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Environmental Surveillance at Los Alamos During 1974

Compiled by

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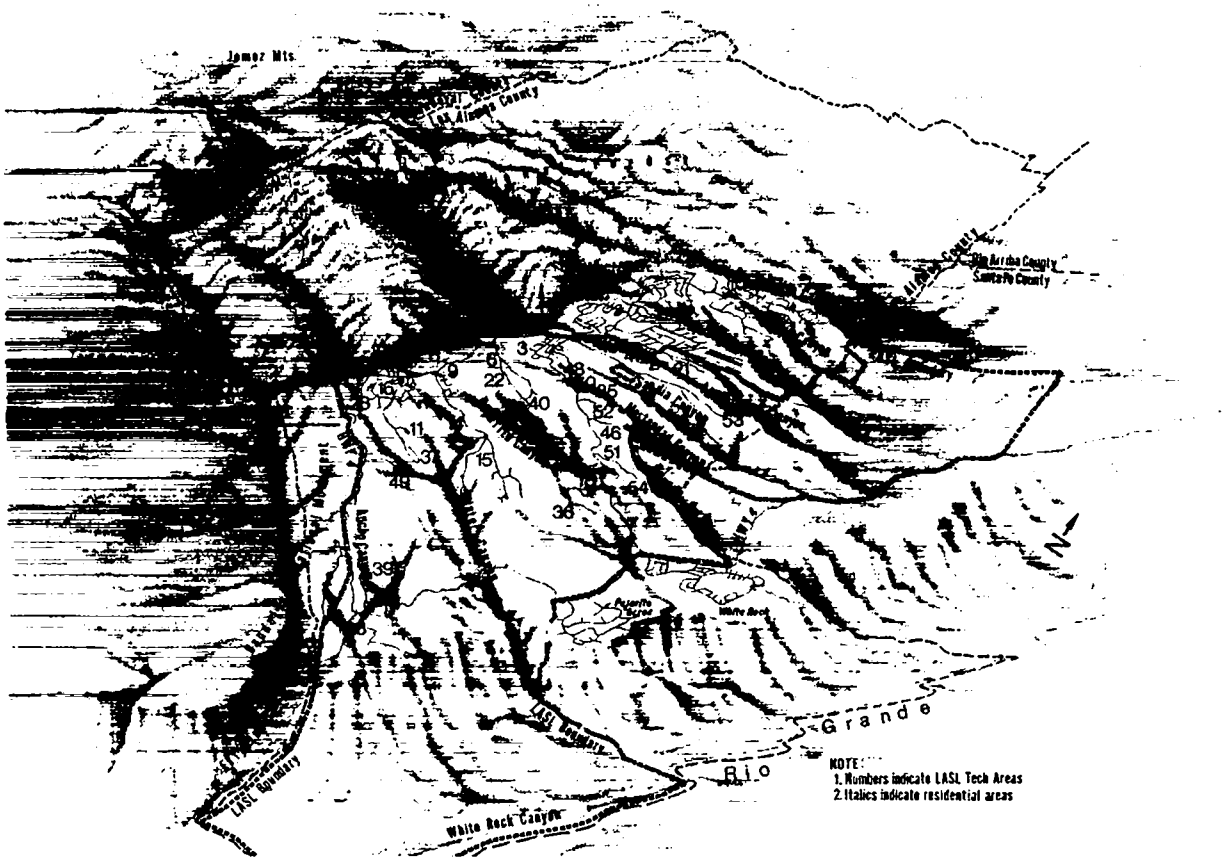

Fig. 1. Topography of the Los Alamos, New Mexico, area.

ENVIRONMENTAL SURVEILLANCE AT LOS ALAMOS DURING 1974

Compiled by

Kenneth E. Apt and Valerie J. Lee

ABSTRACT

This report documents the CY 1974 environmental monitoring program of the Los Alamos Scientific Laboratory (LASL). Data are presented for concentrations of radioactivity measured in air, ground and surface waters, sediments, and soils, and these data are compared with relevant AEC guides and/or data from other reporting periods. Levels of external penetrating radiation measured in the LASL environs are given. The average whole-body radiation dose to residents of Los Alamos County resulting from LASL operations is calculated. Chemical and biological qualities of surface and ground waters of the LASL environs have been determined and are compared to applicable standards. Results of related environmental studies are provided.

I. INTRODUCTION

This report presents the results of the environmental monitoring programs conducted at the Los Alamos Scientific Laboratory (LASL) during Calendar Year 1974. LASL is administered by the University of California for the U. S. Atomic Energy Commission (AEC) (as of January 1975, the Energy Research and Development Administration [ERDA]; however, for the purposes of this report covering CY 1974 the sponsoring agency shall be referred to as the AEC) under Contract W-7405-ENG-36. The LASL environmental programs are conducted by the Environmental Studies Group (LASL, H-8) as part of a continuing comprehensive environmental investigation and documentation.

Scope and Objectives

Small quantities of radionuclides routinely escape from the LASL site. Effluent monitoring, both gaseous and liquid, is conducted continuously at all major release locations to document concentrations and total quantities released. Environmental monitoring is conducted both on the LASL site and in its environs to evaluate the behavior of radioactive and nonradioactive contaminants in the biosphere.

This report principally serves the purpose of providing public documentation of data on environmental quality in the vicinity of the Laboratory, in keeping with AEC and Laboratory philosophy to make information relating to environmental quality and

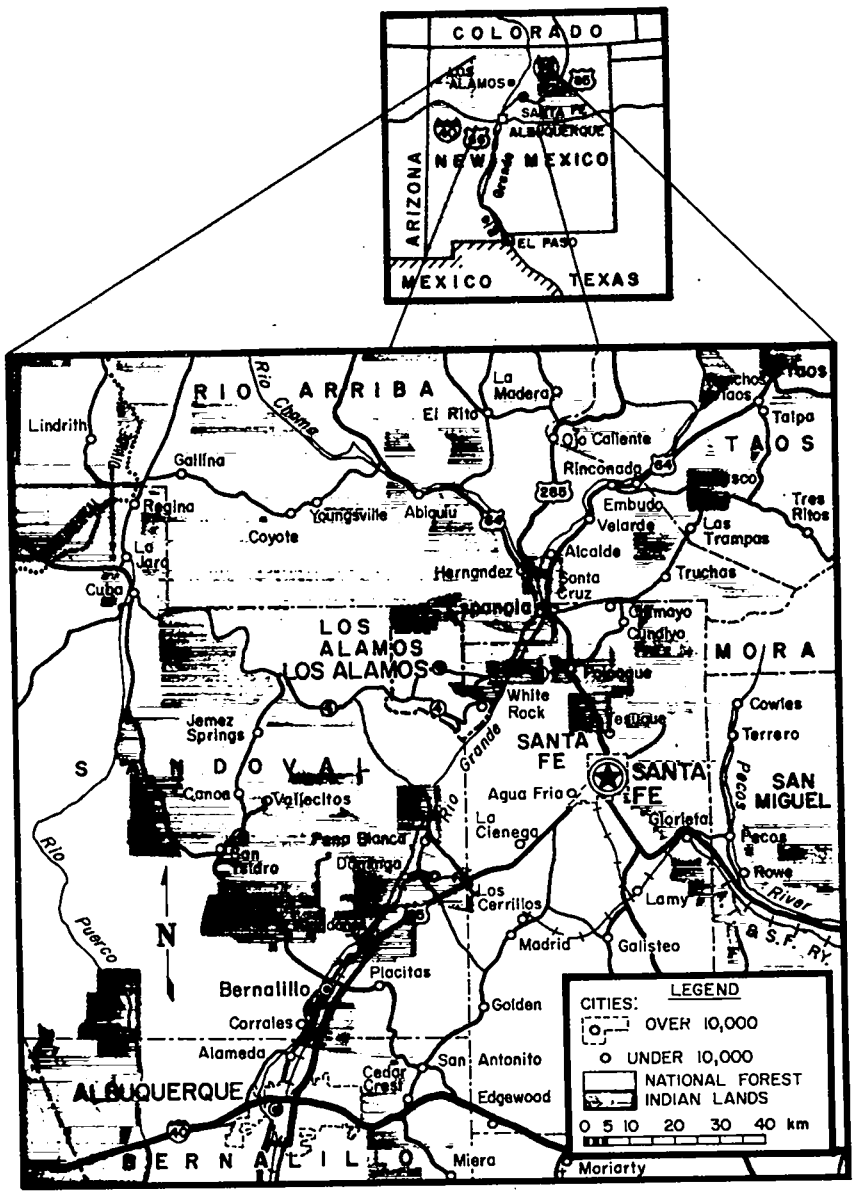

Fig. 2. North-central New Mexico.

controls available to the public. Additionally, in accordance with our contractual agreement, it has been prepared in compliance with the requirements specified in AEC Manual Chapter 0513.

1. Physical Setting. The Los Alamos Scientific Laboratory and its resident communities of Los Alamos and White Rock are located in Los Alamos County in north-central New Mexico. They are situated on the Pajarito Plateau, west of the Rio Grande on the eastern slopes of the Jemez Mountains, with the Laboratory site covering about 110 km^2.

The area surrounding Los Alamos, including Los Alamos County and portions of Sandoval, Rio Arriba, and Santa Fe Counties, is largely undeveloped except for those areas occupied by the Laboratory facilities and associated communities. Large tracts of land north, west, and south of the Laboratory site are held by the U. S. Forest Service and U. S. National Park Service. Sacred Indian land borders the Laboratory to the east. (See Figs. 1 and 2). The major biomes of the area are coniferous forests and piñon-juniper bushlands which support a typical variety of western mountain wildlife.

2. Meteorology. The Los Alamos area has a semiarid, temperate climate, the details of which vary with altitude. The summertime has a high frequency of orographic thunderstorms. Migratory winter cyclonic scale disturbances account for a full variety of midlatitude winter weather.

Climatological Records

Table I shows the means and extremes of temperature and precipitation for the entire period of record and, separately, for 1974. Taken as a whole, 1974 was remarkably close to average, although individual months differed significantly from their long-term averages. After a cool, wet January, spring and summer were warm with precipitation below average. The moisture deficit was made up in October. Fall and early winter temperatures were quite cold.

Winds

Wind roses shown in Fig. 3 are presently the best available meteorological indicators of atmospheric transport of contaminants. Maxima in occurrence frequency of winds from northwest and northeast suggest a higher probability of contaminants on the southeast and southwest sides of sources, respectively. The northwesterly maximum is familiar from previous years while the high occurrence of northeast flow represents a departure from the long-term average. The winds presented here were collected from one location on the roof of the Administration Building in TA-3. Extension to other sites should be made with extreme caution because of the terrain variations and the previously observed dependency of winds on measurement sites. The dependence of the wind roses on stability is not very distinct except for a northerly drainage wind contribution in stable conditions. Figure 4, derived from the wind roses, is a simple Gaussian plume diffusion model which provides an estimate of annual average dilution factors for a continuous source located near ground level in the main technical area of the Laboratory.

3. Population and Economy. The north-central portion of New Mexico contains approximately one-half million people, of whom nearly 70% are concentrated in Albuquerque and another 10% are located in Santa Fe. Within Los Alamos County, about 12 000 people live in the residential area of Los Alamos proper and some 5000 more reside in the White Rock area. The remainder of the population is distributed among small towns and Indian Pueblos ranging in size from a few hundred to a few thousand inhabitants.

The economy of the Santa Fe/Los Alamos area is based largely on government operations (LASL and the New Mexico State government offices in Santa Fe), large tourist trade, arts and crafts, and some light service industries. Subsistence agriculture is practiced to a limited extent within 20-40 km of Los Alamos. In the immediate

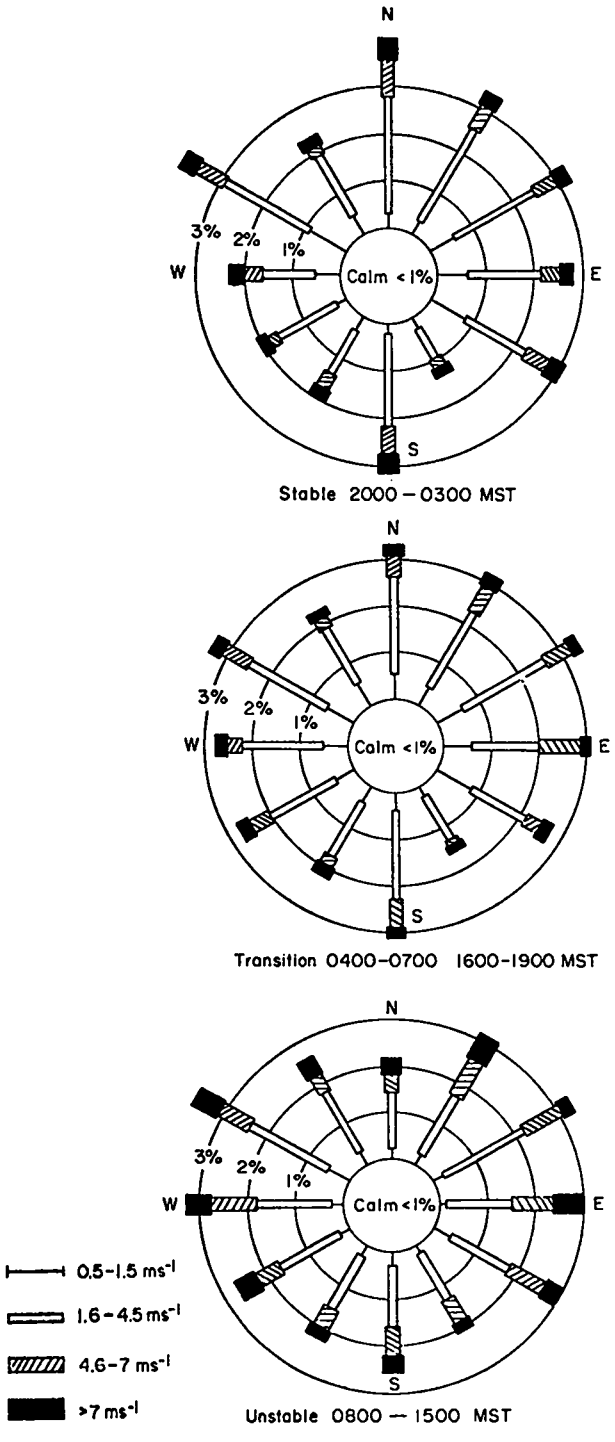

Fig. 3. 1974 wind roses.

area (<20 km from the LASL) many people raise vegetables in home gardens, but very rarely depend on this activity for more than a small fraction of their subsistence.

4. Environmental Releases from LASL Operations. The principal mission of the Laboratory is the design and development of nuclear weapons. This program is supported by extensive research programs in nuclear physics, hydrodynamics, conventional explosives, chemistry, metallurgy, radiochemistry, and biology. In addition, considerable effort is being directed toward the peaceful uses of nuclear energy, including medium-energy physics, controlled thermonuclear fusion, laser and geothermal research, nuclear safeguards, biomedical research, and space physics. These endeavors are carried out in 29 active Technical Areas (TA) widely spread over the LASL site (see Fig. 5).

Site facilities include hundreds of potential sources of effluents and wastes. However, processes with the potential for significant releases are confined to only a few locations and are rigorously controlled and monitored.

The major emphases of the environmental monitoring program are dictated by the types and quantities of potentially hazardous materials used in LASL programs and by the ecology and geology of this location. Emphasis is placed on the analyses for tritium, uranium, and plutonium in samples of environmental media. Fission product radionuclides are of lesser concern, due to the minimal amounts handled; some specific analyses are made for radioactive species of cesium and iodine in selected samples.

The radioactive materials released to the atmosphere from LASL operations are shown in Table II. These data were compiled from stack effluent monitoring determinations. The quantity of plutonium released during 1974 is about ten times lower than that released[1] during 1973; the result of improved filtration and operating procedures introduced during 1974. Also,

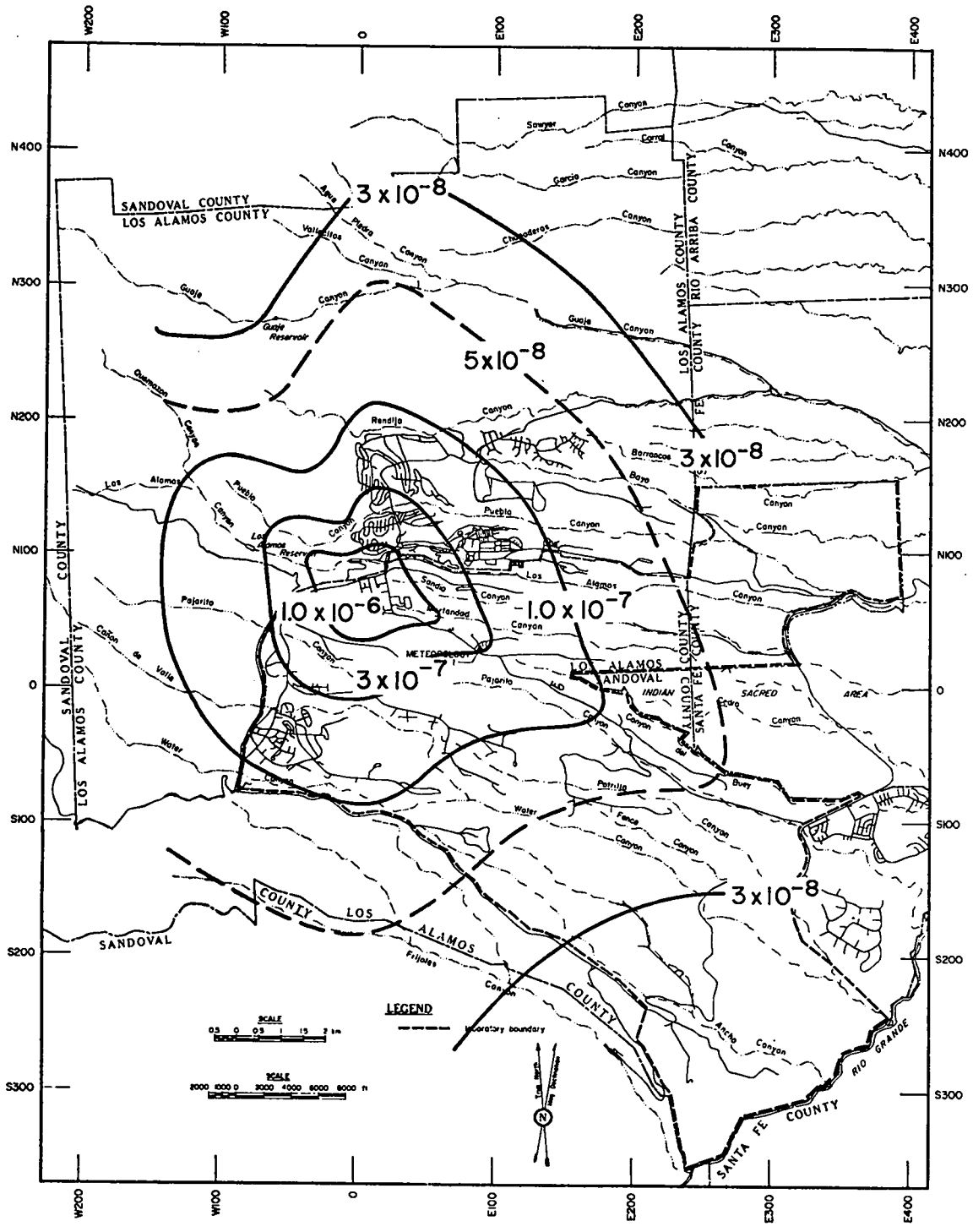

Fig. 4. 1974 plume diffusion model.

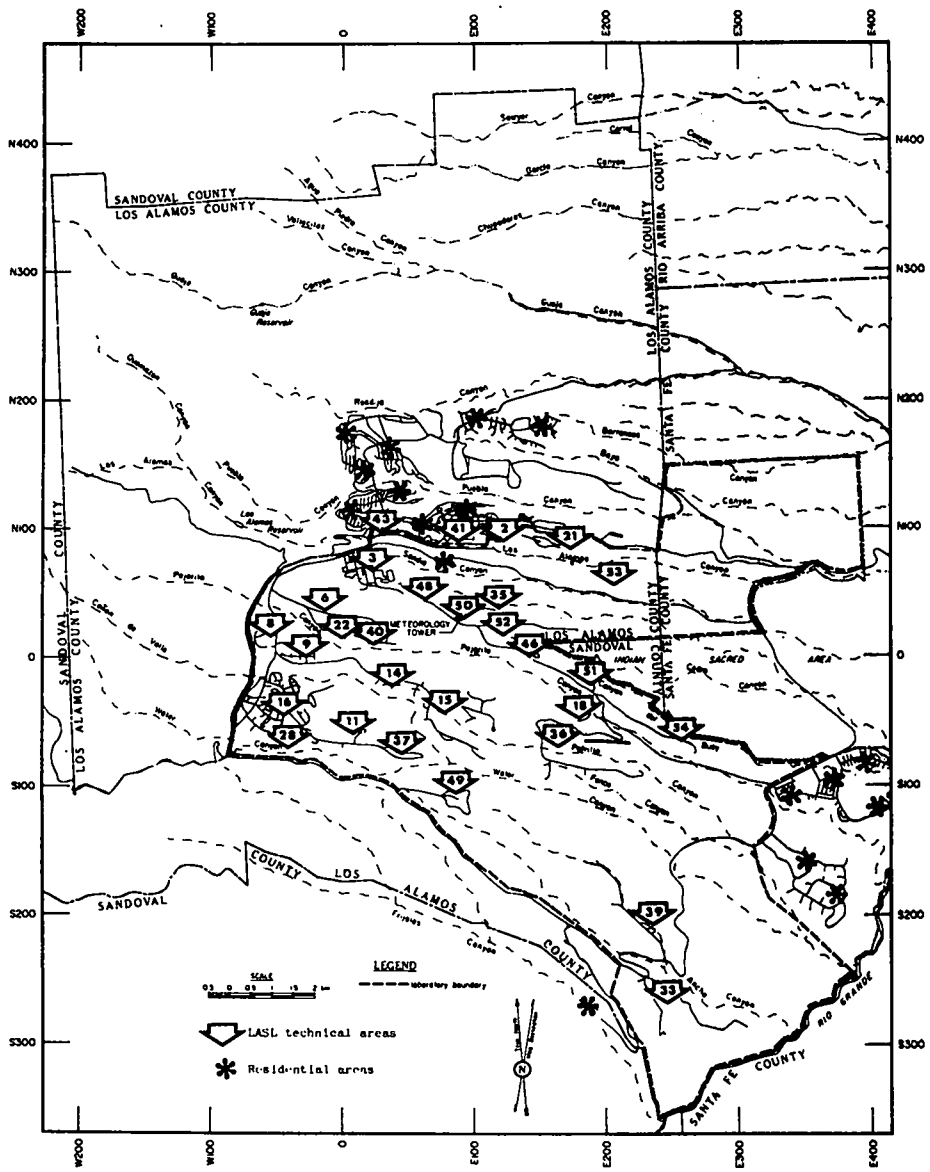

Fig. 5. Los Alamos County residential areas and LASL technical areas (numbered).

releases of ^{88}Rb and $^{133,135}Xe$ have been eliminated as the reactor facility responsible for previous releases has been decommissioned.

II. ENVIRONMENTAL MONITORING

A. Summary of Results

This report summarizes the results of the environmental monitoring program of the LASL. Results of measurements of (1) radioactivity in air, ground and surface waters, sediments and soils, (2) external penetrating radiation, (3) chemical and biological quality of surface and ground waters, and (4) the chemical and radiochemical quality of potable supply waters are presented. The results of the environmental monitoring program for this reporting period confirm the generally low radiation and contaminate levels due to LASL operations previously observed[1,2] in the Los Alamos environs.

External penetrating radiation levels for off-site and perimeter locations were 128 ± 22 and 137 ± 19 mrem/yr. Average concentrations of atmospheric tritium oxide for off-site, perimeter, and on-site locations were 17, 35, and 84 x 10^{-12} μCi/mℓ, respectively. These concentrations are respectively 0.01, 0.02, and 0.002% of the applicable on- and off-site Concentration Guides. Atmospheric long-lived gross-alpha and gross-beta activity concentrations in the LASL environs were 1.3 and 173 x 10^{-15} μCi/mℓ, respectively, or 2.2 and 0.6% of the applicable Concentration Guides. Atmospheric ^{238}Pu and ^{239}Pu concentrations in the LASL environs were 1.7 and 27 x 10^{-18} μCi/mℓ, respectively, which are 0.002 and 0.05% of the appropriate Concentration Guides. Atmospheric uranium concentrations were found to be 0.09 ng/m^3 in the LASL environs, 0.001% of the Concentration Guide.

Radioactivity in surface and ground waters and soils and sediments in the LASL environs were below applicable Concentration Guides. The chemical quality of most surface and ground water samples in the LASL environs met standards set for drinking water. Water samples from some municipal and Laboratory sewage effluent release areas often did not meet drinking water standards. The chemical quality of these samples is typical for such release areas, however, and these releases do not become a source of potable water. The chemical and radiochemical quality of samples of potable supply water were found to meet applicable chemical and radiochemical standards. The only measurable radioactivity above background beyond Laboratory boundaries was from airborne tritiated water vapor. The maximum individual whole body dose at an unoccupied perimeter or off-site location from this tritiated water vapor was calculated to be 0.16 mrem/yr at the boundary of TA-33. The maximum individual dose at an occupied location (Bandelier Lookout) was calculated to be 0.07 mrem/yr which is 0.01% of the individual, and 0.04% of the population, Concentration Guides. The population dose was calculated to be 0.28 man-rem to the 17 000 residents of Los Alamos County. This population dose represents the only measurable dose from Laboratory operations to the population within an 80-km radius of the Laboratory. By contrast, the estimated cosmic, terrestrial, and internal natural radioactivity dose of 144 mrem/yr to each individual[3] would result in a population dose of 2400 and 13 000 man-rem to the residents of Los Alamos County and the approximately 92 000 residents of the 80-rem radius about the Laboratory, respectively.

Two inadvertent releases of radioactive materials occurred on site during 1974. Both were associated with the industrial waste sewer that transports chemically contaminated and radioactive liquid wastes from laboratories at TA-3 to the Central Waste

Treatment Plant at TA-50 (see Fig. 5). One involved a slow subsurface leak from a faulty pipe joint. The second involved an overflow from a manhole during a test of the newly installed replacement sewer line. Contamination resulting from both incidents was successfully removed and no exposures to on- or off-site personnel are known to have occurred. In each incident most of the radioactivity was due to ^{238}Pu; other isotopes detected include ^{89}Sr, ^{90}Sr, and ^{137}Cs.

B. Statement of Particulars

1. Geographic Coordinate System. All Los Alamos County (and vicinity) locations referenced in this report are identified by the LASL Cartesian coordinate system (shown in Fig. 5) standard throughout the Laboratory. This coordinate system is completely independent of the U. S. Geological Survey and the New Mexico State Survey coordinate systems. The major coordinate markers shown on the maps are at 10 000-ft (3.048-km) intervals, but for the purposes of this report, locations are identified to the nearest 1000 ft (0.30 km). The area within the LASL boundaries (Figs. 1 and 5) is a controlled area over which the Laboratory has the capability of strict control. Some of the more remote and little used regions are not routinely controlled to public access, but most of the Laboratory area is restricted for reasons of safety and security.

2. Units of Measurement and Statistical Treatment of Data. As of 1974, all LASL scientific and technical documentation uses metric units, and conversion to the International System of Units (SI) is advised wherever practicable. Table III provides conversions for the units of measure used in this text.

The data in this report are annual averages of individual measurements of environmental conditions or concentrations. For many environmental measurements, particularly those from which a chemical or instrumental background must be substracted, it is possible to obtain net values that are lower than the minimum detection limit (MDL) of the system (see Table IV). It is not uncommon for individual measurements to result in values of zero or negative numbers due to statistical fluctuations in the measurements. Although a negative value for an environmental measurement does not represent a physical reality, a valid long-term average of many measurements can be obtained only if the very small or negative values are included in the population. For this reason, the primary value shown in the numerical tabulations in this report is the actual value obtained from an individual measurement or group of measurements. These primary values are those used in making subsequent statistical analyses and in evaluating the real environmental impact of Laboratory operations. To provide an indication of the validity of each numerical value, an additional value is included in parentheses immediately following each primary numerical value. The interpretation of the value in parentheses is designated by the sign preceding that value.

(± X) indicates that the primary value preceding the parentheses is greater than the MDL, and the parenthetical value indicates the range of the 95% confidence interval for the primary value, i.e., twice the standard deviation assuming Gaussian statistics.

(< Y) indicates that the primary value preceding the parentheses is lower than the MDL, and the parenthetical value represents the two-sigma MDL for that particular measurement.

The statistical distribution of annual averages of environmental conditions or concentrations deserves attention. Most annual-average data are analyzed with respect to a Gaussian or normal distribution. Many environmental data, however, do not fit the normal distribution law; instead, the distributions are often asymmetrical or skewed toward the higher values. It has been observed that even though the data are not normally distributed, the logarithms of the

data quite often obey the normal law. We have used the log-normal probability distribution in describing some of the environmental data reported herein. It is intended that the use of the geometric mean and standard deviation parameters will tell more about the data set than would the conventional arithmetic mean and standard deviation. A more detailed explanation of the log-normal analysis has been presented previously.[1]

3. Standards for Environmental Contaminants. The concentrations of radioactive and chemical contaminants in air, water, sediment, and soil samples collected throughout the environment are compared with the standards contained in regulations of several Federal and State agencies to verify the compliance of the Laboratory with all pertinent standards. LASL operations, including environmental quality control, are conducted in accordance with the directives and procedures contained in the AEC Manual, particularly Part 0500, Health and Safety, Chapters 0510, 0511, 0513, 0524, and 0550.

In the case of radioactive materials in the environment, the standards contained in AECM 0524 (see Table V) take precedence over other Federal or State regulations. However, the AEC standard for uranium in water (1500 and 60 mg/ℓ for controlled and uncontrolled areas, respectively) is not believed to be realistic since it does not consider chemical toxicity. For the purposes of this report, the ICRP[4] uranium water standards of 60 mg/ℓ for an occupational 40-h week and 1.8 mg/ℓ for a nonoccupational 168-h week are preferred. For atmospheric uranium, the AEC and ICRP standards are in agreement. For other kinds of pollutants, e.g., biological or chemical, the controlling standards are those promulgated by either the Environmental Protection Agency or the appropriate State agencies (see Table VI).

4. Quality Control Program. The analyses of quality control samples along with routine samples has been extended to virtually all types of samples analyzed in the radiochemistry laboratory. The blanks, standards, and replicates are prepared in the quality control laboratory and submitted blind to the environmental radiochemistry laboratory for routine analysis. Quality control samples total 10-15% of all samples analyzed.

Until early in 1974, all radiochemical analyses were performed in the analytical laboratory located in the liquid radioactive waste treatment facility. Data from blank samples analyzed in 1973 showed a measurable level of contamination acquired in the Laboratory as a result of exposure to the waste treatment operations in the building. Prior to 1973, the plutonium in samples analyzed ranged from the detection limit to about 10^3 times the detection limit. During 1973, new research programs were initiated which required analyses with plutonium activity as high as 10^6 times the detection limit. As a result, a second environmental radiochemistry laboratory was established, in a relatively uncontaminated facility, specifically for the analyses of background-level samples. Virtually all sample data included in this report were taken in the low-level facility. The blank and swipe data given below verify that the low-level facility was essentially free from plutonium contamination.

Control Sample	Activity (pCi/sample)						No. of Samples
	^{238}Pu			^{239}Pu			
	Min.	Max.	Mean	Min.	Max.	Mean	
Air Filters	-0.005	0.015	0.000	-0.005	0.030	0.003	14
Water (500 mℓ)	-0.015	0.001	-0.002	-0.018	0.017	0.002	17
Soils (10 g)	-0.007	0.04	0.004	-0.016	0.042	0.004	19
Swipes	-0.013	0.022	0.003	-0.008	0.012	0.005	14

The blank samples used were chosen as follows: unused air filters, of the same type as those used in the atmospheric monitoring program, were used for the air particulate analyses; de-ionized water provided the water sample blank; and soil taken from beneath

a building constructed prior to 1940 was used as the soil blank. It should be noted that the soil blank has a high natural thorium content, and occasionally thorium daughter activity appears in the plutonium spectral region elevating the alpha background and thus the detection limit. The maximum values for the soil blanks shown above reflect this elevated background level in two of the 19 soil blanks. The 14 filter paper swipes of laboratory working surfaces were taken near the end of the year. The detection limit of the procedure is 0.02 pCi/sample. None of the values for any of the blanks or swipes were statistically different from zero.

The analytical procedure for plutonium was modified this year to improve the chemical recovery and the quality of the electrodeposited planchets. In addition, the sample-to-detector distance in the measurement system was increased and the counting efficiency was reduced from 30% to 19% in exchange for a 10-15% improvement in resolution. Collectively, these changes have improved the average resolution of the alpha spectra from 80-90 keV to ≈60 keV (full width at half-maximum), thereby eliminating loss of data due to peak-to-peak interference in the alpha spectra. Also, the average tracer recovery for the plutonium has increased from ≈40% with the old procedure to 75-90% with the new procedure, depending on sample type.

The environmental radiochemical analysis laboratory participates in the Laboratory Intercomparison Program sponsored by the EPA's National Environmental Research Center, Las Vegas, NV. In this program, results submitted by participating laboratories are compared with EPA values and the average of all participating laboratories. The results for the analyses of water samples for tritium and gross-alpha and gross-beta activities are shown below.

EPA INTERCOMPARISON PROGRAM

Date	LASL Environmental Analytical Lab	EPA Value	Average of Participating Laboratories
	Tritium in Water (nCi/ℓ)		
1-74	1.8 ± 0.6	1.8 ± 0.3	1.8 ± 0.3
3-74	3.8 ± 0.4	3.4 ± 0.3	3.3 ± 0.3
5-74	3.1 ± 0.4	2.7 ± 0.4	2.7 ± 0.2
10-74	2.9 ± 0.4	2.0 ± 0.4	2.0 ± 0.3
	Gross α in Water (pCi/ℓ)		
7-74	29 ± 3	75 ± 19	59 ± 26
9-74	13 ± 2	25 ± 6	21 ± 8
	Gross β in Water (pCi/ℓ)		
7-74	108 ± 2	103 ± 5	112 ± 21
9-74	82 ± 3	77 ± 5	80 ± 15

In 1974, this laboratory used electroplated standards for gross-alpha and gross-beta analyses. This calibration procedure resulted in low measured gross-alpha values due to self-absorption in the environmental samples which have some dissolved solids. More representative standards are being prepared for both gross-alpha and gross-beta analyses of soils, water, and air particulate filters for the coming year.

C. Radioactivity Monitoring

1. External Penetrating Radiation Procedures

Exposure from external penetrating radiation (primarily gamma radiation) in the LASL environs is monitored by 22 thermoluminescent dosimeter (TLD) stations, of which 10 are located along the perimeter of the Laboratory (within about 1/2 km of the boundary), and 12 are located beyond the Laboratory boundaries. (Locations are given in Fig. 6, map coordinates identify locations in the data tabulation). One group of 8 stations, on a 4-wk integration cycle, covers normal LASL and Los Alamos County locations, while a second group consisting of 14 stations, on a 13-wk integration cycle, includes Espanola, Pojoaque, Santa Fe, Pajarito Ski Area, and LASL and Los Alamos County locations. Most of the 26 air sampling stations also serve as TLD stations. The TLD monitoring locations were

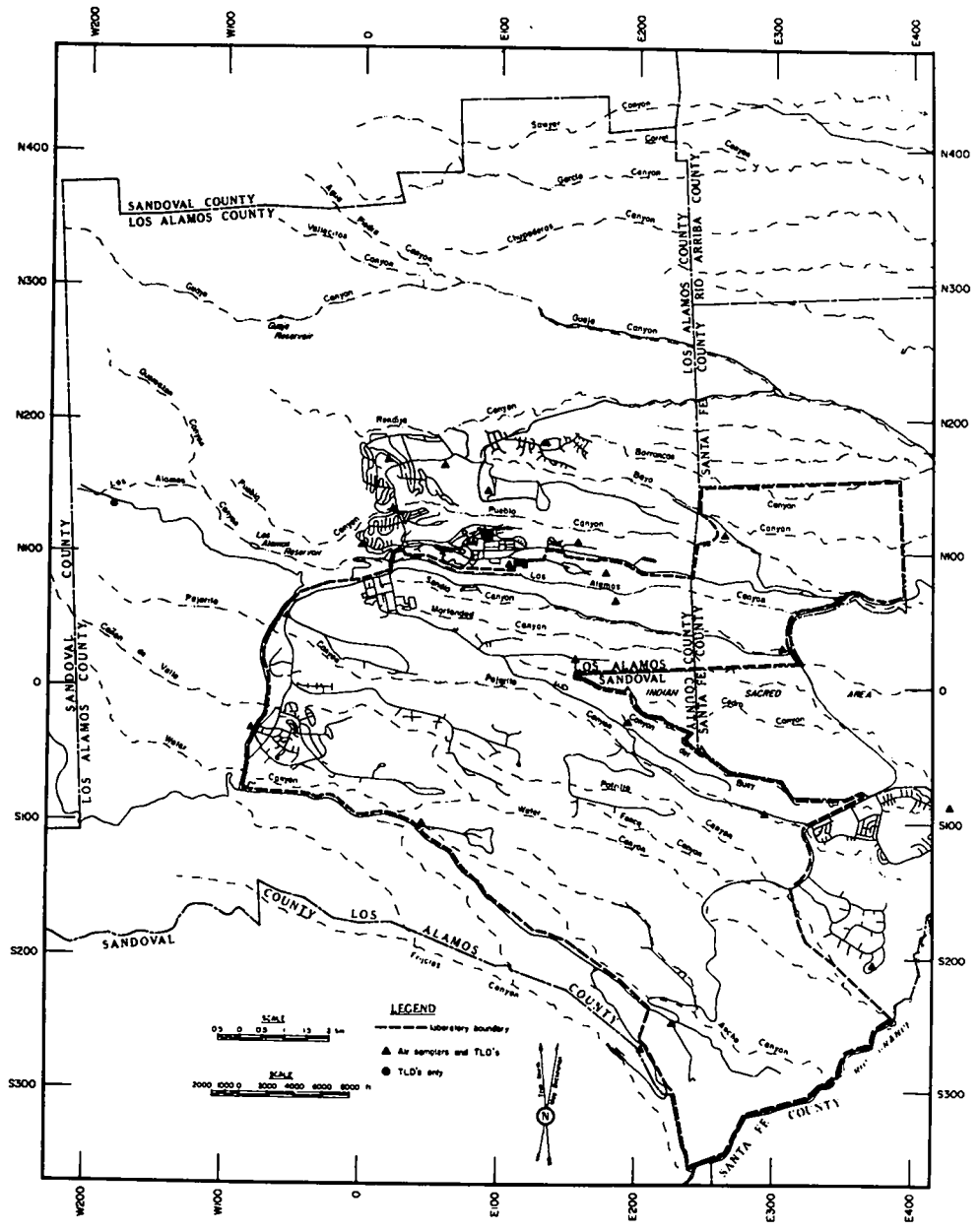

Fig. 6. TLD and air sampler locations.

selected to reduce systematic radiation differences caused by variations in natural background radiation. Each of the TLD monitors consists of 3 Harshaw TLD-100® chips 6.4 mm square by 0.9 mm thick. The chips are heat-sealed in an opaque polyethylene envelope which is sealed in an opaque 7-mℓ polyethylene vial for placement in the field. The TLDs are annealed, calibrated and read via standard techniques. Calibration is accomplished with ^{60}Co gamma rays, and the conversion factor from observed dose in rads to dose equivalent in rems is assumed to be unity.

Results

The annual external penetrating radiation dose values determined from the TLD environmental radiation monitoring program are summarized in Table VII according to off-site and perimeter locations. These dose values are the total dose integrals for 1974 for each station. Parenthetical values represent twice the square root of the variance of the integrals, i.e., the 2 σ 95% confidence interval. The annual dose variance is the sum of the variances of the individual monthly or quarterly dose measurements and is not related to the temporal distribution of the individual dose measurements. Monthly and quarterly variances are derived from the distribution of individual TLD readings, error of calibration, instrumental background subtraction, etc.

Temporal variations in environmental gamma radiation were generally less than 50%. Significant spatial variations were observed, however, which result from differences in the terrestrial component of external environmental gamma radiation. These differences are related to the topography, geology, hydrology, and meteorology of the monitoring site. Elevation is an important factor in natural radiation levels because of atmospheric shielding of cosmic radiation. Accordingly, the lowest levels of environmental gamma-radiation dose were observed at Espanola and Pojoaque (station elevations are given in Table VII). On the Pajarito Plateau, levels around 135 mrem/yr are observed, with approximately 60% of the dose being from cosmic sources and the remainder terrestrial. There was no indication of LASL-related dose at any of the environmental dosimeter stations. The arithmetic mean and arithmetic standard deviation for the distributions of off-site and perimeter dose values are 128 ± 22 and 137 ± 19 mrem/yr, respectively. The environmental gamma radiation data are not characterized by a typical Gaussian curve but are distributed assymetrically toward the higher values. Hence a log-normal treatment is applicable. The geometric mean and geometric standard deviation for the off-site and perimeter distributions are 126, 1.20 and 136 mrem/yr, 1.16, respectively. The average off-site dose and average perimeter dose are statistically indistinguishable.

Various cross-checks of the LASL TLD system are planned for 1975. These include high-pressure ion chamber measurements at TLD locations to determine variations in cosmic and terrestrial radiation, comparison with a different TLD system, and spectral measurements to determine those isotopes contributing to the external penetrating radiation dose.

2. Radioactivity in Air

Sampling Procedures

Atmospheric radioactivity samples were collected at 26 continuously operating air sampling stations in Los Alamos County and vicinity. Station locations are shown in Fig. 6 and map coordinates identify locations in the data tabulations. Samples were collected over 2-wk periods. "Hi-Vol" air pumps with flow rates of approximately 3 ℓ/s were used in the network. The atmospheric aerosol was collected on a 79-mm-diam polystyrene filter. A fraction of the total air flow (approximately 2 mℓ/s) was passed in parallel through a cartridge containing silica gel adsorbent which collects atmospheric water vapor for tritium analysis. Air flow rates through both

sampling cartridges were monitored with variable-area flow meters, and sampling times were recorded with electric clocks.

Table V contains a listing of concentration guides (CGs) for several radioactive species in air and water for uncontrolled and controlled areas. Referring to Fig. 6 and Tables IX through XII, monitoring stations 1 through 12, 14, 17, 20, and 21 are outside the LASL boundary, and concentrations for these locations are compared to CGs for uncontrolled areas. All other stations, however, are within the LASL boundary where the CGs for controlled areas apply. Table VIII summarizes the results of the atmospheric radioactivity monitoring program for CY 74.

Daily Radioactivity

Atmospheric radioactivity samples were collected daily at TA-3 (N50E40) with a Hi-Vol sampler similar to those used in the bi-weekly sampling. The daily atmospheric aerosol filter was counted for gross-alpha and gross-beta activities on the day of collection and again 7 to 10 days after collection. The first measurement could provide an early indication of a major change in general atmospheric levels. The data from the second measurement were used to observe temporal variations in long-lived atmospheric radioactivity.

Gross-beta activities from the second measurement of the daily aerosol samples are shown in Fig. 7. Temporal variation of these data is typical for gross-beta activity arising from world-wide fallout. These atmospheric radioactivity data did not show evidence of the cloud from foreign atmospheric nuclear tests during the year.

Tritium

Silica gel cartridges from the 26 air sampling stations were analyzed bi-weekly for tritiated water. Water was distilled from each silica gel sample giving a 2-wk average atmospheric water sample. A standard aliquot of the distillate was analyzed for tritium by liquid scintillation counting. The resultant tritium concentration was then multiplied by the measured absolute humidity to give the 2-wk average tritiated water vapor concentration in air.

The 2-wk concentrations for each station were averaged for CY 74 and are presented in Table IX. Parenthetical values represent twice the propagated measurement errors, i.e., 2 σ, associated with the annual averages. The variance σ^2 for the annual concentration is the sum of the variances of the individual bi-weekly concentration measurements divided by the square of the number of measurements, and is not related to the temporal distribution of the individual measurements. Bi-weekly concentration variances are derived from nuclear counting statistics, air sample volume uncertainties, etc. The data of Table IX are grouped according to off-site, perimeter, and on-site sampling locations. Minimum values are not presented as they generally did not exceed the MDL for the analysis. The highest observed annual concentration for an uncontrolled area (Bandelier Lookout) was 64 x 10^{-12} μCi/mℓ, and for a controlled area the highest value was 141 x 10^{-12} μCi/mℓ measured at TA-33. These concentrations are respectively 0.03% and 0.003% of the off-site and on-site CGs specified for tritium in air. The tritium concentrations reported herein, as well as the CGs, are for atmospheric tritium oxide. The arithmetic mean and arithmetic standard deviation for the distributions of off-site, perimeter, and on-site annual average tritium concentrations are 17 ± 9, 35 ± 18, 84 ± 39 x 10^{-12} μCi/mℓ, respectively. The atmospheric tritium oxide data are not characterized by a typical Gaussian curve but are distributed asymetrically toward the higher values. Thus, a log-normal treatment is applicable. The geometric mean and geometric standard deviation for these three distributions are 15, 1.67; 31, 1.77; and 76 x 10^{-12} μCi/mℓ, 1.69, respectively. LASL-related spatial variations generally obscure

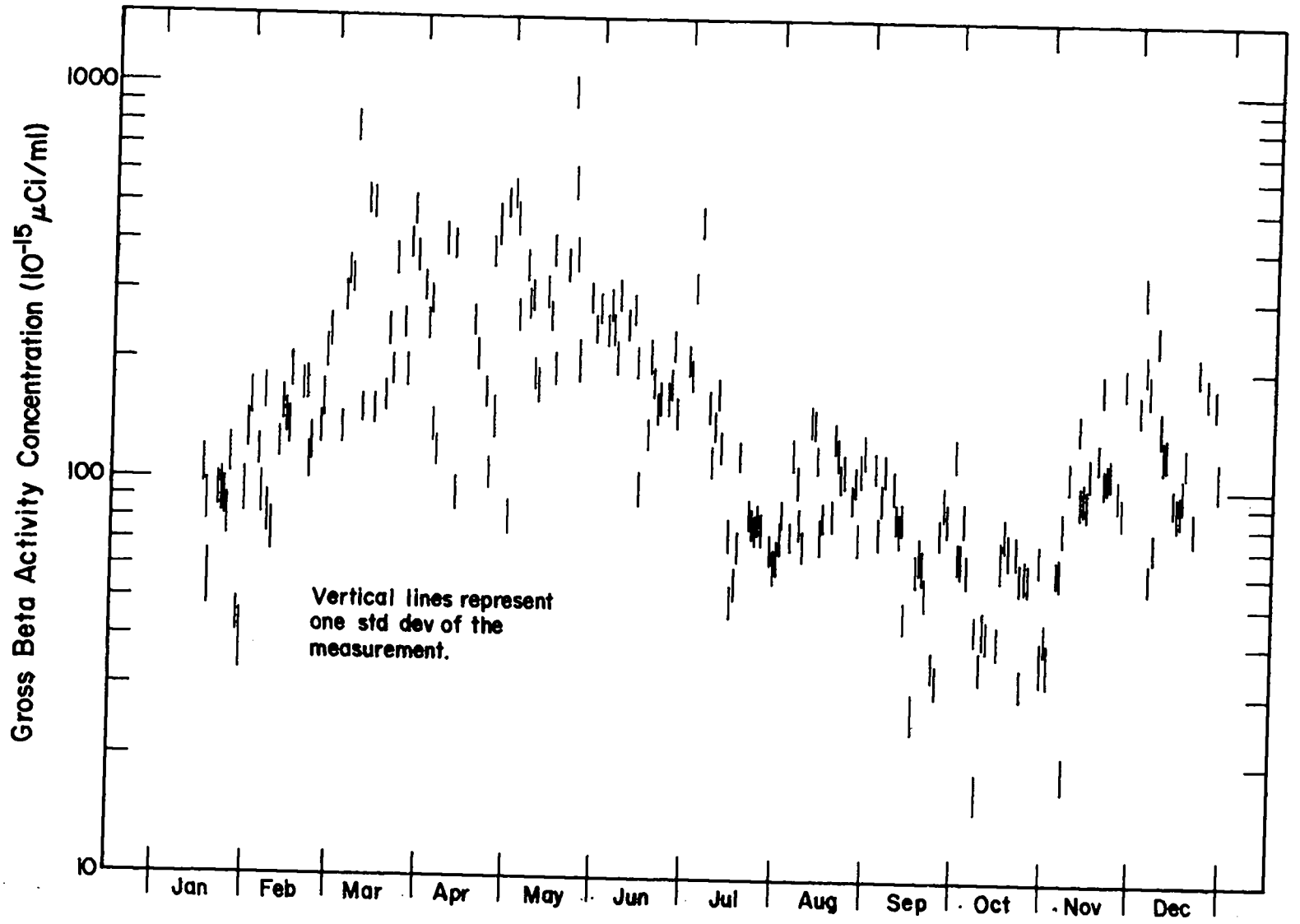

Fig. 7. Gross-beta activity concentrations in daily air samples for 1974.

any temporal variations in atmospheric tritium oxide concentration.

Gross Radioactivity

On the first and tenth day after collection, gross-alpha and gross-beta activities on the bi-weekly air filters were measured with a gas-flow proportional counter. The first count was used to screen the samples for inordinate levels of activity. The second count, free from the activity of the natural radon and thoron daughters, provided a record of long-lived atmospheric radioactivity. The annual average bi-weekly gross-alpha and gross-beta activity concentrations are presented in Table X. Parenthetical values represent twice the propagated measurement errors, i.e., 2 σ, associated with the annual averages. (See atmospheric tritium section for error explanations.) The data are grouped according to off-site, perimeter, and on-site sampling locations. For gross-alpha activity the 26 annual average concentrations are normally distributed around an arithmetic mean of 1.3×10^{-15} μCi/mℓ and have a standard deviation of 0.1×10^{-15} μCi/mℓ. The data give no evidence for systematic spatial variations in annual averages, and the arithmetic means for these three location groups are statistically indistinguishable. The highest average gross-alpha concentration, observed at Arkansas Avenue, is 2.5% of the CG for an uncontrolled area. For the gross-beta activity, the 26 annual average concentrations fit a normal distribution with an arithmetic mean and standard deviation of $173 \pm 13 \times 10^{-15}$ μCi/mℓ. Statistically significant spatial variations are not indicated among stations, and the arithmetic means for the three location groups are statistically indistinguishable. The highest observed annual concentration of 201×10^{-15} μCi/mℓ (at Fuller Lodge) is 0.7% of the CG for an uncontrolled area. Significant temporal variations in long-lived gross-alpha and gross-beta concentrations were observed, typical for North America and representing seasonal mixing of stratospheric nuclear debris into the troposphere. Concentrations varied by as much as a factor of about 7, with the maximum occurring around late April and the minimum around October (cf. Fig. 7).

Plutonium and Americium

After being measured for gross-alpha and gross-beta activities, the bi-weekly filters for each station were combined and dissolved to produce composite four-week samples for each station. An aliquot of each sample was saved for uranium analysis, and plutonium was separated by anion exchange from the remaining solution. The purified plutonium samples were 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 and ^{239}Pu were then integrated, and the concentration of each radionuclide in its respective air sample was calculated. This technique does not differentiate between ^{239}Pu and ^{240}Pu. For 11 stations with a distribution representative of the main air sampling network, the resulting solutions from the plutonium separations were combined to represent 13-wk samples. Americium concentrations were then determined from these solutions by gamma-ray spectrometry.

The 4-wk ^{238}Pu and ^{239}Pu concentrations for each station are listed in Table XI, according to off-site, perimeter and on-site sampling locations. Parenthetical values represent twice the propagated measurement errors, i.e., 2 σ, associated with the annual averages. The variance σ^2 for the annual concentration is the sum of the variances of the individual 4-wk concentration measurements divided by the square of the number of measurements, and is not related to the temporal distribution of the individual measurements. Four-week concentration variances are derived from nuclear counting statistics, air sample volume uncertainties, etc. Minimum values are not presented as they generally did not

exceed the MDL for the analysis. The highest observed annual ^{238}Pu concentration for an uncontrolled area (Diamond Drive) was 10.6×10^{-18} μCi/mℓ, and for a controlled area was 3.8×10^{-18} μCi/mℓ measured at TA-6. These concentrations are, respectively, 0.015% and 0.0002% of the CGs specified for ^{238}Pu in air. The ^{238}Pu average concentration value for the Diamond Drive station deviates from the normal range of values. This average is erratic because of one measurement of 105×10^{-18} μCi/mℓ observed for January. The January value is believed to be unrealistic since a release and dispersion of ^{238}Pu from the Laboratory would most likely be noted at several stations. The high value for this sample is probably due to contamination of the sample in the Laboratory previously used for environmental chemistry. Since the datum could not be unequivocally discredited, it was included in this compilation. For ^{239}Pu, the highest observed annual concentration for an uncontrolled area (Diamond Drive) was 33×10^{-18} μCi/mℓ, and for a controlled area the highest value was 31×10^{-18} μCi/mℓ at TA-49 and LAMPF. These concentrations are, respectively, 0.06% and 0.002% of the CGs specified for ^{239}Pu in air. The arithmetic mean and arithmetic standard deviation for the distributions of off-site, perimeter, and on-site annual average ^{238}Pu concentrations are 2.1 ± 2.9, 1.5 ± 0.9, and $1.3 \pm 0.8 \times 10^{-18}$ μCi/mℓ, respectively. For ^{238}Pu, the arithmetic mean and arithmetic standard deviation for the distributions of off-site, perimeter, and on-site annual average concentrations are 27 ± 5, 27 ± 4, and $26 \pm 3 \times 10^{-18}$ μCi/mℓ, respectively. These data do not suggest statistically significant spatial variations for plutonium concentrations. Multiple high-efficiency particulate air (HEPA) filters were installed for the TA-3 source of airborne plutonium during early CY 74, thereby significantly reducing total plutonium output. Also, improvements in the radioanalytical chemistry procedure for plutonium enhanced the reliability of the data.

Significant temporal variations in atmospheric plutonium concentrations were observed during 1974. These variations closely parallel the pattern manifest in the daily long-lived (fallout) gross-beta concentrations shown in Fig. 7. For ^{239}Pu, the maximum concentrations occurred in April with an all-station average of about 90×10^{-18} μCi/mℓ. The minimum, observed in October, had an all-station average of about 6×10^{-18} μCi/mℓ. For ^{238}Pu, the data are more erratic because of severe detectability limitations. Nevertheless, the same general temporal pattern was observed. These observed seasonal variations suggest that atmospheric plutonium in the LASL environs is from the synoptic injection of stratospheric nuclear debris into the troposphere. The ratio of ^{239}Pu to ^{238}Pu observed for all stations during 1974 was about 16:1 (and without station 5, about 20:1.)

The 13-wk ^{241}Am concentrations for the 11 selected stations are not presented in tabular form. None of these atmospheric concentrations exceeded the MDL of 300×10^{-18} μCi/mℓ for the technique. This MDL is 0.15% of the CG for atmospheric ^{241}Am in an uncontrolled area and 0.005% for a controlled area.

Uranium

For each of the 26 stations a sample was composited, with aliquots taken from the dissolution for the plutonium procedure, to represent a 13-wk sampling period. The uranium content of the samples was determined by fluorometric techniques, and quarterly atmospheric uranium concentrations were calculated. The 13-wk uranium concentrations for each station were averaged for CY 74, and are presented in Table XII according to off-site, perimeter, and on-site sampling locations. Parenthetical values represent twice the propagated errors, i.e., 2 σ, associated with the annual averages. The variance σ^2 for the annual

concentration is the sum of the variances of the individual 13-wk concentration measurements divided by the square of the number of measurements, and is not related to the temporal distribution of the individual measurements. The 13-wk concentration variances are derived from instrumental uncertainties, air sample volume uncertainties, etc. Minimum values are not presented as they generally did not exceed the MDL for the analysis. The fluorometric analysis does not differentiate isotopes of uranium, and the annual average concentrations are thus given in ng/m^3. The highest observed annual uranium concentration for an uncontrolled area (Espanola) was 0.23 ng/m^3, and for a controlled area the highest value was 0.13 ng/m^3 measured at Booster P-1. These concentrations are respectively 0.003% and 0.00006% of the CGs specified for natural uranium in air. The arithmetic mean and arithmetic standard deviation for the distribution of off-site, perimeter, and on-site annual average uranium concentrations are 0.08 ± 0.06, 0.09 ± 0.03, and 0.09 ± 0.03 ng/m^3, respectively. These average values are statistically indistinguishable.

3. Radioactivity in Surface and Ground Waters. Surface and ground water radioactivity monitoring provides a routine surveillance of the potential dispersion of effluents from LASL operations. Water samples are analyzed radiochemically for plutonium (^{238}Pu and ^{239}Pu), tritium (HTO), and cesium (^{137}Cs) as well as for gross-alpha, beta, and gamma activities. A fluorometric technique is used to measure total uranium concentrations.

On-Site Surface and Ground Waters

Radioactivity concentrations were determined for water samples from six on-site locations that are not Laboratory release areas (Fig. 8, Table XIII). The maximum concentrations for these six stations are shown below.

Analyses	Units	Maximum Concentrations
^{3}H	10^{-6} µCi/mℓ	6.2
^{137}CS	10^{-6} µCi/mℓ	< 0.11
^{238}Pu	10^{-9} µCi/mℓ	< 0.04
^{239}Pu	10^{-9} µCi/mℓ	0.02
Gross α	10^{-9} µCi/mℓ	1.0
Gross β	10^{-9} µCi/mℓ	15.0
U	µg/ℓ	< 1.6

Radioactivity concentrations are low and near or below detection limits.

Radioactivity concentrations for surface and ground water were determined from 24 locations in past and present Laboratory release areas (Fig. 8, Table XIII). The surface and ground waters in these areas are not a source of municipal or industrial water supply, nor do streams in these canyons reach the Rio Grande except during storm runoff.

The radioactivity concentrations observed in Acid-Pueblo Canyon (formerly LASL/AEC property) result from residuals of effluent released into the canyon before 1964. The concentrations in DP-Los Alamos and Mortandad Canyons reflect concentrations from current releases of industrial effluents from the TA-21 and TA-50 treatment plants, respectively. Sandia Canyon receives effluents from the TA-3 power plant and some treated sewage effluent. The maximum concentrations in waters in the canyons are as follows.

Analyses	Units	Acid/ Pueblo	Sandia	DP/ Los Alamos	Mort-andad
^{3}H	10^{-6} µCi/mℓ	10.1	1.7	26.8	76.4
^{137}Cs	10^{-6} µCi/mℓ	<0.21	<0.11	<0.11	1.5
^{238}Pu	10^{-9} µCi/mℓ	0.3	<0.03	0.94	14.0
^{239}Pu	10^{-9} µCi/mℓ	1.4	0.02	0.39	0.84
Gross α	10^{-9} µCi/mℓ	9.8	2.0	10.1	15.1
Gross β	10^{-9} µCi/mℓ	140.0	27.0	670.0	660.0
Total, U	µg/ℓ	<1.6	1.9	3.8	9.0

The observed concentrations of radioactivity are low--at or near detection limits, and are the result of naturally occurring or fallout radioactivity. There are no significant changes in concentrations in these canyons compared to previous reporting

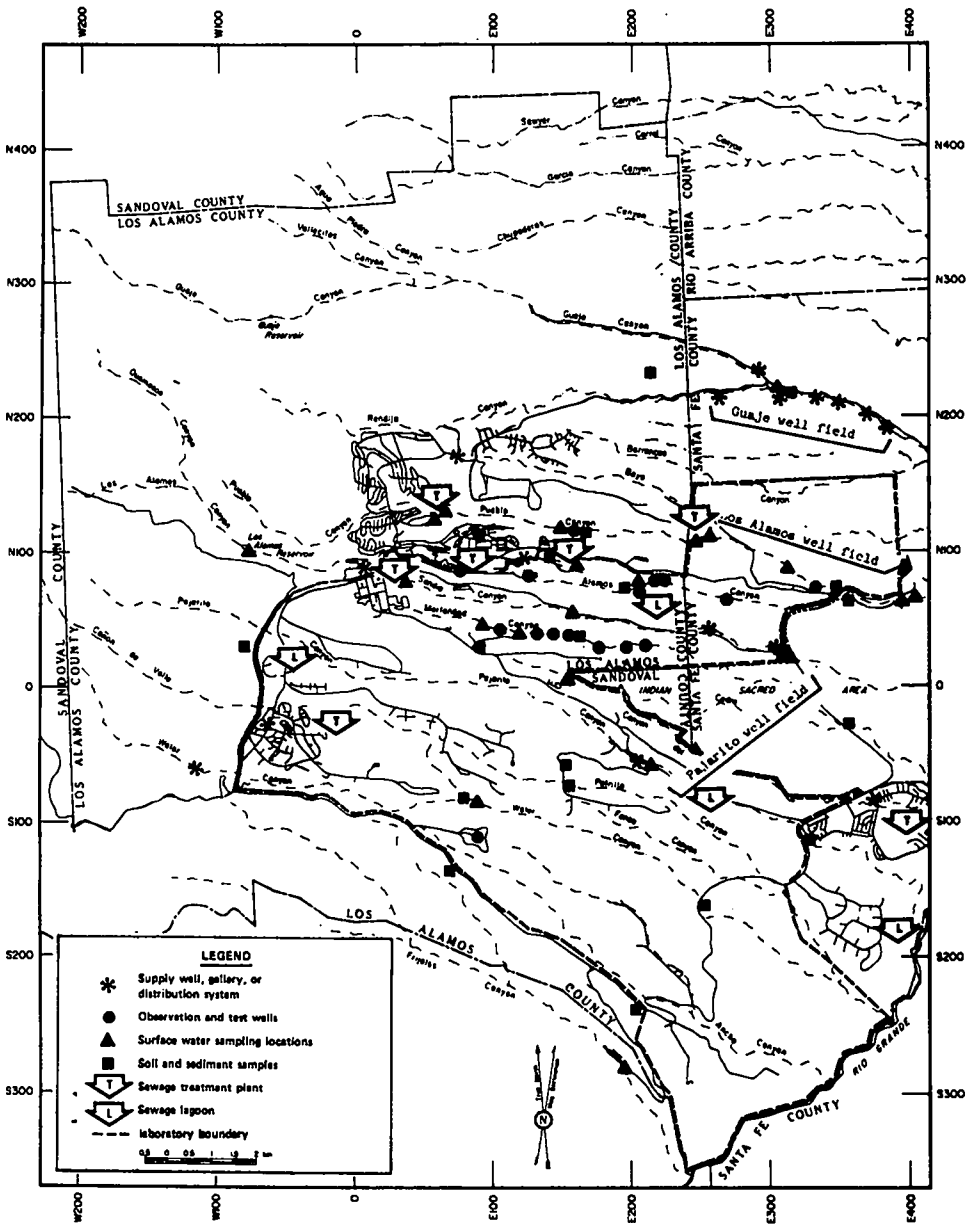

Fig. 8. Water, sediment, and soil sampling locations on or near the LASL site.

periods.[1] In general, the concentration of radionuclides decrease with distance from the effluent outfalls.

Off-Site and Supply Waters

Regional surface waters within 75 km of the LASL are sampled at six locations to ascertain normal levels of radioactivity in waters of the area (Fig. 9, Table XIV). Samples were also collected of perimeter surface and ground waters located <5 km outside the LASL boundary. Six of these stations are located on the Pajarito Plateau and 29 are located in White Rock Canyon (Figs. 8 and 10, Table XIV). Radioactivity concentrations were also determined for 16 wells and 1 gallery of the Los Alamos water supply system, and from 5 stations on the distribution system. The maximum radioactivity concentrations for these waters are

Analyses	Units	Regional Surface Water	Perimeter Surface and Ground Water	Los Alamos Water Supply
^{3}H	10^{-6} µCi/mℓ	1.3	3.8	<0.8
^{137}Cs	10^{-6} µCi/mℓ	0.16	0.11	0.16
^{238}Pu	10^{-12} µCi/mℓ	<80.0	28.0	<46.0
^{239}Pu	10^{-12} µCi/mℓ	<46.0	122.0	40.0
Gross α	10^{-9} µCi/mℓ	3.5	2.8	4.3
Gross β	10^{-9} µCi/mℓ	18.0	11.0	12.0
Total, U	µg/ℓ	5.0	22.0	20.0

The plutonium concentrations are lower than previously reported due to analyses performed in the new low-level facility. The concentrations of radioactivity are low--at or near detection limits--and are the result of naturally occurring or fallout radioactivity.

4. Radioactivity in Soils and Sediments

Soils and Sediments

Soil samples were collected taking five plugs, 75 mm in diameter and 50 mm deep, at the center and corners of a 10-m^2 area. The five plugs were combined to form a composite sample for radiochemical analysis. Sediment samples were collected from dune buildup behind boulders in the main channels of perennially flowing streams. Samples from the beds of intermittently

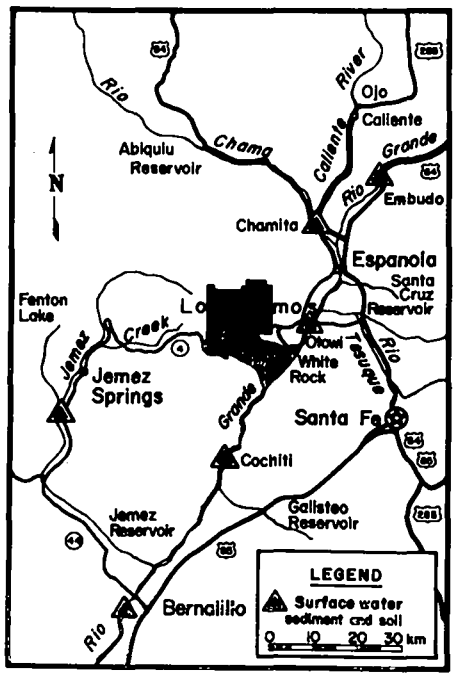

Fig. 9. Regional surface water, sediment, and soil sampling stations.

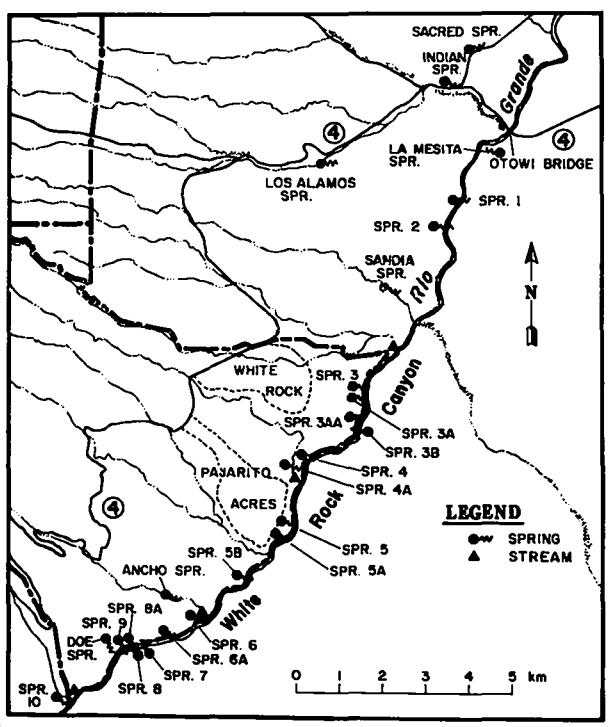

Fig. 10 Water sampling stations in White Rock Canyon.

flowing streams were collected across the main channel. Some soil and sediment samples were collected at on-site locations in the Laboratory area. Soil and sediment samples are analyzed for gross-alpha and gross-beta activities, ^{137}Cs and plutonium (^{238}Pu and ^{239}Pu). Moisture distilled from the soil samples is analyzed for tritium (HTO). (See Fig. 8 and Table XV.) Samples from off-site locations were collected in the same general locations as the regional water samples and analyzed to provide data on the normal concentrations of radioactive materials in the environment beyond the range of possible influence by LASL operations (see Table XV).

The maximum concentrations of radioactivity in regional, perimeter, and on-site soils and sediments are

Analyses	Units	Regional and Perimeter	On-Site
^{3}H [a]	10^{-6} μCi/mℓ	4.5	2.1
^{137}Cs	pCi/g	5.0	2.8
^{238}Pu	pCi/g	0.005	0.002
^{239}Pu	pCi/g	0.041	0.012
Gross α	pCi/g	2.7	2.5
Gross β	pCi/g	22.0	20.0

[a] Soils only, tritium in unbound water distilled from soil.

The on-site concentrations are comparable to regional and perimeter analyses results. The plutonium values are similar to fallout determinations in the region where ^{238}Pu ranged from <0.001 to 0.004 pCi/g and ^{239}Pu ranged from <0.001 to 0.023 pCi/g.[5]

Canyon Studies of Plutonium and Cesium in Soils

A detailed study of three canyon areas which have previously received, or are now receiving, liquid effluents was initiated in 1972 as part of the comprehensive ecological investigations of the LASL site and its environs. The background and periodic results of these studies have been reported elsewhere.[1,2,6] Extensive measurements of plutonium in the alluvial soils of these canyons have been an important part of the radioecology studies, and summarized data are included in this report as an adjunct to the data on soil plutonium from the routine monitoring network. The first set of measurements was reported in the 1973 Environmental Surveillance report.[1] The data presented here (see Table XVI) are for a second set of samples collected from the 33 permanently marked stations. A standard technique was used to obtain cores, 2.5 to 28 cm in depth, depending on the thickness of penetrable soil.[2] These samples were mechanically subdivided according to depth intervals and particle size fractions before radiochemical analysis. The data were combined to obtain the averages and ranges of ^{239}Pu concentrations at each station (see Table XVI).

The highest concentrations of plutonium in DP-Los Alamos and Mortandad Canyons were found at the outfall stations where treated effluents are currently discharged. The maximum in DP-Los Alamos Canyon at the outfall station was 1500 pCi ^{239}Pu/g; all other stations in this canyon had maximum concentrations of 21 pCi/g ^{239}Pu/g or less. The maximum at the outfall station in Mortandad Canyon was 120 pCi ^{239}Pu/g; the station 40-m downgrade had a maximum of 110 pCi ^{239}Pu/g, and all stations at greater distances had maximum concentrations of 14 pCi ^{239}Pu/g or less. The highest concentrations of plutonium in Acid-Pueblo Canyon, (which has not received any waste discharges since 1964) were 500 pCi ^{239}Pu/g observed at the station 80 m from the old outfall site and 2200 pCi ^{239}Pu/g at the 2560-m station. All other stations had maximum concentrations generally decreasing with distance from the outfall locations in all three canyons. At the 5120-m station in DP-Los Alamos Canyon, about 1 km inside the site boundary, the maximum concentration was 0.17 pCi ^{239}Pu/g. At the 5120-m station in Mortandad Canyon, near the site boundary, the maximum concentration was 0.069 pCi ^{239}Pu/g. At the 5120-m station in Acid-Pueblo Canyon, the maximum concentration was 0.51 pCi ^{239}Pu/g.

The portion of Acid-Pueblo Canyon including the reach from the old outfall site to about 5 km downgrade is entirely off-site now because ownership was transferred from the AEC to Los Alamos County in 1967, after decontamination assured the absence of health hazards.

Comparison of data from the two sampling programs shows generally similar levels of plutonium in the alluvial soils, but there are some apparent temporal changes. Decreased soil plutonium concentrations were found in Mortandad Canyon at the 80-, 160-, and 2560-m stations, due to downstream transport and dilution of post-outfall soils by uncontaminated pre-outfalls soils during runoff events. Increased soil plutonium concentrations were found in DP-Los Alamos Canyon at the outfall and 320-m stations due to the addition of effluents and redistribution of material in the canyon. An increase in plutonium concentration from an average of 0.4 pCi total-Pu/g to 870 pCi ^{239}Pu/g was observed at the 2560-m station in Acid-Pueblo Canyon, primarily because deeper core samples were obtained during this second sampling, and plutonium concentrations have been observed to increase with depth in this canyon.[2]

In general, the highest concentrations of plutonium were found on the smallest soil particles. Concentrations of ^{239}Pu on particles <53 μm in diameter were about 9 times higher than those for particles of 2-23-mm diam. However, the highest proportions of the total plutonium inventory were generally found on the coarser soil fractions, reflecting the preponderance of larger particles in the alluvial soils.

The ^{239}Pu/^{238}Pu activity ratios were different for each of the three canyons, reflecting the historic differences in the types of wastes discharged into each canyon.[1] Respective ratios for Acid-Pueblo, DP-Los Alamos, and Mortandad Canyons were 150 ± 72, 5.2 ± 4.5, and 0.26 ± 0.16.

Information relating to the physical transport of radionuclides down Mortandad Canyon was obtained on September 15 following a rainfall of 3.8 cm on the upper Mortandad Canyon watershed that resulted in a total estimated discharge of 3530 m^3 of water. Samples were collected through the subsequent 4.5-h runoff event and measured for concentrations of ^{137}Cs in the liquid and sediment and the amount of suspended sediment in the water. Most samples were collected at the 1200-m post-outfall sampling station above which approximately 75% of the ^{137}Cs inventory resides. Concentrations of ^{137}Cs in sediment ranged from about 200 pCi/g to 600 pCi/g. Concentrations of ^{137}Cs in water were all less than 5 x 10^{-8} μCi/mℓ. An estimated transport across the 1200-m post-outfall station of about 7 mCi ^{137}Cs occurred during the runoff event, representing about 3% of the estimated inventory in the canyon soil. No runoff events in Mortandad Canyon have flowed beyond LASL boundary since at least 1960, and observations on the leading edge of this event verified that the runoff and its associated radioactivity were not leaving site boundaries.[6]

5. Radiation Dose Assessment Methods and Assumptions

The radiation dose assessments presented in this section are based on the environmental monitoring data of this report. Calculations are made for the radionuclides detected by the LASL monitoring network and for critical pathways associated with these effluents. The calculational models are those recommended by the International Commission on Radiological Protection (ICRP). No Laboratory-related concentrations of radionuclides were detected beyond a 20-km radius of the Laboratory. Consequently, it was not considered necessary to do population dose assessments beyond Los Alamos County. The 1974 Los Alamos County population statistics (12 000 and 5000 people in Los Alamos and White Rock, respectively) were obtained from the Los Alamos County Planning Department. For background purposes, the population of the 80-km radius

about the Laboratory (92 000 people) was obtained from the LASL-developed Pathfinder Program[7] with updating from the "Statistical Abstract of the United States - 1974."

External Penetrating Radiation

Analysis of external radiation exposure data as measured by the TLD monitoring network is difficult to assess due to the variations in natural terrestrial radiation and cosmic radiation. As was the case[1] in 1973, the Cumbres Junior High School station gave the highest measured dose, 170 mrem/yr, for an off-site station. The average for all townsite stations (stations 1-4, 6-8, 13, and 15 in Table VII) is 141 mrem, and without the Cumbres station (4) is 137 mrem. The Cumbres dose is not believed to represent a LASL contribution to an off-site dose. Other TLDs in the community did not record values as high, which would be expected in the event of any LASL contribution to an external dose, and the Cumbres TLD is located inside a brick enclosure which apparently contains a higher-than-normal amount of natural radioactivity. All perimeter and off-site stations have dose rates compatible with the expected values (126 and 175 mrem/yr) estimated for New Mexico by the EPA.[3,8] All but the Cumbres station are similar to, or less than, TLD measurements of 143 mrem/yr at Colorado Springs, Colorado (elevation 1880 m).[9]

Airborne Tritium

The dose resulting from continuous inhalation of tritiated water vapor was calculated using the following equation.

$$D(t) = 51\ CI_a f_a Et/\lambda m\ ,$$

where:

$D(t)$ = dose equivalent delivered during continuous exposure time t(days) in rem

$51 = \frac{(1.6 \times 10^{-6}\text{erg/MeV})(8.64 \times 10^{4}\text{s/day})(3.7 \times 10^{4}\text{dis/s-}\mu\text{Ci})}{100\ \text{erg/g-rad}}$

C = average airborne concentration, in μCi/mℓ

I_a = average air intake rate
$= 2 \times 10^{7}$ mℓ/day (Ref. 10)

f_a = fraction of inhaled material reaching organ of interest
= 1 for tritium (oxide) (Ref. 10)

E = effective energy deposition per disintegration, including the quality factor for dose equivalent conversion
= 0.010 MeV-rem/dis-rad (Refs. 4, 10, and 11)

t = duration of exposure, in days

λ = effective elimination rate, in day^{-1}
$= 0.069\ \text{day}^{-1}$ (Ref. 11)

m = mass of organ of interest, in g
$= 4.3 \times 10^{4}$ g for body water (Ref. 10).

Therefore,

$D(t) = 1.2 \times 10^{6}C$.

The average airborne tritium concentration at background stations 9, 10, and 11 (see Table IX) was $8 \pm 2 \times 10^{-12}$ μCi/mℓ, which would result in a whole body dose of 0.010 mrem/yr. The highest measured concentration at an occupied location was at the Bandelier Lookout where the average was 64×10^{-12} μCi/mℓ. The difference between this value and background would result in an increase in the individual whole body dose of 0.07 mrem/yr, or 0.01% of the annual dose limit for an individual member of the public and 0.04% of the dose limit for the population group.

The highest dose at a site boundary would be best represented by the average

concentration measured at TA-33. This concentration of 141 x 10^{-12} μCi/mℓ would give a whole body dose above background of 0.16 mrem/yr which is 0.03% of the individual dose limit.

The estimate of the dose contribution to the Los Alamos community from airborne tritiated water vapor was obtained by averaging the annual concentration measured at stations 1-7 for the townsite and stations 8 and 20 for White Rock. The concentrations of 19 x 10^{-12} μCi/mℓ and 28 x 10^{-12} μCi/mℓ for the townsite and White Rock, respectively, result in a calculated population dose above background of 0.28 man-rem to the 17 000 residents of Los Alamos County.

Airborne Plutonium

The mean values measured on composite air samples for off-site, perimeter, and on-site stations for airborne ^{238}Pu and ^{239}Pu (Table XI) are, with one exception, within the range of values (0.2 - 8.8 x 10^{-18} μCi/mℓ for ^{238}Pu and 5.3 - 41 x 10^{-18} μCi/mℓ for ^{239}Pu) measured as fallout at 11 stations throughout the United States by the U. S. Environmental Protection Agency Radiation Alert Network.[12-15] The one exception is the mean value of 11 x 10^{-18} μCi/mℓ of ^{238}Pu at the Diamond Drive station. This mean is highly influenced by the maximum value of 105 x 10^{-18} μCi/mℓ which appeared on a single sample, and is not believed to be realistic. However, should this value be real, using the formula developed in last year's environmental monitoring report,[1] the annual dose to the lung at the Diamond Drive station would be 0.014 mrem (D = 1.35 x 10^{12} C, where D = dose in rems and C = average airborne concentration in μCi/mℓ). This calculated dose is 0.0009% of the individual dose limit.

Airborne Uranium

The average concentrations of airborne uranium vary from 0.04 to 0.23 ng/m^3 (see Table XII). The mean concentrations of the off-site, perimeter, and on-site stations are not statistically different. The highest single value is at the Espanola station which would normally be beyond Laboratory influence. The uranium concentration at this station was systematically higher during 1974. Had it been affected by Laboratory operations, then the on-site, perimeter, and most off-site stations would logically show values higher than those at Espanola. Local factors are believed to be responsible for the higher airborne uranium concentration at the Espanola station. Because the Espanola value is not considered to be Laboratory caused, and since it is only 0.003% of the Concentration Guide value, a dose calculation was not made for this station.

Other Nuclides and Pathways

Tritium, uranium, and transuranic nuclides are the only significant radioactive materials released from LASL facilities. Although some short-lived radionuclides are routinely measured in Laboratory effluents, they are not detectable in environmental media. The potential doses from these other nuclides are orders of magnitude smaller than the doses from the nuclides evaluated in the preceding sections and consequently are not considered in the overall dose assessment.

Liquid effluents *per se* do not flow beyond the LASL boundary but are absorbed in the alluvium of the receiving canyons; excess moisture is lost primarily by evapotranspiration. These effluents are monitored at the points of discharge and in the alluvium of the canyons below the outfalls. Small quantities of radioactive contaminants have been measured in canyon sediments beyond the LASL boundary, probably transported there during periods of heavy runoff. However, no pathways from the sediments to humans have been indicated.

No radioactivity in excess of normal background concentrations was detected in drinking water, surface water, or ground

water at any off-site location. There are no known significant aquatic pathways or food chains to humans in the local area. Consequently, no potential dose contributions beyond those already discussed could be identified or evaluated.

D. Chemical Quality of Surface and Ground Waters

1. On-Site Surface and Ground Waters

Monitoring for 1974 of on-site noneffuent waters consisted of analyzing samples from Test Wells 3, DT-5A and 8, and from Canada del Buey, Pajarito Canyon, and Water Canyon (Fig. 8). Chemical analyses of these samples (Table XVII) indicate no significant chemical change from previous reporting periods.[1] The quality of the water is good, with total dissolved solids ranging from 134 to 178 mg/ℓ which meets drinking water standards.

Chemical quality was determined for samples of surface and ground water in canyons receiving industrial effluents (Table XVII). Acid-Pueblo Canyon received industrial wastes from 1943 to 1964; and the chemical quality of samples from this area has not changed perceptibly from post-1964 analyses. The mineral concentration range, from 292 to 434 mg/ℓ, results from the Pueblo municipal sewage treatment plant effluent. Chemical analyses from two surface water stations in Sandia Canyon give indication of effluents from the TA-3 steam plant. Thus the high mineral concentrations (total dissolved solids were 654 and 685 mg/ℓ) were not unexpected since, except for storm or spring runoff, these effluents constitute the total canyon stream. The chemical quality of surface and ground waters in DP-Los Alamos Canyon, with a total dissolved solids range of 217 to 667 mg/ℓ, reflects the release of industrial wastes, sanitary sewage, and cooling tower effluents from TA-21 and TA-2. In general, the quality of the water improves downgrade from the confluence of DP and Los Alamos Canyons. Surface and ground waters of Mortandad Canyon (total dissolved solids range from 262 to 884 mg/ℓ) are clearly influenced by the effluent discharge from the industrial waste treatment plant at TA-50. The waters from the noneffluent areas and from DP-Los Alamos, Sandia, and Mortandad Canyons are not sources of either municipal or domestic water supply.

2. Off-Site and Supply Waters

Perimeter surface and ground water samples are collected at six locations on the Pajarito Plateau and 29 locations in White Rock Canyon (Figs. 8 and 10, Table XVIII). The mineral concentrations from the Pajarito Plateau are low, with a total dissolved solids range from 102 to 320 mg/ℓ. The stations in White Rock Canyon, consisting of 25 springs, 3 streams, and 1 effluent stream from the County sewage treatment plant at White Rock Canyon (at the mouth of Mortandad Canyon) have low average mineral concentrations of 128 to 612 mg/ℓ; averaging 222 mg/ℓ. High mineral concentrations occurred from one spring (510 mg/ℓ) which discharges from a fault line, and from the effluent stream (612 mg/ℓ), due to the release of sewage effluents. The chemical quality of the water from these 35 stations has not changed appreciably from previous reporting periods.[1] These waters are not used for municipal or industrial water supply. Except for the spring and effluent stream noted above, all waters meet the U. S. Public Health Service Drinking Water Standards.

The chemical quality of water in the Los Alamos water supply system varies slightly from periods of light production (winter) to periods of heavy pumpage (summer). Location of sampling stations is shown in Fig. 8 and chemical analyses are given in Table XIX. Routine analyses from the supply wells and from the distribution system indicate no significant changes in the quality of water from previous analyses.[1] Mineral concentrations of the water system are low, with total dissolved solids ranging from 96 to 408 mg/ℓ. Maximum chemical concentrations are well below the

limits defined by the U. S. Public Health Standards for drinking water.

Regional rivers and reservoirs within 75 km of the LASL are sampled to provide data on the chemical quality of water in the area. The average concentrations (Table XX) represent two samples each taken from sampling stations located at Chamita, Embudo, Otowi, Cochiti, Bernalillo, and Jemez Creek. The quality of these regional waters has not changed significantly from previous reporting periods. The mineral concentrations in the water range from low to medium, 124 to 526 mg/ℓ. The high concentration is from the station on the Rio Chama and is related to the terrain forming a drainage area.

E. Unplanned Releases

On July 9, 1974, an inspection of the industrial sewer line route detected a joint leak at a cleanout riser; an inspection less than a year previous showed nothing abnormal. Field surveys and preliminary excavation near the leaky joint defined the approximate extent of contamination. Final decontamination of the area was accomplished on October 14-17, 1974. About 280 m^3 of soil was removed so that remaining gross-alpha concentrations in exposed soil did not exceed about 10 pCi/g, compared to the native background of about 3 pCi/g for 12 noncontaminated samples collected in the vicinity of the LASL. About 880 m^3 of fill material and 270 m^3 of topsoil were then used to fill in and regrade the vicinity of the excavation to prevent erosion. The area was reseeded and stabilized. Final estimates made from samples obtained during decontamination indicated that about 10^6 ℓ of liquid waste containing a total of about 200 mCi of principly ^{238}Pu had leaked from the line. An area of about 1000 m^2 was involved; most contamination was at depths less than 1 m below the surface.

Because of the age and questionable integrity of the existing line, it was replaced by a welded-joint polyethylene pipe. On September 3, 1974, during a test of the new line, some 2000 to 4000 ℓ of waste containing a total of about 0.4 mCi of principly ^{238}Pu overflowed from a manhole onto a street and parking lot near TA-3 and into a storm drain discharging into Mortandad Canyon. Street and parking lot areas were cleaned, the contaminated areas covered with asphalt, and the canyon was temporarily dammed to prevent movement of the plutonium. On September 5 and 6, 1974, about 200 m^3 of contaminated soil were removed from the canyon. On September 28 and 29, 1974, about 175 m^3 of asphalt and curbing were removed from the roadway and parking lot for replacement. No measurable contamination remained. All decontamination was carried out according to specially prepared standard-operating procedures by trained personnel wearing suitable protective clothing and with continuous health physics supervision and monitoring. No airborne dispersal of radioactive materials was detected by portable air sampling monitors placed near contaminated areas or by the routine air monitoring network. All materials removed during the decontamination operations were buried in a pit in the nonretrievable radioactive waste disposal area.

Upgrading of the exhaust and air filtration system for a major Laboratory building resulted in the production of a continuous noise noticeable in the community. Sound level measurements indicated that the limits specified in the Los Alamos County noise ordinance had not been exceeded, but the presence of certain pure tones made the noise irritating. Accordingly, the Laboratory engaged a consulting firm specializing in industrial noise control, and studies were devised for interim and long-term noise reduction. Some air flow rates were reduced for immediate minimization of the noise problem. Permanent mufflers are to be installed in phases on the exhaust systems, starting with the loudest units.

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TABLE I

MEANS AND EXTREMES OF TEMPERATURE AND PRECIPITATION

CLIMATOLOGICAL SUMMARY 1910 - 1973

Latitude 35° 32' North
Longitude 106° 19' West
Elevation 2 260 m

Los Alamos, New Mexico

	Temperature (°C)							Precipitation Totals (mm)									Mean No. of Days		
	Means			Extremes				Rain					Snow and Frozen Precipitation						
	Daily Values		Mo																
Mo	Max	Min	Mean	High	Yr	Low	Yr	Mean	Daily Max	Yr	Mo Max	Yr	Mean	Daily Max	Yr	Mo Max	Yr	Precip ≥2.5mm	Max Temp ≥26.7°C[a]	Min Temp ≤-9.4°C[a]
Jan	3.9	-7.9	-2.0	17.8	1963	-27.8	1963	20.83	62.23	1916	171.45	1916	240.7	381.0	1913	989.2	1949	2	0	8
Feb	6.1	-5.8	0.1	18.9	1936	-25.6	1951	17.52	26.67	1915	61.89	1948	206.6	330.2	1915	604.5	1948	2	0	6
Mar	9.4	-3.4	3.1	21.7	1971	-19.4	1948	25.42	57.15	1916	104.4	1973	262.6	457.2	1916	939.8	1973	3	0	3
Apr	14.6	1.0	7.8	26.7	1950	-15.0	1925	24.90	36.83	1969	117.86	1916	104.1	304.8	1958	853.4	1958	3	0	0
May	19.9	6.0	12.9	31.7	1935	-4.4	1938	32.63	45.72	1929	113.54	1929	20.0	228.6	1917	431.8	1917	3	1	0
Jun	25.3	10.9	18.1	33.9	1954	-2.2	1919	34.99	34.80	1931	141.49	1913	0	0	—	0	—	3	14	0
Jul	26.9	12.9	19.9	35.0	1935	2.8	1924	86.06	70.61	1968	202.69	1919	0	0	—	0	—	8	19	0
Aug	25.4	12.3	18.9	33.3	1937	4.4	1947	94.45	57.40	1951	283.97	1952	0	0	—	0	—	8	12	0
Sep	22.4	8.9	15.7	34.4	1934	-5.0	1936	50.13	56.13	1929	147.07	1941	5.0	152.4	1913	152.4	1914	5	5	0
Oct	16.7	3.2	9.9	27.8	1930	-8.9	1970	40.41	88.39	1919	171.96	1957	37.5	228.6	1972	228.6	1959 1972	3	0	0
Nov	9.4	-3.1	3.2	20.6	1937	-20.0	1957	17.86	37.08	1931	83.82	1957	128.1	355.6	1931	876.3	1957	2	0	2
Dec	4.9	-6.8	-1.0	16.7	1933	-23.3	1924	23.02	34.29	1965	72.39	1965	270.4	457.2	1915	1049.0	1967	3	0	6
Year	15.4	2.3	8.9	35.0	1935	-27.8	1963	464.97	88.39	1919	283.97	1952	1274.8	457.2	1915 1916	1049.0	1967	45	51	25

[a] 26.7°C = 80°F; -9.4°C = 15°F.

CLIMATOLOGICAL SUMMARY 1974

	Temperature (°C)					Precipitation Total (mm)				Mean No. of Days		
	Means			Extremes		Rain[a]		Snow or Frozen Precipitation				
	Daily Values											
Mo.	Max	Min	Mo. Mean	High	Low	Total	Daily Max	Total	Daily Max	Precip. ≥2.5mm	Max Temp. ≥26.7°C[b]	Min Temp. ≤-9.4°[b]
Jan	2.5	-8.8	-3.2	12.2	-20.0	39.4	11.7	589	254	4	0	14
Feb	5.0	-8.2	-1.6	13.9	-17.8	9.1	3.3	91	38	3	0	10
Mar	12.9	-0.3	6.3	20.0	-8.3	28.2	23.4	178	178	2	0	0
Apr	14.9	0.6	7.6	23.3	-6.7	11.4	8.9	89	89	2	0	0
May	22.6	7.9	15.2	28.3	0.6	2.8	1.3	0	0	0	2	0
Jun	27.0	12.2	19.6	31.7	3.3	22.4	12.4	0	0	2	20	0
Jul	26.1	12.9	19.5	29.4	8.3	85.9	18.8	0	0	11	14	0
Aug	23.7	11.2	17.4	28.3	7.8	100.1	31.2	0	0	9	6	0
Sept	20.2	7.5	13.8	28.9	-0.6	43.4	23.6	0	0	3	6	0
Oct	13.7	4.0	8.8	21.1	-3.3	98.0	22.4	0	0	8	0	0
Nov	8.7	-3.0	2.8	16.7	-11.7	11.9	5.3	18	15	1	0	2
Dec	2.9	-8.7	-2.9	10.0	-16.1	22.1	9.9	38	15	4	0	14
Year	15.1	2.4	8.8	31.7	-20.0	474.7	31.2	1003	254	49	48	40

[a] Includes liquid water equivalent of frozen precipitation

[b] 26.7°C = 80°F; -9.4°C = 15°F.

TABLE II

ATMOSPHERIC RADIOACTIVE EFFLUENT TOTALS FOR 1974

Location	^{238}Pu ^{239}Pu (μCi)	^{233}U ^{235}U ^{238}U (μCi)	MFP[a] (μCi)	^{131}I (mCi)	^{41}Ar (Ci)	^{32}P (μCi)	^{3}H (Ci)
TA-2	-	-	-	-	312	-	-
TA-3	745	202	342	5	-	-	-
TA-9	-	-	-	-	-	-	1
TA-15	-	-	-	-	-	-	171
TA-21	5.7	600	3	-	-	-	-
TA-33	-	-	-	-	-	-	5916
TA-35	8.0	-	-	-	-	-	1400
TA-41	-	-	-	-	-	-	-
TA-43	6.9	-	-	-	-	74	-
TA-46	-	0.4	-	-	-	-	-
TA-48	23.9	1.3	941	-	-	-	-
TA-50	3.9	-	88	-	-	-	-

[a]Mixed Fission Products.

TABLE III

UNITS OF MEASUREMENT CONVERSIONS

Quantity	This Report	AECM 0524	International (SI)	Common Usage
Radioactivity Concentration				
Airborne	= 10^{-12} µCi/mℓ	= 10^{-12}µCi/mℓ	= 0.037 $s^{-1}m^{-3}$	= 1 pCi/m^3
	= 10^{-15} µCi/mℓ	= 10^{-15}µCi/mℓ	= 3.7 x 10^{-5} $s^{-1}m^{-3}$	= 10^{-3} pCi/m^3
	= 10^{-18} µCi/mℓ	= 10^{-18}µCi/mℓ	= 3.7 x 10^{-8} $s^{-1}m^{-3}$	= 10^{-6} pCi/m^3
In Liquids	= 10^{-9} µCi/mℓ	= 10^{-9} µCi/mℓ	= 37 $s^{-1}m^{-3}$	= 1 pCi/ℓ
	= 10^{-12} µCi/mℓ	= 10^{-12}µCi/mℓ	= 0.037 $s^{-1}m^{-3}$	= 10^{-3} pCi/ℓ
In Solids	1 pCi/g	-	= 37 $s^{-1}kg^{-1}$	= 1 pCi/g
	1 fCi/g	-	= 0.037 $s^{-1}kg^{-1}$	= 10^{-3} pCi/g
Chemical Properties				
Concentrations in Liquids	1 mg/ℓ	-	= 1 g/m^3	= 1 ppm
	1 µg/ℓ	-	= 1 mg/m^3	= 1 ppb
	1 ng/ℓ	-	= 1 $\mu g/m^3$	= 10^{-3} ppb
Exchange Capacity	1 eq/kg	-	= 1 (equivalent)/kg	= 10^2 meq/100g
Electrical Conductance	1 mS/m	-	= 1 mS/m	= 10 µmho/cm
Fluid Flow Rates	1 m^3/s	-	= 1 m^3/s	= 6 x 10^4 ℓpm
				= 2120 cfm
	1 ℓ/s	-	= 1 dm^3 /s	= 60 ℓpm
				= 2.12 cfm
Meteorological Data				
Temperature	°C	-	K = °C + 273.15	°F = 1.8(°C) + 32
Precipitation	1 mm	-	= 1 mm	= 0.039 inch
Wind Speed	1 m/s	-	= 1 m/s	= 2.237 mph
Air Pressure	1 kPa	-	= 1 kPa	= 9.87 x 10^{-3}atmos.
				= 10 mbar
				= 0.145psi
				= 0.295 in. Hg
Geological Data				
Water Volume	1 m^3	-	= 1 m^3	= 8.11 x 10^{-4}ac.ft
	1 ℓ/s	-	= 1 dm^3/s	= 0.0353 cfs
				= 15.9 gpm
				= 2.28 x 10^4 gpd
Stream Flow Rate	1 m^3/s	-	= 1 m^3/s	= 35.3 cfs
				= 1.59 x 10^4 gpm
				= 2.28 x 10^7 gpd

TABLE IV

MINIMUM DETECTION LIMITS (MDLs) FOR ROUTINE ANALYSES OF RADIOACTIVITY IN TYPICAL ENVIRONMENTAL SAMPLES

Analysis	Airborne	Liquids	Solids
^{3}H(oxide)	5×10^{-12} µCi/mℓ	0.6×10^{-6} µCi/mℓ	0.6 nCi/ℓ[a]
^{137}Cs		0.1×10^{-6} µCi/mℓ	0.2 pCi/g
^{238}Pu	10×10^{-18} µCi/mℓ	0.1×10^{-9} µCi/mℓ	5 fCi/g
^{239}Pu	10×10^{-18} µCi/mℓ	0.1×10^{-9} µCi/mℓ	5 fCi/g
Gross α	0.05×10^{-15} µCi/mℓ	0.5×10^{-9} µCi/mℓ	1 pCi/g
Gross β	0.1×10^{-15} µCi/mℓ	1×10^{-9} µCi/mℓ	2 pCi/g
Gross γ		0.2×10^{-6} µCi/mℓ	0.4 pCi/g
U (total)[b]	0.01 ng/m^3	1 µg/ℓ	1 ng/g

[a] Only the tritium contained in the unbound water of the sample is analyzed.

[b] Total mass concentrations of uranium are determined fluorometrically; conversion to activity depends on the isotopic composition of the material.

TABLE V

AEC RADIOACTIVITY CONCENTRATION GUIDES (CGs)

CONCENTRATION GUIDES FOR UNCONTROLLED AREAS[a]

Nuclide	CG for Air		CG for Water	
	(μCi/mℓ)	(pCi/m^3)	(μCi/mℓ)	(nCi/ℓ)
^{3}H	2×10^{-7}	2×10^{5}	3×10^{-3}	3 000
^{89}Sr	3×10^{-10}	300	3×10^{-6}	3
^{90}Sr[c]	3×10^{-11}	30	3×10^{-7}	0.3
^{131}I	1×10^{-10}	100	3×10^{-7}	0.3
^{237}Cs	2×10^{-9}	2 000	2×10^{-5}	20
^{238}Pu	7×10^{-14}	0.07	5×10^{-6}	5
^{239}Pu[c]	6×10^{-14}	0.06	5×10^{-6}	5
^{241}Am	2×10^{-13}	0.2	4×10^{-6}	4
U, natural[b]	3×10^{-12}	$\frac{(\mu g/m^3)^b}{9}$	2×10^{-5}	$\frac{(mg/\ell)^b}{60}$

CONCENTRATION GUIDES FOR CONTROLLED AREAS

Nuclide	CG for Air		CG for Water	
	(μCi/mℓ)	(pCi/m^3)	(μCi/mℓ)	(nCi/ℓ)
^{3}H	5×10^{-6}	5×10^{6}	1×10^{-1}	1×10^{5}
^{89}Sr	3×10^{-8}	3×10^{4}	3×10^{-4}	300
^{90}Sr[c]	1×10^{-9}	1 000	1×10^{-5}	10
^{131}I	9×10^{-9}	9 000	6×10^{-5}	60
^{137}Cs	6×10^{-8}	6×10^{4}	4×10^{-4}	400
^{238}Pu	2×10^{-12}	2	1×10^{-4}	100
^{239}Pu[c]	2×10^{-12}	2	1×10^{-4}	100
^{241}Am	6×10^{-12}	6	1×10^{-4}	100
U, natural[b]	7×10^{-11}	$\frac{(\mu g/m^3)}{210}$	5×10^{-4}	$\frac{(mg/\ell)}{1\ 500}$

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

[b] Fluorometric measurements of U mass may be converted to the AEC "special curie" using the factor 0.33 μCi/g.

[c] Of the possible radionuclides released at LASL, ^{90}Sr and ^{239}Pu are the most restrictive. The CGs for these species are used for the gross-beta and gross-alpha CGs, respectively.

TABLE VI

WATER STANDARDS

DRINKING WATER STANDARDS FOR CHEMICALS

Constituent	Symbol	Concentration Limit (mg/ℓ) PHS and EPA[a] Mandatory	PHS and EPA[a] Recommended	NMWQCC[b]
Alkyl benzene sulfonate	ABS	-	0.5	-
Arsenic	As	0.05	0.01	0.05
Barium	Ba	1.0	-	1.0
Boron	B	-	-	0.75
Cadmium	Cd	0.01	-	0.01
Carbon chloroform extract	CCE	-	0.2	-
Chlorine	Cl	-	250.	-
Chromium hexavalent	Cr^{+6}	0.05	-	-
Total	Cr	-	-	0.01
Copper	Cu	-	1.0	0.05(0.1)[c]
Cyanide	CN	0.2	0.01	-
Fluoride	F	≈1[d]	-	-
Iron	Fe	-	0.3	-
Lead	Pb	0.05	-	0.05
Manganese	Mn	-	0.05	0.1
Mercury	Hg	-	-	0.001
Molybdenum	Mo	-	-	0.01
Nickel	Ni	-	-	0.1
Nitrate	NO_3	-	45.	-
Phenols		-	0.001	-
Selenium	Se	0.01	-	0.01
Silver	Ag	0.05	-	0.05
Total dissolved solids	TDS	-	500.	-
Zinc	Zn	-	5.0	0.1(0.5)[c]

MISCELLANEOUS WATER STANDARDS

Radioactivity in drinking water (PHS):

Gross beta activity: (if strontium-90 and alpha emitters are not present)	1 000 pCi/ℓ
Strontium-90	10 pCi/ℓ
Radium-226:	3 pCi/ℓ

[a] PHS Regulations on Drinking Water Standards, 42 CFR 72, 201-207, Fed. Reg. 27:2152, Mar. 6, 1962. Also in PHS Publ. 956 and EPA Bulletin 956.

[b] New Mexico Water Quality Control Commission Regulations.

[c] Concentrations shown in parentheses are permitted in community sewer systems.

[d] The concentration standard for fluoride varies depending upon temperature, but is centered around 1 mg/ℓ.

TABLE VII

ANNUAL THERMOLUMINESCENT DOSIMETER MEASUREMENTS

Station Location	Coordinates	Elevation (km)	Exposure Period (weeks)	Annual Dose (mrem/yr)
Off-Site Stations				
1 Barranca School	N180 E130	2.22	4	124(±11)
2 Arkansas Avenue	N170 E 20	2.26	13	146(±10)
3 Golf Course	N160 E 60	2.23	13	134(±14)
4 Cumbres School	N150 E 90	2.25	13	170(±14)
5 Pajarito Ski Area	N130 W180	2.82	13	126(±23)
6 Diamond Drive	N130 E 20	2.22	13	136(± 9)
7 48th Street	N110 E 0	2.26	4	144(±10)
8 Fuller Lodge	N110 E 90	2.23	4	139(±10)
9 White Rock STP	S 90 E430	1.92	4	129(±10)
10 Espanola		1.70	13	90(±14)
11 Pojoaque		1.78	13	97(±8)
12 Santa Fe		2.13	13	105(±11)
	Arith Mean:	2.17	Arith Mean:	128
Perimeter Stations				
13 L. A. Airport	N110 E160	2.18	13	150(±13)
14 Bayo STP	N110 E260	1.99	13	143(±27)
15 Acorn Street	N100 E110	2.21	4	122(±10)
16 TA-6	N 60 W 50	2.37	13	158(±25)
17 Well PM-1	N 30 E310	1.98	4	155(±10)
18 TA-16	S 30 W 80	2.35	4	144(±10)
19 TA-49	S100 E 40	2.21	4	121(± 9)
20 Booster P-1	S100 E300	2.00	13	138(±10)
21 Pajarito Acres	S210 E370	1.92	13	97(±12)
22 Bandelier Lookout	S270 E200	1.98	13	142(±16)
	Arith Mean:	2.12	Arith Mean:	137

TABLE VIII

SUMMARY OF ANNUAL ATMOSPHERIC RADIOACTIVITY MONITORING

Number and Type of Sampling Locations	Type of Analysis Performed	Time Period per Composite Sample	Number of Samples Analyzed	Mean Radioactivity Concentration	% CG
11 off-site	gross α	2 week	282	1.4×10^{-15} μCi/mℓ	2.3
10 perimeter	gross α	2 week	259	1.3×10^{-15} μCi/mℓ	2.2
5 on-site	gross α	2 week	130	1.3×10^{-15} μCi/mℓ	0.1
11 off-site	gross β	2 week	282	175×10^{-15} μCi/mℓ	0.6
10 perimeter	gross β	2 week	259	173×10^{-15} μCi/mℓ	0.6
5 on-site	gross β	2 week	130	167×10^{-15} μCi/mℓ	0.02
11 off-site	tritiated H_2O	2 week	266	17×10^{-12} μCi/mℓ	0.01
10 perimeter	tritiated H_2O	2 week	241	35×10^{-12} μCi/mℓ	0.02
5 on-site	tritiated H_2O	2 week	119	84×10^{-12} μCi/mℓ	0.002
11 off-site	^{238}Pu	1 month	129	2.1×10^{-18} μCi/mℓ	0.003
10 perimeter	^{238}Pu	1 month	119	1.5×10^{-18} μCi/mℓ	0.002
5 on-site	^{238}Pu	1 month	59	1.3×10^{-18} μCi/mℓ	0.0001
11 off-site	^{239}Pu	1 month	129	27×10^{-18} μCi/mℓ	0.05
10 perimeter	^{239}Pu	1 month	119	27×10^{-18} μCi/mℓ	0.05
5 on-site	^{239}Pu	1 month	59	26×10^{-18} μCi/mℓ	0.001
11 off-site	uranium	3 month	44	0.08 ng/m^3	0.001
10 perimeter	uranium	3 month	40	0.09 ng/m^3	0.001
5 on-site	uranium	3 month	20	0.09 ng/m^3	0.00004

TABLE IX

ANNUAL ATMOSPHERIC TRITIATED WATER VAPOR CONCENTRATIONS

Station Location	Coordinates	Concentration (10^{-12} µCi/mℓ) Maximum	Mean	% CG
Off-Site Stations				
1 Barranca School	N180 E130	50	20(±2)	0.01
2 Arkansas Avenue	N170 E 20	88	15(±2)	0.01
3 Golf Course	N160 E 60	75	15(±2)	0.01
4 Cumbres School	N150 E 90	39	13(±2)	0.01
5 Diamond Drive	N130 E 20	102	17(±2)	0.01
6 48th Street	N110 E 0	91	19(±2)	0.01
7 Fuller Lodge	N110 E 90	359	36(±2)	0.02
8 White Rock STP	S 90 E430	276	28(±2)	0.01
9 Espanola		37	7(±2)	0.004
10 Pojoaque		28	7(±2)	0.004
11 Santa Fe		73	10(±2)	0.01
		Arith. Mean:	17	0.01
Perimeter Stations				
12 L. A. Airport	N110 E160	426	58(±9)	0.03
13 Bayo STP	N110 E260	108	20(±3)	0.0004
14 Acorn Street	N100 E110	356	45(±4)	0.02
15 TA-6	N 60 W 50	64	16(±2)	0.0003
16 Well PM-1	N 30 E310	335	42(±2)	0.001
17 TA-16	S 30 W 80	83	12(±2)	0.01
18 TA-49	S100 E 40	154	22(±2)	0.0004
19 Booster P-1	S100 E300	198	43(±3)	0.001
20 Pajarito Acres	S210 E370	155	27(±2)	0.01
21 Bandelier Lookout	S270 E200	284	64(±4)	0.03
		Arith. Mean:	35	0.02
On-Site Stations				
22 TA-21	N 90 E170	461	68(±11)	0.001
23 LAMPF	N 60 E190	1 436	98(±24)	0.002
24 TA-52	N 20 E170	257	81(±6)	0.002
25 Booster P-2	S 30 E190	161	34(±3)	0.001
26 TA-33	S250 E230	632	141(±7)	0.003
		Arith. Mean:	84	0.002

TABLE X

ANNUAL ATMOSPHERIC GROSS-ALPHA AND GROSS-BETA ACTIVITY CONCENTRATIONS

Station Location	Coordinates	Gross Alpha Concentrations (10^{-15} µCi/mℓ) Max	Min	Mean	%CG	Gross Beta Concentrations (10^{-15} µCi/mℓ) Max	Min	Mean	%CG
Off-Site Stations									
1 Barranca School	N180 E130	3.7	0.2	1.3(±0.1)	2.2	527	38	169(±7)	0.6
2 Arkansas Avenue	N170 E 20	5.4	0.2	1.5(±0.1)	2.5	459	46	172(±8)	0.6
3 Golf Course	N160 E 60	4.4	0.3	1.4(±0.1)	2.3	577	42	172(±7)	0.6
4 Cumbres School	N150 E 90	4.8	0.2	1.3(±0.1)	2.2	525	38	166(±7)	0.6
5 Diamond Drive	N130 E 20	4.9	0.2	1.5(±0.1)	2.5	563	37	184(±8)	0.6
6 48th Street	N110 E 0	6.2	0.2	1.4(±0.1)	2.3	548	35	181(±8)	0.6
7 Fuller Lodge	N110 E 90	3.5	0.2	1.5(±0.1)	2.5	610	48	201(±9)	0.7
8 White Rock STP	S 90 E430	3.8	0.4	1.4(±0.1)	2.3	539	27	182(±8)	0.6
9 Espanola	-	9.9	0.1	1.5(±0.1)	2.5	707	27	188(±9)	0.6
10 Pojoaque	-	6.5	0.4	1.5(±0.1)	2.5	541	41	171(±8)	0.6
11 Santa Fe	-	5.2	0.5	1.2(±0.1)	2.0	381	31	143(±6)	0.5
		Arith. Mean:		1.4	2.3	Arith. Mean:		175	0.6
Perimeter Stations									
12 L. A. Airport	N110 E160	3.5	0.2	1.2(±0.1)	2.0	660	21	173(±8)	0.6
13 Bayo STP	N110 E260	3.1	0.4	1.2(±0.1)	0.1	454	38	156(±7)	0.02
14 Acorn Street	N110 E110	3.8	0.4	1.2(±0.1)	2.0	522	30	177(±8)	0.6
15 TA-6	N 60 W 50	3.3	0.3	1.2(±0.1)	0.1	437	39	156(±7)	0.02
16 Well PM-1	N 30 E310	4.0	0.4	1.5(±0.1)	0.1	421	32	182(±8)	0.02
17 TA-16	S 30 W 80	3.3	0.3	1.4(±0.1)	2.3	553	47	187(±8)	0.6
18 TA-49	S100 E 40	4.3	0.4	1.3(±0.1)	0.1	554	42	187(±8)	0.02
19 Booster P-1	S100 E300	2.8	0.3	1.1(±0.1)	0.1	459	36	160(±7)	0.02
20 Pajarito Acres	S210 E370	3.1	0.4	1.2(±0.1)	2.0	530	43	168(±7)	0.6
21 Bandelier Lookout	S270 E200	3.8	0.4	1.3(±0.1)	2.2	591	38	183(±8)	0.6
		Arith. Mean:		1.3	2.2	Arith. Mean:		173	0.6
On-Site Stations									
22 TA-21	N 90 E170	3.7	0.4	1.2(±0.1)	0.1	486	28	152(±6)	0.02
23 LAMPF	N 60 E190	3.8	0.4	1.3(±0.1)	0.1	499	43	167(±7)	0.02
24 TA-52	N 20 E170	5.8	0.4	1.3(±0.1)	0.1	494	41	165(±7)	0.02
25 Booster P-2	S 30 E190	4.5	0.3	1.3(±0.1)	0.1	546	34	177(±8)	0.02
26 TA-33	S250 E230	3.8	0.5	1.3(±0.1)	0.1	438	46	173(±7)	0.02
		Arith. Mean:		1.3	0.1	Arith. Mean:		167	0.02

TABLE XI

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

Station Location	Coordinates	^{238}Pu Concentration (10^{-18} µCi/mℓ) Max	Mean	%CG	^{239}Pu Concentration (10^{-18} µCi/mℓ) Max	Mean	%CG
Off-Site Stations							
1 Barranca School	N180 E130	4	0.6(<0.8)	0.001	72	25(±3)	0.04
2 Arkansas Avenue	N170 E 20	6	0.7(<0.8)	0.001	58	24(±3)	0.04
3 Golf Course	N160 E 60	8	1.6(±0.8)	0.002	101	30(±3)	0.05
4 Cumbres School	N150 E 90	3	1.0(±0.7)	0.001	119	31(±4)	0.05
5 Diamond Drive	N130 E 20	105	10.6(±2.7)	0.015	114	33(±4)	0.06
6 48th Street	N110 E 0	6	1.7(±1.2)	0.002	118	32(±4)	0.05
7 Fuller Lodge	N110 E 90	9	2.0(±1.2)	0.003	119	32(±4)	0.05
8 White Rock STP	S 90 E430	8	0.7(<1.8)	0.001	77	24(±4)	0.04
9 Espanola	-	16	2.6(±1.3)	0.004	114	24(±3)	0.04
10 Pojoaque	-	5	0.3(<6.7)	0.0004	113	22(±10)	0.04
11 Santa Fe	-	5	1.2(±0.7)	0.002	84	21(±2)	0.04
		Arith. Mean: 2.1		0.003	Arith Mean:	27	0.05
Perimeter Stations							
12 L. A. Airport	N110 E160	2	0.7(<1.1)	0.001	92	25(±2)	0.04
13 Bayo STP	N110 E260	5	1.0(±0.9)	0.0001	93	27(±3)	0.001
14 Acorn Street	N100 E110	3	0.7(±0.7)	0.001	102	32(±3)	0.05
15 TA-6	N 60 W 50	26	3.8(±0.9)	0.0002	70	22(±2)	0.001
16 Well PM-1	N 60 E310	3	1.5(±1.1)	0.0001	74	25(±3)	0.001
17 TA-16	S 30 W 80	7	0.9(<1.2)	0.001	114	29(±3)	0.05
18 TA-49	S100 E 40	4	0.9(±0.7)	0.00005	83	31(±3)	0.002
19 Booster P-1	S100 E300	7	2.1(±0.8)	0.0001	60	22(±2)	0.001
20 Pajarito Acres	S210 E370	10	1.7(<2.3)	0.002	65	22(±5)	0.04
21 Bandelier Lookout	S270 E200	5	1.6(±0.8)	0.002	88	32(±3)	0.05
		Arith. Mean: 1.5		0.002	Arith. Mean:	27	0.05
On-Site Stations							
22 TA-21	W 90 E170	5	1.1(±0.9)	0.0001	86	23(±2)	0.001
23 LAMPF	N 60 E190	3	0.2(<1.1)	0.00001	105	31(±4)	0.002
24 TA-52	N 20 E170	8	1.3(±0.6)	0.0001	72	23(±2)	0.001
25 Booster P-2	S 30 E190	8	1.9(±1.3)	0.0001	79	25(±3)	0.001
26 TA-33	S250 E230	12	2.2(±1.1)	0.0001	68	26(±3)	0.001
		Arith. Mean: 1.3		0.0001	Arith. Mean:	26	0.001

TABLE XII

ANNUAL ATMOSPHERIC URANIUM CONCENTRATIONS

Station Location	Coordinates	Concentration (ng/m^3) Max	Mean	% CG
Off-Site Stations				
1 Baranca School	N180E130	0.06	0.05(±0.01)	0.001
2 Arkansas Avenue	N170E20	0.11	0.04(±0.02)	0.0004
3 Golf Course	N160E60	0.11	0.06(±0.02)	0.001
4 Cumbres School	N150E90	0.10	0.05(±0.02)	0.001
5 Diamond Drive	N130E20	0.08	0.04(±0.02)	0.0004
6 48th Street	N110E0	0.28	0.09(±0.04)	0.001
7 Fuller Lodge	N110E90	0.08	0.05(±0.02)	0.001
8 White Rock STP	S90E430	0.25	0.15(±0.04)	0.002
9 Espanola	--	0.34	0.23(±0.06)	0.003
10 Pojoaque	--	0.16	0.12(±0.03)	0.001
11 Santa Fe	--	0.07	0.05(±0.01)	0.001
		Arithmetic mean:	0.08	0.001
Perimeter Stations				
12 L. A. Airport	N110E160	0.15	0.08(±0.02)	0.001
13 Bayo STP	N110E260	0.10	0.05(±0.02)	0.00002
14 Acorn Street	N100E110	0.13	0.11(±0.02)	0.001
15 TA-6	N60W50	0.07	0.05(±0.01)	0.00002
16 Well PM-1	N30E310	0.23	0.10(±0.03)	0.00005
17 TA-16	S30W80	0.11	0.07(±0.02)	0.001
18 TA-49	S100E40	0.17	0.09(±0.03)	0.00004
19 Booster P-1	S100E300	0.25	0.13(±0.03)	0.00006
20 Pajarito Acres	S210E370	0.24	0.13(±0.03)	0.001
21 Bandelier Lookout	S270E200	0.11	0.07(±0.02)	0.001
		Arithmetic mean:	0.09	0.001
On-Site Stations				
22 TA-21	N90E170	0.12	0.05(±0.02)	0.00002
23 LAMPF	N60E190	0.23	0.11(±0.03)	0.00005
24 TA-52	N20E170	0.19	0.10(±0.03)	0.00005
25 Booster P-2	S30E190	0.19	0.11(±0.04)	0.00005
26 TA-33	S250E230	0.11	0.07(±0.02)	0.00003
		Arithmetic mean:	0.09	0.00004

TABLE XIII

RADIOACTIVITY IN ON-SITE SURFACE AND GROUND WATERS

Sampling Locations			No.&	Average Radioactive Concentrations						
Name and Coordinates			Type[a]	^{3}H $10^{-6}\mu Ci/m\ell$	^{137}CS $10^{-6}\mu Ci/m\ell$	^{238}Pu $10^{-9}\mu Ci/m\ell$	^{239}Pu $10^{-9}\mu Ci/m\ell$	Gross α $10^{-9}\mu Ci/m\ell$	Gross β $10^{-9}\mu Ci/m\ell$	U $\mu g/\ell$
Noneffluent Areas										
Test Well 3	N 80	E210	4-G	0.4(<0.8)	0.07(<0.10)	0.00(<0.02)	0.02 (<0.03)	0.4(<0.6)	5.7(±1.2)	0.2(<1.4)
Cañada del Buey	N 5	E165	4-S	1.4(±0.8)	0.08(<0.09)	0.01(<0.02)	0.02 (±0.02)	1.0(±0.6)	8.8(±1.4)	-0.1(<1.6)
Pajarito Canyon	S 60	E225	3-S	6.2(±1.0)	-0.01(<0.11)	0.02(<0.04)	0.06 (<0.07)	0.2(<0.6)	6.3(±1.4)	-0.3(<1.6)
Water Canyon	S 90	E 90	3-S	1.0(±0.8)	0.01(<0.11)	0.00(<0.01)	0.02 (±0.02)	0.2(<0.6)	15 (±2)	0.2(<1.0)
Test Well DT-5A	S110	E 90	4-G	0.3(<0.7)	0.01(<0.11)	0.00(<0.01)	-0.002(<0.001)	0.2(<0.6)	2.2(±1.2)	0.2(<1.4)
Test Well 8	W 45	E115	4-G	0.3(<0.8)	0.10(<0.11)	0.01(<0.01)	0.02 (<0.02)	0.4(±0.4)	2.4(±1.2)	-0.3(<1.4)
Acid-Pueblo Canyon (Formerly AEC-LASL Property)										
Acid Weir	N130	E 60	4-S	1.0(±0.8)	0.06(<0.11)	0.02(<0.03)	1.4 (±0.2)	3.2(±1.0)	140 (±4)	1.2(<1.4)
Pueblo 1	N130	E 65	4-S	0.1(<0.8)	0.20(<0.21)	-0.001(<0.01)	0.03 (±0.02)	9.8(±1.2)	24 (±2)	0.8(<1.4)
Pueblo 2	N120	E160	4-S	-0.1(<0.8)	0.03(<0.11)	0.01(±0.01)	0.12 (±0.06)	1.6(±0.4)	17 (±2)	0.7(<1.4)
Obs. Hole PO-3B	N110	E245	4-G	10.1(±1.1)	0.08(<0.11)	0.30(±0.06)	0.80 (±0.12)	1.8(±0.8)	13 (±2)	1.2(<1.4)
Hamilton Bend Spring	N110	E250	3-G	0.2(<0.8)	0.03(<0.10)	0.02(<0.02)	0.03 (<0.03)	0.7(±0.6)	8.3(±1.6)	-0.3(<1.6)
Pueblo 3	N 85	E315	4-S	0.6(<0.8)	0.04(<0.11)	0.10(±0.02)	0.10 (±0.03)	1.3(±0.8)	17 (±2)	0.6(<1.4)
Sandia Canyon										
SCS-1	N 80	E 40	4-S	1.7(±0.8)	0.05(<0.11)	0.03(<0.03)	0.02 (±0.01)	2.0(±0.8)	27 (±2)	1.4(±1.4)
SCS-2	N 55	E 60	4-S	1.5(±0.8)	0.07(<0.11)	0.01(<0.03)	0.02 (<0.02)	1.2(±0.8)	17 (±2)	1.9(±1.4)
DP-Los Alamos Canyon										
DPS-1	N 95	E160	4-S	15.4(±1.2)	0.04(<0.11)	0.16(±0.05)	0.27 (±0.07)	10.1(±1.4)	670 (±20)	3.8(±1.4)
DPS-4	N 80	E205	4-S	22.7(±1.2)	0.04(<0.09)	0.94(±0.11)	0.39 (±0.08)	5.4(±1.2)	500 (±13)	0.9(<1.4)
Obs Hole LAO-C	N 90	E 70	4-G	0.5(<0.8	0.06(<0.11)	0.02(<0.02)	0.01 (<0.01)	1.2(±0.8)	7.7(±1.4)	-0.4(<1.4)
Obs Hole LAO-1	N 85	E130	4-G	26.8(±1.7)	0.01(<0.10)	0.03(±0.03)	0.01 (<0.01)	1.9(±0.8)	150 (±5)	0.6(<1.4)
Obs Hole LAO-2	N 75	E205	3-G	18.1(±1.4)	0.07(<0.11)	0.04(±0.04)	0.11 (±0.06)	2.3(±0.8)	250 (±9)	0.4(<1.4)
Obs Hole LAO-3	N 80	E215	3-G	10.8(±1.2)	0.08(<0.11)	0.34(±0.06)	0.08 (±0.05)	2.5(±0.8)	75 (±4)	0.8(<1.4)
Obs Hole LAO-4.5	N 65	E270	3-G	7.1(±1.0)	0.05(<0.10)	0.02(<0.02)	0.03 (±0.05)	1.5(±0.6)	110 (±3)	1.5(<1.6)
Mortandad Canyon										
Gaging Station 1	N 50	E 95	4-S	6.2(±1.1)	1.46(±0.13)	14 (±1)	0.63 (±0.10)	15.1(±1.8)	660 (±12)	1.4(±1.4)
MCS-3.9	N 45	E125	1-S	46.7(±2.4)	0.06(<0.10)	5.2 (±0.4)	0.47 (±0.09)	3.3(±0.8)	300 (± 5)	NS
Obs. Hole MCO-3	N 45	E105	4-G	76.4(±1.6)	0.05(<0.11)	6.1 (±0.5)	0.41 (±0.10)	5.5(±1.0)	210 (± 6)	4.0(±1.2)
Obs. Hole 4	N 45	E135	4-G	43.5(±2.3)	0.07(<0.11)	4.5 (±1.3)	0.84 (±0.14)	5.6(±1.0)	220 (± 6)	9.0(±1.4)
Obs. Hole 5	N 45	E145	4-G	41.7(±2.2)	0.07(<0.11)	2.2 (±0.2)	0.28 (±0.07)	3.2(±0.8)	760 (± 3)	2.7(±1.4)
Obs. Hole 6	N 40	E155	4-G	41.8(±2.4)	0.02(<0.06)	0.99(±0.15)	0.13 (±0.10)	4.8(±1.0)	77 (± 3	6.1(±1.4)
Obs. Hole 7	N 35	E170	4-G	37.5(±2.1)	0.02(<0.06)	0.74(±0.12)	0.09 (±0.04)	2.4(±0.8)	41 (± 3)	4.5(±1.4)
Obs. Hole 7.5	N 30	E190	4-G	36.5(±2.0)	0.09(<0.11)	0.21(±0.07)	0.10 (±0.05)	3.4(±0.8)	45 (± 3)	3.6(±1.4)

[a] Number of samples analyzed during year and source, G = ground water; S = surface water.

TABLE XIV

RADIOACTIVITY IN OFF-SITE AND SUPPLY WATERS

	Number of Samples	Type of Activity	Units	Min	Max	Av	% CG
Regional Surface Water							
	24	^{3}H	10^{-6} µCi/mℓ	-0.8 (<0.8)	1.3 (±0.8)	0.7 (<0.8)	<0.1
	24	^{137}Cs	10^{-6} µCi/mℓ	-0.11(<0.12)	0.16(±0.09)	0.09(<0.11)	0.5
	24	^{238}Pu	10^{-12} µCi/mℓ	-7 (<6)	24 (<80)	3 (<12)	<0.1
	24	^{239}Pu	10^{-12} µCi/mℓ	-125 (<220)	40 (<46)	1 (<2)	<0.1
	18	U, Total	µg/ℓ	0.5 (<1.0)	5.6 (±2.0)	2.9 (±1.4)	<0.1
	24	Gross α	10^{-9} µCi/mℓ	0.3 (<0.4)	3.5 (±0.8)	0.8 (±0.6)	<0.1
	24	Gross β	10^{-9} µCi/mℓ	0.8 (<1.6)	18 (±2)	6.4 (±1.4)	2
Perimeter Surface and Ground Water	54	^{3}H	10^{-6} µCi/mℓ	-0.9 (<0.8)	3.8 (±1.0)	0.4 (<0.8)	<0.1
	54	^{137}Cs	10^{-6} µCi/mℓ	-0.11(<0.11)	0.11(±0.08)	0.02(<0.12)	0.1
	54	^{238}Pu	10^{-12} µCi/mℓ	-54 (<76)	28 (±22)	-0.4 (<2.0)	<0.1
	54	^{239}Pu	10^{-12} µCi/mℓ	-89 (<224)	122 (±62)	4 (<6)	<0.1
	48	U, Total	µg/ℓ	-1.0 (<2.0)	22 (±4)	1.9 (±1.2)	<0.1
	54	Gross α	10^{-9} µCi/mℓ	-0.7 (<0.6)	2.8 (±0.8)	0.4 (<0.6)	<0.1
	54	Gross β	10^{-9} µCi/mℓ	0.9 (<1.4)	11 (±2)	3.8 (±1.2)	1.2
Los Alamos Water Supply	42	^{3}H	10^{-6} µCi/mℓ	-0.1 (<0.8)	0.7 (<0.8)	0.3 (<0.8)	<0.1
	85	^{137}Cs	10^{-6} µCi/mℓ	-0.13(<0.12)	0.16(±0.14)	0.03(<0.12)	0.1
	85	^{238}Pu	10^{-12} µCi/mℓ	-33 (<24)	39 (<46)	4 (<10)	<0.1
	85	^{239}Pu	10^{-12} µCi/mℓ	-17 (<10)	40 (±40)	3 (±3)	<0.1
	85	U, Total	µg/ℓ	-1.4 (<2.0)	20 (±2)	2.0 (<2.8)	<0.1
	84	Gross α	10^{-9} µCi/mℓ	-0.5 (<0.6)	4.3 (±0.8)	0.6 (±0.6)	<0.1
	84	Gross β	10^{-9} µCi/mℓ	0.1 (<0.8)	12 (±2)	3.4 (±1.4)	1.2

TABLE XV

RADIOACTIVITY IN SOILS AND SEDIMENTS

Regional and Perimeter	Number of Samples	Type of Activity	Units	Min	Max	Av
Soils						
	10	^{3}H[a]	$10^{-6}\mu Ci/m\ell$	-0.1(<0.8)	4.5(<0.8)	0.8(±0.8)
	9	^{137}Cs	pCi/g	0.1(<0.2)	1.9(±0.3)	0.9(±0.3)
	9	^{238}Pu	fCi/g	-2 (<4)	4 (±4)	1 (<4)
	9	^{239}Pu	fCi/g	1 (<4)	41 (±20)	12 (±5)
	9	Gross α	pCi/g	0.1(<0.4)	2.0(±0.6)	1.0(±0.4)
	9	Gross β	pCi/g	7.8(±0.8)	22 (±2)	12 (±1.1)
Sediments	10	^{137}Cs	pCi/g	0.1(<0.2)	1.3(±0.3)	0.4(±0.3)
	10	^{238}Pu	fCi/g	1 (<4)	5 (±4)	1 (<4)
	10	^{239}Pu	fCi/g	1 (<4)	32 (±8)	6 (±3)
	10	Gross α	pCi/g	0.4(±0.4)	2.7(±0.6)	0.8(±0.3)
	10	Gross β	pCi/g	4.6(±0.6)	18 (±2)	9.7(±0.8)
On-Site:						
Soils						
	1	^{3}H[a]	$10^{-6}\mu Ci/m\ell$	-	-	2.1(±0.8)
	2	^{137}Cs	pCi/g	2.1(±0.3)	3.5(±0.3)	2.8(±0.3)
	1	^{238}Pu	fCi/g	-	-	2 (±2)
	1	^{239}Pu	fCi/g	-	-	12 (±6)
	2	Gross α	pCi/g	2.4(±0.6)	2.7(±0.6)	2.5(±0.6)
	2	Gross β	pCi/g	20 (±2)	21 (±2)	20 (±2)
Sediments						
	2	^{137}Cs	pCi/g	0.6(±0.3)	0.8(±0.2)	0.7(±0.3)
	2	^{238}Pu	fCi/g	1 (<2)	1 (<2)	1 (<2)
	2	^{239}Pu	fCi/g	1 (±1)	2 (±2)	1 (<2)
	2	Gross α	pCi/g	0.8(±0.4)	1.1(±0.4)	0.9(±0.4)
	2	Gross β	pCi/g	10 (±1)	11 (±1)	10 (±1)

[a]Tritium in moisture extracted from soil.

TABLE XVI

PLUTONIUM IN ALLUVIAL SOILS IN LIQUID WASTE RECEIVING CANYONS

Plutonium-239 concentration (pCi/g dry)

Distance from waste outfall	Acid-Pueblo Canyon Min	Max	Av		DP-Los Alamos Canyon Min	Max	Av		Mortandad Canyon Min	Max	Av	
-100 m[a]	.066	.075	.071	(± 0.012)	.016	.021	.018	(± 0.004)	.09	2.6	1.1	(< 2.6)
0	8.5	24	16	(< 22)	900	1500	1200	(±900)	18	120	59	(<110)
20 m	17	17	17	(± 0.0)	.77	21	12	(< 20)	17	51	33	(< 34)
40 m	5.8	28	14	(< 20)	.33	15	7.8	(< 14)	47	110	73	(< 62)
80 m	6.2	500	130	(< 480)	.55	7.7	3.2	(< 8)	2.1	6.7	4.3	(< 4.6)
160 m	8.6	20	13	(± 13)	.22	2.1	.69	(< 1.8)	2.6	14	7.0	(< 10)
320 m	7.9	12	9.8	(± 4.2)	.13	2.2	.67	(< 1.7)	1.3	10	7.0	(< 8.2)
640 m	7.8	19	12	(± 10)	.25	.36	.32	(< 0.12)	3.5	6.1	4.7	(± 2.6)
1.28 km	-	-	-	-	.48	1.6	.85	(< 1.0)	2.0	2.4	2.3	(± 0.74)
2.56 km	36	2200	870	(<2400)	.083	.17	.12	(± 0.10)	.79	1.8	1.4	(± 1.0)
5.12 km	.59	1.6	1.2	(± 1.1)	.17	.17	.17	(± 0.00)	.041	.069	.058	(± 0.024)
10.2 km	.40	.51	.45	(± 0.12)	-	-	-	-	-	-	-	-

[a]Negative distance represents background locations upstream from the outfalls.

TABLE XVII

CHEMICAL QUALITY OF ON-SITE SURFACE AND GROUND WATERS

Source Sampled Name and Location		No. & Type of Sample[a]	Average Chemical Concentrations (mg/l) Cr^{+6}	Se^{+4}	As^{+3}	Ca^{+2}	Mg^{+2}	Na^{+1}	CO_3^{-2}	HCO_3^{-1}	Cl^{-1}	F^{-1}	NO_3^{-1}	TDS	Hard	pH	Conductance (mS/m)
Noneffluent Areas																	
Test Well 3	N 80 E210	2-G	<0.006	0.001	0.003	20	3	15	0	92	8	0.3	1.8	179	72	7.8	17.9
Cañada del Buey	N 5 E165	2-S	<0.006	<0.001	<0.002	15	4	21	0	56	11	1.3	0.9	174	56	6.9	17.6
Pajarito Canyon	S 60 E225	2-S	<0.006	<0.001	<0.002	24	6	20	0	66	33	0.2	1.5	175	86	7.2	23.0
Water Canyon	S 90 E 90	2-S	<0.006	<0.001	<0.002	-	-	-	-	-	-	-	-	-	-	-	-
Test Well DT-5 A	S111 E 90	2-G	<0.006	<0.001	<0.002	11	2	9	0	60	5	0.2	1.1	154	38	7.7	10.8
Test Well 8	N 45 E145	2-G	<0.006	<0.001	<0.002	10	6	9	0	72	6	0.2	0.4	134	50	7.7	11.9
Acid-Pueblo Canyon (Formerly AEC-LASL Property)																	
Acid Weir	N130 E 60	2-S	<0.006	0.004	<0.002	18	3	80	0	92	89	0.8	7.3	316	56	7.4	47.5
Pueblo 1	N130 E 65	2-S	<0.006	0.009	<0.002	16	4	78	0	106	45	1.0	32	426	58	7.6	45.5
Pueblo 2	N120 E160	2-S	<0.006	0.008	<0.002	16	2	86	0	120	44	1.0	22	387	48	7.5	48.0
Obs. Hole PO-3 B	N110 E245	2-G	<0.006	0.004	<0.002	26	6	42	0	84	42	0.8	15	292	90	7.6	35.4
Hamilton Bend Spring	N110 E250	2-S	<0.006	0.005	<0.002	16	4	72	0	116	51	3.9	16	374	56	7.4	46.5
Pueblo 3	N 85 E315	2-S	<0.006	0.006	<0.002	18	4	92	0	134	54	1.1	31	434	60	7.5	55.6
Sandia Canyon																	
SCS-1	N 80 E 40	2-S	<0.006	0.004	0.009	41	9	94	8	180	67	3.4	12	685	138	8.1	66.4
SCS-2	N 55 E 60	2-S	<0.006	0.015	0.007	30	8	114	0	170	66	3.1	11	654	106	8.1	69.6
DP-Los Alamos Canyon																	
DPS-1	W 95 E160	2-S	<0.006	0.008	<0.002	19	3	148	0	242	40	5.6	21	667	60	8.1	73.2
DPS-4	N 80 E205	2-S	<0.006	0.006	<0.002	16	2	96	0	142	45	2.7	32	407	48	7.7	45.9
Obs. Hole LAO-C	N 90 E 70	2-G	<0.006	0.003	<0.002	16	4	38	0	86	36	0.2	0.9	217	52	7.6	25.2
Obs. Hole LAO-1	N 85 E130	2-G	<0.006	0.005	<0.002	24	6	74	0	106	35	1.1	7.3	373	86	7.3	42.3
Obs. Hole LAO-2	N 75 E205	1-G	<0.006	0.005	0.004	18	5	105	0	148	50	3.9	20	370	64	7.4	48.0
Obs. Hole LAO-3	N 80 E215	1-G	<0.006	0.006	0.003	13	3	61	0	92	44	4.0	9.7	448	44	7.3	35.0
Obs. Hole LAO-4.5	N 65 E270	1-G	<0.006	<0.001	0.002	16	6	59	0	76	38	0.3	0.9	296	64	7.6	26.0
Mortandad Canyon																	
Gaging Station 1	N 50 E 95	2-S	<0.006	0.004	0.007	14	4	56	0	132	10	1.0	3.7	262	48	8.1	30.1
MCS-3.9	N 45 E125	1-S		-	-	27	5	250	0	284	36	1.5	233	748	88	8.0	108
Obs. Hole MCO-3	N 45 E105	2-G	<0.006	<0.001	0.005	22	2	172	0	260	24	1.8	136	658	60	8.1	83.6
Obs. Hole MCO-4	N 45 E135	2-G	<0.006	0.006	0.006	28	5	208	0	298	34	1.5	222	884	90	7.6	116.2
Obs. Hole MCO-5	N 45 E145	2-G	<0.006	0.003	0.004	28	7	182	0	238	35	0.8	216	811	98	7.4	96.9
Obs. Hole MCO-6	N 40 E155	2-G	<0.006	0.005	0.008	24	8	216	0	264	34	0.9	242	878	92	7.6	102.8
Obs. Hole MCO-7	N 35 E170	2-G	<0.006	0.005	0.003	30	8	190	0	236	32	0.5	220	765	110	7.6	92.6
Obs. Hole MCO-7.5	N 30 E190	2-G	<0.006	0.003	0.002	32	8	164	0	230	33	0.2	205	718	110	7.7	88.4

[a] Number of samples analyzed during year and source, G = ground water, S = surface water.

TABLE XVIII

CHEMICAL QUALITY OF PERIMETER SURFACE AND GROUND WATERS

Sampling Locations	No. & Type of Sample[a]	Average Chemical Concentrations (mg/ℓ)													pH	Conductance (mS/m)
		Cr^{+6}	Se^{+4}	As^{+3}	Ca^{+2}	Mg^{+2}	Na^{+1}	CO_3^{-2}	HCO_3^{-1}	Cl^{-1}	F^{-1}	NO_3^{-1}	TDS	Hard		
Los Alamos Reservoir N105 W75	1-S	<0.006	<0.001	<0.002	10	2	5	0	44	2	0.2	19	114	32	7.2	7.7
Guaje Canyon N215 E315	2-S	<0.006	<0.001	0.003	11	2	6	0	44	6	0.2	1.3	102	36	7.2	10.2
Test Well 2 N115 E260	2-G	<0.006	<0.001	<0.002	15	4	9	0	72	7	0.6	1.3	146	56	7.7	13.5
Basalt Spring N65 E395	2-G	<0.006	<0.001	0.004	28	8	16	0	86	17	0.7	11	206	102	7.9	25.2
La Mesita Spring 18 km E of LA	2-G	<0.006	<0.001	0.002	34	1	32	0	122	13	0.6	11	156	90	7.6	28.0
Test Well 1A N70 E300	2-G	<0.006	<0.001	<0.002	23	6	60	0	120	43	2.1	29	320	84	7.5	43.0
Frijoles Canyon S280 E190	2-S	<0.006	<0.001	0.003	10	6	12	0	54	7	0.6	4.4	108	46	7.4	9.8
White Rock Canyon	Min	-	-	-	10	<1	10	0	54	4	0.1	0.3	128	36	6.8	12.0
of the Rio Grande	Max	-	-	-	35	11	132	0	340	37	10.3	48	612	124	7.9	63.0
(29 Locations, Fig. 10)	Avg	-	-	-	18	3	23	0	99	8	0.8	3.6	222	60	7.4	21.5

[a]Number of samples analyzed during year and source: G = ground water, S = surface water.

TABLE XIX

CHEMICAL QUALITY OF THE LOS ALAMOS WATER SUPPLY

Analysis	No. of Analyses	Concentration (mg/ℓ) Min	Max	Av	% Std[a]
Arsenic	64	<0.001	0.162	0.016	32
Bicarbonate	37	48	324	109	--
Calcium	37	8	29	15	--
Carbonate	37	0	0	0	--
Chloride	37	2	20	8	--
Fluoride	37	<0.1	2.7	0.8	≈80
Magnesium	37	<1	8	3	--
Nitrate	37	1.3	4.0	1.8	4
Selenium	64	<0.001	0.005	0.001	≈10
Silica	37	37	88	58	--
Sodium	37	10	151	33	--
TDS	37	96	408	228	46
Hardness	37	12	100	47	--
pH	37	7.3	8.5	8.0	--
Conductance (mS/m)	37	8.2	70.7	21.3	--

[a] Percent of drinking water standard (EPA and PHS).

TABLE XX

CHEMICAL QUALITY OF REGIONAL SURFACE WATERS

Analysis	No. of Analyses	Concentrations (mg/ℓ) Min	Max	Av	% Std[a]
Arsenic	12	<0.001	0.004	0.002	4
Bicarbonate	12	96	204	134	--
Calcium	12	30	86	51	--
Carbonate	12	0	8	0.7	--
Chloride	12	8	84	26	--
Fluoride	12	0.3	1.1	0.8	~80
Magnesium	12	6	22	10	--
Nitrate	12	0.4	18	0.9	2
Selenium	12	<0.001	0.005	0.001	10
Sodium	12	18	77	38	--
TDS	12	124	526	303	61
Hardness	12	104	308	170	--
pH	12	7.4	8.5	8.1	--
Conductance (mS/m)	12	23.0	74.0	45.3	--

[a] Percent of drinking water standard (EPA and PHS).

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