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Radionuclides and Radioactivity in Soils Within and Around Los Alamos National Laboratory, 1974 through 1994: Concentrations, Trends, and Dose Comparisons

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RADIONUCLIDES AND RADIOACTIVITY IN SOILS WITHIN AND AROUND LOS ALAMOS NATIONAL LABORATORY, 1974 THROUGH 1994: CONCENTRATIONS, TRENDS, AND DOSE COMPARISONS

by

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ABSTRACT

A soil sampling and analysis program is the most direct means of determining the concentration, inventory, and distribution of radionuclides and radioactivity in the environment within and around nuclear facilities. This report summarizes and evaluates the concentrations of ^{3}H, ^{137}Cs, ^{238}Pu, $^{239,240}Pu$, ^{241}Am, ^{90}Sr, total uranium, and gross alpha, beta, and gamma activity in soils collected from Los Alamos National Laboratory (LANL), perimeter, and regional (background) areas over a 21-year period (1974 through 1994). Also, trends in radionuclide concentrations and radioactivity over time and the total effective dose equivalent (TEDE) were determined for each site. The upper-limit regional background concentration (95% upper-confidence level) for each radionuclide and level of radioactivity were as follows: ^{3}H (6.34 pCi mL^{-1}), ^{137}Cs (1.13 pCi dry g^{-1}), ^{238}Pu (0.008 pCi dry g^{-1}), $^{239,240}Pu$ (0.028 pCi dry g^{-1}), ^{241}Am (0.208 pCi dry g^{-1}), ^{90}Sr (0.82 pCi dry g^{-1}), total uranium (4.05 μg dry g^{-1}); and gross alpha (35.24 pCi dry g^{-1}), beta (13.62 pCi dry g^{-1}), and gamma (7.33 pCi dry g^{-1}) activity. Based on the average over the years, most LANL and perimeter soils contained three or more radionuclides and/or gross radioactivity that were significantly higher in concentration ($p < 0.05$) than regional background. The higher concentrations in perimeter soils were attributed to worldwide fallout and to naturally occurring radioactivity in Bandelier tuff soils, whereas the higher concentrations in LANL soils were attributed to worldwide fallout, natural radioactivity, and Laboratory operations. Most radionuclides and radioactivity detected in LANL and perimeter soils, however, showed generally decreasing trends over time; many radionuclides, like ^{3}H and uranium, at most LANL sites exhibited significantly decreasing trends ($p < 0.05$) over time. The net dose (TEDE minus background) for residents living on-site at LANL or along its perimeter ranged from -0.3 mrem y^{-1} (east of TA-54) to 3.8 mrem y^{-1}(east of TA-53) and from -0.4 mrem y^{-1} (White Rock) to 3.6 mrem y^{-1} (west of LANL on Forest Service land across from TA-8/GT site). All net doses were far below the International Commission on Radiological Protection's permissible dose limit of 100 mrem y^{-1}.

I. INTRODUCTION

The sources of most radioactive elements detected in the environment are fallout produced by nuclear weapons testing (Klement 1965), the burn up of satellite power sources in the atmosphere (Perkins and Thomas 1980), reactor accidents (Andersson and Roed 1994), and common minerals in the earth's crust (Wicker and Schultz 1982). Other sources, albeit more localized, include planned or unplanned releases of radioactive gases, solids, and/or liquid effluents from nuclear weapons research and testing facilities such as Los Alamos National Laboratory (LANL) (USDOE 1979).

As part of the Environmental Surveillance Program at LANL, samples of air, water, soil, sediments, foodstuffs, and biota are collected on an annual basis and analyzed for radiological constituents in an effort to determine the impact of Laboratory operations on the surrounding environment (Figure 1) (EPG 1995). One important component of this program is the assessment of soil surface material (USDOE 1991). A soil sampling and analysis program is the most direct means for determining the concentration, inventory, and distribution of radionuclides in the environment within and around nuclear facilities (McLendon 1975, Nyhan and Hakonson 1976, Nyhan et al. 1978a, Hakonson et al. 1981, Gilbert et al. 1988, Litaor et al. 1994, Conrad et al. 1995). Soil provides an integrating medium (reservoir) that can account for contaminants released to the atmosphere, either directly in gaseous effluents (e.g., air stack emissions) or indirectly from resuspension of on-site contamination (e.g., fugitive dust from Solid Waste Management Units [SWMUs]). Subsequently, the knowledge gained from a soil radiological sampling program is critical for providing information about potential pathways (e.g., soil ingestion, food crops, resuspension into the air, and contamination of groundwater) that may result in a radiation dose to humans (Healy 1977, Lee et al. 1985, Pinder et al. 1991, Bunzl et al. 1994, Fresquez et al. 1995a).

Radionuclide concentrations and radioactivity in soils collected from regional (background) locations were first reported by Purtymun et al. (1980, 1987,

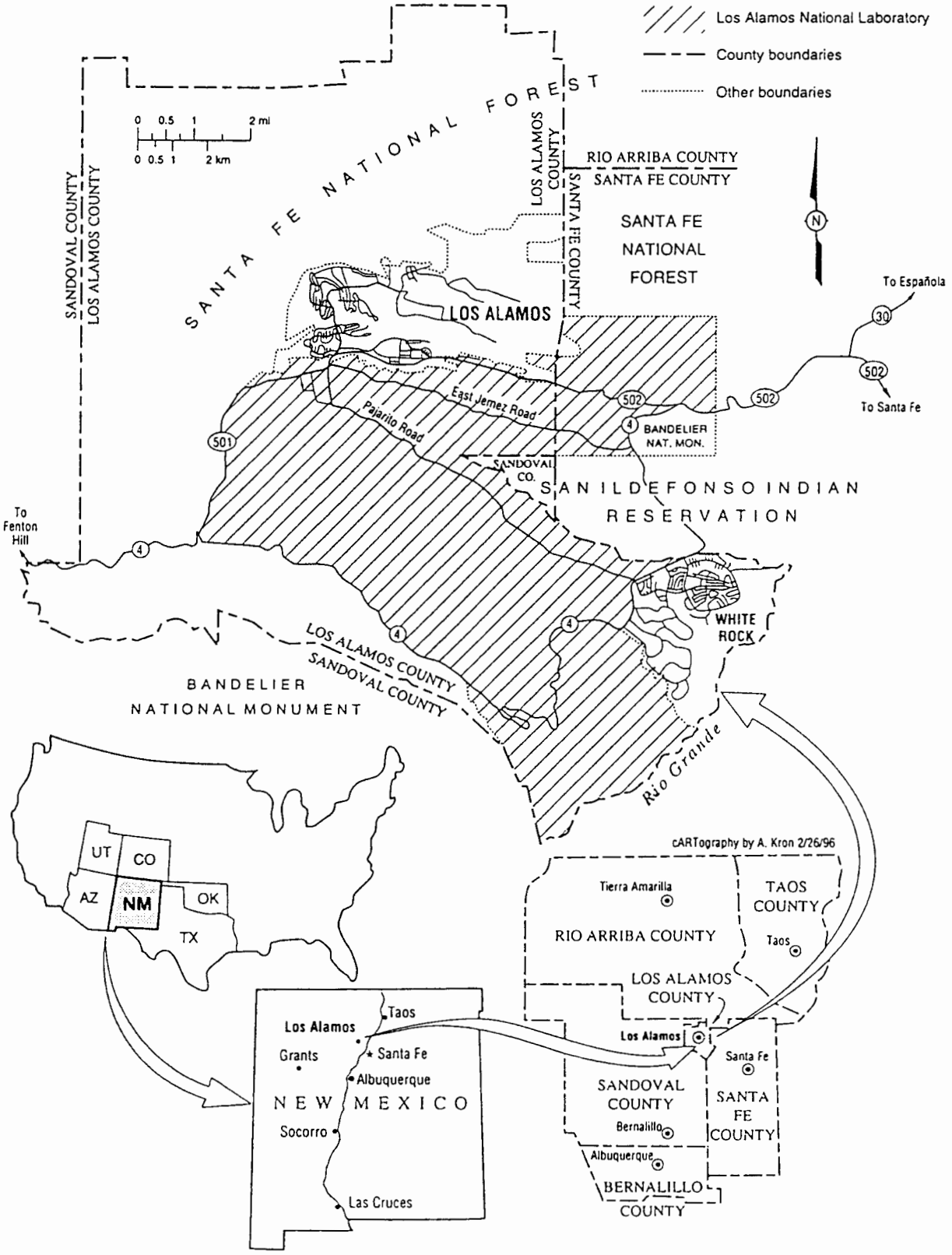


Figure 1. Location of Los Alamos National Laboratory.

and 1990). This paper presents, summarizes, and evaluates the concentrations and distribution of ^{3}H, ^{137}Cs, ^{238}Pu, ^{239}Pu, ^{90}Sr, total uranium, and gross alpha, beta, and gamma activity in soil surface samples collected on-site at LANL, along LANL's perimeter, and from regional background locations from 1974 through 1994. All data, associated with the Soil Surveillance Program, were compiled from Environmental Surveillance Reports and can be found by station and by year in Appendix A. Also, this paper reports (1) the upper-limit concentration (95% confidence level) for the above-mentioned radionuclides and radioactivity from regional locations, (2) radionuclide and radioactivity trends over time, and (3) the total effective dose equivalent (TEDE) to residents in Los Alamos and White Rock.

II. METHODS & MATERIALS

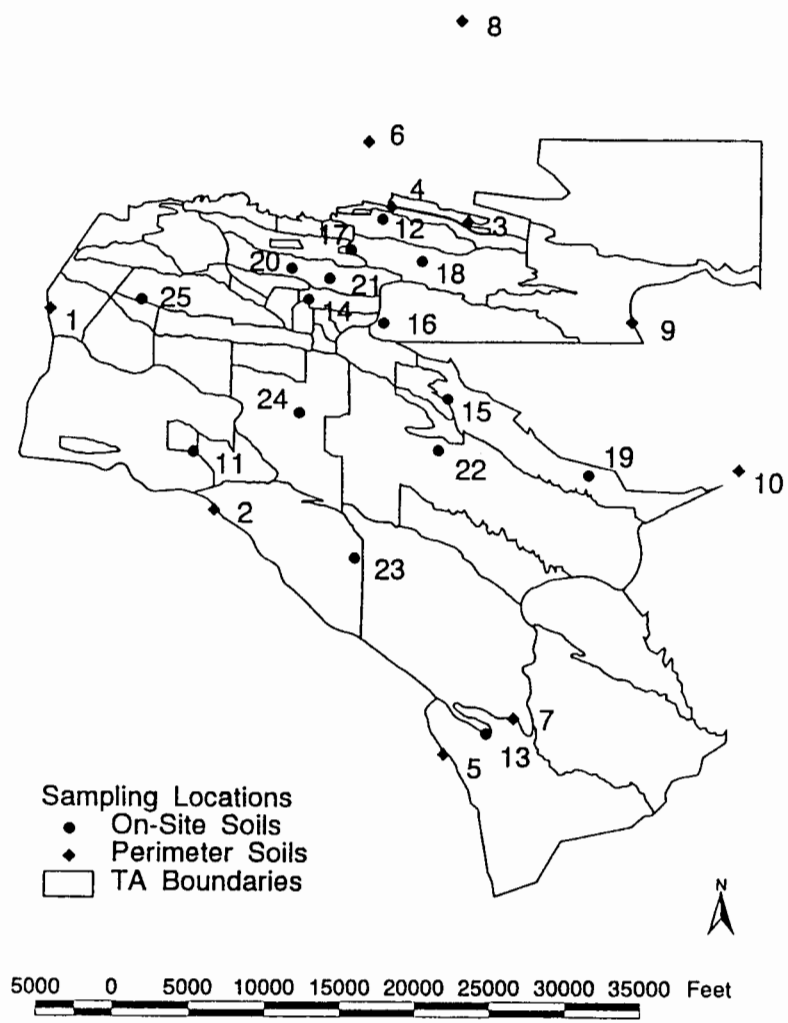
Soil surface samples were collected from relatively level, open, and undisturbed areas at LANL, its perimeter, and surrounding regional locations starting in 1974 (Purtymun et al. 1987). Areas sampled at LANL were not from SWMUs—any discernible site at which solid and/or liquid wastes have been routinely and systematically released (e.g., waste tanks, septic tanks, sumps, firing sites, burn pits, sumps, material disposal areas [like Area G at LANL], and outfalls) (EPG 1995). Instead, the majority of on-site soil-sampling stations were located close to, and downwind from if possible, major facilities and/or operations at LANL in an effort to assess radionuclide and radioactivity in soils that may have been contaminated as a result of air stack emissions (there were approximately 140 stacks at LANL in 1994 that could emit radionuclides) (McNamara 1995) and fugitive dust (e.g., the resuspension of dust from SWMUs).

Approximately 18 stations were sampled at LANL during the 1976 through 1994 measurement period. Three of these sites (TA-11, TA-36, and R-Site Road), however, were sampled for only a very short period of time and/or may have been confused with similar nearby areas; therefore, for the purpose of this study they were combined with the closest sampling station resulting in a total of 15 on-site stations (Figure 2).

Ten perimeter stations, located within 4 km (2.5 mi) of the Laboratory,

Figure 2. Description and Location (New Mexico State Plane Coordinates) of Soil Sampling Stations.

Station	N Coord.	E Coord.	Map Desig.
Regional (Background) Soils			
Rio Chama	1844693.096	1677875.228	
Embudo	1816440.315	1744693.086	
Otowi	1777182.637	1668721.670	
Santa Cruz	1816438.561	1744700.759	
Cochiti	1644216.892	1647114.194	
Bernalillo	1572864.707	1549601.021	
Jemez	1719495.437	1502276.101	
Perimeter Soils			
Near TA-8 (GT Site)	1768805.627	1609433.446	1
Near TA-49	1755456.289	1620318.345	2
East of Airport	1772133.547	1633954.231	3
West of Airport	1775792.773	1631874.119	4
Frijoles	1739410.645	1635679.031	5
North Mesa	1780072.446	1630330.015	6
South SR-4	1741781.810	1640297.293	7
Sportsman Club	1788136.211	1636493.387	8
Tsankawi/PM-1	1768110.302	1647985.099	9
White Rock (east)	1758301.447	1655116.466	10
On-Site Soils			
TA-16 (S-Site)/TA-11	1759328.803	1618868.688	11
TA-21 (DP Site)	1774989.218	1631266.389	12
Near TA-33	1740806.015	1638487.987	13
TA-50	1769548.575	1626390.047	14
TA-51	1762889.272	1635769.143	15
East of TA-52	1767950.182	1631399.519	16
West of TA-53	1772914.010	1629196.631	17
East of TA-53	1772133.547	1633954.231	18
East of TA-54	1757882.733	1645162.755	19
East of Sigma I	1771620.960	1625266.881	20
East of Sigma II	1770949.301	1627783.674	21
Potrillo Drive/TA-36	1759475.770	1635153.829	22
Near Test Well DT-9	1752337.978	1629594.961	23
R-Site Road East/R-Site Road	1761923.229	1625863.108	24
Two-Mile Mesa	1769494.453	1615386.422	25



were sampled to determine the soil conditions of the inhabited areas to the north (Los Alamos' North Mesa, Sportsman's Club, and airport area) and east of the Laboratory (White Rock [east on San Ildefonso Pueblo land] and Tsankawi National Monument). Additional samples were collected on the west (Forest Service land across from TA-8/GT site) and south (Bandelier National Monument [BNM] across from TA-49, Frijoles Canyon in BNM, and south SR-4) side of LANL to provide comprehensive coverage. One perimeter station (PM-1), sampled from 1979 to 1980, was combined with the Tsankawi station. PM-1 was located approximately 100 m (320 ft) away from the Tsankawi station and, coincidentally, the Tsankawi station was missing data from 1979 to 1980.

The regional stations were located in the three major drainages in northern New Mexico surrounding the Laboratory: Rio Chama, Embudo, and Otowi; Cochiti and Bernalillo; and Jemez. One additional soil station was located near Santa Cruz Lake, across the Rio Grande valley to the northeast of the Laboratory. All regional stations are over 15 km (9 mi) from the Laboratory and are beyond the likely range of significant impacts from Laboratory operations; thus, these areas were used to establish "background" levels of radionuclides and radioactivity that can be attributed to naturally occurring radioactive materials and/or to worldwide fallout (EPG 1995).

At each site, soil surface samples were collected with a stainless steel soil ring 10 cm (4 in.) in diameter pushed 5 cm (2 in.) deep from the center and corners of a square area 10 m (33 ft) per side (similar to ASTM 1990). The five samples per site were combined and mixed thoroughly in a large Ziploc bag to form a composite sample. Composite samples were then placed in prelabeled 500-mL polyethylene bottles that were fitted with chain-of-custody tape, placed into another Ziploc plastic bag, and locked in an ice chest cooled to approximately 4°C.

All soil samples were submitted to an environmental chemistry group at LANL (the group is currently named CST-9) for the analysis of ^{3}H, ^{137}Cs, ^{238}Pu, $^{239,240}Pu$, ^{90}Sr, ^{241}Am, total uranium, and gross alpha, beta, and gamma activity. These elements were selected on

the basis of their history of use at the Laboratory, activity, and decay mode (half-life) (EPG 1995). All methods of analysis have been previously reported (Purtymun et al. 1987); uranium, however, was analyzed by a fluorometric method from 1974 to 1976, by a delayed neutron activation (DNA) method from 1977 to 1992, and by kinetic phosphorescence analysis (KPA) from 1993 to 1994.

A nonparametric Wilcoxon Rank Sum test (Gilbert et al. 1995) was used to assess differences in the arithmetic means of radionuclide concentrations and radioactivity in soils collected from on-site LANL and perimeter stations versus regional background (all regional stations were combined) at the 0.01 and 0.05 probability levels (Gilbert 1987).

Also, a Mann-Kendall test was used to evaluate trends in those data sets that contained four or more observations (Gilbert 1987). The probability, taken from Hollander and Wolfe (1973) in those cases with <10 data points, and from the normal approximation in those cases with >10 data points, along with the general direction of trend were reported—a positive value for the statistic indicated an upward trend while a negative value for the statistic indicated a downward trend. The direction indicated by the statistic was reported even when the test result was not significant.

The TEDE (effective dose equivalent [EDE] from external radiation plus the committed effective dose equivalent [CEDE] from internal radiation), based on the average concentration of seven soil radionuclides collected over varying periods of time from on-site LANL, perimeter, and regional background sampling stations (Table 1), was calculated using version 5.60 of the RESRAD code using a residential scenario (Yu et al. 1995). Soil ingestion, inhalation of suspended dust, and ingestion of homegrown fruits and vegetables were the primary exposure pathways for one or more radionuclides. Unit conversions, RESRAD input parameters, model and parameter assumptions, and uncertainty analysis are provided in Appendices B, C, and D, respectively. RESRAD input parameters, established by the Environmental Restoration (ER) program for the calculation of screening action levels (SALs) (FIMAD 1995) for the evaluation

of SWMUs that exist at LANL (Dorries 1994), are conservative estimates for the mesa-top environment around the Los Alamos area.

III. RESULTS & DISCUSSION

Regional Background Stations. The 21-year upper-limit regional background concentrations (mean plus two standard deviations) are given in Table 1. These data represent the 95% upper-confidence limit of the mean for regional soils and are used by the Environmental Soil Surveillance Program as a baseline screening tool to compare radionuclide concentrations in soils that are collected on an annual basis from on-site and perimeter stations. All values were very similar to radionuclide concentrations and radioactivity reported for regional areas in past years (Purtymun et al. 1980, 1987, 1990).

Perimeter vs Regional Stations. Most perimeter areas had mean radionuclide concentrations within or just above upper-limit regional background concentrations (Table 1). However, based on the average, most perimeter areas had soils that contained at least three or more radioisotopes and/or gross radioactivity that were statistically higher in concentration or activity ($p < 0.05$) than regional mean levels. Plutonium-239,240 and total uranium, in particular, were detected in significantly higher mean concentrations in almost all of the perimeter areas as compared with mean regional background levels. The highest mean concentration of $^{239,240}Pu$ (0.135 pCi dry g^{-1}) was detected in soils collected at the western end of the airport. Similarly, the highest concentrations of ^{3}H (28.60 pCi mL^{-1}) was detected in soils from the Frijoles station, the highest concentration of ^{137}Cs (1.36 pCi dry g^{-1}) and gross alpha activity (9.53 pCi dry g^{-1}) were found in soils at the south of the State Road 4 station, the highest concentrations of ^{238}Pu (0.004 pCi dry g^{-1}), ^{90}Sr (1.57 pCi dry g^{-1}), uranium (5.20 μg dry g^{-1}), and gross gamma activity (7.60 pCi dry g^{-1}) were found in soils at the Tsankawi/PM-1 sampling station, and the White Rock soil sampling station contained the highest concentration of gross beta activity (16.83 pCi dry g^{-1}). Although these mean concentrations were significantly higher than regional background levels at either the 0.01 or 0.05 probability level, many of these sites were based on samples

Table 1. Mean (± std. dev.) radionuclide concentrations in soils collected from on-site, perimeter, and regional (background) areas from 1974 to 1994.

Location	^{3}H (pCi/mL)	^{137}Cs (pCi/g dry)	^{238}Pu (pCi/g dry)	$^{239,240}Pu$ (pCi/g dry)	^{90}Sr (pCi/g dry)	Total U (ug/g dry)	^{241}Am (pCi/g dry)	Gross alpha (pCi/g dry)	Gross beta (pCi/g dry)	Gross gamma (pCi/g dry)
ON-SITE										
TA-16 (S-Site)/TA-11[1]	1.78 (2.79)	0.87 (0.97) *[2]	0.003 (0.005)	0.017 (0.023)	0.62 (0.44) *	3.64 (0.65) **	0.002 (0.001)	8.48 (3.39) *	9.34 (5.50)	4.17 (1.95) *
TA-21 (DP Site)	3.52 (3.91) **	0.22 (0.44)	0.013 (0.037) **	0.063 (0.112) **	1.03 (1.67)	3.42 (0.63) **	0.006 (0.012)	7.98 (3.90)	6.49 (3.67)	4.15 (1.89) *
Near TA-33	41.56 (101.91) **	0.40 (0.25)	0.002 (0.003)	0.010 (0.007)	1.45 (2.75)	3.29 (0.68) **	0.020 (0.012)	9.47 (5.82) *	8.20 (2.76)	5.15 (2.04) **
TA-50	6.47 (8.72) **	0.31 (0.49)	0.004 (0.005) **	0.289 (0.875) **	0.43 (1.37)	4.29 (1.30) **	0.035 (0.027)	9.38 (4.54) *	8.31 (3.99)	4.78 (1.77) **
TA-51[3]	3.53 (2.94) *	0.58 (0.41)	0.000 (0.003)	0.038 (0.054)	0.39 (0.49)	3.75 (0.07) *		15.80 (16.30)	15.80 (10.72)	
East of TA-52[4]	5.83 (7.93) *	0.59 (1.08)	0.058 (0.118)	0.034 (0.063)	0.18 (0.22)	3.50 (0.28) *	0.003 (0.002) [5]	14.40 (9.29) *	11.50 (6.60)	
West of TA-53	3.14 (3.17) **	0.63 (0.61)	0.002 (0.004) *	0.040 (0.041) **	0.44 (0.23)	4.01 (1.22) **	0.031 (0.030)	7.89 (3.40)	8.14 (4.08)	5.08 (2.07) **
East of TA-53[6]	7.95 (8.24) *	1.63 (1.25) **	0.001 (0.003)	0.083 (0.089) **	0.72 (0.32) **	7.65 (0.78) **		14.50 (5.74) **	19.50 (8.27)	
East of TA-54	13.69 (38.50) *	0.34 (0.45)	0.810 (2.876) **	0.261 (0.611) *	0.01 (0.49)	3.95 (1.27) **	0.068 (0.090)	9.36 (4.12) *	8.40 (4.35)	4.42 (2.58) *
East of New Sigma I[7]	13.77 (10.43) **	0.59 (0.08)	0.026 (0.045)	0.034 (0.024) *	0.32 (0.07) [5]	4.35 (1.34) *		9.83 (5.25)	11.27 (5.60)	
East of New Sigma II[8]	7.70 (8.71) *	0.95 (0.45) *	0.001 (0.001)	0.032 (0.026) *	0.69 (0.37)	6.05 (0.07) **		10.77 (5.89)	13.50 (5.41)	
Potrillo Drive/TA-36[9]	9.54 (28.77)	0.49 (0.31)	0.003 (0.014)	0.012 (0.011)	0.31 (0.20)	3.74 (0.72) **	0.017 (0.021)	7.73 (3.06)	7.13 (3.13)	4.45 (1.56) **
Near Test Well DT-9	1.95 (3.11)	0.82 (0.32) **	0.001 (0.003)	0.020 (0.017) **	0.35 (0.29)	3.92 (0.96) **	0.021 (0.023)	9.01 (3.61) **	8.84 (3.93)	5.03 (1.61) **
R-Site Road East/R-Site Road[10]	3.22 (3.68) *	0.78 (0.88) *	0.004 (0.011)	0.022 (0.016) **	0.53 (0.21) **	12.54 27.73) **	0.046 (0.053)	12.52 (9.77) **	15.74 (16.34)	4.87 (2.57) **
Two-Mile Mesa	1.82 (2.32)	0.71 (0.55) **	0.003 (0.005) **	0.019 (0.011) **	0.60 (0.24) *	3.45 (0.62) **	0.042 (0.033)	10.11 (7.26) *	9.68 (8.24)	4.15 (1.97) *
Mean	8.46	0.6	0.070	0.070	0.6	4.70	0.030	9.79	9.86	4.6
PERIMETER										
TA-8/GT Site	1.59 (2.40)	1.16 (0.84) **	0.002 (0.004) *	0.043 (0.034) **	1.22 (0.91) **	3.04 (0.72) **	0.068 (0.081)	8.23 (4.75)	11.49 (8.47)	4.15 (2.11) *
TA-49	1.46 (2.18)	0.75 (0.53) **	0.001 (0.002)	0.020 (0.014) **	0.44 (0.26)	3.95 (0.96) **	0.105 (0.126)	9.01 (4.70) *	9.24 (6.13)	5.22 (2.14) **
East of Airport[11]	4.70 (6.53)	0.61 (0.19)	0.000 (0.001)	0.022 (0.009) *	0.92 (0.18) **	4.15 (0.21) *	0.012 (0.030) [5]	7.83 (2.50)	9.03 (3.54)	
West of Airport[12]	4.98 (4.02) *	1.12 (0.31) **	0.004 (0.004) *	0.135 (0.104) **	0.34 (0.30)	5.10 (0.28) **	0.015 (0.030) [5]	8.30 (3.11)	10.98 (2.98)	
Frijoles[13]	28.60 (45.30) *	1.10 (0.26) **	0.000 (0.002)	0.025 (0.007) **	0.53 (0.19)	3.37 (1.35)		9.10 (4.76)	11.90 (6.27)	
North Mesa	1.95 (2.47)	0.40 (0.34)	0.001 (0.003)	0.017 (0.016) *	0.46 (0.30)	3.76 (0.74) **	0.022 (0.027)	8.06 (3.80)	6.72 (2.85)	4.47 (1.67) **
South SR-4 (Near S-Site)[14]	2.17 (1.80)	1.36 (0.45) **	0.001 (0.002)	0.030 (0.017) **	0.74 (0.10) **	2.85 (3.18)	0.020 (0.030) [5]	9.53 (5.21)	9.13 (5.61)	
Sportsman's Club	1.63 (2.12)	0.58 (0.47)	0.002 (0.004)	0.022 (0.018) **	1.11 (1.88)	3.47 (0.83) **	0.092 (0.123)	8.78 (4.60) *	9.05 (5.73)	4.62 (1.94) **
Tsankawi/PM-1[15]	4.02 (7.55)	0.50 (0.40)	0.004 (0.007) *	0.013 (0.006) **	1.57 (2.23) **	5.20 (1.10) **	0.042 (0.057)	6.75 (2.59)	7.41 (3.59)	7.60 (2.98) **
White Rock (east)[16]	2.17 (4.03)	0.39 (0.30)	0.003 (0.003) *	0.013 (0.011)	0.15 (0.07)	3.44 (0.68) **	0.045 (0.059)	9.03 (4.08)	16.83 (25.62)	6.10 (3.26) **
Mean	3.29	0.7	0.002	0.034	0.7	3.84	0.060	8.40	9.91	5.4
REGIONAL (BACKGROUND)	1.46 (2.44)	0.43 (0.35)	0.002 (0.003)	0.010 (0.009)	0.32 (0.25)	2.53 (0.76)	0.042 (0.083)	7.77 (13.74)	6.50 (3.56)	2.95 (2.19)
Mean + 2 Std. Dev.	6.34	1.13	0.008	0.028	0.82	4.05	0.208	35.25	13.62	7.33
SAL[17]	260.00 (pCi/g)[18]	5.10	27.000	24.000	4.40	29.00	22.000			

Table 1. (continued)

[1] TA-11 data collected 1978–1981.

[2] * denotes significance from background levels at the 0.05 p level, ** denotes significance from background levels at the 0.01 p level.

[3] TA-51 data collected 1978–1981.

[4] East of TA-52 data collected 1978–1981.

[5] (+ analytical uncertainty)

[6] West of TA-53 data collected 1978–1981.

[7] East of New Sigma I data collected 1978–1980.

[8] East of New Sigma II data collected 1978–1980.

[9] TA-36 data collected 1976–1980.

[10] R-Site Road data collected 1978–1980.

[11] East of Airport data collected 1978–1980.

[12] West of Airport data collected 1978–1981.

[13] Frijoles data collected 1977–1981.

[14] South SR-4 data collected 1978–1981.

[15] PM-1 (Pajarito Mesa Well #1) data collected 1976–1980.

[16] White Rock (east) data collected 1982-present.

[17] 1995 LANL Screening Action Level.

[18] 260 pCi/g soil: All values were evaluated on a dry weight basis and all were below the SAL. The highest ^{3}H value in the data set (41.5 pCi/mL), for example, contained approximately 12% moisture (ave. 1974 to 1994); thus, 41.5 x 0.12/1 x 0.88 = 5.66 pCi ^{3}H/g soil.

collected for only a few years in late 1970 to early 1980.

The higher mean radionuclide concentrations in soils collected from perimeter areas as compared to regional background locations may be due in part to Laboratory operations but are mostly due to worldwide fallout (Klement 1965) and to naturally occurring radioactive minerals in the earth's crust (Schulz 1965). Radionuclides due to fallout vary from one area to another depending on wind patterns, elevation, and precipitation (Wicker and Schultz 1982). Usually, higher amounts of fallout radionuclides are found at higher elevations that receive greater amounts of precipitation than in areas at lower elevations that receive lower amounts of precipitation (Purtymun et al. 1990, Mitchell et al. 1990). Most of the regional areas in our study, for example, range from around 1,700 m [5,600 ft] to 1,920 m [6,300 ft] above sea level and have an average rainfall of approximately 25 cm (10 in.) per year (USDOE 1995). By contrast, most perimeter areas were located above 2,190 m (7,200 ft) above sea level and received an average rainfall amount of about 48 cm (18.7 in.) per year.

The higher levels of uranium detected in the soils collected from the perimeter areas as compared with regional areas, on the other hand, may be due to differences in the geology or mineralogy of the soils between the two sites. Soils on the Pajarito Plateau are derived from Bandelier (volcanic) tuff and have higher-than-average natural uranium contents, ranging from 3 to 11 μg dry g^{-1} (Crowe et al. 1978, Longmire et al. 1995). Even though mean radionuclide concentrations were higher in perimeter soils, they were below LANL's SALs—a concentration derived from residential exposure assumptions and a 10-mrem y^{-1} dose limit (FIMAD 1995). Therefore, they are considered to be of no significant concern (Dorries 1995).

On-Site vs Regional Stations. As with the perimeter areas, many on-site LANL soil stations contained various mean radionuclide concentrations and/or gross radioactivity that were significantly higher ($p < 0.05$) than mean regional background levels (Table 1). In fact, some mean concentrations for ^{3}H, ^{238}Pu, $^{239,240}Pu$, total uranium, and gross alpha, beta, and gamma activity were higher than they were in perimeter soils; these higher

concentrations were probably a result of Laboratory operations. Elevated levels (i.e., above background) of ^{3}H (Purtymun et al. 1973), $^{239,240}Pu$ (Nyhan and Hakonson 1976, Conrad et al. 1995), ^{90}Sr (Fresquez et al. 1995b), ^{137}Cs (Nyhan et al. 1978, Wenzel et al. 1987), and uranium (Becker 1992, Fresquez 1994) have been reported in soils within Laboratory lands—mostly from SWMU areas. Nevertheless, even though on-site soils were significantly higher ($p < 0.05$) in ^{3}H and gross alpha activity than perimeter soils, they were still far below LANL SALs.

Radionuclide Concentrations and Radioactivity Trends Over Time. Although radionuclide and radioactivity concentrations were generally higher in on-site and perimeter soil samples compared with regional values, they tended to decrease over the 21 years of this study with two exceptions: ^{238}Pu concentrations (increased at ≈96% of the sites) and gross alpha activity (increased at half of the sites) (Table 2). Regional background sites, for that matter, also exhibited generally increasing ^{238}Pu concentration trends—all sites, however, were far from being statistically significant ($p < 0.05$ and the probability for these sites ranged from 0.167 to 0.997). Approximately 60% of ^{238}Pu detected in the environment is from nuclear weapons testing in the atmosphere (Klement 1965) and approximately 40% is from the reentry burn up of satellites containing a ^{238}Pu power source (Perkins and Thomas 1980). Concentrations of ^{3}H, ^{137}Cs ^{239}Pu, and uranium, on the other hand, showed significantly decreasing ($p < 0.05$) trends over time in many soils collected from on-site and perimeter areas. Their decrease may be due in part to reductions in Laboratory operations, air stack emissions, and to better engineering controls employed by the Laboratory (EPG 1995), but is probably more due to (1) the cessation of above-ground nuclear weapons testing in the early 1960s, (2) weathering (wind, water erosion, and leaching), and (3) radioactive decay (half-life) (Rogowski and Tamura 1965, Wicker and Schultz 1982). Tritium, which has a half-life of about 12 years, exhibited the greatest decrease in activity over the 21 years in almost all of the soil sites studied, including regional locations.

Only a few gross alpha readings—one located on-site (TA-51)

Table 2. Results of the Mann-Kendall nonparametric test for trend in soils collected from LANL, perimeter, and regional (background) locations.[ab]

Location	^{3}H	^{137}Cs	^{238}Pu	$^{239,240}Pu$	^{90}Sr	Total U	Gross α	Gross β	Gross γ
On-Site (LANL)									
TA-16 (S-Site)/TA-11	0.019 (D)*	0.045 (D)*	0.631 (U)	0.016 (D)*	0.625 (NT)	0.006 (D)*	0.122 (D)	0.089 (D)	0.005 (D)*
TA-21 (DP Site)	0.001 (D)*	0.455 (D)	0.989 (U)	0.085 (D)	0.500 (D)	0.309 (D)	0.500 (NT)	0.050 (D)*	0.020 (D)*
Near TA-33	0.001 (D)*	0.006 (D)*	0.996 (U)	0.252 (D)	0.500 (D)	0.035 (D)*	0.608 (U)	0.291 (D)	0.002 (D)*
TA-50	0.001 (D)*	0.153 (D)	0.528 (U)	0.066 (D)	0.360 (D)	0.002 (D)*	0.500 (NT)	0.050 (D)*	0.006 (D)*
TA-51	0.375 (D)	0.625 (NT)	0.167 (U)	0.167 (D)	[c]		0.042 (U)*	0.167 (U)	
East of TA-52	0.042 (D)*	0.167 (U)	0.375 (U)	0.500 (U)			0.235 (U)	0.167 (U)	
West of TA-53	0.014 (D)*	0.001 (D)*	0.907 (U)	0.294 (D)	0.242 (D)	0.062 (D)	0.381 (D)	0.108 (D)	0.025 (D)*
East of TA-53	0.375 (D)	0.625 (NT)	0.360 (U)	0.375 (U)			0.360 (U)	0.167 (U)	
East of TA-54	0.026 (D)*	0.582 (U)	0.550 (U)	0.161 (D)	0.360 (D)	0.003 (D)*	0.013 (D)*	0.007 (D)*	0.152 (D)
East of New Sigma I									
East of New Sigma II									
Portrillo Dr./TA-36	0.009 (D)*	0.024 (D)*	0.977 (U)	0.570 (U)	0.408 (D)	0.033 (D)*	0.555 (U)	0.134 (D)	0.001 (D)*
Near Test Well DT-9	0.050 (D)*	0.124 (D)	0.981 (U)	0.705 (U)	0.242 (U)	0.254 (D)	0.428 (D)	0.075 (D)	0.001 (D)*
R-Site Road East/R-Site Road	0.116 (D)	0.133 (D)	0.946 (U)	0.242 (D)	0.235 (D)	0.050 (D)*	0.428 (D)	0.209 (D)	0.012 (D)*
Two-Mile Mesa	0.050 (D)*	0.222 (D)	0.974 (U)	0.783 (U)	0.592 (NT)	0.004 (D)*	0.265 (D)	0.042 (D)*	0.007 (D)*
Perimeter									
TA-8/GT Site	0.047 (D)*	0.200 (D)	0.785 (U)	0.040 (D)*	0.386 (U)	0.053 (D)	0.231 (D)	0.291 (D)	0.066 (D)
TA-49	0.014 (D)*	0.224 (D)	0.848 (U)	0.677 (U)	0.235 (D)	0.133 (D)	0.451 (D)	0.044 (D)*	0.010 (D)*
East of Airport									
West of Airport	0.375 (D)	0.042 (D)*	0.235 (D)	0.167 (D)			0.042 (U)*	0.042 (U)*	
Frijoles	0.375 (D)	0.242 (D)	0.500 (U)	0.408 (U)			0.042 (U)*	0.042 (U)*	
North Mesa	0.015 (D)*	0.005 (D)*	0.996 (U)	0.047 (D)*	0.042 (D)*	0.004 (D)*	0.460 (U)	0.078 (D)	0.042 (D)*
South SR-4		0.375 (U)	0.625 (U)	0.167 (U)			0.042 (U)*	0.375 (U)	
Sportsman's Club	0.024 (D)*	0.015 (D)*	0.997 (U)	0.054 (D)	0.356 (D)	0.107 (D)	0.665 (U)	0.250 (D)	0.043 (D)*
Tsankawi/PM-1	0.010 (D)*	0.010 (D)*	0.972 (U)	0.291 (D)	0.242 (D)	0.113 (D)	0.418 (D)	0.065 (D)	0.019 (D)*
White Rock (East)	0.022 (D)*	0.025 (D)*	0.962 (U)	0.000 (D)*		0.109 (D)	0.136 (D)	0.235 (D)	0.005 (D)*
Reg. (Background)	0.005 (D)*	0.010 (D)*	1.000 (U)	0.999 (U)	0.500 (D)	0.003 (D)*	0.500 (U)	0.106 (D)	0.052 (D)

[a](D)=downward trend, (U)=upward trend, and (NT)=no trend.

[b]*Significant at the 95% confidence level.

[c]Trend analysis was not conducted on locations and/or radioistopes (^{241}Am) with less than four observations (please see Table 1 footnotes for record of collections).

and three located off-site (west of the airport, Frijoles, and south State Road 4)—and a few gross beta readings—one located west of the airport and the other at the Frijoles station—showed significantly increasing trends ($p < 0.05$) over time. In these cases, however, the measurement period was both early and very short (1978 to 1981). If the same general trend of decreasing radionuclide concentrations observed at most other measurement sites were being followed, especially by the alpha ($^{239,240}Pu$ and uranium) and beta (^{90}Sr) emitters, these sites might also have exhibited decreasing gross alpha activity by 1994. To test this hypothesis, soil surface samples from all of these original sites will be collected during the 1996 sampling period.

Total Effective Dose Equivalent. The TEDE, based on the mean radioisotope concentrations, for a person living within LANL boundaries, assuming a residential scenario (Appendix C), ranged from 1.5 mrem y^{-1} (east of TA-54) to 5.6 mrem y^{-1} (east of TA-53) (Table 3). The TEDE was calculated using RESRAD as the effective dose equivalent from external radiation plus the committed effective dose equivalent from internal radiation (Yu et al. 1995). Cesium-137 and ^{90}Sr activity contributed up to 80% of the TEDE that would be received by people living in these areas. When averaged for all LANL sites, the TEDE and net effective dose (TEDE minus the background dose of 1.8 mrem y^{-1}) were 3.1 and 1.3 mrem y^{-1}, respectively.

Similarly, the TEDE for a person living in the perimeter areas ranged from 1.4 mrem y^{-1} (White Rock) to 5.4 mrem y^{-1} (Forest Service property across from TA-8/GT site), with an average TEDE of around 3.4 mrem y^{-1}. The estimated net effective doses for people who live in Los Alamos was 1.7 mrem y^{-1} (west of the airport), 0.4 mrem y^{-1} (North Mesa), and 2.2 mrem y^{-1} (Sportsman's Club), and in White Rock it was -0.4 mrem y^{-1}; the average net effective dose across perimeter sites was 1.6 mrem y^{-1}. As was previously stated, the TEDEs in these perimeter areas that are above regional values may be more a reflection of higher naturally occurring radioactivity and/or higher fallout levels in Los Alamos rather than of Laboratory operations. In any case, all net effective doses, whether one lives on-site at LANL or in perimeter

Table 3. Results of the dose (mrem y^{-1}) received by members of the public living on LANL (on-site), perimeter, and regional (background) areas as calculated by RESRAD.

Location	^{3}H	^{137}Cs	^{238}Pu	$^{239,240}Pu$	^{90}Sr	^{234}U	^{235}U	^{238}U	^{241}Am	Total	Net[b]
On-Site[a]											
TA-16 (S-Site)/TA-11	0.0075	1.70	0.0010	0.0070	1.40	0.105	0.028	0.18	0.0009	3.4	1.6
TA-21 (DP Site)	0.0149	0.43	0.0049	0.0260	2.37	0.098	0.026	0.17	0.0030	3.1	1.3
Near TA-33	0.1756	0.79	0.0007	0.0041	3.33	0.095	0.025	0.16	0.0090	4.6	2.8
TA-50	0.0273	0.61	0.0010	0.1190	0.99	0.123	0.033	0.21	0.0160	2.1	0.3
TA-51	0.0149	1.10	0.0000	0.0160	0.90	0.108	0.029	0.19	0.0100	2.4	0.6
East of TA-52	0.0246	1.20	0.0220	0.0140	0.41	0.101	0.027	0.17	0.0010	2.0	0.2
West of TA-53	0.0133	1.20	0.0007	0.0170	1.00	0.115	0.031	0.20	0.0140	2.6	0.8
East of TA-53	0.0336	3.20	0.0004	0.0340	1.70	0.220	0.059	0.38	0.0100	5.6	3.8
East of TA-54	0.0578	0.67	0.3030	0.1080	0.02	0.114	0.030	0.20	0.0310	1.5	-0.3
E. of New Sigma I	0.0582	1.20	0.0097	0.0140	0.74	0.125	0.034	0.22	0.0100	2.4	0.6
E. of New Sigma II	0.0325	1.90	0.0004	0.0130	1.60	0.174	0.047	0.30	0.0100	4.1	2.3
Portrillo Dr./TA-36	0.0403	0.96	0.0010	0.0050	0.71	0.108	0.029	0.19	0.0076	2.1	0.3
Near Test Well DT-9	0.0083	1.60	0.0004	0.0083	0.80	0.113	0.030	0.19	0.0094	2.8	1.0
R-Site Road East/R-Site Road	0.0136	1.50	0.0010	0.0091	1.20	0.361	0.097	0.62	0.0210	3.8	2.0
Two-Mile Mesa	0.0077	1.40	0.0010	0.0078	1.40	0.099	0.027	0.17	0.0190	3.1	1.3
Perimeter[a]											
TA-8/GT Site	0.0067	2.30	0.0008	0.0170	2.80	0.087	0.023	0.15	0.0310	5.4	3.6
TA-49	0.0060	1.50	0.0004	0.0083	1.00	0.110	0.031	0.20	0.0470	2.9	1.1
East of Airport	0.0200	1.20	0.0000	0.0091	2.10	0.120	0.032	0.20	0.0054	3.7	1.9
West of Airport	0.0210	2.20	0.0010	0.0560	0.77	0.150	0.039	0.25	0.0067	3.5	1.7
Frijoles	0.1200	2.20	0.0000	0.0100	1.20	0.097	0.026	0.17	0.0090[c]	3.8	2.0
North Mesa	0.0082	0.79	0.0004	0.0070	1.10	0.110	0.029	0.19	0.0099	2.2	0.4
South SR-4	0.0092	2.70	0.0004	0.0120	1.70	0.082	0.022	0.14	0.0090	4.6	2.8
Sportsmans	0.0069	1.10	0.0008	0.0091	2.50	0.100	0.027	0.17	0.0410	4.0	2.2
Tsankawi/PM-1	0.0170	0.98	0.0020	0.0054	1.30	0.150	0.041	0.27	0.0190	2.8	1.0
White Rock (East)	0.0092	0.76	0.0010	0.0054	0.34	0.099	0.027	0.17	0.0200	1.4	-0.4
Reg. (Background)	0.0062	0.85	0.0007	0.0041	0.74	0.073	0.019	0.13	0.0190	1.8	

[a]Please see Table 1 footnotes for record of collections.

[b]Net=total dose minus regional background dose.

[c]Missing ^{241}Am data; therefore, value given was from the closest station (South SR4).

areas, were far below the recommended permissible dose limit of 100 mrem y^{-1} above the dose which is received from other natural and/or man-made sources (ICRP 1978). In addition, the dose estimates may be inflated because the means of radionuclides that exhibited decreasing concentrations over time overestimate current conditions. As a matter of reference, the TEDE received by a resident of the Los Alamos and White Rock areas from all sources of radioactivity (e.g., radon, cosmic, terrestrial, building materials, worldwide fallout, gas heaters, and/or cigarette smoking) in 1993 was about 342 and 327 mrem y^{-1}, respectively (EPG 1995).

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V. REFERENCES

Abrahams, J. H., Jr., "Physical Properties of and Movement of Water in the Bandelier Tuff, Los Alamos and Santa Fe Counties, New Mexico," U.S. Geological Survey Administrative Release Albuquerque, NM (1963).

Andersson, K. G., and J. Roed, "The Behavior of Chernobyl ^{137}Cs, ^{134}Cs and ^{106}Ru in Undisturbed Soil: Implications for External Radiation," *Journal of Environmental Radioactivity* **22,** 183-196 (1994).

ASTM (American Society for Testing and Materials), "Standard Practice for Sampling Surface Soil for Radionuclides," in *Annual Book of ASTM Standards*, (American Society for Testing and Materials, Philadelphia, PA 1990).

Becker, N. M., "Quantification of Uranium Transport Away from Firing Sites at Los Alamos National Laboratory--A Mass Balance Approach," in *Proceedings of the Symposium on Waste Management: Technology and Programs for Radioactive Waste Management and*

Environmental Restoration, R.G. Post, Ed., (Tucson, Az 1992).

Bowen, B.M., "Los Alamos Climatology," Los Alamos National Laboratory report LA-11735-MS (1990).

Bunzl, K., H. Forster, W. Kracke, and W. Schimmack, "Residence Times of Fallout $^{239+240}Pu$, ^{238}Pu, ^{241}Am and ^{137}Cs in the Upper Horizons of an Undisturbed Grassland Soil," *Journal of Environmental Radioactivity* **22,** 11-27 (1994).

Conrad, R., M. Childs, C. Rivera-Dirks, and F. Coriz, "Area G Perimeter Surface-Soil and Single-Stage Water Sampling," Los Alamos National Laboratory report LA-12986-MS (1995).

Crowe, B. M., G. W. Linn, G. Heiken, and M. L. Bevier, "Stratigraphy of the Bandelier Tuff in the Pajarito Plateau," Los Alamos National Laboratory report LA-7225-MS (1978).

Dorries, A., "July 1994 Screening Action Levels," Los Alamos National Laboratory memorandum EM/ER:94-S390 (1994).

Dorries, A., "Draft SALs Policy Paper," Los Alamos National Laboratory informal memorandum (1995).

EPG (Environmental Protection Group), "Environmental Surveillance at Los Alamos During 1993," Los Alamos National Laboratory report LA-12973-ENV (1995).

FIMAD (Facility for Information Management Analysis and Display), "Screening Action Levels," http://ees5-www.lanl.gov/EES5/fimad/database/LIMITS/SALS/sals_main.html (1995).

Fresquez, P. R., "Results of the Soil Sampling Survey Conducted Over Active RCRA Firing Site TA-15-184 (PHERMEX)," Los Alamos National Laboratory memorandum No. ESH-8/EFM-94-111 (1994).

Fresquez, P. R., D. R. Armstrong, and J. G. Salazar, "Radionuclide Concentrations in Soils and Produce from Cochiti, Jemez, Taos, and San Ildefonso Pueblo Gardens," Los Alamos National Laboratory report LA-12932-MS (1995a).

Fresquez, P. R., T. E. Foxx, and L. Naranjo, Jr., "Strontium Concentrations in Chamisa (Chrysothamnus nauseosus) Shrub Plants Growing in a Former Liquid Waste Disposal Area in Bayo Canyon," Los Alamos National Laboratory report LA-13050-MS (1995b).

Gilbert, R. O., *Statistical Methods for Environmental Pollution Monitoring*, (Van Nostrand Reinhold, New York 1987).

Gilbert, R. O., J. H. Shinn, E. H. Essington, T. Tamura, E. M. Romney, K. S. Moor, and T. P. O'Farrel, "Radionuclide Transport from Soil to Air, Native Vegetation, Kangaroo Rats and Grazing Cattle on the Nevada Test Site," *Health Physics* **55,** 869-887 (1988).

Gilbert, R. O., J. W. Hardin, and T. LeGore, "Comparing Statistical Tests for Detecting Soil Contamination Greater Than Background," *Health Physics* **68 (6),** S45 (1995).

Healy, J. W., "An Examination of the Pathways from Soil to Man for Plutonium," Los Alamos Scientific Laboratory report LA-6741-MS (1977).

Hakonson, T. E., R. L. Watters, and W. C. Hanson, "The Transport of Plutonium in Terrestrial Ecosystems," *Health Physics* **40,** 63-69 (1981).

Hollander, M., and D. A. Wolfe, *Nonparameteric Statistical Methods*, (Wiley, New York 1973).

ICRP (International Commission on Radiological Protection), "Limits of Intakes of Radionuclides by Workers," International Commission on Radiological Protection Publication 30, (Pergamon Press, New York 1978).

Klement, A. W., "Radioactive Fallout Phenomena and Mechanisms," *Health Physics* **11,** 1265-1274 (1965).

Lee, S. Y., T. Tamura, and E. H. Essington, "Characteristics of Radioactivity Contamination of Soil at the Nevada Test Site," *Nuclear and Chemical Waste Management* **7,** 179-190 (1985).

Litaor, M. I., M. L. Thompson, G. R. Barth, and P. C. Molzer, "Plutonium-239 + 240 and Americium-241 in Soils East of Rocky Flats, Colorado," *Journal of Environmental Quality* **23,** 1231-1239 (1994).

Longmire, P., S. Reneau, P. Watt, J. Garner, C. Duffy, and R. Ryti, "Natural Background Geochemistry, Geomorphology, and Pediogenisis of Selected Soil Profiles and Bandelier Tuff, Los Alamos, New Mexico," Los Alamos National Laboratory report LA-12913-MS (1995).

McNamara, E., Los Alamos National Laboratory, Environment, Safety and Health Division, Air Quality Group (ESH-17), personal communication, April (1995).

Mitchell, P. I., J. A., Sanchez-Cabeza, T. P. Ryan, A. T. McGarry, and A. Vidal-Quadras, "Preliminary Estimates of Cumulative Caesium and Plutonium Deposition in the Irish terrestrial environment," *Journal of Radioanalysis and Nuclear Chemistry Articles* **138,** 241-256 (1990).

McLendon, H. R., "Soil Monitoring for Plutonium at the Savannah River Plant," *Health Physics* **28,** 347-354 (1975).

NCRP (National Council on Radiological Protection), "Ionizing Radiation Exposure of the Population of the United States," NCRP report no. 93 (1987).

Nyhan, J. W., and T. E. Hakonson, "Soil Plutonium in the Los Alamos Environs and at the Trinity Site," Pacific Northwest Laboratories report BNWL-2117 (1976).

Nyhan, J. W., T. E. Hakonson, F. R. Miera, Jr., and K. V. Bostick, "Seasonal Changes in the Distribution of ^{137}Cs in Alluvial Soils at Los Alamos," Los Alamos Scientific Laboratory report LA-7298-MS (1978a).

Nyhan, J. W., L. W. Hacker, T. E. Calhoun, and D. L. Young, "Soil Survey of Los Alamos County, New Mexico," Los Alamos Scientific Laboratory report LA-6779-MS (1978b).

Nyhan, J. W., T. G. Schofield, G. C. White, and G. Trujillo, "Sampling Soils for ^{137}Cs Using Various Field Sampling

Volumes," Los Alamos National Laboratory report LA-8951-MS (1981).

Perkins, R. W., and C. W. Thomas, "Worldwide Fallout," in *Transuranic Elements in the Environment*, (Technical Information Center, U.S. Department of Energy, Washington, D.C. 1980).

Pinder, J. E., K. W. McLeod, R. F. Lide, and K. C. Sherrod, "Mass Loading of Soil Particles on a Pasture Grass," *Journal of Environmental Radioactivity* **13,** 341-354 (1991).

Purtymun, W. D., "Underground Movement of Tritium from Solid Waste Storage Shafts," Los Alamos Scientific Laboratory report LA-5286-MS (1973).

Purtymun, W. D., R. J. Peters, and A. K. Stoker, "Radioactivity in Soils and Sediments in and Adjacent to the Los Alamos Area, 1974-77," Los Alamos Scientific Laboratory report LA-8234-MS (1980).

Purtymun, W. D., R. J. Peters, T. E. Buhl, M. N. Maes, and F. H. Brown, "Background Concentrations of Radionuclide in Soils and River Sediments in Northern New Mexico, 1974-1986," Los Alamos National Laboratory report LA-11134-MS (1987).

Purtymun, W. D., R. J. Peters, and M. N. Maes, "Plutonium Deposition and Distribution from Worldwide Fallout in Northern New Mexico and Southern Colorado," Los Alamos National Laboratory report LA-11794-MS (1990).

Rogowski, A. S., and T. Tamura, "Movement of ^{137}Cs by Runoff, Erosion, and Infiltration on the Alluvial Captina Silt Loam," *Health Physics* **11,** 1333-1340 (1965).

Schulz, R. K. "Soil chemistry of radionuclides," *Health Physics* **11,** 1317-1324 (1965).

Stoker, A. K., W. D. Purtymun, S. McLin, M. Maes, "Extent of Saturation in Mortandad Canyon," Los Alamos National Laboratory report LA-UR-91-1660 (1991).

USDOE, "Final Environmental Impact Statement: Los Alamos Scientific

Laboratory Site, Los Alamos, New Mexico," U.S. Department of Energy report DOE/EIS-0018 (1979).

USDOE, "Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance," U.S. Department of Energy report DOE/EH-0173T (1991).

USDOE, "Final Environmental Impact Statement: Dual Axis Radiogaphic Hydrodynamic Test Facility," U.S. Department of Energy report DOE/EIS-0228 (1995).

Wenzel, W. J., T. S. Foxx, A. F. Gallegos, G. Tierney, and J. C. Rodgers, "Cesium-137, Plutonium-239/240, Total Uranium, and Scandiium in Trees and Shrubs Growing in Transuranic Waste at Area B," Los Alamos National Laboratory report LA-11126-MS (1987).

Wicker, W. F., and V. Schultz, *Radioecology: Nuclear Energy and the Environment*, (CRC Press, Inc., Boca Raton, FL 1982).

Yu, C., A. J. Zielen, J. J. Cheng, T. C. Yuan, L. G. Jones, D. J. Lepoire, Y. Y. Wang, C. O. Loueiro, E. Gnanapragasam, J. E. Faillace, A. Wallo III, W. A. Williams, and H. Peterson, "A Manual for Implementing Residual Radioactive Material Guidelines Using RESRAD, Version 5.60," Argonne National Laboratory report ANL/EAD/LD-2 (1995).

Appendix A. Results of radiochemical analysis (± sigma) of on-site, perimeter, and regional (background) soil samples from 1974 through 1994.

On-Site Soil Stations (Year)	3H pCi/mL	(± σ)	137Cs pCi/g dry	(± σ)	238Pu pCi/g dry	(± σ)	239,240Pu pCi/g dry	(± σ)	90Sr pCi/g dry	(± σ)	Total Uranium ug/g dry	(± σ)	241Am pCi/g dry	(± σ)	Gross Alpha pCi/g dry	(± σ)	Gross Beta pCi/g dry	(± σ)	Gross Gamma pCi/g dry	(± σ)
TA-16 (S-SITE)/TA-11																				
1978	5.3	(0.4)	0.55	(0.14)	-0.002	(0.001)	0.008	(0.003)							5.3	(1.2)	6.6	(0.8)		
1978	4.0	(2.1)	1.46	(0.06)	0.015	(0.022)	0.086	(0.091)							5.3	(1.2)	8.5	(1.0)		
1979	1.7	(0.3)	0.59	(0.06)	0.001	(0.002)	0.010	(0.003)			4.1	(0.4)			6.2	(1.4)	7.0	(0.8)		
1979	0.2	(0.3)	0.74	(0.07)	0.001	(0.001)	0.012	(0.002)			4.1	(0.4)			12.0	(3.0)	14.0	(1.6)		
1980	2.0	(0.3)	1.03	(0.08)	0.003	(0.002)	0.009	(0.003)	0.19	(0.07)	3.9	(0.4)			10.0	(2.0)	9.6	(1.1)		
1980	0.6	(0.3)	0.95	(0.07)	-0.002	(0.002)	0.034	(0.009)	0.58	(0.07)	3.8	(0.4)			12.0	(3.0)	14.0	(1.5)		
1981	0.5	(0.3)	2.90	(0.12)	0.011	(0.003)	0.076	(0.009)	1.43	(0.11)					13.0	(3.0)	20.0	(2.0)		
1981	0.5	(0.3)	3.00	(0.16)	0.003	(0.001)	0.006	(0.002)	0.69	(0.08)					13.0	(3.0)	18.0	(2.0)		
1982	5.6	(0.3)	0.32	(0.00)	0.002	(0.001)	0.018	(0.003)			3.9	(0.4)			9.0	(2.0)	12.0	(1.3)		
1983	1.3	(0.3)	0.15	(0.05)	0.000	(0.001)	0.012	(0.003)			4.0	(0.5)			5.9	(1.3)	6.6	(0.7)	5.8	(0.1)
1984	11.0	(0.6)	0.99	(0.16)	0.001	(0.003)	0.021	(0.004)			3.6	(0.1)							7.5	(0.3)
1985	-1.0	(0.2)	0.29	(0.04)	-0.002	(0.001)	0.005	(0.001)			4.1	(0.2)							5.8	(0.3)
1986	3.7	(0.6)	0.22	(0.08)	0.000	(0.001)	0.011	(0.003)			3.7	(0.4)							5.6	(0.7)
1987	0.7	(0.5)	0.12	(0.06)	0.001	(0.002)	0.000	(0.001)			4.1	(0.4)							5.8	(0.8)
1988	-0.2	(0.3)	0.31	(0.10)	0.004	(0.002)	0.013	(0.002)			3.5	(0.4)							4.5	(0.6)
1989	0.1	(0.3)	0.13	(0.06)	0.000	(0.001)	0.002	(0.001)			3.5	(0.4)							2.9	(0.5)
1990	0.3	(0.3)	1.03	(0.42)	0.001	(0.001)	0.002	(0.001)											1.9	(0.4)
1991	0.3	(0.3)	0.20	(0.10)	0.000	(0.001)	0.001	(0.001)			3.9	(0.4)			11.0	(2.0)	3.0	(0.0)	3.0	(1.0)
1992	0.5	(0.3)	0.10	(0.10)	0.008	(0.002)	0.005	(0.001)	0.30	(0.20)	3.5	(0.4)	0.002	(0.053)	8.0	(2.0)	3.0	(0.0)	1.0	(1.0)
1993	0.4	(0.3)	3.10	(0.50)	0.017	(0.030)	0.022	(0.020)			1.5	(0.2)			3.0	(1.0)	4.0	(0.0)	3.0	(0.0)
1994	-0.1	(0.3)	0.15	(0.04)	0.002	(0.002)	0.007	(0.002)	0.50	(0.20)	3.0	(0.3)	0.001	(0.002)	5.0	(1.0)	4.5	(0.5)	3.2	(0.4)
N	21		21		21		21		6		16		2		14		14		12	
Minimum	-1.00		0.10		-0.002		0.000		0.19		1.50		0.001		3.00		3.00		1.00	
Maximum	11.00		3.10		0.017		0.086		1.43		4.10		0.002		13.00		20.00		7.50	
Mean	1.78		0.87		0.003		0.017		0.62		3.64		0.002		8.48		9.34		4.17	
Std. Dev.	2.79		0.97		0.005		0.023		0.44		0.65		0.001		3.39		5.50		1.95	
TA-21 (DP SITE)																				
1976	9.5	(0.3)			0.005	(0.001)	0.397	(0.015)	0.60	(3.60)	2.9	(0.3)			6.3	(1.0)	5.8	(0.5)		
1977			0.10	(0.04)	0.004	(0.006)	0.006	(0.002)			3.2	(0.9)			7.4	(1.1)	6.7	(1.3)		
1978	15.6	(15.6)	0.07	(0.00)	-0.003	(0.004)	0.022	(0.026)							4.1	(0.9)	5.0	(0.6)		
1979	1.9	(0.3)	0.03	(0.06)	0.001	(0.002)	0.017	(0.003)	0.13	(0.08)	3.5	(0.4)			7.3	(1.6)	6.1	(0.8)		
1980	5.3	(0.4)	0.17	(0.08)	0.000	(0.001)	0.006	(0.002)	0.67	(0.10)	3.8	(0.4)	0.020	(0.006)	6.0	(1.3)	6.4	(0.7)		
1981	3.3	(0.3)	0.47	(0.05)	0.001	(0.001)	0.151	(0.011)	4.40	(0.80)					17.0	(4.0)	17.0	(2.0)		
1982	6.4	(0.4)	0.18	(0.02)	0.002	(0.001)	0.320	(0.019)			4.2	(0.4)			5.6	(1.3)	5.4	(0.7)		
1983	2.7	(0.4)	0.16	(0.03)	0.002	(0.001)	0.020	(0.003)			3.7	(0.4)			10.0	(2.0)	9.3	(1.0)	5.6	(0.1)
1984	2.0	(0.3)	0.00	(0.15)	0.007	(0.004)	0.027	(0.005)			3.6	(0.1)							5.5	(0.3)
1985	-0.6	(0.2)	0.08	(0.04)	0.001	(0.001)	0.051	(0.003)			3.6	(0.1)							5.9	(0.4)
1986	4.1	(0.6)	0.07	(0.06)	0.003	(0.002)	0.006	(0.002)			3.9	(0.4)							5.8	(0.7)
1987	1.9	(0.5)	-0.01	(0.08)	0.005	(0.004)	0.002	(0.002)			3.8	(0.4)							6.6	(0.9)
1988	1.1	(0.4)	0.00	(0.09)	0.164	(0.010)	0.103	(0.008)			3.7	(0.4)							4.9	(0.7)
1989	4.2	(0.6)	0.04	(0.13)	0.005	(0.001)	0.013	(0.002)			3.5	(0.4)							2.7	(0.5)
1990	3.6	(0.5)	0.42	(0.13)	0.002	(0.001)	0.001	(0.001)											3.3	(0.5)
1991	1.4	(0.3)	1.90	(0.30)	0.002	(0.001)	0.002	(0.001)			3.8	(0.4)			12.0	(3.0)	5.0	(1.0)	3.0	(1.0)
1992	0.4	(0.3)	0.20	(0.10)	0.020	(0.002)	0.013	(0.002)	0.10	(0.20)	3.5	(0.4)	-0.002	(0.025)	11.0	(2.0)	4.0	(1.0)	0.0	(1.0)
1993	0.5	(0.3)	0.10	(0.00)	0.025	(0.030)	0.030	(0.020)			1.7	(0.3)			3.0	(1.0)	3.0	(0.0)	3.0	(0.0)
1994	0.1	(0.3)	0.01	(0.01)	0.005	(0.001)	0.009	(0.002)	0.30	(0.20)	2.3	(0.2)	0.001	(0.002)	6.0	(1.0)	4.2	(0.5)	3.5	(0.4)
N	18		18		19		19		6		16		3		12		12		12	
Minimum	-0.60		-0.01		-0.003		0.001		0.10		1.70		-0.002		3.00		3.00		0.00	
Maximum	15.60		1.90		0.164		0.397		4.40		4.20		0.020		17.00		17.00		6.60	
Mean	3.52		0.22		0.013		0.063		1.03		3.42		0.006		7.98		6.49		4.15	
Std. Dev.	3.91		0.44		0.037		0.112		1.67		0.63		0.012		3.90		3.67		1.89	

Appendix A. (cont.)

On-Site Soil Stations (Year)	3H pCi/mL	(± σ)	137Cs pCi/g dry	(± σ)	238Pu pCi/g dry	(± σ)	239,240Pu pCi/g dry	(± σ)	90Sr pCi/g dry	(± σ)	Total Uranium ug/g dry	(± σ)	241Am pCi/g dry	(± σ)	Gross Alpha pCi/g dry	(± σ)	Gross Beta pCi/g dry	(± σ)	Gross Gamma pCi/g dry	(± σ)
NEAR TA-33																				
1976	6.4	(0.2)			0.002	(0.001)	0.021	(0.002)	7.00	(1.60)	2.7	(0.2)			5.1	(0.9)	6.1	(0.4)		
1977			0.43	(0.06)	0.002	(0.002)	0.010	(0.002)	0.15	(0.04)	3.4	(1.6)			7.8	(0.8)	7.9	(0.9)		
1978	28.6	(0.7)	0.51	(0.05)	-0.002	(0.002)	0.003	(0.003)							6.5	(1.4)	8.5	(1.0)		
1979	26.0	(0.6)	0.94	(0.08)	-0.001	(0.002)	0.017	(0.003)			3.6	(0.4)			7.8	(1.7)	8.9	(1.0)		
1980	440	(0.9)	0.73	(0.06)	-0.001	(0.002)	0.005	(0.003)	0.23	(0.09)	3.8	(0.4)			7.4	(1.6)	9.1	(1.0)		
1981	40.0	(0.8)	0.73	(0.06)	0.007	(0.001)	0.025	(0.004)	0.01	(0.08)					11.0	(1.0)	12.0	(1.5)		
1982	93.0	(1.5)	0.47	(0.03)	0.000	(0.000)	0.009	(0.002)			3.9	(0.4)			10.0	(2.0)	13.0	(1.4)		
1983	4.7	(0.5)	0.45	(0.08)	0.000	(0.001)	0.003	(0.001)			4.0	(0.5)			14.0	(3.0)	11.0	(1.1)	7.4	(0.1)
1984	38.0	(4.0)	0.28	(0.15)	0.001	(0.002)	0.005	(0.002)			3.5	(0.1)							7.9	(0.3)
1985	10.0	(0.5)	0.45	(0.05)	0.002	(0.001)	0.017	(0.002)			3.8	(0.2)							6.8	(0.4)
1986	16.0	(2.0)	-0.11	(0.05)	0.000	(0.001)	0.004	(0.002)			3.6	(0.4)							7.1	(0.8)
1987	10.0	(1.0)	0.25	(0.07)	0.001	(0.001)	0.009	(0.002)			3.6	(0.4)							7.2	(0.9)
1988	7.8	(0.9)	0.35	(0.11)	0.003	(0.002)	0.008	(0.002)			3.5	(0.4)							5.4	(0.7)
1989	10.0	(1.0)	0.26	(0.26)	0.002	(0.001)	0.007	(0.002)			3.1	(0.3)							3.6	(0.5)
1990	13.0	(1.0)	0.30	(0.08)	0.001	(0.001)	0.007	(0.001)											3.9	(0.6)
1991	2.0	(0.4)	0.30	(0.10)	0.006	(0.006)	0.005	(0.002)			2.8	(0.3)			26.0	(6.0)	6.0	(1.0)	3.0	(1.0)
1992	0.9	(0.3)	0.10	(0.10)	0.009	(0.002)	0.011	(0.002)	0.20	(0.20)	3.5	(0.4)	0.028	(0.053)	7.0	(2.0)	4.0	(1.0)	2.0	(1.0)
1993	1.1	(0.3)	0.10	(0.00)	0.007	(0.030)	0.001	(0.020)			1.3	(0.1)			5.0	(0.5)	6.0	(1.0)	4.0	(0.0)
1994	0.5	(0.4)	0.61	(0.09)	0.003	(0.001)	0.022	(0.002)	1.10	(0.20)	2.6	(0.4)	0.011	(0.002)	6.0	(1.0)	5.9	(0.6)	3.5	(0.4)
N	18		18		19		19		6		16		2		12		12		12	
Minimum	0.50		-0.11		-0.002		0.001		0.01		1.30		0.011		5.00		4.00		2.00	
Maximum	440.00		0.94		0.009		0.025		7.00		4.00		0.028		26.00		13.00		7.90	
Mean	41.56		0.40		0.002		0.010		1.45		3.29		0.020		9.47		8.20		5.15	
Std. Dev.	101.91		0.25		0.003		0.007		2.75		0.68		0.012		5.82		2.76		2.04	
POTRILLO DRIVE/TA-36																				
1976					0.001	(0.001)	0.007	(0.001)							2.2	(0.3)	2.8	(0.3)		
1977			0.40	(0.09)	0.002	(0.002)	0.012	(0.002)	0.10	(0.02)	3.4	(1.4)			12.0	(5.0)	10.0	(0.0)		
1978	14.6	(0.6)	0.47	(0.06)	-0.002	(0.002)	0.008	(0.003)							4.1	(1.0)	9.7	(0.8)		
1979	1.3	(0.3)	0.48	(0.07)	-0.002	(0.005)	0.009	(0.006)			4.2	(0.4)			9.5	(2.0)	8.3	(1.0)		
1980	2.5	(0.3)	0.78	(0.09)	0.000	(0.002)	0.020	(0.004)	0.56	(0.11)	4.3	(0.5)	0.006	(0.003)	8.9	(2.0)	10.6	(1.3)		
1981	0.4	(0.3)	0.40	(0.06)	0.000	(0.000)	0.008	(0.002)	0.21	(0.06)					9.0	(2.0)	8.0	(1.0)		
1982	11.0	(0.4)	0.66	(0.04)	0.001	(0.001)	0.008	(0.004)			4.4	(0.4)			7.1	(1.5)	7.7	(0.9)		
1983	1.1	(0.3)	1.50	(0.16)	0.001	(0.000)	0.007	(0.001)			5.1	(0.5)			9.0	(2.0)	12.0	(1.3)	6.4	(0.1)
1984	5.1	(0.6)	0.37	(0.15)	-0.005	(0.002)	0.005	(0.003)			3.7	(0.1)							5.9	(0.3)
1985	-0.3	(0.2)	0.76	(0.07)	-0.002	(0.001)	0.029	(0.002)			3.1	(0.1)							6.7	(0.4)
1986	3.5	(0.5)	0.38	(0.09)	-0.001	(0.001)	0.010	(0.002)			4.5	(0.5)							5.2	(0.6)
1987	2.4	(0.6)	0.25	(0.09)	0.000	(0.001)	0.000	(0.001)			3.9	(0.4)							5.2	(0.8)
1988	-0.4	(0.3)	0.18	(0.09)	0.000	(0.001)	0.005	(0.002)			3.4	(0.4)							4.1	(0.6)
1989	120.0	(10.0)	0.28	(0.13)	0.004	(0.001)	0.008	(0.001)			3.6	(0.4)							3.8	(0.5)
1990	1.1	(0.3)	0.63	(0.12)	0.001	(0.001)	0.022	(0.003)											3.8	(0.6)
1991	0.3	(0.3)	0.30	(0.10)	0.001	(0.001)	0.005	(0.001)			4.0	(0.4)			10.0	(2.0)	4.0	(1.0)	4.0	(1.0)
1992	0.2	(0.3)	0.60	(0.20)	0.061	(0.004)	0.046	(0.003)	0.20	(0.20)	3.4	(0.3)	0.041	(0.053)	11.0	(2.0)	4.0	(1.0)	1.0	(1.0)
1993	-0.2	(0.3)	0.20	(0.00)	0.003	(0.030)	0.009	(0.020)			2.3	(0.2)			4.0	(1.0)	4.0	(0.0)	4.0	(0.0)
1994	-0.4	(0.3)	0.20	(0.05)	0.002	(0.001)	0.009	(0.002)	0.50	(0.20)	2.8	(0.3)	0.005	(0.002)	6.0	(1.0)	4.5	(0.5)	3.3	(0.4)
N	17		18		19		19		5		15		3		12		12		12	
Minimum	-0.40		0.18		-0.005		0.000		0.10		2.30		0.005		2.20		2.80		1.00	
Maximum	120.00		1.50		0.061		0.046		0.56		5.10		0.041		12.00		12.00		6.70	
Mean	9.54		0.49		0.003		0.012		0.31		3.74		0.017		7.73		7.13		4.45	
Std. Dev.	28.77		0.31		0.014		0.011		0.20		0.72		0.021		3.06		3.13		1.56	

Appendix A. (cont.)

On-Site Soil Stations (Year)	3H pCi/mL	(± σ)	137Cs pCi/g dry	(± σ)	238Pu pCi/g dry	(± σ)	239,240Pu pCi/g dry	(± σ)	90Sr pCi/g dry	(± σ)	Total Uranium ug/g dry	(± σ)	241Am pCi/g dry	(± σ)	Gross Alpha pCi/g dry	(± σ)	Gross Beta pCi/g dry	(± σ)	Gross Gamma pCi/g dry	(± σ)
TA-50																				
1976	10.9	(0.3)			0.004	(0.001)	0.933	(0.004)	3.20	(1.00)	5.3	(0.2)			5.7	(0.9)	5.8	(0.4)		
1977			1.04	(0.21)	0.011	(0.009)	3.800	(4.450)	0.08	(0.03)	8.4	(0.5)			12.0	(7.0)	12.0	(0.2)		
1978	29.9	(34.7)	0.49	(0.36)	0.008	(0.013)	0.085	(0.002)							6.2	(0.7)	9.4	(1.1)		
1979	1.9	(0.3)	0.16	(0.04)	-0.002	(0.002)	0.023	(0.004)	0.25	(0.10)	4.4	(0.4)			12.0	(1.5)	7.5	(0.9)		
1980	4.1	(0.3)	0.82	(0.08)	0.004	(0.003)	0.207	(0.020)	0.48	(0.11)	5.2	(0.5)			13.0	(3.0)	16.0	(1.6)		
1981	8.3	(0.4)	0.08	(0.06)	0.003	(0.001)	0.010	(0.003)	-1.40	(0.80)					15.0	(3.0)	14.0	(1.5)		
1982	14.0	(0.5)	0.02	(0.03)	0.001	(0.000)	0.002	(0.000)			3.9	(0.4)			3.8	(0.9)	5.6	(0.7)		
1983	4.0	(0.5)	0.09	(0.04)	0.004	(0.001)	0.044	(0.005)			4.0	(0.4)			7.8	(1.8)	6.5	(0.7)	6.1	(0.1)
1984	26.0	(3.0)	0.00	(0.15)	0.000	(0.001)	0.008	(0.002)			3.5	(0.1)							6.4	(0.3)
1985	-0.3	(0.2)	0.12	(0.02)	0.002	(0.001)	0.074	(0.003)			4.1	(0.2)							6.9	(0.4)
1986	4.9	(0.7)	0.19	(0.08)	0.002	(0.001)	0.063	(0.005)			3.8	(0.4)							6.3	(0.7)
1987	2.3	(0.5)	0.11	(0.08)	0.002	(0.001)	0.038	(0.003)			4.2	(0.5)							6.8	(0.9)
1988	2.0	(0.4)	0.17	(0.12)	0.002	(0.001)	0.024	(0.004)			4.6	(0.5)							5.8	(0.7)
1989	3.6	(0.5)	0.09	(0.11)	0.000	(0.000)	0.016	(0.002)			3.7	(0.4)							3.8	(0.5)
1990	2.6	(0.4)	1.90	(0.64)	0.004	(0.001)	0.012	(0.002)											2.8	(0.5)
1991	1.2	(0.3)	0.10	(0.10)	0.001	(0.002)	0.043	(0.003)			3.9	(0.4)			15.0	(3.0)	10.0	(1.0)	4.0	(1.0)
1992	0.5	(0.3)	0.00	(0.10)	0.019	(0.002)	0.023	(0.002)	0.10	(0.20)	3.7	(0.4)	0.054	(0.059)	14.0	(3.0)	4.0	(1.0)	2.0	(1.0)
1993	0.1	(0.3)	0.20	(0.00)	0.005	(0.030)	0.062	(0.020)			2.2	(0.4)			4.0	(1.0)	4.0	(0.5)	3.0	(0.0)
1994	0.4	(0.3)	0.08	(0.03)	0.009	(0.002)	0.032	(0.003)	0.30	(0.20)	3.7	(0.8)	0.016	(0.006)	4.0	(0.5)	5.0	(1.0)	3.4	(0.4)
N	18		18		19		19		7		16		2		12		12		12	
Minimum	-0.30		0.00		-0.002		0.002		-1.40		2.20		0.016		3.80		4.00		2.00	
Maximum	29.90		1.90		0.019		3.800		3.20		8.40		0.054		15.00		16.00		6.90	
Mean	6.47		0.31		0.004		0.289		0.43		4.29		0.035		9.38		8.31		4.78	
Std. Dev.	8.72		0.49		0.005		0.875		1.37		1.30		0.027		4.54		3.99		1.77	
TA-51																				
1978	7.4	(6.7)	0.87	(0.88)	-0.004	(0.009)	0.118	(0.131)							5.8	(1.3)	12.3	(1.3)		
1979	1.1	(0.3)	0.11	(0.05)	0.000	(0.002)	0.013	(0.003)	0.90	(0.10)	3.8	(0.4)			6.4	(1.4)	5.9	(0.7)		
1980	4.2	(0.3)	0.98	(0.07)	0.003	(0.002)	0.019	(0.006)	0.35	(0.07)	3.7	(0.4)			11.0	(2.0)	14.0	(1.5)		
1981	1.4	(0.3)	0.37	(0.06)	0.001	(0.001)	0.000	(0.000)	-0.08	(0.09)					40.0	(9.0)	31.0	(1.5)		
N	4		4		4		4		3		2				4		4			
Minimum	1.10		0.11		-0.004		0.000		-0.08		3.70				5.80		5.90			
Maximum	7.40		0.98		0.003		0.118		0.90		3.80				40.00		31.00			
Mean	3.53		0.58		0.000		0.038		0.39		3.75				15.80		15.80			
Std. Dev.	2.94		0.41		0.003		0.054		0.49		0.07				16.30		10.72			
EAST OF TA-52																				
1978	17.7	(0.5)	-0.11	(0.06)	-0.002	(0.001)	-0.001	(0.001)	-0.05	(0.10)					4.6	(1.1)	5.7	(0.7)		
1979	2.5	(0.3)	0.15	(0.04)	0.234	(0.011)	0.127	(0.008)			3.7	(0.4)			13.0	(3.0)	9.7	(1.1)		
1980	1.7	(0.3)	0.12	(0.10)	-0.001	(0.001)	-0.001	(0.001)	0.19	(0.12)	3.3	(0.3)	0.003	(0.002)	13.0	(3.0)	9.6	(1.1)		
1981	1.4	(0.3)	2.20	(0.10)	0.000	(0.001)	0.009	(0.002)	0.39	(0.08)					27.0	(6.0)	21.0	(2.0)		
N	4		4		4		4		3		2		1		4		4			
Minimum	1.40		-0.11		-0.002		-0.001		-0.05		3.30		0.003		4.60		5.70			
Maximum	17.70		2.20		0.234		0.127		0.39		3.70		0.003		27.00		21.00			
Mean	5.83		0.59		0.058		0.034		0.18		3.50		0.003		14.40		11.50			
Std. Dev.	7.93		1.08		0.118		0.063		0.22		0.28				9.29		6.60			
WEST OF TA-53																				
1978	8.2	(7.3)	1.29	(0.20)	0.013	(0.017)	0.150	(0.193)	0.82	(0.13)					4.5	(1.0)	6.7	(0.8)		
1979	2.0	(0.3)	1.22	(0.10)	0.001	(0.002)	0.031	(0.005)	0.35	(0.08)	4.2	(0.4)			10.0	(2.0)	12.0	(1.3)		
1980	2.7	(0.3)	1.36	(0.08)	-0.005	(0.002)	0.009	(0.006)	0.41	(0.11)	3.9	(0.4)	0.028	(0.008)	13.0	(3.0)	16.0	(1.7)		

Appendix A. (cont.)

On-Site Soil Stations (Year)	3H pCi/mL	(± σ)	137Cs pCi/g dry	(± σ)	238Pu pCi/g dry	(± σ)	239,240Pu pCi/g dry	(± σ)	90Sr pCi/g dry	(± σ)	Total Uranium ug/g dry	(± σ)	241Am pCi/g dry	(± σ)	Gross Alpha pCi/g dry	(± σ)	Gross Beta pCi/g dry	(± σ)	Gross Gamma pCi/g dry	(± σ)
WEST OF TA-53 (cont.)																				
1981																				
1982	10.0	(0.4)	2.13	(0.08)	0.002	(0.001)	0.109	(0.009)			4.0	(0.4)			4.5	(1.0)	9.2	(1.0)		
1983	2.3	(0.3)	0.46	(0.03)	0.002	(0.001)	0.008	(0.002)			4.1	(0.4)			9.0	(2.0)	10.0	(1.1)	6.2	(0.1)
1984	3.0	(0.4)	1.00	(0.17)	0.002	(0.001)	0.048	(0.005)			5.9	(0.2)							7.5	(0.3)
1985	0.6	(0.2)	0.59	(0.06)	0.000	(0.001)	0.061	(0.004)			5.4	(0.2)							6.6	(0.4)
1986	8.7	(1.0)	0.23	(0.08)	0.002	(0.002)	0.014	(0.003)			3.8	(0.4)							6.7	(0.8)
1987	1.0	(0.5)	0.17	(0.08)	0.000	(0.002)	0.012	(0.001)			4.6	(0.5)							7.5	(0.9)
1988	1.0	(0.4)	0.12	(0.08)	0.002	(0.001)	0.009	(0.002)			4.0	(0.4)							6.4	(0.8)
1989	4.0	(2.0)	0.26	(0.08)	0.002	(0.001)	0.012	(0.002)			3.5	(0.4)							2.9	(0.5)
1990	4.5	(0.6)	0.68	(0.12)	0.003	(0.001)	0.056	(0.004)											3.4	(0.5)
1991	1.2	(0.3)	0.30	(0.10)	0.002	(0.003)	0.010	(0.002)			2.4	(0.2)			11.0	(2.0)	4.0	(1.0)	3.0	(1.0)
1992	0.4	(0.3)	0.00	(0.10)	0.001	(0.003)	0.061	(0.004)	0.20	(0.20)	5.9	(0.6)	0.062	(0.046)	10.0	(2.0)	7.0	(1.0)	2.0	(1.0)
1993	0.4	(0.3)	0.20	(0.00)	0.004	(0.030)	0.030	(0.020)			1.9	(0.5)			4.0	(1.0)	4.0	(0.0)		
1994	0.3	(0.3)	0.05	(0.02)	0.007	(0.001)	0.019	(0.002)	0.40	(2.10)	2.5	(0.3)	0.002	(0.001)	5.0	(1.0)	4.4	(0.5)	3.7	(0.4)
N	16		16		16		16		5		14		3		9		9		11	
Minimum	0.30		0.00		-0.005		0.008		0.20		1.90		0.002		4.00		4.00		2.00	
Maximum	10.00		2.13		0.013		0.150		0.82		5.90		0.062		13.00		16.00		7.50	
Mean	3.14		0.63		0.002		0.040		0.44		4.01		0.031		7.89		8.14		5.08	
Std. Dev.	3.17		0.61		0.004		0.041		0.23		1.22		0.030		3.40		4.08		2.07	
EAST OF TA-53																				
1978	17.6	(0.5)	1.03	(0.10)	-0.001	(0.002)	0.020	(0.004)							6.0	(1.3)	8.0	(0.9)		
1979	1.3	(0.3)	1.15	(0.12)	0.000	(0.001)	0.076	(0.005)	0.56	(0.09)	7.1	(0.7)			16.0	(2.0)	19.0	(2.0)		
1980	0.9	(0.3)	3.50	(0.20)	0.006	(0.002)	0.212	(0.015)	1.09	(0.08)	8.2	(0.8)			18.0	(4.0)	26.0	(3.0)		
1981	12.0	(0.4)	0.85	(0.07)	0.000	(0.001)	0.025	(0.004)	0.52	(0.16)					18.0	(4.0)	25.0	(3.0)		
N	4		4		4		4		3		2				4		4			
Minimum	0.90		0.85		-0.001		0.020		0.52		7.10				6.00		8.00			
Maximum	17.60		3.50		0.006		0.212		1.09		8.20				18.00		26.00			
Mean	7.95		1.63		0.001		0.083		0.72		7.65				14.50		19.50			
Std. Dev.	8.24		1.25		0.003		0.089		0.32		0.78				5.74		8.27			
EAST OF TA-54																				
1976																				
1977																				
1978	157.0	(187.0)	0.26	(0.18)	0.448	(0.357)	1.350	(1.660)							5.5	(1.2)	6.3	(0.8)		
1979	13.0	(0.5)	0.18	(0.04)	-0.001	(0.002)	0.001	(0.002)	0.23	(0.13)	4.8	(0.5)			18.0	(4.0)	17.0	(1.8)		
1980	7.2	(0.4)	0.31	(0.09)	1.305	(0.009)	0.427	(0.020)	0.27	(0.07)	4.8	(0.5)			13.0	(3.0)	13.0	(1.4)		
1981	2.8	(0.3)	0.10	(0.20)	0.003	(0.001)	0.018	(0.003)	-0.87	(0.19)					10.0	(2.0)	10.0	(4.0)		
1982	3.1	(0.3)	0.13	(0.04)	0.000	(0.000)	0.015	(0.003)							10.0	(2.0)	9.9	(1.1)		
1983	13.0	(1.3)	0.58	(0.04)	0.003	(0.001)	0.009	(0.002)			6.5	(0.7)			10.0	(2.0)	9.8	(1.0)	1.3	(0.2)
1984	3.8	(0.5)	0.28	(0.15)	0.003	(0.002)	0.008	(0.002)			3.2	(0.1)							5.6	(0.3)
1985	0.0	(0.2)	0.14	(0.03)	11.900	(0.238)	0.281	(0.008)			4.6	(0.2)							8.2	(0.5)
1986	8.1	(0.9)	0.13	(0.09)	0.001	(0.001)	0.001	(0.001)			4.6	(0.5)							8.3	(0.9)
1987	-0.5	(0.5)	0.14	(0.07)	0.002	(0.002)	0.008	(0.004)			3.4	(0.3)							6.0	(0.8)
1988	-0.2	(0.3)	0.29	(0.11)	0.001	(0.002)	0.012	(0.003)			4.8	(0.5)							6.7	(0.8)
1989			0.20	(0.13)	0.004	(0.001)	0.010	(0.002)			4.0	(0.4)							2.3	(0.4)
1990	1.3	(0.4)	0.10	(0.08)	0.001	(0.000)	0.007	(0.001)											3.2	(0.5)
1991	0.2	(0.3)	0.20	(0.10)	0.001	(0.001)	0.005	(0.001)			3.8	(0.4)			10.0	(2.0)	4.0	(1.0)	2.0	(0.0)
1992	0.2	(0.3)	0.60	(0.20)	0.011	(0.002)	0.034	(0.003)	0.20	(0.20)	2.9	(0.3)	0.131	(0.056)	8.0	(2.0)	4.0	(1.0)	1.0	(1.0)
1993	9.5	(0.9)	2.00	(0.30)	0.088	(0.030)	2.248	(0.070)			1.8	(0.4)			5.0	(1.0)	6.0	(0.5)	5.0	(1.0)
1994	0.6	(0.3)	0.10	(0.03)	0.003	(0.001)	0.005	(0.001)	0.20	(0.20)	2.2	(0.2)	0.004	(0.002)	4.1	(0.9)	4.0	(0.4)	3.4	(0.4)

Appendix A. (cont.)

On-Site Soil Stations (Year)	3H pCi/mL	(± σ)	137Cs pCi/g dry	(± σ)	238Pu pCi/g dry	(± σ)	239,240Pu pCi/g dry	(± σ)	90Sr pCi/g dry	(± σ)	Total Uranium ug/g dry	(± σ)	241Am pCi/g dry	(± σ)	Gross Alpha pCi/g dry	(± σ)	Gross Beta pCi/g dry	(± σ)	Gross Gamma pCi/g dry	(± σ)
EAST OF TA-54 (cont.)																				
N	16		17		17		17		5		13		2		10		10		12	
Minimum	-0.50		0.10		-0.001		0.001		-0.87		1.80		0.004		4.10		4.00		1.00	
Maximum	157.00		2.00		11.900		2.248		0.27		6.50		0.131		18.00		17.00		8.30	
Mean	13.69		0.34		0.810		0.261		0.01		3.95		0.068		9.36		8.40		4.42	
Std. Dev.	38.50		0.45		2.876		0.611		0.49		1.27		0.090		4.12		4.35		2.58	
EAST OF NEW SIGMA I																				
1978	22.2	(0.6)	0.50	(0.07)	0.000	(0.002)	0.008	(0.002)							4.5	(1.0)	5.8	(0.7)		
1979	17.0	(0.5)	0.63	(0.06)	0.078	(0.006)	0.054	(0.005)			3.4	(0.3)			10.0	(2.0)	11.0	(1.3)		
1980	2.1	(0.3)	0.65	(0.11)	-0.001	(0.002)	0.040	(0.006)	0.32	(0.07)	5.3	(0.5)	0.003	(0.002)	15.0	(3.0)	17.0	(1.8)		
N	3		3		3		3		1		2		1		3		3			
Minimum	2.10		0.50		-0.001		0.008		0.32		3.40		0.003		4.50		5.80			
Maximum	22.20		0.65		0.078		0.054		0.32		5.30		0.003		15.00		17.00			
Mean	13.77		0.59		0.026		0.034		0.32		4.35		0.003		9.83		11.27			
Std. Dev.	10.43		0.08		0.045		0.024				1.34				5.25		5.60			
EAST OF NEW SIGMA II																				
1978	17.7	(0.5)	0.50	(0.07)	0.000	(0.003)	0.012	(0.003)	0.42	(0.11)					5.3	(1.2)	7.5	(0.9)		
1979	3.6	(0.4)	0.94	(0.10)	0.002	(0.001)	0.061	(0.006)			6.1	(0.6)			10.0	(2.0)	15.0	(1.6)		
1980	1.8	(0.3)	1.40	(0.13)	0.000	(0.002)	0.024	(0.002)	0.95	(0.13)	6.0	(0.6)			17.0	(4.0)	18.0	(1.9)		
N	3		3		3		3		2		2				3		3			
Minimum	1.80		0.50		0.000		0.012		0.42		6.00				5.30		7.50			
Maximum	17.70		1.40		0.002		0.061		0.95		6.10				17.00		18.00			
Mean	7.70		0.95		0.001		0.032		0.69		6.05				10.77		13.50			
Std. Dev.	8.71		0.45		0.001		0.026		0.37		0.07				5.89		5.41			
NEAR TEST WELL DT-9																				
1976																				
1977																				
1978	3.8	(0.4)	1.10	(0.11)	-0.001	(0.001)	-0.021	(0.003)	0.27	(0.14)			0.003	(0.006)	7.1	(1.5)	9.1	(1.0)		
1979	2.5	(0.3)	0.72	(0.07)	-0.002	(0.002)	0.013	(0.004)			4.3	(0.4)			9.0	(2.0)	9.3	(1.1)		
1980	1.2	(0.3)	0.95	(0.07)	0.001	(0.001)	0.013	(0.003)	0.34	(0.09)	3.3	(0.3)	0.014	(0.003)	10.0	(2.0)	13.0	(1.4)		
1981	0.4	(0.3)	1.00	(0.06)	0.001	(0.001)	0.028	(0.004)	0.35	(0.09)					18.0	(4.0)	17.0	(2.0)		
1982	9.0	(0.4)	1.04	(0.06)	0.002	(0.001)	0.025	(0.005)			4.0	(0.4)			7.7	(1.7)	9.8	(1.1)		
1983	9.6	(1.0)	0.69	(0.09)	0.001	(0.001)	0.036	(0.004)			4.6	(0.5)			7.3	(1.6)	8.1	(0.9)	6.0	(0.1)
1984	1.7	(0.3)	1.10	(0.18)	-0.006	(0.005)	0.035	(0.005)			3.6	(0.1)							7.9	(0.3)
1985	-1.0	(0.2)	0.96	(0.09)	-0.001	(0.001)	0.031	(0.003)			3.3	(0.1)							7.3	(0.4)
1986	1.8	(0.4)	0.56	(0.11)	0.003	(0.002)	0.012	(0.002)			4.5	(0.5)							6.3	(0.7)
1987	-0.2	(0.5)	0.79	(0.15)	0.000	(0.001)	0.016	(0.003)			3.1	(0.4)							5.1	(0.7)
1988	-0.3	(0.3)	1.40	(0.25)	0.008	(0.002)	0.048	(0.005)			6.2	(0.6)							5.6	(0.7)
1989	0.1	(0.3)	0.20	(0.14)	0.002	(0.001)	0.004	(0.001)			3.6	(0.4)							4.3	(0.6)
1990	0.6	(0.3)	0.93	(0.43)	0.000	(0.000)	0.005	(0.001)											4.0	(0.6)
1991	-0.3	(0.3)	0.30	(0.20)	0.000	(0.000)	0.000	(0.000)			3.0	(0.3)			10.0	(2.0)	4.0	(0.0)	3.0	(1.0)
1992	4.0	(0.6)	0.30	(0.10)	0.002	(0.001)	0.032	(0.003)	0.00	(0.20)	3.6	(0.4)	0.055	(0.053)	8.0	(2.0)	5.0	(1.0)	3.0	(1.0)
1993	0.2	(0.3)	1.00	(0.20)	0.007	(0.030)	0.031	(0.020)			2.6	(0.6)			4.0	(1.0)	5.0	(0.5)	4.0	(0.0)
1994	0.0	(0.3)	0.94	(0.12)	0.007	(0.001)	0.031	(0.003)	0.80	(0.20)	5.2	(0.5)	0.013	(0.003)	9.0	(2.0)	8.1	(0.9)	3.8	(0.4)
N	17		17		17		17		5		14		4		10		10		12	
Minimum	-1.00		0.20		-0.006		-0.021		0.00		2.60		0.003		4.00		4.00		3.00	
Maximum	9.60		1.40		0.008		0.048		0.80		6.20		0.055		18.00		17.00		7.90	
Mean	1.95		0.82		0.001		0.020		0.35		3.92		0.021		9.01		8.84		5.03	
Std. Dev.	3.11		0.32		0.003		0.017		0.29		0.96		0.023		3.61		3.93		1.61	

Appendix A. (cont.)

On-Site Soil Stations (Year)	3H pCi/mL	(± σ)	137Cs pCi/g dry	(± σ)	238Pu pCi/g dry	(± σ)	239,240Pu pCi/g dry	(± σ)	90Sr pCi/g dry	(± σ)	Total Uranium ug/g dry	(± σ)	241Am pCi/g dry	(± σ)	Gross Alpha pCi/g dry	(± σ)	Gross Beta pCi/g dry	(± σ)	Gross Gamma pCi/g dry	(± σ)
R-SITE ROAD EAST/R-SITE ROAD																				
1978	6.2	(0.4)	0.73	(0.10)	-0.002	(0.002)	0.013	(0.003)	0.63	(0.11)					6.1	(1.3)	7.5	(0.9)		
1978	10.5	(0.4)	0.84	(0.09)	0.001	(0.002)	0.020	(0.001)	0.83	(0.07)					11.0	(2.0)	22.0	(2.0)		
1979	0.4	(0.3)	3.10	(0.20)	0.003	(0.002)	0.061	(0.006)			4.0	(0.4)			8.6	(1.9)	13.0	(1.4)		
1979	5.8	(0.4)	1.04	(0.09)	-0.002	(0.003)	0.031	(0.006)	0.41	(0.09)	7.8	(0.8)			14.0	(3.0)	17.0	(1.9)		
1980	0.9	(0.3)	0.35	(0.06)	-0.002	(0.002)	0.009	(0.003)	0.62	(0.09)	3.9	(0.4)			12.0	(3.0)	13.0	(1.5)		
1980	0.7	(0.3)	0.00	(0.06)	0.028	(0.005)	0.022	(0.004)	0.53	(0.10)	4.1	(0.4)			11.0	(2.0)	13.0	(1.4)		
1981	0.3	(0.3)	0.31	(0.05)	0.002	(0.001)	0.005	(0.002)	0.34	(0.05)					12.0	(3.0)	13.0	(1.5)		
1982	5.5	(0.3)	0.84	(0.05)	0.001	(0.001)	0.017	(0.003)			5.3	(0.3)			12.0	(3.0)	17.0	(1.8)		
1983	9.2	(1.0)	0.46	(0.04)	0.001	(0.001)	0.034	(0.004)			3.7	(0.4)			10.0	(2.0)	7.1	(0.8)	6.1	(0.1)
1984	10.0	(0.6)	3.00	(0.46)	0.003	(0.001)	0.057	(0.005)			5.8	(0.3)							7.8	(0.3)
1985	0.0	(0.2)	0.60	(0.06)	-0.003	(0.001)	0.009	(0.002)			28.0	(1.0)							10.0	(0.5)
1986	4.2	(0.6)	0.19	(0.06)	0.002	(0.001)	0.041	(0.004)			3.9	(0.4)							6.3	(0.7)
1987	0.4	(0.5)	0.05	(0.05)	0.003	(0.001)	0.002	(0.002)			3.9	(0.4)							6.4	(0.8)
1988	0.3	(0.3)	0.04	(0.11)	0.001	(0.001)	0.018	(0.002)			3.8	(0.4)							4.6	(0.7)
1989	6.7	(0.9)	0.57	(0.10)	0.001	(0.001)	0.013	(0.002)			2.9	(0.3)							2.7	(0.5)
1990	0.5	(0.3)	1.88	(0.45)	0.001	(0.001)	0.024	(0.003)											3.2	(0.5)
1991	0.8	(0.3)	0.50	(0.10)	0.002	(0.001)	0.017	(0.002)			2.4	(0.2)			8.0	(2.0)	4.0	(0.0)	2.0	(1.0)
1992	0.6	(0.3)	0.40	(0.20)	0.004	(0.001)	0.009	(0.002)	0.20	(0.20)	3.6	(0.4)	0.083	(0.059)	6.0	(1.0)	3.0	(0.0)	1.0	(1.0)
1993	1.2	(0.3)	0.40	(0.10)	0.042	(0.030)	0.015	(0.020)			3.6	(0.4)			8.0	(2.0)	8.0	(0.5)	4.0	(0.0)
1994	0.1	(0.3)	0.31	(0.06)	0.002	(0.001)	0.016	(0.002)	0.70	(0.20)	114.0	(12.0)	0.008	(0.002)	44.0	(9.0)	67.0	(7.0)	4.3	(0.5)
N	20		20		20		20		8		16		2		13		13		12	
Minimum	0.00		0.00		-0.003		0.002		0.05		0.20		0.008		1.00		0.00		0.00	
Maximum	10.50		3.10		0.042		0.061		0.83		114.00		0.083		44.00		67.00		10.00	
Mean	3.22		0.78		0.004		0.022		0.53		12.54		0.046		12.52		15.74		4.87	
Std. Dev.	3.68		0.88		0.011		0.016		0.21		27.73		0.053		9.77		16.34		2.57	
TWO-MILE MESA																				
1976																				
1977																				
1978	7.1	(0.4)	0.90	(0.08)	-0.002	(0.005)	0.023	(0.005)	0.61	(0.17)					5.8	(1.3)	7.9	(0.9)		
1979	0.9	(0.3)	0.60	(0.06)	0.002	(0.001)	0.009	(0.002)			3.9	(0.4)			6.4	(1.4)	6.5	(0.8)		
1980	0.5	(0.3)	2.38	(0.16)	0.006	(0.003)	0.030	(0.005)	0.76	(0.12)	3.8	(0.4)			13.0	(3.0)	18.0	(2.0)		
1981	1.0	(0.3)			0.002	(0.001)	0.030	(0.006)	0.43	(0.14)					29.0	(7.0)	30.0	(3.0)		
1982	6.1	(0.4)	0.81	(0.05)	0.001	(0.002)	0.017	(0.004)			3.9	(0.4)			6.9	(1.5)	8.9	(1.0)		
1983	1.9	(0.3)	0.46	(0.03)	0.004	(0.002)	0.006	(0.002)			3.6	(0.4)			11.0	(1.0)	7.6	(0.8)	7.5	(0.1)
1984	5.7	(0.6)	0.47	(0.15)	0.000	(0.001)	0.010	(0.002)			3.8	(0.1)							4.4	(0.3)
1985	-0.5	(0.2)	0.68	(0.07)	0.001	(0.001)	0.014	(0.002)			3.8	(0.2)							5.6	(0.3)
1986	2.8	(0.5)	0.03	(0.06)	0.000	(0.000)	0.008	(0.002)			3.5	(0.4)							5.4	(0.6)
1987	0.7	(0.5)	0.51	(0.11)	0.002	(0.002)	0.020	(0.005)			2.9	(0.3)							4.7	(0.7)
1988	-0.2	(0.3)	0.98	(0.18)	0.002	(0.001)	0.033	(0.004)			4.0	(0.4)							6.4	(0.8)
1989	2.3	(0.4)	1.28	(0.20)	0.002	(0.001)	0.035	(0.003)			3.6	(0.4)							3.1	(0.5)
1990	0.2	(0.3)	0.30	(0.40)	0.001	(0.001)	0.003	(0.001)											3.3	(0.5)
1991	0.8	(0.3)	0.20	(0.10)	0.006	(0.003)	0.012	(0.003)			3.7	(0.4)			11.0	(2.0)	4.0	(1.0)	3.0	(1.0)
1992	1.1	(0.3)	0.20	(0.10)	0.018	(0.002)	0.017	(0.002)	0.30	(0.20)	3.5	(0.4)	0.065	(0.057)	9.0	(2.0)	4.0	(0.0)	0.0	(1.0)
1993	0.7	(0.3)	0.70	(0.10)	0.007	(0.030)	0.024	(0.020)			2.5	(0.4)			4.0	(1.0)	4.0	(0.5)	3.0	(0.0)
1994	-0.2	(0.3)	0.90	(0.12)	0.006	(0.001)	0.039	(0.003)	0.90	(0.30)	1.9	(0.3)	0.018	(0.004)	5.0	(1.0)	5.9	(0.6)	3.4	(0.4)
N	17		16		17		17		5		14		2		10		10		12	
Minimum	-0.50		0.03		-0.002		0.003		0.30		1.86		0.018		4.00		4.00		0.00	
Maximum	7.10		2.38		0.018		0.039		0.90		4.00		0.065		29.00		30.00		7.50	
Mean	1.82		0.71		0.003		0.019		0.60		3.45		0.042		10.11		9.68		4.15	
Std. Dev.	2.32		0.55		0.005		0.011		0.24		0.62		0.033		7.26		8.24		1.97	

Appendix A (cont.)

Perimeter Soil Stations (Year)	3H pCi/mL	(±σ)	137Cs pCi/g dry	(±σ)	238Pu pCi/g dry	(±σ)	239,240Pu pCi/g dry	(±σ)	90Sr pCi/g dry	(±σ)	Total Uranium ug/g dry	(±σ)	241Am pCi/g dry	(±σ)	Gross Alpha pCi/g dry	(±σ)	Gross Beta pCi/g dry	(±σ)	Gross Gamma pCi/g dry	(±σ)
TA-8/GT SITE																				
1976	1.6	(0.2)			0.001	(0.001)	0.008	(0.001)	1.08	(0.60)	2.3	(0.2)			7.4	(1.0)	5.6	(0.4)		
1977			1.94	(0.65)	-0.010	(0.020)	0.122	(0.108)	0.35	(0.03)	3.6	(2.2)			6.6	(0.6)	11.7	(0.9)		
1978	9.0	(0.4)	1.56	(0.13)	0.001	(0.003)	0.041	(0.008)							5.1	(1.2)	8.9	(1.0)		
1979	0.4	(0.3)	0.57	(0.05)	-0.001	(0.003)	0.026	(0.006)	0.79	(0.10)	4.0	(0.4)			9.0	(2.0)	14.0	(1.5)		
1980	0.6	(0.3)	1.20	(0.10)	0.001	(0.001)	0.034	(0.004)	2.90	(0.16)	3.3	(0.3)			14.0	(30.0)	21.0	(2.0)		
1981	0.3	(0.3)	0.00	(0.07)	0.004	(0.001)	0.101	(0.007)	1.90	(0.09)					21.0	(3.0)	33.0	(3.0)		
1982	2.9	(0.3)	2.69	(0.13)	0.005	(0.001)	0.085	(0.005)			3.9	(0.4)			6.8	(1.5)	15.0	(1.6)		
1983	2.1	(0.3)	0.25	(0.05)	0.001	(0.000)	0.002	(0.001)			2.5	(0.3)			3.8	(0.9)	4.4	(0.5)	4.1	(0.1)
1984	5.0	(0.6)	2.20	(0.30)	0.003	(0.001)	0.062	(0.005)			4.0	(0.1)							7.2	(0.3)
1985	-0.2	(0.2)	0.87	(0.09)	0.004	(0.001)	0.035	(0.002)			3.2	(0.2)							5.2	(0.2)
1986	2.0	(0.4)	1.90	(0.32)	0.005	(0.002)	0.054	(0.005)			3.2	(0.3)							5.9	(0.7)
1987	0.6	(0.5)	1.30	(0.22)	0.002	(0.001)	0.026	(0.004)			3.1	(0.3)							7.3	(0.9)
1988	-0.7	(0.3)	1.20	(0.22)	0.001	(0.001)	0.026	(0.004)			3.3	(0.3)							3.6	(0.6)
1989	2.9	(0.4)	0.08	(0.13)	0.001	(0.001)	0.006	(0.002)			2.0	(0.2)							1.7	(0.4)
1990																				
1991	0.2	(0.3)	1.20	(0.30)	0.002	(0.002)	0.048	(0.004)			3.1	(0.3)			6.0	(1.0)	6.0	(1.0)	2.0	(1.0)
1992	0.5	(0.3)	-0.10	(0.10)	0.003	(0.001)	0.022	(0.002)	0.40	(0.20)	2.1	(0.2)	0.125	(0.058)	7.0	(1.0)	4.0	(1.0)	1.0	(1.0)
1993	-0.2	(0.3)	2.10	(0.30)	0.008	(0.030)	0.068	(0.020)			1.7	(0.2)			6.0	(1.0)	8.0	(0.5)	4.0	(1.0)
1994	0.1	(0.3)	0.75	(0.10)	0.000	(0.001)	0.000	(0.001)	1.10	(0.20)	3.3	(0.6)	0.010	(0.003)	6.0	(1.0)	6.3	(0.7)	3.6	(0.4)
N	17		17		18		18		7		16		2		12		12		11	
Minimum	-0.70		-0.10		-0.010		0.000		0.35		1.70		0.010		3.80		4.00		1.00	
Maximum	9.00		2.69		0.008		0.122		2.90		4.00		0.125		21.00		33.00		7.30	
Mean	1.59		1.16		0.002		0.043		1.22		3.04		0.068		8.23		11.49		4.15	
Std. Dev.	2.40		0.84		0.004		0.034		0.91		0.72		0.081		4.75		8.47		2.11	
TA-49																				
1976	2.3	(0.2)			0.000	(0.000)	0.017	(0.002)			3.9	(0.2)			10.4	(2.0)	8.9	(0.6)		
1977			0.92	(0.58)	0.004	(0.000)	0.020	(0.020)	0.14	(0.07)	4.5	(0.3)			4.6	(2.9)	7.2	(6.0)		
1978	5.9	(0.4)	0.53	(0.05)	-0.001	(0.002)	0.008	(0.003)							5.2	(1.2)	6.2	(0.8)		
1979	0.4	(0.3)	1.04	(0.10)	-0.001	(0.002)	0.018	(0.004)			4.8	(0.5)			9.0	(2.0)	9.5	(1.1)		
1980	1.3	(0.3)	1.29	(0.08)	0.003	(0.001)	0.023	(0.003)	0.71	(0.07)	3.7	(0.4)	0.059	(0.005)	10.0	(2.0)	14.0	(1.5)		
1981	2.0	(0.3)	2.15	(0.09)	0.003	(0.001)	0.051	(0.006)	0.64	(0.05)					21.0	(5.0)	27.0	(3.0)		
1982	7.2	(0.4)	0.62	(0.05)	0.002	(0.001)	0.014	(0.003)			4.4	(0.4)			7.9	(1.8)	8.8	(1.0)		
1983	1.3	(0.3)	0.06	(0.45)	0.000	(0.001)	-0.001	(0.001)			3.2	(0.3)			9.0	(2.0)	7.5	(0.8)	7.3	(1.3)
1984	2.9	(0.4)	1.00	(0.10)	0.000	(0.001)	0.024	(0.003)			4.5	(0.2)							7.1	(0.3)
1985	-1.0	(0.2)	0.62	(0.06)	0.001	(0.001)	0.012	(0.001)			4.6	(0.2)							6.0	(0.4)
1986	1.2	(0.4)	0.10	(0.07)	0.000	(0.001)	0.002	(0.001)			3.8	(0.4)							7.4	(0.9)
1987	-0.1	(0.5)	0.34	(0.09)	0.000	(0.001)	0.004	(0.002)			4.8	(0.5)							7.1	(0.9)
1988	0.0	(0.3)	0.36	(0.12)	0.001	(0.001)	0.018	(0.003)			5.3	(0.5)							6.6	(0.8)
1989	1.5	(0.3)	1.19	(0.17)	0.002	(0.002)	0.048	(0.005)			4.3	(0.4)							3.5	(0.5)
1990																				
1991	-0.1	(0.3)	1.00	(0.20)	0.003	(0.002)	0.034	(0.003)			4.0	(0.4)			9.0	(2.0)	6.0	(1.0)	4.0	(1.0)
1992	0.2	(0.3)	0.10	(0.10)	0.004	(0.001)	0.008	(0.001)	0.20	(0.30)	3.5	(0.4)	0.247	(0.071)	13.0	(3.0)	5.0	(1.0)	1.0	(1.0)
1993	0.0	(0.3)	1.00	(0.20)	0.001	(0.030)	0.033	(0.020)			1.5	(0.4)			3.0	(1.0)	5.0	(0.5)	4.0	(0.0)
1994	-0.1	(0.3)	0.42	(0.07)	0.002	(0.001)	0.020	(0.002)	0.50	(0.20)	2.5	(0.3)	0.008	(0.003)	6.0	(1.0)	5.8	(0.6)	3.4	(0.4)
N	17		17		18		18		5		16		3		12		12		11	
Minimum	-1.00		0.06		-0.001		-0.001		0.14		1.50		0.008		3.00		5.00		1.00	
Maximum	7.20		2.15		0.004		0.051		0.71		5.30		0.247		21.00		27.00		7.40	
Mean	1.46		0.75		0.001		0.020		0.44		3.95		0.105		9.01		9.24		5.22	
Std. Dev.	2.18		0.53		0.002		0.014		0.26		0.96		0.126		4.70		6.13		2.14	

Appendix A (cont.)

Perimeter Soil Stations (Year)	3H pCi/mL	(±σ)	137Cs pCi/g dry	(±σ)	238Pu pCi/g dry	(±σ)	239,240Pu pCi/g dry	(±σ)	90Sr pCi/g dry	(±σ)	Total Uranium ug/g dry	(±σ)	241Am pCi/g dry	(±σ)	Gross Alpha pCi/g dry	(±σ)	Gross Beta pCi/g dry	(±σ)	Gross Gamma pCi/g dry	(±σ)
EAST OF AIRPORT																				
1978	12.2	(0.5)	0.59	(0.03)	0.000	(0.002)	0.030	(0.001)	0.92	(0.13)					5.1	(1.1)	6.2	(0.8)		
1979	0.3	(0.3)	0.43	(0.04)	0.001	(0.002)	0.013	(0.004)	1.10	(0.10)	4.0	(0.4)			8.4	(1.8)	7.9	(0.9)		
1980	1.6	(0.3)	0.81	(0.15)	0.000	(0.001)	0.023	(0.003)	0.74	(0.09)	4.3	(0.4)	0.012	(0.030)	10.0	(2.0)	13.0	(1.4)		
N	3		3		3		3		3		2		1		3		3			
Minimum	0.30		0.43		0.000		0.013		0.74		4.00		0.012		5.10		6.20			
Maximum	12.20		0.81		0.001		0.030		1.10		4.30		0.012		10.00		13.00			
Mean	4.70		0.61		0.000		0.022		0.92		4.15		0.012		7.83		9.03			
Std. Dev.	6.53		0.19		0.001		0.009		0.18		0.21				2.50		3.54			
WEST OF AIRPORT																				
1978	10.5	(1.6)	1.44	(0.26)	0.010	(0.013)	0.284	(0.249)							4.5	(1.0)	7.9	(0.9)		
1979	0.9	(0.3)	1.18	(0.10)	0.004	(0.002)	0.066	(0.006)	0.03	(0.07)	5.3	(0.5)			7.7	(1.7)	9.0	(1.0)		
1980	4.7	(0.3)	1.17	(0.01)	0.001	(0.001)	0.129	(0.008)	0.62	(0.08)	4.9	(0.5)	0.015	(0.030)	9.0	(6.0)	13.0	(1.4)		
1981	3.8	(0.3)	0.70	(0.05)	0.001	(0.001)	0.061	(0.006)	0.36	(0.07)					12.0	(3.0)	14.0	(1.5)		
N	4		4		4		4		3		2		1		4		4			
Minimum	0.90		0.70		0.001		0.061		0.03		4.90		0.015		4.50		7.90			
Maximum	10.50		1.44		0.010		0.284		0.62		5.30		0.015		12.00		14.00			
Mean	4.98		1.12		0.004		0.135		0.34		5.10		0.015		8.30		10.98			
Std. Dev.	4.02		0.31		0.004		0.104		0.30		0.28				3.11		2.98			
FRIJOLES																				
1977			0.87	(0.11)	0.002	(0.004)	0.020	(0.004)	0.44	(0.14)	2.0	(0.9)			5.6	(1.6)	6.4	(0.2)		
1978	4.0	(0.4)	1.37	(0.17)	0.000	(0.001)	0.029	(0.003)							5.7	(1.2)	7.1	(0.8)		
1979	96.0	(1.6)	1.29	(0.12)	-0.002	(0.002)	0.024	(0.005)			4.7	(0.5)			10.0	(2.0)	13.0	(1.4)		
1980	14.0	(0.5)	1.18	(0.08)	-0.001	(0.001)	0.018	(0.003)	0.40	(0.08)	3.4	(0.3)			7.2	(1.6)	11.0	(1.2)		
1981	0.4	(0.3)	0.77	(0.06)	0.002	(0.003)	0.035	(0.007)	0.75	(0.06)					17.0	(4.0)	22.0	(2.0)		
N	4		5		5		5		3		3				5		5			
Minimum	0.40		0.77		-0.002		0.018		0.40		2.00				5.60		6.40			
Maximum	96.00		1.37		0.002		0.035		0.75		4.70				17.00		22.00			
Mean	28.60		1.10		0.000		0.025		0.53		3.37				9.10		11.90			
Std. Dev.	45.30		0.26		0.002		0.007		0.19		1.35				4.76		6.27			
NORTH MESA																				
1976																				
1977																				
1978	8.6	(0.4)	0.51	(0.05)	-0.002	(0.002)	0.015	(0.005)	0.87	(0.13)					4.3	(1.0)	6.1	(0.7)		
1979	0.5	(0.3)	0.90	(0.08)	-0.001	(0.002)	0.057	(0.006)			4.4	(0.4)			9.0	(2.0)	9.4	(1.1)		
1980	3.6	(0.3)	0.73	(0.14)	-0.001	(0.001)	0.010	(0.003)	0.47	(0.12)	4.3	(0.4)			8.8	(1.9)	9.5	(1.1)		
1981																				
1982	5.9	(0.4)	0.54	(0.03)	0.001	(0.001)	0.049	(0.006)			4.7	(0.5)			10.0	(2.0)	9.3	(1.1)		
1983	1.9	(0.3)	1.11	(0.12)	0.000	(0.000)	0.029	(0.004)			4.2	(0.4)			6.9	(1.6)	10.0	(1.1)	6.1	(0.1)
1984	2.0	(0.6)	0.40	(0.10)	0.000	(0.001)	0.014	(0.003)			3.6	(0.1)							5.8	(0.3)
1985	-0.6	(0.2)	0.31	(0.03)	0.000	(0.001)	0.009	(0.001)			4.0	(0.2)							5.8	(0.4)
1986	2.1	(0.5)	0.01	(0.06)	0.003	(0.002)	0.006	(0.002)			4.0	(0.4)							6.1	(0.7)
1987	0.4	(0.5)	0.25	(0.08)	0.001	(0.001)	0.008	(0.002)			3.8	(0.4)							6.3	(0.8)
1988	0.9	(0.3)	0.61	(0.08)	0.003	(0.001)	0.002	(0.001)			3.9	(0.4)							5.1	(0.7)
1989	2.5	(0.4)	0.29	(0.07)	0.000	(0.001)	0.004	(0.001)			3.1	(0.3)							2.5	(0.4)
1990																				
1991	0.9	(0.3)	0.30	(0.10)	0.003	(0.001)	0.017	(0.002)			4.2	(0.4)			11.0	(2.0)	5.0	(1.0)	3.0	(1.0)

Appendix A (cont.)

Perimeter Soil Stations (Year)	3H pCi/mL	(±σ)	137Cs pCi/g dry	(±σ)	238Pu pCi/g dry	(±σ)	239,240Pu pCi/g dry	(±σ)	90Sr pCi/g dry	(±σ)	Total Uranium ug/g dry	(±σ)	241Am pCi/g dry	(±σ)	Gross Alpha pCi/g dry	(±σ)	Gross Beta pCi/g dry	(±σ)	Gross Gamma pCi/g dry	(±σ)
NORTH MESA (cont.)																				
1992	0.3	(0.3)	-0.10	(0.10)	0.011	(0.002)	0.016	(0.002)	0.30	(0.20)	3.9	(0.4)	0.041	(0.054)	15.0	(3.0)	5.0	(1.0)	2.0	(1.0)
1993	0.3	(0.3)	0.10	(0.00)	0.000	(0.030)	0.015	(0.020)			2.0	(0.2)			3.0	(1.0)	3.0	(0.0)	3.0	(0.0)
1994	-0.1	(0.3)	0.07	(0.03)	0.004	(0.001)	0.005	(0.001)	0.20	(0.20)	2.5	(0.7)	0.003	(0.002)	4.5	(1.0)	3.2	(0.4)	3.5	(0.4)
N	17		17		17		17		6		16		4		11		11		13	
Minimum	-0.60		-0.10		-0.002		0.000		0.00		0.00		0.000		0.00		0.00		0.00	
Maximum	8.60		1.11		0.011		0.057		0.87		4.70		0.041		15.00		10.00		6.30	
Mean	1.72		0.35		0.001		0.015		0.31		3.29		0.011		6.59		5.50		3.78	
Std. Dev.	2.40		0.34		0.003		0.016		0.33		1.46		0.020		4.71		3.73		2.27	
SOUTH SR-4																				
1978	3.4	(0.4)	1.32	(0.10)	0.002	(0.002)	0.018	(0.004)	0.85	(0.13)					5.1	(1.1)	6.9	(0.8)		
1979	3.0	(0.4)	0.96	(0.09)	0.001	(0.002)	0.019	(0.003)			5.1	(0.5)			7.2	(1.6)	8.7	(1.0)		
1980			1.14	(0.11)	-0.002	(0.003)	0.054	(0.008)	0.66	(0.10)	0.6	(0.3)	0.020	(0.030)	8.8	(1.9)	3.9	(0.4)		
1981	0.1	(0.3)	2.00	(0.10)	0.003	(0.001)	0.029	(0.004)	0.71	(0.09)					17.0	(4.0)	17.0	(2.0)		
N	3		4		4		4		3		2		1		4		4			
Minimum	0.10		0.96		-0.002		0.018		0.66		0.60		0.020		5.10		3.90			
Maximum	3.40		2.00		0.003		0.054		0.85		5.10		0.020		17.00		17.00			
Mean	2.17		1.36		0.001		0.030		0.74		2.85		0.020		9.53		9.13			
Std. Dev.	1.80		0.45		0.002		0.017		0.10		3.18				5.21		5.61			
SPORTSMAN'S CLUB																				
1976	3.0	(0.2)			0.003	(0.001)	0.016	(0.002)	5.31	(1.00)	2.5	(0.2)			3.8	(0.5)	4.4	(0.4)		
1977			0.93	(0.16)	-0.003	(0.001)	0.018	(0.005)	-0.01	(0.04)	2.9	(0.2)			7.4	(2.3)	8.6	(0.2)		
1978	3.0	(0.4)	1.08	(0.09)	0.000	(0.003)	0.021	(0.004)	0.87	(0.13)					6.2	(1.4)	7.9	(0.9)		
1979	0.5	(0.3)	1.01	(0.11)	-0.004	(0.002)	0.024	(0.005)			4.2	(0.4)			7.2	(1.6)	8.3	(1.0)		
1980	0.7	(0.3)	0.34	(0.07)	0.000	(0.001)	0.009	(0.002)	0.27	(0.14)	3.9	(0.4)			10.0	(2.0)	12.0	(1.3)		
1981	6.3	(0.4)	0.05	(0.06)	0.000	(0.001)	0.048	(0.007)	0.71	(0.06)					21.0	(5.0)	25.0	(3.0)		
1982	5.5	(0.3)	1.56	(0.08)	0.001	(0.002)	0.082	(0.008)			4.3	(0.4)			8.8	(1.9)	12.0	(1.3)		
1983	2.3	(0.3)	0.91	(0.09)	0.000	(0.001)	0.024	(0.002)			3.7	(0.4)			11.0	(2.0)	9.7	(1.0)	6.2	(0.1)
1984	1.5	(0.3)	0.60	(0.10)	0.002	(0.001)	0.020	(0.003)			3.8	(0.1)							6.0	(0.3)
1985	-1.2	(0.2)	0.50	(0.06)	-0.001	(0.001)	0.017	(0.002)			3.6	(0.1)							6.3	(0.4)
1986	1.5	(0.4)	0.17	(0.07)	0.000	(0.002)	0.013	(0.003)			5.1	(0.5)							7.7	(0.9)
1987	1.1	(0.5)	0.29	(0.09)	0.001	(0.001)	0.018	(0.003)			4.2	(0.4)							4.4	(0.7)
1988	-1.1	(0.3)	1.30	(0.24)	0.001	(0.001)	0.022	(0.004)			3.2	(0.3)							6.0	(0.8)
1989	3.8	(0.5)	0.33	(0.13)	0.008	(0.002)	0.011	(0.002)			3.1	(0.3)							1.9	(0.4)
1990																				
1991	0.1	(0.3)	0.30	(0.10)	0.003	(0.002)	0.008	(0.003)			3.5	(0.4)			12.0	(3.0)	6.0	(1.0)	3.0	(1.0)
1992	0.5	(0.3)	0.00	(0.10)	0.011	(0.002)	0.012	(0.002)	0.30	(0.20)	2.3	(0.2)	0.179	(0.058)	8.0	(2.0)	4.0	(1.0)	2.0	(1.0)
1993	0.4	(0.3)	0.20	(0.10)	0.004	(0.030)	0.006	(0.020)			1.8	(0.5)			4.0	(1.0)	4.0	(0.0)	4.0	(0.0)
1994	-0.2	(0.3)	0.26	(0.05)	0.004	(0.002)	0.018	(0.003)	0.30	(0.20)	3.4	(0.4)	0.005	(0.002)	6.0	(1.0)	6.7	(0.7)	3.3	(0.4)
N	17		17		18		18		7		16		2		12		12		11	
Minimum	-1.20		0.00		-0.004		0.006		-0.01		1.80		0.005		3.80		4.00		1.90	
Maximum	6.30		1.56		0.011		0.082		5.31		5.10		0.179		21.00		25.00		7.70	
Mean	1.63		0.58		0.002		0.022		1.11		3.47		0.092		8.78		9.05		4.62	
Std. Dev.	2.12		0.47		0.004		0.018		1.88		0.83		0.123		4.60		5.73		1.94	
TSANKAWI/PM-1																				
1976	3.5	(0.2)			0.001	(0.002)	0.013	(0.002)	5.55	(1.25)	2.7	(0.3)			4.9	(0.8)	5.0	(0.4)		
1977			0.62	(0.01)	0.001	(0.002)	0.014	(0.004)	0.46	(0.14)	4.6	(0.3)			6.1	(1.1)	8.2	(1.1)		
1978	29.7	(0.7)	0.41	(0.06)	-0.002	(0.002)	0.011	(0.003)							5.8	(1.3)	7.5	(0.9)		

Appendix A (cont.)

Perimeter Soil Stations (Year)	3H pCi/mL	(±σ)	137Cs pCi/g dry	(±σ)	238Pu pCi/g dry	(±σ)	239,240Pu pCi/g dry	(±σ)	90Sr pCi/g dry	(±σ)	Total Uranium ug/g dry	(±σ)	241Am pCi/g dry	(±σ)	Gross Alpha pCi/g dry	(±σ)	Gross Beta pCi/g dry	(±σ)	Gross Gamma pCi/g dry	(±σ)
TSANKAWI/PM-1 (cont.)																				
1979	1.3	(0.3)	0.94	(0.08)	0.002	(0.003)	0.022	(0.002)			6.5	(0.7)			11.0	(2.0)	15.0	(1.6)		
1980	3.1	(0.3)	0.75	(0.07)	0.002	(0.001)	0.013	(0.003)	0.73	(0.11)	5.9	(0.6)			8.9	(1.9)	11.0	(1.2)		
1981																				
1982	12.0	(0.4)	1.37	(0.05)	0.000	(0.000)	0.019	(0.003)			6.3	(0.6)			5.8	(1.3)	8.7	(1.0)		
1983	1.4	(0.3)	0.86	(0.12)	0.002	(0.001)	0.008	(0.002)			5.9	(0.6)			6.0	(1.3)	9.7	(1.0)	10.0	(0.2)
1984	5.8	(0.7)	0.40	(0.10)	0.000	(0.000)	0.006	(0.001)			5.0	(0.3)							9.3	(0.3)
1985	-0.4	(0.2)	0.43	(0.05)	0.001	(0.001)	0.012	(0.001)			5.9	(0.3)							11.0	(0.5)
1986	4.3	(0.6)	0.83	(0.15)	0.005	(0.002)	0.017	(0.003)			5.9	(0.6)							11.0	(1.0)
1987	1.5	(0.5)	0.27	(0.07)	0.029	(0.004)	0.009	(0.002)			5.3	(0.5)							9.0	(1.0)
1988	-0.2	(0.3)	0.08	(0.09)	-0.001	(0.001)	0.001	(0.001)			5.9	(0.6)							10.0	(1.0)
1989	2.6	(0.4)	0.33	(0.09)	0.003	(0.001)	0.014	(0.002)			5.8	(0.6)							6.2	(0.7)
1990																				
1991	0.1	(0.3)	0.70	(0.20)	0.003	(0.002)	0.013	(0.002)			4.0	(0.4)			10.0	(2.0)	5.0	(1.0)	3.0	(1.0)
1992	0.2	(0.3)	-0.20	(0.10)	0.011	(0.002)	0.011	(0.002)	0.40	(0.20)	5.5	(0.5)	0.082	(0.060)	9.0	(2.0)	4.0	(0.0)	5.0	(1.0)
1993	-0.1	(0.3)	0.10	(0.10)	0.003	(0.030)	0.025	(0.020)			3.2	(0.3)			3.0	(1.0)	4.0	(0.0)	4.0	(0.0)
1994	-0.5	(0.3)	0.10	(0.04)	0.005	(0.001)	0.006	(0.001)	0.70	(0.20)	4.8	(0.5)	0.002	(0.001)	3.8	(0.8)	3.4	(0.4)	5.1	(0.5)
N	16		16		17		17		5		16		2		11		11		11	
Minimum	-0.50		-0.20		-0.002		0.001		0.40		2.70		0.002		3.00		3.40		3.00	
Maximum	29.70		1.37		0.029		0.025		5.55		6.50		0.082		11.00		15.00		11.00	
Mean	4.02		0.50		0.004		0.013		1.57		5.20		0.042		6.75		7.41		7.60	
Std. Dev.	7.55		0.40		0.007		0.006		2.23		1.10		0.057		2.59		3.59		2.98	
WHITE ROCK (EAST)																				
1982	14.0	(0.4)	0.70	(0.08)	0.001	(0.001)	0.039	(0.006)			4.0	(0.4)			7.2	(1.6)	7.6	(0.9)		
1983	1.3	(0.3)	0.55	(0.08)	0.002	(0.001)	0.005	(0.001)			3.7	(0.4)			15.0	(3.0)	9.3	(1.0)	14.0	(0.2)
1984	4.3	(0.5)	0.30	(0.10)	0.000	(0.000)	0.010	(0.002)			3.1	(0.1)							6.2	(0.3)
1985	-0.7	(0.2)	1.00	(0.09)	0.003	(0.001)	0.026	(0.002)			3.3	(0.1)							7.2	(0.4)
1986	2.8	(0.5)	0.35	(0.09)	0.001	(0.001)	0.005	(0.002)			4.3	(0.4)							7.9	(0.9)
1987	2.8	(0.6)	0.24	(0.08)	0.001	(0.001)	0.010	(0.002)			4.0	(0.4)							7.5	(0.9)
1988	0.0	(0.3)	0.13	(0.12)	0.001	(0.001)	0.004	(0.001)			4.1	(0.4)							6.8	(0.8)
1989	1.7	(0.3)	0.34	(0.14)	0.001	(0.001)	0.007	(0.001)			3.3	(0.3)							4.1	(0.6)
1990																				
1991	0.1	(0.3)	0.70	(0.20)	0.007	(0.002)	0.020	(0.002)			3.5	(0.4)			12.0	(3.0)	6.0	(1.0)	4.0	(1.0)
1992	0.1	(0.3)	0.10	(0.10)	0.002	(0.001)	0.014	(0.002)	0.20	(0.30)	3.5	(0.4)	0.087	(0.067)	10.0	(2.0)	69	(7.0)	2.0	(1.0)
1993	-0.1	(0.3)	0.00	(0.00)	0.006	(0.030)	0.002	(0.020)			2.0	(0.2)			4.0	(1.0)	4.0	(0.0)	4.0	(0.0)
1994	-0.3	(0.3)	0.21	(0.05)	0.008	(0.001)	0.011	(0.001)	0.10	(0.20)	2.5	(0.3)	0.003	(0.001)	6.0	(1.0)	5.1	(0.6)	3.4	(0.4)
N	12		12		12		12		2		12		2		6		6		11	
Minimum	-0.70		0.00		0.000		0.002		0.10		2.00		0.003		4.00		4.00		2.00	
Maximum	14.00		1.00		0.008		0.039		0.20		4.30		0.087		15.00		69.00		14.00	
Mean	2.17		0.39		0.003		0.013		0.15		3.44		0.045		9.03		16.83		6.10	
Std. Dev.	4.03		0.30		0.003		0.011		0.07		0.68		0.059		4.08		25.62		3.26	

Appendix A. (cont.)

Regional Soil Stations (Month-Year)	3H pCi/mL	(± σ)	137Cs pCi/g dry	(± σ)	238Pu pCi/g dry	(± σ)	239,240Pu pCi/g dry	(± σ)	90Sr pCi/g dry	(± σ)	Total Uranium ug/g dry	(± σ)	241Am pCi/g dry	(± σ)	Gross Alpha pCi/g dry	(± σ)	Gross Beta pCi/g dry	(± σ)	Gross Gamma pCi/g dry	(± σ)
BERNALILLO																				
Jul-74			0.33	(0.12)	0.000	(0.001)	0.006	(0.002)												
May-75					0.001	(0.001)	0.012	(0.002)												
Oct-75					0.000	(0.001)	0.001	(0.001)												
Apr-76			0.24	(0.02)	0.000	(0.001)	0.004	(0.001)												
Oct-76					0.002	(0.001)	0.002	(0.001)												
Mar-77			0.06	(0.02)	-0.002	(0.006)	-0.002	(0.000)	0.05	(0.01)										
Oct-77			0.32	(0.03)	0.000	(0.001)	0.002	(0.002)	0.24	(0.10)					4.9	(0.4)	5.2	(0.9)		
Mar-78	4.7	(0.4)	0.15	(0.05)	-0.001	(0.001)	0.000	(0.002)							3.1	(0.8)	3.4	(0.5)	1.9	(0.1)
Mar-79	1.9	(0.3)	0.56	(0.06)	0.000	(0.001)	0.010	(0.004)	0.18	(0.05)	2.10	(0.20)	0.002	(0.002)	4.8	(1.3)	6.0	(0.8)	0.7	(0.1)
Feb-80	0.9	(0.3)	0.37	(0.10)	-0.001	(0.001)	0.006	(0.002)	0.06	(0.05)	2.10	(0.20)	0.007	(0.003)	5.1	(1.2)	6.6	(0.8)	2.3	(0.1)
Mar-81	4.9	(0.3)	0.00	(0.05)	0.001	(0.001)	0.006	(0.002)	0.49	(0.07)					4.5	(1.1)	5.6	(0.7)	1.2	(0.1)
Mar-82	2.9	(0.3)	0.28	(0.04)	0.001	(0.000)	0.002	(0.001)			2.20	(0.20)			3.7	(0.9)	4.2	(0.6)		
Feb-83	3.6	(0.5)	0.08	(0.03)	0.001	(0.000)	0.000	(0.001)			2.20	(0.20)			4.1	(1.1)	4.9	(0.6)	2.8	(0.1)
Feb-84	8.8	(0.9)	0.30	(0.10)	0.000	(0.001)	0.002	(0.001)			1.90	(0.10)							2.0	(0.3)
Mar-85	0.0	(0.3)	0.22	(0.09)	0.000	(0.001)	0.001	(0.001)			1.60	(0.20)							1.2	(0.3)
Feb-86	2.0	(0.5)	0.22	(0.08)	0.001	(0.001)	0.002	(0.001)			1.30	(0.20)							1.0	(0.3)
Apr-87	13	(1.0)	0.60	(0.13)	0.002	(0.001)	0.013	(0.003)			1.90	(0.20)							3.7	(0.7)
Apr-88	-0.1	(0.3)	0.38	(0.13)	0.002	(0.001)	0.008	(0.002)			1.40	(0.20)							1.8	(0.5)
May-89	1.1	(0.3)	0.39	(0.13)	0.002	(0.001)	0.007	(0.001)			1.50	(0.20)							0.3	(0.4)
Apr-90	0.5	(0.3)	0.16	(0.07)	0.000	(0.004)	0.001	(0.001)			1.50	(0.20)							0.8	(0.4)
Dec-91	-0.1	(0.3)	0.30	(0.10)	0.001	(0.001)	0.004	(0.002)			1.90	(0.20)			6.0	(1.0)	3.0	(0.0)	2.0	(0.0)
Jul-92	0.2	(0.3)	0.10	(0.10)	0.001	(0.001)	0.002	(0.001)	0.20	(0.20)	2.90	(0.30)	0.100	(0.053)	5.0	(1.0)	3.0	(0.0)	-2.0	(1.0)
Jul-93	0.0	(0.3)	0.10	(0.00)	0.005	(0.030)	0.003	(0.020)			2.90	(0.30)			10.0	(4.0)	3.0	(0.0)	2.0	(0.0)
Jul-94	-0.3	(0.3)	0.03	(0.03)	0.003	(0.001)	0.006	(0.001)	0.80	(0.20)	1.32	(0.15)	0.001	(0.001)	2.5	(0.6)	2.1	(0.3)	1.5	(0.2)
N	17		21		24		24		7		15		4		11		11		16	
Minimum	-0.30		0.00		-0.002		-0.002		0.05		1.30		0.001		2.50		2.10		-2.00	
Maximum	13.00		0.60		0.005		0.013		0.80		2.90		0.100		10.00		6.60		3.70	
Mean	2.59		0.25		0.001		0.004		0.29		1.91		0.028		4.88		4.27		1.45	
Std. Dev.	3.62		0.16		0.001		0.004		0.27		0.51		0.048		1.96		1.48		1.25	
CHAMITA																				
Jul-74			0.81	(0.13)	0.001	(0.001)	0.006	(0.002)												
May-75																				
Oct-75					0.000	(0.001)	0.017	(0.003)												
Mar-76			0.68	(0.03)	0.001	(0.001)	0.008	(0.002)												
Oct-76					0.002	(0.002)	0.014	(0.002)	0.38	(0.16)										
Mar-77			0.75	(0.06)	-0.002	(0.001)	0.017	(0.003)	0.09	(0.07)										
Oct-77			0.57	(0.08)	-0.001	(0.000)	0.010	(0.003)	0.29	(0.09)					7.0	(4.3)	4.0	(0.4)		
Mar-78	5.8	(0.4)	0.68	(0.06)	0.000	(0.001)	0.013	(0.002)							3.4	(0.8)	4.9	(0.7)	3.7	(0.1)
Mar-79	1.3	(0.3)	0.82	(0.07)					0.44	(0.08)	2.30	(0.20)	0.022	(0.003)	5.4	(1.2)	8.1	(0.9)		
Feb-80	2.2	(0.3)	0.67	(0.06)	0.000	(0.002)	0.005	(0.002)	0.43	(0.10)	2.30	(0.20)	0.008	(0.003)	6.0	(1.4)	7.0	(0.8)	3.5	(0.1)
Mar-81	0.2	(0.3)	0.69	(0.06)	0.010	(0.006)	0.013	(0.003)	0.45	(0.10)					5.5	(1.4)	9.1	(1.1)	3.8	(0.1)
Mar-82	2.2	(0.3)	0.73	(0.04)	0.001	(0.001)	0.011	(0.003)			3.20	(0.30)			4.1	(1.1)	9.1	(1.1)		
Feb-83	1.4	(0.3)	0.14	(0.03)	0.003	(0.000)	0.000	(0.000)			3.20	(0.30)			3.5	(0.9)	3.3	(0.4)	1.6	(0.1)
Feb-84	1.5	(0.3)	0.80	(0.05)	0.001	(0.001)	0.020	(0.003)			3.90	(0.20)							3.7	(0.3)
Mar-85	-0.8	(0.3)	0.67	(0.07)	0.000	(0.001)	0.014	(0.003)			3.10	(0.20)							3.4	(0.4)
Feb-86	6.4	(0.8)	0.25	(0.04)	0.001	(0.001)	0.003	(0.001)			1.70	(0.20)							1.2	(0.3)
Apr-87	0.2	(0.5)	0.24	(0.07)	0.002	(0.001)	0.008	(0.002)			5.40	(0.50)							6.4	(0.8)
Apr-88	-0.2	(0.3)	0.16	(0.08)	0.000	(0.001)	0.002	(0.001)			1.30	(0.20)							0.5	(0.5)
May-89	0.8	(0.3)	0.25	(0.10)	0.001	(0.001)	0.014	(0.002)			2.80	(0.30)							1.8	(0.4)
Apr-90	0.7	(0.3)	0.36	(0.08)	0.104	(0.007)	0.092	(0.007)			3.60	(0.40)							1.5	(0.4)
Dec-91	0.2	(0.3)	0.20	(0.10)	0.000	(0.002)	0.001	(0.001)			2.20	(0.20)			10.0	(2.0)	4.0	(1.0)	2.0	(1.0)
Jul-92	0.4	(0.3)	-0.20	(0.10)	0.002	(0.001)	0.005	(0.001)	0.00	(0.30)	2.10	(0.20)	0.048	(0.061)	8.0	(2.0)	5.0	(1.0)	-2.0	(1.0)
Jul-93	0.2	(0.3)	0.70	(0.10)	0.003	(0.030)	0.027	(0.020)			1.40	(0.20)			3.0	(1.0)	4.0	(0.5)	3.0	(0.0)
Jul-94	-0.1	(0.3)	0.19	(0.04)	0.001	(0.001)	0.008	(0.001)	0.50	(0.20)	1.54	(0.15)	0.006	(0.001)	3.8	(0.9)	5.4	(0.6)	2.0	(0.3)

Appendix A. (cont.)

Regional Soil Stations (Month-Year)	3H pCi/mL	(± σ)	137Cs pCi/g dry	(± σ)	238Pu pCi/g dry	(± σ)	239,240Pu pCi/g dry	(± σ)	90Sr pCi/g dry	(± σ)	Total Uranium ug/g dry	(± σ)	241Am pCi/g dry	(± σ)	Gross Alpha pCi/g dry	(± σ)	Gross Beta pCi/g dry	(± σ)	Gross Gamma pCi/g dry	(± σ)
CHAMITA (cont.)																				
N	17		21		22		22		8		15		4		11		11		15	
Minimum	-0.80		-0.20		-0.002		0.000		0.00		1.30		0.006		3.00		3.30		-2.00	
Maximum	6.40		0.82		0.104		0.092		0.50		5.40		0.048		10.00		9.10		6.40	
Mean	1.32		0.48		0.006		0.014		0.32		2.67		0.021		5.43		5.81		2.41	
Std. Dev.	1.98		0.29		0.022		0.019		0.18		1.11		0.019		2.20		2.15		1.90	
COCHITI																				
May-75					0.000	(0.001)	0.002	(0.002)												
Oct-75					0.001	(0.001)	0.000	(0.000)												
Apr-76					0.000	(0.001)	0.004	(0.001)	1.00	(1.20)										
Oct-76					0.001	(0.001)	0.003	(0.002)												
Mar-77			0.12	(0.09)	-0.002	(0.002)	0.001	(0.002)	0.03	(0.03)										
Oct-77			0.48	(0.05)	0.001	(0.002)	0.003	(0.002)	0.34	(0.11)					7.0	(4.3)	6.6	(0.9)		
Mar-78	4.9	(0.4)	0.62	(0.08)	0.000	(0.002)	0.004	(0.002)							3.6	(0.9)	5.4	(0.7)	3.5	(0.1)
Mar-79	0.8	(0.3)	0.25	(0.06)	-0.001	(0.002)	0.003	(0.002)	0.10	(0.05)	2.80	(0.30)	0.004	(0.002)	7.8	(1.8)	9.8	(1.1)	4.6	(0.1)
Feb-80	2.0	(0.3)	0.54	(0.10)	-0.005	(0.002)	0.004	(0.005)	0.54	(0.10)	2.40	(0.20)			6.0	(1.4)	7.9	(0.9)	3.4	(0.1)
Mar-81	3.0	(0.3)	0.00	(0.06)	0.001	(0.000)	0.052	(0.006)	0.29	(0.04)					19.0	(4.0)	17.0	(1.9)	4.8	(0.1)
Mar-82	5.0	(0.3)	0.52	(0.04)	0.002	(0.002)	0.006	(0.003)			2.90	(0.30)			11.0	(3.0)	11.0	(1.2)		
Feb-83	2.8	(0.4)	0.23	(0.03)	0.000	(0.001)	0.002	(0.001)			2.60	(0.30)							4.0	(0.1)
Feb-84	5.3	(0.6)	0.40	(0.15)	0.000	(0.001)	0.012	(0.003)			2.70	(0.10)							3.8	(0.3)
Mar-85	-0.8	(0.3)	0.39	(0.09)	0.000	(0.001)	0.002	(0.001)											4.3	(0.5)
Feb-86	2.8	(0.5)	0.60	(0.12)	0.000	(0.001)	0.014	(0.003)			3.00	(0.30)							5.2	(0.6)
Apr-87	4.7	(0.7)	0.43	(0.09)	0.000	(0.001)	0.016	(0.003)			3.00	(0.30)							4.1	(0.7)
Apr-88	-0.4	(0.3)	0.34	(0.10)	0.002	(0.001)	0.010	(0.002)			2.70	(0.30)							4.4	(0.6)
May-89	0.5	(0.3)	0.38	(0.08)	0.002	(0.001)	0.010	(0.002)			2.40	(0.20)							2.3	(0.4)
Apr-90	0.5	(0.3)	0.37	(0.12)	0.000	(0.004)	0.005	(0.001)			1.90	(0.20)							0.5	(0.4)
Dec-91	0.1	(0.3)	1.70	(0.30)	0.001	(0.002)	0.014	(0.002)			2.50	(0.30)			13.0	(3.0)	4.0	(1.0)	4.0	(1.0)
Jul-92	-0.1	(0.3)	0.10	(0.10)	0.015	(0.002)	0.004	(0.001)	0.20	(0.20)	2.50	(0.30)	0.174	(0.058)	10.0	(2.0)	4.0	(0.0)	-2.0	(1.0)
Jul-93	0.2	(0.3)	0.10	(0.10)	0.001	(0.030)	0.010	(0.020)			1.20	(0.20)			4.0	(1.0)	4.0	(0.0)	3.0	(0.0)
Jul-94	-0.6	(0.3)	0.22	(0.05)	0.003	(0.001)	0.009	(0.001)	0.40	(0.20)	1.92	(0.44)	0.004	(0.001)	5.0	(1.0)	5.7	(0.6)	3.0	(0.3)
N	17		19		23		23		8		14		3		10		10		16	
Minimum	-0.80		0.00		-0.005		0.000		0.03		1.20		0.004		3.60		4.00		-2.00	
Maximum	5.30		1.70		0.015		0.052		1.00		3.00		0.174		19.00		17.00		5.20	
Mean	1.81		0.41		0.001		0.008		0.36		2.47		0.061		8.64		7.54		3.31	
Std. Dev.	2.16		0.36		0.003		0.011		0.30		0.50		0.098		4.76		4.13		1.80	
EMBUDO																				
Jul-74			0.56	(0.13)	0.001	(0.001)	0.005	(0.001)												
May-75					0.000	(0.001)	0.008	(0.002)												
Nov-75					0.000	(0.001)	0.009	(0.002)												
Mar-76			0.77	(0.03)	0.001	(0.001)	0.012	(0.002)	0.90	(1.00)										
Oct-76					0.003	(0.002)	0.019	(0.003)												
Mar-77			0.37	(0.03)	0.001	(0.005)	0.010	(0.005)	0.40	(0.10)										
Oct-77			0.72	(0.08)	-0.002	(0.002)	0.015	(0.006)							4.1	(0.3)	7.0	(1.5)		
Mar-78			1.20	(0.20)											3.9	(0.9)	5.8	(0.7)	3.4	(0.1)
Mar-79	0.6	(0.3)	0.88	(0.09)	0.000	(0.002)	0.020	(0.003)	0.26	(0.07)	3.30	(0.30)	0.003	(0.004)	11.0	(2.0)	12.0	(1.3)	1.4	(0.1)
Feb-80	2.5	(0.3)	0.79	(0.09)	0.001	(0.002)	0.017	(0.005)	0.33	(0.08)	2.10	(0.20)			5.4	(1.2)	8.4	(1.0)	3.0	(0.1)
Mar-81	1.2	(0.3)	1.10	(0.11)	0.001	(0.001)	0.021	(0.004)	0.33	(0.06)					9.0	(2.0)	13.0	(1.4)	3.7	(0.1)
Mar-82	3.7	(0.3)	1.40	(0.08)	0.004	(0.001)	0.029	(0.004)			2.20	(0.20)			5.6	(1.3)	9.1	(1.0)		
Feb-83	1.4	(0.3)	0.04	(0.04)	0.006	(0.003)	0.001	(0.001)			2.60	(0.30)			4.5	(1.1)	3.4	(0.4)	7.9	(0.1)
Feb-84	5.4	(0.6)	0.90	(0.15)	0.000	(0.001)	0.016	(0.003)			2.20	(0.10)							8.5	(0.3)
Mar-85	-0.7	(0.3)	0.94	(0.18)	0.001	(0.001)	0.018	(0.003)			2.20	(0.20)							3.2	(0.4)
Feb-86	0.8	(0.4)	0.69	(0.13)	0.001	(0.002)	0.017	(0.003)			2.40	(0.20)							3.7	(0.5)
Apr-87	0.1	(0.5)	0.25	(0.10)	0.000	(0.001)	0.007	(0.002)			4.80	(0.50)							6.0	(0.8)

Appendix A. (cont.)

Regional Soil Stations (Month-Year)	3H pCi/mL	(± σ)	137Cs pCi/g dry	(± σ)	238Pu pCi/g dry	(± σ)	239,240Pu pCi/g dry	(± σ)	90Sr pCi/g dry	(± σ)	Total Uranium ug/g dry	(± σ)	241Am pCi/g dry	(± σ)	Gross Alpha pCi/g dry	(± σ)	Gross Beta pCi/g dry	(± σ)	Gross Gamma pCi/g dry	(± σ)
EMBUDO (cont.)																				
Apr-88	-0.2	(0.3)	0.11	(0.11)	0.014	(0.003)	0.011	(0.003)			2.20	(0.20)							2.5	(0.3)
May-89	1.0	(0.3)	0.88	(0.18)	0.001	(0.001)	0.016	(0.002)			2.00	(0.20)							1.7	(0.4)
Apr-90	0.8	(0.3)	0.72	(0.13)	0.000	(0.001)	0.013	(0.002)			2.10	(0.20)							1.3	(0.4)
Dec-91	-0.2	(0.3)	0.80	(0.20)	0.001	(0.002)	0.016	(0.002)			2.30	(0.20)			8.0	(2.0)	17.0	(2.0)	2.0	(0.0)
Jul-92	0.0	(0.3)	0.10	(0.10)	0.002	(0.001)	0.021	(0.002)	0.30	(0.20)	1.90	(0.20)	0.033	(0.450)	7.0	(2.0)	5.0	(1.0)	-2.0	(1.0)
Jul-93	-0.2	(0.3)	0.60	(0.10)	0.004	(0.030)	0.018	(0.020)			0.80	(0.10)			4.0	(1.0)	4.0	(0.0)	2.0	(0.0)
Jul-94	-1.5	(0.6)	0.38	(0.07)	0.004	(0.001)	0.023	(0.002)	0.40	(0.20)	1.34	(0.40)	0.008	(0.001)	4.3	(1.0)	5.1	(0.6)	2.4	(0.3)
N	16		21		23		23		7		15		3		11		11		16	
Minimum	-1.50		0.04		-0.002		0.001		0.26		0.80		0.003		3.90		3.40		-2.00	
Maximum	5.40		1.40		0.014		0.029		0.90		4.80		0.033		11.00		17.00		8.50	
Mean	0.92		0.68		0.002		0.015		0.42		2.30		0.015		6.07		8.16		3.17	
Std. Dev.	1.72		0.36		0.003		0.006		0.22		0.88		0.016		2.38		4.28		2.57	
JEMEZ RIVER																				
Jul-74			0.11	(0.12)	0.000	(0.000)	0.001	(0.002)												
May-75					-0.002	(0.001)	0.001	(0.001)												
Sep-75					-0.001	(0.001)	0.012	(0.003)												
Apr-76			0.11	(0.02)	0.001	(0.001)	0.002	(0.001)	0.98	(1.20)										
Oct-76			0.14	(0.02)	0.001	(0.001)	0.007	(0.002)	0.05	(0.20)										
Mar-77			0.21	(0.05)	0.010	(0.030)	-0.020	(0.030)	0.14	(0.04)										
Oct-77			0.07	(0.06)	0.000	(0.002)	0.001	(0.002)	0.26	(0.11)					8.4	(9.4)	7.0	(2.3)		
Mar-78			0.06	(0.14)	-0.002	(0.001)	0.001	(0.001)							4.4	(1.1)	5.7	(0.7)	2.7	(0.1)
Mar-79	0.0	(0.3)	0.33	(0.07)	-0.001	(0.001)	0.005	(0.002)	0.17	(0.07)	2.00	(0.20)	0.001	(0.002)	3.3	(0.5)	4.1	(0.6)	-0.2	(0.1)
Feb-80	0.9	(0.3)	0.18	(0.07)	-0.002	(0.001)	0.003	(0.003)	0.63	(0.13)	2.40	(0.20)			7.3	(1.7)	8.9	(1.0)	3.7	(0.1)
Mar-81	5.8	(0.4)	0.23	(0.05)	0.001	(0.001)	0.002	(0.001)	0.07	(0.11)					18.0	(4.0)	18.0	(2.0)	2.5	(0.1)
Mar-82	1.4	(0.3)	0.04	(0.02)	0.005	(0.001)	0.001	(0.001)			2.20	(0.20)			9.0	(2.0)	11.0	(1.3)		
Feb-83	1.3	(0.3)	0.32	(0.05)	0.000	(0.000)	0.003	(0.001)			2.40	(0.20)			3.0	(0.9)	7.2	(0.8)	3.8	(0.1)
Feb-84	7.8	(0.8)	0.00	(0.10)	0.002	(0.001)	-0.001	(0.001)			2.10	(0.20)							3.5	(0.3)
Mar-85	0.4	(0.3)	0.01	(0.06)	0.000	(0.001)	0.001	(0.001)			2.20	(0.20)							2.5	(0.4)
Feb-86	3.9	(0.5)	0.16	(0.07)	0.000	(0.001)	0.004	(0.002)			1.80	(0.20)							2.7	(0.4)
Apr-87	4.3	(0.7)	0.23	(0.08)	0.001	(0.001)	0.010	(0.003)			2.10	(0.20)							1.7	(0.6)
Apr-88	-3.0	(2.0)	0.62	(0.13)	0.000	(0.001)	0.012	(0.003)			1.80	(0.20)							1.5	(0.5)
May-89	0.5	(0.3)	0.14	(0.07)	0.000	(0.000)	0.006	(0.002)			2.20	(0.20)							10.0	(1.0)
Apr-90	0.4	(0.3)	0.25	(0.11)	0.003	(0.004)	0.001	(0.001)			2.00	(0.20)							0.8	(0.4)
Dec-91	-0.1	(0.3)	0.20	(0.10)	0.002	(0.002)	0.003	(0.001)			2.30	(0.20)			110.0	(20.0)	2.0	(0.0)	2.0	(0.0)
Jul-92	0.2	(0.3)	0.20	(0.10)	-0.001	(0.001)	0.007	(0.001)	0.30	(0.30)	2.10	(0.20)	-0.024	(0.032)	7.0	(2.0)	3.0	(0.0)	-2.0	(1.0)
Jul-93	-1.6	(0.9)	0.10	(0.00)	0.002	(0.030)	0.006	(0.020)			1.30	(0.20)			3.0	(1.0)	3.0	(0.0)	2.0	(0.0)
Jul-94	-0.8	(0.4)	0.33	(0.06)	0.010	(0.002)	0.013	(0.002)	0.40	(0.20)	2.51	(0.55)	0.006	(0.001)	4.0	(1.0)	4.7	(0.5)	3.6	(0.4)
N	16		22		24		24		9		15		3		11		11		16	
Minimum	-3.00		0.00		0.000		-0.020		0.05		1.30		-0.024		3.00		2.00		-2.00	
Maximum	7.80		0.62		0.010		0.013		0.98		2.51		0.006		110.00		18.00		10.00	
Mean	1.34		0.18		0.001		0.003		0.33		2.09		-0.006		16.13		6.78		2.55	
Std. Dev.	2.79		0.14		0.003		0.006		0.30		0.30		0.016		31.43		4.61		2.51	
OTOWI																				
Dec-77			1.01	(0.07)	0.150	(210.000)	0.013	(0.012)	0.04	(0.02)	3.80	(0.15)			4.3	(2.2)	6.4	(1.1)	6.4	(1.1)
Dec-78	4.9	(1.7)	1.37	(0.54)	0.001	(0.002)	0.012	(0.069)							4.8	(1.1)	7.6	(0.9)		
Dec-79	1.5	(0.3)	0.96	(0.09)	-0.002	(0.002)	0.023	(0.005)	0.40	(0.08)	4.10	(0.40)	0.011	(0.003)	8.1	(1.9)	13.0	(1.4)		
Dec-80	1.0	(0.3)	1.04	(0.07)	-0.001	(0.002)	0.016	(0.003)	0.15	(0.07)	3.10	(0.30)			5.6	(1.3)	6.7	(0.8)		
Dec-81	0.2	(0.3)	0.57	(0.08)	0.004	(0.001)	0.075	(0.007)	0.15	(0.04)					5.1	(1.2)	10.0	(1.2)		
Dec-82	4.6	(0.3)	1.04	(0.06)							3.70	(0.30)			7.0	(1.5)	9.5	(0.4)		
May-83																				
Dec-84	4.2	(0.5)	0.20	(0.10)	0.000	(0.001)	0.003	(0.002)			3.00	(0.05)							4.6	(0.3)

Appendix A. (cont.)

Regional Soil Stations (Month-Year)	3H pCi/mL	(± σ)	137Cs pCi/g dry	(± σ)	238Pu pCi/g dry	(± σ)	239,240Pu pCi/g dry	(± σ)	90Sr pCi/g dry	(± σ)	Total Uranium ug/g dry	(± σ)	241Am pCi/g dry	(± σ)	Gross Alpha pCi/g dry	(± σ)	Gross Beta pCi/g dry	(± σ)	Gross Gamma pCi/g dry	(± σ)
OTOWI (cont.)																				
Dec-85	-0.4	(0.2)	0.54	(0.07)	0.000	(0.001)	0.026	(0.002)			3.50	(0.10)							6.2	(0.4)
Dec-86	4.5	(0.6)	0.71	(0.13)	0.002	(0.002)	0.016	(0.003)			4.30	(0.40)							6.9	(0.8)
Apr-87	-0.8	(0.5)	0.02	(0.06)	0.000	(0.001)	0.008	(0.002)			5.00	(0.50)							6.1	(0.8)
Apr-88	-0.8	(0.3)	0.26	(0.09)	0.000	(0.001)	0.004	(0.003)			3.10	(0.30)							5.4	(0.7)
May-89	1.4	(0.3)	0.42	(0.08)	0.003	(0.003)	0.019	(0.002)			3.80	(0.40)							3.4	(0.5)
Apr-90	0.5	(0.3)	0.45	(0.10)	0.001	(0.000)	0.023	(0.002)			2.60	(0.30)							2.0	(0.4)
Dec-91	0.5	(0.3)	0.50	(0.10)	0.002	(0.002)	0.064	(0.008)			2.70	(0.30)			4.0	(1.0)	3.0	(0.0)	3.0	(1.0)
Jul-92	0.1	(0.3)	0.10	(0.10)	0.002	(0.001)	0.055	(0.005)	0.00	(0.20)	3.30	(0.30)	0.160	(0.061)	7.0	(1.0)	4.0	(0.0)	1.0	(1.0)
Jul-93	0.0	(0.3)	0.10	(0.00)	0.000	(0.030)	0.024	(0.020)			1.80	(0.20)			2.0	(1.0)	3.0	(0.0)	3.0	(0.0)
Jul-94	-0.6	(0.3)	0.17	(0.04)	0.003	(0.001)	0.009	(0.002)	0.70	(0.20)	2.51	(0.33)	0.008	(0.002)	3.4	(0.8)	3.2	(0.4)	3.3	(0.4)
N	16		17		16		16		6		15		3		10		10		12	
Minimum	-0.8		0.02		0.000		0.003		0.00		1.80		0.008		2.0		3.0		1.0	
Maximum	4.9		1.37		0.150		0.075		0.70		5.00		0.160		8.1		13.0		6.9	
Mean	1.3		0.56		0.010		0.024		0.24		3.35		0.060		5.1		6.6		4.3	
Std. Dev.	2.1		0.40		0.037		0.021		0.26		0.81		0.087		1.9		3.4		1.9	
SANTA CRUZ LAKE																				
Dec-81			0.92	(0.06)	0.004	(0.001)	0.010	(0.007)							0.2	(0.3)	4.0	(0.6)		
Dec-82	3.2	(0.3)	1.27	(0.06)	0.001	(0.001)	0.019	(0.004)			3.40	(0.30)			7.1	(1.9)	8.4	(1.0)		
Dec-83	1.1	(0.3)	0.82	(0.09)	0.000	(0.001)	0.013	(0.003)			3.20	(0.30)			7.9	(1.9)	9.1	(1.0)	8.8	(0.1)
Dec-84	1.6	(0.3)	0.20	(0.10)	0.000	(0.001)	0.001	(0.001)			2.80	(0.10)							5.0	(0.3)
Dec-85	-0.8	(0.2)	0.36	(0.06)	0.001	(0.001)	0.008	(0.001)			3.20	(0.10)							5.8	(0.3)
Dec-86	1.1	(0.4)	0.48	(0.10)	0.000	(0.000)	0.014	(0.002)			3.30	(0.30)							5.0	(0.6)
Apr-87			0.41	(0.10)	0.000	(0.001)	0.007	(0.002)			3.10	(0.30)							4.6	(0.7)
Apr-88	-0.5	(0.3)	1.40	(0.26)	0.005	(0.003)	0.019	(0.004)			3.50	(0.40)							5.5	(0.7)
May-89	1.4	(0.3)	0.09	(0.12)	0.003	(0.001)	0.001	(0.001)			3.30	(0.20)							3.4	(0.5)
Apr-90	0.8	(0.3)	0.44	(0.12)	0.000	(0.000)	0.016	(0.002)			3.00	(0.30)							0.8	(0.4)
Dec-91	-0.2	(0.3)	1.10	(0.20)	0.003	(0.002)	0.042	(0.003)			2.90	(0.30)			12.0	(3.0)	7.0	(1.0)	4.0	(1.0)
Jul-92	0.3	(0.3)	-0.10	(0.10)	0.009	(0.002)	0.008	(0.001)	0.10	(0.20)	3.00	(0.30)	0.336	(0.080)	16.0	(4.0)	4.0	(0.0)	0.0	(2.0)
Jul-93	-0.1	(0.3)	0.10	(0.00)	0.002	(0.030)	0.004	(0.020)			2.10	(0.60)			7.0	(2.0)	3.0	(0.0)	3.0	(0.0)
Jul-94	-0.2	(0.3)	0.31	(0.06)	0.008	(0.001)	0.010	(0.001)	0.20	(0.20)	2.24	(0.22)	0.003	(0.001)	6.0	(1.0)	8.6	(0.9)	3.3	(0.4)
N	12		14		14		14		2		13		2		7		7		12	
Minimum	-0.80		-0.10		0.000		0.001		0.10		2.10		0.003		0.20		3.00		0.00	
Maximum	3.20		1.40		0.009		0.042		0.20		3.50		0.336		16.00		9.10		8.80	
Mean	0.64		0.56		0.003		0.012		0.15		3.00		0.170		8.03		6.30		4.10	
Std. Dev.	1.13		0.47		0.003		0.010		0.07		0.42		0.235		4.94		2.57		2.31	

Appendix B. Conversion of Tritium and Uranium Data for RESRAD.

Tritium

In order to convert the data for input to the RESRAD computer code, ^3H was converted from pico curies per milliliter to pico curies per dry gram of soil.

A value of 10% soil moisture for surface soils on the Pajarito Plateau was used for the data conversion, based upon best professional judgment. The following algorithm was employed:

$$pCi/g = pCi/ml \times \frac{\theta_w}{\rho_w \times (1-\theta_w)},$$

where

θ_w = fraction soil moisture and

ρ_w = soil moisture density (≈1 g/mL).

Uranium

Uranium data were converted to isotope-specific concentrations with units of pico curies per dry gram of soil. In order to perform the conversion, it was assumed that the total uranium contained a natural abundance of each of the principal uranium isotopes. The following physical data were used in the conversion.

uranium isotope	relative mass abundance	specific activity (pCi/g)
uranium-234	0.000058	6.24E+09
uranium-235	0.0072	2.16E+06
uranium-238	0.9928	3.35E+05

Activity concentrations of each isotope in soil were calculated according to

$$pCi\ isotope/g\ soil = \mu g\ total\ U / g\ soil \times RMA \times SA \times CF,$$

where

RMA = relative mass abundance (g isotope/ g total U),

SA = specific activity (pCi / gram isotope), and

CF = conversion factor (1E-06 g/μg).

Appendix C. RESRAD Input Parameters—Typical Mesa Top Conditions Around the Los Alamos Area.

Parameter	Value	Comments/Reference
Area of contaminated zone	10,000 m^2	RESRAD default value; a larger area maximizes exposure via external gamma, inhalation, and ingestion pathways.
Thickness of contaminated zone	3 m	RESRAD default value was 2 m.
Length parallel to aquifer flow	100 m	Corresponds to an area of 10,000 m^2.
Time since placement of material	0 yr	
Cover depth	0 m	Assumption of no cover maximizes dose.
Density of cover material	-	See contaminated zone value.
Cover depth erosion rate	-	See contaminated zone value.
Density of contaminated zone	1.6 g/cm^3	RESRAD default value was 1.5 g/cm^3.
Contaminated zone erosion rate	0.001 m/yr	RESRAD default value.
Contaminated zone total porosity	0.4	RESRAD default value.
Contaminated zone effective porosity	0.2	RESRAD default value.
Contaminated zone hydraulic conductivity	440 m/yr	An average value for soil (not tuff) from Nyhan et al. (1978b).
Contaminated zone b parameter	4.05	RESRAD default value was 5.30.
Humidity in air	8 g/cm^3	RESRAD default value.
Evapotranspiration coefficient	0.999	RESRAD maximum that results in highest soil dose; based on yearly precipitation and evapotranspiration data for Los Alamos (EPG 1995).
Precipitation	0.48 m/yr	Average value from Los Alamos Climatology (Bowen 1990).
Irrigation	0 m/yr	No irrigation soil-based pathways.
Irrigation mode	-	
Runoff coefficient	0.52	RESRAD default value was 0.20.
Watershed area	2.7E+07 m^2	RESRAD default value.
Accuracy for water/soil computations	0.001	RESRAD default value.
Density of saturated zone	1.6 g/cm^3	RESRAD default value was 1.5 g/cm^3.
Saturated zone total porosity	0.3	RESRAD default value was 0.4.
Saturated zone effective porosity	0.3	RESRAD default value was 0.2.
Saturated zone hydraulic conductivity	100 m/yr	RESRAD default value.
Saturated zone hydraulic gradient	0.02	RESRAD default value.
Saturated zone b parameter	4.05	RESRAD default value was 5.30.
Water table drop rate	0.3 m/yr	RESRAD default value was 0.001 m/yr.
Well pump intake depth below water table	10 m	RESRAD default value.
Model: nondispersion (ND) mass balance (MB)	ND	RESRAD default value.
Well pumping rate	250 m^3/yr	RESRAD default value.
Number of unsaturated zone strata	2	RESRAD default value was 1.
Unsaturated. zone 1 thickness	260 m	RESRAD default min. and max. values are listed as 10 and 320 m
Unsat. zone 1 soil density	1.6 g/cm^3	Min. and max. are listed as 1.3 and 1.8 g/cm^3 from Abrahams (1963).

Unsat. zone 1 total porosity	0.5	USDOE (1979).
Unsat. zone 1 effective porosity	0.4	
Unsat. zone 1 soil-specific b parameter	4.05	RESRAD default value was 5.30.
Unsat. zone 1 hydraulic conductivity	3 m/yr	Average value from Stoker et al. (1991).
Unsat. zone 2 thickness	100 m	
Unsat. zone 2 soil density	1.6 g/cm^3	No reference was listed but the zone 1 values for min. and max. were listed as 1.3 and 1.8 g/cm^3 from Abrahams (1963).
Unsat. zone 2 total porosity	0.5	
Unsat. zone 2 effective porosity	0.4	.
Unsat. zone 2 soil-specific b parameter	4.05	RESRAD default value was 5.30.
Unsat. zone 2 hydraulic conductivity	370 m/yr	
Inhalation rate	8040 m^3/yr	Based on 2 h outdoor at 0.83 m^3/h and 18 h indoor at 1.7 m^3/h.
Mass loading for inhalation	9E-05 g/m^3	Based on OU 1086 Phermex risk assessment for respirable particulates.
Dilution length for airborne dust	3 m	RESRAD default value.
Exposure duration	30 yr	Upper Environmental Protection Agency (EPA) value for time at a single residence.
Shielding factor, inhalation	0.4	RESRAD default value.
Shielding factor, external gamma	0.7	RESRAD default value.
Fraction of time spent indoors each year	0.719	Based on 18 h/d LANL default value for nonradionuclides.
Fraction of time spent outdoors	0.08	Based on 2 h/d LANL default value for nonradionuclides.
Shape factor, external gamma	1	Corresponds to a contaminated area larger than a circular area of 1,200 m^2.
Fruits, vegetables, and grain consumption	124 kg/yr	EPA reasonable maximum value (Exposure Factors Handbook) for fruit and vegetable consumption.
Leafy vegetable consumption	14 kg/yr	RESRAD default value.
Milk consumption	-	Pathway not activated.
Meat and poultry consumption	-	Pathway not activated.
Fish consumption	-	Pathway not activated.
Soil ingestion rate	44 g/yr	Calculated based on 100 mg/d for 24 yr (adult) and 200 mg/d for 6 yr (child).
Drinking water intake	-	Pathway not activated.
Contamination fraction of irrigation water	0	No "on-site" well was assumed to exist on the mesa top.
Contamination fraction of plant food	0.36	Based on EPA upper values of 0.4 and 0.3 for vegetables and fruit, respectively.
Mass loading for foliar deposition	0.0001 g/m^3	RESRAD default value.
Depth of soil mixing layer	0.15 m	RESRAD default value.
Depth of roots	0.9 m	RESRAD default value.
Drinking water fraction from groundwater	1.0	No surface water sources are assumed on mesa tops.
Household water fraction from groundwater	1.0	No surface water sources are assumed on mesa tops.
Irrigation water fraction from groundwater	0	No "on-site" well is assumed to exist on the mesa top.
Fraction of grain in beef cattle feed	-	Pathway not activated.

Fraction of grain in milk cow feed	-	Pathway not activated.
Storage time for fruits, vegetables, and grain	14 d	RESRAD default value.
Storage time for leafy vegetables	1 d	RESRAD default value.
Storage time for well water	1 d	RESRAD default value.
Storage time for surface water	1 d	RESRAD default value.
Thickness of building foundation	0.15 m	RESRAD default value.
Bulk density of building foundation	2.4 g/cm^3	RESRAD default value.
Total porosity of cover material	0.4	RESRAD default value.
Total porosity of building foundation	0.1	RESRAD default value.
Volumetric water content of cover	0.05	RESRAD default value.
Volumetric water content of foundation	0.03	RESRAD default value.
Diffusion coefficient for radon in cover	2E-06 m/s	RESRAD default value.
Diffusion coefficient for radon in foundation	3E-07 m/s	RESRAD default value.
Diffusion coefficient for radon in contaminated soil	2E-06 m/s	RESRAD default value.
Radon vertical dimension of mixing	2 m	RESRAD default value.
Average annual wind speed	3 m/s	From Los Alamos Climatology (Bowen 1990).
Average building air exchange rate	1/h	RESRAD default value was 0.5 per hour.
Height of building interior	2.5 m	RESRAD default value.
Building interior area factor	0	RESRAD default value.
Building depth below ground surface	-1	Allows the code to calculate the value from other input.
Emanating power of Rn-222 gas	0.25	RESRAD default value.
Emanating power of Rn-220 gas	0.15	RESRAD default value.

Appendix D. Model and Parameter Assumptions and Uncertainty Assessment

The dose rate estimates in Table 3 were calculated using RESRAD parameters developed for Environmental Restoration (ER) project SALs, and are conservative assumptions that should result in high bias and should not be interpreted as absolute dose rate estimates. It was assumed that an area resident is exposed to radionuclides via soil ingestion, inhalation of suspended dust, ingestion of homegrown fruits and vegetables containing radionuclides absorbed from soil and settled as dust, and to external radiation from radionuclides in the ground. RESRAD ingestion pathways for locally contaminated milk, meat, and poultry, and fish/shellfish were excluded from these assessments because they are inconsistent with a reasonable residential exposure scenario in the Los Alamos area. Additionally, drinking and irrigation water were assumed to be unaffected by local soil contamination because the regional aquifer is located beneath several hundred feet of volcanic tuff forming the Pajarito Plateau.

RESRAD parameters used to generate ER Project SALs result in the lowest soil concentration of a radionuclide that could possibly result in a dose exceeding an annual dose limit. Dose calculations with these parameters, therefore, result in worst-case estimates of annual dose. Some of the conservative bias include (1) the thickness of the contaminated zone, (2) the erosion rate of the contaminated zone, (3) the evapotranspiration coefficient, and (4) the concentration of each radionuclide at each station.

The dose assessments assume that radionuclides measured in surface soil at LANL and perimeter stations are present at these locations at uniform concentrations in an area of 10,000 m^2 and to a depth of three meters (9.8 ft). The assumed thickness of the contaminated zone can affect dose estimates because external gamma irradiation and uptake of radionuclides by plants are a function of the depth of contamination. For example, if measured levels of contamination are assumed to be limited to the top 15 cm (6 in.) of soil, which is more than likely the case, the estimated TEDE for TA-8/GT Site is reduced from 5.4 to 2.8 mrem y^{-1}. This occurs primarily as a result of a reduction in dose via the plant ingestion pathway.

The rate of erosion assumed for the contaminated zone will impact dose estimates for future years. The depth of the contaminated zone decreases commensurate with the erosion rate, resulting in a loss of all contaminated soil in 3,000 years using the

parameters in these assessments. At the same time, the uranium daughter isotopes accumulate over time, contributing to increasing dose rates. However, because cesium-137 and strontium-90 have half-lives of only 30 years and are therefore quickly depleted relative to ingrowth of uranium daughters, combined dose from all radionuclides described here would not exceed current dose estimates for several thousand years, even if no erosion or covering of soil is modeled.

Another model parameter that may have a large influence on future dose is the evapotranspiration coefficient. In these assessments, this value has been set at the RESRAD maximum of 0.999, effectively eliminating leaching of radionuclides from the contaminated zone by water. This value is based on the fact that annual estimated evapotranspiration for the Los Alamos area exceeds the average annual precipitation. Because the value used for the evapotranspiration coefficient results in no leaching, vadose zone hydrogeologic parameters in RESRAD have no influence on the dose estimates for future years. In reality, some leaching of radionuclides from surface soil is likely in the Los Alamos area, where precipitation may occur as brief but intense events. Concentrations in surface soil deposited in previous years would therefore be expected to decrease over time, dependent upon a complex interplay of site hydrogeology and the physical characteristics of each radionuclide.

The estimated dose associated with individual radionuclides at each perimeter station is linearly related to radionuclide soil concentrations. There are numerous sources of uncertainty associated with the radionuclide data used for these dose assessments—soil concentrations in an area are heterogeneous due to fluctuations in the microenvironment caused by topography, wind and water erosion, plant cover, animal activity, soil characterics, etc. The magnitude of this variability relative to yearly trends and observed differences in soil concentrations among the sample stations, however, can be estimated using the variance associated with the individual sample sites (i.e., the standard deviation). Usually the mean plus two standard deviations is a good indicator of the maxiumum TEDE that would be expected at these sites. For example, the maximum TEDE for the east of TA-53 site (the highest measured LANL site) and the TA-8/GT Site (the highest measured perimeter site) was 12.3 and 8.9 mrem y^{-1}, respectively. The maximum TEDE measured at regional locations was 7.4 mrem y^{-1}.

Data gaps and trends in values over time may also impact the feasibility of using

the entire data set to calculate a statistic representative of current radionuclide concentrations. As was previously stated in the text, using the average radionuclide concentration for a dose calculation may overestimate current site conditions, especially because (1) some sites contained data for only a few years and that data was relatively old (1978 to 1981), and (2) most radionuclides at most sites exhibited decreasing concentration trends over time.

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