LA-13646-PR
Progress Report

Area G Perimeter Surface-Soil Sampling

Environmental Surveillance for Fiscal Year 1998

Hazardous and Solid Waste Group (ESH-19)

Los Alamos
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Acronyms and Abbreviations

cpm	counts per minute
CST	Chemical Science and Technology Division, LANL
DOE	Department of Energy
ER	Environmental Restoration Project, LANL
ESH	Environment, Safety, and Health Division, LANL
FIDLER	field instrument for detection of low-energy radiation
FIMAD	Facility for Information Management and Display
FY	fiscal year
keV	kiloelectron volts (10^3 electron volts)
LANL	Los Alamos National Laboratory
MDA	material disposal area
NAD	North American datum
pCi	Picocurie (10^{-12} curies)
RAS	Radioactivity/alpha spectroscopy
SAL	Screening Action Level
SOP	standard operating procedure
TA	technical area
TRU	transuranic (waste)
TWISP	Transuranic Waste Inspectable Storage Project
WILD	brand-name surveying station
WSS	Waste Site Studies Team

AREA G PERIMETER SURFACE-SOIL SAMPLING

Environmental Surveillance for Fiscal Year 1998

Hazardous and Solid Waste Group (ESH-19)

by

Marquis Childs and Ron Conrad

ABSTRACT

Material Disposal Area G (Area G) is at Technical Area 54 at Los Alamos National Laboratory (LANL). Area G has been the principal facility for the disposal of low-level, solid-mixed, and transuranic waste since 1957. It is currently LANL's primary facility for radioactive solid waste burial and storage. As part of the annual environmental surveillance effort at Area G, surface soil samples are collected around the facility's perimeter to characterize possible radionuclide movement off the site through surface water runoff. During 1998, 39 soil samples were collected and analyzed for percent moisture, tritium, plutonium-238 and 239, cesium-137 and americium-241. To assess radionuclide concentrations, the results from these samples are compared with baseline or background soil samples collected in an undisturbed area west of the active portion Area G. The 1998 results are also compared to the results from analogous samples collected during 1996 and 1997 to assess changes over this time in radionuclide activity concentrations in surface soils around the perimeter of Area G. The results indicate elevated levels of all the radionuclides assessed (except cesium-137) exist in Area G perimeter surface soils vs the baseline soils. The comparison of 1998 soil data to previous years (1996 and 1997) indicates no significant increase or decrease in radionuclide concentrations; an upward or downward trend in concentrations is not detectable at this time. These results are consistent with data comparisons done in previous years. Continued annual soil sampling will be necessary to realize a trend if one exists. The radionuclide levels found in the perimeter surface soils are above background but still considered relatively low. This perimeter surface soil data will be used for planning purposes at Area G; techniques to prevent sediment transport off-site are implemented in the areas where the highest radionuclide concentrations are indicated.

1.0 INTRODUCTION

Material Disposal Area G (Area G), in Technical Area 54 (TA-54) (see Figure 1) has been the principal facility at Los Alamos National Laboratory (LANL, the Laboratory) for the storage and disposal of low-level, solid mixed, and TRU (transuranic) radioactive waste since 1957. Figures 2, 3, and 4 are photographs of Area G and some of its waste management features. From the standpoint of the surrounding environment, an important question is whether there has been an environmental impact outside of Area G due to the disposal and storage operations that have taken place within Area G. One aspect of this question is whether contamination associated with surface soil within Area G somehow migrates off-site. The two most likely pathways (other than groundwater, due to its approximate 900-foot depth and geological conditions) for spread of contaminants from Area G surface sediments are airborne dispersion of particulate matter or gases and off-site movement of contaminated sediments and/or dissolved chemical compounds by surface water runoff.

This environmental surveillance investigation was carried out, in part, to ensure ongoing compliance with DOE (Department of Energy) Order 5400.1, "General Environmental Protection Program" (June 1990), and DOE Order 5820.2A, "Radioactive Waste Management" (September 1988).

The principal goal of this investigation is to identify any locations around the perimeter of Area G where elevated levels of radionuclides exist and the locations where the probability of off-site migration is highest. Extensive surface soil sampling was initiated in 1993 around the perimeter of Area G and continues on an annual basis; samples were collected in 1999 and the results are pending analysis. This report will focus on samples collected during 1998 including a

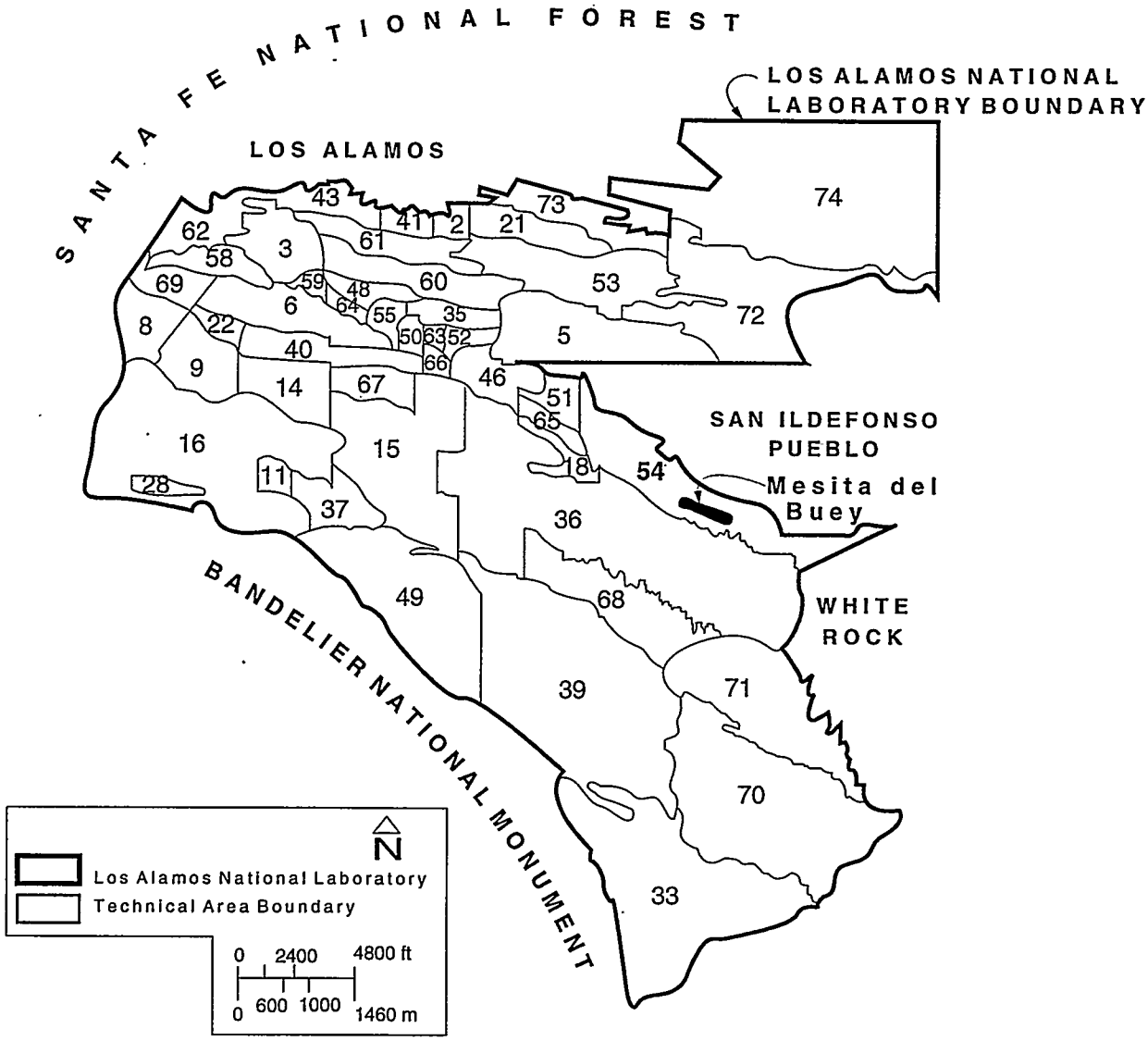


Figure 1. Location of TA-54 and Area G at Los Alamos National Laboratory. The 74 technical areas (TAs) of the Laboratory are shown here, with TA-54 located south of San Ildefonso Pueblo property. Area G (shaded in gray) runs along Mesita del Buey and parallels Pajarito Road.

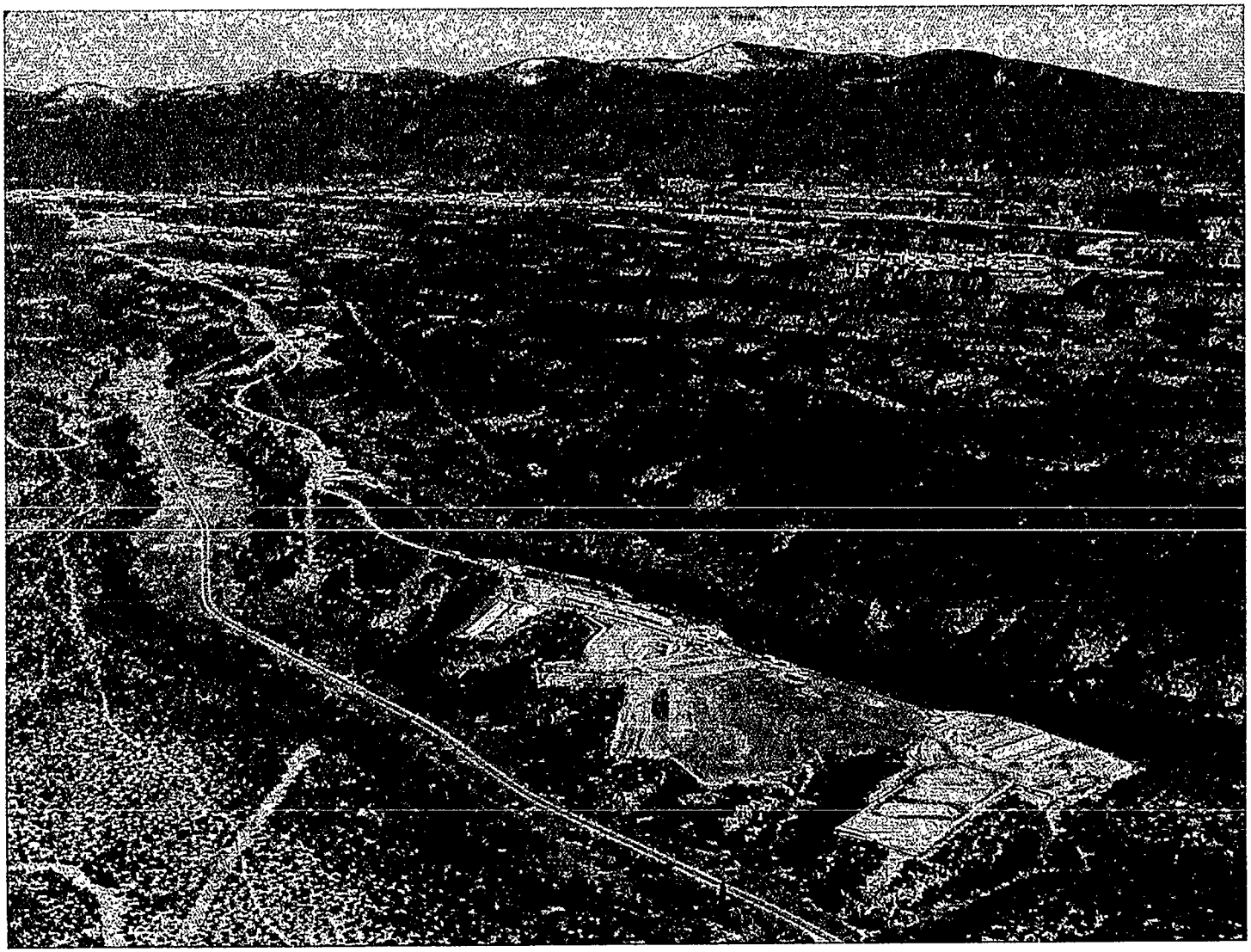


Figure 2. Aerial Photograph of TA-54 / Area G and Surrounding Area, NW View (1993).

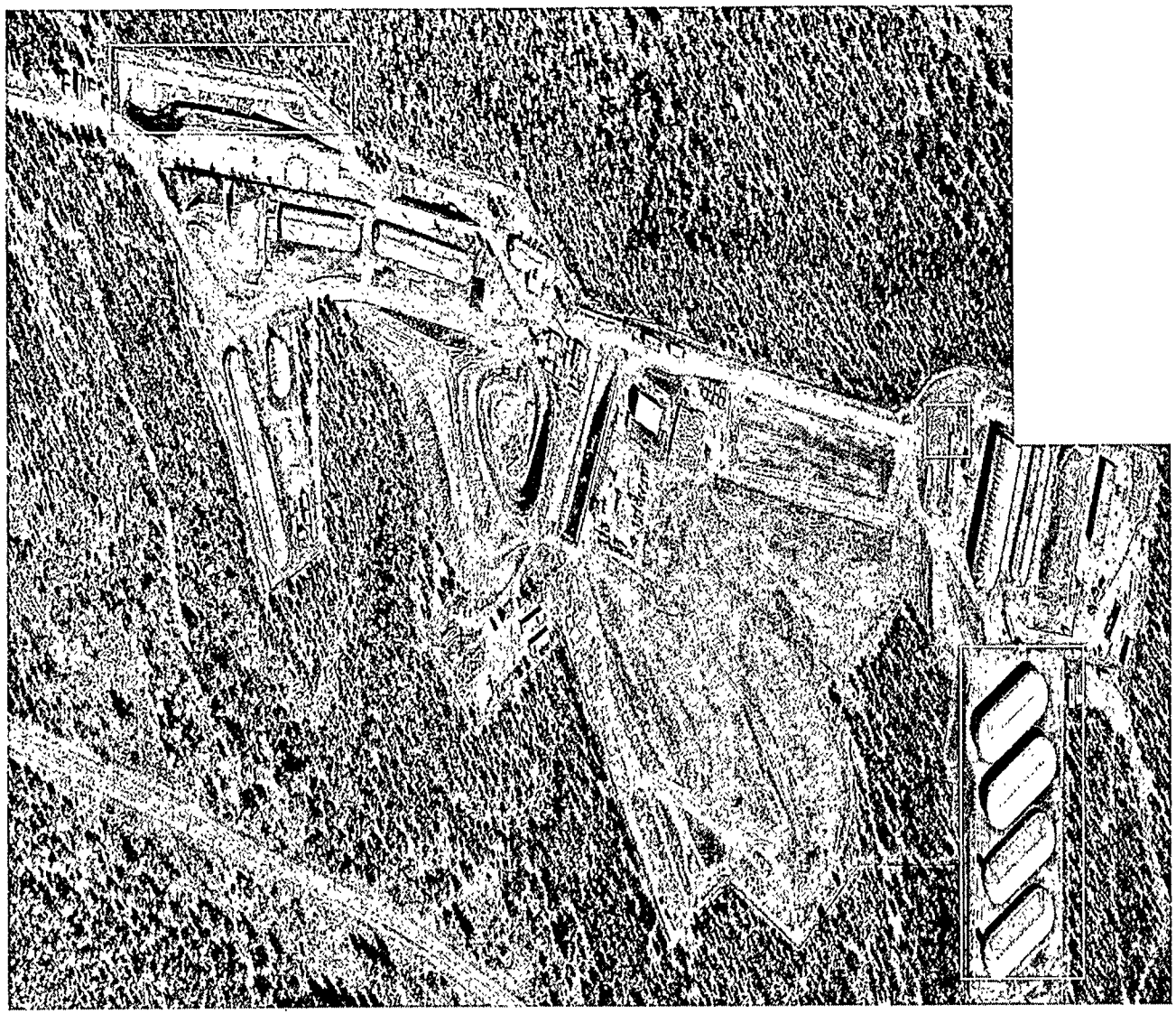
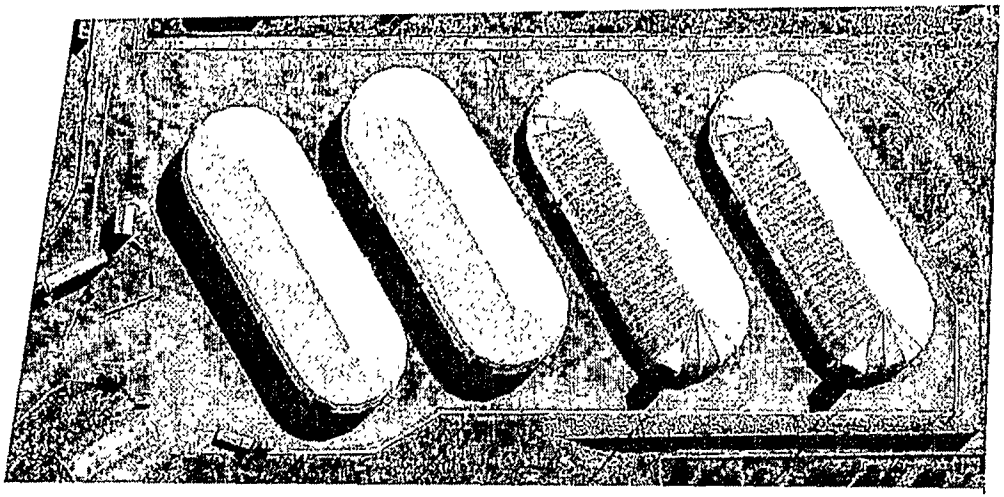
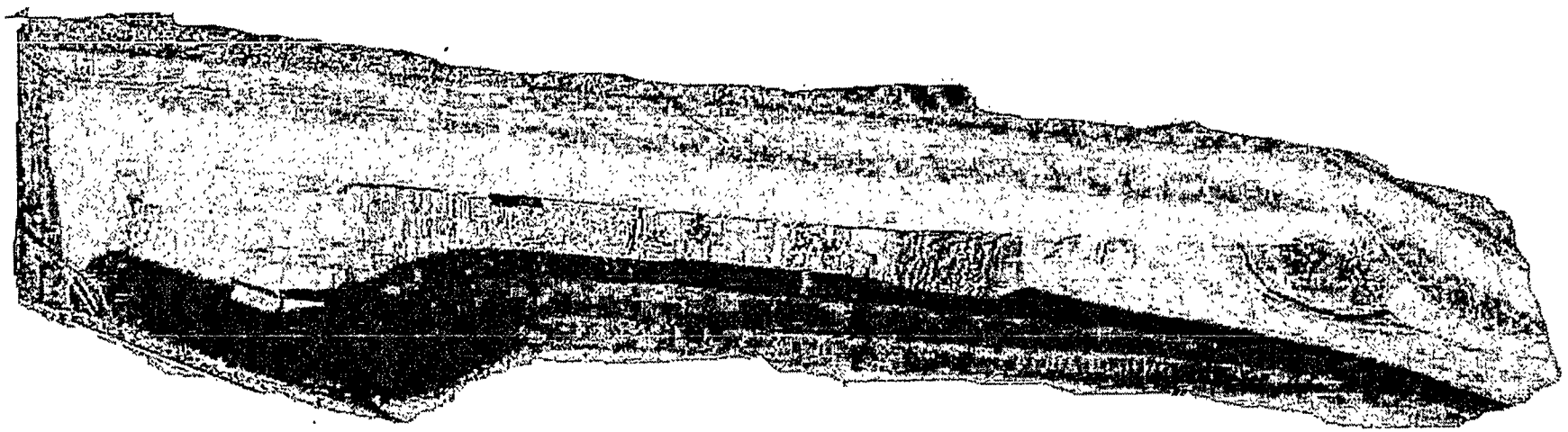


Figure 3. High Resolution Aerial Photograph of Area G. White boxes indicate location of close-ups seen in Figure 4.



(Waste Storage Domes)

(Concrete Capped Disposal Shafts)



(Active Disposal Pit)

Figure 4. Close-ups of Waste Management Features at Area G (from Figure 3).

comparison with sampling results from 1996 and 1997. Sampling locations were intentionally selected to best indicate whether contaminants were moving off-site via the soil transport by stormwater pathway; thus, these sampling locations should be considered as locations most sensitive to possible contaminant migration outside of Area G. The data collected during 1998 can be used to

A. compare with baseline "activity concentrations" (concentrations) of radionuclides on soils sampled in an undisturbed area of TA-54 to determine if radionuclide concentrations in perimeter surface soils are above "background" and to what degree;

B. compare this year's results with the previous years soil sampling results to look for indications of trends (increasing, decreasing, or unchanging radionuclide concentrations);

C. determine whether there has been movement of contaminants off-site; and

D. assist Area G waste management personnel attempts to engineer techniques to prevent off-site movement of contaminants by either indicating areas of concern or assessing effectiveness of engineering fixes already in place to preclude off-site movement of contaminants.

The determination of sediment movement out of Area G via the surface water pathway is important because this is a major mechanism for disseminating nongaseous contaminants from the surface of Area G to outlying areas. Contamination on the ground surface of Area G (and formation of the surface soil source term for surface water runoff) may have resulted from

A. dispersion of material from active pits by natural phenomena and anthropogenic activities;

B. movement of contaminated sediments off the TRU pads or other storage or disposal areas by wind, surface water runoff, mass wasting, or anthropogenic activities;

C. capillary action or vapor movement of buried, radioactive contaminants in pits and shafts to the surface;

D. inadvertent spills or discharges from facilities or vehicles handling contaminated materials;

E. dispersion of contaminants from trucks carrying waste into Area G;

F. transport of contaminants or contaminated materials from inactive pits, shafts, or pads to the surface by burrowing animals, vegetation, or anthropogenic activities; and/or

G. waste disposal of contaminated sediments on the ground surface.

Radioactive surface soil contamination at low levels has been documented within the confines of Area G, and it is necessary to determine if these contaminants are moving off the mesa top to areas where the public may be exposed or where there may be a detrimental impact to the environment. To meet these needs, a soil sampling network was established around the perimeter of Area G. Thirty-nine soil samples were collected in 1998 at the same locations samples were collected in previous years. Figure 5, located in the pocket on the back cover, displays the sampling locations and topographic characteristics of Area G.

2.0 OBJECTIVES OF INVESTIGATION

The objectives of this sampling project and data assessment were to

A. define those perimeter locations at Area G where contaminants are expected to be found in surface soils or in established surface-water-runoff channels. The latter are determined by walking the site and detecting the small channels that are formed by surface water runoff originating in Area G;

B. quantify the levels of radioactive contaminants in surface soils around the perimeter of Area G and compare them with baseline levels from surface soil samples taken in adjacent, non-impacted locations;

C. make a comparison of soil radionuclide concentrations from 1998 with results from previous years soil sampling and look for indications of increasing or decreasing radionuclide concentrations; and

D. document whether contaminants (associated with sediments) have migrated off-site.

Enhanced Area G perimeter surveillance occurs annually in order to provide an up-to-date picture of existing radioactive contamination in perimeter surface soils. Ultimately, any measurable impacts on unimpacted adjacent areas can be documented by comparing these data with those from future surveillance efforts.

2.1 Areal and Temporal Extent

The investigation to define off-site migration of contaminants via the surface water pathway is limited to the near mesa-top perimeter just outside the boundary/security fence of Area G and one major drainage within the disposal area itself (see 1998 sampling locations in Figure 5). Surface soil-sampling stations were installed in small arroyos or rivulets incised into the hillsides around the perimeter of Area G.

This study is not intended to define potential contamination in the environment downstream from Area G. The sediments in the canyon bottoms, surface water, and groundwater located downstream from Area G are all monitored on an annual basis by the Water Quality and Hydrology Group (ESH-18) of the Environment, Safety, and Health Division (ESH). The Canyons Focus Group within LANL's Environmental Restoration Project is undertaking an intensive investigation of the impacts to the canyons resulting from past Laboratory operations and waste disposal practices. Based on available funding, this environmental surveillance project will continue annually so the ability to compare contemporary with historical data is possible.

2.2 Data Needs

The data needs for this 1998 Area G soil investigation are

A. surface soil samples (0–6 inches deep) from existing runoff pathways located just outside the Area G perimeter fence and analyses of these samples for those constituents listed in Section 5.3;

B. the results from the soil sampling that occurred in previous years; and

C. the results from the sampling that occurred in an undisturbed area (the Development Area) of TA-54 during 1994 and 1995; the baseline/background comparison data.

The Development Area (formerly known as the Expansion Area) sites that were sampled in 1994 and 1995 are located where no radioactive waste disposal has occurred and in a location where waste management operations are expected to develop in the future. In 1994, a regular 100 x 100-ft grid was established in this area, just west of the old Area G gate (the area west of the

shaded yellow expanse in Figure 5). The analytical data from 54 samples collected in this area will serve as baseline or preoperational concentrations for constituents of interest when disposal operations are initiated in this development area. This information is also presented in this paper to serve as one benchmark against which perimeter soil radionuclide concentrations will be compared.

3.0 FIELD INVESTIGATION METHODS

Accepted techniques were used to identify and certify sampling locations, install sampling equipment, take samples, and make measurements on these samples. A summary of field protocols is found in the following sections.

3.1 Land Survey

A WILD electronic-theodolite complete surveying station was used in the field. This equipment was used and field data were collected employing WILDsoft 2000 software for data reduction. Bill Kopp, a LANL technical staff member and professional engineer registered in the state of New Mexico, supervised all of the surveying for this project.

At all of the sampling locations (coordinates referenced to North American datum [NAD] 1983), an aluminum stake was placed to memorialize the position.

The unique sampling locations on the perimeter of Area G were coded as G-##-#. The first two numbers after "G" in the sequence refer to 1 of 70 permanent survey monuments, each of which is identified by a piece of rebar driven into the ground and tagged with an aluminum cap marked with the location number. These 70 monuments were originally installed in 1991 as part of the old A411 MDA low-energy gamma, field instrument for detection of low-energy radiation

(FIDLER) study to characterize potential movement of radioactive contaminants off-site. FIDLER readings are still taken on an annual basis at each of these 70 locations. The perimeter soil sampling sites were numbered in reference to these 70 permanent, surveyed locations. For instance, three soil sampling sites are located near monument MDA-29. These locations are identified by aluminum stakes with numbered tags G-29-1, G-29-2, and G-29-3 (see map, Figure 5).

The Development Area soil sampling 100 x 100 ft grid was also memorialized by surveying in the locations. At each location, a 4-ft aluminum stake was pounded into the ground. Numbered brass tags attached to the stake describe the locations with the notation, G-X-##. The gridded locations are numbered consecutively from G-X-1 through G-X-55, excluding point G-X-7 which was located off the edge of the mesa top (numbered as 1 to 55 on Figure 5).

On the map depicting the perimeter and Development Area surveillance locations (Figure 5), soil-sample points are in blue. The Development Area Grid points cover the fenced-in area immediately west of the active (yellow area in Figure 5) portion of Area G. Doug Walther of the LANL Facility for Information Management and Display (FIMAD) team prepared this map.

3.2 Field Techniques

The following standard sampling and instrument procedures were adopted to collect the soil samples and to make associated measurements (these procedures were developed by LANL's Environmental Restoration Program):

Standard Operating Procedure (SOP) Number	**Title**
LANL-ER-SOP-01.02	Sample Containers and Preservation

LANL-ER-SOP-03.01	Land Surveying Procedures
LANL-ER-SOP-06.09	Spade and Scoop Method for Collection of Soil Samples
LANL-ESH-8-008	General Field Work

Before soil samples were collected, one-minute counts were made at the soil surface to define surface soil beta/gamma activity. These readings were made with an Eberline ESP-1 beta/gamma meter equipped with a "pancake" probe (similar to a Geiger counter) . The beta/gamma measurements were taken principally to define any potential radioactive hazards at sampling points. A typical soil-background level taken with the ESP-1 counter at Area G was 300 counts per minute (cpm).

3.3 Chain-of-Custody Procedure

In addition to the above SOPs, LANL-ESH-8-002, "Chain-of-Custody for Environmental Samples" procedure was followed. In this project, each sample was handled under standard chain-of-custody procedures, using traceable forms, transfer signatures, and custody tape. Every sample was always kept within sight or locked in a room or cooler to which only the sampling team had keys. All samples requiring analytical chemistry services were delivered to the Chemical Science and Technology Division's (CST's) Inorganic Trace Analysis group (CST-9) located at SM-59-1, TA-59. CST-9 personnel took formal custody of the samples at that time. All samples collected in 1998 were analyzed on-site at LANL.

4.0 SAMPLE ANALYSIS

The analytical chemistry data for samples referred to in this report are found in Tables 1–4.

Table 1: 1998 TA-54 Area G Perimeter Surface Soil Data (Sample locations can be found in Figures 5-8. Please note that negative values sometimes result from counting statistics when average background activities are subtracted from gross analytical results.)

Sample Location	Collection Date	% Water	^{3}H pCi/L	^{241}Am pCi/g	^{137}Cs pCi/g	^{238}Pu pCi/g	^{239}Pu pCi/g	Total Pu pCi/g
G-29-01	02/10/98	15	19,100	0.23	0.07	0.017	0.013	0.030
G-29-02	02/10/98	29	15,000	0.24	0.35	0.004	0.016	0.020
G-29-03	02/10/98	10.3	162,700	0.09	0.07	0.010	0.029	0.039
G-30-01	02/10/98	16.4	9,700	0.39	0.07	0.015	0.022	0.037
G-31-01	03/13/98	26	33,700	0.04	0.3	0.033	0.025	0.058
G-31-02	03/13/98	9	15,000	0.92	0.14	0.011	0.012	0.023
G-31-03	02/10/98	11	6,500	0.03	0.04	0.002	0.004	0.006
G-32-01	02/10/98	9	5,500	0.45	0.05	0.005	0.011	0.016
G-32-02	02/10/98	26.2	2,900	0.09	0.32	0.007	0.042	0.049
G-34-05	03/25/98	10	520	1.11	0.05	0.012	0.052	0.064
G-34-09	03/25/98	13	1,120	2.01	0.06	0.018	0.046	0.064
G-34-10	03/25/98	5	2,070	1.07	1.04	0.040	1.338	1.378
G-34-15	03/25/98	9	1,220	1.1	0.07	0.222	0.029	0.250
G-38-02	02/25/98	16	8,900	0.94	0.4	0.081	2.109	2.190
G-39-01	02/10/98	15.6	4,070	0.49	0.11	0.378	0.095	0.472
G-39-02	02/25/98	2	8,100	0.14	0.1	0.061	0.145	0.207
G-40-01	02/10/98	11.7	4,640	0.42	0.09	0.621	0.152	0.773
G-40-02	02/10/98	2.58	11,500	0.17	0.14	2.064	0.179	2.243
G-41-02	02/10/98	18.4	5,330	0.45	0.24	2.226	0.260	2.486
G-42-01	02/25/98	23	4,080	-0.3	0.26	0.261	0.136	0.397
G-42-06	03/13/98	17	2,370	1.1	0.24	0.097	0.150	0.247
G-43-01	03/13/98	20	2,140	1.51	0.44	0.507	0.599	1.106
G-44-01	03/13/98	18	4,220	1.1	0.13	0.101	0.077	0.178
G-44-07	03/13/98	18	1,320	0.02	0.48	0.118	0.207	0.325
G-45-01	03/13/98	10	26,300	0.08	0.43	2.519	0.304	2.824
G-45-04	03/13/98	25	2,440	0.4	0.69	0.238	0.566	0.804
G-45-05	03/13/98	26	2,880	0.93	0.72	0.413	1.615	2.028
G-45-06	03/13/98	19	25,700	-0.09	0.37	1.736	0.275	2.011
G-45-07	02/10/98	25.5	2,010	0.27	0.08	0.492	0.347	0.839
G-46-01	03/13/98	19	4,430	0.21	0.51	1.303	0.272	1.575
G-46-02	02/10/98	32.5	1,430	0.28	0.24	1.942	0.690	2.632
G-47-01	03/25/98	12	1,460	0.46	0.47	0.234	0.721	0.955
G-48-02	03/25/98	9.5	1,150	1.67	0.82	0.077	0.583	0.660
G-49-01	03/25/98	12	800	0.63	0.15	0.038	0.357	0.394
G-49-04	03/25/98	12	1,260	-0.14	0.08	0.011	0.065	0.076
G-50-01	03/25/98	7	1,780	1.23	0.12	0.016	0.069	0.085
G-50-02	03/25/98	8	1,210	0.55	0.15	0.028	0.050	0.078
G-52-03	03/25/98	19	1,420	1.7	0.33	0.016	0.034	0.050
G-58-01	03/25/98	7	3,780	0.59	0.15	0.049	0.007	0.056
Mean		**15.2**	**10506**	**0.58**	**0.27**	**0.411**	**0.300**	**0.711**
Median		**15.0**	**3780**	**0.45**	**0.15**	**0.077**	**0.136**	**0.250**
Std. Dev.		**7.5**	**26212**	**0.56**	**0.24**	**0.706**	**0.462**	**0.876**
Max		**32.5**	**162700**	**2.0**	**1.040**	**2.519**	**2.109**	**2.824**
Min		**2.0**	**520**	**-0.3**	**0.040**	**0.002**	**0.004**	**0.006**

Table 2: 1997 TA-54 Area G Perimeter Surface Soil Data (Sample locations can be found in Figures 5-8. Please note that negative values sometimes result from counting statistics when average background activities are subtracted from gross analytical results.)

Sample Location	Collection Date	% Water	^{3}H pCi/L	^{241}Am pCi/g	^{137}Cs pCi/g	^{238}Pu pCi/g	^{239}Pu pCi/g	Total Pu pCi/g
G-29-01	03/19/97	10.7	8,831	0	0.06	0.022	0.014	0.036
G-29-02	03/19/97	20.4	19,327	-0.07	0.35	0.016	0.029	0.044
G-29-03	03/19/97	13.1	67,446	-0.01	0.1	0.003	0.008	0.011
G-30-01	03/19/97	10.4	29,636	0.04	0.27	0.036	0.019	0.054
G-31-01	03/19/97	26.5	111,000	0.07	0.32	0.015	0.032	0.047
G-31-02	03/19/97	12.5	82,562	0.04	0.1	0.006	0.005	0.011
G-31-03	03/19/97	11.5	19,853	-0.05	0.11	0.005	0.007	0.013
G-32-01	03/19/97	13.6	31,377	0.03	0.88	0.014	0.054	0.069
G-32-02	03/19/97	26.3	13,836	-0.03	0.38	0.011	0.063	0.074
G-32-03	03/19/97	13.4	4,918	-0.05	0.19	0.005	0.021	0.027
G-34-04	03/19/97	14.7	635	-0.07	0.14	0.019	0.031	0.050
G-34-07	03/19/97	6.4	1,097	0.04	0.06	0.002	0.016	0.019
G-34-10	03/19/97	7.2	1,443	0.26	0.87	0.037	1.205	1.242
G-34-13	03/19/97	9.3	2,015	-0.05	0.13	0.141	0.056	0.198
G-38-02	03/20/97	11.6	22,723	-0.01	0.18	0.055	0.630	0.685
G-39-01	03/20/97	3.7	1,508	0.21	0.1	0.240	0.120	0.360
G-39-02	03/20/97	2.8	2,316	0.01	0	0.045	0.085	0.130
G-40-01	03/20/97	7.6	784	0.16	0.12	0.790	0.450	1.240
G-40-02	03/20/97	7.9	860	0	0.16	2.400	0.156	2.556
G-41-02	03/20/97	12.1	579	0.15	0.32	0.780	1.710	2.490
G-42-01	03/20/97	16.5	1,288	0.12	0.22	1.180	0.620	1.800
G-43-01	03/20/97	23.2	1,327	0.36	0.4	1.280	0.380	1.660
G-44-07	03/20/97	16.1	1,941	0.15	0.37	0.124	0.214	0.338
G-45-04	03/20/97	23.0	2,509	-0.02	0.25	0.540	0.280	0.820
G-45-05	03/20/97	23.5	3,113	0.18	0.44	0.230	0.550	0.780
G-45-06	03/20/97	18.8	2,508	0.05	0.32	1.740	0.280	2.020
G-45-07	03/20/97	14.7	2,765	0.04	0.08	0.570	0.220	0.790
G-46-01	03/20/97	19.2	6,173	0.43	0.81	4.890	1.580	6.470
G-46-02	03/20/97	27.3	954	0.21	0.23	1.860	0.930	2.790
G-47-01	03/20/97	12.1	2,110	0.25	0.34	0.129	0.420	0.549
G-48-02	03/20/97	9.8	1,340	0.12	0.27	0.050	0.520	0.570
G-49-01	03/19/97	17.4	1,162	0.01	0.03	0.032	0.314	0.346
G-49-04	03/19/97	18.9	909	0.16	0.03	0.018	0.100	0.118
G-50-01	03/19/97	17.0	519	0.43	0.21	0.057	0.161	0.218
G-50-02	03/20/97	21.5	1,147	0.09	0.05	0.043	0.099	0.142
G-52-01	03/19/97	14.5	288	0.06	0.66	0.022	0.039	0.061
G-52-02	03/19/97	11.3	789	0.43	1.01	0.027	0.068	0.095
G-52-03	03/19/97	18.8	544	0.22	0.25	0.034	0.092	0.126
G-55-01	03/19/97	18.1	558	-0.03	0.21	0.002	0.013	0.015
G-58-01	03/19/97	9.8	95	-0.03	0.27	0.016	0.019	0.036
Mean		**14.8**	**11,370**	**0.10**	**0.437**	**0.28**	**0.290**	**0.727**
Median		**14.1**	**1,725**	**0.05**	**0.040**	**0.23**	**0.100**	**0.170**
Std. Dev.		**6.2**	**23,784**	**0.14**	**0.928**	**0.25**	**0.415**	**1.219**
Max		**27.3**	**111,000**	**0.43**	**4.890**	**1.01**	**1.710**	**6.470**
Min		**2.8**	**95**	**-0.07**	**0.002**	**0.00**	**0.005**	**0.011**

Table 3: 1996 TA-54 Area G Perimeter Surface Soil Data (Sample locations can be found in Figures 5-8. Please note that negative values sometimes result from counting statistics when average background activities are subtracted from gross analytical results.)

Sample Location	Collection Date	% Water	^{3}H pCi/L	^{241}Am pCi/g	^{137}Cs pCi/g	^{238}Pu pCi/g	^{239}Pu pCi/g	Total Pu pCi/g
G-29-1	07/25/96	4.6	70,153	0.08	0.20	0.022	0.019	0.041
G-29-2	07/25/96	5.6	316,445	0.14	0.54	0.022	0.029	0.052
G-29-3	07/25/96	4.6	716,004	0.19	0.43	0.002	0.013	0.015
G-30-1	07/25/96	1.7	47,405	0.61	0.18	0.011	0.009	0.020
G-31-1	07/25/96	4.4	47,405	0.20	0.73	0.014	0.048	0.062
G-31-2	07/25/96	1.5	118,665	0.00	0.21	0.012	0.015	0.028
G-31-3	07/25/96	4.0	27,468	1.07	0.20	0.006	0.009	0.015
G-32-1	07/25/96	8.1	14,095	0.02	1.10	0.007	0.054	0.061
G-32-2	07/25/96	3.9	8,638	0.13	0.37	0.007	0.054	0.060
G-32-3	07/25/96	2.3	7,965	0.16	0.23	0.007	0.027	0.034
G-34-4	07/25/96	3.8	1,594	1.10	0.24	0.025	0.053	0.078
G-34-5	08/08/96	5.0	1,493	0.13	0.08	0.022	0.061	0.083
G-34-7	08/08/96	2.6	1,466	0.16	0.10	0.001	0.017	0.018
G-34-9	08/08/96	4.6	1,328	1.08	0.14	0.004	0.011	0.015
G-34-10	08/08/96	3.3	1,652	1.08	1.75	0.079	1.620	1.699
G-34-13	08/08/96	2.2	1,385	0.90	0.12	0.112	0.015	0.127
G-38-2	07/25/96	2.3	19,918	0.32	0.18	0.051	0.452	0.503
G-39-1	07/25/96	2.3	2,725	13.10	0.11	0.590	0.168	0.758
G-39-2	07/25/96	0.1	1,585	0.11	0.10	0.031	0.052	0.083
G-40-1	08/07/96	3.6	1,880	0.55	0.61	2.650	0.763	3.413
G-40-2	08/05/96	4.4	1,480	0.15	0.09	0.511	0.074	0.585
G-41-2	08/07/96	2.7	1,911	0.76	0.29	1.810	0.180	1.990
G-42-1	07/25/96	1.6	2,493	0.27	0.34	0.654	0.661	1.316
G-42-6	08/05/96	6.2	4,550	0.14	0.13	0.113	0.130	0.243
G-44-7	08/05/96	6.9	13,900	0.21	0.46	0.208	0.178	0.385
G-45-4	08/05/96	4.0	18,500	0.37	0.44	0.571	0.320	0.892
G-45-5	08/05/96	5.2	18,500	0.50	0.34	0.243	0.428	0.672
G-45-6	07/26/96	2.8	34,259	0.09	0.03	0.059	0.042	0.101
G-45-7	07/26/96	2.9	38,305	0.02	0.18	0.246	0.119	0.366
G-46-1	08/05/96	6.1	22,960	1.09	0.49	2.866	0.314	3.180
G-46-2	07/26/96	3.1	9,864	0.88	0.28	2.462	0.450	2.912
G-47-1	07/26/96	4.1	7,196	0.09	0.41	0.134	0.443	0.577
G-49-1	08/05/96	2.3	1,340	0.19	0.08	0.005	0.043	0.048
G-49-4	07/26/96	4.3	1,561	0.03	0.08	0.018	0.079	0.096
G-50-1	07/26/96	2.8	5,232	0.09	0.10	0.027	0.067	0.094
G-50-2	07/26/96	5.8	3,602	0.54	0.10	0.068	0.072	0.140
G-52-1	07/26/96	2.6	1,805	0.14	0.53	0.021	0.036	0.057
G-52-2	07/26/96	5.4	835	0.01	0.74	0.028	0.053	0.081
G-52-3	07/26/96	4.0	16,961	0.09	0.33	0.042	0.042	0.084
G-58-1	07/26/96	3.5	566	0.09	0.23	0.032	0.016	0.048
Mean		**3.8**	**40,377**	**0.67**	**0.345**	**0.33**	**0.181**	**0.526**
Median		**3.8**	**6,214**	**0.18**	**0.031**	**0.23**	**0.054**	**0.089**
Std. Dev.		**1.6**	**121,651**	**2.05**	**0.741**	**0.32**	**0.299**	**0.891**
Max		**8.1**	**716,004**	**13.10**	**2.866**	**1.75**	**1.620**	**3.413**
Min		**0.1**	**566**	**0.00**	**0.001**	**0.03**	**0.009**	**0.015**

Table 4: FY 1994 and 1995 TA-54 Area G Development Area (Baseline/Background) Soil Data

Sample Location	Collection Date	% Water	^{3}H pCi/L	^{241}Am pCi/g	^{137}Cs pCi/g	^{238}Pu pCi/g	^{239}Pu pCi/g	Total Pu pCi/g
G-X-6	7/29/94	14.7	420	0.007	<.01	0.009	0.013	0.022
G-X-8	7/29/94	16.9	320	0.016	0.99	0.005	0.036	0.041
G-X-8R	7/29/94	17.9	300	0.014	1.01	0.005	0.043	0.048
G-X-9	7/29/94	13.4	120	0.008	0.64	0.002	0.023	0.025
G-X-10	7/29/94	15.1	710	0.007	<.16	0.007	0.019	0.026
G-X-12	7/29/94	11.2	370	0.014	1.2	0.003	0.051	0.054
G-X-13	7/29/94	12.7	280	0.008	<.16	0.002	0.009	0.011
G-X-16	7/29/94	15.6	260	0.015	0.62	0.002	0.042	0.044
G-X-19	7/29/94	8.7	260	0.008	0.34	0.002	0.012	0.014
G-X-21	7/29/94	9.7	250	0.008	0.32	0.001	0.016	0.017
G-X-24	7/29/94	12.1	380	0.027	<.23	0.005	0.149	0.154
G-X-26	7/29/94	13	630	0.016	1.8	0.005	0.047	0.052
G-X-27	7/29/94	13.5	280	0.011	0.85	0.004	0.03	0.034
G-X-28	7/29/94	10.9	180	0.005	<.17	0.001	0.01	0.011
G-X-30	7/29/94	9.6	350	0.008	0.62	0.002	0.025	0.027
G-X-33	7/29/94	11.5	340	0.014	1.32	0.004	0.054	0.058
G-X-37	7/29/94	7.6	510	0.007	0.47	0.002	0.023	0.025
G-X-38	7/29/94	4.5	580	0.02	0.76	0.009	0.042	0.051
G-X-38R	7/29/94	4.5	490	0.021	0.97	0.007	0.053	0.06
G-X-39	7/29/94	11.2	310	0.005	0.14	0.002	0.014	0.016
G-X-43	7/29/94	12.1	280	0.005	<.17	0.004	0.012	0.016
G-X-44	7/29/94	10.2	440	0.002	<.17	0.001	0.008	0.009
G-X-45	7/29/94	15	150	0.005	<.11	0.003	0.005	0.008
G-X-48	7/29/94	14.8	560	0.005	<.15	0.003	0.01	0.013
G-X-50	7/29/94	4.4	450	0.008	<.15	0.004	0.017	0.021
G-X-51	7/29/94	10.7	410	0.003	<.16	0.001	0.001	0.002
G-X-53	7/29/94	12.5	280	0.011	<.15	0.003	0.028	0.031
G-X-1	6/1/95	8.04	-100	ANP	ANP	0.004	0.011	0.015
G-X-2	6/1/95	11.5	0.0	ANP	ANP	0.003	0.008	0.011
G-X-3	6/1/95	7.46	0.0	ANP	ANP	0.005	0.016	0.021

(continued)

Table 4: 1994 and 1995 TA-54 Area G Development Area (Baseline/Background) Soil Data (continued)

Sample Location	Collection Date	% Water	^{3}H pCi/L	^{241}Am pCi/g	^{137}Cs pCi/g	^{238}Pu pCi/g	^{239}Pu pCi/g	Total Pu pCi/g
G-X-4	6/1/95	5.66	100	ANP	ANP	0.001	0.001	0.002
G-X-5	6/1/95	5.24	-300	ANP	ANP	0.037	0.052	0.089
G-X-11	6/1/95	12.4	-200	ANP	ANP	0.084	0.045	0.129
G-X-14	6/1/95	14.5	-400	ANP	ANP	0.064	0.04	0.104
G-X-15	6/1/95	13.7	0.0	ANP	ANP	0.006	0.012	0.018
G-X-17	6/1/95	16.4	-100	ANP	ANP	0.003	0.052	0.055
G-X-18	6/1/95	23.6	-400	ANP	ANP	0.002	0.031	0.033
G-X-20	6/1/95	15.0	100	ANP	ANP	0.004	0.022	0.026
G-X-20R	6/1/95	17.3	-100	ANP	ANP	0.068	0.088	0.156
G-X-22	6/1/95	14.0	-200	ANP	ANP	0.02	0.005	0.025
G-X-23	6/1/95	9.29	-200	ANP	ANP	0.04	0.03	0.07
G-X-25	6/1/95	7.06	-300	ANP	ANP	0.008	0.015	0.023
G-X-29	6/1/95	11.2	-300	ANP	ANP	0.007	0.047	0.054
G-X-31	6/1/95	7.0	-200	ANP	ANP	0.004	0.016	0.02
G-X-32	6/1/95	13.4	-100	ANP	ANP	0.002	0.004	0.006
G-X-34	6/1/95	18.2	-200	ANP	ANP	0.05	0.04	0.09
G-X-35	6/1/95	8.86	0.0	ANP	ANP	0.009	0.023	0.032
G-X-36	6/1/95	16.7	-200	ANP	ANP	0.002	0.008	0.01
G-X-40	6/1/95	17.8	-100	ANP	ANP	0.047	0.046	0.093
G-X-41	6/1/95	22.3	-300	ANP	ANP	0.003	0.01	0.013
G-X-42	6/1/95	13.3	300	ANP	ANP	0.003	0.007	0.01
G-X-46	6/1/95	10.7	-200	ANP	ANP	0.002	0.005	0.007
G-X-47	6/1/95	16.4	-100	ANP	ANP	0.008	0.011	0.019
G-X-49	6/1/95	15.2	0.0	ANP	ANP	0.062	0.026	0.088
G-X-49R	6/1/95	15.4	-300	ANP	ANP	0.041	0.007	0.048
G-X-54	6/1/95	6.16	-200	ANP	ANP	0.033	0.01	0.043
G-X-55	6/1/95	5.73	-100	ANP	ANP	0.004	0.027	0.031
Mean		**12.2**	**101.9**	**0.010**	**0.80**	**0.013**	**0.026**	**0.039**
Median		**12.4**	**100.0**	**0.008**	**0.76**	**0.004**	**0.019**	**0.026**
Std. Dev.		**4.3**	**294.5**	**0.006**	**0.43**	**0.020**	**0.024**	**0.036**
Max		**23.6**	**710.0**	**0.027**	**1.80**	**0.084**	**0.149**	**0.156**
Min		**4.4**	**-400.0**	**0.002**	**0.14**	**0.001**	**0.001**	**0.002**

ANP = analysis not performed

4.1 Requested Analytical Services

Detailed information on analysis requested and performed on the perimeter soil samples, including method and techniques.

4.1.1 Surface Soil Samples

The data are reported in the units of picocuries per liter (pCi/L) for tritium and picocuries per gram (pCi/g) for all other analytes besides percent water. PCi/g is a unit of measurement which indicates X x 10^{-12} curies (an equivalent amount of radioactivity as emitted by one gram of radium) of the radionuclide is present per gram of soil sample. PCi/L is the same measurement except instead of per gram of soil it is X x 10^{-12} curies per liter of water. This unit is used for tritium because water in the soil sample is extracted and the water is analyzed for tritium.

The following analytical services were requested for soil samples taken during 1998:

1. isotopic plutonium by radioactivity/alpha spectroscopy (RAS);

2. tritium by distillation of soil moisture and scintillation counting;

3. americium-241 and cesium-137 by gamma spectroscopy; and

4. percent water by gravimetric methods.

4.1.2 Laboratory Soil-Sample Preparation

Before the CST-9 soil analyses for radionuclides (excepting tritium), the soils were first dried overnight at 100°C and then sieved through a number 12 Tyler sieve to remove large-sized particles and foreign matter (twigs, grass, etc.). When the dried soil samples were analyzed for plutonium, they were first extracted by a hot nitric acid/hydrofluoric acid leaching procedure that

effectively dissolves the entire sample. Standard CST analytical chemistry procedures were then followed for separating, plating, and counting radionuclides.

For tritium analyses on soils, the soil moisture is distilled from the soil. This soil moisture is analyzed for tritium by scintillation counting [R. Robinson (Analytical Laboratory Manager, CIC-9), personal communication, January, 1998].

5.0 DEVELOPMENT AREA BASELINE STUDY

An approximately 10-acre site directly west of active Area G has been identified as the location for the development of waste management disposal operations in the future. Baseline surface soil and water chemistry data have been collected to define the ambient conditions before any operations are initiated in this area. This baseline data will not only be used in the future to define any impacts from the active operations that will be taking place in this area, but will serve in this study as baseline or local background for comparison to perimeter soil samples collected in 1998. A summary of the Development Area analytical chemistry data is found in Table 4. These data are used in box plots presented in Figures 12 to 14.

6.0 SOIL SAMPLING RESULTS

Figures 6 through 8 illustrate the distribution of radionuclides in surface soils collected on the perimeter of Area G. A discussion of individual constituents is found below. LANL's Screening Action Level (SAL) for each isotope is also presented for comparison purposes. The SAL is an initial screening number used by LANL's Environmental Restoration Program. For radiation, it

is based on a 10 milirem annual dose (very low) for a resident on the site containing the particular soil concentration. This is a conservative number used for initial screening of a site.

6.1 Tritium

The analytical radiochemistry results for the 1998 soil samples are presented in Table 1. Figure 5 is a map that displays the sampling locations, which are color coded to indicate tritium concentrations at each location and the general distribution of tritium in the perimeter surface soils. Figure 9 depicts the perimeter and Development Area tritium distributions for the soil samples collected during 1996, 1997, and 1998. The tritium results are displayed for each sampling location for the three aforementioned years; the mean tritium baseline is also displayed. Figure 12 contains box plots depicting the distribution of tritium concentration on surface soils collected around the Area G perimeter in 1996 through 1998 and compares tritium distributions with data from soil samples collected in the Development Area in 1994 and 1995 (the period used to collect samples and establish baseline). This figure displays minimum, maximum, 25-50 percentile, and median tritium concentrations. From Table 4, baseline tritium concentrations ranged from 0 to 710 pCi/L, with a mean value of 101.9 ± 294.5. The SAL for tritium in soil is 2.3×10^6 pCi/L. The perimeter soil sampling (those samples taken from locations in minor drainages into which sediments are expected to be carried and water to flow during a storm event) shows that there is elevated tritium activity in soils collected around the entire active portion of Area G. The tritium concentrations in soils collected in 1998 are, by and large, lower than analogous samples collected in 1996 and are more similar to samples collected in 1997. Tritium on soil samples collected adjacent to the tritium disposal shafts are most elevated over baseline from sampling locations G-29 to G-32. These locations are along the southern edge and

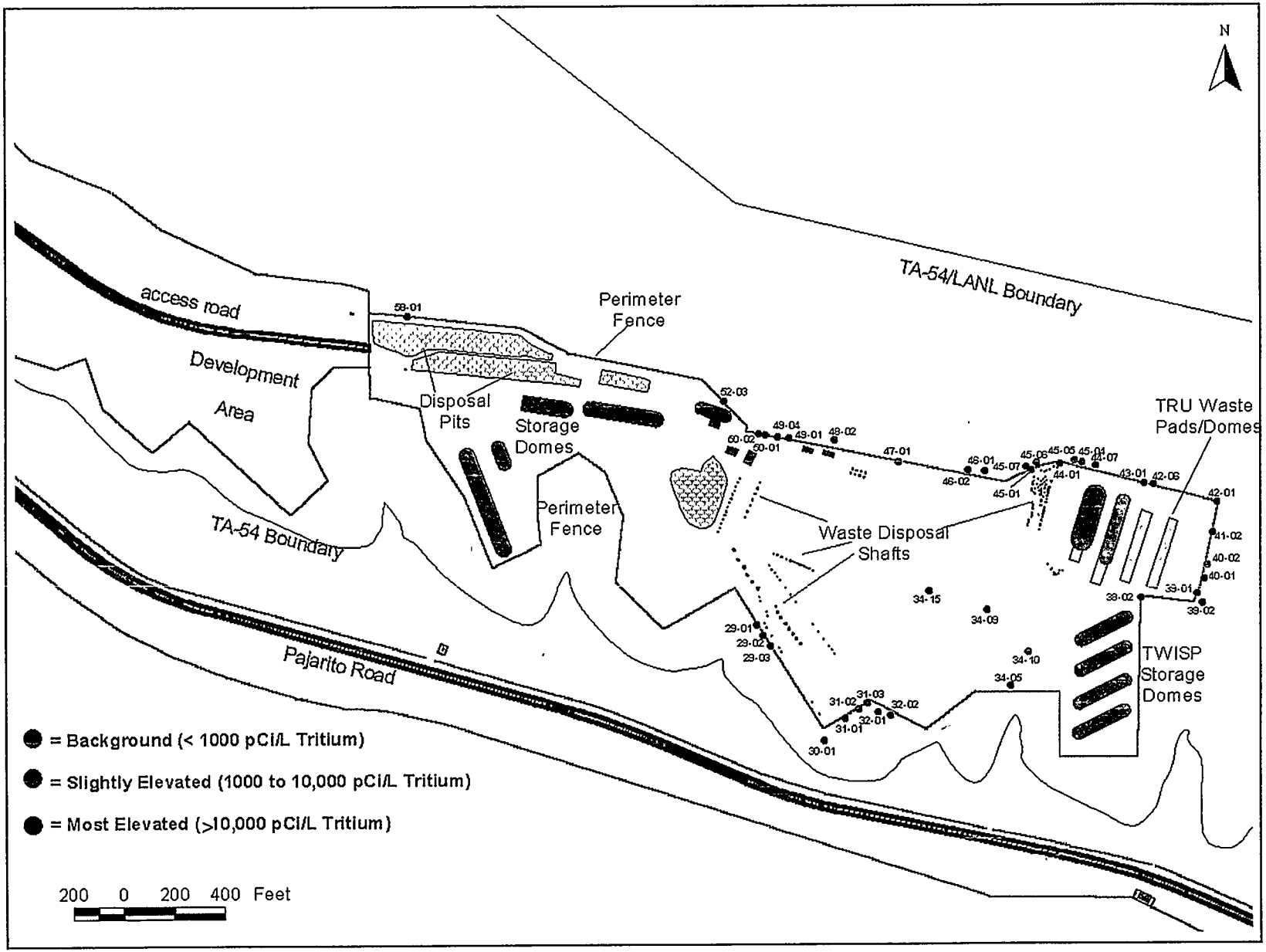


Figure 6. Tritium soil-sample locations and analytical results (1998) at Area G. The number is the sample location identification number, and the color represents its tritium concentration range (in picocuries per liter). There are three categories in the tritium concentration range: background (green), slightly elevated (blue), and most elevated (red). All the significant Area G landmarks and features are identified on the figure.

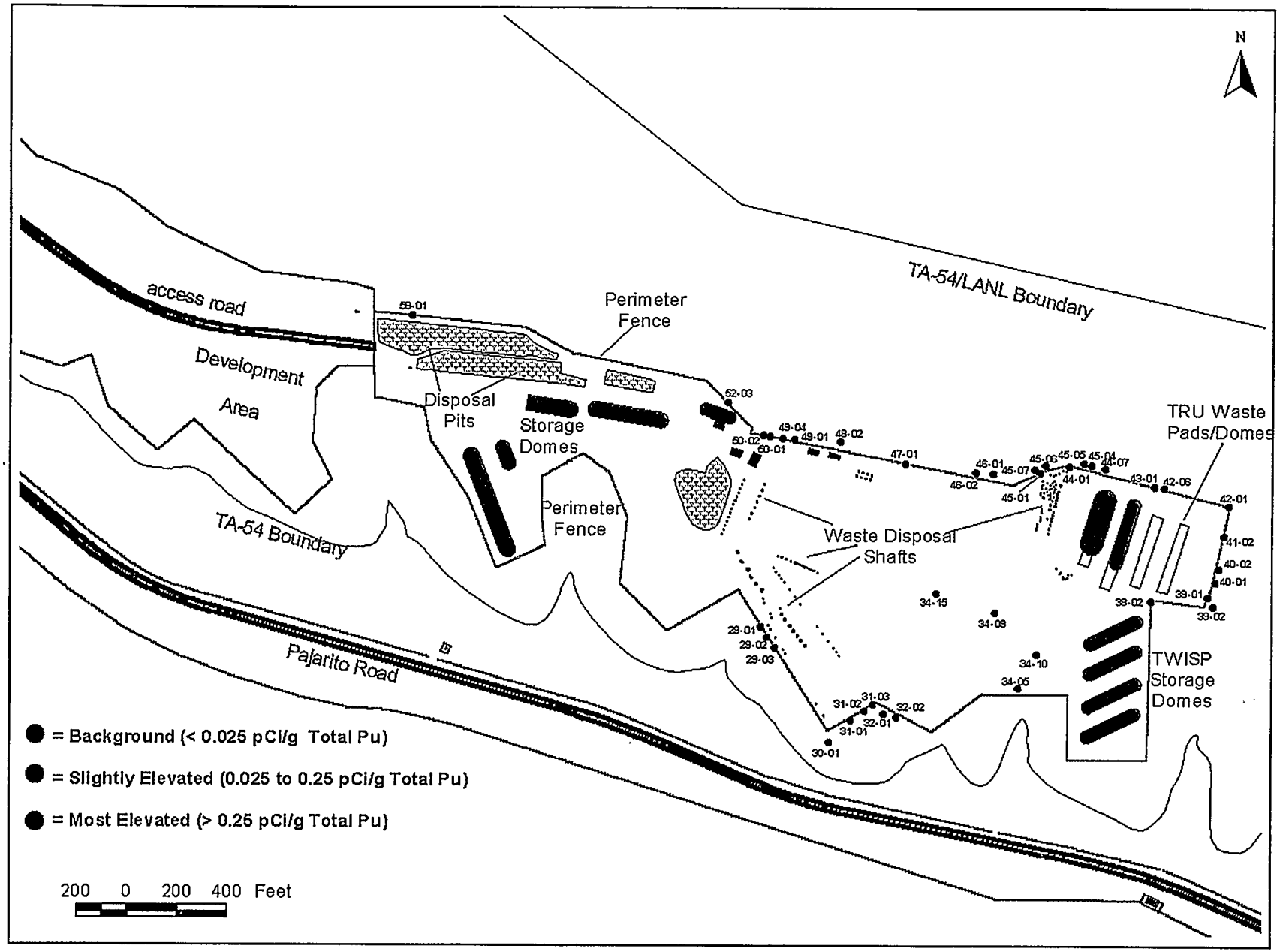


Figure 7. Total plutonium soil-sample locations and analytical results (1998) at Area G. The color represents the americium concentration range (in pCi/g). There are three categories in the plutonium concentration range: background (green), slightly elevated (blue), and most elevated (red). All the significant Area G landmarks and features are identified on the figure.

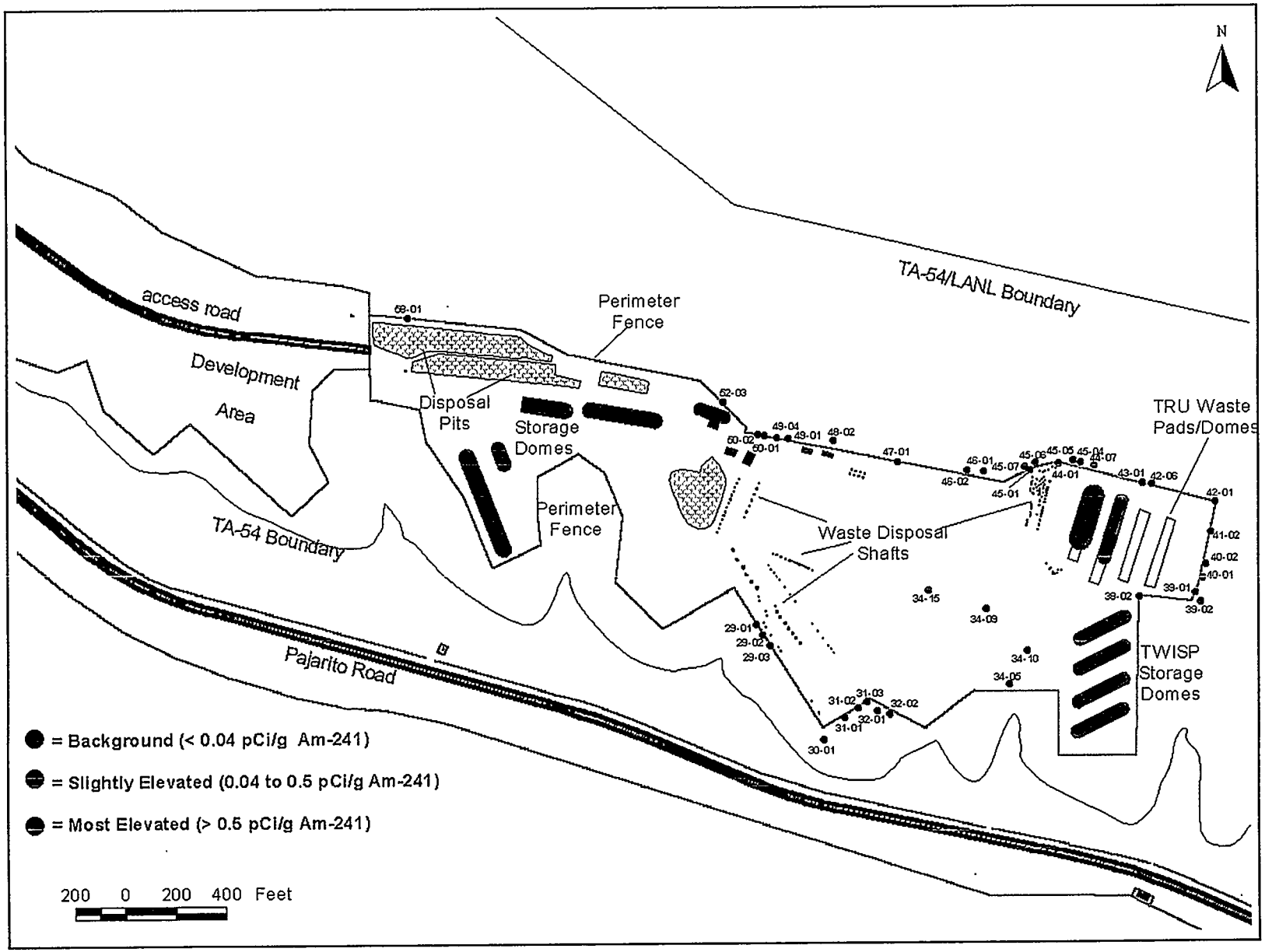


Figure 8. Am-241 soil-sample locations and analytical results (1998) at Area G. The color represents the americium concentration range (in pCi/g). There are three categories in the americium concentration range: background (green), slightly elevated (blue), and most elevated (red). All the significant Area G landmarks and features are identified on the figure.

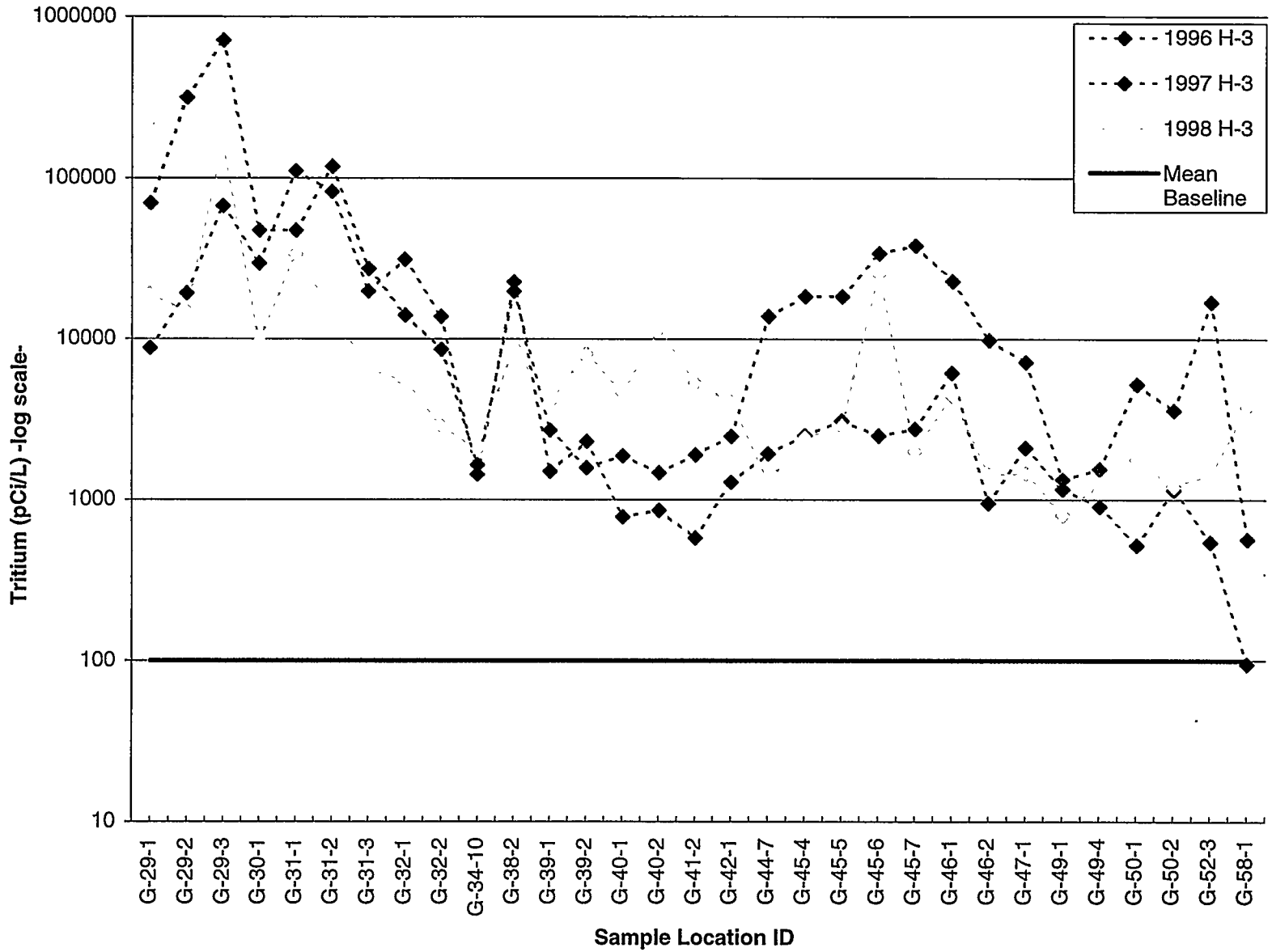


Figure 9. Comparison of Tritium Soil Data from Sampling Years 1996, 1997, and 1998.

adjacent to one set of tritium disposal shafts (see Figure 6). In the area adjacent to the TRU pads northeast corner, locations G-40 to G-45, the soil samples also show moderately elevated tritium activity. One isolated soil sample, G-38-02, on the perimeter at the south edge of the TRU pads, had a relatively high tritium concentration (8,900 pCi/L). This particular soil sample also had elevated tritium concentrations in soil samples collected in 1996 and 1997.

The locale for the most elevated perimeter soil tritium concentrations in 1998 is adjacent to the tritium disposal shafts located on the Pajarito Canyon side of Area G and encompasses sample series G-29 to 32. Soil samples collected from this area in 1998 had tritium activities as high as 162,700 pCi/L. Figure 9 is a scatter plot depicting the soil tritium concentrations at analogous locations for the years 1996, 1997, and 1998. This figure indicates that the localized regions of elevated tritium concentrations on the perimeter of Area G were the same during these years, but soil tritium concentrations varied significantly from year to year. The significance of year-to-year measured soil tritium concentrations is discussed in section 8.1.

Tritium results for surface soils reflect the surface soil environment only at the time of the soil sampling. The ambient conditions at a particular location are one factor that will determine the concentration and availability of tritium at the time a sample is taken. When precipitation falls, soil-surface water interactions are generally limited to the top few inches of soils. At that time, tritium concentrations in the surface soil stratum could be altered by the precipitation, resulting in

1. stormwater transport of tritiated water from a particular location;

2. erosion of tritium-bound sediments; or

3. dilution resulting from tritium-deficient water being added to "soil moisture" containing the soil tritium.

It is known that on soil, tritium is incorporated into associated water molecules that are given the term soil moisture. When the laboratory prepares a soil sample for tritium analysis, soil moisture is distilled out of a weighed sample. The tritium measured in the distilled-off water is deemed to represent the tritium content of the soil and is reported as activity per liter of soil moisture. If it had recently rained or snowed before the sampling event or if the soil came from a location that was naturally damp (e.g., an area shaded from the sun) or where anthropogenic activities (such as a water truck spraying the ground surface) had impacted the soil, this water added to the natural soil moisture would cause a dilution of the tritium concentration in that soil. From year-to-year, the geographical regions of baseline, slightly elevated, and most elevated (see Figure 6) tritium concentrations on soils are the same. However, the absolute concentrations of tritium measured on soil over these time periods are shown to be generally different. In particular, Table 1 indicates that soil samples collected in March 1997 and 1998, when the soil was still relatively moist from the winter snow accumulation and spring rains, contained soil moisture generally greater than the soil moisture found in samples collected in the summer of 1996. Along with the higher soil moistures, it is evident that the tritium concentrations in 1997 and 1998 soils are generally significantly lower that soil tritium concentrations for samples collected in the summer period of 1996. The other factor affecting soil tritium concentrations in the 1996, 1997, and 1998 soil samples is that the tritium flux is greater during the hot summer months than it is during the remainder of the year.

By minimizing the period of time taken for the collection of all the samples for a particular year, one can hopefully eliminate most of the local environmental impacts discussed above (for samples collected in a single year).

6.2 Plutonium Isotopes

During the 1998 perimeter surface soil sampling, 39 soil samples were collected and analyzed for isotopic plutonium (plutonium-238, -239, and -240). Plutonium-239 and -240 are reported as the sum of the activity of these two isotopes, but hereafter they will be referred to only as plutonium-239. The plutonium soil data for 1998, 1997, and 1996 are presented in Tables 1, 2, and 3 respectively. The 1998 plutonium-238 concentrations range from 0 pCi/g to 2.5 pCi/g and the average plutonium-238 activity was 0.411 ± 0.706 pCi/g. The plutonium-238 concentrations in 1997 ranged from 0.002 to 4.89 pCi/g and averaged 0.437 ± 0.928 pCi/g. The plutonium-238 concentrations in 1996 ranged from 0.001 to 2.866 pCi/g and averaged 0.345 ± 0.741 pCi/g. The baseline data (Table 4) ranged from 0.001 to 0.084 pCi/g plutonium-238 and averaged 0.013± 0.02 pCi/g. The SAL for plutonium-238 in soil is 27 pCi/g. The 1998 plutonium-239 concentrations range from 0 pCi/g to 2.1 pCi/g and the average plutonium-239 activity was 0.3 ± 0.462 pCi/g. The plutonium-239 concentrations in 1997 ranged from 0.005 to 1.71 pCi/g and averaged 0.29 ± 0.415 pCi/g. The plutonium-239 concentrations in 1996 ranged from 0.009 to 1.620 pCi/g and averaged 0.181 ± 0.299 pCi/g. The baseline data (Table 4) ranged from 0.001 to 0.149 pCi/g plutonium-239 and averaged 0.026 ± 0.024 pCi/g. The SAL for plutonium-239 in soil is 29 pCi/g. For all three years, the mean values are far above the median values because several samples have elevated plutonium concentrations and the frequency distribution plot is positively skewed for both plutonium-238 and plutonium-239. For convenience, the sum of the

plutonium isotope activity "total" for each sample is also presented in Tables 1 to 4 (box plots of the total plutonium distribution on perimeter and expansion area surface soils collected in 1996, 1997 and 1998 are presented in Figure 13). In Figure 7, total plutonium isotope relative activity in perimeter soils collected in 1998 is plotted by location. Figure 7 shows that perimeter surface soils increase in plutonium concentration as one moves from the west of Area G (with little or no history of waste disposal or storage activity) to the east (where waste disposal or storage has occurred for the longest periods of time). The highest total plutonium activities are associated with the TRU pads and the vicinity of the inactive disposal pits (location series G-38 to 45), with elevated readings also found to the west of the TRU pads along the northern edge of Area G up through location series G-49. There are other elevated plutonium readings from sites scattered around the perimeter, but these sites are found predominantly in the eastern half of Area G. Figure 10 is a plot of the total plutonium concentrations for the 1996, 1997, and 1998 soil samples; the mean baseline activity is also displayed.

6.3 Americium-241

Corroboration of plutonium distribution in soils is possible by using the attendant americium-241 analytical results. Americium-241 was analyzed by the gamma spectroscopy method for all soil samples collected at Area G in 1998. Table 1 includes the soil americium-241 results, whereas Figure 8 depicts the geographic distribution of the 1998 americium-241 readings (box plots depicting the americium-241 distribution in surface soils collected at perimeter and expansion area locations in 1996, 1997 and 1998 can be found in Figure 14). The 1998 americium-241 values for perimeter soils varied from not detectable to 2.01 pCi/g. The mean americium-241 concentration in soils was 0.58 ± .56 pCi/g in 1998. The elevated reading of 13.10 pCi/g in 1996

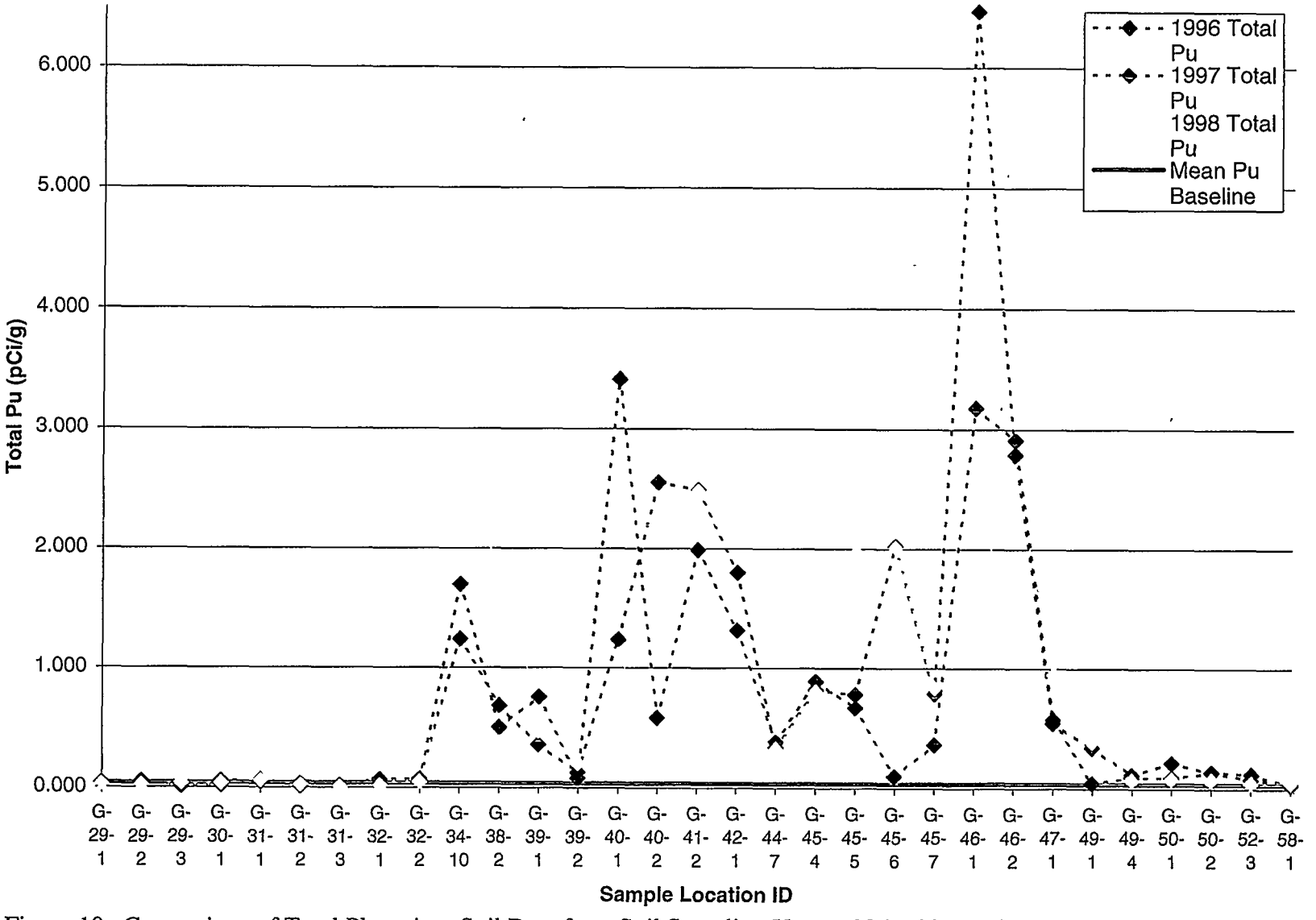


Figure 10. Comparison of Total Plutonium Soil Data from Soil Sampling Years 1996, 1997, and 1998.

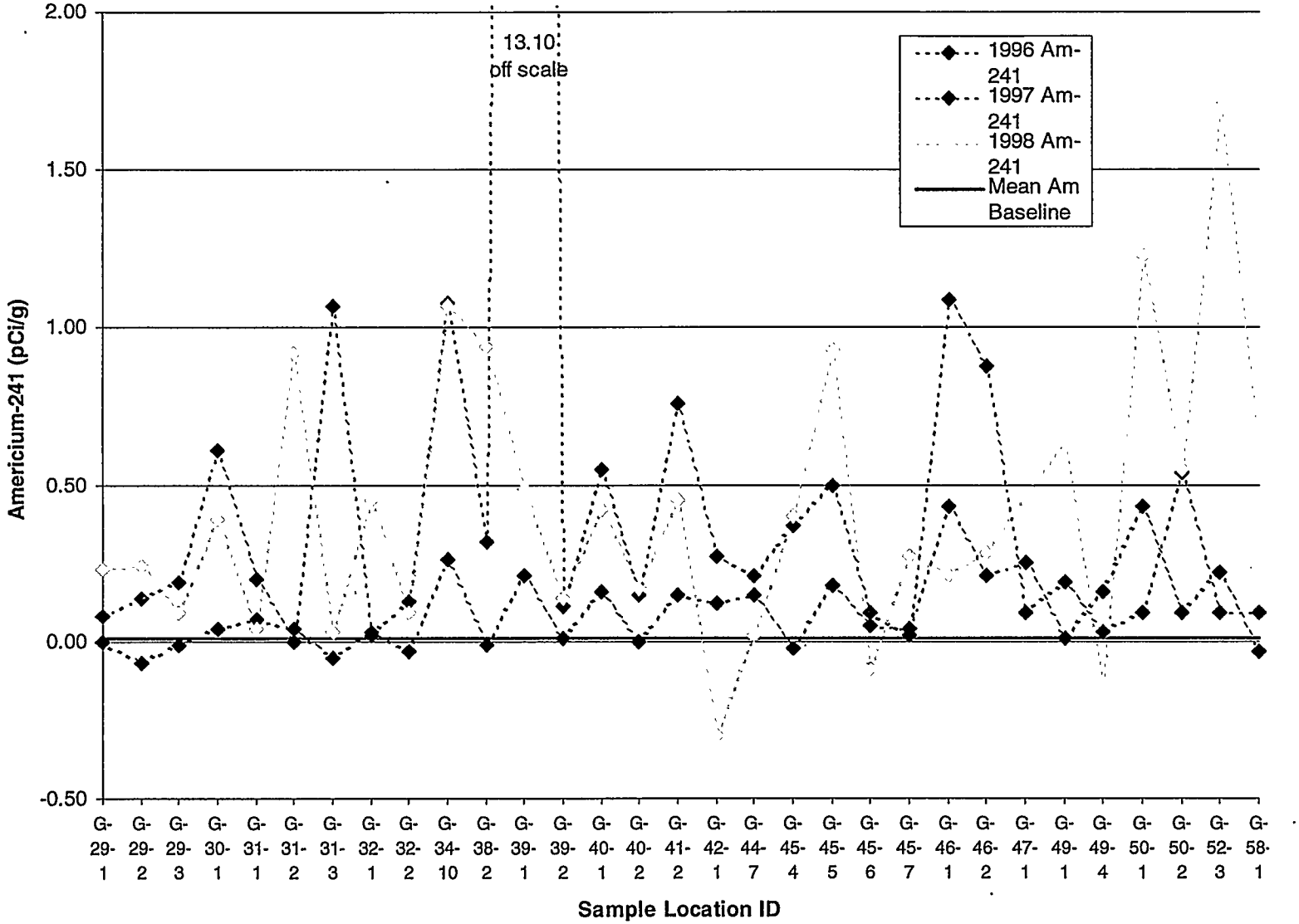


Figure 11. Comparison of Americium Soil Data from Soil Sampling Years 1996, 1997, and 1998.

occurred at location G-39-1. This number is considered to be a statistical outlier, at this location in 1997, the americium-241 activity in soil was 0.21 pCi/g and in 1998 the value was 0.49 pCi/g. The SAL for americium-241 in soil is 22 pCi/g. The mean 1996 americium-241 concentration is subsequently biased high because of the elevated outlier's activity. An area with elevated americium-241 soil levels was found adjacent to the TRU pads in the area of series G-42 to 52. This location of elevated americium-241 reflects the elevated activities of plutonium in soils reported in this section (compare Figures 7 and 8). Figure 11 is a plot of the americium-241 concentrations for 1996, 1997, and 1998 soil samples, for each sampling location; the mean baseline activity is also displayed.

7.0 STATISTICAL CONSIDERATIONS

Independent perimeter surface soil data sets are available for 1993 through 1998 and for the 1994 and 1995 Area G Development Area baseline data. Comparisons were made of previous years data in prior reports (see reference list). The comparisons made in this report are

1. whether the 1998 Area G perimeter soil data are statistically different from the Development Area baseline data; and

2. whether the perimeter radionuclide soil data collected in 1998 are statistically different from the analogous sample data collected in 1996 and 1997.

The soil data for the perimeter soil samples can be shown to be statistically different from the Development Area where disposal operations have not occurred. On the other hand, a more difficult question may be determining whether, for example, the plutonium activity in perimeter soils at Area G is increasing, decreasing, or staying the same from year to year. Because concentration changes from year to year are expected to be small, one can use statistical

techniques to assist in determining whether there truly are significant concentration changes of constituents on soil from one year to the next.

In Figures 12-14, the analytical data are summarized in box plots (pictorial descriptions of concentration distributions), that are used for making the two types of comparisons discussed above. The first comparison is to look at the constituents measured on perimeter soils and compare these concentrations with constituent concentrations measured on soil samples collected in the proposed Area G Development Area (defined as background). Surface soil samples were collected in this Development Area during 1994 and 1995.

The second type of statistical assessment is done by comparing the constituent concentrations for 1998 with constituent concentrations for 1996 and 1997 from analogous locations (for example, by comparing tritium concentrations in soils collected in 1998 to tritium concentrations in soils collected in 1996 and 1997 at and in the vicinity of the same sample locations).

Box plots are used to depict concentration distributions and to assist in comparing the different data sets. Box plots give information on the median, interquantile range, and skew; all of which help describe the distribution spread and normalcy. By placing the box plots on the same scale and in the same figure, there is an immediate impression of the differences and/or similarities of the distributions being compared. Several considerations must be taken into account, however, in comparing year-to-year data in the box plots. The second caution concerns soil tritium activities only. The time of year when soil samples are collected can grossly affect the measured soil tritium activities for that year's set of samples. The highest soil tritium activities have been found in samples taken in the driest part of the summer when the soil moisture percentage is minimized and evaporation rates (and tritium flux) are maximized. The soil samples taken in 1998 and 1997

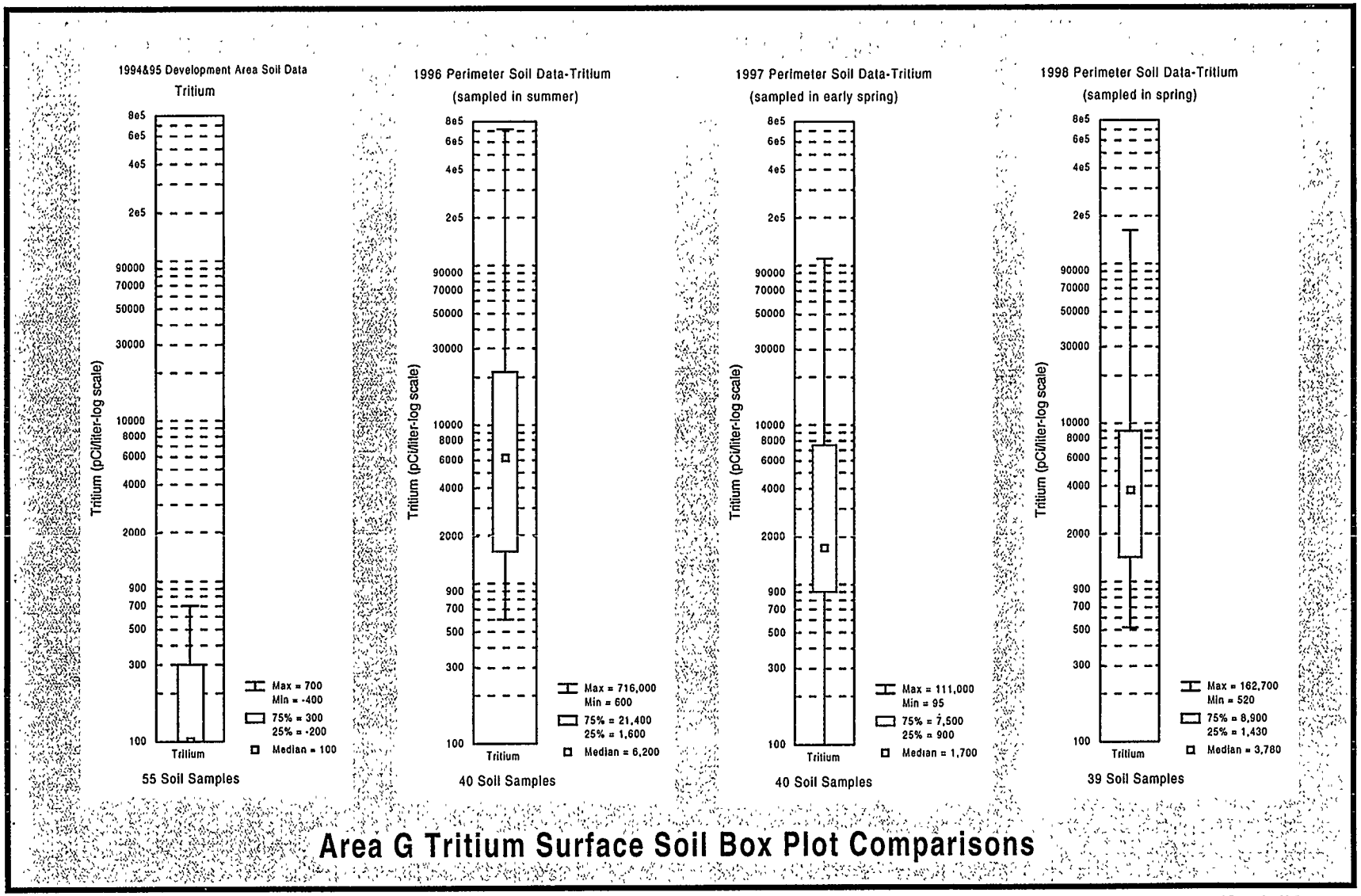


Figure 12. Tritium Box Plot Comparison of Soil Data from 1996, 1997, and 1998 vs Baseline Development Area Data. Each Plot Shows Min, Max, 25-50 Percentile, and Median. All Plots are of the Same Scale.

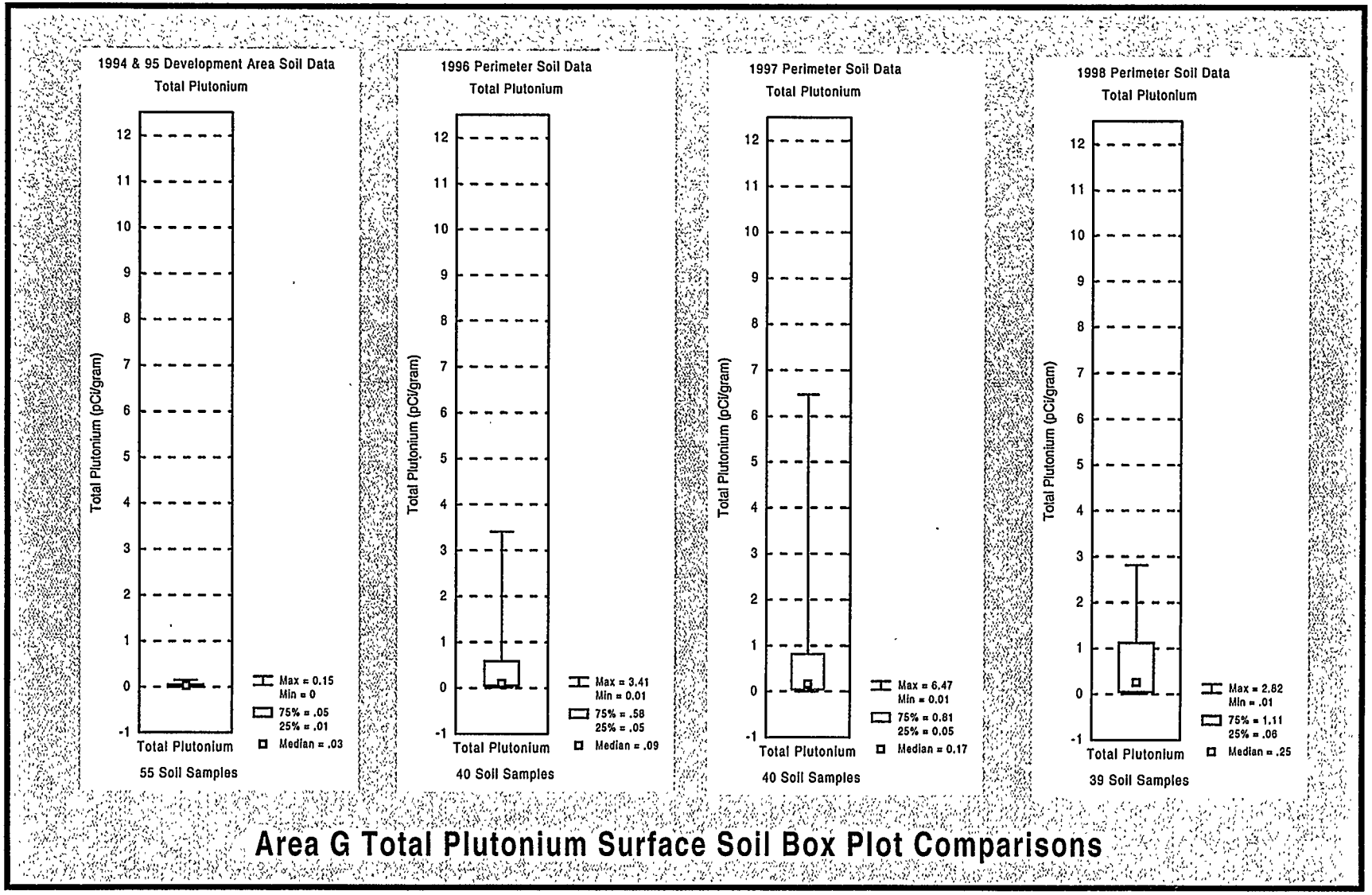


Figure 13. Total Plutonium Box Plot Comparison of Soil Data from 1996, 1997, and 1998 vs Baseline Development Area Data. Each Plot Shows Min, Max, 25-50 Percentile, and Median. All Plots are of the Same Scale.

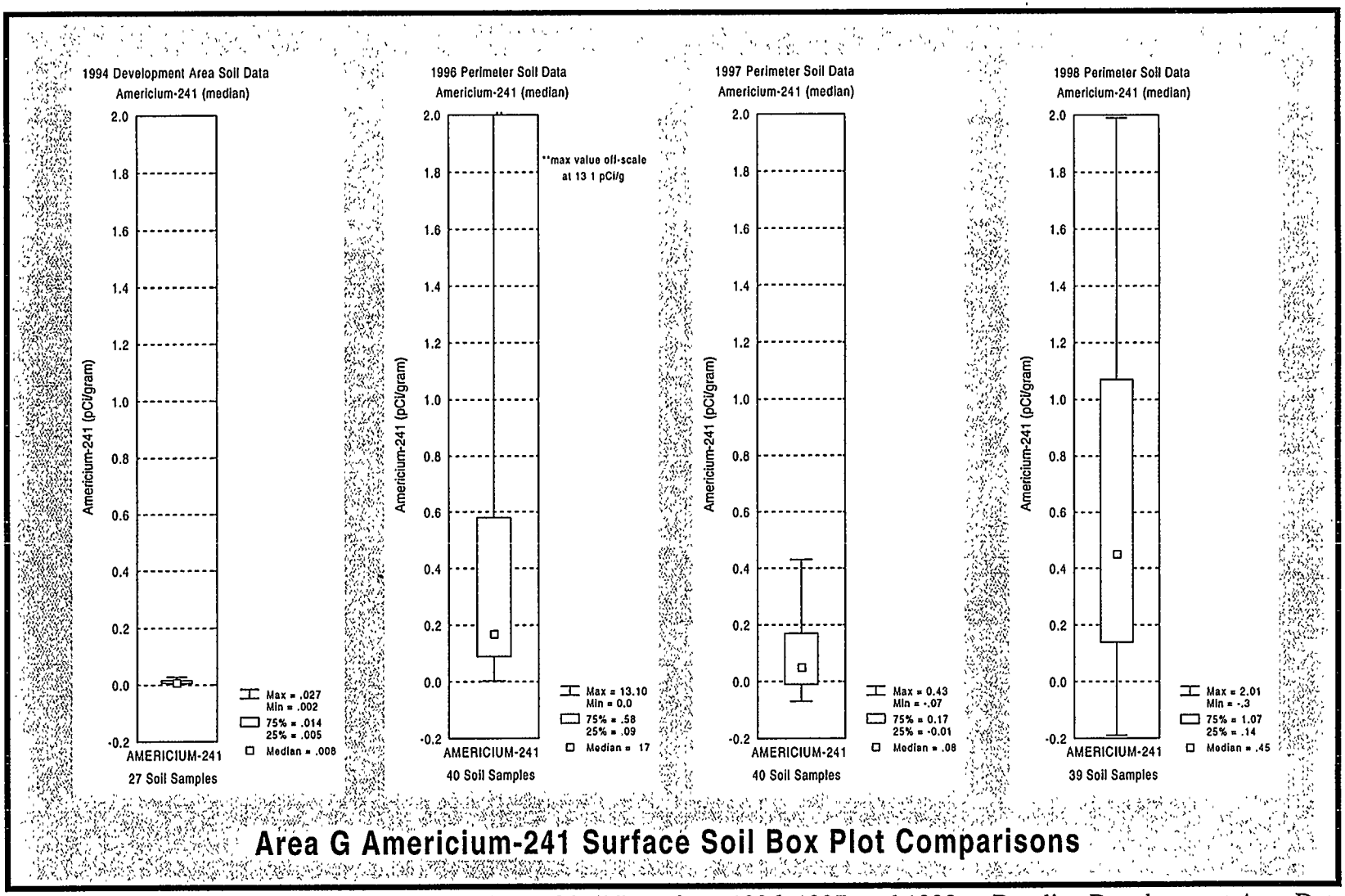


Figure 14. Americium-241 Box Plot Comparison of Soil Data from 1996, 1997, and 1998 vs Baseline Development Area Data. Each Plot Shows Min, Max, 25-50 Percentile, and Median. All Plots are of the Same Scale.

were taken in the early spring, not long after snowmelt had occurred. These samples were moister than samples taken in 1996 during the dry part of the summer (a summer drought occurred in 1996).

8.0 RESULTS

In the following paragraphs, the results of the 1998 perimeter soil sampling at Area G are assessed and data comparisons are discussed.

8.1 Tritium

Tritium has unique chemical properties that distinguish it from most radionuclides. As an isotope of hydrogen, tritium can exchange with the normal hydrogen atoms in compounds such as water. From information gathered at many facilities where tritium is found, including LANL, it is know that tritium can migrate some distance from its place of disposal. Tritium in the surface soils at Los Alamos has a wide distribution resulting from both worldwide fallout and Laboratory activities. Disposal of hundreds of thousands of curies of tritium in a series of pits, shafts, or pads occurred at Area G since this facility opened in 1957. A relatively unstable isotope, tritium has a half-life of 12.26 years, during which time, half of the tritium transmutes into helium by emitting a low-energy beta particle.

An important question that should be addressed is that of the relationship between the tritium found in surface soil samples and the true distribution of tritium at the site. One long-term goal of this study is to better define the actual tritium distribution in surface soils (and possibly in the subsurface) at Area G by gathering these tritium concentration data over a period of years.

Except for inadvertent discharges of tritium to the ground surface, the major sources of surface tritium at Area G are tritium contaminated materials that have been disposed of (buried or emplaced) in one or another of the many shafts, pits, and pads (see Figure 5) at the site. The probability of finding tritium on surface soils at elevated levels is expected to be greatest in the proximity of these sources. Because ground disposal or waste storage entails subsequent covering by natural tuffaceous material, one important question is, by what pathway does subsurface tritium migrate to the surface so that it resides in soils and ultimately could be carried off-site? There are possibly two primary mechanisms for tritium transport to the surface: vapor-phase migration and capillary action. Secondary mechanisms would be evapotranspiration, transport to the surface via vegetative growth or burrowing animals, and anthropogenic activities such as excavation of tritium-contaminated soils, tuff, or waste.

Tritiated water (or other tritiated compounds with elevated vapor pressures) can migrate in the vapor phase from the subsurface to the surface. Upon reaching the surface layer of soils, the question is, does tritium simply vent into the atmosphere or is there a mechanism for it to attenuate with surface soils? Because tritium *is* found on surface soils, there must exist a viable mechanism for attenuation. The only obvious mechanisms for tritiated water vapor migrating upward (or laterally) to attenuate to surface soil sediments are condensation on the surface particles when encountering cooler temperatures (e.g., at night) and/or the tendency of very dry or salt-containing surface soils to temporarily absorb this water vapor.

A second pathway by which tritium could arrive at the surface is capillary action. Capillary action is the phenomenon by which water rises in a tube (or a network of "tubes," as in packed soil) because of the difference in surface tension between the water molecules themselves and between the water molecules and the surface of the tube (or packed soil particles). Unlike water

transported via the vapor phase, water transported by capillary action can also carry dissolved compounds. Thus, non-vapor phase tritium that exists as a dissolved chemical species can also migrate upwards to surface soils by capillary action.

By either of these two mechanisms (vapor-phase transport or capillary action) tritium could move from subsurface soils to surface soils. Tritium's residence time in surface soils is unknown because it is not known how rates of tritium migration from subsurface to surface soil compare to rates of tritium removal from the surface by evaporation or by other mechanisms. It is known, from tritium flux studies (where water vapor escaping from the ground surface is captured on silica gel and the tritium in the water measured) and ambient air monitoring, that tritium is escaping in the vapor phase from the ground surface. It is also known that more tritium escapes the surface during the hotter months. In addition to evaporation, the mechanisms by which tritium can be removed from surface soils are

1. exchange and runoff with surface water;
2. percolation back into the subsurface after a storm event;
3. air dispersion of surface soil particles (containing tritium) during periods of high winds;
4. evapotranspiration of tritium-containing water by vegetation; and
5. removal of tritium-containing materials by human or animal intervention.

These tritium dispersal mechanisms are important because the actual date and time a sample is taken (and concomitant measured tritium concentration) may be impacted by localized environmental effects. For example during long dry periods, one would expect the movement of tritium on subsurface soils to be from the subsurface to the surface and ultimately away from the

surface by one of the mechanisms mentioned above. If soil sampling occurred after a long dry period, the question is, would the tritium in the soil be higher or lower than the average value that would be found for that sampling point if samples were taken every day of the year? ESH-17's (LANL's Air Quality Group) ambient air data indicates that tritium escapes the surface more readily during the hot months of the year [LANL 1997]. Or, if soil samples were taken the day after a precipitation event, would a lower than representative soil tritium concentration be expected because some of the tritiated surface soil were carried off by surface water runoff or because the tritium in the soil moisture was diluted by the rain water? These are difficult questions that may only be answered after many years of quality surface soil sampling and data assessment.

From observing the past three years of soil data from Area G, a pattern is seen in the distribution of tritium in perimeter soils. By viewing the map of Area G tritium concentrations on soil (Figure 6), one can interpret from the data that there are specific regions of Area G where tritium concentrations are particularly elevated. These regions are predominantly in the areas adjacent to the TRU pads (between MDA stations G-42 and G-50) and the tritium storage shafts (between MDA stations G-29 and 31). These tritium data, in fact, mirror the soil tritium data collected at the same locations during 1996 and 97. By examining the line plot in Figure 9, one can see that although the absolute tritium concentrations on soil collected in 1997 and 1998 are significantly lower than the data for samples collected in 1996, the areas of high-, medium-, and low-tritium concentrations on surface soils are similar for the three years. This data indicates that the mechanisms (and sources) supplying tritium to the surface soils are rather constant from year to year, and only the local environment and weather affect the absolute concentrations of tritium on

the surface soils. A comparison of the water content (% water) in the soil samples verifies that the samples collected in 1996 contained the least water (see Tables 1 to 3).

Additional data that supplement the soil information that was collected at Area G are supplied by vegetation sampling done at several Area G locations. Fresquez et al. (1995) found elevated levels of tritium in vegetation collected at just those two locations of Area G where surface soils were most highly elevated in tritium, north of the TRU pads and west of the tritium shafts. In general, Fresquez et al. found that vegetation collected from around Area G was generally elevated in radionuclide concentrations above analogous vegetation radioactive concentrations considered to be background.

By observing the box plots in Figure 12 for the tritium distribution in soils collected in 1996–1998, one notes that the tritium distributions in perimeter soils are different from and higher than the distribution of tritium in soils from the Development Area. This result was expected. Soil tritium concentrations in 1997 and 1998 are much lower than those in 1996. Lower concentrations were anticipated since the 1997 samples were collected in March when the ground was still damp and tritium flux was relatively low, while the 1996 samples were collected during the heat of the summer when soils were dry and tritium flux was relatively high. Unless more is learned about the surface soil tritium history, a sample taken at a particular moment can only provide a snapshot of the tritium surface concentration in soil at that particular time due to the observed variations being caused by changing environmental conditions and probably other factors.

The flux effect or dependence on localized moisture content on soils may be minimized by taking all samples for a sampling year during a one- or two-day sampling period, since in this

case, each sampling location would be subjected to similar atmospheric conditions. A narrow time-window sampling strategy would at least serve as a control for the seasonal and daily changes in the rate at which tritium is removed from the surface. Also, sampling during the same period each year would help reduce year-to year-variations. As sampling for tritium continues on a year-to-year basis, the relative distribution of soil tritium throughout Area G will become more apparent.

8.2 Plutonium Isotopes

As stated in Section 6.2, the locations of elevated soil plutonium readings are consistent with the history of plutonium disposal at Area G. As seen in Figure 5, the lower-numbered, or older pits (1–24), all the disposal shafts, and the TRU pads are located in the eastern half of Area G. It is suspected that increased levels of contaminant concentrations in these surface soils are directly related to the location, quantity, and date when material was disposed of in disposal units. That is, there is a greater probability of finding a contaminant adjacent to a disposal unit where large amounts of contaminants have been disposed. Also, the longer a contaminant is held in a specific location, the higher the probability that this contaminant will be disseminated to its immediate surroundings. In fact, the highest plutonium activities in soils are found at the eastern end of Area G, especially adjacent to the TRU pads and inactive disposal pits 2–10, where waste has been in place for the longest period of time.

The box plots presented in Figure 13 depict the distributions of the total plutonium concentrations in surface soil samples collected in 1996 through 1998, as well as the comparable data for samples collected from the baseline Development Area. The box plots show the similarities of the 1996 through 1998 total plutonium distributions and indicate that the

distributions from all three years have higher concentrations and a wider distribution than the total plutonium in samples from the Development Area.

8.3 Americium

As stated in Section 6.3, the tendency is to find elevated americium-241 levels in soil samples where there are elevated levels of plutonium isotopes. This trend is generally illustrated by comparing the data depicted in Figures 7 and 8. The box plots for the americium-241 distributions found in Figure 14 indicate that there is little statistical difference between the 1996 through 1998 americium-241 data. The data from 1996 include a value from location G-39-1 that can be considered an outlier and of questionable validity. Location G-39-1 was also sampled in 1997 and 1998 with respective americium-241 values of 0.21 and 0.49 pCi/g. The box plots do indicate that the americium-241 concentrations in soils collected from the active part of Area G in all three years are statistically different (greater) than the americium-241 concentrations in soil collected from the Development Area.

9.0 CONCLUSION

The perimeter soil data collected at Area G since 1993 has proven to be very beneficial. The degree of elevated radionuclide concentrations was realized and specific locations within Area G with the highest concentrations were identified. This information can be used to minimize off-site migrations by putting in place engineering features to prevent storm water runoff and sediment transport at areas where concentrations are high. The data can also be used to evaluate features already in place to reduce runoff and sediment transport. Continued collection of perimeter soil samples on an annual basis may also prove to be very beneficial. Historic data can

be compared to contemporary data as more and more annual data is collected. These data may eventually lead to an indication of data trends in Area G. Questions can be answered such as

A. Are perimeter soil concentrations decreasing, increasing, or remaining stable?

B. What has been the effect of management practices to prevent off-site migration of radionuclides?

C. By what mechanism are contaminants reaching perimeter surface soils?

Continuing this environmental surveillance project and the collection of annual data could lead to the answer to some of these questions and possibly more. But even more important, the direct protection of human health and the environment is provided by this surveillance effort. The soil sampling would help detect a significant increase in off-site migration so a rapid mitigation effort could be implemented and impacts to human health and the environment would be minimized.

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