3.0 ONSITE ^{238}PU AND $^{239+240}$PU IN AIR

Forty-seven air sampling units on the Nevada Test Site (NTS) were used to determine plutonium in air concentrations in 1996. Figure 3.1 shows the locations of these air sampling stations. Not shown on this map are an additional three sampling locations in Area 52. This area is about 30 miles north of the northwest corner of the NTS. The locations used for monitoring plutonium in air concentrations are divided into four types: (1) monitoring the perimeter of Radiological Waste Management Sites (RWMS), (2) monitoring inside RWMSs, (3) preoperational monitoring of the Waste Examination Facility (WEF), and (4) routine environmental monitoring locations. Table 3.1 gives the names of the locations for types 1, 2, and 3. Locations not listed in this table are environmental monitoring locations.

Preoperational monitoring at the WEF began in the third quarter of 1996. Monitoring at Area 4 Bunker T-4 commenced at the beginning of 1996 in order to include Area 4 in the plutonium network. Monitoring in Area 20, in the extreme northwest of the NTS, was increased in 1996. In previous years, air monitoring was only done at the Area 20 base camp. At the beginning of 1996, air monitoring was initiated adjacent to the SCHOONER event location, a cratering event detonated in December of 1968. Monitoring in Area 20 adjacent to the CABRIOLET event location began at the beginning of the fourth quarter of 1996. At the beginning of 1996, Area 52 environmental monitoring was included with the NTS environmental monitoring program. The DOUBLE TRACKS and CLEAN SLATE III air sampling locations were established in Area 52 in December of 1995. The CLEAN SLATE I air sampling location was established in August of 1996. Monitoring at locations RWMS Nos. 3, 5, 7, and 9 was discontinued, beginning with the fourth quarter of 1996. These four locations are in the middle of the sides of the RWMS perimeter fence. The remaining RWMS sampling locations are at the corners of this complex.

The air sampling units were equipped with glass-fiber filters and had a nominal air flow rate of 140 L/min (5cfm). The filters were changed after one week of operation. After a 5 to 7 day delay for radon progeny decay, the glass-fiber filter was analyzed by gamma spectroscopy and for gross alpha and gross beta activity. These filters were then composited on a monthly or quarterly basis and analyzed for plutonium. Environmental monitoring locations were composited for each quarter. Radiological operations locations were composited monthly for the first three quarters of 1996, then quarterly for the last quarter. Attachment 3.1 gives the data for ^{238}Pu, and Attachment 3.2 gives the data for $^{239+240}$Pu. (All figures, tables, and attachments are at the end of the chapter.) Negative values in the attachments indicate samples in which the count was less than the corresponding analytical background.

PLUTONIUM-238

Descriptive statistics for ^{238}Pu in air by type of sampling location are given in Table 3.2. There is no column for the WEF locations because there were only two data values for these locations, which are included in the all types combined column. The most striking item to note in this table is that most of the ^{238}Pu concentrations are less than their individual detection limits. Eighty-seven percent of all observed concentrations are less than their individual detection limits, indicating that very little ^{238}Pu was actually detected in air. Also, 46 percent of the observed concentrations are negative; thus, essentially half the data is negative, and half is positive, which suggest that the median is virtually zero. A review of Table 3.2 indicates that there is no distinction of the data by type of monitoring location; thus, all data is included in the following discussion and analysis. Table 3.4 presents descriptive statistics for each sampling location.

Figure 3.2 is a probability plot of all the positive ^{238}Pu data values. This figure suggests that the data have a lognormal statistical distribution. Perhaps some statistical test could be done using the logarithms of the data values, but then almost half of the data, the negative values, would have to be discarded. In view of this, a comprehensive statistical analysis would be of little value. This would be mostly an analysis of background levels and detection limits.

Those locations that have concentrations above detection limits tend to consistently show higher levels for several quarters of the year and also are locations that have historically shown above detection limit concentrations, or are new air sampling locations. Two locations, Area 4 Bunker T-4 and Area 9 9-300 Bunker had all four quarter values above detection limits. The Area 4 location is a new sampling location that is about 200 feet southwest of the T-4 tower location. Four atmospheric test were conducted on towers at this site in the 1950's (FOX on May 25, 1952, NANCY on March 24 1953, APPLE-1 on March 29, 1955, and KEPLER on July 24, 1957). The 9-300 Bunker has historically shown above detection limit concentrations. An additional six air sampling locations have at least half of their quarterly ^{238}Pu values above detection limits. The Area 3 Mud Plant (a concrete batch plant) and the SEDAN Crater location had three quarters of data above detection limits. The UE-7ns location and the EPA Farm location have historically shown concentrations above detection limits. The Area 20 SCHOONER location and the Area 52 DOUBLE TRACKS location are new air sampling stations with no historical record.

Some sense of the variability within and between operational areas can be obtained from simple descriptive statistical summaries of ^{238}Pu concentrations grouped by NTS operational area. Table 3.3 presents summary statistics by operational area, and Figure 3.3 presents boxplots of the data for each operational area. Boxplots, also called box and whisker diagrams, are simple graphical representations of the data. Horizontal lines are drawn at the 25th and 75th percentiles of the data to form the top and bottom of the box. The horizontal line in the middle of the boxes is at the 50th percentile, which is the median of the data. Whiskers extend to the furthest data value that is within one and one-half times the interquartile range from the ends of the box. Values outside the whiskers are indicated by asterisks. Figure 3.3 clearly shows the higher values for the T-4 Bunker in Area 4 and the 9-300 Bunker in Area 9. The large number of asterisks for Area 5 can be attributed to the large number of near zero data values from this area, causing the interquartile range to be comparatively small.

In Figure 3.4, concentrations of ^{238}Pu from all sampling locations are plotted versus the date that sample collection began. The clustering of the data values around zero is evident in this figure. The fewer number of values, as concentrations increase, is characteristic of lognormally distributed data. The dotted line in this figure is approximately at the median detection limit of 2.75×10^{-18} µCi/mL. The solid line in this figure is a “locally weighted scatterplot smoother” line. This is a statistical tool for detecting trend in data plots. In Figure 3.4, the scatterplot smoother line shows very little trend and is obviously below the detection limit line. The three highest data values are listed from highest to lowest: (1) U-3ah/at north for sampling starting August 7, 1996; (2) Bunker T-4 for sampling starting July 3, 1996; and (3) U-3ah/at north for sampling starting June 5, 1996.

A sense of the accuracy of the ^{238}Pu in air measurements can be obtained from the empirical coefficients of variation, also called relative errors. These are defined as the analytic standard deviation divided by the measured concentration. Figure 3.5 is a histogram of the empirical coefficients of variation from the 1996 ^{238}Pu data. It can be readily seen that analytical standard deviations are usually as large or larger than the corresponding concentrations. The most frequent value seems to be a standard deviation about 1.5 times the concentration. This suggest that statistical “noise” from normal laboratory procedures is the primary constituent of the ^{238}Pu in air data. In addition to this source of errors, this data contains sampling errors caused by

statistical variation in the glass-fiber filters; these sources of error are not quantified by the current sample collection procedures.

PLUTONIUM-239+240

Descriptive statistics for $^{239+240}$Pu in air by type of sampling location are given in Table 3.5. There is no column for the WEF locations because there were only two data values for these locations; they are included in the all types combined column. The most striking item in this table is the great differences between the means and the corresponding medians, the large standard deviations, and the large maximum values. This pattern of statistics is characteristic of extremely skewed data. Histograms and probability plots of the data indicated that the data has approximately a lognormal distribution. Figure 3.6 is a lognormal probability plot of the data values with the 16 negative values deleted. This data fails a statistical test for normality (of the logarithms of the data), but the data plots as a smooth curve, indicating it belongs to a single statistical distribution. The straight line in this plot indicates where the data points would plot if the data had exactly a lognormal statistical distribution. The data is somewhat close to this line. The shape of the tails of the data plot indicate that the very large values seen in the data are not outliers. However, the large values do have a great effect on the means and standard deviations; thus, these statistics should be used with reservations.

An examination of the data, displayed in Attachment 3.2, shows that the largest values occur erratically. For example, BJY is the first location in the attachment. It has one value that is an order of magnitude higher than the values for the other three quarters. This pattern of values occurs for several sampling locations, such as the Yucca Complex, the UE-7ns location, the EPA Farm, and the DOUBLE TRACKS location.

Table 3.6 summarizes the $^{239+240}$Pu data values by operational area, and Table 3.7 gives individual sampling location statistics. These tables highlight the wide range of values between locations and within some locations. This is a historical characteristic of this data.

Subtraction of analytical instrument background can result in reported concentrations that have non-positive values. Of the reported $^{239+240}$Pu concentrations, 6 percent were negative. This is about the same as in previous years. In 1995, 9 percent were negative; in 1994, 10 percent were negative; and in 1993, 14 percent were negative. Unlike ^{238}Pu, for which almost all observed concentrations were below detection limits, 41 percent of the $^{239+240}$Pu concentrations were below detection limits. This is also about the same as in previous years. In 1995, 44 percent were below detection limits. In 1996, the median detection limit was 3.2×10^{-18} µCi/mL.

Figures 3.7 and 3.8 display the data for a visual evaluation of differences between operational areas. Figure 3.7 presents boxplots of the concentrations, scaled by 10^{-18}, and Figure 3.8 is the same except natural logarithms of the data values are used. The logarithm plot is better for comparing the areas with all concentration values close to zero. These two figures highlight the large differences in variability between the operational areas. This variability is also evident in the standard deviation column of Table 3.6.

In previous years, time series trends and differences between stations were tested for statistical significance using analysis of variance (ANOVA) on the logarithms of the concentrations. The statistical assumptions underlying the ANOVA are that the data are normally distributed and that the groups of data values have the same variance. The 1996 data does not satisfy either of these assumptions. Figure 3.6 shows that the data are not lognormally distributed, and a transformation that would achieve normality could not be found. Figures 3.7 and 3.8 obviously

show that the variances of the data for each area are not close to being equal. Thus an ANOVA would not be valid for the 1996 data. However, Figures 3.7 and 3.8 do show such considerable differences between areas that a formal statistical analysis is not necessary to conclude that the differences are significant, even though the significance cannot be measured statistically. The areas with the higher $^{239+240}$Pu concentrations are the operational areas that have been extensively used for nuclear testing.

Perhaps of more interest than differences between operational areas is an evaluation of trend in $^{239+240}$Pu concentrations over time. The 1996 data have a further characteristic that makes a formal test for trend difficult. The sampling frequency varies between locations and over the year. The results from environmental locations were reported quarterly. The results from the waste management locations were reported monthly for the first three quarters of the year, then quarterly for the fourth quarter. Again, graphical presentations can be used, and they carry no underlying assumptions that have to be satisfied to make the results valid. Figures 3.9 and 3.10 are time series plots of the $^{239+240}$Pu concentrations and the logarithms of those concentrations. The abscissa in these plots is the date that sample collection began for each plotted sample. The lack of any plotting after October 10, 1996, results from the cessation of monthly sampling at the beginning of the fourth quarter. The solid line passing through the data is a “locally weighted scatterplot smoother” line. This line is essentially horizontal, suggesting no trend with time over the year. If a formal statistical test of trend could be done, one would not anticipate finding any significant trend. In Figure 3.10, with the logarithmic ordinate, it is easy to see that the line passes approximately through the center of the data values at a value of about two. The antilog of two represents a $^{239+240}$Pu concentration of 7.4×18^{-18} µCi/mL.

A sense of the accuracy of the individual measured values can be obtained from the coefficients of variation which is the analytic standard deviation divided by the absolute value of the concentrations. This is a measure of the analytical or counting errors. The errors considered are variability due do differences between sampling location and time of sampling. Empirical coefficients of variation for 1996 $^{239+240}$Pu analyses are presented in Figure 3.10. It can be seen from this figure that the analytic errors are typically smaller than the measured concentrations. The largest coefficients of variation are from the lowest concentration values, those close to zero. The third quartile of the coefficients of variation is 0.745. This means that 75 percent of the results have a standard deviation that is 75 percent or less of the measured concentration.

HISTORICAL TRENDS

In 1996, there were 47 air sampling locations in use, and over the years 71 different locations have been used for various lengths of time. Placement of air sampling stations is determined from health physics considerations, not to give a uniform coverage of the NTS. Hence, in some years, samplers were removed from some locations and moved to other locations which, at that time, were judged to be of greater concern. Were a complete analysis of historical trends done for all air sampling locations, in addition to current year results, the resulting document would be cumbersome. Accordingly, the historical data were searched for a few representative locations. It was found that there are only 11 locations which have data available from all the years that plutonium in air has been assayed, and these were chosen for this presentation of historical trends. Plutonium in air was first reported in the 1971 annual report. From 1971 to 1989 no distinction was made between ^{238}Pu and $^{239+240}$Pu, but it is known from the analytical methods used that $^{239+240}$Pu was being measured. Then in 1989 ^{238}Pu assays began. The 11 chosen locations are identified in Tables 3.8 and 3.9 which present the historical data from 1989, when the distinction between isotopes commenced, to the present. Figures 3.12 and 3.13 present the same data graphically. The two figures contain “locally weighted scatterplot smoother” lines. These give the overall trend of the data and limit the influence of outliers.

Table 3.8 and Figure 3.12 present the historical data from the last eight years for $^{239+240}Pu$. The trend appears to be increasing until 1993 then decreasing. However, the 1993 and 1994 values are somewhat influenced by the values in those years that are close to 100 x 10^{-18} µCi/mL. There is no pattern of locations that show the higher values. Each of the values that appear to be outliers is from a different location and can be identified from Table 3.5. No statistical analysis of trend was performed because of the very low concentrations of plutonium. The highest values in Table 3.8 and Figure 3.12 are just under 100 x 10^{-18} µCi/mL and the public derived concentration guide (DCG) is over an order of magnitude higher at 2 x 10^{-15} µCi/mL. Most of the values are less than 10 x 10^{-18} µCi/mL or over two orders of magnitude less than the public DCG.

Table 3.9 and Figure 3.13 present the historical annual averages for ^{238}Pu at the selected locations. These data show an exponential shaped decline from a level of about 4 x 10^{-18} µCi/mL in 1989 to almost zero in 1996. Again, no formal analysis of trend was performed because of the extremely low concentrations.

CONCLUSIONS

Plutonium 238 and 239+240 measurements are continuing to be made on the NTS, although less frequently than in previous years because observed concentrations are low and, except for the RWMS, there are no new sources of environmental plutonium. At the beginning of 1996, plutonium was assayed quarterly at all locations except the RWMS, and for the fourth quarter, the assay frequency at the RWMS was also changed to quarterly. Perhaps the most significant statistics for plutonium concentrations from 1996 are the very low levels; 87 percent of the ^{238}Pu measurements and 41 percent of the $^{239+240}Pu$ measurements are below detection limits. This pattern of less than detection limits has been seen for a number of years. The plutonium measurements have approximately a lognormal statistical distribution, as has been seen in previous years. Except for a few monitoring locations in known areas of contamination, the $^{239+240}Pu$ levels are close to zero and are over two orders of magnitude less than the derived concentration guide.

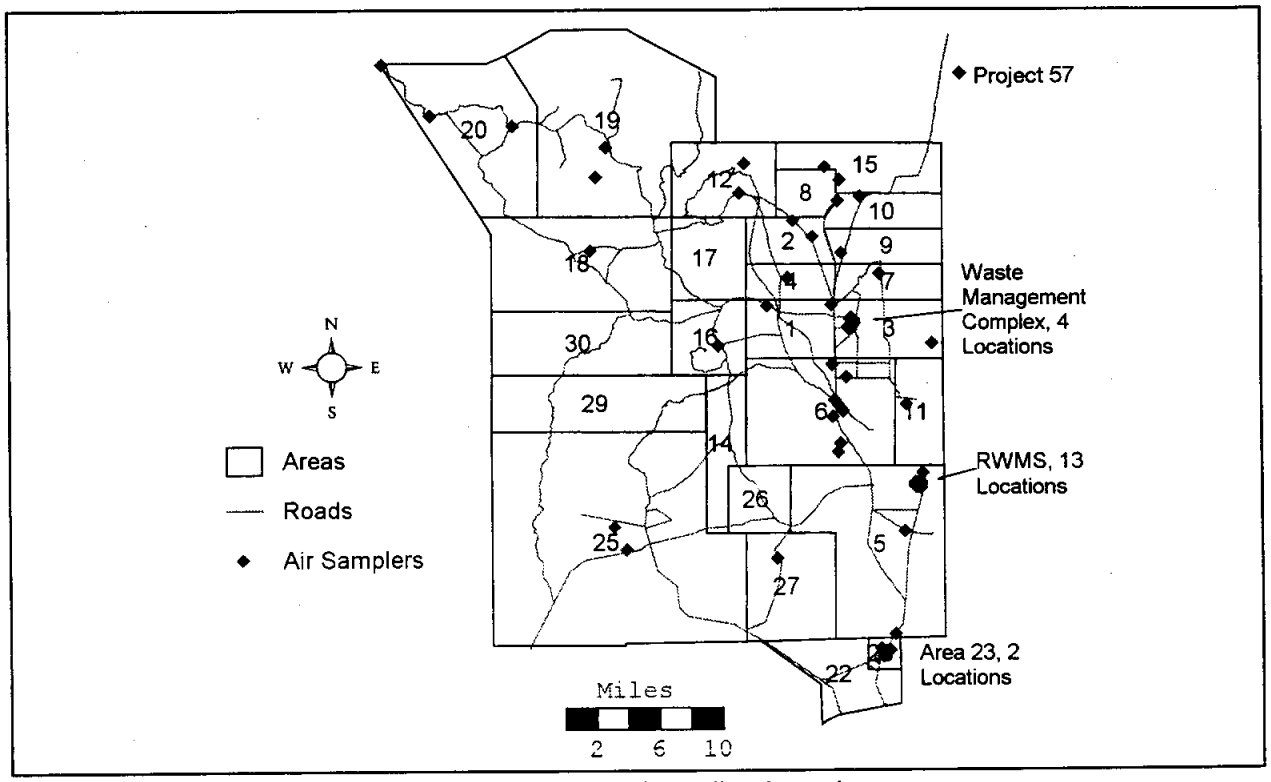

Figure 3.1 NTS Air Sampling Locations

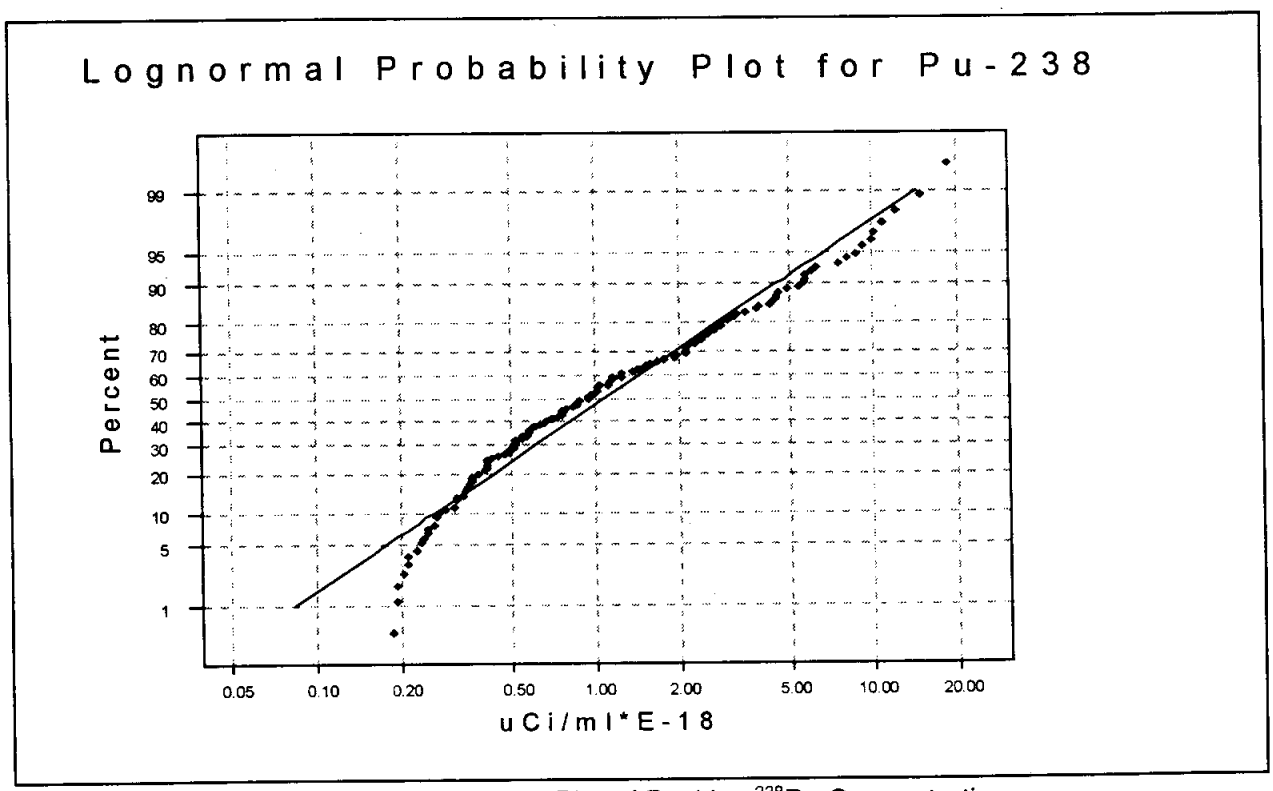

Figure 3.2 Probability Plot of Positive ^{238}Pu Concentrations

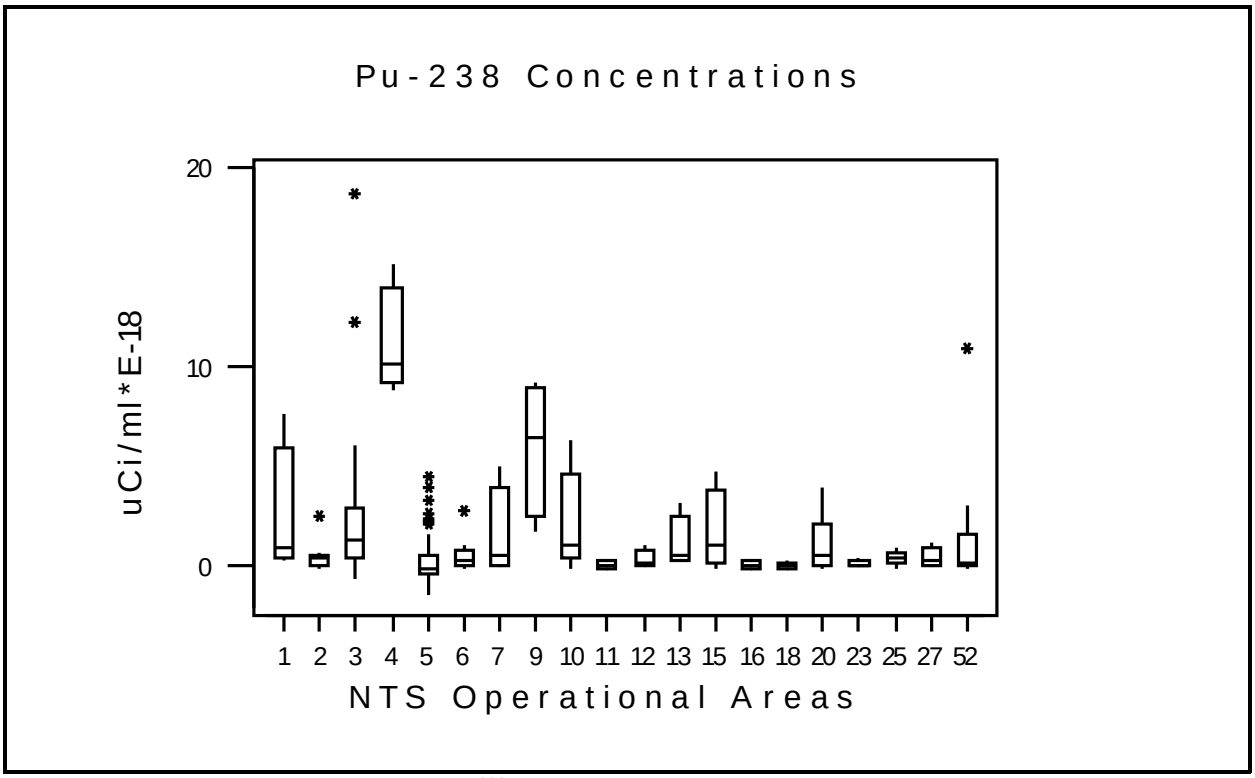

Figure 3.3 Boxplots of ^{238}Pu Concentrations by NTS Operational Area

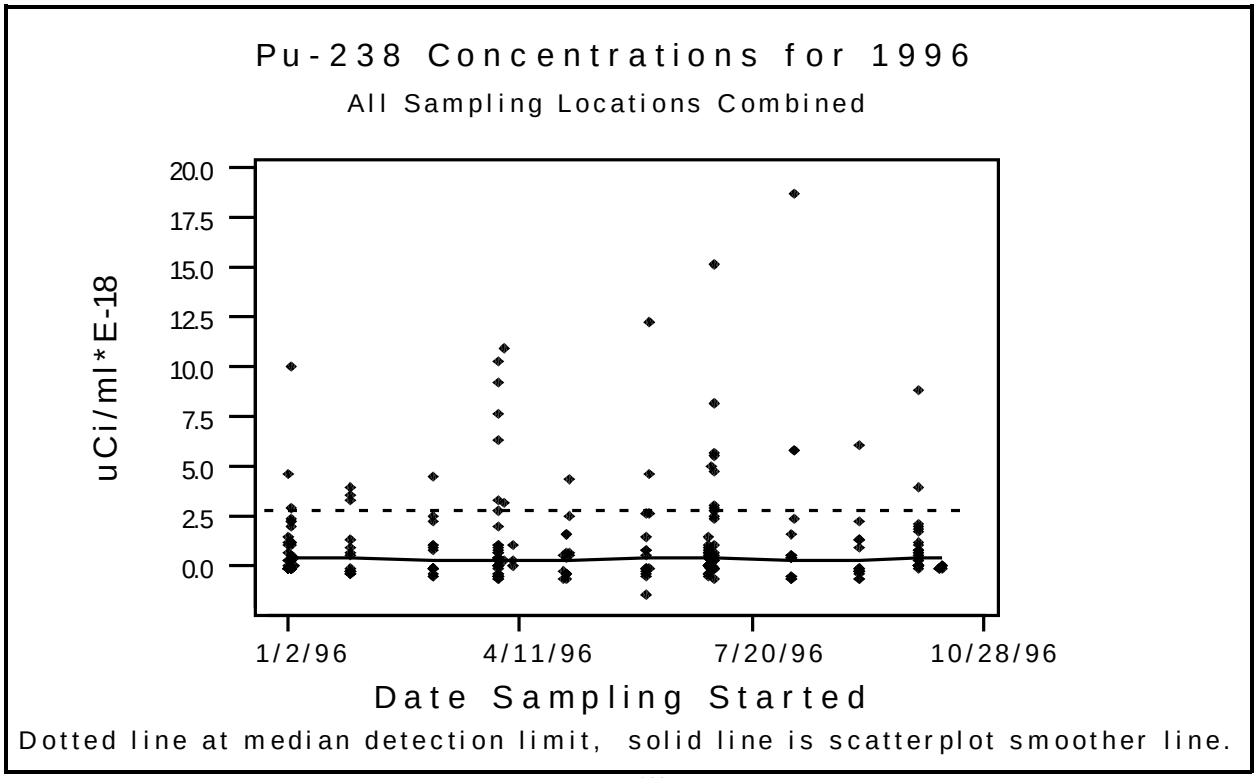

Figure 3.4 Time Series Plot of ^{238}Pu Concentrations for 1996

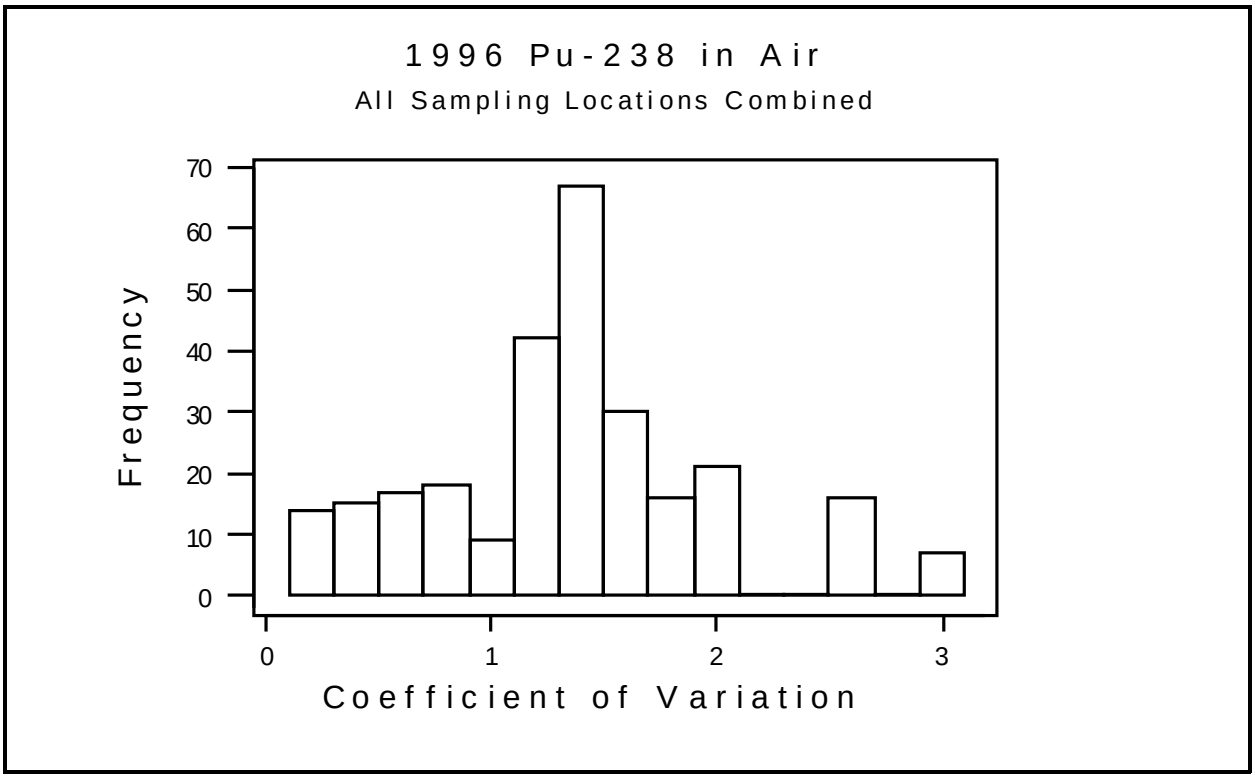

Figure 3.5 Histogram of Empirical Coefficients of Variation

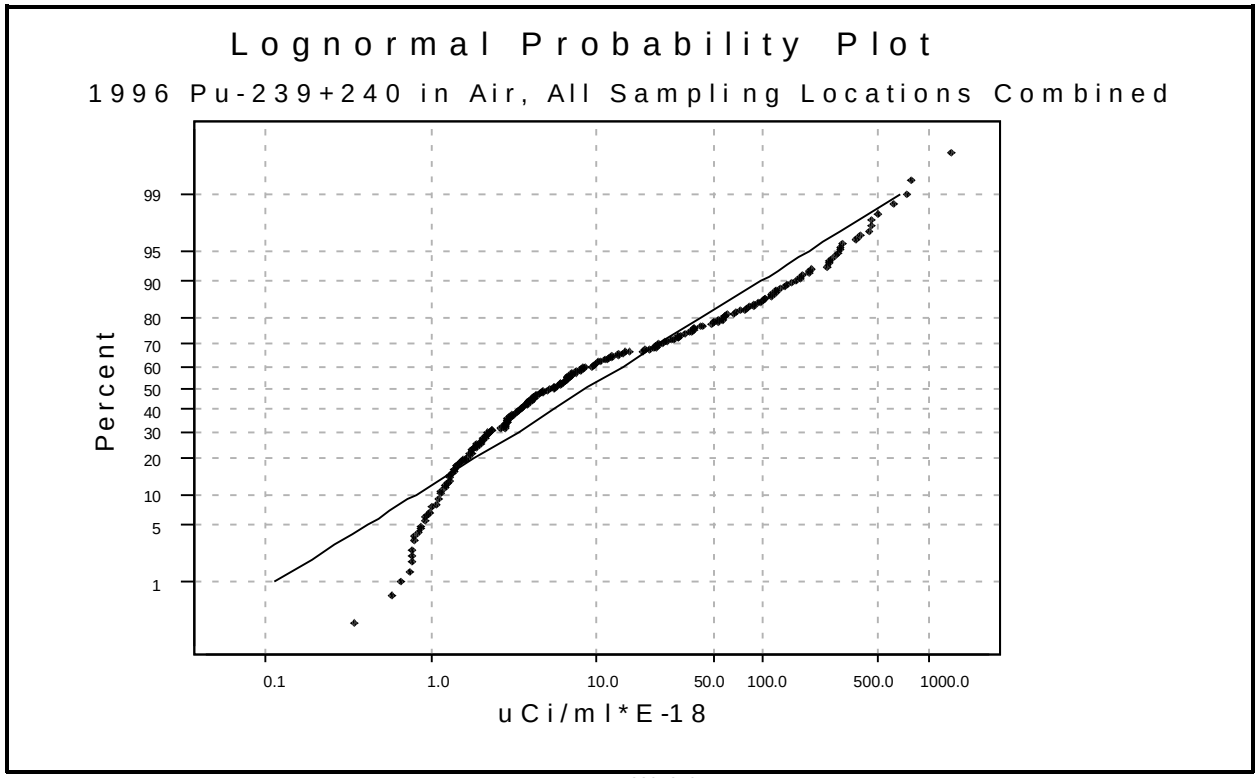

Figure 3.6 Probability Plot of $^{239+240}$Pu in Air Concentrations

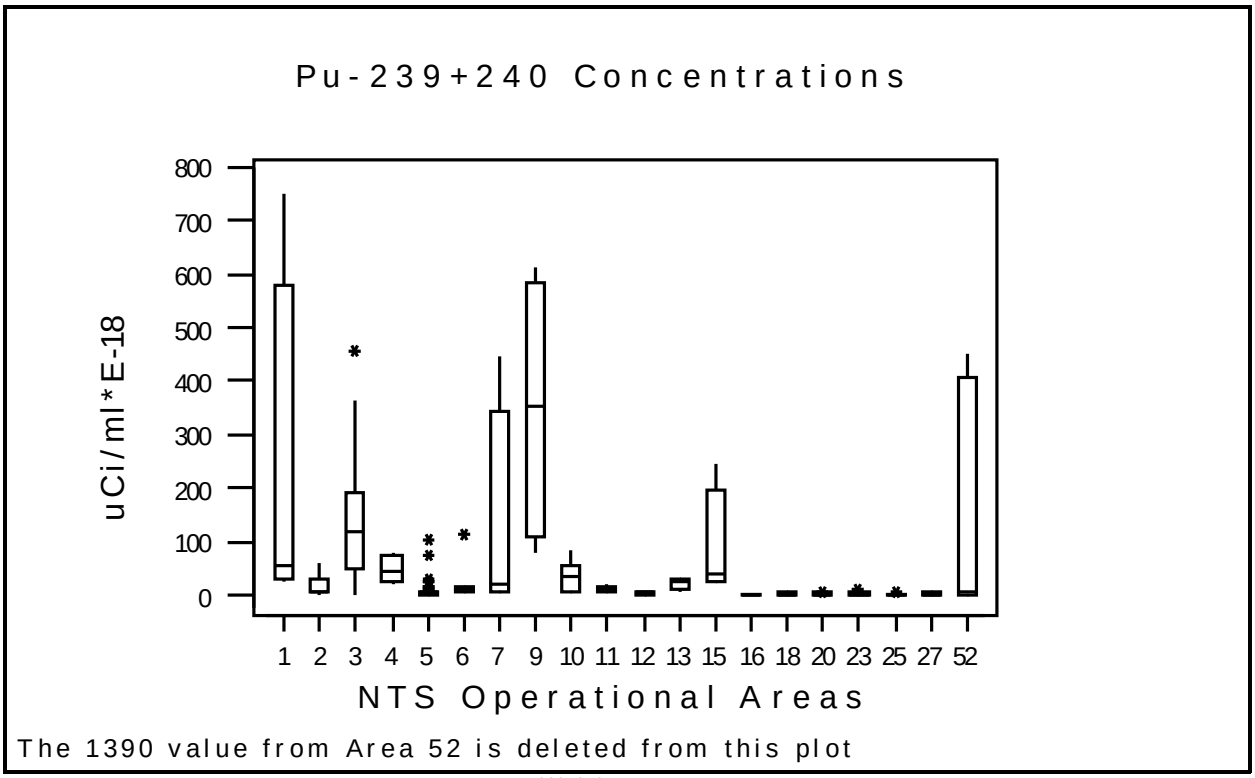

Figure 3.7 Boxplots of $^{239+240}$Pu Concentrations by NTS Area

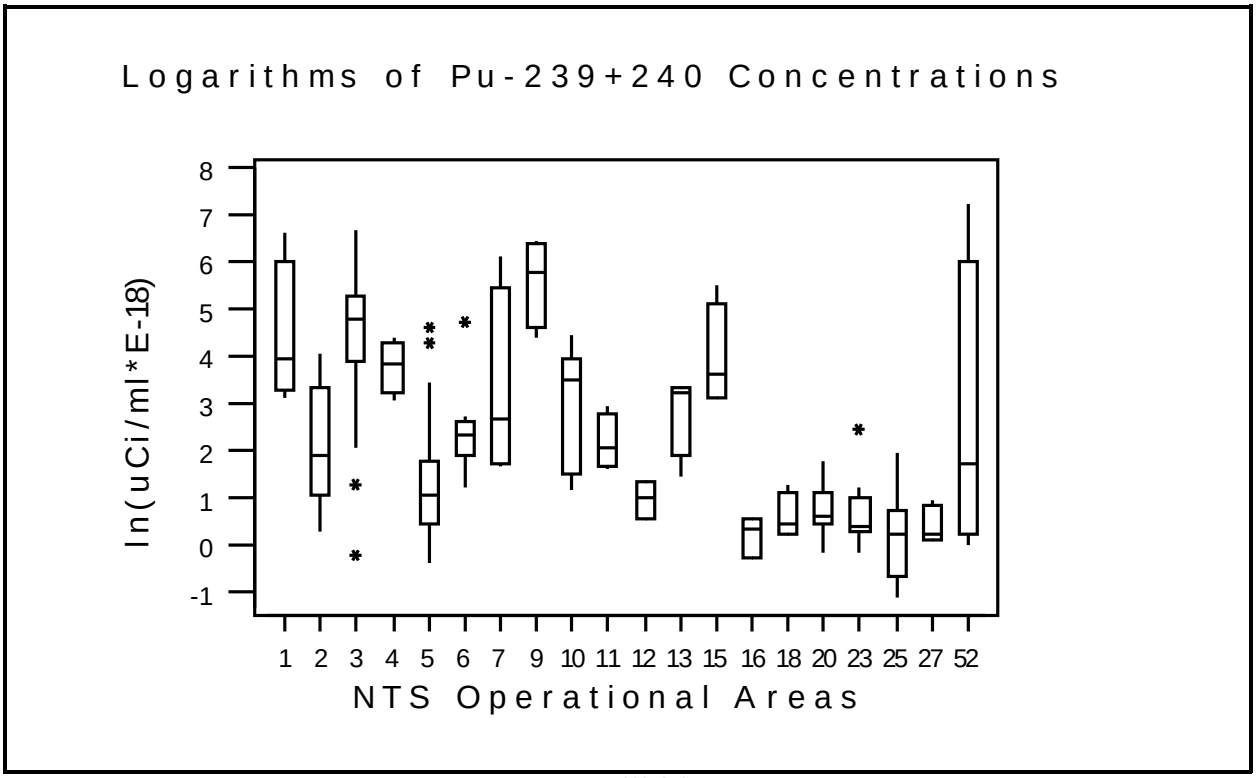

Figure 3.8 Boxplots of Natural Logarithms of $^{239+240}$Pu Concentrations by NTS Area

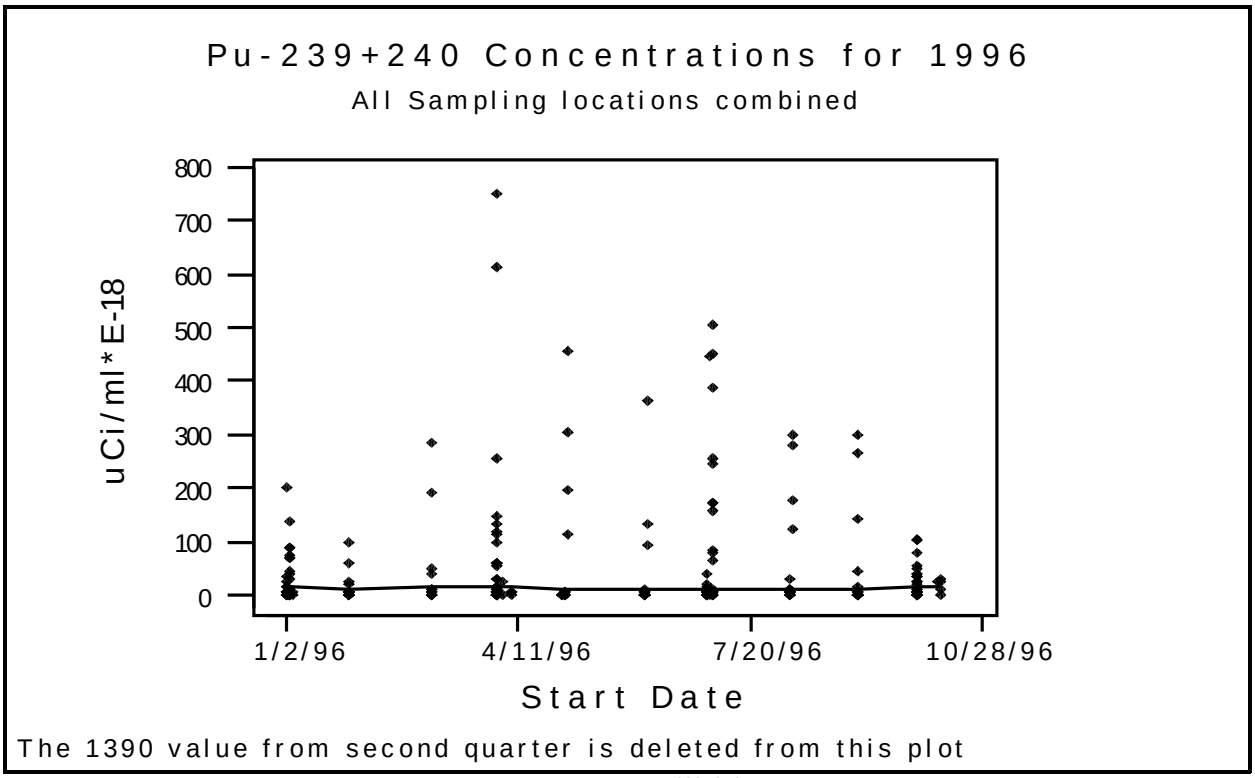

Figure 3.9 Time Series Plot of $^{239+240}$Pu Concentrations

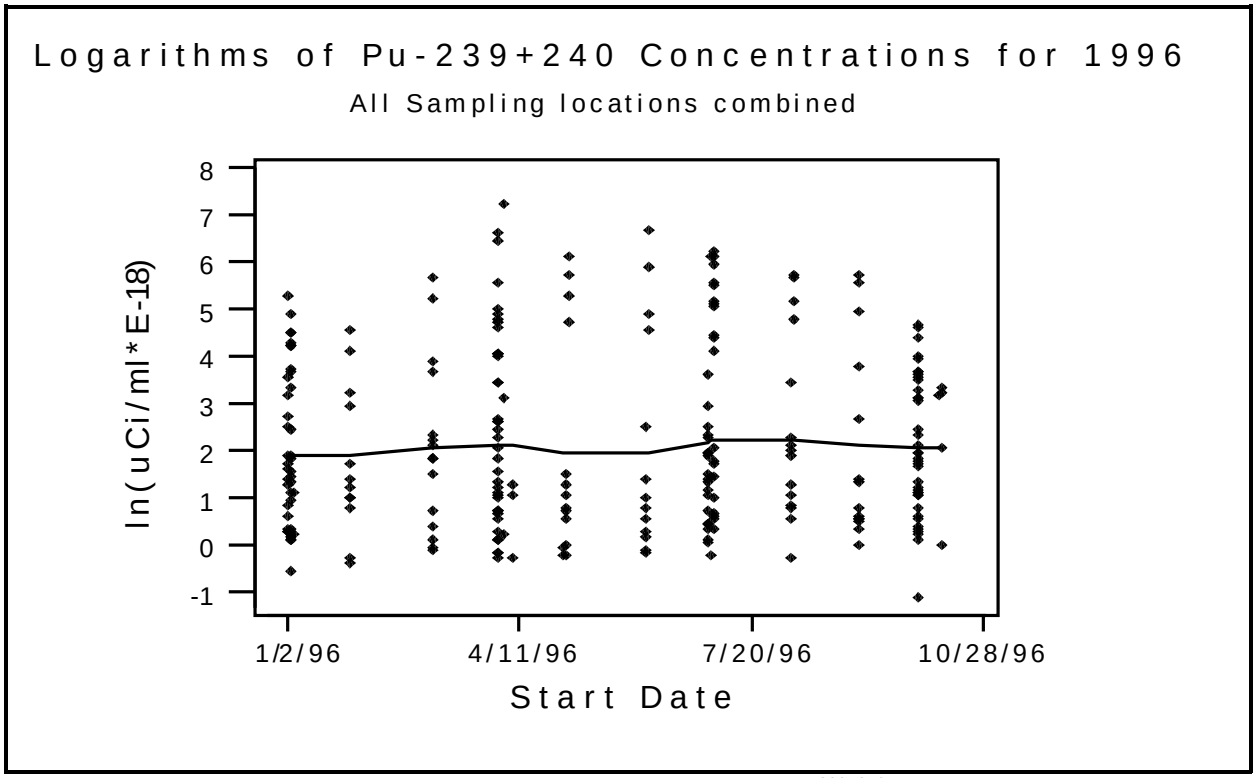

Figure 3.10 Time Series Plot of Natural Logarithms of $^{239+240}$ Pu Concentrations

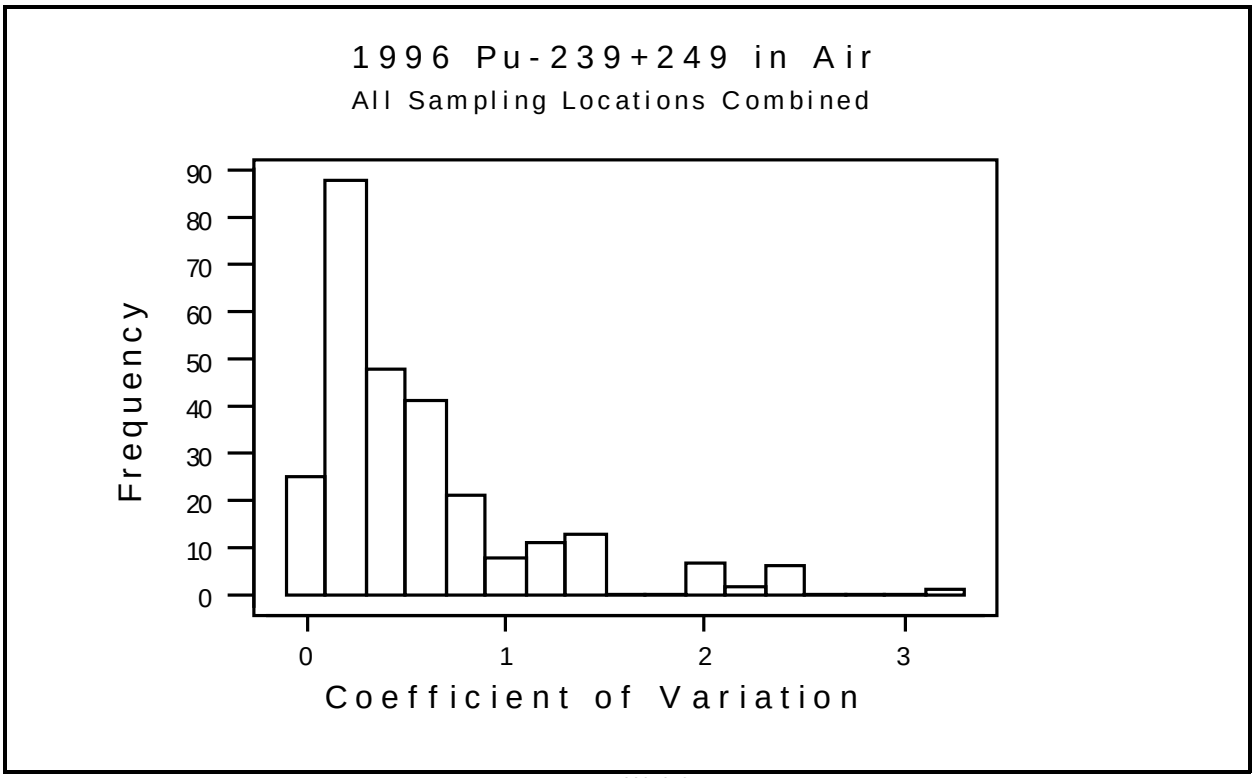

Figure 3.11 Histogram of 1996 $^{239+240}$Pu Coefficients of Variation

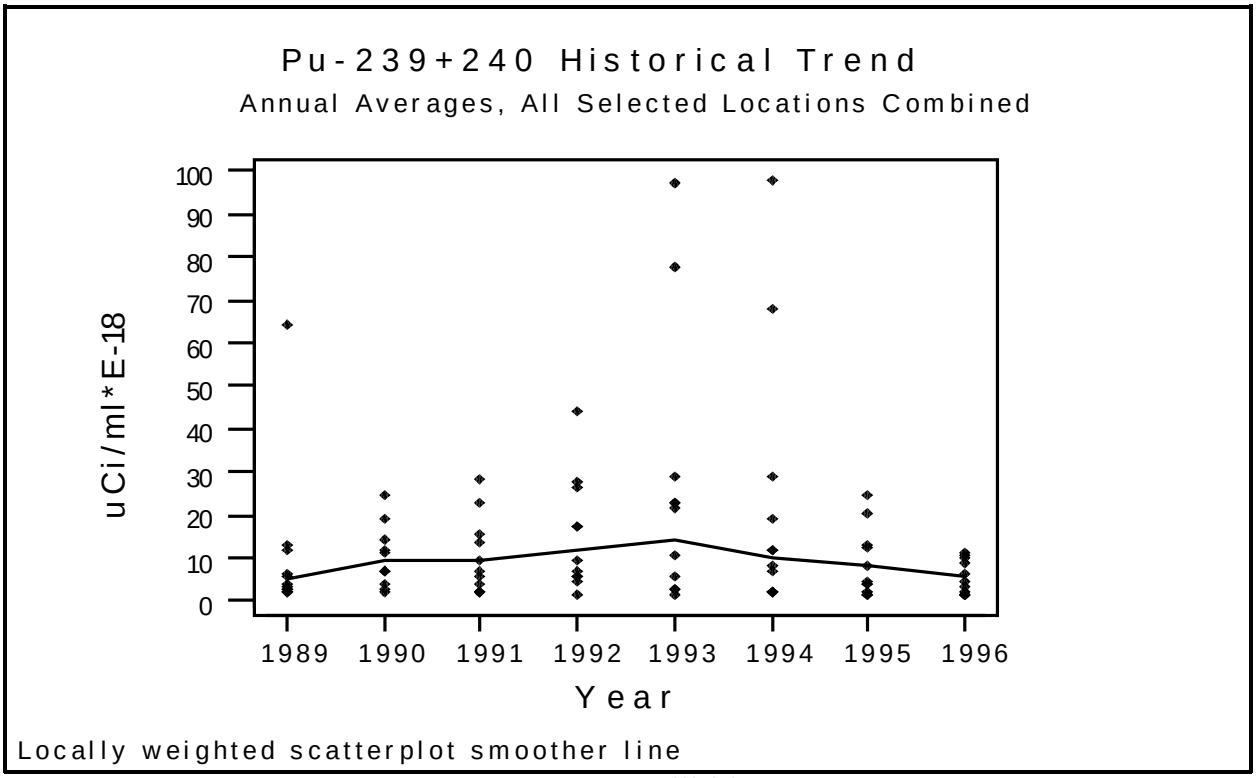

Figure 3.12 Time Series Plot of $^{239+240}$Pu Annual Averages

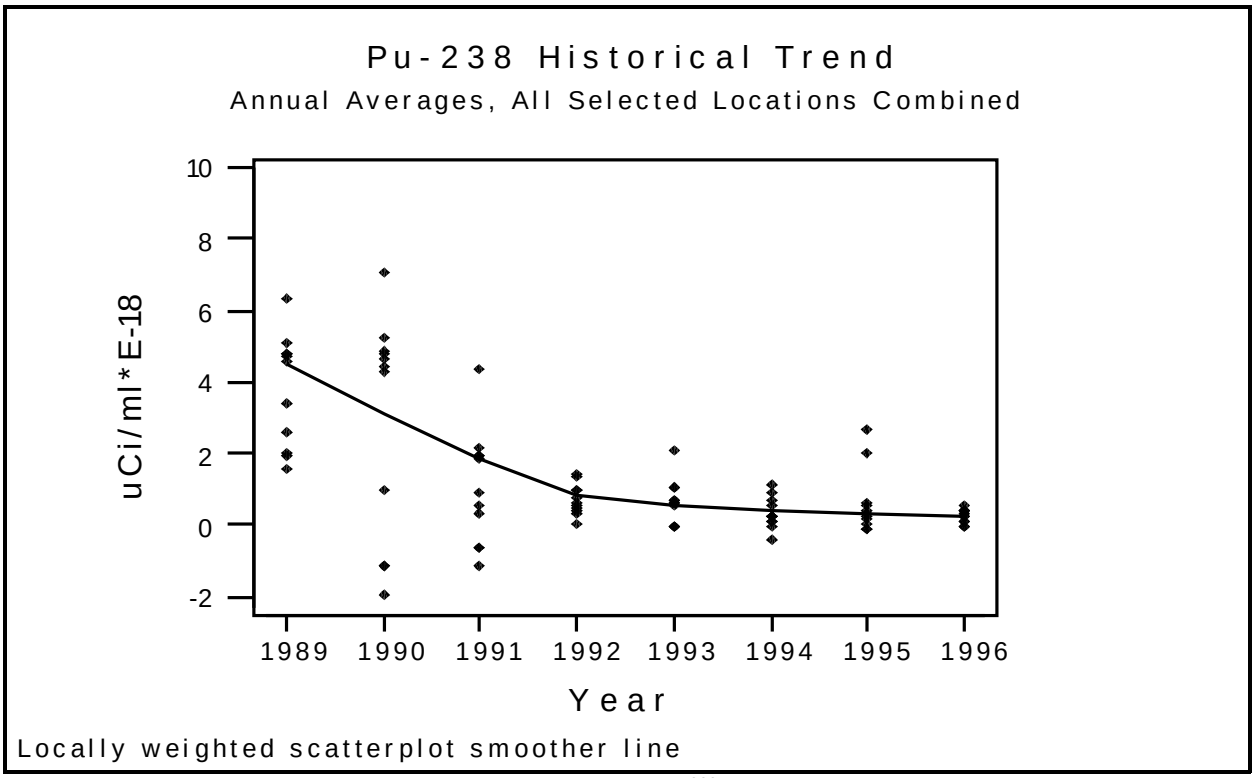

Figure 3.13 Time Series Plot of ^{238}Pu Annual Averages

Table 3.1 Radiological Waste Operations Monitoring Locations

Waste Operations Monitoring, Perimeter

U-3ah/at North	U-3ah/at East	U-3ah/at South	U-3ah/at West
RWNS No. 1	RWMS No. 3	RWMS No. 4	RWMS No. 5
RWMS No. 6	RWMS No. 7	RWMS No. 8	RWMS No. 9

Waste Operations Monitoring, Inside

RWMS Pit 5
RWMS Transuranic Pad Building North RWMS Transuranic Pad Building South

Waste Examination Facility

WEF North WEF South

Table 3.2 Descriptive Statistics for ^{238}Pu in Air by Location Type, µCi/mL x 10^{-18}

Statistic	Environmental	Waste Operations Perimeter	Waste Operations Inside	All Types Combined
Number of Data Values	123	116	30	271
Arithmetic Mean	1.27	0.96	0.28	1.02
Median	0.27	0.16	0.17	0.26
Standard Deviation	2.68	2.53	0.82	2.47
Minimum Value	-0.24	-1.55	-0.65	-1.55
Maximum Value	15.10	18.70	2.15	18.70
Median Mean Detection Limit	1.50	5.17	5.53	2.76
Results > Detection Limit	24%	5%	3%	13%

Table 3.3 Summary Statistics for ^{238}Pu Concentrations Compared Among NTS Operational Areas µCi/mL x 10^{-18}

Operational Area	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum
1	4	2.27	0.82	3.48	0.25	7.57
2	8	0.45	0.29	0.84	-0.14	2.42
3	48	2.22	1.26	3.39	-0.76	18.70
4	4	11.04	10.10	2.78	8.84	15.10

Table 3.3 (Summary Statistics for ^{238}Pu Concentrations Compared Among NTS Operational Areas µCi/mL x 10^{-18}, cont.)

Operational Area	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum
5	117	0.18	-0.13	0.94	-1.55	4.43
6	12	0.49	0.27	0.82	-0.14	2.76
7	4	1.47	0.50	2.34	-0.06	4.95
8	0					
9	4	5.90	6.36	3.45	1.68	9.20
10	8	2.04	1.04	2.45	-0.13	6.29
11	4	-0.01	-0.05	0.18	-0.18	0.25
12	4	0.28	0.08	0.50	-0.06	1.00
13	4	1.04	0.45	1.36	0.19	3.06
14	0					
15	4	1.60	0.96	2.11	-0.19	4.65
16	4	-0.03	-0.06	0.17	-0.19	0.21
17	0					
18	4	-0.02	-0.05	0.15	-0.17	0.19
19	0					
20	9	1.01	0.52	1.43	-0.18	3.86
22	0					
23	8	0.03	-0.05	0.16	-0.08	0.32
25	8	0.32	0.33	0.34	-0.17	0.83
26	0					
27	4	0.40	0.26	0.52	-0.09	1.14
29	0					
30	0					
52	10	1.51	0.10	3.44	-0.21	10.9
All Areas Combined	272	1.02	0.26	3.47	-1.55	18.70

Table 3.4 Descriptive Statistics for ^{238}Pu Concentrations by Sampling Location, µCi/mL x 10^{-18}

Sampling Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum
Area 1, BJY	4	2.37	0.82	3.48	0.25	7.57
Area 2, Complex	4	0.27	0.33	0.30	-0.14	0.58
Area 2, 2-1 Substation	4	0.63	0.10	1.21	-0.12	2.42
Area 3, U-3ah/at South	10	2.11	1.63	2.10	-0.16	5.80
Area 3, U-3ah/at East	10	1.61	0.95	1.70	-0.24	5.76
Area 3, U-3ah/at North	10	4.26	2.29	6.28	-0.76	18.70
Area 3, U-3ah/at West	10	1.93	1.44	2.29	-0.68	6.04
Area 3, Mud Plant	4	1.45	1.41	1.54	-0.24	3.21
Area 3, Well ER 3-1	4	0.47	0.13	0.89	-0.14	1.77
Area 4, Bunker T-4	4	11.04	10.10	2.78	8.84	15.10

Table 3.4 (Descriptive Statistics for ^{238}Pu Concentrations by Sampling Location, µCi/mL x 10^{-18}, cont.)

Sampling Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum
Area 5, WEF North	1	-0.11				
Area 5, WEF South	1	-0.13				
Area 5, RWMS Pit 5	10	0.08	-0.27	0.84	-0.65	1.58
Area 5, RWMS No. 4	10	-0.02	-0.16	0.56	-0.54	1.11
Area 5, RWMS No. 5	9	0.56	0.60	1.05	-0.67	2.57
Area 5, RWMS No. 6	10	0.10	-0.32	1.37	-0.77	3.88
Area 5, RWMS No. 7	9	0.27	-0.32	0.94	-0.46	2.35
Area 5, RWMS No. 8	10	0.24	0.13	0.75	-0.65	1.51
Area 5, RWMS No. 9	9	-0.18	-0.34	0.84	-1.55	1.54
Area 5, DOD Yard	4	-0.08	-0.06	0.06	-0.16	-0.03
Area 5, RWMS No. 3	9	0.60	-0.21	1.89	-0.69	4.43
Area 5, RWMS No. 1	10	-0.18	-0.24	0.43	-0.74	0.52
Area 5, Transuranic Bldg. North	10	0.58	0.51	0.75	-0.54	2.15
Area 5, Transuranic Bldg. South	10	0.17	-0.19	0.87	-0.14	1.77
Area 5, Well 5B	4	0.10	0.11	0.24	-0.14	0.33
Area 6, Yucca	4	0.62	-0.07	1.43	-0.13	2.76
Area 6, CP 6	4	0.31	0.30	0.49	-0.14	0.77
Area 6, Well 3	4	0.52	0.41	0.36	0.26	1.02
Area 7, UE-7ns	4	1.47	0.50	2.34	-0.06	4.95
Area 9, 9-300 Bunker	4	5.90	6.36	3.45	1.68	9.20
Area 10, Gate 700 South	4	0.38	0.34	0.45	-0.13	0.95
Area 10, SEDAN Crater	4	3.70	3.69	2.54	1.14	6.29
Area 11, Gate 293	4	-0.01	-0.05	0.18	-0.18	0.25
Area 12, Complex	4	0.28	0.08	0.50	-0.06	1.00
Area 13, Project 57	4	1.04	0.45	1.36	0.19	3.06
Area 15, EPA Farm	4	1.60	0.96	2.11	-0.19	4.65
Area 16, 3545 Substation	4	-0.03	-0.06	0.17	-0.19	0.21
Area 18, Well UE-18t	4	-0.02	-0.05	0.15	-0.17	0.19
Area 20, SCHOONER	4	2.25	2.06	1.29	1.03	3.86
Area 20, Camp	4	0.06	-0.04	0.31	-0.18	0.52
Area 20, CABRIOLET	1	-0.14				
Area 23, Building 790 No. 2	4	-0.06	-0.06	0.02	-0.07	-0.03
Area 23, H & S Building	4	0.11	0.10	0.20	-0.08	0.32
Area 25, E-MAD North	4	0.21	0.14	0.40	-0.17	0.73
Area 25, NRDS	4	0.43	0.35	0.27	0.20	0.83
Area 27, Camp	4	0.40	0.26	0.52	-0.09	1.14
Area 52, DOUBLE TRACKS	4	3.55	1.68	5.08	-0.05	10.90
Area 52, CLEAN SLATE III	4	-0.02	-0.04	0.18	-0.21	0.23
Area 52, CLEAN SLATE I	2	0.47	0.47	0.70	-0.13	0.97

Table 3.5 Descriptive Statistics for $^{239+240}Pu$ in Air by Location Type, µCi/mL x 10^{-18}

Statistic	Environmental	Waste Operations Perimeter	Waste Operations Inside	All Types Combined
Number of Data Values	123	116	30	271
Arithmetic Mean	57.08	59.77	5.58	52.32
Median	5.56	5.11	1.41	4.39
Standard Deviation	170.49	114.92	18.64	138.12
Minimum Value	-0.08	-0.26	-0.76	-0.76
Maximum Value	1390.0	804.00	103.00	1390.0
Median Mean Detection Limit	1.61	4.87	5.04	3.21
Results > Detection Limit	76%	37%	20%	59%

Table 3.6 Summary Statistics for $^{239+240}Pu$ Concentrations Compared Among NTS Operational Areas, µCi/mL x 10^{-18}

Operational Area	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum
1	4	219.47	51.85	354.76	22.90	751.00
2	8	16.01	6.74	20.49	1.31	58.40
3	48	149.31	117.00	142.46	0.79	804.00
4	4	48.35	46.05	25.22	20.80	80.50
5	116	5.34	2.25	12.19	-0.76	103.00
6	12	18.44	10.25	30.30	3.44	114.00
7	4	122.43	18.81	216.71	5.13	447.00
8	0					
9	4	349.07	352.00	251.77	79.30	613.00
10	8	31.83	32.70	28.49	3.20	83.80
11	4	10.01	7.88	6.51	4.96	19.30
12	4	2.03	2.23	1.62	-0.07	3.70
13	4	20.53	24.55	11.09	4.33	28.70
14	0					
15	4	86.58	40.50	105.53	22.30	243.00
16	4	0.95	1.05	0.78	-0.04	1.75
17	0					
18	4	1.99	1.63	1.05	1.22	3.48
19	0					
20	9	2.50	1.88	1.50	0.83	5.97
22	0					
23	8	2.83	1.50	3.46	0.85	11.20
25	8	1.46	1.86	2.33	-0.08	7.05
26	0					
27	4	1.56	1.26	1.71	1.13	2.61
29	0					
30	0					
52	10	227.91	5.88	443.57	1.01	1390.00
All Areas Combined	271	52.32	4.39	138.32	-0.76	1390.00

Table 3.7 Descriptive Statistics for $^{239+240}Pu$ Concentrations by Sampling Location, µCi/mL x 10^{-18}

Sampling Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum
Area 1, BJY	4	219.40	51.85	354.76	22.90	751.00
Area 2, Complex	4	6.62	6.36	3.93	2.34	11.40
Area 2, 2-1 Substation	4	25.41	20.96	26.99	1.31	58.40
Area 3, U-3ah/at South	10	110.06	117.00	71.53	18.80	253.00
Area 3, U-3ah/at East	10	124.99	90.85	104.78	24.80	305.00
Area 3, U-3ah/at North	10	260.28	211.50	227.68	38.60	804.00
Area 3, U-3ah/at West	10	161.49	145.50	104.35	50.10	362.00
Area 3, Mud Plant	4	123.95	119.50	105.08	0.79	256.00
Area 3, Well ER 3-1	4	25.78	22.84	24.16	3.53	53.90
Area 4, Bunker T-4	4	48.35	46.05	25.22	20.80	80.50
Area 5, WEF North	1	25.50				
Area 5, WEF South	1	23.10				
Area 5, RWMS Pit 5	10	3.22	2.05	3.69	-0.76	10.10
Area 5, RWMS No. 4	10	2.06	1.00	2.71	-0.15	8.21
Area 5, RWMS No. 5	9	7.31	2.74	9.93	1.20	31.00
Area 5, RWMS No. 6	10	5.14	3.92	3.61	-0.09	12.00
Area 5, RWMS No. 7	9	11.56	2.84	23.28	0.75	73.00
Area 5, RWMS No. 8	10	5.64	5.93	4.00	1.20	13.60
Area 5, RWMS No. 9	9	2.51	2.02	1.89	0.76	6.66
Area 5, DOD Yard	4	4.31	4.38	2.13	2.01	6.50
Area 5, RWMS No. 3	9	1.84	1.73	0.89	0.86	3.82
Area 5, RWMS No. 1	10	2.71	2.79	1.47	-0.26	4.73
Area 5, Trans. Bldg. North	10	2.20	2.01	1.90	-0.26	6.34
Area 5, Trans. Bldg. South	10	12.13	0.95	32.19	-0.24	103.00
Area 5, Well 5B	4	3.24	3.04	0.62	2.77	4.13
Area 6, Yucca Complex	4	35.92	10.79	52.08	8.10	114.00
Area 6, CP 6	4	8.59	8.25	3.29	5.56	12.30
Area 6, Well 3	4	10.81	12.15	5.43	3.44	15.50
Area 7, UE-7ns	4	122.43	18.81	216.71	5.13	447.00
Area 9, 9-300	4	349.07	352.00	250.77	79.30	613.00
Area 10, Gate 700 South	4	11.08	4.92	13.52	3.20	31.30
Area 10, SEDAN Crater	4	52.58	46.20	23.74	34.10	83.80
Area 11, Gate 293	4	10.01	7.88	6.51	4.96	19.30
Area 12, Complex	4	2.02	2.23	1.62	-0.07	3.70
Area 13, Project 57	4	20.53	24.55	11.09	4.33	28.70
Area 15, EPA Farm	4	86.58	40.50	105.53	22.30	243.00
Area 16, 3545 Substation	4	0.95	1.05	0.78	-0.04	1.75
Area 18, Well UE-18t	4	1.99	1.63	1.05	1.22	3.48
Area 20, SCHOONER	4	3.15	2.39	1.94	1.85	5.97
Area 20, Camp	4	1.74	1.56	0.93	0.83	3.03
Area 20, CABRIOLET	1	2.95				
Area 23, Building 790 No. 2	4	4.40	2.46	4.61	1.50	11.20
Area 23, H & S Building	4	1.26	1.35	0.29	0.86	1.51
Area 25, E-MAD North	4	2.37	1.25	3.19	-0.08	7.05

Table 3.7 (Descriptive Statistics for $^{239+240}Pu$ Concentrations by Sampling Location, cont.)

Sampling Location	Number of Samples	Mean	Median	Standard Deviation	Minimum	Maximum
Area 25, NRDS Warehouse	4	0.54	0.46	0.56	-0.04	1.29
Area 27, Camp	4	1.56	1.26	0.71	1.13	2.61
Area 52, DOUBLE TRACKS	4	447.67	198.79	653.87	3.10	1390.00
Area 52, CLEAN SLATE III	4	1.91	1.23	1.52	1.01	4.18
Area 52, CLEAN SLATE I	2	240.40	240.40	300.66	27.80	543.00

Table 3.8 Historical $^{239+240}Pu$ Annual Averages at Selected Locations, µCi/mL x 10^{-18}

Sampling Location	1989	1990	1991	1992	1993	1994	1995	1996
Area 2, Camp	12.0	11.9	6.0	26.5	21.4	98.0	4.7	6.6
Area 5, DOD Yard	2.5	2.0	15.5	1.7	5.5	8.1	3.9	4.3
Area 5, Well 5B	3.7	3.9	6.9	5.5	10.4	19.0	20.3	3.2
Area 6, CP-6	5.7	6.8	9.3	6.8	22.8	6.8	8.1	8.6
Area 6, Well 3	6.2	14.1	22.7	9.1	29.1	12.0	13.1	10.8
Area 10, Gate 700 South	13.0	11.4	13.7	44.2	22.8	12.0	12.3	11.1
Area 11, Gate 293	64.0	18.9	28.2	27.7	77.8	29.0	24.6	10.0
Area 12, Camp	2.6	2.7	3.8	5.7	97.4	2.1	3.9	2.0
Area 16, 3545 Substation	2.4	2.0	4.3	5.5	3.7	2.7	4.4	1.0
Area 23, H & S Building	3.3	24.9	2.3	4.3	1.6	68.0	2.1	1.3
Area 27, Camp	2.2	7.2	2.1	17.4	2.7	1.9	1.6	1.6
All selected locations combined	10.7	9.6	10.4	14.0	26.8	23.6	9.0	5.5

Table 3.9 Historical ^{238}Pu Annual Averages at Selected Locations, µCi/mL x 10^{-18}

Sampling Location	1989	1990	1991	1992	1993	1994	1995	1996
Area 2, Camp	6.3	7.1	-0.6	0.6	0.7	0.9	0.3	0.3
Area 5, DOD Yard	4.6	4.4	2.1	0.8	0.6	0.0	0.0	-0.1
Area 5, Well 5B	2.6	4.7	1.9	0.3	0.5	-0.4	2.7	0.1
Area 6, CP-6	3.4	4.8	0.3	0.4	0.6	0.1	0.6	0.3
Area 6, Well 3	5.1	5.2	0.5	1.4	0.7	0.3	2.0	0.5
Area 10, Gate 700 South	4.7	4.3	4.3	0.5	1.1	0.6	0.6	0.4

Table 3.9 (Historical ^{238}Pu Annual Averages at Selected Locations, µCi/mL x 10^{-18}, cont.)

Sampling Location	1989	1990	1991	1992	1993	1994	1995	1996
Area 11, Gate 293	2.0	-2.0	0.9	0.6	2.1	1.1	0.2	0.0
Area 12, Camp	1.9	1.0	-0.6	1.4	1.0	0.1	0.4	0.3
Area 16, 3545 Substation	6.8	3.6	-0.7	0.0	-0.1	0.1	-0.1	0.0
Area 23, H & S Building	1.6	4.9	-1.2	0.0	-0.1	0.7	0.3	0.1
Area 12, Camp	4.8	-1.2	1.9	1.0	-0.1	0.3	-0.1	0.4
All selected locations combined	4.0	3.3	0.8	0.6	0.6	0.3	0.6	0.2