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Environmental Surveillance at Los Alamos During 1975

Compiled by

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CONTENTS

ABSTRACT		1
I.	INTRODUCTION	1
	A. Physical Setting	1
	B. Meteorology	2
II.	SUMMARY OF RESULTS	5
III.	STATEMENT OF PARTICULARS	6
	A. Geographic Coordinate System and Access Control	6
	B. Units of Measurement and Statistical Treatment of Data	8
	C. Standards for Environmental Contaminants	8
	D. Analytical Quality Control Program	9
IV.	ENVIRONMENTAL RELEASES FROM LASL OPERATIONS	11
V.	EXTERNAL PENETRATING RADIATION	12
	A. Procedures	12
	B. Results	12
VI.	RADIOACTIVITY IN AIR	14
	A. Sampling Procedures	14
	B. Daily Radioactivity	14
	C. Tritium	15
	D. Gross Radioactivity	16
	E. Plutonium and Americium	16
	F. Uranium	17
VII.	RADIOACTIVITY IN SURFACE AND GROUND WATERS	18
	A. On-Site Surface and Ground Waters	18
	B. Off-Site and Supply Waters	20
VIII.	RADIOACTIVITY IN SOILS AND SEDIMENTS	20
IX.	RADIOACTIVITY IN FOODSTUFFS	21
X.	RADIATION DOSE ASSESSMENT	22
	A. Methods and Assumptions	22
	B. External Penetrating Radiation	22
	C. Radioactivity in Air	22
	D. Other Nuclides and Pathways	24
XI.	CHEMICAL QUALITY OF SURFACE AND GROUND WATERS	24
	A. On-Site Surface and Ground Waters	24
	B. Off-Site and Supply Waters	25
	C. Fenton Hill Site Surface and Ground Waters	25
XII.	ECOLOGICAL STUDIES	26
	A. Long-Term Ecological Effects of Exposure to Uranium	26
	B. Storm Runoff Transport of Plutonium in Mortandad Canyon	28
	C. Radionuclides in Rio Grande Sediments and Fish	30
XIII.	UNPLANNED RELEASES	30
REFERENCES		31
TABLES		33-53
DISTRIBUTION LIST		54

TABLES

I.	Means and Extremes of Temperature and Precipitation	33
II.	Units of Measurement Conversions	34
III.	Minimum Dectection Limits (MDLs) for Routine Analyses of Radioactivity in Typical Environmental Samples	35
IV.	ERDA Radioactivity Concentration Guides (CGs)	36
V.	Water Standards	37
VI.	Atmospheric Radioactive Effluent Totals for 1975	38
VII.	Annual Thermoluminescent Dosimeter Measurements	39
VIII.	Summary of Annual Atmospheric Radioactivity Monitoring	40
IX.	Annual Atmospheric Tritiated Water Vapor Concentrations	41
X.	Annual Atmospheric Gross-Alpha and Gross-Beta Activity Concentrations	42
XI.	Annual Atmospheric ^{238}Pu, ^{239}Pu, and ^{241}Am Concentrations	43
XII.	Annual Atmospheric Uranium Concentrations	44
XIII.	Radioactivity in On-Site Surface and Ground Water	45
XIV.	Radioactivity in Off-Site and Supply Waters	46
XV.	Radioactivity in Soil and Sediments	47
XVI.	Chemical Quality of On-Site Surface and Ground Waters	48
XVII.	Chemical Quality of Perimeter Surface and Ground Waters	49
XVIII.	Chemical Quality of Regional Surface Water	50
XIX.	Chemical Quality of the Los Alamos Water Supply	51
XX.	Chemical Quality of Water in the Vicinity of Fenton Hill	52
XXI.	Rio Grande Radionuclide Survey	53

FIGURES

1.	Topography of the Los Alamos, New Mexico, area	v
2.	North-central New Mexico	3
3.	1975 wind roses	5
4.	Los Alamos County residential areas and LASL technical areas.	7
5.	Tritium in water crosscheck program	10
6.	Gross-beta in water crosscheck program	10
7.	Cesium-137 in water crosscheck program	10
8.	TLD and air sampler locations	13
9.	Daily gross-beta radioactivity for 1975	15
10.	Water, sediment, and soil sampling locations on or near the LASL site	19
11.	Regional surface water, sediment, and soil sampling locations	20
12.	Fenton Hill Sampling Station map	27

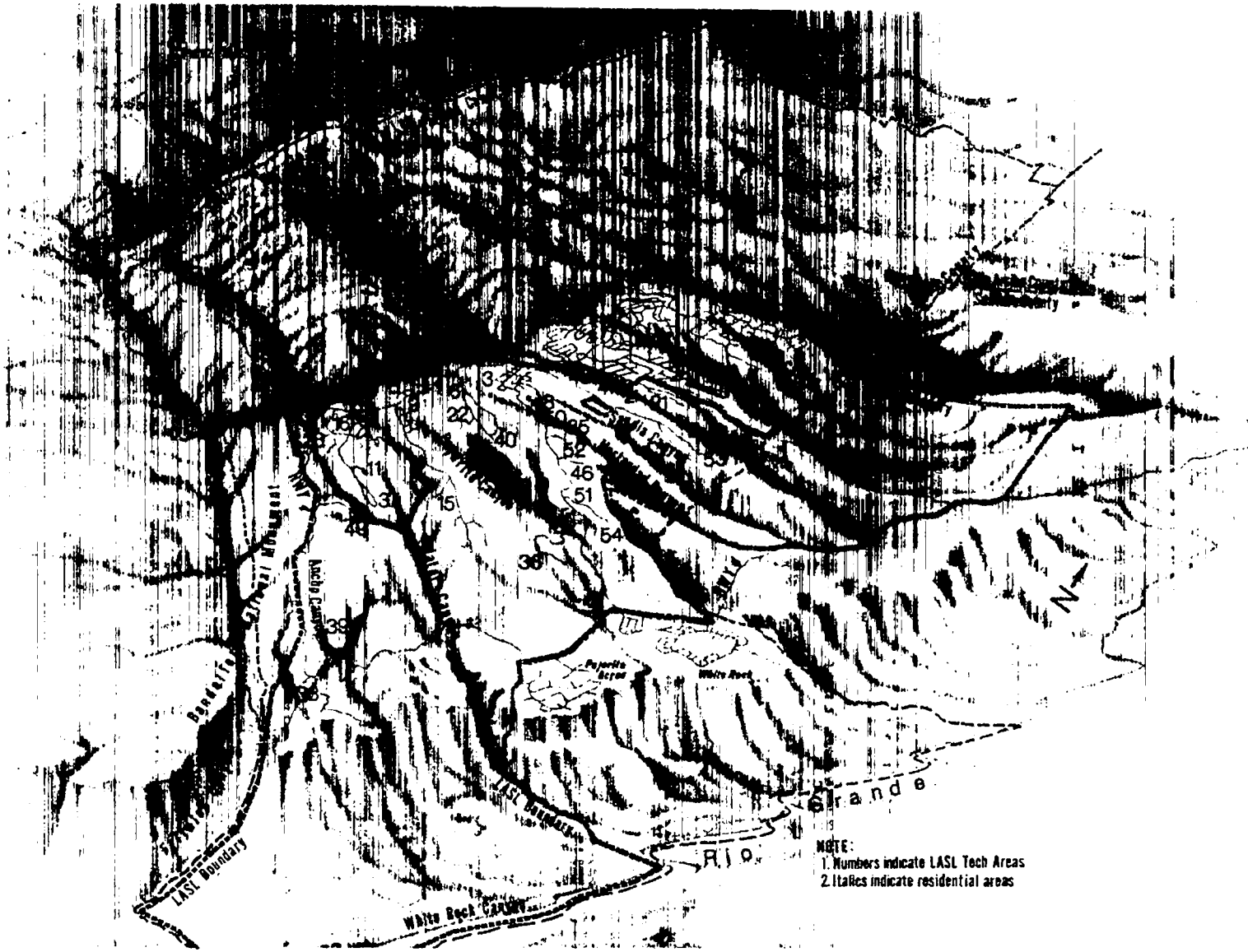

Fig. 1. Topography of the Los Alamos, New Mexico, area.

ENVIRONMENTAL SURVEILLANCE AT LOS ALAMOS DURING 1975

Compiled by

K. E. Apt and V. J. Lee

ABSTRACT

This report documents the CY 1975 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, soils, and foodstuffs, and are compared with relevant U.S. Energy Research and Development Administration 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 qualities of surface and ground waters in the LASL environs have been determined and compared to applicable standards. Results of related environmental studies are summarized.

I. INTRODUCTION

This report documents the results of the environmental monitoring program conducted at the Los Alamos Scientific Laboratory (LASL) during CY 1975. In keeping with Energy Research and Development Administration (ERDA) and Laboratory intent to keep information on environmental quality available to the public, it principally serves the purpose of providing public documentation of data on environmental quality and conditions in the vicinity of the Laboratory. In accordance with LASL contractual agreement, it additionally complies with the requirements specified in ERDA Manual Chapter (ERDAM) 0513.

LASL is administered by the University of California for ERDA, under contract W-7405-ENG-36. The LASL environmental program is conducted by the Environmental Studies Group (Group H-8) as part of continuing environmental investigation and documentation.

Since its inception in 1943, the Laboratory's primary mission has been nuclear weapons research and development. In addition to its national security programs, which include weapons development, laser fusion, nuclear materials, and laser isotopes separation, LASL conducts research programs in the physical sciences, energy research and development, and biomedical and environmental studies.

A. Physical Setting

The Los Alamos Scientific Laboratory and the residential communities of Los Alamos and White Rock are located in Los Alamos County in north-central New Mexico, about 100 km NNE of Albuquerque and 40 km NW of Santa Fe, by air. The 110-km^2 Laboratory site and adjacent communities are situated

on the Pajarito Plateau which consists of a series of mesas separated by deep canyons that run eastward from the Jemez Mountains to the Rio Grande valley. Most Laboratory and community development is confined to the mesa tops. The surrounding land is essentially undeveloped. 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. Indian pueblo lands border the Laboratory to the east (Figs. 1 and 2). The major plant associations of the area are coniferous forests and piñon-juniper bushlands which support a typical variety of western mountain wildlife.

North-central New Mexico contains approximately one-half million people, of whom nearly 70% are concentrated in Albuquerque and another 10% are located in Santa Fe. 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. About 12 000 people live in the residential area of Los Alamos proper and some 5700 more reside in the White Rock area.

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 to 40 km of Los Alamos. In the immediate area (less than 20 km from LASL) home gardening is practiced but is insignificant from the population subsistence viewpoint.

B. Meteorology

Los Alamos has a semiarid continental mountain climate. The annual precipitation of 46 cm is accounted for by warm-season orographic convective rain showers and winter migratory storms. Seventy-five percent of the annual total falls between May and October, primarily as thunderstorms. Peak shower activity is in August, when one day in four will have at least 2.5 mm of rain accumulation and some rain is observed on half of the days. The annual average of 62 thunderstorm-days per year makes this area equivalent to the Gulf Coast states in thundershower occurrence. The showers tend to develop in early afternoon, with a secondary maximum about 1800 MST. They are accompanied by lightning, gusty surface winds (10-20 m/s), and occasional hail. Tornadoes have not been observed in this area.

Winter precipitation falls primarily as snow with annual accumulations of about 1.3 m. The water equivalent of snowfall in Los Alamos varies between 1:10 and 1:20, the latter occurring in cold conditions and higher altitudes.

Summers are cool and pleasant. Maximum temperatures are generally below 32°C, and a large diurnal variation keeps nocturnal temperatures in the 12-15°C range. Winter temperatures are typically in the range from -10°C to 5°C. Many winter days are clear with light winds, and strong solar radiation makes conditions quite comfortable even when air temperatures are cold. The annual total of heating degree days (Celsius) is 3500, with January accounting for over 610 while July and August average zero degree days.

An analysis of one year's solar radiation is described by Balcomb et al.[1] By estimating an envelope to the observations of daily insolation, an annual observed value of about two-thirds the potential insolation is obtained. The reduction is due to cloudiness, implying that approximately one-third of the daylight hours in one year were affected by cloudiness. The most cloud-free month (January) had 85% of potential insolation while the minimum (July) had 55%.

Average relative humidity is 40%, ranging from 30% in May and June to above 50% in July, January, and February. The diurnal variation is very large and basically inverted to the diurnal temperature cycle. The summer months have nocturnal maxima of 80% and minima of 30%, while the driest

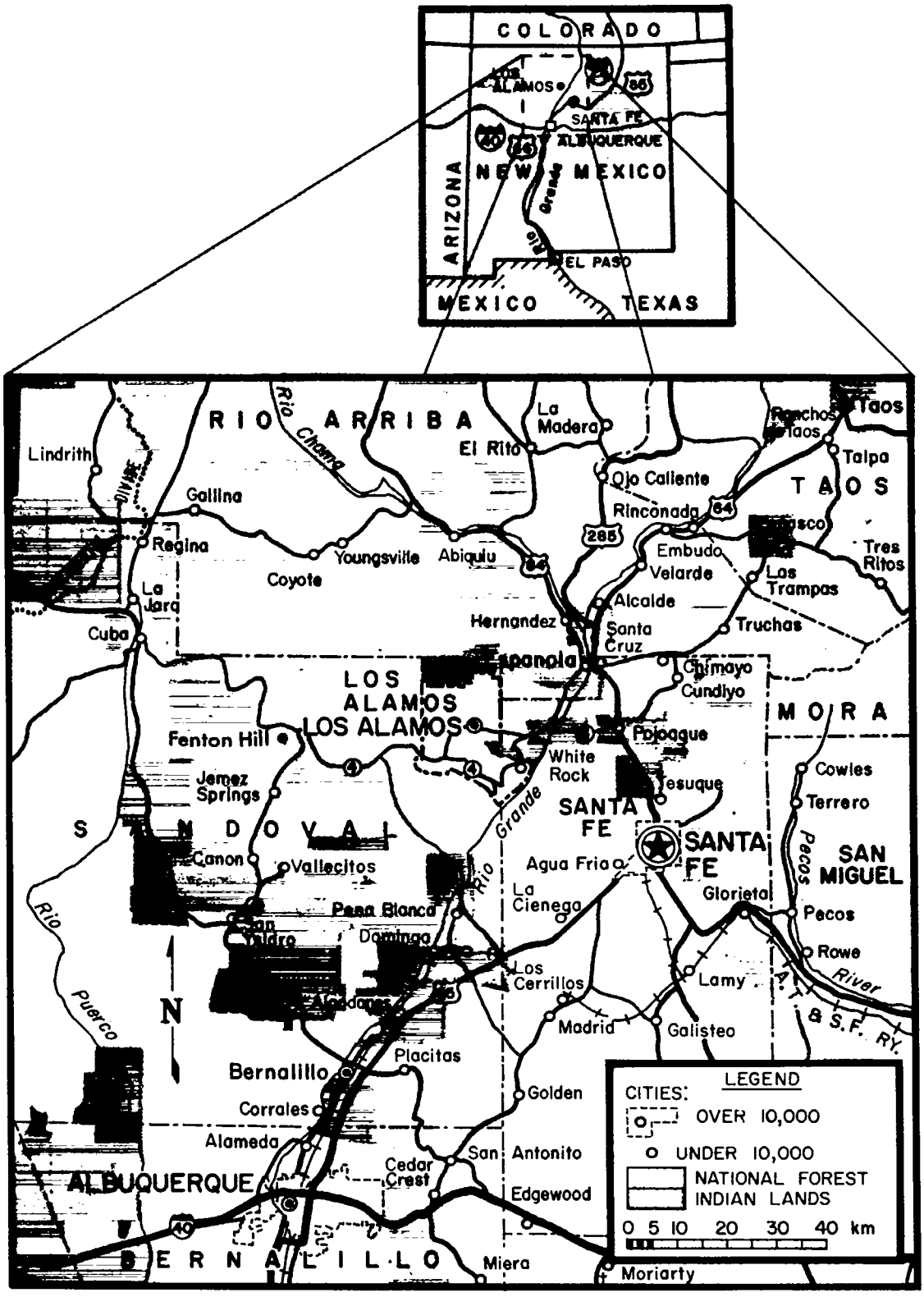

Fig. 2. North-central New Mexico.

time, spring, has a diurnal range from 15-50%.

The local conditions for the transport and dilution of air contaminants are of interest. Atmospheric diffusion depends on three primary considerations: source factors (size, duration, elevation-above-ground, temperature), terrain factors (roughness, slope, vegetative cover, solar heating), and meteorological factors (wind speed and direction, temperature, stratification, turbulence energy). There is considerable interdependency among all of the factors listed, and many of the available formulae for estimating atmospheric dispersion represent attempts at generalizing the interrelationships. The fundamental formulation for most practical diffusion prediction schemes is the Gaussian plume model, which can be expressed as

$$\chi = \frac{Q_i}{(2\pi)^{\frac{3}{2}}\ \sigma_y(x)\ \sigma_z(x)\ \sigma_x(x)}$$

$$\text{x exp} \left\{ - \left[\frac{(x-\bar{u}t)^2}{2\sigma_x^{\,2}(x)} + \frac{y^2}{2\sigma_y^{\,2}(x)} + \frac{z^2}{2\sigma_z^{\,2}(x)} \right] \right\}$$

for instantaneous sources, or

$$\chi = \frac{Q_c}{\pi\ \bar{u}\ \sigma_y(x)\ \sigma_z(x)}$$

$$\text{x exp} \left[- \frac{1}{2} \left(\frac{y^2}{\sigma_y^{\,2}(x)} + \frac{z^2}{\sigma_z^{\,2}(x)} \right) \right]$$

for continuous sources. In this framework, the diffusion parameters σ_y and σ_z can be interpreted as a measure of the plume's lateral and vertical dimensions at appropriate distances x. Various authors have used different empirical meteorological parameters to specify σ_y, σ_z, including wind speed, temperature profiles, time-of-day, cloudiness, and direct measure of gustiness. A comparison of a number of frequently used methods, and the frequency of occurrence observed during a 1-yr experiment at TA-3, is shown below:

Description	Pasquill	σA[a]	Wind Dir. Range	Sutton C	Sutton N	Freq. of Occur.
Very stable	F	2.3°	0-30°	.21	.50	2.4%
Stable	E	4.6°	30-60°	.12	.33	14.1
Near neutral	D	7-10°	60-90°	.08	.25	25.7
Moderately unstable	C	10-15°	90-120°	.07	.22	27.1
Unstable	B	15-20°	120-180°	.06	.20	21.4
Extremely unstable	A	>20°	>180°	-	-	8.9

[a]Standard deviation of azimuth wind direction fluctuations.

The application of the meteorological parameters depends on modeling assumptions tying them to the diffusion coefficients, either mathematical expressions (such as power laws in downwind distance), tables or graphs of σ_y, σ_z vs x, and the above parameters. Such relationships are readily available in references such as Slade,[2] Pasquill,[3] or Cramer et al.[4]

Table I shows the means and extremes of temperature and precipitation for the entire period of record, and separately, for 1975. By comparison, 1975 was generally cool and wet. Temperatures were below average in every month except December. A heavy surplus of precipitation in late winter and spring offset dry months in May, June, and August. July and September had above-average rain; however, very dry conditions were established in the last three months of the year.

Wind roses, shown in Fig. 3, are indicators of atmospheric transport of contaminants. Under stable conditions, the influence of topography is maximized in a northwest-southeast major axis orientation--basically parallel with the slope of the Pajarito Plateau. The winds, under stable daytime conditions, tend to be somewhat more uniformly distributed in direction, responding to the variety of pressure gradients induced by migratory weather systems. The periods reflecting the sunrise and sunset transitions are not distinctly different from the nocturnal regimes. The wind data presented here were collected from a location on the roof of the Administration

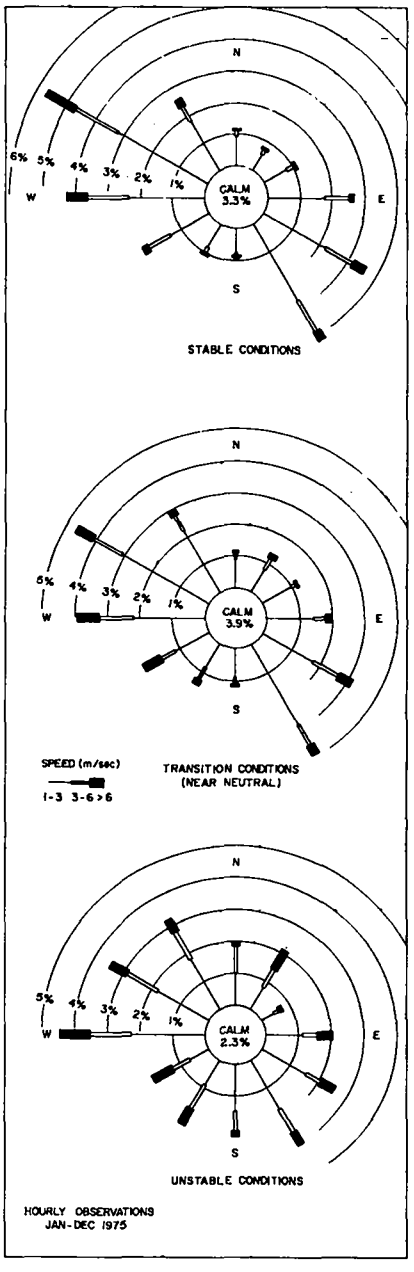

Fig. 3. 1975 wind roses.

Building in TA-3. Extension to other sites must be made with extreme caution because of terrain variability and the previously observed dependence of winds on measurement sites.

II. SUMMARY OF RESULTS

This report summarizes the results of LASL's environmental monitoring program. Results of measurements of (1) radioactivity in air, ground and surface waters, sediments and soils, and foodstuffs, (2) external penetrating radiation, (3) chemical quality of surface and ground waters, (4) the chemical and radiochemical quality of potable supply waters, and (5) related ecological investigations are presented. The results of the environmental monitoring program for this reporting period confirm the generally low radiation and contaminant levels due to LASL operations previously observed[5] in the Los Alamos environs.

Average external penetrating radiation levels for off-site, perimeter, and on-site locations were 124, 134, and 211 mrem/yr, respectively. Average concentrations of atmospheric tritium oxide for off-site, perimeter, and on-site locations were 20, 42, and 104 x 10^{-12} μCi/mℓ, respectively. These concentrations are, respectively, 0.01, 0.02, and 0.002% of the applicable uncontrolled-area and controlled-area Concentration Guides (CGs). Atmospheric long-lived gross-alpha and gross-beta activity concentrations in the LASL environs were 1.1 and 78 x 10^{-15} μCi/mℓ, respectively, or 2 and 0.3% of the applicable CGs. Atmospheric ^{238}Pu and ^{239}Pu concentrations in the LASL environs were 0.6 and 21 x 10^{-18} μCi/mℓ, respectively, which are 0.001 and 0.04% of the appropriate CGs. Atmospheric uranium concentrations were found to be 0.04 ng/m^3 in the LASL environs, 0.0005% of the CG.

Radioactivity in surface and ground waters in the LASL environs was below applicable Concentration Guides. The chemical quality of most surface and ground water samples in the LASL environs met standards

set for drinking water. The chemical quality of municipal and Laboratory sewage effluent samples is typical for such release areas, and these releases do not become a source of the potable water. The samples of potable supply water were found to meet applicable standards for all chemical and radiochemical constituents measured except arsenic. Water from one supply well was determined to have natural arsenic concentrations that exceeded the Environmental Protection Agency (EPA) drinking water standard, and use of the well has been suspended pending special studies (see Section XI.B).

No Laboratory-related concentrations of radionuclides were detected beyond a 20-km radius of the Laboratory. Consequently, individual and population dose assessments were made for Los Alamos County only. The only whole-body dose that could be attributed to the Laboratory was from tritiated water vapor. The maximum individual whole-body dose at a site boundary (near TA-33) was calculated to be 0.34 mrem, which is 0.068% of the individual dose limit of 500 mrem/yr for uncontrolled areas. The maximum dose at an occupied location occurred at the Los Alamos Airport, where the calculated whole-body dose was 0.18 mrem, 0.036% of the individual dose limit and 0.11% of the population dose limit of 170 mrem/yr. The tritiated water vapor contributes a total population dose of approximately 0.42 man-rem to the residents of Los Alamos County. The maximum lung dose from airborne transuranic nuclides was calculated to be 0.062 mrem (at TA-6) which is 0.004% of the individual dose limit.

Related ecological investigations are also reported herein. The storm runoff of trace-level plutonium in a LASL canyon system is described. Initial results are presented for a sampling program for radionuclides in Rio Grande sediments and fish. A study designed to characterize the long-term ecological behavior of exposure to uranium is also described.

One inadvertent release of radioactive materials occurred on-site in 1975. An abnormal chemical reaction at the Central Waste Treatment Plant at TA-50 (see Fig. 4) caused about 3000 ℓ of a contaminated liquid-sludge mixture to flow out of the building. All contamination was confined to an area of about 500 m^2, including portions of a blacktop parking lot and driveway and an adjacent soil area. The entire area was inside a fenced technical site. The contamination involved mixed alpha-, beta-, and gamma-emitting radioisotopes with principal activities being due to ^{238}Pu, ^{90}Sr, and ^{137}Cs. All detectable contamination was successfully removed. Exposure pathway analysis indicated that measurable exposure to on- and off-site personnel did not occur.

III. STATEMENT OF PARTICULARS

A. Geographic Coordinate System and Access Control

All Los Alamos County and vicinity locations referenced in this report are identified by the LASL Cartesian coordinate system (see Fig. 4) which is standard throughout the Laboratory and 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 boundary (see Figs. 1 and 4) is considered a controlled area in that the Laboratory has the capability of complete access restriction. Complete control would be instituted, were it deemed necessary for any significant reason. Under normal circumstances, however, public access roads that traverse the Laboratory site are open to commuters and other travelers; no continuous occupancy of these areas is permitted. Access to individual Technical Areas is restricted for reasons of safety and security. Some of the more remote and little-used regions of the site are not actively controlled against

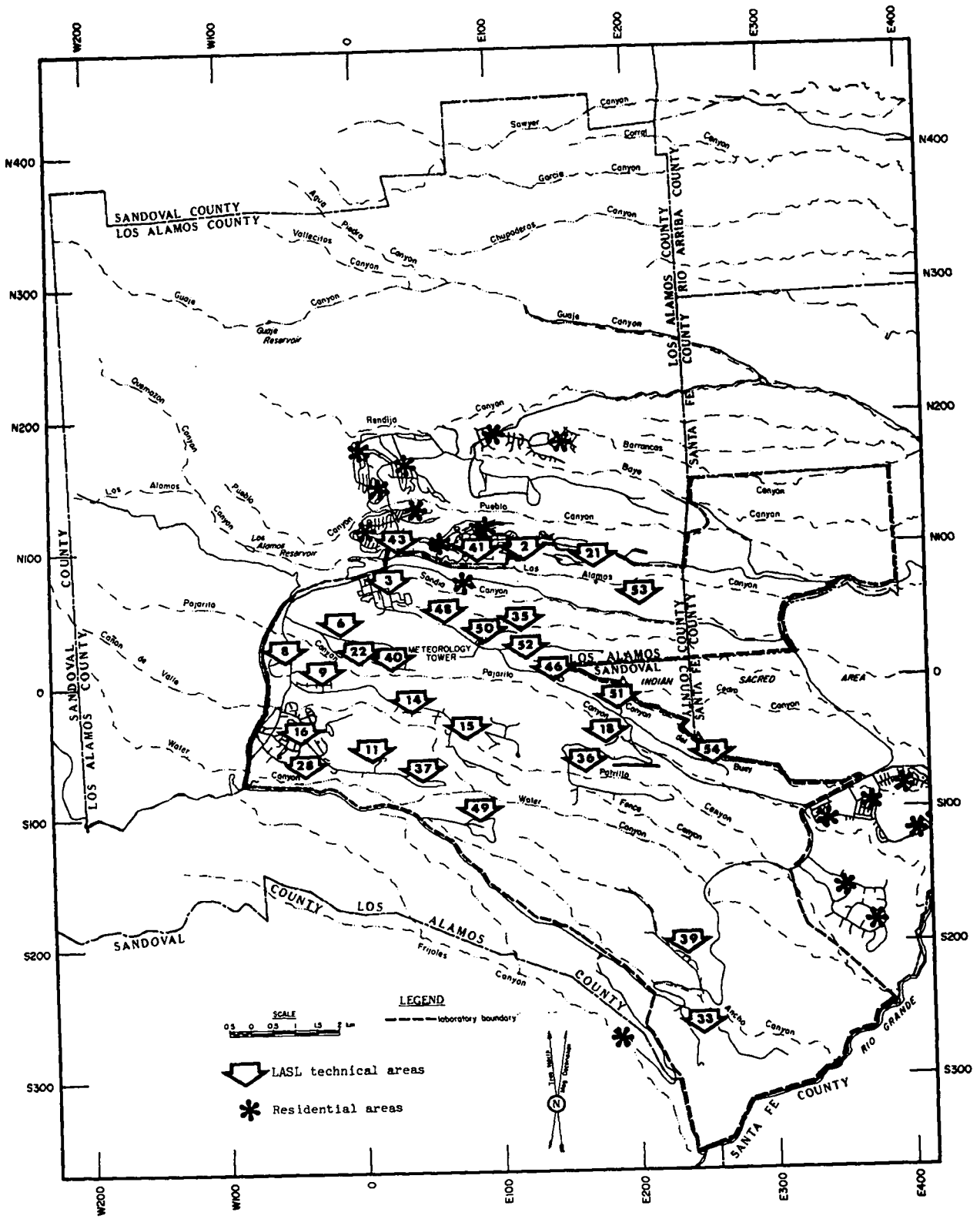

Fig. 4. Los Alamos County residential areas and LASL technical areas.

public access, although most of the site is posted against trespassing and routine security patrols cover the entire site.

B. Units of Measurement and Statistical Treatment of Data

LASL scientific and technical documentation uses metric units, and conversion to the International System of Units (SI) is preferred wherever practicable. Table II provides conversion data for units of measure given in this text.

For many environmental measurements, particularly those from which a chemical or instrumental background must be subtracted, it is possible to obtain net values that are lower than the minimum detection limit (MDL) of the system (see Table III). 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 given 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 precision and accuracy of the numerical value, an additional value is included in parentheses immediately following the primary numerical value. For contiguous measurements, such as air monitoring and environmental radiation, the parenthetical value indicates the 95% confidence range for the primary value, i.e., twice the square root of the variance, or 2σ. For discrete data, e.g., water samples, soil samples, etc., the parenthetical value represents twice the standard deviation of the distribution of observed values.

It has been observed that some environmental data are not well described by the Gaussian distribution function. However, the logarithms of the data quite often fit the Gaussian function. Therefore, the log-normal probability distribution is used in describing some of the environmental data reported. It is intended that use of the geometric mean and standard deviation parameters will tell more about the data than would the conventional arithmetic mean and standard deviation. An explantion of log-normal analysis was given in "Environmental Surveillance at Los Alamos during 1973."[6]

C. Standards for Environmental Contaminants

The concentrations of radioactive and chemical contaminants in air and water samples collected throughout the environment are compared with the standards contained in the regulations of several Federal and State agencies to verify the compliance of the Laboratory with all pertinent standards. LASL operations pertaining to environmental quality control are conducted in accordance with the directives and procedures contained in ERDAM 0500, Health and Safety, Chapters 0510, 0511, 0513, 0524, and 0550.

In the case of radioactive materials in the environment, the standards contained in ERDAM 0524 (see Table IV) take precedence over other Federal or State regulations. However, the ERDA standard for uranium in water (1500 and 60 mg/ℓ for controlled and uncontrolled areas, respectively) does not consider chemical toxicity. Therefore, for the purposes of this report the more restrictive standards[7] of the International Commission on Radiological Protection (ICRP) for uranium in water of 60 mg/ℓ for an occupational 40-h week, and 1.8 mg/ℓ for a non-occupational 168-h week, are preferred. For atmospheric uranium, the ERDA and ICRP standards are in agreement. For chemical pollutants, the controlling standards are those promulgated by either the EPA or the appropriate New Mexico State agencies (Table V).

D. Analytical Quality Control Program

In order to ascertain the quality of the analytical capabilities supporting the environmental programs reported herein, a rigorous laboratory quality control program is maintained. A detailed presentation of both interlaboratory and intralaboratory quality control data is included to provide the reader with the necessary information with which to judge this laboratory and the environmental report.

Quality control for gross-alpha, gross-beta, ^{137}Cs, and tritium analyses has consisted of participation in the EPA laboratory intercomparison program. The EPA routinely presents the results of the intercomparison studies to the environmental analytical laboratory. As a measure of procedural accuracy, the EPA graphically reports the normalized deviation of the mean of three reported values from the known value. The precision of an analytical procedure is measured from a graphical presentation of the normalized range of the three reported results. To provide a means of evaluating laboratory results, the EPA includes a warning level (WL) and a control level (CL) on the graphs. The warning level is $2\sigma_M$, twice the standard deviation (std dev) of the mean, or $\bar{R} + 2\sigma_R$, the mean range plus 2 std dev of the range. The control limit for the normalized deviation of the mean is $3\sigma_M$, and for the range is $\bar{R} + 2\sigma_R$. Values that fall above or below CL indicate serious problems with the analysis. A detailed discussion of the EPA program may be found in "Environmental Radioactivity Laboratory Intercomparison Studies Program, 1975."[8]

Group H-8 analytical laboratory performance during 1974 and 1975 for analyses of tritium, gross-beta, and ^{137}Cs in water is represented by the results shown in Figs. 5, 6, and 7. The more recent results show that these procedures are currently providing satisfactory results. However, there is an indication of problems with each of the analyses during 1975. Causes of the gross-beta and tritium excursions beyond the control limits could not be attributed to any specific problem. However, the extremely high results for ^{137}Cs in December 1974 were apparently associated with problems in the NaI(Tl) detection system, since extremely low results were obtained upon changing to the Ge(Li) detector system in the early months of 1975. The inaccuracy of results from the Ge(Li) system could be attributed to an inaccurate standard. The results improved after preparation of new standards in June 1975.

An internal quality control program for more complicated routine analyses was begun in October 1975. The program consists of analyzing control samples in conjunction with routine samples submitted to the laboratory. Control samples consist of blanks, i.e., materials containing none or very little of the subject material, and blank plus known quantities of the element or isotope of interest. Various blanks are available so that a blank matrix can be selected which corresponds to the matrix material of the companion samples.

Three parameters are calculated to evaluate the performance of the procedure: (1) the accuracy is judged from

$$\% \text{ Recovery} = \frac{\text{Reported Quantity} \times 100}{\text{Known Quantity}} ;$$

(2) the precision is evaluated from calculation of twice the percentage standard deviation from the mean of replicate control samples

$$\% \ 2\sigma = \frac{200\sqrt{\Sigma\ (X-\bar{X})^2}}{(N-1)\ \bar{X}} ;$$

(3) the quantity of element or isotope introduced during the analysis is evaluated from the absolute quantity in the unspiked blanks.

Approximately 10-15% of the samples analyzed in the environmental analytical laboratory are control samples. The parameters discussed below are calculated for

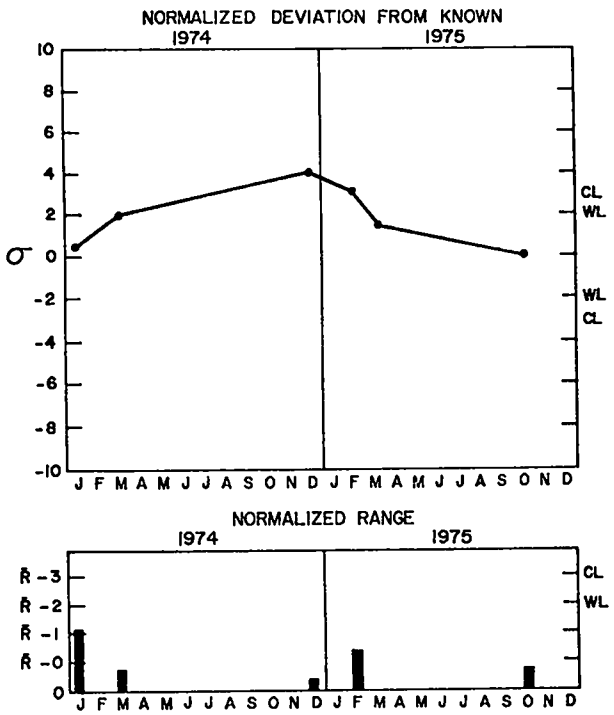

Fig. 5. Tritium in water crosscheck program.

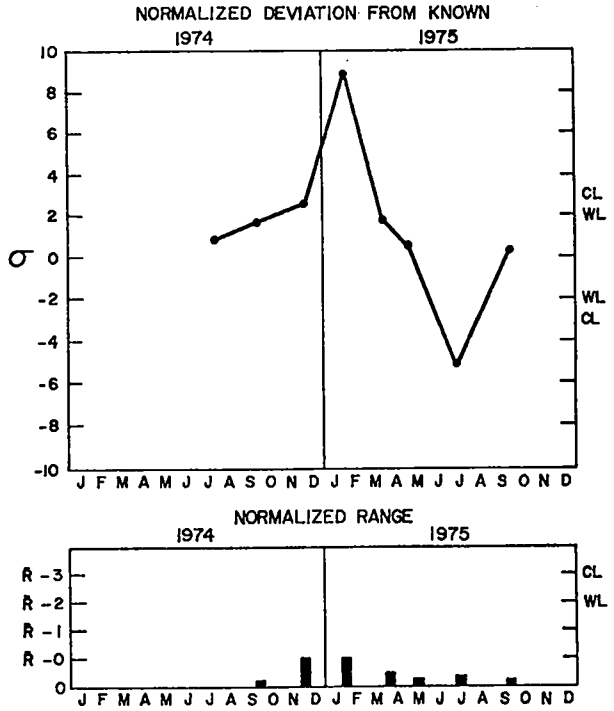

Fig. 6. Gross-beta in water crosscheck program.

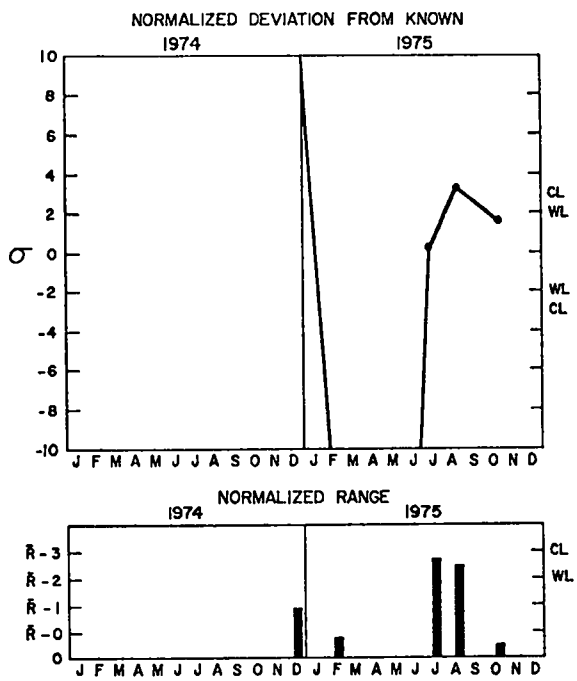

Fig. 7. Cesium-137 in water crosscheck program.

controls that were included with each set of samples and forwarded to the person who submitted the samples. The results for all the controls are tabulated and reported periodically. These tabulations include the mean value for each parameter, twice the standard deviation as a measure of the population distribution and the number of results N included in the tabulation.

Quality control data for $^{238,239}Pu$ analyses on a variety of matrices are

	N	$\bar{X}$	2σ
% Recovery (^{239}Pu)	30	99%	42%
% 2σ from Mean	6	37%	53%
pCi ^{239}Pu (blank)	36	0.0027	0.0026
pCi ^{238}Pu (blank)	75	-0.0006	0.019

The large 2σ associated with each of the quantities reflects very large excursions in about 10% of the samples, rather than a large scatter in the distribution for the entire population.

A quality control program has not yet been initiated for analysis of ^{241}Am.

Analytical capabilities for analyses of uranium in geologic materials were evaluated by running standardized fly ash from the National Bureau of Standards (NBS) and standardized samples of pitchblend from the International Atomic Energy Agency (IAEA). Triplicate sets of these standard materials were analyzed six times to evaluate the capabilities of the procedure. This is not the same as including control samples routinely with normal sample analysis. The quality control data for uranium analysis in geologic materials is

	N	$\bar{X}$	2σ
% Recovery	18	105%	21%
% 2σ Mean of Replicates	6	20%	18%

Interferences to this procedure from nine common metals were evaluated as well as the effect of variations in several critical steps in the procedure. A LASL report describing the uranium fluorometric procedure and the results of the evaluation is in preparation.

A quality control program for the analysis of arsenic in water by atomic absorption spectrophotometry has recently been initiated. In addition to the normal quality control program, other procedures were used to evaluate arsenic. Atomic absorption analysis standard additions and dilutions were performed on replicate samples from the Los Alamos well water system. The % 2σ from the mean of these replicates was calculated to evaluate the reproducibility of the results measured at various arsenic concentrations. Selected samples of these waters were analyzed by radiochemical neutron activation analysis and by atomic absorption spectrophotometry, and the results obtained by the different methods were compared. The % 2σ from the mean arsenic concentrations determined by the two methods is reported below along with the other quality control data for the arsenic procedure.

	N	$\bar{X}$	2σ
% Recovery	11	95%	13%
% 2σ from Mean of Replicates	4	5%	9%
% 2σ from Mean of Replicates (Standard Addition & Dilution)	10	12%	22%
% 2σ from Mean of Duplicates (RNAA and AA)[a]	15	7%	8%
ppb As (tap water)[b]	3	4.3	0.5

[a] RNAA, radiochemical neutron activation analysis; AA, atomic absorption spectrophotometry.

[b] Assumed to be actual concentration in tap water.

IV. ENVIRONMENTAL RELEASES FROM LASL OPERATIONS

LASL's activities are carried out in 30 active technical areas (TA) distributed over the LASL site (Fig. 4). These facilities include hundreds of potential sources of waste effluent; however, processes with potential for significant releases are confined to only a few locations which are rigorously controlled and monitored.

The environmental monitoring program emphases are dictated by the types and quantities of potentially hazardous materials being used in LASL programs and by the

demography, ecology, hydrology, and geology of this location. Emphasis is placed on the analyses for tritium, uranium, and plutonium in samples of the environmental media; fission product radionuclides are of lesser concern, due to the minimal amounts handled. Selected samples are analyzed for radioactive species of cesium.

The documented release of radioactive materials to the atmosphere from LASL operations is shown in Table VI. These data were compiled from stack effluent monitoring determinations and represent no significant change from effluents documented in CY 74.[5]

V. EXTERNAL PENETRATING RADIATION

A. Procedures

Exposure from external penetrating radiation (primarily gamma radiation) in the LASL environs is monitored by 44 thermoluminescent dosimeter (TLD) stations, 11 of which are located along the perimeter of the Laboratory (within about 1/2 km of the boundary), 12 are located beyond the Laboratory boundaries, and 21 are located on-site and in the immediate vicinities of LASL nuclear facilities. (Locations are given in Fig. 8, and map coordinates identify locations in the data tabulation; see Table VII.) A group of 27 stations, on a 4-wk integration cycle, covers normal LASL and Los Alamos County locations in addition to the nuclear facilities. A second group consisting of 17 stations, on a 13-wk integration cycle, includes Espanola, Pojoaque, Santa Fe, Pajarito Ski area, and the remaining LASL and Los Alamos County locations. All of the 26 air sampling stations serve as TLD stations. The TLD monitoring locations were selected to reduce systematic radiation differences caused by variations in natural background radiation.

Each of the TLD monitors consists of three Harshaw TLD-100® LiF (natural isotopic composition) chips 6.4 mm square by 0.9 mm thick. The TLDs are annealed, calibrated, and read by standard techniques. The annealing cycle is 2 h at 673 K, followed by 1 h at 373 K. For each annealing batch, an independent calibration factor is determined by standard radiation (from 10 mR to 160 mR) with ^{60}Co. 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. Latent thermoluminescence after annealing and transit dose are compensated for by control dosimeters. All TLDs are read with an Eberline model TLR-5 reader with 15-s, 413 K preheat and 15-s, 513 K integration cycles. All handling operations are conducted under "dark" conditions. As the TLDs are calibrated in mR, a conversion factor of 1 rem (tissue) = 1.061 R is used.[9]

B. 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, perimeter, and on-site locations. The values are the total dose integrals for 1975 for each station. Parenthetical values represent twice the square root of the variance of the integrals, i.e., the 2σ 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 variations of the individual dose measurements. Monthly and quarterly dose variances are derived from the distribution of the three individual TLD readings, the error of calibration, the control dosimeter corrections, and the instrumental background subtractions.

Temporal variations in environmental gamma radiation were generally less than 50%. However, significant spatial variations were observed which result from differences in the terrestrial component of external environmental gamma radiation. These differences are a complex function of the topography, geology, hydrology, and meteorology of the monitoring sites. Due to atmospheric shielding of cosmic radiation,

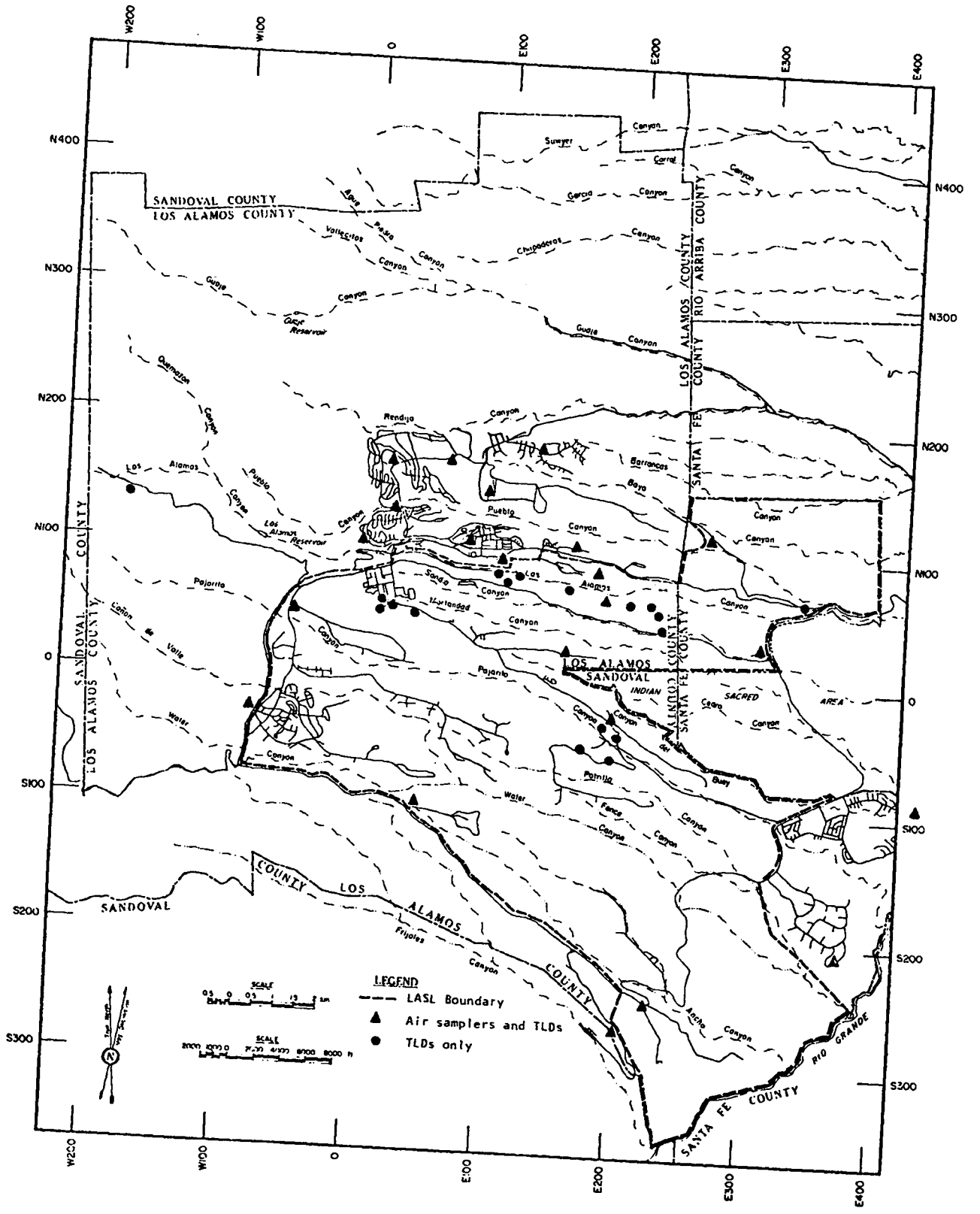

Fig. 8. TLD and air sampler locations.

elevation is also a factor in natural radiation levels. As would be expected, the lower monitoring locations, e.g., Espanola, Pojoaque, and Pajarito Acres, record the smallest dose rates. A linear relationship between elevation and dose can be assumed for the range of elevations encountered, whereby dose and elevation are found to have a linear correlation coefficient r of 0.52 ($P \lesssim 0.01$) for a sample of 23 background locations. The relatively poor correlation results from the aforementioned variations in terrestrial radiation, which remain unaccounted for by this simple linear fit. For those background stations on the Pajarito Plateau, the mean dose rate is about 130 mrem/yr with a standard deviation of 11 mrem/yr. The terrestrial component of environmental radiation for New Mexico has been estimated[10,11] to be 40 to 70 mrem/yr. Thus, approximately 60% of the total environmental gamma-ray dose in the LASL environs is of cosmic origin.

There was no LASL-related dose indicated for any of the off-site environmental dosimeter stations. The perimeter station #16, located in a LASL controlled area, has an anomalous dose rate which is believed to result from an isolated region of trace radionuclide contamination associated with stream runoff and alluvial movement in the LASL effluent receiving canyon. The arithmetic mean and standard deviation of the off-site and perimeter dose values were 124 ± 17 and 134 ± 24 mrem/yr, respectively. An arithmetic mean is not considered the best description for on-site doses because the on-site locations at TA-2 (Omega West Reactor), TA-3 (Van de Graaff Facility), TA-18 (criticality experiments), and TA-53 (Los Alamos Meson Physics Facility) are special monitoring sites designed to chronicle the levels of direct radiation resulting from LASL nuclear facilities. These monitors, e.g., TA-53 (D), TA-3 (A), and TA-18 (C), are as close as 0.3 km to radiation sources and record doses of up to an order of magnitude greater than background rates. Because of these special locations, the distribution of all 44 dose-rate values is asymmetrical; thus, the geometric mean and standard geometric deviation of 166 mrem/yr, $\sigma_g = 1.48$, best describe the total assemblage of dose-rate data.

VI. RADIOACTIVITY IN AIR

A. 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. 8 and map coordinates identify locations in the data tabulations. Samples were collected over 2-wk periods for a total of 676 samples for CY 75. "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 IV contains a listing of Concentration Guides (CGs) for several radioactive species in air and water for uncontrolled and controlled areas. Referring to Fig. 8 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 are within the LASL boundary where the CGs for controlled areas apply (see Section III.A). Table VIII summarizes the results of the atmospheric radioactivity monitoring program for CY 75.

B. Daily Radioactivity

Atmospheric radioactivity samples were collected daily at TA-3 (N50E40) with a

"Hi-Vol" sampler similar to those used in the biweekly 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 radioactivity levels. The data from the second measurement were used to observe temporal variations in long-lived atmospheric radioactivity.

Atmospheric gross-beta concentrations for 1975 are shown in Fig. 9. Because the daily concentrations are approximately log-normally distributed in time, geometric averaging is appropriate. The smoothed data of Fig. 9 represent the geometric means of daily concentration values for each week of 1975. Temporal variation of these data is typical for gross-beta activity arising from stratospheric fallout and natural phenomena.

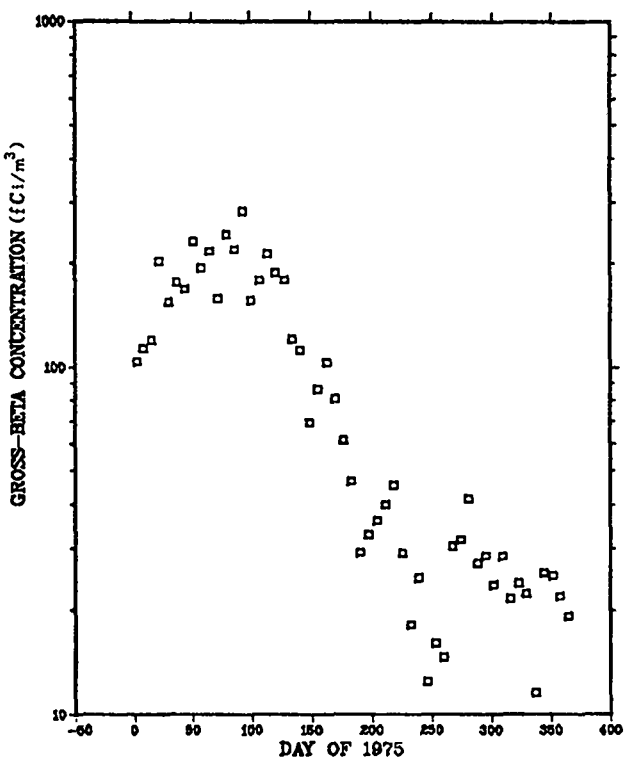

Fig. 9. Atmospheric gross-beta radioactivity for 1975.

The highest gross-beta concentration, observed on 19 March, was 1475 x 10^{-15} μCi/mℓ. These data did not show evidence of radioactivity from foreign atmospheric nuclear tests during the year.

C. Tritium

Silica gel cartridges from the 26 air sampling stations were analyzed biweekly 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 75 and are presented in Table IX. Parenthetical values represent twice the propagated measurement errors, i.e., 2σ associated with the annual averages. The variance (σ^2) for the annual concentration is the sum of the variation measurements divided by the square of the number of measurements, and is not related to the temporal distribution of the individual measurements. Biweekly concentration variances are derived from nuclear counting statistics, air sample volume uncertainties, instrumental uncertainties, etc. The data of Table IX are grouped according to off-site, perimeter, and on-site sampling locations. Minimum values are not presented because they generally did not exceed the MDL for the analysis. The highest observed annual concentration for an uncontrolled area (Los Alamos Airport) was 88 x 10^{-12} μCi/mℓ, and for a controlled area the highest value was 174 x 10^{-12} μCi/mℓ measured at TA-52. These concentrations are respectively 0.04% and 0.003% of the uncontrolled-area and controlled-area CGs specified for tritium in air. The tritium concentrations reported herein, as well as the CGs, are for atmospheric tritium oxide (HTO). The arithmetic mean and arithmetic standard deviation for the distributions of off-site, perimeter,

and on-site annual average tritium concentrations are 20 ± 6, 42 ± 24, and 104 ± 57 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 19, 1.3; 37, 1.8; and 92 x 10^{-12} μCi/mℓ, 1.7; respectively. For the stations on the Pajarito Plateau, LASL-related tritium releases generally obscure any temporal variations in synoptic atmospheric tritium-oxide concentration.

D. Gross Radioactivity

Gross-alpha and gross-beta activities on the biweekly air filters were measured with a gas-flow proportional counter on the first and tenth day after collection. The first count was used to screen the samples for inordinate levels of activity. The second count, free from the activity of adsorbed radon and thoron daughters, provided a record of long-lived atmospheric radioactivity. The annual average biweekly gross-alpha and gross-beta activity concentrations are presented in Table X. Parenthetical values represent twice the propagated measurement errors, i.e., 2σ, 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 1.1 x 10^{-15} μCi/mℓ and have a standard deviation of 0.1 x 10^{-15} μCi/mℓ. The highest average gross-alpha concentration, 1.2 x 10^{-15} μCi/mℓ, is 2% of the CG for a controlled area. For the gross-beta activity, the 26 annual average concentrations fit a normal distribution with an arithmetic mean and standard deviation of 78 ± 4 x 10^{-15} μCi/mℓ. The highest observed annual concentration of 86 x 10^{-15} μCi/mℓ (at Bandelier Lookout) is 0.3% 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 phenomena and mixing of stratospheric nuclear debris into the troposphere. Gross-beta concentrations varied by as much as a factor of 16, with the maximum occurring around late March and the minimum around early September (cf. Fig. 9).

E. Plutonium and Americium

After being measured for gross-alpha and gross-beta activities, the biweekly filters for each station were combined and dissolved to produce composite 6- or 8-wk 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. For 11 selected stations, the eluent solutions from the plutonium separation were combined to represent 12- or 14-wk samples. For each of the 11 stations, americium was then separated from three 1/4-yr composite samples via cation exchange. The purified plutonium and americium samples were separately electro-deposited and measured for alpha-particle emission with a solid-state alpha detection system. Alpha-particle energy groups associated with the decay of ^{238}Pu, ^{239}Pu, and ^{241}Am 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.

The annual average ^{238}Pu and ^{239}Pu concentrations for each station are listed in Table XI according to off-site, perimeter and on-site sampling locations. The averages are time-weighted, and parenthetical values represent twice the propagated measurement errors, i.e., 2σ, associated with the annual averages. The variance σ^2 for the annual concentration is the sum of the variances of the individual 6- or 8-wk concentration measurements divided by the

square of the number of measurements. Six- or 8-wk concentration variances are derived from nuclear counting statistics, air sample volume uncertainties, etc. Minimum values are not presented in Table XI as they generally did not exceed the MDL for the analysis. The highest observed annual ^{238}Pu concentration for an uncontrolled area (Fuller Lodge) was 2.3×10^{-18} μCi/mℓ, and for a controlled area was 1.6×10^{-18} μCi/mℓ measured at TA-6. These concentrations are, respectively, 0.003% and 0.0001% of the CGs specified for ^{238}Pu in air. For ^{239}Pu, the highest observed annual concentration for an uncontrolled area (Fuller Lodge) was 29×10^{-18} μCi/mℓ, and for a controlled area the highest value was 53×10^{-18} μCi/mℓ at TA-6. These concentrations are, respectively, 0.05% and 0.003% of the CGs specified for ^{239}Pu in air. The ^{239}Pu annual concentration value for the TA-6 station deviates from the normal range of values. This average is erratic because of the maximum measurement of 317×10^{-18} μCi/mℓ observed in July. The July value is believed to be unrealistic since a release and dispersion of ^{239}Pu from the Laboratory would most likely be noted at several stations. The high value for this sample is probably due to cross-contamination in the chemistry laboratory. Since the datum could not be unequivocably discredited, it was included in this compilation. The arithmetic mean and arithmetic standard deviation for the distributions of off-site, perimeter, and on-site annual average ^{238}Pu concentrations are 0.8 ± 0.6, 0.6 ± 0.5, and $0.5 \pm 0.4 \times 10^{-18}$ μCi/mℓ, respectively. For ^{239}Pu, the arithmetic mean and arithmetic standard deviation for the distributions of off-site, perimeter, and on-site annual average concentrations are 20 ± 4, 24 ± 10, and $20 \pm 2 \times 10^{-18}$ μCi/mℓ, respectively. These data do not suggest statistically significant spatial variations for plutonium concentrations.

Significant temporal variations in atmospheric plutonium concentrations were observed during 1975. These variations closely parallel the pattern manifest in the daily long-lived (fallout) gross-beta concentrations shown in Fig. 9. For ^{239}Pu, the maximum concentrations occurred in April with an all-station average of about 44×10^{-18} μCi/mℓ. The minimum, observed during August and September, had an all-station average of about 4×10^{-18} μCi/mℓ. The ^{239}Pu all-station averages for the eight periods of CY 1975 (excluding the one erratic value for station #15) were compared to the gross-beta all-station averages representing the same time periods. The data were found to be highly correlated with a linear correlation coefficient r of +0.90 ($N = 8$, $P = 0.002$). The correlation between gross-beta concentration and ^{238}Pu concentration was far less conclusive ($r = +0.58$) primarily because of the inherent analytical uncertainty in the ^{238}Pu data. Nevertheless, the same general chronological pattern was indicated. These correlations of seasonal radioactivity imply that atmospheric plutonium in the LASL environs is at least in part from the synoptic injection of stratospheric nuclear debris into the troposphere. The ratio of ^{239}Pu to ^{238}Pu observed for all stations during CY 1975 was 33 ± 27.

The annual average ^{241}Am concentrations for the 11 selected stations are also presented in Table XI. Not only are the data widely scattered, but the 2σ errors associated with the concentrations are large. Hence, no attempt was made at statistical analysis. The highest observed annual average concentration of ^{241}Am (observed at Los Alamos Airport) was 0.01% of the CG for an uncontrolled area.

F. Uranium

A sample was composited for each of the 26 stations, with aliquots taken from the dissolution from the plutonium and americium procedure, to represent a 12- or 14-wk sampling period. The uranium content of the samples was determined by fluorometric techniques, and quarterly atmospheric

uranium concentrations were calculated. The 12- or 14-wk uranium concentrations for each station were averaged for CY 75, and are presented in Table XII according to off-site, perimeter, and on-site sampling locations. The averages are time-weighted, and parenthetical values represent twice the propagated errors, i.e., 2σ, associated with the annual averages. The variance σ^2 for the annual concentration is the sum of the variances of the individual 12- or 14-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 12- or 14-wk concentration variances are derived from instrumental uncertainties, air-sample volume uncertainties, etc. The fluorometric analysis does not differentiate isotopes of uranium, and the annual average concentrations are thus given in pg/m^3. The highest observed annual uranium concentration for an uncontrolled area (Acorn Street) was 97 pg/m^3, and for a controlled area the highest value was 72 pg/m^3 measured at TA-52. These concentrations are respectively 0.001% and 0.00003% 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 45 ± 20, 37 ± 21, and 45 ± 19 pg/m^3, respectively. These average values are statistically indistinguishable.

VII. 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 collected in 4-ℓ polyethylene bottles, acidified in the field with 5 mℓ of concentrated nitric acid, and returned to the laboratory within a few hours for filtration through 0.45-μm-pore membrane filters. The samples are analyzed radiochemically for dissolved plutonium (^{238}Pu and ^{239}Pu) and tritium as HTO, as well as for dissolved gross-alpha, -beta, and -gamma activities. Selected samples were analyzed for americium (^{241}Am). A fluorometric technique is used to measure total uranium concentrations.

A. On-Site Surface and Ground Waters

Radioactivity concentrations were determined for water samples from six on-site locations that are not Laboratory effluent release areas (Fig. 10, Table XIII). The maximum concentrations for these six stations are

Analyses	Units	Maximum Concentrations
^{3}H	10^{-6} μCi/mℓ	4.8
^{241}Am	10^{-9} μCi/mℓ	<0.16
^{238}Pu	10^{-9} μCi/mℓ	<0.02
^{239}Pu	10^{-9} μCi/mℓ	<0.01
Gross α	10^{-9} μCi/mℓ	1.0
Gross β	10^{-9} μCi/mℓ	9.4
Total U	μg/ℓ	<1.0

The radioactivity concentrations are near or below detection limits, and are of the same magnitude as reported for 1974.[5]

The radioactivity concentrations for surface and ground waters were determined from 22 locations in past and present Laboratory release areas (Fig. 10, Table XIII). The surface and ground waters in these areas are not a source of municipal, industrial, or agricultural supply, and do not reach the Rio Grande except during storm runoff. The maximum concentrations in these canyon waters are

		Canyon			
Analyses	Unit (μCi/mℓ)	Pueblo	Sandia	DP-Los Alamos	Mortandad
^{3}H	10^{-6}	2.3	8.2	76	195
^{241}Am	10^{-9}	1.2	<0.2	0.4	1.1
^{238}Pu	10^{-9}	0.02	<0.02	0.27	125
^{239}Pu	10^{-9}	0.34	0.01	0.84	3.6
Gross α	10^{-9}	6.9	12	22	46
Gross β	10^{-9}	61	23	500	1400
Total U	μg/ℓ	2.3	1.7	6.3	5.4

The radioactivity concentrations observed in Acid-Pueblo Canyon result from residuals of effluent released into the canyon before 1964. Sandia Canyon receives cooling tower blowdown from the TA-3 power plant and some

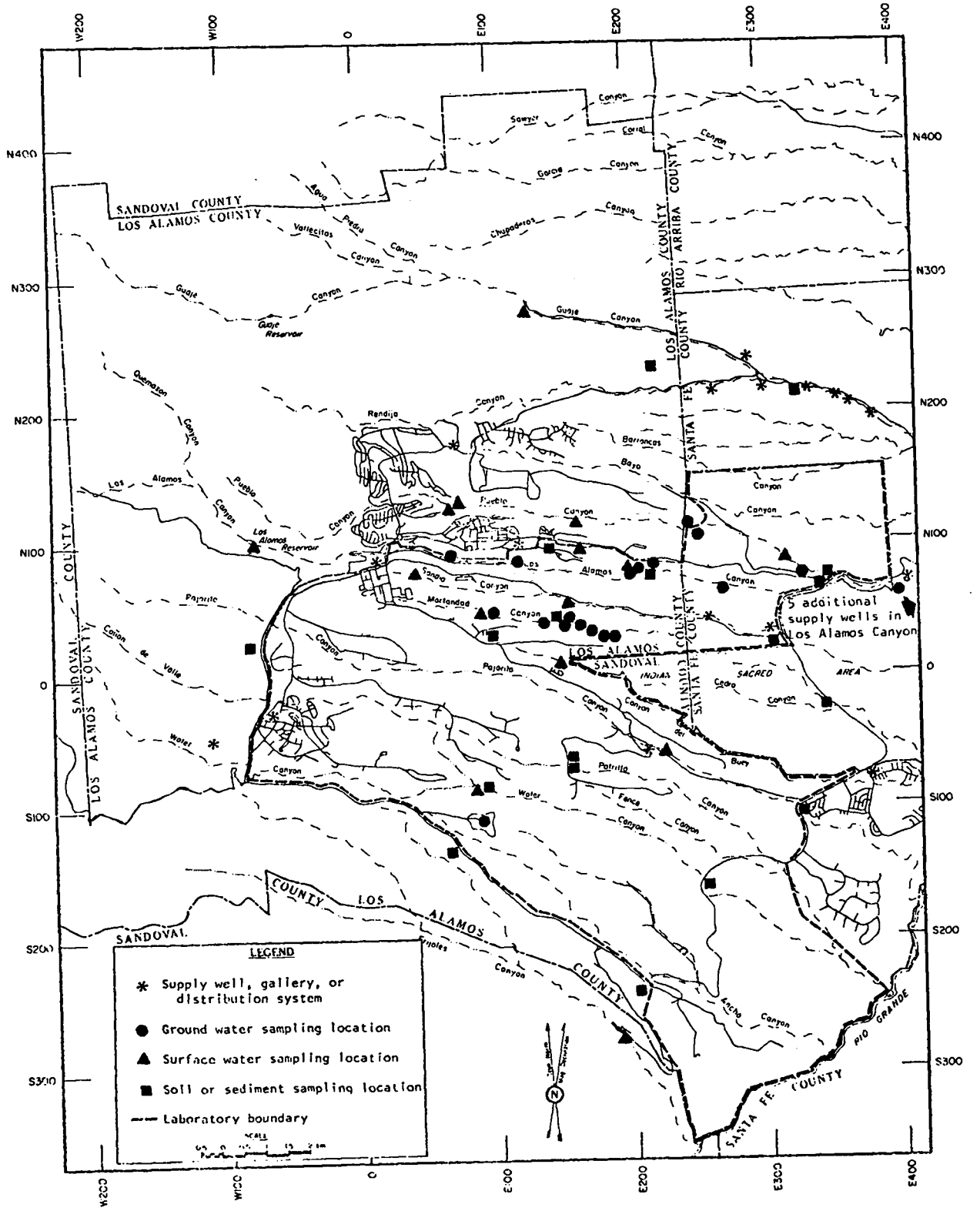

Fig. 10. Water, sediment, and soil sampling locations on or near the LASL site.

treated sewage effluents. The maximum concentrations in these canyons are low, at or near detection limits, and are about the same levels as reported for 1974.[5]

The concentrations in DP-Los Alamos and Mortandad Canyons reflect concentrations from current release of effluents from the TA-21 and TA-50 industrial waste treatment plants, respectively. The maximum observed concentrations of ^{3}H, ^{239}Pu, and gross-alpha and gross-beta activities increased from 1974 to 1975. The maximum observed concentration of ^{238}Pu decreased in DP-Los Alamos. The maximum observed concentration of ^{238}Pu in Mortandad increased ninefold from the previous reporting period, reflecting recent ^{238}Pu additions to the canyon. As observed in the past, the concentrations of radionuclides decreased with distance from the effluent outfalls. The maximum observed concentrations were well below the CGs for uncontrolled areas (Table IV).

B. Off-Site and Supply Waters

Regional surface waters within 75 km of LASL were sampled at six locations to ascertain normal levels of radioactivity in waters of the area (Fig. 11, Table XIV). Radioactivity concentrations were also determined for samples from six perimeter surface and ground water stations located <5 km outside the LASL boundary, from 16 wells and 1 gallery that furnish the water supply for Los Alamos, and from 5 stations on the distribution system (Fig. 10, Table XIV). The maximum observed radioactivity concentrations for these waters are

Analyses	Units (μCi/mℓ)	Regional Surface Water	Perimeter Surface and Ground Water	Los Alamos Water Supply
^{3}H	10^{-6}	1.8	2.3	1.5
^{238}Pu	10^{-9}	<0.15	<0.10	<0.06
^{239}Pu	10^{-9}	<0.04	0.08	0.03
Gross α	10^{-9}	3.9	4.8	7.0
Gross β	10^{-9}	15.2	11	7.5
Total U	μg/ℓ	2.9	10	17

The concentrations of radioactivity are low, at or near the limits of detection. There has been no significant change in concentrations from those reported in 1974.[5]

VIII. RADIOACTIVITY IN SOILS AND SEDIMENTS

Soil samples were collected by taking five plugs, 75 mm in diameter and 50 mm deep, at the center and corners of a square area 10 m on a side. The five plugs were combined to form a composite sample for radiochemical analyses. Sediment samples were collected from dune build-up behind boulders in the main channels of perenially flowing streams. Samples from the beds of intermittently flowing streams were collected across the main channel. The soil and sediment samples were analyzed for gross-alpha and gross-beta activities, total uranium, and ^{238}Pu and ^{239}Pu. Moisture distilled from the soil samples was analyzed for ^{3}H.

Soil and sediment samples were collected in the same general locations as the regional water samples to provide data on the normal concentrations of radioactive materials in the environment beyond the range of possible influence by LASL operations (Fig. 11, Table XV). Samples were also collected at off-site, perimeter, and on-site stations (Fig. 10 and Table XV).

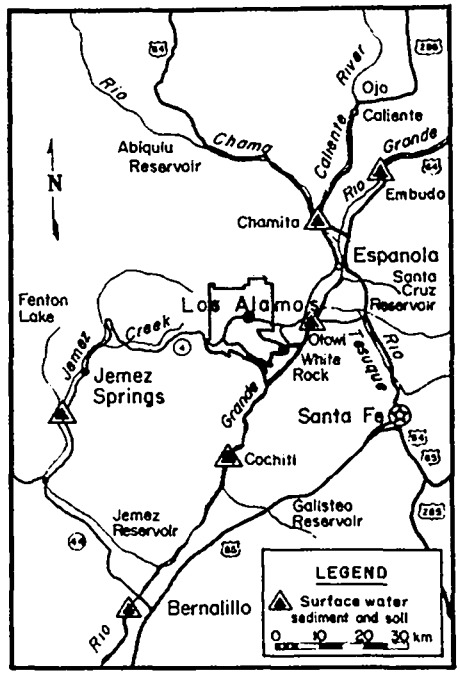

Fig. 11. Regional surface water, sediment, and soil sampling locations.

The maximum observed concentrations of radioactivity in the regional, perimeter, and on-site soil and sediments are

Analyses	Units	Regional and Perimeter	On-Site
^{3}H	10^{-6} μCi/mℓ	123	8.3
^{238}Pu	fCi/g	3.5	5000
^{239}Pu	fCi/g	44	1200
Gross α	pCi/g	8	5.9
Gross β	pCi/g	9.8	10
Total U	μg/g	3.8	1.8

The regional and perimeter analyses results for 1975 are consistent with those for 1974. The plutonium values are similar to fallout determinations in the region with ^{238}Pu ranging from < 1 to 4 fCi/g and ^{239}Pu ranging from < 1 to 23 fCi/g.[5] One ^{3}H value of 123 pCi/mℓ occurred at a perimeter soil station which is near the tritium processing laboratory at TA-33. The range of remaining regional and perimeter analyses was from 1.9 to 4.8 pCi/mℓ of ^{3}H. Plutonium values from on-site locations are higher because the results include analyses from sediments in the canyons that have received, or are now receiving, industrial effluents (Pueblo, DP-Los Alamos, and Mortandad Canyons). Remaining on-site soils and sediment analytical results are comparable to the regional and perimeter values.

IX. RADIOACTIVITY IN FOODSTUFFS

A sampling program was initiated during CY 75 in order to evaluate possible dose commitment resulting from the consumption of locally produced foodstuffs. As an initial objective, radionuclide detectability was established for certain foodstuff samples collected during the fall harvest. Sampling locations included Los Alamos County and the Rio Grande Depression (both above and below the confluences of Laboratory-site originating stream channels; see Fig. 2). Levels of tritium oxide (HTO), ^{238}Pu and ^{239}Pu, and uranium were determined for selected samples of fruits, vegetables, and cows' milk.

Plutonium analysis of foodstuff samples generally yielded values below the detection limit, i.e., where the 2σ analytical error is greater than the principal value. Of the 23 ^{238}Pu and 23 ^{239}Pu analyses, the six values above the detection limit are

Location	Water Source	Sample	fCi/g (dry wt) ^{238}Pu	fCi/g (dry wt) ^{239}Pu
TA-1[a] (N90E80)	soil moisture	peaches	--	3.2 (±1.0)
TA-1[a] (N90E80)	soil moisture	apples	0.25 (±0.20)	0.37 (±0.20)
Villa St. (N160E40)	L. A. County	lettuce	--	1.8 (±1.0)
Cochiti	Rio Grande	corn	--	0.10 (±0.10)
Espanola	Rio Chama[b]	carrots	--	0.68 (±0.39)

[a]The decommissioned, original Los Alamos Technical Area currently privately owned.
[b]A tributary of the Rio Grande.

Tritium in foodstuffs was determined by distillation of the samples and subsequent liquid scintillation analysis of the distillate. The data presented below summarize the tritium content in water from various samples according to different water supplies. The values were within a range comparable to meteoric concentrations.

Location	Water Source	No. of Samples	Tritium Concentration (pCi/mℓ) Average	Range
Espanola	Rio Chama[a]	4	5(±6)	1.8-9.0
Ranchitos	Rio Grande[a]	4	5(±10)	1.5-12.8
Cochiti	Rio Grande[b]	6	5(±2)	3.7-6.2
White Rock	L.A. County	5	3(±1)	2.8-4.0
Los Alamos	L.A. County	3	9(±3)	5.4-7.5
Los Alamos	soil moisture	2	15(±14)	10.2-2.0

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

Uranium concentrations in foodstuff samples are presented below according to water supply.

Location	Water Source	No. of Samples	Uranium (ng/g dry wt) Average	Range
Espanola	Rio Chama[a]	4	19(±24)	6-36
Ranchitos	Rio Grande[a]	4	10(±8)	7-16
Cochiti	Rio Grande[b]	6	8(±8)	2-29
White Rock	L.A. County	5	14(±24)	2-12
Los Alamos	L.A. County	2	76(±100)	6-146
Los Alamos	soil moisture	2	5(±8)	2-8

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

X. RADIATION DOSE ASSESSMENT

A. 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 calculations represent estimates of doses incurred during the 1-yr period covered by the monitoring data. The calculational models are those recommended by the ICRP.[7,12,13] 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 1975 Los Alamos County population estimates (12 000 and 5700 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 (94 000) was obtained from the LASL-developed Pathfinder Program[14] with updating from the "Statistical Abstract of the United States - 1975."

B. External Penetrating Radiation

Variations in terrestrial radiation and cosmic radiation complicate any analysis of external radiation exposure as measured by the TLD network (Table VII). With the exception of the station at State Highway 4 (#16), the highest exposure was at Cumbres School. High-pressure ionization chamber measurements taken at the Cumbres School station and on the lawn at Cumbres School showed that the dose rate at the TLD station was 22% higher than on the lawn. This indicates that the natural radioactivity in the materials making up the brick enclosure for the Cumbres station contribute a significant percentage of the dose measured at Cumbres School. This station has now been moved to a different location.

As was discussed earlier, the measured dose at State Highway 4 is believed to result from radionuclide contamination from radioactive liquid waste discharges into canyons upstream from this station. This dose does not represent a dose to the people of Los Alamos County because there is no residence or usage of this area by the populace. With the exception of the State Highway 4 station, all perimeter and off-site stations have dose rates compatible with the expected values (between 126 and 175 mrem/yr) estimated for New Mexico by the EPA.[10,11] The mean dose rate of 130 mrem/yr at background stations on the Pajarito Plateau is similar to a TLD measured dose rate of 143 mrem/yr at Colorado Springs, Colorado.[15] Because there was no indication of off-site incremental external penetrating radiation resulting from Laboratory operations, individual and population doses for such an exposure were not calculated.

C. Radioactivity in Air

The whole-body dose resultant from continuous inhalation of tritiated water vapor can be calculated using the equation $D = 1.2 \times 10^{6} C$ (where D = dose in rems and C = concentration in $\mu Ci/m\ell$). Derivation of this equation is given in previous reports.[5-7,12,13] However, inhalation is not the only means of entry of tritiated water vapor into the body. At rest or during light activity, the rate of vapor absorption by the lungs is approximately equal to the rate by way of exposed skin of the whole body.[13] Clothing provides only a short-term, temporary barrier to water vapor so the entire skin surface of the body should be considered as exposed to the tritiated water vapor. Thus, the constant in the above equation should be doubled because of the doubling of the intake of tritiated water vapor. The equation used for dose calculations for this report is then $D = 2.4 \times 10^{6} C$.

The average airborne tritium concentration at background stations 9, 10, and 11 (see Table IX) was 14×10^{-12} $\mu Ci/m\ell$ which results in a whole-body dose of 0.034 mrem/yr. The highest average airborne tritium concentration at an occupied location in 1975 was 88×10^{-12} $\mu Ci/m\ell$ at the Los Alamos

Airport. This average concentration results in a whole-body dose of 0.18 mrem/yr above background, which is 0.036% of the annual dose limit of 500 mrem/yr for an individual member of the public and 0.11% of the dose limit of 170 mrem/yr for a suitable sample of the population (ERDAM 0524).

The highest dose at a site boundary is approximated by the average concentration of 156×10^{-12} μCi/mℓ at TA-33. This concentration represents a whole-body dose above background of 0.34 mrem, which is 0.068% of the individual dose limit.

An 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 2.2×10^{-12} and 25×10^{-12} μCi/mℓ for the townsite and White Rock, respectively, and allowing for a population of 200 near the Los Alamos Airport being exposed to 88 $\times 10^{-12}$ μCi/mℓ, give a resultant calculated population dose above background of 0.42 man-rem to the estimated 17 700 residents of Los Alamos County. This population dose represents the whole-body dose from Laboratory effluents to the populace within an 80-km radius of the Laboratory. By comparison, the 17 700 residents of Los Alamos County would receive 2550 man-rem, and the population of 94 000 residents within the 80-km radius would receive 13 500 man-rem, from natural radiation sources. (This calculation assumes that the individual dose from cosmic, terrestrial, and internal radioactivity was 144 mrem/yr[10]).

For ^{239}Pu in air, two stations are of possible interest--Fuller Lodge and TA-6 (Table XI). Both have mean concentrations of ^{239}Pu in air significantly above means from other stations. Each mean is strongly influenced by its maximum value. These maxima appear as a strong spike in plots of concentration vs time. No other station in the network recorded a spike for these times. It is unlikely that a release could have occurred within the Laboratory confines that would only be detected at Fuller Lodge or at TA-6. However, it is assumed for this discussion that each station experienced a localized phenomenon.

The incremental lung doses above background for the mean concentrations of 53×10^{-18} and 29×10^{-18} μCi/mℓ for TA-6 and Fuller Lodge, respectively, were calculated from the formula $D = 1.3 \times 10^{12} C$ (where D = lung dose in rem and C = concentration in μCi/mℓ) which has been developed previously.[5-7,12,13] With a background subtraction of 17×10^{-18} μCi/mℓ (average of the concentrations at Espanola, Pojoaque, and Santa Fe) the incremental ^{239}Pu lung doses above background at TA-6 and Fuller Lodge are 0.047 and 0.016 mrem/yr, respectively. These doses are 0.003% and 0.001% of the individual dose limit of 1500 mrem/yr, respectively.

The range of values (means and maximum) for ^{238}Pu concentrations in air, as shown in Table XI, all fall within the range of 0.2 - 8.8 $\times 10^{-18}$ μCi/mℓ measured as fallout at 11 stations throughout the United States by the U. S. Environmental Protection Agency Radiation Alert Network.[16-19] Hence, no dose assessment was calculated for atmospheric ^{238}Pu.

Measurement of atmospheric ^{241}Am involves difficult chemical procedures and is attempted by only a few laboratories throughout the country. In the ^{241}Am measurements reported in Table XI, the values for Los Alamos Airport (22×10^{-18} μCi/mℓ) and TA-6 (11×10^{-18} μCi/mℓ) are above the others. It is not clear whether these data represent real concentrations from worldwide fallout, laboratory procedural difficulties, or LASL effluent releases. The calculated dose to the lung from these concentrations, allowing for no background subtraction, would be 0.031 and 0.015 mrem for the airport and TA-6 stations, respectively; these values are 0.002% and 0.001% of the individual lung dose limit, respectively. These doses were calculated from

the formula[5-7, 12, 13] $D = 1.4 \times 10^{12} C$ (where D = dose in rems and C = concentration in μCi/mℓ).

The annual average concentrations of airborne uranium range from 22 to 97 pg/m^3 (Table XII). The atmospheric uranium concentrations are variable, and statistically significant spatial variations in the data were not indicated. The maximum uranium concentration of 97 pg/m^3, observed at the perimeter station at Acorn Street, was 0.001 and 0.00005% of the respective uncontrolled- and controlled-area CGs. Since the observed concentrations are in an expected range resulting from natural sources (i.e., from resuspended continental crustal material), a calculation of Laboratory influenced dose was not indicated for this radionuclide.

D. 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 identified.

No radioactivity in excess of normal background concentrations was detected in drinking water, perennial 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.

XI. CHEMICAL QUALITY OF SURFACE AND GROUND WATERS

Monitoring of selected chemical quality parameters of surface and ground waters provides an additional means for detecting the potential dispersion of effluents from LASL operations. Water samples are collected in 1-ℓ polyethylene bottles and returned to the laboratory for filtration through Whatman #2 filters. Standard methods are used to analyze samples for gross chemical characteristics and a selected list of ions. Samples are collected twice a year for chemical quality analyses.

A. On-Site Surface and Ground Waters

Chemical analyses were made on samples from three on-site ground water and three on-site surface water locations that are not in Laboratory effluent release areas (Fig. 10, Table XVI). There was no indication of any significant change from previous reporting periods.[5,6] These waters all met drinking water standards (Table V) for the constituents measured; however, none of them is used for municipal or domestic supply. The maximum concentrations of Cl^-, F^-, NO_3^-, and total dissolved solids (TDS), constituents that are indicators of Laboratory releases, for these six stations are

Constituent	Maximum Concentration (mg/ℓ)
Cl^-	134.0
F^-	1.1
NO_3^-	7.5
TDS	450.0

Chemical quality was determined for samples of surface and ground waters in canyons which are current or former recipients of industrial effluents (Fig. 10, Table XVI). Acid-Pueblo Canyon received industrial wastes from 1943 to 1964 and currently receives treated municipal sewage

effluent, which is a large portion of the total flow. Sandia Canyon receives cooling tower blowdown from the TA-3 power plant and some treated sewage effluent. Except for snowmelt or storm runoff, these effluents constitute the total flow in Sandia Canyon. DP-Los Alamos Canyon receives effluents from industrial waste and sanitary sewage treatment plants and cooling tower blowdown from TA-21 and TA-2. Mortandad Canyon receives the effluent from the Central Waste Treatment Plant at TA-50. This effluent is a major part of the flow except during storm runoff or spring snowmelt. The maximum observed concentrations of Cl^-, F^-, NO_3^-, and TDS for these canyons are

	Maximum Concentrations (mg/ℓ)			
Constituent	Acid-Pueblo	Sandia	DP-Los Alamos	Mortandad
Cl^-	65	470	98	28
F^-	1.0	1.4	3.6	1.7
NO_3^-	59	33	90	480
TDS	410	1500	840	1100

The chemical quality of waters in each of these areas is clearly influenced by the input of effluents. None of these waters is a source of either municipal or domestic water supply, but the surface waters in these canyon areas are used by wildlife. In some places these waters do not meet drinking water standards for chemical criteria, particularly for TDS, F^-, and NO_3^-, but they do meet proposed EPA[20] criteria for these substances in water used for livestock.

B. Off-Site and Supply Waters

Perimeter surface water and ground water is sampled at six locations (Fig. 10, Table XVII). Locations on regional rivers and reservoirs within 75 km of LASL (Fig. 11, Table XVIII) are sampled to provide data on the chemical quality of water in the area. All of these waters meet drinking water standards for the constituents measured, with the occasional exception of TDS. No significant changes from previous reporting periods have been noted.[5,6] The maximum observed concentrations of Cl^-, F^-, NO_3^-, and TDS for these perimeter and regional samples are

	Maximum Concentrations (mg/ℓ)	
Constituent	Regional	Perimeter
Cl^-	110	43
F^-	1.0	2.5
NO_3^-	1.3	26
TDS	470	360

The Los Alamos water supply system, which serves the Laboratory and the community, is sampled at each of the 16 supply wells and a supply gallery, and at five points in the distribution system (Fig. 10, Table XIX). The chemical quality varies slightly from periods of light production (winter) to periods of heavy pumpage (summer). Maximum concentrations for all substances measured are well below the EPA Interim Primary Drinking Water Standards (Table V) with the exception of arsenic. One supply well in Los Alamos Canyon routinely produces water samples with concentrations of naturally present arsenic up to about three times the EPA standard. In the past, dilution by water from other wells has reduced the concentration of arsenic in the distribution system to levels meeting standards. During 1975, increasingly higher concentrations occurred in water samples from the well, occasionally resulting in levels of arsenic in parts of the distribution system that exceeded the standard. The well was taken out of service in August 1975. Studies are under way to determine the source of the arsenic in the well and means of controlling well pumpage so that levels in the distribution system meet standards continuously.

C. Fenton Hill Site Surface and Ground Waters

The chemical quality of surface and ground waters in the vicinity of the Fenton Hill site of the LASL Dry Hot Rock Geothermal Energy Experiment (≈30 km W of Los Alamos, see Fig. 2) has been measured to fulfill monitoring requirements and provide basic information for environmental studies. The results of a preliminary study and data

for 1974 have been reported elsewhere.[21,22] These studies have shown that quality of surface water in the drainage area of the Jemez River and the Rio Guadalupe is complex. Sources of the base flow in the various streams in the drainage area of the Jemez River differ in chemical quality. Predominant ions in streams that drain the Valles Caldera were sodium and chloride in Redondo Creek, calcium and sulfate in Sulphur Creek, and calcium and bicarbonate in San Antonio Creek. The mixture of water from these three streams in the Jemez River below the junction with the East Fork of the Jemez results in water which contains a significant quantity of sodium and bicarbonate. Inflow of mineral and thermal springs into the river below the East Fork is highly mineralized and contributes sodium and chloride. Inflow from the springs is the main contribution to a decrease in water quality in the remainder of the Jemez River.

Predominant ions in the water from the Rio Cebolla and Rio Guadalupe drainage area are calcium and bicarbonate. Springs discharging from the Cenozoic volcanic substrate contain significant quantities of sodium and bicarbonate.

Table XX summarizes the results of chemical quality analyses performed during 1975. The samples were collected from 9 surface water and 14 ground water sources (Fig. 12) three times during the year. Ponded drilling fluids were sampled irregularly. The results are presented as averages for groups of sampling locations with related characteristics. No significant changes from previous data were observed.[21, 22]

XII. ECOLOGICAL STUDIES

A. Long-Term Ecological Effects of Exposure to Uranium

Several thousand kilograms of natural uranium (U) and depleted uranium (DU) have been dispersed to the environment at several LASL explosives testing sites as a result of development and testing exercises from 1949 to the present.[23] Two explosives testing areas were selected for study on the basis of their use history: E-F Testing Site, located within TA-15, and Lower Slobbovia Testing Site, located within TA-36.

Objectives of initial studies of U-DU released to the LASL testing site environs were to

1. describe the concentration and distribution of uranium in the environs by analyzing appropriate samples of soil and biota,

2. describe resident plant communities and small mammal populations which have been exposed to varying amounts and physical forms of uranium,

3. analyze the composition of plant and soil invertebrate communities associated with various gradients of uranium present in the environs to determine possible responses to uranium chemical toxicity.

E-F Testing Site showed averages of 2400 ppm of U-DU in the upper 5 cm of soil and 1600 ppm in the 5- to 10-cm depth. Lower Slobbovia Testing Site had two subplots in which soil U-DU concentrations were about 2.5 and 0.6% of the E-F Site values. Differences in the U-DU concentrations in soil, with depth and distance from detonation points, were ascribed to the different explosives test designs peculiar to each area.

Dry-weight concentrations of U-DU in unwashed vegetation samples at the E-F Site were about 320 ppm during November 1974 and about 125 ppm during June 1975. These apparent variations in vegetation U-DU concentrations were probably due to: (1) variable external deposition over considerable time, (2) the different species of plants available at sampling times, and (3) the greater amounts of fresh growth included in the June 1975 samples that effectively reduced the concentrations by dilution of the biomass. Ratios of plant/soil U-DU concentrations varied from 0.08 during November to 0.05 during June. This is within the range reported from other studies of plants in high uranium areas.[24]

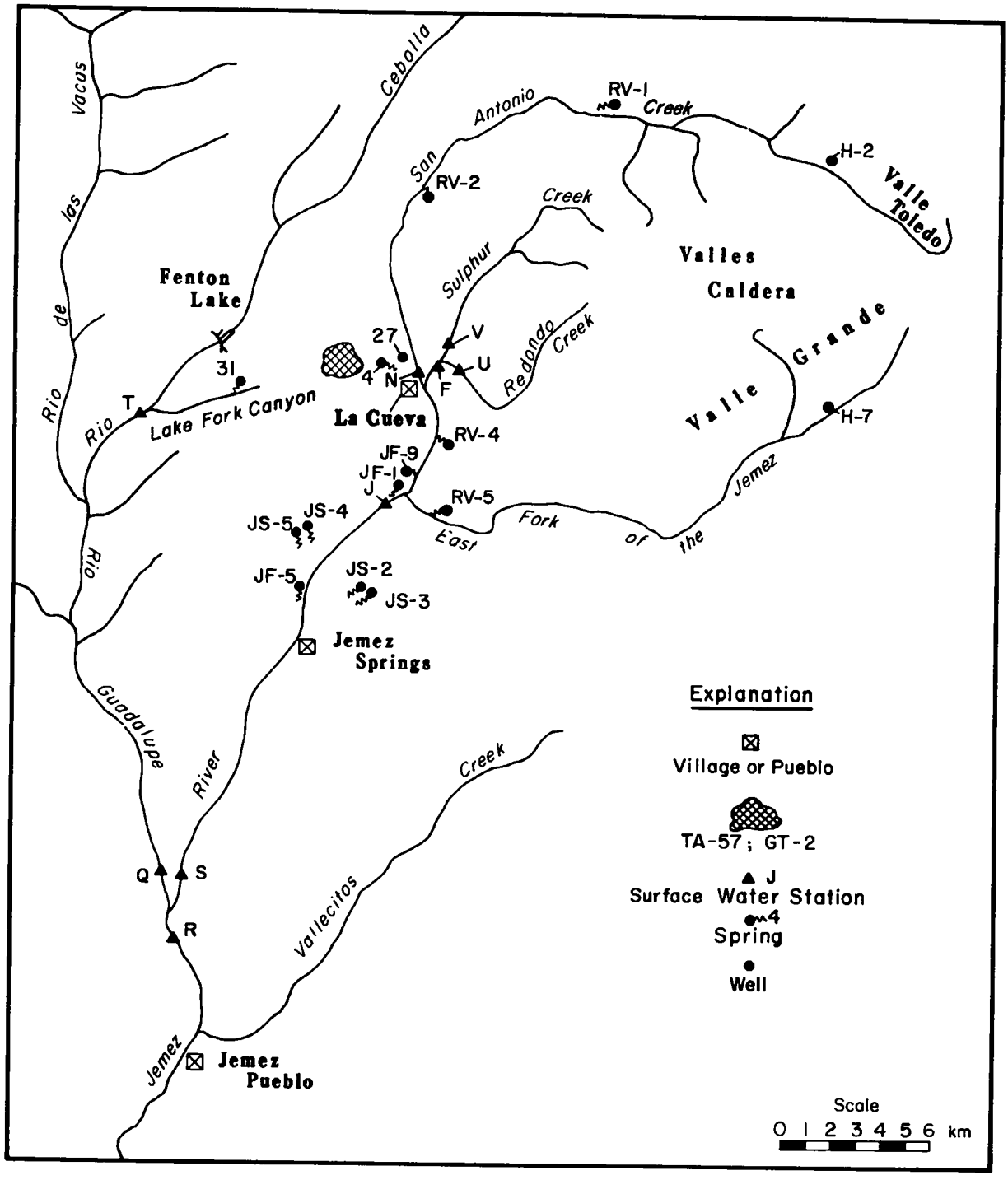

Fig. 12. Fenton Hill Sampling Station map.

Small mammals trapped in the study areas during November contained mean dry-weight concentration values (n = 17) of 210 ppm U-DU in gastrointestinal tract contents, 24 ppm in the pelt, and 4 ppm in the remaining carcass. During June, mean (n = 9) dry-weight concentrations were 110, 50, and 2 ppm in similar samples, and 6 ppm in lungs. Lung samples from rodent species that actively forage on the ground surface were about eight times greater in U-DU concentration than similar samples from subterranean pocket gophers. These data emphasize the importance of resuspension of respirable particles in the upper few millimeters of soil as a contamination mechanism in several components of the ecosystem.

Vegetation community composition and initial results of the soil invertebrate studies did not reveal conclusive differences between areas of high and low soil concentrations of U-DU in the study sites and their control counterparts. Soil and surface litter macrofauna (0.2-2.0 mm in length) populations appeared to be reduced at the high U-DU study area compared to the adjacent control area; however, more intensive sampling is required to determine the significance of the observation. The anomalous character of the E-F firing point, compared to its adjacent control area, complicated the faunistic studies because of strong environmental influences upon soil moisture, absorbed solar radiation regimes, and aspect responses; this may require adjustment of the study areas to provide more comparable sampling sites.

B. Storm Runoff Transport of Plutonium in Mortandad Canyon

Rainstorm runoff was identified as a potential mechanism in radioactivity transport at Los Alamos nearly 30 years ago.[25] Work has recently begun to characterize and quantify runoff transport of trace plutonium and ^{137}Cs.[26,27] The results of the work concerning ^{137}Cs in Mortandad Canyon[27] were summarized in the environmental surveillance report for 1974.[5] The corresponding plutonium concentration data are presented here along with the comparative behavior of the two elements.

The runoff event investigated in this study resulted from a 2.9-cm rainstorm on the upper Mortandad Canyon watershed. Samples were taken through a 4.25-h period at one location 1200 m below the liquid waste effluent outfall to associate the respective radionuclides with the suspended sediment and liquid fractions and to measure the total activities transported by the event.

The concentrations of ^{137}Cs, ^{238}Pu, and $^{239-240}Pu$ in runoff samples exhibited very similar patterns with time. The filtered water contained low concentrations of all the radionuclides; levels ranged from about 30-80 pCi/ℓ ^{137}Cs, 2-5 pCi/ℓ ^{238}Pu, and 0.2-1 pCi/ℓ $^{239-240}Pu$. Concentrations of the radionuclides in water were variable and did not exhibit a consistent pattern with time. However, concentrations of all three radionuclides in suspended sediment were relatively high, ranging from 100-600 pCi/g ^{137}Cs, 10-100 pCi/g ^{239}Pu, and 1-10 pCi/g $^{239-240}Pu$, and generally increased throughout the event. The total amount of radioactivity associated with suspended sediments in each water sample (pCi/ℓ) steadily decreased through the runoff event though the concentrations (pCi/g) generally increased.

Significantly higher ($P \leq 0.05$) concentrations of the radionuclides were measured in particulate samples collected near the surface of the flow compared to those collected from near the bottom of the stream channel, partly due to a greater proportion of fine particle sizes in the surface samples. Previous studies in this canyon have shown that particles less than 53-μm diam comprised only 2% of bed sediments by weight, but contained about 15% of the radioactivity.

About 1% of the radionuclide inventory in each sample was present in the water fraction, whereas 99% was associated with the suspended particulates. More total

radioactivity was associated with suspended sediments in bottom samples than with corresponding surface samples, even though the latter exhibited significantly higher radionuclide concentrations.

There was a significant relationship ($P \leq 0.05$) between ^{137}Cs and the corresponding plutonium isotopes in the suspended sediment samples. This relationship was observed previously in Mortandad Canyon sediments and indicates that the two elements are distributed similarly along the stream channel and in the various size fractions.

The changes in radionuclide and suspended sediment concentrations were both relatively unaffected by flow rates in the range 0.07-0.25 m^3/s, possibly indicating that all available fine materials were in suspension at these flow rates. However, radionuclide and suspended sediment concentrations were directly correlated with increasing flow in the range of 0.25-0.3 m^3/s. It seems likely that the water flowing at rates in excess of about 0.25 m^3/s suspended the coarser particles (>105 μm) which contained over 95% of the bulk and 80% of the radionuclide inventory.

Suspended sediment concentrations were used in a power function relationship to predict total concentrations of the specific radionuclides in runoff water samples. The equations resulting from the least squares fit of the data were

$$Y = 110\ x^{0.40},\ r^2 = 0.82,\ n = 11;$$
$$Z = 14\ x^{0.47},\ r^2 = 0.87,\ n = 11;\ \text{and}$$
$$C = 580\ x^{0.62},\ r^2 = 0.94,\ n = 11;$$

where Y, Z, and C are the average total ^{238}Pu, $^{239-240}Pu$, and ^{137}Cs concentrations, respectively, in unfiltered runoff water (pCi/ℓ), and X is the average suspended sediment concentration (g/ℓ). The coefficients of determination (r^2) were all highly significant ($P \leq 0.01$).

The total amount of radioactivity transported by the event was calculated from average total radionuclide concentrations and accumulative runoff throughout the event. The estimated transport was 0.5 mCi ^{137}Cs, 1.1 mGi ^{238}Pu, and 0.2 mCi $^{239-240}Pu$. In the case of plutonium, this activity represents 1-2% of the total inventory of the canyon as of September 1975.

The most efficient transport of radionuclides occurred during the beginning of the storm runoff event when sediment concentrations were high as a result of high velocities and flow rates. Nearly 80% of the sediments and 70% of the radioactivity were transported during the first 120 min of the 270-min observation period.

In the 12 years that Mortandad Canyon has been receiving treated effluents, over 50% of the radioactivity has been transported into the dry portion of the canyon by snowmelt and storm runoff. The relative distribution of plutonium within the canyon demonstrates that transport occurs beyond the extent of surface water and that runoff from summer rainstorms can transport radionuclides in landscapes exhibiting these hydrologic features. There appears to be a highly significant relationship between suspended sediment concentrations and total amounts of radioactivity in water. The flow rates achieved during runoff events play an important part in determining the total amount of sediment and thus radioactivity transported downstream.

Although fine materials (<53 μm) exhibited higher radionuclide concentrations, the bulk of the radioactivity was associated with the more abundant coarse materials which serve as the most important sediment component involved in radionuclide transport. The water fraction was relatively unimportant although the water flow served as the transport vector.

Additional studies are to be conducted to determine the radionuclide transport characteristics of runoff events which vary in size from the one examined in this study. Particle size determinations would be valuable in relating flow rates (or velocity) to types of suspended material in the runoff. Factors to minimize runoff include adequate planning during site construction activities,

revegetation of disturbed areas, and engineering practices which minimize channeling. Storm runoff serves as a transport vector for sediment-deposited radioactivity much the same as wind in arid terrestrial environments.

C. Radionuclides in Rio Grande Sediments and Fish

A sampling program was initiated in 1973 to measure the concentrations of selected radionuclides in fish and sediments from the Rio Grande, and preliminary results are presented here. Sampling locations were chosen along the river at the outfalls of the major canyons draining the Laboratory area and at about 2-km intervals downstream to the Cochiti Reservoir.

Sediment cores were obtained along the river and reservoir edges to depths of about 20 cm. The samples were thoroughly mixed prior to radiochemical analysis.

The fish samples consisted of three species, namely carp (Cyprinus carpio), western white sucker (Catostomus commersoni), and Rio Grande chub (Gila nigrescens). These species generally feed on detritus, algae, and invertebrates; however, specific food habits are unknown in the sampling area. The complete carcass and the gastrointestinal contents were processed for radiochemical analyses.

All the available data from the Rio Grande fish and sediment sampling program are summarized in Table XXI. The means and coefficients of variation were obtained from all the data, including calculated concentrations that were negative or zero.

Data are not currently available on the ^{137}Cs concentrations in sediments from the sampling area. Plutonium concentrations in 35 separate sediment samples were generally not significantly above the analytical detection limit of 0.005 pCi/g.

Concentrations of ^{137}Cs in three species of fish from the sampling area generally were not significantly above the detection limits of about 0.4 pCi/g dry tissue. Five of the 19 samples collected in September 1974 contained measurable concentrations of ^{137}Cs. However, these concentrations, which ranged from 1.3 to 1.8 pCi/g dry weight, can be attributed to worldwide fallout sources of ^{137}Cs.

Most of the plutonium data for fish are not available, with the exception of the September 1974 collection. Plutonium-238 was not detectable in any of the fish samples analyzed to date. A mean concentration of 0.9 fCi/g of ^{239}Pu was measured in fish with individual concentrations ranging from 0 to 7 fCi/g ^{239}Pu.

The extremely low concentrations and high variability of ^{137}Cs and plutonium in fish and sediments demonstrate the need to consider the level of sampling effort required to detect significant changes in radionuclide concentrations. A coupling of the experimental design with analytical capabilities and with potential health implications is mandatory to providing meaningful data.

XIII. UNPLANNED RELEASES

On August 27, 1975, the contents of a 20 000-ℓ storage tank in the Central Waste Treatment Plant at TA-50 (see Fig. 4) foamed over causing about 3000 ℓ of a contaminated liquid-sludge mixture to flow out of the building. The foaming was apparently caused by the inadvertent mixing of an acid solution from ion-exchange column regeneration with a carbonate-rich sludge from radioactive waste treatment. The liquid escaping the building flowed over a portion of the blacktop parking lot and access road adjacent to the building and onto a partly vegetated soil area. A total area of about 500 m^2 was contaminated. The entire area was within a security-fenced Laboratory site. The liquid contained a mixture of radioisotopes and had activity concentrations of approximately 40×10^{-6} μCi/mℓ gross-alpha, 15×10^{-6} μCi/mℓ gross-beta, and 140×10^{-6} μCi/mℓ gross-gamma. These activities were attributable primarily to

^{238}Pu, ^{90}Sr, and ^{137}Cs. Other isotopes detected included ^{239}Pu, ^{241}Am, and ^{89}Sr. Soil was contaminated to maximum levels of about 2 nCi/g gross-alpha.

The contaminated blacktop and soil were dug up and loaded into plastic-lined trucks. About 80 m^3 of contaminated material were hauled to the contaminated solid waste disposal area at TA-54 on August 27, 1975.

Surveys with field instruments and gross-alpha analyses of soil samples identified some remaining contamination which was removed by hand excavation. Final stages of cleanup and documentation were delayed because of rain. The decontamination was completed on September 15, 1975. Soil samples taken at about 2-m intervals over the excavated area all showed gross-alpha levels below the 20 pCi/g detection limit of a zinc-sulfide analysis sytem used for the documentation. Continuous air monitoring measurements from the immediate vicinity of the release and cleanup operations showed no measurable alpha activity greater than natural background levels.

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TABLE I

MEANS AND EXTREMES OF TEMPERATURE AND PRECIPITATION

CLIMATOLOGICAL SUMMARY 1910-1974[a]

	TEMPERATURE (°C)							PRECIPITATION TOTAL (mm)									MEAN NO. OF DAYS		
	MEANS			EXTREMES				RAIN[c]					SNOW/FROZEN PRECIPITATION						
Mo	Max	Min	Mo Mean	High	Yr	Low	Yr	Mean	Daily Max	Yr	Mo Max	Yr	Mean	Daily Max	Yr	Mo Max	Yr	Precip. ≥2.5mm	Max[b] Temp ≥26.7°C	Min[b] Temp ≤-9.4°C
Jan	3.9	-7.9	-2.0	17.8	1963	-27.8	1963	21.21	62.23	1916	171.45	1916	246.1	381.0	1913	989.2	1949	2	0	8
Feb	6.1	-5.8	0.1	18.9	1936	-25.6	1951	17.38	26.67	1915	61.89	1948	204.8	330.2	1915	604.2	1948	2	0	6
Mar	9.4	-3.4	3.1	21.7	1971	-19.4	1948	25.38	57.15	1916	104.4	1973	261.3	457.2	1916	938.8	1973	3	0	3
Apr	14.6	1.0	7.8	26.7	1950	-15.0	1925	24.69	36.83	1969	117.86	1916	103.9	304.8	1958	853.4	1958	3	0	0
May	19.9	6.0	12.9	31.7	1935	- 4.4	1938	32.16	45.72	1929	113.54	1929	19.7	228.6	1917	431.8	1917	3	1	0
Jun	25.3	10.9	18.1	33.9	1954	- 2.2	1919	34.64	34.80	1931	141.49	1913	0.0	0.0	—	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	0.0	—	0.0	—	8	19	0
Aug	25.4	12.3	18.9	33.3	1937	4.4	1947	94.53	57.40	1951	283.97	1952	0.0	0.0	—	0.0	--	8	12	0
Sep	22.4	8.9	15.7	34.4	1934	- 5.0	1936	50.02	56.13	1929	147.07	1941	4.9	152.4	1913	152.4	1913	5	5	0
Oct	16.7	3.2	9.9	27.8	1930	- 8.9	1970	41.31	88.39	1919	171.96	1957	36.9	228.6	1972	228.6	1959 1972	3	0	0
Nov	9.4	-3.1	3.2	20.6	1937	-20.0	1957	17.77	37.08	1931	83.82	1957	126.4	335.6	1931	876.3	1957	2	0	2
Dec	4.9	-6.8	-1.0	16.7	1933	-23.3	1924	23.01	34.29	1965	72.39	1965	266.8	457.2	1915	1049.0	1967	3	0	6
Year	15.4	2.3	8.9	35.0	1935	-27.8	1963	468.16	88.39	1919	283.97	1952	1270.8	457.2	1915	1049.0	1967	45	51	25

CLIMATOLOGICAL SUMMARY 1975[a]

	TEMPERATURE (°C)					PRECIPITATION TOTAL (mm)				NO. OF DAYS		
	MEANS (Daily Values)			EXTREMES		RAIN[c]		SNOW/FROZEN PRECIPITATION				
Mo	Max	Min	Mo Mean	High	Low	Total	Daily Max	Total	Daily Max	≥2.5mm	≥26.7°C	≤-9.4°C
Jan	3.7	-9.5	-2.9	16.1	-23.3	32.8	17.5	399.0	165.0	3	0	14
Feb	4.3	-7.5	-1.6	11.7	-20.0	46.7	24.4	584.0	267.0	3	0	9
Mar	8.4	-2.7	2.9	15.6	-11.1	32.5	8.1	305.0	76.0	5	0	4
Apr	11.8	-1.1	5.4	21.1	- 7.8	82.0	50.8	843.0	508.0	3	0	0
May	18.7	4.3	11.5	24.4	- 3.3	4.1	1.5	0.0	0.0	0	0	0
Jun	25.0	10.0	17.5	31.0	0.0	8.9	5.8	0.0	0.0	1	14	0
Jul	25.6	12.0	18.8	28.9	9.4	98.6	29.2	0.0	0.0	11	13	0
Aug	26.0	12.0	19.0	29.0	9.0	41.4	11.2	0.0	0.0	4	17	0
Sep	19.9	7.8	13.9	28.0	1.0	115.6	29.0	0.0	0.0	7	2	0
Oct	16.8	2.3	9.6	23.3	- 7.8	5.6	2.5	0.0	0.0	1	0	0
Nov	9.1	-3.8	2.7	18.9	-14.4	15.0	7.6	38.1	25.4	2	0	5
Dec	5.4	-6.7	-0.7	12.2	-13.9	7.6	4.3	76.2	63.5	2	0	8
Year	14.6	1.4	8.0	31.0	-23.3	490.8	50.8	2245.3	508.0	42	46	40

[a] Los Alamos, New Mexico; Latitude 35° 32' North, Longitude 106° 19' West; Elevation 2260 m.

[b] 26.7°C = 80°F; -9.4°C = 15°F.

[c] Includes liquid water equivalent of frozen precipitation.

TABLE II

UNITS OF MEASUREMENT CONVERSIONS

Quantity	This Report	ERDAM 0524	International (SI)	Common Usage
Radioactivity Concentrations				
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 µg/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
Discharge	1 ℓ/s	-	= 1 dm^3/s	= 0.0353 cfs
				= 15.9 gpm
				= 2.28 x 10^4 gpd
	1 m^3/s	-	= 1 m^3/s	= 35.3 cfs
				= 1.59 x 10^4 gpm
				= 2.28 x 10^7 gpd
Absorbed Radiation	rad, rem	rem	Gy (gray)	= 100 rad
Radioactivity	Ci	-	Bq (bequerel)	= 2.70 x 10^{-11}Ci

TABLE III

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 IV

ERDA 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}	30	3×10^{-7}	0.3
^{137}Cs	2×10^{-9}	2 000	3×10^{-5}	20
^{238}Pu	7×10^{-14}	0.0	5×10^{-6}	5
^{239}Pu	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}	$\frac{(\mu g/m^3)}{9}$[b]	2×10^{-5}	$\frac{(mg/\ell)}{60}$[b]

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	$3 \times 10^{-}$	3×10	3×10	300
^{90}Sr[c]	1×10^{-9}	1 000	1×10^{-5}	10
^{131}I	4×10^{-9}	4 000	3×10^{-5}	30
^{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 (ERDA Manual Chap. 0524, Annex A).

[b]Fluorometric measurements of U mass may be converted to the ERDA "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 V

WATER STANDARDS

DRINKING WATER STANDARDS FOR CHEMICALS

Constituent	Symbol	Concentration Limit (mg/ℓ) PHS and EPA[a] Mandatory	PHS and EPA[a] Recommended	EPA[b] Primary Regulations	NMWQCC[c]
Alkyl benzene sulfonate	ABS	-	0.5	-	-
Arsenic	As	0.05	0.01	0.05	0.05
Barium	Ba	1.0	-	1.0	1.0
Boron	B	-	-	-	0.75
Cadmium	Cd	0.01	-	0.01	0.01
Carbon chloroform extract	CCE	-	0.2	-	-
Chloride	Cl	-	250.	-	-
Chromium hexavalent	Cr^{+6}	0.05	-	-	-
Total	Cr	-	-	0.05	0.01
Copper	Cu	-	1.0	-	0.05 (0.1)[d]
Cyanide	CN	0.2	0.01	-	-
Fluoride	F	≈1[e]	-	2.0[e]	-
Iron	Fe	-	0.3	-	-
Lead	Pb	0.05	-	0.05	0.05
Manganese	Mn	-	0.05	-	0.1
Mercury	Hg	-	-	0.002	0.001
Molybdenum	Mo	-	-	-	0.01
Nickel	Ni	-	-	-	0.1
Nitrate	NO_3	-	45.	45.	-
Phenols		-	0.001	-	-
Selenium	Se	0.01	-	0.01	0.01
Silver	Ag	0.05	-	0.05	0.05
Total dissolved solids	TDS	-	500.	-	-
Zinc	Zn	-	5.0	-	0.1(0.5)[d]

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] EPA National Interim Primary Drinking Water Regulations, 40 CFR 141, Fed. Reg. 40: 59566-59588, Dec. 24, 1975.

[c] New Mexico Water Quality Control Commission Regulations.

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

[e] The concentration standard for fluoride varies depending upon temperature. The values given are appropriate for Los Alamos conditions.

TABLE VI

ATMOSPHERIC RADIOACTIVE EFFLUENT TOTALS FOR 1975

Location	^{238}Pu ^{239}Pu (μCi)	^{233}U ^{235}U ^{238}U (μCi)	^{234}Th (mCi)	MFP[a] (μCi)	^{131}I (mCi)	^{41}Ar (Ci)	^{32}P (μCi)	^{3}H (Ci)
TA-2	-	-	-	-	-	237	-	-
TA-3	211	194	6.6	184	1.4	-	-	22
TA-9	-	-	-	-	-	-	-	-
TA-15	-	-	-	-	-	-	-	-
TA-21	11.1	721	-	1.4	-	-	-	306
TA-33	-	-	-	-	-	-	-	3478
TA-35	5.9	-	-	-	-	-	-	2394
TA-41	-	-	-	-	-	-	-	-
TA-43	1.7	-	-	-	-	-	49	-
TA-46	-	0.5	-	-	-	-	-	-
TA-48	12.3	3.9	-	722	-	-	-	-
TA-50	4.1	-	-	42	-	-	-	-

[a]Mixed Fission Products.

TABLE VII

ANNUAL THERMOLUMINESCENT DOSIMETER MEASUREMENTS

	Station Location	Coordinates	Exposure Period (weeks)	Annual Dose (mrem/yr)
Off-Site Stations				
1	Barranca School	N180 E130	4	128 (±4)
2	Arkansas Avenue	N170 E020	13	132 (±8)
3	Golf Course	N160 E060	13	126 (±8)
4	Cumbres School	N150 E090	13	152 (±10)
5	Pajarito Ski Area	N130 W180	13	117 (±8)
6	Diamond Drive	N130 E020	13	120 (±9)
7	48th Street	N110 E000	4	142 (±5)
8	Fuller Lodge	N110 E090	4	140 (±4)
9	White Rock STP	S090 E430	4	125 (±4)
10	Espanola	-	13	101 (±5)
11	Pojoaque	-	13	95 (±6)
12	Santa Fe	-	13	104 (±7)
Perimeter Stations				
13	L. A. Airport	N110 E160	13	131 (±6)
14	Bayo STP	N110 E260	13	134 (±8)
15	Acorn Street	N100 E110	4	125 (±4)
16	State Hwy 4	N070 E350	13	197 (±18)
17	TA-6	N060 W050	13	125 (±6)
18	Well PM-1	N030 E310	4	148 (±8)
19	TA-16	S030 W080	4	130 (±4)
20	TA-49	S100 E040	4	128 (±4)
21	Booster P-1	S100 E300	13	131 (±6)
22	Pajarito Acres	S210 E370	13	98 (±8)
23	Bandelier Lookout	S270 E200	13	128 (±11)
On-Site Stations				
24	TA-21	N090 E170	13	128 (±6)
25	TA-2 (A)	N080 E100	4	150 (±5)
26	TA-2 (B)	N080 E120	4	172 (±5)
27	TA-2 (C)	N080 E110	4	135 (±4)
28	TA-53 (A)	N070 E160	4	126 (±5)
29	TA-53 (B)	N060 E190	4	146 (±4)
30	TA-53 (C)	N060 E200	4	135 (±5)
31	TA-53 (D)	N060 E220	4	292 (±5)
32	TA-53 (E)	N050 E230	4	144 (±4)
33	TA-53 (F)	N040 E230	4	138 (±5)
34	TA-3 (A)	N050 E010	4	964 (±9)
35	TA-3 (B)	N060 E010	4	252 (±6)
36	TA-3 (C)	N050 E020	4	164 (±4)
37	TA-3 (D)	N050 E040	4	141 (±4)
38	TA-52	N020 E170	13	113 (±5)
39	TA-18 (A)	S040 E190	4	199 (±4)
40	TA-18 (B)	S030 E190	4	140 (±5)
41	TA-18 (C)	S040 E200	4	413 (±6)
42	TA-18 (D)	S060 E190	4	162 (±5)
43	TA-18 (E)	S050 E170	4	186 (±5)
44	TA-33	S250 E230	4	136 (±4)

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	285	1.0×10^{-15} μCi/mℓ	1.8
10 perimeter	gross α	2 week	259	1.1×10^{-15} μCi/mℓ	1.9
5 on-site	gross α	2 week	130	1.1×10^{-15} μCi/mℓ	0.1
11 off-site	gross β	2 week	285	76×10^{-15} μCi/mℓ	0.3
10 perimeter	gross β	2 week	259	80×10^{-15} μCi/mℓ	0.3
5 on-site	gross β	2 week	130	77×10^{-15} μCi/mℓ	0.01
11 off-site	tritiated H_2O	2 week	284	20×10^{-12} μCi/mℓ	0.01
10 perimeter	tritiated H_2O	2 week	259	42×10^{-12} μCi/mℓ	0.02
5 on-site	tritiated H_2O	2 week	129	104×10^{-12} μCi/mℓ	0.002
11 off-site	^{238}Pu	6 to 8 week	88	0.8×10^{-18} μCi/mℓ	0.001
10 perimeter	^{238}Pu	6 to 8 week	80	0.6×10^{-18} μCi/mℓ	0.001
5 on-site	^{238}Pu	6 to 8 week	40	0.5×10^{-18} μCi/mℓ	0.00003
11 off-site	^{239}Pu	6 to 8 week	88	19×10^{-18} μCi/mℓ	0.03
10 perimeter	^{239}Pu	6 to 8 week	80	24×10^{-18} μCi/mℓ	0.04
5 on-site	^{239}Pu	6 to 8 week	40	20×10^{-18} μCi/mℓ	0.001
11 off-site	uranium	3 month	44	45 pg/m^3	0.0005
10 perimeter	uranium	3 month	40	37 pg/m^3	0.0004
5 on-site	uranium	3 month	20	45 pg/m^3	0.00002
4 off-site	^{241}Am	3 month	15	4×10^{-18} μCi/mℓ	0.002
5 perimeter	^{241}Am	3 month	20	8×10^{-18} μCi/mℓ	0.004
2 on-site	^{241}Am	3 month	7	5×10^{-18} μCi/mℓ	0.0001

TABLE IX

ANNUAL ATMOSPHERIC TRITIATED WATER VAPOR CONCENTRATIONS

Station Location	Coordinates	Concentration pCi/m^3 (10^{-12} $\mu Ci/m\ell$) Maximum	Mean	% CG
Off-Site Stations				
1 Barranca School	N180 E130	41	14(±1)	0.01
2 Arkansas Avenue	N170 E 20	76	18(±1)	0.01
3 Golf Course	N160 E 60	70	22(±2)	0.01
4 Cumbres School	N150 E 90	83	25(±2)	0.01
5 Diamond Drive	N130 E 20	81	27(±2)	0.01
6 48th Street	N110 E 0	62	20(±1)	0.01
7 Fuller Lodge	N110 E 90	93	28(±2)	0.01
8 White Rock STP	S 90 E430	57	25(±2)	0.01
9 Espanola		42	13(±1)	0.01
10 Pojoaque		38	14(±2)	0.01
11 Santa Fe		35	14(±1)	0.01
Perimeter Stations				
12 L. A. Airport	N110 E160	724	88(±6)	0.04
13 Bayo STP	N110 E260	84	29(±2)	0.001
14 Acorn Street	N100 E110	314	64(±4)	0.03
15 TA-6	N 60 W 50	69	22(±2)	0.0004
16 Well PM-1	N 30 E310	123	48(±3)	0.001
17 TA-16	S 30 W 80	44	18(±2)	0.01
18 TA-49	S100 E 40	67	21(±2)	0.0004
19 Booster P-1	S100 E300	109	49(±3)	0.001
20 Pajarito Acres	S210 E370	48	24(±2)	0.01
21 Bandelier Lookout	S270 E200	218	61(±5)	0.03
On-Site Stations				
22 TA-21	N 90 E170	208	64(±4)	0.001
23 LAMPF	N 60 E190	208	71(±4)	0.001
24 TA-52	N 20 E170	592	174(±12)	0.003
25 Booster P-2	S 30 E190	229	54(±3)	0.001
26 TA-33	S250 E230	949	156(±17)	0.003

TABLE X

ANNUAL ATMOSPHERIC GROSS-ALPHA AND GROSS-BETA ACTIVITY CONCENTRATIONS

Station Location	Coordinates	Gross-Alpha Concentrations fCi/m^3 (10^{-15} $\mu Ci/m\ell$) Max	Min	Mean	%CG	Gross-Beta Concentrations fCi/m^3 (10^{-15} $\mu Ci/m\ell$) Max	Min	Mean	%CG
Off-Site Stations									
1 Barranca School	N180 E130	1.6	0.4	1.1(±0.1)	1.8	195	12	78(±4)	0.3
2 Arkansas Avenue	N170 E 20	1.7	0.5	1.0(±0.1)	1.7	211	13	75(±4)	0.3
3 Golf Course	N160 E 60	1.7	0.7	1.0(±0.1)	1.7	212	10	80(±5)	0.3
4 Cumbres School	N150 E 90	1.5	0.4	1.0(±0.1)	1.7	218	13	71(±4)	0.2
5 Diamond Drive	N130 E 20	2.3	0.5	1.1(±0.1)	1.8	227	13	78(±4)	0.3
6 48th Street	N110 E 0	1.7	0.5	1.0(±0.1)	1.7	195	12	75(±4)	0.3
7 Fuller Lodge	N110 E 90	1.7	0.6	1.0(±0.1)	1.7	209	11	74(±4)	0.2
8 White Rock STP	S 90 E430	1.8	0.6	1.1(±0.1)	1.8	205	12	77(±4)	0.3
9 Espanola	-	1.9	0.6	1.0(±0.1)	1.7	198	15	75(±4)	0.3
10 Pojoaque	-	1.6	0.7	1.1(±0.1)	1.8	190	13	77(±4)	0.3
11 Santa Fe	-	1.8	0.5	1.1(±0.1)	1.8	226	13	72(±4)	0.2
Perimeter Stations									
12 L. A. Airport	N110 E160	2.0	0.6	1.2(±0.1)	2.0	245	15	84(±4)	0.3
13 Bayo STP	N110 E260	2.5	0.4	1.1(±0.1)	0.1	190	13	74(±4)	0.01
14 Acorn Street	N110 E110	1.8	0.5	1.1(±0.1)	1.8	205	13	77(±4)	0.3
15 TA-6	N 60 W 50	2.6	0.6	1.2(±0.1)	0.1	214	13	79(±4)	0.01
16 Well PM-1	N 30 E310	1.9	0.7	1.2(±0.1)	0.1	223	13	83(±4)	0.01
17 TA-16	S 30 W 80	1.4	0.6	1.0(±0.1)	1.7	200	11	74(±4)	0.2
18 TA-49	S100 E 40	1.8	0.4	1.1(±0.1)	0.1	256	15	84(±4)	0.01
19 Booster P-1	S100 E300	1.9	0.5	1.1(±0.1)	0.1	213	15	78(±4)	0.01
20 Pajarito Acres	S210 E370	2.2	0.6	1.2(±0.1)	2.0	189	13	81(±4)	0.3
21 Bandelier Lookout	S270 E200	2.2	0.5	1.2(±0.1)	2.0	235	13	86(±4)	0.3
On-Site Stations									
22 TA-21	N 90 E170	1.5	0.5	1.0(±0.1)	0.1	236	9	75(±4)	0.01
23 LAMPF	N 60 E190	1.7	0.5	1.1(±0.1)	0.1	186	15	77(±4)	0.01
24 TA-52	N 20 E170	2.0	0.5	1.2(±0.1)	0.1	212	12	80(±4)	0.01
25 Booster P-2	S 30 E190	1.8	0.5	1.1(±0.1)	0.1	225	14	77(±4)	0.01
26 TA-33	S250 E230	2.0	0.4	1.2(±0.1)	0.1	199	15	78(±4)	0.01

TABLE XI

ANNUAL ATMOSPHERIC ^{238}Pu, ^{239}Pu, AND ^{241}Am CONCENTRATIONS

Station Location	Coordinates	^{238}Pu aCi/m^3 (10^{-18} µCi/mℓ)			^{239}Pu aCi/m^3 (10^{-18} µCi/mℓ)			^{241}Am aCi/m^3 (10^{-18} µCi/mℓ)		
		Max	Mean	%CG	Max	Mean	%CG	Max	Mean	%CG
Off-Site Stations										
1 Barranca School	N180 E130	3	0.6(±0.7)	0.001	44	21(±2)	0.04		—	
2 Arkansas Avenue	N170 E 20	2	0.8(±0.7)	0.001	38	20(±2)	0.03		—	
3 Golf Course	N160 E 60	2	0.4(±0.7)	0.001	52	20(±2)	0.03		--	
4 Cumbres School	N150 E 90	3	0.7(±0.7)	0.001	31	15(±2)	0.03	9	4(±3)	0.002
5 Diamond Drive	N130 E 20	2	0.3(±1.0)	0.0004	47	20(±2)	0.03	4	3(±3)	0.002
6 48th Street	N110 E 0	2	0.7(±0.7)	0.001	40	20(±2)	0.03		—	
7 Fuller Lodge	N110 E 90	7	2.3(±1.2)	0.003	60	29(±4)	0.05		—	
8 White Rock STP	S 90 E430	3	0.9(±0.6)	0.001	40	18(±2)	0.03	7	4(±4)	0.002
9 Espanola	-	7	1.0(±1.4)	0.001	46	17(±2)	0.03		--	
10 Pojoaque	-	2	0.3(±1.0)	0.0004	35	18(±2)	0.03		--	
11 Santa Fe	-	2	0.4(±1.0)	0.001	34	16(±2)	0.03	9	4(±4)	0.002
Perimeter Stations										
12 L. A. Airport	N110 E160	4	0.6(±0.6)	0.001	52	24(±4)	0.04	50	22(±5)	0.01
13 Bayo STP	N110 E260	1	0.2(±0.5)	0.00001	41	19(±2)	0.001	3	2(±2)	0.00003
14 Acorn Street	N100 E110	5	0.9(±0.9)	0.001	45	21(±3)	0.04		—	
15 TA-6	N 60 W 50	6	1.6(±0.7)	0.0001	317	53(±5)	0.003	22	11(±3)	0.0002
16 Well PM-1	N 60 E310	1	0.3(±0.6)	0.00002	49	20(±2)	0.001		--	
17 TA-16	S 30 W 80	1	0.2(±0.6)	0.0003	41	19(±2)	0.03	7	4(±2)	0.002
18 TA-49	S100 E 40	1	0.1(±0.7)	0.00001	50	21(±2)	0.001	2	1(±2)	0.00002
19 Booster P-1	S100 E300	3	0.8(±0.7)	0.00004	48	22(±2)	0.001		--	
20 Pajarito Acres	S210 E370	2	0.5(±0.6)	0.001	45	21(±2)	0.04		—	
21 Bandelier Lookout	S270 E200	2	0.3(±0.6)	0.0004	50	23(±2)	0.04		—	
On-Site Stations										
22 TA-21	W 90 E170	1	0.0(±0.6)	0.000	43	18(±2)	0.001		--	
23 LAMPF	N 60 E190	2	1.0(±0.7)	0.00005	53	22(±2)	0.001	9	3(±2)	0.0001
24 TA-52	N 20 E170	2	0.5(±0.8)	0.00003	44	21(±2)	0.001		--	
25 Booster P-2	S 30 E190	2	0.5(±0.6)	0.00003	44	18(±2)	0.001	10	7(±5)	0.0001
26 TA-33	S250 E230	2	0.5(±0.5)	0.00003	66	22(±2)	0.001		--	

TABLE XII

ANNUAL ATMOSPHERIC URANIUM CONCENTRATIONS

			Concentration (pg/m^3)			
	Station Location	Coordinates	Max	Min	Mean	% CG
	Off-Site Stations					
1	Barranca School	N180 E130	71	14	40(±5)	0.0004
2	Arkansas Avenue	N170 E 20	38	8	22(±3)	0.0002
3	Golf Course	N160 E 60	54	10	32(±4)	0.0004
4	Cumbres School	N150 E 90	73	20	39(±4)	0.0004
5	Diamond Drive	N130 E 20	67	12	43(±6)	0.0005
6	48th Street	N110 E 0	53	17	39(±5)	0.0004
7	Fuller Lodge	N110 E 90	66	26	43(±5)	0.0005
8	White Rock STP	S 90 E430	117	14	45(±6)	0.0005
9	Espanola	--	192	52	95(±11)	0.001
10	Pojoaque	--	139	31	69(±8)	0.0008
11	Santa Fe	--	49	13	28(±3)	0.0003
	Perimeter Stations					
12	L. A. Airport	N110 E160	69	23	36(±4)	0.0004
13	Bayo STP	N110 E260	60	9	32(±4)	0.00002
14	Acorn Street	N100 E110	272	29	97(±15)	0.001
15	TA-6	N 60 W 50	40	8	27(±3)	0.00001
16	Well PM-1	N 30 E310	58	13	32(±4)	0.00002
17	TA-16	S 30 W 80	54	7	26(±3)	0.0003
18	TA-49	S100 E 40	43	12	27(±3)	0.00001
19	Booster P-1	S100 E300	60	9	33(±4)	0.00002
20	Pajarito Acres	S210 E370	53	9	28(±3)	0.0003
21	Bandelier Lookout	S270 E200	52	9	30(±3)	0.0003
	On-Site Locations					
22	TA-21	N 90 E170	54	16	31(±3)	0.00001
23	LAMPF	N 60 E190	94	22	53(±6)	0.00003
24	TA-52	N 20 E170	215	21	72(±10)	0.00003
25	Booster P-2	S 30 E190	73	15	46(±5)	0.00002
26	TA-33	S250 E230	42	9	25(±3)	0.00001

TABLE XIII

RADIOACTIVITY IN ON-SITE SURFACE AND GROUND WATER

Name and Coordinate		No. and Type	^{3}H $10^{-6}\mu Ci/m\ell$	^{241}Am $10^{-9}\mu Ci/m\ell$	^{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 E120	3-G	-0.7(±2.5)	0.05(±0.19)	-0.01(±0.03)	-0.01(±0.01)	0.3(±1.2)	3.2(±5.0)	0.4(±0.7)
Canada del Buey	N 10 E150	3-S	3.3(±4.9)	-0.05(±0.16)	-0.01(±0.01)	0.00(±0.01)	0.5(±1.8)	9.4(±16.7)	0.4(±0.7)
Pajarito Canyon	S 60 E225	3-S	4.8(±5.3)	-0.16(±0.16)	-0.01(±0.04)	0.00(±0.01)	0.1(±1.4)	8.2(±8.9)	0.1(±0.3)
Water Canyon	S 90 E 85	2-S	1.3(±0.1)	-0.09(±0.16)	-0.03(±0.04)	0.00(±0.04)	0.9(±2.5)	5.7(±4.9)	0.0(±1.0)
Test Well DT-54	S110 E 90	2-G	0.5(±0.8)	0.06(±0.16)	-0.00(±0.01)	0.00(±0.01)	0.8(±0.4)	1.9(±0.9)	0.8(±2.1)
Test Well 8	N 40 E150	3-G	0.2(±0.5)	-	-0.06(±0.22)	-0.03(±0.11)	1.0(±5.0)	2.4(±3.8)	0.2(±0.6)
Acid-Pueblo Canyon (Former Release Area)									
Acid Weir	N130 E 60	3-S	2.3(±2.5)	-0.03(±0.20)	-0.02(±0.02)	0.04(±0.10)	2.3(±4.7)	61(±100)	1.3(±1.0)
Pueblo 1	N130 E 75	3-S	1.5(±0.6)	0.02(±0.08)	-0.01(±0.01)	0.01(±0.01)	1.1(±2.4)	11(±8.2)	1.0(±0.6)
Pueblo 2	N115 E160	3-S	0.9(±0.5)	-0.15(±0.04)	-0.00(±0.01)	0.34(±0.66)	0.5(±0.1)	17(±10)	0.8(±2.0)
Obs. Hole PO-3B	N110 E245	3-G	5.7(±1.1)	1.2 (±0.20)	0.02(±0.02)	0.23(±0.06)	6.9(±3.0)	38(±7.6)	2.1(±1.0)
Hamilton Bend Spr.	N110 E250	3-G	0.9(±1.6)	0.08(±0.08)	0.00(±0.02)	0.01(±0.03)	1.1(±1.2)	7.3(±1.6)	1.7(±2.0)
Pueblo 3	N 85 E315	3-S	0.9(±0.8)	0.05(±0.08)	0.00(±0.02)	0.01(±0.02)	1.3(±1.8)	19(±11)	2.3(±1.8)
Sandia Canyon									
SCS-1	N 80 E 40	3-S	8.3(±17)	-	-0.01(±0.02)	0.01(±0.01)	5.5(±20)	23(±9.5)	1.4(±1.6)
SCS-2	N 55 E155	3-S	6.8(±9.0)	-0.10(±0.20)	0.00(±0.02)	0.00(±0.02)	12(±40)	20(±14)	1.7(±1.1)
DP-Los Alamos Canyon									
DPS-1	N 95 E160	3-S	76(±200)	0.68(±0.69)	0.27(±0.17)	0.84(±1.1)	22(±23)	500(±75)	6.3(±3.1)
DPS-4	N 80 E205	2-S	46(±100)	0.29(±0.14)	0.01(±0.01)	0.11(±0.11)	8.3(±16)	410(±250)	1.3(±1.0)
Obs. Hole LAO-C	N 85 E 70	3-G	1.1(±1.8)	0.08(±0.01)	0.02(±0.07)	0.00(±0.02)	2.6(±2.1)	7.0(±2.8)	1.6(±1.0)
Obs. Hole LAO-1	N 85 E115	3-G	11(±7.1)	0.12(±0.14)	0.01(±0.01)	0.01(±0.02)	1.5(±1.8)	56(±29)	0.8(±0.7)
Obs. Hole LAO-2	N 80 E205	3-G	35(±100)	0.26(±0.47)	0.00(±0.01)	0.05(±0.07)	3.9(±8.8)	160(±80)	1.1(±0.6)
Obs. Hole LAO-3	N 80 E215	3-G	11(±18)	0.18(±0.74)	0.00(±0.01)	0.01(±0.01)	6.4(±1.2)	74(±30)	3.1(±1.7)
Obs. Hole LAO-4.5	N 65 E270	3-G	14(±30)	0.26(±0.62)	-0.01(±0.06)	0.10(±0.15)	1.6(±1.7)	48(±110)	0.8(±0.6)
Mortandad Canyon									
Gaging Station 1	N 50 E 90	3-S	116(±340)	0.54(±0.39)	125(±410)	3.6(±11)	46(±110)	1400(±3000)	3.1(±2.1)
Obs. Hole MCO-3	N 45 E 95	3-G	195(±570)	0.36(±0.34)	5.4(±5.9)	0.45(±0.04)	8.9(±14)	460(±780)	3.6(±3.5)
Obs. Hole MCO-4	N 35 E135	3-G	49(±110)	0.84(±1.48)	4.1(±6.8)	0.70(±1.3)	9.0(±16)	100(±140)	2.6(±2.7
Obs. Hole MCO-5	N 40 E150	3-G	44(±86)	0.34(±0.69)	1.3(±0.72)	0.21(±0.29)	3.5(±2.4)	33(±12)	2.6(±1.0)
Obs. Hole MCO-6	N 35 E160	3-G	24(±9.5)	0.47(±0.31)	0.55(±0.10)	0.06(±0.16)	6.7(±4.0)	29(±4.2)	5.4(±5.0)
Obs. Hole MCO-7	N 30 E170	3-G	26(±25)	1.1(±1.1)	0.59(±0.06)	0.07(±0.09)	4.5(±1.8)	24(±4.0)	3.2(±1.3)
Obs. Hole MCO-7.5	N 30 E180	3-G	33(±25)	0.9(±1.4)	1.0(±2.1)	0.12(±0.14)	6.7(±1.9)	33(±26)	11(±9.7)
Obs. Hole MCO-8	N 30 E185	3-G	41(±28)	2.4(±2.5)	0.51(±0.94)	0.10(±0.16)	4.9(±7.2)	25(±23)	6(±5)

TABLE XIV

RADIOACTIVITY IN OFF-SITE AND SUPPLY WATERS

	No. of Samples	Type of Activity	Units	Min.	Max.	Ave.	% CG
Regional Surface Water	18	^{3}H	$10^{-6}\mu Ci/m\ell$	-0.2(±0.8)	1.8(±1.0)	0.8(±1.4)	<0.1
	18	^{238}Pu	$10^{-12}\mu Ci/m\ell$	-4.4(±14)	79(±148)	0.6(±46)	<0.1
	18	^{239}Pu	$10^{-12}\mu Ci/m\ell$	-1.2(±8)	16(±42)	0.9(±14)	<0.1
	12	U, total	$\mu g/\ell$	1.2(±1.0)	2.9(±0.6)	2.0(±1.0)	3.3
	18	Gross α	$10^{-9}\mu Ci/m\ell$	-0.8(±1.2)	3.9(±1.4)	1.3(±3.5)	<0.1
	18	Gross β	$10^{-9}\mu Ci/m\ell$	2.8(±1.0)	15.2(±3.4)	6.7(±7.4)	2.2
Perimeter Surface and Ground Water	14	^{3}H	$10^{-6}\mu Ci/m\ell$	0.1(±0.8)	2.3(±1.0)	0.9(±1.3)	<0.1
	18	^{238}Pu	$10^{-12}\mu Ci/m\ell$	-1.4(±17)	50(±100)	1.5(±34)	<0.1
	18	^{239}Pu	$10^{-12}\mu Ci/m\ell$	-0.8(±12)	77(±36)	7.9(±48)	<0.1
	12	U, total	$\mu g/\ell$	0.0(±1.0)	10(±2.6)	2.2(±6.9)	3.7
	18	Gross α	$10^{-9}\mu Ci/m\ell$	-0.6(±1.6)	4.8(±2.6)	0.8(±3.2)	<0.1
	18	Gross β	$10^{-9}\mu Ci/m\ell$	2.4(±1.2)	11(±1.6)	5.8(±8.7)	1.9
Los Alamos Water Supply	64	^{3}H	$10^{-6}\mu Ci/m\ell$	-0.9(±0.8)	1.5(±1.0)	0.3(±1.2)	<0.1
	64	^{238}Pu	$10^{-12}\mu Ci/m\ell$	-1.0(±18)	60(±60)	-0.3(±40)	<0.1
	64	^{239}Pu	$10^{-12}\mu Ci/m\ell$	-1.1(±12)	29(±26)	-0.3(±48)	<0.1
	43	U, total	$\mu g/\ell$	0.0(±1.0)	17(±1.0)	1.9(±5.9)	3.2
	64	Gross α	$10^{-9}\mu Ci/m\ell$	-0.7(±0.2)	7.0(±4.0)	0.9(±3.1)	<0.1
	64	Gross β	$10^{-9}\mu Ci/m\ell$	0.1(±0.8)	7.5(±2.2)	3.0(±3.8)	1.0

TABLE XV

RADIOACTIVITY IN SOIL AND SEDIMENTS

		Number of Samples	Type of Activity	Units	Min.	Max.	Ave.
Regional and Perimeter							
	Soils						
		9	^{3}H	pCi/mℓ	1.9(±1.0)	123(± 6)	16(±80)
		18	^{238}Pu	fCi/g	0.0(±0.1)	3.5(±3.2)	0.5(±2.7)
		18	^{239}Pu	fCi/g	0.0(±0.0)	44(±9.6)	12(±25)
		19	Gross α	pCi/g	1.4(±0.8)	8.0(±3.6)	3.7(±3.2)
		19	Gross β	pCi/g	2.5(±0.8)	9.8(±2.2)	5.8(±3.5)
		19	Total U	μg/g	<0.1(±0.2)	2.7(±0.4)	0.9(±1.6)
	Sediments						
		16	^{238}Pu	fCi/g	0.0(±7.2)	2.8(±3.0)	-0.4(±5.4)
		16	^{239}Pu	fCi/g	-0.2(±1.0)	13(±4.6)	2.5(±10)
		17	Gross α	pCi/g	1.1(±0.6)	5.0(±2.0)	2.2(±2.4)
		17	Gross β	pCi/g	1.1(±0.6)	6.4(±2.6)	2.5(±2.7)
		17	Total U	μg/g	<0.1(±0.2)	3.8(±1.2)	0.8(±1.9)
On-Site							
	Soils						
		4	^{3}H	pCi/mℓ	3.0(±1.0)	8.3(±1.0)	6.0(±4.7)
		6	^{238}Pu	fCi/g	-0.6(±2.0)	2.8(±2.6)	1.0(±2.9)
		6	^{239}Pu	fCi/g	1.8(±1.8)	180(±20)	40(±140)
		7	Gross α	pCi/g	2.9(±1.4)	5.9(±2.4)	4.4(±2.0)
		7	Gross β	pCi/g	1.9(±1.0)	10(±4.0)	6.4(±6.0)
		7	Total U	μg/g	<0.1(±0.2)	1.8(±0.4)	0.6(±1.4)
	Sediments						
		13	^{238}Pu	fCi/g	-0.2(±1.2)	5000(±240)	700(±3400)
		13	^{239}Pu	fCi/g	0.1(±1.4)	1200(±80)	270(±760)
		10	Gross α	pCi/g	0.6(±0.4)	3.5(±1.6)	7.9(±1.8)
		10	Gross β	pCi/g	0.2(±0.4)	5.6(±2.4)	2.5(±3.3)
		10	Total U	μg/g	<0.1(±0.4)	1.3(±0.4)	0.5(±0.9)

TABLE XVI

CHEMICAL QUALITY OF ON-SITE SURFACE AND GROUND WATERS

Source Sampled Name & Location		No. & Type of Sample[a]	Average Chemical Concentrations (mg/ℓ) Ca^{2+}	Mg^{2+}	Na^{+}	CO_3^{2-}	HCO_3^{-}	Cl^{-}	F^{-}	NO_3^{-}	TDS	Hard	pH	Conductance mS/m
Noneffluent Areas														
Test Well 3	N 80 E120	2-G	18	6	18	0	90	6	0.8	1.3	188	69	7.4	19.8
Canada del Buey	N 10 E150	1-S	10	1	7	0	40	10	.5	.9	180	28	7.2	10.4
Pajarito Canyon	S 60 E225	2-S	34	10	25	0	54	87	.5	4.2	347	128	7.4	44.2
Water Canyon	S 90 E 85	1-S	10	1	19	0	52	10	<.1	2.2	190	28	7.2	14.0
Test Well DT-5A	S110 E 90	2-G	10	3	11	0	60	4	.7	1.6	142	38	7.6	12.5
Test Well 8	N 40 E150	2-G	11	4	12	0	68	5	.4	.2	108	47	7.9	13.5
Acid-Pueblo Canyon (Former Release Area)														
Acid Weir	N130 E 60	2-S	22	4	59	0	95	50	.7	26	324	74	7.7	50.5
Pueblo 1	N130 E 75	2-S	8	6	61	0	64	39	.7	42	362	50	7.3	46.5
Pueblo 2	N115 E160	2-S	14	4	64	0	79	38	.6	36	225	54	7.2	45.5
Obs. Hole PO-3B	N110 E245	2-G	30	9	23	0	78	31	.4	13	299	113	7.6	37.0
Hamilton Bend Spring	N110 E250	2-G	11	6	70	0	90	37	.9	22	359	51	7.7	46.5
Pueblo 3	N 85 E315	2-S	12	6	72	0	97	36	.8	48	380	56	7.2	53.5
Sandia Canyon														
SCS-1	N 80 E 40	2-S	74	22	108	0	102	258	1.0	21	964	279	7.4	120
SCS-2	N 55 E155	2-S	32	10	106	3	166	66	1.2	4.4	579	122	8.2	80
DP-Los Alamos Canyon														
DPS-1	N 95 E160	2-S	16	3	176	18	334	65	2.3	59	816	54	8.8	108
DPS-4	N 80 E205	2-S	20	2	107	0	169	46	2.9	67	479	57	7.6	73.5
Obs. Hole LAO-C	N 85 E 70	2-G	16	4	35	0	67	46	.2	.9	213	61	7.4	31.0
Obs. Hole LAO-1	N 85 E115	2-G	21	3	58	0	77	56	1.0	13	344	72	7.7	45.5
Obs. Hole LAO-2	N 80 E205	2-G	18	3	77	2	153	42	3.6	42	476	58	8.2	62.0
Obs. Hole LAO-3	N 80 E215	2-G	24	3	70	2	152	38	2.8	47	411	76	7.9	60.2
Obs. Hole LAO-4.5	N 65 E270	2-G	16	3	39	0	91	25	1.8	8.8	252	55	7.4	33.5
Mortandad Canyon														
Gaging Station 1	N 50 E 90	2-S	16	4	86	2	108	12	.6	116	429	54	8.2	58.5
Obs. Hole MCO-3	N 45 E 95	2-G	34	2	152	0	224	20	.6	303	792	99	8.1	116
Obs. Hole MCO-4	N 35 E135	2-G	18	4	128	4	223	18	1.0	119	554	59	8.4	82.5
Obs. Hole MCO-5	N 40 E150	2-G	19	4	114	8	229	20	1.1	116	557	67	8.6	78.0
Obs. Hole MCO-6	N 35 E160	2-G	15	5	130	12	229	21	1.5	100	619	58	8.4	88.0
Obs. Hole MCO-7	N 30 E170	2-G	22	4	122	6	229	22	.5	104	540	70	8.4	91.2
Obs. Hole MCO-7.5	N 30 E180	2-G	23	6	135	0	246	22	.4	126	618	85	8.0	91.0
Obs. Hole MCO-8	N 30 E185	2-G	42	10	120	2	211	26	.5	160	629	145	8.0	93.5

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

TABLE XVII

CHEMICAL QUALITY OF PERIMETER SURFACE AND GROUND WATERS

Sampling Locations		No. & Type of Sample	Ca^{2+}	Mg^{2+}	Na^{+}	CO_3^{2-}	HCO_3^{-}	Cl^{-}	F^{-}	NO_3^{-}	TDS	Hard	pH	Conductance (mS/m)
Los Alamos Reservoir	N105 W 75	2-S	8	2.5	5	0	35	4	0.2	0.4	147	30	7.3	10
Guaje Canyon	N215 E315	2-S	7.5	3.5	9	0	40	3	0.3	0.6	136	34	7.3	10
Basalt Spring	N 65 E395	2-G	23	7	13	0	81	15	0.6	10	209	93	7.6	29
La Mesita Spring	18km E of L.A.	2-G	32	1	26	0	116	9	0.2	9.9	223	84	8.0	30
Test Well IA	N 70 E300	2-G	20	8	63	0	109	39	1.6	26	326	81	7.4	49
Frijoles Canyon	S280 E190	2-S	10	3.5	10	0	43	4.5	0.2	0.2	159	39	8.0	11

TABLE XVIII

CHEMICAL QUALITY OF REGIONAL SURFACE WATER

Analyses	No. of Analyses	Concentrations (mg/ℓ) Min	Max	Av
Bicarbonate	14	74	192	120(±68)
Calcium	14	25	59	43(±18)
Carbonate	14	0	10	1.1(±6.0)
Chloride	14	5	111	26(±70)
Fluoride	14	0.2	1.0	0.47(±0.51)
Magnesium	14	2	14	6.9(±6.0)
Nitrate	14	0.4	1.3	0.81(±0.87)
Sodium	14	11	84	32(±44)
TDS	14	176	470	310(±170)
Hardness	14	72	206	140(±65)
pH	14	7.4	8.4	7.9(±0.6)
Conductance (mS/m)	14	20	74	45(±31)

TABLE XIX

CHEMICAL QUALITY OF THE LOS ALAMOS WATER SUPPLY

Analyses	No. of Analyses	Concentrations (mg/ℓ) Min	Max	Av	% std[a]
Arsenic	57	0.001	0.23	0.02(±0.08)	40
Bicarbonate	42	34	300	101(±105)	—
Calcium	42	3	26	12.7(±12)	—
Carbonate	42	0	16	0.8(±2.7)	—
Chloride	42	<0.1	18	6.2(±7.2)	—
Chromium	57	<0.0001	0.029	0.007(±0.014)	14
Fluoride	42	0.1	2.4	0.7(±1.2)	35
Magnesium	42	<1	10	2.7(±4.8)	—
Mercury	6	<0.0002	0.0002	0.0002	10
Nitrates	42	<0.4	3.9	1.5(±1.7)	3.4
Selenium	57	<0.0002	0.0005	0.0002(±0.0002)	2
Silica	41	32	92	61(±41)	—
Sodium	42	4	132	30(±53)	—
TDS	41	48	510	190(±170)	—
Hardness	42	8	104	42(±48)	—
pH	42	7.1	8.6	8.0(±0.6)	—
Conductance (mS/m)	42	4	65	21(±23)	—

[a] Percent of drinking water standard (EPA National Interim Primary Drinking Water Standards).

TABLE XX

CHEMICAL QUALITY OF WATER IN THE VICINITY OF FENTON HILL

	Surface Water	Water Supply (Jemez Spr-LaCueva)	Springs (Jemez Fault)	Springs (Recent Volcanics)	Misc. Well and Test Holes	Fenton Hill (Drilling Fluids)
Number of Stations[a]	9	3	3	5	3	3
Number of Samples	27	9	7	9	5	4
Analyses (mg/ℓ)						
Bicarbonate	80(±130)	68(±15)	720(±890)	77(±55)	250(±390)	240(±440)
Calcium	31(±37)	13(±4.6)	120(±140)	9.3(±6.2)	19(±24)	42(±52)
Carbonate	0.9(±4.9)	0(±0)	8(±42)	0(±0)	0.0(±0.0)	78(±310)
Chloride	26(±71)	3.9(±3.9)	760(±1100)	6.3(±7.4)	3.8(±5.4)	145(±435)
Fluoride	0.6(±0.7)	0.2(±0.1)	2.7(±2.2)	0.9(±0.5)	1.0(±1.1)	1.1(±1.3)
Magnesium	4.6(±6.2)	3.6(±2.0)	28(±35)	2.9(±3.2)	5.6(±8.6)	3.2(±4.4)
Nitrates	0.6(±0.4)	1.3(±1.3)	1.3(±3.3)	1.0(±2.0)	2.6(±3.2)	3.6(±8.1)
Silica	41(±23)	57(±63)	44(±16)	65(±31)	66(±19)	50(±54)
Sodium	25(±50)	14(±2.8)	550(±670)	24(±32)	73(±110)	120(±78)
Sulfate	40(±170)	5.6(±9.3)	71(±200)	7.6(±10)	2.5(±3.1)	170(±340)
TDS	240(±290)	160(±55)	2400(±2500)	176(±112)	350(±430)	1200(±2000)
Hardness (as $CaCO_3$)	95(±110)	49(±17)	400(±420)	35(±27)	70(±94)	120(±140)
pH	7.5(±2.5)	7.6(±0.7)	7.4(±1.1)	7.8(±0.6)	7.6(±0.3)	8.5(±3.5)
Conductance (mS/m)	34(±47)	15(±31)	420(±450)	18(±12)	47(±69)	170(±260)

[a]Sampling locations keyed on Fig. 10 as follows.

Surface Water - F, J, N, Q, R, S, T, U, V.

Water Supply (Jemez Springs-LaCueva) - JS-2 and JS-3, JS-4 and JS-5, 4.

Springs (Jemez Fault) - JF-1, JF-5, JF-9.

Springs (Recent Volcanics) - 31, RV-1, RV-2, RV-4, RV-5.

Miscellaneous Well and Test Holes - 27, H-2, H-7.

Fenton Hill (Drilling Fluids) - TA-57.

TABLE XXI

RIO GRANDE RADIONUCLIDE SURVEY

		Fish (fCi/g dry)[a]				Sediment (f Ci/g dry)[a]			
Year	Month	No. Samples	^{137}Cs	^{238}Pu	^{239}Pu	No. Samples	^{137}Cs	^{238}Pu	^{239}Pu
1973	Sept.	6	330(53%)	NC	NC	11	--	3.4(74%)	4.7(57%)
			100-510					1.0-9.0	2.0-8.0
1974	May	3	46(120%)	NC	NC	10	--	0.5(420%)	2.2(45%)
			0-100					0-5.0	0.1-5.6
1974	Sept.	19	860(69)	0.0(0.0%)	0.9(210%)	14	--	0.4(210%)	7.4(140%)
			0-1800	0	0-7.0			0-2.0	0-39

[a]Mean (100 x σ/mean%); range.

NC: not completed.

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