LA-13165-PR
Progress Report

Area G Perimeter Surface-Soil and Single-Stage Water Sampling

Environmental Surveillance for Fiscal Year 94

Group: ESH-19

Los Alamos
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Acronyms and Abbreviations

AA	atomic absorption
COPC	contaminants of potential concern
cpm	counts per minute
CST	Chemical Science and Technology Division, LANL
EPA/DOE	Environmental Protection Agency/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
HAZWOPER	hazardous waste operations
HASP	Health and Safety Plan
ICP	inductively coupled plasma spectrograph
keV	kiloelectron volts (10^3 electron volts)
KPA	kinetic phosphorescence analysis
LANL	Los Alamos National Laboratory
MDA	material disposal area
µg	microgram (10^{-6} grams)
µmhos	micromhos (10^{-6} ohms^{-1}, a measure of conductance)
µm	micrometer (10^{-6} meters)
NAD	North American Datum
OU	Operable Unit
pCi	picocurie (10^{-12} curies)
RAS	radioactivity/alpha spectroscopy
RCRA	Resource Conservation and Recovery Act
RFI	RCRA Facility Investigation
ROI	(spectral) region of interest
SOP	standard operating procedure
SW	solid waste
TA	Technical Area
TRU	transuranic (waste)
TWISP	Transuranic Waste Inspectable Storage Project
WILD	brand-name surveying station
WSS	Waste Site Studies
XRF	x-ray fluorescence

AREA G PERIMETER SURFACE-SOIL AND SINGLE-STAGE WATER SAMPLING

Environmental Surveillance for Fiscal Year 94

Group: ESH-19

by

Ron Conrad, Marquis Childs, Catherine Rivera Lyons, and Fawn Coriz

ABSTRACT

ESH-19 personnel collected soil and single-stage water samples around the perimeter of Area G at Los Alamos National Laboratory during FY 94 to characterize possible contaminant movement out of Area G through surface-water and sediment runoff. These samples were analyzed for tritium, total uranium, isotopic plutonium, americium-241, and cesium-137. Ten metals were also analyzed on selected soils using analytical laboratory techniques. All radiochemical data was compared with analogous samples collected during FY 93 and reported in LA-12986.

Elevated levels of tritium (as high as 1,715,560 pCi/L) were found in perimeter soil samples during FY 94. Ten single-stage water runoff samples had a tritium activity greater than 1000 pCi/L. The tritium concentrations in soils are generally higher than those found during analogous sampling accomplished in FY 93. Although we propose two major subsurface-to-surface tritium migration mechanisms, we do not know how well these surface-sample results reflect the true Area G near-surface tritium distribution.

For soil samples, the average plutonium-238 activity was 0.435 pCi/g, while for plutonium-239 the average activity was 0.203 pCi/g. The locations of elevated plutonium readings in soil samples were consistent with the history of plutonium disposal at Area G, which was also reflected in the americium-241 results. Am-241 on soils had a mean concentration of 0.059 pCi/g. Cesium-137 activities in soils had a wide distribution and ranged from 0.12 to 1.89 pCi/g. The uranium soil concentrations had an average value of 4.3 µg/g and were uniformly distributed around Area G.

Of the ten metals analyzed on twenty-one perimeter soils collected around Area G, all were within the baseline concentrations for metals established from the soil sampling done in the undisturbed Area G expansion grid.

Baseline concentrations for future disposal operations were established for metals and radionuclides by a sampling program in the proposed Area G Expansion Area.

Considering the amount of radioactive waste that has been disposed at Area G, there is evidence of only low concentrations of radionuclides on perimeter surface soils. Consequently, little radioactivity is leaving the confines of Area G via the surface water runoff pathway.

EXECUTIVE SUMMARY

Area G, in Technical Area 54, has been the principal facility at Los Alamos National Laboratory for the storage and disposal of low-level and transuranic (TRU) radioactive waste since 1957. Our investigation during FY 94 focused on defining whether surface water has moved contaminated sediments out of the Area G site perimeter. Soil samples were analyzed for tritium, total uranium, isotopic plutonium, americium-241, and cesium-137. Ten metals — silver, arsenic, barium, beryllium, cadmium, chromium, mercury, nickel, lead and selenium — were analyzed on soils using standard analytical chemistry techniques. Filtered-water fractions from single-stage collectors were analyzed for tritium. Filtered-sediment fractions of the single-stage samples were analyzed for isotopic plutonium only.

Elevated levels of tritium (as high as 1,715,560 pCi/L) in soil were found for sampling locations adjacent to the tritium burial shafts located on the south-central perimeter of Area G. Additionally, tritium concentrations in soil as high as 435,560 pCi/L were detected adjacent to the transuranic waste (TRU) pads in the northeast corner of Area G. The majority of soil samples collected from sampling points surrounding the TRU pads and extending to the west were elevated in tritium concentration. During FY 94, ten single-stage water samples (out of a total of 159) had tritium concentration greater than 1000 pCi/L, with the highest value measured at 17,200 pCi/L. The highest tritium readings in runoff water were from locations adjacent to the tritium shafts. Two primary mechanisms, vapor-phase transport and capillary action, may allow tritium to move from the subsurface to surface soils. Tritiums residence time in surface soils is unknown, however, and we do not know how well our sample results reflect tritiums actual surface distribution at Area G.

The uranium on soil concentrations ranged from 2.6–7.0 μg/g with an average value of 4.3 ± 0.80 μg/g. Plutonium-238 activities ranged from 0.001–16.68 pCi/g with an average of 0.44 ± 0.01 pCi/g. Plutonium-239 activities in soils ranged from 0.006 to 2.773 pCi/g with an average of 0.203 ± 0.03 pCi/g. The total activities for plutonium-238 and -239 isotopes ranged from 0.01–17.86 pCi/g with an average of 0.638 + 0.034 pCi/g. The locations of elevated plutonium readings were consistent with the history of plutonium disposal at Area G: the sampling stations adjacent to the TRU pads and the oldest disposal pits had the highest plutonium levels for both surface-soil and single-stage sediment fraction samples. The two areas of elevated americium-241 activity reflected the elevated activities found for plutonium. Cesium-137 activities in soils had a wide distribution and ranged from 0.12–1.89 pCi/g, with an average value of 0.46 ± 0.17 pCi/g. There was no perimeter area where soil concentrations of cesium-137 were significantly elevated.

For the ten metals in soil analyzed, there were no apparent elevated concentrations over the metal in soil concentrations measured in the baseline soils collected from the proposed Area G Expansion Area located immediately west of the active part of Area G.

1.0 INTRODUCTION

Area G, in Technical Area 54 (TA-54), has been the principal facility at Los Alamos National Laboratory (LANL or the Laboratory) for the storage and disposal of low-level and TRU radioactive waste since 1957 (see Figure 1). From the environmental surveillance standpoint, one question that has to be addressed is whether there has been an impact on the surrounding environment from the disposal operations that have taken place at 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 (ignoring the improbable ground water pathway) for spread of contamination 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 Department of Energy (DOE) Order 5400.1, "General Environmental Protection Program" (June, 1990), and DOE order 5820.2A, "Radioactive Waste Management" (September, 1988), and to satisfy criticisms from the Nuclear Facility Defense Safety Board on the paucity of formal environmental surveillance activities at Area G.

Our investigation focuses principally on defining the potential for the transport of contaminated sediment and surface-water runoff out of Area G. Extensive surface-soil and surface-water-runoff sampling was initiated in FY 93 around the perimeter of Area G and continued during FY 94. Sampling locations were intentionally selected to best indicate whether contaminants were moving offsite; thus, these sampling locations should be considered as those locations most sensitive to possible contaminant migration outside of Area G. The data collected during FY 94 can be used to

1. determine whether there has been movement of contaminants out of the site;
2. compare with baseline concentrations of constituents on soils sampled in an undisturbed area of TA-54 proposed for the expansion of Area G disposal operations;
3. compare with baseline concentrations established at the same locations during the FY 93 sampling and to define contaminants of potential concern (COPCs) and locales for future Area-G surveillance efforts; and

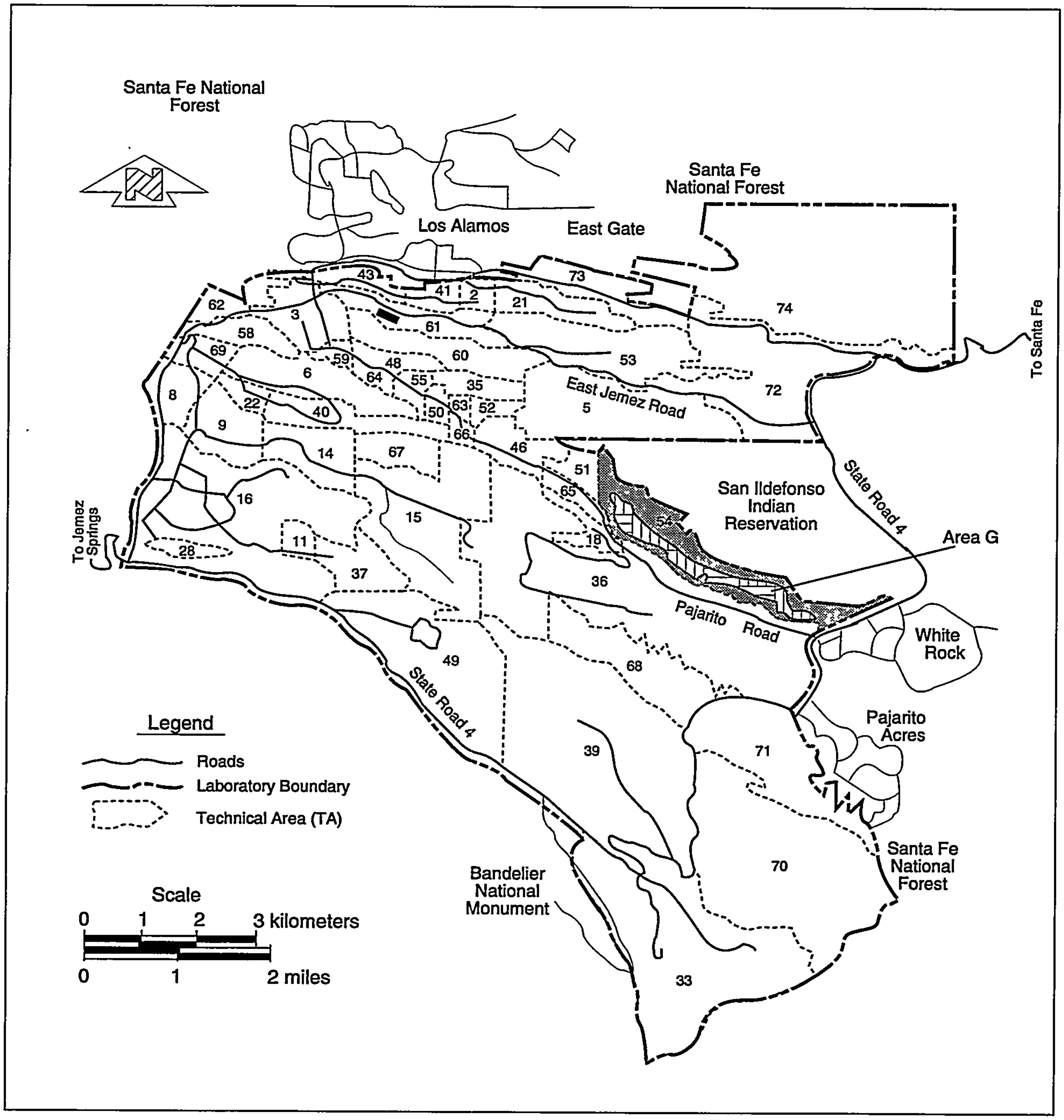

Figure 1: Location of TA-54 and Area G at Los Alamos National Laboratory. The 74 technical areas (TAs) of the Laboratory are shown here, with TA-54 located south of San Ildefonso Indian Reservation property. Area G (line pattern) runs along Mesita del Buey and parallels Pajarito Road.

4. 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 in place to preclude off-site movement of contaminants.

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 of the ground surface of Area G (and formation of the surface soil source term for surface water runoff) may have resulted from

1. dispersion of material from active pits by natural phenomena and anthropic activities;
2. movement of contaminated sediments off the TRU pads or other disposal areas by wind, surface-water runoff, mass wasting, or anthropic activities;
3. capillary action or vapor movement of buried, radioactive contaminants in pits and shafts to the surface;
4. inadvertent spills or discharges from facilities or vehicles handling contaminated materials;
5. dispersion of radioactive material from trucks carrying waste into Area G; and
6. transport of contaminants or contaminated materials to the surface by burrowing animals, vegetation, or anthropic activities.

Radioactive surface soil contamination has been documented within the confines of Area G, and it is important to determine if these contaminants are moving off the mesa top to areas where the public may be exposed or to where there may be a detrimental impact to the environment.

To this end, an extensive perimeter sampling network has been established at Area G (Figure 2, inside back cover pocket).

2.0 OBJECTIVES OF INVESTIGATION

The objectives of these investigations are to

1. define those perimeter locations at Area G where concentrations of radioactive contaminants are expected to be elevated in surface soils or where surface-water-runoff channels are established. These are established by walking the site and detecting the small channels that are formed by surface water runoff originating in Area G;
2. quantify the levels of radioactive and Resource Conservation and Recovery Act (RCRA) regulated metal contaminants in surface soils around the perimeter of Area G

and compare to baseline levels from surface-soil samples taken in adjacent, nonimpacted locations;

3. provide contaminant concentration data that can be compared to analogous baseline data collected in FY 93; and
4. document whether contaminants (either dissolved in water or as sediments) are moving off-site through surface-water runoff and compare to contaminant concentrations in samples collected from adjacent areas where disposal has not occurred.

Enhanced Area G surveillance is expected on an annual basis (depending on funding) in order to provide an up-to-date picture of existing radioactive (and other constituent) contamination in perimeter surface soils and surface-water runoff. Ultimately, measurable impacts on 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 is limited to the near mesa top perimeter outside the fence of Area G, the hillsides directly below Area G, and one major drainage within the disposal area itself. Surface-soil sampling stations and single-stage water samplers were installed in small arroyos or rivulets incised into the hillsides around the perimeter of Area G. The single-stage-sampler locations are designed to collect runoff either on the mesa top (just outside the fence line) or at points before the runoff enters the bottom of either of the two adjoining canyons, Cañada del Buey and Pajarito Canyon. This micro-scale surface water runoff sampling complements the macro-scale storm water runoff sampling performed by Environmental Safety and Health Division, Group 18 (ESH-18).

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 ground water from wells located downstream from Area G are all monitored on an annual basis by ESH-18.

Based on available funding, this investigation will be performed yearly with annual reports being prepared to compare contemporary with historical data.

2.2 Data Needs

The data needs for the FY 94 perimeter surveillance study are

1. surface-soil samples (0–6 in. deep) from existing runoff pathways located just outside the Area G perimeter fence and analyses of these samples for those constituents listed below in Section 5.4;

2. surface-water-runoff samples collected with single-stage samplers from minor runoff pathways that were estimated to have significant runoff volumes originating in Area G and analyses of these surface-water-runoff samples for constituents listed below in Section 5.4.; and
3. surface soil and single-stage runoff water samples from the undisturbed proposed Expansion Area, and analyses of these samples for constituents listed below in Section 5.4.

The Expansion Area is located where no radioactive-waste disposal has occurred, but is an area into which Waste Management operations are expected to expand. In FY 94 a regular 100 × 100 foot grid was established in this area, just west of the old Area G gate (the area west of the shaded yellow expanse in Figure 2). The analytical data from samples collected in this area will serve as baseline concentrations for constituents of interest when disposal operations are initiated in this Expansion Area. This information is presented in this paper to serve as one benchmark against which perimeter soil and water constituent concentrations will be compared.

3.0 HEALTH AND SAFETY TRAINING FOR WSS PERSONNEL

All field work was performed by members of the ESH-19 Waste Site Studies (WSS) team. Each member of the team has received and is up-to-date with all the requisite health and safety training required to perform environmental sampling at Area G. This training includes HAZWOPER (Hazardous Worker Operations), Rad Worker and General Employment Training. All field work was done following the guidelines of the WSS site-specific Health and Safety Plan (HASP) for Area G.

All members of the team also received radiation support personnel training, which allowed them to competently operate the Eberline ESP-1 beta/gamma and Ludlum Model 139 alpha meters and to perform routine frisking and radiation screening operations.

In addition, each team member watched the Area G site-specific training video, was aware of the health and safety rules and guidelines under which Area G employees operate, and performed field duties according to the Area G in-house health and safety protocols. Each WSS team member formally checked in and out of Area G daily if the work was within Area G. Work outside the fence at Area G did not require formal check-in. Each field task was performed using the buddy system: at no time did team members undertake a task at Area G without another team member being present. Finally, all team members were also enrolled in an annual LANL medical surveillance program.

4.0 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.

4.1 Land Survey

A WILD brand 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 NAD 1983), an aluminum stake was emplaced 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 one of seventy 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 material disposal area (MDA) low-energy gamma (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 data collected in FY 94 are found in Appendix A of this report. For the perimeter surveillance study, the soil and single-stage sampling sites were numbered in reference to these 70 permanent, surveyed locations. For instance, two soil or combination soil/single-stage sampling locations are sited near monument MDA-24. These locations are identified by a tagged aluminum stake with tags G-24-1 and G-24-2.

The Expansion Area soil sampling 100 × 100 foot grid was also memorialized by surveying in the locations. At each one of these locations, a four-foot aluminum stake was pounded in the ground. 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-54 (excluding point G-X-7).

On the map depicting the perimeter and Expansion Area surveillance locations (Figure 2), soil-sample points are in orange, single-stage water sample points are in blue, and the combination points for surface-soil and single-stage samples are in green. The Expansion Area grid points are depicted by purple numbers. This map was prepared by Jan Benson of the Facility for Information Management and Display (FIMAD).

4.2 Field Techniques

The following standard sampling and instrument procedures, adopted by the WSS team to collect soil and water samples and to make associated measurements, were used during this investigation:

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-ER-SOP-06.29	Single-Stage Sampling for Surface-Water Runoff
LANL-ER-SOP-10.04	MCA-465/FIDLER Instrument System
LANL-ER-SOP-14.01	Berthold Low Alpha and Beta Activity Counter. Calibration, Quality Control, Detection Limit, and Use
LANL-ESH-8-008	General Field Work
Spectrace 9000	Instrumental Procedure for XRF Measurement
DOE GJ/TMC-07(83), UC-70A	"Procedures for Field Chemical Analyses of Water Samples," by Nic Korte and Dennis Ealey

Before soil samples were collected, 60-s 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. The beta/gamma measurements were taken principally to define any potential radioactive hazards at sampling points. A typical soil-background level for ESP-1 counts at Area G was 300 cpm.

4.3 Chain-of-Custody Procedure

In addition to the above standard operating procedures (SOPs), we followed procedure LANL-ESH-8-002, "Chain-of-Custody for Environmental Samples." 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 of one of the WSS team members or locked in a room, refrigerator, or cooler to which only the WSS team members have keys. After samples were screened for gross radioactivity (see Section 5.1 below), those requiring analytical chemistry services were delivered to the Sample Receiving Facility (Chemical Science and Technology Division, Group 3, or CST-3), located at SM-59-1, TA-59. CST-3 personnel took formal custody of the samples at that time. All FY 94 samples were analyzed on-site at LANL except the soil samples from the Expansion Area which were analyzed by a contract laboratory.

5.0 SAMPLE ANALYSIS

The FY94 analytical chemistry data is found in Tables 1, 2, and 3.

5.1 Soil Samples — Gross Alpha and Beta Counting

After the soil samples were collected, they were taken to TA-59 where small aliquots of each sample were prepared for gross radioactivity counting and x-ray fluorescence (XRF) metal measurements. The main purpose of the gross counts was to determine whether the samples could be brought into Building SM-59-1 (that is, whether the samples met the CST-3 building limits for radioactivity, which have been established to minimize background counts in the building).

5.2 Soil Samples — XRF Measurements

Little information is available on metal concentrations in soils at Area G. Thus, we determined beginning in FY 93 that it would be valuable to begin developing a data base containing concentrations of metals on soils using the XRF technique. These potential soil contaminants, in their elemental forms or as ionic compounds associated with soils, are expected to be disseminated into the environment by the same routes discussed above in Section 1.0. Although XRF measurements were again made on soils collected in FY 94, these data are not included in this report since more accurate wet chemistry analytical techniques for metals on soils were performed and these metal data are included in this report.

5.3 Water Samples — pH and Conductivity Measurements

The single-stage water samples were collected in 1-gal. polyethylene bottles. The bottles were collected as soon as possible after a storm event and brought back to TA-59, where temperature, pH, and specific conductivity measurements were made (Korte, 1983). The pH and specific conductivity results are found in Table 2.

Table 1: 1994 TA-54 Area G (OU 1148) perimeter soil data. Samples can be located on the maps of Figures 3–9 by referring to the sample location numbers listed in the first column of this table.

		Soil	Radioisotope data						
Sample		**Moisture**	^{3}H	^{241}Am	^{137}Cs	**Total U**	^{238}Pu	^{239}Pu	**Total Pu**
Location	**Date**	**wt %**	**pCi/l**	**pCi/g**	**pCi/g**	**µg/g**	**pCi/g**	**pCi/g**	**pCi/g**
G-5-1	7/14/94	4.9	690	0.075	<0.52	7.0	0.030	0.094	0.124
G-5-2	7/14/94	2.5	620	0.014	<0.28	5.4	0.006	0.024	0.030
G-6-1	7/14/94	2.4	600	0.005	<0.23	3.7	0.004	0.006	0.010
G-7-1	7/14/94	3.2	840	0.003	<0.33	4.1	0.005	0.007	0.012
G-8-1	7/14/94	2.3	370	0.006	<0.32	3.8	0.001	0.007	0.008
G-8-2	7/14/94	1.5	540	0.030	<0.36	4.4	0.001	0.010	0.011
G-9-1	7/14/94	7.8	1000	0.030	<0.56	5.6	0.007	0.100	0.107
G-10-1	7/14/94	3.3	520	0.102	<0.38	4.6	0.004	0.009	0.013
G-10-2	7/14/94	6.2	920	0.026	<0.39	5.1	0.007	0.067	0.074
G-11-1	7/14/94	2.1	620	0.007	<0.30	4.2	0.007	0.013	0.020
G-12-1	7/14/94	1.2	1170	0.013	<0.21	4.0	0.003	0.012	0.015
G-12-3	7/14/94	2.5	1360	0.030	<0.47	4.5	0.007	0.090	0.097
G-13-1	7/14/94	4.2	1010	0.007	<0.34	3.8	0.000	0.020	0.020
G-13-9	7/14/94	2.1	970	0.011	<0.30	5.1	0.005	0.028	0.033
G-14-1	7/14/94	1.4	590	0.013	<0.16	2.6	0.007	0.008	0.015
G-15-1	7/14/94	1.8	790	0.014	<0.31	5.0	0.016	0.043	0.059
G-15-2	7/14/94	1.0	1550	0.018	0.58	4.1	0.015	0.060	0.075
G-15-2R	7/14/94	1.3	1130	0.010	<0.34	4.1	0.020	0.031	0.051
G-16-1	7/14/94	2.8	2110	0.011	0.32	3.4	0.004	0.019	0.023
G-17-1	7/14/94	1.6	1800	0.008	<.36	4.3	0.004	0.006	0.010
G-17-2	7/14/94	4.0	2360	0.021	<.36	5.1	0.009	0.079	0.088
G-17-3	7/14/94	1.7	2070	0.013	<.26	4.4	0.004	0.029	0.033
G-18-1	7/14/94	2.3	1430	0.010	<.38	5.2	0.004	0.024	0.028
G-19-1	7/14/94	1.0	1240	0.134	<.37	5.0	0.011	0.037	0.048
G-19-2	7/14/94	1.6	2490	0.008	<.31	3.5	0.003	0.010	0.013
G-20-1	7/14/94	2.1	5470	0.017	1.05	4.5	0.009	0.038	0.047
G-20-2	7/14/94	2.6	4410	0.006	<.26	4.2	0.003	0.009	0.012
G-21-1	7/14/94	0.9	2560	0.013	0.84	4.0	0.014	0.013	0.027

(continued)

Table 1 (continued): 1994 TA-54 Area G (OU 1148) perimeter soil data. Samples can be located on the maps of Figures 3–9 by referring to the sample location numbers listed in the first column of this table.

Sample		Soil Moisture	Radioisotope data						
			^{3}H	^{241}Am	^{137}Cs	Total U	^{238}Pu	^{239}Pu	Total Pu
Location	Date	wt %	pCi/l	pCi/g	pCi/g	µg/g	pCi/g	pCi/g	pCi/g
G-21-1R	7/14/94	1.4	2340	0.016	<0.34	4.0	0.020	0.028	0.048
G-22-1	7/14/94	2.0	3630	0.003	<0.33	3.6	0.005	0.002	0.007
G-23-1	7/14/94	2.4	2180	0.003	<0.36	4.1	0.002	0.007	0.009
G-23-2	7/14/94	1.2	8550	0.015	<0.30	4.0	0.007	0.042	0.049
G-24-1	7/14/94	1.0	2490	0.007	<0.33	3.8	0.005	0.012	0.017
G-24-2	7/14/94	5.8	2520	0.010	<0.36	4.3	0.006	0.027	0.033
G-25-1	7/14/94	2.3	2590	0.021	1.68	4.9	0.007	0.057	0.064
G-26-1	7/14/94	3.4	3310	0.018	1.75	4.8	0.006	0.065	0.071
G-27-1	7/14/94	2.8	13330	0.017	1.40	4.2	0.004	0.033	0.037
G-28-1	7/14/94	1.5	19960	0.010	<0.33	3.5	0.004	0.023	0.027
G-28-2	7/14/94	0.9	30760	0.015	<0.37	4.1	0.009	0.029	0.038
G-29-1	7/14/94	0.7	253300	0.009	<0.22	2.8	0.023	0.011	0.034
G-29-2	7/14/94	1.4	1097620	0.018	<0.40	4.4	0.026	0.045	0.071
G-29-3	7/14/94	1.3	1715560	0.006	<0.39	4.4	0.005	0.015	0.020
G-30-1	7/14/94	0.6	205310	0.007	<0.31	3.3	0.009	0.025	0.034
G-31-1	7/14/94	3.2	404100	0.032	1.89	5.4	0.024	0.117	0.141
G-31-1R	7/14/94	2.9	403030	0.027	0.81	4.8	0.019	0.096	0.115
G-31-2	7/14/94	0.8	201950	0.006	<0.31	4.3	0.009	0.010	0.019
G-31-3	7/14/94	0.5	115680	0.006	<0.26	3.0	0.007	0.010	0.017
G-32-1	7/14/94	2.0	53840	0.076	<0.39	5.4	0.022	0.392	0.414
G-32-2	7/14/94	1.7	47160	0.010	<0.32	4.1	0.007	0.027	0.034
G-32-3	7/14/94	1.6	31130	0.025	<0.31	4.5	0.010	0.058	0.068
G-33-1	7/14/94	1.8	14100	0.020	<0.38	4.4	0.016	0.122	0.138
G-34-1	7/14/94	0.9	6320	0.008	<0.39	4.0	0.006	0.012	0.018
G-34-2	7/14/94	1.5	4700	0.016	<0.33	4.4	0.005	0.046	0.051
G-34-3	7/14/94	1.4	3900	0.008	<0.28	4.8	0.004	0.040	0.044
G-34-4	7/14/94	1.2	4200	0.016	<0.28	4.4	0.020	0.050	0.070
G-34-5	7/21/94	1.1	8210	0.017	<0.39	3.3	0.050	0.049	0.099
G-34-6	7/21/94	6.7	2870	0.015	<0.52	4.7	0.017	0.088	0.105

(continued)

Table 1 (continued): 1994 TA-54 Area G (OU 1148) perimeter soil data. Samples can be located on the maps of Figures 3–9 by referring to the sample location numbers listed in the first column of this table.

Sample		Soil Moisture	Radioisotope data						
			^{3}H	^{241}Am	^{137}Cs	Total U	^{238}Pu	^{239}Pu	Total Pu
Location	Date	wt %	pCi/l	pCi/g	pCi/g	µg/g	pCi/g	pCi/g	pCi/g
G-34-7	7/21/94	3.0	5110	0.007	<0.40	3.8	0.009	0.023	0.032
G-34-8	7/21/94	1.8	4210	0.033	<0.46	4.8	0.008	0.048	0.056
G-34-9	7/21/94	4.6	6400	0.012	<0.36	4.7	0.008	0.065	0.073
G-34-10	7/21/94	5.8	3830	0.412	0.70	4.7	0.106	2.773	2.88
G-34-11	7/21/94	7.0	3980	0.090	<0.54	4.9	0.052	0.542	0.594
G-34-12	7/21/94	4.2	4140	0.006	<0.39	4.0	0.006	0.007	0.013
G-34-13	7/21/94	3.2	17690	0.012	<0.44	4.1	0.259	0.028	0.287
G-34-14	7/21/94	6.1	4080	0.006	<0.43	3.2	0.098	0.022	0.120
G-34-15	7/21/94	6.1	3820	0.011	<0.48	3.7	0.157	0.028	0.185
G-35-1	7/14/94	1.6	5480	0.084	1.26	4.2	0.010	0.125	0.135
G-35-2	7/14/94	1.5	8660	0.053	<0.31	4.1	0.016	0.643	0.659
G-36-1	7/14/94	2.1	2730	0.053	0.54	5.1	0.009	0.122	0.131
G-36-1R	7/14/94	2.6	3070	0.047	0.65	4.5	0.014	0.115	0.129
G-36-2	7/14/94	1.6	3120	0.015	<0.35	4.1	0.005	0.034	0.039
G-38-1	7/21/94	3.6	3920	0.014	<0.48	4.0	0.005	0.031	0.036
G-38-2	7/21/94	2.0	79620	0.181	<0.39	4.5	0.211	0.982	1.193
G-39-1	7/21/94	0.9	11430	0.042	<0.39	3.7	0.681	0.203	0.884
G-39-2	7/21/94	1.6	8100	0.021	<0.43	3.1	0.042	0.068	0.110
G-40-1	7/21/94	2.0	4490	0.068	<0.55	5.1	2.489	0.281	2.77
G-40-2	7/21/94	3.1	3020	0.059	<0.39	4.6	3.434	0.295	3.73
G-41-2	7/21/94	4.7	3170	0.051	<0.46	4.4	1.163	0.156	1.32
G-42-1	7/21/94	1.2	5110	0.082	<0.42	4.5	0.385	1.031	1.42
G-43-1	7/21/94	5.9	8200	0.249	<0.46	4.2	0.574	1.814	2.39
G-43-1R	7/21/94	5.5	9410	0.106	<0.47	4.3	0.687	0.481	1.17
G-43-2	7/21/94	3.5	9240	0.119	<0.48	3.9	0.508	0.711	1.22
G-44-1	7/21/94	2.1	158550	0.242	<0.44	4.3	15.778	0.588	16.37
G-45-1	7/21/94	3.1	436560	0.270	<0.46	4.4	1.266	0.639	1.95
G-46-1	7/21/94	4.0	49400	0.336	<0.43	5.2	16.683	1.173	17.86
G-46-2	7/21/94	3.4	27750	0.249	<0.53	4.5	1.863	1.093	2.96

(continued)

Table 1 (continued): 1994 TA-54 Area G (OU 1148) perimeter soil data. Samples can be located on the maps of Figures 3–9 by referring to the sample location numbers listed in the first column of this table.

Sample		**Soil Moisture**	**Radioisotope data**						
			^{3}H	**^{241}Am**	**^{137}Cs**	**Total U**	**^{238}Pu**	**^{239}Pu**	**Total Pu**
Location	**Date**	**wt %**	**pCi/l**	**pCi/g**	**pCi/g**	**µg/g**	**pCi/g**	**pCi/g**	**pCi/g**
G-47-1	7/21/94	3.7	4800	0.242	<0.46	3.7	0.078	1.782	1.86
G-48-1	7/21/94	4.2	5400	0.050	<0.68	4.3	0.131	0.297	0.428
G-48-2	7/21/94	3.7	5070	0.103	<0.69	4.8	0.081	0.579	0.660
G-48-3	7/21/94	3.7	4990	0.126	<0.45	4.3	0.085	1.157	1.24
G-48-2	7/21/94	3.7	5070	0.103	<0.69	4.8	0.081	0.579	0.660
G-48-3	7/21/94	3.7	4990	0.126	<0.45	4.3	0.085	1.157	1.242
G-49-1	7/21/94	5.5	1870	0.055	<0.42	2.7	0.028	0.216	0.264
G-50-1	7/18/94	0.9	31160	1.546	<0.14	3.8	0.142	1.063	1.21
G-50-2	7/18/94	0.7	30100	0.102	<0.12	3.9	0.033	0.075	0.108
G-51-1	7/18/94	2.7	5420	0.015	<.014	4.5	0.017	0.031	0.048
G-52-1	7/18/94	1.8	4200	0.008	<0.14	4.3	0.006	0.011	0.017
G-52-2	7/18/94	1.8	5990	0.007	<0.14	3.2	0.009	0.031	0.040
G-52-3	7/18/94	1.5	6690	0.020	<0.14	3.9	0.031	0.050	0.081
G-53-1	7/18/94	2.4	2330	0.014	0.89	4.5	0.015	0.043	0.058
G-54-1	7/18/94	0.9	6760	0.007	0.29	4.2	0.016	0.019	0.039
G-54-2	7/18/94	1.4	3900	0.012	<0.16	4.1	0.008	0.033	0.041
G-55-1	7/18/94	1.5	3530	0.014	0.23	3.7	0.007	0.044	0.051
G-55-1R	7/18/94	2.4	2190	0.020	<0.13	3.9	0.006	0.098	0.104
G-57-1	7/18/94	1.3	1900	0.012	1.14	4.4	0.008	0.037	0.045
G-58-1	7/18/94	1.3	2420	0.008	0.30	4.2	0.052	0.025	0.077
G-59-1	7/18/94	1.5	1280	0.010	1.17	5.4	0.005	0.029	0.034
G-60-1	7/18/94	1.5	930	0.009	0.58	4.4	0.003	0.022	0.025

(continued)

Table 1 (continued): 1994 TA-54 Area G (OU 1148) perimeter soil data. Samples can be located on the maps of Figures 3–9 by referring to the sample location numbers listed in the first column of this table.

Sample		**Soil Moisture**	**Radioisotope data**						
			^{3}H	**^{241}Am**	**^{137}Cs**	**Total U**	**^{238}Pu**	**^{239}Pu**	**Total Pu**
Location	**Date**	**wt %**	**pCi/l**	**pCi/g**	**pCi/g**	**µg/g**	**pCi/g**	**pCi/g**	**pCi/g**
G-62-1	7/18/94	1.2	760	0.003	<.18	4.6	0.002	0.013	0.015
G-64-1	7/18/94	1.1	830	0.012	<.22	5.2	0.005	0.029	0.034
G-65-1	7/18/94	3.9	530	0.013	1.28	4.1	0.006	0.057	0.063
G-65-2	7/18/94	0.8	860	0.006	<.17	4.5	0.003	0.008	0.011
Mean		NC*	52128	0.059	NC*	4.3	0.435	0.203	NA**
Median		NC*	3910	0.015	NC*	4.3	0.009	0.039	NA**
Std. Dev.		NC*	204805	0.161	NC*	0.7	2.211	0.428	NA**
Upper Limit		NC*	1715560	1.546	NC*	7.0	16.683	2.773	NA**
Lower Limit		NC*	370	0.003	NC*	2.6	0.000	0.002	NA**

*Not Calculated

**Not Applicable

Table 2: 1994 TA-54 Area G (OU 1148) water fraction data from single-stage samplers. Samples can be located on the maps of Figures 3–9 by referring to the sample location numbers listed in the first column of this table. Please note that negative values sometimes result from counting statistics when average background activities are subtracted from gross analytical results.

Sample		^3H		Conductivity
Location	**Date**	**pCi/l**	**pH**	**µmhos**
G-5-1	9/14/94	-400	6.90	50
G-5-2	8/8/94	0	6.91	30
G-6-1	8/8/94	-200	6.52	40
G-6-1	8/23/94	300	6.12	52
G-8-2	9/14/94	-100	6.20	55
G-9-1	8/8/94	0	6.30	40
G-9-1	8/23/94	0	6.29	40
G-10-2	9/14/94	-200	6.10	80
G-12-1	8/8/94	-100	6.55	50
G-12-2	9/8/94	100	6.30	32
G-12-3	9/8/94	-100	6.00	51
G-13-1	8/8/94	0	6.92	90
G-13-2	9/8/94	-300	5.90	100
G-13-2	7/28/94	100	6.70	140
G-13-3	8/23/94	200	7.34	30
G-13-5	7/28/94	0	6.80	180
G-13-5	8/30/94	-100	6.70	205
G-13-6	7/28/94	0	7.01	40
G-13-7	8/8/94	100	6.89	40
G-13-7	8/8/94	-200	7.30	31
G-13-8	8/4/94	-100	6.50	170
G-13-8	8/23/94	100	6.37	152
G-13-9	8/8/94	100	6.95	110
G-13-9	8/23/94	200	6.70	138
G-14-1	7/28/94	100	6.08	260
G-14-1	8/8/94	-100	6.96	250
G-14-1	9/12/94	-100	7.96	500
G-14-1	8/23/94	-100	6.96	400
G-15-1	9/14/94	-100	6.20	270

(continued)

Table 2 (continued): 1994 TA-54 Area G (OU 1148) water fraction data from single-stage samplers. Samples can be located on the maps of Figures 3–9 by referring to the sample location numbers listed in the first column of this table. Please note that negative values sometimes result from counting statistics when average background activities are subtracted from gross analytical results.

Sample		^3H		Conductivity
Location	**Date**	**pCi/l**	**pH**	**µmhos**
G-16-1	8/8/94	-200	7.71	40
G-16-1	8/23/94	-100	7.50	20
G-17-1	8/8/94	-100	7.26	80
G-17-1	8/12/94	-100	8.36	50
G-17-1	8/23/94	300	6.83	30
G-17-2	8/12/94	100	7.86	120
G-17-3	8/12/94	-100	8.00	30
G-18-1	9/14/94	0	7.10	20
G-18-1	9/8/94	-300	6.30	40
G-18-2	8/8/94	0	7.82	50
G-18-2	8/12/94	100	7.78	80
G-18-2	8/23/94	200	7.03	50
G-18-3	9/8/94	-100	6.50	31
G-18-3	8/12/94	300	7.80	50
G-19-1	8/8/94	100	7.42	90
G-19-2	9/14/94	-200	7.10	70
G-19-2	8/12/94	-200	7.81	30
G-21-2	8/8/94	1800	7.39	200
G-21-2	8/23/94	200	7.06	202
G-22-1	8/8/94	0	7.84	50
G-22-1	9/8/94	-100	6.40	30
G-24-1	8/8/94	-100	7.40	40
G-28-2	9/8/94	-200	6.30	49
G-28-3	8/8/94	0	7.32	50
G-28-3	8/12/94	200	7.68	40
G-29-2	8/8/94	6100	8.10	320
G-29-2	9/8/94	200	6.30	60
G-30-1	8/8/94	1800	7.16	60
G-30-1	8/23/94	7400	6.79	49

(continued)

Table 2 (continued): 1994 TA-54 Area G (OU 1148) water fraction data from single-stage samplers. Samples can be located on the maps of Figures 3–9 by referring to the sample location numbers listed in the first column of this table. Please note that negative values sometimes result from counting statistics when average background activities are subtracted from gross analytical results.

Sample		^3H		Conductivity
Location	Date	pCi/l	pH	µmhos
G-31-2	8/12/94	2500	7.60	300
G-31-2	8/23/94	4300	7.10	120
G-31-2	8/8/94	9000	7.15	150
G-31-3	9/8/94	500	6.20	140
G-32-1	8/8/94	1300	7.54	130
G-32-1	8/23/94	17200	7.58	195
G-34-1	8/8/94	500	8.29	2000
G-34-1	9/8/94	200	6.50	50
G-34-2	9/8/94	-100	6.40	65
G-34-3	8/8/94	100	6.90	40
G-34-3	9/8/94	-200	6.60	25
G-34-4	8/8/94	100	7.61	40
G-34-4	8/23/94	100	7.35	53
G-34-6	8/8/94	0	6.14	70
G-34-6	8/25/94	-200	6.45	58
G-34-7	7/28/94	400	7.10	150
G-34-7	8/25/94	-300	6.30	158
G-34-8	8/25/94	-400	6.40	22
G-34-9	8/25/94	-200	6.40	119
G-34-9	8/8/94	0	6.24	20
G-34-10	7/28/94	-300	7.10	135
G-34-10	8/8/94	100	6.14	70
G-34-11	9/14/94	-100	6.50	155
G-34-12	8/25/94	-600	6.51	55
G-36-1	8/8/94	100	6.54	110
G-39-3	9/14/94	100	6.60	110
G-39-4	9/14/94	-100	6.60	115
G-41-1	8/12/94	-100	8.00	110
G-41-3	8/29/94	0	7.00	60

(continued)

Table 2 (continued): 1994 TA-54 Area G (OU 1148) water fraction data from single-stage samplers. Samples can be located on the maps of Figures 3–9 by referring to the sample location numbers listed in the first column of this table. Please note that negative values sometimes result from counting statistics when average background activities are subtracted from gross analytical results.

Sample		**^{3}H**		**Conductivity**
Location	**Date**	**pCi/l**	**pH**	**µmhos**
G-41-3	8/12/94	-200	8.10	120
G-41-4	8/8/94	0	7.60	90
G-41-4	9/12/94	-300	7.90	97
G-42-2	8/29/94	-100	6.80	31
G-42-3	7/28/94	100	6.60	70
G-42-3	8/8/94	0	7.15	40
G-42-3	8/12/94	-100	8.31	30
G-42-4	9/12/94	-200	8.20	30
G-42-4	7/28/94	0	6.40	70
G-42-5	8/8/94	-100	7.58	20
G-43-3	8/12/94	100	8.27	25
G-43-3	7/28/94	100	6.70	20
G-44-2	7/28/94	100	6.80	30
G-44-2	8/8/94	-300	6.96	70
G-44-2	8/4/94	-200	7.94	60
G-44-3	8/12/94	0	7.91	60
G-44-3	9/12/94	-200	8.00	30
G-44-4	8/8/94	100	7.33	30
G-44-5	8/25/94	-100	7.40	20
G-45-2	7/28/94	100	6.90	20
G-45-2	8/8/94	-200	7.06	50
G-45-2	8/12/94	-100	7.91	50
G-45-3	8/25/94	100	6.48	19
G-46-3	8/12/94	0	8.04	20
G-46-4	8/8/94	100	6.83	190
G-46-4	8/4/94	100	7.80	120
G-47-2	7/28/94	100	7.00	30
G-47-2	8/8/94	-200	6.89	40
G-47-3	8/12/94	0	7.90	30
G-47-4	9/13/94	-200	7.80	25

(continued)

Table 2 (continued): 1994 TA-54 Area G (OU 1148) water fraction data from single-stage samplers. Samples can be located on the maps of Figures 3–9 by referring to the sample location numbers listed in the first column of this table. Please note that negative values sometimes result from counting statistics when average background activities are subtracted from gross analytical results.

Sample		^{3}**H**		**Conductivity**
Location	**Date**	**pCi/l**	**pH**	**µmhos**
G-48-4	8/25/94	0	6.60	79
G-48-4	8/8/94	-100	7.53	40
G-49-1	7/28/94	200	6.90	550
G-49-1	8/8/94	-100	6.54	340
G-49-1	8/4/94	-100	7.57	350
G-49-2	7/28/94	-200	6.90	50
G-49-2	8/12/94	-100	7.70	220
G-49-3	8/25/94	700	7.50	260
G-49-3	7/28/94	200	7.00	600
G-50-1	7/28/94	-100	7.10	600
G-50-1	8/8/94	0	6.77	390
G-50-1	7/28/94	300	7.10	25
G-51-1	8/12/94	-100	8.80	30
G-51-2	8/8/94	-200	6.87	50
G-51-2	9/12/94	-200	7.70	30
G-51-3	7/28/94	300	6.70	500
G-51-3	8/8/94	100	6.82	40
G-51-4	9/12/94	3800	7.20	70
G-52-4	9/13/94	100	7.10	78
G-52-4	8/8/94	0	7.20	90
G-54-3	8/8/94	-200	8.25	60
G-55-2	8/29/94	-100	6.90	150
G-55-3	8/8/94	-100	6.42	40
G-55-3	9/13/94	200	7.40	35
G-56-1	7/28/94	0	7.40	20
G-56-1	8/8/94	-100	7.30	20
G-56-2	9/12/94	-300	7.50	15
G-56-2	8/8/94	-200	6.98	30
G-56-3	8/8/94	-100	6.91	30

(continued)

Table 2 (continued): 1994 TA-54 Area G (OU 1148) water fraction data from single-stage samplers. Samples can be located on the maps of Figures 3–9 by referring to the sample location numbers listed in the first column of this table. Please note that negative values sometimes result from counting statistics when average background activities are subtracted from gross analytical results.

Sample		**^{3}H**		**Conductivity**
Location	**Date**	**pCi/l**	**pH**	**μmhos**
G-56-3	8/12/94	0	7.99	30
G-56-4	8/8/94	0	7.24	30
G-56-4	9/13/94	0	7.40	15
G-57-2	8/29/94	-200	7.10	25
G-57-2	7/28/94	0	7.30	30
G-57-3	9/13/94	-300	7.20	10
G-58-2	9/13/94	0	7.00	30
G-58-3	8/8/94	-300	NS*	NS*
G-58-3	8/12/94	0	8.01	25
G-59-1	8/8/94	-300	6.33	30
G-60-1	8/8/94	-100	6.38	30
G-65-1	9/13/94	-200	6.80	50
G-65-1	8/25/94	0	6.81	108

*Not submitted.

5.4 Requested Analytical Services

5.4.1 Surface-Soil Samples

The following analytical services were requested for soil samples taken during FY 94:

1. isotopic plutonium by radioactivity/alpha spectroscopy (RAS),
2. total uranium by kinetic phosphorescence analysis (KPA) or inductively coupled plasma spectrograph (ICP),
3. tritium by distillation of soil moisture and scintillation counting,
4. cesium-137 and americium-241 by gamma spectroscopy,
5. percent moisture by gravimetric methods, and
6. metals extracted by Environmental Protection Agency (EPA) SW-846 Method 3050 followed by appropriate ICP or atomic absorption (AA) analytical techniques.

5.4.2 Single-Stage Water Samples

For each water sample, we requested that the sample first be filtered through a 0.45-µm filter. The following analyses were then requested:

Filtered-water fractions

1. Tritium.

Filtered-sediment fractions

1. Isotopic plutonium (for the majority but not all samples).

5.4.3 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 these dried soil (or the sediment-fraction of the single-stage water sample) samples were analyzed for plutonium and uranium, these radionuclides were first extracted from the dried soils 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.

Before soils were analyzed for metals, they were dried at between 100° and 150°F for between 4 and 12 hours, and subsequently milled for one hour in a shaker mill. The soils were then digested prior to metal analysis according to EPA SW-846 Method 3050 (hot nitric acid digestion).

6.0 EXPANSION AREA BASELINE STUDY

As stated above, an approximately ten acre site directly west of active Area G has been identified as the location for the expansion of Waste Management disposal operations. It is appropriate to gain baseline surface soil and water chemistry data 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 and surface water runoff samples collected during FY 94 in the active part of Area G.

During FY 94, an 100 ft × 100 ft regular grid was established in the Expansion Area. In FY 94, twenty-five randomly chosen surface soil samples were collected from the Expansion Area grid. The analyses requested on these samples are found listed in Section 5.4.1.

In addition, ten baseline single-stage runoff collection and soil sampling stations were installed along the mesa top adjacent to the Expansion Area. These stations are G-8-2, 9-1, 10-2, 11-1, 12-1, 12-2, 12-3, 13-1, 59-1 and 60-1. During FY 94, single-stage water samples were collected at 9 of these 10 stations. The requested analyses for these water samples are listed in Section 5.4.2. The analytical chemistry data for the Expansion Area samples are included in Tables 2 and 3.

7.0 PERIMETER SOIL-SAMPLE RESULTS FOR CONSTITUENTS OF INTEREST

7.1 Tritium

The analytical radiochemistry results for the soil and single-stage samples are presented in Tables 1 and 2. Figures 3 and 4 depict the perimeter and Expansion Area tritium distributions for the soil and single-stage water samples. Appendix B contains box plots depicting the distribution of tritium concentration on surface soils collected around the Area G perimeter and in the Expansion Area during FY 93 and FY 94. The tritium values for the water samples collected at a particular sampling station as depicted in Figure 4 may be an average of several measurements if several samples were collected after different individual storm events. From the perimeter soil sampling (those samples taken from locations in minor drainages into which we expected sediments to be carried and water to flow during a storm event), it is shown that there is elevated soil tritium activity over the entire active portion of Area G. The tritium concentrations in soils collected in FY 94 are by-and-large slightly elevated above analogous samples collected in FY 93 (see Box plots in Appendix B). Tritium on soil samples collected adjacent to the TRU pads and tritium shafts are most highly elevated over baseline. From Figure 3, one can see elevated levels

Table 3: 1994 TA-54 Area G (OU1148) sediment fraction data from single-stage samplers. Listed here are the plutonium results for sediment filtered from the single-stage water samples.

Sample		^{238}Pu	^{239}Pu	Total Pu
Location	Date	pCi/g	pCi/g	pCi/g
G-5-1	9/14/94	0.016	0.09	0.025
G-5-2	8/8/94	0.059	0.009	0.068
G-6-1	8/23/94	0.001	0.015	0.016
G-6-1	8/8/94	0.005	0.218	0.223
G-9-1	8/23/94	0.008	0.076	0.084
G-10-2	9/14/94	0.224	0.164	0.388
G-12-3	9/8/94	0.01	0.43	0.44
G-13-1	8/8/94	0.056	0.02	0.076
G-13-2	9/8/94	0.009	0.022	0.031
G-13-2	7/28/94	0.006	0.006	0.012
G-13-6	7/28/94	0.001	0.007	0.008
G-13-7	8/23/94	0.047	0.04	0.087
G-13-7	8/8/94	0.008	0.014	0.022
G-13-8	8/8/94	0.008	0.029	0.037
G-14-1	7/28/94	0.022	0.04	0.062
G-14-1	8/23/94	0.036	0.018	0.054
G-14-1	8/12/94	0.018	0.012	0.030
G-14-1	8/8/94	0.033	0.025	0.058
G-16-1	8/23/94	0.042	0.09	0.132
G-16-1	8/8/94	0.018	0.049	0.067
G-17-1	8/23/94	0.037	0.125	0.162
G-17-1	8/12/94	0.021	0.05	0.071
G-17-2	8/12/94	0.011	0.017	0.028
G-17-3	8/12/94	0.016	0.039	0.055
G-18-1	9/8/94	0.012	0.015	0.027
G-18-1	9/14/94	0.198	0.114	0.312
G-18-2	8/23/94	0.016	0.016	0.032
G-18-2	8/12/94	0.006	0.014	0.020
G-18-2	8/8/94	0.009	0.051	0.060

(continued)

Table 3 (continued): 1994 TA-54 Area G (OU 1148) sediment fraction data from single-stage samplers. Listed here are the plutonium results for sediment filtered from the single-stage water samples.

Sample		^{238}Pu	^{239}Pu	Total Pu
Location	Date	pCi/g	pCi/g	pCi/g
G-18-3	9/8/94	0.021	0.011	0.032
G-18-3	8/12/94	0.01	0.009	0.019
G-19-1	8/8/94	0.012	0.008	0.020
G-19-2	9/14/94	0.017	0.031	0.048
G-21-2	8/23/94	0.013	0.012	0.025
G-21-2	8/8/94	0.023	0.009	0.032
G-22-1	9/8/94	0.024	0.016	0.040
G-22-1	8/8/94	0.027	0.018	0.045
G-24-1	8/8/94	0.008	0.32	0.328
G-28-2	9/8/94	0.032	0.027	0.059
G-28-3	8/12/94	0.06	0.055	0.115
G-28-3	8/8/94	0.082	0.05	0.132
G-29-2	9/8/94	0.039	0.046	0.085
G-29-2	8/8/94	0.014	0.033	0.047
G-30-1	8/23/94	0.041	0.045	0.086
G-31-2	8/23/94	0.035	0.037	0.072
G-31-2	8/12/94	0.153	0.007	0.160
G-31-2	8/8/94	0.016	0.022	0.038
G-31-3	9/8/94	0.012	0.017	0.029
G-32-1	8/8/94	0.018	0.049	0.067
G-34-1	9/8/94	0.023	0.141	0.164
G-34-1	8/8/94	0.007	0.017	0.024
G-34-2	9/8/94	0.005	0.025	0.030
G-34-3	9/8/94	0.013	0.079	0.092
G-34-3	8/8/94	0.01	0.265	0.275
G-34-4	8/23/94	0.096	0.136	0.232
G-34-4	8/8/94	0.022	0.109	0.131
G-34-6	8/25/94	0.008	0.144	0.152
G-34-7	7/28/94	0.028	0.486	0.514
G-34-7	8/25/94	0.039	0.247	0.286
G-34-8	8/25/94	0.042	0.158	0.200

(continued)

Table 3 (continued): 1994 TA-54 Area G (OU1148) sediment fraction data from single-stage samplers. Listed here are the plutonium results for sediment filtered from the single-stage water samples.

Sample		^{238}Pu	^{239}Pu	Total Pu
Location	**Date**	**pCi/g**	**pCi/g**	**pCi/g**
G-34-9	8/25/94	0.037	0.011	0.048
G-34-10	7/28/94	0.033	0.177	0.210
G-34-11	9/14/94	0.143	0.16	0.303
G-34-12	8/25/94	0.132	0.201	0.333
G-36-1	8/8/94	0.02	0.151	0.171
G-39-3	9/14/94	0.286	0.182	0.468
G-39-4	9/14/94	0.139	0.111	0.250
G-41-1	8/12/94	7.75	0.378	8.12
G-41-3	8/29/94	0.062	0.049	0.111
G-41-3	8/12/94	0.041	0.039	0.080
G-41-4	9/14/94	0.038	0.016	0.054
G-41-4	8/8/94	0.044	0.014	0.058
G-42-2	8/29/94	0.143	0.443	0.586
G-42-3	7/28/94	0.111	0.092	0.203
G-42-3	8/12/94	0.183	0.075	0.258
G-42-3	8/8/94	0.275	0.134	0.409
G-42-4	7/28/94	0.165	0.024	0.189
G-42-4	9/14/94	0.498	0.111	0.609
G-42-5	8/8/94	1.513	1.069	2.58
G-43-3	7/28/94	0.337	0.066	0.403
G-43-3	8/12/94	0.421	0.191	0.615
G-44-2	7/28/94	0.106	0.027	0.133
G-44-2	8/8/94	0.229	0.052	0.281
G-44-2	8/12/94	0.282	0.047	0.329
G-44-3	9/14/94	0.256	0.092	0.348
G-44-3	8/12/94	0.316	0.027	0.343
G-44-4	8/8/94	0.555	1.404	1.96
G-44-5	8/25/94	1.357	2.347	3.704
G-45-2	7/28/94	0.291	0.028	0.319
G-45-2	8/12/94	0.269	0.034	0.309
G-45-2	8/8/94	0.364	0.016	0.380

(continued)

Table 3 (continued): 1994 TA-54 Area G (OU 1148) sediment fraction data from single-stage samplers. Listed here are the plutonium results for sediment filtered from the single-stage water samples.

Sample		^{238}Pu	^{239}Pu	Total Pu
Location	**Date**	**pCi/g**	**pCi/g**	**pCi/g**
G-45-3	8/25/94	4.880	1.113	5.99
G-46-4	8/8/94	1.101	1.860	2.96
G-47-2	8/894	0.380	0.052	0432
G-47-4	9/14/94	0.460	6.086	6.55
G-48-4	8/25/94	0.550	1.292	1.84
G-49-1	7/28/94	0.027	0.091	0.118
G-49-1	8/12/94	0.048	0.235	0.283
G-49-1	8/8/94	0.060	0.116	0.176
G-49-2	7/28/94	0.024	0.056	0.08
G-49-2	8/12/94	0.052	0.231	0.283
G-49-3	7/28/94	0.052	0.592	0.644
G-49-3	8/25/94	0.022	0.031	0.053
G-50-1	7/28/94	0.045	0.138	0.183
G-50-1	8/8/94	0.078	0.078	0.156
G-51-1	7/28/94	0.013	0.017	0.030
G-51-1	8/12/94	0.022	0.044	0.066
G-51-2	9/14/94	0.020	0.047	0.067
G-51-3	7/28/94	0.041	0.178	0.219
G-51-3	8/8/94	0.220	0.056	0.276
G-51-4	9/14/94	0.017	0.034	0.051
G-54–3	8/8/94	0.038	0.043	0.081
G-55-2	8/29/94	0.009	0.062	0.051
G-55-3	9/14/94	0.034	0.139	0.173
G-55-3	8/8/94	0.076	0.066	0.142
G-56-1	7/28/94	0.012	0.043	0.055
G-56-1	8/8/94	0.013	0.046	0.059
G-56-2	8/8/94	0.000	0.016	0.016
G-56-3	8/12/94	0.010	0.013	0.023
G-56-3	8/8/94	0.008	0.034	0.042
G-56-4	8/8/94	0.021	0.037	0.058
G-56-4	9/14/94	0.009	0.037	0.046
G-57-2	8/29/94	0.016	0.031	0.047

(continued)

Table 3 (continued): 1994 TA-54 Area G (OU 1148) sediment fraction data from single-stage samplers. Listed here are the plutonium results for sediment filtered from the single-stage water samples.

Sample		**^{238}Pu**	**^{239}Pu**	**Total Pu**
Location	**Date**	**pCi/g**	**pCi/g**	**pCi/g**
G-57-2	7/28/94	0.003	0.009	0.009
G-58-3	8/12/94	0.026	0.056	0.082
G-65-1	8/25/94	0.010	0.013	0.023
G-65-1	9/14/94	0.027	0.031	0.058

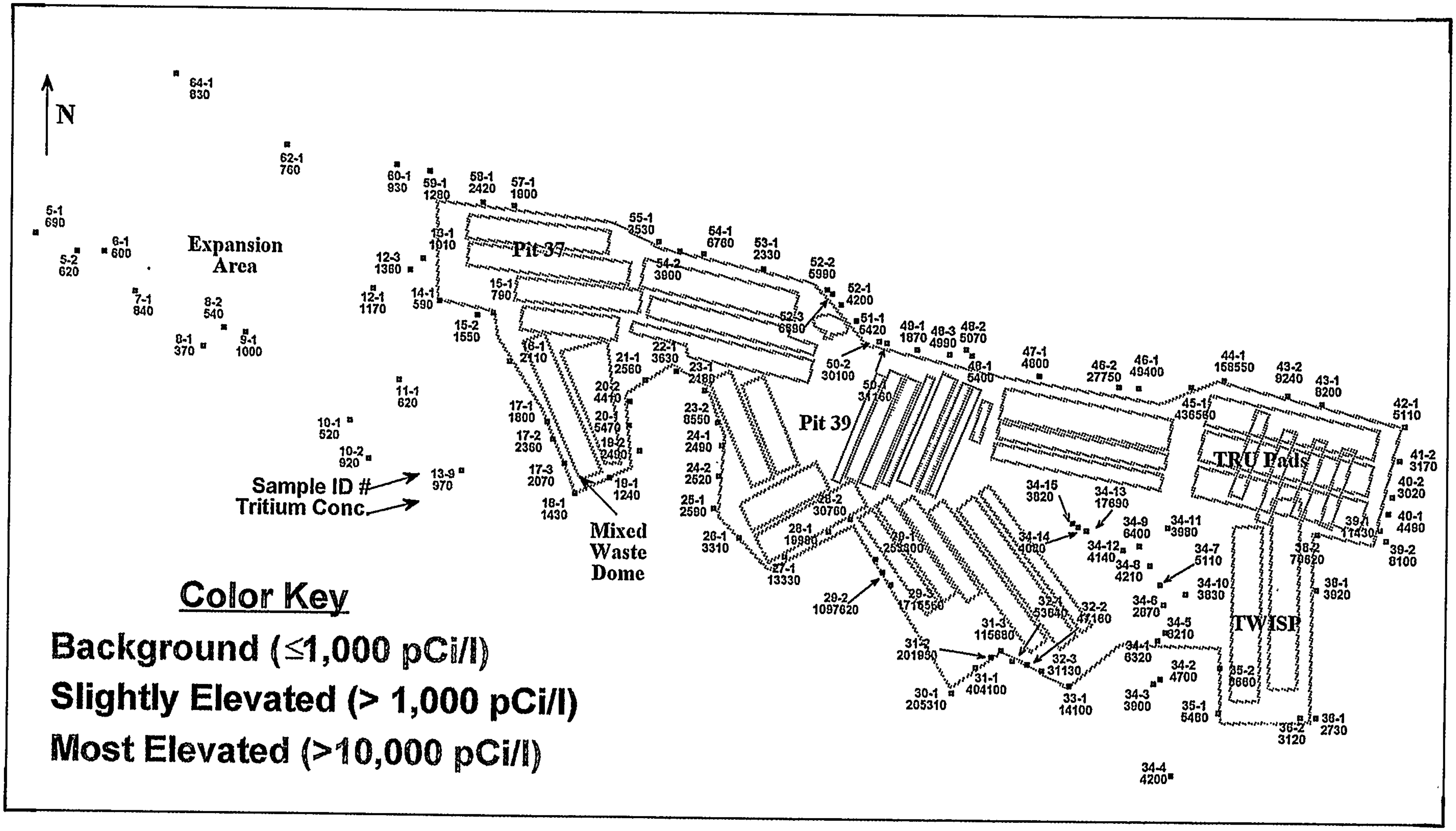

Figure 3: Tritium soil-sample locations and analytical results at Area G. Tritium soil-sample locations are indicated by the square points. Next to each point is a pair of color-coded numbers: the hyphenated sample identification number and the tritium concentration in pico-curies per liter. Several Area G landmarks are outlined and labeled for orientation: the perimeter fence line, active pits 37 and 39, the expansion area to the west, and the transuranic waste pads (TRU Pads) and the Transuranic Waste Inspectable Storage Project (TWISP) to the east.

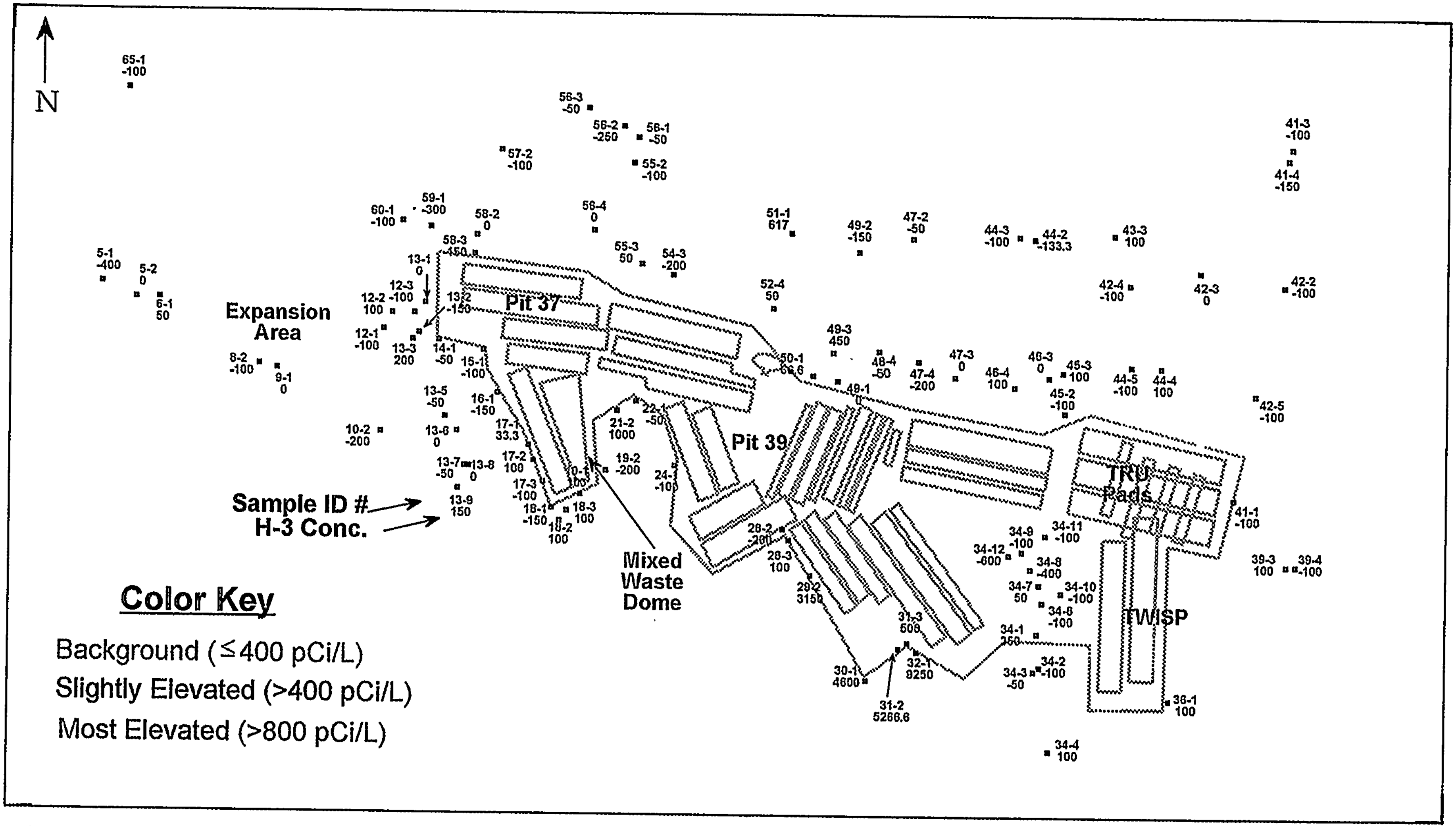

Figure 4: Tritium analytical results for the filtered-water fraction from single-stage samples at Area G. Single-stage water-sample locations are indicated by the square points. Next to each point is a pair of color-coded numbers: the hyphenated sample identification number and the tritium concentration in picocuries per liter of filtered water. Several Area G landmarks are outlined and labeled for orientation: the perimeter fence line, active pits 37 and 39, the expansion area to the west, and the transuranic waste pads (TRU Pads) and the Transuranic Waste Inspectable Storage Project (TWISP) to the east.

soil-moisture interactions are limited to the top few centimeters of surface soils. At that time, tritium concentrations in the surface-soil stratum could be altered by the

1. exchange and entrainment in water of available tritium on soils by water running off of a particular location or
2. erosion away of tritium-bound sediments.

It is assumed that on soil, tritium is incorporated into the associated water that is termed "soil moisture." When the laboratory prepares a soil sample for tritium analysis, soil moisture is distilled out of a weighed sample of soil. 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 of tritium (as high as 436,560 pCi/L) in soil from sampling locations between monuments G-42 and G-51. These locations are along the northern edge of the TRU pads and extend along the fenceline to the west some 600 feet. To the east and south of the TRU pads (between monuments G-34 and G-41), 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 (79,620 pCi/L). This particular soil sample also had an elevated tritium concentration during the FY 93 sampling campaign. The locale for the most elevated soil tritium soil concentrations in FY 94 is adjacent to the tritium disposal shafts and encompasses sample series G-27 through G-32. Soil samples from this area had tritium activities as high as 1,715,560 pCi/L. Figure 10 is a scatter plot depicting the tritium in soil concentrations at analogous locations for the years FY 93 and FY 94. This figure indicates that the localized regions of elevated tritium concentrations on the perimeter of Area G were the same during FY 93 and FY 94 but tritium concentrations for FY 94 were generally higher that the tritium activities from equivalent samples collected in FY 93. The significance of year-to-year measured tritium concentrations in soil (and runoff water) will be discussed below.

Storm-water runoff (single-stage) samples were also collected in the majority of those locations where perimeter soil samples were taken. We collected 159 water samples by the single-stage-sampler method during FY 94 (at many stations multiple collections were made on different dates). The analytical chemistry data for these samples are presented in Tables 2 (tritium) and 3 (plutonium). Only the water fractions of the single-stage samples were analyzed for tritium. The tritium activity of the vast majority (92%) of the samples ranged from reported values of -600–400 pCi/L. Although the detection limit for tritium analyzed by this method is 300 pCi/L, the counting statistics may generate values that are less than the detection limit, and sometimes even negative values may be reported. We consider the activity range of -600–400 pCi/L to be the baseline tritium concentration range for surface-water runoff at Area G.

Ten single-stage water samples had tritium concentrations over 1000 pCi/L, and in FY 94 one single-stage water sample (from the tritium shaft area, sample G-32-1) had a tritium activity measured at 17,200 pCi/L. Multiple (collected after different storm events) samples from the same station collected from the tritium shaft area illustrate how the tritium concentrations can vary depending on the most recent "weather" extant at Area G (see Table 2). The rationale for this variability is discussed by the authors below.

An important consideration regarding the tritium results for surface soils or single-stage samplers is that they reflect the surface-soil environment only at the time of the soil sampling or the storm event. The ambient conditions at a particular location are factors that will determine the concentration and availability of tritium at the time a sample is taken. When precipitation falls, soil-moisture interactions are limited to the top few centimeters of surface soils. At that time, tritium concentrations in the surface-soil stratum could be altered by the

1. exchange and entrainment in water of available tritium on soils by water running off of a particular location or
2. erosion away of tritium-bound sediments.

It is assumed that on soil, tritium is incorporated into the associated water that is termed "soil moisture." When the laboratory prepares a soil sample for tritium analysis, soil moisture is distilled out of a weighed sample of soil. 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 before the sampling event or if the soil came from a location that was naturally damp (shaded area) or where anthropic activities (such as a water truck spraying on the ground surface) had impacted the soil, this added water to the natural soil moisture would cause a dilution of the tritium concentration on that soil that had a source resulting from disposal of tritium at Area G. Figures 4 and 10 illustrate the manifestation of this hypothesis. In both FY 94 and FY 93, the regions of baseline, slightly elevated and most elevated tritium concentrations on soils are the same. However, the absolute concentrations of tritium measured on soil during those two years are shown to be generally different.

By minimizing the period of time taken for the collection of all the samples and purposefully collecting samples during dry periods, one can hopefully eliminate most of the local environmental impacts discussed above.

7.2 Uranium

Total uranium analysis data (Table 1) are reported as the mass of uranium present in a soil sample (µg uranium per gram of soil). For the 110 perimeter soil samples analyzed in FY 94, the uranium concentrations ranged from 2.6–7.0 µg/g. The average value for total uranium in perimeter soils was 4.3 ± 0.8 µg/g. The geographic distribution for these soil uranium readings is depicted in Figure 5. The uranium in soil concentrations reported for FY 94 data are biased higher than the soil uranium values reported in FY 93 (see Box plot in Appendix B). One reason for this apparent difference in total uranium concentrations is that the samples analyzed in FY 93 were done in-house by the KPA method while the FY 94 samples were done by an outside laboratory by the ICPMS method. Obviously there is a positive bias with the ICPMS method with respect to the KPA method.

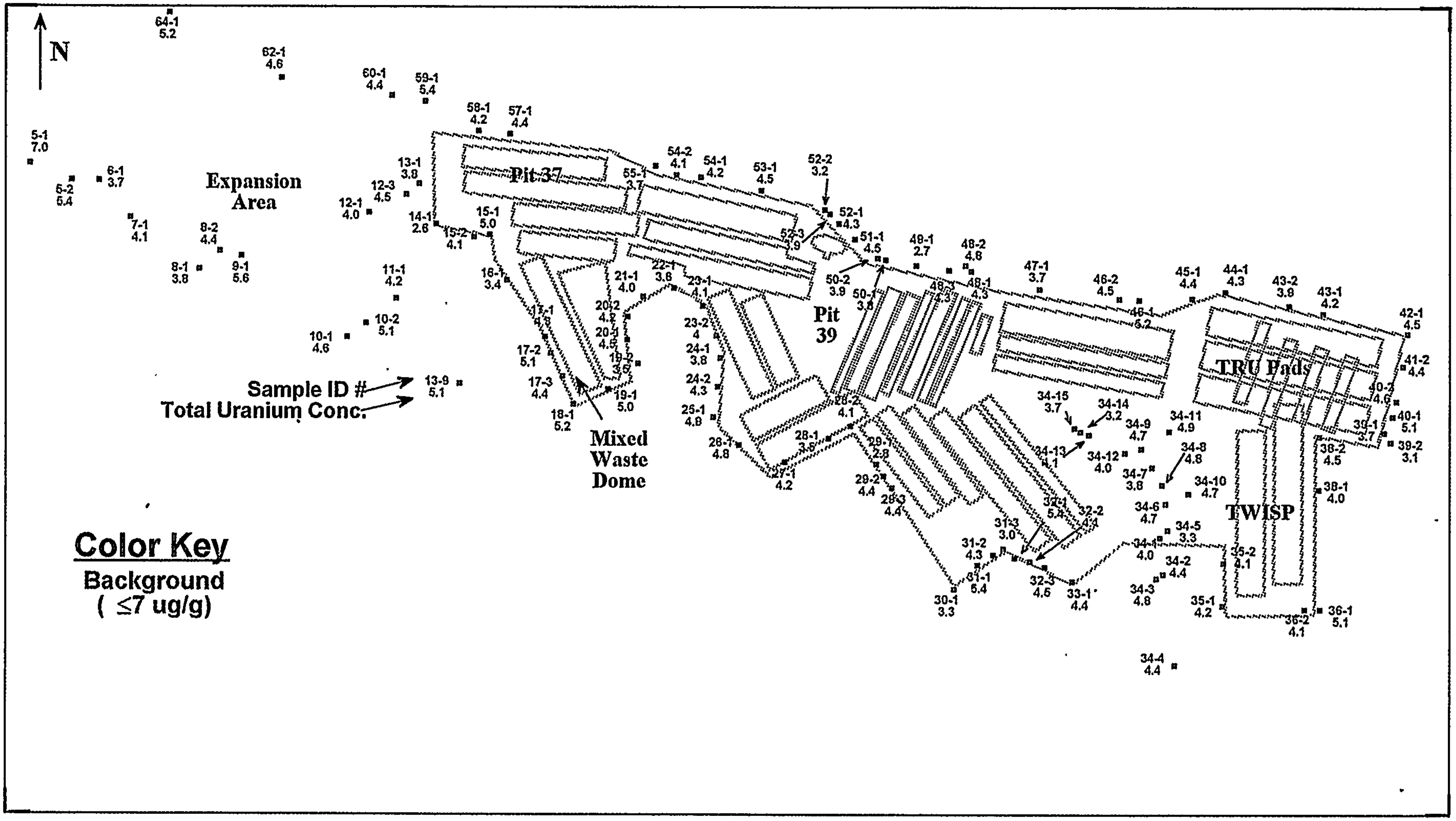

Figure 5: Uranium soil-sample locations and analytical results at Area G. Soil-sample locations are indicated by the square points. Next to each point is a pair of color-coded numbers: the hyphenated sample identification number and the uranium concentration in micrograms per gram of soil. Several Area G landmarks are outlined and labeled for orientation: the perimeter fence line, active pits 37 and 39, the expansion area to the west, and the transuranic waste pads (TRU Pads) and the Transuranic Waste Inspectable Storage Project (TWISP) to the east.

Uranium concentrations were not determined in the sediment fraction of the single-stage samples during FY 94 since the analogous data collected during FY 93 illustrated no significant distribution of uranium on sediment fractions collected in the single-stage runoff samples. This, in fact, is to be expected since the perimeter soils on the mesa top that would serve as the source term for sediments collected in the single-stage sample bottles have no obvious or significant uranium distribution.

7.3 Plutonium Isotopes

During the FY 94 perimeter surface-soil sampling campaign, 110 perimeter soil samples were 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 are presented in Table 1. The plutonium-238 activities range from 0.001 pCi/g to 16.683 pCi/g. The average plutonium-238 activity is 0.44 ± 0.01 pCi/g. The mean value is far above the median value (0.009 pCi/g) because several samples have elevated plutonium levels and the frequency distribution plot is positively skewed. For plutonium-239, activities range from 0.01–2.77 pCi/g. The mean plutonium-239 activity is 0.20 ± 0.03 pCi/g. The plutonium-239 data is also positively skewed, with the median plutonium-239 value for the same sample set being 0.039 pCi/g. For convenience, the sum of the plutonium isotope activity (total) for each sample is also presented in Table 1 (box plots of the total plutonium distribution on perimeter and Expansion Area surface soils collected in FY 93 and FY 94 are presented in Appendix B). In Figure 6, total plutonium isotope activity in perimeter soils is plotted by location. Figure 6 shows that perimeter surface soils increase slightly in plutonium activity as one moves from the west of Area G (with little or no history of waste-disposal activity) to the east (where waste disposal occurred). The highest total plutonium activities are associated with the TRU pads and the lower-numbered inactive disposal pits (location series G-38–46), with elevated readings also found to the west of the TRU pads along the northern edge of Area G up through location series G-50. 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.

The single-stage samples collected during FY 94 were separated into a water fraction and a sediment fraction. Isotopic plutonium analyses were run on the sediment fraction. These data are included in Table 3 and depicted in Figure 7. The locations of single-stage samples where the sediment contains elevated levels of plutonium reflect the areas where soils are also elevated in plutonium. That is, in the vicinity of the TRU pads.

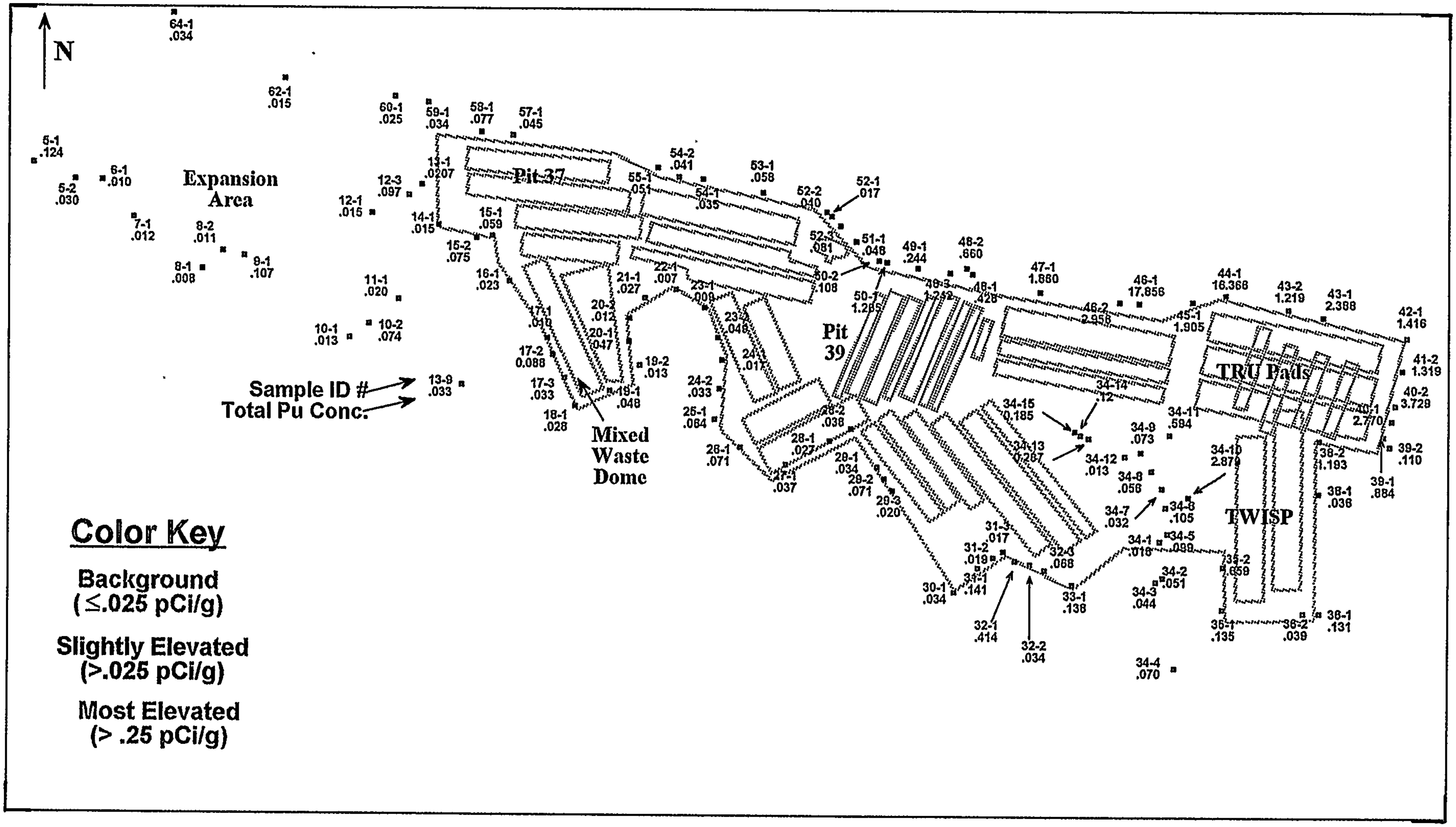

Figure 6: Total isotopic plutonium soil-sample locations and analytical results at Area G. Soil-sample locations are indicated by the square points. Next to each point is a pair of color-coded numbers: the hyphenated sample identification number and the total isotopic plutonium concentration in picocuries per gram of soil. Several Area G landmarks are outlined and labeled for orientation: the perimeter fence line, active pits 37 and 39, the expansion area to the west, and the transuranic waste pads (TRU Pads) and Transuranic Waste Inspectable Storage Project (TWISP) to the east.

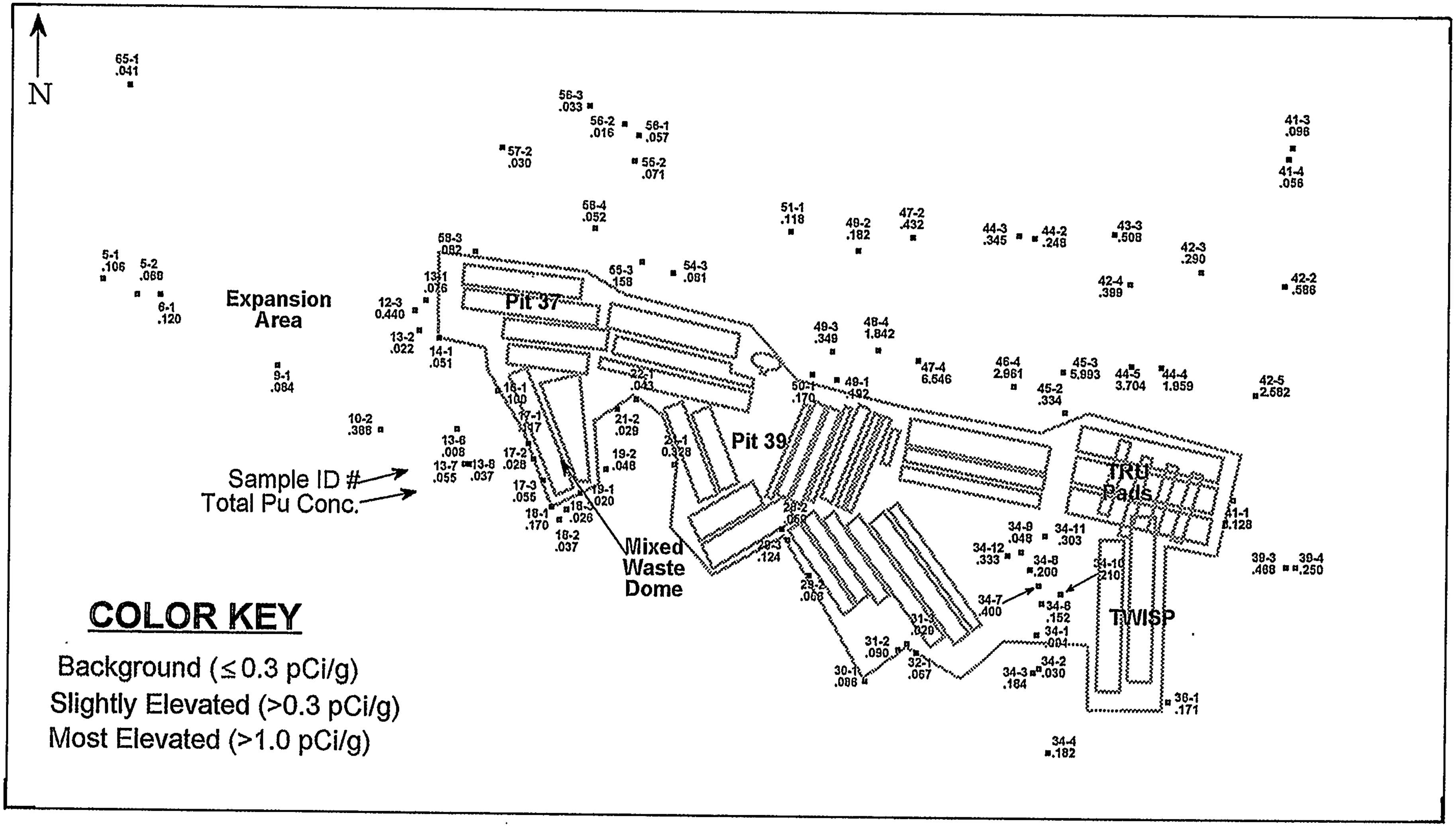

Figure 7: Total isotopic plutonium analytical results for sediments from single-stage samplers at Area G. Tritium soil-sample locations are indicated by the square points. Next to each point is a pair of color-coded numbers: the hyphenated sample identification number and the total isotopic plutonium concentration in pricocuries per gram of filtered sediment. Several Area G landmarks are outlined and labeled for orientation: the perimeter fence line, active pits 37 and 39, the expansion area to the west, and the transuranic waste pads (TRU Pads) and the Transuranic Waste Inspectable Storage Project (TWISP) to the east.

7.4 Americium-241

Americium-241 is normally found with plutonium in soils because it is a direct radioactive decay product of plutonium-241. Corroboration of plutonium distribution in soils is possible by using the attendant americium-241 analytical results. Table 1 includes the soil americium-241 results, while Figure 8 depicts the geographic distribution of the americium-241 readings (box plots depicting the americium-241 distribution in surface soils collected at perimeter and Expansion Area locations in FY 93 and 94 can be found in Appendix B). The americium-241 values for perimeter soils varied from 0.003 pCi/g to 1.55 pCi/g. The mean americium-241 concentration in soils was 0.059 ± 0.031 pCi/g. An area with elevated americium-241 soil levels was found adjacent to the TRU pads in the area of series G-48–51. This location of elevated americium-241 reflects the elevated activities of plutonium in soils reported above in Section 7.3 (compare Figures 6 and 8).

7.5 Cesium-137

Cesium-137 is another isotope of interest at Area G. All perimeter soils were analyzed by gamma spectroscopy for cesium-137, and these data are found in Table 1. Figure 9 illustrates a fairly even distribution of cesium-137 in perimeter surface soils at Area G. Cesium-137 activities in soils range from less than 0.12 pCi/g to 1.89 pCi/g, with an average concentration in soils of 0.43 ± 0.17 pCi/g. These data show a wide distribution of low levels of cesium-137 in Area G perimeter soils.

7.6 Metals

Because little analytical data are available on RCRA-regulated metals in Area G surface soils, we continued a program begun in FY 93 for collection of soil samples for analysis of metals. In FY 94, ten RCRA metals were analyzed on twenty one soil samples collected from the perimeter of Area G. We submitted these twenty one soil samples for EPA SW-846 metal analyses of Ag, As, Ba, Be, Cd, Cr, Hg, Ni, Pb, and Se. Table 4 summarizes the metal-on-soil data. There is no apparent contamination of Area G perimeter surface soils by any of the metals analyzed. Included in the summary table are the mean, median, and standard deviation from the mean for the metals Ba, Cr, and Pb. These are the only metals that were analyzed that yielded enough "non-detect" data points to calculate basic statistical parameters. Box plots comparing distributions of these three metals on FY 93 and FY 94 perimeter soils, as well as soils from the Expansion Area are presented in Appendix B of this report.

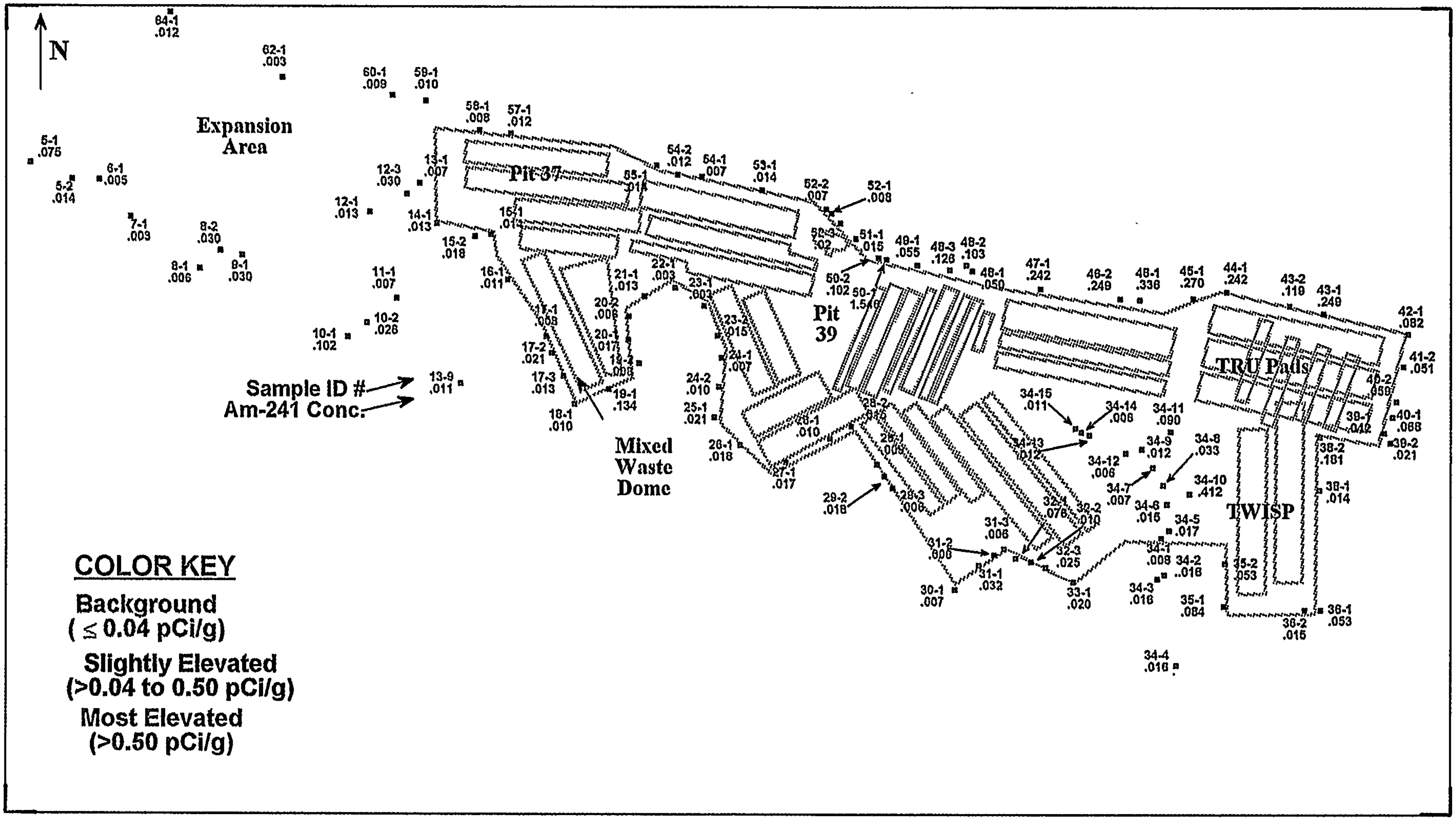

Figure 8: Americium-241 soil-sample locations and analytical results at Area G. Soil-sample locations are indicated by the square points. Next to each point is a pair of color-coded numbers: the hyphenated sample identification number and the americium-241concentration in picocuries per gram of soil. Several Area G landmarks are outlined and labeled for orientation: the perimeter fence line, active pits 37 and 39, the expansion area to the west, and the transuranic waste pads (TRU Pads) and the Transuranic Waste Inspectable Storage Project (TWISP) to the east.

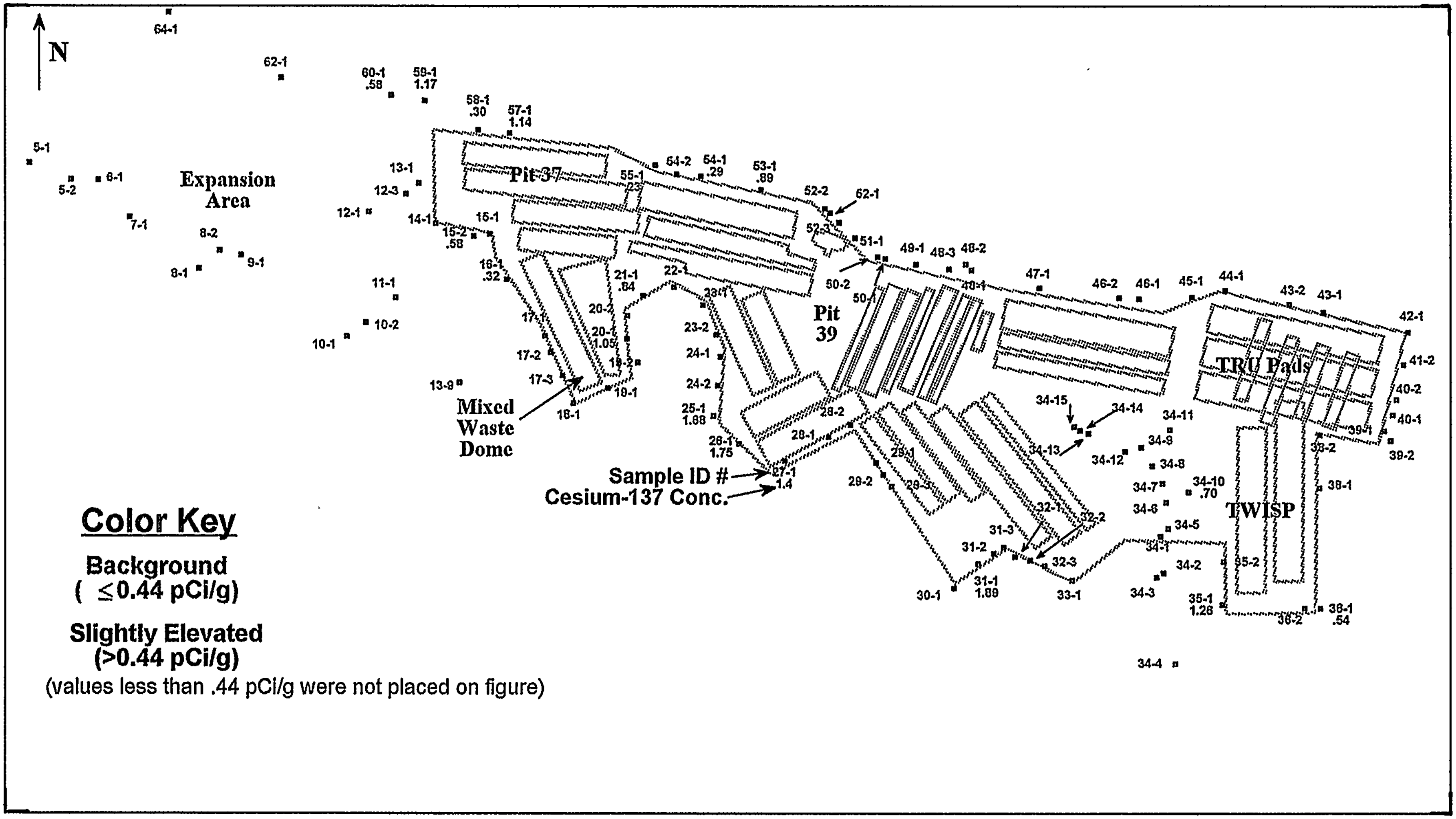

Figure 9: Cesium-137 soil-sample locations and analytical results at Area G. Soil-sample locations are indicated by the square points. Next to each point is a pair of color-coded numbers: the hyphenated sample identification number and the cesium-137 concentration in picocuries per gram of soil. Several Area G landmarks are outlined and labeled for orientation: the perimeter fence line, active pits 37 and 39, the expansion area to the west, and the transuranic waste pads (TRU Pads) and the Transuranic Waste Inspectable Storage Project (TWISP) to the east.

Table 4: 1994 TA-54 Area G (OU 1148) metal on perimeter soil data.

Sample		**Laboratory Metal Analyses (µg/g)**									
Location	**Date**	**Ag**	**As**	**Ba**	**Be**	**Cd**	**Cr**	**Hg**	**Ni**	**Pb**	**Se**
G-9-1	7/14/94	<0.63	3.3	110	<0.88	<1	6.5	<0.02	<3.8	23.8	<0.63
G-10-1	7/14/94	<0.62	<1.9	86.9	1.7	<0.47	6.8	0.22	<4.2	13.9	<0.62
G-17-3	7/14/94	<0.61	<1.9	74.3	<0.74	<0.9	8.5	<0.02	<5.2	11.6	<0.61
G-21-1	7/14/94	<0.61	<1.4	44.9	<0.41	<0.53	3.5	<0.04	<1.2	7	<0.61
G-21-1R	7/14/94	<0.6	<1	44	<0.39	<0.52	3.1	<0.03	<2	6.2	<0.6
G-24-2	7/14/94	<0.64	3.1	178	1.7	<1.4	13.7	<0.02	9.2	15.7	<0.64
G-34-2	7/14/94	<0.61	<1.4	70.5	<0.65	<0.58	3.7	0.14	<1.3	8.4	<0.61
G-35-2	7/14/94	<0.61	<1.7	116	<0.74	<0.78	6	<0.04	<3.5	12.8	<0.61
G-38-1	7/21/94	<0.61	3.4	87.2	<0.89	<0.6	5.8	<0.02	<5.8	8.4	<0.61
G-38-2	7/21/94	<0.61	<1.5	78.5	<0.52	<0.68	4.3	<0.02	<3.8	8.9	<0.61
G-40-2	7/21/94	<0.61	<2	51.1	<0.5	<0.37	2.8	<0.02	<3.6	7.6	<0.61
G-43-1	7/21/94	0.62	<1.3	59	<0.55	<0.21	3.5	<0.02	<3.1	8.6	<0.62
G-43-1R	7/21/94	<0.62	<.83	57.7	<0.49	<0.51	4.3	<0.02	<3.4	8.7	<0.62
G-44-1	7/21/94	<0.61	<1.4	<31.8	<0.34	<0.2	2.6	<0.02	<1.2	5.9	<0.61
G-45-1	7/21/94	<0.61	2.8	52.6	<0.51	<0.75	4	<0.02	<2.3	9.7	<0.61
G-46-1	7/21/94	<0.94	<1.8	58.6	<0.47	<0.48	7.7	<0.02	<4.1	14.9	<0.62
G-48-3	7/21/94	<0.62	2.4	74	<0.46	<0.77	5.6	<0.02	<4.2	11.7	<0.32
G-50-2	7/18/94	<0.6	<.84	51.1	<0.42	<0.36	3.9	<0.02	<1.9	5.9	<0.6
G-51-1	7/18/94	<0.61	2.5	99.7	<0.81	<0.52	5.6	<0.02	<4.4	11.9	<0.61
G-54-1	7/18/94	<0.6	<1.3	45.3	<0.5	<0.25	4.1	<0.02	<1.5	7.5	<0.6
G-58-1	7/18/94	<0.6	2.9	65.7	<0.53	<0.39	4.9	<0.02	<3.5	9.6	<0.6

Each soil sample collected was also run for metals on the XRF instrument. This continues a practice started in FY 93. The XRF technique is a nondestructive method that irradiates soil particles with x-rays from one of several sources. Measurements of the subsequent fluorescent radiation can identify particular metals and determine their quantity as internal calibrations are performed using pure metals. These data are collected to give an Area G metal-on-soil data base for those locations where metals were not analyzed for by the more accurate ICP and AA wet chemistry methods mentioned above. The XRF data are not presented in this report but are available upon request.

8.0 STATISTICAL CONSIDERATIONS

Independent perimeter surface soil data sets are now available for FY 93 and FY 94 and the Area G Expansion Area so that it is appropriate to compare this information. The comparisons we choose to make are:

1. whether the FY 94 Area G perimeter soil chemistry data are statistically different from the Expansion Area data,
2. and whether the soil chemistry data collected in FY 94 are statistically different from the analogous data collected in FY 93 (considered the baseline year).

It is expected that the soil data for several constituents (especially tritium, plutonium, and americium-241) for the perimeter G samples can be shown to be statistically different (for instance, constituents will have higher average concentrations) than the soil data collected from the Expansion Area where disposal operations have not occurred.

On the other hand, a more difficult question is determining whether, for example, the plutonium activity in perimeter soils at Area G is increasing (or decreasing) from year to year. Because concentration changes from year to year are expected to be small, only by statistical analysis can one determine whether there truly are concentration changes of constituents on soil from one year to the next.

In Appendix B, the data is presented as box plots to assist in 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 to constituent concentrations measured on soil samples collected in the proposed Area G Expansion (defined as background) Area. Surface soil and single-stage water samples were collected in this Expansion Area during FY 94.

The second type of statistical assessment is done by comparing the constituent concentrations for FY 94 with constituent concentrations for FY 93 from analogous locations. For instance, by comparing tritium concentrations on soils collected in FY 94 to tritium concentrations on soils collected in FY 93. Box plots are used to depict all the distributions discussed below and to assist in comparing the different data sets. Box plots give information on the median, interquartile range, skewness, and other information which helps determine whether a distribution is normal. By placing the box plots on the same scale and in the same figure, we have an immediate impression of the differences and similarities of the distributions we are attempting to compare.

9.0 CONCLUSIONS

In the paragraphs below are discussions of the results of the FY 94 perimeter soil and water sampling performed at Area G.

9.1 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 stored, including LANL, we know that tritium can migrate some distance from its place of disposal. Tritium in the soils at Los Alamos has a wide distribution from both 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 needs to be addressed is that of the relationship between the tritium found in annual surface-soil and water-runoff 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 materials that have been disposed (buried or emplaced) in one or another of the many shafts, pits, and pads at the site. We expect the probability of finding tritium at elevated levels to be greatest in closest proximity to these sources. Because disposal of waste occurs in a fashion that entails subsequent covering by natural tuffaceous material (and at times asphalt or cement), one important question is, by what pathway does subsurface tritium migrate to the surface, so that it could possibly be carried offsite? We have postulated 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 anthropic 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 absorb this water vapor.

A second pathway by which tritium could arrive at the surface (and have some residence time) would be capillary action. Capillary action is the phenomenon by which a liquid 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, 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. Tritiums residence time in surface soils is unknown because we do not know how the tritium migration rates from subsurface to surface soils compare to the rates of tritium removal from the surface by evaporation or by other mechanisms. We do know from tritium flux studies (where water vapor is captured on silica gel and the tritium in the water measured) that tritium is escaping in the vapor phase from the ground surface. 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 impacts. 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? Or if soil samples were taken the day after a storm, would a lower than representative tritium concentration be expected because some of the tritiated surface sediments were carried off by surface water runoff or 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.

After two years of systematic soil sampling at Area G, we begin to see a pattern in the distribution of tritium in perimeter soils. By observing the maps of Area G tritium concentrations on soil and surface water runoff (Figures 3 and 4), it is evident from the FY 94 data that there are specific regions of Area G where tritium concentrations are particularly elevated. These regions are predominantly in the area adjacent to the TRU pads (between MDA stations G-42 and 51) and the tritium storage shafts (between MDA stations G-28 and 31). These tritium data, in fact, mirror the tritium-on-soil data collected at the same locations in FY 93. By observing the scatter plot in Figure 10, one can see that although the absolute tritium concentrations on soil collected in FY 94 vary somewhat from the data for samples collected in FY 93, the areas of high, medium and low tritium concentrations on surface soils are similar for the two years. This indicates that the mechanisms (and sources) supplying tritium to the surface soils are rather constant from year to year and only the local environment affects the absolute concentrations of tritium on the surface soils.

An additional piece of data that supplements the soil and surface water information we collected at Area G, is 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 located on the south-central section of the disposal site. Also, Fresquez found that vegetation collected from around Area G was generally elevated in radionuclide concentrations above analogous vegetation sample radioactive concentrations considered to be background.

By observing the box plots for the tritium distribution in soils collected in FY 93 and 94, it is apparent that the tritium distributions in perimeter soils are different from and higher than the distribution of tritium in soils from the Expansion Area. This result was expected. The difference in the distributions of tritium (slightly higher in the FY 94 soils) in the soils collected in FY 93 and FY 94 have been discussed above.

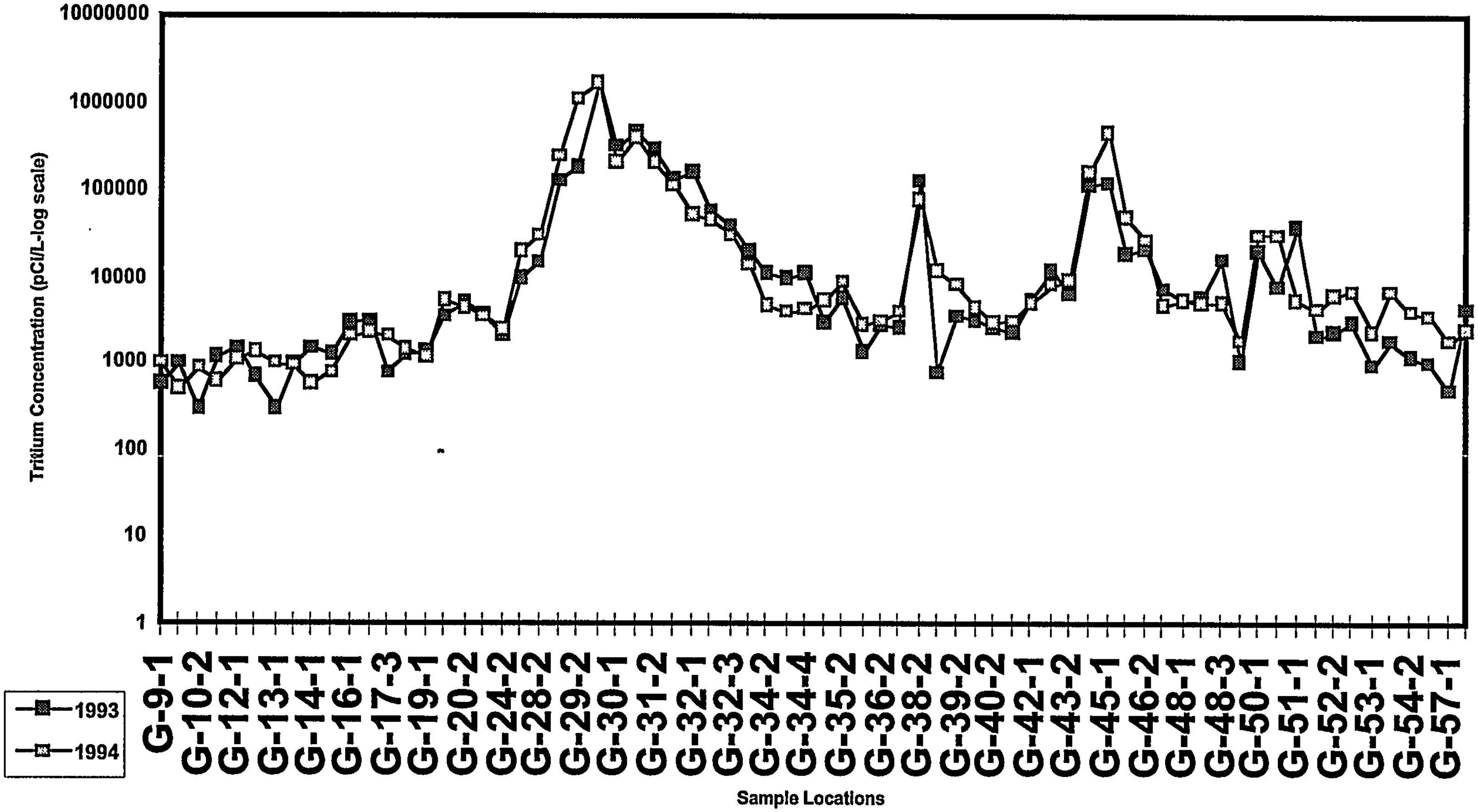

Figure 10. Comparison of H-3 concentrations for Area G perimeter soil samples between 1993 and 1994.

Unless more is learned about the surface tritium flux (and there are ongoing studies at Area G), a sample taken at any given time can only provide a snapshot of the tritium surface concentration in soil at that particular time.

The flux effect or dependence on localized moisture content on soils may be minimized by taking all samples 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. This surface sampling approach will be adopted in future years.

As sampling for tritium continues on a year-to-year basis, the true or representative distribution of tritium on soils throughout Area G should become more apparent. With more surface tritium sample data in hand, the overall distribution of surface tritium at Area G should be established so that a determination can be made as to whether it is possible to define true annual increases or decreases in tritium activity in surface soils and runoff water.

9.2 Uranium

There is no apparent unnatural distribution of uranium in Area G perimeter soils indicating little or no impact from disposal operations on uranium concentrations in surface soils. When compared to Expansion Area background data (2.79 ± 0.39 µg/g), perimeter soils collected in FY 94 (mean concentration of 4.3 ± 0.8 µg/g), it appears that the perimeter soil uranium concentrations are higher than background by a factor of approximately 1.5. This apparent elevation of uranium concentrations in perimeter soils collected in FY 94 is, however, believed to be a manifestation of the analytical technique used to analyze uranium in soils. The Expansion Area samples were analyzed by LANL in-house laboratories by the KPA method while the FY 94 perimeter soil samples were analyzed by an outside laboratory using the ICPMS analytical technique. If we go back and look at the FY 93 perimeter soil data (uranium mean concentration of 2.59 ± 0.70 µg/g), also analyzed by the KPA method, the mean concentration is very similar to the Expansion Area data set. In the future, to preclude having questions of this nature arise, all samples will be analyzed in-house so that similar work-up procedures and analytical techniques will be used.

9.3 Plutonium Isotopes

As stated above in Section 6.3, the locations of elevated plutonium readings are consistent with the history of plutonium disposal at Area G. Figure 2 indicates that 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. We assume that increased levels of contaminant concentrations in surface soils are directly related to the location, quantity, and date when material was disposed 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 emplaced, and the longer a contaminant is held in a specific location, the higher the probability that this contaminant will be disseminated to its surroundings. In fact, we find the highest plutonium activities in soils at the eastern end of Area G, in particular adjacent to the TRU pads and inactive disposal pits 2–10. At no sampling location where soil samples were collected in FY 94, is there a significantly higher total plutonium concentration on soil than was found at that same location during the FY 93 sampling.

We also observe a geographic correlation between elevated plutonium levels in perimeter soils and elevated levels of plutonium in the sediment fractions of the water samples. Figure 7 (plutonium levels in perimeter soils) and Figure 8 (plutonium levels in single-stage sample sediments), show that the area adjacent to the TRU pads and inactive disposal pits 2–10 have the highest plutonium levels for both surface-soil and single-stage sediment fraction samples.

Box plots are presented in the appendix which depict the distributions of the logs of total plutonium concentrations in surface soil samples collected in FY 93 and FY 94, as well as the same data for samples collected from the baseline Expansion Area. The box plots show similarities of the FY 93 and FY 94 total plutonium distributions, while indicating that both distributions have higher concentrations and a wider distribution than total plutonium in samples from the Expansion Area.

9.4 Americium-241

As stated above in Section 6.4, the tendency is to find elevated americium-241 levels in perimeter surface-soil samples where there are elevated levels of plutonium isotopes. This trend is generally illustrated by comparing the data depicted in Figures 6 and 8. The box plots for the americium-241 distributions found in Appendix B indicate there is no statistical difference between the FY 94 americium-241 data and the FY-93 americium-241 data. The box plots do indicate that the americium-241 concentrations in soils collected from the active part of Area G are statistically different from the americium-241 concentrations in soil collected from the Expansion Area.

9.5 Cesium-137

The FY 94 distribution of cesium-137 in perimeter soils is similar to that found in FY 93. There are no locales along the Area G perimeter where cesium-137 is found in soils in significantly elevated concentrations. The range and mean of cesium-137 concentrations in perimeter soils are very similar to the Expansion Area cesium-137 range and mean. The box plots comparing FY 93 and FY 94 concentration distributions indicates there is no statistical difference between the FY 94 cesium-137 data and the FY 93 cesium-137 data. The box plots indicate that the cesium-137 in soil distribution in the active part of Area G is different (slightly greater) from cesium-137 in soil distribution in the Expansion Area.

9.6 Metals

Our initial results (reported in LA-12986) for metal concentrations in perimeter soils at Area G are based on the X-ray fluorescence analytical technique. These results indicate that the three metals measured by XRF in soils — barium, mercury, and lead — are within background metal concentrations for Laboratory soils. The XRF technique, however, is not an accepted EPA method for quantitative metal analysis. For this reason, during the FY 94 field season, twenty one perimeter soils were collected and submitted to CST-3 for metal analyses. The analytical chemistry results for metals on soils (Table 4) when compared to the metals-on-soils concentrations from the Expansion Area found in Table 5 indicate that there is very little or no impact on metal surface soil concentrations due to disposal operations in the active part of Area G. Box plots were constructed for the three metals (barium, chromium, and lead), where there were enough values reported out to yield a meaningful distribution. These box plots indicate similar distributions and concentrations for both FY 93 and 94 and the Expansion Area soil samples.

Table 5: 1994 TA-54 Area G (OU 1148) Expansion Area soil data.

Sample		Laboratory Metal Analyses ug/g												Soil Moisture	Radioisotope Data								
															3H	241Am	137Cs	234U	235U	238U	238Pu	239Pu	Total Pu
Location	Date	Ag	As	Ba	Be	Cd	Cr	Hg	Ni	Pb	Sb	Se	Tl	wt %	pCi/l	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g
G-X-6	7/29/94	<.69	2.9	159	1.2	<.52	8.1	<.02	<8.6	13.4	<.23	<.69	<.23	14.7	420	0.007	<.01	1.42	0.08	1.42	0.009	0.013	0.022
G-X-8	7/29/94	<.72	<2.2	65.8	<.54	<.43	4	<.02	<4.3	14.7	<.24	<.72	<.24	16.9	320	0.016	0.99	1.27	0.07	1.43	0.005	0.036	0.041
G-X-8R	7/29/94	<.7	<2.1	95.8	<.6	<.23	5.1	<.02	<4.4	14.1	<.23	<.7	<.23	17.9	300	0.014	1.01	1.79	0.08	1.88	0.005	0.043	0.048
G-X-9	7/29/94	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	13.4	120	0.008	0.64	1.43	0.10	1.43	0.002	0.023	0.025
G-X-10	7/29/94	<.71	<2.1	80.3	<.63	<.24	6.2	<.02	<5.7	11.3	<.24	<.71	<.24	15.1	710	0.007	<.16	1.36	0.04	1.54	0.007	0.019	0.026
G-X- 12	7/29/94	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	11.2	370	0.014	1.20	1.38	0.06	1.52	0.003	0.051	0.054
G-X-13	7/29/94	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	12.7	280	0.008	<.16	1.23	0.07	1.39	0.002	0.009	0.011
G-X-16	7/29/94	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	15.6	260	0.015	0.62	1.55	0.08	1.58	0.002	0.042	0.044
G-X-19	7/29/94	<.66	<1.9	56.8	<.45	<.44	3.8	<.02	<2.6	9.9	<.22	<.66	<.22	8.7	260	0.008	0.34	1.06	0.05	1.11	0.002	0.012	0.014
G-X-21	7/29/94	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	9.7	250	0.008	0.32	1.18	0.06	1.38	0.001	0.016	0.017
G-X-24	7/29/94	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	12.1	380	0.027	<.23	2.02	0.09	1.91	0.005	0.149	0.154
G-X-26	7/29/94	<.67	2.2	67.1	<.56	<.34	4.5	<.02	<3.7	12.9	<.22	<.67	<.22	13.0	630	0.016	1.80	1.65	0.11	1.63	0.005	0.047	0.052
G-X-27	7/29/94	<.67	<2	85.1	<.5	<.22	4.7	<.02	<3.3	10.1	<.22	<.67	<.22	13.5	280	0.011	0.85	1.39	0.09	1.40	0.004	0.03	0.034
G-X-28	7/29/94	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	10.9	180	0.005	<.17	1.20	0.06	1.24	0.001	0.01	0.011
G-X-30	7/29/94	<.65	2.2	133	<.4	<.22	4.7	<.02	<4.2	11.4	<.22	<.65	<.22	9.6	350	0.008	0.62	1.57	0.12	1.51	0.002	0.025	0.027
G-X-33	7/29/94	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	11.5	340	0.014	1.32	1.70	0.04	1.78	0.004	0.054	0.058
G-X-37	7/29/94	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	7.6	510	0.007	0.47	1.25	0.07	1.23	0.002	0.023	0.025
G-X-38	7/29/94	<.62	2.2	62.2	<.75	<.52	7.2	<.02	<7.9	15.8	<.21	<.62	<.21	4.5	580	0.020	0.76	1.36	0.05	1.41	0.009	0.042	0.051
G-X-38R	7/29/94	<.62	4.8	136	<.68	<.53	7.4	<.02	<7.2	15	<.21	<.62	<.21	4.5	490	0.021	0.97	1.39	0.06	1.47	0.007	0.053	0.06
G-X-39	7/29/94	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	11.2	310	0.005	0.14	1.09	0.06	1.27	0.002	0.014	0.016
G-X-43	7/29/94	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	12.1	280	0.005	<.17	1.63	0.10	1.80	0.004	0.012	0.016
G-X-44	7/29/94	<.63	3	261	<.85	<.59	7.5	<.02	<8.3	10.5	<.21	<.63	<.21	10.2	440	0.002	<.17	1.17	0.04	1.23	0.001	0.008	0.009
G-X-45	7/29/94	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	15.0	150	0.005	<.11	1.16	0.06	1.10	0.003	0.005	0.008
G-X-48	7/29/94	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	14.8	560	0.005	<.15	1.35	0.08	1.42	0.003	0.01	0.013
G-X-50	7/29/94	<.63	2.7	76.6	<.42	<.59	5.7	<.02	<3.5	19.2	<.21	<.63	<.21	4.4	450	0.008	<.15	1.75	0.09	1.77	0.004	0.017	0.021
G-X-51	7/29/94	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	10.7	410	0.003	<.16	1.06	0.06	1.23	0.001	0.001	0.002
G-X-53	7/29/94	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	NS*	12.5	280	0.011	<.15	1.01	0.04	0.94	0.003	0.028	0.031

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APPENDIX A

FIDLER PROBE MEASUREMENTS AT AREA G PERIMETER SITES

FY 94

I. PURPOSE

A FIDLER (field instrument for the detection of low-energy radiation) probe was utilized during FY 94 to measure low-energy gamma and x-radiation on surface soils at 70 locations around the perimeter of Area G. These 70 locations were sited in 1991 at minor drainages emanating from Area G and represent what are considered locations biased to receive surface water runoff (and associated sediments) from Area G during precipitation events. By configuring the FIDLER probe so that it is measuring gamma and x-ray activity emanating from surface soils, one can determine whether there is elevated gamma and x-ray activity on soils at these specific sites located in small drainages around the perimeter of Area G. Upon measurement of low-energy gamma radiation on an annual basis at the MDA survey points, it may be possible to discern whether there are changes from year to year of the surface soils low-energy gamma activity, and receive an early warning of the movement of radioactive contaminants out of Area G.

The FIDLER measurements continue a practice of environmental surveillance done at radioactive material disposal areas (MDAs) located at LANL. Until 1991, a PHOSWICH instrument was used to take these surface soil low-energy gamma measurements at Area G, and at that time 16 unsurveyed locations were the sites of the annual measurements. In 1991, 70 locations were surveyed in and permanent markers were established for standardizing the measurement points. In 1992, a FIDLER probe was purchased and this probe was used to make the Area G low-energy gamma survey at the 70 locations. This procedure was continued in FY 93 and FY 94.

II. METHODOLOGY

A FIDLER probe (a thin layer sodium iodide crystal-photomultiplier tube assembly) in association with a multi-channel analyzer (MCA) can focus in on the low-energy gamma and x-ray spectrum that represent radionuclides of interest.

At Area G, the radionuclides of interest are americium-241 (as an indicator for the presence of plutonium) and cesium-137. Americium-241 is known to always be found with plutonium and because it has a strong peak (60 keV) in the low-energy gamma spectrum, it can be measured in the field with a FIDLER probe to serve indirectly as an indicator of the presence of Pu on surface soils. The regions of interest (ROI) around the 60 keV peak is termed ROI 2. A second peak at 17 keV is surrounded by another region of interest, ROI (1), which is also indicative of the presence of americium/plutonium. Cesium-137 has a peak in the low-energy gamma spectrum at 32 keV. The ROI about the 32 keV peak is termed ROI 3.

The calibration of the instrument and measurements taken with the FIDLER are done in accordance with LANL-ER-SOP-10.04, FIDLER Instrument System.

During field measurements, the probe is situated in a fixed geometry in a tripod with the entry window of the probe 12.0 inches from the ground surface. At each of the 70 MDA survey locations (and 10 background soil points located immediately across the road from Area J), a 100 second count is made for ROI 1 and 2, and ROI 3. Three numbers are received at each survey point. These numbers are in units of μCi/m^2 for ROI 1 and 2, and counts per 100 sec for ROI 3. In the spreadsheet (Table 1), the values of the regions of interest that reflect Am/Pu (ROIs 1 and 2), is listed for each survey point. The 100 sec count for ROI 3 (the Cs-137 ROI) is also listed.

III. RESULTS AND DISCUSSION

The ten background soil location counts (taken across highway adjacent to Area J) yielded an average of 0 μCi/m^2 and 0.613 μCi/m^2 for ROIs 1 and 2, and 872 counts per 100 sec for ROI 3. By comparing these averages with the equivalent counts measured at each of the 70 MDA survey points, it is easy to see from Apppendix A Table 1 that except for MDA location Number 1, the low-energy gamma activity for the 70 survey points around Area G is decidedly higher than the activity measured by the FIDLER for the three ROIs for the 10 background locations.

A scatter plot of the counts for ROI 2 for each MDA survey point is found in Appendix A Figure 1. The count results at 2 of these locations (MDA-17 and MDA-43) are definitively higher than the measurements at adjacent locations. It is not mere coincidence that these two MDA survey points are adjacent to radioactive waste storage domes. One dome (the one nearest MDA-17) is the mixed waste storage dome where thousands of drums of mixed waste are stored. The second dome is over TRU pad 2. The higher than expected gamma counts at these two MDA survey locations have been attributed to "shine" that originates from the domes. Shine can be thought of as gamma radiation emanating from a non-point source location (such as a dome or pile of hot material). Shine manifests itself over a larger distance than the 1 foot distance between the FIDLER probe and the ground surface. That is, if shine is present at a particular MDA survey location, the FIDLER probe will add the shine gamma component to the gamma component emanating from the soil. By placing a shield (e.g. a persons body) between the suspected source of the shine, or by pointing the probe opening away from the suspected source of the shine, one can determine (if one obtains lower 100 sec counts or activity) that, in fact, the elevated low-energy gamma counts are due to shine. Also, a soil sample taken at this location would not exhibit any extraordinary gamma activity because the soil itself is not the source of the gamma radiation. By following up on all three of these tests for shine, we determined that the high readings at MDA 17 and 43 were due to shine and not high gamma activity on soils.

Finally, the scatter plot (Appendix A Figure 1) indicates that except for location MDA-1, all of the MDA survey point counts are elevated over background. From points 2–13 (moving from Area L to the old Area G gate), the counts are slightly elevated. From MDA survey points 14–44 (encompasses all the MDA survey points from the old gate through the TRU pads), there is a slow trend in gamma activity upward. From MDA survey points 45–55, the gamma activity trends first downward through MDA survey point 51, than upward through MDA survey point 55. Finally, from MDA survey points 56–70, the gamma activity trend is slowly downwards as the survey points proceed westward and out of Area G. It is difficult at this time to determine whether the trends in low-energy gamma radiation for the Area G MDA survey points are due to incremental increases or decreases in soil gamma activity, or whether these trends are due to manifestations of area wide shine that affects the individual soil gamma activities.

Appendix A: Table 1 - FIDLER surveillance counts of low-energy gamma activity around the periphery of Area G.

	Spectroscopic Regions of Interest		
MDA Survey Point	**ROI 1 (μCi/m^2)**	**ROI 2 (μCi/m^2)**	**ROI 3 Counts/100 s**
G-1	0	0.511	730
G-2	0	0.681	935
G-3	0	0.745	1060
G-4	0	0.681	1020
G-5	0	0.745	1040
G-6	0	0.745	1030
G-7	0	0.786	1020
G-8	0	0.724	980
G-9	0	0.765	1050
G-10	0	0.745	1040
G-11	0	0.786	1070
G-12	0	0.766	1010
G-13	0	0.765	984
G-14	0	0.788	1070
G-15	0	0.848	1140
G-16	0	0.873	1140
G-17	0	1.30	1740
G-18	0	0.915	1240
G-19	0	0.931	1260
G-20	0	0.894	1260
G-21	0	0.919	1180
G-22	0	1.01	1480
G-23	0	1.01	1460
G-24	0	0.873	1180
G-25	0	0.890	1170
G-26	0	0.809	1100
G-27	0	0.807	1070
G-28	0	0.937	1210
G-29	0	0.972	1250
G-30	0	0.809	1020
G-31	0	0.848	1010

(continued)

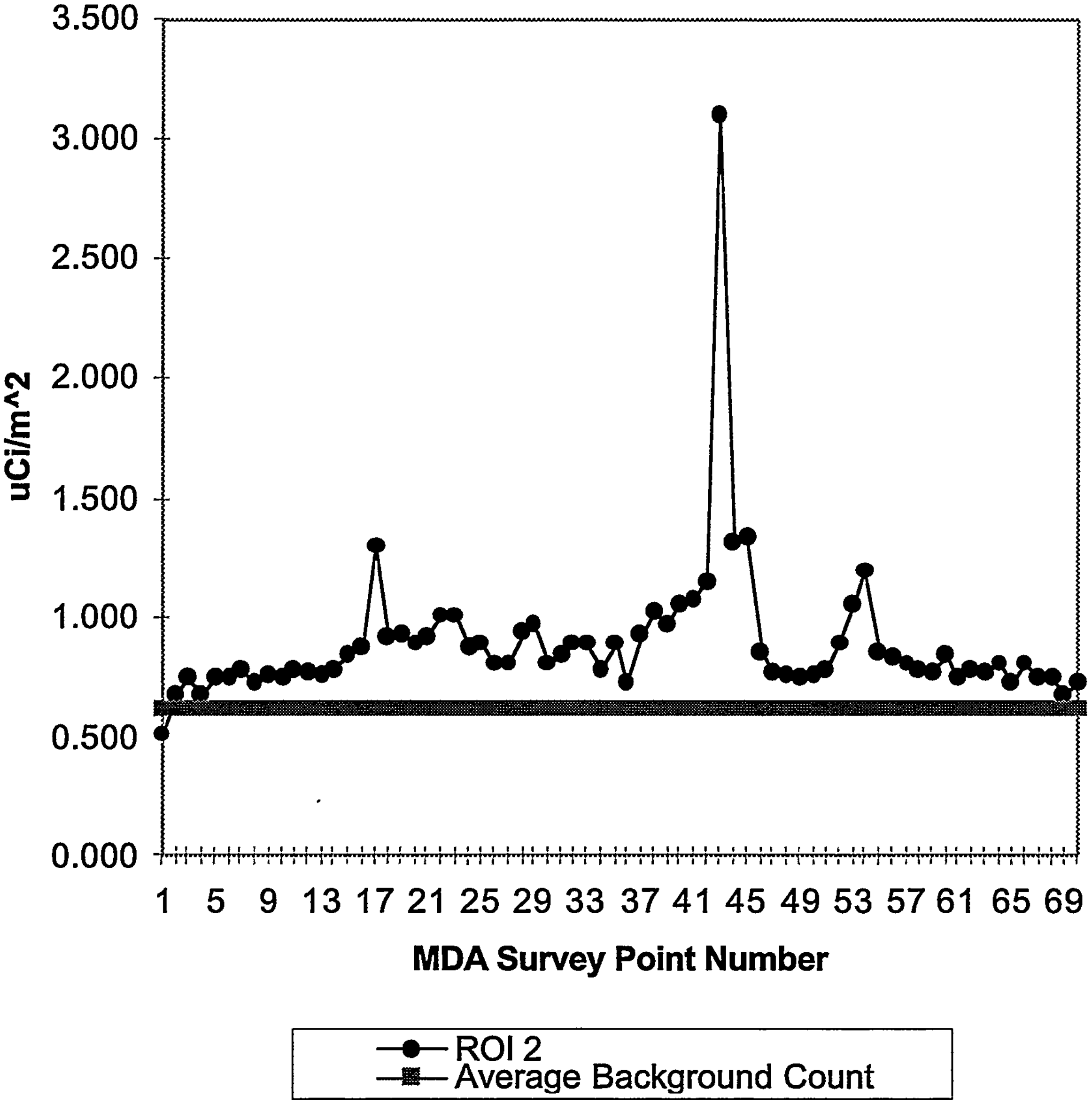
Appendix A: Table 1 (continued) - FIDLER surveillance counts of low-energy gamma activity around the periphery of Area G.

MDA Survey Point	Spectroscopic Regions of Interest ROI 1 (μCi/m^2)	ROI 2 (μCi/m^2)	ROI 3 Counts/100 s
G-32	0	0.894	1150
G-33	0	0.890	1140
G-34	0	0.788	1010
G-35	0	0.890	1180
G-36	0	0.724	1010
G-37	0	0.931	1350
G-38	0	1.02	1680
G-39	0	0.972	1570
G-40	0	1.06	1790
G-41	0	1.08	1840
G-42	0	1.15	1910
G-43	0	3.10	6670
G-44	0	1.32	2580
G-45	0	1.34	2120
G-46	0	0.851	1353
G-47	0	0.766	1120
G-48	0	0.765	1030
G-49	0	0.745	1030
G-50	0	0.765	1050
G-51	0	0.788	1200
G-52	0	0.890	1290
G-53	0	1.06	2010
G-54	0	1.20	1830
G-55	0	0.851	1310
G-56	0	0.827	1210
G-57	0	0.809	1070
G-58	0	0.786	1040
G-59	0	0.766	1020
G-60	0	0.848	1110
G-61	0	0.745	1040
G-62	0	0.786	1090

(continued)

Appendix A: Table 1 (continued) - FIDLER surveillance counts of low-energy gamma activity around the periphery of Area G.

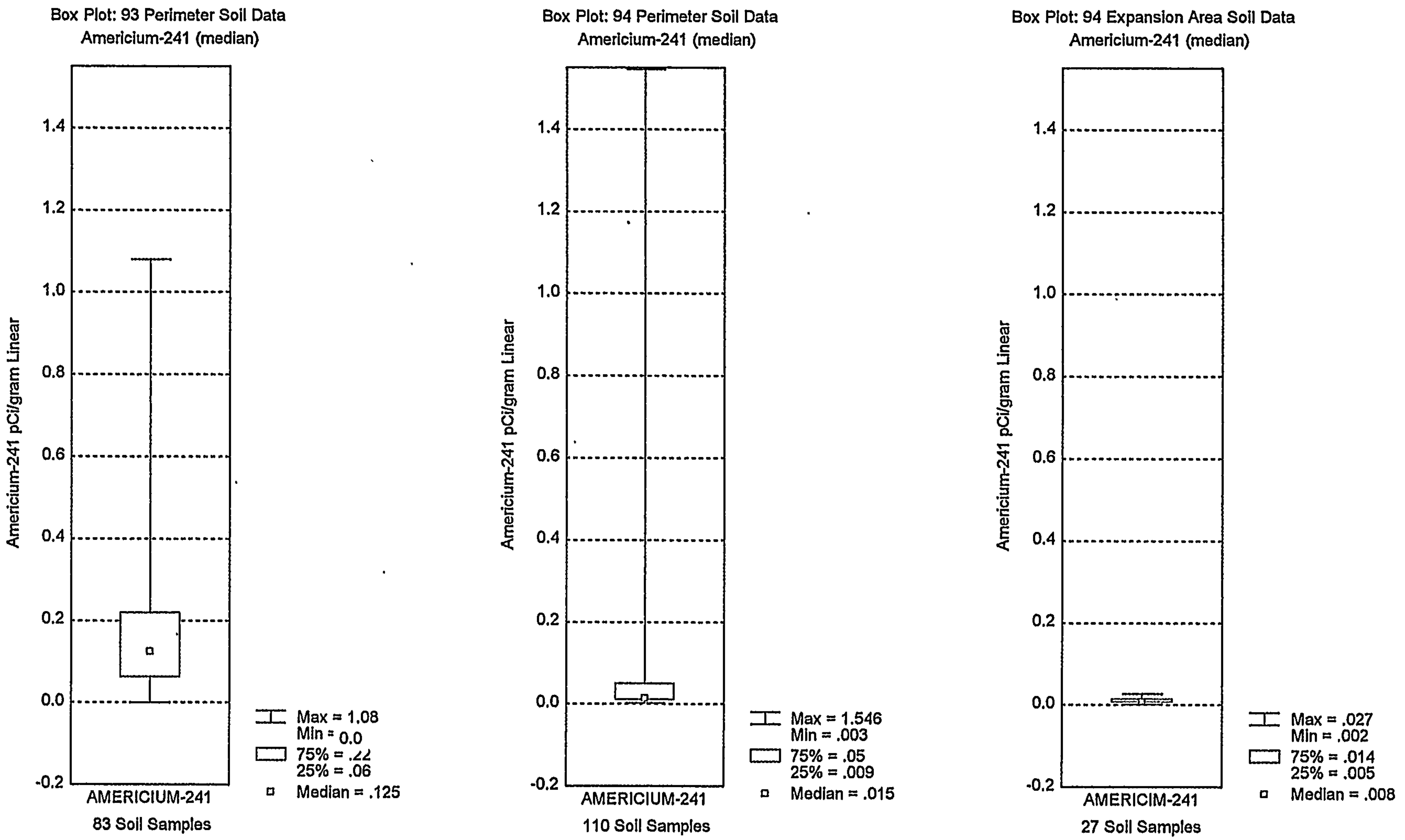
MDA Survey Point	Spectroscopic Regions of Interest ROI 1 (μCi/m^2)	ROI 2 (μCi/m^2)	ROI 3 Counts/100 s
G-63	0	0.766	1080
G-64	0	0.807	1090
G-65	0	0.724	1000
G-66	0	0.807	1160
G-67	0	0.745	972
G-68	0	0.745	1030
G-69	0	0.681	967
G-70	0	0.724	1020
BKG-1	0	0.600	783
BKG-2	0	0.617	899
BKG-3	0	0.620	936
BKG-4	0	0.638	918
BKG-5	0	0.579	866
BKG-6	0	0.638	874
BKG-7	0	0.579	856
BKG-8	0	0.638	892
BKG-9	0	0.579	832
BKG-10	0	0.638	868



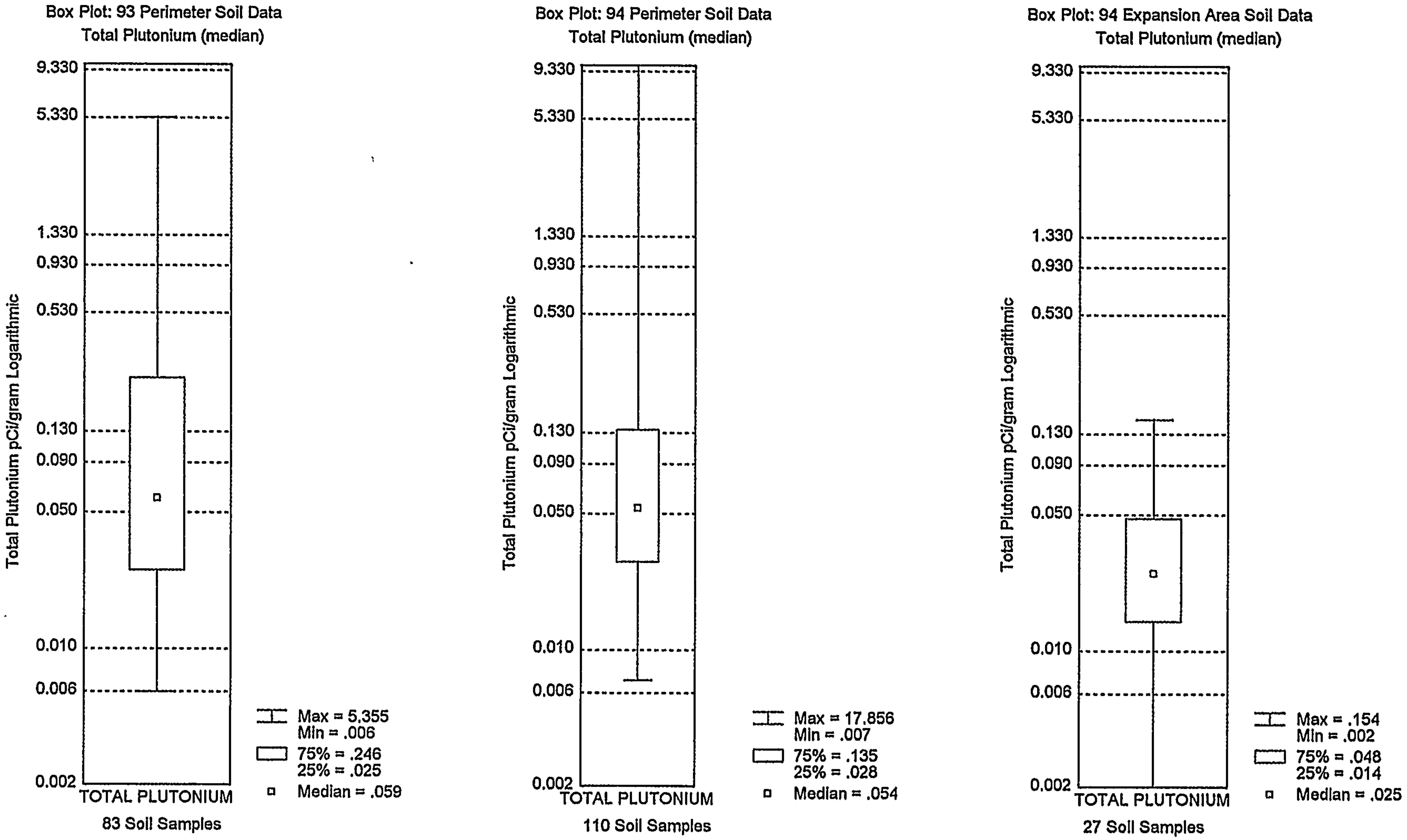
Appendix A: Figure 1 - Scatter plot of FY 94 FIDLER surveillance measurements of low-energy gamma activity around the periphery of Area G. Counts per 100 seconds for ROI 2, the spectral region that indicates americium and plutonium activity, are plotted verses the MDA survey point number. The high values for the circled points at locations G-17 and G-43 were believed to be due to shine artifacts.

APPENDIX B

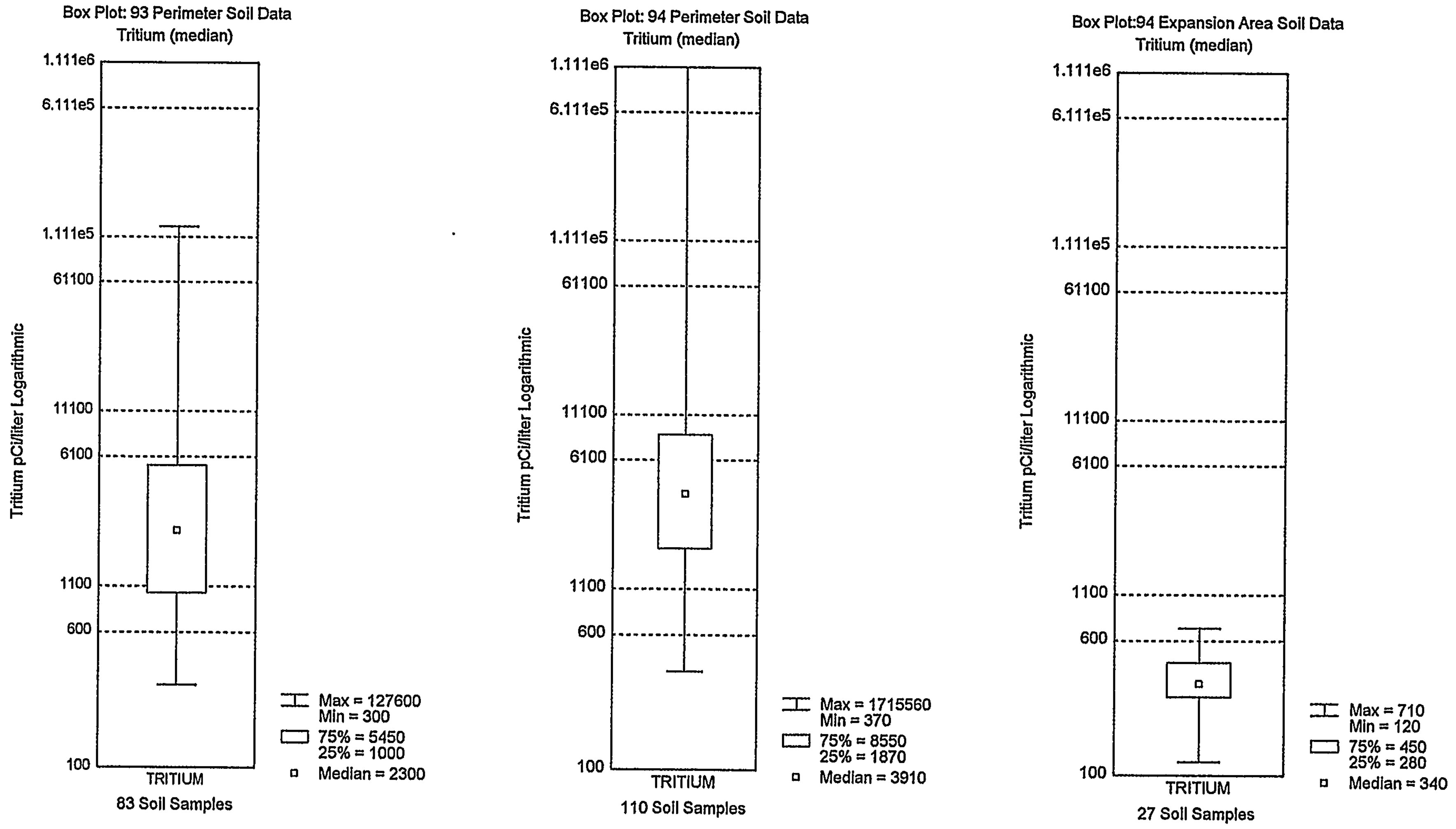
BOX PLOTS



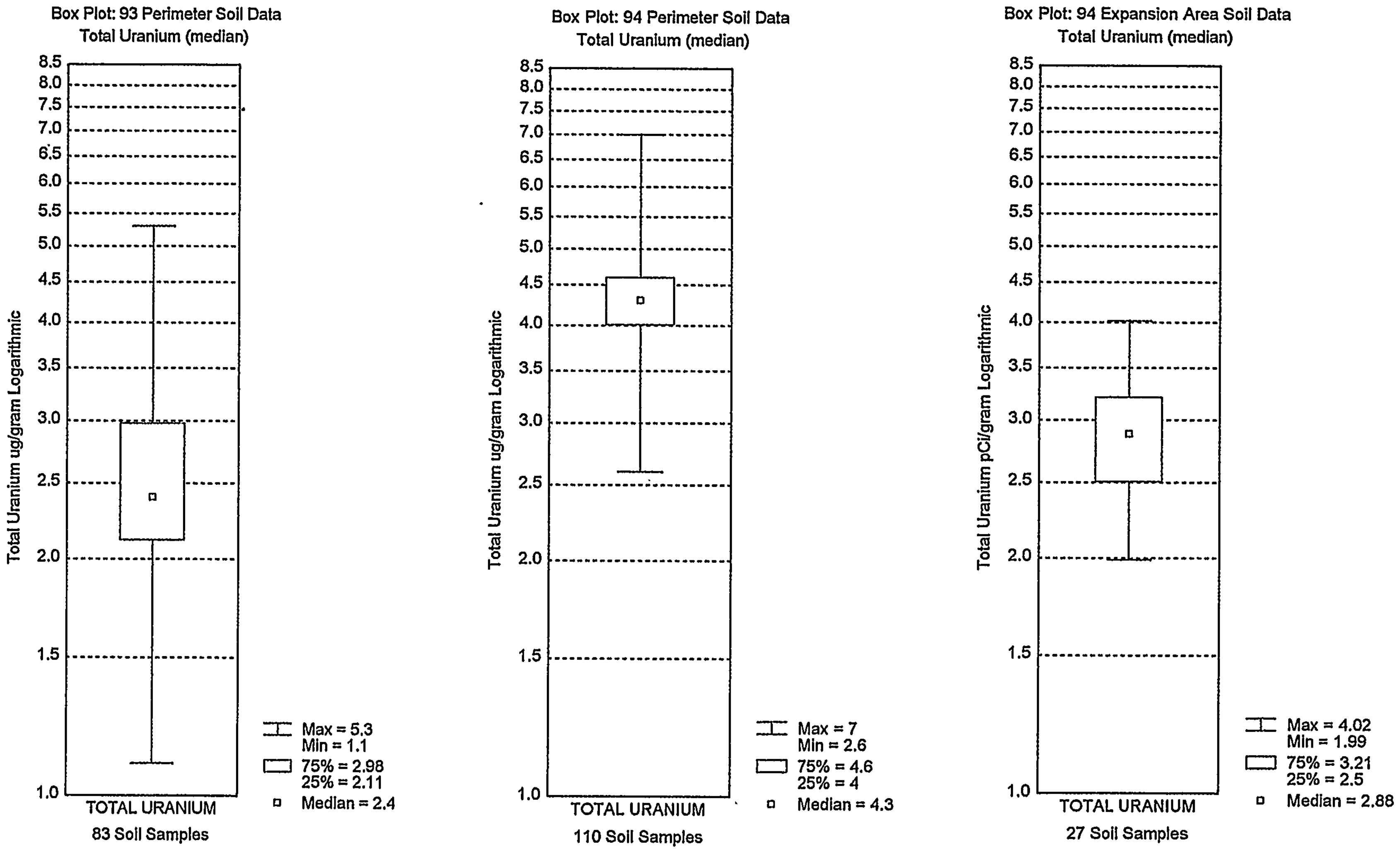
Area G Americium-241 Surface Soil Box Plot Comparisions



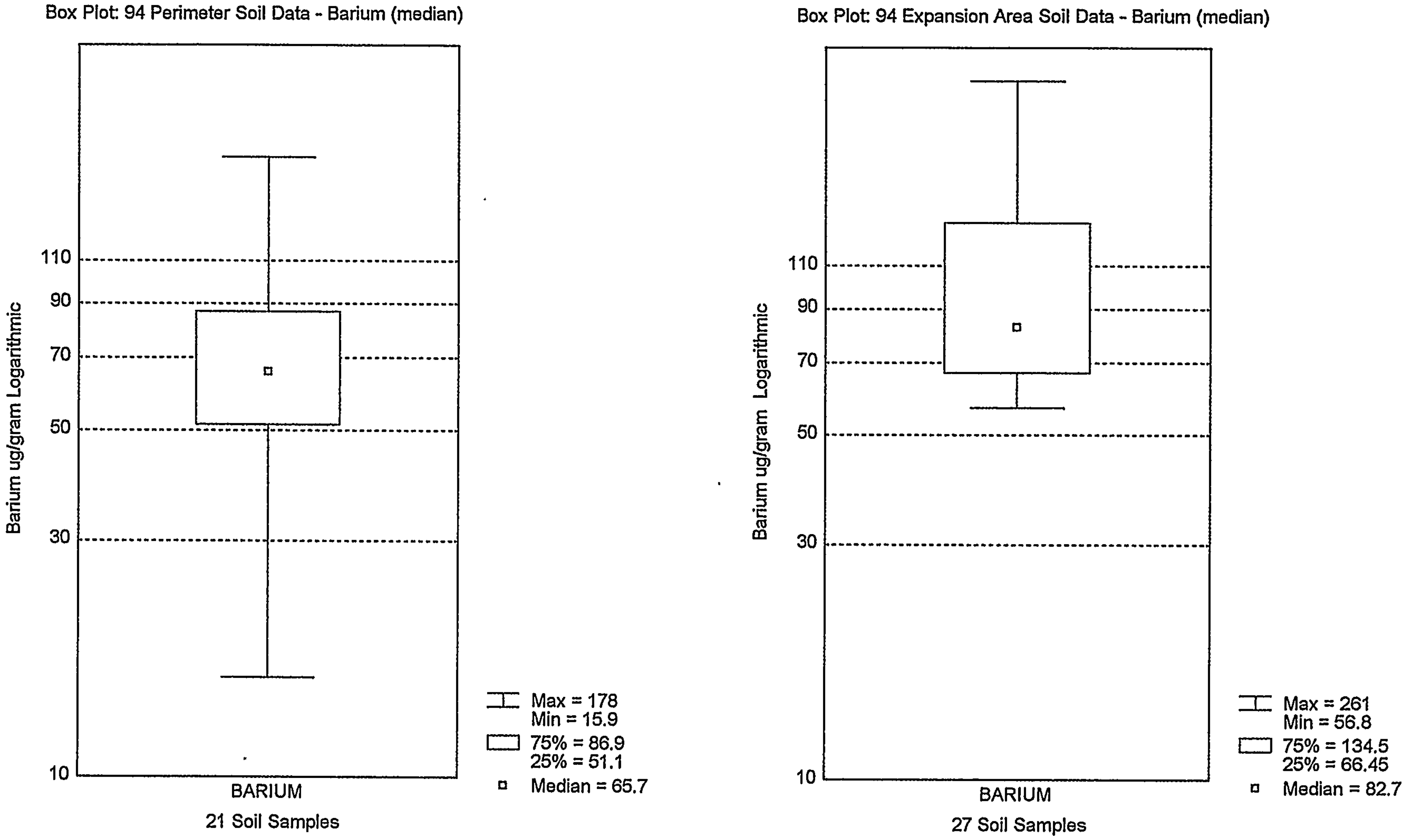
Area G Total Plutonium Surface Soil Box Plot Comparisons



Area G Tritium Surface Soil Box Plot Comparisons



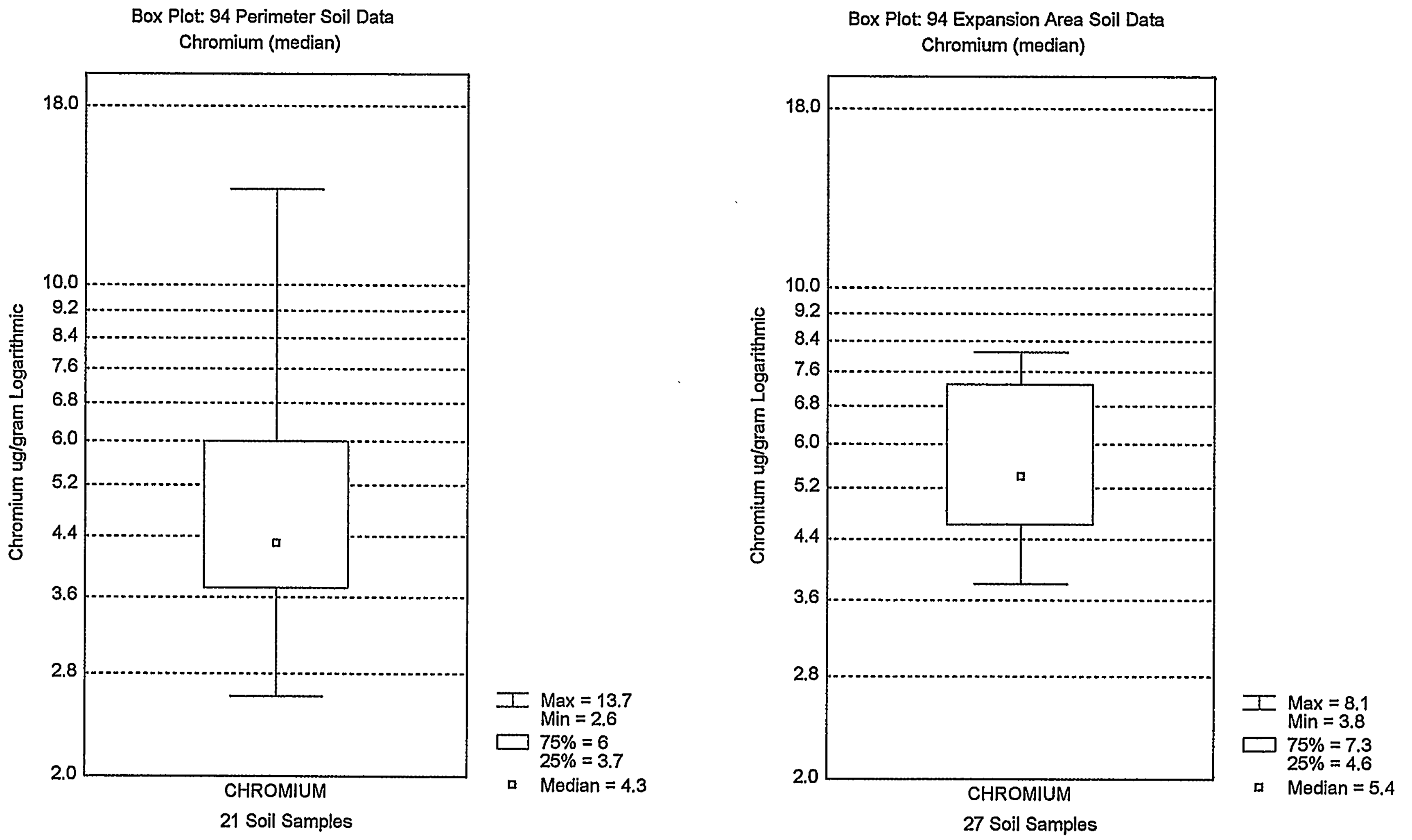
Area G Total Uranium Surface Soil Box Plot Comparisons



Box Plot: 94 Perimeter Soil Data - Barium (median)

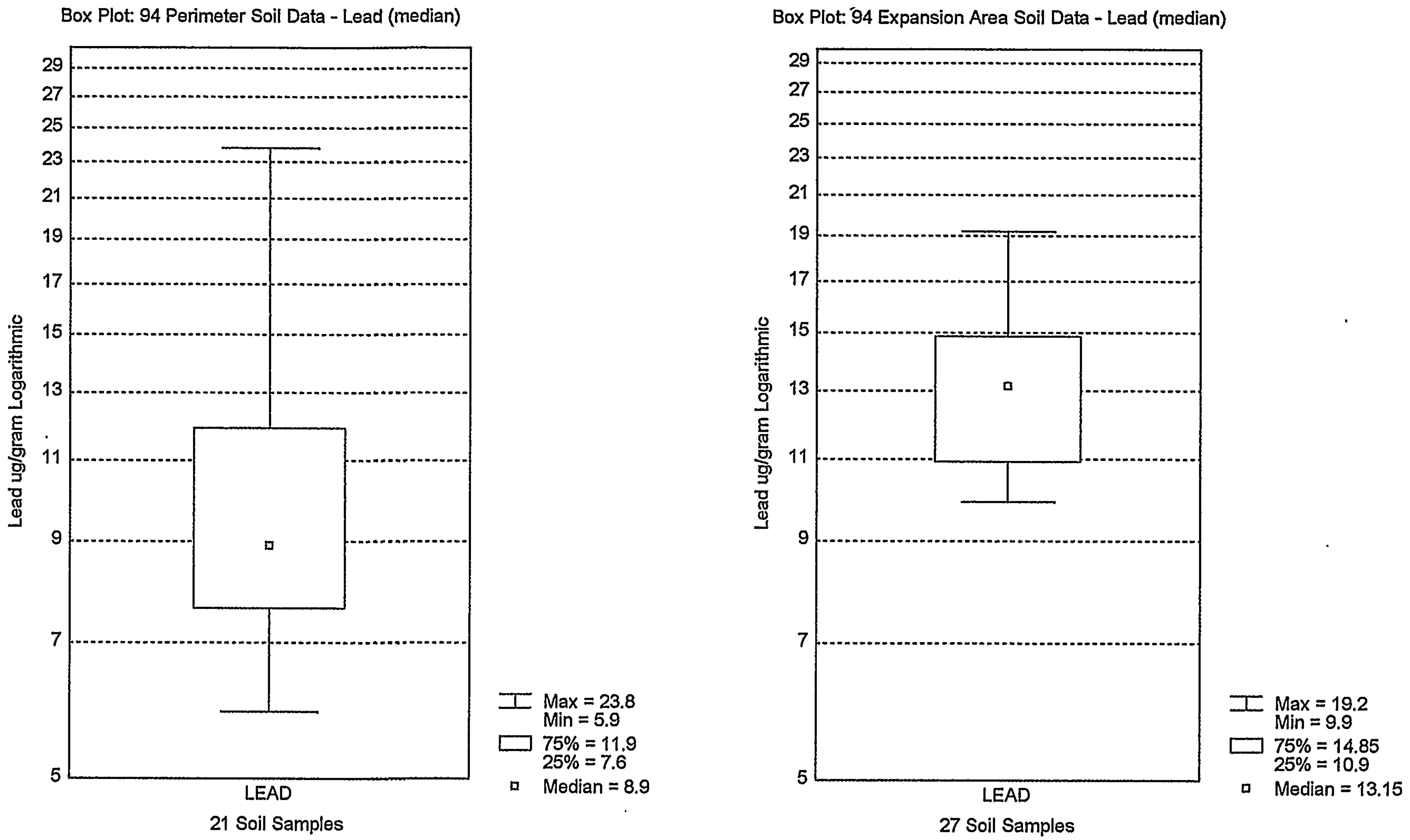
Box Plot: 94 Expansion Area Soil Data - Barium (median)

Area G Barium Surface Soil Box Plot Comparisons


Box Plot: 94 Perimeter Soil Data
Chromium (median)

Box Plot: 94 Expansion Area Soil Data
Chromium (median)

Area G Chromium Surface Soil Box Plot Comparisons



Box Plot: 94 Perimeter Soil Data - Lead (median)

Box Plot: '94 Expansion Area Soil Data - Lead (median)

Area G Lead Surface Soil Box Plot Comparisons