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Soil-Gas Survey and Well Installations at the 618-10 Burial Ground, 300-FF-5 Operable Unit, Hanford Site, Washington

B. A. Williams
R. E. Peterson
K. B. Olsen

June 2003

Prepared for the U.S. Department of Energy
under Contract DE-AC06-76RL01830

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Richland, Washington 99352

Summary

As part of the data quality objective (DQO) process, a need was identified for increased monitoring capability and subsurface characterization at the 618-10 burial ground, part of the 300-FF-5 Operable Unit, a groundwater operable unit that includes the 300 Area and groundwater underlying the 618-10 and 618-11 burial grounds. One outcome of the DQO process was a requirement to install two groundwater monitoring wells in the immediate vicinity of the 618-10 burial ground. The purpose of these wells is to monitor the impact, if any, that potential releases from the burial ground may have on current groundwater conditions.

A soil-gas survey was conducted to help determine the optimal locations for these two wells. Results of the soil-gas survey indicated that tritium levels are probably similar to the levels found in the regional tritium groundwater plume; therefore, the well locations were equally spaced to provide the best coverage downgradient of the burial ground. The wells (699-S6-E4K and 699-S6-E4L) were installed in February and March 2003. The wells were constructed to the specifications and requirements of WAC 173-160. During drilling and construction of the new wells, sampling was conducted to screen for radiological contaminants in the vadose zone and to develop a preliminary hydrogeologic model for the area.

This report describes the results of the soil-gas survey and provides the details of the installation of the two new groundwater monitoring wells at the 618-10 burial ground.

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1.0 Introduction

The need for increased monitoring capability and subsurface characterization at the 618-10 burial ground was identified during the data quality objectives (DQO) process for the 300-FF-5 Operable Unit, a groundwater operable unit that includes the 300 Area and groundwater underlying the 618-10 and 618-11 burial grounds. The DQO process was used to help update and expand the operations and maintenance plan for this operable unit (DOE 2002a) and to prepare a new sampling and analysis plan for the operable unit (DOE 2002b).

One outcome of the DQO process was a requirement to install two groundwater monitoring wells in the immediate vicinity of the 618-10 burial ground. The purpose of these wells is to monitor the impact, if any, that potential releases from the burial ground may have on current groundwater conditions. A soil-gas survey was used to help determine the optimal locations for these two wells. The next section summarizes the results of the soil-gas survey and well location criteria. This report describes the results of the soil-gas survey and the installation of the two new groundwater monitoring wells at the 618-10 burial ground.

1.1 Soil-Gas Survey

The soil-gas survey was conducted during September 2002. Samples were analyzed for helium isotopes, which provide an indication of nearby tritium. The tritium may be present in an underlying groundwater plume and/or a buried vadose zone source. At some locations, analyses for volatile organic compounds were also performed.

The soil-gas results did not reveal any definitive information that suggested releases from the burial ground are currently impacting groundwater (see Section 7.0 for a detailed description of the results). While some evidence of tritium was detected, the levels are consistent with those associated with the leading edge of the site-wide plume that originates at the 200 East Area. Consequently, the two new monitoring wells were equally spaced across the inferred groundwater flow path immediately downgradient of the burial ground.

1.2 New Groundwater Monitoring Wells

The two new groundwater monitoring wells were installed during February and March 2003. Figure 1 is a photo showing the typical operating setup at the drill site. The wells are named 699-S6-E4K (well ID C4072) and 699-S6-E4L (well ID C4073). A location map is presented in Figure 2, which also includes the locations where soil-gas samples were collected. The new wells were constructed to the specifications and requirements described in Washington Administrative Code (WAC) 173-160, Part III (resource protection wells), and the groundwater monitoring description of work for the drilling and installation. During drilling and construction of the wells, sampling and analysis were conducted to support screening for radiological contaminants (none were detected) in the vadose zone and to develop a preliminary hydrogeologic model for the area.

Figure 1. Photo Showing General Conditions at Drill Sites

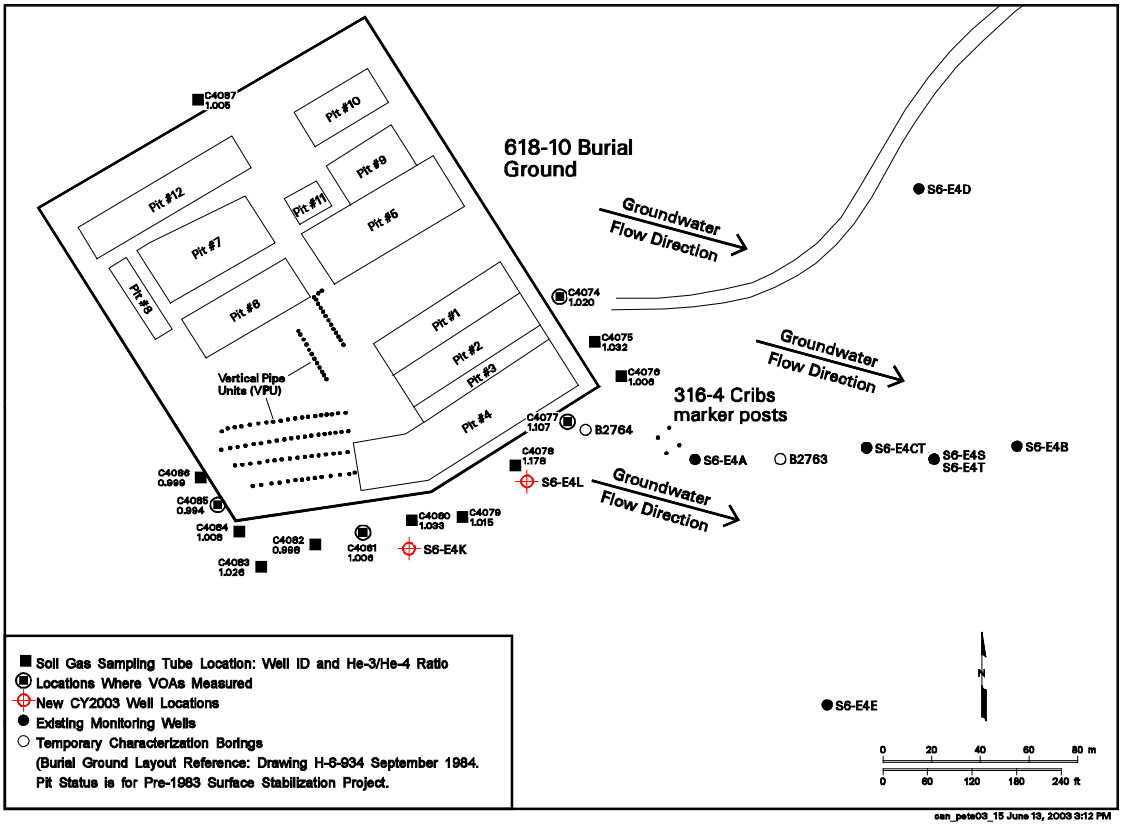

Figure 2. Map of 618-10 Burial Ground showing Locations of Wells in the Groundwater Monitoring Network and Soil-Gas Probes in the Vadose Zone

This document provides a compilation of information obtained during drilling, well construction, well development, pump installation, and sample collection/analysis activities. Appendix A contains the well construction summary report, well summary sheet (as-built), well development and pump installation reports, and the well survey data report. Appendix B contains the borehole log (geologic descriptions) and sediment sample sieve results. Appendix C contains borehole geophysical logs. Appendix D contains vadose zone soil-gas survey results. Additional documentation concerning well construction is on file with Fluor Hanford, Inc., Richland, Washington. Records Management Information System (RMIS) and the Hanford Well Information System (HWIS) are two electronic databases that also contain the drilling and construction records for these two wells.

English units are used in this report to describe drilling and well completion activities because that is the system of units used by drillers to measure and report depths and well construction measurements. Conversion to metric can be done by multiplying feet by 0.3048 to obtain meters or by multiplying inches by 2.54 to obtain centimeters.

1.3 Historical Information

Historical information on the 618-10 burial ground (originally named the 300 North Solid Waste Burial Ground) is presented in the Technical Baseline Report for the 300-FF-2 Operable Unit (Deford et al. 1994). The 618-10 burial ground is located approximately 4 miles northwest of the 300 Area. The burial ground was operated between 1954 and 1963 and received a wide variety of solid or dry radioactive waste in shallow trenches and vertical pipe units. The vertical pipes, consisting of 55-gallon drums welded end-to-end, were installed to store radioactive waste collected in lead pans known as "gunk catchers" from 300 Area operations buildings. This waste was dropped from the gunk catchers into the vertical pipe units and covered with sand until radiation levels at the surface declined to an acceptable level.

There is no evidence of significant quantities of liquid waste being placed in the burial ground, although small amounts of various liquid waste may have been included with solid materials. Also, several fires occurred at the burial ground during which significant quantities of water may have been applied to the ground surface. In 1982, the surface cover of the burial ground was stabilized using bulldozers, and a black, oily substance was noted, although no further characterization of this substance was conducted. An investigation of underground features using surface geophysical methods was completed in 1995 (Bergstrom et al. 1997). Those results provided the best indication of the actual locations for burial trenches and vertical pipe units.

A determination of groundwater conditions and the suitability of existing monitoring wells for coverage downgradient of the 618-10 burial ground and nearby 316-4 cribs was completed about the same time as the geophysical survey and is described in the limited field investigation report for the 300-FF-2 Operable Unit (DOE 1997). A compilation of all available information on the use of this burial ground was completed in 1993 (Webb 1993).

2.0 Well 699-S6-E4K

This section contains information about the installation of well 699-S6-E4K at the 618-10 burial ground.

2.1 Drilling and Sampling

Well 699-S6-E4K (well ID C4072) was drilled with a cable tool drill rig and drive barrel between the ground surface and 87.3 feet below ground surface (bgs). Temporary 11 5/8-inch-outside-diameter, carbon steel casing was used between the ground surface and total depth (87.3 feet bgs). Grab samples of sediment for geologic description and archive were collected at approximately 5-foot intervals from ground surface to total depth. Also, two 2-foot-long, 4-inch-diameter split spoon samples were collected for physical property analysis. The split spoons retrieved 100 % of sample from 67 to 69.5 feet bgs and 79 to 81.5 feet bgs.

Sediment encountered during drilling was predominantly sand to gravelly sand of the Hanford formation from the surface to about 59 feet bgs. Ringold Formation silty sandy gravel to sandy gravel was encountered from approximately 59 feet bgs to 87.3 feet bgs (total depth). A geologist's borehole log is included in Appendix B. The stratigraphy is interpreted in Section 6 of this report using sediment sample photographs, geophysical logs, and geologic descriptions from 5-foot intervals. The operations and maintenance plan for the 300-FF-5 Operable Unit (DOE 2002a) describes the hydrogeology of the area.

The borehole and drill cuttings were monitored regularly for organic vapors and radionuclide contaminants. No manmade contamination was noted. The well was geophysically logged using high resolution, spectral gamma-ray instrumentation. No gamma-emitting manmade radionuclides were detected during geophysical logging. The geophysical logs are in Appendix C.

2.2 Well Completion

The permanent casing and screen were installed in well 699-S6-E4K in February 2003. A 4-inch-inner-diameter, stainless steel, continuous wire-wrap (0.02-inch slot) screen was set from 80.3 to 65.3 feet bgs. Below the screen interval there is a 3-foot-long stainless steel sump placed from 83.3 to 80.3 feet bgs. The permanent well casing is 4-inch-inside-diameter, stainless steel from 65.3 feet bgs to 2 feet above ground surface. The static water level was 65.53 feet bgs on March 5, 2003.

The screen filter pack is 10 to 20 mesh silica sand placed from 85.5 to 60.4 feet bgs. The annular seal is composed of bentonite pellets from 60.4 to 55.7 feet bgs and bentonite crumbles from 55.7 to 10.8 feet bgs. The surface seal is composed of Portland cement from 10.8 feet bgs to ground surface. A 4 by 4 foot by 6 inch concrete pad was placed around the well at the surface. A protective well head casing with locking cap, four protective steel posts, and a brass marker stamped with the well ID number and Hanford well number were set into the concrete pad. The Well Construction Summary Report and Well Summary Sheet (as-built diagrams) are included in Appendix A.

The vertical and horizontal coordinates of the well were surveyed by Fluor Federal Services in March 2003. The horizontal position of the well was referenced to horizontal control stations established by the U.S. Army Corps of Engineers. The coordinates are for the Washington Coordinate System, South Zone, and referenced to the North American Datum of 1983, as revised in 1991 (NAD83[91]). The vertical datum is North American Vertical Datum of 1988 (NAVD88) and is based on existing U.S. Army Corps of Engineers bench marks. Survey data are included in Table 1 and Appendix A.

Table 1. Survey Data for Wells 699-S6-E4K and 699-S6-E4L

Well Name (Well ID)	Easting (meters)	Northing (meters)	Elevation (meters)	Comments
699-S6-E4K (C4072)	590,867.37	121,626.77		Center of casing
			135.077	Top of casing, N. edge
			134.348	Brass survey marker
			135.083	Top pump base plate, N. edge
699-S6-E4L (C4073)	590,915.84	121,654.35		Center of casing
			134.428	Top of casing, N. edge
			133.725	Brass survey marker
			134.434	Top pump base plate, N. edge
NOTES: Horizontal Datum is NAD83 (1991); Vertical Datum is NAVD88; Washington State Plane Coordinates (South Zone); surveyed March 19, 2003.				

2.3 Well Development and Pump Installation

Well 699-S6-E4K was developed in March 2003. A temporary, submersible pump was used to remove approximately 1,443 gallons of formation water from the well at a rate of 35 to 37 gallons per minute. The pump intake was at 80.6 feet below the top of the protective casing. The approximate drawdown during development was 1.1 foot and a final turbidity was 3.11 NTU. Groundwater conductivity and temperature stabilized at 479 μS/cm and 17.7°C, respectively.

A dedicated Redi-Flo 2-1/4 horsepower (hp) Grundfos™ submersible pump was installed in well 699-S6-E4K on March 5, 2003. The sampling pump intake was set at 77.19 feet below the top of the protective surface casing and connected to the surface with 3/4-inch-diameter stainless steel pipe.

3.0 Well 699-S6-E4L

This section contains information about the installation of well 699-S6-E4L at the 618-10 burial ground.

3.1 Drilling and Sampling

Well 699-S6-E4L (ID C4073) was drilled with a cable tool drill rig and drive barrel between ground surface and 91 feet total depth bgs. Temporary 8 5/8-inch-outside-diameter, carbon steel casing was used between the ground surface and total depth (91 feet bgs). Grab samples of sediment for geologic description and archive were collected at approximately 5-foot intervals from ground surface to total depth. Moisture samples from drill cuttings were collected every 5 feet from 10 to 65 feet bgs. Also, two 2-foot-long, 4-inch-diameter split spoon samples were collected for physical property analysis. The split spoons retrieved 10% and 100% of sample from 65 to 67.5 feet bgs and 77 to 79.5 feet bgs, respectively.

Sediment encountered during drilling was predominantly sand to gravelly sand of the Hanford formation from the surface to about 59 feet bgs. Ringold Formation sand, silty sandy gravel to sandy gravel was encountered from approximately 59 feet bgs to 91 feet bgs (total depth). A geologist's borehole log is included in Appendix B. The stratigraphy is interpreted in Section 6 of this report using sediment sample photographs, geophysical logs, and geologic descriptions from 5-foot intervals.

The borehole and drill cuttings were monitored regularly for organic vapors and radionuclide contaminants. Beta/gamma was slightly elevated above background levels during field scans of drill cuttings (see borehole geology log, Appendix B). No organics were detected. The well was geophysically logged using high resolution, spectral gamma-ray and neutron-moisture instrumentation. No gamma-emitting manmade radionuclides were detected during geophysical logging. The geophysical logs are in Appendix C.

3.2 Well Completion

The permanent casing and screen were installed in well 699-S6-E4L in March 2003. A 4-inch-inner-diameter, stainless steel, continuous wire-wrap (0.02-inch slot) screen was set from 78.5 to 63.5 feet bgs. Below the screen interval there is a 3-foot-long stainless steel sump placed from 81.5 to 78.5 feet bgs. The permanent well casing is 4-inch-inside-diameter, stainless steel from 63.5 feet bgs to 2 feet above ground surface. The static water level was 63.53 feet bgs on February 28, 2003.

The screen filter pack is 10 to 20 mesh silica sand placed from 91 to 57.8 feet bgs. The annular seal is composed of bentonite pellets from 57.8 to 50.9 feet bgs and bentonite crumbles from 50.9 to 11.2 feet bgs. The surface seal is composed of Portland cement from 11.2 feet bgs to ground surface. A 4 by 4 foot by 6 inch concrete pad was placed around the well at the surface. A protective well head casing with locking cap, four protective steel posts, and a brass marker stamped with the well ID number and Hanford well number were set into the concrete pad. The Well Construction Summary Report and Well Summary Sheet (as-built) are included in Appendix A.

The vertical and horizontal coordinates of the well were surveyed by Fluor Federal Services in March 2003 and one described in the previous paragraphs and listed in Table 1 and Appendix A.

3.3 Well Development and Pump Installation

Well 699-S6-E4L was developed in March 2003. A temporary, submersible pump was used to remove approximately 2,805 gallons of formation water from the well. The well was initially pumped at a rate of 35 gallons per minute and then slowed to 20 gallons per minute due to excessive drawdown at the higher pump rate. The pump intake was at 80.6 feet below the top of the protective casing. The approximate drawdown during development initially exceeded 6 feet until the pump rate was reduced. The final turbidity was 2.53 NTU. Groundwater specific conductivity and temperature stabilized at 518 μS/cm and 17.4°C, respectively.

A dedicated Redi-Flo 2-1/4 hp Grundfos™ submersible sampling pump was installed in well 699-S6-E4L on March 4, 2003. The sampling pump intake was set at 76 feet below the top of the protective surface casing and connected to the surface with 3/4-inch-diameter stainless steel pipe.

4.0 Sampling and Analysis During Drilling

This section describes the collection and analysis of sediment samples collected during drilling from wells 699-S6-E4K and 699-S6-E4L.

4.1 Field Screening

Soil samples were screened in the field prior to sample collection for indications of contamination. The drill cuttings and samples were screened for volatile organic contamination, beta-gamma activity, and alpha activity by radiation control technicians and site safety staff. All activity levels were at or below background for well 699-S6-E4K. Volatile organic screening was performed with a photo-ionization detector. No volatile organics were detected during drilling.

Radiation screening during drilling of well 699-S6-E4L revealed beta and gamma slightly above background in a few cuttings and alpha was also detected but determined to be radon. No actions were required. No volatile organics were detected during drilling.

4.2 Borehole Sampling

Sediment samples were collected for geologic description and archival from both boreholes at 5-foot intervals from ground surface to total depth. The geologic borehole logs are included in Appendix B. Archive sediment samples are logged into the archive library for storage by the Pacific Northwest National Laboratory (PNNL) who administers the library. The archive library is located at 2101-M

building in 200 East Area. Sediment moisture samples were also collected from 699-S6-E4L every 5 feet, from 10 to 65 feet (approximate water table), for moisture determination. Table 2 presents the results of the moisture analysis.

Table 2. Moisture Analysis Results for Well 699-S6-E4L

Sample ID	Depth of Sample	Tin Tare	+ Wet Soil	Wet Soil wt	+ Dry Soil	Dry Soil wt	% Moisture
C4073 10'	10	34.13	165.69	131.56	152.99	118.86	10.68
C4073 15'	15	34.25	166.57	132.32	161.85	127.60	3.70
C4073 20'	20	33.75	197.17	163.42	193.19	159.44	2.50
C4073 25'	25	33.87	191.10	157.23	184.40	150.53	4.45
C4073 30'	30	34.07	165.03	130.96	159.05	124.98	4.78
C4073 35'	35	33.63	187.56	153.93	181.87	148.24	3.84
C4073 40'	40	33.42	187.39	153.97	182.06	148.64	3.59
C4073 45'	45	34.01	197.23	163.22	191.01	157.00	3.96
C4073 50'	50	33.48	189.64	156.16	183.64	150.16	4.00
C4073 55'	55	33.79	180.65	146.86	174.78	140.99	4.16
C4073 60'	60	34.03	180.94	146.91	177.08	143.05	2.70
C4073 65'	65	33.96	173.47	139.51	169.00	135.04	3.31

Two split spoon samples were collected from the interval to be screened at each borehole and sieved for particle size distribution to provide data for screen slot size selection. Sieve data and distribution curves are available in Appendix B.

All sediment sample locations, with respect to ground surface, are documented in the geologist's borehole log for each well found in Appendix B.

5.0 Geophysical Logging

A spectral gamma-ray borehole geophysical survey was conducted in borehole 699-S6-E4K, and spectral gamma-ray and neutron moisture borehole geophysical surveys were conducted in borehole 699-S6-E4L. Logging was performed on February 20, 2003. The spectral gamma-ray and neutron moisture tools were used to determine the presence and concentration of manmade and naturally occurring gamma-emitting radionuclides, and the volume fraction of moisture (volume of water/volume total) in the formation. The geophysical logs are correlated with the geologic log data and the interpreted results are presented in Section 6.0.

In well 699-S6-E4K, the spectral gamma-ray tool was run from the ground surface to a depth of 86 feet bgs inside ~12-inch-diameter temporary carbon steel casing. A repeat section was run from 86 to 77 feet bgs. Measurements were made in a "move-stop-acquire" mode and at a rate of 100 seconds per

1 foot. Manmade radionuclides were not detected in this borehole. Neutron-moisture logging was not completed because the casing diameter was too large for the calibrated tool.

In well 699-S6-E4L, the spectral gamma-ray tool was run from the ground surface to a depth of 85 feet bgs inside ~9-inch-diameter temporary carbon steel casing. A repeat section was run from 85 to 75 feet bgs. Measurements were made in a "move-stop-acquire" mode and at a rate of 100 seconds per 1 foot. Manmade radionuclides were not detected in this borehole. The neutron-moisture tool was run from the water table (~64 feet bgs) to ground surface inside the ~9-inch-diameter temporary casing. A repeat section was logged from 63 to 57 feet bgs. Except for the upper 5 feet of the borehole, the volume percent moisture in the borehole never exceeded 5%.

Detailed geophysical logging reports for the two wells are provided in Appendix C. The reports describe calibration requirements, data processing, and log plots.

6.0 Subsurface Characterization Results

Results from the sediment sampling, physical property analysis, geologic log, and geophysical logs from each borehole are correlated to provide an interpretation of the stratigraphy at each borehole. This section includes a discussion of the criteria used to evaluate and interpret the data. Figures 3 and 4 provide the interpreted stratigraphy developed for each well.

6.1 Physical Properties

Sediment samples for particle size distribution, and gravimetric moisture content were sent to PNNL for analysis. The gravimetric moisture content ranged from 2.50 to 10.68% (Table 2, Section 4). The highest moisture value was measured from the shallowest sample. Particle size distribution results (sieve results) are provided in Appendix B.

6.2 Geophysical Logging

No manmade radionuclides were detected in these boreholes. For well 699-S6-E4K, plots of naturally occurring radionuclides indicate there are several distinct activity changes (inflection points) at depths of 22, 58, and 66 feet bgs. These major changes correlate to stratigraphic features and the water table as identified on the interpreted borehole log (Figure 3).

For well 699-S6-E4L, plots of naturally occurring radionuclides and moisture indicate there are several distinct activity changes (inflection points) at depths of 20, 59, and 64 feet bgs. These major changes correlate to stratigraphic features and the water table as identified on the interpreted borehole log (Figure 4). Volumetric moisture ranged from approximately 5% from the surface to 5 feet bgs to an

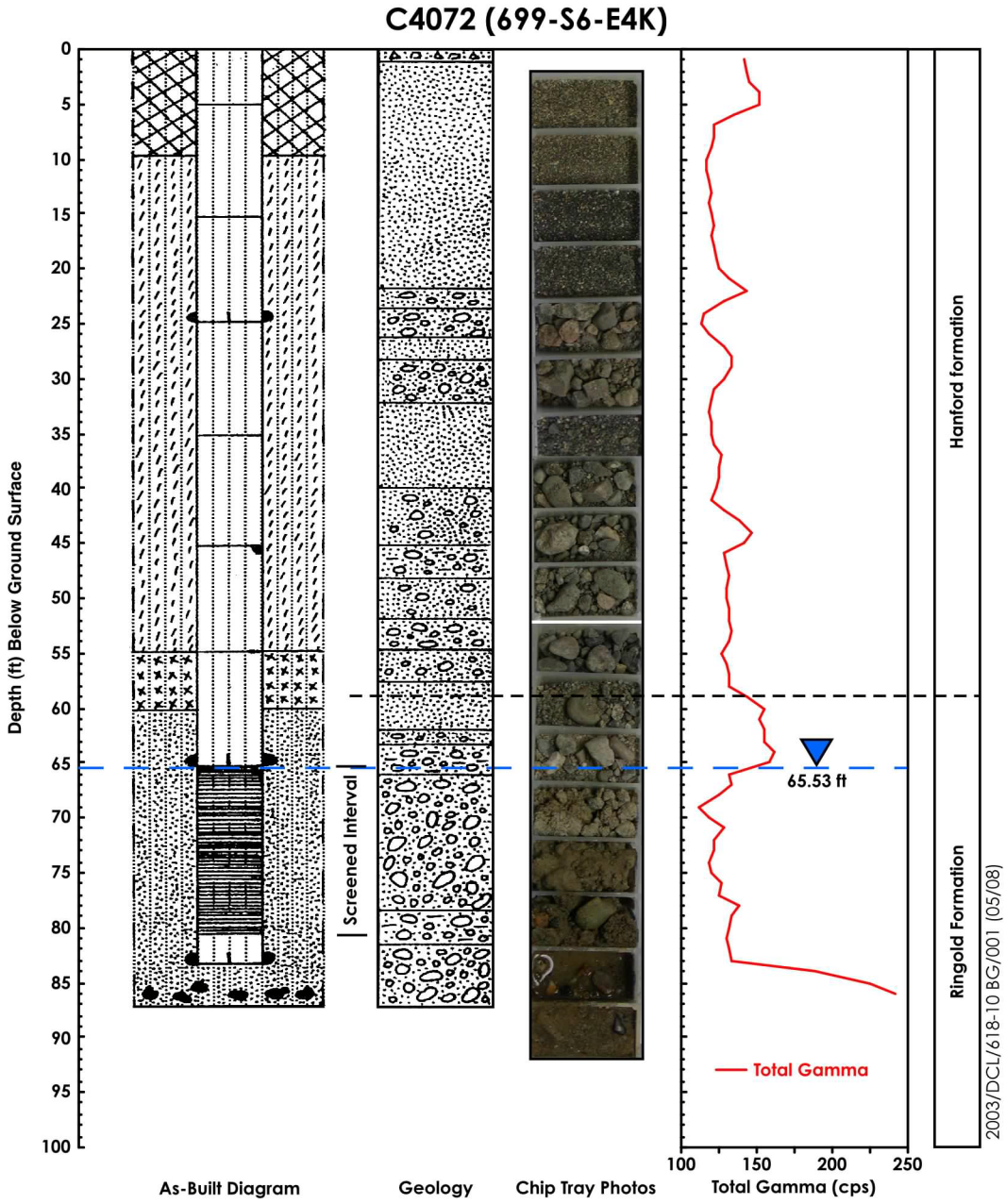

Figure 3. Stratigraphic Interpretation for Well 699-S6-E4K near the 618-10 Burial Ground

average of about 3% throughout the rest of the borehole down to the Ringold Formation, then increased slightly. This trend in volumetric moisture is similar to the gravimetric moisture values generated from analysis of sediment samples (Table 2). It does not appear that there are any anomalously elevated moisture intervals related to releases from the 618-10 burial ground in this area.

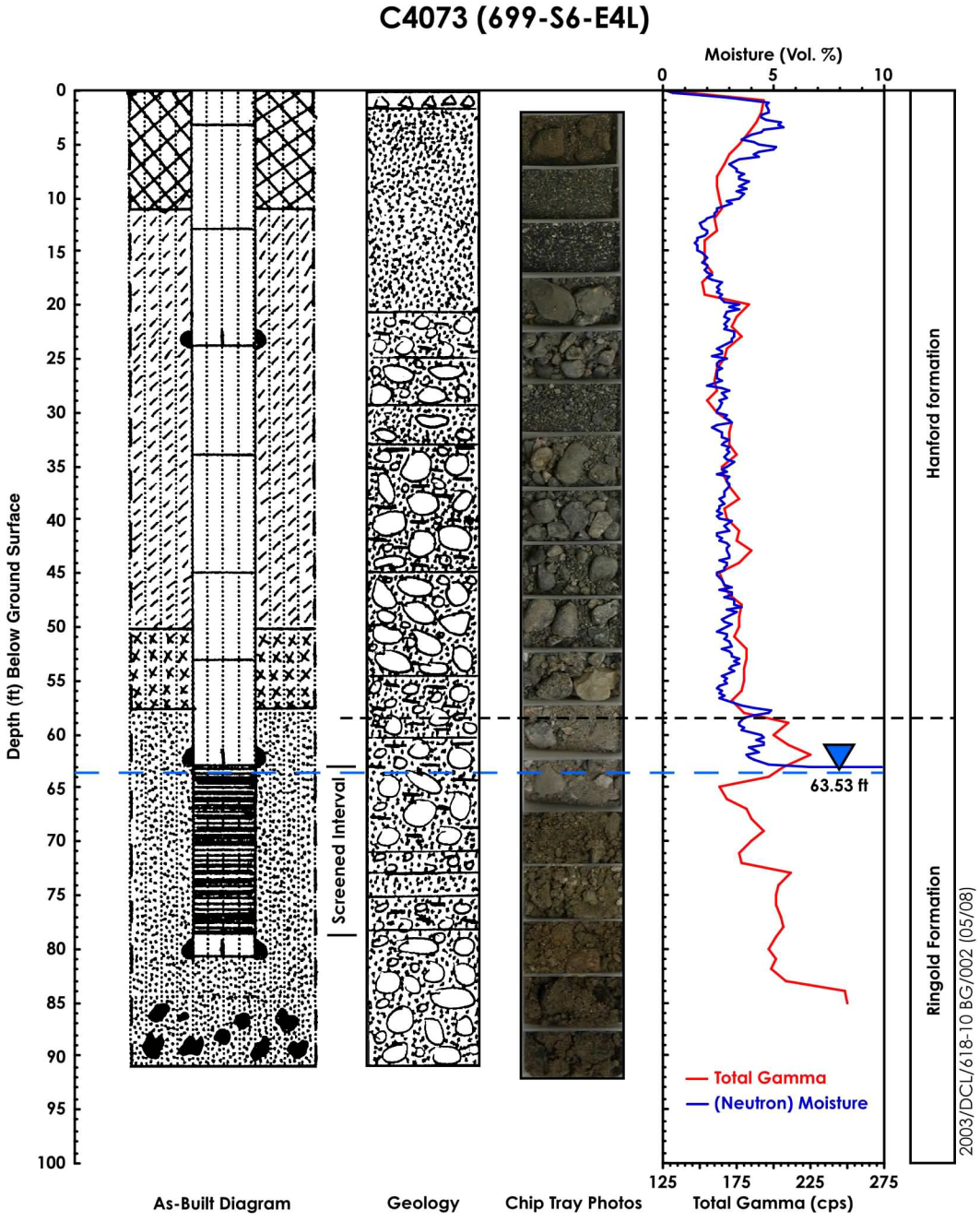

Figure 4. Stratigraphic Interpretation for Well 699-S6-E4L near the 618-10 Burial Ground

7.0 Soil-Gas Investigation

The use of helium-3/helium-4 ratios in soil gas to detect and delineate tritium contamination in the subsurface at the 618-11 burial ground is described in Olsen et al. (2001). The method is based on the decay of tritium to helium-3, which is a stable, inert isotope:

$$^{3}H \rightarrow {}^{3}He + \beta^{-} \quad t_{½} = 12.32 \text{ years}$$

When tritium-bearing waste comes in contact with soil moisture, it reacts to produce tritiated moisture, which may migrate away from the source in the vadose zone. The tritiated soil moisture mixes with infiltrating moisture from precipitation (e.g., rainfall, snowmelt), or moisture from anthropogenic activities (e.g., dust control and/or irrigation water), and migrates downward to subsequently enter groundwater. Concurrent with tritium's release to the vadose zone, its daughter isotope, helium-3, begins to build up in the vadose zone at the rate of tritium decay. The helium-3 diffuses away from its vadose zone and/or groundwater tritium source and migrates toward the surface. Helium-3 thus acts as a non-reactive tracer for tritium.

Because of similarities in the historical use of the 618-10 and the 618-11 burial grounds, the possibility existed that a tritium plume, similar to that present at the 618-11 site, was present beneath and downgradient of the 618-10 burial ground. A soil-gas investigation was conducted around the perimeter of the 618-10 burial ground to search for evidence of tritium in the environment near the burial ground and to provide an indication of the potential source. This information would be used to help position two new groundwater monitoring wells that were planned as part of the monitoring strategy for the burial ground. The results of this investigation are presented in the following sections and in Appendix D.

7.1 Soil-Gas Sampling and Analysis

During September 2002, soil-gas sampling tubes were installed and soil-gas samples collected and analyzed for helium isotopes and volatile organic compounds (see Figure 1 for the locations of the soil-gas sampling sites). Sampling points were installed to a depth of ~20 feet bgs using a GeoProbe™ direct-push system. The 14 sample locations chosen for the survey were intended to detect tritium in groundwater near the potential source (i.e., the vertical pipe units) and in adjacent areas downgradient of the burial ground. One location upgradient of the burial ground was included to provide background levels for constituents of interest. Six of the 14 soil-gas locations were sampled for analyses of volatile organic compounds. The parameters recorded during field sampling are listed in Appendix D (Table D.1).

7.2 Helium Isotopes

Soil-gas samples were collected and analyzed for helium isotopes following procedures established previously during investigations at the 618-11 burial ground (Olsen et al. 2001). The helium-3/ helium-4 ratios from sampling tube sites along the southeastern perimeter of the 618-10 burial ground do not indicate high levels of tritium in the area (Table 3). The highest observed helium-3/helium-4 ratio was 1.178 (ambient air ratio is 1.000). By comparison, helium-3/helium-4 ratios observed in soil gas

Table 3. Helium Isotope Results for Soil-Gas Samples Collected near the 618-10 Burial Ground

Location	$^3He/^4He$ (R/R_a)	He/Ne (relative to air)	^4He (ppm)	N_2 (%)	O_2 (%)	Ne (ppm)	Ar (ppm)	N_2/Ar	Cylinder Pressure (atm)
C4074	1.020	1.096	5.40	79.79	19.29	17.09	9179	86.92	2.17
C4077	1.107	1.014	5.45	77.82	21.25	18.68	9233	84.28	1.59
C4078	1.178	1.052	5.32	78.35	20.73	17.58	9275	84.48	2.08
C4075	1.032	1.086	5.57	80.75	18.28	17.82	9643	83.74	2.24
C4076	1.006	1.079	5.40	81.19	17.89	17.38	9263	87.64	2.30
C4076	1.013	1.054	5.43	81.01	18.07	17.89	9232	87.74	2.54
C4079	1.015	1.177	5.71	80.13	18.94	16.84	9321	85.97	2.30
C4080	1.033	1.017	5.12	82.02	17.01	17.49	9756	84.07	2.25
C4081	1.006	1.125	5.80	80.86	18.16	17.90	9844	82.13	2.46
C4082	0.998	1.109	5.33	81.37	17.66	16.70	9725	83.67	2.45
C4083	1.026	1.084	5.28	80.55	18.49	16.92	9600	83.90	2.49
C4084	1.008	1.123	5.30	79.89	19.20	16.39	9099	87.80	2.28
C4085	0.994	1.069	5.57	79.05	20.02	18.08	9311	84.90	2.39
C4086	0.999	1.047	5.50	82.84	16.19	18.24	9718	85.25	2.26
Ambient Air	0.996	1.093	6.07	79.56	19.50	19.30	9372	84.89	2.63
C4087	1.005	1.178	5.72	80.34	18.74	16.87	9208	87.25	2.31
C4087	1.027	1.105	5.39	79.85	19.20	16.93	9477	84.26	2.29

near the 618-11 burial ground are much higher – up to 62 times the ambient air ratio near suspected buried sources of tritium and up to 1.68 over the tritium groundwater plume that extends downgradient from that burial ground.

Slightly elevated ratios are present at two locations along the southeast perimeter fence of the 618-10 burial ground, along the presumed downgradient flow path from the vertical pipe units (see Figure 1). The elevated ratios at sampling sites C4077 and C4078 could represent helium-3 enrichment from a tritium source in the vadose zone and/or tritium in the underlying groundwater.

The cause for the slight elevated helium-3/helium-4 ratio at the two locations cannot be conclusively determined by the soil-gas data alone. One possibility is the release of tritium gas from irradiated material buried in the vertical pipe units. If that is the case, it is occurring at a much smaller scale than at the 618-11 burial ground. A second possibility is that the excess helium-3 has migrated upward from an underlying groundwater plume. Tritium is present in groundwater flowing through the general area at concentrations just below the 20,000 pCi/L standard for drinking water supplies.

7.3 Volatile Organic Compounds

The analyses for volatile organic compounds revealed several chlorinated hydrocarbon compounds (Table 4) and numerous tentatively identified compounds (Table 5) in all six of the samples collected for volatile organics analysis. All of the soil-gas samples contained a similar composition of C10-C13 hydrocarbon compounds, which suggested a contamination problem with the sampling equipment. Total concentrations ranged from 789 ng/L at soil-gas sampling site C4077 to 3,209 ng/L at site C4074.

To identify the source for the anomalous results, a sample of the polyethylene tubing used for the installations (similar in length to those in the field) was obtained and purged with air or nitrogen onto a triple sorbent trap. Total concentrations for this test ranged from 931 to 1,849 ng/L. These results strongly suggest that the origin for the C10-C13 hydrocarbon compounds is out gassing from the tubing, and that the compounds are not present in the soil gas at the sampling points. The gas chromatograph fingerprint profile of the eluting compounds suggests diesel fuel is the source of the tubing contamination.

The tubing blank did not reveal any of the volatile chlorinated organic compounds that were identified in the samples from the field. These target compounds included carbon tetrachloride, trichloroethlene, and perchloroethylene (see Table 4). The concentrations measured are as follows: carbon tetrachloride (2.9 to 28.2 ng/L); trichloroethene (4.1 to 82.7 ng/L); and perchloroethylene (4.5 to 241.8 ng/L). Converting these concentrations to parts per billion by volume (ppb_v), concentrations would range from a low of 0.42 ppb_v for carbon tetrachloride to a high of 32.7 ppb_v for perchloroethylene. The lowest concentration of these three compounds consistently occurred at site C4085, which is located at the southwest corner of the burial ground. The highest concentrations occurred at sites C4074 and C4077, which are located near the southeast corner of the burial ground and the trenches where a black, oily substance was discovered during surface stabilization activities in 1982 (see Figure 1, pits #1 through #4).

7.4 Discussion of Soil-Gas Results

Based on the helium isotope results for the soil-gas samples, there appears to be minor contribution of helium-3 from nearby tritium to soil gas in the vicinity of the 618-10 burial ground. The source for the excess helium-3 may be tritium in the underlying groundwater, which is at concentrations consistent with the leading edge of the site-wide plume that originates at the 200 East Area. The possibility that tritium gas is being released from subsurface waste in the burial ground cannot be excluded, although if that is occurring, the release is at much lower levels than those observed at the 618-11 burial ground. Consequently, the two new monitoring wells were equally spaced across the inferred groundwater flow path immediately downgradient of the burial ground.

In summary, the results for volatile chlorinated organic compounds in the soil-gas samples suggest that there is a source of carbon tetrachloride, perchloroethylene, and trichloroethene in or around the burial ground. Because of the pervasiveness of C10-C13 hydrocarbon contamination in the sample tubing, it was not possible to determine if hydrocarbon compounds were present in soil gas.

Table 4. Target Compound Results from Soil-Gas Samples Collected Around the Perimeter of 618-10 Burial Ground

Sample Location -->	Soil Gas C4074	Soil Gas C4077	Soil Gas C4081	Soil Gas C4085	Soil Gas C4087		Diaphram Pump/Sample Tubing	Metal Bellow Pump/Sample Tubing	Sample Tubing Only
Canister-->	**139**	**215**	**237**	**275**	**432**	**Blank**			
Target Compounds	**ng/L**	**ng/L**	**ng/L**	**ng/L**	**ng/L**	**ng/L**	**ng/L**	**ng/L**	**ng/L**
Dichlorodifluoromethane	2.6	3.2	3.2	2.1	2.8	N.D	N.D	N.D	N.D
1,2 dichloro-1,1,2,2 tetra	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
Methanol	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
Vinyl Chloride	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
Chloromethane	1.2	N.D	N.D	0.6	0.7	N.D	3.1	1.9	1.20
1,3 butadiene	0.1	N.D	N.D	N.D	N.D	N.D	1.1	0.5	0.16
Bromomethane	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
Chloroethane	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
Ethanol	N.D	N.D	N.D	N.D	6.5	N.D	N.D	N.D	N.D
Acetonitrile	N.D	N.D	1.1	0.8	1.0	N.D	N.D	N.D	N.D
Acetone	15.0	33.9	12.9	18.8	31.4	1.8	13.4	7.9	4.33
Trichloromonofluoromethane	2.4	2.7	2.3	2.0	1.8	N.D	N.D	N.D	N.D
Pentane	0.4	N.D	N.D	0.3	0.5	N.D	N.D	N.D	N.D
1,1-Dichloroethene	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
3-chloropropene	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
Methylene Chloride	10.7	9.0	8.7	10.6	8.6	3.0	6.6	5.1	7.73
1,1,2 trichloro-1,2,2 trifluoroethane	1.0	1.1	1.1	0.8	1.0	N.D	N.D	0.2	0.11
2-butanone	2.8	5.7	2.5	4.9	7.1	N.D	5.2	4.3	1.55
1,1 dichloroethane	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
cis1,2-dichloroethene	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
chloroform	1.8	0.8	1.5	0.5	9.8	N.D	N.D	N.D	N.D
1,2 dichloroethane	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
1,1,1 trichloroethane	0.9	1.1	1.8	0.7	0.8	N.D	N.D	N.D	N.D
benzene	5.9	2.1	3.3	2.5	4.0	N.D	5.8	2.8	0.40
carbon tetrachloride	21.5	28.2	9.0	2.9	25.4	N.D	N.D	N.D	N.D
1, 2 dichloropropane	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D

Table 4. (contd)

Sample Location -->	Soil Gas C4074	Soil Gas C4077	Soil Gas C4081	Soil Gas C4085	Soil Gas C4087		Diaphram Pump/Sample Tubing	Metal Bellow Pump/Sample Tubing	Sample Tubing Only
Canister-->	**139**	**215**	**237**	**275**	**432**	**Blank**			
Target Compounds	**ng/L**	**ng/L**	**ng/L**	**ng/L**	**ng/L**	**ng/L**	**ng/L**	**ng/L**	**ng/L**
trichloroethene	82.7	56.0	14.3	4.1	60.1	N.D	N.D	N.D	N.D
cis 1,3 dichloropropene	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
trans1,3 dichloropropene	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
1,1,2 trichloroethane	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
toluene	144.7	29.9	77.1	37.6	56.5	N.D	128.3	56.5	2.73
1,2 dibromoethane	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
perchloroethylene	241.8	18.5	33.5	4.5	24.7	N.D	0.4	N.D	N.D
chlorobenzene	0.7	0.3	0.4	0.1	0.3	0.1	0.6	0.3	N.D
ethyl benzene	41.7	3.6	20.3	13.2	21.9	0.3	52.2	23.7	0.46
p/m xylene	173.4	16.3	87.3	53.9	89.4	0.2	215.6	97.4	1.88
styrene	2.4	0.7	1.3	0.8	1.2	0.1	2.8	1.3	N.D
1,1,2,2 tetrachloroethane	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D	N.D
o-xylene	70.5	7.4	34.3	21.8	37.7	N.D	91.2	41.3	1.39
1-methylethylbenzene	5.9	0.7	2.9	2.0	3.9	0.2	8.6	4.0	0.21
1,3,5 trimethylbenzene	29.2	1.2	15.5	9.2	18.6	N.D	46.3	18.6	0.21
1,2,4 trimethylbenzene	28.1	1.1	11.3	7.7	14.6	N.D	39.8	15.8	0.28
1,3 dichlorobenzene *	0.8	0.5	0.4	0.3	0.5	0.4	1.2	0.7	0.3
1,4 dichlorobenzene *	1.8	1.1	0.9	0.8	1.1	0.7	1.7	1.0	0.3
1,2 dichlorobenzene *	1.4	0.9	0.7	0.6	0.9	0.7	1.6	1.1	0.5

* Did not exceed level in blank - N.D.
Shaded - Positive detection in soil gas.

Table 5. Tentatively Identified Compound Results from Soil-Gas Samples Collected Around the Perimeter of 618-10 Burial Ground

Sample Location -->			Soil Gas C4074	Soil Gas C4077	Soil Gas C4081	Soil Gas C4085	Soil Gas C4087	Diaphram Pump/Sample Tubing	Metal Bellow Pump/Sample Tubing	Sample Tubing Only
Canister-->			**139**	**215**	**237**	**275**	**432**			
Tentatively Identified Compounds	CAS #	**RT**	**ng/L**	**ng/L**	**ng/L**	**ng/L**	**ng/L**	**ng/L**	**ng/L**	**ng/L**
2-Propanol, 2-methyl-	75-65-0	**8.72**						12.5	8.3	8.5
1-Butanol	71-36-3	**12.18**	0	4.255	0	0	2.6			
2-Pentenal	1576-87-0	**12.40**	2.13	0	2.05	0	0			
Hexane, 3-mehtyl-	589-34-5	**12.99**	2.51	0	0	0	0	6.15	4.62	
Methyl Isobutyl ketone	108-10-1	**14.12**	1.675	0	0	0	0	2.035	0	
Cyclohexane, methyl-	108-87-2	**14.35**	2.085	0	2.05	0	0	0	1.695	
Ethene, 1,2-dibromo	540-49-8	**14.42**	0	0	0	0	2.8	0	0	
Heptane, 4-methyl-	589-53-7	**14.93**	5.7	0	2.75	0	3.31	7.15	3.275	
Heptane, 3-methyl-	589-81-1	**15.32**	5.4	0	2.15	0	0	6.75	0	
Hexane,2,2,5-trimethyl-	3522-94-9	**15.60**	4.29	0	0	0	0	4.1	0	
Octane	111-65-9	**15.88**	8.15	0	5.7	0	2.69	3.655	2.59	
Benzene. Propyl-	103-65-1	**19.20**	29	0	11.9	8.2	15.75	40.1	17.65	
Benzene, 1-ethyl-3-methyl-	620-14-4	**19.31**	101.5	0	0	27	54.5	137.5	60	
3-Nonene, 3-methyl	69405-42-1	**19.65**	14.8	0	8.85	14.95	28.65	58.5	35.45	7.55
Benzene, 1-ethyl-2-methyl-	611-14-3	**19.73**	32.5	0	17.5	20.5	39.5	66.5	39	
Decene	872-05-9	**19.73**	32.5	0	17.5	20.5	39.5	65	39	24.5
Decane	124-18-5	**19.94**	82	20.25	48	59.5	110.5	150.5	112.5	43.45
Benzene, 1,2,3-trimethyl-	526-73-8	**20.00**	206.5	0	93	71.5	139	292	143.5	
4-Decene	19689-18-0	**20.18**	13.55	0	7.6	9.9	18.25	26.6	18.2	6.3
Benzene, 1-ethyl-2,4 -dimethyl-	874-41-9	**20.52**	7.6	0	5.4	8	8.5	11.85	5.6	
Benzene, 1-ethyl-4-methyl-	622-96-8	**20.60**	31.35	0	13.6	7.45	15.2	35.25	15.75	
Limonene	138-86-3	**20.74**	107.5	65.5	62.5	58	65.5	85	54.5	22.6
Benzene, 1-ethenyl-2-methyl-	611-15-4	**20.94**	34.15	0	18.45	5.8	9.55	24.95	10.1	
Benzene, 1-methyl-2-propyl-	1074-17-5	**21.00**	21.7	0	11.2	0	0	0	0	

Table 5. (contd)

Sample Location -->			Soil Gas C4074	Soil Gas C4077	Soil Gas C4081	Soil Gas C4085	Soil Gas C4087	Diaphram Pump/Sample Tubing	Metal Bellow Pump/Sample Tubing	Sample Tubing Only
Canister-->			**139**	**215**	**237**	**275**	**432**			
Tentatively Identified Compounds	CAS #	**RT**	**ng/L**	**ng/L**	**ng/L**	**ng/L**	**ng/L**	**ng/L**	**ng/L**	**ng/L**
Benzene, 1,4-diethyl-	105-05-5	**21.08**	53.5	0	28.3	11.5	23.95	50.5	21.7	
Heptane, 4-ethyl-2,2,6,6-tetramethyl	62108-31-0	**21.29**	20.95	19.1	9.9	7.75	8.65	30.45	14.45	8.95
Benzene, 1-ethyl-2,3 -dimethyl-	933-98-2	**21.49**	19.95	0	12.15	2.195	6.45	18.35	7.2	
Heptane, 3,4-dimethyl	922-28-1	**21.57**	0	10.7	0	0	0	0	0	
Benzene, 2-ethyl -1,3 -dimethyl-	2870-04-4	**21.64**	37.4	0	28.7	5.55	10.2	25.35	0	
Undecane	1120-21-4	**21.70**	0	7.8	0	0	0	0	0	
5-Dodecene	7206-28-2	**22.22**	0	0	0	14.75	24.65	28.3	23.6	13.3
Benzene, 4-ethyl -1,2 -dimethyl-	934-80-5	**22.26**	35.95	0	19.8	0	0	0	0	
Benzene, 1,2,4,5-tetramethyl-	95-93-2	**22.34**	35.75	7.7	22.8	14.25	29.2	41.35	24.9	11.9
Decane, 5-propyl-	17312-62-8	**22.49**	0	0	0	8.15	13.65	14.85	12.1	6.6
4-Undecene, 4-methyl-	61142-40-3	**22.73**	32.95	0	24.25	18	33.6	34.05	30.5	15.75
Undecane, 3-methyl-	1002-43-3	**22.94**	85.5	113.5	0	56.5	100.5	49.5	51.5	33.5
3-Undecene, 3-methyl-	23381-94-4	**23.09**	209.5	27.95	85.7	130.5	210.5	60	80	76.25
1-Dodecene	112-41-4	**23.20**	977	161.5	414	543	768.5	237	244	291.5
2-Undecene, 3-methyl	57024-90-5	**23.28**	131	34.95	60	62.5	128	66.5	88.5	70.5
Dodecane	112-40-3	**23.35**	394	69.5	163.5	220	291	71	73	91
3-Dodecene	7206-14-6	**23.59**	109	16.9	43.1	61.5	83	17.8	22.8	33.85
Naphthalene	91-20-3	**23.68**	32.8	0	20.15	0	18	15.5	12	34.5
3-Dodecene,(E)	7239-23-8	**24.29**	38.35	0	14.3	24	34.5	16.5	18	18.5
4-Tetradecene	41446-65-5	**26.07**	14.55	0	27.5	11.3	44	0	0	9.5
1-Tetradecene	1120-36-1	**26.19**	41.75	143.5	114	154.5	141	20.5	30	30.45
Tetradecane	629-59-4	**26.33**	116.5	45.65	57.5	112	109	15.5	16.5	41.5
Tridecane, 3-methylene	19780-34-8	**26.41**	65	28.25	49	57.5	64.5	0	10.5	30.5
Cyclotetradecane	295-17-0	**26.55**	11.05	12.4	16	20	25	0	0	
Total Tentatively Identified Compounds			**3,209**	**789**	**1,541**	**1,847**	**2,724**	**1,849**	**1,353**	**931**

8.0 References

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Appendix A

Well Construction and Completion Documentation

WELL CONSTRUCTION SUMMARY REPORT

Start Date: 2/7/03
Finish Date: 3/5/03
Page 1 of 1

Well ID: MSH 60 C4072 | Well Name: 699-56-64K | Approximate Location: 618-10 Burial Ground
Project: FY 2003 CERCLA GW: WELL DRILLING | Other Companies: FH, CHG
Drilling Company: Blue Star Enterprises [BSE] | Geologist(s): C. Martinez, J. Hocking, D. Weekes
Driller: Mo Wrasper License #: 1909

TEMPORARY CASING AND DRILL DEPTH			DRILLING METHOD	HOLE DIAMETER (in) / INTERVAL (ft)
*Size/Grade/Lbs. Per Ft.	Interval	Shoe O.D./I.D.	Auger:	Diameter ____ From ____ to ____
11 3/4" / 10 5/8" C.S. FJ	0 - 88'	11 3/8" / 10 1/4"	Cable Tool: ✓	Diameter 9 1/2" From 0 to 76'
	____ - ____		Air Rotary:	Diameter ____ From ____ to ____
	____ - ____		A.R. w/Sonic:	Diameter ____ From ____ to ____
	____ - ____		Cable Tool	Diameter 8 5/8" From 76' to 87.3'
	____ - ____			Diameter ____ From ____ to ____
*Indicate Welded (W) - Flush Joint (FJ) Coupled (C) & Thread Design				Diameter ____ From ____ to ____

Drilling Fluid: NA

Total Drilled Depth: 87.3' | Hole Dia @ TD: 8 5/8" | Total Amt. Of Water Added During Drilling: 2.5 Gal.
Well Straightness Test Results: Passed (2/19/03) using 20.4' long, 8.5" od C.S. straightness tool. | Static Water Level: 68.53' TOC | Date: 2/26/03

GEOPHYSICAL LOGGING

Sondes (type)	Interval	Date	Sondes (type)	Interval	Date
Spectral Gamma	0' - 86'	2/20/03		____ - ____	
	____ - ____			____ - ____	
	____ - ____			____ - ____	

COMPLETED WELL

Size/Wt./Material	Depth	Thread	Slot Size	Type	Interval Annular Seal/Filter Pack	*Volume	Mes Siz
4" sch. 5 ss 304 sump	83.3' - 80.3'	✓	NA	Colorado Silica Sand	85.5' - 60.4'	34 bag	10-20
4" sch. 5 ss 304 cont. wire wrap scrn.	80.3' - 65.3'	✓	0.020"	Bentonite Pellets	60.4' - 55.7'	5 bucket	1/4"
4" sch. 5 ss 304 Riser	65.3' - +2.00'	✓	NA	Bentonite Crumbles	55.7' - 10.8'	40 bags	NA
	____ - ____			Portland Cement	10.8' - 0	8 bags	TP-Fill
	____ - ____				____ - ____		

OTHER ACTIVITIES

Aquifer Test: WELL DEVELOPMENT	Date: 3/4/03	Well Decommission:	Yes:	No:	Date:
Description: Pumped well @ 37 GPM for 39 min. Final Turb = 3.11 NTU; Recovery test run 15 min. for 100% rec. Total amt pumped = 1,443 Gal.		Description:			

WELL SURVEY DATA (If applicable)

	Protective Casing Elevation:
Washington State Plane Coordinates:	Brass Survey Marker Elevation:

COMMENTS/REMARKS

*Vol. Calc.: Portland Cement: 8 bag x 1.285 ft^3/bag = 10.28 ft^3; Bentonite pellets: 5 buckets x 0.62 ft^3/bucket = 3.1 ft^3; Bentonite Crumbles: 40 bag x 0.71 ft^3/bag = 28.4 ft^3; Colorado Silica: 34 bag x 0.535 ft^3/bag = 18.19 ft^3

Reported By: Jess Hocking Title: Geologist Signature: Jess Hocking Date: 2/26/03

Original to: Document & Information Services, H0-09/HWIS
Distribution by DIS: Environmental Technologies Well Coordinator, H0-02

BHI-EE-181 (07/27/2001)

WELL SUMMARY SHEET

Start Date: 2/7/03
Finish Date: 3/5/03
Page: 1 of 1

Well ID: C4072	Well Name: 699-56-E4K
Location: 618-10 Burial Ground	Project: FY 2003 CERCLA G.W. Well drilling
Prepared By: Jess Hacking Date: 2/27/03	Reviewed By: L.D. Walker Date: 3-6-03
Signature: Jess Hacking	Signature: L.D. Walker

CONSTRUCTION DATA

Description	Diagram
4" sch. 5 ss 304 Sump 83.3' — 80.3'	
CONT. WIRE 0.020" 4" sch. 5 ss 304 WRAP SCREEN 80.3' — 65.3'	
4" sch. 5 ss 304 Riser 65.3' — +2.00'	
10-20 Mesh Colorado Silica Sand 85.5' — 60.4'	
1/4" Bentonite Pellets 60.4' — 55.7'	
Wyoming Bentonite Crumbles 55.7' — 10.8'	
Type I/II Portland Cement 10.8' — 0	
NOTE: All temp. casing removed from ground. All depths reported below ground surface NOT TO SCALE	

GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description
0		0 - 1.5' Backfill Material
		1.5 - 22' Sand (S)
		Hanford Formation @ 1.5'
15		
		22-23' Gravelly Sand (gS)
		23-26' Sandy Gravel (sG)
		26-28.5' Sand (S)
		28.5-32' Sandy Gravel (sG)
30		32 - 40' Sand (S)
		40 - 45' Gravelly Sand (gS)
		45-48' Silty Sandy Gravel (msG)
45		48-52' Gravelly Sand (gS)
		52 - 55' Sandy Gravel (sG)
		55-57.5' Gravelly Sand (gS)
		57.5-62' Sand (S)
60		
		62-63.5' Gravelly Sand (gS)
▼		Ringold Formation @ 63.5'
		63.5-66' Silty Sandy Gravel (msG)
		66-79' Sandy Gravel (sG)
75		
		79-82' Silty Sandy Gravel (msG)
		82-87.3' Sandy Gravel (sG)
		TD = 87.3' bgs
		DTW = 65.53' bgs (3/5/03)

Original to: Document & Information Services, H0-09/HWIS
Distribution by DIS: Environmental Technologies Well Coordinator, H0-02

BHI-EE-189 (02-20-2002)

WELL DEVELOPMENT AND TESTING DATA

Well Name: 699-56-E4K	Well ID: C4072	Well Location: 618-10 Bur. Ground	Date: 3/4/03

Reference Measuring Point (unless otherwise noted): ~~GROUND LEVEL~~ (ACM) Top of protective casing

Has the well been surveyed? ☐ Yes ☒ No

Does the well have a cement pad? ☒ Yes ☐ No

PART 1

STATIC WATER LEVEL:

Start of Job	68.5'
End of Job	68.52'

DEPTH TO BOTTOM:

Start of Job	86.0'
End of Job	85.8'

PART 2

WELL DEVELOPMENT DATA

Pump Model	2243025202 Franklin
Intake Depth	80.55'
Starting Turbidity	>1000 NTU

Pump Start	Stop	Flow Rate
1438	1517	37 gpm

Total Pumped	1443 gallons
Final Turbidity	3.11 NTU
Transducer Range (PSI)	20.0 Psi

PART 3

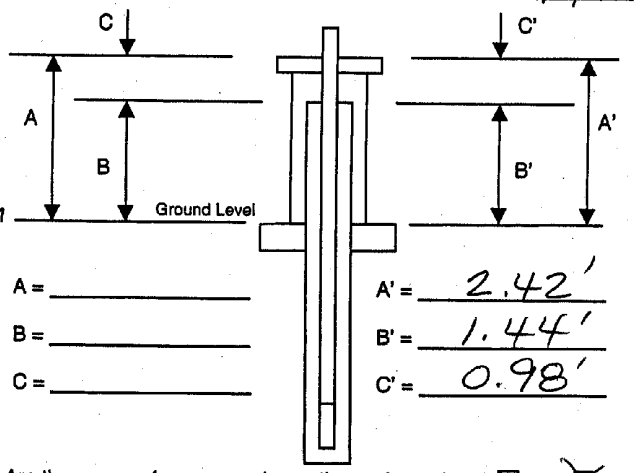
INSTANTANEOUS SLUG TEST

Static Water Level (TOC)	
Transducer Depth	
Baseline Start	
Injection Start	
Baseline Start	
Withdrawal Start	
Slug Volume	
Transducer Range (PSI)	

PART 4

Last Recorded Measurements Date:

Current Measurements Date: 3/4/03



A = _____

B = _____

C = _____

A' = 2.42'

B' = 1.44'

C' = 0.98'

Are there any reference marks on the casing strings? ☐ Yes ☒ No

PART 5

COMMENTS:

1330 Tagged water @ 68.5' bTOC (65.5' bgs)
Tagged bottom @ 85.1' bTOC (82.1' bgs)
There is ~1.2' of fill in sump. Driller will bail well. Chris Wright here from 1330-1345
Bottom of well should be 86.3' bTOC (83.3' bgs)
1345-1402 Using sand pump to clean out well.
1402 Tagged bottom @ 86' bTOC. Good.
1403-1430 Installing development pump
1436 Head = 10.124' (ACM) 2.14'
1438 Start pumping. Test #6.
1448 Head = 9.119' (1.095' drawdown)

Prepared by (print name): DCWeekes	Signature: DCWeekes
Reviewed by (print name): L.D. Walker	Signature: LD Walker

TO CHECK A BOX: Double click the box; select "Default Value – Checked"

BHI-EE-112 (12/97)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 2 of 2

Date: 3/4/03

Well ID: C4072 | Well Name: 699-S6-E4K

Location: 618-10 Burial Ground | Report No.: 1

Start	Finish	Total
Time 1330	Time 1600	Time 2:30
Hole Depth/Csg NA / NA	Hole Depth/Csg NA / NA	Hole Depth/Csg NA / NA

Reference Measuring Point: GROUND SURFACE

Casing String No. 1 2 3 4 ____ Rod Size:

See Report No. 1

Time/Depth From	To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
1513		Head = 9.113' (1.101' drawdown).
1517		Turn off pump. Start recovery test (#7). Pumped for 39 min.
1518		Head = 10.186'. 99.7% recovered.
1536		Head = 10.213'. 100% recovered.
1532		Test #7 (recovery) stopped.
1533	1600	Driller pulled out development pump.
		Well development equipment installed in well was a 3hp Franklin submersible pump model # 2243025202 (same as C4073 development).
		Monitoring equipment included Hach 2100P turbidimeter and Orion model 124 conductivity meter/temp.
		Delayed entry.
		Development Data

Turb	Cond.	Temp	DO	pH	Time	Pump Rate
150	—	—	—	—	1442	37 gpm
18	477	17.7	ND	ND	1446	37 gpm
7.15	479	17.6	ND	ND	1454	37 gpm
8.27	479	17.5	ND	ND	1507	37 gpm
3.790	—	—	—	—	1511	35 gpm
—	479	17.7	—	—	1513	35 gpm
3.11	—	—	—	—	1515	35 gpm

Reported By: DC Weekes | Reviewed By: L. D. Walker

Title: Geologist | Date: 3/4/03 | Title: Geologist | Date: 3-6-03

Signature: DC Weekes | Signature: LD Walker

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-018 (07/27/2001)

FIELD ACTIVITY REPORT
WELL SERVICES

Page 1 of 2

Date	Well No.	Rig Type/Model	Rig No.	Contract/Work Order No.	Report No.
3/5/03	C4072 699-56-E4K	Pump Truck			1

Purpose: INSTALL SAMPLING PUMP INTO GW MONITORING WELL

Reference:

Location: 618-10 Burial Grnd.

HISTORICAL DATA

Construction Depth	87.3' TD
Casing Size / Type / Set At	4" sch 5 ss 304 +2.00' – 65.26' bgs
Casing Perforations Schedule / Interval	NA / NA
Well Screen(s) Type / Interval	4" sch. 5ss 304 0.020" cont. wire wrap 65.26 – 80.26' bgs
Last Recorded Depth-to-Water	68.52' TOC
Last Recorded Depth-to-Bottom	85.80' TOC
Current Depth-to-Water	68.53' TOC
Current Depth-to-Bottom	85.85' TOC

PUMP SYSTEM CONFIGURATION

	Pre-Maintenance	Post-Maintenance
Pump Type	Redi-Flo 2	
Pump Model	½ HP 4W Grundfos	
Tubing Size/Type	¾" TP-304L	
Length-Bottom of Tubing to Pump Intake	1.15'	
Tubing Length	10.0'	
Length-Top of Tubing to Reference Point	0.13'	
Pump Intake Set at (Depth)	77.19' TOC	

Reference/Measuring Point
BGS: Below Ground Surface TD: Total Depth
TOC: Top of protective Casing

Start Time 0600
End Time 0830
Time 2hrs. 30min.
Contract Time NA
Total Time 2hrs. 30min.

Personnel
M. Wrasper - Driller (BSE)
J. Hocking - Geologist (CHG)
T. Hottell - BTR (FH)
M. Gordon - Driller's Asst. (BSE)

Materials Used
5' ¾" sch. 40s TP-304L riser (1)
10' ¾" sch. 40s TP-304L riser (7)
½ HP 4W Grundfos Redi-Flo2 (1)
weather plate - 3 hole (1)

Description of Operations/Remarks

0600 - 0635: P.O.D / Safety Mtg.
0635 - 0700: Drillers set up to install sampling pump.
0710 - Begin to "trip" in sampling pump.
0746 - Sample pump set; intake @ ~~76~~ 77.19' TOC (8.66' below current DTW)
0747 - Sample pump tested @ depth
0748 - Test passed: 1.5 Gal. bucket in 1 minute.
0749 - Geologist makes sure e-tape is "free to pass"; has no trouble getting in or out.
0750 - Well cap put on and locked with standard well lock
0758 - Drillers begin to clean site of equipment – wells ready for acceptance walkdown.
0817 - Pump rig "broken" down and moved off C4072.
0828 - Geologist no longer needed; heads for town.
0830 - Geologist off-site.

NOT USED
3/5/03

Report By Jess Hocking
Title Geologist
Signature

Reviewed By L.D. Walker
Title Geologist Date 3-6-03
Signature

DISTRIBUTION: White-Field File Custodian Yellow-Group Files Pink-Project Coordinator Goldenrod-Team Leader BC-6000-278 (04/91)

WELL CONSTRUCTION SUMMARY REPORT

Start Date: 02/14/03
Finish Date: 3/4/03
Page 1 of 1

Well ID: C4073	Well Name: 699-56-E4L	Approximate Location: 618-10 Burial Ground	
Project: CY2003 CERCLA G.W. well drilling		Other Companies: FH, CHG	
Drilling Company: Blue Star Enterprises (BSE)		Geologist(s): C. Martinez, J. Hocking, D. Weekes	
Driller: Mo Wanaspic	License #: 1909		

TEMPORARY CASING AND DRILL DEPTH			DRILLING METHOD	HOLE DIAMETER (in) / INTERVAL (ft)
*Size/Grade/Lbs. Per Ft.	Interval	Shoe O.D./I.D.	Auger:	Diameter ____ From ____ to ____
8 5/8" / 7 5/8" FJ C.S.	0' - 91'	8 3/4" / 7 3/4"	Cable Tool: ✓	Diameter 7" From 0' to 91'
	____ - ____		Air Rotary:	Diameter ____ From ____ to ____
	____ - ____		A.R. w/Sonic:	Diameter ____ From ____ to ____
	____ - ____			Diameter ____ From ____ to ____
	____ - ____			Diameter ____ From ____ to ____
*Indicate Welded (W) - Flush Joint (FJ) Coupled (C) & Thread Design				Diameter ____ From ____ to ____

		Drilling Fluid: N/A	
Total Drilled Depth: 91'	Hole Dia @ TD: 7"	Total Amt. Of Water Added During Drilling: none	
Well Straightness Test Results: PASSED using 20.4' long, 8.5" OD C.S. Centralizers		Static Water Level: 63.53' bgs	Date: 2/28/03

GEOPHYSICAL LOGGING

Sondes (type)	Interval	Date	Sondes (type)	Interval	Date
Spectral Gamma	0' - 85'	2/20/03		____ - ____	
Neutron-Moisture	0' - 64'	2/21/03		____ - ____	
	____ - ____			____ - ____	

COMPLETED WELL

Size/Wt./Material	Depth	Thread	Slot Size	Type	Interval Annular Seal/Filter Pack	* Volume	Mesh Size
4" sch. 05 s TP-304L Sump	81.53' - 78.53'	✓	NA	Colorado Silica Sand	91' - 57.75'	17 bags	10-20
4" sch. 05 s TP-304L Screen (Cont. Wire Wrap Screen)	78.53' - 63.52'	✓	0.020"	Bentonite Pellets	57.75' - 50.90'	3 buckets	1/4"
4" sch. 05 s TP-304L Riser	63.52' - +2.00	✓	NA	Bentonite Crumbles	50.90' - 11.15'	17 bags	NA
	____ - ____			Portland Cement	11.15' - 0	5 bags	FP. I/II
	____ - ____				____ - ____		

OTHER ACTIVITIES

Aquifer Test: WELL DEVELOPMENT	Date: 3/4/03	Well Decommission:	Yes:	No:	Date:
Description: Pumped well @ 35 GPM for 71 min. and @ 20 GPM for 16 min.; Final Turb = 2.53 NTU and ran recovery for 5 min. for 100% rec. 2,805 Gal. Pumped		Description:			

WELL SURVEY DATA (if applicable)

	Protective Casing Elevation:
Washington State Plane Coordinates:	Brass Survey Marker Elevation:

COMMENTS/REMARKS

* Vol. Calc: 17 bags Colorado Silica x 0.535 ft³/bag = 9.095 ft³. 3 buckets bentonite pellets x 0.62 ft³/bucket = 1.86 ft³. 17 bags bentonite crumbles x 0.71 ft³/bag = 12.07 ft³. 5 bags portland cement x 1.285 ft³/bag = 6.425 ft³

Reported By: Jess Hocking Title: Geologist Signature: Jess Hocking Date: 3/3/03

Original to: Document & Information Services, H0-09/HWIS
Distribution by DIS: Environmental Technologies Well Coordinator, H0-02

BHI-EE-181 (07/27/2001)

WELL SUMMARY SHEET

Start Date: 02/14/03 Finish Date: 3/3/03 Page: 1 of 1

Well ID: C4073	Well Name: 699-56-E4
Location: 618-10 Burial Ground	Project: C4 2003 CERCLA G.W. well drilling
Prepared By: Jess Hocking Date: 3/3/03	Reviewed By: L.D. Walker Date: 3-6-03
Signature: Jess Hocking	Signature: L.D. Walker

CONSTRUCTION DATA

Description	Diagram
4" sch. .05$_s$ TP-304L SS Sump 81.53' → 78.53'	
4" sch. .05$_s$ TP-304L SS .020" cont. wirewrap scrn. 78.53' → 63.52'	
4" sch. .05$_s$ TP-304L SS Riser 63.52' → +2.00'	
10:20 Colorado Silica Sand 91.0' → 57.75'	
1/4" Bentonite Pellets 57.75' → 50.90'	
Wyoming Bentonite Crumbles 50.90' → 11.15'	
Type I/II Portland Cement 11.15' → 0	
NOTE: ALL TEMP. CASING REMOVED FROM GROUND	
ALL DEPTHS REPRESENT FEET BELOW GROUND SURFACE	

GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description
0		0'-1.5' Backfill (crushed gravel)
		1.5'-20' Sand (S) Hanford formation
20		20'-24.5' silty sandy GRAVEL (msG)
		24.5'-29' sandy GRAVEL (sG)
		29'-32.5' gravelly SAND (gS)
		32.5'-44.5' silty sandy Gravel (msG)
40		44.5'-54.5' sandy GRAVEL (sG)
		54.5'-60' silty sandy GRAVEL (msG)
60		60'-71' silty sandy GRAVEL (msG) Ringold @ 60' bgs
		71'-72.5' sandy GRAVEL (sG)
		72.5'-75' SAND (S)
		75'-78' silty sandy GRAVEL (msG)
80		78'-91' sandy GRAVEL (sG)
100		TD = 91' bgs
		DTW = 63.53' bgs (2/28/03)
		NOT TO SCALE

Original to: Document & Information Services, H0-09/HWIS
Distribution by DIS: Environmental Technologies Well Coordinator, H0-02

BHI-EE-189 (02-20-2002)

Report 1 of Well Dev. & Testing

WELL DEVELOPMENT AND TESTING DATA

Well Name: 699-56-E4L	Well ID: C4073	Well Location: 618-10 Burial Ground	Date: 3/4/03

Reference Measuring Point (unless otherwise noted): ~~GROUND LEVEL~~ Top of Prot. Casing (TOC)

Has the well been surveyed? ☐ Yes ☒ No

Does the well have a cement pad? ☒ Yes ☐ No

PART 1

STATIC WATER LEVEL:

Start of Job	66.39'
End of Job	66.40'

DEPTH TO BOTTOM:

Start of Job	83.9'
End of Job	83.8'

PART 2

WELL DEVELOPMENT DATA

Pump Model 2243025202 Franklin

Intake Depth 80.55'

Starting Turbidity > 1000 NTU

Pump Start	Stop	Flow Rate
0814	0925	35 gpm
1103	1119	20 gpm

Total Pumped 2805 gallons

Final Turbidity 2.53 NTU

Transducer Range (PSI) 20.0 Psi

PART 3

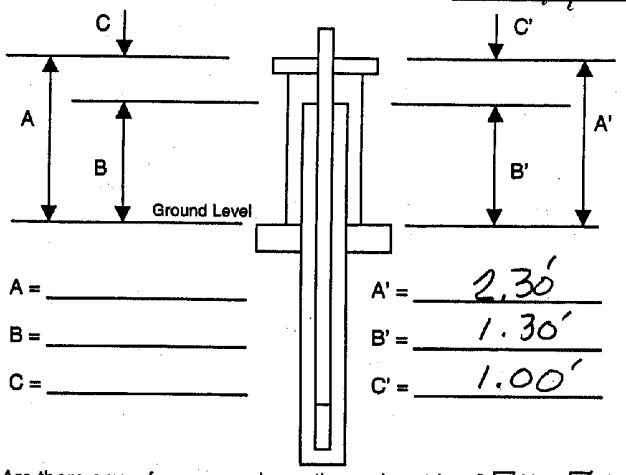
INSTANTANEOUS SLUG TEST

Static Water Level (TOC)	
Transducer Depth	
Baseline Start	
Injection Start	
Baseline Start	
Withdrawal Start	
Slug Volume	
Transducer Range (PSI)	

PART 4

Last Recorded Measurements Date:

Current Measurements Date: 3/4/03



A = _____

B = _____

C = _____

A' = 2.30'

B' = 1.30'

C' = 1.00'

Are there any reference marks on the casing strings? ☐ Yes ☒ No

PART 5

COMMENTS:

0600-0615: POD/Safety Meeting

0630 – Tagged WL @ 66.39' btoc, Depth to bottom is 83.9' btoc, there is 0.8' of fill in sump, will proceed to install development pump

0705-0745 Installing 3-hp development pump Intake set @ 80.55' btoc

Initial head = +2.632 PCW 12.656'

0804 Started pump but leaks were everywhere

Initial head = 12.687'

0811 Started test #1 then stopped it.

0814 Started test #2 (pump running full bore)

Prepared by (print name):	DC Weekes	Signature:	DC Weekes
Reviewed by (print name):	LD Walker	Signature:	LD Walker

TO CHECK A BOX: Double click the box; select "Default Value – Checked"

BHI-EE-112 (12/97)

FIELD ACTIVITY REPORT - DAILY DRILLING

Date: 3/4/03

Well ID: C4073 | Well Name: 699-56-E4L

Location: 618-10 Burial Ground | Report No.: 1

Start	Finish	Total
Time 0600	Time 1302	Time 7:02
Hole Depth/Csg NA / NA	Hole Depth/Csg NA / NA	Hole Depth/Csg NA / NA

Reference Measuring Point: **GROUND SURFACE**

Casing String No. 1 2 3 4 ____ Rod Size: NA

See Report No. 1

Well Development

Description of Activities/Operations with Depth
(Attach applicable drawings and document straightness test results)

Time/Depth From	To	
0836		Head = 6.795' (5.892' drawdown)
0848		Head = 6.627' (6.06' drawdown)
0901		Head = 6.337' (6.35' drawdown)
0918		Head = 6.175' (6.512' drawdown)
0923		Head = 6.106' (6.581' drawdown)
0925		Stopped pumping test #2. Started recovery (test #3)
		Pumped ~ 2485 gallons. Total of 71 minutes.
0932		Purgewater truck driven off site.
1012		99.6% recovered. Head = 12.641'
1018	1032	L. Walker + LC Swanson (FH) visit site. Will pump@20gpm per Walker.
1059		Purge water truck on site.
1100		Head = 12.658'
1103		Start pumping. Test #4 started. Pumping@20 gpm.
1107		Head = 10.615'
1119		Stopped pump. Started recovery Test #5 a little late.
1122		Head = 12.655'.
1124		Stopped recovery test (#5). Recovered 99.9%.
1126		Pulled out transducer. Driller starts removing dev. pump.
		Pumped ~ 320 gallons. Total of 16 minutes.
		Not used DCWeekes 3/4/03

Reported By: DCWeekes		Reviewed By: L. D. Walker	
Title: Geologist	Date: 3/4/03	Title: Geologist	Date: 3-6-03
Signature: DC Weekes		Signature: LD Walker	

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-018 (07/27/2001)

FIELD ACTIVITY REPORT - DAILY DRILLING

Date: 3/4/03

Well ID: C4073 | Well Name: 699-56-E4L

Location: 618-10 Burial Ground | Report No.: 1

Start	Finish	Total
Time NA	Time NA	Time NA
Hole Depth/Csg /	Hole Depth/Csg /	Hole Depth/Csg /

Reference Measuring Point: GROUND SURFACE

Casing String No. 1 2 3 4 ____ Rod Size:

See Report No. 1 Well Development

Time/Depth From | To

Description of Activities/Operations with Depth
(Attach applicable drawings and document straightness test results)

Well Development Equipment:
Pump: Franklin Electric 3hp Model# 2243025202
230 volts 3456 rpm
1.97' from bottom to intake

Monitoring Equipment:
Hach 2100P Turbidimeter
~~YSI 55 Dissolved oxygen meter~~ DCW not used
Orion Model 142 conductivity meter/temp
~~Orion model 290A ph meter~~ DCW didn't work

Development Data

Turb (NTU)	Cond (mS/cm)	Temp (°C)	DO (mg/L)	pH (Standard Unit)	Time	Pump Rate (gpm)
>1000	517	12.3	ND	ND	0814	35
31.2	515	15.8	ND	ND	0834	35
9.57	517	17.0	ND	ND	0844	35
10.2	519	16.8	ND	ND	0854	35
13.3	519	16.1	ND	ND	0924	35
129	523	17.0	ND	ND	1104	20
6.89	519	17.3	ND	ND	1113	20
2.53	518	17.4	ND	ND	1117	20

Reported By: D C Weekes | Reviewed By: L. D. Walker

Title: Geologist | Date: 3/4/03 | Title: Geologist | Date: 3-6-03

Signature: DC Weekes | Signature: LD Walker

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-018 (07/27/2001)

FIELD ACTIVITY REPORT - DAILY DRILLING

Page 4 of 4

Date: 3/4/03

Well ID: C4073 | Well Name: 699-56-E4L

Location: 618-10 Burial Ground | Report No.: 1

Start	Finish	Total
Time NA	Time NA	Time NA
Hole Depth/Csg /	Hole Depth/Csg /	Hole Depth/Csg /

Reference Measuring Point: **GROUND SURFACE**

Casing String No. 1 2 3 4 ____ Rod Size:

See Report No. 1

Sampling Pump Installation.

Time/Depth From	Time/Depth To	Description of Activities/Operations with Depth (Attach applicable drawings and document straightness test results)
		Casing Size 4" Type 304 stainless steel
		Well screen: 0.020" cont. wire wrap screen 63.5'-78.5' bgs
		Current depth to water: 63.4' bgs (66.4' bTOC)
		Construction depth: 81.5' bgs (bottom of sump)
		Current depth to bottom: 80.8' bgs (83.8' bTOC)
		Pump Type: Redi-flo2 with shroud (½ hp) Grundfos
		Pump Model: MP1 1A107303
		Tubing size/type: SS 3/4" OD sch40s Type 304L
		Length-bottom of tubing to pump intake: 0.96' (inc. Shroud)
		Length-Top of tubing to ref pt: —
		Tubing length: 75.04' to top of prot. casing
		Pump intake set at depth: 73' bgs (76' bTOC)
1212	1254	Installed sampling pump. Teflon tape on threads.
1255		Pumped about 1 gallon of water using sampling pump.
1300		Able to tag water table through pump plate.
1302		Driller is moving pump setting pump off the well.
		Well is complete. Moving to C4072 after decon pipe.
		Not used DC Weekes 3/4/03

Reported By: DC Weekes | Reviewed By: L.D. Walker

Title: Geologist | Date: 3/4/03 | Title: Geologist | Date: 3-6-03

Signature: DC Weekes | Signature: L.D. Walker

Original to: Document and Information Services, H0-09/HWIS

BHI-EE-018 (07/27/2001)

WELL SURVEY DATA REPORT

Project:	**Prepared By:** Neil P. Fastabend **Company:** Fluor Federal Services
Date Requested: 03/10/03	**Requestor:** Chris S. Wright (FH)
Date of Survey: 03/19/03	**Surveyor:** Fluor Federal Services Survey Dept.
ERC Point of Contact:	**Survey Co. Point of Contact:** Grant F. Brazil, P.L.S.
Description of Work: Civil Survey of 2 Groundwater Monitoring Wells. CACN #118147	**Horizontal Datum:** NAD83(91) **Vertical Datum:** NAVD88 **Units:** Meters **Hanford Area Designation:** 600 Area

Coordinate System: Washington State Plane Coordinates (South Zone)

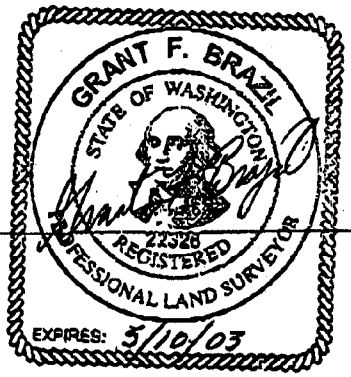
Horizontal Control Monuments:
400-3 and 400-4 (FFS), N323 (USACE)

Vertical Control Monuments:
Q323 and R323 (USACE)

Well ID	Well Name	Easting	Northing	Elevation	
	C4072	590867.37	121626.77		Center of Casing
				135.077	Top of Casing, N.Edge
				134.348	Brass Survey Marker
				135.083	Top Pump Baseplate, N. Edge

Notes:
Unable to access top rim of casing to stamp "X" due to Pump Baseplate.

Surveyor Statement:
I, Grant F. Brazil, a professional land surveyor registered in the state of Washington (Registration No. 22326), hereby certify that this report is based on a field survey performed in March, 2003 under my direct supervision, and that the data contained here is true and correct.



Original to:
Distribution by DIS:

WELL SURVEY DATA REPORT

Project:	**Prepared By:** Neil P. Fastabend **Company:** Fluor Federal Services
Date Requested: 03/10/03	**Requestor:** Chris S. Wright (FH)
Date of Survey: 03/19/03	**Surveyor:** Fluor Federal Services Survey Dept.
ERC Point of Contact:	**Survey Co. Point of Contact:** Grant F. Brazil, P.L.S.
Description of Work: Civil Survey of 2 Groundwater Monitoring Wells. CACN #118147	**Horizontal Datum:** NAD83(91) **Vertical Datum:** NAVD88 **Units:** Meters **Hanford Area Designation:** 600 Area

Coordinate System: Washington State Plane Coordinates (South Zone)

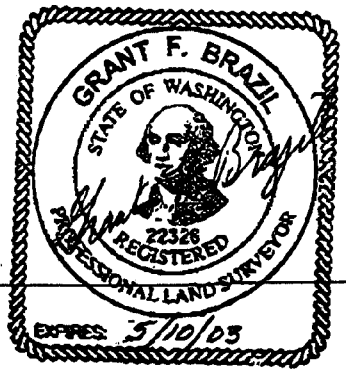
Horizontal Control Monuments:
400-3 and 400-4 (FFS), N323 (USACE)

Vertical Control Monuments:
Q323 and R323 (USACE)

Well ID	Well Name	Easting	Northing	Elevation	
	C4073	590915.84	121654.35		Center of Casing
				134.428	Top of Casing, N.Edge
				133.725	Brass Survey Marker
				134.434	Top Pump Baseplate, N. Edge

Notes:
Unable to access top rim of casing to stamp "X" due to Pump Baseplate.

Surveyor Statement:
I, Grant F. Brazil, a professional land surveyor registered in the state of Washington (Registration No. 22326), hereby certify that this report is based on a field survey performed in March, 2003 under my direct supervision, and that the data contained here is true and correct.



Original to:
Distribution by DIS:

Fluor Federal Services	SURVEY DATA REPORT	Request No. 032-170
Project	Title: Well Locations / C4072 and C4073	File No. 6AT11R28

FFS Job No.	Prepared By	Date	Reviewer	
65400851.1180580 / DB00	N.P. Fastabend	3/20/03		1 of 3

DESCRIPTION OF WORK	DISTRIBUTION	SDR	PLOT	DWG
Surveyed Wells C4072 and C4073 for horizontal and vertical location per Statement of Work for Civil Survey of Environmental Characterization and Monitoring Wells. Horizontal Datum: WCS83S/91 (meters) Vertical Datum: NAVD88 (meters)	Survey File	OR		
	C.S. Wright	1		

SURVEY RESULTS AND COMMENTS

See Attached Well Survey Data Report Sheets

A-6002-199 (5/97) KEF082

Appendix B

Geologic Descriptions and Sieve Data

BOREHOLE LOG

Page 1 of 5

Date: 02/07/03

Well ID: C4072 | Well Name: 699-56-E41C | Location: 618-10 Burial Ground

Project: FY 2003 CERCLA G.W. well drilling. | Reference Measuring Point: Ground surface.

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
0	DIB 9 1/2'	n/a		0'-1.5' Backfill material. Crushed gravel	Cable tool using 9 5/8" OD drive barrel.
				1.5'-22' SAND(s) 100%. Med-vcse grained, sub-round to sub-angular particles. High basalt content. (70%), 30% qtz/other.	
5	Grab DIB 9 1/2'			trace sub round-round gravel (<1%). 10YR 3/2 (very dark grayish brown) moist. no rxn HCl. mod. sorted.	Grab 5' archive
				@7' bgs, sand is 90% basalt, 10% felsics. Moderately sorted. 15% med, 40% coarse, 45% vcse. 10YR2/1 black (moist) no rxn HCl.	
10	Grab DIB 9 1/2"				Grab 10' archive
				22'-23' gravelly SAND.(gS) 25% gravel, 75% sand. Gravel, pred. basalt w/some qtz/feldspar/other metamorphics, A-R, poorly sorted, sm pebbles to med cobbles, mps ~ 7". Sand, SR-SA, mod sorted, m-vcse grained, 20% med, 40% cse, 40% v cse. 55-60% basalt, 5-20% qtz/other. 10YR 3/2	
15	Grab DIB 9 1/2"				Grab 15' archive
20	Grab DIB 9 1/2"			very dark grayish brown (moist) no rxn HCl	Grab 20' archive
				23'-26' sandy GRAVEL (sG) 55% gravel, 40% sand, 5% silt. Gravel, SR-SA poorly sorted, pred. basalt (75%) w/qtz/feldspar/other. Sand, SR-SA, poorly sorted, fn-vcse grained, 70% basalt, 30% qtz/other. 2.5YR 4/3 olive brown (moist) no rxn HCl.	
25	Grab DIB 9 1/2"				Grab 25' archive. E.O.S @ 25' bgs (2/7/03). Start 02/10/03. clastic dyke @ 26' visible. CaCO3 + Fe oxide staining. v. compact matrix. micaceous

Reported By: Charlene Martinez | Reviewed By: L.D. Walker

Title: Geologist | Title: Geologist

Signature: Charlene Martinez | Date: 2/10/03 | Signature: L.D. Walker | Date: 3-6-03

BHI-EE-183 (12/97)

BOREHOLE LOG

Page 2 of 5

Date: 02/10/03

Well ID: C4072 | Well Name: 699-56-E4K | Location: 618-10 Burial Ground

Project: FY 2003 CERCLA G.W. well drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
30	DIB	N/A		26' - 28.5' SAND (S) 95% sand, 5% gravel. Gravel, SR-R, poorly sorted, basaltic, mps ~ 4". Sand, SR-SA, med-vcse grained, mod-sorted, 20% med, 45% cse, 35% vcse, 60% basalt, 40% qtz/other. 2.5Y 4/3 olive brown (moist) no rxn HCl.	Cable Tool using 5 1/2" OD drive barrel. Grab 30' archive
	Grab				
	DIB 9 1/2"				
35	Grab				Grab 35' archive
	DIB 9 1/2"			28.5' - 32' Sandy GRAVEL (sg) 60% gravel, 35% sand, 5% silt. Gravel, SR-SA, poorly sorted pebbles-cobbles, mps ~ 4". Sand, SR-SA, mod sorted, fn-vcse grained. 15% fn, 20% med, 40% cse, 25% vcse. 60% basalt, 40% qtz/other metamorphics micaceous. 2.5Y 4/3 olive brown (moist) no rxn HCl.	
40	Grab				Grab 40' archive A.M. RCT ok 9, 3, 1 @ background.
	DIB 9 1/2"				
45	Grab			32' - 40' SAND (S) 95% sand, 5% gravel. Gravel, basaltic, SR-SA, mod sorted, mps ~ 4". Sand, mod sorted, m-vcse grained, SR-SA, 90% basalt, 15% med, 45% cse, 40% vcse, 10YR 2/1 black (moist) no rxn HCl.	
50		not used			
55				40' - 45' gravelly SAND (gS) 87% sand, 13% gravel. Gravel, mod-sorted SA-R, mps ~ 1.5", basaltic. Sand, mod-sorted SR-SA, med-vcse grained, 90% basalt, 10% felsics, 15% med, 45% cse, 40% vcse, 10YR 2/1 black, moist, no rxn HCl.	

Reported By: Charlene Martinez | Title: Geologist | Signature: Charlene Martinez | Date: 02/10/03

Reviewed By: L.D. Walker | Title: Geologist | Signature: L.D. Walker | Date: 3-6-03

BHI-EE-183 (12/97)

BOREHOLE LOG

Page 3 of 5

Date: 02/10/03

Well ID: C4072 | Well Name: 699-S16-E4K | Location: 618-10 Burial Ground

Project: FY2003 CERCLA G.W. drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
45	DIB	n/a		45'-48' silty Sandy GRAVEL (SiG) 55% gravel, 35% sand, 10% silt. Gravel, v. poorly sorted, R-A, pea-size to 5m. cobbles, mps ~ 5.5", basaltic. Sand, SR-SA, mod. sorted, vfn-vcse grained, 20% vfn-fn, 40% med, 35% cse, 5% vcse. Trace mica, trace caliche on cobbles. Basalt 60%, felsics 40%. No rxn HCl. 10YR 4/2, dark grayish brown (moist)	Cable tool using 4 1/2" OD drive barrel. Grab 45' archive. Hitting large rock @ 46' bgs
	Grab				
	DIB 9 1/2"				
50	Grab				P.m. RCT ck. 9, 8.8 @ background
	DIB 9 1/2"				Grab 50' archive
55	Grab			48'-52' gravelly SAND (gS) 25% gravel, 75% sand. Gravel, v. poorly sorted, SR-SA, basaltic, pea-size to cobbles, mps ~ 7.5". Sand, SR-SA, mod sorted, med-vcse, 25% med, 35% cse, 40% v. cse, 90% basalt, 10% felsics. 10YR 2/1 black, moist. No rxn HCl.	Grab 55' archive.
60				52'-58' Sandy GRAVEL (sG) 45% gravel, 55% sand. Gravel, SR-SA, mod-sorted, pea-size to 5m. cobbles, 50% sm pebbles, 20% med pebbles, 25% lg pebbles, 5% cobbles, basaltic. Sand, mod-sorted, SR-SA, med-vcse grained, 25% med, 45% cse, 30% vcse, 90% basalt, 10% felsic/other. Trace caliche, trace mica. 10YR 2/1 black, moist. No rxn HCl.	
65					
70					

Not used

Reported By: Charlene Martinez | Reviewed By: L. D. Walker

Title: Geologist | Title: Geologist

Signature: Charlene Martinez | Date: 02/10/03 | Signature: L D Walker | Date: 3-6-03

BHI-EE-183 (12/97)

BOREHOLE LOG

Page 4 of 5
Date: 02/10/03

Well ID: c4072 | Well Name: 699-56-E4K | Location: 618-10 Burial Ground
Project: F403 CERCLA G.W. well drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
55	DIB Grab	n/a		55'-57.5' gravelly SAND(gS) 15% gravel, 85% sand. Gravel, well-sorted, SR-R, 5m-med pebbles, basaltic. Sand, mod sorted, SR-SA, mod-sorted, med-vcse, 25% med, 40% cse, 35% vcse, 90% basalt, 10% qtz/other, 10YR 2/1 black, moist, no rxn HCl.	Cable tool using 9½" OD drive barrel. Grab 55' archive
60	DIB 9 1/2" Grab DIB 9 1/2"				Grab 60' archive
65	Grab DIB 9 1/2"	SS#1 100% recovery		57.5'-62' SAND(s) 95% sand, 5% gravel. Gravel, well sorted, SR-R, med to lg pebbles. Sand, mod sorted, SR-SA, med to vcse grained. 25% med, 40% cse, 35% vcse, 90% basalt, 10% qtz/other, trace mica, 10YR 2/1 black, moist, non rxn HCl.	E.O.S. @ 62.5' bgs Start 02/11/03 Ringold @ 63.5' bgs Grab 65' archive Split spoon #1 @ 62'-65' Large cobbles @ 62.5' >9".
70	Grab DIB 9 1/2"	n/a		62'-63.5' gravelly SAND(s), similar to 55' description, except occasional cobble. mps ~ 5.5".	@ 73' bgs, sand & gravel in more compact matrix; much tighter formation. Cobbles ~7".
75	Grab DIB 8 3/8"	SS#2 100% recovery		63.5'-66' silty Sandy GRAVEL (msG) Gravel 65%, Sand 25%, silt 10%. Gravel, v. poorly sorted, sm pebbles to cobbles, mps ~ 6", SR-SA. Sand, vfn-vcse, SR-SA, 40% vfn-fn grained, 25% med, 20% cse, 15% vcse, mod. sorted basalt content < 20%. felsics 80%+	5⅝" DIB @ 73' Heaving sand @ 73' bgs SS#2 @ 79'-81.5' rec. 100%
80	Grab DIB 8 3/8"	n/a		10YR 5/3 brown, moist. Weak rxn HCl	Cobbles ~ 8" @ 82' E.O.S. @ 83' 02/11/03
				66'-79' Sandy GRAVEL (sG) Gravel 60%, sand 35%, silt 5%. Gravel, SR-R	Start 02/14/03 (Cont. page 5)

Reported By: Charlene Martinez | Reviewed By: L. D. Walker
Title: Geologist | Title: Geologist
Signature: Charlene Martinez | Date: 02/10/03 | Signature: L D Walker | Date: 3/6/03

BHI-EE-183 (12/97)

BOREHOLE LOG

Page 5 of 5
Date: 02/14/03

Well ID: C4072 | Well Name: 699-51-E41C | Location: 618-10 Burial Ground
Project: FY03 CERCLA G.W. well drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
85	D13 Grab	n/a		66' (cont.) gravel, mod-sorted, sm-lg pebbles, mps ~ 2", 30% basalt, 70% qtz other. Sand, SR-R, mod. sorted, med-v cse grained, 10% basalt, 90% qtz/other. 30% med grained, 45% coarse, 25% v cse grained. micaceous 10YR 4/2 dark grayish brown (moist) no rxn HCl.	Cable tool using 9610 drive barrel. 8 5/8" OD
	D14 8 5/8" Grab				Grab 85' archive EOS on 02/14/03 start @ 83' bgs
90		TD = 87.3' bgs		79'-82' silty SANDY GRAVEL (msG) 60% gravel, 28% sand, 12% silt. Gravel, v poorly sorted, sm pebbles - med cobbles. SR-SA, mps ~ 7", 30% basalt, 70% qtz/other. Sand SR-SA, mod-sorted 15% cse-v cse, 28% med, 36% fine, 23% v fn. micaceous, 10YR 4/2, dark grayish brown (moist) no rxn HCl.	due to heaving sands 02/14/03 Am RCT ck. 9, 3, 5 @ background
				82'-87.3' Sandy GRAVEL (sG). similar to 66'-79' description except gravel is v. poorly sorted. mps ~ 7.5".	

Used Coarse Gravel Marker 02/14/03

Reported By: Charlene Martinez | Reviewed By: L. D. Walker
Title: Geologist | Title: Geologist
Signature: Charlene Martinez | Date: 02/14/03 | Signature: LD Walker | Date: 3/6/03

BHI-EE-183 (12/97)

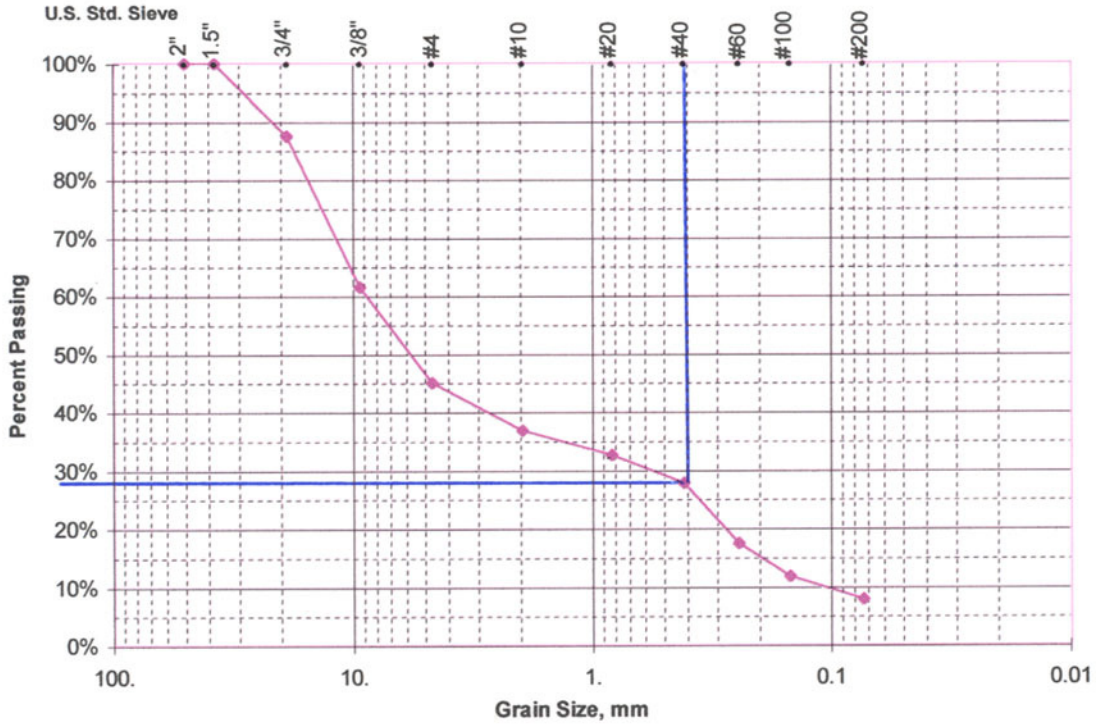
CH2M Hill Hanford, Inc.

SIEVE ANALYSIS

WELL NAME	699-S6-E4K	DEPTH	67-69.5	SAMPLE#	S6-E4K-67.0	WELL ID#	C4072
TESTED BY	CRM	CONTACT	Dave Weekes	PHONE	372-9350	DATE	02/13/2003

SAMPLE WT (g)	SIEVE SIZE IN.	CUMULATIVE WEIGHT(g)	% WEIGHT RETAINED	% PASSING	Grain Size (mm)	COMMENTS
1878.60	2"	0.0	0.0	100.0	50.80	
	1.5"	0.0	0.0	100.0	38.10	
	3/4"	234.7	12.5	87.5	19.05	
	3/8"	722.2	38.4	61.6	9.42	
	#4	1033.6	55.0	45.0	4.70	
	#10	1187.0	63.2	36.8	1.98	
	#20	1265.6	67.4	32.6	0.83	
	#40	1355.7	72.2	27.8	0.42	
	#60	1551.6	82.6	17.4	0.25	
	#100	1657.2	88.2	11.8	0.150	
	#200	1730.6	92.1	7.9	0.074	

Sieve Analysis Data for Sample S6-E4K-67.0



Comments: Sandy Gravel

All data are accurately and completely recorded.

Checked By: Date:

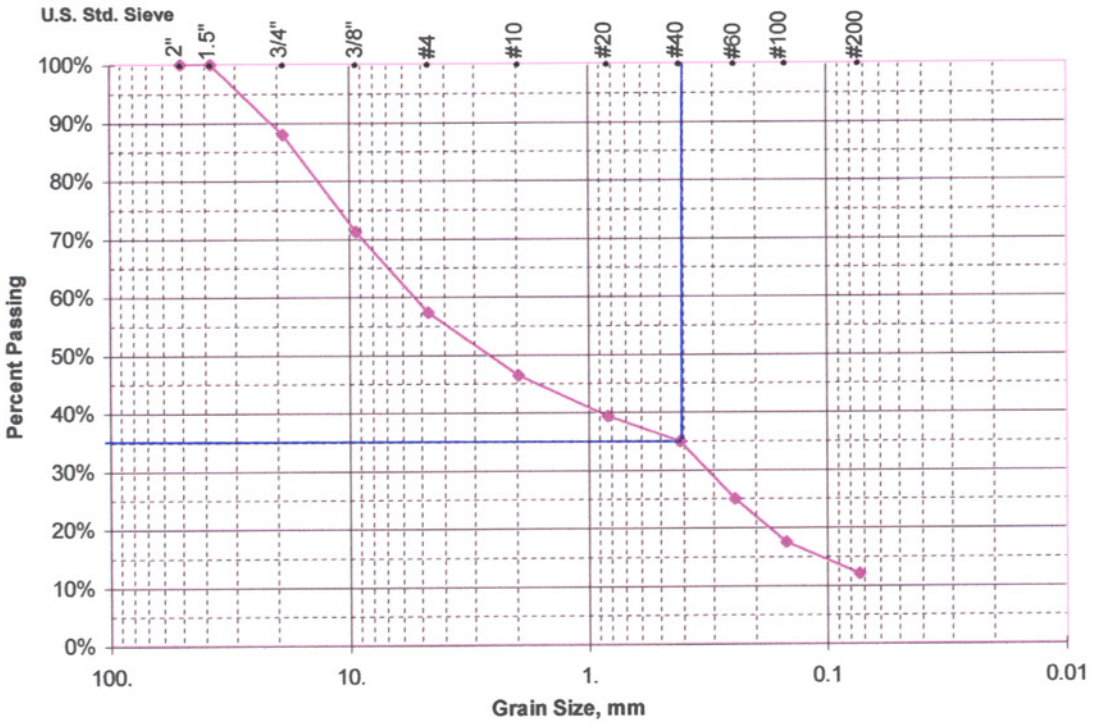
CH2M Hill Hanford, Inc.

SIEVE ANALYSIS

WELL NAME	699-S6-E4K	DEPTH	79-81.5	SAMPLE#	S6-E4K-79.0	WELL ID#	C4072
TESTED BY	CRM	CONTACT	Dave Weekes	PHONE	372-9350	DATE	02/13/2003

SAMPLE WT (g)	SIEVE SIZE IN.	CUMULATIVE WEIGHT(g)	% WEIGHT RETAINED	% PASSING	Grain Size (mm)	COMMENTS
1609.40	2"	0.0	0.0	100.0	50.80	
	1.5"	0.0	0.0	100.0	38.10	
	3/4"	194.1	12.1	87.9	19.05	
	3/8"	464.4	28.9	71.1	9.42	
	#4	688.2	42.8	57.2	4.70	
	#10	863.4	53.6	46.4	1.98	
	#20	976.8	60.7	39.3	0.83	
	#40	1047.7	65.1	34.9	0.42	
	#60	1208.6	75.1	24.9	0.25	
	#100	1329.5	82.6	17.4	0.150	
	#200	1417.0	88.0	12.0	0.074	

Sieve Analysis Data for Sample S6-E4K-79.0



Comments: Silty Sandy Gravel

All data are accurately and completely recorded.

Checked By: Date:

BOREHOLE LOG

Page 1 of 4

Date: 02/14/03

Well ID: C4073 | Well Name: 699-56-64L | Location: 618-10 Burial Ground

Project: C4 2003 CGRELA G.W. well drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
0	DIB	n/A		0'-1.5' Backfill material. Crushed gravel	Cable tool using 7" old drive barrel.
				1.5'-20' SAND(S) 95% sand, 5% silt. sand, m-vcse, mod sorted, SR-SA, 75% basalt, 25% qtz/other, 35% med grained, 45% coarse, 20% vcse, 7.5Y 3/2 very dark grayish brown (moist), no rxn HCl.	Hanford fmtn.
5	Grab DIB			@7' bgs, sand 90% basalt, 10% felsics. m-vcse, mod-sorted SR-SA, 15% med, 40% cse, 45% vcse. 2.5Y 2.5/1 black, moist. no rxn HCl.	Grab 5' archive. E.O.S. @ 7' bgs. (02/14/03) Start 02/18/03
10	Grab DIB	moisture n/A			Grab 10' archive & moisture tin
				20'-24.5' Silty Sandy GRAVEL (msG) 55% gravel, 33% sand, 12% silt. Gravel, poorly sorted, SR-A, basaltic mps ~ 6.5". Sand, SR-SA, well sorted, vfn-med, 50% vfn, 25% fn, 25% med, 55% felsics, 45% basalt, 10YR 5/2 grayish brown, dry. Moderate rxn HCl:	
15	Grab DIB	moisture n/A			Grab 15' archive & moisture tin
					@18' lg. basalt rock. > 7"
20	Grab DIB	moisture n/A			@19' 2 more basalt rocks > 7"
				@22' trace caliche & silt nodules. Strong rxn HCl.	Grab 20' archive & moisture tin.
				@23' slight cementation & Fe oxide staining noted. Hard drilling.	
25	Grab DIB	moisture n/A			Grab 25' archive & moisture sample.
				24.5'-29' Sandy Gravel (sG) 70% gravel, 25% sand, 5% silt. Gravel, SA-R, poorly sorted, basaltic, mps ~ 5". Sand, poorly sorted, SR-SA, fn-vcse, 10% fine, 30% med,	Increased moisture beginning @ 24.5' bgs

Reported By: Charlene Martinez | Reviewed By: L. D. Walker

Title: Geologist | Title: Geologist

Signature: Charlene Martinez | Date: 02/14/03 | Signature: L D Walker | Date: 3-6-03

BHI-EE-183 (12/97)

BOREHOLE LOG

Page 2 of 4

Date: 02/18/03

Well ID: C4023 | Well Name: 699-56-E4L | Location: 618-10 Burial Ground

Project: CY 2003 CERCLA G.W. well drilling | Reference Measuring Point: Ground surface

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
30	DIB	n/a		24.5' (cont.) 30% coarse grained & 30% v cse. 80% basalt, 20% felsics. 2.5Y3/2 v. dark grayish brown, moist. No rxn HCl.	Cable tool using 7" OD drive barrel
	Grab	moistur			
	Collect 30' archive & moisture sample				A.M. rad clr. (0-27')
	DIB	n/a			B.G. @ 1187 cpm; background @ 835 cpm
35				29'-32.5' gravelly SAND (gS) 25% gravel, 70% sand, 5% silt. Gravel SA-R, poorly sorted, mps ~ 4". Sand poorly sorted, SR-SA, 10% fine, 20% med, 45% coarse, 25% v cse, 80% basalt, 20% qtz/other 2.5Y3/2 v.	not at action level. Grab 35' archive & moisture sample.
	Grab	moistur			
	DIB	n/a			
40	Grab	moistur		dark grayish brown, moist. No rxn HCl.	Grab 40' archive & moisture sample
	DIB	n/a			
				32.5'-44.5' silty, sandy GRAVEL (msG) 60% gravel, 30% sand, 10% silt. Gravel, poorly sorted, sm pebbles to med cobbles, basaltic. SA-R, mps ~ 5".	@37' gravel mod sorted, pea - size to lg. pebbles
45	Grab	moistur			@43' trace caliche
	DIB	n/a		Sand, vfn-vcse, SA-R, poorly sorted 5% vfn-fn, 15% med, 35% cse, 45% v cse. Silt nodules, slight cementation. 80% basalt, 20% qtz/other. 10YR4/2	Grab 45' archive & moisture sample
50	Grab	moistur		dark grayish brown, moist. Weak to no rxn HCl.	Grab 50' archive & moisture sample
	DIB	n/a			B.G. ret. @ 1296 cpm
				44.5'-54.5' Sandy GRAVEL (sG) 55% gravel, 37% sand, 8% silt. Gravel	Background @ 1104 cpm
55	Grab	moistur		mod sorted, SA-R, pea size to lg pebbles, basaltic. Sand, SR-SA, poorly sorted, vfn-vcse, 15% vfn-fn, 30% med, 35% cse, 30% vcse, 80% basalt, 20% felsics	Grab 55' archive & moisture sample. Harder drilling @ 55' bgs. Still
	DIB	n/a		some cementation. Fe oxide staining. No rxn HCl.	hard drilling @ 58'

Reported By: Charlene Martinez | Title: Geologist | Signature: Charlene Martinez | Date: 02/18/03

Reviewed By: L.D. Walker | Title: Geologist | Signature: L.D. Walker | Date: 3-6-03

BHI-EE-183 (12/97)

BOREHOLE LOG

Page 3 of 4
Date: 02/18/03

Well ID: C4023 | Well Name: 699-56-64L | Location: 618-10 Burial Grounds
Project: C4 2003 CERCLA G.W. well drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
60	D|B	n/a		54.5'-60' Silty Sandy GRAVEL (msG)	Cable tool using 7"
	Grab	moisture		70% gravel, 28% sand, 12% silt	dd drive barrel
	D|B	n/a		Gravel, SA-R, poorly sorted, pea-size-lg pebbles, mod cementation. Trace caliche. Sand, SR-SA, vfn-csc, poorly sorted. 75% basalt, 25% qtz|other. 10YR4|2, dark grayish brown, dry. No rxn HCl.	Grab 60' archive & moisture sample. Ringold @ 60' bgs E.O.S. @ 60' (02/18/03) start 02/19/03)
65	Grab	moisture			Grab 65' archive & moisture sample.
	D|B	SS#1 10% rec.		60'-71' Silty Sandy GRAVEL (msG) 60% gravel, 25% sand, 15% silt. Gravel, SA-R, poorly sorted, 40% basalt, 60% qtz|other, sm pebbles to sm cobbles. mps ~ 3.5". Sand, SR-SA, poorly sorted, vfn-vcse, 15-20% basalt, 80-85% qtz|other. 35% vfn-fn grained, 15% med, 30% cse, 20% vcse. 2.5Y 6|3 light yellowish brown, dry. no rxn HCl.	SS#1 => 65'-67.5' 10% rec.
		n/a			
70	Grab	no more moisture samples			Grab 70' archive.
	D|B				A.M. RCT ck. ok < 3.5 @ background.
		n/a			
75	Grab				Grab 75' archive.
	D|B				Heaving sands @ 71' bgs
		SS#2 100% rec.		71'-72.5' Sandy GRAVEL (sG) 45% gravel, 50% sand, 5% silt. Gravel, mod sorted, sm-lg pebbles, SA-R, <20% basalt, >80% qtz|other. Sand, SR-R, m-vcse grained, well sorted, 25% vcse, 35% cse, 30% med, non basaltic micaceous. Sample wet, not a slurry	
		n/a			
80	Grab				Grab 80' archive
	D|B				Heaving sands @ 82'
					P.M. RCT on site.
					ok < detect.
					83' in drum 1298 cpm
					83' (background) 868 cpm
85	Grab				
	D|B			72.5'-75' SAND(s) 95% sand, 5% silt. Sand, med-vcse, well sorted non-basaltic, SR-R, 20% med, 35% cse, 45% v.cse. micaceous. Sample wet, not a slurry	If tech. organics < detect.

Reported By: Charlene Martinez | Reviewed By: L.D. Walker
Title: Geologist | Title: Geologist
Signature: Charlene Martinez | Date: 02/18/03 | Signature: L.D. Walker | Date: 3-6-03

BHI-EE-183 (12/97)

BOREHOLE LOG

Page 4 of 4
Date: 02/19/03

Well ID: C 4073 | Well Name: 699-56-E42 | Location: 618-10 Burial Ground
Project: CY 2003 CERCLA well drilling | Reference Measuring Point: Ground Surface

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
90	SD3	n/a		75'-78' Silty Sandy GRAVEL (msG) 55% gravel, 30% sand, 15% silt. Gravel, SR-SA, mod sorted, sm-lg pebbles mps ~2", non-basaltic. Sand, vfn-med, trace of csel vcse, felsic rich, some caco3, micaceous. SR-R, 70% vfn-fn, 15% med, 15% vcse-cse. very compact matrix. Sample wet, but not slurry- No rxn HCl.	Cable tool using 7" OD drive barrel. Grab 9' archive sample (TD) E.O.S @ 87' bgs 02/19/03 start 02/20/03 A.M. RET CK. ~~2, 3, 5 @ background~~
	Grab			TD = 91' bgs	
				78'-91' Sandy GRAVEL (sG) 67% gravel, 25% sand, 8% silt. Gravel, poorly sorted, SR-SA, sm pebbles-sm cobbles, 20% basalt, 80% felsics. Sand, SR-A, mod sorted, vfn-vcse grained, non basaltic (~10%), felsics 90%. 10% vfn-fn, 60% med. 20% cse, 10% vcse. Very compact matrix, numerous feldspar & mica grains, some caco3. No rxn HCl. Sample wet, not a slurry	

Reported By: Charlene Martinez | Reviewed By: L.D. Walker
Title: Geologist | Title: Geologist
Signature: Charlene Martinez | Date: 02/19/03 | Signature: L.D. Walker | Date: 3-6-03

BHI-EE-183 (12/97)

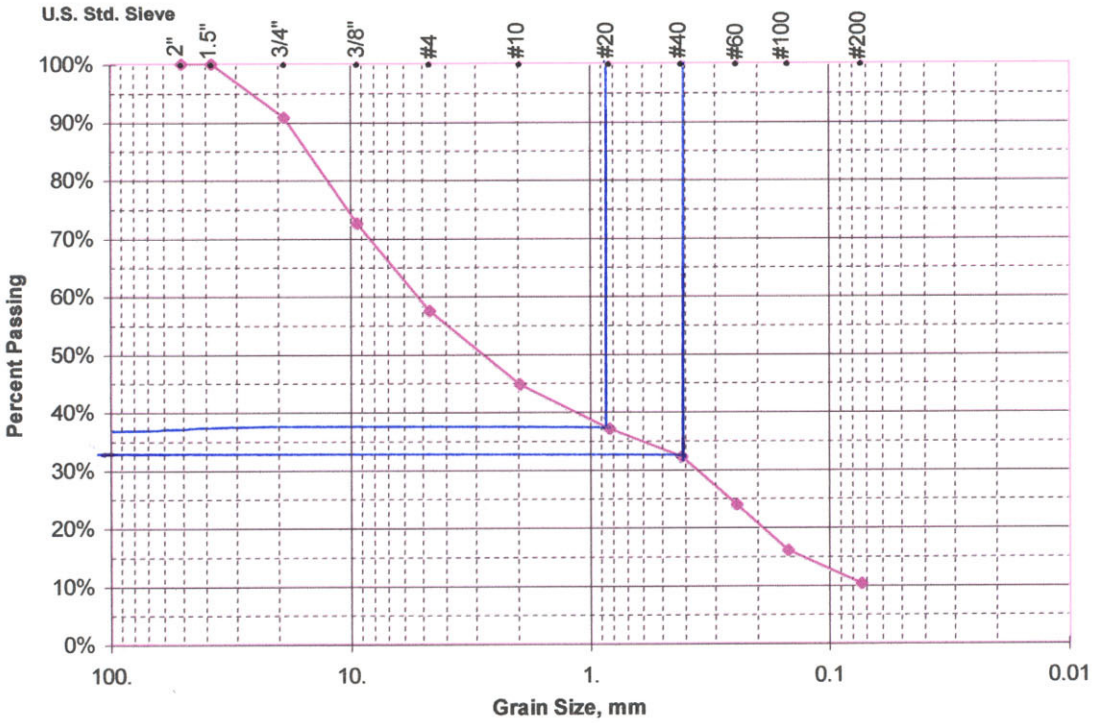
CH2M Hill Hanford, Inc.

SIEVE ANALYSIS

WELL NAME	699-S6-E4L	DEPTH	77-79.5	SAMPLE#	S6-E4L-77.0	WELL ID#	C4073
TESTED BY	CRM	CONTACT	Dave Weekes	PHONE	372-9350	DATE	02/20/2003

SAMPLE WT (g)	SIEVE SIZE IN.	CUMULATIVE WEIGHT(g)	% WEIGHT RETAINED	% PASSING	Grain Size (mm)	COMMENTS
1645.70	2"	0.0	0.0	100.0	50.80	
	1.5"	0.0	0.0	100.0	38.10	
	3/4"	152.4	9.3	90.7	19.05	
	3/8"	453.0	27.5	72.5	9.42	
	#4	700.4	42.6	57.4	4.70	
	#10	909.2	55.2	44.8	1.98	
	#20	1036.2	63.0	37.0	0.83	
	#40	1116.2	67.8	32.2	0.42	
	#60	1253.2	76.1	23.9	0.25	
	#100	1382.3	84.0	16.0	0.150	
	#200	1477.1	89.8	10.2	0.074	

Sieve Analysis Data for Sample S6-E4L-77.0



Comments: Silty Sandy Gravel

All data are accurately and completely recorded.

Checked By: Date:

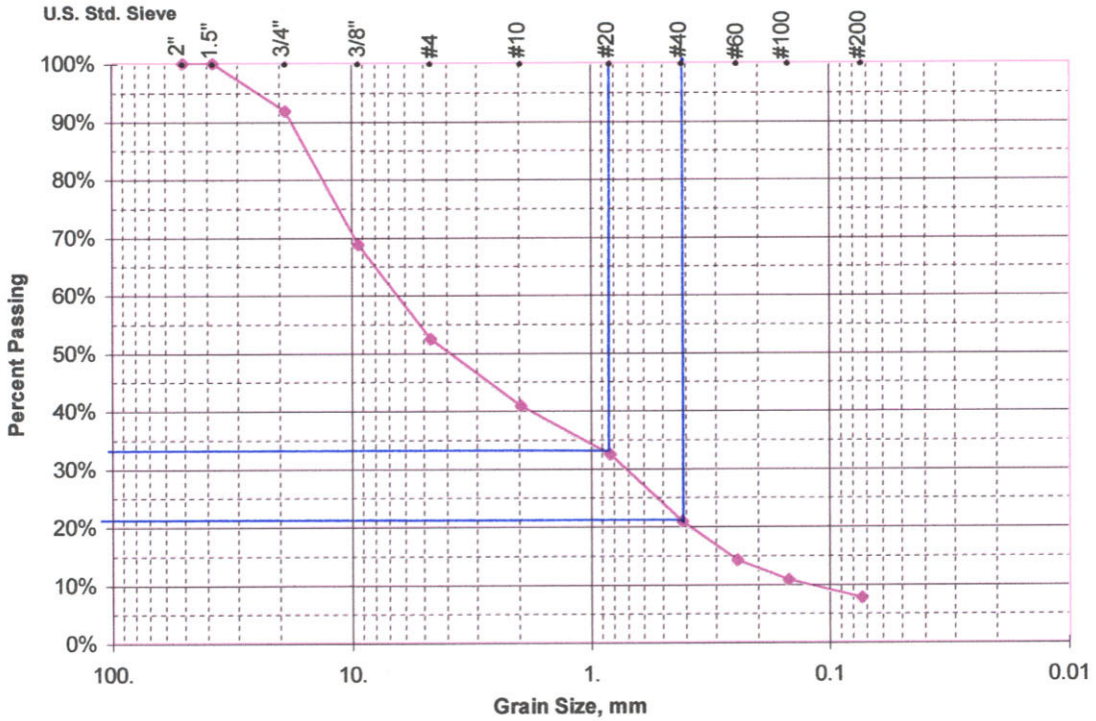
CH2M Hill Hanford, Inc.

SIEVE ANALYSIS

WELL NAME	699-S6-E4L	DEPTH	65-67.5	SAMPLE#	S6-E4L-65.0	WELL ID#	C4073
TESTED BY	CRM	CONTACT	Dave Weekes	PHONE	372-9350	DATE	02/20/2003

SAMPLE WT (g)	SIEVE SIZE IN.	CUMULATIVE WEIGHT(g)	% WEIGHT RETAINED	% PASSING	Grain Size (mm)	COMMENTS
1523.20	2"	0.0	0.0	100.0	50.80	
	1.5"	0.0	0.0	100.0	38.10	
	3/4"	125.4	8.2	91.8	19.05	
	3/8"	476.3	31.3	68.7	9.42	
	#4	724.6	47.6	52.4	4.70	
	#10	901.9	59.2	40.8	1.98	
	#20	1028.9	67.5	32.5	0.83	
	#40	1205.3	79.1	20.9	0.42	
	#60	1307.0	85.8	14.2	0.25	
	#100	1359.7	89.3	10.7	0.150	
	#200	1406.2	92.3	7.7	0.074	

Sieve Analysis Data for Sample S6-E4L-65.0



Comments: Sandy Gravel

All data are accurately and completely recorded.

Checked By: Date:

Appendix C

Borehole Geophysical Logs

Stoller
Grand Junction Office established 1959

699-S6-E4K (C4072)
Log Data Report

Borehole Information:

Borehole:	699-S6-E4K (C4072)		Site:	618-10 Burial Ground	
Coordinates (WA State Plane)		GWL (ft)[1]:	65.5	GWL Date:	2/20/2003
North	East	Drill Date	TOC[2] Elevation	Total Depth (ft)	Type
N/A[3]	N/A	2/20/2003	NA	87.3	Cable Tool

Casing Information:

Casing Type	Stickup (ft)	Outer Diameter (in.)	Inside Diameter (in.)	Thickness (in.)	Top (ft)	Bottom (ft)
Threaded Steel	1.66	11 3/4	10 3/4	1/2	+1.66	88.0
The geologist was the source for the casing information and all depths.						

Borehole Notes:

Zero reference is the ground surface. This borehole was logged through the drill pipe. This borehole is located approximately 40 ft southeast of the 618-10 Burial Ground.

Logging Equipment Information:

Logging System:	Gamma 3E (RLS-1)		Type: 70% HPGe
Calibration Date:	10/02	Calibration Reference:	GJO-2002-386-TAR
		Logging Procedure:	MAC-HGLP 1.6.5, Rev. 0

Spectral Gamma Logging System (SGLS) Log Run Information:

Log Run	1	2/Repeat	3	4	5
Date	2/20/03	2/20/03			
Logging Engineer	Kos	Kos			
Start Depth (ft)	0.0	86.0			
Finish Depth (ft)	86.0	77.0			
Count Time (sec)	100	100			
Live/Real	R	R			
Shield (Y/N)	N	N			
MSA Interval (ft)	1.0	1.0			
ft/min	n/a[4]	n/a			
Pre-Verification	CE101CAB	CE101CAB			
Start File	CE101000	CE101087			
Finish File	CE101086	CE101096			
Post-Verification	CE111CAA	CE111CAA			
Depth Return Error (in.)	0	1 low			

Log Run	1	2/Repeat	3	4	5
Comments	See logging notes below.	None			

Logging Operation Notes:

Zero reference was the ground surface, and the borehole was logged through drill pipe. Logging was performed with a centralizer installed on the sonde. Data were collected using Gamma 3E, HO 68B-4330. Pre- and post-survey verification measurements for the RLS employed the Amersham KUT (^{40}K, ^{238}U, and ^{232}Th) verifier with serial number 118. Fine-gain adjustments were made after files CE101020 and CE101080 to maintain the 1460-keV (^{40}K) photopeak at a pre-described channel. The bottom 2 ft of this borehole appeared to be mud (higher count rate).

Analysis Notes:

Analyst:	Sobczyk	Date:	2/27/03	Reference:	GJO-HGLP 1.6.3, Rev. 0

SGLS pre-run and post-run verification spectra were collected at the beginning and end of the day and compared to the control limits established on 12/05/2002. The verification spectra were all within the control limits. The peak counts per second (cps) at the 609-keV, 1461-keV, and 2615-keV photopeaks on the post-run verification spectra as compared to the pre-run verification spectra for the day were stable and between 1 and 3 percent of one another.

SGLS log spectra were processed in batch mode using APTEC SUPERVISOR to identify individual energy peaks and determine count rates. Post-run verification spectra were used to determine the energy and resolution calibration for processing the data using APTEC SUPERVISOR. Concentrations were calculated in EXCEL (source file: G3Eoct02.xls), using parameters determined from analysis of recent calibration data. Zero reference was the ground surface. Data were analyzed using a uniform casing correction based on a casing thickness of 0.5 in. to a depth of 86 ft. This casing thickness was measured at the wellhead. A water correction was applied to the data below 65.5 ft.

For the 70% HPGe detector, dead time at background count rates varies from 2 to 6 percent, averaging about 4 percent. Dead time corrections are required when dead time exceeds 18 percent. As the dead time did not exceed 18 percent, a dead time correction was not needed or applied.

Log Plot Notes:

Separate log plots are provided for gross gamma and dead time, gross gamma and volume fraction of water, naturally occurring radionuclides (^{40}K, ^{238}U, and ^{232}Th), and man-made radionuclides. Plots of the repeat logs versus the original logs are included. For each radionuclide, the energy value of the spectral peak used for quantification is indicated. Unless otherwise noted, all radionuclides are plotted in picocuries per gram (pCi/g). The open circles indicate the minimum detectable level (MDL) for each radionuclide. Error bars on each plot represent error associated with counting statistics only and do not include errors associated with the inverse efficiency function, dead time correction, or casing correction. These errors are discussed in the calibration report. A combination plot is also included to facilitate correlation. The ^{214}Bi peak at 1764 keV was used to determine the naturally occurring ^{238}U concentrations on the combination plot rather than the ^{214}Bi peak at 609 keV because it exhibited slightly higher net counts per second.

At the bottom of the borehole, the KUT concentrations appear abnormally high. The apparent concentrations are elevated because the sonde is near the open end of the drill pipe, and the casing correction is overcompensating for the shielding effect of the drill pipe. Thus, the KUT concentrations were plotted at the usual scales, and the KUT concentrations were allowed to go off-scale at the bottom of the borehole.

Results and Interpretations:

Man-made radionuclides were not detected in this borehole. ^{137}Cs was indicated at 77 ft during the repeat survey. After examination of the spectrum at this depth, it was determined that there is no evidence of a photopeak at 662 keV. This reported peak is probably the result of statistical fluctuation.

The plots of the repeat logs demonstrate reasonable repeatability of the RLS data for the natural radionuclides at energy levels of 609, 1461, 1764, and 2614 keV.

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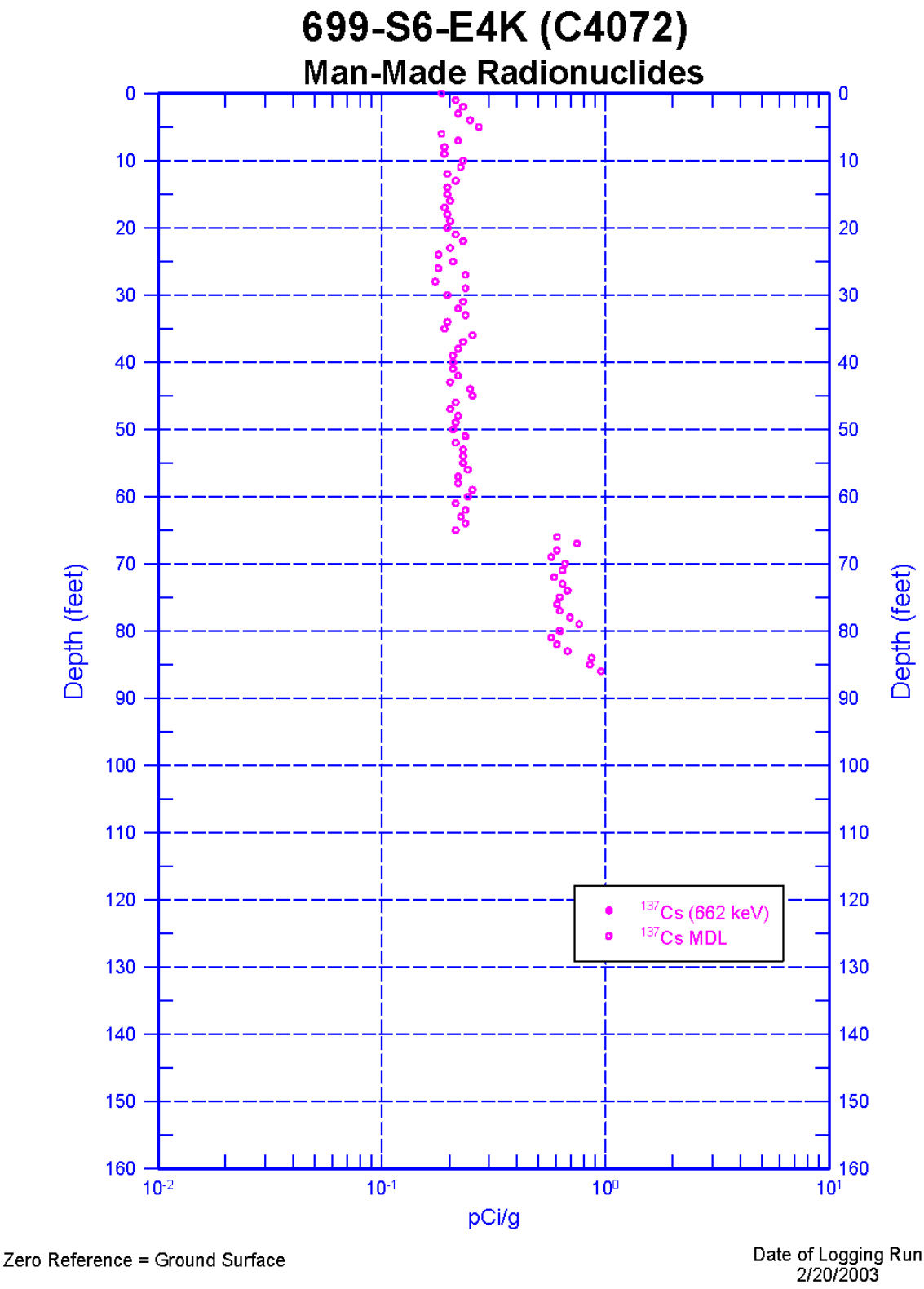
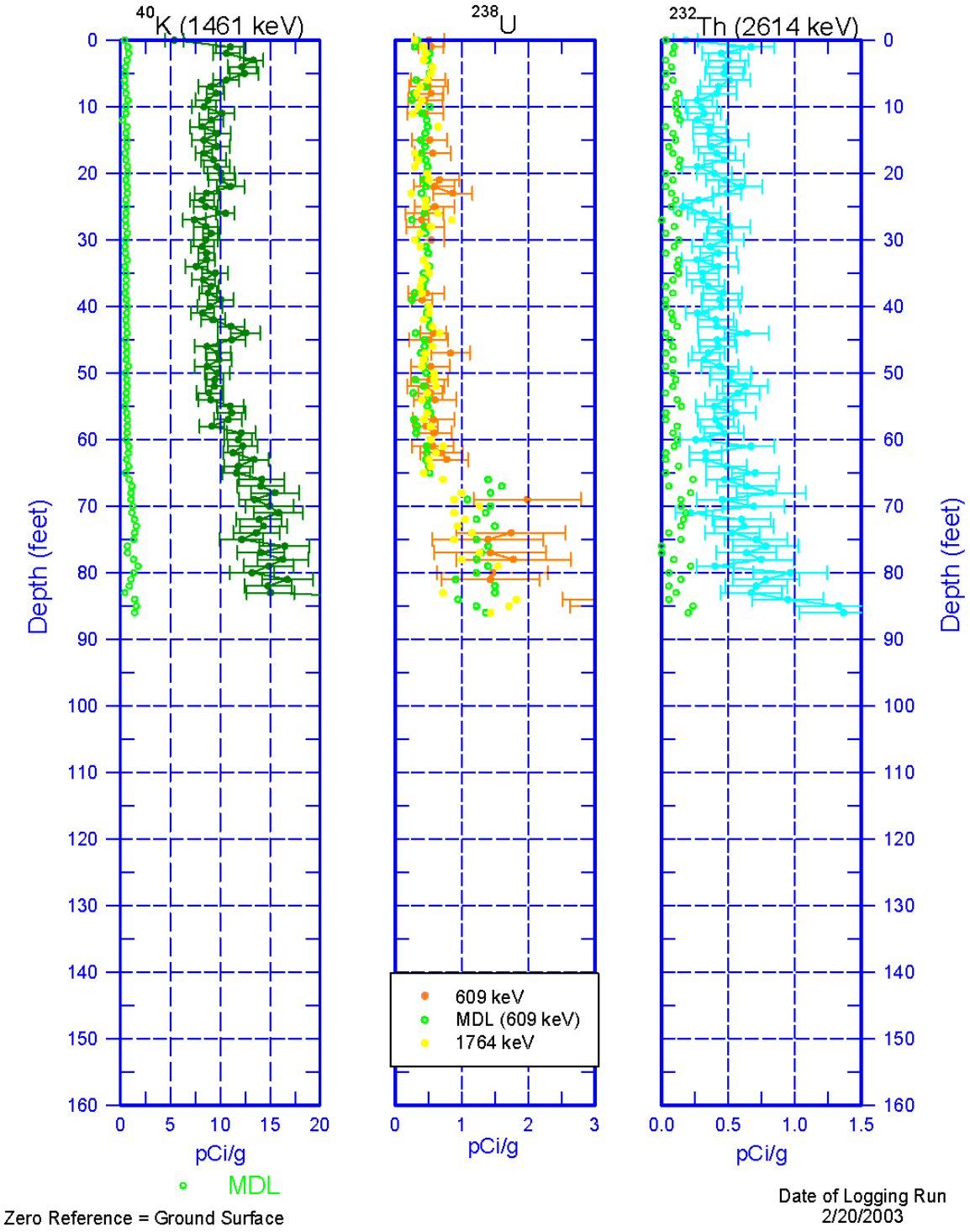
[1] GWL – groundwater level
[2] TOC – top of casing
[3] N/A – not available
[4] n/a – not applicable



Zero Reference = Ground Surface

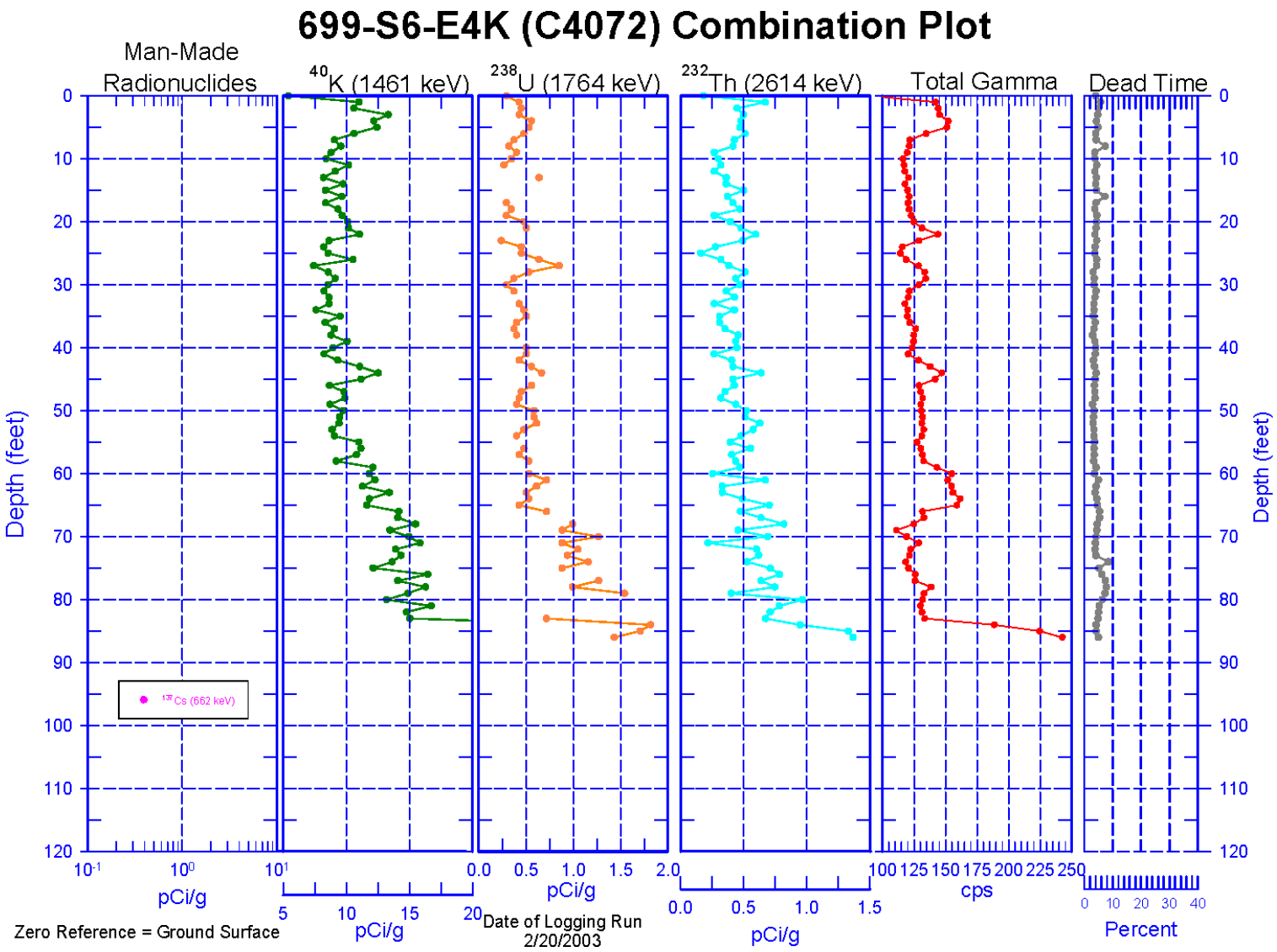
Date of Logging Run
2/20/2003

699-S6-E4K (C4072)
Natural Gamma Logs

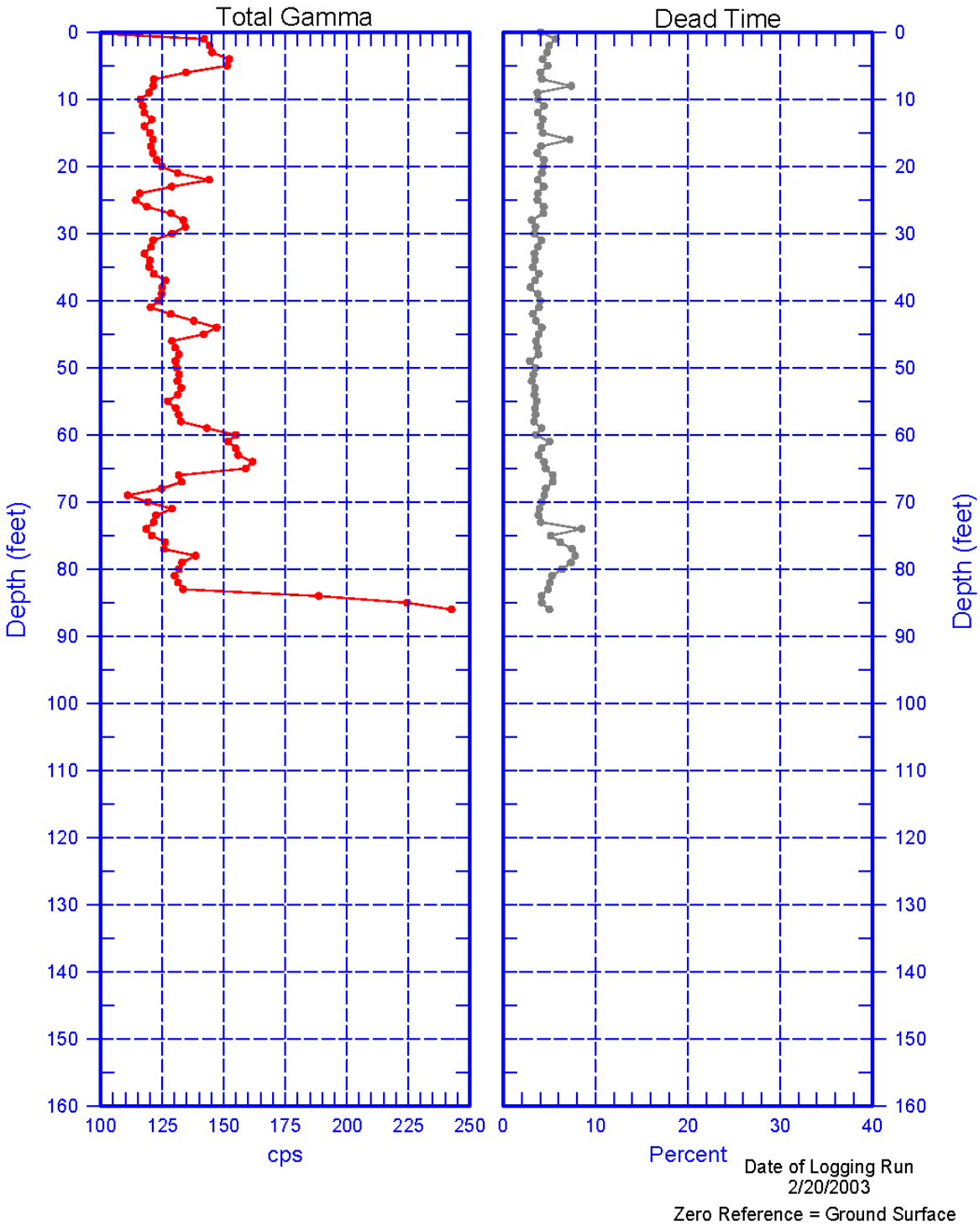


Zero Reference = Ground Surface

Date of Logging Run
2/20/2003

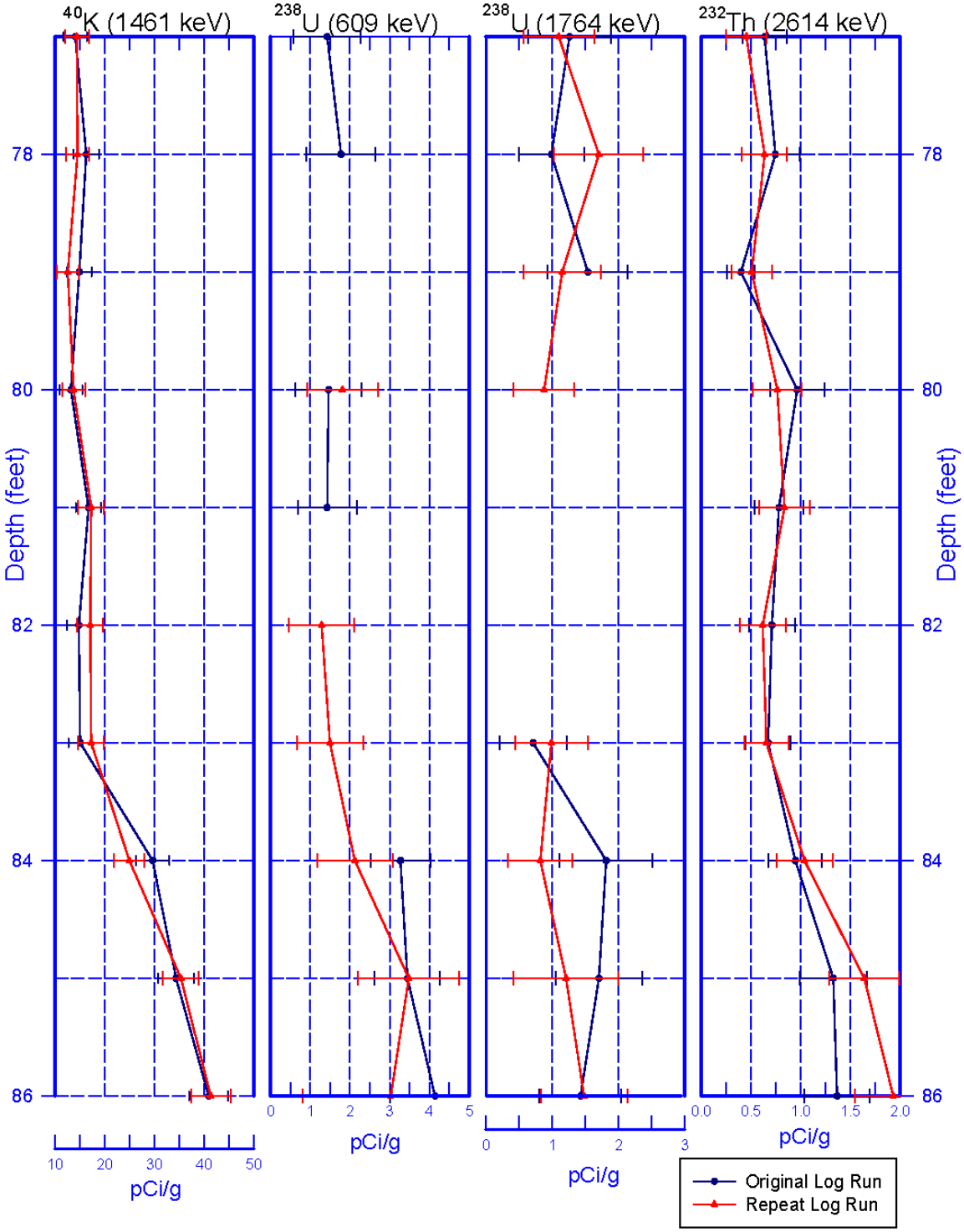

699-S6-E4K (C4072) Combination Plot
Man-Made Radionuclides
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Total Gamma
Dead Time
Depth (feet)
137Cs (662 keV)
pCi/g
pCi/g
pCi/g
cps
Percent
Zero Reference = Ground Surface
Date of Logging Run
2/20/2003

699-S6-E4K (C4072)
Total Gamma & Dead Time



699-S6-E4K (C4072)

Rerun of Natural Gamma Logs (75.0 to 85.0 ft)



Stoller
Grand Junction Office established 1959

699-S6-E4L (C4073)
Log Data Report

Borehole Information:

Borehole:	699-S6-E4L (C4073)		Site:	618-10 Burial Ground	
Coordinates (WA State Plane)		GWL (ft)[1]:	64.2	GWL Date:	2/20/2003
North	East	Drill Date	TOC[2] Elevation	Total Depth (ft)	Type
N/A[3]	N/A	2/20/2003	N/A	87.5	Cable Tool

Casing Information:

Casing Type	Stickup (ft)	Outer Diameter (in.)	Inside Diameter (in.)	Thickness (in.)	Top (ft)	Bottom (ft)
Threaded Steel	2.6	8 3/4	7 3/4	1/2	+2.6	89.0
The geologist was the source for the casing information and all depths.						

Borehole Notes:

Zero reference is the ground surface. This borehole was logged through the drill pipe. This borehole is located approximately 30 ft southeast of the 618-10 Burial Ground.

Logging Equipment Information:

Logging System:	Gamma 3E (RLS-1)		Type:	70% HPGe
Calibration Date:	10/02	Calibration Reference:	GJO-2002-386-TAR	
		Logging Procedure:	MAC-HGLP 1.6.5, Rev. 0	

Logging System:	Gamma 3F (RLS-1)		Type:	Moisture (H380932510)
Calibration Date:	02/03	Calibration Reference:	GJO-2003-417-TAC	
		Logging Procedure:	MAC-HGLP 1.6.5, Rev. 0	

Spectral Gamma Logging System (SGLS) Log Run Information:

Log Run	1	2/Repeat	3	4	5
Date	2/20/03	2/20/03			
Logging Engineer	Pearson	Pearson			
Start Depth (ft)	0.0	75.0			
Finish Depth (ft)	85.0	85.0			
Count Time (sec)	100	100			
Live/Real	R	R			
Shield (Y/N)	N	N			
MSA Interval (ft)	1.0	1.0			
ft/min	n/a[4]	n/a			
Pre-Verification	CE101CAB	CE101CAB			
Start File	CE111000	CE111086			

Log Run	1	2/Repeat	3	4	5
Finish File	CE111085	CE111096			
Post-Verification	CE111CAA	CE111CAA			
Depth Return Error (in.)	0	0			
Comments	None	None			

Neutron-Moisture Logging System (NMLS) Log Run Information:

Log Run	1	2/Repeat	3	4
Date	2/21/03	2/21/03		
Logging Engineer	Pearson	Pearson		
Start Depth (ft)	0.0	57.0		
Finish Depth (ft)	64.0	63.0		
Count Time (sec)	n/a	n/a		
Live/Real	n/a	n/a		
Shield (Y/N)	N	N		
MSA Interval (ft)	0.25	0.25		
ft/min	0.9	0.9		
Pre-Verification	CF022CAB	CF022CAB		
Start File	CF022000	CF02257		
Finish File	CF022256	CF022280		
Post-Verification	CF022CAA	CF022CAA		
Depth Return Error (in.)	n/a	1 low		
Comments	None	None		

Logging Operation Notes:

Zero reference was the ground surface, and the borehole was logged through drill pipe. Logging was performed with a centralizer installed on the sonde. Data were collected using Gamma 3E, HO 68B-4330. Pre- and post-survey verification measurements for the RLS employed the Amersham KUT (^{40}K, ^{238}U, and ^{232}Th) verifier with serial number 118. Fine-gain adjustments were not needed to maintain the 1460-keV (^{40}K) photopeak at a pre-described channel.

Analysis Notes:

Analyst:	Sobczyk	Date:	2/26/03	Reference:	GJO-HGLP 1.6.3, Rev. 0

SGLS pre-run and post-run verification spectra were collected at the beginning and end of the day and compared to the control limits established on 12/05/2002. The verification spectra were all within the control limits. The peak counts per second (cps) at the 609-keV, 1461-keV, and 2615-keV photopeaks on the post-run verification spectra as compared to the pre-run verification spectra for the day were stable and between 1 and 3 percent of one another.

NMLS pre-run and post-run verification spectra were collected at the beginning and end of the day and compared to the control limits established on 12/05/2002. The verification spectra were all within the control limits.

SGLS log spectra were processed in batch mode using APTEC SUPERVISOR to identify individual energy peaks and determine count rates. Post-run verification spectra were used to determine the energy and resolution calibration for processing the data using APTEC SUPERVISOR. Concentrations were calculated in EXCEL (source file: G3Eoct02.xls), using parameters determined from analysis of recent calibration data. Zero reference was the ground surface. Data were analyzed using a uniform casing correction based on a casing thickness of 0.5 in. to a depth of 85 ft. This casing thickness was measured at the wellhead. A water correction was applied to the data below 64.2 ft.

For the 70% HPGe detector, dead time at background count rates varies from 2 to 6 percent, averaging about 4 percent. Dead time corrections are required when dead time exceeds 18 percent. As the dead time did not exceed 18 percent, a dead time correction was not needed or applied.

NMLS log spectra were processed in batch mode using APTEC SUPERVISOR to determine count rates. The volume fraction of water was calculated in EXCEL, using parameters determined from analysis of recent calibration data. Zero reference was the ground surface. Data were analyzed using a uniform casing correction based on a casing thickness of 0.28 in. to a depth of 64 ft. Calibration data are based on 8-in. casing with a thickness of 0.32 in. This casing thickness is thinner than the 0.5-in.-thick drill pipe that was present during logging. A constant was applied to the data to compensate for the to 0.5-in. steel casing to estimate the actual volume fraction of water present at the time of logging.

Log Plot Notes:

Separate log plots are provided for gross gamma and dead time, gross gamma and volume fraction of water, naturally occurring radionuclides (^{40}K, ^{238}U, and ^{232}Th), and man-made radionuclides. Plots of the repeat logs versus the original logs are included. For each radionuclide, the energy value of the spectral peak used for quantification is indicated. Unless otherwise noted, all radionuclides are plotted in picocuries per gram (pCi/g). The open circles indicate the minimum detectable level (MDL) for each radionuclide. Error bars on each plot represent error associated with counting statistics only and do not include errors associated with the inverse efficiency function, dead time correction, or casing correction. These errors are discussed in the calibration report. A combination plot is also included to facilitate correlation. The ^{214}Bi peak at 1764 keV was used to determine the naturally occurring ^{238}U concentrations on the combination plot rather than the ^{214}Bi peak at 609 keV because it exhibited slightly higher net counts per second.

At the bottom of the borehole, the KUT concentrations appear abnormally high. The apparent concentrations are elevated because the sonde is near the open end of the drill pipe, and the casing correction is overcompensating for the shielding effect of the drill pipe. Thus, the KUT concentrations were plotted at the usual scales, and the KUT concentrations were allowed to go off-scale at the bottom of the borehole.

Results and Interpretations:

Man-made radionuclides were not detected in this borehole. ^{137}Cs was indicated at 81 ft during the repeat survey. After examination of the spectrum at this depth, it was determined that there is no evidence of a photopeak at 662 keV. This reported peak is probably the result of statistical fluctuation.

The plots of the repeat logs demonstrate reasonable repeatability of the RLS data for the natural radionuclides at energy levels of 609, 1461, 1764, and 2614 keV. The ^{238}U concentrations based on the 1764-keV photopeak do not repeat at 78 and 82 ft.

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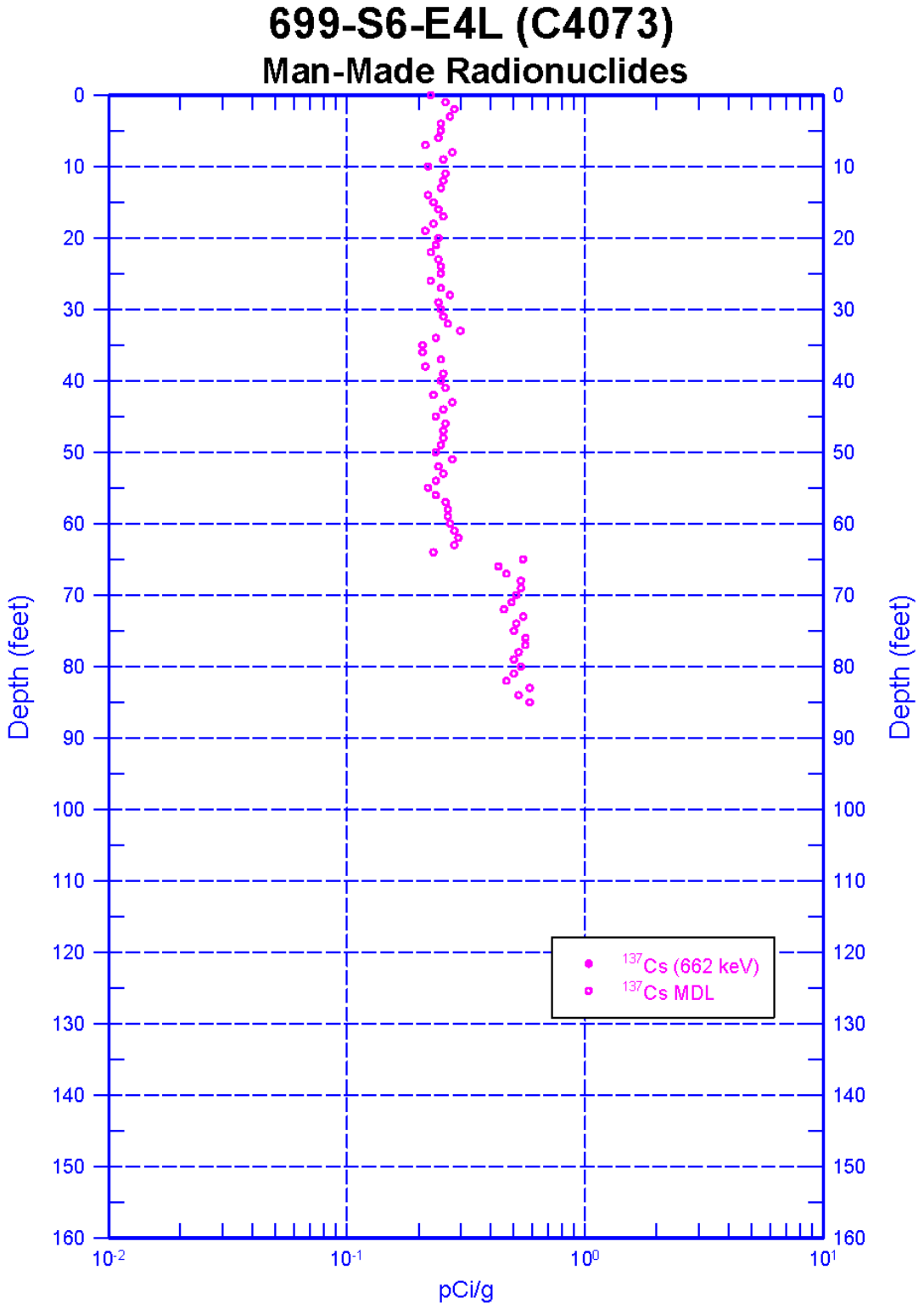
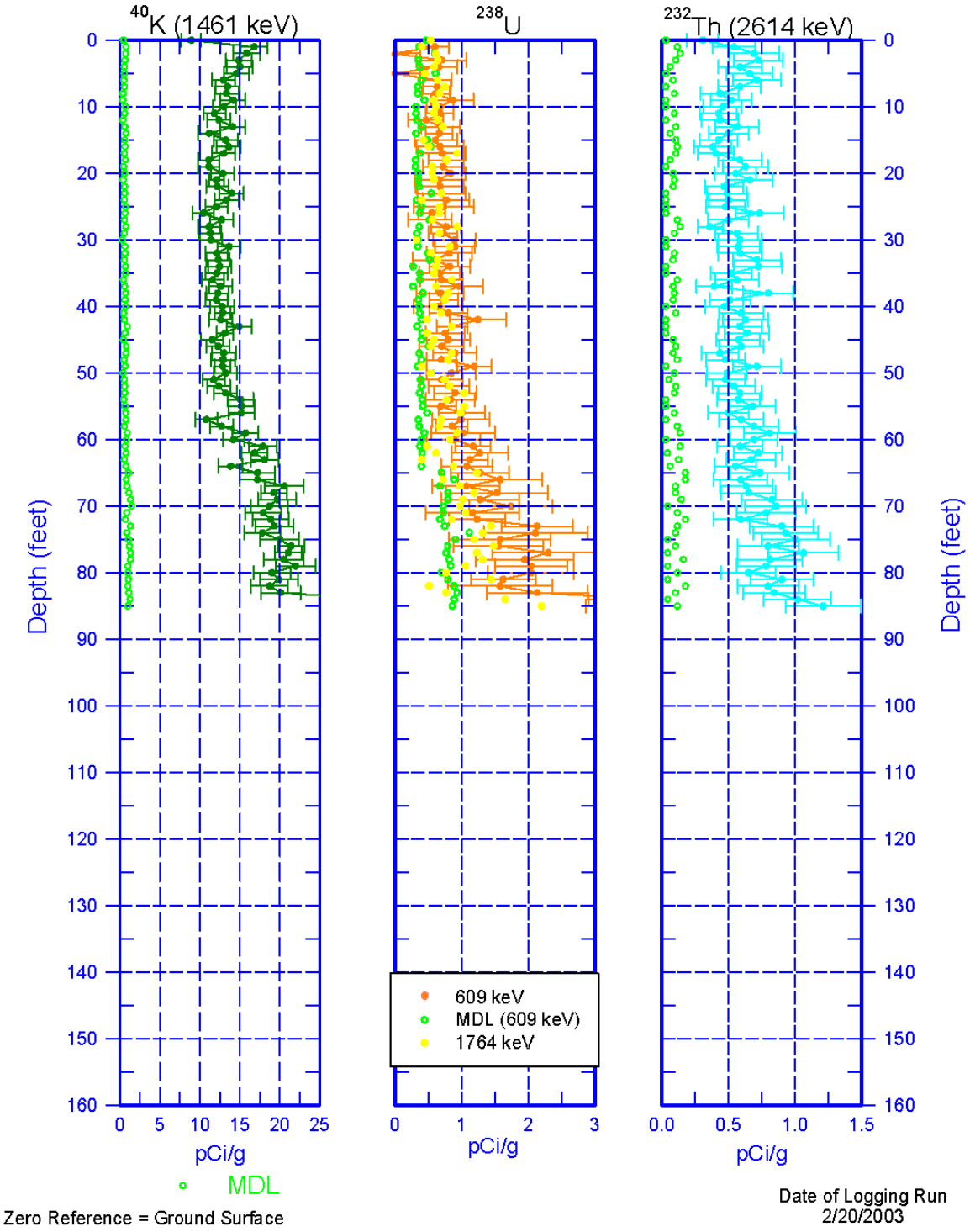
[1] GWL – groundwater depth
[2] TOC – top of casing
[3] N/A – not available
[4] n/a – not applicable



Zero Reference = Ground Surface

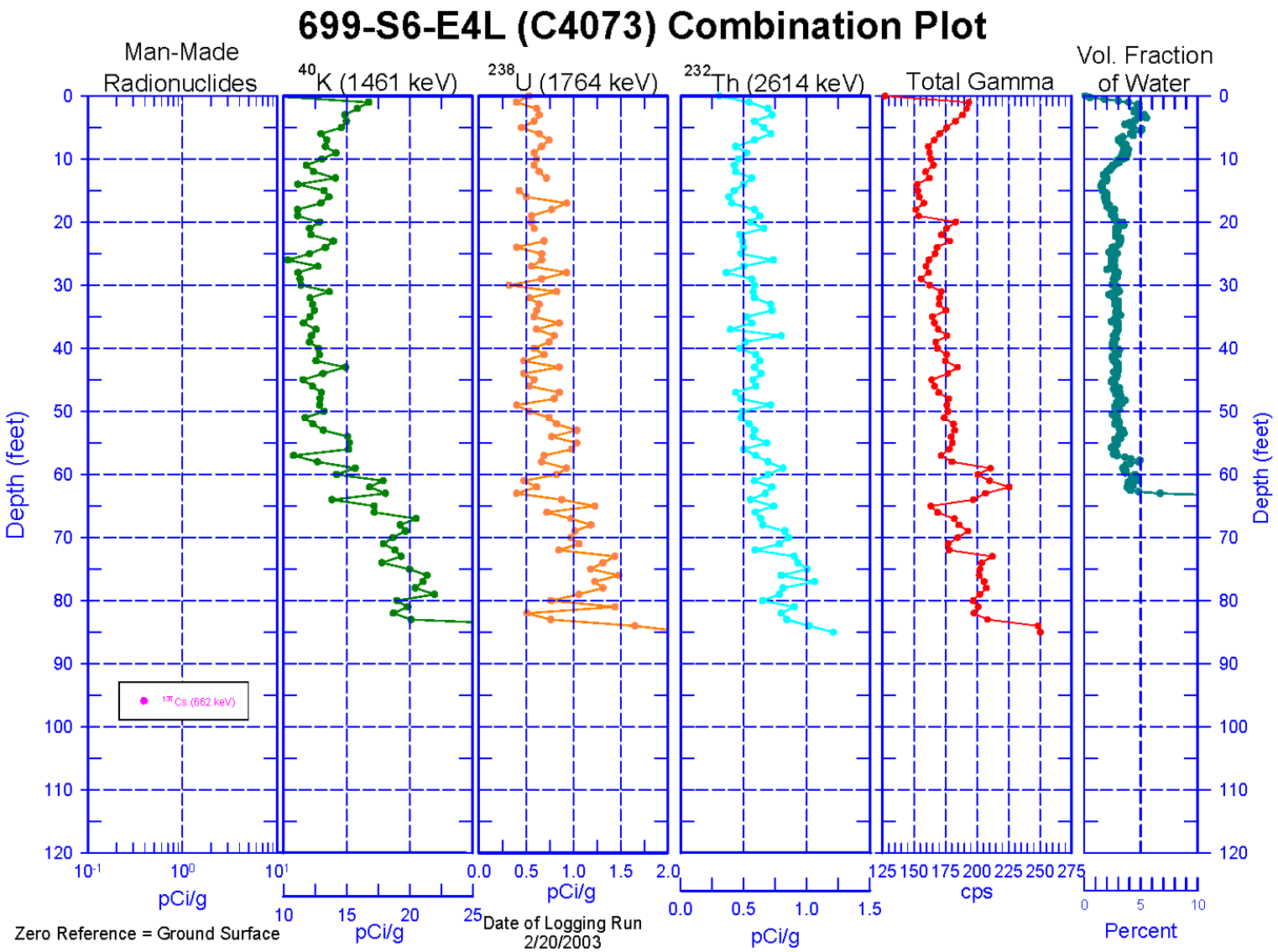
Date of Logging Run
2/20/2003

699-S6-E4L (C4073)
Natural Gamma Logs

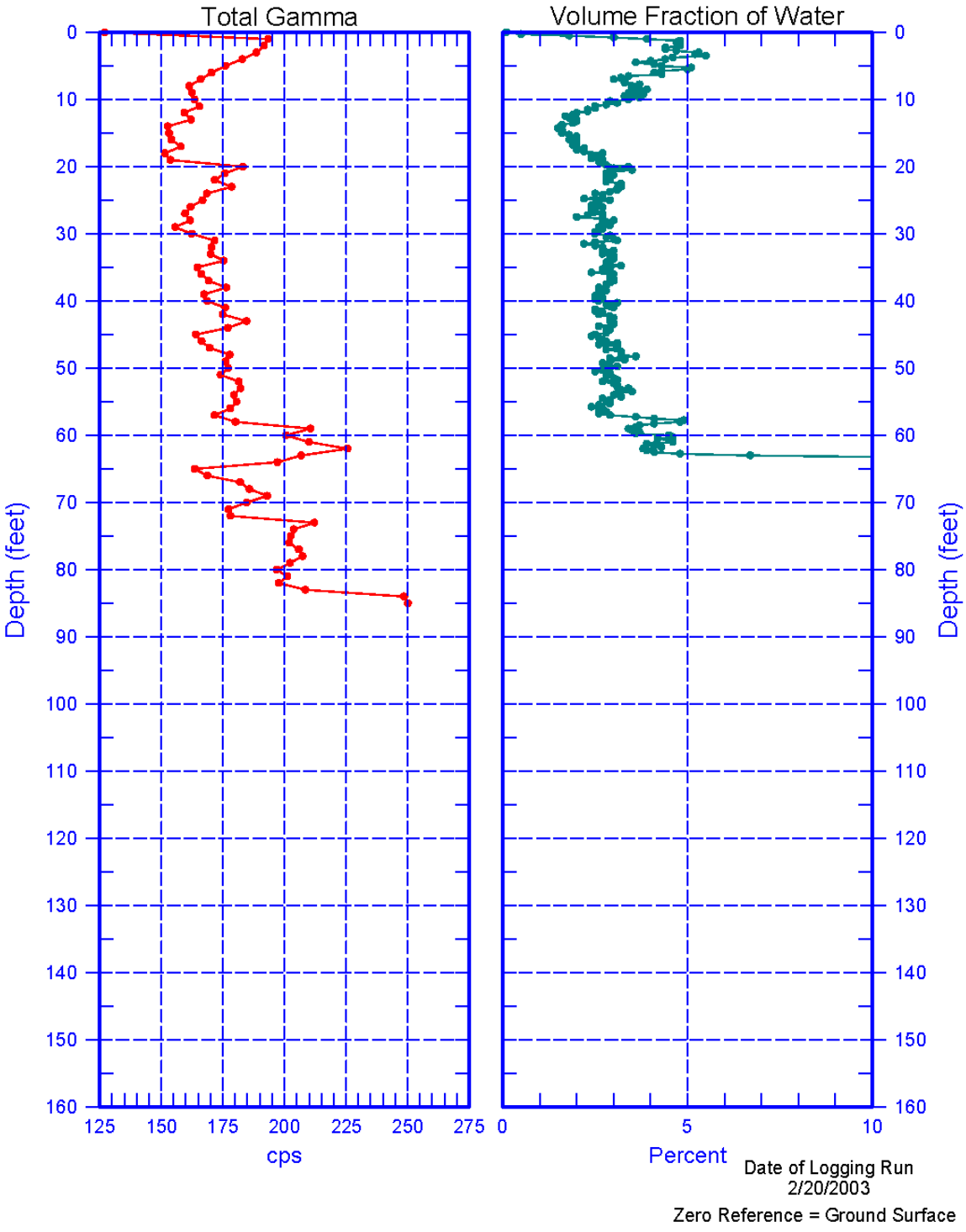


Zero Reference = Ground Surface

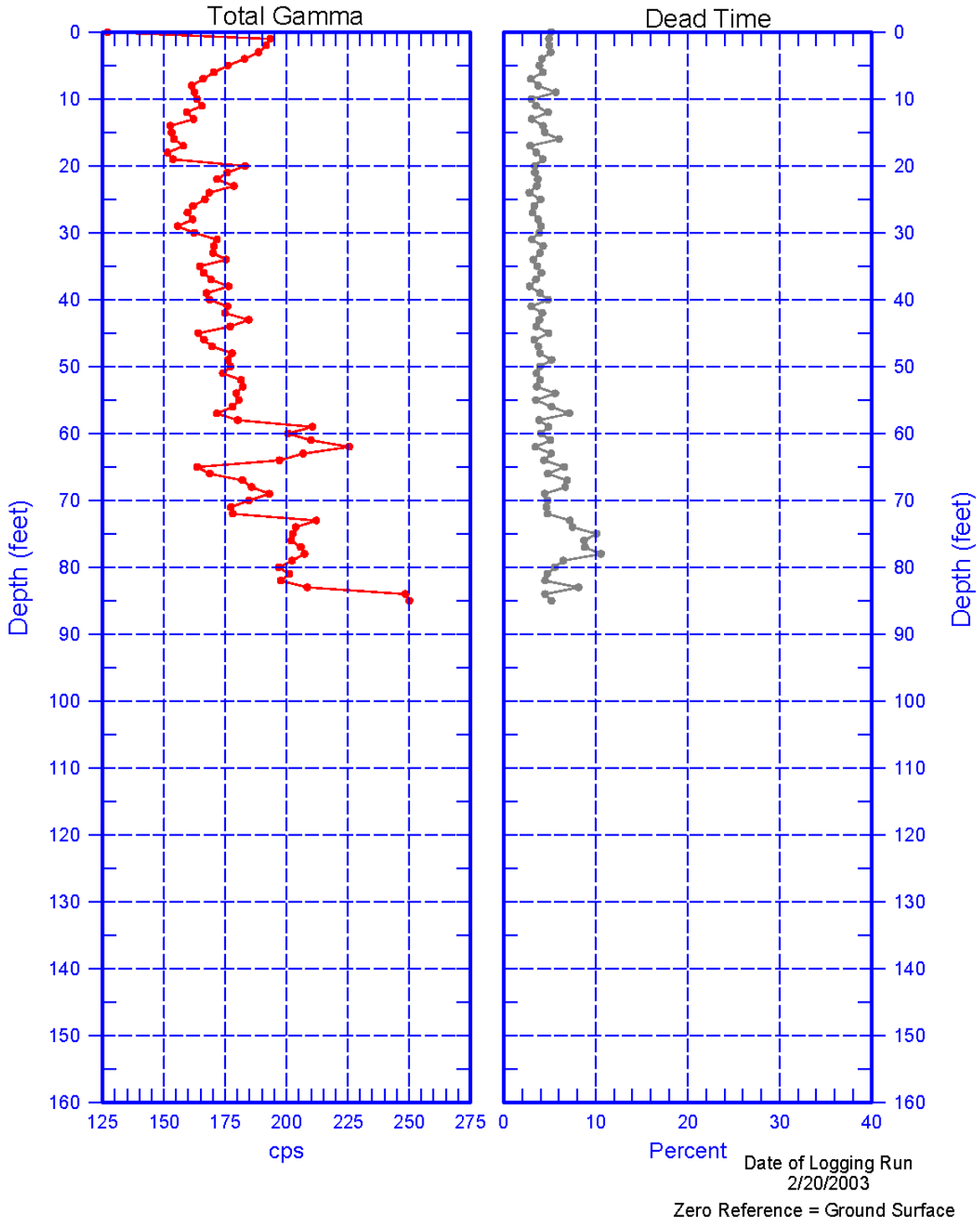
Date of Logging Run
2/20/2003


699-S6-E4L (C4073) Combination Plot
Man-Made Radionuclides
40K (1461 keV)
238U (1764 keV)
232Th (2614 keV)
Total Gamma
Vol. Fraction of Water
Depth (feet)
137Cs (662 keV)
pCi/g
pCi/g
pCi/g
pCi/g
cps
Percent
Zero Reference = Ground Surface
Date of Logging Run
2/20/2003

699-S6-E4L (C4073)
Total Gamma & Neutron

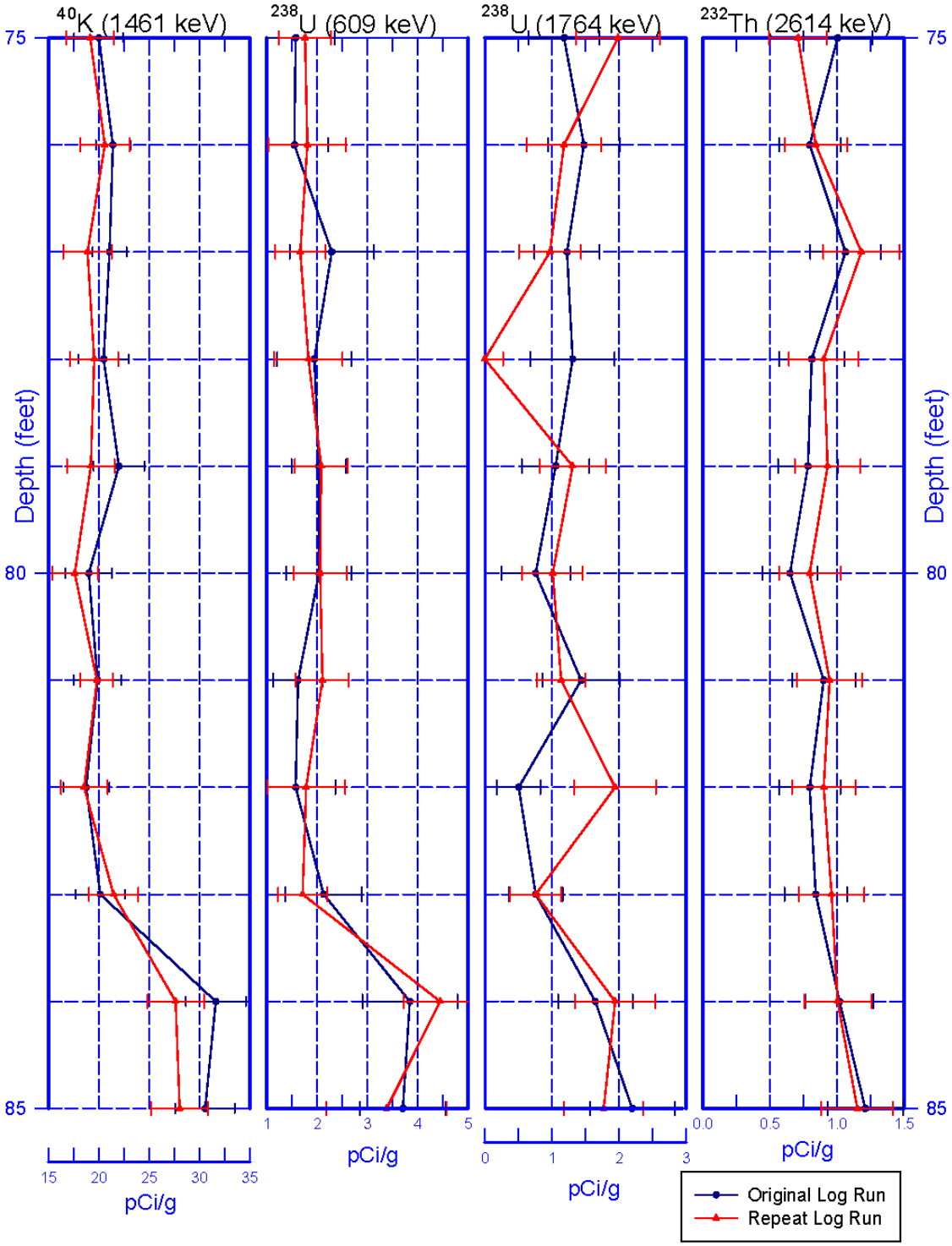


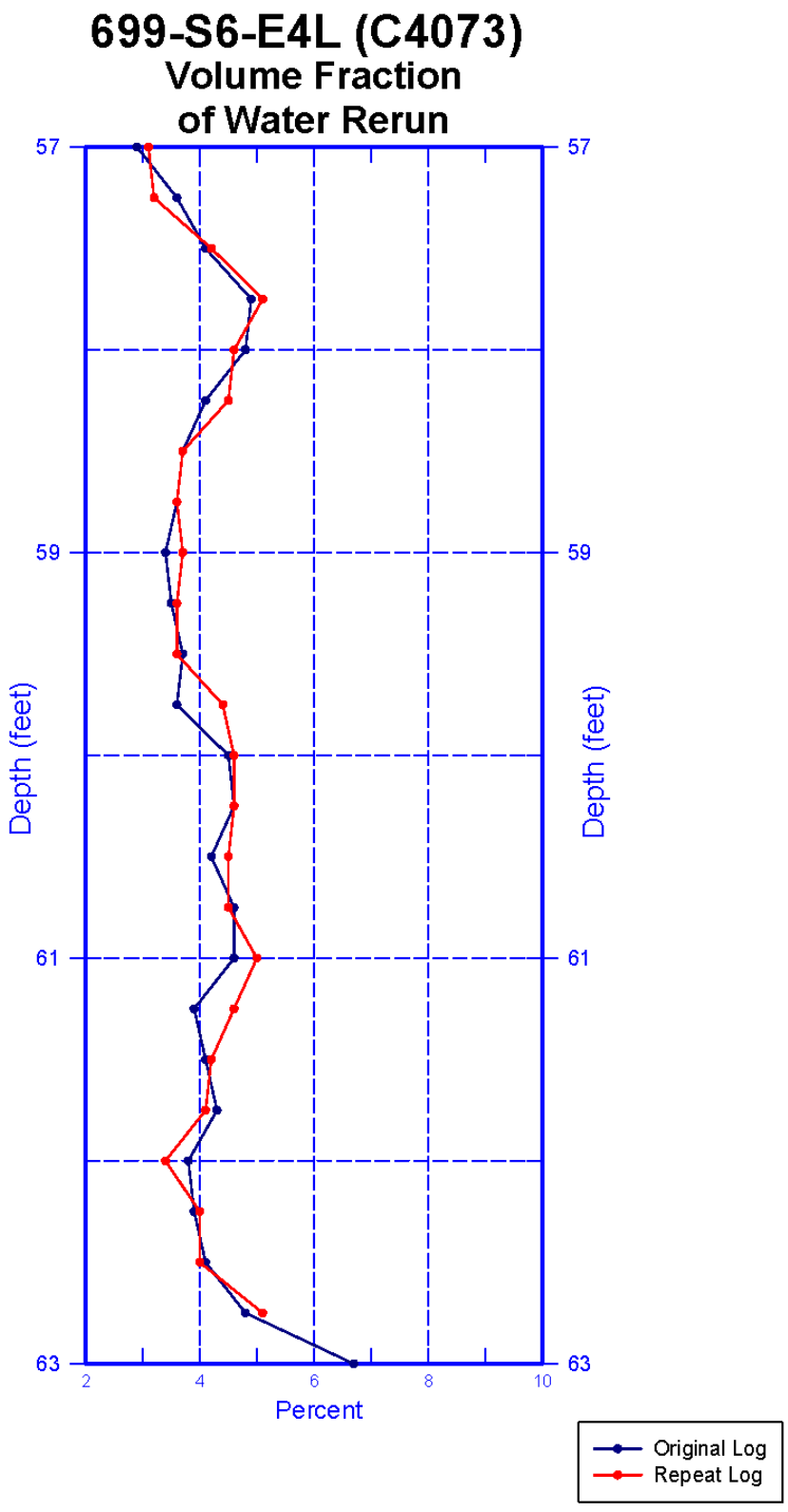
699-S6-E4L (C4073)
Total Gamma & Dead Time



699-S6-E4L (C4073)

Rerun of Natural Gamma Logs (75.0 to 85.0 ft)




699-S6-E4L (C4073)
Volume Fraction
of Water Rerun
57
59
61
63
Depth (feet)
2
4
6
8
10
Percent
Original Log
Repeat Log

Appendix D

Vadose Zone Soil-Gas Survey Sample Collection Parameters

Table D.1. Field Collection Parameters for Soil-Gas Samples Collected Near the 618-10 Burial Ground

Location	Date	Purge Time On	Flow Rate (L/min)	Collection Time	Cylinder Number	Pump Number	Pressure (psig)	Field Notes
C4077	9/16/2002	13:30	1.0	13:57	27	5	8	He
C4077	9/16/2002	13:30	1.0	13:59	50	5	8	Rare Gas
C4077	9/16/2002	13:30	1.0	14:08	215	5	8	Summa
C4078	9/16/2002	13:30	1.0	14:10	28	6	18	He
C4076	9/16/2002	13:46	1.0	14:16	30	7	20	He
C4076	9/16/2002	13:46	1.0	14:15	31	7	20	He Duplicate at C4076
C4075	9/16/2002	13:47	1.0	14:18	29	3	17	He
C4074	9/16/2002	13:53	1.0	14:19	26	?	17.5	He
C4074	9/16/2002	13:53	1.0	14:21	49	?	17.5	Rare Gas
C4074	9/16/2002	13:53	1.0	14:29	139	?	15	Summa
C4081	9/16/2002	14:44	1.0	15:03	34	6	18	He
C4081	9/16/2002	14:14	1.0	15:03	48	6	18	Rare Gas
C4081	9/16/2002	14:44	1.0	15:10	237	6	13	Summa
C4080	9/16/2002	14:44	1.0	15:13	33	3	17	He
C4079	9/16/2002	14:44	1.0	15:16	32	?	17	He
C4082	9/16/2002	14:44	1.0	15:20	35	7	20	He
C4085	9/16/2002	15:28	1.0	15:45	38	6	18	He
C4085	9/16/2002	15:28	1.0	15:47	46	6	18	Rare Gas
C4085	9/16/2002	15:28	1.0	15:52	275	6	15	Summa
C4084	9/16/2002	15:28	1.0	15:55	37	?	17	He
C4083	9/16/2002	15:28	1.0	15:56	36	7	20	He
Ambient Air	9/16/2002	Na	1.0	16:12	40	7	21	He
Ambient Air	9/16/2002	Na	1.0	16:13	47	7	21	Rare Gas
C4086	9/16/2002	15:28	1.0	15:59	39	3	17	He
C4087	9/16/2002	16:06	1.0	16:23	41	3	17	He
C4087	9/16/2002	16:06	1.0	16:25	45	3	17	Rare Gas
C4087	9/16/2002	16:06	1.0	16:32	432	3	15	Summa
C4087	9/16/2002	16:06	1.0	16:24	42	3	17	He Duplicate at C4087

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