



Characterization Report for the 903 Drum Storage Area, 903 Lip Area, and Americium Zone

RF/RMRS-99-427.UN

DOCUMENT CLASSIFICATION
REVIEW WAIVER PER
CLASSIFICATION OFFICE



ADMIN RECEIVED

September 21, 1999
Draft

1/251

Best Available Copy

1112-A-00028
000028

TABLE OF CONTENTS

EXECUTIVE SUMMARY	E-1
1.0 INTRODUCTION	1
1.1 SITE BACKGROUND	1
1.2 ROCKY FLATS CLEANUP AGREEMENT	2
1.3 EXISTING DATA	5
1.3.1 Surface Soils	5
1.3.2 Subsurface Soils	6
1.3.3 Groundwater	7
1.4 SURFICIAL GEOLOGY	8
1.5 SITE CONCEPTUAL MODEL	9
1.6 PROJECT INVESTIGATION AREA	10
2.0 FIELD INVESTIGATION	11
2.1 OVERVIEW	11
2.2 SURFACE SOIL INVESTIGATION	11
2.2.1 HPGe Methodology	11
2.2.2 Double Sampling Correlation Technique	13
2.2.3 FIDLER Surveys	25
2.3 SUBSURFACE SOIL INVESTIGATION	25
2.3.1 Radiological Investigation I	26
2.3.2 VOC Investigation Boreholes	27
2.4 903 PAD ASPHALT SAMPLES	29
2.5 WORK CONTROLS	29
3.0 DATA QUALITY ASSESSMENT	30
3.1 VERIFICATION OF RESULTS	30
3.2 VALIDATION	31

3.3	PARCC PARAMETERS.....	32
3.3.1	Precision	32
3.3.2	Accuracy.....	38
3.3.3	Representativeness.....	42
3.3.4	Completeness.....	42
3.3.5	Comparability.....	45
3.3.6	Sensitivity.....	46
3.3.7	Summary.....	46
4.0	NATURE AND EXTENT OF CONTAMINATION	47
4.1	SOIL RADIOLOGICAL CONTAMINATION IN THE AMERICIUM ZONE.....	47
4.1.1	Comparison of HPGe Measurements to Tier I and Tier II RSALs	47
4.1.2	Spatial Distribution of Radiological Contamination in the Americium Zone.....	48
4.1.3	FIDLER Surveys	49
4.2	SOIL RADIOLOGICAL CONTAMINATION IN THE 903 PAD AND LIP AREA	50
4.2.1	Radionuclide Activities in Native Soils.....	51
4.2.2	Spatial Distribution of Contamination.....	52
4.2.3	Radionuclide Activities in 903 Pad Asphalt and 903 Pad Artificial Fill.....	55
4.3	SUBSURFACE SOIL VOC INVESTIGATION.....	57
5.0	SOIL VOLUME ESTIMATES BASED ON RSAL AND SSAL EXCEEDANCES	60
5.1	903 PAD ASPHALT AND ARTIFICIAL FILL VOLUME ESTIMATES	60
5.2	SOIL VOLUME ESTIMATES BASED ON TIER I RSAL EXCEEDANCES.....	60
5.3	SOIL VOLUME ESTIMATES BASED ON TIER II RSAL EXCEEDANCES	61
5.4	SOIL VOLUME ESTIMATES BASED ON SSAL EXCEEDANCES	63
5.4.1	Soil Volume Estimates Based on Tier I SSAL Exceedances	63
5.4.2	Soil Volume Estimates Based on Tier II SSAL Exceedances	63
5.5	SOIL VOLUME ESTIMATES BASED ON RSAL AND SSAL EXCEEDANCES	64
5.6	SOIL VOLUME ESTIMATES BASED ON SSAL EXCEEDANCES EXCLUDING RSAL EXCEEDANCES	64
6.0	REFERENCES	65
	Appendix A – Boring Logs.....	A-1

Appendix B– Precision (DER) Calculations.....B-1
Appendix C– 903 Pad *In-Situ* Models and UncertaintiesC-1
Appendix D – Summary Statistics..... D-1
Appendix E – CD ROM-Electronic Copy of Analytical Database.....E-1
Appendix F – CD ROM-Electronic Copy of SOR Results..... F-1

FIGURES

1-1 Study Area Location Map
1-2 1994 HPGe Survey Data for Am-241 in Investigation Area
1-3 OU2 Phase II RFI/RI Surface Soil Sampling Plots Study Area
1-4 Investigation Area Location Map
2-1 HPGe Measurement Location Map
2-2 Americium-241 Activities in Soil – Gamma Spectroscopy vs. Alpha Spectroscopy
Correlation
2-3 HPGe 15-Point Surface Soil Sampling Pattern
2-4 Alpha Spectroscopy vs. HPGe Gamma Spectroscopy – Americium-241 Correlation
2-5 Alpha Spectroscopy vs. HPGe Gamma Spectroscopy – Americium-241 vs. Plutonium
239/40 Correlation
2-6 RSAL Exceedances in Surface Soil Using Direct HPGe Results-HPGe Survey
2-7 RSAL Exceedances in Surface Soil Using Best Fit Line-HPGe Survey
2-8 RSAL Exceedances in Surface Soil Using 95% UCL-HPGe Survey
2-9 HPGe Surface Soil Samples - Plutonium-239/240 vs. Americium-241 Correlation
(Pu/Am Activity Ratio)
2-10 Alpha Spectroscopy vs. HPGe Gamma Spectroscopy – Uranium-235 Correlation
2-11 Alpha Spectroscopy vs. HPGe Gamma Spectroscopy – Uranium-238 Correlation
2-12 Radiological Subsurface Soil Sampling Locations – 903 Pad and 903 Lip Area
2-13 VOC Investigation Borehole Location Map
4-1 Range of Radionuclide Activities in Surface Soil-HPGe Survey
4-2 RSAL Exceedances in Surface Soil-HPGe Survey
4-3 Distribution of Am-241 in Surface Soil- HPGe Survey
4-4 Distribution of Pu-239/240 in Surface Soil-HPGe Survey
4-5 Range of Radionuclide Activities in Native 1, Native 2, and Native 3 Soil Horizons
4-6 RSAL Exceedances in Native 1 Soil Horizon
4-7 Distribution of Am-241 in Native 1 Soil Horizon
4-8 Distribution of Pu-239/240 in Native 1 Soil Horizon
4-9 RSAL Exceedances in Native 2 Soil Horizon
4-10 Distribution of Am-241 in Native 2 Soil Horizon
4-11 Distribution of Pu-239/240 in Native 2 Soil Horizon
4-12 RSAL Exceedances in Native 3 Soil Horizon

- 4-13 Distribution of Am-241 in Native 3 Soil Horizon
- 4-14 Distribution of Pu-239/240 in Native 3 Soil Horizon
- 4-15 Radionuclide Distribution in Asphalt
- 4-16 RSAL Exceedances in Artificial Fill Beneath 903 Pad
- 4-17 Range of Radionuclide Activities in Asphalt and Artificial Fill
- 4-18 VOC Distribution in Subsurface Soil
- 4-19 Range of VOC Concentrations in Subsurface Soil
- 5-1 Composite Map of Tier I RSAL Exceedances
- 5-2 Composite Map of Tier II RSAL Exceedances
- 5-3 Composite Map of Proposed Tier I and II SSAL Exceedances

TABLES

1-1	RFCA Tier I and II Radionuclide Soil Action Levels	4
1-2	RFCA ALF Tier I Subsurface Soil Action Levels - VOCs.....	5
1-3	Comparison of Pure Phase Aqueous Solubility with Concentrations in Groundwater Samples - Selected VOCs	8
2-1	Laboratory Gamma Spectroscopy Results vs. Laboratory Alpha Spectroscopy Results – ²⁴¹ Am	13
2-2	HPGe Americium-241 Results at Double Sample Locations	15
2-3	Surface Soil Samples, Weighted Average Calculations	16
2-4	Alpha Spectroscopy Results for Americium-241 at Double Sampling Locations.....	17
2-5	Alpha Spectroscopy Results for Plutonium-239/240 at Double Sampling Locations	19
2-6	OU2 RFI/RI Trench Soil Sample Results	22
2-7	Alpha Spectroscopy Results of Surface Soil Samples	24
2-8	Alpha Spectroscopy Results f Surface Soil Samples – Actinide Migration Evaluation Project	24
3-1	Sample Types & Data Quality Objectives	30
3-2	Surface Soil Duplicate Assessment – Gamma Spectroscopy Results.....	34
3-3	Surface Soil Duplicate Assessment – Alpha Spectroscopy Results.....	35
3-4	Radionuclide Subsurface Soil Replicate Assessment – Alpha Spectroscopy Results	35
3-5	Duplicate Sample Results – Volatile Organic Compound Analysis.....	37
3-6	Comparison of Detection Limits – In Situ Gamma Spectroscopy.....	38
3-7	Comparison of Detection Limits – Alpha Spectroscopy	39
3-8	Comparison of Detection Limits – Volatile Organic Compound Analysis	40
3-9	Quality Control Sample Summary.....	41
3-10	Planned vs. Actual Sample Comparison.....	43
3-11	QC Sample Type, Quantity.....	44
4-1	Frequency of RFCA Tier I and Tier II RSAL Exceedances – HPGe Survey Results	48
4-2	Frequency of RFCA Tier I and Tier II RSAL Exceedances – Native Soil Results	51
4-3	Descriptive Summary Statistics for 903 Pad Asphalt	56
4-4	Descriptive Summary Statistics for 903 Pad Artificial Fill	57
4-5	Frequency of VOC of VOC SSAL Exceedances in Subsurface Soil.....	58
5-1	Summary of Tier I RSAL Volume Calculations.....	60
5-2	Summary of Tier II RSAL Volume Calculations	61
5-3	Summary of 903 Pad Asphalt and Artificial Fill Volumes.....	62
5-4	Summary of Radiological and VOC Contaminated Soil Volumes-RSAL and SSAL Exceedances.....	65

ACRONYMS

ALF	Action Levels & Standards Framework for Surface Water, Groundwater & Soil
Am	Americium
bgs	below ground surface
C	Carbon
CAD	Corrective Action Decision
CCL ₄	Carbon Tetrachloride

6

CDH	Colorado Department of Health
CDPHE	Colorado Department of Health and Environment
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
cm	centimeter
cpm	counts per minute
COC	Contaminant of Concern
CRQL	Contract Required Quantitation Limit
1,2-DCE	1,2-Cis-Dichloroethylene
DER	Duplicate Error Ratio
DNAPL	Dense Nonaqueous Phase Liquid
DOE	U. S. Department of Energy
DOT	Department of Transportation
DQA	Data Quality Assessment
DQO	Data Quality Objective
EPA	Environmental Protection Agency
Eq	Equation
FIDLER	Field Instrument for the Detection of Low Energy Radiation
FOV	Field of View
g/cc	density (gram/cubic centimeter)
HPGe	High Purity Germanium Detector
IHSS	Individual Hazardous Substance Site
IM/IRA	Interim Measures/Interim Remedial Action
ISOCS	In Situ Object Counting System
kg	kilogram
K-H	Kaiser-Hill Company, L.L.C.
m	meter
MeV	Value of Energy
mg/L	micrograms per liter
MS/MSD	Matrix Spike/Matrix Spike Duplicate
OU	Operable Unit
PARCC	Precision, Accuracy, Representativeness, Completeness, & Comparability
PCE	Tetrachloroethene
pCi/g	picocuries per gram
Pu	Plutonium
QA	Quality Assurance
QAPD	Quality Assurance Program Description
RCRA	Resource Conservation and Recovery Act
RFCA	Rocky Flats Cleanup Agreement
RFETS	Rocky Flats Environmental Technology Site
RFFO	Rocky Flats Field Office
RFI/RI	RCRA Facility Investigation/Remedial Investigation
RIN	Routine Identification Number
RMRS	Rocky Mountain Remediation Services, L.L.C.
ROD	Record of Decision
RPD	Relative Percent Difference
RSAL	Radionuclide Soil Action Level
RWP	Radiation Work Permit
SAP	Sampling and Analysis Plan

SOR	Sum of Ratios
TCE	Trichloroethene
TMU	Total Measurement Uncertainty
TPU	Total Propagated Uncertainty
U	Uranium
UCL	Upper Confidence Limit
ug/kg	micrograms/kilogram
ug/L	microgram per liter
V&V	Verification/Validation
VOC	Volatile Organic Compound
WAC	Waste Acceptance Criteria

8

EXECUTIVE SUMMARY

Investigation of soil contamination at the 903 Drum Storage Area (903 Pad), 903 Lip Area (Lip Area), and Americium Zone was performed to provide characterization data for subsequent evaluation of remedial alternatives for site cleanup. Historically, drums which were stored at the 903 Pad between 1958 and 1967 leaked hydraulic fluids and lathe coolant containing plutonium and depleted uranium. This release-contaminated surface and subsurface soil with radionuclides and volatile organic compounds (VOCs). The VOCs have migrated into the shallow groundwater system beneath the 903 Pad.

The primary purpose of this investigation was to estimate the volume of contaminated soil above the Rocky Flats Cleanup Agreement (RFCA) Tier I Radionuclide Soil Action Levels (RSALs) and Subsurface Soil Action Levels (SSALs). Another objective of the investigation was to characterize surface soil to 10 pCi/g americium-241 (^{241}Am) using gamma spectroscopy field instrumentation. This characterization would allow for identification of surface soils exceeding Tier II RSALs. Remedial alternatives will be evaluated in the Interim Measure/Interim Remedial Action (IM/IRA) Decision Document based on these volume estimates.

Delineation of radiologically-contaminated soil in the Americium Zone was performed in-situ using gamma-ray spectroscopy methods, which employ a high purity germanium detector (HPGe). The HPGe instrument was used to obtain 1110 contiguous gamma ray measurements with a circular field of view of 10 meters in diameter within the investigation area. Given this coverage, nearly the entire Americium Zone investigation area was surveyed for radionuclides.

The HPGe measurement results were correlated with alpha spectroscopy measurements of radionuclides in eight co-located surface soil samples. The resulting best-fit regression model was used to standardize each HPGe ^{241}Am measurement to a laboratory-derived ^{241}Am and $^{239/240}\text{Pu}$ alpha spectroscopy measurement. The correlation results for ^{241}Am and $^{239/240}\text{Pu}$ were input into the RFCA Tier I and II RSAL sum of ratios equations to determine HPGe measurements locations exceeding the respective action levels.

Based on the standardized HPGe results, surface soil at approximately 37% of the HPGe measurements locations within the Americium Zone has radionuclides exceeding the RFCA Tier II RSALs. The RFCA Tier II RSAL exceedances are a result of elevated activities of $^{239/240}\text{Pu}$ and ^{241}Am . Within the Americium Zone, $^{239/240}\text{Pu}$ activities ranged from 6.32 pCi/g to 938.42 pCi/g and ^{241}Am activities ranged from 4.91 pCi/g to 149.22 pCi/g.

Contamination of surface and subsurface soils at the 903 Pad and Lip Area was delineated with data obtained from borings at evenly spaced grid nodes. Radiological samples from 79 boring locations were analyzed for $^{233/234}\text{U}$, ^{235}U , ^{238}U , $^{239/240}\text{Pu}$, and ^{241}Am using alpha spectroscopy. VOC samples were collected from 17 boring locations and were analyzed for VOC contaminants of concern which included carbon tetrachloride, chloroform, cis-1,2-dichloroethene, methylene chloride, tetrachloroethene, and trichloroethene.

Based on the data obtained from borings in the 903 Pad and Lip Area, most of the surface soil (0 to 6 inches) is contaminated above Tier I and Tier II RSALs. $^{239/240}\text{Pu}$ and ^{241}Am activities within the 903 Pad and Lip Area ranged from 0.82 pCi/g to 152,260 pCi/g and 0.15 pCi/g to 31,670

pCi/g, respectively. Radiological contamination was also detected in the subsurface soil at depths of 6 to 12 inches and 12 to 18 inches within the 903 Pad and Lip Area; however, $^{239/240}\text{Pu}$ and ^{241}Am activities decreased by orders of magnitude at progressively deeper soil horizons.

Artificial fill at the 903 Pad is contaminated above the RFCA Tier II RSALs at one location (Boring 91898). Soil at this boring has elevated levels of ^{241}Am (126 pCi/g) and $^{239/240}\text{Pu}$ (558 pCi/g). Asphalt samples from the 903 Pad were also collected for waste characterization profiling but were not compared to RFCA Tier I and Tier II RSALs.

Contaminated soil volumes were based on the areas and depths of Tier I and Tier II RSAL exceedances. The total volume of contaminated soil exceeding Tier I RSALs is $2,236 \text{ m}^3$ ($2,924 \text{ yds}^3$). The total volume of soil exceeding Tier II RSALs is estimated at $11,287 \text{ m}^3$ ($14,762 \text{ yds}^3$). Relative to Tier II RSAL exceedances, the amount of radiologically-contaminated soil at the 903 Pad is $1,889 \text{ m}^3$ ($2,471 \text{ yds}^3$); in the Lip Area is $4,027 \text{ m}^3$ ($5,267 \text{ yds}^3$); and in the Americium Zone is $5,371 \text{ m}^3$ ($11,287 \text{ yds}^3$).

No VOCs were detected above the SSALs in the samples collected from the 17 boring locations within the 903 Pad and Lip Area. However, PCE, TCE and 1,2-DCE exceeded proposed Tier I and Tier II SSALs in several borings near well 08891. The total volumes of contaminated soil above Tier I and Tier II SSALs are 557 yds^3 and $3,566 \text{ yds}^3$, respectively. In addition, 138 yds^3 of contaminated soil containing elevated levels of radionuclides and VOCs are also present.

1.0 INTRODUCTION

This report summarizes data collected to determine the location, area, and volume of soils potentially requiring evaluation, management, or remedial action at Individual Hazardous Substance Site (IHSS) 112 - 903 Drum Storage Area (903 Pad), IHSS 155 - 903 Lip Area (Lip Area) and Americium Zone, located at the Rocky Flats Environmental Technology Site (RFETS). Figure 1-1 provides the locations of the IHSSs and the Americium Zone. Remedial alternatives will be evaluated in the Interim Measures/Interim Remedial Action (IM/IRA) Decision Document based on these volume estimates.

Previous investigations have been conducted in these areas to evaluate the extent of contamination, and the data collected have been reported in the Operable Unit (OU) No. 2 Phase II Resource Conservation and Recovery Act (RCRA) Facility Investigation/ Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) Remedial Investigation (RFI/RI) Report (DOE, 1995). However, these data do not provide the resolution necessary to accurately quantify the volume of soils that may require evaluation, management, or remedial action. Furthermore, with respect to VOC contaminated soils, the data do not support the conceptual model of a dense non-aqueous phase liquids (DNAPL) release at the 903 Pad, a model convincingly supported by groundwater data collected at this IHSS. Accordingly, the data reported herein were collected to fill these data gaps.

1.1 SITE BACKGROUND

Releases at the 903 Pad (IHSS 112) are considered the primary source of radiological contamination in the surficial soil in this part of the RFETS. Drums that contained hydraulic fluids and lathe coolant contaminated with plutonium and uranium were stored at this location from the Summer of 1958 to January 1967. Approximately three fourths of the drums contained liquids contaminated with plutonium while most of the remaining drums contained liquids contaminated with uranium. Of the drums containing plutonium, the liquid was primarily lathe coolant and carbon tetrachloride in varying proportions. Also stored in the drums were vacuum pump oils, trichloroethene (TCE), tetrachloroethene (PCE), silicone oils, and acetone still bottoms (DOE, 1995; RMRS, 1997b).

Leaking drums were noted in 1964 during routine handling operations. The contents of the leaking drums were transferred to new drums, and the area was fenced to restrict access. When cleanup operations began in 1967, a total of 5,237 drums were at the drum storage site. Approximately 420 drums leaked to some degree. Of these, an estimated 50 drums leaked their entire contents. The total amount of leaked material was estimated at around 5,000 gallons of contaminated liquid containing approximately 86 grams of plutonium (DOE, 1995; RMRS, 1997b).

From 1968 through 1970, some of the radiologically-contaminated material was removed from the 903 Pad and Lip Area, some of the surrounding Lip Area was regraded, and much of the area was covered by an imported base coarse material and an asphalt cap was placed over the most contaminated area resulting in the 903 Pad. However, during drum removal and cleanup activities, wind and rain (stormwater erosion) spread plutonium-contaminated soils to the east and southeast from the 903 Pad area resulting in IHSS 155 (903 Lip Area). Several limited excavations have removed some of the plutonium-contaminated soils from the Lip Area (DOE, 1995; Barker, 1982; and RMRS, 1997a). However, results from the OU2 Phase II RFI/RI sampling and analysis and this investigation confirm that radiologically-contaminated soils remain.

Surface soils to the east and southeast of the Lip Area also exhibit elevated Plutonium-239/240 ($^{239/240}\text{Pu}$) and Americium-241 (^{241}Am) activities. This contamination is primarily attributed to wind dispersion from the 903 Pad with potential contributions from historical fires, stack effluent, and stormwater related surface soil erosion. Areas exhibiting elevated $^{239/240}\text{Pu}$ and ^{241}Am activities east and southeast of the Lip Area are known as the Americium Zone.

1.2 ROCKY FLATS CLEANUP AGREEMENT

The Rocky Flats Cleanup Agreement (RFCA) is a legally binding agreement between the Department of Energy (DOE), the Environmental Protection Agency (EPA) and the Colorado Department of Health and Environment (CDPHE) to accomplish the required cleanup of radioactive and other hazardous substance contamination at and around the RFETS. Action levels and cleanup levels for interim remedial actions have been established for surface water,

ground water, and soils and are presented in Attachment 5 of RFCA; "Action Levels and Standards Framework for Surface Water, Ground Water, and Soils (ALF)" (DOE, 1996). Tier I action levels are numeric levels that, when exceeded, trigger an evaluation, remedial action, and/or management action. Tier II action levels are numeric levels that, when met, do not require remedial action and/or institutional controls. Action levels for surface and subsurface soils have been established. Surface soil is defined in the ALF as shallow soil to a depth of 15-cm. Subsurface soil is defined in ALF as soil between a depth of 15-cm and the top of the water table. Currently, Radionuclide Soil Action Levels (RSALs) for surface soils are being applied to subsurface soils until subsurface soil action levels are established. This application of RSALs to subsurface soil is conservative since human exposure to subsurface soil would be less than to surface soil under a given future use scenario.

The DOE, EPA, and CDPHE have committed to an annual review of all applicable new and revised statutes, regulations, written policy, and guidance to determine if an amendment to RFCA is necessary. Based on the 1998 annual review, revisions to the Subsurface Soil Action Levels (SSALs) have been proposed which has resulted in revised Tier I action levels and the inclusion of new Tier II action levels for organic compounds. In addition, an independent review of the soil action levels is currently being conducted by the Rocky Flats Soil Action Level Oversight Panel. Based on this independent review and the results from erosion modeling being performed by the Actinide Migration Evaluation Panel additional revisions to the soil action levels may be proposed in the future.

For this site characterization, contaminant concentrations in surface and subsurface soils have been compared to both Tier I and II RSALs, current Tier I SSALs, and proposed Tier I and Tier II SSALs (Kaiser-Hill, 1999a) in order to assist in the development of the best management strategy for site cleanup.

The parameters of interest include the activity/concentrations of the following radionuclides/compounds:

- Plutonium. -239/240 ($^{239/240}\text{Pu}$);
- Americium-241 (^{241}Am);

- Uranium-234 (²³⁴U);
- Uranium-235 (²³⁵U);
- Uranium-238 (²³⁸U); and
- VOCs (subsurface soils only).

Metals, semivolatile organic compounds, pesticides, and polychlorinated biphenyls were eliminated as potential contaminants of concern based on data evaluation from previous investigations (DOE, 1995).

Radionuclides- Table 1-1 provides the Tier I and Tier II RSALs for an open space use exposure scenario (RSALs for an industrial use exposure scenario also exist but are not applicable to the study area).

Table 1-1 RFCA Tier I and II Radionuclide Soil Action Levels

RADIONUCLIDE	TIER I RSAL (pCi/g)	TIER II RSAL (pCi/g)
²⁴¹ Am	215	38
^{239/240} Pu	1429	252
²³⁴ U	1738	307
²³⁵ U	135	24
²³⁸ U	586	103

If a mixture of radionuclide contaminants a, b, c are present in the soil with activities a_a , a_b , and a_c , and if the applicable RSALs, are A_a , A_b , and A_c respectively, then the activity in the soil shall be considered as exceeding the RSALs if the sum of ratios (SOR) is greater than 1, i.e.,

$$\text{Sum of Ratios (SORs)} = \frac{a_a}{A_a} + \frac{a_b}{A_b} + \frac{a_c}{A_c} > 1 \quad (\text{Equation 1-1})$$

If individual radionuclide activities in surface or subsurface soils exceed Tier I or Tier II RSALs, or the sum of ratios exceed 1, an evaluation, remedial action, and/or management action is triggered.

14

Volatile Organic Compounds -Table 1-2 provides the current Tier I SSALs and the proposed Tier I and Tier II SSALs for VOC contaminants of concern in soils at the 903 Pad .

Table 1-2 Subsurface Soil Action Levels - VOCs

COMPOUND	Current TIER I SSAL (mg/kg)	Proposed TIER I SSAL (mg/kg)	Proposed TIER II SSAL (mg/kg)
Carbon Tetrachloride	11.00	3.56	0.0356
Chloroform	152.00	21.4	0.214
1,2,-Dichloroethene (Total)	9.51	14.0	0.14
Methylene Chloride	5.77	0.578	0.00578
Tetrachloroethene	11.5	3.15	0.0315
Trichloroethene	9.27	3.28	0.0328

As with the radionuclides, if the concentrations of VOCs in soil exceed Tier I or Tier II SSALs (either current or proposed), an evaluation, remedial action, and/or management action is triggered.

1.3 EXISTING DATA

Numerous investigations to assess the extent of contamination at the 903 Pad, Lip Area, and Americium Zone have been conducted. These investigations are briefly described below.

1.3.1 Surface Soils

High Purity Germanium (HPGe) Surveys - HPGe surveys conducted in 1990 (EG&G; 1991) and 1994 (DOE, 1995; RMRS, 1997b) provide useful information on the activity of ²⁴¹Am in surface soils over the Americium Zone study area. These data were collected on a 150-foot grid to accommodate the HPGe detector's field of view (FOV) of 150 feet in diameter (17,671 ft²) (Figure 1-2). Surveys were not conducted over the 903 Pad and Lip Area and soil samples were not collected to supplement the surveys. The results from these surveys were utilized to define the boundaries of this characterization's investigation area.

Surface Soil Radiological Data - Surface soil samples were collected in support of the OU2 Phase II RFI/RI (DOE, 1995). As detailed in the RFI/RI, samples were collected utilizing two sampling

methods; the Colorado Department of Health (CDH) sampling method and the Rocky Flats (RF) sampling method. Surface soil sample results were compared with Tier I RSALs. The results of the comparison indicated that samples collected from five 2.5-acre plots exceed the Tier I RSALs. These plots include two 2.5-acre plots (Plots 28 and 34) sampled using the CDH sampling method and three 2.5-acre plots (Plots 29, 36, and 46) sampled using the RF method (Figure 1-3).

1.3.2 Subsurface Soils

Subsurface Soil Radiological Data - Three data sources were evaluated to determine the depth of radiological contamination within the study area: 1) RFI/RI borehole data (DOE, 1995); 2) RFI/RI soil profile pits (DOE, 1995); and 3) samples collected in support of a 1980 soil decontamination project (Rutherford, 1981). Results from the RFI/RI borehole samples were compared to RSALs and revealed that no samples exceed the Tier I RSALs. However, samples collected from soil profile pit TR08 exceeded Tier I RSALs to a depth of 27 centimeters (cm) (10.6 inches[in]). Soil profile pits were sampled at 3 cm (1.2 in) intervals to a total depth of 1 meter (m) (3.28 feet). Samples collected at soil profile pit TR06, located adjacent to pit TR08, were not analyzed because activities exceeded the DOT shipping requirements. It is assumed that radiochemical results from pit TR06 would also exceed Tier I RSALs, if analyzed.

Soil samples collected beneath the 903 Pad in support of the 1980 soil decontamination project exceeded Tier I RSALs to a depth of 66 cm (26-inches) (RMRS, 1997b). This depth exceeds the thickness of the asphalt pad and the depth of imported base coarse material and indicates radiological contamination of natural undisturbed soils at the 903 Pad. However, no RFI/RI soil borings detected radiological contamination in excess of Tier I RSALs. As a result, a discrepancy with the depth of radiological contamination between these investigations exists.

Subsurface Soil VOC Data - Three sources of data were evaluated to determine the nature and extent of contamination at the 903 Pad: 1) RFI/RI borehole data (DOE, 1995); 2) IM/IRA soil gas survey results (DOE, 1994); and 3) groundwater monitoring well data.

Borehole sample results from the RFI/RI were compared with current Tier I SSALs revealed that no samples exceeded the current Tier I SSALs for organic contaminants. The soil gas survey

16

indicated that the highest VOC concentrations were located immediately south of the southeast corner of the 903 Pad. Tetrachloroethene was detected at 27,000 micrograms per liter (ug/L) at a depth of 5 feet. However, at adjacent soil gas locations and boreholes, tetrachloroethene is either not detected or detected at very low concentrations. Soil gas concentrations for the remaining portion of the 903 Pad ranged from 0-500 ug/L with the highest concentrations around and north of monitoring well 08891 (Figure 1-4).

1.3.3 Groundwater

A VOC-contaminated groundwater plume extends from the 903 Pad area to the east. The highest concentrations are found in groundwater samples collected from wells 06691 and 08891, which are located on the asphalt portion of the 903 Pad. Concentrations of contaminants in groundwater decrease rapidly moving eastward from the 903 Pad area. The primary groundwater contaminant in well 06691 is carbon tetrachloride with concentrations ranging from 51 to 100,000 ug/L. Methylene chloride (150 to 29,000 ug/L) and chloroform (92 to 46,000 ug/L) are also observed. Groundwater sample results for well 08891 indicate the primary contaminant as PCE at concentrations ranging from 470 to 27,000 ug/L, along with carbon tetrachloride (290 to 17,000 ug/L), cis-1,2,dichloroethene (94 to 2,900 ug/L) and TCE (210 to 4,600 ug/L). The next highest concentration of carbon tetrachloride in groundwater is found in samples collected from well 13191, which is located west of the well 06691 and off the western edge of the 903 Pad. At this location, observed carbon tetrachloride levels ranged from 122 to 4,800 ug/L.

Concentrations of VOCs in groundwater decrease rapidly moving eastward from the 903 Pad area which is supported by a review of historical groundwater data (DOE, 1995; RMRS, 1997b). As a recent example, during the June 1998 groundwater sampling, well 06991 had 210 ug/L PCE and well 1587 had 880 ug/L PCE which are two orders of magnitude less than the concentration observed in well 08891 with 27,000 ug/L PCE (Figure 1-4). This decrease in concentration is a result of contaminant dilution due to the distance between the well on the 903 Pad and downgradient well locations east of the 903 Pad.

Because of the complex nature of DNAPL transport and fate, DNAPL may often be undetected by direct methods leading to incomplete site assessments and inadequate remedial designs (EPA,

1992). A guide for estimating the potential for a DNAPL source at a site includes assessing if concentrations of DNAPL-related chemicals in groundwater are greater than 1% of the pure phase solubility of the compound (EPA, 1992).

Table 1-3 provides a comparison of the pure phase aqueous solubility and concentrations of DNAPL-compounds detected in groundwater at the 903 Pad (wells 06691 and 08891) from a June 1998 sampling event of monitoring wells 06691 and 08891. The comparison indicates that PCE and carbon tetrachloride have been detected in groundwater samples at 13.5% and 10.7% of their aqueous solubilities, respectively. The results of this comparison and known historical site uses, indicate there is a potential for pure phase organic contaminants in subsurface soils beneath the 903 Pad.

TABLE 1-3 Comparison of Pure Phase Aqueous Solubility with Concentrations in Groundwater Samples - Selected VOCs

Compound	Pure Phase Aqueous Solubility at 25°C (mg/l)	Concentration Detected in Groundwater June 1998 (mg/l)	Ratio Groundwater/Aqueous Solubility (%)
Carbon Tetrachloride	793	85.0	10.7
Chloroform	7,920	4.4	0.1
cis-1,2,dichloroethene	3,500	1.3	0.04
Methylene Chloride	13,000	29.0	2.2
PCE	200	27.0	13.5
TCE	1,100	1.3	0.12

¹EPA, 1996. Soil Screening Guidance: Technical Background Document

1.4 SURFICIAL GEOLOGY

The surficial geology in the study area consists of Quaternary alluvium, colluvium and slump deposits along with artificial fill, soil and debris deposits, and disturbed soil. The surficial deposits overlie bedrock which consists of weathered claystone and minor bedrock sandstones of the Cretaceous Arapahoe and Laramie Formations. Surficial deposits consist of sandy clay and clayey gravel. Soil developed over the alluvium is rocky and sandy in contrast to the clayey soils developed over the claystone bedrock.

For this investigation, the surface and subsurface soils were subdivided into six soil horizons: (1) the Native 1 soil horizon consists of natural soils from 0 to 6 inches (surface soils); (2) the Native 2 soil horizon designates subsurface soils from 6 inches to 1 foot; (3) the Native 3 soil horizon designates subsurface soil from 1 to 1.5 feet; (4) the Native 4 soil horizon designates subsurface soil from 1.5 to 2.0 feet; (5) the Native group consists of Quaternary alluvium from the bottom of the Native 4 soil horizon (2.0 feet) to the bedrock contact; and (6) the Bedrock group consists of consolidated geologic material from the undifferentiated Laramie/Arapahoe Formations.

Artificial fill is present directly beneath the 903 Pad and in the Lip Area as a result of previous remediation activities. In November 1968 "slightly-contaminated" soil was graded from outside the fence at the 903 Pad into the fenced area to be capped. In September of 1969 a base coarse (artificial fill) material overlay, soil sterilant, and asphalt primer were constructed for the 903 "containment barrier" (Pad). The asphalt pad was constructed in October of 1969 and was reportedly 3 in (7.6 cm) thick. The thickness of the base coarse materials beneath the 903 Pad was assumed to be approximately 8 inches (20 cm). In February 1970, operations were initiated to apply additional fill (base coarse) over the Lip Area due to soil contamination. The thickness of the fill material reportedly ranged from 0.8 in (2 cm) to 5.1 in (13 cm) (DOE, 1995; RMRS, 1997b).

1.5 SITE CONCEPTUAL MODEL

The contaminants present in the surface and subsurface soil are primarily a result of drum storage in the 903 Pad area. Drums containing hydraulic fluids and lathe coolant contaminated with plutonium and uranium leaked onto the surface soil. The liquids from the drums may have moved downward towards the bedrock surface, possibly carrying a fraction of the radionuclides into the subsurface along preferential pathways such as rodent holes, desiccation cracks, and/or along decayed roots. High winds and heavy rains spread the surficial radiological contamination outward from the 903 Pad, depositing it on surface soils in the Lip Area and Americium Zone.

Previous HPGc surveys from the study area and surface soil sample data show that, in general, higher concentrations are present near the 903 Pad, and concentrations decrease with increasing

distance from the 903 Pad. Immediately east and south of the 903 Pad and Lip Area, there are areas of higher concentrations which may be the result of wind and surface water dispersion of contaminants (DOE, 1995). Accounting for the surface soil and HPGe sampling already collected from the 903 Pad area to Indiana Street, and the direction of surface water flow from the 903 Pad towards the South Interceptor Ditch, it was concluded that hot spots are not likely to be present to the east, outside of the Investigation Area (Figure 1-4).

The source of subsurface VOC contamination is suspected to be present directly beneath the area where drums were previously stored (DOE, 1995; RMRS; 1997b). The liquid contained in the drums may have migrated downward towards the bedrock surface. An east-west paleochannel is cut into the bedrock, with the greatest depth to bedrock located toward the middle of the 903 Pad (DOE, 1995; RMRS, 1997b; RMRS, 1997c). Available subsurface and groundwater VOC data (see Section 1.3) indicates that any potential source of DNAPL contamination is limited to the area under the present 903 Pad. The VOC contamination east of the 903 Pad is limited to the dissolved phase in groundwater as supported by groundwater data (see Section 1.3.3) (DOE, 1995; RMRS, 1998e).

1.6 PROJECT INVESTIGATION AREA

Based on the foregoing evaluation of the existing data in the study area, an Investigation Area was defined for this site characterization that represents the area where additional data is required to refine the volume estimate of contaminated soils (Figure 1-4). The Investigation Area represents that portion of the study area which is known, or in which a potential exists, for surface and/or subsurface soils to exceed Tier I RSALs and current Tier I SSALs. These areas include:

- Surface soils exceeding 10 pCi/g ²⁴¹Am as identified in the 1990 and 1994 HPGe surveys;
- Areas where artificial fill (and asphalt) has been placed over natural soils including the 903 Pad, Lip Area, and areas remedied in 1976, 1978, and 1984;
- Five 2.5-acre plots identified as exceeding Tier I soil action levels based on OU2 RFI/RI surface soil sampling results: and
- The 903 Pad and Lip Area where a subsurface VOC source is suspected as the source of a groundwater contaminant plume.

2.0 FIELD INVESTIGATION

2.1 OVERVIEW

The lateral and vertical extent of radiological and VOC contamination was assessed within the proposed investigation area. The lateral extent of radiological contamination in the Americium Zone and a portion of the Lip Area were primarily assessed using a non-intrusive HPGe field method. The HPGe method results were "standardized" by correlation to radiochemical data collected by sampling surface soils from selected HPGe measurement locations, and analyzing these samples for radionuclides using alpha spectroscopy. The lateral and vertical extent of contamination of the 903 Pad and a majority the Lip Area was assessed utilizing sample collection methods employing a Geoprobe[®], and analyzing the samples for radionuclides and VOCs in a laboratory. The data were collected pursuant to the Sampling and Analysis Plan for the Site Characterization of the 903 Drum Storage Area (IHSS 112), 903 Lip Area (IHSS 155), and Americium Zone (SAP) (RMRS, 1998a).

2.2 SURFACE SOIL INVESTIGATION

The activities of ²⁴¹Am, ^{239/240}Pu, ^{233/234}U, ²³⁵U, and ²³⁸U in surface soils within the Americium Zone and a portion of the Lip Area were measured *insitu* using an HPGe survey together with radiochemical analyses of surface soil samples.

2.2.1 HPGe Methodology

The HPGe instrument measures *insitu* activities of ²⁴¹Am, ²³⁵U and ²³⁸U. For this investigation, the HPGe measurement had a field of view (FOV) of 10 m in diameter with the detector placed 1-meter (m) over the ground surface. The Compendium of *Insitu* Radiological Methods and Applications at Rocky Flats Plant (EG&G, 1993) provides a detailed discussion on the physics of *insitu* measurement of radionuclides in the environment.

The HPGe survey focused on the Americium Zone (Figure 2-1) and includes all surface soils with elevated concentrations of ^{239/240}Pu and/or ²⁴¹Am identified during the OU2 RFI/RI including:

- The 35 HPGe measurements which exhibit elevated (above 10 pCi/g) ^{241}Am activities;
- The area directly below the culvert which drains the 903 Pad and Lip Area where sediments are deposited during surface runoff events; and
- The five 2.5-acre plots which surface soils exceed Tier I RSALs.

The HPGe system used to perform *insitu* measurements for the investigation employs the Canberra *Insitu* Object Counting System (ISOCS) software. In order to estimate counting efficiencies, this software requires the entry of various parameters which should accurately represent the actual field conditions at the site. One important parameter is the distribution of contaminants vertically. In the HPGe investigation area, contamination was deposited via airborne and/or surface water releases. This resulted in a distribution with high activities near the surface and decreasing activities with depth, which may follow an exponential function. Surface soil sampling was previously performed in the study area to determine the vertical distributions. In general, the radionuclides are concentrated in the top 5-cm. Based on available data, the ISOCS model assumes all contamination is contained in the top 5-cm, and it is distributed with 66% in the top 3-cm and 33% in the next 2-cm. This distribution was used to be consistent with the surface soil sampling methodologies (RMRS, 1998a), which specifies sampling surface soil to a depth of two inches (5 cm). In addition, the contribution from ^{241}Am below a depth of 5 cm in soil is quite small. It is possible that the actual distributions in the top 5-cm may be more concentrated near the surface or more uniformly distributed throughout the 5-cm layer. A set of efficiencies with different vertical distributions was prepared and the standard acquisition analyzed.

Results:

Default 2 layer 0-3 cm 66%, 3-5 cm 33%	$^{241}\text{Am} = 12.2 \text{ pCi/g}$
Single layer, 0-5 cm uniform	$^{241}\text{Am} = 14.3 \text{ pCi/g}$
3 layers, 0-1.5cm 50%, 1.5-3 cm 30%, 3-5 cm 20%	$^{241}\text{Am} = 11.6 \text{ pCi/g}$
3 layers, default with 1cm grass cover	$^{241}\text{Am} = 13.2 \text{ pCi/g}$
2 layer with 0-3 cm 60%, 3-5 cm 40%	$^{241}\text{Am} = 12.2 \text{ pCi/g}$

As can be seen, the overall error of a likely range of possible distributions is about +/- 10 %.

2.2.2 Double Sampling Correlation Technique

To "standardize" the *in-situ* method, a double sampling technique was employed whereby soil samples were collected from select HPGe measurement locations (RMRS, 1998a) and analyzed in the laboratory for ^{241}Am , $^{239/240}\text{Pu}$, $^{233/244}\text{U}$, ^{235}U , and ^{238}U using alpha spectroscopy, and ^{241}Am and ^{235}U using gamma spectroscopy. [The gamma spectroscopy data was collected by the laboratory to simply "validate" the alpha spectroscopy results, and the two sets of results are comparable as indicated by their linear relationship with a slope of one [(Table 2-1) (Figure 2-2)].

Table 2-1 Laboratory Gamma Spectroscopy Results vs. Laboratory Alpha Spectroscopy Results – ^{241}Am

HPGe Measurement Location	Laboratory Gamma Spectroscopy Results ^{241}Am (pCi/g) dry wt	Laboratory Alpha Spectroscopy Results ^{241}Am (pCi/g) dry wt
30*	3.67	3.67
104	19.08	27.80
265	45.46	49.32
266	21.89	22.60
305	7.45	11.05
406	107.86	77.27
460*	111.09	148.23
669*	57.84	57.85

* Real and Duplicate Sample Results Averaged

In order to acquire a good double sampling correlation over the anticipated range of ^{241}Am activities, eight HPGe measurement locations were selected that encompass five ^{241}Am activity intervals; 0-10 (three measurements), 10-20, 20-50 (two measurements), 50-100, and 100-200 pCi/g. These intervals were selected based on detection frequencies of ^{241}Am activities measured in surface soil samples collected in support of the OU2 Phase II RFI/RI (DOE, 1995; RMRS, 1998a).

Multiple HPGe measurements were taken at some of the double sampling locations for quality control. These results are provided in Table 2-2. In these cases, the measurements at each double

sampling location were averaged to create the HPGe data set used in the correlation. Table 2-2 also indicates the HPGe measurements at each double sampling location are relatively uniform.

Fifteen (15) grab samples were then collected at each double sampling location; one grab sample from the center; four grab samples collected at 1-m radius, and ten grab samples from 3-m radius. Figure 2-3 provides this surface soil sampling geometry which was developed by the DOE (DOE, 1997) at the Fernald Environmental Management Project site in Ohio in order to correlate HPGe results to surface soil results. The 1-m and 3-m radius grab samples were then composited into a 1-m and 3-m sample representative of each individual band. Therefore, three separate alpha (and gamma) spectroscopy analyses were performed at each double sampling location.

Samples were collected in this "bull's eye" pattern to mimic the averaging done by the field HPGe detector over the instrument FOV. The HPGe detector receives gamma-ray photons from every point within the circle; however, it receives more gamma rays from soil closer to the detector than from soil further from the detector. If the circle is divided into concentric bands, the relative weighting factor for each band can be calculated based upon the percentage influence of gamma photons at the detector which originates from a given band of soil, assuming a uniform source distribution with depth and a one MeV photon energy. The relative weighting factor is the relative importance of each band with respect to the probability of gamma-rays emitted from within that band being detected by the HPGe (Table 2-3). The sample results were multiplied by the weighting factor per band, then the products were summed to determine the activity of the soils in the FOV area. Tables 2-4 and 2-5 provide the results of these calculations, including adjustment for moisture content in order to report results on a wet weight or "insitu moisture" basis. Note that if field duplicate samples were collected at a given double sampling location, the "real" and "duplicate" data were averaged (denoted as "combined"), and the "combined" data were used in the weighted averaging process to develop the data for the correlation.

Table 2-2 HPGe Americium-241 Results at Double Sampling Locations

HPGe Measurement 30		HPGe Measurement 104		HPGe Measurement 265		HPGe Measurement 266		HPGe Measurement 305		HPGe Measurement 406		HPGe Measurement 460		HPGe Measurement 669	
Count Duration (sec)	Am-241 (pCi/g)														
900	1.1	900	14.5	900	34.3	900	9.1	1200	7.0	900	70.2	900	106.3	900	32.2
		900	17.6	900	39.0			1200	7.5	900	62.9	900	113.2	1200	32.8
		900	20.6	900	39.1			1200	4.7	900	61.7	900	80.2	1200	39.5
		1200	15.5	900	37.3			1200	6.0	900	62.6	900	98.3	1200	35.3
		1200	22.6	900	31.7			1200	4.9	900	65.9	900	115.7	1200	35.2
		1200	17.6	900	29.2			1200	5.7			900	80.8		
		1200	23.0	900	31.3			1200	5.4						
		900	15.1	900	39.3			1200	4.0						
		900	17.6	900	34.4										
		1200	13.0												
		1200	18.6												
		1200	19.4												
		1200	15.8												
		1200	15.8												
Average	1.1		17.6		35.1		9.1		7.7		64.7		99.1		35.0

29

Table 2-3 Surface Soil Samples, Weighted Average Calculations

Horizontal Distance from Point Under Detector (m)	Weight (per circle)
0	0.1
1	0.36
3	0.54
Total	1.00

2.2.2.1 Alpha Spectroscopy/HPGe Plutonium-239/240 and Americium-241 Correlations

The linear regressions (using the method of least squares) between the alpha spectrometry data ($^{239/240}\text{Pu}$ and ^{241}Am) and the HPGe data (^{241}Am) show very high degrees of correlation (Figures 2-4 and 2-5). The correlation coefficients (R) are greater than or equal to 0.97. The ^{241}Am (alpha spectrometry) to ^{241}Am (HPGe) correlation has a slope (1.25) near 1.0 and a small intercept (4.43 pCi/g) near zero as would be expected when correlating the activities of the same radionuclide. The $^{239/240}\text{Pu}$ (alpha spectrometry) to ^{241}Am (HPGe) correlation has a slope of 8.08 which is within the expected range of $^{239/240}\text{Pu}$ to ^{241}Am activity ratios considering the in-growth of ^{241}Am in weapons grade plutonium over 30 to 40 years (elapsed time since the release). The intercept (3.24 pCi/g) is also small in magnitude. These results indicate the regression lines are appropriate models to correlate HPGe data to alpha spectrometry data.

However, according to the SAP (RMRS, 1998a), the 95% upper confidence limits (UCL) of the linear regressions are to provide the equations to calculate the activities of these isotopes in the surface soils at all *in-situ* measurement locations (see Figures 2-4 and 2-5). Examination of the results from using the 95% UCL to determine RSAL exceedances strongly suggest this alternative "model" to be overly conservative. Figures 2-6, 2-7, and 2-8 show RSAL exceedances in surface soils in the Americium Zone based on the direct HPGe results¹, the least square regression lines ("best fit" lines), and the 95% UCL equations for the "best fit" lines,

¹ Because $^{239/240}\text{Pu}$ is not measured directly by the HPGe instrument at low levels, the $^{239/240}\text{Pu}$ data used to determine RSAL exceedances was estimated using the $^{239/240}\text{Pu}$ to ^{241}Am activity ratio of 5.8 derived from the slope of the regression line (Figure 2-9) for the $^{239/240}\text{Pu}$ and ^{241}Am alpha spectroscopy results from the surface soil samples collected at the eight double sampling locations (using real and duplicate sample results).

Table 2-4
Alpha Spectroscopy Results for Americium-241 at Double Sampling Locations

HPGe Measurement Location	Sample Type	Sample No	Radius (m)	Am241 (pCi/g)	Moisture Content (%)	Am-241 Weighted Average (pCi/g)	Am-241 Weighted Average Corrected for Moisture (pCi/g)
30	Real	99A5936-002.001	0	2.3659	4.99	.24	.2253
	Real	99A5936-004.001	1	4.6643	4.6	1.68	1.6053
	Real	99A5936-006.001	3	3.574	5.18	1.93	1.8349
		Average		3.535		3.85	3.666
30	Duplicate	99A5936-003.001	0	1.7105	4.99	.17	.1629
	Duplicate	99A5936-005.001	1	4.4612	4.6	1.61	1.5354
	Duplicate	99A5936-007.001	3	3.1966	5.18	1.73	1.6412
		Average		3.123		3.50	3.339
30	Combined		0	2.0382	4.99	.2	.1941
	Combined		1	4.5628	4.6	1.64	1.5704
	Combined		3	3.3853	5.18	1.83	1.738
		Average		3.329		3.67	3.503

HPGe Measurement Location	Sample Type	Sample No	Radius (m)	Am241 (pCi/g)	Moisture Content (%)	Am-241 Weighted Average (pCi/g)	Am-241 Weighted Average Corrected for Moisture (pCi/g)
104	Real	98A5590-001.002	0	11.2017	4.28	1.12	1.0742
	Real	98A5590-001.004	1	29.3735	3.63	10.57	10.2041
	Real	99A5590-004.001	3	29.824	2.56	16.1	15.703
		Average		23.466		27.80	26.981

HPGe Measurement Location	Sample Type	Sample No	Radius (m)	Am241 (pCi/g)	Moisture Content (%)	Am-241 Weighted Average (pCi/g)	Am-241 Weighted Average Corrected for Moisture (pCi/g)
265	Real	98A5590-002.002	0	36.6004	2.34	3.66	3.5764
	Real	98A5590-002.004	1	70.1548	9.99	25.26	22.9618
	Real	98A5590-002.006	3	37.785	2.83	20.4	19.8424
		Average		48.180		49.32	46.381

HPGe Measurement Location	Sample Type	Sample No	Radius (m)	Am241 (pCi/g)	Moisture Content (%)	Am-241 Weighted Average (pCi/g)	Am-241 Weighted Average Corrected for Moisture (pCi/g)
266	Real	98A3372-003.002	0	33.7418	18.91	3.37	2.8376
	Real	98A3372-003.004	1	22.6443	9.6	8.15	7.4379
	Real	98A3372-003.006	3	20.503	12.55	11.07	9.8371
		Average		25.630		22.60	20.113

HPGe Measurement Location	Sample Type	Sample No	Radius (m)	Am241 (pCi/g)	Moisture Content (%)	Am-241 Weighted Average (pCi/g)	Am-241 Weighted Average Corrected for Moisture (pCi/g)
305	Real	98A5590-003.002	0	9.947	5.04	.99	.947
	Real	98A5590-003.004	1	9.2659	1.13	3.34	3.2985
	Real	98A5590-003.006	3	12.4345	1.2	6.71	6.635
		Average		10.549		11.05	10.88

31

Table 2-4
Alpha Spectroscopy Results for Americium-241 at Double Sampling Locations

HPGe Measurement Location	Sample Type	Sample No.	Radius (m)	Am241 (pCi/g)	Moisture Content (%)	Am-241 Weighted Average (pCi/g)	Am-241 Weighted Average Corrected for Moisture (pCi/g)
406	Real	98A3372-001.002	0	101.9353	5.91	10.19	9.6247
	Real	98A3372-001.004	1	77.7979	5.2	28.01	26.6229
	Real	98A3372-001.006	3	72.3595	4.38	39.07	37.4345
		Average		84.031		77.27	73.682

HPGe Measurement Location	Sample Type	Sample No.	Radius (m)	Am241 (pCi/g)	Moisture Content (%)	Am-241 Weighted Average (pCi/g)	Am-241 Weighted Average Corrected for Moisture (pCi/g)
460	Real	98A3372-002.002	0	90.1227	11.65	9.01	8.0719
	Real	98A3372-002.004	1	151.9866	12.66	54.72	48.5666
	Real	98A3372-002.006	3	137.9899	8.67	74.51	68.5696
		Average		126.700		138.24	125.208
460	Duplicate	99A3372-002.007	0	175.1638	11.65	17.52	15.6887
	Duplicate	99A3372-002.008	1	172.9098	12.66	62.25	55.2526
	Duplicate	99A3372-002.009	3	145.2979	8.67	78.46	72.201
		Average		164.457		158.22	143.142
460	Combined		0	132.6433	11.65	13.26	11.8803
	Combined		1	162.4482	12.66	58.48	51.9096
	Combined		3	141.6439	8.67	76.49	70.3853
		Average		145.578		148.23	134.175

HPGe Measurement Location	Sample Type	Sample No.	Radius (m)	Am241 (pCi/g)	Moisture Content (%)	Am-241 Weighted Average (pCi/g)	Am-241 Weighted Average Corrected for Moisture (pCi/g)
669	Real	99A4878-003.001	0	40.8194	8.62	4.08	3.758
	Real	99A4878-005.001	1	55.0517	10.	19.82	18.0169
	Real	99A4878-007.001	3	60.4235	7.99	32.63	30.2145
		Average		52.098		56.53	51.989
669	Duplicate	99A4878-004.001	0	75.9211	8.62	7.59	6.9896
	Duplicate	99A4878-006.001	1	66.7147	10.	24.02	21.8339
	Duplicate	99A4878-008.001	3	51.0332	7.99	27.56	25.519
		Average		64.556		59.17	54.342
669	Combined		0	58.3703	8.62	5.84	5.3738
	Combined		1	60.8832	10.	21.92	19.9254
	Combined		3	55.7284	7.99	30.09	27.8668
		Average		58.327		57.85	53.166

32

Table 2-5
Alpha Spectroscopy Results for Plutonium-239/240 at Double Sampling Locations

HPGe Measurement Location	Sample Type	Sample No.	Radius (m)	Pu-239/240 (pCi/g)	Moisture Content (%)	Pu-239/240 Weighted Average (pCi/g)	Pu-239/240 Weighted Average Corrected for Moisture (pCi/g)
30	Real	99A5936-002.001	0	12.8235	4.99	1.28	1.2214
	Real	99A5936-004.001	1	21.7524	4.6	7.83	7.4865
	Real	99A5936-006.001	3	23.8498	5.18	12.88	12.2446
		Average		19.475		21.99	20.953
30	Duplicate	99A5936-003.001	0	8.4155	4.99	.84	.8016
	Duplicate	99A5936-005.001	1	23.1372	4.6	8.33	7.9631
	Duplicate	99A5936-007.001	3	15.5486	5.18	8.4	7.9827
		Average		15.700		17.57	16.747
30	Combined		0	10.6195	4.99	1.06	1.0115
	Combined		1	22.4448	4.6	8.08	7.7248
	Combined		3	19.6992	5.18	10.64	10.1137
		Average		17.588		19.78	18.85

HPGe Measurement Location	Sample Type	Sample No.	Radius (m)	Pu-239/240 (pCi/g)	Moisture Content (%)	Pu-239/240 Weighted Average (pCi/g)	Pu-239/240 Weighted Average Corrected for Moisture (pCi/g)
104	Real	98A5590-001.002	0	61.0754	4.28	6.11	5.8569
	Real	98A5590-001.004	1	121.7496	3.63	43.83	42.2946
	Real	98A5590-001.006	3	161.424	2.56	87.17	84.9931
		Average		114.750		137.11	133.145

HPGe Measurement Location	Sample Type	Sample No.	Radius (m)	Pu-239/240 (pCi/g)	Moisture Content (%)	Pu-239/240 Weighted Average (pCi/g)	Pu-239/240 Weighted Average Corrected for Moisture (pCi/g)
265	Real	98A5590-002.002	0	150.7151	2.34	15.07	14.7269
	Real	98A5590-002.004	1	150.3247	9.99	54.12	49.2016
	Real	98A5590-002.006	3	151.1863	2.83	81.64	79.3938
		Average		150.742		150.83	143.322

HPGe Measurement Location	Sample Type	Sample No.	Radius (m)	Pu-239/240 (pCi/g)	Moisture Content (%)	Pu-239/240 Weighted Average (pCi/g)	Pu-239/240 Weighted Average Corrected for Moisture (pCi/g)
266	Real	98A3372-003.002	0	250.0412	18.91	25.	21.0278
	Real	98A3372-003.004	1	194.6868	9.6	70.09	63.9482
	Real	98A3372-003.006	3	87.7801	12.55	47.4	42.1157
		Average		177.503		142.49	127.092

HPGe Measurement Location	Sample Type	Sample No.	Radius (m)	Pu-239/240 (pCi/g)	Moisture Content (%)	Pu-239/240 Weighted Average (pCi/g)	Pu-239/240 Weighted Average Corrected for Moisture (pCi/g)
305	Real	98A5590-003.002	0	80.7024	5.04	8.07	7.683
	Real	98A5590-003.004	1	67.9077	1.13	24.45	24.1736
	Real	98A5590-003.006	3	48.3793	1.2	26.12	25.815
		Average		65.663		58.64	57.672

**Table 2-5
Alpha Spectroscopy Results for Plutonium-239/240 at Double Sampling Locations**

HPGe Measurement Location	Sample Type	Sample No.	Radius (m)	Pu239/240 (pCi/g)	Moisture Content (%)	Pu-239/240 Weighted Average (pCi/g)	Pu-239/240 Weighted Average Corrected for Moisture (pCi/g)
406	Real	98A3372-001.002	0	906.2229	5.91	90.62	85.5654
	Real	98A3372-001.004	1	524.8652	5.2	188.95	179.6117
	Real	98A3372-001.006	3	519.3453	4.38	280.45	268.6784
		Average		650.144		560.02	533.855

HPGe Measurement Location	Sample Type	Sample No.	Radius (m)	Pu239/240 (pCi/g)	Moisture Content (%)	Pu-239/240 Weighted Average (pCi/g)	Pu-239/240 Weighted Average Corrected for Moisture (pCi/g)
460	Real	98A3372-002.002	0	554.3172	11.65	55.43	49.6478
	Real	98A3372-002.004	1	1,481.6998	12.66	533.41	473.4706
	Real	98A3372-002.006	3	675.0613	8.67	364.53	335.4496
		Average		903.693		953.38	858.568
460	Duplicate	99A5936-002.001	0	782.3574	11.65	78.24	70.0723
	Duplicate	99A5936-004.001	1	684.6637	12.66	246.48	218.7812
	Duplicate	99A5936-006.001	3	841.5062	8.67	454.41	418.159
		Average		769.509		779.13	707.013
460	Combined		0	668.3373	11.65	66.83	59.86
	Combined		1	1,083.1818	12.66	389.95	346.1259
	Combined		3	758.2838	8.67	409.47	376.8043
		Average		836.601		866.25	782.79

HPGe Measurement Location	Sample Type	Sample No.	Radius (m)	Pu239/240 (pCi/g)	Moisture Content (%)	Pu-239/240 Weighted Average (pCi/g)	Pu-239/240 Weighted Average Corrected for Moisture (pCi/g)
669	Real	99A4878-003.001	0	265.908	8.62	26.59	24.4806
	Real	99A4878-005.001	1	318.3239	10.	114.6	104.1787
	Real	99A4878-007.001	3	376.36	7.99	203.23	188.1974
		Average		320.197		344.42	316.857
669	Duplicate	99A4878-004.001	0	525.3358	8.62	52.53	48.3646
	Duplicate	99A4878-006.001	1	435.6164	10.	156.82	142.5654
	Duplicate	99A4878-008.001	3	297.2583	7.99	160.52	148.6429
		Average		419.404		369.87	339.573
669	Combined		0	395.6219	8.62	39.56	36.4226
	Combined		1	376.9702	10.	135.71	123.372
	Combined		3	336.8092	7.99	181.88	168.4202
		Average		369.800		357.15	328.215

34

respectively. Also plotted on these figures are RSAL comparisons for historical surface soil data (0-2 inches) from the OU2 RFI/RI trenching investigations (DOE, 1995) and a surface soil investigation conducted by the Actinide Migration Evaluation Project (RMRS, 1998f). These figures also provided RSAL comparisons for the alpha spectrometry results of surface soil samples collected at the eight double sampling locations for this investigation. Analytical results and RSAL comparisons for these surface soil samples are provided in Tables 2-6, 2-7 and 2-8.

As would be expected, Figures 2-6, 2-7, and 2-8 indicate progressively higher actinide levels in surface soils, i.e. increasing numbers of Tier I, and in particular, Tier II RSAL exceedances. As can be seen, the "best fit" line results (Figure 2-7) are substantiated by the historical data. For example, unlike the HPGe "direct" results (Figure 2-6), the Tier II exceedances plotted using with the "best fit" line (Figure 2-7) extend to the south bordering on location TR09 (a Tier II exceedance), and extend to the east encompassing locations TR12 and AME 5398 (also Tier II exceedances). Also, unlike the 95% UCL results (Figure 2-8), the "best fit" results (Figure 2-7) indicate actinide levels below Tier II to the north at HPGe Measurement Location 30, to the east at HPGe Measurement Location 305, and southeast at TR11. Thus, RSAL exceedances for the "best fit" line (Figure 2-7) are most consistent with the historical and the alpha spectroscopy data, and the best fit line is the chosen model to standardize the HPGe results.

2.2.2.2 Alpha Spectroscopy/HPGe Uranium-235, -238 Correlations

As shown in Figures 2-10 and 2-11, correlations for the alpha spectrometry/HPGe data for ^{235}U and ^{238}U were not performed because in both cases the uranium isotopes were not detected by *insitu* HPGe. The plots show minimum detectable activities when the isotopes were non-detected. Also, alpha spectrometry did not measure detectable levels of ^{235}U , and only in a few instances was ^{238}U detected at estimated activities. Therefore, ^{235}U and ^{238}U results from the HPGe survey in the Americium Zone were used directly as the surface soil radiological data for these isotopes. The lack of correlation for the uranium data does not impact the findings reported herein because the activities of uranium isotopes are well below the Tier II RSALs throughout the investigation area.

The activity of $^{233/234}\text{U}$ was calculated based on the fact that ^{234}U is usually in equilibrium with ^{238}U (the activity contribution of ^{233}U is insignificant). The equilibrium between the radioactive

Table 2-6 Alpha Spectroscopy Results of Trench Soil Samples - OU2 RFI/RI

LOCATION	EASTING	NORTHING	SAMPLE	SAMPLING INTERVAL (cm)	QC	ANALYTE	RESULT	UNITS	QUAL	Titel I SOR	Titel II SOR
TR04	2086630	748884	TR00422WCU2	0-3	REAL	AM-241	109.9000	pCi/g	J	0.889	5.036
					REAL	PU-239/40	535.3000	pCi/g			
					REAL	U-233,-234	1.0080	pCi/g			
					REAL	U-235	0.0819	pCi/g			
					REAL	U-238DA	1.3520	pCi/g			
			TR00421WCU2	3-6	REAL	AM-241	63.7300	pCi/g	J	0.622	3.523
					REAL	PU-239/40	459.9000	pCi/g			
					REAL	U-233,-234	1.2540	pCi/g			
					REAL	U-235	0.0359	pCi/g			
					REAL	U-238DA	1.5680	pCi/g			
TR05	2086570	748918	TR00367WCU2	0-3	REAL	AM-241	71.1800	pCi/g	J	0.789	4.468
					REAL	PU-239/40	646.6000	pCi/g			
					REAL	U-233,-234	2.2070	pCi/g			
					REAL	U-235	0.0000	pCi/g			
					REAL	U-238DA	2.2070	pCi/g			
			TR00366WCU2	3-6	REAL	AM-241	34.1200	pCi/g	J	0.429	2.433
					REAL	PU-239/40	381.3000	pCi/g			
					REAL	U-233,-234	1.4260	pCi/g			
					REAL	U-235	0.0483	pCi/g			
					REAL	U-238DA	1.6100	pCi/g			
TR09	2086350	748432	TR00300WCU2	0-3	REAL	AM-241	23.3700	pCi/g	J	0.251	1.424
					REAL	PU-239/40	198.7000	pCi/g			
					REAL	U-233,-234	1.1960	pCi/g			
					REAL	U-235	0.0636	pCi/g			
					REAL	U-238DA	1.3920	pCi/g			
			TR00299WCU2	3-6	REAL	AM-241	22.2800	pCi/g	J	0.251	1.422
					REAL	PU-239/40	204.4000	pCi/g			
					REAL	U-233,-234	2.0480	pCi/g			
					REAL	U-235	0.0439	pCi/g			
					REAL	U-238DA	1.6620	pCi/g			

SOR - Sum or ratios

36

LOCATION	EASTING	NORTHING	SAMPLE	SAMPLING INTERVAL (cm)	QC	ANALYTE	RESULT	UNITS	QUAL	SOR	SOR
TR11	2086830	748455	TR00284WCU2	0-3	REAL	AM-241	15.5600	pc/g		0.139	0.785
					REAL	U-239/40	88.6500	pc/g			
					REAL	U-233,-234	1.6220	pc/g			
					REAL	U-235	0.0796	pc/g			
					REAL	U-238DA	1.5400	pc/g			
			TR00283WCU2	3-6	REAL	AM-241	8.3860	pc/g		0.081	0.461
					REAL	U-239/40	53.9900	pc/g			
					REAL	U-233,-234	1.4840	pc/g			
					REAL	U-235	0.0921	pc/g			
					REAL	U-238DA	1.7660	pc/g			
TR12	2087340	749045	TR00267WCU2	0-3	REAL	AM-241	34.1700	pc/g		0.577	3.271
					REAL	U-239/40	591.2000	pc/g			
					REAL	U-233,-234	1.0140	pc/g			
					REAL	U-235	0.1239	pc/g			
					REAL	U-238DA	1.8320	pc/g			
			TR00266WCU2	3-6	REAL	AM-241	13.5300	pc/g		0.131	0.743
					REAL	U-239/40	93.0900	pc/g			
					REAL	U-233,-234	0.7726	pc/g			
					REAL	U-235	0.0323	pc/g			
					REAL	U-238DA	1.3680	pc/g			

Table 2-6 Alpha Spectroscopy Results of Trench Soil Samples - OU2 Rf/RI

Table 2-7 Alpha Spectroscopy Results of Surface Soil Samples - HPGe Double Sampling Locations

HPGe Measurement Location	Easting	Northing	Am-241 (pCi/g)	Pu-239/240 (pCi/g)	U-233/234 (pCi/g)	U-235 (pCi/g)	U-238 (pCi/g)	Tier II SOR
30	2087180.071	749564.78	3.503	18.850	0.784	0.075	1.128	0.03
104	2086540.732	748734.16	26.981	133.145	0.899	0.072	1.315	0.22
265	2086703.63	749219.19	46.381	143.322	0.795	0.063	1.472	0.32
266	2086716.983	749249.52	20.113	127.092	0.684	0.026	0.915	0.18
305	2087381.285	749310.79	10.880	57.672	0.797	0.041	1.108	0.09
406	2086548.208	749086.09	73.682	533.855	0.804	0.077	1.671	0.72
460	2086554.05	749026.53	134.175	782.790	0.967	0.069	2.197	1.18
669	2085947.078	748667.47	53.166	328.215	0.748	0.028	1.108	0.48

Radionuclide results reported as the weighted averages over the HPGe measurements field of view

SOR - Sum of ratios

Table 2-8 Alpha Spectroscopy Results of Surface Soil Samples - Actinide Migration Evaluation Project

Sample Number	Easting	Northing	Am-241 (pCi/g)	Pu-239/240 (pCi/g)	U-233/234 (pCi/g)	U-235 (pCi/g)	U-238 (pCi/g)	Tier II SOR
SSSE05398	2087390	749012	20.100	397.000	NA	NA	NA	0.37
SSSE05498	2087398	748502	0.855	4.770	NA	NA	NA	0.01

NA - Not Analyzed

SOR- Sum or ratios

parent (^{238}U) and daughter (^{234}U) suggests the activity ratio between these two isotopes should be 1.0. Surface soil data collected in support of the OU2 Phase II RFI/RI supports this relationship with an average activity ratio of 0.97 between the two isotopes. Therefore, the activity of $^{233/234}\text{U}$ in surface soil was assigned the value measured by the HPGe survey for ^{238}U .

2.2.3 FIDLER Surveys

A FIDLER survey was conducted in a selected area where an isolated HPGe measurement exceeded the 10 pCi/g ^{241}Am decision level. The FIDLER survey was conducted at HPGe measurement location 301 to determine if the measurement result was caused by the presence of a smaller area containing a hot spot. In addition, two FIDLER surveys were conducted at HPGe measurement locations 460 and 462 where HPGe measurements exceeded the RFCA Tier I RSALs based on preliminary results using the sum-of-ratios methodology. The purpose of the survey was to determine whether contamination was homogeneous and widespread as suggested by the conceptual model, or heterogeneous and consists of numerous individual hot spots.

A grid with four-foot spacings was staked in the field to encompass the circular FOV for the HPGe measurement. A total of 37 FIDLER measurements were collected from each selected HPGe measurement location. FIDLER measurements were taken with the instrument placed on the ground surface at each of the four-foot grid nodes for a one-minute count. FIDLER surveys were conducted in accordance with Radiological Safety Procedure, 3-PRO-112-RSP-2.01, Job Aid: 4-JOB-010-RSP-02.01.07, Bicron FIDLER (Kaiser-Hill, 1999b).

2.3 SUBSURFACE SOIL INVESTIGATION

The subsurface soil investigation consisted of two phases. One phase was the radiological investigation consisting of shallow boreholes. The second phase consisted of the VOC investigation.

2.3.1 Radiological Investigation

Subsurface soil sampling for radiological characterization was conducted at the 903 Pad and Lip Area. The depth of radiological contamination is required to estimate the volume of soil requiring remedial action. Figure 2-12 provides the radiological subsurface sampling locations for the 903 Pad and Lip Area. Samples were analyzed for ^{241}Am , $^{239/240}\text{Pu}$, $^{233/244}\text{U}$, ^{235}U , and ^{238}U using alpha spectrometry. Boring logs are presented in Appendix A.

903 Pad - Twenty-five shallow boreholes were drilled for the characterization of radionuclide contamination beneath the 903 Pad. Twenty-five boreholes over the 3.4-acre 903 Pad represents a borehole completed at each node of a 23 m by 23 m (75 ft by 75 ft) grid (Figure 2-12). Subsurface soil samples were collected from artificial fill material and natural soils beneath the 903 Pad for radiochemical analysis utilizing single-tube Geoprobe hydraulic push drilling technique. Soils were continuously cored to a total depth of approximately 1.2 m (4 ft) to ensure core recovery or to a depth where the FIDLER indicated less than 5,000 cpm. Samples were collected at approximately 15 cm (6 in) intervals from the top of and below the asphalt or as appropriate to differentiate the sample interval between asphalt, artificial fill material, and natural soils. This was done to prevent potential dilution of the natural soil samples below the artificial fill material. Borings and core were checked by engineer's tape for total depth and recovery. Samples for radiological screening were collected as a composite sample from the radiological sample. Soil samples were screened for alpha, beta/gamma, and VOCs using portable field instruments. If VOCs were detected above 10 parts per million by field instrumentation at any sampling location, the VOC subsurface soil sampling program, as described in the SAP (RMRS, 1998a), was implemented to characterize VOC contamination at that location.

Subsurface soil samples for radiochemical analysis were also collected during the VOC subsurface investigation as described in Section 2.3.2. Soil samples were collected from 12 original and three "step-out" boreholes on the 903 Pad, one borehole west of the 903 Pad, and one borehole east of well 07191 in the Lip Area (see Figure 2-13).

40

Lip Area - A total of thirty-seven boreholes were completed over the Lip Area where artificial fill was placed in 1970 and where surface soils were remediated in 1976, 1978, and 1984. Of the 37 boreholes, 25 borings were original and twelve were "step-out" borings (Figure 2-12). Of the 37 boreholes, two boreholes were completed in the 1976 remediation area, six boreholes were completed in the 1978 remediation area, and three boreholes were placed in the 1984 remediation area.

Shallow soil borings located in the 903 Lip Area and soil samples were collected utilizing single-tube Geoprobe hydraulic push drilling technique. Soils were continuously cored to either a total depth of 0.9 m (3 ft) or 1.2 m (4 ft) to ensure core recovery, or to a depth where the FIDLER indicated less than 5,000 cpm. Samples were collected at approximately 15 cm (6 in) intervals or as necessary to differentiate the sample interval between artificial fill material and natural soils. This was done to prevent potential dilution of the natural soil sample below the artificial fill material. Borings and core were checked by engineer's tape for total depth and recovery. Samples for radiological screening were collected as a composite sample from the radiological sample. Soil samples were screened for alpha, beta/gamma, and VOCs using portable field instruments.

A detailed surface soil characterization using HPGe was not performed in portions of the Lip Area where surface/subsurface soils were collected (RMRS, 1998a).

2.3.2 VOC Investigation Boreholes

Investigation of VOC contamination at the 903 Pad, completed per the SAP (RMRS, 1998a), targeted the highest areas of groundwater contamination as well as the anomalous PCE soil gas results, east of groundwater well 07191. Figure 2-13 shows the borehole locations for the VOC investigation. Samples were analyzed for ^{241}Am , $^{239/240}\text{Pu}$, $^{233/244}\text{U}$, ^{235}U , and ^{238}U using alpha spectrometry and for VOCs using EPA Method 8260 or 8260B (EPA, 1986). Boring logs are presented in Appendix A.

Subsurface soil sampling was conducted near existing groundwater monitoring wells 06691, and 08891 using an upgradient radial placement geometry with the well location serving as the

downgradient location. Boreholes were located approximately 20 ft to the north, south, and west of well locations 06691, and 08891. Six boreholes were placed along the west to northwest side of the 903 Pad on the basis of aerial photographs showing drum storage and surface staining. A total of 15 boreholes were required to investigate the VOC contamination at the 903 Pad, the original 12 boreholes, two "step-out" boreholes (95998 and 97698), and one completion of a shallow subsurface radiological borehole (90998) as a VOC borehole (96498) where VOCs were observed with concentrations greater than 10 percent of the respective current Tier I SSALs.

The soil gas anomaly in the Lip Area at the southeast corner of the 903 Pad adjacent to well 07191 was evaluated. One borehole (97298) was located 20 ft east and 10 ft south of well location 07191. A surface area with little or no vegetation and FIDLER readings greater than 10,000 cpm was identified 30 feet east of well 6591, adjacent to the west side of the 903 Pad. One combined VOC and shallow radiological borehole (92598) was located to evaluate this area. The radiological sampling methodology for the Lip Area radiological subsurface investigation and the VOC sampling methodology, was followed for this borehole is described as follows.

VOC soil borings located in the 903 Pad and Lip Area and soil samples were collected utilizing a dual-wall Geoprobe hydraulic push drilling technique. Boreholes were advanced from the surface to either a depth of 0.31 to 0.62-m (1 to 2 feet) below the top of bedrock, or to a depth below the vertical extent of VOC contamination (based on field instruments), whichever was greater, provided refusal of the Geoprobe drilling equipment was not encountered. Samples were collected at approximately 1.22-m (4 ft) intervals below ground surface, or at intervals where VOCs were detected with field instrumentation. In general, the VOC samples were collected from approximately the lower 15-cm (6 in) interval and the radiological sample was collected from the 15-cm (6 in) interval above the VOC sample. Samples for radiological screening were collected from the 15-cm (6 in) interval above the radiological sample. Because of the different ionization potential between PCE and CCl₄, two photoionization detectors were used (10.4 and an 11.7 electron volt bulb). If VOCs were detected above 10% of the current Tier I SSALs, then the sampling grid was extended an additional 6.1-m (20 ft) in an upgradient direction of that location, and additional samples were collected for laboratory analysis.

42

2.4 903 PAD ASPHALT SAMPLES

Asphalt samples from the 903 Pad were collected to obtain preliminary waste characterization data for disposal purposes. Nine asphalt samples were collected randomly from the following locations over the 903 Pad: 90098; 90198; 90398; 90698; 90798; 91198; 91298; 91898; and 19198 (Figure 2-12). Random sampling techniques are appropriate methods for estimating the population mean and the standard error of this estimate. Locations were determined randomly based on the 903 Pad subsurface soil sampling grid. Samples were collected using a Geoprobe® and analyzed for ^{241}Am , $^{239/240}\text{Pu}$, $^{233/234}\text{U}$, ^{235}U , and ^{238}U using alpha spectroscopy.

2.5 WORK CONTROLS

Field activities were conducted in accordance with the procedures detailed in the SAP (RMRS, 1998a), the Task-Specific Health and Safety Plan (RMRS, 1998b) and additional controls summarized herein. Additional work controls implemented for the project included the ALARA Job Review (#903Pad-98-001) for fieldwork performed under job-specific Radiation Work Permits (RWPs). Contamination control included measurement of direct and removable contamination levels on equipment, wind speed monitoring (soil handling activities suspended with two consecutive 15-minute wind speed average of 15 miles per hour), high volume air sampling during soil handling activities, and requirements for personal protective equipment. Fieldwork also could not be performed due to sensitivity of the radiological field instruments when the humidity was greater than 90% and ambient temperatures less than 32 degrees Fahrenheit.

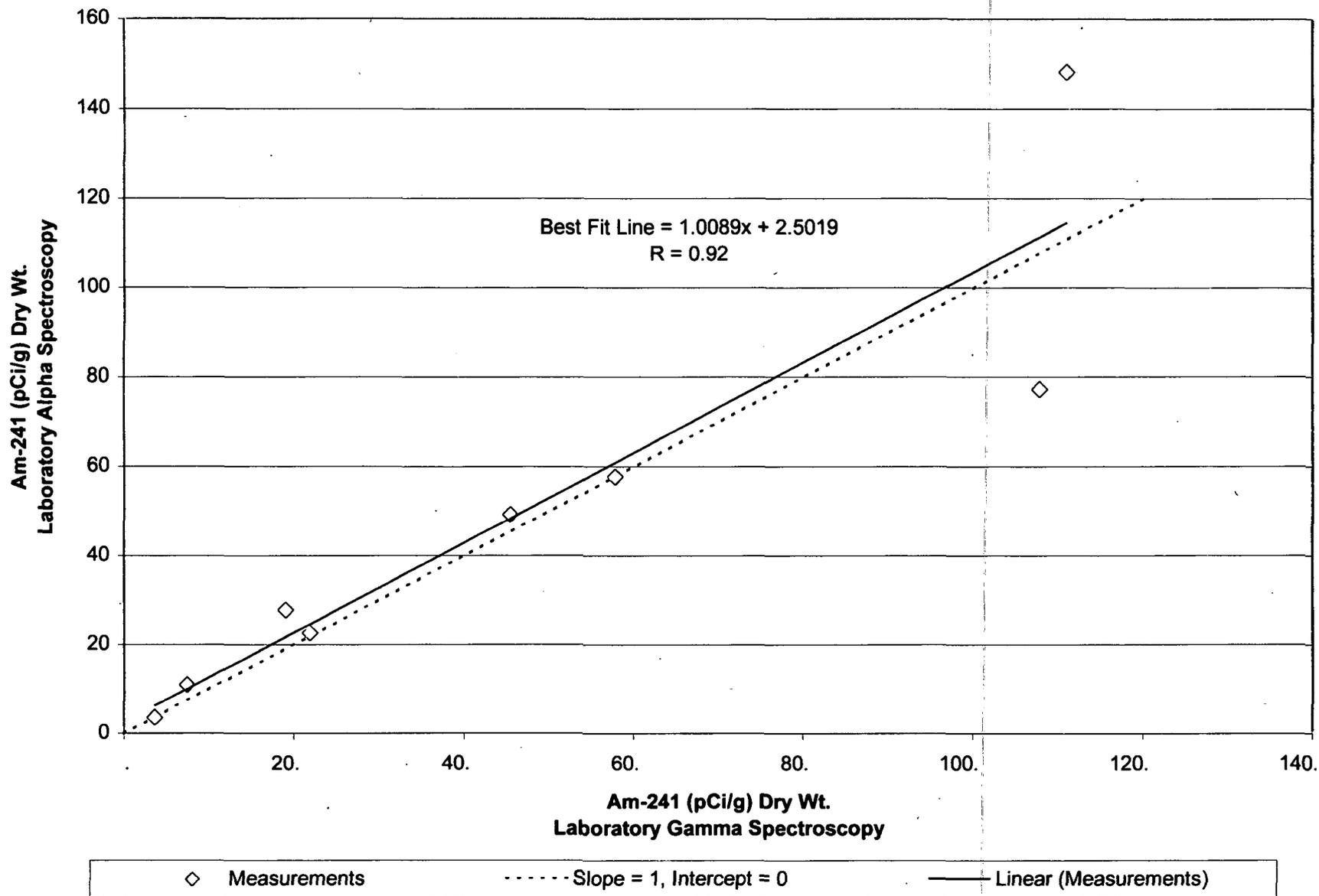
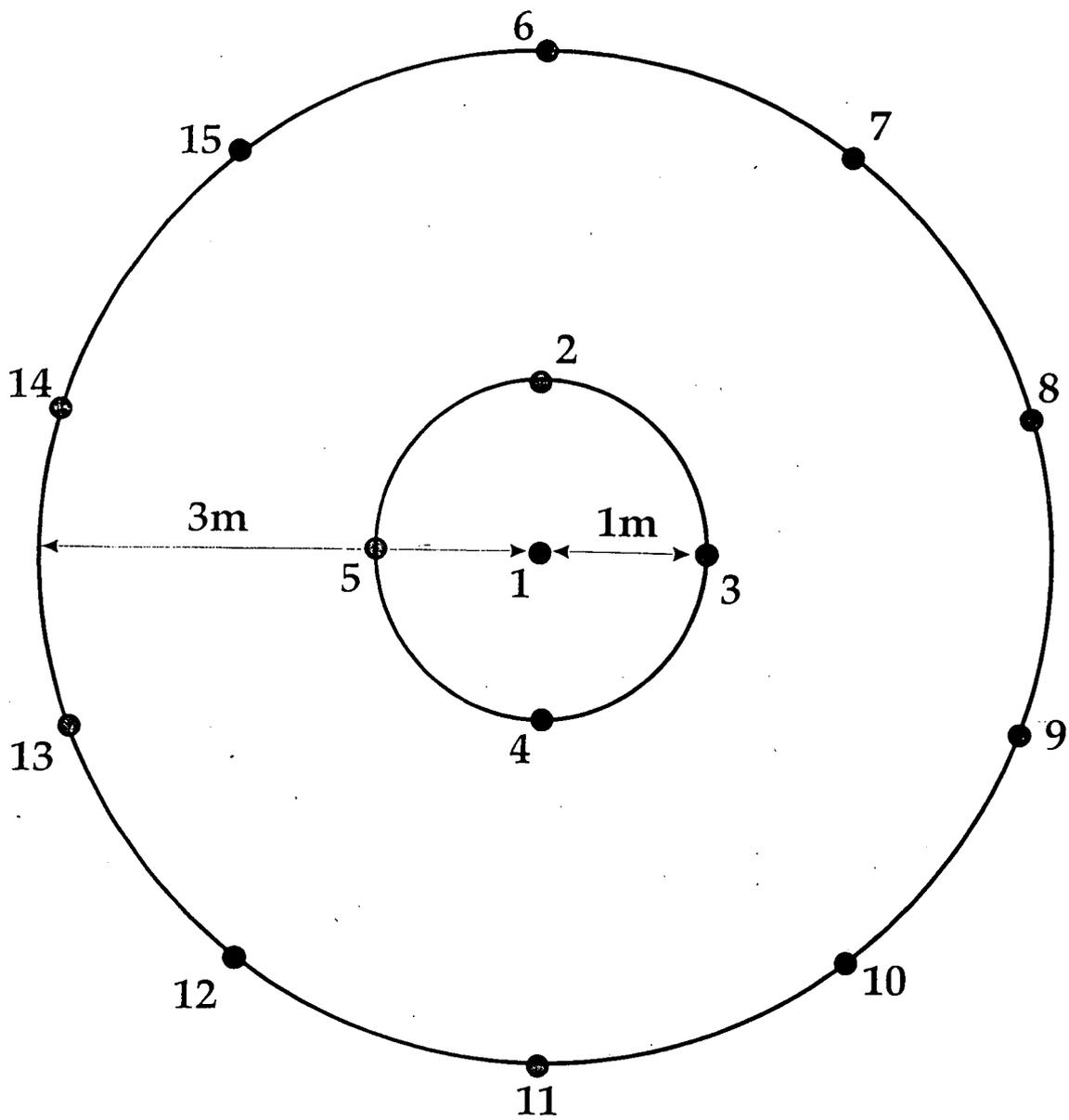


Figure 2-2 Laboratory Results of Soil Samples - Gamma Spectroscopy - Americium-41 vs. Plutonium-239/240 Correlation

45



15-Point Sampling Pattern

Characterization Report for the 903 Drum
Storage Area, 903 Lip Area
and Americium Zone

HPGe 15-Point Surface Soil Sampling Pattern

Figure 2-3

Explanation:

● Grab Sampling Location

46

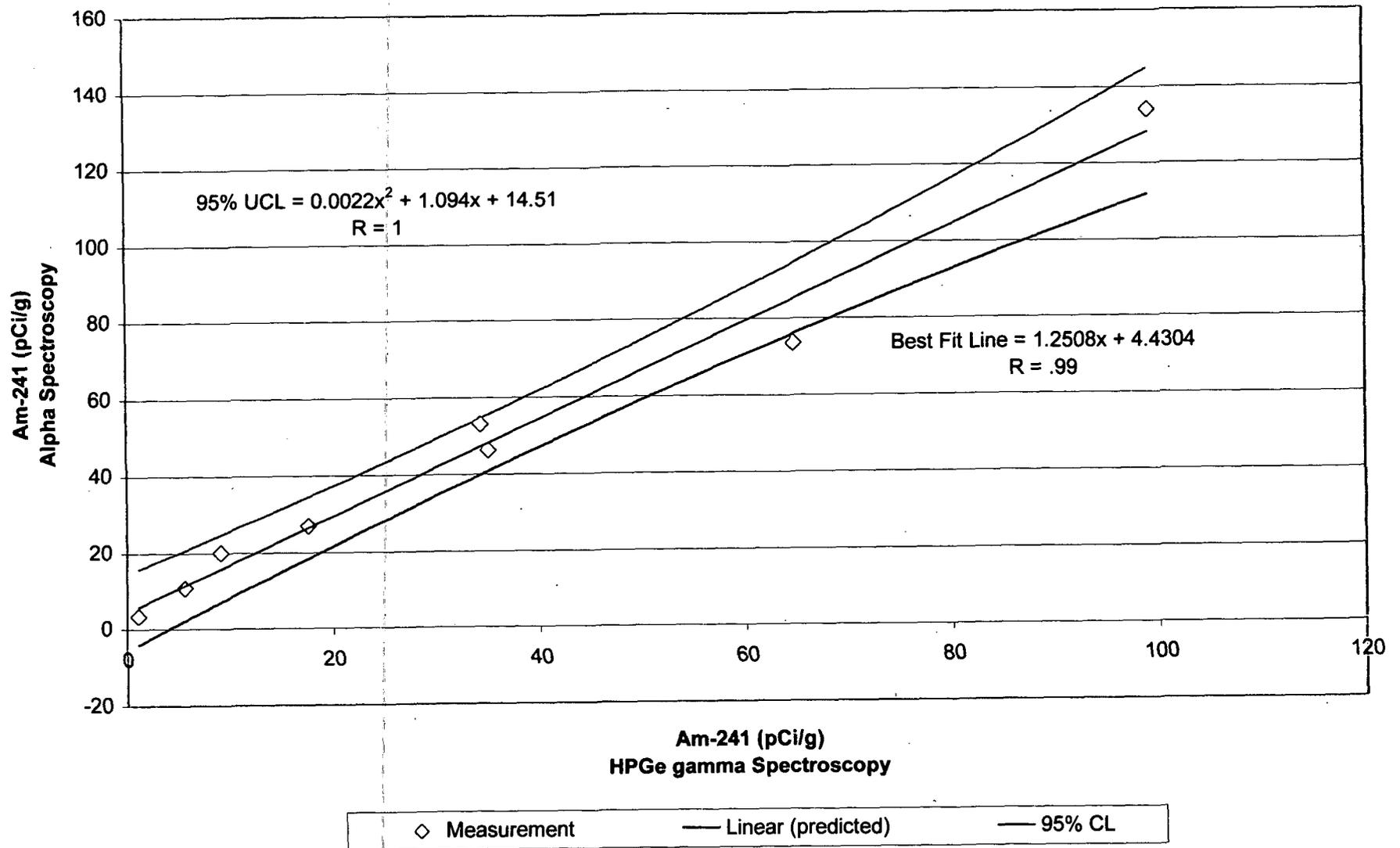


Figure 2-4 Alpha Spectroscopy vs. HPGe Gamma Spectroscopy - Americium-241 Correlation

47

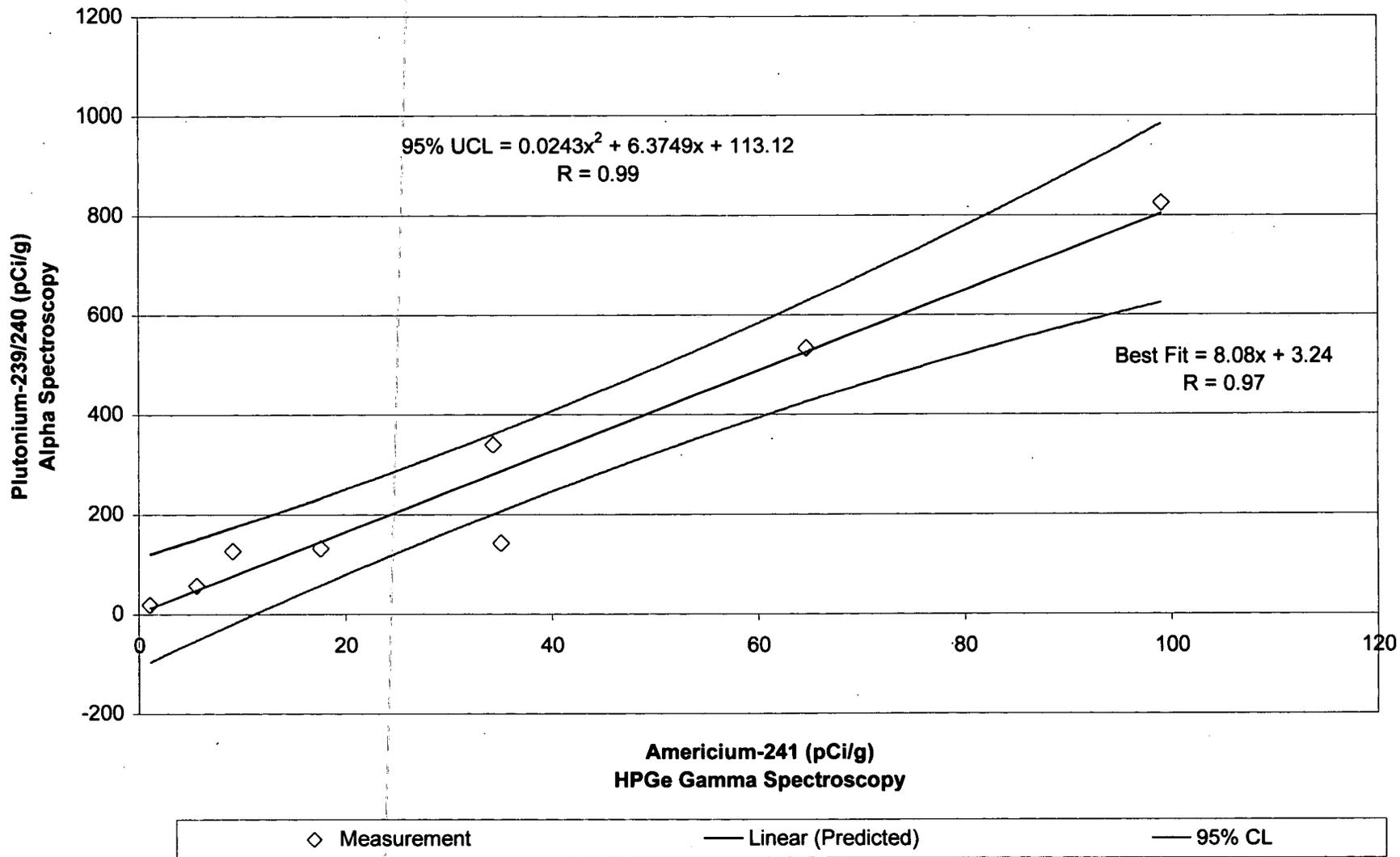


Figure 2-5 Alpha Spectroscopy vs. HPGe Gamma Spectroscopy - Americium-241 vs. Plutonium-239/240 Correlation

2/8

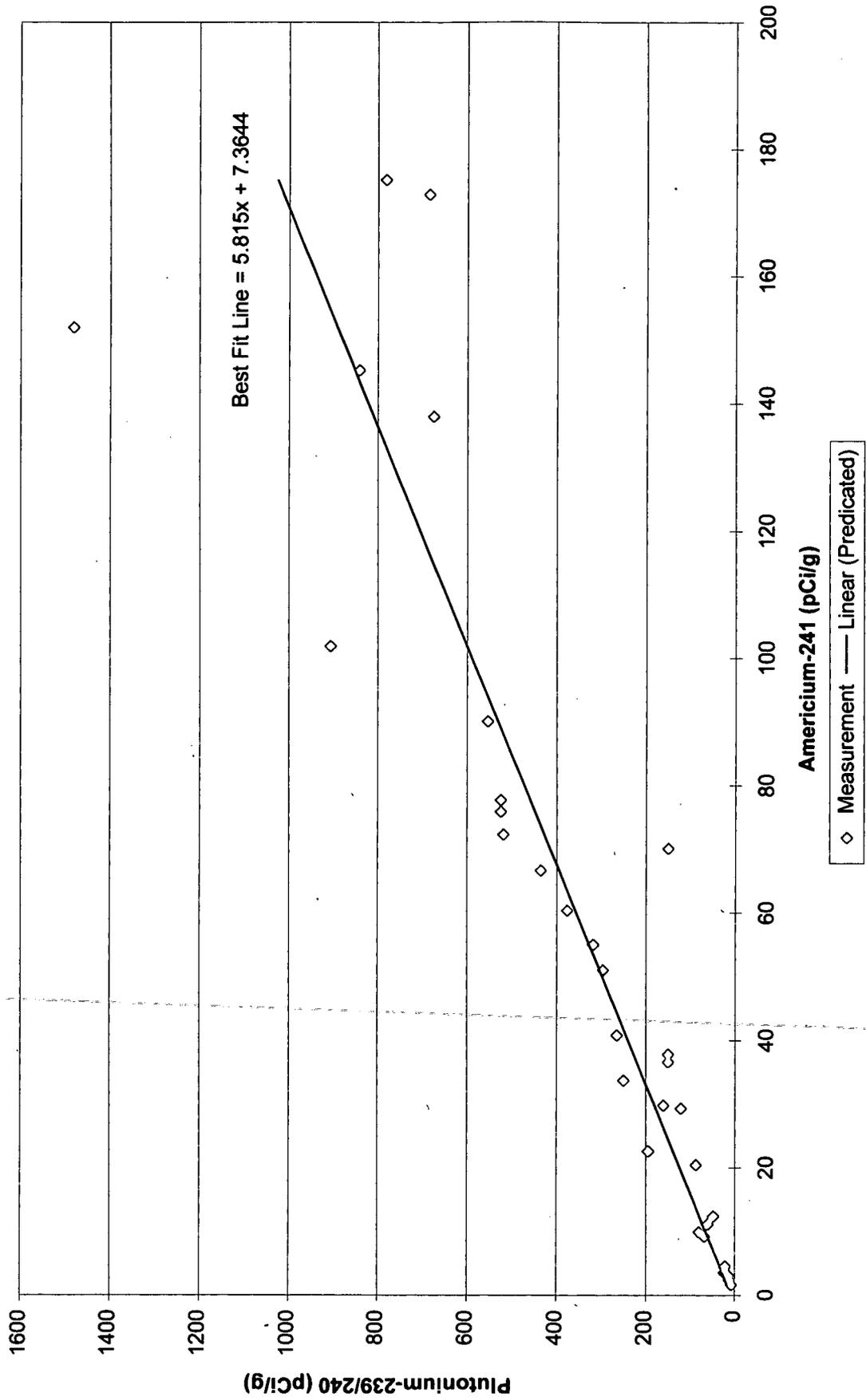


Figure 2-9 HPGe Survey Soil Sample Results- Plutonium239/240 vs. Americium-241 Correlation (Pu/Am Activity Ratio)

52

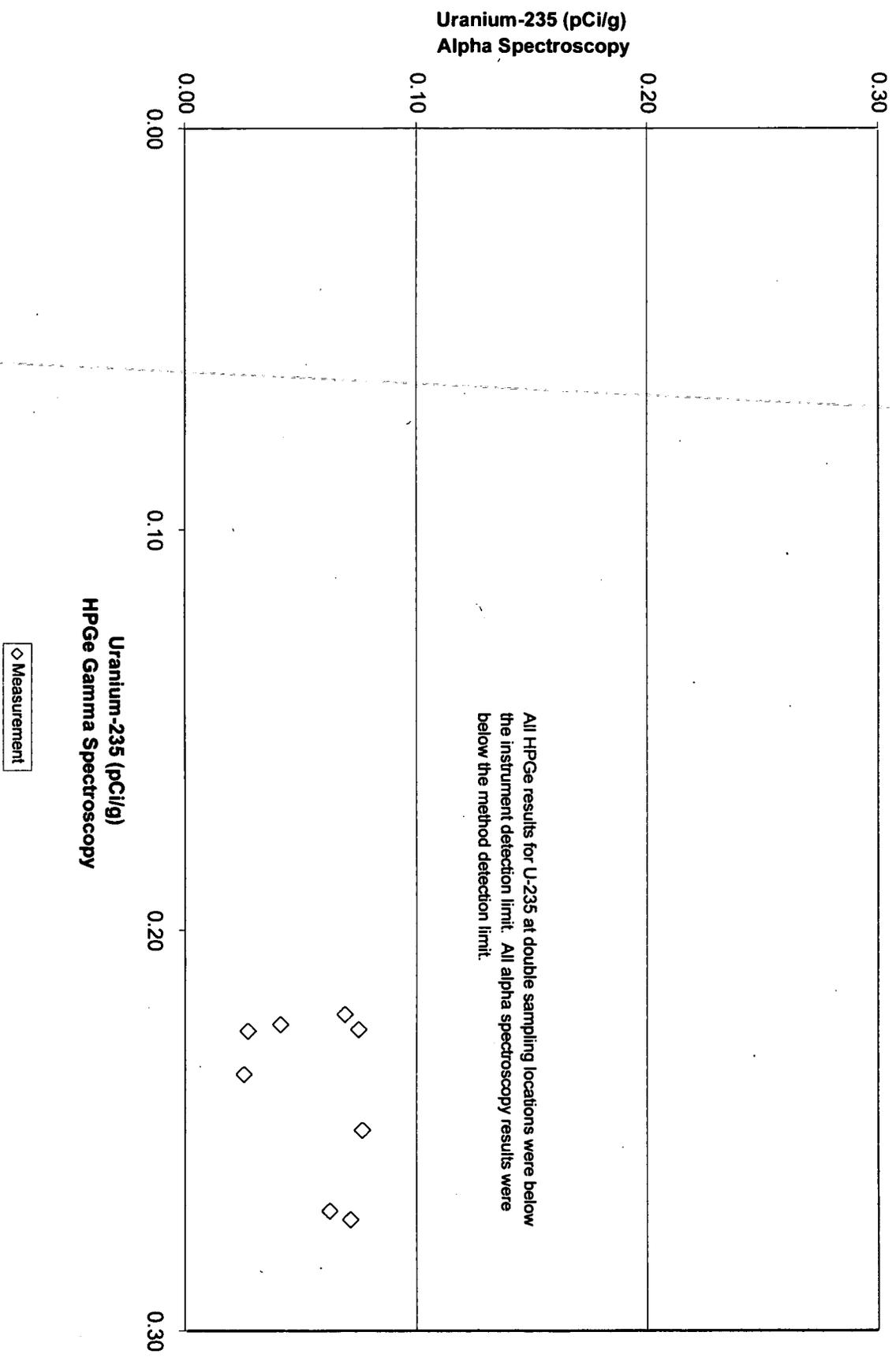


Figure 2-10 Alpha Spectroscopy vs. HPGe Gamma Spectroscopy - Uranium-235 Correlation

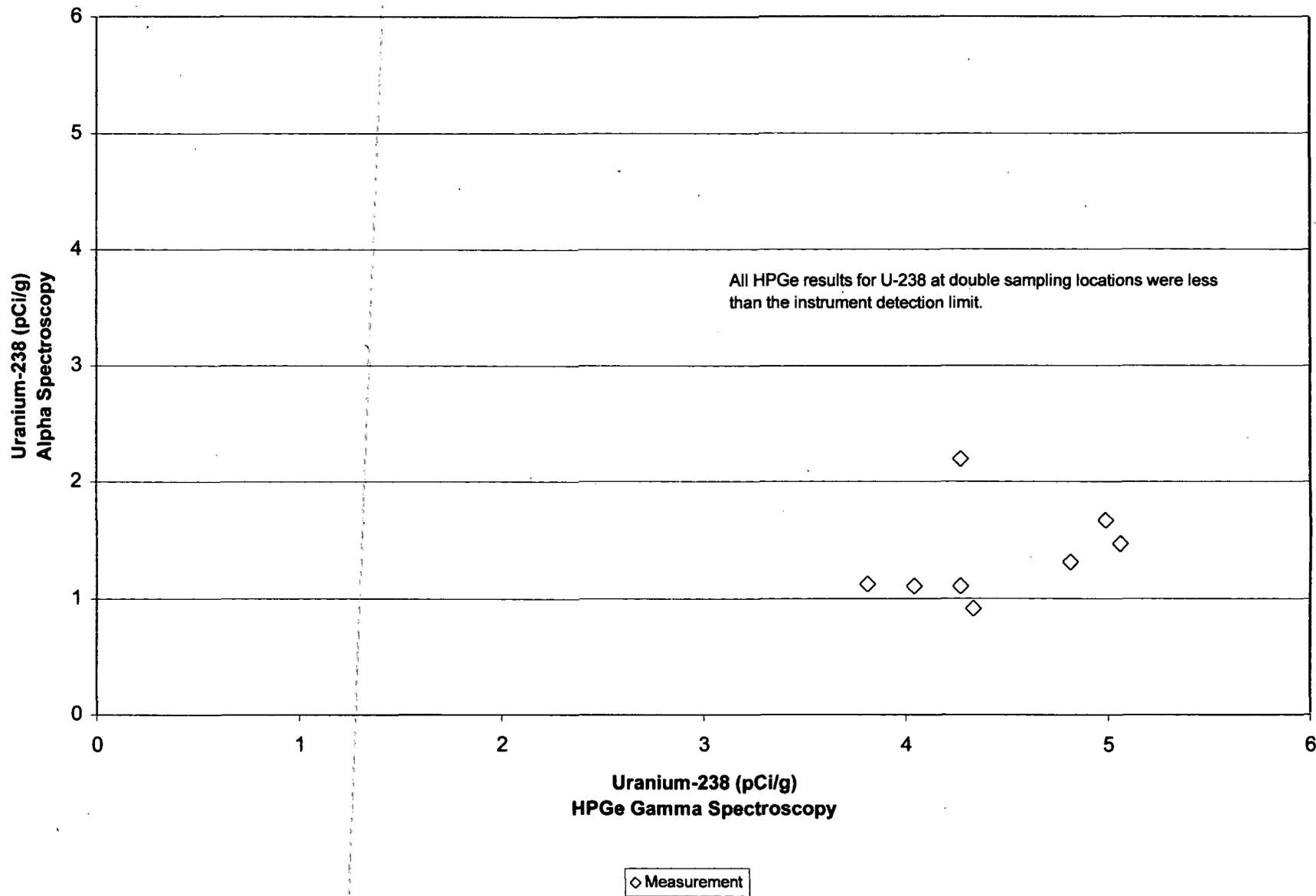


Figure 2-11 Alpha Spectroscopy vs. HPGe Gamma Spectroscopy - Uranium-238 Correlation

54

3.0 DATA QUALITY ASSESSMENT

This section provides the results of the data quality assessment that was conducted in accordance with the Evaluation of Data for Usability in Final Reports (RMRS Procedure, ER/RMRS-98-200 [RMRS, 1998c]). This assessment ensures that data used in making management decisions for remedial actions is of adequate quality to support the decisions.

As discussed herein, Data Quality Objectives for the project were achieved. A summary of project DQOs and the corresponding project decisions is presented in Table 3-1.

Table 3-1 Sample Types & Data Quality Objectives

Sample Type	DQO	Decision
Actinides in Surface Soils using <i>In situ</i> Gamma Spectroscopy.	Quantify spatial distribution of RFETS actinide activities that meet or exceed Tier I RSALs to estimate soil volumes requiring remediation. Quantify spatial distribution of ²⁴¹ Am to 10 pCi/g using HPGe gamma ray survey.	Spatial extent of actinide activities exceeding Tier I RSALs. Volume estimates of soils exceeding Tier I and Tier II RSALs.
VOCs in Subsurface Soils.	Quantify three-dimensional distribution of VOC concentrations that meet or exceed Tier I Soil Action Levels to estimate soil volumes requiring remediation.	Three-dimensional extent of VOC concentrations relative to Tier I soil action levels. Volume estimates of soils exceeding Tier I soil action levels.
Actinides in Subsurface Soils.	Quantify three-dimensional distribution of actinides to estimate soil volumes requiring remediation.	Three-dimensional extent of actinide activities relative to Tier I & II RSALs. Volume estimates of soils exceeding Tier I and II RSALs.

3.1 VERIFICATION OF RESULTS

Verification ensures that data produced and used by the project are documented and traceable per quality requirements. Generally, verification consists of reviewing the data to determine whether:

- Chain-of-Custody was intact from initial sampling through transport and final analysis;
- Preservation and hold-times were within tolerance;
- Selected samples underwent analysis at certified labs; and
- Format and content of the data is clearly presented relative to goals of the project.

In addition to the criteria noted above, verification of the data also included additional checks sometimes acknowledged as within the "validation" category, depending on the type of analysis:

- Surrogate recovery;
- MS/MSD recovery;
- Calibrations;
- Blanks;
- Sample preparations; and
- Other quality control.

In order to provide an integrated evaluation of the data quality, results of the verification are collectively discussed with validation in Section 3.2.

3.2 VALIDATION

Validation consists of a technical review of the data, or portion of the data, so that any limitations of the data relative to project goals are identified, and the associated data are qualified accordingly. Data were validated relative to the precision, accuracy, representativeness, completeness, and comparability (PARCC) parameters described in the next section. K-H Analytical Services Division also currently performs validation on a site-wide basis at 25% frequency. Satisfactory validation at this frequency indicates that the subcontracted labs are operating competently relative to industry-wide standards, and more specifically, that sample custody and analytical procedures are implemented under defined quality controls. Site-wide data-validation coupled with annual lab audits provides the inference that all analytical and radiochemical results not specifically validated, are represented by the percentage that is validated.

Validation by an independent third party was performed on 37 percent of the alpha spectroscopy data and 32 percent of the VOC data, which exceeded the requirement of 25 percent validation by an independent third party. The remaining alpha spectroscopy and VOC data were verified by an independent third party. Original verification and validation (V&V) packages for the project are managed and filed by the K-H Analytical Services Division, Building 881.

Verification and validation of the project data, summarized in Sections 3.1 through 3.3, included use of the following protocols and guidance:

- RMRS Procedure RF/RMRS-98-200, Evaluation of Data for Usability in Final Reports (RMRS, 1998c);
- USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review, EPA 540/R-94/013, (EPA, 1994b);
- USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review, EPA 540/R-94/012, (EPA, 1994a);
- Guidance for Data Quality Assessment, Practical Methods for Data Analysis, EPA QA/G-9, (EPA, 1996b);
- *Kaiser-Hill Team Quality Assurance Program*, Rev. 5, (K-H, 1997); and
- *RMRS Quality Assurance Program Description (QAPD)*, RMRS-QAPD-001, Rev. 2, (RMRS, 1998d).

3.3 PARCC PARAMETERS

3.3.1 Precision

Precision is a measure of the reproducibility of results. Precision is evaluated by comparing results from field duplicate and/or replicate (duplicate/replicate) samples with results from associated real samples. Precision will be evaluated quantitatively by using two functions, relative percent difference (RPD), and duplicate error ratio (DER), where the latter function is used to account for the stochastic nature of error of radioactivity. The DER is a test for bias between a field duplicate or replicate and the associated real sample for radionuclides.

Equations 3.1 and 3.2 present the RPD and DER equations

$$\text{RPD} = \frac{|C_1 - C_2|}{|(C_1 + C_2)/2|} * 100 \quad (\text{Eq. 3.1})$$

where:

C_1 = Concentration of the analyte in the real sample

C_2 = Concentration of the analyte in the duplicate sample

$$\text{DER} = \frac{|C_1 - C_2|}{\sqrt{(\text{TPU}_{C_1}^2 + \text{TPU}_{C_2}^2)}} \quad (\text{Eq. 3.2})$$

where:

TPU = total propagated uncertainty

Duplicate/Replicate Sample Collection Methodology

Field duplicate samples collected in support of the surface soil programs were collected as unique samples. The duplicate samples were generated from grab samples of surface soils collected at HPGe measurement locations. The grab samples were collected adjacent to the real samples collected over the same HPGe FOV, composited, and placed into sample jars. Replicate and real samples of subsurface soils collected for alpha spectroscopy analysis were generated by splitting the recovered core in half lengthwise. VOC quality control (QC) samples are identified as duplicates because the real and QC samples were collected from adjacent depth intervals (i.e. not split).

The purpose of the field duplicate and replicates are to evaluate the precision of the field sampling process. The QC criterion for RPDs is $\leq 40\%$, and for DERs the criterion is ≤ 1.96 . Individual RPDs/DERs can be found in Appendix B. Duplicate/replicate samples exceeding the DER QC criterion of 1.96 are interpreted as different at the 5% level of significance, are qualified as "J", and the conclusion is reached that the sample and duplicate/replicate differ. Duplicate/replicate samples exceeding the RPD QC criterion of 40%, indicate that precision does not comply with DQO specifications, and require an explanation and justification for deficiencies, and a determination if additional sampling is required. At least 85% of all quality control samples are required to comply with the established precision or RPD goals. The following sections describe the results of duplicate/replicate sample results for each laboratory analytical program.

Insitu Gamma Spectroscopy (HPGe) Program

The gamma spectroscopy unit collected a total of 1,110 *insitu* measurements. The required frequency of duplicate samples was one measurement for each set of 20 real measurements. A total of 58 duplicate measurements were collected (1 in 19.1) meeting the required collection frequency. All 58 duplicate measurements acquired were within error tolerances ($DER \leq 1.96$) for the measurable actinides of interest (^{241}Am , ^{235}U , and ^{238}U). This excellent performance by the *insitu* system indicates the large-area, physical-averaging is a repeatable method. Appendix C provides the TPU for HPGe measurements used in the DER calculations.

60

Laboratory Gamma Spectroscopy

A total of 24 real and nine duplicate surface soil samples (1 in 2.7) from three double sampling HPGe measurement locations were provided to the laboratory for gamma spectroscopy analysis for ²⁴¹Am. The frequency for duplicate sample collection for gamma spectroscopy analysis was met for this program. ²⁴¹Am activities were detected above the method detection limit in all samples. As shown in Table 3-2 two of the nine duplicate samples failed DER tolerances for an overall precision of 78%. Because DERs were calculated using the laboratory instrument's counting error as the only source of TPU, this overall precision is considered acceptable.

Table 3-2 Surface Soil Duplicate Assessment – Gamma Spectroscopy Results

Analyte	Total Real Samples Collected	Total Duplicates Collected	Number of Duplicates within DER	Overall Precision Compliance
²⁴¹ Am	24	9	7	78%

Laboratory Alpha Spectroscopy

As indicated in this section, the precision results for ²⁴¹Am and ^{239/240}Pu did not meet the project goal of 85% compliance. However, as discussed subsequently, the precision results do not compromise the objectives of the investigation.

Surface Soils

A total of 24 real and nine duplicate surface soil samples were collected from three double sampling HPGe measurement locations and were provided to the laboratory for alpha spectroscopy analysis for ²⁴¹Am, ^{239/240}Pu, and uranium isotopes. The frequency for duplicate sample collection for alpha spectroscopy analysis was met for this program. ²⁴¹Am activities were detected above the method detection limit in all samples. As shown in Table 3-3 eight of the nine duplicates failed DER tolerances for ^{239/240}Pu with an overall precision compliance of 11%. Five of the nine duplicates failed DER tolerances for ²⁴¹Am with an overall precision compliance of 44%. Uranium isotopes met the project's precision compliance goal. As with the laboratory gamma spectroscopy, DERs were calculated using the laboratory instrument's counting error as the only source of TPU.

61

Table 3-3 Surface Soil Duplicate Assessment – Alpha Spectroscopy Results

Analyte	Total Real Samples Collected	Total Duplicates Collected	Number of Duplicates within DER	Overall Precision Compliance
^{239/240} Pu	24	9	1	11%
²⁴¹ Am	24	9	4	44%
^{233/234} U	24	9	8	89%
²³⁵ U	24	9	9	100%
²³⁸ U	24	9	8	89%

Subsurface Soils

A total of 349 real and nineteen replicate surface and subsurface soil samples and asphalt samples were collected from boring locations and were provided to the laboratory for alpha spectroscopy analysis for ²⁴¹Am, ^{239/240}Pu, and uranium isotopes. The frequency for replicate sample collection (1 in 18.5) for alpha spectroscopy analysis was met for this program. As shown in Table 3-4, ten of the replicates failed DER tolerances for ^{239/240}Pu for an overall precision compliance of 44%. Six of the nineteen samples failed DER tolerances for ²⁴¹Am for an overall precision compliance of 68%. All uranium isotopes met the project's precision compliance goal. Again, DERs were calculated using the laboratory instrument's counting error as the only source of TPU.

Table 3-4 Radionuclide Subsurface Soil Replicate Assessment – Alpha Spectroscopy Results

Analyte	Total Real Samples Collected	Total Replicates Collected	Number of Replicates within DER	Overall Precision Compliance
^{239/240} Pu	349	19	9	47%
²⁴¹ Am	49 349	19	13	68%
^{233/234} U	349	19	19	100%
²³⁵ U	349	19	19	100%
²³⁸ U	349	19	18	95%

Discussion

One source of the apparent imprecision of the radionuclide data may be attributed to the exclusion of sources of uncertainty beyond the instrument counting error. The DER calculation incorporates TPU that includes all uncertainties introduced from sample collection in the field

62

through radiological analysis. However, the only uncertainty included in the TPU for this data quality assessment is the counting error at the 2-sigma level. This reduction in uncertainty in the TPU term leads to an exaggerated number of samples exceeding the DER of 1.96.

Secondly, when comparing the gamma and alpha spectroscopy DER results there appears to be an increased error associated with analyzing only an aliquot (0.25 to 2.0 grams) of the sample using alpha spectroscopy versus analyzing the entire sample (gamma spectroscopy). The overall precision for ^{241}Am using gamma spectroscopy was 78% compared to 44% for alpha spectroscopy. Since the duplicate samples were collected from the same locations as the samples analyzed using gamma spectroscopy, a significant portion of difference in overall precision for ^{241}Am between these two methods may be attributed to the heterogeneous distribution of ^{241}Am on a small scale, as exemplified by this comparison.

This heterogeneity is also obvious by comparing the surface soil "duplicate" sample results (Table 3-3) to the subsurface soil "replicate" sample results (Table 3-4). As can be seen from the subsurface sample program, the overall precision of "replicate" samples for ^{241}Am and $^{239/240}\text{Pu}$ (47% and 68%, respectively) are higher than the overall precision of "duplicate" samples (^{241}Am at 11% and $^{239/240}\text{Pu}$ at 44%). "Duplicate" samples were unique samples collected from adjacent locations whereas "replicate" samples for subsurface soils were splits from the same recovered core. The heterogeneous distribution of ^{241}Am and $^{239/240}\text{Pu}$ activities in surface soils is evident at these small intersample distances. Heterogeneity is also observed in the FIDLER survey results (Section 4.1.3).

Although it is clear that micro-scale heterogeneous distributions exist for ^{241}Am and $^{239/240}\text{Pu}$ activities in surface soil, the high degree of correlation between the lower precision alpha spectroscopy results and the higher precision HPGe gamma spectroscopy results indicate insignificant impact to the regression "model". With respect to subsurface soils, the distributions of ^{241}Am and $^{239/240}\text{Pu}$ activities do not indicate patterns anomalous to those expected from the site conceptual model and/or historical data.

Volatile Organic Compound Analysis (EPA 8260B)

A total of 86 real and five duplicate subsurface soil samples (1 in 17.2) were collected and provided to the laboratory for analysis of VOCs. Therefore, the frequency for duplicate sample collection for VOC analysis was met for this program. Table 3-5 provides the number of samples collected under this program and the results of the RPD for the duplicate assessment. One sample pair detected VOCs in both the duplicate and associated real sample. The four other RPD calculations were conducted on sample pairs that had VOC detections in the real samples but not in the associated duplicate sample. The method detection limit was used in RPD calculations when no detections were found in the duplicate sample. Overall precision compliance for the VOC investigation was 60% where two of five duplicate sample sets were observed to exceed the RPD of 40%. Although the relative percent differences in concentrations between the real duplicate samples for each of these analytes may be significant, the detected concentrations are all well below their respective current RFCA Tier I soil action levels, i.e. because of the relatively low magnitudes of the concentrations, imprecision does not affect overall project decisions relative to VOC contamination.

Table 3-5 Duplicate Sample Assessments – Volatile Organic Compound Analysis

Analyte	Total Real Samples Collected	Total Duplicates Collected	Number of Duplicates within RPD	Overall Precision Compliance
PCE	86	5	3	60%
TCE	86	5	3	60%
CCL ₄	86	5	4	80%
1,2-DCE	86	5	3	60%

Although the overall precision compliance is less than project completeness goals, precision of the VOC results is acceptable. The apparent imprecision noted is limited to values well below the Tier I soil action levels (i.e., between detection limits and 10% of Tier I soil action levels), and, as such, does not impact project decisions relative to nature and extent of VOC contamination in the soil.

64

3.3.2 Accuracy

Accuracy is a measure of how closely an analytical or survey result corresponds to the true concentration or activity in a sample. Systematic uncertainties that affect accuracy, also known as bias, are also discussed in this section.

In-Situ Gamma Spectroscopy

The accuracy of *insitu* gamma spectroscopy is corroborated through two methods of validation implemented for the project: systematic validation, and more importantly, performance validation, that is, through the use of comparing and correlating surface soil samples analyzed by laboratory alpha spectroscopy. The quality of the correlation, which exhibited a high correlation coefficient for linearity (Figure 2-5), validate the entire gamma spectroscopy measurement system relative to the site-specific matrix types and radiological levels of interest.

The systematic validation of gamma spectroscopy results yielded no significant qualifications to the data. Detailed technical considerations and their effects on data quality are further detailed in the Appendix C under "903 Pad *insitu* Models and Uncertainties".

Another measure of accuracy is determined by comparing the detection limit proposed to the actual detection limit reported for the sample results. Table 3-6 provides a comparison of detection limits for the *Insitu* Gamma Spectroscopy program.

Table 3-6 Comparison of Detection Limits – *Insitu* Gamma Spectroscopy

Analyte	Required Analytical Method	Required Detection Limit (pCi/g)	Actual Detection Limit (pCi/g)
²⁴¹ Am	<i>Insitu</i> Gamma Spectroscopy	1.0	0.38 – 1.43
²³⁵ U	<i>Insitu</i> Gamma Spectroscopy	0.5	0.36 - 0.72
²³⁸ U	<i>Insitu</i> Gamma Spectroscopy	5.0	1.31 – 6.49

As can be seen in Table 3-6 the lower limit of the actual detection limit was met for all three radionuclides. The required detection limit was exceeded for ^{241}Am and ^{238}U in a limited number of analyses; however, these exceedances do not significantly impact the results of the HPGe survey nor the resulting volume estimates.

Laboratory Alpha Spectroscopy

The accuracy of laboratory alpha spectroscopy data was evaluated with respect to detection limits. Table 3-7 provides a comparison between required detection limits and actual detection limits.

Table 3-7 Comparison of Detection Limits – Alpha Spectroscopy

Analyte	Required Analytical Method	Required Detection Limit (pCi/g)	Actual Detection Limit (pCi/g)
$^{239/240}\text{Pu}$	RC01B001	0.3	0.028 - 0.122
^{241}Am	RC01B001	0.3	0.0061- 0.168
$^{233/234}\text{U}$	RC01B001	1.0	0.015 – 0.472
^{235}U	RC01B001	1.0	0.016 – 0.472
^{238}U	RC01B001	1.0	0.008 – 0.643

As can be seen in Table 3-7 the actual detection limit was lower than the required detection limit for all radionuclides. Therefore, accuracy from alpha spectroscopy detection limits were adequate for all sample analyses for decision making purposes.

Volatile Organic Compound Analysis (EPA 8260B)

The accuracy of VOC data was evaluated with respect to detection limits. Table 3-8 provides a comparison between required detection limits and actual detection limits.

The method detection limit was changed during the middle of the VOC Subsurface Investigation from the mid-level detection limit (Method 8260B) specified in the SAP (RMRS, 1998b) to a low-level detection limit (Method 8260). The required detection limit of 740 ug/kg was exceeded for the target analytes in all samples from boring 96498, and in one sample each from borings 96198 and 96298. The detection limit exceedance in samples from boring 96498 was due to sample analysis using the VOA-CLP, medium level, method. However, the actual detection limit

is lower than the current Tier I soil action levels for VOCs and therefore did not impact decision making.

Table 3-8 Comparison of Detection Limits – Volatile Organic Compound Analysis

Analyte	Required Analytical Method	Required Detection Limit (ug/kg)	Actual Detection Limit (ug/kg)
Carbon Tetrachloride	8260B	740	5.0 – 1500
Chloroform	8260B	740	0.1 – 1500
Cis-1,2-dichloroethene	8260B	740	0.1 – 1500
Methylene Chloride	8260B	740	1.4 – 1500
Tetrachloroethene	8260B	740	0.41 – 1500
Trichloroethene	8260B	740	0.31 - 1500

During review of the data the following biases were noted that cause the data to be qualified. Two other types of QC samples were generated in support of the VOC subsurface soil investigation; equipment rinse blanks and trip blanks. Table 3-9 provides a QC summary for methylene chloride detected in an equipment rinse blank and the associated real samples. Per EPA guidance (EPA, 1989) the methylene chloride detections in the real samples are less than ten times the detection in the associated equipment rinse blank and will be qualified as non-detect. Although trip blanks were submitted and analyzed with real samples, no qualifications were required for the associated real samples.

Methylene chloride was detected at estimated (J) concentrations in 16 samples (0.59 J to 410 J ug/Kg) at less than the method reporting limit. However, the maximum detected concentration in a method blank from the entire sample data set is 860 ug/Kg. Using EPA guidance (EPA, 1989) the concentration in the samples do not exceed ten times the maximum amount detected in any blank. Therefore, methylene chloride detections are considered a result of laboratory contamination.

Acetone was not detected in the associated rinse or method blanks in several samples from boring 97698 (99A8275), however, acetone may not be present in the sample because the continuing calibration verification criteria were not met. Acetone was detected in samples from boring 96398 (99A4102) (ranging from 1,200 up to 3,300 ug/Kg). However, the maximum detected

concentration in a method blank from the entire sample data set is 670 ug/Kg. Using EPA guidance (EPA, 1989) the concentration in the samples do not exceed ten times the maximum amount detected in any blank. Therefore, acetone detections are considered a result of laboratory contamination.

Table 3-9 Quality Control Sample Summary

QC Sample ID	QC Sample Type	Assoc. Real Sample(s)	Analyte(s) Detected in QC Sample	Detect in Real Samples Associated Method-Blank (yes/no)	Comments
99A6650-007.002	equipment rinse blank	99A6650-002.002	Methylene chloride	no	Methylene chloride detections in field samples <10 times the detection in the QC sample. Result will be qualified as non-detect (U) (EPA, 1989).
		99A6650-003.002		no	
		99A6650-004.002		no	
		99A6650-005.002		no	
		99A6650-006.002		no	
				no	

The compound trichlorotrifluoroethane was detected in several samples from borehole 97698 (99A8275). Detections of trichlorotrifluoroethane are not considered repeatable as the dilution results for this sample indicated trichlorotrifluoroethane was no longer present. The results were assigned the J148 qualifier, as the associated value is estimated and the linear range of the measurement system was exceeded. Results were then adjusted with the dilution Contract Required Quantitation Limit and given the qualifier UD, the associated value is considered undetected at an elevated level of detection.

PCE was detected in two samples from boring 95998, at 1,540 ug/kg and 343 ug/kg with an E (estimated) qualifier. When re-analyzed by the lab the PCE results were 3,060 ug/kg and 174 ug/kg, respectively, with a D qualifier (dilution).

Qualifications of VOC data did not affect accuracy or project decision making. VOC samples were analyzed using an expedited turn-around to assist field decisions based on "Form-1's" faxed from the laboratory. Although VOC detection limits varied during the course of the project, the

detection limits were lower than the current Tier I soil action levels for VOCs and therefore did not impact decision making.

3.3.3 Representativeness

Representativeness is evaluated by comparing the number and types of samples identified in the SAP with the number and type of samples actually collected. The number of samples required was based on meeting the DQOs of the characterization. Table 3-10 provides a comparison of planned samples vs. actual samples collected in support of the investigation. Table 3-11 provides a comparison of QC samples and real samples collected for the investigation.

As can be seen from Table 3-10, all areas met or exceeded planned sample requirements with the exception of the HPGe survey in the Lip Area and characterization of the asphalt and fill at the 903 Pad by alpha spectroscopy. Surface soils in the Lip Area were characterized by twenty borings completed during the subsurface radiological program. Sample results collected from the 0-6 inch interval were used to characterize surface soils in this area. Asphalt and fill samples were to be collected at all 25 boring locations within the 903 Pad. This number of samples was later determined to be excessive and the SAP was revised to include the collection of samples at nine randomly selected locations.

As can be seen from Table 3-11, the collection frequency of quality control samples was met for all analytical programs with the exception of trip blanks. Detections of VOCs in soil samples shipped without trip blanks are considered actual detections except where qualified previously as a laboratory contaminant.

3.3.4 Completeness

Completeness is typically expressed as a percentage, calculated as a ratio of usable results to the number of samples collected. One hundred percent of the data were verified at the project level based on comparing usable data points with non-usable data points (RMRS, 1998c).

Completeness is 100% exceeding the project's goal of 90%. Additional sampling is not required

Table 3-10 Planned vs. Actual Sample Comparison

Area (Program)	Analysis	Planned No. of Samples (per SAP)	Actual Number of Samples Collected	Deviation	Justification
Lip Area and Americium Zone	<i>In situ</i> Gamma Spectroscopy	1,200	1,110	-90	Borehole samples from 0 – 6 inch interval were used to characterize Lip Area east of the 903 Pad. This deviation from the SAP was approved by the agencies.
Americium Zone Surface Soils	Alpha Spectroscopy and Gamma Spectroscopy	18 from 6 FOVs	24 from 8 FOVs	+6	Collected samples from two additional FOVs for correlation of HPGe samples and field quality control locations.
903 Pad Radiological	Alpha Spectroscopy	150	107	-43	Original estimate erroneously included samples of asphalt and fill for 25 boreholes. Reduced number of fill samples to same frequency as asphalt samples. This deviation from the SAP was approved by the agencies.
903 Pad Asphalt	Alpha Spectroscopy	9	9	0	
903 Pad VOC (Subsurface VOC)	Alpha Spectroscopy	72	76	+4	Collected additional samples as a result of "stepout" borings.
903 Pad VOC	VOC	72	77	+5	Collected additional samples as a result of "stepout" borings.
903 Lip Area Radiological	Alpha Spectroscopy	100	148	+48	Collected additional samples as a result of "stepout" borings.
903 Lip Area VOC	Alpha Spectroscopy	6	9	+3	Collected additional samples as a result of "stepout" borings.
903 Lip Area VOC	VOC	6	9	+3	Collected additional samples as a result of "stepout" borings.

Table 3-11 QC Sample Type, Quantity

Sample Type (Program)	Analysis	Number of Investigative Samples	Number of Duplicate/ Replicate Samples	Number of Rinse Blank Samples	Number of Trip Blank Samples
Americium Zone Surface Soils (HPGe)	Alpha Spectroscopy	24	9	3	
Americium Zone Surface Soils (HPGe)	Gamma Spectroscopy	24	9	0	
903 Pad Radiological (Subsurface)	Alpha Spectroscopy	107	6	4	
903 Pad Asphalt (Subsurface)	Alpha Spectroscopy	9	1	0	
903 Pad VOC (Subsurface)	Alpha Spectroscopy	76	4	4	
903 Pad VOC (Subsurface)	VOC	77	4	3	2
903 Lip Area Radiological (Subsurface)	Alpha Spectroscopy	148	8	10	
903 Lip Area VOC (Subsurface)	Alpha Spectroscopy	9	0	0	
903 Lip Area VOC (Subsurface)	VOC	9	1	2	1
Project Totals	Alpha Spectroscopy	373	28	21	
	Gamma Spectroscopy	24	9	0	
	VOC	86	5	5	3

to meet the project objectives of estimating soil volumes exceeding action levels and characterizing surface soils to 10 pCi/g ²⁴¹Am.

3.3.4.1 Deviations

Despite weather constraints and field activities conducted non-sequentially among the subsurface investigations of the 903 Pad, Lip Area, and the VOC program, quality control samples were collected at a frequency of one in 20 during the entire subsurface investigation. Trip blank samples for VOC samples were reduced to a frequency of one trip blank for every 20 real VOC samples, detections not associated with a trip blank will be considered actual detects. Two of the required VOC trip blank samples were missed. This deviation from the SAP is justifiable as the analytical data is adequate to characterize subsurface soil and thus is representative of the subsurface soil conditions. Gamma spectroscopy analysis of aqueous samples could not be performed on rinse blank water samples. Two of the VOC investigation boreholes were not completed to bedrock due to refusal of the geoprobe sampling equipment at boreholes 96798 and 97698. Data collected from these boreholes are adequate and representative of subsurface soil conditions.

3.3.5 Comparability

All results presented are comparable with historical sampling and analyses results. This comparability is based on standard methods (EPA-approved methods), systematic quality controls, and thorough documentation of the planning, sampling, and analysis process.

The comparability of two samples were questioned during the investigation. One sample from HPGe measurement location 104 at 3 meters (98A5590-001.006) was reanalyzed as sample 98A5590-004.001 because ²⁴¹Am results from the first analysis were elevated and not comparable to the other sample results collected at this location. One alpha spectroscopy sample result from boring 94298 (98A2014-001.002) was rejected due to the MDA exceeding the RDL. However, sample results are reported high and are comparable to other native 1 soil radiological results and therefore are usable. The remaining soil samples results are comparable because consistent

sample collection activities and analysis were performed in accordance with the SAP (RMRS, 1998) and procedures described in Section 2.0.

3.3.6 Sensitivity

Sensitivity was evaluated by comparing actual quantitation limits of the results with the regulatory or project-specific action levels required for decision-making. All analytical and radiological methods achieved adequate sensitivities based on quantitation limits well below regulatory thresholds, typically with a quantitation limit at less than 50% of the threshold.

3.3.7 Summary

In summary, the data sets acquired and evaluated for the 903 Pad Project were satisfactory for supporting the Data Quality Objectives. The following project objectives were achieved:

- 1) Defining actinide activities that exceed 10 pCi/g ^{241}Am in surficial soils for waste volume estimates;
- 2) Defining actinide activities in subsurface soil that exceed Tier I & II RSALs soils for waste volume estimates; and
- 3) Defining VOC activities in subsurface soil volumes that exceed Tier I soil action levels for waste volume estimates.

4.0 NATURE AND EXTENT OF CONTAMINATION

The nature and extent of soil contamination related to releases from the 903 Pad has been evaluated by analysis of radionuclide and chemical data obtained as described in Section 2. The primary objective of the investigation is to determine the areal extent and depth of radiological and organic contamination above Tier I RSALs and Tier I SSALs, respectively. Another objective of the investigation was to characterize ^{241}Am in surface soils to 10 pCi/g using gamma spectroscopy field instrumentation. This characterization would allow for identification of surface soils exceeding Tier II RSALs. Remedial alternatives will be evaluated in the IM/IRA decision document based on these criteria.

Detailed descriptions of contamination in surface and subsurface soil are presented in this section. Results of the HPGe survey of the Americium Zone are presented in Section 4.1. Sections 4.2 and 4.3 respectively summarize radionuclide and VOC soil data collected for the 903 Pad and Lip Area. Descriptive summary statistics of the data are presented in Appendix D. Electronic copies of analytical results are provided in Appendix E and Tier I and Tier II RSAL SOR calculations are provided in Appendix F.

4.1 SOIL RADIOLOGICAL CONTAMINATION IN THE AMERICIUM ZONE

Results presented in this section are based on the double sampling technique in which HPGe measurements were correlated to alpha spectroscopy laboratory results. The linear regression between the HPGe results and laboratory results showed a high degree of correlation ($R > 0.97$), and was therefore used to standardize each HPGe measurement to laboratory derived alpha spectroscopy results (see Section 2.2.2). This provided an accurate model for estimating radiological contamination in surface soil relative to Tier I and Tier II RSALs at each survey location.

4.1.1 Comparison of HPGe Measurements to Tier I and Tier II RSALs

Based on 1,110 HPGe measurements in the Americium Zone (Figure 2-1), radiological contamination appears to extend approximately 1,050 feet east of the Lip Area. Surface soil contamination is defined by Tier I and Tier II RSAL exceedances, which are summarized in

Table 4-1. Using the best-fit regression model, nearly 37 % of the measurement locations exceed the Tier II RSALs. Less than 1% of the measurement locations exceed the Tier I RSALs. HPGe results and RSAL calculations are presented in Appendices E and F, respectively.

Table 4-1 Frequency of RFCA Tier I and Tier II RSAL Exceedances-HPGe Survey Results

HPGe Survey	Number of Measurements	Number Of Exceedances RFCA Tier I RSALs	Number Of Exceedances RFCA Tier II RSALs
Surface Soil	1110	4	416

The range of measured ^{241}Am , $^{239/240}\text{Pu}$, ^{235}U , and ^{238}U activities are presented graphically in Figure 4-1. Comparison of radionuclide results to Tier I and Tier II RSALs indicate that RSAL exceedances are due to elevated activities of $^{239/240}\text{Pu}$ and ^{241}Am . For $^{239/240}\text{Pu}$, activities range from 6.32 pCi/g to 938.42 pCi/g with a mean value of 105.05 pCi/g. Approximately 7% of the $^{239/240}\text{Pu}$ measurements exceed the Tier II RSAL of 252 pCi/g. None of the $^{239/240}\text{Pu}$ measurements exceed the Tier I RSAL of 1429 pCi/g. ^{241}Am activities range from 4.91 pCi/g to 149.22 pCi/g with a mean value of 20.19 pCi/g. Approximately 10% of the ^{241}Am measurements exceed the Tier II RSAL of 38 pCi/g. Like $^{239/240}\text{Pu}$, none of the ^{241}Am measurements exceed the Tier I RSAL of 215 pCi/g. HPGe measurements for ^{235}U and ^{238}U were all below Tier I and Tier II RSALs.

4.1.2 Spatial Distribution of Radiological Contamination in the Americium Zone

Figure 4-2 shows the distribution of Tier I and Tier II RSAL exceedances in surface soil within the Americium Zone. The highest level of contamination as indicated by Tier I RSAL exceedances is isolated at a cluster of three locations near the northwest corner of the Americium Zone and at one location in the south central portion of the Lip Area. Tier II exceedances encompass nearly 37% of the Americium Zone Investigation Area. The HPGe also define the extent of soil contamination by bounding the area with survey results that are below Tier II RSALs (Figure 4-2). The accuracy of the HPGe survey data is corroborated by historical data as discussed in Section 2.2.2.1. The HPGe data also indicate, as expected, noncontaminated areas

76

where clean fill was used for the road south of the cement and wetland areas, and for the road that borders the western and northern perimeter of the Americium Zone.

The Tier I and Tier II RSAL exceedances are associated with elevated activities of $^{239/240}\text{Pu}$ and ^{241}Am . The distribution of ^{241}Am activities is shown in Figure 4-3. The highest activities of ^{241}Am exceed 140 pCi/g near the northwest corner of the Americium Zone. As shown, the distribution of ^{241}Am Tier II RSAL exceedances trend in a northeast-southwest orientation, which extends from the southwest corner of the Lip Area to the north-central portion of the Americium Zone. The distribution of $^{239/240}\text{Pu}$ activities in surface soil (Figure 4-4) is similar to that of the ^{241}Am activities, with the highest activities exceeding 900 pCi/g near the northwest corner of the Americium Zone. The pattern of Tier I RSAL exceedances is also similar to that observed for ^{241}Am , with a northeast-southwest trend of contamination. This trend is a result of contaminant deposition from the source area. The similar spatial configurations of ^{241}Am and $^{239/240}\text{Pu}$ are to be expected because ^{241}Am is a daughter product of weapons grade plutonium decay.

4.1.3 FIDLER Surveys

A FIDLER survey was conducted at HPGe measurement location 301 (Figure 2-1) where an isolated HPGe measurement (direct field measurement) exceeded the 10 pCi/g ^{241}Am decision level. The FIDLER survey was used to determine if the result was caused by the presence of a smaller area containing a hot spot. It should be noted that all ^{241}Am activities discussed in this section are presented as direct field measurements. The activity of ^{241}Am from the in-situ HPGe measurement location 301 was 10.977 pCi/g and the surrounding HPGe measurements were less than 10 pCi/g. FIDLER survey results ranged from 1,224 to 2,841 cpm with a mean of 2,056 cpm. Background measurements of 910 and 1,107 cpm for the two FIDLERs used for the survey were taken at the step-off pad on the north side of the Americium Zone, adjacent to the East Access Road. Because of the low level of ^{241}Am detected in the soil and two FIDLER instruments used for the survey, the results are qualitative at best. However, contamination appears to be homogeneous as would be expected at this distant location from the source where contamination is a result of wind dispersal of plutonium contaminated soil from the 903 Pad and Lip Area.

FIDLER surveys were also conducted at HPGe locations 460 and 462 (Figure 2-1) where surface soils exceeded the RFCA Tier I RSALs. The surveys were conducted to determine whether contamination was homogeneous and widespread as suggested by the conceptual model, or heterogeneous consisting of numerous individual hot spots. The activities of ^{241}Am from the in-situ HPGe measurements were 115.74 and 109.04 pCi/g for HPGe measurement locations 460 and 462, respectively, and the surrounding HPGe measurements were less than 100 pCi/g. FIDLER survey results for HPGe measurement location 460 ranged from 2,928 to 17,039 cpm with a mean of 8,293 cpm. FIDLER survey results for FOV 462 ranged from 3,466 to 15,331 cpm with a mean of 8,729 cpm. Background measurements of 1,430 and 2,127 cpm for the two FIDLERs were taken at the step-off pad on the southwest corner of the Americium Zone, adjacent to the access road for the old firing range. Because two FIDLER instruments were used for the surveys, the results are qualitative. However, contamination appears to be heterogeneous and consists of numerous individual hot spots as might be expected from soil disturbance, localized erosional paths, or depositional areas near the source of contamination.

4.2 SOIL RADIOLOGICAL CONTAMINATION IN THE 903 PAD AND LIP AREA

Surface and subsurface soil samples were analyzed for ^{241}Am , $^{239/240}\text{Pu}$, $^{233/234}\text{U}$, ^{235}U , and ^{238}U using alpha spectroscopy methods. Surface and subsurface soil samples were aggregated into four native soil horizons (Native 1 [0-6 in], Native 2 [6-12 in], Native 3 [12-18 in], Native 4 [18-24 in]), bedrock soil, and artificial fill under the 903 Pad. Artificial fill in the Lip Area was classified as Native 1 soil because native soil and artificial fill could not be differentiated in the field.

Based on the radiological results, contamination appears to be confined to the top 1.5 feet of native soil, and is most extensive in the Native 1 soil horizon. Table 4.2 summarizes the Tier I and Tier II RSAL exceedances. The frequency of Tier I and II exceedances decreases with increasing depth. No samples collected beneath the Native 3-soil horizon exceeded Tier I and Tier II RSALs². Radiological data and RSAL SOR calculations for surface and subsurface soil are presented in Appendices E and F, respectively.

² Radiological sample results from the subsurface VOC investigation indicate no contamination above Tier II RSALs. Activities of all measured radionuclides from the VOC investigation were below 3 pCi/g.

Table 4.2 Frequency of RFCA Tier I and Tier II RSAL Exceedances-Native Soil Results

Geologic/Fill Material	Number of Measurements	Frequency Of Exceedances RFCA Tier I RSALs	Frequency Of Exceedances RFCA Tier II RSALs
Asphalt	9	N/A	N/A
Bedrock	12	0	0
Fill	12	0	1
Native	72	0	0
Native 1	62	17	34
Native 2	62	5	11
Native 3	62	0	3
Native 4	58	0	0

N/A Not Applicable; Asphalt samples were not comparable to RSALs

4.2.1 Radionuclide Activities in Native Soils

The range of activities for ^{241}Am , $^{239/240}\text{Pu}$, $^{233/234}\text{U}$, ^{235}U , and ^{238}U in Native 1, Native 2, and Native 3 soil types are shown graphically in Figure 4-5. As discussed in the following subsections, the amount of contamination decreases significantly with depth.

4.2.1.1 Native 1 Surface Soil Contamination

The Native 1 soil has the most extensive contamination as indicated by activities of ^{241}Am , $^{239/240}\text{Pu}$ and ^{231}U that exceed Tier I and Tier II RSALs (Table 4-2 and Figure 4-5). ^{238}U activities range from 0.49 pCi/g to 780 pCi/g with a geometric mean value of 1.99 pCi/g³. The high activity of 780 pCi/g is the only exceedance above Tier I and Tier II RSALs of 586 pCi/g and 103 pCi/g, respectively. Approximately 44 percent of the $^{239/240}\text{Pu}$ and ^{241}Am results exceed Tier II RSALs.

$^{239/240}\text{Pu}$ activities range from 0.82 pCi/g to 152,260 pCi/g with a geometric mean value of 146.69 pCi/g. For $^{239/240}\text{Pu}$, 15% of the samples exceed the Tier I RSAL of 1,429 pCi/g and 44%

³ The data appear to have a lognormal distribution, and therefore, a geometric mean is a better measure of the central tendency of the distribution.

of the samples exceed the Tier II RSAL of 252 pCi/g. ^{241}Am activities in Native 1 soil appear more extensive than that of ^{239}Pu with activities ranging from 0.15 pCi/g to 31,670 pCi/g. For ^{241}Am activities, 19.1% of the samples exceed the Tier I (215 pCi/g) RSAL and 47.1% exceed the Tier II (38 pCi/g) RSAL.

4.2.1.2 Native 2 Subsurface Soil Contamination

The Native 2 soil horizon is substantially less contaminated than the Native 1 soil horizon but still contains activities above Tier I and Tier II RSALs for ^{241}Am and $^{239/240}\text{Pu}$ (Figure 4-5). $^{239/240}\text{Pu}$ activities range from 0.14 pCi/g to 1,820 pCi/g with a geometric mean of 8.65 pCi/g. For $^{239/240}\text{Pu}$, 0.03% of the samples exceed the Tier I RSAL (1,429 pCi/g) and 11% of the samples exceed the Tier II RSAL (252 pCi/g). ^{241}Am activities range from non-detectable (0.03 pCi/g) to 406 pCi/g with a geometric mean value of 1.79 pCi/g. ^{241}Am contamination is similar to that of $^{239/240}\text{Pu}$ contamination as indicated by frequency of exceedances of 0.03% and 11% above Tier I (215 pCi/g) and Tier II (38 pCi/g) RSALs.

4.2.1.3 Native 3 Subsurface Soil Contamination

The amount of contamination in the Native 3 soil is minimal relative to the Tier II RSALs (Figure 4-5). Only one sample for ^{241}Am exceeds the corresponding Tier II RSAL of 38 pCi/g. ^{241}Am in the Native 3 soil horizon ranges from non-detectable to 54.40 pCi/g with a median value of 0.23 pCi/g⁴. Activities of $^{239/240}\text{Pu}$ in the Native 3 soil horizon were below the respective Tier I and Tier II RSALs.

4.2.2 Spatial Distribution of Contamination

Examination of the *spatial distribution of contamination* is useful for evaluating potential sources and contaminant migration pathways. This section discusses the spatial distribution of Tier I and Tier II RSALs for Native 1, Native 2, and Native 3 soil horizons. Also presented are the spatial distributions of $^{239/240}\text{Pu}$ and ^{241}Am activities because of their exceedance of Tier I and Tier II RSALs.

4.2.2.1 Spatial Distribution of Radionuclides in the Native 1 Soil Horizon

As shown in Figure 4-6, Tier I and Tier II RSAL exceedances (>1 for the sum of ratios) in Native 1 soil are located throughout the 903 Pad and Lip Area. There is no distinct pattern to the Tier I and Tier II exceedances at the 903 Pad. Most of the southern boundary and portions of the northern boundary do not exceed Tier II RSALs. For the Lip Area, Tier I exceedances are most prevalent in the center area due east of the 903 Pad, with Tier II exceedances surrounding this area. Relatively "clean" areas as indicated by RSALs less than Tier II are located further to the east and south of the 903 Pad. Apparent spatial gaps in contamination may be explained by past remedial activities. For example, the soil in the Lip Area was graded back toward the 903 Pad during past remedial actions, and therefore the soil closest to the Pad is not as contaminated as the soil near the central portion of the Lip Area. Similar remedial activities in 1984 removed contaminated soil in the western portion of the Lip Area.

The RSAL exceedances are associated with elevated levels of $^{239/240}\text{Pu}$ and ^{241}Am . Figure 4-7 shows the distribution of ^{241}Am in the Native 1 surface soil. The highest ^{241}Am activities exceed 30,000 pCi/g and are centered near boring 91598 (Figure 4-7). However, as shown in Figure 4-7, the majority of the Native 1 soils in the 903 Pad (approximately half of the Native 1 soil) and Lip Area exceed the Tier II RSAL for ^{241}Am of 38 pCi/g. The distribution of the $^{239/240}\text{Pu}$ activities is similar to that of the ^{241}Am activities, with the highest activities exceeding 150,000 pCi/g at boring 91598 (Figure 4-8). Like ^{241}Am , the $^{239/240}\text{Pu}$ activities are elevated with respect to the Tier II RSAL (252 pCi/g) in most of the Native 1 soil within the 903 Pad and approximately half of the Native 1 soil in the Lip Area.

4.2.2.2 Spatial Distribution of Contamination in the Native 2 Soil Horizon

Figure 4-9 shows the distribution of the Tier I and Tier II RSAL exceedances (>1 for the sum of ratios) in the Native 2 soil horizon. The RSAL exceedances are not as ubiquitous as in the Native 1 soil horizon. RSAL exceedances are isolated to an area around boreholes 91598, 91398, 91898, and 91998 at the 903 Pad and around several boreholes throughout the Lip Area (boreholes 94998, 94898, 95198, 95398, 95498, 95598, and 97598). Like the Native 1 soil horizon, RSAL exceedances in the Native 2 soil horizon are associated with elevated levels of ^{241}Am and ^{239}Pu .

²⁴¹Am activities exceed 400 pCi/g in the 903 Lip Area with the highest activity observed at 95198 (Figure 4-10). The distribution of Pu-239 in the Native 2 soil horizon is very similar to that of ²⁴¹Am (Figure 4-11). ²³⁹Pu exceeds 18,000 pCi/g (above the Tier I RSAL) at boring 95198. ^{239/240}Pu activities exceeding the Tier II RSAL (252 pCi/g) are distributed like the ²⁴¹Am activities (Figure 4-11). The ^{239/240}Pu and ²⁴¹Am activities in the Native 2 soil horizon are generally one to two orders of magnitude less than those observed in the Native 1 soil horizon.

Historical grading activity at the 903 Pad likely explains the somewhat different ^{239/240}Pu and ²⁴¹Am distributions between Native 1 and Native 2 soils. For example, grading activities at boring 91998 may have redistributed contamination in Native 1 soil leaving higher contaminated soils in the Native 2 soil horizon. In the Lip Area, the amount of artificial fill in the Native 1 soil horizon would explain higher activities in Native 2 soil relative to the Native 1 soil.

4.2.2.3 Spatial Distribution of Contamination in the Native 3 Soil Horizon

Figure 4-12 shows the distribution of the Tier II RSAL exceedances (>1 for the sum of ratios) in the Native 3 soil horizon⁵. The amount of radionuclide contamination in the Native 3 soil horizon is significantly less than that in the Native 1 and Native 2 soil horizons. Tier II RSAL exceedances are isolated along the northern boundary of the Lip Area at borings 94898 and 95198. One other isolated Tier II RSAL exceedance is observed east of the 903 Pad at boring 95498. Like the Native 1 and Native 2 soil horizons, the RSAL exceedances within the Native 3 soil horizon are associated with elevated levels of ²⁴¹Am and ^{239/240}Pu.

As shown in Figure 4-13, elevated levels of ²⁴¹Am with respect to the Tier II RSAL (38 pCi/g) are observed along the northern boundary of the Lip Area at boring 94898. Another area east of the 903 Pad near boring 95498 shows relatively high activities of ²⁴¹Am (up to 26 pCi/g) but these activities are slightly less than the Tier II RSALs⁶. The spatial distribution of ²³⁹Pu in the Native 3 soil horizon similar to that of ²⁴¹Am, (Figure 4-14). Although none of the ^{239/240}Pu samples exceed Tier I or Tier II RSALs, the relatively high activities near borings 94898 and 95498 contribute to the Tier II RSAL exceedances at these locations.

⁵ Tier I RSAL exceedances were not observed in the Native 3 Soil horizon.

⁶ Tier I RSAL exceedances for ²⁴¹Am were not observed in the Native 3 Soil horizon.

Overall, the area of ^{241}Am and $^{239/240}\text{Pu}$ contamination decreases significantly with depth. Despite nearly identical spatial trends, the ^{241}Am -241 and ^{239}Pu activities within the Native 3 soil horizon are an order of magnitude less than those within the Native 2 soil horizon.

4.2.3 Radionuclide Activities in 903 Pad Asphalt and 903 Pad Artificial Fill

Asphalt samples from the 903 Pad were collected to obtain preliminary estimates of the sample variance and mean for waste characterization purposes⁷. Random sampling techniques were used as an appropriate method to estimate the population mean and to determine the total amount of contamination. Nine asphalt samples were collected from sample locations randomly selected from the twenty-five 903 Pad subsurface soil sampling locations as shown in Figure 4-15.

Asphalt thickness ranged from 0.4 to 0.7 feet with an average thickness of 0.5 feet.

Twelve artificial fill samples were collected from locations randomly selected from the twenty-five 903 Pad subsurface soil sampling locations as shown in Figure 4-16. Artificial fill thickness ranged from 0.3 to 0.9 feet with an average thickness of 0.5 feet beneath the 903 Pad. Artificial fill results were compared to RFCA Tier I and Tier II RSALs. Samples were analyzed for $^{233/234}\text{U}$, ^{235}U , ^{238}U , ^{241}Am , and $^{239/240}\text{Pu}$ using alpha spectroscopy methods. The descriptive summary statistics are provided in Appendix D.

4.2.3.1 Radionuclide Distribution in Asphalt

The radionuclide activities in asphalt were low relative to the activities observed in the Native 1 Soil horizon. As shown in Figures 4-15 and 4-17, the activities for Am, Pu, $^{233/234}\text{U}$, ^{235}U , and ^{238}U are all below 1.5 pCi/g. The mean, standard deviation, and other descriptive statistics are summarized in Table 4-3.

⁷ Asphalt samples were not comparable to RSALs, which are based the physical and chemical properties of soil. Instead, waste disposal WAC requirements for asphalt will be based on the mean and variance.

82

Table 4-3. Descriptive Summary Statistics for 903 Pad Asphalt

Descriptive Statistic	^{233/234} U (pCi/g)	²³⁵ U (pCi/g)	²³⁸ U (pCi/g)	^{239/240} Pu (pCi/g)	²⁴¹ Am (pCi/g)
Mean	0.81	0.05	0.75	0.16	0.07
Geometric Mean	0.80	0.04	0.74	N/A	0.04
Standard Error	0.05	0.01	0.04	0.13	0.03
Median	0.78	0.04	0.75	0.03	0.04
Standard Deviation	0.15	0.03	0.13	0.40	0.10
Sample Variance	0.02	0.00	0.02	0.16	0.01
Kurtosis	1.70	7.01	-1.60	8.85	8.28
Skewness	1.22	2.46	-0.08	2.97	2.84
Coefficient of Variation	0.19	0.72	0.17	2.42	1.46
Range	0.47	0.12	0.32	1.22	0.33
Minimum	0.66	0.01	0.60	0.00	0.02
Maximum	1.13	0.13	0.92	1.22	0.34
Sum	7.27	0.42	6.74	1.48	0.63
Count	9	9	9	9	9
Confidence Level (90.0%)	0.08	0.02	0.07	0.22	0.06

NA Not Applicable.

Figure 4-15 shows the distribution of radionuclides in asphalt. With exception to ²³⁸U, the highest radionuclide activities are present at boring 91898 (^{233/234}U [1.13 pCi/g], ²³⁵U [0.133 pCi/g], ²⁴¹Am [0.341 pCi/g], and ^{239/240}Pu [1.22 pCi/g]). The highest ²³⁸U (0.919 pCi/g) activity was reported at boring 90198.

4.2.3.2 Radionuclide Distribution in 903 Pad Artificial Fill

The ranges of activities for the measured isotopes in artificial fill are presented in Figure 4-17. Overall, the radionuclide activities in artificial fill are low relative to the activities observed in the Native 1, Native 2, and Native 3 soil horizons. However, one Tier II RSAL SOR exceedance is observed within the 903 Pad Area at boring 91898 (Figure 4-16). The Tier II RSAL exceedance is associated with elevated levels of ²⁴¹Am (126 pCi/g) and ^{239/240}Pu (558 pCi/g), which both exceed the respective Tier II RSALs of 38 pCi/g and 252 pCi/g. ²⁴¹Americium activities in

artificial fill range from 0.02 pCi/g to 126 pCi/g with a geometric mean value of 1.18 pCi/g. Elevated activities within the artificial fill appear to be isolated around this single boring considering that the highest $^{233/234}\text{U}$ (2.02 pCi/g), ^{235}U (0.49 pCi/g), ^{238}U (2.77 pCi/g), and $^{239/240}\text{Pu}$ (558 pCi/g) activities were also observed at boring 91898 (Figure 4-17). Descriptive summary statistics for the 903 Pad artificial fill are presented in Table 4-4.

Table 4-4. Descriptive Summary Statistics for 903 Pad Artificial Fill

Descriptive Statistic	$^{233/234}\text{U}$ (pCi/g)	^{235}U (pCi/g)	^{238}U (pCi/g)	$^{239/240}\text{Pu}$ (pCi/g)	^{241}Am (pCi/g)
Mean	1.06	0.09	1.15	53.75	12.01
Geometric Mean	1.02	0.06	1.00	5.78	1.18
Standard Error	0.11	0.04	0.18	45.95	10.38
Median	0.98	0.06	1.13	4.48	0.85
Mode	0.84	0.07	1.24	N/A	N/A
Standard Deviation	0.38	0.13	0.61	159.19	35.97
Sample Variance	0.14	0.02	0.37	25340.90	1294.08
Kurtosis	4.79	11.19	5.53	11.88	11.90
Skewness	1.51	3.30	1.72	3.44	3.44
Coefficient of Variation	0.36	1.43	0.53	2.96	2.99
Range	1.61	0.49	2.60	557.99	125.98
Minimum	0.41	0.00	0.17	0.01	0.02
Maximum	2.02	0.49	2.77	558.00	126.00
Sum	12.25	1.00	13.33	642.14	143.51
Count	12	12	12	12	12
Confidence Level (90.0%)	0.18	0.06	0.29	75.59	17.08
Number of Detections Above Tier I	0	0	0	0	0
Number of Detections Above Tier II	0	0	0	1	1

N/A Not Applicable

4.3 SUBSURFACE SOIL VOC INVESTIGATION

Seventeen boreholes were completed to investigate VOC contamination at the 903 Pad and Lip Area, which included the original 13 boreholes and four "step-out" boreholes (Figure 4-18). Subsurface soil VOC contaminants of concern as identified in the SAP (RMRS, 1998a) include carbon tetrachloride (CCl_4), PCE, TCE, and 1,2-cis-dichloroethylene (1,2-DCE). Despite the

absence of DNAPLs during drilling, VOCs were detected at several boring locations. As shown in Figure 4-18, detections of CCl₄ ranged from 2.3 ug/kg in borehole 96698 (22.4 to 22.8 ft) up to 5.3 ug/kg in borehole 96798 (20.4 to 20.8 ft). Detections of PCE ranged from 1.1 ug/kg in borehole 97698 (8.2 to 8.6 ft) up to 6,100 ug/kg in borehole 90998 (3.8 to 4.0 ft). Detections of TCE ranged from 0.89 ug/kg in borehole 96698 (20.4 to 20.8 ft) up to 290 ug/kg in borehole 90998 (3.8 to 4.0 ft). Detections of 1,2-DCE ranged from 1.1 ug/kg in boreholes 96798 (12.5 to 12.9 ft) and 97698 (8.2 to 8.6 ft) up to 4,400 ug/kg in borehole 90998 (3.8 to 4.0 ft). In general, the majority of the VOC detections were observed in the northeastern quadrant of the 903 Pad at borings 90998, 95998, 96498, 96698, 97698, and 96798. VOC detections were also observed in the 903 Lip Area at boring 97298 and within the central portion of the 903 Pad at boring 96898. The ranges of VOC concentrations are presented in Figure 4-19.

No VOC detections were observed equal to or greater than the current Tier I SSALs (Table 4-5). However, proposed SSAL revisions would be 1 to 4 orders of magnitude less than the current Tier I SSALs (Table 1-2). Given the proposed revisions, only one value (6,100 ug/kg observed at borehole 90998) exceeds the proposed Tier I SSAL for PCE (3,150 ug/kg). The VOCs that exceed the proposed Tier II SSALs include PCE (31.5 ug/kg), TCE (32.8 ug/kg), and 1,2-DCE (140 ug/kg) (Table 4-5). As shown in Figure 4-18, the proposed Tier II exceedances are observed at boreholes BH97698 (PCE), BH96498 (PCE), BH90998 (PCE, TCE, and 1,2-DCE), BH95998 (PCE), and BH96798 (PCE). The proposed Tier I SSAL exceedances occur within a relatively small area around monitoring well 08891. PCE is the most ubiquitous of the contaminants, occurring at five of the borings. The depth of contamination (relative to the proposed SSALs) varies from the 3.8 feet bgs at borehole BH90998 to 24.6 feet bgs at borehole BH95998. The proposed Tier I exceedances that occur below the water table are observed at borings BH97698, BH95998, and BH96798.

Table 4-5. Frequency of VOC SSAL Exceedances in Subsurface Soil.

VOC	Number of Measurements	Number of Detections	Number Of Exceedances Current Tier I SSAL	Number Of Exceedances Proposed Tier I SSAL	Number Of Exceedances Proposed Tier II SSAL
Carbon Tetrachloride	86	3	0	0	0
PCE	86	19	0	1	7

VOC	Number of Measurements	Number of Detections	Number Of Exceedances Current Tier I SSAL	Number Of Exceedances Proposed Tier I SSAL	Number Of Exceedances Proposed Tier II SSAL
TCE	86	7	0	0	1
1,2-DCE	32	1	0	0	1

Some of the deeper borehole samples may reflect solute (dissolved) concentrations in groundwater rather than concentrations in soil. Groundwater beneath the 903 Pad is relatively shallow with depth to water averaging approximately 19 feet below ground surface (bgs). During high flow regimes depth to water may decrease to 12 feet bgs. Therefore, it is likely that detections of CCL₄, PCE and TCE observed at depths greater than 20 feet at boreholes 96698 and 96798 may represent partitioning of VOCs between the aqueous and solid phases. In general, the presence of VOCs in subsurface soils below the water table is likely due to chemical adsorption from groundwater to the solid soil particles.

The delineation of VOC contamination was optimized during the field investigation by the "step-out" boring approach (RMRS, 1998a). This decision making process was triggered by detections of VOCs above 10 percent of the respective current Tier I SSALs at any boring location. Such levels required an additional "step-out" boring approximately 20 feet in the upgradient direction from the boring where VOCs were detected at 10 percent of the current Tier I SSALs. Detections above 10 percent of the current Tier I SSALs were observed at borings 90998 and 95998. Borehole 90998 was completed as a shallow subsurface radiological borehole to a depth of 4.0 ft and based on field instrument readings a soil sample for VOC analysis was collected at a depth of 3.8 to 4.0 ft. As summarized above, the highest concentrations of PCE (6,100 ug/kg), TCE (290 ug/kg), and 1,2-DCE (4,400 ug/kg) were observed in borehole 90998. Concentrations of 1,2-DCE and PCE were above 10 percent of the current Tier I SSALs.

Borehole 96498 was completed to bedrock within one foot of borehole 90998 per the SAP (RMRS, 1998a) requiring completion of a shallow radiological borehole as a VOC borehole if VOCs were detected above 10 percent of the current Tier I SSALs. Similarly, borehole 95998 was completed to bedrock 20 ft in an upgradient direction west of boreholes 90998 and 96498. Detections of PCE (3,060 ug/kg), TCE (9.9 ug/kg), and 1,2-DCE (5.4 ug/kg) were observed in borehole 95998 at a depth of 5.0 to 5.6 ft. The concentrations of PCE that were observed in

borehole 95998 were above 10 percent of the current Tier I SSAL. Therefore, borehole 97698 was completed in an upgradient direction 20 feet west of borehole 95998 in compliance with the SAP. Although PCE, TCE, and 1,2-DCE were detected in borehole 97698 none of the concentrations met or exceeded 10 percent of the current Tier I SSALs for the respective analytes.

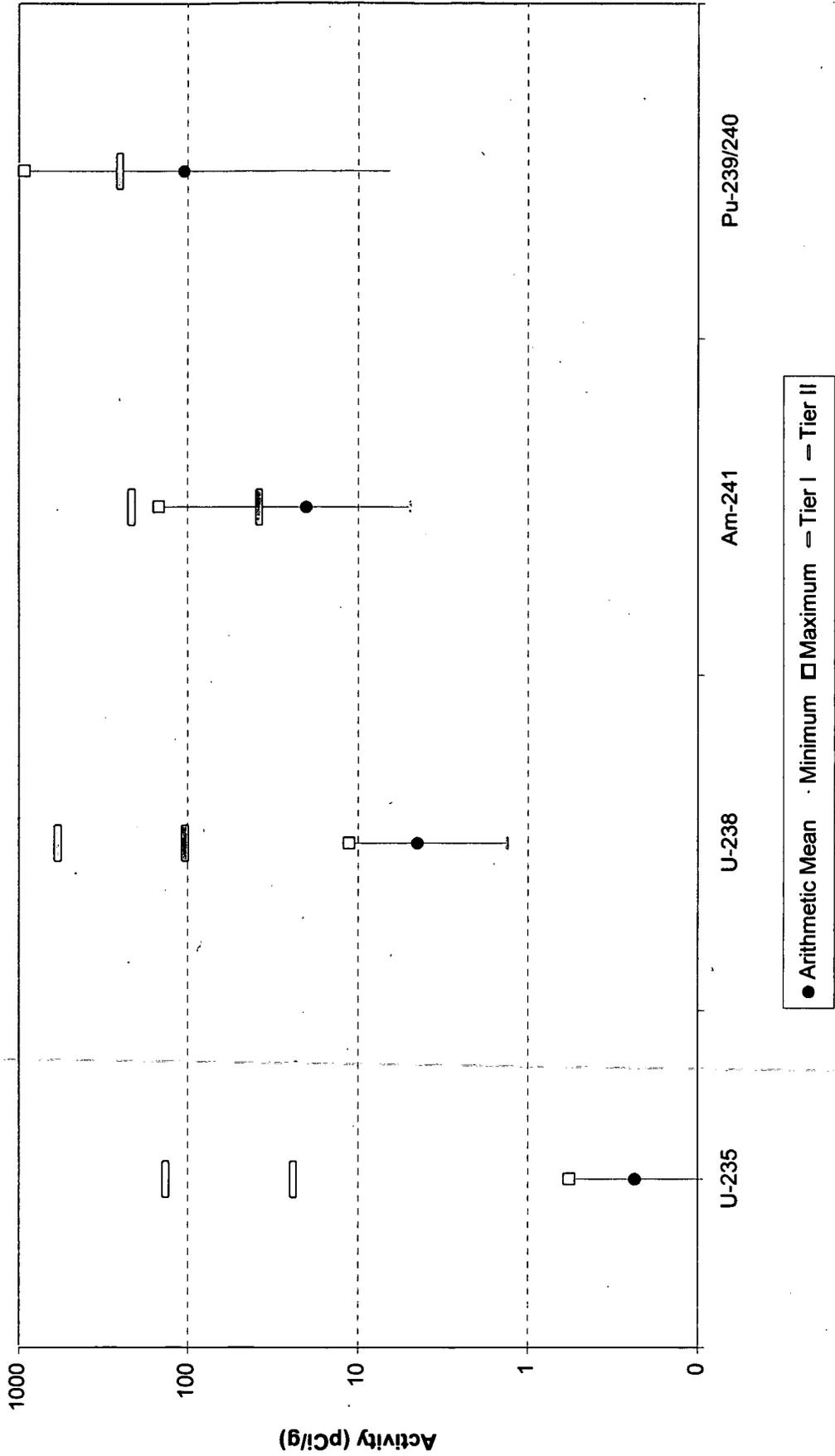
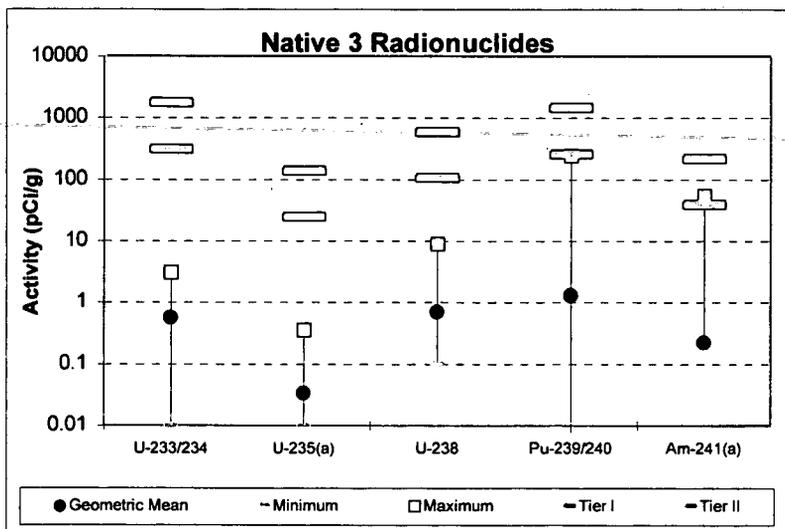
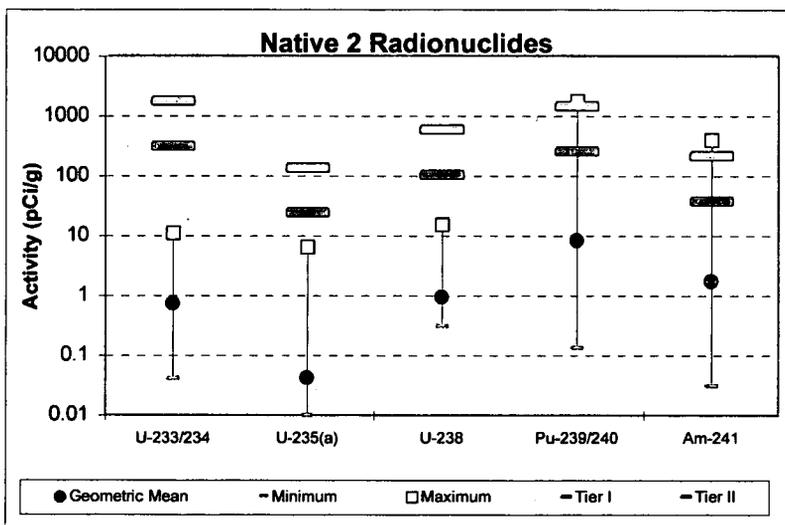
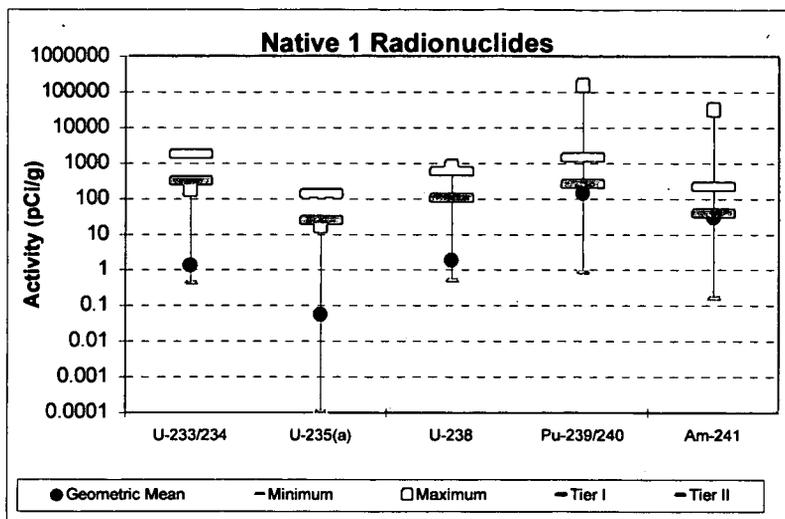
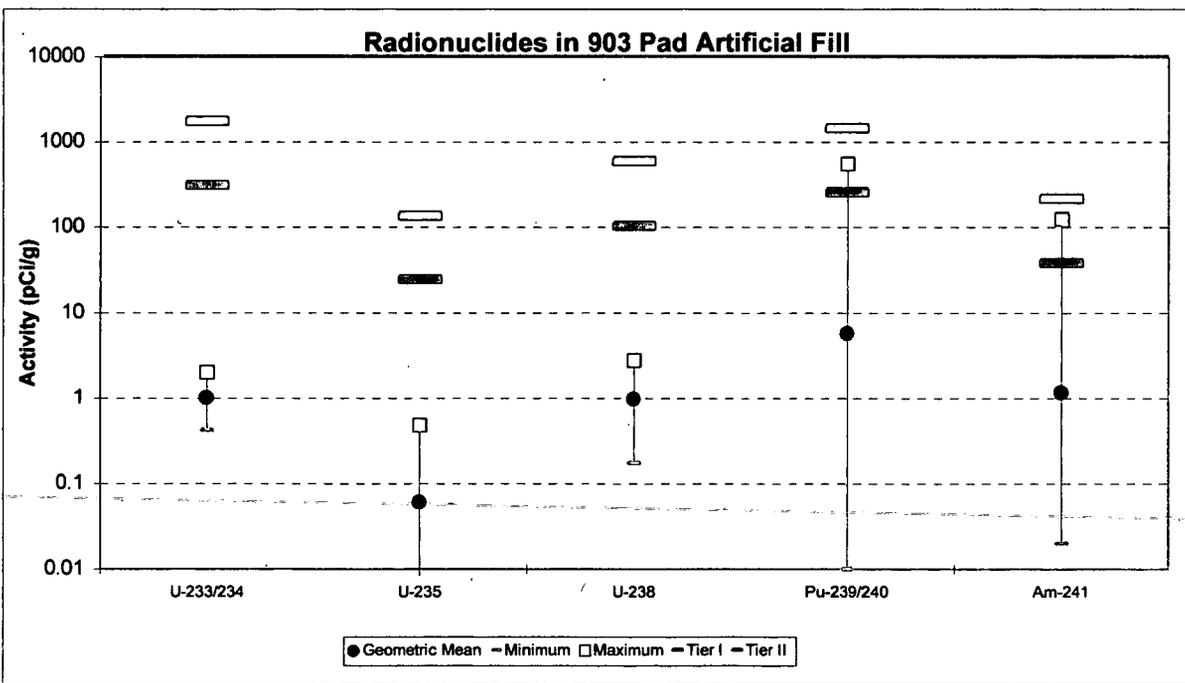
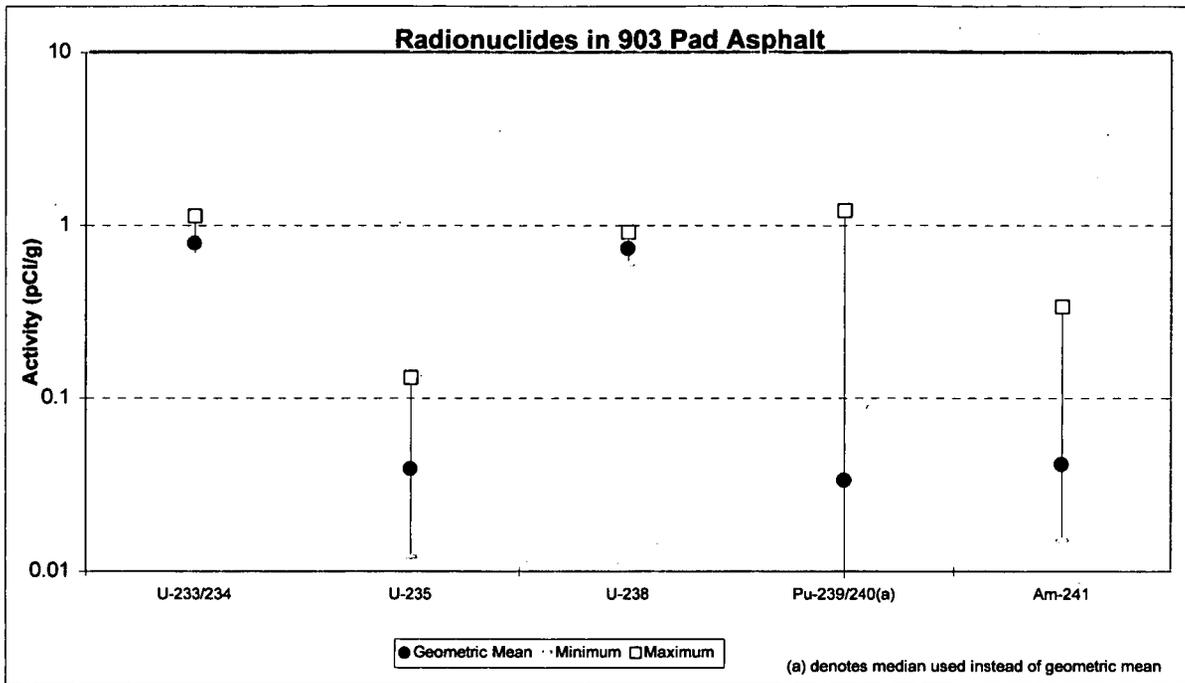


Figure 4-1 Range of Radionuclide Activities in Surface Soil - HPGe Survey



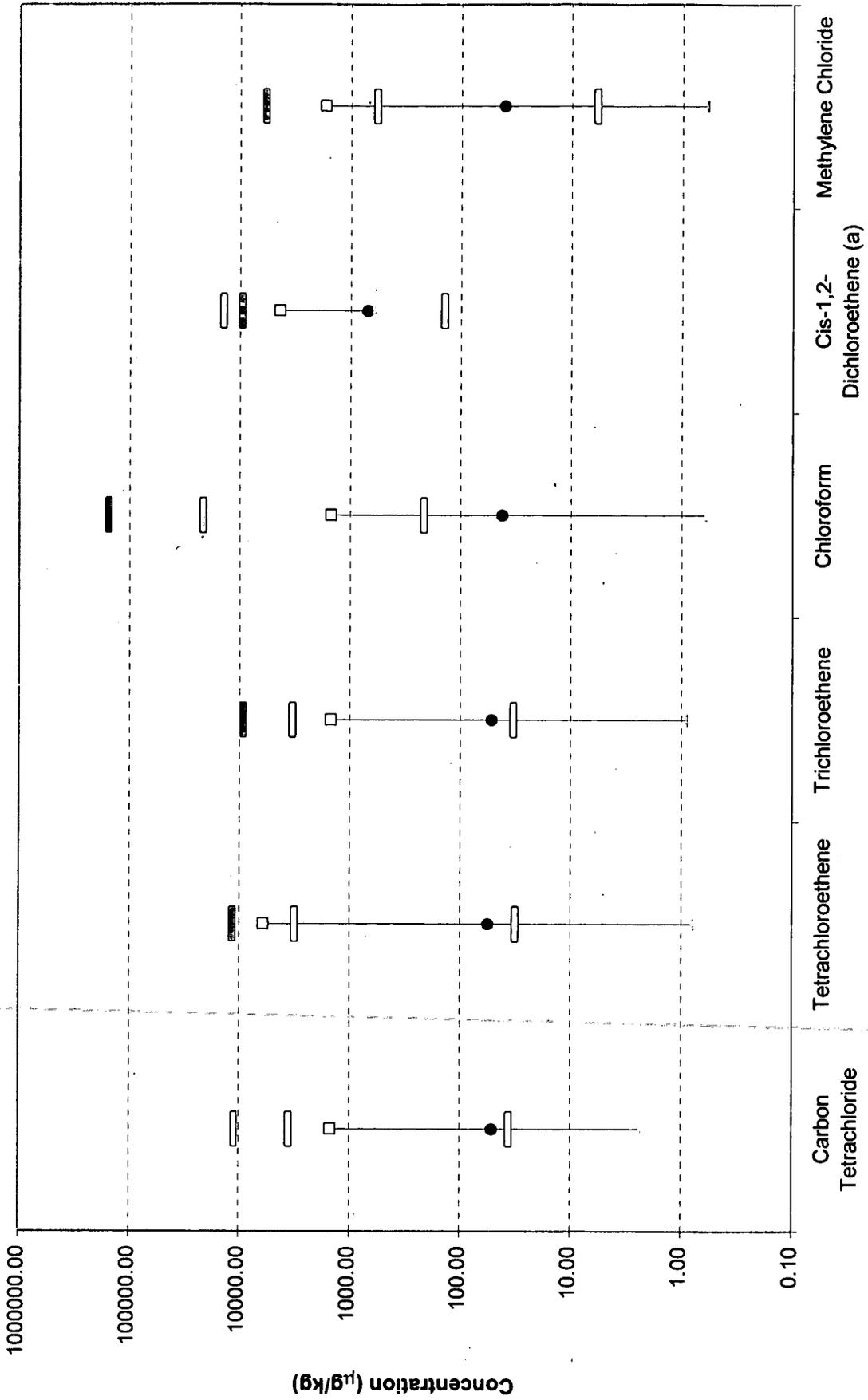
(a) Denotes median used instead of geometric mean

92
Figure 4-5. Range of Radionuclide Activities in Native 1, Native 2, and Native 3 Soils Horizons.



104

Figure 4-17. Range of Radionuclide Activities in Asphalt and Artificial Fill



● Geometric Mean □ Minimum □ Maximum □ Proposed Tier I SSAL □ Proposed Tier II SSAL
 (e) denotes median used instead of geometric mean

Figure 4-19. Range of VOC Concentrations in Subsurface Soil

Wp

6.0 REFERENCES

- Barker, C.J. 1982. Removal of Plutonium-Contaminated Soil from the 903 Lip Area During 1976 and 1978. RFP-3226, January 25, 1982. Rockwell International. Rocky Flats Plant, Golden, CO. 80402.
- DOE, 1994. OU2 Subsurface Interim Measures/Interim Remedial Action Plan/Environmental Assessment, Soil Vapor Survey Report. U.S. Department of Energy. Rocky Flats Plant. Golden, CO. 80402.
- DOE, 1995. Final Phase II RFI/RI Report, 903 Pad, Mound, East Trenches Area, Operable Unit No. 2, RF/ER-95-0079.UN. U.S. Department of Energy. Rocky Flats Plant. Golden, CO. 80402.
- DOE, 1996. Final Rocky Flats Cleanup Agreement. U.S. Department of Energy. Rocky Flats Environmental Technology Site. Golden, CO. 80402.
- DOE, 1997. Comparability of In-Situ Gamma Spectrometry and Laboratory Data. 20701-RF-001 U.S. Department of Energy. Fernald Area Office, Fernald, OH.
- EG&G, 1991. In Situ Surveys of the United States Department of Energy's Rocky Flats Plant. EG&G Energy Measurements. EGG-10617-1129. May 1991. Rocky Flats Plant. Golden, CO. 80402.
- EG&G, 1993. Compendium of In Situ Radiological Methods and Applications at Rocky Flats Plant. December 1, 1993. EG&G Rocky Flats Inc. Rocky Flats Plant. Golden, CO. 80402.
- EPA, 1986. Test Methods for Evaluating Solid Waste. U.S. Environmental Protection Agency. Office of Solid Waste and Emergency Response, Washington, DC 20460.
- EPA, 1989. Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual (Part A). Office of Solid Waste and Emergency Response, Washington, DC, 20460; EPA/540/1-89/002.
- EPA, 1992. Estimating Potential for Occurrence of DNAPL at Superfund Sites, OSWER Publication 9355.4-07/FS. U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, DC 20460.

- EPA, 1994a. USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review. Office of Solid Waste and Emergency Response, Washington, DC, 20460; EPA/540/R-94/012.
- EPA, 1994b. USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review. Office of Solid Waste and Emergency Response, Washington, DC, 20460; EPA/540/R-94/013.
- EPA, 1996a. Soil Screening Guidance: Technical Background Document. Office of Solid Waste and Emergency Response, Washington, DC, 20460; EPA/540/R-95/128.
- EPA, 1996b. Guidance for Data Quality Assessment, Practical Methods for Data Analysis. Office of Solid Waste and Emergency Response, Washington, DC, 20460; EPA QA/G-9.
- ESRI, 1999. ArcInfo, Version 7.2.2. Redlands, CA. 92373
- Gilbert, R.O. 1987. Statistical Methods for Environmental Pollution Monitoring. Van Nostrand Reinhold. New York, New York. 10003.
- Golden Software, Inc., 1996. Surfer (Win 32). Version 6.04. Golden, CO. 80401.
- Kaiser-Hill (K-H), 1997. Kaiser-Hill Team Quality Assurance Program, Rev. 5. Rocky Flats Environmental Technology Site. Golden, CO. 80402. December.
- Kaiser-Hill, 1999a. Final Rocky Flats Cleanup Agreement, Attachment 5, Action Levels and Standards for Surface Water, Ground Water, and Soils, dated May 17, 1999. Submitted for public comment on July 28, 1999.
- Kaiser-Hill, 1999b. Radiological Safety Procedures. Rocky Flats Environmental Technology Site. Golden, CO. 80402
- Rocky Mountain Remediation Services (RMRS), 1997a. Closeout Report for the Remediation of Individual Hazardous Substance Site 109, Ryan's Pit. RF-ER-96-0034-UN, Rev. 0. Rocky Flats Environmental Technology Site. Golden, CO. 80402. July.
- RMRS, 1997b. 903 Drum Storage Area, 903 Lip Area and Americium Zone Data Summary. RF/RMRS-97-086-UN. Rocky Flats Environmental Technology Site. Golden, CO. 80402. September.

111

RMRS, 1998a. Sampling and Analysis Plan for the Site Characterization of the 903 Drum Storage Area, 903 Lip Area and Americium Zone. RF/RMRS-97-084, Rev. 1. Rocky Flats Environmental Technology Site. Golden, CO. 80402. August.

RMRS, 1998b. Groundwater Monitoring Program, Special Task Health and Safety Plan for the Site Characterization of the 903 Drum Storage Area, 903 Lip Area and Americium Zone. RF/RMRS-97-103, Rev. 1. Rocky Flats Environmental Technology Site. Golden, CO. 80402. August.

RMRS, 1998c. Evaluation of Data for Usability in Final Reports. RF/RMRS-98-200, Rev. 0. Rocky Flats Environmental Technology Site. Golden, CO. 80402. August.

RMRS, 1998d. Quality Assurance Program Description (QAPD). RMRS-QAPD-001, Rev. 2. Rocky Flats Environmental Technology Site. Golden, CO. 80402. April.

RMRS, 1998e. Final 1997 Annual Rocky Flats Cleanup Agreement (RFCA) Groundwater Monitoring Report for the Rocky Flats Environmental Technology Site. RF/RMRS-98-273.UN. Rocky Flats Environmental Technology Site. Golden, CO. 80402. November.

RMRS, 1998f. Actinide Content and Aggregate Size Analyses for Surface Soil in the Walnut Creek and Woman Creek Watersheds at the Rocky Flats Environmental Technology Site. Revision 1. RF/RMRS-98-281.UN. Rocky Flats Environmental Technology Site, Golden, CO. 80402. September.

Rutherford, D.W. 1981. Sampling Design for Use by the Soil Decontamination Project. Rockwell International. RF-3163. Rocky Flats Plant, Golden, CO. 80402.

112

Characterization Report for the
903 Drum Storage Area,
903 Lip Area, and Americium Zone

Document Number: RF/RMRS-99-427.UN
Revision: 0
Date: September 21, 1999
Page: A-1

Appendix A

Boring Logs

ROCKY FLATS PLANT BOREHOLE LOG

PAGE 1 OF 1

Borehole Number: BH 90198
 Location - North: 749214 East: 2085686
 Date: 4/21/98
 Geologist: R. KOEHLER
 Drilling Equip.: GEOPROBE

Surface Elevation: 5977
 Area: 903 PAD/LIP
 Total Depth: 4.0ft Date: 8/25/98
 Company: TIERRA Project No.: GE600000
 Sample Type: CONTINUOUS CORE

EG&G LOGGING SUPERVISOR

APPROVAL Mark Wood

DATE 8/25/98

TOP POSITION OF CORE BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FLUCTUATE ANGLE	BENDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOG. LOG	SAMPLE DESCRIPTION	
Box 1 of 1	0.0-4.0ft	0.0-4.0ft	001				NA			0.0-0.5ft, Asphalt, black, fractured, gravel to 1.5cm rounded, membrane present.	
			002	0.95	10:38		GM	0.5		0.5-0.9ft, FILL, sand and gravel, light olive brown, (2.5Y 5/6), gravel up to 1.5cm, rounded and fractured.	
			003						1.0-0.9		0.9-2.9ft, soil, <u>↑ unconsolidated, moist. ↑</u> clay sand gravel, 0.9-1.5 very dark gray (5YR 3/1) 1.5-2.9 yellowish red (5YR 5/8)
			004	0.9	10:42		GC				
			005							1.5-1.4	
			006							2.0-1.9	
			014	1.4	10:51					2.5-2.4	
			007							3.3-2.9	
			008							3.5	
			009	1.9	10:48					4.0	
			010	2.4	10:44						
			011								
012	2.9	10:42									
									2.9-4.0ft No Recovery		
									T.D. = 4.0ft		

NOTES General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible.

115

ROCKY FLATS PLANT BOREHOLE LOG

PAGE 1 OF 1

Borehole Number: BH 90293
 Location - North: 749211 East: 2085761
 Date: 02-13-98
 Geologist: J. Baylan
 Drilling Equip.: Geoprobe

Surface Elevation: 5977 ft
 Area: 903 Pad
 Total Depth: 3.6 ft
 Company: Tierra Project No.: GE600006
 Sample Type: Continuous core

EG&G LOGGING SUPERVISOR

APPROVAL M. Word

DATE 2/23/98

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL/LITHOLOGIC LOG	SAMPLE DESCRIPTION	
0.0	0.0	0.0	0.5				PT?	0.0		Asphalt - dry, chippy, crumbly. Contains fibrous geomembrane.	
Box 1 of 1 0.0 - 3.6	RUN 1: 0.0 - 3.6	3.0	0.5				SM	0.5		Sand fill - d. moist. Traces gravel (fine). Dark brown (10YR 3/3). Bottom contact blurred.	
			0.8				SM	0.8		Gravelly, sandy silt w/ clay to sand-silt-clay mixture w/ gravel - Very dark brown (10YR 2/2), to dark brown (7.5YR 3/2, 3/3) below 1.8'. Increasing caliche below 2.6 brings color to v. pale brown (10YR 7/4). Sl. moist throughout. Elevated activity (FIBER) @ 0.8-1.1'.	
			1.7						1.7		
			2.4							2.4	
			2.4							2.4	
			2.4							2.4	
			2.4							2.4	
			2.4							2.4	
			2.4							2.4	
			2.4							2.4	
3.0								3.0			
3.6	3.6	3.6	N/A					3.6		NO RECOVERY "3.0-3.6"	
								3.6			
								4.0			
								5.0			
								6.0			
								7.0			
								8.0			
								9.0			
								10.0			

TD = 3.6'

NOTES: General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible.

RS = rad screen
 R = rads

116

ROCKY FLATS PLANT BOREHOLE LOG PAGE 1 OF 1

Borehole Number: BH90398 Surface Elevation: 5976 ft.

Location - North: T49.215 East: 2085835 Area: 903 PAD/LTP

Date: 4/21/98 Total Depth: 4.0 ft.

Geologist: R. KOEHLER Company: TIERRA Project No. GE60000

Drilling Equip.: GEOPROBE/MACROCORE Sample Type: CONTINUOUS CORE

EG&G LOGGING SUPERVISOR
 APPROVAL Mark Wood DATE 6/25/98

TOP/BOTTOM OF CORE INDEX	TOP/BOTTOM OF INTERVAL	FEET OF CORE INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRAC. TIME	DRILLING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOGS	SAMPLE DESCRIPTION
			011	13:30	4/22/98		NA	0.0	NA	0.0-0.4 Asphalt black, fractured=brittle, gravel upto 1cm, rounded, membrane present.
		0.4	012					0.4		
			013	13:33	4/21/98		GM	0.5		0.4-0.8, FILL, Olive Brown (2.5Y 4/4), sand and gravel olive brown (2.5Y 4/4), gravel to 1.5cm rounded, cus sand,
		0.8	014					0.8		
			001	13:11	4/21/98		GC	1.0		0.8-3.2, Soil, clay, sand, (unconsolidated, moist, gravel, 0.8-1.4ft Very dark grayish brown (pyr 3/a), 1.4-3.2 ft brownish yellow (pyr 6/c) gravel up to 3cm fractured, gravel composed of quartzites and metamorphic rock frags, gravel & sand micaceous in part, fine to medium sands, well graded, generally firm and but unconsolidated, moist.
		1.3	002					1.3		
		1.3	003					1.5		
		1.3	004	13:08				1.8		
		1.8	005					2.0		
		1.8	006	13:04				2.3		
		2.3	007					2.5		
		2.3	008	13:04				2.8		
		2.8					3.0			
							3.2			No Recovery 3.2-4.0ft.
							3.5			
							4.0			
			009	RS - Rns	40ml	13:18				T.D. = 4.0 ft
			010	R - Rns	1 gall	13:18				

NOTES: General: USCS is modified for this log as follows.
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible.

117

ROCKY FLATS PLANT BOREHOLE LOG

PAGE 1 OF 1

Borehole Number: BH90498
 Location - North: 749216 East: 2085910
 Date: 5/5/98
 Geologist: R. KOEHLER
 Drilling Equip.: GEO PROBE/MACROCORE

Surface Elevation: 5975 ft.
 Area: 903 PAD / HP
 Total Depth: 4.0ft
 Company: TIERRA Project No.: GE600002
 Sample Type: CONTINUOUS CORE

EG&G LOGGING SUPERVISOR
 APPROVAL Mark Wood

DATE 8/25/98

TOPHOLE OF CORE BOX	TOPHOLE OF INTERVAL	FEET OF CORE INTERVAL (FEET MEASUREMENT)	SAMPLE NUMBER	FLUORESCENCE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL / LITHOLOGICAL LOGS	SAMPLE DESCRIPTION
Box 1 of 1	Run # 1	0.0-4.0ft.					NA	0.0		0.0-0.5; Asphalt, black, brittle, fractured, gravel up to 2 cm, rounded, membrane at 0.1ft.
				001	12:51		GM	0.5	0.5-0.7: Fill; Sand and Gravel; Brownish yellow (PYR 6/6)	
				002	1.2		GC	1.0	0.7-2.8: Soil; Gravel up to 1.5 cm, rounded, granitic and metamorphic rock fragments, clay, sand, gravel	
				003	12:49			1.2	top is dark brown	
				004	1.7			1.5	Coarse sand, partly granitic, unconsolidated, moist.	
				005	12:46			1.7	to very dark grayish brown (PYR 3/3 to 3/2), bottom 0.5ft	
				006	2.2			2.0	is dark brown (10YR 4/3), gravel up to 3cm, fractured,	
				007	12:44			2.2	quartz (crystalline) and rotten granite, fine sand,	
				008	2.7			2.5	firm, unconsolidated, moist.	
								2.7, 2.8		
							3.0			
								3.5		No Recovery 2.8-4.0ft.
								4.0		
								4.5		T.D. = 4.0ft.
								5.0		
								5.5		
								6.0		
								6.5		
								7.0		
								7.5		
								8.0		
								8.5		
								9.0		
								9.5		

NOTES: General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible

118

ROCKY FLATS PLANT BOREHOLE LOG

PAGE 1 OF 1

Borehole Number: BH 90598
 Location - North: 749137 East: 2085610
 Date: 3/27/98
 Geologist: R. KOEHLER
 Drilling Equip.: GEOPROBE

Surface Elevation: 5979 ft
 Area: 903 PAD / AT Pad 8/25/98
 Total Depth: 3.5 ft
 Company: TIERRA Project No. GE600000
 Sample Type: CONTINUOUS CORE

EG&G LOGGING SUPERVISOR

APPROVAL Mark Wood

DATE 8/25/98

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE AREA	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION
Box 1 of 1 0.0-3.5ft	Run # 1 0.0-3.5ft.	Recovery 2.7ft.	1.001					0.5		0.0-0.7 Asphalt black, brittle fractured ft. 0.7-1.1 ft. Fill: Sand and Gravel, gravel up to 1cm, sub-rounded, igneous rock frags, fine to coarse sand, angular 1.1-2.7ft. Clay, sand, gravel; dominantly dark reddish brown (SYR 3/3) one patch (1.3-1.5 ft) very dark gray (SYR 3/1), gravel up to 3cm, igneous rock frags (granitic), commonly rotten, clay - firm, plastic, moist. No Recovery 2.7-3.5ft.
			1.002	10:30	1.1	6P	0.7			
			1.003		1.6	6C	1.0			
			1.004	10:38	1.1		1.1			
			1.005		2.1		1.5			
			1.006	10:26	2.0		2.0			
			1.007		2.6		2.5			
			1.008	10:23	2.7		2.7			
					3.1		3.0			
							3.5			
				4.0						
				5.0						
				6.0						
				7.0						
				8.0						
				9.0						

uncorrec
 Lt. clivel
 2.5Y 5/

NOTES: General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible.

119

ROCKY FLATS PLANT BOREHOLE LOG

PAGE 1 OF 1

Borehole Number: BH90698
 Location - North: 749139 East: 2085685
 Date: 02/29/98
 Geologist: J. Baylan
 Drilling Equip.: Geoprobe

Surface Elevation: 5978 ft.
 Area: 903 Pad
 Total Depth: 3.5 ft
 Company: Tierra Project No.: GE60000
 Sample Type: Continuous core

EG&G LOGGING SUPERVISOR

APPROVAL M. Wood

DATE 2/23/98

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION
0.0	0.0	0.0	003/025 R				PT?	0.0		Apsat - dry, chippy crumbly; contains fibrous glomembrane.
			003/026 R				SM	0.5		Sand fill - dark yellowish brown (10YR 4/4) sl. moist; trace gravel. Elevated FIDLER activities (to 15000) & 2250 - see notes below.
			003/032 R				SM	0.2		Gravelly silt-sand mixture - v. dark brown (10YR 2/2) sl. moist. Elevated FIDLER @ top - see notes below - to about brown (10YR 3/3) below 1.3'.
			003/027 RS				SM	1.0		
			003/033 R				GM	1.7		Silty sand-gravel-caliche mixture - mottled colors w/ most caliche @ 1.7-2.1', decreasing gradually below that. sl. moist. Colors are v. pale brown (10YR 8/4) in upper portion, prominently, and darkens towards bottom (7.5YR 5/6) @ bottom.
			003/034 R				GM	2.0		
			003/035 R					2.1		
			003/035R					2.2		
			N/A					3.0		NO RECOVERY
								3.5		2.8-3.5
								4.0		
								5.0		
								6.0		
								7.0		
								8.0		
								9.0		
								10.0		

Box 1 of 1
0.0-3.5

RUN
0.0-3.5

2.8

TD = 3.5 (most core included in samples)

RS = rad screen
R = rods

NOTES: General: USCS is modified for this log as follows:

- Materials amounts are estimated by % volume instead of % weight.
- (1) Badly broken core, accurate footage measurements not possible.
- (2) Core breaks cannot be matched, accurate footage measurements not possible.

Excl. log of elevating FIDLER readings
 uncertain due to 20' interval core,
 @ FIDLER log covers 2' interval max.
 Best estimate interval USCS is 2.1-2.4'
 or both first interval max. 2.1-2.4'

120

ROCKY FLATS PLANT BOREHOLE LOG

PAGE 1 OF 1

Borehole Number: BH 90798
 Location - North: 249137 East: 2085760
 Date: BH 90798 2/1/98
 Geologist: J. Barton R. KOEHLER
 Drilling Equip.: Geoprobe

Surface Elevation: 5977 ft
 Area: 903 pad
 Total Depth: 3.6 ft
 Company: Tierra Project No.: GE60000
 Sample Type: Continuous core

EG&G LOGGING SUPERVISOR

APPROVAL M. Wood

DATE 2/23/98

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION	
0.0 - 3.6 ft.	0.0 - 3.6 ft.	Recovery 3.1 ft.	0.0	RS R	Even / Fracture			0.0		Asphalt Black (10YR 2/1), gravel, sand, organic binder, gravel to 1.5cm, rounded/fracture, dry, Membrane at bottom Sand Gravel mix, pale yellow (2.5Y 7/4), gravel to 1.5cm, subround to round, unconsolidated, moist. Clay Sand Gravel, mottled - (top) very dark grayish brown (10YR 3/2), (middle) very pale brown (10YR 8/4), (bottom) reddish yellow (5YR 6/6), gravel to 4cm, much gravel fractured, unconsolidated, slightly moist. Clay tends to occur in clots.
			0.4	Dup RS R	2.013 2.019 2.020		PT	0.4		
			0.8	RS R	2.024 2.022		GM	0.8		
			1.5	RS R	2.025 2.023			1.0		
			2.0	RS R	2.016 2.025			1.5		
			2.5	RS R	2.017 2.024		GC	2.0		
			2.5	RS R	2.017 2.024			2.5		
			3.1	RS R	2.018 2.021			3.0		
		No Sample					3.1	No Recovery, 3.1-3.6 ft.		
3.6							4.0			
							5.0			
							6.0			
							7.0			
							8.0			
							9.0			
							0.0			

NOTES: General: USCS is modified for this log as follows:

Materials amounts are estimated by % volume instead of % weight.

- (1) Badly broken core, accurate footage measurements not possible.
- (2) Core breaks cannot be matched, accurate footage measurements not possible.

RS = red screen
 R = rads

121

ROCKY FLATS PLANT BOREHOLE LOG

PAGE 1 OF 1

Borehole Number: BH90898
 Location - North: 749140 East: 2085835
 Date: 4/22/98
 Geologist: R. KOEHLER
 Drilling Equip.: GEOPROBE/MACROCORE

Surface Elevation: 5977 ft
 Area: 903 PAD/HP MW 8/25/98
 Total Depth: 4.0 ft.
 Company: TIERRA Project No.: GE600000
 Sample Type: CONTINUOUS CORE

EG&G LOGGING SUPERVISOR

APPROVAL Mark Wood

DATE 8/25/98

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION
Box lot 1 0.0-4.0 ft. Run # 1 0.0-4.0 ft. Recovery 2.4 ft.							NA	0.0		0.0-0.4 Asphalt, black, fractured, membrane at 0.2 ft, gravel up to 1 cm - rounded
			001	0.9			GM	0.4		0.4-0.9 fill, sand and gravel, light olive brown (2.5Y 5/6) gravel to 1.5 cm, rounded, med to coarse sand, unconsolidated, slightly micaceous, moist.
			002	1.4			GC	0.9		0.9-1.4 soil, clay sand gravel, very dark grayish brown (2.5Y 3/2), gravel to 3 cm, fractured, 15 pieces rock frags - granitic in part, fine to medium sand, firm, unconsolidated, moist, well graded.
			003	11:16				1.5		
			004	11:16				1.9		1.4-2.4 soil, clay sand, gravel, yellow (10YR 7/6) gravel to 1.5 cm, rounded, mixed lithology - some granitic, medium to coarse sand, unconsolidated, firm, moist.
			005	1.9			2.0			
			006	11:15			2.5			
			007	2.4				2.9		No Recovery 2.4-4.0 ft.
			008	11:14				3.0		Some of gravel "rotten" or weathered.
		008	2.9				3.5			
							4.0		T.D. = 4.0 ft.	
							5.0			
							6.0			
							7.0			
							8.0			
							9.0			

NOTES: General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible.

122

ROCKY FLATS PLANT BOREHOLE LOG PAGE 1 OF 1

Borehole Number: BH90998 Surface Elevation: 5976 ft.

Location - North: 5 RPX 8/8/98 East: 2085910 Area: 903 PAD / LIP 2/25/98

Date: 5/4/98 NORTH 749141 Total Depth: 4.0 ft.

Geologist: R. KOEHLER Company: TIERRA Project No.: GEG00000

Drilling Equip.: GEOPROBE/MACROCORE Sample Type: CONTINUOUS CORE

EG&G LOGGING SUPERVISOR APPROVAL Mark Wood DATE 8/25/98

TOP/BOTTOM OF CORE BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	TIME/URE ATRE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION
Box 1 of 1 0.0-4.0 ft.	Run # 1 0.0-4.0 ft.	Recovery 3.1 ft.	001	0.8	10:27				0.04	0.0-0.4; Asphalt, black, brittle, rounded gravel up to 1cm, membrane at about 0.2 ft.
			002	1.3					0.8	0.4-0.8; Fill; Sand and gravel; brown to dark brown (10YR 4/3), gravel up to 1.5cm, granitic and metamorphic
			003	1.8	10:24				1.0	0.8-3.1; Soil; rock fragments, coarse sand, unconsolidated, moist.
			004	2.3					1.3	Clay-Gravel
			005	2.8	10:21				1.5	with minor sandy, very dark grayish brown (10YR 3/8)
			006	3.3					1.8	gravel up to 3cm, fractured, granitic and quartzitic (?)
			007	3.8	10:18				2.0	rock fragments, granitics rotten, coarse sand
			008	4.0					2.3	granitic in part, firm, unconsolidated, moist.
			009	4.0					2.5	
			010	4.0					2.8	
								3.0		
								3.5		No Recovery 3.1-4.0 ft.
								3.8		
								4.0		
								4.5		T.D. = 4.0 ft
								5.0		Note: Up to 15 ppm Foxboro TVA and
								5.5		16 ppm Mini Rae VOC's
								6.0		measured. Some VOC's present throughout
								6.5		core. Maximum between 1.3 and 1.8 ft.
								7.0		
								7.5		
								8.0		
								8.5		
								9.0		
								9.5		

NOTES: General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible.

ROCKY FLATS PLANT BOREHOLE LOG

Borehole Number: BH91098
 Location - North: 749062 East: 2085610
 Date: 3/25/98
 Geologist: Brandon R. KOEHLER
 Drilling Equip.: Geoprobe

Surface Elevation: 5979 ft
 Area: 903 PAD/HP/MS 8/25/98
 Total Depth: 6.5 ft.
 Company: Tierra Project No. GE600000
 Sample Type: Continuous core MACROCORE

EG&G LOGGING SUPERVISOR

APPROVAL Mark Wood

DATE 8/25/98

SAMPLE DESCRIPTION

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FLUORESCENCE AVERAGE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL/ LITHOLOGIC LOGS	SAMPLE DESCRIPTION
			1.001	14			ASPHALT	0.0		0.0-0.5 Asphalt, black, fractured/brittle.
			1.002	11:52			GM	0.5		0.5-1.4 (FILL) Sand and Gravel, olive brown (2.5Y 4/3) Gravel fractured to rounded, up to 1.5 cm, fine to medium sand, poorly graded, unconsolidated, moist.
			1.003	1.9			GC	1.4		
			1.004	11:50				1.9		1.4-2.6 (Soil) Clay Sand Gravel, dark reddish brown (5YR 3/3), Gravel fractured to rounded up to 3cm, Igneous Rock Fragments (IRF's), fine sand, matrix firm, breaks into blocks, slightly plastic, moist, less gravel than BH91598, moist
			1.005	2.4			GM	2.4		
			1.006	11:48				2.5		No Recovery 2.8-3.5 ft. Clay Sand 2.6-2.8 ft olive sand (2.5Y 6/8) in yellow silt brown (10YR 4/3) Clay, fine sand, slightly consolidated to crumbly poorly graded, moist.
			1.007	2.9			GM	2.9		
			1.008	3.4			GM	3.4		3.5-3.9 ft As Above 2.6-2.8 ft
							GC	3.5		
								3.9		3.9-5.9 ft. Clay/Sand/Gravel mottled light olive brown (2.5Y 5/6) dominant, gravel much greater than clay or sand, fractured, granitic, up to 3cm, fine sand, well graded, poorly sorted, moist.
							GC	4.5		
								5.0		5.9-6.5 No Recovery
							GC	5.5		
								5.9		
								6.0		
								6.5		
			1.009	40 ml RS	Rinse			7.0		TD = 6.5 ft.
			1.010	1 gallon R	Rinse			7.0		

Box 1 of 1 0.0-6.5 ft.

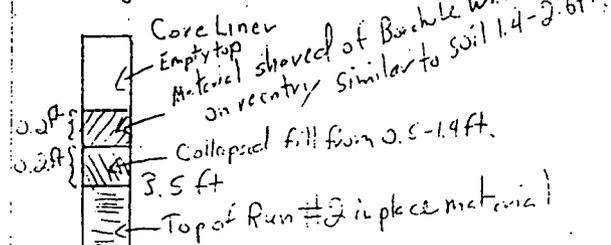
Run #1 0.0-3.5 ft.

Recovery 2.8 ft.

Run #2 3.5-6.5 ft.

Recovery 2.8 ft including 0.4 ft splash.

Diagram: Run #2



NOTES: General: USCS is modified for this log as follows:

Materials amounts are estimated by % volume instead of % weight.

(1) Badly broken core, accurate footage measurements not possible.

(2) Core breaks cannot be matched, accurate footage measurements not possible.

124

ROCKY FLATS PLANT BOREHOLE LOG

PAGE 1 OF 3

Borehole Number: 8H91198
 Location - North: 749064 East: 2085085
 Date: 021798 021898
 Geologist: J. Baylan
 Drilling Equip.: Geoprobe - Dual Wall

Surface Elevation: 5979 ft.
 Area: 903 Pad
 Total Depth: 21.4 ft
 Company: Tierra Project No.: CEG00000
 Sample Type: Continuous core

EG&G LOGGING SUPERVISOR

APPROVAL M. Wood

DATE 2/23/98

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION
0.0	0.0	0.0	001/001 RS 001/017 R				PT?	0.0		Asphalt - dry, chippy. Contains fibrous membrane.
			001/002 RS 001/018 R				SM	0.4		Fill - sand w/ fine gravel. Sl. moist. Dk brown (10YR 3/3) to dk. yellowish brn. (10YR 4/4).
			001/003 RS 001/019 R				SM/GM	1.0		Sand-silt mixture w/ gravel to gravelly, sandy silt -
			001/004 RS 001/020 R					1.8		peds of caliche common below ~ 1.8'. Sl. moist. V dk brown (10YR 2/2) above 1.8', then mottled below w/ dk brown (10YR 3/3), caliche (v. pale brn., 10YR 8/3), and other colors. To 8000 cpm on FIBER Q 1.0'
			001/005 RS 001/021 R					2.0		
			001/006 RS 001/022 R					2.5		
			31					3.0		
			001/033 -V					3.4		
			34					3.4		
			N/A					4.0		NO RECOVERY 3.4 - 4.0
							GM	4.0		
								5.0		Sandy, silty gravel - strong brown (7.5YR 5/6 to 1/6), sl. moist, scattered clay pockets. Abundant shattered gravels. No "hits." off color is mottled, but dominantly strong brown.
								6.0		
								7.0		
								8.0		same as above 4.0-8.0' w/ more rotting gravels. Color mostly lighter (pale) very mottled due to some to abundant rock flow, shattered gravels, rotting gravels. Sl. moist.
								9.0		
								10.0		

NOTES: General: USCS is modified for this log as follows:

- Materials amounts are estimated by % volume instead of % weight.
- (1) Badly broken core, accurate footage measurements not possible.
- (2) Core breaks cannot be matched, accurate footage measurements not possible.

In sample info: RS = rad screen
 R = rads
 V = VOCs

125

ROCKY FLATS PLANT BOREHOLE LOG

PAGE 2 OF 3

Borehole Number: BH91198
 Location - North: 749064 East: 2085685
 Date: 021898
 Geologist: J. Baylan
 Drilling Equip.: Geoprobe

Surface Elevation: 5979 ft
 Area: 903 Pad
 Total Depth: 21.4 ft
 Company: Tierra Project No.: GE60000
 Sample Type: Continuous core

EG&G LOGGING SUPERVISOR

APPROVAL M. Wood

DATE 2/23/98

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE INTERVAL IN FIELD MEASUREMENT	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION	
Box 2 of 3: 9.0-17.5'	10.0	10.0	N/A				GM	10.0		Same as above, 8.0-10.0'. Zone of fine grained material @ 11.1-12.0 composed of rotten gravels. Most consumed by samples.	
	10.0	10.0						11.0			
	12.0	3.1'	11.1 001/024 R 001/008 R 11.6 001/035 V 11.9 1.0 N/A				SC	11.1		Sandy clay. Clayey sand w/ gravel - sl. moist. Several altered or clayey rotten gravels. Mottled colors, but mainly strong brown (7.5YR4/6) w/ streaks of light olive brown (2.5Y5/3). Some zones to sandy clay w/ gravel. Abrupt bottom contact, fairly sharp upper.	
	12.0	12.0						12.0			
	12.0	14.0	3.0					13.0			
	14.0	14.0					GM	13.5		Same as above, 8.0-10.0'.	
	14.0	14.0						14.0			
	14.0	16.0	2.8	15.1 001/009 R 001/025 Z 15.5 001/036 - VCL 15.7 16.0				SC/GC		14.2	Same as above, 11.1-13.5, w/ increased gravel (to GC) @ 14.2-14.7. Then SC to 15.7, GC to 16.0.
	16.0	16.0						15.0			
	16.0	16.0						16.0			
Box 3 of 3: 17.5-21.4'	16.0	16.0						16.0		Same as above, 11.1-13.5. Sl. moist.	
	16.0	18.0	2.5	N/A				17.0			
	18.0	18.0						17.2	Sandy clay to clay-sand mixture, w/ trace gravel. Sl. moist. Some colors as noted for 11.1-13.5.		
	18.0	20.0	1.5'	16.6 001/010 R 001/026 R 17.1 001/037 V 17.2 001/038 V 17.3 001/011 R 001/027 R				C/SX	17.2	Same as above but more SC. Sl. moist. Tr. gravel. SC portion @ base of recovery. Replaced "No Recovery" pattern w/ claystone pattern.	
18.0	20.0						18.0				
18.0	20.0							19.0			
18.0	20.0							19.5		TOP OF BEDROCK = 19.5 NO RECOVERY See next page for description. 17.5 zone	
17.5	21.4	3.9						20.0			

NOTES: General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible.

126

ROCKY FLATS PLANT BOREHOLE LOG

Borehole Number: B491198
 Location - North: 749064 East: 2085685
 Date: 02/19/98
 Geologist: J. Baylan
 Drilling Equip.: Geoprobe

Surface Elevation: 5979 ft
 Area: 903 Pad
 Total Depth: 21.4 ft
 Company: Tierra Project No.: GE60000
 Sample Type: Continuous core

EG&G LOGGING SUPERVISOR

APPROVAL M. Wood

DATE 2/23/98

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL/LITHOLOGIC LOG	SAMPLE DESCRIPTION
Box 3 of 3 17.5 - 21.4' ↑	Run 19.0 - 21.4	3.1	20-2 20-2 N/A					20.0 21.0 21.4	Claystone to claystone w/silt-grayish brown (2.5Y 5/2). Sl. moist. Traces carbonaceous flecks in some zones. Sand & gravel streamers @ ~0.7-1.1' below top of core remaining after sampling probably due to gravels @ contact falling into hole when core was lost in previous run. No hits. (Expect sands & gravels noted above to be out of place, not in original setting.) See logbook. No recovery 21.3214'	
								21.0 22.0 23.0 24.0 25.0 26.0 27.0 28.0 29.0 30.0		TD = 21.4' for more detailed explanation of lost core recovered core, imported sands & gravels.

NOTES: General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible.

127

ROCKY FLATS PLANT BOREHOLE LOG

PAGE 1 OF 1

Borehole Number: BH 91298
 Location - North: 74906Z East: 2085760
 Date: 021099
 Geologist: J. Baylan
 Drilling Equip.: Geoprobe

Surface Elevation: 5978 ft
 Area: 903 Pad
 Total Depth: 3.5 ft
 Company: Tierra Project No.: GE600000
 Sample Type: Continuous core

EG&G LOGGING SUPERVISOR

APPROVAL M. Wood

DATE 2/23/98

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION
0.0	0.0	0.0	Bottle 001 (CS) 007 (R)				PT?	0.0		Asphalt - dry, crumbly, & lumpy. Containing fibrous membrane, or other fibrous material - single cut disc present. Both samples contain paint from hole marking.
	0.0 - 1.0	2.6	Bottle 002 (CS) 008 (R)				SM	0.5		Fill - sand w/ silt & gravel. Lower contact not as clear as locs 417, 922. Sl. moist. Dk. yellowish brown (04R 4/4).
	0.0 - 3.5		Bottle 003 (CS) 009 (C)				GM	1.0		Silty gravel to silt sand gravel - caliche mixture - caliche minor, then sharply increases below 1.3' to become dominant to major component. Very light brown (10YR 7/2) above 1.5', mottled w/ very pale brown (10YR 8/4) to 1.7', then mainly v. pale brown (10YR 8/4). The pale color is caliche. Sl. moist. Some pads of clay present. Lowest 0.1' shows strong brown (7.5 YR 5/3) pad which may become dominant color below 2.5'.
			Bottle 4 (RS) 10 (R, red)					2.0		
			Bottle 5 (RS) 12 (R)					2.6		
								3.0		NO RECOVERY 2.6 - 3.5'
								3.5		TD = 3.5' Measured TD = 3.6'
								4.0		
								5.0		
								6.0		
								7.0		
								8.0		
								9.0		
								10.0		

NOTES: General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible.

RS = red screen
 R = red

128

ROCKY FLATS PLANT BOREHOLE LOG

PAGE 1 OF 1

Borehole Number: BH91398
 Location - North: 749065 East: 2095834
 Date: 4/27/98 (Core 4/22/98)
 Geologist: R. KOEHLER
 Drilling Equip.: GEOPROBE/Macvaco

Surface Elevation: 5977 ft
 Area: 903 PAD/LTP
 Total Depth: 4.0 ft 8/25/98
 Company: TIERRA Project No.: GE60000
 Sample Type: CONTINUOUS CORE

EG&G LOGGING SUPERVISOR

APPROVAL Mark Weid

DATE 8/25/98

TOP/BOTTOM OF CORE INTERVAL	TOP/BOTTOM OF INTERVAL	FEET OF CORE INTERVAL	SAMPLE NUMBER	STRUCTURE ANGLE	BEDDING ANGLE	GRANULARITY DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL/ LITHOLOGIC LOG	SAMPLE DESCRIPTION
Box 1 of 1 0.0-4.0ft.	Run #1 0.0-4.0ft.	Recovery 2.4ft.	001	0.8			NA		0.0-0.4	0.0-0.4; Asphalt, black, membrane about 0.3ft, ductile breaks into slabs, rounded gravel up to 1 cm.
			002	11:12			GM		0.4-0.8	0.4-0.8; Fill sand and gravel; dark yellowish brown (10YR 4/2) gravel up to 2cm, rounded, mixed lithologies, coarse sand, poorly graded, unconsolidated, moist.
			003	1.3			GC		0.8-1.3	0.8-1.3ft; Soil, clay, sand, gravel; dark grayish brown (10YR 4/2), minor gravel content up to 2cm, fractured, granitic igneous rock frags, fine to medium sand, well graded.
			004	11:10				1.3-1.5	1.3-1.5ft; Transition fine, unconsolidated, moist.	
			005	1.8					1.5-2.0	1.5-2.4ft soil, clay sand gravel, yellow (10YR 7/6), gravel up to 3cm, rounded and fractured, granitic igneous rock fragments, quartzite, fine to medium sand, firm, sticky, moist.
			006	11:08					2.0-2.4	
			007	2.3					2.4-4.0	2.4-4.0ft; No Recovery
			008	11:06						
					2.8					
		3.0								
		3.5								
		4.0							T.D. = 4.0 ft.	

NOTES: General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible.

129

ROCKY FLATS PLANT BOREHOLE LOG

PAGE 1 OF 1

Borehole Number: BH91598
 Location - North: 748987 East: 2085610
 Date: 3/25/98
 Geologist: R. KOEHLER
 Drilling Equip.: Geoprobe

Surface Elevation: 5980 ft
 Area: 903 PAD / LTP / m / Nest 8
 Total Depth: 3.5 ft
 Company: Tierra Project No. GE60000
 Sample Type: Continuous core MACROCORE

EG&G LOGGING SUPERVISOR

APPROVAL Mark Ward

DATE 8/25/98

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FIXTURE AIRIE	READING AIRIE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOGS	SAMPLE DESCRIPTION		
Box 1 of 1 0.0-3.5 ft.	Run #1 0.0-3.5 ft.	Recovery 2.5 ft.	1.001		12:58		AS	0.0		0.0-0.8 ft, Asphalt, black, consolidated at top fractured in lower half.		
			1.002		12:58			0.5				
			1.010					GM	2.8		0.8-1.5 ft. (Fill) sand and gravel, olive-brown (S.Y. 4/3) subangular gravel, granitic and metamorphic, up to 1.5 cm, fine to coarse sand, well graded, unconsolidated, friable, moist.	
			1.005	RS	12:55				1.0			
			1.004	RS				GC	1.5		1.5-2.5 ft. (Soil) Clay Sand Gravel, very dark brown (10YR 2/3) in top half, brown (7.5 YR 4/3) in bottom half, gravel, fractured, up to 3 cm, granitic and quartzite, and fine sands, top half more clayey, bottom more sandy, clays plastic, crumbly to blocks, well graded, moist.	
			1.005	RS	12:53				2.0			
			1.006	RS						2.5		2.5-3.5 No Recovery
			1.007	RS	12:52				3.0			
			1.002	R						3.5		
										4.0		
							5.0					
							6.0					
							7.0					
							8.0					
							9.0					
							0.0					

TD = 3.5 ft.

NOTES: General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible
 (2) Core breaks cannot be matched, accurate footage measurements not possible.

131

ROCKY FLATS PLANT BOREHOLE LOG

PAGE 1 OF 1

Borehole Number: RH91698
 Location - North: 748989 East: 2085684
 Date: 5/6/98
 Geologist: R. KOEHLER
 Drilling Equip.: GEOPROBE/MACROCORE

Surface Elevation: 5979 ft
 Area: 903 PAD/LIP ms 8/25/98
 Total Depth: 4.0ft
 Company: TIERRA Project No.: GE600000
 Sample Type: CONTINUOUS CORE

EG&G LOGGING SUPERVISOR

APPROVAL Mark Wood

DATE 8/25/98

TOP POSITION OF CORE IN BOX	TOP POSITION OF IRRADIATION	FEET OF CORE INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACURE ANGLE	DEFLECTING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL/ROCK LOG	SAMPLE DESCRIPTION	
Box lot 1 0.0-4.0ft.	Run #1 0.0-4.0ft.	Recovery 3.4ft.	001				NA			0.0-0.5: Asphalt, black/gray, fractured - unusually powdery, fractured gravel up to 1cm, granitic and metamorphic rocks	
			002	0.9	11:43		GM	0.5		0.5-0.9: F. 1/2 Sand and Gravel, light yellowish brown (10YR 6/4), rounded granitic and metamorphic rock frags, rounded, RPK 5/6/98	
			003	1.4			GC	1.0		0.9-3.4: Unconsolidated, dry, coarse sand	
			004	1.9	11:38				1.4		Soil; clay, sandy, gravel; very dark grayish brown (10YR 3/2) at top grades to dark reddish brown (5YR 3/2) at bottom; gravel to 3cm, fractured, rotten granitic rock fragments and quartzites, fine sand, var. coarse sand, firm to hard, unconsolidated, slightly moist to dry.
			005	2.4	11:35				1.6		
			006	2.9					1.9		
			007	3.4	11:32				2.0		
			008	3.9					2.4		
				4.0					2.5		
			009 - Red Screen - 40ml gl. Rinse - 11:51					3.0		No Recovery 3.4-4.0ft.	
			010 - Red Isotope - 1 gall poly Rinse - 11:51					3.4		T.D. = 4.0ft.	
								3.5		Note: Sample interval 0.9-1.4 had high α and γ -ray readings $\delta = 28,000$ counts per minute with fiddler.	
								4.0			
								4.5			
								5.0			
								5.5			
								6.0			
								6.5			
								7.0			
								7.5			
								8.0			
								8.5			
								9.0			
								9.5			

NOTES: General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Slightly broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible.

132

ROCKY FLATS PLANT BOREHOLE LOG

PAGE 1 OF 1

Borehole Number: BH91898
 Location - North: 748990 East: 2085834
 Date: 4/28/98
 Geologist: R. KOEHLER
 Drilling Equip.: GEOPROBE / MACROCORE

Surface Elevation: 5977 FT
 Area: 903 PAD / LTP RWY
 Total Depth: 4.0ft
 Company: TIERRA Project No.: GE60000
 Sample Type: CONTINUOUS CORE

EG&G LOGGING SUPERVISOR

APPROVAL Mark Wood

DATE 8/25/98

TOP POSITION OF CORE IN BOX	TOP POSITION OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FLUCTUATION AIRSIE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL / LITHOLOGIC LOG	SAMPLE DESCRIPTION	
Box 1 of 1 0.0-4.0ft.	Run #1 0.0-4.0ft.	Recovery 2.7 ft.	001	10:07			NA	0.0		0.0-0.2 Asphalt, black, fractured, membrane at approx 0.3ft, gravel to 1cm, rounded and fractured.	
			002	0.4					0.5		
			003	10:09				GM	1.0		0.6-1.1 Fill, Sand and Gravel, light yellowish brown (10YR 6/4), medium to coarse sand dominant in top half, gravel to 1.5cm dominant in bottom half, gravel fractured, granitic.
			004	1.1					1.1		
			005	10:12				GC	1.5		1.1-2.0 Soil, clay sand gravel unconsolidated, dry to slightly moist.
			006	1.4					1.6		
			007	10:06					2.0		Very dark greyish brown (10YR 3/2), gravel to 2.5cm, fractured, granitic igneous rock frags., medium to coarse sand, firm, dry to slightly moist.
			008	2.1					2.1		
			009	10:04				SC	2.5		2.0-2.7, Soil, clay sand, yellow (10YR 7/6), fine to med. sand, caliche?, crumbly, slightly moist.
			010	2.4					2.6		
			011	10:03					2.7		
			012	3.1					3.0		No Recovery 2.7-4.0ft.
							3.1				
							3.5				
							4.0		T.D. = 4.0ft.		
							5.0				
							6.0				
							7.0				
							8.0				
							9.0				

NOTES: General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible.

134

ROCKY FLATS PLANT BOREHOLE LOG

PAGE 1 OF 1

Borehole Number: BH91998
 Location - North: 748990 East: 2085909
 Date: 4/27/98
 Geologist: R. KOEHLER
 Drilling Equip.: GEOPROBE/MACROCORE

Surface Elevation: 5976 ft.
 Area: 903 PAD/LTP
 Total Depth: 4.0 ft. 8/25/98
 Company: TIERRA Project No.: GE600000
 Sample Type: CONTINUOUS CORE

EG&G LOGGING SUPERVISOR

APPROVAL Mark Wood

DATE 8/25/98

TOP POSITION OF CORE IN BOX	TOP POSITION OF INTERVAL	FEET OF CORE INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FINAL TIME	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL/ LITHOLOGIC LOG	SAMPLE DESCRIPTION	
Box 1 of 1 0.0-4.0 ft.	Run # 1 0.0-4.0 ft.	Recovery 2.7 ft.	001	13:06			MA		0.0-0.5	Asphalt, black, brittle, gravel to 1 cm - rounded and fractured, membrane at 0.3 ft. RPK 4/29/98	
			002	0.5			GM	0.5	0.5-0.9	Fill, sand and gravel, brown to dark brown (10YR4/3), minor rounded 1 cm gravel, med. to coarse sand.	
			003	13:08			GC	1.0	0.9-2.5	Soil, clay sand (unconsolidated, moist gravel, very dark grayish brown (10YR 3/2) with dark reddish brown (5YR 3/2) from 2.0-2.5 ft. fractured granitic and quartzite rock frags to 3 cm. Fine to medium sand, firm, generally moist-very moist 0.9-1.9.	
			004	0.9					1.0		
			005	13:16					1.5		
			006	1.4					2.0		
			007	13:13					2.5		
			008	1.9					2.7		
			009	13:23					2.9		
			010	2.4					3.0		
			011	13:01					SC	2.5-2.9	Clay Sand - TRACE Gravel, yellow (10YR 9/6) fractured gravel to 1 cm, fine sand, firm, sticky, moist.
			012	2.9						3.0-4.0	No Recovery 2.7-4.0 ft.
								4.0	F.D. = 4.0 ft.		
								5.0			
								6.0			
								7.0			
								8.0			
								9.0			

135

NOTES: General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible.

ROCKY FLATS PLANT BOREHOLE LOG

PAGE 1 OF 1

Borehole Number: BH92098
 Location - North: 748913 East: 2085609
 Date: 5/7/98
 Geologist: R. KOEHLER
 Drilling Equip.: GEOPROBE/MACROCORE

Surface Elevation: 5980 ft
 Area: 903 PAD/LIP and 8/25/98
 Total Depth: 4.0ft.
 Company: TIERRA Project No.: GE60000
 Sample Type: CONTINUOUS CORE

EG&G LOGGING SUPERVISOR

APPROVAL Mark Wood

DATE 8/25/98

IDENTIFICATION OF CORE IN BOX	IDENTIFICATION OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	TIME	DEPTH (FEET)	USCS SYMBOL	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION
Box 1 of 1 0.0-4.0ft.	Run # 1 0.0-4.0ft.	Recovery 3.1 ft.	001	13:37	0.9	NA		0.0-0.5: Asphalt, black, brittle, top in coin shaped pieces, gravel less than 1.0cm, rounded, no obvious membrane.
			002	1.4	GM	0.5		0.5-0.9: Fill, Sand and Gravel; dark yellowish brown (10YR4/4) rounded gravel up to 1cm, coarse sand, unconsolidated, moist
			003	1.9	GC	1.0		0.9-3.1: Soil, clay, sand, gravel, top is dark reddish brown (5YR3/7) grading down to white (10YR8/6) at bottom, gravel up to 3cm, larger pieces fractured, smaller pieces rounded, metamorphic and rotten granitic clasts, medium grained sand, granitic in part, crumbly, slightly moist, caliche heavy in lower 1.5 ft.
			004	13:34		1.4		
			005	1.9		1.9		
			006	13:32		2.0		
			007	2.4		2.4		
			008	13:30		2.9		
	2.9	3.0						
	3.1	3.1						
					3.5		No. Recovery 3.1-4.0ft.	
					4.0			
					4.5			T.D. = 4.0ft.
					5.0			
					5.5			
					6.0			
					6.5			
					7.0			
					7.5			
					8.0			
					8.5			
					9.0			
					9.5			

NOTES: General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible.

136

ROCKY FLATS PLANT BOREHOLE LOG

PAGE 1 OF 1

Borehole Number: BH92198
 Location - North: 748914 East: 2085684
 Date: 5/7/98
 Geologist: R. KOEHLER
 Drilling Equip.: GEOPROBE/MACROCORE

Surface Elevation: 5979 ft.
 Area: 903 PAD/LTP no dist/98
 Total Depth: 4.0ft.
 Company: TIERRA Project No.: EG600000
 Sample Type: CONTINUOUS CORE

EG&G LOGGING SUPERVISOR

APPROVAL

Made Wood

DATE

8/25/98

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL FIELD MEASUREMENT	SAMPLE NUMBER	FLUORESCENCE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION
Box 1 of 1 0.0-4.0ft.	Run #1 0.0-4.0ft.	Recovery 3.4 ft.					NA			0.0-0.4: Asphalt, black, brittle, fractured, rounded gravel up to 1cm, membrane at 0.2 ft.
			001	0.7			GM	0.5 ³⁴		0.4-0.7 ft. Fill: Sand and Gravel; dark grayish brown (10YR4/2), rounded gravel up to 1cm, gravel granitic in part, coarse Sand, unconsolidated, moist
			002	11:14				0.7		
			003	1.2			GC	1.0		0.7-3.4ft Soil; clay, Sand and gravel; dark reddish brown (5YR3/2-3/3), gravel up to 3cm, fractured, rotten granitic and micaceous metamorphic rock fragments, medium sized sand-micaceous, unconsolidated, firm, well graded, slightly moist.
			004	11:12				1.2		
			005	1.7				1.5		
			006	11:08				1.7		
			007	2.2				2.0		
			008	11:06				2.2		
				2.7				2.5		
					2.7					
					3.0					
					3.5 ³⁴				No Recovery 3.4-4.0ft.	
					4.0					
					4.5				T.D. = 4.0ft.	
					5.0					
					5.5					
					6.0					
					6.5					
					7.0					
					7.5					
					8.0					
					8.5					
					9.0					
					9.5					

NOTES. General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible.

137

ROCKY FLATS PLANT BOREHOLE LOG

PAGE 1 OF 1

Borehole Number: B.H 92298
 Location - North: 778914 East: 2085760
 Date: 020498
 Geologist: J. Baylan
 Drilling Equip.: Geoprobe

Surface Elevation: 5977 ft
 Area: 903 pad
 Total Depth: 3.0 ft
 Company: Tierra Project No.: GE60000
 Sample Type: Continuous core

EG&G LOGGING SUPERVISOR

APPROVAL M. Ward

DATE 2/23/98

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION
0.0	0.0	0.0	ALL ARE RIN EVENT 001					0.0		NO RECOVERY 0.0-0.3 (solid point bit)
0.0	0.3	0.3	BOTTLE 7 = mds				Asphalt	0.3		Asphalt - crumbly black.
0.0	0.5	0.5	BOTTLE 8 = mds				SM	0.5		Fill - sand w/silt fine gravel. Light yellowish brown (2.5-4.6%). Dry.
0.0	0.9	0.9	BOTTLE 5 = mds					0.9		Simply silty gravel. Consumed by samples.
0.0	1.0	1.0	BOTTLE 6 = f.s.					1.0		Dry. Some to abundant rock flour, abundant shattered gravels.
0.0	1.6	1.6	BOTTLE 3 = mds				GM	1.6		
0.0	2.0	2.0	BOTTLE 4 = cs.					2.0		
0.0	2.3	2.3	BOTTLE 1 = mds				GC	2.3		Clayey gravel to gravelly clay. Yellowish red, 5-10% f-4/w. w/silt, sand traces. Moderately stiff. Sl. moist.
0.0	2.3	2.3	BOTTLE 2 = cs.					2.3		NO RECOVERY 2.3-3.0
3.0	3.0	3.0	N/A					3.0		TD=30'

NOTES: General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible.

138

ROCKY FLATS PLANT BOREHOLE LOG

PAGE 1 OF 1

Borehole Number: B#92398
 Location - North: 748915 East: 2085834
 Date: 4/28/98
 Geologist: R. KOEHLER
 Drilling Equip.: GEOPROBE/MACROCORE

Surface Elevation: 5976 Ft.
 Area: 903 PAD/LTP *and 8/25/98*
 Total Depth: 4.0 ft.
 Company: TIERRA Project No.: GE60000
 Sample Type: CONTINUOUS CORE

EG&G LOGGING SUPERVISOR
 APPROVAL Mark Wood

DATE 8/25/98

TOP POSITION OF CORE IN BOX	TOP POSITION OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	PH. TIME	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL/LITHOLOGIC LOG	SAMPLE DESCRIPTION	
Box 1 of 1 0.0-4.0 ft.	Run #1 0.0-4.0 ft.	Recovery 2.9 ft.	001	13:04				NA	0.5		0.0-0.7 Asphalt, black, brittle-fractured, gravel to 1cm, rounded, membrane at about 0.2 ft, dry
			002	1.3				6M	0.7		
			003	1.8					1.0		0.7-1.3 Fill, sand and gravel, light yellowish brown (10YR 6/4), minor gravel to 1cm - rounded, med-coarse sand, unconsolidated, dry.
			004	13:02					1.3		
			005	2.3					1.5		1.3-2.9 Soil, clay, sand, gravel, brown to dark brown (10YR 4/3), fractured gravel to 3cm, granitic rock frag, quartzitic too, minor sand - fine to medium, firm, unconsolidated, slightly moist.
			006	13:00					1.8		
			007	2.8					2.0		
			008	12:58					2.3		
				3.3				3.0		No Recovery 2.9-4.0 ft.	
								3.3			
								3.5			
								4.0		T.D. = 4.0 ft.	
								5.0			
								6.0			
								7.0			
								8.0			
								9.0			

139

NOTES: General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible.

ROCKY FLATS PLANT BOREHOLE LOG

PAGE 1 OF 1

Borehole Number: BH92498
 Location - North: 749915 East: 2085909
 Date: 4/29/98
 Geologist: R. KOEHLER
 Drilling Equip.: GEOPROBE/MACROCORE

Surface Elevation: 5976 ft.
 Area: 903 PAD/LTP 8/25/98
 Total Depth: 4.0
 Company: TIERRA Project No.: GE600000
 Sample Type: CONTINUOUS CORE

EG&G LOGGING SUPERVISOR,
 APPROVAL Mark Ward

DATE 8/25/98

TOP POSITION OF CORE INTERVAL	TOP POSITION OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FINAL TIME	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL/ LITHOLOGIC LOGS	SAMPLE DESCRIPTION		
Box lot 1 0.0-4.0 ft.	Run # 1 0.0-4.0 ft.	Recovery 2.9 ft.	001	1.1			NA	0.5		0.0-0.5 Asphalt, black, brittle, 1cm rounded gravel,		
			002	10:27			GM	1.0		0.5-1.1 Fill, sand and gravel, yellowish brown (10YR 5/4), minor rounded gravel up to 1.5cm, medium to coarse sand, unconsolidated, slightly moist.		
			003	10:25			GC	1.5		1.1-2.1 Soil, gravel dominant with minor clay and sand, very dark grayish brown (10YR 3/2), fractured granitic rock fragments up to 3cm, crumbly, slightly moist.		
			004	2.1				2.0				
			005	10:20				2.5				
			006	2.6				2.5				
			007	10:19				2.9				
			008	3.1				3.1				
								3.5				No Recovery 2.9-4.0 ft.
								4.0				T.D = 4.0 ft.
			011	And Screen Rinse 40ml								
			012	Rad Isotope Rinse 1 gallon								
				both 10:33								

NOTES: General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible.

140

ROCKY FLATS PLANT BOREHOLE LOG

PAGE 1 OF 2

Borehole Number: BH92598 Surface Elevation: 5978 ft
 Location - North: 74895 East: 208590920855 Area: 903 PAD/LIP Area
 Date: 2/23/98 2/24/98 3/2/98 7/1/97 Total Depth: 18.5 ft
 Geologist: B. R. KOEHLER Company: Tierra Project No.: GE60000
 Drilling Equip.: Geoprobe - Dual Wall Sample Type: Continuous Core Dual Wall

EG&G LOGGING SUPERVISOR

APPROVAL Mark Wood

DATE 8/25/98

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION	
Box 1 of 2: 0.0-10.0 ft	Run #1 0.0-4.0 ft (46.5 inches)	Recovery 2.6 ft.	RS/R	1.001	1.017		GM	0.0	0.0-0.2 ft	Sand and gravel, light yellowish brown (8.5Y 6/4)	
			RS	1.002	1.018		GC	0.2	0.2-0.6 ft	Rock flour with medium sand, quartz and granitic sand and gravel; pale yellowish brown (10YR 6/2); med. quartzite and igneous rock fragments, unconsolidated, dry	
			RS	1.003	1.019			1.0	0.6-2.6 ft.	Clay, sand, gravel; fine to 2.5 cm, fractured, dark yellowish brown (10YR 7/4) Unconsolidated, dry	
			RS	1.004	1.020			1.5			
			RS	2.0 ft				2.0			
			VOA RS	1.033	1.021		GM	2.6		rare yellow (10YR 8/6); medium angular sand, quartz and gravel up to 2.5 cm, angular to fractured composed of 19 rock frags and quartzite; clay/sand adhere to gravel but crumbly if touched generally unconsolidated, fines slightly moist.	
			VOA RS	1.034	1.022		GC	4.0		No Recovery 2.6-4.0 ft.	
	Run #2 4.0-7.0 ft.	Recovery 3.0 ft.					GM	4.0		TD as of 2/23/98 4.0-7.0 ft; sand and gravel, minor clay; grayish orange (10YR 7/4) to moderate reddish orange (10R 6/6), medium angular quartz and granitic sand, gravel up to 2 cm, fractured and angular composed of granitic and quartzite rock fragments, unconsolidated, dry to slightly moist. White crust on some gravel may indicate caliche but no caliche layers observed.	
	Run #3 7.0-10.0 ft.	Recovery 2.6 ft.					GC	7.5		7.0-7.5 As Above	
			VOA RS	1.034	1.022		GC	7.5		7.5-9.0 Clay, sand, gravel; moderate reddish orange (10R 6/6), medium angular quartz and igneous rock fragment sand, less gravel than above amount of gravel decreases downward, gravel mostly quartzite w/ a few granitic pieces - 2 cm most fractured trace rounded, unconsolidated, moist	
			RS	8.0			SC	9.0		9.0-9.6 Clay sand, sand dominant, moderate reddish orange; medium angular, quartz and 19 rock frags, unconsolidated, moist	
								9.6		No Recovery 9.6-10.0 ft.	

NOTES: General: USCS is modified for this log as follows:

Materials amounts are estimated by % volume instead of % weight.

(1) Badly broken core, accurate footage measurements not possible.

(2) Core breaks cannot be matched, accurate footage measurements not possible.

141

ROCKY FLATS PLANT BOREHOLE LOG

PAGE 2 OF 2

Borehole Number: BH 92598
 Location - North: 749064 East: 2085560
 Date: 03/02/98
 Geologist: J. Bayless R. KOEHLER
 Drilling Equip.: Geoprobe - Dual Wall

Surface Elevation: 5978 ft.
 Area: 903 PAD/LIP Area
 Total Depth: 18.5 ft.
 Company: Tierra Project No.: GE60000
 Sample Type: Continuous core Dual Wall

EG&G LOGGING SUPERVISOR
 APPROVAL Mark Wood

DATE 8/25/98

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION	
Box 2 of 2 10.0-8.5 ft.	13.0	Run #4 10.0-13.0 ft	13.0				SC	10.0	[Hatched pattern]	10.0-13.0 Clayey Sand, yellowish red (5YR 5/6), medium to coarse grained, granitic and quartz grains, well graded, firm, plastic? (forms sausage like extrusion on coring), moist.	
		Recovery 3.6 ft	RS R VOA	1.007 1.023 1.035				11.0			
			12.0					12.0			0.1 ft gravel lense, fractured pieces up to 8 cm. possibly quartzite, no fines.
		13.0	Run #5 13.0-16.0 ft	13.5				GC	13.0	[Hatched pattern]	0.1 ft gravel lense as above.
		Recovery 2.5 ft						14.0			13.0-15.5 ft, similar to above but gravel appears to be more quartzitic than granitic (quartzitic) throughout. Gravel fragments up to 2 cm. <u>with RPK</u>
			15.0					15.0			
	15.5		16.0					15.5	[Cross-hatched pattern]	15.5-16.0 No Recovery	
	16.0	Run #6 16.0-18.5 ft	16.75				Sand stone	16.0	[Dotted pattern]	16.00 = Bedrock Contact.	
	Recovery 4.0 ft		RS R VOA VOA-DIP	1.003 1.023 1.036 1.037				16.75			16.0-18.5 ft, Fine to medium grained "sandstone", probably clayey, yellowish brown (10YR 5/6) is dominant, some light gray (10YR 7/1) at top, well sorted, unconsolidated to lightly indurated (crumbles easily), dry to slightly moist, massive
		17.0						17.0			
								18.0			
								19.0		Total Depth = 18.5 ft.	
								20.0			

NOTES: General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible.

142

ROCKY FLATS PLANT BOREHOLE LOG

PAGE 1 OF 1

Borehole Number: BH92698
 Location - North: 248977 East: 2085551
 Date: 5/19/98
 Geologist: R. KOEHLER
 Drilling Equip.: GEOPROBE/MACROCORE

Surface Elevation: 5979 ft
 Area: 903 PAD/LIP Area
 Total Depth: 3.0ft
 Company: TIERRA Project No.: GE60000
 Sample Type: CONTINUOUS CORE

EG&G LOGGING SUPERVISOR

APPROVAL Mark Ward

DATE 8/25/98

TOP/BOTTOM OF CORE INTERVAL	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENTS)	SAMPLE NUMBER	TIME	BENDING ANGLE	GRAVIMETRIC DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION
Box 1061 0.0-3.0ft Run #1 0.0-3.0ft. Recovery 2.5ft.			001	12:05			GM	0.0	9	0.0-0.4 ft: Fill: Sand & Gravel: brown (7.5YR 5/3) rounded gravel to 2.5cm, medium grained sand, well graded, gravel includes granitic and metamorphic rock frags, unconsolidated dry, trace root hairs. 0.4-2.5 ft: Soil dark reddish brown (5YR 3/3) with speckled reddish yellow (5YR 7/6) between 1.5 and 2.2 ft, gravel up to 3cm, fractured, mostly quartzite minor medium to coarse sand, poorly graded, firm, unconsolidated, slightly moist.
			002	0.4				0.5	10	
			003	12:03			6C	1.0	11	
			010	0.9				1.4	12	
			005	12:00				1.6	13	
			006	1.4				1.9	14	
			007	11:58				2.0	15	
			008	1.9				2.5	16	
							3.0		No Recovery 2.5-3.0ft.	
			011	12:15	Rns	40ml Astc	Water	3.5		T.D. = 3.0ft.
			012	12:15	Rns	1gall Poly	Water	4.0		
								4.5		
								5.0		
								5.5		
								6.0		
								6.5		
								7.0		
								7.5		
								8.0		

NOTES. General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible.

143

ROCKY FLATS PLANT BOREHOLE LOG

PAGE 1 OF 1

Borehole Number: BH92798
 Location - North: 748827 East: 8085553
 Date: 5/18/98
 Geologist: R. KOEHLER
 Drilling Equip.: GEO PROBE/MACROCORE

Surface Elevation: 5980 ft
 Area: 903 PAD/LIP Area
 Total Depth: 3.0ft
 Company: TIERRA Project No.: GE60000
 Sample Type: CONTINUOUS CORE

EG&G LOGGING SUPERVISOR

APPROVAL Mark Wood DATE 8/25/98

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENTS)	SAMPLE NUMBER	FLUCTURE A/R/E	BEDDING A/R/E	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGICAL LOG	SAMPLE DESCRIPTION	
Box lot 1 0.0-3.0ft	Run #1 0.0-3.0ft	Recovery 2.6ft	001				GM	0.0	●	0.0-0.4ft; Fill, sand and gravel, brown (10YR 5/3) granitic gravel broken rounded fragments, medium to coarse sand; unconsolidated - friable, dry; root hairs	
			002	0.4			GC	0.5	●		
			003						1.0	●	0.4-2.6ft) Soil; dark reddish brown (5YR 3/2) grades to reddish gray (5YR 5/2) at 1.5ft., 1.5-2ft yellowish red (5YR 5/c) gravel, sand, clay; fractured gravel up to 2.5cm, looks like mostly quartzite; medium to coarse sand, not abundant; caliche - 0.2ft intervals at 1.2 and 2.3 ft; firm, unconsolidated, well graded, slightly moist to dry.
			004	0.9					1.09	●	
			005						1.5	●	
			006	1.4					1.54	●	
			007						2.0	●	
			008	1.9					2.19	●	
						2.3	●				
							2.4	●	2.6-3.0ft No Recovery		
							3.0				
							3.5				
							4.0				
							4.5				
							5.0				
							5.5				
							6.0				
							6.5				
							7.0				
							7.5				
							8.0				
							8.5				
							9.0				
							9.5				

NOTES: General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible

144

ROCKY FLATS PLANT BOREHOLE LOG

PAGE 1 OF 1

Borehole Number: BH92898
 Location - North: 748830 East: 2085703
 Date: 5/12/98
 Geologist: R. KOEHLER
 Drilling Equip.: GEOPROBE/MACROCORE

Surface Elevation: 5978 ft
 Area: 903 PAD/LIP Area
 Total Depth: 3.0ft.
 Company: TIERRA Project No.: GE60000
 Sample Type: CONTINUOUS CORE

EG&G LOGGING SUPERVISOR

APPROVAL

Mark Wood

DATE 8/25/98

FORMATION OF CORE BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACATURE AREA	DIP/SLICE ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOGS	SAMPLE DESCRIPTION	
Box 1 of 1 0.0-3.0 ft.	Run #1 0.0-3.0 ft.	Recovery 2.4 ft.	001	0.5				0.5		0.0-0.5 ft: Fill, Clay Sand (mostly) dark grayish brown (10YR 4/2), gravel up to 3 cm, fractured, granitic in part, medium to coarse sand, well graded, friable, unconsolidated, slightly moist to moist. 0.5-2.4 ft: Soil clay, sand, gravel, dark reddish brown (2.5 YR 2.5/4), gravel to 5 cm, fractured, granitic and micaceous metamorphic fragments, poorly graded, medium micaceous sand, trace coarse, firm to hard, possible caliche in lower 1 ft, slightly moist.	
			002	1.0				1.0			
			003	1.5							1.5
			004	1.5							1.5
			005	1.5							1.5
			006	1.5							1.5
			007	2.0							2.0
			008	2.5							2.5
							2.5		No Recovery 2.4-3.0 ft.		
								3.0			
								3.5			
								4.0			

NOTES: General: USCS is modified for this log as follows:

Materials amounts are estimated by % volume instead of % weight.

(1) Badly broken core, accurate footage measurements not possible.

(2) Core breaks cannot be matched, accurate footage measurements not possible.

145

ROCKY FLATS PLANT BOREHOLE LOG

PAGE 1 OF 1

Borehole Number: BH92998
 Location - North: 748830 East: 2085853
 Date: 3/23/98
 Geologist: J. Brian R. KOEHLER
 Drilling Equip.: Geoprobe

Surface Elevation: 5976 ft.
 Area: 903 PAD/LIP Area
 Total Depth: 2.5 ft.
 Company: Tierra Project No.: GE60000
 Sample Type: Continuous Core MACROCORE

EG&G LOGGING SUPERVISOR

APPROVAL Mark Wood

DATE 8/25/98

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGICAL LOGS	SAMPLE DESCRIPTION
Box 1 of 1 0.0-2.5	Run #1 0.0-2.5 ft	Recovery 2.2 ft.	1.001	11:06			GC	0.0		0.0 - 2.2 ft; Clay/Sand/Gravel, dark reddish brown (2.5YR 2.5/4) with mottling of yellow (10YR 8/8) at base. Gravel fractured top 3cm, with ^{fine} PP sand, granitic and quartzitic grains, well graded, massive, clayey parts plastic form clumps, moist.
			1.002	0.5		0.5				
			1.003	11:04		1.0				
			1.004	1.0		1.5				
			1.005	11:03		2.0				
			1.006	1.5						
			1.007	11:01						
			1.008	2.0						
							2.2		No Recovery 2.2-2.5 ft.	
							2.5		TD = 2.5 ft.	
							3.0			
							4.0			
							5.0			
							6.0			
							7.0			
							8.0			
							9.0			
							9.5			

NOTES: General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible.

146

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

PAGE 1 OF 1

Borehole Number: BH93098
 Location - North: 748817 East: 2086005
 Date: 1-12-99
 Geologist: T. LUTHERER
 Drilling Equip.: GEOPROBE DUAL

Surface Elevation: 5958 FT
 Area: 903 PAD Lip Area
 Total Depth: 3.6
 Company: TERRA Project No. GE600000
 Sample Type: CONTINUOUS

RMRS LOGGING SUPERVISOR

APPROVAL Mark Wood

DATE 2/2/99

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL IN INTERVAL MEASUREMENT	FEET OF CORE IN INTERVAL MEASUREMENT	SAMPLE NUMBER	FRAC TIONS	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL/ROCK QUALITY	SAMPLE DESCRIPTION	
Box 1 of 1 0.0 - 3.6'	Run #1 0.0 - 4.0'	Recovery 3.6'	001	RS ISO	001			1.5		0.0-2.1 Gravelly Silt 27R 2/2 very dark brown, very fine to medium angular sand, up to 3.5mm broken lithic gravel, trace to some clay, some organic material, moist. Locally grading to Gravelly Sand.	
			002	RS ISO	001			1.0			
			003	RS ISO	002			1.5			
			004	RS ISO	002			2.0			
			005	ISO DUP.	001	DUP. CATF					
			006	RS ISO	001	JAL RIN-SATE			3.0		
			99A 43 53	RS RI	001 001 (002)		5.0		2.1-3.6 Gravelly Sand 74R 7/1 to 74R 7/6, light clay to hard A/A, silty, very fine to medium angular sand, trace clay det.		
					002 001 (002)						
					003 001 (002)						
					004 001 (002)						
					005 001		6.0				
					006 001 (002)						
							7.0		3.6-4.0 No Recovery		
							8.0				
							9.0				

NOTES: General: USCS is modified for this log as follows:

Materials amounts are estimated by % volume instead of % weight.

(1) Badly broken core, accurate footage measurements not possible.

(2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101

Revision 0

Date effective: 12/31/98

Page 27 of 28

147

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

PAGE 1 OF 1

Borehole Number: BH93199
 Location - North: 748839 East: 2086167
 Date: 1-13-99
 Geologist: T. LUTHERER
 Drilling Equip.: GEO PROBE DUAL WALL

Surface Elevation: 5956 Ft
 Area: 903 PAD Lip Area
 Total Depth: 3.7
 Company: TIERRA Project No. GE600000
 Sample Type: CONTINUOUS

RMRS LOGGING SUPERVISOR

APPROVAL Mark Wood

DATE 7-2-99

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRAC. #/P.L. ANGLE	BED. #/P.L. ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGICAL (LN)	SAMPLE DESCRIPTION
Box 1 of 1 0.0 - 3.7'	Run #1 0.0 - 4.0'	Recovery: 3.7'	001	RS 001				15		0.0-3.7 Silty Sand 3YR 3/2 to 3YR 3/2 very dark gray to dark brown, very fine, trace medium to coarse, subangular sand, silty, trace broken vitric gravel up to 4mm, trace clay, trace organics, dry
				RS 002						
			002	RS 001				10		
				RS 002						
			003	RS 002		SM	20			
				RS 001				30		
			004	RS 002				3.7		
								4.0	X	3.7-4.0 No Recovery
								5.0		
			99A 43 58	RS 001	RS 001(002)			6.0		
				002	001(002)					
				003	001(002)					
				004	001(002)					
								7.0		
								8.0		
								9.0		

NOTES: General: USCS is modified for this log as follows:

Materials amounts are estimated by % volume instead of % weight.

- (1) Badly broken core, accurate footage measurements not possible.
- (2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101

Revision 0

Date effective: 12/31/98

Page 27 of 28

148

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

PAGE 1 OF 1

Borehole Number: BH 93298
 Location - North: 748671 East: 2085755
 Date: 1-12-99
 Geologist: T. LUTHERER
 Drilling Equip.: GEO PROBE DUAL WALL

Surface Elevation: 5964 Ft
 Area: 903 PAD Lip Area
 Total Depth: 2.4
 Company: TERRA Project No. GE600000
 Sample Type: CONTINUOUS

RMRS LOGGING SUPERVISOR

APPROVAL Mark Wood

DATE 7/2/99

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	ANALYZE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGICAL LINE	SAMPLE DESCRIPTION
Box 1 of 1 0.0 - 2.4	Run # 1 0.0 - 4.0	Recovery: 2.4	001	RS 001 ISO 002	no	CL	0.5	[Hatched pattern]	0.0 - 0.6 Silty Clay 3YR 0/3 very dark gray, with traces sand and up to 3cm silty gravel, with roots, moist, mod. plasticity
			002	RS 001 ISO 002			1.0		
			003	RS 001 ISO 002			1.5		
			004	RS 001 ISO 002			2.0		
						2.4	[Hatched pattern]	0.6 - 2.4 Gravely Clayey Sand 6R6/4 → 4YR 4/3 Light brown to dark brown, very fine to coarse, subangular to angular, grain equal as a fine silty, moderately plastic moist	
						3.0	[X pattern]	2.0 - 4.0 No Recovery JAL 1-12-98	
						4.0			
			99A 4356	001	RS RI 001 (002)		5.0		
			"	002	001 (002)				
			"	003	001 (002)				
			"	004	001 (002)		6.0		
							7.0		
							8.0		
							9.0		

NOTES: General: USCS is modified for this log as follows:

Materials amounts are estimated by % volume instead of % weight.

- (1) Badly broken core, accurate footage measurements not possible.
- (2) Core broken cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101

Revision 0

Date effective: 12/31/98

Page 27 of 28

149

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

PAGE 1 OF 1

Borehole Number: BH 93398
 Location - North: 748698 East: 2085857
 Date: 1-12-99
 Geologist: T. LUTHERER
 Drilling Equip.: GEO PROBE DUAL WALL

Surface Elevation: 5956 Ft
 Area: 903 PAD Lip Area
 Total Depth: 3.8
 Company: TERRA Project No. GE600000
 Sample Type: CONTINUOUS

RMRS LOGGING SUPERVISOR
 APPROVAL Mark Wood

DATE 7-2-99

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRAC TIONAL ANGLE	BLDURAL ANGLE	GMIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGICAL LOG	SAMPLE DESCRIPTION
Box 1 of 1 0.0 - 3.8	Run # 1 0.0 - 4.0	Recovery: 3.8	001	RS	001			1.5	[Hatched pattern]	2.0-2.7 Silty Clay 2YR 2/2 very dark brown with organics, very fine to fine sand, trace up to 2.5 cm angular lithic gravel. non to trace plasticity, moist.
			002	RS	001		CL	1.0		
			003	RS	001			1.5		
			004	RS	001			2.0		
							2.7		2.0-2.7 Silty Clay 5YR 4/6 dark yellowish brown, A/A, moderate to high plasticity moist	
							3.0		2.7-3.8 Sandy Clay 5YR 5/2 to 6YR 6/6 reddish gray to reddish yellow very fine to fine angular sand, some mod. to med plasticity, gravel A/A, moist	
							4.0		3.8-4.0 No Recovery	
								5.0		
			99 A 4357				RS RS			
								6.0		
								7.0		
								8.0		
								9.0		

NOTES: General: USCS is modified for this log as follows:

- Materials amounts are estimated by % volume instead of % weight.
- (1) Badly broken core, accurate footage measurements not possible.
- (2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101

Revision 0

Date effective: 12/31/98

Page 27 of 28

150

5.0 SOIL VOLUME ESTIMATES BASED ON RSAL and SSAL EXCEEDANCES

Volume estimates of radiological and VOC contaminated surface and subsurface soil are based on the areal and vertical extent of contamination above Tier I and Tier II RSALs and proposed SSALs. An ArcInfo, version 7.2.2, Thiessen polygon command (ESRI, 1999) was used to perform the in-place volume calculations. Remedial alternatives will be evaluated in the IM/IRA Decision Document based on these volume estimates. In-place volume estimates for the 903 Pad asphalt and artificial fill are also presented.

5.1 903 PAD ASPHALT AND ARTIFICIAL FILL VOLUME ESTIMATES

Characterization data for the asphalt covering the 903 Pad were collected for waste characterization profiling; data were not compared to Tier I or Tier II RSALs. The estimated in-place volume of asphalt is 2,743 yds³. The estimated in-place volume of artificial fill is 2,743 yds³. The amount of radiologically contaminated artificial fill, relative to Tier II RSALs, beneath the 903 Pad is estimated at 104 yds³. The 104 yds³ estimate is based on a 75 ft by 75 ft area surrounding boring 91898 and a 6 inch thickness of artificial fill. Table 5-1 summarizes the estimated areal extent, depth, and in-place volumes of asphalt and artificial fill for the 903 Pad.

Table 5-1 Summary of 903 Pad Asphalt and Artificial Fill Volumes*

903 Pad	Depth (ft)	Area (ft ²)	Volume (ft ³)	Volume (yd ³)	Volume (m ³)	Volume Greater Than Tier I RSAL (yd ³)	Volume Greater Than Tier II RSAL (yd ³)
Asphalt	0.5	148,104	74,052	2,743	2,097	NA	NA
Artificial Fill	0.5	148,104	74,052	2,743	2,097	0	104
Total		296,208	148,104	5,485	4,194	0	104

*Volumes represent materials in-place
NA = Not Applicable

5.2 SOIL VOLUME ESTIMATES BASED ON TIER I RSAL EXCEEDANCES

A composite map of the areal extent of Tier I RSAL exceedances in soil is presented in Figure 5-1. As shown, soil with radionuclides exceeding the Tier I RSALs is located at the 903 Pad, east of the 903 Pad in the Lip Area, and sporadically in the southern portion of the Lip Area and

151

western portion of the Americium Zone. Table 5-2 summarizes the estimated areal extent, depth, and in-place volumes of soils exceeding Tier I RSALs by IHSS. The areal extent of radiologically contaminated soil (relative to Tier I RSALs) is 157,908 ft². Depth of contamination varies from 0 to 6 inches to 0 to 12 inches throughout the investigation area. Based on the areal and vertical extent of Tier I RSAL exceedances, the total volume of in-place radiologically contaminated soil is 2,924 cubic yards (yds³). The in-place volumes of contaminated soil by IHSS as follows: 1,268 yds³ for the 903 Pad; 1,598 yds³ for the Lip Area; and 100 yds³ for the Americium Zone.

Table 5-2 Summary of Radiologically Contaminated Soil Volumes*-Tier I RSAL Exceedances

903 Pad	Depth (ft)	Area (ft ²)	Volume (ft ³)	Volume (yd ³)	Volume (m ³)
Native 1	0.5	62,953	31,477	1,166	891
Native 2	0.5	5,532	2,766	102	78
Total¹		68,485	34,243	1,268	970
Lip Area					
Native 1	0.5	54,260	27,130	1,005	768
Native 2	0.5	32,044	16,022	593	454
Total		86,304	43,152	1,598	1,222
Americium Zone					
Total	0.5	5,395	2,698	100	76
Grand Total		157,908	78,954	2,924	2,236

Note:

¹ Excludes Asphalt and Artificial Fill.

*Volumes represent materials in-place

Assumptions:

Thiessen polygon, ArcInfo software used to estimate area.

5.3 SOIL VOLUME ESTIMATES BASED ON TIER II RSAL EXCEEDANCES

A composite map of the areal extent of Tier II RSAL exceedances in soils is presented in Figure 5-2. As expected, contamination above the Tier II RSALs is much more extensive than that of the Tier I RSAL exceedances. In general, Tier II RSAL exceedances encompasses most of the 903 Pad, the Lip Area, and the Americium Zone. Tier II RSAL exceedances in two portions of the Lip Area extend down to the Native 3 soil horizon, a depth of 1.5 feet. Figure 5-2 shows the areal extent of the Tier II RSAL exceedances for the Native 1 (0 to 6-inch), Native 2 (6 to 12-

152

inch), and Native 3 (12 to 18-inch) soil horizons. Table 5-3 summarizes the estimated areal extent, depth, and in-place volumes of soils exceeding Tier II RSALs by IHSS.

The areal extent of contaminated soil (relative to Tier II RSALs) is 797,167 ft². Depth of contamination varies from 0 to 6 inches to 0 to 18 inches throughout the investigation area. Based on the areal and vertical extent of Tier II RSAL exceedances, the total volume of in-place radiologically contaminated soil is 14,762 yds³. A depth of 6 inches was used to estimate volumes of soil in the Americium Zone. Radiologically contaminated soil volumes based on Tier II RSAL exceedances are summarized in Table 5-3.

The in-place volumes of contaminated soil by IHSS are as follows: 2,471 yds³ for the 903 Pad, 5,267 yds³ for the Lip Area; and 7,025 yds³ for the Americium Zone.

Table 5-3 Summary of Radiologically Contaminated Soil Volumes*-Tier II RSAL Exceedances

903 Pad	Depth (ft)	Area (ft ²)	Volume (ft ³)	Volume (yd ³)	Volume (m ³)
Native 1	0.5	111,676	55,838	2,068	1,581
Native 2	0.5	21,738	10,869	403	308
Total¹		133,414	66,707	2,471	1,889
Lip Area					
Native 1	0.5	209,689	104,845	3,883	2,969
Native 2	0.5	52,790	26,395	978	747
Native 3	0.5	21,941	10,971	406	311
Total		284,420	142,210	5,267	4,027
Americium Zone					
Total	0.5	379,333	189,667	7,025	5,371
Grand Total		797,167	398,584	14,762	11,287

Note:

¹ Excludes Asphalt and Artificial Fill.

*Volumes represent materials in-place

Assumptions:

Thiessen polygon, ArcInfo software used to estimate area.

5.4 SOIL VOLUME ESTIMATES BASED ON SSAL EXCEEDANCES

VOC contaminants of concern (CCl₄, PCE, 1,2-DCE, and TCE) did not exceed the current Tier I SSALs. However, as discussed in Section 4.3, PCE exceeds the proposed Tier I SSAL in boring 90998 (Figure 4-18). Proposed Tier II SSAL exceedances for PCE were also observed in five borings east of well 08891. 1,2-DCE exceeds the proposed Tier II SSAL in boring 90998. The areal extent of contamination was bounded one-half the distance between adjacent borings where VOC results were below their respective SSALs, and by the edge of the 903 Pad to the east. Several proposed Tier II SSAL exceedances were observed below the water table (average depth to water is 19 feet bgs) at boreholes 95998, 96798, and 97698. VOC contamination below the water table will be addressed under the groundwater program.

5.4.1 Soil Volume Estimates Based on Tier I SSAL Exceedances

A composite map showing the areal extent of contamination as defined by the proposed Tier I SSALs is presented in Figure 5-3. The depth of VOCs that exceed proposed Tier I SSALs is assumed to extend from the natural soil surface below the top of the asphalt to 4.0 feet bgs (a thickness of 3.0 feet). This is a valid assumption given that VOC samples were not collected above the four-foot sample interval. Based on the areal extent of the Tier I SSAL exceedances (5,017 ft²) and a thickness of 3.0 feet, the total in-place volume of contaminated soil is 557 yds³ (Table 5-4).

5.4.2 Soil Volume Estimates Based on Tier II SSAL Exceedances

A composite map showing the areal extent of contamination as defined by the proposed Tier II SSALs is presented in Figure 5-3. The areal extent of proposed Tier II SSAL contamination is slightly more extensive than that of Tier I SSAL contamination. The depth of VOCs that exceed Tier II SSALs is assumed to extend from the natural soil surface below the asphalt to 13.9 feet bgs (a thickness of 12.9 feet). This assumption includes natural soils from the 1 foot to 4 foot interval where samples were not collected. Based on the areal extent of the Tier II SSAL exceedances (7,464 ft²) and a thickness of 12.9 feet, the total in-place volume of contaminated soil is 3,566 yds³ (Table 5-4).

5.5 SOIL VOLUME ESTIMATES BASED ON RSAL AND SSAL EXCEEDANCES

Two small areas within the 903 Pad contain surface soil with elevated levels of both radionuclides (RSALs) and VOCs (SSALs). Soil exceeding proposed SSALs occur in the two areas shown in Figure 5-3. Soil exceeding Tier I and Tier II RSALs are provided in Figures 5-1 and 5-2, respectively. Comparing these figures with Figure 5-3 shows that there are areas where both RSALs and SSALs exceedances overlap. Proposed Tier I SSAL exceedances in natural soils occur to a depth 4.0 feet. Tier I (and consequently Tier II) RSAL exceedances in natural soils are present to a depth of 6 inches in this area. Therefore, an estimated total of 93 yds³ (5,017 ft² x 0.5 ft) of soils exceed both Tier I (and II) RSALs and proposed Tier I SSALs.

Proposed Tier II SSAL exceedances in natural soils occur to a depth 13.9 feet. Tier I (and consequently Tier II) RSAL exceedances in natural soils are present to a depth of 6 inches. Therefore, an estimated total of 138 yds³ (7,464 ft² x 0.5 ft) of soils exceed both Tier I and II RSALs and proposed Tier II SSALs.

5.6 SOIL VOLUME ESTIMATES BASED ON SSAL EXCEEDANCES EXCLUDING RSAL EXCEEDANCES

This section provides volume estimates of VOC contaminated soil (relative to SSALs) below the Native 1 Soil horizon where radiologically contaminated soil (relative to RSALs) is present. The total in-place soil volume estimates, therefore, excludes the radiologically contaminated Native 1 Soil addressed in Sections 5.2 and 5.3.

Soil exceeding SSALs occur in two areas within the 903 Pad (Figure 5-3). Proposed Tier I SSAL exceedances in natural soils occur to a depth 4.0 feet below top of asphalt. Therefore, excluding the upper 1.5 feet of radiologically contaminated soil, the artificial fill and the asphalt (2.5 foot depth interval), a total of 464 yds³ (5,017 ft² x 2.5 ft) of soil is estimated to exceed Tier I SSALs.

Proposed Tier II SSAL exceedances in natural soils occur to a depth of 13.9 feet below top of asphalt. Excluding the upper 1.5 feet of radiologically contaminated soil, the artificial fill and the

155

asphalt (12.4 foot depth interval) a total of 3,428 yds³ (7,464 ft² x 12.4 ft) of soils is estimated to exceed Tier II SSALs.

Table 5-4 Summary of Tier II SSAL Exceedances

Area/Volume	Volume* of Soils Greater Than Current Tier I SSALs (yds ³)	Volume* of Soils Greater than Proposed Tier I SSALs (yds ³)	Volume* of Soils Greater than Tier II SSALs (yds ³)
Area with Soils Greater than Tier I and II RSALs	0	93	138
Area with Soils Less than Tier II RSALs	0	464	3,428

* Volumes represent in-place volume.

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

PAGE 1 OF 1

Borehole Number: BH 93498
 Location - North: 748702 East: 2086198
 Date: 1-19-99
 Geologist: T. LUTHERER
 Drilling Equip.: GEOPROBE DUAL WALL

Surface Elevation: 5942
 Area: 903 PAD Lip Area
 Total Depth: 3.2
 Company: TIERRA Project No. GE600000
 Sample Type: CONTINUOUS

RMRS LOGGING SUPERVISOR
 APPROVAL Mark Ward

DATE 7-2-99

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL MEASUREMENT	SAMPLE NUMBER	FRAC TAIL ANGLE	BEARING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL/ROCK LOG	SAMPLE DESCRIPTION
Box 1 of 1	0.0 - 3.2	Recovery: 3.2	001	RS ISO	001		CL	0.0		0.0-1.0 Silty (fat) 6YR 6/2 to 3YR 3/1 pinkish gray to very dark gray, traces sand, traces broken siliceous gravel up to 3.5cm, low to mod. plasticity, traces organics moist.
			002	RS ISO	002	1.0				
			003	RS ISO	002	2.0				
			004	RS ISO	002	3.0				
						SM	2.0		1.0-3.2 Silty Sand color A/A, prod. very fine to fine, some coarse subangular silty, trace gravel, trace gravel A/A, trace caliche, dirt	
							3.0		3.2-4.0 No Recovery	
							4.0			
							5.0			
			99A 4850		RS RI		001 (002)	6.0		
							002 (002)	6.0		
							003 (002)	7.0		
							004 (002)	7.0		
								8.0		
								9.0		

NOTES: General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101

Revision 0

Date effective: 12/31/98

Page 27 of 28

157

ROCKY FLATS PLANT BOREHOLE LOG

PAGE 1 OF 1

Borehole Number: BH93598
 Location - North: 778977 East: 2085978
 Date: 3/23/98
 Geologist: J. Taylor R. KOEHLER
 Drilling Equip.: Geoprobe

Surface Elevation: 5973 ft
 Area: 903 PAD/LIP Area
 Total Depth: 2.5 ft.
 Company: Terra Project No.: GE600000
 Sample Type: Continuous Core

EG&G LOGGING SUPERVISOR

APPROVAL Mark Wood

DATE 8/25/98

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL	SAMPLE NUMBER	FIXTURE AXIAL	BEARING AXIAL	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL/ROCK LOGS	SAMPLE DESCRIPTION	
Box lot 1 0.0-2.5 ft	Run #1 0.0-2.5 ft.	Recovery 1.4 ft.	1.001	10:34				0.0		0.0-0.4 Clay Sand, w/abundant root hairs, dark brown (10YR 3/3), fine sand, soft clumps, moist to wet.	
			1.002	04				0.4			
			1.003	10:32					0.5		0.4-1.4 Clay, Sand, Gravel, dark reddish brown (2.5YR 3/4) fractured granitic IRF up to 3cm in clay sand matrix, angular medium sand, massive, minor root hairs, moist, firm.
			1.004	4-0.8 mw 7/20/99				1.0			
			1.005	10:30					1.4		
			1.006	1.2					1.5		1.4-2.5 No Recovery
			1.007	10:28					2.0		
			1.008	2.0-1.4 mw 7/20/99					2.5		
			1.009	10:42					3.0		T.D. = 2.5 ft.
			1.010	40 ml 1 cell.					4.0		
						5.0					
						6.0					
						7.0					

158

NOTES. General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible
 (2) Core breaks cannot be matched, accurate footage measurements not possible

ROCKY FLATS PLANT BOREHOLE LOG

PAGE 1 OF 1

Borehole Number: BH93698
 Location - North: 148988 East: 208453
 Date: 3/12/98
 Geologist: R. KOEHLER
 Drilling Equip.: GEOPROBE

Surface Elevation: 5972 ft
 Area: 903 PAD/WIP Area
 Total Depth: 2.5 ft.
 Company: TIERRA Project No.: GE60000
 Sample Type: CONTINUOUS CORE

EG&G LOGGING SUPERVISOR

APPROVAL M. Wood

DATE 4/14/98

TOP POSITION OF CORE BLOCK	TOP POSITION OF INTERVAL	FEET OF CORE INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FLUORESCENCE ALKALINE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOGS	SAMPLE DESCRIPTION
Box lot 1 0.0-2.5 ft.	Run #1 0.0-2.5 ft.	Recovery 2.1 ft.	1.007	RS						0.0-0.8 ft; Clay, Sand, Gravel; dark brown (N. SYR 3/2), quartzite gravel up to 3cm, fractured, fine sand, clumpy, plastic, grass shoots and root hairs, moist. 0.8-2.1 ft; Clay, Sand with some gravel (1.4 to 2.1 ft) reddish yellow (SYR 7/6) fine sand, crumbly to unconsolidated, gravel is fractured, quartzite, moist. 2.1-2.5 ft. No Recovery
			1.002	R				GC	0.5	
			1.005	RS					0.8	
			1.004	R					1.0	
			1.010	RS					1.5	
			1.003	R					2.0	
			1.006	RS					2.1	
1.001	RS					2.5				
			1.008	R						
			1.009	RS	RNS	40% VOA VIA				T.D. = 2.5 ft.
			1.012	R	RNS	1 gal. poly.				

NOTES: General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible.

159

ROCKY FLATS PLANT BOREHOLE LOG

PAGE 1 OF 1

Borehole Number: BH 93798
 Location - North: 748976 East: 2086300
 Date: 3/12/98
 Geologist: Robert R. KOEHLER
 Drilling Equip.: Geoprobe

Surface Elevation: 5970 ft
 Area: 903 Lip Area
 Total Depth: 2.5 ft
 Company: Tierra Project No.: GE60000
 Sample Type: Continuous core Macrocore

EG&G LOGGING SUPERVISOR

APPROVAL Mark Ward

DATE 3/25/98

TOP/BOTTOM OF CLINE IF BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION
Box 1 of 1 0.0-2.5ft	Run #1 0.0-2.5ft	Recovery 1.8ft	1.001	Rs			GC	0.0		0.0-0.4 ft Clay Sand, Gravel, dark brown (7.5YR 3/2)
			1.002	R	0.45			0.4		Gray fractured gravel up to 3cm, quartzite maybe
			1.003	Rs				0.5		0.4-1.8 ft; Clay
			1.004	R	0.9			1.0		Sand Gravel, yellow
			1.005	Rs				1.5		(10YR 7/6), gravel concentrated at top (0.4-0.6 ft)
			1.006	R	1.35			1.8		1 piece rounded quartzite rest is fractured quartzite
			1.007	Rs				2.0		gravel to 3cm, possibly caliche?, possible clay
			1.008	R	1.8			2.5		clasts, wet to moist
								No Recovery 1.8-2.5 ft		
									T.D. = 2.5 ft.	

NOTES: General: USCS is modified for this log as follows:

Materials amounts are estimated by % volume instead of % weight.

(1) Badly broken core, accurate footage measurements not possible.

(2) Core breaks cannot be matched, accurate footage measurements not possible.

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

PAGE 1 OF 1

Borehole Number: BH 93898
 Location - North: 249003 East: 2086406
 Date: 2-17-99
 Geologist: T. LUTHERER
 Drilling Equip.: GEO PROBE DUAL WALL

Surface Elevation: 5968 FT
 Area: 903 PAD Lip Area
 Total Depth: 3.9'
 Company: TERRA Project No. GE600000
 Sample Type: CONTINUOUS

RMRS LOGGING SUPERVISOR

APPROVAL Mark R. Wood

DATE 7-2-99

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL FIELD MEASUREMENT	SAMPLE NUMBER	FUNCTIONAL ANGLE	BEDDING ANGLE	GIMM SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGICAL LINE	SAMPLE DESCRIPTION
Box 1 of 1 0.0 - 3.9'	Run #1 0.0 - 4.0'	Recovery: 3.9'	001	RS	001		CL	0.0		No "Nois" FOR CL SYMBOL 0.0-1.0 Sandy Clay, Dark Reddish Brown 37R 3/4, slightly plastic, some fine to coarse sand, angular - subrounded trace angular to subrounded up to 3 cm lithic gravel. Moist
			002	RS	001		CL	0.5		
			003	RS	001		CL	1.0		
			004	RS	001		CL	1.5		
						SC	2.0		1.0-3.7 Clayey Sand color and components same as above. damp	
								3.0		3.7-3.9 Gravelly Sand color and components same as above dry
								4.0		3.9-4.0 No Recovery
								5.0		
			99A4852 001	RS	001			6.0		
			002	RS	001			7.0		
			003	RS	001			8.0		
			004	RS	001			9.0		

NOTES: General: USCS is modified for this log as follows:

Materials amounts are estimated by % volume instead of % weight.

- (1) Badly broken core, accurate footage measurements not possible.
- (2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101
 Revision 0

Date effective: 12/31/98

Page 27 of 28

161

ROCKY FLATS PLANT BOREHOLE LOG

PAGE 1 OF 1

Borehole Number: BH 939 98
 Location - North: 749123 East: 208600
 Date: 3/16/98 RPK 3/17/98
 Geologist: Brian R. KOEHLER
 Drilling Equip.: Geoprobe

Surface Elevation: 5973 ft
 Area: 903 Lip Area
 Total Depth: 2.5 ft
 Company: Tierra Project No.: GE 600000
 Sample Type: Continuous core Macro Core

EG&G LOGGING SUPERVISOR

APPROVAL Mark Ward

DATE 8/25/98

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION	
Box lot 1 0.0 - 2.5 ft	Run # 1 0.0 - 2.5 ft	Recovery 2.2 ft	1.001	Rs	12:02			GC	0.0		0.0-0.4 ft; Clay Sand Gravel; dark brown (10YR 4/3 + 0.3/3); rounded spherical gravel up to 3 cm, granitic IRF
			1.002	R							
			1.003	Rs	12:00						
			1.004	R							
			1.005	Rs	11:58						
			1.006	R							
			1.007	Rs	11:56						
			1.008	R							
							SC	1.7		0.4-1.7 ft; Clay Sand Gravel; yellowish red (5YR 4/6) to dark yellowish brown (10YR 3/4) fractured gravel (granitic IRF) in clay sand matrix, fine sand gravel to 3 cm, well graded, clumpy or clotty, moist trace roots at top	
								2.0		1.7-2.2 ft; Clay Sand; yellow brown (10YR 5/4) to very pale brown (10YR 8/4), fine sand, clay clasts (to 1.5 cm), possible cobble, clumpy, porous, moist	
								2.2			
								2.5		2.2-2.5 ft No Recovery.	
								3.0		T.D. = 2.5 ft.	
								4.0			
								5.0			
								6.0			
								7.0			
								8.0			
								9.0			
								0.0			

NOTES: General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible.

162

ROCKY FLATS PLANT BOREHOLE LOG

PAGE 1 OF 1

Borehole Number: BH94198
 Location - North: 749123 East: 2086298
 Date: 3/16/98
 Geologist: J. Barton R. KOEHLER
 Drilling Equip.: Geoprobe

Surface Elevation: 5969 ft.
 Area: 903 Lip Area
 Total Depth: 2.5 ft
 Company: Tierra Project No.: GE60000
 Sample Type: Continuous Core Maculcore

EG&G LOGGING SUPERVISOR
 APPROVAL Mark Wood

DATE 8/25/98

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACATURE ANGLE	BEDDING ANGLE	CHAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION
Box lot 0.0-2.5ft	Run # 0.0-2.5ft	Recovery 1.6 ft	1.001	Rs			GC	0.0		0.0-0.8 Clay Sand Gravel; dark brown (7.5 YR 3/2) gravel upto 2cm, rounded, quartz and IRF, well graded, medium grn sand, rounded?, fractured 2cm gravel at base, clumpy, friable, moist 0.8-1.6 Clay Sand Gravel root hair abundant less gravel than above, pink (7.5 YR 8/3) gravel fractured, to 2cm, friable fine sand, may be massive caliche, clay clasts? partly cemented "chunks", poorly graded, moist, some root hairs, IRF at bottom.
			1.002	R				0.5		
			1.003	Rs				1.0		
			1.004	R				1.5		
			1.005	Rs				1.6		
			1.006	R				2.0		
			1.007	Rs						
			1.008	R						
			1.009	Rs-Rinse	4on1		3.0		T.D. = 2.5 ft.	
			1.010	R-Rinse	1gall.		4.0			
							5.0			
							6.0			
							7.0			
							8.0			
							9.0			
							0.0			

NOTES: General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible.

164

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

PAGE 1 OF 1

Borehole Number: BH94298
 Location - North: 749112 East: 2086438
 Date: 2-18-99
 Geologist: T. LUTHERER
 Drilling Equip.: GEO PROBE DUAL WALL MW 7/2/99

Surface Elevation: 5968 FT
 Area: 903 PAD Lip Area
 Total Depth: 3.85
 Company: TIERRA Project No. GE600000
 Sample Type: CONTINUOUS

RMRS LOGGING SUPERVISOR

APPROVAL Mark Wood

DATE 7-2-99

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL IN FIELD MEASUREMENT	FEET OF CORE INTERVAL IN FIELD MEASUREMENT	TA SAMPLE NUMBER EVENT	FRAC/TIME ANGLE	SAMPLE BED/DEPTH BY NUMBER	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL/ROCK LOG	SAMPLE DESCRIPTION
Box 10 FT 0.0 - 3.85'	Run # 1 0.0 - 4.0	Recovery: 3.85'	001	RS 001	001	SP	SP	0.0		0.0-0.7 Gravelly Sand, Dark reddish brown, 2YR 2/5 Silt, just coarse sand, some medium to fine, subangular to subround, have to abundant up to 5 cm broken angular lithic gravel, trace clay, trace organics, moist.
			002	ISO 002	002			0.5		
			003	RS 001	003			1.0		
			004	ISO 002	004			1.5		
			005	RS 001	005			2.0		
			006	ISO 002	006			3.0		
						SP	3.7		3.85-4.0 No Recovery	
							4.0		3.7-3.85 Gravelly sand, color and components same as above day.	
			99A4849	001	001(002)			6.0		
				002	001(002)					
				003	001(002)			7.0		
				004	001(002)					
				005	001					
				006	001(002)			8.0		
								9.0		

NOTES: General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101
 Revision 0
 Date effective: 12/31/98
 Page 27 of 28

165

ROCKY FLATS PLANT BOREHOLE LOG

PAGE 1 OF 1

Borehole Number: BH94398
 Location - North: 749129 East: 2085550
 Date: 5/21/98
 Geologist: R. KOEHLER
 Drilling Equip.: GEOPROBE/MACROCORE

Surface Elevation: 5978 ft
 Area: 903 PAD/LIP Area
 Total Depth: 3.0ft
 Company: TIERRA Project No.: GE600000
 Sample Type: CONTINUOUS CORE

EG&G LOGGING SUPERVISOR

APPROVAL Mark Wood

DATE 8/25/98

DEPTH OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FLUORESCENCE AIRIE	BENDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL/ LITHOLOGIC LOG	SAMPLE DESCRIPTION	
Box 1 of 1, 0.0-3.0ft.	Run # 1 0.0-3.0ft.	Recovery 1.4ft.	0001	11:20			GM	0.3	0.0-0.3; fill; sand and gravel; grayish brown (10YR 5/2) gravel to 2cm, round occasionally fractured, granitic and quartzite		
			0002	0.3			GC	0.5	0.3-1.4; soil; rock fragments; medium to fine sand, clay, sand, gravel; unconsolidated, dry, root hairs.		
			0003	11:23					0.7		
			0004	0.7					1.0		
			0005	11:25					1.1		
			0006	1.1				1.4			
			0007	11:27				1.4			
			0008	1.4				1.6			
								2.0		No Recovery 1.4-3.0ft.	
								2.5			
								3.0			
								3.5		T.D = 3.0ft.	
								4.0			
								4.5			
								5.0			
								5.5			
								6.0			
								6.5			
								7.0			
								7.5			
								8.0			
								8.5			
								9.0			
								9.5			

NOTES: General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible.

1166

ROCKY FLATS PLANT BOREHOLE LOG

PAGE 1 OF 1

Borehole Number: BH94498
 Location - North: 749264 East: 2085552
 Date: 06/08/98
 Geologist: R. KOEHLER
 Drilling Equip.: GEO PROBE/MACROCORE

Surface Elevation: 5976 ft
 Area: 903 PAD/LIP Area
 Total Depth: 3.0 ft.
 Company: TIERRA Project No.: GE600000
 Sample Type: CONTINUOUS CORE

EG&G LOGGING SUPERVISOR

APPROVAL Mark Wood

DATE 8/25/98

DEPTH OF CORE IN BOX	TOP-BOTTOM OF INTERVAL	FEET OF CORE INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FLUORESCENCE ARIE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGICAL LOGS	SAMPLE DESCRIPTION
Box 1 of 1 0.0-3.0ft.	Run #1 0.0-3.0ft.	Recovery 1.8 ft.	001	12:10					0.0-0.3	0.0-0.3 ft. fill clay, sand, gravel; dark brown (5.5YR 3/2), gravel up to 2cm, rounded and fractured, granitic common, subangular clay, medium sand, unconsolidated, moist, root hairs and plant fragments
			002	0.3					0.3	
			003	12:08					0.5	0.3-1.2 ft. soil; clay, sand, gravel; dark brown (5.5YR 3/2), gravel up to 3cm, angular-fractured, quartzitic common, fine calciche (?) in lower half, slightly moist
			004	0.8					0.8	
			005	12:06					1.0	
			006	1.3					1.3	1.2-1.8 ft. Soil; Clay-Sand, trace gravel, yellow to yellowish brown (10YR 8/6 to 10YR 6/6), fine to medium sand, soft unconsolidated, slightly moist, 1cm dia black subround gravel
			007	12:04					1.8	
			008	1.8					1.8	
							2.0	No Recovery 1.8-3.0ft.		
							2.5			
								3.0		
								3.5		
								4.0	T.D. = 3.0ft.	
								4.5		
								5.0		
								5.5		
								6.0		
								6.5		
								7.0		
								7.5		
								8.0		
								8.5		
								9.0		
								9.5		

NOTES. General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible.

167

ROCKY FLATS PLANT BOREHOLE LOG

PAGE 1 OF 1

Borehole Number: BH94598
 Location - North: 749265 East: 2085703
 Date: Drilled: 9.16.98 sampled: 9.17.98
 Geologist: R. Rupp
 Drilling Equip.: Geoprobe

Surface Elevation: 5976 ft
 Area: 903 Lip Area
 Total Depth: 3.0 feet
 Company: STOLLER Project No.: GE 60000
 Sample Type: Continuous Core

EG&G LOGGING SUPERVISOR

APPROVAL Mark Wood

DATE 9/30/98

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION	
Box 1 of 1 0.0 - 3.0 ft.	Run # 1 0.0 - 3.0 ft.	Recovery 2.4 ft.	1.001	1029	RS					0.0 - 0.5 Fill, 60% gravel 40% sand, light yellowish brown (2.5y 6/4), 80% medium to coarse sand, gravel minus 0.5 inch subrounded to rounded, dry 1.0 - 1.5 Gravel, 90% gravel, 10% sand / rock fragments, poorly graded 1/8 to 1 inch, pinkish gray (5YR 7/2), subrounded to angular, broken, dry 1.5 - 2.4 Gravel-Clay-Sand, predominant gravel top and bottom, clay sand center, reddish brown (5YR 5/3) gravel subangular moderately graded, mainly sand and clay 2.0 - 2.3 ft., damp 2.4 - 3.0 No Recovery	
			1.005	0.5	R		GM	0.5			
			1.002	1033	RS						1.0
			1.006	10	R		GP	1.0			
			1.003	1022	RS						1.5
			1.007	15	R						2.0
			1.004	1036	RS						2.5
			1.008	20	R						3.0
			1.009	20	R						
			2.001	RS	ENS	40ml	1043		T.D. = 3.0 ft.		
			2.002	R	KNS	4L	1043				

NOTES: General: USCS is modified for this log as follows
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible.

168

ROCKY FLATS PLANT BOREHOLE LOG

PAGE 1 OF 1

Borehole Number: BH94698
 Location - North: 749265 East: 2085852
 Date: Drilled: 9-16-98 sampled: 9-17-98
 Geologist: R. Rupp
 Drilling Equip.: Genprobe

Surface Elevation: 5975 ft
 Area: 903 Lip
 Total Depth: 2.0 ft.
 Company: STOLLER Project No.: GE60000
 Sample Type: continuous core

EG&G LOGGING SUPERVISOR

APPROVAL Mark Wood

DATE 9-30-98

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION
Box 1 of 1 0.0 - 2.0 ft.	Run 1 of 1 0.0 - 2.0 ft.	Recovery 1.8 ft.	1.001	1408	Rs		GC	0.5	/ /	0.0 - 1.8 Clayey Sandy Gravel, 30% clay 50% sand 20% gravel, Reddish gray (Syr 5/2) 80% of sand is medium to coarse grain, gravel is subrounded to angular and broken, with fragments less than 0.1 ft diameter, well graded loose, dry. 0.2 ft. of caliche @ 1.5 ft.
			1.005	0.45	R					
			1.002	1409	Rs					
			1.006	0.9	R					
			1.003	1410	Rs					
			1.007	1.35	R					
			1.004	1411	Rs					
			1.008	1.80	R					
							1.8	/ /	1.8 - 2.0 No Recovery	
T.D. = 2.0 ft. Refusal										

NOTES: General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible
 (2) Core breaks cannot be matched, accurate footage measurements not possible

169

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

PAGE 1 OF 1

Borehole Number: BH94798
 Location - North: 749266 East: 2086000
 Date: 3-17-99
 Geologist: T. LUTHERER
 Drilling Equip.: GEOPROBE AVAL VALL ^{mw} _{7/2/99}

Surface Elevation: 5972 FT
 Area: 903 PAD Lip Area
 Total Depth: 4.0
 Company: TIERRA Project No. GE60000
 Sample Type: CONTINUOUS

RMRS LOGGING SUPERVISOR
 APPROVAL Mark Wood

DATE 7-2-99

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL MEASUREMENT	SAMPLE NUMBER	FIACHTINE ANGLE	BEDDING ANGLE	CLININ SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOGS	SAMPLE DESCRIPTION
Box 104/1	Run # 1 0.0 - 4.0'	Recovery 4.0'	001	RS	001		LL	1.0		0.0 - 1.0 Sandy Silty Clay. very dark clay gray, 37R U3 medium plasticity trace up to 3.5 cm broken lithic gravel with organics, trace fine to coarse sand damp.
			002	RS	001					
			003	RS	001					
			004	RS	001					
			99A5833		RS RI					
			001		001(002)			5.0		
			002		001(002)					
			003		001(002)					
			004		001(002)			6.0		
			Sampled on 3-18-99					7.0		
								8.0		
								9.0		

NOTES: General: USCS is modified for this log as follows:

- Materials amounts are estimated by % volume instead of % weight.
- (1) Badly broken core, accurate footage measurements not possible.
- (2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101

Revision 0

Date effective: 12/31/98

Page 27 of 28

170

ROCKY FLATS PLANT BOREHOLE LOG

STAGE 1 OF 1

Borehole Number: BH 94898
 Location - North: 749243 East: 2086149
 Date: drilled: 9-23-98 sampled: 9-25-98
 Geologist: R. Rupp
 Drilling Equip.: Geoprobe

Surface Elevation: 5970 ft
 Area: 903 Lip
 Total Depth: 2.6 ft.
 Company: STOLLER Project No.: GE60000D
 Sample Type: CONTINUOUS CORE

EG&G LOGGING SUPERVISOR

APPROVAL Mark Wood

DATE 9-30-98

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION	
Box 1 of 1 0.0 - 2.6 ft.	Run #1 0.0 - 2.6 ft.	RECOVERY 2.0 ft.	1.001	1472	RS					0.0-1.0 Silt, sandy, gravelly 60% silt, 20% sand, 20% gravel, light gray (5yr 4/1) medium to very coarse sand, subrounded gravel, broken quartzite, poorly graded, loose, dry, with abundant roots to 0.2 ft.	
			1.005	0.5	RS		GM	0.5			
			1.002	144	R						1.0
			1.006	1.0	RS						
			1.003	1410	R						1.5
			1.007	1.5	RS		GC	1.5			
			1.004	1406	R						2.0
			1.008	2.0	R						
									2.0-2.6 NO RECOVERY		
										T.D. = 2.6 ft.	

NOTES: General: USCS is modified for this log as follows:

Materials amounts are estimated by % volume instead of % weight.

- (1) Badly broken core, accurate footage measurements not possible.
- (2) Core breaks cannot be matched, accurate footage measurements not possible.

171

ROCKY FLATS PLANT BOREHOLE LOG

PAGE 1 OF 1

Borehole Number: BH 94998
 Location - North: 7492.44 East: 2086298
 Date: drilled: 9.23.98 sampled: 9.28.98
 Geologist: R. Rupp
 Drilling Equip.: Genprobe

Surface Elevation: 5968 ft
 Area: 903 Lip
 Total Depth: 2.0 ft.
 Company: STOLLER Project No.: GE 60000
 Sample Type: CONTINUOUS CORE

EG&G LOGGING SUPERVISOR

APPROVAL Mark Wood

DATE 9-30-98

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION
Box 1 of 1 0.0 - 2.0 ft	Run #1 0.0 - 2.0 ft	Recovery 1.7 ft.	1.001	1022	NS					0.0 - 0.7 Silty sand/gravel, 60% sand, 35% silt, 5% gravel, dark gray, sk brown (10yr 9/2) low plasticity, 80% medium to coarse sand, subrounded gravel to 0.1 ft. diameter, poorly graded, loose, dry, lots of roots. 0.7 - 1.3 GRAVEL, sandy; 80% gravel, 20% sand, silt; light brownish gray (10yr 6/2) low plasticity, sand coarse, gravel subangular and broken, poorly graded, loose, dry. 1.3 - 1.7 Gravel, clay sandy, 55% gravel, 25% clay, 20% sand, reddish brown (5yr 4/3) coarse sand, angular gravel, loose, dry. 1.7 - 2.0 No Recovery
			1.005	0.4	R		GM	0.5		
			1.006	1021	NS				0.7	
			1.003	0.8	R		GP	1.0		
			1.007	1023	NS				1.3	
			1.004	1.2	R				1.5	
			1.008	1024	NS		GC	1.7		
			1.008	1.7	R				2.0	
									T.D. = 2.0 ft. Refusal	

NOTES: General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible.

172

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

PAGE 1 OF 1

Borehole Number: BH 95098
 Location - North: 749243 East: 2086447
 Date: 2-9-99
 Geologist: T. LUTHERER
 Drilling Equip.: GEO PROBE DUAL WALL ^{mw} _{7/2/99}

Surface Elevation: 5967 Ft
 Area: 903 PAD Lip Area
 Total Depth: 3.4'
 Company: TIERRA Project No. GE600000
 Sample Type: CONTINUOUS

RMRS LOGGING SUPERVISOR

APPROVAL Mark Wood

DATE 7-2-99

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FUNCTIONAL ANGLE	REDUCED AREA	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGICAL LOG	SAMPLE DESCRIPTION
Box 1 of 1 0.0 - 3.4'	Run # 1 0.0 - 4.0'	Recovery: 3.4'	001	RS ISO	001		SC	0.5		0.0-0.5 clayey silty sand, pink yellowish brown 3/4 R 3/4 very fine to fine sand, locally medium to coarse, subangular to subrounded silty, clayey, slightly plastic w/ traces broken vitric gravel up to 3mm some organics, moist.
			002	RS ISO	002			1.0		0.5-2.2 Gravelly Silty Clay, Dark Red, 3/4 R 3/4, trace sand A/A, trace to fine gravel A/A, slightly to moderately plastic moist
			003	RS ISO	002		CL	1.5		2.2-3.4 Gravelly Silty Sand, Pink to light reddish brown, Gravel A/A
			004	RS ISO	002			GM	3.0	
							4.0			
			99A4851	001	RS 001 (002)			5.0		Sand same as @ 0.0-0.5 trace clay, dry.
				002	RS 001 (002)					
				003	RS 001 (002)					
				004	RS 001 (002)			6.0		
								7.0		
								8.0		
								9.0		

NOTES: General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101
 Revision 0
 Date effective: 12/31/98
 Page 27 of 28

173

ROCKY FLATS PLANT BOREHOLE LOG

PAGE 1 OF 1

Borehole Number: BH 95198
 Location - North: 749188 East: 2086149
 Date drilled: 9-17-98 sampled: 9-24-98
 Geologist: R. Rupp
 Drilling Equip.: Geoprobe

Surface Elevation: 5970 ft
 Area: 903 Lip
 Total Depth: 2.7 ft.
 Company: STOLLER Project No.: GE600000
 Sample Type: Continuous Core

EG&G LOGGING SUPERVISOR

APPROVAL Mark Wood

DATE 9-30-98

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION
Box 1 of 1 0.0 - 2.7 ft.	Run #1 0.0 - 2.7 ft.	Recovery 2.4 ft.	1.001	1433	RS		GM	0.5	●	0.0 - 0.5 Silty GRAVEL, brown (7.5yr 5/3) TO GRAY (7.5yr 5/6) 60% silt 10% sand 30% gravel, coarse sand, subrounded gravel, well graded, dry, ROOTS
			1.005	0.5	RS					
			1.002	1434	R		GM	1.0	●	0.5 - 1.0 Silty Gravel, 70% gravel 30% silt, brown (7.5yr 5/3) subrounded triangular gravel, 0.1 ft. broken rock fragments, fines are mainly broken rock, poorly graded, dry
			1.006	1.0	R					
			1.003	1435	RS		GC	1.5	/ 0 0	1.0 - 2.4 Clay, sandy, gravelly; 40% clay, 30% sand, 30% gravel, dark brown (7.5yr 4/3) Low Plasticity, sand grains medium to coarse, loose, dry; gravel fractured and angular
			1.007	1.5	R					
			1.004	1436	RS					
			1.008	2.0	R					
							2.5	/ 0 0		
							2.7	/ 0 0		
							2.4 - 2.7	X	NO Recovery	
									T.D. = 2.7 ft.	

NOTES: General: USCS is modified for this log as follows:
 Materials amounts are estimated by volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible.

174

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

PAGE 1 OF 1

Borehole Number: BH 95398
 Location - North: 749120 East: 2086211
 Date: 3-22-99
 Geologist: T. LUTHERER
 Drilling Equip.: GEO PROBE ~~AVIAL WALL~~ ^{MD}

Surface Elevation: 5970 FT
 Area: 903 PAD Lip Area
 Total Depth: 40' JAL 3.8'
 Company: TERRA ^{7/1/99} Project No. GE600000
 Sample Type: CONTINUOUS

RMRS LOGGING SUPERVISOR
 APPROVAL Mark Wood

DATE 7-2-99

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FINAL TIME ANGLE	TAC BEARING ANGLE	1/4" CHAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGICAL TEXT	SAMPLE DESCRIPTION
Box 1 of 1 0.0 - 3.2'	Run # 1 0.0 - 3.8'	RECOVERY: 3.2'	001 RS				SM	0.0		0.0-1.0 Silty Sand very dark greyish brown 3TB 3/2 prod very fine to fine some medium to coarse, subangular, silty, some to trace clay, some up to 6cm, subangular, dry 1.0-3.2 Clayey Sand/Sandy Clay mottled light brownish gray to reddish brown 4YR 4/3 → 6YR 6/2 prod. very fine to fine some med + coarse, subangular, low plasticity clay, trace to some up to 4cm gravel dry. 3.2-3.8 No RECOVERY
			002 ISO					0.5		
			001 RS					1.0		
			002 ISO						1.5	
			003 RS			SC	2.0			
			004 ISO					3.0		
							4.0			
							5.0			
							6.0			
							7.0			
			99A 6157					8.0		
								9.0		
			SAMPLED ON		3-26-99					

NOTES: General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101
 Revision 0
 Date effective: 12/31/98
 Page 27 of 28

176

ROCKY FLATS PLANT BOREHOLE LOG

PAGE 1 OF 1

Borehole Number: BH 95498
 Location - North: 748987 East: 2086078
 Date: Drilled: 9-23-98 sampled: 9-28-98
 Geologist: R. Rupp
 Drilling Equip.: Genprobe

Surface Elevation: 5973 ft
 Area: 903 Lip
 Total Depth: 2.35 ft
 Company: STOLLER Project No.: GE 600000
 Sample Type: continuous core

EG&G LOGGING SUPERVISOR

APPROVAL Mark Wood

DATE 9/30/98

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION	
Box 1 of 1 0.0 - 2.35 ft.	Run #1 0.0 - 2.35 ft.	Recovery 1.75 ft.	1.001	1429	RS						0.0-0.8 GRAVEL, SILTY, SANDY; 50% gravel 40% silt 10% sand dark gray to brown (10YR 4/2) sand medium to coarse; gravel subangular, poorly graded, loose, dry, very heavy roots
			1.005	045	R			GM	0.5		
			1.002	1431	RS				0.8		
			1.006	0.9	R			GP	10		
			1.003	1425	RS				11		
			1.007	1.35	R						
			1.004	1427	RS			GC	1.5		
			1.008	1.75	R						
							2.0		1.75-2.35 No Recovery		
							2.35			T.D. = 2.35 ft.	

NOTES: General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible.

177

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

PAGE 1 OF 1

Borehole Number: BH95598
 Location - North: 748984 East: 2086229
 Date: 3-24-99
 Geologist: T. LUTHERER
 Drilling Equip.: GEO PROBE DUAL WALL

Surface Elevation: 5972 Ft
 Area: 903 PAD Lip Area
 Total Depth: 4'
 Company: TERRA Project No. GE600000
 Sample Type: CONTINUOUS

RMRS LOGGING SUPERVISOR

APPROVAL Mark Wood

DATE 7-2-99

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL MEASUREMENT	SAMPLE NUMBER	FLUORINE ANGLE	TAL BEVEL ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOGS	SAMPLE DESCRIPTION
Box 1 of 1 0.0 - 2.85	Run # 1 0.0 - 4.0	RECOVERY: 2.85	001	RS	001		SM	0.5		0.0-0.9 Clayey Silty Sand, dark yellowish brown, 3/4 R 3/4, med. very fine and fine, some med and coarse, silty, medium plasticity clay with up to 5cm angular lithic gravel, organics, damp at 8, otherwise dry
			002	ISO	002			1.0		
			003	RS	001		1.5			
			004	ISO	002		2.0			
						GM	2.5		0.9-2.85 Gravelly Silty Sand, very pale brown 8/8 R 8/3 med. very fine to silt, some fine to coarse, with up to 4cm subangular lithic gravel 90% of material appears to be Caliche dry	
						2.85				
							3.0			
							4.0			
								5.0		
			99A 6158	RS	RS			6.0		
				001	001	(002)				
				002	001	(002)				
				003	001	(002)				
				004	001	(002)				
								7.0		
								8.0		
								9.0		

NOTES: General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS-OPS-PRO.101
 Revision 0
 Date effective: 12/31/98
 Page 27 of 28

178

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

PAGE 1 OF 1

Borehole Number: BH95698
 Location - North: 749248 East: 2086077
 Date: 3-18-99
 Geologist: T. LUTHERER
 Drilling Equip.: GEOPROBE DUAL WALL ^{MD} 7/2/99

Surface Elevation: 5971 FT
 Area: 903 PAD Lip Area
 Total Depth: 4'
 Company: TIERRA Project No. GE600000
 Sample Type: CONTINUOUS

RMRS LOGGING SUPERVISOR

APPROVAL

Mark Wood

DATE 7-2-99

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL IN FIELD MEASUREMENT	SAMPLE NUMBER	FRACATURE ANGLE	TAL BOLDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION
Box 1051	Run # 1	0.0 - 4.0	Recovery: 3.2'	001	RS ISO	001	GM	0.0		0.0-3.2 Gravely Silty Sand, very dusky red to very pale brown 2.5-TR to 8-TR g. 0.0-0.9 prod. very fine to fine becoming coarser w/depth, trace to some organics locally clayey, trace to some sub-angular lithic gravel up to 5mm, 0.0-0.9 damp, 0.9-3.2 dry
				002	RS ISO	002		1.0		
				003	RS ISO	002		2.0		
				004	RS ISO	002		3.0		
							4.0		3.2-4.0 No Recover	
			99A5835		RS RI			5.0		
			001		001 (002)			6.0		
			002		001 (002)			7.0		
			003		001 (002)			8.0		
			004		001 (002)			9.0		

NOTES: General: USCS is modified for this log as follows:

Materials amounts are estimated by % volume instead of % weight.

(1) Badly broken core, accurate footage measurements not possible.

(2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101

Revision 0

Date effective: 12/31/98

Page 27 of 28

179

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

PAGE 1 OF 1

Borehole Number: BH95798
 Location - North: 749268 East: 2086148
 Date: 3-17-99
 Geologist: T. LUTHERER
 Drilling Equip.: GEOPROBE DUAL WALL

Surface Elevation: 5970 FT
 Area: 903 PAD Lip Area
 Total Depth: 4'
 Company: TERRA Project No. GE660000
 Sample Type: CONTINUOUS

RMRS LOGGING SUPERVISOR

APPROVAL Mark Wood

DATE 7-2-99

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL MEASUREMENT	SAMPLE NUMBER	FLUORINE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL/LITHOLOGIC LOG	SAMPLE DESCRIPTION
Box 1 of 1 0.0 - 3.3'	Run# 1 0.0 - 4.0	Recovery: 3.3'	001	RS 001			SC	0.0		0.0-0.8 Clayey Sand, dark brown 3/4R 3/3. med fine to very fine, some medium to coarse, subangular trace slightly plastic clay, w/ trace to some up to 4mm angular to subrounded lithic gravel, dump.
			002	RS 001		CL	0.8			
			003	RS 001			1.0			
			004	RS 001			1.2			
			005	RS 001			2.0			
			006	RS 001		SC	3.0			
							3.3		3.3-4.0, No Recovery	
								4.0		reddish yellow 6/4R 6/3 to 6/4R 6/8 med. fine to very fine, some medium to coarse, subangular, slight to no plasticity, with up to 4mm angular to subrounded lithic gravel dry.
			001	RS RI 001 (002)				5.0		
			002	RS RI 001 (002)						
			003	RS RI 001 (002)						
			004	RS RI 001 (002)						
			005	RS RI 001 (002) TAL						
			006	RS RI 001 (002)						
								6.0		
								7.0		
								8.0		
								9.0		

NOTES: General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101
 Revision 0
 Date effective: 12/31/98
 Page 27 of 28

180

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

PAGE 1 OF 1

Borehole Number: BH95898
 Location - North: 749244 East: 2086219
 Date: 3-17-99
 Geologist: T. LUTHERER
 Drilling Equip.: GEO PROBE ADAL WALL ^{mw} _{12/99}

Surface Elevation: 5969 Ft
 Area: 903 PAD Lip Area
 Total Depth: 4.0'
 Company: TIERRA Project No. GE600000
 Sample Type: CONTINUOUS

RMRS LOGGING SUPERVISOR

APPROVAL Mark Wood

DATE 7-2-99

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FINALIAL ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL/ LITHOLOGIC TEXT	SAMPLE DESCRIPTION
Box 1 of 1 0.0 - 2.9	Run # 1 0.0 - 4.0	Recovery: 2.9'	001	RS	001	CL	CL	1.0		0.0-1.6 Silty Clay, 3TR 3/3 dark brown, slight to some plasticity, traces fine to coarse sand, silty, traces to some up to 6mm subrounded to subangular, clay, damp to moist.
			002	ISO	002					
			003	RS	001					
			004	ISO	002					
99A5836			001	RS	001	SM		2.0		1.6-2.9 Gravelly Sand, pinkish white 8TR 8/2, med. v. fine to fine, some mud to coarse, angular to subrounded, slightly silty up to 4cm subrounded to fine gravel, dry
			002	RI	002					
			003	RI	001					
			004	RI	002					
			001	RI	001			3.0		2.9-4.0 No Recovery
			002	RI	002					
			003	RI	001					
			004	RI	002					
							4.0			
							5.0			
							6.0			
							7.0			
							8.0			
							9.0			

NOTES: General: USCS is modified for this log as follows:

Materials amounts are estimated by % volume instead of % weight.

- (1) Badly broken core, accurate footage measurements not possible.
- (2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101

Revision 0

Date effective: 12/31/98

Page 27 of 28

181

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

PAGE 1 OF 3

Borehole Number: BH5998
 Location - North: 749140 East: 2085893
 Date: 6-3-99 → 6-7-99
 Geologist: T. LUTHERER
 Drilling Equip.: GEOPROBE WALL WALL

Surface Elevation: 5976 FT
 Area: 903 PAD
 Total Depth: 25.0 FT
 Company: TIERRA Spec. No: GE600000
 Sample Type: CONTINUOUS

RMRS LOGGING SUPERVISOR

APPROVAL Mark Wood

DATE 7-6-99

TOP/BOTTOM OF LOG INTERVAL	TOP/BOTTOM OF INTERVAL	FEET OF CORE INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FUNCTIONAL AREA	ULTRAPURE AREA	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH (FEET)	SOIL/ROCK/CLAY (LINK)	SAMPLE DESCRIPTION
	0.0 - 3.8	Recovery: 3.5'						1.0 2.0 3.0		0.0-4.0 similar to BH 90998 see log
	3.8 - 6.8	Recovery: 3.7'	001 4.8 003 5.0 002 5.6 003	RS ISO			SC	4.0 5.0 6.0		3.8-6.8 Clayey Sand, brown 7.5 GR 5/4, fine to coarse, sub-angular to subrounded, lithic sand, low plastic clay, some silt, with up to 4cm broken to subangular lithic gravel, damp
	6.8 - 8.8	Recovery: 1.95'					SC	7.0 8.0		6.8-8.8 Clayey Sand, A/A
	8.8 - 10.8	Recovery: 2.4'	99A 7799 002				SC	9.0		8.8-10.8 Clayey Sand A/A

NOTES: General: USCS is modified for this log as follows:

Materials amounts are estimated by % volume instead of % weight.

(1) Badly broken core, accurate footage measurements not possible.

(2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101

Revision 0

Date effective: 12/31/98

Page 27 of 28

182

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

PAGE 2 OF 3

Borehole Number: BH95998
 Location - North: 749140 East: 2085893
 Date: 6-3-99 → 6-7-99
 Geologist: J. LUTHERER
 Drilling Equip.: GEOPROBE DUAL WALL

Surface Elevation: 5976 ft
 Area: 903 PAD
 Total Depth: 25.0 ft
 Company: TERRA Project No.: 6E60000
 Sample Type: CONTINUOUS

RMRS LOGGING SUPERVISOR
 APPROVAL Mark Wood

DATE 7-6-99

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION
Run #4	8.8-10.8	Recovery 2.4					SC	10.0		Clayey Sand A/A
Run #5	10.8-12.8	Recovery 2.8	99A7799 003				XX	11.0		10.8-12.5 Clayey Sand
			001	12.2	RS			20		
			003	12.4	ISO					
			002	12.7	VOA		CL			12.5-12.8 Clay light-yellowish brown 2.5 x 6/3 to light olive yellow; 2.5 x 6/8
Run #6	12.8-15.8	Recovery 2.9					SC	13.0		low to no plasticity, dense, fine, w/ traces fine to coarse lithic + calcic sand, also w/ traces fine up to 1.5 cm subrounded gravel, damp to moist.
			001	14.6	RS			14.0		
			002	14.8	VOA			15.0		
			003	15.2	ISO					
			003	15.4	ISO					12.8-15.8 Clayey Sand A/A.
Run #7	15.8-17.0	Recovery 2.35	99A7799 004				XXX	16.0		15.8-17.0 Clayey Sand A/A
Run #8	17.0-18.8	Recovery 2.45					SC	17.0		17.0-18.8 Clayey Sand A/A
			001	17.3						
			003	17.5						
			002	17.7						
			002	18.2			SC	18.0		
			99A7799 005				XXV			
Run #9	18.8-20.0	Recovery 2.19					SC	19.0		18.8-19.9 Clayey Sand A/A
										TAL 6-27-99
										19.9-20.0 No Recovery

NOTES: General: USCS is modified for this log as follows:

Materials amounts are estimated by % volume instead of % weight.

- (1) Badly broken core, accurate footage measurements not possible.
- (2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101

Revision 0

Date effective: 12/31/98

Page 27 of 28

183

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

Borehole Number: BH95998
 Location - North: 749140 East: 2085893
 Date: 6-3-99 → 6-7-99
 Geologist: T. LUTHERER
 Drilling Equip. GEOPROBE DUAL WALL

Surface Elevation: 5976 FT
 Area: 903 PAD
 Total Depth: 25.0 FT
 Company: TIERRA Projec: No GEG0000
 Sample Type: CONTINUOUS

RMRS LOGGING SUPERVISOR

APPROVAL Mark Wood

DATE 7-6-99

DEPTH OF CORE (FEET)	SAMPLE DESCRIPTION																			
20.0	20.2	20.2	RS	SL																20.0-20.5 Clayey Sand. A/A, wet.
20.5	20.6	20.6	RS	BR																20.5-20.6 (claystone, light gray 2.5Y 6/1) massive, dense, tan to some silt, mod. plasticity, moist
21.0	21.0	21.0	99A7799006001RS																	No Recov. 20.6-21.5 Top of Bedrock = 20.5 FT (approximate) TAL 6-29-99
21.8	22.8	22.8	99A7799006003ISO																	21.8-22.8' No Recovery
22.8	24.8	24.8	99A7799007001RS																	22.8-24.8' Claystone A/A with some weathering, olive yellow 2.5Y 6/6.
24.0	24.0	24.0	99A7799007002VOA																	
24.4	24.4	24.4	99A7799007002VOA																	
24.6	24.6	24.6	99A7799007003VOA																	
25.0	25.0	25.0	99A7799007005ISO																	
25.0	25.0	25.0	99A7799007001RS																	T.D. = 25.0

NOTES: General: USCS is modified for this log as follows.
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS OPS-PRO.101-
 Revision 0
 Date effective: 12/31/98
 Page 27 of 28

184

ROCKY FLATS PLANT BOREHOLE LOG

PAGE 1 OF 2

Borehole Number: BH 96098
 Location - North: 749211TA East: 2085612
 Date: 10/29/98 → 11/30/98
 Geologist: T. LUTHERER
 Drilling Equip.: GEOPROBE - Dual Well

Surface Elevation: 5978 FT
 Area: 903 PAD
 Total Depth: 17.0 FT
 Company: TIERRA Project No.: 6E.00000
 Sample Type: CONTINUOUS

EG&G LOGGING SUPERVISOR

APPROVAL Mark Wood

DATE 7-6-99

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRAC/ ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL/ LITHOLOGIC LOG	SAMPLE DESCRIPTION
	Run # 1 0.0 - 3.8	Recovery: 3.4						1.0 2.0 3.0 3.4		0.0-3.8 See Borehole log of BH 90098
	Run # 2 3.8 - 7.0	Recovery: 3.0	001 RS 007 ISO 013 UOA A 993210-002-XXX				SC	4.0 4.3 4.5 4.8 5.0 6.0 7.0		3.8-7.0 Sand; Light Brown to Strong Brown 7.5 7R 6/3 to 7.5 7R 5/6 fine to coarse, subangular to subrounded, some to abundant up to 4cm grains and subangular to angular lithic gravel, some to abundant low plastic clay, locally grading to clayey sand. Dry to damp with some powdery Caliche white; #1/8, 5/16, 8/1
	Run # 3 7.0 - 9.0	Recovery: 3.0	002 RS 008 ISO 014 UOA				SC	8.0 8.2 8.5 8.8 9.0		7.0-9.0 Sand; locally grading to clayey sand. A/A damp
	Run # 4						CL			9.0-12.0 Clay A/A with sand, A/A with traces coarse, rounded Caliche sand - lithic subangular fine to coarse sand

NOTES: General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.

185

ROCKY FLATS PLANT BOREHOLE LOG

PAGE 2 OF 2

Borehole Number: BH96098
 Location - North: 749211 TALE East: 2085612
 Date: 10/29/98 → 11/30/98
 Geologist: T. LUTHERER
 Drilling Equip.: GEOPROBE DUAL WALL

Surface Elevation: 5978 FT
 Area: 903 PAD
 Total Depth: 17.0 FT
 Company: TIERRA Project No.: 6E600000
 Sample Type: CONTINUOUS

EG&G LOGGING SUPERVISOR

APPROVAL Mark Wood

DATE 7-6-99

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	RACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION
	Run #4 9.0-12.0	Recovery: 4.0						10.0 11.0		locally grading to sandy clay
	Run #5 12.0-15.0	Recovery: 4.0	003 009 749 005 015	RS LSO VOA				12.0 12.3 12.5 13.0 14.0		12.0-15.0 clay; locally grading to sandy clay A/A
	Run #6 15.0-16.3	Recovery: 1.25	004 010 016	RS LSO VOA				15.0 15.6 15.8		15.0-15.8 clay; locally grading to sandy clay A/A
	Run #7 16.3-17.0	Rec: 1.25						16.0 16.3 16.25 17.0		Sandstone; yellow 107R 8/8 fine to medium, subrounded, mostly unconsolidated; highly friable, oxidized, granitic; saturated trace clay + silt
								18.0 19.0		Bedrock contact: 15.8 TD: 17.0

NOTES: General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.

186

ROCKY FLATS PLANT BOREHOLE LOG

PAGE 1 OF 2

Borehole Number: BH 96198
 Location - North: 749213 East: 2085687
 Date: 12/03/98 12-2-98 → 12-3-98
 Geologist: R. KOEHLER
 Drilling Equip.: GEO PROBE - DUAL WALL

Surface Elevation: 5977 FT
 Area: 903 PAD
 Total Depth: 18.8 FT.
 Company: TIERRA Project No.: GE600000
 Sample Type: CONTINUOUS

EG&G LOGGING SUPERVISOR
 APPROVAL Mark Wad

DATE 7-7-99

DEPTH OF CORE (FEET)	TOP/MIDDLE OF INTERVAL (FEET OF CORE)	RECOVERY (FEET)	SAMPLE NUMBER	STRUCTURAL ALKRE	DEPTH (FEET)	USCS SYMBOL	DEPTH (FEET)	SON/LOGGING LOG	SAMPLE DESCRIPTION
BOX 1 of 3 0.0 - 9.5 ft.									
	Run #1 0.0 - 3.35	RECOVERY: 2.0							FOR INTERVAL 0.0 - 3.35 SEE LOG OF BOREHOLE BH90198
	Run #2 3.35 - 6.5	RECOVERY: 3.0	99A3210-003	XXX	4.0	4.0	4.0		3.35 - 6.35 Clayey Sand, silty brown 7.5 YR 5/6; fine to medium, locally coarse sand, subround to subangular, lithic, very slight to non plastic sand clay, trace fine to coarse gravel, damp.
			001 1106	Rad S	4.2				
			007 1107	Is	4.4				
			013 1108	VGC	4.7	SL			
					6.0				6.35 - 6.50 - No Recovery
	Run #3 6.5 - 9.0 ft.	RECOVERY 3.6 ft including 0.7 ft slough	99A3210-003	XXX	7.5	7.5	7.5		6.5 - 9.0 ft; Clayey-sandy gravel; very pale brown (10YR 7/4) grades down to light reddish brown (5YR 6/4); quartzite gravel up to 2 cm, fractured, fine to medium subround to subangular sand, firm, not plastic, slightly moist.
			09:53 002	Rad S	7.7	GC			
			09:53 008	Is	8.1				
			09:53 014	VGC	8.5				
	Run #4 9.0 - 11.5 ft.				9.0	GC			9.0 - 9.5 As above 6.5 - 9.0 ft.
					9.5	SC			9.5 - 11.5 ft; Clayey sand (w/ gravel); continued next page.

NOTES: General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.
 (2) ... accurate footage measurements not possible.

187

ROCKY FLATS PLANT BOREHOLE LOG

PAGE 2 OF 2

Borehole Number: BH96198
 Location - North: 749213 East: 2085687
 Date: 12/03/98
 Geologist: R. KOEHLER
 Drilling Equip.: GEOPROBE - DUALWALL

Surface Elevation: 5977 ft.
 Area: 903 PAD
 Total Depth: 18.8 ft.
 Company: TIERRA Project No.: GEG00000
 Sample Type: CONTINUOUS

EG&G LOGGING SUPERVISOR

APPROVAL Mark Wood

DATE 7-7-99

TOP DEPTH OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FUNCTION AREA	DETERMINING AREA	GRAIN SIZE DISTRIBUTION	TEST NUMBER	DEPTH IN FEET	SOIL TEMPERATURE LOGS	SAMPLE DESCRIPTION
BOX 2 of 3 9.5-17.0 ft.	RUN #4 9.0-11.5 ft.	RECOVERY 4.0 ft.						11.0		light reddish brown (SYR 6/4), fine to medium sand, subround to subangular, firm, slightly moist, gravel may be in lenses.
	RUN #5 11.5-14.0 ft.	RECOVERY 4.0 ft.	10:55 003 10:54 009 10:53 015	Rad S Iso VOC				11.8 12.0 12.5		As above 9.5-11.5 ft. 11.5-14.0 ft.
	RUN #6 14.0-16.5 ft.	RECOVERY 3.0 ft.						13.0		
	RUN #7 16.5-18.8 ft.	RECOVERY 4.0 ft.						14.0		
BOX 3 of 3 17.0-18.8 ft.	RUN #6 14.0-16.5 ft.	RECOVERY 3.0 ft.	99A3210-003.XXX					15.0		14.0-16.5 Similar to RUN#3 6.5-9.0 ft. Pinkish clayey-sandy gravel, quartzite gravel to 2 cm.
	RUN #7 16.5-18.8 ft.	RECOVERY 4.0 ft.	13:20 004 13:19 010 13:19 016	Rad S Iso VOC				15.3 15.5 15.8 16.0 16.2		Bedrock contact 16.6 ft. 16.6-18.8 ft; Clayey sand, light yellowish brown to yellow (10YR 6/4-10YR 7/6), fine sand, firm to hard, slightly moist.
								16.5		
								17.0		
								18.0		
								18.8		
								19.0		T D 18.8 ft.

NOTES: General: LSCS is modified for this log as follows:

Materials amounts are estimated by % volume instead of % weight.

(1) Badly broken core, accurate footage measurements not possible.

(2) Core breaks cannot be matched, accurate footage measurements not possible.

188

ROCKY FLATS PLANT BOREHOLE LOG

PAGE 1 OF 2

Borehole Number: BH96298
 Location - North: 749135 East: 2085611
 Date: 12/04/98
 Geologist: R. KOEHLER
 Drilling Equip.: GEOPROBE-DUALWALL

Surface Elevation: 5979 FT.
 Area: Q03 PAD
 Total Depth: 16.5 ft
 Company: TIERRA Project No. GE600000
 Sample Type: CONTINUOUS

EG&G LOGGING SUPERVISOR,

APPROVAL Mark Wood

DATE 7-6-99

TOP BOTTOM OF INTERVAL	FEET OF CORE INTERVAL (FIELD MEASUREMENTS)	SAMPLE ID	TESTS	DETERMINING ANAL.	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH (FEET)	SOIL / LITHOLOGIC LOGS	SAMPLE DESCRIPTION
0.0 - 3.8 ft.	3.1 ft.						0.0 - 3.8		0.0-0.4 ft: Asphalt 0.4-3.8 ft; Clayey-sandy gravel; yellowish red (5YR 5/6), quartzite gravel up to 2 cm (most about 0.5 cm), fractured to subround, fine to medium sand - subangular to subround, firm, slightly moist,
3.8 - 6.5 ft.	2.8 ft.	10:46 001 10:46 007 10:46 013	Rad S Iso VOC				3.8 - 6.5		As above 0.4-3.8 ft.
6.5 - 9.0 ft.	2.7 ft.	11:16 002 11:15 009 11:15 008 11:11 015 11:11 014	Rad S Iso Dup Iso VOC Dup VOC				6.5 - 9.0		As above 0.4-3.8 ft. 7.5-8.0 ft; Clayey sand; clay white 10YR 9/2, sand-dark gray 10YR 4/1, weathered cobble?, fine sand, moist, sat.
9.0 - 11.5 ft.	3.1 ft.						9.0 - 11.5		As above 0.4-3.8 ft.

BOX 1 OF 2 0.0 - 10.7 ft.

NOTES: General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Easily broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible.

189

ROCKY FLATS PLANT BOREHOLE LOG

PAGE 2 OF 2

Borehole Number: BH96298
 Location - North: 749135 East: 2085611
 Date: 12/04/98
 Geologist: R. KOEHLER
 Drilling Equip.: GEOPROBE - DUAL WALL

Surface Elevation: 5979 ft
 Area: 903 PAD
 Total Depth: 16.5 ft
 Company: TIERRA Project No.: GE60000
 Sample Type: CONTINUOUS

EG&G LOGGING SUPERVISOR

APPROVAL Mark Wood

DATE 7-6-99

TOP/BOTTOM OF CORE INTERVAL	TOP/BOTTOM OF INTERVAL	FEET OF CORE INTERVAL (FIELD MEASUREMENTS)	SAMPLE NUMBER	FUNCTIONAL AIR/LE	BEARING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL/ LITHOLOGIC LOG	SAMPLE DESCRIPTION
10.7	Run #4 9.0-11.5	Recovery 3.1 ft.		XXX				10.5 10.7 11.0	SC	See previous page
11.5-14.0	Run #5 11.5-14.0 ft.	Recovery 3.8 ft. * *Looks like fill back.	11:53 003 11:53 010 11:53 016	Rad S Iso VOC			11.6 11.9 12.25 12.75	11.5 11.9 12.0 12.25 12.75 13.0	SC	11.5-14.0 Clayey sand as above 10.5-11.5 ft. 1 cm gravel, subrounded from 13.5 to 14.0 ft. matrix is clayey sand
14.0 ft. BEDROCK CONTACT										
14.0-16.5	Run #6 14.0-16.5 ft	Recovery 2.9 ft ** ** suspect part above fill back	01:34 004 12:33 011 12:32 017	Rad S Iso VOC			15.7 15.9 16.1	14.0 15.0 15.7 15.9 16.0 16.5		14.0-16.5 Clayey sand, ^{stone} brownish yellow (10YR 6/8), fine sand, firm, slightly moist, friable
16.5	Run #7 16.5-16.5 ft							16.5		16.5 ft. T.D.
17.0	13:15 Trip Blank		99A3210-006.003					17.0		
17.5	13:15 Rad Screen Rinse		99A3210-006.001					17.5		
18.0	13:15 Isotope Rinse		99A3210-006.002					18.0		
19.0	13:15 VOC Rinse		99A3210-006.004					19.0		** On removing the outer steel core liner from the hole about 1 ft of additional cored material was found. Evidently this material fell out of the plastic core liner, some also from cutting shoe. This material was put into core box.

NOTES: General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Easily broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible.

190

ROCKY FLATS PLANT BOREHOLE LOG

PAGE 1 OF 2

Borehole Number: BH96398
 Location - North: 749061 East: 2085610
 Date: 12-7-98 → 12-8-98
 Geologist: T. LUTHERER
 Drilling Equip.: GEOPROBE DUAL WALL

Surface Elevation: 5979 FT
 Area: 903 PAD
 Total Depth: 16.5 FT
 Company: TIERRA Project No.: 6E600000
 Sample Type: CONTINUOUS

EG&G LOGGING SUPERVISOR

APPROVAL Mark Ward

DATE 7-6-99

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION
	Run# 1, 0.0-3.8	Recovery: 2.7'						1.0 2.0 2.7 3.0		0.0-3.8 See Borehole log of BH 91098 2.7-3.8 No Recovery
	Run# 2 3.8-6.5	Recovery: 3.0'	001 RS 002 TSO 003 VOA				CL	3.8 4.0 4.3 4.5 4.8 5.0		3.8-6.5 Sandy clay; light yellowish brown 1PTR 6/4, Non to low plasticity, with fine to coarse, subangular to subrounded lithic sand, trace gravel damp.
	Run# 3 6.5-9.0	Recovery: 3.0'	99A4102-002-XXX 004 RS 005 TSO 006 VOA				SL	6.0 6.5 7.0 8.0 8.2 8.4 8.5 8.9 9.0		6.5-9.0 Sand; strong brown 7.5TR 5/6 fine to coarse, subrounded to angular, locally silty to clayey, also with fine to medium sized gravel damp Locally grading to clayey sand.
	Run# 4	Recovery: 3.1'					SC			9.0-11.5 clayey sand/ locally grading to:

NOTES: General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.

191

ROCKY FLATS PLANT BOREHOLE LOG

PAGE 2 OF 2

Borehole Number: BH96398
 Location - North: 749061 East: 2085610
 Date: 12-7-98 → 12-8-98
 Geologist: T. LUTHERER
 Drilling Equip.: GEOPROBE DUAL WALL

Surface Elevation: 5979 FT
 Area: 903 PAD
 Total Depth: 16.5 FT
 Company: TIERRA Project No.: 6E6000 00
 Sample Type: CONTINUOUS

EG&G LOGGING SUPERVISOR

APPROVAL Mark Ward

DATE 7-6-99

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRacture ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION
	Ran # 4 9.0-11.5	Rec. 3.1					SC CL	10.0 11.0		Sandy Clay A/A, damp
	Ran # 5 11.5-14.0	RECOVERY 3.3	007 008 009	RS ISO VOA			CL G17 SC	12.0 12.2 12.4 12.7 13.0 14.0		12.7 tan 11.5 to 14.0 Sandy Clay; Reddish Brown, 5/8 & 4/3 trace to some plasticity, with fine to coarse subangular sand (L-type), locally some fine unangular lentic gravel, silty clay 12.7 to 13.8 Gravily Sand; see above for consistents. 13.8-14.0 Clayey Sand see above for consistents
	Ran # 6 14.0-16.5	RECOVERY 3.8	010 011 012	RS ISO VOA			BR mo 76/100	15.0 16.0 16.2 16.4		14.0-16.5 Claystone, light olive gray 5/8 5/16 locally weathered, mottled w/ light olive brown 5/8 5/16. Plastic, dense, locally silty, with some light gray N7 very fine sand. dry - wet @ 14.0-14.2
								17.0 18.0 19.0		Assumed Bedrock contact @ 14.0 Last sample lost from sampler, retrieved with dual wall. TD = 16.5'

(192)

NOTES: General: USCS is modified for this log as follows:

Materials amounts are estimated by % volume instead of % weight.

(1) Badly broken core, accurate footage measurements not possible.

(2) Core breaks cannot be matched, accurate footage measurements not possible.

ROCKY FLATS PLANT BOREHOLE LOG

PAGE 1 OF 3

Borehole Number: BH 964 98
 Location - North: 749141 East: 2085910
 Date: 10/21/98 → 10/26/98
 Geologist: T. LUTHERER
 Drilling Equip.: GEOPROBE DUAL WALL

Surface Elevation: 5976 FT
 Area: 903 PAD
 Total Depth: 23.0 FT
 Company: TIERRA Project No.: 6E000000
 Sample Type: CONTINUOUS

EG&G LOGGING SUPERVISOR
 APPROVAL Mark Wood

DATE 7-6-99

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL/LITHOLOGIC LOG	SAMPLE DESCRIPTION
	Run # 1 0.0-3.8'	Recovery: 2.25'						1.0 2.0 2.25		0.0-3.8 See Borehole log of BH 90998
								3.8		
	Run # 2 3.8-7.8'	Recovery: 3.73'	001 007 013	RS ISO VOA		4.0 4.4 4.8 5.2	SC	4.0 4.4 4.8 5.0 5.2		3.8-7.53 clayey Sand med. fine some coarse, subangular to subrounded some medium, feldspar and quartz; clayey, some silt. traces up to 3mm broken lithic gravel, non-loy plasticity, well graded, moist
			99A3210-001-xxx				SC	6.0		
								7.0		
								7.53		7.53-7.8 NO Recovery
	Run # 3 7.5-11.0		002 008 014	RS ISO VOA			SM	8.0 9.0 10.0		Repositioned sampler to 7.5 due to soil between liner and shoe 7.5-11.0 Silty Gravelly Sand med very fine to fine, trace med and coarse, subrounded to subangular, locally very silty, some clay, sp. platy sand to abundant broken lithic gravel

NOTES: General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible.

193

ROCKY FLATS PLANT BOREHOLE LOG

Borehole Number: BH 96498
 Location - North: 749141 East: 2085910
 Date: 10/21/98
 Geologist: T. LUTHERER
 Drilling Equip.: GEOPROBE DUAL WALL

Surface Elevation: 5976 Ft
 Area: 903 PAD
 Total Depth: 23.0 Ft
 Company: TIERRA Project No.: 6E600000
 Sample Type: CONTINUOUS

EG&G LOGGING SUPERVISOR

APPROVAL Mark Wood

DATE 7-6-99

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE INTERVAL IN FIELD (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION
	Run #3						GM	10.0		7.5-11.0 Cont. Gravel size A/A, traces Calcite, dry
	Run #4 11.0-14.0	Recovery: 3.6'	003 009 015	RS TSO VOA			SC	11.0 12.0 12.2 13.0 13.5		11.0-14.0 clayey sand same as @ 3.8-7.53 dry
	Run #5 14.0-17.0	Recovery: 1.9"	004 010 016	RS TSO VOA			SC GM CL	14.0 14.5 15.0 15.9 16.0 16.5		14.0-14.5 Clayey Sand same as above. 14.5-15.9 S-Hr gravelly sand same as @ 7.5-11.0 dry 15.9-16.5 Sandy Clay size and texture same as @ 3.8-7.53 dry. 16.5-17.0 No Recover
	Run #6 17.0-20.0	Recovery: 2.6'					SC	17.0 18.0 18.6 19.0 19.9		17.0-18.6 Clayey Sand same as @ 11.0-14.5. Obstruction @ 18.6 which required run # 7 from 18.6-19.9 18.6-19.9 Clayey Sand. as above

NOTES: General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible.

194

ROCKY FLATS PLANT BOREHOLE LOG

PAGE 3 OF 3

Borehole Number: BH76498
 Location - North: 749141 East: 2085910
 Date: 10-21-98 → 10-26-98
 Geologist: LUTHERER
 Drilling Equip.: GEOPROBE DUAL WALL

Surface Elevation: 5976 FT
 Area: 903 MAD
 Total Depth: 23.0 FT
 Company: TIERRA Project No.: 6E6000 00
 Sample Type: CONTINUOUS

EG&G LOGGING SUPERVISOR
 APPROVAL Mark Wood

DATE 7-6-99

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION
	Run # 8 19.9-23.0	Recovery: 3.6'	006	R5			SC	20.0		19.9-22.0 Clayey sand same as above
			012	T50			21.0	21.4		
			018	VOA			22.0			
								23.0		22.0-23.0 Silt. Claystone, Top of Bedded. = 22.0 FT slightly weathered, slightly oxidized, generally blocky, dense, mgd. friable, some MnO dendritic patterns, dry
										TD = 23.0'

NOTES: General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible.

195

7-7-99

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

PAGE 1 OF 2

Borehole Number: BH96598
 Location - North: 249147 East: 2085867
 Date: 5-17-99
 Geologist: L. LUTHERER
 Drilling Equip.: GEOPROBE DUAL WALL

Surface Elevation: 5976 ft
 Area: 903 PAD
 Total Depth: 23.8
 Company: TIERRA Project No: 6E600000
 Sample Type: CONTINUOUS

RMRS LOGGING SUPERVISOR

APPROVAL Mark Wood

DATE 7-7-99

TOP POSITION OF CORE IN BOX	TOP POSITION OF INTERVAL	FEET OF CORE IN INTERVAL MEASUREMENT	SAMPLE NUMBER	FUNCTIONAL GRADE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGY LOG	SAMPLE DESCRIPTION
	Run #1 0.0-3.8	Recovery: 3.9'						0.0-3.8		0.0-3.8' see log for BH90898
	Run #2 3.8-6.8	Recovery: 3.15'	001 4.0 003 4.2 002 4.6		RS ISO V0A		SC	3.8 4.0 5.0 6.0		3.6-6.8' Clayey Sand. weak med 2.5 TR 5/2, 2.5 TR 4/2, pred very fine to fine, some med to coarse, subangular to subrounded, sand no plasticity, trace to some silt, sandy up to 3.5 cm below and angular lithic gravel dry to damp
	Run #3 6.8-9.8	Recovery: 2.8	001 8.0 003 8.2 002 8.4 8.8		RS ISO V0A		SC	6.8 7.0 8.0 9.0 9.8		6.8-9.8' Clayey Sand 6.8-8.4 grading to sandy clay @ 8.4-9.8. strong Brown 7.5 TR 5/6. Components A/A dry to damp

NOTES: General: USCS is modified for this log as follows:

Materials amounts are estimated by % volume instead of % weight.

(1) Badly broken core, accurate footage measurements not possible.

(2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101

Revision 0

Date effective: 12/31/98

Page 27 of 28

196

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

PAGE 2 OF 3

Borehole Number: BH 965-98
 Location - North: 749147 East: 2085867
 Date: 5-17-99 → 5-21-99
 Geologist: J. LUTHERER
 Drilling Equip.: GEOPROBE DUAL WALL

Surface Elevation: 5976 FT
 Area: 903 PAD
 Total Depth: 23.8
 Company: TIERRA Project No.: 6E600000
 Sample Type: CONTINUOUS

RMRS LOGGING SUPERVISOR

APPROVAL

Mark Wood

DATE

7-7-99

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION
Run # 4; 9.8-12.0	9.8-12.0	Recovery: 3.1	99A 1817-003-XXX 001 003 002	11.2 11.4 11.6			SC	10.0 11.0 12.0		9.8-12.8 Clayey Sand: light brown to dark brown 7.5 TR 6/3 to 7.5 TR 3/3
Run # 5 12.0-15.0	12.0-15.0	Recovery: 4.0	002 TAL 6-15-99				SC	13.0		12.0-12.8 (Clayey Sand) with some gravel reddish yellow fine to coarse sand, fine to coarse, sub rounded to sub angular dense, moist-wet.
Run # 5 12.0-15.0	12.0-15.0	Recovery: 4.0	002 TAL 6-15-99				CL	14.0		12.8-15.0 Sandy clay with trace fine gravel fine to coarse sand, sub rounded slight plasticity, stiff to calcic nodules moist. 12.8-13.5 light olive gray 2.5 TR 4/2
Run # 5 12.0-15.0	12.0-15.0	Recovery: 4.0	002 TAL 6-15-99				CL	15.0		13.5-15.0 mottled, dom. red 2.5 TR 5/6 to lite olive gray 2.5 TR 6/2
Run # 6 15.0-18.0	15.0-18.0	Recovery: 4.0	002 003 001 99A 1817-004-XXX	15.2 15.6 15.8 16.0			CL	16.0		15.0-17.0 Sandy clay (CL) with some fine gravel fine to coarse sand sub rounded to sub angular stiff moist mottled light olive gray (2.5 TR 6/2) to yellowish red (5 TR 4/6)
Run # 6 15.0-18.0	15.0-18.0	Recovery: 4.0	002 003 001 99A 1817-004-XXX	15.2 15.6 15.8 16.0			SC	17.0		17.0-18.0 Clayey Sand, gravel. H. gray (5 TR 7/7) fine to coarse sand, fine to coarse gravel with clay dense moist.
Run # 7 18.0-18.6	18.0-18.6	Rec: .2					GW	18.0		Gravel: quartzite rubble - broken, angular to ~ 4 cm. wet.
Run # 8 18.6-21.1	18.6-21.1	RECOVERY: 1.3					GC	19.0		18.2-18.6 No Recovery 18.6-21.1 Gravelly Sand reddish yellow 7.5 TR 6/6, fine to coarse sub angular to sub rounded, lithic, broken to sub angular up to 4 cm lithic gravel, silty, locally

NOTES: General: USCS is modified for this log as follows:

Materials amounts are estimated by % volume instead of % weight.

- (1) Badly broken core, accurate footage measurements not possible.
- (2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101

Revision 0

Date effective: 12/31/98

Page 27 of 28

197

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

PAGE 3 OF 3

Borehole Number: BH96598
 Location - North: 749147 East: 2085867
 Date: 5-17-99 → 5-21-99
 Geologist: LUTHERER
 Drilling Equip.: GEOPROBE DUAL WALL

Surface Elevation: 5976 FT.
 Area: 903 PAD
 Total Depth: 23.8
 Company: TIERRA Project No.: 6E600000
 Sample Type: CONTINUOUS

RMRS LOGGING SUPERVISOR

APPROVAL Mark Ward

DATE 7-7-99

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION
	Run # 8 18.6-21.1	RECOVERY: 1.3					6C	20.0 21.0	X	abundant low plastic clay, saturated to 18.8 - damp 18.8-19.9
	Run # 9 21.1-22.5	UNABLE TO DETERMINE RECOVERY	002	223			6C 5L	22.0	█	21.1-22.5 21.1-22.4 Gravelly Sand A/A wet. locally grading to clayey sand 22.4-22.5 Claystone, BR contact @ 22.4
	Run # 10 20.8-23.8	Recovery 3.5	003 001	224 ISO-22.9 RS 23.1			BR 7/11/99	23.0 23.8	█ █ █	22.5-23.8 Claystone 2.5YR 3/3 dark olive brown, 10YR 7/1 light grey some 10YR 6/8 brownish yellow-oxidized weathered, locally dense + waxy, poorly indurated magnesian, w/ very fine (grey) sand, silty locally grading to silty claystone ID = 23.8
<p>* Hole collapsed to 20.5 Event 005 sampled in interval 20.8-23.8</p>										

NOTES: General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101
 Revision 0
 Date effective: 12/31/98
 Page 27 of 28

198

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

PAGE 1 OF 3

Borehole Number: BH96698
 Location - North: 74912B East: 2085846
 Date: 5-12-99 7-5-99 + 6/8/99
 Geologist: T. LUTHERER
 Drilling Equip.: GEO PROBE DUAL WALL

Surface Elevation: 5977 FT
 Area: 903 PAD
 Total Depth: 23.1 FT
 Company: TERRA Projec: No. GE600000
 Sample Type: CONTINUOUS

RMRS LOGGING SUPERVISOR

APPROVAL Mark Wood

DATE 7-7-99

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FLUORINE AVERAGE	ULTRAFINE AVERAGE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL TEMPERATURE LINE	SAMPLE DESCRIPTION
	Run # 1, 0.0 - 3.8	Recovery: 2.9'						1.0 2.0 3.0		0.0 - 3.8 See borehole log of BH 90898
	Run # 2 3.8 - 6.8	Recovery: 3.9'	001 4.0 003 4.2 002 4.6		RS ISO VDA		SL	3.8 4.0 5.0 6.0		2.9 - 3.8; No Recovery
	Run # 3 6.8 - 9.8	Recovery: 3.7'	001 7.8 003 8.0 002 8.2 002 8.6		RS ISO VDA		SL	6.8 7.0 8.0 9.0		3.8 - 6.8' Clayey Sand, Strong brown to light brown 7.5 to 5/16 to 7.5 to 6/3 prod. very fine, some medium to coarse angular to subrounded, little sand, low plastic clay, silty, with some up to 3mm angular to broken little gravel, damp
			99A6649 001 xxx							6.8 - 9.8' Clayey Sand, with gravel A/A
			99A6649 002 xxx							

NOTES. General: USCS is modified for this log as follows:

Materials amounts are estimated by % volume instead of % weight.

- (1) Badly broken core, accurate footage measurements not possible.
- (2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101

Revision 0

Date effective: 12/31/98

Page 27 of 28

199

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

PAGE 2 OF 3

Borehole Number: BH96698
 Location - North: 749128 East: 2085846
 Date: 5-12-99 → 5-13-99 AND 6-8-99 → 6-9-99
 Geologist: T. LUTHERER
 Drilling Equip.: GEOPROBE DUAL WALL

Surface Elevation: 5977 FT
 Area: 903 PAD
 Total Depth: 23.1 FT
 Company: TERRA Project No.: 6E600000
 Sample Type: CONTINUOUS

RMRS LOGGING SUPERVISOR
 APPROVAL Mark Word

DATE 7-7-99

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL IN FIELD MEASUREMENT	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION
	Run 9.8 - 12.8	Recovery 2.4	99A6649 003 x2x				60/40 CL	10.0 11.0 12.0 12.2 12.8 13.0		9.8-12.8 9.8-10.4 Gravely Sand; very pale brown DTR 8/4, primarily very fine to fine, some medium to coarse, subangular to subrounded. lithic sand, fine to coarse, subangular lithic gravel, with trace to some clay. moist 10.4-12.2 Sand + clay grading to clay w/ some sand + gravel, very pale brown to weather 10.7R 7/3 to 10R 4/2 moist, 12.0-12.2 saturated *
	Run 15.17.8 - 15.8	Recovery 2.9					CL	14.0 15.0 15.8		12.8-15.8 clay with perched water to 10.1' 12.8-14.2 Clay, with some sand, A/A moist. 14.2-15.7 Sandy clay A/A moist. locally grading to clayey sand 15.7-15.8; no recovery Borehole abandoned 5/13/99
	Run 15.8-17.3	Recovery 1.1					SC	17.0 17.3		15.8-17.3 Clay: reddish yellow to very pale brown 7.5 YR 7/6 to 10YR, slight plasticity, trace to some prod. fine to coarse sand, traces of some broken to subangular, up to 4cm lithic gravel, moist
	Run 17.3-18.3	Recovery 1.6	001 17.5 003 17.7 002 99A7530 001 x2x				SC	18.0		17.3-18.3 Clayey Sand: strong brown to very pale brown. 7.5 YR 5/8 to 10YR 7/3 fine to coarse. subangular, lithic sand, low to nonplastic clay, gravel A/A wet.
	Run 18.3-17.8	RECOVERY 1.5					SC	19.0		18.3-19.8 Clayey Sand: A/A wet 18.3-18.9

36296698
 FFSET
 6/8/99
 finished
 6/9/99

200

NOTES: General: USCS is modified for this log as follows:

Materials amounts are estimated by % volume instead of % weight.

- (1) Badly broken core, accurate footage measurements not possible.
- (2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101

Revision 0

Date effective: 12/31/98

Page 27 of 28

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG PAGE 3 OF 3
 Borehole Number: BH96698 Surface Elevation: 5977 FT
 Location - North: 749128 East: 2085846 Area: 903 PAD
 Date: 5-12-99 → 5-13-99 Total Depth: 23.1
 Geologist: T. LUTHERER Company: TIERRA Project No.: GE600000
 Drilling Equip.: GEOPROBE Dual Wall Sample Type: CONTINUOUS

RMRS LOGGING SUPERVISOR APPROVAL Mark Wood DATE 7-7-99

TOP POSITION OF CORE IN BOX	TOP-BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FINAL TIME ATAGE	BEDDING ATAGE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL/ LITHOLOGIC LOGS	SAMPLE DESCRIPTION
Run# 9	19.8-20.6	1.3	001				SC	20.0		19.8-20.6 Clayey Sand A/A moist
Run# 10	20.6-21.6	1.4	002	99A7930009			SC	21.0		20.6-21.6 Clayey Sand A/A moist
Run# 11	21.6-23.1	1.5	001	JAL 6/29/99			SC	22.0		21.6-22.45 Clayey Sand A/A moist
			002					22.45		22.45-23.1 Silty claystone very pale brown 10YR 7/3, dense locally waxy, mod friable, mod conglomeratic, grading to claystone w/ silty sand
			003					23.0		
			004					23.1		Top of Bedrock = 22.45
			005					23.5		TD = 23.1

NOTES: General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS-OPS-PRO.101
 Revision 0
 Date effective: 12/31/98
 Page 27 of 28

201

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

PAGE 1 OF 3

Borehole Number: BH96798
 Location - North: 749108 East: 2085866
 Date: 4/28/99 → 5-12-99
 Geologist: T. LUTHERER
 Drilling Equip.: GEOPROBE DUAL WALL

Surface Elevation: 5977 FT
 Area: 903 PAD
 Total Depth: 20.8 FT
 Company: TERRA Project No. GE600000
 Sample Type: CONTINUOUS

RMRS LOGGING SUPERVISOR

APPROVAL Mark Wood

DATE 7-6-99

TOP POSITION OF CORE IN BOX	TOP POSITION OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ABLE	BEDDING ABLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGICAL TESTS	SAMPLE DESCRIPTION
	Run # 1 0.0-3.8	RECOVERY: 3.8						0.0-3.3 See borehole log for BH90898 or BH91398		
			TALS-25-99					3.3-3.8; No Recovery		
	Run # 2, 3.8-6.8	RECOVERY: 3.3	001 4.0 RS 002 4.2 RS 003 4.4 ISO 002 4.8 VOA				SC	3.8-6.8 Clayey Sand; yellowish red to pale yellow, 5 YR 5/6 to 2.5 Y 3/4 some light red 10R 4/6 near top of interval. fine to coarse, angular to subrounded lithic sand, non to low plastic clay, some to abundant, fine to coarse, subrounded to broken, lithic gravel. damp.		
	Run # 3 6.8-9.8	RECOVERY: 3.4	001 8.2 RS 003 8.4 ISO 002 8.8 VOA				CL	6.8-9.8 Sand-clay; light gray to yellowish brown, 10YR 7/1 to 10YR 5/6, primarily very fine to fine, some medium to coarse subangular to subrounded lithic + quartz sand with traces up to 4cm broken, to angular lithic gravel, non to low plastic clay dry to damp.		

NOTES: General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101
 Revision 0
 Date effective: 12/31/98
 Page 27 of 28

202

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

PAGE 2 OF 3

Borehole Number: BH96798
 Location - North: 74910B East: 2085B66
 Date: 4-28-99 → 5-12-99
 Geologist: T. LUTHERER
 Drilling Equip.: GEOPROBE DUAL WALL

Surface Elevation: 5977 Ft
 Area: 903 PAD
 Total Depth: 20.8 Ft
 Company: TERRA Project No.: 6E600000
 Sample Type: CONTINUOUS

RMRS LOGGING SUPERVISOR
 APPROVAL Mark Wood

DATE 7-6-99

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACATURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION
								10.0		9.8-11.8
	Run # 4.98-11.8	RECOVERY: 2.9'					CL	11.0		Sandy Clay with some gravel A/A - damp-dry
								11.8		
	Run # 5.118-13.8	RECOVERY: 3.1'	001 RS 12.0 002 IS 12.2 002 VOA 12.5				CL	13.0		11.8-13.8 Sandy Clay with some gravel locally grading to clayey sand dry - damp A/A
								13.8		
	Run # 6.13.8-15.8	RECOVERY: 2.1'	99A6650-003-xxx				CL	14.0		13.8-15.8 Sandy Clay, with some gravel dry - damp
								15.0		
	Run # 7.15.8-18.8	RECOVERY: 3.95'	002 16.0 VOA 001 16.4 RS 003 16.6 IS 16.8 IS				CL	16.0		TAL 6-22-99 15.8-18.8 17.5 Clay, locally grading to gravelly clay. Light gray 2.57 7/2 low to no plasticity, trace to some silt, trace to some fine to coarse sand, angular to subangular with up to 4cm angular to subangular also broken little gravel dry-damp
								17.0		
								17.5		
							SL	18.0		17.5-18.8 clayey sand, olive yellow to light gray 2.57 5/16 to 2.57 1/7 A/A dry.
	Run # 8.18.8-19.8	RECOVERY: 1.0'					SC	19.0		18.8-19.8 clayey sand A/A with some gravel, damp
								19.8		
			001 20.0 RS					20.0		

NOTES: General: USCS is modified for this log as follows:

Materials amounts are estimated by % volume instead of % weight.

(1) Badly broken core, accurate footage measurements not possible.

(2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101

Revision 0

Date effective: 12/31/98

Page 27 of 28

203

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

PAGE 1 OF 2

Borehole Number: BH 96898
 Location - North: 749095 East: 2085713
 Date: 4-12-99 → 4-13-99
 Geologist: T. LUTHERER
 Drilling Equip.: GEO PROBE DUAL WALL

Surface Elevation: 5978 FT
 Area: 903 PAD
 Total Depth: 18.8 FT
 Company: TIERRA Project No. GE600000
 Sample Type: CONTINUOUS

RMRS LOGGING SUPERVISOR

APPROVAL Mark Word

DATE 7-6-99

TOP/BOTTOM OF CORE HUB BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FUNCTIONAL ABBREVIATION	DEBITER'S ABBREVIATION	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGICAL TEXT	SAMPLE DESCRIPTION
	Run #1 0.0 - 3.8'	Recovery: 2.4'						1.0 2.0 2.4 3.0		0.0-2.4 See Borehole log for BH 91198 2.4 to 3.8; No Recovery
	Run #2 3.8 - 6.8'	Recovery: 3.8'	001 RS 002 ISO 003 003 VOA 002	TAL	4/21/99		SC	4.0 4.2 4.4 4.7 5.0 6.0		3.8-6.8 Sandy clay/clayey sand; pink to reddish yellow, 5TR 7/4 to 5TR 7/6. fine to coarse subangular sand moderately plastic clay, some up to 4cm angular to subangular lithic gravel, damp.
	Run #3 6.8 - 9.8'	Recovery: 3.5'	001 RS 002 ISO 003 003 VOA 002	TAL	4/21/99		SC	6.8 7.0 8.0 8.2 8.4 8.7 9.0 9.8		6.8-9.8 clayey sand, as above. dry, locally grading to sandy clay.

NOTES: General: USCS is modified for this log as follows:

Materials amounts are estimated by % volume instead of % weight.

- (1) Badly broken core, accurate footage measurements not possible.
- (2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101

Revision 0

Date effective: 12/31/98

Page 27 of 28

205

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

PAGE 2 OF 2

Borehole Number: BH 96898
 Location - North: 249095 East: 2085713
 Date: 4-12-99 → 4/13/99
 Geologist: T. LUTHERER
 Drilling Equip.: GEOPROBE DUAL WALL

Surface Elevation: 5978 FT
 Area: 903 PAD
 Total Depth: 18.8 FT
 Company: TERRA Project No.: 6E600000
 Sample Type: CONTINUOUS

RMRS LOGGING SUPERVISOR

APPROVAL Mark Wood

DATE 7-6-99

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION
	Run # 4 9.8-12.8	Recovery: 3.6'	99A6307-003				XXY	10.0	[Hatched pattern]	9.8-12.8 clayey sand same as above
			001 RS				SC	11.0		
			002 ISO 003					11.9		
			003 VOA 002			TAL 4/21/99		12.1		
4/14/99	TAL Run # 5 12.8-15.8	Recovery 2.0'						12.8	[Hatched pattern]	12.8-15.8 clayey sand same as above.
							SC	14.0		
								15.0		
	Run # 6 15.8-18.8	Recovery 4.0'						15.8	[Hatched pattern]	15.8 to 17.3 clayey sand same as above
			001 RS				SC	16.0		
			002 ISO 003			TAL 4/21/99		17.0		
			003 VOA 002					17.3		17.3-18.8 claystone, strong brown to light gray 75 YR 5/8 to 7.5 YR 4/4 highly oxidized near top of interval. (light weathered, locally waxy, dense, becoming silty claystone in 18. Brownish less weathered and more indurated. 45° beds, plane bedded
			99A6307-004				XXY	18.0		TD = 18.8 slightly weathered (w/18.1) Top of Bedrock = 17.3 FT

NOTES: General: USCS is modified for this log as follows:

Materials amounts are estimated by % volume instead of % weight.

(1) Badly broken core, accurate footage measurements not possible.

(2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101

Revision 0

Date effective: 12/31/98

Page 27 of 28

206

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

PAGE 1 OF 2

Borehole Number: BH96998
 Location - North: 749038 East: 2085711
 Date: 4-20-99 → 4-28-99
 Geologist: T. LUTHERER
 Drilling Equip.: GEO PROBE DUAL WALL

Surface Elevation: 5978 Ft.
 Area: 903 PAD
 Total Depth: 18.8 Ft
 Company: TERRA Project No. GE600000
 Sample Type: CONTINUOUS

RMRS LOGGING SUPERVISOR

APPROVAL Mark Wood

DATE 7-6-99

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL FIELD MEASUREMENT	SAMPLE NUMBER	FUNCTIONAL AREA	DEFINING AREA	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGICAL LINE	SAMPLE DESCRIPTION
								0.0-2.65		See Borehole log for BH 91198
	Run #1, 0.0-3.8	Recovery = 2.65'						1.0		
								2.0		
								3.0		2.65 to 3.8 No Recovery
								3.8		
	Run #2, 3.8-6.8	Recovery = 3.17'	001 4.2 RS 003 4.4 ISO 002 4.8 VOA				SC	4.0		3.8-6.8 Sandy clay; very pale brown to yellowish red very fine to fine, locally medium to coarse, angular to subangular from 5-25-99 low to medium plasticity. Silty with some up to 3.5 angular to subangular lithic gravel. damp locally grading to clayey sand
								5.0		
								6.0		
								6.8		TAL 5-25-99
								7.0		
	Run #3; 6.8-9.8	Recovery = 2.17'	001 8.2 003 8.4 002 8.8				SC	8.0		9.8-9.8 Sandy Clay A/A locally grading to clayey sand, dry
								9.0		
								9.5		9.5-9.8 No Recovery

NOTES: General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101
 Revision 0
 Date effective: 12/31/98
 Page 27 of 28

207

ROCKY FLATS PLANT BOREHOLE LOG

PAGE 2 OF 2

Borehole Number: BH96998
 Location - North: 74903B East: 2085711
 Date: 4-20-99 → 4-28-99
 Geologist: T. LUTHERER
 Drilling Equip.: GEOPROBE DUAL WALL

Surface Elevation: 5978 FT
 Area: 903 PAD
 Total Depth: 18.8 FT
 Company: TIERRA Project No.: 6E00000
 Sample Type: CONTINUOUS

EG&G LOGGING SUPERVISOR

APPROVAL

Mark Wood

DATE

7-6-99

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION
	Run # 4; 9.8 - 12.8	Recovery: 4.0	99A6824-003-XXX				SC	10.0	[Hatched pattern]	9.8-12.8 Sandy Clay; A/A locally clay with some sand. dry
			201 12.0 202 12.2 202 12.4	RS ISO			11.0			
			202 12.7	VOA			12.0			
							12.8			
	Run # 5; 12.8 - 15.8	Recovery: 3.2					SC	13.0	[Hatched pattern]	12.8-15.8 Sandy Clay; A/A locally grading to clay with some sand A/A. dry
							14.0			
							15.0			
	Run # 6; 15.8 - 17.8	Recovery: 3.2	99A6824-004-XXX				SC	15.8	[Hatched pattern]	15.8-17.4 Sandy Clay; A/A locally grading to clay with some sand A/A dry → damp
			201 17.4 202 17.5				17.0			
			202 17.6 202 17.5				17.8			
							17.4			
Run # 7	Recovery: 1.1			45°			BR	18.0	[Hatched pattern]	17.4-17.8 Gravely Sand; very pale brown med fine to very fine, some med to coarse angular, silty with up to 4mm angular & broken lithic gravel with
							18.8			
								18.8		17.8-18.8 Claystone; grading d. (weathered) to 18.2. light gray to brownish yellow; 2.5% w/ - 1/16" massive, stiff, trace to some silt. very friable, with twinned 45° scalloped, non-oxidized, non-striated, dry
								19.0		TO = 18.8 Bedrock = 17.8 FT Top of

NOTES: General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible.

208

Sandy Clay Bluffs dam

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

PAGE 1 OF 2

Borehole Number: BH97098
 Location - North: 748986 East: 2085611
 Date: 3-29-99 → 4-7-99
 Geologist: T. LUTHERER
 Drilling Equip.: GEO PROBE DUAL WALL

Surface Elevation: 5979 FT
 Area: 903 PAD
 Total Depth: 18.8
 Company: TERRA Project No. GE600000
 Sample Type: CONTINUOUS

RMRS LOGGING SUPERVISOR

APPROVAL Mark Ward

DATE 7-7-99

TOP/BOTTOM OF CORE INTERVAL	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL MEASUREMENT	SAMPLE NUMBER	FLUORINE ASHLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGICAL UNIT	SAMPLE DESCRIPTION
								0.0		0.0-3.8 See Borehole Log of BH 91598
								1.0		
								2.0		
								2.7		2.7-3.8: No Recovery
								3.0		
								3.8		3.8-6.8: Sandy Clay, light brown, 6YR 6/4 very fine to medium subangular sand, locally coarse, trace to some up to 4cm angular and broken lithic gravel. locally silty, no plasticity, dry.
			4001 RS					4.0		
			4002 250							
			003 10A			SC		5.0		
			4.7					6.0		
								6.15		6.15-6.8: No Recovery
								6.8		6.8-9.8 Sandy Clay, locally grading to clayey sand. Red to 6YR 6/8 reddish yellow. Red: 5YR 5/8 A/A dry.
								7.0		
			99A6308-002-XXXX					8.0		
			80			SC		9.0		
			001 8.2 RS					9.7		
			002 8.4 150					9.8		9.7-9.8: No Recovery
			003 8.5 10A					10.0		

NOTES: General: USCS is modified for this log as follows:

Materials amounts are estimated by % volume instead of % weight.

- (1) Badly broken core, accurate footage measurements not possible.
- (2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101

Revision 0

Date effective: 12/31/98

Page 27 of 28

209

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

Borehole Number: BH97098
 Location - North: 248986 East: 2085611
 Date: 3-29-99 → 4-7-99
 Geologist: J. LUTHERER
 Drilling Equip.: GEOPROBE DUAL WALL

Surface Elevation: 5979 ft.
 Area: 903 PAD
 Total Depth: 18.8
 Company: TIERRA Project No.: 6E600000
 Sample Type: CONTINUOUS

RMRS LOGGING SUPERVISOR
 APPROVAL Mark Wood

DATE 7-7-99

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION
	Run # 4: 9.8-12.8	Recovery: 3.9'	99A6308-001-xxx 12.0 RS 002 12.4 ISO 003 12.6 VOA				CL	10.0 11.0 11.1 20 12.8		9.8-11.1 Clay some to low plasticity, trace to Sand Sand A/A, trace Silt, trace Gravel A/A; dense, mass spec, damp. 11.1-12.8 Sandy Clay; pink to dark brown 7.5 YR 7/3 to 7.5 YR 3/4, same as @ 3.8-6.8' locally medium plasticity damp. Locally grading to Clayey Sand
	Run # 5: 12.8-15.8	Recovery: 3.5'					CL	13.0 14.0 15.0		12.8-15.8 Sandy Clay A/A locally grading to Clayey Sand. damp A/A
	Run # 6: 15.8-18.8	Recovery: 3.7'	TAL 4/8/99 001 16.0 002 16.2 RS 003 16.5 ISO VOA 17.0 99A6308-004-xxx				CL	15.8 16.0 17.0 18.0		15.8-16.8 Sandy Clay A/A locally grading to Clayey Sand damp A/A 16.8 to 18.8 Broken Clayey Sandstone light gray 5 YR 7/1, some reddish yellow 7.5 YR 8/8 very poorly indurated, slightly weathered predominantly very fine to fine subangular to rounded, quartz, low to non plastic clay, damp.
								19.0		TD = 18.8 FT

NOTES: General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101

Revision 0

Date effective: 12/31/98

Page 27 of 28

210

ROCKY FLATS PLANT BOREHOLE LOG

PAGE 1 OF 3

Borehole Number: BH 97198
 Location - North: 248911 East: 2085611
 Date: 12-14-98 → 1-7-99
 Geologist: T. LUTHERER
 Drilling Equip.: GEOPROBE DUAL WALL

Surface Elevation: 5980 FT
 Area: 907 PAD
 Total Depth: 26.5 FT.
 Company: TIERRA Project No.: GE600000
 Sample Type: CONTINUOUS

EG&G LOGGING SUPERVISOR

APPROVAL Mark Wood

DATE 7-7-99

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE AKA/LE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION
	Run # 1, 0.0 - 3.8'	Recovery: 2.3'						1.0 2.0 3.0 3.8		0.0 - 3.8 See Borehole log for BH 92098 2.3 - 3.8 No Recovery
	* Run # 2, 3.8 - 6.5'	Recovery: 2.8'	004 RS 005 ISO 006 VOA				SC	4.0 4.2 4.4 4.8 5.0		3.8 - 6.5 Clayey Sand; yellowish red to yellow silt 5/8 to 2.57 7/4, fine to coarse, angular to subangular, lentic sand, ^{trace to subangular} similar to subangular, lentic gravel fine to coarse, more to low plastic clay damp
	Run # 3 6.5 - 9.0'	Recovery: 3.4'	001 RS 6.8 002 ISO 7.0 003 VOA 7.3 7.6				SC	7.0 8.0		6.5 - 9.0 Clay w/ some sand grading to clayey sand damp clay: non to low plasticity, fine 7.0 - 7.5 possible graphite/carbon black, soft, powdery
	Run # 4 Rec: 3.2'		99A4102.002 xxy				SC	9.0		9.0 - 11.5 Clayey Sand; damp

NOTES: General: USCS is modified for this log as follows:

Materials amounts are estimated by % volume instead of % weight.

(1) Badly broken core, accurate footage measurements not possible.

* OFFSET STARTED ON 12-15-98
 ORIGINAL BOREHOLE ENCOUNTERED
 REFUSAL AT 12.0' BES

211

ROCKY FLATS PLANT BOREHOLE LOG

Borehole Number: BH97198
 Location - North: 748911 East: 2085611
 Date: 12-14-98 → 1-7-99
 Geologist: T. LUTHERER
 Drilling Equip.: GEOPROBE DUAL WALL

Surface Elevation: 5980 Ft
 Area: 903 PAD
 Total Depth: 26.5 ft
 Company: TIERRA Project No.: 6E600000
 Sample Type: CONTINUOUS

EG&G LOGGING SUPERVISOR

APPROVAL Mark Wood

DATE 7-7-99

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BENDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION
	Run # 4 9.0-11.5	Rec: 3.2'					SC	10.0 11.0		9.0-11.5 Clayey Sand; damp
	Run # 5 11.5-14.0	Rec: 3.8'	7-7-99 006 007 008				6M SC	12.0 12.2 12.4 12.8 13.0		11.5-14.0 11.5-12.0 Sandy Gravel. Sand A/A, very silty, Gravel A/A, dry Gravel: Quartzose 12.0-14.0 Clayey Sand; Brown 7.5TR 4/8 damp
	Run # 6 14.0-16.5	Recovery 3.0	TAL 7-7-99 009 010 011				SC CL	14.0 15.0 15.3 15.4 16.0 16.1		14.0-16.5 Clayey Sand; A/A grading to Clay w/ sand towards bottom of interval. 15.6-16.5 Clay; pinkish gray to reddish yellow 7.5TR 6/2 to 7.5TR 6/6, dense, slightly elastic trace sand, trace gravel dry.
	Run # 7 16.5-19.0	Recovery 3.7					CL SC	17.0 18.0		16.5-17.8 Clay, with sand; A/A damp 17.8-19.0 Clayey Sand; A/A damp
	Run # 8 19.0-21.5 RECOVERY 2.5						SC	19.0		19.0-21.5 Clayey Sand A/A damp

212

NOTES: General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible.

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

PAGE 3 OF 3

Borehole Number: BH97198
 Location - North: 248911 East: 2085411
 Date: 12-14-99 → 1-7-99
 Geologist: L. WITHEPFRER
 Drilling Equip.: GEO PROBE

Surface Elevation: 5980 FT
 Area: 903 PAD
 Total Depth: 26.5 FT
 Company: TIERRA Project No. GE600000
 Sample Type: Continuous

RMRS LOGGING SUPERVISOR

APPROVAL Mark Ward

DATE 7-7-99

TOP-BOTTOM OF CORE IN BOX	TOP-BOTTOM OF INTERVAL	FEET OF CORE INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FLUORINE ANAL	HEAVY METALS ANAL	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOLUBLE SULPHUR (LBS)	SAMPLE DESCRIPTION
	Run #8 19.0 - 21.5	RECOVERY 2.5'	012 013 014 7AL 7-7-99	BS 013 SO 014 VOA 015			2a2 2a4 20.S SL	20.0 21.0		Clayey Sand A/A damp
	Run #9 21.5 - 24.0	RECOVERY 2.2'					SL	22.0 24.0		Clayey Sand A/A moist
	Run #10 24.0 - 26.5	RECOVERY 4.0'	015 7AL 7-7-99	RS 016 SO 017 VOA 018			24.2 24.4 24.8	25.0 26.0		24.0 - 26.5 Sandstone: white to light gray also very pale brown to dark yellow brown. 2.5x N8L, 2.5x N8H, 10xR 7/3 to 10xR 4/6, locally very silty, very fine to fine, subrounded, primarily qtz, locally very clayey, locally grading to silty claystone w/ sand, friable, poorly indurated, oxidized, locally dense. damp Bedrock at 24.0 FT TD = 26.5 FT

NOTES: General: USCS is modified for this log as follows:

Materials amounts are estimated by % volume instead of % weight.

- (1) Badly broken core, accurate footage measurements not possible.
- (2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS OPS-PRO.101

Revision 0

Date effective: 12/31/98

Page 27 of 28

213

ROCKY FLATS PLANT BOREHOLE LOG

PAGE 1 OF 2

Borehole Number: BH97298
 Location - North: 748844 East: 2085930
 Date: 5-26-99 → 6-2-99
 Geologist: T. LUTHERER
 Drilling Equip.: GEO PROBE DUAL WALL

Surface Elevation: 5974 FT
 Area: 903 PAD Lip Area
 Total Depth: 18.5 FT
 Company: TERRA Project No.: 6E00000
 Sample Type: CONTINUOUS

EG&G LOGGING SUPERVISOR

APPROVAL

Mark Wood

DATE 7-6-99

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRAC TURE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL/ LITHOLOGIC LOG	SAMPLE DESCRIPTION
	Run # 1, 0.0 - 3.8	Recovery: 2.65'				SC	0		0.0 - 2.65 Gravelly Sand; very dark gray 5TR 3/1 to .5, remaining interval is reddish brown to dark reddish brown, 5TR 4/3 to 5TR 2.5/2 fine to coarse, subangular to subrounded, lithic, fine to 4.0mm subrounded to broken lithic gravel, some silt, clay, damp.
	Run # 2, 3.8 - 6.8	Recovery: 2.7	62899 TAL 002 4.4 003 4.6 001 4.8			SC	4		3.8 - 6.5 Gravelly Sand; reddish brown to dark reddish brown, A/A
	Run # 3, 6.8 - 8.8	Recovery: 2.7	99A6825 001 xxx			SC	6		
	Run # 4, 8.8 - 11.0	Recovery: 2.2	99A6825 002 xxx RS 8.2 001 ISO 8.4 002 VOA 8.8 003			SC	8		6.5 - 8.8 Clayey Sand, light red, 10TR 6/8 to reddish gray 10TR 6/11, with some light yellowish brown 2.5TR 8/6, fine to coarse, subangular to subrounded, up to 4.4mm angular, lithic gravel, low plasticity, some silt, damp
							9		8.8 - 11.0 Clayey Sand A/A

NOTES: General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible.

214

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

PAGE 2 OF 2

Borehole Number: BH97298
 Location - North: 748844 East: 2085930
 Date: 5-26-99
 Geologist: L. LUTHERER
 Drilling Equip.: GEOPROBE DUAL WALL

Surface Elevation: 5974 FT
 Area: 903 PAD Lip Area
 Total Depth: 18.5 FT
 Company: TIERRA Project No.: 6E600000
 Sample Type: CONTINUOUS

RMRS LOGGING SUPERVISOR
 APPROVAL Mark Wood

DATE 7-6-99

Run # 8, 15.5-16.0

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL MEASUREMENT	SAMPLE NUMBER ANALYSIS	FRACTURE ANGLE	BEDDING ANGLE SAMPLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION
	Run # 4 10.8-11.0	NO RECOVERY REC. 2.2			NP		SC	10.0		
								11.0		USED SOLID POINT TO BREAK THROUGH OBSTRUCTION @ 11.0 - INTERVAL WAS NOT SAMPLED
	(13.6) Run # 6, 11.4-12.8	RECOVERY: 2.1	RS 12.2 ISO 12.4 VOA 12.8	12.2 12.4 12.8	001 002 003		SC	12.0		11.4-13.6 Clayey Sand A/A
								13.0		
								13.6		
	Run # 7, 13.6-15.5	RECOVERY: 1.3					SC	14.0		13.6-15.5 Clayey Sand A/A, wet @ 13.8
								15.0		
								16.0		15.5-16.0; Clayey Sand A/A, damp to wet
	Run # 9 16.0-17.0	REC. 1.1	RS 16.2 ISO 16.4 VOA 17.0	16.2 16.4 17.0	001 002 003		SC	17.0		16.0-17.0; Clayey Sand A/A, damp to wet
								17.0		
	Run # 10 17.0-18.5	Rec. 1.5	VOA 17.3 ISO 17.9 RS 18.1 18.3	17.3 17.9 18.1 18.3	002 003 001		SC	17.8		17.0-17.8 Clayey Sand A/A; wet
								18.0		17.8-18.5 Slightly claystone slightly weathered mostly light gray 2.5% R 17/1, some brownish yellow. 10% R 6/6, very poorly indurated locally dense, massive, stiff - damp. Top of Bedrock = 17.8 FT TD = 18.5 FT

NOTES: General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101
 Revision 0
 Date effective: 12/31/98
 Page 27 of 28

219

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

PAGE 1 OF 1

Borehole Number: BH97398
 Location - North: 748827 East: 2086090
 Date: 6-14-99
 Geologist: T. LUTHERER
 Drilling Equip.: GEO PROBE DUAL WALL

Surface Elevation: 5956 FT
 Area: 903 PAD Lip Area
 Total Depth: 4.0
 Company: TIERRA Project No. GE600000
 Sample Type: CONTINUOUS

RMRS LOGGING SUPERVISOR
 APPROVAL Mark Wood

DATE 7-2-99

TOP/BOTTOM OF CORE (FEET)	TOP/BOTTOM OF INTERVAL (FEET)	FEET OF CORE INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	ANALYTIC NO.	BOTTOM DENOMINATOR	CLASSIFICATION	USCS SYMBOL	DEPTH (FEET)	SOIL/ LITHOLOGICAL TEXT	SAMPLE DESCRIPTION
Box 1 of 1 0.0-3.4'	Run # 1 0.0-4.0'	Recovery: 3.4'	001	RS ISO 001	001	ML	ML	0.0	[Diagrammatic representation of soil layers with patterns: horizontal lines for ML, diagonal lines for CL, and a cross-hatch for GC]	0.0-2.0 Clayey Silt, very dark gray
			002	RS ISO 001	002			2.5-7 1/3, dense, moderate plasticity		
			003	RS ISO 001	002			traces fine to coarse, angular to sub-angular, lithic sand, traces fine to coarse, broken and angular lithic gravel		
			004	RS ISO 001	002			with organic matter, wet → moist.		
						GC		2.0	2.0-3.4 Clayey Sand, light reddish brown STR 6/3, components as above.	
								3.0		
								4.0		
								5.0		
			99A 6155-001	001 (002)				6.0		
				002 (002)				7.0		
				003 (002)				8.0		
				004 (002)				9.0		

TD: 4.0

NOTES. General: USCS is modified for this log as follows:

Materials amounts are estimated by % volume instead of % weight.

- (1) Badly broken core, accurate footage measurements not possible.
- (2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101

Revision 0

Date effective: 12/31/98

Page 27 of 28

216

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

PAGE 1 OF 1

Borehole Number: BH 977498
 Location - North: 248770 East: 2086182
 Date: 6-14-99
 Geologist: T. LUTHERER
 Drilling Equip.: GEOPROBE DUAL WALL

Surface Elevation: 5947 Ft.
 Area: 903 PAD Lip Area
 Total Depth: 4.0
 Company: TIERRA Project No. GE600000
 Sample Type: CONTINUOUS

RMRS LOGGING SUPERVISOR

APPROVAL _____

DATE _____

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL MEASUREMENT	SAMPLE NUMBER	FUNCTIONAL ALIAS	BLENDED ALIAS	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH (FEET)	SOIL/ROCK LOG	SAMPLE DESCRIPTION
Box 1 of 1, 0.0-1.8'	Run # 1, 0.0-4.0	Recovery: 1.8'	001	RS	RS		ML	0.45		0.0-1.3 Clayey Silt; dark reddish brown 57R 4/3; dense, mod. plasticity, traces fine to coarse, angular to subangular lithic sand; traces fine to coarse, broken and angular lithic gravel; with organic matter, wet to moist. 1.3-1.8 Layered Sand reddish brown; 57R 5/3; compacts as above; damp.
			002	ISO	ISO		CL	0.9		
			003	RS	RS			1.0		
			004	ISO	ISO		SC	1.35		
							1.8			
							2.0			
							3.0			
							4.0			
										TD = 4.0
			99A 6156	RS	RS			5.0		
				001	001					
				002	002					
				003	003					
				004	004			6.0		
								7.0		
								8.0		
								9.0		

NOTES: General: USCS is modified for this log as follows:
 Materials amounts are estimated by % volume instead of % weight.
 (1) Badly broken core, accurate footage measurements not possible.
 (2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS-OPS-PRO.101
 Revision 0
 Date effective: 12/31/98
 Page 27 of 28

217

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

PAGE 1 OF 1

Borehole Number: BH97598
 Location - North: 748845 East: 2086247
 Date: 6-14-99
 Geologist: T. LUTHERER
 Drilling Equip.: GEO PROBE DUAL WALL

Surface Elevation: 5954 Ft.
 Area: 903 PAD Lip Area
 Total Depth: 4.0
 Company: TIERRA Project No. GE600000
 Sample Type: CONTINUOUS

RMRS LOGGING SUPERVISOR

APPROVAL Mark Wood

DATE 7-2-99

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	FRACTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGICAL LOG	SAMPLE DESCRIPTION
Box 1 of 1, 0.0-2.7'	Run #1, 0.0-4.0'	Recovery: 2.7'	001	RS ISO	001					0.0-2.7 Clayey Silt: reddish black 10R 2.5/1, dense, mod. plasticity, textures fine to coarse, angular to sub- angular lentic sand, textures fine to coarse, broken and angular lentic gravel with organic matter lump to mass.
			002	RS ISO	002		ML	1.0		
			003	RS ISO	001		CL			
			004	RS ISO	002			2.0		
			005	ISO D.P.	001	DUPLICATE				
			006	RS ISO	001 002	AINSTATES				
			37	RS 001	001	21 (002)		5.0		
				002	001	(002)				
				003	001	(002)		6.0		
				004	001	(002)				
				005	001			7.0		
				006	001	(002)				
								8.0		
								9.0		

NOTES: General: USCS is modified for this log as follows:

Materials amounts are estimated by % volume instead of % weight.

(1) Badly broken core, accurate footage measurements not possible.

(2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101

Revision 0

Date effective: 12/31/98

Page 27 of 28

218

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

PAGE 1 OF 3

Borehole Number: BH 97698
 Location - North: 249135 East: 2085880
 Date: 6-18-99 → 6-23-99
 Geologist: T. LUTHERER
 Drilling Equip.: GEOPROBE DUAL WALL

Surface Elevation: 5976 FT
 Area: 903 PAD
 Total Depth: 443 PAD 6-29-99 22.8
 Company: TIERRA Project No. GE60000
 Sample Type: CONTINUOUS

RMRS LOGGING SUPERVISOR

APPROVAL

Mark Wood

DATE 7-6-99

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE INTERVAL (FIELD MEASUREMENT)	EVENT NUMBER	FRACTURE ANGLE	BLOOMING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGICAL TEXT	SAMPLE DESCRIPTION
	Run #1: 0.0-3.8'	Recovery: 2.5'						0.0		0.0-3.8 See Borehole log of BH 90998
	Run #2: 3.8-6.8'	Recovery: 3.9'	7AL 6-29-99					3.8		
			001 4.0 RS 001					4.0		
			001 4.2 IS 003							
			006 4.4 IS 003 DUP							
			4.6 VOA 002							
			001 5.2				SC	5.0		
			006 5.8							
			99A 8275 001 xx					6.0		
			00 break							
	Run #3: 6.8-9.8'	Recovery: 3.5'						7.0		
			BOTTLE NO.							
			001 RS 8.2					8.0		
			003 VOA							
			002 ISO 8.6					9.0		
			8.8							
			99A 827 002 xx				SC			
								10.0		

NOTES: General: USCS is modified for this log as follows:

Materials amounts are estimated by % volume instead of % weight.

- (1) Badly broken core, accurate footage measurements not possible.
- (2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101

Revision 0

Date effective: 12/31/98

Page 27 of 28

219

ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE BOREHOLE LOG

Borehole Number: BH97698
 Location - North: 749135 East: 2085880
 Date: 6-18-99 → 6-23-99
 Geologist: T. LUTHERER
 Drilling Equip.: GEOPROBE TUAL WALL

Surface Elevation: 5976 ft
 Area: 903 PAD
 Total Depth: 22.8
 Company: TERRA Project No.: 6E600000
 Sample Type: CONTINUOUS

RMRS LOGGING SUPERVISOR
 APPROVAL Mark Wood

DATE 7-6-99

TOP/BOTTOM OF CORE IN BOX	TOP/BOTTOM OF INTERVAL	FEET OF CORE IN INTERVAL (FIELD MEASUREMENT)	SAMPLE NUMBER	STRUCTURE ANGLE	BEDDING ANGLE	GRAIN SIZE DISTRIBUTION	USCS SYMBOL	DEPTH IN FEET	SOIL LITHOLOGIC LOG	SAMPLE DESCRIPTION
	Run # 4 9.8 - 12.8	Recovery: 3.3	001 11.0 RS 002 11.2 VOA 003 11.8 ISO				SC	10.0 11.0		9.8-11.9 Sandy Clay, A/A w/ locally abundant gravel, at times locally grading to sandy gravel A/A damp
	Run # 5 12.8 - 14.8	Recovery 3.3	001 13.2 RS 002 13.4 VOA 003 13.9 ISO 14.1				SC	13.0 14.0		12.8-14.8 Clayey Sand, pale yellow to olive yellow 2.57 7/4 to 2.57 6/8 fine to coarse sand, subangular to rounded lithic and calcic grains, trace trigonal lithic gravel, low plasticity, locally silty damp
	Run # 6 14.8 - 16.8	Recovery 2.65	001 15.9 003 16.1 002 16.3 16.7				SC	15.0 16.0		14.8-16.8 Clayey Sand; A/A, locally with abundant gravel, damp w/ @
	Run # 7 16.8 - 18.8	Recovery 3.25	001 17.8 003 18.0 002 18.2 18.8				SC	17.0 18.0		16.8-18.8 Clayey Sand with some to abundant gravel A/A brownish yellow 10YR 6/6 to yellowish brown 10YR 5/6 and dark yellowish brown. damp
	Run # 8 Recovery 2.4		001 19.2 002 19.4 003 19.8				SC	18.8 19.0		18.8-20.8 Clayey Sand A/A

220

NOTES: General: USCS is modified for this log as follows:

Materials amounts are estimated by % volume instead of % weight.

(1) Badly broken core, accurate footage measurements not possible.

(2) Core breaks cannot be matched, accurate footage measurements not possible.

Procedure No. RMRS/OPS-PRO.101

Revision 0

Date effective: 12/31/98

Page 27 of 28

Characterization Report for the
903 Drum Storage Area,
903 Lip Area, and Americium Zone

Document Number: RF/RMRS-99-427.UN
Revision: 0
Date: September 21, 1999
Page: B-1

Appendix B

Precision (DER) Calculations

222

Surface Soil Characterization Precision Results
Gamma Spectroscopy - Americium-241

HPGe Measurement Location	Sample Type	Real Sample No.	Radius (m)	QA Sample No.	Real Sample Am241 (pCi/g)	Real Sample 2s Counting Error	QA Sample Am241 (pCi/g)	QA Sample 2s Counting Error	DER
30	Real	99A5936-002.001	0	99A5936-003.001	2.37	.332	1.71	.276	1.528695
	Real	99A5936-004.001	1	99A5936-005.001	4.66	.366	4.46	.374	0.382198
	Real	99A5936-006.001	3	99A5936-007.001	3.57	.426	3.2	.313	0.699928

HPGe Measurement Location	Sample Type	Real Sample No.	Radius (m)	QA Sample No.	Real Sample Am241 (pCi/g)	Real Sample 2s Counting Error	QA Sample Am241 (pCi/g)	QA Sample 2s Counting Error	DER
460	Real	98A3372-002.002	0	98A3372-002.007	62.4	6.82	86.6	14.2	1.53623
	Real	98A3372-002.004	1	98A3372-002.008	183.	19.9	91.3	9.7	4.142161
	Real	98A3372-002.006	3	98A3372-002.009	95.	14.3	106.	12.9	0.571169

HPGe Measurement Location	Sample Type	Real Sample No.	Radius (m)	QA Sample No.	Real Sample Am241 (pCi/g)	Real Sample 2s Counting Error	QA Sample Am241 (pCi/g)	QA Sample 2s Counting Error	DER
669	Real	99A4878-003.001	0	99A4878-004.001	40.8	2.41	75.9	3.35	8.505349
	Real	99A4878-005.001	1	99A4878-006.001	55.1	7.35	66.7	3.15	1.450623
	Real	99A4878-007.001	3	99A4878-007.001	60.4	3.93	51.	3.93	1.691299

Surface Soil Characterization Program
Precision Results
Alpha Spectroscopy

HPGe MEASUREMENT LOCATION	SAMPLE TYPE	SAMPLE NUMBER	ANALYTE	RESULT	UNIT CODE	RC SIGMA ERROR	DER
30	Duplicate	99A5936-005.001	Am-241	4.4612	PCI/G	0.3741	0.39
30	Real	99A5936-004.001	Am-241	4.6643	PCI/G	0.3659	
30	Duplicate	99A5936-007.001	Am-241	3.1966	PCI/G	0.3134	0.71
30	Real	99A5936-006.001	Am-241	3.574	PCI/G	0.4259	
30	Duplicate	99A5936-003.001	Am-241	1.7105	PCI/G	0.2759	1.52
30	Real	99A5936-002.001	Am-241	2.3659	PCI/G	0.332	
460	Duplicate	99A3372-002.008	Am-241	172.9098	PCI/G	5.4249	2.69
460	Real	99A3372-002.004	Am-241	151.9866	PCI/G	5.5795	
460	Duplicate	99A3372-002.009	Am-241	145.2979	PCI/G	4.8513	0.99
460	Real	99A3372-002.006	Am-241	137.9899	PCI/G	5.5697	
460	Duplicate	99A3372-002.007	Am-241	175.1638	PCI/G	5.6641	12.16
460	Real	99A3372-002.002	Am-241	90.1227	PCI/G	4.0973	
669	Duplicate	99A4878-006.001	Am-241	66.7147	PCI/G	3.1482	2.74
669	Real	99A4878-005.001	Am-241	55.0517	PCI/G	2.8592	
669	Duplicate	99A4878-008.001	Am-241	51.0332	PCI/G	2.5161	2.35
669	Real	99A4878-007.001	Am-241	60.4235	PCI/G	3.1018	
669	Duplicate	99A4878-004.001	Am-241	75.9211	PCI/G	3.3548	8.49
669	Real	99A4878-003.001	Am-241	40.8194	PCI/G	2.413	
30	Duplicate	99A5936-005.001	Pu-239/240	23.1372	PCI/G	0.8293	1.19
30	Real	99A5936-004.001	Pu-239/240	21.7524	PCI/G	0.8192	
30	Duplicate	99A5936-007.001	Pu-239/240	15.5486	PCI/G	1.2054	5.12
30	Real	99A5936-006.001	Pu-239/240	23.8498	PCI/G	1.0835	
30	Duplicate	99A5936-003.001	Pu-239/240	8.4155	PCI/G	0.7811	4.31
30	Real	99A5936-002.001	Pu-239/240	12.8235	PCI/G	0.6603	
460	Duplicate	99A3372-002.008	Pu-239/240	684.6637	PCI/G	12.2161	36.09
460	Real	99A3372-002.004	Pu-239/240	1481.6998	PCI/G	18.4008	
460	Duplicate	99A3372-002.009	Pu-239/240	841.5062	PCI/G	15.1618	8.94
460	Real	99A3372-002.006	Pu-239/240	675.0613	PCI/G	10.7885	
460	Duplicate	99A3372-002.007	Pu-239/240	782.3574	PCI/G	13.1426	13.22
460	Real	99A3372-002.002	Pu-239/240	554.3172	PCI/G	11.1808	
669	Duplicate	99A4878-006.001	Pu-239/240	435.6164	PCI/G	8.6241	10.35
669	Real	99A4878-005.001	Pu-239/240	318.3239	PCI/G	7.3486	
669	Duplicate	99A4878-008.001	Pu-239/240	297.2583	PCI/G	7.2987	7.13
669	Real	99A4878-007.001	Pu-239/240	376.36	PCI/G	8.3559	
669	Duplicate	99A4878-004.001	Pu-239/240	525.3358	PCI/G	9.415	22.44
669	Real	99A4878-003.001	Pu-239/240	265.908	PCI/G	6.7098	
30	Duplicate	99A5936-005.001	U-233,-234	0.7917	PCI/G J	0.1928	0.00
30	Real	99A5936-004.001	U-233,-234	0.7905	PCI/G J	0.184	
30	Duplicate	99A5936-007.001	U-233,-234	0.6254	PCI/G J	0.1677	0.26
30	Real	99A5936-006.001	U-233,-234	0.5568	PCI/G J	0.1997	
30	Duplicate	99A5936-003.001	U-233,-234	2.3662	PCI/G	0.6882	2.13
30	Real	99A5936-002.001	U-233,-234	0.8336	PCI/G J	0.2129	
460	Duplicate	99A3372-002.008	U-233,-234	1.0197	PCI/G	.1613	0.70
460	Real	99A3372-002.004	U-233,-234	.8624	PCI/G J	.1556	
460	Duplicate	99A3372-002.009	U-233,-234	1.184	PCI/G	.2339	0.16
460	Real	99A3372-002.006	U-233,-234	1.1367	PCI/G	.1879	

224

Surface Soil Characterization Program
Precision Results
Alpha Spectroscopy

HPGe MEASUREMENT LOCATION	SAMPLE TYPE	SAMPLE NUMBER	ANALYTE	RESULT	UNIT CODE	RC_SIGMA @ ERROR	DER
460	Duplicate	99A3372-002.007	U-233,-234	.8937	PCI/G	J .1574	0.95
460	Real	99A3372-002.002	U-233,-234	1.1157	PCI/G	.1721	
669	Duplicate	99A4878-006.001	U-233,-234	0.842	PCI/G	J 0.3213	0.52
669	Real	99A4878-005.001	U-233,-234	0.6224	PCI/G	J 0.2696	
669	Duplicate	99A4878-008.001	U-233,-234	0.8276	PCI/G	J 0.3128	0.25
669	Real	99A4878-007.001	U-233,-234	0.9393	PCI/G	J 0.326	
669	Duplicate	99A4878-004.001	U-233,-234	0.6928	PCI/G	J 0.4082	0.12
669	Real	99A4878-003.001	U-233,-234	0.7556	PCI/G	J 0.3191	
30	Duplicate	99A5936-005.001	U-235	0.08	PCI/G	J 0.0614	0.52
30	Real	99A5936-004.001	U-235	0.0413	PCI/G	U 0.0433	
30	Duplicate	99A5936-007.001	U-235	0.0434	PCI/G	U 0.0454	0.66
30	Real	99A5936-006.001	U-235	0.1111	PCI/G	U 0.0926	
30	Duplicate	99A5936-003.001	U-235	0.1025	PCI/G	U 0.1417	0.07
30	Real	99A5936-002.001	U-235	0.0907	PCI/G	J 0.0725	
460	Duplicate	99A3372-002.008	U-235	.0883	PCI/G	J .0489	0.23
460	Real	99A3372-002.004	U-235	.0729	PCI/G	J .045	
460	Duplicate	99A3372-002.009	U-235	.0837	PCI/G	J .0618	0.36
460	Real	99A3372-002.006	U-235	.0566	PCI/G	J .0418	
460	Duplicate	99A3372-002.007	U-235	.0986	PCI/G	J .0525	0.05
460	Real	99A3372-002.002	U-235	.0948	PCI/G	J .0505	
669	Duplicate	99A4878-006.001	U-235	0.0524	PCI/G	U 0.0835	0.06
669	Real	99A4878-005.001	U-235	0.0457	PCI/G	U 0.0854	
669	Duplicate	99A4878-008.001	U-235	0.065	PCI/G	U 0.0993	0.84
669	Real	99A4878-007.001	U-235	-0.0205	PCI/G	U 0.0231	
669	Duplicate	99A4878-004.001	U-235	-0.0382	PCI/G	U 0.0431	0.87
669	Real	99A4878-003.001	U-235	0.0463	PCI/G	U 0.0865	
30	Duplicate	99A5936-005.001	U-238	0.9948	PCI/G	J 0.2135	0.53
30	Real	99A5936-004.001	U-238	1.1579	PCI/G	0.2215	
30	Duplicate	99A5936-007.001	U-238	1.0056	PCI/G	0.212	0.05
30	Real	99A5936-006.001	U-238	1.024	PCI/G	0.2661	
30	Duplicate	99A5936-003.001	U-238	2.8263	PCI/G	0.751	2.57
30	Real	99A5936-002.001	U-238	0.823	PCI/G	J 0.211	
460	Duplicate	99A3372-002.008	U-238	2.5451	PCI/G	.2547	1.71
460	Real	99A3372-002.004	U-238	1.9538	PCI/G	.2339	
460	Duplicate	99A3372-002.009	U-238	2.442	PCI/G	.3347	0.50
460	Real	99A3372-002.006	U-238	2.661	PCI/G	.2875	
460	Duplicate	99A3372-002.007	U-238	2.2426	PCI/G	.2482	0.61
460	Real	99A3372-002.002	U-238	2.4613	PCI/G	.2549	
669	Duplicate	99A4878-006.001	U-238	1.4272	PCI/G	0.4037	0.78
669	Real	99A4878-005.001	U-238	1.0122	PCI/G	0.3429	
669	Duplicate	99A4878-008.001	U-238	1.3592	PCI/G	0.3867	0.60
669	Real	99A4878-007.001	U-238	1.0519	PCI/G	0.3389	
669	Duplicate	99A4878-004.001	U-238	1.1399	PCI/G	0.4882	0.02
669	Real	99A4878-003.001	U-238	1.1541	PCI/G	0.3669	

225

**Subsurface Soil Characterization Program
Precision Results - Americium-241**

Borehole	Sample Type	RIN/Event/Bottle	Analyte	Result	Unit	Q	Detect Limit	Sigma Error	DER
90198	Replicate	98A1496-001.014	AM-241	3.93	PCI/G		0.024	0.51	6.803
	Real	98A1496-001.006	AM-241	87	PCI/G		1.09	12.2	
90698	Replicate	98A1055-003.036	AM-241	590	PCI/G		0.224	69.1	5.415
	Real	98A1055-003.033	AM-241	1880	PCI/G		5.13	228	
90798	Replicate	98A1055-002.020	AM-241	0.043	PCI/G	U	0.086	0.044	0.163
	Real	98A1055-002.019	AM-241	0.053	PCI/G	J	0.027	0.043	
91298	Replicate	98A1055-001.011	AM-241	0.32	PCI/G		0.038	0.085	0.817
	Real	98A1055-001.010	AM-241	0.229	PCI/G	J	0.040	0.072	
91598	Replicate	98A1296-001.010	AM-241	13010	PCI/G		94.6	1604	4.548
	Real	98A1296-001.002	AM-241	31670	PCI/G		51.5	3776	
91698	Replicate	98A2017-001.012	AM-241	4030	PCI/G		25.6	546	0.132
	Real	98A2017-001.002	AM-241	3930	PCI/G		53.2	526	
92498	Replicate	98A1502-001.010	AM-241	16.7	PCI/G		0.904	3.38	5.443
	Real	98A1502-001.002	AM-241	59.5	PCI/G		0.118	7.1	
92698	Replicate	98A2022-001.010	AM-241	0.311	PCI/G		0.099	0.133	0.182
	Real	98A2022-001.004	AM-241	0.345	PCI/G		0.059	0.131	
93098	Replicate	99A4353-005.001	AM-241	0.181	PCI/G	J	0.115	0.120	0.819
	Real	99A4353-004.002	AM-241	0.361	PCI/G		0.146	0.184	
93698	Replicate	98A1289-001.010	AM-241	76.8	PCI/G		19.8	23.8	2.805
	Real	98A1289-001.004	AM-241	9.95	PCI/G		0.084	1.31	
94298	Replicate	99A4849-005.002	AM-241	0.26	PCI/G	J	0.123	0.147	1.456
	Real	99A4849-004.002	AM-241	0.026	PCI/G	U	0.107	0.065	
94598	Replicate	98A5489-001.009	AM-241	0.026	PCI/G	U	0.074	0.048	0.090
	Real	98A5489-001.008	AM-241	0.032	PCI/G	U	0.066	0.046	
95298	Replicate	98A5494-001.009	AM-241	0.225	PCI/G	J	0.057	0.105	0.084
	Real	98A5494-001.008	AM-241	0.238	PCI/G	J	0.083	0.114	
95798	Replicate	99A5832-005.002	AM-241	0.031	PCI/G	U	0.123	0.075	0.777
	Real	99A5832-004.002	AM-241	0.13	PCI/G	J	0.113	0.103	
95998	Replicate	99A7799-009.003	AM-241	0.035	PCI/G	U	0.048	0.050	0.317
	Real	99A7799-006.003	AM-241	0.016	PCI/G	U	0.045	0.033	
96298	Replicate	99A3210-004.009	AM-241	0.018	PCI/G	U	0.200	0.110	3.144
	Real	99A3210-004.008	AM-241	1.8	PCI/G		0.143	0.556	
96798	Replicate	99A6650-006.003	AM-241	0	PCI/G	U	0.054	0.000	0.841
	Real	99A6650-005.003	AM-241	0.053	PCI/G	J	0.048	0.063	
97598	Replicate	99A7937-005.001	AM-241	0.301	PCI/G	B	0.041	0.152	0.558
	Real	99A7937-004.002	AM-241	0.194	PCI/G	J	0.041	0.117	
97698	Replicate	99A8275-006.003	AM-241	0	PCI/G	U	0.052	0.000	0.268
	Real	99A8275-001.003	AM-241	0.011	PCI/G	U	0.090	0.041	

226

**Subsurface Soil Characterization Program
Precision Results - Plutonium-239/240**

Borehole	Sample Type	IRIN/Event/Bottle	Analyte	Result	Unit	Q	Det. Limit	Sigma Error	DER
90198	Replicate	98A1496-001.014	PU-239	20.6	PCI/G		0.016	2.41	6.951
90198	Real	98A1496-001.006	PU-239	711	PCI/G		6.49	99.3	
90698	Replicate	98A1055-003.036	PU-239	7320	PCI/G		3.04	858	2.211
90698	Real	98A1055-003.033	PU-239	10670	PCI/G		1.91	1249	
90798	Replicate	98A1055-002.020	PU-239	0.039	PCI/G	U	0.040	0.032	0.747
90798	Real	98A1055-002.019	PU-239	0.01	PCI/G	U	0.051	0.022	
91298	Replicate	98A1055-001.011	PU-239	1.5	PCI/G		0.034	0.263	0.028
91298	Real	98A1055-001.010	PU-239	1.49	PCI/G		0.032	0.247	
91598	Replicate	98A1296-001.010	PU-239	70030	PCI/G		37	8213	4.194
91598	Real	98A1296-001.002	PU-239	152260	PCI/G		17.8	17801	
91698	Replicate	98A2017-001.012	PU-239	373	PCI/G		42.5	95.9	0.112
91698	Real	98A2017-001.002	PU-239	389	PCI/G		50.4	106	
92498	Replicate	98A1502-001.010	PU-239	94.8	PCI/G		0.582	12.3	6.547
92498	Real	98A1502-001.002	PU-239	474	PCI/G		0.583	56.6	
92698	Replicate	98A2022-001.010	PU-239	0.464	PCI/G		0.061	0.156	2.378
92698	Real	98A2022-001.004	PU-239	1.22	PCI/G		0.061	0.277	
93098	Replicate	99A4353-005.001	PU-239/240	0.812	PCI/G		0.083	0.291	2.121
93098	Real	99A4353-004.002	PU-239/240	2.33	PCI/G	B	0.037	0.654	
93698	Replicate	98A1289-001.010	PU-239	495	PCI/G		15.3	80.7	5.506
93698	Real	98A1289-001.004	PU-239	49.5	PCI/G		0.049	5.91	
94298	Replicate	99A4849-005.002	PU-239/240	7.35	PCI/G		0.034	1.82	3.760
94298	Real	99A4849-004.002	PU-239/240	0.471	PCI/G		0.033	0.186	
94598	Replicate	98A5489-001.009	PU-239/240	0.08	PCI/G	J	0.020	0.052	0.013
94598	Real	98A5489-001.008	PU-239/240	0.081	PCI/G	J	0.050	0.060	
95298	Replicate	98A5494-001.009	PU-239/240	0.982	PCI/G		0.037	0.291	0.690
95298	Real	98A5494-001.008	PU-239/240	1.31	PCI/G		0.022	0.376	
95798	Replicate	99A5832-005.002	PU-239/240	0.531	PCI/G		0.060	0.205	0.817
95798	Real	99A5832-004.002	PU-239/240	0.816	PCI/G		0.082	0.282	
95998	Replicate	99A7799-009.003	PU-239/240	0	PCI/G	U	0.041	0.000	0.826
95998	Real	99A7799-006.003	PU-239/240	-0.019	PCI/G	U	0.102	0.023	
96298	Replicate	99A3210-004.009	PU-239/240	0.028	PCI/G	U	0.037	0.040	3.245
96298	Real	99A3210-004.008	PU-239/240	1.63	PCI/G		0.070	0.492	
96798	Replicate	99A6650-006.003	PU-239/240	-0.007	PCI/G	U	0.079	0.014	0.500
96798	Real	99A6650-005.003	PU-239/240	0	PCI/G	U	0.052	0.000	
97598	Replicate	99A7937-005.001	PU-239/240	2.88	PCI/G		0.048	0.833	2.187
97598	Real	99A7937-004.002	PU-239/240	0.913	PCI/G		0.085	0.339	
97698	Replicate	99A8275-006.003	PU-239/240	0.037	PCI/G	U	0.049	0.052	0.261
97698	Real	99A8275-001.003	PU-239/240	0.06	PCI/G	J	0.054	0.071	

Subsurface Soil Characterization Program
Precision Results - Uranium-233/234

Borehole	Sample Type	IRIN/Event/Bottle	Analyte	Result	Unit	Q	Det Limit	Sigma	Error	DER
93098	Replicate	99A4353-005.001	U-233/234	0.575	PCI/G	J	0.035	0.212		0.573
93098	Real	99A4353-004.002	U-233/234	0.773	PCI/G	J	0.040	0.273		
94298	Replicate	99A4849-005.002	U-233/234	0.549	PCI/G	J	0.088	0.209		0.428
94298	Real	99A4849-004.002	U-233/234	0.686	PCI/G	J	0.074	0.242		
94598	Replicate	98A5489-001.009	U-233/234	0.735	PCI/G	J	0.017	0.211		0.214
94598	Real	98A5489-001.008	U-233/234	0.802	PCI/G	J	0.019	0.232		
95298	Replicate	98A5494-001.009	U-233/234	0.652	PCI/G	J	0.033	0.196		0.346
95298	Real	98A5494-001.008	U-233/234	0.562	PCI/G	J	0.017	0.171		
95798	Replicate	99A5832-005.002	U-233/234	0.783	PCI/G	J	0.095	0.272		0.363
95798	Real	99A5832-004.002	U-233/234	0.654	PCI/G	J	0.068	0.228		
95998	Replicate	99A7799-009.003	U-233/234	0.769	PCI/G	J	0.046	0.285		0.880
95998	Real	99A7799-006.003	U-233/234	0.455	PCI/G	J	0.054	0.215		
96298	Replicate	99A3210-004.009	U-233/234	0.4	PCI/G	J	0.076	0.172		0.869
96298	Real	99A3210-004.008	U-233/234	0.656	PCI/G	J	0.038	0.239		
96798	Replicate	99A6650-006.003	U-233/234	0.591	PCI/G	J	0.039	0.226		0.041
96798	Real	99A6650-005.003	U-233/234	0.578	PCI/G	J	0.040	0.225		
97598	Replicate	99A7937-005.001	U-233/234	0.95	PCI/G	J	0.075	0.323		0.061
97598	Real	99A7937-004.002	U-233/234	0.978	PCI/G	J	0.042	0.327		
97698	Replicate	99A8275-006.003	U-233/234	0.407	PCI/G	J	0.050	0.196		0.382
97698	Real	99A8275-001.003	U-233/234	0.519	PCI/G	J	0.079	0.218		
90198	Replicate	98A1496-001.014	U-234	0.756	PCI/G	J	0.024	0.128		1.255
90198	Real	98A1496-001.006	U-234	1.58	PCI/G		0.479	0.644		
90698	Replicate	98A1055-003.036	U-234	1.83	PCI/G	U	2.72	1.75		1.067
90698	Real	98A1055-003.033	U-234	5.14	PCI/G		2.68	2.56		
90798	Replicate	98A1055-002.020	U-234	0.82	PCI/G	J	0.024	0.118		0.231
90798	Real	98A1055-002.019	U-234	0.859	PCI/G	J	0.015	0.121		
91298	Replicate	98A1055-001.011	U-234	0.368	PCI/G	J	0.014	0.062		1.038
91298	Real	98A1055-001.010	U-234	0.284	PCI/G	J	0.012	0.052		
91598	Replicate	98A1296-001.010	U-234	31.5	PCI/G		23.6	20.7		0.415
91598	Real	98A1296-001.002	U-234	19.8	PCI/G	U	30.6	19.1		
91698	Replicate	98A2017-001.012	U-234	14.2	PCI/G	U	27.6	16.7		0.568
91698	Real	98A2017-001.002	U-234	1.83	PCI/G	U	30.1	14.0		
92498	Replicate	98A1502-001.010	U-234	1.47	PCI/G		0.748	0.746		0.928
92498	Real	98A1502-001.002	U-234	0.758	PCI/G	J	0.043	0.181		
92698	Replicate	98A2022-001.010	U-234	0.477	PCI/G	J	0.057	0.145		0.180
92698	Real	98A2022-001.004	U-234	0.442	PCI/G	J	0.059	0.130		
93698	Replicate	98A1289-001.010	U-234	0.883	PCI/G	J	0.037	0.156		1.867
93698	Real	98A1289-001.004	U-234	0.511	PCI/G	J	0.057	0.124		

228

Subsurface Soil Characterization Program
Precision Results - Uranium-235

Borehole	Sample Type	RIN/Event/Bottle	Analyte	Result	Unit	Q	Det Limit	Sigma Error	DER
90198	Replicate	98A1496-001.014	U-235	0.038	PCI/G	J	0.022	0.022	1.016
90198	Real	98A1496-001.006	U-235	0.384	PCI/G	U	0.514	0.34	
90698	Replicate	98A1055-003.036	U-235	0.412	PCI/G	U	1.94	1.03	0.106
90698	Real	98A1055-003.033	U-235	0.577	PCI/G	U	2.42	1.16	
90798	Replicate	98A1055-002.020	U-235	0.045	PCI/G	J	0.014	0.018	0.427
90798	Real	98A1055-002.019	U-235	0.035	PCI/G	J	0.009	0.015	
91298	Replicate	98A1055-001.011	U-235	0.018	PCI/G	J	0.013	0.011	0.774
91298	Real	98A1055-001.010	U-235	0.007	PCI/G	U	0.016	0.009	
91598	Replicate	98A1296-001.010	U-235	-1.748	PCI/G	U	19.2	10.2	0.602
91598	Real	98A1296-001.002	U-235	7.2	PCI/G	U	19.8	10.8	
91698	Replicate	98A2017-001.012	U-235	3.34	PCI/G	U	21.2	12.8	0.224
91698	Real	98A2017-001.002	U-235	-0.913	PCI/G	U	23.2	14.0	
92498	Replicate	98A1502-001.010	U-235	0.438	PCI/G	U	0.603	0.413	0.830
92498	Real	98A1502-001.002	U-235	0.092	PCI/G	J	0.043	0.057	
92698	Replicate	98A2022-001.010	U-235	0.008	PCI/G	U	0.049	0.029	0.341
92698	Real	98A2022-001.004	U-235	0.022	PCI/G	U	0.049	0.029	
93098	Replicate	99A4353-005.001	U-235	0.072	PCI/G	U	0.076	0.075	0.960
93098	Real	99A4353-004.002	U-235	0	PCI/G	U	0.050	0.000	
93698	Replicate	98A1289-001.010	U-235	0.05	PCI/G	J	0.027	0.029	0.439
93698	Real	98A1289-001.004	U-235	0.032	PCI/G	U	0.039	0.029	
94298	Replicate	99A4849-005.002	U-235	0.056	PCI/G	U	0.076	0.066	0.249
94298	Real	99A4849-004.002	U-235	0.034	PCI/G	U	0.091	0.059	
94598	Replicate	98A5489-001.009	U-235	0.031	PCI/G	J	0.021	0.032	0.231
94598	Real	98A5489-001.008	U-235	0.043	PCI/G	J	0.024	0.041	
95298	Replicate	98A5494-001.009	U-235	0.038	PCI/G	U	0.040	0.040	0.307
95298	Real	98A5494-001.008	U-235	0.023	PCI/G	J	0.021	0.028	
95798	Replicate	99A5832-005.002	U-235	0.01	PCI/G	U	0.081	0.037	0.120
95798	Real	99A5832-004.002	U-235	0.017	PCI/G	U	0.084	0.045	
95998	Replicate	99A7799-009.003	U-235	0.084	PCI/G	J	0.057	0.088	0.683
95998	Real	99A7799-006.003	U-235	0.21	PCI/G	J	0.117	0.162	
96298	Replicate	99A3210-004.009	U-235	-0.007	PCI/G	U	0.079	0.014	1.200
96298	Real	99A3210-004.008	U-235	0.113	PCI/G	J	0.083	0.099	
96798	Replicate	99A6650-006.003	U-235	-0.007	PCI/G	U	0.085	0.014	0.919
96798	Real	99A6650-005.003	U-235	0.055	PCI/G	J	0.050	0.066	
97598	Replicate	99A7937-005.001	U-235	0.081	PCI/G	U	0.109	0.093	0.033
97598	Real	99A7937-004.002	U-235	0.077	PCI/G	J	0.052	0.080	
97698	Replicate	99A8275-006.003	U-235	0.114	PCI/G	J	0.062	0.108	0.053
97698	Real	99A8275-001.003	U-235	0.122	PCI/G	J	0.055	0.106	

229

Subsurface Soil Characterization Project
Precision Results - Uranium-238

Borehole	Sample Type	RIN/Event/Bottle	Analyte	Result	Unit	Q	Det. Limit	Sigma Error	DER
90198	Replicate	98A1496-001.014	U-238	0.828	PCI/G	J	0.025	0.137	1.471
90198	Real	98A1496-001.006	U-238	1.9	PCI/G		0.546	0.716	
90698	Replicate	98A1055-003.036	U-238	2.89	PCI/G	U	3.69	2.37	1.289
90698	Real	98A1055-003.033	U-238	7.92	PCI/G		2.42	3.1	
90798	Replicate	98A1055-002.020	U-238	0.689	PCI/G	J	0.020	0.102	1.024
90798	Real	98A1055-002.019	U-238	0.851	PCI/G	J	0.016	0.121	
91298	Replicate	98A1055-001.011	U-238	0.395	PCI/G	J	0.015	0.065	0.879
91298	Real	98A1055-001.010	U-238	0.319	PCI/G	J	0.020	0.057	
91598	Replicate	98A1296-001.010	U-238	90.9	PCI/G		26.9	35	1.571
91598	Real	98A1296-001.002	U-238	28.2	PCI/G		19.8	19.2	
91698	Replicate	98A2017-001.012	U-238	4.18	PCI/G	U	31.9	12.8	0.172
91698	Real	98A2017-001.002	U-238	0.913	PCI/G	U	32.7	14.0	
92498	Replicate	98A1502-001.010	U-238	1.31	PCI/G		0.501	0.68	0.293
92498	Real	98A1502-001.002	U-238	1.1	PCI/G		0.056	0.229	
92698	Replicate	98A2022-001.010	U-238	0.658	PCI/G	J	0.064	0.175	0.628
92698	Real	98A2022-001.004	U-238	0.516	PCI/G	J	0.059	0.143	
93098	Replicate	99A4353-005.001	U-238	0.592	PCI/G	J	0.061	0.217	0.163
93098	Real	99A4353-004.002	U-238	0.645	PCI/G	J	0.072	0.242	
93698	Replicate	98A1289-001.010	U-238	1.62	PCI/G		0.030	0.246	2.922
93698	Real	98A1289-001.004	U-238	0.764	PCI/G	J	0.044	0.159	
94298	Replicate	99A4849-005.002	U-238	0.739	PCI/G	J	0.061	0.253	0.093
94298	Real	99A4849-004.002	U-238	0.773	PCI/G	J	0.073	0.263	
94598	Replicate	98A5489-001.009	U-238	0.659	PCI/G	J	0.035	0.193	0.506
94598	Real	98A5489-001.008	U-238	0.813	PCI/G	J	0.019	0.235	
95298	Replicate	98A5494-001.009	U-238	0.733	PCI/G	J	0.018	0.214	0.495
95298	Real	98A5494-001.008	U-238	0.595	PCI/G	J	0.030	0.179	
95798	Replicate	99A5832-005.002	U-238	0.66	PCI/G	J	0.066	0.240	0.373
95798	Real	99A5832-004.002	U-238	0.792	PCI/G	J	0.067	0.260	
95998	Replicate	99A7799-009.003	U-238	0.854	PCI/G	J	0.096	0.308	0.463
95998	Real	99A7799-006.003	U-238	1.08	PCI/G		0.094	0.379	
96298	Replicate	99A3210-004.009	U-238	0.353	PCI/G	J	0.084	0.161	1.902
96298	Real	99A3210-004.008	U-238	1.06	PCI/G	B	0.038	0.335	
96798	Replicate	99A6650-006.003	U-238	0.798	PCI/G	J	0.069	0.278	0.795
96798	Real	99A6650-005.003	U-238	0.52	PCI/G	J	0.083	0.212	
97598	Replicate	99A7937-005.001	U-238	0.828	PCI/G	J	0.042	0.292	0.147
97598	Real	99A7937-004.002	U-238	0.89	PCI/G	J	0.074	0.306	
97698	Replicate	99A8275-006.003	U-238	0.472	PCI/G	J	0.088	0.216	0.092
97698	Real	99A8275-001.003	U-238	0.5	PCI/G	J	0.078	0.213	

Subsurface Soil Characterization Program
Precision Results - Relative Percent Difference - VOCs

Borehole	Sample Type	RIN/Event/Bottle	Analyte	Result	Unit	Q	%RPD
92598	Dup	98A1092-001.037	Carbon Tetrachloride	740	UG/KG	U	2.7
92598	Real	98A1092-001.036	Carbon Tetrachloride	720	UG/KG	U	
95998	Dup	99A7799-009.002	Carbon Tetrachloride	6.1	UG/KG	U	3.2
95998	Real	99A7799-006.002	Carbon Tetrachloride	6.3	UG/KG	U	
96298	Dup	99A3210-004.015	Carbon Tetrachloride	700	UG/KG	U	4.4
96298	Real	99A3210-004.014	Carbon Tetrachloride	670	UG/KG	U	
96798	Dup	99A6650-006.002	Carbon Tetrachloride	0.81	UG/KG	J	147
96798	Real	99A6650-005.002	Carbon Tetrachloride	5.3	UG/KG	J	
97698	Dup	99A8275-006.002	Carbon Tetrachloride	5.4	UG/KG	U	1.9
97698	Real	99A8275-001.002	Carbon Tetrachloride	5.3	UG/KG	U	
97698	Dup	99A8275-006.002	1,2-Cis-Dichloroethylene	5.4	UG/KG	U	1.9
97698	Real	99A8275-001.002	1,2-Cis-Dichloroethylene	5.3	UG/KG	U	
96798	Dup	99A6650-006.002	1,2-Cis-Dichloroethylene	6.8	UG/KG	U	74.7
96798	Real	99A6650-005.002	1,2-Cis-Dichloroethylene	14.9	UG/KG		
96298	Dup	99A3210-004.015	1,2-Cis-Dichloroethylene	700	UG/KG	U	4.4
96298	Real	99A3210-004.014	1,2-Cis-Dichloroethylene	670	UG/KG	U	
95998	Dup	99A7799-009.002	1,2-Cis-Dichloroethylene	6.1	UG/KG	U	171.5
95998	Real	99A7799-006.002	1,2-Cis-Dichloroethylene	79.5	UG/KG		
92598	Dup	98A1092-001.037	1,2-Cis-Dichloroethylene	740	UG/KG	U	2.7
92598	Real	98A1092-001.036	1,2-Cis-Dichloroethylene	720	UG/KG	U	
97698	Dup	99A8275-006.002	Tetrachloroethene	5.4	UG/KG	U	1.9
97698	Real	99A8275-001.002	Tetrachloroethene	5.3	UG/KG	U	
96798	Dup	99A6650-006.002	Tetrachloroethene	7.8	UG/KG		161
96798	Real	99A6650-005.002	Tetrachloroethene	72.2	UG/KG		
96298	Dup	99A3210-004.015	Tetrachloroethene	700	UG/KG	U	4.4
96298	Real	99A3210-004.014	Tetrachloroethene	670	UG/KG	U	
95998	Dup	99A7799-009.002	Tetrachloroethene	6.1	UG/KG	U	193
95998	Real	99A7799-006.002	Tetrachloroethene	343	UG/KG	E	
92598	Dup	98A1092-001.037	Tetrachloroethene	740	UG/KG	U	2.7
92598	Real	98A1092-001.036	Tetrachloroethene	720	UG/KG	U	
97698	Dup	99A8275-006.002	Trichloroethene	5.4	UG/KG	U	1.9
97698	Real	99A8275-001.002	Trichloroethene	5.3	UG/KG	U	
96798	Dup	99A6650-006.002	Trichloroethene	0.85	UG/KG	J	179.9
96798	Real	99A6650-005.002	Trichloroethene	16.1	UG/KG		
96298	Dup	99A3210-004.015	Trichloroethene	700	UG/KG	U	4.4
96298	Real	99A3210-004.014	Trichloroethene	670	UG/KG	U	
95998	Dup	99A7799-009.002	Trichloroethene	6.1	UG/KG	U	71.6
95998	Real	99A7799-006.002	Trichloroethene	12.9	UG/KG		
92598	Dup	98A1092-001.037	Trichloroethene	740	UG/KG	U	2.7
92598	Real	98A1092-001.036	Trichloroethene	720	UG/KG	U	

231

Characterization Report for the
903 Drum Storage Area,
903 Lip Area, and Americium Zone

Document Number: RF/RMRS-99-427.UN
Revision: 0
Date: September 21, 1999
Page: C-1

Appendix C

903 Pad *In-Situ* Models and Uncertainties

903 PAD *IN SITU* MODELS AND UNCERTAINTIES

In Situ Models

The Canberra *in situ* systems used to perform measurements at the RFETS 903 Pad project site employ the Canberra In Situ Object Counting System (ISOCS) software. This software package allows the user to calculate efficiencies for *in situ* quantification of defined objects using standard templates. One such template has been used to define the *in situ* measurement of contaminants in soils at the 903 Pad locations. This template requires the entry of various parameters which should accurately represent the actual conditions at the project site.

The template selected for this application is the circular plane source. This template requires the user to define a horizontal source size, a vertical source size, material composition and material density. In addition, the software uses detector specific physical parameters and user definable environmental parameters such as humidity, pressure and temperature. Each of these parameters has been defined in the model to represent actual conditions at 903 Pad, using existing knowledge of the site and project defined parameters. These parameter values, and the basis for selection, are described below.

Use of inappropriate values could lead to errors in *in situ* measurements. The model used for routine measurements contains the values most representative of actual conditions, however it is possible that actual measurement locations may vary from these assumed default conditions. Since it is not possible to verify all parameter values at each measurement location, default values will be used except where it is known that conditions vary significantly. An evaluation of the potential errors associated with deviation from default parameters has been performed and forms the basis of the total propagated measurement uncertainty (TMU) used when reporting *in situ* measurement results. These are also described below.

903 Pad Project ISOCS Model

Horizontal Distribution (Field of View)

As indicated above, the model selected for the 903 Pad Project (and normally used for any *in situ* soil assays) is the circular plane geometry. The circular plane is appropriate since the detector typically views a circular area which is defined by detector height above ground and the collimator employed, if any, to restrict the field of view (FOV). For this project, the field of view was defined in the Statement of Work as a 12 m diameter FOV. However, calculations performed using ISOCS showed that an "infinite field of view" for Am-241 is about 10 meters. This is due to the low energy Am-241 photon (59 keV) which is attenuated by soil, and even air, such that there is little contribution to the detector measurement at distances beyond 5 meters from the detector. Therefore, all efficiencies assumed a FOV of 10 meters diameter. In addition, the collimator used, 5 cm with a 180 degree collimation, effectively limits the FOV to 10 meters at a height of one meter.

Vertical Distribution

The distribution of contaminants vertically will impact the efficiency used. For naturally occurring radionuclides, the distribution is basically uniform throughout the top 20-30 cm of soil. However, man-made contamination will usually have a different distribution, depending on the mode of deposition. At 903 Pad locations, contamination was deposited via airborne and/or surface water releases. This results in a distribution which will tend to have higher concentrations near the surface and decreasing concentrations with depth, which may follow an exponential function. Surface soil sampling has been performed in the 903 Pad areas to determine the vertical distributions. In general, the activities are concentrated in the top 5 cm, which may contain 60-80% of the total contamination. The sampling was generally performed in 2 or 3 cm layers, therefore the distribution in the top 5 cm layer can only be subdivided into two layers, one for the top 3 cm and a second for the next 2 (or 3) cm. Based on available data, the ISOCS model assumes all contamination is contained in the top 5 cm, and it is distributed with 66% in the top 3 cm and 33% in the next 2 cm. This distribution is used to be consistent with the soil sampling protocol, which calls for sampling to a depth of two inches. In addition, the contribution from Am-241 below a depth of 5 cm in soil is quite small. This distribution, however, will skew results for naturally occurring radionuclides due to the different distributions.

Soil Composition

The chemical composition of the soils, including moisture content, will impact efficiency determinations. A number of soil samples from the 903 Pad locations have been analyzed and reported for chemical composition. The ISOCS software contains several soil models with varying elemental content. Based on the available data, a soil composition containing measurable amounts of metals, including Fe, and a small amount of H₂O (low moisture content) was selected as most representative of RFETS soils. This soil model is termed "dry dirt" and has a composition of: 49O, 27Si, 4Fe, 1.6Mg, 4Ca, 7Al, 0.8Na.

235

Soil Density

The available soil density data from 903 Pad locations shows densities ranging from 1.0 to 1.3 g/cc. *In Situ* soil densities are typically on the order of 1.6 g/cc, but it is believed that, due to the lower moisture content of RFETS soils, this value may be too high. The ISOCS model uses a value of 1.3 g/cc as a mean value for 903 Pad soils.

Uniformity

The uniformity, or non-uniformity, of contamination, both vertically and horizontally, will impact measurement results. Based on the mode of contamination deposition and on prior survey results (including *in situ* surveys), it is believed that the contamination is relatively uniform within the field of view in the ISOCS systems. This is a reasonable assumption since the *in situ* measurements integrate the readings over nearly 80 sq m areas. Thus, any individual "hot spots" are averaged over the entire area, or volume, and their impacts are minimized. The ISOCS model is based on uniform distributions.

Environmental Conditions

Environmental temperature, humidity and pressure may impact some measurements. The ISOCS models assume standard environmental conditions; i.e. 20 C, 50 % relative humidity and 760 mm barometric pressure. Normal barometric pressure at RFETS is less, but the impact is negligible, as shown below.

Detector Parameters

An ISOCS efficiency for each detector has been generated, using the specific detector characteristics, which tend to remain constant for long periods of time. The parameter of concern is the detector surface dead layer, which, if it increases could effect detection of low energy photons. This can be monitored by routine check source counts using a source with a low energy photon, such as Am-241. There have been no changes to these parameters over the course of the 903 Pad Project.

The ISOCS template used for the 903 Pad ISOCS efficiency is attached.

ISOCS Model Uncertainties.

As described above, the default ISOCS models are based on assumed mean values for the given set of model parameters. It is recognized that the actual conditions may vary and that it is not possible to characterize each measurement location to use location specific values. Therefore, Canberra has attempted to bound the likely range of parameter values based on existing data, evaluate the potential errors of using mean values when compared to the likely ranges, then assign an error to each parameter and propagate a total measurement uncertainty (TMU). Each parameter has been evaluated, as shown below, and a maximum error estimated for the mean value, based on the likely range of values for a given parameter. The impact of a deviation from the mean value was assessed by entering that value into an ISOCS efficiency, then analyzing a standard count and comparing the Am-241 result to that obtained with the mean value. Each parameter was evaluated independently. The variation from the mean value was considered to be the maximum deviation and equivalent to a 3 sigma boundary.

Horizontal Distribution (Field of View)

The field of view is limited by the 180 degree collimator and the range of Am-241 photons in soil. It is assumed that the horizontal distribution is uniform. There are no likely maximum or minimum ranges for this parameter and no error estimate is provided.

Vertical Distribution

The model distribution was estimated from soil sampling data but is rather coarse. It is possible that the actual distributions in the top 5 cm may be more concentrated near the surface or more uniformly distributed throughout the 5 cm layer. A set of efficiencies with different vertical distributions were prepared and the standard acquisition analyzed.

Results:

Default 2 layer 0-3 cm 66%, 3-5 cm 33%	Am-241 = 12.2 pCi/g
Single layer, 0-5 cm uniform	Am-241 = 14.3 pCi/g
3 layers, 0-1.5cm 50%, 1.5-3 cm 30%, 3-5 cm 20%	Am-241 = 11.6 pCi/g
3 layers, default with 1cm grass cover	Am-241 = 13.2 pCi/g
2 layer with 0-3 cm 60%, 3-5 cm 40%	Am-241 = 12.2 pCi/g

The overall impact of a likely range of possible distributions is about +/- 10 %.

Soil Composition

Soil compositions were varied from dirt with little heavy metal component (Dirt 2) to soils with a significant composition of metals (Dirt 4)

Results:

237

Default soil; Dry Dirt (49O, 27Si, 4Fe, 1.6Mg, 4Ca, 2.7K, 7Al)	Am-241 = 12.2 pCi/g
Dirt 2 (55O, 31Si, 3Fe, 7Al)	Am-241 = 11.6 pCi/g
Dirt 4 (45O, 25Si, 12Fe, 2.5Mg, 4.1Ca, 2Mn, 8.3Al, 0.7Ti)	Am-241 = 15.4 pCi/g

The overall impact of a likely range of compositions is about +/- 25%

Soil Density

Soil densities were varied from the minimum of 1.0 to a maximum of 1.6 g/cc.

Results

Default density 1.3 g/cc	Am-241 = 12.2 pCi/g
Density 1.6 g/cc	Am-241 = 12.0 pCi/g
Density 1.0 g/cc	Am-241 = 13.8 pCi/g

The overall impact of density changes is about +/- 10 %-

Environmental Conditions

The default temperature and relative humidity are close to the ranges at RFETS but the default pressure is 20 % higher than normal barometric pressure at this altitude. However, changing the parameters to the RFETS values had no impact (same Am-241 results).

Detector Parameters

Detector characteristics have been shown to be unchanged since factory calibration by verifying response by counting a standard reference material and obtaining the correct result. There is no error assigned to this.

Propagation of Uncertainties.

All significant sources of error should be included in an assessment of total measurement uncertainty (TMU). The model uncertainties described above for vertical distribution, soil composition, soil density, etc. should be considered random errors and are propagated in quadrature. These are then added to the systematic uncertainty defined below.

Random error components, and the magnitude of the estimated 3 sigma range, excluding counting statistics, are shown as:

Horizontal distribution	negligible
Vertical distribution	+/- 10 %
Soil Composition	+/- 25%
Soil Density	+/- 10%
Environmental conditions	negligible

These are propagated as $\text{Total Random Error} = (10^2 + 25^2 + 10^2)^{1/2}$
 $= 29\%$

The systematic error is primarily a calibration uncertainty and is estimated to be +/- 5%.

The Total Measurement Uncertainty (excluding counting statistics) is $= 29\% + 5\% = 34\%$
 at the 3 sigma level.

Due to reporting requirements, this error is entered into the software as the systematic error, which is then added to the counting error to arrive at a TMU. This method may overestimate the total error slightly (the correct method would be to propagate the counting error with the other random uncertainties, then add the systematic error) but is necessary so that the software can report individual values for the counting error and the TMU.

Typical TMU values for detected Am-241 in natural background locations may range from as high as 70% for low levels (e.g. <10 pCi/g) to 40% for high levels.

Data Quality Objectives for Measurement Data

Data Quality Objectives (DQOs) are qualitative and quantitative statements that describe the *in situ* characterization technical and quality objectives, define the appropriate type of data and specify acceptable levels of decision errors used to establish the quality of data. These data are used to assist RMRS in developing remedial action or management actions for the affected areas. For 903 Pad *in situ* measurements, the DQO is:

- To classify surface soils as exceeding Tier I soil action levels. This objective is met by measuring soil concentrations of Am-241, U-235 and U-238. Concentrations of Pu and other U isotopes are derived from these measurements. In order to provide sufficient margin for detection of Tier I levels, detection limits for the three nuclides measurable by *in situ* methods have been set at; 1 pCi/g Am-241, 0.5 pCi/g U-235 and 5.0 pCi/g U-238.

Data Quality Objectives used to validate all data generated by *in situ* measurements include the following: precision, accuracy, sensitivity, completeness, comparability and total uncertainty. For the 903 Pad Project, these are defined as follows:

- Precision A quantitative measure of the reproducibility or degree of agreement among replicate or duplicate measurements of a parameter. For the 903 Pad Project, precision shall be demonstrated by performing duplicate counts of specified soil locations on a frequency not to exceed once per 20 measurement locations. The reproducibility shall be calculate using accepted methods for evaluation of duplicate counting.
- Accuracy The degree of agreement between measured concentration values and the true or known values. For *in situ* measurements, true values are difficult to establish and may be estimated from alternate assay methods. For this project. *In situ* results will be compared to laboratory analyses of discrete soil samples. Comparable measurements at the action levels are expected to agree within +/- 50%. Evaluation of accuracy will be performed by RMRS and Canberra technical representatives.
- Sensitivity Sensitivity limits are defined as that level of radioactivity which, if present, will yield a measured value less than the critical limit with 5% probability. The critical limit is defined as that value which measurements of background will exceed with a 5% probability. Sensitivity limits for three detectable radionuclides are specified above.
- Completeness A quantitative measure expressed as a percentage of valid or acceptable data obtained from a measurement system. A goal of 90% has been set for this project.

- Comparability A qualitative measure of the confidence with which a set of data from one assay system can be compared to another from a second system. See the DQO for accuracy.
- Total Uncertainty This includes both random and systematic uncertainties and are propagated to arrive at a total uncertainty at the 95% confidence level. Random uncertainties include counting errors and uncertainties related to non-uniform distribution of contamination. Systematic errors include calibration and positioning. Uncertainties will be obtained from measurements or estimated by *in situ* technical specialists.

Characterization Report for the
903 Drum Storage Area,
903 Lip Area, and Americium Zone

Document Number: RF/RMRS-99-427.UN
Revision: 0
Date: September 21, 1999
Page: D-1

Appendix D

Summary Statistics

242

Appendix D. Summary Statistics
HPGe Data

HPGe Prtedicted Data							
Descriptive Statistic	²³⁵ U	²³⁸ U	HPGe ²⁴¹ Am	95% UCL Predicted ²⁴¹ Am ¹	95% UCL Predicted ^{239/240} Pu ²	Best Fit Predicted ²⁴¹ Am ³	Best Fit Predicted ^{239/240} Pu ⁴
	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)	(pCi/g)
Mean	0.24	4.46	12.60	28.43	201.20	20.19	105.05
Geometric Mean	0.00	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!	#NUM!
Standard Error	1.37E-03	0.02	0.38	0.45	3.00	0.48	3.07
Median	0.23	4.37	9.62	24.80	176.67	16.46	80.94
Mode	0.23	3.63	0.90	15.46	118.91	5.56	10.55
Standard Deviation	0.05	0.67	12.67	15.02	100.11	15.85	102.38
Sample Variance	2.07E-03	0.45	160.54	225.69	10021.87	251.25	10481.30
Kurtosis	4.18	10.50	13.05	18.39	22.63	13.05	13.05
Skewness	-0.12	1.10	2.84	3.36	3.74	2.84	2.84
Coefficient of Variation	0.19	0.15	1.01	0.53	0.50	0.78	0.97
Range	0.51	10.04	115.36	150.48	1060.92	144.31	932.10
Minimum	0.07	1.31	0.38	14.91	115.55	4.91	6.32
Maximum	0.58	11.35	115.74	165.39	1176.47	149.22	938.42
Sum	261.72	4946.04	13985.89	31555.57	223330.46	22414.09	116602.40
Count	1110	1110	1110	1110	1110	1110	1110
Confidence Level (95.0%)	2.68E-03	0.04	0.75	0.88	5.89	0.93	6.02
Number of Detections Above Tier I	0	0	0	0	0	0	0
Number of Detections Above Tier II	0	0	48	162	183	0	82

¹ Predicted ²⁴¹Am Based on Regression Equation:
$$^{241}\text{Am} = 0.0022 * ^{241}\text{Am}^2 + 1.049 * ^{241}\text{Am} + 14.509$$

² Predicted ^{239/240}Pu Based on Regression Equation:
$$^{239/240}\text{Pu} = 0.0243 * ^{241}\text{Am}^2 + 6.3749 * ^{241}\text{Am} + 113.12$$

³ Predicted ²⁴¹Am Based on Regression Equation:
$$^{241}\text{Am} = 1.251 * ^{241}\text{Am} + 4.43$$

⁴ Predicted ^{239/240}Pu Based on Regression Equation:
$$^{239/240}\text{Pu} = 8.08 * ^{241}\text{Am} + 3.24$$

243

Appendix D. Summary Statistics
Borehole Radiological Data-903 Pad and Lip Area

Asphalt					
Descriptive Statistic	U233/234 (pCi/g)	U235 (pCi/g)	U238 (pCi/g)	Pu239/240 (pCi/g)	Am241 (pCi/g)
Mean	0.81	0.05	0.75	0.16	0.07
Geometric Mean	0.80	0.04	0.74	#N/A	0.04
Standard Error	0.05	0.01	0.04	0.13	0.03
Median	0.78	0.04	0.75	0.03	0.04
Mode	#N/A	#N/A	#N/A	#N/A	#N/A
Standard Deviation	0.15	0.03	0.13	0.40	0.10
Sample Variance	0.02	0.00	0.02	0.16	0.01
Kurtosis	1.70	7.01	-1.60	8.85	8.28
Skewness	1.22	2.46	-0.08	2.97	2.84
Coefficient of Variation	0.19	0.72	0.17	2.42	1.46
Range	0.47	0.12	0.32	1.22	0.33
Minimum	0.66	0.01	0.60	0.00	0.02
Maximum	1.13	0.13	0.92	1.22	0.34
Sum	7.27	0.42	6.74	1.48	0.63
Count	9	9	9	9	9
Confidence Level (90.0%)	0.08	0.02	0.07	0.22	0.06

Bedrock					
Descriptive Statistic	U233/234 (pCi/g)	U235 (pCi/g)	U238 (pCi/g)	Pu239/240 (pCi/g)	Am241 (pCi/g)
Mean	0.49	0.04	0.62	0.09	0.04
Geometric Mean	0.45	N/A	0.58	0.05	N/A
Standard Error	0.06	0.01	0.06	0.03	0.02
Median	0.43	0.05	0.69	0.04	0.03
Mode	#N/A	#N/A	#N/A	0.01	0.01
Standard Deviation	0.19	0.03	0.19	0.11	0.06
Sample Variance	0.04	0.00	0.04	0.01	0.00
Kurtosis	1.08	-0.02	0.13	1.89	3.71
Skewness	0.86	0.50	-0.96	1.69	1.51
Coefficient of Variation	0.39	0.81	0.31	1.26	1.54
Range	0.72	0.12	0.63	0.35	0.26
Minimum	0.19	-0.01	0.22	0.01	-0.05
Maximum	0.90	0.11	0.84	0.36	0.21
Sum	5.83	0.51	7.43	1.07	0.50
Count	12	12	12	12	12
Confidence Level (95.0%)	0.11	0.02	0.11	0.06	0.04
Number of Detections Above Tier I	0	0	0	0	0
Number of Detections Above Tier II	0	0	0	0	0

244

**Appendix D. Summary Statistics
Borehole Radiological Data-903 Pad and Lip Area**

Fill					
Descriptive Statistic	U233/234 (pCi/g)	U235 (pCi/g)	U238 (pCi/g)	Pu239/240 (pCi/g)	Am241 (pCi/g)
Mean	1.06	0.09	1.15	53.75	12.01
Geometric Mean	1.02	0.06	1.00	5.78	1.18
Standard Error	0.11	0.04	0.18	45.95	10.38
Median	0.98	0.06	1.13	4.48	0.85
Mode	0.84	0.07	1.24	#N/A	#N/A
Standard Deviation	0.38	0.13	0.61	159.19	35.97
Sample Variance	0.14	0.02	0.37	25340.90	1294.08
Kurtosis	4.79	11.19	5.53	11.88	11.90
Skewness	1.51	3.30	1.72	3.44	3.44
Coefficient of Variation	0.36	1.43	0.53	2.96	2.99
Range	1.61	0.49	2.60	557.99	125.98
Minimum	0.41	0.00	0.17	0.01	0.02
Maximum	2.02	0.49	2.77	558.00	126.00
Sum	12.25	1.00	13.33	642.14	143.51
Count	12	12	12	12	12
Confidence Level (90.0%)	0.18	0.06	0.29	75.59	17.08
Number of Detections Above Tier I	0	0	0	0	0
Number of Detections Above Tier II	0	0	0	1	1

Native					
Descriptive Statistic	U233/234 (pCi/g)	U235 (pCi/g)	U238 (pCi/g)	Pu239/240 (pCi/g)	Am241 (pCi/g)
Mean	0.51	0.04	0.63	0.27	0.11
Geometric Mean	0.49	N/A	0.60	N/A	N/A
Standard Error	0.02	0.01	0.02	0.06	0.03
Median	0.48	0.03	0.59	0.05	0.04
Mode	0.58	0.02	0.66	0.01	0.00
Standard Deviation	0.16	0.05	0.21	0.53	0.25
Sample Variance	0.02	0.00	0.04	0.28	0.06
Kurtosis	13.79	2.25	4.58	9.25	31.76
Skewness	2.74	1.65	1.72	2.94	5.20
Coefficient of Variation	0.31	1.10	0.33	2.00	2.32
Range	1.12	0.22	1.16	2.86	1.81
Minimum	0.28	-0.01	0.30	-0.02	-0.01
Maximum	1.40	0.21	1.46	2.84	1.80
Sum	36.37	3.18	45.03	19.18	7.70
Count	72	72	72	72	72
Confidence Level (95.0%)	0.04	0.01	0.05	0.12	0.06
Number of Detections Above Tier I	0	0	0	0	0
Number of Detections Above Tier II	0	0	0	0	0

245

Appendix D. Summary Statistics
Borehole Radiological Data-903 Pad and Lip Area

Native 1					
Descriptive Statistic	U233/234 (pCi/g)	U235 (pCi/g)	U238 (pCi/g)	Pu239/240 (pCi/g)	Am241 (pCi/g)
Mean	5.31	0.60	16.83	3595.75	775.68
Geometric Mean	1.43	N/A	1.99	146.69	30.48
Standard Error	2.91	0.30	12.58	2462.86	514.23
Median	0.99	0.06	1.32	152.00	34.80
Mode	1.14	0.04	1.54	#N/A	#N/A
Standard Deviation	22.90	2.38	99.08	19392.56	4049.07
Sample Variance	524.52	5.65	9817.55	376071264.13	16394945.59
Kurtosis	55.37	38.00	60.51	59.32	58.16
Skewness	7.30	5.87	7.74	7.63	7.53
Coefficient of Variation	4.31	3.94	5.89	5.39	5.22
Range	177.58	17.81	779.51	152259.18	31669.85
Minimum	0.42	-0.91	0.49	0.82	0.15
Maximum	178.00	16.90	780.00	152260.00	31670.00
Sum	329.51	37.38	1043.61	222936.51	48092.47
Count	62	62	62	62	62
Confidence Level (95.0%)	5.70	0.59	24.66	4827.10	1007.87
Number of Detections Above Tier I	0	0	1	9	12
Number of Detections Above Tier II	0	0	1	27	27

Native 2					
Descriptive Statistic	U233/234 (pCi/g)	U235 (pCi/g)	U238 (pCi/g)	Pu239/240 (pCi/g)	Am241 (pCi/g)
Mean	1.00	0.16	1.50	122.11	25.23
Geometric Mean	0.76	N/A	0.98	8.65	1.79
Standard Error	0.18	0.11	0.29	41.76	8.90
Median	0.73	0.04	0.88	7.62	1.50
Mode	1.63	0.02	0.40	#N/A	#N/A
Standard Deviation	1.42	0.83	2.32	328.85	70.12
Sample Variance	2.00	0.69	5.39	108142.37	4916.12
Kurtosis	49.56	61.25	24.30	15.58	16.02
Skewness	6.73	7.80	4.59	3.81	3.82
Coefficient of Variation	1.41	5.08	1.55	2.69	2.78
Range	11.36	6.58	15.40	1819.87	405.97
Minimum	0.04	-0.01	0.30	0.14	0.03
Maximum	11.40	6.57	15.70	1820.00	406.00
Sum	62.21	10.12	92.74	7571.08	1564.40
Count	62	62	62	62	62
Confidence Level (95.0%)	0.35	0.21	0.58	81.86	17.45
Number of Detections Above Tier I	0	0	0	2	2
Number of Detections Above Tier II	0	0	0	7	8

246

Appendix D. Summary Statistics
Borehole Radiological Data-903 Pad and Lip Area

Native 3					
Descriptive Statistic	U233/234 (pCi/g)	U235 (pCi/g)	U238 (pCi/g)	Pu239/240 (pCi/g)	Am241 (pCi/g)
Mean	0.70	0.05	0.96	16.24	3.14
Geometric Mean	0.59	N/A	0.71	1.33	N/A
Standard Error	0.06	0.01	0.16	5.09	1.07
Median	0.61	0.03	0.64	0.94	0.23
Mode	0.38	0.02	0.57	0.06	0.25
Standard Deviation	0.44	0.06	1.23	40.12	8.46
Sample Variance	0.19	0.00	1.52	1609.25	71.49
Kurtosis	14.59	16.55	32.01	20.03	23.95
Skewness	3.03	3.70	5.22	4.19	4.60
Coefficient of Variation	0.63	1.23	1.28	2.47	2.69
Range	3.11	0.37	9.00	246.99	54.41
Minimum	0.01	-0.01	0.10	0.01	-0.01
Maximum	3.12	0.36	9.10	247.00	54.40
Sum	43.32	2.92	59.60	1007.14	194.71
Count	62	62	62	62	62
Confidence Level (95.0%)	0.11	0.01	0.31	9.99	2.10
Number of Detections Above Tier I	0	0	0	0	0
Number of Detections Above Tier II	0	0	0	0	1

Native 4					
Descriptive Statistic	U233/234 (pCi/g)	U235 (pCi/g)	U238 (pCi/g)	Pu239/240 (pCi/g)	Am241 (pCi/g)
Mean	0.58	0.03	0.64	4.97	0.90
Geometric Mean	0.54	N/A	0.59	N/A	N/A
Standard Error	0.03	0.00	0.04	1.40	0.23
Median	0.55	0.03	0.59	0.80	0.23
Mode	0.76	0.01	0.63	34.50	0.15
Standard Deviation	0.21	0.02	0.29	10.63	1.72
Sample Variance	0.04	0.00	0.08	112.97	2.95
Kurtosis	1.50	2.86	6.66	9.49	6.52
Skewness	1.03	0.19	1.96	3.04	2.67
Coefficient of Variation	0.36	0.74	0.45	2.14	1.92
Range	1.05	0.15	1.78	54.00	7.68
Minimum	0.27	-0.05	0.19	0.00	-0.05
Maximum	1.32	0.10	1.97	54.00	7.63
Sum	33.44	1.79	37.07	288.35	51.98
Count	58	58	58	58	58
Confidence Level (95.0%)	0.05	0.01	0.07	2.74	0.44
Number of Detections Above Tier I	0	0	0	0	0
Number of Detections Above Tier II	0	0	0	0	1

N/A Not Applicable

247

Appendix D. Summary Statistics
VOC Borehole Data

Bedrock						
Descriptive Statistic	Carbon Tetrachloride (µg/Kg)	Tetrachloroethene (µg/Kg)	Trichloroethene (µg/Kg)	Chloroform (µg/Kg)	Cis-1,2- Dichloroethene (µg/Kg)	Methylene Chloride (µg/Kg)
Mean	428.37	458.71	428.85	427.25	698.57	493.06
Geometric Mean	71.75	87.43	73.06	45.48	697.70	59.10
Standard Error	117.96	122.44	117.83	118.24	13.88	151.12
Median	620.00	660.00	620.00	620.00	700.00	390.00
Mode	700.00	700.00	700.00	700.00	700.00	700.00
Standard Deviation	456.84	458.13	456.36	457.95	36.71	585.27
Sample Variance	208701.85	209885.96	208265.48	209715.19	1347.62	342541.03
Kurtosis	0.23	0.20	0.23	0.21	4.75	-0.20
Skewness	0.73	0.63	0.73	0.72	-2.05	0.96
Coefficient of Variation	1.07	1.00	1.06	1.07	0.05	1.19
Range	1497.70	1498.40	1499.11	1499.40	110.00	1699.17
Minimum	2.30	1.60	0.89	0.60	620.00	0.83
Maximum	1500.00	1500.00	1500.00	1500.00	730.00	1700.00
Sum	6425.50	6421.90	6432.79	6408.79	4890.00	7395.93
Count	15	14	15	15	7	15
Confidence Level (95.0%)	231.19	239.98	230.95	231.75	27.19	296.18
Number of Detections Above Current Tier I	0	0	0	0	0	0
Number of Samples at 10% of Current Tier I	1	1	1	0	0	6
Number of Detections Above Proposed Tier I	0	0	0	0	0	6
Number of Detections Above Proposed Tier II	8	8	8	8	7	9
Number of Non Detections	13	12	13	10	7	7
Number of Detections	2	2	2	5	0	8

248

Appendix D. Summary Statistics
VOC Borehole Data

Descriptive Statistic	Native					
	Carbon Tetrachloride (µg/Kg)	Tetrachloroethene (µg/Kg)	Trichloroethene (µg/Kg)	Chloroform (µg/Kg)	Cis-1,2- Dichloroethene (µg/Kg)	Methylene Chloride (µg/Kg)
Mean	351.59	438.75	344.72	351.36	838.40	385.12
Geometric Mean	47.84	51.01	47.91	40.84	742.11	36.97
Standard Error	50.73	94.02	50.33	50.76	148.57	60.20
Median	6.00	24.80	6.30	6.20	700.00	5.90
Mode	5.30	5.30	5.30	700.00	700.00	5.30
Standard Deviation	427.48	797.76	424.12	427.68	742.86	507.21
Sample Variance	182742.10	636420.43	179878.11	182907.29	551839.00	257264.17
Kurtosis	-0.37	35.93	-0.24	-0.37	24.87	-0.12
Skewness	0.82	5.21	0.87	0.82	4.98	1.06
Coefficient of Variation	1.22	1.82	1.23	1.22	0.89	1.32
Range	1494.90	6099.22	1497.00	1499.36	3790.00	1699.41
Minimum	5.10	0.78	3.00	0.64	610.00	0.59
Maximum	1500.00	6100.00	1500.00	1500.00	4400.00	1700.00
Sum	24962.60	31589.97	24475.40	24946.28	20960.00	27343.80
Count	71	72	71	71	25	71
Confidence Level (95.0%)	99.43	184.27	98.65	99.48	291.19	117.98
Number of Detections Above Current Tier I	0	0	0	0	0	0
Number of Samples at 10% of Current Tier I	0	6	5	0	1	25
Number of Detections Above Proposed Tier I	0	1	0	0	0	25
Number of Detections Above Proposed Tier II	31	33	31	0	25	37
Number of Non Detections	70	55	66	64	24	36
Number of Detections	1	17	5	7	1	35

Characterization Report for the
903 Drum Storage Area,
903 Lip Area, and Americium Zone

Document Number: RF/RMRS-99-427.UN
Revision: 0
Date: September 21, 1999
Page: E-1

Appendix E

CD ROM

Electronic Copy of Analytical Database

250

Characterization Report for the
903 Drum Storage Area,
903 Lip Area, and Americium Zone

Document Number: RF/RMRS-99-427.UN
Revision: 0
Date: September 21, 1999
Page: F-1

Appendix F

CD ROM

Electronic Copy of SOR Results

251 / 251

**Characterization Report
for the
903 Drum Storage Area, 903 Lip Area
and Americium Zone**

**Study Area
Location Map**

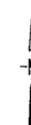
Figure 1-1

EXPLANATION

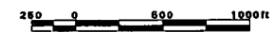
-  903 Lip Area
 -  Study Area
 -  903 Pad
- Standard Map Features**
-  Buildings and other structures
 -  Solar Evaporation Ponds (SEP)
 -  Lakes and ponds
 -  Streams, ditches, or other drainage features
 -  Fences and other barriers
 -  Contour (20-Foot)
 -  Paved roads
 -  Dirt roads

DATA SOURCE:
Buildings, fences, hydrography, roads and other structures from ESRI aerial fly-over data captured by ESRI G.P.S., Las Vegas.
Digitized from the orthophotographs, 1986. Topology (contours) were derived from digital elevation model (DEM) data by Microbit Knowledge (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours. The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~10 meter resolution. DEM post-processing performed by MK, Winter 1997.

DISCLAIMER:
Neither the United States Government nor KBR H2 Co., nor Rocky Mountain Remediation Services, L.L.C., nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights.



Scale = 1 : 12690
1 inch represents approximately 1058 feet



State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

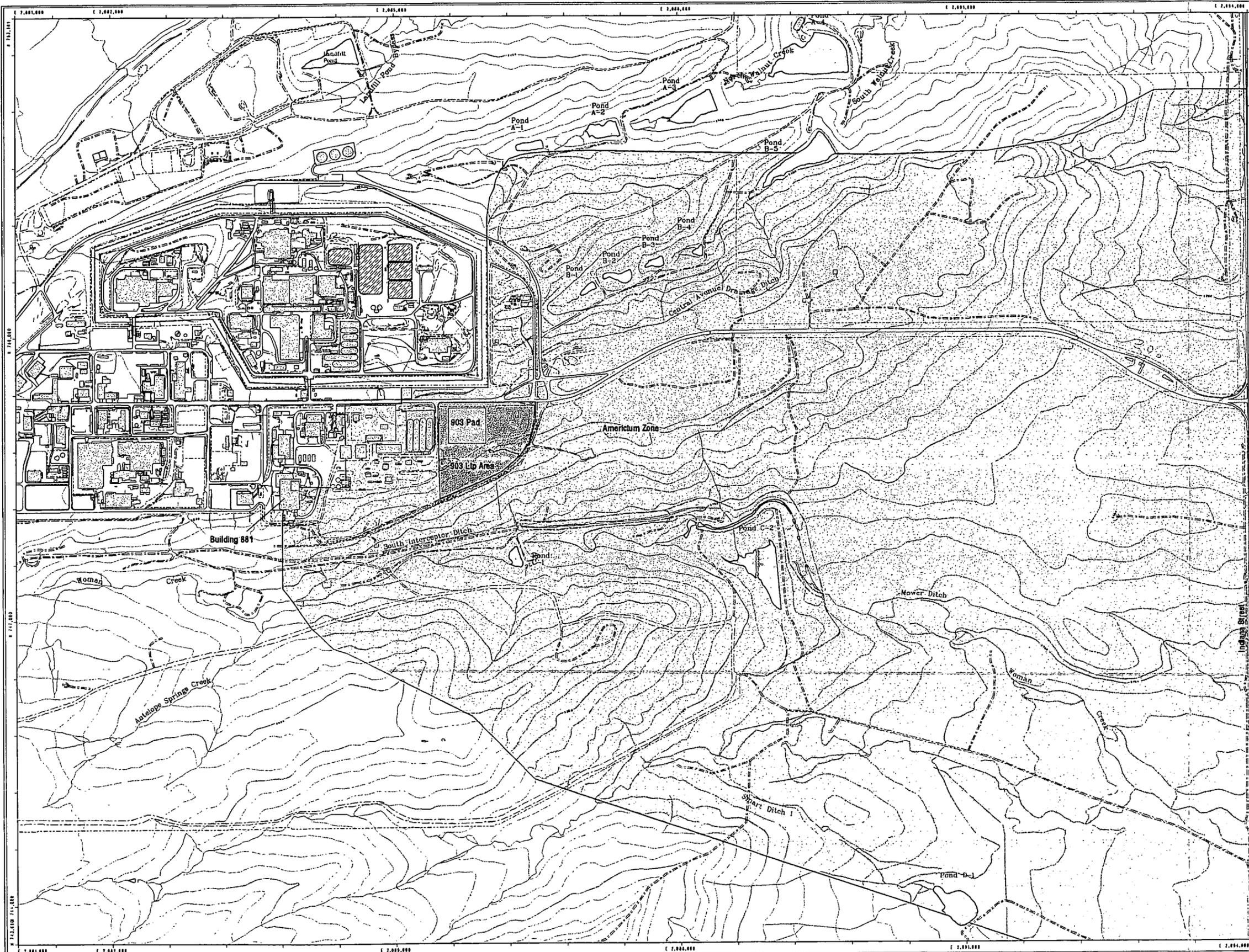
U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:



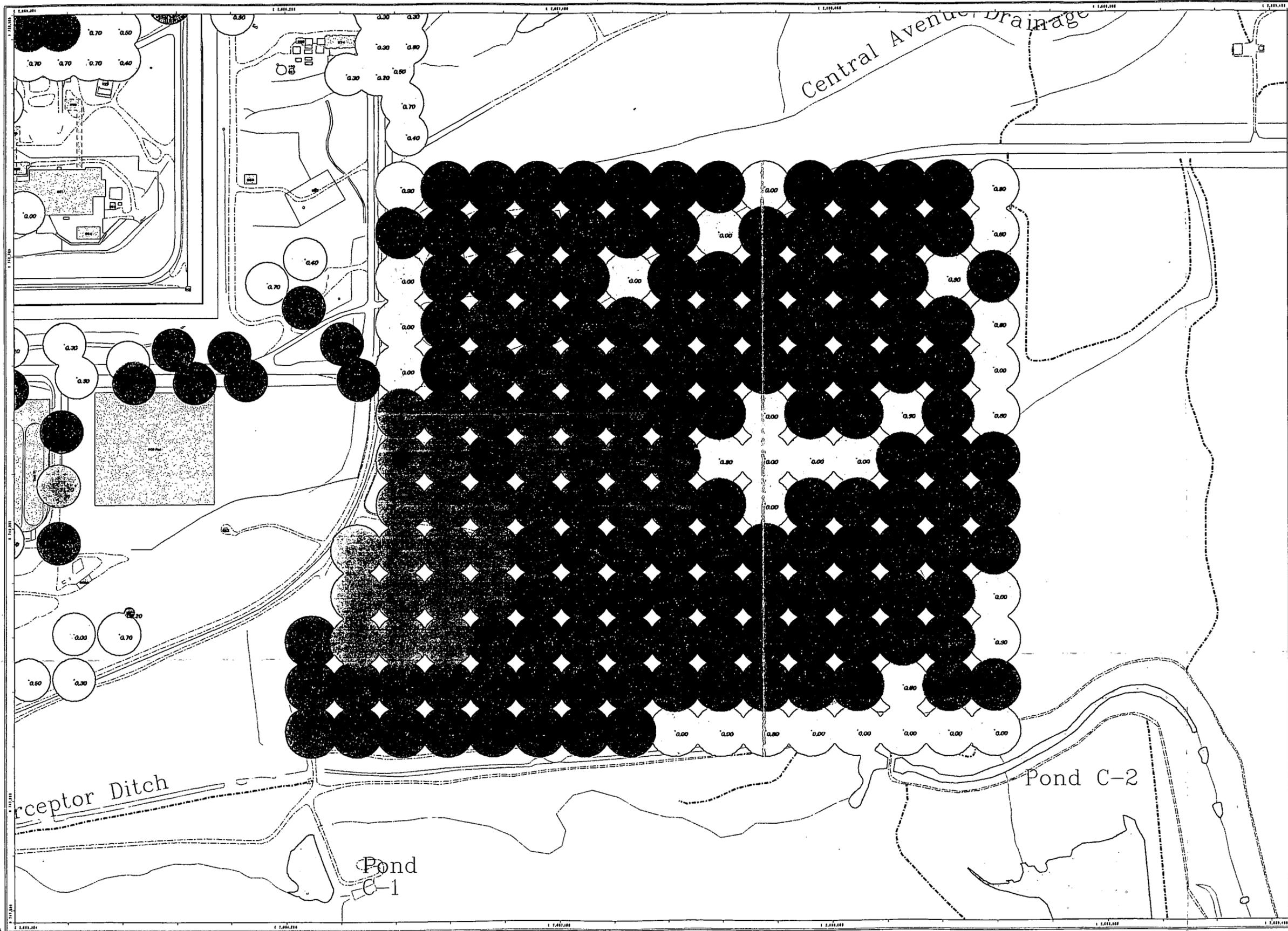
**Rocky Mountain
Remediation Services, L.L.C.**
Geographic Information System Group
Rocky Flats Environmental Technology Site
P.O. Box 484
Golden, CO 80402-4484

MAP ID: 99-0403 September 20, 1999



21

NT_Srv_w:\projects\99\99-0408\fig1-1.dwg



**Characterization Report
for the 903 Drum
Storage Area, 903 Lip Area
'and Americium Zone**

**1994 HPGe Survey Data
for Am-241
in Investigation Area**

Figure 1-2

- HPGe Data Ranges-- pCi/g for a Field of View of 150 feet (DOE, 1995)**
- 0.0 - 0.1
 - 0.1 - 1
 - 1 - 10
 - ▨ 10 - 100
 - 100 - 1000
 - 1000 - 10000

- Standard Map Features**
- ▭ Buildings and other structures
 - ▭ Lakes and ponds
 - Streams, ditches, or other drainage features
 - Fences and other barriers
 - Rocky Flats boundary
 - Paved roads
 - Dirt roads

DATA SOURCE:
Buildings, fences, hydrography, roads and other structures from 1984 aerial photos, data captured by EG&G FSL, Las Vegas. Digitized from the orthophotograph, 1985.

NOTE:
Raw field data which has not been edited and may be influenced by building shadows.

The HPGe field of view (FOV) or radius of influence, assumes a homogeneous surface distribution. The FOV represents a circle whose 80% of the flux originates. The radius, for each HPGe sampling location, is based on the height of the detector above the ground.

The FOV for the majority of the points is 150 feet; however, 1% of the survey locations have a FOV of less than 150 feet.

DISCLAIMER:
Neither the United States Government nor James Hill Co., nor Rocky Mountain Remediation Services, LLC, nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights.



Scale = 1 : 3270
1 inch represents approximately 323 feet



State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD83

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:
RMRS Rocky Mountain Remediation Services, LLC.
Geographic Information Systems Group
Rocky Flats Environmental Technology Site
P.O. Box 484
Golden, CO 80402-0484

22

NT_Srv_w:\projects\99\99-0403\fig1-2.e.m



**Characterization Report
for the 903 Drum
Storage Area, 903 Lip Area
and Americium Zone**

**OU2 Phase II RFI/RI
Surface Soil Sampling Plots
Study Area**

Figure 1-3

EXPLANATION

- CDH & RF Surface Soil Sampling Plots - (DOE, 1995a)
 - Study Area
 - 903 Lip Area
 - Sampling Plots Exceeding Tier I Soil Actions Levels - Radionuclides (DOE, 1995a)
- Standard Map Features**
- Buildings and other structures
 - Solar Evaporation Ponds (SEP)
 - Lakes and ponds
 - Streams, ditches, or other drainage features
 - Fences and other barriers
 - Contour (20-Foot)
 - Paved roads
 - Dirt roads

DATA SOURCE:
Buildings, fences, hydrography, roads and other structures from 1994 aerial 1/4-acre data captured by EG&G RSL, Las Vegas.
Digitized from the orthophotograph, 1/95.
Topography contours were derived from digital elevation model (DEM) data by Morrison Knudsen (MK) using ESRI Arc TIN and LATICE to process the DEM data to create 1-foot contours.
The DEM data was captured by the Racore Surveying Lab, Las Vegas, NV 1394 Aerial Flyover at 10 meter resolution.
DEM post-processing performed by MK, Winter 1997.

DISCLAIMER:
Neither the United States Government nor Kaiser H&S Co., nor Rocky Mountain Remediation Services, L.L.C., nor any agency thereof, nor any of their contractors, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, especially, or process disclosed, or represents that its use would not infringe privately owned rights.

Scale - 1 : 12630
 1 inch represents approximately 1063 feet

 State Plane Coordinate Projection
 Colorado Central Zone
 Datum: NAD27

U.S. Department of Energy
 Rocky Flats Environmental Technology Site

Prepared by:

**Rocky Mountain
Remediation Services, L.L.C.**
 Geographic Information Systems Group
 Rocky Flats Environmental Technology Site
 P.O. Box 484
 Golden, CO 80402-0484

MAP ID: 99-0403 September 15, 1999

23

NT_Srv_w:\projects\fy99\99-0403\fig1-3.am

**Characterization Report
for the 903 Drum
Storage Area, 903 Lip Area
and Americium Zone**

**Investigation Area
Location Map**

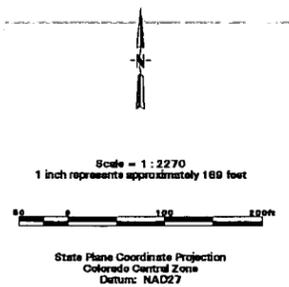
Figure 1-4

EXPLANATION

- HPGs 150 foot FOV Circles (above 10pCi/g Am-241)
- Plots above Tier I Action Levels
- Groundwater Well Locations
- Soil profile Sampling Sites
- 1978 Soil Removal Area (approx)
- 1978 Soil Removal Area (approx)
- 1970 Soil Fill Area (approx)
- 1984 Soil Fill Area (approx)
- Standard Map Features**
- Buildings and other structures
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Paved roads
- Dirt roads

DATA SOURCE:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by ES&G R2, Las Vegas. Digitized from the orthophotographs, 1/95. HPGs data from Ron Reiman, Gamma Survey Group, Colorado Measurements, 2000 Rocky Flats, Inc. June 1994.

DISCLAIMER:
Neither the United States Government nor Kaiser Hill Co., nor Rocky Mountain Remediation Services, L.L.C., nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights.

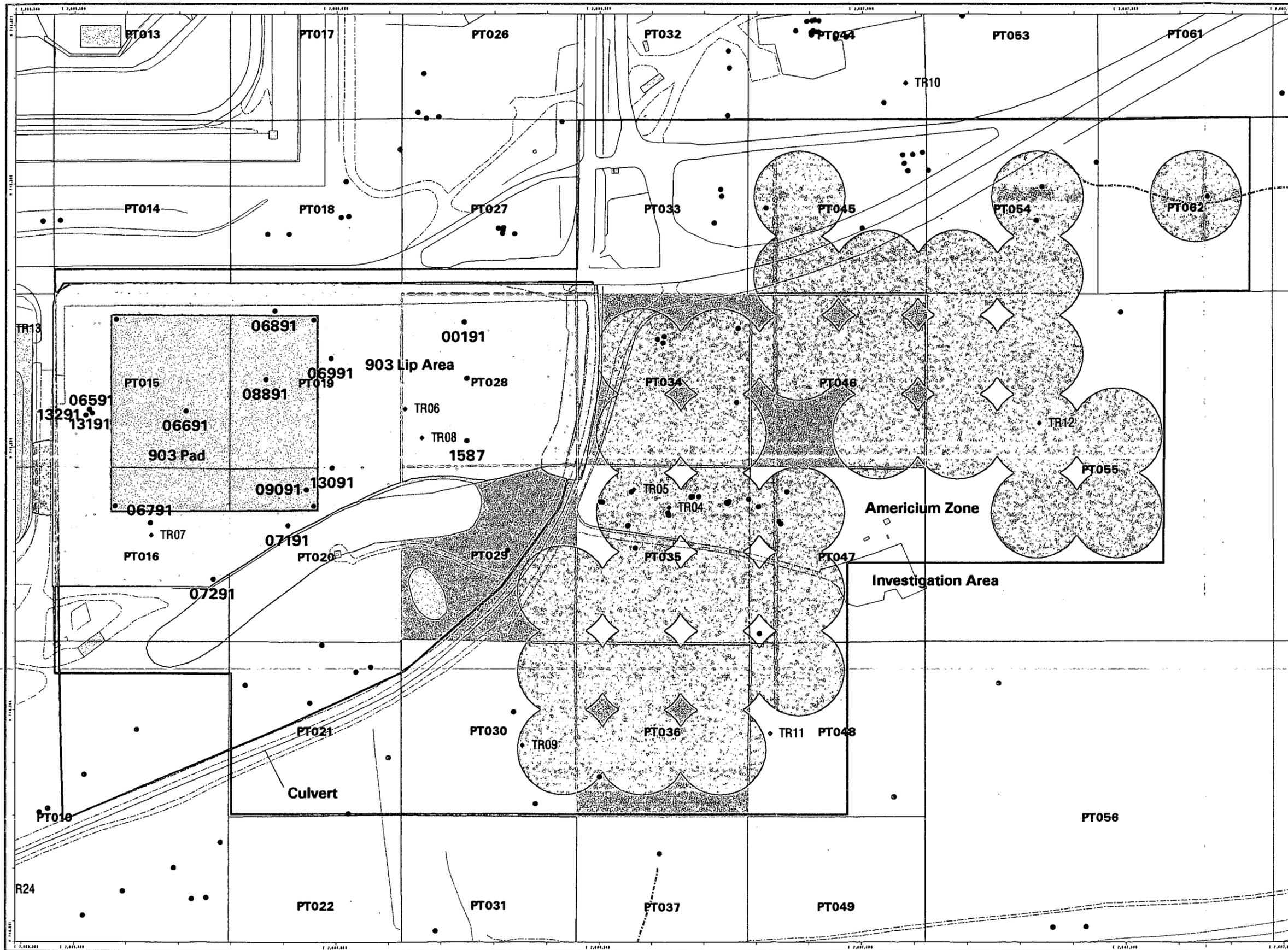


U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:
 Rocky Mountain Remediation Services, L.L.C.
Geographic Information Systems Group
Rocky Flats Environmental Technology Site
P.O. Box 484
Golden, CO 80402-0484

MAP ID: 99-0403

September 16, 1999



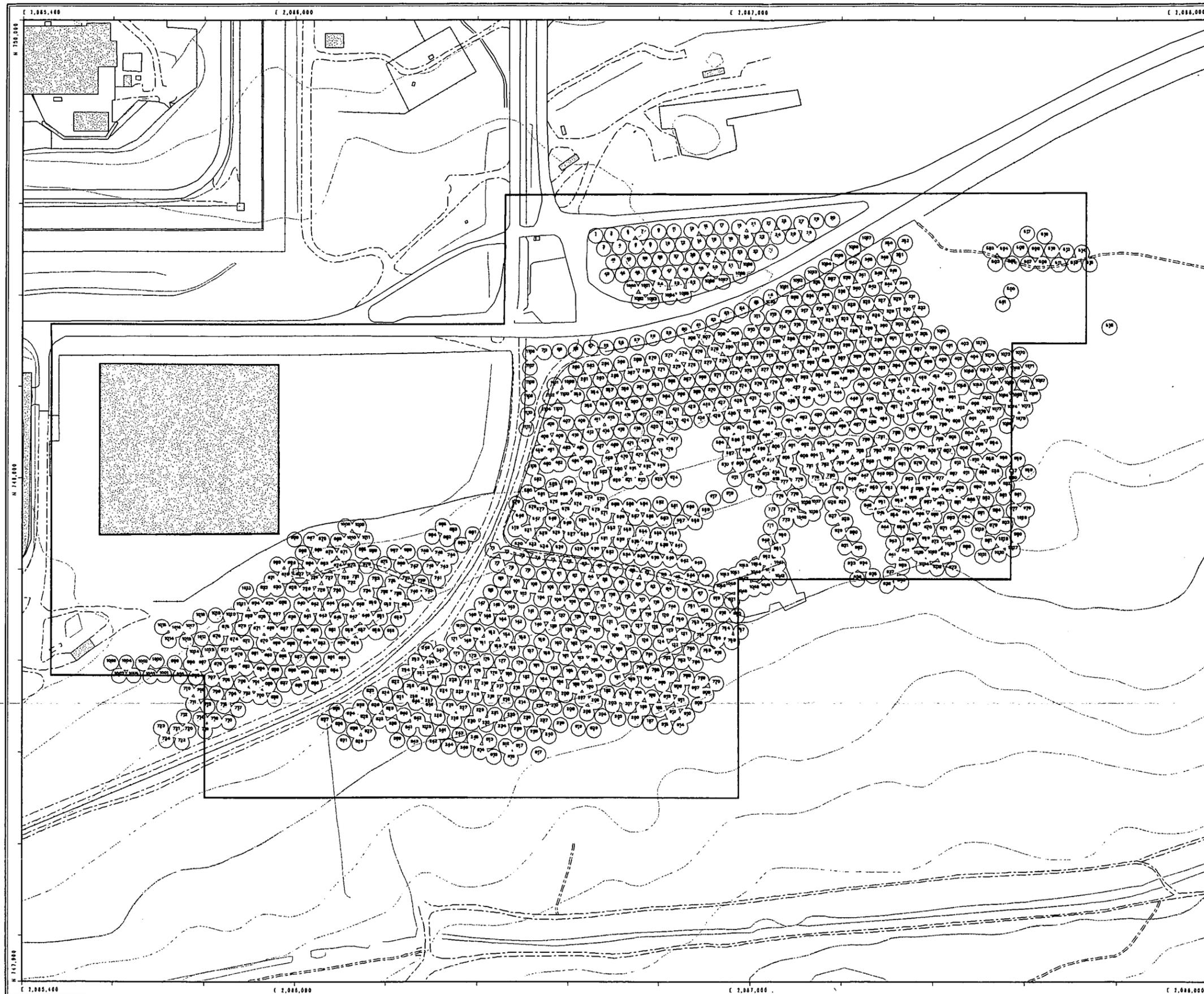
24

NT_Srv_w:/projects/1999/99-0403/fig1-4.am

**Characterization Report
for the
903 Drum Storage Area, 903 Lip Area
and Americium Zone**

HPGe Measurement Location Map

Figure 2-1



EXPLANATION

-  Investigation Area
-  FOV (Field of View) Stake Number

Standard Map Features

-  Buildings and other structures
-  Lakes and ponds
-  Streams, ditches, or other drainage features
-  Fences and other barriers
-  Contour (20-Foot)
-  Paved roads
-  Dirt roads

DATA SOURCE:
Buildings, fences, hydrography, roads and other structures from 1994 aerial flyover data captured by EG&G RSL, Las Vegas.
Digitized from the orthophotograph, 1995.
Topology (contours) were derived from digital elevation model (DEM) data by Maribon Koudoun (MK) using ESRI Arc TIN and LATICE to process the DEM data to create 5-foot contours.
The DEM data was captured by the Science Consulting Lab, Las Vegas, NV 1994 Aerial Flyover at 10 meter resolution.
DEM post-processing performed by MK, Victor 1997.

DISCLAIMER:
Neither the United States Government nor Kaiser Hill Co., nor Rocky Mountain Remediation Services, L.L.C., nor any agency thereof, nor any of their employees, make any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights.



Scale = 1 : 2710
1 inch represents approximately 226 feet



State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:



**Rocky Mountain
Remediation Services, L.L.C.**
Geographic Information Systems Group
Rocky Flats Environmental Technology Site
P.O. Box 404
Golden, CO 80402-0404

MAP ID: 99-0408

September 17, 1999

44

NT_Srv_w:\projects\99\99-0408\hpge_fov_b.am

Characterization Report
for the
903 Drum Storage Area, 903 Lip Area
and Americium Zone

RSAL Exceedances in Surface
Soil using HPGe Results

Figure 2-6

EXPLANATION

- Gamma Survey Locations
- ∇ Investigative Area
- HPGe Data Ranges**
 - Below Tier II Action Levels
 - ▒ Exceeds Tier II Action Levels
 - ▓ Exceeds Tier I Action Levels
- Surface Soil Data Ranges**
 - △ Below Tier II Action Levels
 - ▲ Exceeds Tier II Action Levels
- TR = Trench
- HPGe = HPGe Measurement
- AME = Actinide Migration Evaluation

- Standard Map Features**
- ▒ Steep Topography
 - ▒ Wetland Area
 - ▒ Cement
 - ▒ Buildings and other structures
 - ▒ Lakes and ponds
 - ▒ Streams, ditches, or other drainage features
 - ▒ Fences and other barriers
 - ▒ Contour (20-Foot)
 - ▒ Paved roads
 - ▒ Dirt roads



Scale = 1 : 2180
1 inch represents 180 feet

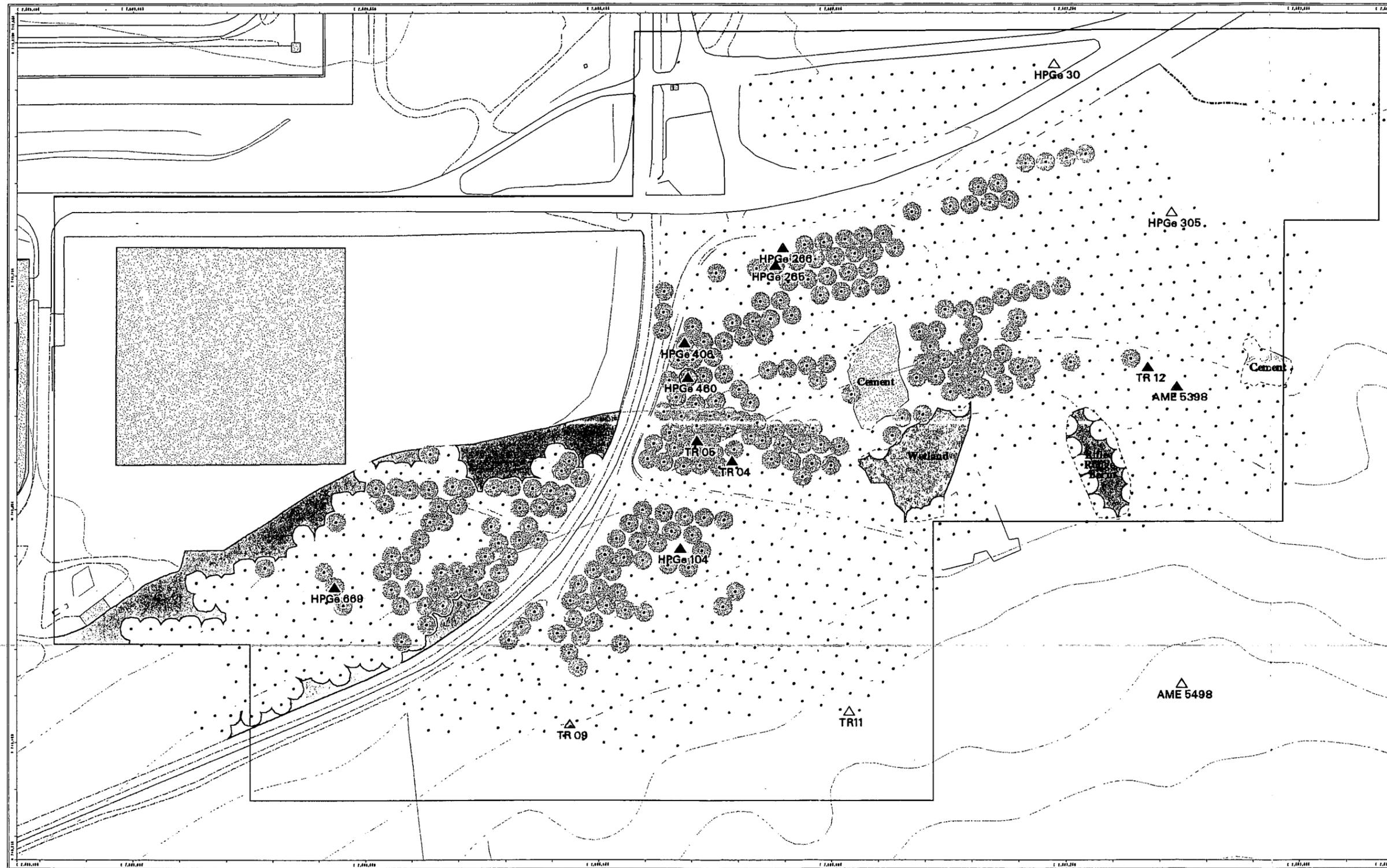


State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

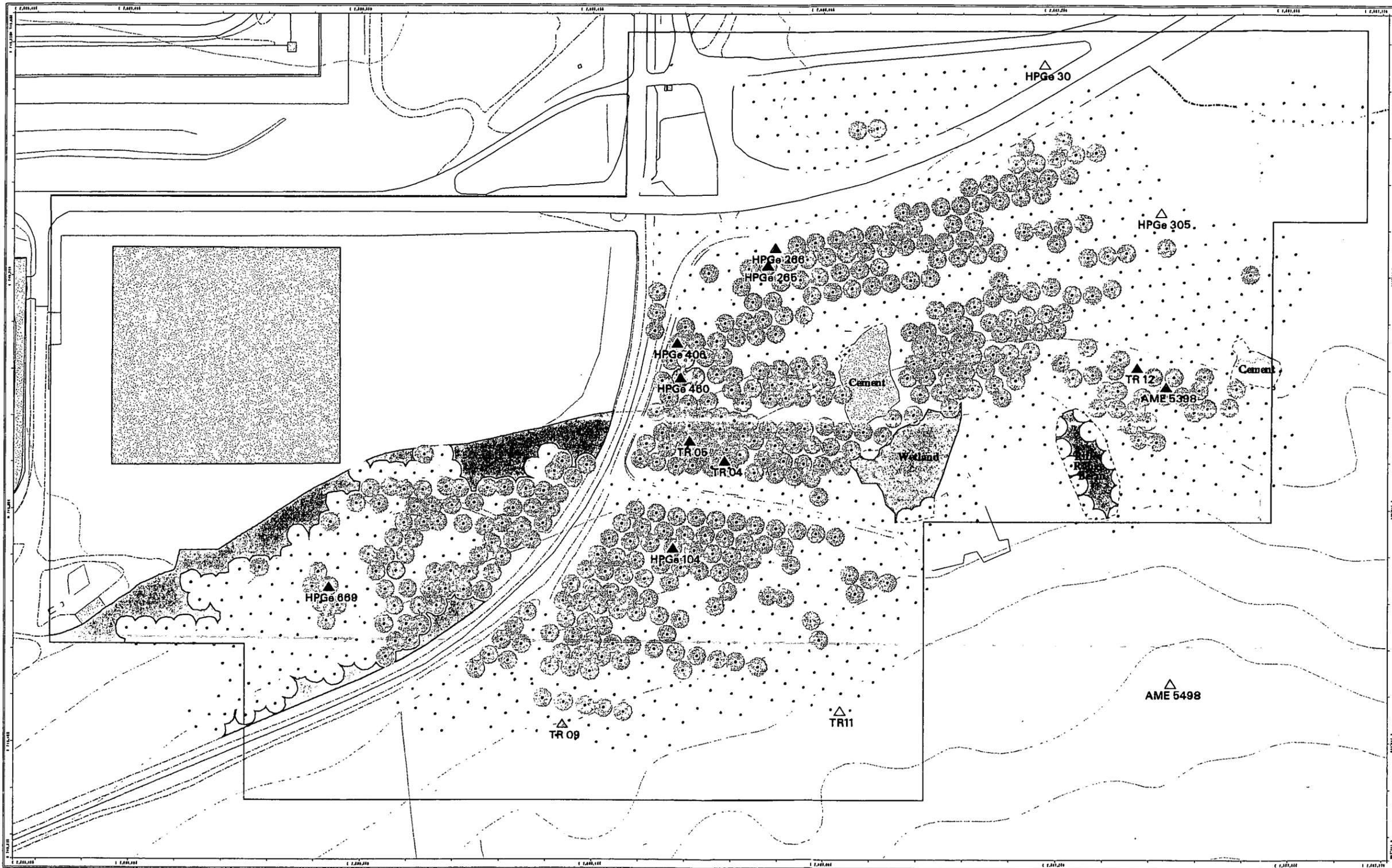
Prepared by:
RMRS Rocky Mountain
Remediation Services, L.L.C.
Geographic Information Systems Group
Rocky Flats Environmental Technology Site
P.O. Box 408
Golden, CO 80402-0408

MAP ID: 00-046 September 16, 1999



49

NT_9r_w:\projects\9809-0445\er_hpge\direct-bb.am



**Characterization Report
for the
903 Drum Storage Area, 903 Lip Area
and Americium Zone**

**RSAL Exceedances in Surface
Soil using Best Fit Line - HPGe Survey**

Figure 2-7

EXPLANATION

- Gamma Survey Locations
- ∇ Investigative Area
- HPGe Data Ranges**
- Below Tier II Action Levels
- ▨ Exceeds Tier II Action Levels
- ▩ Exceeds Tier I Action Levels
- Surface Soil Data Ranges**
- ▲ Below Tier II Action Levels
- ▲ Exceeds Tier II Action Levels
- TR = Trench
- HPGe = HPGe Measurement
- AME = Actinide Migration Evaluation

- Standard Map Features**
- ▨ Steep Topography
- ▨ Wetland Area
- ▨ Cement
- ▨ Buildings and other structures
- ▨ Lakes and ponds
- ▨ Stream, ditches, or other drainage features
- ▨ Fences and other barriers
- ▨ Contour (20-Foot)
- ▨ Paved roads
- ▨ Dirt roads



Scale = 1 : 2100
1 inch represents 180 feet



State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:

RMRS Rocky Mountain Remediation Services, L.L.C.
6400 South University Avenue
Rocky Flats Environmental Technology Site
P.O. Box 504
Golden, CO 80402-0044

50

NT_Srv_w:\projects\9909-04\903\903_bestfit-a.o.m

**Characterization Report
for the
903 Drum Storage Area, 903 Lip Area
and Americium Zone**

**RSAL Exceedances in Surface
Soil using 95% UCL - HPGe Survey**

Figure 2-8

EXPLANATION

- Gamma Survey Locations
- ∇ Investigative Area
- HPGe Data Ranges**
- Below Tier II Action Levels
- ▨ Exceeds Tier II Action Levels
- ▩ Exceeds Tier I Action Levels
- Surface Soil Data Ranges**
- △ Below Tier II Action Levels
- ▲ Exceeds Tier II Action Levels
- TR = Trench
- HPGe = HPGe Measurement
- AME = Actinide Migration Evaluation

- Standard Map Features**
- ▨ Steep Topography
- ▨ Wetland Area
- ▨ Cement
- ▨ Buildings and other structures
- ▨ Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- - - Contour (20-Foot)
- == Paved roads
- - - Dirt roads

Scale = 1 : 2180
1 inch represents 180 feet

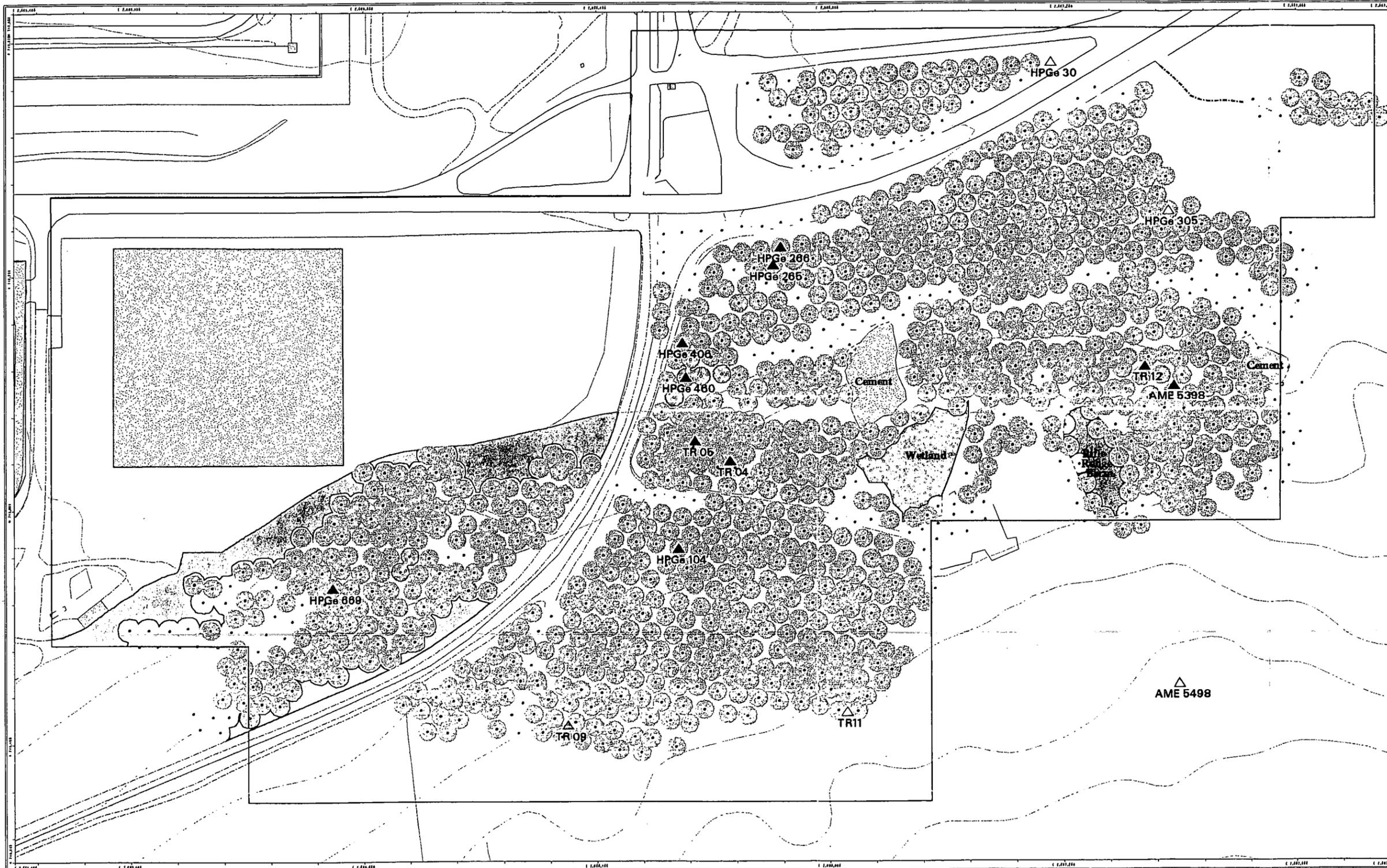
State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U. S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:
RMRS Rocky Mountain
Remediation Services, L.L.C.
Geographic Information Systems Group
Rocky Flats Environmental Technology Site
P.O. Box 400
Golden, CO 80402-0400

MAP ID: 00-0446

September 16, 1999



51

NT_Srv_w/projects/ty99/99-0446/fig_0006-ss.eml

**Characterization Report
for the
903 Drum Storage Area, 903 Lip Area
and Americium Zone**

**Radiological Subsurface
Sampling Locations**

Figure 2-12

EXPLANATION

- ▲ Radiological Boreholes, Original
- ▼ Radiological Boreholes, Stepout
- ▨ 1970 Soil Fill Area
- ▩ 1976 Soil Removal Area (approx)
- ▧ 1978 Soil Removal Area (approx)
- ▦ 1984 Soil Removal Area (approx)

Standard Map Features

- ▭ Buildings and other structures
- ▨ Solar Evaporation Ponds (SEP)
- Streams, ditches, or other drainage features
- Fences and other barriers
- - - Contour (5-Foot)
- Paved roads
- - - Dirt roads

DATA SOURCE:
Buildings, fences, hydrographs, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1985 Topology contours were derived from digital elevation model (DEM) data by Morrison Knudsen (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours. The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover II - 10 meter resolution. DEM post-processing performed by MK, Winter 1997.

DISCLAIMER:
Neither the United States Government nor Kaiser Hill Co., nor Rocky Mountain Remediation Services, L.L.C., nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights.

Scale = 1 : 1030
1 inch represents approximately 86 feet



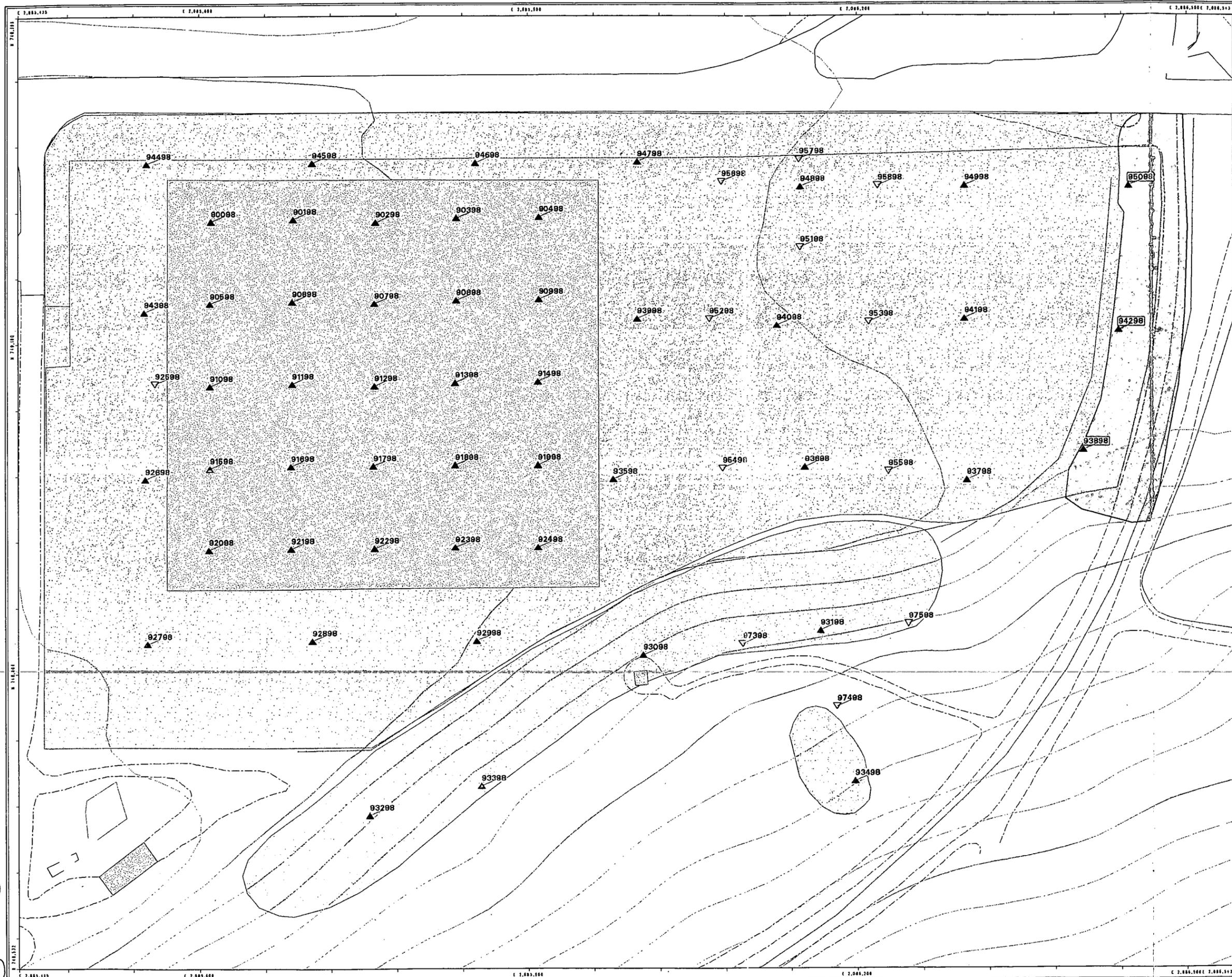
State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:
RMRS Rocky Mountain
Remediation Services, L.L.C.
Geographic Information Systems Group
Rocky Flats Environmental Technology Site
P.O. Box 464
Golden, CO 80402-0464

MAP ID: 89-0408

September 16, 1999



55

NT_Srv:\projects\fy99\89-0408\red_subsurface.am

**Characterization Report
for the
903 Drum Storage Area,
903 Lip Area
and Americium Zone**

**VOC Investigation
Borehole Location Map**

Figure 2-13

EXPLANATION

- ▲ VOC Boreholes, Original
- ▽ VOC Boreholes, Stepout
- Radiological Borehole where VOC Sample was Collected
- ◇ Groundwater Well

Standard Map Features

- Buildings and other structures
- Solar Evaporation Ponds (SEP)
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (5-Foot)
- Paved roads
- Dirt roads

DATA SOURCE:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G ISL, Las Vegas. Digitized from the orthophotographs. USGS Topology (contours) were derived from digital elevation model (DEM) data by Mountain Remediation Services (MRS) using ESRI Arc Triangulated Irregular Network (TIN) and LAATICE to process the DEM data to create 5-foot contours. The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~10 meter resolution. DEM post-processing performed by MRS, Winter 1997.

DISCLAIMER:
Neither the United States Government nor Kelsci Hill Co., nor Rocky Mountain Remediation Services, L.L.C., nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights.



Scale = 1 : 830
1 inch represents approximately 69 feet



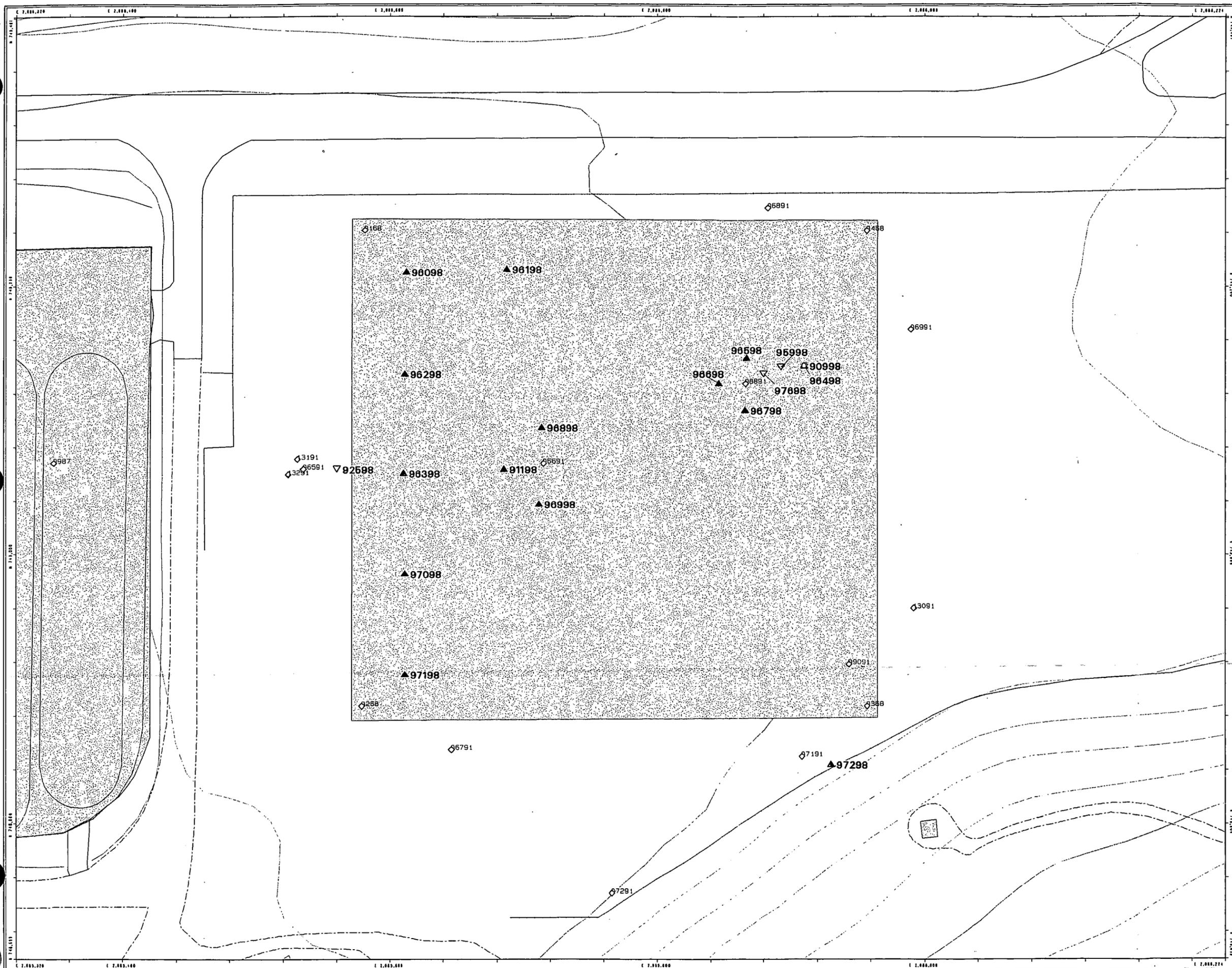
State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:



**Rocky Mountain
Remediation Services, L.L.C.**
Geographic Information Systems Group
Rocky Flats Environmental Technology Site
P.O. Box 464
Golden, CO 80402-0464



50

NT_BVT_w:\projects\1999-0408\veo_borehole.mxd

**Characterization Report
for the
903 Drum Storage Area, 903 Lip Area
and Americium Zone**

**RSAL Exceedances in Surface
Soil using Best Fit Line - HPGe Survey**

Figure 4-2

EXPLANATION

- Gamma Survey Locations
- ∇ Investigative Area
- HPGe Data Ranges**
- Below Tier II Action Levels
- ▨ Exceeds Tier II Action Levels
- ▩ Exceeds Tier I Action Levels
- TR = Trench
- HPGe = HPGe Measurement
- AME = Actinide Migration Evaluation

- Standard Map Features**
- ▨ Steep Topography
 - ▨ Wetland Area
 - ▨ Cement
 - ▨ Buildings and other structures
 - Lakes and ponds
 - Streams, ditches, or other drainage features
 - Fences and other barriers
 - Contour (20-Foot)
 - Paved roads
 - Dirt roads


 Scale = 1 : 2160
 1 inch represents 160 feet

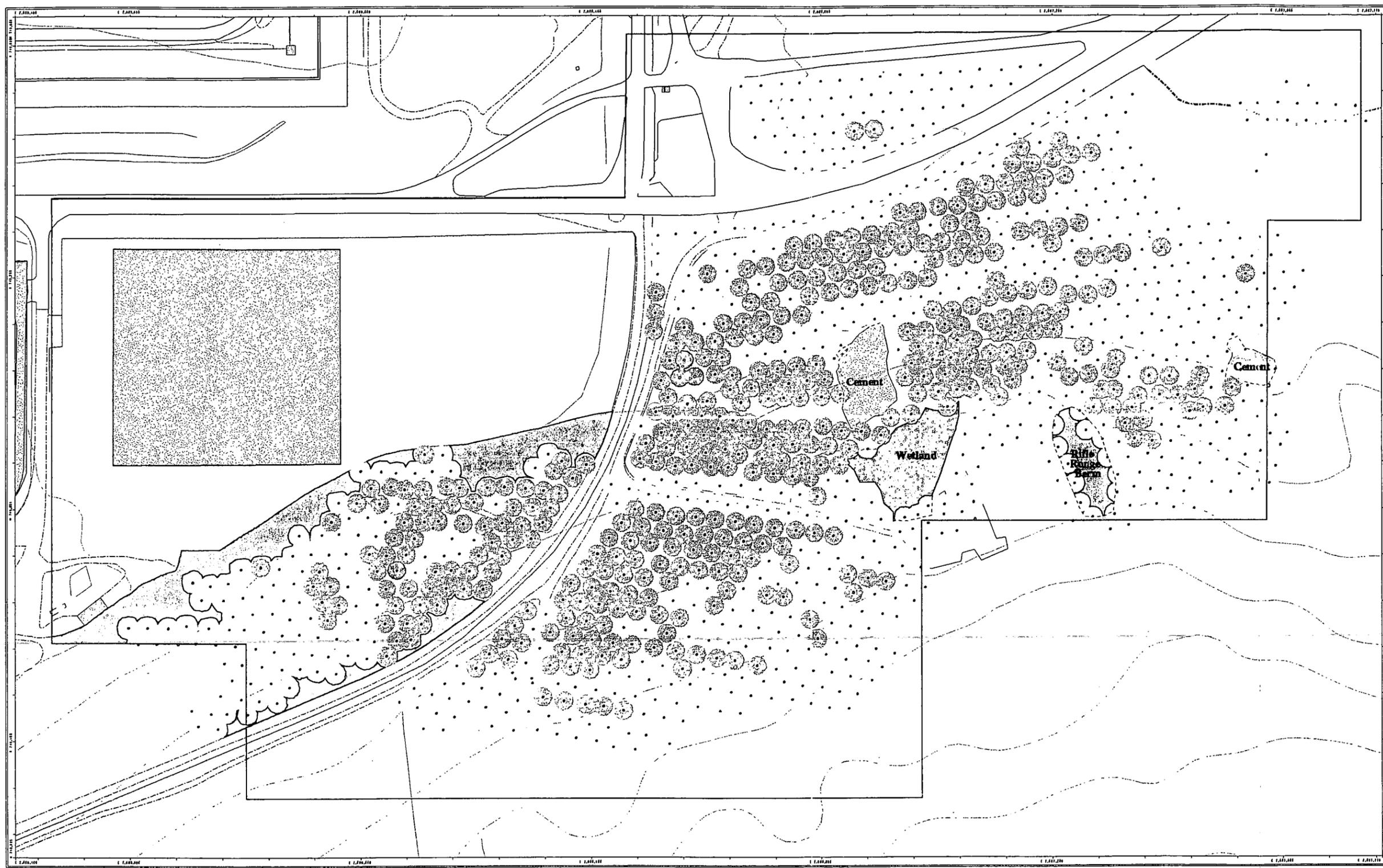
 State Plane Coordinate Projection
 Colorado Central Zone
 Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:



**Rocky Mountain
Remediation Services, L.L.C.**
 Geographic Information Systems Group
 Rocky Flats Environmental Technology Site
 P.O. Box 409
 Golden, CO 80402-0409



NT_Srv_w/projects/99/99-0446/fig_0446_tier_bestfit-bb.am

89

**Characterization Report
for the
903 Drum Storage Area, 903 Lip Area
and Americium Zone**

**Distribution of Am-241 in
Surface Soil - HPGe Survey**

Figure 4-3

EXPLANATION

-  Am-241 Levels and Isoactivity Contour
(Contour Interval = 10 pCi/g)
-  Extent of RFCA Tier I Exceedences
(215 pCi/g)
-  Extent of RFCA Tier II Exceedences
(38 pCi/g)
-  Investigation Area

Standard Map Features

-  Buildings and other structures
-  Fences and other barriers
-  Contour (20-Foot)
-  Paved roads
-  Dirt roads

DATA SOURCE:
Buildings, fences, hydrography, roads and other structures from ESRI aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotograph. US Topology contours were derived from digital elevation model (DEM) data by Microtec Systems (MSK) using ESRI Arc TIN and LUTICE to process the DEM data to create 5-foot contours. The DEM data were captured by the Quercus Surveying Lab, Las Vegas, NV, 1994 Aerial Flyover at ~10 meter resolution. DEM post-processing performed by MK, White 1997.

DISCLAIMER:
Neither the United States Government nor Kidder Inc Co, nor Rocky Mountain Remediation Services, L.L.C., nor any agency thereof, nor any of their employees make any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights.



Scale = 1 : 2410
1 inch represents approximately 201 feet



State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:



**Rocky Mountain
Remediation Services, L.L.C.**
Geographic Information Systems Group
Rocky Flats Environmental Technology Site
P.O. Box 404
Golden, CO 80402-0404

MAP ID: 99-0408

September 15, 1999



90

NT_Srvr:\projects\99\99-0408\am-241.am

**Characterization Report
for the
903 Drum Storage Area, 903 Lip Area
and Americium Zone**

**Distribution of Pu-239/240 in
Surface Soil - HPGe Survey**

Figure 4-4

EXPLANATION

-  Pu-239/240 Levels and Isoactivity Contour
(Contour Interval = 100 pCi/g)
-  Extent of RFCA Tier I Exceedances
(1429 pCi/g)
-  Extent of RFCA Tier II Exceedances
(252 pCi/g)
-  Investigation Area

Standard Map Features

-  Buildings and other structures
-  Fences and other barriers
-  Contour (20-Foot)
-  Paved roads
-  Dirt roads

DATA SOURCE:
Buildings, fences, hydrographs, roads and other structures from 1998 aerial fly-over data captured by EG&G RSI, Las Vegas. Digitized from the orthophotographs. USGS Topography (contours) were derived from digital elevation model (DEM) data by Morrison Knudsen (M&K) using ESRI Arc TIN and LUTICE to process the DEM data to create 5-foot contours. The DEM data were captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at 10 meter resolution. DEM post-processing performed by M&K, Winter 1997.

DISCLAIMER:
Neither the United States Government nor Kolar Hill Co., nor Rocky Mountain Remediation Services, L.L.C., nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights.



Scale = 1 : 2410
1 inch represents approximately 201 feet



State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:



**Rocky Mountain
Remediation Services, L.L.C.**
Geographic Information Systems Group
Rocky Flats Environmental Technology Site
P.O. Box 454
Golden, CO 80402-0454

MAP ID: 99-0408

September 16, 1999

N:_svr\w\projects\fy99\99-0408\pu-239-40.am



91

**Characterization Report
for the
903 Drum Storage Area, 903 Lip Area
and Americium Zone**

**RSAL Exceedances in
Native 1 Soil Horizon**

Figure 4-6

EXPLANATION

Boreholes locations

- Location
- Sample Depth (ft.)
- Tier I Sum of Ratio
- Tier II Sum of Ratio

Exceed Tier I

Exceed Tier II

Standard Map Features

- ▭ Buildings and other structures
- ▭ Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (20-Foot)
- Paved roads
- Dirt roads

DATA SOURCE:
Buildings, fences, hydrography, roads and other structures from 1958 aerial fly-over data captured by EG&G RSI, Las Vegas.
Digitized from the orthophotographs, 1995.
Topography (contours) were derived from digital elevation model (DEM) data by Morrison Knudsen (MK) using ESRI Arc TIN and LRTICE to process the DEM data to create 5-foot contours. The DEM data were captured by the Remotely Sensed Data, Las Vegas, NV, 1994 Aerial Flyover at ~10 meter resolution. DEM post-processing performed by MK, Winter 1997.

DISCLAIMER:
Neither the United States Government nor Lockheed Martin Corp., nor Rocky Mountain Remediation Services, L.L.C., nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, opinions, products, or processes disclosed, or represents that they would not infringe privately owned rights.

Scale = 1 : 1280
1 inch represents approximately 108 feet



State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

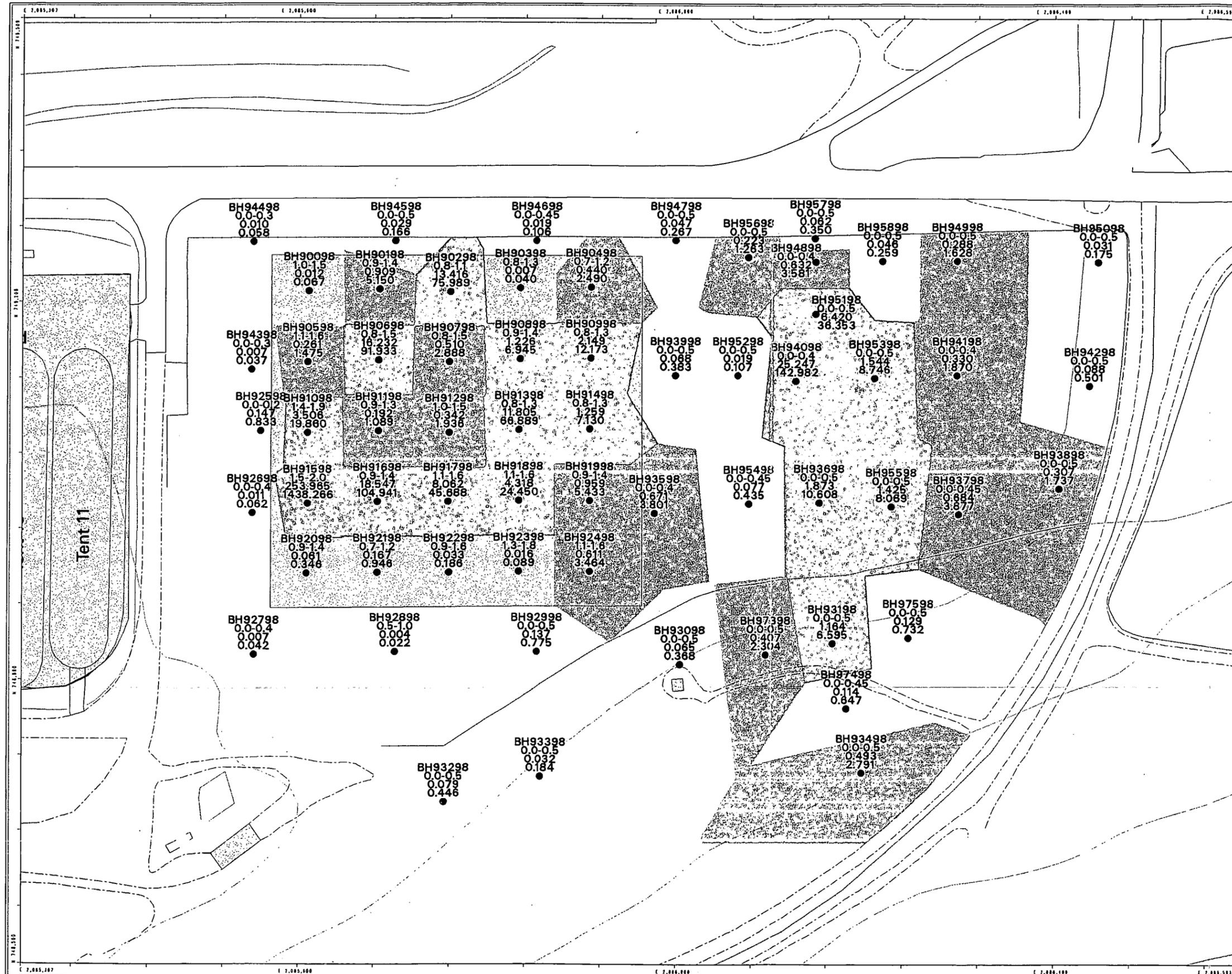
Prepared by:



Rocky Mountain
Remediation Services, L.L.C.
Geographic Information Systems Group
Rocky Flats Environmental Technology Site
P.O. Box 484
Golden, CO 80402-0484

MAP ID: 99-0408

September 15, 1999



93

N_T_Srv_w:\projects\99\99-0408\99-04082\am\hpge-908pad_thee.am

**Characterization Report
for the
903 Drum Storage Area, 903 Lip Area
and Americium Zone**

**Distribution of Am-241 in
Native 1 Soil Horizon**

Figure 4-7

EXPLANATION

- Am-241 Levels and Isoactivity Contour
(Contour Interval = 2000 pCi/g)
- Extent of RFCA Tier I Exceedances
(215 pCi/g)
- Extent of RFCA Tier II Exceedances
(38 pCi/g)
- Investigation Area
- Borehole Locations
- Standard Map Features**
- Buildings and other structures
- Fences and other barriers
- Contour (20-Foot)
- Paved roads
- Dirt roads

DATA SOURCE:
Buildings, fences, hydrographs, roads and other structures from 1994 aerial fly-over data captured by ECG RSL, Las Vegas. Digitized from the orthophotography. 1/95
Topology (contours) were derived from digital elevation model (DEM) data by Mountain Remediation (MR) using ESRI Arc 1W and LANTICE to process the DEM data to create 5-foot contours. The DEM data was captured by the Hamette Stamping Lab, Las Vegas, NV, 1994. Aerial Flyover at 1:10 meter resolution. DEM post-processing performed by MK, Winter 1997.

DISCLAIMER:
Neither the United States Government nor Ecolab HCl Co., nor Rocky Mountain Remediation Services, L.L.C., nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights.



Scale = 1 : 1080
1 inch represents 90 feet



State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:
 **Rocky Mountain
Remediation Services, L.L.C.**
Geographic Information Systems Group
Rocky Flats Environmental Technology Site
P.O. Box 46
Golden, CO 80402-4484

MAP ID: 98-0408

September 15, 1999



94

NT_Srv:\projects\fy98\98-0408\em_r1.em

**Characterization Report
for the
903 Drum Storage Area, 903 Lip Area
and Americium Zone**

**Distribution of Pu-239/240 in
Native 1 Soil Horizon**

Figure 4-8

EXPLANATION

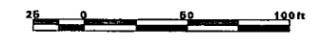
- Pu-239/240 Levels and Isoactivity Contour (Contour Interval = 10,000 pCi/g)
 - Extent of RFCA Tier I Exceedances (1429 pCi/g)
 - Extent of RFCA Tier II Exceedances (252 pCi/g)
 - Investigation Area
 - Borehole Locations
- Standard Map Features**
- Buildings and other structures
 - Fences and other barriers
 - Contour (20-Foot)
 - Paved roads
 - Dirt roads

DATA SOURCE:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSI, Las Vegas. Digitized from the orthophotograph. USGS Topology (contours) were derived from digital elevation model (DEM) data by Morrison Knudsen (MK) using ESRI Arc 7M and LANTICE to process the DEM data to create 5-foot contours. The DEM data were captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~10 meter resolution. DEM post-processing performed by MK, Winter 1997.

DISCLAIMER:
Neither the United States Government nor EG&G RSI Co., nor Rocky Mountain Remediation Services, L.L.C., nor any agency thereof, nor any of their employees, make any warranty, express or implied, or assume any legal liability or responsibility for the accuracy, completeness, or availability of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights.



Scale = 1 : 1080
1 inch represents 90 feet



State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

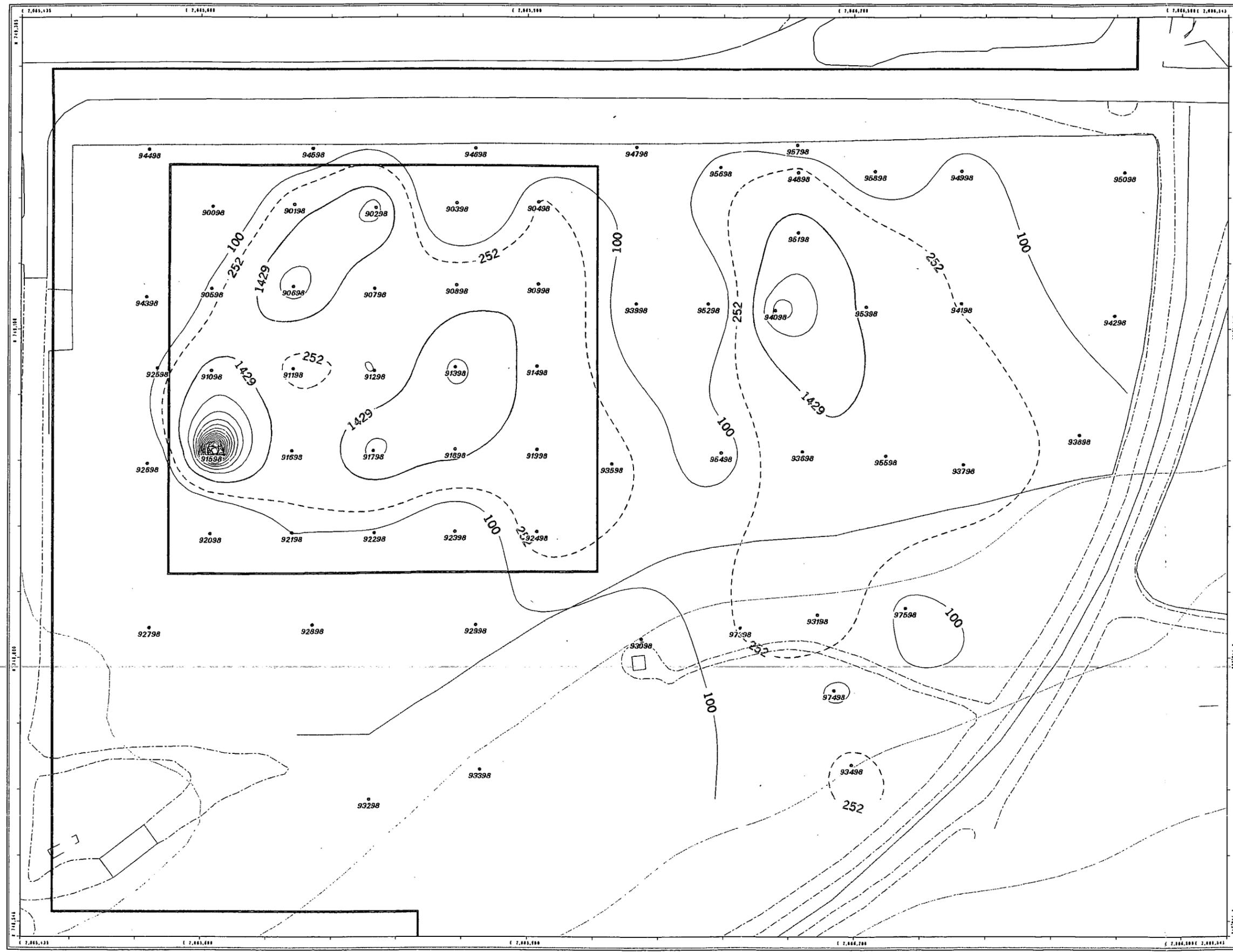
U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:



**Rocky Mountain
Remediation Services, L.L.C.**
Geographic Information Systems Group
Rocky Flats Environmental Technology Site
P.O. Box 484
Golden, CO 80402-0484

MAP ID: 99-0406 September 15, 1999



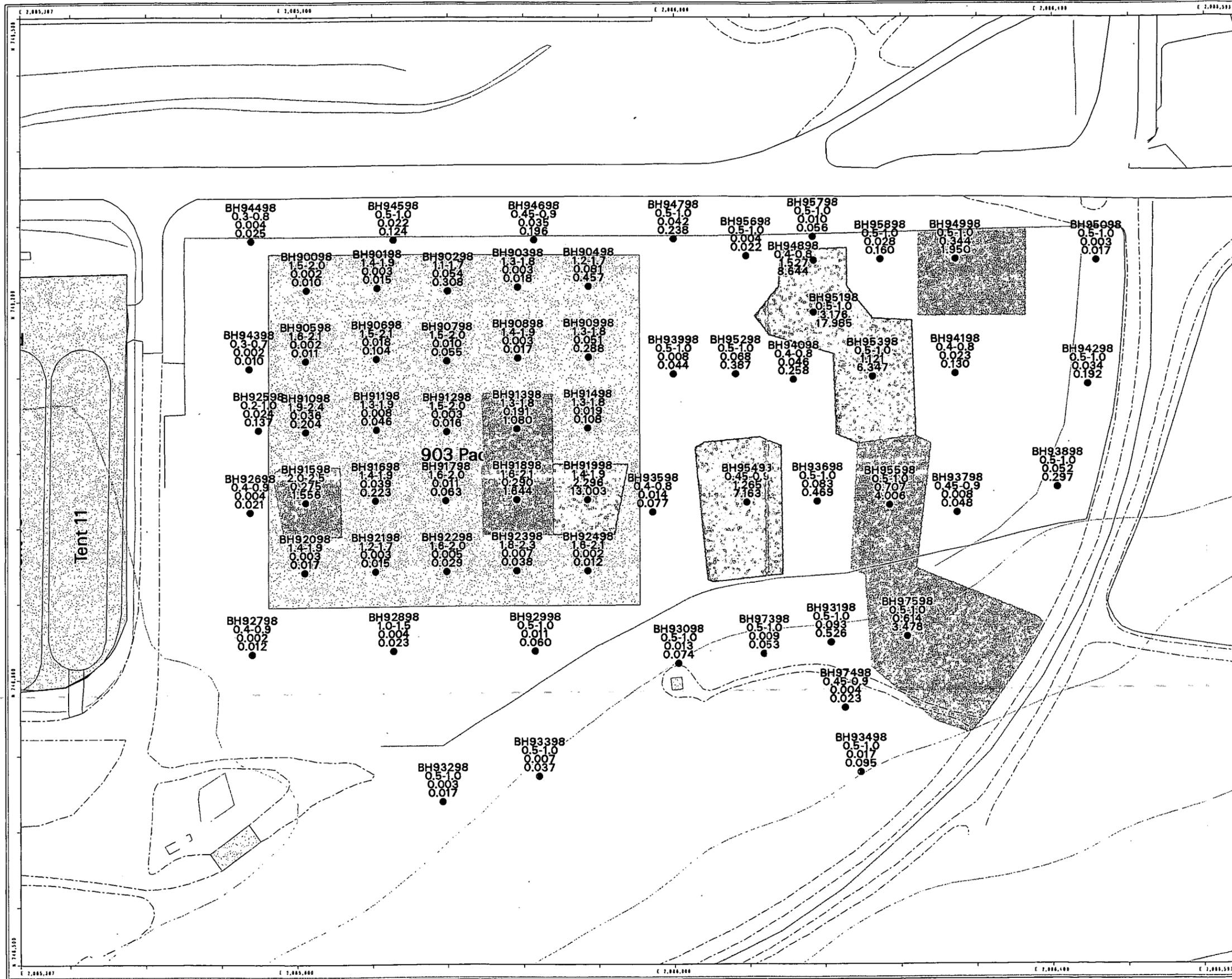
95

NT_Srv_w:\projects\fy99\99-0408\pu_n1.mxd

**Characterization Report
for the
903 Drum Storage Area, 903 Lip Area
and Americium Zone**

**RSAL Exceedances in
Native 2 Soil Horizon**

Figure 4-9



EXPLANATION

Boreholes locations

- Location
- Sample Depth (ft.)
- Tier I Sum of Ratio
- Tier II Sum of Ratio

Exceed Tier I

Exceed Tier II

Standard Map Features

- ▨ Buildings and other structures
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (20-Foot)
- Paved roads
- Dirt roads

DATA SOURCE:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs, 1995. Topology (contours) were derived from digital elevation model (DEM) data by Morrison Knudsen (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours. The DEM data was captured by the Racote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at 10 meter resolution. DEM post-processing performed by MK, Winter 1997.

DISCLAIMER:
Neither the United States Government nor Lockheed Martin Corp., nor Rocky Mountain Remediation Services, L.L.C., nor any agency thereof, nor any of their subcontractors, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, opinions, products, or processes disclosed, or represents that its use would not infringe privately owned rights.

Scale = 1 : 1290
1 inch represents approximately 108 feet



State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:

**Rocky Mountain
Remediation Services, L.L.C.**
Geographic Information Systems Group
Rocky Flats Environmental Technology Site
P.O. Box 464
Golden, CO 80462-0464

96

NT_Srv_w:\projects\9809-0408\98-0082\am\hpge-903pac_this.am

**Characterization Report
for the
903 Drum Storage Area, 903 Lip Area
and Americium Zone**

**Distribution of Am-241 in
Native 2 Soil Horizon**

Figure 4-10

EXPLANATION

-  Am-241 Levels and Isoactivity Contour (Contour Interval = 20 pCi/g)
 -  Extent of RFCA Tier I Exceedances (215 pCi/g)
 -  Extent of RFCA Tier II Exceedances (38 pCi/g)
 -  Investigation Area
 -  Borehole Locations
- Standard Map Features**
-  Buildings and other structures
 -  Fences and other barriers
 -  Contour (20-Foot)
 -  Paved roads
 -  Dirt roads

DATA SOURCE:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EGIS RSI, Las Vegas.
Digitized from the orthophotograph, 1998.
Topography (contours) were derived from digital elevation model (DEM) data by Morrison Knudsen (MK) using ESRI Arc TIN and LATICE to process the DEM data to create 5-foot contours. The DEM data were captured by the Ilmorog Scanning Lab, Las Vegas, NV, 1994 Aerial Flyover at 10 meter resolution. DEM post-processing performed by MK, Winter 1997.

DISCLAIMER:
Neither the United States Government nor KRC/RTI Co., nor Rocky Mountain Remediation Services, L.L.C., nor any agency thereof, nor any of their employees, makes any warranty, expressed or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights.



Scale = 1 : 1080
1 Inch represents 90 feet



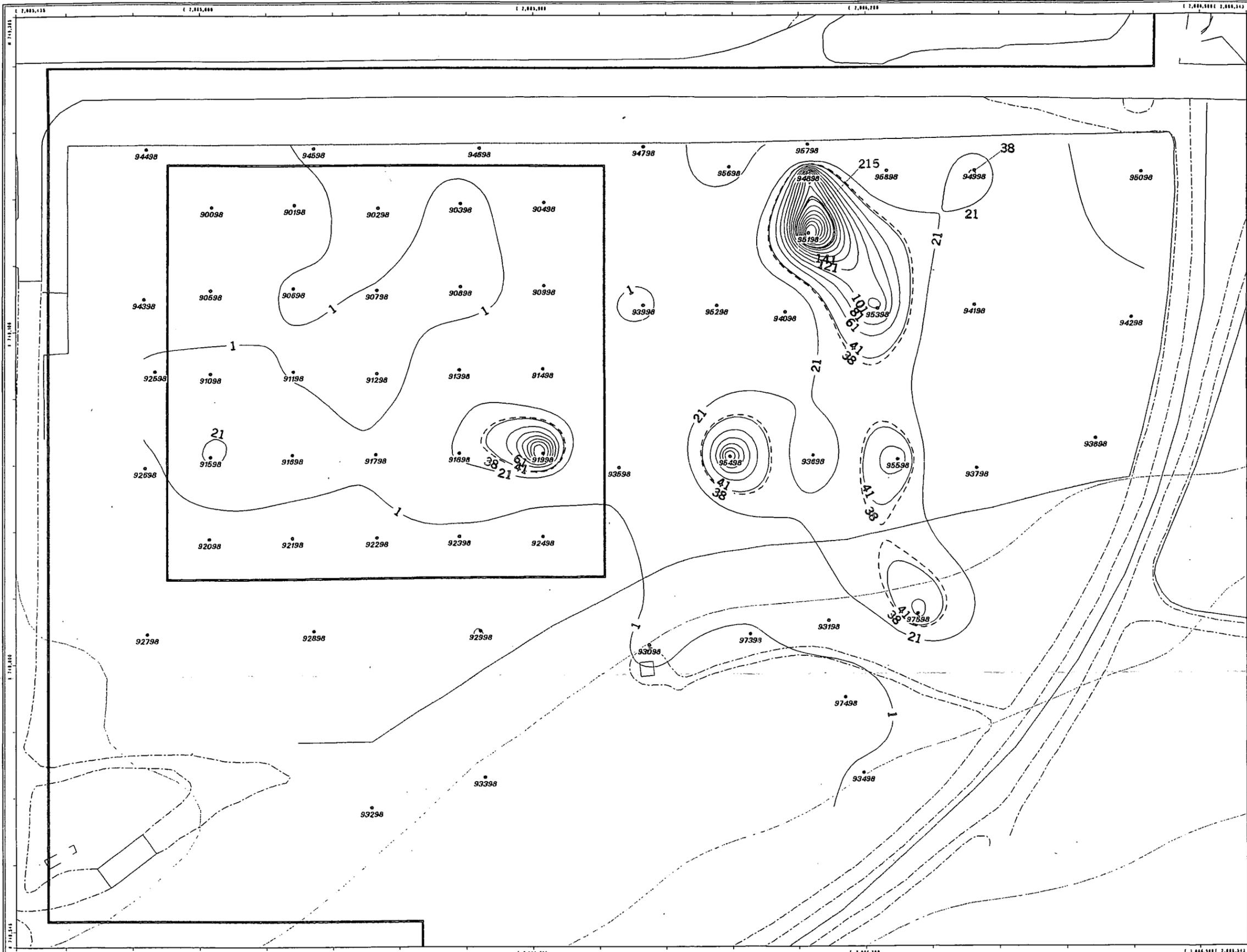
State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:
 **Rocky Mountain
Remediation Services, L.L.C.**
Geographic Information Systems Group
Rocky Flats Environmental Technology Site
P.O. Box 404
Golden, CO 80402-2404

MAP ID: 98-0408

September 15, 1999



97

NT_Srv w:\projects\fy98\98-0408\am_n2.am

**Characterization Report
for the
903 Drum Storage Area, 903 Lip Area
and Americium Zone**

**Distribution of Pu-239/240 in
Native 2 Soil Horizon**

Figure 4-11

EXPLANATION

-  Pu-239/240 Levels and Isoactivity Contour
(Contour Interval = 100 pCi/g)
 -  Extent of RFCA Tier I Exceedances
(1429 pCi/g)
 -  Extent of RFCA Tier II Exceedances
(252 pCi/g)
 -  Investigation Area
 -  Borehole Locations
- Standard Map Features**
-  Buildings and other structures
 -  Fences and other barriers
 -  Contour (20-Foot)
 -  Paved roads
 -  Dirt roads

DATA SOURCE:
Buildings, fences, hydrographs, roads and other structures from 1994 aerial fly-over data captured by EG&G RSI, Las Vegas. Digitized from the orthophotographs. 1/95 Topology (contours) were derived from digital elevation model (DEM) data by Morrison Knudsen (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours. The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at 10 meter resolution. DEM post-processing performed by MK, Winter 1997.

DISCLAIMER:
Neither the United States Government nor KBR HCT Co., or Rocky Mountain Remediation Services, L.L.C., nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights.

Scale = 1 : 1090
1 inch represents 90 feet



State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:



**Rocky Mountain
Remediation Services, L.L.C.**
Geographic Information Systems Group
Rocky Flats Environmental Technology Site
P.O. Box 484
Golden, CO 80402-4484



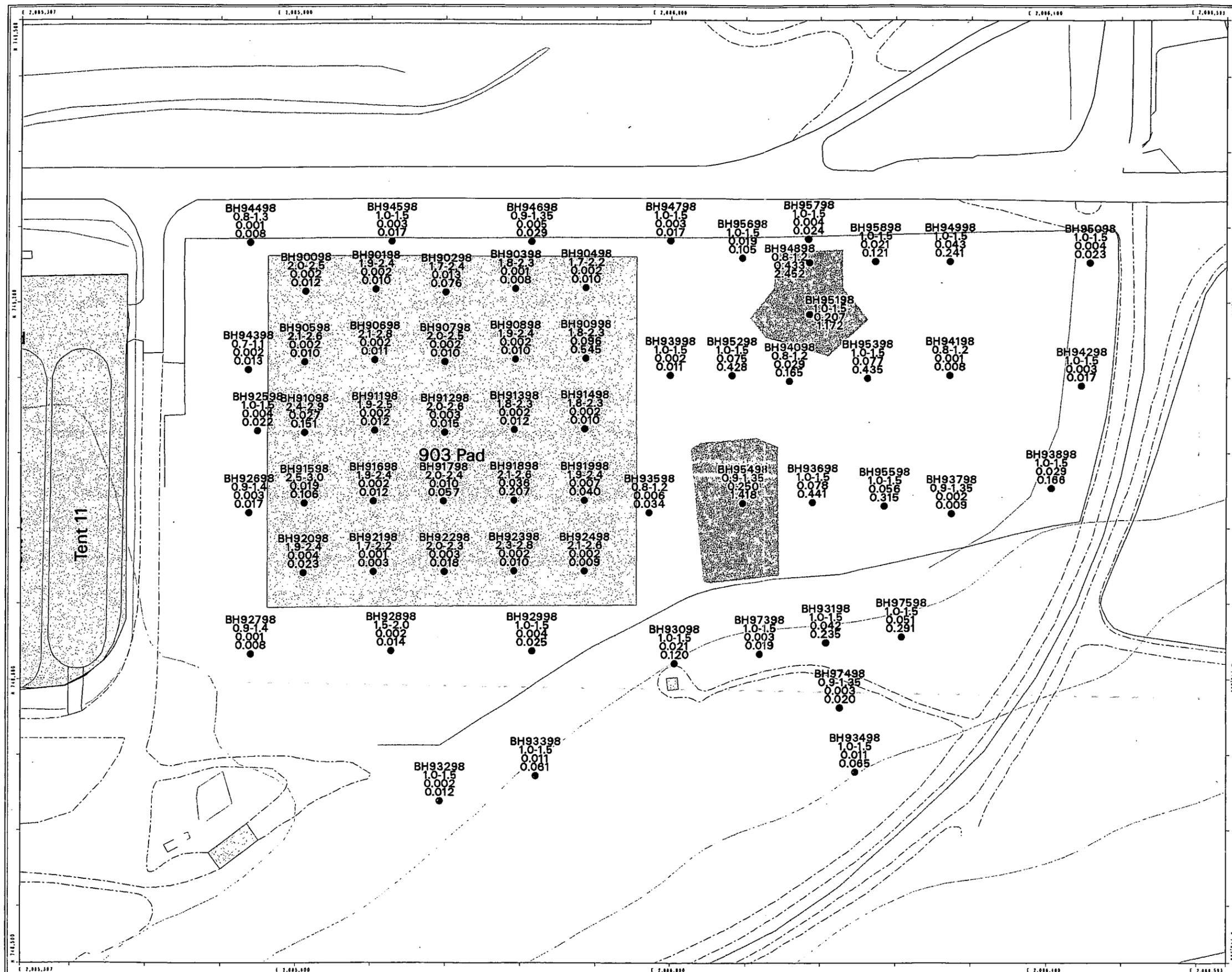
98

NT_Srv_w:\projects\99\99-0408\pu_n2_e.m

**Characterization Report
for the
903 Drum Storage Area, 903 Lip Area
and Americium Zone**

**RSAL Exceedances in
Native 3 Soil Horizon**

Figure 4-12



EXPLANATION

Boreholes locations

- Location
- Sample Depth (ft.)
- Tier I Sum of Ratio
- Tier II Sum of Ratio

Exceed Tier I

Exceed Tier II

Standard Map Features

- ▨ Buildings and other structures
- ▭ Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (20-Foot)
- Paved roads
- Dirt roads

DATA SOURCE:

Buildings, fences, hydrographs, roads and other structures from 1994 aerial fly-over data captured by EG&G RSI, Las Vegas. Digitized from the orthophotographs, 1/95. Topology (contours) were derived from digital elevation model (DEM) data by Mountain Remediation (MR) using ESRI Arc 7M and LATTICE to process the DEM data to create 5-foot contours. The DEM data were captured by the Remote Sensing Lab, Las Vegas, NV, using Aerial Frame at 10 meter resolution. DEM post-processing performed by MK, Winter 1997.

DISCLAIMER:

Neither the United States Government nor EG&G RSI Co., nor Rocky Mountain Remediation Services, L.L.C., nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights.

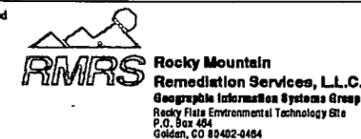
Scale = 1 : 1290
1 inch represents approximately 108 feet



State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:



MAP ID: 99-0409

September 15, 1999

NT_Svr_w:\projects\fy99\99-0409\99-0062\am\hpgs-903pad_thes.eam

99

**Characterization Report
for the
903 Drum Storage Area, 903 Lip Area
and Americium Zone**

**Distribution of Am-241 in
Native 3 Soil Horizon**

Figure 4-13

EXPLANATION

-  Am-241 Levels and Isoactivity Contour
(Contour Interval = 5 pCi/g)
 -  Extent of RFCA Tier I Exceedances
(215 pCi/g)
 -  Extent of RFCA Tier II Exceedances
(38 pCi/g)
 -  Investigation Area
 -  Borehole Locations
- Standard Map Features**
-  Buildings and other structures
 -  Fences and other barriers
 -  Contour (20-Foot)
 -  Paved roads
 -  Dirt roads

DATA SOURCE:
Buildings, fences, hydrographs, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1995 Topography (contours) were derived from digital elevation model (DEM) data by Morrison Knudsen (MK) using ESRI Arc TIN and LANTICE to process the DEM data to create 5-foot contours. The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~ 10 meter resolution. DEM post-processing performed by MK, Winter 1997.

DISCLAIMER:
Neither the United States Government nor KBR HCl Co., nor Rocky Mountain Remediation Services, L.L.C., nor any agency thereof, nor any of their employees, make any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights.



Scale = 1 : 1090
1 inch represents 90 feet



State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

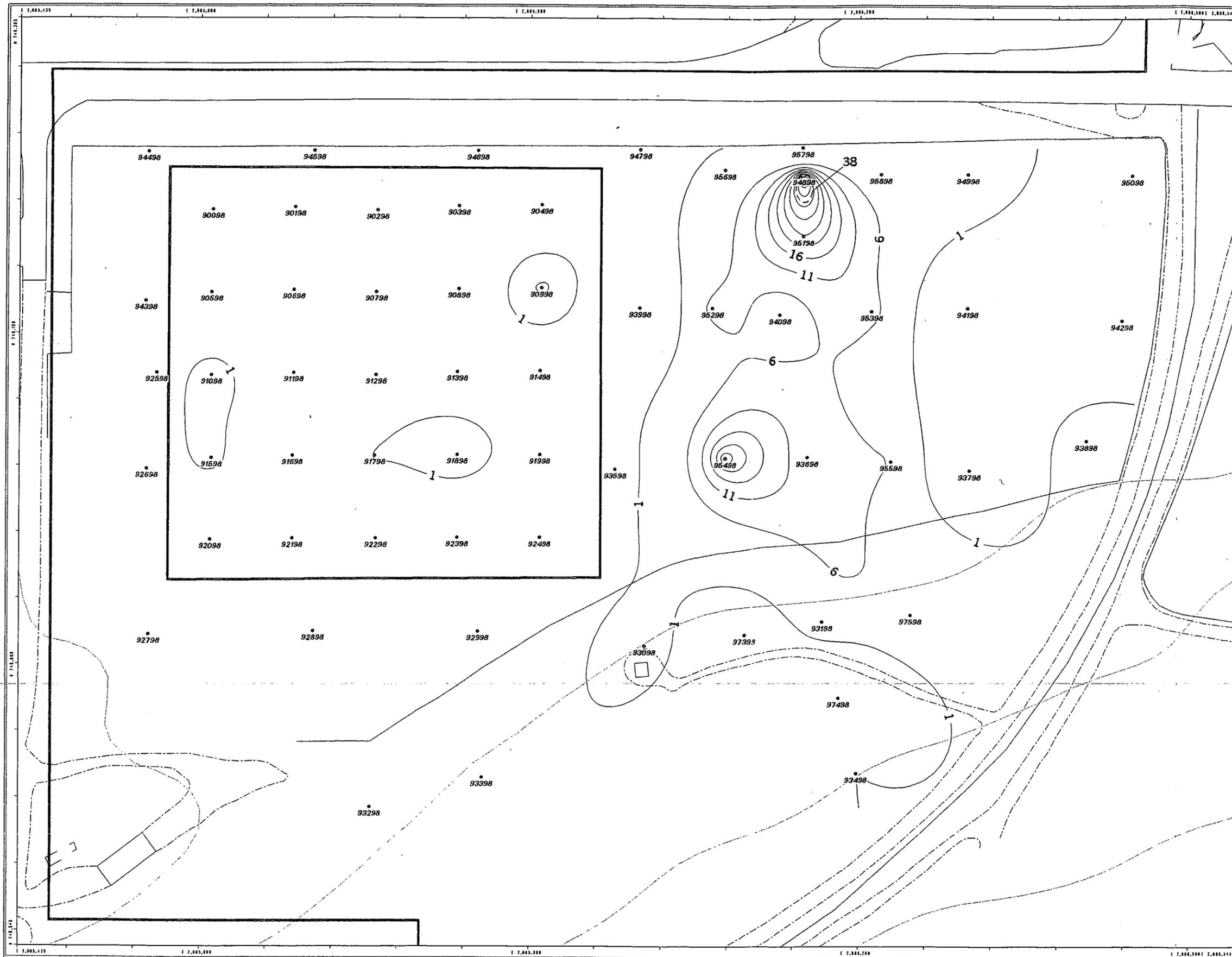
Prepared by:



**Rocky Mountain
Remediation Services, L.L.C.**
Geographic Information Systems Group
Rocky Flats Environmental Technology Site
P.O. Box 484
Golden, CO 80402-0484

MAP ID: 99-0408

September 15, 1999



100

NT_Srvr:\projects\fy99\89-0408\am_n3.m

**Characterization Report
for the
903 Drum Storage Area, 903 Lip Area
and Americium Zone**

**Distribution of Pu-239/240 in
Native 3 Soil Horizon**

Figure 4-14

EXPLANATION

-  Pu-239/240 Levels and Isoactivity Contour
(Contour Interval = 20 pCi/g)
-  Extent of RFCA Tier I Exceedances
(1429 pCi/g)
-  Extent of RFCA Tier II Exceedances
(252 pCi/g)
-  Investigation Area
-  Borehole Locations

Standard Map Features

-  Buildings and other structures
-  Fences and other barriers
-  Contour (20-Foot)
-  Paved roads
-  Dirt roads

DATA SOURCE:
Buildings, fences, hydrography, roads and other structures from 1994 aerial Li-cams data captured by EG&G RSL, Las Vegas. Digitized from the orthophotograph. USGS Topology (contours) were derived from digital elevation model (DEM) data by Morrison Knudsen (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours. The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at 10 meter resolution. DEM post-processing performed by MK, Winter 1997.

DISCLAIMER:
Neither the United States Government nor EG&G RSL, nor Rocky Mountain Remediation Services, L.L.C., nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights.



Scale = 1 : 1080
1 inch represents 90 feet



State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

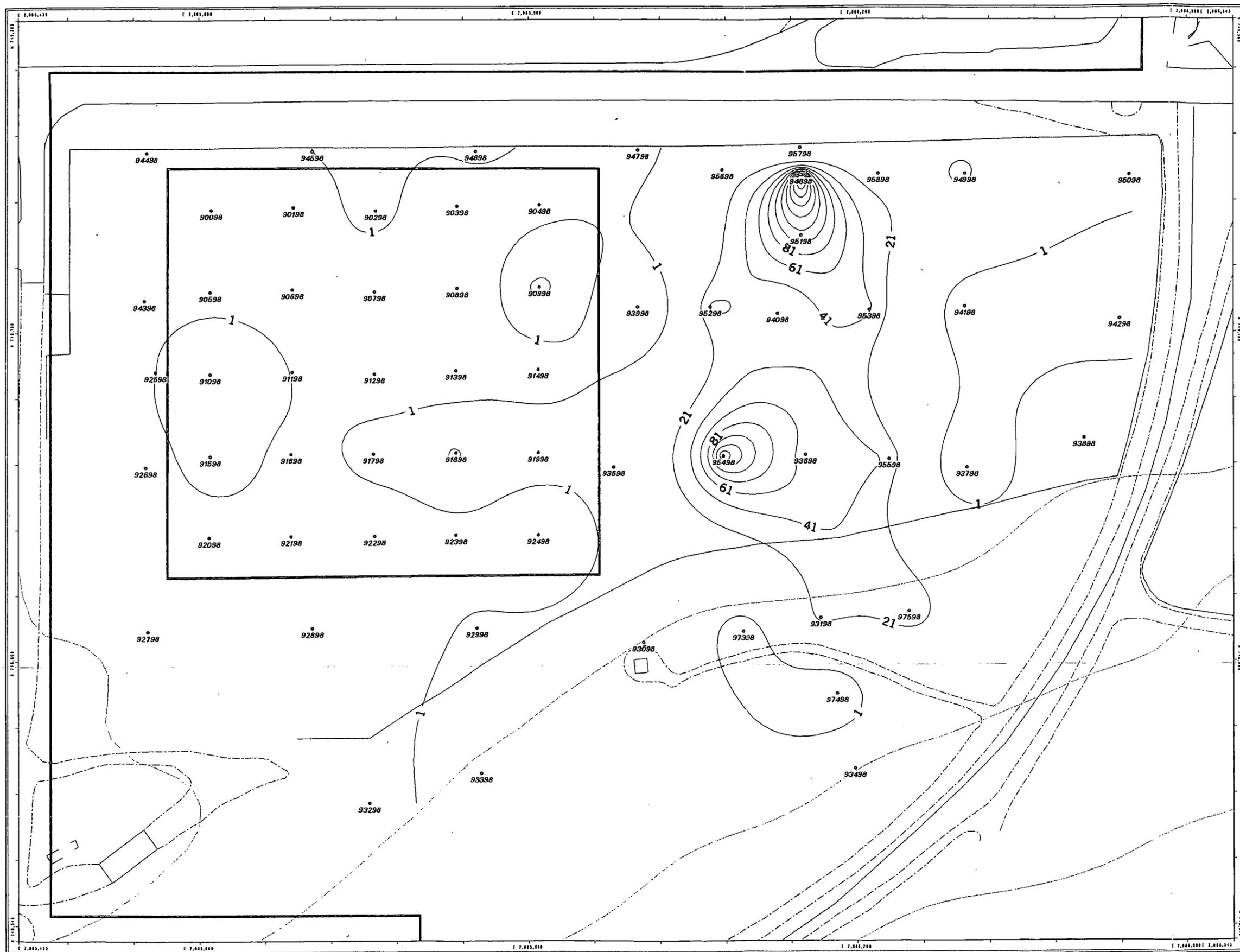
U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:



**Rocky Mountain
Remediation Services, L.L.C.**
Geographic Information Systems Group
Rocky Flats Environmental Technology Site
P.O. Box 464
Golden, CO 80402-0464

MAP ID: 99-0408 September 15, 1999



101

NT_Srv_w:/projects/ty99/99-0408/pu_n8.am

Characterization Report
for the
903 Drum Storage Area, 903 Lip Area
and Americium Zone

Radionuclide Distribution
in Asphalt

Figure 4-15

EXPLANATION

Boreholes locations

- Location
- Sample Depth (ft.)
- AM241 (pCi/g)
- PU239/240 (pCi/g)
- U233/234 (pCi/g)
- U235 (pCi/g)
- U238 (pCi/g)

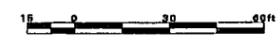
Standard Map Features

- Buildings and other structures
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (5-Foot)
- == Paved roads
- Dirt roads

DATA SOURCE
Buildings, fences, hydrography, roads and other structures from 1984 aerial flyover data captured by EG&G FSL, Las Vegas. Digitized from the orthophotograph, 1985. Topology (contours) were derived from digital elevation model (DEM) data by Intersect (Intersect) and LATTICE to process the DEM data to create 5-foot contours. The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1984 Aerial Flyover at ~10 meter resolution. DEM post-processing performed by M.K. Wicker 1997.



Scale = 1 : 700
1 inch represents approximately 68 feet



State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

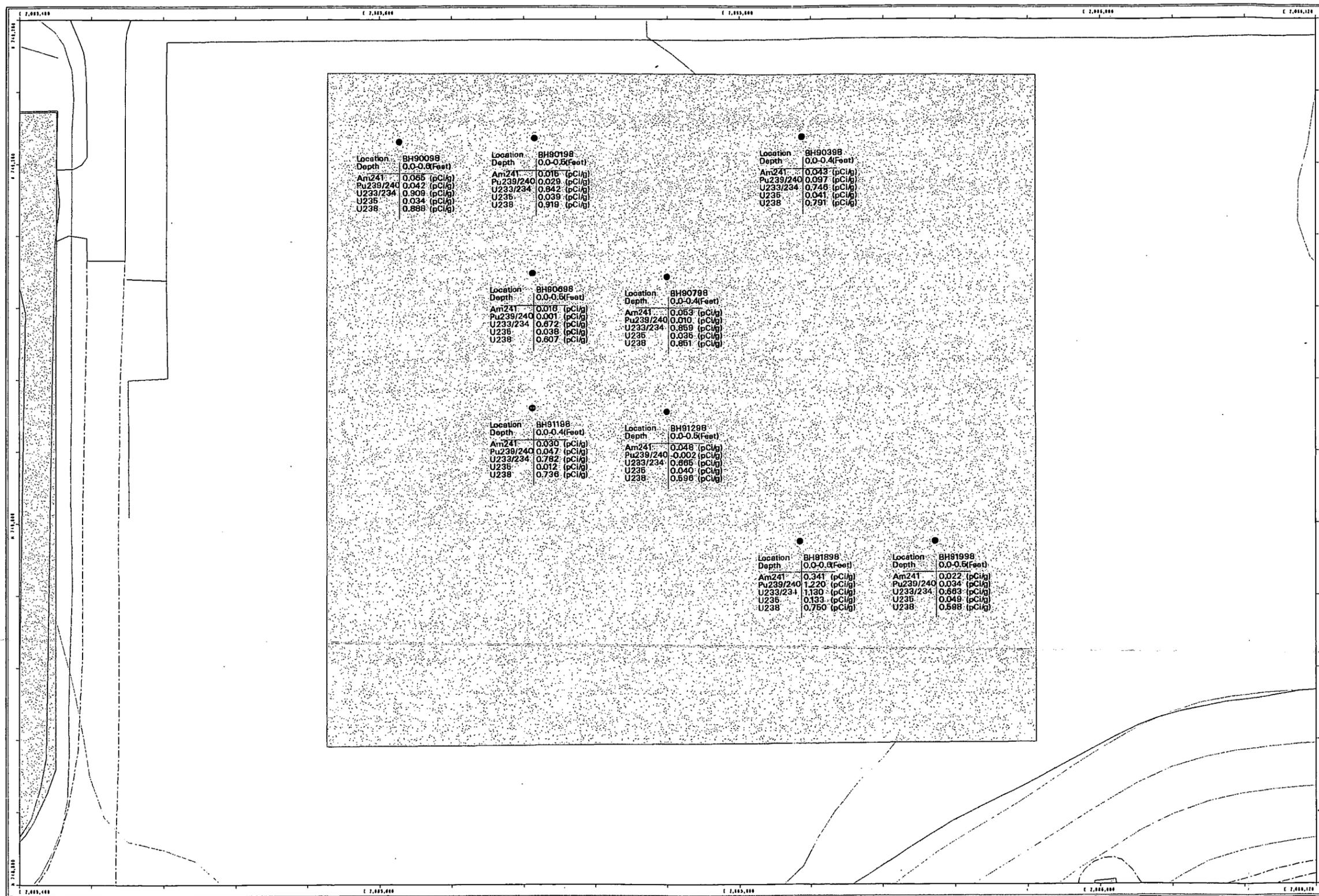
U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:



MAP ID: 89-0409

September 15, 1999



102

NT:8vr:w:/projects/ry99/99-0409/am/1/asphalt-bh_nt.am

Characterization Report
for the
903 Drum Storage Area, 903 Lip Area
and Americium Zone

RSAL Exceedances in Artificial
Fill Beneath the 903 Pad

Figure 4-16

EXPLANATION

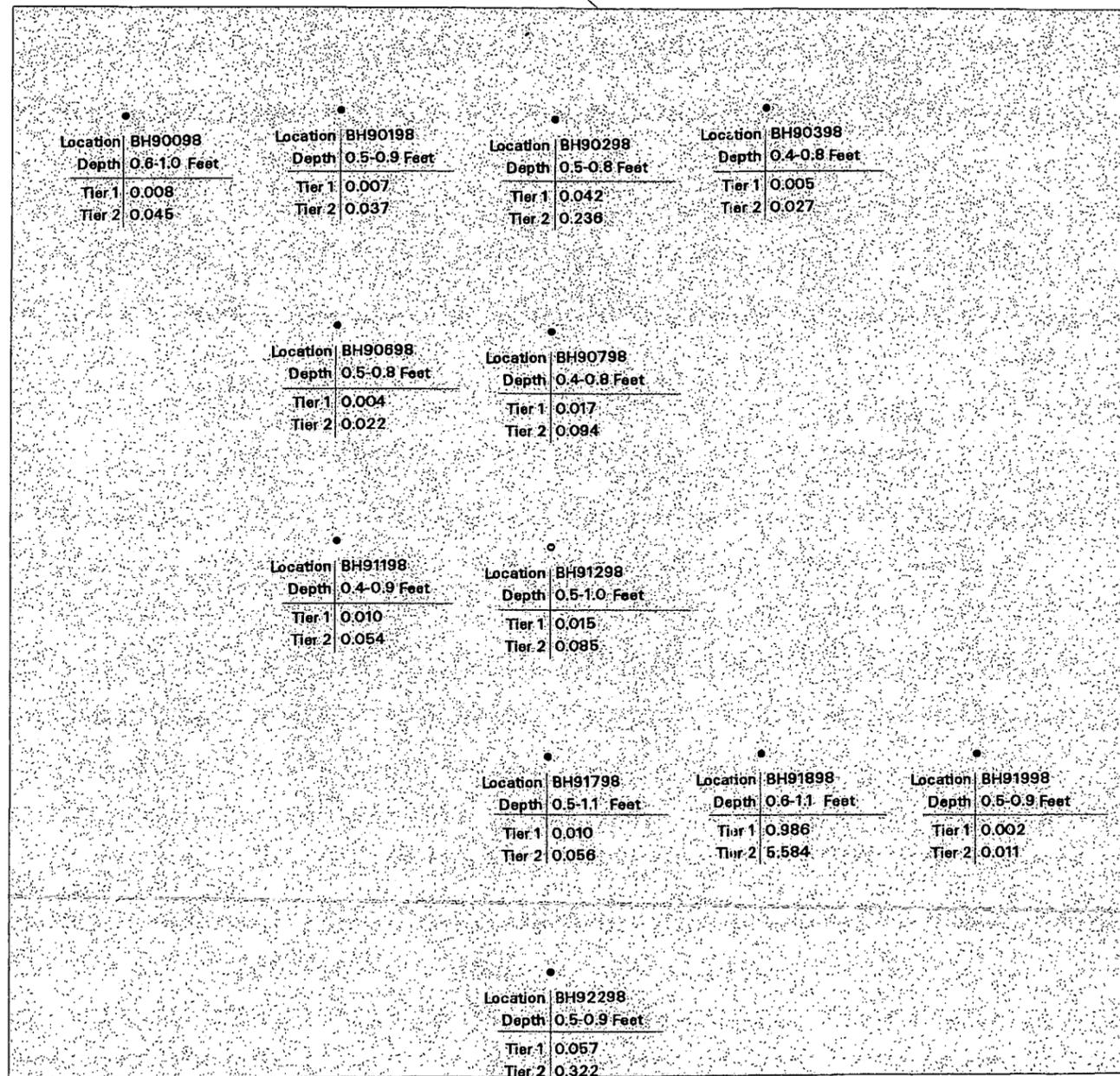
Boreholes locations

- Location
- Sample Depth (ft.)
- Tier I Sum of Ratio
- Tier II Sum of Ratio

Standard Map Features

- ▨ Buildings and other structures
- ▭ Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (5-Foot)
- == Paved roads
- Dirt roads

DATA SOURCE:
Buildings, fences, hydrography roads and other structures from 1994 aerial fly-over data captured by EG&G ASI, Las Vegas.
Digitized from the orthorectified 1985 imagery (coverage) were derived from digital elevation model (DEM) data by Morrison Knudsen (MK) using ESRI Arc 1W and LATNCE to process the DEM data to create 5-foot contours. The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1984 Aerial Flyover at 30 meter resolution. DEM post-processing performed by MK, Winter 1997.



Scale = 1:650
1 inch represents 65 feet



State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:
RMRS Rocky Mountain
Remediation Services, L.L.C.
Geographic Information Systems Group
Rocky Flats Environmental Technology Site
P.O. Box 404
Golden, CO 80402-0404

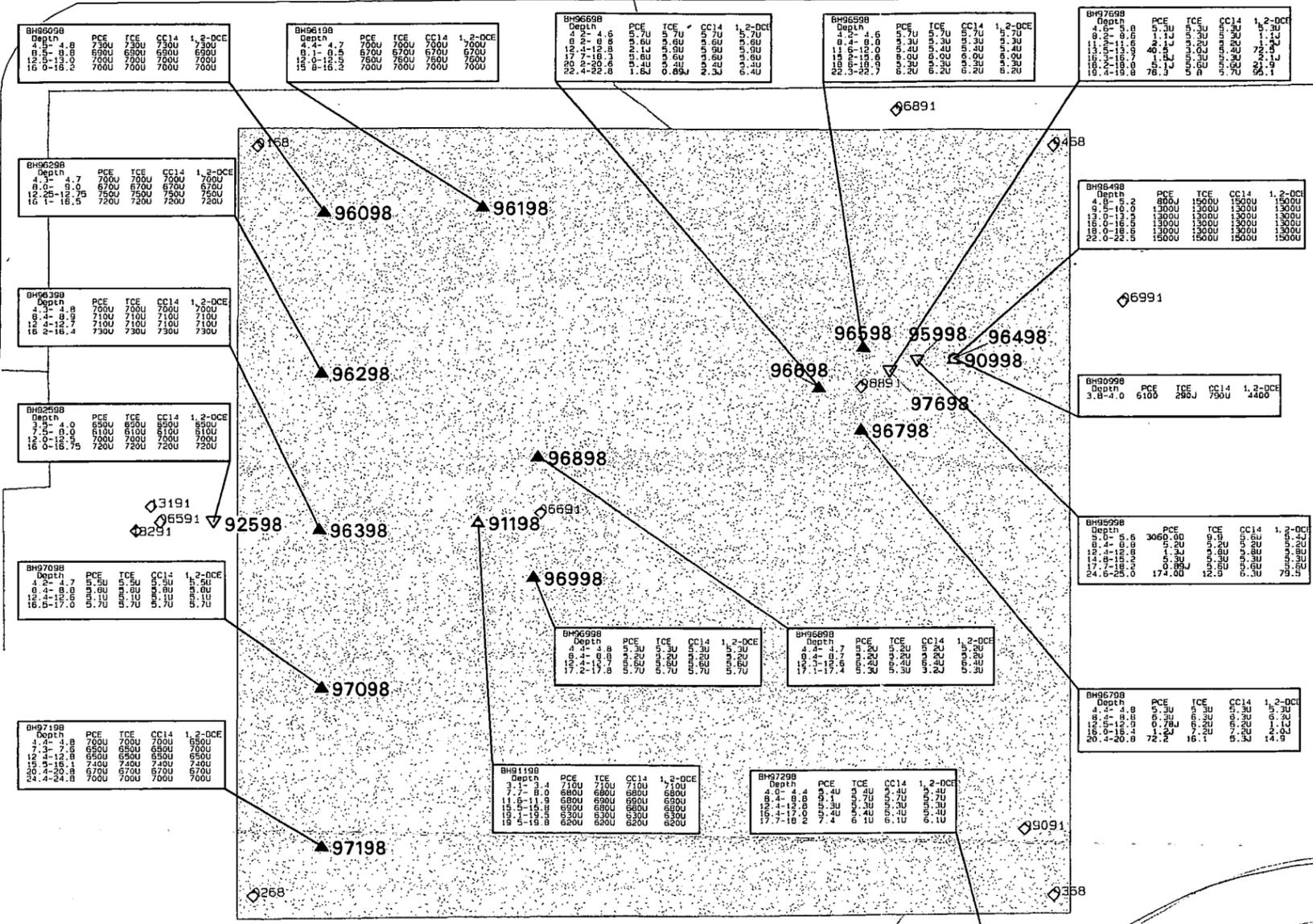
103

NT_Srv_w:\projects\fy99\99-0408\am\map99-003_fill_nt.am

Characterization Report
for the
903 Drum Storage Area, 903 Lip Area
and Americium Zone

VOC Distribution in Soil

Figure 4-18



- EXPLANATION**
- ▲ VOC Boreholes, Original
 - ▽ VOC Boreholes, Stepout
 - Radiological Borehole where VOC Sample was Collected
 - Borehole location
Borehole PCE TCE CCL4 1,2-DCE
Sample Depth Results in Feet
VOC Compound Results in ug/kg
Proposed Tier I Exceedance in red
Proposed Tier II Exceedance in green
 - ◇ Groundwater Well

NOTE:
PCE = Tetrachloroethene
TCE = Trichloroethene
CCL4 = Carbon Tetrachloride
1,2-DCE = 1,2-Cis-Dichloroethylene

U = Undetected, Contract Required
Quantitative Limit
J = Associated Value is an
Estimated Quantity
D = Dilution

- Standard Map Features**
- Buildings and other structures
 - Streams, ditches, or other drainage features
 - Fences and other barriers
 - Contour (5-Foot)
 - Paved roads
 - Dirt roads

DISCLAIMER: Neither the United States Government nor Ketch Hill Co., nor Rocky Mountain Remediation Services, L.L.C., nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights.

Scale = 1 : 830
1 inch represents approximately 69 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:

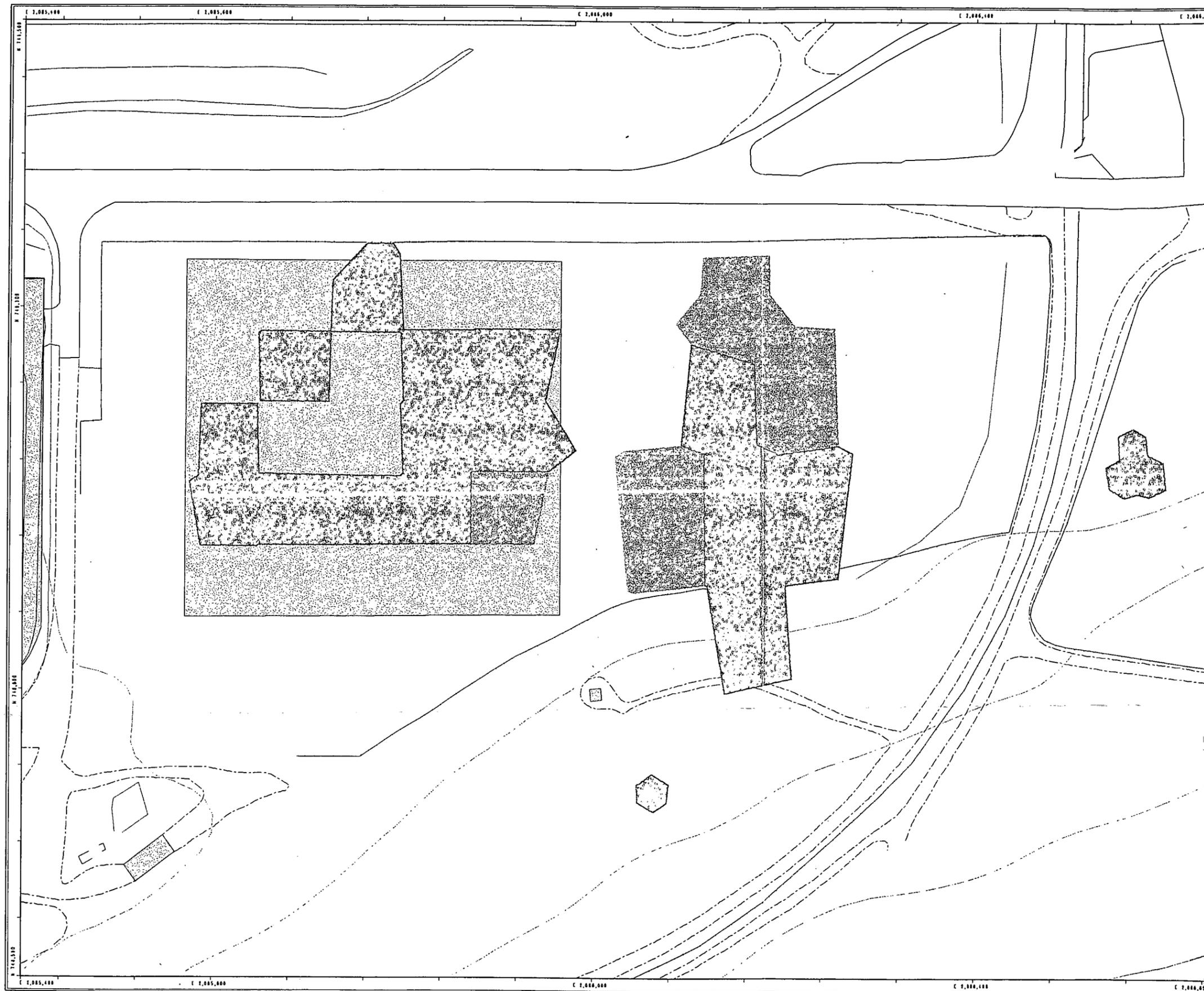
Rocky Mountain Remediation Services, L.L.C.
Geographic Information Systems Group
Rocky Flats Environmental Technology Site
P.O. Box 464
Golden, CO 80402-0464

105

**Characterization Report
for the
903 Drum Storage Area, 903 Lip Area
and Americium Zone**

**Composite Map of
Tier I RSAL Exceedances**

Figure 5-1



EXPLANATION

- Native 1 (0-6 inches)
- Native 2 (6-12 inches)

Standard Map Features

- Buildings and other structures
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (20-Foot)
- Paved roads
- Dirt roads

DATA SOURCE:
Buildings, terrain, hydrography, roads and other structures from 1996 aerial fly-over data captured by EG&G RSI, Las Vegas. Digitized from the orthophotograph, 1/26 Topology (contours) were derived from digital elevation model (DEM) data by Mountain Remediation (MR) using ESRI Arc 7M and LANTIS to process the DEM data to create 5-foot contours. The DEM data was captured by the Racoma Scanning Lab, Las Vegas, NV, 1994 Aerial Flyover at 10 meter resolution. DEM post-processing performed by M.C. Wilner 1997.

DISCLAIMER:
Neither the United States Government nor Kaiser M&E Co., nor Rocky Mountain Remediation Services, L.L.C., nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights.



Scale = 1 : 1290
1 inch represents approximately 108 feet



State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

**U.S. Department of Energy
Rocky Flats Environmental Technology Site**

Prepared by:



MAP ID: 99-0408

September 18, 1999

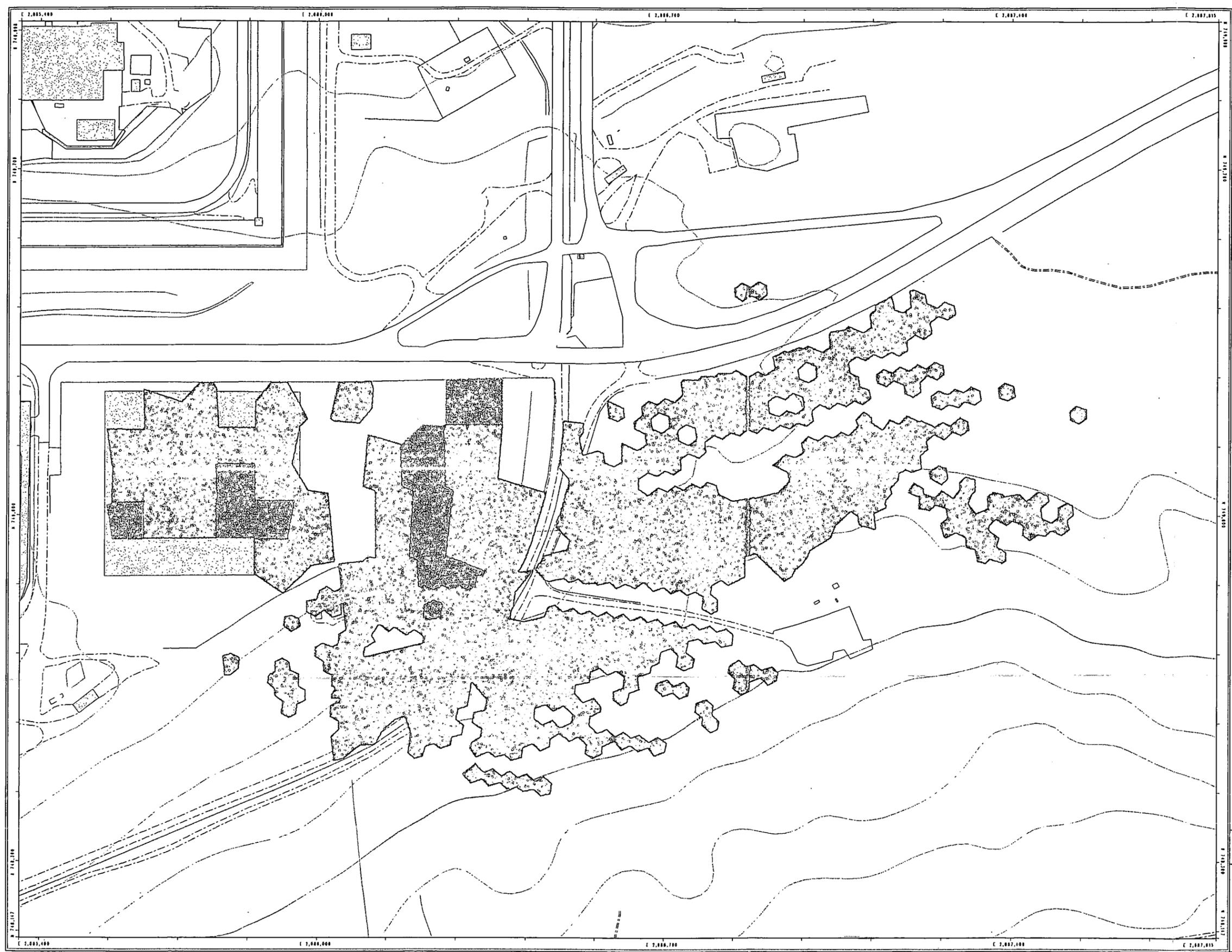
NT_Srv_w:\projects\9909-0408\fsa_tier1.dwg

107

**Characterization Report
for the
903 Drum Storage Area, 903 Lip Area
and Americium Zone**

**Composite Map of
Tier II RSAL Exceedances**

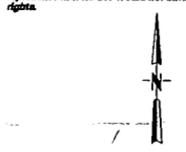
Figure 5-2



- EXPLANATION**
- Native 1 (0-6 inches)
 - Native 2 (6-12 inches)
 - Native 3 (12-18 inches)
- Standard Map Features:**
- Buildings and other structures
 - Lakes and ponds
 - Streams, ditches, or other drainage features
 - Fences and other barriers
 - Contour (20-Foot)
 - Paved roads
 - Dirt roads

DATA SOURCE:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by ECHG RSL, Las Vegas. Digitized from the orthophotograph, 1/35 Topography (contours) were derived from digital elevation model (DEM) data by Morrison Knudsen (MK) using ESRI Arc TIG and LATICE to process the DEM data to create 5-foot contours. The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at 10 meter resolution. DEM post-processing performed by MK, Winter 1997.

DISCLAIMER:
Neither the United States Government nor Kelco HCl Co., nor Rocky Mountain Remediation Services, L.L.C., nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights.



Scale = 1 : 2390
1 inch represents approximately 199 feet



State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

Prepared by:

Rocky Mountain Remediation Services, L.L.C.
Geographic Information Systems Group
Rocky Flats Environmental Technology Site
P.O. Box 404
Golden, CO 80402-0404

108

NT_Srv_w:\projects\99\99-0408\rfes_tier2.a.m

**Characterization Report
for the
903 Drum Storage Area, 903 Lip Area
and Americium Zone**

**Composite Map of
Tier I and Tier II
SSAL Exceedences**

Figure 5-3

EXPLANATION

- ▲ VOC Boreholes, Original
- ▽ VOC Boreholes, Stepout
- Radiological Borehole where VOC Sample was Collected
- Borehole location
Borehole PCE TCE CCL4 1,2-DCE
Sample Depth Results in Feet
VOC Compound Results in ug/kg
Proposed Tier I Exceedence in red
Proposed Tier II Exceedence in green
- ◇ Groundwater Well
- Areal Extent of Tier I SSAL Exceedences
- Areal Extent of Tier II SSAL Exceedences

Standard Map Features

- ▨ Buildings and other structures
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (5-Foot)
- Paved roads
- Dirt roads

DISCLAIMER:
Neither the United States Government nor KCBor HCl Co., nor Rocky Mountain Remediation Services, L.L.C., nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights.

Scale = 1 : 830
1 inch represents approximately 69 feet



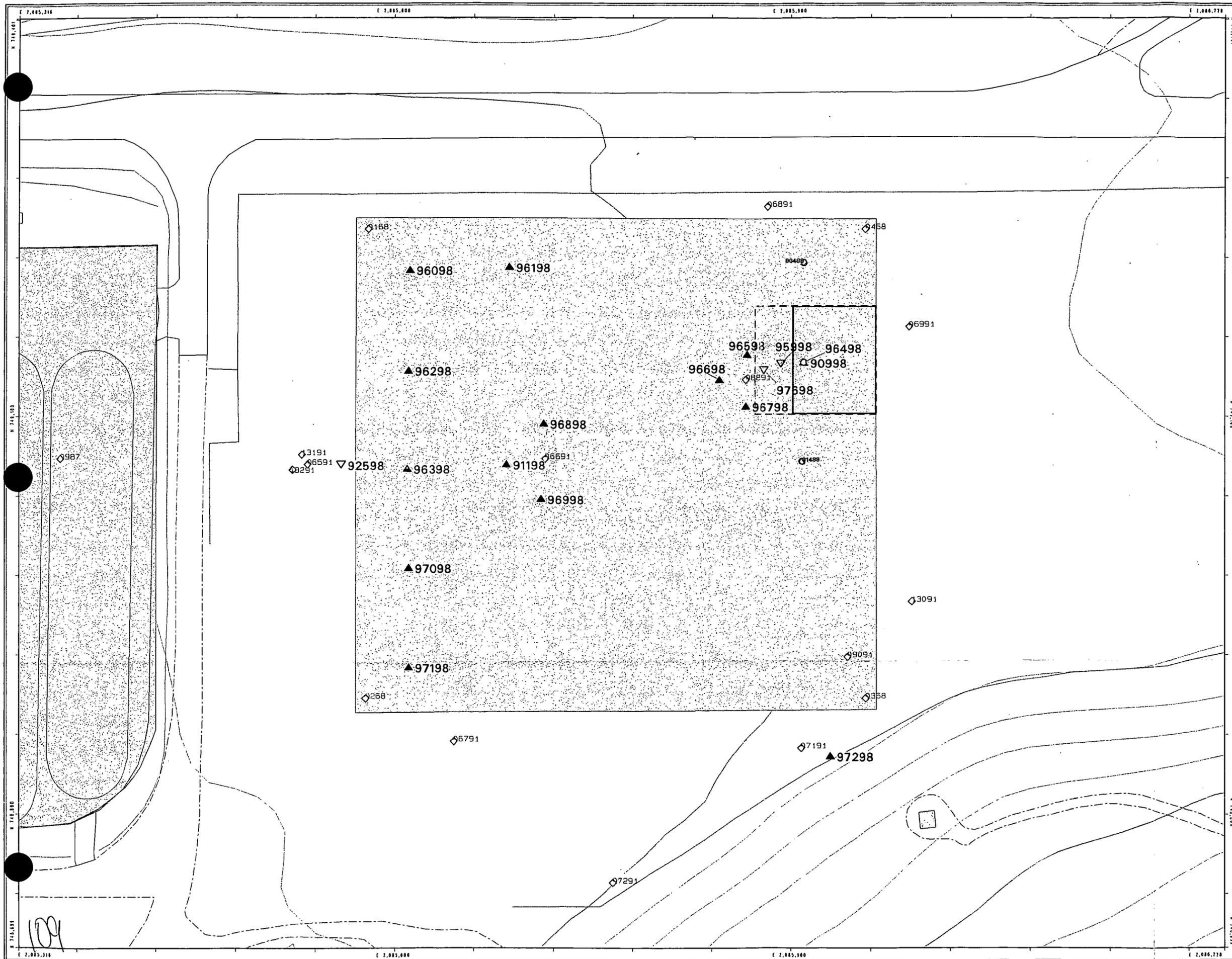
State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

**U.S. Department of Energy
Rocky Flats Environmental Technology Site**

Prepared by:



**Rocky Mountain
Remediation Services, L.L.C.**
Geographic Information Systems Group
Rocky Flats Environmental Technology Site
P.O. Box 464
Golden, CO 80402-0464



109