SGW-63047
Revision 0

Borehole Summary Report for the Installation of Wells 199-K-235 (C9973) and 100-K-236 (C9974) in the 100-KR-4 OU, FY19, Rev. 0

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management

Contractor for the U.S. Department of Energy
under Contract DE-AC06-08RL14788

CH2MHILL
Plateau Remediation Company

P.O. Box 1600
Richland, Washington 99352

Approved for Public Release;
Further Dissemination Unlimited

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GRAM Northwest, LLC

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Terms

bgs	below ground surface
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CHPRC	CH2M HILL Plateau Remediation Company
DOW	description of work
Ecology	Washington State Department of Ecology
HCl	hydrochloric acid
Carpenter	Carpenter Drilling Company
hp	horsepower
LEL	lower explosive limit
NMLS	neutron moisture logging system
NTU	nephelometric turbidity unit
OD	outer diameter
OU	operable unit
Rwie	Ringold Formation member of Wooded Island – unit E
RUM	Ringold Formation upper mud
SAP	sampling and analysis plan
SGLS	spectral gamma logging system
TD	total depth
VOC	volatile organic compound

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1 Introduction

This borehole summary report provides an overview of the well drilling and construction activities performed during installation of two dual-purpose monitoring wells in the 100-KR-4 Groundwater Operable Unit (OU) along the River Corridor of the Hanford Site (Figure 1). SGW-62588, *Description of Work for the Installation of Two Wells in the 100-KR-4 Groundwater Operable Unit, FY 2019* (hereinafter referred to as the description of work [DOW]), is the controlling document for installation of the two new wells.

The two dual-purpose wells were drilled, constructed, and developed between October 23 and December 19, 2018, by Carpenter Drilling Company (Carpenter) for CH2M HILL Plateau Remediation Company (CHPRC). Well site geology, well drilling documentation, and construction documentation services were provided by GRAM Northwest, LLC. Geophysical logging services were provided by Bay West LLC.

The new wells were installed to support monitoring efforts associated with DOE/RL-2017-30, *KW Soil Flushing/Infiltration Treatability Test Plan*. Data collected during drilling and sampling of these wells will be used to define the lateral extent of contamination (SGW-62588). The wells will be used to perform groundwater monitoring of hexavalent chromium and field parameters for the initial response to vadose zone flushing from the addition of pH-adjusted effluent through the soil column (SGW-62588). Installation of the new wells supports Ecology et al., 1989, *Hanford Federal Facility Agreement and Consent Order*. The wells were installed in compliance with substantive standards of the *Resource Conservation and Recovery Act of 1976* and the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA).

Table 1 lists the well names, well identification numbers, Washington State Department of Ecology (Ecology) unique well tag numbers, and installation dates for the two new wells. Well summary sheets, borehole logs, geophysical log data reports, final civil survey reports, photo logs, and the well development and testing data sheets are presented in Appendix A for well 199-K-235 (C9973) and in Appendix B for well 199-K-236 (C9974). Figure 2 shows the well locations.

1.1 Drilling, Sampling, and Well Construction Activities

This section summarizes the field activities associated with installing dual-purpose wells 199-K-235 (C9973) and 199-K-236 (C9974).

1.2 General Information

The two new wells were constructed in accordance with substantive standards of WAC 173-160, “Minimum Standards for Construction and Maintenance of Wells,” and the construction specifications identified in the DOW (SGW-62588). All well drilling and construction activities were documented in daily field activity reports, and borehole geology was logged. The sampling activities are outlined in DOE/RL-2013-36, *100-KR-4 Groundwater Operable Unit Well Installation Sampling and Analysis Plan*; and DOE/RL-2013-36-ADD6, *100-KR-4 Groundwater Operable Unit Well Installation Sampling and Analysis Plan, Addendum 6: Wells 199-K-235 and 199-K-236* (hereinafter referred to as the sampling and analysis plans [SAPs]).

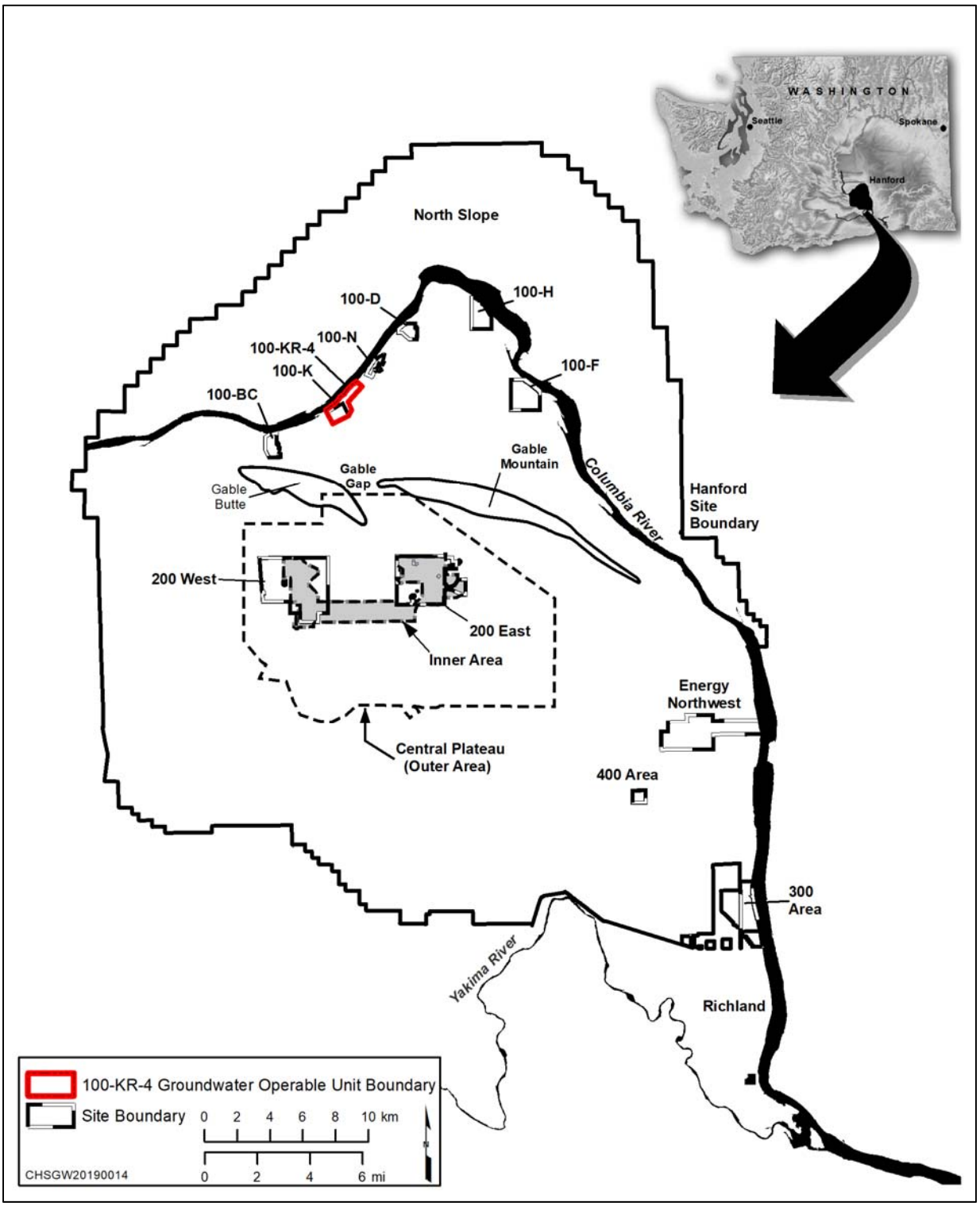

Figure 1. Hanford Site Map

Table 1. Project Well Identification and Drilling Date Summary

Well ID Number	Well Name	Well Installation Date		Ecology Well Tag Number
		Start	Finish	
C9973	199-K-235	10/23/2018	12/19/2018	BKG 094
C9974	199-K-236	10/29/2018	12/19/2018	BKG 097

Ecology = Washington State Department of Ecology
ID = identification

1.2.1 Drilling, Sampling, and Borehole Logging

The drilling, sampling, and borehole logging activities for installing the two new dual-purpose wells are summarized in the following sections.

1.2.1.1 Drilling

Boreholes C9973 and C9974 were drilled with a Bucyrus-Erie® 22W cable tool drill rig, operated by Carpenter. Each well was drilled with an 11 in. outer-diameter (OD) carbon steel casing to total depth (TD). The boreholes were drilled using a combination of an 8.50 in. OD or 8.75 in. OD drive barrel. All temporary casing was advanced to TD with a 10.75 in. OD and 9.75 in. inner-diameter shoe. Both boreholes were drilled to ~38.1 m (125 ft) below ground surface (bgs).

1.2.1.2 Sampling

Sampling was conducted in accordance with the DOW (SGW-62588) and the SAPs (DOE/RL-2013-36 and DOE/RL-2013-36-ADD6). Geologic grab samples were collected and archived at 1.5 m (5 ft) intervals and at major lithologic changes during the drilling of each borehole. Archive grab samples were placed in labeled pint-size glass mason jars and in labeled chip tray compartments for storage. Additional grab samples were collected every 1.5 m (5 ft) once water was encountered and then composited into 6.1 m (20 ft) sieve analysis samples. Sieve analyses of the composited samples were performed to determine particle-size distribution, and the results were used to select the filter pack and well screen slot size for well construction.

Three split-spoon soil samples were collected at each borehole for chemical analysis. The first split spoon for each borehole was collected at the estimated depth for the contact between the Hanford formation and the Ringold Formation. The second and third split spoons were collected in the upper portion and lower portion of the unconfined aquifer, respectively. During drilling, two groundwater samples were collected at both C9973 and C9974. The groundwater samples were collected to determine ambient chemical concentrations, to determine the concentrations within the aquifer near the new wells, and to identify if a vertical contaminant distribution is present in the aquifer. A post-development groundwater sample was also collected during final development of each well for laboratory analysis to confirm field test results and quantify other potential contaminants. All samples collected for chemical analysis were collected by CHPRC nuclear chemical operators. Section 2.2 provides additional well-specific sampling information.

Bucyrus-Erie® is a registered trademark of Caterpillar, Inc., Deerfield, Illinois.

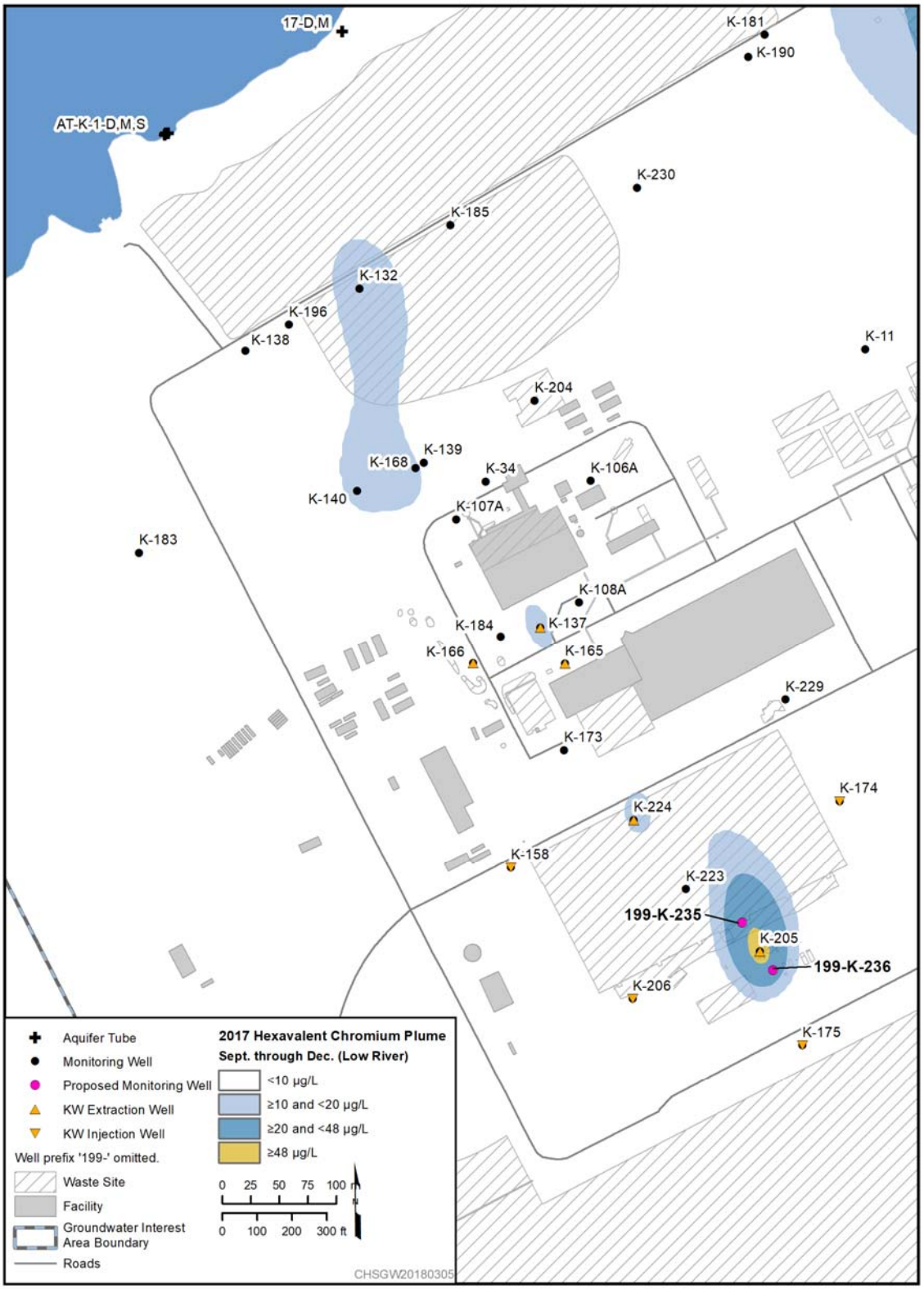

Figure 2. Locations of the Two New Wells in the 100-KR-4 OU

1.2.1.3 Geophysical Logging

The two boreholes were logged using a spectral gamma logging system (SGLS) to detect natural and manmade gamma-emitting radionuclides and a neutron moisture logging system (NMLS) to detect the soil moisture in the vadose zone. Each borehole was drilled using 11 in. OD temporary casing and was logged after drilling to TD.

1.2.2 Health and Safety Screening

The health and safety screening included radiological field screening and air monitoring for volatile organic compounds (VOCs) and lower explosive limit (LEL), as discussed in the following sections.

1.2.2.1 Radiological Field Screening

A radiological control technician performed radiological surveys twice daily (once in the morning and once in the afternoon) during drilling, construction, and development activities. The radiological control technician conducted the surveys using standard radiological field screening instruments to detect any contaminants with alpha, beta, or gamma radiation on drill cuttings, geologic samples, temporary casings, and any other equipment that was used downhole. Radiological contamination was not detected above background levels during drilling activities at either borehole.

1.2.2.2 Air Monitoring for Volatile Chemicals

An industrial hygiene technician performed atmospheric monitoring twice daily(once in the morning and once in the afternoon) during drilling activities. The industrial hygiene technician used a photoionization detector and a multi-gas meter to confirm acceptable atmospheric conditions during drilling. Conditions monitored using the photoionization detector included total VOCs. Conditions monitored using the multi-gas meter included carbon monoxide, hydrogen sulfide, LELs, ammonia, and oxygen. LEL wellhead monitoring was required prior to welding activities. Areas monitored for VOCs included the driller's breathing zone near the wellhead, the wellhead or source, any fresh drill cuttings and/or geologic samples, and any other areas of potential concern.

Very low to nonexistent levels of the monitored reagents were detected downhole during drilling activities, except for C9973, where VOC readings of 15 parts per million were found at the source on November 7, 2018. VOCs were not detected in the breathing zone at either borehole location. Additionally, the LEL never exceeded 0% at either borehole location.

1.2.3 Well Construction and Development

This section provides additional details on the well construction and development activities.

1.2.3.1 Screen and Casing Materials

Each well was constructed with permanent casing consisting of 6-3/4 in. OD, 6 in. inner-diameter, Schedule 10S Type 304/304L stainless-steel blank casing, vee-wire screens, and sumps with end caps. Well 199-K-235 (C9973) had a break in the 6 in. inner-diameter screen at ~30.5 m (100 ft) bgs, and a 5-1/4 in. OD, 5 in. inner-diameter, Schedule 10S Type 304/304L insert with corresponding stainless-steel blanks, screen, and sump (with no end cap) was placed inside the 6 in. inner-diameter well. Screens used at both wells were continuous vee-wire wrap with a 40-slot (0.040 in.) aperture, and each well used a 1.5 m (5 ft) sump (i.e., 1.5 m [5 ft] of blank with a welded end cap) located below the screened interval. Section 2.2 provides further details on the construction materials used for each well.

1.2.3.2 Well Completion

A straightness test was conducted in each well with a tool that was 6.1 m (20 ft) in length with an 8-3/4 in. OD. The test was conducted prior to setting the permanent well in accordance with WAC 173-160 requirements.

The screen size and filter pack size used for construction were determined based on sieve analysis results, geologic borehole logs, geophysical logs, and intended well use. The two wells were constructed with a filter pack consisting of 10-20 mesh Colorado silica sand, with an addition of 8-16 mesh Colorado silica sand at well 199-K-236 (C9974). The filter pack was settled using a dual-flange surging method.

The annular seals for the two wells used 3/8 in. coated bentonite pellets immediately above the silica filter pack of the uppermost screened interval as an ~0.9 m (3 ft) seal, followed by granular #8 (8-20 mesh) bentonite crumbles. The granular bentonite was placed from the top of the bentonite pellet seal to ~3 m (10 ft) bgs. Type I/II Portland neat cement was used for the surface seal and was placed from the top of the granular bentonite to the ground surface. Any remaining unfilled annular space was filled with high-strength concrete during well pad construction.

The surface completion consists of the permanent casing surrounded by a stainless-steel protective monument with a unique Ecology well tag number riveted to the monument. Each surface completion has a 1.2 m by 1.2 m by 15.2 cm (4 ft by 4 ft by 6 in.) concrete pad constructed around the wellhead protective monument. The wells are located within the center of the concrete pad with a brass surveyor's marker (stamped with the well name, identification number, and date of final construction) imbedded on the northern side of the pad. The monuments have a lockable cap, and the lock hasps were positioned to face northward. The surface completion also includes four steel bollards (1.8 m [6 ft] long and 7.6 cm [3 in.] diameter, one of which is removable) placed at the four corners of each concrete pad, with 0.9 m (3 ft) stickup for wellhead protection. The bollards were painted yellow in accordance with ANSI Z535.1-2017, *American National Standard for Safety Colors*, for increased visibility of physical hazards. Section 2.2 provides further details on well construction.

1.2.3.3 Final Well Development

Final well development for the two wells was conducted during construction activities, after the filter pack was added and settled and before the bentonite seal was placed. Well 199-K-235 (C9973) was developed in two ~4.6 m (15 ft) intervals within the 6 in. diameter stainless-steel casing, and an additional interval was developed after the 5 in. diameter stainless-steel insert was placed. Well 199-K-236 (C9974) was developed in two ~4.6 m (15 ft) intervals, both using an electric submersible pump. The groundwater was pumped while water quality parameters (turbidity, conductivity, dissolved oxygen, pH, and temperature) were monitored. Each development interval was completed when the turbidity read <5 nephelometric turbidity units (NTUs) and the remaining water quality parameters stabilized. A LevelTROLL® 700 data logger was used to record the drawdown and recovery data during development activities. Table 2 provides the final water quality data for each well interval. Well development and testing data sheets are provided in Appendices A and B for C9973 and C9974, respectively.

LevelTROLL® is a registered trademark of In-Situ, Inc., Fort Collins, Colorado.

1.2.3.4 Washington State Department of Ecology Well Identification

Each well received a unique Ecology well identification number that was embossed onto a stainless-steel tag and riveted to the protective monument. When the monuments were set, all identification tags were set to face toward the north. Table 1 lists the Ecology tag numbers and the associated wells.

Table 2. Well Development Data Summary

Well ID Number	Well Name	Date Developed	Initial Water Level (ft bgs)	Pump Intake Depth (ft bgs)	Duration Pumped (minutes)	Average Flow Rate (gal/min)	Maximum Drawdown (ft)	Final Turbidity (NTU)	Specific Conductance (µS/cm)	Dissolved Oxygen (mg/L)	pH	Temperature (°C)	Total Gallons Pumped
C9973	199-K-235	11/28/2018	88.35	115.72	57	82	7.98	2.66	463	6.01	7.58	18.07	4,800
		11/29/2018	88.10	100.46	61	78	7.09	0.91	473	6.24	7.63	17.88	4,758
		12/19/2018	88.27	111.60	58	80	9.55	2.83	*	*	*	*	4,600
C9974	199-K-236	12/13/2018	87.63	116.25	52	80	4.93	3.05	411	7.17	7.67	15.1	4,200
		12/13/2018	87.61	99.97	60	80	4.56	2.18	416	7.29	7.67	14.5	4,800

*The CH2M HILL Plateau Remediation Company buyer's technical representative and hydrogeologist directed that specific conductance, dissolved oxygen, pH, and temperature did not need to be monitored while developing the 5 in. stainless-steel insert.

bgs = below ground surface

ID = identification

NTU = nephelometric turbidity unit

1.3 Well-Specific Information

This section summarizes the drilling, air monitoring, sampling, geophysical logging, construction, and development activities specific to each well.

1.3.1 Well 199-K-235 (C9973)

Drilling began at well 199-K-235 (C9973) on October 23, 2018, using a Bucyrus-Erie 22W cable tool drill rig. The well was constructed between November 14 and December 19, 2018. The borehole was drilled to a TD of 38.1 m (125.0 ft) bgs, and the 11 in. casing was advanced to a depth of 38.10 m (125.01 ft) bgs on November 8. The temporary casing was 11 in. OD carbon steel with threaded joints.

Sampling at C9973 included collecting soil samples for geologic archival purposes, composited soil sieve samples for determining particle-size distribution (sieve analysis), three soil grab samples and three split-spoon samples for chemical analysis, as well as two groundwater samples and one post-development water sample for chemical analysis. Geologic archive soil samples were collected by the field geologist at 1.5 m (5 ft) intervals and at lithology changes throughout the borehole. Samples for sieve analysis were collected as 6.1 m (20 ft) composites of each 1.5 m (5 ft) soil grab sample from the top of the water table to TD. Three soil grab samples were collected at ~13.7 m, 22.9 m, and 24.4 m (45 ft, 75 ft, and 80 ft) bgs. The first split-spoon sample was planned to be collected at the estimated contact depth between the Hanford formation and Ringold Formation but was collected sooner at ~19.1 m (62.5 ft) bgs where the Ringold Formation was encountered. The remaining two split-spoon samples were collected as planned in the upper and lower portions of the unconfined aquifer. Groundwater samples were collected during drilling at ~29.0 m and 37.2 m (95 ft and 122 ft) bgs prior to reaching TD. Static water was tagged at 27.12 m (88.97 ft) bgs on October 31. A final static water level was tagged at 26.91 m (88.30 ft) on December 19. Table 3 provides summary information for the samples collected for chemical analysis.

Geophysical logging was performed through the 11 in. OD casing on November 12 using NMLS from the surface to 26.83 m (88.02 ft) bgs and using SGLS from the surface to 37.80 m (124.03 ft) bgs. Manmade radionuclides were not detected in the borehole. Appendix A provides the geophysical logging report for C9973 (HGLP-LDR-1058).

Well completion activities began on November 14. Carpenter performed a straightness test with a 6.1 m (20 ft) long, 8-3/4 in. OD tester. The tester passed through the 11 in. temporary casing without binding. Well installation materials included 6 in. inner-diameter and 6-3/4 in. OD, Schedule 10S Type 304/304L stainless-steel blank casing, screen, and sump. A total of 6.10 m (20.00 ft) of continuous vee-wire wrap, stainless-steel screen with a 40-slot (0.040 in.) aperture was used. Stainless-steel centralizers were placed at the bottom and top of the screen interval and at 12.2 m (40 ft) intervals above the screened section. A liner consisting of 5 in. inner-diameter and 5-1/4 in. OD stainless-steel blank casing, screen, and sump (no end cap) was placed inside of the 6 in. inner-diameter permanent casing on December 19 due to a break in the 6 in. inner-diameter screen at ~30.5 m (100 ft) bgs. Table 4 provides information on the well construction materials and associated depths for C9973, and Appendix A provides the well summary sheet.

Table 3. Sample Summary for Well 199-K-235 (C9973)

Sample Date	Sample Interval	Sample Depth (ft bgs)	Sample Medium	Sample Method	HEIS Number
10/25/2018	Waste	45.1 – 46.6	Soil	Grab	B3MDF8
10/292018	I-001	62.7 – 65.2	Soil	Split spoon	B3M7F8, B3M7F9, B3M7H0
10/30/2018	I-002	74.9 – 76.9	Soil	Grab	B3M7H1, B3M7H2 (DUP)
10/30/2018	I-003	79.7 – 81.7	Soil	Grab	B3M7H3
10/31/2018	I-004	84.7 – 87.2	Soil	Split spoon	B3M7H4, B3M7H5, B3M7H6
11/1/2018	I-005	94.61	Water	Pumped	B3M7R6 (filtered), B3M7T6, B3M7J0 (filtered), B3M7T7, B3M7J1
11/7/2018	I-006	119.8 – 122.3	Soil	Split spoon	B3M7H7, B3M7P1, B3M7P2
11/8/2018	I-007	121.90	Water	Pumped	B3M7R7 (filtered), B3M7T8, B3M7J2 (filtered), B3M7T9, B3M7R8 (filtered) (DUP), B3M7V0 (DUP), B3M7J4 (filtered), B3M7V1 (DUP), B3M7J3
11/29/2018	Post-development	100.46	Water	Pumped	B3M7K0 (filtered), B3M7K1, B3M7T1 (filtered), B3M7T2, B3M7T3, B3M7T4, B3M7T5, B3M7K2

bgs = below ground surface
HEIS = Hanford Environmental Information System

Well development at C9973 was performed during construction, prior to adding the final bentonite seal. Development operations were conducted from November 28 to November 29. A total of two intervals at ~4.6 m (15 ft) apart were used to complete development on the 6 in. inner-diameter stainless-steel casing using a 5-horsepower (hp) submersible pump. The average purge rate for all intervals was 303 L/min (80 gal/min). One redevelopment interval was conducted on the 5 in. inner-diameter insert on December 19 and no significant change was seen with the liner (see Table 2 for redevelopment data). For all development intervals, the requirement was to pump until the turbidity decreased to <5 NTUs and until other key parameters (specific conductance, pH, and temperature) stabilized. A total of 53,593.9 L (14,158 gal) of water was purged during development at C9973. Table 2 presents the results for all three stages of development for this well, and Appendix A provides the well development and testing data sheet.

Table 4. Construction Summary for Well 199-K-235 (C9973)

Borehole Total Depth (ft bgs)	Static Water Level (ft bgs)	6 in. Diameter Stainless-Steel Permanent Casing and 5 in. Diameter Stainless-Steel Insert Well Materials			Annular Materials		
		Material	Interval (ft bgs)	Screen Slot Size (in.)	Material	Interval (ft bgs)	Mesh Size
125.0	88.30 (12/19/2018)	Stainless-steel monument	+3.00 –2.00	N/A	Portland cement	0.0 – 12.5	Type I/II
		6 in. stainless-steel blank casing	+2.00 – 79.85	N/A	Bentonite crumbles	12.5 – 72.9	#8
		6 in. stainless-steel screen	79.85 – 119.85	0.040	Bentonite pellets	72.9 – 76.5	3/8 in.
		6 in. stainless-steel sump (end cap)	119.85 – 124.85	N/A	Filter pack sand	76.5 – 125.0	10-20
		5 in. stainless-steel blank casing	+1.25 – 78.22	N/A			
		5 in. stainless-steel screen	78.22 – 119.25	0.040			
		5 in. stainless-steel sump (no end cap)	119.25 – 124.57	N/A			

bgs = below ground surface
N/A = not applicable

1.3.2 Well 199-K-236 (C9974)

Well 199-K-236 (C9974) was installed between October 29 and December 19, 2018. The borehole was drilled to a TD of 38.3 m (125.5 ft) bgs. Drilling began on October 29 using a Bucyrus-Erie 22W cable tool drill rig. The temporary casing used was 11 in. OD carbon steel with threaded joints. The 11 in. casing was advanced to a final depth of 38.40 m (125.98 ft) bgs on November 27.

Sampling at C9974 included collecting soil samples for geologic archival purposes, composited soil sieve samples for sieve analysis, three split-spoon samples, and three grab samples, as well as two groundwater samples during drilling and one post-development water sample for chemical analysis. Geologic archive soil samples were collected by the field geologist at 1.5 m (5 ft) intervals and at lithology changes throughout the borehole. Samples for sieve analysis were collected as 6.1 m (20 ft) composites of each 1.5 m (5 ft) soil grab sample from the top of the water table to TD. Split-spoon samples were collected approximately at the estimated Hanford formation/Ringold Formation contact, as well as in the upper portion and the lower portion of the unconfined aquifer, at 16.2 m, 26.5 m, and 36.6 m (53 ft, 87 ft, and 120 ft) bgs, respectively. Grab samples were collected in the vadose zone at ~18.3 m, 22.3 m, and 24.4 m (60 ft, 73 ft, and 80 ft) bgs. Groundwater samples were collected at ~29.0 m and 37.2 m (95 ft and 122 ft) bgs during drilling; a single groundwater sample was also collected during well development. A final static water level was tagged at 27.04 m (87.73 ft) on December 18. Table 5 provides summary information for the samples collected for chemical analysis.

Table 5. Sample Summary for Well 199-K-236 (C9974)

Sample Date	Sample Interval	Sample Depth (ft bgs)	Sample Medium	Sample Method	HEIS Number
11/6/2018	I-001	52.7 – 55.2	Soil	Split spoon	B3M7K4, B3M7K5, B3M7K6, B3MDF9
11/7/2018	I-002	60.0 – 62.0	Soil	Grab	B3M7K7
11/7/2018	I-003	73.0 – 75.0	Soil	Grab	B3M7K8
11/8/2018	I-004	80.0 – 82.0	Soil	Grab	B3M7K9, B3M7L0 (DUP)
11/12/2018	I-005	87.2 – 89.7	Soil	Split spoon	B3M7L1, B3M7L2, B3M7L3
11/13/2018	I-006	95.56	Water	Pumped	B3M7V6 (filtered), B3M7V7, B3M7J8 (filtered), B3M7W6, B3M7J9
11/20/2018	I-007	120.2 – 122.7	Soil	Split spoon	B3M7P3, B3M7P4, B3M7L4
11/26/2018	I-008	122.26	Water	Pumped	B3M7V8 (filtered), B3M7V9, B3M7W0 (filtered) (DUP), B3M7W1 (DUP), B3M7M4 (filtered), B3M7W7, B3M7M6 (filtered) (DUP), B3M7W8 (DUP), B3M7M5
12/17/2018	Post-development	99.97	Water	Pumped	B3M7N0 (filtered), B3M7N1, B3M7N2 B3M7X6, B3M7X2 (filtered), B3M7X3, B3M7X4 (filtered), B3M7X5

bgs = below ground surface
HEIS = Hanford Environmental Information System

Geophysical logging was performed through the 11 in. OD casing using NMLS from the surface to 26.84 m (88.07 ft) bgs on November 28 and using SGLS from the surface to 37.50 m (123.02 ft) bgs on November 27. Manmade radionuclides were not detected in the borehole. Appendix B provides the geophysical logging report for C9974 (HGLP-LDR-1059).

Well completion activities began on November 28. Carpenter performed a straightness test with a 6.1 m (20 ft) long, 8-3/4 in. OD tester. The tester passed through the 11 in. temporary casing without binding. Well installation began on November 28 using 6 in. inner-diameter and 6-3/4 in. OD, Schedule 10S Type 304/304L stainless-steel blank casing, screen, and sump. A total of 12.19 m (40.00 ft) of continuous vee-wire wrap, stainless-steel screen with a 40-slot (0.040 in.) aperture was used. Stainless-steel centralizers were placed at the bottom and top of the screen interval and at every 12.2 m (40 ft) thereafter. Table 6 provides information on the well construction materials and associated depths for C9974, and Appendix B provides the well summary sheet.

Well development at C9974 was performed during construction, prior to adding the final bentonite seal. Development operations were conducted on December 13. A total of two intervals at ~4.6 m (15 ft) increments were conducted to complete development using a 5-hp submersible pump. The average purge rate for all intervals was ~303 L/min (80 gal/min). For all development intervals, the requirement was to pump until the turbidity decreased to <5 NTUs and until other key parameters (specific conductance, pH, and temperature) stabilized. A total of ~34,068.7 L (9,000 gal) of water was purged during development. Table 2 presents the results for the two intervals of development for this well, and Appendix B provides the well development and testing data sheet.

Table 6. Construction Summary for Well 199-K-236 (C9974)

Borehole Total Depth (ft bgs)	Static Water Level (ft bgs)	6 in. Diameter Stainless-Steel Permanent Casing Well Materials			Annular Materials		
		Material	Interval (ft bgs)	Screen Slot Size (in.)	Material	Interval (ft bgs)	Mesh Size
125.5	87.73 (12/18/2018)	Stainless-steel monument	+3.00 – 2.00	N/A	Portland cement	0.0 – 10.5	Type I/II
		Stainless-steel blank casing	+2.00 – 80.20	N/A	Bentonite crumbles	10.5 – 71.7	#8
		Stainless-steel screen	80.20 – 120.20	0.040	Bentonite pellets	71.7 – 74.7	3/8 in.
		Stainless-steel sump	120.20 – 125.21	N/A	Filter pack sand	74.7 – 113.7	10-20
					Filter pack sand	113.7 – 125.5	8-16

bgs = below ground surface
N/A = not applicable

2 Geologic Observations

This chapter summarizes the general geology of the 100-KR-4 OU and the geology encountered at each of the well sites during drilling.

2.1 Geology of the 100-KR-4 Operable Unit

The 100-KR-4 OU is in the northwest portion of the Hanford Site along the southern shoreline of the Columbia River, and it is located ~48 km (30 mi) north-northwest of Richland, Washington. The 100-KR-4 OU includes the KE and KW Reactor areas and adjacent portions of the 600 Area (SGW-62588). The stratigraphy of this area is comprised of several different sedimentary deposits that lie above the Columbia River Basalt Group. The major units that are found in the 100-K Area include the following (from youngest to oldest):

- Holocene eolian deposits, disturbed sediments, and recent sand and gravel backfill
- Pleistocene sand and gravel sediments of the Hanford formation
- Miocene-Pliocene Ringold Formation sediments:
  - Sand and gravel sediments of the Ringold Formation member of Wooded Island – unit E (Rwie)
  - Fine-grained sediments of the Ringold Formation upper mud (RUM)
- Miocene Elephant Mountain Member of the Saddle Mountains Basalt of the Columbia River Basalt Group

The ground surface of the 100-K Area has been extensively disturbed by grading, soil backfilling, construction, and demolition work, generally ranging from 3.0 m to 9.1 m (10 ft to 30 ft) bgs but it can extend more deeply (SGW-62588). The Pleistocene Hanford formation is divided into three facies including gravel-dominated, sand-dominated, and slack water cataclysmic flood and interflood deposits

that resulted from the Missoula floods that occurred 15,000 to 12,000 years ago (SGW-62588). The gravel-dominated facies are highly mafic due to a basaltic composition, ranging from ~50% to 80%. The sand-dominated facies consists of ~50% mafic and 50% quartz-feldspar that is relatively thicker than the gravel-dominated facies and predominantly horizontally laminated of fine- to coarse-grained sand. The Ringold Formation is below the Hanford formation and consists of semiconsolidated fluvial silt, sand, and mostly gravels of the Rwie, along with paleosol and overbank silt deposits of the RUM below the Rwie (SGW-62588). For this project, drilling did not continue below the Rwie; therefore, the underlying RUM and Columbia River Basalt Group were not encountered.

Additional information regarding the geology of the 100-K Area is presented in the following:

- BHI-00184, *Miocene- to Pliocene-Aged Suprabasalt Sediments of the Hanford Site, South-Central Washington*
- BHI-01648, *Late Pleistocene and Holocene-Age Columbia River Sediments and Bedforms: Hanford Reach Area, Washington, Part 1*
- Lindsey, 1996, *The Miocene to Pliocene Ringold Formation and Associated Deposits of the Ancestral Columbia River System, South-central Washington and North-central Oregon*
- WHC-SA-0740-FP, *Sedimentology and Stratigraphy of the Miocene-Pliocene Ringold Formation, Hanford Site, South-Central Washington*
- WHC-SD-EN-TI-011, *Geology of the Northern Part of the Hanford Site: An Outline of Data Sources and the Geologic Setting of the 100 Areas*
- WHC-SD-EN-TI-155, *Geology of the 100-K Area, Hanford Site, South-Central Washington*

Summaries of geologic units encountered throughout each borehole are presented in the following discussion.

2.2 Borehole Geology

This section describes the geologic characteristics and stratigraphic units that were observed from grab samples during drilling of the two new boreholes (C9973 and C9974). Appendices A and B provide the respective borehole logs.

The interpretations included in this report regarding the stratigraphy of each drill site are based on field observations from drill cuttings collected every 1.5 m (5 ft) or where major lithologic changes occurred; therefore, the depths of contacts included should be viewed as approximations. Final stratigraphic unit contacts will be determined from field observations, borehole geophysical logging data, and regional stratigraphic interpretations. It should also be noted that prior to drilling, it was postulated that potential areas of yellow-stained soil (presumed to be concentrated hexavalent chromium contamination) could be present during drilling; however, no such sediments were observed from ground surface to TD in either borehole.

Due to the drilling method used, grab samples may appear more angular than the actual formation. Samples also could appear more homogenous due to grab samples being collected in a 5 gal bucket and transferred into a stainless-steel bowl prior to being able to observe the material. Samples may also have a weaker reaction to 10% diluted hydrochloric acid (HCl) in the presence of water. The following sections discuss the determination of estimated stratigraphic unit contacts for each of the borehole summaries.

2.2.1 Well 199-K-235 (C9973)

Well 199-K-235 (C9973) is located ~300 m (~1,000 ft) south of the KW Reactor in the 100-K Area. The major stratigraphic units encountered after drilling past the gravel backfill placed during remediation operations include the Hanford formation and the Rwie.

Sandy gravel backfill extended from ground surface to ~7.9 m (26 ft) bgs. The sandy gravels ranged from 35% to 55% gravel, 40% to 65% sands, and 0% to 5% silt. The gravels are dominantly mafic (95%). The gravels are poorly to moderately sorted, very well rounded to subrounded, and ranged from very fine pebble to large cobble (2 mm to 160 mm). The sands are also dominantly mafic (70%) and are poorly sorted, ranging from very fine to very coarse and are subrounded to angular. There is very little silt present (~5%), which is grayish-brown in color. No reaction was observed with the gravel, sand, or silt when tested with HCl.

The Hanford formation was observed at depths of ~7.9 m to 16.8 m (26 ft to 55 ft) bgs. The contact was at ~7.9 m (26 ft) due to the increase in angularity of the gravels, slight decrease in mafic concentrations in both the gravels (~90%) and the sands (~55%), and decrease in moisture content at this depth. The soil classification throughout the formation was sandy gravel and ranged from 50% to 70% gravels, 25% to 50% sand, 0% to 10% silt. The sand ranged from 55% to 80% mafic, and the gravel ranged from 65% to 90% mafic. No reaction to a slight reaction with HCl was observed throughout the Hanford formation. The gravel and sand angularity observed was rounded to angular, but both averaged from subrounded to subangular. Sand grain size ranged from very fine to very coarse (62.5 µm to 2 mm). Gravel size ranged from very fine to small cobble (2 mm to 120 mm).

The contact between the lower Hanford formation and the Rwie was at ~16.8 m (55 ft) bgs, evidenced by a change from mafic-dominant to felsic-dominant sands and gravels, increase in sand content, and increased reaction observed when tested with HCl. The soil classifications for the Rwie include slightly silty gravelly sand, gravelly sand, silty-sandy gravel, sandy gravel, and gravel. Sand composition ranged from 60% to 80% felsic. The gravel composition ranged from 55% to 75% felsic. There were moderate to strong HCl reactions throughout the formation until water was encountered, where no reactions were thereafter observed to TD. Gravel angularity ranged from rounded to angular, but on average was subrounded to subangular. Sand grain size ranged from very fine to very coarse grain (62.5 µm to 2 mm). Gravel ranged from very fine pebbles to large cobbles (2 mm to 175 mm).

The final static water level was measured at 26.91 m (88.30 ft) bgs on December 19, 2018. Appendix A provides the borehole log for C9973.

2.2.2 Well 199-K-236 (C9974)

Well 199-K-236 (C9974) is located ~50 m (~160.0 ft) south of well 199-K-235 (C9973). The major stratigraphic units encountered after drilling past the gravel backfill placed during remediation operations include the Hanford formation and the Rwie.

Sandy gravel backfill extended from ground surface to ~7.9 m (26 ft) bgs. The sandy gravels ranged from 40% to 60% gravel, 40% to 60% sands, and 0% to 5% silt. The gravels are dominantly mafic (65% to 80%). The gravels are ranged from poorly to moderately sorted, rounded to angular, and ranged from very fine pebble to small cobble (2 mm to 80 mm). The sands are also dominantly mafic (~80%) and are poorly sorted, ranging from fine to coarse (0.125 mm to 1 mm), and are subangular. There is very little silt present (~5%), which is dark grayish-brown in color. A slight to no reaction was observed with the gravel, sand, or silt when tested with HCl.

The Hanford formation was observed at depths of ~7.9 m to ~16.8 m (26 ft to 55 ft) bgs. The contact was at ~7.9 m (26 ft) due to the increase in angularity of the gravels and sands, decrease in mafic concentrations in the gravels (~60%), and increased presence of fine sands and silts. The soil classifications throughout the formation included silty-sandy gravel, sandy gravel and gravelly sand that ranged from 15% to 60% gravel, 40% to 80% sand, and 0% to 20% silt. The sand ranged from 40% to 80% mafic, and the gravel ranged from 40% to 90% mafic. No reaction to a slight reaction with HCl was observed throughout the Hanford formation. The gravel angularity observed was rounded to angular, and the sand angularity ranged from angular to subangular. Sand grain size ranged from very fine to coarse (62.5 µm to 1 mm) and was very well sorted. Gravel size ranged from very fine to small cobble (2 mm to 120 mm).

The contact between the lower Hanford formation and the Rwie was at ~16.8 m (55 ft) bgs, evidenced by a change from mafic-dominant to felsic-dominant sands and gravels, increase in sand content, and increased moderate reaction observed when tested with HCl. The soil classifications for the Rwie include gravelly sand, silty-sandy gravel, sandy gravel, and sand. Sand composition ranged from 70% to 90% felsic. The gravel composition ranged from 50% to 80% felsic. There were moderate to very strong HCl reactions throughout the formation until water was encountered, but no reactions were observed thereafter to TD. Gravel angularity ranged from angular to rounded. Sand grain size ranged from very fine to very coarse grain (62.5 µm to 2 mm). Gravel ranged from very fine pebbles to large cobbles (2 mm to 135 mm). The silt present was very dark yellowish-brown to brown in color.

A final static water level was measured at 26.74 m (87.73 ft) bgs on December 18, 2018. Appendix B provides the borehole log for C9974.

3 Waste Management

Waste generated during installation of the two dual-purpose wells included drill cuttings, purgewater, and miscellaneous solid waste. Waste was managed in accordance with CERCLA and DOE/RL-97-01, *Interim Action Waste Management Plan for the 100-HR-3 and 100-KR-4 Operable Units*.

3.1 Drill Cuttings

All drill cuttings from boreholes C9973 and C9974 were collected in tip dumpsters, with water removed when necessary. The drill cuttings were then placed into designated Environmental Restoration Disposal Facility roll-off boxes. Miscellaneous solid waste associated with sampling activities was contained in clear plastic bags and was also disposed in the roll-off boxes. The roll-off boxes were then transported to the Environmental Restoration Disposal Facility for disposal at the completion of the project.

3.2 Purgewater

Purgewater was generated during well drilling, sampling, and development activities. All purgewater was collected and contained at the wellhead until it was transported to the purgewater modular storage units using purge trucks in accordance with DOE/RL-2009-80, *Investigation Derived Waste Purgewater Management Work Plan*; and DOE/RL-2011-41, *Hanford Site Strategy for Management of Investigation Derived Waste*.

4 Civil Survey

The locations for well 199-K-235 (C9973) and well 199-K-236 (C9974) were surveyed using a Trimble® R8 RTK global positioning system and a Trimble DiNi 12 level to collect coordinates. Washington State Plane (south zone) *North American Datum of 1983* (NAD83) (with the 1991 adjustment) was used to record the horizontal coordinates; *North American Vertical Datum of 1988* (NAVD88) was used to record the vertical survey data. Wells 199-K-235 and 199-K-236 were both surveyed on January 7, 2019. Table 7 identifies the locations of the surveyed wells. Survey reports for each well are provided in Appendices A and B, respectively.

Table 7. Civil Survey Summary

Well ID Number	Well Name	Northing[a] (m)	Easting[a] (m)	Brass Survey Marker Elevation[b] (m)	Top of Casing[b,c] Elevation (m)
C9973	199-K-235	146115.87	568829.62	148.003	148.758
C9974	199-K-236	146074.39	568856.97	147.947	148.697

a. Northing and easting coordinates are based on Washington State Plane coordinates (*North American Datum of 1983* [NAD83]).

b. *North American Vertical Datum of 1988* (NAVD88) values rounded to 0.001 m.

c. Protective casing.

ID = identification

5 Well Acceptance

The final step of the installation process is well acceptance. Well acceptance represents confirmation that the wells meet the requirements outlined in the scope of work. Well acceptance also indicates the contractual completion of the finished wells.

After the wells were completed, representatives from CHPRC and Carpenter performed inspections for both wells. Work site assessments were conducted for wells 199-K-235 and 199-K-236 on January 8, 2019. Both wells were accepted by CHPRC.

6 References

ANSI Z535.1-2017, 2017, *American National Standard for Safety Colors*, National Electrical Manufacturers Association (approved by the American National Standards Institute, Inc.), Rosslyn, Virginia. Available at: https://www.nema.org/Standards/ComplimentaryDocuments/ANSI%20Z535_1-2017%20CONTENTS%20AND%20SCOPE.pdf.

BHI-00184, 1995, *Miocene- to Pliocene-Aged Suprabasalt Sediments of the Hanford Site, South-Central Washington*, Rev. 00, Bechtel Hanford, Inc., Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0083482H.

BHI-01648, 2004, *Late Pleistocene and Holocene-Age Columbia River Sediments and Bedforms: Hanford Reach Area, Washington, Part 1*, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.

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Comprehensive Environmental Response, Compensation, and Liability Act of 1980, Pub. L. 107-377, as amended, 42 USC 9601, et seq., December 31, 2002. Available at: https://www.csu.edu/cerc/researchreports/documents/CERCLASummary1980.pdf.

DOE/RL-97-01, 2016, *Interim Action Waste Management Plan for the 100-HR-3 and 100-KR-4 Operable Units*, Rev. 6, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0077175H.

DOE/RL-2009-80, 2009, *Investigation Derived Waste Purgewater Management Work Plan*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0094946.

DOE/RL-2011-41, 2011, *Hanford Site Strategy for Management of Investigation Derived Waste*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0093937.

DOE/RL-2013-36, 2013, *100-KR-4 Groundwater Operable Unit Well Installation Sampling and Analysis Plan*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0087913.

DOE/RL-2013-36-ADD6, 2018, *100-KR-4 Groundwater Operable Unit Well Installation Sampling and Analysis Plan, Addendum 6: Wells 199-K-235 and 199-K-236*, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington. Available at: https://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0064702H.

DOE/RL-2017-30, 2018, *KW Soil Flushing/Infiltration Treatability Test Plan*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington. Available at: https://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=0065970H.

Ecology, EPA, and DOE, 1989, *Hanford Federal Facility Agreement and Consent Order*, 2 vols., as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and U.S. Department of Energy, Olympia, Washington. Available at: http://www.hanford.gov/?page=81.

Lindsey, Kevin A., 1996, *The Miocene to Pliocene Ringold Formation and Associated Deposits of the Ancestral Columbia River System, South-central Washington and North-central Oregon*, Open File Report 96-8, Washington Division of Geology and Earth Resources, Washington State Department of Natural Resources, Olympia, Washington. Available at: http://www.dnr.wa.gov/Publications/ger_ofr96-8_ringold_formation.pdf.

NAD83, 1991, *North American Datum of 1983*, as revised, National Geodetic Survey, Federal Geodetic Control Committee, Silver Spring, Maryland.

NAVD88, 1988, *North American Vertical Datum of 1988*, as revised, National Geodetic Survey, Federal Geodetic Control Committee, Silver Spring, Maryland. Available at: https://www.ngs.noaa.gov/PUBS_LIB/NAVD88/navd88report.htm.

SGW-62588, 2018, *Description of Work for the Installation of Two Wells in the 100-KR-4 Groundwater Operable Unit, FY 2019*, Rev. 0, CH2M HILL Plateau Remediation Company, Richland, Washington.

WAC 173-160, "Minimum Standards for Construction and Maintenance of Wells," *Washington Administrative Code*, Olympia, Washington. Available at: http://apps.leg.wa.gov/WAC/default.aspx?cite=173-160.

WHC-SA-0740-FP, 1989, *Sedimentology and Stratigraphy of the Miocene-Pliocene Ringold Formation, Hanford Site, South-Central Washington*, Westinghouse Hanford Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=E0020132.

WHC-SD-EN-TI-011, 1992, *Geology of the Northern Part of the Hanford Site: An Outline of Data Sources and the Geologic Setting of the 100 Areas*, Rev. 0, Westinghouse Hanford Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196090817.

WHC-SD-EN-TI-155, 1993, *Geology of the 100-K Area, Hanford Site, South-Central Washington*, Rev. 0, Westinghouse Hanford Company, Richland, Washington. Available at: http://pdw.hanford.gov/arpir/index.cfm/viewDoc?accession=D196129512.

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Appendix A

Well Documentation for 199-K-235 (C9973)

- Well Summary Sheet for C9973
- Borehole Log for C9973
- Geophysical Log Data Report for C9973
- Final Survey Report for C9973
- Well Development and Testing Data Sheet C9973
- Photo Log for C9973

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WELL SUMMARY SHEET

Well ID: C9973	Well Name: 199-K-235	Start Date: 10/23/18
Project: 2 Wells in the 100-KR-4 GW OU	Location: ~300 m S of KW reactor	End Date: 12/19/18

CONSTRUCTION DATA

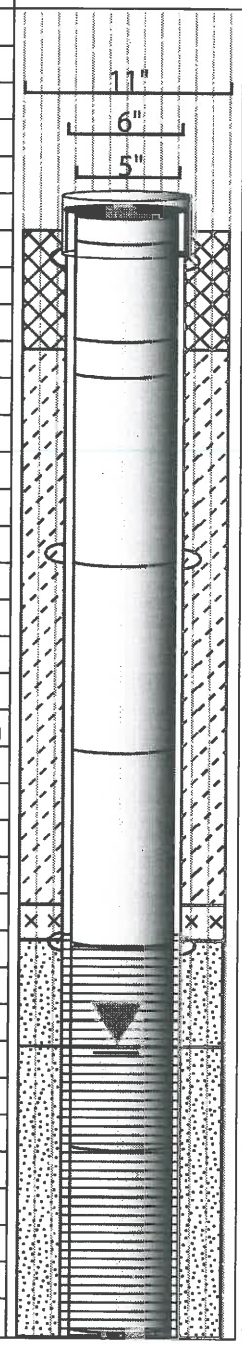
Surface Completion:
4' x4' x 6" Concrete Pad with brass survey marker and protective monument (3.00' ags - 2.00'bgs)
Ecology Well # BKG-094

Well Completion Material:
Type I/II Portland Cement
0.0' bgs - 12.5' bgs
Bentonite Crumbles
12.5' bgs - 72.9' bgs
Bentonite Pellet Seal
72.9' bgs - 76.5' bgs
10-20 mesh Primary Filterpack
76.5' bgs - 125.0' bgs

Permanent Well:
6" ID Stainless Steel Blank
2.00' ags - 79.85' bgs
6" ID Stainless Steel 0.040-in Screen
79.85' bgs - 119.85' bgs
6" ID Stainless Steel Sump
119.85' bgs - 124.85' bgs
5" ID Stainless Steel Blank Liner
1.25' ags - 78.22' bgs
5" ID Stainless Steel 0.040-in Screen
78.22' bgs - 119.25' bgs
5" ID Stainless Steel Sump
119.25' bgs - 124.57' bgs

Hole Dimensions:
11" Temporary Casing: 125.01' bgs
(all temporary casing removed)
Total Depth : 125.0
ags = above ground surface
bgs = below ground surface

Diagram



Depth in Feet: 0, 20, 40, 60, 80, 100, 120

GEOLOGIC/HYDROLOGIC DATA

Graphic Log

Lithologic Description (ft bgs)

Backfill
0 - 26 : Sandy Gravel (sG)

Hanford Formation
26 - ~55 : Sandy Gravel (sG)

Ringold Formation
~55 - 74: Sandy Gravel (sG)
74 - 87.5: Silty Sandy Gravel (msG)
87.5 - 88.5: Sandy Gravel (sG)
Depth to water 88.30 (12/19/18)
88.5 - 94: Silty Sandy Gravel (msG)
94 - 95: Sandy Gravel (sG)
95 - 104: Slightly Silty Gravelly Sand [(m)gS]
104 - 109: Sandy Gravel (sG)
109 - 110: Silty Sandy Gravel (msG)
110 - 115: Sandy Gravel (sG)
115 - 119: Silty Sandy Gravel (msG)
119 - 125.0: Sandy Gravel (sG)

Reported By:			
Brandon Thurnau	Geologist	Brandon Thurnau	1/2/19
Print Name	Title	Signature	Date

Reviewed By:			
Jennifer Richart	Well Coordinator	J. Richart	1/8/19
Print Name	Title	Signature	Date

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OR Doc Type:	WMU Code(s):

A-6003-643 (REV 2)

WELL SUMMARY CONTINUATION SHEET

Well ID: C9973 | Well Name: 199-K-235 | Project: 2 Wells in the 100-KR-4 OU

CONSTRUCTION DATA

Well Completion Material:

Type I/II Portland Cement
0.0' bgs - 12.5' bgs
Bentonite Crumbles
12.5' bgs - 72.9' bgs
Bentonite Pellet Seal
72.9' bgs - 76.5' bgs
10-20 mesh Primary Filterpack
76.5' bgs - 125.0' bgs

Permanent Well:

6" ID Stainless Steel Blank
2.00' ags - 79.85' bgs
6" ID Stainless Steel 0.040-in Screen
79.85' bgs - 119.85' bgs
6" ID Stainless Steel Sump
119.85' bgs - 124.85' bgs
5" ID Stainless Steel Blank Liner
1.25' ags - 78.22' bgs
5" ID Stainless Steel 0.040-in Screen
78.22' bgs - 119.25' bgs
5" ID Stainless Steel Sump
119.25' bgs - 124.57' bgs

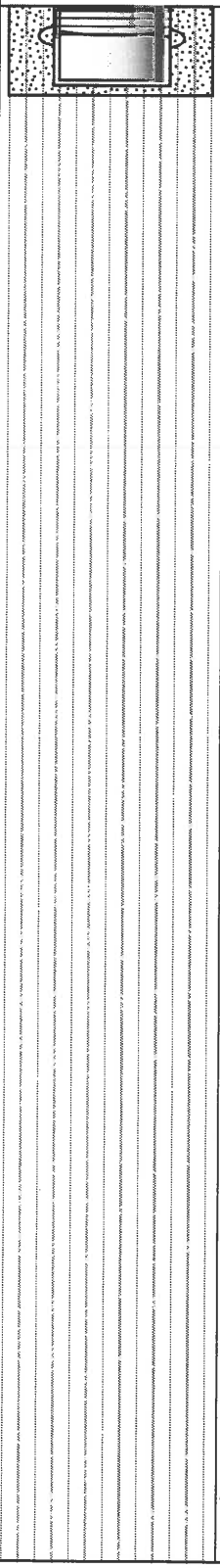
Hole Dimensions:

11" Temporary Casing: 125.01' bgs
(all temporary casing removed)

Total Depth : 125.0

bgs = below ground surface

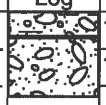
Diagram



Depth in Feet: 120, 140, 160, 180, 200, 220, 240, 260, 280

GEOLOGIC/HYDROLOGIC DATA

Graphic Log



Lithologic Description (ft bgs)

115 - 119: Sility Sandy Gravel (msG)
119 - 125.0: Sandy Gravel (sG)

A-6006-992 (REV 0)

BOREHOLE LOG

Page 1 of 7

Date: 10/23/18

Well ID: C9973 | Well Name: 199-K-235 | Location: ~300m S of the KW reactor

Project: Installation of Two Wells in the 100-KR-4 GW OU | Reference Measure Point: Ground Surface

Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other	Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other
0			0-26': Backfill - Sandy Gravel (SGr)	Cable tool w/ 2.05' x 8½" OD drive barrel and 10¾" carbon steel temporary casing
			@5' - 35% Gravel: 95% M/5% F, u. well rounded-subrounded, mod. sorted, 2mm-96mm (max), moist, no rxn to HCl; 60% Sand: 70% M/30% F, u. fn.-u. crs. (avg. size-crs.), subrounded-angular, poorly sorted, moist, no rxn to HCl; 5% Silt: no rxn w/ HCl (moist), no plasticity, 5Y 5/1 gray (dry), 2.5Y 5/2 grayish brown	
2.5				Cable samples may appear more homogeneous as drillers are collecting samples in 5gal bucket then transferring to stainless steel bowls used to collect and archive G.S. every 5'
0.5				
5	G.S. 10/23/18			
7.5				
	BT 10/23/18			
10	G.S. ~~10/23/18~~ No G.S. req. for drenche from 0-26' as still in backfill			
			@12' more large cobbles present (max = 160mm)	
12.5				
				Pieces of rebar present @ ~135' from past backfill operations
15	G.S. ~~10/23/18~~ BT 10/23/18			
				Drilling slow @ 16' due to large cobbles (~130mm)

Reported By:

Print Name	Title	Signature	Date
Brandon Thurnau	Geologist	[signature]	10/23/18

Reviewed By:

Print Name	Title	Signature	Date
Sarah Springer	Sr. Geologist	[signature]	11-28-18

For Office Use Only

OR Doc Type:	WMU Code(s):

A-6003-642 (REV 1)

BOREHOLE LOG (Cont.)

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Date: 10/24/18

Well ID: C9973 | Well Name: 199-K-235 | Location: ~300 m S of KW reactor

Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other	Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other
17.5			@18' slight ↓ Gravel 30%, ↑ ~~70%~~ 65% Sand, ~~±5%~~ 5% Silt BT 10/24/18 BT 10/24/18	
			@19' ↑ Gravel 45%, ↓ Sand ~~55%~~ 50%, ± ~~5%~~ 5% Silt BT 10/24/18 BT 10/24/18	
20	~~G.S. 10/24/18~~ BT 10/24/18			
			@22' ↑ Gravel 55%, ↓ Sand ~~45%~~ 40%, ~~±5%~~ 5% Silt, increase moisture content BT 10/24/18	
22.5				@22.5' more sands present during cleanout likely similar to cuttings @19'
			@24' ↑ 10% F ↓ 90% M, 50% Gravel, 50% Sand, ↑ in angularity, v. well rounded - angular	@24' angularity increase maybe due to core barrel breaking/splitting apart large cobbles
25	G.S. 10/24/18		BT 10/24/18 ~~@26'~~ 26 - ~55' : Sandy Gravel (sG) · ~~Hanford Contact~~ Possible V. BT 10/24/18 @26' BT 10/24/18 @26' (60% Gravel: 90% M/10% F, well rounded - angular (avg. subrounded-subangular), poorly sorted, 2mm - 97mm (45mm avg), no rxn w/ HCl; 38% Sand: v.fn.-crs. sand, mod. sorted, rounded-subangular, no-slight rxn w/ HCl, 55% M/45% F, moist; 2.5Y 5/1 Gray (dry), 2% Silt - medium-high plasticity, no rxn w/ HCl (moist), 2.5Y 3/2 very dark grayish brown (moist)	@26' less moist than previous Possible Hanford Contact @26'
27.5				
30	G.S. 10/24/18		@31' - max gravel size is 63mm, gravel ↓ 80% F	
			@32' - gravel ↓ ~75%.	
32.5				
			@33.5' - Gravel ↓ ~70%; more subangular - subrounded large (max 177mm) cobbles present; ranges from well rounded - angular (avg. subrounded - sub angular	
35	G.S. 10/24/18		@34.5' - gravel ↓ ~65%; more well rounded (avg. well rounded - subrounded; 120mm vesicular basalt cobble	
			@35' - ~~72%~~ 70% Gravel: 2mm - 100mm max, poorly sorted, well rounded - subangular, 85% M/15% F; moist; no rxn w/ HCl; 25% sand: v. fn. - v. crs. (avg. med. sand), subrounded - subangular, moist, no rxn w/ HCl; ±5% silt, 2.5Y 3/1 very dark gray (moist) BT 10/24/18	

Reported By:

Print Name	Title	Signature	Date
Brandon Thurnau	Geologist	[signature]	

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

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Date: 10/25/18

Well ID: C9973 | Well Name: 199-K-235 | Location: ~300m S of the KW reactor

Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other	Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other
37.5			@37' - 70% Gravel, decrease in size 65mm max	
40	G.S. 10/25/18		@40' - ↓60% Gravel: 80% M/20% F, rounded-subangular, mod. sorted, 2mm-140mm max, moist, no rxn w/ HCl; ~~40%~~ 25% Sand: Fine-v. crs., subrounded-angular, 80% M/20% F, mod. sorted, moist, no - slight rxn w/ HCl; ± 5% Silt: 2.5Y 3/1 very dark gray BT 10/25/18	
42.5			@42.5' - ↑65% Gravel	
45	G.S. 10/25/18		@45' - 70% Gravel: 75% M/25% F, rounded-subrounded, 2mm-90mm max, moist, no rxn w/ HCl; ~~30%~~ 25% Sand: 95% M/25% F, v. fn.-v. crs. (crs. avg), subangular-subrounded, moist, no rxn w/ HCl, 2.5Y 2.5/1 black (moist), 2.5Y 3/1 very dark gray; ± 5% silt, no plasticity BT 10/25/18	Optional Geob sample Info - Actual Depth: 45.1' bgs - 46.6' bgs; bottom of casing: 44.82' bgs; bottom of borehole: 45.1' bgs; sample time @ 0925 on 10/25/18, 100% recovery Sandy Gravel; HEIS #B3MDF8
	Optional NCO G.S. 45.1-46.6' bgs			
47.5			@48' - max size: 175mm (avg. 36mm), color of large cobble - 2.5Y 5/1 gray (dry), ↓55% gravel, 45% ↑ sand	
50	G.S. 10/25/18		@50': 50% Gravel: 65% M/35% F, rounded-subangular, 2-78mm max (avg 25mm), mod. sorted, moist, no rxn w/ HCl; 40% Sand: 55% M/45% F, subangular-subrounded, v. fn.-v. crs., mod. sorted, moist, slight or no rxn w/ HCl, 10% Silt: 2.5Y 3/2 dark olive gray (moist), 2.5Y 5/1 gray (dry), no plasticity	
52.5				
55	G.S. 10/25/18		BT 10/25/18 ~~Possible Ringold Contact~~ @55' - 74' : Sandy Gravel (SG) 50% Gravel: 55% F/45% M, rounded-subrounded, 2mm-66mm (avg. 20mm), mod. sorted, dry, mod. rxn w/ HCl; 45% Sand: 60% F/40% M, subrounded-subangular, v. fn.-v. crs. (med. avg), mod. sorted, mod. rxn w/ HCl; 5% Silt: no plasticity, 2.5Y 5/2 grayish brown @56' ~~↓60%~~ BT 10/25/18 ↓ ~~Max~~ avg. size to 10mm and ↑60% F for gravels BT 10/25/18	Possible Ringold contact @55'

Reported By:

Print Name	Title	Signature	Date
Brandon Thurnau	Geologist		10/25/18

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

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Date: 10/29/18

Well ID: C9973 | Well Name: 199-K-235 | Location: ~300 m S of the KW reactor

Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other	Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other
57.5			@57'-Sand ↑70%F, 60% Sand: mod.-strong rxn w/ HCl, 2.5Y 5/4 light olive brown sand appearing, avg. fn.-med. sand; 35% Gravel; 5% silt	
			@58'-65% Sand; ↑75% F sands, 2.5Y 6/3 light yellowish brown w/ 2.5Y 5/4 light olive brown sands becoming more prevalent; 30% Gravel, 5% silt	
60	G.S. 10/25/18		@58.5'-40 mm u. fn.-fn. grained thick layer/clast in grab sample strong rxn w/ HCl	
			@61'-↑ Sand 80% BT 10/25/18: 70%F/30%M, subrounded-angular, u. fn.-u. crs., mod. sorted, no rxn w/ HCl (moist), Gravel 15%: well rounded-sub rounded, 65%F/35%M, 2 mm-55 mm max, mod.-well sorted, ±5% silt: overall color-2.5Y 4/3 olive brown: Gravelly Sand: gS	
62.5	Broke 9/11 S.S. I-001		@62' Gravel ↑ 25%	Split Spoon I-001: Actual Depth-62.7-65.2', Bottom of casing-62.78' bgs; bottom of borehole @ 62.7' bgs; sample time @ 0925 on 10/29/18, 75% recovery of sandy gravel; HE15 #s B3M7F8, B3M7H0, B3M7F9
			Sandy Gravel (sG)	
65	G.S. 10/29/18		@65': 55% Gravel: 60%F/40%M, rounded-subangular, 2 mm-72 mm, well sorted; 40% Sand: 70%F/30%M, u. fn.-u. crs., mod.-well sorted, ±5% silt-2.5Y 5/3 light olive brown BT 10/29/18	
			@66'-↑ Sand 60%, ↓ Gravel 40%	
			@67'-125% Gravel: ↑ angularity, strong rxn w/ HCl; 65% Sand, 10% Silt; Gravelly Sand (gS)	
67.5			@68'-max gravel size ↑ 130 mm	@68' drilling slows likely due to large cobbles found in returns; cobbles were also likely bigger, but broken from core barrel
			@68.5'-max gravel size ↑ 160 mm	
70	G.S. 10/29/18		@70'-65% Gravel: 60%F/40%M, 2 mm-117 mm, poorly sorted, rounded-subangular, mod. rxn w/ HCl; 25% Sand: 75%F/25%M, u. fn.-u. crs., mod. sorted, rounded-subrounded, mod. rxn w/ HCl 10% silt: 2.5Y 6/3 light yellowish brown	
72.5			@73'-↓ 55% Gravel, 35% Sand, 10% silt	
			74-87.5': silty sandy Gravel (msG)	I-002 G.S.: Actual Depth-74.9-76.9'; bottom of csg-75.30' bgs, bottom of borehole @ 74.9' bgs, sample time @ 0925 on 10/30/18, 100% recovery of silty sandy Gravel, HE15 #s B3M7H1, B3M7H2 (Dup)
			@74' ↓ 50% Gravel, ↑ 35% Sand, ↑ 15% Silt	
75	G.S. I-002 G.S. 10/30/18		@75' (from I-002 G.S.)-60% Gravel: 55%F/45%M, 2 mm-83 mm max, avg 25 mm, poorly sorted, rounded-subrounded, mod. rxn w/ HCl; 25% Sand: 70%F/30%M, u. fn.-u. crs., well sorted (avg. u. fn.-fn.), well rounded-subrounded, mod. rxn w/ HCl, 15% silt; no plastic fines, 2.5Y 6/3 light yellowish brown	

Reported By:

Print Name	Title	Signature	Date
Brandon Thurman	Geologist	Brandon Thurman	10/30/18

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

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Date: 10/30/18

Well ID: C9973 | Well Name: 199-K-235 | Location: ~300m S of KW reactor

Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other	Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other
BT 11/8/18 75.5 77.5	G.S. 10/30/18		@77' - ↓50% Gravel, ↑30% Sand, ↑20% Silt	
			@79' - ↓40% Gravel, ↑40% Sand, 20% Silt; max gravel grain size is 130mm and well rounded-subangular	
80	G.S. 10/30/18		@80' (taken from I-003 G.S.) - 60 65% Gravel: 65% F/35% M, 2mm-150 mm, poorly sorted, slight rxn w/ HCl, well rounded-angular; 25% Sand: 65% F/35% M, v.fn.-v.crs. (fn. sand o.y.), mod. sorted, mod. rxn w/ HCl, sub-rounded-subangular; 15 15% Silt, no plasticity, 5Y light olive brown BT 10/30/18	I-003 G.S.: Actual Depth-79.7-81.7' bgs; bottom of casing @ 79.98' bgs, bottom of borehole @ 79.7' bgs; Sample time @ 1345 on 10/30/18; 100% recovery Silty Sandy Gravel; HE15 # B3M7H3
82.5	I-003 G.S.		@82'-160mm large granite cobble in return, ↓55% Gravel, 30% sand, 15% Silt	
			@83' - ↓40% Gravel, 45 50% Sand, 15 10% Silt BT 10/30/18 BT 10/30/18	@83' 185mm cobble found in return may be cause of slow drilling
	S.S. I-004		@83.5' - ↓35% Gravel, 50% Sand, 15% Silt: 2.5Y 6/2 light brownish gray (dry), 2.5Y 4/2 dark grayish brown (moist)	
85	G.S. 10/31/18		@85' (taken from I-004 split spoon) - 30% Gravel: rounded-subangular, 65% F/35% M, 2-81mm, avg. 35mm, mod. sorted, slight rxn w/ HCl, 55% Sand: v.fn.-med. sand: 70% F/30% M, well sorted, slight rxn w/ HCl, subrounded-subangular; 15% Silt: no plasticity, 2.5Y 4/3 olive brown (moist)	I-004 S.S.: Actual depth-84.7-87.2' bgs, bottom of casing @ 83.96' bgs, bottom of borehole @ 84.7' bgs; sample time @ 1105 on 10/31/18, 100% recovery of Silty Sandy Gravel; HE15 #S B3M7H4, B3M7H5, B3M7H6
			87.5 - 88.5 : Sandy Gravel (sG)	
87.5			@87.5 - ↑50% Gravel, 40% Sand, 10% Silt, appears more moist	
			@88' - moisture content ↑, sands coarsen, 60% G/35% S/5% Silt	
		H_2O @ 88.14' bgs on 11/1/18	@88.5 - ↑ 60 65% Gravel: 55% F/45% M, 2mm-175mm, avg. 30mm, poorly sorted, no rxn w/ HCl (moist), 35% Sand: 65% F/35% M, rounded-subangular, v. fn.-v. crs. (avg. med-crs.), mod. sorted, no rxn w/ HCl (moist), 5% 5Y Silt, no plasticity, 2.5Y 4/2 dark grayish brown, More moist BT 10/31/18	H_2O tagged @88.97' bgs on 10/31/18 after collection of 90' G.S.; H_2O tagged @88.19' bgs on morning of 11/1/18
90	G.S. 10/31/18		@89.8 - wet sample - ↑15% Silt, 50% Gravel, 35% Sand	
			88.8 - 94' - Silty Sandy Gravel (mSG)	
92.5			@93.5' - 15% Silt, ↓40% Gravel, 45% ↑ Sand	
			~~@94' -~~ 94-95: Sandy Gravel (SG)	
			BT 10/31/18 @94' - ↓10% Silt, ↑55% Gravel, 35% ↓ Sand; BT 10/31/18	
			~~@95' -~~ similar to 88.5' description	
95	W.S. I-005 G.S. 11/5/18		95 - 100 105: Slightly Silty Gravelly Sand [(m)gS] BT 10/30/18 20% Gravel: rounded-subrounded, 60% F/40% M, 2mm-100mm, avg. 15mm, poorly sorted, no rxn w/ HCl (wek); 60% Sand: 70% F/30% M, subrounded-subangular, v. fn.-v. crs. (avg. fine sand), well sorted, higher mica content (~15%), no rxn w/ HCl (wek); 20% Silt - no plasticity, 5Y 4/2 olive gray	I-005 W.S. - Actual depth and bottom of csg @ 94.61'; bottom of borehole @ 95.4'; purge rate ~1.8 gpm; purged vol. req. 26.7 gal, time on and H_2O to surface @ 1352; sample time 1501 on 11/1/18, time off (1508), HE15#s B3M7R6, B3M7T6, B3M7T0, B3M7T7, B3M7S1

Reported By:

Brandon Thurnau — Print Name | Geologist — Title | Signature | 11/5/18 — Date

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

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Date: 11/5/18

Well ID: C9973 | Well Name: 199-K-235 | Location: ≈300 m S of KW reactor

Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other	Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other
97.5				
			Gravelly Sand (gS)	
100	G.S. 11/5/18		@100'-65% Sand: 75% F/25% M, subrounded-subangular, v. fn.-v. crs. (avg. med.-crs. sand), mod. sorted, no rxn w/ HCl (wet); 25% Gravel: 60% F/40% M, 2mm-125mm, (avg. 25mm), poorly sorted, no rxn w/ HCl (wet), rounded-subangular; 10% Silt: no plasticity, 2.5Y 4/2 dark grayish brown BT 11/5/18	
102.5			@102'-↓10% Gravel, ↑75% Sand, ↑15% Silt: ~~Silty~~ Slightly Silty Gravelly Sand-(m)gS	
			~~111.5'~~ 109' BT 11/7/18	
			~~104-108~~: Sandy Gravel (sG) BT 11/6/18	
105	G.S. 11/5/18		@104' ↑35% Gravel, ↓55% Sand ↓10% Silt	
			@105'-40% Gravel: 55% F/45% M, rounded-subangular, 2mm-92mm, poorly sorted, no rxn w/ HCl (wet), 50% Sand: 70% F/30% M, subrounded-subangular, v. fn.-v. crs. (avg. crs.), mod. sorted, no rxn w/ HCl (wet), 10% Silt: 2.5Y 4/2 dark grayish brown, no plasticity	
107.5			@108'-55% Gravel ↑, ↓35% Sand, 10% Silt	
			109-110: Silty Sandy Gravel (msG)	Large cobble (150mm) in return that was likely slowing down drilling
			@109'-50% Gravel, 30% Sand, 20% Silt	
110	G.S. 11/6/18		@109.5'-60% Gravel, 25% Sand, 15% Silt, gravel size ↑ (max 175mm)	
			@110' - Sandy gravel (sG): 110'-111.5': 60% gravel: 70% F/30% M, sub-angular - rounded, 2mm-85mm (avg. 25mm), poorly sorted, no rxn w/ HCl (wet), Sand 30%: 75% F/25% M, sub-angular-sub-rounded, Very coarse-Very fine (avg. Coarse-medium), poorly sorted, no rxn w/ HCl (wet), Silt 10%: no plasticity, 5Y 3/2 Dark olive Gray	@110' while cleaning out sluff a 135mm Cobble was found ~~and as much as~~ and 40% of grab was Sand. TC 11/7/18 TC 11/7/18
112.5				
			@115' - Silty Sandy Gravel (msG) - 55% Gravel: 75% F/25% M; poorly sorted, sub-angular - rounded; ~~max size 70m (avg. size 20mm)~~ TC 11/7/18 max size 135mm (avg. size 25mm); no rxn w/ HCl (wet); 25% Sand: v. fine - coarse (avg. medium); poor sorting; sub-angular-sub-rounded; no rxn w/ HCl (wet); 80% F/20% M; Silt 20%; Plasticity none; Color - Dark Grayish Brown 2.5Y-4/2	
115	G.S. 11/7/18			

Reported By:

Brandon Thurman/Trevor Clark | Geologist/Geologist | Signature | 11/7/18

Print Name | Title | Signature | Date

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

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Date: 11/7/18

Well ID: C9973 | Well Name: 199-K-235 | Location: ~300 m. S. of KW reactor

Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other	Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other
117.5	11/7/18		@118' silty sandy Gravel (msG): 60% Gravel, 20% Sand, 20% silt	
	11/7/18 I006 S.S.		@119' Sandy Gravel (sG): 65% Gravel, 25% sand, 10% silt	@119' Large cobble found (170mm) Silt content may have been washed out of I006 split spoon.
120	G.S. 11/7/18		@120' sample taken from I006 split spoon. Sandy Gravel (sG): 55% Gravel: 75%F/25%M; poorly sorted; sub-rounded – Angular; Max size 70mm (Avg. size 20mm); no rxn w/ HCl (wet); 45% Sand: V.fine – Coarse (Avg. medium); poorly sorted; sub-rounded – Angular; no rxn w/ HCl (wet); 80%F/25%M; Color – Dark Grayish Brown – 2.5Y-4/2	I006 Split Spoon: Depth – 119.8-122.3'; Bottom of casing – 119.98'; Bottom of Borehole – 119.8'; Sample time: 1205; 100% recovered; Sandy Gravel; D – 119.8'-120.3'; C – 120.3'-120.8'; B – 120.8'-121.3'; A – 121.3'-121.8'; Shoe – 121.8'-122.3'; I006 HEIS = B3M7H7
	W.S. I007 11/8/18			
122.5	G.S. 11/8/18		@124.5' Sandy silty Gravel: 60% Gravel: 80%F/20%M; poorly sorted; rounded – sub-angular; Max size 110mm (Avg. 35mm); 20% sand: V.fine – Coarse (Avg. size medium); poorly sorted; sub-angular – rounded; no rxn w/ HCl (wet); 90%F/10%M; Silt 20%: no plasticity; Color – Brown – 10YR-4/3	I007 water sample: Depth – 121.90' bgs; Bottom of casing – 121.40' bgs; Bottom of borehole – 121.45' bgs; Purge Rate – 7.1 gpm; Purge Volume Required: 160.3 gall; Time on – 0809; Time water – 0810; Time Purge – 185 min.; Time sample – 1105; Time off – 1115; HEIS #'s: B3M7V0, B3M7R8 (filtered), B3M7V1, B3M7J4 (f), B3M7R7 (f), B3M7T8, B3M7J2 (f), B3M7T9
125				
127.5			@125' bgs is final TD. Borehole @125.0' bgs, casing @125.01' bgs. Reached at time 1425.	

Reported By:

Print Name	Title	Signature	Date
Trevor Clark	Geologist	Trevor Clark	11/8/18

A-6006-993 (REV 0)

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199-K-235 (C9973)
Log Data Report

Borehole Information

Log Date	2018-11-12	Filename	C9973_HG-NM_2018-11-12	Site	100-KR-4

DTW[1] (ft)	DTW Date	DTW Source	Drill Date	Total Depth (ft)	Depth Datum
88.0	11/12/18	Bay West	11/08/18	125	Ground Surface

Casing Information

Casing Type	Drill Type	Stickup (ft)	Diameter (in.)		Thickness (in.)	Top (ft)	Bottom (ft)
			Outer	Inside			
Threaded Steel	Cable Tool	3.2	10.75	9.55	0.60	-3.2	125.01

Borehole Notes

The onsite geologist provided the total depth and casing depth. The logging engineer measured casing stick-up using a steel tape measure, casing diameter using a dial caliper, and thickness using a precision wall-thickness gauge. The maximum logging depth achieved was 124 ft. Zero reference is ground surface.

Logging Equipment Information

Logging System	Gamma 4NC	Type	60% Coaxial HPGe (SGLS)[2]
Effective Calibration Date	12/07/2017	Serial No.	45-TP22010A
Calibration Reference	HGLP-CC-168, Rev. 0	Logging Procedure	SGRP-PRO-OP-53023, Rev. 0, Change 2

Logging System	Gamma 4MC	Type	H3-3 (CPN 503DR)[3]
Effective Calibration Date	12/04/2017	Serial No.	H340207279
Calibration Reference	HGLP-CC-165, Rev. 0	Logging Procedure	SGRP-PRO-OP-53024, Rev. 0, Change 2

SGLS Log Run Information

Log Run	1	2 Repeat			
HEIS Number	1020240	1020241			
Date	11/12/18	11/12/18			
Logging Engineer	Spatz	Spatz			
Start Depth (ft)	0.0	80.0			
Finish Depth (ft)	124.03	95.03			
Count Time (sec)	100	100			
Live/Real	R	R			
Shield (Y/N)	N	N			
MSA Interval (ft)	1.0	1.0			
Log Speed (ft/min)	NA	NA			
Pre-Verification	C9973DNC2018 1112AV00CAB1	C9973DNC2018111 2AV00CAB1			

[1] depth to water inside casing
[2] Spectral Gamma Logging System
[3] Neutron Moisture Logging System

Log Run	1	2 Repeat			
Start File	AD000000	BD008000			
Finish File	AD012403	BD009503			
Post-Verification	C9973DNC2018 1112BV00CAA1	C9973DNC2018111 2BV00CAA1			
Depth Return Error (in.)	N/A	5.0 high			
Comments	No fine gain adjustments made	No fine gain adjustments made			

NMLS Log Run Information

Log Run	3	4 Repeat			
HEIS Number	1020242	1020243			
Date	11/12/18	11/12/18			
Logging Engineer	Spatz	Spatz			
Start Depth (ft)	0.0	78.0			
Finish Depth (ft)	88.02	88.02			
Count Time (sec)	15	15			
Live/Real	R	R			
Shield (Y/N)	N	N			
MSA Interval (ft)	0.25	0.25			
Log Speed (ft/min)	NA	NA			
Pre-Verification	C9973DMC2018 1112AV00CAB1	C9973DMC201811 12AV00CAB1			
Start File	AD000000	BD007800			
Finish File	AD008802	BD008802			
Post-Verification	C9973DMC2018 1112BV00CAA1	C9973DMC201811 12BV00CAA1			
Depth Return Error (in.)	N/A	2.0 high			
Comments	None	None			

Logging Operation Notes

A centralizer was installed on the sondes.

Analysis Notes

Analyst	P.D. Henwood	Date	11/15/18
Reference(s)	SGRP-PRO-OP-53040, Rev. 0; SGRP-PRO-OP-53051, Rev. 0		

A casing correction for a 0.6-in. thick casing was applied to the SGLS log data.

Casing diameter and thickness corrections for 10 3/4-in. OD casing and 0.6-in. thick casing were applied to the NMLS data to convert to volume percent moisture. An initial count rate correction for a sediment composition of a 50-50% ratio of basalt fragments to quartzofeldspathic sand (HGLP-OTH-028) was also applied.

For the SGLS, a water correction was applied below 88 ft.

SGLS spectra were processed in batch mode in APTEC SUPERVISOR to identify individual energy peaks and determine count rates. Concentrations for the SGLS were calculated in an EXCEL template identified as DNC20171207 using an efficiency function and corrections for casing and dead time as determined by annual calibrations.

Moisture is reported in volume percent as calculated in EXCEL template defined as DMC_MCNP_assay.

HGU[4] is an empirical unit of gamma activity proposed as a means to standardize gamma log response across multiple logging systems with different response characteristics. The HGU is defined in terms of measurements in the Hanford Borehole Calibration Facility, and the magnitude is selected such that 1 HGU is approximately equivalent to typical Hanford background activity, based on data from background samples as reported in *Hanford Site Background: Part 2, Soil Background for Radionuclides* (DOE/RL-96-12).

Results and Interpretations

No manmade radionuclides were detected in this borehole.

The neutron moisture log primarily responds to moisture present in the surrounding formation. In general, an increase in count rate reflects an increase in moisture content. Moisture content generally increases as the sediment becomes more fine-grained. For example, moisture content would be expected to be greater near the top of a fining upward Hanford flood sequence.

The KUT and moisture repeat plots indicate that the systems were working properly. Naturally occurring U-238 detections were sporadic using the 1764 keV energy level. Although indicated at each depth interval in the spectra, the counts in the energy peak are very low with high error and do not exceed the MDL calculated by the processing software. Causes may include the 0.6-in. thick casing and spectra acquired within water that attenuates gamma rays. It is also possible the sediments include boulders and large gravel that typically do not produce significant count rates from uranium.

List of Log Plots

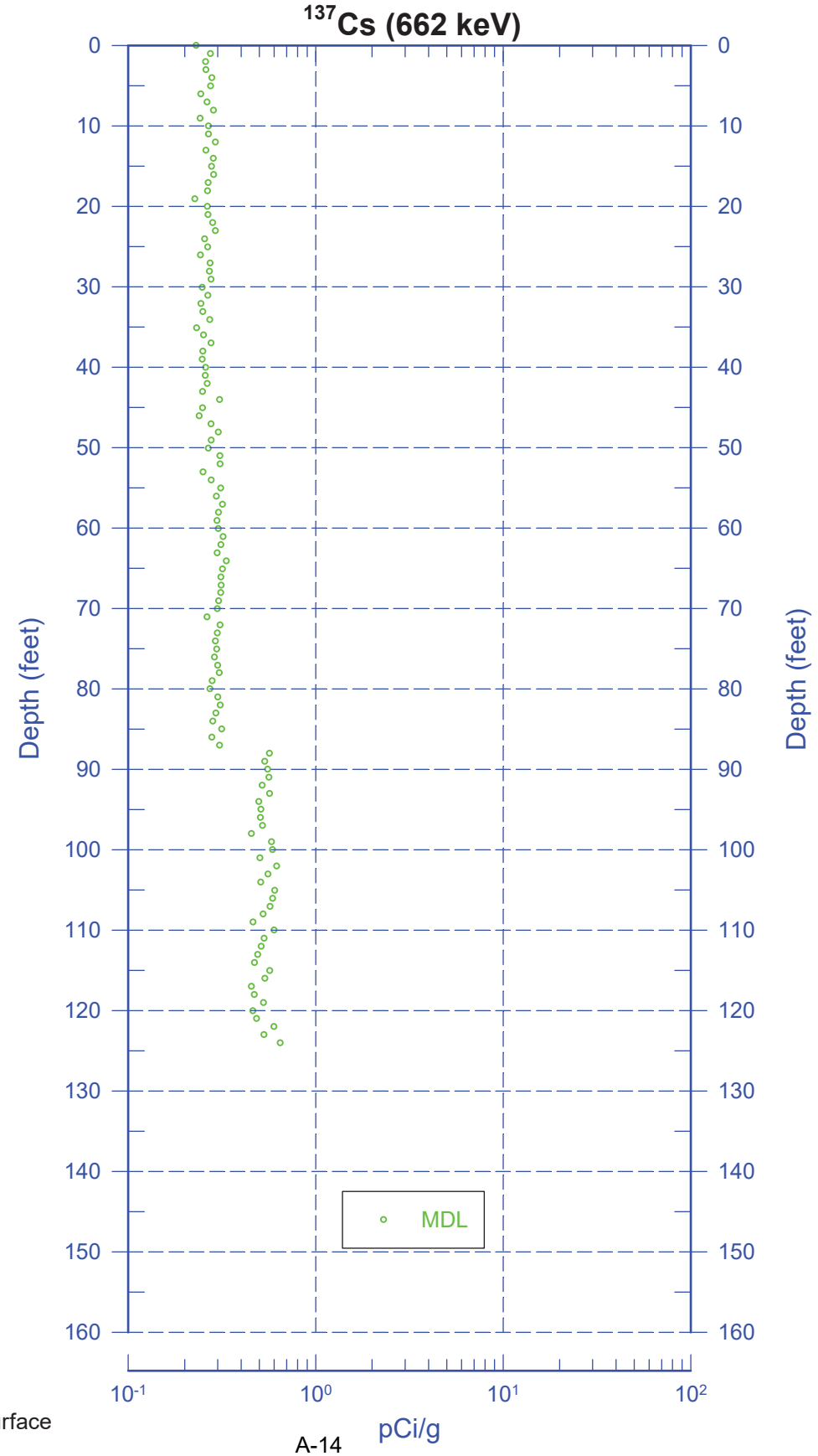
Depth Reference is top of casing.

Manmade Radionuclides (0-160 ft)
Natural Gamma Logs (0-160 ft)
Combination Plot (0-140 ft)
Moisture (0-160 ft)
Total Gamma & Moisture (0-160 ft)
Total Gamma & Hanford Gamma Unit (0-160 ft)
Repeat Section of Natural Gamma Logs (80-95 ft)
Moisture Repeat Section (78-88 ft)

[4] Hanford Gamma Unit

Bay West
Customer-Focused Environmental & Industrial Solutions

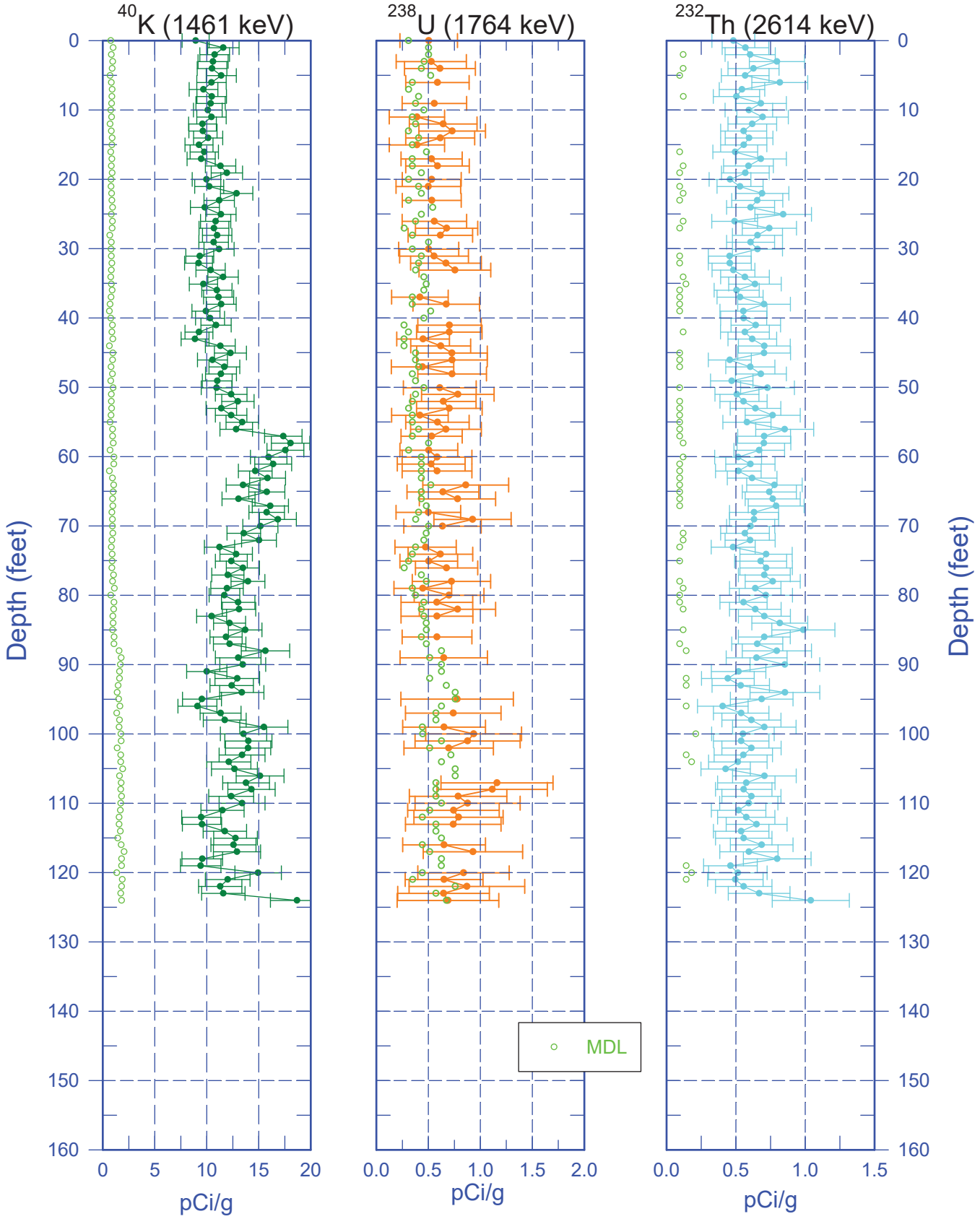
199-K-235 (C9973)
Manmade Radionuclides



Zero Reference - ground surface

Bay West
Customer-Focused Environmental & Industrial Solutions

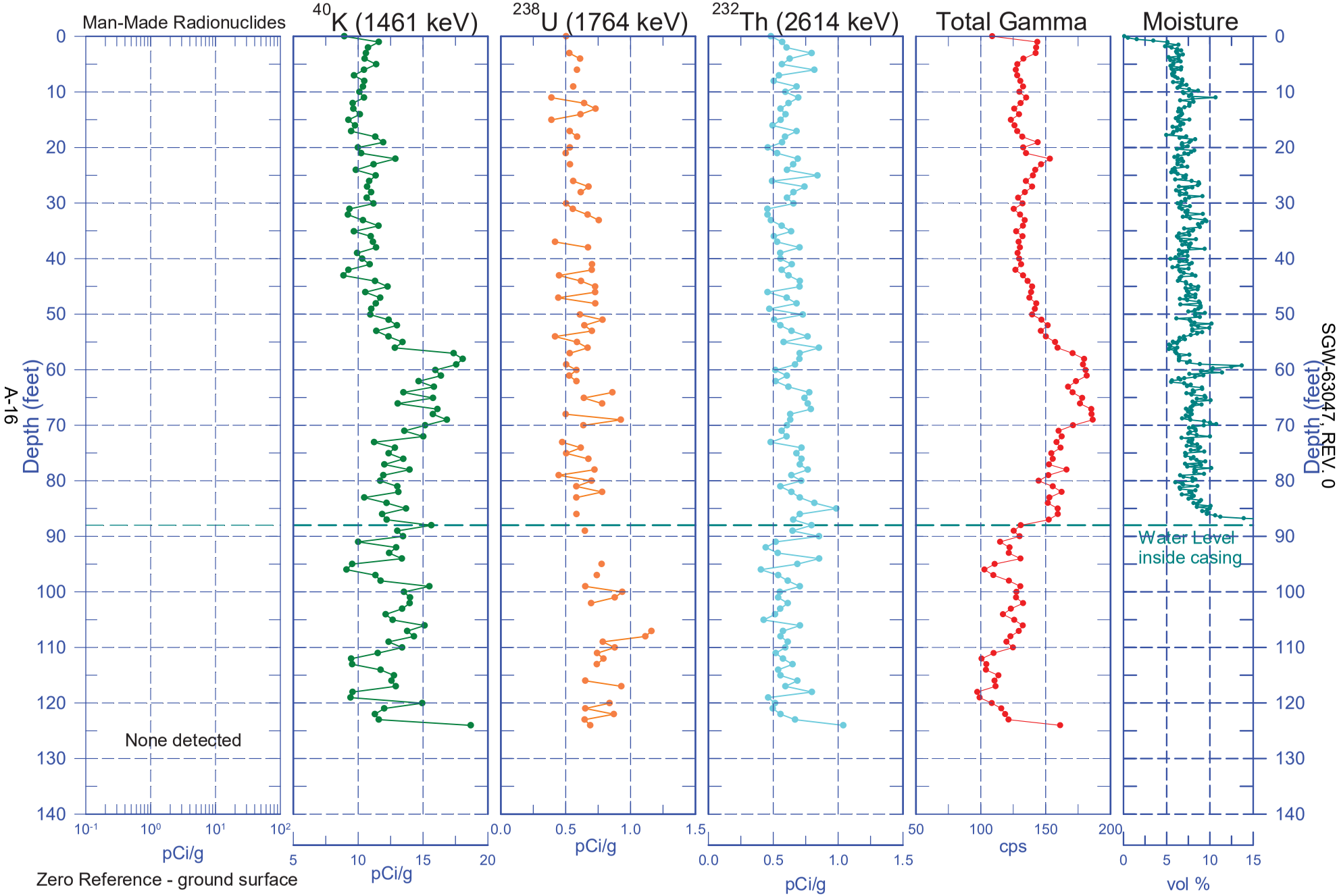
199-K-235 (C9973)
Natural Gamma Logs



Zero Reference - ground surface

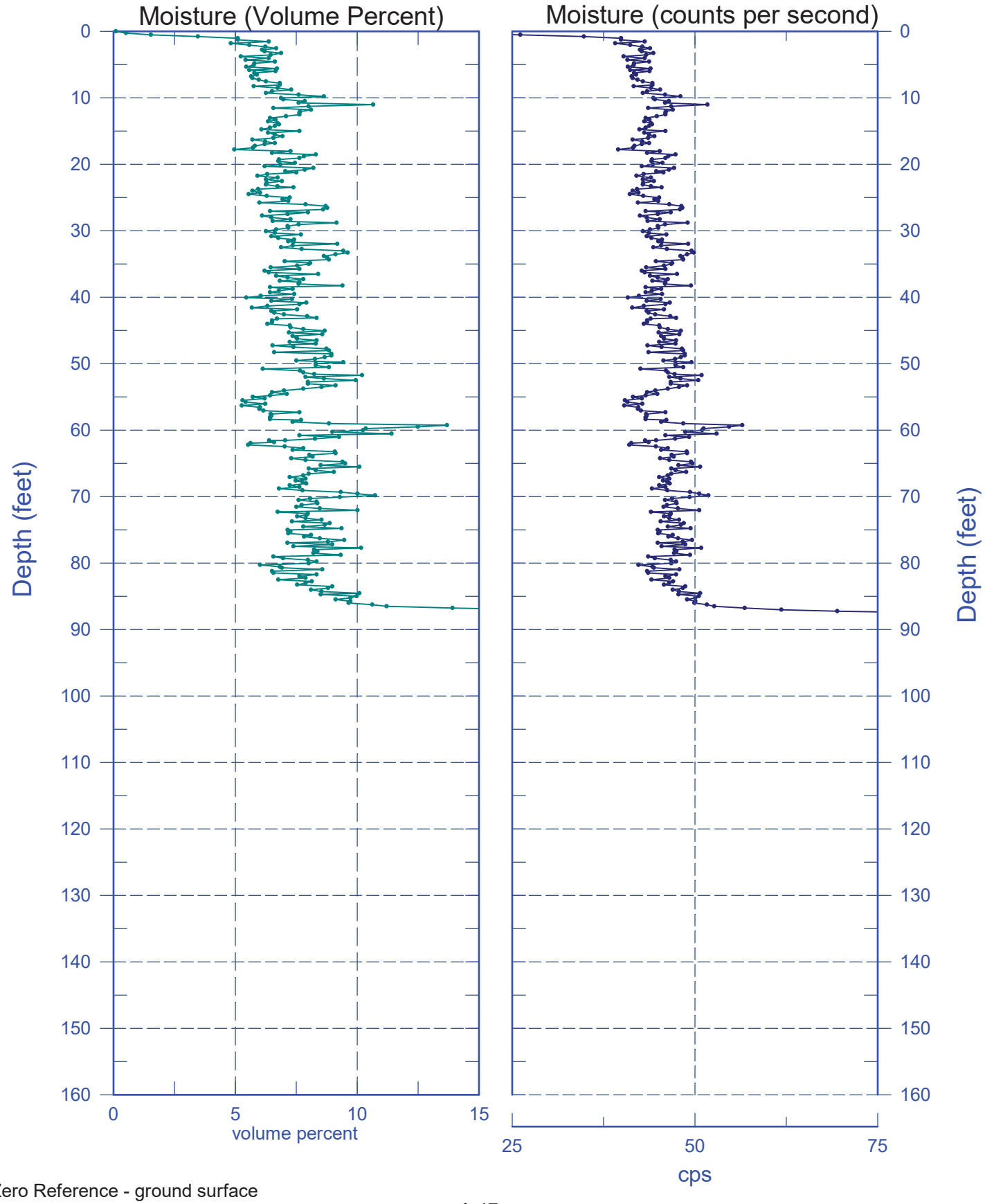
Bay West
Customer-Focused Environmental & Industrial Solutions

199-K-235 (C9973) Combination Plot



Bay West
Customer-Focused Environmental & Industrial Solutions

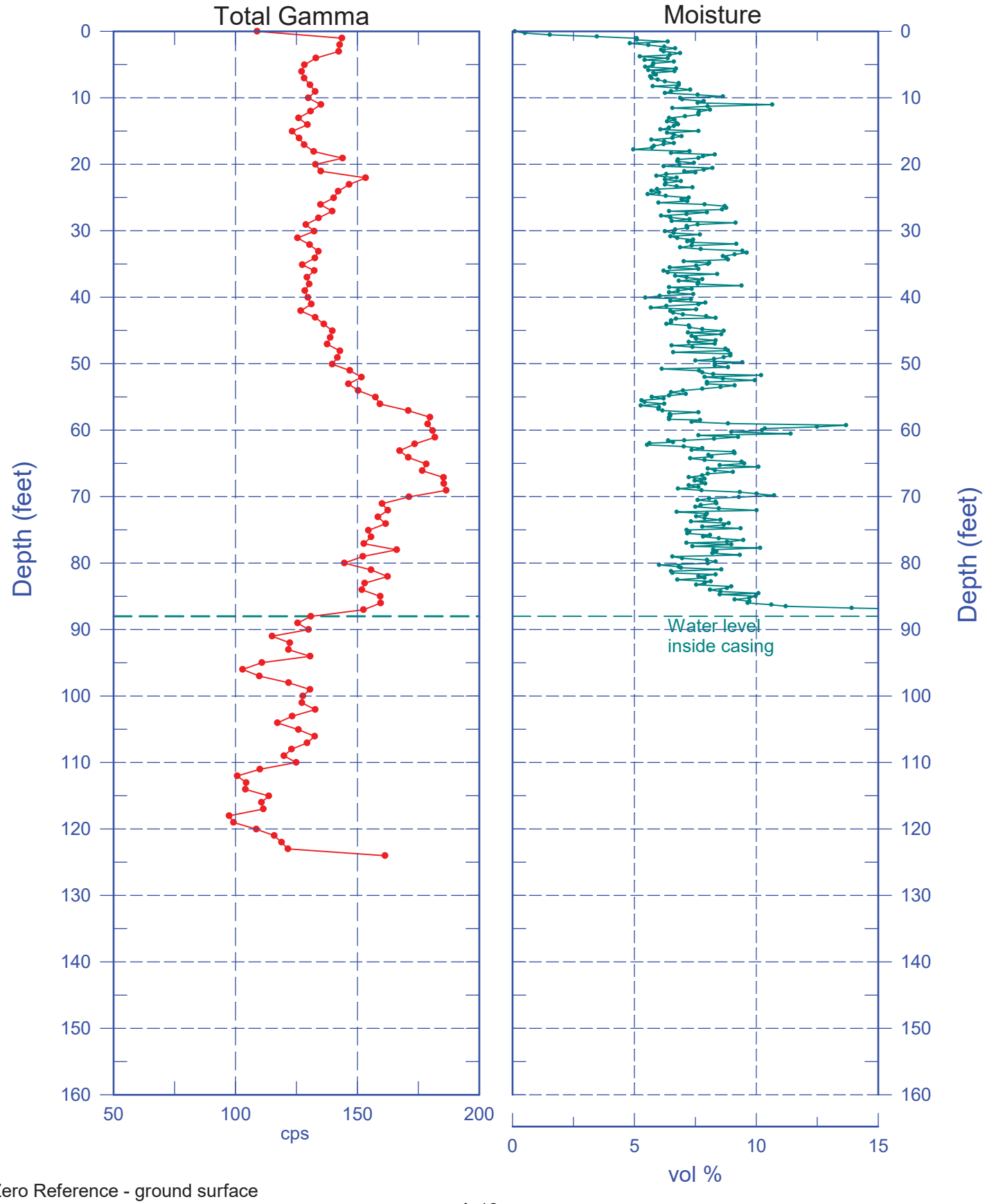
199-K-235 (C9973)
Moisture



Zero Reference - ground surface

Bay West
Customer-Focused Environmental & Industrial Solutions

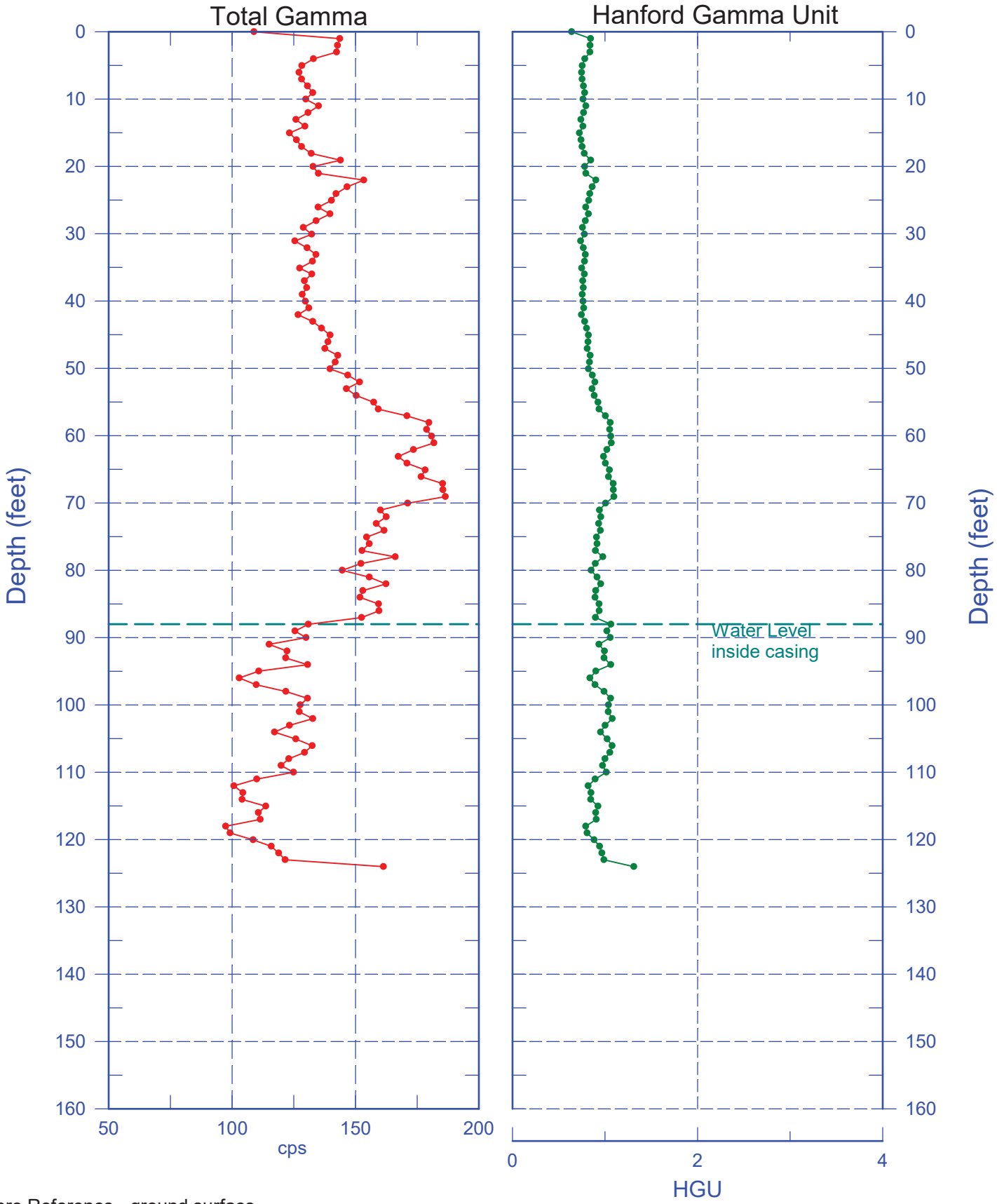
199-K-235 (C9973)
Total Gamma & Moisture



Zero Reference - ground surface

Bay West
Customer-Focused Environmental & Industrial Solutions

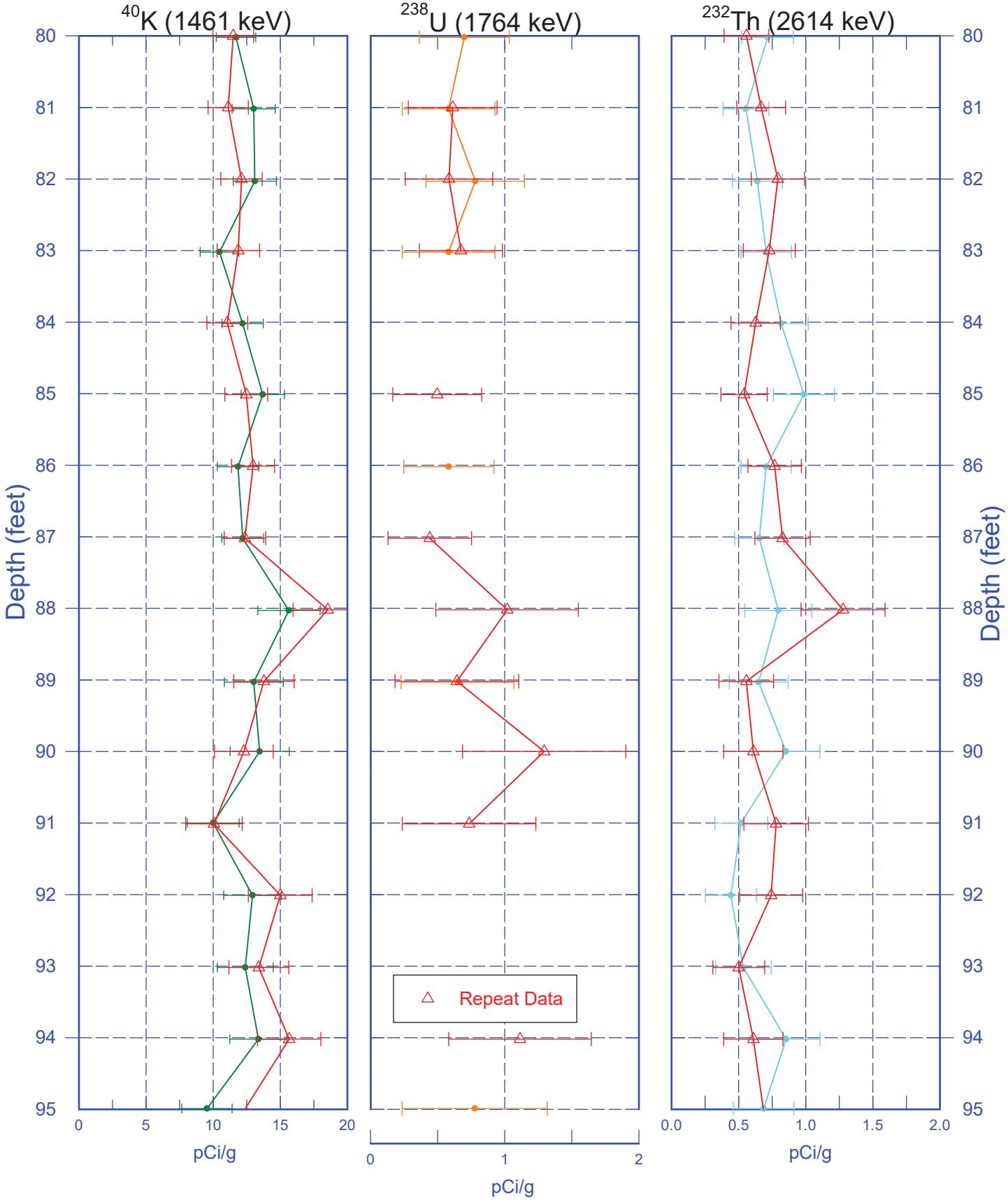
199-K-235 (C9973)
Total Gamma & Hanford Gamma Unit



Zero Reference - ground surface

Bay West
Customer-Focused Environmental & Industrial Solutions

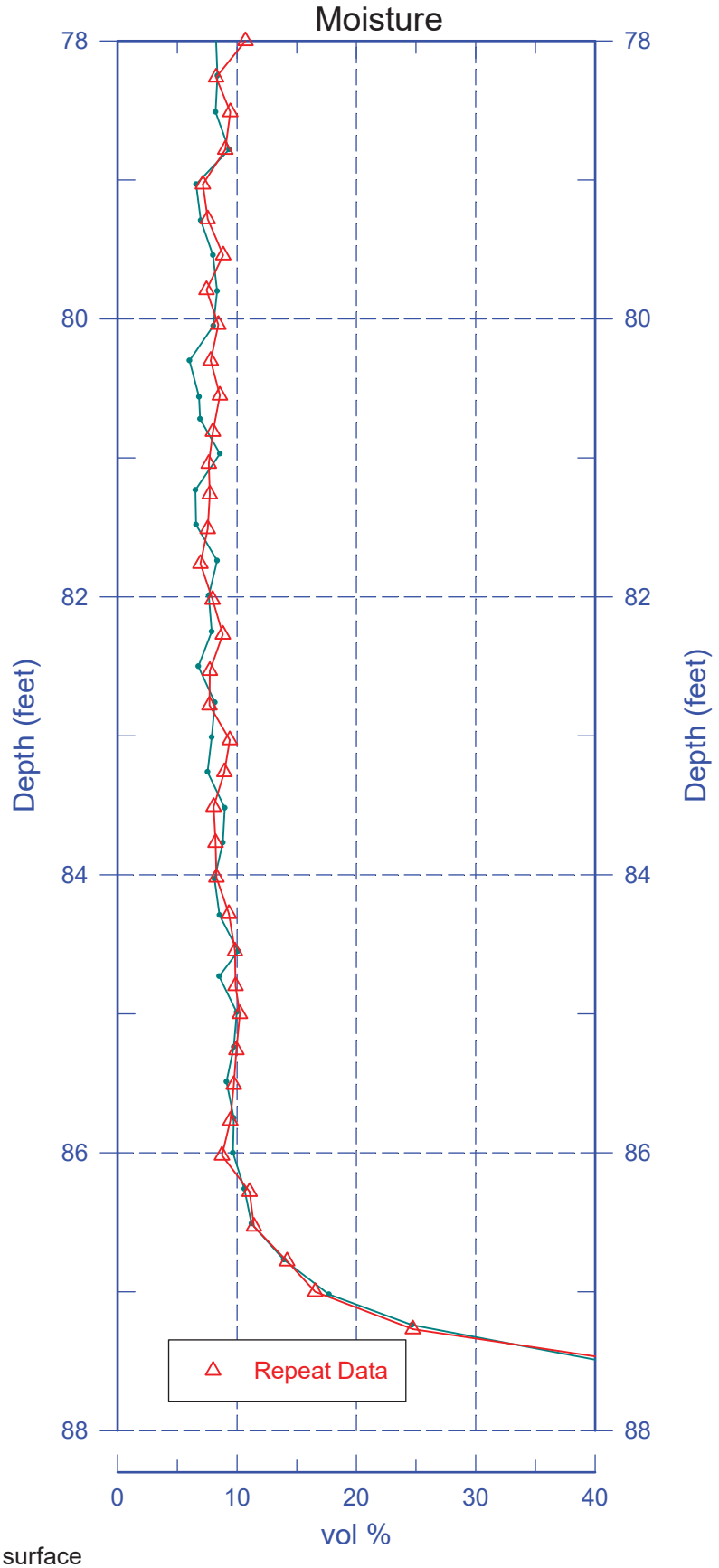
199-K-235 (C9973)
Repeat Section of Natural Gamma Logs



Zero Reference - ground surface

Bay West
Customer-Focused Environmental & Industrial Solutions

199-K-235 (C9973)
Moisture Repeat Section



Zero Reference - ground surface

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SURVEY DATA REPORT

Request No. 192-026

Project No.	Title	File No.
	KR-4 Wells C9973 and C9974 Final Surveys	1KT13R26

Job. No.	Prepared By	Date	Reviewer
CACN: 304836-JPRC	N.P. Fastabend	1/7/19	LBM

DESCRIPTION OF WORK	DISTRIBUTION	SDR	PLOT	DWG
Obtained final coordinates (C/L Casings) and elevations of KR-4 Wells C9973 (199-K-235) and C9974 (199-K-236) located in southwest portion of 100K Area.	Survey File	OR		
	J.D. Mehrer	1		
	J.L. Richart	1		
	J.L. Smoot	1		
	J.B. Geiger	1		
Horizontal Coordinate System: WCS83S/91 (Meters) Vertical Datum: NAVD88 (Meters)	B.J. Howard	1		
	J.M. Phipps	1		

SURVEY RESULTS AND COMMENTS

See Attached Well Survey Data Report Sheets

FOR OFFICE USE ONLY

OR Doc Type:	WMU Code(S):

A-6006-495 (REV 1)

WELL SURVEY DATA REPORT

Project:	**Prepared By:** Neil P. Fastabend
	Company: CHPRC
Date Requested: 01/02/19	Requestor: James D. Mehrer (CHPRC)
Date of Survey: 01/07/19	Surveyor / Company: Lawrence B. Munnell (CHPRC)
Description of Work: Obtained final survey coordinates (C/L Casing) and elevations of KR-4 Well C9973 (199-K-235) located in southwest portion of 100K Area.	Horizontal Datum: NAD83 (91)
	Vertical Datum: NAVD88
	Units: Meters
	Hanford Area Designation: 100K

Coordinate System: Washington State Plane Coordinates (South Zone)

Horizontal Control Monuments:
Washington State Reference Network

Vertical Control Monuments:
100K-3 (CHPRC) and HSWB-045 (COE)

Well ID	Well Name	Easting	Northing	Elevation	
C9973	199-K-235	568829.62	146115.87		Center of Casing
				148.758	Top Outer Casing,N.Edge Stamped "X"
				148.229	Top Inner 5"SS Casing, N.Edge
				148.459	Top Inner 6"SS Casing, N.Edge
				148.003	Brass survey marker

Notes:

Brass Survey Marker elevation was taken on top domed brass cap in concrete.

Equipment Used: Trimble R8 RTK GPS
Trimble DiNi 12 Level

Surveyor Statement:

I, Lawrence B. Munnell, a Professional Land Surveyor registered in the State of Washington (Registration No. 16216), hereby certify this report is based on a field survey performed by me, or under my direct supervision.

LAWRENCE B. MUNNELL
STATE OF WASHINGTON
16216
REGISTERED
PROFESSIONAL LAND SURVEYOR
1-7-19

WELL SURVEY DATA REPORT

Project:	**Prepared By:** Neil P. Fastabend
	Company: CHPRC
Date Requested: 01/02/19	Requestor: James D. Mehrer (CHPRC)
Date of Survey: 01/07/19	Surveyor / Company: Lawrence B. Munnell (CHPRC)
Description of Work: Obtained final survey coordinates (C/L Casing) and elevations of KR-4 Well C9974 (199-K-236) located in southwest portion of 100K Area.	Horizontal Datum: NAD83 (91)
	Vertical Datum: NAVD88
	Units: Meters
	Hanford Area Designation: 100K

Coordinate System: Washington State Plane Coordinates (South Zone)

Horizontal Control Monuments:

Washington State Reference Network

Vertical Control Monuments:

100K-3 (CHPRC) and HSWB-045 (COE)

Well ID	Well Name	Easting	Northing	Elevation	
C9974	199-K-236	568856.97	146074.39		Center of Casing
				148.697	Top Outer Casing,N.Edge Stamped "X"
				148.395	Top Inner 6"SS Casing, N.Edge
				147.947	Brass survey marker

Notes:

Brass Survey Marker elevation was taken on top domed brass cap in concrete.

Equipment Used: Trimble R8 RTK GPS
Trimble DiNi 12 Level

Surveyor Statement:

I, Lawrence B. Munnell, a Professional Land Surveyor registered in the State of Washington (Registration No. 16216), hereby certify this report is based on a field survey performed by me, or under my direct supervision.

LAWRENCE B. MUNNELL
STATE OF WASHINGTON
16216
REGISTERED
PROFESSIONAL LAND SURVEYOR
1-7-19

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WELL DEVELOPMENT AND TESTING DATA

Well ID: C9973 | Well Name: 199-K-235 | Date: 11/28/18

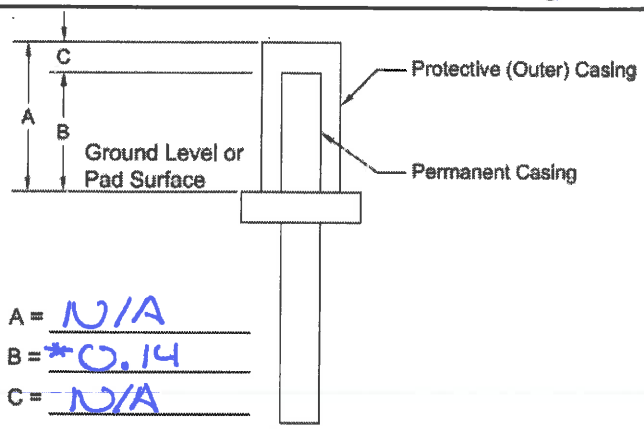
Location: ~300m South of KW Reactor

Reference Measuring Point *(unless otherwise noted)*: TOP OF OUTER CASING (TOC)

Has the well been surveyed? ○ Yes ⊗ No | Does the well have a cement pad? ○ Yes ⊗ No

Initial Conditions

	Start of Job	End of Job
STATIC WATER LEVEL:		
Date: 11/28/18	~~111.8'~~ 92.5'	N/A
Date: 11/29/18	N/A	90.97'
DEPTH TO BOTTOM:		
Date: 11/28/18	128.8'	NOT measured
Date: 11/29/18	NOT measured	NOT measured



A = N/A
B = *0.14
C = N/A

Intake Depth (ft bgs)	Specific Capacity (gpm/ft)	Troll Depth (ft bwt)	Turbitidy (NTU) Initial	Turbitidy (NTU) Final	Pump Start	Pump Stop	Pumping Rate (gpm)	Maximum Drawdown (ft)
115.72	10.28	29.78	25.0	2.66	1303	1400	~82	7.98
100.46	11.00	10.09	2.28	0.91	0831	0932	~78	7.09
# 111.60	8.38	22.88	70.8	2.83	1353	1451	~80	9.55
						JLR 1/8/19		

Total Pumped: Int. 1 = ~4800 gal Int 2 = ~41,758 Total = 9558

Pump Model: Grundfos 62GPM model A 98914843 244ft, 12 stage

Troll Serial Number and Pressure Range (PSI and depth): 158724 LVL Troll 700 Range 21m

Comments:
*5.00' of stainless steel casing removed temporarily for development

#Turbidity and drawdown data collected for developing the 5" insert w/ initial depth to bottom = 124.7' bgs and DTW = 88.27' bgs. log file name: C9973_develop_5in_liner_12-19-18, ~4600 gal pumped

Prepared By:

S Sexton — Print Name | [signature] — Signature | 11/28/18 — Date

Reviewed By:

Jennifer Richart — Print Name | J Richart — Signature | 1/8/19 — Date

For Office Use Only

OR Doc Type:	WMU Code(s):

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C9973 Photo Log

0-26 ft bgs (backfill)

26-30 ft bgs

30-35 ft bgs

35-40 ft bgs

40-45 ft bgs

45-50 ft bgs

50-55 ft bgs

55-60 ft bgs

60-65 ft bgs

65-70 ft bgs

70-75 ft bgs

75-80 ft bgs

80-85 ft bgs

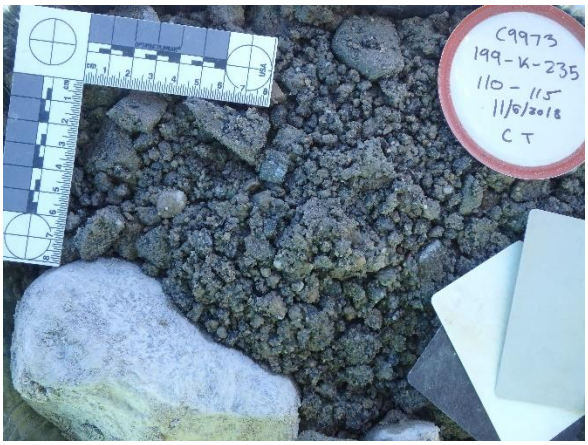
85-90 ft bgs

90-95 ft bgs

95-100 ft bgs

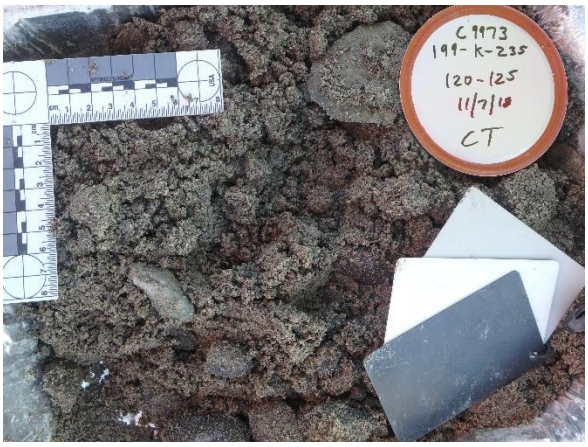
100-105 ft bgs

105-110 ft bgs

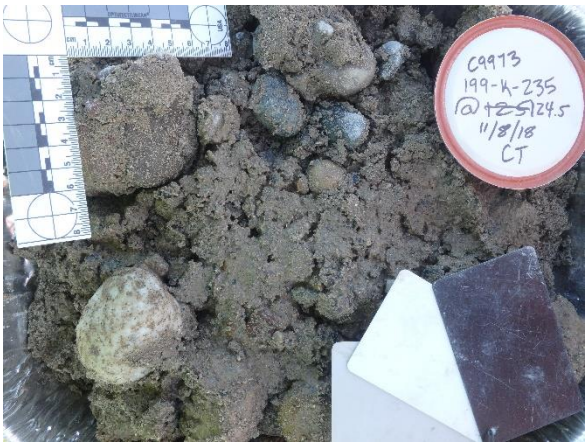


110-115 ft bgs

115-120 ft bgs



120-125 ft bgs



124.5 ft bgs (last sample collected)

Appendix B

Well Documentation for 199-K-236 (C9974)

- Well Summary Sheet for C9974
- Borehole Log for C9974
- Geophysical Log Data Report for C9974
- Final Survey Report for C9974
- Well Development and Testing Data Sheet C9974
- Photo Log for C9974

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WELL SUMMARY SHEET

Page 1 of 2

Well ID: C9974	Well Name: 199-K-236	Start Date: 10/29/18
Project: 2 Wells in the 100-KR-4 GW OU	Location: 100-K Area	End Date: 12/19/18

CONSTRUCTION DATA

Surface Completion:
4' x 4' x 6" Concrete Pad with brass survey marker and protective monument (3.00' ags - 2.00'bgs)
Ecology Well # BKG-097

Well Completion Material:
Type I/II Portland Cement
0.0' bgs - 10.5' bgs
Bentonite Crumbles
10.5' bgs - 71.7' bgs
Bentonite Pellet Seal
71.7' bgs - 74.7' bgs
10-20 mesh Primary Filterpack
74.7' bgs - 113.7' bgs
8-16 mesh Primary Filterpack
113.7' bgs - 125.5' bgs

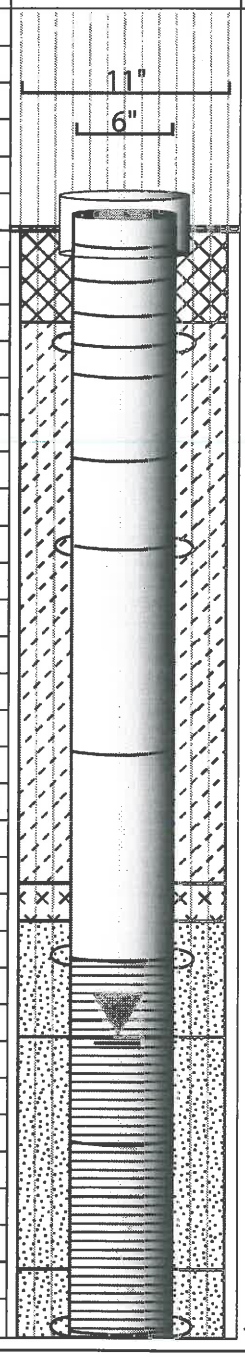
Permanent Well:
6" ID Stainless Steel Blank
2.00' ags - 80.20' bgs
6" ID Stainless Steel 0.040-in Screen
80.20' bgs - 120.20' bgs
6" ID Stainless Steel Sump
120.20' bgs - 125.21' bgs

Hole Dimensions:
11" Temporary Casing: 125.98' bgs
(all temporary casing removed)

Total Depth : 125.5

ags = above ground surface
bgs = below ground surface

Diagram



GEOLOGIC/HYDROLOGIC DATA

Graphic Log

Backfill
0 - 26 : Sandy Gravel (sG)

Hanford Formation
26 - 28 : Silty Sandy Gravel (msG)
28 - 52.5: Sandy Gravel (sG)
52.5 - 57.5 : Gravelly Sand (gS)
(Possible Ringold contact at ~55'
57.5 - 70 : Sandy Gravel (sG)
70 - 75 : Gravelly Sand (gS)
75 - 80: Silty Sandy Gravel (msG)
80 - 94 : Sandy Gravel (sG)
Depth to water 87.73 (12/18/18)
94 -94.5: Silty Sandy Gravel (msG)
94.5 - 97: Sandy Gravel (sG)
97 - 102: Silty Sandy Gravel (msG)
102 - 105: Sandy Gravel (sG)
105 - 112.5: Gravelly Sand (gS)
112.5 - 114: Silty Sandy Gravel (msG)
114 - 117.5: Sandy Gravel (sG)
117.5 - 120: Silty Sandy Gravel (msG)

Reported By:			
Brandon Thurnau	Geologist	Brandon Thurnau	1/2/19
Print Name	Title	Signature	Date
Reviewed By:			
Jennifer Richart	Well Coordinator	J. Richart	1/8/19
Print Name	Title	Signature	Date

For Office Use Only

OR Doc Type:	WMU Code(s):

A-6003-643 (REV 2)

WELL SUMMARY CONTINUATION SHEET

Well ID: C9974 | Well Name: 199-K-236 | Project: 2 Wells in the 100-KR-4 OU

CONSTRUCTION DATA

Surface Completion:
4' x4' x 6" Concrete Pad with brass survey marker and protective monument (3.00' ags - 2.00'bgs)
Ecology Well # BKG-097

Well Completion Material:
Type I/II Portland Cement
0.0' bgs - 10.5' bgs
Bentonite Crumbles
10.5' bgs - 71.7' bgs
Bentonite Pellet Seal
71.7' bgs - 74.7' bgs
10-20 mesh Primary Filterpack
74.7' bgs - 113.7' bgs
8-16 mesh Primary Filterpack
113.7' bgs - 125.5' bgs

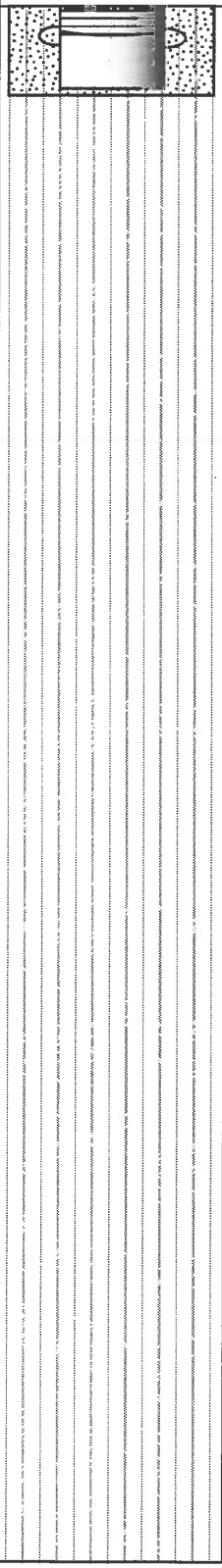
Permanent Well:
6" ID Stainless Steel Blank
2.00' ags - 80.20' bgs
6" ID Stainless Steel 0.040-in Screen
80.20' bgs - 120.20' bgs
6" ID Stainless Steel Sump
120.20' bgs - 125.21' bgs

Hole Dimensions:
11" Temporary Casing: 125.98' bgs
(all temporary casing removed)

Total Depth : 125.5

bgs = below ground surface

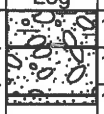
Diagram



Depth in Feet: 120, 140, 160, 180, 200, 220, 240, 260, 280

GEOLOGIC/HYDROLOGIC DATA

Graphic Log



Lithologic Description (ft bgs)

117.5 - 120: Silty Sandy Gravel (msG)
120 -125: Sandy Gravel (sG)
125 - 125.5: Sand (S)

A-6006-992 (REV 0)

BOREHOLE LOG

Page 1 of 7
Date: 10/29/18

Well ID: C9974 | Well Name 199-4-236 | Location: 100K Area
Project: Installation of two wells in the 100-KR4 | Reference Measure Point: Ground Surface

Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other	Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other
0			0-0.5 crushed aggregrate Drill Pad	Cable Tool w/ Drive Barrel
1			0.5-5.0 Backfill ~~(Gravel)~~ SG 60% Gravel, 40% sand	
2	G 10/29/18		round/sub round gravels, 1/2-4 cm, poorly sorted 90% basalt	Archive samples every 5'
2.5			sands: fine to coarse grain, 80% mafic / 20% felsic, no rxn, moist	
3				
4			5.0- Backfill (Gravel)	
5.0			Gravel: Ang to sub-ang, 0.5-10cm, poorly sorted, 80% mafic * 60% sand / 40% gravel *	
6			Sands: fine to coarse 80/20 mafic all else same	
7				
7.5	G			
8				
9			10' increase in felsic gravel content - 65% mafic, 35% fel all else same	
10				
11				
12				
12.5	G			
13				
14				
15.0				
16				
17				

Reported By:

Print Name	Title	Signature	Date
S. Sexton	Geologist		11/05/18

Reviewed By:

Print Name	Title	Signature	Date
Sarah Springer	Sr. Geologist		12-17-18

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OR Doc Type:	WMU Code(s):

A-6003-642 (REV 1)

BOREHOLE LOG (Cont.)

Page 2 of 7

Date: 10-31-2018

Well ID: C9974 | Well Name: 199-K-236 | Location: 100-K AREA

Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other	Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other
17.5	G		@ 17.5' Back fill: 55% S, 40% G, 5% M = Sandy Gravel (sG); Sand: 50% med, 50% crse grain, sub. ang., damp, slt.- no rxn to HCl; Gravel: 90% rnd. - 10% sub. ang (most likely due to drilling), 98% basalt, 2% other (quartzite/granite), mod - poor sort, max size = 8cm, min. size = granule. (2mm); 10YR 3/2 v. drk. grayish brown.	CABLE TOOL w/ DB. 11" TEMP. CASING.
20.0				
22.5	G		increase gravels to 60%, sands are moist and clumping out of the drive barrel	
25				
			~26 ft bgs increase in fine grained component silty sandy gravel 60% g, 20% sand, 20% silt	~poss. Hanford formation 26.0' bgs Based on ↑ moisture & silt cont.
27.5	G			
			~28ft bgs, decrease in fine grained component sandy gravel 60% gravel, 40% sand angular basaltic gravels & sands 60% basalt, 40% other (mostly Quartz)	
30				
32.5	G			
35				

Reported By:

S Sexton	Geologist		11/28/18
Print Name	Title	Signature	Date

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Page 3 of 7

Date: 11/5/18

Well ID: C9974 | Well Name: 199-K-236 | Location: 100-K Area

Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other	Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other
	G		~ Hanford formation ~ Sandy Gravel: 60% gravel, 40% sand, ang basalts, gravels & sands 60% basalt, 40% other (mostly Qtz)	Cable tool w/ DB 11" temp Casing
40				
	G		Sandy Gravel (42.5 ft bgs) 40% Gravel, 60% sand Gravel: 80% Basalt, 20% Quartz & Other, angular to sub-ang.; Poorly Sorted; 2 cm-12 cm Sands: med to crs grain.; sub ang; damp;	
45				
	G		@ 47.5' bgs : Sandy Gravel (60% G, 40% S); Gravel: ang-rnd., 90% basalt, 10% quartzite, v. poor sort, ~ 2mm - 5cm size range.; Sand: v. well sort, dry, v.fine - crse grn. (80% v.fine, 10% crse, 5% med, 5% fine), sub. ang., dry, 80% m / 20% f; 10YR 5/1 GRAY; slt. rxn to HCl.	
50				
	G		@ 52.5' bgs : HOMO. GRAB AFTER SPLITSPOON TAKEN - NOT REPRESENTATIVE Gravelly Sand: (80% S, 15% G, 5% M); Sand: v.fine - crse grn (predom. med grn ~ 80%), sub. ang., dry, well sort., 90% f / 10% m, slt. - mod. rxn to HCl, 10YR 6/2 lt. brownish gray; Gravel: sub. ang. - rnd., ~2mm - 7cm size range, v. poor sort, 50% basalt, 50% quartzite; Silt: loose, dry, v.fine.	SPLITSPOON SAMPLE 52.67' - 55.17' bgs REC. = 100% HEIS # : B3M7K4, B3M7K5, B3M7K6 HANFORD / RINGOLD E contact ~ 54.5 - 55' bgs.
55				

Reported By:

Print Name	Title	Signature	Date
S Sexton	geologist	SS	11/28/18

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Page 4 of 7

Date: 11/6/18

Well ID: C9974 | Well Name: 199-K-236 | Location: 100-K AREA.

Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other	Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other
	G		@ 57.5' Sandy Gravel (sG): (55% G, 40% S, 5% M); Gravel: ang-rnd., 80% basalt, 20% quartzite, ~2mm-4cm size range, slt damp-dry, poor sort. Sand: v. fine-crse grn (80% fine, 5% crse, 5% med, 20% v. fine) sub. ang., dry-slt. damp, well sort., 10YR 6/2 lt. brownish gray, v. strong rxn to HCl; Silt: loose, dry, v. fine.	CABLE TOOL W/DRIVE BARREL; 11" TEMP. CASING
60	NCO Grab			60-62' I-002 NCO Grab B3M7K7
	G		increase in sands to 60% sand, 40% gravel, gravels up to 10 cm in size; all else same	
65	G		~64 ft ~~Gravelly Sand~~ sG 11/28/18 70% sand, 30% gravel Sands: coarse grained, angular to sub angular w/ vis. quartz & feldspars Gravels: rounded to subrounded, 2cm to 10cm, poorly sorted; 80% qtz, 20% basalt	
70	G		~70 ft ~~Sand~~ gS 11/28/18 90% sand, 10% gravels Sands: Coarse grained Angular to sub angular w/ vis. qtz & feldspars Gravels: rounded to subrounded <2 cm, well sorted, Qtz	
75	G NCO Grab		~75 ft - msG (silty sandy Gravel) increase in gravels and silts ~~40% gravels~~, 40% gravels 30% sand, 30% silt Angular to subrounded gravels, 70% felsic, 30% mafic, 2cm-10cm, poorly sorted, broken from drilling Sands: fn grained, rnd/sub rnd, 10YR 6/1, Dry, slight Rxn	73-75' I-003 NCO Grab B3M7K8

Reported By:

Print Name	Title	Signature	Date
J Sexton	Geologist	[signature]	11/28/18

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Page 5 of 7

Date: 11/7/18

Well ID: C9974 | Well Name: 199-K-236 | Location: 100-K Area

Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other	Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other
77.5	G		77 ft → nearly completely angular gravels, 2cm to 20+cm broken from drilling	Cable Tool w/ DB 11' Temp casing
80	G NCO Grab		80': Sandy Gravel, 60% Gravel, 40% sand. Gravel: rounded/subrounded, ~2cm-10cm, ~60% qtz & felsic, sand: fn-med grained sand, dry, slight rxn	80-82' I-004 NCO Grab B3M7K9 & B3M7L0 (DUP)
85				
	I-005 S.S.			I-005 Split spoon: Actual depth: 87.2-89.7' bgs; bottom of casing @87.16' bgs, borehole depth 87.2' bgs, sample time @1005 on 11/12/18 w/ 100% recovery of Sandy Gravel; HE15 #5 B3M7L1, B3M7L2, B3M7L3
	G DTW = 88.70' (11/12/18)		@87.5' bgs: Homogeneous grab sample taken from I-005 spun spoon - 70% Gravel: 65%F/35%M, rounded-subangular, 2mm-87mm, poorly sorted, moist, no rxn w/ HCl; 2.5% Sand: U.fn.-v.crs. (avg. medium), subrounded-subangular, poorly sorted, moist, no rxn w/ HCl; 5% Silt: no plasticity, 2.5Y 3/3 dark olive brown - Sandy Gravel (SG)	
90			@89' bgs - returns appear wet/moisture ↑	
			@91' - ↑10% Silt: 5Y 3/2 dark olive gray (wet), 65% ↓ Gravel, 25% Sand - Sandy Gravel (SG)	
			Sandy Gravel (SG)	
	G		@93' - 65% Gravel: 65%F/35%M, rounded-subangular, 2mm-135mm, poorly sorted, wet, no rxn w/ HCl; 30% Sand: 70%F/30%M, subrounded-subangular, U.fn.-v.crs. (avg. med.-crs.), wet, no rxn w/ HCl, poorly sorted; 5% Silt: no plasticity, 5Y 3/2 dark olive gray	I-006 Water Sample: Actual and csg. depth: 92.56', bottom of borehole: 96.8', purge rate 1.6 gpm, sample time @1500 on 11/13/18; HE15HS: B3M7V6 (filtered), B3M7V7, B3M7J8 (filtered), B3M7V6, B3M7J9
95			@94 - 65% Gravel, 25%: avg. size ↓ v.fn.-med., 20% silt: medium plasticity, 5Y 4/1 dark gray - Silty Sandy Gravel (MSG)	
			@94.5' - similar to 93' w/ 70% Gravel/20% Sand/10% Silt BT 11/13/18	
			Sandy Gravel (SG)	

Reported By:

Print Name	Title	Signature	Date
S Sexton / Brandon Thurman	geologist / Grabgist		11/28/18 / 11/13/18

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Date: 11/13/18

Well ID: C9974 | Well Name: 199-K-236 | Location: 100-K-Area

Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other	Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other
	G		97' bgs - msG ~40% gravel, 40% sand, 20% silt all else similar to previous	Cable tool w/ DB 11" temp casing
100			102' bgs Sandy Gravel 40% gravel, 60% sand Sand: Coarse grained w/ easily vis qtz & feldspars, angular - sub-ang. Gravel: 80% felsic, rnd/subrnd. 2cm - 10 cm, poorly sorted, wet	
	G			
105			11/28/18 105 ft - ~~Sand~~ gS 80% sand, 20% gravel sand: coarse grained qtz & feldspars, angular/sub-angular 10YR 4/1 Gravel: 80% felsic, rnd/subrnd 2cm-5cm, mod sorted, wet	
	G			
110				
	G		TC 11/19/18 @112.5' ~~Sandy Gravel (sG)~~ Silty sandy Gravel (msG) 65% Gravel: Poorly sorted; Angular - sub rounded; Avg size 30mm; Sand 20%: Poorly sorted; Rounded - Angular; Fine - Coarse (Avg. Medium); No rxn w/ HCl (wet); 15% silt: No rxn w/ HCl (wet); no plasticity; 10YR - 3/4 - Dark Yellowish Brown	@112.5 very muddy runny water dumped out; fines likely went with some
115			@114 Sandy Gravel (sG): 60% gravel; 35% sand; 5% silt @115 Sandy Gravel (sG): 60% gravel; 40% sand	

Reported By:

Brandon Thurnau / S Sexton — Print Name

Geologist / Geologist — Title

Brandon Thurnau / SS — Signature

11/28/18 — Date

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Page 7 of 7

Date: 11/19/18

Well ID: C9974 | Well Name: 199-K-236 | Location: ~~K~~ 100K Area TC 11/19/18

Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other	Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other
	G		@117.5' Silty Sandy Gravel (nsG): 65% Gravel: 80% F/20% M; Poorly sorted; Angular – Sub-rounded; 2mm – 90mm (Avg. 30mm); No rxn w/ HCl; 20% Sand: 75% F/25% M; v. fine – coarse; poorly sorted; rounded – sub-angular; no rxn w/ HCl; Silt 15%: no rxn w/ HCl; no plasticity; 10YR – 3/2 – very Dark grayish Brown	
120	I∅∅7 S.S. I∅∅6 TC 11/20/18		@120' – 122.5' Taken from split spoon I∅∅7. ~~Gravelly Sand~~ Sandy Gravel: ~~35~~ 30% Gravel: Poorly sorted; Angular – Rounded; 2mm – 120mm; No rxn w/ HCl; 65% Sand: 80% F/20% M; v. fine – coarse; poorly sorted; sub-angular – rounded; no rxn w/ HCl; Silt 5%: No rxn w/ HCl; no plasticity; 10YR – 4/3 – Brown	I∅∅8 WATER sample: Actual Depth – 122.26'; Bottom of casing – 122.26'; Bottom of borehole – 121.6'; Purge Rate – 9.1 gpm; Purge volume Req. – 159.4; Time on – 1035; Time water 1035; Time purge – 180 min.; Time sample – 1335; Time off – 1342; HEIS #'s: B3M7V8(F), B3M7V9, B3M7W0(F), B3M7W1, B3M7W4(F), B3M7W7, B3M7M6(F), B3M7W6
	I∅∅8 W.S.V TC 11/20/18			
	G			
125	G		@125' Taken from sand pump. Sand 90%: Poorly sorted; Angular – sub-rounded; V. fine – V. Coarse (Avg. Medium); 70% F/30% M; no rxn w/ HCl (wet); Silt 5%: no rxn w/ HCl (wet); no plasticity; 10YR – 5/3 – Brown; Gravel 5%: Angular – sub-angular; 2mm – 50mm; Sample called "Sand". (S)	@125 sample taken with Sand is not entirely accurate with regards to depth and ~~S~~ soil representation @ that depth. TC 11/27/18
			TD @ 125.5' bgs	

Reported By:

Print Name	Title	Signature	Date
Trevor Clark	Geologist	Trevor Clark	11/27/18

A-6006-993 (REV 0)

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199-K-236 (C9974)
Log Data Report

Borehole Information

Log Date	2018-11-28	Filename	C9974_HG-NM_2018-11-12	Site	100-KR-4

DTW[1] (ft)	DTW Date	DTW Source	Drill Date	Total Depth (ft)	Depth Datum
88.35	11/28/18	Bay West	11/27/18	125.5	Ground Surface

Casing Information

Casing Type	Drill Type	Stickup (ft)	Diameter (in.) Outer	Diameter (in.) Inside	Thickness (in.)	Top (ft)	Bottom (ft)
Threaded Steel	Cable Tool	2.5	10.84	9.62	0.61	-2.5	125.01

Borehole Notes

The onsite geologist provided the total depth and casing depth. The logging engineer measured casing stick-up using a steel tape measure, casing diameter using a dial caliper, and thickness using a precision wall-thickness gauge. The maximum logging depth achieved was 123 ft. Zero reference is ground surface.

Logging Equipment Information

Logging System	Gamma 4NC	Type	60% Coaxial HPGe (SGLS)[2]
Effective Calibration Date	12/07/2017	Serial No.	45-TP22010A
Calibration Reference	HGLP-CC-168, Rev. 0	Logging Procedure	SGRP-PRO-OP-53023, Rev. 0, Change 2

Logging System	Gamma 4MC	Type	H3-3 (CPN 503DR)[3]
Effective Calibration Date	12/04/2017	Serial No.	H340207279
Calibration Reference	HGLP-CC-165, Rev. 0	Logging Procedure	SGRP-PRO-OP-53024, Rev. 0, Change 2

SGLS Log Run Information

Log Run	1	2 Repeat			
HEIS Number	1020244	1020245			
Date	11/27/18	11/27/18			
Logging Engineer	Spatz	Spatz			
Start Depth (ft)	0.0	80.0			
Finish Depth (ft)	123.02	95.02			
Count Time (sec)	100	100			
Live/Real	R	R			
Shield (Y/N)	N	N			
MSA Interval (ft)	1.0	1.0			
Log Speed (ft/min)	NA	NA			
Pre-Verification	C9974DNC2018 1127AV00CAB1	C9974DNC2018112 7AV00CAB1			

[1] depth to water inside casing
[2] Spectral Gamma Logging System
[3] Neutron Moisture Logging System

Log Run	1	2 Repeat			
Start File	AD000000	BD008000			
Finish File	AD012302	BD009502			
Post-Verification	C9974DNC2018 1127BV00CAA1	C9974DNC2018112 7BV00CAA1			
Depth Return Error (in.)	N/A	3.5 high			
Comments	No fine gain adjustments made	No fine gain adjustments made			

NMLS Log Run Information

Log Run	3	4 Repeat			
HEIS Number	1020246	1020247			
Date	11/28/18	11/28/18			
Logging Engineer	Spatz	Spatz			
Start Depth (ft)	0.0	77.0			
Finish Depth (ft)	88.07	87.55			
Count Time (sec)	15	15			
Live/Real	R	R			
Shield (Y/N)	N	N			
MSA Interval (ft)	0.25	0.25			
Log Speed (ft/min)	NA	NA			
Pre-Verification	C9974DMC2018 1128AV00CAB1	C9974DMC201811 28AV00CAB1			
Start File	AD000000	BD007700			
Finish File	AD008807	BD008755			
Post-Verification	C9974DMC2018 1128BV00CAA1	C9974DMC201811 28BV00CAA1			
Depth Return Error (in.)	N/A	3.0 low			
Comments	None	None			

Logging Operation Notes

A centralizer was installed on the sondes.

Analysis Notes

Analyst	P.D. Henwood	Date	11/29/18
Reference(s)	SGRP-PRO-OP-53040, Rev. 0; SGRP-PRO-OP-53051, Rev. 0		

A casing correction for a 0.61-in. thick casing was applied to the SGLS log data.

Casing diameter and thickness corrections for 10.84-in. OD casing and 0.61-in. thick casing were applied to the NMLS data to convert to volume percent moisture. An initial count rate correction for a sediment composition of a 50-50% ratio of basalt fragments to quartz sand (HGLP-OTH-028) was also applied.

For the SGLS, a water correction was applied below 88.35 ft.

SGLS spectra were processed in batch mode in APTEC SUPERVISOR to identify individual energy peaks and determine count rates. Concentrations for the SGLS were calculated in an EXCEL template identified as DNC20171207 using an efficiency function and corrections for casing and dead time as determined by annual calibrations.

Moisture is reported in volume percent as calculated in EXCEL template defined as DMC_MCNP_assay.

HGU[4] is an empirical unit of gamma activity proposed as a means to standardize gamma log response across multiple logging systems with different response characteristics. The HGU is defined in terms of measurements in the Hanford Borehole Calibration Facility, and the magnitude is selected such that 1 HGU is approximately equivalent to typical Hanford background activity, based on data from background samples as reported in *Hanford Site Background: Part 2, Soil Background for Radionuclides* (DOE/RL-96-12).

Results and Interpretations

No manmade radionuclides were detected in this borehole.

The neutron moisture log primarily responds to moisture present in the surrounding formation. In general, an increase in count rate reflects an increase in moisture content. Moisture content generally increases as the sediment becomes more fine-grained. For example, moisture content would be expected to be greater near the top of a fining upward Hanford flood sequence.

The KUT and moisture repeat plots indicate that the systems were working properly. The post verification measurement for the SGLS failed the upper limits for the HASQARD criteria. Spectra were scrutinized and the cause of the increased count rate could not be determined. Spectra in the log data appeared normal with calculated concentrations for KUT being typical for Hanford sediments. The next time the sonde was used in borehole C9923, the verification criteria were met in the pre- and post-verification measurements. It is concluded the post-verification measurement for this borehole was an aberration that has not been repeated and the data are accepted.

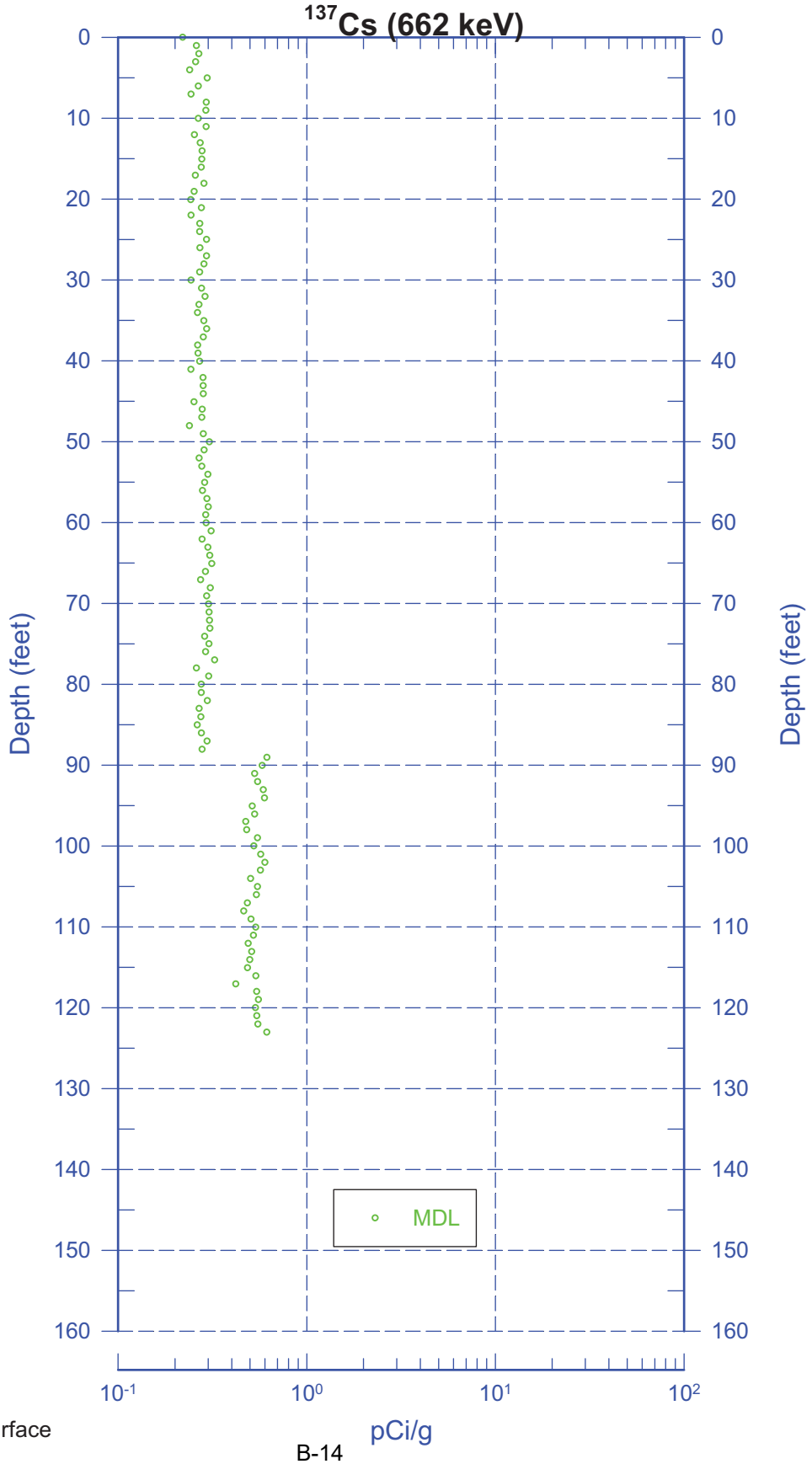
List of Log Plots

Depth Reference is top of casing.

Manmade Radionuclides (0-160 ft)
Natural Gamma Logs (0-160 ft)
Combination Plot (0-140 ft)
Moisture (0-160 ft)
Total Gamma & Moisture (0-160 ft)
Total Gamma & Hanford Gamma Unit (0-160 ft)
Repeat Section of Natural Gamma Logs (80-95 ft)
Moisture Repeat Section (77-88 ft)

[4] Hanford Gamma Unit

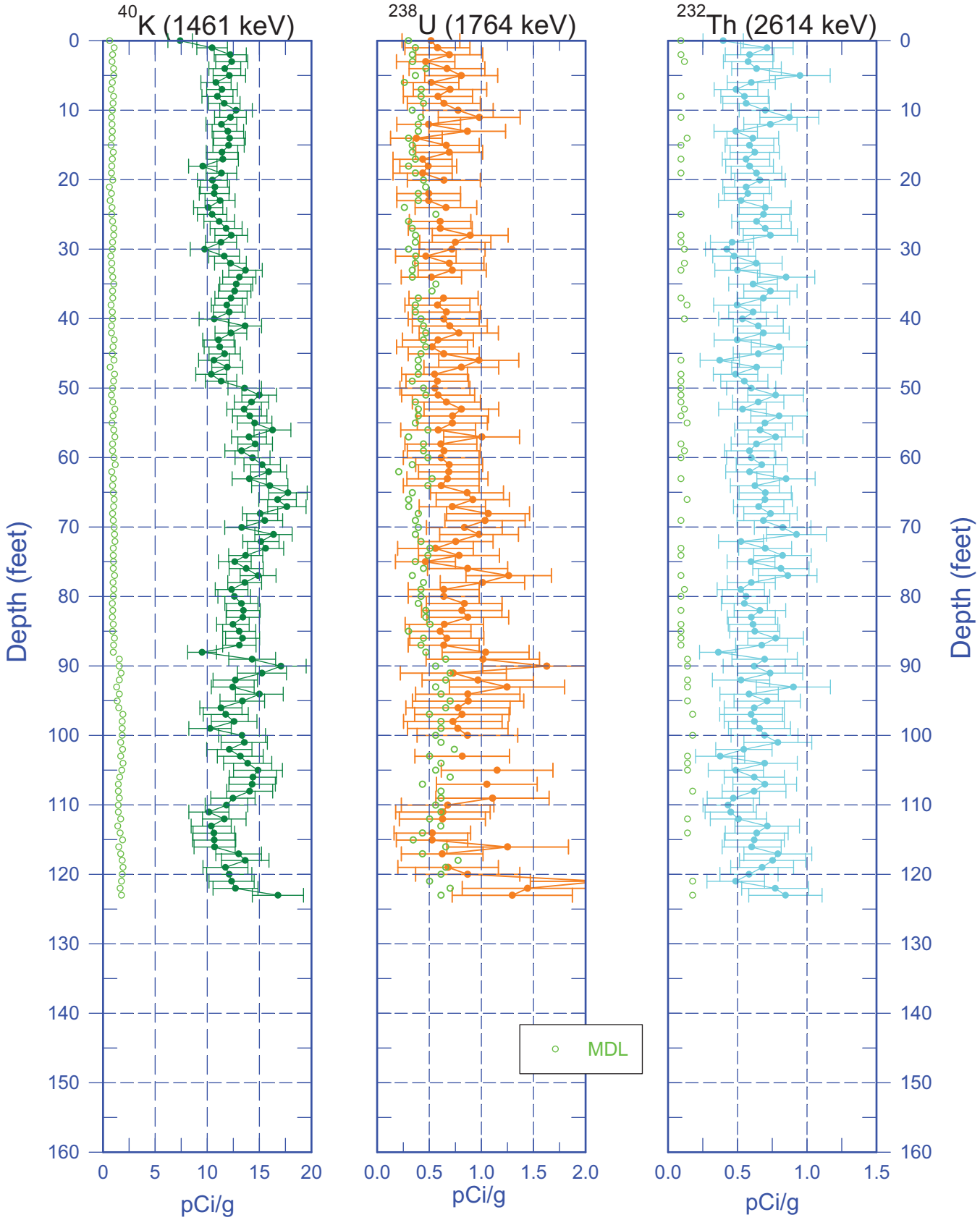
199-K-236 (C9974)
Manmade Radionuclides



Zero Reference - ground surface

Bay West
Customer-Focused Environmental & Industrial Solutions

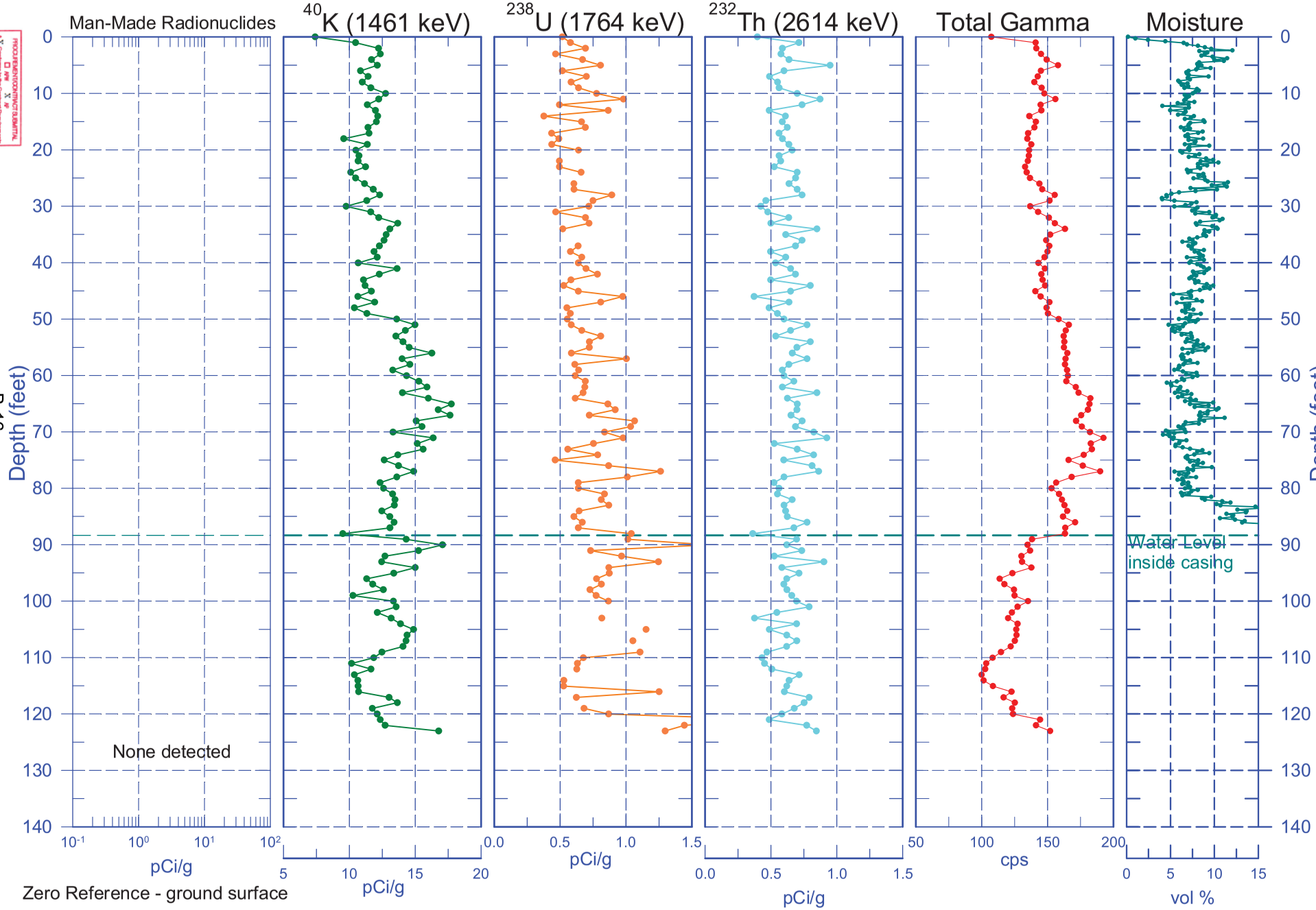
199-K-236 (C9974)
Natural Gamma Logs



Zero Reference - ground surface

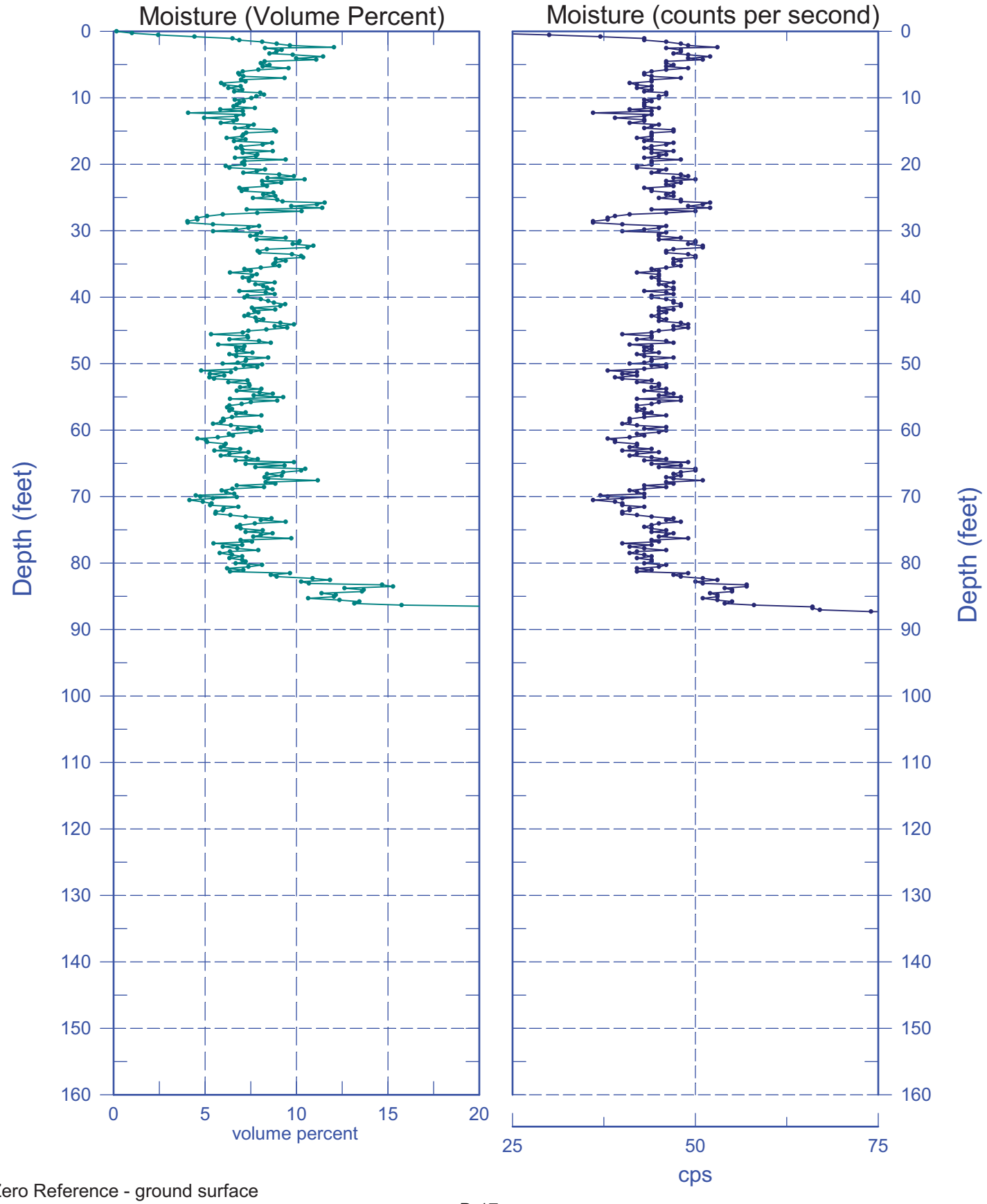
Bay West
Customer-Focused Environmental & Industrial Solutions

199-K-236 (C9974) Combination Plot



Bay West
Customer-Focused Environmental & Industrial Solutions

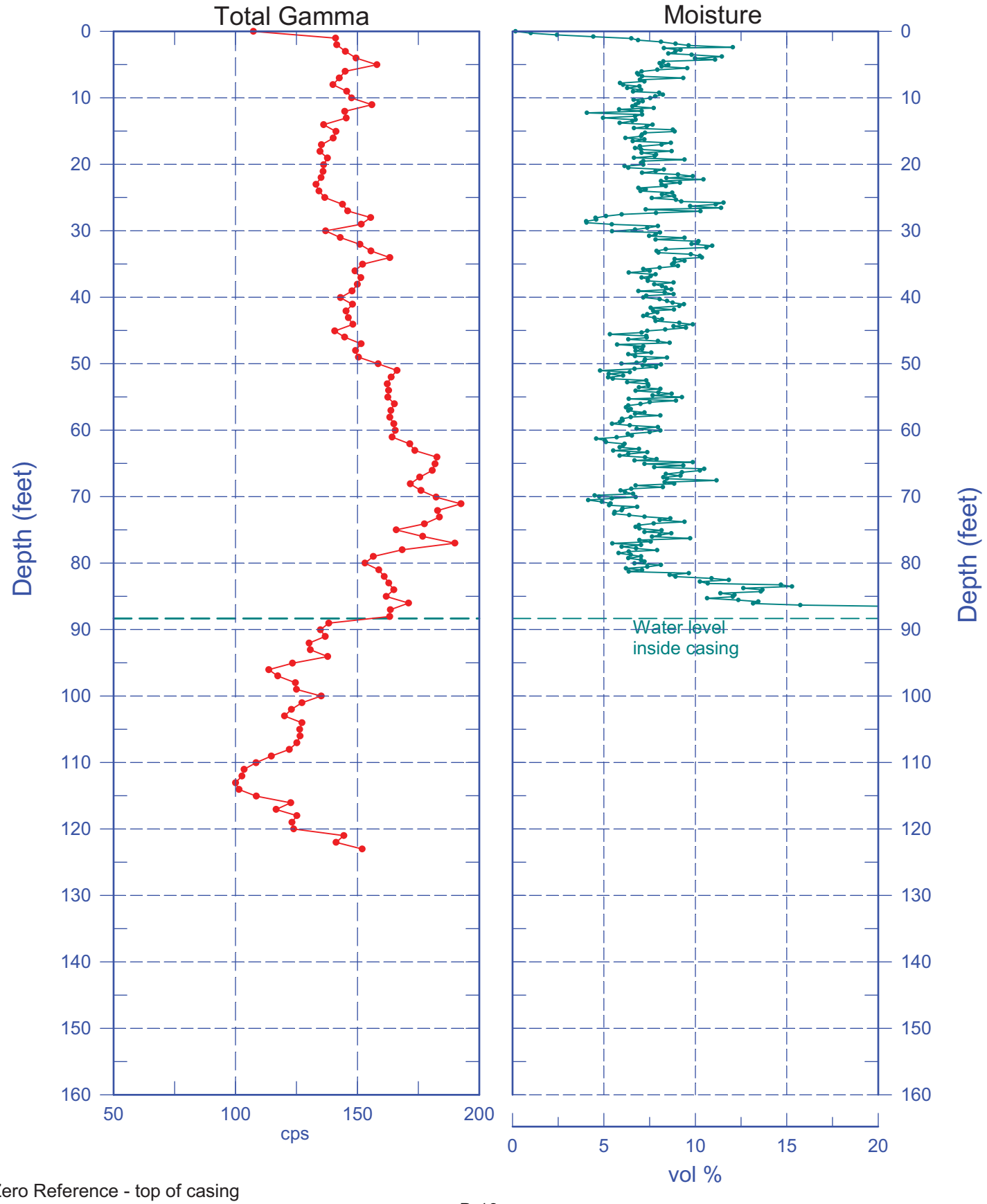
199-K-236 (C9974)
Moisture



Zero Reference - ground surface

Bay West
Customer-Focused Environmental & Industrial Solutions

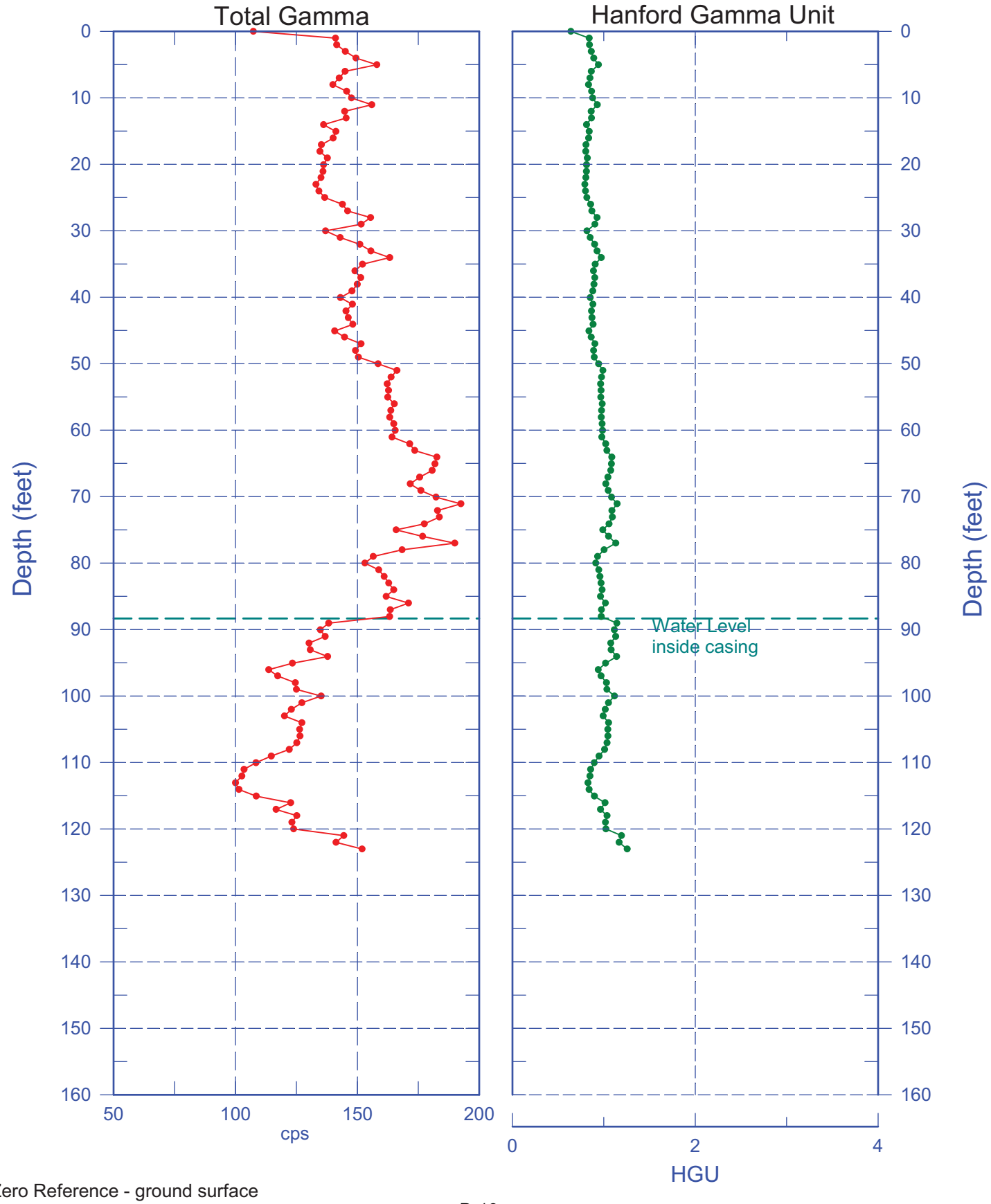
199-K-236 (C9974)
Total Gamma & Moisture



Zero Reference - top of casing

Bay West
Customer-Focused Environmental & Industrial Solutions

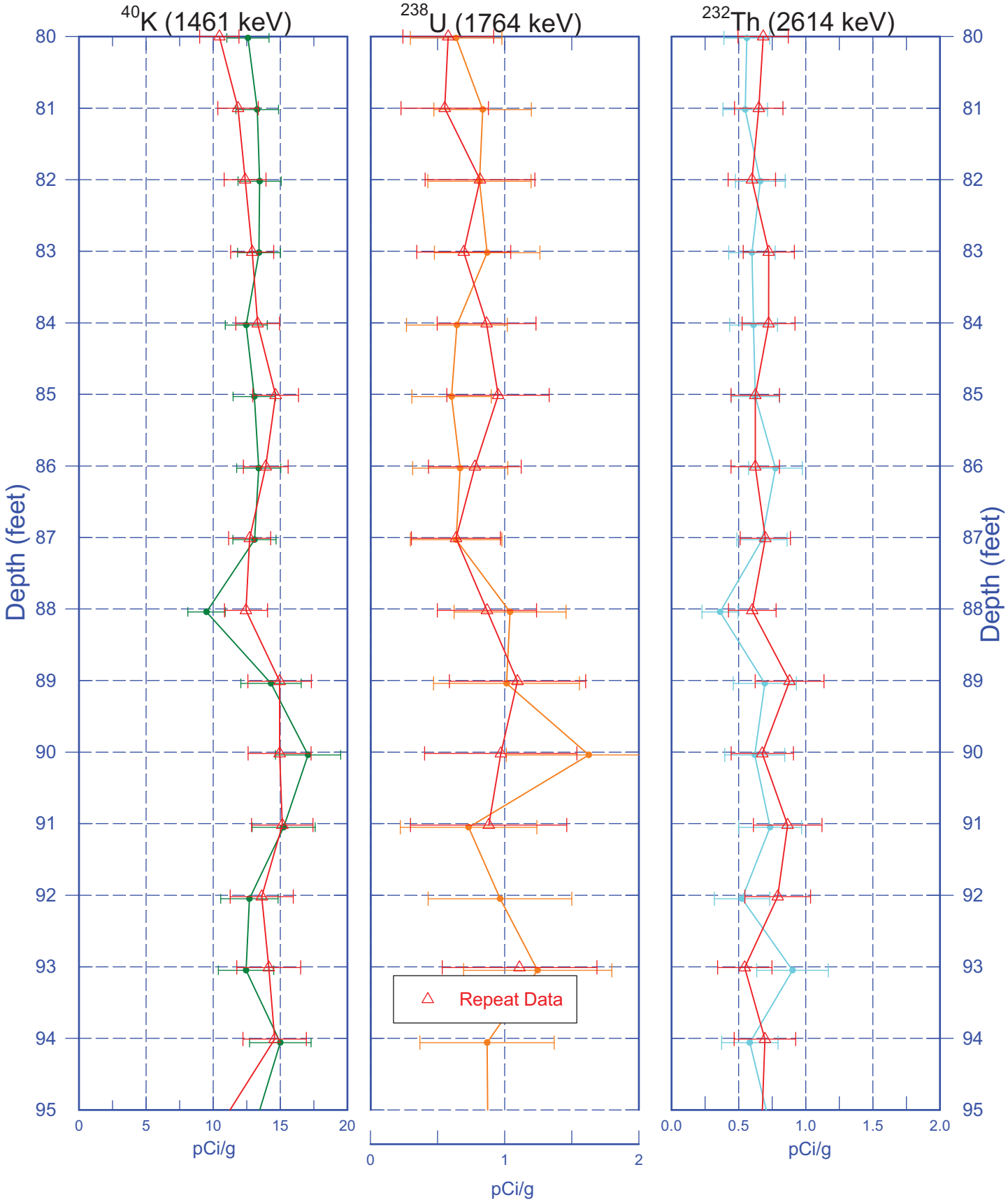
199-K-236 (C9974)
Total Gamma & Hanford Gamma Unit



Zero Reference - ground surface

Bay West
Customer-Focused Environmental & Industrial Solutions

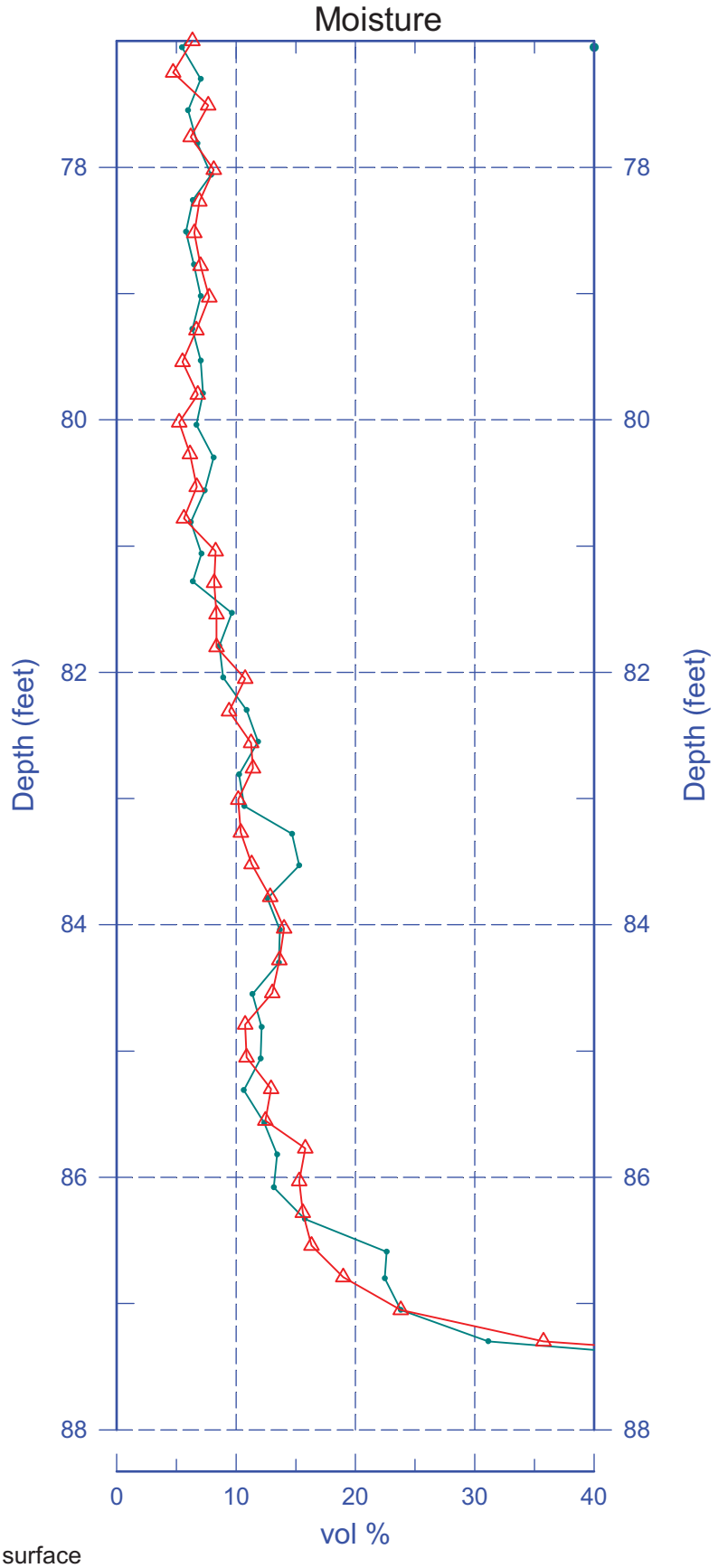
199-K-236 (C9974)
Repeat Section of Natural Gamma Logs



Zero Reference - ground surface

Bay West
Customer-Focused Environmental & Industrial Solutions

199-K-236 (C9974)
Moisture Repeat Section



Zero Reference - ground surface

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SURVEY DATA REPORT

Request No. 192-026

Project No.	Title	File No.
	KR-4 Wells C9973 and C9974 Final Surveys	1KT13R26

Job. No.	Prepared By	Date	Reviewer
CACN: 304836-JPRC	N.P. Fastabend	1/7/19	LBM

DESCRIPTION OF WORK	DISTRIBUTION	SDR	PLOT	DWG
Obtained final coordinates (C/L Casings) and elevations of KR-4 Wells C9973 (199-K-235) and C9974 (199-K-236) located in southwest portion of 100K Area.	Survey File	OR		
	J.D. Mehrer	1		
	J.L. Richart	1		
	J.L. Smoot	1		
	J.B. Geiger	1		
Horizontal Coordinate System: WCS83S/91 (Meters) Vertical Datum: NAVD88 (Meters)	B.J. Howard	1		
	J.M. Phipps	1		

SURVEY RESULTS AND COMMENTS

See Attached Well Survey Data Report Sheets

FOR OFFICE USE ONLY

OR Doc Type:	WMU Code(S):

A-6006-495 (REV 1)

WELL SURVEY DATA REPORT

Project:	**Prepared By:** Neil P. Fastabend
	Company: CHPRC
Date Requested: 01/02/19	Requestor: James D. Mehrer (CHPRC)
Date of Survey: 01/07/19	Surveyor / Company: Lawrence B. Munnell (CHPRC)
Description of Work: Obtained final survey coordinates (C/L Casing) and elevations of KR-4 Well C9973 (199-K-235) located in southwest portion of 100K Area.	Horizontal Datum: NAD83 (91)
	Vertical Datum: NAVD88
	Units: Meters
	Hanford Area Designation: 100K

Coordinate System: Washington State Plane Coordinates (South Zone)

Horizontal Control Monuments:
Washington State Reference Network

Vertical Control Monuments:
100K-3 (CHPRC) and HSWB-045 (COE)

Well ID	Well Name	Easting	Northing	Elevation	
C9973	199-K-235	568829.62	146115.87		Center of Casing
				148.758	Top Outer Casing,N.Edge Stamped "X"
				148.229	Top Inner 5"SS Casing, N.Edge
				148.459	Top Inner 6"SS Casing, N.Edge
				148.003	Brass survey marker

Notes:

Brass Survey Marker elevation was taken on top domed brass cap in concrete.

Equipment Used: Trimble R8 RTK GPS
Trimble DiNi 12 Level

Surveyor Statement:

I, Lawrence B. Munnell, a Professional Land Surveyor registered in the State of Washington (Registration No. 16216), hereby certify this report is based on a field survey performed by me, or under my direct supervision.

LAWRENCE B. MUNNELL
STATE OF WASHINGTON
16216
REGISTERED
PROFESSIONAL LAND SURVEYOR
1-7-19

A-6003-659 (REV 1)

WELL SURVEY DATA REPORT

Project:	**Prepared By:** Neil P. Fastabend
	Company: CHPRC
Date Requested: 01/02/19	Requestor: James D. Mehrer (CHPRC)
Date of Survey: 01/07/19	Surveyor / Company: Lawrence B. Munnell (CHPRC)
Description of Work: Obtained final survey coordinates (C/L Casing) and elevations of KR-4 Well C9974 (199-K-236) located in southwest portion of 100K Area.	Horizontal Datum: NAD83 (91)
	Vertical Datum: NAVD88
	Units: Meters
	Hanford Area Designation: 100K

Coordinate System: Washington State Plane Coordinates (South Zone)

Horizontal Control Monuments:

Washington State Reference Network

Vertical Control Monuments:

100K-3 (CHPRC) and HSWB-045 (COE)

Well ID	Well Name	Easting	Northing	Elevation	
C9974	199-K-236	568856.97	146074.39		Center of Casing
				148.697	Top Outer Casing,N.Edge Stamped "X"
				148.395	Top Inner 6"SS Casing, N.Edge
				147.947	Brass survey marker

Notes:

Brass Survey Marker elevation was taken on top domed brass cap in concrete.

Equipment Used: Trimble R8 RTK GPS
Trimble DiNi 12 Level

Surveyor Statement:

I, Lawrence B. Munnell, a Professional Land Surveyor registered in the State of Washington (Registration No. 16216), hereby certify this report is based on a field survey performed by me, or under my direct supervision.

LAWRENCE B. MUNNELL
STATE OF WASHINGTON
16216
REGISTERED
PROFESSIONAL LAND SURVEYOR
1-7-19

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WELL DEVELOPMENT AND TESTING DATA

Well ID: C9974 | Well Name: 199-K-236 | Date: 12/13/18

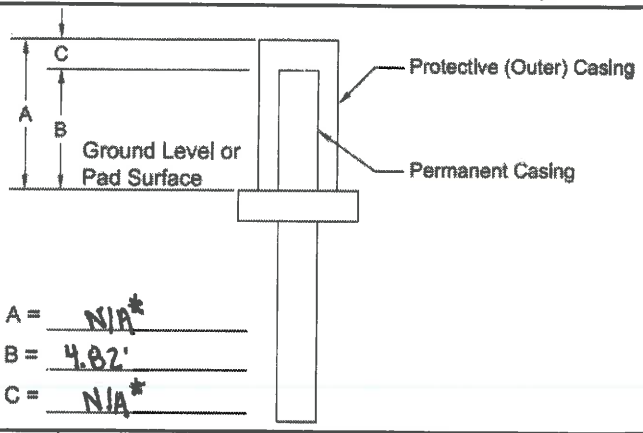
Location: 100-K Area

Reference Measuring Point *(unless otherwise noted)*: TOP OF OUTER CASING (TOC)

Has the well been surveyed? ◯ Yes ⊗ No | Does the well have a cement pad? ◯ Yes ⊗ No

Initial Conditions

	Start of Job	End of Job
STATIC WATER LEVEL:		
Date: 12/13/18	87.63' bgs	87.69' bgs
Date:		
DEPTH TO BOTTOM:		
Date: 12/13/18	130.0' TOS	129.8' TOS
Date:		



A = N/A*
B = 4.82'
C = N/A*

Intake Depth (ft bgs)	Specific Capacity (gpm/ft)	Troll Depth (ft bwt)	Turbitidy (NTU) Initial	Turbitidy (NTU) Final	Pump Start	Pump Stop	Pumping Rate (gpm)	Maximum Drawdown (ft)
116.25	~16.2	28.52	21.3	3.05	1003	1055	~80	4.93'
99.97	~17.5	12.24	11.8	2.18	1136	1236	~80	4.56

JR 1/8/19

Total Pumped: Interval 1: ~4200 gal; Interval 2: ~4800 gal; Total: 9,000 gal

Pump Model: GRUNDFOS MS4000 S/N 00183735; 60 Hz, 230 V, 5 HP

Troll Serial Number and Pressure Range (PSI and depth): S/N 168724 In-Situ Inc. Level Troll 700 Range: 21m (69 ft) vented

Comments: Development conducted after surging; *no monument set yet during development; TOS= Top of Stainless Steel Casing; Log file names: C9974_Develop_Interval1_12-13-18 and C9974_Develop_Interval2_12-13-18
Total stainless steel casing = 130.01' during development

Prepared By:

Brandon Thurnau (Print Name) | Brandon Thurnau (Signature) | 12/13/18 (Date)

Reviewed By:

Jennifer Richart (Print Name) | J. Richart (Signature) | 1/8/19 (Date)

For Office Use Only

OR Doc Type:	WMU Code(s):

A-6005-205 (REV 2)

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C9974 Photo Log

0-5 ft bgs

5-10 ft bgs

10-15 ft bgs

15-20 ft bgs

20-25 ft bgs

25-30 ft bgs

30-35 ft bgs

35-40 ft bgs

40-45 ft bgs

45-50 ft bgs

50-55 ft bgs

55-60 ft bgs

60-65 ft bgs

65-70 ft bgs

70-75 ft bgs

75-80 ft bgs

80-85 ft bgs

85-90 ft bgs

90-95 ft bgs

95-100 ft bgs

100-105 ft bgs

105-110 ft bgs

110-115 ft bgs

115-120 ft bgs

120-125 ft bgs

125 ft bgs (last sample collected)

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