25×10^{-3}	1.56×10^{-4}	3.16×10^{-5}	0.0	1.15×10^{-4}	0.0	7.50×10^{-5}
^{239}Pu	Inhalation	5.24	6.44×10^{-1}	1.28×10^{-1}	0.0	4.78×10^{-1}	5.72×10^{-1}	4.24×10^{-5}
	Ingestion	1.36×10^{-3}	1.65×10^{-4}	3.31×10^{-5}	0.0	1.22×10^{-4}	0.0	6.85×10^{-5}
^{241}Am	Inhalation	1.74	7.85×10^{-1}	1.24×10^{-1}	0.0	7.63×10^{-1}	2.02×10^{-1}	4.73×10^{-5}
	Ingestion	1.43×10^{-3}	6.40×10^{-4}	1.02×10^{-4}	0.0	6.03×10^{-4}	0.0	7.64×10^{-5}

[a]Includes an increase of 50% to account for skin absorption.
[b]Gastrointestinal—Lower large intestine.

TABLE D-II (Continued)

Teen Dose Conversion Factors
(mrem/50-yr per pCi intake in first year)

Radio-nuclide	Pathway	Organ						
		Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI[b]
^{3}H	Inhalation[a]	0.0	1.59×10^{-7}	1.59×10^{-7}	1.59×10^{-7}	1.59×10^{-7}	1.59×10^{-7}	1.59×10^{-7}
	Ingestion	0.0	1.06×10^{-7}	1.06×10^{-7}	1.06×10^{-7}	1.06×10^{-7}	1.06×10^{-7}	1.06×10^{-7}
^{137}Cs	Ingestion	1.12×10^{-4}	1.49×10^{-4}	5.19×10^{-5}	0.0	5.07×10^{-5}	1.97×10^{-5}	2.12×10^{-6}
Total U	Inhalation	1.42×10^{-2}	0.0	8.66×10^{-4}	0.0	3.33×10^{-3}	8.43×10^{-2}	3.85×10^{-5}
	Ingestion	1.14×10^{-3}	0.0	6.93×10^{-5}	0.0	2.67×10^{-4}	0.0	6.21×10^{-5}
^{238}Pu	Inhalation	2.86	4.06×10^{-1}	7.22×10^{-2}	0.0	3.10×10^{-1}	3.12×10^{-1}	4.37×10^{-5}
	Ingestion	7.12×10^{-4}	1.02×10^{-4}	1.82×10^{-5}	0.0	7.80×10^{-5}	0.0	7.73×10^{-5}
^{239}Pu	Inhalation	3.31	4.50×10^{-1}	8.05×10^{-2}	0.0	3.44×10^{-1}	2.93×10^{-1}	4.46×10^{-5}
	Ingestion	8.27×10^{-4}	1.12×10^{-4}	2.01×10^{-5}	0.0	8.57×10^{-5}	0.0	7.06×10^{-5}
^{241}Am	Inhalation	1.06	4.07×10^{-1}	7.10×10^{-2}	0.0	5.32×10^{-1}	1.05×10^{-1}	4.88×10^{-5}
	Ingestion	8.62×10^{-4}	3.29×10^{-4}	5.75×10^{-5}	0.0	4.31×10^{-4}	0.0	7.87×10^{-5}

Adult Dose Conversion Factors
(mrem/50-yr per pCi intake in first year)

^{3}H	Inhalation[a]	0.0	1.58×10^{-7}	1.58×10^{-7}	1.58×10^{-7}	1.58×10^{-7}	1.58×10^{-7}	1.58×10^{-7}
	Ingestion	0.0	1.05×10^{-7}	1.05×10^{-7}	1.05×10^{-7}	1.05×10^{-7}	1.05×10^{-7}	1.05×10^{-7}
^{137}Cs	Ingestion	7.97×10^{-5}	1.09×10^{-4}	7.14×10^{-5}	0.0	3.70×10^{-5}	1.23×10^{-5}	2.11×10^{-6}
Total U	Inhalation	9.93×10^{-3}	0.0	6.06×10^{-4}	0.0	2.33×10^{-3}	4.90×10^{-2}	3.63×10^{-5}
	Ingestion	8.01×10^{-4}	0.0	4.85×10^{-5}	0.0	1.87×10^{-4}	0.0	5.86×10^{-5}
^{238}Pu	Inhalation	2.74	3.87×10^{-1}	6.90×10^{-2}	0.0	2.96×10^{-1}	1.82×10^{-1}	4.52×10^{-5}
	Ingestion	6.80×10^{-4}	9.58×10^{-5}	1.71×10^{-5}	0.0	7.32×10^{-5}	0.0	7.30×10^{-5}
^{239}Pu	Inhalation	3.19	4.31×10^{-1}	7.75×10^{-2}	0.0	3.30×10^{-1}	1.72×10^{-1}	4.13×10^{-5}
	Ingestion	7.87×10^{-4}	1.06×10^{-4}	1.91×10^{-5}	0.0	8.11×10^{-5}	0.0	6.66×10^{-5}
^{241}Am	Inhalation	1.01	3.59×10^{-1}	6.71×10^{-2}	0.0	5.04×10^{-1}	6.06×10^{-2}	4.60×10^{-5}
	Ingestion	8.19×10^{-4}	2.88×10^{-4}	5.41×10^{-5}	0.0	4.07×10^{-4}	0.0	7.42×10^{-5}

[a]Includes an increase of 50% to account for skin absorption.
[b]Gastrointestinal—Lower large intestine.

TABLE D-III

DOSE CONVERSION FACTORS FOR FIRST YEAR DOSE

Adult Dose Conversion Factors
(mrem/first year per pCi intake)

Radio-nuclide	Pathway	Organ						
		Bone	Liver	Total Body	Thyroid	Kidney	Lung	GI-LLI[a]
^{3}H	Inhalation[a]	0.0	---	1.0×10^{-7}	1.0×10^{-7}	---	1.0×10^{-7}	1.0×10^{-7}
	Ingestion	0.0	1.0×10^{-7}	1.0×10^{-7}	1.0×10^{-7}	1.0×10^{-7}	---	1.0×10^{-7}
^{137}Cs	Ingestion	4.3×10^{-5}	7.3×10^{-5}	4.3×10^{-5}	0.0	3.1×10^{-5}	---	2.1×10^{-6}
Total U	Inhalation	1.5×10^{-3}	---	1.9×10^{-4}	0.0	---	2.8×10^{-2}	3.6×10^{-5}
	Ingestion	2.6×10^{-4}	0.0	3.1×10^{-5}	0.0	7.8×10^{-5}	---	5.8×10^{-5}
^{238}Pu	Inhalation	7.3×10^{-3}	---	1.9×10^{-4}	0.0	---	5.1×10^{-2}	4.5×10^{-5}
	Ingestion	8.9×10^{-6}	1.4×10^{-6}	2.3×10^{-7}	0.0	1.1×10^{-6}	---	7.3×10^{-5}
^{239}Pu	Inhalation	7.1×10^{-3}	---	1.7×10^{-4}	0.0	---	4.8×10^{-2}	4.1×10^{-5}
	Ingestion	8.6×10^{-6}	1.3×10^{-6}	2.1×10^{-7}	0.0	9.9×10^{-7}	---	6.7×10^{-5}
^{241}Am	Inhalation	5.2×10^{-3}	---	4.2×10^{-4}	0.0	---	3.5×10^{-2}	4.6×10^{-5}
	Ingestion	9.3×10^{-6}	1.1×10^{-5}	7.6×10^{-7}	0.0	5.3×10^{-6}	---	7.4×10^{-5}

[a]Gastointestinal—Lower large intestine.

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

External radiation doses are monitored with H-8's TLD network. Measured doses, considered as whole body doses in this report, are given in Table E-III. 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 due to Laboratory activities that an individual would receive if he were to spend 100% of his time during an entire year at the monitoring location.

Boundary and maximum individual doses from ^{41}Ar releases from the Omega West Reactor (TA-2) are estimated using standard meteorological models and measured stack releases[D6] (see Table E-XXVI). Procedures used in making the calculations are described in the following section. A dose rate correction for plume size is taken from standard graphical compilations[D6] in making this dose estimate.

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 given in the text.

E. Population Dose

Calculation of whole body population dose estimates (in person-rem) are based on measured data to the extent possible. For background radiation, average measured values 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 regional stations). These doses are multiplied by population data incorporating results of the 1980 census, which is summarized in Table D-IV.

For ^{41}Ar, ^{11}C, ^{13}N, 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 (based on Gaussian plume dispersion models)

$$\chi(r,\theta)/Q$$

and the source term Q. Source terms, obtained by stack measurements, are listed in Table E-XXVI. Dispersion factors for the LAMPF and Omega West Reactor are given in Table D-V. The gamma dose rate in a semi-infinite cloud at time t, γ_∞ (r,θ,t), can be represented by the equation[D6]

$$\gamma_\infty (r,\theta,t) = 0.25 \, \bar{E}_\gamma \, \chi(r,\theta,t)$$

where

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

$\bar{E}_\gamma$ = average gamma energy per decay (MeV) (1.02 MeV for position emitters and 1.29 MeV for ^{41}Ar), and

$\chi(r,\theta,t)$ = plume concentration in Ci/m^3 at time t, at a distance r, and angle θ.

The annual dose is calculated from the dose rate, and then multiplied by the appropriate population figure to give the estimated population dose.

Background radiation doses due to airline travel are based on the number of trips taken by Laboratory personnel. It was assumed that 85% of these trips were taken by Laboratory personnel residing in Los Alamos County and that non-Laboratory travel was 10% of the Laboratory trips. Average air time at altitude for each trip was estimated to be 4.5 h, where the average dose rate is 0.22 mrem/h.[D7]

TABLE D-IV

ESTIMATES OF NUMBER OF PEOPLE LIVING WITHIN 80 km OF LABORATORY

A. Cities and towns included in preliminary census results[a]

Town	No. of People	Town	No. of People
Alcalde	432	San Felipe	1 940
Bernalillo	2 721	San Felipe/Santo Domingo Joint Area	393
Chama	1 098	San Ildefonso	1 492
Chimayo	1 930	San Ysidro	199
Cochiti	804	Sandia	239
Cuba	605	Santa Ana	395
Española	6 700	Santa Clara	2 448
Jemez	1 542	Santa Fe	48 914
Jemez Springs	328	Santo Domingo	2 054
Los Alamos	11 038	Tesuque (Pueblo)	362
Nambe	1 124	Tesuque	1 000
Pecos	886	White Rock	6 548
Ranchos de Taos	1 198	Zia	517.
		Total	96 907

B. Estimate of number of people not included in preliminary census results. 15 216

C. Estimate of number of people in rural areas not included in preliminary census results. 112 123

[a]Preliminary 1980 census counts. Source: U. S. Bureau of the Census.

TABLE D-V

DISPERSION FACTOR (x/Q) USED FOR POPULATION DOSE ESTIMATES

Source	Location	x/Q (sec/m^3)
TA-2	Boundary	5×10^{-5}
TA-2	Maximum individual	4×10^{-5}
TA-2	Los Alamos	2×10^{-6}
TA-2	White Rock	7×10^{-8}
TA-53	Los Alamos	5×10^{-7}
TA-53	White Rock	1×10^{-7}

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APPENDIX E

ENVIRONMENTAL DATA TABLES

TABLE E-I

MEANS[a] AND EXTREMES OF TEMPERATURE AND PRECIPITATION—
CLIMATOLOGICAL SUMMARY (1911-1980) FOR LOS ALAMOS, NEW MEXICO[b]

	Temperature (°C)										
	Means			Extremes							
				High		Low		High		Low	
	Mean	Mean		Monthly		Monthly		Daily		Daily	
Month	Max	Min	Avg	Mean	Year	Mean	Year	Max	Date	Min	Date
Jan	4.3	−7.5	−1.6	3.1	1953	−6.2	1930	17.8	1/12/53	−27.8	1/13/63
Feb	6.1	−5.8	0.2	3.0	1934	−5.0	1939	18.9	2/24/36	−25.6	2/1/51 2/8/33
March	9.3	−3.0	3.2	7.7	1972	0.0	1948	21.7	3/26/71 3/30/76	−19.4	3/11/48
April	14.2	1.0	7.6	12.4	1954	4.3	1973	26.1	4/23/38	−15.0	4/9/28
May	19.4	6.0	12.7	15.8	1956	10.1	1957	31.7	5/29/35	−4.4	4 Dates
June	25.4	11.3	18.4	20.8	1980	15.8	1965	34.4	6/25/80 6/29/80	−2.2	6/3/19
July	26.9	13.4	20.2	21.9	1980	17.4	1926	35.0	7/11/35	2.8	7/7/24
Aug	25.2	12.4	18.8	21.3	1936	16.1	1929	33.3	8/10/37	4.4	8/16/47
Sept	22.3	9.1	15.7	18.8	1956	13.4	1965	34.4	9/11/34	−5.0	9/29/36
Oct	16.7	3.7	10.2	12.6	1963	6.9	1976	28.9	10/1/80	−9.4	10/19/76
Nov	9.3	−2.7	3.3	6.9	1949	−0.8	1972	22.2	11/1/50	−25.6	1/28/76
Dec	5.2	−6.5	−0.6	10.1	1980	−4.1	1931	17.8	12/27/80	−25.0	12/9/78
Annual	15.3	2.6	9.0	11.1	1954	6.8	1932	35.0	7/11/35	−27.8	1/13/63

	Precipitation (mm)										Mean No. of Days		
	Rain[c]					Snow							
Month	Mean	Mo. Max	Year	Daily Max	Date	Mean	Mo. Max	Year	Daily Max	Date	Precip ≥2.5 mm	Max Temp >32°C	Min Temp <0°C
Jan	21.6	171.5	1916	64.5	1/27/16	246	998	1949	381	1/5/13	2	0	30
Feb	17.3	62.0	1948	26.7	2/20/15	186	605	1948	330	2/20/15	2	0	26
March	25.7	104.4	1973	57.2	3/30/16	247	914	1973	457	3/30/16	3	0	24
April	21.8	117.9	1915	50.8	4/12/75	129	853	1958	508	4/12/75	2	0	13
May	28.7	113.5	1929	45.7	5/21/29	21	432	1917	305	5/2/78	3	0	2
June	28.5	141.5	1913	63.8	6/10/13	0	---	---	---	---	3	1	0
July	80.8	202.7	1919	62.7	7/31/68	0	---	---	---	---	8	1	0
Aug	99.8	284.0	1952	57.4	8/1/51	0	---	---	---	---	9	0	0
Sept	41.4	147.1	1941	56.1	9/22/29	2	152	1913	152	9/25/13	4	0	0
Oct	38.6	172.0	1957	88.4	10/5/11	42	229	1972	229	10/31/72	3	0	7
Nov	24.4	167.6	1978	45.0	11/25/78	128	665	1931	356	11/22/31	2	0	22
Dec	24.9	72.4	1965	40.6	12/6/78	293	1049	1967	559	12/6/78	3	0	30
Annual	453.4	770.6	1941	88.4	10/5/11	1295	2540	1958	559	12/6/78	43	2	154

TABLE E-I (Continued)

CLIMATOLOGICAL SUMMARY 1980

	Temperature (°C)						
	Means			Extremes			
Month	Mean Max	Mean Min	Avg	High	Date	Low	Date
Jan	6.0	−4.4	0.8	12.2	(13)	−11.1	(3)
Feb	8.8	−4.1	2.4	17.8	(28)	−12.2	(9)
March	8.7	−4.9	1.9	14.4	(14)	−10.0	(17)
April	13.8	−0.9	6.5	22.2	(19)	−10.0	(1)
May	18.5	3.2	10.9	25.0	(22)	−2.8	(12)
June	29.2	12.4	20.8	34.4	(25)	4.4	(2)
July	30.7	13.0	21.9	33.9	(5)	10.0	(8)
Aug	27.5	12.0	20.8	32.8	(1)	9.4	(12)
Sept	23.8	9.5	16.7	31.1	(4)	3.9	(23)
Oct	16.3	1.1	8.7	28.9	(1)	−7.8	(29)
Nov	10.1	−3.6	3.3	21.7	(9)	−12.2	(17)
Dec	10.1	−2.9	3.6	17.8	(27)	−9.4	(10)
Annual	17.0	2.6	9.8	34.4	(6/25)	−12.2	(2/9) (11/17)

	Precipitation (mm)						No. of Days		
	Rain[b]			Snow					
Month	Total	Daily Max	Date	Total	Daily Max	Date	Precip ≥2.5 mm	Max Temp <32°C	Min Temp <0°C
Jan	39.4	10.7	(19)	279	25	(19)	5	0	29
Feb	24.4	10.2	(14)	51	25	(7)	3	0	28
March	21.6	10.4	(27)	236	114	(27)	2	0	29
April	41.1	13.7	(24)	305	102	(2)	4	0	17
May	36.3	10.9	(15)	0	0	---	5	0	5
June	0.0	0.0	---	0	0	---	0	9	0
July	8.9	3.3	(28)	0	0	---	1	11	0
Aug	50.0	14.5	(8)	0	0	---	6	0	2
Sept	30.0	14.0	(9)	0	0	---	3	0	0
Oct	26.4	13.7	(15)	152	140	(27)	2	0	15
Nov	17.3	15.0	(24)	211	203	(24)	1	0	19
Dec	8.4	7.6	(8)	178	178	(8)	1	0	25
Annual	303.8	15.0	(11/24)	2962	203	(11/24)	33	20	169

[a]Means based on standard 30-year period: 1911-1980.
[b]Latitude 35° 32' north, longitude 106° 19' west; elevation 2260 m.
[c]Includes liquid water equivalent of frozen precipitation.

TABLE E-II

HIGHLIGHTS OF WEATHER DURING 1980

January	Average temperature = 0.8°C (33.4°F). Warmest since 1969. 6th warmest January.
February	Average temperature = 2.3°C (36.2°F). 6th warmest February. SMDH on the 27th: 16.7°C (62°F). SMDH on the 28th: 17.8°C (64°F).
Winter 79-80 (Dec. 79-Feb. 80)	Average temperature = 1.5°C (34.7°F). Tied with winter of 1953-1954 for warmest winter.
April	SMDL on the 1st: −10°C (14°F). SMDL on the 18th: −7.8°C (18°F). SMDP on the 24th: 13.7 mm (0.54 in). SMDS on the 24th: 101.6 mm (4 in).
May	SMDL on the 12th: −2.8°C (27°F). SMDL on the 25th: −1.1°C (30°F). TMDL on the 18th: 0°0°C (32°F).
June	Average temperature = 20.8°C (69.4°F). Average maximum temperature = 29.2°C (84.5°F) Warmest June. Highest average maximum temperature for June. Most days ≥32°C (90°F) for June: 9 (Previous record: 3-1954). Most days ≥32°C (90°F) for any month: 9 (Previous record: 6-1946). Tied record for least rain in June: 0.0 (1951, 1929, 1916) SMDH on the 24th:32.2°C (90°F). SMDH on the 25th: 34.4°C (94°F). SMDH on the 26th: 33.9°C (93°F). SMDH on the 28th: 32.8°C (91°F). SMDH on the 29th: 34.4°C (94°F). SMDH on the 30th: 33.3°C (92°F). TMDH on the 6th: 27.8°C (82°F). TMDH on the 7th: 27.2°C (81°F). TMDH on the 17th: 32.2°C (90°F). TMDH on the 23rd: 32.2°C (90°F). TMDH on the 27th: 32.2°C (90°F).

TABLE E-II (Continued)

July	Average temperature = 21.9°C (71.4°F). Average maximum temperature = 30.7°C (87.3°F). Warmest July. Warmest month (any). Highest average maximum for July. Highest average maximum for any month. Most days ≥32°C (90°F) for July:11. (Previous record:6-1946). Most days ≥32°C (90°F) for any month: 11. (Previous record: 9-1980. Driest July on record—8.9 mm (0.35 in). SMDH on the 5th: 33.9°C (93°F). SMDH on the 17th: 33.3°C (92°F). SMDH on the 26th: 32.2°C (90°F). TMDH on the 6th: 32.2°C (90°F). TMDH on the 18th: 32.8°C (91°F).
August	Average temperature = 20.8°C (69.4°F). 2nd warmest August. Most days ≥32°C (90°F) for August: 2. SMDH on the 1st: 32.8°C (91°F). SMDH on the 4th: 32.2°C (90°F). SMDH on the 5th: 31.1°C (88°F).
Summer 1980 (June-August)	Average temperature = 20.8°C (69.4°F). Average maximum temperature = 29.1°C (84.4°F). Warmest summer. Highest average maximum for summer. Driest summer: 58.9 mm (2.32 in). [Previous dry summer was 1922: 630 mm (2.48 in)]. Most days ≥32°C (90°F): 22. Previous record: 7 (1936). [There were previously only 74 days ≥32°C (90°F) between 1919 and 1979.]
September	SMDH on the 18th:27.8°C (82°F). SMDH on the 30th: 27.2°C (81°F). TMDH on the 19th: 27.8°C (82°F).
October	Broke October maximum high temperature for any date on the 1st: 28.9°C (84°F). SMDH on the 1st: 28.9°C (84°F). SMDH on the 19th: 24.4°C (76°F). SMDL on the 29th: −7.8°C (19°F). SMDP on the 15th: 13.7 mm (0.54 in). SMDS on the 27th: 140 mm (5.5 in).

TABLE E-II (Continued)

November	SMDH on the 7th: 18.9°C (66°F). SMDH on the 8th: 19.4°C (67°F). SMDH on the 9th: 21.7°C (71°F). SMDH on the 10th: 20.0°C (68°F). SMDH on the 11th: 19.4°C (67°F). SMDL on the 17th: −12.2°C (10°F). SMDS on the 24th: 203 mm (8 in).
December	Average temperature = 3.6°C (38.4°F). Average maximum temperature: 10.1°C (50.1°F). Average minimum temperature = −2.9°C (26.7°F). Warmest December. Highest average maximum for December. Highest average minimum for December. Broke December maximum high temperature for any date on the 27th: 28.9°C (84°F). SMDH on the 15th: 12.8°C (5.5°F). SMDH on the 16th: 13.9°C (57°F). SMDH on the 17th: 15.6°C (60°C). SMDH on the 26th: 16.1°C (61°F). SMDH on the 27th: 17.8°C (64°F). SMDH on the 28th: 14.4°C (58°F). SMDH on the 30th: 11.7°C (53°F).
Annual	Average temperature = 9.76°C (49.57°F). Mean annual temperature (1951-1980) = 8.9°C (48.14°F). 5th warmest year. Warmest since 1956. 1980 precipitation = 303.8 mm (11.96 in). Mean annual precipitation (1951-1980) = 453.4 mm (17.85 in). 4th driest year. Driest since 1964. 1980 snowfall = 146.3 mm (57.6 in). Mean annual snowfall (1951-1980) = 1295 mm (51.0 in).

Key for Abbreviations

SMDH: Set Maximum Daily High Temperature Record
SMDL: Set Minimum Daily Low Temperature Record
SMDP: Set Maximum Daily Precipitation Record
SMDS: Set Maximum Daily Snowfall Record
TMDH: Tied Maximum Daily High Temperature Record
TMDL: Tied Minimum Daily Low Temperature Record

TABLE E-III

ANNUAL THERMOLUMINESCENT DOSIMETER MEASUREMENTS

Station Location	Coordinates	Annual Dose: Dose (mrem)	Annual Dose: 95% Conf Interval (mrem)	Annual Dose: 95% Conf Interval (per cent)
Regional Stations (28-44 km)		**Uncontrolled Areas**		
1. Española	---	89.7	2.4	2.7
2. Pojoaque	---	98.8	2.4	2.4
3. Santa Fe	---	98.3	2.5	2.5
Perimeter Stations (0-4 km)		**Uncontrolled Areas**		
5. Barranca School	N180 E130	123.0	2.5	2.0
6. Arkansas Avenue	N170 E030	112.1[a]	3.1	2.8
7. Cumbres School	N150 E090	116.1	2.5	2.2
8. 48th Street	N110 W010	137.2	2.5	1.8
9. LA Airport	N110 E170	126.3	2.5	2.0
10. Bayo Canyon S.T.P.	N120 E250	148.7	2.5	1.7
11. Gulf Station	N090 E120	126.9	2.6	2.1
12. Royal Crest	N080 E080	120.7	2.5	2.1
13. White Rock S.T.P.	S080 E420	119.1	2.5	2.1
14. Pajarito Acres	N130 W180	108.2	2.7	2.5
15. Bandelier Lookout	S280 E200	131.1	2.5	1.9
16. Pajarito Ski Area	N130 W180	114.0	2.5	2.2

Station Location	Coordinates	Annual Dose: Dose (mrem)	Annual Dose: 95% Conf Interval (mrem)	Annual Dose: 95% Conf Interval (per cent)
Onsite Stations		**Controlled Areas**		
17. TA-21	N085 E190	118.3	2.5	2.1
18. TA-6	N045 W050	123.4	2.5	2.0
19. TA-53	N055 E190	146.2	2.5	1.7
20. Well PM-1	N080 E285	142.3	2.6	1.8
21. TA-16	S030 W075	124.6	2.5	2.0
22. Booster P-2	S030 E220	300.7	2.5	0.8
23. TA-54	S090 E300	134.0	2.5	1.9
24. State Hwy 4	N070 E350	195.3	2.5	1.3
25. TA-49	S080 E030	118.9	2.5	2.1
26. TA-2	N075 E120	129.3	2.5	1.9
27. TA-2	N085 E120	163.5	2.5	1.5
28. TA-18	S040 E205	303.0	2.5	0.8
29. TA-35	N040 E105	127.3	2.5	2.0
30. TA-35	N040 E110	127.4	2.5	2.0
31. TA-3	N050 E020	215.2[a]	3.1	1.4
32. TA-3	N050 E040	136.0	2.5	1.8
33. Pistol Range	N040 E240	133.7	2.5	1.9

[a]Data for one quarter missing.

TABLE E-IV

LOCATIONS OF AIR SAMPLING STATIONS

Station	Latitude or N-S Coord	Longitude or E-W Coord
Regional (28-44 km)		
1. Española	36°00′	106°06′
2. Pojoaque	35°52′	106°02′
3. Santa Fe	35°40′	106°56′
Perimeter (0-4 km)		
4. Barranca School	N180	E130
5. Arkansas Avenue	N170	E030
6. Cumbres School	N150	E090
7. 48th Street	N110	W010
8. LA Airport	N110	E170
9. Bayo STP	N120	E250
10. Gulf 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	N085	E190
16. TA-6	N045	W050
17. TA-53 (LAMPF)	N055	E190
18. Well PM-1	N080	E285
19. TA-52	N020	E155
20. TA-16	S030	W100
21. Booster P-2	S030	E220
22. TA-54	S090	E300
23. TA-49	S080	E030
24. TA-33	S250	E240
25. TA-39	S190	E230

TABLE E-V

REGIONAL AVERAGE BACKGROUND ATMOSPHERIC RADIOACTIVITY CONCENTRATIONS

Radioactive Constituent	Units	EPA[a]	Laboratory[b]	Uncontrolled Area CG
Gross alpha	10^{-15} μCi/mℓ	Not reported	1.8 ± 0.3	6×10^{1}
Gross beta	10^{-15} μCi/mℓ	18 ± 4	18 ± 3	1×10^{5}
^{241}Am	10^{-18} μCi/mℓ	Not reported	−0.4 ± 0.5	2×10^{11}
^{238}Pu	10^{-18} μCi/mℓ	4.2 ± 2.0	−2.1 ± 0.4	7×10^{4}
^{239}Pu	10^{-18} μCi/mℓ	17 ± 5.4	1.1 ± 0.9	6×10^{4}
^{3}H	10^{-12} μCi/mℓ	Not reported	7.7 ± 5.8	2×10^{5}
U	10^{-18} μCi/mℓ	50 ± 4.7	20 ± 6.9	3×10^{6}
U	pg/m^3	152 ± 14	60 ± 21	9×10^{6}

[a]"Environmental Radiation Data," USEPA, Office of Radiation Programs, Report 19-20 (April 1980). Data are from the Santa Fe, New Mexico sampling location and were taken from July through December 1979.

[b]Data annual averages are from the regional stations (Española, Pojoaque, Santa Fe) and were taken during calendar year 1980.

TABLE E-VI

LONG-LIVED ATMOSPHERIC GROSS BETA CONCENTRATIONS FOLLOWING CHINESE NUCLEAR TEST ON OCTOBER 16, 1980

Sampling Period[a]	Gross Beta (10^{-15} μCi/mℓ) OHL (Onsite)	Española (28 km from Los Alamos)
10/20-10/21(Esp.) 10/17-10/21 (OHL)	24 ± 3	22 ± 3
10/21-10/22	28 ± 4	13 ± 2
10/22-10/13	59 ± 8	31 ± 4
10/23-10/24	39 ± 5	28 ± 4
10/24-10/27	230 ± 30	105 ± 14
10/27-10/28	54 ± 7	34 ± 5
10/28-10/29	170 ± 20	81 ± 11
10/28-10/30	160 ± 20	290 ± 40
10/30-10/31	84 ± 11	141 ± 18
10/31-11/3	41 ± 5	46 ± 6
11/3-11/4	107 ± 14	44 ± 6
11/4-11/5	123 ± 16	93 ± 12
11/5-11/6	100 ± 13	50 ± 7
11/6-11/7	55 ± 7	13 ± 2
11/7-11/12	250 ± 30	83 ± 11
11/12-11/13	190 ± 20	180 ± 20

[a]Filters changed at ~0800 MDT or MST.

TABLE E-VII

ANNUAL ATMOSPHERIC LONG-LIVED
GROSS ALPHA AND GROSS BETA ACTIVITY CONCENTRATIONS[a]

Station Location	Total Air Volume[b] (m^3)	Gross Alpha Concentrations—fCi/m^3 (10^{-15} μCi/mℓ)						Gross Beta Concentrations—fCi/m^3 (10^{-15} μCi/mℓ)					
		No. Monthly Samples	No. Samples <MDL[c]	Max[d]	Min[d]	Mean[d]	Mean as % CG[e]	No. Monthly Samples	No. Samples <MDL[c]	Max[d]	Min[d]	Mean[d]	Mean as % CG[e]
Regional Stations (28-44 km)—Uncontrolled Areas													
1. Española	90 707	12	0	3.9 ± 1.0	0.6 ± 0.3	1.6 ± 0.5	2.7	12	0	34 ± 8	3.3 ± 0.8	14 ± 6	0.01
2. Pojoaque	79 469	12	0	4.3 ± 1.8	0.9 ± 0.4	1.9 ± 0.6	3.2	12	0	37 ± 10	16 ± 4	25 ± 4	0.02
3. Santa Fe	91 930	12	2	3.5 ± 1.6	0.3 ± 0.1	1.8 ± 0.6	3.0	12	0	27 ± 6	1.2 ± 0.3	15 ± 6	0.02
Regional Group Summary	262 106	36	2	4.3 ± 1.8	0.3 ± 0.1	1.8 ± 0.3	3.0	36	0	37 ± 10	1.2 ± 0.3	18 ± 3	0.02
Perimeter Stations (0-4 km)—Uncontrolled Areas													
4. Barranca School	91 702	12	0	6.2 ± 2.6	1.6 ± 0.8	3.6 ± 0.8	5.9	12	0	48 ± 12	14 ± 4	33 ± 6	0.03
5. Arkansas School	80 586	12	0	8.2 ± 3.6	2.4 ± 1.0	4.0 ± 0.9	6.6	12	0	52 ± 14	21 ± 6	30 ± 5	0.03
6. Cumbres School	75 243	12	0	10 ± 4	1.8 ± 0.8	4.0 ± 1.3	6.6	12	0	43 ± 12	20 ± 6	28 ± 4	0.03
7. 48th Street	81 818	12	0	6.9 ± 3.0	1.9 ± 0.8	3.4 ± 0.9	5.7	12	0	31 ± 8	14 ± 4	24 ± 3	0.02
8. LA Airport	93 089	12	0	5.2 ± 2.2	0.9 ± 0.4	3.3 ± 0.9	5.4	12	0	30 ± 8	4.4 ± 1.2	23 ± 5	0.02
9. Bayo STP	87 404	12	0	6.8 ± 3.0	1.1 ± 0.6	2.7 ± 0.9	4.5	12	0	32 ± 8	16 ± 4	23 ± 3	0.02
10. Gulf Station	85 428	12	0	5.0 ± 2.2	1.1 ± 0.4	2.3 ± 0.7	3.8	12	0	38 ± 10	4.0 ± 1.0	22 ± 5	0.02
11. Royal Crest	85 463	12	1	4.6 ± 2.0	0.0 ± 0.1	2.0 ± 0.7	3.4	12	1	35 ± 8	6.7 ± 1.8	20 ± 4	0.02
12. White Rock	77 150	12	0	3.6 ± 1.6	1.1 ± 0.4	2.0 ± 0.5	3.3	12	0	31 ± 8	11 ± 3	21 ± 3	0.02
13. Pajarito Acres	79 278	12	0	6.5 ± 2.8	1.4 ± 0.6	3.4 ± 1.0	5.7	12	0	35 ± 8	13 ± 3	26 ± 5	0.03
14. Bandelier	88 772	12	0	5.5 ± 2.4	2.0 ± 0.8	3.5 ± 0.7	5.8	12	0	39 ± 10	18 ± 4	26 ± 4	0.03
Perimeter Group Summary	925 933	132	1	10 ± 4	0.0 ± 0.1	3.1 ± 0.3	5.2	132	1	52 ± 14	4.0 ± 1.0	25 ± 2	0.03
Onsite Stations—Controlled Areas													
15. TA-21	81 563	12	0	4.7 ± 2.0	0.9 ± 0.4	2.4 ± 0.6	0.12	12	0	37 ± 10	8.2 ± 2.2	24 ± 5	0.0006
16. TA-6	86 372	12	0	6.7 ± 2.8	1.0 ± 0.4	3.0 ± 1.1	0.15	12	0	43 ± 12	8.8 ± 2.2	24 ± 6	0.0006
17. TA-53 (LAMPF)	89 641	12	0	4.2 ± 1.8	1.4 ± 0.6	2.9 ± 0.5	0.14	12	0	46 ± 12	22 ± 6	30 ± 4	0.0007
18. Well PM-1	88 740	12	0	6.8 ± 3.0	1.6 ± 0.8	3.3 ± 0.9	0.17	12	0	38 ± 10	15 ± 4	27 ± 5	0.0007
19. TA-52	90 660	12	0	4.5 ± 2.0	0.3 ± 0.2	2.5 ± 0.7	0.12	12	0	26 ± 6	1.7 ± 0.4	16 ± 5	0.0004
20. TA-16	68 661	12	0	6.9 ± 3.0	1.5 ± 0.6	3.1 ± 0.8	0.16	12	0	41 ± 10	14 ± 4	23 ± 4	0.0006
21. Booster P-2	91 473	12	0	6.4 ± 2.8	0.7 ± 0.3	2.8 ± 1.1	0.14	12	0	30 ± 8	8.2 ± 2.2	21 ± 4	0.0005
22. TA-54	95 669	12	0	7.1 ± 3.0	1.3 ± 0.6	2.9 ± 0.9	0.14	12	0	41 ± 10	15 ± 4	28 ± 5	0.0007
23. TA-49	98 014	12	0	4.6 ± 2.0	1.2 ± 0.6	2.4 ± 0.5	0.12	12	0	32 ± 8	14 ± 4	21 ± 4	0.0005
24. TA-33	90 505	12	0	6.7 ± 3.0	1.2 ± 0.6	3.1 ± 1.1	0.16	12	0	37 ± 10	18 ± 4	29 ± 4	0.0007
25. TA-39	94 008	12	0	7.4 ± 3.2	0.7 ± 0.3	2.5 ± 1.1	0.13	12	0	36 ± 10	14 ± 4	24 ± 4	0.0006
Onsite Group Summary	970 306	132	0	7.4 ± 3.2	0.3 ± 0.2	2.8 ± 0.3	0.14	132	0	46 ± 12	1.7 ± 0.4	24 ± 2	0.0006

[a]The filters are held 7 10 days before analysis to allow naturally-occurring radon-thoron daughters to reach equilibrium with their long lived parents.

[b]Air volumes (m^3) at average ambient conditions of 77 kPa barometric pressure and 15°C.

[c]Minimum detectable limit = 0.3×10^{-15} μCi/mℓ (α)
= 0.3×10^{-15} μCi/mℓ (β).

[d]Uncertainties are ±2 standard deviations (see Appendix B.2).

[e]Of the possible radionuclides released at the laboratory, ^{239}Pu and ^{131}I are the most restrictive. The CGs for these species are used for the gross alpha and gross beta CGs, respectively.
Controlled area radioactivity concentration guide = 2×10^{-12} μCi/mℓ (α)
= 4×10^{-9} μCi/mℓ (β)
Uncontrolled area radioactivity concentration guide = 6×10^{-14} μCi/mℓ (α)
= 1×10^{-10} μCi/mℓ (β).

TABLE E-VIII

ANNUAL ATMOSPHERIC TRITIATED WATER VAPOR CONCENTRATIONS

Station Location	Total Air Volume[a] (m^3)	No. Monthly Samples	No Samples <MDL[b]	Concentrations—pCi/m^3 (10^{-12} μCi/mℓ) Max[c]	Min[c]	Mean[c]	Mean as % CG[d]
Regional Stations (28-44 km)—Uncontrolled Areas							
1. Española	115	12	4	88 ± 28	−2.2 ± 1.6	12 ± 15	0.006
2. Pojoaque	114	12	4	7.8 ± 3.0	−1.0 ± 1.2	2.2 ± 1.5	0.001
3. Santa Fe	115	12	6	38 ± 12	−1.0 ± 1.4	9.2 ± 8.2	0.005
Regional Group Summary	344	36	14	88 ± 28	−2.2 ± 1.6	7.7 ± 5.8	0.004
Perimeter Stations (0-4 km)—Uncontrolled Areas							
4. Barranca School	116	12	4	12 ± 4	0.4 ± 1.0	3.8 ± 2.2	0.002
5. Arkansas Ave	116	12	3	72 ± 24	0.3 ± 0.2	8.3 ± 12	0.004
6. Cumbres School	116	12	4	55 ± 18	0.5 ± 1.2	9.6 ± 9.4	0.005
7. 48th Street	116	12	2	34 ± 12	0.1 ± 1.0	7.9 ± 6.5	0.004
8l LA Airport	113	12	0	33 ± 10	1.5 ± 0.8	9.1 ± 6.2	0.005
9. Bayo STP	116	12	3	11 ± 4	0.3 ± 0.3	3.8 ± 2.0	0.002
10. Gulf Station	115	12	4	31 ± 10	0.2 ± 0.6	9.0 ± 6.6	0.004
11. Royal Crest	107	12	0	27 ± 8	2.0 ± 0.8	9.0 ± 4.0	0.005
12. White Rock	115	12	1	47 ± 16	1.3 ± 1.6	11 ± 9	0.005
13. Pajarito Acres	116	12	0	10 ± 4	2.0 ± 0.8	5.6 ± 1.3	0.003
14. Bandelier	116	12	0	170 ± 60	1.3 ± 0.8	34 ± 33	0.017
Perimeter Group Summary	1 262	132	21	170 ± 60	0.1 ± 1.0.	10 ± 4	0.005
Onsite Stations—Controlled Areas							
15. TA-21	115	12	0	41 ± 14	3.1 ± 1.2	11 ± 8	0.0002
16. TA-6	113	12	4	15 ± 4	0.3 ± 1.2	3.8 ± 2.6	0.0001
17. TA-53 (LAMPF)	116	12	0	14 ± 4	2.5 ± 1.0	6.2 ± 2.2	0.0001
18. Well PM-1	114	12	0	17 ± 6	1.8 ± 1.0	5.9 ± 3.0	0.0001
19. TA-52	116	12	1	90 ± 28	1.2 ± 1.2	17 ± 18	0.0003
20. TA-16	116	12	3	54 ± 18	0.3 ± 1.4	11 ± 9	0.0002
21. Booster P-2	116	12	3	42 ± 14	0.4 ± 0.3	12 ± 9	0.0002
22. TA-54	116	12	0	120 ± 40	2.3 ± 1.0	53 ± 21	0.0011
23. TA-49	116	12	7	10 ± 3	0.1 ± 1.2	2.1 ± 1.6	0.0000
24. TA-33	116	12	0	117 ± 38	21 ± 6	44 ± 17	0.0009
25. TA-39	115	12	0	160 ± 60	6.3 ± 1.8	28 ± 25	0.0006
On-Site Group Summary	1 269	132	18	160 ± 60	0.1 ± 1.2	17 ± 5	0.0003

[a]Air volumes (m^3) at average ambient conditions of 77 kPa barometric pressure and 15°C.
[b]Minimum detectable limit = 1×10^{-12} μCi/mℓ.
[c]Uncertainties are ±2 standard deviations (see Appendix B.2).
[d]Controlled area radioactivity concentration guide = 5×10^{-6} μCi/mℓ.
Uncontrolled area radioactivity concentration guide = 2×10^{-7} μCi/mℓ.

TABLE E-IX

ANNUAL ATMOSPHERIC ^{238}Pu and ^{239}Pu CONCENTRATIONS

Station Location	Total Air Volume[a] (m^3)	^{238}Pu $\mu Ci/m^3$ (10^{-18} $\mu Ci/m\ell$) No. of Samples	No. <MDL[b]	Max[c]	Min[c]	Mean[c]	Mean as % CG[d]	^{239}Pu $\mu Ci/m^3$ (10^{-18} $\mu Ci/m\ell$) No. of Samples	No. <MDL[b]	Max[c]	Min[c]	Mean[c]	Mean as % CG[d]
Regional Stations (28-44 km)—Uncontrolled Area													
1. Española	90 811	4	4	−1.0 ± 2.1	−3.3 ± 2.3	−1.9 ± 1.0	0.0	4	4	2.0 ± 2.0	1.1 ± 3.0	1.6 ± 0.4	0.003
2. Pojoaque	79 469	4	4	−2.0 ± 1.9	−3.4 ± 2.7	−2.5 ± 0.6	0.0	4	3	4.7 ± 2.9	−1.0 ± 2.0	1.6 ± 2.4	0.003
3. Santa Fe	91 980	4	4	−1.6 ± 1.9	−2.1 ± 2.6	−1.9 ± 0.2	0.0	4	4	1.2 ± 2.2	−0.9 ± 1.4	0.1 ± 0.9	0.0002
Regional Group Summary	262 210	12	12	−1.0 ± 2.1	−3.4 ± 2.7	−2.1 ± 0.4	0.0	12	11	4.7 ± 2.9	−1.0 ± 2.0	1.1 ± 0.9	0.002
Perimeter Stations (0-4 km)—Uncontrolled Areas													
4. Barranca School	91 702	4	4	0.1 ± 2.8	−2.6 ± 2.1	−1.5 ± 1.2	0.0	4	2	182 ± 19	−1.0 ± 1.6	46 ± 90	0.077
5. Arkansas Ave	79 586	4	4	−1.8 ± 2.5	−2.4 ± 1.7	−2.1 ± 0.3	0.0	4	2	6.4 ± 3.3	−0.2 ± 2.9	3.2 ± 2.9	0.005
6. Cumbres School	75 333	4	4	−0.3 ± 2.6	−2.6 ± 1.9	−1.9 ± 1.1	0.0	4	2	6.4 ± 3.1	0.9 ± 1.8	4.0 ± 2.7	0.007
7. 48th Street	88 664	4	4	−0.3 ± 2.7	−4.6 ± 2.2	−2.2 ± 1.8	0.0	4	2	19 ± 4	−1.6 ± 2.9	6.0 ± 9.7	0.010
8. LA Airport	98 689	4	4	1.9 ± 2.6	−2.8 ± 3.4	−0.9 ± 2.0	0.0	4	2	34 ± 6	0.4 ± 1.3	9.8 ± 16	0.016
9. Bayo STP	86 404	4	4	−1.2 ± 2.2	−2.1 ± 2.7	−1.6 ± 0.4	0.0	4	2	7.1 ± 4.0	0.6 ± 1.9	3.5 ± 3.4	0.006
10. Gulf Station	87 488	4	4	−1.1 ± 1.8	−4.2 ± 2.9	−2.0 ± 1.5	0.0	4	1	14 ± 4	3.2 ± 3.9	7.5 ± 5.1	0.013
11. Royal Crest	86 024	4	4	−1.3 ± 1.6	−2.5 ± 2.5	−2.0 ± 0.5	0.0	4	3	5.1 ± 2.6	−0.5 ± 6.3	1.5 ± 2.5	0.003
12. White Rock	76 953	4	4	−1.7 ± 3.6	−2.0 ± 2.0	−1.8 ± 0.1	0.0	4	3	7.3 ± 7.0	−0.8 ± 1.5	2.6 ± 3.4	0.004
13. Pajarito Acres	81 948	4	4	−1.0 ± 2.9	−2.6 ± 1.6	−2.0 ± 0.8	0.0	4	1	5.4 ± 2.7	−1.6 ± 2.0	3.4 ± 3.4	0.006
14. Bandelier	88 772	4	4	−1.4 ± 1.7	−2.9 ± 1.6	−2.2 ± 0.7	0.0	4	3	3.4 ± 2.2	−0.7 ± 1.9	0.8 ± 1.8	0.001
Perimeter Group Summary	936 563	44	44	1.9 ± 2.6	−4.6 ± 2.2	−1.9 ± 0.3	0.0	44	23	182 ± 19	−1.6 ± 2.9	8.1 ± 8.3	0.013
Onsite Stations—Controlled Areas													
15. TA-21	81 563	4	4	−0.1 ± 2.0	−3.0 ± 4.4	−1.9 ± 1.4	0.0	4	1	109 ± 11	1.2 ± 2.0	31 ± 52	0.0015
16. TA-6	86 959	4	4	−1.5 ± 2.3	−1.9 ± 1.6	−1.7 ± 0.2	0.0	4	3	8.1 ± 2.8	0.1 ± 1.4	2.6 ± 3.8	0.0001
17. TA-53 (LAMPF)	89 641	4	4	0.1 ± 2.7	−2.0 ± 1.9	−1.4 ± 1.0	0.0	4	2	27 ± 5	−2.4 ± 13	7.2 ± 13	0.0004
18. Well PM-1	88 741	4	4	−1.4 ± 1.9	−2.4 ± 2.4	−1.8 ± 0.4	0.0	4	2	6.4 ± 4.2	−0.6 ± 5.2	2.6 ± 3.5	0.0001
19. TA-52	90 838	4	4	−0.8 ± 1.8	−3.4 ± 2.0	−1.9 ± 1.1	0.0	4	3	3.2 ± 2.6	−0.4 ± 1.1	1.0 ± 1.7	0.0001
20. TA-16	71 151	4	4	−2.6 ± 2.5	−3.9 ± 5.2	−3.0 ± 0.6	0.0	4	3	4.9 ± 3.6	−1.1 ± 2.7	1.1 ± 2.7	0.0001
21. Booster P-2	91 473	4	4	−1.6 ± 2.0	−2.6 ± 1.7	−2.0 ± 0.5	0.0	4	3	5.1 ± 2.9	−0.3 ± 2.0	1.6 ± 2.4	0.0001
22. TA-54	95 669	4	3	4.2 ± 3.1	−1.2 ± 1.5	1.3 ± 2.3	0.0	4	1	30 ± 6	0.9 ± 2.2	13 ± 13	0.0007
23. TA-49	92 914	4	4	−1.0 ± 1.9	−2.2 ± 1.9	−1.7 ± 0.5	0.0	4	2	21 ± 6	−0.3 ± 2.0	6.4 ± 9.9	0.0003
24. TA-23	90 555	4	4	−1.1 ± 2.6	−2.1 ± 1.6	−1.6 ± 0.4	0.0	4	2	7.9 ± 3.5	−0.3 ± 1.9	3.5 ± 3.9	0.0001
25. TA-39	94 008	4	4	−1.7 ± 1.9	−2.7 ± 1.9	−2.1 ± 0.5	0.0	4	1	7.0 ± 3.4	−0.3 ± 2.0	4.4 ± 3.4	0.0002
Onsite Group Summary	973 512	12	43	4.2 ± 3.1	−3.9 ± 5.2	−1.6 ± 0.4	0.0	44	23	109 ± 11	−2.4 ± 13	6.7 ± 5.2	0.0003

[a]Air volumes (m^3) at average ambient conditions of 77 kPa barometric pressure and 15°C.

[b]Minimum detectable limits = 2×10^{-10} $\mu Ci/m\ell$ (^{238}Pu).
= 3×10^{-18} $\mu Ci/m\ell$ (^{239}Pu).

[c]Uncertainties are ±2 sample standard deviations (see Appendix B.2).

[d]Controlled area radioactivity concentration guide = 2×10^{-12} $\mu Ci/m\ell$ (^{238}Pu).
= 2×10^{-12} $\mu Ci/m\ell$ (^{239}Pu).

Uncontrolled area radioactivity concentration guide = 7×10^{-14} $\mu Ci/m\ell$ (^{238}).
= 6×10^{-14} $\mu Ci/m\ell$ (^{239}).

TABLE E-X

ANNUAL ATMOSPHERIC URANIUM CONCENTRATIONS
(concentrations in pg/m^3)

Station Location	Total Air Volume[a] (m^3)	No. Quarterly Samples	No. Samples <MDL[b]	Max[c]	Min[c]	Mean[c]	Mean as % CG[d]
Regional Stations (28-44 km)—Uncontrolled Areas							
1. Española	90 811	4	0	140 ± 20	56 ± 17	83 ± 39	0.0009
2. Pojoaque	79 469	4	0	94 ± 21	28 ± 20	71 ± 30	0.0008
3. Santa Fe	91 930	4	2.	40 ± 33	18 ± 4	26 ± 10	0.0003
Regional Group Summary	262 210	12	2	140 ± 20	18 ± 4	60 ± 21	0.0007
Perimeter Stations (0-4 km)—Uncontrolled Areas							
4. Barranca School	91 702	4	1	56 ± 11	15 ± 16	43 ± 20	0.0005
5. Arkansas Ave	79 586	4	1	67 ± 23	26 ± 38	42 ± 17	0.0005
6. Cumbres School	75 333	4	1	99 ± 23	18 ± 41	50 ± 35	0.0006
7. 48th Street	88 664	4	1	50 ± 21	−1.4 ± 14	31 ± 23	0.0003
8. LA Airport	93 689	4	1	221 ± 37	14 ± 32	97 ± 88	0.0011
9. Bayo STP	86 404	4	1	69 ± 14	34 ± 36	48 ± 15	0.0005
10. Gulf Station	87 488	4	0	94 ± 32	69 ± 24	79 ± 11	0.0009
11. Royal Crest	86 024	4	0	50 ± 17	29 ± 21	40 ± 8	0.0004
12. White Rock	76 953	4	1	125 ± 23	24 ± 17	61 ± 44	0.0007
13. Pajarito Acres	81 948	4	2	50 ± 21	10 ± 24	32 ± 19	0.0004
14. Bandelier	88 772	4	2.	30 ± 6	15 ± 33	22 ± 7	0.0002
Perimeter Group Summary	936 563	44	11	221 ± 37	−1.4 ± 14	49 ± 11	0.0005
Onsite Stations—Controlled Areas							
15. TA-21	81 563	4	1	124 ± 21	26 ± 37	72 ± 42	0.00003
16. TA-6	86 959	4	1	57 ± 20	−1.6 ± 32	28 ± 24	0.00001
17. TA-53 (LAMPF)	89 641	4	0	104 ± 21	56 ± 17	83 ± 22	0.00004
18. Well PM-1	88 741	4	2	59 ± 21	16 ± 17	32 ± 19	0.00002
19. TA-52	90 838	4	2	162 ± 39	−1.7 ± 17	56 ± 72	0.00003
20. TA-16	71 151	4	2	42 ± 22	22 ± 25	30 ± 9	0.00001
21. Booster P-2	91 473	4	2	49 ± 11	−1.7 ± 35	27 ± 24	0.00001
22. TA-54	95 669	4	0	203 ± 37	21 ± 15	88 ± 83	0.00004
23. TA-49	92 914	4	2	98 ± 18	14.+0.32	38 ± 40	0.00002
24. TA-33	90 555	4	0	63 ± 32	26 ± 19	45 ± 16	0.00002
25. TA-39	94 008	4	0.	66 ± 13	22 ± 16	47 ± 21	0.00002
Onsite Group Summary	973 512	44	12	203 ± 37	−1.7 ± 35	50 ± 13	0.00002

[a]Air volumes (m^3) at average ambient conditions of 77 kPa barometric pressure and 15°C.
[b]Minimum detectable limit = 1 pg/m^3.
[c]Uncertainties ±2 sample standard deviations (see Appendix B.2).
[d]Controlled area radioactivity concentration guide = 2.1 × 10^8 pg/m^3.
Uncontrolled area radioactivity concentration guide = 9 × 10^6 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} μCi/pg.

TABLE E-XI

ANNUAL ATMOSPHERIC ^{241}Am CONCENTRATIONS

Station Location	Total Air Volume (m^3)[a]	Number of Quarterly Samples	No. Samples <MDL[b]	Max[c]	Min[c]	Mean[c]	Mean as % CG[d]
Regional Stations (28-44 km)							
3. Santa Fe	91 930	4	4	−0.0 ± 4.4	−0.4 ± 0.5	0.0	0.0
Regional Group Summary	91 930	4	4	−0.0 ± 4.4	−1.0 ± 4.4	−0.4 ± 0.3	0.0
Perimeter Stations (0-4 km)							
6. Cumbres	75 333	4	4	1.2 ± 5.7	−0.8 ± 5.6	−1.0 ± 0.9	0.0
8. LA Airport	93 689	4	3	48 ± 8	−0.5 ± 4.4	13 ± 24	0.006
9. Bayo STP	86 404	4	4	1.0 ± 5.2	−1.8 ± 4.9	−0.7 ± 1.3	0.0
12. White Rock	76 953	4	4	4.6 ± 6.5	−1.6 ± 5.6	1.3 ± 2.6	0.0007
Perimeter Group Summary	332 379	16	15	48 ± 8	−1.8 ± 4.9	3.3 ± 6.0	0.002
Onsite Stations—Controlled Areas							
16. TA-6	86 959	4	4	1.6 ± 4.6	−1.2 ± 5.5	0.1 ± 1.2	0.00000
17. TA-53 (LAMPF)	89 641	4	4	1.8 ± 5.1	−0.2 ± 4.4	0.9 ± 1.1	0.00002
20. TA-16	71 151	4	4	1.1 ± 6.0	−2.8 ± 6.9	−0.5 ± 1.8	0.00000
21. Booster P-2	91 473	4	2	23 ± 5	−1.6 ± 4.3	7.8 ± 11	0.00013
22. TA-54	95 669	4	2	8.4 ± 5.3	0.3 ± 4.2	4.2 ± 3.0	0.00007
23. TA-49	92 914	4	3	6.7 ± 5.4	−1.7 ± 4.3	2.2 ± 3.5	0.00004
Onsite Group Summary	527 807	24	19	23 ± 5	−2.8 ± 6.9	2.5 ± 2.2	0.00004

[a]Air volumes (m^3) at average ambient conditions of 77 kPa barometric pressure and 15°C.
[b]Minimum detectable limit = 2×10^{-18} μCi/mℓ.
[c]Uncertainties are ±2 sample deviations (see Appendix B.2).
[d]Controlled area radioactivity concentration guide = 5×10^{-6} μCi/mℓ.
Uncontrolled area radioactivity concentration guide = 2×10^{-7} μCi/mℓ.

TABLE E-XII

LOCATIONS OF SURFACE AND GROUND WATER STATIONS

Station	Latitude or N-S Coordinate	Longitude or E-W Coordinate	Map Designation[a]	Type[b]
Regional[c]				
Chamita—Rio Chama	36°05'	106°07'	---	SW
Embudo—Rio Grande	36°12'	105°58'	---	SW
Otowi—Rio Grande	35°52'	106°08'	---	SW
Cochiti—Rio Grande	35°37'	106°19'	---	SW
Bernalillo—Rio Grande	35°17'	106°36'	---	SW
Jemez River	35°40'	106°44'	---	SW
Perimeter				
Los Alamos Reservoir	N105	W090	1	SW
Guaje Canyon	N300	E100	2	SW
Basalt Spring	N060	E395	3	GWS
Frijoles Canyon	S280	E180	4	SW
La Mesita Spring	N080	E550	5	GWD
White Rock Canyon[d]				
Puye Formation	---	---	---	GWD
Tesuque Fm (F.G. Sed)	---	---	---	GWD
Tesuque Fm (F.G. Sed)	---	---	---	GWD
Tesuque Fm (Basalts)		---	---	GWD
Surface Water	---	---	---	SW
Surface Water (Sanitary Effluents)	---	---	---	SW
Water Supply				
Distribution				
Fire Station 1	N080	E015	12	D
Fire Station 2	N100	E120	13	D
Fire Station 3	S085	E375	14	D
Fire Station 4	N185	E070	15	D
Fire Station 5	S010	W065	16	D
Los Alamos Field				
LA-1B	N115	E530	17	GWD
LA-2	N125	E505	18	GWD
LA-3	N130	E490	19	GWD
LA-4	N070	E405	20	GWD
LA-5	N076	E435	21	GWD
LA-6	N105	E465	22	GWD
Guaje Field				
G-1	N190	E385	23	GWD
G-1A	N197	E380	24	GWD
G-2	N205	E365	25	GWD
G-3	N215	E350	26	GWD
G-4	N213	E315	27	GWD
G-5	N228	E295	28	GWD
G-6	N215	E270	29	GWD

TABLE E-XII (Continued)

Station	Latitude or N-S Coordinate	Longitude or E-W Coordinate	Map Designation[a]	Type[b]
Pajarito Field				
PM-1	N030	E305	30	GWD
PM-2	S055	E202	31	GWD
PM-3	N040	E255	32	GWD
Water Canyon Gallery	S040	W125	33	GWD
Noneffluent Areas				
Test Well 1	N070	E345	34	GWD
Test Well 3	N080	E215	35	GWD
Deep Test-5A	S110	E090	36	GWD
Test Well-8	N035	E170	37	GWD
Deep Test-9	S155	E140	38	GWD
Deep Test-10	S120	E125	39	GWD
Canada del Buey	N010	E150	40	SW
Pajarito Canyon	S060	E215	41	SW
Water Canyon	S090	E090	42	SW
Test Well 2	N120	E150	43	GWD
Effluent Release Area				
Acid-Pueblo Canyon (Former Release Area)				
Acid Weir	N125	E070	44	SW
Pueblo 1	N130	E080	45	SW
Pueblo 2	N120	E155	46	SW
Pueblo 3	N085	E315	47	SW
Hamilton Bend Spring	N110	E255	48	GW
Test Well 1A	N070	E335	49	GWS
Test Well 2A	N120	E140	50	GWS
DP —Los Alamos Canyon				
DPS-1	N090	E160	51	SW
DPS-4	N080	E200	52	SW
Obs: Hole LAO-C	N085	E070	53	GWS
Obs: Hole LAO-1	N080	E120	54	GWS
Obs: Hole LAO-2	N080	E210	55	GWS
Obs: Hole LAO-3	N080	E220	56	GWS
Obs: Hole LAO-4	N070	E245	57	GWS
Obs: Hole LAO-4.5	N065	E270	58	GWS
Sandia Canyon				
SCS-1	N080	E040	59	SW
SCS-2	N060	E140	60	SW
SCS-3	N050	E185	61	SW

TABLE E-XII (Continued)

Station	Latitude or N-S Coordinate	Longitude or E-W Coordinate	Map Designation[a]	Type[b]
Mortandad Canyon				
GS-1	N040	E100	62	SW
MCS-3.9	N040	E140	63	SW
Obs. Hole MCO-3	N040	E110	64	GWS
Obs. Hole MCO-4	N035	E150	65	GWS
Obs. Hole MCO-5	N030	E160	66	GWS
Obs. Hole MCO-6	N030	E175	67	GWS
Obs. Hole MCO-7	N025	E180	68	GWS
Obs. Hole MCO-7.5	N030	E190	69	GWS

[a]See Fig. 12 for numbered locations.
[b]SW = surface water; GWD = deep or main aquifer; GWS = shallow or alluvial aquifer; I) = water supply distribution system.
[c]See Fig. 6 for regional locations.
[d]Puye Formation 9 stations; Tesuque Fm (F. G. Sed) 2 stations; Tesuque Fm (C. G. Sed) 11 stations; Tesuque (basalts) 3 stations; surface water 2 stations; surface water (sanitary effluents) 1 station.

TABLE E-XIII

RADIOCHEMICAL AND CHEMICAL QUALITY OF SURFACE WATER FROM REGIONAL STATIONS

Station	No. of Analyses	^{137}Cs (10^{-9} μCi/mℓ)	^{90}Sr (10^{-9} μCi/mℓ)	^{238}Pu (10^{-9} μCi/mℓ)	^{239}Pu (10^{-9} μCi/mℓ)	Gross Alpha (10^{-9} μCi/mℓ)	Gross Beta (10^{-9} μCi/mℓ)	^{3}H (10^{-6} μCi/mℓ)	Total U (μg/ℓ)
		Radiochemical (average of a number of analyses)							
Chamita	2	56 ± 98	0.7 ± 0.8	0.005 ± 0.024	0.027 ± 0.066	1.4 ± 2.2	3.6 ± 0.8	0.4 ± 2.0	1.9 ± 2.2
Embudo	2	26 ± 18	1.0 ± 0.6	−0.006 ± 0.042	0.008 ± 0.034	2.0 ± 0.6	4.1 ± 2.4	−0.1 ± 2.5	2.4 ± 1.8
Otowi	2	14 ± 66	0.9 ± 0.8	−0.022 ± 0.068	0.002 ± 0.050	2.4 ± 0.2	4.2 ± 1.8	0.5 ± 0.8	1.7 ± 1.6
Cochiti	2	35 ± 42	1.6 ± 0.8	−0.005 ± 0.042	−0.015 ± 0.014	2.4 ± 1.8	3.8 ± 1.6	0.6 ± 0.8	2.6 ± 3.2
Bernalillo	2	11 ± 40	0.7 ± 0.8	−0.010 ± 0.040	−0.001 ± 0.038	3.2 ± 2.8	8.0 ± 1.2	1.0 ± 1.4	2.9 ± 0.0
Jemez	2	31 ± 88	0.6 ± 0.6	−0.990 ± 0.129	−0.028 ± 0.064	14 ± 10	20 ± 2.8	0.4 ± 1.0	1.1 ± 0.1
No. of Analyses		12	6	12	12	12	12	12	12
Minimum		−10 ± 24	0.6 ± 0.6	−0.190 ± 0.320	−0.050 ± 0.360	0.6 ± 1.2	3.2 ± 1.4	−1.0 ± 0.6	1.0 ± 0.8
Maximum		90 ± 80	1.6 ± 0.8	0.017 ± 0.028	0.050 ± 0.040	18 ± 8.0	22 ± 4.0	1.5 ± 0.6	3.7 ± 0.8
Average		29	0.9	−0.019	0.000	4.3	7.3	4.8	2.1
2s		56	0.7	0.106	0.048	10	12	1.3	1.9

Station	SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	SO_4	Cl	F	NO_3	TDS	Hard	pH	Cond (mS/m)
	Chemical (concentrations in mg/ℓ, one analysis)														
Chamita	6	38	8.1	2.3	18	0	92	78	4	0.2	0.5	240	124	8.2	21
Embudo	18	28	5.7	2.6	14	0	92	33	4	0.4	1.7	192	88	8.1	19
Otowi	12	34	6.5	2.4	16	0	100	55	4	0.3	1.2	200	108	8.1	19
Cochiti	12	37	6.6	2.9	19	0	116	53	5	0.4	1.4	224	116	8.1	19
Bernalillo	9	39	7.1	3.4	29	0	120	65	15	0.5	1.0	230	122	8.5	11
Jemez	44	38	5.2	11	61	0	156	5	68	1.3	0.9	300	116	8.5	32
No. of Analyses	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Minimum	6	28	5.2	2.3	14	---	92	5	4	0.2	0.5	192	88	8.1	11
Maximum	44	39	8.1	11	61	0	156	78	68	1.3	1.7	300	124	8.5	32
Average	17	36	6.5	4.1	26	---	113	48	17	0.5	1.1	231	112	8.2	20
2s	28	8	2.1	6.8	36	---	49	52	51	0.8	0.8	77	26	0.4	14

Note: The ± value represents twice the standard deviation of the distribution of observed values unless only one analysis is reported, then the value represents twice the uncertainty term for that analysis.

TABLE E-XIV

RADIOCHEMICAL AND CHEMICAL QUALITY OF SURFACE AND GROUND WATER FROM PERIMETER STATIONS

Station	No. of Analysis	Radiochemical (average of a number of analyses) ^{137}Cs (10^{-9} μCi/mℓ)	^{90}Sr (10^{-9} μCi/mℓ)	^{238}Pu (10^{-9} μCi/mℓ)	^{239}Pu (10^{-9} μCi/mℓ)	Gross Alpha (10^{-9} μCi/mℓ)	Gross Beta (10^{-9} μCi/mℓ)	^{3}H (10^{-6} μCi/mℓ)	Total U (μg/ℓ)
Los Alamos Reservoir	2	26 ± 18	0.8 ± 0.8	0.018 ± 0.022	−0.017 ± 0.092	0.2 ± 0.3	3.2 ± 0.1	0.7 ± 0.2	0.0 ± 0.0
Guaje Canyon	2	7 ± 20	0.7 ± 0.8	0.016 ± 0.040	0.019 ± 0.032	0.4 ± 0.0	3.1 ± 1.1	0.6 ± 0.0	0.0 ± 0.0
Basalt Spring	2	−40 ± 90	−0.2 ± 1.4	−0.007 ± 0.036	−0.005 ± 0.042	1.6 ± 1.1	14 ± 22	1.0 ± 1.6	2.6 ± 4.6
Frijoles Canyon	2	−12 ± 34	0.7 ± 1.2	0.099 ± 0.288	0.033 ± 0.102	0.4 ± 0.4	2.8 ± 0.8	0.6 ± 0.7	0.0 ± 0.0
La Mesita Springs	2	−54 ± 72	−0.2 ± 0.6	0.001 ± 0.022	0.011 ± 0.012	8.2 ± 7.8	6.2 ± 1.4	0.4 ± 0.8	15 ± 6.8
Indian Springs	1	−10 ± 60	−0.3 ± 1.0	0.019 ± 0.038	0.000 ± 0.040	3.8 ± 2.0	30 ± 6.0	0.2 ± 0.6	2.4 ± 0.8
Sacred Spring	1	30 ± 60	−0.1 ± 1.4	−0.008 ± 0.028	0.030 ± 0.080	0.8 ± 1.0	4.5 ± 1.4	0.5 ± 0.6	1.0 ± 0.8
Santa Fe STP	2	26 ± 74	0.9 ± 0.8	0.004 ± 0.004	0.018 ± 0.012	16 ± 19	19 ± 16	0.5 ± 1.0	17 ± 40
No. of Analyses		14	8	14	14	14	14	14	14
Minimum		−71 ± 50	−0.3 ± 1.0	−0.200 ± 0.180	−0.070 ± 0.220	0.1 ± 0.8	2.5 ± 5.0	0.1 ± 0.6	0.0 ± 0.8
Maximum		52 ± 88	0.9 ± 0.8	0.030 ± 0.080	0.030 ± 0.080	29 ± 12	30 ± 6.0	1.6 ± 0.5	31 ± 6.2
Average		−5	0.3	−0.009	−0.002	4.1	9.3	0.6	5.2
2s		74	1.1	0.113	0.058	15	19	0.8	18

Station	Chemical (concentrations in mg/ℓ, one analysis) SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	SO_4	Cl	F	NO_3	TDS	Hard	pH	Cond (mS/m)
Los Alamos Reservoir	48	5	2.2	2.2	6	0	52	3	1	0.1	0.5	92	22	7.7	8
Guaje Canyon	48	6	2.3	2.7	7	0	40	4	1	0.1	4.8	86	22	7.8	3
Basalt Spring	38	23	6.5	3.3	14	0	88	20	10	0.4	13	186	82	8.5	24
Frijoles Canyon	54	7	2.7	2.0	9	0	40	4	2	0.1	0.2	138	30	8.1	8
La Mesita	12	29	0.8	2.9	3	0	132	14	7	0.2	13	92	76	8.1	21
Indian Springs	38	25	2.2	2.7	23	0	112	6	15	0.4	1.2	206	72	8.2	19
Sacred Spring	26	20	0.4	2.6	22	0	112	6	2	0.5	0.5	138	52	8.3	17
Buckman PS Well	26	24	2.9	3.1	9	0	360	23	4	0.4	11	534	158	7.6	52
No. of Analyses	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Minimum	12	5	0.4	2.0	3	---	40	3	1	0.1	0.2	86	22	7.6	3
Maximum	54	29	6.5	3.3	23	0	360	23	15	0.5	13	534	158	8.5	52
Average	36	17	2.5	2.7	12	---	117	10	5	0.3	5.5	184	64	8.0	19
2s	28	20	3.7	0.9	15	---	209	16	10	0.3	12	296	90	0.6	30

Note: The ± value represents twice the standard deviation of the distribution of observed values unless only one analysis is reported, then the value represents twice the uncertainty term for that analysis.

TABLE E-XV

RADIOCHEMICAL AND CHEMICAL QUALITY OF SURFACE AND GROUND WATER FROM WHITE ROCK CANYON, OCTOBER 1980

Station	Radiochemical							
	^{137}Cs (10^{-9} µCi/mℓ)	^{90}Sr (10^{-9} µCi/mℓ)	^{238}Pu (10^{-9} µCi/mℓ)	^{239}Pu (10^{-9} µCi/mℓ)	Gross Alpha (10^{-9} µCi/mℓ)	Gross Beta (10^{-9} µCi/mℓ)	^{3}H (10^{-6} µCi/mℓ)	Total U (µg/ℓ)
Group I—Totavi Lentil								
Sandia Springs	62 ± 92	0.2 ± 0.6	0.010 ± 0.040	−0.028 ± 0.034	0.8 ± 1.2	2.3 ± 1.2	0.3 ± 0.6	1.0 ± 0.8
Spring 3	−1 ± 28	−0.2 ± 0.6	−0.030 ± 0.060	−0.030 ± 0.060	1.1 ± 1.2	6.3 ± 1.8	−0.1 ± 0.6	1.8 ± 0.8
Spring 3A	48 ± 58	0.1 ± 0.4	−0.016 ± 0.026	−0.010 ± 0.030	0.2 ± 1.0	2.0 ± 1.2	0.0 ± 0.6	1.1 ± 0.8
Spring 3AA	48 ± 102	0.7 ± 1.4	0.006 ± 0.036	0.006 ± 0.036	0.6 ± 1.0	2.2 ± 1.2	0.0 ± 0.6	1.2 ± 0.8
Spring 4	10 ± 32	0.2 ± 0.4	0.010 ± 0.100	0.010 ± 0.120	−0.2 ± 1.0	3.4 ± 1.2	0.2 ± 0.6	0.8 ± 0.8
Spring 4A	−19 ± 84	0.4 ± 0.4	−0.008 ± 0.032	0.020 ± 0.040	0.9 ± 1.2	3.4 ± 1.4	0.2 ± 0.6	0.8 ± 0.8
Spring 5	6 ± 72	0.9 ± 0.8	0.004 ± 0.018	0.004 ± 0.022	0.0 ± 0.8	2.4 ± 1.2	0.0 ± 0.6	0.0 ± 0.8
Spring 5AA	38 ± 54	0.4 ± 0.8	−0.016 ± 0.026	−0.005 ± 0.032	−0.3 ± 0.8	4.1 ± 1.4	0.1 ± 0.6	0.0 ± 0.8
Ancho Spring	−14 ± 96	−0.2 ± 0.8	−0.033 ± 0.024	−0.005 ± 0.034	−0.1 ± 0.8	2.4 ± 1.2	0.3 ± 0.6	0.0 ± 0.8
No. of Analyses	9	9	9	9	9	9	9	9
Minimum	−19 ± 84	−0.2 ± 0.6	−0.033 ± 0.024	−0.030 ± 0.060	−0.3 ± 0.8	2.0 ± 1.2	−0.1 ± 0.6	0.0 ± 0.8
Maximum	62 ± 92	0.9 ± 0.8	0.010 ± 0.040	0.020 ± 0.040	1.1 ± 1.2	6.3 ± 1.8	0.3 ± 0.6	1.8 ± 0.8
Average	20	0.3	−0.008	−0.004	0.3	3.2	0.1	0.7
2s	60	0.8	0.034	0.034	1.0	2.8	0.3	1.2
Group II—Tesuque Fm. Coarse-Grained								
Spring 5A	7 ± 66	0.1 ± 0.4	0.013 ± 0.022	0.009 ± 0.022	1.5 ± 1.2	3.8 ± 1.4	0.1 ± 0.6	1.8 ± 0.8
Spring 6	−10 ± 102	0.0 ± 0.4	0.006 ± 0.028	−0.006 ± 0.032	−0.2 ± 0.8	2.4 ± 1.0	0.2 ± 0.6	0.0 ± 0.8
Spring 6A	−12 ± 98	−0.1 ± 0.6	0.005 ± 0.028	−0.005 ± 0.024	0.0 ± 0.8	3.6 ± 1.2	0.2 ± 0.6	0.0 ± 0.8
Spring 7	−12 ± 44	−1.9 ± 3.2	0.010 ± 0.040	0.010 ± 0.040	0.8 ± 1.0	4.8 ± 1.4	0.3 ± 0.6	1.3 ± 0.8
Spring 8	20 ± 18	−0.1 ± 0.4	−0.007 ± 0.036	−0.020 ± 0.040	1.0 ± 1.0	2.5 ± 1.2	0.0 ± 0.6	2.2 ± 0.8
Spring 8A	19 ± 36	−0.1 ± 0.8	−0.030 ± 0.060	−0.010 ± 0.040	0.6 ± 0.8	3.7 ± 1.2	0.0 ± 0.6	0.0 ± 0.8
Spring 9	−26 ± 44	−0.1 ± 0.8	−0.010 ± 0.032	−0.010 ± 0.036	0.4 ± 0.8	3.5 ± 1.2	−0.2 ± 0.6	0.8 ± 0.8
Spring 9A	74 ± 134	0.4 ± 0.8	0.004 ± 0.024	−0.009 ± 0.024	0.0 ± 0.8	5.4 ± 1.6	0.3 ± 0.6	0.0 ± 0.8
Spring 9B	31 ± 42	−0.3 ± 0.6	−0.020 ± 0.060	−0.020 ± 0.040	0.0 ± 0.8	26 ± 6.0	0.6 ± 0.6	0.0 ± 0.8
Doe Spring	−28 ± 32	0.2 ± 1.0	0.010 ± 0.040	−0.037 ± 0.038	0.0 ± 0.8	2.2 ± 1.0	0.6 ± 0.6	0.0 ± 0.8
Spring 10	56 ± 114	1.0 ± 1.2	−0.012 ± 0.024	0.004 ± 0.020	0.6 ± 1.0	2.3 ± 1.2	−0.1 ± 0.6	0.0 ± 0.8
No. of Analyses	11	11	11	11	11	11	11	11
Minimum	−28 ± 32	−1.9 ± 3.2	−0.030 ± 0.060	−0.037 ± 0.038	−0.2 ± 0.8	2.2 ± 1.0	−0.2 ± 0.6	0.0 ± 0.8
Maximum	74 ± 134	1.0 ± 1.2	0.013 ± 0.022	0.010 ± 0.040	1.5 ± 1.2	26 ± 6.0	0.6 ± 0.6	2.2 ± 0.8
Average	11	−0.1	−0.003	−0.009	0.4	5.5	0.2	0.6
2s	33	1.4	0.028	0.028	1.0	14	0.5	1.6

TABLE E-XV (Continued)

Station	Radiochemical							
	^{137}Cs (10^{-9} μCi/mℓ)	^{90}Sr (10^{-9} μCi/mℓ)	^{238}Pu (10^{-9} μCi/mℓ)	^{239}Pu (10^{-9} μCi/mℓ)	Gross Alpha (10^{-9} μCi/mℓ)	Gross Beta (10^{-9} μCi/mℓ)	^{3}H (10^{-6} μCi/mℓ)	Total U (μg/ℓ)
Group III—Tesuque Fm. Fine-Grained								
Spring 1	9 ± 116	0.3 ± 0.4	−0.030 ± 0.080	0.020 ± 0.060	0.8 ± 1.2	2.2 ± 1.2	0.3 ± 0.6	1.4 ± 0.8
Spring 2	−21 ± 52	0.9 ± 0.8	−0.008 ± 0.022	−0.008 ± 0.032	1.6 ± 1.6	4.7 ± 1.4	0.6 ± 0.6	2.5 ± 0.8
No. of Analyses	2	2	2	2	2	2	2	2
Minimum	−21 ± 52	0.3 ± 0.4	−0.008 ± 0.022	−0.008 ± 0.032	0.8 ± 1.2	2.2 ± 1.2	0.3 ± 0.6	1.4 ± 0.8
Maximum	9 ± 116	0.9 ± 0.8	−0.030 ± 0.080	0.020 ± 0.060	1.6 ± 1.6	4.7 ± 1.4	0.6 ± 0.6	2.5 ± 0.8
Average	−6	0.6	−0.019	0.006	1.2	3.4	0.4	1.9
2s	42	0.8	0.032	0.020	1.2	3.6	0.4	1.6
Group IV—Tesuque Fm. Fine-Grained Basalt Intrusion or Faults								
Ancha Spring	−12 ± 34	0.8 ± 1.0	−0.021 ± 0.032	−0.015 ± 0.024	8.0 ± 4.0	11 ± 3.0	−0.3 ± 0.6	14 ± 2.8
Spring 3B	36 ± 98	−0.3 ± 0.6	0.006 ± 0.030	0.006 ± 0.036	14 ± 6.0	8.2 ± 2.2	−0.2.+0.0.6	18 ± 3.8
Cañada Spring	−30 ± 60	0.5 ± 1.4	−0.007 ± 0.020	−0.200 ± 0.026	3.2 ± 2.4	5.1 ± 2.0	−0.3 ± 0.6	3.7 ± 0.8
No. of Analyses	3	3	3	3	3	3	3	3
Minimum	−30 ± 60	−0.3 ± 0.6	−0.021 ± 0.032	−0.200 ± 0.026	3.2 ± 2.4	5.1 ± 2.0	−0.3 ± 0.6	3.7 ± 0.8
Maximum	36 ± 98	0.8 ± 1.0	0.006 ± 0.030	0.006 ± 0.036	14 ± 6.0	11 ± 3.0	−0.2 ± 0.6	18 ± 3.8
Average	−2	0.3	−0.007	−0.070	8.4	8.1	−0.3	12
2s	68	1.2	0.028	0.226	11	6.0	0.1	15
Streams								
Mortandad[a]	−8 ± 120	−0.2 ± 0.6	−0.003 ± 0.040	−0.020 ± 040	1.5 ± 2.2	19 ± 4.0	0.4 ± 0.6	1.4 ± 0.8
Pajarito	20 ± 48	−0.6 ± 1.0	−0.018 ± 0.038	−0.020 ± 0.040	0.7 ± 1.4	3.9 ± 1.4	0.2 ± 0.6	0.6 ± 0.8
Ancho	54 ± 120	0.2 ± 0.8	0.009 ± 0.034	−0.010 ± 0.060	0.8 ± 1.0	2.5 ± 1.2	0.5 ± 0.6	0.7 ± 0.8
No. of Analyses	3	3	3	3	3	3	3	3
Minimum	−8 ± 120	−0.6 ± 1.0	−0.018 ± 0.038	−0.020 ± 0.040	0.7 ± 1.4	2.5 ± 1.2	0.4 ± 0.6	0.6 ± 0.8
Maximum	54 ± 120	0.2 ± 0.8	0.009 ± 0.034	−0.010 ± 0.060	1.5 ± 2.2	19 ± 4.0	0.5 ± 0.6	1.4 ± 0.8
Average	22	−0.2	−0.004	−0.017	1.0	8.5	0.4	0.9
2s	62	0.8	0.028	0.012	0.8	18	0.3	0.8

TABLE E-XV (Continued)

Station	Chemical (mg/l)														Cond (mS/m)
	SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	PO_4	SO_4	Cl	F	NO_3	TDS	Hard	
Group I—Totavi Lentil															
Sandia Spring	36	34	3	3	18	0	144	2	7	4	0.7	0.6	240	110	22
Spring 3	41	15	2	3	16	0	88	<1	<1	3	0.5	3.0	140	64	19
Spring 3A	41	15	2	3	15	0	92	1	<1	3	0.4	2.6	120	66	19
Spring 3AA	34	16	<1	3	19	0	96	<1	<1	3	0.5	0.4	180	52	18
Spring 4	41	15	4	3	14	0	96	<1	12	7	0.6	5.6	200	74	19
Spring 4A	51	12	4	2	13	0	96	<1	8	6	0.6	4.6	200	76	17
Spring 5	54	12	4	2	14	0	100	<1	<1	5	0.6	0.6	220	72	17
Spring 5AA	45	13	3	2	13	0	96	<1	9	5	0.6	3.5	200	70	16
Ancho Spring	64	6	2	2	11	0	72	<1	<1	2	0.4	2.1	180	46	14
No. of Analyses	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
Minimum	34	6	<1	2	11	---	72	<1	<1	2	0.4	0.4	120	46	14
Maximum	64	34	4	3	19	0	144	2	12	7	0.7	5.6	240	110	22
Average	45	15	2.8	2.5	15	---	98	<1.1	<4	4	0.5	2.6	187	70	18
2s	19	15	2.2	1.0	5	---	38	0.6	9	3	0.2	3.6	74	36	45
Group II—Tesuque Fm; Coarse-Grained															
Spring 5A	45	17	3	3	22	0	116	<1	12	5	0.6	3.8	220	74	17
Spring 6	64	6	2	2	11	0	76	<1	<1	2	0.4	2.1	120	42	14
Spring 6A	66	5	1	2	10	0	60	<1	<1	2	0.3	2.4	160	44	13
Spring 7	64	9	3	2	18	0	88	<1	8	3	0.5	2.2	200	58	14
Spring 8	64	12	3	3	23	0	116	<1	11	3	0.5	2.5	200	66	14
Spring 8A	71	4	1	2	12	0	72	<1	<1	2	0.2	0.9	160	40	11
Spring 9	66	5	2	2	11	0	72	<1	<1	2	0.2	2.0	220	38	11
Spring 9A	62	4	2	1	11	0	72	<1	<1	2	0.3	1.6	160	38	11
Spring 9B	60	5	2	1	11	0	64	<1	<1	2	0.4	2.4	160	40	11
Doe Spring	66	6	2	2	13	0	76	<1	<1	3	0.5	0.7	160	46	12
Spring 10	58	6	2	2	13	0	76	<1	<1	3	0.4	3.2	160	44	11
No. of Analyses	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
Minimum	45	4	1	1	10	---	60	---	<1	2	0.2	0.7	120	38	11
Maximum	71	17	3	3	23	0	116	0	12	5	0.6	3.8	220	74	17
Average	62	7	2.1	2.0	14	---	81	---	<4	3	0.4	2.2	175	48	13
2s	134	8	1.4	1.2	10	---	38	---	9	2	0.2	1.8	62	24	4

TABLE E-XV (Continued)

Station	Chemical (mg/l)														Cond (mS/m)
	SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	PO_4	SO_4	Cl	F	NO_3	TDS	Hard	
Group III—Tesuque Fm. Fine-Grained															
Spring 1	23	18	1	2	32	0	116	2	8	4	0.6	1.5	240	66	22
Spring 2	28	19	1	2	61	0	200	1	12	5	1.2	0.5	380	68	25
No. of Analyses	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Minimum	23	18	---	---	32	---	116	1	8	4	0.6	0.5	240	66	22
Maximum	28	19	1	2	61	0	200	2	12	5	1.2	1.5	380	68	25
Average	26	18	—	---	46	---	158	1.5	10	4	0.9	1.0	310	67	24
2s	8	1	---	—	42	—	108	1.4	6	1	0.8	1.4	198	3	4
Group IV—Tesuque Fm. Fine-Grained Basalt Intrusions or Faults															
Ancha Spring	16	66	23	6	49	0	144	<1	213	5	0.3	12	508	214	47
Spring 3B	39	20	2	5	143	0	348	<1	18	4	1.6	10	540	72	21
Cañada	28	81	5	2	10	0	176	<1	11	3	0.3	32	298	178	35
No. of Analyses	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Minimum	16	20	2	2	10	—	144	---	11	3	0.3	10	298	72	21
Maximum	39	81	23	6	143	0	348	<1	213	5	1.6	32	540	214	47
Average	28	56	10	4	67	—	223	---	81	4	0.7	18	449	155	34
2s	24	64	22	4	138	---	220	—	230	2	1.6	12	262	148	26
Streams															
Mortandad[a]	5	11	4	8	45	0	180	48	39	49	1.3	11	540	110	24
Pajarito	58	12	4	2	14	0	124	<1	<1	6	0.6	3.1	80	74	14
Ancho	64	5	2	2	11	0	72	<1	<1	3	0.4	0.6	200	42	11
No. of Analyses	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Minimum	5	5	2	2	11	---	72	<1	<1	3	0.4	0.6	8.0	42	11
Maximum	64	12	4	8	45	0	180	48	39	49	1.3	11	540	110	24
Average	42	9	3	4	23	---	125	<17	<14	19	0.8	4.9	273	75	16
2s	64	8	2	6	38	---	108	54	44	52	1.0	11	478	68	14

[a]Sanitary effluent released from the County treatment plant at White Rock.

Note: The ± value represents twice the standard deviation of the distribution of observed values unless only one analysis is reported, then the value represents twice the uncertainty term for the analysis.

TABLE E-XVI

RADIOCHEMICAL AND CHEMICAL QUALITY OF SURFACE AND GROUND WATER FROM ONSITE STATIONS

Station	No. of Analyses	Radiochemical (average of a number of analyses) ^{137}Cs (10^{-9} µCi/mℓ)	^{241}Am (10^{-9} µCi/mℓ)	^{90}Sr (10^{-9} µCi/mℓ)	^{238}Pu (10^{-9} µCi/mℓ)	^{239}Pu (10^{-9} µCi/mℓ)	Gross Alpha (10^{-9} µCi/mℓ)	Gross Beta (10^{-9} µCi/mℓ)	^{3}H (10^{-6} µCi/mℓ)	Total U (µg/ℓ)
Test Well 1	1	−29 ± 28	0.04 ± 0.12	0.7 ± 1.0	0.030 ± 0.040	−0.029 ± 0.038	−0.6 ± 1.8	3.9 ± 1.8	0.9 ± 0.6	0.0 ± 0.4
Test Well 3	2	51 ± 3	−0.20 ± 0.40	0.1 ± 0.5	−0.003 ± 0.022	−0.014 ± 0.006	0.5 ± 1.6	3.8 ± 2.3	0.3 ± 0.8	0.8 ± 0.3
DT-5A	2	2 ± 150	−0.10 ± 1.8	0.6 ± 0.6	0.008 ± 0.020	0.010 ± 0.016	0.9 ± 2.4	1.1 ± 1.0	0.3 ± 0.8	0.0 ± 0.0
Test Well 8	2	−14 ± 70	−0.01 ± 0.10	0.8 ± 0.8	0.001 ± 0.018	−0.004 ± 0.018	3.2 ± 8.4	4.7 ± 5.0	0.7 ± 0.0	0.0 ± 0.0
DT-9	1	−30 ± 60	0.00 ± 0.12	0.0 ± 0.6	0.002 ± 0.020	0.017 ± 0.032	1.8 ± 1.8	2.5 ± 1.6	1.0 ± 0.6	0.0 ± 0.8
DT-10	1	50 ± 80	0.09 ± 0.12	0.5 ± 1.0	0.019 ± 0.032	0.012 ± 0.024	0.0 ± 1.4	1.2 ± 1.6	0.3 ± 0.6	0.0 ± 0.8
Cañada del Buey	2	24 ± 10	0.14 ± 0.10	0.6 ± 0.8	−0.024 ± 0.074	−0.008 ± 0.064	1.8 ± 5.0	5.7 ± 6.8	0.6 ± 1.6	0.6 ± 1.7
Pajarito	1	20 ± 80	0.01 ± 0.08	1.1 ± 1.0	0.006 ± 0.032	0.016 ± 0.026	−0.1 ± 1.4	3.4 ± 1.8	1.8 ± 0.6	0.0 ± 0.8
Water at Beta	1	−20 ± 40	0.09 ± 0.18	1.3 ± 0.8	−0.011 ± 0.032	0.019 ± 0.038	1.6 ± 1.4	4.5 ± 1.8	0.6 ± 0.6	0.0 ± 0.8
Test Well 2	2	−95 ± 296	−0.03 ± 0.18	1.2 ± 0.6	−0.012 ± 0.050	0.007 ± 0.010	0.3 ± 0.6	4.9 ± 8.2	−0.2 ± 1.0	0.0 + 0.0
No. of Analyses		15	10	10	15	15	15	15	15	15
Minimum		200 ± 30	−0.20 ± 0.40	0.0 ± 0.6	−0.050 ± 0.080	−0.030 ± 0.060	−0.6 ± 1.8	0.8 ± 1.4	−1.0 ± 0.6	0.0 ± 0.8
Maximum		54 ± 82	0.14 ± 0.10	1.3 ± 0.8	0.030 ± 0.040	0.019 ± 0.038	6.2 ± 2.8	8.1 ± 2.0	1.8 ± 0.6	1.2 ± 0.8
Average		−5	0.00	0.7	−0.001	0.001	1.2	3.7	0.5	0.2
2s		129	0.20	0.8	0.038	0.034	3.4	4.6	1.2	0.8

Station	Chemical (concentrations in mg/ℓ, one analysis) SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	SO_4	Cl	F	NO_3	TDS	Hard	pH	Cond (mS/m)
Test Well 1	---	35	1.8	4.0	21	0	132	2	12	0.4	0.2	156	90	8.3	21
Test Well 3	100	14	5.1	2.5	12	0	92	3	3	0.4	2.9	186	62	8.5	18
DT−5A	76	8	2.4	1.9	11	0	64	1	1	0.3	1.5	148	28	8.3	20
Test Well 8	---	8	1.9	2.0	11	0	60	1	2	0.2	0.2	62	26	9.4	35
DT−9	70	8	2.7	1.4	10	0	64	1	1	0.3	1.5	156	30	8.2	8
DT−10	86	10	3.0	1.6	11	0	72	2	2	0.3	0.2	62	36	8.2	10
Cañada del Buey	34	7	1.7	2.3	12	0	48	3	3	0.8	0.2	136	24	7.5	8
Pajarito	22	18	5.6	4.1	16	0	68	18	19	0.2	0.8	152	66	8.1	18
Water at Beta	34	10	3.2	3.3	15	0	60	12	6	0.3	0.7	146	36	8.1	15
Test Well 2	61	14	3.0	4.0	9	0	58	19	3	0.5	0.3	188	50	6.9	14
No. of Analyses	8	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Minimum	22	7	1.7	1.4	9	—	48	1	1	0.2	0.2	62	24	6.9	8
Maximum	100	35	5.6	4.1	21	0	132	19	19	0.8	2.9	188	90	9.4	21
Average	60	13	3.0	2.7	13	---	72	6	5	0.4	0.8	139	45	8.2	17
2s	56	16	2.6	2.2	8	---	48	14	12	0.4	1.8	88	44	1.2	16

Note: The ± value represents twice the standard deviation of the distribution of observed values unless only one analysis is reported, then the value represents twice the uncertainty term for that analysis.

TABLE E-XVII

RADIOCHEMICAL AND CHEMICAL QUALITY OF SURFACE AND GROUND WATER
FROM ACID PUEBLO CANYON, FORMER EFFLUENT RELEASE AREAS

Radiochemical
(average of a number of analyses)

Station	No. of Analyses	^{137}Cs (10^{-9} µCi/mℓ)	^{241}Am (10^{-9} µCi/mℓ)	^{90}Sr (10^{-9} µCi/mℓ)	^{238}Pu (10^{-9} µCi/mℓ)	^{239}Pu (10^{-9} µCi/mℓ)	Gross Alpha (10^{-9} µCi/mℓ)	Gross Beta (10^{-9} µCi/mℓ)	^{3}H (10^{-6} µCi/mℓ)	Total U (µg/ℓ)
Acid Weir	2	−24 ± 46	0.22 ± 0.10	61 ± 6.0	0.014 ± 0.058	1.18 ± 3.10	6.8 ± 9.2	171 ± 252	3.7 ± 7.6	1.6 ± 1.3
Pueblo 1	2	28 ± 36	0.04 ± 0.10	5.1 ± 0.8	0.010 ± 0.012	−0.001 ± 0.022	1.8 ± 6.6	19 ± 32	0.8 ± 0.7	0.4 ± 1.0
Pueblo 2	2	6 ± 100	−0.22 ± 0.26	−0.9 ± 1.0	0.013 ± 0.006	1.29 ± 3.64	4.4 ± 10	38 ± 42	0.4 ± 0.3	0.0 ± 0.0
Pueblo 3	2	2 ± 32	0.12 ± 0.16	0.8 ± 1.2	−0.014 ± 0.052	0.136 ± 0.408	37 ± 46	60 ± 108	0.5 ± 0.4	6.0 ± 8.5
Hamilton Bend Spring	1	0 ± 80	0.11 ± 0.12	1.3 ± 0.6	0.007 ± 0.036	0.014 ± 0.036	5.8 ± 3.0	14 ± 3.2	1.0 ± 0.6	3.4 ± 0.8
TW-1A	2	−120 ± 84	0.00 ± 0.08	0.7 ± 0.8	−0.001 ± 0.032	−0.028 ± 0.092	1.9 ± 4.0	7.2 ± 1.0	0.6 ± 0.1	0.6 ± 1.8
TW-2A	2	−4 ± 44	0.23 ± 0.20	0.4 ± 0.8	−0.013 ± 0.014	−0.008 ± 0.004	0.2 ± 1.6	3.5 ± 0.8	17 ± 6.2	0.0 ± 0.0
No. of Analyses		13	7	7	13	13	13	13	13	13
Minimum		−150 ± 110	−0.22 ± 0.26	−0.9 ± 1.0	−0.032 ± 0.034	−0.060 ± 0.060	−0.5 ± 1.6	3.2 ± 1.2	0.2 ± 0.6	0.0 ± 0.4
Maximum		41 ± 20	0.23 ± 0.20	61 ± 6.0	0.034 ± 0.038	2.58 ± 0.260	69 ± 32	260 ± 60	19 ± 0.6	12 ± 2.4
Average		−17	0.07	9.8	0.002	0.398	8.4	47	3.6	1.6
2s		106	0.30	45	0.034	1.82	37	142	12	6.6

Chemical
(average of a number of analyses, concentrations in mg/ℓ)

Station	No. of Analyses	SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	PO_4	SO_4	Cl	F	NO_3	TDS	Hard	pH	Cond (mS/m)
Acid Weir	2	22	26	3.5	9.5	80	0	64	5.2	17	129	0.5	7.4	388	84	6.1	46
Pueblo 1	2	41	11	3.5	11.5	49	0	103	12	28	44	0.6	20	354	4.8	7.4	19
Pueblo 2	2	49	14	3.0	14	78	0	116	27	34	39	0.9	28	419	57	7.2	35
Pueblo 3	1	50	15	3.0	16	70	0	94	---	36	40	0.7	38	362	49	6.9	39
Hamilton Bend Spring	1	49	4	4.0	15	70	0	86	---	24	40	0.3	0.8	304	52	6.5	40
TW-1A	1	6	3	3.0	1.0	57	0	92	---	27	39	0.6	<0.4	212	49	7.4	33
TW-2A	1	6	2	2.0	4.0	18	0	30	---	12	29	0.4	7.0	68	37	8.7	16
No. of Analyses		10	10	10	10	10	10	10	3	10	10	10	10	10	10	7	10
Minimum		6	2	1.0	1.0	18	---	30	5.2	11	29	0.3	<0.4	68	34	6.1	15
Maximum		56	44	6.0	17	110	0	138	27	36	220	1.3	43	516	134	8.7	79
Average		33	13	3.2	11	70	---	87	15	26	58	0.6	17	327	58	7.2	36
2s		39	24	3.1	12	50	---	69	23	18	114	0.6	31	260	57	1.6	41

TABLE E-XVII (Continued)

Station	Other Chemical Constituents (concentrations in mg/ℓ, one analysis)									
	Zn	Pb	Hg	B	Cd	Cu	Cr	Li	COD	NH_3
Acid Weir	0.056	0.007	<0.0001	0.07	0.0006	0.053	0.033	0.025	34	<0.1
Pueblo 1	0.231	0.034	0.0003	0.31	0.0005	0.077	<0.005	0.066	54	13
Pueblo 2	0.113	0.005	0.0002	0.21	0.0004	0.047	<0.005	0.077	41	11
Pueblo 3	0.044	0.014	0.0002	0.18	0.0010	0.073	<0.005	0.029	34	1.9
Hamilton Bend Spring	0.130	0.005	<0.0001	0.29	0.0003	0.070	0.073	0.013	20	<0.1
TW-1A	0.704	0.592	<0.0001	0.25	0.0032	0.093	0.057	0.039	20	0.1
TW-2A	25	0.220	0.0013	<0.05	0.0021	<0.003	<0.005	0.029	17	<0.1
No. of Analyses	7	7	7	7	7	7	7	7	7	7
Minimum	0.044	0.005	<0.0001	<0.05	0.0004	<0.003	<0.005	0.013	17	<0.1
Maximum	25	0.592	0.0013	0.31	0.0032	0.093	0.073	0.077	54	13
Average	3.89	0.125	0.0003	0.19	0.0011	0.059	<0.026	0.040	31	<3.8
2s	19	0.440	0.0009	0.20	0.0022	0.058	0.058	0.046	27	12

Note: The ± value represents twice the standard deviation of the distribution of observed values unless only one analysis is reported, then the value represents twice the uncertainty term for that analysis.

TABLE E-XVIII

RADIOCHEMICAL AND CHEMICAL ANALYSES OF SURFACE WATER FROM SANDIA CANYON, ACTIVE EFFLUENT RELEASE AREAS

Radiochemical
(average of a number of analyses)

Station	No. of Analyses	^{137}Cs (10^{-9} μCi/mℓ)	^{241}Am (10^{-9} μCi/mℓ)	^{90}Sr (10^{-9} μCi/mℓ)	^{238}Pu (10^{-9} μCi/mℓ)	^{239}Pu (10^{-9} μCi/mℓ)	Gross Alpha (10^{-9} μCi/mℓ)	Gross Beta (10^{-9} μCi/mℓ)	^{3}H (10^{-6} μCi/mℓ)	Total U (μg/ℓ)
SCS-1	2	−66 ± 102	−0.15 ± 0.16	0.2 ± 0.8	−0.002 ± 0.022	0.004 ± 0.026	2.5 ± 8.0	24 ± 16	17 ± 18	0.8 ± 2.4
SCS-2	2	42 ± 4	---	1.3 ± 1.0	0.007 ± 0.008	0.008 ± 0.002	1.0 ± 8.2	26 ± 16	20 ± 2.2	0.8 ± 2.4
SCS-3	2	6 ± 17	0.00 ± 0.12	0.8 ± 1.0	0.012 ± 0.020	0.004 ± 0.024	2.5 ± 1.4	22 ± 13	19 ± 3.1	0.9 ± 0.8
No. of Analyses		6	2	3	6	6	6	6	6	6
Minimum		−102 ± 100	−0.15 ± 0.16	0.2 ± 0.8	−0.009 ± 0.024	−0.005 ± 0.018	−2.0 ± 8.0	17 ± 4.0	11 ± 1.0	0.0 ± 0.8
Maximum		43 ± 40	0.00 ± 0.12	1.3 ± 1.0	0.019 ± 0.030	0.013 ± 0.032	5.3 ± 3.8	31 ± 6.0	24 ± 1.2	1.7 ± 0.8
Average		−6	−0.08	0.8	0.006	0.005	2.0	24	19	0.9
2s		108	0.22	1.2	0.018	0.016	5.4	12	8.7	1.6

Chemical
(average of a number of analyses, concentrations in mg/ℓ)

Station	No. of Analyses	SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	PO_4	SO_4	Cl	F	NO_3	TDS	Hard	pH	Cond (mS/m)
SCS-1	2	96	15	4.5	13	93	0	76	4.6	80	80	1.3	16	550	65	7.5	44
SCS-2	2	69	28	6.0	16	151	0	133	8.2	146	128	1.5	12	767	104	8.4	62
SCS-3	2	72	28	5.5	17	172	0	130	9.4	154	128	1.7	8.6	766	106	8.2	63
No. of Analyses		6	6	6	6	6	6	6	3	6	6	6	6	6	6	3	6
Minimum		45	10	2.0	6.0	46	---	62	4.6	49	34	0.8	2.2	340	50	7.5	17
Maximum		147	43	8.0	20	200	0	154	9.4	168	182	2.2	25	934	138	8.4	101
Average		79	24	5.3	15	139	---	113	7.4	127	112	1.5	12	694	92	8.0	56
2s		73	27	4.6	119	60	---	66	5.0	88	110	1.1	20	421	66	0.9	72

Other Chemical Constituents
(concentrations in mg/ℓ, one analysis)

Station	Zn	Pb	Hg	B	Cd	Cu	Cr	Li	COD	NH_3
SCS-1	0.258	0.032	0.0002	0.60	0.0040	0.387	0.250	0.083	58	1.5
SCS-2	0.418	0.020	0.0017	0.23	0.0034	0.180	0.097	0.093	27	0.1
SCS-3	0.192	0.020	<0.0001	0.23	0.0021	0.130	0.067	0.061	27	0.1
No. of Analyses	3	3	3	3	3	3	3	3	3	3
Minimum	0.192	0.020	<0.0001	0.23	0.0021	0.130	0.067	0.061	27	0.1
Maximum	0.418	0.032	0.0017	0.60	0.0040	0.387	0.250	0.093	58	1.5
Average	0.289	0.024	0.0007	0.35	0.0032	0.232	0.138	0.079	37	0.6
2s	0.232	0.014	0.0018	0.43	0.0019	0.273	0.196	0.033	36	1.6

Note: The ± value represents twice the standard deviation of the distribution of observed values unless only one analysis is reported, then the value represents twice the uncertainty term for that analysis.

TABLE E-XIX

RADIOCHEMICAL AND CHEMICAL QUALITY OF SURFACE AND GROUND WATER
FROM DP—LOS ALAMOS CANYON, ACTIVE EFFLUENT RELEASE AREAS

Station	No. of Analyses	Radiochemical (average of a number of analyses) ^{137}Cs (10^{-9} μCi/mℓ)	^{241}Am (10^{-9} μCi/mℓ)	^{90}Sr (10^{-9} μCi/mℓ)	^{238}Pu (10^{-9} μCi/mℓ)	^{239}Pu (10^{-9} μCi/mℓ)	Gross Alpha (10^{-9} μCi/mℓ)	Gross Beta (10^{-9} μCi/mℓ)	^{3}H (10^{-6} μCi/mℓ)	Total U (μg/ℓ)
DPS-1	2	19 ± 60	4.7 ± 0.60	9.5 ± 1.0	0.40 ± 0.620	0.970 ± 1.84	269 ± 710	150 ± 340	4.1 ± 8.4	56 ± 20
DPS-4	2	22 ± 60	0.26 ± 0.12	137 ± 6.0	0.034 ± 0.016	0.215 ± 0.438	12 ± 7.0	232 ± 248	4.4 ± 6.9	3.2 ± 3.0
LAO-C	2	26 ± 46	0.19 ± 0.12	0.7 ± 0.8	−0.018 ± 0.036	−0.014 ± 0.002	1.2 ± 2.6	5.9 ± 2.0	1.4 ± 1.0	1.2 ± 1.8
LAO-1	2	26 ± 38	0.45 ± 0.20	53 ± 4.0	−0.002 ± 0.010	0.002 ± 0.006	4.6 ± 3.2	131 ± 62	19 ± 16	0.0 ± 0.0
LAO-2	2	−1 ± 84	0.00 ± 0.12	95 ± 4.0	0.029 ± 0.060	0.200 ± 0.424	12 ± 14	236 ± 240	3.6 ± 4.5	2.4 ± 3.6
LAO-3	2	−18 ± 3	0.05 ± 0.14	1.3 ± 0.6	0.017 ± 0.074	0.205 ± 0.184	8.5 ± 4.2	110 ± 57	3.4 ± 3.8	3.9 ± 3.4
LAO-4	2	−18 ± 6	---	3.6 ± 1.0	-0.008 ± 0.034	0.034 ± 0.010	1.2 ± 1.0	18 ± 0.0	1.9 ± 0.0	0.6 ± 1.6
LAO-4.5	2	42 ± 108	---	88 ± 4.0	0.001 ± 0.060	0.013 ± 0.000	1.6 ± 1.6	12 ± 15	2.8 ± 0.2	1.0 ± 1.0
No. of Analyses		16	6	8	16	16	16	16	16	16
Minimum		−30 ± 80	0.00 ± 0.12	0.7 ± 0.8	−0.030 ± 0.040	−0.014 ± 0.030	0.3 ± 1.2	5.2 ± 2.0	1.1 ± 0.6	0.0 ± 0.8
Maximum		83 ± 136	4.7 ± 0.60	137 ± 6.0	0.620 ± 0.120	1.61 ± 0.200	520 ± 220	320 ± 60	24 ± 1.2	63 ± 12
Average		9	0.94	48	0.057	0.203	39	112	5.0	8.4
2s		64	3.7	106	0.316	0.800	256	222	12	38

Station	No of Analyses	Chemical (average of a number of analyses, concentrations in mg/ℓ) SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	PO_4	SO_4	Cl	F	NO_3	TDS	Hard	pH	Cond (mS/m)
DPS–1	2	8	12	2	6	76	0	87	2.9	16	68	1.7	34	294	44	8.4	40
DPS–4	2	12	14	2	15	70	0	125	<0.1	12	53	5.0	33	424	44	7.0	31
LAO–C	2	23	12	4	6	50	0	91	2.4	14	38	1.9	8.1	285	48	6.7	25
LAO–1	2	23	13	3	5	54	0	109	2.3	16	25	1.9	11	225	48	6.6	25
LAO–2	2	18	14	2	13	80	0	102	2.4	14	60	3.8	30	357	48	6.7	40
LAO–3	2	22	16	3	18	71	0	124	<0.1	14	57	2.6	28	399	55	6.5	37
LAO–4	2	22	12	4	7	45	0	111	<0.1	12	18	2.3	7.5	261	46	6.5	23
LAO–4.5	2	22	11	3	6	41	0	94	2.4	20	16	2.0	4.6	363	40	6.9	20
No. of Analyses		16	16	16	16	16	16	16	8	16	16	16	16	16	16	8	16
Minimum		6	8	1	1	31	---	52	<0.1	9	13	0.4	0.4	180	28	6.5	16
Maximum		33	23	5	28	112	0	136	2.9	27	124	6.7	60	474	76	8.4	64
Average		19	13	3	10	61	---	105	1.6	15	42	2.6	20	326	47	6.9	30
2s		18	11	3	14	46	---	52	2.5	9	80	3.2	41	190	30	1.2	35

TABLE E-XIX (Continued)

Station	Other Chemical Constituents (concentrations in mg/ℓ), one analysis)									
	Zn	Pb	Hg	B	Cd	Cu	Cr	Li	COD	NH_3
DPS-1	0.091	0.076	<0.0001	0.06	0.0008	0.207	0.177	<0.002	58	0.2
DPS-4	0.065	0.090	<0.0001	0.11	0.0007	0.210	0.220	0.009	24	0.1
LAO-C	0.155	0.058	<0.0001	<0.05	0.0007	0.270	0.197	<0.002	17	0.1
LAO-1	0.191	0.011	0.0002	0.07	0.0007	0.313	0.027	0.015	14	<0.1
LAO-2	0.284	0.017	0.0012	0.07	0.0010	0.543	<0.005	0.018	24	0.1
LAO-3	0.083	0.025	<0.0001	0.08	0.0004	0.273	<0.005	0.022	24	0.7
LAO-4	0.068	0.012	<0.0001	<0.05	0.0002	0.247	0.010	0.002	14	0.1
LAO-4.5	0.368	0.065	0.0015	0.07	0.0041	3.88	0.190	<0.002	17	0.1
No. of Analyses	8	8	8	8	8	8	8	8	8	8
Minimum	0.065	0.011	<0.0001	<0.05	0.0002	0.207	<0.005	<0.002	14	<0.1
Maximum	0.368	0.090	0.0015	0.11	0.0041	3.88	0.220	0.022	58	0.7
Average	0.163	0.044	<0.0004	0.07	0.0011	0.743	0.104	<0.009	24	0.2
2s	0.223	0.063	0.0012	0.04	0.0025	2.54	0.199	0.017	29	0.4

Note: The ± value represents twice the standard deviation of the distribution of observed values unless only one analysis is reported, then the value represents twice the uncertainty term for that analysis.

TABLE E-XX

RADIOCHEMICAL AND CHEMICAL QUALITY OF SURFACE AND GROUND WATER
FROM MORTANDAD CANYON, ACTIVE EFFLUENT RELEASE AREA

Station	No. of Analyses	Radiochemical (average of a number of analyses) ^{137}Cs (10^{-9} µCi/mℓ)	^{241}Am (10^{-9} µCi/mℓ)	^{90}Sr (10^{-9} µCi/mℓ)	^{238}Pu (10^{-9} µCi/mℓ)	^{239}Pu (10^{-9} µCi/mℓ)	Gross Alpha (10^{-9} µCi/mℓ)	Gross Beta (10^{-9} µCi/mℓ)	^{3}H (10^{-6} µCi/mℓ)	Total U (µg/ℓ)
GS-1	2	75 ± 212	0.00.±0.10	30 ± 3.0	1.45 ± 3.80	4.26 ± 12.0	51 ± 138	149 ± 372	54 ± 36	0.6 ± 1.6
MCS-3.9	1	120 ± 60	62 ± 4.0	58 ± 3.6	5.60 ± 0.400	11.5 ± 0.800	140 ± 60	320 ± 60	48 ± 2	1.5 ± 0.8
MCO-3	2	56 ± 30	39 ± 6.0	22 ± 2.2	0.950 ± 2.98	3.74 ± 10.9	47 ± 120	121 ± 156	58 ± 8	0.8 ± 2.4
MCO-4	2	–12 ± 106	4.8 ± 0.60	36 ± 3.2	1.08 ± 2.78	0.540 ± 1.47	10 ± 16	60 ± 132	48 ± 0	4.4 ± 7.0
MCO-5	2	96 ± 18	---	3.4 ± 1.6	0.530 ± 0.420	0.270 ± 0.460	9 ± 0	51 ± 17	18 ± 1	2.4 ± 3.6
MCO-6	2	53 ± 76	0.97 ± 0.20	3.1 ± 1.0	0.176 ± 0.380	0.061 ± 0.082	16 ± 32	42 ± 80	33 ± 45	3.4 ± 2.8
MCO-7	2	11 ± 60	0.37 ± 0.20	2.2 ± 1.2	0.080 ± 0.170	0.063 ± 0.104	4.6 ± 9.4	16 ± 10	39 ± 21	1.0 ± 2.8
MCO-7.5	2	44 ± 16	2.0 ± 0.40	1.3 ± 1.0	0.490 ± 1.10	0.174 ± 0.328	15 ± 20	31 ± 42	78 ± 74	4.1 ± 6.6
No. of Analyses		15	7	8	15	15	15	15	15	15
Minimum		–50 ± 60	0.00 ± 0.10	1.1 ± 1.2	–0.110 ± 0.260	–0.110 ± 0.260	2.0 ± 1.8	11 ± 2.6	17 ± 1	0.0 ± 0.8
Maximum		163 ± 100	62 ± 4.0	58 ± 3.6	5.60 ± 0.400	11.5 ± 0.800	106 ± 40	320 ± 60	103 ± 3	6.8 ± 0.8
Average		55	16	20	1.01	1.98	30	84	47	2.3
2s		117	50	42	3.11	7.65	86	210	22	4.3

Station	No. of Analysis	Chemical (average of a number of analyses, concentrations in mg/ℓ) SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	PO_4	SO_4	Cl	F	NO_3	TDS	Hard	pH	Cond (mS/m)
GS-1	2	26	23	1.0	7.0	141	107	235	<0.1	49	17	1.9	73	515	32	11.1	79
MCS-3.9	1	22	13	<0.1	3.0	123	62	144	---	27	19	1.0	219	544	32	9.6	83
MCO-3	2	28	23	<0.1	6.5	132	93	220	<0.1	48	16	1.3	67	274	28	10.8	73
MCO-4	1	16	12	<0.1	1.0	140	0	138	---	31	22	1.6	271	646	32	8.0	94
MCO-5	2	19	16	2.0	3.5	188	0	181	3.5	40	26	1.1	219	841	36	7.0	60
MCO-6	2	20	16	4.0	4.0	140	0	153	3.0	38	25	1.1	116	681	60	7.1	39
MCO-7	2	22	16	4.0	3.0	149	0	142	<0.1	46	25	0.9	219	619	58	6.8	48
MCO-7.5	2	28	14	4.0	5.5	82	0	129	<0.1	30	24	0.4	102	459	58	7.1	54
No. of Analyses		14	14	14	14	14	14	14	6	14	14	14	14	14	14	8	14
Minimum		15	9	<0.1	1.0	43	0	86	<0.1	17	14	<0.1	23	280	26	6.8	20
Maximum		34	34	5.0	11	272	210	274	3.5	65	30	2.4	374	1160	68	11.1	124
Average		23	16	2.4	4.5	138	33	172	1.2	40	22	1.1	165	599	43	8.4	68
2s		11	16	3.1	6.5	121	142	111	3.3	28	10	1.3	213	464	30	3.6	68

TABLE E-XX (Continued)

Station	Other Chemical Constituents (concentrations in mg/ℓ, one analysis)									
	Zn	Pb	Hg	B	Cd	Cu	Cr	Li	COD	NH_3
GS–1	0.022	0.008	<0.0001	0.08	0.0002	0.033	<0.005	0.027	31	0.9
MCS–3.9	0.069	0.034	0.0002	0.08	0.0002	0.030	<0.005	0.021	27	0.4
MCO–3	0.023	0.234	<0.0001	0.08	<0.0001	0.017	<0.005	0.024	31	0.1
MCO–4	0.105	0.023	<0.0001	0.05	0.0014	0.047	<0.005	0.016	14	0.1
MCO–5	0.164	0.018	<0.0001	0.06	0.0012	0.130	0.010	0.033	17	0.1
MCO–6	0.350	0.150	0.0002	0.08	0.0006	0.053	0.103	0.039	20	0.1
MCO–7	0.501	0.103	<0.0001	<0.05	0.0011	0.300	<0.005	0.067	17	0.1
MCO–7.5	2.89	0.246	0.0009	0.07	0.0043	2.08	0.045	0.027	7	0.1
No. of Analyses	8	8	8	8	8	8	8	8	8	8
Minimum	0.022	0.008	<0.0001	<0.05	<0.0001	0.017	<0.005	0.016	7	0.1
Maximum	2.89	0.246	0.0009	0.08	0.0043	2.08	0.103	0.067	31	0.9
Average	0.516	0.102	0.0002	0.07	0.0011	0.336	<0.023	0.032	20	0.2
2s	1.95	0.196	0.0006	0.03	0.0028	1.42	0.070	0.032	17	0.6

Note: The ± value represents twice the standard deviation of the distribution of observed values unless only one analysis is reported, then the value represents twice the uncertainty term for that analysis.

TABLE E-XXI

RADIOCHEMICAL AND CHEMICAL QUALITY OF WATER FROM MUNICIPAL SUPPLY AND DISTRIBUTION

Location	Radiochemical							
	^{137}Cs (10^{-9} μCi/mℓ)	^{90}Sr (10^{-9} μCi/mℓ)	^{238}Pu (10^{-9} μCi/mℓ)	^{239}Pu (10^{-9} μCi/mℓ)	Gross Alpha (10^{-9} μCi/mℓ)	Gross Beta (10^{-9} μCi/mℓ)	^{3}H (10^{-6} μCi/mℓ)	Total U (μg/ℓ)
Los Alamos Well Field								
Well LA-1B	50 ± 80	0.4 ± 0.6	0.001 ± 0.026	0.125 ± 0.060	10 ± 6.0	4.4 ± 2.2	−0.2 ± 0.6	6.4 ± 0.8
Well LA-2	−70 ± 100	0.1 ± 0.6	−0.013 ± 0.020	0.010 ± 0.026	2.1 ± 2.0	5.4 ± 2.0	−0.1 ± 0.6	4.8 ± 0.8
Well LA-3	−19 ± 30	0.7 ± 0.6	−0.006 ± 0.032	0.018 ± 0.026	1.5 ± 1.6	3.1 ± 1.6	−0.2 ± 0.6	2.9 ± 0.8
Well LA-4	20 ± 60	−0.2 ± 0.8	−0.007 ± 0.022	0.003 ± 0.026	0.4 ± 1.2	2.7 ± 1.6	0.1 ± 0.6	0.8 ± 0.8
Well LA-5	0 ± 60	0.1 ± 1.0	0.001 ± 0.018	0.015 ± 0.026	1.7 ± 1.8	2.1 ± 1.6	0.4 ± 0.6	7.5 ± 0.8
Guaje Well Field								
Well G-1	20 ± 40	1.1 ± 0.8	0.001 ± 0.026	0.018 ± 0.028	0.8 ± 1.4	4.4 ± 1.8	0.0 ± 0.6	0.6 ± 0.8
Well G-1A	−10 ± 40	0.6 ± 0.6	0.002 ± 0.032	0.012 ± 0.026	0.7 ± 1.4	4.4 ± 1.8	0.1 ± 0.6	0.6 ± 0.8
Well G-2	10 ± 40	0.4 ± 1.0	0.002 ± 0.036	0.030 ± 0.040	0.5 ± 1.4	5.5 ± 2.0	0.3 ± 0.6	1.1 ± 0.8
Well G-3	40 ± 80	−0.8 ± 0.8	−0.010 ± 0.020	0.017 ± 0.024	1.1 ± 1.4	2.1 ± 1.6	0.5 ± 0.6	0.7 ± 0.8
Well G-4	−70 ± 80	0.2 ± 0.8	0.013 ± 0.034	−0.005 ± 0.020	1.4 ± 1.4	1.0 ± 1.4	0.4 ± 0.6	1.0 ± 0.8
Well G-5	−20 ± 34	−0.4 ± 0.8	−0.011 ± 0.026	−0.014 ± 0.030	0.3 ± 1.2	2.3 ± 1.6	0.3 ± 0.6	0.8 ± 0.8
Well G-6	50 ± 80	0.7 ± 0.6	0.004 ± 0.028	0.011 ± 0.034	2.0 ± 1.6	3.2 ± 1.6	−0.8 ± 0.6	0.0 ± 0.8
Pajarito Well Field								
PM-1	50 ± 60	0.1 ± 0.6	−0.010 ± 0.040	−0.011 ± 0.030	2.4 ± 2.0	5.6 ± 2.0	0.5 ± 0.6	2.3 ± 0.8
PM-2	10 ± 80	0.2 ± 0.6	−0.008 ± 0.026	0.020 ± 0.040	0.5 ± 1.2	1.2 ± 1.4	0.4 ± 0.6	0.0 ± 0.8
PM-3	10 ± 30	0.0 ± 0.8	−0.013 ± 0.026	−0.060 ± 0.060	1.4 ± 1.8	4.9 ± 1.8	0.4 ± 0.6	1.2 ± 0.8
Water Canyon								
Gallery	40 ± 100	0.3 ± 1.0	−0.008 ± 0.030	0.004 ± 0.032	1.9 ± 1.6	2.1 ± 1.4	0.9 ± 0.6	0.0 ± 0.8
No. of Analyses	16	16	16	16	16	16	16	16
Minimum	−70 ± 100	−0.8 ± 0.8	−0.013 ± 0.020	−0.060 ± 0.060	0.4 ± 1.2	1.0 ± 1.4	−0.8 ± 0.6	0.0 ± 0.8
Maximum	50 ± 80	1.1 ± 0.8	0.013 ± 0.034	0.125 ± 0.060	10 ± 6.0	5.6 ± 2.0	0.9 ± 0.6	6.4 ± 0.8
Average	7	0.2	−0.004	0.012	1.8	3.4	0.2	2.4
2s	76	0.9	0.015	0.073	4.5	3.1	0.8	4.8
Distribution								
Fire Station 1	−20 ± 80	0.6 ± 0.8	−0.025 ± 0.034	0.040 ± 0.080	0.8 ± 1.0	1.4 ± 1.2	0.1 ± 0.6	0.0 ± 0.8
Fire Station 2	14 ± 34	−1.0 ± 0.8	0.007 ± 0.022	0.040 ± 0.040	1.6 ± 1.4	2.6 ± 1.4	−0.1 ± 0.6	3.2 ± 0.8
Fire Station 3	20 ± 60	0.0 ± 0.8	−0.029 ± 0.028	0.008 ± 0.030	0.0 ± 1.2	3.4 ± 1.4	0.1 ± 0.6	1.6 ± 0.8
Fire Station 4	30 ± 40	1.2 ± 1.2	0.002 ± 0.016	0.016 ± 0.030	0.2 ± 1.0	2.6 ± 1.4	−0.4 ± 0.6	0.7 ± 0.8
Fire Station 5	10 ± 40	1.0 ± 0.6	−0.008 ± 0.026	0.004 ± 0.036	0.4 ± 1.6	−0.7 ± 1.4	−0.1 ± 0.6	1.4 ± 0.8
Bandelier, NM	60 ± 80	0.3 ± 0.8	−0.019 ± 0.026	0.060 ± 0.040	1.7 ± 1.6	1.3 ± 1.6	0.3 ± 0.6	0.6 ± 0.8
Fenton Hill (TA-57)	30 ± 80	0.3 ± 1.0	−0.007 ± 0.024	−0.019 ± 0.032	2.0 ± 2.2	3.2 ± 1.8	—	—

TABLE E-XXI (Continued)

Location	Radiochemical							
	^{137}Cs (10^{-9} μCi/mℓ)	^{90}Sr (10^{-9} μCi/mℓ)	^{238}Pu (10^{-9} μCi/mℓ)	^{239}Pu (10^{-9} μCi/mℓ)	Gross Alpha (10^{-9} μCi/mℓ)	Gross Beta (10^{-9} μCi/mℓ)	^{3}H (10^{-6} μCi/mℓ)	Total U (μg/ℓ)
No. of Analyses	7	7	7	7	7	7	6	6
Minimum	−20 ± 80	−1.0 ± 0.8	−0.029 ± 0.028	−0.019 ± 0.032	0.0 ± 1.2	−0.7 ± 1.4	−0.4 ± 0.6	0.0 ± 0.8
Maximum	60 ± 80	1.2 ± 1.2	0.007 ± 0.022	0.060 ± 0.040	2.0 ± 2.2	3.4 ± 1.4	0.3 ± 0.6	3.2 ± 0.8
Average	20	0.4	−0.011	0.021	1.0	2.0	0.0	1.3
2s	48	1.6	0.027	0.054	1.6	2.9	0.5	2.2
Los Alamos Well LA-6[a]	−10 ± 20	0.1 ± 0.6	0.010 ± 0.028	0.007 ± 0.022	4.1 ± 3.0	3.7 ± 1.8	−0.1 ± 0.6	4.3 ± 0.8

Location	Chemical Quality of Water Required for Municipal Use (concentrations in mg/ℓ, one analysis)									
	Ag	As	Ba	Cd	Cr	F	Hg	NO_3	Pb	Se
Los Alamos Well Field										
Well LA-1B	0.0004	0.045	0.071	<0.0001	0.023	2.5	<0.00005	2.3	<0.002	<0.005
Well LA-2	<0.0003	0.007	0.130	<0.0001	0.017	1.2	<0.00005	2.5	<0.002	<0.005
Well LA-3	<0.0003	0.003	0.075	<0.0001	0.007	0.5	<0.00005	2.4	<0.002	<0.005
Well LA-4	<0.0003	0.003	0.029	<0.0001	0.004	0.4	<0.00005	2.0	0.005	<0.005
Well LA-5	<0.0003	0.034	0.079	<0.0001	0.017	0.9	<0.00005	2.3	<0.002	<0.005
Guaje Well Field										
Well G-1	<0.0003	0.003	0.081	<0.0001	0.004	0.5	<0.00005	2.1	0.005	<0.005
Well G-1A	<0.0003	0.003	0.065	<0.0001	0.003	0.5	<0.00005	2.1	<0.002	<0.005
Well G-2	<0.0003	0.045	0.083	<0.0001	0.009	0.8	<0.00005	1.9	<0.002	<0.005
Well G-3	<0.0003	0.003	0.019	0.0001	0.005	0.3	<0.00005	2.5	<0.002	<0.005
Well G-4	<0.0003	0.003	0.019	0.0001	0.002	0.2	<0.00005	2.7	<0.002	<0.005
Well G-5	<0.0003	0.003	0.025	0.0001	0.003	0.2	<0.00005	2.9	<0.002	<0.005
Well G-6	<0.0003	0.002	0.031	<0.0001	0.003	0.2	<0.00005	1.8	<0.002	<0.005
Pajarito Well Field										
PM-1	<0.0003	0.002	0.103	0.0001	0.004	0.2	<0.00005	2.6	<0.002	<0.005
PM-2	<0.0003	0.002	0.038	0.0002	0.004	0.2	<0.00005	1.7	0.005	<0.005
PM-3	<0.0003	0.002	0.063	0.0002	0.005	0.2	<0.00005	2.2	<0.002	<0.005
Water Canyon										
Gallery	<0.0003	0.002	0.017	0.0002	<0.002	<0.1	<0.00005	0.9	<0.002	<0.005
No. of Analyses	16	16	16	16	16	16	16	16	16	16
Minimum	<0.0003	0.002	0.017	<0.0001	<0.002	<0.1	---	0.9	<0.002	---
Maximum	0.0004	0.045	0.103	0.0002	0.023	2.5	<0.00005	2.9	0.005	<0.005
Average	<0.0003	0.010	0.058	<0.0001	0.007	0.6	---	2.2	<0.003	---
2s	0.0001	0.031	0.068	0.0001	0.013	1.2	---	1.0	0.002	---

TABLE E-XXI (Continued)

Chemical Quality of Water Required for Municipal Use
(concentrations in mg/ℓ, one analysis)

Location	Ag	As	Ba	Cd	Cr	F	Hg	NO_3	Pb	Se
Distribution										
Fire Station 1	<0.0003	<0.002	0.049	0.0001	0.004	0.3	<0.00005	1.5	<0.002	<0.005
Fire Station 2	<0.0003	0.007	0.053	<0.0001	0.007	0.6	<0.00005	2.1	<0.002	<0.005
Fire Station 3	<0.0003	0.003	0.096	<0.0001	0.003	0.7	<0.00005	2.1	<0.002	<0.005
Fire Station 4	<0.0003	0.012	0.057	<0.0001	0.006	0.5	<0.00005	2.3	<0.002	<0.005
Fire Station 5	<0.0003	0.003	0.033	<0.0001	0.002	0.3	<0.00005	1.6	<0.002	<0.005
Bandelier, NM	<0.0003	0.004	0.034	0.0007	0.004	0.4	<0.00005	1.8	<0.002	<0.005
Fenton Hill (TA-57)	<0.0003	0.002	0.086	0.0003	<0.002	0.1	<0.00005	1.3	0.003	<0.005
No. of Analyses	7	7	7	7	7	7	7	7	7	7
Minimum	---	<0.002	0.033	<0.0001	<0.002	0.1	---	1.3	<0.002	---
Maximum	<0.0003	0.012	0.096	0.0007	0.007	0.7	<0.00005	2.3	0.003	<0.005
Average	---	0.005	0.058	<0.0002	0.004	0.4	---	1.8	0.002	---
2s	---	0.007	0.048	0.0005	0.004	0.4	---	0.7	0.001	---
USEPA and NMEID MCL	0.05	0.05	1.0	0.01	0.05	2.0	0.002	45	0.05	0.01
Los Alamos Well LA-6[a]	<0.0003	0.025	0.089	<0.0001	0.017	1.6	<0.00005	2.3	<0.002	<0.005

Chemical Quality of Water from Municipal Well and Distribution
(concentrations in mg/ℓ, one analysis)

Location	SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	SO_4	Cl	TDS	Hard	pH	Cond (mS/m)
Los Alamos Well Field													
Well LA-1B	40	7	0.4	3.0	25	0	320	37	15	514	16	8.4	33
Well LA-2	26	7	0.2	1.6	50	0	136	13	11	130	16	8.5	27
Well LA-3	24	11	0.2	1.9	30	0	96	7	3	112	28	8.4	55
Well LA-4	30	10	0.2	2.2	20	0	80	3	2	70	24	8.5	20
Well LA-5	36	7	0.2	1.8	50	0	140	5	2	198	20	8.7	20
Guaje Well Field													
Well G-1	86	10	0.5	3.3	23	0	84	4	2	172	34	8.3	13
Well G-1A	78	9	0.5	3.3	26	0	124	4	2	134	30	8.4	20
Well G-2	78	9	0.6	3.1	36	0	116	4	2	222	24	8.5	20
Well G-3	54	12	1.5	2.3	18	0	84	4	2	144	36	8.3	30
Well G-4	52	14	2.5	2.1	14	0	96	3	2	150	48	8.2	16
Well G-5	64	15	3.7	2.1	11	0	88	4	3	162	54	8.2	13
Well G-6	70	16	3.6	2.6	12	0	88	3	2	190	54	7.9	20
Pajarito Well Field													
PM-1	84	20	5.9	3.6	19	0	136	5	6	236	84	8.2	17
PM-2	100	8	3.2	2.4	11	0	64	2	2	172	38	7.9	12
PM-3	98	18	7.1	3.6	18	0	136	5	6	248	92	8.1	20
Water Canyon													
Gallery	36	6	2.7	1.7	5	0	44	2	1	104	24	8.1	7

TABLE E XXI (Continued)

Chemical Quality of Water from Municipal Well and Distribution
(concentrations in mg/ℓ, one analysis)

Location	SiO_2	Ca	Mg	K	Na	CO_3	HCO_3	SO_4	Cl	TDS	Hard	pH	Cond (mS/m)
No. of Analyses	16	16	16	16	16	16	16	16	16	16	16	16	16
Minimum	24	6	0.2	1.6	5	---	44	2	1	70	16	7.9	7
Maximum	100	20	5.9	3.6	50	0	320	37	15	514	92	8.5	55
Average	60	11	2.1	2.5	23	---	114	7	4	185	39	8.3	21
2s	52	8	4.3	1.4	26	---	123	17	8	201	45	0.4	22
Distribution													
Fire Station 1	102	9	3.1	2.2	10	0	60	2	2	124	40	8.2	12
Fire Station 2	42	9	0.4	2.1	33	0	100	5	3	172	20	8.4	17
Fire Station 3	96	20	7.3	3.9	19	0	124	5	7	200	86	8.4	20
Fire Station 4	74	11	1.7	2.5	22	0	88	4	3	172	36	8.5	17
Fire Station 5	44	8	2.4	2.0	14	0	60	3	2	86	24	8.3	9
Bandelier, NM	44	9	2.0	2.2	21	0	80	4	3	94	32	8.4	12
Fenton Hill (TA-57)	68	31	4.0	4.4	12	0	124	7	15	236	106	8.4	17
No. of Analyses	7	7	7	7	7	7	7	7	7	7	7	7	7
Minimum	44	8	0.4	2.0	10	---	60	2	2	86	20	8.2	9
Maximum	102	31	7.3	4.4	33	0	124	7	15	236	106	8.5	20
Average	67	14	3.0	2.8	19	---	91	4	5	155	49	8.4	15
2s	50	17	4.4	2.0	16	---	54	3	9	111	66	0.2	8

[a]Los Alamos Well LA-6 on stand by; not used (see LA-7012-MS).

Note: ± value represents twice the standard deviation of the distribution of observed values unless only one analysis is reported, then the value represents twice the uncertainty term for that analysis.

TABLE E-XXII

LOCATIONS OF SOIL AND SEDIMENT STATIONS

Station	Latitude or N-S Coordinate	Longitude or E-W Coordinate	Map Designation (Figure 14)[a]
Regional Soils[b]			
Regional Sediments			
Rio Chama			
Chamita	36°05'	106°07'	---
Rio Grande			
Embudo	36°12'	105°58'	---
Otowi	N085	E550	A
Sandia	S060	E490	B
Pajarito	S185	E410	C
Ancho	S305	E335	D
Frijoles	S375	E235	E
Bernalillo	35°17'	106°36'	---
Jemez River	35°40'	106°44'	---
Perimeter Soils			
Sportsman's Club	N240	E215	S1
TA-8	N060	W075	S2
TA-49	S165	E085	S3
Frijoles	S245	E180	S4
North Mesa	N135	E165	S5
East of Airport	N095	E220	S6
West of Airport	N115	E135	S7
South SR-4 near S-Site	S085	W035	S8
Perimeter Sediments			
Guaje near G-4	N215	E325	1
Guaje at SR-4	N135	E480	2
Bayo at SR-4	N100	E455	3
Pueblo at Acid Weir	N125	E070	4
Pueblo at PC-1	N130	E070	5
Pueblo at Pueblo 1	N130	E085	6
Pueblo at Pueblo 2	N120	E145	7
Los Alamos at Reservoir	N100	W065	8
Los Alamos at Totavi	N065	E405	9
Los Alamos at LA-2	N125	E510	10
Los Alamos at Rio Grande	N095	E555	11
Sandia at Rio Grande	S055	E490	12
Canada del Ancha	S060	E505	13
Mortandad at SR-4	S030	E350	14
Mortandad at Rio Grande	S075	E480	15
Canada del Buey at SR-4	S090	E360	16
Pajarito at Rio Grande	S175	E410	17
Frijoles at Park Hdq	S280	E185	18
Frijoles at Rio Grande	S365	E235	19

TABLE E-XXII (Continued)

Station	Latitude or N-S Coordinate	Longitude or E-W Coordinate	Map Designation (Figure 14)[a]
Onsite Soils			
TA-21	N095	E140	S9
TA-50	N035	E095	S10
TA-36	S090	E150	S11
PM-1	N020	E310	S12
West of TA-53	N070	E105	S13
East of TA-53	N050	E220	S14
East of New Sigma	N060	E065	S15
Sigma Mesa	N050	E135	S16
East of TA-52	N020	E145	S17
2-Mile Mesa	N025	E030	S18
Near TA-51	S030	E200	S19
East of TA-54	S080	E295	S20
R-Site Road	S015	E030	S21
R-Site Road East	S040	E100	S22
Potrillo Drive	S065	E195	S23
S-Site	S035	W025	S24
Near TA-11	S070	E020	S25
Near DT-9	S150	E140	S26
TA-33	S245	E225	S27
Onsite Sediments			
Pueblo at Hamilton Bend Spr	N105	E255	20
Pueblo at Pueblo 3	N090	E315	21
Pueblo at SR-4	N070	E350	22
DP Canyon at DPS-1	N090	E160	23
DP Canyon at DPS-4	N075	E205	24
Los Alamos Canyon at Bridge	N095	E020	25
Los Alamos at LAO-1	N080	E120	26
Los Alamos at GS-1	N075	E200	27
Los Alamos at TW-3	N075	E215	28
Los Alamos at LAO-4	N075	E240	29
Los Alamos at SR-4	N065	E355	30
Sandia at SCS-2	N050	E175	31
Sandia at SR-4	N025	E315	32
Mortandad near CMR	N060	E036	33
Mortandad West of GS-1	N045	E095	34
Mortandad Near MCO-2	N035	E090	35
Mortandad at GS-1	N040	E105	36
Mortandad at MCO-5	N035	E155	37
Mortandad at MCO-7	N025	E190	38
Mortandad at MCO-9	N030	E215	39
Mortandad at MCO-13	N015	E250	40
Pajarito at TA-18	S055	E195	41

TABLE E-XXII (Continued)

Station	Latitude or N-S Coordinate	Longitude or E-W Coordinate	Map Designation (Figure 14)[a]
Pajarito at SR-4	S105	E320	42
Potrillo at TA-36	S075	E150	43
Potrillo East of TA-36	S085	E225	44
Potrillo at SR-4	S145	E295	45
Water at Beta Hole	S090	E095	46
Water at SR-4	S170	E260	47
Water at Rio Grande	S240	E385	48
Ancho at SR-4	S255	E250	49
Ancho at Rio Grande	S295	E340	50
Chaquihui at Rio Grande	S335	E265	51

[a]See Fig. 14 for numbered locations.
[b]Locations are the same as for surface water stations (Table E-XII).

TABLE E-XXIII

RADIOCHEMICAL ANALYSES OF REGIONAL SOILS AND SEDIMENTS

Location	Map Designation	^{137}Cs (pCi/g)	^{241}Am (pCi/g)	^{90}Sr (pCi/g)	^{238}Pu (pCi/g)	^{239}Pu (pCi/g)	Gross Alpha (pCi/g)	Gross Beta (pCi/g)	Total U (μg/g)	^{3}H (10^{-6} μCi/mℓ)
Regional Soils										
Chamita	---	0.67 ± 0.12	0.008 ± 0.006	0.43 ± 0.20	0.000 ± 0.004	0.005 ± 0.004	6.0 ± 2.8	7.0 ± 1.6	2.3 ± 0.4	2.2 ± 0.6
Embudo	---	0.79 ± 0.18	---	0.33 ± 0.16	0.001 ± 0.004	0.017 ± 0.008	5.4 ± 2.4	8.4 ± 2.0	2.1 ± 0.4	2.5 ± 0.6
Otowi	---	1.04 ± 0.14	---	0.15 ± 0.14	−0.001 ± 0.004	0.016 ± 0.006	5.6 ± 2.6	6.7 ± 1.6	3.1 ± 0.6	1.0 ± 0.6
Cochiti	---	0.54 ± 0.20	---	0.54 ± 0.20	−0.005 ± 0.004	0.004 ± 0.010	6.0 ± 2.8	7.9 ± 1.8	2.4 ± 0.4	2.0 ± 0.6
Bernalillo	---	0.37 ± 0.20	0.007 ± 0.006	0.06 ± 0.10	−0.001 ± 0.002	0.006 ± 0.004	5.1 ± 2.4	6.6 ± 1.6	2.1 ± 0.4	0.9 ± 0.6
Jemez	---	0.18 ± 0.14	---	0.63 ± 0.26	−0.002 ± 0.002	0.003 ± 0.006	7.3 ± 3.4	8.9 ± 2.0	2.4 ± 0.4	0.9 ± 0.6
No. of Analyses		6	2	6	6	6	6	6	6	6
Minimum		0.18 ± 0.14	0.007 ± 0.006	0.06 ± 0.10	−0.005 ± 0.004	0.003 ± 0.006	5.1 ± 2.4	6.6 ± 1.6	2.1 ± 0.4	0.9
Maximum		1.04 ± 0.14	0.008 ± 0.006	0.63 ± 0.26	0.001 ± 0.004	0.017 ± 0.008	7.3 ± 3.4	8.9 ± 2.0	3.1 ± 0.6	2.5
Average		0.60	0.008	0.36	−0.001	0.009	5.9	7.6	2.4	1.6
2s		0.61	0.001	0.44	0.004	0.013	1.5	1.9	0.7	1.5
Regional Sediments										
Rio Chama										
Chamita	---	0.18 ± 0.06	0.080 ± 0.060	0.82 ± 0.22	0.001L-.0.002	0.003 ± 0.002	3.0 ± 1.4	2.9 ± 1.0	1.5 ± 0.4	---
Rio Grande										
Embudo	---	0.34 ± 0.18	---	0.10 ± 0.08	−0.002 ± 0.004	0.004 ± 0.004	4.7 ± 2.2	5.5 ± 1.4	4.6 ± 1.0	---
Otowi	A	0.09 ± 0.10	−0.003 ± 0.006	0.42 ± 0.16	0.00 ± 0.002	0.000 ± 0.002	3.3 ± 1.6	3.2 ± 1.0	2.6 ± 0.3	
Sandia	B	0.40 ± 0.10	---	---	0.000 ± 0.002	0.007 ± 0.004	3.9 ± 1.8	3.2 ± 0.6	3.2 ± 0.6	---
Pajarito	C	0.05 ± 0.08	---	---	0.001 ± 0.002	0.003 ± 0.002	7.1 ± 3.2	9.6 ± 2.0	2.9 ± 0.6	---
Ancho	D	0.30 ± 0.08	---	---	−0.001 ± 0.004	0.005 ± 0.004	7.8 ± 3.4	11 ± 2.4	2.7 ± 0.6	---
Frijoles	E	0.10 ± 0.10	---	---	−0.001 ± 0.002	0.004 ± 0.004	3.2 ± 1.6	4.4 ± 1.0	2.6 ± 0.6	---
Bernalillo	---	0.18 ± 0.20	−0.003 ± 0.006	0.11 ± 0.12	−0.002 ± 0.004	0.009 ± 0.006	11 ± 6.0	10 ± 2.4	3.2 ± 0.6	---
Jemez River										
Jemez Pueblo	---	0.04 ± 0.08	---	1.1 ± 0.22	−0.002 ± 0.002	0.000 ± 0.006	3.3 ± 1.8	3.5 ± 1.2	2.0 ± 0.4	---
No. of Analyses		9	3	5	9	9	9	9	9	---
Minimum		0.04 ± 0.08	−0.003 ± 0.006	0.10 ± 0.08	−0.002 ± 0.002	0.000 ± 0.002	3.0 ± 1.4	2.9 ± 1.0	1.5 ± 0.4	---
Maximum		0.40 ± 0.10	0.080 ± 0.060	1.1 ± 0.22	0.001 ± 0.002	0.009 ± 0.006	11 ± 6.0	11 ± 2.4	4.6 ± 1.0	---
Average		0.19	0.025	0.51	−0.001	0.004	5.3	5.9	2.8	---
2s		0.26	0.096	0.88	0.003	0.006	5.6	6.6	1.7	---

Note: The ± value represents twice the standard deviation of the distribution of observed values unless only one analysis is reported, then the value represents twice the uncertainty term for that analysis.

TABLE E-XXIV

RADIOCHEMICAL ANALYSES OF PERIMETER SOILS AND SEDIMENTS

Station	Map Designation	^{137}Cs (pCi/g)	^{241}Am (pCi/g)	^{90}Sr (pCi/g)	^{238}Pu (pCi/g)	^{239}Pu (pCi/g)	Gross Alpha (pCi/g)	Gross Beta (pCi/g)	Total U (μg/g)	^{3}H (10^{-6} μCi/mℓ)
Soils										
Sportsman Club	S1	0.34 ± 0.14	---	0.27 ± 0.28	0.000 ± 0.002	0.009 ± 0.004	10 ± 4.0	12 ± 2.6	3.9 ± 0.8	0.7 ± 0.6
TA-8	S2	1.20 ± 0.20	---	2.90 ± 0.32	0.001 ± 0.002	0.034 ± 0.008	14 ± 60	21 ± 4.0	3.3 ± 0.6	0.6 ± 0.6
TA-49	S3	1.29 ± 0.16	0.059 ± 0.010	0.71 ± 0.14	0.003 ± 0.002	0.023 ± 0.006	10 ± 4.0	14 ± 3.0	3.7 ± 0.8	1.3 ± 0.6
Frijoles	S4	1.18 ± 0.16	---	0.40 ± 0.16	−0.001 ± 0.002	0.018 ± 0.006	7.2 ± 3.2	11 ± 2.4	3.4 ± 0.6	14 ± 1.0
North Mesa	S5	0.73 ± 0.28	---	0.47 ± 0.24	−0.001 ± 0.002	0.010 ± 0.006	8.8 ± 3.8	9.5 ± 2.2	4.3 ± 0.8	3.6 ± 0.6
East of Airport	S6	0.81 ± 0.30	0.012 ± 0.060	0.74 ± 0.18	0.000 ± 0.002	0.023 ± 0.006	10 ± 4.0	13 ± 2.8	4.3 ± 0.8	1.6 ± 0.6
West of Airport	S7	1.17 ± 0.020	0.015 ± 0.060	0.62 ± 0.16	0.001 ± 0.002	0.088 ± 0.012	9.0 ± 12	13 ± 2.8	4.9 ± 1.0	4.7 ± 0.6
West of Airport	S7	---	---	---	0.000 ± 0.002	0.169 ± 0.016	---	---	---	---
South of SR-4 Near S-Site	S8	1.14 ± 0.22	0.02 ± 0.060	0.66 ± 0.20	−0.003 ± 0.004	0.097 ± 0.016	8.8 ± 3.8	3.9 ± 0.8	0.6 ± 0.6	
South of SR-4 Near S-Site	S8	---	---	---	−0.001 ± 0.006	0.011 ± 0.008	---	---	---	---
No. of Analyses	---	8	4	8	10	10	8	8	8	8
Minimum	---	0.34 ± 0.14	0.012 ± 0.060	0.27 ± 0.28	−0.003 ± 0.004	0.009 ± 0.004	7.2 ± 3.2	9.5 ± 2.2	3.3 ± 0.6	0.6
Maximum	---	1.29 ± 0.16	0.059 ± 0.010	2.90 ± 0.32	0.003 ± 0.002	0.169 ± 0.016	14 ± 6.0	21 ± 4.0	4.9 ± 1.0	14.0
Average	---	0.98	0.027	0.85	−0.0001	0.048	9.7	13.3	4.0	3.4
2s	---	0.65	0.044	1.69	0.0032	0.106	3.9	6.8	1.0	9.1
Sediments										
Guaje Near G-4	1	0.07 ± 0.08	0.004 ± 0.004	0.14 ± 0.14	−0.001 ± 0.002	−0.001 ± 0.002	1.4 ± 0.8	1.0 ± 0.6	2.3 ± 0.4	---
Guaje at SR-4	2	0.23 ± 0.14	0.002 ± 0.004	−0.06 ± 0.18	−0.001 ± 0.002	0.002 ± 0.004	1.7 ± 1.0	1.8 ± 0.8	2.4 ± 0.4	---
Bayo at SR-4	3	0.11 ± 0.10	0.024 ± 0.010	0.22 ± 0.20	0.002 ± 0.002	0.001 ± 0.002	2.5 ± 1.2	2.0 ± 0.8	1.8 ± 0.4	---
Pueblo at Acid Weir	4	0.8 ± 0.20	0.449 ± 0.032	1.23 ± 0.28	0.039 ± 0.008	6.46 ± 0.320	7.7 ± 3.2	4.2 ± 1.2	2.1 ± 0.4	---
Pueblo at Acid Weir	4	---	---	---	---	---	17 ± 8.0	9.2 ± 2.0	---	---
Pueblo at PC-1	5	0.02 ± 0.12	---	0.12 ± 0.16	0.013 ± 0.004	1.81 ± 0.100	2.7 ± 1.4	2.4 ± 0.8	1.6 ± 0.4	---
Pueblo at PC-1	5	---	---	---	0.007 ± 0.002	1.88 ± 0.100	4.8 ± 2.0	7.7 ± 1.6	---	---
Pueblo at Pueblo 1	6	0.98 ± 0.18	---	0.98 ± 0.20	0.060 ± 0.014	7.50 ± 0.600	13 ± 6.0	5.9 ± 1.4	2.1 ± 0.4	---
Pueblo at Pueblo 1	6	---	---	---	0.000 ± 0.002	0.002 ± 0.004	2.6 ± 1.2	3.1 ± 0.4	---	---
Pueblo at Pueblo 2	7	0.27 ± 0.22	---	0.05 ± 0.20	0.001 ± 0.004	0.195 ± 0.024	1.9 ± 1.0	2.0 ± 0.8	1.9 ± 0.4	---
Los Alamos at Reservoir	8	0.38 ± 0.14	0.001 ± 0.006	0.11 ± 0.14	0.002 ± 0.002	0.005 ± 0.004	5.0 ± 2.4	5.9 ± 1.4	3.1 ± 0.6	---
Los Alamos at Totavi	9	7.74 ± 0.24	---	0.56 ± 0.16	0.019 ± 0.006	0.146 ± 0.018	6.1 ± 2.8	9.2 ± 2.0	3.1 ± 0.6	---
Los Alamos at Totavi	9	---	---	---	0.008 ± 0.004	0.110 ± 0.014	---	---	---	---
Los Alamos at LA-2	10	0.97 ± 0.20	0.037 ± 0.008	0.35 ± 0.18	0.005 ± 0.004	0.123 ± 0.016	2.8 ± 1.4	3.2 ± 1.0	2.2 ± 0.4	---
Los Alamos at LA-2	10	---	---	---	0.003 ± 0.002	0.078 ± 0.100	---	---	---	---
Los Alamos at Rio Grande	11	---	---	---	0.004 ± 0.004	0.089 ± 0.012	---	---	---	---
Sandia at Rio Grande	12	0.10 ± 0.04	---	---	0.000 ± 0.002	−0.001 ± 0.002	2.9 ± 1.4	2.5 ± 0.8	2.5 ± 0.6	---
Cañada Ancha	13	0.10 ± 0.10	---	---	0.001 ± 0.004	0.003 ± 0.004	1.1 ± 0.6	1.6 ± 0.6	1.4 ± 0.4	---
Mortandad at SR-4	14	0.38 ± 0.20	---	0.19 ± 0.14	−0.001 ± 0.002	0.005 ± 0.012	4.3 ± 2.0	2.9 ± 1.0	2.4 ± 0.4	---
Mortandad at Rio Grande	15	0.06 ± 0.08	---	---	0.002 ± 0.004	0.010 ± 0.002	---	---	---	---

TABLE E-XXIV (Continued)

Station	Map Designation	^{137}Cs (pCi/g)	^{241}Am (pCi/g)	^{90}Sr (pCi/g)	^{238}Pu (pCi/g)	^{239}Pu (pCi/g)	Gross Alpha (pCi/g)	Gross Beta (pCi/g)	Total U (µg/g)	^{3}H (10^{-6} µCi/mℓ)
Cañada del Buey at SR-4	16	0.14 ± 0.14	0.040 ± 0.040	0.17 ± 0.20	−0.001 ± 0.002	0.002 ± 0.002	3.6 ± 1.6	3.0 ± 1.0	1.6 ± 0.4	---
Pajarito at Rio Grande	17	0.06 ± 0.08	---	---	0.000 ± 0.002	−0.001 ± 0.002	2.5 ± 1.2	2.4 ± 0.8	1.5 ± 0.4	---
Frijoles at Park Hdq.	18	0.16 ± 0.12	0.120 ± 0.020	0.09 ± 0.16	0.002 ± 0.002	0.002 ± 0.002	2.2 ± 1.2	2.8 ± 0.8	3.1 ± 0.6	---
Frijoles at Rio Grande	19	0.02 ± 0.12	---	---	−0.005 ± 0.024	0.003 ± 0.022	0.9 ± 0.6	1.0 ± 0.4	1.2 ± 0.4	---
No. of Analyses	---	18	8	13	24	24	21	21	17	---
Minimum	---	0.02 ± 0.12	0.001 ± 0.006	−0.06 ± 0.18	−0.005 ± 0.024	−0.001 ± 0.002	0.9 ± 0.6	1.0 ± 0.4	1.2 ± 0.4	---
Maximum	---	1.74 ± 0.24	0.449 ± 0.032	1.23 ± 0.28	0.060 ± 0.014	13.5 ± 0.400	17 ± 8.0	9.2 ± 2.0	3.1 ± 0.6	---
Average	---	0.37	0.085	0.32	0.007.1.33	4.4	3.7	2.1	---	
2s	---	0.93	0.305	0.77	0.029	6.52	8.0	4.9	1.2	---

Note: The ± value represents twice the standard deviation of the distribution of observed values unless only one analysis is reported, then the value represents twice the uncertainty term for that analysis.

TABLE E XXV

RADIOCHEMICAL ANALYSES OF ONSITE SOIL AND SEDIMENTS

Station	Map Designation	^{137}Cs (pCi/g)	^{241}Am (pCi/g)	^{90}Sr (pCi/g)	^{238}Pu (pCi/g)	^{239} (pCi/g)	Gross Alpha (pCi/g)	Gross Beta (pCi/g)	Total U (µg/g)	^{3}H 10^{-6} µCi/ml
Soils										
TA-21	S9	0.17 ± 0.16	0.02 ± 0.012	0.67 ± 0.20	0.00 ± 0.002	0.006 ± 0.004	6.0 ± 2.6	6.4 ± 1.4	3.8 ± 0.8	5.3 ± 0.8
TA-50	S10	0.82 ± 0.16	---	0.48 ± 0.22	0.006 ± 0.006	0.360 ± 0.040	13 ± 6.0	16 ± 3.2	5.2 ± 1.0	4.1 ± 0.6
TA-50	S10	---	---	---	0.002 ± 0.002	0.054 ± 0.008	---	---	---	
TA-36	S11	–0.01 ± 0.10	---	0.02 ± 0.16	–0.001 ± 0.002	0.000 ± 0.002	10 ± 4.0	9.2 ± 2.0	3.8 ± 0.4	4.0 ± 0.6
PM-1	S12	0.75 ± 0.14	---	0.73 ± 0.22	0.002 ± 0.002	0.013 ± 0.006	8.9 ± 3.8	11 ± 2.4	5.9 ± 1.2	3.1 ± 0.6
West of TA-53	S13	3.5 ± 0.40	---	---	0.010 ± 0.004	0.330 ± 0.030	18 ± 8.0	26 ± 6.0	8.2 ± 1.6	0.9 ± 0.6
West of TA-53	S13	---	---	1.09 ± 0.16	0.002 ± 0.002	0.093 ± 0.014	---	---	---	---
East of TA-53	S14	1.36 ± 0.16	0.028 ± 0.016	0.41 ± 0.22	–0.005 ± 0.004	0.009 ± 0.012	13 ± 6.0	16 ± 3.4	3.9 ± 0.8	2.7 ± 0.6
East of New Sigma	S15	0.65 ± 0.22	0.003 ± 0.004	0.32 ± 0.14	–0.001 ± 0.004	0.040 ± 0.012	15 ± 6.0	17 ± 3.6	5.3 ± 1.0	2.1 ± 0.6
New Sigma	S16	1.4 ± 0.26	---	0.95 ± 0.26	0.000 ± 0.004	0.024 ± 0.004	17 ± 8.0	18 ± 3.8	6.0 ± 1.2	1.8 ± 0.6
East of TA-52	S17	0.12 ± 0.20	0.003 ± 0.004	0.19 ± 0.24	–0.001 ± 0.002	–0.001 ± 0.002	13 ± 6.0	9.6 ± 2.2	3.3 ± 0.6	1.7 ± 0.6
Two Mile Mesa	S18	2.38 ± 0.32	---	0.76 ± 0.24	0.006 ± 0.006	0.030 ± 0.010	13 ± 6.0	18 ± 4.0	3.8 ± 0.8	0.5 ± 0.6
Near TA-51	S19	0.98 ± 0.14	---	0.35 ± 0.14	0.003 ± 0.004	0.019 ± 0.012	11 ± 4.0	14 ± 3.0	3.7 ± 0.8	4.2 ± 0.6
East of TA-54	S20	0.31 ± 0.18	---	0.27 ± 0.14	2.59 ± 0.018	0.610 ± 0.040	13 ± 6.0	13 ± 2.8	4.8 ± 1.0	7.2 ± 0.8
East of TA-54	S20	---	---	---	0.002 ± 0.004	0.243 ± 0.028	---	---	---	---
R-Site Road	S21	0.35 ± 0.12	---	0.62 ± 0.18	–0.002 ± 0.004	0.009 ± 0.006	12 ± 6.0	13 ± 3.0	3.9 ± 0.8	0.9 ± 0.6
R-Site Road East	S22	0.0 ± 0.12	---	0.53 ± 0.20	0.028 ± 0.010	0.022 ± 0.008	11 ± 4.0	13 ± 2.8	4.1 ± 0.8	0.7 ± 0.6
Potrillo Drive	S23	1.56 ± 0.18	0.006 ± 0.006	1.10 ± 0.22	0.001 ± 0.004	0.039 ± 0.012	7.8 ± 3.4	12 ± 2.6	4.8 ± 1.0	0.9 ± 0.6
S-Site	S24	0.95 ± 0.14	---	0.58 ± 0.14	–0.002 ± 0.004	0.034 ± 0.018	12 ± 6.0	14 ± 3.0	3.8 ± 0.8	0.6 ± 0.6
Near TA-11	S25	1.03 ± 0.16	---	0.19 ± 0.14	0.003 ± 0.004	0.009 ± 0.006	10 ± 4.0	9.6 ± 2.2	3.9 ± 0.8	2.0 ± 0.6
Near DT-9	S26	0.95 ± 0.14	0.014 ± 0.006	0.34 ± 0.18	0.001 ± 0.002	0.013 ± 0.006	10 ± 4.0	13 ± 2.8	3.3 ± 0.6	1.2 ± 0.6
Near TA-33	S27	0.73 ± 0.12	—	0.23 ± 0.18	–0.001 ± 0.004	0.005 ± 0.006	7.4 ± 3.2	9.1 ± 2.0	3.8 ± 0.8	440 ± 1.8
No. of Analyses		19	6	19	22	22	19	19	19	19
Minimum		–0.01 ± 0.10	0.003 ± 0.004	0.02 ± 0.16	–0.005 ± 0.004	–0.001 ± 0.002	6.0 ± 2.6	6.4 ± 1.4	3.3 ± 0.6	0.5 ± 0.6
Maximum		3.5 ± 0.40	0.028 ± 0.016	1.10 ± 0.22	2.59 ± 0.018	0.610 ± 0.040	18 ± 8.0	26 ± 6.0	8.2 ± 1.6	440 ± 1.8
Average		1.00	0.013	0.52	0.120	0.089	11.6	13.6	4.5	25.5
2s		1.66	0.021	0.16	1.103	0.313	6.2	8.8	2.4	200.8
*Sediments										
Pueblo at Hamilton Bend Spring	20	0.12 ± 0.10	---	–0.01 ± 0.18	0.000 ± 0.004	0.196 ± 0.022	3.6 ± 1.6	2.0 ± 0.8	1.6 ± 0.4	---
Pueblo at Hamilton Bend Spring	20	---	---	---	0.004 ± 0.004	0.291 ± 0.022	3.3 ± 1.4	2.6 ± 0.8	---	---
Pueblo at Pueblo 3	20	0.10 ± 0.14	---	0.10 ± 0.22	0.000 ± 0.002	0.201 ± 0.020	0.9 ± 0.6	0.9 ± 0.6	1.2 ± 0.4	---
Pueblo at Pueblo 3	21	---	---	---	0.012 ± 0.014	2.73 ± 0.080	14 ± 6.0	14 ± 3.0	---	---
Pueblo at SR-4	22	0.22 ± 0.14	0.03 ± 0.008	0.12 ± 0.16	0.002 ± 0.004	0.557 ± 0.038	2.7 ± 1.4	2.7 ± 0.8	2.0 ± 0.4	---
Pueblo at SR-4	22	---	---	---	0.003 ± 0.002	0.453 ± 0.022	4.6 ± 2.0	4.7 ± 1.0	---	---
DP Canyon at DPS-1	23	1.48 ± 0.36	---	1.60 ± 1.00	2.32 ± 0.060	5.30 ± 0.120	43 ± 18	69 ± 14	6.7 ± 1.4	---
DP Canyon at DPS-1	23	---	—	---	0.065 ± 0.080	0.234 ± 0.016	5.9 ± 2.4	12 ± 2.4	---	---
DP Canyon at DPS-4	24	16.0 ± 1.60	---	2.44 ± 0.28	0.113 ± 0.014	0.403 ± 0.026	3.3 ± 1.6	14 ± 3.0	1.8 ± 0.4	---
DP Canyon at DPS-4	24	---	---	---	0.121 ± 0.012	0.455 ± 0.022	3.4 ± 1.4	22 ± 4.0	---	---
Los Alamos at Bridge	25	0.26 ± 0.18	---	–0.04 ± 0.22	0.001 ± 0.002	0.001 ± 0.002	2.7 ± 1.4	1.9 ± 0.8	1.9 ± 0.4	---
Los Alamos at LAO-1	26	0.24 ± 0.18	0.018 ± 0.040	0.10 ± 0.20	0.006 ± 0.008	0.910 ± 0.080	3.7 ± 1.8	3.4 ± 1.0	2.2 ± 0.4	---

TABLE E-XXV (Continued)

Station	Map Designation	^{137}Cs (pCi/g)	^{241}Am (pCi/g)	^{90}Sr (pCi/g)	^{238}Pu (pCi/g)	^{239} (pCi/g)	Gross Alpha (pCi/g)	Gross Beta (pCi/g)	Total U (μg/g)	^{3}H 10^{-6} μCi/mℓ
LAO-1	26	---	---	---	0.007 ± 0.036	1.79 ± 0.100	---	---	---	---
Los Alamos at GS-1	27	0.47 ± 0.22	---	0.07 ± 0.16	0.097 ± 0.012	0.281 ± 0.240	2.9 ± 1.4	2.2 ± 0.8	2.1 ± 0.4	---
Los Alamos at GS-1	27	---	---	---	−0.001 ± 0.002	0.144 ± 0.022	---	---	---	---
Los Alamos at TW-3	28	12.2 ± 1.20	---	2.16 ± 0.28	0.003 ± 0.004	0.520 ± 0.040	3.9 ± 1.8	17 ± 3.6	1.5 ± 0.4	---
Los Alamos at TW-3	28	---	---	---	0.188 ± 0.018	0.760 ± 0.040	---	---	---	---
Los Alamos at LAO-4	29	5.90 ± 0.6	0.285 ± 0.034	1.21 ± 0.22	0.036 ± 0.008	0.189 ± 0.020	3.6 ± 1.6	12 ± 2.4	1.5 ± 0.4	---
Los Alamos at LAO-4	29	---	---	---	0.084 ± 0.010	0.320 ± 0.014	---	---	---	---
Los Alamos at SR-4	30	2.14 ± 0.26	---	0.48 ± 0.16	0.012 ± 0.004	0.076 ± 0.012	2.1 ± 1.0	4.8 ± 1.2	1.7 ± 0.4	---
Sandia at SCS-2	31	0.05 ± 0.10	0.008 ± 0.008	−0.05 ± 0.18	0.000 ± 0.002	0.004 ± 0.002	4.4 ± 2.0	2.7 ± 0.8	3.1 ± 0.6	---
Sandia at SR-4	32	0.17 ± 0.18	---	0.11 ± 0.24	0.000 ± 0.002	0.001 ± 0.002	4.0 ± 1.8	4.2 ± 1.2	2.9 ± 0.6	---
Mortandad Near CMR	33	0.79 ± 0.22	---	0.14 ± 0.14	0.24 ± 0.009	0.483 ± 0.028	4.4 ± 2.0	5.5 ± 1.4	2.9 ± 0.6	---
Mortandad Near CMR	33	---	---	---	0.340 ± 0.060	0.170 ± 0.060	4.1 ± 1.8	3.2 ± 0.8	---	---
Mortandad West of GS-1	34	1850 ± 180	---	23.5 ± 1.80	14.6 ± 2.20	100 ± 40	1020 ± 200	5.5 ± 1.2	---	
Mortandad at MCO-2	35	0.17 ± 0.22	---	0.05 ± 0.20	0.001 ± 0.004	0.039 ± 0.040	2.2 ± 1.2	1.6 ± 0.8	2.1 ± 0.4	---
Mortandad at GS-1	36	560 ± 60	---	---	6.64 ± 0.200	10.6 ± 0.300	78 ± 32	450 ± 80	4.6 ± 1.0	---
Mortandad at GS-1	36	---	---	8.8 ± 0.80	1.70 ± 0.040	3.4 ± 0.600	2.5 ± 1.2	3.0 ± 0.8	---	---
Mortandad at MCO-5	37	47 ± 6.0	---	1.81 ± 0.26	3.30 ± 0.100	1.13 ± 0.060	6.0 ± 2.6	29 ± 6.0	4.6 ± 1.0	---
Mortandad at MCO-5	37	---	---	---	1.66 ± 0.060	0.695 ± 0.030	12 ± 6.0	62 ± 12	---	---
Mortandad at MCO-7	38	52 ± 6.0	---	1.17 ± 0.20	1.95 ± 0.012	0.650 ± 0.600	6.9 ± 3.0	34 ± 6.0	2.2 ± 0.4	---
Mortandad at MCO-7	38	---	---	---	1.80 ± 0.060	0.557 ± 0.028	6.3 ± 2.6	44 ± 8.0	---	---
Mortandad at MCO-9	39	0.97 ± 0.12	---	0.30 ± 0.10	−0.001 ± 0.004	0.020 ± 0.006	5.3 ± 2.4	7.2 ± 0.8	3.1 ± 0.6	---
Mortantad at MCO-13	40	1.13 ± 0.14	---	0.52 ± 0.20	0.000 ± 0.002	0.023 ± 0.006	5.6 ± 2.4	5.7 ± 1.4	2.6 ± 0.6	---
Pajarito at TA-18	41	0.23 ± 0.14	0.001 ± 0.004	0.02 ± 0.12	0.001 ± 0.002	0.001 ± 0.002	2.0 ± 1.0	2.5 ± 0.8	1.6 ± 0.4	---
Pajarito at SR-4	42	0.35 ± 0.10	0.020 ± 0.040	0.01 ± 0.14	−0.005 ± 0.004	0.007 ± 0.006	5.6 ± 2.6	5.8 ± 1.4	2.2 ± 0.4	---
Potrillo at TA-36	43	0.14 ± 0.14	---	0.26 ± 0.30	0.001 ± 0.004	0.002 ± 0.004	3.6 ± 1.6	3.9 ± 1.0	7.5 ± 1.6	---
Potrillo East of TA-36	44	0.39 ± 0.20	0.017 ± 0.038	0.12 ± 0.20	−0.001 ± 0.002	0.002 ± 0.004	7.1 ± 3.0	8.6 ± 2.0	4.4 ± 0.8	---
Potrillo at SR-4	45	0.12 ± 0.12	---	−0.01 ± 0.26	−0.002 ± 0.002	0.004 ± 0.006	2.9 ± 1.4	2.1 ± 0.8	1.8 ± 0.4	---
Water at Beta Hole	46	0.24 ± 0.20	---	0.50 ± 0.20	−0.001 ± 0.002	0.003 ± 0.004	2.3 ± 1.2	2.5 ± 0.8	1.8 ± 0.4	---
Water at SR-4	47	0.34 ± 0.10	---	0.40 ± 0.30	0.000 ± 0.004	0.000 ± 0.004	3.7 ± 1.8	4.8 ± 1.2	3.4 ± 0.6	---
Water at Rio Grande	48	0.03 ± 0.12	---	---	0.001 ± 0.006	−0.001 ± 0.004	1.5 ± 0.8	1.4 ± 0.6	1.4 ± 0.4	---
Ancho at SR-4	49	0.27 ± 0.12	0.030 ± 0.020	0.12 ± 0.18	0.001 ± 0.002	0.006 ± 0.004	6.5 ± 2.8	7.3 ± 1.8	4.0 ± 0.8	---
Ancho at Rio Grande	50	0.14 ± 0.06	---	---	---	---	1.3 ± 0.8	1.8 ± 0.6	1.9 ± 0.4	
Chaquihui at Rio Grande	51	0.07 ± 0.14	---	---	---	---	2.0 ± 1.0	3.1 ± 0.8	2.6 ± 0.6	---
No. of Analyses		32	8	29	43	43	41	41	32	---
Minimum		0.03 ± 0.12	0.001 ± 0.004	−0.05 ± 0.18	−0.005 ± 0.004	−0.001 ± 0.004	0.09 ± 0.6	0.9 ± 0.6	1.2 ± 0.4	---
Maximum		1850 ± 180	0.285 ± 0.034	23.5 ± 1.80	14.6 ± 0.200	46.3 ± 2.20	100 ± 40	1020 ± 200	7.5 ± 1.6	---
Average		79.80	0.050	1.59	0.822	1.859	9.4	46.4	2.8	---
2s		675.63	0.191	9.08	4.958	14.354	39.1	342.0	3.1	---

Note: The ± value represents twice the standard deviation of the distribution of observed values unless only one analysis is reported, then the value represents twice the uncertainty term for that analysis.

TABLE E-XXVI

ATMOSPHERIC RADIOACTIVE EFFLUENT TOTALS FOR 1980

Location	^{238}Pu ^{239}Pu (μCi)	^{241}Am (μCi)	^{235}U ^{238}U (μCi)	^{232}Th ^{234}Th (μCi)	MFP[a] (μCi)	^{131}I (μCi)	^{41}Ar (Ci)	^{32}P (μCi)	^{3}H (Ci)	$^{11}C,^{13}N,^{15}O$[b] (Ci)	^{7}Be (mCi)	^{203}Hg (μCi)
TA-2	---	---	---	---	---	---	513	---	---	---	---	---
TA-3	741	---	155	566	424	94	---	---	4.55	---	---	---
TA-9	---	---	---	---	---	---	---	---	5.0	---	---	---
TA-15	---	---	---	---	---	---	---	---	---	---	---	---
TA-18	---	---	---	---	---	---	---	---	---	---	---	---
TA-21	2.27	0.061	633	---	4.18	---	---	---	106	---	---	---
TA-33	---	---	---	---	---	---	---	---	6 965	---	---	---
TA-35	0.21	---	---	---	---	---	---	---	25	---	---	---
TA-41	---	---	---	---	---	---	---	---	414	---	---	---
TA-43	0.18	---	---	---	---	---	---	3.72	---	---	---	---
TA-46	---	---	1.48	---	---	---	---	---	---	---	---	---
TA-48	1.57	---	0.67	---	1 755	---	---	---	---	---	---	---
TA-50	1.17	---	---	---	8.25	---	---	---	---	---	---	---
TA-53	---	---	---	---	---	---	438	---	1.17	145 600	12.2	46.7
TA-54	0.003	---	---	---	---	---	---	---	---	---	---	---
TA-55	0.294	---	---	---	---	---	---	---	---	---	---	---

[a]Mixed fission products.

[b]The half-lives of ^{11}C, ^{13}N, and ^{15}O range from about 2 to 20 minutes, so these nuclides decay rapidly.

Note: --- means no discharge of that radionuclide at that location.

TABLE E-XXVII

QUALITY OF EFFLUENTS FROM LIQUID RADIOACTIVE WASTE TREATMENT PLANTS

	Waste Treatment Plant Location			
	TA-50		TA-21	
Radioisotope	Activity Released (mCi)	Average Concentration (μCi/mℓ)	Activity Released (mCi)	Average Concentration (μCi/mℓ)
^{239}Pu	8.2	0.15×10^{-6}	0.031	0.016×10^{-6}
^{238}Pu	1.3	0.025×10^{-6}	0.014	0.007×10^{-6}
^{241}Am	5.7	0.11×10^{-6}	0.052	0.026×10^{-6}
^{89}Sr	40.9	0.77×10^{-6}	0.056	0.028×10^{-6}
^{90}Sr	18.0	3.41×10^{-7}	0.124	0.62×10^{-7}
^{3}H	44 900	0.85×10^{-3}	77.5	0.0039×10^{-3}
^{137}Cs	132	0.25×10^{-5}	0.47	0.024×10^{-5}
^{234}U	0.45	0.087×10^{-7}	0.44	2.2×10^{-7}
Total Effluent Volume		5.283×10^{7} ℓ		1.987×10^{6} ℓ

	Waste Treatment Plant Location	
	TA-50	TA-21
Nonradioactive Constituent	Average Concentration (mg/ℓ)	Average Concentration (mg/ℓ)
Cd[a]	0.0003	0.006
Ca	81	12
Cl	50	77
Cr[a]	0.02	0.10
Cu[a]	0.18	0.11
F	3.6	137
Hg[a]	0.002	0.001
Mg	2.7	2.4
Na	690	1 890
Pb[a]	0.007	0.009
Zn[a]	0.22	0.44
Cn	0.034	---
COD[a]	59	106
$NO_3(N)$	176	412
PO_4	0.43	1.1
TDS	2 060	5 740
pH[a]	6.8 - 12.7	9.6 - 12.7
Total Effluent Volume	5.283×10^{7} ℓ	1.987×10^{6} ℓ

[a]Constituent regulated by NPDES permit.

TABLE E-XXVIII

TOTAL SUSPENDED PARTICULATES IN AIR AT LOS ALAMOS AND WHITE ROCK DURING 1980

(Data from New Mexico Environmental Improvement Division. All concentrations in $\mu g/m^3$.)

Los Alamos (Annual Geometric Mean = 38)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
No. of Samples	5	5	5	5	6	5	5	6	5	5	5	5
Maximum	64	44	86	60	92	55	52	43	49	51	53	84
Minimum	30	23	14	22	18	32	27	21	16	27	33	48
Mean	53	30	35	46	45	45	36	32	34	41	42	65
±1s	13	8	29	18	29	9	10	10	14	9	9	14

White Rock (Annual Geometric Mean = 33)

No. of Samples	5	3	5	4	7	4	5	6	5	5	5	5
Maximum	33	34	113	37	102	113	45	32	43	72	49	42
Mimimum	17	15	8	18	13	42	33	16	16	31	29	28
Mean	24	24	39	25	58	76	38	25	28	46	38	32
±1s	6	9	43	8	33	29	5	6	13	16	9	6

TABLE E-XXIX

QUANTITIES OF VOLATILE CHEMICALS AND COMPRESSED GASES USED AT LOS ALAMOS
(All amounts in kg)

	1972	1973	1974	1975	1976	1977	1978	1979	1980
Acids									
Acetic	---	---	---	---	---	---	410	220	190
Hydrochloric	---	---	---	---	---	---	3 700	4 200	5 400
Hydrofluoric	---	---	---	---	---	---	8 100	6 400	170
Nitric	---	---	---	---	---	---	80 000	58 100	71 900
Perchloric	---	---	---	---	---	---	390	140	290
Phosphoric	---	---	---	---	---	---	710	450	320
Sulfuric	---	---	---	---	---	---	1 700	2 300	1 800
Gases									
Ammonia	4 200	2 700	3 200	2 600	2 600	2 900	3 000	2 500	2 600
Carbon Monoxide	---	---	---	---	4 900	6 200	9 300	5 500	4 800
Chlorine	---	---	---	---	500	680	500	640	1 100
Freon 12	---	---	---	---	2 500	3 400	2 800	2 000	2 100
Hydrogen Fluoride	---	---	---	---	1 300	950	360	500	1 300
Nitrogen Oxides	---	---	---	---	7 800	6 700	640	1 200	350
Sulfur Dioxide	---	---	---	---	120	290	160	110	150
Sulfur Hexafluoride	17 400	6 700	10 300	11 400	12 200	13 700	9 200	11 400	6 900
Inorganic Chemicals									
Ammonium Hydroxide	---	---	---	---	---	---	---	2 200	1 600
Mercury	---	---	---	---	500	290	180	140	140
Organic Chemicals									
Acetone	18 800	9 200	12 400	16 100	15 500	12 700	10 600	8 300	7 900
Carbon Tetrachloride	300	290	250	100	250	230	200	280	100
Chloroform	360	250	500	380	370	190	160	200	310
Ethanol	---	---	---	---	---	9 200	10 900	9 900	9 400
Freons	10 900	13 300	15 000	10 200	12 400	13 800	8 200	9 200	12 800
Kerosene	8 100	5 000	5 900	4 800	4 600	4 400	3 800	4 100	5 800
Methanol	590	540	1 500	1 700	6 600	4 300	2 600	3 300	2 400
Methylene Chloride	820	820	310	1 000	820	2 200	250	170	180
Methyl Ethyl Ketone	---	---	---	2 300	9 400	10 600	14 300	22 000	11 400
Perchloroethylene	3 400	680	1 000	820	680	1 000	1 400	340	1 400
Toluene	2 300	2 100	1 200	2 700	3 300	1 600	2 100	2 100	650
Trichloroethane	25 600	18 300	25 800	22 900	34 000	28 300	24 100	23 800	28 200
Trichloroethylene	20 400	15 500	16 200	9 400	13 200	10 200	7 400	6 900	3 400

TABLE E-XXX

ESTIMATED CONCENTRATIONS OF TOXIC ELEMENTS
AEROSOLIZED BY DYNAMIC EXPERIMENTS

Element	1980 Total Usage (kg)	Percent Aerosolized (%)	Annual Avg. Concentration (ng/m^3) 4 km	8 km	Applicable Standard (ng/m^3)
Uranium	881	10	0.09	0.03	9000[a]
Be	10.7	2	0.0003	0.0001	10[b] (30 day avg)
Pb	0.4	100[c]	0.0004	0.0002	10 000[b] (for total heavy metals, N > 21)

[a]ERDA Manual Chapter 0524.
[b]Section 201 of the Ambient Air Quality Standards and Air Quality Control Regulations adopted by the New Mexico Health and Social Services Board, April 19, 1974.
[c]Assumed percentage aerosolization.

TABLE E-XXXI

SANITARY SEWAGE TREATMENT FACILITIES EFFLUENT QUALITY SUMMARY[a]

Discharge Location	Permit Constituents	No. of Deviations	Range of: Deviation / Limiting Standard or pH	Discharge Location	Permit Constituents	No. of Deviations	Range of: Deviation / Limiting Standard or pH
TA-3	BOD_5[b]	2	1.0 - 9.6	TA-41	BOD_5	0	---
	TSS[c]	1	40.2		TSS	0	---
	Fecal Coliform[d]	3	85 - 3145		Fecal Coliform[d]	2	14.5 - 115
	Flow (MGD)	0	---		Flow (MGD)	21	1.0 - 1.2
	pH[e]	0	---		pH	0	---
TA-9	BOD_5	0	---	TA-46	BOD_5	0	---
	TSS	1	1.47		TSS	0	---
	Flow (MGD)	14	1.0 - 8.4		Flow (MGD)	38	1.0 - 1.5
	pH	1	9.1		pH	0	---
TA-16	BOD_5	0	---	TA-48	BOD_5	0	---
	TSS	1	8.4		TSS	0	---
	Flow (MGD)	0	---		Flow	0	---
	pH	0	---		pH	0	---
TA-18	BOD_5	1	1.2	TA-53	BOD_5	5	1.1 - 2.2
	TSS	5	1.3 - 39.4		TSS	11	1.1 ± 15.1
	Flow (MGD)	113	1.0 - 18.8		Flow	36	1.0 - 2.6
	pH	7	1.0 - 1.1		pH	19	9.2 ± 10.6
TA-21	BOD_5	0	---	TA-35	BOD_5	1	1.3
	TSS	0	---		TSS	12	1.1 - 3.8
	Fecal Coliform[d]	35	1.05 - 310		Flow (MGD)	11	1.0 - 2.6
	Flow (MGD)	0	---		pH	2	9.1 - 9.7

[a]Single NPDES permit NM 0028355.
[b]BOD_5 limits are 30 mg/ℓ (20-day avg), 45 mg/ℓ (7 day avg).
[c]TSS limits are 30 mg/ℓ (20-day avg), 45 mg/ℓ (7 day avg).
[d]Fecal coliform limits are 2000/100 mℓ (daily max) and 1000/100 mℓ (geometric mean).
[e]pH limits not less than 6.0 or greater than 9.0 standard units.

TABLE E-XXXII

INDUSTRIAL LIQUID EFFLUENT QUALITY SUMMARY[a]

Discharge Category	No. of Outfalls	Permit Constituents	No. of Deviations	Range of: [Deviation / Limiting Standard] or pH[b]	No. of Outfalls Causing Deviations
Power Plant	6[c]	TSS	10	1.8 - 244.5	1
		Free Cl	0	---	0
		pH	14	4.0 - 11.0	4
Boiler Blowdown	3[c]		1	1.8	1
		Fe	0	---	0
		Cu	4	1.2 - 6.4	1
		P	8	1.0 - 3.3	2
		pH	19	9.5 - 11.6	3
Treated Cooling Water	35	TSS	2	1.28 - 14.48	2
		Free Cl	0	---	0
		P	0	---	0
		pH	1	5.0	1
Noncontact Cooling Water	33	pH	0	---	0
Radioactive Waste Treatment Plant Discharges	2	NH_3	0	---	0
		COD	0	---	0
		TSS	0	---	0
		Cd	0	---	0
		Cr	0	---	0
		Cu	0	---	0
		Fe	1	2.06	1
		Pb	0	---	0
		Hg	0	---	0
		Zr	0	---	0
		pH	0	---	0
High Explosives Waste Discharges	22[d]	COD	10	1.2 - 129	7
		TSS	5	1.1 - 77.67	5
		pH	1	2.21 - 5.4	2
Photo Waste Discharges	15	Cn	0	---	0
		TSS	0	---	0
		pH	0	---	0
		Ag	3	1.07 - 2.89	2

TABLE E-XXXII (Continued)

Discharge Category	No. of Outfalls	Permit Constituents	No. of Deviations	Range of: [Deviation / Limiting Standard] or pH[b]	No. of Outfalls Causing Deviations
Printed Circuit Board Development Wastes	1	COD	2	2.72 - 9.55	1
		Cu	2	1.11 - 6.2	1
		Fe	9	1.2 - 20.03	1
		Ni	0	---	0
		P	0	---	0
		pH	6	2.2 - 5.8	1
Acid Dip Tank Rinse	1	Cu	0	---	0
		pH	0	---	0
Gas Cylinder Cleaning Waste	1	TSS	0	---	0
		P	0	---	0
		pH	0	---	0

[a]Summary of reports to EPA or NPDES Permit NM 0028355.
[b]pH range limit on all outfalls is not less than 6.0 or greater than 9.0 standard units.
[c]Outfalls responsible for deviations scheduled for correction.
[d]Six of 22 outfalls responsible for deviations scheduled for correction.

TABLE E-XXXIII

CHEMICAL QUALITY OF WATER IN VICINITY OF FENTON HILL
(average of a number of analyses)

	Surface Water	Water Supply	Springs (Jemez Fault)	Spring (Volcanics)	Abandon Well	Fenton Hill (Pond Fluids)
No. of stations and analyses[a]	9	4	2	1	1	4
Chemical (mg/ℓ)						
SiO_2	30 ± 6	71 ± 19	40 ± 8	48	65	90 ± 41
Ca	17 ± 11	19 ± 23	120 ± 61	14	26	31 ± 9
Mg	2 ± 1	4 ± 2	15 ± 14	2	8	4 ± 3
Na	13 ± 18	15 ± 5	518 ± 1022	11	112	465 ± 297
CO_3	0 ± 0	0 ± 0	0 ± 0	0	0	0 ± 0
HCO_3	42 ± 52	78 ± 46	807 ± 1168	54	326	622 ± 381
SO_4	42 ± 186	<3 ± 9	34 ± 18	<1	22	112 ± 200
Cl	11 ± 22	5 ± 9	832 ± 1732	3	4	114 ± 51
F	0.4 ± 0.2	0.4 ± 0.3	2.8 ± 1.8	1.0	0.8	1.7 ± 0.6
NO_3	<0.1 ± 0.1	1.5 ± 1.2	<0.1 ± 0.0	1.0	<1	<0.1 ± 0.0
TDS	159 ± 89	200 ± 73	2390 ± 4129	138	488	1873 ± 1036
Hard	52 ± 31	61 ± 67	363 ± 208	43	95	94 ± 27
pH	6.9 ± 2.2	7.3 ± 0.5	6.6 ± 0.7	6.5	6.9	7.4 ± 1.0
Conductance (mS/m)	18.5 ± 13.3	17.0 ± 10.9	369.0 ± 653.0	13.0	56.0	186.7 ± 93.5

[a]Sampling locations key on Fig. 22 as follows:
Surface waters—Locations F, J, N, Q, R, S, T, U, V.
Water supply—Locations JS 2-3, JS4-5, FH-1, 4.
Springs (Jemez Fault)—Locations JF-1, JF-5.
Spring (Volcanic)—Location 31.
Abandoned well—Location 27.
Fenton Hill (pond fluids)—Drilling fluids and circulation fluids from tests.

TABLE E-XXXIV

METAL ION ANALYSES OF VEGETATION AND SOILS IN POND RELEASE AREA AT FENTON HILL
(all values in ppm)

Sample Type	Channel											
	100 m			200 m			400 m			1000 m		
	Vegetation	Roots	Soil	Vegetation	Roots	Soil	Vegetation	Roots	Soil	Vegetation	Roots	Soil
Spring 78												
As	---	---	---	---	---	---	---	---	---	---	---	2.4
B	---	---	0.9	---	---	---	---	---	---	---	---	---
Cd	---	---	---	---	---	---	---	---	---	---	---	0.0005
F	---	---	1.5[a]	---	---	1.1[a]	---	---	0.7[a]	---	---	0.1[a]
Fall 78												
As	0.22	---	---	0	---	---	0.12	---	---	0.34	---	---
Cd	0	---	---	0	---	---	0	---	---	0	---	---
Li	3.5	---	---	9.1	---	---	12.9	---	---	1.93	---	---
Spring 79												
As	0.7	---	---	0.7	---	---	0.7	---	---	0.7	---	---
B	150	---	---	286	---	---	350	---	---	26	---	---
Cd	0.17	---	---	0.15	---	---	0.15	---	---	0.19	---	---
Li	46	---	---	109	---	---	239	---	---	2.6	---	---
Fall 79												
B	---	13	---	---	21	---	---	28	---	---	20	---
Spring 80												
B	236	56	22	245	64	44	237	34	25	21	9	18
F	---	---	380	---	---	290	---	---	160	---	---	110
Fall 80												
B	173	---	31	182	---	42	113	---	36	18	---	18
F	---	---	420	---	---	140	---	---	180	---	---	105

TABLE E-XXXIV (Continued)

Sample Type	Bank														
	100 m			200 m			400 m			1000 m			Lower Canyon		
	Vegetation	Roots	Soil	Vegetation	Roots	Soil	Vegetation	Roots	Soil	Vegetation	Roots	Soil	Vegetation	Roots	Soil
Fall 78															
As	0.13	---	---	0.14	---	---	0.06	---	---	0	---	---	0.08	---	---
Cd	0	---	---	0	---	---	0	---	---	0	---	---	0	---	---
Li	1.93	---	---	1.93	---	---	0.69	---	---	1.00	---	---	1.00	---	---
Spring 79															
As	0.7	---	---	0.7	---	---	0.7	---	---	0.7	---	---	0.7	---	---
B	0	---	---	0	---	---	0	---	---	0	---	---	0	---	---
Cd	0.27	---	---	0.19	---	---	0.14	---	---	0.27	---	---	0.15	---	---
Li	0.8	---	---	0.8	---	---	3.3	---	---	0.8	---	---	2.6	---	---
Fall 79															
B	---	14	---	---	0	---	---	9	---	---	8	---	---	0	---
Spring 80															
B	21	9	16	14	0	19	13	13	15	11	0	25	10	0	14
F	---	---	100	---	---	110	---	---	100	---	---	200	---	---	220
Fall 80															
B	32	---	---	30	---	13	9	---	19	9	---	23	10	---	20
F	---	---	---	---	---	80	---	---	95	---	---	160	---	---	210

[a]Extractable.

APPENDIX F

DESCRIPTIONS OF TECHNICAL AREAS AND THEIR ASSOCIATED PROGRAMS

Locations of the 31 active technical areas (TA's) 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, Personnel Administration Department offices, Materials Department, the science museum, Chemistry and Metallurgy Division, Physics Division, 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 insuring quality of materials, 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 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 sources 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 tritium research. DP East is the high temperature chemistry site where studies are conducted on the chemical stability and interaction of materials at temperatures up to and exceeding 3300°C.

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

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

TA-33, HP-Site: Design and development of nuclear and other components of weapon systems are conducted here. A major 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, interaction of explosives, and explosions with other materials.

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

TA-41, W-Site: Personnel at this site are engaged primarily in engineering design and development of nuclear components, including fabrication and evaluation of test materials for weapons. Also located here is an underground laboratory that is used for physics experiments.

TA-43, Health Research Laboratory: The Biomedical Research Group does research here in cellular radiobiology, molecular 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-enchancement 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 contaminated liquid waste received from Laboratory technical areas, for development of improved methods of waste treatment, and for containment of radioactivity removed by treatment. Radioactive waste is piped to this site for treatment from many of the technical areas.

TA-51, Radiation Exposure Facility: Here animals are irradiated 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, materials studies, and isotope production.

TA-54, Waste Disposal Site: This is a disposal area for 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.

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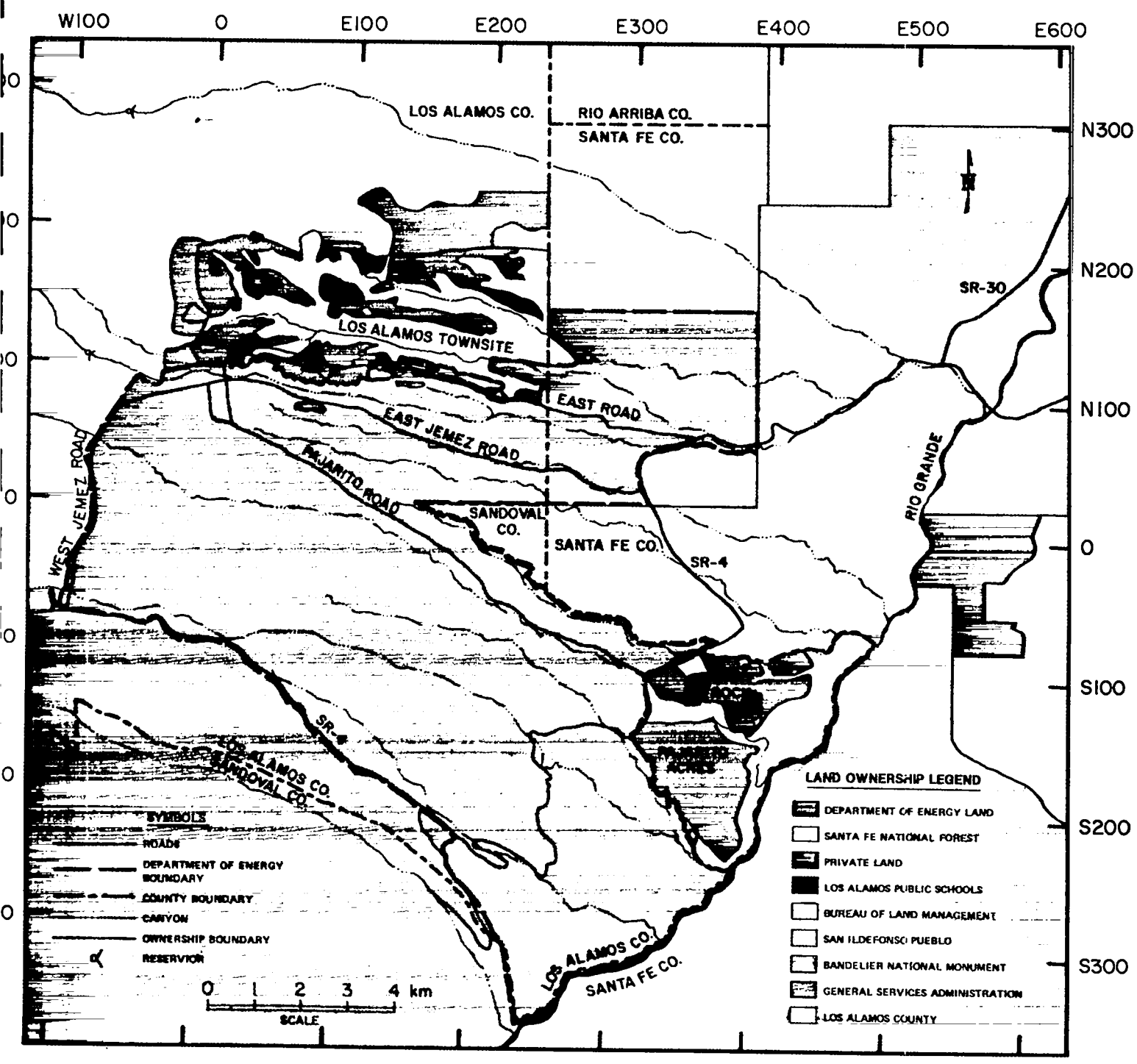

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