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Final Data Summary Report for the Characterization of UBCs 123 and 886

August 2001

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LIST OF ACRONYMS

AL	Action Level
Am	americium
Be	beryllium
bgs	below ground surface
BTEX	benzene, toluene, ethylbenzene, and xylene
CA	Contamination Area
CAFA	Casing Advancement Framework Assembly
CDPHE	Colorado Department of Public Health and Environment
CERCLA	Comprehensive Environmental, Response, Compensation and Liability Act
Cs	cesium
D&D	Decontamination and Decommissioning
DOE	U. S. Department of Energy
DQA	Data Quality Assessment
DQO	Data Quality Objective
Dup	Duplicate
EDD	Electronic Disc Deliverable
EMWD	Environmental-Measurement-While-Drilling
EPA	U. S. Environmental Protection Agency
ER	Environmental Restoration
FO	Field Operations
ft	feet
FY	Fiscal Year
GC/MS	Gas Chromatography/Mass Spectrometry
GP	Geoprobe® sample location
GRS	Gamma Ray Spectrometer
HDD	Horizontal Directional Drilling
HEUN	Highly Enriched Uranyl Nitrate
HRR	Historical Release Report
IA	Industrial Area
IHSS	Individual Hazardous Substance Site
in	inch
IWCP	Integrated Work Control Package
K-H	Kaiser Hill Company
LCS	Laboratory Control Sample
LD	Laboratory Duplicate
MB	Method Blank
MDA	Minimum Detectable Activty
MDL	Method Detection Level
MH	manhole
MS	Matrix Spike
MSD	Matrix Spike Duplicate
NFA	No Further Action
NPWL	New Process Waste Line

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ACRONYMS (continued)

OPWL	Original Process Waste Line
OU	Operable Unit
PAC	Potential Area of Concern
PARCC	Precision, Accuracy, Representativeness, Completeness, and Comparability
PB	Laboratory Preparation Blank
PCE	tetrachloroethene
pCi/L	picocuries per liter
pCi/g	picocuries per gram
PCOC	Potential Contaminant of Concern
ppb	parts per billion
PPE	personal protective equipment
Pu	plutonium
PVC	Poly-Vinyl Chloride
QA/QC	Quality Assurance/Quality Control
QAPD	Quality Assurance Program Description
RCRA	Resource Conservation and Recovery Act
RFCA	Rocky Flats Cleanup Agreement
RFETS	Rocky Flats Environmental Technology Site
RFI/RI	RCRA Facility Investigation/Remedial Investigation
RIN	Report Identification Number
RLC	Reconnaissance Level Characterization
RMRS	Rocky Mountain Remediation Services
RPD	Relative Percent Difference
RQL	Required Quantitation Limit
RSOP	RFCA Standard Operating Protocols
RWP	Radiological Work Permit
Sandia	Sandia National Laboratories, Albuquerque, New Mexico
SAP	Sampling and Analysis Plan
Site	Rock Flats Environmental Technology Site
SOR	Sum of Ratios
SP	Source Storage Pit
SVOC	Semi-Volatile Organic Compound(s)
TCFM	trichlorofluoromethane
TPU	Total Propagated Uncertainty
U	uranium
UBC	Under Building Contamination
μg/L	micrograms per liter
μg/kg	micrograms per kilogram
V	volt(s)
V&V	Verification and Validation
VOC	Volatile Organic Compound
WPS	Waste Pumping Station

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1.0 INTRODUCTION

The Kaiser-Hill Company, LLC (K-H) conducted an investigation beginning in October 2000 and completed in March 2001 to characterize the potential Under Building Contamination (UBC) associated with Buildings 123 and 886 at the Rocky Flats Environmental Technology Site (RFETS) (Figure 1-1). This investigation was conducted by K-H Environmental Restoration (ER) in accordance with the *Sampling and Analysis Plan for the Characterization of Under Building Contamination of UBC 123 and Building 886, Implementing Horizontal Directional Drilling and Environmental-Measurement-While-Drilling* (SAP), (RMRS 2000).

RFETS has 31 buildings with suspected or verified UBC that is the result of suspected or documented spills or leaks from building processes, Original Process Waste Lines (OPWL), New Process Waste Lines (NPWL), or operations adjacent to the buildings. Because of the compressed schedule required to reach closure, UBC characterization must take place concurrently with building deactivation, or decontamination where deactivation is not required, and cannot disrupt building activities. Therefore, methods to characterize UBC sites with minimal impact to buildings must be developed.

In conjunction with traditional, vertical soil sampling techniques, this project demonstrated the implementation of a new technology at RFETS, Horizontal Directional Drilling (HDD) and Environmental Measurement While Drilling (EMWD). The results of this demonstration will be used in conjunction with previously collected data from UBC 123 to support no action/remedial determinations and supplement the *Final Close-Out Report for the Building 123 Decommissioning Project,* (RMRS 1998). The Building 886 investigation will serve as only a partial characterization of UBC 886. Final characterization will take place in conjunction with the decontamination and decommissioning (D&D) of this building.

This report includes a summary of the analytical data collected as part of the soil characterization effort. Data collected include HDD and Geoprobe® sampling techniques and the EMWD measurements conducted by Sandia National Laboratories (Sandia) in conjunction with the HDD operations. The results of the EMWD are presented in a separate report from Sandia as Attachment A, *Characterization of Under-Building Contamination at Rocky Flats Implementing Environmental-Measurement-While-Drilling Process with Horizontal Directional Drilling, (SNL June 2001).*

1.1 Objectives

This report details the field characterization activities and analytical results performed at UBC 123 and Building 886 in support of closure of RFETS. The objectives in implementing the HDD/EMWD for this project were to:

1. Implement and test a new technology and determine its effectiveness in UBC characterization at RFETS. Data collected from soil samples along a horizontal profile will be qualitatively compared by vertical profile characterization techniques. This assessment will be used to determine the applicability of HDD/EMWD characterization at future sites around RFETS and other DOE facilities.

2. Determine the presence or absence of radioactive and/or hazardous contamination in the soils beneath Building 123 associated with leaks adjacent to selected process waste lines, sumps, pits, and waste pumping stations; localized spills beneath the concrete slab; and the general condition of the subsurface area beneath the former criticality lab (Room 101) of Building 886. Data generated are intended to be valid and usable for future remedial decisions; and
3. Determine the cost effectiveness of HDD/EMWD characterization techniques as compared to vertical drilling and sample collection methods. A list of applications and limitations of the HDD/EMWD methodologies has also been included in this report.

Additional subsurface Geoprobe® and hand-auger soil collection and sampling were conducted as supplement to the HDD/EMWD characterization to better define the remediation area potentially required for UBC 123 and Building 886 and to make qualitative data comparisons.

2.0 BACKGROUND AND SITE HISTORY

2.1 UBC 123

UBC 123 is located on Central Avenue between Third and Fourth Streets in the RFETS Industrial Area (IA) (Plate 1) and consists of the Building 123 slab, soil, Individual Hazardous Substance Site (IHSS) 148, and all underground process systems (IHSS 121). The building footprint is approximately 18,444 square feet. Building 123 went into service in 1953 and housed the Radiological Health Physics Laboratory which analyzed water, biological materials, soil, air and filter samples for the presence of plutonium, americium (Am), uranium (U), alpha radiation, beta radiation, gamma radiation, tritium, beryllium, and organics. Additionally, personnel radiation badges were counted and repaired. Low-level liquid and chemical wastes were generated at this location and transferred to treatment systems via the process waste lines system. The process waste systems at this location consist of underground pipelines composed of steel, polyethylene, cast iron, and other materials, sumps, and pumps. Potential contaminants of concern (PCOCs) beneath the slab are uranium, plutonium, cesium, metals, and volatile organic compounds (VOCs).

The D&D of Building 123 and the surrounding area was completed in 1998. The project included the removal of Buildings 123, 123S, 113, 114. The Building 123 floor slab was sampled to assess potentially contaminated areas. Areas of the slab that could not be decontaminated to unrestricted release were encapsulated with epoxy paint to fix any removable contamination and covered with steel plate. The building slab and process waste lines were left in place. Several source storage pits of various dimensions were used to store radioactive sources and are also present under the slab. All of the pipelines were grouted at the slab level.

UBC 123 was chosen for deployment of EMWD/HDD because the slab was easily accessed. There are numerous underground utilities in the vicinity, but compared to other RFETS buildings, the underground layout is relatively uncomplicated.

2.1.1 Original Process Waste Lines

IHSS 121 consists of the OPWL system which includes the plant-wide process waste system comprised of tanks and underground pipelines constructed to transport and temporarily store process wastes from point of origin to on-site treatment and discharge points. Specifically, IHSS 121 includes process waste lines P-1, P-2, and P-3. These waste lines were described in the *Final Phase I Resource Conservation and Recovery Act (RCRA) Facility Investigation/Remedial Investigation (RFI/RI) Work Plan For Operable Unit 9* (DOE 1992a) and in the *Historical Release Report* (HRR) (DOE 1992b).

In 1998, the pipe chases and sumps from Rooms 125, 156, 157, and 158 were flushed with a trisodium phosphate/sodium carbonate decontamination solution during D&D of Building 123. No contaminants of concern were found to exceed Rocky Flats Cleanup Agreement (RFCA) Tier II action levels (ALs) in the associated final rinsates except for lead (56 parts per billion [ppb]) from the sump in Room 125 (RMRS 1998).

2.1.2 IHSS 148

The eastern wing of Building 123 is encompassed by IHSS 148 which was part of Operable Unit (OU) 13. The *Final Phase I RFI/RI Work Plan for Operable Unit 13, 100 Area* (DOE 1992c) described proposed characterization plans for IHSS 148. Characterization of OU 13 was conducted from September 1993 to February 1995 and the results were documented in the *Draft Data Summary 2, Operable Unit No. 13, 100 Area* (DOE 1995).

Thirty-four analytes were detected in the surface soil samples, including twenty-six inorganic compounds and eight radionuclides. Eleven analytes exceeded background concentrations at a minimum of one sample location throughout IHSS 148. Constituents that exceeded background concentrations are listed in Table 3-1 of the SAP.

A soil-gas survey was conducted on a 25-foot grid in accordance with the OU-13 RFI/RF Work Plan (DOE 1992c) and samples were analyzed in the field using Gas Chromatography/Mass Spectrometry (GC/MS). Sixty-four soil-gas locations were sampled during the survey. Thirteen samples contained VOC levels in excess of the 1 microgram per liter (µg/L) method detection limit. Benzene, toluene, ethylbenzene, and xylene (BTEX) fuel constituents were detected in samples collected from the perimeter of Building 123 and within the east and west wings of the building. Trichlorofluoromethane (TCFM) was detected in nine samples distributed throughout the IHSS 148 area at levels up to 2.6 µg/L. Tetrachloroethene (PCE) was detected at 1.5 µg/L in a sample collected east of Building 123. The presence of organic extraction constituents is consistent with unconfirmed reports that liquids used in radionuclide analyses were occasionally disposed onto the soil surface outside of Building 123 and allowed to evaporate. The soil-gas analytical results indicate that a potential for residual subsurface VOC contamination of soils exists at UBC 123.

Unconfirmed reports of contaminant spills have been indicated in interviews with building employees. In the late 1960's or early 1970's, a cesium-contaminated liquid was reportedly spilled on the concrete floor in Room 109. The floor was immediately sealed to immobilize the contamination. Room 109 also contained source storage pits (SPs).

Undocumented thorium research was performed in Room 105. Scoping surveys conducted in May through July 1997 revealed elevated levels of radioactivity in both Rooms 105 and 109. In-situ gamma spectroscopic measurements performed in August 1997 indicated the presence of cesium-137 and thorium-232 in Rooms 109 and 105, respectively (RMRS 1998).

Four associated Potential Areas of Concern (PACs), 100-601, 100-602, 100-603, and 100-611, have been identified as associated with UBC 123, as shown in Plate 1. The PACs were established as the result of documented spill incidents. PAC 100-601 was approved as a No Further Action (NFA) site in 1992.

2.2 Building 886

Building 886, located in the northeastern portion of the 800 Area, was commissioned into service in 1965 (Plate 2). In approximately 1980, Trailer 886A was built immediately east of the building and was later connected by the existing breezeway. Building 886 housed the Critical Mass Laboratory where low-level criticality experiments were performed on liquids, powder, and solid forms of fissionable materials. The building currently houses offices and a small electronics/machine shop. Enriched uranium solutions, solid enriched uranium, and plutonium metal have been used in this building. The building footprint is approximately 14,197 square feet. Highly enriched uranyl nitrate (HEUN) solutions were spilled in Rooms 101 and 103. Room 103 contained seven HEUN tanks and a tank storage pit. Various utilities are beneath the building slab and two buried tanks (T-21) are just west of the building. The date of the last criticality experiment was in October 1987.

Reconnaissance-Level Characterization (RLC) studies were conducted and focused on the identification of potential sources of chemical contamination within the building. The hazards identified during the RLC were physical and chemical (i.e., lead and metals, Polychlorinated Biphenyls (PCBs), and asbestos). Potential radiological contamination has not yet been fully characterized (RMRS, 1999).

IHSS 164.2, Radioactive Site #2, 800 Area, Building 886 Spill, surrounds Building 886 and is the result of a previous release of an unknown colorless liquid from a 500-gallon tank onto the concrete slab. Surface soils in IHSS 164.2 were sampled during the RFI/RI for Operable Unit 14. Results indicated that uranium (U)-238 was above background values at locations north, south, east, and west of Building 886; plutonium (Pu) was above background values north and east of the building; and americium (Am)-241 was above background east of Building 886 (DOE 1995b). Building 886 has no process waste lines directly underneath, however a few exist, along with a foundation drain for surface water, west of the building. These process waste lines and foundation drain are not within the scope of this project.

3.0 SAMPLE COLLECTION AND FIELD ACTIVITIES

Characterization of the two UBCs was achieved utilizing three methods of soil sampling and data collection conducted in three separate phases of sampling activities:

1. Horizontal Directional Drilling (HDD) and Environmental Measurement While Drilling (EMWD) sampling and radiological measurement collection;
2. Geoprobe® boring and sampling; and,
3. Concrete coring and hand-auger sampling.

All sampling activities and methodologies were conducted in accordance with the SAP. Additionally, all field work was conducted under the guidelines specified by the job-specific Radiological Work Permits (RWP), and As Low As Reasonably Achievable (ALARA) Job Review.

3.1 HDD Sample Collection and EMWD Measurements

The HDD portion of the project differs from traditional horizontal drilling and was specifically developed by the project staff and drilling subcontractor for use at RFETS to minimize drilling wastes. Also referred to as the Casing Advancement Frame Assembly (CAFA), this horizontal drilling mechanism utilized a 900 lb. pneumatic hammer on a 20-foot steel frame to simultaneously drive the drill bit and 4-inch exterior steel casing and create the boreholes. This method of advance casing drilling displaced the surrounding soils throughout borehole advancement and used no drilling muds/fluids. This process resulted in zero drilling returns and greatly reduced the amount of wastes generated by the characterization project. Use of the 4-inch casing was necessary to keep the borehole open in the alluvial soils and industrial fill present at RFETS. A detailed description of directional drilling/hammering and soil sampling operating procedures is provided in the *Standard Operating Procedure, Directional Under Building Casing Advancement and Soil Sampling* (Corrocon 2000).

Five boreholes were drilled with the CAFA and a total of 21 real soil samples were collected along OPWLs P-1 and P-2 (see Plate 1). EMWD measurements were collected the entire length of each boring in one-foot intervals from within the 4-inch steel casing.

The CAFA (refer to Picture 1, Attachment C) is a non-rotary, pneumatically powered hammer which drives the casing and drill stems into the ground in a horizontal position at relatively low angles of inclination (less than 12 degrees). The CAFA assembly is horizontally situated on a 20-foot steel frame which operates directly on the ground surface and is powered by two connecting air compressors and multiple hydraulic lines. Directional steering of the borehole is accomplished by orienting the steering bit to a position which will achieve the desired directional control. Drilling distance, drill bit orientation, and angle of pitch are monitored by radio signal readings transmitted from the subsurface sonde, located directly behind the drill bit, to the operator and to above ground Digi-Trak receiver. The Digi-Trak is a hand held unit and requires the operator to be able to stand directly over the current extent of the borehole as well as its projected path (see Picture 2).

Due to the limited flexibility of the 4-inch casing and operational requirements of the CAFA unit, borehole initiation first required specific positioning of the CAFA and support equipment. HDD Lines 1, 2, 3, and 6 each required a trench excavation adequately sized for the operators to work within and graded to an appropriate slope to achieve the desired borehole depths. The excavations were typically 6-feet wide x 20 to 25-feet long and no deeper than 4 feet at any point. The trenches allowed for the point of entry to be closer to the desired sampling depths, i.e., the process waste lines located approximately 5 to 6-feet below the Building 123 slab. This method reduced the additional layback distance and drilling time that would have been otherwise needed if the borehole was initiated from ground or slab level. Additionally, the borehole then had to be initiated by coring an 8-inch diameter hole through the foundation wall at HDD Lines 1, 2, 4, and 6 prior to the commencement of the HDD process.

Of the five boreholes planned for installation and sampling for this project, only HDD Line 4 was completed as described in the SAP. Deviations from the planned drill paths were due to contact with unforeseen subsurface obstacles and casing compromise. However, sufficient characterization was achieved at UBC 123 from the compilation of data collected from previous D&D sampling with this HDD and Geoprobe® characterization project. Borehole-specific information is provided in Table 3-1.

Table 3-1 HDD Borehole Drilling Information

Borehole ID	Length of Boring (in ft)	Location	No. of HDD Soil Samples Collected	EMWD Measurements Collected?	Comments
HDD Line 1	43	UBC 123	0	Yes	Hit building footer, no HDD soil samples collected
HDD Line 2	137	UBC 123	8	Yes	Collected last soil sample at 127 ft (HDD-2-09); Casing bent at ~100 ft
HDD Line 3	63	UBC 123	5	Yes	Casing bent
HDD Line 4	114	UBC 123	6	Yes	All samples collected
HDD Line 6	18	UBC 886 Rm 101	2	Yes	Hit obstruction at 18 ft, unable to collect 3rd soil sample

Soil sample collection was achieved by tripping out the 1 ¾-inch drill stem and directional steering bit from within the 4-inch steel casing, leaving the casing in the ground. The directional bit was then removed from the stems and a 3-inch x 24-inch stainless steel split spoon soil sampler was attached and reinserted into the casing. Once at total horizontal depth, sample collection was achieved by horizontally hammering the spoon into the undisturbed soil just in front of the furthest extent of the casing thereby driving the soil into the sampling tube. The drill stem was then tripped out again and the sample was then collected. The process was then repeated as desired. Table 3-2 provides the actual HDD soil sampling locations in UBCs 123 and 886 as shown in Plates 1 and 2, respectively.

Table 3-2 HDD Sample Locations and Specifications

HDD Line Sample ID	Location/Area of Interest[1]	Horizontal Distance of Sample Location from Borehole Entry[2]	Actual Soil Interval Collected (Inches below top of slab)	Sample Recovery (Inches)	Percent Recovery	Comments (Distances are Horizontal)
HDD Line 1 (UBC123)						**Initiated at North foundation wall**
HDD-1-01 to –06	P1 (1972)	n/a	n/a	n/a	n/a	Not Collected- Hit foundation wall at 43 ft
HDD Line 2 (UBC123)						**Initiated at North foundation wall**
HDD-2-01	Room 107A	8"	47	7	29%	Immediately inside foundation wall
HDD-2-02	P2 (1952) North Hallway	n/a	n/a	n/a	n/a	Not Collected due to close proximity of HDD-4-06
HDD-2-03	P2 (1952) Rm 122	27' 3"	62	24	100%	
HDD-2-04	P2 (1952) Rm 123	42' 3"	68	21	88%	
HDD-2-05	P2 (1952) Rm 124	54' 4"	65	21	88%	
HDD-2-06	P2 (1952) Rm 125	74' 2"	63	24	100%	
HDD-2-07	P2 (1952) Rm 125	92' 2"	62.5	22	92%	4" Casing bent at ~100 ft down hole
HDD-2-08	P2 (1952) Rm 126C	107'	62	12	50%	
HDD-2-09	P2 (1952) Rm 127	122'	61.5	12	50%	
HDD-2-10	P2 (1952) Rm128	137'	61	n/a	n/a	Not Collected - Casing Bent
HDD-2-11 to –13	P2 (1952) Rms 128,143,144	n/a	n/a	n/a	n/a	Not Collected - Casing Bent; Drilling never advanced to these points
HDD Line 3 (UBC123)						**Initiated South of West Wing**
HDD-3-01	P1 (1972) Parking Lot Area South of Building	0'	52	17	71%	HDD-3 depths from concrete TOS
HDD-3-02		18'	62	24	100%	
HDD-3-03		33'	76	24	100%	Wet, well-sorted sand in sample-Trench
HDD-3-04		48'	87	24	100%	
HDD-3-05		63'	85	17	71%	
HDD-3-06 to –11	P3 (1968)	n/a	n/a	n/a	n/a	Not Collected - Casing Bent
HDD Line 4 (UBC123)						**Initiated at East foundation wall**
HDD-4-01	P2 (1952) North Hallway	112' 11"	76	24	100%	
HDD-4-02		102' 1"	74	24	100%	
HDD-4-03		87'	71	24	100%	
HDD-4-04		72' 3"	64	24	100%	
HDD-4-05		57'	58	24	100%	
HDD-4-06		43' 6"	47	24	100%	
HDD Line 6 (UBC886)						**Initiated at East side of foundation wall**
HDD-6-01	Room 101	4'	24 to 30	24	100%	
HDD-6-02	Room 101	14'	24 to 30	16	67%	
HDD-6-03 & -04	Room 101	n/a	n/a	n/a	n/a	Not Collected due to uknown subsurface obstruction
				Average Recovery	86%	

[1]P1, P2, and P3 are Process Waste Lines identified in Plate 1.
[2]All HDD soil samples were collected in a horizontal orientation utilizing a 3-inch by 24-inch stainless steel split-spoon sampler.

3.1.1 EMWD Measurements

Immediately prior to the collection of each HDD soil sample, a down-hole Gamma Ray Spectrometer (GRS) was tripped into the casing to its furthest extent. Real-time radiological measurements were then collected at this point, inclusive of the undisturbed soil to be sampled at the casings edge. The GRS was then pulled back at one-foot intervals and one-minute readings were subsequently collected at each point along the casing, logging the intervals previously drilled. Results of the EMWD/GRS data collection for each HDD borehole has been provided by Sandia as Attachment A of this report.

3.2 Geoprobe® Sample Collection

Geoprobe® soil sampling was conducted at the Building 123 slab and on the west side of Building 886, the locations of which are specified in Plates 1 and 2, respectively. The eastern wing of Building 123 is encompassed by IHSS 148 which was part of OU 13. 27 locations were sampled at UBC 123 which correlated to historical and process knowledge points of interest and HDD Line collocation areas (refer to Plate 1). In addition, four locations were sampled outside and immediately west of Building 886 (Plate 2). The purpose of Geoprobe® sampling at Building 123 was to further characterize UBC 123 and to make qualitative data comparisons to several previously collected HDD soil sample locations. The Building 886 locations were collected to characterize the soil beneath two existing external concrete pads. One pad previously supported an above ground tank just north of Building 828, and the second pad formerly supported a filter plenum on the west exterior wall of Room 101.

For the 123 and 886 Geoprobe® characterization sampling, a Geoprobe® model 54LT and a two-inch diameter stainless steel Macro-Core sampler were utilized at all collection locations (see Picture 3). Sampling was initiated by coring a three-inch diameter hole through the concrete slab at each sample location. The slab thickness varied from 6 to 15 inches at the Building 123 slab and 7 to 10 inches on the two slabs west of Building 886. Once the concrete cores were removed and the underlying soil exposed, the Geoprobe® was positioned over the hole and the soil sample intervals were collected in accordance with Site procedure RMRS/OPS-PRO.124, *Push Subsurface Soil Sampling*, and the specifications and requirements of the SAP and Integrated Work Control Package (IWCP). The specific sample intervals collected are identified in Tables 3-3 and 3-4 below.

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Table 3-3 Geoprobe® Sample Locations along HDD Boreholes

Geoprobe® Sample ID	Collocated HDD Line Sample ID	Location/Area of Interest	Target Soil Interval (ft below slab)	Actual Soil Interval Collected (depth below top of slab)	Recovery (Inches)	Percent Recovery	Comments
Geoprobe® Locations South of HDD Line 1							
GP-1-01	HDD-1-01 (n/a)	Rm 156 Sump	3'2" to 5'2"	4' to 6'	4	17%	Sump bottom is 4'2" BGS
GP-1-02	n/a	OPWL- Rm 157 Area	n/a	4' to 6'	15	63%	Additional Sample- Target OPWL
GP-1-03	HDD-1-03 (n/a)	Rm 157 Sump	4'0" to 6'0"	4' to 6'	18	75%	Sump bottom is 5'0" BGS- DUP Collected
GP-1-04	HDD-1-04 (n/a)	Rm 158 Sump	4'3" to 6'3"	4' to 6'	20	83%	Sump bottom is 5'3" BGS
GP-1-07	HDD-1-07 (n/a)	MH-1	5' to 7'	Not Collected	-	-	Intended to bound HDD-1-07 by one foot above & below
Geoprobe® Locations Along HDD Line 2							
GP-2-01	HDD-2-01	Northern footing Rm 107	5' to 7'	Not Collected	-	-	Not Collected- Substitute location at GP-2-03
GP-2-03	HDD2-03	Room 122 Area, OPWL	n/a	4'2" to 6'2"	15	63%	Additional Sample- Target OPWL
GP-2-04	HDD-2-04	P-1/P-2 Intersection	5' to 7'	4'4" to 6'4"	16	67%	Bound HDD-2-04 by one foot above & below (64")
GP-2-06	HDD-2-06	WPS P-1/OPWL P-2	0' to 2'	8" to 32"	11.5	48%	Collect 1st 2 feet of soil (8" Concrete Core)
GP-2-06	HDD-2-06	WPS P-1/OPWL P-2	5' to 7'	4'3" to 6'3"	16.5	69%	Bound HDD-2-06 by one foot above & below (63")
GP-2-08	HDD-2-08	Room 126 Area	5' to 7'	4'2" to 6'2"	18	75%	Bound HDD-2-08 by one foot above & below (62")
GP-2-10	HDD-2-10	Room 128 Area	5' to 7'	4' to 6'	11	46%	Bound OPWL depth by one foot above & below; HDD-2-10 not collected due to refusal
GP-2-11	n/a	OPWL- Rm 127 Area	n/a	4' to 6'	11	46%	Additional Sample- Target OPWL
GP-2-13	HDD-2-13	S. edge of Rm 144/146	5' to 7'	4' to 6'	16	67%	HDD-2-13 not collected
Geoprobe® Locations Along HDD Line 3							
GP-3-01	HDD-3-01	~3 Ft west of MH-1	5' to 7'	Not Collected	-	-	Not Collected- Substitute by adding GP-3-02
GP-3-02	n/a	Just east of MH-1	n/a	4'2" to 6'2"	19.5	81%	Additional-Bound HDD-3-02 by one foot above & below (62")
GP-3-04	HDD-3-04	Comparison	5' to 7'	4' to 6'	9	38%	Bound HDD-3-04 by one foot above & below
GP-3-07	HDD-3-07	MH-2	5' to 7'	4' to 6'	13	54%	Bound HDD-3-07 by one foot above & below
GP-3-09	HDD-3-09	Comparison	5' to 7'	4' to 6'	12	50%	Bound HDD-3-09 by one foot above & below
GP-3-11	HDD-3-11	MH-3	5' to 7'	Not Collected	-	-	Not Collected- Out of IHSS and Area of Interest
Geoprobe® Locations Along HDD Line 4							
GP-4-01	HDD-4-01	NE corner of Rm 111	5' to 7'	5' to 7'	17	71%	Bound HDD-4-1 by one foot above & below
GP-4-04	HDD-4-04	Room 119 Area	5' to 7'	4'4" to 6'4"	11	46%	Bound HDD-4-04 by one foot above & below (64")
GP-4-06	HDD-4-06	NW corner of RM 122	5' to 7'	3' to 5'	11.5	48%	Bound HDD-4-06 by one foot above & below (47")
					Average Recovery	58%	

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Table 3-4 Geoprobe® Sample Locations in Additional Areas of Interest

Geoprobe® Sample I.D.	Sample Name/ Rationale	Location/Area of Interest	Target Soil Interval (ft below slab)	Actual Soil Interval Collected (depth below top of slab)	Recovery (Inches)	Percent Recovery	Comments
Geoprobe® Locations at Additional Areas of Interest – Building 123							
SP-1	Source Pit #1	Source Storage Pits Room 109	0" to 24"	6" to 30"	4	17%	Collect soil to bound bottom of pit elevation by one foot above & below
SP-2	Source Pit #2	Source Storage Pits Room 109	4" to 28"	6" to 30"	11	46%	Collect soil to bound bottom of pit elevation (16") by one foot above & below
SP-3	Source Pit #3	Source Storage Pits Room 109	4" to 28"	6" to 30" & 30" to 42"	5.5	15%	Collect soil to bound bottom of pit elevation (16")- Poor recoveries
SP-4	Source Pit #4	Source Storage Pits Room 109B	4" to 28"	15" to 39"	17	71%	Collect soil to bound bottom of pit elevation (16")- Collect only VOA & RadScreen- Slab was 15"
WPS-1	Waste Pumping Station #1	Immediately east (downgradient) of WPS-1	0" to 24"	Not Collected- GP-2-06 covers this area of interest		N/A	Collect soil to bound bottom of concrete pit elevation (12") by one foot above & below
WPS-2	Waste Pumping Station #2	Immediately east (downgradient) of WPS-2	0" to 24"	6" to 30"	15	63%	Above ground WPS, no pit. Collect first 24" of soil beneath slab (6" Concrete Core)
WPS-3	Waste Pumping Station #3	Immediately east (downgradient) of WPS-3	0" to 24"	5" to 29"	22	92%	Above ground WPS, no pit. Collect first 24" of soil beneath slab (5" Concrete Core)
WPS-4	Waste Pumping Station #4	Immediately east (downgradient) of WPS-4	0" to 24"	6" to 30"	8	33%	Above ground WPS, no pit. Collect first 24" of soil beneath slab (6" Concrete Core)
WPS-5	Waste Pumping Station #5	Immediately east (downgradient) of WPS-5	1' 3" to 3'3"	Refusal- Unable to Collect		N/A	Refusal at 15" – Possibly contacted subsurface concrete slab from old loading dock
WPS-6	Waste Pumping Station #6	Immediately east (downgradient) of WPS-6	1' 3" to 3'3"	Refusal- Unable to Collect		N/A	Refusal at 15" – Possibly contacted subsurface concrete slab from old loading dock
Lab-1	Suspected Cesium spill	Soil adjacent to drains of Room 105 Lab	0" to 24"	8" to 32"	9.5	40%	Collect first 24" of soil beneath slab near drain (8" Concrete Core)
Lab-2	Suspected Cesium spill	Soil adjacent to drains of Room 105 Lab	0" to 24"	8" to 32"	16	67%	Collect first 24" of soil beneath slab (8" Concrete Core)
Geoprobe® Locations on Concrete Pads West of Building 886							
GP-886-Pad-1	Above-ground tank slab	Soil immediately beneath tank slab	Additional Sample- n/a	6" to 30"	24	100%	Collect 1st 24" below slab; Slab 6"
GP-886-Pad-2	Above-ground tank slab	Soil immediately beneath tank slab	Additional Sample- n/a	6" to 30"	24	100%	Collect 1st 24" below slab; Slab 6"
GP-886-Plenum-1	Room 101 Filter Plenum slab	Soil immediately beneath Plenum slab	Additional Sample- n/a	8" to 38"	7	23%	Collect 1st 24" below slab; Slab 8"
GP-886-Plenum-2	Room 101 Filter Plenum slab	Soil immediately beneath Plenum slab	Additional Sample- n/a	8" to 32"	9	38%	Collect 1st 24" below slab; Slab 8"
					Average Recovery	54%	

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3.3 Hand-Auger Sample Collection

For all Geoprobe® and Hand-Augering sample locations, it was necessary to initiate sampling by coring through the building's concrete slab in order to access the underlying soils. A Hilti wet-diamond coring machine was used to core through the reinforced concrete slab. A point source negative pressure system was used in conjunction with the wet method coring to prevent the potential for any migration of airborne or water contamination in the work areas.

For this project, the areas of interest of UBC 886 were the soils immediately beneath the concrete slab and underlying gravel base. Concrete coring revealed that the reinforced slab and gravel layer thicknesses varied significantly and were inconsistent with the as-built building drawings. The thicknesses of the four concrete cores removed from Room 101 ranged from 9 ½ to 19 inches but the seven concrete cores removed from the Room 103 Pit area varied only from 9 to 10 inches thick. The underlying gravel base varied from 8 to 26 inches in thickness at the sample locations in each room.

Eleven soil samples were collected from under Building 886 to characterize the general conditions of the UBC; four from within Room 101, and seven from within the Room 103 Pit (Table 3-5). The sample locations were selected based on historical process knowledge and documented HEUN spills. The eleven samples were collected from beneath the building's concrete slab from within the building utilizing a stainless steel hand-auger and a Hilti concrete coring machine (refer to Picture 4). Generally, each sample consisted of a composite of the first 12 to 24 inches of soil beneath the sub-slab gravel layer. The gravel layers beneath the slabs varied from 6 to 19 inches in thicknesses. The Geoprobe® unit was not used inside the building due to access limitations, health and safety concerns, and potential contamination issues.

Table 3-5 Hand-Auger Sample Locations within Building 886

Sample I.D.	Sample Location/Area of Interest	Concrete Slab Thickness (Inches)	Soil Interval Collected (Inches below top of slab)	Comments
Room 101				
886-101-01	NE corner of Room	19	19 to 32	Gravel layer matrixed w/ soil & clay
886-101-04	NW corner of Room near trench	16	16 to 23	Utilized stainless steel Hand Auger only
886-101-05	SE corner of Room	10	10 to 29	Gravel layer matrixed w/ soil & clay
886-101-06	SW corner of Room	10	10 to 29	Gravel layer matrixed w/ soil & clay
Room 103 Pit Area				
886-103-01	Pit Floor – See Plate 2	9	17 to 29	Composite 12" of Soil
886-103-02	Pit Floor – See Plate 2	9	18 to 28	Composite 10" of Soil
886-103-03	Pit Floor – See Plate 2	9	19 to 29	Composite 10" of Soil
886-103-04	Pit Floor – See Plate 2	10	16 to 28	Composite 12" of Soil
886-103-05	Pit Floor – See Plate 2	9	15 to 3	Composite 15" of Soil
886-103-06	Pit Floor – See Plate 2	9	16 to 31	Composite 15" of Soil
886-103-07	Pit Floor	8	N/A	Sample not collected; Electrical conduit utility immediately under slab
886-103-08	Pit Floor – See Plate 2	10	15 to 39	Composite 24" of Soil

These variations in subsurface conditions resulted in an increase in time and effort in collecting the soil samples. In order to access underlying soils, a combination of sampling techniques was performed. It became necessary to remove the gravel by hand, by drilling methods (using the concrete coring machine), and with hand-augers. These steps were often performed several times per location in order to establish an open borehole. In addition, 3-inch Poly-Vinyl Chloride (PVC) pipe was occasionally driven into various sampling holes to prevent the gravel from caving which allowed for hand-augering and mechanical coring through the PVC pipe. Once the underlying soils were exposed, the samples were extracted from the ground by means of the stainless steel hand auger or by a 3-inch Hilti concrete coring bit. This combination of sampling methods ultimately proved effective in collecting the soils underlying the building's concrete slab and gravel fill.

3.4 Borehole Abandonment

Upon completion of each HDD, Geoprobe®, and hand auger sampling, each borehole was properly abandoned with grout and/or bentonite in accordance with RMRS/OPS-PRO.117, *Plugging and Abandonment of Boreholes*. For HDD Lines 1-4 and 6, the 4-inch steel casing was abandoned in place beneath the slabs and capped. The CAFA excavation trenches were backfilled with the material previously excavated, compacted to the original grade, and reseeded.

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3.5 Equipment Decontamination and Waste Disposition

Reusable sampling equipment was decontaminated between each sampling event in accordance with procedure FO.03, *Field Decontamination Operations*. Decontamination waters generated during the project were managed according to procedure RMRS/OPS-PRO.112, *Handling of Field Decontamination Water* and were dispositioned to the Building 891 treatment facility.

The design of this project allowed for only minimal amounts of waste to be generated throughout this project. Several types of waste media were generated. Table 3-6 below lists the types, total quantities and disposition destinations of these wastes.

Table 3-6 Project Generated Wastes

Waste Media	Location Generated	Quantity	Units	Dispositioned to
Asphalt	HDD Line 3 Trench	3	Cubic Yards	Sanitary Landfill
Decon/Concrete Coring Water	B123 Slab	80	Gallons	B891 Treatment Facility
Decon/Concrete Coring Water	B886, Room 101	50	Gallons	B891 Treatment Facility
Decon/Concrete Coring Water	B886, Room 103	45	Gallons	B891 Treatment Facility
PPE (Tyvek, gloves, paper, etc.)	B123 Slab	3.5	55-Gallon Drums	Sanitary Landfill
PPE (Tyvek, gloves, paper, etc.)	B886 Exterior	0.5	55-Gallon Drums	Sanitary Landfill
PPE (Tyvek, gloves, paper, etc.)	B886 Rooms 101/103	1	55-Gallon Drums	Low-Level Waste
Excess Soil Samples	B123 Slab Sampling	0.5	55-Gallon Drums	Points of Excavation[1]
Excess Soil Samples	B886 Int/Ext Sampling	0.5	55-Gallon Drums	Points of Excavation[1]

[1]Disposition will be determined upon finalization of RFCA Standard Operating Protocols (RSOP) for Soil and Asphalt Management.

4.0 MODIFICATIONS TO THE WORK SCOPE AND SAMPLING AND ANALYSIS PLAN

Five of the six planned HDD boreholes were installed, and more vertical (Geoprobe® and hand auger) soil sampling was conducted than proposed in the SAP. However, it was necessary to modify scope specified in the SAP due to actual conditions in the field. The alterations to the work scope and the SAP and their respective justifications are provided in Table 4-1 below and were executed to benefit the project as a whole and in the interest of worker safety.

Table 4-1 Work Scope Modifications

Scope Modified or Deleted	Rationale
Building 123	
Horizontal soil sampling not conducted along HDD Line 1	HDD Line 1 boring contacted concrete building footer at the south end of Room 111 at 43 feet (prior to reaching sample locations) and could not be redirected. Sample locations HDD-1-01 to 04 were therefore not collected.
Omit HDD-2-10 through 13 sample locations	Exterior steel casing became bent and borehole strayed too far east of area of interest.
Geoprobe® soil samples at locations WPS-5, WPS-6, and WPS-1 were not collected	Numerous Geoprobe® attempts but refusal at 15" at and around WPS-5 & -6. Possible cause may be due to a large subsurface concrete slab in former loading area. GP-2-06 is close to WPS-1 location and was collected in its stead.
Omit HDD-2-02 sample collection	Sample location too close to HDD-4-06 sample location.
Omit HDD-3-10 & 11 and GP-3-11 sample collection	These three sample locations are east of IHSS and UBC boundaries and too many underground utilities exist in the proposed bore path to be safely collected.
Building 886	
Omit drilling and sampling of HDD Line 5 (beneath Room 103 Pit area) from scope of work	• Potential of introducing highly contaminated soils to surface and areas open to environment • Potential of not being able to free release drill equipment if contaminated • HDD/EMWD operations at B886 were demonstrated by HDD Line 6
Add four vertical samples within Room 103 to existing four samples	To help offset the cancellation of HDD Line 5 by additional hand-auger sampling to better characterize the soils beneath Room 103. The hand-auger sampling method replaced the proposed Geoprobe® sampling method as proposed in the SAP. The Geoprobe® was not utilized within Room 103.
Add four Geoprobe® samples outside of Building 886, West of Room 101 (Pad-1&2 and Plenum 1&2)	Four shallow soil sample locations added to characterize soil beneath two pads for historical spills. "Pad" slab supported above ground tank and "Plenum" slab supported Room 101 filter plenum (tank and plenum previously removed).

5.0 HDD/EMWD APPLICATIONS AND LIMITATIONS

A description of the applications and limitations of the HDD/EMWD system are provided below.

5.1 Pros

1. Waste minimization (2000 DOE Pollution Prevention Award); no mud was utilized with pneumatic hammering method of drilling.
   - Eliminates the generation and spread of potentially contaminated drilling returns
   - Total displacement of soils during drilling/borehole advancement
   - Only media returned to surface is media sample collected with split spoon
   - Wastes generated include only residual soil samples, Personal Protective Equipment (PPE), and sampling tool decontamination wash-water
   - Less than one 55-gallon drum filled with residual soil sample wastes
   - Greatly reduced waste disposition costs.
2. The EMWD allowed for remote characterization sampling of potentially contaminated soils beneath buildings and structures prior to their decommissioning.

This method helped to promote worker safety by implementing ALARA and reducing contact with unknown contamination.

3. EMWD provided information to the workers before each sample event. Although time consuming in logging the data, it provided useful information before the sample was extracted.

5.2 Cons

Significant costs incurred by utilizing HDD Subcontractor, support equipment, and labor. Refer to Cost Comparison Analysis in Section 5-3.

1. Pneumatic hammer/casing advancement method requires significantly more time than the more traditional rotary method of Horizontal Directional Drilling to complete borings and soil sampling.
   - EMWD measurements cannot be collected simultaneously when drilling due to hammer-action and the fragility of the EMWD equipment. Drilling must pause and drill stems and bit must be tripped out by hand prior to EMWD data collection and tripped back in prior to restart of drilling.
   - Pneumatic hammer method is a non-rotary method which results in having to "steer" the direction on the bore-path by rotating drill stem and bit with hand methods.
   - Limited flexibility for directional steering due to drill casing.
   - Because of limited flexibility, shallow trenches were excavated to position the CAFA (Casing Advancement Framework Assembly) near the required elevation of drilling to minimize the layback distance.
   - Steel casing required to maintain open borehole for extracting soil samples due to all alluvium instability and dry drilling methods used.
2. Limitations on achieving desired borehole lengths (horizontal depths).
   - Steel casing can often collapse or bend resulting in refusal of borehole advancement (often at approximately 100 feet total depth).
   - Directional bit and drill stem can frequently get stuck down-hole in casing due to casing compromising.
3. Limited steering capabilities with pneumatic hammer/advance casing method as compared to traditional HDD drilling.
   - Casing is not very flexible so direction requires additional boring length to make steering adjustments, if possible.
4. High levels of noise (>100 decibels) generated in work area during operation of hammer and support equipment.
5. The drill bit typically follows path of least resistance in soils. A sandy lens of material will have a preferential pathway versus harder bedrock or other obstructions.
6. Numerous radio signal interferences created problems for the Digi-Trak identifying the location of the bit. This was possibly due to the concrete or rebar in the concrete slabs and/or by the casing and other unidentified subsurface obstructions. The transmitter had to penetrate through all of this medium before the receiver (Digi-Trak) could receive the bit locating information.

7. The hammer drilling generates excessive vibration which repeatedly created problems with the sonde transmitter. Work had to be paused routinely for battery replacement and sonde repair throughout operations.

5.3 Cost Analysis for HDD/EMWD – UBC 123

Table 5-1 below shows the linear footage and associated costs of horizontal drilling and sample collection performed under the scope of this project. This information is being provided to assist in comparing cost effectiveness of horizontal drilling with other available characterization methods for future projects.

Table 5-1 Costs for HDD/EMWD Work Scope Completed

Actual Scope of Work Performed			
Borehole ID	**No. of HDD Samples Collected**	**Length of Boring (ft)**	**Cost per Borehole[1]**
HDD Line 1	0	43	$22,679
HDD Line 2	8	137	$54,891
HDD Line 3	5	63	$37,403
HDD Line 4	6	114	$40,167
HDD Line 6	2	18	$27,865
Totals	**21**	**375 ft**	**$183,005**
Cost per Linear Foot			**$488**
Additional Associated Costs			
Mob/Demob			$67,555
EMWD Retrofit to HDD Rig			$19,630
Health and Safety Plans, Job Hazards Analyses, and Bonds			$28,526
Total Project Costs			**$298,716**
Total Project Costs per Linear Foot			**$797**

[1] HDD Costs – Includes setup, materials, and labor for hammer drilling, soil sampling, and abandonment.

6.0 DATA QUALITY ASSESSMENT

The Data Quality Objectives (DQO) of this project, as defined in the SAP, were achieved based on the Data Quality Assessment (DQA) provided herein, which details project discussion and Verification and Validation of project data. The DQOs were designed to ensure that the type, quantity, and quality of environmental data used in decision making are appropriate. Data requirements to support this project were developed and implemented using criteria established in *Guidance for the Data Quality Objective Process*, QA/G-4 (EPA 2000).

Data used in making management decisions for remediation and waste management must be of adequate quality to support the decisions. Adequate data quality for decision-making is required by the Kaiser-Hill Team Quality Assurance Program Manual (K-H, 2000), as well as by the customer (DOE, RFFO; Order 414.1A, Quality Assurance, §4.b.(2)(b)). Regulators and the public also expect decisions and data that are technically and legally defensible. Verification and validation of the data ensure that data used in decommissioning and waste management decisions are usable and defensible.

Verification and validation (V&V) of the data are the primary components of the DQA. The final data are compared with original DQOs of the project, and evaluated with respect to project decisions, uncertainty within the decisions, quality criteria associated with the data, particularly precision, accuracy, representativeness, completeness, comparability, and sensitivity. Data sets subject to V&V consist of all analytical and radiochemical results presented in the report.

Chemical and radiological media sample results were validated consistent with the following RFETS-specific documents and industry guidelines:

- KH V&V Guidelines
  - ✓ *General Guidelines for Data Verification and Validation*, DA-GR01-v1, December 3, 1997
  - ✓ *V&V Guidelines for Isotopic Determinations by Alpha Spectrometry*, DA-RC01-v1, 2/13/98
  - ✓ *V&V Guidelines for Volatile Organics,* DA-SS01-v1, 12/3/97
  - ✓ *V&V Guidelines for Semivolatile Organics,* DA-SS02-v1, 12/3/97
- EPA 540/R-94/013, USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review
- EPA 540/R-94/012, USEPA Contract Laboratory Program National Functional Guidelines for Organic Data Review
- Lockheed-Martin, 1997. Evaluation of Radiochemical Data Usability, ES/ER/MS-5.

This report will be submitted to the Comprehensive Environmental, Response, Compensation and Liability Act (CERCLA) Administrative Record for permanent storage within 30 days of approval by the regulators (CDPHE). Until that time, all quality records reside with the Project.

6.1 DQO Decisions

Consistent with the original DQO decision rules of the project, a sum-of-ratios (SOR) calculation was performed for radiological and non-radiological contaminants across each UBC area of interest. The maximum value for each contaminant of concern was divided by its corresponding RFCA Action Level (Tier I and Tier II, respectively, for Open Space exposure scenarios, except for lead, where only an Industrial Area scenario is published) for subsurface soil and cumulatively summed. Per the DQO decision logic, if the summation for radiological or non-radiological constituents, using maximum values, does not exceed one (1), then no further action is required.

Calculations and query logic may be found in the files referenced below. Execution of the cited queries will reproduce the results as stated in this report. Radiological action levels used "industrial" exposure scenarios, whereas all other action levels used "open space" exposure scenarios. Use of these numbers generally represent the most conservative comparison of values (i.e., presenting the most likely scenario for sample results to exceed associated RFCA Action Levels).

6.2 UBC 123 Data Summary

A data summary table for all samples collected at UBC 123 is provided in Table D-1 of Attachment D. This table displays the number of analyses performed by the labs and provides a means to easily compare maximum values for each analyte/radionuclide with RFCA action levels (DOE 1996) and/or background concentrations (DOE 1995b).

6.2.1 UBC 123 Radiological Results

Calculation of the sum-of-ratios for the five radiological contaminants of concern (Am-241, Pu-239/240, U-234, U-235, and U-238) yielded a value of 0.04 for Tier II (0.01 for Tier I), well below the action level of one. Therefore, no environmental remediation action is required relative to radionuclides at UBC 123.

6.2.1.1 UBC 123 Cesium Results

The soils adjacent to the abandoned subsurface source pits (sample locations SP-2, SP-3, and SP-4) were analyzed for Cesium-137 as required by the SAP. Of the three sample locations, the highest activity measured for Cesium-137 was estimated (J-qualified) at 0.097 picocuries per gram (pCi/g), well below the Site background value of 1.685 pCi/g. SP-2 and SP-4 each resulted in non-detectable values.

6.2.2 UBC 123 Chemical Results

Calculation of the sum-of-ratios for non-radiological constituents yielded the following values:

	Tier I	Tier II
Metals	**3.64**	**10.32**
Organics	0.05	**5.19**
TOTAL SOR	**3.69**	**15.22**

Values exceeding unity are bolded above. The exceedances of Tier I and 2 Action Levels for both metals and organics are shown in Attachment D.

Metals exceedances are due to lead, beryllium, and arsenic. Only one lead sample (LAB-1) exceeded both background and the Tier I Action Level, as indicated in Table 6-1 below. Although beryllium exceeded Tier II Action Levels, it did not exceed background levels, and therefore, its presence is not considered contamination. Arsenic exceeded Tier II levels for two samples, (HDD-2-09 and GP-1-1) but exceeded background levels only twice at less than 2 milligrams per kilogram (mg/kg) difference (see Table 6-1). Therefore, the two arsenic concentrations are considered insignificant because it is well within the range background concentrations. All background values used in database queries, including those quoted below, are defined as the arithmetic mean plus 2 standard deviations of the background sample sets, DOE, 1993 (Table D-16).

Table 6-1 Samples Exceeding RFCA Action Levels – UBC 123

RIN #	Sample Location	Analytical Concentration	Tier I Action Level	Tier II Action Level	Background Concentration[1]
01R0013-009.003	HDD-2-09	As - 14.7 mg/kg	381 mg/kg	3.81 mg/kg	13.14 mg/kg
01R0021-022.003	GP-1-1	As - 14.4 mg/kg	381 mg/kg	3.81 mg/kg	13.14 mg/kg
01R0021-013.003	LAB-1	Pb - 3470 mg/kg	1000 mg/kg	1000 mg/kg	24.97 mg/kg

[1]Source: DOE, 1993. Background Geochemical Report, Table D-16, RFETS, September, 1993.

The SOR exceedance of Tier II by organics was due wholly to methylene chloride detections, which are attributed to laboratory cross-contamination of the soil samples. Rationale for concluding methylene chloride concentrations as being due to lab cross-contamination is detailed within the Section 6.4.2.

6.3 UBC 886 Data Summary

A data summary table for all samples collected at UBC 123 is provided in Attachment D. This table displays the number of analysis runs performed by the labs and provides a means to easily compare maximum values for each analyte/radionuclide with RFCA action levels (DOE 1996) and/or background concentrations (DOE 1995b). Interpretation of the data work up for the radiological and chemical results are presented in the subsections below.

6.3.1 UBC 886 Radiological Results

Calculation of the sum-of-ratios for the five radiological contaminants of concern yielded a value of 0.04 for Tier II (0.01 for Tier I), well below the action level of one. Therefore, no environmental remediation action is required relative to radionuclides at UBC 886.

6.3.2 UBC 886 Chemical Results

Calculation of the sum-of-ratios for non-radiological constituents yielded the following values:

	Tier I	Tier II
Metals	0.14	**5.05**
Organics	0.05	**4.60**
TOTAL SOR	0.19	**9.65**

Tier I Action Levels were not exceeded. Values exceeding unity are bolded above. Exceedance of Tier II Action Levels for both metals and organics is explained as follows.

Metals exceedances are due to arsenic alone; however, because all arsenic detections are below the subsurface background level of 13.14 mg/kg, the presence of arsenic is not considered contamination. Tier II Action Levels for organics were exceeded due to methylene chloride and 1,1,2,2-Tetrachloroethane. The methylene chloride is due to lab cross-contamination as explained in Section 6.4.2. An estimated value of 3 micrograms per kilogram (ug/kg) ("J" qualified by the lab) was measured in sample 886-101-04 at Room 101 (See Plate 2 for physical location).

Because this estimated value is below the detection limit, there is not adequate confidence to conclude that it is truly a detection *above the action level.* Stated differently, this estimated value should be treated no differently than nondetect values at the detection limit, where the detection limit exceeds Tier II, typical of this compound and many others. In such cases where Method Detection Levels (MDLs), derived from standard SW-846 methodology, exceed associated RFCA Action Levels, it is suggested that Action Levels be adjusted to equal the MDLs, if current analytical technology does offer greater analytical sensitivity (i.e., lower MDLs).

6.4 Verification and Validation of Results

Verification ensures that data produced and used by the project are documented and traceable per quality requirements. Validation consists of a technical review of all data that directly support the project decisions, such that any limitations of the data relative to project goals are delineated, and the associated data are qualified (caveated) accordingly. The V&V process was graded relative to the original DQOs of the project, as defined in Section 3.1, and specific criteria, as they pertain to Precision, Accuracy, Representativeness, Completeness, Comparability and Sensitivity (PARCCS) parameters described below.

- 1.0 Chain-of-Custody;
- 2.0 Preservation and hold-times;
- 3.0 Instrument Calibrations;
- 4.0 Preparation Blanks;
- 5.0 Interference Check Samples (metals);
- 6.0 Matrix Spikes/Matrix Spike Duplicates (MS/MSD);
- 7.0 Lab Control Samples (LCS);
- 8.0 Field Duplicate measurements;
- 9.0 Chemical yield (radiochemistry);
- 10.0 Required Quantitation Limits/Minimum Detectable Activities (sensitivity of chemical and radiochemical measurements, respectively); and,
- 11.0 Sample Analysis and Preparation methods.

PARCCS parameters are indicators of data quality. Analytical data collected in support of the EMWD/HDD were evaluated using the guidance in procedure RF/RMRS-98-2000, *Evaluation of Data for Usability in Final Reports*. This procedure establishes the guidelines for evaluating analytical data with respect to the PARCC parameters. The following paragraphs define these PARCC parameters in conjunction with this project.

6.4.1 Precision

Radiochemistry (Alpha Spectroscopy)

Results from laboratory duplicates (replicates) indicate adequate reproducibility based on duplicate results within statistical tolerance values (>95% confidence of equivalency between the original sample and the duplicate).

Chemical Results

There are no qualifications to any chemical results based on evaluation of quality criteria listed in the last section.

Three (3) field duplicates were acquired to evaluate sampling precision for samples collected at UBC 123. Relative percent difference (RPD) values were calculated for *each detected analyte* to evaluate repeatability of the sampling process. All RPD values were ≤25%, which is satisfactory for lab precision within a soil matrix, hence, also satisfactory for repeatability within the field sampling process.

Two (2) field duplicates were acquired to evaluate sampling precision for samples collected at UBC 886. RPD values were calculated for *each detected analyte* to evaluate repeatability of the sampling process. Field duplicates were also blind to the laboratory to prevent any potential analytical bias. All RPD values were ≤26%, which is satisfactory for lab precision within a soil matrix, hence, also satisfactory for repeatability within the field sampling process.

6.4.2 Accuracy (and Bias)

Distance measurements recorded on maps are within 3% of actual distances based on the laser technology used for distance measurements associated with the surveys.

Radiochemistry (Alpha Spectroscopy)

The frequency of laboratory Quality Control (QC) samples was adequate, at greater than a 1:10 ratio of LCS samples to real samples for batch control (Tables D-1 and D-3). Blank samples were also analyzed at a satisfactory frequency for batch control (>1:10).

Accuracy of radiochemistry results was generally within 20% of full scale measurement, and about ±1 pCi/g and for all actinides of interest at or near contractually required detection limits (i.e., 0.3 pCi/g or pCi/l for 241Am, 239,240Pu; 1 pCi/g or pCi/l for the U species). Sample-specific accuracies are reported on the laboratory reports as either total error (e.g., total propagated uncertainty [TPU]), or counting error. Accuracy of radiochemistry results was controlled through periodic laboratory calibrations, use of lab control samples, and measurement of chemical yields. Recoveries of laboratory control samples (LCS) were within ±20% of the spike amount, consistent with contractually required- and industry standards. Other quality controls, such as sample-specific yield percentages, are maintained in the original laboratory data packages managed by K-H Analytical Services Division in Building 881.

Blanks yielded no concentrations significant enough to cause a high bias in the corresponding real samples; stated differently, there are no false positive results due to blank contamination.

Chemical Results

Building 123 –

A summary of the V&V for all electronic records indicates a minor percentage of rejects (<5% of all records) limited to VOCs and semi-volatile organic compounds (SVOCs). The frequency of laboratory QC samples was adequate, at greater than a 1:10 ratio of LCS samples to real samples for batch control (Tables 6-4 and 6-5). Blank samples were also analyzed at a satisfactory frequency for batch control (>1:10).

Table 6-2 UBC 123, Summary of Validated Records

VAL_QUALIFIER	Total Of	Alpha Spec	SW-846 8260	SW-846 8270B	SW-6010+Hg
	1491	45	534	540	372
1	6047	141	3890	1626	390
J	181		6		175
J1	73		8	23	42
R1	80		6	74	
U	6		2	4	
U1	1		1		
V	1849		684	369	796
V1	2120	224	356	1248	292
JB	2			2	
JB1	40		23	17	
UJ	213		114	21	78
UJ1	3586		2080	1476	30
V1	1		1		
Total V&V Percent	**90%**	**89%**	**93%**	**90%**	**83%**

Several records containing LCS information are indeterminate. Some "LC1" lab qualifiers are reported as non-detects, though associated verification/validation information does not recognize the association as a quality problem.

Methylene chloride results were biased high due to blank contamination for both data sets (UBCs 123 and 886). Use of the 10x rule as provided by the EPA (EPA 1994) indicates that detections of the contaminant in real samples are not significant, but are caused by laboratory cross-contamination. Ratios of real sample concentrations to blank concentrations did not exceed 5 for any given lab batch. All samples were represented by batch control samples for Building 886; 10 of 11 were represented for 123. Those samples with methylene chloride detections not represented by batch control may be inferred as being due to lab cross-contamination based on the large majority of batch control represented.

Building 886 -

A summary of the V&V for all Electronic Data Deliverable (EDD) records indicates no rejection of the data. The ramifications of blank contamination – the same for Building 886 results as for Building 123 -- were discussed above. All estimated values were well less than associated RFCA Action Levels.

Table 6-3 UBC 886, Summary of Validated Records

VAL_QUALIFIER	Total Of	Alpha Spec	SW-846 8260	SW-846 8270B	SW-6010+Hg
	2963		871	1314	778
1	1304	108	635	281	280
J1	77		9	19	49
V1	639	110	183	195	151
JB	6			6	
JB1	11		11		
UJ	192			192	
UJ1	647		309	314	24
Total V&V Percent	**49%**	**100%**	**57%**	**43%**	**39%**

6.4.3 Representativeness

Samples acquired for the project are representative based on the following criteria:

1. Familiarity with facilities -- multiple walk-downs and collaborations by management and technical staff;
2. Implementation of industry-standard Chain-of-Custody protocols;
3. Compliance with sample preservation and hold times;
4. Documented and Site approved methods, particularly RSPs for scans/surveys and the following documents for alpha spectroscopy; and
5. In accordance with the SAP.

All real samples were subsurface soil samples.

6.4.4 Completeness

Sampling completeness is addressed in Table D-1 below.

QC samples were taken at adequate frequencies for all QC sample types, >>5% QC/real sample ratio, for both UBC data sets.

Table 6-4 123 UBC Sample Completeness Summary

# Samples Planned (incl. Media; Real & QC Samples)	# Samples Taken (Real & QC Samples)	Project Decisions (Conclusions) & Uncertainty	Comments
VOC			
37 HDD Real 30 Geoprobe® Real 3 Field Dups	50 (total) 47 Real, 3 Field Dups 5 LCS 4 MS 16 MB	No contamination per SOR calculation	14 Samples not Collected – Refer to Table 4-1
SVOC			
37 HDD Real 30 Geoprobe® Real 3 Field Dups	49 (total) 46 Real, 3 Field Dups 9 LCS 9 MB	No contamination per SOR calculation	14 Samples not Collected – Refer to Table 4-1
METALS			
37 HDD Real 30 Geoprobe® Real 3 Field Dups	49 (total) 46 Real, 3 Field Dups 9 LCS 4 MS 9 MB	No contamination per SOR calculation (As, Pb, and Be exceed Tier II, but at or below background levels)	14 Samples not Collected – Refer to Table 4-1
RADIOCHEMCIAL (Alpha Spec)			
37 HDD Real 30 Geoprobe® Real 3 Field Dups	49 (total) 46 Real, 3 Field Dups 10 LCS 10 LD 10 PB	No contamination per SOR calculation	14 Samples not Collected – Refer to Table 4-1
4 Geoprobe® Real (SP-1 through SP-4)	3 (Total) Cesium 3 Real, 0 Dups	No Contamination-Levels below Background	Not enough sample recovery in SP-1
Acronyms: Dups = Duplicate Sample LCS = Lab Control Sample LD = Lab Duplicate MB = Method Blank MS = Matrix Spike PB = Preparation Blank			

Table 6-5 886 UBC Sample Completeness Summary

# Samples Planned (incl. Media; Real & QC Samples)	# Samples Taken (Real & QC Samples)	Project Decisions (Conclusions) & Uncertainty	Comments
VOC			
13 Total 4 HDD Real 8 Geoprobe® Real 1 Field Dup	15 (total) 13 Real, 2 Field Dups 2 LCS 2 MS 5 MB	No contamination per SOR calculation	No VOCs collected outside of B886 (Pad –1&2 and Plenum- 1&2)
SVOC			
13 Total 4 HDD Real 8 Geoprobe® Real 1 Field Dup	19 (total) 17 Real, 2 Field Dups 4 LCS 5 MB	No contamination per SOR calculation	4 Samples added to scope during operations (Pad-1&2, Plenum-1&2)
METALS			
13 Total 4 HDD Real 8 Geoprobe® Real 1 Field Dup	19 (total) 17 Real, 2 Field Dups 8 LCS 4 MS 8 MB	No contamination per SOR calculation (As and Be exceed Tier II, but are below background levels)	4 Samples added to scope during operations (Pad-1&2, Plenum-1&2)
RADIOCHEMCIAL (Alpha Spec)			
13 Total 4 HDD Real 8 Geoprobe® Real 1 Field Dup	19 (total) 17 Real, 2 Field Dups 7 LCS 7 LD 7 PB	No contamination per SOR calculation	4 Samples added to scope during operations (Pad-1&2, Plenum-1&2)

6.4.5 Comparability

All results presented are comparable with CERCLA data on a site- and DOE complex-wide basis. This comparability is based on:

1. Use of standardized engineering units in the reporting of measurement results;
2. Consistent sensitivities of measurements (≤ the Required Quantitation Limit [RQL] or MDA);
3. Use of site-approved procedures (Contractual Statements of Work for lab analyses, §1.1);
4. Systematic quality controls; and
5. Thorough documentation of the planning, sampling/analysis process, and data reduction into formats designed for making decisions posed from the project's original data quality objectives.

6.4.6 Sensitivity

Adequate sensitivities, in units of ug/kg for SVOCs and VOCs, mg/kg for metals, and pCi/g, were attained for most analytes, with a listing of the exceptions given below. Most of the analytes given in Table 6-6 did not fail the Tier II SOR calculations because nondetect results – at the detection limit value – were not factored into the equation. Ideally, detection limits are at least one-half the action level; for those exceedances listed below, the RFCA Tier II Action Levels are currently under review.

Table 6-6 Analytes with Detection Limits Exceeding Tier II Action Levels

123 UBC ANALYTE NAME	886 UBC ANALYTE NAME
cis-1,3-Dichloropropene	cis-1,3-Dichloropropene
Trans-1,3-Dichloropropene	Trans-1,3-Dichloropropene
2,4-Dimethylphenol	1,4-Dichlorobenzene
1,4-Dichlorobenzene	4-Chloroaniline
4-Chloroaniline	bis(2-Chloroethyl)ether
bis(2-Chloroethyl)ether	Hexachlorobenzene
Hexachlorobenzene	2,4-Dichlorophenol
Anthracene	2,4-Dinitrotoluene
1,2,4-Trichlorobenzene	2,4-Dinitrophenol
2,4-Dichlorophenol	Dibenzo(a,h)anthracene
2,4-Dinitrotoluene	Benzo(a)anthracene
Indeno(1,2,3-cd)pyrene	2,6-Dinitrotoluene
Benzo(b)fluoranthene	N-Nitroso-di-n-propylamine
Benzo(a)pyrene	Hexachloroethane
2,4-Dinitrophenol	Vinyl Chloride
Dibenzo(a,h)anthracene	Methylene Chloride
Benzo(a)anthracene	Isophorone
2,6-Dinitrotoluene	1,1,2,2-Tetrachloroethane
N-Nitroso-di-n-propylamine	N-Nitrosodiphenylamine (1)
Hexachloroethane	Pentachlorophenol
Vinyl Chloride	2,4,6-Trichlorophenol
Methylene Chloride	3,3'-Dichlorobenzidine
Isophorone	2,4,5-Trichlorophenol
1,1,2,2-Tetrachloroethane	Nitrobenzene
Butylbenzylphthalate	
N-Nitrosodiphenylamine (1)	
Hexachlorobutadiene	
Pentachlorophenol	
2,4,6-Trichlorophenol	
3,3'-Dichlorobenzidine	
2-Methylphenol	
1,2-Dichlorobenzene	
2-Chlorophenol	
2,4,5-Trichlorophenol	
Nitrobenzene	

6.5 Qualitative Data Comparison (Horizontal vs. Vertical Profiles)

As stated in the SAP, one of the primary objectives of this project was to make a qualitative comparison of the data collected from soil samples along a horizontal profile (HDD) with the data collected by vertical profile (Geoprobe®) characterization techniques. The intent of this assessment is to assist in determining the potential of utilizing HDD or HDD/EMWD characterization techniques at future sites around RFETS and at other DOE facilities. This assessment is achieved by determining whether or not the data from the two sampling methodologies compare favorably, given two comparable, or immediately adjacent, sample locations from which a sample was collected by each method.

Table 6-7 below identifies the collocated HDD and Geoprobe® sample locations collected as part of this project. In all cases, the Geoprobe® collection interval (a 24-inch composite interval) vertically bound the HDD 24-inch horizontal composite interval by one-foot above to one-foot below. Tables 2 and 3 identify the actual depths collected by each method. Plates 1 and 2 show the respective locations of these samples in relationship to the Buildings 123 and 886 structures.

Table 6-7 HDD and Geoprobe® Collocated Sample Identification

HDD Sample Location and RIN/Event IDs		Collocated Geoprobe Sample Location and RIN/Event IDs		Sample Interval Depths-HDD/Geoprobe[1]
UBC 123				
HDD-2-03	01R0012.003	GP-2-03	01R0021.008	62"/ 50" to 74"
HDD-2-04	01R0012.004	GP-2-04	01R0021.007	68"/ 52" to 76"
HDD-2-06	01R0012.006	GP-2-06	01R0021.006	63"/ 51" to 75"
HDD-2-08	01R0013.008	GP-2-08	01R0021.004	62"/ 50" to 74"
HDD-3-02	01R0016.002	GP-3-02	01R0021.028	62"/ 50" to 74"
HDD-3-04	01R0020.001	GP-3-04	01R0021.029	87"/ 48" to 72"[3]
HDD-4-01	01R0007.001	GP-4-01	01R0021.017	76"/ 60" to 84"
HDD-4-04	01R0007.004	GP-4-04	01R0021.010	64"/ 52" to 76"
HDD-4-06	01R0007.006	GP-4-06	01R0021.009	47"/ 36" to 50"
Building 886				
HDD-6-01	01R0024.001	886-101-01[2]	01R0081.002	27"/ 19" to 32"

[1]Sample depths measured from top of concrete slab.
[2]Sample location 886-101-01 collected utilizing a hand auger.
[3]HDD sample location too deep; field decision to bound depth of OPWL instead of HDD sample.

The results of the data from the above sample locations are summarized in Tables D-1 and D-2 of Attachment D. All data indicate either non-detects or values below RFCA Action Levels for all Contaminants of Concern. Therefore, the data are considered comparable between the two sample collection methods.

7.0 SUMMARY

This characterization effort was performed to make remedial and waste disposition decisions for the subsurface soils at UBCs 123 and 886. The characterization included all potential contaminants, both radiological and chemical, based on previous sampling in the industrial area and process knowledge of the buildings. The data presented in this report have been verified and validated for the purpose of corroborating decisions to acceptable levels of confidence as stated in the project's original data quality objectives.

UBC 123

With the exception of arsenic and lead at three isolated sample locations, the results of the data indicate that no radiological or chemical contamination exists in excess of RFCA Tier I or Tier II Action Levels at the sample locations collected in UBC 123. Removal and disposal of the former Building 123 foundation and slab is currently scheduled for fiscal year (FY) 2002.

UBC 886

Results indicate that no radiological or chemical contamination exists in excess of RFCA Tier I or Tier II Action Levels at the sample locations collected in UBC 886. D&D of Building 886 is currently scheduled for FY 2002.

This project was completed in a safe and efficient manner with no lost work time. Additionally, the project was successful in accomplishing its objective of making qualitative data comparisons between the vertical and horizontal sampling methods.

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Attachment A
EMWD Results Report
Sandia National Labs

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SAND2001-1809
Unlimited Release
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Characterization of Under-Building Contamination at Rocky Flats Implementing Environmental-Measurement While Drilling Process with Horizontal Directional Drilling

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ABSTRACT

Characterization is required on thirty-one buildings at Rocky Flats Environmental Technology Site (RFETS or the Site) with known or suspected under building contamination. The Site has teamed with Sandia National Laboratory (SNL) to deploy Environmental Measure-While-Drilling (EMWD) in conjunction with horizontal directional drilling (HDD) to characterize under building contamination and to evaluate the performance and applicability for future characterization efforts. The Environmental Measurement-While-Drilling-Gamma Ray Spectrometer (EMWD-GRS) system represents an innovative blend of new and existing technology that provides the capability of producing real-time environmental and drill bit data during drilling operations.

The project investigated two locations, Building 886 and Building 123. Building 886 is currently undergoing D&D activities. Building 123 was demolished in 1998; however, the slab is present with under building process waste lines and utilities. This report presents the results of the EMWD Gamma Ray Spectrometer logging of boreholes at these two sites. No gamma emitting contamination was detected at either location.

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ACRONYMS

AC	alternating current
Am	americium
COC	contaminants of concern
Co	cobalt
CPM	counts per minute
Cm	curium
Cs	cesium
DC	direct current
D&D	Decommissioning and Deactivation
DOE	U.S. Department of Energy
Em	Environmental Management
EMWD	Environmental Measurement-While-Drilling
FM	frequency modulated
GRS	Gamma Ray Spectrometer
HEUN	Highly Enriched Uranyl Nitrate
HDD	Horizontal Directional Drilling
IDW	Investigative Derived Waste
IHSS	Individual Hazardous Substance Site
kHz	kilo-hertz
PAC	Potential Area of Concern
ppm	Parts Per Million
Pu	Plutonium
RCRA	Resource Conservation and Recovery Act
RFETS	Rocky Flats Environmental Technology Site
SNL	Sandia National Laboratory
UBC	Under Building Contamination
U	uranium
V	Volt

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Introduction

Characterization is required on thirty-one buildings at Rocky Flats Environmental Technology Site (RFETS) with known or suspected under building contamination. (UBC). UBCs are a result of known spills, leaks, or building processes during years of production. Recent demonstrations performed at other Nuclear Weapons Facilities (e.g. Hanford and Savannah River Site) have proven successful in characterization of subsurface contamination using the Environmental Measurement-While-Drilling technology with horizontal directional drilling. Sandia National Laboratories teamed with these sites to conduct the successful demonstrations.

The RFETS has teamed with Sandia National Laboratory (SNL) to deploy Environmental Measure-While-Drilling (EMWD) in conjunction with horizontal directional drilling (HDD) to characterize under building contamination and to evaluate the performance and applicability for future characterization efforts. Data collected using EMWD/HDD will be compared to data collected by conventional geoprobe techniques. The project investigated two locations, Building 886 and Building 123. Building 886 is currently undergoing D&D activities.

Background

The U.S. Department of Energy (DOE) Environmental Management (EM-50) has funded the development of the EMWD-GRS. During development, the EMWD-GRS system was tested at the U.S DOE radiation test facility in Grants, New Mexico and at the directional boring test site owned by Charles Machine Works in Perry, Oklahoma. The EMWD-GRS has been demonstrated at the Savannah River Site (SRS) F-Area Retention Basin. The EMWD-GRS with a Position Location Tool (PLT) was demonstrated at Hanford. The characterization activities at Rocky Flats represent the first deployment of the EMWD-GRS funded in part by Environmental Restoration (EM-40).

Rocky Flats Environmental Technology Site

The Rocky Flats Environmental Technology Site (RFETS or the Site) is located approximately 16 miles northwest of Denver, Colorado, in northern Jefferson County. RFETS comprises approximately 6,550 acres of land in Sections 1 through 4 and 9 through 15 of Township 2 South, Range 70 West, 6th Principal Meridian. Major buildings are located within the industrial area, which encompasses approximately 400 acres and are surrounded by a buffer zone of approximately 6,150 acres. RFETS is government-owned, U.S. Department of Energy (DOE), contractor-operated facility in the nuclear weapons production complex. The former mission at RFETS was to produce components for nuclear weapons from plutonium, uranium, and non-radioactive materials.

The current mission is to safely close the Site under an aggressive schedule. The emphasis of closure is focused on Deactivation and Decommissioning (D&D) activities for the remaining buildings that have the highest priority and critical path at this time. To accomplish closure in a timely fashion, characterization is required on thirty-one buildings across the Site with suspected or verified Under Building Contamination (UBCs). UBCs resulted from known spills, leaks, or building processes during the years of production. Characterization activities will be required to be conducted in parallel with D&D activities in-order to meet the aggressive closure schedule.

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Environmental Measurement-While-Drilling (EMWD)

The Environmental Measurement-While-Drilling Gamma Ray Spectrometer with position location capability (EMWD-GRS) system represents an innovative blend of new and existing technology that produces the capability of providing real-time environmental and drill bit data during drilling operations. These real-time measurements provide technical data for field screening (i.e., "steering" the drill bit in or out of contaminated zones). There are also time, cost, and safety advantages to using the EMWD-GRS system's field screening approach: (1) data on the nature of contamination are available in minutes, as opposed to weeks or months for offsite confirmatory analysis; (2) substantial cost savings result by minimizing the number of samples required for off-site confirmatory analyses; and (3) worker safety is enhanced through the minimization of waste generated during drilling and by quickly alerting field personnel to potentially hazardous conditions; and (4) the amount of investigation derived waste (IDW) is reduced.

The EMWD-GRS system is compatible with a variety of directional drilling techniques that include (1) push systems that use minimal drilling fluids generating little or no secondary waste and (2) mud systems using rotary drilling or mud motors The down hole sensors are located behind the drill bit and are linked by a high-speed data transmission system to a computer at the surface. Windows™-based software, developed by Sandia National Laboratories, is used for data display and storage. During drilling operations, data on the nature and extent of contamination are collected. Instant access to the data provides information for on-site decisions regarding drilling and sampling strategies.

Down-hole components of the EMWD-GRS system being deployed consist of a gamma ray spectrometer, a multichannel analyzer, a 900V power supply, a signal conditioning and transmitter board, and a coil containing coaxial cable for transmitting data to the surface. To protect them from the drilling environment, down-hole components are contained within O-ring-sealed stainless steel tubes. The up-hole system consists of a personal computer, a battery pack/coil, a pickup coil, and a receiver. During drilling, the GRS system monitors (1) gamma radiation, (2) the +12V and -12V required at the down-hole signal conditioning and transmitter board, (3) the up-hole battery voltage as measured down-hole, and (4) two temperatures associated with the detector and instrumentation. The system design incorporates data quality assurance techniques to ensure data reliability.

The EMWD system can provide real-time data on an 8 differential/single analog multiplexer and on any number of digital channels. Sampling speed from the analog channels can reach 100 kHz. For the EMWD-GRS system, three digital channels are used. Readings are taken at a rate of 20 per second. The telemetry system is programmable firmware that can easily support many different data formats and additional data channels. The currently used format (Digital FM Bi-phase, 4800 baud) provides excellent noise rejection. A Sandia National Laboratories (SNL) designed receiver removes FM carrier noise, generates data clock, and buffers data to be used by an IBM or compatible personal computer. A 28V rechargeable battery pack can supply down-hole instrumentation power for more than 18 hours of drilling. The battery pack remains topside for easy maintenance.

RFETS Deployment of EMWD-GRS

The RFETS teamed with Sandia National Laboratory (SNL) to use EMWD in conjunction with horizontal directional drilling to characterize under building contamination and to evaluate the performance and applicability for future characterization efforts. Data collected using horizontal directional drilling with real time measurement-while-drilling will be compared to data collected by conventional geoprobe techniques.

The project investigated two locations, UBC 123 and Building 886. UBC 123 was demolished in 1998; however, the slab is present with under building process waste lines and utilities. Building 886 is currently undergoing D&D activities. A brief summary of the site history and contaminants of concern is given here.

Field activities met the following objectives:

- Characterize the under building contamination at Buildings 123 and 886
- Implement Sandia National Laboratories' real time measurement-while-drilling system (Environmental Measurement-While-Drilling) in conjunction with horizontal drilling to determine the effectiveness for characterizing under building contamination.

Project Description for UBC 123

UBC 123 (Figure 1) is located on Central Avenue between Third and Fourth Streets in the RFETS Industrial Area. In 1998 the building, which covered approximately 18,444 square feet, was D&D. Utilities were either disconnected and abandoned in place or removed in their entirety during the demolition of the superstructure. Remaining structural components are the building slab on grade, perimeter grade beam and spread footings.

History

Building 123 was constructed in 1953 and was used as the Site Radiological Health Physics Laboratory. The lab analyzed water, biological materials, soil, air, and filter samples for the presence of plutonium, americium, uranium, alpha radiation, beta radiation, gamma radiation, tritium, beryllium, and organics. Personnel radiation badges were counted and repaired and in the building as well. Radiological low-level liquid and chemical wastes were generated at this location and transferred to the Site treatment system, Building 374, via the process waste lines system.

UBC 123 consists of several potential areas of contamination (PACs) and two Individual Hazardous Substance Sites (IHSSs)

- IHSS 121 – Original Process Waste Lines: process waste lines P-1, P-2 and P-3 (see Appendix I: Plates showing locations of Bores at UBC 123 and Building 886, Plate 2).
- IHSS 148 which was established due to possible leaks from line P-2 and reported nitrate-bearing spills along the east side of UBC 123.

Contaminants of Concern

While in service, the Site Radiological Health Physics Laboratory used a wide variety of chemical including acids, bases, solvents, metals, radionuclides, and other. Wastes from operations were transferred for disposal via the process waste lines. Radionuclides of concern

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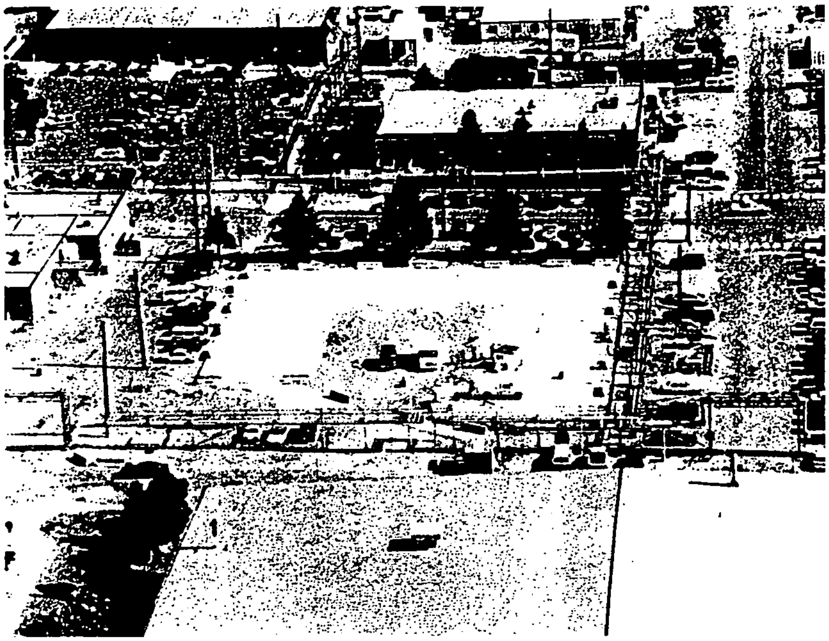
include: various isotopes of plutonium (Pu), americium (Am), uranium (U), and curium (Cm). This report only addresses efforts to identify gamma-emitting contamination.

Figure 1. Under Building Contamination 123: the 'U' shaped concrete slab is located in the center of the photograph.



Environmental Measurement-While-Drilling/Horizontal Directional Drilling (EMWD/HDD)

Four HDD boring line locations (HDD Lines 1 – 4) have been chosen for characterization of the soils immediately beneath and along the process waste lines, manholes, and sumps of UBC 123. Locations of the bores are shown in Appendix B, Plate #1.

Project Description for Building 886

Building 886, located in the northeastern portion of the 800 Area (Figure 2), was put into service in 1965. The building is approximately 14,197 square feet. In approximately 1980, Trailer 886A was built immediately east of the building and was later connected by the existing breezeway. Trailer 886A currently houses offices and a small electronics/machine shop. Various underground utilities are adjacent the building on the west side that are process waste lines that feed two underground storage tanks

History

Building 886 housed the Critical Mass Laboratory where low-level criticality experiments were performed on liquids, powder, and solid forms of fissionable materials. The date of the last criticality experiment was in October 1987. No operations are currently performed in Building 886 except for D&D activities. Enriched uranium solutions, solid enriched uranium, and plutonium metal have been used in this building. Room 103 contained seven Highly

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enriched uranyl nitrate (HEUN) tanks and a tank storage pit. HEUN solutions were spilled numerous times in rooms 101 and 103 during operations. The HEUN solutions spills were decontaminated and followed by sealing the concrete floor with paint to fix any residual contamination. Fluctuations of high groundwater under the building have periodically permeated the floor slab and have stained the concrete floor in room 103 with yellow cake after groundwater subsidence. The process of decontamination and sealing the concrete surface was repeated a number of times. Individual Hazardous Substance Site 164.2 located around Building 886 perimeter, resulted from an incident on September 26, 1989 where a 500-gallon stainless steel tank was found leaking a colorless liquid from its drain valve onto a concrete surface.

Figure 2. Building 886: building 886 is located behind the trailer.

Contaminants of Concern

The primary contaminants of concern at Building 886 based on past operational history are metals and radionuclides. The specific radionuclides of concern include: Pu-239/240, U-233/234, U-235, U-238, and Am-241).

Environmental Measurement-While-Drilling/Horizontal Directional Drilling (EMWD/HDD)

The EMWD/HDD effort was conducted on the east side due to underground utilities on the west side of the building. Two horizontal directional boreholes, HDD line 5-6, were planned for this facility (See Appendix B, Plate #2). Room 101 is the criticality laboratory with perimeter walls that are constructed of reinforced concrete and 4 feet thick. These walls extend below grade approximately five feet deep and are heavily reinforced with #6 and #8 rebar at twelve inches on center each way. HDD Line 5 was not attempted because of the possible high levels of HEUN contamination.

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Procedures

The calibration of the EMWD-GRS was conducted in a steel pipe. It was calibrated in the laboratory at Sandia National Laboratories using Cs-137, Co-60, and Na-22. It was also calibrated at the Field Calibration Facility for Environmental Measurement of radium, thorium, and potassium, DOE Grants Calibration Site, Grants, NM. The tool was calibrated using the thorium source and the potassium-40 source. The calibration curves age given in Appendix H: EMWD Gamma Ray Spectrometer Calibration.

RFETS selected Microtunneling as the directional drilling method. The Microtunneling technique uses a pneumatic hammer to develop the bore and install casing. This method was selected because it used no drilling fluid

EMWD, designed for use with rotating drilling methods, has never been tested in this environment. We had the following concerns using EMWD with the microtunneling:

- the pneumatic hammer would subject the EMWD tool to a shock environment for which it has not been tested;
- the magnetometer, for position location, could not be used;
- the Gamma spectrometer will be ~3 ft behind bit;
- cable handling would be a problem; and
- mounting the battery pack, that supplies power to the tool, would be an issue.

An alternative use of EMWD for Rocky Flats Deployment was devised. The following procedure was developed:

- A walkover position indicator is used to track drill bit position
- The casing would be emplaced to the first sampling point with the pneumatic hammer, without EMWD
- Pull out pneumatic hammer
- Push in EMWD, log hole as EMWD tool is withdrawn
- Push in sampler and take soil sample
- Re-insert pneumatic hammer to emplace casing to the next sampling point.

This procedure does not subject the EMWD tool to shock, but provides for real-time data on gamma contamination prior to taking soil sample. This was a completely new type of deployment of the EMWD tool. The method operation of the EMWD tool will not is given here, but can be found in Reference 4.

EMWD Tool Logging Set Up

The following procedure was used to collect gamma spectra in the RFETS bores:

1) EMWD tool set-up
   a) The EMWD tool is placed in a PVC housing.
   b) The tool is secured to the PVC housing so that tool does not turn and twist the cable off.

2) The EMWD tool is pushed into the open hole to the bit face, sampling point.

3) Data collection:
   a) Collect EMWD spectra at this point for 5 minutes.

b) Pull the EMWD tool out 1 foot, collect 1 spectrum. If no contamination is detected, continue this procedure until the tool reaches the next sampling point or exits the hole.
c) Repeat this procedure for each sampling point.

Results

UBC-123 Bore #1

UBC-123 HDD Line #1, located on the west side of UBC-123 and runs north-south (See Appendix B: Plates Showing Locations of Bores at UBC-123 and Building 886) was to be approximately 110 feet long and with seven soil samples to be taken. Background gamma spectra of the UBC-123 area were collected (Figure 3). The next spectra were taken at 20 ft (not a soil sampling point) into the bore (Figure 4). Comparison of Figures 3 and 4 indicate no readings above background at the 20 ft location. (Note: Only representative gamma spectra are included in the body of the report. The complete set of gamma spectra for all the soil sampling points are provided in Appendix D: EMWD Gamma Spectra for UBC 123 and Appendix D: EMWD Gamma Spectra for Building 886).

The next tool insertion was to be at 80 ft, the first soil sample point 1-01. Eighty feet was not achieved. A concrete footer was hit at ~40ft and could not be penetrated and the driller was having trouble getting depth reading from his locator tool. UBC-123HDD Line #1 was abandoned in place at the 40 ft point because the foundation wall of the building extension could not be penetrated.

Before pulling away from the first bore site, bore #1 was logged. The tool was pulled-back one foot at a time and a spectrum was taken. This was the technique use to fully log the remaining bores. A few representative samples of these spectra are given in Appendix D: EMWD Gamma Spectra for UBC 123 HHD #1. These spectra are essentially the same as the background spectra.

Figure 3. UBC-123 Gamma Spectrum background, Rocky Flats.

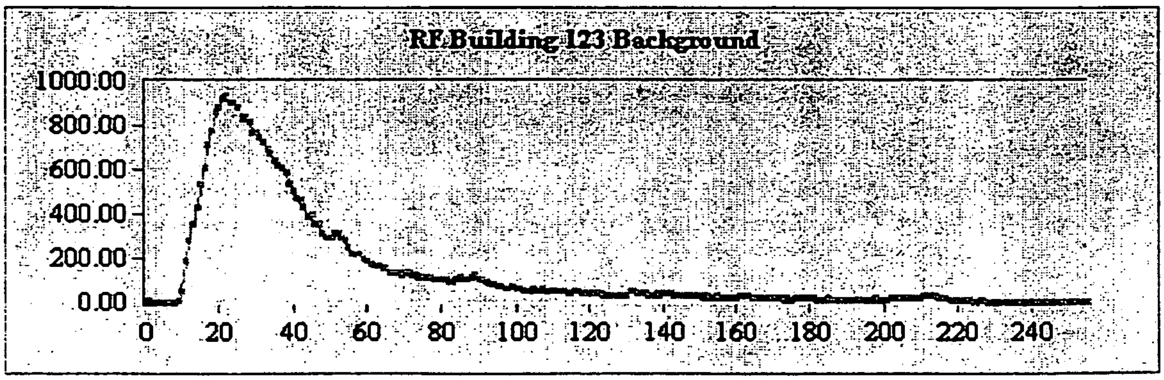

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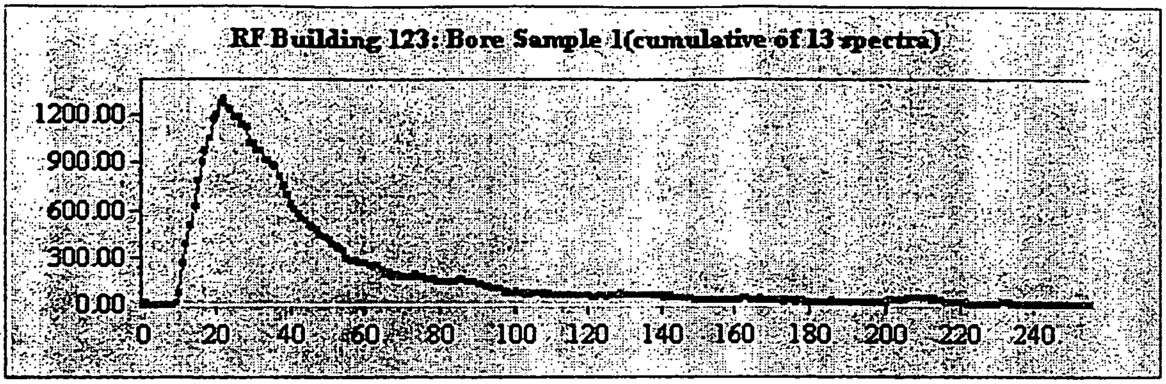
Figure 4. Cumulative Gamma Spectrum (13 spectra) from Bore 1 Sample 1, 20 ft into bore.



UBC-123 Bore #2

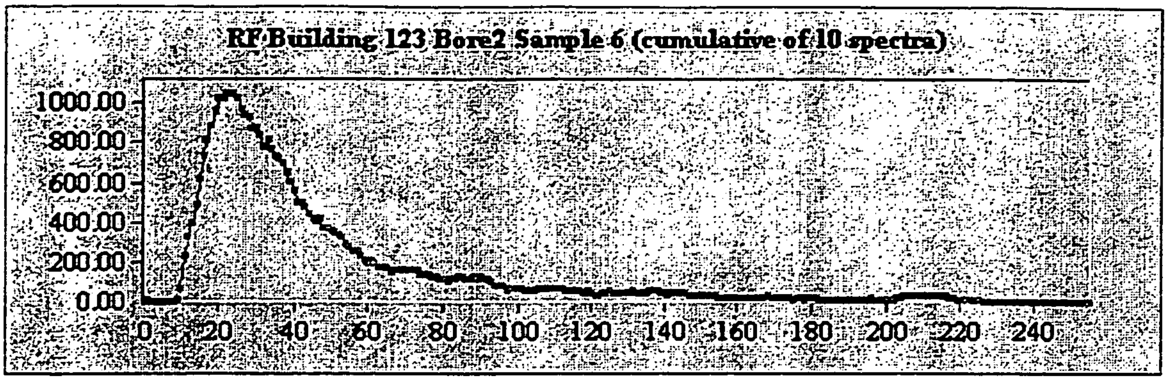
UBC-123 HDD Line #2 was to be approximately 190 feet long and thirteen soil samples were to be extracted (See Appendix B: Plates Showing Locations of Bores at UBC-123 and Building 886). HDD Line #2 is on the east side of the site and runs north south. This bore was completed to 126 feet at HDD #2 soil sample point 10. This bore was abandoned at this point because the casing was bent and further advancement could not be achieved.

Table 1 correlates the gamma spectra sampling locations with the soil sample locations and feet advanced. Sample point HDD Line #2-02 coincides with sampling point HDD Line #4-06. No gamma spectra were taken at UBC-123 HDD Line #2-02. Gamma spectral data for this point was taken onUBCu-123 HDD Line #4-06. Gamma spectra were collected at the soil sampling points and at 1-ft intervals between the soil sampling points. No gamma emitting contamination was detected anywhere along this bore. A representative gamma spectrum from UBC-123 HDD Line #2 indicating this fact is shown in Figure 5. Figure 5 is accumulative gamma spectrum of 10 gamma spectra collected at soil sampling point UBC-123 HHD Line #2-06 The gamma spectra for each soil sampling point of UBC-123 HDD Line #2 are given in Appendix D: EMWD Gamma Spectra for UBC-123. The gamma spectra gathered at the 1-ft intervals are not included in this report since no gamma contamination was detected.

Table 1: EMWD-GRS results from UBC-123 HDD Line #2.

Soil Sampling Number	Location (feet advanced)	EMWD-GRS Number	Results of GRS Reading
HDD #2-01	10	1	No contamination detected
HDD #2-03	27	2	No contamination detected
HDD #2-04	42.3	3	No contamination detected
HDD #2-05	54.4	4	No contamination detected
HDD #2-06	74	5	No contamination detected
HDD #2-07	92.3	6	No contamination detected
HDD #2-08	100	7	No contamination detected
HDD #2-08	102	8	No contamination detected
HDD#2-10	126	9	No contamination detected

Figure 5. Representative gamma spectrum for UBC-123 Bore #2: Cumulative Gamma Spectrum (10 spectra) from Bore 2 Sample 6.



UBC-123 Bore #3

UBC-123 HDD Line #3 was to be approximately 150 feet long and eleven soil samples were to be extracted. HDD Line #3 is on the south side of the site and runs east-west (See Appendix B: Plates Showing Locations of Bores at UBC-123 and building 886). This bore was completed to 63 feet at HDD #3 soil sample point 5. This bore was abandoned at this point because the casing was bent and further advancement could not be achieved.

Table 2 correlates the gamma spectra sampling locations with the soil sample locations and feet advanced. Gamma spectra were collected at the sampling points and at 1-ft intervals between the sampling points. No gamma emitting contamination was detected anywhere along this bore. A representative gamma spectrum from UBC-123 HDD Line #3 indicating this fact is shown in Figure 6. Figure 6 is accumulative gamma spectrum of 10 gamma spectra collected at soil sampling point UBC-123 HHD Line #3-03. The gamma spectra for each soil sampling point of UBC-123 HDD Line #3 are given in Appendix D: EMWD Gamma Spectra for UBC 123.

Table 2: EMWD-GRS results from UBC-123 HDD Line #3.

Soil Sampling Number	Location (feet advanced)	EMWD-GRS Number	Results of GRS Reading
HDD #3-02	18	2	No contamination detected
HDD #3-03	33	3	No contamination detected
HDD #3-04	48	4	No contamination detected
HDD #3-05	63	5	No contamination detected

UBC-123 Bore #4

UBC-123 HDD Line #4 was to be approximately 85 feet long and six soil samples were to be extracted. HDD Line #4 is on the north side of the site and runs east-west (See Appendix B: Plates Showing Locations of Bores at UBC-123 and Building 886). This bore was completed in its entirety.

Figure 6. Representative gamma spectrum for UBC-123 Bore #3: Cumulative Gamma Spectrum (10 spectra) from Bore 3 Sample 3.

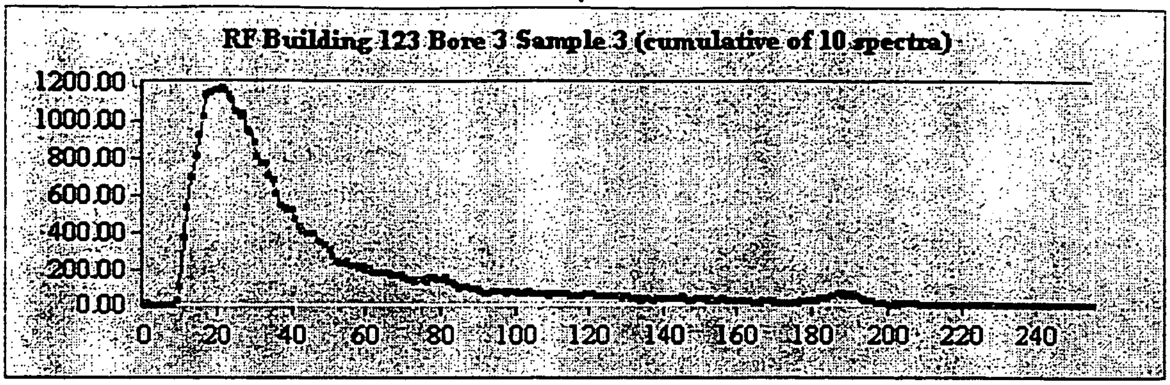
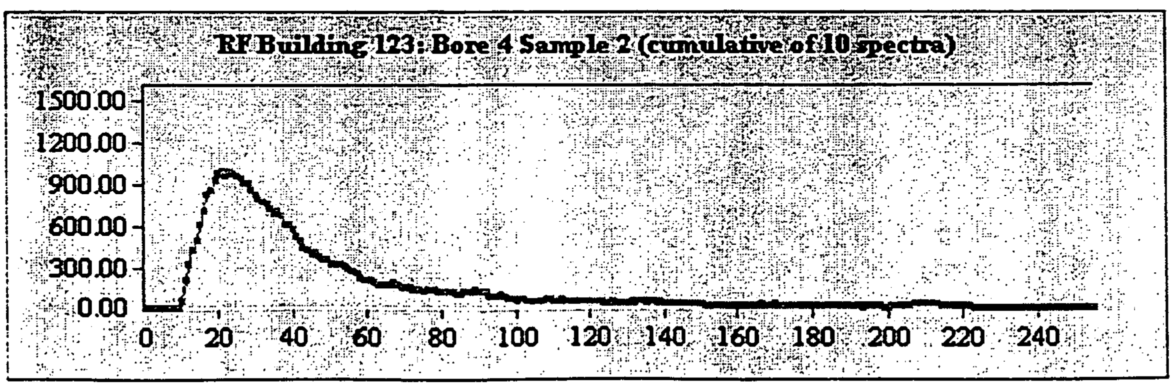


Table 3 correlates the gamma spectra sampling locations with the soil sample locations and feet advanced. Gamma spectra were collected at the soil sampling points and at 1-ft intervals between the soil sampling points. No gamma emitting contamination was detected anywhere along this bore. A representative gamma spectrum from UBC-123 HDD Line #4 indicating this fact is shown in Figure 7. Figure 7 is accumulative gamma spectrum of 10 gamma spectra collected at soil sampling point UBC-123 HHD Line #3-03. The gamma spectra for each soil sampling point of UBC-123 HDD Line #3 are given in Appendix D: EMWD Gamma Spectra for UBC 123.

Table 3: EMWD-GRS results from UBC-123 HDD Line #4.

Soil Sampling Number	Location (feet advanced)	EMWD-GRS Number	Results of GRS Reading
HDD #4-01	112	6	No contamination detected
HDD #4-02	102	5	No contamination detected
HDD #4-03	87	4	No contamination detected
HDD #4-04	72	3	No contamination detected
HDD #4-05	53	2	No contamination detected
HDD #4-06	42	1	No contamination detected

Figure 7. Representative gamma spectrum for UBC-123 Bore #4: Cumulative Gamma Spectrum (10 spectra) from Bore 4 Sample 2.



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Building 886 Bore #6

Building 886 HDD Line # 6 was to be approximately 40 feet long and extract four soil samples as shown on Plate. This line went under the north end room 101 and runs east-west. (See Appendix B: Plates Showing Locations of Bores at UBC-123 and Building 886). This bore was completed to 18 feet at HDD #6 soil sample point 2. This bore was abandoned atthis point because further advancement could not be achieved.

Background gamma spectra of the Building 886 area were collected (Figure 8). Table 4 correlates the gamma spectra sampling locations with the soil sample locations and feet advanced. Gamma spectra were collected at the sampling points and at 1-ft intervals between the sampling points. No gamma emitting contamination was detected anywhere along this bore. A representative gamma spectrum from Building 886 HDD Line #6 indicating this fact is shown in Figure 9. Figure 9 is accumulative gamma spectrum of 10 gamma spectra collected at soil sampling point Building 886 HHD Line #6-03. The gamma spectra for each soil sampling point of Building 886 HDD Line #6 are given in Appendix F: EMWD Gamma Spectra for Building 886.

Table 4: EMWD-GRS results from Building 886 HDD Line #6.

Soil Sampling Number	Location (feet advanced)	EMWD-GRS Number	Results of GRS Reading
HDD #6-02	18	1	No contamination detected
HDD #6-01	10	2	No contamination detected
HDD #6-bore opening	0	2	No contamination detected

Figure 8. Building 886 Gamma Spectrum background, Rocky Flats.

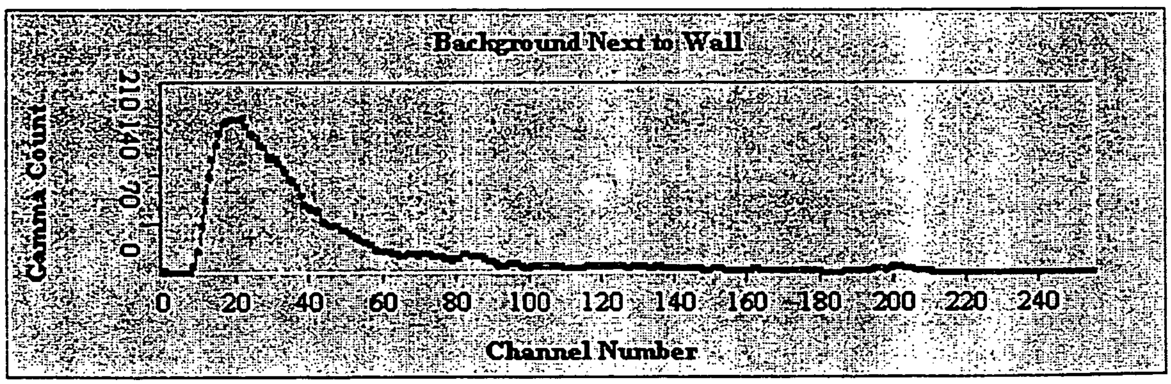

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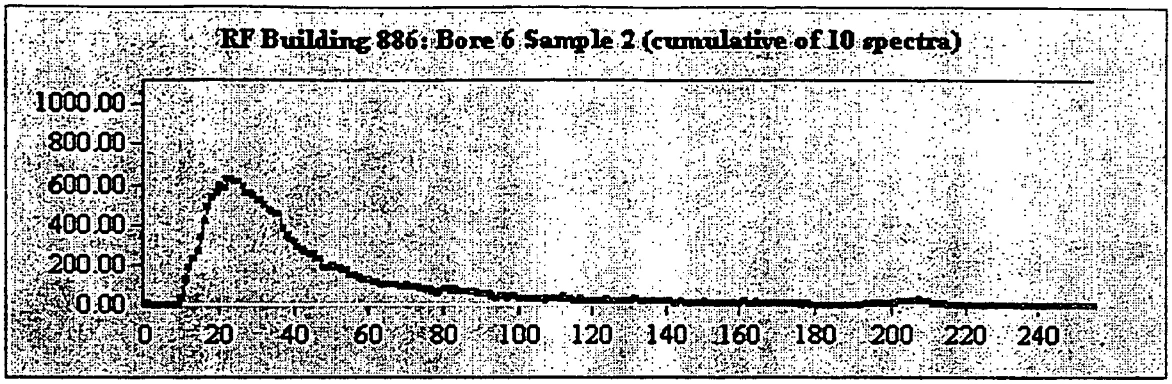
Figure 9. Representative gamma spectrum for Building 886 Bore #6: Cumulative Gamma Spectrum (10 spectra) from Bore 6 Sample 2.



SUMMARY

Five bores were drilled at two sites at the Rocky Flats Environmental Technology Site, four under UBC-123 and one under Building 886. The bores were developed using a microtunneling technique that uses a pneumatic hammer with no drilling fluid to advance the bore and install casing. Since the EMWD-GRS tool was not designed for this type of drilling, there were several concerns not the least of which the EMWD-GRS tool has never been tested in this type of shock environment. Additionally, since steel casing was installed, the EMWD-GRS position location capability could not be used. The EMWD-GRS tool was used to log the boreholes for gamma emitting contaminants prior to taking each soil sample.

Only one of the five bore attempted was completed in its entirety. The EMWD-GRS tool was used to log the bores for gamma emitting contaminants. No gamma emitting contaminants were detected.

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1. G. J. Lockwood, R. A. Normann, L. K Bishop, R. J. Floran, and C. V. Williams, (1995) *Environmental Measurement-While-Drilling System for Real-Time Field Screening Contaminants*, NO-DIG '95, Toronto, Canada, April 30-May 3, 1995.

2. G. J. Lockwood, R. A. Normann, L. B. Bishop, M. M. Selph, and C. V. Williams, (1996) *Environmental Measurement-While-Drilling System for Real-Time Field Screening of Contaminant IIs*, SAND 99-0460C, presented at the ADPA 22nd Environmental Symposium and Exhibition, Orlando, FL, March 1996.

3. C. V. Williams, G. J. Lockwood, and R. A. Normann, *Environmental Measurement-While-Drilling System for Real-Time Field Screening of Contaminants III*, (1996) SAND99-0461C, Spectrum '96, Seattle, WA, August 18-23, 1996.

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5. G. J. Lockwood, R. A. Normann, and C. V. Williams (1997) *Final Report of the Environmental Measurement-While Drilling-Gamma Ray Spectrometer System Technology Demonstration at the Savannah River Site F-Area Retention Basin,* SAND97-2028, Sandia National Laboratories, Albuquerque, New Mexico.

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9. B. Shleien, (1992) *The Health Physics and Radiological Health Handbook* (Revised Edition). Scinta Inc., Silver Spring, MD, 1992.

10. Statement of Work for Characterization for Characterization of Under-building Contamination (UBC) at UBC 123 and Building 886 Implementing Horizontal Directional Drilling (HDD) Environmental Measurement-While-Drilling (EMWD) Process, Kaiser Hill L.L.C., February 2000

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APPENDICES

A. Statement of Work for Sandia National Laboratories Implementing Environmental Measurement-While-Drilling at UBC 123 and Building 886.

B. Plates showing locations of Bores at UBC 123 and Building 886

C. EMWD Background Gamma Spectra: UBC 123

D. EMWD Gamma Spectra for UBC 123

E. EMWD Background Gamma Spectra: Building 886

F. EMWD Gamma Spectra for Building 886

G. EMWD Gamma Ray Spectrometer Calibration Methodology

H. EMWD Gamma Ray Spectrometer Calibration

I. Rocky Flats Field Notes

Statement of Work for Sandia National Laboratories Implementing Environmental Measurement-While-Drilling at UBC 123 and Building 886

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Statement of Work

1.0 Introduction

Sandia National Laboratories is working jointly with personnel at Rocky Flats to deploy the Environmental Measurement-While-Drilling (EMWD) system. The EMWD system is normally used while drilling. A number of factors resulted in the EMWD tool not being used while drilling for this deployment. In stead, the Rocky Flats drilling contractor will drill the hole without the EMWD tool. When the hole is completed or before a soil sample is taken, the Sandia EMWD tool will be manually placed into the hole using plastic tubing. With the tool in the hole, Sandia and Sandia contracted personnel will measure the wellbore gamma radiation levels.

The gamma radiation measurement is a full 256-channel spectrum. This data will be recorded in a Sandia supplied PC and Sandia software. If any notable radiation levels are detected, Sandia personnel will report and document their reading to Rocky Flats personnel. The Rocky Flats personnel will take appropriate action.

2.0 Scope of Work

2.1 Prior to deployment, Sandia will calibrate the EMWD for sub-surface gamma measurement. This calibration will be performed at the DOE calibration facility in Grants, NM.

2.2 Field Deployment of the EMWD

Sandia will supply one EMWD system and two appropriately trained personnel to the Rocky Flats Environmental Technology site. The Sandia and Sandia contracted personnel will support and/or assist in the deployment of the EMWD system to survey possible radioactive waste. Typical Sandia personnel duties may include:

- Assist in or perform placing the EMWD tool into the hole
- Record the measured results
- Report results to appropriate personnel

2.3 Training

The Sandia personnel are required to have a combination of 40-hour HAZWOPER with current HAZWOPER 8-hour refresher, DOE certificate of radiological training RW II, and complete site specific training ON site at Rocky Flats prior to start of work.

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3.0 Task Control

Cecelia Williams, Department 6803, is the designated Task Leader and will be consulted for approval if technical decisions concerning the scope of the work are needed. Randy Normann will provide the day-to-day interface.

4.0 Deliverables

4.1 Sandia will provide radiation spectrums from calibration testing at Grants NM.
4.2 Sandia will provide timely radiation measurements prior to drilling contractor soil sampling.
4.3 Sandia will provide a record of gamma reading taken within 6 months following completion of the Rocky Flats deployment.

5.0 Expected level of funding from Rocky Flats to support this activity is $55K.

5.1 Calibration at Grants NM
5.2 Field support personnel for up to consecutive 6 weeks
5.3 Final report providing the entire gamma record for the deployment

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APPENDIX B - Locations of Bores

Plates showing locations of Bores at UBC 123 and Building 886

Pl[illegible] 1
Building [illegible]DD Lines Process Waste Lines and Soil Sample Location Map

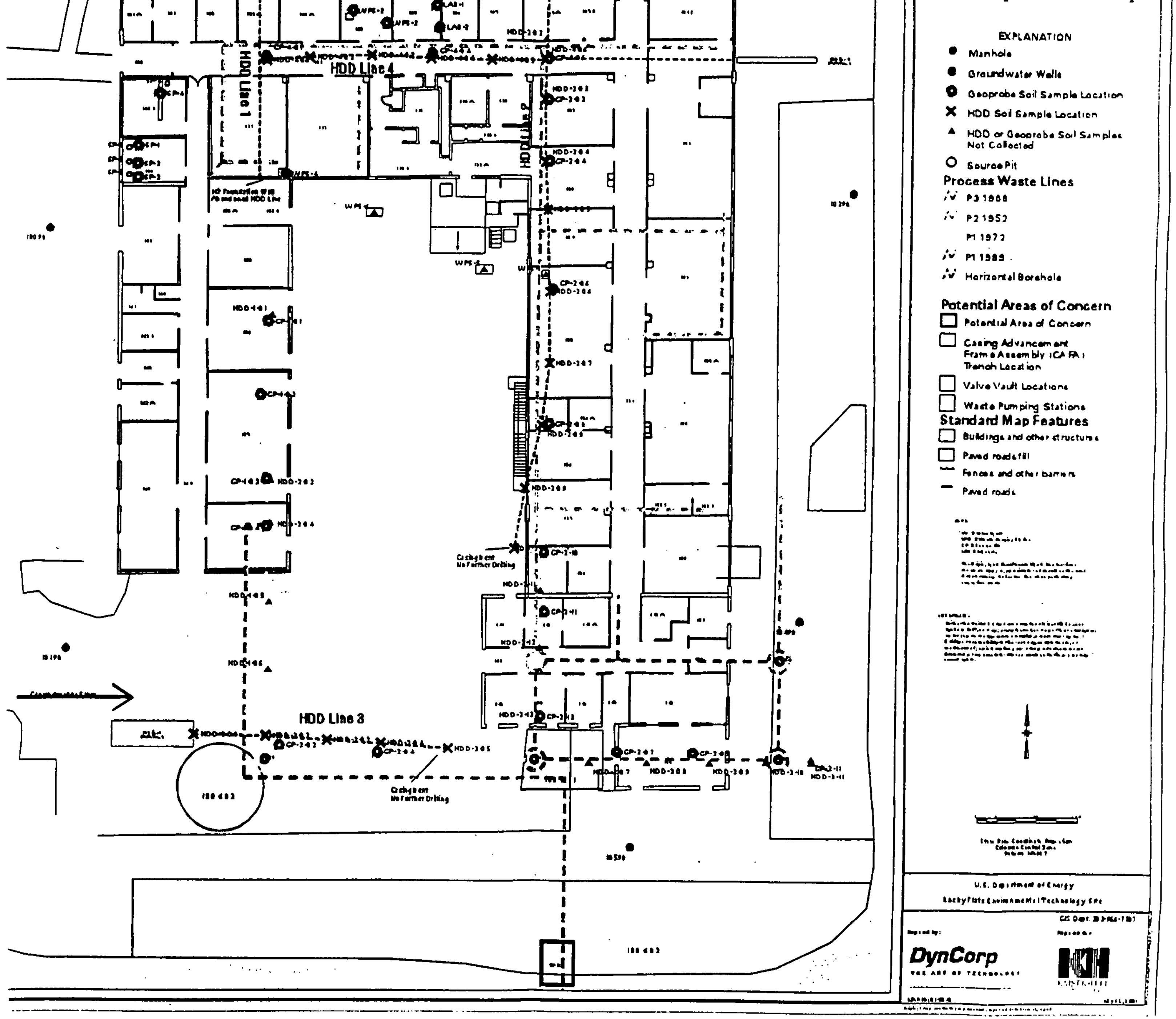
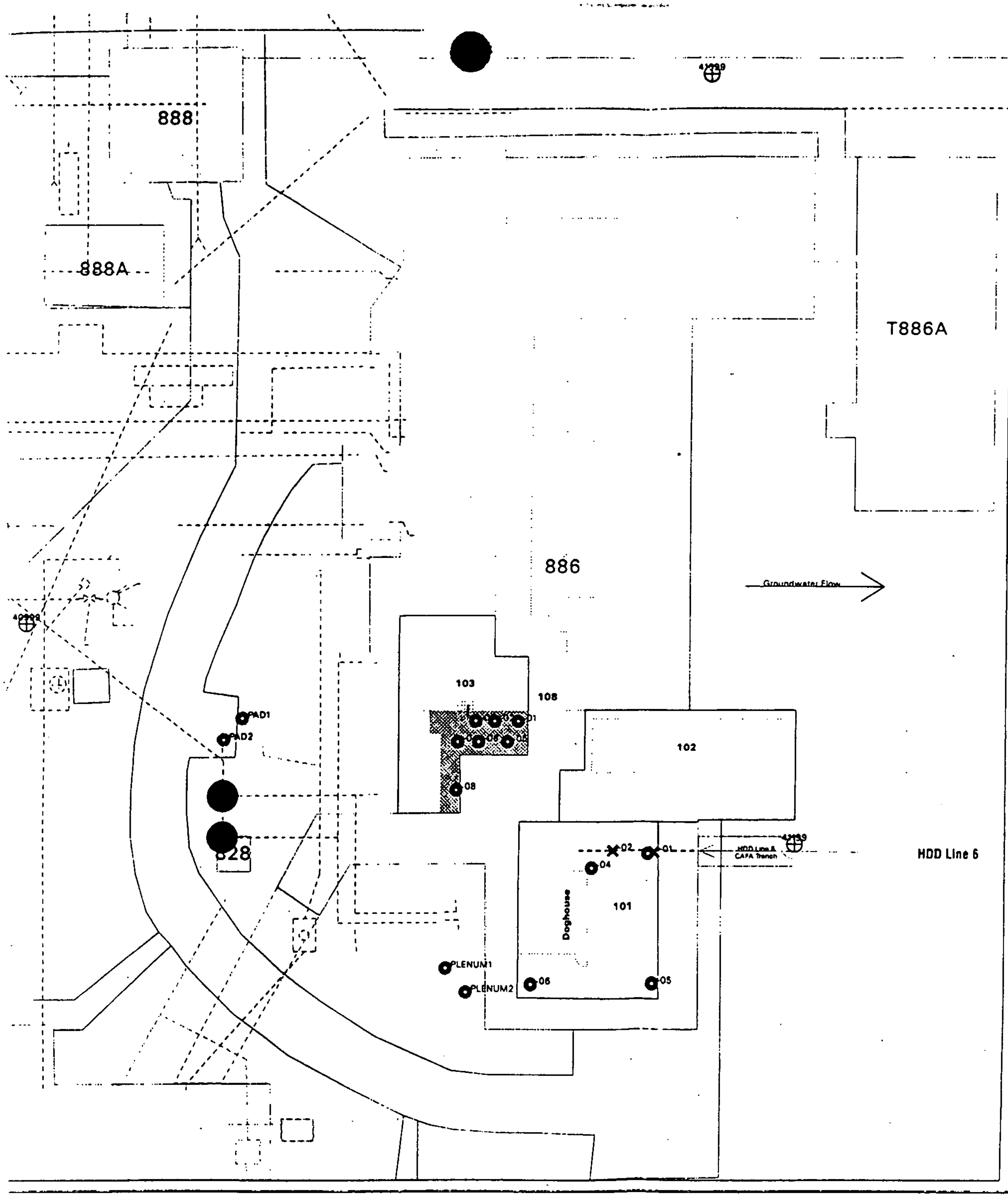


PLATE 2
Building 886 HDD Lines Process Waste Lines and Soil Sample Location Map



EXPLANATION

- Geoprobe Soil Sample Location
- HDD Soil Sample Location
- Horizontal Borehole
- New Groundwater Monitoring Well (Preliminary Survey Location)

General Utilities

- Water Lines
- Natural Gas Lines
- Process Waste Lines
- Storm Sewer Lines
- Sewer Lines
- Electric Lines
- Casing Advancement Frame Assembly (CAFA) Trench Location
- Tanks of Concern
- Building 886 Room 103 Pit Area

Standard Map Features

- Buildings and other structures
- Paved roads fill
- Demolished buildings
- Fences and other barriers
- Paved roads

NOTE:
The Original and New Process Waste Line locations shown on map are approximate and should not be used for determining the line location when performing excavation work.

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State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

GIS Dept 303-966-

Prepared by: DynCorp — The Art of Technology

Prepared for: Kaiser-Hill

MAP ID 01-0550

Original map contents are preserved. Logo and date have changed.

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EMWD Background Gamma Spectra Calibration: UBC 123

Figure C1a: Lab Calibration-Gamma Spectrum of K-40.

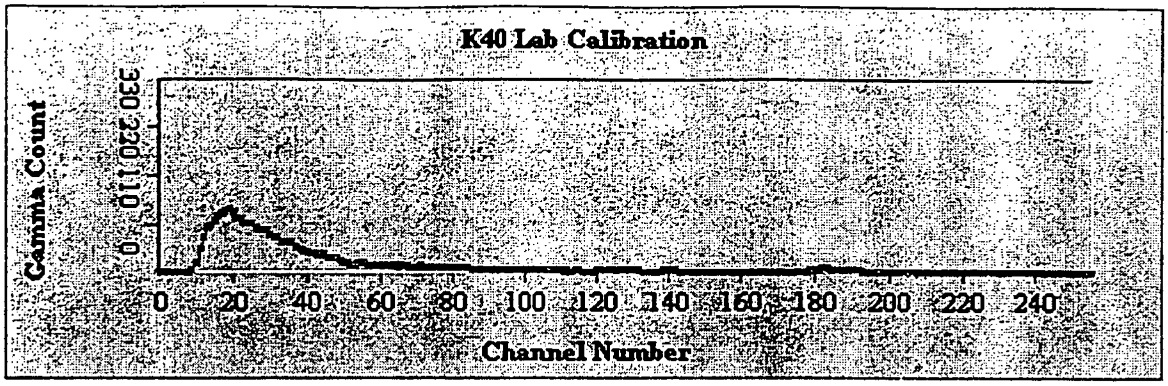

Figure C1b: Lab Calibration-Cumulative Gamma Spectrum (14 spectra) of K-40.

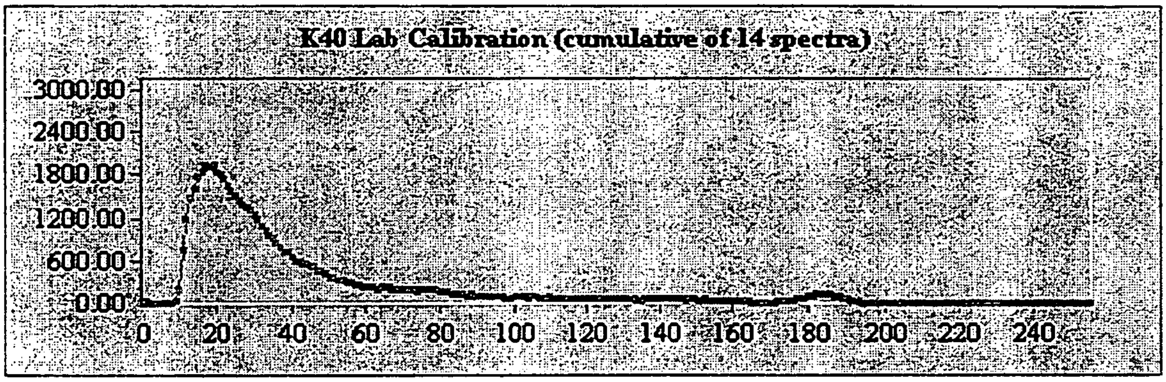

Figure C2a: Field Calibration-Gamma Spectrum of K-40 at UBC 123

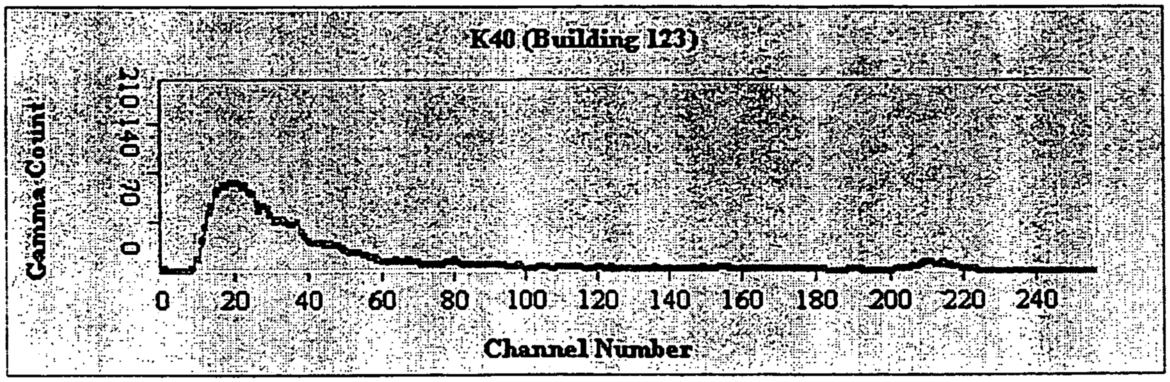

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Figure C2b: Field Calibration-Cumulative Gamma Spectrum (8 spectra) of K-40 at UBC 123

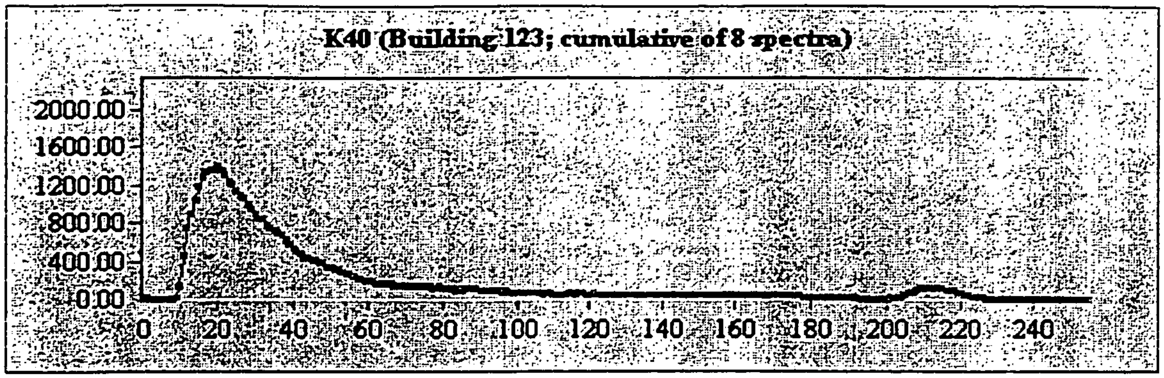


Figure C3a: Field Background Calibration-Gamma Spectrum of K-40 at UBC 123

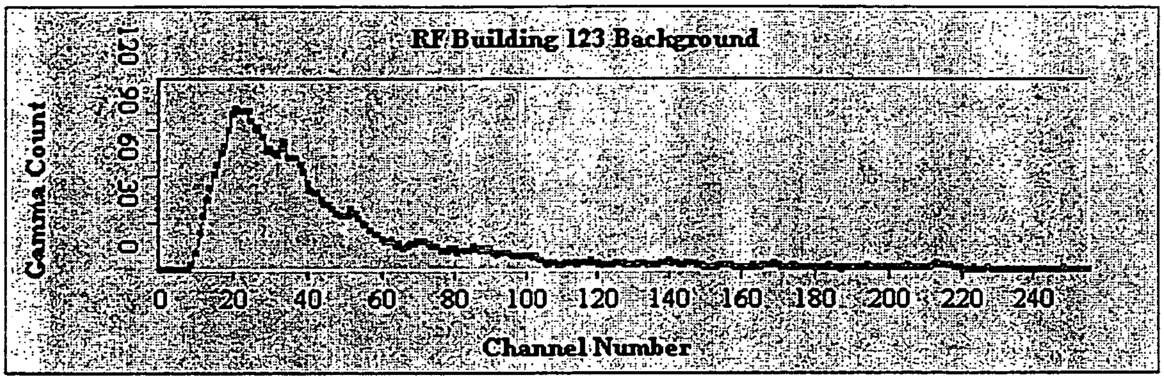
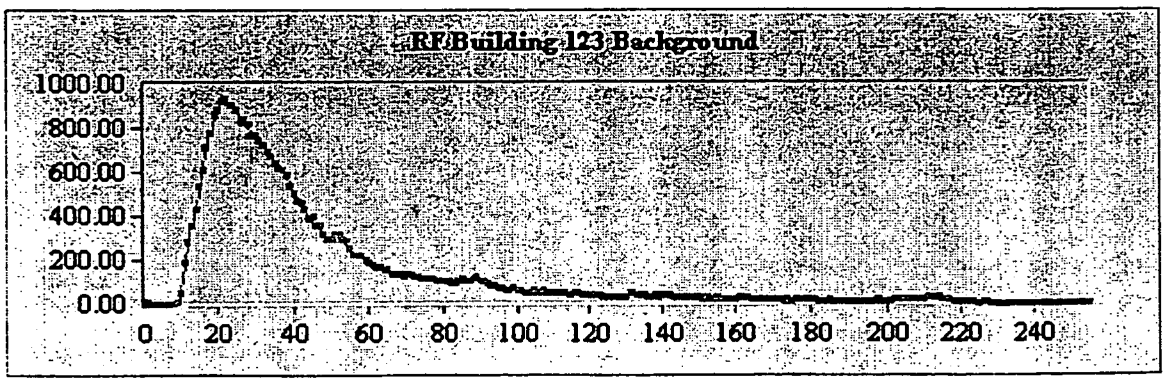


Figure C2b: Field Background Calibration-Cumulative Gamma Spectrum (8 spectra) of K-40 at UBC 123



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EMWD Gamma Spectra for UBC 123

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UBC 123-Bore Number 1

Figure D 1-1a: Gamma Spectrum from Bore 1 Sample 1.

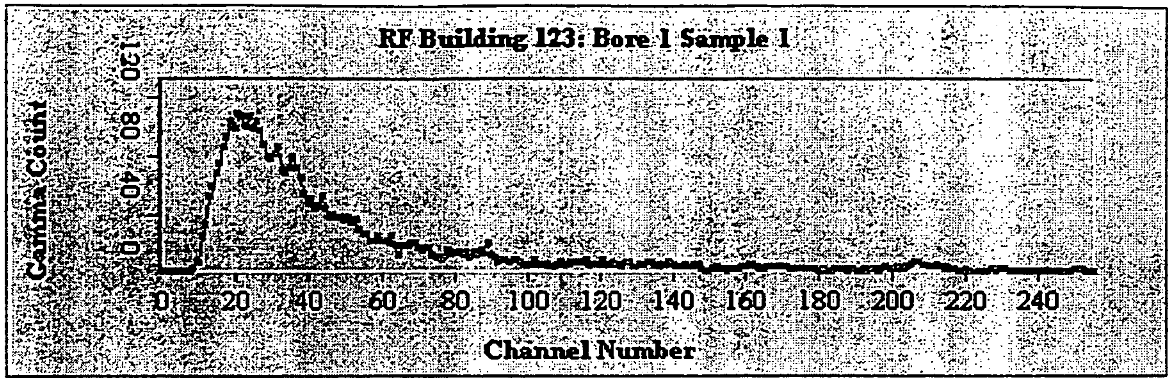

Figure D 1-1b: Cumulative Gamma Spectrum (13 spectra) from Bore 1 Sample 1.

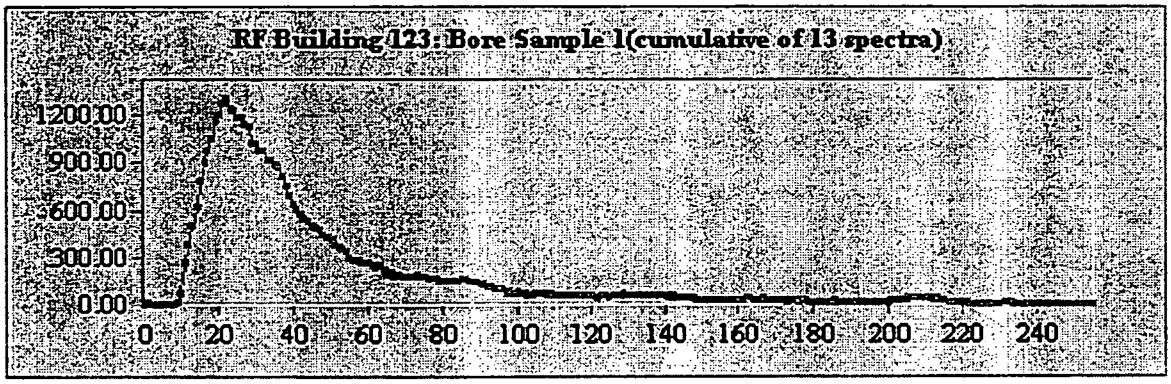

Figure D 1-2a: Gamma Spectrum from Bore 1 Sample 2.

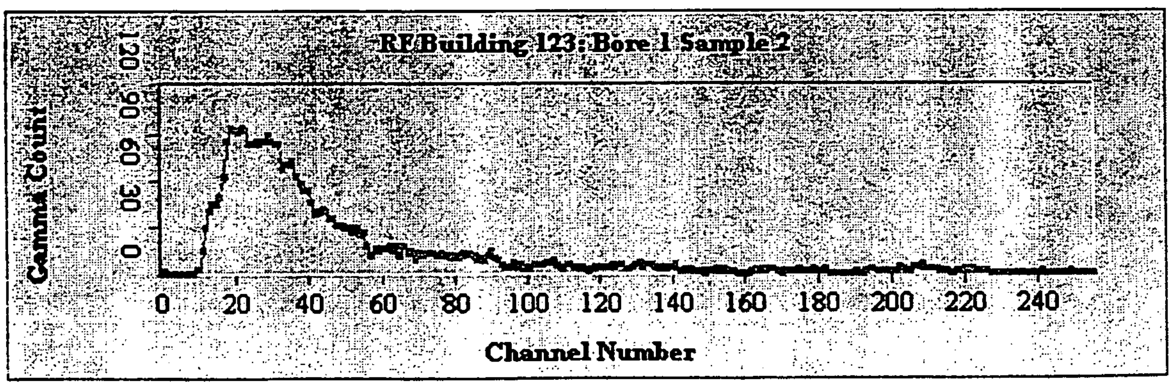

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Figure D 1-2b: Cumulative Gamma Spectrum (15 spectra) from Bore 1 Sample 2.

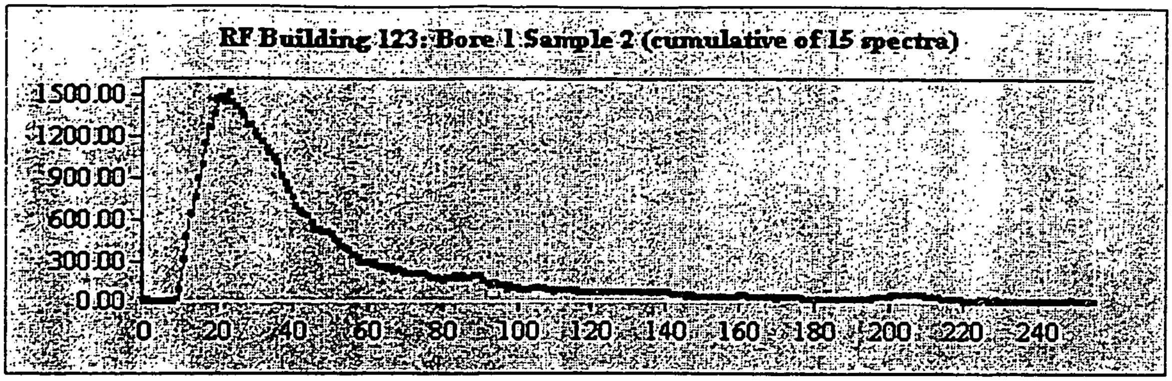


Figure D 1-3a: Gamma Spectrum from Bore 1 Sample 3.

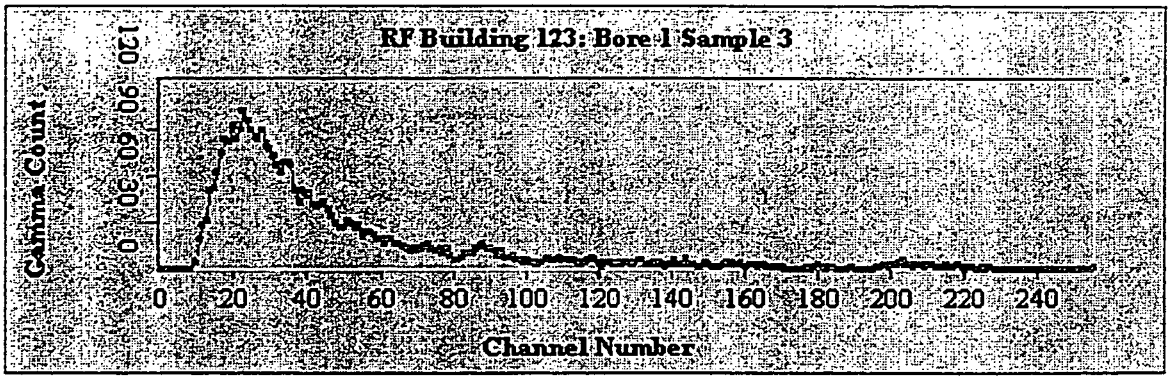
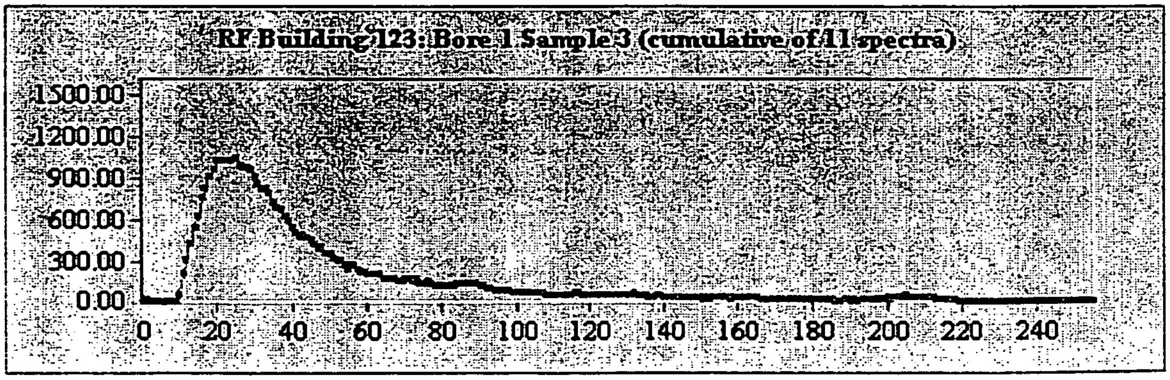


Figure D 1-3b: Cumulative Gamma Spectrum (11 spectra) from Bore 1 Sample 3.



UBC 123-Bore Number 2

Figure D 2-1a: Gamma Spectrum from Bore 2 Sample 1.

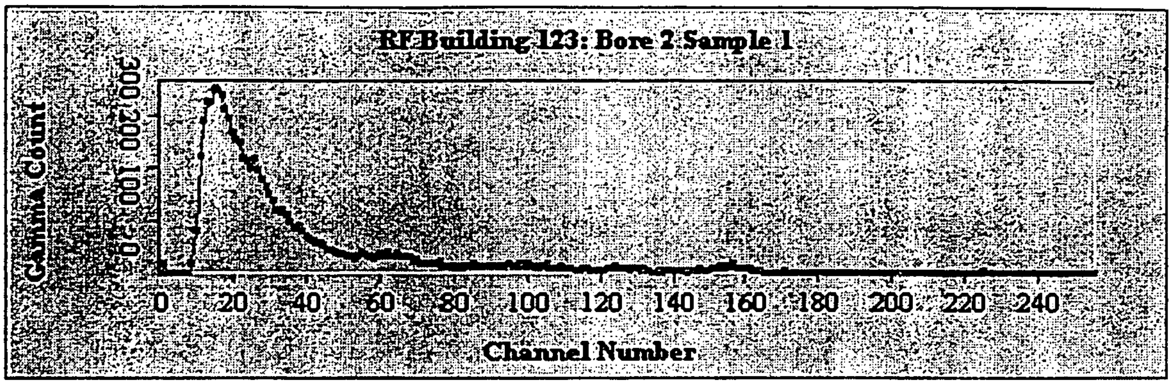


Figure D 2-1b: Cumulative Gamma Spectrum (10 spectra) from Bore 2 Sample 1.

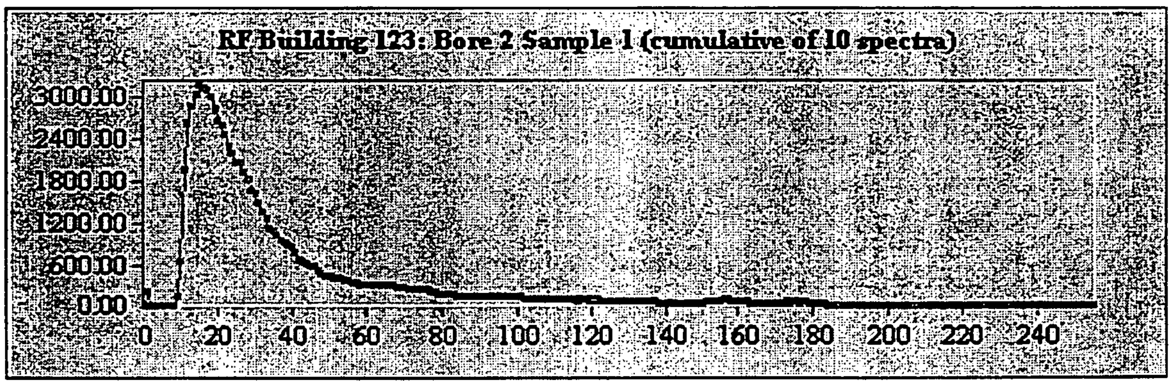


Figure D 2-2a: Gamma Spectrum from Bore 2 Sample 2.

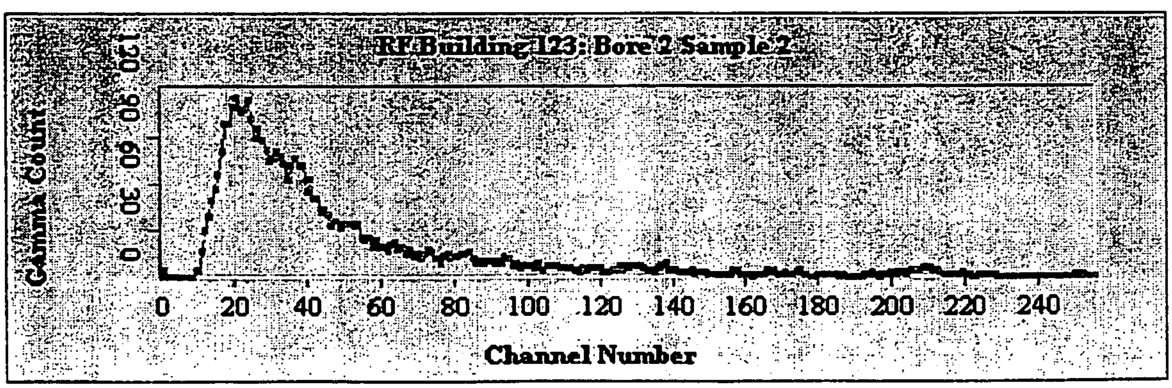


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Figure D 2-2b: Cumulative Gamma Spectrum (10 spectra) from Bore 2 Sample 2.

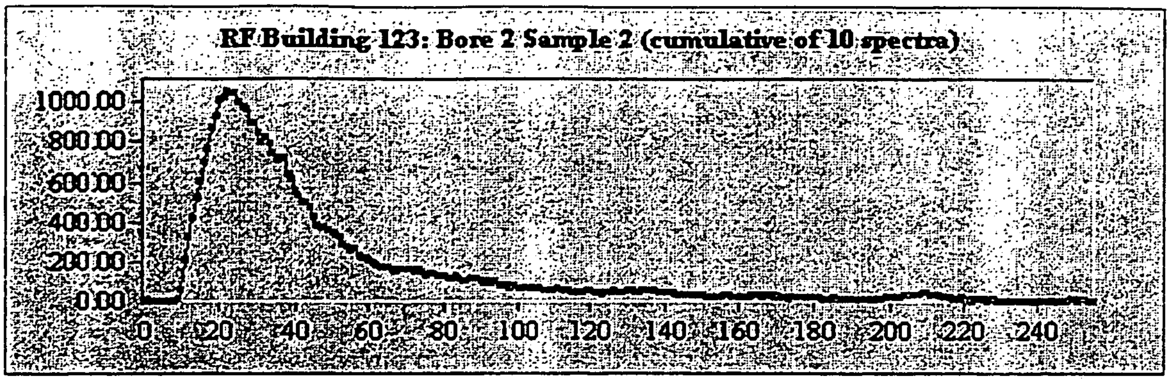

Figure D 2-3a: Gamma Spectrum from Bore 2 Sample 3.

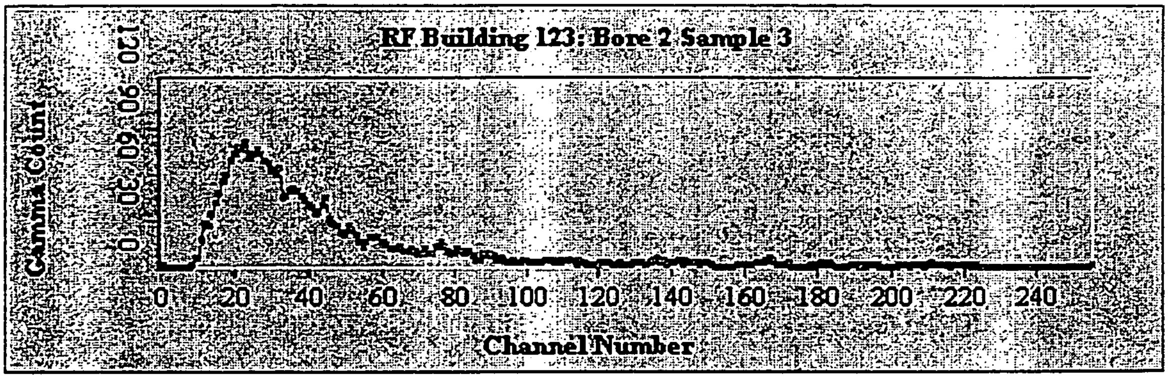

Figure D 2-3b: Cumulative Gamma Spectrum (10 spectra) from Bore 2 Sample 3.

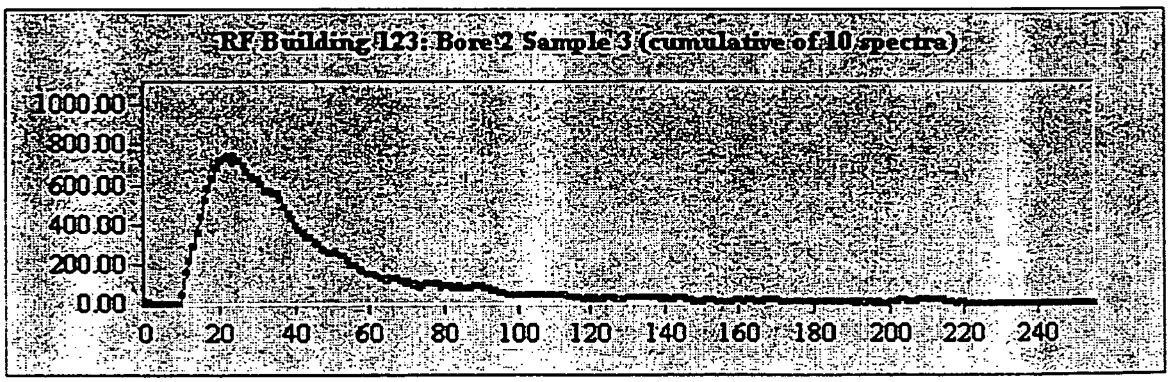

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Figure D 2-4a: Gamma Spectrum from Bore 2 Sample 4.

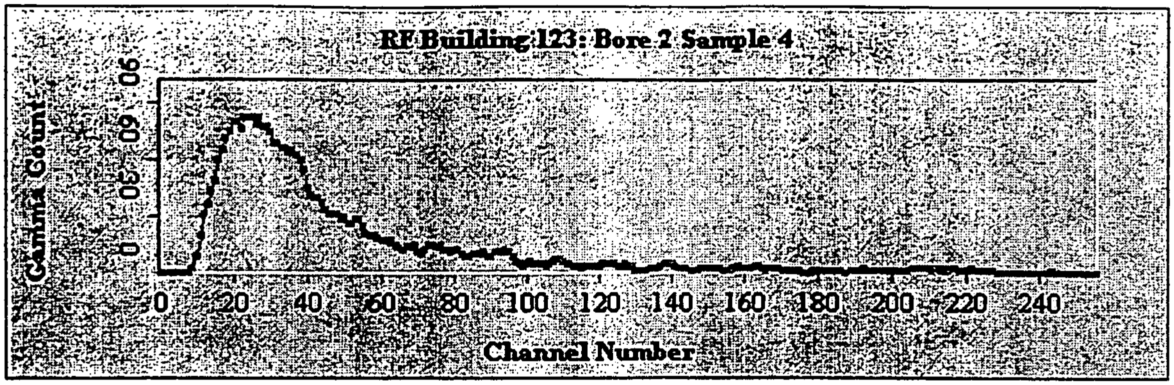

Figure D 2-4b: Cumulative Gamma Spectrum (9 spectra) from Bore 2 Sample 4.

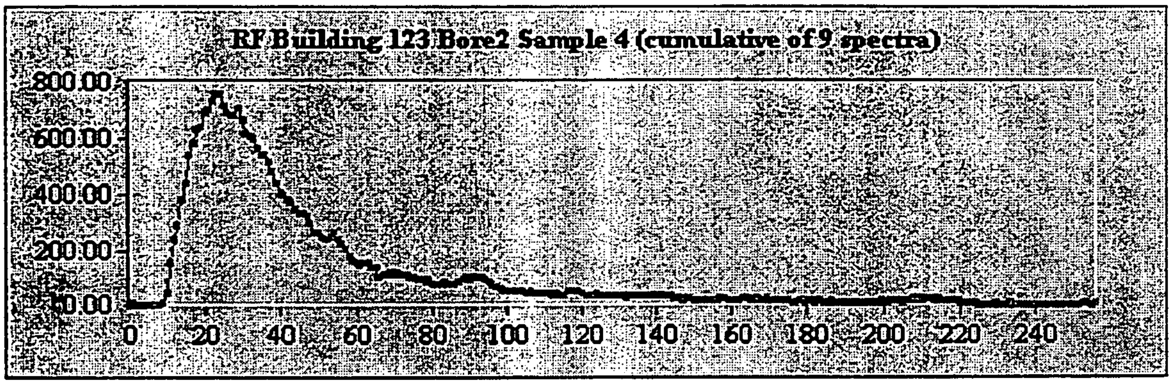

Figure D 2-5a: Gamma Spectrum from Bore 2 Sample 5.

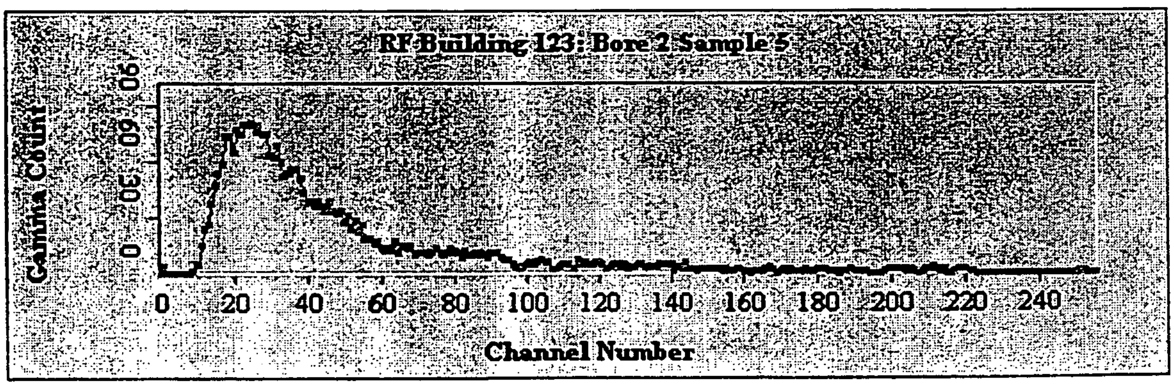

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Figure D 2-5b: Cumulative Gamma Spectrum (10 spectra) from Bore 2 Sample 5

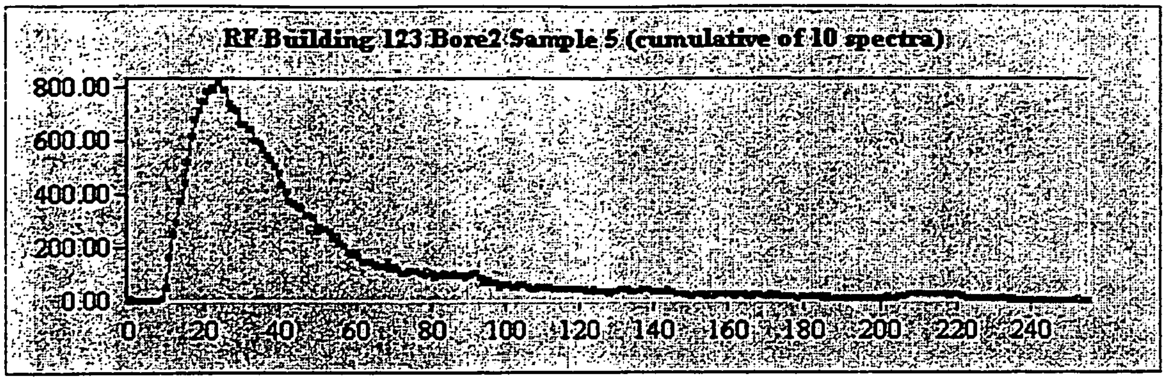

Figure D 2-6a: Gamma Spectrum from Bore 2 Sample 6.

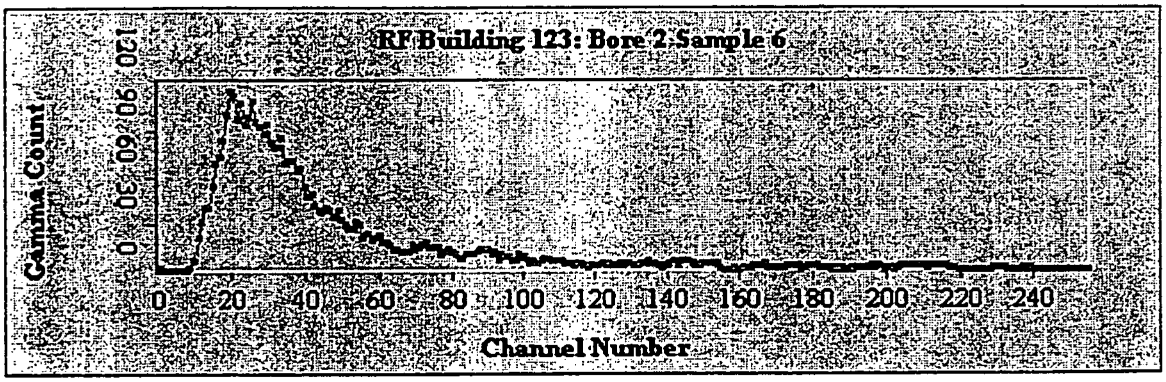

Figure D 2-6b: Cumulative Gamma Spectrum (10 spectra) from Bore 2 Sample 6 . .

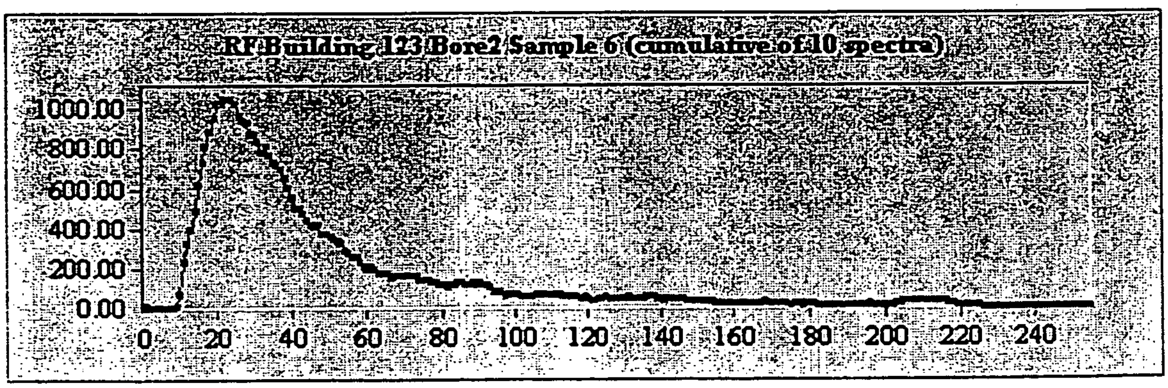

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Figure D 2-7a: Gamma Spectrum from Bore 2 Sample 7.

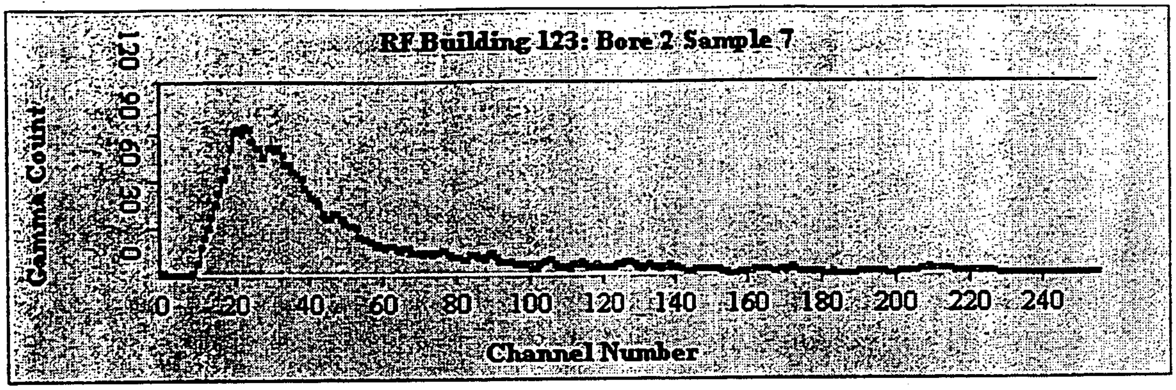


Figure D 2-7b: Cumulative Gamma Spectrum (10 spectra) from Bore 2 Sample 7.

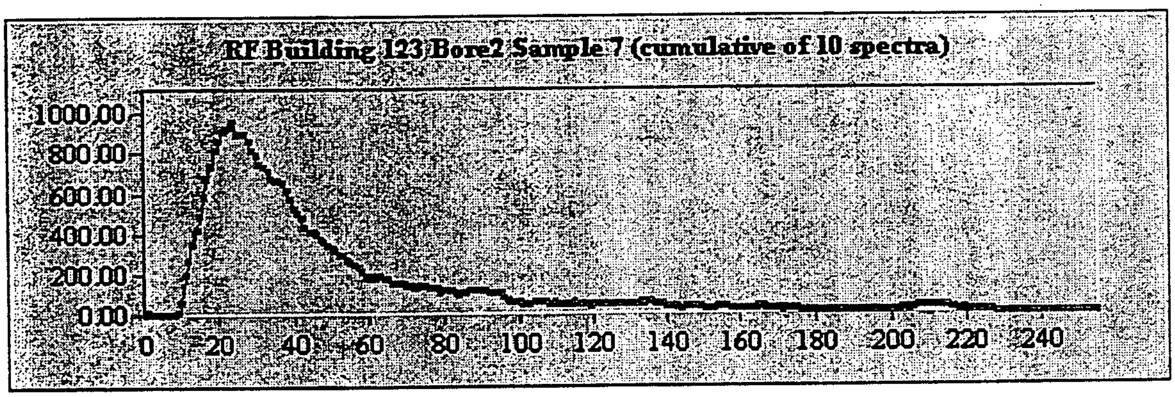


Figure D 2-8a: Gamma Spectrum from Bore 2 Sample 8.

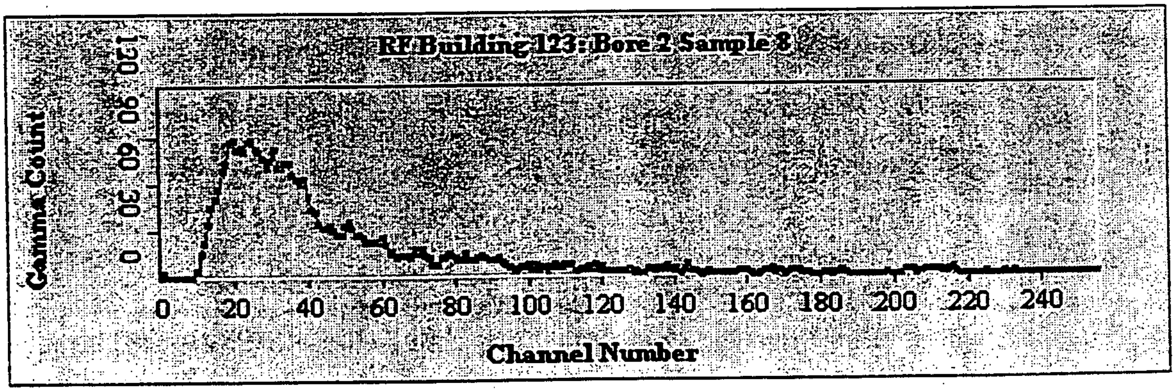


Figure D 2-8b: Cumulative Gamma Spectrum (10 spectra) from Bore 2 Sample 8.

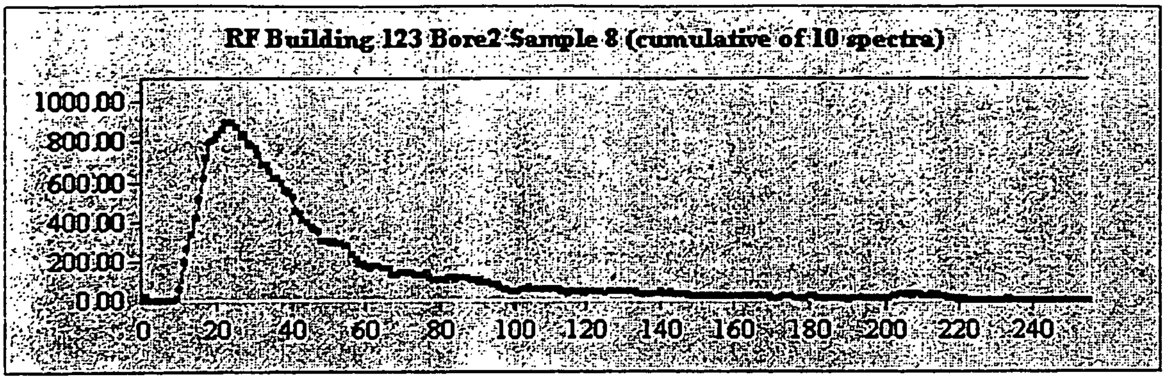


Figure D 2-9a: Gamma Spectrum from Bore 2 Sample 9.

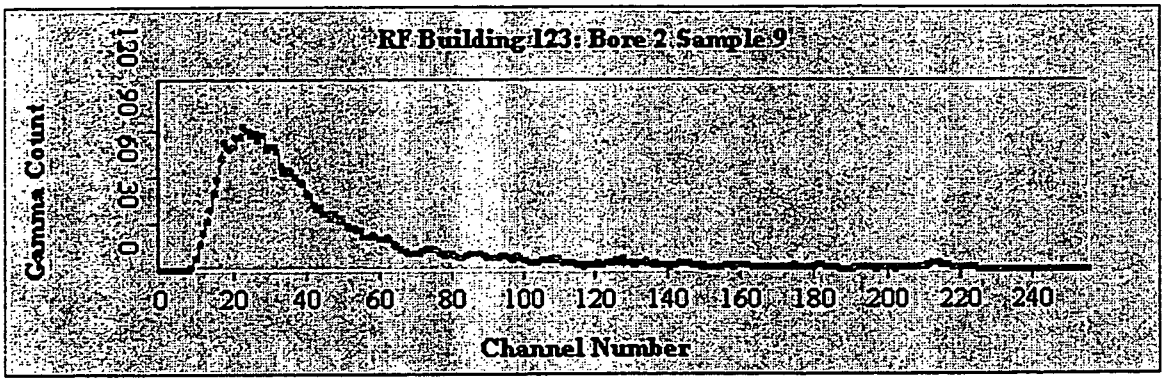
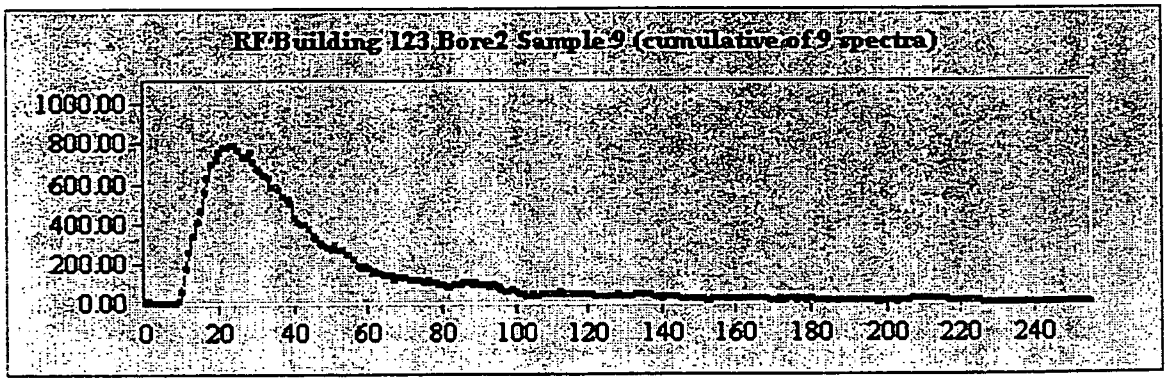


Figure D 2-9b: Cumulative Gamma Spectrum (9 spectra) from Bore 2 Sample 9.



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UBC 123-Bore Number 3

Figure D 3-2a: Gamma Spectrum from Bore 3 Sample 2.

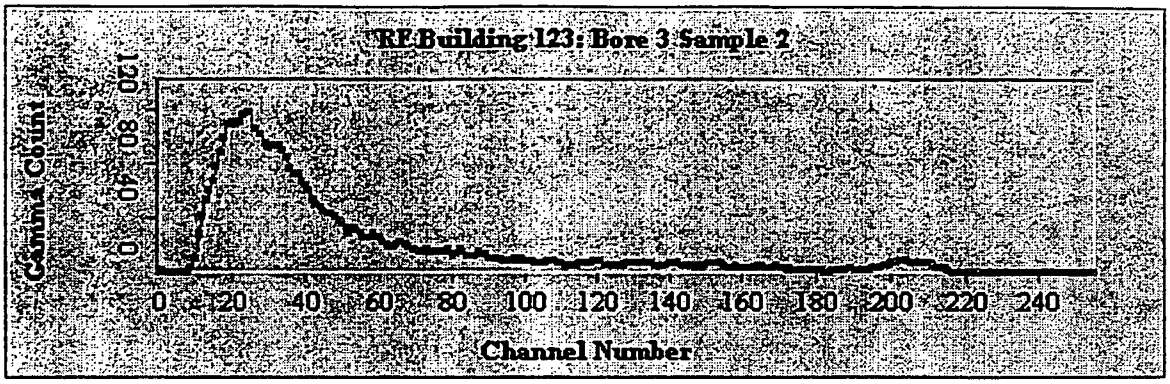

Figure D 3-2b: Cumulative Gamma Spectrum (6 spectra) from Bore 3 Sample 2.

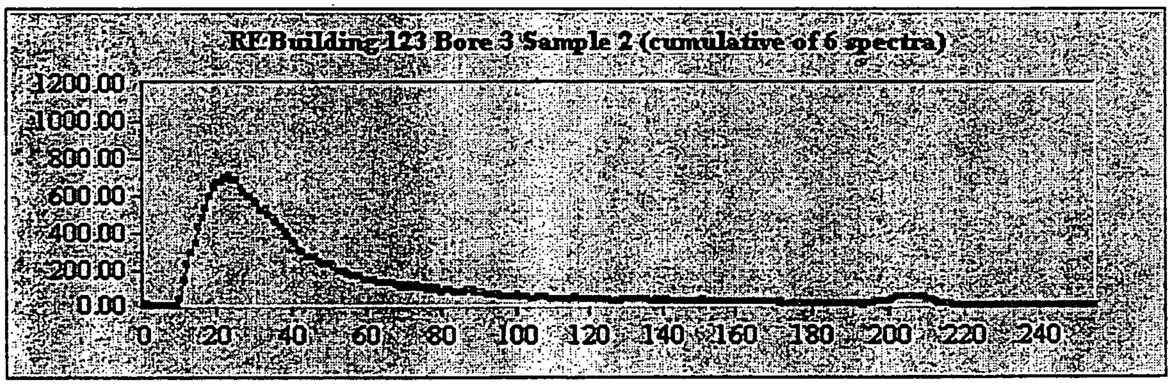

Figure D 3-3a: Gamma Spectrum from Bore 3 Sample 3.

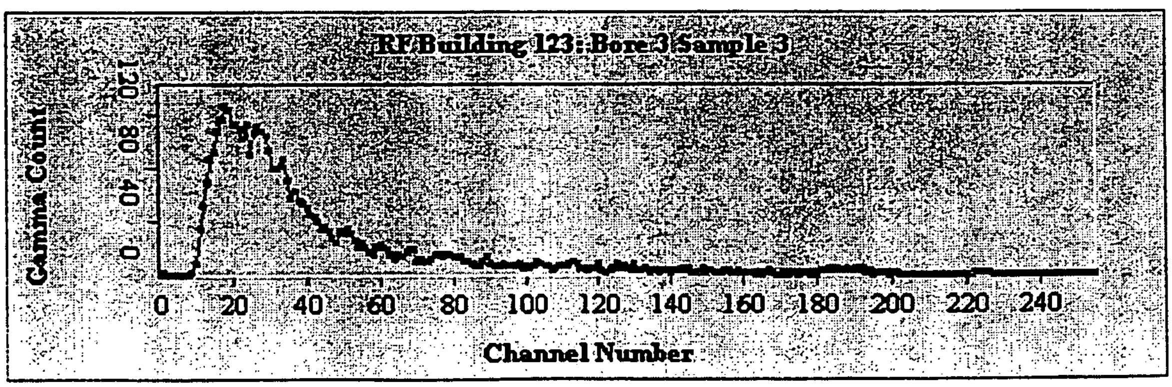

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Figure D 3-3b: Cumulative Gamma Spectrum (10 spectra) from Bore 3 Sample 3.

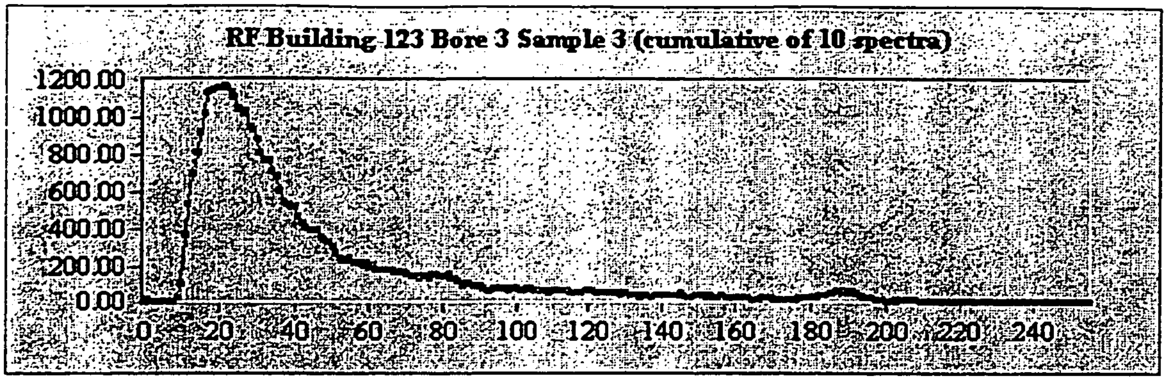

Figure D 3-4a: Gamma Spectrum from Bore 3 Sample 4.

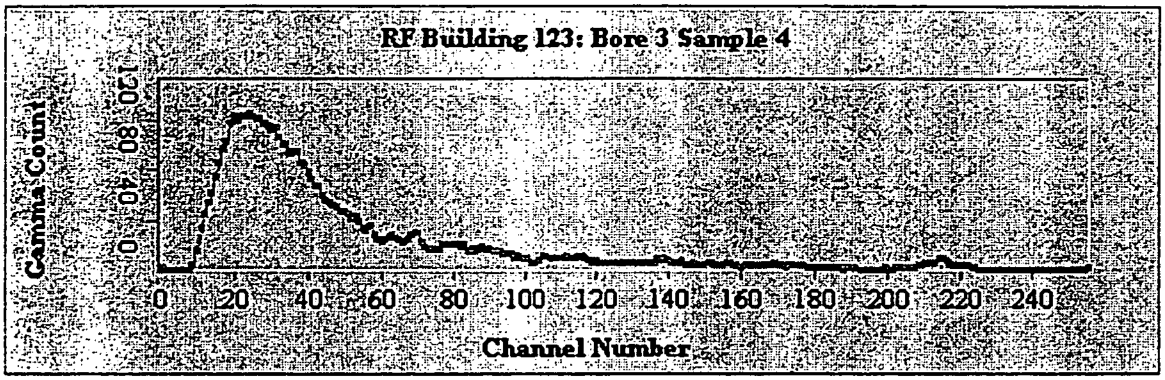

Figure D 3-4b: Cumulative Gamma Spectrum (8 spectra) from Bore 3 Sample 4.

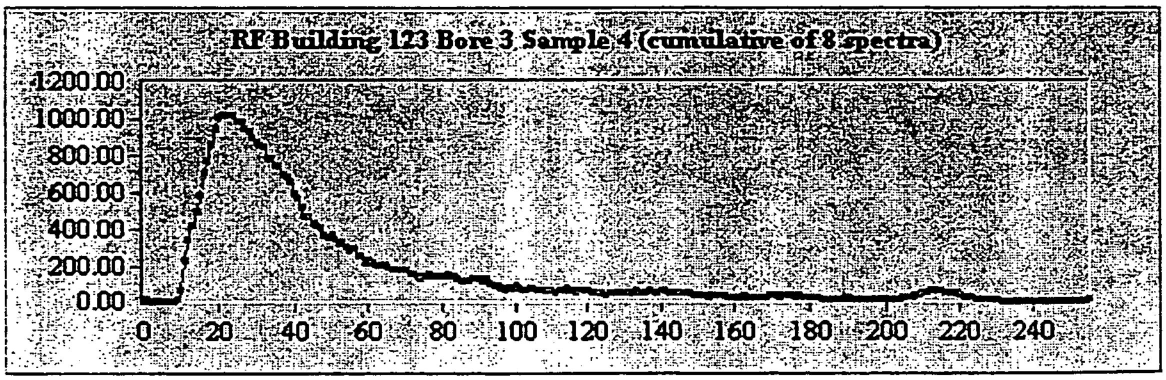

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Figure D 3-5a: Gamma Spectrum from Bore 3 Sample 5.

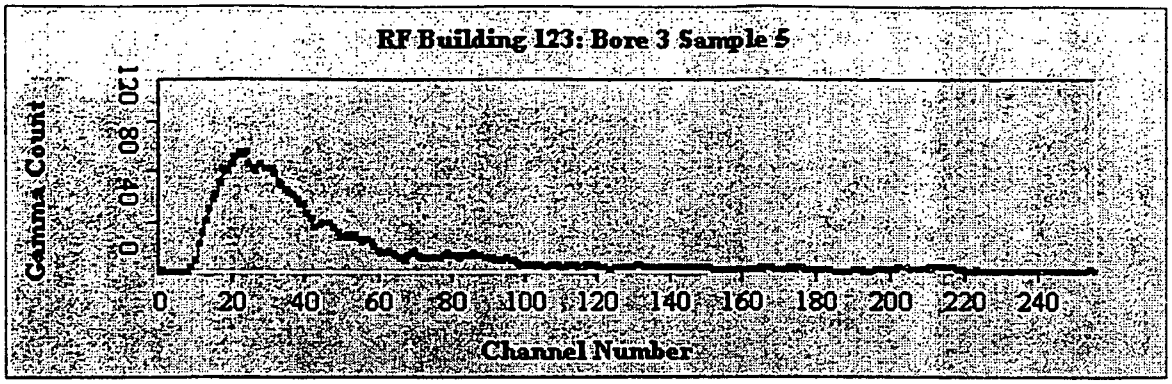
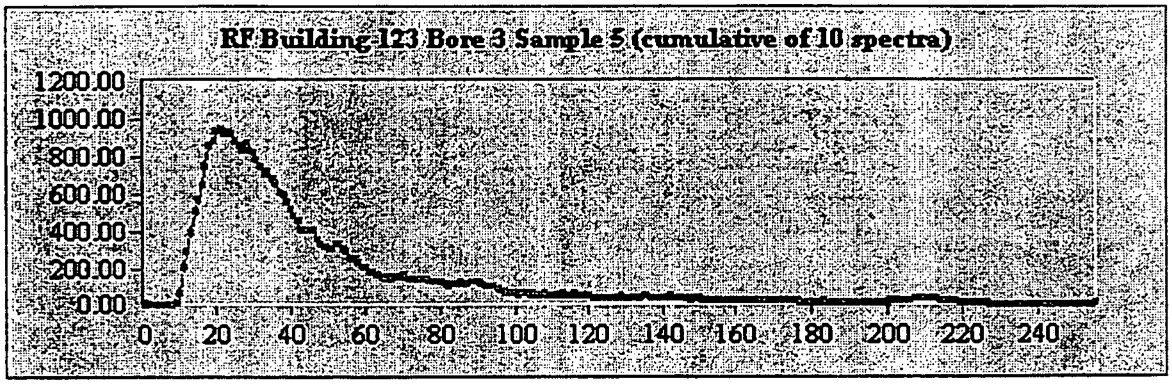


Figure D 3-5b: Cumulative Gamma Spectrum (10 spectra) from Bore 3 Sample 5.



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UBC 123-Bore Number 4

Figure D 4-1a: Gamma Spectrum from Bore 4 Sample 1.

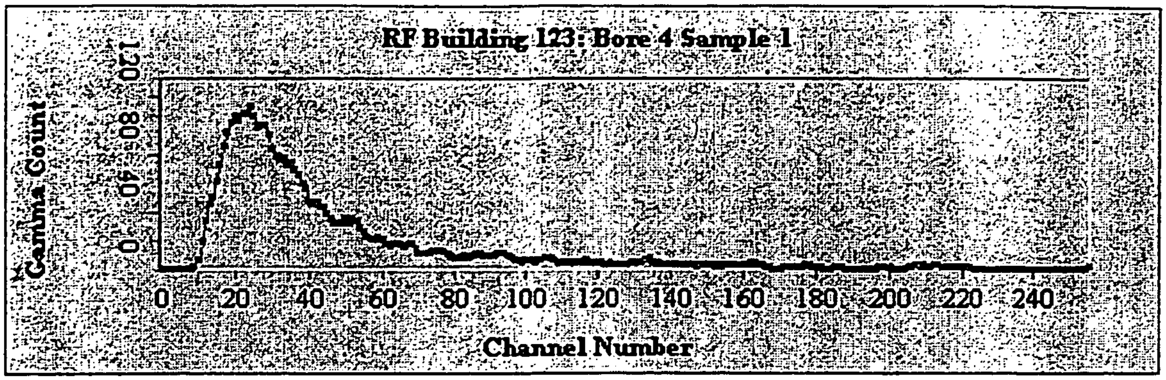

Figure D 4-1b: Cumulative Gamma Spectrum (15 spectra) from Bore 4 Sample 1.

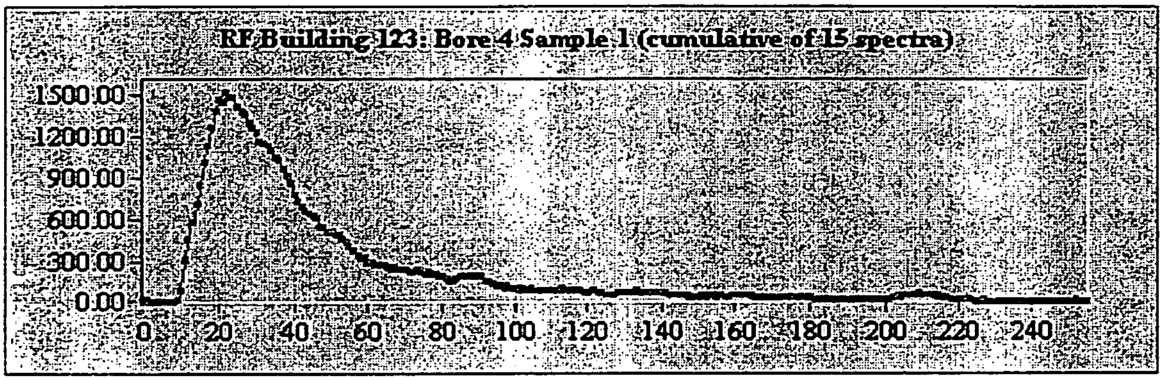

Figure D 4-2a: Gamma Spectrum from Bore 4 Sample 2.

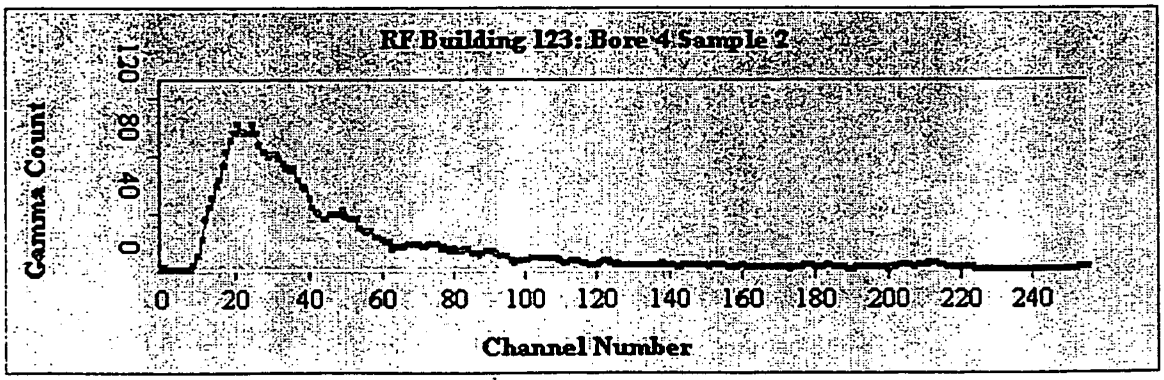

Figure D 4-2b: Cumulative Gamma Spectrum (10 spectra) from Bore 4 Sample 2.

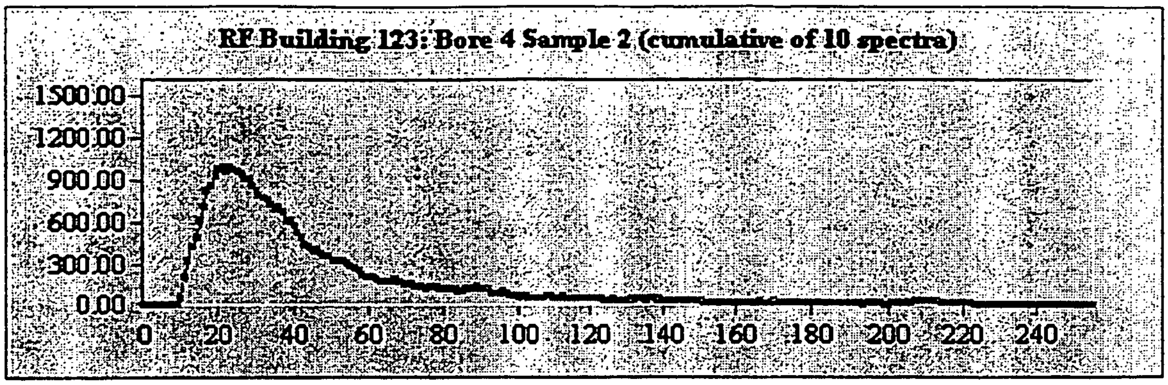

Figure D 4-3a: Gamma Spectrum from Bore 4 Sample 3.

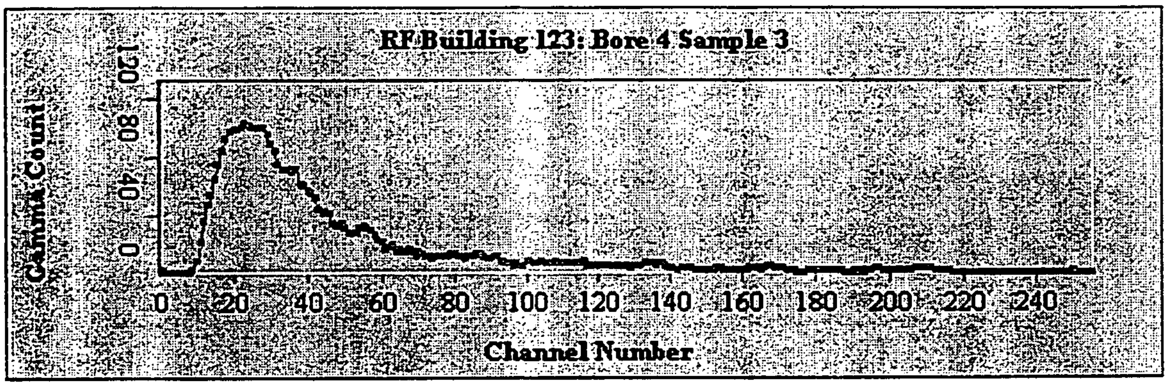

Figure D 4-4a: Gamma Spectrum from Bore 4 Sample 4.

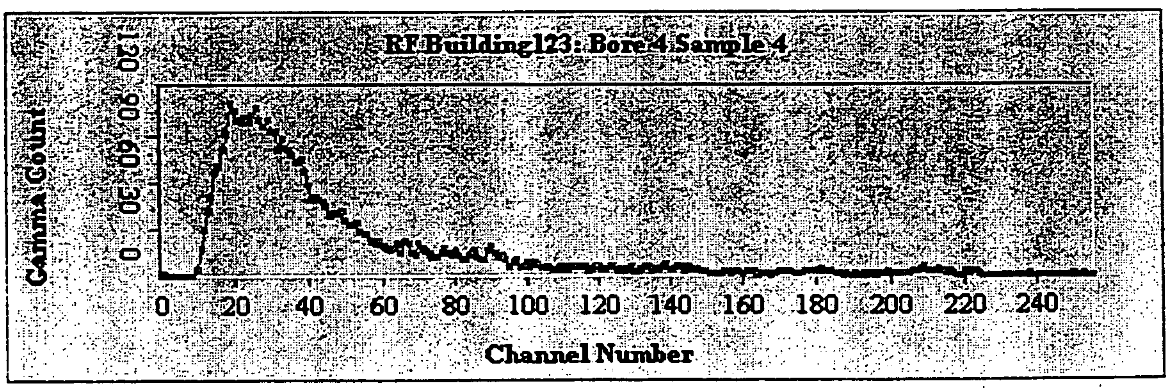

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Figure D 4-4b: Cumulative Gamma Spectrum (10 spectra) from Bore 4 Sample 4.

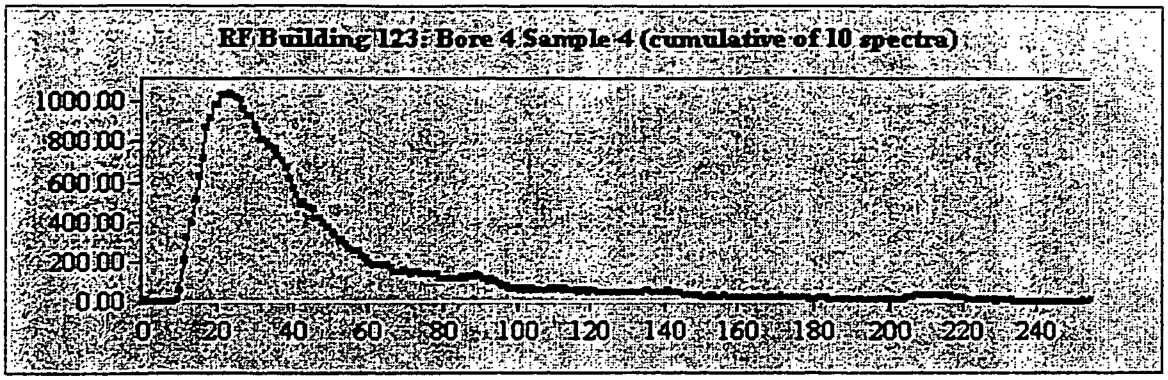

Figure D 4-5a: Gamma Spectrum from Bore 4 Sample 5.

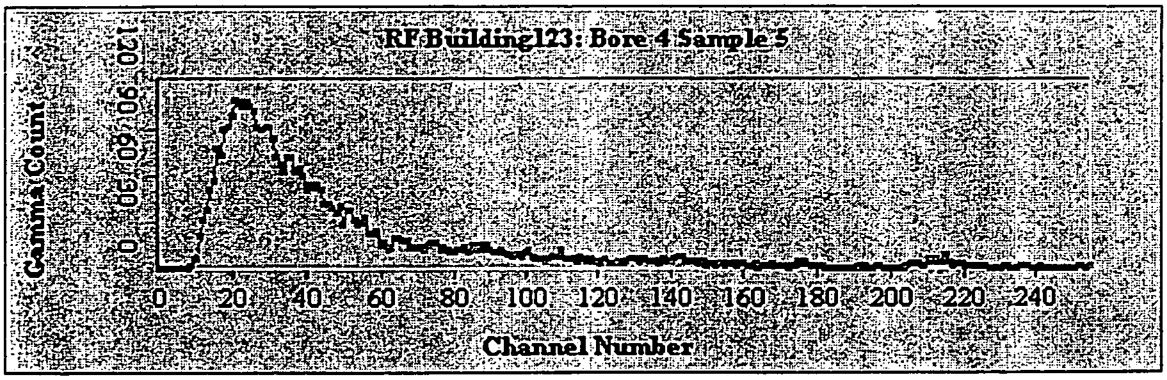

Figure D 4-5b: Cumulative Gamma Spectrum (10 spectra) from Bore 4 Sample 5.

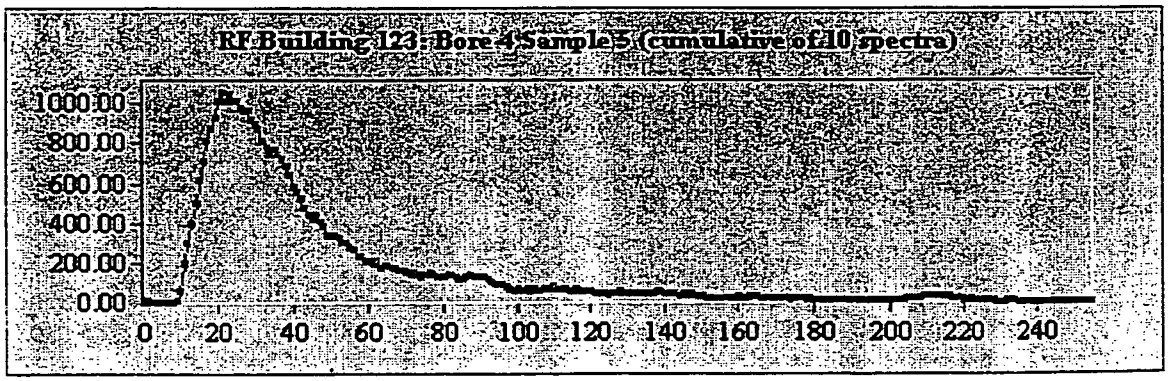

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Figure D 4-6a: Gamma Spectrum from Bore 4 Sample 6.

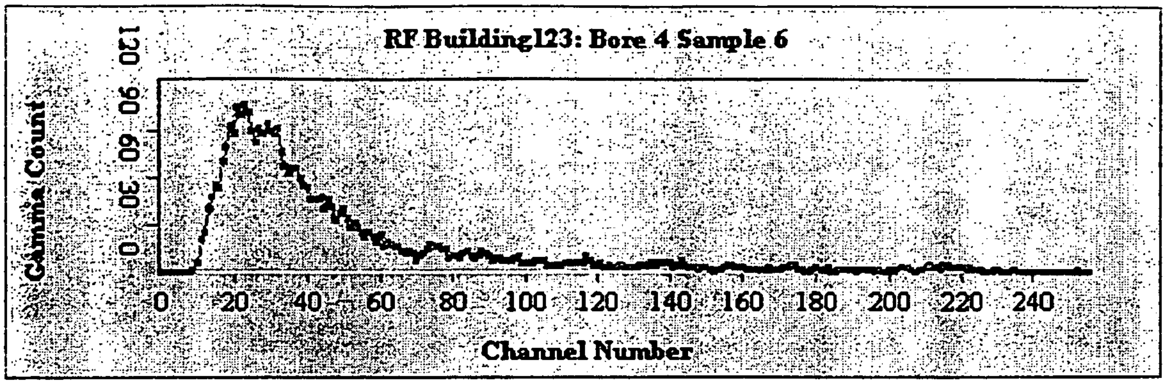
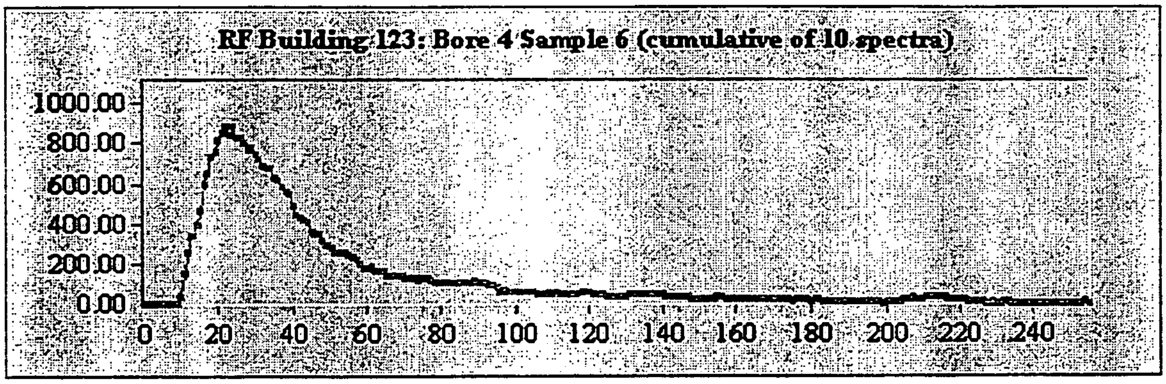


Figure D 4-6b: Cumulative Gamma Spectrum (10 spectra) from Bore 4 Sample 6.



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EMWD Background Gamma Spectra: Building 886

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Figure E 1a: Lab Calibration-Gamma Spectrum of K-40

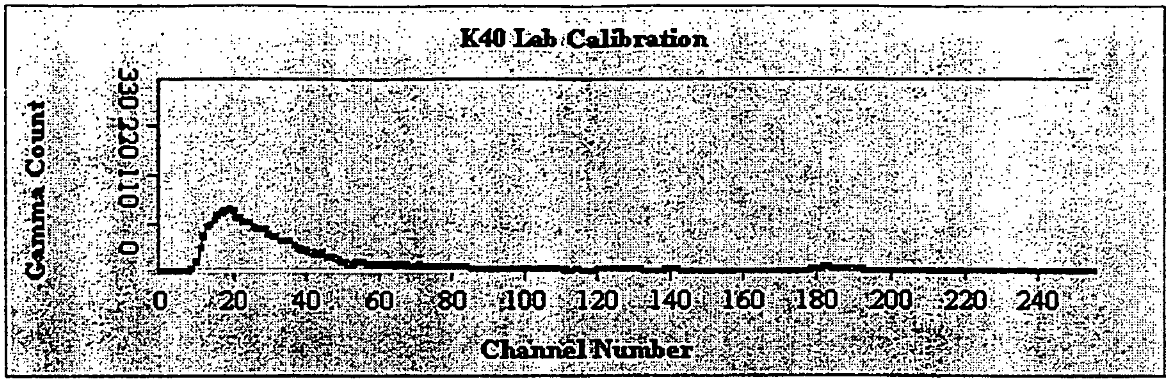

Figure E 1b: Lab Calibration-Cumulative Gamma Spectrum (14 spectra) of K-40.

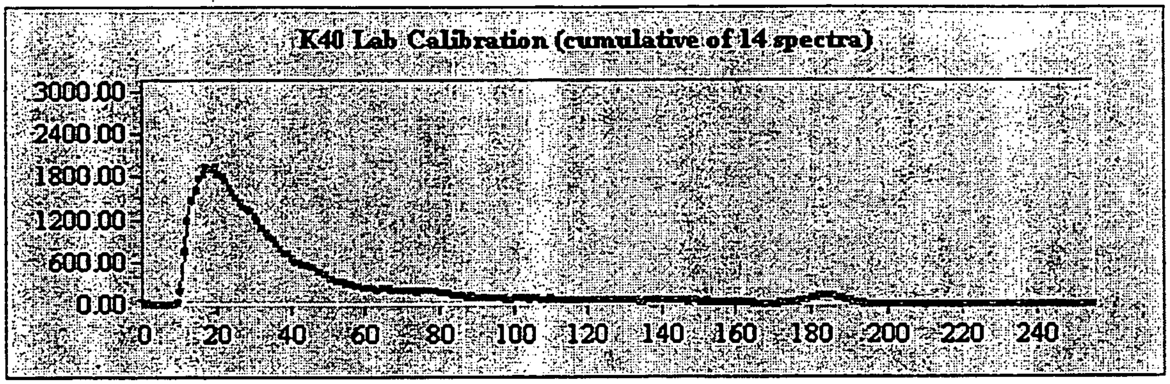

Figure E 2a: Field Calibration-Gamma Spectrum of K-40 at Building 886

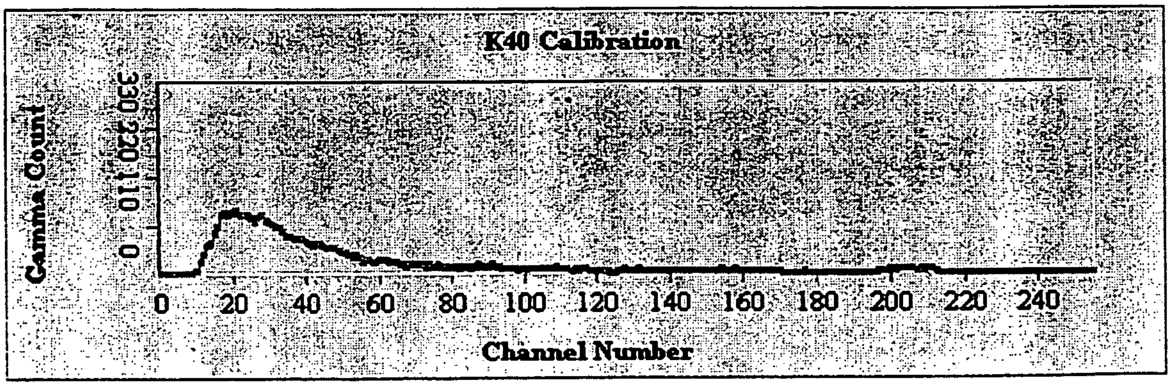

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Figure E 2b: Field Calibration-Cumulative Gamma Spectrum (20 spectra) of K-40 at Building 886

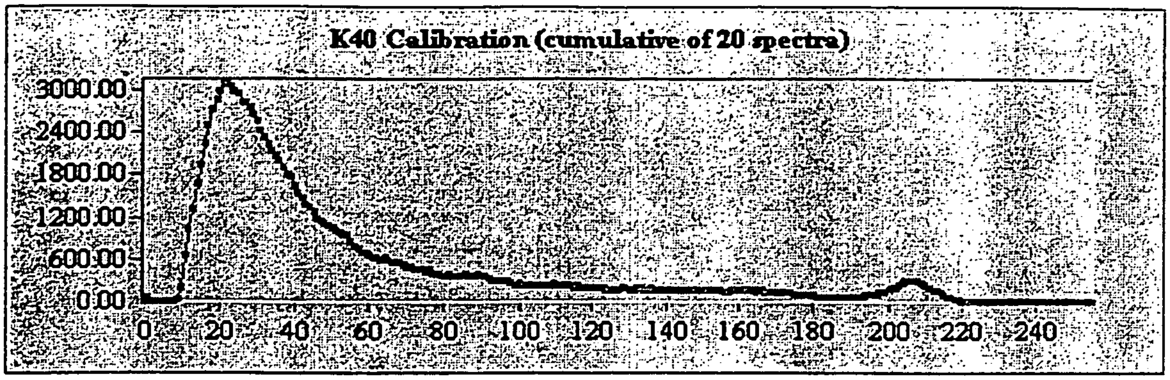


Figure E 3a: Field Calibration-Gamma Spectrum of K-40 at Building 886 next to wall

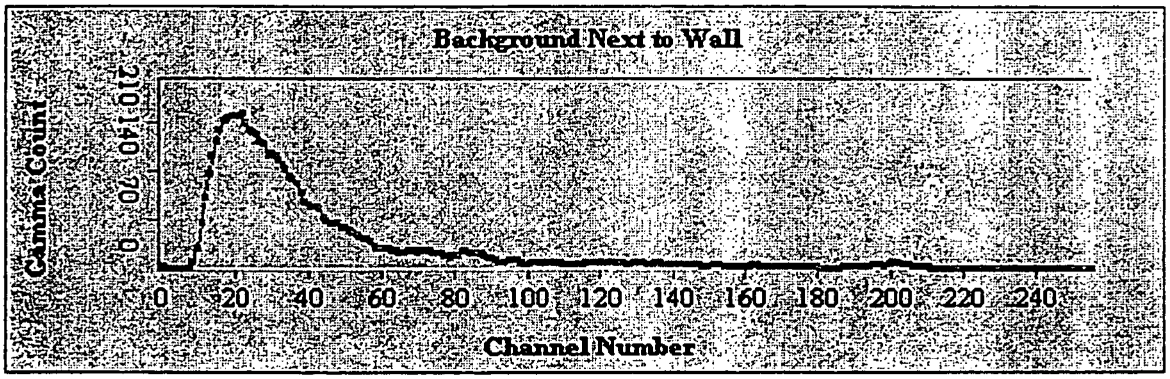
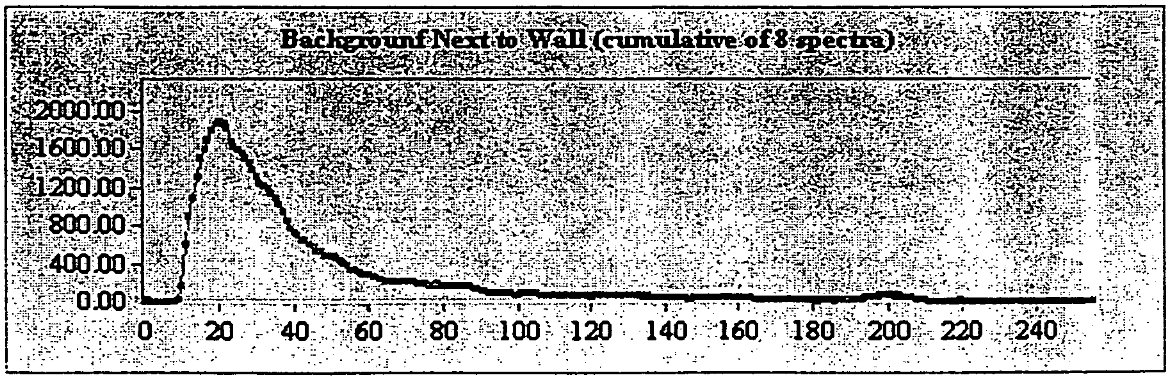


Figure E 2b: Field Calibration-Cumulative Gamma Spectrum (8 spectra) of K-40 at Building 886 next to wall.



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EMWD Gamma Spectra for Building 886

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Building 886-Bore Number 5: This bore was not carried out.

Building 886-Bore Number 6

Figure F 6-1a: Gamma Spectrum from Bore 6 Sample 1

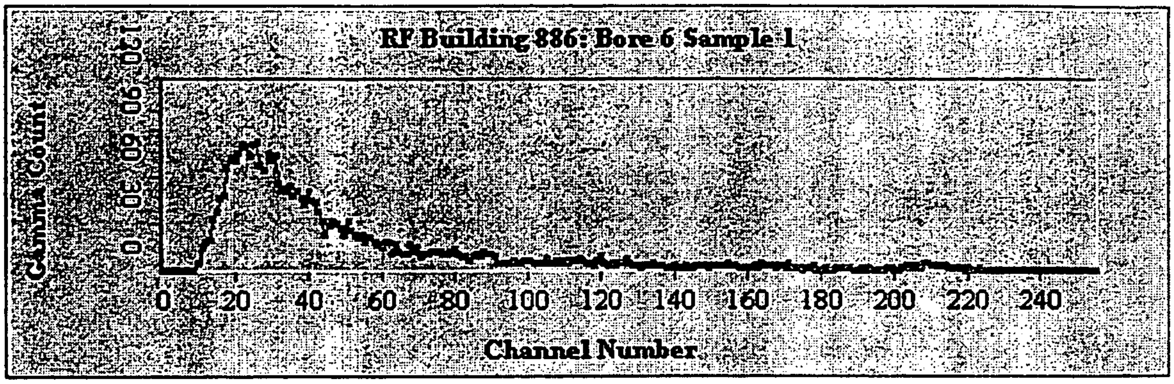


Figure F 6-1b: Cumulative Gamma Spectrum (10 spectra) from Bore 6 Sample 1.

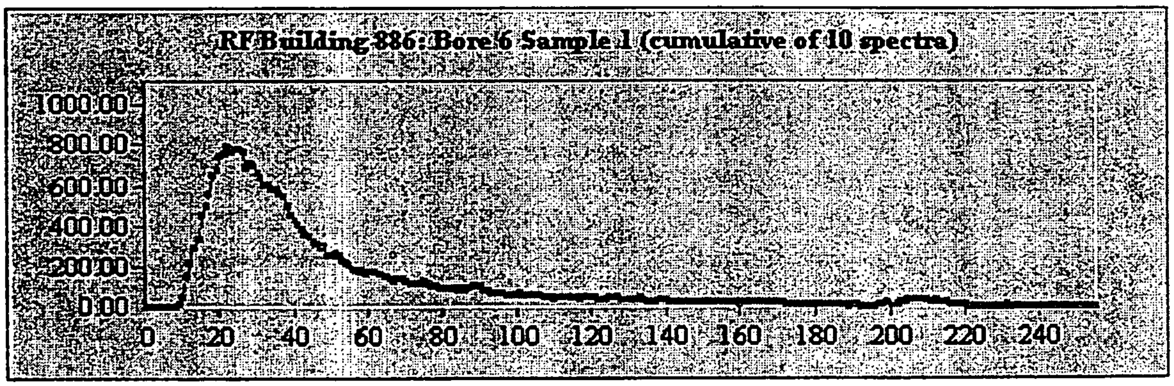


Figure F 6-2a: Gamma Spectrum from Bore 6 Sample 2.

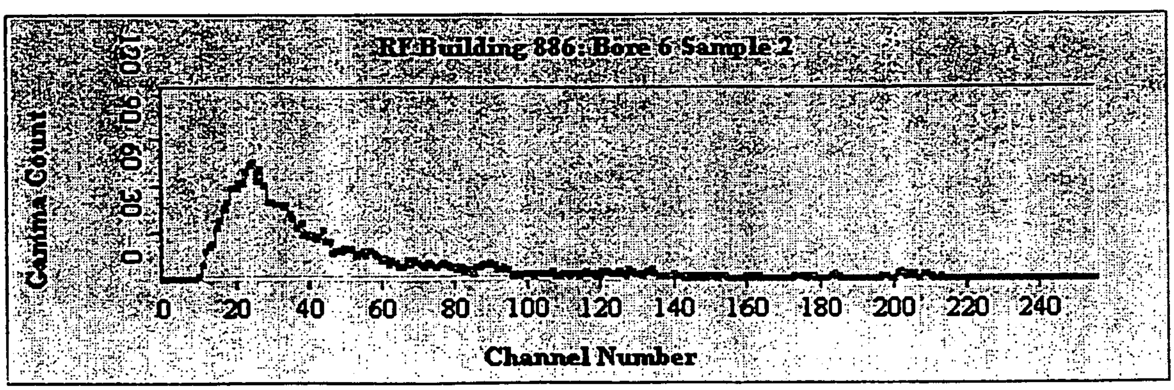


Figure F 6-2b: Cumulative Gamma Spectrum (10 spectra) from Bore 6 Sample 2.

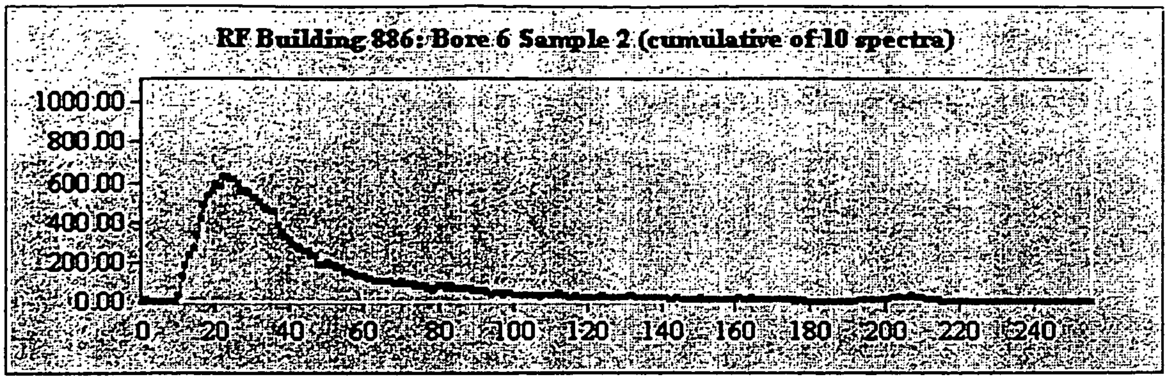


Figure F 6-3a: Gamma Spectrum from Bore 6 Sample 3.

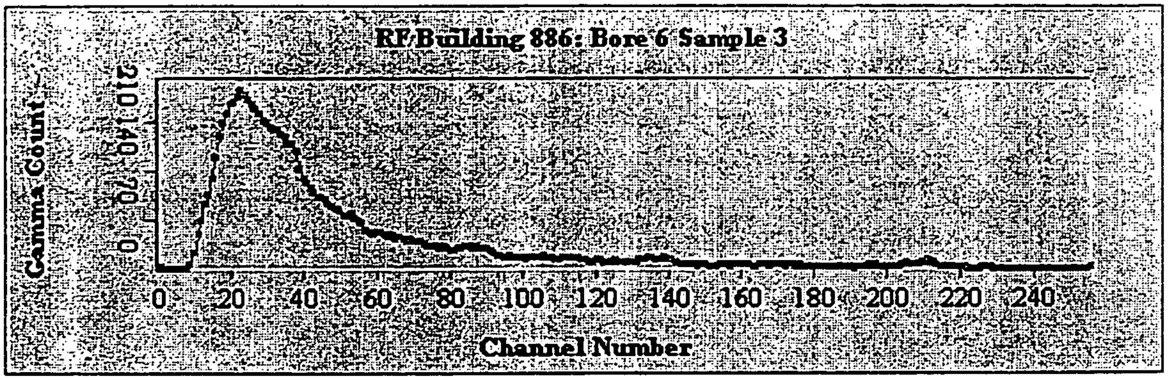
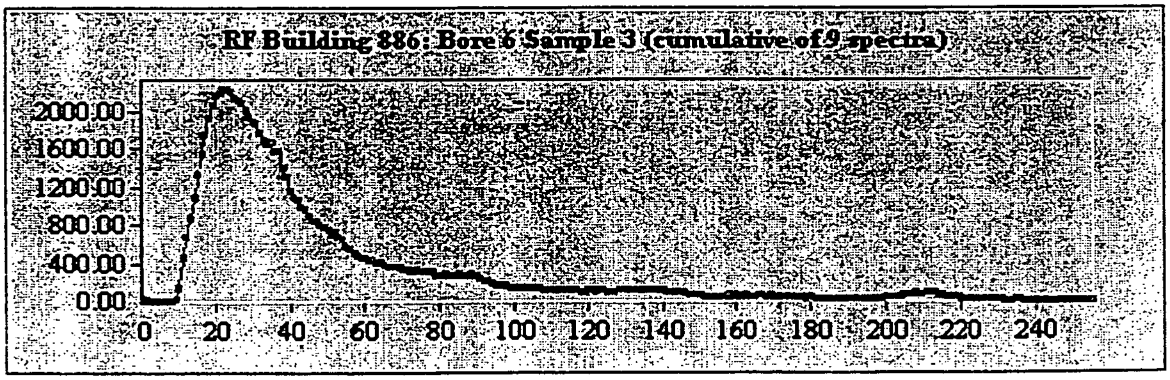


Figure F 6-3b: Cumulative Gamma Spectrum (10 spectra) from Bore 6 Sample 3.



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EMWD Gamma Ray Spectrometer Calibration Methodology

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EMWD Spectral Gamma Calibration and Field Measurement

Introduction

There are two main elements for converting spectral gamma energy readings into an indication of soil contamination levels. First is the linear correlation of gamma energy Vs channel location. In general this correlation can be determined in the lab using known source material emitting gamma particles at differing energy levels. Second is the calibration of gamma flux density Vs contamination levels. This second process is not directly determined by laboratory standards. In fact this second step is under investigation at many DOE waste sites.

In this report a calibration process is looked at for the spectral gamma NaI detector used in the Environmental Measurement-While-Drilling system (EMWD). A quick look at linear channel calibration is given, using actual EMAD laboratory data. To better understand the unfolding process for calculating radionuclides, a short explanation for unfolding naturally occurring radionclides for uranium exploration is given. This process is also used to gage the performance of newly developed spectral systems for environmental work. Following the unfolding process for natural radiation will be a look at actual spectral logging data from a waste site and an unfolding method for cesium and cobalt.

The final goal of this work is to justify and document reasoning for taking a simpler approach concentrating on cesium detection.

Gamma Energy Vs Channel Location

This function very closely matches a straight line with a zero intercept, measured gamma energy = a * (Channel Number) + b. The NaI crystal sensor is exposed to differing radio nuclide, emitting gamma particles of differing energy levels. Exposure is continued until peaks appear in the spectrum at count levels assuring accurate peak channel measurement, normally >100 counts or X10 background. Below are the laboratory-measured values for the given sources.

Table 1: Linear Calibration Results

Source Element	Peak Energy (MeV)	Peak Channel Number	% Difference From Calc.
Cs 137	0.662	92	1.1
Co 60	1.173, 1.332	163, 186	0.7, 0
Mn 54	0.835	115	1.7
Na 22	0.511, 1.275	74,178	2.9, 0

The resulting linear regression for energy Vs channel number is: Y MeV = 7.18×10^{-3} MeV * (Channel Number) – 4.90×10^{-3} MeV @ room temperature. Working backwards using the given channel number and the known energy gamma the percent deference was calculated. The correlation coefficient of Table I values is 0.9996. The linear response of a NaI detector is very good. However, a number of factors can cause the slope 'a' to change while drilling, primarily temperature, high voltage drift, and photon-multiplier tube aging. Controlling these parameters is critical to proper measurement.

Flux Density Vs Contamination Levels

Gamma counts rate is a relative measure of gamma flux, dependent on many factors as detector size, housings, etc. This flux is proportional to the amount of radioactive material in the soil. Thus, the measured flux is converted to pCi/g by calibration coefficients derived from calibration models. These models have known amounts of source material distributed in a large enough volume to appear infinitely large to traveling gamma rays, about a two to four foot radius about the sensor.

However, soil conditions infinitely vary for moister content and physical make up. Moister and soil types influence the measured gamma flux Limitations in calibration for flux density Vs contamination levels in soil result in an assumption that all soil conditions are consistent with the calibration models.

The most commonly used calibration models are maintained for Doe's Grand Junction Projects Office in Grand Junction Co. by contract with Rust Geodic Inc[a]. These models were built to calibrate instrumentation used for uranium exploration. As such these models contain three naturally occurring elements, K-40, Ra-226, and Th-232, (KUT). Because these models are well characterized and documented they are used to set baseline accuracy for all subterranean gamma instrumentation. Stromswold (1981) uses gamma count windows centered about energy peaks of the three naturals that unfold from highest energy to lowest. Table 2 shows his suggested windows.

Table 2 Spectral Energy Windows for Unfolding KUT

Element	Unique Gamma Ray (MeV)	Energy Window (MeV)
Potassium (K40)	1.46	1.320-1.575
Uranium (Ra-226)	1.76 & 2.20	1.650-2.390
Thorium (Th-232)	2.61	2.475-2.765

In working with subterranean gamma there is a problem of higher energy gamma rays being counted in lower channels, down scattering. By choosing the Thorium. Window about the 2.6 1 MeV gamma, Thorium can be solved for because potassium and uranium don't have any gamma rays higher than 2.39MeV. Once thorium is known then the solution for uranium can be found because potassium is below the 1.65MeV window used for uranium. This process is called unfolding. The Grand Junction B models are well suited for this unfolding process. The B model concentrations listed in Table 3 below.

Table 3. Grand Junction B-Model Concentrations

Model	Concentration Th (Pci/g)	Concentration Ra (Pci/g)	Concentration K (Pci/g)
BT Upper	58.78 ± 1.53	10.46 ± 0.51	10.13 ± 1.34
BU Upper	0.65 ± 0.06	194.59 ± 5.94	10.63 ± 1.00
BK Lower	0.10 ± 0.02	1.03 ± 1.67	54.00 ± 1.67

By placing the spectrometer into each of the three models, subtracting electrical noise, and counting gamma for each of the three windows in Table 2, a rate matrix R is produced. Matrix R is guaranteed to be nonsingular because of the window selection process assures an upper triangular form. Using the concentrations of Table 3 a set of coefficients relating window count

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rates to concentrations (pCi/g) can be solved for using Eq1. An important note on counting periods; The statistical nature of gamma counting requires long enough counting periods to gain a meaning full count rate. The standard deviation of the gamma count is equal to its square root, i.e. 100counts has a 10count sdv.

$$A = CR^{-1} \quad \text{Eq1}$$

A is a 3X3 Matrix of Calibration Coefficients
R is a 3X3 Matrix of Count Rate reading for each of the three windows
C is a 3X3 Matrix of Known model concentrations from Table 3

Once A is known then the system is tested against a forth model (BM) which is a mix of all three elements. A properly calibrated spectrometer then solves for concentration levels for KUT using equation Eq2.

$$C = AR \quad \text{Eq2}$$

Equation 2 is used to convert gamma flux rates to density measurements in pCi/g as the system is drilling or logging. There are a number of additional considerations to the process which should be addressed. First, the linear calibration relating gamma energy peaks to channel numbers in the spectrum is used for setting the KUT windows of Table 2. Anything that alters this calibration affects the calculated concentration levels. The measure of the gamma rate is dependent on concentration levels but also the MCA conversion rate. Low power MCAs normally employ slow conversion methods increasing dead time (DT). Where DT and R are both in units of seconds, Eq3 below is used compensate for a slow MCA.

$$R' = R^{*}\ 1\text{sec} / (1\text{sec} - DT) \quad \text{Eq3.}$$

DT is a function of MCA total counts and conversion time
R' is a new MCA compensated rate matrix

In the general solution of converting gamma count rates to KUT soil concentrations, a basic assumption was made; Only naturally occurring gamma sources are found in the soil. The man-made radioactive waste creates a new set of gamma mitters in contaminated soils.

In the case of Cesium (Cs-137), its' gamma ray is at 0.66MeV. Using this unfolding process Cesium would be unfolded after potassium. Too follow this logic; every radioactive element distributed within the soil must be accounted for in the unfolding process. The dominant waste radionuclides generally found in the soils at Hanford and Savannah River are Cesium- 137, Europium- 154, Europium-1 52, and Cobalt-60. Ina Westinghouse Savannah River 1994 report on H-Area retention basin list maximum concentrations as shown in Table 4. Table 4 is by no means a complete list of man-made waste, radioactive or otherwise.

Table 4. Example of found Radionuclides at a Waste Site

Radionuclides	Max. Concentration, pCi/g
Cesium- 13 7	33000
Europium-152	47
Europium-1 54	33
Cobalt-60	1.8

Figure 1 is log data taken with a HPGe detector used at Hanford, (C.J. Koizumi, 1993). There are two important attributes demonstrated by this data. First, the total count is a good indicator of waste radionuclides in the soil. Second, cesium waste maybe independent of other radionuclides.

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A complete gamma spectrum is shown in Figure 2. This spectrum was taken at 16.8m depth in the log run shown in Figure 1. Here the spectrum is scaled out to 2.8MeV. By scaling out so high the thorium peak at 2.61 MeV can be monitored for changing backgrounds. The measured concentrations for this spectrum at as follows: 3 pCi/g of Co-60, 29 pCi/g of Eu-154 and 8 pCi/g of K-40. The vast majority of spectral activity is below the K-40 peak at 1.46MeV.

Looking again at Figure 2, the down scattering of higher energy gamma into the 0.66MeV energy channel is a concern. Because of the low energy Cs-137 gamma virtually all background and other man-made radioactive waste interferes with the cesium measurement.

Unfolding Co and Cs From Background, An Example

Unfolding the three naturals along with cesium and cobalt (Randall and Stromswold, 1995) used windows 1.105 to 1.420MeV for cobalt and 0.590 to 0.715MeV for cesium. Lumping the background Th and U counts as a single constant term, the Cs and Co unfolding formulas are shown below.

$$C_{co} = aR_{co} - bR_K - cR_{CS} - BKG_{CO} \quad \text{Eq4.}$$

$$C_{cs} = dR_{cs} - ER^2_{cs} - fR_{co} - BKG \quad \text{Eq5.}$$

Terms "a" – "f" are unique coefficients.

BKG is the constant background subtraction of each element.
In all cases BKGcs, > BKGco.

Both equations 4 and 5 use the K40 rates directly. This is done because the cobalt upper gamma is very near that of potassium. The NaI detector resolution will overlap gamma counts. In Eq5 has a cobalt count rate term for calculation of cesium. Often cesium and cobalt are found together and the down scattering of the higher energy cobalt is a significant. Eq5 incorporates a squared term for pile up correction at very high count rates.

Suggested Approaches For EMWD

The EMWD MCA is a 256 channel multi-channel analyzer. The NaI crystal is (at present) a four by one inch cylinder. Complete spectrums are transmitted to the surface every 30 seconds. Spectrums are not being taken while data is being transmitted. The actual sample period is ~20 seconds. Spectrums can be summed at the surface to longer sample periods.

The main focus of the EMWD system is to detect and measure cesium contamination levels while drilling. There are no cesium waste models for calibration of spectral gamma logging systems. Even if such a model existed there are too many types of mixed radionuclides at each DOE site for any NaI system to accurately unfold. Two methods are suggested for calibrating a system to unfold Cs-13 7 from natural background spectrums. In both cases, total gamma counts will be used to detect increased levels of man-made waste. The total count might also help detect when count rates are increased by manmade waste other than Cs-13 7 by the simple relationship in Eq6.

$$TC - aR_{cs} - bR_K - BKG_{TC} = 0 \quad \text{Eq6}$$

TC = total counts
BKG_{TC} taken from reading is a clean area
a & b coefficients derived from field testing.

92

Calibration Method I
This method would treat the spectrum readings in the same fashion as calibrating any spectral gamma logging system as addressed earlier in this report.

Set the linear range to 2.8OmeV, full scale. Choose windows for all three naturals plus Cs-137. Eq1 is now composed of 4X4 matrixes. B-models can be used where the model concentration of Cs-137 is assumed zero. To solve for matrix A, a fourth model of known concentration of Cs-137 must be used. This Cs-137 model may actually be a characterized well as logged in Figure 1 at a waste site. This approach is heavily dependent on the quality of the Cs-137 model. The matrix inversion simultaneous solution of linear equations produces a least squares fit to given data. The solution maybe sensitive to slight changes in concentration levels, non-robust. This problem is compounded by the lack of a properly configured mixed model to help test the solution.

Calibration Method 2
The energy range will be low, upper end limited at 1.6MeV. This is done to utilize system sensitivity about the range of interest, see Figure 2. Gamma rays above this threshold are counted as a total and stored in channel 255. By monitoring this channel normal thorium and uranium background levels can be monitored. These background levels will be characterized at the site by drilling a short bore outside of the contaminated area. Along with channel 255, the potassiumand cesium windows will also be characterized for background down scattering. Using the B-model, the cesium window can be characterized for potassium down scattering.

$C_{cs} = aR_{cs} - bR_K - BKG_{cs}$ Eq7

Several cesium dominated wells of differing levels will be required to curve fit system response to cesium. If background reading remain constant and Cs-137 dominates all other types of man-made waste then the linear relationship should be well bounded.

Conclusion

The EMWD spectrometer is capable of linear calibration of gamma energy peaks at room temperature. The logging industry in cooperation with DOE has developed spectral gamma calibration methods and facilities. These method and facilities are not sufficient to fully calibrate spectral gamma systems for subterranean measurement of man-made mixed waste.

Actual logging data taken of radioactive waste by a HPGe system points to the complexity of the problem. For the EMWD system using a NaI detector there is no recognized solution for calibration or unfolding spectrums in man-made radioactive waste sites with unknown radionuclide.

Two methods were looked for calibration and unfolding. One method expands the accepted method used for spectral gamma logging tool calibration used in uranium exploration wells. The second method assumes a fixed background and attempts to equate a linear relationship between gamma count rates in cesium directly. Both methods or some combination of approaches needs to be tested before release for site characterization.

93

‘R- Leino, D.C. George, B.N. Key, L. Knight, and W.D. Steele, June 1994, Third Edition, Field Calibration Facilities for Environmental Measurement of Radium, Thorium, and Potassium, technical Measurements Center Grand Junction Projects Office.

94

EMWD Gamma Ray Spectrometer Calibration

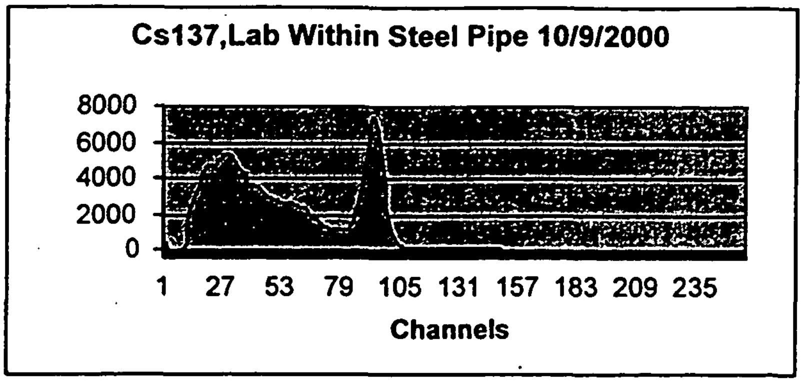
95

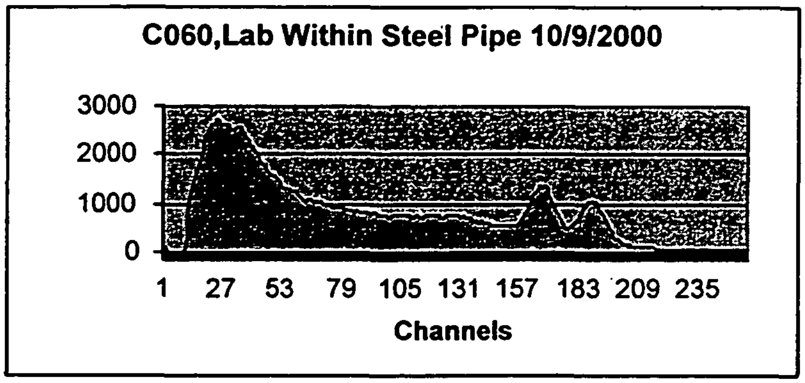
The EMWD Gamma Ray Spectrometer (GRS) was calibrated in the laboratory and in the DOE calibration models at the Grants Facility. These models were built to calibrate instrumentation used for uranium exploration. As such these models contain three naturally occurring elements, K-40, Ra-226, and Th-232, (KUT).

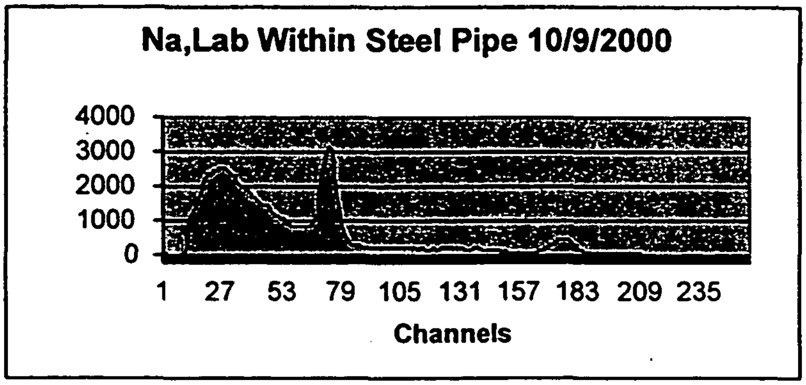
The calibration in the laboratory was conducted in a steel pipe to simulate the steel housing. The results for calibration with Cs-137, Co-60, and Na are shown in Figure H 1. The Cs-137 peak occurs between channels 80-100. The Co-60 spectra contains two peaks occurring in the range of channels 160-200. The Na spectra is bimodal with predominant peak occurring in ~channel 75 and a second broader peak occurring at about channel 180.

The EMWD-GRS also was calibrated using the calibration models at the DOE Grants Calibration Facility. The results for the Th and K-40 calibrations are shown in Figure H-2. The Th spectra occur as a shoulder in the area of channels 85 and 121. The K-40 spectra show a broad peak in the range of channels 200.

Figure H-1: Laboratory calibration of the EMWD-GRS using Cs-137, Co60, and Na.

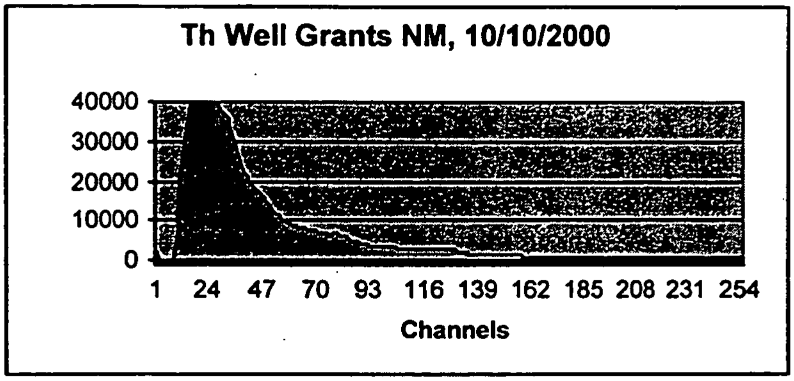


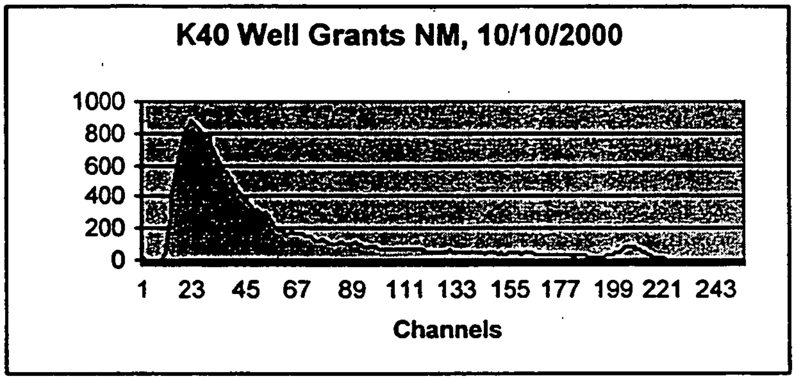




97

Figure H-2: EMWD-GRS calibration curves for Th and K-40 using the calibration models at the DOE Grants Calibration Facility





Rocky Flats UBC 123 and Building 886 Field Data

99

I-1: UBC 123 Bore #1

180

Rocky Flats EMWD Deployment

Date: 10/27/2000 Starting time: 8:35 am

Bore: First actual bore

File Name: SER1.PCM

Notes: Bore hit foundation at ~50ft. Bore stopped.

Spectrum #	Total Count Reading
1	2968 1st Bit
2	3230
3	2940
4	2722
5	2898
6	3065
7	2929
8	2890
9	2733
10	2976
11	2790
12	2923
13	3183

First attempted log. Tool placed in hole. (2 spectrum, take at bit Bit1.pcm) see [illegible]

Tool then pulled out ~1ft for each reading. Files SER 1, 2, & 3 are in series coming out the entire 50ft. The operator used a 1ft mark on the ground to measure 1ft. His eye was mostly off as we have only 39 spectrums.

101

Rocky Flats EMWD Deployment

Date: 10/27/2000 Starting time: 8:23

Bore: First actual bore Reading from the bit at 250ft

File Name: Bit 1

Notes: The bore was stopped short hitting the foundation. This is not a single point

Spectrum #	Total Count Reading
1	2904
2	2949

102

Rocky Flats EMWD Deployment

Date: 10/27/2000 Starting time: 8:49 a.m.

Bore: Second set coming out of the first actual bore

File Name: SER 2

Notes: Joint with SER 1 & 3. Created files incase the computer crashed

Spectrum #	Total Count Reading
1	2994
2	3098
3	3210
4	2984
5	2721
6	3115
7	3066
8	3002
9	2861
10	2993
11	2974
12	3021
13	3051
14	2993
15	2880

103

Rocky Flats EMWD Deployment

Date: 10/22/2002 Starting time: 8:52 a

Bore: First Actual Bore

File Name: SER 3

Notes: This goes with file SER 1 & 2.

Spectrum #	Total Count Reading
1	2994
2	2980
3	2884
4	3025
5	3079
6	3108
7	3062
8	2977
9	2836
10	2853
11	4848 * At the foundation wall. Image SER3Wall.BMP

104

I-2: UBC 123 Bore #2

105

Rocky Flats EMWD Deployment

Date: 11-7-00 Starting time: ____________

Bore: #2 1st SAMPLE @ 10"

File Name: RFB2 S1 (5min @ SAMPLE PT)

Notes: AT 01 PLATE 2 BUILDING 123 HDD LINES

Spectrum #	*	Total Count Reading
1	0	
2	1	
3	2	
4	3	
5	4	

AT 10" ONLY

S1

TOTAL COUNTS	
1	5672
2	5747
3	5809
4	5769
5	5256
6	5147
7	5327
8	5342
9	5179
10	5211

NOTE: 1.46 MeV ~ 187 CH
Temp ~ 3°C

RFB2 K40 TOOL ON GND W/ salt on top

4908
4863
4820
4878
4869
4708
4940
4732
4894
4901

* DISTANCE BACK FROM SAMPLE PT. IN FT.
NOTE: DETECTOR IN COPED HOLE IN FORMATION

106

Rocky Flats EMWD Deployment

Date: 11-7-00 Starting time: 1:39

Bore: #2 2nd SAMPLE @ 27'

File Name: RFB2S2 (5min @ SAMPLE Pt.) RFB2S3 (@ 1' INTERVALS)

Notes: AT 03+ PLATE 2 BUILDING 123 HDD LINES

TIME 1:30

Spectrum #	*	S3 Total Count Reading		S2 TOTAL COUNTS
1	0	3104	1	3183
2	1	3126	2	3275
3	2	2877	3	3218
4	3	2899	4	3174
5	4	2917	5	3203
6	5	3188	6	3244
7	6	3257	7	3156
8	7	3089	8	3198
9	8	3019	9	3273
10	9	3357	10	3244
11	10	3338		
12	11	3380		
13	12	3353		
14	13	3449		
15	14	3813		
16	15	3398		
17	16	3276		
18	17	3294		
19	18	3409		
20	19	3283		
21	20	3278		
22	21	3452		
23	22	3339		
24	23	3351		
25	24	3198		
26	25	2828		

⟨3217⟩

TEMP 12-14 °C

* DISTANCE BACK FROM SAMPLE Pt. IN FEET

+ PLATE 2 IS IN ERROR BORE 4-06 COINSIDES WITH BORE 2-[illegible] THUS BORE 2-02 WILL NOT BE A SAMPLE POINT. THE SECOND SAMPLE POINT IN BORE 2 WILL BE 03

107

Rocky Flats EMWD Deployment

Date: 11-7-00 Starting time: 359

Bore: #2 3rd SAMPLE @ 42.3'

File Name: RFB2S4 (5min @ SAMPLE PT) RFB2S5 (@ 1' INTERVALS)

Notes: AT 04 PLATE 2 BUILDING 123 HDD LINES

Spectrum #	*	S5 Total Count Reading		S4 TOT A COUNTS	TIME
1	0	2234	1	2288	3:53
2	1	2681	2	2337	
3	2	2580	3	2266	
4	3	2636	4	2353	
5	4	2563	5	2344	
6	5	2829	6	2297	
7	6	2981	7	2285	
8	7	2908	8	2415	
9	8	2901	9	2266	
10	9	2727	10	2326	
11	10	2660			
12	11	2830			
13	12	2948			
14	13	3049			
15	14	3242			

↑ TEMP 10-12°C (2318)

← TEMP 12-14°C

* DISTANCE BACK FROM SAMPLE POINT IN FEET.

108

Rocky Flats EMWD Deployment

Date: 11-8-00 Starting time: ______________

Bore: #2, 4th sample @ 54.4'

File Name: RFB2S6 (5min @ sample pt.), RFB2S7 (@ 1' intervals)

Notes: AT O 5 PLATE 2 BUILDING 123 HDD LINES

Spectrum #	*	S7 Total Count Reading
1	0	2717
2	1	2950
3	2	2934
4	3	2755
5	4	2713
6	5	2637
7	6	2695
8	7	2625
9	8	2679
10	9	2623
11	10	2769
12	11	2654
13	12	2430
14	13	2576
15	14	2581

S6 1:05

	S6 TOTAL COUNTS	
1	2619	
2	2684	
3	2625	
4	2712	5-7°C
5	2686	
6	2692	
7	2619	
8	2689	
9	2685	<26[illegible]>
10	2602	

+RFB2S8 RETAKE OF S6 DATE - TOOL ~Rm

1	2772	
2	2628	
3	2632	
4	2692	
5	2603	
6	2645	12-14°C
7	2697	
8	2662	
9	2693	
10	LOCKED UP	

LOCKED UP TWICE AT START

<2669>

* DISTANCE BACK FROM SAMPLE POINT IN FEET.

+NOTE: TEMP DURING S6 5-7°C — Will warm tool in trailer during sa[illegible] and Retake sample point data after sampling (RFB2S?)

109

Rocky Flats EMWD Deployment

Date: 11-9-00 Starting time: ______

Bore: #2, 5th SAMPLE @ 74'

File Name: RFB2S9 (5min @ SAMPLE Pt.) RFB2S10 (@ 1' INTERVALS)

Notes: AT 06 PLATE 2 BUILDING 123 HDD LINES

8:47 - 9:[illegible]

Spectrum #	*	S10 Total Count Reading	S9 #	S9 TOTAL COUNTS
1	0	2577	1	2540
2	1	3014	2	2576
3	2	2893	3	2664
4	3	2952	4	2542
5	4	2786	5	2549
6	5	2750	6	2565
7	6	2872	7	2586
8	7	2756	8	2594
9	8	2731	9	2625
10	9	2542	10	2556
11	10	2157		
12	11	2400		<2580>
13	12	2510		
14	13	2564		
15	14	2661		
16	15	2851		
17	16	2474		
18	17	2549		13-14°C
19	18	2515		
20	19	2738		

TEMP 11-12°C

* DISTANCE BACK FROM SAMPLE POINT IN FEET.
20 SPECTRUM TO COVER THE DISTANCE [illegible] SAMPLE POINTS 05 AND 06.

110

Rocky Flats EMWD Deployment

Date: 11-9-00 Starting time: ______

Bore: #2 6th SAMPLE @ 92.3'

File Name: RFB2S11 (5min @ SAMPLE PT.) RFB2S12 (@ 1' INTERVALS)

Notes: AT07 PLATE 2 BUILDING 123 HDD LINES

Spectrum #	*	S12 Total Count Reading	S13		S11 TOTAL COUNTS 3:00
1	0	3229	3170	1	3301
2	1	3284	3140	2	3308
3	2	3452	3233	3	3193
4	3	3196	3255	4	3249
5	4	3020	3317	5	3195
6	5	↑ 2886	2865	6	3251
7	6		STUCK 2922	7	3200
8	7		Free 2204	8	3220
9	8		3269	9	3166
10	9		2784	10	3130
11	10		2805		⟨3221⟩
12	11		2912		14 – 16 °C
13	12		3173		
14	13		3025		
15	14		3068		
16	15		2849		
17	16		3059		
18	17		3016		
19	18		2882		

LOCKED UP TWICE
SHUT DOWN ONCE

3025 when stuck

* DISTANCE BACK FROM SAMPLING POINT IN FEET

↑ TOOL STUCK – WHEN IT WAS JERKED TO FREE IT THE CONNECTOR [illegible] – [illegible] CONTAMINATED

NEW DATA SET RFB2S13

|||

Rocky Flats EMWD Deployment

Date: 11-10-00 Starting time: ____________

Bore: #2 7th SAMPLE @ 100'

File Name: RFB2S14 (5min @ SAMPLE Pt.) RFB2S15 (@ [illegible])

Notes: AT 08 PLATE 2 BUILDING 123 HDD LINE

Spectrum #	*	S15 Total Count Reading		S14 TOTAL COUNTS
1	0	2844	1	2939
2	1	2788	2	3047
3	2	2969 Lost Connection	3	3001
4	3	to tool	4	2977
			5	2989
			6	2982
			7	2999
			8	2928
			9	2874
			10	2935

*DISTANCE BACK FROM SAMPLE POINT IN FEET

Splice connection in poly Tubing broke, will pull and repair or replace.

112

Rocky Flats EMWD Deployment

Date: 11-13-00 Starting time: ______

Bore: #2 8th Sample @ 102'

File Name: RFB 2517 (5min @ sample point) RFB 2518 (@1' intervals)

Notes: AT 08 PLATE 2 BUILDING 123 HDD LINE
8 repeat

Spectrum #	*	Total Count Reading S-18		TOTAL COUNTS S17
1	0	2765	1	2758
2	1	2957	2	2807
3	2	2827	3	2801
4	3	2707	4	2776
5	4	2809	5	2798
6	5	2949	6	2814
7	6	3092	7	2774
8	7	3134	8	2901
9	8	2904	9	2858
10	9	3089	10	2794
11	10	3032		

* DISTANCE BACK FROM SAMPLE POINT IN FEET

Pulled New cable thru poly and Terminated both ends Tested - OK!

13

Rocky Flats EMWD Deployment

Date: 11-14-00 Starting time: 12:55

Bore: #2 9th Sample @ 126'

File Name: RFB2519 (5 min @ sample point) RFB2520 (@1' intervals)

Notes: AT ~~08~~ 10 PLATE 2 BUILDING 123 HDD LINES

Spectrum #	*	S20 Total Count Reading		S19 TOTAL COUNTS		
1	0	2778	2849	1	2825	2821
2	1	3017	2844	2	2813	2876
3	2	3031	2819	3	2912	2828
4	3	2924	3033	4	2856	2804
5	4	2979	2894	5	2828	2783
6	5	2970	2819	6	2844	2835
7	6		2809	7	2814	2859
8	7		2610	8	2845	2850
9	8		2933	9	2762	2842
10	9		2564	10	2780	2818
11	10		2876			
12	11		2680			
13	12		2862			
14	13		2883			
15	14		2933			
16	15		2839			
17	16		2972			
18	17		2669			
19	18		2713			
20	19		2921			
21	20		2855			
22	21		3007			
23	22		2941			
24	23		2949			
25	24		3004			
26	25		3064			
27	26		2984			
28	27		3329			
29	28		2992			
30	29		2539			
31	30		2810			

114

I-3: UBC 123 Bore #3

115

Rocky Flats EMWD Deployment

Date: 11-28-00 Starting time: 10:05

Bore: # 3 2nd sample @ 18'

File Name: RFB351 (5min @ Sample point) RFB352 (@1' intervals)

Notes: AT PLATE 2 BUILDING 123 HDD LINES 3

Spectrum #	*	S2 Total Count Reading
1	0	3562
2	1	3734
3	2	4302
4	3	4187
5	4	4051
6	5	3760
7	6	4053
8	7	3972
9	8	3283
10	9	3182
11	10	3066
12	11	3767
13	12	3713
14	13	3626
15	14	3930
16	15	3744
17	16	3574
18	17	3774
19	18	3607
20	19	3478
	20	

S1	
1	3610
2	3602
3	3634
4	3734
5	3562
6	3634
7	3707
8	3553
9	3628
10	3640

* Distance back from Sample point in Feet

114

Rocky Flats EMWD Deployment

Date: 11-28-00 Starting time: 2:20

Bore: #3 3rd Sample @ 33'

File Name: RFB353 (5min @ Sample point) RFB354 (@ 1' INTERVALS)

Notes: AT PLATE 2 BUILDING 123 HDD LINE 3

Spectrum #	*	S4 Total Count Reading	S3	
1	0	3790	1	3172
2	1	3391	2	3047
3	2	2939	3	3065
4	3	2647	4	3140
5	4	2104	5	3115
6	5	3180	6	3058
7	6	3145	7	3205
8	7	3221	8	3086
9	8	3305	9	3130
10	9	3380	10	3139
11	10	3250		
12	11	11795 (3547)		
13	12	7629 (3610)		
14	13	3780		
15	14	3875		
16	15	4289 (4896)		
17	16	3867 (4331)		
		@18' 3614		
		TOTAL of 28 spectrums		

* DISTANCE BACK FROM SAMPLE POINT IN FEET

10

Rocky Flats EMWD Deployment

Date: 11-29-00 Starting time: 8:50

Bore: 3

File Name: RFB3UT

Notes: UTILITY LINE PVC @ 0'

Spectrum #	* Total Count Reading
	4341
	4400
	4283
	4362
	4318
	4399
	4473
	4385
	4368
	4357
	4250
	4279
	4263
	4269
	4237
	4401
	4271
	4332
	4309
	4247
	4399
	4258
	4297
	4241
	4197
	4312
	4208
	4262
	4308
	4222

* Survey of UTILITY LINE

118

Rocky Flats EMWD Deployment

Date: 12-01-00 Starting time: 9:45

Bore: #3 4th Sample @ 48'

File Name: RFB355 (5min @ sample point) RFB356 (@ 1' INTERVALS)

Notes: AT PLATE 2 BUILDING 123 HDD LINE 3

Spectrum #	*	56 Total Count Reading
1	0	4082
2	1	4230
3	2	4435
4	3	4229
5	4	4021
6	5	4234
7	6	4381
8	7	4239
9	8	4235
10	9	4569
11	10	4239
12	11	4188
13	12	3825
14	13	3705
15	14	3576
16	15	3316
17	16	3310

	55
1	4270
2	4048
3	4206
4	4093
5	4076
6	4244
7	4155
8	4168
9	4203
10	4251

* Distance back from sample point in feet

119

Rocky Flats EMWD Deployment

Date: 12-01-00 Starting time: ____________

Bore: #3 5th Sample point @ 63'

File Name: RFB357 (5 min @ Sample Point) RFB358 (@ 1' INTERVALS)

Notes: AT PLATE 2 BUILDING 123 HDD LINE 3

Spectrum #	*	58 Total Count Reading		57
1	0	3059	1	3021
2	1	2998	2	2864
3	2	2874	3	2987
4	3	2953	4	3003
5	4	3044	5	3071
6	5	2836	6	2998
7	6	2862	7	3004
8	7	2768	8	2978
9	8	2864	9	2989
10	9	3013	10	2948
11	10	4785		
12	11	4468		
13	12	4002		
14	13	4092		
15	14	4088		
16	15	4085		
17	16	4400		
18	17	4654 → 4664		

* DISTANCE BACK FROM SAMPLE POINT IN FEET.

120

I-4: UBC 123 Bore #4

121

Rocky Flats EMWD Deployment

Date: 10-31-00 Starting time: 2:28

Bore: RFB 4 (S1 5 min) (S2 15@ 30sec ea)

File Name: RFB4S1 + RFB4S2

Notes: 1ST SAMPLE POINT @ 42'
at 06 PLATE 2 BLDG 123

Spectrum #	Total Count Reading
1	3486
2	3446
3	3366
4	3100
5	2963
6	3173
7	3077
8	2762
9	2528
10	3015
11	3082
12	3200
13	3041
14	2914
15	3111

2:35

DURING 5 min Run
THESE are some
of the total
counts
SORRY I DIDN'T get
them all.

3506
3387
3357
3496
3450

3440

122

Rocky Flats EMWD Deployment

Date: 11-1-00 Starting time: 9:03

Bore: #4

File Name: RFB4 S3, RFB4S4

Notes: 2nd SAMPLE PT. @ 57' S3 IS 5 min TEST & S4 is 30 [illegible] FOOT
at 05

Spectrum #	S4	S4 Total Count Reading
1	0	3169
2	1	3386
3	2	3578
4	3	3508 *
5	4	3316
6	5	3174
7	6	3103
8	7	3426
9	8	3459
10	9	3079
11	10	3216
12	11	3080
13	12	3211
14	13	3395
15	14	3377

S3 TOTAL COUNTS

Time 1056

1	3217
2	3059
3	3156
4	3197
5	3146
6	3094
7	3061
8	3200
9	3159
10	3111

3138

* 3431
3349
3344
3399

123

Rocky Flats EMWD Deployment

Date: 11-1-00 Starting time: 3:34

Bore: #4 3rd SAMPLE POINT @ 72'

File Name: RFB455 (5min @ sample P4) RFB456 (@ 1' intervals)

Notes: At 04 Plate 2 Building 123 HDD lines

3:26

56

Spectrum #	Total Count Reading
1	3141
2	3539
3	3721 *
4	3759
5	3627
6	3702
7	3707
8	3569
9	3489
10	3329
11	3302
12	3311
13	3154
14	3194
15	3090

55
TOTAL COUNTS

1	3206
2	3165
3	3225
4	3176
5	3073
6	3304
7	3171
8	3206
9	3173
10	3119
	3182

* 3763
3760
3794
3764
3851

124

Rocky Flats EMWD Deployment

Date: 11-2-00 Starting time: 10:30 - 10:50

Bore: 4 4th SAMPLE POINT @ 87'

File Name: RFB4S7 (5 min @ SA...) RFB4S8a (@ 1' ...)

Notes: AT 03 PLATE 2 BUILDING ...

S8a

Spectrum #	*	Total Count Reading
1	0	RESTART 3267
2	1	3373
3	2	3589
4	3	3434
5	4	3564
6	5	3254
7	6	3684
8	7	3652
9	8	3263
10	9	3059
11	10	3173
12	11	3372
13	12	3163
14	13	3212
15	14	

TOTAL CTS. S7 10:21

1	3227
2	3303
3	3260
4	3277
5	3239
6	3172
7	3245
8	3355
9	3280
10	3350

3272

* DISTANCE BACK FROM SAMPLE POINT ... FT.

125

Rocky Flats EMWD Deployment

Date: 11-2-00 Starting time: ____________

Bore: 4 5th sample pt. @ 10 2'

File Name: RFB4S9 (5 min @ sample -ŝ) RFB4S10 (@ 1' intervals)

Notes: A1O2 PLATE 2 BUILDING 123 [illegible] LINES

Spectrum #	*	S10 Total Count Reading
1	0	3252 -- 3259
2	1	3195
3	2	3375
4	3	3128
5	4	3137
6	5	3141
7	6	3180
8	7	3309
9	8	3274
10	9	3074
11	10	3226
12	11	3260
13	12	3189
14	13	3329
15	14	3268

4:47

S9	TOTAL COUNTS
1	3181
2	3295
3	3240
4	3296
5	3232
6	3312
7	3373
8	3297
9	3240
10	3288
	3275

* DISTANCE BACK FROM [illegible]

126

Rocky Flats EMWD Deployment

Date: 11-3-00 Starting time: ____________

Bore: 4 6th SAMPLE PT @ 112'

File Name: RFB4S11 (5min @ SAMPLE PT) RFB4S12 (@ 1' INTERVALS)

Notes: AT 01 PLATE 2 BUILDING [illegible] H [illegible] LINES

Spectrum #	*	S12 Total Count Reading	S11 TOTAL COUNTS w/1:27
1	0	3030	3058
2	1	2850	3112
3	2	3133	3104
4	3	3301	3024
5	4	3046	3023
6	5	3239	3121
7	6	3237	2965
8	7	3067	3104
9	8	3044	3112
10	9	3131	3113
11	10	3146	
12	11		
13	12		
14	13		
15	14		

3074

* DISTANCE BACK FROM SAMPLE PT. IN FEET

127

I-5: Building 886 Bore #6

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128

Rocky Flats EMWD Deployment

Date: 7 Dec 2000 Starting time: 4:40 T = 13-14° C

Bore: # 6 886 Sample @ ~~20ft~~ 18ft cw

File Name: RF886s1 ; RF886s2

Notes: Push 10 ft, sampled, pushed ~~10ft~~ 8ft ww more & logged hole

T = 14-15°C

	Spectrum #	*	S2 Total Count Reading		S1
18ft	1	0	2546 ; 2711	1	2466
	2	1	2414	2	2553
	3	2	2505	3	2500
15ft	4	3	2410	4	2522
	5	4	2425	5	2490
	6	5	2022	6	2522
	7	6	2235	7	2450
cw? ~~10ft~~	8	7	2155	8	2501
10ft	9	8	1815	9	2497
ww	~~10~~	~~9~~		10	2474
cw	~~11~~	~~10~~			

* distance back from sample pt in feet

Other files:

Air: RF886SØ
K40: RF886SK
Floor: RF886sF
[illegible]: RF886sW

129

Rocky Flats EMWD Deployment

Date: 7 Dec 2000 Starting time: 5:08

Bore: # 6 886 Sample @ 10 ft

File Name: RF886s3 ; RF886s4

T = 15-16°C

Notes: Battery Voltage = 24 for S3

CW 24.4 ~~25 Ft~~

	Spectrum #	*	S4 Total Count Reading		S3
10 ft	1	0	1851	1	1895
	2	1	2224	2	1874
	3	2	2622	3	1903
	4	3	2471	4	1880
	5	4	2050	5	1884
5 ft	6	5	2136	6	1893
	7	6	2733	7	1938
	8	7	2718	8	1930
	9	8	3239	9	1904
	10	9	6751	10	1921
0 ft	11	10	7786		

* distance back from sample pt in feet

Note: Computer locks up each time try to Record

130

Rocky Flats EMWD Deployment

Date: 7 Dec 2000 Starting time: 5:23

Bore: #6 886 Sample @ 0 ft

File Name: RF886s 5

T = 17-18°

Notes:

Spectrum #	Total Count Reading		S5
		1	7706
		2	7733
		3	7799
		4	7853
		5	7689
		6	7918
		7	7748
		8	7731
		9	7944
		10	7937

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Attachment B
Plates 1 and 2

133

THIS TARGET SHEET REPRESENTS AN OVER-SIZED MAP / PLATE FOR THIS DOCUMENT: No Unique Numeric Identifier (Ref: 01-RF-01851)

FINAL DATA SUMMARY REPORT FOR THE CHARACTERIZATION OF UBCs 123 & 886

August 2001

Plate 2:

Building 886 HDD Lines Process Waste Lines and Soil Sample Location Map

Map ID: 10-0550

May 23, 2001

CERCLA Administrative Record Document, IA - A -

U.S. DEPARTEMENT OF ENERGY
ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE

GOLDEN, COLORADO

/35

Attachment C
Project Photographs

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Picture 1 – Casing Advancement Frame Assembly (CAFA) and Support Equipment in HDD Line 1 Trench, Building 123 Slab

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Picture 2 – HDD Bit Location with Digi-Trak Receiver, Building 123 Slab

Picture 3 – Geoprobe Soil Sampling on the Former Building 123 Concrete Slab

Picture 4 – Concrete Coring and Soil Sampling in Room 103 Pit, Building 886

Attachment D
Data Summary Tables

Table D-1 Building 123 Analytical Summary

CAS Number	Analyte Name	No. of Analysis Runs[1]	Maximum Value[2]	Tier I Action Level[2]	Tier II Action Level[2]	Background[3]
630-20-6	1,1,1,2-Tetrachloroethane	50	ND	-	-	
71-55-6	1,1,1-Trichloroethane	50	ND	94800	948	
79-34-5	1,1,2,2-Tetrachloroethane	50	ND	168	1.68	
79-00-5	1,1,2-Trichloroethane	50	ND	1230	12.3	
76-13-1	1,1,2-Trichlorotrifluoroethane	50	6	-	-	
75-34-3	1,1-Dichloroethane	50	ND	689000	6890	
75-35-4	1,1-Dichloroethene	50	6	14100	141	
563-58-6	1,1-dichloropropene	50	ND	-	-	
87-61-6	1,2,3-Trichlorobenzene	50	ND	-	-	
96-18-4	1,2,3-Trichloropropane	50	ND	-	-	
120-82-1	1,2,4-Trichlorobenzene	97	ND	433000	4330	
95-63-6	1,2,4-Trimethylbenzene	50	ND	-	-	
96-12-8	1,2-Dibromo-3-chloropropane	50	ND	-	-	
106-93-4	1,2-Dibromoethane	50	ND	-	-	
95-50-1	1,2-Dichlorobenzene	98	ND	1320000	13200	
107-06-2	1,2-Dichloroethane	50	ND	668	6.68	
78-87-5	1,2-Dichloropropane	50	ND	1130	11.3	
108-67-8	1,3,5-Trimethylbenzene	50	ND	-	-	
541-73-1	1,3-Dichlorobenzene	98	ND	-	-	
142-28-9	1,3-Dichloropropane	50	ND	-	-	
106-46-7	1,4-Dichlorobenzene	97	ND	165000	1650	
594-20-7	2,2-Dichloropropane	50	ND	-	-	
95-95-4	2,4,5-Trichlorophenol	48	ND	279000	2790	
88-06-2	2,4,6-Trichlorophenol	48	ND	10700	107	
120-83-2	2,4-Dichlorophenol	48	ND	63500	635	
105-67-9	2,4-Dimethylphenol	48	ND	577000	5770	
51-28-5	2,4-Dinitrophenol	48	ND	5290	52.9	
121-14-2	2,4-Dinitrotoluene	47	ND	50.1	0.501	
606-20-2	2,6-Dinitrotoluene	48	ND	38.8	0.388	
78-93-3	2-Butanone	50	30	-	-	
91-58-7	2-Chloronaphthalene	48	ND	-	-	
95-57-8	2-Chlorophenol	47	ND	257000	2570	
95-49-8	2-Chlorotoluene	50	ND	-	-	
591-78-6	2-Hexanone	50	ND	-	-	
91-57-6	2-Methylnaphthalene	48	ND	-	-	
95-48-7	2-Methylphenol	48	ND	706000	7060	
88-74-4	2-Nitroaniline	48	ND	-	-	
88-75-5	2-Nitrophenol	48	ND	-	-	
91-94-1	3,3'-Dichlorobenzidine	48	ND	484	4.84	
99-09-2	3-Nitroaniline	48	ND	-	-	
534-52-1	4,6-Dinitro-2-methylphenol	48	ND	-	-	
101-55-3	4-Bromophenyl-phenylether	48	ND	-	-	
59-50-7	4-Chloro-3-methylphenol	47	18000	-	-	
106-47-8	4-Chloroaniline	48	ND	43800	438	
7005-72-3	4-Chlorophenyl-phenylether	48	ND	-	-	

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CAS Number	Analyte Name	No. of Analysis Runs[1]	Maximum Value[2]	Tier I Action Level[2]	Tier II Action Level[2]	Background[3]
106-43-4	4-Chlorotoluene	50	ND	-	-	
99-87-6	4-Isopropyltoluene	50	6	-	-	
108-10-1	4-Methyl-2-pentanone	50	ND	-	-	
106-44-5	4-Methylphenol	48	ND	-	-	
100-01-6	4-Nitroaniline	48	ND	-	-	
100-02-7	4-Nitrophenol	48	ND	-	-	
83-32-9	Acenaphthene	47	18000	5.34E+07	5.34E+05	
208-96-8	Acenaphthylene	48	ND	-	-	
67-64-1	Acetone	50	160	2.72E+07	2.72E+05	
7429-90-5	Aluminum, Total	49	28200	1.00E+06	1.00E+06	35373.17
14596-10-2	AM-241	49	1.14	209	38	0.02
120-12-7	Anthracene	48	18000		11200	
7440-36-0	Antimony, Total	49	0.61	768	768	16.97
7440-38-2	Arsenic, Total	49	14.7	299	2.99	13.14
7440-39-3	Barium, Total	49	99.3	133000	133000	289.38
71-43-2	Benzene	50	ND	1410	14.1	
56-55-3	Benzo(a)anthracene	48	ND	160000	1600	
50-32-8	Benzo(a)pyrene	48	ND	701000	7010	
205-99-2	Benzo(b)fluoranthene	48	ND	495000	4950	
191-24-2	Benzo(g,h,i)perylene	48	18000	-	-	
207-08-9	Benzo(k)fluoranthene	48	18000	4.95E+06	4.95E+04	
65-85-0	Benzoic acid	48	45000	1.09E+07	1.09E+05	
100-51-6	Benzyl alcohol	48	18000	-	-	
7440-41-7	Beryllium, Total	49	1.9	104	1.04	14.2
111-91-1	bis(2-Chloroethoxy)methane	48	ND	-	-	
111-44-4	bis(2-Chloroethyl)ether	48	ND	9.73	0.0973	
108-60-1	bis(2-Chloroisopropyl)ether	48	ND	-	-	
117-81-7	bis(2-Ethylhexyl)phthalate	49	7500	3.11E+08	3.11E+06	
108-86-1	Bromobenzene	50	ND	-	-	
74-97-5	Bromochloromethane	50	ND	-	-	
75-27-4	Bromodichloromethane	50	ND	26400	264	
75-25-2	Bromoform	50	ND	37200	372	
74-83-9	Bromomethane	50	6	5980	59.8	
85-68-7	Butylbenzylphthalate	48	ND		14400	
7440-43-9	Cadmium, Total	49	0.17	1920	1920	1.7
7440-70-2	Calcium, Total	49	74300	-	-	39382.27
75-15-0	Carbon Disulfide	50	6	988000	9880	
56-23-5	Carbon Tetrachloride	50	ND	3560	35.6	
108-90-7	Chlorobenzene	50	ND	83000	830	
75-00-3	Chloroethane	50	ND	-	-	
67-66-3	Chloroform	50	ND	21400	214	
74-87-3	Chloromethane	50	6	-	-	
7440-47-3	Chromium, Total	49	75.4	-	-	68.27
218-01-9	Chrysene	48	18000	-	-	
156-59-2	cis-1,2-dichloroethene	50	ND	-	-	
10061-01-5	cis-1,3-Dichloropropene	50	ND	120	1.2	

CAS Number	Analyte Name	No. of Analysis Runs[1]	Maximum Value[2]	Tier I Action Level[2]	Tier II Action Level[2]	Background[3]
7440-48-4	Cobalt, Total	49	21.1	115000	115000	29.04
7440-50-8	Copper, Total	49	293	71100	71100	38.21
84-74-2	Di-n-Butylphthalate	48	18000	4.26E+08	4.26E+06	
117-84-0	Di-n-Octyl phthalate	48	18000	-	-	
53-70-3	Dibenzo(a,h)anthracene	48	ND	153000	1530	
132-64-9	Dibenzofuran	48	ND	-	-	
124-48-1	Dibromochloromethane	50	ND	-	-	
74-95-3	Dibromomethane	50	ND	-	-	
75-71-8	Dichlorodifluoromethane	50	ND	-	-	
84-66-2	Diethylphthalate	48	ND	3.10E+07	3.10E+05	
131-11-3	Dimethyphthalate	48	ND	-	-	
100-41-4	Ethylbenzene	50	ND	932000	9320	
206-44-0	Fluoranthene	48	18000	5.37E+08	5.37E+06	
86-73-7	Fluorene	48	ND	6.94E+07	6.94E+05	
118-74-1	Hexachlorobenzene	48	ND	189000	1890	
87-68-3	Hexachlorobutadiene	98	ND	201000	2010	
77-47-4	Hexachlorocyclopentadiene	48	ND	3.44E+07	3.44E+05	
67-72-1	Hexachloroethane	48	ND	37700	377	
193-39-5	Indeno(1,2,3-cd)pyrene	48	18000	1.40E+06	14000	
7439-89-6	Iron, Total	49	32500	576000	576000	41046.52
78-59-1	Isophorone	48	ND	20900	209	
98-82-8	Isopropylbenzene	50	ND	-	-	
7439-92-1	Lead, Total	49	**3470**	1000	1000	24.97
7439-93-2	Lithium, Total	49	13.4	38400	38400	34.66
7439-95-4	Magnesium, Total	49	2420	-	-	9315.44
7439-96-5	Manganese, Total	49	303	83600	83600	901.62
7439-97-6	Mercury, Total	49	2.7	576	576	1.52
75-09-2	Methylene Chloride	50	29	578	5.78	
7439-98-7	Molybdenum, Total	49	25.6	9610	9610	25.61
104-51-8	N-butybenzene	50	ND	-	-	
621-64-7	N-Nitroso-di-n-propylamine	47	ND	1.89	0.0189	
86-30-6	N-Nitrosodiphenylamine (1)	48	ND	78400	784	
103-65-1	N-propylbenzene	50	ND	-	-	
91-20-3	Naphthalene	98	ND	1.01E+07	1.01E+05	
7440-02-0	Nickel, Total	49	27.5	38400	38400	62.21
98-95-3	Nitrobenzene	48	ND	5390	53.9	
87-86-5	Pentachlorophenol	48	ND	2110	21.1	
85-01-8	Phenanthrene	48	18000	-	-	
108-95-2	Phenol	47	18000	3.75E+06	37500	
7440-09-7	Potassium, Total	49	2250	-	-	6196.81
10-12-8	PU-239/240	49	0.445	1088	252	0.02
129-00-0	Pyrene	47	18000	3.97E+08	3.97E+06	
110-86-1	Pyridine	48	ND	-	-	
135-98-8	Sec-butylbenzene	50	ND	-	-	
7782-49-2	Selenium, Total	49	0.82	9610	9610	4.8

CAS Number	Analyte Name	No. of Analysis Runs[1]	Maximum Value[2]	Tier I Action Level[2]	Tier II Action Level[2]	Background[3]
7440-22-4	Silver, Total	49	0.34	9610	9610	24.54
7440-23-5	Sodium, Total	49	404	-	-	1251.24
7440-24-6	Strontium, Total	49	60.5	1.00E+06	1.00E+06	211.38
100-42-5	Styrene	50	ND	274000	2740	
98-06-6	Tert-butylbenzene	50	ND	-	-	
127-18-4	Tetrachloroethene	50	ND	3150	31.5	
7440-28-0	Thallium, Total	49	0.69	-	-	1.84
7440-31-5	Tin, Total	49	30.6	1.00E+06	1.00E+06	286.31
108-88-3	Toluene	50	6	707000	7070	
156-60-5	Trans-1,2-dichloroethene	50	6	-	-	
10061-02-6	Trans-1,3-Dichloropropene	47	ND	120	1.2	
79-01-6	Trichloroethene	50	6	3290	32.9	
75-69-4	Trichlorofluoromethane	50	6	-	-	
11-08-5	U-233/234	49	1.87	1627	307	2.64
15117-96-1	U-235	49	0.114	113	24	0.12
7440-61-1	U-238	49	1.52	506	103	1.49
11-09-6	Uranium, Total	49	ND	-	-	
7440-62-2	Vanadium, Total	49	59.7	13400	13400	88.49
75-01-4	Vinyl Chloride	50	ND	347	3.47	
1330-20-7	Xylenes (Total)	50	6	9.74E+06	97400	
7440-66-6	Zinc, Total	49	37.7	576000	576000	139.1

[1]Estimated Number of Real and Duplicate Samples Collected.

[2]Units are µg/kg (ppb) for Organics, mg/kg for Inorganics, and pCi/g for Radionuclides. Cells noting the "-" symbol denote analytes for which Action Levels have not been established by RFCA. Cells noting a "ND" symbol are non-detectable concentrations.

[3]Source: DOE, 1993. Arithmetic Mean + 2 Standard Deviations, Background Geochemical Report, Table D-16, RFETS, September, 1993. Applies to metals and radionuclides only.

Table D-2 Building 886 Analytical Summary

CAS Number	Analyte Name	No. of Analysis Runs[1]	Maximum Value[2]	Tier I Action Level[2]	Tier II Action Level[2]	Background[3]
630-20-6	1,1,1,2-Tetrachloroethane	16	ND	-	-	
71-55-6	1,1,1-Trichloroethane	16	ND	94800	948	
79-34-5	1,1,2,2-Tetrachloroethane	16	ND	168	1.68	
79-00-5	1,1,2-Trichloroethane	16	ND	1230	12.3	
76-13-1	1,1,2-Trichlorotrifluoroethane	16	ND	-	-	
75-34-3	1,1-Dichloroethane	16	ND	689000	6890	
75-35-4	1,1-Dichloroethene	16	ND	14100	141	
563-58-6	1,1-dichloropropene	16	ND	-	-	
87-61-6	1,2,3-Trichlorobenzene	16	6	-	-	
96-18-4	1,2,3-Trichloropropane	16	6	-	-	
120-82-1	1,2,4-Trichlorobenzene	35	2000	433000	4330	
95-63-6	1,2,4-Trimethylbenzene	16	ND	-	-	
96-12-8	1,2-Dibromo-3-chloropropane	16	6	-	-	
106-93-4	1,2-Dibromoethane	16	ND	-	-	
95-50-1	1,2-Dichlorobenzene	35	ND	1320000	13200	
107-06-2	1,2-Dichloroethane	16	ND	668	6.68	
78-87-5	1,2-Dichloropropane	16	ND	1130	11.3	
108-67-8	1,3,5-Trimethylbenzene	16	ND	-	-	
541-73-1	1,3-Dichlorobenzene	35	ND	-	-	
142-28-9	1,3-Dichloropropane	16	ND			
106-46-7	1,4-Dichlorobenzene	35	ND	165000	1650	
594-20-7	2,2-Dichloropropane	16	ND	-	-	
95-95-4	2,4,5-Trichlorophenol	19	ND	279000	2790	
88-06-2	2,4,6-Trichlorophenol	19	ND	10700	107	
120-83-2	2,4-Dichlorophenol	19	ND	63500	635	
105-67-9	2,4-Dimethylphenol	19	ND	577000	5770	
51-28-5	2,4-Dinitrophenol	19	ND	5290	52.9	
121-14-2	2,4-Dinitrotoluene	19	ND	50.1	0.501	
606-20-2	2,6-Dinitrotoluene	19	ND	38.8	0.388	
78-93-3	2-Butanone	16	ND	-	-	
91-58-7	2-Chloronaphthalene	19	ND	-	-	
95-57-8	2-Chlorophenol	19	ND	257000	2570	
95-49-8	2-Chlorotoluene	16	ND	-	-	
591-78-6	2-Hexanone	16	ND	-	-	
91-57-6	2-Methylnaphthalene	19	ND	-	-	
95-48-7	2-Methylphenol	19	ND	706000	7060	
88-74-4	2-Nitroaniline	19	ND	-	-	
88-75-5	2-Nitrophenol	19	ND	-	-	
91-94-1	3,3'-Dichlorobenzidine	19	ND	484	4.84	
99-09-2	3-Nitroaniline	19	ND	-	-	
534-52-1	4,6-Dinitro-2-methylphenol	19	ND	-	-	
101-55-3	4-Bromophenyl-phenylether	19	ND	-	-	
59-50-7	4-Chloro-3-methylphenol	19	ND	-	-	
106-47-8	4-Chloroaniline	19	ND	43800	438	
7005-72-3	4-Chlorophenyl-phenylether	19	ND	-	-	

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CAS Number	Analyte Name	No. of Analysis Runs[1]	Maximum Value[2]	Tier I Action Level[2]	Tier II Action Level[2]	Background[3]
106-43-4	4-Chlorotoluene	16	ND	-	-	
99-87-6	4-Isopropyltoluene	16	ND	-	-	
108-10-1	4-Methyl-2-pentanone	16	13	-	-	
106-44-5	4-Methylphenol	19	ND	-	-	
100-01-6	4-Nitroaniline	19	ND	-	-	
100-02-7	4-Nitrophenol	19	ND	-	-	
83-32-9	Acenaphthene	19	ND	5.34E+07	5.34E+05	
208-96-8	Acenaphthylene	19	ND	-	-	
67-64-1	Acetone	16	36	2.72E+07	2.72E+05	
7429-90-5	Aluminum, Total	24	59000	1.00E+06	1.00E+06	35373.17
14596-10-2	AM-241	19	0.394	209	38	0.02
120-12-7	Anthracene	19	ND		11200	
7440-36-0	Antimony, Total	24	0.58	768	768	16.97
7440-38-2	Arsenic, Total	24	12.3	299	2.99	13.14
7440-39-3	Barium, Total	24	796	133000	133000	289.38
71-43-2	Benzene	16	ND	1410	14.1	
56-55-3	Benzo(a)anthracene	19	ND	160000	1600	
50-32-8	Benzo(a)pyrene	19	2000	701000	7010	
205-99-2	Benzo(b)fluoranthene	19	2000	495000	4950	
191-24-2	Benzo(g,h,i)perylene	19	2000	-	-	
207-08-9	Benzo(k)fluoranthene	19	2000	4950000	49500	
65-85-0	Benzoic acid	19	5000	1.09E+07	1.09E+05	
100-51-6	Benzyl alcohol	19	ND	-	-	
7440-41-7	Beryllium, Total	24	0.87	104	1.04	14.2
111-91-1	bis(2-Chloroethoxy)methane	19	ND	-	-	
111-44-4	bis(2-Chloroethyl)ether	19	ND	9.73	0.0973	
108-60-1	bis(2-Chloroisopropyl)ether	19	ND	-	-	
117-81-7	bis(2-Ethylhexyl)phthalate	19	1800	3.11E+08	3.11E+06	
108-86-1	Bromobenzene	16	ND	-	-	
74-97-5	Bromochloromethane	16	ND	-	-	
75-27-4	Bromodichloromethane	16	ND	26400	264	
75-25-2	Bromoform	16	6	37200	372	
74-83-9	Bromomethane	16	ND	5980	59.8	
85-68-7	Butylbenzylphthalate	19	ND		14400	
7440-43-9	Cadmium, Total	24	0.23	1920	1920	1.7
7440-70-2	Calcium, Total	24	412000	-	-	39382.27
75-15-0	Carbon Disulfide	16	ND	988000	9880	
56-23-5	Carbon Tetrachloride	16	ND	3560	35.6	
108-90-7	Chlorobenzene	16	ND	83000	830	
75-00-3	Chloroethane	16	ND	-	-	
67-66-3	Chloroform	16	ND	21400	214	
74-87-3	Chloromethane	16	ND	-	-	
7440-47-3	Chromium, Total	24	35.2	-	-	68.27
218-01-9	Chrysene	19	2000	-	-	
156-59-2	cis-1,2-dichloroethene	16	ND	-	-	
10061-01-5	cis-1,3-Dichloropropene	16	ND	120	1.2	
7440-48-4	Cobalt, Total	24	14	115000	115000	29.04

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CAS Number	Analyte Name	No. of Analysis Runs[1]	Maximum Value[2]	Tier I Action Level[2]	Tier II Action Level[2]	Background[3]
7440-50-8	Copper, Total	24	1190	71100	71100	38.21
84-74-2	Di-n-Butylphthalate	19	2000	4.26E+08	4.26E+06	
117-84-0	Di-n-Octyl phthalate	19	ND	-	-	
53-70-3	Dibenzo(a,h)anthracene	19	ND	153000	1530	
132-64-9	Dibenzofuran	19	ND	-	-	
124-48-1	Dibromochloromethane	16	ND	-	-	
74-95-3	Dibromomethane	16	ND	-	-	
75-71-8	Dichlorodifluoromethane	16	ND	-	-	
84-66-2	Diethylphthalate	19	ND	3.10E+07	3.10E+05	
131-11-3	Dimethyphthalate	19	ND	-	-	
100-41-4	Ethylbenzene	16	ND	932000	9320	
206-44-0	Fluoranthene	19	2000	5.37E+08	5.37E+06	
86-73-7	Fluorene	19	ND	6.94E+07	6.94E+05	
118-74-1	Hexachlorobenzene	19	ND	189000	1890	
87-68-3	Hexachlorobutadiene	35	ND	201000	2010	
77-47-4	Hexachlorocyclopentadiene	19	ND	3.44E+07	3.44E+05	
67-72-1	Hexachloroethane	19	ND	37700	377	
193-39-5	Indeno(1,2,3-cd)pyrene	19	ND	1.40E+06	14000	
7439-89-6	Iron, Total	24	33000	576000	576000	41046.52
78-59-1	Isophorone	19	ND	20900	209	
98-82-8	Isopropylbenzene	16	ND	-	-	
7439-92-1	Lead, Total	24	28.24	1000	1000	24.97
7439-93-2	Lithium, Total	24	14.2	38400	38400	34.66
7439-95-4	Magnesium, Total	24	4570	-	-	9315.44
7439-96-5	Manganese, Total	24	298	83600	83600	901.62
7439-97-6	Mercury, Total	22	0.15	576	576	1.52
75-09-2	Methylene Chloride	16	29	578	5.78	
7439-98-7	Molybdenum, Total	24	2	9610	9610	25.61
104-51-8	N-butybenzene	16	ND	-	-	
621-64-7	N-Nitroso-di-n-propylamine	19	ND	1.89	0.0189	
86-30-6	N-Nitrosodiphenylamine (1)	19	ND	78400	784	
103-65-1	N-propylbenzene	16	ND	-	-	
91-20-3	Naphthalene	35	ND	1.01E+07	1.01E+05	
7440-02-0	Nickel, Total	24	20.1	38400	38400	62.21
98-95-3	Nitrobenzene	19	ND	5390	53.9	
87-86-5	Pentachlorophenol	19	ND	2110	21.1	
85-01-8	Phenanthrene	19	2000	-	-	
108-95-2	Phenol	19	ND	3750000	37500	
7440-09-7	Potassium, Total	24	2690	-	-	6196.81
10-12-8	PU-239/240	19	0.408	1088	252	0.02
129-00-0	Pyrene	19	2000	3.97E+08	3.97E+06	
110-86-1	Pyridine	19	ND	-	-	
135-98-8	Sec-butylbenzene	16	ND	-	-	
7782-49-2	Selenium, Total	24	ND	9610	9610	4.8
7440-22-4	Silver, Total	24	3.8	9610	9610	24.54

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CAS Number	Analyte Name	No. of Analysis Runs[1]	Maximum Value[2]	Tier I Action Level[2]	Tier II Action Level[2]	Background[3]
7440-23-5	Sodium, Total	24	994	-	-	1251.24
7440-24-6	Strontium, Total	24	322	1.00E+06	1.00E+06	211.38
100-42-5	Styrene	16	ND	274000	2740	
98-06-6	Tert-butylbenzene	16	ND	-	-	
127-18-4	Tetrachloroethene	16	ND	3150	31.5	
7440-28-0	Thallium, Total	24	1.1	-	-	1.84
7440-31-5	Tin, Total	24	2.8	1.00E+06	1.00E+06	286.31
108-88-3	Toluene	16	ND	707000	7070	
156-60-5	Trans-1,2-dichloroethene	16	ND	-	-	
10061-02-6	Trans-1,3-Dichloropropene	16	ND	120	1.2	
79-01-6	Trichloroethene	16	ND	3290	32.9	
75-69-4	Trichlorofluoromethane	16	ND	-	-	
11-08-5	U-233/234	19	3.78	1627	307	2.64
15117-96-1	U-235	19	0.141	113	24	0.12
7440-61-1	U-238	19	1.35	506	103	1.49
11-09-6	Uranium, Total	24	ND	-	-	
7440-62-2	Vanadium, Total	24	64	13400	13400	88.49
75-01-4	Vinyl Chloride	16	ND	347	3.47	
1330-20-7	Xylenes (Total)	16	8	9.74E+06	9.74E+04	
7440-66-6	Zinc, Total	24	46.3	576000	576000	139.1

[1]Estimated Number of Real and Duplicate Samples Collected.

[2]Units are µg/kg (ppb) for Organics, mg/kg for Inorganics, and pCi/g for Radionuclides. Cells noting the "-" symbol denote analytes for which Action Levels have not been established by RFCA. Cells noting a "ND" symbol are non-detectable concentrations.

[3]Source: DOE, 1993. Arithmetic Mean + 2 Standard Deviations, Background Geochemical Report, Table D-16, RFETS, September, 1993. Applies to metals and radionuclides only.

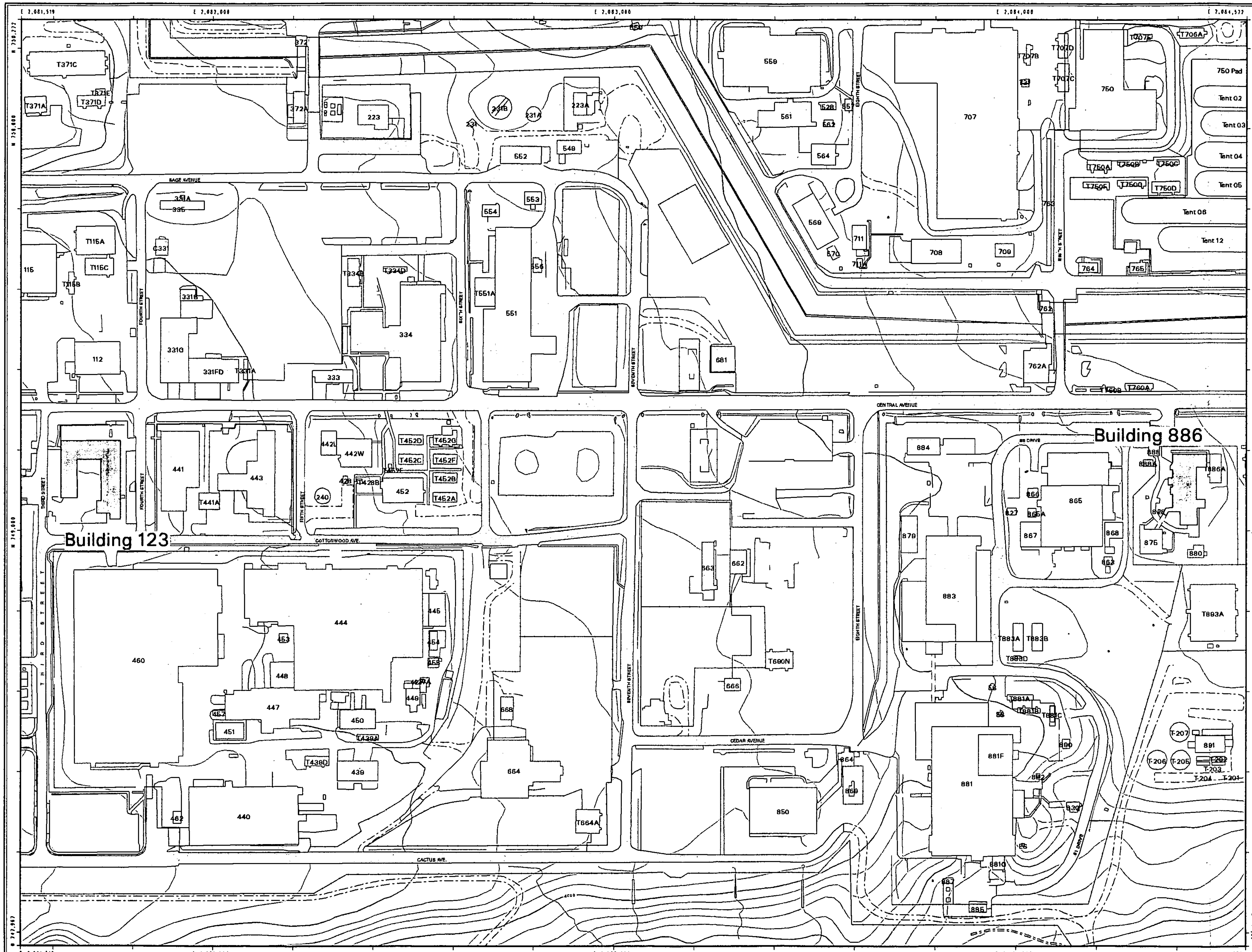

Figure 1-1

Site Location Map

EXPLANATION

Standard Map Features

- Buildings and other structures
- Paved roads fill
- Solar Evaporation Ponds (SEP)
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (5-Foot)
- Paved roads
- Dirt roads

DATA SOURCE BASE FEATURES:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95
Topology (contours) were derived from digital elevation model (DEM) data by Morrison Knudson (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.

N

Scale = 1 : 2970
1 inch represents approximately 248 feet

100 0 200 400ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

GIS Dept. 303-966-7707

Prepared by: **DynCorp** THE ART OF TECHNOLOGY

Prepared for: KAISER-HILL COMPANY

MAP ID: 2k-0153 June 19, 2001

Original map contents are preserved. Logo and date have changed.

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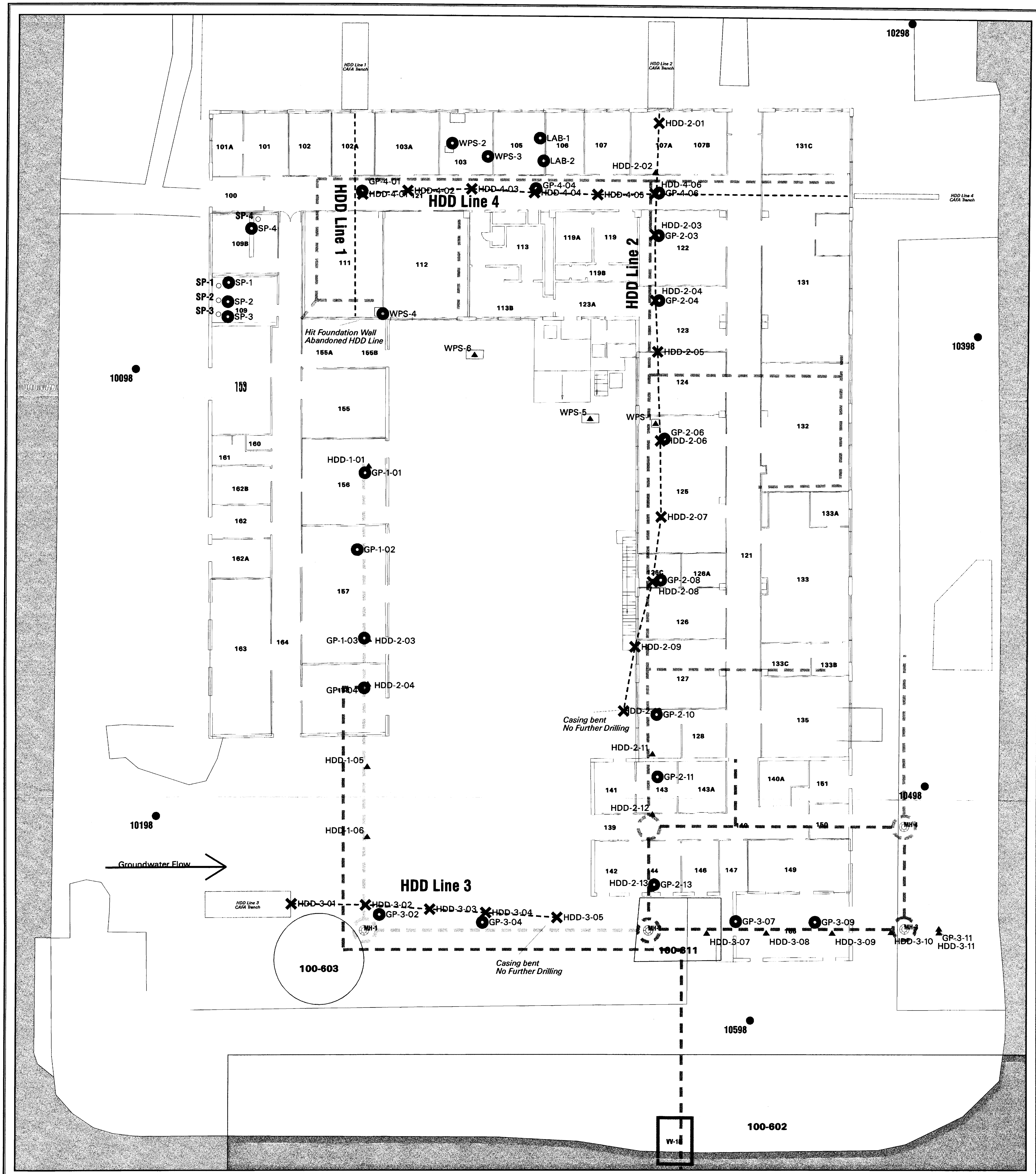

PLATE 1

Building 123 HDD Lines Process Waste Lines and Soil Sample Location Map

EXPLANATION

- Manhole
- Groundwater Wells
- Geoprobe Soil Sample Location
- HDD Soil Sample Location
- HDD or Geoprobe Soil Samples Not Collected
- Source Pit

Process Waste Lines

- P3 1968
- P2 1952
- P1 1972
- P1 1989
- Horizontal Borehole

Potential Areas of Concern

- Potential Area of Concern
- Casing Advancement Frame Assembly (CAFA) Trench Location
- Valve Vault Locations
- Waste Pumping Stations

Standard Map Features

- Buildings and other structures
- Paved roads fill
- Fences and other barriers
- Paved roads

NOTE:

VV = Valve Vault
WPS = Waste Pumping Station
SP = Source Pit
MH = Manhole

The Original and New Process Waste Line locations shown on map are approximate and should not be used for determining the line location when performing excavation work.

Scale = 1 : 120
1 inch represents 10 feet

5 0 10 20ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy

Rocky Flats Environmental Technology Site

GIS Dept. 303-966-7707

Prepared by: DynCorp THE ART OF TECHNOLOGY

Prepared for: KAISER•HILL COMPANY

MAP ID: 01-0543

May 23, 2001

Original map contents are preserved. Logo and date have changed.

1 OF 1