ENVIRONMENTAL CALCULATION COVER PAGE

Section 1: Completed by the Responsible Manager

Project: Sampling/Drilling

Date: 6/30/2016

Calculation Title & Description: Well Design for 299-E26-15 (C8913) - Calculation for Filter Pack, Screen Slot Size and Final Well Design

RELEASE / ISSUE

DATE: Jun 30, 2016 HANFORD RELEASE

Section 2: Completed by Preparer

Calculation No.: ECF-200BP5-15-0077 **Revision No.:** 0

Revision History

Revision No.	Description	Date	Affected Pages ADD ROW
			☒

Section 3: Completed by the Responsible Manager

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Does document contain scientific and technical information intended for public use? ☒ Yes ~~☒~~ No JDA 6/30/16

Does document contain controlled-use information? ☐ Yes ☒ No

Section 4: Document Review & Approval

	Name /Position	Signature	Date
Preparer:	John Smoot / Well Design	John Smoot	06/30/2016
Checker:	Roger Whitlock / Design P&T Eng	Approved via Attached email	06/06/16
Senior Reviewer:	Joe Fritts / Well Maintenance	Approved via Attached email	06/08/16
Responsible Manager:	David Capelle / Drilling	/Sign for D Capelle	06/30/2016

Section 5: Applicable if calculation is a risk assessment or uses an environmental model

PRIOR TO INITIATING MODELING:

Required training for modelers completed:

	Name /Position	Signature	Date
Integration Lead			

Safety Software Approved:

	Name /Position	Signature	Date
Integration Lead			

CALCULATION APPROVED:

	Name /Position	Signature	Date
Risk/Modeling Integration Manager:			

Green, Amie J

From: Whitlock, Roger W
Sent: Monday, June 06, 2016 9:26 AM
To: Smoot, John L
Subject: Approve: Review: ECF-200BP5-15-0077, Well Design for 299-E26-15 (C8913)

Green, Amie J

From: Fritts, Joseph E
Sent: Wednesday, June 08, 2016 1:01 PM
To: Smoot, John L
Subject: Approve: Review: ECF-200BP5-15-0077, Well Design for 299-E26-15 (C8913)

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Appendix

Supporting Documents **A-1**

1 Purpose

The purpose of this calculation is to document the selection of appropriate filter pack and well screen materials for groundwater monitoring well C8913 (299-E26-15).

2 Background

This well is part of a fiscal year 2015 well campaign to add eight M-24 Tri-Party Agreement groundwater monitoring wells at the 200-BP-5 and 200-UP-1 Operable Units (SGW-58433, *Description of Work for the Installation of Eight M-24 Tri-Party Agreement Groundwater Monitoring Wells in FY2015*).

3 Methodology

The methodology follows the approach described by Fletcher G. Driscoll in Groundwater and Wells, 2nd Edition, Chapter 13: Water Well Design documented in ECF-HANFORD-15-0015, *Determination of Filter Pack and Well Screen Size in Hanford Groundwater Wells*.

3.1 General Description

In general, soil samples are collected during drilling for grain size analysis about every five feet below the groundwater table and composited over a 20-ft interval. The grain size distribution is then determined using the composited sample according to procedure SGRP-PRO-OP-50037 (GRP-EE-05-1.21) *Particle Size Distribution of Sediment - Wet Sieve Analysis*. Compositing is not performed if the aquifer is thin. Standard monitoring well design with a 20-slot screen and 10-20 mesh filter pack was planned for C8913.

The filter pack mesh size is selected first based on the formation grain-size distribution. A screen slot-size is then selected that will allow approximately 10% of the filter pack to pass through the screen (Driscoll, 1986), within the technically accepted range of 5% passing (Department of the Interior, 1981) to 30% passing (Roscoe Moss, 1990). Removal of a small portion of the filter pack through the well screen during the construction process enhances the development and efficiency of monitoring and production wells.

The sieve analysis data set(s) is normalized to finer than the #4 sieve size (0.187 in) to remove bias toward the larger sediment material (pebble/cobble size fraction) and thereby reduce the likelihood of designing a sand-producing well.

The screen length is selected based on controlling document requirements, e.g., from the Description of Work (DOW) for drilling and the applicable Sampling and Analysis Plan (SAP) with adjustments for aquifer thickness and elevation encountered during drilling. The screen placement also may factor in depth discrete contaminant levels.

3.2 Specific Calculations

The filter pack mesh size is calculated by multiplying the formation sediment D30 size by a range of values based on the formation's uniformity coefficient. The D30 value is the formation particle size at the 30% passing grain size. The range of filter pack sizes is between D30 times 4 and D30 times 6 if the formation is both uniform (Cu < 5) and the formation D60 is <0.01 inches; or between D30 times 6 and D30 times 10 if the formation is non-uniform (Cu > 5).

The uniformity coefficient is defined as the ratio D60:D10 where D60 is the particle size at the 60% passing grain size and D10 is the particle size at the 10% passing grain size. A uniformity coefficient of <5 indicates a uniform formation (small range in particle size), and a uniformity coefficient >5 indicates a non-uniform formation (large range in particle size).

The well screen slot size is chosen so that it passes approximately less than or equal to 10% of the filter pack material; therefore, the well screen slot size is selected at the filter pack D10 size. If more aggressive well designs are warranted, a larger well screen slot size may be selected such that between 10-20% of the filter pack passes through the well screen.

This evaluation is performed for each sieve analysis. The final filter pack and well screen slot size for an interval is selected based on the finest-grained interval (finest filter pack) if a single screen slot size will be used. However, more than one filter pack and screen slot size may be used in a well if a more sophisticated well design is desired.

A review of the borehole log is performed concurrently with the grain-size distribution analysis to analyze for fine-grained texture in the aquifer matrix. Significant zones of uniform fine sand may not be evident from the sieve analyses and require mitigation by selecting a smaller filter-pack size or isolating the interval; otherwise, fine sand can flow through the filter pack and screen indefinitely, creating a sand producing well.

4 Assumptions and Inputs

Inputs include:

- Description of Work (SGW-58433, *Description of Work for the Installation of Eight M-24 Tri-Party Agreement Groundwater Monitoring Wells*)
- Sieve analysis results per interval of the borehole (200-205 ft bgs)
- Standard configuration for monitoring wells using a 10-20 filter pack and 20-slot screen per ECF-HANFORD-15-0015 was planned for the well
- Borehole log

Assumptions:

- Sieve numbers and slot sizes are based on the U.S. Standard (Appendix 12, Driscoll)
- The Driscoll approach used is appropriate for designing wells at the Hanford Site

5 Software Applications

A Microsoft Excel®[1] spreadsheet is used for evaluating the sieve particle size analysis and the selection of both the filter pack and screen slot size. The methodology meets the requirements for utility calculations and is documented in ECF-HANFORD-15-0015. The results are validated by a Checker using a hand calculator.

6 Calculation

The calculation and results for each step of the design are described by a series of supporting documents:

- Design drawing and description of the final design
- Normalized sieve analyses and graphs for each borehole interval
- Borehole log

The calculation indicates that the 20-slot screen and 10-20 mesh filter pack design is conservative. The calculation supports a much larger screen and associated filter pack as indicated by the graph in the

[1] Microsoft Excel is a Registered Trademark of Microsoft Corporation, Redmond, WA 98052-6399

Appendix. Therefore, given the thin aquifer in the vicinity of the well, a 30-slot screen and 10-20 mesh filter pack was selected to provide additional capacity for monitoring purposes.

7 Results/Conclusions

The final well design and supporting documents are presented in the Appendix. The key features of the design are:

- Total depth of borehole: 206.9 ft bgs
- 4-in diameter completion with stainless steel (SS)
- 193.5 ft of 4-in SS blank casing from +2-191.5 ft bgs
- 15 ft of 4-in 30 slot SS screen from 191.5-206.5 ft bgs
- SS end cap placed at base of screen near basalt contact at 206.5 ft bgs, no sump
- 19.4 ft of 10-20 mesh filter pack from 187.5-206.9 ft bgs
- 3 ft of bentonite pellet seal from 184.5-187.5 ft bgs
- 174.5 ft of bentonite crumbles from 10-184.5 ft bgs
- 10 ft of cement grout surface seal from 0-10 ft bgs

8 References

Driscoll, Fletcher G., 1986, *Groundwater and Wells*, 2nd Edition, Johnson Division, St. Paul, MN, Chapter 13: Water Well Design

ECF-HANFORD-15-0015, *Determination of Filter Pack and Well Screen Size in Hanford Groundwater Wells*, CH2M Hill Plateau Remediation Company, Richland, Washington

Fetter, Carl W, 1994, *Applied Hydrogeology*, 3rd Edition, Prentice Hall, Englewood Cliffs, NJ, 691 p

Roscoe Moss Company, 1990, *Handbook of Ground Water Development*, 258 p

SGRP-PRO-OP-50037 (GRP-EE-05-1.21), *Particle Size Distribution of Sediment - Wet Sieve Analysis*

SGW-58433, 2015, *Description of Work for the Installation of Eight M-24 Tri-Party Agreement Groundwater Monitoring Wells*, CH2M Hill Plateau Remediation Company, Richland, Washington

United States Department of the Interior, 1985, *Ground Water Manual*, Reprint, 330 p

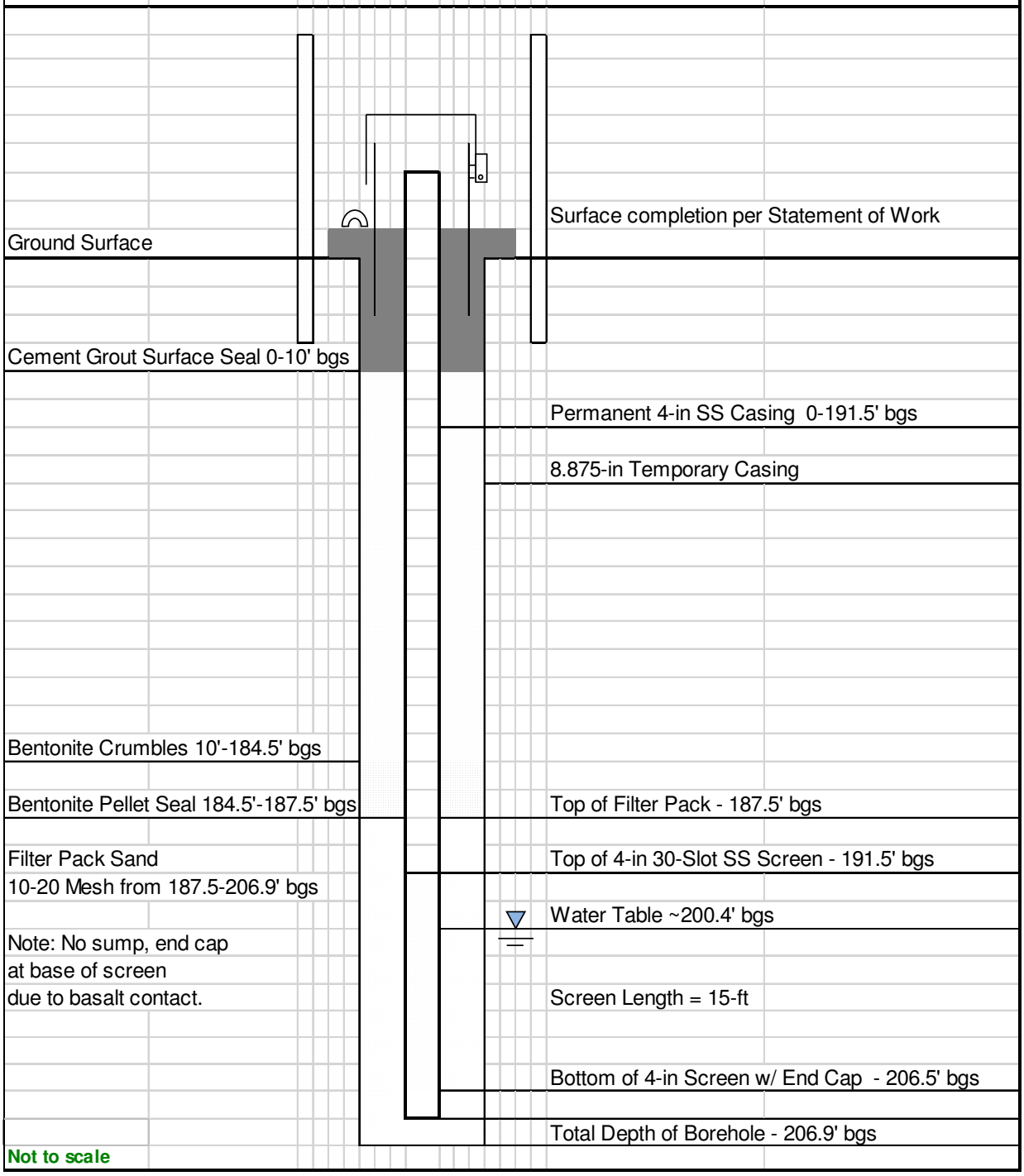
WAC 173-160, *Minimum Standards for Construction and Maintenance of Wells*, Washington Administrative Code, as amended

Appendix

Supporting Documents

Well Design: 200-BP-1 M-24 Well

Drilling Method:	Becker Hammer	Well Name:	**299-E26-15**
Drilling Fluid:	N/A	Well I.D.:	**C8913**
Drillers name:	N/A	State Coordinates:	N137051.50
Drilling Company:	Layne		E575919.00
Date Started:	5/19/2015	Start Card #:	N.D.
Design Doc:	SGW-58433	Elevation Ground Surface:	~181.7 m amsl



Sieve Analysis Data Set

Location:	200-BP-1 ETF
Well ID:	C8913
Sample Number:	1
Sample Depth (ft bgs):	200-205
Sample Date:	Multiple
	5/21/2015
Tested By:	
Contact:	Cameron Penner-Ash
Phone:	509-943-5222
Analysis Date	5/22/2015
Dry Sample Weight (grams):	1056.5
Washed Sample Weight (grams):	1031.1

Sieve No.	Sieve Size (inches)	Weight of Soil Retained (grams)	Cumulative Weight Retained (grams)	Cumulative Weight Percent Retained	Cumulative Weight Percent Passing
2 inch	2	455.3	N/A	N/A	N/A
1 1/2 inch	1.5	202.8	N/A	N/A	N/A
3/4 inch	0.75	77.6	N/A	N/A	N/A
3/8 inch	0.375	33	N/A	N/A	N/A
#4	0.187	26.8	N/A	N/A	100.00
#10	0.0787	71	71.00	27.28	72.72
#20	0.0331	84.4	155.40	59.70	40.30
#40	0.0165	40.5	195.90	75.26	24.74
#60	0.0098	11.1	207.00	79.52	20.48
#100	0.0059	5.6	212.60	81.67	18.33
#200	0.0029	7.8	220.40	84.67	15.33
Pan	NA	14.5 25.4	260.3	NA	NA

Dry Sample Weight - Pan Cumulative Weight (grams):	-0.70	% Error =	-0.1%

Formation D10 Size (inches) =	**0.0001**	est. neg D10
Formation D30 Size (inches) =	**0.0221**	
Formation D60 Size (inches) =	**0.0608**	
Formation Uniformity Coefficient (Cu) =	**608.06**	
Formation Sieve Analysis is:	**Nonuniform since Cu > 5**	
Filter Pack D30 Range (inches) =	**0.1327 to 0.2211**	
Chosen Filter Pack Material =	**Colorado Silica 10-20**	
Chosen Well Screen Slot Size (inches) =	**0.0300**	

Notes:

N/A = not applicable

Gravel fraction removed from calculation (#4 and greater)

References:

Driscoll, F.G., 1986. Groundwater and Wells, second edition.

Fetter, C.W., 1994. Applied Hydrogeology, third edition.

Calculations Continued for : 200-BP-1 ETF, Well C8913, 200-205

Formation Uniformity Coefficient: Cu = D60/D10

Cu =	608.06	D60 =	0.0608

Nonuniform since Cu > 5

Filter Pack Selection: Choose filter pack D30 by multiplying formation D30 by multiplier

Formation D30 multiplier between 4 and 6 if formation uniform and D60 <= 0.01

Formation D30 multiplier between 6 and 10 if formation nonuniform or D60 >0.01

Multiplier =	6 to 10			
6	*	D30 =	0.1327	inches
10	*	D30 =	0.2211	inches

**** Choose the filter pack from grain-size chart on next sheet by selecting a filter pack***

Select Filter Pack from List Below

Colorado Silica 10-20

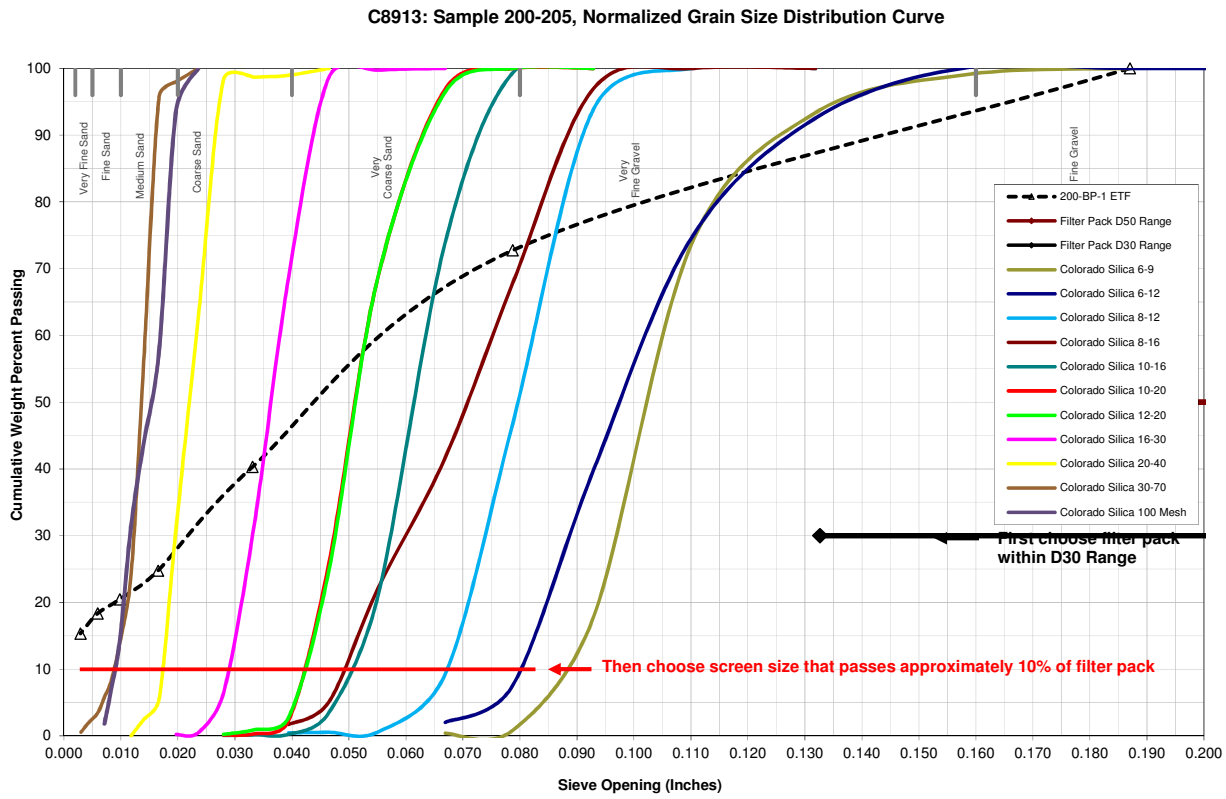
D10 of chosen filter pack material = 0.0417 inches

Well Screen Selection:

Well screen size for 10% passing = 0.0417 inches

*** Select a well screen size from the list below that is the closest value to 10% passing of the filter pack through the well screen**

	Select From List Below	
Well screen size =	0.030	inches


C8913: Sample 200-205, Normalized Grain Size Distribution Curve
Cumulative Weight Percent Passing
Sieve Opening (Inches)
Very Fine Sand
Fine Sand
Medium Sand
Coarse Sand
Very Coarse Sand
Very Fine Gravel
Fine Gravel
200-BP-1 ETF
Filter Pack D50 Range
Filter Pack D30 Range
Colorado Silica 6-9
Colorado Silica 6-12
Colorado Silica 8-12
Colorado Silica 8-16
Colorado Silica 10-16
Colorado Silica 10-20
Colorado Silica 12-20
Colorado Silica 16-30
Colorado Silica 20-40
Colorado Silica 30-70
Colorado Silica 100 Mesh
First choose filter pack within D30 Range
Then choose screen size that passes approximately 10% of filter pack

BOREHOLE LOG

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Date: 5/19/15

Well ID: C8913	Well Name: 299-E26-15	Location: 20m South of Catch Basin 242AL-43
Project: 8 M24 TPA GW Monitoring Well		Reference Measuring Point: ground surface

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
0				0'-20' Gravel (G) 90% Gravel, 10% Sand. Gravel: F-VC, max= 50mm, rounded to angular, 80% VC, 20% F, 60% Mafic, poorly sorted. Sand: VF-C, angular, 70% C, 30% VF, 80% mafic, poorly sorted. 2.5yr 5/2, Grayish brown, No rxn to HCl. Moist.	• Drilling: AP1000 Becker Hammer. • Grab Samples every 5'. • 8 3/8" OD temp casing used. • 0'-10' bgs, no grab samples due to possible contamination. • Drillers adding water (~2gal/5ft) for dust suppression.
5					
10					
15	G				
20	G			20'-30' Sandy Gravel (sG) 50% Gravel, 50% Sand. Gravel: MP-VCP, max= 50mm, Subrounded to angular, 80% mafic, poorly sorted. Sand: VFS-VCS, angular. 80% mafic, poorly sorted. 2.5yr 4/1, dark Gray, No rxn to HCl @ 25' bgs ↓ gravel size	
25	G				
30	G			Slightly Silty Gravelly Sand ((m) g S) 30'-35' ~~Silty Sand (m S)~~ 20% Gravel, 65% Sand, 15% Silt. Gravel: VFP-FP, max= 70mm Very angular, 60% mafic, well sorted. Sand: F-VFS, well sorted, 90% mafic. 2.5yr 4/1, dark Gray no rxn to HCL. Moist	
35	G			35'-40' Sandy Gravel (sG) 50% Gravel, 50% Sand. Gravel: FP-VCP, angular, 60% mafic, poorly sorted Sand: VFS-VCS, angular, 60% mafic, poorly sorted 2.5yr 4/1, dark Gray, no rxn to HCL. Moist	

Reported By: Cameron Renner-Ash		Reviewed By: Kevin Bergstrom	
Title: Geologist		Title: Sr. Geologist	
Signature: [signature]	Date: 5/19/15	Signature: [signature]	Date: 7/22/15

A-6003-642 (03/03)

BOREHOLE LOG

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Date: 5-19-15

Well ID: C8913
Well Name: 299-E26-15
Location: 20m South of Catch Basin 242AL-43
Project: 8 M24 TPA GWA Monitoring Well
Reference Measuring Point: ground surface

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
40	G			40'-60' Gravelly Sand (gS) 20% Gravel, 80% Sand. Gravel: FP-VFP, angular, 50% mafic, well sorted. Sand: FS-CS, angular, 50% mafic, well sorted. 2.5yr 4/1, dark gray, no rxn to HCL. Moist	• Drilling: AP1000 Becker Hammer • Grab samples every 5'. • 9 7/8" OD Temp. Casing used.
45	G			@ 45' bgs ↑ Gravel: FP-MP	• 0'-10' bgs, no grab samples collected due to possible contamination. • Drillers adding water (~2gal / 5ft) for dust supression.
50	G				
55	G			@ 55' bgs ↑ >120 mm Cobbles	
60	G			60'-70' Gravel (G) 90% Gravel, 10% Sand. Gravel: MP-VCP, Subrounded, max: 70mm, moderate sorting, 80% mafic. Sand: VFS-CS, angular, poorly sorted, 70% mafic. 2.5yr 3/1, Very dark gray. No rxn to HCL. Moist.	
65	G			@ 65' bgs ↑ Trace Silt	
70	G			70'-75' Sandy Gravel (sG) 70% Gravel, 30% Sand, Trace silt. Gravel: FP-MP, max: 70mm, 80% mafic, angular. Sand: FS-CS, 70% mafic, angular, poorly sorted. 2.5yr 4/2, dark gray brown. No rxn HCL. Moist.	
75	G				

Reported By: Cameron Penner-Ash
Title: Geologist
Signature: [signature] Date: 5/19/15

Reviewed By: Kevin Bergstrom
Title: Sr. Geologist
Signature: [signature] Date: 7/22/15

A-6003-642 (03/03)

BOREHOLE LOG

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Date: 5/19/15

Well ID: C8913	Well Name: 299-E26-15	Location: 20m South of Catch Basin 242AL-43
Project: 8 M24 TPAGW Monitoring Well		Reference Measuring Point: ground surface

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
80	G			75'-85' Gravel (G) 80% Gravel, 15% Sand 5% silt. Gravel: VCP-VFP, cobbles/VCP = well rounded, VFP = angular, max: 75mm, 80% mafic. Sand: FS-CS, 70% mafic, poorly sorted. 2.5yr 4/2, dark grey brownish. No rxn to HCL. Moist.	• Drilling: AP1000 Becker Hammer • Grab samples every 5'. • 9 3/8" OD Temp. Casing used. • 0'-10' bgs, no grab samples collected due to possible contamination. • Drillers adding water (~2gal / 5ft) for dust supression.
85	G			85'-95' Sandy Gravel (sG) 70% Gravel, 30% Sand. Gravel: MP-VCP, max: 70mm, 90% mafic, submounded. Sand: CS-VCS, well sorted, angular, 70% mafic. 2.5yr 4/1, dark grey. No rxn to HCL. Moist.	
90	G				
95	G			@ 95' bgs ↑ Trace silt 95'-190' Gravel (G) 80% Gravel, 20% Sand. Gravel: CP-FP, max: 20mm, 80% mafic, angular, poorly sorted. Sand: CS, well sorted, angular, 80% mafic. 2.5yr 3/1, very dark grey, no rxn to HCL. Moist.	
100	G				
105	G			@ 105' bgs Max clast ↑ 65mm	
110	G				
115	G				

Reported By: Cameron Penner-Ash		Reviewed By: Kevin Bergstrom	
Title: Geologist		Title: Sr. Geologist	
Signature: [signature]	Date: 5/19/15	Signature: [signature]	Date: 7/22/15

A-6003-642 (03/03)

BOREHOLE LOG

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Date: 5/14/15

Well ID: C8913	Well Name: 299-E26-15	Location: 20m South of Catch Basin 242AL-43
Project: 8 M24 TPA GW Monitoring Wells		Reference Measuring Point: ground surface

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
120	G			95'-190' Gravel (G) 80% Gravel, 20% Sand, Gravel: CP-FP, max: 20mm, 80% mafic, angular, poorly sorted. Sand: CS, well sorted, angular, 80% mafic. 2.5 yr 3/1, very dark gray. No rxn to HCl. Moist.	• Drilling: AP1000 Becker Hammer • Grab samples every 5'. • 9 3/8" OD Temp casing used. • 0'-10' bgs, no grab samples due to possible contamination • Drillers adding water (~2 gal/5 ft) for dust suppression.
125	G			@ 125' bgs max: 80mm	
130	G				
135	G				
140	G			@ 140' bgs max: 200mm	
145	G			@ 145' bgs ↑ Silt to trace	
150	G				
155	G				

Reported By: Cameron Penner-Ash		Reviewed By: Kevin Bergstrom	
Title: Geologist		Title: Sr. Geologist	
Signature: [signature]	Date: 5/14/15	Signature: [signature]	Date: 7/22/15

A-6003-642 (03/03)

BOREHOLE LOG

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Date: 5/19/15

Well ID: C8913	Well Name: 299-E26-15	Location: 20m South of Catch Basin 240AL-43	
Project: 8 MZU^TPA GW Monitoring Wells		Reference Measuring Point: ground Surface	

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
160	6			95'-190' Gravel (G) 80% Gravel, 20% Sand. Gravel: CP-FP, max: 20mm, 80% mafic, angular, poorly sorted. Sand: CS, well sorted, angular, 80% mafic. 2.5yr 3/1, very dark gray. no rxn to HCL, moist.	• Drilling: AP1000 Becur Hammer. • Grab Samples every 5'. • 9 7/8" OD Temp Casing used. • 0'-10' bgs, no grab Samples due to possible Contamination. • Drillers adding water (~2 gal / 5 ft) for dust Suppression.
165	6				
170	6				
175	6			@ 175' bgs Pebbles become more rounded.	
180	6			@ 180' bgs Color change: 5yr 3/1, dark olive gray.	
185	6			@ 185' bgs Color change: 2.5yr 4/3, Olive brown.	
190	6			190'-208' Sandy Gravel (SG) 60% Gravel 40% Sand. Gravel: FP-CP, max: 30mm, 90% mafic, angular, poorly sorted. Sand: CS, well sorted, angular, 90% mafic. 5yr 3/2, dark olive gray. No rxn to HCl, Moist.	Reached DTB @ ~~199.1'~~ 206.9' bgs on 5/20/15 Shoe @ ~~199.1'~~ 206.2' bgs
200	6	200.4 5/20/15		@ 200' bgs max: 200 mm Cobble	DTW encountered @ 200.4' bgs on 5/20/15

Reported By: Cameron Pinner-Ash		Reviewed By: Kevin Bergstrom	
Title: Geologist		Title: Sr. Geologist	
Signature: [signature]	Date: 5/19/15	Signature: [signature]	Date: 7/22/15

A-6003-642 (03/03)

BOREHOLE LOG

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Date: 5/19/15

Well ID: C8913	Well Name: 299-E26-15	Location: 20 m South of Catch Basin 242AL-43
Project: 8 M24 TPA GW Monitoring wells		Reference Measuring Point: ground Surface

Depth (Ft.)	Sample Type No.	Sample Blows Recovery	Graphic Log	Sample Description: Group Name, Grain Size Distribution, Soil Classification, Color, Moisture Content, Sorting, Angularity, Mineralogy, Max Particle Size, Reaction to HCl	Comments: Depth of Casing, Drilling Method, Method of Driving Sampling Tool, Sampler Size, Water Level
205	6			190' - ~~208'~~ 206.9' Sandy Gravel (sG) 60% Gravel 40% Sand. Gravel: FP-CP, max: 200mm, 90% mafic, angular, poorly sorted. Sand: CS, well-sorted, angular, 90% mafic. Syr 3/2, dark olive gray. Nonxn to HCl, moist.	• Drilling: AP1000 Becker Hammer • Grab samples every 5'. • 9"8 OD Temp. Casing used.
210				206.9 - basalt encountered Total Depth: 206.9' bgs 5/20/15 Depth to water: 200.4' bgs 5/20/15	• 0'-10' bgs, no grab samples due to possible contamination. • Drillers adding water (~2 gal / 5 ft) for dust suppression. - unable to collect archive of basalt; drill rig could not return a sufficient amount of basalt cuttings

Reported By: Cameron Penner-Ash		Reviewed By: Kevin Bergstrom	
Title: Geologist		Title: Sr. Geologist	
Signature: [signature]	Date: 5/19/15	Signature: [signature]	Date: 7/22/15

A-6003-642 (03/03)