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Rev. 0

Borehole Summary Report for the 216-B-2-2 Ditch

HANFORD

Prepared for the U.S. Department of Energy
Office of Environmental Restoration

Bechtel Hanford, Inc.
Richland, Washington

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METRIC CONVERSION CHART

The following conversion chart is provided to aid the reader in conversion.

Into Metric Units

If You Know	*Multiply By*	*To Get*
Length		
inches	25.4	millimeters
inches	2.54	centimeters
feet	0.305	meters
yards	0.914	meters
miles	1.609	kilometers
Area		
sq. inches	6.452	sq. centimeters
sq. feet	0.093	sq. meters
sq. yards	.0836	sq. meters
sq. miles	2.6	sq. kilometers
acres	0.405	hectares
Mass (weight)		
ounces	28.35	grams
pounds	0.454	kilograms
ton	0.907	metric ton
Volume		
teaspoons	5	milliliters
tablespoons	15	milliliters
fluid ounces	30	milliliters
cups	0.24	liters
pints	0.47	liters
quarts	0.95	liters
gallons	3.8	liters
cubic feet	0.028	cubic meters
cubic yards	0.765	cubic meters
Temperature		
Fahrenheit	subtract 32, then multiply by 5/9	Celsius
Radioactivity		
picocuries	37	millibecquerel

Out of Metric Units

If You Know	*Multiply By*	*To Get*
Length		
millimeters	0.039	inches
centimeters	0.394	inches
meters	3.281	feet
meters	1.094	yards
kilometers	0.621	miles
Area		
sq. centimeters	0.155	sq. inches
sq. meters	10.76	sq. feet
sq. meters	1.196	sq. yards
sq. kilometers	0.4	sq. miles
hectares	2.47	acres
Mass (weight)		
grams	0.035	ounces
kilograms	2.205	pounds
metric ton	1.102	ton
Volume		
milliliters	0.033	fluid ounces
liters	2.1	pints
liters	1.057	quarts
liters	0.264	gallons
cubic meters	35.315	cubic feet
cubic meters	1.308	cubic yards
Temperature		
Celsius	multiply by 9/5, then add 32	Fahrenheit
Radioactivity		
millibecquerel	0.027	picocuries

1.0 INTRODUCTION

A characterization borehole, 299-E33-333 (well identification number B8079), was drilled through the 216-B-2-2 Ditch to groundwater during late December 1997 and early January 1998. The characterization activities were conducted according to the *Description of Work for a Vadose Zone Characterization Borehole at the 216-B-2-2 Ditch* (DOW) (Faurote and Wittreich 1997). The location of the borehole is shown in Figure 1. A sampling and analysis plan and data quality objectives for the characterization effort are also defined in the DOW.

The purpose of this borehole summary report is to provide the results of the drilling and sampling as a data package. The 216-B-2-2 Ditch borehole data will be evaluated with other existing data during remedial investigation/feasibility study (RI/FS) work plan development for the Gable Mountain Pond/B-Pond and Ditches Cooling Water Group (200-CW-1). Additional characterization needs for the ditch, as well as for the 200-CW-1 Waste Group in general, will be defined in an RI/FS work plan for the 200-CW-1 Waste Group planned for preparation in fiscal year 1999. After characterization activities have been completed for the waste group, the information (including the 216-B-2-2 borehole data) will be collectively evaluated and documented in a remedial investigation report.

The 216-B-2-2 Ditch was selected for characterization based on the *Waste Site Grouping Report for 200 Areas Soil Investigations* (DOE-RL 1997), which identified this ditch as a representative site for the Gable Mountain Pond/B-Pond and Ditches Cooling Water Group (formerly the 200-BP-11 Operable Unit). The 216-B-2-2 Ditch was selected as a representative site because (1) it was operationally typical of a ditch and contains a representative inventory of contaminants; (2) it is expected to contain typical to higher levels of contamination at the head end of the ditch system, plus high levels of strontium-90 associated with a 1,000 Ci unplanned release; and (3) it lies in the middle of the 216-B-2 Ditch System, providing composite data for all three ditches at depth. The purpose of drilling the borehole was to refine the preliminary physical conceptual models of contaminant distribution and hydrogeology, to assess the nature and extent of subsurface contaminants, and to support remedial action/closure decisions for the Gable Mountain Pond/B-Pond and Ditches Cooling Water Group (Faurote and Wittreich 1997).

The 216-B-2 Ditch System, consisting of the 216-B-2-1, 216-B-2-2, and 216-B-2-3 Ditches, was designed to convey cooling water from 200 East Area plants to the 216-B-3 Pond (B Pond) and to the 216-A-25 Pond (Gable Mountain Pond) (Figure 2). The 216-B-2-2 Ditch was excavated to replace the 216-B-2-1 Ditch and was active from November 1963 to May 1970. It was an open, unlined earthen ditch approximately 4.6 m (15 ft) wide at ground level, 1.8 to 2.4 m (6 to 8 ft) deep, approximately 0.9 m (3 ft) wide at the bottom, and 1,067 m (3,500 ft) long (DOE-RL 1995). Detailed descriptions of the history of operations and the sources of the cooling water for the 216-B-2 Ditch System can be found in the *B Plant Source Aggregate Area Management Study Report* (DOE-RL 1993).

On March 22, 1970, approximately 1,000 Ci of strontium-90 was released to the ditch as a result of Unplanned Release UPR-200-E-138; 14 Ci of cesium-137 and 150 Ci of cerium-144/ praseodymium-144 were also released (Hanson 1971). On March 23, 1970, earthen dams were built in the open ditch to keep as much contamination as possible out of the 216-B-3 Main Pond,

Figure 1. Location of the 216-B-2-2 Characterization Borehole, 299-E33-333.

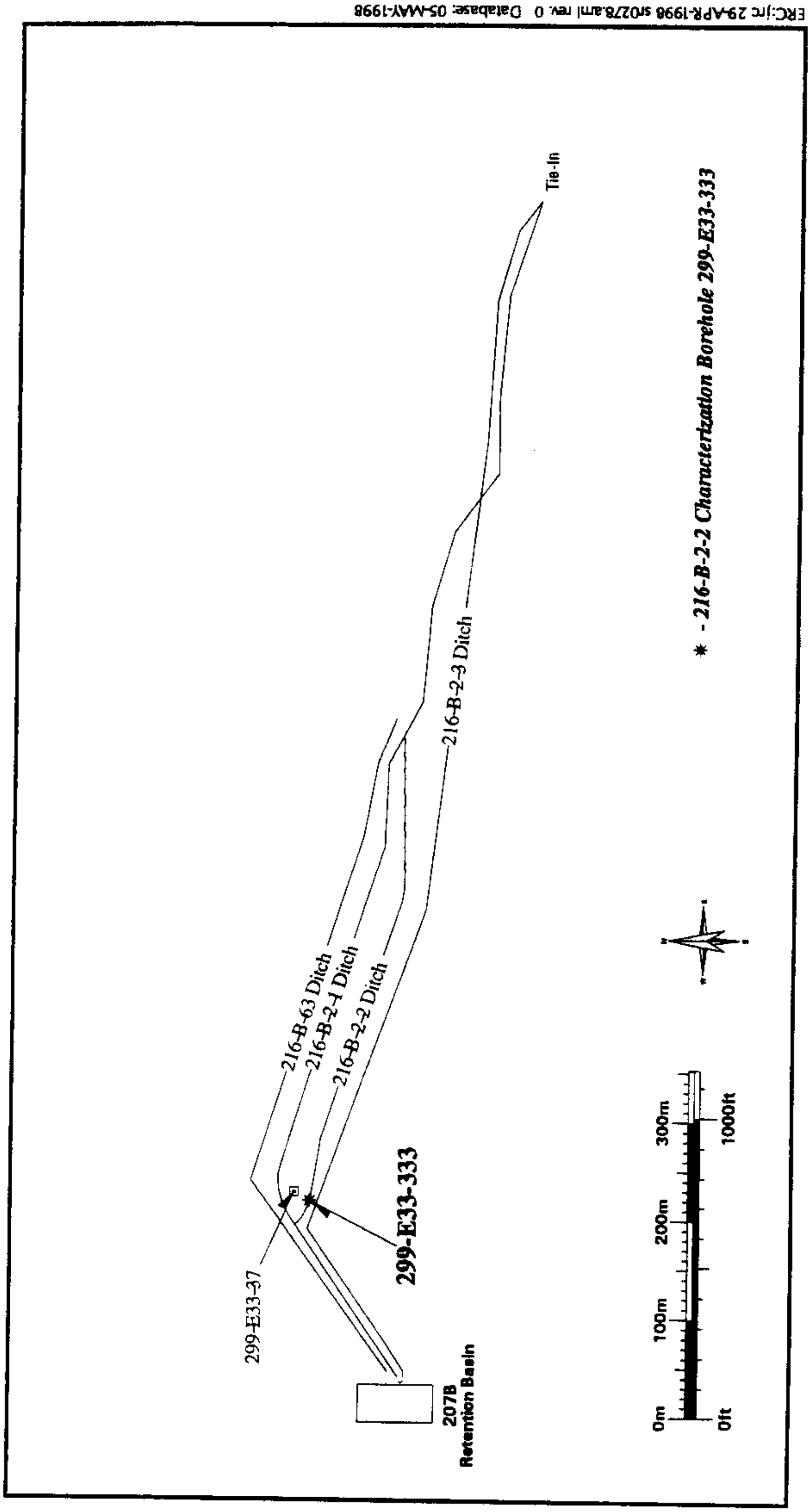
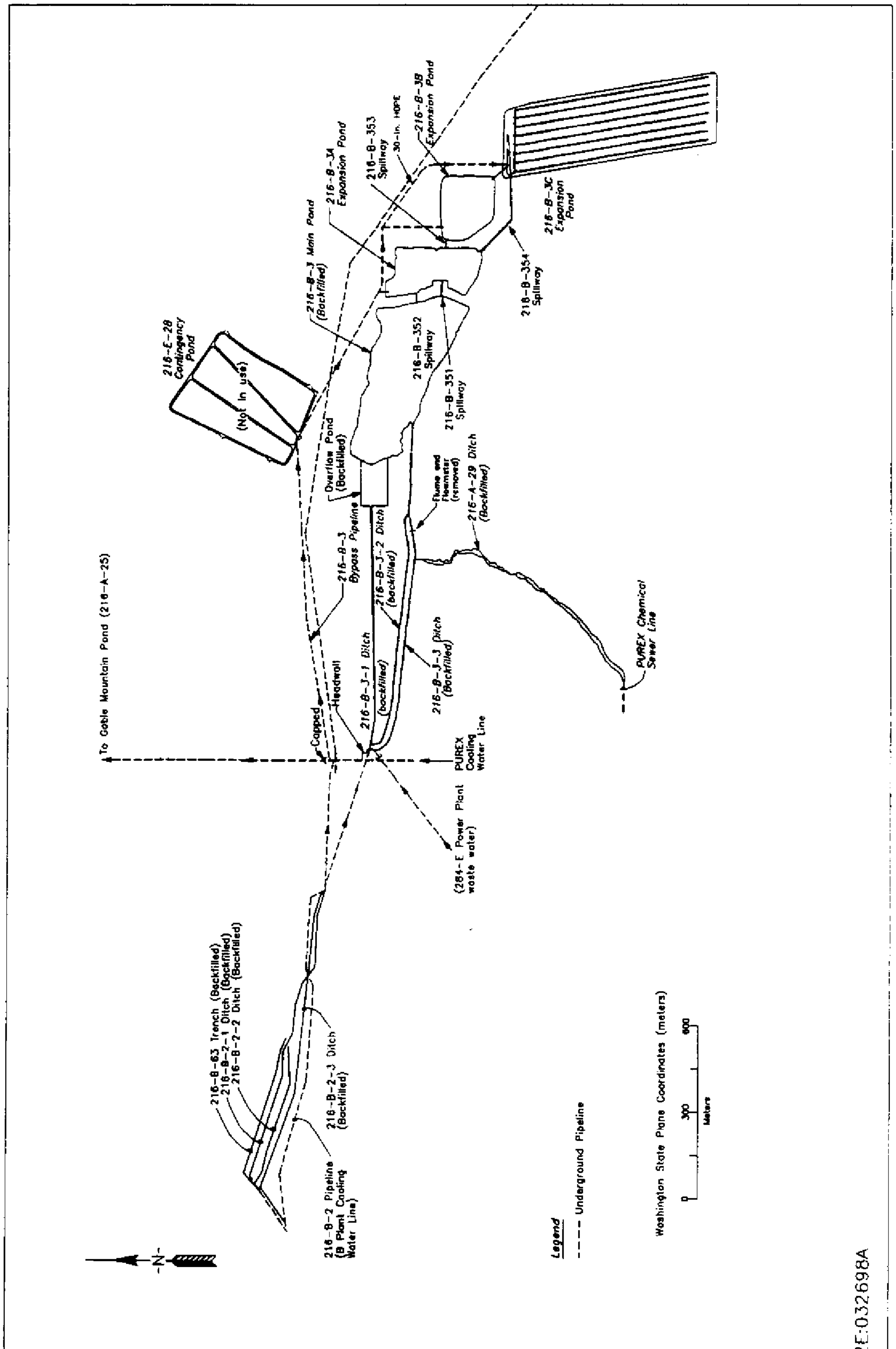


Figure 2. Location of the 216-B-2 Ditch System.



and chicken wire was placed over the ditch to keep tumbleweeds from blowing in to or out of the ditch (Smith et al. 1970). The exact locations of these dams are not known. In 1970, the 216-B-2-2 Ditch was backfilled to grade with 2.4 m (8 ft) of clean fill material. In 1973, the first 731 m (2,400 ft) of the ditch was covered with sand and plastic root liners because Russian thistles and willow trees growing on the backfilled area showed internal beta-gamma contamination up to a maximum of 3,000 counts per minute (cpm). The ditch was restabilized with 61 cm (24 in.) of soil in 1986.

Characterization borehole 299-E33-333 was drilled at the influent end of the 216-B-2-2 Ditch (Figure 1) because it was the location considered the most likely to have the highest concentration of contaminants along the ditch. The borehole was extended to a depth of 254 ft below ground surface (bgs), which is below the water table, to investigate the extent of contamination throughout the vadose zone.

In the area of the 216-B-2 Ditch System, the vadose zone is primarily composed of the glaciofluvial gravel sequences and interbedded sand unit of the Hanford formation (Figure 3). These Hanford formation sediments overlie finer grained silt and/or the lower mud sequence of the Ringold Formation. Static water level is situated at the top of the Ringold Formation unit A gravel sequence, if present, or at the top of the Columbia River Basalt Group.

2.0 FIELD ACTIVITIES AND SAMPLING

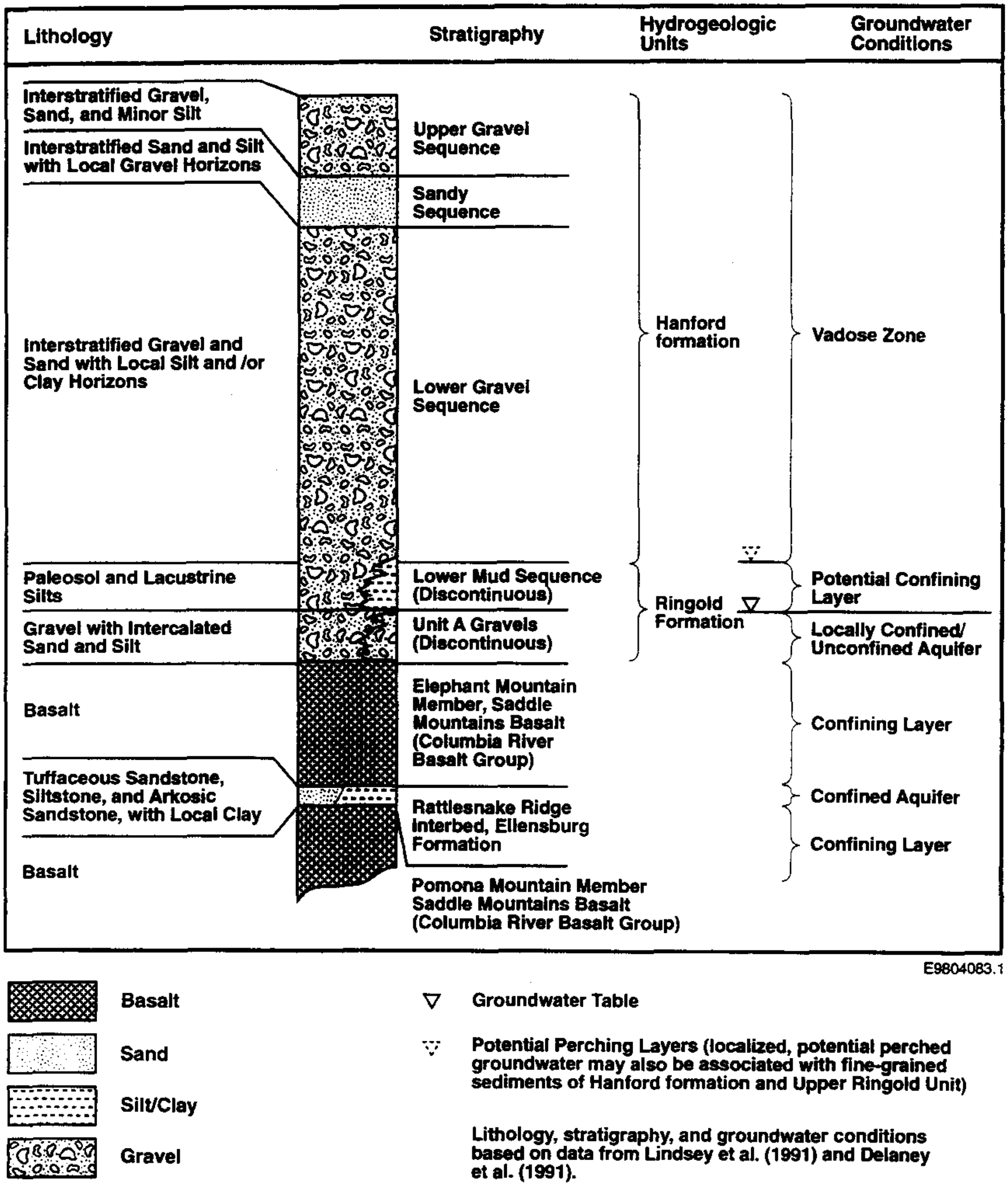
The primary objective of the field work at the 216-B-2-2 Ditch was to collect soil samples to characterize the vadose zone within and underlying the contaminated ditch. Four primary types of field activities were associated with characterization of the 216-B-2-2 Ditch. In order of occurrence, these activities were:

1.	Trenching to locate the ditch	10/20/97
2.	Drilling the characterization borehole	12/29/97 – 1/7/98
3.	Sampling for hydrogeologic and contaminant characteristics	12/29/97 – 1/7/98
4.	Geophysical logging	1/2/98, 1/8/98-1/9/98

2.1 TRENCHING

Despite careful review of historical photographs, maps, and documents, and a ground penetrating radar survey of the area, the precise location of the centerline of the 216-B-2-2 Ditch remained uncertain. The characterization borehole was required to be drilled through the contaminated ditch bottom. Therefore, a trench was dug to confirm the location of the ditch.

Figure 3. Stratigraphy Underlying the 216-B-2 Ditch System.



Potential Perching Layers (localized, potential perched groundwater may also be associated with fine-grained sediments of Hanford formation and Upper Ringold Unit)

Lithology, stratigraphy, and groundwater conditions based on data from Lindsey et al. (1991) and Delaney et al. (1991).

Trenching across the 216-B-2-2 Ditch was successfully completed on October 20, 1997, using a wheeled backhoe (Appendix A). The trench was constructed approximately north-south across the east-west-trending ditch at the influent end of the ditch. Positive indicators of the presence of the ditch included chicken wire (placed over the ditch in 1970) below black plastic sheeting (placed over the ditch in 1973). During excavation through the middle of the trench, contamination was first observed at approximately 7 ft bgs at 3,200 disintegrations per minute (dpm) beta-gamma. Contamination subsequently increased from 4,000 to 1,600,000 dpm in the next three backhoe buckets. The 1,600,000 dpm reading at approximately 8 ft bgs was from a 3/8-in.-thick, 3- to 4-in.-diameter black crystalline material (i.e., not soil). These observations indicated that the highly contaminated area associated with the ditch bottom had been located and that additional trenching was not needed.

2.2 DRILLING

Borehole 299-E33-333 (B8079) was drilled using cable-tool techniques. Drilling began on December 29, 1997, and abandonment was completed by January 13, 1998. The hole was drilled to a depth of 251.5 ft bgs where a final split-spoon sample was collected. Bottom depth of the split-spoon was 254 ft bgs. Static water level was measured at 249.6 ft bgs on January 9, 1998. Threaded carbon-steel casing was used during drilling: 11-in.-outside-diameter casing from ground surface to 51.5 ft bgs; and 8.875-in.-outside-diameter casing from ground surface to 250 ft bgs (Appendix B1). A graphical summary of the daily drilling progress, temporary casings at final depth, lithology, and water level are shown in Figure 4. All geologic materials removed from the borehole were logged by the site geologists (Appendix B2). Table 1 summarizes the drilling information. No water was added to the hole during drilling. Well Guard (a trademark of Jet-Lube, Inc., Houston, Texas), a nonpetroleum-based lubricant, was used on casing threads.

Radiological hazards were expected and encountered while drilling the hole. Radiological control technicians monitored radiological conditions during the borehole drilling and collection of soil samples. Field radiological measurements obtained using hand-held instruments of drill cuttings are presented in Table 2. The drilling area and drilled material were monitored continuously for beta-gamma, beta, and alpha activity in the upper 53 ft of the borehole. Every drive barrel and split-spoon sample was carefully wrapped in clear plastic sheeting to protect workers from airborne radiological contamination in the upper portion of the borehole (Figure 5), and workers were dressed in personal protective equipment as required by the radiological work permit. Material retrieved from the borehole below 53 ft was continuously monitored, but other controls were downgraded based on lack of detectable contamination in the soil and release surveys taken by the radiological control technicians.

The borehole was continuously monitored for volatile organic compounds during drilling using an organic vapor monitor with a 10.6-eV lamp (Table 3). An unknown volatile organic was detected at up to 18 ppmv at the wellhead when the drilling had advanced to about 13 ft bgs; however, it was probably due to a nearby kerosene heater rather than to downhole conditions. Activity was stopped briefly but resumed after readings dropped to background. No other volatile organic compounds were detected during drilling.

Figure 4. Graphical Summary of 299-E33-333 Drilling Activity.

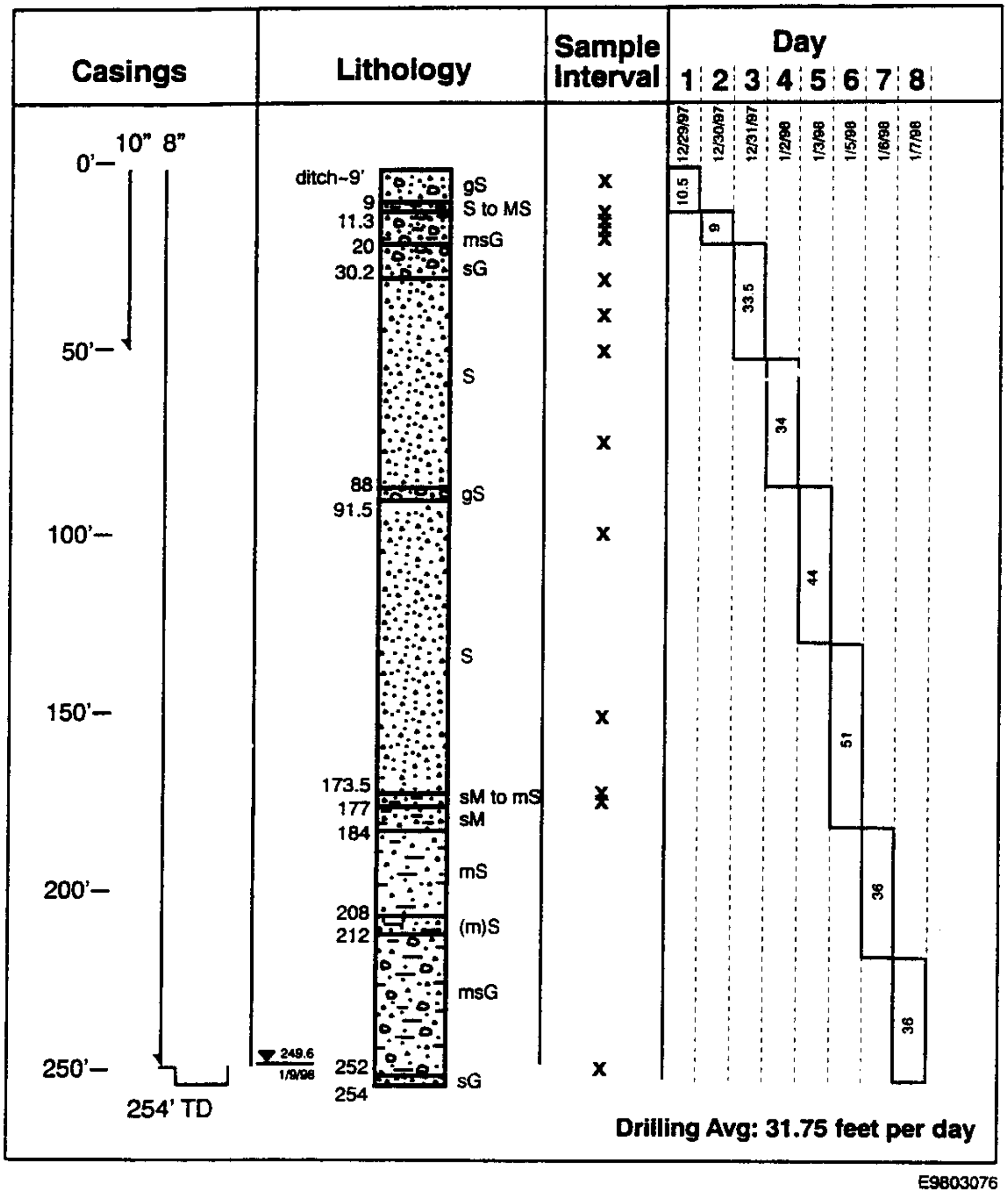


Table 1. Drilling Summary for Borehole 299-E33-333.

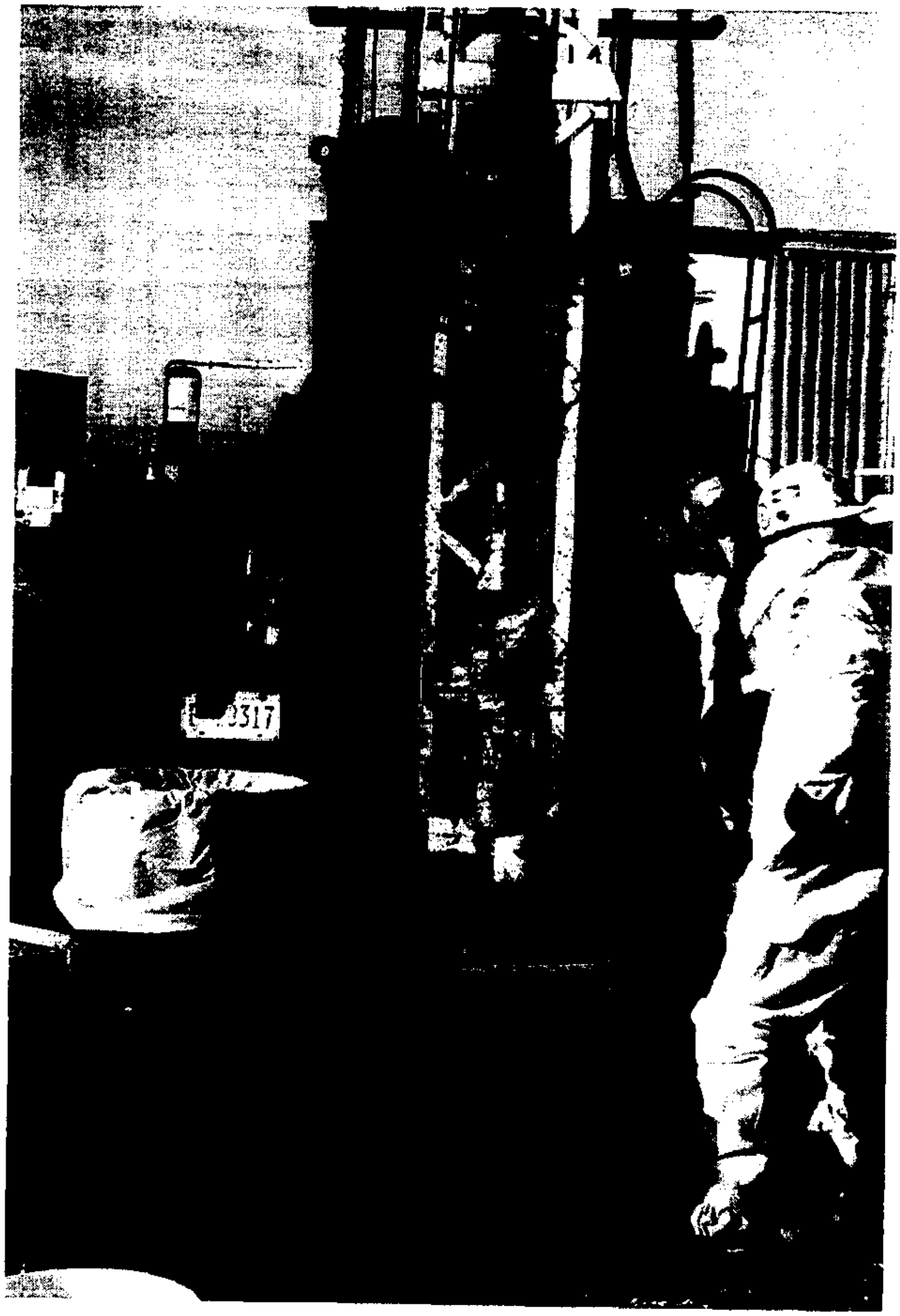
Drilling start date	12/29/97
Drilling end date	1/13/98
Total depth of borehole (ft bgs)	254
Static water level (ft bgs) and date	249.6 (1/9/98)
Washington Coordinate System of 1983, south zone (1991) (m)	N137181.278 E574086.410
Elevation of brass cap (NAVD88) (m)	199.163
Number of chemical samples (soil)	16
Number of radiological samples (soil)	14
Number of physical properties samples (soil)	15
Abandonment end date	1/13/98
Number of waste drums generated	30

NOTE: Chemical sample total includes physical properties samples (pH and total organic carbon).

Table 2. Field Radiological Measurements on Drive Barrel Drill Cuttings.

Depth (ft bgs)	Total Alpha Above Background (dpm)	Total Beta-Gamma Above Background (dpm)	Beta Dose (mrad/hr)	Gamma Dose (mrad/hr)
0-8.5	<20	<1,000	<0.5	<0.5
8.5	<20	80,000	2.1	<0.5
10.5	<20	68,000	2.1	<0.5
13	<20	8,000	<0.5	<0.5
15.5	<20	<1,000	<0.5	<0.5
18	<20	<1,000	<0.5	<0.5
20	<20	<1,000	<0.5	<0.5
21 to 30	<20	<1,000	<0.5	<0.5
34.5	<20	1,200	<0.5	<0.5
34.5 to 53	<20	<1,000	<0.5	<0.5
53 to 251.5	<20	<1,000	<0.5	<0.5

Figure 5. Use of Plastic Sheeting to Control Contamination During Retrieval of Subsurface Soils.



E9804135b

Table 3. Summary of Volatile Organic Compound Monitoring.

Date	Time	Reading (ppmv)
12/29/97	1340 to 1624	<d
12/30/97	0847	<d
12/30/97	0910	13, 18
12/30/97	0915 to 1512	<d
12/31/97	0910 to 1240	<d
1/2/98	1150 to 1615	<d
1/3/98	0735 to 1411	<d
1/5/98	0725 to 1630	<d
1/6/98	0835 to 1648	<d
1/7/98	0911 to 1545	<d

<d = less than detectable.

Soil samples were collected throughout the drilling for various analyses and tests and are explained in detail in Section 2.3. All drilled material not sent off site for testing and analysis was placed in 208-L (55-gal) drums. A total of 30 drums of waste were generated as well as 9 pieces of steel casing that are radiologically contaminated (Table 4).

Drilling was completed on January 7, 1998, with the 8.875-in.-outside-diameter casing set at 250 ft bgs. Abandonment began on January 9, 1998, after the hole bottom was tagged at 249.7 ft bgs. Portland cement with bentonite powder added was emplaced from 249.7 to 228.6 ft bgs, and dry bentonite was emplaced from 228.6 to 0.5 ft bgs. The dry bentonite consisted of bentonite crumbles and 3/8-in. bentonite chunks and pellets. A cement cap with a brass marker stamped with the hole number and abandonment date was emplaced at ground surface. Abandonment was completed on January 13, 1998. A licensed land surveyor surveyed the brass marker location on January 30, 1998 (Appendix B3).

2.3 SAMPLING

To meet the sampling and analysis requirements for characterizing the vadose zone at the 216-B-2-2 Ditch, soil samples were collected at specific intervals for chemical analysis, radiological analysis, physical property testing, and archiving. The sampling objectives are summarized in the DOW (Faurote and Wittreich 1997). Characterization samples were collected primarily using split-spoon samplers; some physical property samples and the archive samples were collected from the contents of the drive barrel.

Table 4. Inventory of Waste Drums Generated by Drilling Activities at the 299-E33-333 Borehole.

Drum Number	Depth Interval (ft bgs)	Package Date	Waste Description
200E-97-013	0-6	12/29/97	Soil, plastic, tape, cloth
200E-97-014	6-12	12/30/97	Soil, plastic, tape, cloth
200E-97-015	12-16	12/30/97	Soil, plastic, tape, cloth
200E-97-016	16-20	12/30/97	Soil, plastic, tape, cloth
200E-97-017	NA	12/30/97	HEPA filters, clamps, cloth
200E-97-018	NA	12/29/97	Disposable laundry, plastic, tape
200E-97-019	50-53	12/31/97	Soil, plastic, tape, cloth
200E-97-020	20-25	12/31/97	Soil, plastic, tape, cloth
200E-97-021	25-29	12/31/97	Soil, plastic, tape, cloth
200E-97-022	29-40	12/31/97	Soil, plastic, cloth
200E-97-023	40-50	12/31/97	Soil
200E-97-024	53-69	1/2/98	IDW investigation well drillings, soil
200E-97-025	69-98.5	1/3/98	IDW investigation well drillings, soil
200E-97-026	98.5-109	1/3/98	IDW investigation well drillings, soil
200E-97-027	109-124	1/3/98	IDW investigation well drillings, soil
200E-97-028	124-130	1/3/98	IDW investigation well drillings, soil
200E-97-029	130-137	1/5/98	IDW investigation well drillings, soil
200E-97-030	137-150	1/5/98	IDW investigation well drillings, soil
200E-97-031	150-164	1/5/98	Soil
200E-97-032	164-172	1/5/98	Soil
200E-97-033	198.5-212	1/6/98	Soil
200E-97-034	172-186	1/5/98	Soil
200E-97-035	186-198.5	1/6/98	Soil
200E-97-036	212-226	1/6/98	Soil
200E-97-037	226-244	1/7/98	Soil
200E-97-038	244-254	1/7/98	Soil
200E-97-039	NA	1/13/98	Trash, PPE, decontamination material from backpulling casing from 50 to 0 ft
200E-97-040	NA	1/13/98	Materials from backpulling casing from 50 to 0 ft, trash, PPE decontamination materials
200E-97-041	NA	1/13/98	Materials from backpulling and dry decontamination of equipment and tooling
200E-97-042	NA	1/13/98	Archived geologic/chemical samples taken throughout borehole

HEPA = high-efficiency particulate air
IDW = investigation-derived waste
NA = not applicable
PPE = personal protective equipment.

Chemical and radiological analytes and physical properties for soil samples are detailed in the sampling and analysis plan in the DOW (Faurote and Wittreich 1997). The categories of target chemical analytes included volatile organics, semivolatile organics including polychlorinated biphenyls (PCBs), inorganics (metals), and general chemistry (Table 5). All physical property samples were to be tested for a limited set of physical analyses (Type A samples), including bulk density, particle density, particle size distribution, moisture content, pH, and calcium carbonate content. In addition, a sample from each major lithology (as determined by the site geologist) within the borehole was to be tested for a larger set of physical analyses (Type B samples), including the six Type A analyses, saturated and unsaturated hydraulic conductivity, matric potential and soil moisture retention curves, cation exchange capacity, and total organic carbon content.

Discrete soil samples for chemical and radiological analyses and Type A physical property testing were collected at approximate depths of 5, 10, 12, 14, 20, 30, 40, 50, 75, 100, 150, and 252 (water table) ft bgs using a split-spoon sampler, as specified in the sampling and analysis plan (Faurote and Wittreich 1997). The differences between these planned depths and the actual depths are presented in Table 6. A total of 15 split-spoon samplers were driven for sampling purposes. Based on the judgment of the site geologist, a sample was collected at 174 ft bgs based on the significant lithologic change at that depth (Figure 4). A duplicate sample for chemical and radiological analyses was collected at 20 ft bgs. A total of 45 samples were collected for chemical and radiological analyses and Type A physical properties testing. Three split-spoon samples were collected for Type B physical properties testing at depths of 15.5, 40, and 174 ft bgs. A duplicate sample for physical properties testing was collected at 174 ft bgs.

Collection of the deepest sample was planned for immediately above the water table. The static water level measured in nearby well 299-E33-37 (Figure 1) on the morning of the sampling day, January 7, 1998, to confirm the depth to water was 249.5 ft bgs. When the borehole reached 247 ft bgs, the depth at which driving the split-spoon sampler was to begin, a representative sample could not be collected because of soil sloughing into the open hole. The borehole was cleaned out and driving the final split-spoon sampler began at 251.5 ft bgs. During the borehole and split-spoon sampler advancement on January 7, 1998, the water table was encountered at 252 ft bgs. However, prior to beginning abandonment activities on January 9, 1998, the water table was measured at 249.6 ft bgs. This discrepancy in the measured depths to water is not understood. The split-spoon sampler included 6 in. of material from above the water table and 18 in. of material from below. The samples packaged for laboratory analyses and physical properties testing were from the material immediately below the water table.

Table 5. Target Soil Analytes Identified in the Description of Work for the 216-B-2-2 Characterization Borehole (Table B-2 in Faurote and Wittreich 1997). (5 Sheets)

Target Analytes	Analytical Method per DOW		Target Quantitation Limit		Deviations and Notes
	Source	Method	Per DOW	Actual	
Volatile Organics			(µg/kg)		
Acetone	EPA	8260	10	25	
Butanol, 1-	EPA	8260 (TIC)	5,000	220	
Butanone, 2- (MEK)	EPA	8260	10	25	
Carbon Tetrachloride	EPA	8260	5	5	
Chloroform	EPA	8260	5	5	
Ethyl Ether (Diethyl Ether)	EPA	8260 (TIC)	5	10	
Methylene Chloride	EPA	8260	5	5	
Toluene	EPA	8260	5	5	
Trichloroethane, 1,1,1-	EPA	8260	5	5	
Trichloroethane, 1,1,2-	EPA	8260	5	5	
Semivolatile Organics			(µg/kg)		
Formaldehyde	Not Available		NA	1,000 (estimated)	Can be detected as TIC under EPA 8270 if present at sufficient concentration
Kerosene	EPA	8270 (TIC)	5,000	10,000 (estimated)	Constituent compounds can be detected as TICs under EPA 8270 if present
Tributyl Phosphate	EPA	8270 (special calibration)	500	700	
Polychlorinated Biphenyls (PCBs)	EPA	8080	21 or 33	33	Laboratory exceeded holding time for 8 samples
Naphthalene	EPA	8270	660	330	
Inorganics (Metals)			(mg/kg)		
Arsenic	EPA	6010	0.3	1	Analyzed using EPA 6010 supertrace
Barium	EPA	6010	1	20	
Beryllium	EPA	6010	1	0.5	
Bismuth	EPA	6010	10	20	Analyzed using special calibration under EPA 6010
Boron	EPA	6010	10	20	Analyzed using special calibration under EPA 6010

Table 5. Target Soil Analytes Identified in the Description of Work for the 216-B-2-2 Characterization Borehole (Table B-2 in Faurote and Wittreich 1997). (5 Sheets)

Target Analytes	Analytical Method per DOW		Target Quantitation Limit		Deviations and Notes
	Source	Method	Per DOW	Actual	
Cadmium	EPA	6010	2	0.5	
Chromium	EPA	6010	2	1	
Copper	EPA	6010	2	2.5	
Iron	EPA	6010	10	10	
Lead	EPA	6010	0.5	0.3	Analyzed using EPA 6010 supertrace
Manganese	EPA	6010	1	1.5	
Mercury	EPA	7471	0.1	0.035	
Nickel	EPA	6010	4	4	
Potassium	EPA	6010	500	500	
Selenium	EPA	6010	0.5	0.5	Analyzed using EPA 6010 supertrace
Silver	EPA	6010	20	1	
Tin	EPA	6010	50	10	Analyzed using special calibration under EPA 6010
Vanadium	EPA	6010	2	5	
Zinc	EPA	6010	2	2	
General Chemistry			(mg/kg)		
Acetate	EPA	8270 (TIC)	50	0.1 (estimated)	Can be detected as TIC under EPA 8270 if present at sufficient concentration
Ammonia	EPA	350.1	0.5	0.5	
Cyanide	EPA	9010	0.5	0.5	Laboratory exceeded holding time for 10 samples
Nitrate (Nitrogen in Nitrate)	EPA	300.0 modified	1.0	0.2	
Nitrite (Nitrogen in Nitrite)	EPA	300.0 modified	1.0	0.2	
Nitrate/Nitrite (NO_2/NO_3)	EPA	353.1	1.0	0.5	
Sulfate	EPA	300.0	5	5	
Radionuclides			(pCi/g)		
Americium-241	Lab SOP	Alpha Spectrometry	1	0.1	Americium-241 detected using gamma spectrometry in one sample

Table 5. Target Soil Analytes Identified in the Description of Work for the 216-B-2-2 Characterization Borehole (Table B-2 in Faurote and Wittreich 1997). (5 Sheets)

Target Analytes	Analytical Method per DOW		Target Quantitation Limit		Deviations and Notes
	Source	Method	Per DOW	Actual	
Cesium-137	Lab SOP	Gamma Spectrometry	0.1	0.02	Cesium-137 concentration derived from analysis of barium-137m concentration
Cobalt-60	Lab SOP	Gamma Spectrometry	0.05	0.02	
Curium-244	Lab SOP	Alpha Spectrometry	1.0	0.02	
Europium-152	Lab SOP	Gamma Spectrometry	0.1	0.04	
Europium-154	Lab SOP	Gamma Spectrometry	0.1	0.06	
Europium-155	Lab SOP	Gamma Spectrometry	0.1	0.04	
Gross alpha	Lab SOP	Alpha Proportional Counting	10.0	5.0	
Gross beta	Lab SOP	Beta Proportional Counting	15.0	6.0	
Iodine-129	Lab SOP	Beta Scintillation	2.0	0.6	Analyzed using gamma spectrometry, an equivalent analytical method to beta scintillation
Neptunium-237	Lab SOP	Alpha Spectrometry	1.0	0.05	
Plutonium-238	Lab SOP	Alpha Spectrometry	1.0	0.02	
Plutonium-239/240	Lab SOP	Alpha Spectrometry	1.0	0.03	
Plutonium-241	Lab SOP	Liquid Scintillation	15.0	2.0	
Selenium-79	Lab SOP	Beta Proportional Counting	10.0	2.0	Analyzed using liquid scintillation, a better analytical method than beta proportional counting for low beta emitters
Strontium-90	Lab SOP	Beta Proportional Counting	1.0	0.1	Strontium-90 concentration derived from analysis of yttrium-90 concentration

Table 5. Target Soil Analytes Identified in the Description of Work for the 216-B-2-2 Characterization Borehole (Table B-2 in Faurote and Wittreich 1997). (5 Sheets)

Target Analytes	Analytical Method per DOW		Target Quantitation Limit		Deviations and Notes
	Source	Method	Per DOW	Actual	
Technetium-99	Lab SOP	Beta Proportional Counting	15.0	0.8	Analyzed using liquid scintillation, a better analytical method than beta proportional counting for low beta emitters
Thorium-228	Lab SOP	Alpha Spectrometry	1.0	0.1	
Thorium-230	Lab SOP	Alpha Spectrometry	1.0	0.04	
Thorium-232	Lab SOP	Alpha Spectrometry	1.0	0.04	
Uranium, Total Chemical	Lab SOP		1.0 µg/g	0.0002 µg/g	Uranium (U) isotopic analysis planned for sample if total U concentration exceeded 10 µg/g. Although total U never exceeded 10 µg/g, one U isotopic analysis was conducted.
Uranium-233/234	Lab SOP	Alpha Spectrometry	1.0	2.0	
Uranium-235	Lab SOP	Gamma Spectrometry	0.5	0.1	Uranium-235 concentration derived from analysis of protactinium-231
Uranium-235/236	Lab SOP	Alpha Spectrometry	1.0	3.0	
Uranium-238	Lab SOP	Alpha Spectrometry	1.0	2.0	Uranium-238 detected using gamma spectrometry in 7 samples
Physical Properties					
Bulk Density	ASTM	D-3550	NA	NA	Analyzed using ASTM D-2937, equivalent test method to D-3350 for driven cylindrical sampler, or in the field as part of the sampling routine
Particle Size Distribution	TBD		NA	NA	Analyzed using ASTM D-422
Moisture Content	ASTM	D-2216	NA	0.5%	

Table 5. Target Soil Analytes Identified in the Description of Work for the 216-B-2-2 Characterization Borehole (Table B-2 in Faurote and Wittreich 1997). (5 Sheets)

Target Analytes	Analytical Method per DOW		Target Quantitation Limit		Deviations and Notes
	Source	Method	Per DOW	Actual	
Calcium Carbonate Content	ASTM	D-4373	NA	NA	Not analyzed because analytical capability not available
Saturated Hydraulic Conductivity	ASTM	D-5084	NA	NA	Not analyzed because analytical capability not available
Unsaturated Hydraulic Conductivity	Not Available		NA	NA	Not analyzed because analytical capability not available
Matric Potential and Soil Moisture Retention Curves	ASTM	D-2325 D-3152	NA	NA	Not analyzed because analytical capability not available
Particle Density (Specific Gravity)	ASTM	D-854	NA	NA	
Cation Exchange Capacity	EPA	9081	NA	0.01 meq/100 g	
Organic Carbon Content	EPA	9060	NA	25 µg/g	
pH	EPA	9045	NA	NA	Laboratory exceeded holding time for all samples

ASTM = American Society for Testing and Materials
DOW = description of work
EPA = U.S. Environmental Protection Agency
meq = milli-equivalents
NA = not applicable
SOP = standard operating procedure
TIC = tentatively identified compound.

Table 6. Sample Intervals in Borehole 299-E33-333.

Sampler Number	Sampler Interval (ft bgs)	Sampler RCD (%)	Sample Date	Trip Blank HEIS Number	Chemical/ Radiological Sample HEIS Number	Physical Properties Sample HEIS Number	Bulk Density Interval (ft bgs)	Planned Top Depth (ft bgs)	Actual Top Depth (ft bgs)
SS-1	4.0-6.5	40	12/29/97	B0MK76	B0MJC2	B0MJC4	NE	5	4
SS-2	8.0-10.5	100	12/29/97	B0MK77	B0MJC5	B0MJC7	9-9.5	10	8
SS-3	10.5-13.0	100	12/30/97	B0MK78	B0MJC8	B0MJD0	11-11.5	12	10.5
SS-4	13.0-15.5	100	12/30/97	B0MK79	B0MJD1	B0MJD3	14-14.5	14	13
SS-5	15.5-18.0	100	12/30/97	NA	B0MJD4 (phys. prop. only)	B0MJD6	NA	NA	15.5
SS-6	20.0-22.5	100	12/31/97	B0MK81 B0MK82	B0MJD7 B0MJF0 (duplicate of B0MJD7)	B0MJD9	NE	20	20
SS-7	30.0-32.5	100	12/31/97	B0MK83	B0MJF3	B0MJF5	31-31.5	30	30
SS-8	40.0-42.5	100	12/31/97	B0MK93	B0MJJ1	B0MJJ3	41-41.5	40	40
SS-9	50.0-52.5	100	12/31/97	B0MK94	B0MJJ4	B0MJJ6	51-51.5	50	50
SS-10	75.0-77.5	100	1/2/98	B0MK88	B0MJF6	B0MJF8	76-76.5	75	75
SS-11	100.0-102.5	100	1/3/98	B0MK89	B0MJF9	B0MJH1	NA	100	100
SS-12	150.0-152.5	100	1/5/98	B0MK95	B0MJJ7	B0MJJ9	151-151.5	150	150
SS-13 SS-14	174.0-179.0	100	1/5/98	B0MK96 NA	B0MJK0 B0MJK3 (duplicate of B0MJK0 for phys. prop. only)	B0MJK2 B0MJK5 (duplicate of B0MJK2)	174.5-175 175-175.5	NA	174
SS-15[a]	251.5-254.0	100	1/7/98	B0MK98	B0MJK6	B0MJK8	252-252.5	250	251.5

NOTE: The bottom 0.5 ft of the sampler interval is the drive shoe material that was not used for sample collection. Chemical and radiological samples included physical property samples for pH and total organic carbon.

[a] Soil sample collected across interface between vadose zone and groundwater.

bgs = below ground surface
HEIS = Hanford Environmental Information System
NA = not applicable
ND = not determined
NE = not enough sample available
RCD = recovery rate of split-spoon sampler
SS = split-spoon sampler including drive shoe.

The recovery rate in all of the split-spoon samples was 100%, with the exception of the first sample (Table 6). The sample priorities established for the drilling were used to determine which analyses would take precedence in the event that sample volume was insufficient for all analyses (Table 7). For Type A physical properties, supplemental soil volume could be retrieved from the drive barrel, if necessary. The physical properties sample from the 4- to 6.5-ft bgs interval was collected during the drive barrel cleanout. A total of four split-spoon liners were sent to an offsite laboratory for Type A physical properties testing. For eight samples, data were collected in the field to calculate bulk density.

Table 7. Sample Priority.

Priority	Sample Type	Analyses
1	Radiological	Radionuclides
2	Chemical	Metals
3	Chemical	Semivolatile organics
4	Chemical	Volatile organics
5	Chemical	General chemistry, pH, total organic carbon
6	Physical Property	Bulk density, particle density, particle size distribution, moisture content, saturated hydraulic conductivity, unsaturated hydraulic conductivity, matric potential, soil moisture curves, cation exchange capacity
7	Archive	NA

NA = not applicable.

The samplers weighed a full liner in the field for determining bulk density as part of the sampling routine. The initial rationale for this test was to obtain the data for the radiologically contaminated samples that would not be sent off site for the physical properties testing. A full representative split-spoon liner was weighed to determine the wet sample weight with liner. The sample was removed from the liner and the empty liner was weighed. The wet bulk density was determined by dividing the wet sample weight by the soil volume. The interval used for determining bulk density (field and laboratory) is indicated in Table 6.

Archive samples were collected each time a physical sample was collected as an additional sample source, if needed. These samples were stored on site during the field activities and will be disposed of as investigation-derived waste, as specified in the sampling and analysis plan.

All samples retrieved from the borehole were monitored by radiological control technicians for radiological activity using field screening instruments. Samples from the upper 15 ft were determined to be radiologically contaminated; samples from 15 to 20 ft bgs had less than detectable contamination levels (Table 8, Appendix B2). The four radiologically contaminated samples (SS-1 through SS-4) were handled using a glovebag to control contamination (Figure 6). The glovebag was then determined to be unnecessary after reaching a drilled depth of 20 ft bgs and was dismantled.

Table 8. Radiological Field Screening Between Split-Spoon Liner Samples.

Sampler Number	Screening Depth (ft bgs)	Screening Location	Beta-Gamma Activity above background (dpm)
SS-1	4.0 - 6.0	split-spoon sampler	background
SS-2	8.0 - 10.0	homogenized soil sample in stainless steel bowl	80,000
	10.0	bottom surface of split-spoon liner 4	350 - 400
SS-3	10.5 - 12.5	homogenized soil sample in stainless steel bowl	6,000
	12.5	bottom surface of split-spoon liner 4	800
SS-4	13.0-15.0	homogenized soil sample in stainless steel bowl	150,400
	13.0	top surface of split-spoon liner 1	400
	13.5	surfaces between split-spoon liners 1 and 2	120,000
	14.0	surfaces between split-spoon liners 2 and 3	80,000
	14.5	surfaces between split-spoon liners 3 and 4	10,000
	15.0	bottom surface of split-spoon liner 4	400
SS-5	15.5 - 17.5	homogenized soil sample in stainless steel bowl	background
	15.5	top surface of split-spoon liner 1	background
	16.0	surfaces between split-spoon liners 1 and 2	background
	16.5	surfaces between split-spoon liners 2 and 3	background
	17.0	surfaces between split-spoon liners 3 and 4	background
	17.5	bottom surface of split-spoon liner 4	background
SS-6	20.0 - 22.0	homogenized soil sample in stainless steel bowl	600
	20.0	top surface of split-spoon liner 1	200
	20.5	surfaces between split-spoon liners 1 and 2	200 - 600
	21.0	surfaces between split-spoon liners 2 and 3	200
	21.5	surfaces between split-spoon liners 3 and 4	200 - 400
	22.0	bottom surface of split-spoon liner 4	400
SS-7	30.0 - 32.0	homogenized soil sample in stainless steel bowl	600
	30.0	top surface of split-spoon liner 1	600
	30.5	surfaces between split-spoon liners 1 and 2	100 - 300
	31.0	surfaces between split-spoon liners 2 and 3	200 - 400
	31.5	surfaces between split-spoon liners 3 and 4	200 - 400
	32.0	bottom surface of split-spoon liner 4	200
SS-8	40.0 - 42.0	homogenized soil sample in stainless steel bowl	600
	40.0	top surface of split-spoon liner 1	200
	40.5	surfaces between split-spoon liners 1 and 2	200 - 400
	41.0	surfaces between split-spoon liners 2 and 3	200 - 400
	41.5	surfaces between split-spoon liners 3 and 4	200
	42.0	bottom surface of split-spoon liner 4	200
SS-9	50.0 - 52.0	homogenized soil sample in stainless steel bowl	400
	50.0	top surface of split-spoon liner 1	200
	50.5	surfaces between split-spoon liners 1 and 2	200
	51.0	surfaces between split-spoon liners 2 and 3	100 - 120
	51.5	surfaces between split-spoon liners 3 and 4	100 - 150
	52.0	bottom surface of split-spoon liner 4	200
SS-10	75.0 - 77.0	homogenized soil sample in stainless steel bowl	background
	75.0 - 77.0	all split-spoon liner surfaces	background
SS-11	100.0 - 102.0	homogenized soil sample in stainless steel bowl	background
	100.0 - 102.0	all split-spoon liner surfaces	background
SS-12	150.0 - 152.0	all split-spoon liner surfaces	background
SS-13	174.0 - 176.0	all split-spoon liner surfaces	background
SS-14	176.5 - 178.5	all split-spoon liner surfaces	background
SS-15	251.1 - 253.5	screening of sampler not conducted because controls downgraded	

Split-Spoon Sampler Configuration

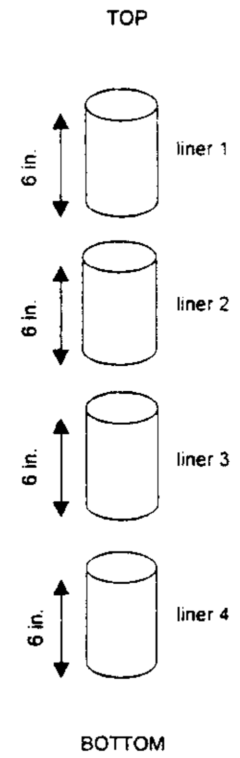
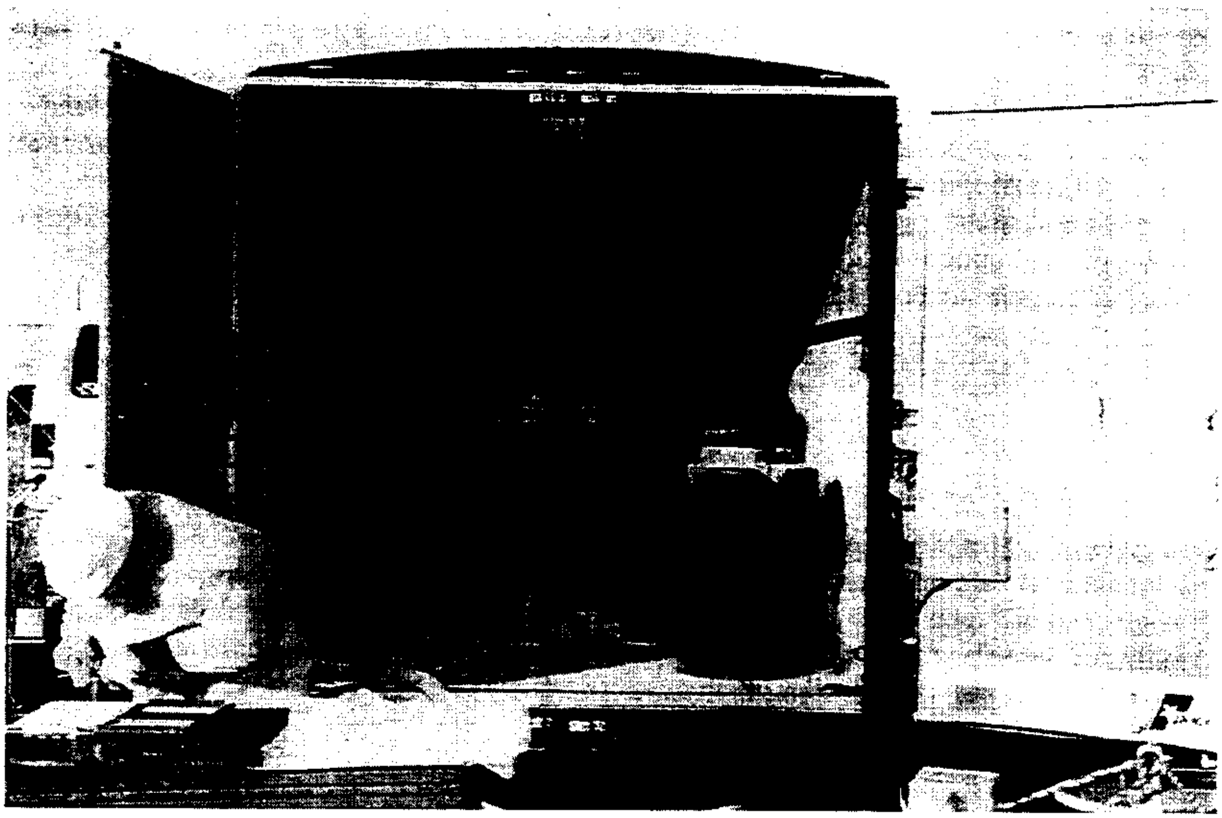


Figure 6. Use of Glovebag to Control Contamination During Sample Breakdown and Bottling.



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For the samples determined in the field to be radiologically contaminated, the split-spoon sampler was opened inside the glovebag. Each split-spoon sampler contained four 6-in.-long liners. The radiological control technician checked the top and bottom of each liner for activity (Table 8). The liners were emptied into a stainless steel bowl and homogenized for analysis.

Samples were bottled and surveyed for radiological activity and packed on ice for transport to the sample storage and shipping area in the 300 Area. The samples were stored in refrigeration units at between 2° and 6°C, then transported to the appropriate analytical laboratory. Trip blanks were prepared in the storage area and transported to the field with empty containers, stored with soil samples, and transferred to the laboratory. Chain-of-custody was maintained at all times.

2.4 GEOPHYSICAL LOGGING

Geophysical logging of borehole 299-E33-333 included both spectral gamma logging and neutron-neutron logging surveys (Appendix D). Spectral gamma logging was conducted to characterize the vertical profile of gamma-emitting radionuclides in the vadose zone. Neutron-neutron logging was conducted to characterize the vertical profile of the moisture content of the vadose zone.

Spectral gamma logging was conducted twice: once from ground surface to 51.5 ft bgs following installation of the 10-in. nominal diameter casing; and once from 45 ft bgs to 249.5 ft bgs following installation of the 8-in. nominal diameter casing. All spectral gamma data were collected at an acquisition rate of 100 seconds real time for every 0.5 ft of borehole length.

Neutron-neutron logging was conducted only once, from 45 ft bgs to 249.5 ft bgs following installation of the 8-in.-diameter casing, because there is no direct calibration standard available for 10-in.-diameter boreholes. The neutron-neutron data were collected at 0.25-ft-depth increments because the instrument is capable of resolving features 2 to 3 in. thick. The data were acquired in a continuous logging mode at a logging speed of 1.0 ft/minute or less; this speed resulted in a sample time of 15 seconds real time.

3.0 RESULTS

Based on the field activities conducted during characterization of the 216-B-2-2 Ditch, results were obtained on the geological materials encountered during drilling; the chemical and radiological constituents and physical properties of the vadose zone samples; and the radiological and moisture profiles of the vadose zone from geophysical logging. The duplicate samples and data validation process provided results to evaluate quality control.

3.1 GEOLOGICAL

The borehole was drilled entirely within the unconsolidated Hanford formation and ditch fill (Figure 4). In general, the upper 30 ft is primarily silty sandy gravel to sandy gravel with thin lenses of sand and silty sand. From ground surface to 9 ft, the material consists of brown gravelly sand and is ditch fill. Below the gravelly material at 30 ft is a thick sequence of sand with minor gravel and silt to a depth of 173.5 ft where there is a sharp contact with sandy silt. The sandy silt layer extends from 173.5 to 184 ft and contains some clean sand layers and higher moisture content. Below the sandy silt is a 24-ft-thick layer of silty sand overlying relatively clean sand. The 4-ft-thick sand overlies silty sandy gravel to sandy gravel. This layer extends to below the water table. Perched water was not observed in the borehole.

3.2 CHEMICAL

Samples for chemical analyses were sent to an offsite laboratory. All of the results for the target analytes, and all detections of nontarget analytes, are provided in Appendix C1.

Volatile organic analyses were conducted on all chemical samples with the exception of the uppermost sample from 4 to 6 ft bgs, which had insufficient sample volume to accommodate all the planned analyses. Three target volatile organic contaminants were detected at estimated concentrations below the quantitation limit: acetone, methylene chloride, and toluene (Table 9).

Table 9. Volatile Organic Detections.

Sample Interval		HEIS Number	Sample Date	Acetone (µg/kg)	Methylene Chloride (µg/kg)	Toluene (µg/kg)	Xylenes (total) (µg/kg)
Top (ft bgs)	Bottom (ft bgs)						
4	6.5	B0MJC2	a				
8	10.5	B0MJC5	12/29/97				
10.5	13	B0MJC8	12/30/97				
13	15.5	B0MJD1	12/30/97				
20	22.5	B0MJD7	12/31/97		2 J		
20	22.5	B0MJF0	12/31/97		2 J		
30	32.5	B0MJF3	12/31/97		2 J		
40	42.5	B0MJJ1	12/31/97		2 J		
50	52.5	B0MJJ4	12/31/97		3 J		
75	77.5	B0MJF6	1/2/98	17 BJ			
100	102.5	B0MJF9	1/3/98	17 BJ			
150	152.5	B0MJJ7	1/5/98			2 J	8
174	179	B0MJK0	1/5/98	18 BJ	2 BJ		
251.5	254	B0MJK6	1/7/98	22 B			

[a]Insufficient sample for volatile organic analyses.
B = also detected in laboratory blank
HEIS = Hanford Environmental Information System
J = concentration is estimated.

One nontarget volatile organic, total xylenes, was detected at 8 µg/kg in the interval from 150 to 152.5 ft bgs.

Semivolatile organic analyses were conducted on all chemical samples. The only PCB detected was aroclor-1260, which was found in the interval from 8 to 15.5 ft bgs with a maximum concentration of 9,200 µg/kg in the interval from 8 to 10.5 ft bgs (Table 10). Two nontarget semivolatile organic contaminants were detected at estimated concentrations below the quantitation limit: butyl benzyl phthalate and di-n-octyphthalate (Table 10).

Three target analytes can be detected as tentatively identified compounds (TICs) during the semivolatile organic analysis if they are present at sufficient concentrations. Neither acetate nor formaldehyde was detected as a TIC in any sample during the semivolatile organic analyses. Therefore, neither compound was present at sufficient concentrations to generate an instrument response. The presence of kerosene, which would have been indicated by the detection of constituent compounds as TICs, was also not detected in any sample.

Table 10. Semivolatile Organic Detections.

Sample Interval		HEIS Number	Sample Date	Aroclor-1260 (µg/kg)	Butylbenzylphthalate (µg/kg)	Di-n-octylphthalate (µg/kg)
Top (ft bgs)	Bottom (ft bgs)					
4	6.5	B0MJC2	12/29/97			
8	10.5	B0MJC5	12/29/97	9200 J		
10.5	13	B0MJC8	12/30/97	150 J		
13	15.5	B0MJD1	12/30/97	1100 J		52 J
20	22.5	B0MJD7	12/31/97			
20	22.5	B0MJF0	12/31/97			
30	32.5	B0MJF3	12/31/97			
40	42.5	B0MJJ1	12/31/97			
50	52.5	B0MJJ4	12/31/97			
75	77.5	B0MJF6	1/2/98		230 J	
100	102.5	B0MJF9	1/3/98		220 J	
150	152.5	B0MJJ7	1/5/98			
174	179	B0MJK0	1/5/98		230 J	
251.5	254	B0MJK6	1/7/98		240 J	

HEIS = Hanford Environmental Information System
J = concentration is estimated.

A limited number of volatile and semivolatile TICs were reported by the laboratory. No compounds of significant concern were identified as part of the TIC reports. Any TIC identified as a specific compound is included in Appendix C of this report; any TIC identified only as "unknown" is not included in this report. TICs are not included in HEIS.

General chemistry analyses for nitrate, nitrite, sulfate, ammonia, and cyanide were conducted on all chemical samples, with one exception: cyanide was not analyzed in the uppermost sample from 4 to 6 ft bgs, which had insufficient sample volume to accommodate all the planned analyses. Cyanide was not detected in any sample. The maximum nitrate, nitrite, sulfate, and ammonia concentrations were 35.8 mg/kg, 0.38 mg/kg, 43.3 mg/kg, and 0.533 mg/kg, respectively, and were all detected in the interval from 4 to 10.5 ft bgs (Table 11). Ammonia and nitrate were detected in only the uppermost sample from 4 to 6 ft bgs.

Metal and inorganic analyses were conducted on all chemical samples. Cadmium and tin were the only metals not detected in any samples. The maximum concentrations of each metal and the associated depth are listed in Table 12. For 12 of the 17 target metals detected, the maximum concentration was found in the interval from 8 to 15.5 ft bgs.

Table 11. General Chemistry Detections.

Sample Interval		HEIS Number	Sample Date	Nitrogen in Ammonia (mg/kg)	Cyanide (mg/kg)	Nitrogen in Nitrate (mg/kg)	Nitrogen in Nitrite (mg/kg)	Nitrate/ Nitrite (mg/kg)	Sulfate (mg/kg)
Top (ft bgs)	Bottom (ft bgs)								
4	6.5	B0MJC2	12/29/97	0.533	a	35.8 J	0.380	32.4 J	32.2
8	10.5	B0MJC5	12/29/97			31.1 J		26.7 J	43.3
10.5	13	B0MJC8	12/30/97			13.0 J		11.7 J	18.8
13	15.5	B0MJD1	12/30/97			13.5 J		11.8 J	26.0
20	22.5	B0MJD7	12/31/97			4.07		3.48 J	8.88
20	22.5	B0MJF0	12/31/97			4.16		3.34 J	9.11
30	32.5	B0MJF3	12/31/97			6.02		4.98 J	13.6
40	42.5	B0MJJ1	12/31/97			0.341			
50	52.5	B0MJJ4	12/31/97						
75	77.5	B0MJF6	1/2/98						
100	102.5	B0MJF9	1/3/98						
150	152.5	B0MJJ7	1/5/98						
174	179	B0MJK0	1/5/98						10.1
251.5	254	B0MJK6	1/7/98			0.256			18.4

[a] Insufficient B0MJC2 sample for cyanide analysis.
HEIS = Hanford Environmental Information System
J = concentration is estimated.

Table 12. Maximum Inorganic (Metal) Detections.

Inorganic (Metal)	Maximum Concentration	
	Result (mg/kg)	Depth (ft bgs)
Target Analytes		
Arsenic	3.7	75-77.5 100-102.5
Barium	89.4	8-10.5
Beryllium	0.70	8-10.5
Bismuth	37.1	8-10.5
Boron	6.3 B	8-10.5
Cadmium	ND	
Chromium	15.7	174-179
Copper	14.9	13-15.5
Iron	25,000 J	8-10.5
Lead	7.5	8-10.5
Manganese	356 J	8-10.5
Mercury	0.15	13-15.5
Nickel	15.0	174-179
Potassium	1490	174-179
Selenium	0.50 B	75-77.5
Silver	0.86 B	8-10.5
Tin	ND	
Vanadium	70.2	8-10.5
Zinc	58.1 E	8-10.5
Nontarget Analytes		
Aluminum	7,090 J	10.5-13
Antimony	5.0 BJN	4-6.5
Calcium	16,100	40-42.5
Cobalt	11.4	8-10.5
Magnesium	5,600	100-102.5
Sodium	671 E	10.5-13

ND = not detected.

B = Applied to inorganic analyses only. Concentration greater than or equal to the instrument detection limit, but less than the contract-required detection limit.

E = Applied to inorganic analyses only. Concentration is estimated because of the presence of interference.

J = Concentration is estimated.

N = Spiked sample recovery not within control limits.

3.3 RADIOLOGICAL

Samples for radiological analyses were sent to an offsite laboratory. All of the results for the target radionuclides, and all detections of nontarget radionuclides, are provided in Appendix C2.

Analyses were conducted on all radiological samples for both man-made and naturally-occurring radionuclides. The primary man-made radionuclides detected were strontium-90, cesium-137, and europium-154 at maximum concentrations of 4,710 pCi/g, 100 pCi/g, and 1.29 pCi/g, respectively (Table 13). The concentrations were 1 to 2 orders of magnitude higher in the intervals from 8 to 10.5 ft bgs and 13 to 15.5 ft bgs than in the intervening sample interval from 10.5 to 13 ft bgs. No man-made radionuclides were detected below 15 ft bgs. Cobalt-60 was not detected in any sample (Table C-2).

The concentrations of total uranium, which is a naturally-occurring element, were analyzed for each sample and ranged from 1.4 to 2.4 µg/g (Table 13). Isotopic analysis for uranium-234, uranium-235, and uranium–238, conducted on the sample with the highest total uranium concentration, produced no detections of these isotopes (Table C2). (For this particular sample, the detection limit for the total uranium analysis was lower than that for the isotopic uranium analysis because the laboratory used a reduced sample volume for the isotopic analysis based on the high activity of other radionuclides in the sample.) Analyses for uranium-235 on two other samples also produced no detections. Uranium-238 was detected in seven of eight samples analyzed from depths throughout the vadose zone (Table 13). The concentrations of uranium-238 are consistent with those of total uranium (when converted to activity units of pCi/g). The presence of uranium-238 daughters thorium-230 and radium-226 throughout the vadose zone indicates that the presence of uranium-238 is a result of natural rather than nuclear waste disposal processes. Other naturally-occurring radionuclides (potassium-40 and thorium-232 plus decay products thorium-228, radium-228, and radium-224) were also detected throughout the vadose zone (Tables 13 and C2).

3.4 PHYSICAL

Samples for pH and total organic carbon analyses were sent with the samples for chemical and radiological analyses to an offsite laboratory. Samples for physical properties testing for water content, cation exchange capacity, specific gravity, bulk density, and particle size distribution were sent to a different offsite laboratory. Bulk density was calculated for some samples based on field measurements. All of the results are provided in Appendix C3.

Total organic carbon ranged from 206 to 367 µg/g (Table 14). The pH measurements, which are estimated because the holding time was exceeded by the laboratory, range from 8.2 to 8.7 (Table C3). The cation exchange capacity ranged from 6.3 to 11.9 milli-equivalents/100 g; water contents ranged from 2.4 to 11.0 weight percent; specific gravity ranged from 2.10 to 2.64; and dry bulk density ranged from 1.4 to 2.0 g/cm^3 (Table 14).

Particle size distribution data are provided in Table C3. The samples were analyzed a second time because an incomplete sieve set was used the first time. The second analysis indicates a significantly larger fraction of finer grained particles. The size distribution data may be unusable for decision-making purposes.

Table 13. Radionuclide Detections. (2 Sheets)

Sample Interval		HEIS Number	Sample Date	Am-241 (pCi/g)	Cs-137 (pCi/g)	Eu-154 (pCi/g)	Gross Alpha (pCi/g)	Gross Beta (pCi/g)	Pu-238 (pCi/g)	Pu-239/240 (pCi/g)	Sr-90 (pCi/g)	Th-228 (pCi/g)	Th-230 (pCi/g)	Th-232 (pCi/g)	U (µg/g)	U-238 (pCi/g)
Top (ft bgs)	Bottom (ft bgs)															
4.0	6.5	B0MJC2	12/29/97		0.393		11.1	26.4				0.733	0.565 J	0.743 J	1.36	0.652 J[b]
8.0	10.5	B0MJC5	12/29/97	0.589[a]	71.4	1.29	12.1	10000			3780		2.67 J		2.31	NA
10.5	13.0	B0MJC8	12/30/97	0.0615 J	6.30		11.1	279			86.7	0.931	0.689 J	0.888 J	1.87	NA
13.0	15.5	B0MJD1	12/30/97		100	0.774	9.76 J	13900		4.97 J[b]	4710				2.38	
20.0	22.5	B0MJD7	12/31/97	0.0295 J				22.0	0.0213 J[b]			0.528	0.489 J	0.535 J	1.54	0.609 J[b]
20.0	22.5	B0MJF0	12/31/97					21.4					0.0365 J		1.39	0.576 J[b]
30.0	32.5	B0MJF3	12/31/97				6.00 J	25.7				0.975	0.811 J	1.02 J	2.20	NA
40.0	42.5	B0MJJ1	12/31/97				5.28 J	28.1				0.873	0.586 J	0.791 J	1.91	NA
50.0	52.5	B0MJJ4	12/31/97				8.32 J	24.5				0.857	0.511 J	0.938 J	2.07	NA
75.0	77.5	B0MJF6	1/2/98				9.14 J	32.6				0.994	0.614 J	0.928 J	1.78	0.366 J[b]
100.0	102.5	B0MJF9	1/3/98				9.76 J	29.9				1.47	0.629 J	1.03 J	1.70	NA
150.0	152.5	B0MJJ7	1/5/98					27.4				0.562	0.426 J	0.657 J	1.40	0.588 J[b]
174.0	179.0	B0MJK0	1/5/98				7.52 J	18.8				0.735	0.691 J	0.683 J	1.97	0.412 J[b]
251.5	254.0	B0MJK6	1/7/98	0.0161 J[c]			7.17 J	21.5				0.551	0.470 J	0.485 J	1.46	0.653 J[b]

Table 13. Radionuclide Detections. (2 Sheets)

Sample Interval		HEIS Number	Sample Date	K-40 (pCi/g)	Ra-224 (pCi/g)	Ra-226 (pCi/g)	Ra-228 (pCi/g)
Top (ft bgs)	Bottom (ft bgs)						
4	6.5	B0MJC2	12/29/97	15.0	0.910	0.762	0.917
8	10.5	B0MJC5	12/29/97	12.0	0.640	0.552	0.696
10.5	13	B0MJC8	12/30/97	13.7	0.690	0.563	0.741
13	15.5	B0MJD1	12/30/97	11.3	0.626		0.629
20	22.5	B0MJD7	12/31/97	14.0	0.520	0.444	0.487
20	22.5	B0MJF0	12/31/97	14.7	0.589	0.516	0.609
30	32.5	B0MJF3	12/31/97	16.8	0.742	0.607	0.745
40	42.5	B0MJJ1	12/31/97	17.1	0.625	0.514	0.585
50	52.5	B0MJJ4	12/31/97	16.5	0.632	0.527	0.732
75	77.5	B0MJF6	1/2/98	18.4	0.625	0.524	0.688
100	102.5	B0MJF9	1/3/98	16.5	0.619	0.534	0.665
150	152.5	B0MJJ7	1/5/98	15.0	0.532	0.426	0.532
174	179	B0MJK0	1/5/98	14.3	0.636	0.609	0.625
251.5	254	B0MJK6	1/7/98	14.2	0.632	0.670	0.792

[a] Sample B0MJC5 concentration based on gamma spectrometry; other sample concentrations based on alpha spectrometry.
[b] Concentration considered an estimate because counting error within factor of two of result; qualifier added by author of this report.
[c] Concentration equal to counting error and is likely a nondetect.
HEIS = Hanford Environmental Information System
J = concentration is estimated.

Table 14. Summary of Selected Physical Properties.

Sample Interval		HEIS Number		Sample Date	Total Organic Carbon (µg/g)	Water Content (%)[a]	Cation Exchange Capacity meq/100g[b]	Specific Gravity (no units)	Dry Bulk Density (g/cm³)
Top (ft bgs)	Bottom (ft bgs)	Chemical	Physical						
4	6.5	B0MJC2	B0MJC4	12/29/97	NA	6.8	7.8	2.51	NA[c]
8	10.5	B0MJC5	B0MJC7	12/29/97	NA	9.4	9.3	2.56	1.6
10.5	13	B0MJC8	B0MJD0	12/30/97	NA	4.5	6.3 U	2.43	2.0
13	15.5	B0MJD1	B0MJD3	12/30/97	NA	3.7	7.0	2.57	1.9
15.5	18	B0MJD4	B0MJD6	12/30/97	206	4.0	6.2 U	2.57	1.8
20	22.5	B0MJD7	B0MJD9	12/31/97	NA	3.4	7.3	2.61	NA[c]
30	32.5	B0MJF3	B0MJF5	12/31/97	NA	11.0	11.9	2.38	1.7
40	42.5	B0MJJ1	B0MJJ3	12/31/97	342	3.4	6.2 U	2.55	NA
50	52.5	B0MJJ4	B0MJJ6	12/31/97	NA	2.4	6.1 U	2.61	1.7
75	77.5	B0MJF6	B0MJF8	1/2/98	NA	3.3	6.3	2.60	1.6
100	102.5	B0MJF9	B0MJH1	1/3/98	NA	3.1	6.2 U	2.56	1.5
150	152.5	B0MJJ7	B0MJJ9	1/5/98	NA	2.7	6.2 U	2.63	1.7
174	179	B0MJK0	B0MJK2	1/5/98	297	8.1	6.5 U	2.10	1.5
174	179	B0MJK3	B0MJK5	1/5/98	367	7.1	6.4 U	2.64	1.4
251.5	254	B0MJK6	B0MJK8	1/7/98	NA	7.3	6.4 U	2.46	2.0

[a] Water content reported on a gravimetric basis: (mass of water/mass of dry soil) x 100.
[b] Cation exchange capacity results reported on a dry weight basis; meq = milli-equivalents.
[c] Insufficient sample for analysis.
HEIS = Hanford Environmental Information System
NA = not analyzed
U = not detected at or above reporting limit.

Laboratory capabilities were not available for measuring the following physical properties: calcium carbonate content, saturated hydraulic conductivity, unsaturated hydraulic conductivity, matric potential, and soil moisture retention curves. Although these physical properties were not tested, a fairly extensive knowledge base is available for these properties for 200 Area soils. For example, hydraulic properties are available for at least 60 samples in the 200 East Area (WHC 1992), including 6 samples from well 299-E33-38, which is 645 m northwest of the 299-E33-333 borehole. Samples of both the Hanford gravel and the Hanford sand units are included in the existing dataset. The need for physical properties for the Gable Mountain Pond/B-Pond and Ditches Cooling Water Group will be reevaluated as part of the work plan (i.e., data quality objective process) to be prepared for the waste group in fiscal year 1999. If needed, the opportunity exists to collect additional physical properties data as part of the implementation of the work plan.

3.5 GEOPHYSICAL LOGGING

Results of the spectral gamma and neutron-neutron geophysical logging are described in detail in a separate report, provided in Appendix D.

Based on the spectral gamma logging, man-made radionuclides cesium-137, cobalt-60, and europium-154 were detected in borehole 299-E33-333. The presence of cesium-137 was detected from the ground surface to a depth of 2.5 ft bgs and at depths between 6 and 11 ft bgs. The maximum cesium-137 concentration was approximately 400 pCi/g measured at a depth of 9 ft bgs. Analysis of the data indicates that within the zone of highest cesium-137 concentration, the contamination is uniformly distributed in the formation as a thin layer 0.5 to 1.0 ft thick (Appendix D).

The presence of cobalt-60 was detected at the ground surface and at a depth of 0.5 ft bgs. The maximum cobalt-60 concentration was approximately 0.15 pCi/g. The presence of europium-154 was detected at three assay points at depths between 8.5 and 9.5 ft bgs within the interval of highest cesium-137 concentration. The maximum europium-154 concentration was 2.0 pCi/g.

Naturally-occurring radionuclides potassium-40, uranium-238, and thorium-232 were detected throughout the borehole. The concentrations of these radionuclides appeared to the geophysical analysts to be consistent with values observed for these radionuclides in other 200 East Area boreholes logged with the spectral gamma logging system. The increase in potassium-40 concentrations between depths of 26 and 32 ft bgs most likely represents the contact between the Hanford formation sandy gravel and silty sand to sand units (Appendix D).

Based on the neutron-neutron logging, moisture contents ranged from approximately 1 to 3 volume percent throughout the vadose zone with the exception of four zones of increased moisture content at depths of 174 ft, 180 ft, 186 ft, and 212 ft bgs. The first three zones correlate with increases in the uranium-238 and thorium-232 concentrations, indicating the higher moisture content is related to lithologic features, probably thin silt horizons (Appendix D). The fourth zone corresponds to a sand interval that caused a reduced drilling rate, which may indicate cemented sediments (Appendix D).

3.6 DATA VALIDATION AND QUALITY CONTROL

The chemical and radiological analytical data package provided by the laboratory was validated at level C (WHC 1993a, 1993b). As part of a level C validation, the laboratory sample and analytical process is checked for the following quality control parameters:

- Compliance with applicable analytical holding time requirements through comparison of actual and required holding times

- Extent of laboratory contamination introduced through sampling, sample preparation, and analysis through the use of method blank analyses

- Analytical accuracy of the reported data and the effect of the matrix on the ability to accurately quantify sample concentrations through the use of matrix spike/matrix spike duplicate analyses

- Analytical accuracy for individual samples through the use of matrix-specific surrogate compound analyses

- Analytical precision of a method for specific target compound classes through the use of matrix spike/matrix spike duplicate analyses

- Analytical precision through the comparison of sample results and field duplicate sample results

- Compliance with applicable detection levels through comparison of the reported laboratory detection levels and the contract required quantitation levels

- Completeness.

The results of the data validation led to the rejection of all PCB nondetections in eight samples because the laboratory exceeded the holding times. Other data qualifiers were added primarily on the bases of laboratory holding time exceedances, laboratory blank contamination problems, or laboratory matrix spike recovery problems (Table 15). All of the qualifiers added as a result of the validation process are reflected in the tables in this report and have been entered into the HEIS database.

Comparison of the analytical results for the sample and the field duplicate sample collected during drilling was acceptable (relative percent difference values within ±35%) for all chemical and radiological constituents.

The trip blanks, analyzed for volatile organics, indicated no contamination problems. The equipment and field blanks, analyzed for volatile organics, anions, metals, and selected radionuclides, also indicated no contamination problems.

Table 15. Summary of Qualifiers Added to Data Through the Data Validation Process. (2 Sheets)

Category	Qualifiers Added to Laboratory Results Based on Data Validation	Basis for Change
Semi-VOCs	Bis(2)ethylhexylphthalate results for 9 samples raised to CRQL and qualified as undetected	Laboratory method blank contamination
PCBs	All PCB results in 3 samples qualified as estimates	Laboratory matrix spike recovery above QC limits
PCBs	All PCB results (with one exception) in 7 samples qualified as estimates	Laboratory matrix spike recovery below QC limits

Table 15. Summary of Qualifiers Added to Data Through the Data Validation Process. (2 Sheets)

Category	Qualifiers Added to Laboratory Results Based on Data Validation	Basis for Change
PCBs	All PCB detections in 8 samples qualified as estimates, and all PCB nondetections in the same 8 samples qualified as rejected	Laboratory exceeded holding time by greater than twice the limit
PCBs	All PCB results in 2 samples qualified as estimates	Laboratory surrogate recoveries above QC limits
VOCs	All 35 results in B0MJC8 qualified as estimates	Laboratory exceeded holding time
VOCs	Acetone results in 8 samples qualified as undetected	Laboratory method blank contamination
VOCs	Methylene chloride results in 3 samples raised to the CRQL and qualified as undetected	Laboratory method blank contamination
General Chemistry	Cyanide results for 10 samples qualified as estimates	Laboratory exceeded holding time
General Chemistry	pH results in all 16 samples qualified as estimates	Laboratory exceeded holding time by greater than twice the limit
General Chemistry	Nitrate results in 4 samples qualified as estimates	Laboratory method blank analysis lacking
General Chemistry	Nitrate/nitrite results in all 14 samples qualified as estimates	Laboratory matrix spike recovery below QC limits
Metals	Arsenic result in one sample qualified as estimate	Laboratory preparation blank negative result
Metals	Antimony and tin results in all 14 samples qualified as estimates	Laboratory matrix spike recoveries below QC limits
Metals	Iron and manganese detections in all 14 samples qualified as estimates	Laboratory matrix spike recoveries above QC limits
Metals	Aluminum detections in all 14 samples qualified as estimates	Laboratory matrix spike duplicate recovery above QC limits
Metals	Aluminum, iron, and manganese detections in all 14 samples qualified as estimates	Laboratory duplicate RPDs outside QC limits

CRQL = contract required quantitation limit
PCB = polychlorinated biphenyl
QC = quality control
RPD = relative percent differences
VOC = volatile organic compound.

4.0 SUMMARY AND CONCLUSIONS

The laboratory analytical results for the radionuclide contaminants were consistent with the geophysical logging results (Table 16). The man-made radionuclides detected through laboratory analysis were strontium-90, cesium-137, and europium-154. The gamma-emitting man-made radionuclides detected through spectral gamma logging were cesium-137, cobalt-60, and europium-154. Cobalt-60 was found only in the interval from 0 to 1 ft bgs, which was not sampled for laboratory analysis. Strontium-90, a beta-emitter, was not detectable using the spectral gamma logging instrument.

For both data sets, man-made radionuclides are found within the upper 15 ft of the soil column. One zone of high concentration was found at a depth of 8 to 10.5 ft in both data sets. The laboratory analytical data also indicated a zone of high concentration from 13 to 15 ft.

Table 16. Comparison of Maximum Man-Made Radionuclide Concentrations.

Radionuclide	Maximum Laboratory Analytical Result	Maximum Spectral Gamma Logging Result
Strontium-90	4,710 pCi/g	Not detectable by this method
Cesium-137	100 pCi/g	400 pCi/g
Europium-154	1.3 pCi/g	2.0 pCi/g
Cobalt-60	Not detected[a]	0.15 pCi/g

[a] A sample was not collected at the depth (0 to 1 ft bgs) at which spectral gamma logging detected cobalt-60.

Based on both the laboratory analytical results and the geophysical logging results, naturally-occurring radionuclides are present throughout the vadose zone. The naturally-occurring radionuclides detected through laboratory analysis were potassium-40; thorium-232 and decay products radium-228, thorium-228, and radium-224; and uranium-238 and decay products thorium-230 and radium-226. The naturally-occurring radionuclides detected by spectral gamma logging were potassium-40, thorium-232 (based on decay of daughter products), and uranium-238 (based on decay of daughter products).

The distribution of naturally-occurring radionuclides was also consistent between the two methods. For example, an increase in potassium-40 concentrations was indicated by both the laboratory and geophysical logging results at a depth of approximately 30 ft bgs.

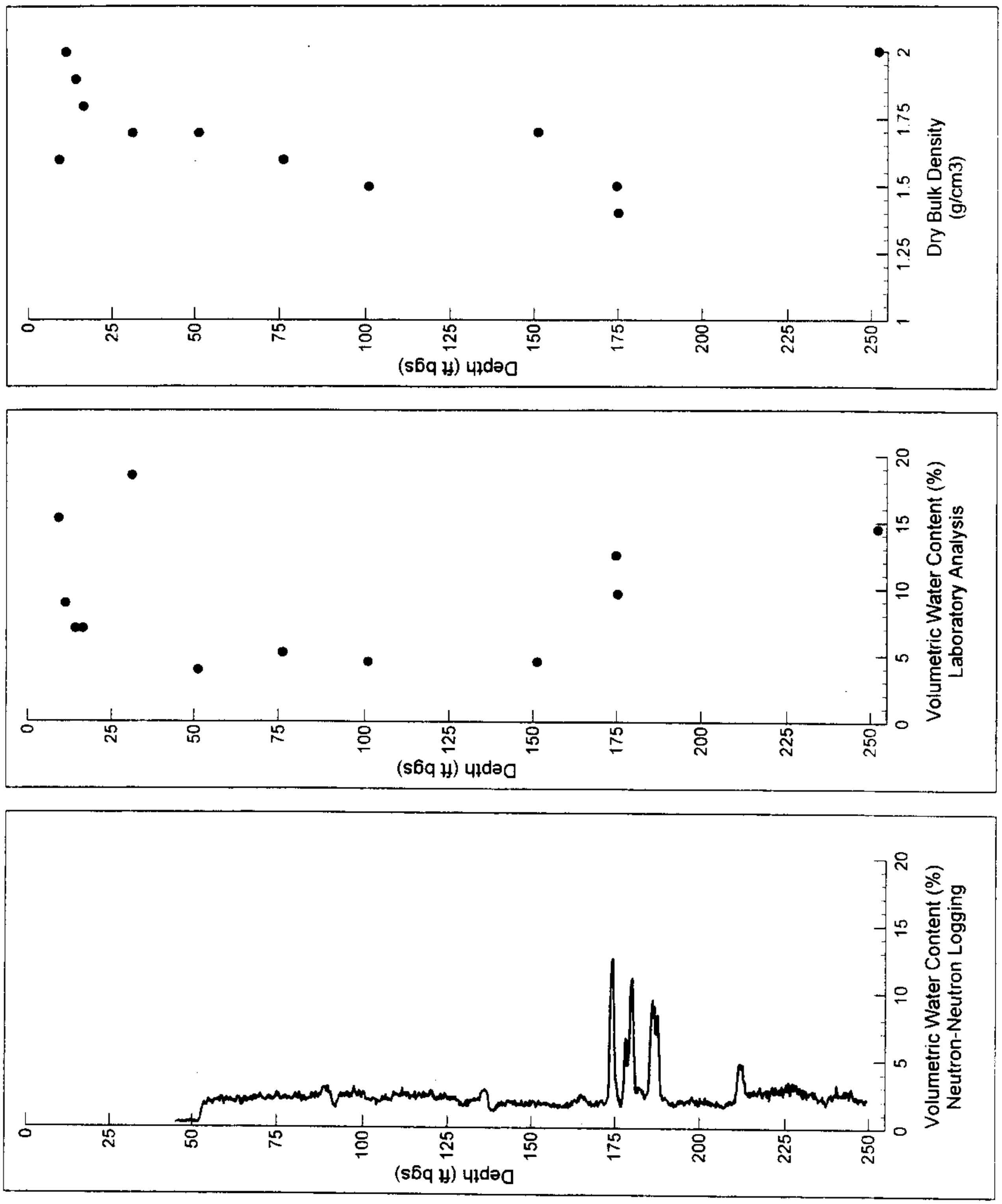
The distribution of man-made radionuclides underlying the 216-B-2-2 Ditch is consistent with the conceptual model developed for the Gable Mountain Pond/B-Pond and Ditches Cooling Water Group (DOE-RL 1997). The conceptual model for this group is that the highest concentration of the primary contaminants of concern (e.g., strontium-90) will be directly underlying the head end of the ditch. Furthermore, according to the conceptual model, most of the contaminants were expected to be within the uppermost gravel unit, which at this site extends to a depth of 30 ft. The data indicate that in fact the radionuclide contamination does not extend below 15 ft.

The vadose zone moisture content determined using the neutron-neutron logging instrument is consistent with the moisture contents determined on soil samples by the offsite laboratory (Figure 7). The maximum moisture content determined by the laboratory was 11 weight percent (18.5 volume percent) at 30 ft bgs, which was within the 0 to 45 ft interval not logged using the neutron-neutron instrument. Between 45 ft and 249.5 ft (the interval of geophysical logging), the maximum moisture content determined by the laboratory was 8.1 weight percent (12.5 volume percent) in the interval from 174 to 179 ft bgs. The maximum moisture content determined by neutron-neutron logging was approximately 12.6 volume percent at 174.4 ft bgs.

In general, the vadose zone moisture content was relatively low, approximately 2 to 5 weight percent, with the exception of the zone of higher moisture content in the interval from 174 to 186 ft bgs.

All of the sampling objectives defined in the DOW were achieved during this characterization effort with the following exceptions. The lack of sufficient sample volume precluded conducting all of the chemical and physical property testing for the uppermost sample in the 4 to 6 ft interval. Five of the physical property tests specified in the DOW were not conducted because the analytical capability was unavailable. However, existing data from numerous other 200 East Area borehole samples may be considered representative of the physical properties of materials encountered by the B-2-2 characterization borehole. The two sets of analyses for particle size distribution are inconsistent, suggesting that those data may be of limited value. All PCB nondetection results in eight samples were qualified as rejected (i.e., unusable) because the holding time was exceeded at the laboratory by greater than twice the limit. Quality control deficiencies were identified for a limited number of additional chemical analyses for specific samples, causing these results to be qualified as estimated or undetected. No quality control deficiencies were identified for any of the radiological analyses.

Figure 7. Comparison of Moisture Content Determined Using Geophysical Logging and Laboratory Analysis.



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APPENDIX A

DOCUMENTATION OF 216-B-2-2 DITCH TRENCHING ACTIVITY

/

Originator	C.D. Wittreich	**Date**	10/24	**Calc. No.**		**Rev. No.**	
Project	200-CW-1	**Job No.**		**Checked**		**Date**	
Subject	216-B-2-2 Ditch Trenching Summary					**Sheet No.**	

The trenching through the 216-B-2-2 Ditch was successfully completed on Monday 10/20/97 using a wheeled backhoe. The trench was constructed more or less north-south across the east-west running ditch at the headend of the ditch close to the -37 well. The prejob meeting occurred about 9:00am to 10:00am. Actual trenching started after lunch at ~ 12:00pm. Field support personnel included 3 RCTs, 3 D&D laborers, 1 Backhoe Operator, 1 D&D Supervisor (Ken Turner). Observers/technical support included Bryan Foley, Greg Mitchem, Curt Wittreich, Steve Demers, Bill Hayward (Field Engineer), Cliff St John (S&H), and Randy Havenor (Field Support) The trenching process included four steps. All buckets of soil removed were screened for radiation and the results recorded (attached).

The first step was to remove the ~3 feet of clean stabilization fill across the entire length of the trench. This clean fill was field screened for rad (zero hits) and separately stockpiled on the west side of the trench. This took 22 bucket loads.

The second step was to excavate further down starting on the south end of the trench. We first encountered contamination in the bucket of 25K dpm beta/gamma taken from ~ 8 feet (bucket #34). The contaminated soil and all subsequent buckets of soil were stockpiled on plastic on the east side of the trench. The next two buckets were 0 dpm at ~ 9 ft (at which time a change in soil was observed) followed by two additional buckets of 12 - 15K dpm between 9 feet and 10 feet (bucket #s 38 & 39). Chicken wire was observed originating below black plastic sheeting at ~3.5 ft. Black plastic was placed over the backfilled trench as part of a later stabilization effort. Chicken wire was placed over the open trench after the spill in 1970 to keep tumbleweeds from blowing in and out of the ditch. The observations indicate that we penetrated the southern side-wall of the ditch at a~9 feet and no additional vertical digging was needed.

The third step was to excavate down through the middle of the trench. Contamination was first observed at ~ 7 feet (bucket # 49) at 3.2K dpm beta/gamma. Contamination subsequently increased from 4K to 1,600K dpm in the next 3 buckets. The 1,600K dpm reading exceeded radiation limits for the job and was placed backed in the trench (bucket #52). The 1,600K dpm reading from ~8 feet was from an ~3/8-inch thick, 3 to 4-inch diameter black crystalline material (i.e., not soil). These observations indicated that we had found the high contaminated area associated with the ditch bottom and additional trenching was not needed.

The fourth step was to backfill the trench with the contaminated spoil first followed by the clean spoil on top. The borehole location was then staked horizontally 2-3 ft east (down ditch) of where the 1,600 dpm material was encountered.

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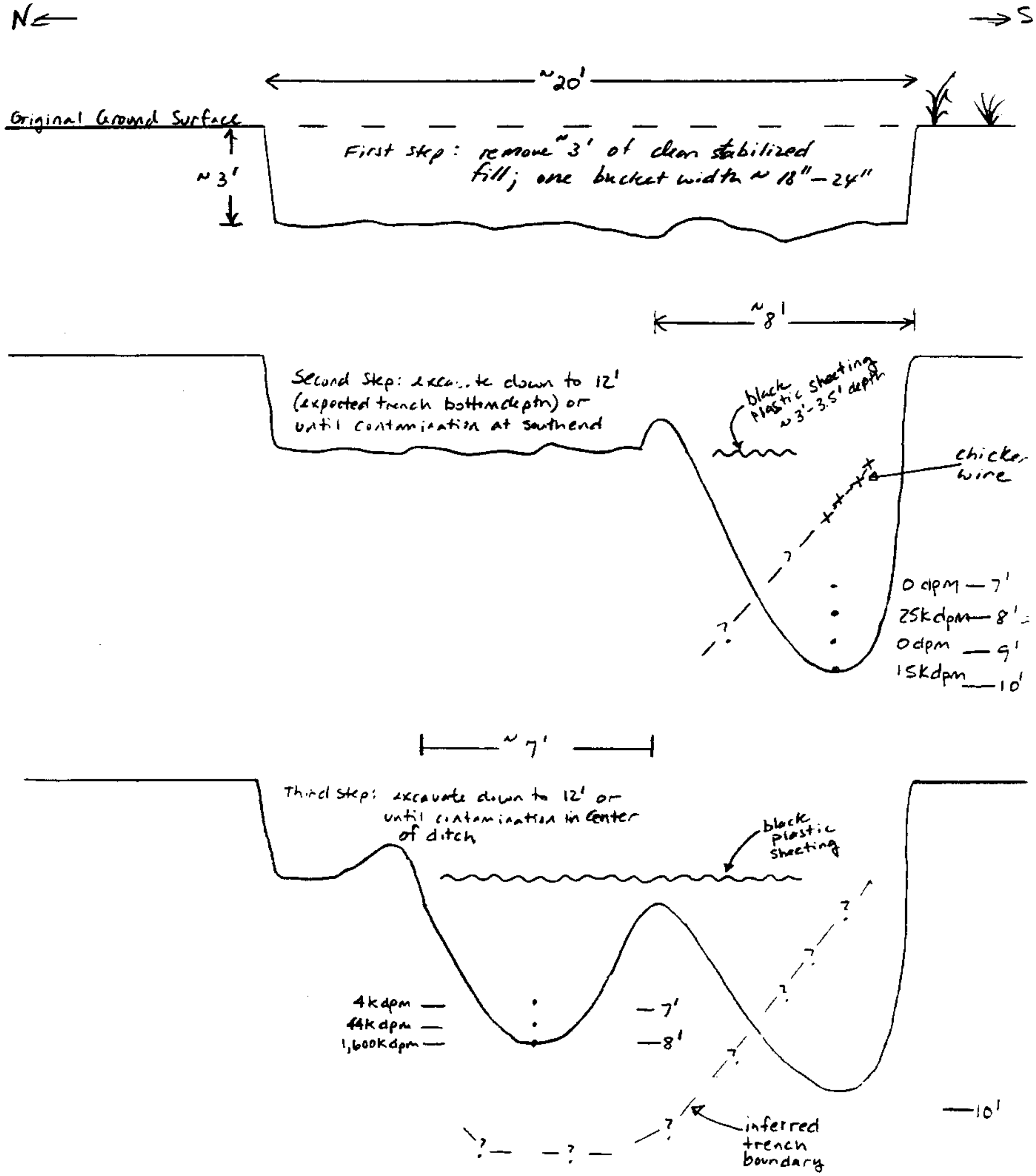
Originator C.D. Wittreich **Date** 10/21/97 **Calc. No.** ____ **Rev. No.** ____
Project ____ **Job No.** ____ **Checked** ____ **Date** ____
Subject Trench construction across 216-B-2-2 Ditch on 10/20/97 **Sheet No.** ____



E94101

216-B-2-2 Ditch Excavation Date: 10/26/97 Page 1 of 2

Recorded by C.D. Wittreich

Bucket Number	dpm/probe area Beta/Gamma	dpm/probe area Alpha				Curies Sr-90
1	0		start excavate south end to 3' : 1205 pm			
2	0					
3	0					
4	0					
5	0					
6	0					
7	0					
8	0					
9	0					
10	0					
11	0					
12	0					
13	0					
14	0					
15	0					
	0					
	0					
	0					
	0					
20	0					
	0					
	0		last bucket for initial 3' cut on north end			
	0		begin excavat. to 12 feet south end			
	0					
25	0					
	0					
	0					
	0					
	0					
30	0					
	0					
	0					
	0					
	25K	250	~8 ft deep @ south end assoc w/ chicken wire; 1:25pm			
35	0					
	0		higher more uniform gravel content indicates contact			
	12K	250	~9 ft deep			
	15K	0	last bucket south end cut < 0.5 mRad/hr			
	0		begin excavat'g to 12' center of trench			
40	0					
	0					
	0					
	0					
	0					
45	0					
	0					
	0					
	0					
49	3.2K	140	~7' depth			

If spoils > 100,000 dpm/probe area beta/gamma but < 1 R/hr or > 2,000 dpm/probe area but <350,000 dpm alpha must contain/apply fixant. If >1R/hr return spoils to excavation and cover with fill

4

216-B-2-2 Ditch Excavation Date: 10/20/97 Page 2 of 2

Bucket Number	dpm/probe area	dpm/probe area				Curies Sr-90
	Beta/Gamma	Alpha				
50	4k		@ 7'			
51	44k		@~8'	0.3 mRad/hr		
52	1,600K		@+8'	last bucket; stopped excavation		
				due to high dpm @ ~ 2:40p		
				1.6 mill dpm assoc w/ 50 mRad/hr		
				dose rate		
			backfill trench ~ 3:00 – 4:15 pm			
			stacked borehole w/ Havenor ~ 4:30 pm			

If spoils > 100,000 dpm/probe area beta/gamma but < 1 R/hr or > 2,000 dpm/probe area but <350,000 dpm alpha must contain/apply fixant. If >1R/hr return spoils to excavation and cover with fill

APPENDIX B

DOCUMENTATION OF 216-B-2-2 DITCH DRILLING ACTIVITY

APPENDIX B1

WELL SUMMARY SHEET FOR CHARACTERIZATION BOREHOLE 299-E33-333

WELL SUMMARY SHEET

Boring or Well No. B8079

Sheet 1 of 1

Location: Head End of 216-B-2-2 Ditch

Project: 216-B-2-2 Ditch Characterization

Reviewed By: LD Walker / LD Walker 1-27-98

Prepared By: DC Weekes / DC Weekes 1/14/98

CONSTRUCTION DATA

Description

10" nom. dia. temp casing shoe O.D. = 11" set at 51.5'

Cement Grout: 0'-0.5'

Dry Bentonite from 0.5'-228.6' consisting of 3/8" bentonite pellets and chunks and granular bentonite

Cement Grout: 228.6'-249.7'

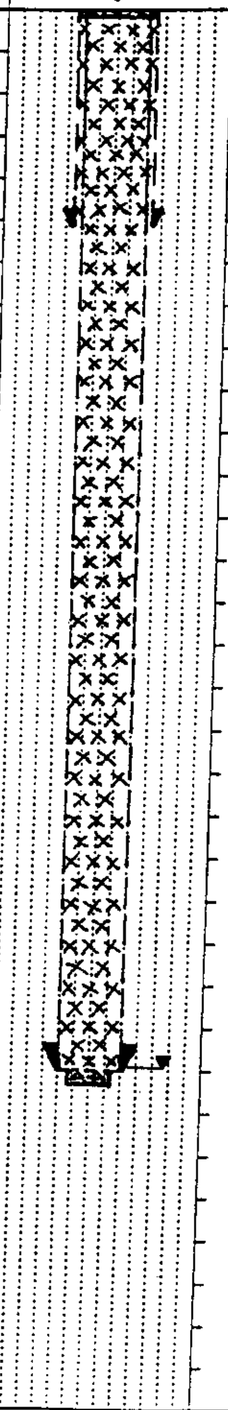
Slough: 249.7'-254'

8" nom. dia. temp. casing shoe O.D. = 8 7/8" set at 250'

All temporary casing removed from the ground.

Depths are measured from ground surface.

Diagram

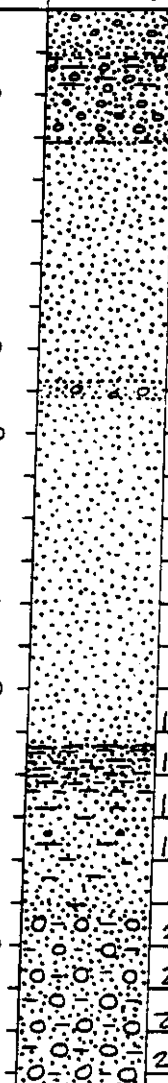


Depth in Feet

20, 40, 60, 80, 100, 120, 140, 160, 180, 200, 220, 240, 260

GEOLOGIC/HYDROLOGIC DATA

Graphic Log



Lithologic Description

0'-9': Ditch Fill - Gravelly SAND
9'-10.5': SAND
10.5'-11.3': Silty SAND
11.3'-20': Silty Sandy GRAVEL
20'-30.2': Sandy GRAVEL
30.2'-31.2': Silty SAND
31.2'-88': SAND
88'-91.5': Gravelly SAND
91.5'-173.5': SAND
173.5'-174.8': Sandy SILT
174.8'-177.0': Silty SAND
177'-184': Sandy SILT
184'-208': Silty SAND
194': trace GRAVEL
208'-212': Slightly Silty SAND
212'-225': Silty Sandy GRAVEL
225'-252': Silty Sandy GRAVEL
252'-254': Sandy GRAVEL
TD = 254' bgs
Water level = 249.6' (1/9/98)

A-6000-384 (01/93)

APPENDIX B2

BOREHOLE LOG FOR CHARACTERIZATION BOREHOLE 299-E33-333

BOREHOLE LOG

Boring or Well No. B8079

Sheet 1 of 8

Location: Head End of 216-B-2-2 Ditch   Project: 216-B-2-2 Ditch Characterization

Prepared By: DC Weekes / DC Weekes (Sign/Print Name)   Date: 12/30/97   Reviewed By: LD Walker / L.D. Walker (Sign/Print Name)   Date: 1-28-98

Depth (ft)	Sample: Type and No.	Sample: Blows or Recovery	Graphic Log	Sample Description (Group Name, Group Symbol, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl)	Comments (Depth of Casing, Drilling Rate, Casing Size & Type, Bit Size, Water Level)
	Dradise	Rcd, 1.5'		0-9' Ditch Fill	9"OD DB used between
	SS			Gravelly SAND (gS): 80% sand	split spoon intervals
	0-2.5'			(fine to coarse), 20% gravel (fine	Split spoon is 5"OD with
				to medium pebbles), brown, moist	four liners
					β, γ < det., OVM < det.
	DB				Background βγ is ~175 to
	↓				100 cpm.
					SS-1:
	SS-1	Rcd 1.0'			β, γ < det., OVM < det.
5	4'-6.5'				BOMK76 VOA
					BOMJC3[2] (JCW 3/30/98) Quanterra Rad & chem
					insufficient volume for semi-
					VOA sample; Physical Prop
	DB				sample collected from cleanout
					of ss interval (BOMJC4), archive
	↓				also. No weigh for bulk density.
	SS-2	Rcd, 2.5'		Drive barrel cleanout @ 8.5 ft reads	SS-2: 400 dpm βγ on bottom of SS
	8'-10.5'			80,000 dpm βγ, 2.1 mrad/hr β dose rate	80,000 dpm βγ directly
				9'-10.5' SAND (S): tr gravel, fine	on soil in sample bowl (homogenized)
10				to coarse, moist, brown	OVM<det. Samples collected
				DB@10.5' 68,000 dpm βγ	from SS-2 include: BOMJC5
	SS-3	Rcd, 2.5'		10.5'-11.3' Silty SAND (mS): 30% silt,	Quan chem & rad, BOMJC6
				70% sand, brown, moist	rad screen, BOM~~K77~~ TMA
	10.5'-			11.3'-20' Silty Sandy GRAVEL (msG)	Phy Prop, Archive JC7 JCW 3/30/98
	13'			35% grav, 55% sand, 10% silt,	SS-3 → 6,000 dpm βγ directly
				brown, moist; grav is predom	on soil in sample bowl (homogenized)
	SS-4	Rcd 2.5'		bas, SR-R; sand is mostly m to	OVM<det, samples collected
	13'-			vc, A to SR, basaltic	were: BOMJC8 Quan rad &
	15.5'			Note: Rad (β) readings started to	chem, BOMJC9 rad screen,
15				be taken directly from each ss liner	BOMK78 VOA Trip blank,
				separation starting at 13 ft.	BOMJD0 TMA Phy Prop Type A.
	SS-5	Rcd, 2.5'		13 ft 400 dpm β	Archive Note: OVM registered 18 ppm in borehole briefly
	15.5'-			13.5 ft 120,000 dpm β	SS-4 → 150,400 dpm β
	18'			14 ft 80,000 dpm β	directly on soil in sample bowl (homogenized)
				14.5 ft 10,000 dpm β	OVM<det., samples collected: BOMJD1
				15 ft 400 dpm β	Quan rad & chem, BOMK79 VOA Trip,
	DB			15.5 ft < det	BOMJD3 TMA Phy Prop Type A, Archive
				16 ft < det	SS-5 → βγ<det on bowl sample,
				16.5 ft < det	OVM<det, samples collected for Phy prop
	↓			17 & 17.5 ft < det, 18 & 20' < det	Type A & B, Archive BOMJD4 TOC, BOMJD6 Phy Prop.

A-6000-382 (01/93)

BOREHOLE LOG

Boring or Well No. B8079

Sheet 2 of 8

Location Head End of 216-B-2-2 Ditch | Project 216-B-2-2 Ditch Characterization

Prepared By DCWeekes (Sign/Print Name) Date 12/31/97 | Reviewed By LD Walker (Sign/Print Name) Date 1-28-98

Depth (ft)	Sample: Type and No.	Sample: Blows or Recovery	Graphic Log	Sample Description: Group Name, Group Symbol, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Rate, Casing Size & Type, Bit Size, Water Level; βγ values above background
20	SS-6 20'-22.5'	2.5' run 2.5' rec'd		20'-30.2' Sandy GRAVEL: 40% grav, 55% sand, 5% silt, gravel is mostly bas, A to R; sand is c to vc, mostly bas (60% bas, 40% other), moderately sorted, slightly moist, 2.5Y5/3 light olive brown (moist) max part size 8 cm	600 dpm βγ on homogenized sample; B0MJD7 main set; B0MJF0 duplicate; Archive sample; 20' 200 dpm βγ; 20½' 200 to 600 dpm βγ; 21' 200 dpm βγ; 21½' 200 to 400 dpm βγ; 22' 400 dpm βγ
25					22' to 30' <1,000 dpm βγ
30	SS-7 30'-32.5'	2.5' Rcd		30.2'-31.2' Silty SAND: 30% silt, 70% vf-f sand, moist, 2.5Y4/3 olive brown (moist), well sorted, tr mica; 31.2'-88 SAND: f-c sand, tr gravel, 5% silt, moist, 2.5Y5/3 light olive brown, max part size 4mm, sand is 30% bas, 70% other, A to SR; Thin silty layer at 33 ft.	600 dpm βγ homogenized SS-7; B0MJF5 Phy Prop; B0MJF3 Chem, rad; Archive sample; B0MK83 Trip VOA; 30' 600 dpm βγ; 30½' 100 to 300 dpm βγ; 31' 200 to 400 dpm βγ; 31½' 200 to 400 dpm βγ; 32' 200 dpm βγ
35					34.5' 1,200 dpm βγ; 34.5' to 40' <1,000 dpm βγ

A-6000-382 (01/93)

BOREHOLE LOG

Boring or Well No. B 8079
Sheet 3 of 8

Location Head End of 216-B-2-2 Ditch
Project 216-B-2-2 Ditch Characterization
Prepared By DC Weekes / DC Weekes (Sign/Print Name) Date 12/31/97
Reviewed By [signature] / LD Walker (Sign/Print Name) Date 1/28/98

Depth (ft)	Sample: Type and No.	Sample: Blows or Recovery	Graphic Log	Sample Description (Group Name, Group Symbol, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl)	Comments (Depth of Casing, Drilling Rate, Casing Size & Type, Bit Size, Water Level)
40	SS-8 40'-42.5'	2.5' Rcd		31.2'-88' SAND: see p. 2	Bγ values above background
					600 dpm Bγ homogenized SS-8
				Slightly moist	BOMVV1 Chem, Rad
					BOMK93 Trip Blank VOA
					BOMVV3 TMA/Weston Type A phy prop sample
					Type B ss liner collected at 41'-41.5'
					40' 200 dpm Bγ
					40½' 200 to 400 dpm Bγ
45					41' 200 to 400 dpm Bγ
					41½' 200 dpm Bγ
					42' 200 dpm Bγ
					Drive barrels 40' to 50' <1,000 dpm Bγ
50	SS-9 50'-52.5'	2.5' Rcd		As above, slight moist	400 dpm Bγ homogenized SS-9
				SS-9: BOMVV4 Chem + Rad	
				BOMK94 VOA Trip	12/31/97 End of day
				BOMVV6 TMA/Weston Phy Prop	Bottom of casing @ 51.5'
				50' 200 dpm Bγ	Bottom of hole @ 53'
				50½' 200 dpm Bγ	1-2-98
				51' 100 to 120 dpm Bγ	Advance hole with
				51.5' 100 to 150 dpm Bγ 52' 200 dpm Bγ	8" nom dia temp casing
					OVM < detect
55				SAND: similar to above.	Bγ < detect.
				F-vc sand, tr gravel (fn peb), tr silt, dry, light olive brown	Drive barrels 50' to 53' <1,000 dpm Bγ
				mineralogy as above	

A-6000-382 (01/93)

BOREHOLE LOG

Boring or Well No. B8079

Sheet 4 of 8

Location: Head End of 216-B-2-2 Ditch

Project: 216-B-2-2 Ditch Characterization

Prepared By: [signature] / L.D. Walker (Sign/Print Name) Date: 1/2/98

Reviewed By: [signature] / DC Weekes (Sign/Print Name) Date: 1/26/98

Depth (Ft.)	Sample Type and No.	Sample Blows or Recovery	Graphic Log	Sample Description (Group Name, Group Symbol, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl)	Comments (Depth of Casing, Drilling Rate, Casing Size & Type, Bit Size, Water Level)
60	DB			SAND: see page 3	8" nom carbon steel casing, shoe O.D. = 8 7/8" Drive barrel O.D. = 7"
					β, γ < detectable OVM < detect.
				68' thin layer gravelly SAND. max gravel 3 cm dia, rounded. 30% gravel / 70% sand, tr silt. Sand mineralogy similar to above. (layer less than one Ft thick)	
70					
	SS-10 75'-77.5'	2.5' Rcd		88' SAND: (S) fn-v.cse, tr silt, 2.5Y5/3 light olive brown, moist, max part. size 2 mm; 30% basalt, 70% qtz and Felds, angular	Split Spoon Sample SS-10 75'-77.5' β,γ < detect OVM < detect
	DB				BOMJF6 Main set BOMK88 VOA Trip Blank BOMJF8 TMA Phy Props
80					
					End of shift 1-2-98 87' bgs
				5" diameter basalt clast @ 88'	
				88'–91.5' Gravelly SAND (gS): 15% grav, 85% sand (vf-vc), tr silt, 2.5Y5/2 grayish brown (moist), moist; gravel is 70% bas, 30% other, SA to R; sand is 50% bas, 50% other, A to SR; max part size 13 cm, slightly consolidated; 2.5Y6/2 light brownish gray (dry), poorly sorted	Driller indicates drilling is slightly easier
90					β, γ < detect OVM < detect Formation got tighter after 91.5'
				91.5'–173.5' SAND (S): same as sand above 88 ft, max part size 5 mm, tr grav, slightly moist	

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BOREHOLE LOG

Boring or Well No. B8079

Sheet 5 of 8

Location: Head End of 216-B-2-2 Ditch

Project: 216-B-2-2 Ditch Characterization

Prepared By: DCWeekes / DC Weekes (Sign/Print Name) Date 1/5/98

Reviewed By: LD Walker / LD Walker (Sign/Print Name) Date 1/28/98

Depth (ft)	Sample: Type and No.	Sample: Blows or Recovery	Graphic Log	Sample Description (Group Name, Group Symbol, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl)	Comments (Depth of Casing, Drilling Rate, Casing Size & Type, Bit Size, Water Level)
100	SS-11 100'-102.5'	2.5' Rcd		SAND as previous page. Tr gravel, slightly moist; silt content increases downhole from ~105' to ~10% to ~113 ft.	B, γ < detect, ovm < detect
	DB			SS-11 is similar to SS-10	100.5'-101 ss liner for bulk density
					BOMJH1 Phy Prop TMA (type A)
					BOMK89 VOA Trip
					BOMJF9 Quanterra + main moist
					Archive collected
					Full QA/QC sample set collected
110					
120					
130					End of shift 1/3/98 131 ft

A-6000-382 (01/93)

BOREHOLE LOG

Boring or Well No. B8079
Sheet 6 of 8

Location Head End of 216-B-2-2 Ditch Project 216-B-2-2 Ditch Characterization
Prepared By DC Weekes/DC Weekes (Sign/Print Name) Date 1/5/98 Reviewed By [signature] / LD Walker (Sign/Print Name) Date 1/28/98

Depth (ft)	Sample: Type and No.	Sample: Blows or Recovery	Graphic Log	Sample Description: Group Name, Group Symbol, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Rate, Casing Size & Type, Bit Size, Water Level
140	DB			SAND (S): see previous page.	8" nom carbon steel casing (8⅝" OD), drive barrel OD = 7"
150					β, γ < det, OVM < det.
	SS-12 150'-152.5'	2.5' Rcd		91.5'-173.5' SAND (S): tr gravel, tr silt, 100% sand (vf-vc), 2.5Y6/2 light brownish gray (dry), slightly moist, moderately sorted, A to SA, 40% bas, max part size 4mm, tr mica, FeOx trace	151'-151.5' ss liner for bulk density (not saved) BOMJJ9 TMA Phy Prop (Type A) BOMK95 VOA Trip BOMJJ7 Quanterra chem + rad Archive collected
	DB				
160					
170					
				173.5'-174.8' Sandy SILT: 50% vf sand, 50% silt, 2.5Y5/3 light olive brown ~~(dry)~~ moist	Note: sharp contact @ 173.5' only
	SS-13 174'-176.5'	2.5' Rcd			β, γ < det, OVM < det. 174.5'-175' ss liner (A) BOMKZ (PP)
	SS-14 176.5'-179'	2.5' Rcd		174.8'-177' Silty SAND: 85% sand, 15% silt, tr gravel, crude layers	175'-175.5' ss liner (A dup) BOMK5 (PP) BOMK0 Quan Chem + Rad Homogen. 174-176',
				177'-184' Sandy SILT: same as 173.5-174.8'	175.5-176; BOMK96 VOA Trip; BOMK3 ... Type B 177-177.5 Archive from chem leftover, Type B dup 177.5-180

A-6000-382 (01/93)

BOREHOLE LOG

Boring or Well No. B8079
Sheet 7 of 8

Location: Head End of 216-B-2-2 Ditch
Project: 216-B-2-2 Ditch Characterization

Prepared By: L.D. Walker / L.D. Walker (Sign/Print Name) Date: 1-6-98
Reviewed By: DC Weekes / DC Weekes (Sign/Print Name) Date: 1/26/98

Depth (ft)	Sample: Type and No.	Sample: Blows or Recovery	Graphic Log	Sample Description (Group Name, Group Symbol, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl)	Comments (Depth of Casing, Drilling Rate, Casing Size & Type, Bit Size, Water Level)
180	DB			Sandy SILT: see previous page.	
					End of shift 1/5/98 182 ft
					Begin 1/6/98
				184'-208' Silty SAND: 75% sand	8" nom. carbon steel casing
				(sand 20% m, 80% fn-v. fn) 25% silt,	shoe O.D = 8 7/8"; DB OD = 7"
				tr pebbles, light olive brown-dry	β, γ < Detect
				color; moist, sub-angular	OVM < Detect
				Thin beds (<.2') of sandy silt	Difficult to penetrate
					with drive barrel
190					
				194': trace gravel. well rounded	
				2-3 cm	Drilling rate increases
					slightly
					β, γ < Detect
200					OVM < Detect
				silt content decreases at 208 ft.	
				208'-212': Slightly Silty SAND	
				(m) S, 80% sand (20% med, 40%	
210				fn, 40% v. fn) 20% silt, tr fn	
				pebs, dry color 2.5Y 5/2 grayish	210 ft drill rate slows
				brown, moist, mod. sorted, sub	partially cemented?
				round to sub-ang; 30% basalt	
				70% qtz + felds, max part 4 mm.	
				212'-225': Silty Sandy GRAVEL	End shift 1/6/98; 218 ft
				msG, 40% gravel (tr. cse peb, 50% m,	Begin 1/7/98
				50% fn) 40% sand (50% cse-m, 50% fn)	
				20% silt, 2.5Y 5/2, grayish brown	
				moist, poorly sorted, gravel rounded -	
				partially cement	

A-6000-382 (01/93)

BOREHOLE LOG

Boring or Well No. B8079
Sheet 8 of 8

Location: Head End of 216-B-2-2 Ditch
Project: 216-B-2-2 Ditch Characterization
Prepared By: [signature] / L.D. Walker (Sign/Print Name) Date: 1-7-98
Reviewed By: [signature] / D.C. Weekes (Sign/Print Name) Date: 1/26/98

Depth (Ft.)	Sample: Type and No.	Sample: Blows or Recovery	Graphic Log	Sample Description (Group Name, Group Symbol, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl)	Comments (Depth of Casing, Drilling Rate, Casing Size & Type, Bit Size, Water Level)
220	DB				8" nom dia carbon steel casing shoe O.D. = 8 7/8", DB OD=7"
				silt content increases about 225'	OVM < Detect
				225'-252': Silty Sandy GRAVEL (msG) 40% gravel, 30% sand, 30% silt 10YR7/2 light gray, dry, poorly sorted, gravel well rounded - some broken cobble frags, sand subround to sub angular, partially cemented Max gravel size ≈ 10cm	
230					
				At ≈ 236' gravel is loose - no longer cemented, dry	β, γ < Detect
240				240' large cobble/small boulder frags	240': drill rate indicates possible boulder
250					OVM < Detect
					Saturated sediment begins at 252 Ft.
	SS-15 251.5'-254' 1/7/98	2.5' Rcd		252'-254': Sandy Gravel (sG) 60% gravel (tr sm. cob, 30% v.cse-cse peb, 50% med, 20% fn-v.fn peb), 30% sand, 10% silt, wet, poorly sorted, gravel subround to round, 30% basalt, 70% other, max gravel size 6-7 cm	SS-15: ~~151.5'-154'~~ 251.5'-254'
					B0MJK6 Chem rad
					B0MK98 VOA trip
					B0MJK8 Physical Prop.
					End shift ~~1-8~~ 1-7-98 at 254 Ft.
					8" casing at 250 Ft.
					TD = 254 Ft bgs

A-6000-382 (01/93)

APPENDIX B3

SURVEY REPORT FOR CHARACTERIZATION BOREHOLE 299-E33-333

Survey Data Report

ERC Project: 22192	Prepared By: **Company: Rogers Surveying, Inc.**
Date of Survey: **January 30, 1998**	Surveyor: **Gary B. Wagner**
ERC Point of Contact: **Mr. Randy Havenor**	Survey Company Point of Contact: **Gary B. Wagner**
Description of Work: **Civil Survey for Bore Hole B 8079**	Horizontal Datum: **NAD83(91)**
	Vertical Datum: **NAVD88**
	Units: **Meters**
	Hanford Area Designation: 200 East

Coordinate System: **Washington State Plane Coordinates (South Zone)**

Horizontal Control Monuments: GPS #40 and GPS #2 from U.S. D.O.E. Aerial Mapping Control for Hanford 200 East Area.

Vertical Control Monuments: HSWB 032 from U.S. D.O.E. "Secondary Vertical Control Network – Phase II"

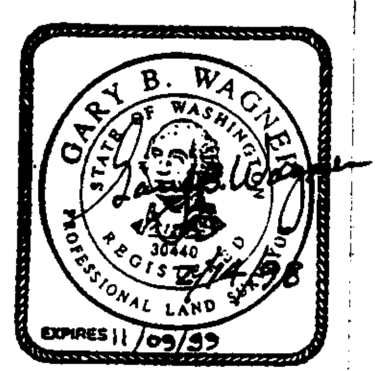
Wellname:	Easting	Northing	Elevation	
B 8079 Borehole				Center of Casing
				"X" on rim
	574,086.410	137,181.278	199.163	Brass Cap

Notes: Elevation taken to top of B 8079 brass cap set in concrete.
Cap is stamped B 8079
Abandoned
January 13, 1998

Surveyor Statement:

I, Gary B. Wagner, a professional land surveyor registered in the state of Washington (Registration No. 30440), hereby certify that this report is based on a field survey performed in January, 1997 under my direct supervision and that the data contained here is true and correct.

Certification/Seal



APPENDIX C

SUMMARY OF CHARACTERIZATION BOREHOLE 299-E33-333 ANALYTICAL RESULTS

APPENDIX C1

SUMMARY OF CHEMICAL ANALYTICAL RESULTS

Table C1-1. Volatile Organic Analytical Results for 216-B-2-2 Characterization Borehole, 299-E33-333.

					Target Volatile Organic Results									
Sample Interval		SAF B98-004			Acetone	1-Butanol	2-Butanone	Carbon Tetrachloride	Chloroform	Diethyl Ether	Methylene Chloride	Toluene	1,1,1-Trichloroethane	1,1,2-Trichloroethane
Top Depth (ft bgs)	Bottom Depth (ft bgs)	HEIS Number	Sample Date	CAS	67-64-1	71-36-3	78-93-3	56-23-5	67-66-3	60-29-7	75-09-2	108-88-3	71-55-6	79-00-5
				Units	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
				QL	25	220	25	5	5	10	5	5	5	5
4	6.5	B0MJC2	(a)		NA(a)	NA(a)	NA(a)	NA(a)	NA(a)	NA(a)	NA(a)	NA(a)	NA(a)	NA(a)
8	10.5	B0MJC5	12/29/97		12 U	220 U	22 U	5 U	5 U	11 U	10 U	5 U	5 U	5 U
10.5	13	B0MJC8	12/30/97		24 UJ	240 UJ	24 UJ	6 UJ	6 UJ	12 UJ	10 UJ	6 UJ	6 UJ	6 UJ
13	15.5	B0MJD1	12/30/97		21 U	210 U	21 U	5 U	5 U	10 U	10 U	5 U	5 U	5 U
20	22.5	B0MJD7	12/31/97		24 U	210 U	21 U	5 U	5 U	10 U	2 J	5 U	5 U	5 U
20	22.5	B0MJF0	12/31/97		36 U	210 U	21 U	5 U	5 U	10 U	2 J	5 U	5 U	5 U
30	32.5	B0MJF3	12/31/97		40 U	220 U	22 U	5 U	5 U	11 U	2 J	5 U	5 U	5 U
40	42.5	B0MJJ1	12/31/97		14 U	210 U	21 U	5 U	5 U	10 U	2 J	5 U	5 U	5 U
50	52.5	B0MJJ4	12/31/97		25 U	200 U	20 U	5 U	5 U	10 U	3 J	5 U	5 U	5 U
75	77.5	B0MJF6	1/2/98		17 BJ	210 U	21 U	5 U	5 U	10 U	5 U	5 U	5 U	5 U
100	102.5	B0MJF9	1/3/98		17 BJ	210 U	21 U	5 U	5 U	10 U	5 U	5 U	5 U	5 U
150	152.5	B0MJJ7	1/5/98		20 U	200 U	20 U	5 U	5 U	10 U	5 U	2 J	5 U	5 U
174	179	B0MJK0	1/5/98		18 BJ	210 U	21 U	5 U	5 U	11 U	2 BJ	5 U	5 U	5 U
251.5	254	B0MJK6	1/7/98		22 B	220 U	22 U	5 U	5 U	11 U	5 U	5 U	5 U	5 U

(a) Insufficient sample for volatile organic analyses (VOA)
(b) Also identified as a semivolatile TIC at a concentration of 240 JN µg/kg.
NA Not Analyzed
U Analyzed for but not detected. Value reported is the quantitation limit.
J Concentration is estimated.
B Also detected in laboratory blank
N Tentatively Identified Compound.
CAS = Chemical Abstracts Service registry number (or HEIS identification number)
QL = Quantitation Limit
SAF = Sampling Authorization Form

					Nontarget Volatile Organic Detections	Tentatively Identified Compounds (TICs)	
Sample Interval		SAF B98-004			Xylenes (total)	2-Ethyl-1-Hexanol	1,2,4-Trimethylbenzene
Top Depth (ft bgs)	Bottom Depth (ft bgs)	HEIS Number	Sample Date	CAS	1330-20-7	104-76-7	95-63-6
				Units	µg/kg	µg/kg	µg/kg
				QL	10		
4	6.5	B0MJC2	(a)		NA (a)	NA (a)	NA (a)
8	10.5	B0MJC5	12/29/97				
10.5	13	B0MJC8	12/30/97				
13	15.5	B0MJD1	12/30/97			6 JN	
20	22.5	B0MJD7	12/31/97				
20	22.5	B0MJF0	12/31/97				
30	32.5	B0MJF3	12/31/97			6 JN	
40	42.5	B0MJJ1	12/31/97				
50	52.5	B0MJJ4	12/31/97				
75	77.5	B0MJF6	1/2/98				
100	102.5	B0MJF9	1/3/98				
150	152.5	B0MJJ7	1/5/98		8		10 JN
174	179	B0MJK0	1/5/98				
251.5	254	B0MJK6	1/7/98			12 JN (b)	

Table C1-2a. Semivolatile Organic Analytical Results for 216-B-2-2 Characterization Borehole, 299-E33-333.

Target Semivolatile Organic Results						
Sample Interval		SAF B98-004			Naphthalene	Tributyl phosphate
Top Depth (ft bgs)	Bottom Depth (ft bgs)	HEIS Number	Sample Date	CAS	91-20-3	126-73-8
				Units	µg/kg	µg/kg
				QL	330	700
4	6.5	B0MJC2	12/29/97		330 U	660 U
8	10.5	B0MJC5	12/29/97		360 U	720 U
10.5	13	B0MJC8	12/30/97		390 U	770 U
13	15.5	B0MJD1	12/30/97		350 U	690 U
20	22.5	B0MJD7	12/31/97		340 U	680 U
20	22.5	B0MJF0	12/31/97		340 U	690 U
30	32.5	B0MJF3	12/31/97		350 U	710 U
40	42.5	B0MJJ1	12/31/97		340 U	680 U
50	52.5	B0MJJ4	12/31/97		340 U	670 U
75	77.5	B0MJF6	1/2/98		340 U	680 U
100	102.5	B0MJF9	1/3/98		340 U	680 U
150	152.5	B0MJJ7	1/5/98		340 U	680 U
174	179	B0MJK0	1/5/98		350 U	680 U
251.5	254	B0MJK6	1/7/98		350 U	710 U

(a) For B0MJC2, insufficient sample for % moisture; data reported assuming 100% solids
U Analyzed for but not detected. Value reported is the quantitation limit.
J Concentration is estimated.
B Also detected in laboratory blank.
N Tentatively Identified Compound.
CAS = Chemical Abstracts Service registry number (or HEIS identification number)
QL = Quantitation Limit
SAF = Sampling Authorization Form

Nontarget Semivolatile Organic Detections							Tentatively Identified Compounds (TICs)	
Sample Interval		SAF B98-004			Butylbenzylphthalate	Di-n-octylphthalate	Hexadecanoic Acid (9 CI)	Octadecanoic Acid
Top Depth (ft bgs)	Bottom Depth (ft bgs)	HEIS Number	Sample Date	CAS	85-68-7	117-84-0	57-10-3	57-11-4
				Units	µg/kg	µg/kg	µg/kg	µg/kg
				QL	330	330		
4	6.5	B0MJC2	12/29/97					
8	10.5	B0MJC5	12/29/97					
10.5	13	B0MJC8	12/30/97					
13	15.5	B0MJD1	12/30/97			52 J		
20	22.5	B0MJD7	12/31/97					
20	22.5	B0MJF0	12/31/97					
30	32.5	B0MJF3	12/31/97					
40	42.5	B0MJJ1	12/31/97					
50	52.5	B0MJJ4	12/31/97					
75	77.5	B0MJF6	1/2/98		230 J		560 BJN	91 JN
100	102.5	B0MJF9	1/3/98		220 J		450 BJN	
150	152.5	B0MJJ7	1/5/98				380 BJN	
174	179	B0MJK0	1/5/98		230 J		560 BJN	86 JN
251.5	254	B0MJK6	1/7/98		240 J		740 BJN	140 JN

Table C1-2b. Polychlorinated Biphenyl (PCB) Analytical Results for 216-B-2-2 Characterization Borehole, 299-E33-333.

Target Polychlorinated Biphenyl (PCB) Results											
Sample Interval		SAF B98-004			Aroclor-1016	Aroclor-1221	Aroclor-1232	Aroclor-1242	Aroclor-1248	Aroclor-1254	Aroclor-1260
Top Depth (ft bgs)	Bottom Depth (ft bgs)	HEIS Number	Sample Date	CAS	12674-11-2	11104-28-2	11141-16-5	53469-21-9	12672-29-6	11097-69-1	11096-82-5
				Units	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg	µg/kg
				QL	33	33	33	33	33	33	33
4	6.5	B0MJC2	12/29/97		33 U	33 U	33 U	33 U	33 U	33 U	33 U
8	10.5	B0MJC5	12/29/97		36 UR	36 UR	36 UR	36 UR	36 UR	36 UR	9200 J
10.5	13	B0MJC8	12/30/97		39 UR	39 UR	39 UR	39 UR	39 UR	39 UR	150 J
13	15.5	B0MJD1	12/30/97		35 UR	35 UR	35 UR	35 UR	35 UR	35 UR	1100 J
20	22.5	B0MJD7	12/31/97		34 UR	34 UR	34 UR	34 UR	34 UR	34 UR	34 UR
20	22.5	B0MJF0	12/31/97		34 UR	34 UR	34 UR	34 UR	34 UR	34 UR	34 UR
30	32.5	B0MJF3	12/31/97		36 UR	36 UR	36 UR	36 UR	36 UR	36 UR	36 UR
40	42.5	B0MJJ1	12/31/97		34 UR	34 UR	34 UR	34 UR	34 UR	34 UR	34 UR
50	52.5	B0MJJ4	12/31/97		34 UR	34 UR	34 UR	34 UR	34 UR	34 UR	34 UR
75	77.5	B0MJF6	1/2/98		34 U	34 U	34 U	34 U	34 U	34 U	34 U
100	102.5	B0MJF9	1/3/98		34 U	34 U	34 U	34 U	34 U	34 U	34 U
150	152.5	B0MJJ7	1/5/98		34 UJ	34 UJ	34 UJ	34 UJ	34 UJ	34 UJ	34 UJ
174	179	B0MJK0	1/5/98		35 UJ	35 UJ	35 UJ	35 UJ	35 UJ	35 UJ	35 UJ
251.5	254	B0MJK6	1/7/98		36 UJ	36 UJ	36 UJ	36 UJ	36 UJ	36 UJ	36 UJ

U Analyzed for but not detected. Value reported is the quantitation limit.
R Data are unusable as a result of a Quality Control deficiency.
J Concentration is estimated.
CAS Chemical Abstracts Service registry number (or HEIS identification number)
QL Quantitation Limit
SAF Sampling Authorization Form
Note: Two unknown PCBs identified in sample B0MJC5 as semivolatile Tentatively Identified Compounds at concentrations of 240 J and 380 J µg/kg.

Table C1-3. General Chemistry Analytical Results for 216-B-2-2 Characterization Borehole, 299-E33-333.

Target General Chemistry Results										
Sample Interval		SAF B98-004			Nitrogen in Ammonia	Cyanide	Nitrogen in Nitrate	Nitrogen in Nitrite	Nitrate/Nitrite	Sulfate
Top Depth (ft bgs)	Bottom Depth (ft bgs)	HEIS Number	Sample Date	CAS	NH3-N	57-12-5	NO3-N	NO2-N	NO2+NO3-N	14808-79-8
				Units	µg/g	µg/g	µg/g	µg/g	µg/g	µg/g
				QL	0.5	0.5	0.2	0.2	0.5	5
4	6.5	B0MJC2	12/29/97		0.533	NA(a)	35.8 J	0.380	32.4 J	32.2
8	10.5	B0MJC5	12/29/97		0.547 U	0.548 UJ	31.1 J	0.214 U	26.7 J	43.3
10.5	13	B0MJC8	12/30/97		0.587 U	0.588 UJ	13.0 J	0.231 U	11.7 J	18.8
13	15.5	B0MJD1	12/30/97		0.523 U	0.527 UJ	13.5 J	0.209 U	11.8 J	26.0
20	22.5	B0MJD7	12/31/97		0.518 U	0.517 UJ	4.07	0.206 U	3.48 J	8.88
20	22.5	B0MJF0	12/31/97		0.517 U	0.517 UJ	4.16	0.191 U	3.34 J	9.11
30	32.5	B0MJF3	12/31/97		0.536 U	0.539 UJ	6.02	0.214 U	4.98 J	13.6
40	42.5	B0MJJ1	12/31/97		0.514 U	0.517 UJ	0.341	0.200 U	0.514 UJ	5.01 U
50	52.5	B0MJJ4	12/31/97		0.512 U	0.512 UJ	0.196 U	0.196 U	0.512 UJ	4.91 U
75	77.5	B0MJF6	1/2/98		0.517 U	0.517 U	0.207 U	0.207 U	0.517 UJ	5.17 U
100	102.5	B0MJF9	1/3/98		0.510 U	0.514 U	0.203 U	0.203 U	0.510 UJ	5.07 U
150	152.5	B0MJJ7	1/5/98		0.509 U	0.510 UJ	0.204 U	0.204 U	0.509 UJ	5.10 U
174	179	B0MJK0	1/5/98		0.530 U	0.529 UJ	0.206 U	0.206 U	0.529 UJ	10.1
251.5	254	B0MJK6	1/7/98		0.538 U	0.538 U	0.256	0.214 U	0.539 UJ	18.4

(a) Insufficient sample for cyanide analysis
U Analyzed for but not detected. Value reported is the quantitation limit.
J Concentration is estimated.
CAS Chemical Abstracts Service registry number (or HEIS identification number)
QL Quantitation Limit
SAF Sampling Authorization Form

Table C1-4. Inorganic (Metal) Analytical Results for 216-B-2-2 Characterization Borehole, 299-E33-333. (2 Sheets)

Target Inorganic (Metal) Results																	
Sample Interval		SAF B98-004			Arsenic	Barium	Beryllium	Bismuth	Boron	Cadmium	Chromium	Copper	Iron	Lead	Manganese	Mercury
Top Depth (ft bgs)	Bottom Depth (ft bgs)	HEIS Number	Sample Date	CAS	7440-38-2	7440-39-3	7440-41-7	7440-69-9	7440-42-8	7440-43-9	7440-47-3	7440-50-8	7439-89-6	7439-92-1	7439-96-5	7439-97-6
				Units	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
				QL	1	20	0.5	20	20	0.5	1	2.5	10	0.3	1.5	0.035
4	6.5	B0MJC2	12/29/97		2.6	58.1	0.54	27.5	5.1 B	0.33 UN	9.7	13.0	20000 J	4.7	277 J	0.02 U
8	10.5	B0MJC5	12/29/97		3.0	89.4	0.70	37.1	6.3 B	0.36 UN	8.5	14.6	25000 J	7.5	356 J	0.14
10.5	13	B0MJC8	12/30/97		1.9	72.6	0.57 B	36.5	5.5 B	0.39 UN	9.4	13.1	21900 J	3.9	320 J	0.02 U
13	15.5	B0MJD1	12/30/97		2.0	73.1	0.56	31.0	5.4 B	0.35 UN	9.6	14.9	22000 J	6.9	315 J	0.15
20	22.5	B0MJD7	12/31/97		1.4	58.9	0.36 B	21.9	3.4 B	0.34 UN	7.5	8.9	13400 J	2.5	208 J	0.02 U
20	22.5	B0MJF0	12/31/97		1.6	40.4	0.34 B	22.3	2.8 B	0.34 UN	6.2	13.9	12500 J	2.7	183 J	0.02 U
30	32.5	B0MJF3	12/31/97		3.5	61.2	0.42 B	23.0	4.9 B	0.36 UN	11.2	10.1	14800 J	4.8	330 J	0.02 U
40	42.5	B0MJJ1	12/31/97		3.4	47.3	0.40 B	22.3	3.6 B	0.34 UN	10.2	11.2	13900 J	2.9	229 J	0.02 U
50	52.5	B0MJJ4	12/31/97		2.7	33.7	0.34 B	19.1 B	3.5 B	0.34 UN	8.1	7.3	12400 J	3.0	191 J	0.02 U
75	77.5	B0MJF6	1/2/98		3.7	55.5	0.37 B	20.1 B	5.0 B	0.34 UN	9.5	8.9	13500 J	4.1	254 J	0.02 U
100	102.5	B0MJF9	1/3/98		3.7	52.0	0.38 B	26.2	4.7 B	0.34 UN	14.0	10.5	15800 J	3.3	233 J	0.02 U
150	152.5	B0MJJ7	1/5/98		2.6	43.1	0.30 B	19.3 B	2.9 B	0.34 UN	9.1	10.5	12900 J	2.4	199 J	0.02 U
174	179	B0MJK0	1/5/98		3.3	61.7	0.42 B	23.5	4.9 B	0.35 UN	15.7	14.8	16700 J	3.3	274 J	0.02 U
251.5	254	B0MJK6	1/7/98		0.72 BJ	31.3	0.23 B	12.4 B	3.0 B	0.36 UN	7.8	6.7	8930 J	1.4	147 J	0.02 U

U Analyzed for but not detected. Value reported is the quantitation limit.
J Concentration is estimated.
B Applied to inorganic analyses only. Concentration greater than or equal to the instrument detection limit but less than the contract-required detection limit.
N Spiked sample recovery not within control limits.
E Applied to inorganic analyses only. Concentration is estimated because of the presence of interference.
CAS = Chemical Abstracts Service registry number (or HEIS identification number)
QL = Quantitation Limit
SAF = Sampling Authorization Form

Nontarget Inorganic (Metal) Detections										
Sample Interval		SAF B98-004			Aluminum	Antimony	Calcium	Cobalt	Magnesium	Sodium
Top Depth (ft bgs)	Bottom Depth (ft bgs)	HEIS Number	Sample Date	CAS	7429-90-5	7440-36-0	7440-70-2	7440-48-4	7439-95-4	7440-23-5
				Units	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
				QL	5	5	10	1	10	15
4	6.5	B0MJC2	12/29/97		5710 J	5.0 BJN	5430	8.7	3780	302 BE
8	10.5	B0MJC5	12/29/97		6320 J	4.7 UJN	8760	11.4	4390	494 BE
10.5	13	B0MJC8	12/30/97		7090 J	5.0 UJN	5220	9.4	4600	671 E
13	15.5	B0MJD1	12/30/97		5510 J	4.5 UJN	5850	9.8	3730	374 BE
20	22.5	B0MJD7	12/31/97		4420 J	4.4 UJN	6510	5.7	3160	281 BE
20	22.5	B0MJF0	12/31/97		4300 J	4.4 UJN	5840	5.4	2920	271 BE
30	32.5	B0MJF3	12/31/97		6290 J	4.6 UJN	8110	5.9	4690	231 BE
40	42.5	B0MJJ1	12/31/97		5660 J	4.4 UJN	16100	5.1 B	4820	252 BE
50	52.5	B0MJJ4	12/31/97		4520 J	4.4 UJN	7410	4.1 B	3890	229 BE
75	77.5	B0MJF6	1/2/98		6090 J	4.4 UJN	9130	5.1 B	5110	122 BE
100	102.5	B0MJF9	1/3/98		6980 J	4.4 UJN	7830	6.8	5600	151 BE
150	152.5	B0MJJ7	1/5/98		4930 J	4.3 UJN	5260	5.5	3970	151 BE
174	179	B0MJK0	1/5/98		6850 J	4.5 UJN	7810	7.2	5230	226 BE
251.5	254	B0MJK6	1/7/98		3530 J	4.6 UJN	2920	4.6 B	2300	265 BE

Table C1-4. Inorganic (Metal) Analytical Results for 216-B-2-2 Characterization Borehole, 299-E33-333. (2 Sheets)

Target Inorganic (Metal) Results												
Sample Interval		SAF B98-004			Nickel	Potassium	Selenium	Silver	Tin	Vanadium	Zinc
Top Depth (ft bgs)	Bottom Depth (ft bgs)	HEIS Number	Sample Date	CAS	7440-02-0	7440-09-7	7782-49-2	7440-22-4	7440-31-5	7440-62-2	7440-66-6
				Units	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
				QL	4	500	0.5	1	10	5	2
4	6.5	B0MJC2	12/29/97		9.6	1210	0.45 B	0.73 B	3.5 UJN	47.3	36.8 E
8	10.5	B0MJC5	12/29/97		10.2	1090	0.32 B	0.86 B	3.8 UJN	70.2	58.1 E
10.5	13	B0MJC8	12/30/97		12.8	1110	0.45 B	0.71 U	4.1 UJN	51.5	41.2 E
13	15.5	B0MJD1	12/30/97		10.2	950	0.23 U	0.63 U	3.7 UJN	60.4	52.0 E
20	22.5	B0MJD7	12/31/97		7.5	773	0.23 U	0.62 U	3.6 UJN	30.0	26.9 E
20	22.5	B0MJF0	12/31/97		6.3	668	0.36 B	0.62 U	3.6 UJN	31.0	25.2 E
30	32.5	B0MJF3	12/31/97		12.9	1380	0.24 U	0.65 U	3.8 UJN	27.5	33.4 E
40	42.5	B0MJJ1	12/31/97		13.0	972	0.26 B	0.62 B	3.6 UJN	26.5	28.3 E
50	52.5	B0MJJ4	12/31/97		7.9	1010	0.23 U	0.61 U	3.6 UJN	23.7	28.5 E
75	77.5	B0MJF6	1/2/98		9.0	1320	0.50 B	0.79 B	3.6 UJN	22.7	29.0 E
100	102.5	B0MJF9	1/3/98		14.6	1050	0.26 B	0.62 U	3.6 UJN	32.1	33.0 E
150	152.5	B0MJJ7	1/5/98		13.9	870	0.32 B	0.61 U	3.6 UJN	28.1	24.7 E
174	179	B0MJK0	1/5/98		15.0	1490	0.42 B	0.64 U	3.7 UJN	37.7	33.2 E
251.5	254	B0MJK6	1/7/98		7.0	579	0.24 U	0.65 U	3.8 UJN	22.9	18.5 E

U Analyzed for but not detected. Value reported is the quantitation limit.
J Concentration is estimated.
B Applied to inorganic analyses only. Concentration greater than or equal to the instrument detection limit but less than the contract-required detection limit.
N Spiked sample recovery not within control limits.
E Applied to inorganic analyses only. Concentration is estimated because of the presence of interference.
CAS = Chemical Abstracts Service registry number (or HEIS identification number)
QL = Quantitation Limit
SAF = Sampling Authorization Form

APPENDIX C2

SUMMARY OF RADIOLOGICAL ANALYTICAL RESULTS

Table C2. Radiological Analytical Results for 216-B-2-2 Characterization Borehole, 299-E33-333. (3 Sheets)

Target Radionuclide Results

Sample Interval		SAF B98-004			Americium-241	Cesium-137	Cobalt-60	Curium-244	Europium-152	Europium-154	Europium-155	Gross alpha	Gross beta	Iodine-129	Neptunium-237
Top Depth (ft bgs)	Bottom Depth (ft bgs)	HEIS Number	Sample Date	CAS	14596-10-2	10045-97-3	10198-40-0	13981-15-2	14683-23-9	15585-10-1	14391-16-3	12587-46-1	12587-47-2	15046-84-1	13994-20-2
				Units	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g
				QL	0.1 (a)	0.02	0.02	0.02	0.04	0.06	0.04	5	6	0.6	0.05
4	6.5	B0MJC2	12/29/97		0.00676 U	0.393	-0.00801 U	0.00422 U	-0.00540 U	-0.0547 U	0.0371 U	11.1	26.4	-0.00634 U	-0.00124 U
8	10.5	B0MJC5	12/29/97		0.589	71.4	-0.00207 U	0.433 U	-0.0827 U	1.29	0.987 U	12.1	10000	-0.338 U	0.256 U
10.5	13	B0MJC8	12/30/97		0.0615 J	6.30	-0.00103 U	-0.00101 U	-0.0338 U	0.0273 U	0.0751 U	11.1	279	-0.0571 U	-0.00876 U
13	15.5	B0MJD1	12/30/97		1.49 U	100	-0.00159 U	-0.0326 U	-0.0969 U	0.774	0.672 U	9.76 J	13900	0.688 U	0.00 U
20	22.5	B0MJD7	12/31/97		0.0295 J	-0.00106 U	0.0107 U	-0.00034 U	-0.0195 U	0.00500 U	0.0212 U	2.06 U	22.0	0.328 U	0.0447 UJ
20	22.5	B0MJF0	12/31/97		0.00408 U	-0.00544 U	-0.0197 U	0.00445 U	-0.0174 U	-0.00496 U	0.0358 U	3.58 U	21.4	0.000452 U	0.0114 U
30	32.5	B0MJF3	12/31/97		0.00419 U	-0.0129 U	-0.00175 U	-0.00073 U	-0.00109 U	0.00283 U	0.0319 U	6.00 J	25.7	-0.0144 U	0.0155 U
40	42.5	B0MJJ1	12/31/97		0.00484 U	-0.00455 U	0.00297 U	0.00895 U	0.00432 U	0.0274 U	0.0362 U	5.28 J	28.1	-0.0104 U	0.0160 U
50	52.5	B0MJJ4	12/31/97		0.00831 U	-0.00668 U	-0.00895 U	0.00 U	-0.0143 U	0.00276 U	0.0502 U	8.32 J	24.5	0.0320 U	0.0455 UJ
75	77.5	B0MJF6	1/2/98		0.00829 U	-0.0171 U	0.00581 U	0.00 U	-0.0695 U	0.0312 U	0.0327 U	9.14 J	32.6	-0.0391 U	0.0156 U
100	102.5	B0MJF9	1/3/98		0.0146 UJ	-0.00537 U	0.00732 U	0.00304 U	-0.0123 U	-0.0306 U	0.0170 U	9.76 J	29.9	-0.0563 U	-0.00251 U
150	152.5	B0MJJ7	1/5/98		0.0105 U	0.00495 U	0.00181 U	0.0120 U	0.00754 U	0.00384 U	0.0374 U	2.96 U	27.4	-0.0119 U	0.0147 U
174	179	B0MJK0	1/5/98		-0.000713 U	-0.00789 U	-0.00075 U	0.00448 U	-0.00373 U	0.00449 U	0.0567 U	7.52 J	18.8	-0.0248 U	-0.00329 U
251.5	254	B0MJK6	1/7/98		0.0161 J (c)	0.00649 U	0.00630 U	-0.00032 U	-0.00918 U	-0.0609 U	0.0272 U	7.17 J	21.5	0.0423 U	0.0149 U

(a) Sample B0MJC5 concentration based on gamma spectrometry (QL = 0.2 pCi/g)
(b) Concentration considered an estimate because counting error within factor of two of result; qualifier added by author of this report
(c) Concentration equal to counting error and is likely a nondetect.
N/A Not Applicable
NA Not Analyzed
U Analyzed for but not detected above the minimum detectable activity in sample. Value reported is the result.
J Concentration is estimated
CAS = Chemical Abstracts Service registry number (or HEIS identification number)
QL = Quantitation Limit
SAF = Sampling Authorization Form

Nontarget Radionuclide Detections

Sample Interval		SAF B98-004			Potassium-40	Radium-224	Radium-226	Radium-228
Top Depth (ft bgs)	Bottom Depth (ft bgs)	HEIS Number	Sample Date	CAS	13966-00-2	13233-32-4	13982-63-3	15262-20-1
				Units	pCi/g	pCi/g	pCi/g	pCi/g
				QL	0.1	0.1	0.1	0.2
4	6.5	B0MJC2	12/29/97		15.0	0.910	0.762	0.917
8	10.5	B0MJC5	12/29/97		12.0	0.640	0.552	0.696
10.5	13	B0MJC8	12/30/97		13.7	0.690	0.563	0.741
13	15.5	B0MJD1	12/30/97		11.3	0.626		0.629
20	22.5	B0MJD7	12/31/97		14.0	0.520	0.444	0.487
20	22.5	B0MJF0	12/31/97		14.7	0.589	0.516	0.609
30	32.5	B0MJF3	12/31/97		16.8	0.742	0.607	0.745
40	42.5	B0MJJ1	12/31/97		17.1	0.625	0.514	0.585
50	52.5	B0MJJ4	12/31/97		16.5	0.632	0.527	0.732
75	77.5	B0MJF6	1/2/98		18.4	0.625	0.524	0.688
100	102.5	B0MJF9	1/3/98		18.5	0.619	0.534	0.665
150	152.5	B0MJJ7	1/5/98		15.0	0.532	0.426	0.532
174	179	B0MJK0	1/5/98		14.3	0.636	0.609	0.625
251.5	254	B0MJK6	1/7/98		14.2	0.632	0.670	0.792

Table C2. Radiological Analytical Results for 216-B-2-2 Characterization Borehole, 299-E33-333. (3 Sheets)

					Target Radionuclide Results								
Sample Interval		SAF B98-004			Plutonium-238	Plutonium-239/240	Plutonium-241	Selenium-79	Strontium-90	Technetium-99	Thorium-228	Thorium-230	Thorium-232
Top Depth (ft bgs)	Bottom Depth (ft bgs)	HEIS Number	Sample Date	CAS	13981-16-3	PU-239/240	14119-32-5	15758-45-9	10098-97-2	14133-76-7	14274-82-9	14269-63-7	TH-232
				Units	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g	pCi/g
				QL	0.02	0.03	2	2	0.1	0.8	0.1	0.04	0.04
4	6.5	B0MJC2	12/29/97		0.00 U	0.00914 U	-0.235 U	-0.991 U	0.110 U	-0.338 U	0.733	0.565 J	0.743 J
8	10.5	B0MJC5	12/29/97		-0.121 U	0.348 U	32.2 U	-23.7 U	3780	-28.2 U	1.24 U	2.67 J	0.00 U
10.5	13	B0MJC8	12/30/97		-0.000860 U	0.0107 U	0.999 U	-0.442 U	86.7	0.193 U	0.931	0.689 J	0.888 J
13	15.5	B0MJD1	12/30/97		0.431 U	4.97 J (b)	61.6 U	-17.7 U	4710	-15.3 U	2.17 U	-0.0454 U	1.14 U
20	22.5	B0MJD7	12/31/97		0.0213 J (b)	-0.000425 U	0.465 U	0.178 U	0.0937 U	-0.111 U	0.528	0.489 J	0.535 J
20	22.5	B0MJF0	12/31/97		-0.00130 U	0.00616 U	0.224 U	0.101 U	0.0779 U	-0.212 U	-0.00205 U	0.0365 J	0.00 U
30	32.5	B0MJF3	12/31/97		0.00437 U	0.00 U	-0.00644 U	-0.496 U	0.0244 U	-0.256 U	0.975	0.811 J	1.02 J
40	42.5	B0MJJ1	12/31/97		-0.00141 U	0.00 U	0.591 U	-0.376 U	0.0163 U	-0.450 U	0.873	0.586 J	0.791 J
50	52.5	B0MJJ4	12/31/97		-0.00136 U	-0.00136 U	-0.602 U	-0.328 U	0.0203 U	-0.633 U	0.857	0.511 J	0.938 J
75	77.5	B0MJF6	1/2/98		0.00 U	0.00 U	-0.316 U	-1.38 U	0.0553 U	0.241 U	0.994	0.614 J	0.928 J
100	102.5	B0MJF9	1/3/98		0.00545 U	0.00454 U	0.252 U	-0.369 U	-0.0184 U	-0.525 U	1.47	0.629 J	1.03 J
150	152.5	B0MJJ7	1/5/98		-0.00046 U	0.00525 U	0.255 U	-0.386 U	0.0145 U	0.323 U	0.562	0.426 J	0.657 J
174	179	B0MJK0	1/5/98		-0.00047 U	0.00 U	-1.31 U	-0.635 U	0.0110 U	0.180 U	0.735	0.691 J	0.683 J
251.5	254	B0MJK6	1/7/98		-0.00043 U	0.00531 U	0.0791 U	0.0402 U	0.00334 U	0.494 U	0.551	0.470 J	0.485 J

(a) Sample B0MJC5 concentration based on gamma spectrometry (QL = 0.2 pCi/g).
(b) Concentration considered an estimate because counting error within factor of two of result; qualifier added by author of this report.
(c) Concentration equal to counting error and is likely a nondetect
N/A Not Applicable
NA Not Analyzed
U Analyzed for but not detected above the minimum detectable activity in sample. Value reported is the result.
J Concentration is estimated.
CAS = Chemical Abstracts Service registry number (or HEIS identification number)
QL = Quantitation Limit
SAF = Sampling Authorization Form

Table C2. Radiological Analytical Results for 216-B-2-2 Characterization Borehole, 299-E33-333. (3 Sheets)

					Target Radionuclide Results			
Sample Interval		SAF B98-004			Uranium	Uranium-234	Uranium-235	Uranium-238
Top Depth (ft bgs)	Bottom Depth (ft bgs)	HEIS Number	Sample Date	CAS	7440-61-1	13966-29-5	15117-96-1	U-238
				Units	µg/g	pCi/g	pCi/g	pCi/g
				QL	0.0002	2	3	2
4	6.5	B0MJC2	12/29/97		1.36	NA	NA	0.652 J (b)
8	10.5	B0MJC5	12/29/97		2.31	NA	NA	NA
10.5	13	B0MJC8	12/30/97		1.87	NA	NA	NA
13	15.5	B0MJD1	12/30/97		2.38	0.388 U	-0.148 U	1.81 U
20	22.5	B0MJD7	12/31/97		1.54	NA	NA	0.609 J (b)
20	22.5	B0MJF0	12/31/97		1.39	NA	NA	0.576 J (b)
30	32.5	B0MJF3	12/31/97		2.20	NA	NA	NA
40	42.5	B0MJJ1	12/31/97		1.91	NA	NA	NA
50	52.5	B0MJJ4	12/31/97		2.07	NA	NA	NA
75	77.5	B0MJF6	1/2/98		1.78	NA	0.0593 U	0.366 J (b)
100	102.5	B0MJF9	1/3/98		1.70	NA	0.0196 U	NA
150	152.5	B0MJJ7	1/5/98		1.40	NA	NA	0.588 J (b)
174	179	B0MJK0	1/5/98		1.97	NA	NA	0.412 J (b)
251.5	254	B0MJK6	1/7/98		1.46	NA	NA	0.653 J (b)

(a) Sample B0MJC5 concentration based on gamma spectrometry (QL = 0.2 pCi/g).
(b) Concentration considered an estimate because counting error within factor of two of result; qualifier added by author of this report.
(c) Concentration equal to counting error and is likely a nondetect.
N/A Not Applicable
NA Not Analyzed
U Analyzed for but not detected above the minimum detectable activity in sample. Value reported is the result.
J Concentration is estimated
CAS = Chemical Abstracts Service registry number (or HEIS identification number)
QL = Quantitation Limit
SAF = Sampling Authorization Form

APPENDIX C3

SUMMARY OF PHYSICAL PROPERTY RESULTS

Table C3. Physical Property Analytical Results for 216-B-2-2 Characterization Borehole, 299-E33-333. (3 Sheets)

Target Physical Property Results												
Sample Interval		SAF B98-004				pH Measurement	Total Organic Carbon	Water Content	Cation Exchange Capacity	Specific Gravity	Dry Bulk Density	
Top Depth (ft bgs)	Bottom Depth (ft bgs)	HEIS Number (chemical)	HEIS Number (physical)	Sample Date	CAS	PH	TOC				Laboratory	Field
					Units	pH units	µg/g	% (a)	meq/100g (b)	(none)	g/cm3	g/cm3
					QL	N/A	25	0.5	0.01	N/A	N/A	(c)
4	6.5	B0MJC2	B0MJC4	12/29/97		8.17 J	NA	6.8	7.8	2.51	NA	NA (d)
8	10.5	B0MJC5	B0MJC7	12/29/97		8.27 J	NA	9.4	9.3	2.56	NA	1.6
10.5	13	B0MJC8	B0MJD0	12/30/97		8.74 J	NA	4.5	6.3 U	2.43	NA	2.0
13	15.5	B0MJD1	B0MJD3	12/30/97		8.44 J	NA	3.7	7.0	2.57	NA	1.9
15.5	18	B0MJD4	B0MJD6	12/30/97		8.40 J	206	4.0	6.2 U	2.57	1.8	NA
20	22.5	B0MJD7	B0MJD9	12/31/97		8.32 J	NA	3.4	7.3	2.61	NA	NA (d)
20	22.5	B0MJF0		12/31/97		8.45 J	NA					
30	32.5	B0MJF3	B0MJF5	12/31/97		8.18 J	NA	11.0	11.9	2.38	NA	1.7
40	42.5	B0MJJ1	B0MJJ3	12/31/97		8.19 J	342	3.4	6.2 U	2.55	NA	NA
50	52.5	B0MJJ4	B0MJJ6	12/31/97		8.19 J	NA	2.4	6.1 U	2.61	NA	1.7
75	77.5	B0MJF6	B0MJF8	1/2/98		8.46 J	NA	3.3	6.3	2.60	NA	1.6
100	102.5	B0MJF9	B0MJH1	1/3/98		8.52 J	NA	3.1	6.2 U	2.56	1.5	NA
150	152.5	B0MJJ7	B0MJJ9	1/5/98		8.48 J	NA	2.7	6.2 U	2.63	NA	1.7
174	179	B0MJK0	B0MJK2	1/5/98		8.42 J	297	8.1	6.5 U	2.10	1.5	NA
174	179	B0MJK3	B0MJK5	1/5/98		8.43 J	367	7.1	6.4 U	2.64	1.4	NA
251.5	254	B0MJK6	B0MJK8	1/7/98		8.36 J	NA	7.3	6.4 U	2.46	NA	2.0

(a) Water content reported on a gravimetric basis:
(mass of water / mass of dry soil) x 100
(b) Cation exchange capacity results reported on a dry weight basis; meq = milli-equivalents
(c) Bulk density calculated from field measurements
(d) Insufficient sample for analysis

U Analyzed for but not detected. Value reported is the reporting limit.
J Estimated
NA Not Analyzed
ND Not Detected
QL Quantitation Limit
CAS Chemical Abstracts Service registry number (or HEIS identification number)
SAF Sampling Authorization Form
N/A Not applicable

Table C3. Physical Property Analytical Results for 216-B-2-2 Characterization Borehole, 299-E33-333. (3 Sheets)

Target Physical Property Results											
Sample Interval		SAF B98-004			Particle Size Distribution, Initial Analysis						
Top Depth (ft bgs)	Bottom Depth (ft bgs)	HEIS Number (chemical)	HEIS Number (physical)	Sample Date	Size Units	12-in Sieve % Passing	4-in Sieve % Passing	1-in Sieve % Passing	No. 4 Sieve % Passing	No. 40 Sieve % Passing	No. 200 Sieve % Passing
					QL	N/A	N/A	N/A	N/A	N/A	N/A
4	6.5	B0MJC2	B0MJC4	12/29/97		100.0	100.0	85.3	66.9	2.3	1.5
8	10.5	B0MJC5	B0MJC7	12/29/97		100.0	100.0	89.3	74.5	1.6	0.4
10.5	13	B0MJC8	B0MJD0	12/30/97		100.0	100.0	96.3	63.1	3.7	1.0
13	15.5	B0MJD1	B0MJD3	12/30/97		100.0	100.0	74.0	44.0	3.7	1.6
15.5	18	B0MJD4	B0MJD6	12/30/97		100.0	100.0	96.2	62.8	6.4	0.1
20	22.5	B0MJD7	B0MJD9	12/31/97		100.0	100.0	89.8	57.1	0.2	ND
20	22.5	B0MJF0		12/31/97							
30	32.5	B0MJF3	B0MJF5	12/31/97		100.0	100.0	100.0	97.1	1.1	0.2
40	42.5	B0MJJ1	B0MJJ3	12/31/97		100.0	100.0	100.0	99.5	2.5	0.4
50	52.5	B0MJJ4	B0MJJ6	12/31/97		100.0	100.0	100.0	100.0	7.4	1.4
75	77.5	B0MJF6	B0MJF8	1/2/98		100.0	100.0	100.0	99.7	14.9	1.5
100	102.5	B0MJF9	B0MJH1	1/3/98		100.0	100.0	100.0	97.3	14.3	2.1
150	152.5	B0MJJ7	B0MJJ9	1/5/98		100.0	100.0	100.0	99.9	15.8	3.4
174	179	B0MJK0	B0MJK2	1/5/98		100.0	100.0	100.0	100.0	100.0	0.4
174	179	B0MJK3	B0MJK5	1/5/98		100.0	100.0	100.0	100.0	3.6	1.5
251.5	254	B0MJK6	B0MJK8	1/7/98		100.0	100.0	80.8	21.3	0.5	ND

(a) Water content reported on a gravimetric basis: (mass of water / mass of dry soil) x 100
(b) Cation exchange capacity results reported on a dry weight basis; meq = milli-equivalents
(c) Bulk density calculated from field measurements
(d) Insufficient sample for analysis

U Analyzed for but not detected. Value reported is the reporting limit.
J Estimated
NA Not Analyzed
ND Not Detected
QL Quantitation Limit
CAS Chemical Abstracts Service registry number (or HEIS identification number)
SAF Sampling Authorization Form
N/A Not applicable

Table C3. Physical Property Analytical Results for 216-B-2-2 Characterization Borehole, 299-E33-333. (3 Sheets)

Target Physical Property Results															
Sample Interval		SAF B98-004			Particle Size Distribution, Second Analysis										
Top	Bottom	HEIS	HEIS		Size	3-in Sieve	2-in Sieve	1 1/2-in Sieve	1-in Sieve	3/4-in Sieve	3/8-in Sieve	No. 4 Sieve	No. 10 Sieve	No. 40 Sieve	No. 200 Sieve
Depth	Depth	Number	Number	Sample	Units	% Passing	% Passing	% Passing	% Passing	% Passing	% Passing	% Passing	% Passing	% Passing	% Passing
(ft bgs)	(ft bgs)	(chemical)	(physical)	Date	QL	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
4	6.5	B0MJC2	B0MJC4	12/29/97		100.0	100.0	100.0	83.9	80.1	70.2	64.2	55.8	42.2	16.8
8	10.5	B0MJC5	B0MJC7	12/29/97		100.0	100.0	100.0	88.7	82.4	77.0	74.0	70.5	35.0	9.2
10.5	13	B0MJC8	B0MJD0	12/30/97		100.0	100.0	100.0	96.0	93.4	74.4	62.3	44.4	14.9	5.1
13	15.5	B0MJD1	B0MJD3	12/30/97		100.0	100.0	100.0	87.0	77.5	61.4	50.2	32.8	8.7	3.0
15.5	18	B0MJD4	B0MJD6	12/30/97		100.0	100.0	100.0	94.9	92.5	73.0	50.1	30.3	4.7	1.7
20	22.5	B0MJD7	B0MJD9	12/31/97		100.0	100.0	100.0	87.4	79.3	67.5	56.7	35.5	6.7	1.9
20	22.5	B0MJF0		12/31/97											
30	32.5	B0MJF3	B0MJF5	12/31/97		100.0	100.0	100.0	100.0	100.0	99.0	97.4	94.1	53.7	16.5
40	42.5	B0MJJ1	B0MJJ3	12/31/97		100.0	100.0	100.0	100.0	100.0	99.3	98.9	97.5	13.9	2.7
50	52.5	B0MJJ4	B0MJJ6	12/31/97		100.0	100.0	100.0	100.0	100.0	100.0	100.0	98.1	18.7	3.0
75	77.5	B0MJF6	B0MJF8	1/2/98		100.0	100.0	100.0	100.0	100.0	100.0	100.0	96.8	43.8	5.2
100	102.5	B0MJF9	B0MJH1	1/3/98		100.0	100.0	100.0	100.0	100.0	100.0	95.5	87.6	37.7	6.0
150	152.5	B0MJJ7	B0MJJ9	1/5/98		100.0	100.0	100.0	100.0	100.0	100.0	100.0	96.4	26.0	6.0
174	179	B0MJK0	B0MJK2	1/5/98		100.0	100.0	100.0	100.0	100.0	100.0	100.0	98.6	55.3	14.9
174	179	B0MJK3	B0MJK5	1/5/98		100.0	100.0	100.0	100.0	100.0	100.0	100.0	96.8	50.0	16.4
251.5	254	B0MJK6	B0MJK8	1/7/98		100.0	100.0	100.0	79.6	70.8	48.2	34.6	22.9	11.7	5.9

(a) Water content reported on a gravimetric basis: (mass of water / mass of dry soil) x 100
(b) Cation exchange capacity results reported on a dry weight basis; meq = milli-equivalents
(c) Bulk density calculated from field measurements
(d) Insufficient sample for analysis

U Analyzed for but not detected. Value reported is the reporting limit.
J Estimated
NA Not Analyzed
ND Not Detected
QL Quantitation Limit
CAS Chemical Abstracts Service registry number (or HEIS identification number)
SAF Sampling Authorization Form
N/A Not applicable

APPENDIX D

REPORT ON GEOPHYSICAL LOGGING OF CHARACTERIZATION BOREHOLE 299-E33-333

D-ii

Waste Management Federal Services Inc., Northwest Operations/ MACTEC-MEIER

Report of Log Survey for Borehole B8079

This report presents a summary of spectral gamma and neutron-neutron log surveys of characterization borehole B8079, which is located at the influent end of the 216–B–2–2 Ditch in the north-central region of the Hanford Site 200 East Area. The spectral gamma and neutron-neutron surveys were conducted by MACTEC–MEIER and Waste Management Federal Services Inc., Northwest Operations, respectively.

Summary of Logging Operations

Spectral Gamma Survey

The spectral gamma survey of borehole B8079 was completed in three log runs, and as the result of logistics involved with maintenance and ongoing tank farm vadose zone characterization logging, two logging units completed these surveys. The first log run followed the installation of a 10-inch (in.) diameter casing and was conducted from the ground surface to a depth of 51.5 feet (ft) with logging system Gamma-1A. The second and third log runs were conducted when the total depth (TD) of the borehole was reached with the 8-in.-diameter casing. These two log runs surveyed the borehole over the depth interval from 45 to 249.5 ft with logging system Gamma-2B. Due to the extended logging time in the 8-in.-diameter casing, it was necessary to withdraw from the borehole, replenish the liquid nitrogen dewar of the germanium spectral gamma detector, and reenter the borehole and complete the survey. A short survey overlap interval, at depths from 45 to 51.5 ft, was conducted within both the 10-in. and 8-in.-diameter casing strings. Logging a section of overlap between surveys is a routine logging operation. All spectral gamma data were collected at an acquisition rate of 100 seconds (s) real time (clock time) for every 0.5 ft of borehole length. The logging tool was centralized within the borehole in all of the spectral gamma surveys. The procedures governing the spectral gamma logging operations are presented in *Hanford Tank Farms Vadose Zone, High Resolution Passive Spectral Gamma-Ray Logging Procedures* (MAC–VZCP–1.7.3, Rev. 2).

The zero reference for the spectral gamma logging surveys was the ground surface. Tool zero position is located at the center of the germanium detector, which is 5 in. above the bottom of the logging tool. This location is scribed onto the case of the logging tool and ensures consistent tool positioning. Minimal depth return errors occurred and they are recorded on the log header. No depth adjustments were made to the log data.

The pre- and post-survey field verification spectra met the acceptance criteria established for the peak shape and detector efficiency, confirming that both logging systems were operating within specifications. The energy calibration and peak-shape calibration from these spectra were used to establish the channel-to-energy parameters used in processing the spectra acquired during the borehole survey.

Neutron-Neutron Survey

In accordance with the statement of work, the neutron-neutron survey was conducted throughout the 8-in.-diameter section of the borehole (at depths from 45 to 249 ft) because there is no direct calibration standard available for 10-in. boreholes. The neutron-neutron data were collected at 0.25-ft depth increments because the instrument is capable of resolving features 2 to 3 in. thick. The data were acquired in a continuous logging mode at a logging speed of 1.0 ft/minute or less; this speed resulted in a sample time of 15 s real time. Given the count rate of the instrument and sample time, the statistical accuracy is within the specified precision. The guidelines for conducting the neutron-neutron survey are outlined in *Vadose Neutron Moisture Logging Procedure* (WNNW–MAC–ES–PRO–001).

The neutron moisture instrument is depth zeroed at the top of cable head (the cable to logging tool connection) to minimize exposure to the logging operator from the neutron source. The distance from the top of the cable head to the scribe line zero of the neutron instrument (half way between the source and detector) is entered for the depth datum of the borehole. The neutron-neutron survey zero depth reference is the ground surface.

The source shield is used as a pre- and post-survey field verification of proper instrument operation. Consistent results for the verifications indicated that the equipment was operating properly during the neutron-neutron survey.

Data Processing

Spectral Gamma Data

The gamma-ray spectra acquired in the borehole were processed utilizing a variety of software to calculate concentrations of individual gamma-emitting radionuclides. Details regarding the algorithms used to calculate the concentrations and their application are included in *Hanford Tank Farms Vadose Zone, Data Analysis Manual* (MAC–VZCP–1.7.9, Rev. 1).

Equipment calibrations are conducted annually and the data acquired during the calibrations are used to derive factors that convert measured peak area count rate to radionuclide concentrations in picocuries per gram (pCi/g). The calibration dates and calibration reports (presenting the mathematical functions that determine the calibration factors) for each logging unit utilized are referenced on the log header. The details of the base calibration are discussed in *Vadose Zone Characterization Project at the Hanford Tank Farms, Calibration of Two Spectral Gamma-Ray Logging Systems for Baseline Characterization Measurements in the Hanford Tank Farms* (GJPO–HAN–1). The current calibration reports for the equipment utilized for logging borehole B8079 are *Hanford Tank Farms Vadose Zone, Fourth Biannual Recalibration of Spectral Gamma-Ray Logging Systems Used for Baseline Characterization Measurements in the Hanford Tank Farms* (GJO–HAN–14) for logging system Gamma-2B, and *Hanford Tank Farms Vadose Zone, Fifth Biannual Recalibration of Spectral Gamma-Ray Logging Systems Used for Baseline Characterization Measurements in the Hanford Tank Farms* (GJO–HAN–20) for logging system Gamma-1A.

Casing corrections were applied to the data to compensate for the gamma-ray attenuation by the casing. The wall thicknesses for both the 10-in. and 8-in.-diameter casings were 0.45 in. The thick threaded casing produced a flush joint at the casing sections, resulting in a uniform thickness throughout each of the casing strings. A casing correction for 0.50-in. casing was used to process the data, because it was the closest thickness option in the processing program. Accordingly, the calculated radionuclide concentrations are slightly higher (i.e., 1 to 2 percent) than the actual concentrations.

A short interval of the borehole at depths from 45.0 to 51.5 ft was logged within both casing strings. It is routine for most logging operations to log a short overlap section between surveys; however, this interval of data was not processed because there is no casing factor to compensate for a borehole configuration consisting of two casings and an air-filled annulus.

Shape factor analysis is a technique that is utilized to determine the spatial distribution of a contamination source relative to the detector. This method of analysis allows the analyst to differentiate between contamination inside the casing, contamination on the outside of the casing, contamination distributed evenly through the formation, and contamination that is essentially a point source located at a remote distance from the borehole. The ratios of gamma-ray count rates within defined portions of the spectra continuum associated with specific gamma-ray emitters encountered at each 0.5-ft logging interval are indicators of the distribution of the particular source. The ratios are known as shape factors, and, relative to borehole B8079, they are designated CsSF1 and CsSF2. Different shape factors are calculated if other contaminants are present, (i.e., CoSF1 if ^{60}Co is present).

CsSF1 is the ratio of the total number of counts in the continuum window (60 to 650 kilo-electron-volts [keV]) to the counts in the ^{137}Cs peak (662 keV). This factor is useful for evaluating the distribution of ^{137}Cs. CsSF2 is the ratio of the total number of counts in the lower energy portion of the continuum window (60 to 350 keV) to the counts in the higher energy portion of the continuum window (350 to 650 keV). This parameter is most applicable to differentiating between remotely located ^{137}Cs and the occurrence of high concentrations of the high-energy beta emitter ^{90}Sr.

Effective use of shape factor analysis is dependent on determining shape factor parameters for the continuum from the radionuclides of interest and not to the portion of the continuum produced by the naturally occurring radionuclides such as ^{40}K and ^{238}U. The contribution to the continuum from these radionuclides is determined and removed using a process designated as background stripping. It is noteworthy that correctly stripping log intervals wherein only natural radionuclides are present results in no net continuum, and the SF2 values in these interval will be random because they simply reflect the statistical variation in the measurement of the 60 to 350 and 350 to 650 keV windows.

The details of shape factor analysis are presented in *Spectrum Shape Analysis Techniques Applied to the Hanford Tank Farms Spectral Gamma Logs* (GJO–HAN–7). At the present time, ^{137}Cs and ^{60}Co contamination with concentrations greater than about 1.6 and 0.7 pCi/g, respectively, are routinely analyzed with this technique. Because the ^{60}Co concentrations in borehole B8079 did not exceed the 0.7-pCi/g threshold, ^{60}Co was not analyzed.

Neutron-Neutron Moisture Data

The neutron-neutron moisture data were acquired in spectral form and converted to gross counts at each depth interval. The data were depth shifted down 0.5 ft because of an error in zeroing the instrument. The counts were converted to volume fraction moisture (volume water/volume total) using the calibration transform described in *Radionuclide Logging System In Situ Vadose Zone Moisture Measurement Calibration* (WHC-SD-EN-TI-306, Rev. 1).

Descriptions of the accuracy and precision estimates for the neutron-neutron measurements are presented in the following discussions. Accuracy is the instrumentation response compared to the calibration model values. The precision is a function of the counting statistics and the instrument response. Both of these characterizations of the instrumentation utilized for this work are quantified and displayed below.

Accuracy

The accuracy as established by the Data Quality Objective (DQO) for moisture logging instrumentation is to be determined by the comparison of the calibrated instrument response to the assigned model values of moisture as per PNNL assignment during construction (*PNL-10801,UC606, "Calibration Models for Measuring Moisture in Unsaturated Formations by Neutron Logging", Engelman, et al., Oct. 1995)*. The following table provides the results for the 8-in.-diameter casing calibration data collected on Dec 18, 1997 for the RLSM3.1 series of instrumentation, since this is the most recent calibration data for the instrument utilized for the logging survey for borehole B8079.

8-in. casing model moisture (volume fraction water in %)	Calibrated RLSM3.1 results (volume fraction water in %)	Percent difference between model value and instrument measurement
19.7	19.80	+0.50
11.9	11.80	-0.80
5.0	5.0	+0.30

Thus, the largest difference between the model value and the RLSM3.1 measurement in these three Pasco models is less than 1% volume fraction of moisture. These observed deviations are well below the limits established in the master agreement for logging for BHI.

Precision

Precision is the ability of an instrument to reproduce a given measurement; thus, the variance observed for a given repeat sequence is used to determine the system or instrument's precision. During model data collection, 10 samples or repeat measurements were acquired for each model. These data were then used to compute a root mean square or an estimated observed standard deviation. These data were also used to compute a theoretical standard deviation based solely on counting statistics, and the comparison agreed within statistical limits of sample size.

The model data collected for the calibration demonstrated that the observed deviations for any model were the same as predicted by the counting statistics,(i.e., no extraneous instrumentation random errors were introduced). Therefore, it is possible to predict the statistical precision for any given logging condition. The total counts observed for each depth sample determine the statistical precision. Furthermore, because the count rate is a function of the observed moisture content, it is possible to derive the statistical precision as a function of moisture for either calibrated casing configuration. Note that the casing thickness will affect this prediction, but only to the second order, unless it is extremely thick (more than 1.25 in.).

The sample time per depth increment is multiplied by the projected count rate from the calibration coefficients. This results in the number of counts for each logging sample as a function of moisture content. The 1 σ is then a simple square root of these counts per sample.

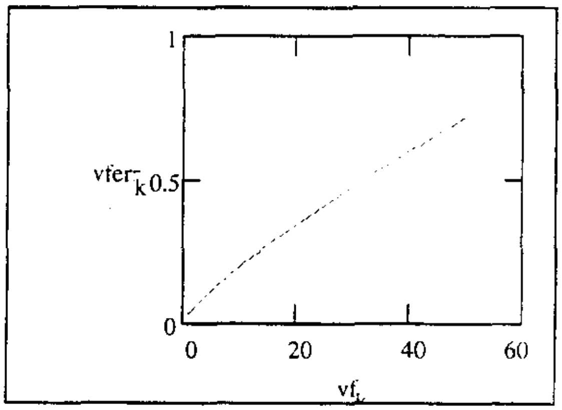
For the given borehole logging, the highest logging speed was .94 ft/min with a sampling frequency of one sample per 0.25 ft. The resulting sampling time is therefore 16 seconds or more. The casing thickness correction for the 0.5-in. wall thickness is 0.833. The count rate to volume fraction of moisture conversion is performed by the equation

$$V=a*C^{\alpha},$$

where V is the instrument reading of volume fraction of moisture, C is the observed count rate, and the coefficient a and α are the calibration coefficients. For this instrument, RLSM3.1, the calibration coefficients were measured to be:

a = 0.00001305
α = 2.568

for the 8 in. diameter casing condition.



Given these parameters and logging conditions, the error in the volume fraction of moisture versus the volume fraction of moisture for this particular borehole logging configuration is shown in the following plot. The x axis is the volume fraction of moisture and the y axis is the instrument precision error in the measured volume fraction of moisture. Note that the y axis, volume fraction moisture error is scaled from 0 to 1, where 1 is 1% by volume of moisture precision error.

Clearly, the largest observable error, which occurs at 50% moisture (an unreasonably high content) is 0.72% by volume of moisture. The highest reading did not exceed this moisture level and thus the error in all the log data is well below the levels required by the master agreement. In fact, the specified limit was quoted for 0.5-ft samples, and extrapolating to this sampling, the error is at most near 0.5 % or 1 order of magnitude lower than the required minimum.

Bulk Density Effects

The assumed bulk density for the moisture log is the bulk density of the moisture calibration models (hydrated alumina+sand) and is 1.76 grams per cubic centimeter (gm/cc).

Due to the lack of a continuous measurement of bulk density over the complete logged interval bulk density correction to moisture is not possible.

The document *Radionuclide Logging System In Situ Vadose Zone Moisture Measurement Calibration* (WHC–SD–EN–TI–306, Rev. 1) provides a density correction curve (Figure 6) based on computer modeling. This data could be used to provide an estimate of how the density assumption affects accuracy but is not provided here because all accuracy and precision statements or representations made per the Master Agreement are for "performance under known conditions such as calibration models."

Casing Thickness corrections

Casing thickness corrections for the 0.5-in.-thick steel casing were applied in accordance with the document mentioned above. The data acquired within the interval of both the 10-in. and 8-in. casings (at depths between 46 and 53 ft) will not indicate the correct moisture because there is no correction for this borehole configuration.

Log Plots

Separate log plots show the man-made and naturally occurring radionuclides potassium-40 (^{40}K), uranium-238 (^{238}U), and thorium-232 (^{232}Th) (KUT). The headings of these log plots identify the specific gamma rays used to calculate the concentrations.

Various log plots show the concentrations of the individual radionuclides, the total gamma count rate, and the volumetric moisture content along the entire length of the borehole. The total gamma count rate for each 0.5-ft interval is a sum of the counts from the spectrum divided by the counting time. Some of the log plots show the statistical uncertainties in the calculated radionuclide concentrations at the 95-percent confidence level (±2 standard deviations).

The KUT plot allows correlation of the log data with lithologic features, man-made contamination, and moisture content. The statistical uncertainty for gamma rays emitted from low-concentration radionuclides such as ^{238}U and ^{232}Th can be high for the 100-s acquisition time utilized for logging borehole B8079, and the plots of these radionuclides show high levels of uncertainty. This is shown on the KUT plots by scatter on the plotted data and large error bars. Nevertheless, these data are useful for correlation with other lithology data.

The minimum detection level (MDL) of a radionuclide represents the lowest concentration at which positive identification of a gamma-ray peak for that radionuclide is statistically defensible. The spectral analysis program calculates the MDL for a particular peak on the basis of a statistical comparison with the background energy level in the vicinity of the peak. The MDL's for the radionuclides are indicated on the plots as open circles.

The shape factor analysis plot show the values of CsSF1 and CsSF2 from the processed log data as well as other parameters needed for evaluation and interpretation. These other factors include the expected shape factor values for typical source distributions, the radionuclide count rates, the system dead time, and the existence of other radionuclides that might affect the shape factor analysis.

The values of CsSF1 and CsSF2 are shown on the first two graphs of the shape factor plot. The general expected values for the CsSF1 and CsSF2 parameters for ^{137}Cs contamination distributed on the outer surface of the casing and uniformly in the formation surrounding the casing are shown as vertical lines on these graphs. SF1 values greater than the uniform distribution line indicate an isolated source remote from the borehole casing. SF2 values greater than the uniform distribution line can indicate bremsstrahlung radiation which is indicative of the presence of ^{90}Sr.

The count rates for gamma-ray-emitting radionuclides encountered in the log are shown on the graph on the far right as an indicator of the quality of the shape factor computation. At higher count rates from a radionuclide such as ^{137}Cs, the continuum is less affected by the naturally occurring radionuclides and the quality of the calculated shape factors improves. The activity threshold that must be exceeded in order to achieve reliable shape factor calculations is readily determined by reference to this graph. The activity from specific radionuclides is expressed as count rate, rather than as concentrations, because some radionuclides emit multiple gamma rays. The count rate threshold below which shape factor calculations are unreliable is 1 count per second (cps) for ^{137}Cs, which corresponds to a ^{137}Cs concentration of 1.6 pCi/g. The ^{60}Co threshold is 1.5 cps, corresponding to a ^{60}Co concentration of about 0.7 pCi/g.

The presence of other radionuclides in addition to ^{137}Cs and ^{60}Co is shown by a symbol on this same graph. The presence of these radionuclides does not preclude the use of shape factor analysis, but does alert the analyst that certain revised procedures are required in the analysis (i.e., background stripping) to adjust the calculated shape factors to account for the contribution of these other radionuclides to the continuum under consideration.

The dead time plotted on this graph reflects the deleterious effect on a gamma-ray detection system of relatively high count rates and indicates intervals of the borehole where the shape factor calculations are influenced by the measured distortion introduced by abnormally high count rates. When a gamma-ray (photon) impinges on a detector, the detector is "dead" or ceases to function for a very short portion of the counting time while the system analyzes, measures, and records the photon. At higher and higher count rates, this dead time becomes a significant portion of the counting time (100 s for this borehole). As dead time approaches a high percentage of the nominal counting time, the count rates recorded at each energy level of the spectrum become distorted, or are not recorded at all. This distortion of the spectrum will influence the shape factor analysis. At dead times greater than 20 percent, the calculated shape factors can be affected; therefore, dead time is plotted and utilized as a data quality indicator.

A plot of the volumetric moisture content measured in borehole B8079 is provided with error bars for every tenth moisture measurement (more frequent error bars obscured the features of the plot). The error bars represent the 68-percent confidence level (± 1 standard deviation), which was determined by converting the square root of the counts in each interval to an equivalent moisture content. The definition of "Detection Limit" or threshold limit is defined as "minimum concentration or level at which a contaminant or natural element can be positively identified." Since moisture can be measured to zero volume fraction, threshold limit is not applicable to moisture measurements and is not indicated on the log plots.

Results

The radionuclides cesium-137 (^{137}Cs), cobalt-60 (^{60}Co), and europium-154 (^{154}Eu) were detected in borehole B8079. The presence of ^{137}Cs was detected from the ground surface to a depth of 2.5 ft and at depths between 6 and 11 ft. The maximum ^{137}Cs concentration of about 400 pCi/g was measured at a depth of 9 ft. The presence of ^{60}Co was detected at the ground surface and at a depth of 0.5 ft. The ^{60}Co concentrations were about 0.15 pCi/g. The presence of ^{154}Eu was detected at three assay points at depths between 8.5 and 9.5 ft within the interval of highest ^{137}Cs concentrations. The ^{154}Eu concentrations ranged between 0.9 and 2.0 pCi/g.

What appears on the shape factor analysis CsSF1 plot as reverse peaks (as compared to the ^{137}Cs concentration plots) for the two zones of ^{137}Cs contamination actually reflects the position of the ^{137}Cs contamination relative to the location of the detector. As the detector approaches a contamination zone, either from above or below, the contamination is more remote to the detector than when the detector passes through the zone. The CsSF1 plot shows that within the zone of highest ^{137}Cs concentration, the contamination is uniformly distributed in the formation.

In 1986, the surface area at the site of the 216–B2–2 Ditch was stabilized with a 2-ft-thick layer of soil (*200–BP–11 Operable Unit RFI/CMS and 216–B–3 Main Pond, 216–B–63 Trench, and 216–A–29 Ditch Work/Closure Plan* [DOE/RL–93–74]). The ^{137}Cs contamination detected near the top of borehole B8079 most likely reflects contamination on the former surface. Shape factor analysis indicates that this ^{137}Cs contamination is distributed uniformly in the formation.

The zone of ^{137}Cs and ^{154}Eu contamination at a depth of 9 ft occurs near the bottom of the original 216–B2–2 Ditch, which, according to the *B Plant Source Aggregate Area Management Study Report* (DOE/RL–92–05), was constructed to a depth of 8 ft. However, with the addition of the 2-ft-thick layer of stabilization material in 1986, the depth of the ditch bottom is now about 10 ft. Spectral shape analysis indicates that this ^{137}Cs contamination is distributed as a thin layer 0.5 to 1.0 ft thick that may be an accumulation or coating at the bottom of the ditch.

Several data gaps occur on the ^{238}U concentration plot. The 609-keV peak was observed in many of the spectra for these depth intervals; however, the low ^{238}U concentrations caused a high statistical uncertainty for this gamma-ray creating gaps in the log. The 609-keV peak at depths from 7 to 10 ft is obscured by the Compton continuum from the high ^{137}Cs contamination at a depth of 8.5 ft. The high continuum from the ^{137}Cs extends into the 609-keV region of the spectrum and results in a high MDL for ^{238}U.

The KUT concentrations appear to be consistent with the values observed for these radionuclides in other boreholes logged with the spectral gamma logging systems in the nearby BX and BY Tank Farms (below the tank farm backfill). An increase in ^{40}K concentrations between depths of 26 and 32 ft most likely represents the contact between the Hanford formation upper coarse and Hanford formation fine-grained units. The lithologic descriptions on the borehole log within this depth range indicate a transition from sandy gravel to silty sand and sand.

The increase in total gamma count rate at the bottom of the borehole observed in data from the first log run (at a depth of 51 ft) reflects the contact of the logging tool with sediment material that entered the inside of the casing as the casing was driven. The gamma rays emanating from these sediments are not attenuated by the casing, and increased count rate is observed. The decreased count rate at a depth of 51 ft, observed in data acquired in the third log run, reflects the depth location of the casing shoe. Because the casing shoe is thicker than the casing and has an increased attenuating effect on the gamma rays (that was not compensated during processing because of its limited extent), decreased count rate occurs in this region of the borehole.

Increased volumetric moisture content is observed at depths of 174 ft, 180 ft, 186 ft, and 212 ft. The first three zones correlate to increases in the ^{238}U and ^{232}Th concentrations, indicating the higher moisture content is related to lithologic features, probably thin silt horizons. The lithologic descriptions on the borehole log indicate sandy silt in the depth interval between 173.5 and 174.8 ft, and in the depth interval between 177.0 and 184 ft, with silty sand between these two intervals. At a depth of 210 ft (the depth of the deepest elevated moisture content interval), the borehole lithology log indicates the sediments consist of slightly silty sand; reduced drilling rate, which was possibly due to cemented sediments, was noted for this depth.

Two 3.5-in. floppy disks are provided with this report and they contain the following data files:

Disk A	B8079.JNB SigmaPlot 4.0 format of the log plots
	B8079DATA.XLS Microsoft Excel 7.0 format of the log data
	B8079LH.WPD Word Perfect 6.1/7.0 format of the logheader
	B8079RPT.WPD Word Perfect 6.1/7.0 format of the report
	B8079SF.JNB SigmaPlot 4.0 format of the shape factor analysis results
Disk B	B8079VMC.JNB SigmaPlot 4.0 format for the moisture content plot

Waste Management Federal Services Inc., Northwest Operations/ MACTEC-MEIER

Borehole Survey Report

Borehole B8079

Project: 216-B-2-2 Ditch Location: 200 East Area

Borehole Information			
North Coordinate:		West Coordinate:	
Elevation:			
Date Drilled:	1-7-98	Depth Drilled:	254 ft
Water Level:	249.6 ft	Water Level Date:	1-9-98

Casing Information

Casing Size I.D. (in.)	Casing Thickness (in.)	Top Depth (ft)	Base Depth (ft)
10	0.450	+0.4	51.5
8	0.450	+1.7	249.7

Spectral Gamma Survey Information

Logging Engineer: A. Pearson
Log Depth Reference at Zero (0.0) depth is Ground surface
Acquisition rate: 100 s real time

Log Date	Archive File Names	Log Mode[1]	Speed	Depth Interval (ft) Top	Base	Incr.	Depth Return Error (ft)
1-2-98	BTRA1000	MSA	N/A	0.0	51.5	0.5	0
1-8-98	BTRA2000	MSA	N/A	120.0	249.5	0.5	+0.09
1-8-98	BTRA3000	MSA	N/A	45.0	121.0	0.5	+0.04

[1] MSA: Move-Stop-Acquire

Moisture Survey Information							
Logging Engineers: J.E. Meisner Log Depth Reference at Zero (0.0) depth is Ground surface							
Log Date	Archive File Names	Log Mode1	Speed	Depth Interval (ft) Top	Base	Incr.	Depth Return Error (ft)
1-9-98	MS50	N/A	.9 ft/min	175	249	0.25	0
1-9-98	MS51	N/A	.9 ft/min	175	45	0.25	0

,MSA: Move-Stop-Acquire

Spectral Gamma Logging Equipment Information

Logging Systems: γ1A & γ2B Detector Type: HPGE 35% Calibration Date: γ-1A, 10-21-97 Calibration Reference: γ-1A: GJO-HAN-20
γ-2B, 5-6-97 γ-2B: GJO-HAN-14
Logging Procedure: MAC-VZCP-1.7.3, Rev. 2

Moisture Logging Equipment Information

Logging Systems: RLSM3.1 Detector Type: Neutron-neutron
Calibration Date: 12-19-97 Calibration Reference: WHC-SD-EN-TI-306, Rev. 0
Logging Procedure: WNNW-MAC-ES-PRO-001

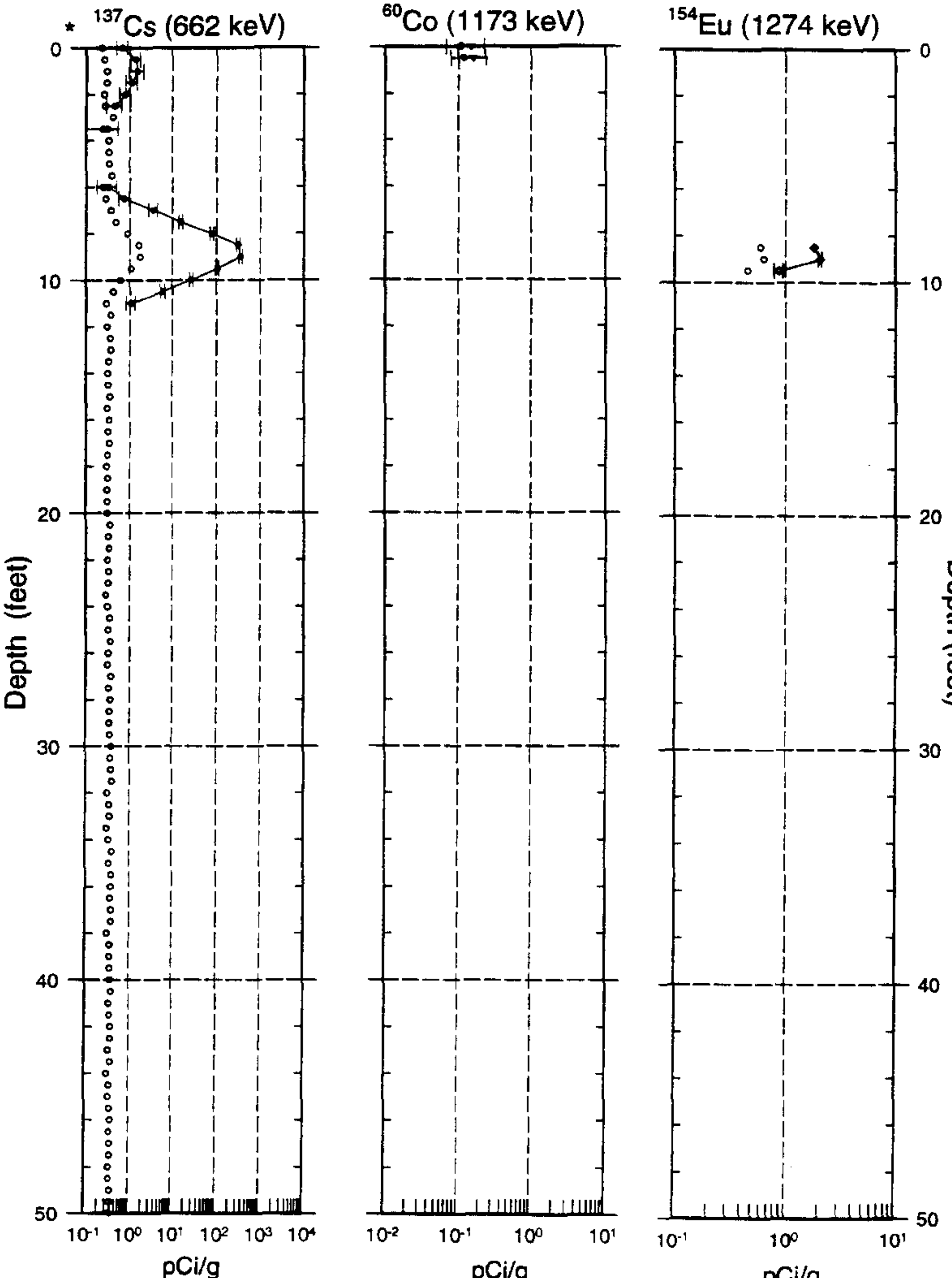
Spectral Gamma Log Data Processing and Analysis Information

Analyst: S.E. Kos Analysis Date: 1-24-98
Data Processing References: Log data analysis: MAC-VZCP-1.7.9, Rev. 1
Spectral shape factor analysis: GJO-HAN-7

Neutron Data Processing and Analysis Information

Analyst: J.E. Meisner Analysis Date: 1-17-98
Data Processing Reference: Log data analysis: WHC-SD-EN-TI-306, Rev. 0

Man-Made Radionuclide Concentrations
B8079

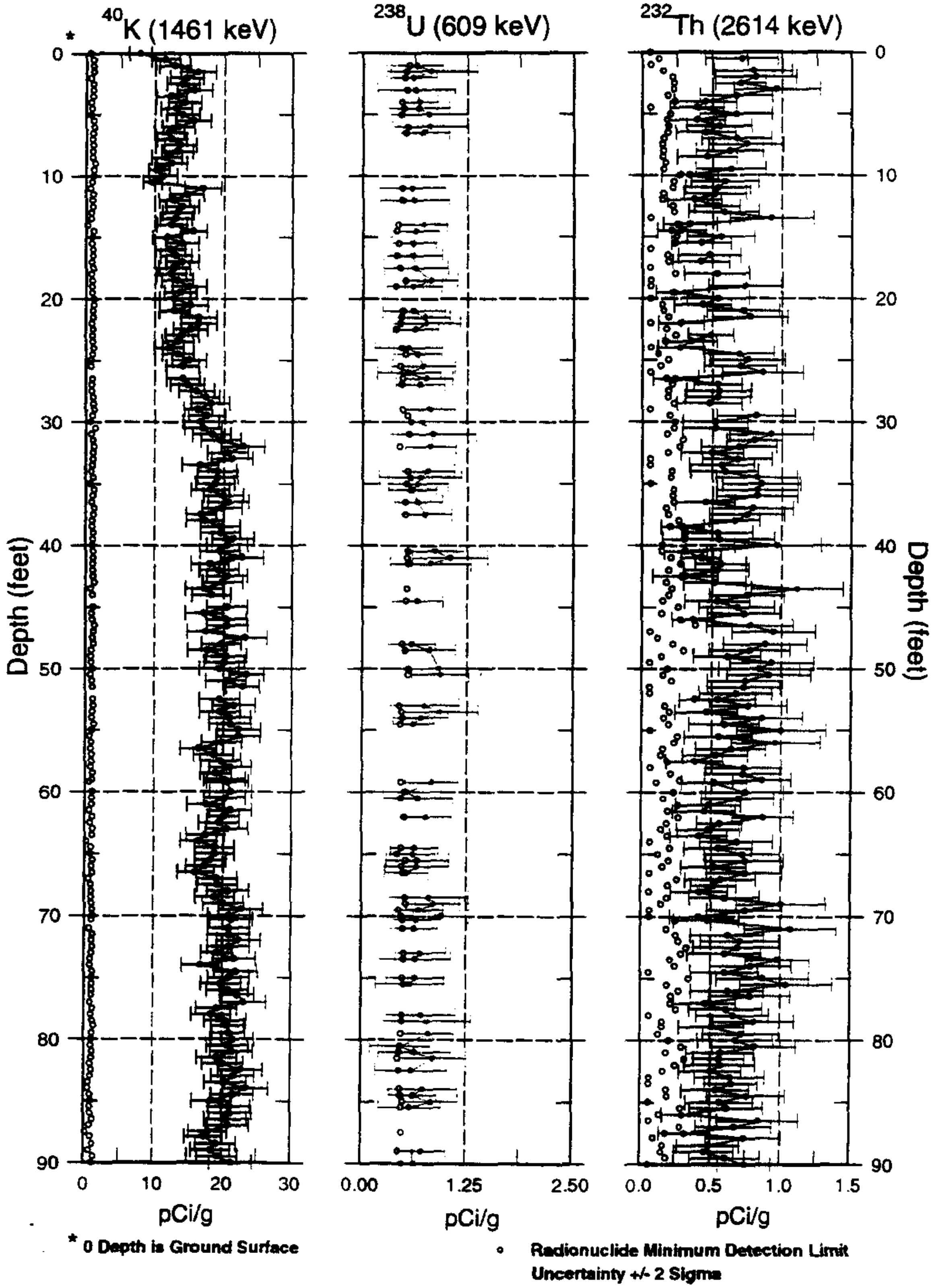


* 0 Depth is Ground Surface

o Radionuclide Minimum Detection Limit
Uncertainty +/- 2 Sigma

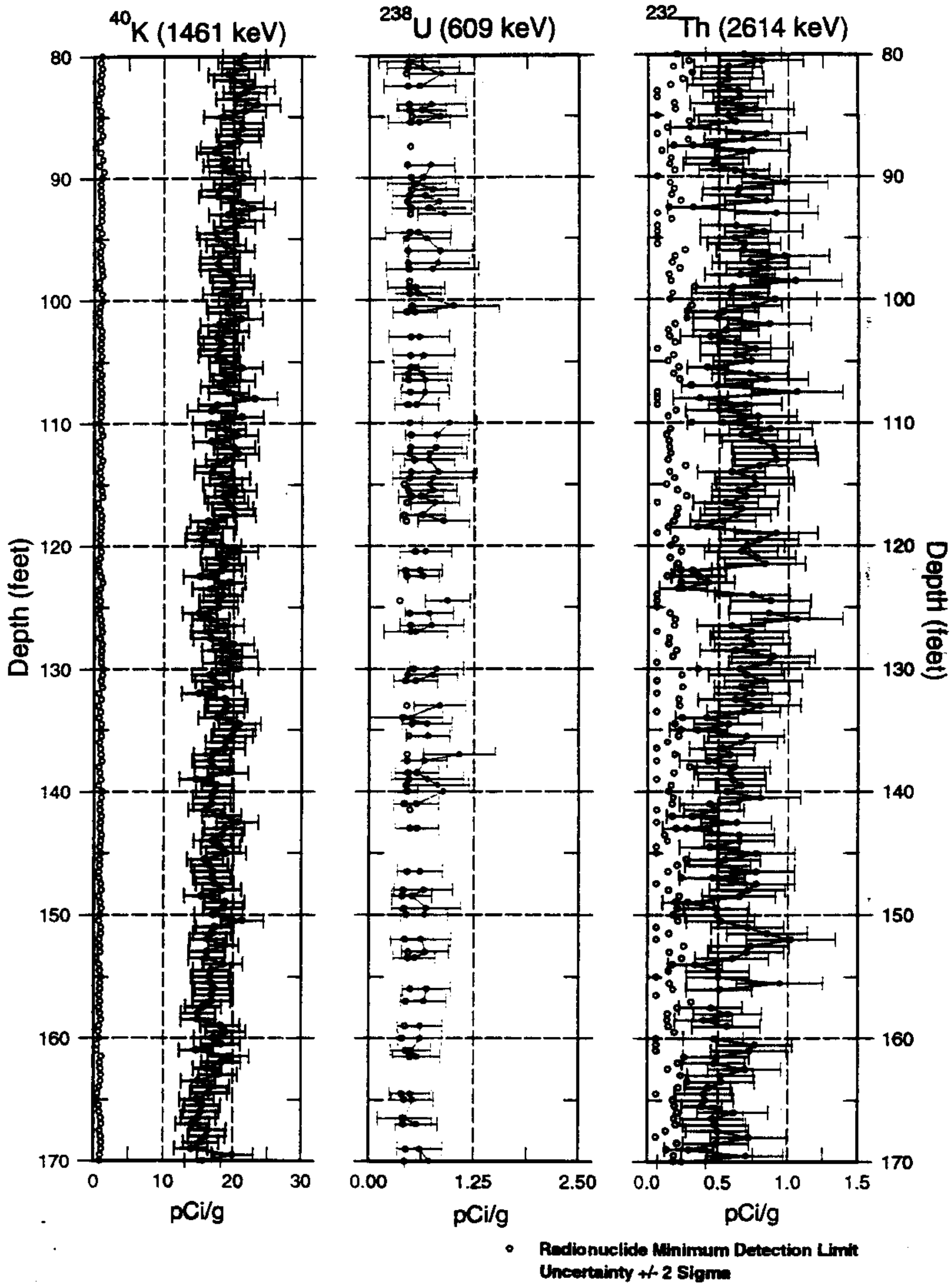
Natural Gamma Logs

B8079



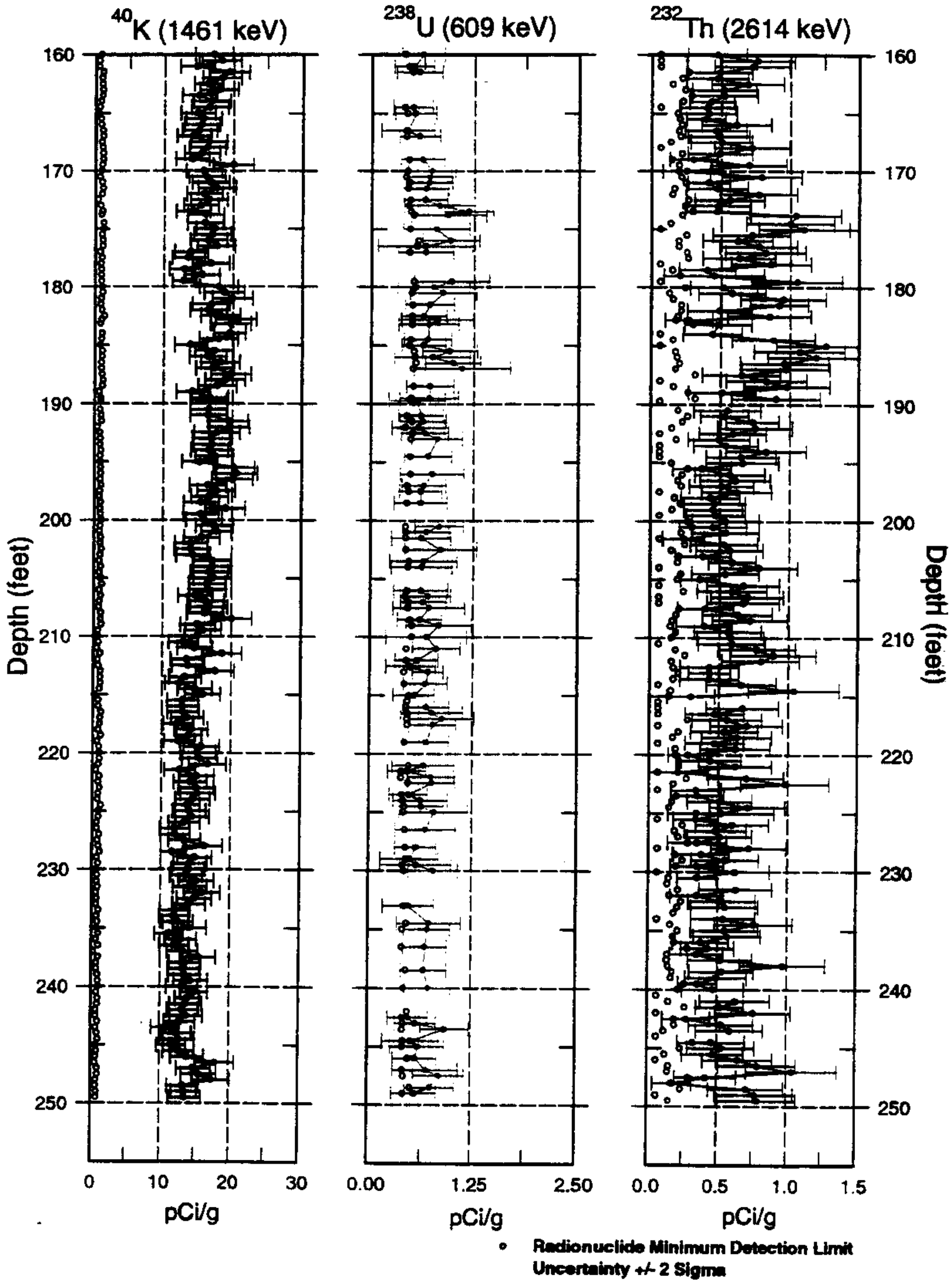
Natural Gamma Logs

B8079

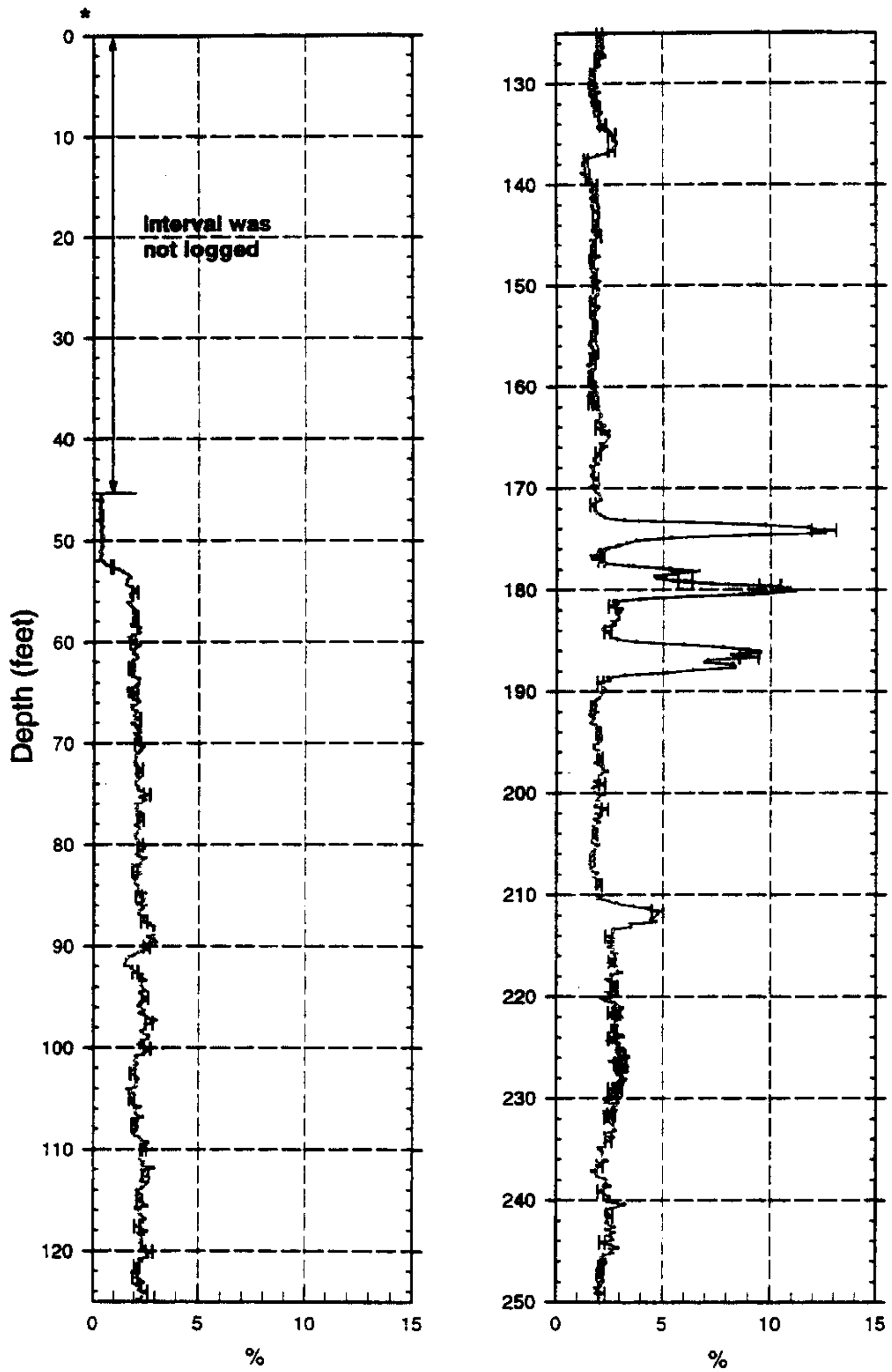


Natural Gamma Logs

B8079

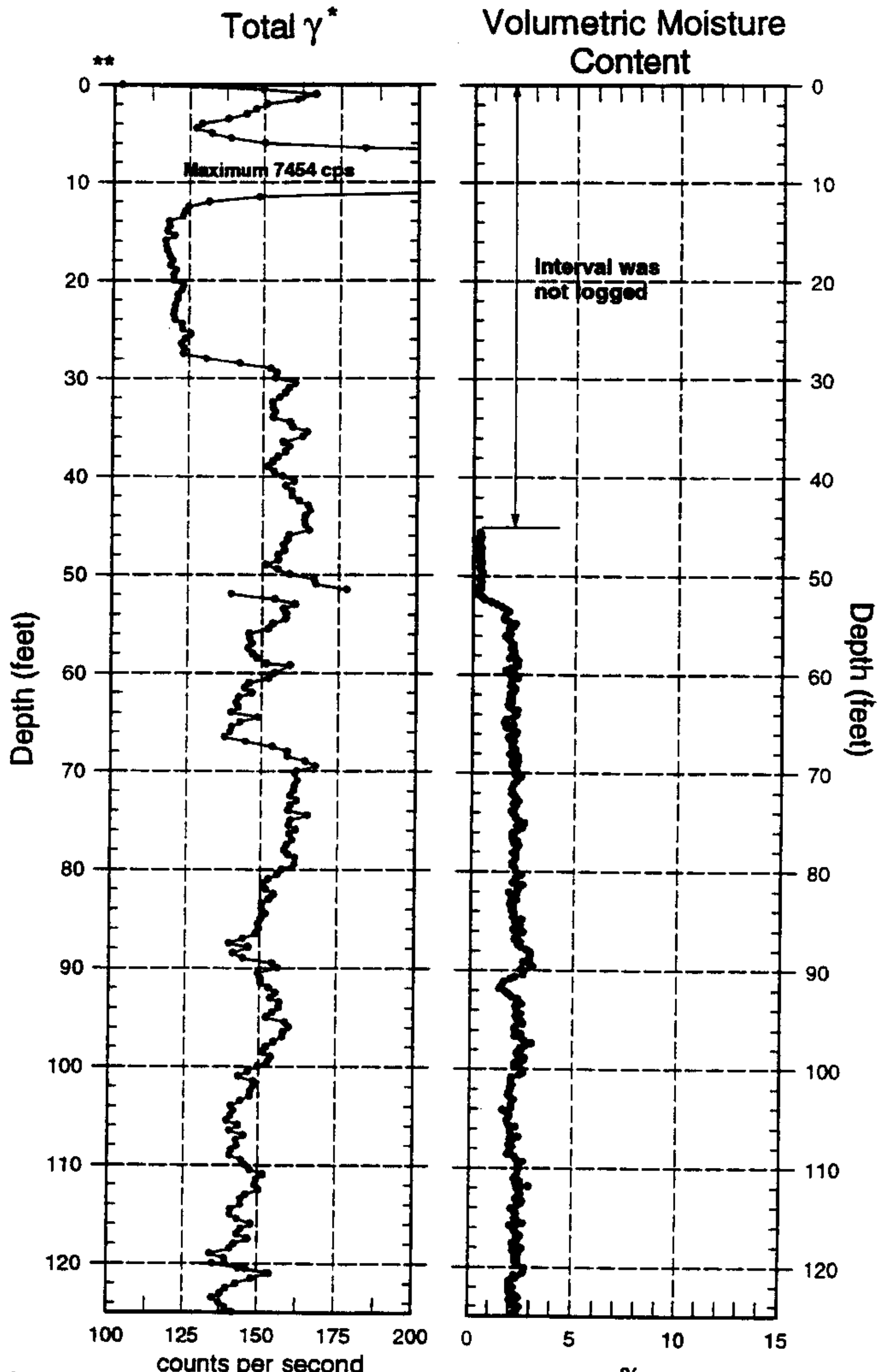


Volumetric Moisture Content
B8079



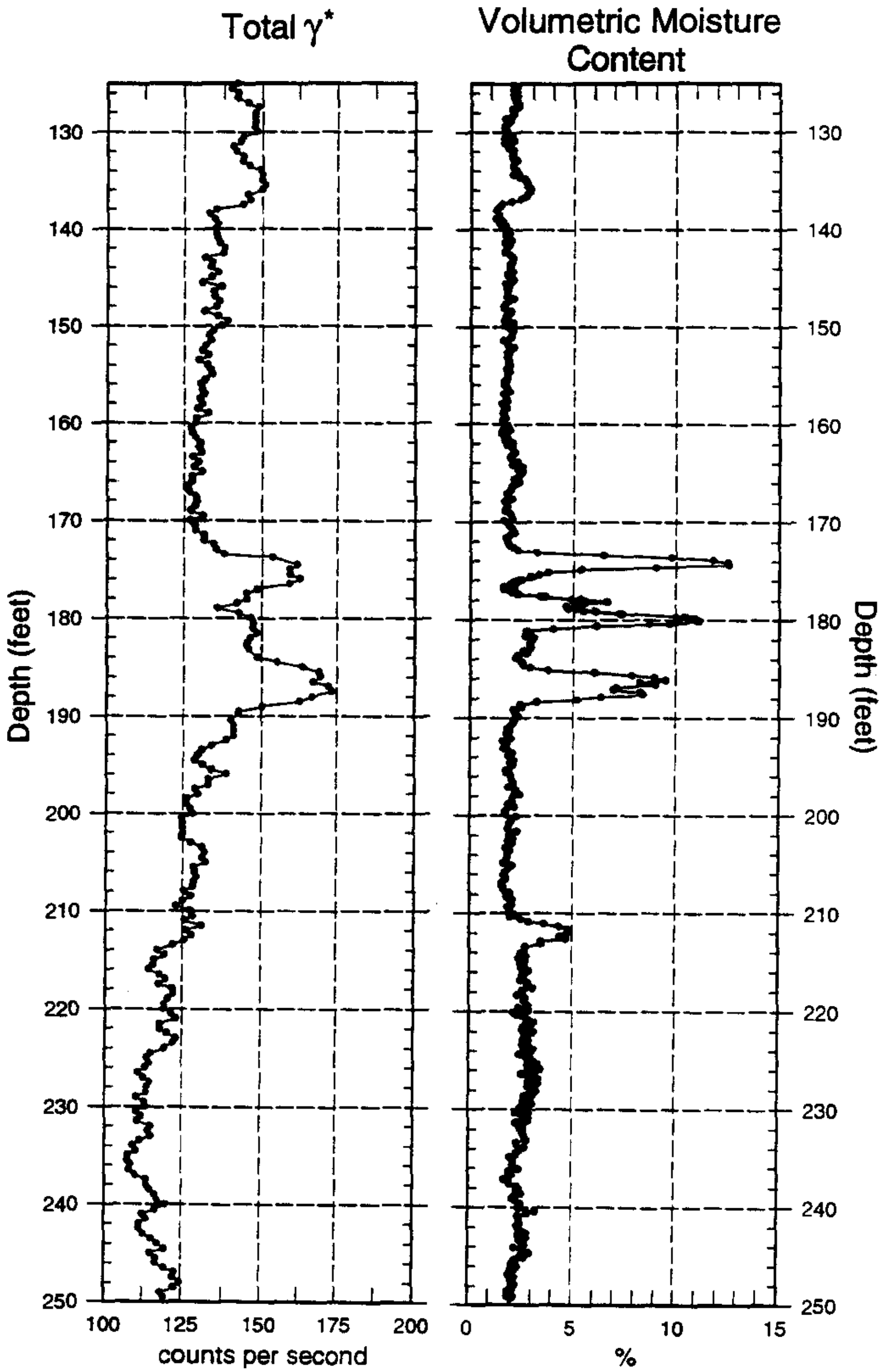
* 0 Depth is Ground surface
Uncertainty +/- 1 Sigma

Total Gamma and Moisture Content
B8079



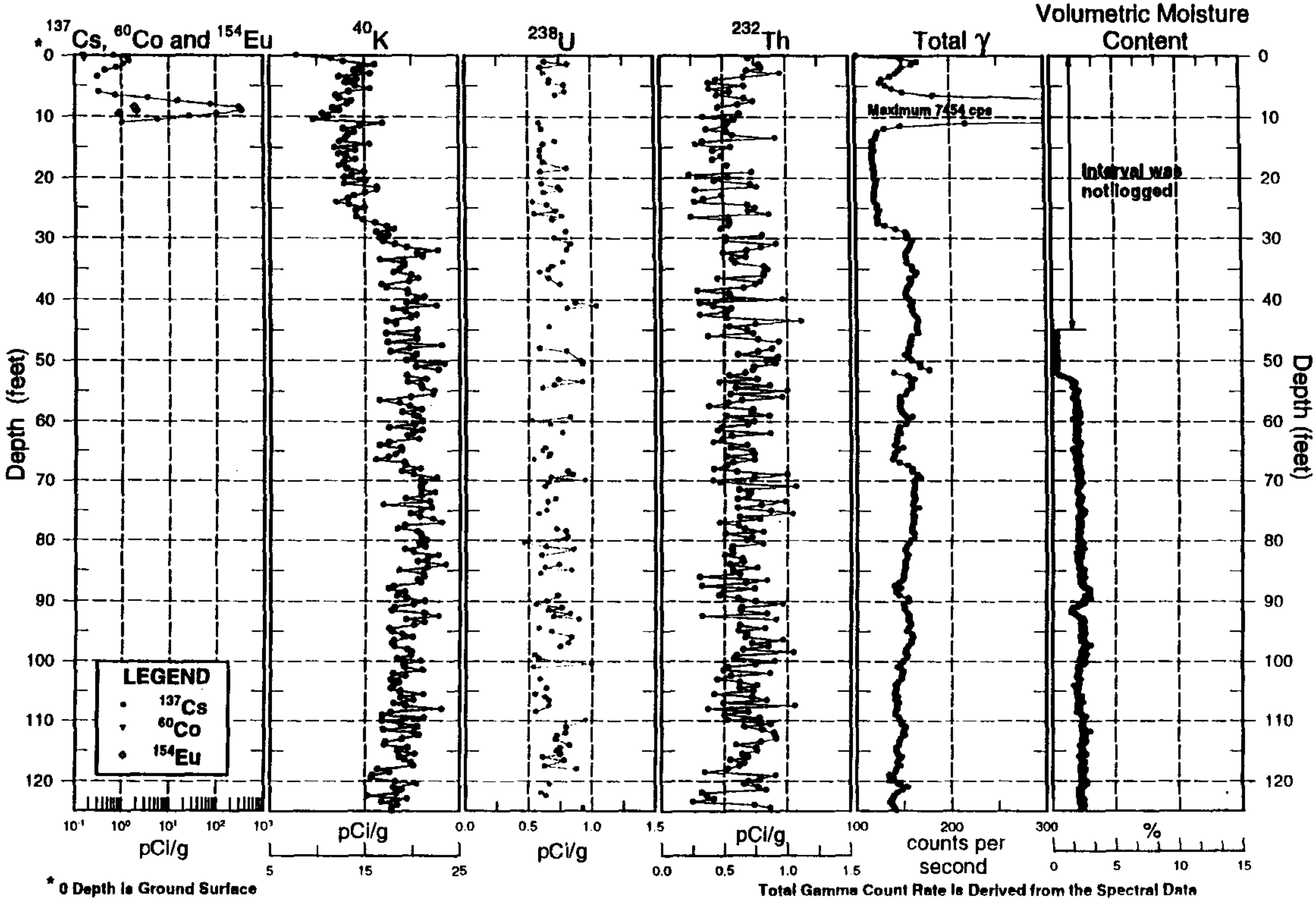
* Total Gamma Count Rate is Derived from Spectral Data
** 0 Depth is Ground Surface

Total Gamma and Moisture Content
B8079

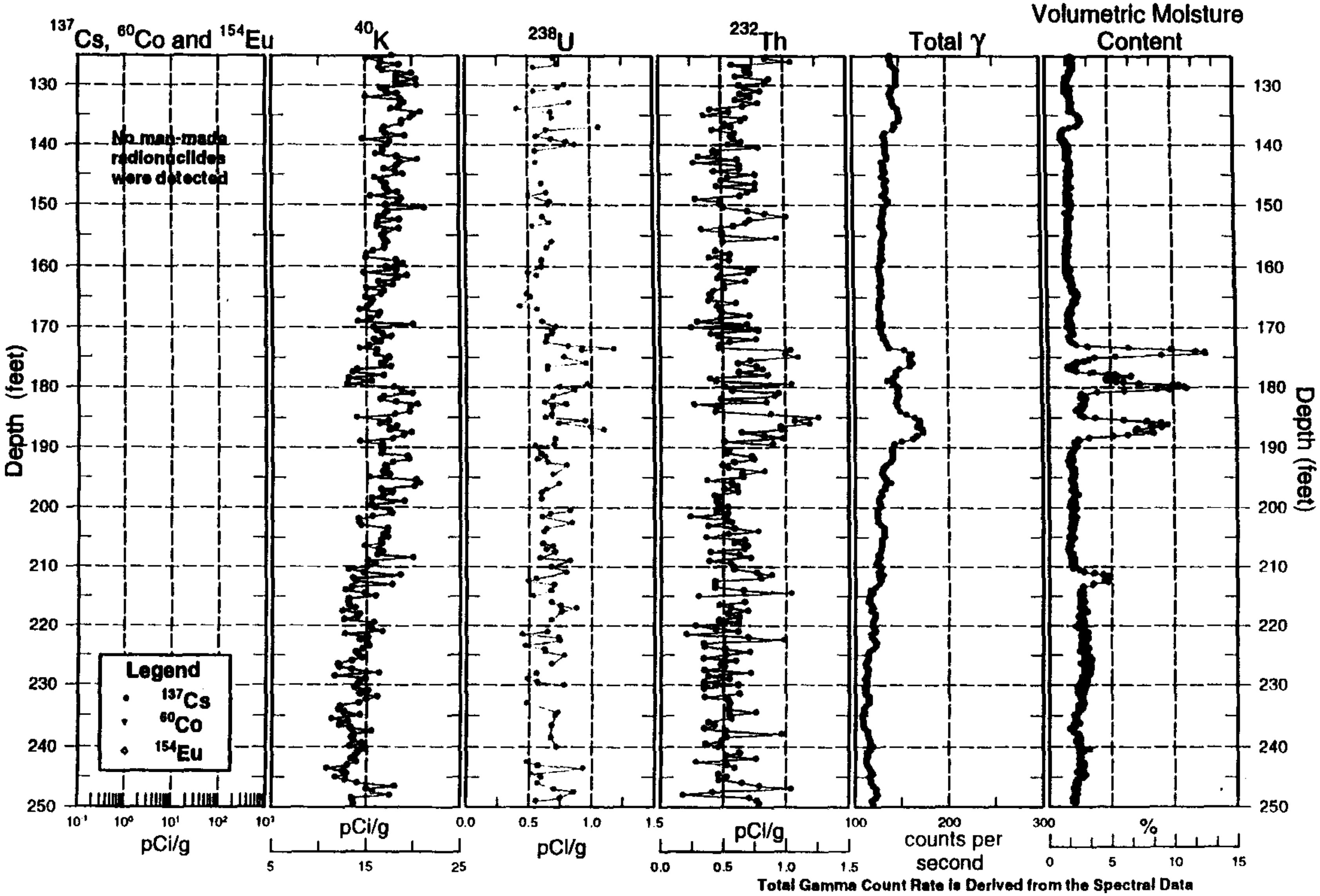


* Total Gamma Count Rate is Derived from Spectral Data

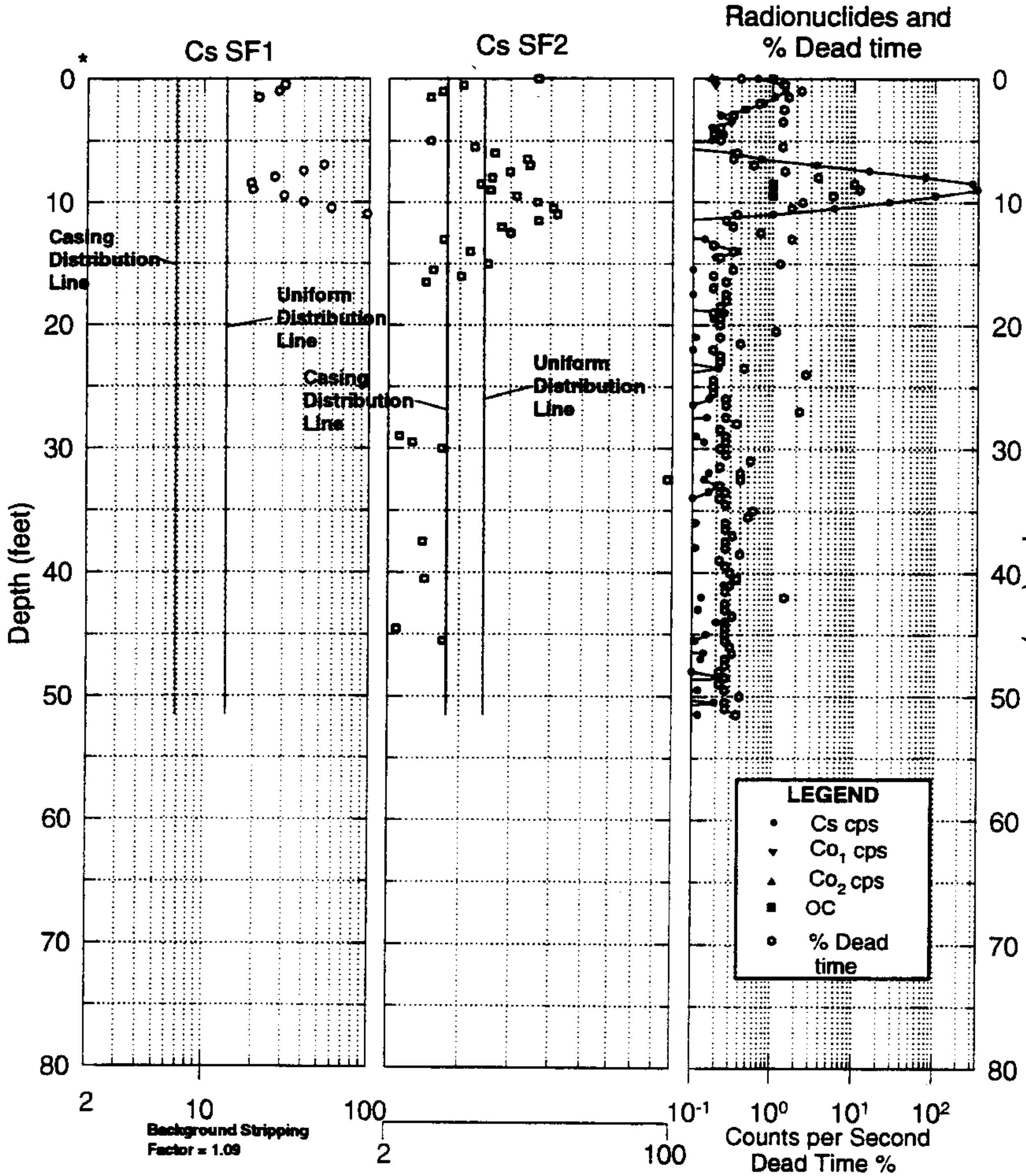
Combination Plot
B8079



Combination Plot
B8079



Shape Factor Analysis Logs
B8079



CsSF1 = ratio of total counts in the continuum window (60 to 650 keV) to the counts in the ^{137}Cs window

CsSF2 = the ratio of the counts in the continuum window (60 to 650 keV) to the counts in the continuum window (350 to 650 keV)

* 0 Depth is ground surface

Cs cps = counts per second 662 keV energy peak

Co_1 cps = counts per second 1173 keV energy peak

Co_2 cps = counts per second 1333 keV energy peak

OC = Contaminants (other than ^{137}Cs) that may affect the count rates observed in the continuum windows

% Dead time = % dead time of total counting time

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