SGW-63811
Revision 0

Borehole Summary Report for the Installation of Three Wells in the 200-ZP-1 Operable Unit, FY2019

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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Freestone Environmental, Inc.

Date Published
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Terms

bgs	below ground surface
Carpenter	Carpenter Drilling, LLC.
CCU	Cold Creek unit
CHPRC	CH2M Hill Plateau Remediation Company
DOE	U.S. Department of Energy
Ecology	Washington State Department of Ecology
ft	feet
gpm	gallons per minute
HCl	hydrochloric acid
HEIS	Hanford Environmental Information System
ID	identification
hp	horsepower
m	meters
NMLS	Neutron Moisture Logging System
NTU	Nephelemetric Turbidity Units
OU	operable unit
RCT	Radiological Control Technician
RLM	Ringold Formation, member of Wooded Island - lower mud unit
Rwia	Ringold Formation, member of the Wooded Island - unit A
Rwie	Ringold Formation, member of the Wooded Island - unit E
SGLS	Spectral Gamma Logging System
TD	total depth
WAC	Washington Administrative Code
Yellow Jacket	Yellow Jacket Drilling Services

Metric Conversion Chart

Into Metric Units			Out of Metric Units		
If you know	*Multiply by*	*To get*	*If you know*	*Multiply by*	*To get*
Length			**Length**		
inches	25.40	millimeters	millimeters	0.0394	inches
inches	2.54	centimeters	centimeters	0.394	inches
feet	0.305	meters	meters	3.281	feet
yards	0.914	meters	meters	1.094	yards
miles (statute)	1.609	kilometers	kilometers	0.621	miles (statute)
Area			**Area**		
sq. inches	6.452	sq. centimeters	sq. centimeters	0.155	sq. inches
sq. feet	0.0929	sq. meters	sq. meters	10.764	sq. feet
sq. yards	0.836	sq. meters	sq. meters	1.196	sq. yards
sq. miles	2.591	sq. kilometers	sq. kilometers	0.386	sq. miles
acres	0.405	hectares	hectares	2.471	acres
Mass (weight)			**Mass (weight)**		
ounces (avoir)	28.349	grams	grams	0.0353	ounces (avoir)
pounds	0.454	kilograms	kilograms	2.205	pounds (avoir)
tons (short)	0.907	ton (metric)	ton (metric)	1.102	tons (short)
Volume			**Volume**		
teaspoons	5	milliliters	milliliters	0.034	ounces (U.S., liquid)
tablespoons	15	milliliters	liters	2.113	pints
ounces (U.S., liquid)	29.573	milliliters	liters	1.057	quarts (U.S., liquid)
cups	0.24	liters	liters	0.264	gallons (U.S., liquid)
pints	0.473	liters	cubic meters	35.315	cubic feet
quarts (U.S., liquid)	0.946	liters	cubic meters	1.308	cubic yards
gallons (U.S., liquid)	3.785	liters			
cubic feet	0.0283	cubic meters			
cubic yards	0.764	cubic meters			
Radioactivity			**Radioactivity**		
picocurie	37	millibecquerel	millibecquerel	0.027	picocurie

1 Introduction

This report presents field-generated records and summarizes field activities performed during the installation of three monitoring wells in the 200-ZP-1 groundwater Operable Unit (OU). As an ongoing effort under the remedial design/remedial action work plan, *200 West Area 200-ZP-1 Pump-and-Treat Remedial Design/Remedial Work Plan* (DOE/RL-2008-78), the three new monitoring wells expand the existing well network for the 200-ZP-1 OU pump-and-treat system . Field activities carried out during the installation of the three new monitoring wells included drilling, soil and groundwater sampling, geophysical logging, and well construction and development.

The 200-ZP-1 OU underlies the northern portion of the 200 West Area, and located on the western portion of the Hanford Site, approximately 25 miles northwest of Richland, Washington.

In 1995, a 200-ZP-1 OU interim pump-and-treat system was brought on-line to remove carbon tetrachloride, chloroform and trichloroethylene from groundwater. To meet corrective measure standards and timelines, a new pump-and-treat system was devised under the *Record of Decision, Hanford 200 Area, 200-ZP-1 Superfund Site, Benton County, Washington* (EPA et al. 2008) as the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980*-approved remedial action for the 200-ZP-1 OU. The remedial action pump-and-treat system was set forth in concurrence with the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1989) and other vested regulatory parties associated with cleanup at the Hanford Site.

Drilling and construction activities occurred from February 20, 2019 to July 1, 2019 and was performed by Yellow Jacket Drilling Services (Yellow Jacket) and its' subcontractor Carpenter Drilling (Carpenter) under the direction of CH2M HILL Plateau Remediation Company (CHPRC). Well development occurred from April 25, 2019 to June 11, 2019 and was performed by Yellow Jacket at C9740 and C9936 and Carpenter at C9738. Freestone Environmental Services Inc., provided well site geology and well construction documentation services. Bay West LLC provided geophysical logging services.

1.1 Purpose and Scope

This document summarizes the observations and measurements made during the drilling and installation of three monitoring wells in the 200-ZP-1 OU. Table 1-1 lists the wells' identification number and name, and Figure 1-1 presents the well locations. This summary report includes copies of the field notes and forms prepared during the drilling, sampling, construction, and development of the wells. Additional information provided in this report includes geologic observations, geophysical log data reports, results of the well location and elevation civil survey, descriptions of the management and disposition of drilling-derived waste, and a summary of the well acceptance activity.

Technical requirements, applicable CHPRC procedures, and other supporting information were summarized in SGW-60782, *Description of Work for the Installation of Three Monitoring Wells in the 200-ZP-1 Groundwater Operable Unit, FY2019*. Soil and groundwater samples were collected as described in DOE/RL-2010-72, *Sampling and Analysis Plan for Remediation Wells in the 200-ZP-1 Operable Unit*, Revision 2, as amended by applicable change notices.

Appendices A (C9738), B (C9740) and C (C9936) contain the Well Summary Sheet, borehole geologic log, drill cutting photographs, Well Development and Testing Data, Log Data Report, and Well Survey Data Report for each respective well.

All drilling data are reported in the original units recorded at the time of measurement. The three monitoring wells will hereinafter be referred to in the text by the borehole identification number (e.g. C9738).

Table 1-1. Identification and Location of New Wells in the 200-ZP-1 Operable Unit

Borehole ID	Well Name	Ecology Tag ID	Northing[a]	Easting[a]	Elevation of Brass Survey Marker[b]	Field Activity Dates	
			meters			Initiate Drilling	Conclude Field Work
C9738	299-W6-17	BLD012	137473.37	567767.41	220.56	February 21, 2019	June 6, 2019[c]
C9740	699-44-70B	BLD021	136810.37	568670.06	224.76	April 8, 2019	July 1, 2019[c]
C9936	699-46-61	BKG088	137442.38	571431.17	211.17	February 20, 2019	April 25, 2019

a. Final survey coordinates are in Washington State Plane South (FIPS 4602) using the *North American Datum of 1983* (NAD83).

b. Elevation values are based on *North American Vertical Datum of 1988* (NAVD88) and are rounded to 0.01 meter.

c. This date does not include installation of well pad and posts.

Ecology = Washington State Department of Ecology.

ID = identification.

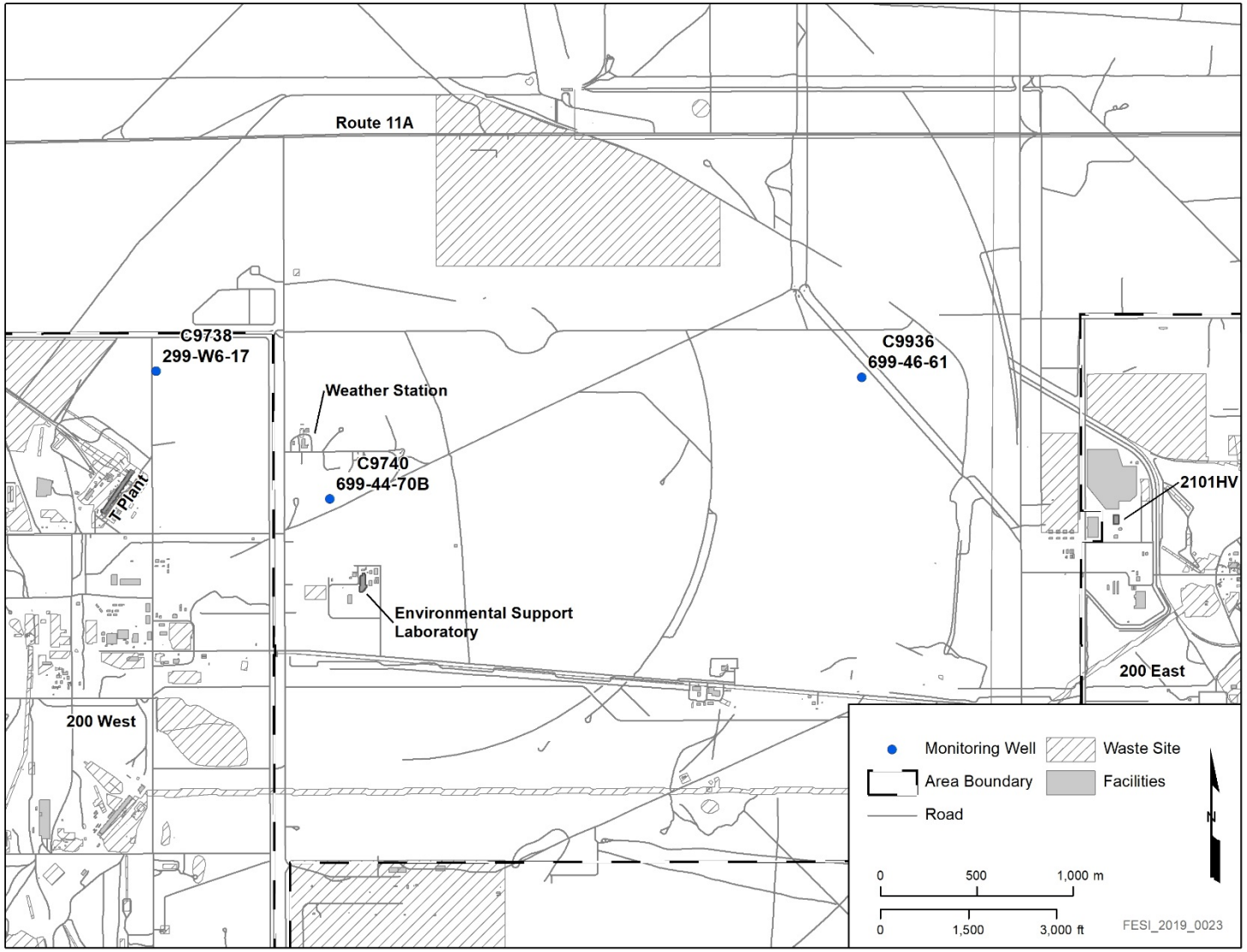

Figure 1-1. New Well Locations in the 200-ZP-1 Operable Unit

2 Drilling, Sampling, and Well Construction Activities

This section summarizes field activities associated with three monitoring wells. Drilling, sampling, well construction, and development details common to all the wells are summarized in Section 2.1 and well-specific information is presented in Section 2.2.

2.1 General Information

The new wells were constructed in compliance with Washington Administration Code (WAC) 173-160, *Minimum Standards for Construction and Maintenance of Wells.* Well construction and development activities were recorded, and borehole geology was logged in accordance with applicable CHPRC procedures.

2.1.1 Drilling, Sampling, and Borehole Logging

The boreholes were advanced to depths between 356.0 and 510.7 feet below ground surface (ft bgs), extending between 63.5 and 188.4 ft below the static water level. Boreholes were drilled using a Speedstar 50K Air Rotary drill rig (Figure 2-1). Two strings of temporary threaded carbon steel casing with outer diameters of 11 3/8-in. and 9 5/8-in. were used at C9738 and C9936. Three strings of temporary threaded carbon steel casing with outer diameters of 11 3/8-in., 9 5/8-in., and 7 5/8-in. were used at C9740.

Figure 2-1. Yellow Jacket Speedstar 50K Air Rotary Drill Rig

Archive grab samples were collected from the drill cuttings at each borehole at 5-ft intervals and at changes in lithology. Samples were placed in labeled one-pint glass jars and sequential chip tray compartments for archive storage. Scaled digital photographs of drill cuttings were taken during archive sample collection to accompany the field descriptions. Borehole geologic logs and drill cutting

photographs for each borehole are presented in Appendices A, B and C. Two grab sample for the purpose of waste characterization were collected from the vadose zone cuttings at C9740 and C9936. Sediment samples were collected for sieve analysis throughout the saturated zone every 5 ft and subsequently composited over 20-ft intervals. A sieve analysis was performed on each composite sample and results were used to determine the appropriate screen slot size for each completed well.

During drilling, depth-discrete groundwater samples were collected using a 1.5-horsepower (hp) Grundfos temporary submersible pump. Samples were collected every 20 ft, starting near the water table and continuing until total depth. Samples were submitted for laboratory analysis to determine the vertical profile of groundwater contamination and subsequent plume characterization. Groundwater samples were collected by CHPRC nuclear chemical operators after a minimum of one borehole volume had been purged and field parameters (temperature, pH, conductivity, dissolved oxygen, turbidity, and oxidation-reduction potential) stabilize within 10 % of variance over three consecutive measurements. Final groundwater samples were also collected at the end of well development for laboratory analysis. All groundwater sample depths and associated Hanford Environmental Information System (HEIS) numbers are included in Section 2.2.

Each borehole was logged using Bay West's Spectral Gamma Logging System (SGLS) and Neutron Moisture Logging System (NMLS) to identify natural and man-made gamma-emitting radionuclides and moisture levels in near-borehole sediments. Before temporary casing was down-sized and after total depth (TD) was achieved prior to well construction, the temporary casing strings were logged individually to produce a geophysical log of the entire length of the borehole. Log Data Reports of all geophysical logging results, provided by Bay West, are presented in Appendices A, B and C.

2.1.2 Health and Safety Screening

A radiological control technician (RCT) performed radiological surveys of the drill cuttings, geologic samples, temporary drive casing, and drillers' control station using standard field screening instruments. The boreholes were surveyed every morning and afternoon. The RCTs used standard field screening instruments to detect and measure alpha, beta, and gamma radiological contamination, if present. No field measurements above background levels were reported during drilling activities.

Air quality monitoring was performed by an industrial hygiene technician using a hand-held multi-gas meter and a photoionization detector. Monitoring was performed at least twice daily of the drillers' breathing zone near the wellhead, any fresh drill cuttings, geologic samples, and any other areas of potential concern. No measurements above background levels were reported during drilling activities.

2.1.3 Well Construction and Development

The monitoring wells were constructed using 4-in. nominal diameter, Schedule 10, Type 304/304L stainless steel casing, V-slot continuous wire wrap 20-slot (0.020-in.) screen and sump with end cap. Centralizers were installed above and below the screen and at 40-ft intervals to ground surface. The primary filter pack consists of 12-20 mesh silica sand extending from below the well sump to between 3.0 and 4.7 ft above the top of the screen. Following the placement of each 10-ft interval of filter pack within a saturated zone, the filter pack was surged using a dual surge block in 10-ft increments until measured settling met CHPRC well development specifications (i.e. less than 0.1 ft of settling in 15 minutes of surging). Annular seal materials include 1/4-in. bentonite pellets, 3/8-in. bentonite chips, and type I/II/V cement grout. Well-specific installation and construction depths are presented in Section 2.2 and in Table 2-1.

The surface completion consists of a stainless steel protective casing, a 4- by 4-ft concrete pad, and a protective cap with locking hasp. Four painted 3-in. diameter steel posts were installed at each corner

of the cement pad, extending 3 ft above the ground surface. Well tags with unique Ecology identification numbers were affixed to the protective casing of each well. These identification numbers are found in Table 1-1.

Well development occurred at each well following placement of the filter pack. Development was performed in one interval using a 1.5-hp Grundfos motor and submersible pump. Each interval was pumped until water was less than 5.0 nephelometric turbidity units (NTU) and additional water quality parameters (conductivity, pH, and temperature) stabilized. The water level was monitored using an In-Situ Inc., Level TROLL[1] 700 pressure transducer accompanied by an electronic depth sounder and Rugged Reader[2]. Final development data is summarized in Table 2-2

2.2 Well-Specific Information

This section summarizes borehole drilling, sampling, geophysical logging, well construction, and well development activities specific to each well. Well construction information for each well is summarized in Table 2-1. Well development information for each well is summarized in Table 2-2.

[1] Level TROLL® Instrument is a registered trademark of In-Situ, Inc., Fort Collins, Colorado.

[2] RuggedReader® Handheld Computer is a registered trademark of In-Situ, Inc., Fort Collins, Colorado.

Table 2-1. Well Construction Information

Borehole ID	Total Depth (ft bgs)	Permanent Casing and Screen					Annulus: Seal and Filter Pack				Filter Pack Size (mesh)
		Screen and Casing Diameter (inch)	Screen Slot Size (inch)	Blank Casing[a]	Screen[a]	Sump/ End Cap[a]	Cement Surface Seal[b]	Granular Bentonite Seal[c]	Pellet Bentonite Seal[d]	Filter Pack[e]	
				Interval (ft bgs)							
C9738	489.0	4	0.020	+2.00 – 419.80	419.80 – 439.85	439.85 – 442.83	0.0 – 9.6	9.6 – 305.2	305.2 – 416.8 445.9 – 472.4	416.8 – 445.9	12 - 20
C9740	510.7	4	0.020	+2.39 – 400.24	400.24 – 420.27	420.27 – 423.25	0.0 – 9.6	9.6 – 316.7	316.7 – 395.5 426.1 – 510.1	395.5 – 426.1	12 - 20
C9936	356.0	4	0.020	+2.25 – 293.94	293.94 – 314.24	314.24 – 317.22	0.0 – 3.9 9.8 -10.8	3.9 – 9.8 10.8 – 289.6 320.9 – 356.0	289.6 – 290.6 317.8 – 320.9	290.6 – 317.8	12 - 20

a. Schedule 10, Type 304/304L Stainless Steel

b. Type I/II/V cement grout

c. Medium bentonite chips (3/8-in.)

d. Bentonite pellets (1/4-in.)

e. Premier silica sand

+ = above ground surface.

ft bgs = feet below ground surface.

ID = identification.

Table 2-2. Well Development Information

Borehole ID	Static Water Level ft bgs / date		Intake Depth (ft bgs)	Duration (min)	Average Flow Rate (gpm)	Final Turbidity (NTU)	Maximum Drawdown (ft)	Total Gallons Pumped[a]	Specific Capacity (gpm/ft)
C9738	300.4	5/20/2019	332.1	68	15.0	53.2	16.2	1,020	0.9
	300.6	5/21/2019	437.2	128	16.0	3.41	13.0	2,048	1.2
C9740	323.4	6/10/2109	413.3	202	9.1	5.66	10.5	1,838	0.9
	324.3	6/11/2019	413.3	153	11.8	3.56	13.0	1,805	0.9
C9936	292.5	04/25/2019	302.7	105	13.6	16.7	2.1	1,428	6.6
			302.7	42	6.4	3.79	1.7	269	3.7
			302.7	16[b]	14.6	-	1.7	234	8.5

a. Total gallons pumped calculated based on duration and average flow rate unless otherwise noted.

b. Pumping at this duration was a stress test.

ft bgs = feet below ground surface.

gpm = gallons per minute.

ID = identification.

min = minutes.

NTU = nephelometric turbidity unit.

2.2.1 Well 299-W6-17 (C9738)

Borehole C9738 was drilled from February 21, 2019 through April 3, 2019 to a TD of 489.0 ft bgs. The borehole was drilled using 11 3/4-in. diameter threaded carbon steel casing to a depth of 150.0 ft bgs and 9 5/8-in. diameter threaded carbon steel casing to a depth of 466.4 ft bgs. Drilling continued with the inner drill rods with a 6 1/4-in. bit to a TD of 489.0 ft bgs. Approximately 85 gallons of water was added to the borehole during drilling operations in the vadose zone to aid in advancement of the borehole and provide dust suppression.

Eleven groundwater samples were collected and are summarized in Table 2-3. The last groundwater sample was collected during the final interval of well development.

Following placement of the 11 3/4-in. temporary casing, the borehole was logged by Bay West using SGLS and NMLS. SGLS logging occurred on February 28, 2019 and March 4, 2019 from ground surface to 146.0 ft bgs, and NMLS logging occurred on March 4, 2019 from ground surface to 147.0 ft bgs. Following placement of 9 5/8-in. temporary casing, the borehole was logged using SGLS on April 8, and April 9, 2019 from 145.0 to 468.01 and NMLS on April 9, 2019 from 146.0 to 300.0 ft bgs.

A borehole straightness test was successfully performed on April 24, 2019. Well construction took place from April 18, 2019 through June 6, 2019. The well was constructed as a 4-in. nominal diameter well with 421.80 ft of stainless steel blank casing, 20.05 ft of 20-slot (0.020-in.) screen, and a 2.98 ft sump with end cap. The well was placed at 442.83 ft bgs, extending 2.00 feet above ground surface. Stainless steel centralizers were installed above and below the screen every 40 ft. From TD to surface, the annulus was filled with 16.6-ft of natural fill, 26.5-ft interval of uncoated bentonite pellets, 29.1-ft interval of 12-20 mesh sand, 111.6-ft interval of 1/4-in. bentonite pellets, 295.6-ft interval of 3/8-in. medium bentonite crumbles, and 9.6-ft interval of cement grout. All temporary casing was removed during well construction. The protective casing was installed on June 6, 2019. Well construction information is summarized in Table 2-1 and documentation is provided in Appendix A.

Well development occurred from May 20, 2019 through May 21, 2019 using a 1.5-hp Grundfos submersible pump. Static water level was measured before well development at 300.4 ft bgs on May 20, 2019. Well development is summarized in Table 2-2.

Table 2-3. C9738 Groundwater Sample Collection Summary

Date	Sample Interval	Sample Depth (ft bgs)	Sample Method	Pump Rate (gpm)	Volume Purged (gallons)[a]	Turbidity (NTU)	D.O. at Sample Collection (mg/L)	HEIS Number
03/13/2019	I-001	311.3	Submersible Pump	5	663	16.2	9.99	B3ND77, B3ND78, B3ND79, B3ND80, B3ND81, B3ND82

Table 2-3. C9738 Groundwater Sample Collection Summary

Date	Sample Interval	Sample Depth (ft bgs)	Sample Method	Pump Rate (gpm)	Volume Purged (gallons)[a]	Turbidity (NTU)	D.O. at Sample Collection (mg/L)	HEIS Number
03/18/2019	I-002	331.4	Submersible Pump	11	611	4.73	11.26	B3ND83, B3ND84, B3ND85, B3ND86, B3ND87, B3ND88
03/19/2019	I-003	350.9	Submersible Pump	9	628	9.75	10.00	B3ND91, B3ND92, B3ND93, B3ND94, B3ND95, B3ND96
03/20/2019	I-004	371.3	Submersible Pump	9	564	7.77	9.28	B3ND97, B3ND98, B3ND99, B3NDB0, B3NDB1, B3NDB2, B6NDB3, B3NDB4, B3NDB5, B3NDB6, B3NDB7
03/21/2019	I-005	391.2	Submersible Pump	11	900	6.19	9.12	B3NDB9, B3NDC0, B3NDC1, B3NDC2, B3NDC3, B3NDC4
03/25/2019	I-006	411.4	Submersible Pump	10	1,179	2.90	7.95	B3NDC5, B3NDC6, B3NDC7, B3NDC8, B3NDC9, B3NDD0
03/26/2019	I-007	431.3	Submersible Pump	9	1,191	7.19	7.28	B3NDD1, B3NDD2, B3NDD3, B3NDD4, B3NDD5, B3NDD6

Table 2-3. C9738 Groundwater Sample Collection Summary

Date	Sample Interval	Sample Depth (ft bgs)	Sample Method	Pump Rate (gpm)	Volume Purged (gallons)[a]	Turbidity (NTU)	D.O. at Sample Collection (mg/L)	HEIS Number
04/01/2019	I-008	451.3	Submersible Pump	10	983	8.66	5.53	B3NDD7, B3NDD8, B3NDD9, B3NDF0, B3NDF1, B3NDF2
04/03/2019	I-009	466.4	Submersible Pump	11	1,371	8.59	6.45	B3NDF3, B3NDF4, B3NDF5, B3NDF6, B3NDF7, B3NDF8
4/04/2019	I-010	479.0	Submersible Pump	10	1,432	11.5	6.19	B3NDF9, B3NDH0, B3NDH1, B3NDH2, B3NDH3, B3NDH4
5/21/2019	Post Development	437.2[b]	Submersible Pump	16	2,048	3.80	7.28	B3NDK3, B3NDK4, B3NDK5, B3NDK6, B3NDK7

a. Total gallons pumped calculated based on duration and average flow rate unless otherwise noted.

b. Sample collected during last well development interval.

D.O. = dissolved oxygen.

ft bgs = feet below ground surface.

gpm = gallons per minute.

HEIS = *Hanford Environmental Information System*.

mg/L = milligrams per liter.

NTU = nephelometric turbidity unit.

2.2.2 Well 699-44-70B (C9740)

Borehole C9740 was drilled from April 8, 2019 through May 14, 2019 to a TD of 510.7 ft bgs. The borehole was drilled using 11 3/4-in. diameter threaded carbon steel casing to a depth of 163.7 ft bgs, 9 5/8-in. diameter threaded carbon steel casing to a depth of 360.9 ft bgs, 7 5/8-in. diameter threaded carbon steel casing to a depth of 501.0 ft bgs, and inner drill rods with a 6 1/2-in. bit to a TD of 510.7 ft bgs. Approximately 60 gallons of water was added to the borehole during drilling operations in the vadose zone to aid in the advancement of the borehole and provide dust suppression.

Eight groundwater samples were collected and are summarized in Table 2-4. One waste sample was collected and is summarized in Table 2-5. The last groundwater sample was collected during the final interval of well development. One waste sample was collected on April 17, 2019 with HEIS number B3ND76.

Following placement of the 11 3/4-in. temporary casing, the borehole was logged by Bay West using SGLS and NMLS. SGLS logging occurred on April 10, 2019 from ground surface to 162.0 ft bgs, and NMLS logging occurred on April 10, 2019 from ground surface to 163.0 ft bgs. Following placement of the 9 5/8-in. temporary casing the borehole was logged using SGLS on April 23, 2019 from 159.0 to 360.0 ft bgs, and NMLS logging occurred on April 24, 2019 from 159.0 to 325.0 ft bgs. Following placement of the 7 5/8-in. temporary casing the borehole was logged using SGLS on May 16, 2019 from 349.0 to 498.0 ft bgs.

A borehole straightness test was successfully performed on May 30, 2019. Well construction took place from May 29, 2019 through June 27, 2019. The well was constructed as a 4-in. nominal diameter well with, 402.63 ft of stainless steel blank casing, 20.03 ft of 20-slot (0.020-in.) screen, and a 2.98 ft sump with end cap. The well was placed at 423.25 ft bgs, extending 2.39 feet above ground surface. Stainless steel centralizers were installed above and below the screen every 40 ft. From TD to surface, the annulus was filled with a 0.6 ft of natural fill, 84.0-ft interval of 1/4-in. bentonite pellets, 30.6-ft interval of 12-20 mesh sand, 78.8-ft interval of 1/4-in. bentonite pellets, 307.1-ft interval of 3/8-in. bentonite crumbles, and 9.6-ft interval of cement grout. All temporary casing was removed during well construction. The protective casing was installed on July 1, 2019. Well construction information is summarized in Table 2-1 and documentation is provided in Appendix B.

Well development occurred from June 10, 2019 through June 11, 2019 using a 1.5-hp Grundfos submersible pump. Well development information is summarized in Table 2-2. Static water level was measured before well development at 323.4 ft bgs on June 10, 2019.

Table 2-4. C9740 Groundwater Sample Collection Summary

Date	Sample Interval	Sample Depth (ft bgs)	Sample Method	Pump Rate (gpm)	Volume Purged (gallons)[a]	Turbidity (NTU)	D.O. at Sample Collection (mg/L)	HEIS Number
04/18/2019	I-001	340.2	Submersible Pump	3	324	8.40	10.28	B3NCY8, B3NCY9, B3ND00, B3ND01, B3ND02, B3ND03

Table 2-4. C9740 Groundwater Sample Collection Summary

Date	Sample Interval	Sample Depth (ft bgs)	Sample Method	Pump Rate (gpm)	Volume Purged (gallons)[a]	Turbidity (NTU)	D.O. at Sample Collection (mg/L)	HEIS Number
04/29/2019	I-002	396.5	Submersible Pump	4	825	8.28	9.21	B3ND04, B3ND05, B3ND06, B3ND07, B3ND08, B3ND09
05/01/2019	I-003	416.5	Submersible Pump	4	1,010	19.7	7.90	B3ND10, B3ND11, B3ND12, B3ND13, B3ND14, B3ND15
05/07/2019	I-004	436.6	Submersible Pump	3	555	42.3	8.00	B3ND16, B3ND17, B3ND18, B3ND19, B3ND20, B3ND21, B3ND22, B3ND23, B3ND24, B3ND25, B3ND26
05/08/2019	I-005	457.0	Submersible Pump	3	684	101	6.41	B3ND27, B3ND28, B3ND29, B3ND30, B3ND31, B3ND32
05/13/2019	I-006	476.6	Submersible Pump	10	1,820	38.3	8.05	B3ND33, B3ND34, B3ND35, B3ND36, B3ND37, B3ND38
05/14/2019	I-007	496.5	Submersible Pump	10	1,375	8.69	8.89	B3ND41, B3ND42, B3ND43, B3ND44, B3ND45, B3ND46

Table 2-4. C9740 Groundwater Sample Collection Summary

Date	Sample Interval	Sample Depth (ft bgs)	Sample Method	Pump Rate (gpm)	Volume Purged (gallons)[a]	Turbidity (NTU)	D.O. at Sample Collection (mg/L)	HEIS Number
06/11/2019	Post Development	413.3[b]	Submersible Pump	12	1,608	9.01	7.32	B3ND71, B3ND72, B3ND73, B3ND74, B3ND75

a. Total gallons pumped calculated based on duration and average flow rate unless otherwise noted.

b. Sample collected during last well development interval.

D.O. = dissolved oxygen.

ft bgs = feet below ground surface.

gpm = gallons per minute.

HEIS = *Hanford Environmental Information System*.

mg/L = milligrams per liter.

NTU = nephelometric turbidity unit.

Table 2-5. C9740 Waste Characterization Sample Collection Summary

Date	Sample Depth (ft bgs)	Sample Method	Media	HEIS Number
04/17/2019	338.0	Grab	Soil	B3ND76

ft bgs = feet below ground surface.

HEIS = *Hanford Environmental Information System*.

2.2.3 Well 699-46-61 (C9936)

Borehole C9936 was drilled from February 20, 2019 through March 18, 2019 to a TD of 356.0 ft bgs. The borehole was drilled using 11 3/4-in. diameter threaded carbon steel casing to a depth of 151.0 ft bgs and 9 5/8-in. diameter welded carbon steel casing to a depth of 341.1 ft bgs and inner drill rods with a 8 1/2-in. bit to a TD of 356.0 ft bgs.

Four groundwater samples were collected and are summarized in Table 2-6. One waste sample was collected and is summarized in Table 2-7. The last groundwater sample was collected post well development.

Following placement of the 11 3/4-in. temporary casing, the borehole was logged by Bay West using SGLS and NMLS. SGLS logging occurred on February 27, 2019 from ground surface to 149.0 ft bgs, and NMLS logging occurred on February 28, 2019 from ground surface to 151.3 ft bgs. Following the placement of the 9 5/8-in. temporary casing the borehole was logged using SGLS on March 20, 2019 through March 21, 2019 from 148.0 to 342.0 ft bgs, and NMLS logging occurred on March 21, 2019 from 150.0 to 292.0 ft bgs.

A borehole straightness test was successfully performed on April 8, 2019. Well construction took place from April 4, 2019 through April 23, 2019. The well was constructed as a 4-in. nominal diameter well with 296.19 ft of stainless steel blank casing, 17.30 ft of 20-slot (0.020-in.) screen, and a 2.98 ft sump with end cap. The well was placed at 317.22 ft bgs, extending 2.25 feet above ground surface. Stainless steel centralizers were installed above and below the screen every 40 ft. From TD to surface, the annulus was filled with a 35.1-ft interval of 3/8-in. medium bentonite chips, 3.1-ft interval of 1/4-in. bentonite pellets, 27.2-ft interval of 12-20 mesh sand, 1.0-ft interval of 1/4-in. bentonite pellets, 278.8-ft interval of 3/8-in. medium bentonite chips, 1.0-ft interval of cement grout, 5.9-ft interval of 3/8-in. medium bentonite chips, and 3.9-ft interval of cement grout. All temporary casing was removed during well construction. The protective casing was installed on April 22, 2019. Well construction information is summarized in Table 2-1 and documentation is provided in Appendix C.

Well development occurred on April 25, 2019 using a 1.5-hp Grundfos submersible pump. Well development information is summarized in Table 2-2. Static water level was measured before well development at 292.5 ft bgs on April 25, 2019.

Table 2-6. C9936 Groundwater Sample Collection Summary

Date	Sample Interval	Sample Depth (ft bgs)	Sample Method	Pump Rate (gpm)	Volume Purged (gallons)[a]	Turbidity (NTU)	D.O. at Sample Collection (mg/L)	HEIS Number
03/07/2019	I-001	301.4	Submersible Pump	10	1,010	5.72	10.86	B3NDP9, B3NDR0, B3NDR1, B3NDR2, B3NDR3, B3NDR4
03/13/2019	I-002	322.0	Submersible Pump	11	721	7.56	11.36	B3NDR5, B3NDR6, B3NDR7, B3NDR8, B3NDR9, B3NDT0, B3NDT1, B3NDT2, B3NDT3, B3NDT4, B3NDT5
03/18/2019	I-003	341.1	Submersible Pump	11	594	8.30	9.29	B3NDT9, B3NDV0, B3NDV1, B3NDV2, B3NDV3, B3NDV4

Table 2-6. C9936 Groundwater Sample Collection Summary

Date	Sample Interval	Sample Depth (ft bgs)	Sample Method	Pump Rate (gpm)	Volume Purged (gallons)[a]	Turbidity (NTU)	D.O. at Sample Collection (mg/L)	HEIS Number
04/25/2019	Post Development	302.7[b]	Submersible Pump	13.6	1,697	3.79	10.37	B3NDX9, B3NDY0, B3NDY1, B3NDY2, B3NDY3
				6.4				

a. Total gallons pumped calculated based on duration and average flow rate unless otherwise noted.

b. Sample collected post well development.

D.O. = dissolved oxygen.

ft bgs = feet below ground surface.

gpm = gallons per minute.

HEIS = *Hanford Environmental Information System*.

mg/L = milligrams per liter.

NTU = nephelometric turbidity unit.

Table 2-7. C9936 Waste Characterization Sample Collection Summary

Date	Sample Depth (ft bgs)	Sample Method	Media	HEIS Number
03/14/2019	326.0	Grab	Soil	B3NDY4

ft bgs = feet below ground surface.

HEIS = *Hanford Environmental Information System*.

3 Geologic Observations

This section summarizes the general geology in the 200 West Area near the new well locations, and presents the stratigraphy encountered during the drilling of each well.

3.1 Geology of the 200-ZP-1 Operable Unit

The major stratigraphic units encountered during drilling in the 200-ZP-1 OU are sand and gravel of the Hanford formation and/or surficial deposits, sand and silty sand of the Cold Creek unit (CCU), sand and gravel of the Ringold Formation, member of the Wooded Island - unit E (Rwie), clay and silt of the Ringold Formation, member of Wooded Island - lower mud unit (RLM), sand and gravel of Ringold Formation, member of the Wooded Island - unit A (Rwia), and basalt of the Columbia River Basalt Group.

Holocene eolian deposits at the surface are considered recent deposits and are present across most of the Hanford Site. These deposits consist of a discontinuous veneer of silty sand or backfill mixtures of sand and gravel. The Hanford formation underlies any anthropogenically-disturbed sediment and largely consists of cataclysmic flood deposits related to episodic ice dam failures at glacial Lake Missoula that resulted in varying grain size from high-energy gravel rich deposits to low-energy silts and sands. Floodwaters scoured hundreds of miles of the Columbia River Flood basalts, resulting in sediments predominately composed of sandy gravel or gravelly sand lithology, and occasionally finer lithology formed from slackwater facies. The sand fraction consists of loose, fine-to-course-grained sand, composed of, on average, 50% mafic-rich minerals and 50% silicates. This gives many of the Hanford formation sediments a “salt and pepper” appearance (DOE/RL-2002-39, *Standardized Stratigraphic Nomenclature for Post-Ringold Formation Sediments Within the Central Pasco Basin*).

The CCU disconformably underlies the Hanford formation within the area. The CCU is generally fine-grained calcareous sediments and represent mainstream alluvial, calcic paleosol, side stream alluvial, colluvial, and overbank-aeolian environments.

Disconformably underlying the CCU is the Ringold Formation. The Ringold Formation, in the project area, comprises the deepest portion of the sedimentary sequence and consists of (in descending order): semi consolidated fluvial silt, sand, and mostly gravels of Rwie; paleosol and lacustrine clay and silt of the RLM; and quartz-feldspar-lithic gravel, sand, and paleosols of the basal Rwia. The RLM underlies sediments of the Rwie and consists of fluvial overbank sediments, paleosols, lacustrine silt and clay deposits, and minor sand and gravel lenses. The RLM extends under the south, west, and central portion of the 200 West Area. However, the RLM is eroded away along the northern border of the 200 West Area and is absent in a north-south oriented channel extending from the coal plant to the northeast corner of the 200 West Area. The RLM is the base of the unconfined aquifer and was only encountered at C9740. The Rwia underlies sediments of the RLM in various thicknesses and extends to the top of the Columbia River Basalt Group.

Underlying the 200-ZP-1 OU is the Elephant Mountain Member of the Saddle Mountains Basalt. The uppermost surface of the Elephant Mountain Member basalt is considered the base of the suprabasalt aquifer system (bedrock) because of its low permeability relative to the overlying sediments.

3.2 Borehole Geology

The following discussion focuses on the geologic conditions encountered at individual boreholes. Copies of the original borehole logs are presented in Appendices A, B, and C.

Stratigraphic unit contacts included in this document are based on field drill cuttings examination (i.e., lithology, texture, color, reaction to 10% dilute hydrochloric acid [HCl], etc.) and drilling observations (i.e., drill rate) in the field. As such, the unit contacts included herein should not be considered final. It should be noted that geologic field descriptions of Air Rotary drill cuttings may not be completely representative of the geologic formation due to sorting, crushing, and binding as the cuttings exit the borehole. Final stratigraphic unit contact depths will be determined during data review and will incorporate the field observations, borehole geophysical logging information, and regional stratigraphic interpretations. The basis for the field stratigraphic unit contacts is included in the individual borehole summaries below.

3.2.1 Borehole Geology for C9738 (299-W6-17)

Stratigraphic units encountered during drilling of C9738 were the Hanford formation, CCU, Rwie, and basalt. Recovered sediments from C9738 are primarily sand, sandy gravel, gravel, and gravelly sand.

The sediments encountered from ground surface to 95.0 ft bgs consist of Hanford formation sand, sandy gravel, gravel, and gravelly sand. Sand is present from ground surface to 10.0 ft bgs with sandy gravel present from 10.0 to 20.0 ft bgs. The sand is composed of 95% sand and 5% silt. Sandy gravel present from 10.0 to 20.0 ft bgs contains 30 to 75% gravel, 20 to 65% sand, and 5% silt. Sand content in the sediment decreases at 20.0 ft bgs and gravel is present until 40.0 ft bgs. The gravel consists of 90% gravel, 5% sand, and 5% silt. At 40.0 ft bgs alternating layers of sand and sandy gravel are present until 80.0 ft bgs. Sand is present from 40.0 to 55.0 ft bgs and 60.0 to 70.0 ft bgs with sandy gravel encountered from 55.0 to 60.0 ft bgs and 70.0 to 80.0 ft bgs. The sand layers are composed of 90 to 95% sand, 5 to 10% gravel, and up to 5% silt. The sandy gravel layers encountered from 55.0 to 60.0 ft bgs and 70.0 to 80.0 ft bgs are composed of 30 to 40% gravel, 60 to 65% sand, and up to 5% silt. At 80.0 ft bgs gravelly sand is encountered and is present until 95.0 ft bgs. The gravelly sand is composed of 25% gravel and 75% sand. The gravels within the Hanford formation are moderately sorted, subangular to subround clasts ranging from very fine to very coarse pebbles with occasional small cobbles encountered from 40.0 to 80.0 ft bgs. The gravels are 90% mafic in composition decreasing with depth to 50% mafic in composition at 80.0 ft bgs. The sands within the Hanford formation are moderately sorted, very fine to fine grained, consisting of 95% mafic grains that decrease with depth to 50% mafic grains at 55.0 ft bgs. The Hanford formation sediments have no reaction to HCl and are predominantly olive brown (2.5Y 4/3) to dark olive brown (2.5Y 3/3) in color.

The Hanford formation to CCU contact is interpreted to be at 95.0 ft bgs where there is an increase of silt and carbonate cementation. The CCU extends to 145.0 ft bgs and consists of sand, silty sand, and sandy silt. The sediments in the CCU displayed a weak to HCl and are predominately olive brown (2.5Y 4/3) in color. Sand is present from 95.0 to 115.0 ft bgs and contains trace gravels and up to 5% silt. The silt content increases with depth and silty sand is encountered from 115.0 to 125.0 ft bgs. The silty sand is composed of 60% sand and 40% silt. The silt in the sediment increases to 75% at 125.0 ft bgs and sandy silt is present until 145.0 ft bgs. The sand grains within the CCU are moderately to well sorted, very fine to coarse grained with 25% mafic grains increasing to 60% mafic grains at 125.0 ft bgs. The silt within the CCU has a medium plasticity.

The CCU to Rwie contact is interpreted to be at 145.0 ft bgs where there is no longer carbonate cementation and the sediments have no reaction to HCl. Slightly silty sand is present from 145.0 to 150.0 ft bgs. The slightly silty sand is composed of 5% gravel, 80% sand, and 15% silt and is dark olive brown (2.5Y 3/3) in color. The gravel increases at 150.0 ft bgs and gravelly silty sand is present until 155.0 bgs. The gravelly silty sand is made up of 10% gravel, 60% sand, and 30% silt and is light olive brown (2.5Y 5/4) in color. Sandy gravel is encountered at 155.0 ft bgs and continues to 160.0 ft bgs. The

sandy gravel is made up of 30% gravel, 60% sand and 10% silt. At 160.0 ft bgs gravelly sand is present until 175.0 ft bgs. The gravelly sand is composed of 20 to 25% gravel, 70 to 75% sand, 5 to 10% silt, and is olive brown (2.5Y 4/3) to light olive brown (2.5Y 5/4) in color. Gravel in the sediment increases at 175.0 ft bgs and gravel is present until 190.0 ft bgs. The gravel contains 15 to 20% sand and up to 5% silt. The gravel is olive brown (2.5Y 4/3) in color. From 190.0 to 210.0 ft bgs sandy gravel is present and consists of 75% gravel, 25% sand and trace silt. The sandy gravel is light olive brown (2.5Y 5/4) in color. The gravels from 145.0 to 210.0 are poor to moderately sorted, subangular to round clasts ranging from very fine to very coarse pebbles that are 50 to 90% mafic in composition. The sands encountered in the sediments from 145.0 to 210.0 ft bgs are well to moderately sorted, very fine to very coarse grained, with 25 to 60% mafic grains. The silt encountered has a medium plasticity from 150.0 to 155.0 ft bgs.

From 210.0 to 305.0 ft bgs alternating layers of gravel and gravelly sand are present with two layers of sandy gravel encountered from 260.0 to 270.0 ft bgs and 290.0 to 295.0 ft bgs. The gravel is present from 210.0 to 215.0 ft bgs, 225.0 to 230.0 ft bgs, 240.0 to 260.0 ft bgs, 270.0 to 280.0 ft bgs, 285.0 to 290.0 ft bgs, and 295.0 to 305.0 ft bgs. The gravelly sand is present from 215.0 to 225.0 ft bgs, 230.0 to 240.0 ft bgs, and 280.0 to 285.0 ft bgs. The gravel is composed of 85 to 90% gravel, 5 to 10% sand, and up to 5% silt. The gravelly sand is composed of 15 to 25% gravel, 75 to 80% sand and up to 5% silt. The sandy gravel is composed of 45 to 70% gravel and 30% to 55% sand. The gravels encountered from 210.0 to 305.0 ft bgs are poorly to moderately sorted, subangular to round clasts, ranging from very fine to very coarse pebbles that are 40 to 50% mafic in composition. The sands encountered are moderately sorted, very fine to very coarse grained with 40 to 50% mafic grains. The sediments encountered from 210.0 to 305.0 ft bgs are light olive brown (2.5Y 5/4), olive brown (2.5Y 4/4), and dark olive brown (2.5Y 3/3) in color.

Silty gravel is encountered from 305.0 to 310.0 ft bgs and is composed of 70% gravel, 10% sand, and 20% silt. At 310.0 to 315.0 ft bgs sandy gravel is present and is composed of 75% gravel, 20% sand, and 5% silt. Gravel is encountered at 315.0 ft bgs until 325.0 ft bgs and is composed of 85 to 90% gravel, 10% sand and up to 5% silt. The silt content in the sediment increases at 325.0 ft bgs and silty sandy gravel is present until 330.0 ft bgs and is composed of 40% gravel, 45% sand, and 15% silt. From 330.0 to 335.0 ft bgs gravel is present and contains 10% sand and 5% silt. The sand content in the sediment increases at 335.0 ft bgs and sandy gravel is present until 355.0 ft bgs. The sandy gravel is composed of 60 to 79% gravel and 21 to 40% sand. The gravels encountered from 305.0 to 355.0 ft bgs are moderately sorted, subangular to subround clasts, ranging from very fine to very coarse pebbles with occasional small cobbles encountered from 315.0 to 355.0 ft bgs. The gravels are 20 to 40% mafic in composition. Sands encountered from 305.0 to 355.0 ft bgs are poorly to moderately sorted, very fine to very coarse grained, with 25 to 40% mafic grains. The sediments encountered from 305.0 to 355.0 ft bgs are olive brown (2.5Y 4/4), and light olive brown (2.5Y 5/3) in color.

Gravel is encountered from 355.0 to 479.0 ft bgs and contains 5 to 10% sand and up to 5% silt. The gravel is moderately sorted, subround to round clasts ranging from very fine to very coarse pebbles with occasional small cobbles that are 25 to 95% mafic in composition. The sand fraction is moderately sorted, coarse to very coarse grained with 25to 95% mafic grains. As the mafic content in the gravel increases with depth the gravel changes from dark olive brown (2.5Y 3/3) in color at 435.0 ft bgs to very dark grayish brown (2.5Y 3/2), to dark olive brown (2.5Y 3/3) at 450.0 ft bgs, to olive gray (2.5Y 4/2) at 465.0 ft bgs, to dark olive gray (2.5Y 3/2) at 470.0 ft bgs, to very dark gray (2.5Y 3/1) at 475.0 ft bgs.

The basalt was encountered at 479.0 ft bgs. The basalt showed blue/green clay-like weathering and trace vesicles. The basalt is black (2.5Y 5/1) in color and drilling continued in the basalt until TD was reached at 489.0 ft bgs.

3.2.2 Borehole Geology for C9740 (699-44-70B)

Stratigraphic units encountered during drilling of C9740 were the Hanford formation, CCU, Rwie, RLM, and basalt. Recovered sediments from C9740 are primarily gravel, gravelly sand, sandy gravel, and sand.

The sediments encountered from ground surface to 75.0 ft bgs consist of Hanford formation silty gravel, gravel, gravelly sand, and sandy gravel. Silty gravel is present from ground surface to 15.0 ft bgs with gravel present from 15.0 to 20.0 ft bgs. The silty gravel is composed of 75% gravel, 10% sand, and 15% silt. Gravel present from 15.0 to 20.0 ft bgs contains 10% sand and 5% silt. Alternating layers of gravelly sand and sandy gravel are present from 20.0 to 75.0 ft bgs. Gravelly sand is present from 20.0 to 25.0 ft bgs and 30.0 to 55.0 ft bgs. The sandy gravel is present from 25.0 to 30.0 ft bgs, and 55.0 to 75.0 ft bgs. The gravelly sand is composed of 10 to 20% gravel, 70 to 85% sand, and 5 to 10% silt. The sandy gravel is composed of 35 to 40% gravel, 50 to 65% sand, and up to 10% silt. The gravels in the Hanford formation are poorly to moderately sorted, angular to subround clasts, ranging from very fine to coarse pebbles that are 50 to 75% mafic in composition. The sands within the Hanford formation are moderately sorted, very fine to very coarse grained, and are 25 to 75% mafic in composition. Sediments in the Hanford formation are olive brown (2.5Y 4/3), dark grayish brown (2.5Y 4/2), and olive gray (5Y 5/2) in color.

The Hanford formation to CCU contact is interpreted to be at 75.0 ft bgs where there is an increase of silt and carbonate cementation. The CCU extends to 200.0 ft bgs and consists of alternating layers of sand and slightly silty sand. The CCU sediments displayed a strong reaction to HCl. Sand is present from 75.0 to 80.0 ft bgs, 90.0 to 115.0 ft bgs, 120.0 to 125.0 ft bgs, and 130.0 to 195.0 ft bgs. Slightly silty sand is present from 80.0 to 90.0 ft bgs, 115.0 to 120.0 ft bgs, 125.0 to 130.0 ft bgs, and 195.0 to 205.0 ft bgs. The sand present from 75.0 to 80.0 ft bgs is composed of trace gravel, 90% sand, and 10% silt. The slightly silty sand present from 80.0 to 90.0 ft bgs is composed of 80% sand, and 20% silt. The sand present from 90.0 to 115.0 ft bgs is composed of up to 5% gravel, 90 to 95% sand, and 5% silt. The slightly silty sand present from 115.0 to 120.0 ft bgs is composed of 5% gravel, 84% sand, and 11% silt. The sand present from 120.0 to 125.0 ft bgs is composed of 95% sand, and 5% silt. The slightly silty sand present from 125.0 to 130.0 ft bgs is composed of 89% sand, and 11% silt. The sand present from 130.0 to 195.0 ft bgs is composed of up to 9% gravel, 91 to 95% sand, and up to 5% silt. The slightly silty sand encountered at 195.0 ft bgs is composed of 87% sand, and 13% silt. The gravels encountered within the CCU are moderately to well sorted, angular to subangular clasts, ranging from very fine to medium pebbles that are 10 to 50% mafic in composition. The sands encountered within the CCU are moderately to well sorted, very fine to medium grained, and are 50 to 65% mafic in composition. The silt within the CCU displayed a low to medium plasticity. The CCU sediments are yellowish brown (2.5Y 6/4), light yellowish brown (2.5Y 6/4), light olive brown (2.5Y 5/4), and grayish brown (2.5Y 5/2) in color.

The CCU to Rwie contact is interpreted to be at 200.0 ft bgs where organic remnants were encountered. The slightly silty sand continues to 205.0 ft bgs where silty sand is present. The silty sand is composed of trace gravel, 75% sand, and 25% silt. The silty sand continues to 210.0 ft bgs where there is an increase in gravel and gravelly silty sand is encountered. The gravelly silty sand extends to 215.0 ft bgs and is composed of 10% gravel, 60% sand, and 30% silt. From 215.0 to 225.0 ft bgs silty sand is present and is composed of trace gravels, 60% sand, and 40% silt. As gravel increases and silt decreases at 225.0 ft bgs, slightly silty gravelly sand is present until 240.0 ft bgs. The slightly silty gravelly sand is composed of 10 to 20% gravel, 65 to 70% sand, and 15 to 20% silt. As silt continues to decrease with depth, gravelly sand is encountered 240.0 ft bgs and continues to 250.0 ft bgs. The gravelly sand is composed of 10 to 15% gravel, 80 to 85% sand, and 5% silt. Gravel percentage in the sediment continues to increase with depth and sandy gravel is encountered from 250.0 to 255.0 ft bgs and gravel is present from 255.0 to 345.0 ft bgs. The sandy gravel is composed of 35% gravel, 65% sand, trace silt and is olive brown (2.5Y 4/4) in

color. The gravel present from 255.0 to 345.0 ft bgs is composed of 80 to 95% gravel, 5 to 15% sand, and up to 10% silt. The gravels encountered within the Rwie are poorly to moderately sorted, subangular to round clasts, ranging from very fine to very coarse pebbles with occasional small cobbles encountered from 255.0 to 345.0 ft bgs. The gravels are 60% mafic in composition decreasing to 10% to 25% mafic from 255.0 to 345.0 ft bgs. The sands encountered within the Rwie are well sorted, very fine to very coarse grained that are 60% mafic in composition decreaseing to 10 to 25% mafic in composition from 255.0 to 345.0 ft bgs. The Rwie sediments are light olive brown (2.5Y 5/4), olive brown (2.5Y 4/4), and light yellowish brown (2.5Y 6/3) in color.

The transition from the Rwie to RLM is interpreted to start at 345.0 ft bgs where there is an increase in silt and silty gravel is encountered. The silty gravel is composed of 60% gravel, 15% sand, 25% silt and is olive brown (2.5Y 4/4) in color. The gravel is moderately sorted, subround to round clasts ranging from very fine to very coarse pebbles that are 10% mafic in composition. The sand is well sorted very fine to coarse grained that is 25% mafic in composition. The silt is nonplastic and has no reaction to HCl. Sandy silt is present from 350.0 to 390.0 ft bgs and is composed of trace gravels, 30% sand, 70% silt that is light yellowish brown (2.5Y 6/3) in color. The sand is well sorted, very fine to medium grained that is 25% mafic in composition. The silt displays low to medium plasticity and is approximately 20% clay.

The transition from the RLM to the Rwia is interpreted to start at 390.0 ft bgs where silty gravel is encountered. The silty gravel is composed of 65% gravel, 15% sand, 20% silt and is olive gray (5Y 5/2) in color. The silt decreases at 395.0 ft bgs and silty sandy gravel is encountered. The silty sandy gravel is composed of 70% gravel, 15% sand, and 15% silt. The gravel percentage in the sediment increases with depth and gravel is encountered at 405.0 and continues to 497.0 ft bgs. The gravel is composed of 80 to 95% gravel, 5 to 10% sand, and up to 10% silt. The gravels within the Rwia are poorly to moderately sorted, subround to round clasts ranging from very fine to very coarse pebbles that are 10% mafic at 390.0 ft bgs and up to 98% mafic at 495.0 ft bgs. The sands within the Rwia are well sorted, very fine to very coarse grained with mafic content increasing from 40% at 390.0 ft bgs to 100% at 495.0 ft bgs. The silt encountered is nonplastic and has no reaction to HCl. The sediments of the Rwia are olive gray (5Y 5/2), light olive brown (2.5Y 5/3), and olive brown (2.5Y 4/4) in color.

Basalt is encountered at 497.0 ft bgs. The basalt is black (5Y 2.5/1) in color and competent with no apparent signs of weathering. The basalt was broken from drilling into angular, 3 to 14mm sized cuttings. Drilling in the basalt continued until TD was reached at 510.7 ft bgs.

3.2.3 Borehole Geology for C9936 (699-46-61)

Stratigraphic units encountered during drilling of C9936 were the Hanford formation and basalt. Recovered sediments from C9936 are primarily sand, sandy gravel, gravelly sand, and gravel.

The sediments encountered from ground surface to 345.0 ft bgs consist of Hanford formation sand, sandy gravel, gravelly sand, and gravel. Recovered sediments display a reaction to HCl from ground surface to 10.0 ft bgs, at 200.0 to 205.0 ft bgs, and once more at 235.0 to 240.0 ft bgs. Sand is present from ground surface to 10.0 ft bgs, consisting of 2% gravel, 88% sand, 10% silt and is olive brown in color (2.5Y 4/4). From 10.0 to 30.0 ft bgs sandy gravel is encountered and changes in color to a light olive brown (2.5Y 5/3). Within the sandy gravel present a gravelly sand interval is encountered from 15.0 to 20.0 ft bgs. The sandy gravel from 10.0 to 15.0 ft bgs and 20.0 to 30.0 ft bgs consists of 45% gravel, 50 to 52% sand, and 3 to 5% silt. The gravelly sand from 15.0 to 20.0 ft bgs decreases in gravel to 27%, increases to 70% sand and has 3% silt. Gravels encountered from ground surface to 30.0 ft bgs are moderately sorted, angular to subangular clasts, ranging from very fine to very coarse pebbles that are 75% to 90% mafic in composition. The sands encountered are moderately sorted, very fine to very coarse grained, with 70 to 75% mafic grains. All silt from ground surface to 30.0 ft bgs is non-plastic.

Gravel is encountered from 30.0 to 40.0 ft bgs, made up of 80% gravel, 20% sand, and trace amounts of silt and is light olive brown (2.5Y 5/3) in color. From 40.0 to 45.0 ft bgs, sand is present consisting of 5% gravel, 90% sand, and 5% silt. The sand from 40.0 to 45.0 ft bgs changes in color to an olive brown (2.5Y 4/3). From 45.0 to 65.0 ft bgs, sandy gravel is present and consists of 30% gravel, 70% sand, and trace silt. At 60.0 ft bgs, gravel increases and sand decreases, to 60 and 40%, respectively. The sandy gravel from 45.0 to 65.0 ft bgs changes to light olive brown in color (2.5Y 5/3). From 65.0 to 70.0 ft bgs, gravelly sand is encountered and consists of 10% gravel, 90% gravel, and trace silt. The color of the gravelly sand changed to light olive brown (2.5Y 5/4). Gravels encountered from 30.0 to 70.0 ft bgs are moderately to well sorted, angular to subangular clasts ranging from very fine to very coarse pebbles that are 50 to 90% mafic in composition. The sands encountered are moderately sorted, very fine to very coarse grained with 50 to 75% mafic grains.

Sand is encountered from 70.0 to 145.0 ft bgs and is light olive brown (2.5Y 5/4) in color. The sand is composed of 2 to 5% gravel, 95 to 98% sand and trace silt. The gravel fraction consists of poorly sorted, angular to sub-angular, very fine to very coarse pebbles. The composition of the gravel fraction remains 50% mafic all throughout the sand. Sand grains in the sand fraction are coarse on average and range from fine to very coarse. The sand is well-sorted, 50% mafic, and has angular to sub-angular grains. The gravel fraction becomes moderately sorted at 95.0 ft bgs and is well-sorted at 130.0 ft bgs within the sand interval. From 95.0 to 145.0 ft bgs, the gravel fraction ranges from very fine to fine with an occasional medium pebble. At 95.0 ft bgs the sand interval increased to 70% mafic in composition. The sand interval's composition slightly changed at 130.0 ft bgs to 2% gravel and 98% sand but returns to 5% gravel and 95% sand at 140.0ft bgs.

Sandy gravel is encountered from 145.0 to 250.0 ft bgs with a layer of gravelly sand from 190.0 to 195.0 ft bgs and a gravel interval from 205.0 to 210.0 ft bgs. The sandy gravel interval at 145.0 ft bgs consists of 40 to 60% gravel, 40 to 60% sand, and trace silt. From 190.0 ft bgs to 195.0 ft bgs, the gravelly sand consists of 15% gravel, 80% sand, and 5% silt. From 205.0 to 210.0 ft bgs the gravel interval consists of 90% gravel, 8% sand, and 2% silt. The sandy gravel from 195.0 to 205.0 ft bgs consists of 70% gravel, 25% sand, and 5% silt. From 210.0 to 235.0 ft bgs, the sandy gravel consists of 75% gravel, 25% sand and trace silt. The sandy gravel consists of 40% gravel, 60% sand and trace silt at 235.0 ft bgs and returns to 75% gravel, 25% sand and trace silt at 240.0 ft bgs. The gravels encountered from 145.0 to 250.0 ft bgs are moderately sorted, angular to subround clasts, ranging from very fine to coarse pebbles that are 50 to 60% mafic in composition. The sands encountered are moderate to well sorted, very fine to very coarse grained with 50% mafic grains. The recovered sediments from 195.0 to 250.0 ft bgs are dark grayish brown (2.5Y 4/2) in color.

From 250.0 to 255.0 ft bgs, gravelly sand is present, consisting of 10% gravel, 80% sand and 10% silt. The gravelly sand interval is olive brown (2.5Y 4/3) in color. From 255.0 to 260.0 sandy gravel is present and is dark grayish brown (2.5Y 4/2) in color. The sandy gravel consists of 50% gravel, 45% sand, and 5% silt. Alternating layers of gravel, gravelly sand, and sandy gravel are encountered from 260.0 to 345.0 ft bgs. From 260.0 to 280.0 gravel is present and consists of 80 to 90% gravel, 10 to 20% sand, and up to 5% silt. At 275.0 ft bgs the color changes to light olive brown (2.5Y 5/3). From 280.0 to 285.0 gravelly sand is encountered consisting of 10% gravel, 90% sand, and trace silt. The gravelly sand interval is light brownish gray (2.5Y 6/2). Gravel is encountered from 285.0 to 300.0 ft bgs and is light brownish gray (2.5Y 6/2) in color. The gravel ranges from of 90 to 95% gravel, 5 to 10% sand and up to 5% silt. From 300.0 to 340.0 ft bgs, sandy gravel is present and consists of 30% gravel, 70% sand, and trace silt. The sandy gravel is olive brown (2.5Y 4/3) in color. At 305.0 the sandy gravel changes to 75% gravel, 20% sand, and 5% silt. From 310.0 to 330 ft bgs, gravel ranges from 30 to 40%, sand ranges from 60 to 70% and trace silt is present. At 330.0 ft bgs, the sandy gravel consists of 70% gravel, 25% sand, and 5% silt. At 330.0 ft bgs the sandy gravel changes color to dark olive brown (2.5Y 3/3). The

gravels encountered from 250.0 to 340.0 ft bgs are moderately to well sorted, very fine to coarse pebbles that are 40 to 50% mafic in composition. The sands encountered are well sorted, angular to subangular grains that are 40 to 50% mafic in composition.

Gravel is encountered from 340.0 to 345.0 ft bgs and consists of 85% gravel, 15% sand, and trace silt. The gravel fraction is poorly sorted, very fine to coarse, angular to round pebbles and is 50% mafic in composition. The sand fraction is well sorted, angular to subangular, fine to very coarse grained, and 50% mafic in composition. Some basalt present and the color changes to dark grayish brown (2.5Y 4/2). Basalt is encountered at 345.0 ft bgs. The basalt is black (2.5Y 2.5/1) in color and shows no apparent weathering. The basalt was broken from drilling into angular, 4 to 30 mm sized cuttings. Drilling in the basalt continued until TD was reached at 356.0 ft bgs.

4 Waste Management

Waste generated during the activities described in this document were managed in accordance with DOE/RL-2009-124, *200 West Pump and Treat Operations and Maintenance Plan* (TPA-0794) (Appendix B, "Waste Management Plan for the 200 West Pump and Treat") and was characterized to the extent necessary to meet the requirements of 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*. Waste generated throughout performance of this project include drill cuttings from both the vadose zone and groundwater saturated zone, and miscellaneous solid waste such as sampling equipment, plastic, paper, and personal protective equipment.

All vadose zone drill cuttings from above the historic high water mark were placed on sheets of plastic to dry. Cuttings were surveyed by RCT and Industrial Hygiene personnel and were determined to meet Return to Earth criteria. These cuttings were then spread around the well location at the completion of well activities. Miscellaneous solid waste associated with vadose zone cuttings, including nitrile gloves, plastic bags, and other waste associated with sampling activities, were contained in black plastic bags and placed in the designated roll off box.

All drill cuttings collected at or below the water table were released into tip dumpsters, dewatered, and placed in designated waste roll off boxes. Dewatered fluid was treated as purgewater. Water-absorbing crystals were spread over the dewatered drill cuttings to absorb free liquids, allowing the waste container to be designated as solid waste. All waste was managed as investigation-derived waste and surveyed by RCTs and industrial hygiene personnel prior to transfer and disposal at the Environmental Restoration Disposal Facility.

Purgewater and decontamination fluids were collected and contained at the well head until it was transported to the Modular Storage Unit.

5 Civil Survey

The well locations were surveyed in accordance with applicable procedures. Vertical survey data were recorded using *North American Vertical Datum of 1988* (NAVD88) and the horizontal coordinates were recorded using the Washington State Plane (South Zone) *North American Datum of 1983* (NAD83), with the 1991 adjustment for horizontal coordinates. Surveyed coordinates and elevation for each well are presented in Table 1-1 and survey data reports are included in Appendices A, B, and C, for each respective well.

6 Well Acceptance

Well acceptance is the final step in the well construction process and represents confirmation of meeting requirements of the work scope. Well acceptance also serves as the contractual completion of the finished product.

Representatives from CHPRC and Yellow Jacket (drilling contractor) participated in the acceptance inspection for C9936 on May 2, 2019, and the inspection for C9738 and C9740 on July 11, 2019. Final well acceptance was documented by completion of a checklist and signatures from representatives of the drilling contractor and CHPRC. A Quality Assurance Work Site Assessment form was prepared for each well to document well acceptance.

7 References

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Appendix A

Well Documentation for C9738 (299-W6-17)

Contents

Well Summary Sheet ……..……..…..... A-1
Borehole Log ……...…….…. A-7
Drill Cutting Photographs …….....…….……..... A-20
Well Develepment and Testing Data ……..……....……...…....… A-31
Log Data Report …….....…..…..……....……...…....… A-32
Well Survey Data Report …….....…..…..……....……...…....… A-53

WELL SUMMARY SHEET

Well ID : C9738	Well Name: 299-W6-17	Start Date: 2/21/2019
Project: Install 3 Wells in 200-ZP-1 OU	Location: 600 m North of T-Plant	Finish Date: 6/6/2019

CONSTRUCTION DATA

Description

Concrete Pad: 0.5 ft above ground surface (ags)

6-in. Protective Casing: 3.00 ft ags - 2.00 ft below ground surface (bgs)

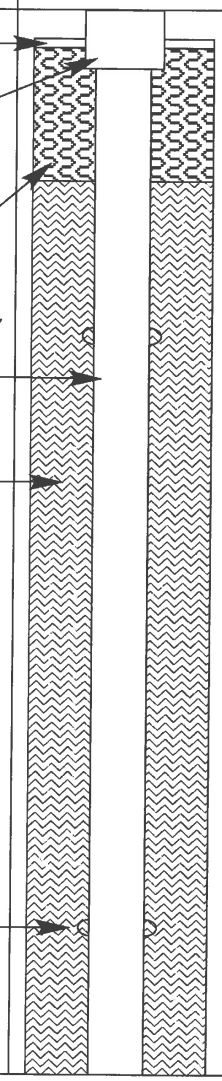
Type I/II Portland Cement Grout: 0.0 - 9.6 ft bgs

4-in. I.D. Schedule 10, Type 304/304L, Stainless Steel Blank Casing: 2.00 ft ags - 419.80 ft bgs

Medium Bentonite Crumbles: 9.6 - 305.2 ft bgs

Stainless steel centralizer installed above and below screen and every 40 ft

Diagram



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet: 0, 10, 20, 30, 40, 50, 60

Graphic Log

Lithologic Description (ft bgs)

0.0 - 10.0 Sand (S)

10.0 - 20.0 Sandy Gravel (sG)

20.0 - 40.0 Gravel (G)

40.0 - 55.0 Sand (S)

55.0 - 60.0 Sandy Gravel (sG)

60.0 - 70.0 Sand (S)

Reported By:			
Beth Morter	Geologist	Beth Morter	6/14/2019
Print Name	*Title*	*Signature*	*Date*

Reviewed By:			
Jennifer Richart	Well Coordinator	J Richart	6/26/19
Print Name	*Title*	*Signature*	*Date*

For Office Use Only

OR Doc Type:	WMU Code(s):

A-6003-643 (REV 2)

WELL SUMMARY CONTINUATION SHEET			Page 2 of 6
Well ID: C9738	Well Name: 299-W6-17	Project : Install 3 Wells in 200-ZP-1 OU	

CONSTRUCTION DATA			GEOLOGIC/HYDROLOGIC DATA	
Description	Diagram	Depth in Feet	Graphic Log	Lithologic Description (ft bgs)
4-in. I.D. Schedule 10, Type 304/304L, Stainless Steel Blank Casing: 2.00 ft ags - 419.80 ft bgs		70		60.0 - 70.0 Sand (S)
				70.0 - 80.0 Sandy Gravel (sG)
		80		80.0 - 95.0 Gravelly Sand (gS)
Medium Bentonite Crumbles: 9.6 - 305.2 ft bgs		90		
				95.0 - 115.0 Sand (S)
		100		
		110		
				115.0 - 125.0 Silty Sand (mS)
		120		
				125.0 - 145.0 Sandy Silt (sM)
		130		
		140		
				145.0 - 150.0 Slightly Silty Sand ((m)S)
		150		150.0 - 155.0 Gravelly Silty Sand (gmS)
				155.0 - 160.0 Sandy Gravel (sG)
		160		160.0 - 175.0 Gravelly Sand (gS)

WELL SUMMARY CONTINUATION SHEET

Well ID: C9738 | Well Name: 299-W6-17 | Project: Install 3 Wells in 200-ZP-1 OU

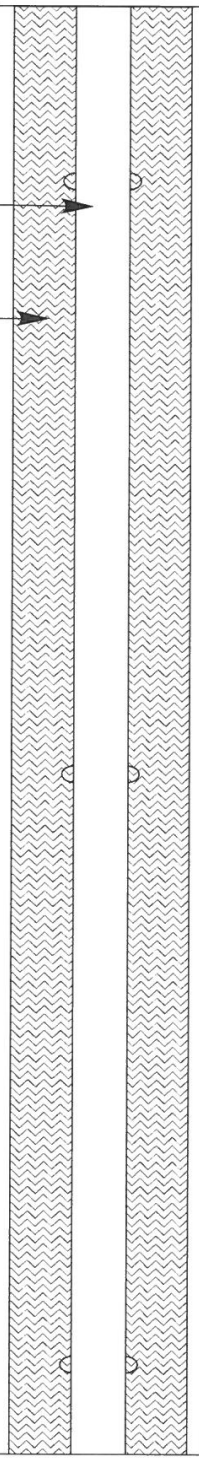
CONSTRUCTION DATA

Description

4-in. I.D. Schedule 10, Type 304/304L, Stainless Steel Blank Casing: 2.00 ft ags - 419.80 ft bgs

Medium Bentonite Crumbles: 9.6 - 305.2 ft bgs

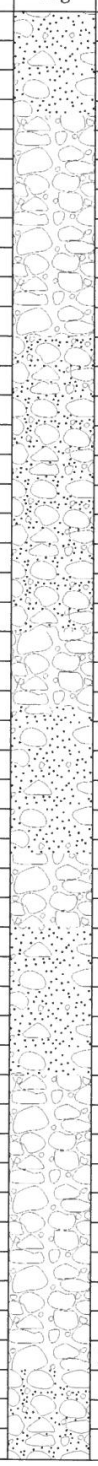
Diagram



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet: 170, 180, 190, 200, 210, 220, 230, 240, 250, 260

Graphic Log



Lithologic Description (ft bgs)

160.0 - 175.0 Gravelly Sand (gS)

175.0 - 190.0 Gravel (G)

190.0 - 210.0 Sandy Gravel (sG)

210.0 - 215.0 Gravel (G)

215.0 - 225.0 Gravelly Sand (gS)

225.0 - 230.0 Gravel (G)

230.0 - 240.0 Gravelly Sand (gS)

240.0 - 260.0 Gravel (G)

260.0 - 270.0 Sandy Gravel (sG)

WELL SUMMARY CONTINUATION SHEET

Well ID: C9738 | Well Name: 299-W6-17 | Project: Install 3 Wells in 200-ZP-1 OU

CONSTRUCTION DATA

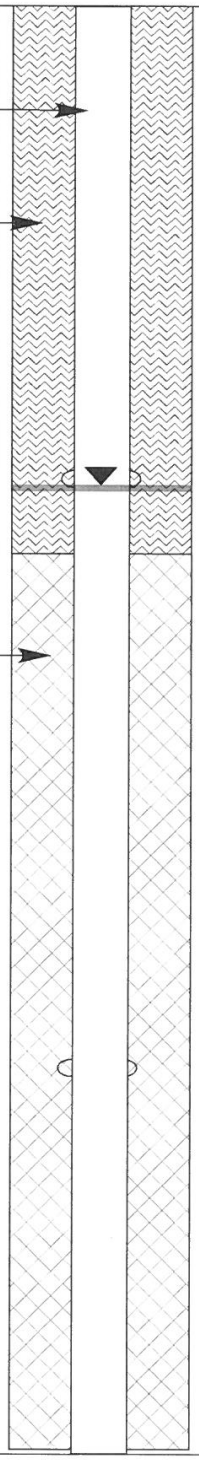
Description

4-in. I.D. Schedule 10, Type 304/304L, Stainless Steel Blank Casing: 2.00 ft ags - 419.80 ft bgs

Medium Bentonite Crumbles: 9.6 - 305.2 ft bgs

1/4-in. Coated Bentonite Pellet Seal: 305.2 - 416.8 ft bgs

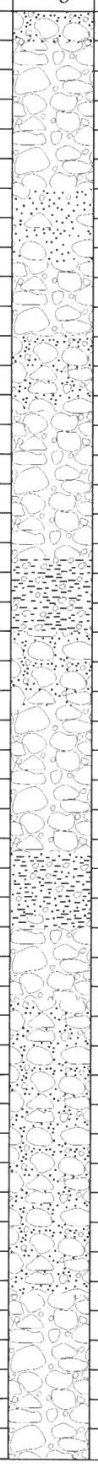
Diagram



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet: 270, 280, 290, 300, 310, 320, 330, 340, 350, 360

Graphic Log

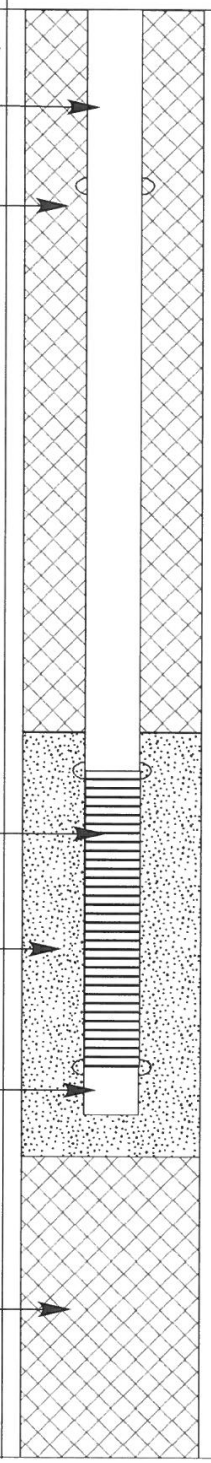


Lithologic Description (ft bgs)

- 260.0 - 270.0 Sandy Gravel (sG)
- 270.0 - 280.0 Gravel (G)
- 280.0 - 285.0 Gravelly Sand (gS)
- 285.0 - 290.0 Gravel (G)
- 290.0 - 295.0 Sandy Gravel (sG)
- 295.0 - 305.0 Gravel (G)
- Depth to Water: 300.6 (5/21/19)
- 305.0 - 310.0 Silty Gravel (mG)
- 310.0 - 315.0 Sandy Gravel (sG)
- 315.0 - 325.0 Gravel (G)
- 325.0 - 330.0 Silty Sandy Gravel (msG)
- 330.0 - 335.0 Gravel (G)
- 335.0 - 355.0 Sandy Gravel (sG)
- 355.0 - 479.0 Gravel (G)

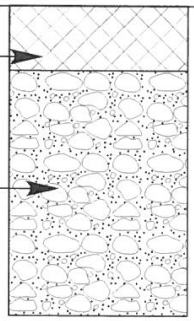
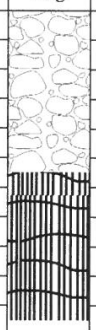
WELL SUMMARY CONTINUATION SHEET			Page 5 of 6
Well ID: C9738	Well Name: 299-W6-17	Project: Install 3 Wells in 200-ZP-1 OU	

CONSTRUCTION DATA		GEOLOGIC/HYDROLOGIC DATA		
Description	Diagram	Depth in Feet	Graphic Log	Lithologic Description (ft bgs)
4-in. I.D. Schedule 10, Type 304/304L, Stainless Steel Blank Casing: 2.00 ft ags - 419.80 ft bgs		370		355.0 - 479.0 Gravel (G)
1/4-in. Coated Bentonite Pellet Seal: 305.2 - 416.8 ft bgs		380		
		390		
		400		
		410		
4-in. I.D. Schedule 10, Type 304/304L, 20-slot (0.020 in.) Stainless Steel Screen: 419.80 - 439.85 ft bgs		420		
12-20 mesh Silica Filter Pack Sand: 416.8 - 445.9 ft bgs		430		
4-in. I.D. Schedule 10, Type 304/304L, Stainless Steel Sump: 439.85 - 442.83 ft bgs		440		
		450		
1/4-in. Uncoated Bentonite Pellets: 445.9 - 472.4 ft bgs		460		



WELL SUMMARY CONTINUATION SHEET

Well ID: C9738 | Well Name: 299-W6-17 | Project: Install 3 Wells in 200-ZP-1 OU

CONSTRUCTION DATA		Depth in Feet	GEOLOGIC/HYDROLOGIC DATA	
Description	Diagram		Graphic Log	Lithologic Description (ft bgs)
1/4-in. Uncoated Bentonite Pellets: 445.9 - 472.4 ft bgs		470		355.0 - 479.0 Gravel (G)
Natural Fill: 472.4 - 489.0 ft bgs		480		479.0 - 489.0 Basalt
		490		Total depth: 489.0 ft bgs (04/03/2019)

Straightness Test: Pass, 04/24/2019

Depths are in ft below ground surface.
Borehole drilled with 11 3/4-in. O.D. casing from 0.0 - 150.0 ft bgs
Borehole drilled with 9 5/8-in. O.D. casing from 150.0 - 466.4 ft bgs
Borehole drilled with 6 1/4-in. O.D. drill bit from 466.4 - 489.0 ft bgs
All temporary drill casing was removed from the ground.

BOREHOLE LOG

Page 1 of 13
Date: 2-21-19

Well ID: C9738 | Well Name: 299-W6-17 | Location: 600m North of T-Plant
Project: Installation of 3 monitoring wells in 200-ZP-1 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'-10': Sand (S) g=0%, s=95%, m=5%. S: VF-F sand, well sort, 5% Fel, 95% maf, moist, strong rxn HCl. 2.5y-3/3: Dark Olive brown, sub-ang to rnd. m: low-med plasticity.	0'-20' bgs 27-30 gal H_2O added Air Rotary Drilling with 11 3/4" OD/10 5/8" ID Temporary casing 0.0'-150.0' bgs, + 9 5/8" OD/8 1/2" ID 150.0-476.0.4' bgs + 8" OD. 6 1/4" tricone bit 476.4'-489.0' bgs. Grab samples collected every 5' or change in lithology.
5	G			
10	G		10'-20': Sandy Gravel (sG): g=30%, s=65%, m=5%. g: F-VC peb, Avg=11mm, max=20mm, mod sort, 10% Fel, 90% maf, sub-ang to rnd. S: VF-VC sand, poor sort, 10% Fel, 90% maf, sub-ang, moist, no rxn HCl, 2.5y 4/3-Olive bwn	
13			@13': g↑ 75%, s↓ 20%, m=5%. g: avg↑ 15mm, max↑ 25mm, Fel↓ 5%, maf↑ 95%. S: Med-VC sand, mod sort, wet.	
15	G			
20	G		20'-40': Gravel (G) g=90%, s=5%, m=5%. Gravel: V.F. peb-V. coarse peb. Avg=10mm, max=50mm, poor-mod sort, 10% fel + 90% mafic, sub-ang to sub-round. Sand: V.F. Sand-V. Coarse sand, mod-well sort, 10% Fel + 90% mafic, sub-ang, wet, + no rxn to HCl. 2.5y 4/3-Olive Brown.	
25	G		@25: g↑ 60mm max size.	
30	G		@30: g↑ Fine peb-V. Coarse peb, Avg size↑ 13mm, max↑ 80mm, + poor sort. S: ↑ coarse sand-V. coarse sand, ↑ well sort, weak rxn to HCl.	

Reported By:			
Lindsey Getchell (Print Name)	Geologist (Title)	Lindsey Getchell (Signature)	2-21-19 (Date)
Reviewed By:			
Sarah Springer (Print Name)	Sr. Geologist (Title)	Sarah Springer (Signature)	05-29-19 (Date)

For Office Use Only

OR Doc Type:	WMU Code(s):

A-6003-642 (REV 1)

BOREHOLE LOG (Cont.)

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Date: 2-28-19

Well ID: C9738 | Well Name: 299-W6-17 | Location: 600m N of T-Plant

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
35	G		20'-40': Gravel(G) g=90%, s=5%, m=5%. @35: g: F.peb-v.coarse peb, Avg=13mm, Max=80mm, poor sort, 10% Fel, 90% mafic, sub-ang. S=Coarse Sand-v.coarse Sand, well sort, 10% Fel, 90% maf, sub-ang, wet, weak rxn HCl, 2.5y 4/3-Olive Brown.	Air Rotary Drilling with 11 3/4" OD / 10 5/8" ID Temp. casing 0.0-150.0'bgs, 9 5/8" OD / 8 1/2" ID 150.0-466.4'bgs, & 8" OD 6 1/4" bit 466.4-489.0'bgs.
40	G		40'-55': Sand (S): g=5%, s=90%, m=5%. g: med peb-c.peb, Avg=20mm, max=40mm, mod sort, 90% Fel, 10% maf, sub-round to round. S: v.f.sand-c.sand, well sort, 90% Fel, 10% maf, sub-ang, moist, strong rxn HCl. 2.5y 4/3-Olive Brown.	Grab samples collected every 5' or change in lithology.
45	G		@45: Sand(S): g=5, s=85, m=10. g: ↑ coarse peb-v.coarse peb, Avg↑ 35mm, max↑ 60mm, 50% Fel, + 50% mafic, sub-round. 2.5y 5/3-Light Olive Brown.	
50	G		@50: Sand(S): g=5, s=95%, m=Trace. g: ↑ v.coarse peb-cobble. Avg↑ 50mm, max↑ 90mm, 25% Fel + 75% maf, sub-ang to sub-round. S: ↑ med sand-v. coarse sand, 75% Fel, 25% maf, 2.5y 5/6-light olive brown.	
55	G		55'-60': Sandy Gravel (sG): g=30%, s=65%, m=5%. g: v.f.peb-coarse peb, Avg=5mm, Max=20mm, mod sort, 65% Fel, 35% Maf, sub-round. S: med sand-v. coarse sand, mod sort, 75% Fel, 25% maf, moist, + strong rxn HCl. 2.5y 6/6-olive yellow.	
60	G		60'-70': Sand(S): g=10, s=90, m=Trace. g: v.f.peb-med peb, Avg=5mm, max=10mm, mod sort, 65% Fel + 35% maf, sub round. S: coarse-v.coarse sand, well sort, 50% Fel, 50% maf salt + pep comp, sub-ang, moist, weak rxn HCl. 2.5y 6/6-Olive yellow.	
65	G		@65: Sand (S): g: max ↑ 15mm, 40% Fel, 60% maf. S: ↓ med-v.coarse sand, mod-well sort, no rxn HCl.	
70	G		70'-80': Sandy Gravel (SG): g=40%, s=60%, m=0%. g: v.f.peb-med peb, Avg=5mm, max=15mm, mod-well sort, 40% Fel, 60% maf, sub-round. S: med-v.coarse sand, mod sort, 50% Fel, 50% maf, sub-ang, moist, no rxn HCl, 2.5y 3/3-Dark Olive Brown.	

Reported By:

Lindsey Getchell	Geologist	Lindsey Getchell	2-28-19
Print Name	Title	Signature	Date

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

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Date: 3-12-19

Well ID: C9738 | Well Name: 299-W6-17 | Location: 600m North of T Plant

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
75	G		70'-80': Sandy Gravel (sG): g=40%, s=60%, m=0%. @75: g: v.f. peb - med peb, Avg=5mm, max=15mm, mod sort, 40% Fel, 60% maf, sub-round. S: med-v. coarse sand, mod sort, 50% Fel, 50% maf, sub-ang, moist, no rxn HCl. 2.5y 3/3 - Dark Olive Brown.	Air Rotary Drilling with 11 3/4 OD/10 5/8 ID Temp Casing 0.0-150.0' bgs, 9 5/8 OD/8 1/2 ID 150.0-460.4' bgs, + 8" OD, 6 1/4" tri cone 460.4-489.0' bgs. Grab samples collected every 5' or change in lithology.
80	G		80'-95': Gravelly Sand (gS): g=25%, s=70%, m=5%. g: v.f. peb - coarse peb, Avg=5mm, max=20mm, mod sort, 50% Fel, 50% maf, sub-round. S: med-v. coarse sand, poor - mod sort, 40% Fel, 60% maf, sub-ang, moist, no rxn HCl, silt clasts, 2.5y 3/3 - Dark olive brown.	
85	G		@85: Gravelly Sand (gS): g=25%, s=75%, m=0%. g: v.f. - fine peb, max ↓ 8mm, well - mod sort, 60% Fel + 40% maf, sub-ang. S: coarse - v. coarse sand, mod sort, no silt clasts.	
90	G		@90: Gravelly Sand (gS): g=29%, s=71%, m=0%. g: Max ↑ 10mm. S: med - v. coarse sand.	
95	G		95'-115': Sand (S): g: Trace, s: 95%, m=5%. S: v.f. sand - coarse sand, mod-well sort, 75% Fel, 25% maf, sub-ang, moist, weak rxn HCl, 2.5y 4/4 - Olive Brown.	
100	G		@100': Sand (S): g=0%, s=95%, m=5%. S: ↑ well sort.	
105	G		@105': Sand (S): g=0%, s=95%, m=5%.	
110	G		@110': Sand (S): g=Trace, s=95%, m=5%.	

Reported By:

Lindsey Getchell	Geologist	Lindsey Getchell	3-12-19
Print Name	Title	Signature	Date

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

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Date: 3-27-19

Well ID: C9738 | Well Name: 299-W6-17 | Location: 600m North of T-Plant

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
115			115-125: Silty Sand (mS): g=0%, s=60%, m=40%. S: v.f. sand-coarse sand, well sort, 50% Fel, 50% maf, sub-ang, moist, med. plasticity, no rxn HCl. 2.5y 4/3-Olive Brown.	Air Rotary Drilling with 11 3/4 / 10 5/8 Temp casing from 0.0-150.0' bgs
120			@120: Silty Sand (mS): g=0%, s=70%, m=30%. S: 40% Fel, 60% maf, weak rxn HCl, smaller clasts of silt.	118'-135' bgs 30gal H_2O added 9 5/8 / 8 1/2" 150.0-460.4' bgs + 8" OD, 6 1/4" bit 460.4-489.0' bgs. Grab samples collected every 5' or change in lithology.
125			125'-145': Sandy Silt (sM): g=0%, s=25%, m=75%. S: v.f. sand- coarse sand, mod sort, 40% Fel, 60% maf, sub-ang, wet, no rxn HCl, 2.5y 5/4-Light Olive Brown.	
130			@130: Sandy Silt (sM): g=0%, s=40%, m=60%. S: v.f. sand - v. coarse sand, mod sort, 40% Fel, 60% maf, med plasticity.	
135			@135: Sandy Silt (sM): g=Trace, s=40%, m=60%. S: well - mod sort.	
140			@140: Sandy Silt (sM)	140'-150' bgs 35gal H_2O added
145			145'-150': Slightly silty Sand: ((m)S): g=5%, s=80%, m=15%. g: v.f. - v. coarse peb, Avg=20mm, max=40mm, mod sort, 50% Fel, 50% maf, sub-ang. S: v.f. - v. coarse sand, well sort, 25% Fel, 75% maf, sub-ang, wet, no rxn HCl, 2.5y 3/3-Dark Olive Brown, low-no plasticity.	
150			150'-155': Gravelly silty Sand: (gmS): g=10, s=60, m=30%. g: v.f. - med peb, Avg=5mm, max=15mm, mod sort, 25% Fel + 75% maf, sub-ang. S: v.f - v. coarse sand, well sort, 40% Fel, 60% maf, sub ang, wet, no rxn HCl. 2.5y 5/4-light olive Brown, med plasticity.	

Reported By:

Lindsay Getchell	Geologist	Lindsay Getchell	3-27-19
Print Name	Title	Signature	Date

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Date: 3-28-19

Well ID: C9738 | Well Name: 299-W6-17 | Location: 600m North of T-Plant

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
155			155'-160': Sandy Gravel (sG): g=30%, s=60%, m=10%. g: v.f-med peb, avg=10mm, Max=20mm, poor-mod sort, 10% Fel, 90% maf, round-sub round. S: v.f-v.coarse sand, mod sort, 40% Fel, 60% maf, sub-ang, moist, no rxn HCl, mica present, 2.5y 4/3-Olive Brown.	Air Rotary Drilling with 11 3/4 OD 10 5/8 ID Temp casing 0.0-150.0'bgs, 9 5/8 / 8 1/2 150.0-460.4'bgs to 8" 6 1/4" triconebit 460.4-489.0'bgs Grab samples collected every 5' or change in lithology.
160			160'-175': Gravelly Sand (gS): g=20%, s=70%, m=10%. g: v.f.peb-med peb, trace coarse peb, Avg=8mm, max=30mm, poor sort, 10% Fel, 90% maf, sub-round to round shape. S: v.f.-v.coarse sand, mod sort, 40% Fel, 60% maf, sub-ang, moist, no rxn HCl, 2.5y 4/3-Olive brown.	
165			@165: Gravelly Sand (gS): g=20%, s=75%, m=5%. g: v.f.-v.coarse peb, Avg: ↑ 10mm, Max: ↑ 36mm, 75% Fel, 25% maf, Ang to sub-angular. S: F. Sand-v.coarse Sand, ↑ well-mod sorting, 75% Fel, 25% maf, weak rxn HCl, 2.5y 5/4-light olive brown.	
170			@170: Gravelly Sand (gS): g=25%, s=75%, m=Trace. g: Avg: ↑ 15mm, Max: ↑ 50mm, sub-ang to sub-round.	
175			175'-190': Gravel (G): g=80%, s=15%, m=5%. g: v.f-v.coarse peb, Avg=20mm, max=40mm, mod sort, 60% Fel, 40% maf, sub-round to round. S: F-v.coarse sand, mod sort, 40% Fel, 60% maf, sub-ang, moist, weak rxn HCl, 2.5y 4/3-Olive brown.	
180			@180': Gravel (G): g=80%, s=20%, m=Ø%. g: Avg ↓ 10mm, Max ↑ 55mm, ↓ poor sort, Ang to sub-ang shape.	180'-210'bgs 10-15 gal H_2O added
185			@185: Gravel (G): g=80%, s=20%, m=Trace. g: Avg: ↓ 8mm, Max ↓ 35mm, v.f-coarse peb. S: Angular-sub-ang, rxn to HCl.	
190			190'-210': Sandy Gravel (sG): g=75%, s=25%, m=Trace. g: v.f-coarse peb, Avg=10mm, max=35mm, poor sort, 40% Fel, 60% maf, Angular to sub-ang. S: v.f-v.coarse sand, mod sort, 40% Fel, 60% maf, ang to sub-ang, moist, rxn HCl, 2.5y-Olive brown.	

Reported By:

Print Name	Title	Signature	Date
Lindsey Getchell	Geologist	Lindy Mfell	3-28-19

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

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Date: 3-29-19

Well ID: C9738 | Well Name: 299-W6-17 | Location: 650m North of T-Plant

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
195			190'-210': Sandy Gravel (sG): g=75%, s=25%, m=Trace. @195': Sandy Gravel (sG): g=30%, s=65%, m=5%. g: V.F-coarse peb, Avg=5mm, Max=35mm, poor sort, 50% Fel, 50% maf, sub-ang. S: V.F-V. Coarse Sand, well sort, 60% Fel, 40% maf, sub-ang, moist, rxn HCl, 2.5y 5/4-Light olive brown.	Air Rotary Drilling with 11 3/4"/10 3/4" temporary casing 0.0-150.0' bgs. 9 5/8"/8 1/2" 150.0-476.4' bgs & 8": 6 1/4" bit 476.4-489.0' bgs. Grab samples collected every 5' or change in lithology.
200			@200': Sandy Gravel (sG): g=70%, s=25%, m=5%. g: V.F-V. coarse peb, avg↑ 15mm, max↑ 40mm, ↑ mod-poor sort, sub-ang to round. S: ↓ mod sort.	
205			@205': Sandy Gravel (sG): g=75%, s=25%, m=0%/Trace. g: Avg↓ 10mm, max↑ 50mm, sub-ang to sub-round. S: ↓ weak rxn HCl.	
210			210'-215': Gravel (G): g=90%, s=10%, m=Ø. g: V.F-V. Coarse peb, mostly med peb, avg=15mm, max=35mm, mod-well sort, 50% Fel, 50% maf, sub-round to round. S: V.F-V. coarse sand, mod sort, 60% ~~maf~~ Fel, 40% maf, sub-ang, moist, weak rxn HCl, 2.5y 5/4-light olive brown.	
215			215'-225': Gravelly Sand (gS): g=15%, s=85%, m=Trace. g: V.F. peb-V. coarse peb, Avg=10mm, Max=50mm, poor sort, 50% Fel, 50% maf, sub-ang to round. S: V.F. sand-coarse sand, well sort, 60% Fel, 40% maf, sub-ang, moist, rxn HCl, 1-2mm sheets of mica, 2.5y 5/4-light olive brown.	
220			@220: Gravelly Sand (gS): g=20%, s=80%, m=Trace. g: V.F. peb-coarse peb, max↓ 35mm, poor-mod sort, majority v.fine + fine peb. S: V.F-V. coarse sand, 2.5y 4/4-Olive brown	
225			225'-230': Gravel (G): g=90%, s=5%, m=5%. g: F. peb-V. coarse peb, avg=20mm, max=35mm, poor sort, 75% Fel, 25% maf, sub-ang. S: V. coarse sand, mod sort, 40% Fel, 60% maf, angular, dry, no rxn HCl. Colorful; 2.5 3/3 Dark Olive Brown.	
230			230'-240: Gravelly Sand (gS): g=15, s=80, m=5. g: V.F.-coarse peb, avg=7mm, max=30mm, mod sort, 50% Fel, 50% maf, sub-ang. S: V.F-V. coarse sand, well sort, 60% Fel, 40% maf, sub-ang, moist, rxn HCl, 2.5y 4/4-Olive brown.	

Reported By:

Lindsey Getchell	Geologist	Lindsey Getchell	3-29-19
Print Name	Title	Signature	Date

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

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Date: 3-29-19

Well ID: C9738 | Well Name: 299-W6-17 | Location: 600m North of T-Plant

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
235			230'-240': Gravelly Sand (gS): g=15, s=80, m=5.	Air Rotary Drilling with 11 3/4" / 10 5/8 Temporary casing, 0.0-150.0' bgs 9 5/8 / 8 1/2 150.0-466.4 8" 6 1/4" bit 466.4-489.0' bgs. Grab Samples collected every 5' or change in lithology.
			@ 235 - Gravelly Sand (gS): g=25, s=70, m=5.	
			g: V.F peb - med peb, avg ↑ 20mm, max ↑ 40mm,	
			Trace coarse peb, 60% Fel, 40% maf, sub-ang	
			to sub-round. S: No rxn HCl.	
240			240'-260': Gravel (G): g=90%, s=5%, m=5%.	
			g: V.F-coarse peb, avg=6mm, max=45mm, poor-mod	
			sort, 60% Fel, 40% maf, sub-ang to sub-round. S=V. coarse	
			Sand, mod-well sort, 75% Fel, 25% maf, ang, moist,	
			no rxn HCl. 2.5y 4/4 - Olive Brown.	
245			@ 245: (G): g=95%, s=5%, m=0%. g: Avg ↑ 10mm,	
			max ↓ 35mm, ↑ mod-sort. S: Dry, 2.5y 4/3 - Olive	
			brown; colorful pebbles.	
250			@ 250: Gravel (G)	
255			@ 255: (G) g: max ↑ 50mm.	
260			260'-270': Sandy Gravel (sG): g=45%, s=55%, m=0%.	
			g: V.F-coarse peb, avg=12mm, max=50mm, mod	
			sort, 60% Fel, 40% maf, sub-ang to sub-round.	
			S: V.F-V. Coarse Sand, well sort, 60% Fel, 40% maf,	
			sub-ang, moist, no rxn HCl. 2.5y 5/4 - Light Olive Brwn.	
265			@ 265: (sG): g=60%, s=35%, m=5%.	
			g: sub-angular, more med coarse peb.	
270			270'-280': Gravel (G): g=85%, s=10%, m=5%.	
			g: V.F-V. coarse peb, Avg=10mm, max=40mm, mod	
			sort, 60% Fel, 40% maf, sub-ang to sub-rounded.	
			S: V.F-V. coarse sand, poor-mod sort, 60% Fel, 40% maf,	
			sub-ang, dry, no rxn HCl, 2.5y 4/3 - Olive Brown.	

Reported By:

Lindsey Gotchell	Geologist	Lindsey Gotchell	3-29-19
Print Name	Title	Signature	Date

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Page 8 of 13

Date: 3-29-19

Well ID: C9738 | Well Name: 299-W6-17 | Location: 600m North of T Plant

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
275	G		270'-280': (Gravel)(G): g=85%, s=10%, m=5%. @ 275: (G): g=80%, s=15%, m=5%. g: v.f-coarse peb, avg ↓ 5mm, max ↓ 35mm, mod-well sort. S: Mod sort, moist.	Air Rotary Drilling with 11 3/4 OD/10 5/8 ID Temp. Casing 0.0-150.0' bgs, 9 5/8 OD/8 1/2 ID 150.0-466.4' bgs & 8 1/2 ID 466.4-489.0' bgs tricone bit. Grab samples collected every 5' or change in lithology.
280	G		280'-285': Gravelly Sand (gS): g=25%, s=75%, m=Trace g: v.f-coarse peb, avg=10mm, max=35mm, poor-mod sort, 50% Fel, 50% maf, sub-ang. S: v.f-med sand with trace amounts of coarse + v.coarse sand, mod-well sort, 60% Fel, 40% maf, sub-ang to round, moist, no rxn Hcl. 2.5y-3/3-Dark Olive Brwn.	
285	G		285'-290': Gravel (G): g=90%, s=5%, m=5%. g: v.fine-coarse peb, avg=4mm, max=25mm, poor-mod sort, 60% Fel, 40% maf, sub-ang to sub-round. S: F-v.coarse sand, mod sort, 50% Fel, 50% maf, sub-ang, moist, no rxn Hcl, 2.5y 4/3-Olive Brown, colorful pebbles.	
290	G		290'-295': Sandy Gravel (sG): g=70%, s=30%, m=0%. g: v.f-coarse peb, avg=20mm, max=40mm, mod sort, 60% Fel, 40% maf, sub-ang to sub-round. S: med-v.coarse sand, mod sort, 50% Fel, 50% maf, round, moist, no rxn Hcl, 2.5y-5/4-Light olive Brown.	
295	G		295'-305': Gravel (G): g=90%, s=10%, m=0%. g: v.f-coarse peb w/trace v.coarse peb, avg=7mm, max=35mm, mod sort, 60% Fel, 40% maf, sub-ang. S: med-v.coarse sand, mod sort, 50% Fel, 50% maf, sub-ang to round, moist, no rxn Hcl, 2.5y-5/4-light olive brown.	
300	G		@ 300: ~~v.f-F 3.29.19~~ (G) g=90%, s=5%, m=5%. g: v.f-v.coarse peb, poor-mod sort, sub-ang to sub-round, avg↑ 20mm, max↑ 50mm. S: sub-ang angularity, weak rxn Hcl.	Water level: 300.4' (4-4-19)
305	G		305'-310': Silty Gravel (mG): g=70%, s=10%, m=20%. g: v.f-coarse peb, avg=12mm, max=35mm, poor sort, 60% Fel, 40% maf, sub-ang to sub-round. S: v.f-v.coarse sand, mod-well sort, 75% Fel, 25% maf, sub-ang to round, moist, weak rxn Hcl, fine grained-size mica, high plasticity silt, 25% mica amount, 2.5y 4/4-Olive Brown.	
310	G WS		310'-315': Sandy Gravel (sG): g=75%, s=20%, m=5%. g: v.f-fine peb sub-ang, med-v.coarse peb sub-round to round, avg=25mm, max=50mm, mod sort, 80% Fel, 20% maf. S: F-v.c. sand, well sort, 75% Fel, 25% maf, sub-ang, wet, no rxn Hcl, 2.5y 4/4-Olive Brwn.	Water Sample: I-001 @ 311.3'

Reported By:

Print Name	Title	Signature	Date
Lindsey Getchell	Geologist	Lindsey Getchell	3-29-19

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Page 9 of 13

Date: 3-29-19

Well ID: C9738 | Well Name: 299-W6-17 | Location: 600m North of T-Plant

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
315	G		315'-325': Gravel (G): g=90%, s=10, m=Trace. g: V.F-V.C peb, Tr Cob. Avg=20mm, Max=40mm, mod sort, 75% Fel, 25% maf, sub-ang (F-med peb)-Rnd (C peb). S: VF-VC sand, mod sort, 60% Fel, 40% maf, ang, wet, no rxn HCl, 2.5y 5/3-light olive brwn.	Air Rotary Drilling with 14" 10 5/8" Temp casing 0.0-150.0'bgs, 9 5/8/8 1/2 150.0'bgs - 4606.4'bgs. 8" Tricone bit 4606.4-4890.0'bgs
320	G		@320: (G) g=85%, s=10%, m=5%. g: VF-C peb, avg ↓ 10mm, max ↓ 35mm, 60% Fel, 40% maf, s.ang. S: F-VC Sand, sub-ang.	Grab samples collected every 5' or change in lithology.
325	G		325'-330': Silty Sandy Gravel (~~SmG~~ MSG) g=40% s=45%, m=15%. g: VF-med peb, Tr C peb. Avg 10mm, Max 30mm, poor-mod sort, 60% Fel, 40% maf, sub-ang. S: med-VC sand, mod-well sort, 60% Fel, 40% maf, sub-ang, moist, weak rxn HCl, 2.5y 4/3-Olive brown, med size mica, silt clasts.	
330	G WS		330'-335': Gravel (G): g=85%, s=10%, m=5%. g: VF-C peb, VC peb-Trace, avg 15mm, max 40mm, mod sort, 75% Fel, 25% maf, s.ang (VF peb)-s.rnd (C peb). S: F-VC sand, poor-mod sort, 60% Fel, 40% maf, sub-ang, dry, strong rxn HCl, F. size mica, 2.5y 5/3-light olive brown.	Water Sample: I-002 @331.4'
335	G		335'-355': Sandy Gravel (sG): g=70%, s=30%, m=0%. g: VF-VC peb, tr Cob, avg 30mm, max 60mm, poor sort, 75% Fel, 25% maf, sub-ang to sub-round. S: med-VC sand, poor-mod sort, 60% Fel, 40% maf, s.ang, wet, no rxn HCl, coarse-sized mica, 2.5y 4/4-Olive Brwn.	
340	G		@340: (sG) g=60%, s=40%, m=0%. g: F-Cob, avg ↓ 25mm, max ↑ 80mm, ↑ med-well sort, 95% round. S: F-C sand, well sort, rnd, 2.5y 4/3-Olive Brwn.	
345	G		@345: (sG) g=79%, s=21%, m=0%. g: VF-VC peb, avg ↓ 20mm, max ↓ 45mm, ↓ poor-mod sort, sub-ang to rnd. S: med-VC sand, mod sort, s.ang-ang, 2.5y 4/4-Olive brwn.	
350	G WS		@350: (sG) g=79%, s=21%, m=0%. g: VF-C peb, avg ↓ 15mm, sub-ang to sub-round.	Water Sample: I-003 @350.9'

Reported By:

Print Name	Title	Signature	Date
Lindsey Getchell	Geologist	Lindsey Getchell	3-29-19

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BOREHOLE LOG (Cont.)

Page 10 of 13

Date: 3-29-19

Well ID: C9738 | Well Name: 299-W6-17 | Location: 600m North of T-Plant

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
355	G		355'-479': Gravel (G): g=90%, s=10%, m=Tr.	Air Rotary Drilling with 13 1/4" / 10 5/8" Temp casing
			g: VF-VC peb, Tr small cob. Avg 40mm, max 75mm, mod sort,	0.0-150.0'bgs, 9 5/8 / 8 1/2
			75% Fel, 25% maf, sub-round to rnd. S: Tr med sand, C-VC	150.0-466.4'bgs 8" 6 1/4"
			sand, mod sort, 75% Fel, 25% maf, ang-sub. ang, wet, no rxn	Triconebit 466.4-489.0'bgs.
			HCl, 2.5y 4/4-olive bwn.	
360	G		@360': (G): ↑ VF peb-med cob. (cob avg 85mm). Avg ↓	Grab samples collected
			30mm, max ↑ 105mm, sub-ang to Rnd.	every 5' or change in
			S: Tr F. sand, med sand-VC sand. mostly VC sand.	lithology.
365	G		@365': (G) g: VF-VC peb, avg ↓ 25mm, max ↓ 60mm.	
370	G		@370': (G) g: Max ↓ 55mm.	
	WS			Water Sample: I-004 @ 371.3'
375	G		@375': (G) g: VF-C peb, Tr VC peb + Tr Cob. ~~Max 75mm~~ LG 3-25-19	
			Max ↑ 80mm, sub rnd-rnd.	
			S: f-VC sand, poor sort, sub-ang, 5-10% mica (VC	
			Sand-size). 2.5y 4/3-olive bwn.	
380	G		@380': (G) g: max: >75mm, sub ang-rnd. Vesicular peb.	
			S: Med-VC sand, poor-mod sort, ang-subang.	
385	G		@385': (G) g=85%, s=10%, m=5%. g: VF-C peb, Tr VC peb,	
			avg ↓ 20mm, max ↓ 55mm, More VF/F peb.	
			S: VF-VC sand, silt clasts. 2.5y 4/4-olive bwn.	
390	G		@390': (G) g: VF-C peb, Tr VC peb + small cob, max ↑	
			>80mm, sub rnd-rnd.	
	WS		S: Silt clasts	Water Sample: I-005 @ 391.2'

Reported By:

Print Name	Title	Signature	Date
Lindsey Getchell	Geologist	Lindsey Getchell	3-29-19

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Page 11 of 13

Date: 3-29-19

Well ID: C9738 | Well Name: 299-W6-17 | Location: 600m North of T-Plant

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
395	G		355'-479': Gravel (G) g=85%, s=10%, m=5%.	Air Rotary Drilling with
			@395': (G) g=90%, s=5%, m=5%.	11 3/4 / 10 5/8 temp. casing
			g: Avg ↓ 15mm; majority med peb, Max ↓ 70mm, Tr.	0.0-150.0' bgs, 9 5/8 / 8 1/2
			VC peb, poor-mod sort, ang-sub rnd. Med sand	150.0'-466.4' bgs 8 6 1/4"
			cemented onto peb. S: Med-VC sand (most VCs) ang,	tricone bit 466.4-489.0 bgs
400	G		less silt clasts, 2.5y 4/3-Olive Brwn.	Grab samples collected
			@400': (G) g=95%, s=5%, m=Tr.	every 5' or change in
			g: VF-med peb, Tr. C peb, avg ↓ 10mm, max ↓ 30mm,	lithology.
			mod sort, 60% fel, 40% maf, ang-s.ang	
			S: Tr-none silt clasts, 2.5y 3/3-Dark olive brwn.	
405	G		@405': (G)	
			g: ↑ Tr. VC peb, max ↑ 60mm.	
410	G		@410': (G) g=90% LG 3-29-19 s=5%, m=5%.	
	WS		g: Tr C peb, angular.	
				Water Sample: I-006 @ 411.4'
415	G		@415': (G) g=90%, s=10%, m=Tr.	
			g: Mostly F. peb, Tr. VC peb, max ↓ 50mm, poor sort,	
			sub-ang to sub-rnd.	
			S: F-VC sand, poor sort, 60% fel, 40% maf, sub-ang,	
			2.5y 3/3-Dark olive brwn. Mostly VC sand.	
420	G		@420': (G)	
			g: Avg ↑ 15mm, sub-ang to rnd. More C. peb.	
			S: Tr amount of mica.	
425	G		@425': (G)	
			g: Max ↑ 55mm, poor-mod sort, sub-ang to rnd.	
430	G		@430': (G)	
			g: Avg ↑ 20mm, Max ↓ 45mm, mod sort.	
	WS			Water Sample: I-007 @ 431.3'

Reported By:

Print Name	Title	Signature	Date
Lindsey Getchell	Geologist	Lindsey Getchell	3-29-19

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BOREHOLE LOG (Cont.)

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Date: 4-4-19

Well ID: C9738 | Well Name: 299-W6-17 | Location: 600m North of T-Plant

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
435	G		355'-479': Gravel (G) g=90%, s=10%, m=Tr.	Air Rotary Drilling with 11 3/4 / 10 5/8" Temp. Casing from 0.0-150.0' bgs, 9 5/8 & 1/2 150-466.4' bgs to 8", 6 1/4" Tricone bit 466.4-479.0' bgs Grab samples collected every 5' or change in lithology.
			@ 435': (G) g=90%, s=10%, m=Ø%.	
			g: poor-mod sort, avg ↓ 10mm, max ↑ > 50mm, 50% Fel, 50% maf, ang-s.ang.	
			s: F-VC sand, poor-mod sort, 50% Fel, 50% maf, ang, 2.5y 3/2-Very dark grayish brwn. Tr. med mica flakes.	
440	G		@ 440': (G)	
			g: Max ↓ 45mm, ang-sub rnd, Med Vesicular peb.	
			s: Med-VC sand. less mica. Cemented sand on peb.	
445	G		@ 445': (G) g=90%, s=5%, m=5%	
			g: VF-Med peb, Tr. C peb; 75% VF-F peb, avg ↓ 5mm max ↓ 35mm, mod sort, ang-sub ang.	
			s: Mostly VC sand.	
450	G		@ 450': (G) g=90%, s=10%, m=Ø%	
	WS		g: VF-VC peb, avg ↑ 12mm, max ↑ 750mm, 60% Fel, 40% maf, sub-ang-rnd. ↑ rnd med peb.	Water Sample: I-008 @ 451.3' 452' bgs 15gal H_2O added
			s: F-VC sand, mod sort, 2.5y 3/3-Dark olive brwn.	
455	G		@ 455': (G)	
			g: VF-med peb, Tr C peb. Avg ↓ 5mm, max ↓ 30mm, v. broken-up peb due to drilling - mostly VF peb size. poor-mod sort, 40% fel, 60% maf, sub rnd-rnd.	
			s: Med-VC sand, mostly VC sand, well-mod sort, 2.5y 4/4-Olive brwn. Vesicular + cemented peb.	
460	G		@ 460': (G) g=85%, s=15%, m=Tr.	
			g: ↑ Tr VC peb as well, max ↑ 65mm, sub-ang to sub-rnd.	
			s: 60% Fel, 40% maf, ang-s.ang. 5y 4/4-Olive.	
465	G		@ 465': (G) g=90%, s=10%, m=Ø%.	465' bgs Shoe brake-metal shavings
	WS		g: ↓ VF-Med peb, Tr. C peb, max ↓ 35mm, 25% Fel, 75% maf, ang.	Water Sample: I-009 @ 466.4'
			s: 40% Fel, 60% maf, sub-ang, 5y 4/2-Olive gray.	
470	G		@ 470': (G) g=95%, s=5%, m=Ø%.	
			g: ↑ Tr. VC peb, max ↑ 50mm, mod-well sort, 10% Fel, 90% maf, ang w/med-high sphericity - Rnd w/med sphericity.	
			s: C-VC sand, well sort, 10% Fel, 90% maf, 5y 3/2-Dark olive gray, vasicular, possible feldspar/olivine in mafic peb.	

Reported By:

Print Name	Title	Signature	Date
Lindsey Getchell	Geologist	Lindsey Getchell	4-4-19

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Page 13 of 13

Date: 4-4-19

Well ID: C9738 | Well Name: 299-W6-17 | Location: 600m North of T-Plant

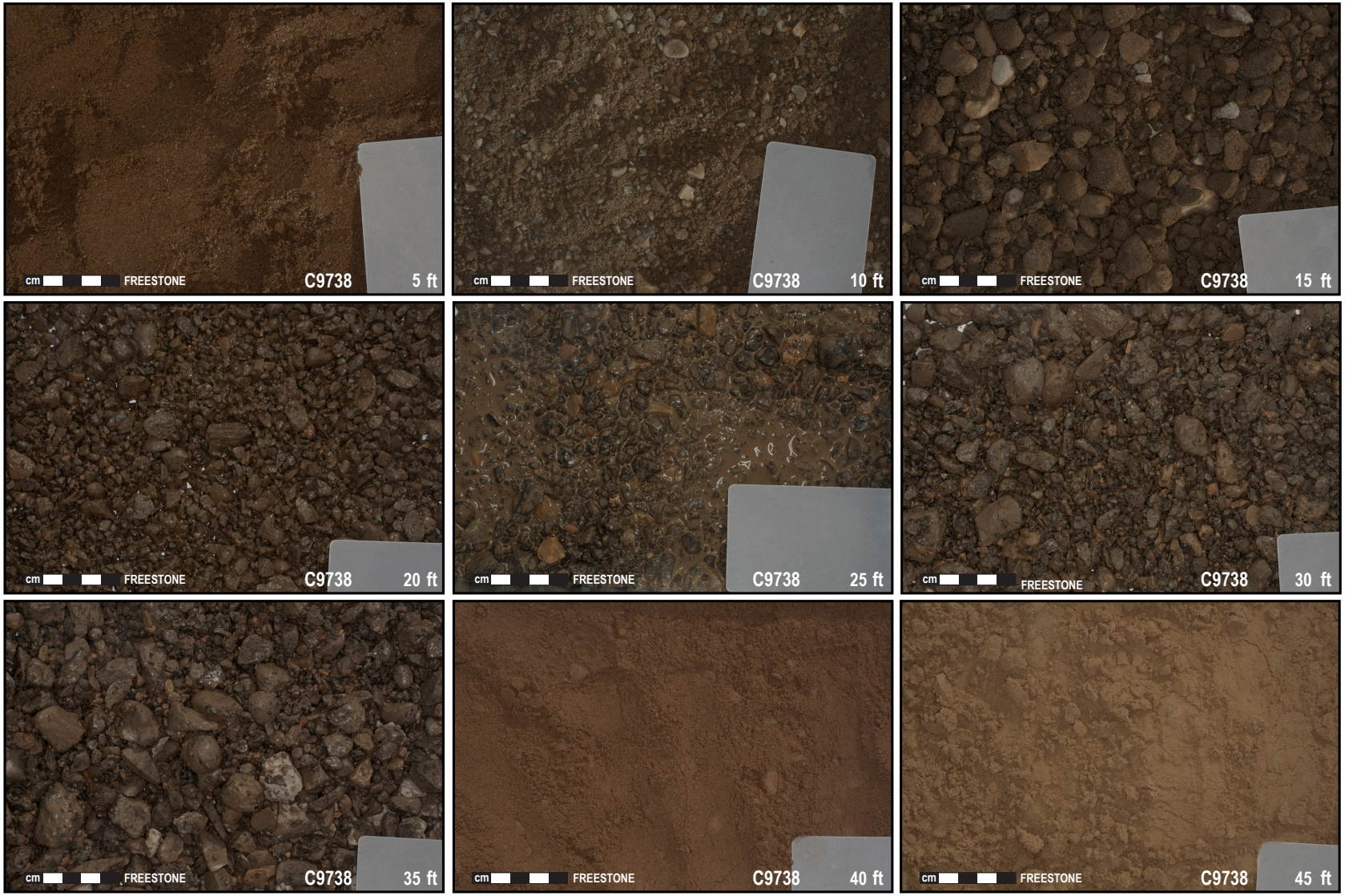
Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other	Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other
475	G		355'-479': Gravel (G) g=95%, s=5%, m=0%.	Air Rotary of Drilling with
			@475': (G) g: VF-Tr. Med pcb, avg↓ 3mm, max↓ 25mm, well sort, 5% Fel, 95% maf, S: Med-VC sand, 5% Fel, 95% maf, 5y 3/1 - Very dark gray.	11 3/4 / 10 5/8" Temp Casing 0.0-150.0' bgs, 9 5/8 / 8 1/2 150.0-466.4' bgs & 8", 6 1/4" Tricone bit 466.4-489.0' bgs
479	WS		@479': 100% Basalt contact	
480	G		479'-489': Basalt: Competent.	Grab samples collected
			@480': Blue/green clay-like weathering (<2 on Mohs hardness) deposits visable. Tr. vasicular pieces. 5y 2.5/1 - Black	every 5' or change in lithology.
				Water Sample: I-010 @479.0'
485	G			
489	G			489' bgs added 10 gal H_2O
490				Total Depth: 489.0' (4-4-19)

Not Used LG 4-4-19

Reported By:

Print Name	Title	Signature	Date
Lindsey Getchell	Geologist	Lindsey Getchell	4-4-19

A-6006-993 (REV 0)



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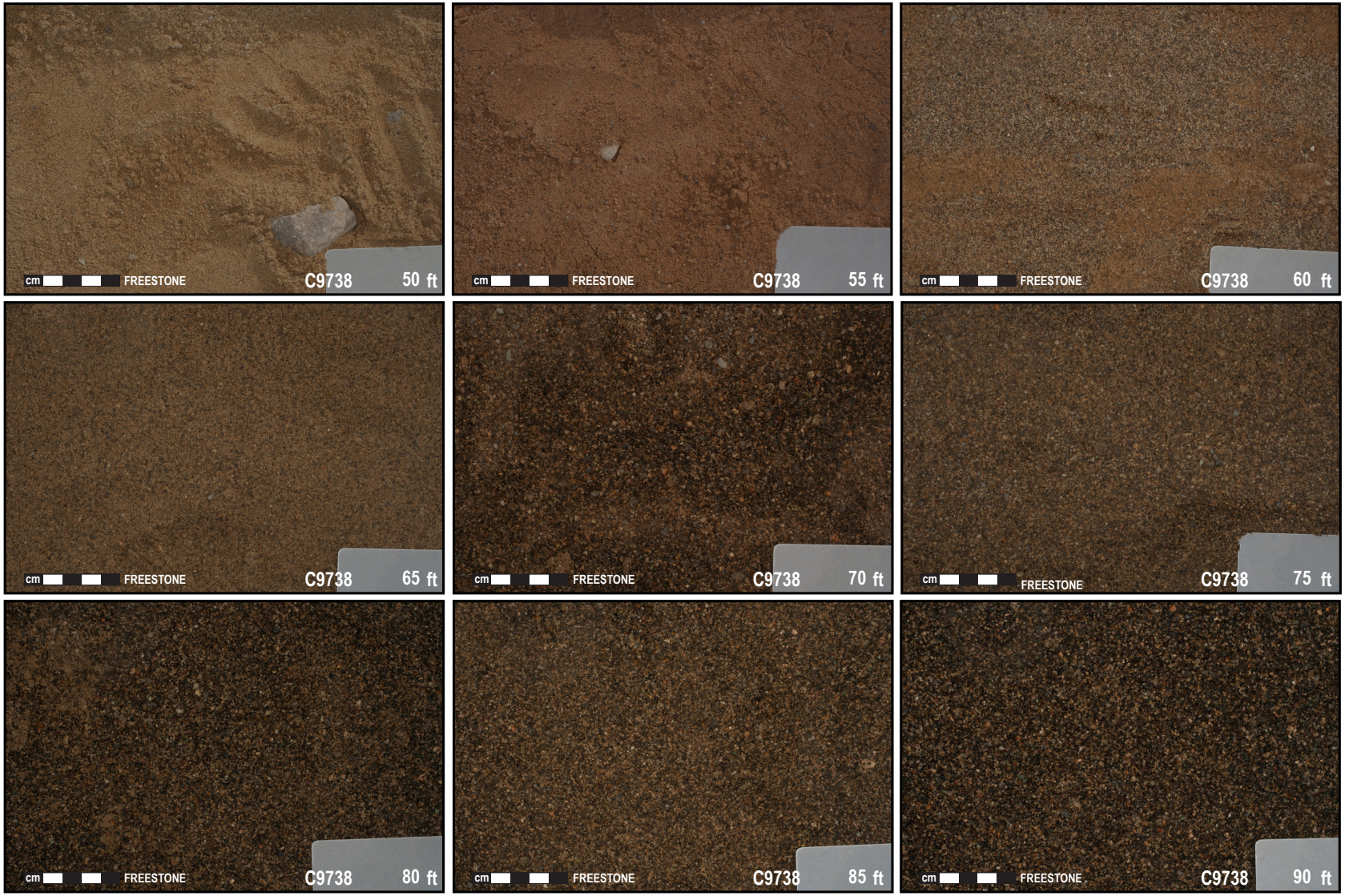
Drill Cutting Photographs for C9738 (299-W6-17)



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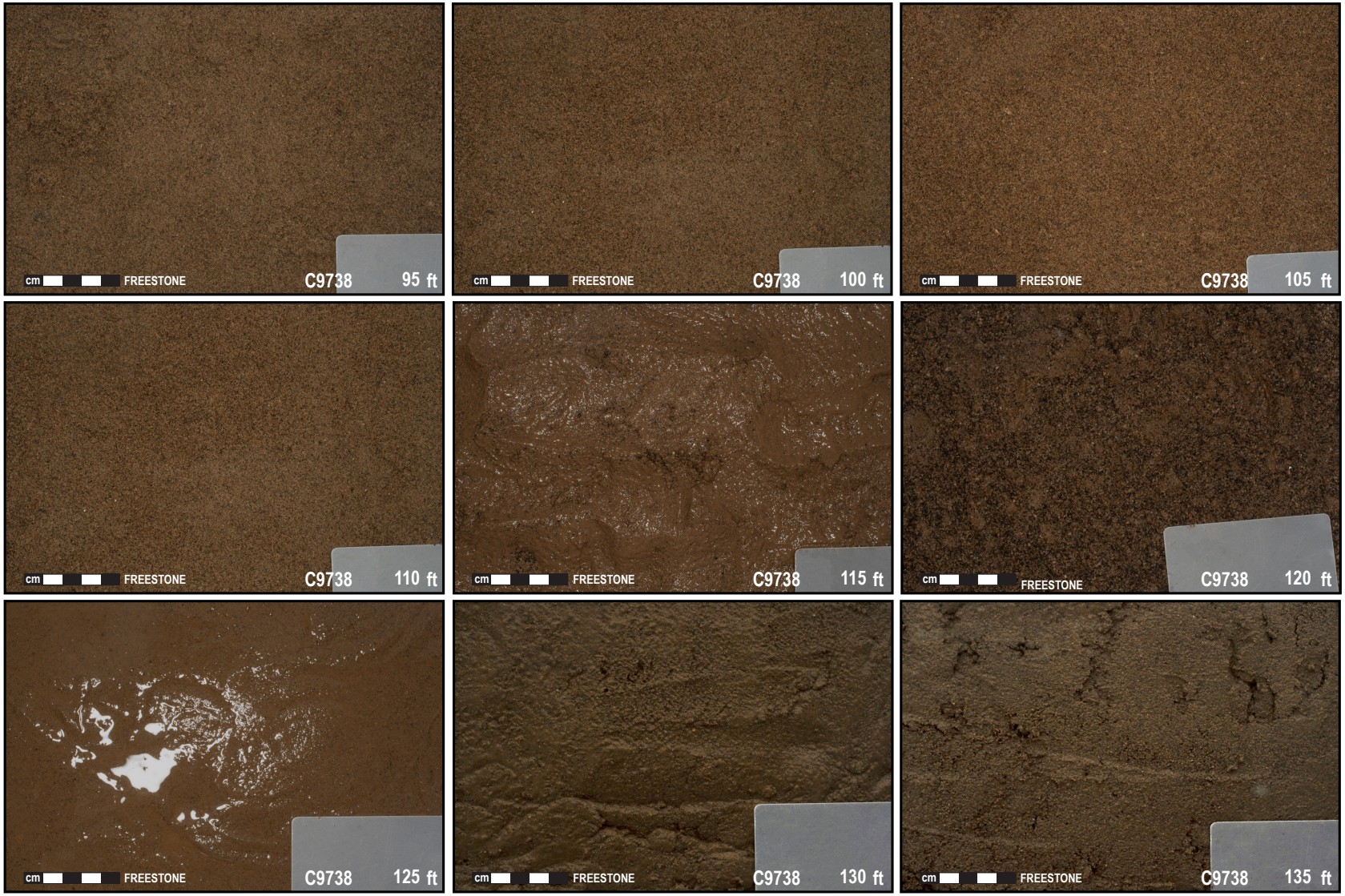

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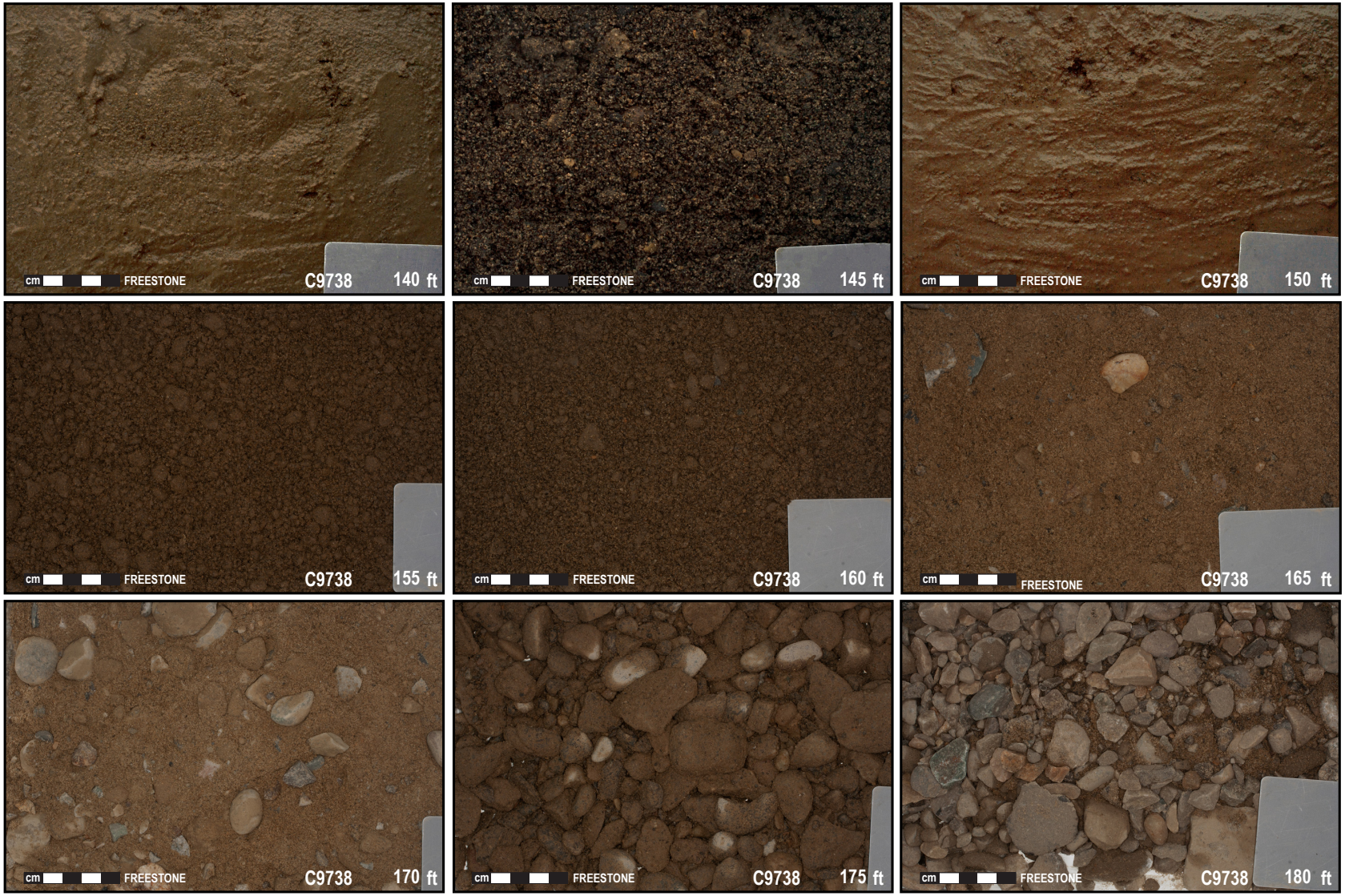

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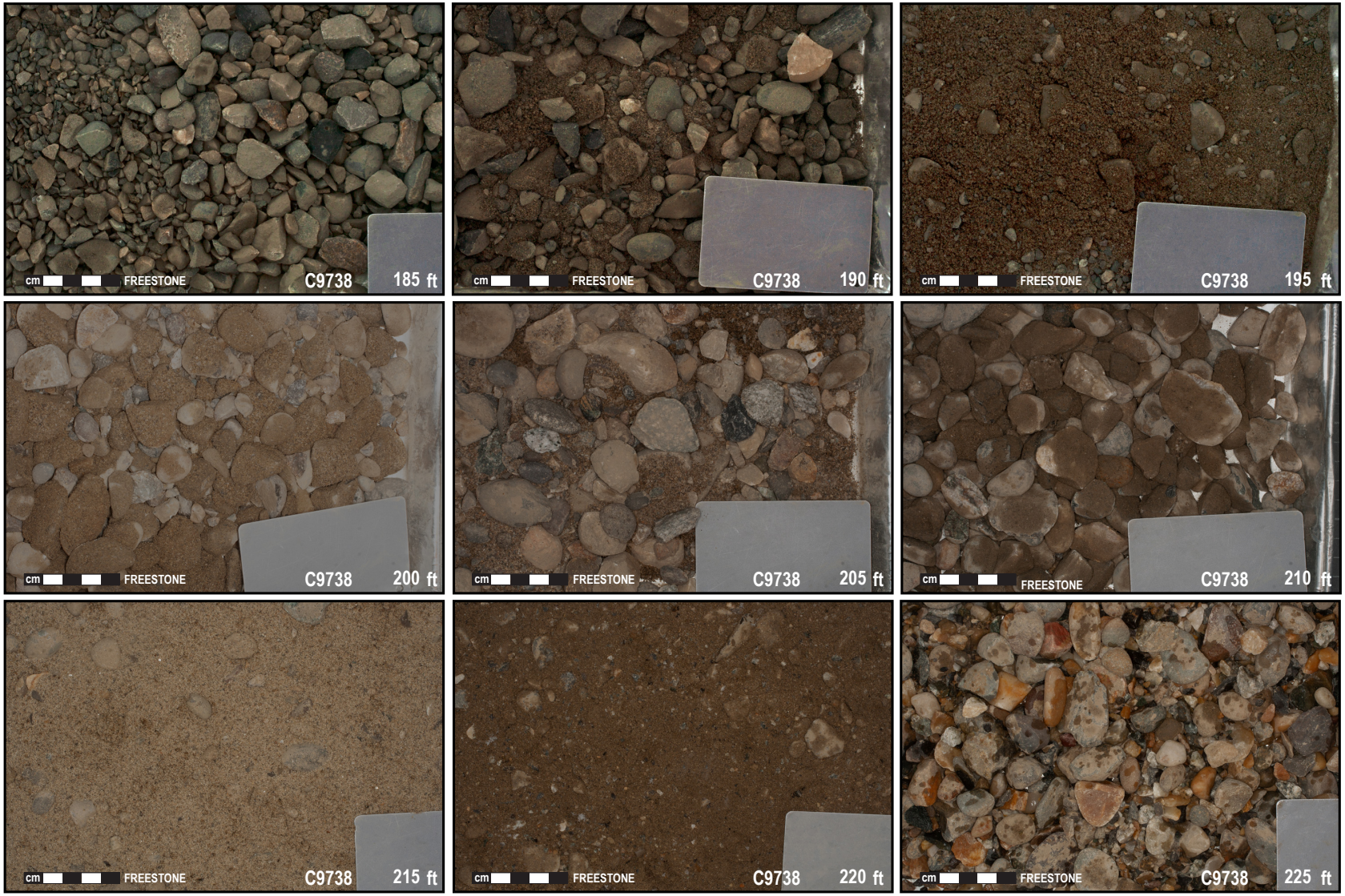

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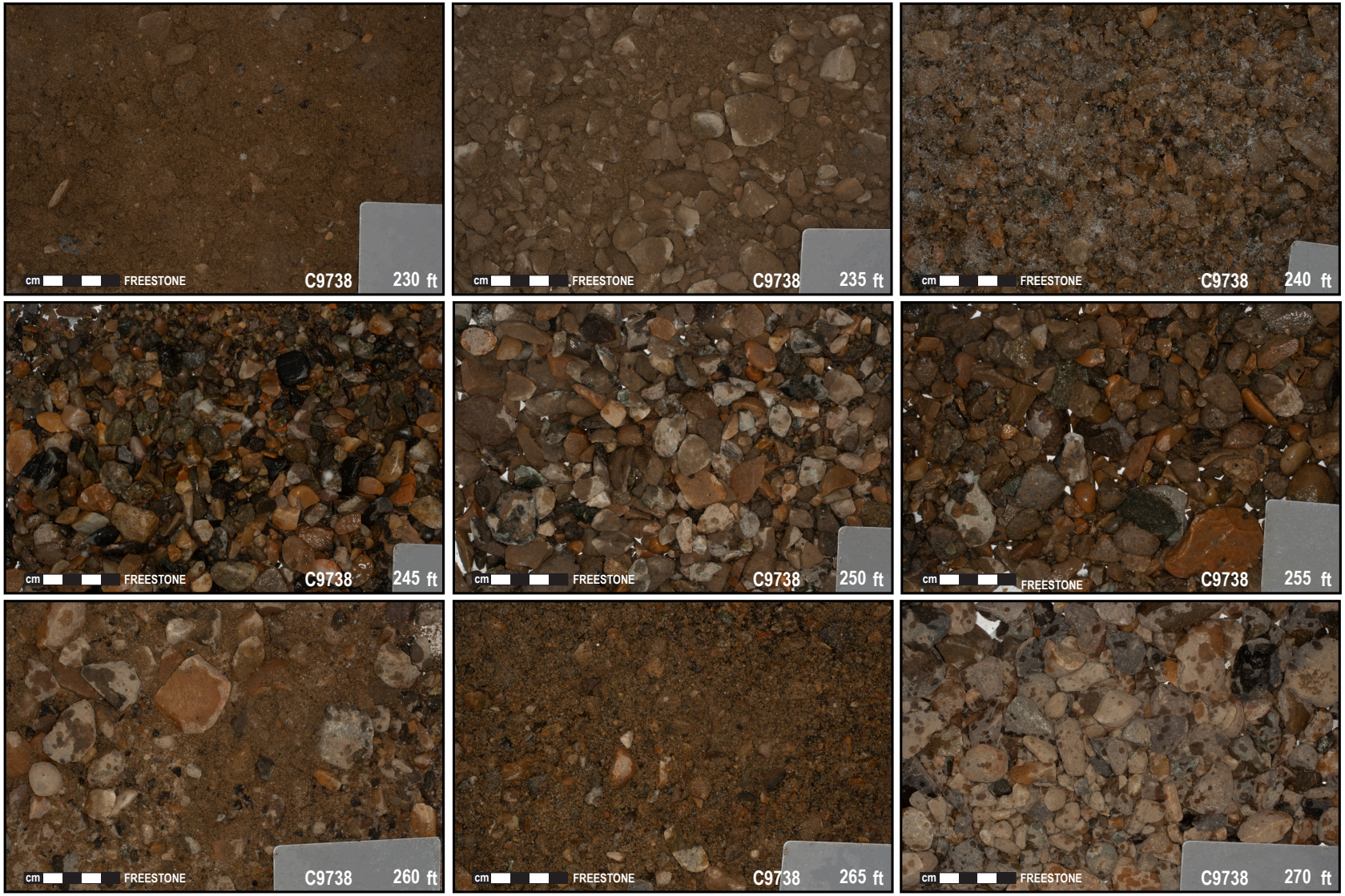

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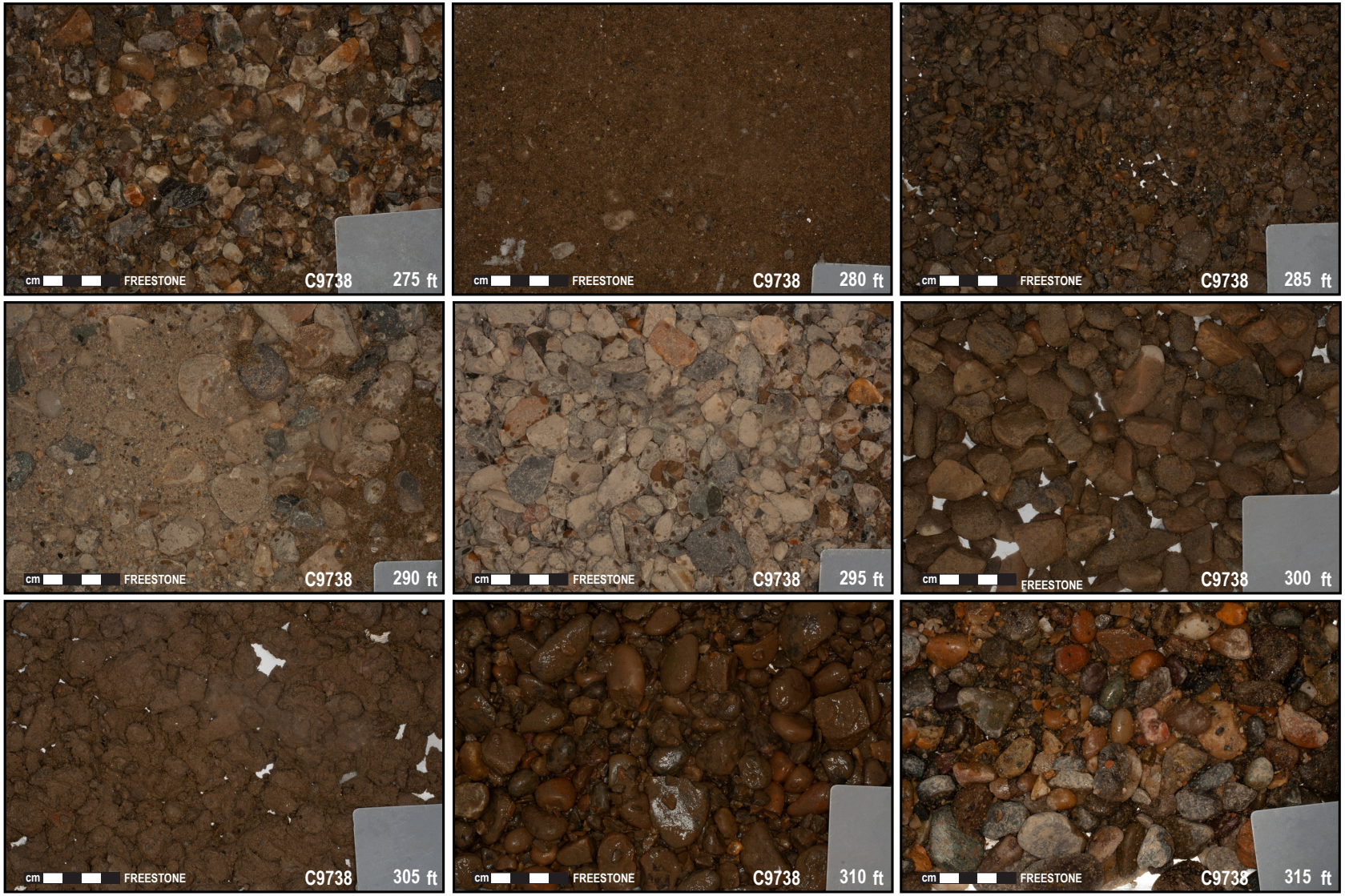

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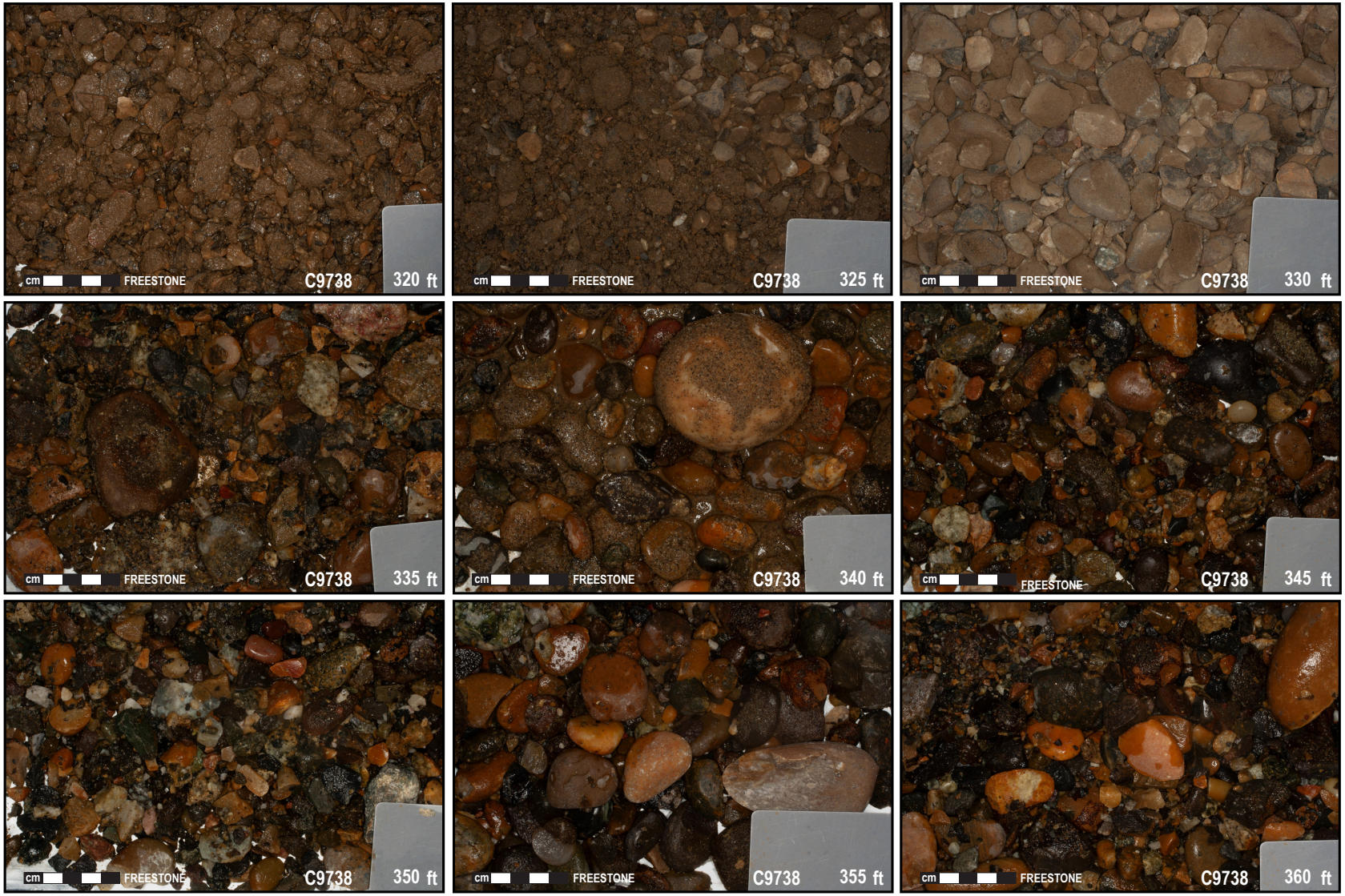

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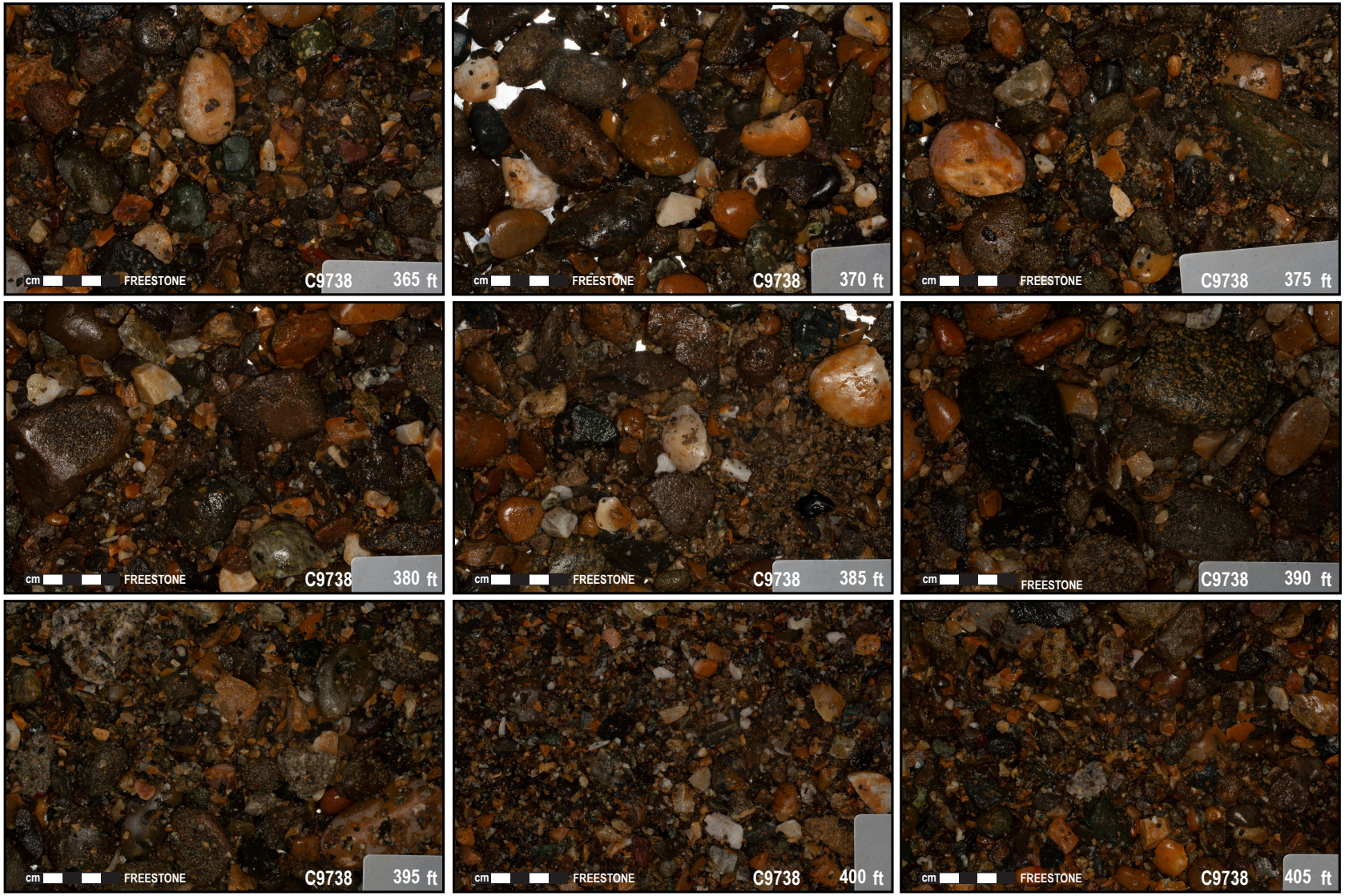

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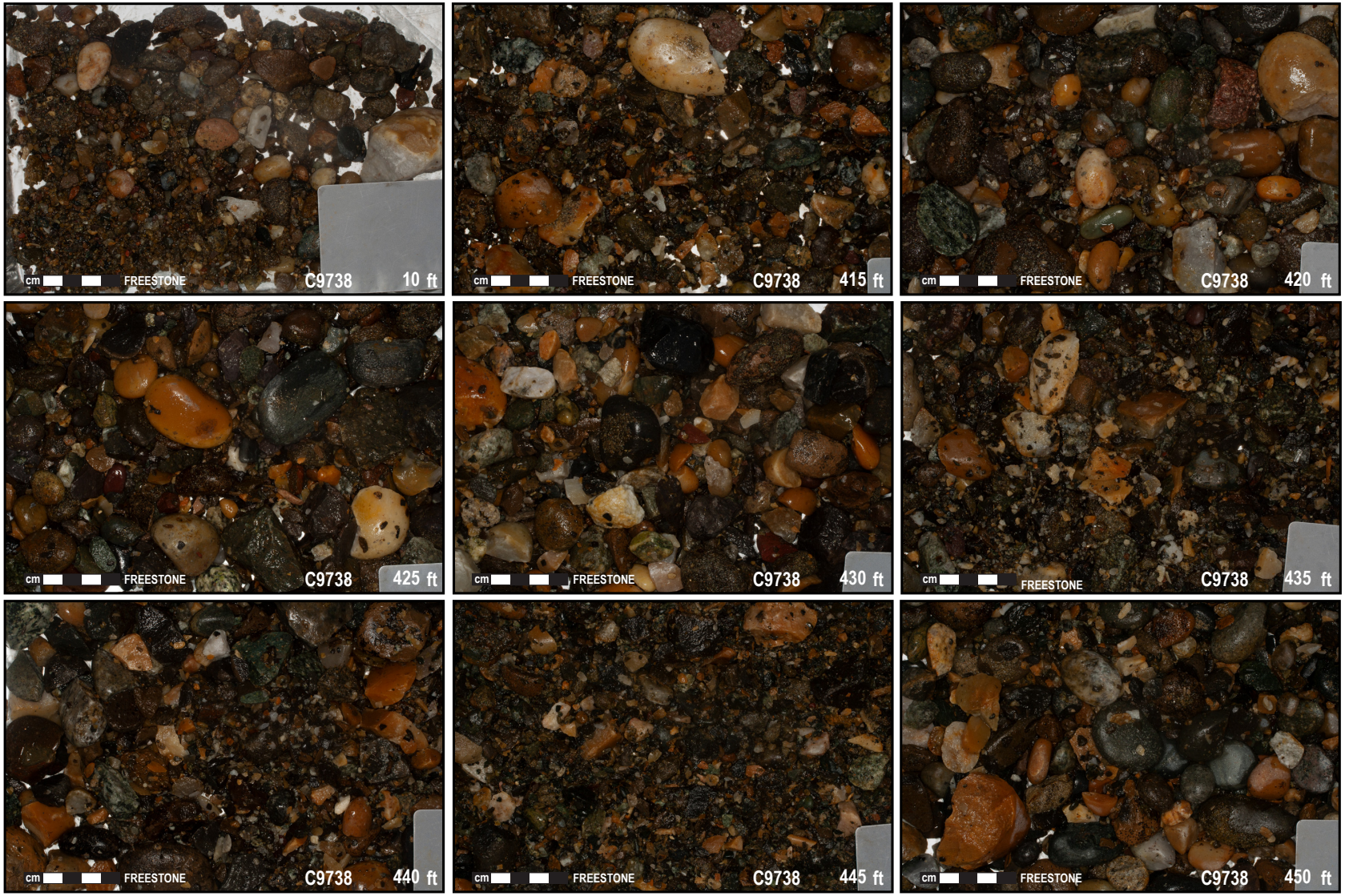

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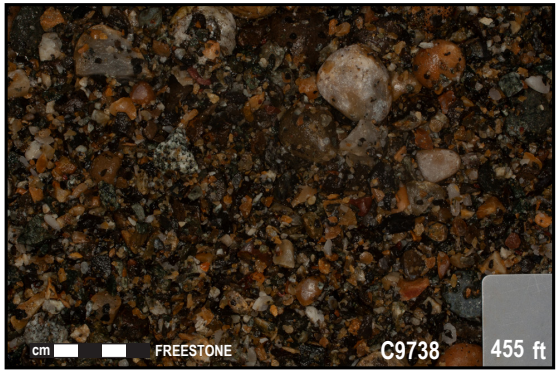

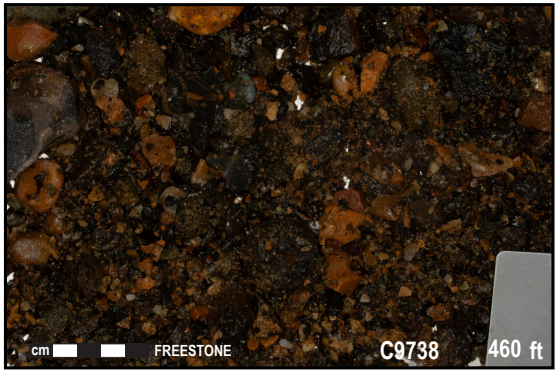

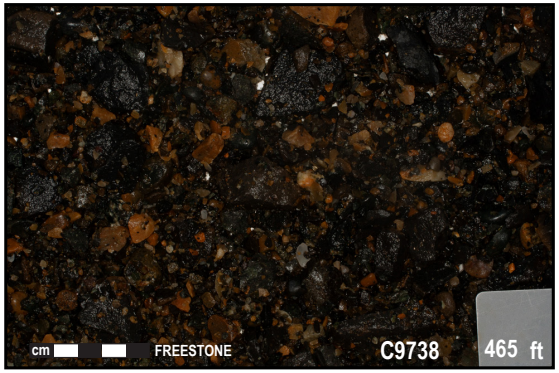

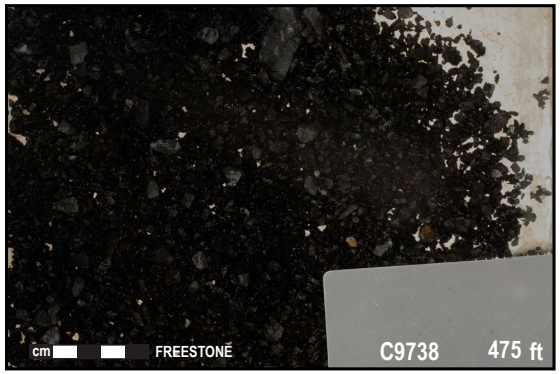

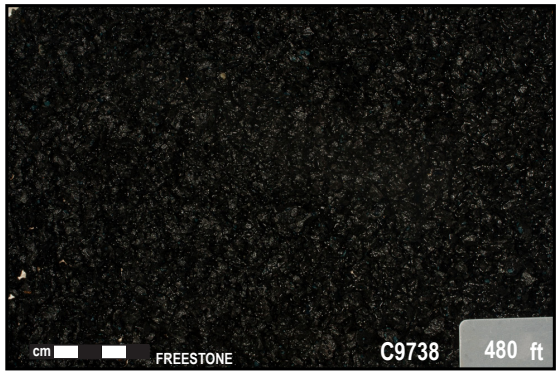

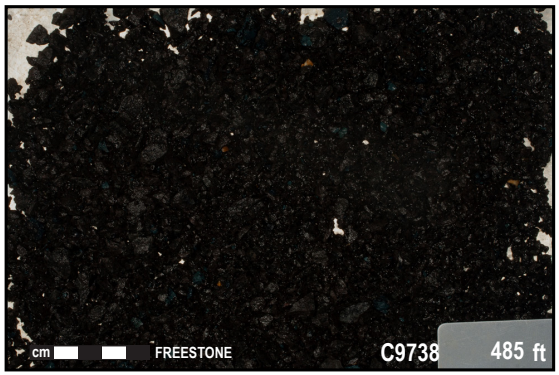

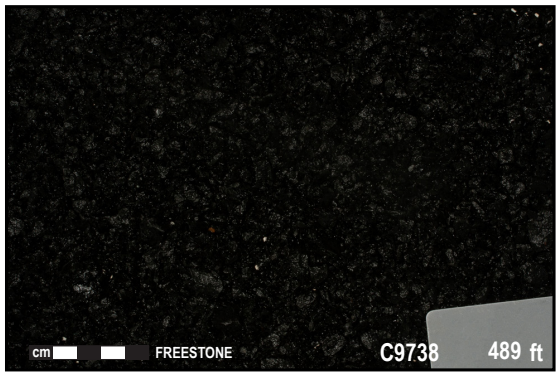

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Drill Cutting Photographs for C9738 (299-W6-17)

WELL DEVELOPMENT AND TESTING DATA

Well ID: C9738 | Well Name: 299-W6-17 | Date: 5/20/19

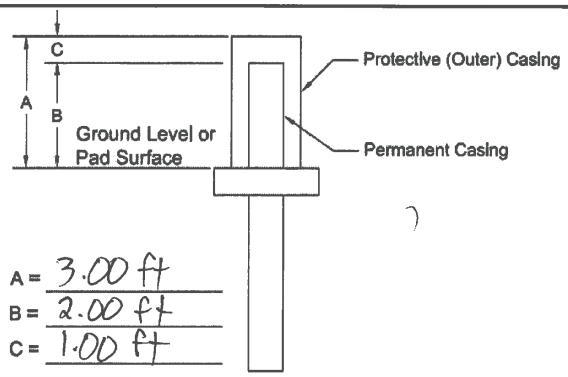
Location: 600m North of T-Plant

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: 5/20/19	300.4 ft bgs	NOT USED BM 5/20/19
Date: 5/21/19	NOT USED BM 5/21/19	300.6 ft bgs
DEPTH TO BOTTOM:		
Date: 5/20/19	449.0 ft	NOT USED BM 5/20/19
Date: 5/21/19	NOT USED BM 5/21/19	448.9 ft



A = 3.00 ft
B = 2.00 ft
C = 1.00 ft

	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)
5/20	332.1	1	31.7	>1000	53.2	1455	1603	15	16.2
5/21	437.2	1	137.2	50.8	3.41	0830	1038	16	13.0

NOT USED BM 5/21/19

Total Pumped: 3,068 gallons

Pump Model: Grundfos submersible pump, 1.5 HP

Troll Serial Number and Pressure Range (PSI and depth): S/N: 546780, 210m/692ft, 300 PSI

Comments:
Rugged Reader File: C9738_develop_05-21-19
DTB for start of job and end of job are longer than total amount of stainless material (448.43 ft) – this is attributed to tape stretch.

Prepared By:

Print Name	Signature	Date
Beth Morter	Beth Morter	6/14/19

Reviewed By:

Print Name	Signature	Date
Jennifer Richart	J. Richart	6/26/19

For Office Use Only

OR Doc Type:	WMU Code(s):

A-6005-205 (REV 2)

Bay West
Customer-Focused Environmental & Industrial Solutions

299-W6-17 (C9738)
Log Data Report

Borehole Information

Log Date	2019-04-09	Filename	C9738_HG-NM_2019-04-09	Site	200-ZP-1
DTW[1] (ft)	**DTW Date**	**DTW Source**	**Drill Date**	**Total Depth (ft)**	**Depth Datum**
300.4	04/04/19	Freestone	04/04/19	489	Ground Surface

Casing Information

Casing Type	Drill Type	Stickup (ft)	Diameter (in.) Outer	Diameter (in.) Inside	Thickness (in.)	Top (ft)	Bottom (ft)
Threaded Steel	Air Rotary	TC[2]	11.87	10.75	0.56	0.4 AGS[3]	150
Threaded Steel	Air Rotary	TC	9.71	8.85	0.43	4.4 AGS	466.4

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. Maximum logging depth achieved was 468 ft, approximately 1.5 ft below the reported casing depth. The geologist reports drillers encountering basalt at approximately 479 ft. The remainder of the borehole was drilled without casing which was not logged. Zero reference is ground surface.

Logging Equipment Information

Logging System	Gamma 4NC	Type	60% Coaxial HPGe (SGLS) [4]
Effective Calibration Date	12/19/2018	Serial No.	45-TP22010A
Calibration Reference	HGLP-CC-178, Rev. 0	Logging Procedure	SGRP-PRO-OP-53023, Rev. 0, Change 2

Logging System	Gamma 1LD	Type	60% Coaxial HPGe (SGLS)
Effective Calibration Date	12/04/2018	Serial No.	47-TP-32211A
Calibration Reference	HGLP-CC-175, Rev. 0	Logging Procedure	SGRP-PRO-OP-53023, Rev. 0, Change 2

Logging System	Gamma 4MC	Type	He-3 (CPN 503DR) NMLS [5]
Effective Calibration Date	12/20/2018	Serial No.	H340207279
Calibration Reference	HGLP-CC-179, Rev. 0	Logging Procedure	SGRP-PRO-OP-53024, Rev. 0, Change 2

Logging System	Gamma 1HD	Type	He-3 (CPN 503DR) NMLS
Effective Calibration Date	12/04/2018	Serial No.	H310700352
Calibration Reference	HGLP-CC-176, Rev. 0	Logging Procedure	SGRP-PRO-OP-53024, Rev. 0, Change 2

[1] depth to water inside casing
[2] Temporary casing
[3] Above ground surface
[4] Spectral Gamma Logging System
[5] Neutron Moisture Logging System

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SGLS Log Run Information

Log Run	3	4	5 Repeat	6
HEIS Number	1021053	1021054	1021055	1021056
Date	02/28/19	03/04/19	03/04/19	04/08/19
Logging Engineer	Meisner/McClellan	Spatz/Meisner	Spatz/Meisner	Spatz
Start Depth (ft)	0.0	120.0	35.0	145.0
Finish Depth (ft)	121.03	146.02	50.01	337.01
Count Time (sec)	100	100	100	100
Live/Real	R	R	R	R
Shield (Y/N)	N	N	N	N
MSA Interval (ft)	1.0	1.0	1.0	1.0
Log Speed (ft/min)	NA	NA	NA	NA
Pre-Verification	C9738DNC20190228AV00CAB1	C9738DNC20190304AV00CAB1	C9738DNC20190304AV00CAB1	C9738ALD20190408AV00CAB1
Start File	AD000000	BD012000	CD003500	AD014500
Finish File	AD012103	BD014602	CD005001	AD033701
Post-Verification	C9738DNC20190304CV00CAA1	C9738DNC20190304CV00CAA1	C9738DNC20190304CV00CAA1	C9738ALD20190408AV00CAA1
Depth Return Error (in.)	2.0 low	N/A	1.0 low	1.0 low
Comments	None	None	Tip of sonde covered in silt upon extraction	None

Log Run	7	8 Repeat		
HEIS Number	1021057	1021058		
Date	04/09/19	04/09/19		
Logging Engineer	Spatz	Spatz		
Start Depth (ft)	336.0	285.0		
Finish Depth (ft)	468.01	317.02		
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	C9738ALD20190409BV00CAB1	C9738ALD20190409BV00CAB1		
Start File	BD033600	CD028500		
Finish File	BD046801	CD031702		
Post-Verification	C9738ALD20190409CV00CAA1	C9738ALD20190409CV00CAA1		
Depth Return Error (in.)	N/A	1.0 low		
Comments	None	None		

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NMLS Log Run Information

Log Run	1	2 Repeat	9	10 Repeat
HEIS Number	1021059	1021060	1021061	1021062
Date	03/04/19	03/04/19	04/09/19	04/09/19
Logging Engineer	Spatz	Spatz	Spatz/Meisner	Patterson/Meisner
Start Depth (ft)	0.0	130.75	146.0	250.0
Finish Depth (ft)	147.02	144.76	300.03	266.02
Count Time (sec)	15	15	15	15
Live/Real	R	R	R	R
Shield (Y/N)	N	N	N	N
MSA Interval (ft)	0.25	0.25	0.25	0.25
Log Speed (ft/min)	NA	NA	NA	NA
Pre-Verification	C9738DMC2019 0304AV00CAB1	C9738DMC201903 04AV00CAB1	C9738AHD2019 0409AV00CAB1	C9738AHD20190 409AV00CAB1
Start File	AD000000	BD013075	AD014600	BD025000
Finish File	AD014702	BD014476	AD030003	BD026602
Post-Verification	C9738DMC2019 0304BV00CAA1	C9738DMC201903 04BV00CAA1	C9738AHD2019 0409BV00CAA1	C9738AHD20190 409BV00CAA1
Depth Return Error (in.)	N/A	0.0	N/A	1.0 low
Comments	None	12” of sonde covered in silt upon return	None	None

Logging Operation Notes

A centralizer was installed on the sondes. Verification measurements passed the acceptance criteria.

Analysis Notes

Analyst	P.D. Henwood	Date	04/30/19
Reference(s)	SGRP-PRO-OP-53040, Rev. 0; SGRP-PRO-OP-53051, Rev. 0		

Casing corrections for a 0.56 and 0.43-in. thick casings were applied to the SGLS and NMLS log data.

For the SGLS, a water correction was applied below 300.4 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 EXCEL templates identified as DNC20181219 and ALD20181204 using an efficiency function and corrections for casing and dead time as determined by annual calibrations.

Casing diameter and thickness corrections for 0.56-in. thick, 11.87-in. OD casing were applied to the NMLS data for the first casing to 147 ft and for 0.43-in. thick 9.71-in. OD for the second casing. Integrated with the casing diameter and thickness corrections is an initial count rate correction for a sediment composition of a 50-50% ratio of basalt fragments to quartz sand (HGLP-OTH-028).

NMLS data are reported in counts per second for the entire length of the borehole. NMLS data are also reported in vol% moisture. Conversions from count rate to vol% moisture were performed using EXCEL templates identified as AHD_MCNP_assay and DMC_MCNP_assay.

HGU[6] 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.

Bi-214 energy peaks at 609 and 1764 keV are plotted on the Combination log plots. These energy peaks are used to calculate naturally occurring U-238. Where the concentrations diverge, radon (Rn-222) is indicated that has disrupted the secular equilibrium (activity of the parent is equal to the activity of its daughters) between the parent U-238 and its daughters below Rn-222 in the uranium decay chain. It is interpreted that intervals of relatively low moisture that coincide with relatively high U-238 using the 609 keV energy peak suggest partial voids behind the casing where radon is trapped and neutron count rate is low. For example, this may be occurring at approximately 180, 193, 217, 230, 246, 263, 275, and 297 ft.

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 almost rhythmic nature of the highs and lows in the moisture in the absence of any significant changes in the K and T logs suggests that the nature of the sediments are not changing significantly and the possibility of the driller introducing water during drilling is a distinct possibility. For example, water may have been introduced at 250 and 265 ft. Water was apparently introduced into the bottom of the first casing where elevated moisture is observed at 143 ft.

The KUT and moisture repeat plots indicate that the systems were working properly.

List of Log Plots

Depth Reference is ground surface.

Manmade Radionuclides (0-480 ft)
Natural Gamma Logs (0-160 ft)
Natural Gamma Logs (160-320 ft)
Natural Gamma Logs (320-480 ft)
Combination Plot (0-120 ft)
Combination Plot (120-240 ft)
Combination Plot (240-360 ft)
Combination Plot (360-480 ft)
Combination Plot (0-480 ft)
Total Gamma & Moisture (0-320 ft)
Moisture (0-160 ft)
Moisture (160-320 ft)
Total Gamma & Hanford Gamma Unit (0-480 ft)
Repeat Section of Natural Gamma Logs (35-50 ft)
Repeat Section of Natural Gamma Logs (285-317 ft)
Moisture Repeat Section (130-144 ft)
Moisture Repeat Section (250-266 ft)

[6] Hanford Gamma Unit

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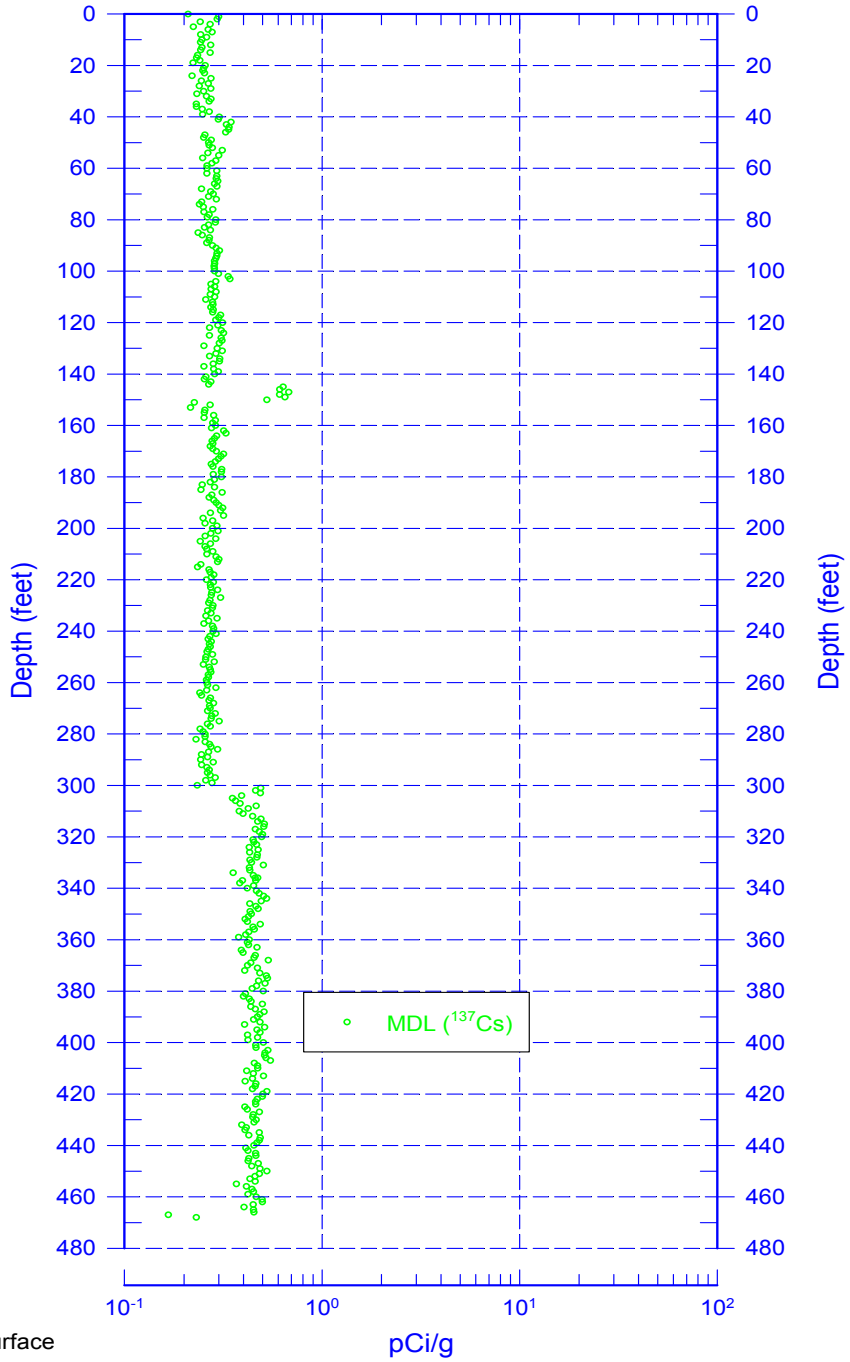
299-W6-17 (C9738)
Manmade Radionuclides



Zero Reference - ground surface

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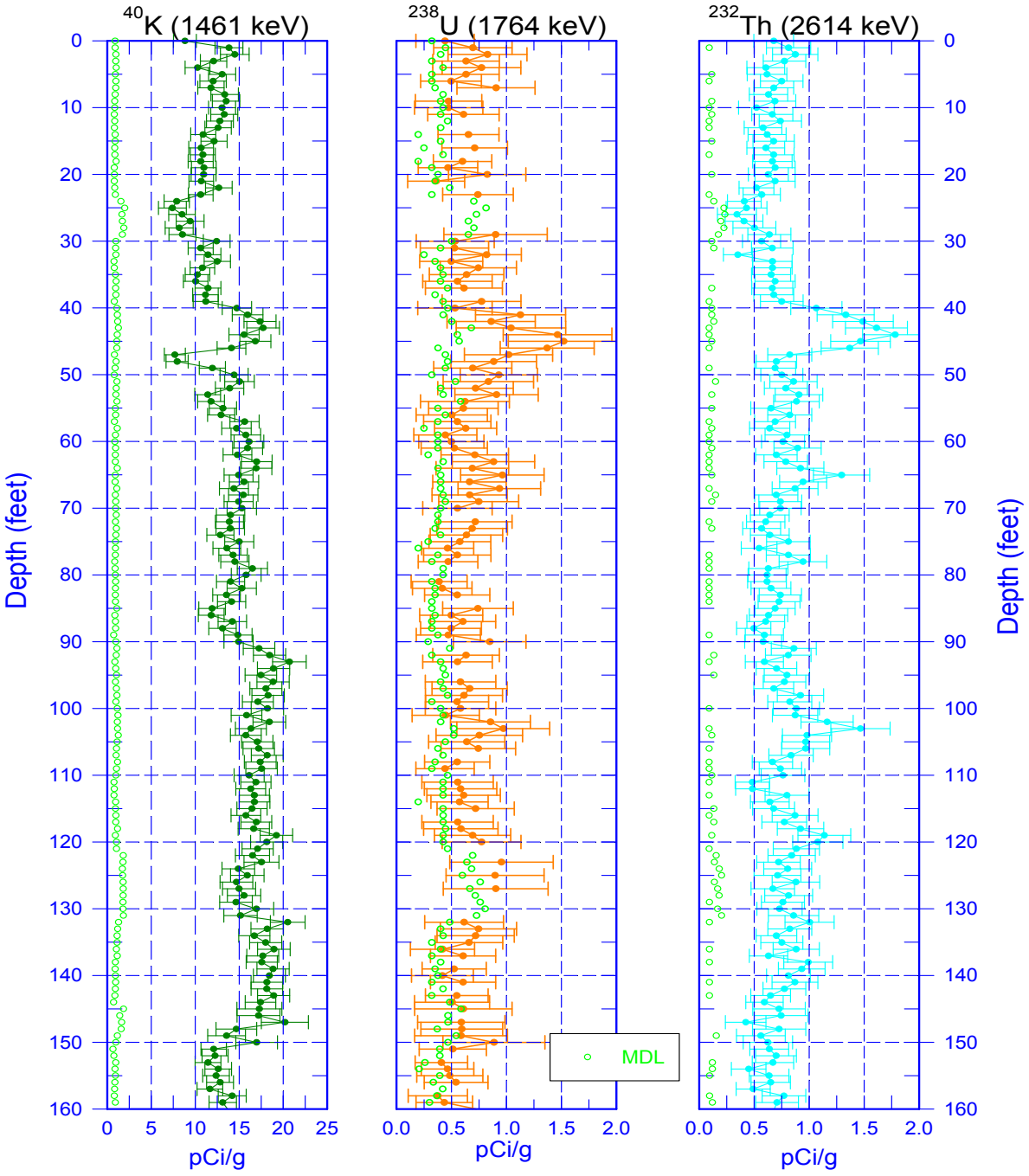
299-W6-17 (C9738)
Natural Gamma Logs



Zero Reference - ground surface

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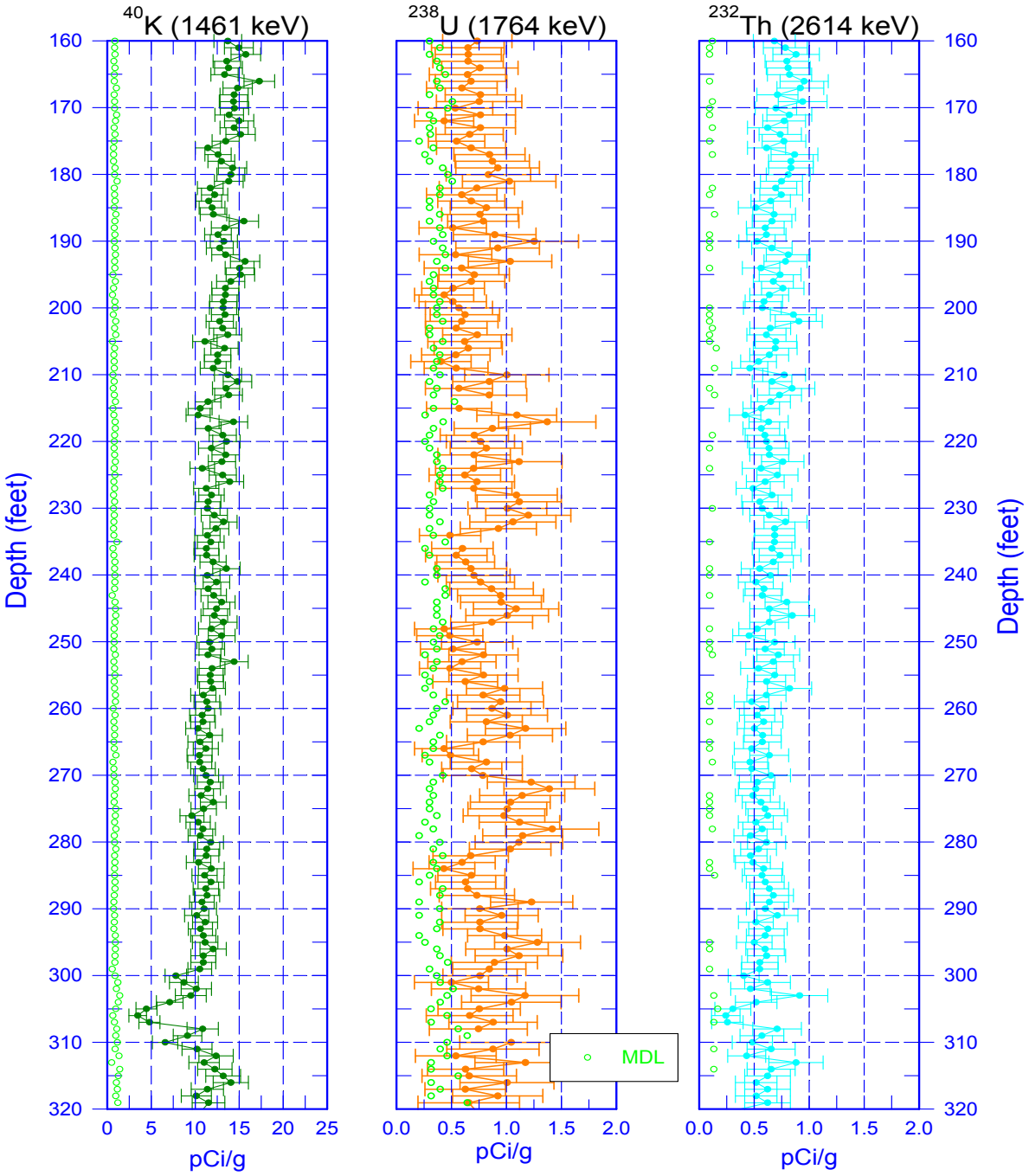
299-W6-17 (C9738)
Natural Gamma Logs



Zero Reference - ground surface

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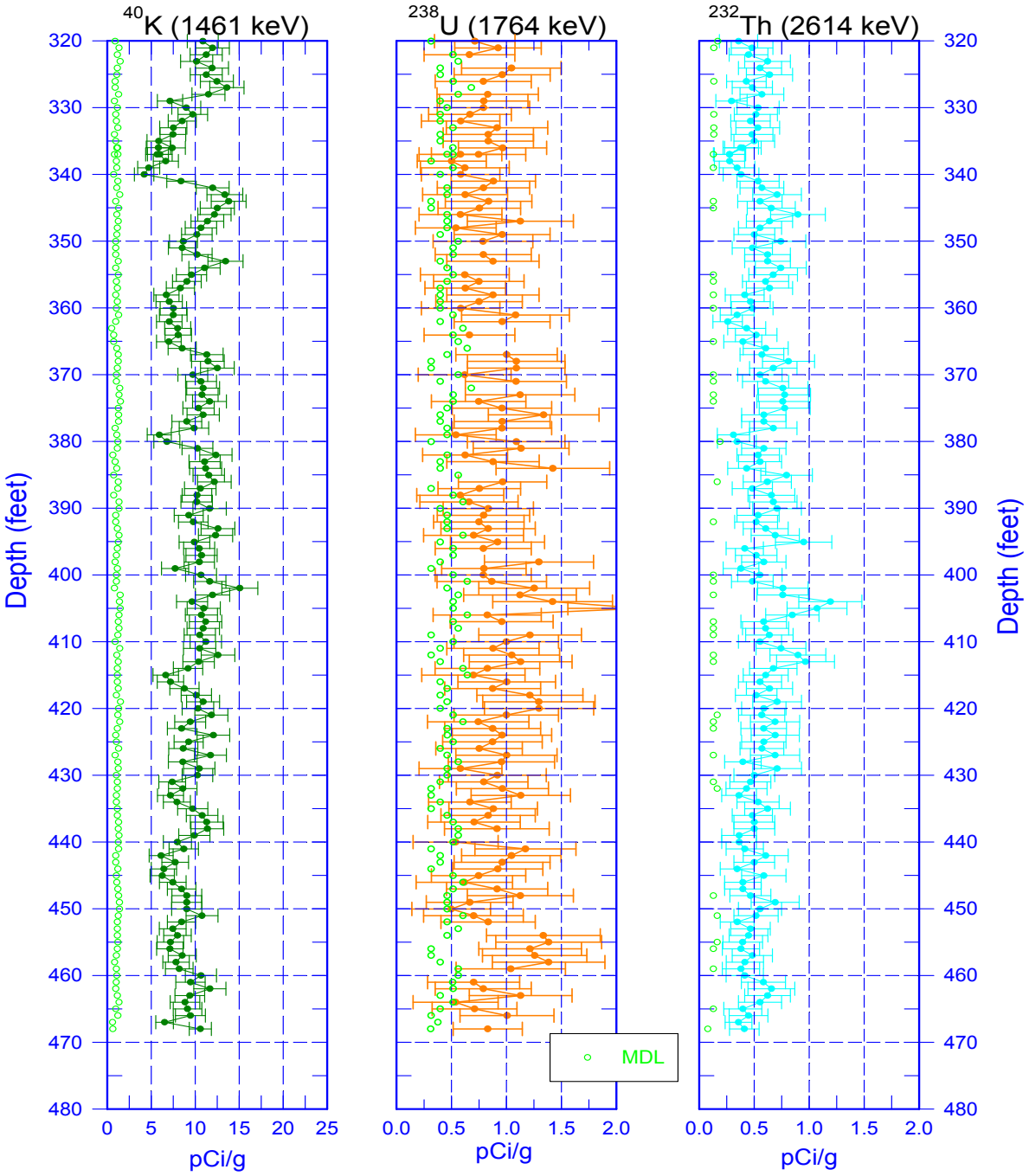
Customer-Focused Environmental & Industrial Solutions

299-W6-17 (C9738)
Natural Gamma Logs



Zero Reference - ground surface

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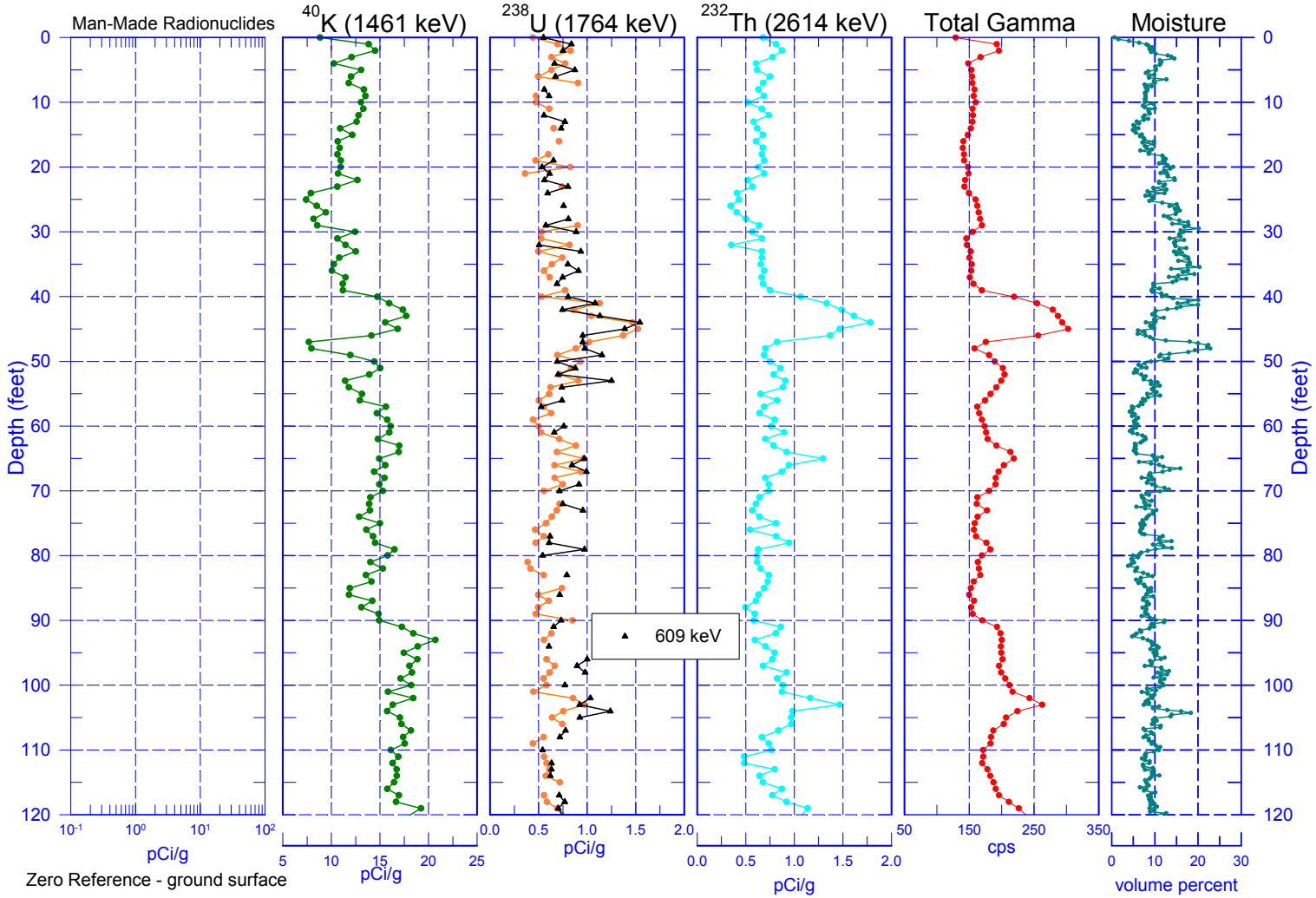
299-W6-17 (C9738) Combination Plot



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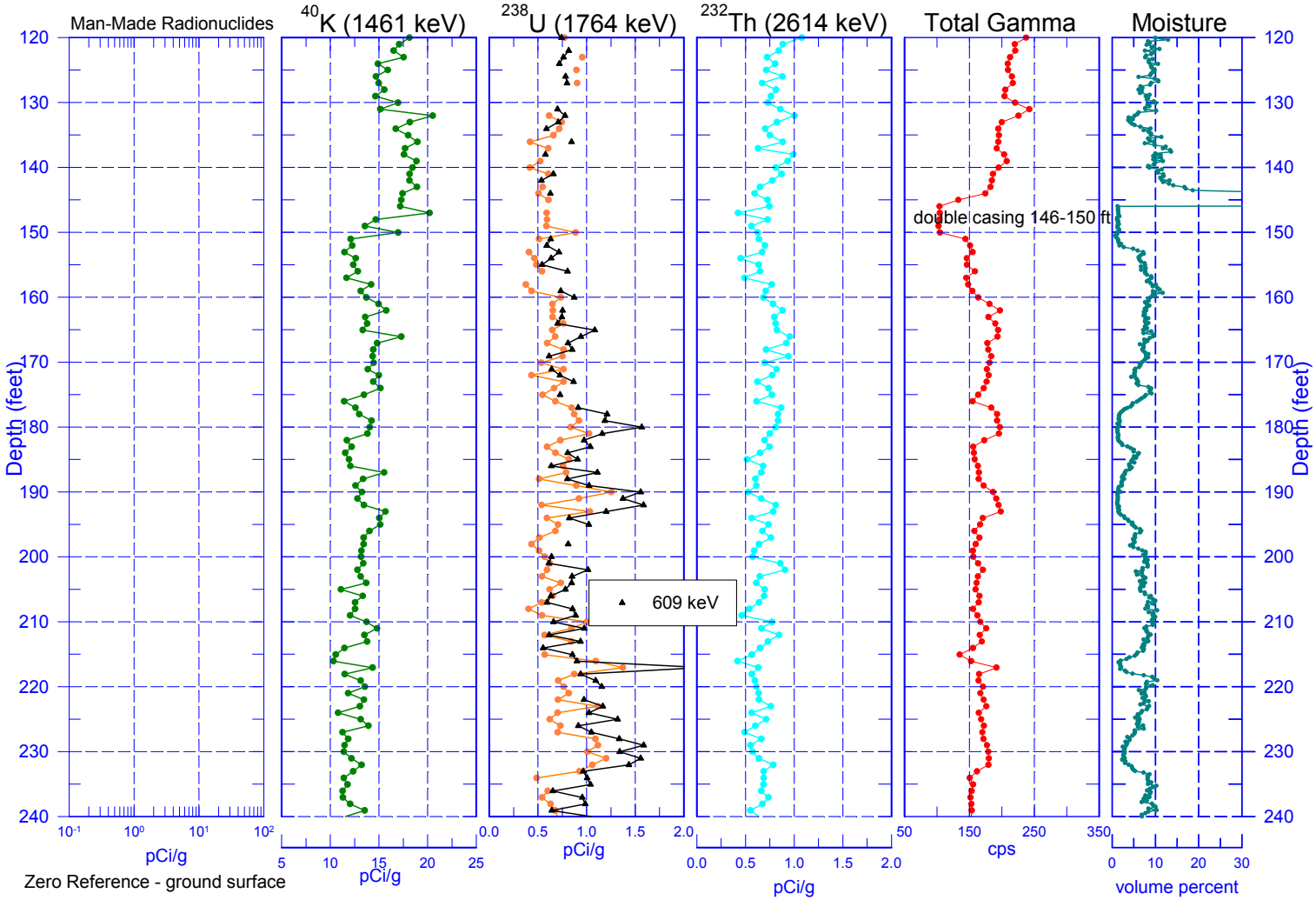
299-W6-17 (C9738) Combination Plot



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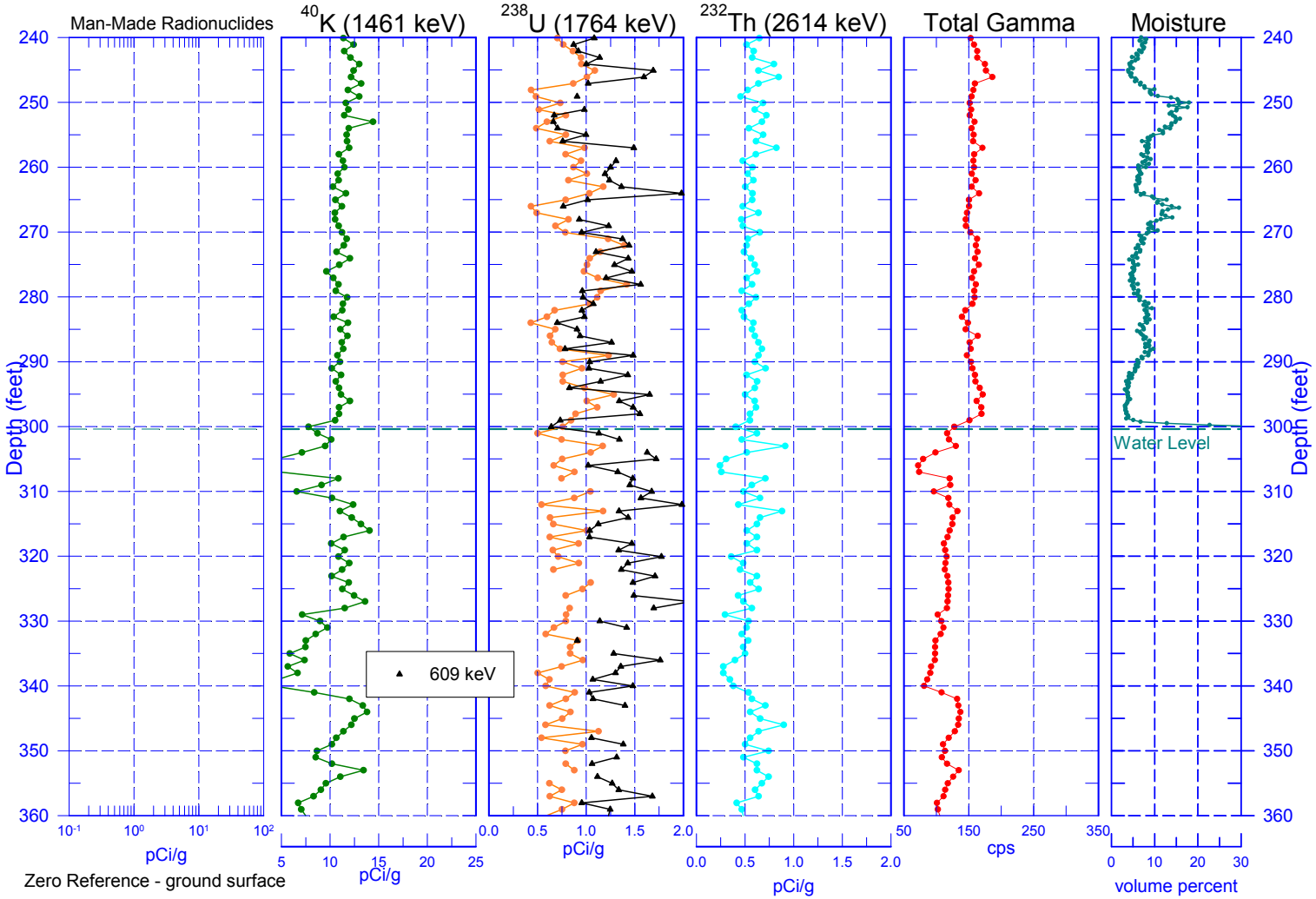
299-W6-17 (C9738) Combination Plot



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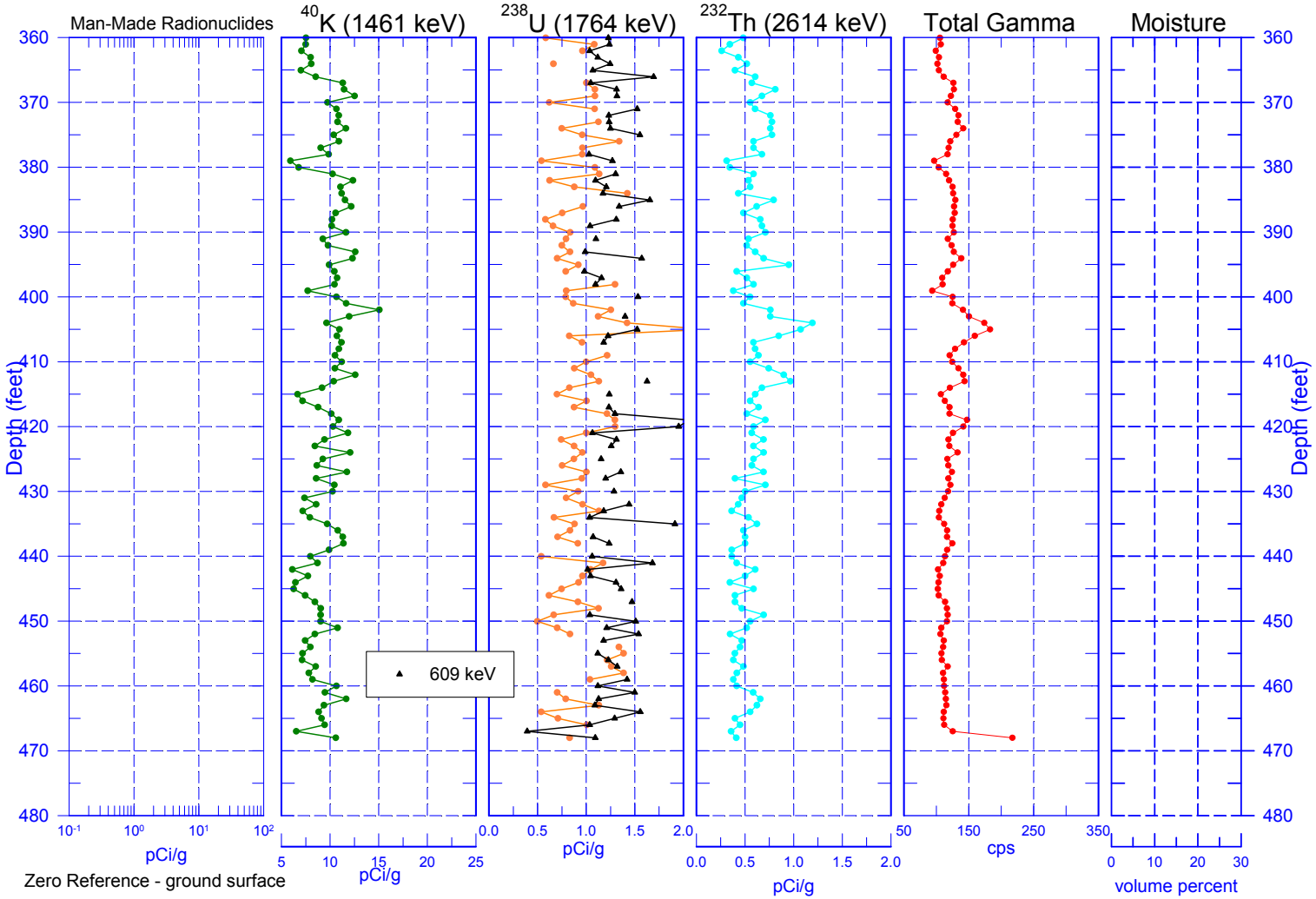
299-W6-17 (C9738) Combination Plot



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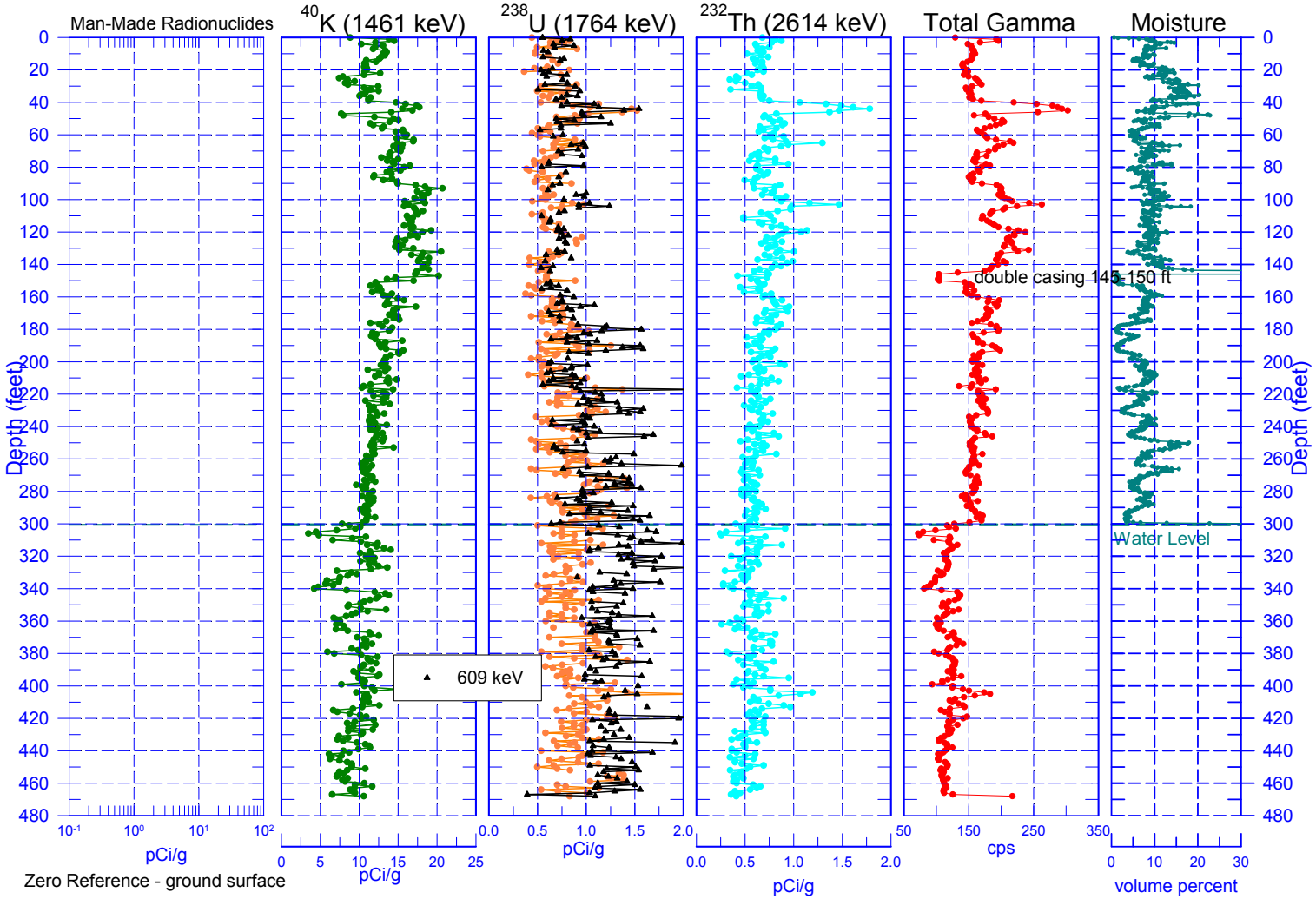
299-W6-17 (C9738) Combination Plot



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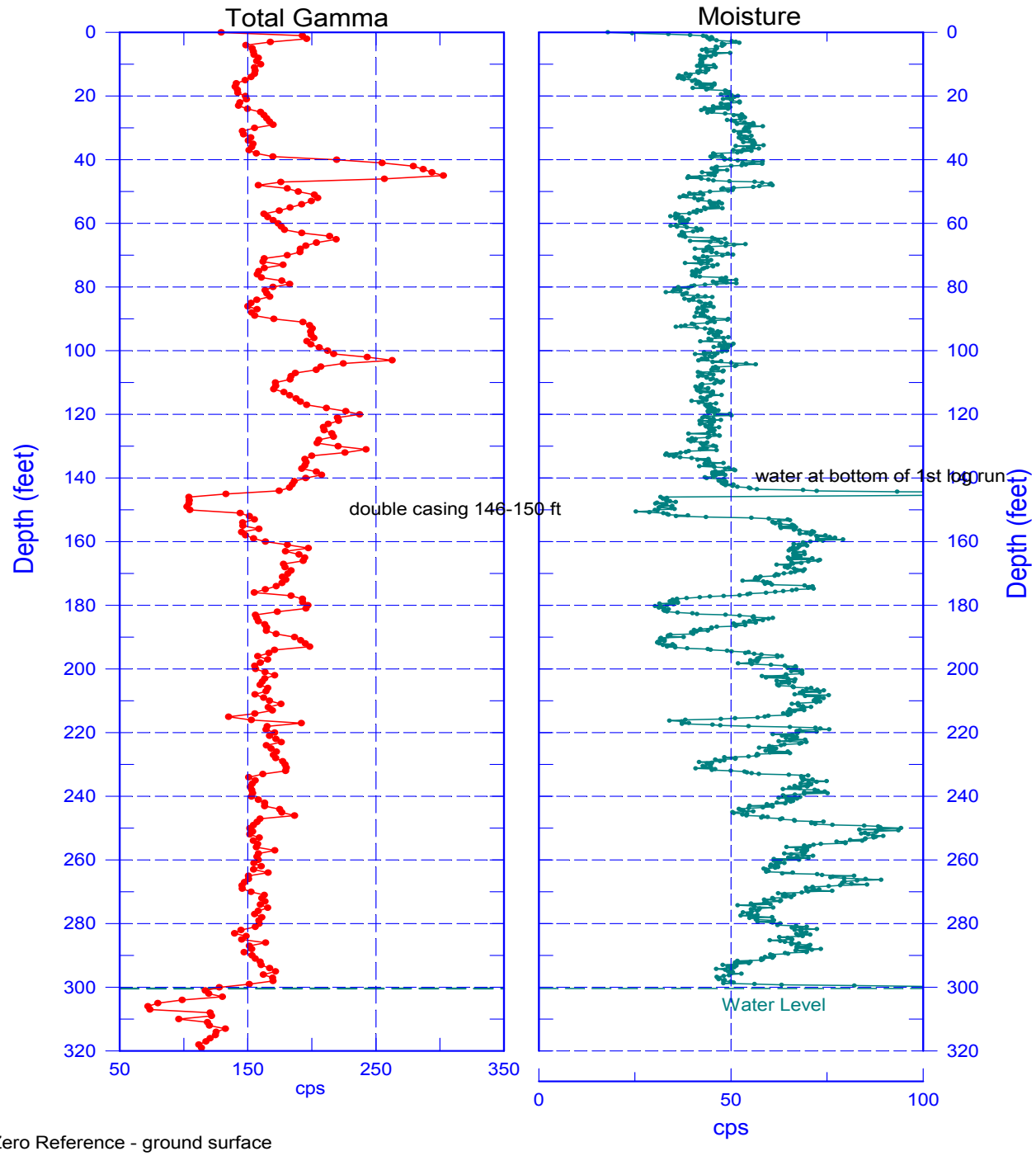
299-W6-17 (C9738)
Total Gamma & Moisture



Zero Reference - ground surface

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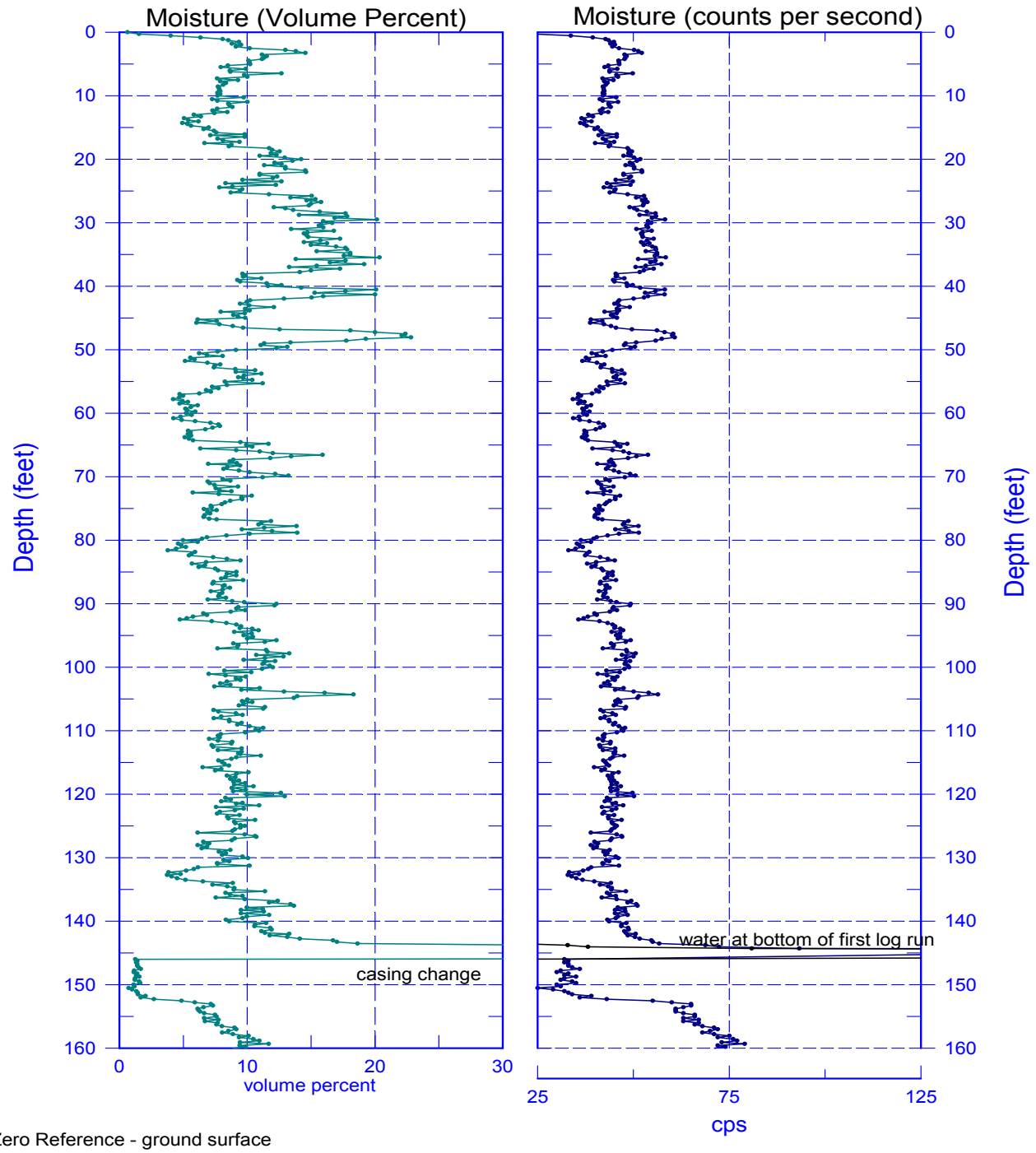
299-W6-17 (C9738)
Moisture



Zero Reference - ground surface

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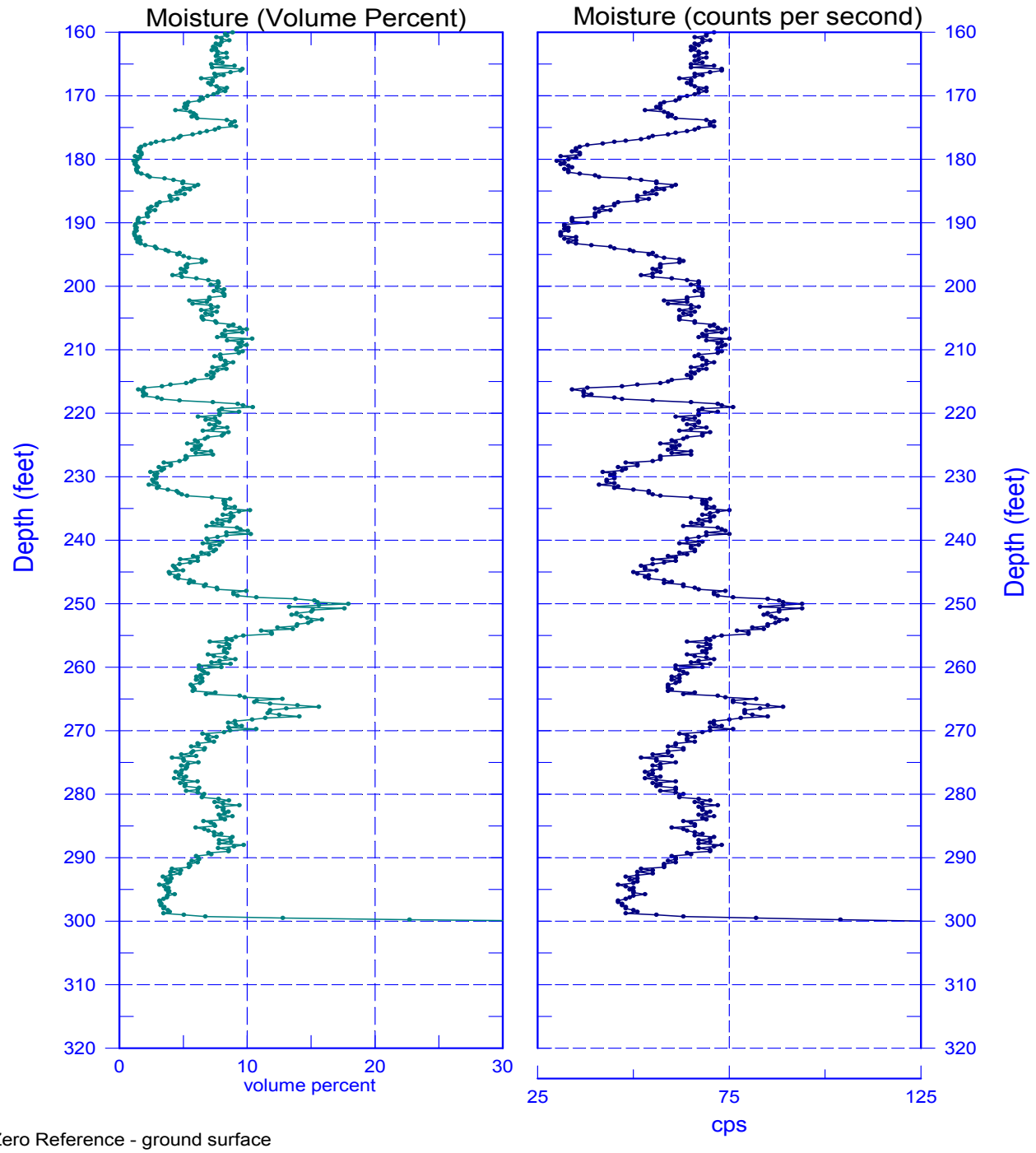
299-W6-17 (C9738)
Moisture



Zero Reference - ground surface

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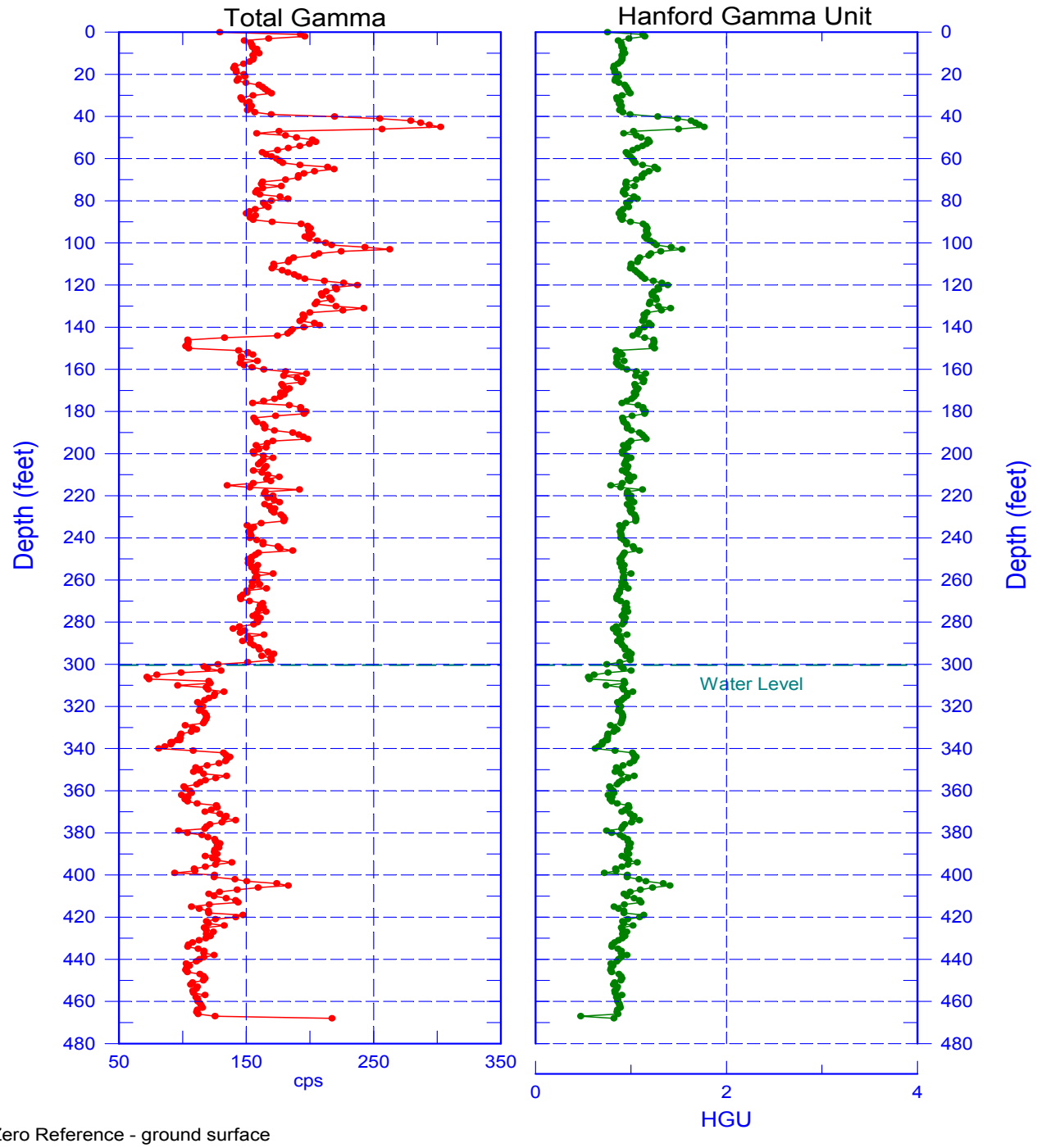
299-W6-17 (C9738)
Total Gamma & Hanford Gamma Unit



Zero Reference - ground surface

Bay West
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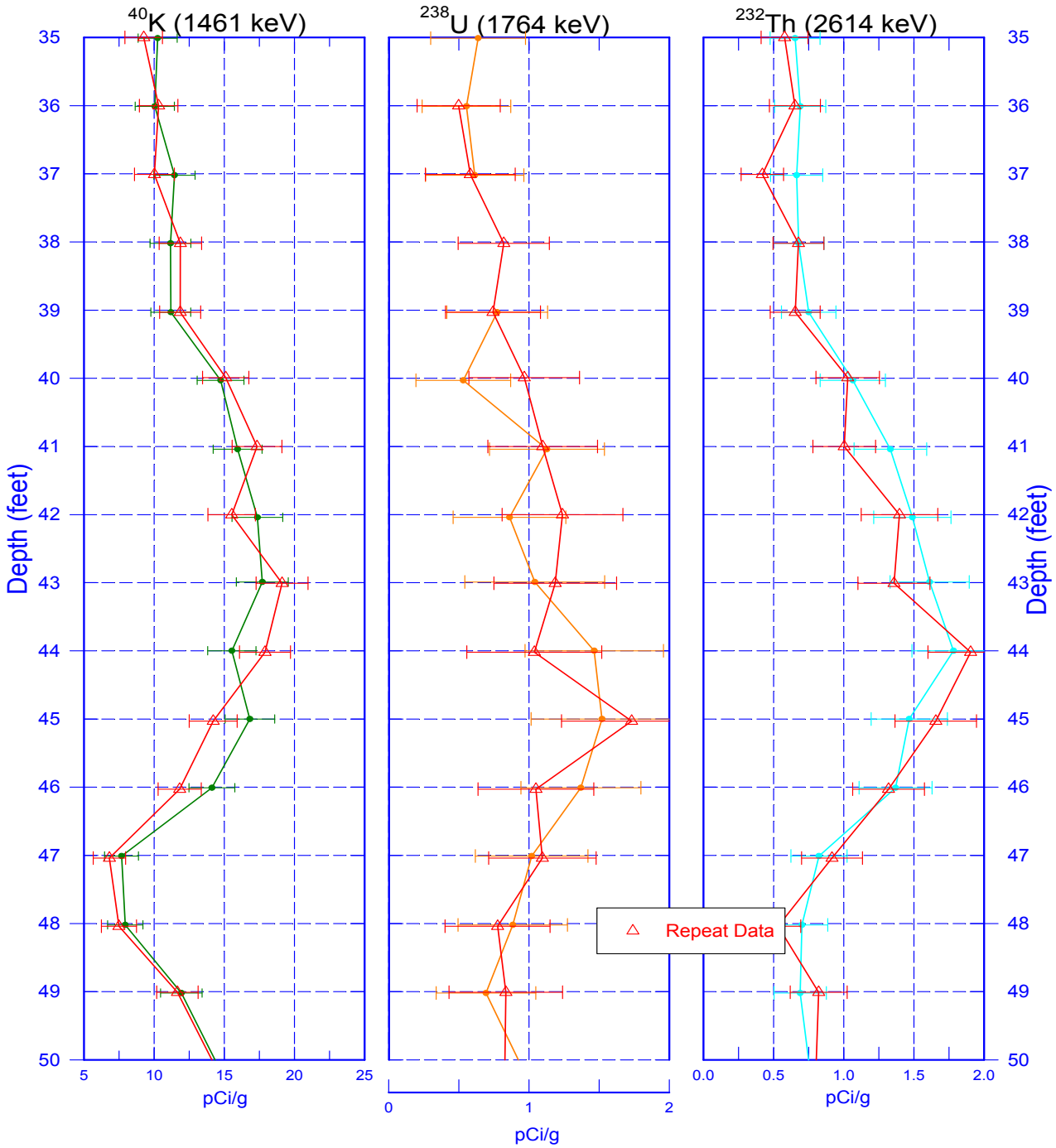
299-W6-17 (C9738)
Repeat Section of Natural Gamma Logs



Zero Reference - ground surface

Bay West
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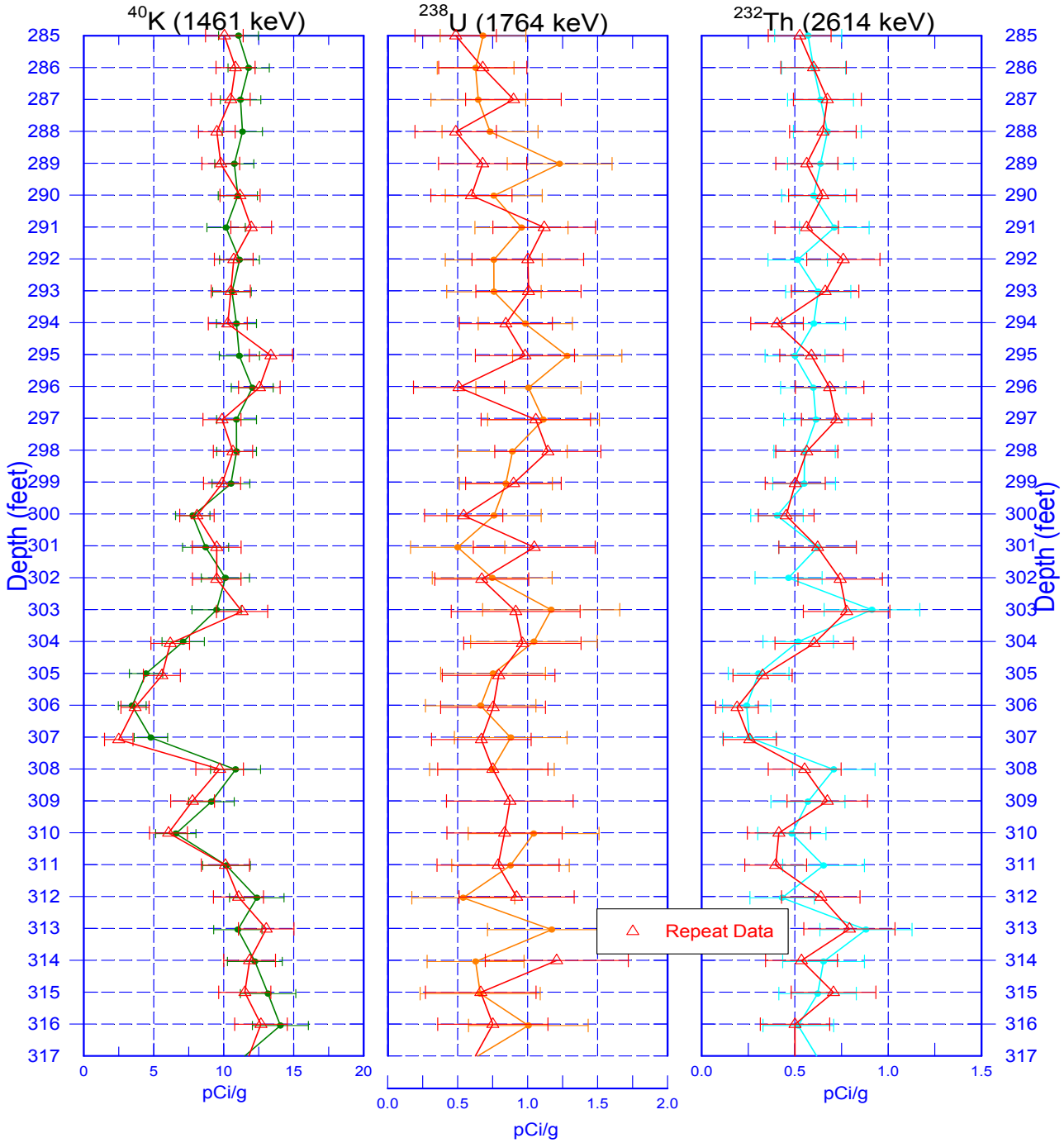
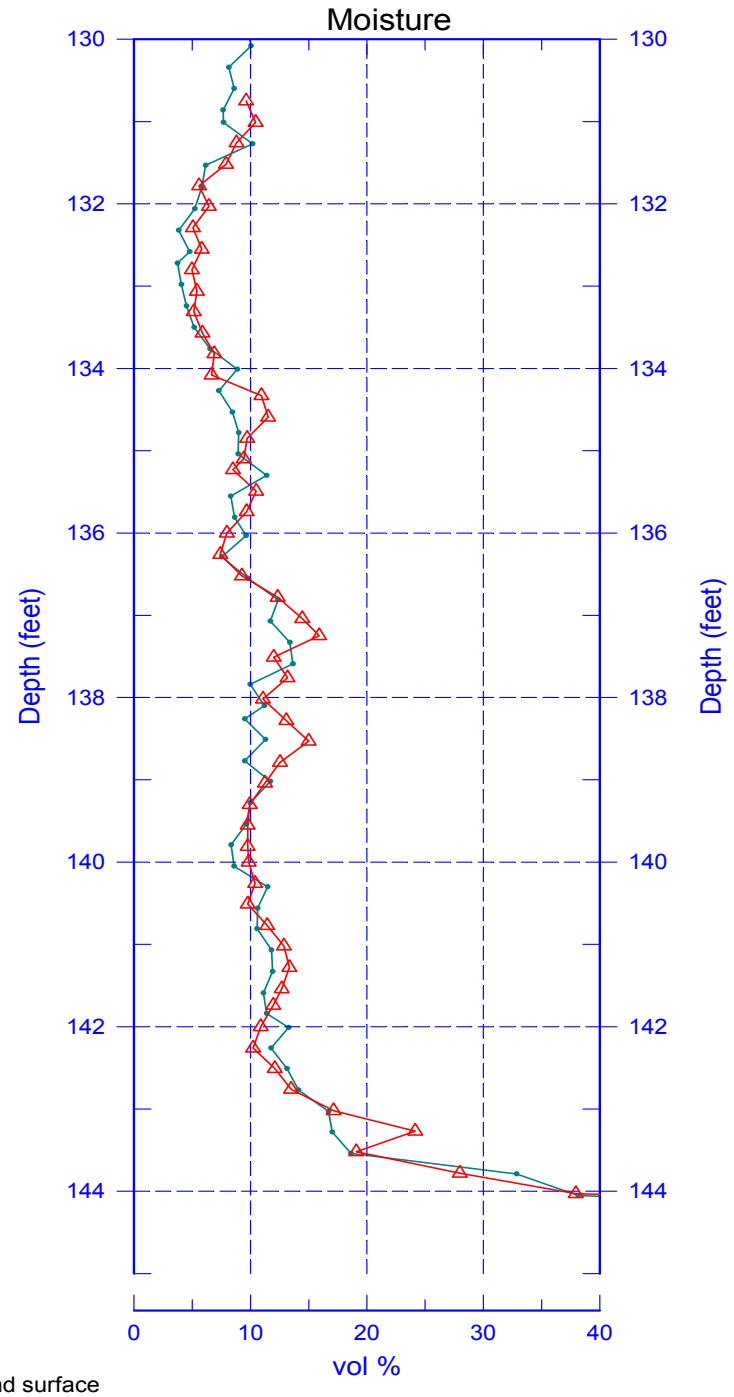
299-W6-17 (C9738)
Repeat Section of Natural Gamma Logs



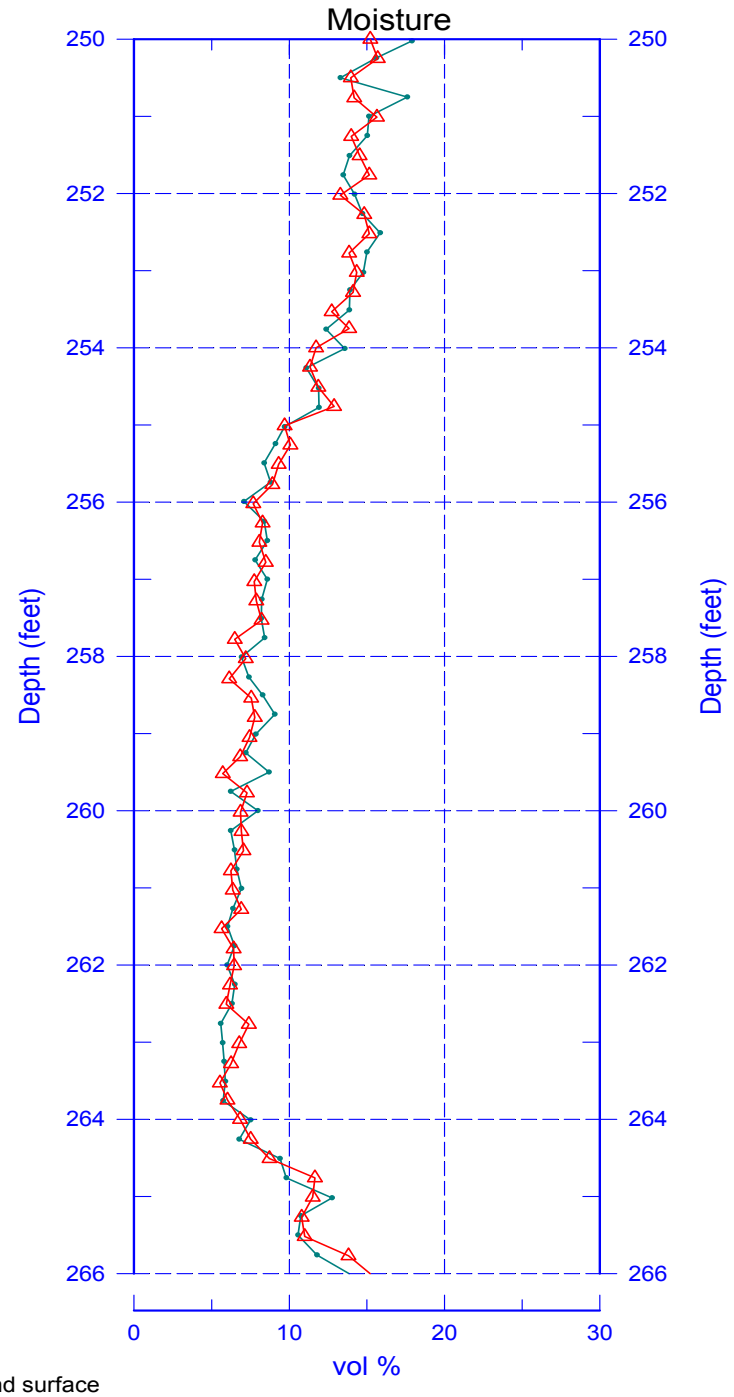
Zero Reference - Ground Surface

299-W6-17 (C9738)
Moisture Repeat Section



Zero Reference - ground surface

299-W6-17 (C9738)
Moisture Repeat Section



Zero Reference - ground surface

WELL SURVEY DATA REPORT

Project:	**Prepared By:** Neil P. Fastabend
	Company: CHPRC
Date Requested: 06/13/19	Requestor: Matthan G. Wilson (CHPRC)
Date of Survey: 06/17/19	Surveyor / Company: Lawrence B. Munnell / CHPRC
Description of Work: Obtained final survey coordinates (C/L Casing) and elevations of ZP-1 Well C9738 (299-W6-17) located northeast of T-Plant in 200W Area.	Horizontal Datum: NAD83 (91)
	Vertical Datum: NAVD88
	Units: Meters
	Hanford Area Designation: 200W

Coordinate System: Washington State Plane Coordinates (South Zone)

Horizontal Control Monuments:
Washington State Reference Network

Vertical Control Monuments:
2W-5 (CHPRC) and 2W-18 (CHPRC)

Well ID	Well Name	Easting	Northing	Elevation	
C9738	299-W6-17	567767.41	137473.37		Center of Casing
				220.997	Top Inner 4"Casing, N.Edge
				221.321	Top Outer Casing,N.Edge Stamped "X"
				220.564	Brass Survey Marker

Notes:

Brass Survey Marker elevation was taken on top of 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
6-17-19

A-6003-659 (REV 1)

Appendix B

Well Documentation for C9740 (699-44-70B)

Contents

Well Summary Sheet ……..……..…..... B-1
Borehole Log ……...…….…. B-7
Drill Cutting Photographs …….....…….……..... B-20
Well Develepment and Testing Data ……..……....……...…....… B-32
Log Data Report …….....…..…..……....……...…....… B-33
Well Survey Data Report …….....…..…..……....……...…....… B-57

WELL SUMMARY SHEET

Well ID : C9740	Well Name: 699-44-70B	Start Date: 4/8/2019
Project: 3 Monitoring Wells in 200-ZP-1 OU	Location:360m S. of weather station	Finish Date: 6/27/2019

CONSTRUCTION DATA

Description

Concrete Pad: 0.50 ft above ground surface (ags)

6-in. Protective Casing: 3.00 ft ags - 2.10 ft below ground surface (bgs)

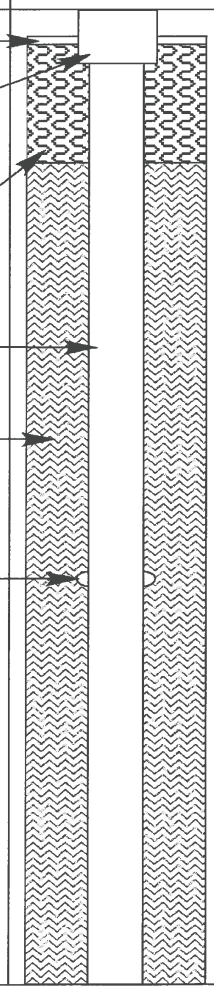
Type I/II Portland Cement Grout: 0.0 - 9.6 ft bgs

4-in. I.D. Schedule 10, Type 304/304L, Stainless Steel Blank Casing: 2.39 ft ags - 400.24 ft bgs

3/8" Bentonite Crumbles: 9.6 - 316.7 ft bgs

Stainless steel centralizer installed above and below screen and every 40 ft

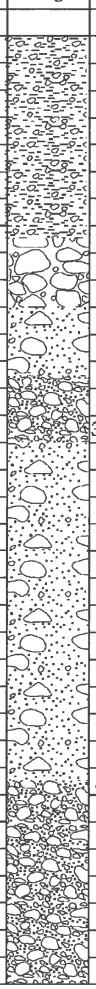
Diagram



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet: 0, 10, 20, 30, 40, 50, 60

Graphic Log



Lithologic Description (ft bgs)

0.0 - 15.0 Silty Gravel (mG)

15.0 - 20.0 Gravel (G)

20.0 - 25.0 Gravelly Sand (gS)

25.0 - 30.0 Sandy Gravel (sG)

30.0 - 55.0 Gravelly Sand (gS)

55.0 - 75.0 Sandy Gravel (sG)

Reported By: Lindsey Getchell (Print Name)	Geologist (Title)	[signature] (Signature)	5/21/2019 (Date)
Reviewed By: Jennifer Richart (Print Name)	Well Coordinator (Title)	[signature] (Signature)	7/16/19 (Date)

For Office Use Only

OR Doc Type:	WMU Code(s):

A-6003-643 (REV 2)

WELL SUMMARY CONTINUATION SHEET			Page 2 of 6
Well ID: C9740	Well Name: 699-44-70B	Project: 3 Monitoring Wells in 200-ZP-1 OU	

CONSTRUCTION DATA		GEOLOGIC/HYDROLOGIC DATA		
Description	Diagram	Depth in Feet	Graphic Log	Lithologic Description (ft bgs)
4-in. I.D. Schedule 10, Type 304/304L, Stainless Steel Blank Casing: 2.39 ft ags - 400.24 ft bgs		70		55.0 - 75.0 Sandy Gravel (sG)
				75.0 - 80.0 Sand (S)
		80		80.0 - 90.0 Slightly Silty Sand ((m)S)
3/8" Bentonite Crumbles: 9.6 - 316.7 ft bgs				
		90		90.0 - 115.0 Sand (S)
		100		
		110		
				115.0 - 120.0 Slightly Silty Sand ((m)S)
		120		120.0 - 125.0 Sand (S)
				125.0 - 130.0 Slightly Silty Sand ((m)S)
		130		130.0 - 195.0 Sand (S)
		140		
		150		
		160		

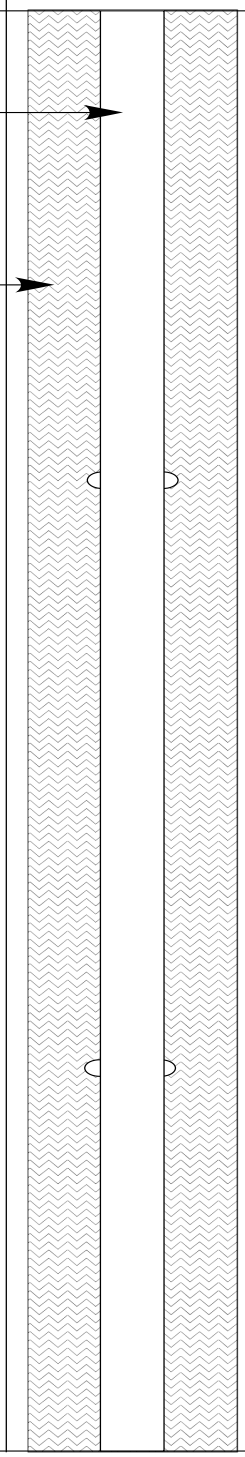
A-6006-992 (Rev 2)

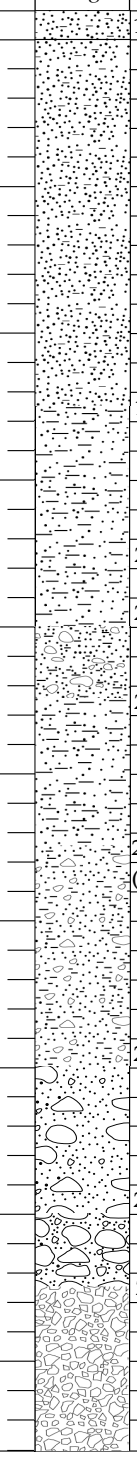
WELL SUMMARY CONTINUATION SHEET			Page 3 of 6
Well ID: C9740	Well Name: 699-44-70B	Project: 3 Monitoring Wells in 200-ZP-1 OU	

CONSTRUCTION DATA		GEOLOGIC/HYDROLOGIC DATA	
Description	Diagram	Depth in Feet	Lithologic Description (ft bgs)

4-in. I.D. Schedule 10, Type 304/304L, Stainless Steel Blank Casing: 2.39 ft ags - 400.24 ft bgs

3/8" Bentonite Crumbles: 9.6 - 316.7 ft bgs





Depth in Feet: 170, 180, 190, 200, 210, 220, 230, 240, 250, 260

Lithologic Description (ft bgs):

- 130.0 - 195.0 Sand (S)
- 195.0 - 205.0 Slightly Silty Sand ((m)S)
- 205.0 - 210.0 Silty Sand (mS)
- 210.0 - 215.0 Gravelly Silty Sand (gmS)
- 215.0 - 225.0 Silty Sand (mS)
- 225.0 - 240.0 Slightly Silty Gravelly Sand ((m)gS)
- 240.0 - 250.0 Gravelly Sand (gS)
- 250.0 - 255.0 Sandy Gravel (sG)
- 255.0 - 345.0 Gravel (G)

A-6006-992 (Rev 2)

WELL SUMMARY CONTINUATION SHEET		Page 4 of 6
Well ID: C9740	Well Name: 699-44-70B	Project: 3 Monitoring Wells in 200-ZP-1 OU

CONSTRUCTION DATA		Depth in Feet	GEOLOGIC/HYDROLOGIC DATA	
Description	Diagram		Graphic Log	Lithologic Description (ft bgs)
4-in. I.D. Schedule 10, Type 304/304L, Stainless Steel Blank Casing: 2.39 ft ags - 400.24 ft bgs		270		255.0 - 345.0 Gravel (G)
3/8" Bentonite Crumbles: 9.6 - 316.7 ft bgs		280		
		290		
		300		
		310		
1/4-in. Coated Bentonite Pellet Seal: 316.7 - 395.5 ft bgs		320		Static Water Level: 323.34 ft bgs (7/1/2019)
		330		
		340		345.0 - 350.0 Silty Gravel (mG)
		350		350.0 - 390.0 Sandy Silt (sM)
		360		

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WELL SUMMARY CONTINUATION SHEET			Page 5 of 6
Well ID: C9740	Well Name: 699-44-70B	Project: 3 Monitoring Wells in 200-ZP-1 OU	

CONSTRUCTION DATA		Depth in Feet	GEOLOGIC/HYDROLOGIC DATA	
Description	Diagram		Graphic Log	Lithologic Description (ft bgs)
4-in. I.D. Schedule 10, Type 304/304L, Stainless Steel Blank Casing: 2.39 ft ags - 400.24 ft bgs		370		350.0 - 390.0 Sandy Silt (sM)
1/4-in. Coated Bentonite Pellet Seal: 316.7 - 395.5 ft bgs		380		
		390		390.0 - 395.0 Silty Gravel (mG)
				395.0 - 405.0 Silty Sandy Gravel (msG)
8-16 mesh Silica Filter Pack Sand: 395.5 - 426.1 ft bgs		400		
				405.0 - 497.0 Gravel (G)
4-in. I.D. Schedule 10, Type 304/304L, 20-slot (0.020 in.) Stainless Steel Screen: 400.24 - 420.27 ft bgs		410		
4-in. I.D. Schedule 10, Type 304/304L, Stainless Steel Sump: 420.27 - 423.25 ft bgs		420		
1/4-in. Noncoated Bentonite Pellet: 426.1 - 510.1 ft bgs		430		
		440		
		450		
		460		

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WELL SUMMARY CONTINUATION SHEET			Page 6 of 6
Well ID: C9740	Well Name: 699-44-70B	Project: 3 Monitoring Wells in 200-ZP-1 OU	

CONSTRUCTION DATA

Description

1/4-in. Noncoated Bentonite Pellet:
426.1 - 510.1 ft bgs

Natural Fill:
510.1 - 510.7 ft bgs

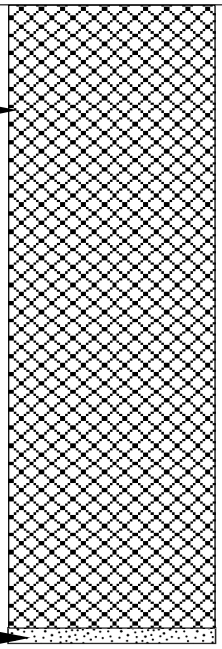
Straightness Test: Pass, 05/30/2019

Depths are in ft below ground surface.
Borehole drilled with 11 3/4-in. O.D. casing from 0.0 - 163.7 ft bgs

Borehole drilled with 9 5/8-in. O.D. casing from 163.7 - 360.9 ft bgs
Borehole drilled with 7 5/8-in. O.D. casing from 360.9 - 501.0 ft bgs
Borehole drilled with 6 1/2-in. O.D. drill bit from 501.0 to 510.7 ft bgs.

All temporary drill casing was removed from the ground.

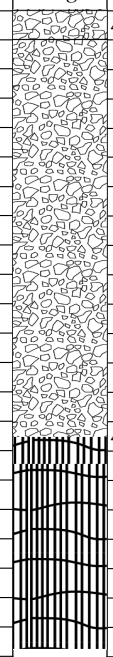
Diagram



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet

Graphic Log



Lithologic Description (ft bgs)

405.0 - 497.0 Gravel (G)

497.0 - 510.7 Basalt

Total Depth: 510.7 ft (5/14/2019)

470
480
490
500
510
520
530
540
550
560

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BOREHOLE LOG

Page 1 of 13

Date: 4-10-2019

Well ID: C9740 | Well Name: 699-44-70B | Location: 360m South of Weather Station

Project: Installation of 3 monitoring wells in 200-ZP-1OU | 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'-15': Silty Gravel (mG): g=75%, s=10%, m=15%. G: VF-C peb, avg 10mm, max 40mm, poor-mod sort, 25% Fel, 75% maf, sub ang-ang. S: VF-VC sand, mod sort, 25% fel, 75% maf, ang, moist, rxn Hcl, 2.5y 4/3-Olive brwn.	Air Rotary Drilling with 11 3/4" OD 10 5/8" ID Temp. casing 0.0-163.3, 9 5/8 OD/8 1/2 ID 163.3-360.0, 7 5/8" OD 6 5/8" ID 360.0-496.5, & 6 1/4" Tricone bit 496.5-510.7' bgs. Grab samples collected every 5ft or change in lithology.
5	G			
10	G		@10': G ↓ VF-Med peb, avg ↓ 5mm, max ↓ 25mm. S: 2.5y 4/2-Dark grayish brwn.	
15	G		15'-20': Gravel (G): g=85%, s=10%, m=5%. G: VF-C peb, avg 15mm, max 30mm, mod sort, 30% Fel, 70% maf, sub-ang-subrnd. S: VF-VC sand, mod sort, sub-ang, dry, weak rxn Hcl, 2.5y 4/2-Dark grayish brwn, 25% Fel, 75% maf.	
20	G		20'-25': Gravelly Sand (gS): g=20%, s=70%, m=10%. G: VF-C peb, avg 4mm, max 32mm, mod sort, 40% fel, 60% maf, ang-subang. S: VF-VC sand, well sort, 50% fel, 50% maf, sub-ang, dry, rxn Hcl, 2.5y 4/2-dark grayish brwn.	
25	G		25'-30': Sandy Gravel (sG): g=40%, s=50%, m=10%. G: VF-C peb, avg 15mm, max 40mm, mod sort, 40% fel, 60% maf, subang-subrnd. S: C-VC sand, well sort, 60% Fel, 40% maf, ang, moist, rxn Hcl, 2.5y 4/3-Olive brwn.	
30	G		30'-55': Gravelly Sand (gS): g=10%, s=85%, m=5%. G: VF-Med peb, avg 2mm, max 15mm, mod sort, 50% fel, 50% maf, subang-subrnd. S: F-VC sand, mod sort, 75% fel, 25% maf, subang, dry, weak rxn Hcl, 5y 5/3-Olive.	

Reported By:			
Lindsey Getzhell	Geologist	Lindsey Getzhell	4-10-19
Print Name	Title	Signature	Date

Reviewed By:			
Sarah Springer	Sr. Geologist	Sarah Springer	05-29-19
Print Name	Title	Signature	Date

For Office Use Only

OR Doc Type:	WMU Code(s):

A-6003-642 (REV 1)

BOREHOLE LOG (Cont.)

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Date: 4-10-19

Well ID: C9740 | Well Name: 699-44-70B | Location: 360m South of Weather Station

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
35	G		30'-55': Gravelly Sand (gS): g=10%, s=85%, m=5%.	Air Rotary Drilling with 11 3/4" OD / 10 5/8" ID
			@35': (gS) g=20%, s=75%, m=5%.	Temp. casing 0.0-163.3, 9 5/8" OD / 8 1/2" ID
			G: Avg ↑ 4mm, max ↑ 18mm.	163.3-360.0, 7 5/8" OD / 6 5/8" ID. 360.0-496.5', 6 1/4" Tricone bit 496.5-510.7' bgs. Grab samples collected every 5' or change in lithology.
			S: ↓ VF-VC sand.	
40	G		@40': (gS)	
			S: moist, 2.5y 4/3-Olive brn.	
45	G		@45': (gS)	
			G: ↓ VF peb, avg ↓ 1mm, max ↓ 4mm.	
			S: ~~f~~ med-VC sand, well sort, 50% maf, 50% fel, ang, dry, 5y 5/3-Olive	
50	G		@50': (gS) Same as above.	
55	G		55'-75': Sandy Gravel (sG): G=35%, s=65%, m=Tr.	
			G: VF-Med peb, avg 2mm, max 10mm, mod sort, 50% fel 50% maf Sub-ang to sub-rnd.	
			S: F-VC sand, mostly VC sand, well sort, 50% fel 50% maf, sub-ang dry, weak rxn HCl. 5y 5/2-Olive gray. 7cm-size mica flakes.	
60	G		• @60': (sG)	
			S: 5y 5/1-gray. ↑ mica.	
65	G		@65': (sG)	
			S: 45% fel, 55% maf, rxn HCl, 5y 5/2-olive gray.	
70	G		@70': (sG)	
			G: Avg ↑ 3mm, max ↑ 15mm, sub-rnd.	
			S: 5y 5/1-Gray.	

Reported By:

Lindsey Getchell	Geologist	Zeley Mcree	4-10-19
Print Name	Title	Signature	Date

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

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Date: 4-10-19

Well ID: C9740 | Well Name: 699-44-70B | Location: 360m South of Weather Station

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
75	G		75'-80': Sand(s) G=Tr, S=90%, m=10%.	Air Rotary Drilling with 11 3/4" OD
			S: VF-med sand w/Tr. c sand. Majority VF-F sand, well	10 5/8" ID Temp. casing 0.0'-163.3',
			Sort, 40% fel, 60% maf, sub ang, dry, strong rxn Hcl,	9 5/8" OD/8 1/2" ID 163.3-360.0', 7 5/8" OD/6.5" ID
			2.5y 6/4-light yellowish brwn, mica present.	360.0'-496.5', 6" Tricone bit
			m: Low-med plasticity.	496.5-510.7' bgs. Grab samples
80	G		80'-90': Slightly Silty sand ((m)S)): g=0%, s=80%, m=20%.	collected every 5ft or change
			S: VF-F sand, 35% fel, 65% maf, dry, strong rxn Hcl, 2.5y	in lithology.
			5/4-light olive brwn. Mica present.	
			m: Med plasticity.	
85	G		@85': (m)S:	
			S: ↑ VF-med sand.	
90	G		90'-115': Sand (s): g=5%, s=90%, m=5%.	
			G: VF-med peb, avg 8mm, max 20mm, mod sort, 90% ~~maf~~ fel, 10%	
			maf, calcareous, strong rxn Hcl, ang.	
			S: VF-VC sand, mod sort, 65% fel, 35% maf, sub-ang, dry,	
			strong rxn Hcl, 2.5y 6/4-light yellowish brwn.	
95	G		@95': (s)	
			S: ↑ F-VC sand, 2.5y 5/4-light olive brwn.	
100	G		@100': (s)	
			S: ↑ C-VC sand, well sort, 50% fel 50% maf, sub-ang, 2.5y 5/2-grayish brwn.	
			G: ↓ VF-F peb, avg ↓ 4mm.	
105	G		@105': (s) g=Tr. s=95%, m=5%.	
110	G		@110': (s) Same as above.	

Reported By:

Lindsey Getchell	Geologist	Lindsey Getchell	4-10-19
Print Name	Title	Signature	Date

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Page 4 of 13

Date: 4-10-19

Well ID: C9740 | Well Name: 699-44-70B | Location: 360m South Weather Station

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
115	G		115'-120': Slightly Silty Sand ((m)S): g=5%, s=84%, m=11%. G: F peb, avg 10mm, max 15mm, well sort, 50% maf, 50% fel, sub-ang. S: VF-VC sand, well sort, 40% fel, 60% maf, sub-ang, moist, rxn HCl, 2.5y 5/4-light olive brn. m: low plasticity.	Air Rotary Drilling with 11 3/4" OD 10 5/8" ID Temp casing 0.0-163.3, 9 5/8" OD/8 1/2" ID 163.3-360.0, 7 5/8" OD 6 5/8" ID, 360.0-496.5, & 6 1/4" Tricone bit 496.5'-510.7' bgs. Grab samples collected every 5ft or change in lithology.
120	G		120'-125': Sand (S): g=0, s=95%, m=5%. S: med-VC sand, well sort, 50% fel 50% maf, sub-ang, dry, rxn HCl, 2.5y 5/2-grayish brn.	
125	G		125'-130': Slightly Silty Sand ((m)S): g=0, s=89%, m=11%. S: VF-VC sand, well sort, 40% fel 60% maf, Subang, moist, rxn w/HCl, 2.5y 5/4-light olive brn. ↑ med sand-size mica. m: low plasticity.	
130	G		130'-195': Sand (S) g=Tr, s=95%, m=5%. S: VF-C sand, well sort, 60% fel 40% maf, sub-ang, dry, rxn w/HCl. 2.5y 5/2-grayish brn. Mica present.	
135	G		@135': (S) S: ↑ VC sand, strong rxn HCl.	
140	G		@140': (S) S: ↓ VF sand - C sand, grain size	
145	G		@145': (S) g=0%, s=95%, m=5%. S: ↓ VF-med sand grain size.	
150	G		@150': (S) g=Tr., s=95%, m=5%. S: ↑ VF-C sand grain size. Tr calcareous peb; strong rxn HCl.	

Reported By:

Print Name	Title	Signature	Date
Lindsey Getchell	Geologist	Lindsey Getchell	4-10-19

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

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Date: 4-10-19

Well ID: C9740 | Well Name: 699-44-70B | Location: 360m South Weather Station

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
155	G		130'-195': Sand (S) g=Tr, s=95%, m=5%.	Air Rotary Drilling with 11 3/4" OD 10 5/8" ID Temp casing D.O. to 3.3'; 9 5/8" OD 8 1/2" ID to 3.3'-360.0'; 7 5/8" OD / 6 5/8" ID 360.0-496.5'; & 6 1/4" Tricone bit 496.5'-510.7' bgs. Grab samples collected every 5 ft or change in lithology.
			@155': (S)	
			S: ↑ VF-VC sand grain size.	
160	G		@160': (S) g=9%, s=91%, m=Tr.	
			G: VF peb, avg 2mm, max 5mm, mod sort, 50% fel, 50% maf, Subang-Subrnd.	
			S: Same as above.	
165	G		@165': (S) g=5%, s=95%, m=Tr.	
170	G		@170': (S) g=Tr. s=95%, m=5%	
			S: Fs-Csand w/Tr VCsand, 40% fel 60% maf, subang, moist, 2.5y-4/4-Olive brwn, approx 30% med size mica flakes.	
			m: VF peb-size silt clasts.	
175	G		@175': (S)	
			S: ↑ size of mica flakes to VCsand.	
180	G		@180': (S)	
			G: ↓ calcareous trace peb.	
185	G		@185': (S)	
			S: ↑ Fs-VCsand.	
190	G		@190': (S)	
			S: ↓ Fs-Csand	

Reported By:

Print Name	Title	Signature	Date
Lindsey Getchell	Geologist	Jdey Shele	4-10-19

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BOREHOLE LOG (Cont.)

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Date: 4-19-19

Well ID: C9740 | Well Name: 699-44-70B | Location: 360m S. of weather Station

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
195	G		195'-205': Slightly silty sand ((m)S): g=0, s=87%, m=13%. S: VF-F sand w/Tr Med sand, well sort, 40% fel, 60% maf, sub-ang, moist, rxn HCl, 2.5y 4/4-olive brn, ↓ mica. m: silt clasts, low-med plasticity.	Air Rotary Drilling with 11 3/4" OD 10 5/8" ID Temp. casing 0.0-163.3, 9 5/8" OD 8 1/2" ID 163.3-360.0, 7 5/8" OD 6 5/8" ID 360.0-496.5', & 6 1/4" tricone bit 496.5-510.7' bgs. Grab samples collected every 5ft or change in lithology.
200	G		@200': ((m)S): g=0, s=85%, m=15%. S: 2.5y 5/4-light olive brn. Remnants of organics (roots).	
205	G		205'-210': Silty sand (mS): g=Tr, s=75%, m=25%. S: VF-F sand w/Tr med sand, well sort, 40% fel 60% maf, sub-ang, moist, rxn HCl, 2.5y 5/4-light olive brn.	
210	G		210'-215': Gravelly silty sand (gmS): g=10%, s=60%, m=30%. g: Med-VC peb, avg 20mm, max 65mm, mod sort, 50% fel 50% maf, sub-rnd. S: VF-F sand, well sort, 40% fel 60% maf, sub-ang, moist, rxn HCl, 2.5y 5/4-light olive brn.	
215	G		215'-225': Silty sand (mS): g=Tr, s=60%, m=40%. S: VF-F sand, well sort, 40% fel 60% maf, sub-ang, moist, rxn HCl, 2.5y 5/4-light olive brn.	
220	G		@220: (mS)	
225	G		225'-240': Slightly silty gravelly sand ((m)gS): g=20%, s=65%, m=15%. G: VF-Med peb w/tr. VC peb & small cob, avg 10mm, max >35mm, poor sort, 60% fel, 90% maf, sub-ang to sub-rnd. S: VF-med sand, well sort, 40% fel 60% maf, sub-ang, moist, rxn HCl, 2.5y 5/4-light olive brn.	
230	G		@230: ((m)gS): g=15%, s=70%, m=15%. G: VC peb-small cob, avg 50mm, max ↑ 110mm, poor sort, sub-rnd to rnd. S: ↓ VF-F sand.	

Reported By:

Lindsey Getchell (Print Name) | Geologist (Title) | [signature] (Signature) | 4-19-19 (Date)

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Page 7 of 13

Date: 4-19-19

Well ID: C9740 | Well Name: 699-44-70B | Location: 360m S. of weather station

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
235	G		225'-240': Slightly Silty Gravelly Sand ((m)gS): g=20%, s=65%, m=15%.	Air Rotary Drilling with 11 3/4" OD 10 5/8" ID Temp. casing 0.0-163.3, 9 5/8" OD / 8 1/2" ID 163.3-360.0', 7 5/8" OD / 6 5/8" ID 360.0-496.5', & 6 1/4" Tricone bit 496.5-510.7' bgs. Grab samples collected every 5ft or change in lithology.
			@235': ((m)gS): g=10%, s=70%, m=20%.	
			G: ↓VF-Med peb, avg ↓10mm, max ↓50mm, sub-ang to sub-rnd.	
240	G		S: 2.5y 5/6-light olive brwn.	
			240'-250': Gravelly Sand (gS): g=10%, s=85%, m=5%.	
			G: F-med peb, avg 20mm, max 60mm, poor sort, 10% fel, 90% maf, sub-ang.	
			S: VF-med sand, well sort, 60% fel 40% maf, sub-ang, moist, rxn HCl, 2.5y 4/4-olive brwn.	
245	G		@245': (gS) g=15%, s=80%, m=5%.	
			G: Sub-rnd to rnd angularity.	
250	G		250'-255': Sandy Gravel (sG): g=35%, s=65%, m=Tr.	
			G: F-VC peb, avg 20mm, max 62mm, mod sort, 50% fel, 50% maf, rnd to sub-rnd.	
			S: VF-VC sand, well sort, 60% fel 40% maf, sub-ang, moist, rxn HCl, 2.5y 4/4-olive brwn.	
255	G		255'-345': Gravel (G): g=80%, s=15%, m=5%.	
			G: VF-C peb, avg 25mm, max 45mm, mod sort, 75% fel 25% maf, sub-rnd to rnd.	
			S: VF-VC sand, mod sort, 75% fel 25% maf, sub-ang, dry, strong rxn HCl, 2.5y 6/3-light yellowish brwn.	
260	G		@260': (G)	
			G: Max ↑ 60mm	
265	G		@265': (G)	
			G: Avg ↓ 20mm.	
			S: Well-mod sort, moist, 2.5y 4/4-olive brwn.	
270	G		@270': (G)	
			G: Avg ↓ 15mm, max ↓ 45mm, sub-ang to rnd.	
			S: VF-med sand, well sort, dry, 2.5y 6/3-light yellowish brwn.	

Reported By:

Print Name	Title	Signature	Date
Lindsey Getchell	Geologist	Lindsey Getchell	4-19-19

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Page 8 of 13

Date: 4-19-19

Well ID: C9740 | Well Name: 699-44-70B | Location: 360m S. of weather station

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
275	G		255'-345': Gravel (G): g=80%, s=15%, m=5%.	Air Rotary Drilling with 11 3/4" OD
			@275: (G) g=80%, s=15%, m=5%.	10 5/8" ID Temp casing 0.0'-163.3',
			G: Avg ↑ 20mm,	9 5/8"/8 1/2" 163.3'-360.0', 7 5/8" OD
			S: ↑ VF-VC Sand, mod-well sort, moist, 2.5y 4/4-Olive brwn.	6 5/8" ID 360.0'-496.5' & 6 3/4"
				Tricone bit 496.5'-510.7' bgs.
280	G		@280: (G) g=85%, s=10%, m=5%.	Grabsamples collected every
			G: VF-VC peb, avg ↑ 30mm, max ↑ 60mm, poor sort,	5ft or at change in lithology
			S: VF-C sand, mod-sort, sub-ang to rnd. visable mineral deposits.	
285	G		@285: (G) g=90%, s=5%, m=5%.	
			G: Avg ↓ 25mm, max ↓ 55mm, sub-rnd to rnd.	
			S: VF-Med sand, mod-well sort, dry, weak rxn HCl, 2.5y 6/3-light yellowish brwn.	
290	G		@290: (G) g=85%, s=10%, m=5%.	
			G: VF-C peb, avg ↓ 15mm, max ↓ 35mm, sub-ang to rnd.	
			S: VF-C sand, mod sort, moist, 2.5y 4/4-Olive brwn.	
295	G		@295: (G) g=90%, s=10%, m=Tr.	
			G: VF-Med peb, avg ↓ 13mm, max ↓ 25mm, poor-mod sort, ang (broken up)-sub rnd.	
			S: VF-VC sand, mod-well sort, dry, 2.5y 6/3-light yellowish brwn.	
300	G		@300: (G) g=95%, s=5%, m=Tr.	
			G: Max ↑ 55mm	
			S: VF-Med sand.	
305	G		@305: (G)	
			G: VF-C peb, avg ↑ 15mm, max ↓ 45mm, ang-rnd.	
310	G		@310: (G) g=90%, s=5%, m=5%.	
			G: VF-Med peb w/tr Coarse peb, avg ↓ 10mm, max ↑ 50mm mod sort.	
			S: Tr Coarse sand, well sort, moist, 2.5y 4/4-Olive brwn.	

Reported By: Lindsey Getchell (Print Name) | Geologist (Title) | Lindsey Getchell (Signature) | 4-25-19 (Date)

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

4-30-19 LG

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Date: 4-30-19

Well ID: C9740 | Well Name: 699-44-70B | Location: 360m S. of ~~weather~~ weather station

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
315	G		255'-345': Gravel (G) g=80%, s=15%, m=5%.	Air Rotary Drilling with 11 3/4" OD
			@315: (G) g=85%, s=5%, m=10%.	10 5/8" ID Temp. casing 0.0-163.3,
			G: VF-VC peb, avg ↑ 35mm, max ↑ 55mm, poor-mod	9 5/8" OD / 8.42 ID 163.3-360.0', 7 5/8" OD
			sort, sub-ang to rnd.	6 5/8" ID 360.0-496.5' bgs + 6 1/4"
			S: Dry, 2.5Y 6/3-light yellowish brwn.	Tricone bit 496.5-510.7' bgs.
320	G		m: 1-2mm silty layers on VC peb.	Grab samples collected every
			@320: (G)	5ft or change in lithology.
			G: VF-C peb, avg ↓ 15mm, max ↓ 38mm, sub-rnd to	
			rnd.	
			S: VF-Med sand w/trace C+VC sand.	Water Level: 323.1' bgs on
325	G		@325: (G) g=80%, s=20, m=Tr.	5/14/2019
			G: Max ↓ 35mm, sub-ang.	
			S: VF-C sand w/tr. VC sand, rnd.	
330	G		@330: (G)	
			G: Avg ↓ 12mm	
335	G		@335: (G) g=80%, s=15%, m=5%	
			G: Avg ↓ 10mm, max ↓ 30mm.	
340	Gws		@340: (G) g=85%, s=10%, m=5%.	Water Sample: I-001 @340.2'
			G: VF-Sm cob, avg ↑ 40mm, max ↑ >85mm, mod	
			sort, 90% fel 10% maf, sub-rnd to rnd.	
			S: VF-C sand, mod-well sort, rnd, wet, weak rxn HCl,	
			2.5Y 4/4-Olive brwn.	
345	G		345'-350': Silty Gravel (mG): g=60%, s=15%, m=25%	
			G: VF-VC peb, avg=30mm, max=70mm, mod sort, 90% fel 10% maf,	
			sub-rnd to rnd.	
			S: VF-C sand, well sort, 75% fel 25% maf, rnd, wet, no rxn HCl,	
			2.5Y 4/4-Olive brwn.	
350	G		350'-390': Sandy Silt (SM): g=Tr, s=30%, m=70%	
			S: VF-Med w/Tr C sand, well sort, 75% fel, 25% maf, sub-ang-rnd,	
			wet, no rxn HCl, 2.5Y 6/3-light yellowish brwn.	
			m: VF peb-size clay pieces, low-med plasticity. Approx. 20%	
			clay pieces.	

Reported By:

Lindsey Getchell (Print Name) | Geologist (Title) | Lindsey Getchell (Signature) | 4-30-19 (Date)

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BOREHOLE LOG (Cont.)

Page 10 of 13

Date: 4-30-19

Well ID: C9740 | Well Name: 699-44-70B | Location: 360m S. of weather station

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
355	G		350'-390': Sandy Silt (sM): g=Tr, s=30%, m=70%.	Air Rotary Drilling with 11 3/4" OD/10 5/8" ID
			@355': (sM)	Temp casing 0.0-163.3', 9 5/8" OD
			S: VF-med sand.	8 1/2" ID 163.3-360.0', 7 5/8" OD/6 5/8" ID
				360.0-496.5' 6 1/4" Tricone bit
				496.5'-510.7' bgs. Grab samples
360	G		@360': (sM) g=Tr, S=25%, m=75%.	collected every 5 ft or change in lithology.
			S: 2.5y 5/6-light olive brwn.	361.0'-398.0' added 60 gal
			m: ↓ 15%. clay pieces/clasts.	H_2O.
365	G		@365': (sM) g=Ø, S=20%, m=80%.	
			S: VF-F sand.	
			m: ↓ 10%. clay clasts, ↓ size to VF-F-size peb.	
370	G		@370': (sM) g=Ø, S=30%, m=70%.	
			S: VF-med sand, 2.5y 6/3-light yellowish brwn.	
			m: Thicker, + med peb-size clay clasts (10%).	
375	G		@375': (sM) g=Ø, S=20%, m=80%.	
			S: VF-F sand, 2.5y 5/6-light olive brwn.	
380	G		@380' - Same as above.	
385	G		@385' - Same as above.	
390	G		390'-395': Silty Gravel (mG): g=65%, S=15%, m=20%.	
			G: VF-C peb, avg=12mm, max=25mm, poor sort, 90% fel 10% maf,	
			ang-sub ang.	
			S: VF-Med sand, well sort, 60% fel 40% maf, sub-ang-rnd, wet,	
			rxn HCl, 5y 5/2-olive gray.	

Reported By:

Print Name	Title	Signature	Date
Lindsey Getchell	Geologist	Lindsey Getchell	4-30-19

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Page 11 of 13

Date: 4-30-19

Well ID: C9740 | Well Name: 699-44-70B | Location: 36cm S. of weather station

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
395	G		395'-405': Silty Sandy Gravel (msG): g=70%, s=15%, m=15%	Air Rotary Drilling with 11 3/4" OD
	WS		G: VF-VC peb, avg=20mm, max>50mm, mod sort, 90% fel 10% maf, sub-rnd → rnd.	10 5/8" ID, Temp casing 0.0'-163.3', 9 5/8" OD / 8 5/8" ID
			S: VF-C sand w/ tr. VC sand, well sort, 60% fel, 40% maf, subang-rnd, wet, no rxn HCl, 5Y 5/2 - Olive gray.	163.3-3600', 7 5/8" OD / 6 5/8" ID
				3600-4965'. + 6 1/4 tricone bit
400	G		@400': (msG)	4965-5107' bgs. Grab samples
			G: VF-C peb, avg ↓ 12mm, max>35mm, poor-mod sort,	collected every 5ft or change
			Subang-rnd.	in lithology.
			S: VF-Med sand, mod-well sort.	398.0-498.0': Underreamer:
				8 1/4" OD / 6 1/2" ID
				Water Sample: I-002 @ 396.5'
405	G		405'-497': Gravel (G) g=80%, s=10%, m=10%	
			G: VF-C peb, majority Fine peb, avg=10mm, max=30mm, mod	
			Sort, 90% fel 10% maf, subang-rnd.	
			S: VF-VC sand, mod-well sort, 75% fel 25% maf, sub-ang-rnd, wet,	
			no rxn HCl, 2.5Y 5/4 - light olive brwn.	
410	G		@410': (G) g=85%, s=10%, m=5%	
			G: VF-VC peb, avg ↑ 20mm, max ↑ 50mm.	
415	G		@415': (G)	
			G: Avg ↓ 15mm, max ↓ 45mm	
	WS			Water Sample: I-003 @ 416.5'
420	G		@420': (G) g=90%, s=10%, m=Tr.	
			G: Avg ↓ 10mm, max ↓ 30mm, ↓ VF-C peb, poor sort,	
			75% fel, 25% maf, rnd-subrnd.	
			S: Med-VC sand, poor-mod sort, sub-ang to ang. 2.5Y	
			5/2 - Grayish brwn. Cementation on gravel.	
425	G		@425': (G)	
			G: Max ↑ 35mm, sub-ang to sub-rnd	
430	G		@430': (G)	
			G: Avg ↓ 8mm, max ↓ 25mm, 40% fel 60% maf,	
			S: 50% fel 50% maf, 2.5Y 5/3 - light olive brwn.	

Reported By:

Lindsey Getchell	Geologist	[signature]	4-30-19
Print Name	Title	Signature	Date

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Page 12 of 13

Date: 5-8-19

Well ID: C9740 | Well Name: 699-44-70B | Location: 360 m S. of weather station

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
435	G		405'-497': (G) g=80%, s=10%, m=10%.	Air Rotary Drilling with 11 3/4" OD 16 5/8" ID Temp casing 0.0-163.3', 9 5/8" OD/8 1/2" ID 163.3-360.0', 7 5/8"/6 5/8" 360.0'-496.5' + 6 1/4" tricone bit 496.5-510.7 ft bgs. Grab samples collected every 5 ft or change in Lithology. 398.0'-498.0' 8 1/4" OD/6 1/2" ID underreamer used. Water Sample: I-004 @ 436.6'
	WS		@435: (G) g=85%, s=15%, m=Tr.	
			G: Avg ↑ 10mm, fel 50%, maf 50%, sub-rnd to rnd.	
			S: Same as above.	
440	G		@440: (G)	
			G: Avg ↑ 15mm, max ↑ 35mm, poor-mod sort, sub-rnd.	
			S: VC-size flakes of mica.	
445	G		@445: (G) g=90%, s=10%, m=Tr.	
			G: VF-C peb w/ tr VC peb, max ↑ 60mm.	
450	G		@450: (G)	
			G: Avg ↑ 18mm, max ↓ 35mm, VF-C peb, mod sort, sub-rnd to rnd.	
455	G		@455: (G)	
			G: Avg ↓ 10mm, max ↑ 40mm, mod-poor sort, sub-rnd.	
	WS			Water Sample: I-005 @ 457.0'
460	G		@460: (G) g=95%, s=5%, m=Tr.	
			G: Avg ↓ 5mm, max ↓ > 20mm, VF-Med peb, mod sort, fel 40%, maf 60%.	
			S: Med-VC sand. Cemented peb.	
465	G		@465: (G) g=90%, s=10%, m=Tr.	
			G: VF-C peb, avg ↑ 10mm, max = 30mm, poor sort, 50% fel, 50% maf.	
			S: C-VC sand.	
470	G		@470: (G)	
			G: Avg ↓ > 20mm	
			S: 50% fel, 50% maf, 2.5Y 5/6-light olive brwn-	

Reported By:

Lindsey Getchell — Print Name | Geologist — Title | Lindsey Getchell — Signature | 5-8-19 — Date

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Page 13 of 13

Date: 5-14-19

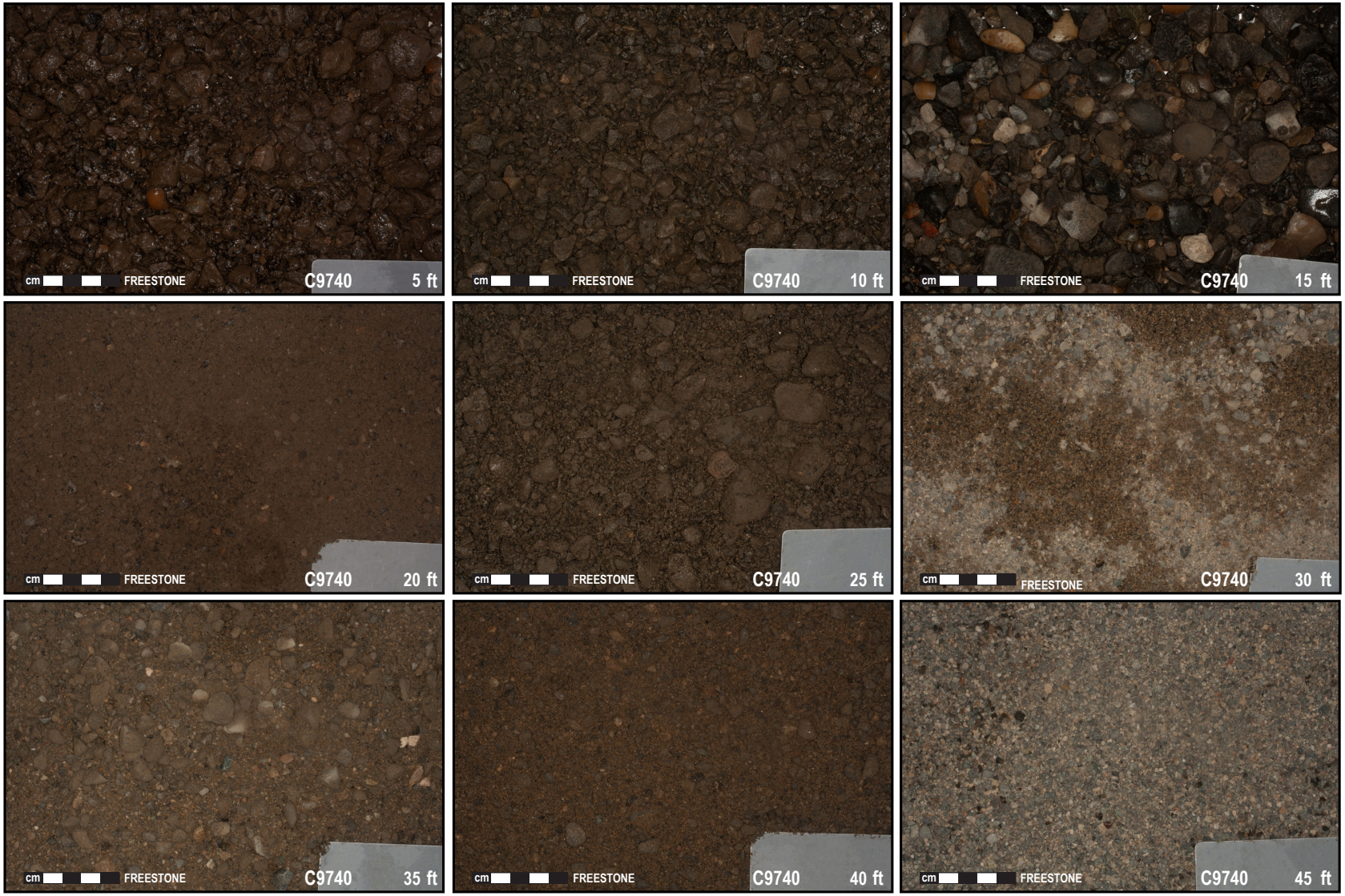
Well ID: C9740 | Well Name: 699-44-70B | Location: 360 m S. of weather station

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
475	G		405'-497': Gravel (G) g=80%, s=10%, m=10%.	Air Rotary Drilling with 11 3/4" OD
			@475: (G) g=90%, s=10%, m=0%.	10 5/8" ID Temp casing 0.0-163.3',
	WS		G: VF-VC peb, avg ↓ 10mm, max ↑ 35mm, poor-mod	9 5/8" OD / 8 1/2" ID 163.3-360.0', 7 5/8" OD
			Sort, 40% fel 60% maf, sub-ang to sub-rnd.	6 5/8" ID 360.0-496.5' + 6 1/4" tricone
			S: ↓ mod sort. ↑ cementation	bit 360.0-510.7' bgs. Grab
480	G		@480: (G) g=85%, s=10%, m=5%.	samples collected every 5ft
			G: VF-C peb, Tr VC peb, avg ↑ 15mm, max ↑ 40mm, poor	or change in lithology.
			sort.	398.0'-498.0' 8 1/4" OD / 6 1/2" ID
			S: med-VC sand, majority VC sand, mod-wen sort, 40%	Underreamer used.
			fel 60% maf 2.5Y 4/4 - Olive brwn.	Water Sample: I-006 @ 476.6'
485	G		@485: (G)	
			G: Avg ↓ 12mm, max ↓ 30mm, no tr. VC peb, 35% fel 65%	
			maf.	
			S: VC sand-size mica flakes.	
490	G		@490: (G) g=95%, s=5%, m=0	
			G: VF-Med w/tr. C peb, avg ↓ 3mm, max ↑ 10mm,	
			5% fel, 95% maf.	
			S: 5% fel, 95% maf, 5Y 3/1 - very dark gray. 4mm-size	
			clasts of clay - 5G 4/2 - Grayish green, med plasticity.	
495	G		@495: (G)	
			G: max ↓ 15mm, 2% fel 98% maf.	
497	G		S: Well sort, 0% fel 100% maf, 5Y 2.5/1 - Black. No mica.	
	WS		497'-510.7' Basalt: g=100%, s=Tr., m=0%.	Water Sample: I-007 @ 498.0'
			G: VF-F w/tr. med peb, avg=3mm, max=14mm, 0% fel, 100% mafic.	
			No rxn HCl, 5Y 2.5/1 - Black. Competent, → drill bit drilling	
			smoothly.	
502	G			
			@505': Drill bit catching → potentially fractured	
			Basalt.	
507	G			
510.7				Total Depth: 510.7' (5-14-19)

Reported By:

Lindsey Getchell	Geologist	Lindsey Getchell	5-14-19
Print Name	Title	Signature	Date

A-6006-993 (REV 0)



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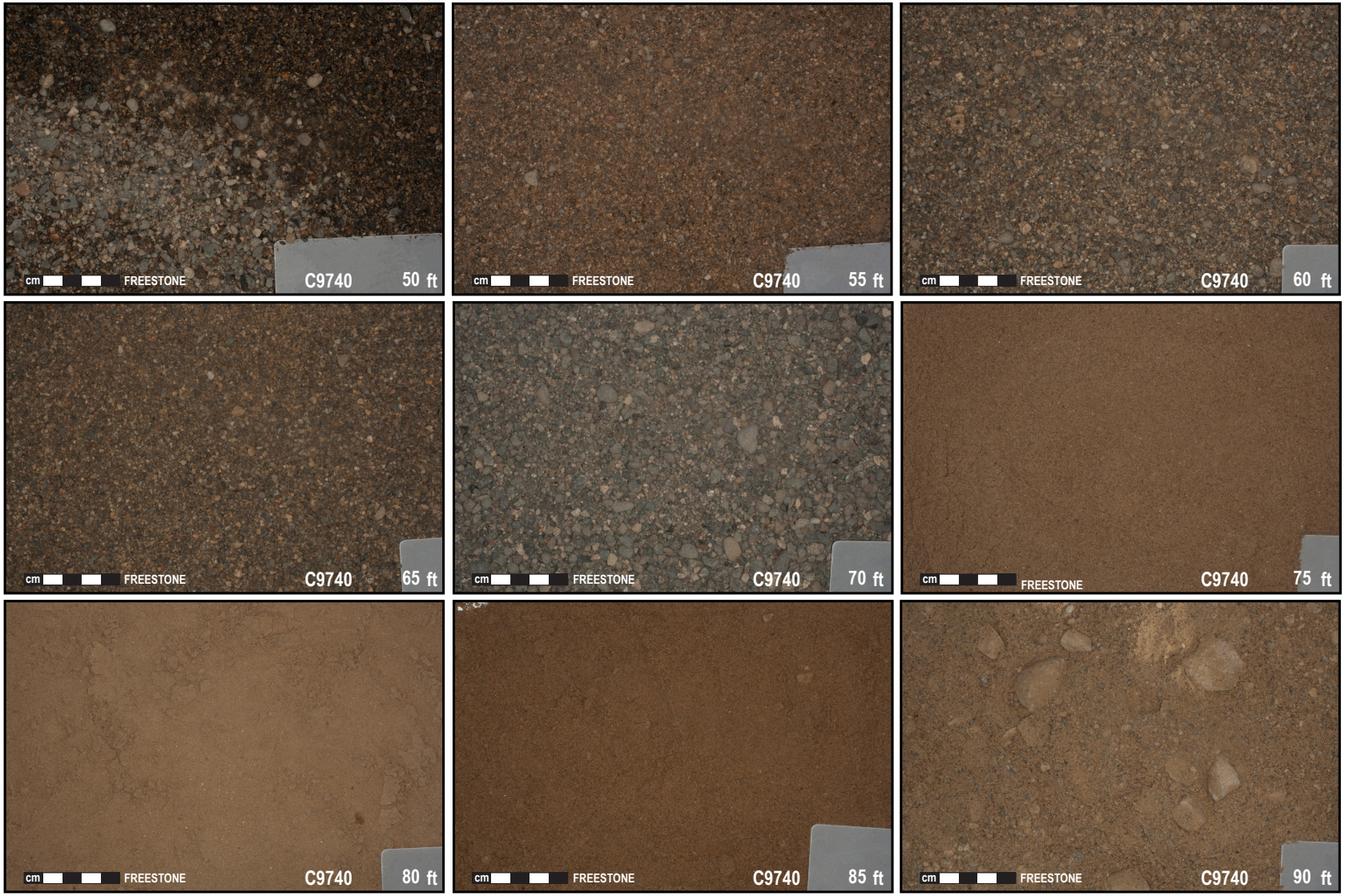

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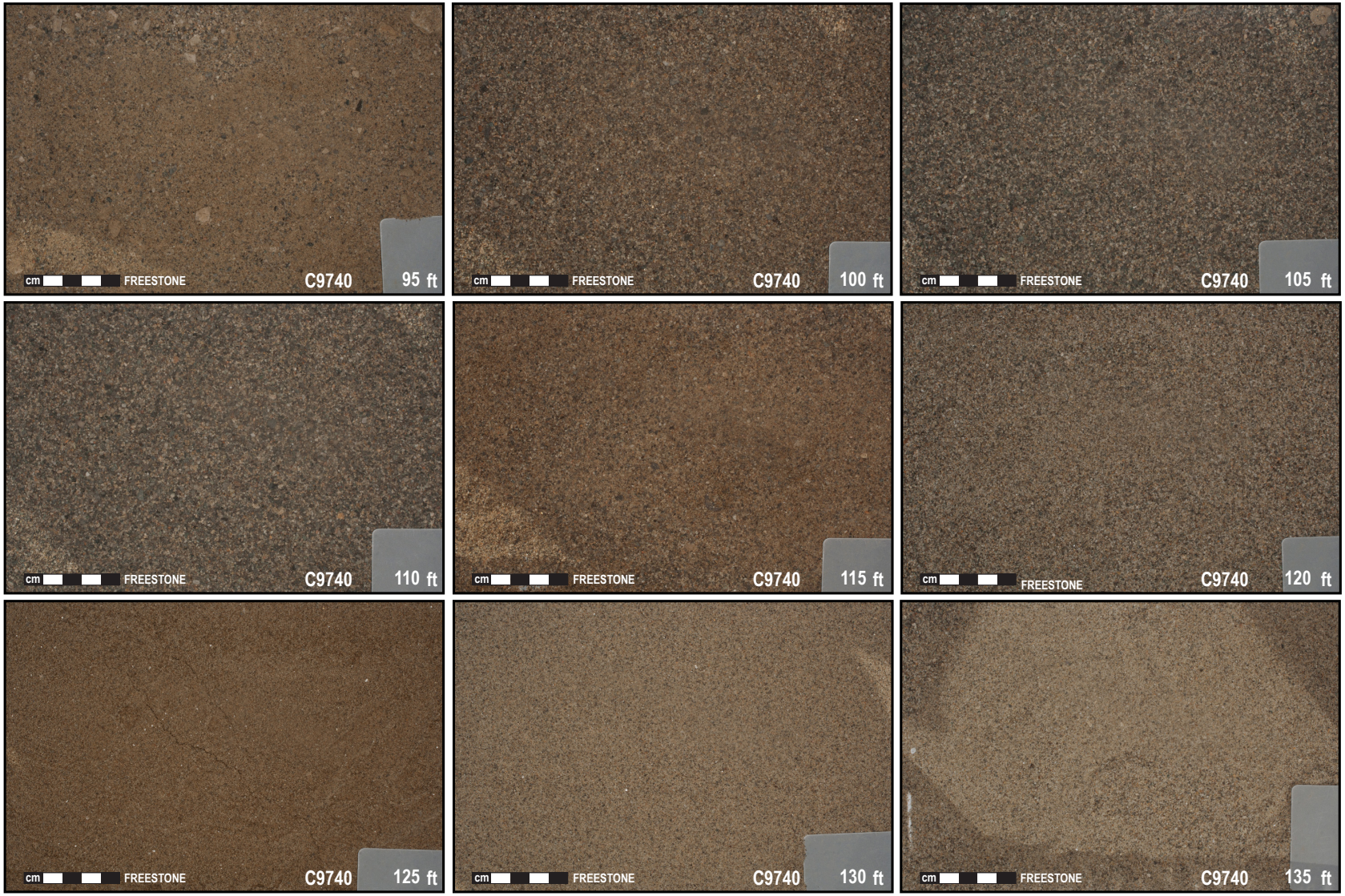

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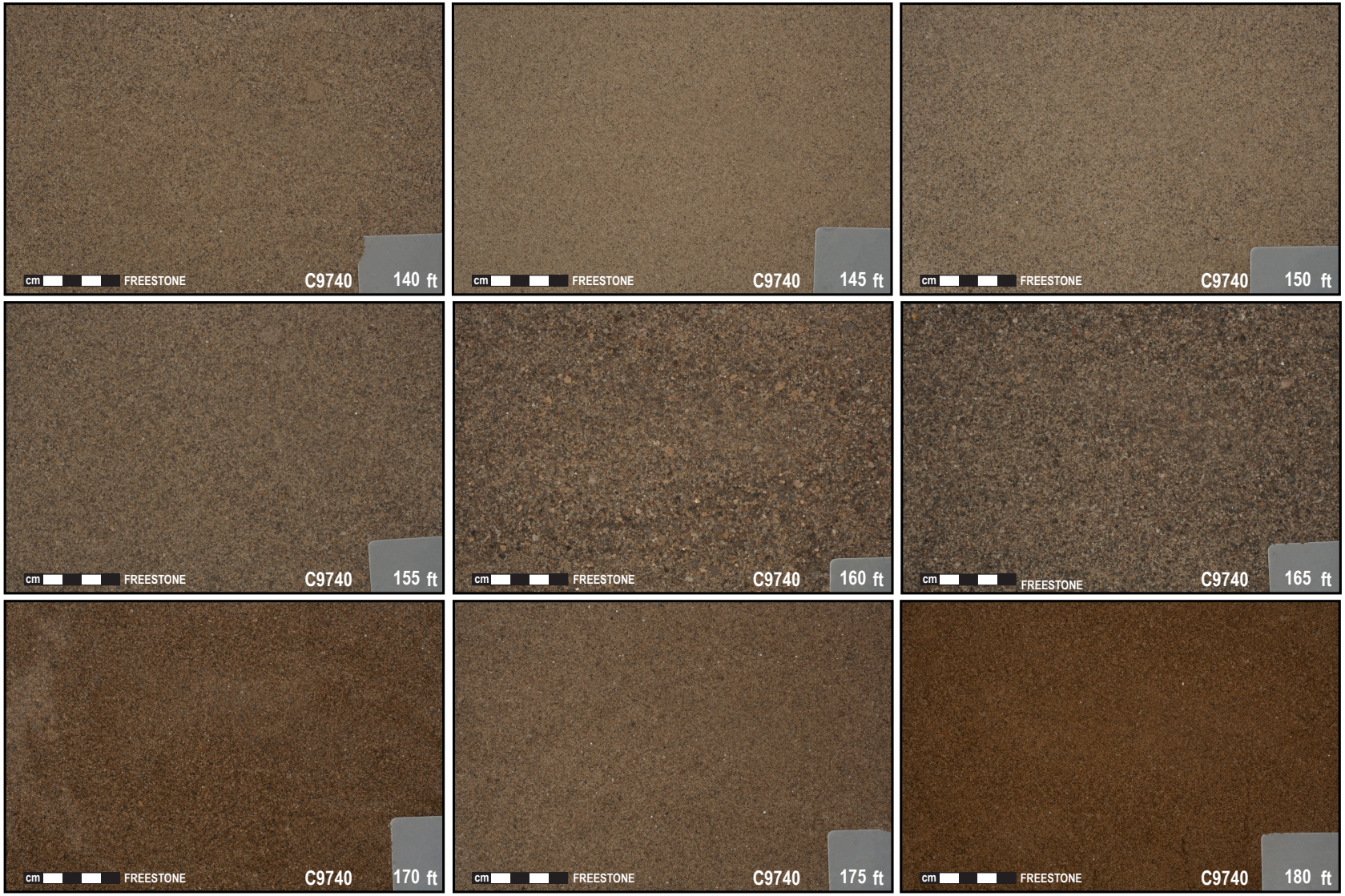

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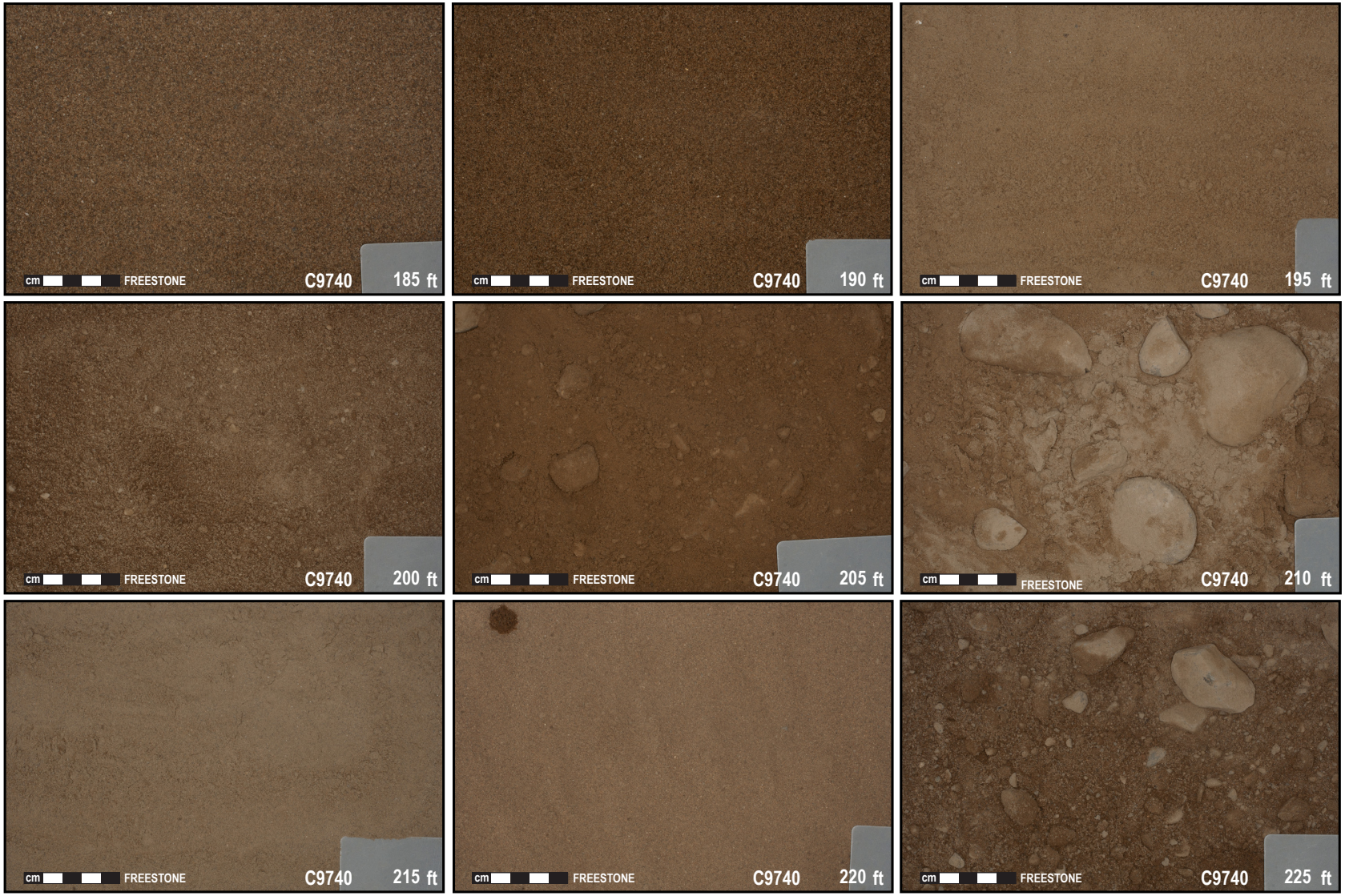

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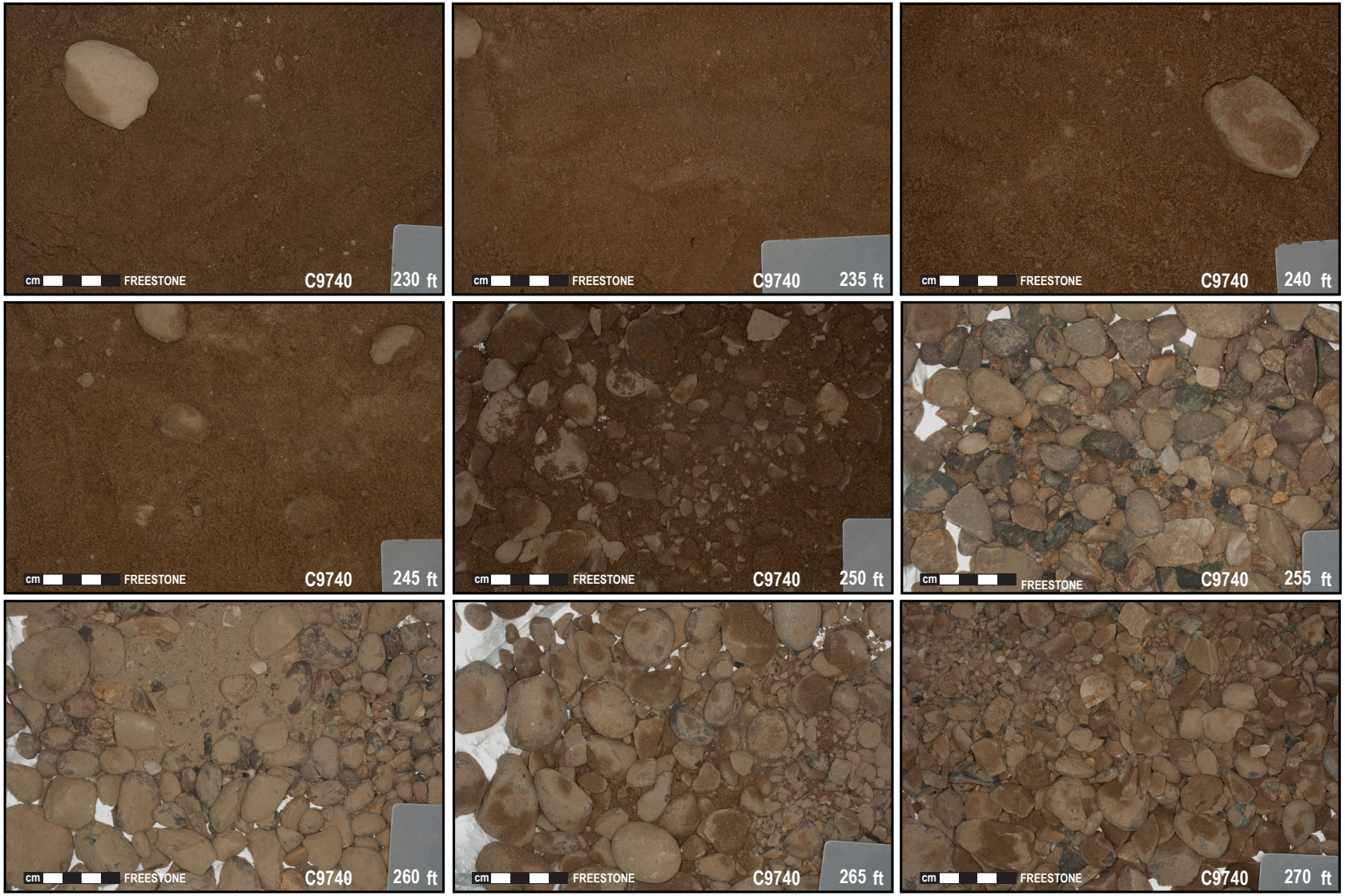

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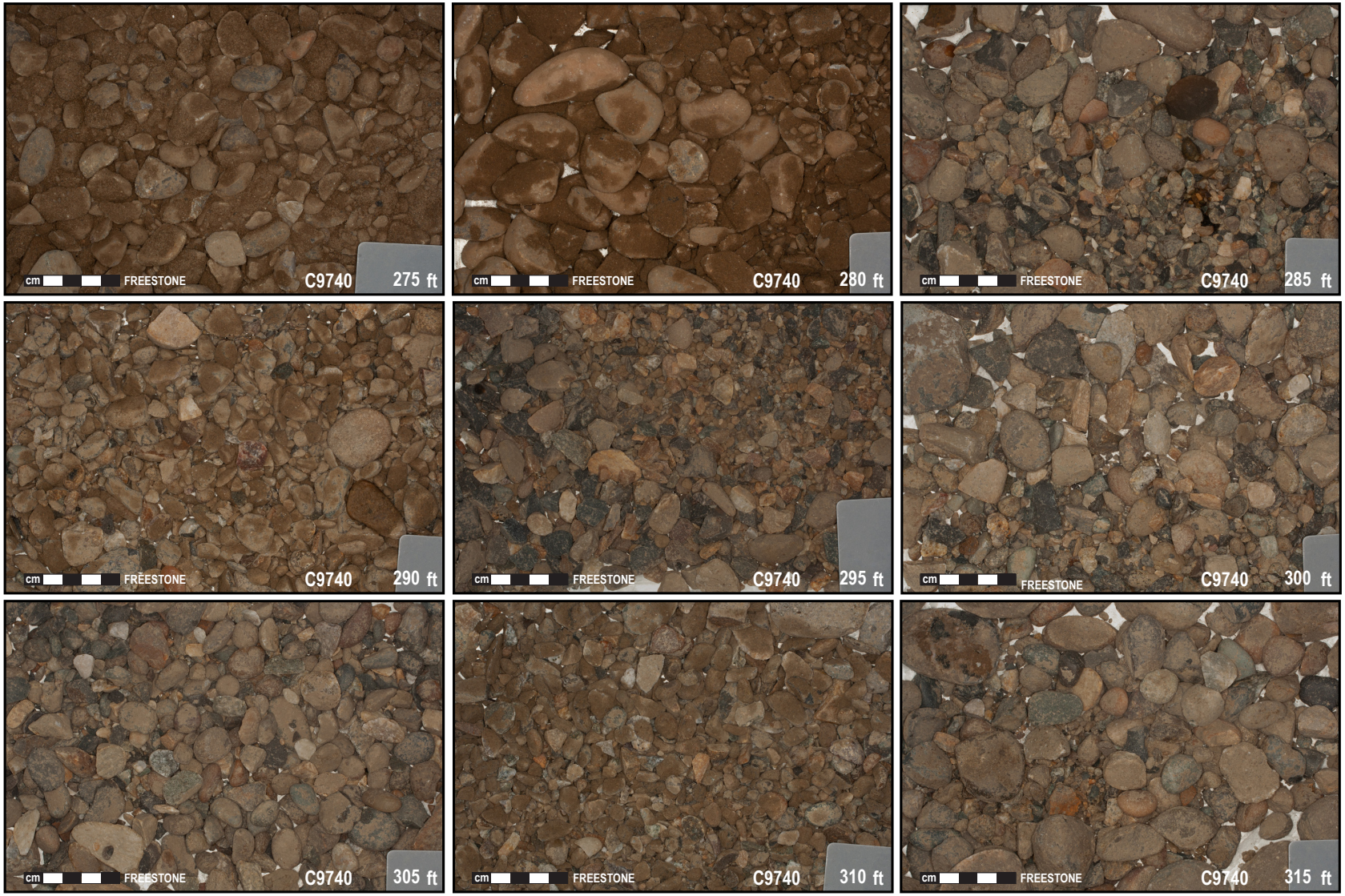

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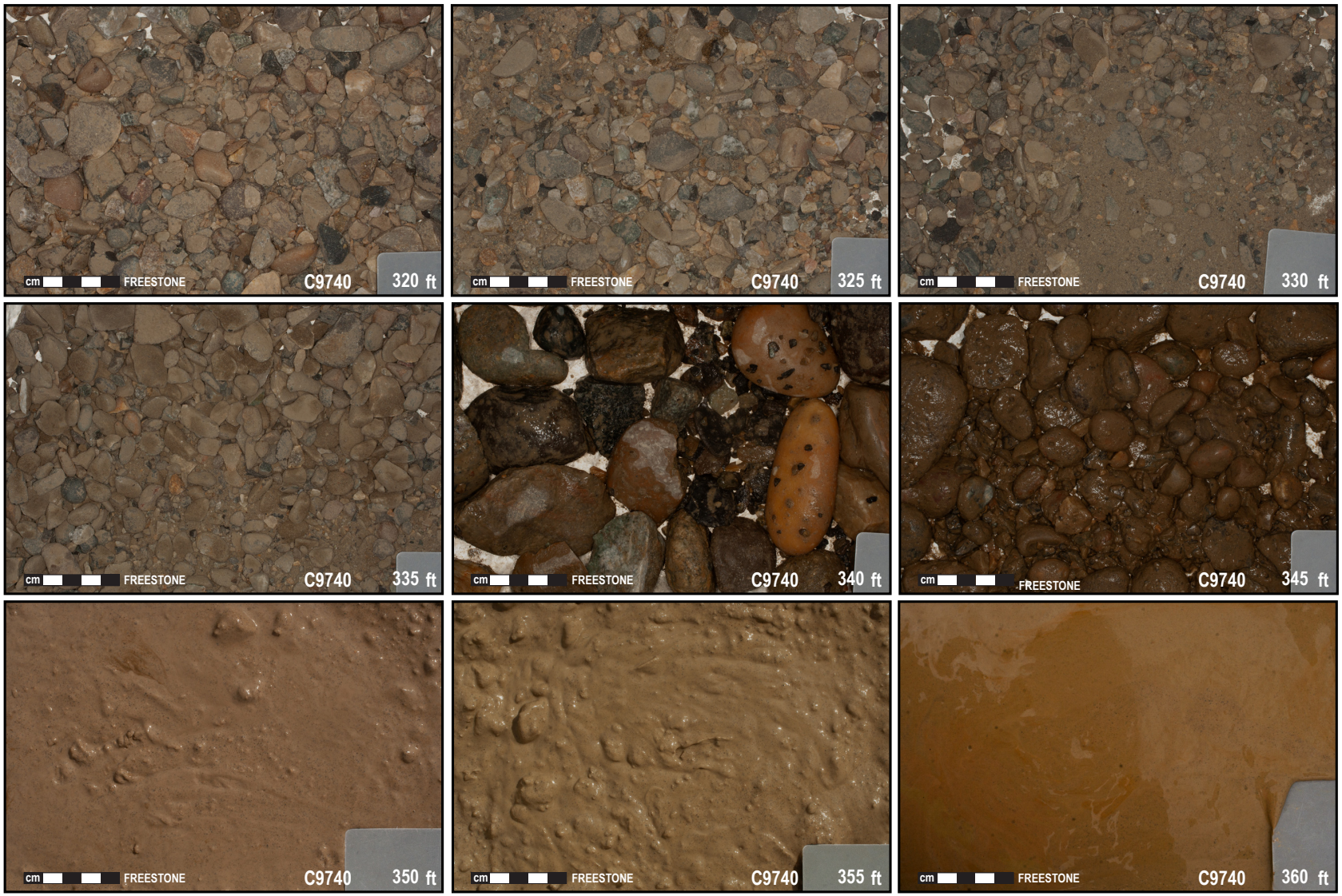

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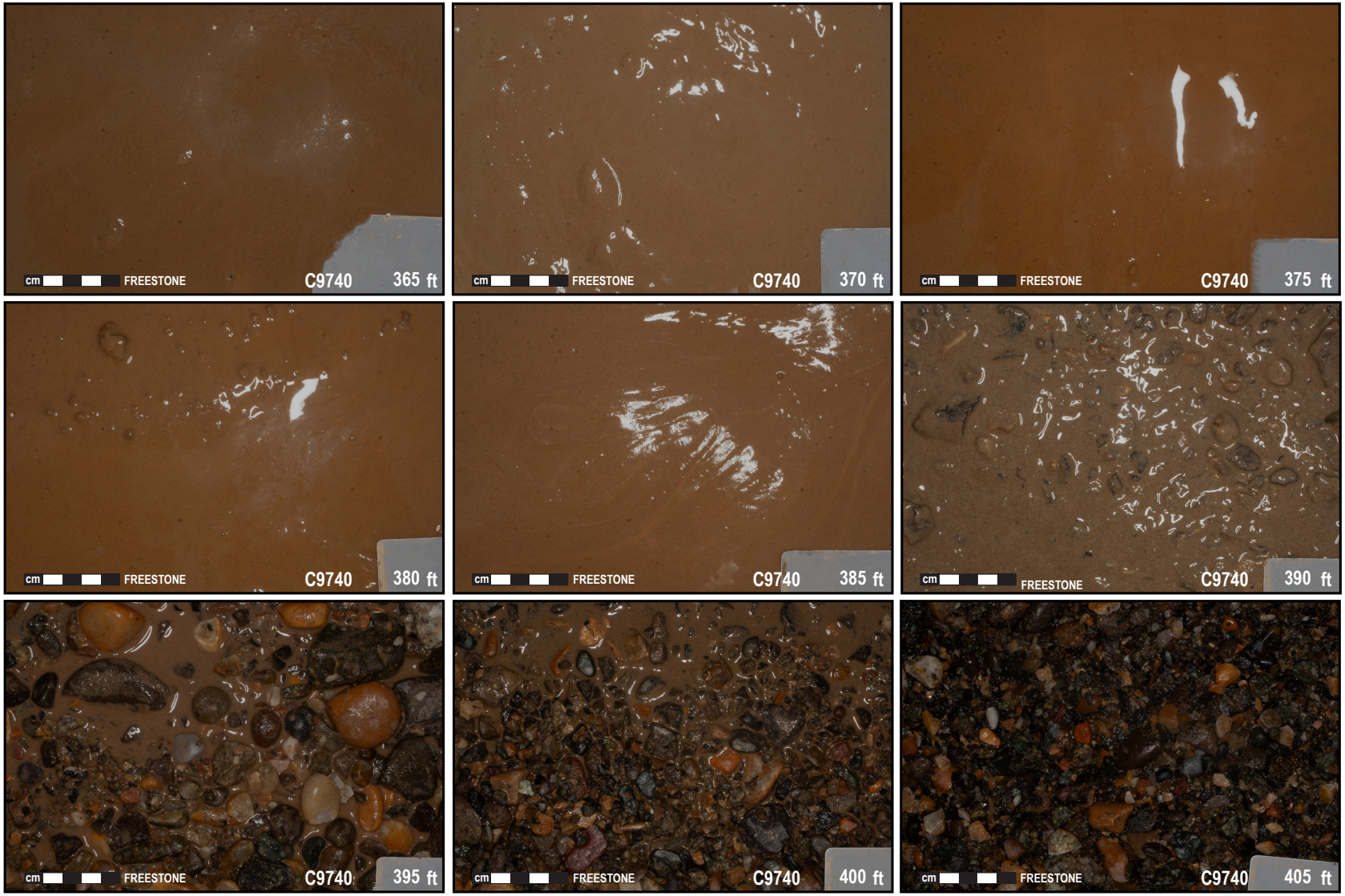

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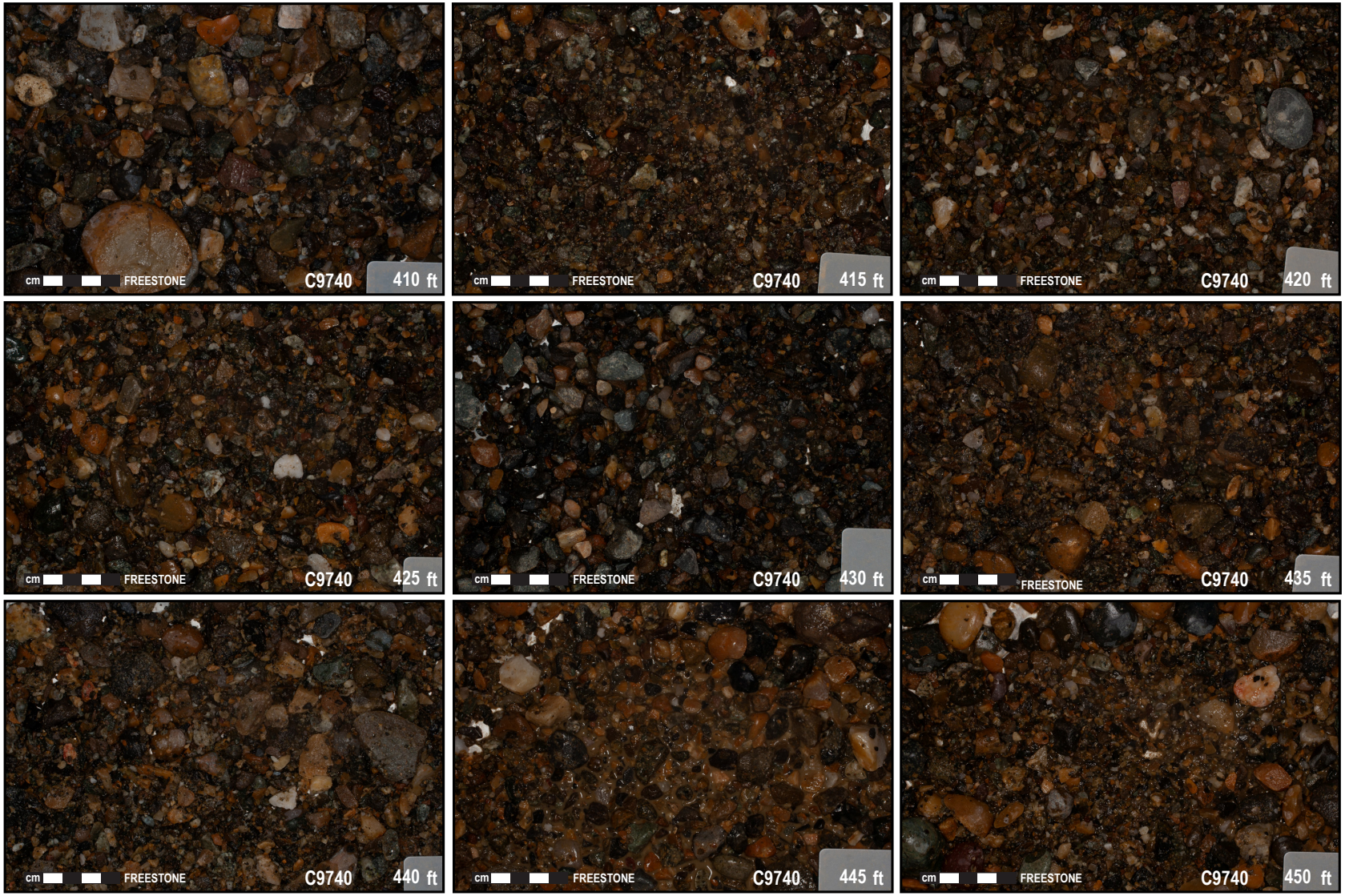

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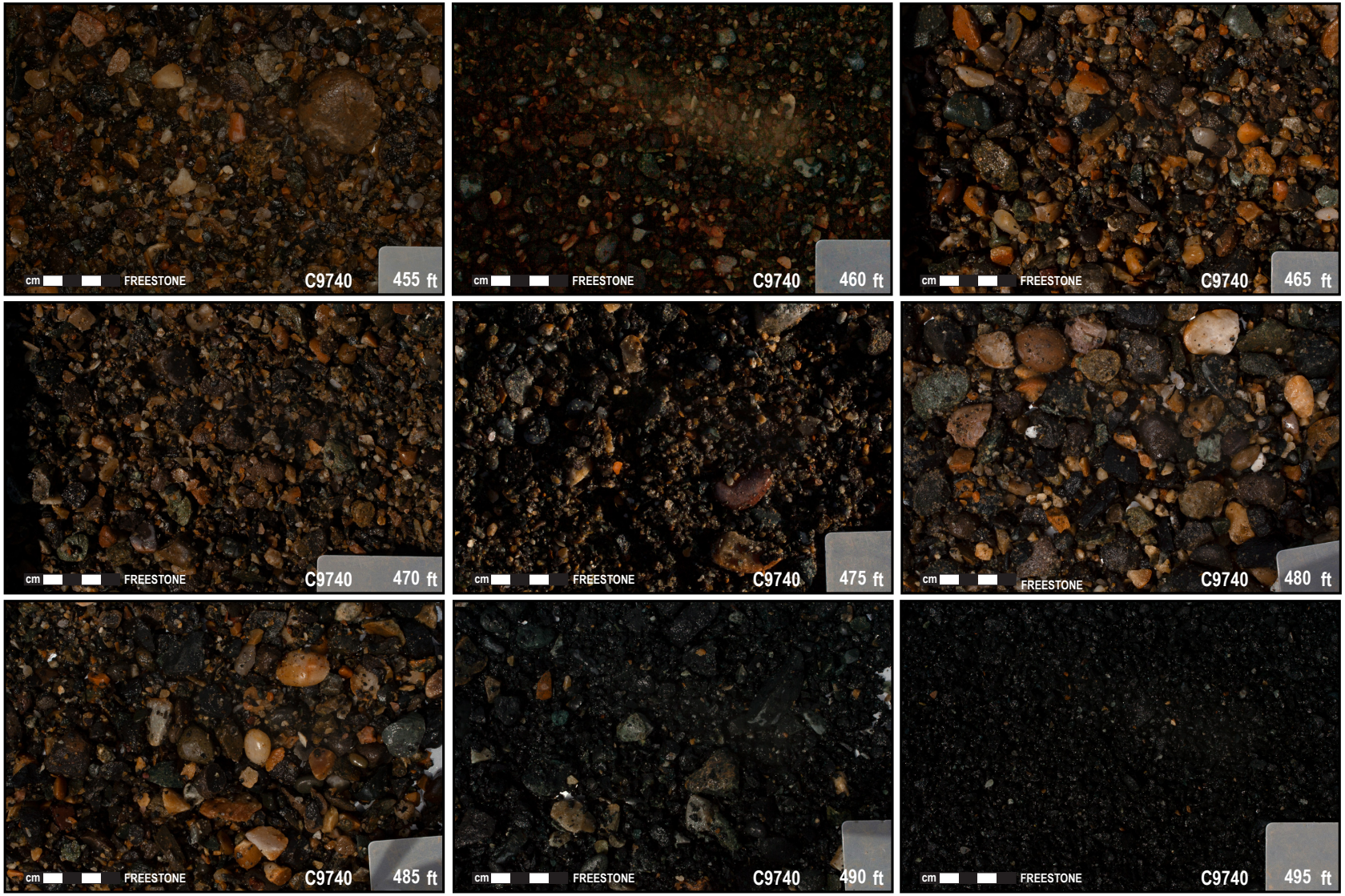

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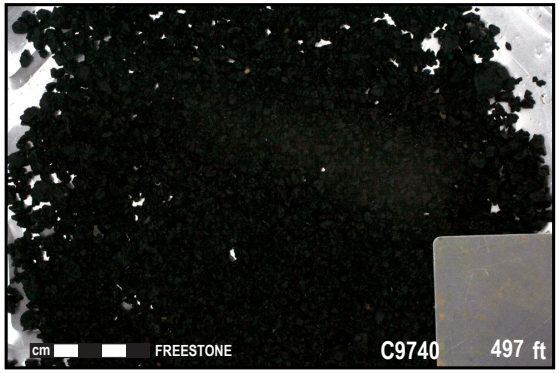
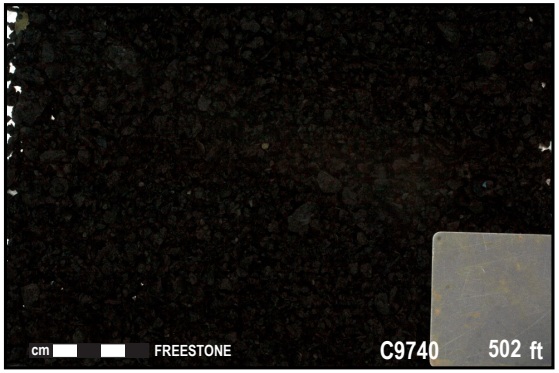
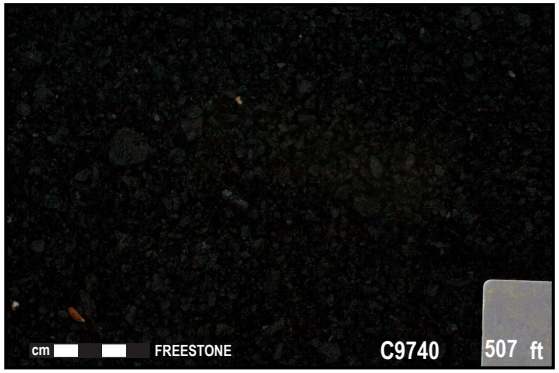






FREESTONE
ENVIRONMENTAL SERVICES, INC.

Drill Cutting Photographs for C9740 (699-44-70B)

WELL DEVELOPMENT AND TESTING DATA

Well ID: C9740 | Well Name: 699-44-70B | Date: 6-10-19

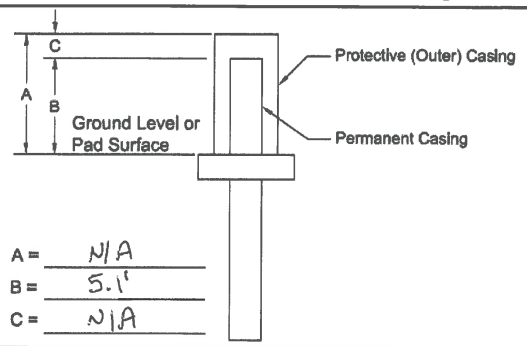
Location: 360 m S. of weather station

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: 6-10-19	323.44 bgs	331.86 bgs
Date: 6-11-19	324.28 bgs	324.71 bgs
DEPTH TO BOTTOM:		
Date: 6-10-19	423.10	423.10
Date: 6-11-19	423.05	423.05



A = N/A
B = 5.1'
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)
6-10-19	413.30	0.864	412.00	over range	5.66	1104	1431	* 9.10	10.53
6-11-19	413.30	0.902	412.00	60.10	3.56	0714	0947	** 11.75	13.02

JLR 7/16/19

Total Pumped: 3360.2 gal

Pump Model: Grundfos - 96160152 1.5 HP

Troll Serial Number and Pressure Range (PSI and depth): 546780 210m/692ft

Comments: * Avg pumping Rate used (9.1 gpm) 8.1 gpm for 144 min + 10.1 gpm for 58 min.
** Avg pumping rate used (11.75 gpm) 10.1 gpm for 134 min + 13.4 gpm for 19 min.
C9740_develop_Int1_6102019
C9740_develop_Int1_06112019

Prepared By:

Lindsey Getchell (Print Name) | Lindsey Getchell (Signature) | 06-11-19 (Date)

Reviewed By:

Jennifer Richart (Print Name) | J. L. Richart (Signature) | 7/16/19 (Date)

For Office Use Only

OR Doc Type: | WMU Code(s):

Page 1 of 1 A-6005-205 (REV 2)

Bay West
Customer-Focused Environmental & Industrial Solutions

699-44-70B (C9740)
Log Data Report

Borehole Information

Log Date	2019-05-16	Filename	C9740_HG-NM_2019-05-16	Site	200-ZP-1
DTW[1] (ft)	**DTW Date**	**DTW Source**	**Drill Date**	**Total Depth (ft)**	**Depth Datum**
323.1	05/14/19	Freestone	05/14/19	510.7	Ground Surface

Casing Information

Casing Type	Drill Type	Stickup (ft)	Diameter (in.) Outer	Diameter (in.) Inside	Thickness (in.)	Top (ft)	Bottom (ft)
Threaded Steel	Air Rotary	TC[2]	11.75	10.75	0.5	0.3 AGS[3]	163.3
Threaded Steel	Air Rotary	TC	9.71	8.85	0.43	0.51 AGS	360.0
Threaded Steel	Air Rotary	TC	7.63	6.63	0.5	4.3 AGS	496.5

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 steel circumference tape, and thickness using a precision wall-thickness gauge. Maximum logging depth achieved was 498 ft, approximately 1.5 ft below the reported casing depth. The geologist reports drillers encountering basalt at approximately 497 ft. The remainder of the borehole was drilled without casing which was not logged. Zero reference is ground surface.

Logging Equipment Information

Logging System	Gamma 5TB	Type	60% Coaxial HPGe (SGLS) [4]
Effective Calibration Date	12/12/2018	Serial No.	54-TP13441B
Calibration Reference	HGLP-CC-180, Rev. 0	Logging Procedure	SGRP-PRO-OP-53023, Rev. 0, Change 2

Logging System	Gamma 4NC	Type	60% Coaxial HPGe (SGLS)
Effective Calibration Date	12/19/2018	Serial No.	45-TP22010A
Calibration Reference	HGLP-CC-178, Rev. 0	Logging Procedure	SGRP-PRO-OP-53023, Rev. 0, Change 2

Logging System	Gamma 1LD	Type	60% Coaxial HPGe (SGLS)
Effective Calibration Date	12/04/2018	Serial No.	47-TP-32211A
Calibration Reference	HGLP-CC-175, Rev. 0	Logging Procedure	SGRP-PRO-OP-53023, Rev. 0, Change 2

Logging System	Gamma 4MC	Type	He-3 (CPN 503DR) NMLS [5]
Effective Calibration Date	12/20/2018	Serial No.	H340207279
Calibration Reference	HGLP-CC-179, Rev. 0	Logging Procedure	SGRP-PRO-OP-53024, Rev. 0, Change 2

[1] depth to water inside casing
[2] Temporary casing
[3] Above ground surface
[4] Spectral Gamma Logging System
[5] Neutron Moisture Logging System

Logging System	Gamma 5PB	**Type**	He-3 (CPN 503DR) NMLS
Effective Calibration Date	12/12/2018	**Serial No.**	H34055445
Calibration Reference	HGLP-CC-177, Rev. 0	**Logging Procedure**	SGRP-PRO-OP-53024, Rev. 0, Change 2

SGLS Log Run Information

Log Run	**1**	**2 Repeat**	**5**	**6**
HEIS Number	1021069	1021070	1021071	1021072
Date	04/10/19	04/10/19	04/23/19	04/23/19
Logging Engineer	Spatz	Spatz	Patterson/ Meisner	Patterson/Meisner
Start Depth (ft)	0.0	75.0	159.0	351.0
Finish Depth (ft)	162.0	92.0	350.01	360.02
Count Time (sec)	100	100	100	100
Live/Real	R	R	R	R
Shield (Y/N)	N	N	N	N
MSA Interval (ft)	1.0	1.0	1.0	1.0
Log Speed (ft/min)	NA	NA	NA	NA
Pre-Verification	C9740FTB20190 410AV00CAB1	C9740FTB2019041 0AV00CAB1	C9740DNC2019 0423AV00CAB1	C9740DNC20190 423AV00CAB1
Start File	AD000000	BD007500	AD015900	BD035100
Finish File	AD016200	BD009200	AD035001	BD036002
Post-Verification	C9740FTB20190 410BV00CAA1	C9740FTB2019041 0BV00CAA1	C9740DNC2019 0423BV00CAA1	C9740DNC20190 423BV00CAA1
Depth Return Error (in.)	N/A	2.5 high	N/A	5.0 low
Comments	None	None	None	None

Log Run	**7 Repeat**	**10**	**11 Repeat**	
HEIS Number	1021073	1021074	1021075	
Date	04/24/19	05/16/19	05/16/19	
Logging Engineer	Patterson/ Meisner	Spatz	Spatz	
Start Depth (ft)	235.0	349.0	393.0	
Finish Depth (ft)	257.01	498.01	408.02	
Count Time (sec)	100	100	100	
Live/Real	R	R	R	
Shield (Y/N)	N	N	N	
MSA Interval (ft)	1.0	1.0	1.0	
Log Speed (ft/min)	NA	NA	NA	
Pre-Verification	C9740DNC2019 0424AV00CAB1	C9740ALD2019051 6AV00CAB1	C9740ALD2019 0516AV00CAB1	
Start File	CD023500	AD034900	BD039300	
Finish File	CD025701	AD049801	BD040802	
Post-Verification	C9740DNC2019 0424CV00CAA1	C9740ALD2019051 6BV00CAA1	C9740ALD2019 0516BV00CAA1	

Log Run	7 Repeat	10	11 Repeat	
Depth Return Error (in.)	2.0 low	N/A	1.0 low	
Comments	None	None	None	

NMLS Log Run Information

Log Run	3	4 Repeat	8	9 Repeat
HEIS Number	1021076	1021077	1021078	1021079
Date	04/10/19	04/10/19	04/24/19	04/24/19
Logging Engineer	Spatz	Spatz/Patterson	Patterson	Patterson
Start Depth (ft)	0.0	75.0	159.0	300.0
Finish Depth (ft)	163.0	92.0	325.01	318.01
Count Time (sec)	15	15	15	15
Live/Real	R	R	R	R
Shield (Y/N)	N	N	N	N
MSA Interval (ft)	0.25	0.25	0.25	0.25
Log Speed (ft/min)	NA	NA	NA	NA
Pre-Verification	C9740FPB20190410AV00CAB1	C9740FPB20190410AV00CAB1	C9740DMC20190424AV00CAB1	C9740DMC20190424AV00CAB1
Start File	AD000000	BD007500	AD015900	BD030000
Finish File	AD016300	BD009200	AD032501	BD031801
Post-Verification	C9740FPB20190410BV00CAA1	C9740FPB20190410BV00CAA1	C9740DMC20190424BV00CAA1	C9740DMC20190424BV00CAA1
Depth Return Error (in.)	N/A	1.5 high	N/A	1.5 low
Comments	None	None	None	None

Logging Operation Notes

A centralizer was installed on the sondes. Verification measurements passed the acceptance criteria.

Analysis Notes

Analyst	P.D. Henwood	Date	06/06/19
Reference(s)	SGRP-PRO-OP-53040, Rev. 0; SGRP-PRO-OP-53051, Rev. 0		

Casing corrections for a 0.5 and 0.43-in. thick casings were applied to the SGLS and NMLS log data.

For the SGLS, a water correction was applied below 323.1 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 EXCEL templates identified as FTB20181218, DNC20181219, and ALD20181204 using an efficiency function and corrections for casing and dead time as determined by annual calibrations.

Casing diameter and thickness corrections for 0.5-in. thick, 11.75-in. OD casing were applied to the NMLS data for the first casing to 163 ft and for 0.43-in. thick 9.71-in. OD for the second casing. Integrated with the casing diameter and thickness corrections is an initial count rate correction for a sediment composition of a 50-50% ratio of basalt fragments to quartz sand (HGLP-OTH-028).

NMLS data are reported in counts per second for the entire length of the borehole. NMLS data are also reported in vol% moisture. Conversions from count rate to vol% moisture were performed using EXCEL templates identified as FPB_MCNP_assay and DMC_MCNP_assay.

HGU[6] 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.

Bi-214 energy peaks at 609 and 1764 keV are plotted on the Combination log plots. These energy peaks are used to calculate naturally occurring U-238. Where the concentrations diverge, radon (Rn-222) is indicated that has disrupted the secular equilibrium (activity of the parent is equal to the activity of its daughters) between the parent U-238 and its daughters below Rn-222 in the uranium decay chain. Rn-222 appears to be in the groundwater.

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 cause of the relatively high moisture at 314 ft is unknown. It coincides with a very low K-40 concentration, suggesting drilling activity may have caused a void and water was introduced into the borehole at this depth.

The KUT and moisture repeat plots indicate that the systems were working properly.

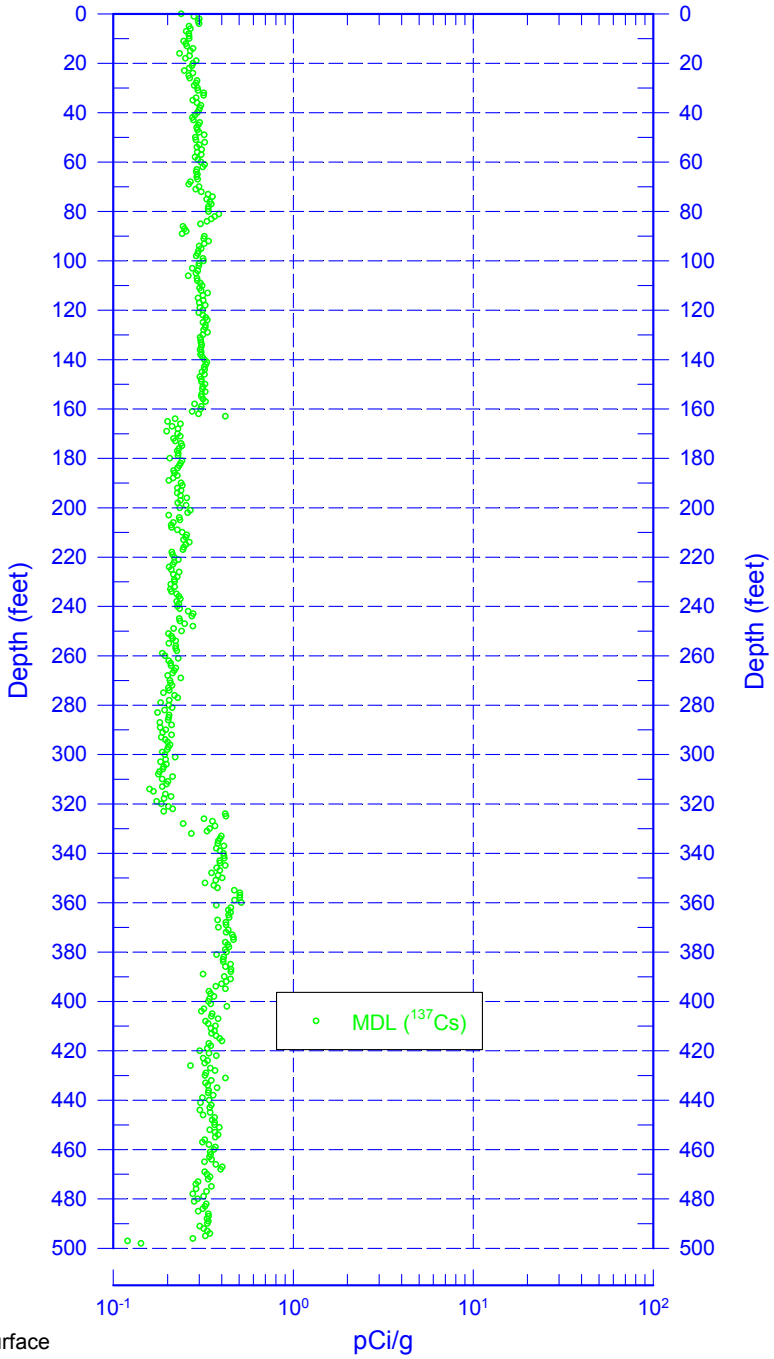
List of Log Plots

Depth Reference is ground surface.

Manmade Radionuclides (0-500 ft)
Natural Gamma Logs (0-160 ft)
Natural Gamma Logs (150-310 ft)
Natural Gamma Logs (300-460 ft)
Natural Gamma Logs (450-610 ft)
Combination Plot (0-120 ft)
Combination Plot (110-230 ft)
Combination Plot (220-340 ft)
Combination Plot (330-450 ft)
Combination Plot (440-560 ft)
Combination Plot (0-520 ft)
Total Gamma & Moisture (0-340 ft)
Moisture (0-160 ft)
Moisture (160-330 ft)
Total Gamma & Hanford Gamma Unit (0-500 ft)
Repeat Section of Natural Gamma Logs (75-92 ft)
Repeat Section of Natural Gamma Logs (235-257 ft)
Repeat Section of Natural Gamma Logs (393-408 ft)
Moisture Repeat Section (75-92 ft)
Moisture Repeat Section (300-318 ft)

[6] Hanford Gamma Unit

699-44-70B (C9740)
Manmade Radionuclides



Zero Reference - ground surface

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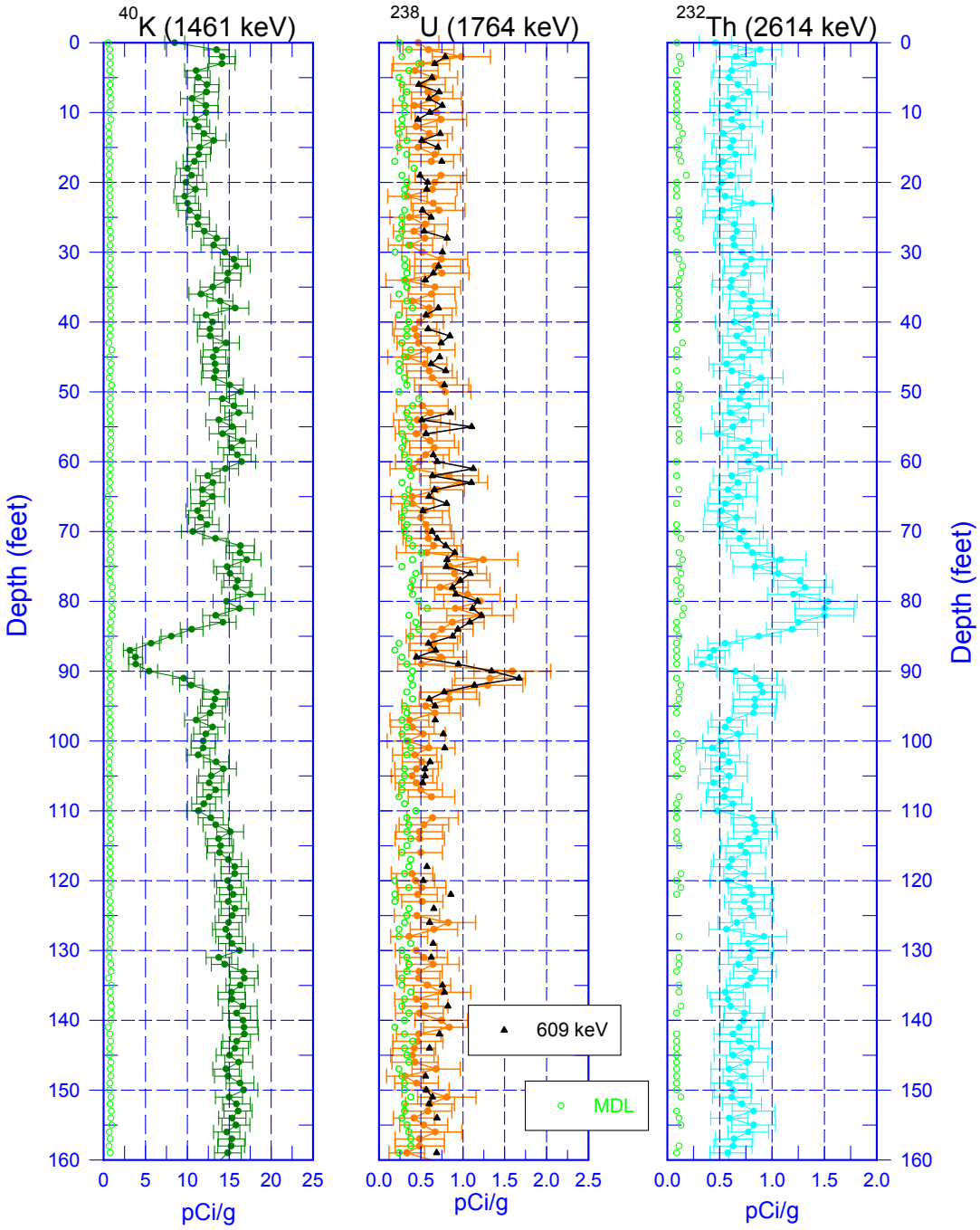
Customer-Focused Environmental & Industrial Solutions

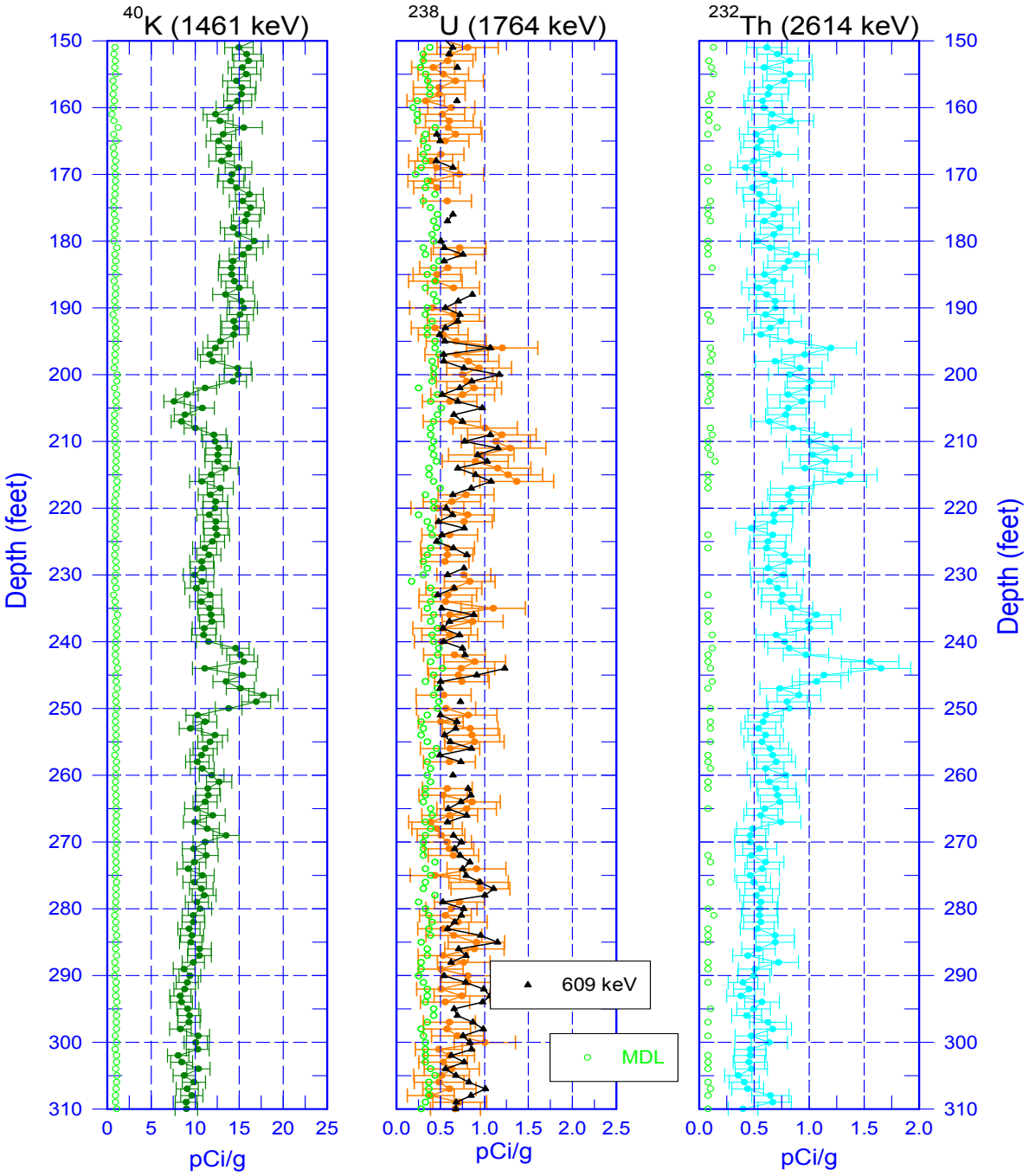
699-44-70B (C9740)
Natural Gamma Logs



Zero Reference - ground surface

Bay West
Customer-Focused Environmental & Industrial Solutions

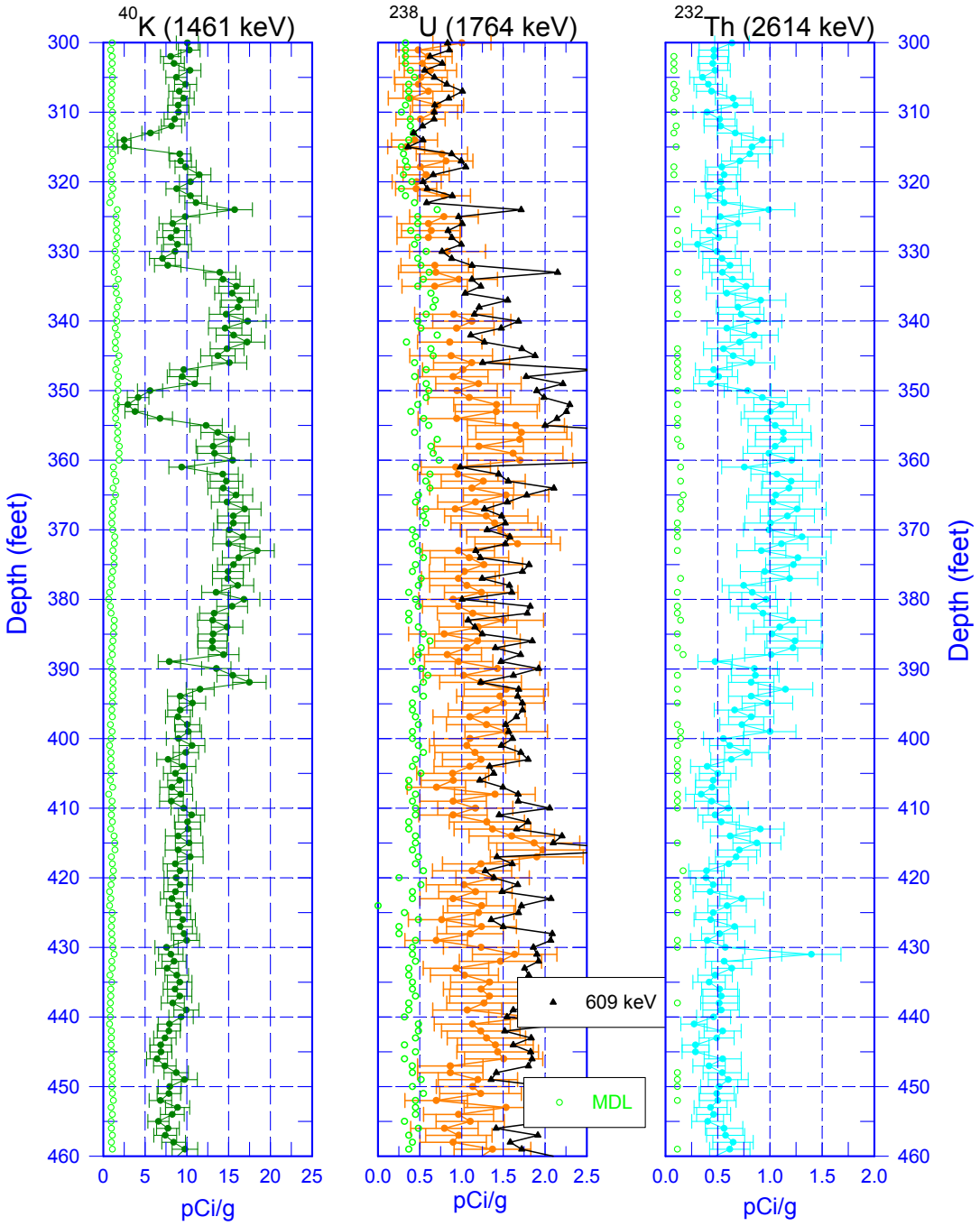
699-44-70B (C9740)
Natural Gamma Logs



Zero Reference - ground surface

Bay West
Customer-Focused Environmental & Industrial Solutions

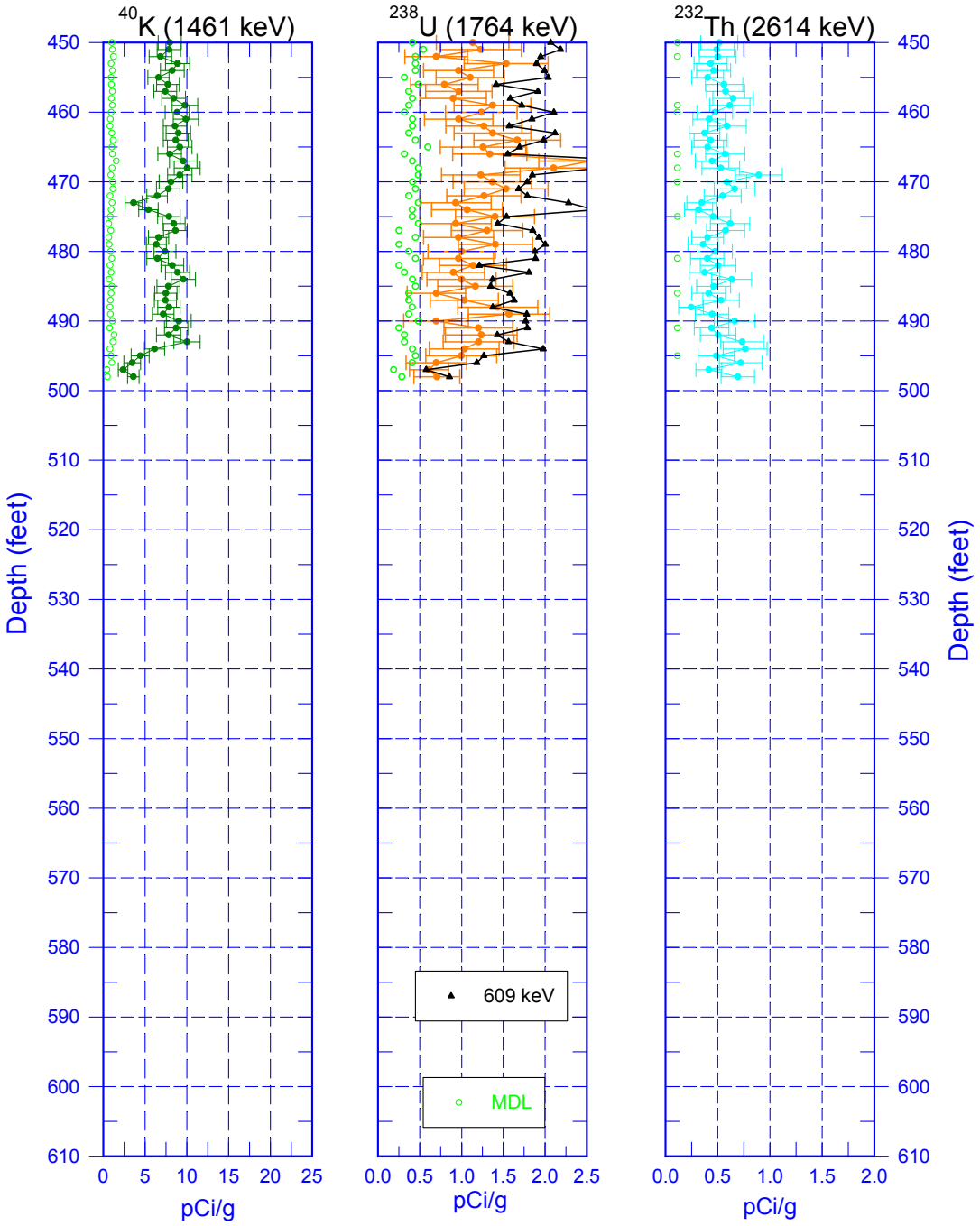
699-44-70B (C9740)
Natural Gamma Logs



Zero Reference - ground surface

Bay West
Customer-Focused Environmental & Industrial Solutions

699-44-70B (C9740)
Natural Gamma Logs



Zero Reference - ground surface

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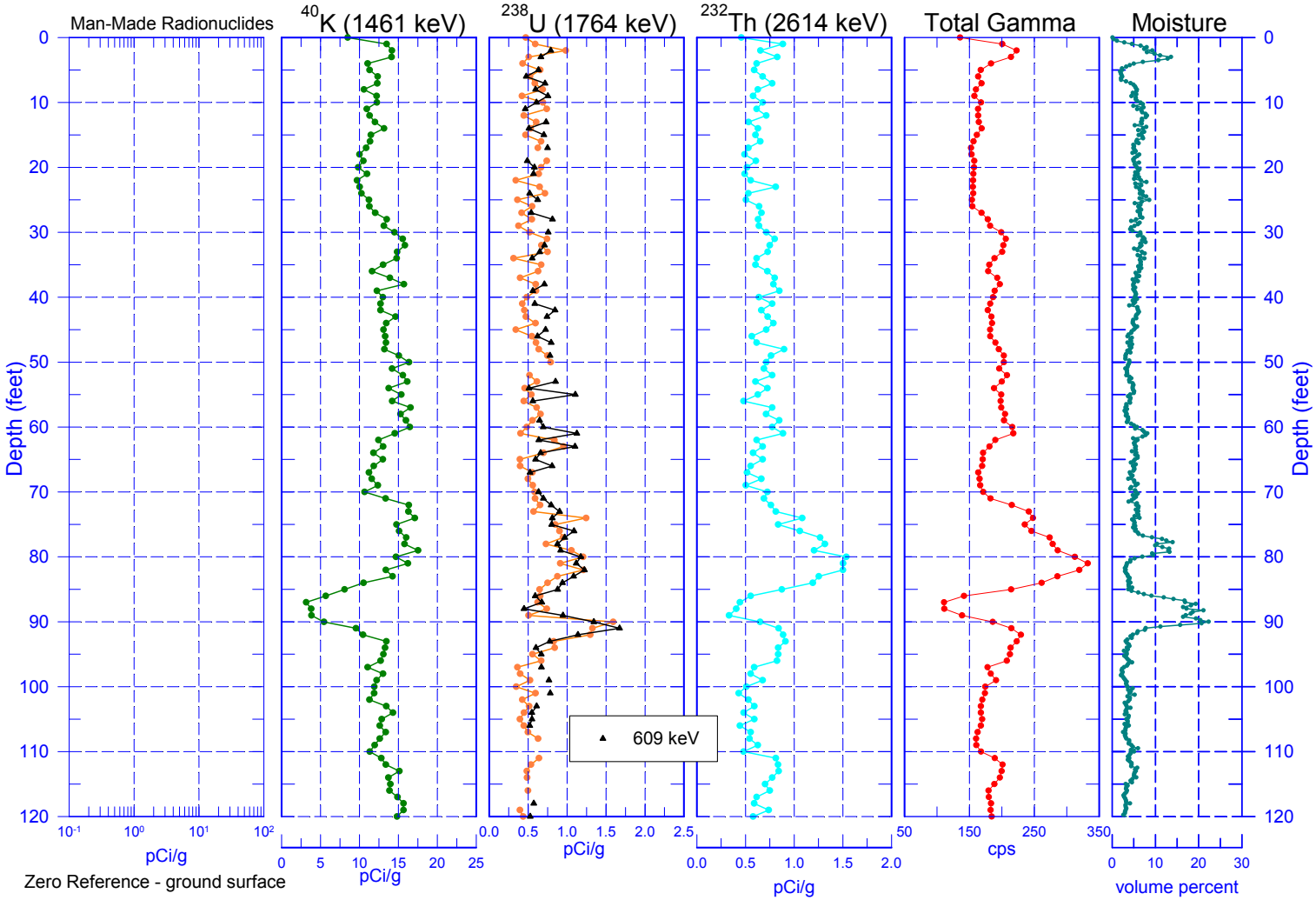
699-44-70B (C9740) Combination Plot



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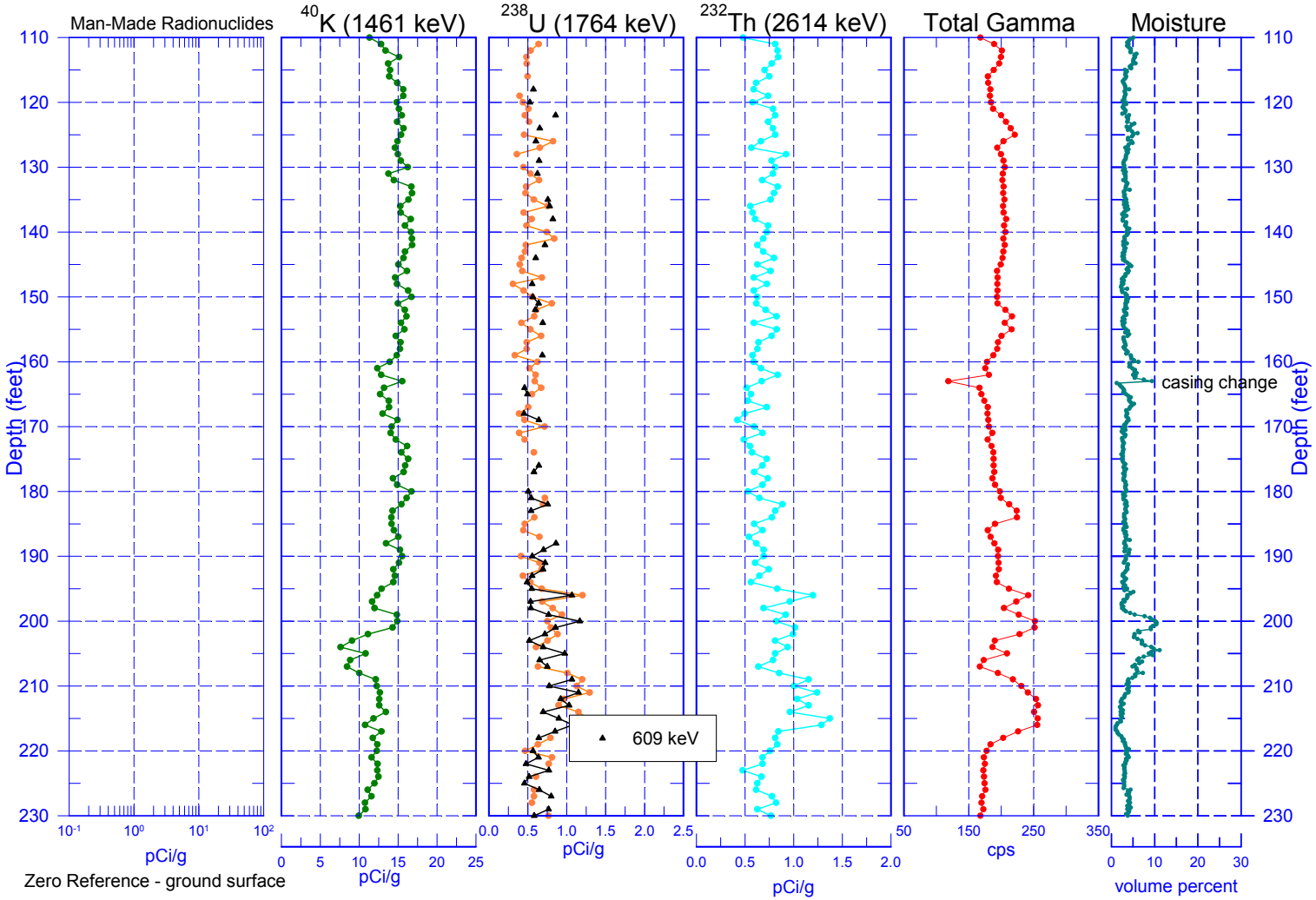
699-44-70B (C9740) Combination Plot



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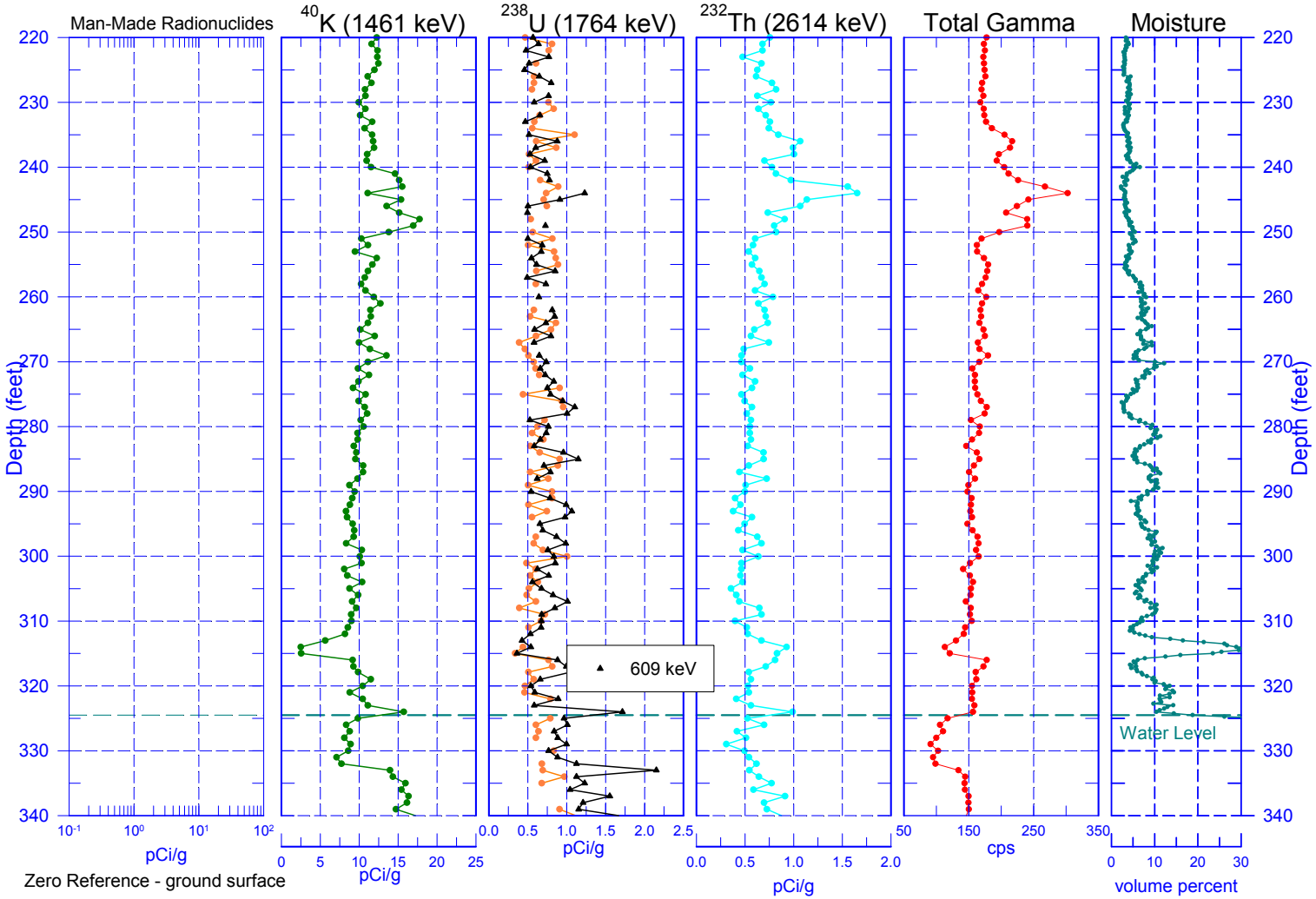
699-44-70B (C9740) Combination Plot



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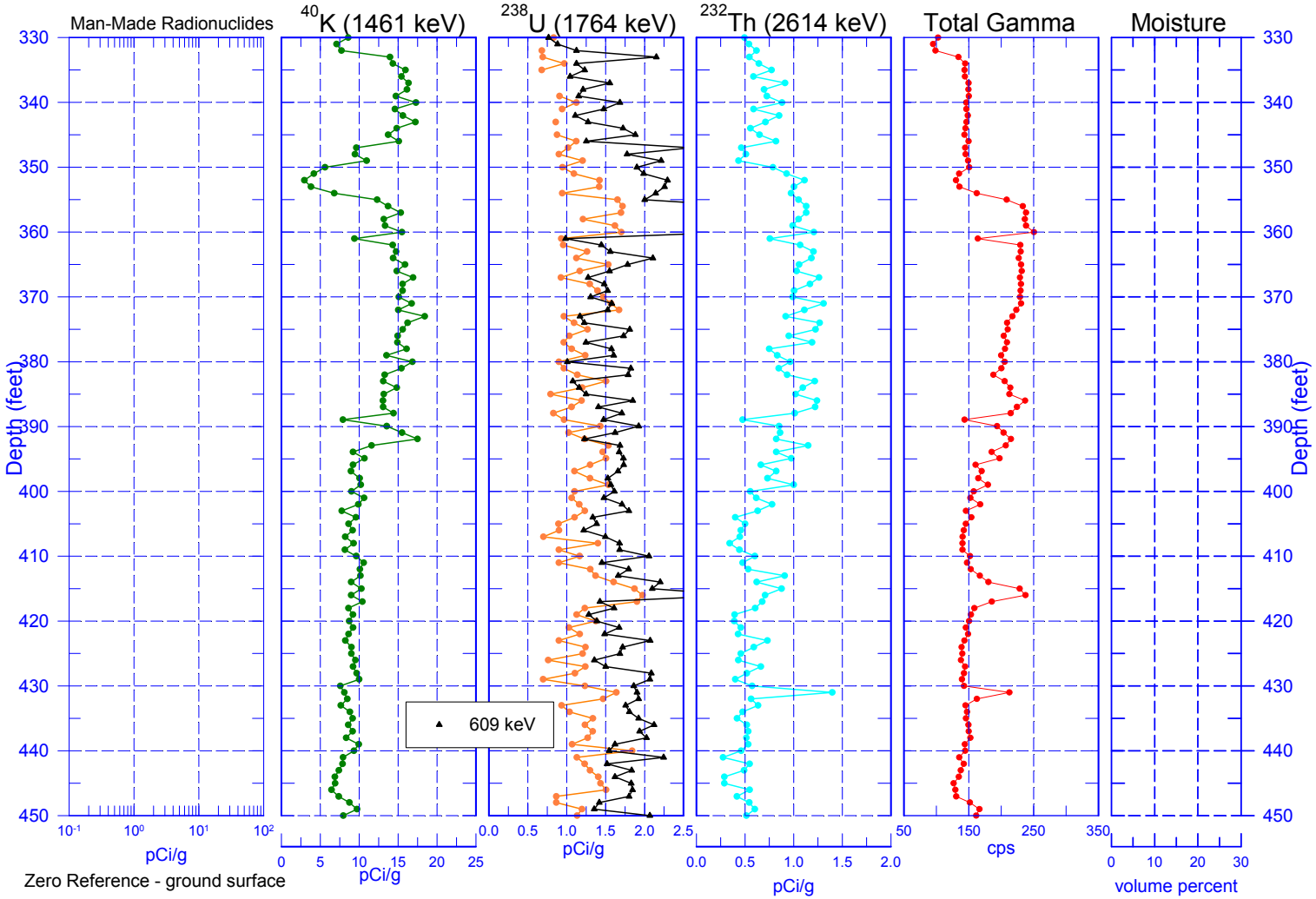
699-44-70B (C9740) Combination Plot



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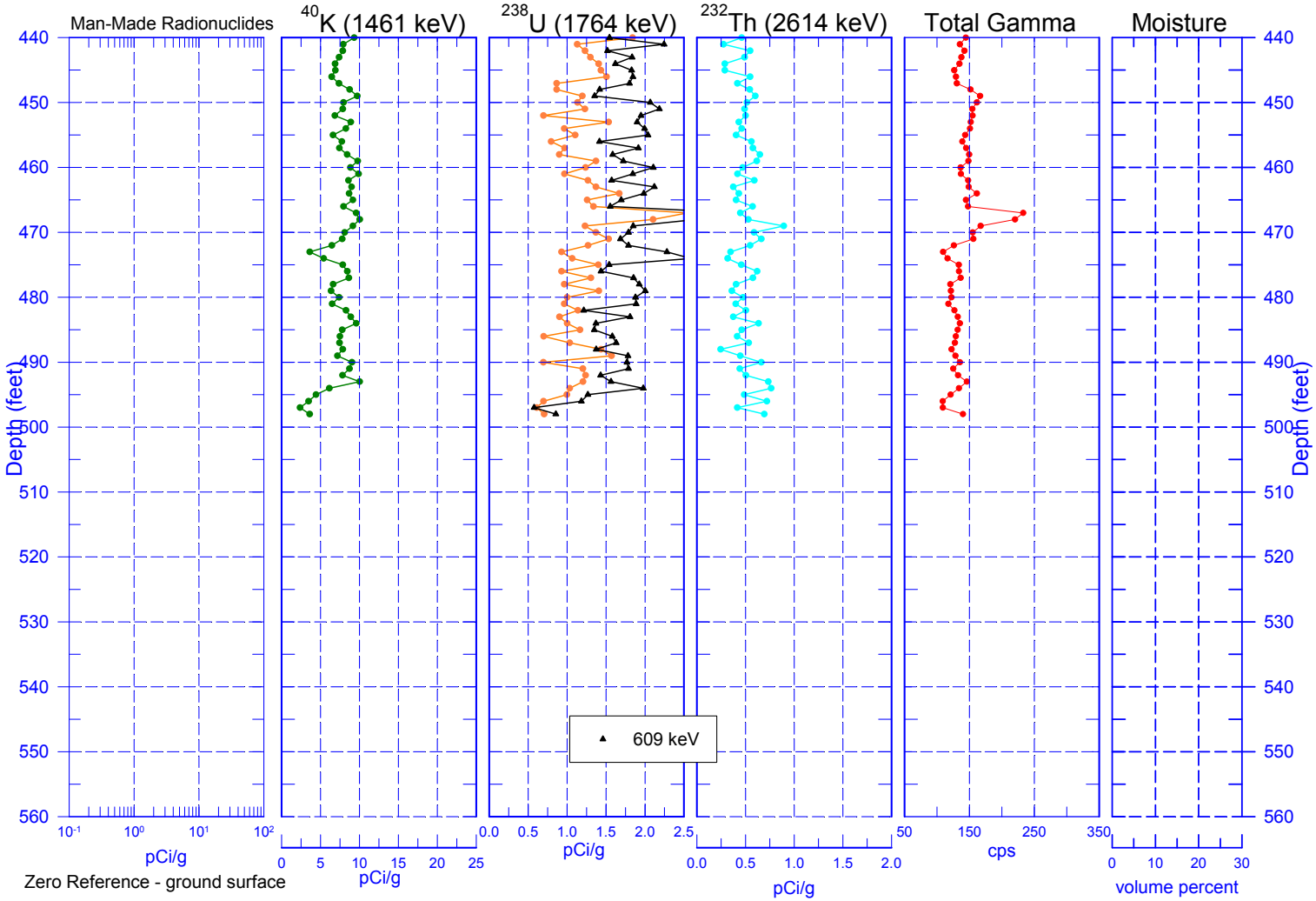
699-44-70B (C9740) Combination Plot



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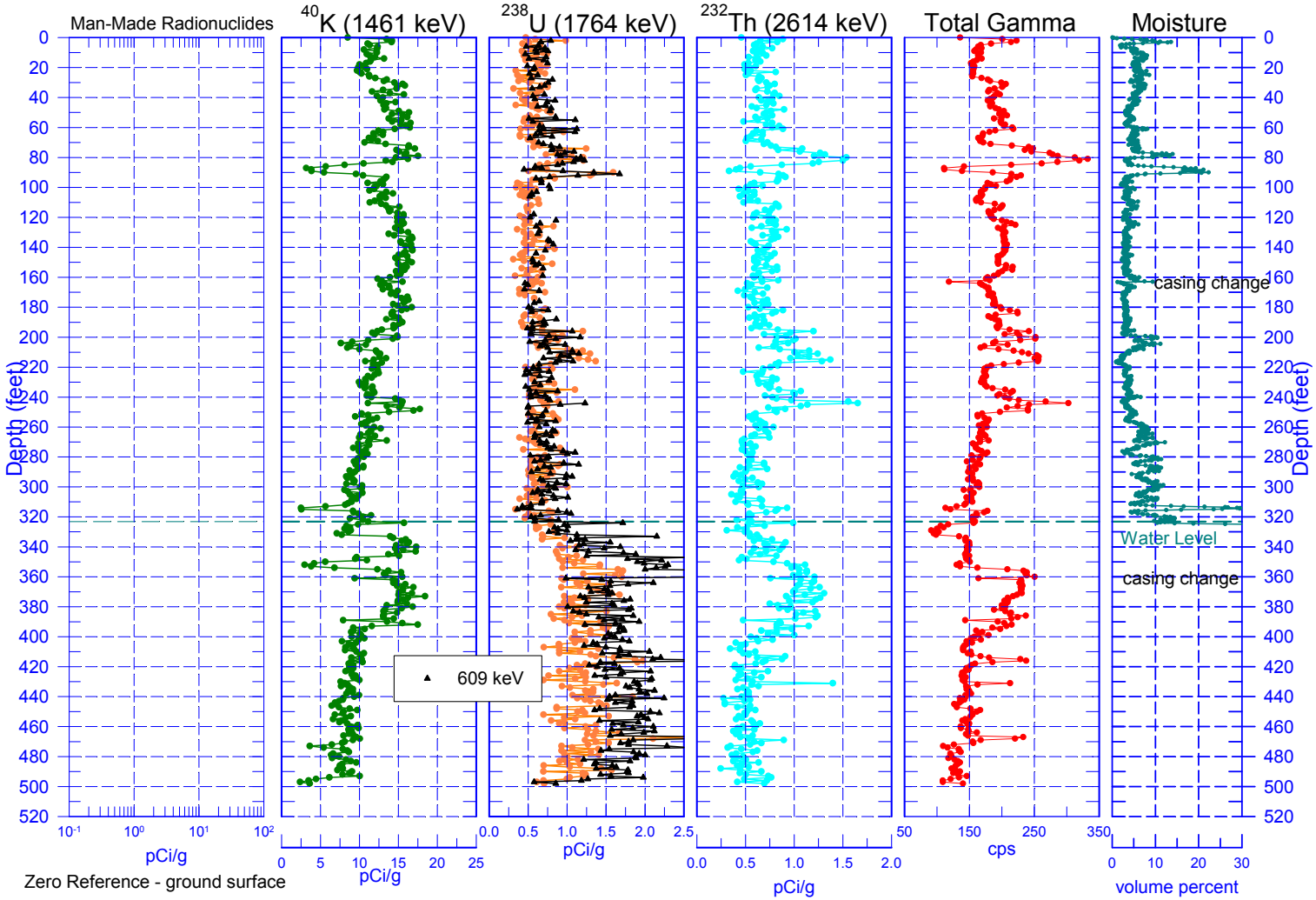
699-44-70B (C9740) Combination Plot



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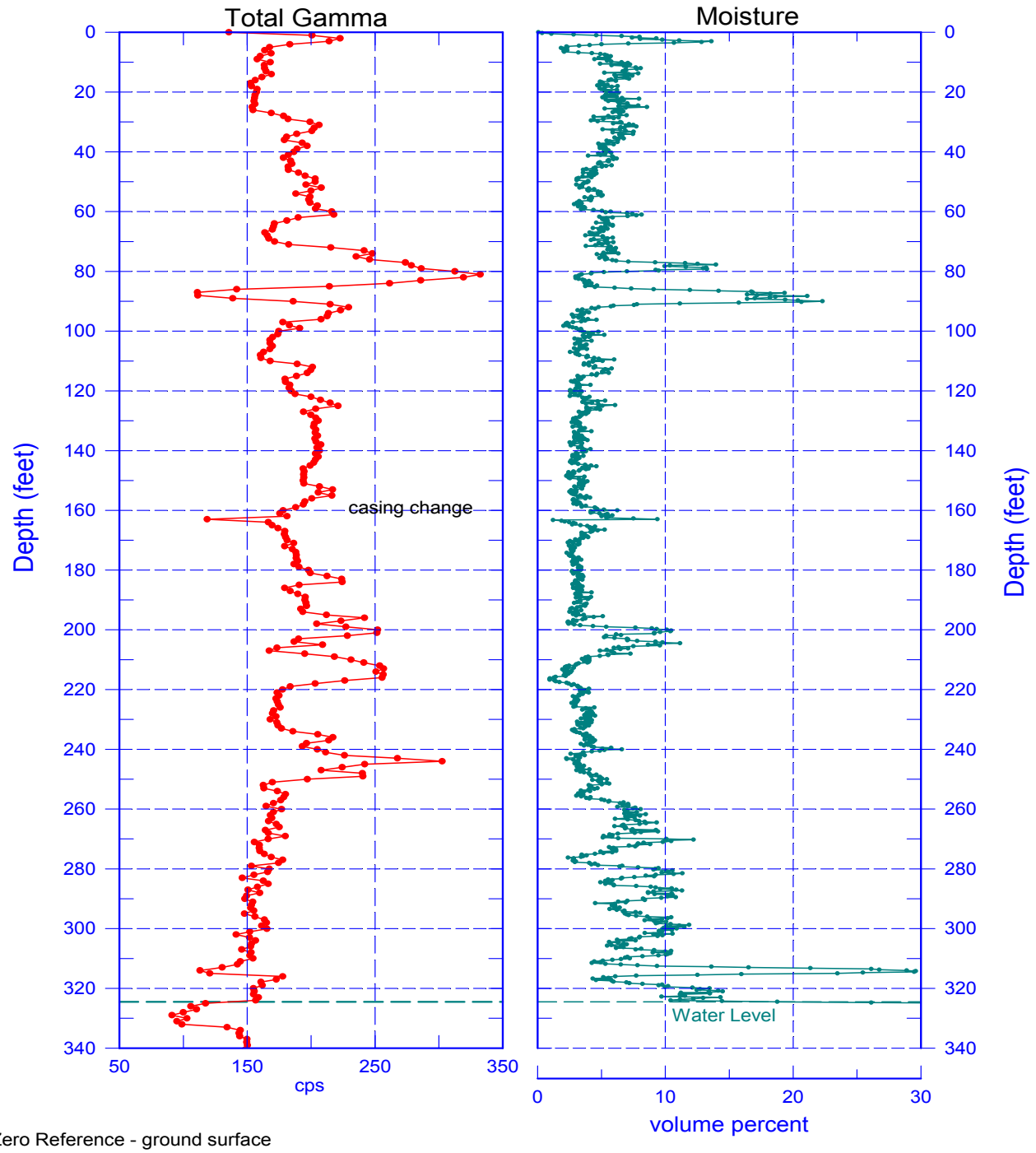
699-44-70B (C9740)
Total Gamma & Moisture



Zero Reference - ground surface

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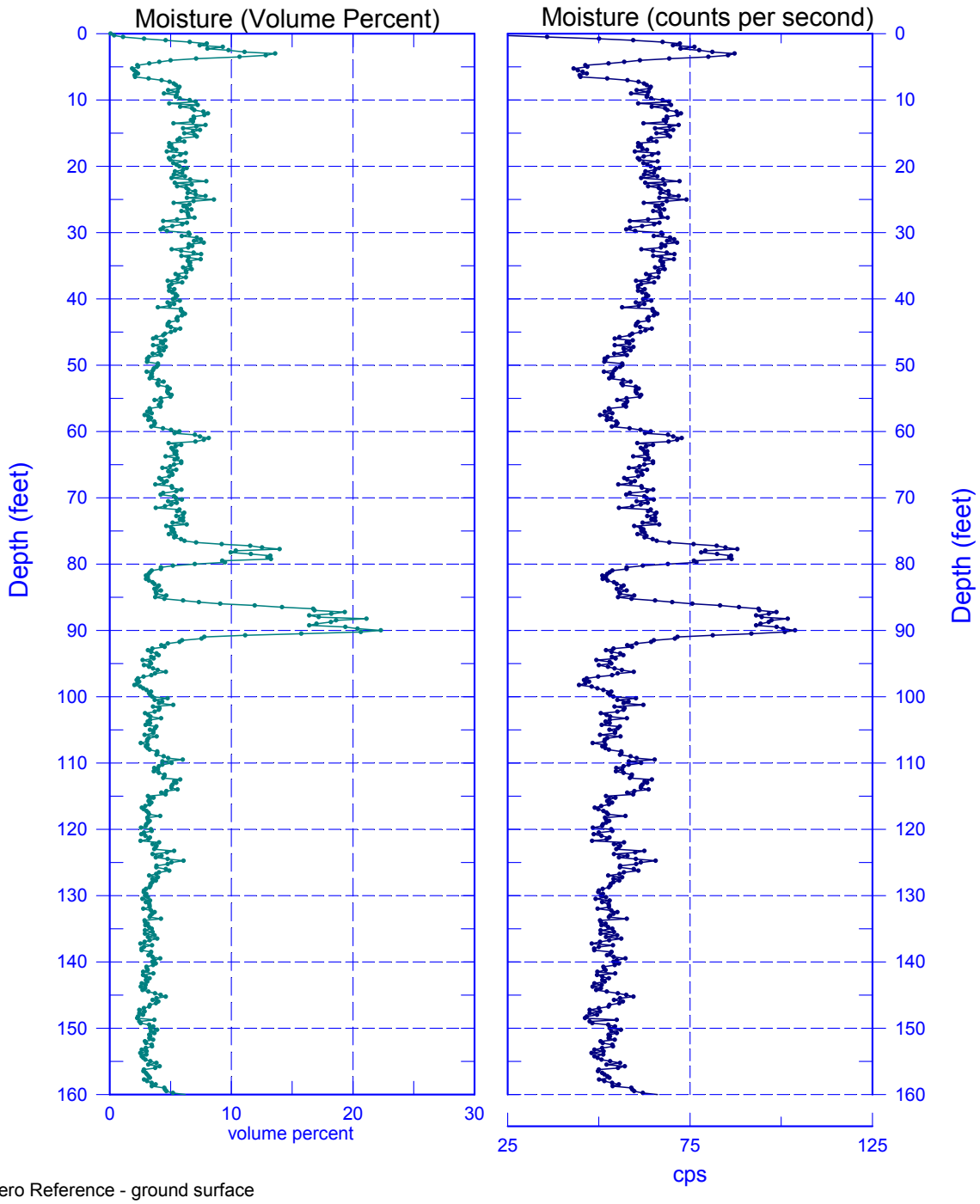
699-44-70B (C9740)
Moisture



Zero Reference - ground surface

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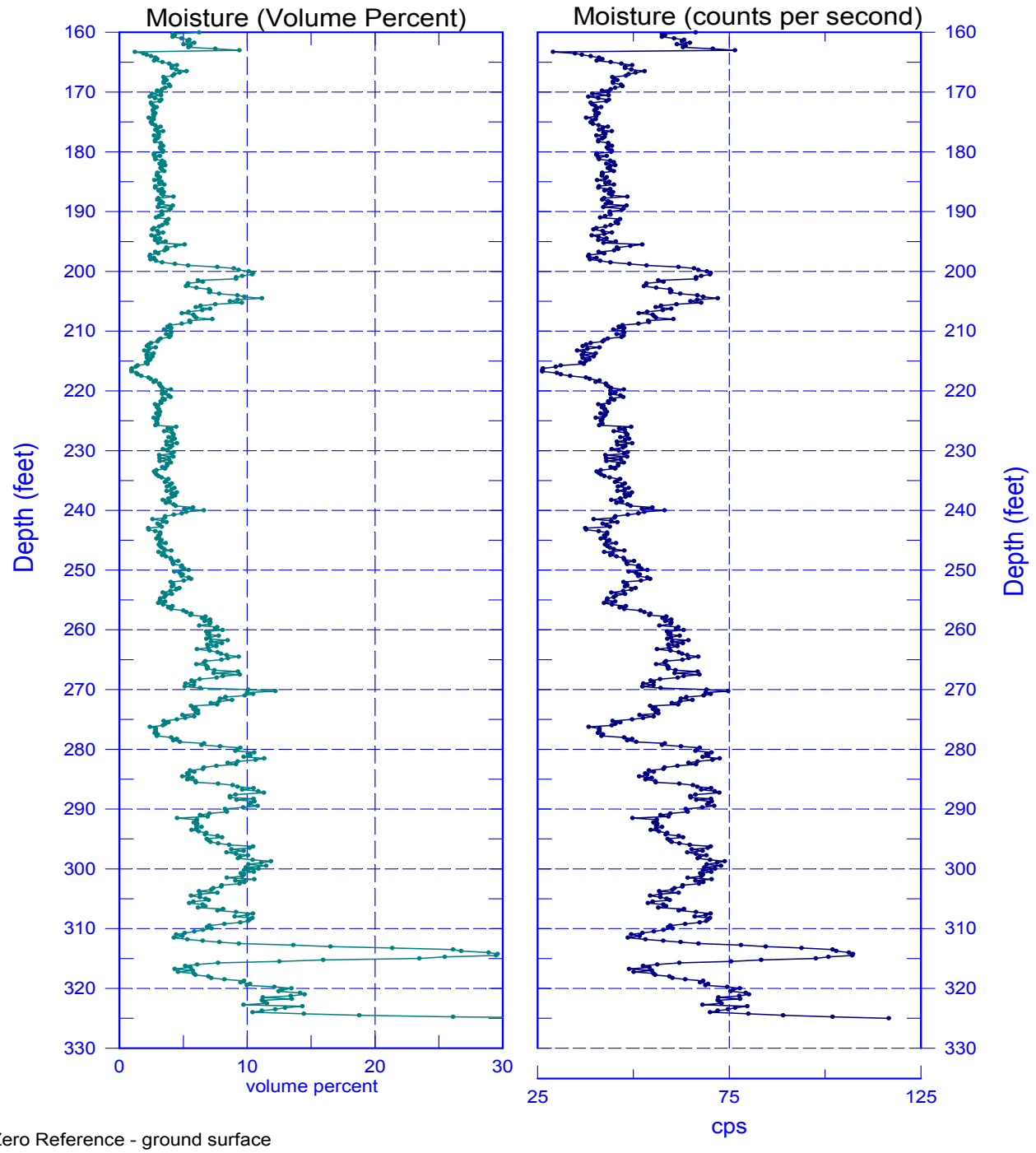
699-44-70B (C9740)
Moisture



Zero Reference - ground surface

Bay West
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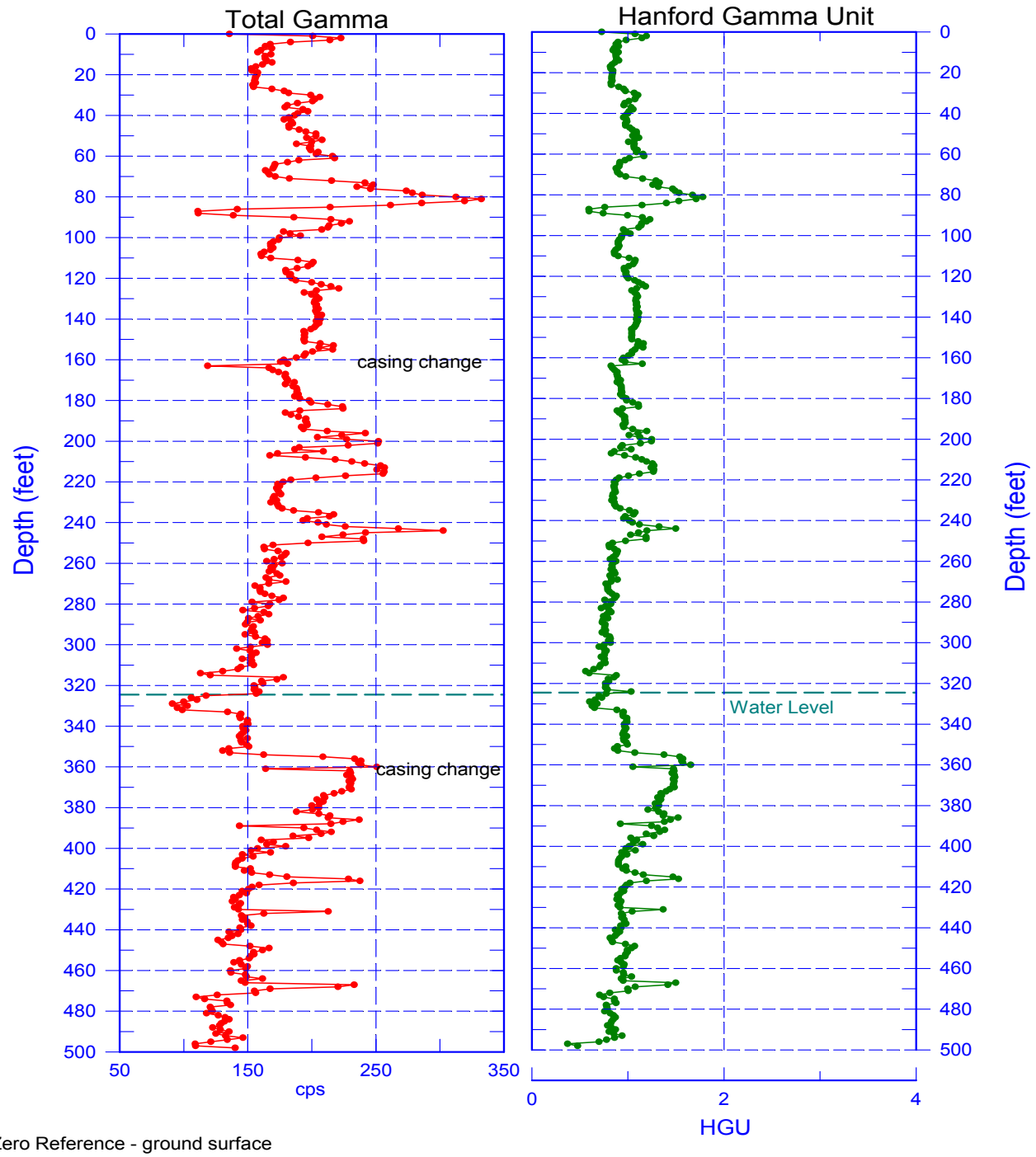
699-44-70B (C9740)
Total Gamma & Hanford Gamma Unit



Zero Reference - ground surface

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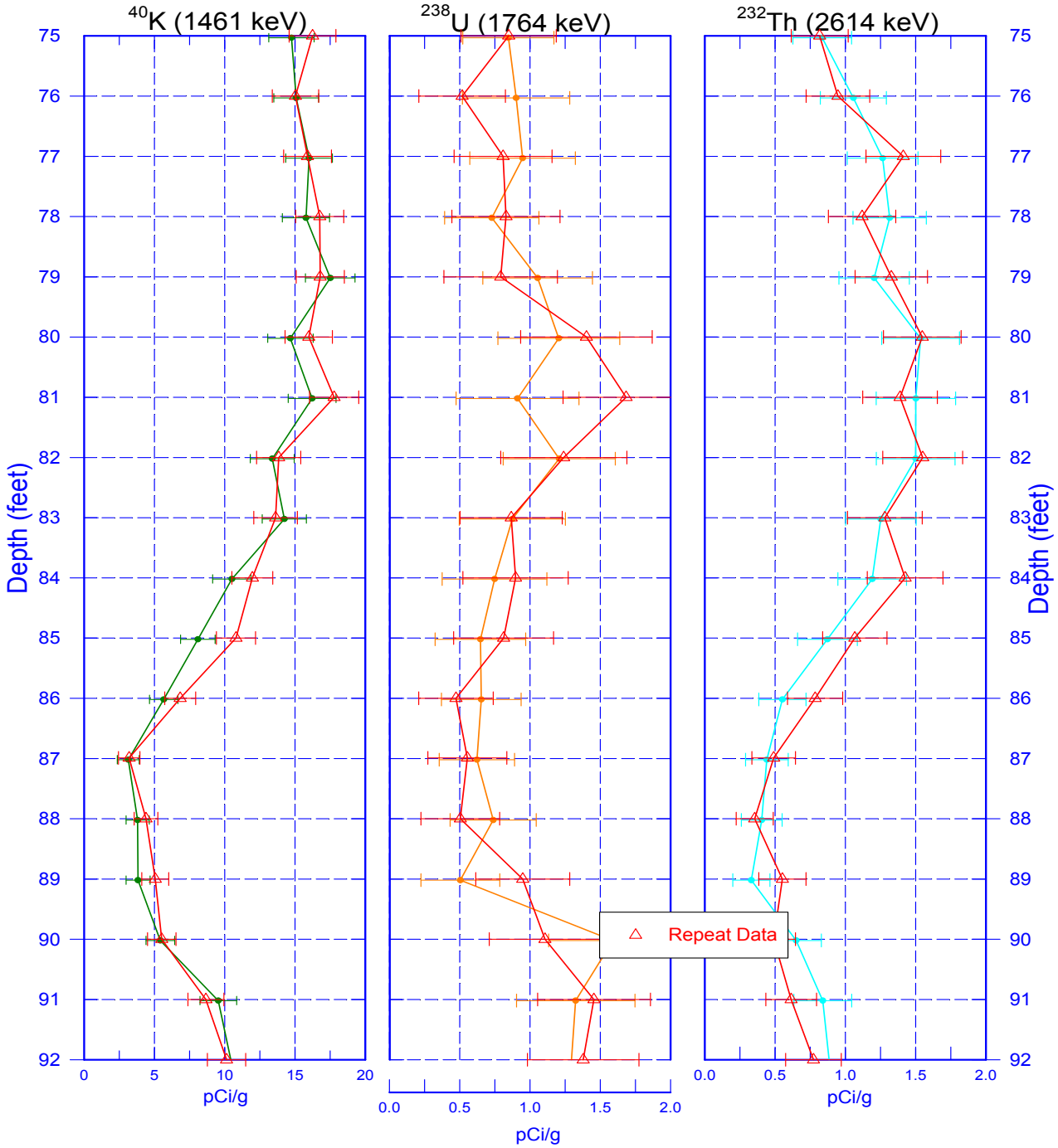
699-44-70B (C9740)

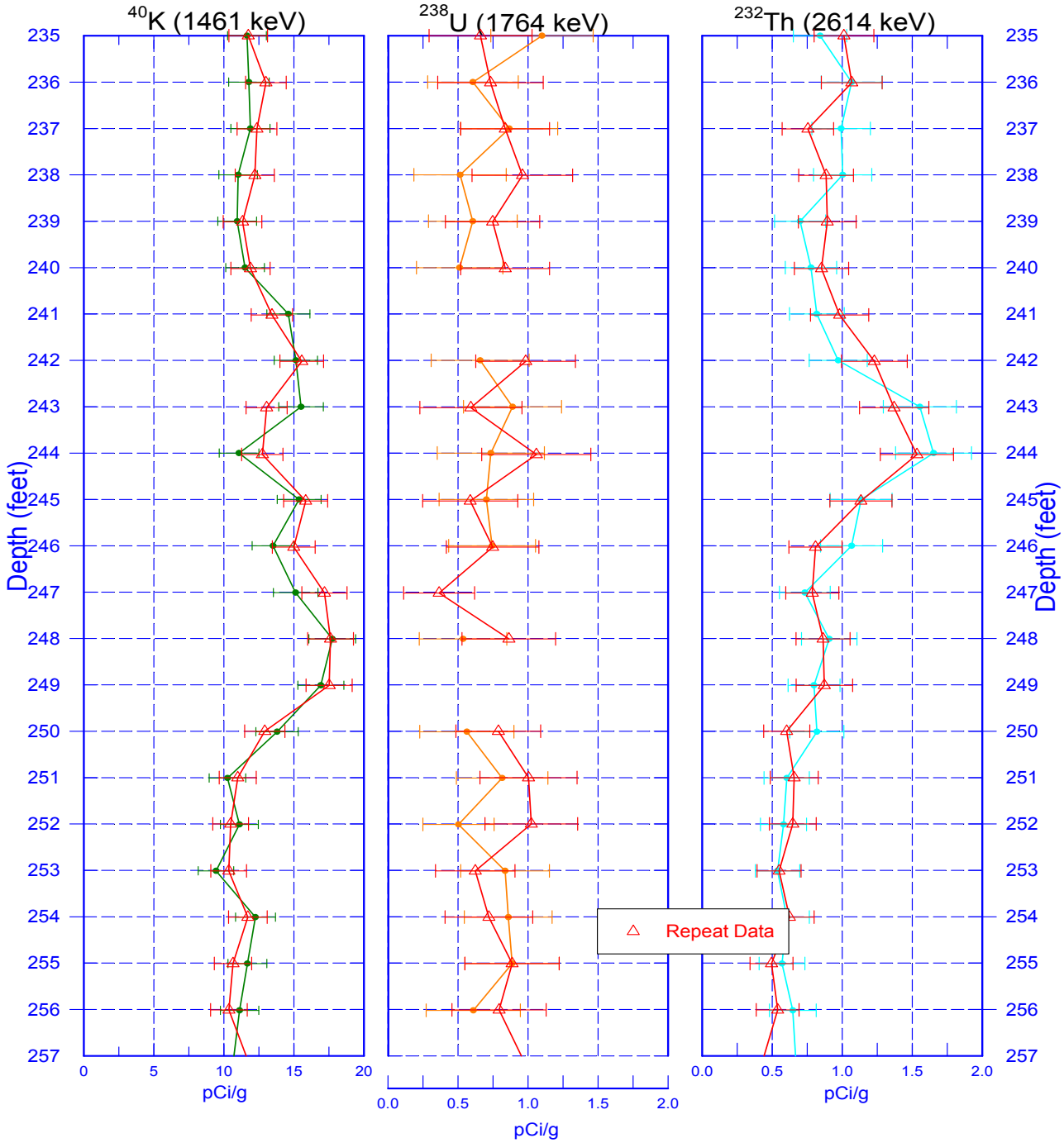
Repeat Section of Natural Gamma Logs



Zero Reference - ground surface

Bay West
Customer-Focused Environmental & Industrial Solutions

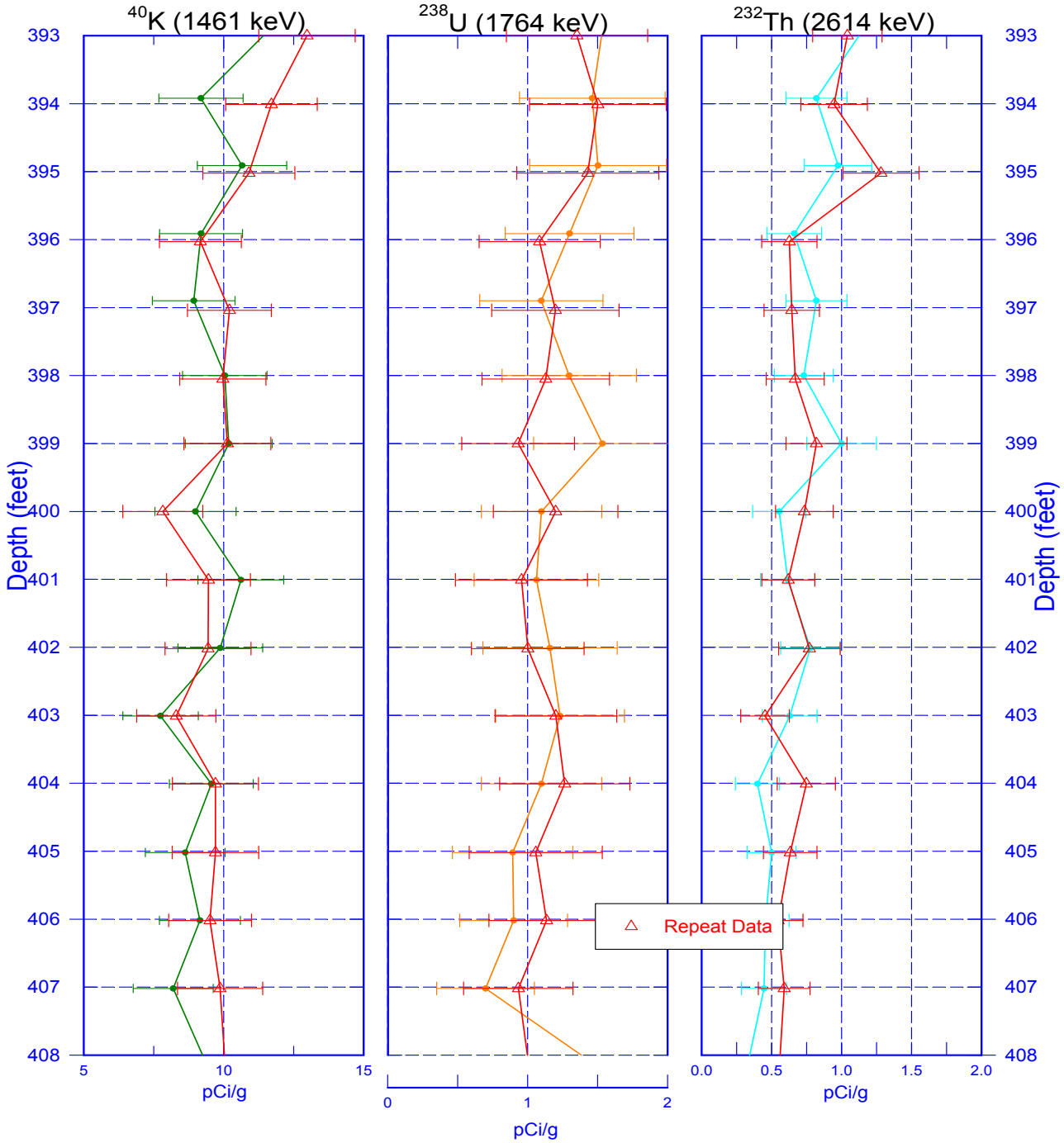
699-44-70B (C9740)
Repeat Section of Natural Gamma Logs



Zero Reference - Ground Surface

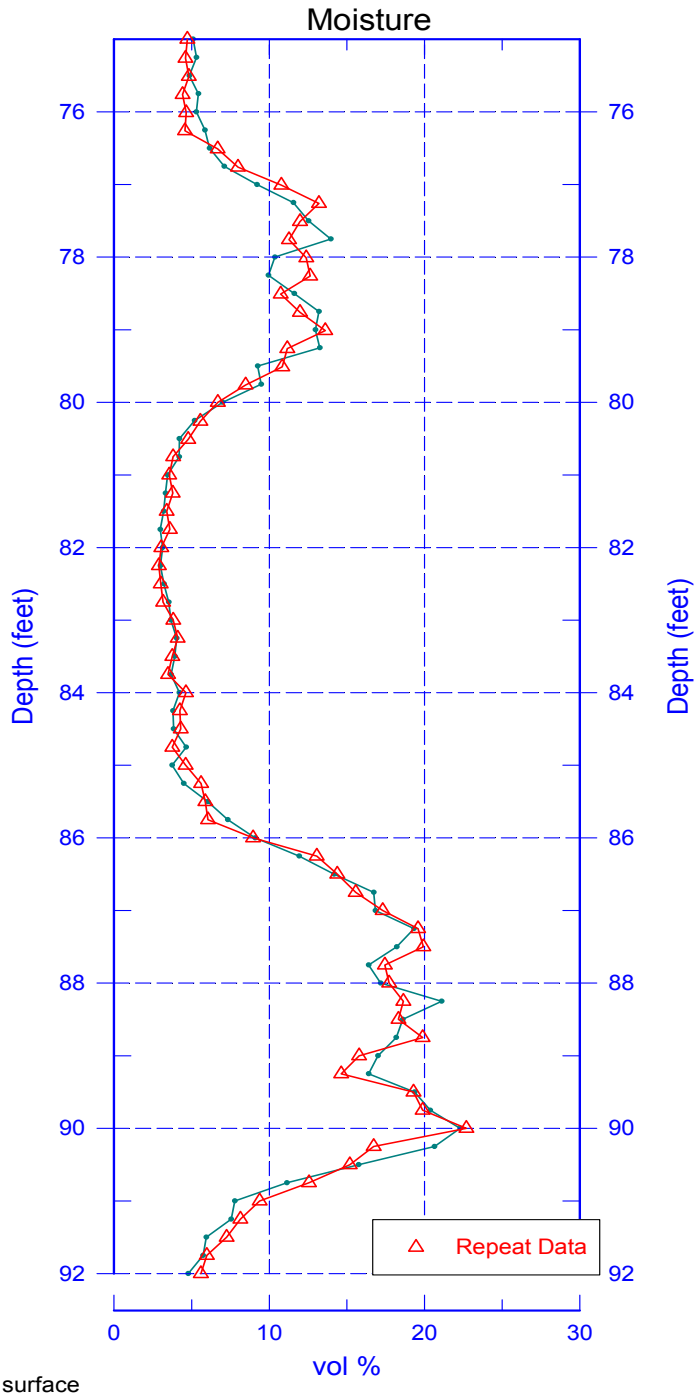
Bay West
Customer-Focused Environmental & Industrial Solutions

699-44-70B (C9740)
Repeat Section of Natural Gamma Logs



Zero Reference - ground surface

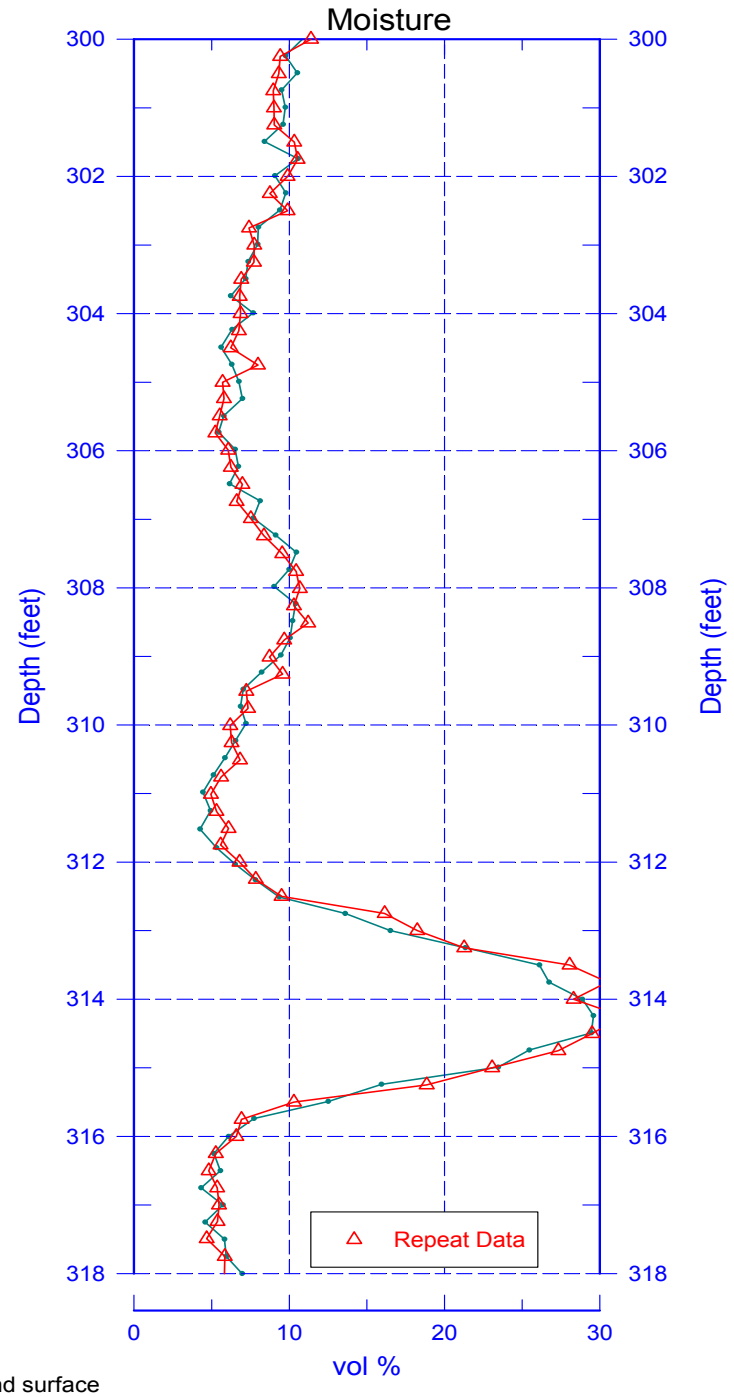
699-44-70B (C9740)
Moisture Repeat Section



Zero Reference - ground surface

Bay West
Customer-Focused Environmental & Industrial Solutions

699-44-70B (C9740)
Moisture Repeat Section



Zero Reference - ground surface

WELL SURVEY DATA REPORT

Project:	**Prepared By:** Neil P. Fastabend
	Company: CHPRC
Date Requested: 07/15/19	Requestor: Matthan G. Wilson (CHPRC)
Date of Survey: 07/29/19	Surveyor / Company: Lawrence B. Munnell / CHPRC
Description of Work: Obtained final survey coordinates (C/L Casing) and elevations of ZP-1 Well C9740 (699-44-70B) located south of the 622R Weather Station in 600 Area.	Horizontal Datum: NAD83 (91)
	Vertical Datum: NAVD88
	Units: Meters
	Hanford Area Designation: 600A

Coordinate System: Washington State Plane Coordinates (South Zone)

Horizontal Control Monuments:
Washington State Reference Network

Vertical Control Monuments:
R3-3 (CHPRC) and 2W-21 (CHPRC)

Well ID	Well Name	Easting	Northing	Elevation	
C9740	699-44-70B	568670.06	136810.37		Center of Casing
				225.240	Top Inner 4"Casing, N.Edge
				225.543	Top Outer Casing,N.Edge Stamped "X"
				224.764	Brass Survey Marker

Notes:

Brass Survey Marker elevation was taken on top of 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
7-29-19

A-6003-659 (REV 1)

Appendix C

Well Documentation for C9936 (699-46-61)

Contents

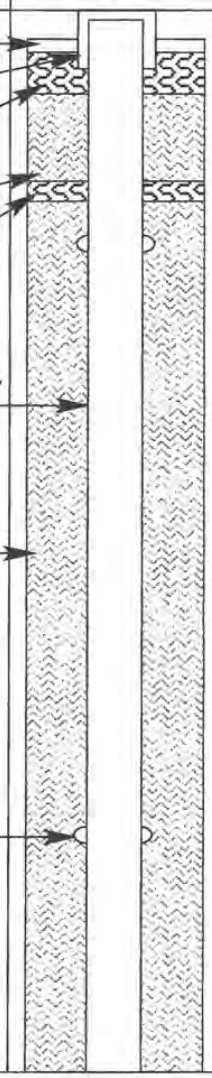
Well Summary Sheet ……..……..…..... A-1
Borehole Log ……...…….…. A-5
Drill Cutting Photographs …….....…….……..... A-15
Well Develepment and Testing Data ……..……....……...…....… A-23
Log Data Report …….....…..…..……....……...…....… A-24
Well Survey Data Report …….....…..…..……....……...…....… A-43

WELL SUMMARY SHEET

Page 1 of 4

Well ID : C9936	Well Name: 699-46-61	Start Date: 2/20/2019
Project: 3 Monitoring Wells in 200-ZP-1 OU	Location: 1400m NW of 2704 HV	Finish Date: 4/25/2019

CONSTRUCTION DATA

Description	Diagram
Concrete Pad: 0.46 ft ags - 1.0 ft bgs 6-in. Protective Casing: 2.87 ft ags - 1.67 ft bgs Type I-II Portland Cement Grout: 1.0 - 3.9 ft bgs 3/8-in. Medium Bentonite Chips: 3.9 - 9.8 ft bgs Type I-II Portland Cement Grout: 9.8 - 10.8 ft bgs 4-in. I.D. Schedule 10, Type 304/304L, Stainless Steel Blank Casing: 2.25 ft ags - 293.94 ft bgs 3/8-in. Medium Bentonite Chips: 10.8 - 289.6 ft bgs Stainless steel centralizer installed above and below screen and every 40 ft Depths measured above ground surface (ags) or below ground surface (bgs)	

GEOLOGIC/HYDROLOGIC DATA

Depth in Feet	Graphic Log	Lithologic Description (ft bgs)
0		0.0 - 10.0 Sand (S)
10		10.0 - 15.0 Sandy Gravel (sG)
		15.0 - 20.0 Gravelly Sand (gS)
20		20.0 - 30.0 Sandy Gravel (sG)
30		30.0 - 40.0 Gravel (G)
40		40.0 - 45.0 Sand (S)
		45.0 - 65.0 Sandy Gravel (sG)
50		
60		
		65.0 - 70.0 Gravelly Sand (gS)

Reported By: Nicole Combs (Print Name)	Geologist (Title)	[signature] (Signature)	4/25/2019 (Date)
Reviewed By: Jennifer Richart (Print Name)	Well Coordinator (Title)	[signature] (Signature)	5/16/19 (Date)

For Office Use Only

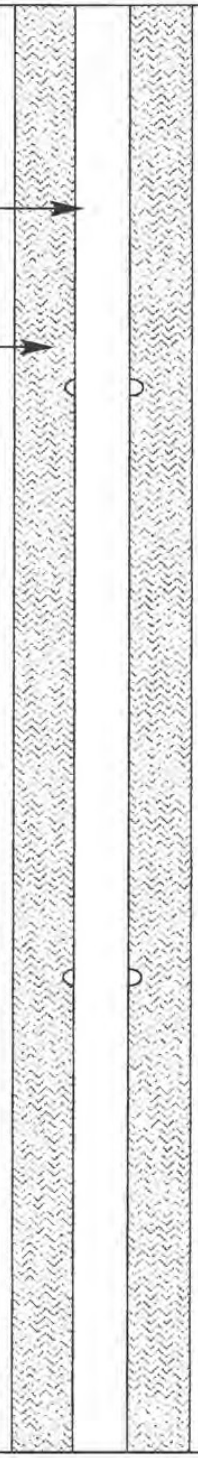
OR Doc Type:	WMU Code(s):

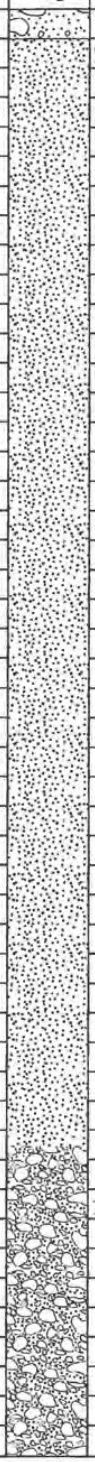
A-6003-643 (REV 2)

WELL SUMMARY CONTINUATION SHEET

Well ID: C9936 | Well Name: 699-46-61 | Project: 3 Monitoring Wells in 200-ZP-1 OU

CONSTRUCTION DATA		GEOLOGIC/HYDROLOGIC DATA		
Description	Diagram	Depth in Feet	Graphic Log	Lithologic Description (ft bgs)
4-in. I.D. Schedule 10, Type 304/304L, Stainless Steel Blank Casing: 2.25 ft ags - 293.94 ft bgs		70		70.0 - 145.0 Sand (S)
		80		
3/8-in. Medium Bentonite Chips: 10.8 - 289.6 ft bgs		90		
		100		
		110		
		120		
		130		
		140		
		150		145.0 - 190.0 Sandy Gravel (sG)
		160		





A-6006-992 (Rev 2)

WELL SUMMARY CONTINUATION SHEET

Well ID: C9936 | Well Name: 699-46-61 | Project: 3 Monitoring Wells in 200-ZP-1 OU

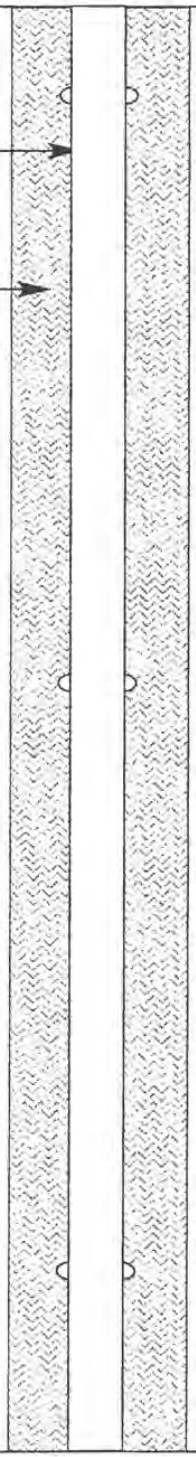
CONSTRUCTION DATA

Description

4-in. I.D. Schedule 10, Type 304/304L, Stainless Steel Blank Casing: 2.25 ft ags - 293.94 ft bgs

3/8-in. Medium Bentonite Chips: 10.8 - 289.6 ft bgs

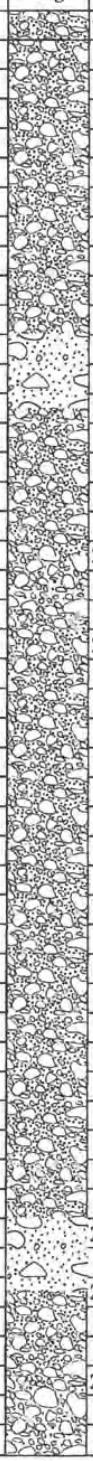
Diagram



GEOLOGIC/HYDROLOGIC DATA

Depth in Feet: 170, 180, 190, 200, 210, 220, 230, 240, 250, 260

Graphic Log



Lithologic Description (ft bgs)

145.0 - 190.0 Sandy Gravel (sG)

190.0 - 195.0 Gravelly Sand (gS)

195.0 - 205.0 Sandy Gravel (sG)

205.0 - 210.0 Gravel (G)

210.0 - 250.0 Sandy Gravel (sG)

250.0 - 255.0 Gravelly Sand (gS)

255.0 - 260.0 Sandy Gravel (sG)

260.0 - 280.0 Gravel (G)

A-6006-992 (Rev 2)

WELL SUMMARY CONTINUATION SHEET

Well ID: C9936 | Well Name: 699-46-61 | Project: 3 Monitoring Wells in 200-ZP-1 OU

CONSTRUCTION DATA

4-in. I.D. Schedule 10, Type 304/304L, Stainless Steel Blank Casing: 2.25 ft ags - 293.94 ft bgs

3/8-in. Medium Bentonite Chips: 10.8 - 289.6 ft bgs

1/4-in. Non-Coated Bentonite Pellet Seal: 289.6 - 290.6 ft bgs

4-in. I.D. Schedule 10, Type 304/304L, 20-slot Stainless Steel Screen: 293.94 - 314.24 ft bgs

12/20 mesh Silica Filter Pack Sand: 290.6 - 317.8 ft bgs

4-in. I.D. Schedule 10, Type 304/304L, Stainless Steel Sump: 314.24 - 317.22 ft bgs

1/4-in. Non-Coated Bentonite Pellet Seal: 317.8 - 320.9 ft bgs

3/8-in. Medium Bentonite Chips: 320.9 - 356.0 bgs

Straightness Test: Pass, 04/08/2019

Depths are in ft below ground surface.

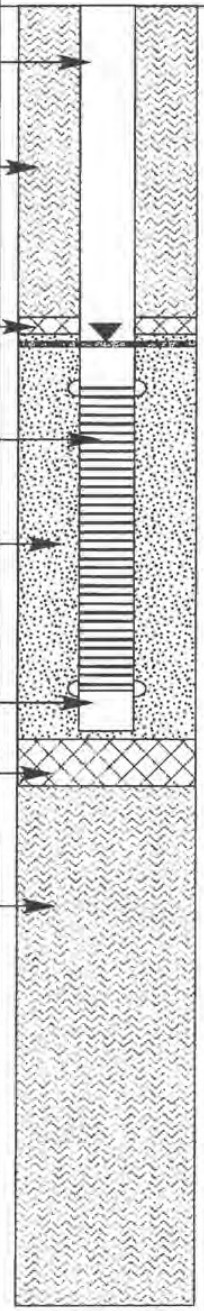
Borehole drilled with 11 3/4-in. O.D. casing from 0.0 - 151.0 ft bgs

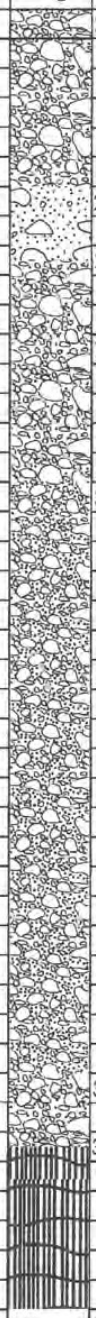
Borehole drilled with 9 5/8-in. O.D. casing from 151.0 - 341.1 ft bgs

Borehole drilled with 8 1/2-in. O.D. drill bit from 341.1 - 356.0 ft bgs

All temporary drill casing was removed from the ground.

GEOLOGIC/HYDROLOGIC DATA





Depth in Feet	Lithologic Description (ft bgs)
270	260.0 - 280.0 Gravel (G)
280	280.0 - 285.0 Gravelly Sand (gS)
	285.0 - 300.0 Gravel (G)
290	Depth to Water: 292.5 (4/25/19)
300	300.0 - 340.0 Sandy Gravel (sG)
310	
320	
330	
340	340.0 - 345.0 Gravel (G)
	345.0 - 356.0 Basalt
350	
	Total Depth: 356.0 (3/18/2019)
360	

A-6006-992 (Rev 2)

BOREHOLE LOG

Page 1 of 10
Date: 2-20-19

Well ID: C9936 | Well Name: C99-416-C1 | Location: 1400m NW of 2704 HV
Project: Installation of 3 Monitoring Wells in 200-ZP-1 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'-10': Sand (S) g=2% s=88% m=10% gravel: very fine pebbles, avg 2mm, max 3mm well sorted. maf: 75% ang. Sand: vf to v. coarse, mod sorted, 70% maf, 30% fel, ang silt: nonplastic. Dry ~~No rxn HCl~~ weak reaction HCl 2.5Y 4/4 Olive Brown. JW 2/20/19	Air Rotary Drilling with 11 3/4" OD / 10 5/8" ID temporary casing 0.0' – 151.0' bgs. 9 5/8" OD / 8 1/2" ID temp. casing 151.0' – ~~346~~ 341.1' bgs. NE 3-4-19 4 1/2" OD drill rod & 8" OD hammer bit. Grab samples collected every 5' or change in lithology.
5	G			
10	G		10'-15': sandy Gravel (sG) g=45% s=50% m=5%. Gravel: vfine to coarse pebbles, avg 8mm max 20mm, mod sort, 95% maf 5% fel, ang-sub ang. Sand: v fine - v. coarse, mod sort, 75% maf, 25% fel silt: nonplastic, Dry No rxn HCl, 2.5Y 5/3 Light Olive Brown.	0'-20' drill with 10 5/8" OD tri-cone bit.
15	G		15-20': gravelly Sand (gS) g=27% s=70% m=3% Gravel: v fine - coarse peb, avg 15-20mm, max 32mm poor sort, 80% maf 20% fel, ang to sub round. v. occ round Sand: vf to v. coarse, mod sort, 75% maf, 25% fel subang. Dry No rxn HCl 2.5Y 5/3 Light Olive Brown	
20	G		20'-30': sandy Gravel (sG) g=45%, s=52%, m=3%. Gravel: vfine to vcoarse pebbles, avg. 15-20mm, max 35mm, mod sorted, 80% maf, 20% fel, angular to sub-rounded. Sand: vfine to vcoarse, well-sorted, 75% maf 25% fel, angular, dry, no rxn to HCl, 2.5Y 5/3 light olive brown.	20'-39' drill with 12" OD underreamer
25	G		@ 25' g ↑ to 50% s ↓ to 50% m=trace 30'-40': Gravel (G) g=80% s=20% m=T Gravel: vfine - vcoarse pebble, avg. 10mm, max. 40mm, mod sort, 10% fel, 90% maf, ang. to sub-ang. Sand: coarse - vcoarse, well-sort, 25% fel, 75% maf, angular, dry, no rxn HCl, 2.5Y 5/3 light olive brown	
30	G			

Reported By: Nicole Combs / Tracy Mallgren — Geologist — 4-26-19
Print Name — Title — Signature — Date

Reviewed By: Sarah Springer — Sr. Geologist — 25-08-19
Print Name — Title — Signature — Date

For Office Use Only
OR Doc Type: | WMU Code(s):

A-6003-642 (REV 1)

BOREHOLE LOG (Cont.)

Page 2 of 10

Date: 2-21-19

Well ID: C9936 | Well Name: 699-46-61 | Location: 1400m NW of 2704 HV

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
35	G		30-40': Gravel (G): g=80%. s=20%. m=T, Gravel: vfine - vcoarse pebble, avg. 10mm, max. 40mm, mod-sort, 10% fel, 90% maf, ang.- sub-ang. Sand: coarse - vcoarse, well-sort, 25% fel, 75% maf, ang., dry, no rxn HCl, 2.5Y 5/3 light olive brown.	Air Rotary Drilling with 11 3/4" OD / 10 5/8" ID temp. casing 0.0' - 151.0' bgs. 9 5/8" OD / 8 1/2" ID temp. casing 151.0' - 341.1' bgs. 4 1/2" OD drill rod & 8" OD hammer bit. Grab samples every 5' or change in lithology.
40	G		40-45': Sand (S) g=5%. s=90%. m=5%. Gravel: vfine - fine pebble, avg. 4mm, well-sorted, 25% fel. 75% maf, ang. Sand: vfine to vcoarse, avg. coarse, well-sort, 75% maf 25% fel, ang., dry, no rxn to HCl, 2.5Y 4/3 olive brown	39' - 345' tricone 8 1/2" OD
45	G		45-65': sandy Gravel (sG) g=30%. s=70%. m=T. Gravel: vfine - vcoarse pebble, avg. 5mm max. 40mm, poor sort, 10% fel, 90% maf., ang- sub-round, Sand: vfine - vcoarse, avg. coarse, well-sort, 25% fel, 75% maf., ang., dry, no rxn HCl, 2.5Y 5/3 light olive brown.	
50	G			
55	G			
60	G		@60ft, g↑ to 60%, s↓ to 40%, m=T. Gravel avg.↑ to 10mm, mod. sorted.	
65	G		65'-70': gravelly Sand (gS) g=10%. s=90%. m=T. Gravel: vfine - vcoarse pebble, avg. 10mm max. 35mm, poor sort, 50% fel, 50% maf, ang. - sub-ang, Sand: fine - vcoarse, avg. coarse, well-sort, 50% fel., 50% maf, ang.- sub-ang., dry, no rxn HCl, 2.5Y 5/4, light olive brown	
70	G		70' - 145': Sand (S) g=5%, s=95%, m=T. Description on page 3	

NC 2-22-19

Reported By:

Print Name	Title	Signature	Date
Nicole Combs	Geologist	[signature]	4-26-19

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Page 3 of 10

Date: 2-22-19

Well ID: C9936 | Well Name: 699-46-61 | Location: 1400m NW of 2704 HV

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
75	G		70'-145': Sand (S): g=5% s=95% m=T. Gravel: vfine-vcoarse pebble, avg. 10mm, max. 35mm, poor sort, 50% fel., 50% maf., angular-sub-ang., Sand: fine-vcoarse, avg. coarse, well-sort, 50% fel., 50% maf., ang-sub-angular, dry, no rxn HCl, 2.5Y 5/4 light olive brown.	Air Rotary Drilling with 11 3/4" OD 10 5/8" ID temp. casing 0.0'-151.0'. 9 5/8" OD 8 1/2" ID temp casing 151.0'-341.1' bgs. 4 1/2" OD drill rod & 8" OD hammer bit. Grab sample collected every 5' or change in lithology
80	G			
85	G		@85' very slight ↑ in medium pebble	
90	G			
95	G		@95' gravel = vfine-fine pebble, occ. medium pebble, avg. ↓ to 5mm, max. ↓ to ~~m~~ NC 2-22-19 10mm, mod-sort. Sand = fel. ↑ to 70%, maf ↓ to 30%.	
100	G			
105	G			
110	G			

Reported By:

Print Name	Title	Signature	Date
Nicole Combs	Geologist	[signature]	4-26-19

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Page 4 of 10

Date: 3-01-19

Well ID: C9936 | Well Name: 699-46-61 | Location: 1400m NW of 2704 HV

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
115	G		70'-145': Sand (S): g=5%. s=95%. m=T. Gravel: vfine-medium pebble, avg. 8mm, max. 10mm, moderate sort, 50% fel, 50% maf, sub-ang. to sub-round, Sand: vfine-vcoarse, avg. coarse, mod-sort, 50% fel, 50% maf, angular to sub-ang., moist, no rxn HCl, 2.5Y 5/4 light olive brown.	Air Rotary Drilling with 11 3/4" OD / 10 5/8" ID temp. casing 0.0'-151.0' bgs. 9 5/8" OD / 8 1/2" ID temp casing 151.0'-341.1' bgs. 4 1/2" OD drill rod & 8" OD hammer bit. Grab sample every 5' or change in lithology.
120	G			
125	G			
130	G		@130', g↓ 2%., s↑ to 98%., m=T. Gravel avg. ↓ to 3mm, max. ↓ 5mm, well sorted.	
135	G			
140	G		@140' g↑ to 5%., s↓ to 95%., m=T.	
145	G		145'-190': sandy Gravel (sG): g=60%. s=40%., m=T. Gravel: vfine-medium pebble, avg. 3mm, max. 9mm, mod. sort, 40% fel, 60% maf., ang. to sub-ang., Sand: vfine-vcoarse, avg. coarse, mod. sort, 50% fel, 50% maf, ang. to sub-ang., moist, no rxn HCl, 2.5Y 4/2 dark grayish brown.	
150	G			

Reported By:

Print Name	Title	Signature	Date
Nicole Combs	Geologist	[signature]	4-26-19

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Page 5 of 10

Date: 3-08-19

Well ID: C9936 | Well Name: 699-46-61 | Location: 1400m NW of 2704 HV

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
155	G		145'-190': sandy Gravel (sG) @155' g=60% s=40% m=T. Gravel: VF-coarse peb, avg. 3mm, max 25mm, mod sort, 40% fel 60% maf, sub-ang. to sub-round. Sand: VF-VC, well sort, 50% fel, 50% maf, ang. to sub-ang., dry, no rxn HCl, 2.5Y 4/2 dark grayish brown.	Air Rotary Drilling with 11 3/4" OD / 10 5/8" ID temp casing 0.0'-151.0' bgs. 9 5/8" OD / 8 1/2" ID temp casing 151.0'-341.1' bgs. 4 1/2" OD drill rod & 8" OD hammer bit. Grab sample 5' or change in lithology.
160	G		@160' gravel: max ↑ to 30mm	
165	G		@165' g=40% s=60% m=T, sandy Gravel (sG) ang. to sub-ang.	
170	G			
175	G		@175' gravel: max ↓ 20mm, sub-ang.	
180	G		@180' gravel: avg. ↑ 4mm, max ↓ 15mm, sub-ang. to sub-round	
185	G			
190 ~~195~~ NC 3-8-19	G		190'-195': gravelly Sand (gS) g=15% s=80% m=~~7~~ 5% NC 3-8-19. Gravel: VF-coarse peb, avg. 4mm, max 11mm well sort, 50% fel, 50% maf, ang-sub-ang. Sand: VF-VC, well sort, 50% fel, 50% maf, ang. to sub-ang., dry, no rxn to HCl, 2.5Y 4/2 dark grayish brown.	
			NC 3-8-19	

Reported By:

Print Name	Title	Signature	Date
Nicole Combs	Geologist	[signature]	4-26-19

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

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Date: 3-08-19

Well ID: C9936 | Well Name: 699-46-61 | Location: 1400m NW of 2704 HV

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
195	G		195'-205': Sandy Gravel (sG) g=70% s=25% ~~m=1~~ NC 3-8-19 m=5% Gravel: VF-coarse peb, avg. 6mm, max 11mm, ~~poort~~ NC 3-8-19 poor sort, 40% fel, 60% maf, sub-ang to round, avg. sub-ang. Sand: VF-VC, well sort, 50% fel 50% maf, ang to sub-ang. dry, no rxn to HCl, 2.5Y 4/2 dark grayish brown.	Air Rotary Drilling with 11 3/4" OD / 10 5/8" ID temp. casing 0.0'-151.0' bgs. 9 5/8" OD / 8 1/2" ID temp. casing 151.0'-341.1' bgs. 4 1/2" OD drill rod & 8" OD hammer bit. Grab sample 5' or change in lithology.
200	G		@200' gravel ↓ VF-med. peb, avg ↓ to 4mm, max ↓ 7mm, well sort, ang-sub-ang sand weak rxn to HCl	
205	G		205'-210': Gravel (G) g=90% s=8% m=2% gravel: VF-VC, avg. coarse peb, avg. 9mm, max 20mm mod sort, 40% fel 60% maf, sub-ang to sub-rnd. Sand: VF-VC, well sort, 50% fel 50% maf, ang to sub-ang. dry, no rxn HCl, 2.5Y 4/2 dark grayish brown.	
210	G		210'-250': Sandy Gravel (sG) g=75% s=25% m=5% gravel: VF-coarse peb, avg. fine peb, avg. 4mm, max 11mm, well sort, 40% fel, 60% maf, sub-ang to sub-round. Sand: VF-VC, avg. coarse, well sort, 50% fel, 50% maf, ang to sub-ang, wet, no rxn HCl, 2.5Y 4/2 dark grayish brown.	
215	G			
220	G			
225	G		@225' g=75% s=23% m=2% gravel: avg ↑ to 6mm, max ↑ 18mm. sand: dry	
230	G		@230' ~~↑ felsic, ↓ mafic: 60% fel, 40% maf~~ NC 3-8-19 gravel ↑ 60% fel, ↓ to 40% maf	

Reported By:

Nicole Combs	Geologist		4-26-19
Print Name	Title	Signature	Date

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

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Date: 3-12-19

Well ID: C9936 | Well Name: 4 699-46-61 NC 3-12-19 | Location: 1400m NW of 2704 HV

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
235	G		210'-250': Sandy Gravel (SG) @235' g=40% s=60% m=T, gravel: VF-med peb, avg. 5mm, max 15mm, mod sort, 30% fel, 70% maf, sub-ang to sub-round. Sand: VF-VC, well sort, 50% fel, 50% maf, ang-sub-ang, moist, weak rxn HCl, 2.5Y 4/2 dark grayish brown.	Air Rotary Drilling with 11 3/4" OD / 10 5/8" ID temp. casing 0.0'-151.0' bgs. 9 5/8" OD / 8 1/2" ID temp casing 151.0'-341.1' bgs. 4 1/2" OD drill rod & 8" OD hammer bit. Grab sample 5' or change in lithology
240	G		@240' g=75% ~~s=25% m=5%~~ s=23% m=2% NC 5-3-19 gravel ↑ 70% fel ↓ 30% maf, ang-sub-ang. sand: dry, no rxn HCl	
245	G		@245' gravel: VF-VC peb, avg ↑ 6mm, max ↑ 25mm, ↓ 60% fel, ↑ 40% maf, ang. sand: moist	
250	G		250'-255': gravelly Sand (gS): g=10% s=80% m=10% gravel: VF-coarse peb, avg. 5mm, max 21mm, poor sort, 60% fel, 40% maf, ang-sub-ang. Sand: VF-VC, well sort, 50% fel, 50% maf, ang-sub-ang, moist, no rxn HCl, 2.5Y 4/3 olive brown.	
255	G		255'-260': Sandy Gravel (sG): g=50% s=45% m=5% gravel: VF-coarse peb, avg. 4mm, max 20mm, mod sort, 60% fel, 40% maf, ang to sub-ang. Sand: VF-VC, avg. 1mm well sort, 50% fel, 50% maf, ang-sub-ang, moist, no rxn HCl, 2.5Y 4/2 dark grayish brown.	
260	G		260'-280': Gravel (G): g=80% s=20% m=T. gravel: VF-fine, avg. 4mm, max 8mm, well sort, 60% fel, 40% maf, ang. Sand: VF-VC, avg. 1mm, well sort, 50% fel, 50% maf, ang-sub-ang, moist, no rxn HCl, 2.5Y 4/2 dark grayish brown.	
265	G		@265' Gravel (G): g ↑ 90% s ↓ 10% m=T. gravel: VF-coarse peb, max ↑ 20mm, mod sort, 70% fel, 30% maf, ang-sub-ang.	
270	G		@270' Gravel (G): max ↓ 11mm, well sort, 60% fel, 40% maf.	

Reported By:

Print Name	Title	Signature	Date
Nicole Combs	Geologist		4-26-19

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Page 8 of 10

Date: 3-12-19

Well ID: C9936 | Well Name: 699-46-61 | Location: 1400m NW of 2704 HV

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
275	G		260'-280': Gravel (G)	Air Rotary Drilling with 11 3/4" OD / 10 5/8" ID temp casing 0.0'-151.0' bgs. 9 5/8" OD / 8 1/2" ID temp casing 151.0'-341.1' bgs. 4 1/2" OD drill rod & 8" OD hammer bit. Grab sample 5' or change in lithology.
			@275' g=85% s=10% m=5%. gravel: VF-coarse peb, avg. med 12mm, max 25mm, med sort, 50% fel, 50% maf, sub-ang to sub-rnd. sand=VF-VC, avg 1mm, well sort, 50% fel, 50% maf, ang-sub-ang, dry,	
280	G		no rxn HCl, 2.5Y 5/3 light olive brown.	
			280'-285': gravelly Sand (gS) g=10% s=90% m=T. gravel: VF-coarse, avg. 7mm, max 15mm, well sort, 70% fel, 30% maf, ang- to sub-ang. Sand=VF-VC, well sort, 60% fel, 40% maf, ang-sub-ang, dry, no	
285	G		rxn HCl, 2.5Y 6/2 light brownish gray.	
			285'-300': Gravel (G): g=90% s=10% m=T gravel: VF-coarse, avg. 6mm, max 23mm, well sort, 60% fel, 40% maf, ang to sub-ang. Sand: VF-VC, well sort, 60% fel, 40% mafic, ang-sub-ang, ~~dry~~ moist NC 3-12-19, no rxn HCl,	
290	G		2.5Y 6/2 light brownish gray.	
			@290' sand: wet	
295	G		@295' Gravel (G) g=95% s=5% m=T. avg ↑ 13mm, max ↑ 28mm, mod sort, 50% fel, 50% maf, ang-sub-rnd.	
			300' - ~~335~~ 340' NC 3-12-19: sandy Gravel (SG) g=30% s=70%	Water sample: I-001 at 301.4' bgs.
300	G		m=T. gravel: ~~avg~~ NC 3-12-19 VF-coarse peb, avg. 7mm, max	Water Sample: Post Develop, at 302.7' bgs
	WS WS		20mm, mod sort, 60% fel, 40% maf, ang to sub-ang. sand=VF-VC, well sort, 60% fel, 40% maf, ang-	
			sub-ang, moist, no rxn HCl, 2.5Y 4/3 olive brown,	
305	G		mica present	
			@305' sandy Gravel (SG) g↑75% s↓20% m↑5% gravel: avg↑10mm, ang. sand: avg. fine, mod sort,	
			ang., wet.	
310	G		@310' sandy Gravel (SG) g↓40% s↑60% m↓T.	
			NC 3-12-19 ~~↓40%~~ gravel: ↓40% fel, ↑60% maf, ang to sub-ang	
			sand: avg. coarse, moist	
			NC 3-12-19	

Reported By:

Print Name	Title	Signature	Date
Nicole Combs	Geologist	[signature]	4-26-19

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Page 9 of 10

Date: 3-12-19

Well ID: C9936 | Well Name: 699-46-61 | Location: 1400m NW of 2704 HV

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
315	G		340' NC 3-18-19 300' - 335' : Sandy Gravel (SG): @315' g=30% s=70% m=T. gravel: VF-med. peb. avg. 1 mm, max. 10mm, mod sort, 40% fel, 60% maf, sub-ang. sand: VF, well sort, 60% fel, 40% maf, ang. to sub-ang, moist, no rxn HCl, 2.5Y 4/3 olive br.	Air Rotary Drilling with 11 3/4" OD / 10 5/8" ID temp. casing 0.0' - 151.0' bgs. 9 5/8" OD / 8 1/2" ID temp casing 151.0' - 341.1' bgs. 4 1/2" OD drill rod & 8" OD hammer bit. Grab sample 5' or change in lithology.
320	G		@320' g↑40% s↓60% m=T. gravel: VF-VC, avg↑ 5mm, max↑20mm, subrnd. sand: VF-VC, mod sort, sub-ang.	
	WS			Water sample I-002 @ 322.0' bgs
325	G			
330	G		@330' sandy Gravel (SG): g↑70% s↓25% m↑5% gravel: VF-VC, avg↑11mm, max↑40mm ↑60% fel, ↓40% maf, sub-ang to subrnd. sand: ↓50% fel, ↑50% maf, ang to subang., wet, 2.5Y 3/3 dark olive brown	
335	G		@335' gravel: VF-Coarse peb, avg.↓ 6mm, max ↓20mm, ↓50% fel, ↑50% maf, ang.-rnd. sand: avg↑ coarse,	
340	G		340-345' Gravel (G): g=85% s=15% m=T. gravel: VF-VC, avg. 10mm, max. 50mm, poor sort, 50% fel, 50% maf, ang.-rnd. sand: F-VC, avg. VC, well sort, 50% fel, 50% maf, ang-subang., wet, no rxn HCl, maf. in gravel are basalt, 2.5Y 4/2 dark grayish br.	
	WS			Water sample I-003 @ 341.1' bgs
345	G		345' - 356' : Basalt. 99% basalt, 1% felsics, no apparent weathering 4mm - 30mm, ang., no rxn HCl, 2.5Y 2.5/1 black, wet	345'-356' 8" OD hammer bit
350	G			

Reported By:

Nicole Combs	Geologist	[signature]	4-26-19
Print Name	Title	Signature	Date

A-6006-993 (REV 0)

BOREHOLE LOG (Cont.)

Page 10 of 10

Date: 3-19-19

Well ID: C9936 | Well Name: 699-46-61 | Location: 1400m NW of 2704 HV

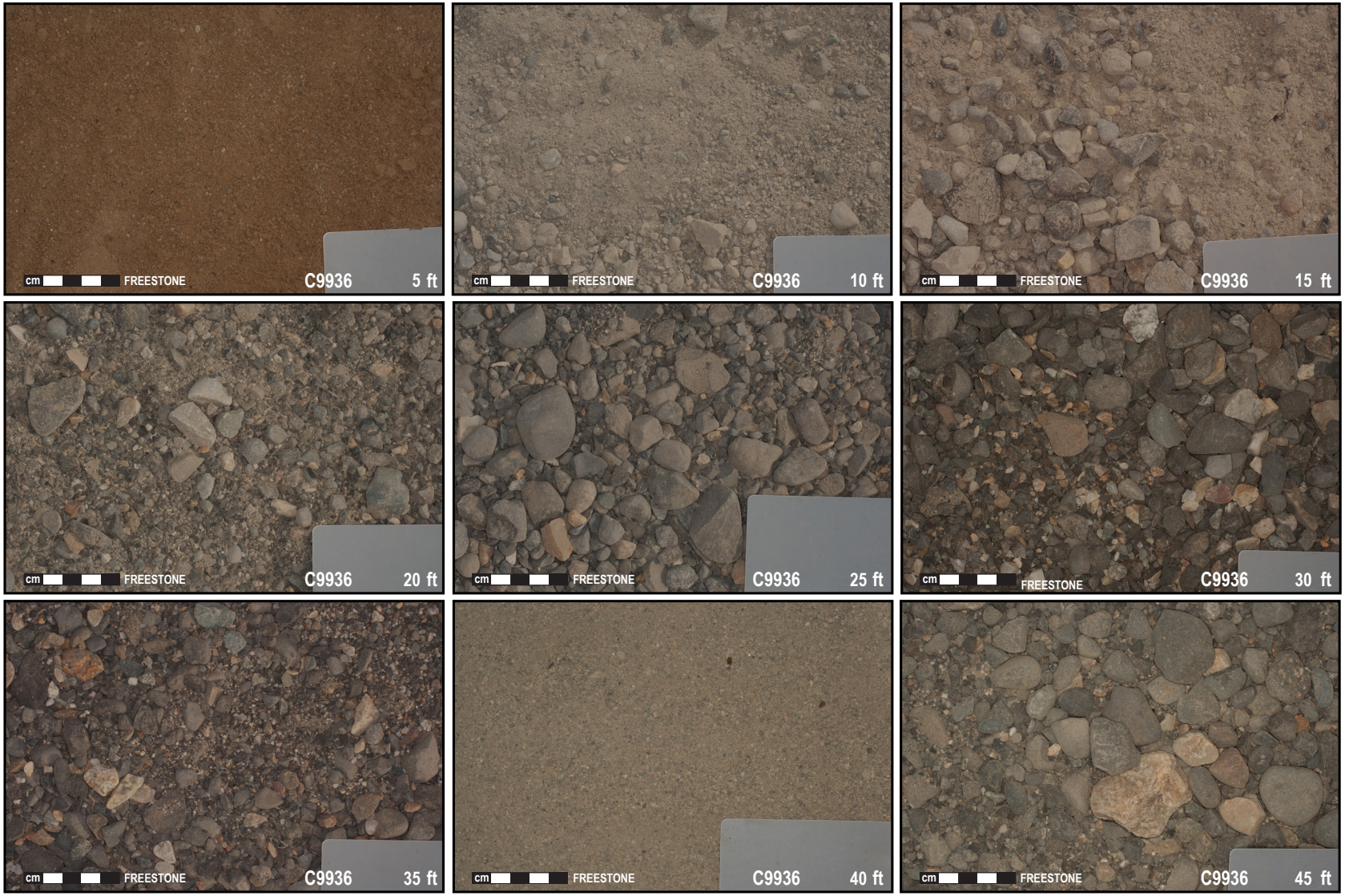
Depth (ft)	Sample	Graphic Log	Sample Description: Sediment Classification, Grain Size Distribution, Color, Moisture Content, Sorting, Angularity, Mineralogy, Particle Size, Reaction to HCl, Other	Comments: Depth of Casing, Drilling Method, Sampling Method, Sampler Size, Water Level, Other
355			345'-356' Basalt	Air Rotary Drilling with 11 3/4" OD / 10 5/8" ID temp casing 0.0'-151.0' bgs. 9 5/8" OD / 8 1/2" ID temp. casing 151.0'-341.1' bgs. 4 1/2" OD drill rod & 8" OD hammer bit. Grab sample 5' or every change in lithology.
356	G		99% basalt, 1% felsics, no apparent weathering, 4mm-30mm, ang., wet, no rxn HCl, 2.5Y 2.5/1 Black	
				TD: 356.0'
				Depth to water: 292.49'

NC 3.19.19 NOT USED.

Reported By:

Print Name	Title	Signature	Date
Nicole Combs	Geologist	[signature]	4-26-19

A-6006-993 (REV 0)



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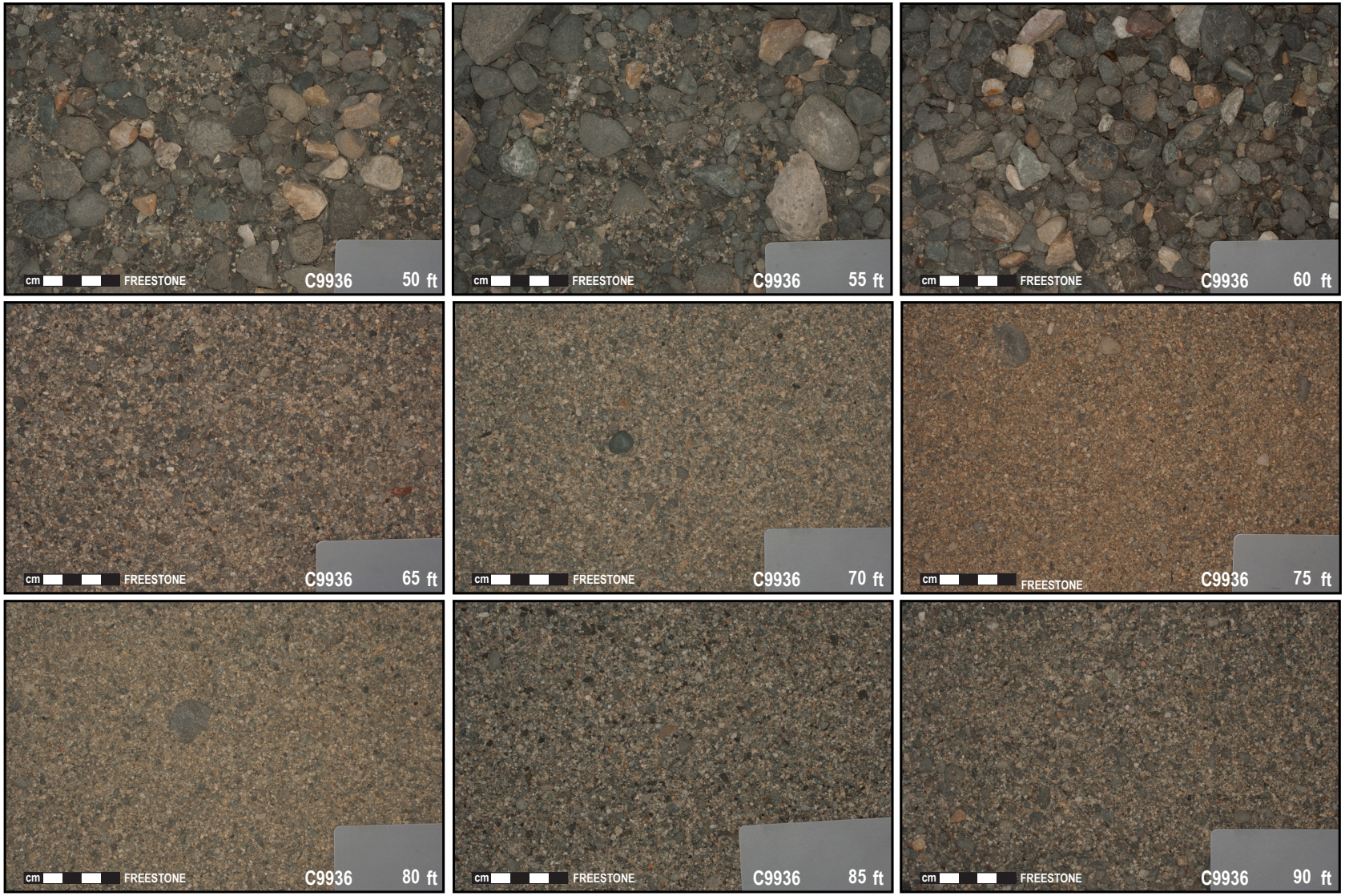
Drill Cutting Photographs for C9936 (699-46-61)



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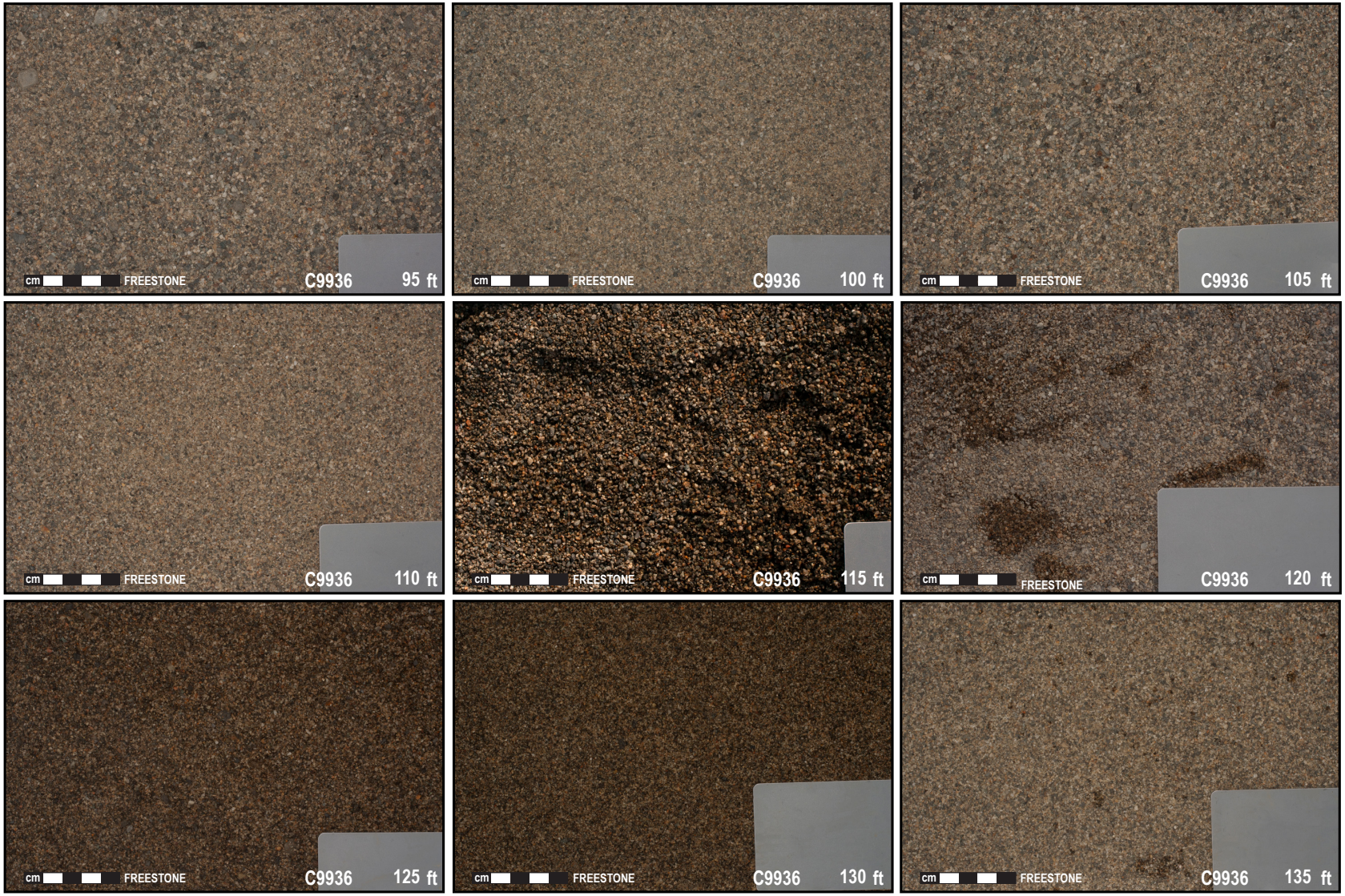
Drill Cutting Photographs for C9936 (699-46-61)



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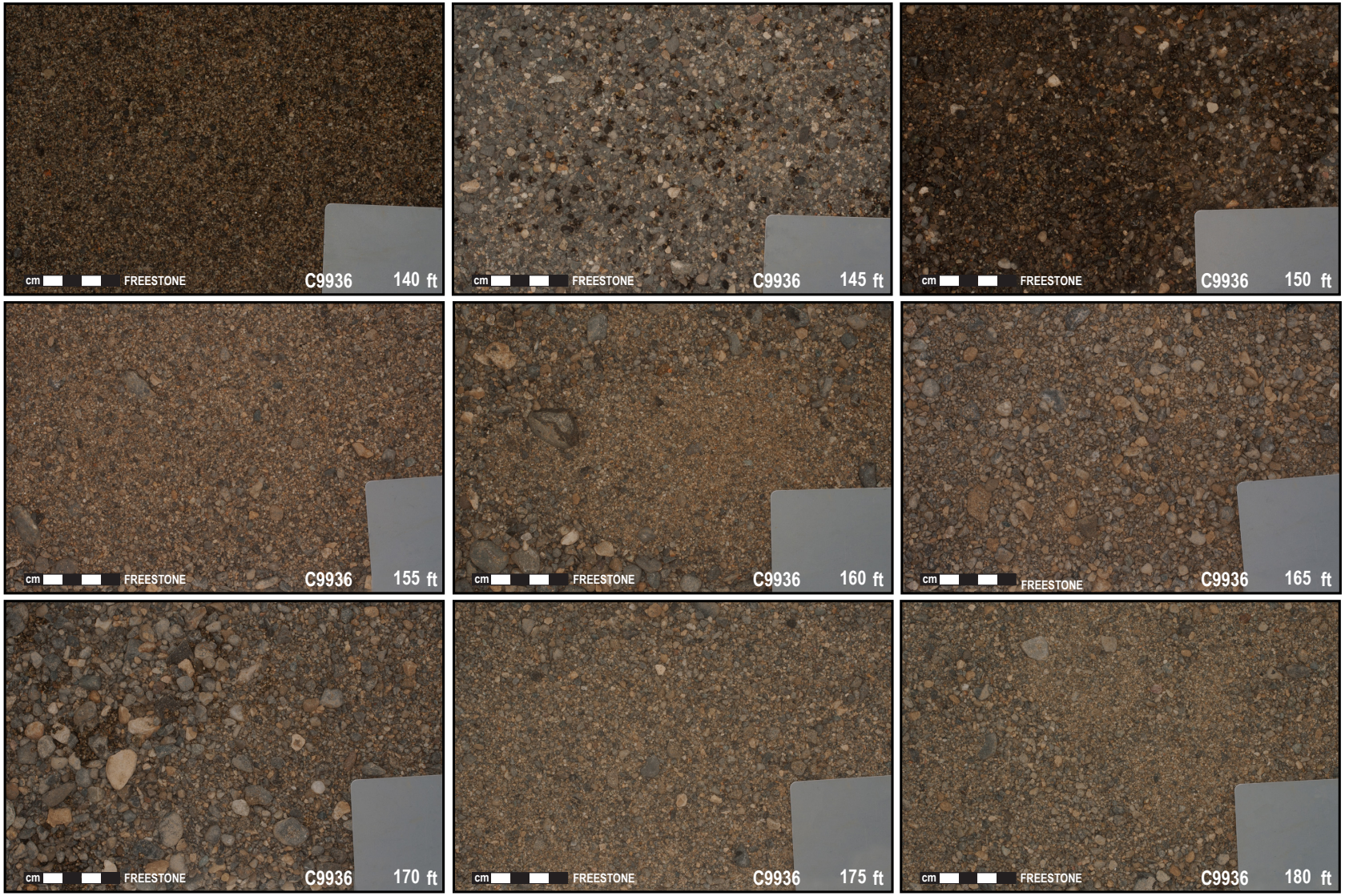
Drill Cutting Photographs for C9936 (699-46-61)



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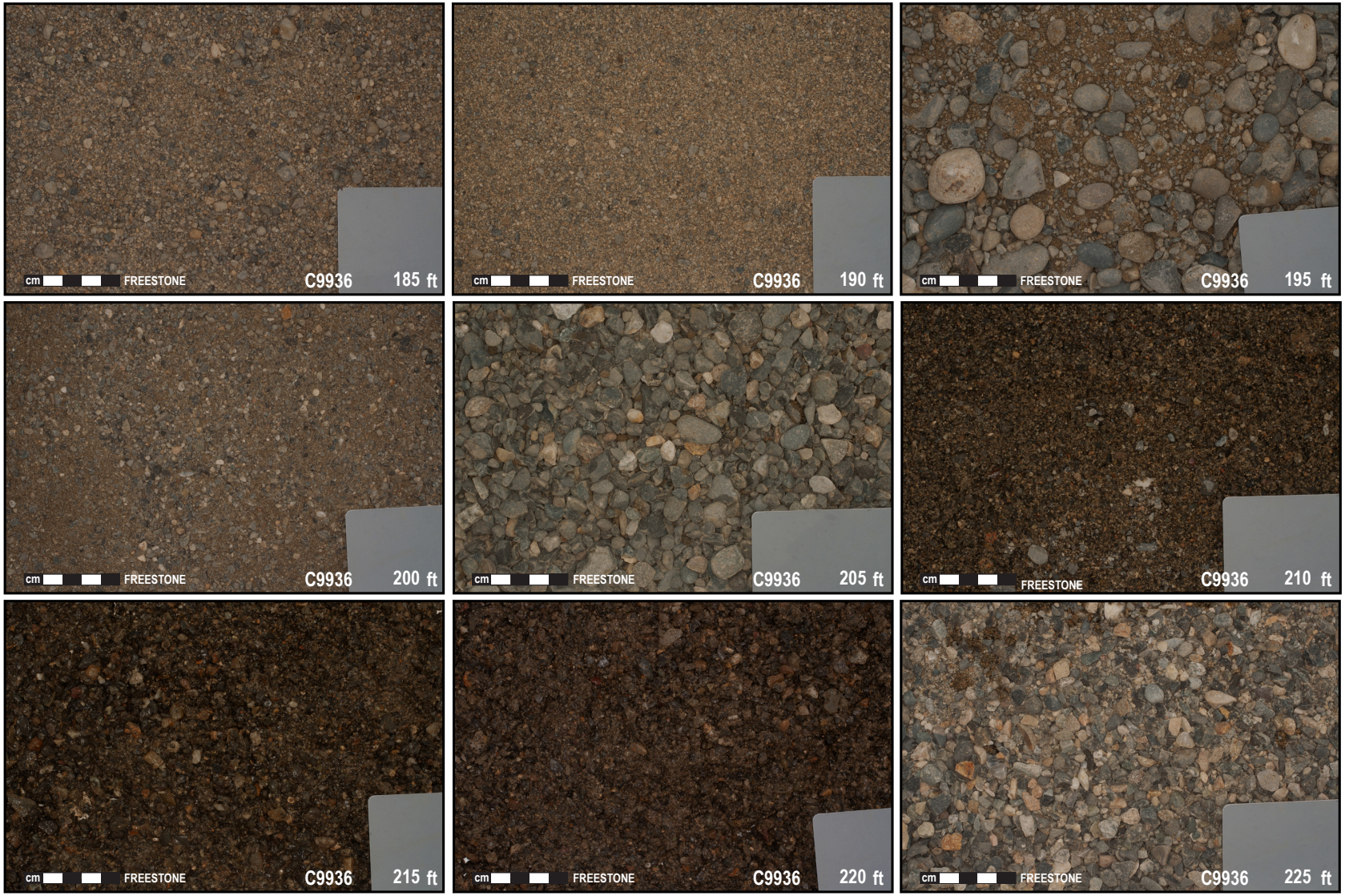
Drill Cutting Photographs for C9936 (699-46-61)



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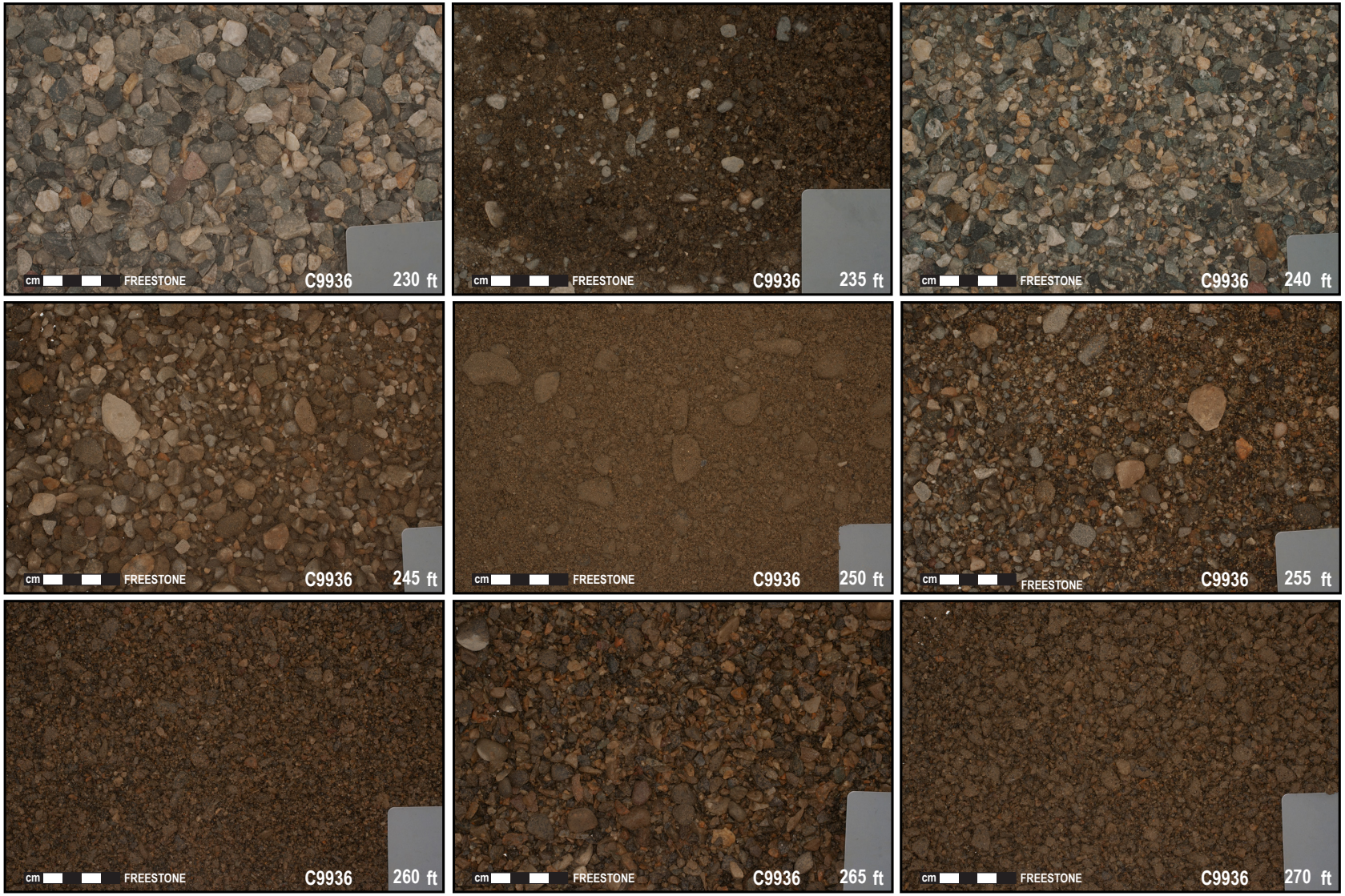
Drill Cutting Photographs for C9936 (699-46-61)



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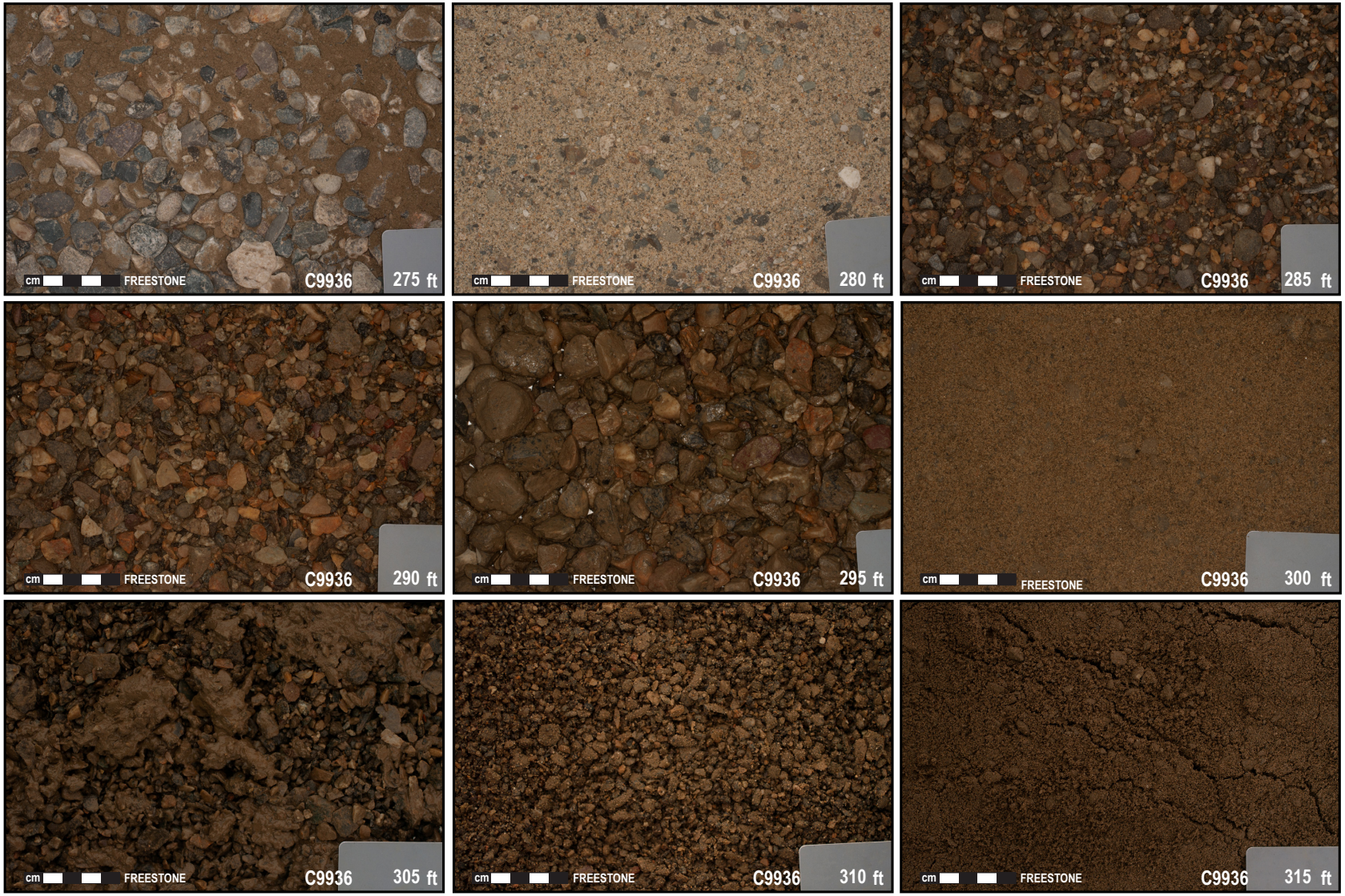
Drill Cutting Photographs for C9936 (699-46-61)



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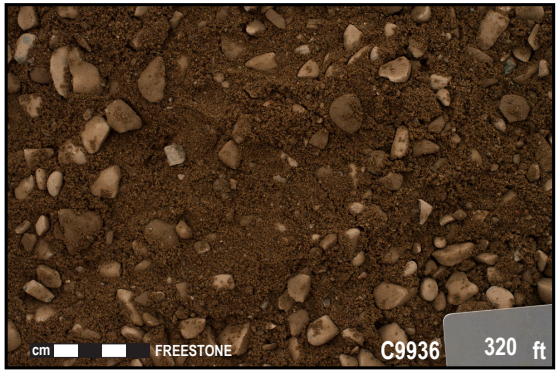
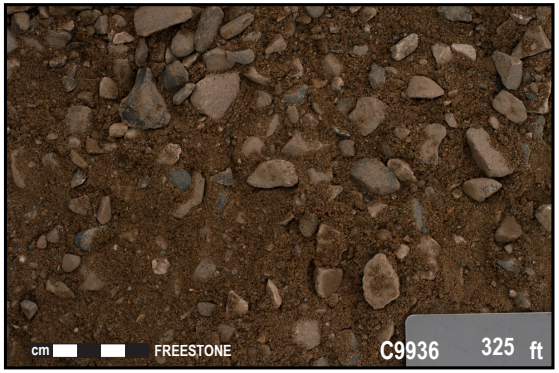
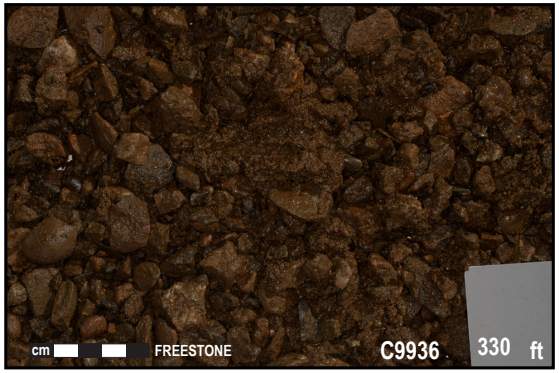
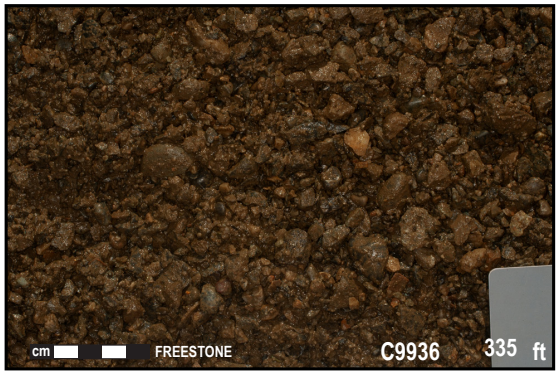
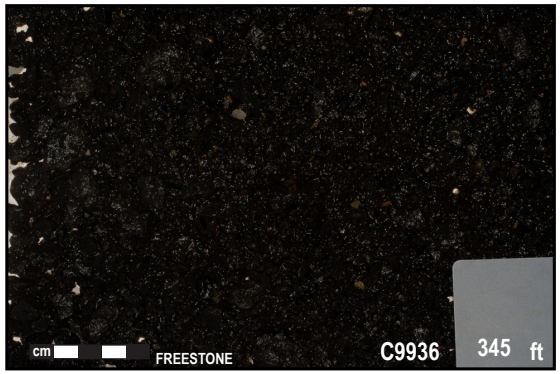
Drill Cutting Photographs for C9936 (699-46-61)

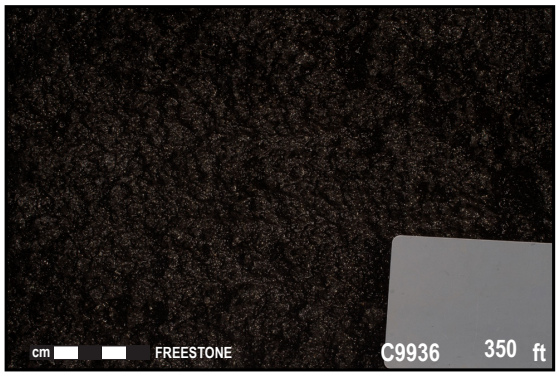


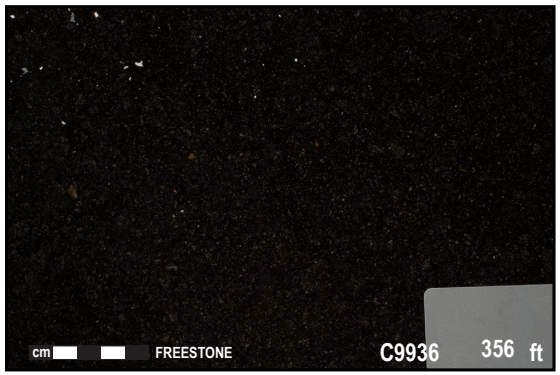












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Drill Cutting Photographs for C9936 (699-46-61)

WELL DEVELOPMENT AND TESTING DATA

Well ID: C9936 | Well Name: 699-46-61 | Date: 4-26-19

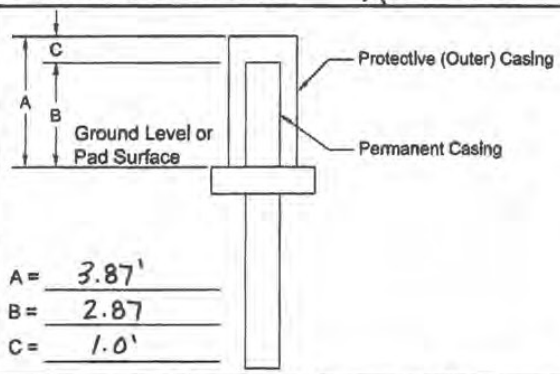
Location: 1400m NW of 2704HV

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: 4-25-19	292.49' bgs	292.69' bgs
Date: N/A	N/A	N/A
DEPTH TO BOTTOM:		
Date: 4-25-19	313.64' bgs	313.64' bgs
Date: N/A	N/A	N/A



A = 3.87'
B = 2.87
C = 1.0'

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)
302.73	6.6	301.53	77.60	16.70	0726	0911 *	13.6	2.06
302.73	3.7	301.53	6.65	3.79	0911	0953	6.4	1.73
302.73	8.5	301.53	N/A	N/A	1041	1057	14.6	1.71
					N/A			
					JLR 5/20/19			

Total Pumped: 1930.4 gal

Pump Model: Grundfos B/E P2 1711

Troll Serial Number and Pressure Range (PSI and depth): 54678 – 210m/692ft, vented

Comments:
* Pump was not turned off at 0911 → flow rate was reduced from 13.6gpm to 6.4gpm @ 0911 during pumping & was shut off @ 0953.
Logs: C9936_develop_int#1_4-25-19
C9936_stresstest_4-25-19

Prepared By:

Nicole Combs (Print Name) | [signature] (Signature) | 4-26-19 (Date)

Reviewed By:

Jennifer Richart (Print Name) | [signature] (Signature) | 5/20/19 (Date)

For Office Use Only

OR Doc Type: | WMU Code(s):

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699-46-61 (C9936)
Log Data Report

Borehole Information

Log Date	2019-03-21	Filename	C9936_HG-NM_2019-03-21	Site	200-ZP-1
DTW[1] (ft)	**DTW Date**	**DTW Source**	**Drill Date**	**Total Depth (ft)**	**Depth Datum**
291.3	03/18/19	Freestone	03/18/19	356	Ground Surface

Casing Information

Casing Type	Drill Type	Stickup (ft)	Diameter (in.) Outer	Diameter (in.) Inside	Thickness (in.)	Top (ft)	Bottom (ft)
Threaded Steel	Air Rotary	TC[2]	11.87	10.75	0.56	0.0 AGS[3]	152
Threaded Steel	Air Rotary	TC	9.71	8.85	0.43	4.67 AGS	341.1

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. Maximum logging depth achieved was 342 ft, approximately 1 ft above the reported casing depth. The geologist reports drillers encountering basalt at approximately 339 ft and setting casing two ft into the basalt. The remainder of the borehole was drilled without casing which was not logged. Zero reference is ground surface.

Logging Equipment Information

Logging System	Gamma 4NC	Type	60% Coaxial HPGe (SGLS) [4]
Effective Calibration Date	12/19/2018	**Serial No.**	45-TP22010A
Calibration Reference	HGLP-CC-178, Rev. 0	**Logging Procedure**	SGRP-PRO-OP-53023, Rev. 0, Change 2

Logging System	Gamma 5PB	Type	He-3 (CPN 503DR) NMLS [5]
Effective Calibration Date	12/12/2018	**Serial No.**	H34055445
Calibration Reference	HGLP-CC-177, Rev. 0	**Logging Procedure**	SGRP-PRO-OP-53024, Rev. 0, Change 2

Logging System	Gamma 4MC	Type	He-3 (CPN 503DR) NMLS
Effective Calibration Date	12/20/2018	**Serial No.**	H340207279
Calibration Reference	HGLP-CC-179, Rev. 0	**Logging Procedure**	SGRP-PRO-OP-53024, Rev. 0, Change 2

SGLS Log Run Information

Log Run	1	2	3 Repeat	6
HEIS Number	1021043	1021044	1021045	1021046
Date	02/27/19	02/27/19	02/27/19	03/20/19

[1] depth to water inside casing
[2] Temporary casing
[3] Above ground surface
[4] Spectral Gamma Logging System
[5] Neutron Moisture Logging System

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Log Run	1	2	3 Repeat	6
Logging Engineer	Spatz/Meisner/McClellan	Spatz/Meisner/McClellan	Spatz/Meisner/McClellan	Spatz
Start Depth (ft)	0.0	70.0	55.0	148.01
Finish Depth (ft)	70.01	149.04	75.0	325.0
Count Time (sec)	100	100	100	100
Live/Real	R	R	R	R
Shield (Y/N)	N	N	N	N
MSA Interval (ft)	1.0	1.0	1.0	1.0
Log Speed (ft/min)	NA	NA	NA	NA
Pre-Verification	C9936DNC20190227AV00CAB1	C9936DNC20190227AV00CAB1	C9936DNC20190227AV00CAB1	C9936DNC20190320AV00CAB1
Start File	AD000000	BD007000	CD005500	AD014801
Finish File	AD007001	BD014904	CD007500	AD032500
Post-Verification	C9936DNC20190227CV00CAA1	C9936DNC20190227CV00CAA1	C9936DNC20190227CV00CAA1	C9936DNC20190320AV00CAA1
Depth Return Error (in.)	11.5 high	N/A	1.0 low	2.0 low
Comments	Temperature in teens affected depth control	Brought sonde to surface and re-established zero reference	No fine gain adjustments made	No fine gain adjustments made

Log Run	7	8 Repeat		
HEIS Number	1021047	1021048		
Date	03/21/19	03/21/19		
Logging Engineer	Spatz	Spatz		
Start Depth (ft)	324.0	280.0		
Finish Depth (ft)	342.01	300.01		
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	C9936DNC20190321BV00CAB1	C9936DNC20190321BV00CAB1		
Start File	BD032400	CD028000		
Finish File	BD034201	CD030001		
Post-Verification	C9936DNC20190321CV00CAA1	C9936DNC20190321CV00CAA1		
Depth Return Error (in.)	N/A	2.0 low		
Comments	No fine gain adjustments made	No fine gain adjustments made		

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NMLS Log Run Information

Log Run	4	5 Repeat	9	10 Repeat
HEIS Number	1021049	1021050	1021051	1021052
Date	02/28/19	02/28/19	03/21/19	03/21/19
Logging Engineer	Spatz	Spatz	Spatz	Spatz
Start Depth (ft)	0.0	57.0	150.0	277.0
Finish Depth (ft)	151.26	72.01	292.01	292.01
Count Time (sec)	15	15	15	15
Live/Real	R	R	R	R
Shield (Y/N)	N	N	N	N
MSA Interval (ft)	0.25	0.25	0.25	0.25
Log Speed (ft/min)	NA	NA	NA	NA
Pre-Verification	C9936FPB20190228AV00CAB1	C9936FPB20190228AV00CAB1	C9936DMC20190321AV00CAB1	C9936DMC20190321AV00CAB1
Start File	AD000000	BD005700	AD015000	BD027700
Finish File	AD015126	BD007201	AD029201	BD029201
Post-Verification	C9936FPB20190228BV00CAA1	C9936FPB20190228BV00CAA1	C9936DMC20190321BV00CAA1	C9936DMC20190321BV00CAA1
Depth Return Error (in.)	N/A	1.0 low	N/A	0.5 low
Comments	None	None	None	None

Logging Operation Notes

A centralizer was installed on the sondes. Verification measurements passed the acceptance criteria.

Analysis Notes

Analyst	P.D. Henwood	Date	04/30/19
Reference(s)	SGRP-PRO-OP-53040, Rev. 0; SGRP-PRO-OP-53051, Rev. 0		

Casing corrections for a 0.56 and 0.43-in. thick casings were applied to the SGLS and NMLS log data.

For the SGLS, a water correction was applied below 291.3 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 DNC20181219 using an efficiency function and corrections for casing and dead time as determined by annual calibrations.

Casing diameter and thickness corrections for 0.56-in. thick, 11.87-in. OD casing were applied to the NMLS data for the first casing to 151.26 ft and for 0.43-in. thick 9.71-in. OD for the second casing. Integrated with the casing diameter and thickness corrections is an initial count rate correction for a sediment composition of a 50-50% ratio of basalt fragments to quartz sand (HGLP-OTH-028).

NMLS data are reported in counts per second for the entire length of the borehole. NMLS data are also reported in vol% moisture. Conversions from count rate to vol% moisture were performed using EXCEL templates identified as FPB_MCNP_assay and DMC_MCNP_assay.

HGU[6] 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.

Bi-214 energy peaks at 609 and 1764 keV are plotted on the Natural Gamma log plots. These energy peaks are used to calculate naturally occurring U-238. Where the concentrations diverge, radon (Rn-222) is indicated that has disrupted the secular equilibrium (activity of the parent is equal to the activity of its daughters) between the parent U-238 and its daughters below Rn-222 in the uranium decay chain. It is interpreted that intervals of relatively low moisture that coincide with relatively high U-238 using the 609 keV energy peak suggest partial voids behind the casing where radon is trapped and neutron count rate is low. For example, this may be occurring at approximately 260, 278, and 292 ft.

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.

List of Log Plots

Depth Reference is ground surface.

Manmade Radionuclides (0-340 ft)
Natural Gamma Logs (0-160 ft)
Natural Gamma Logs (150-310 ft)
Natural Gamma Logs (300-460 ft)
Combination Plot (0-120 ft)
Combination Plot (120-240 ft)
Combination Plot (240-360 ft)
Combination Plot (0-350 ft)
Total Gamma & Moisture (0-350 ft)
Moisture (0-160 ft)
Moisture (150-310 ft)
Total Gamma & Hanford Gamma Unit (0-350 ft)
Repeat Section of Natural Gamma Logs (55-75 ft)
Repeat Section of Natural Gamma Logs (280-300 ft)
Moisture Repeat Section (57-72 ft)
Moisture Repeat Section (277-292 ft)

[6] Hanford Gamma Unit

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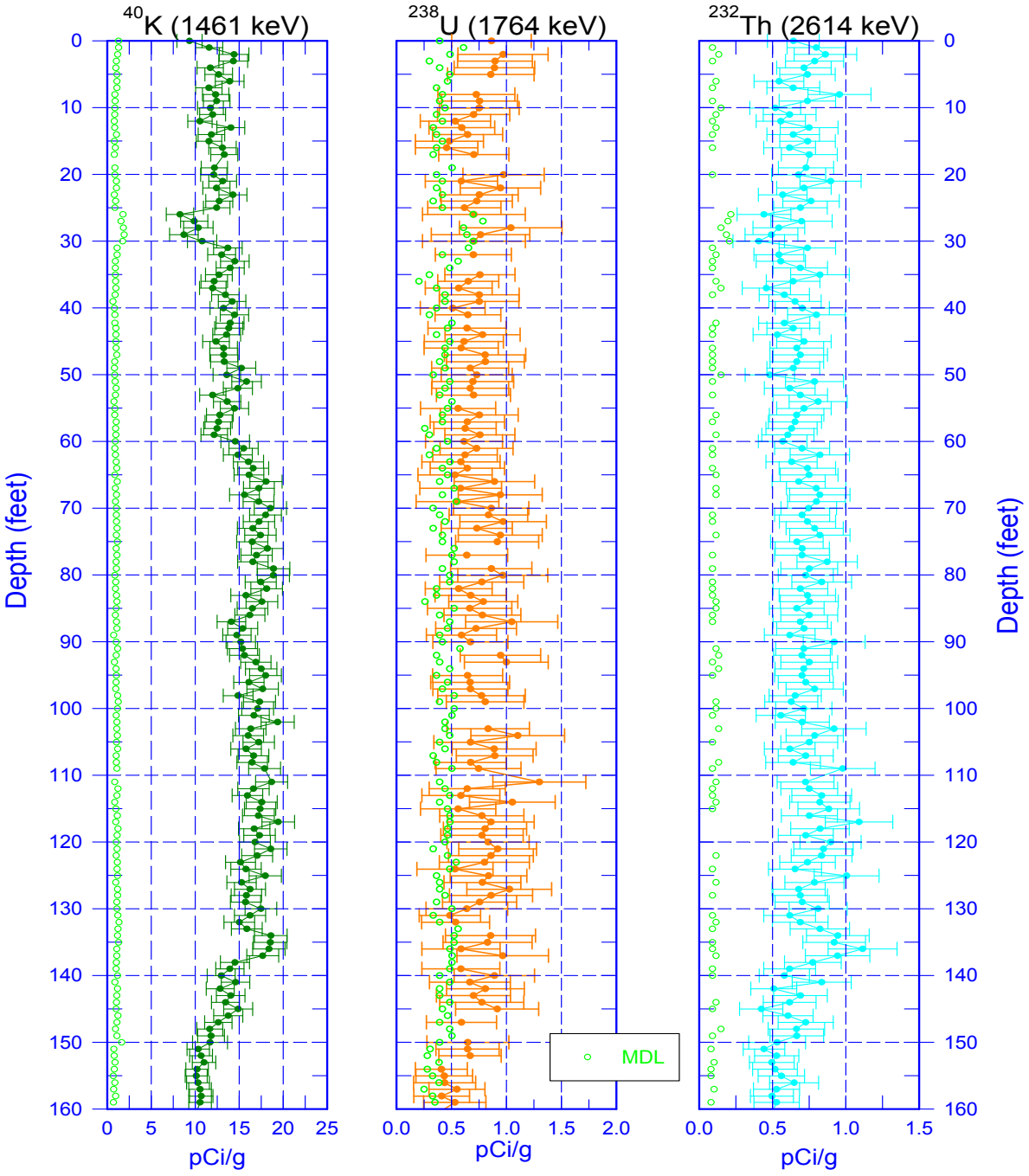
699-46-61 (C9936)
Natural Gamma Logs



Zero Reference - ground surface

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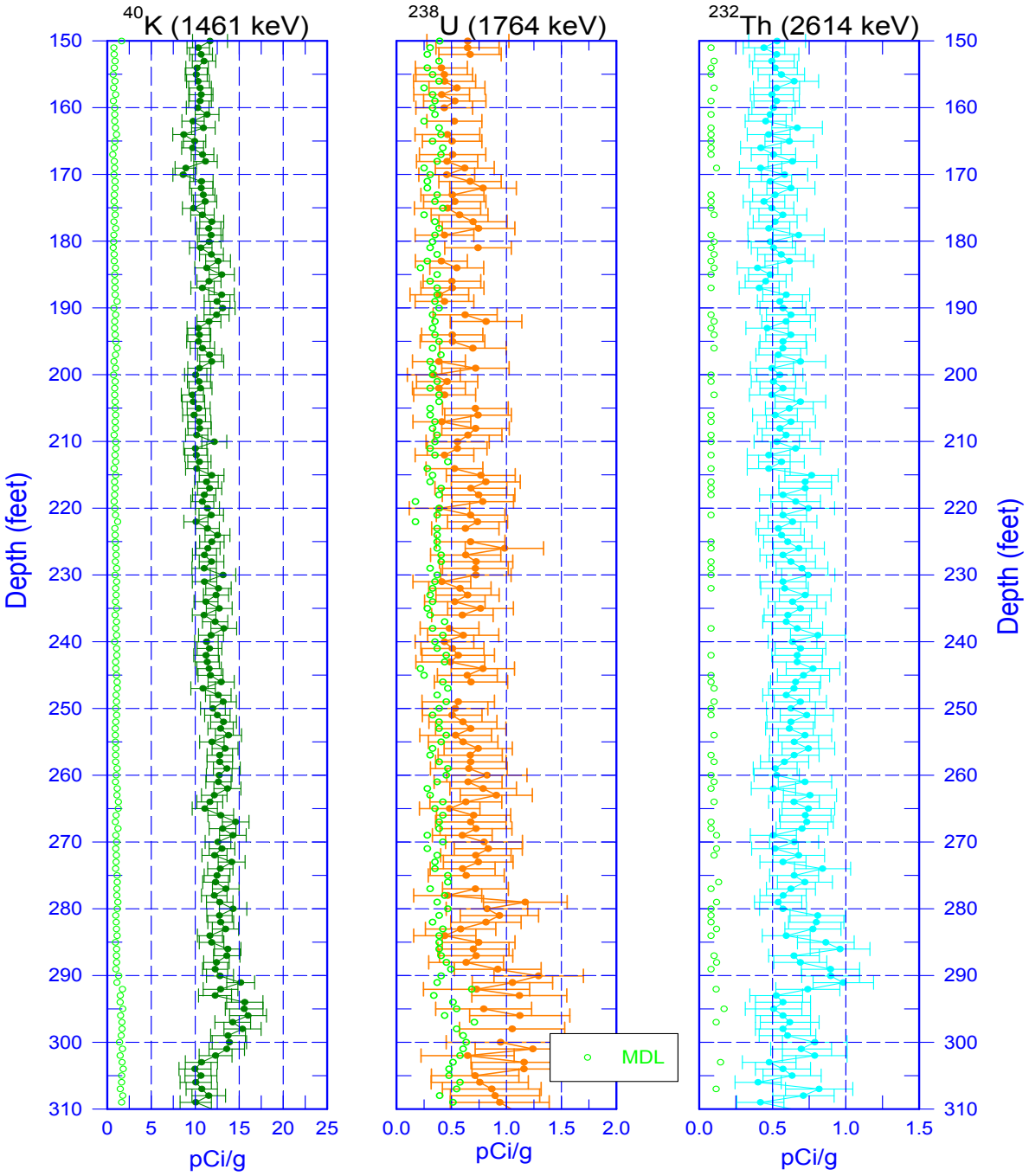
699-46-61 (C9936)
Natural Gamma Logs



Zero Reference - ground surface

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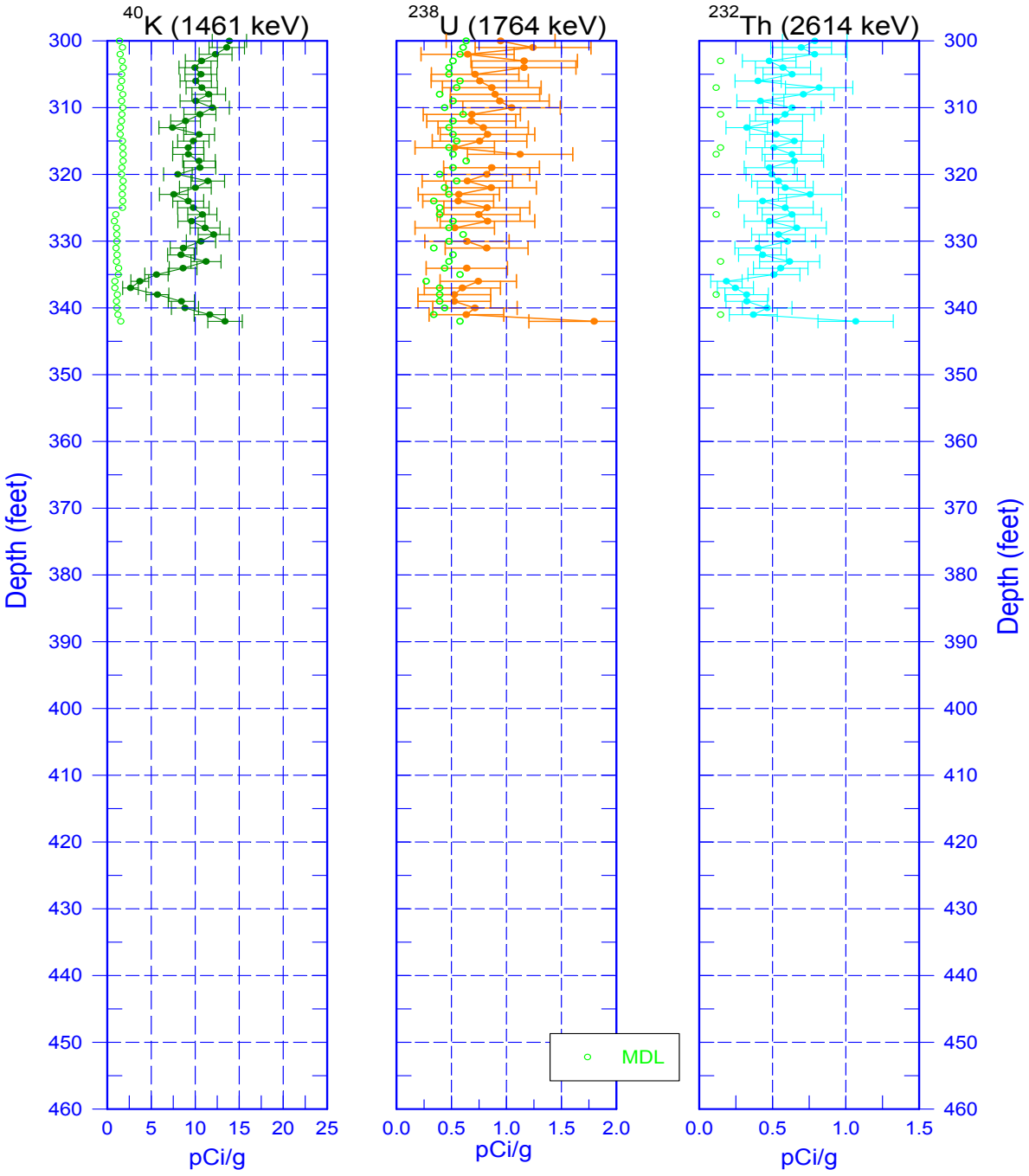
699-46-61 (C9936)
Natural Gamma Logs



Zero Reference - ground surface

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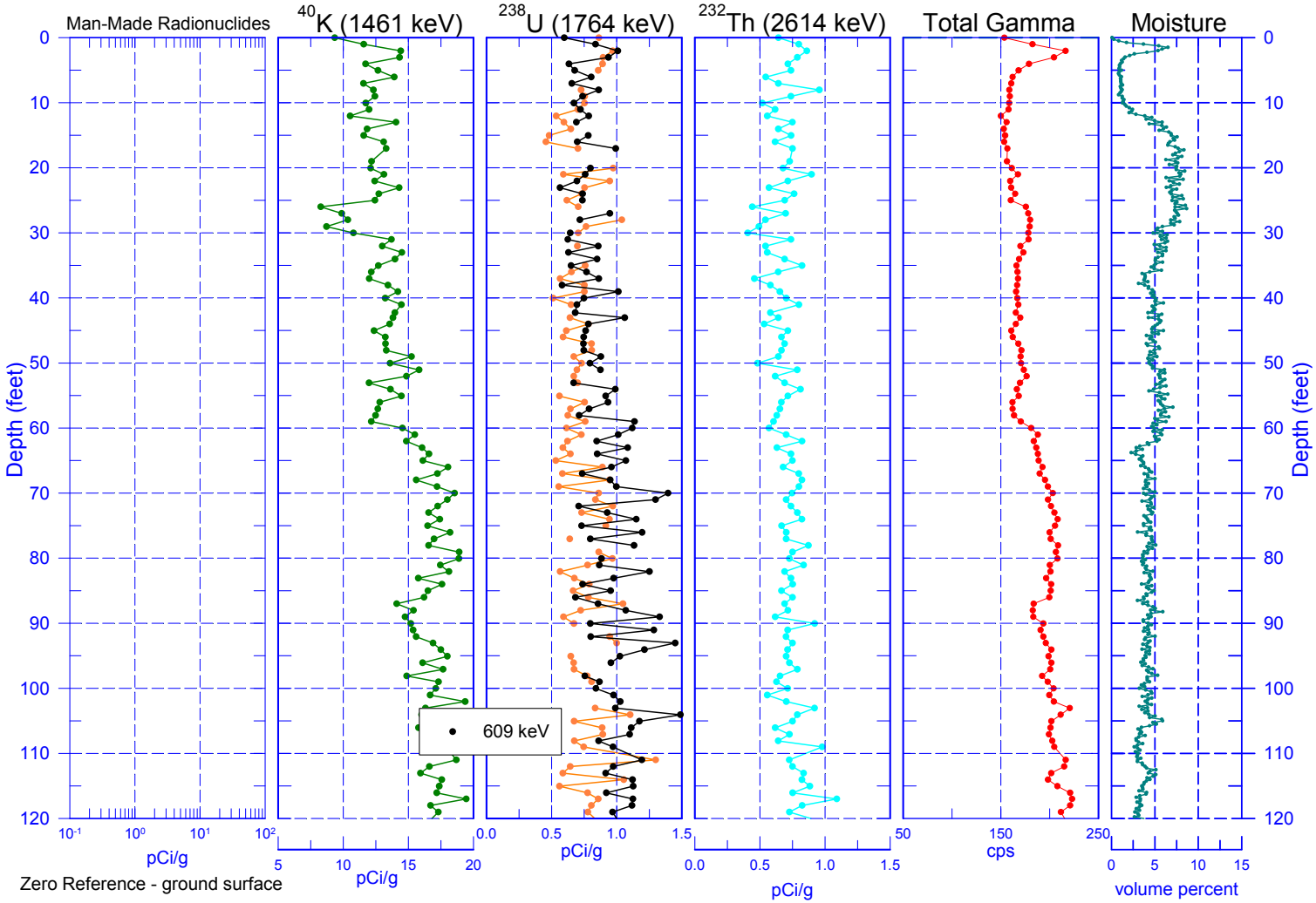
699-46-61 (C9936) Combination Plot



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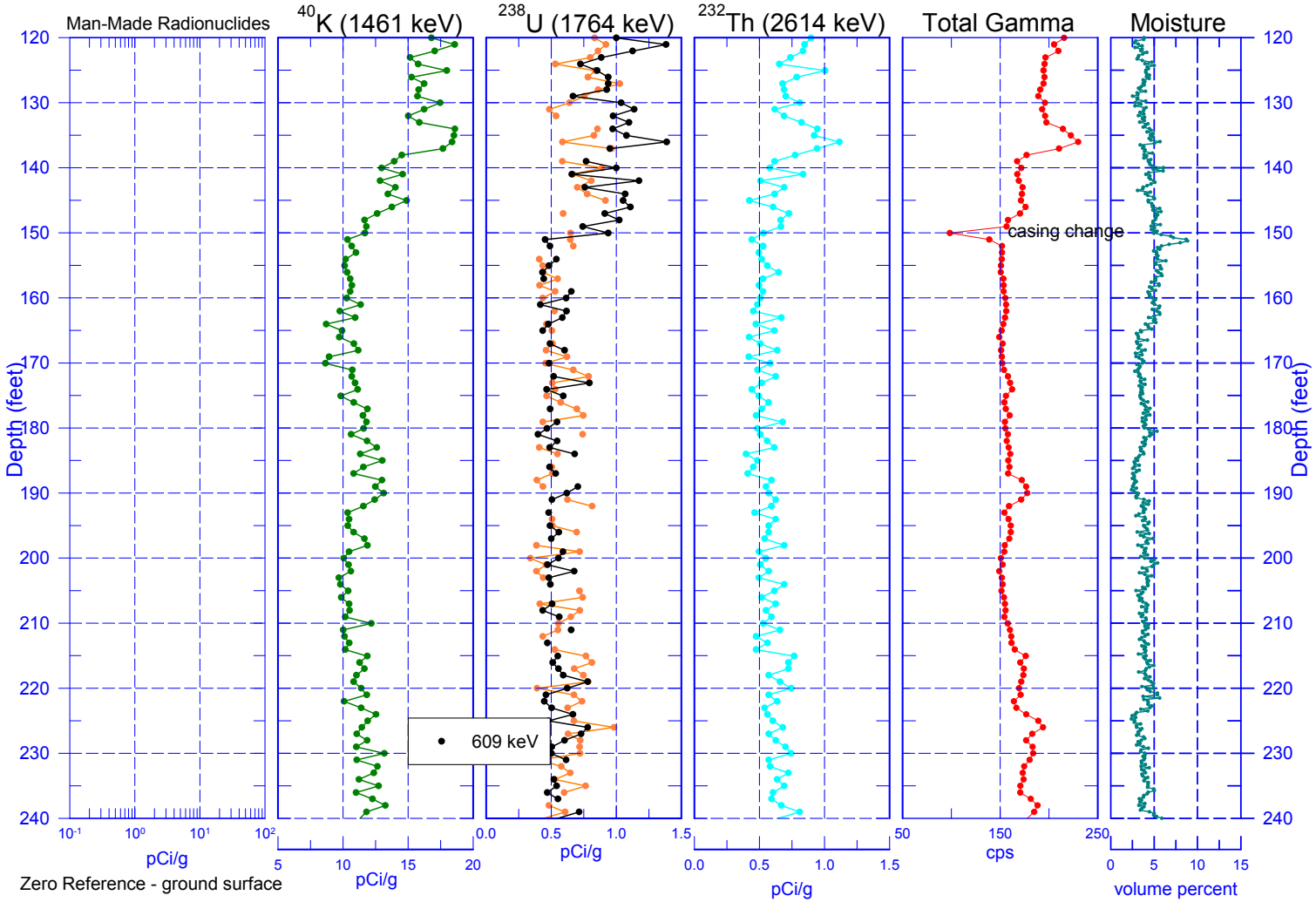
699-46-61 (C9936) Combination Plot



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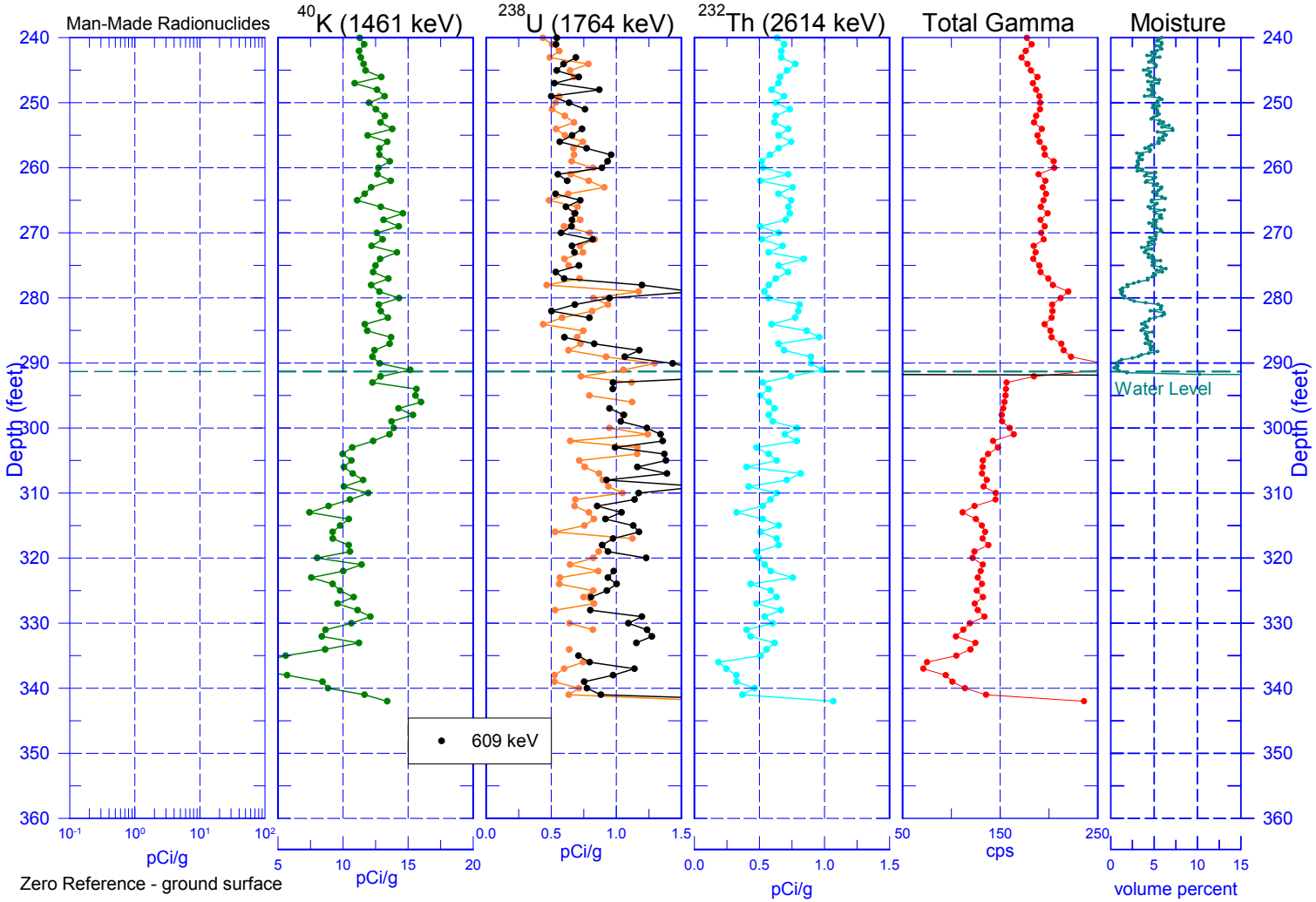
699-46-61 (C9936) Combination Plot



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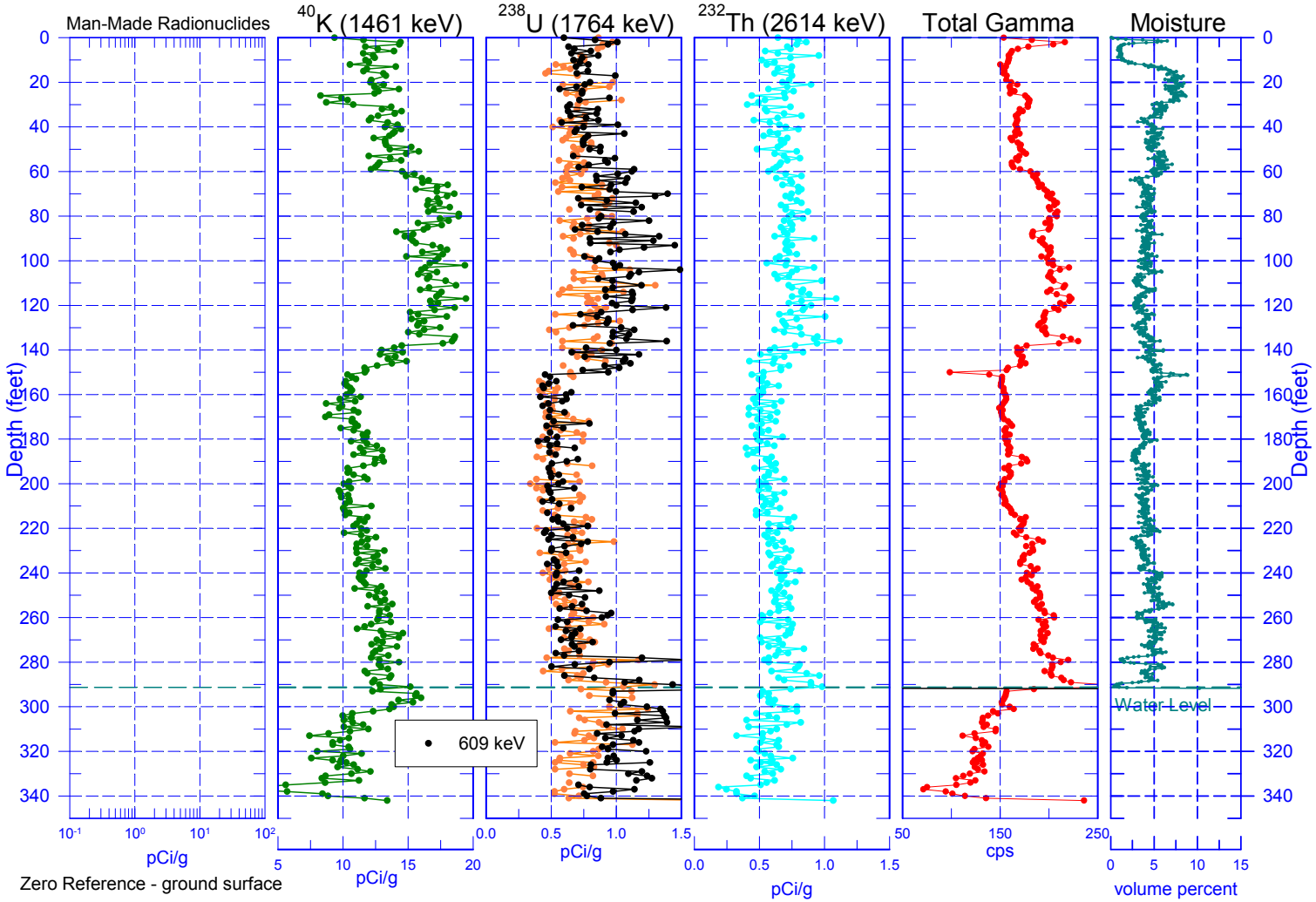
699-46-61 (C9936) Combination Plot



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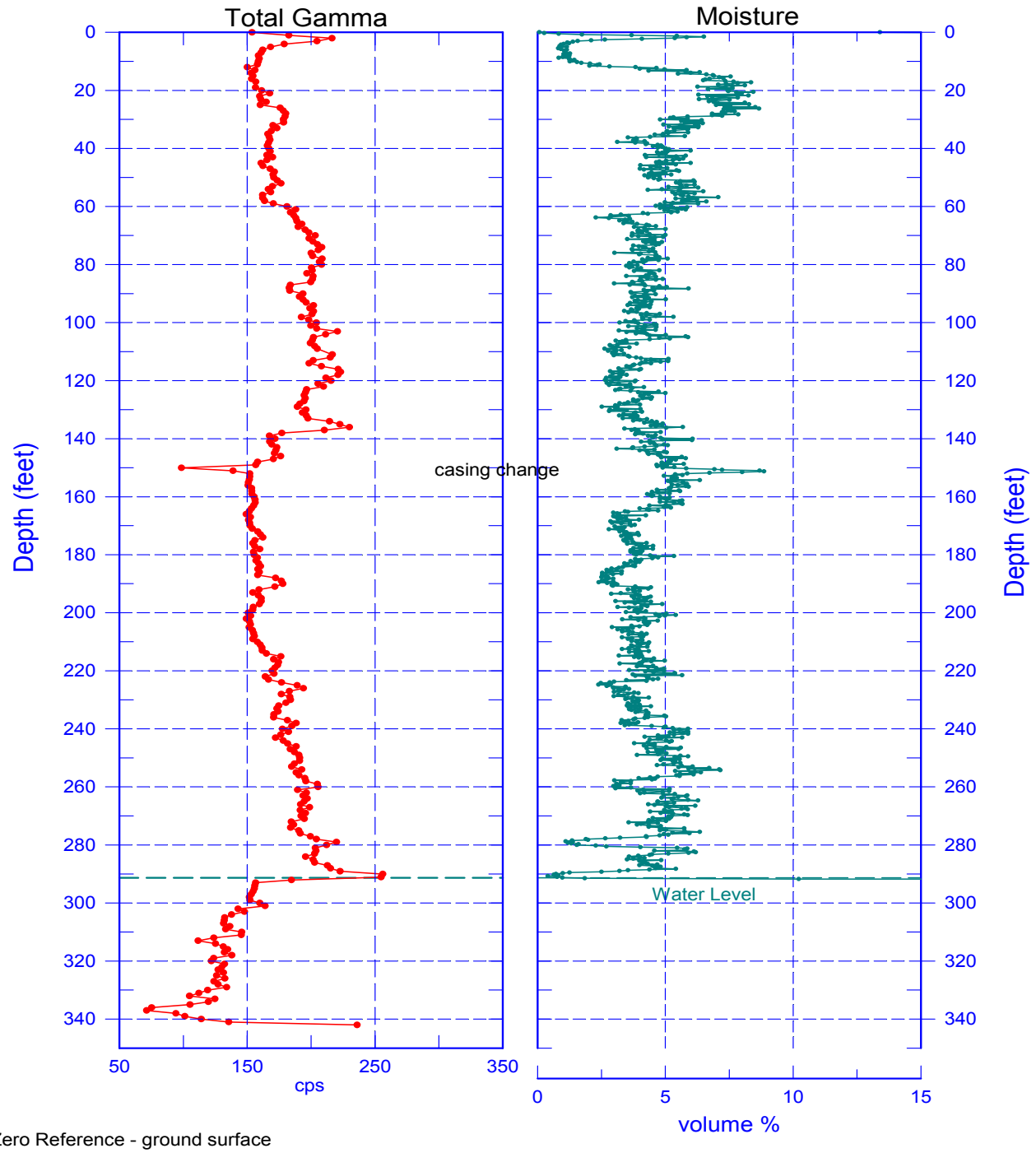
699-46-61 (C9936)
Total Gamma & Moisture



Zero Reference - ground surface

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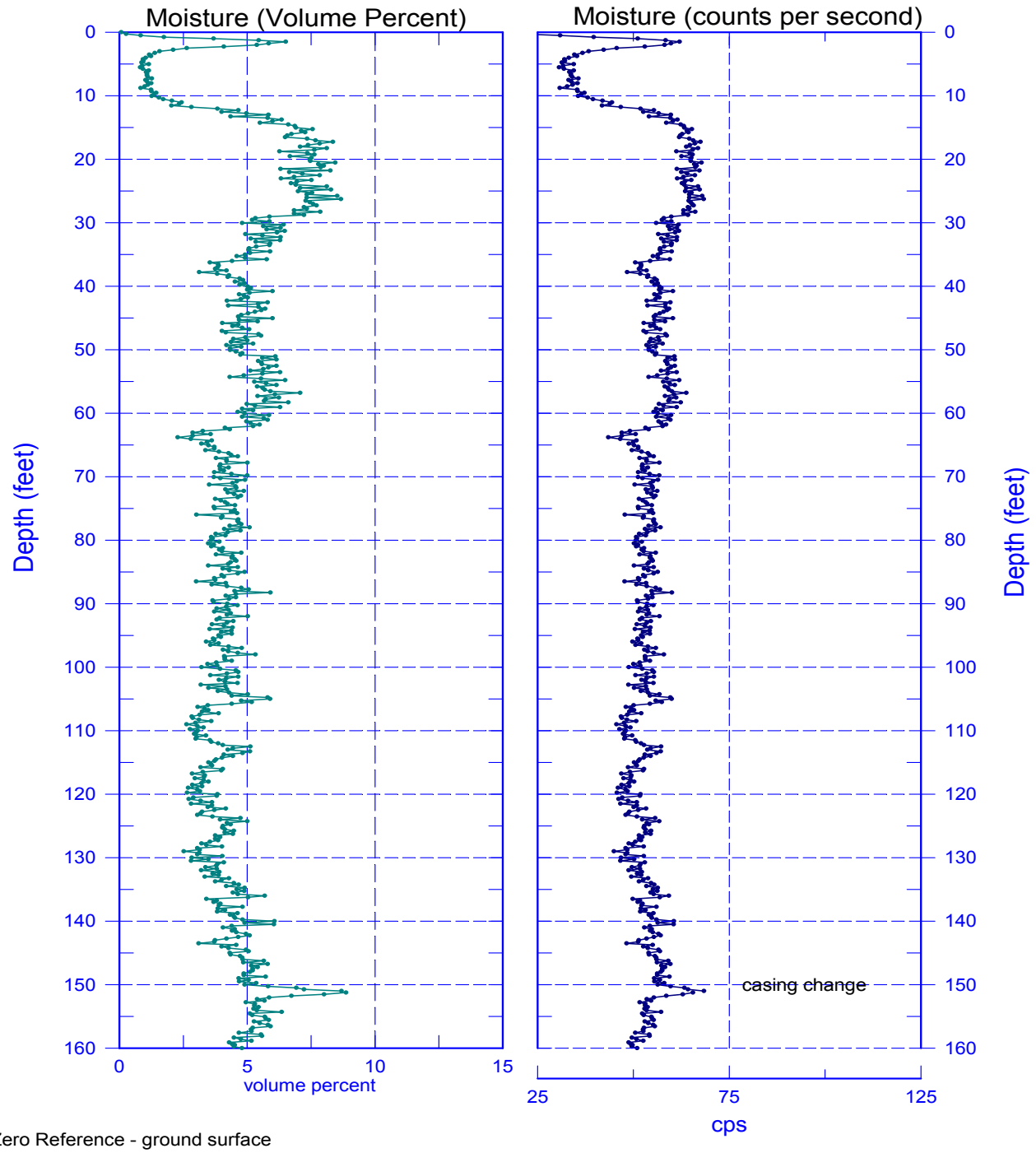
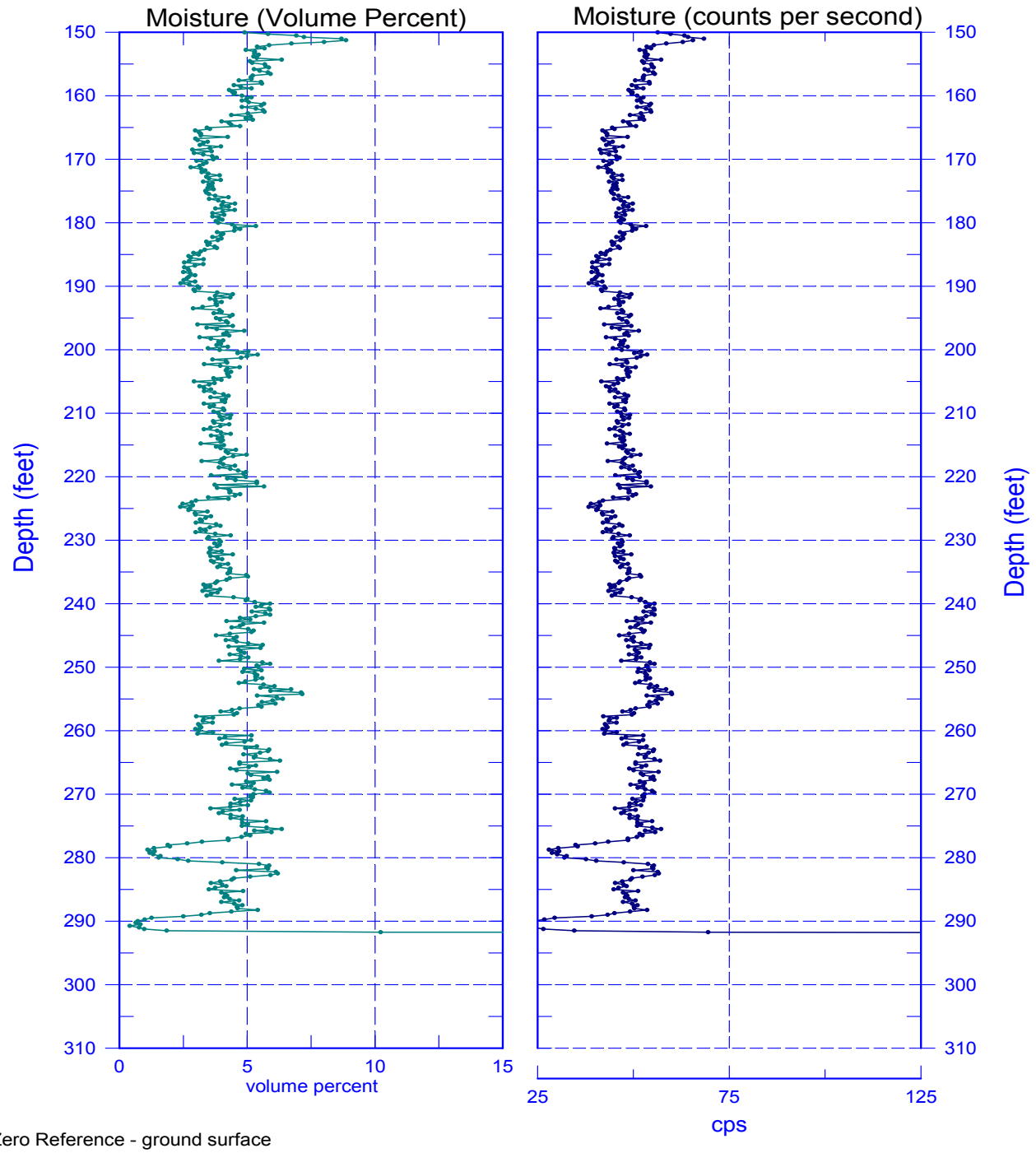
699-46-61 (C9936)
Moisture



Zero Reference - ground surface

Bay West
Customer-Focused Environmental & Industrial Solutions

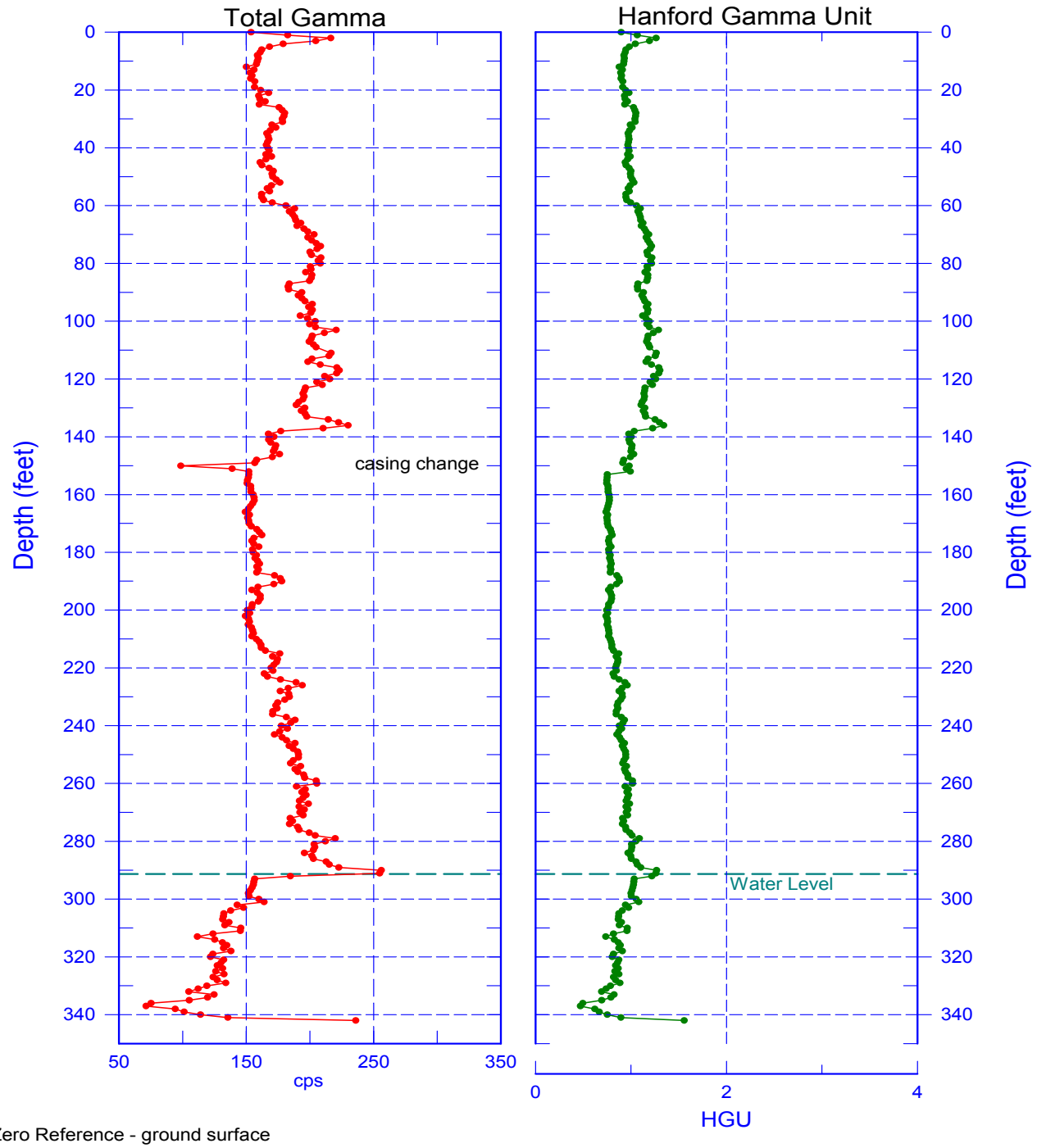
699-46-61 (C9936)
Moisture



Zero Reference - ground surface

Bay West
Customer-Focused Environmental & Industrial Solutions

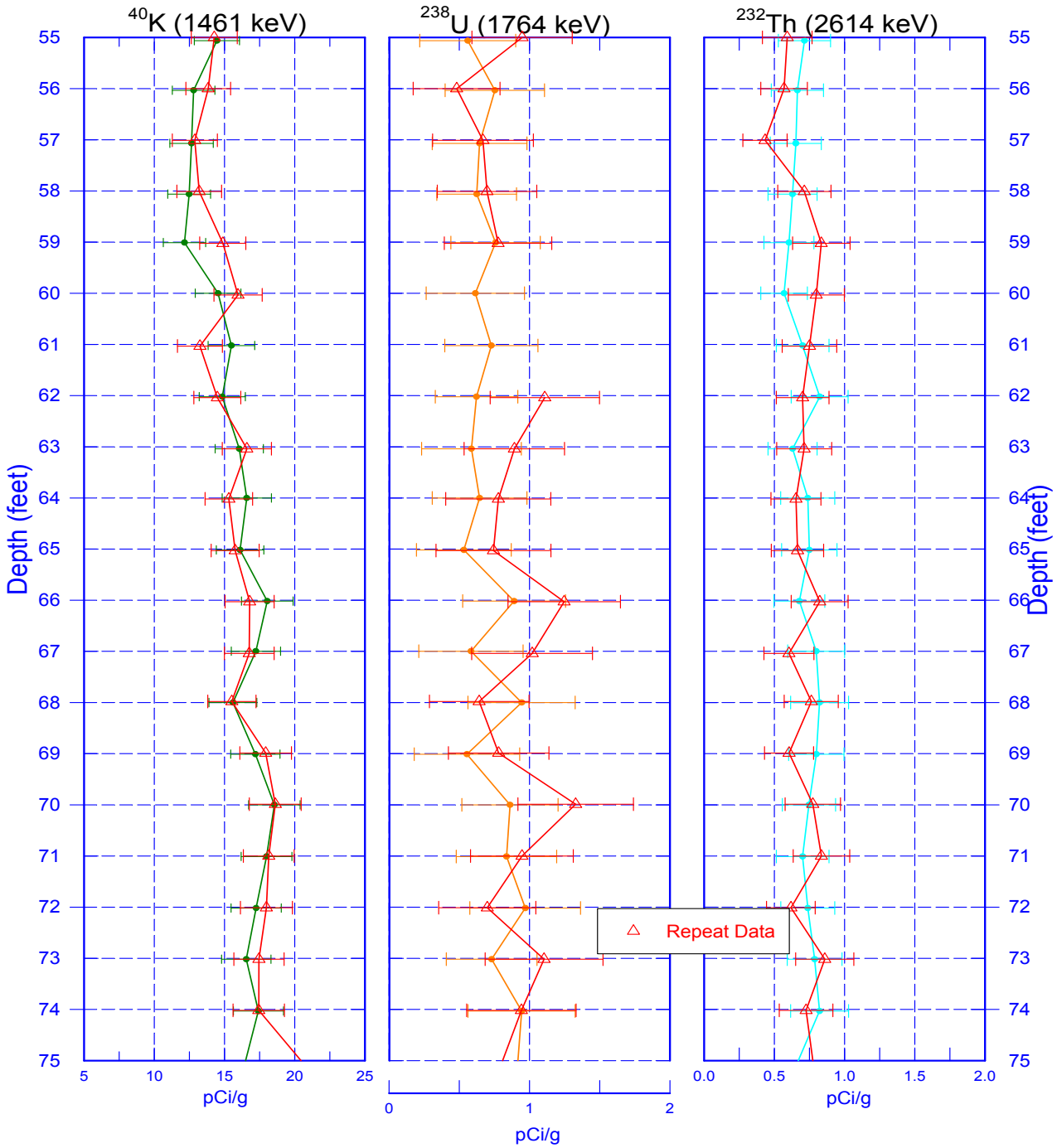
699-46-61 (C9936)
Total Gamma & Hanford Gamma Unit



Zero Reference - ground surface

Bay West
Customer-Focused Environmental & Industrial Solutions

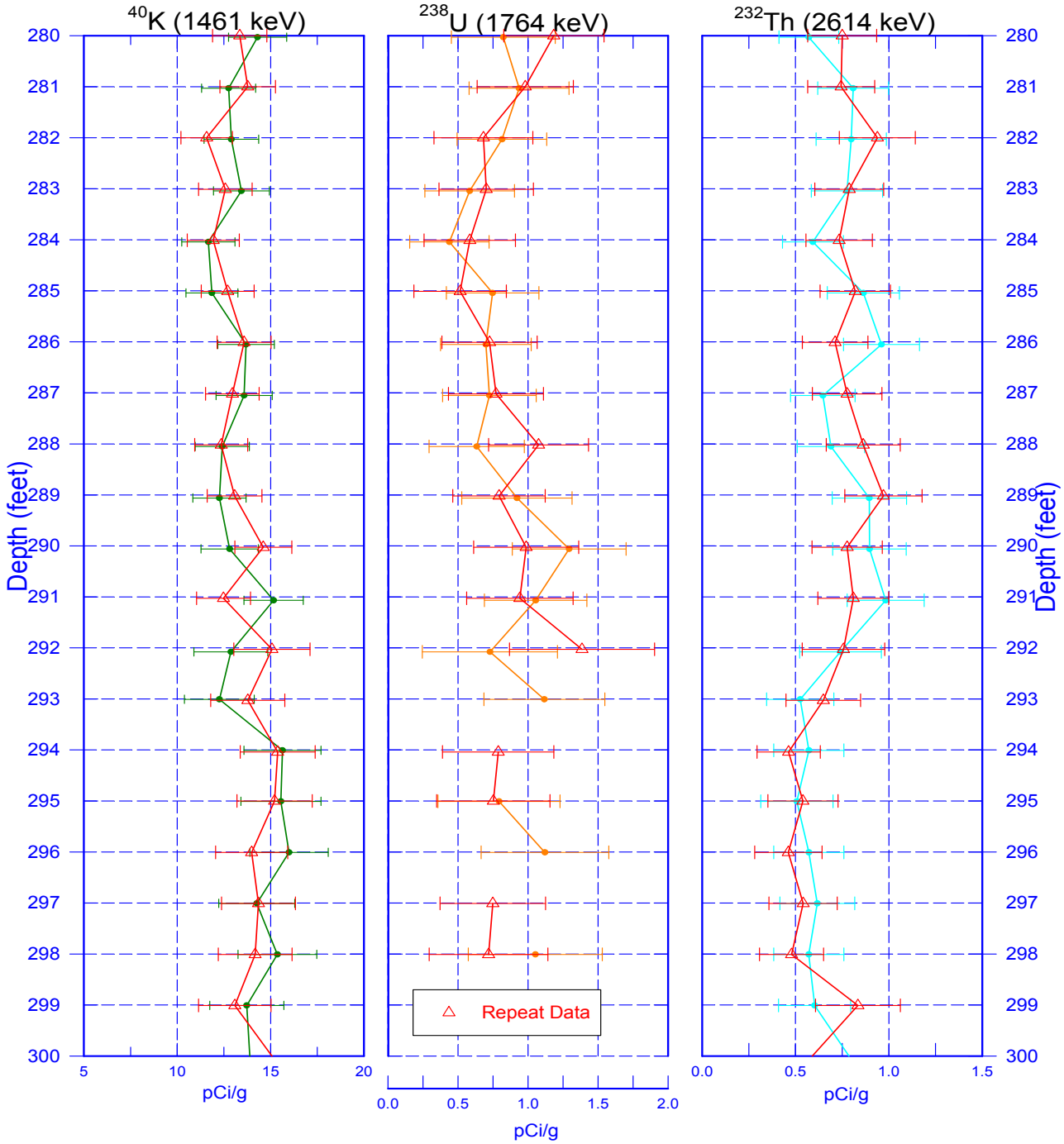
699-46-61 (C9936)
Repeat Section of Natural Gamma Logs



Zero Reference - ground surface

Bay West
Customer-Focused Environmental & Industrial Solutions

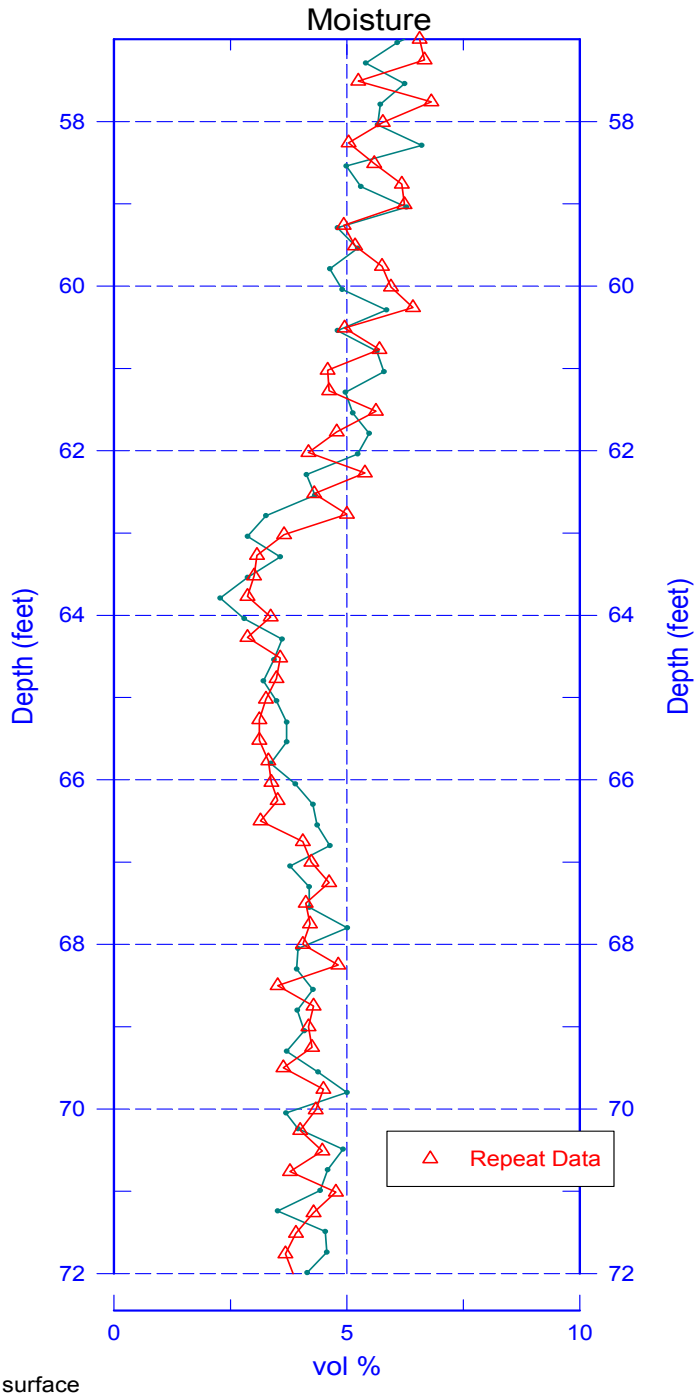
699-46-61 (C9936)
Repeat Section of Natural Gamma Logs



Zero Reference - Ground Surface

Bay West
Customer-Focused Environmental & Industrial Solutions

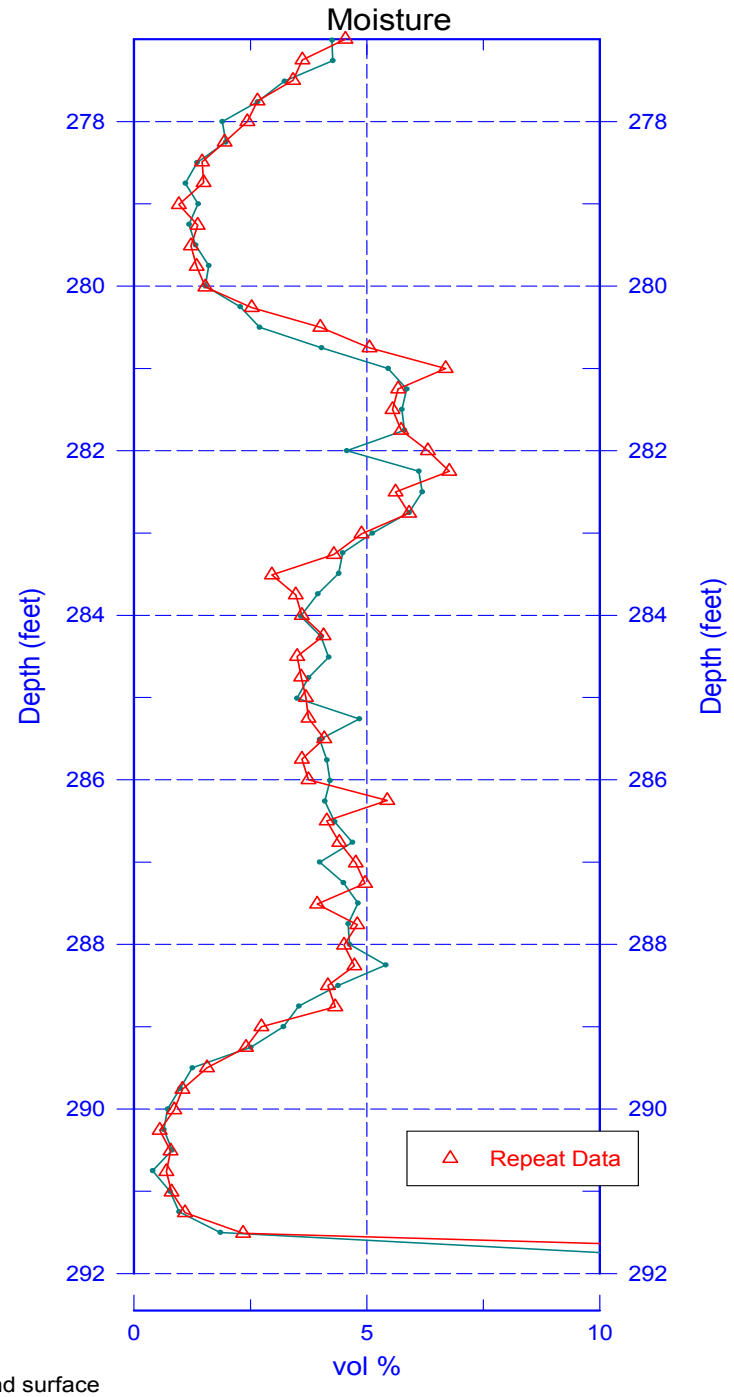
699-46-61 (C9936)
Moisture Repeat Section



Zero Reference - ground surface

Bay West
Customer-Focused Environmental & Industrial Solutions

699-46-61 (C9936)
Moisture Repeat Section



Zero Reference - ground surface

WELL SURVEY DATA REPORT

Project:	**Prepared By:** Neil P. Fastabend
	Company: CHPRC
Date Requested: 05/08/19	Requestor: Matthan G. Wilson (CHPRC)
Date of Survey: 05/23/19	Surveyor / Company: Lawrence B. Munnell / CHPRC
Description of Work: Obtained final survey coordinates (C/L Casing) and elevations of ZP-1 Well C9936 (699-46-61) located west of 200E Area.	Horizontal Datum: NAD83 (91)
	Vertical Datum: NAVD88
	Units: Meters
	Hanford Area Designation: 600A

Coordinate System: Washington State Plane Coordinates (South Zone)

Horizontal Control Monuments:
Washington State Reference Network

Vertical Control Monuments:
2E-92 (CHPRC) and 2E-93 (CHPRC)

Well ID	Well Name	Easting	Northing	Elevation	
C9936	699-46-61	571431.17	137442.38		Center of Casing
				211.617	Top Inner 4"Casing, N.Edge
				211.923	Top Outer Casing,N.Edge Stamped "X"
				211.171	Brass Survey Marker

Notes:

Brass Survey Marker elevation was taken on top of 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
5-23-19

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A-6003-659 (REV 1)