Pawnee Station, Morgan County, Colorado

Monitoring Well Installation Report

Pawnee Station

Xcel Energy

February 1, 2016

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Table of Abbreviations and Acronyms

Abbreviation	Definition
AMSL	above mean sea level
BGS	below ground surface
BTOC	below top of casing
CCR	Coal Combustion Residuals
cm/sec	centimeter per second
HP Geotech	Hepworth-Pawlak Geotechnical, Inc.
µS/cm	microsiemens per centimeter
NTU	nephelometric turbidity unit
PSCo	Public Service Company of Colorado
TOC	top of casing
USCS	Unified Soil Classification System

1.0 Introduction

The purpose of this Monitoring Well Installation Report is to document details pertaining to the drilling, construction, and development of three groundwater monitoring wells installed at the Xcel Energy Pawnee Generating Station (Pawnee Station) in Morgan County, Colorado (**Figure 1**). The groundwater monitoring system is intended to support compliance with the U.S. Environmental Protection Agency's final Coal Combustion Residuals (CCR) Rule (40 CFR Parts 257 and 261). Pawnee Station has one CCR landfill unit subject to the CCR Rule. The drilling and well installation was performed in accordance with the State of Colorado Water Well Construction Rules (2 Code of Colorado Regulations 402-2).

HDR was contracted to locate, design, permit and oversee the installation of the three groundwater monitoring wells at Pawnee Station. HDR retained Hepworth-Pawlak Geotechnical, Inc. (HP Geotech) to provide on-site drilling services, while HDR provided oversight of the drilling, well installation, and development. All on-site personnel completed the site-specific safety training. Additionally, daily safety briefs were conducted by the on-site project team prior to commencing work. The training and safety briefs were documented in accordance with the *PSCo CCR Rule Compliance Health & Safety Plan.*

2.0 Background Information

Prior hydrogeologic and geotechnical investigations have been conducted at Pawnee as documented in reports identified and summarized in the Pawnee Monitoring Well Installation Plan (HDR, 2015). Dune sand deposits are present at the Pawnee Station CCR landfill, which overlie a fine-grained soil (weathered Pierre Shale) and Pierre Shale Formation bedrock. Groundwater is generally found at the bedrock and residual soil contact. Dune sands in the CCR landfill area overlay the residual soil and generally do not contain water; however, perched water-table conditions can be present in localized areas underlain by low-permeability material (PSCo, 2015).

Regional groundwater flow is generally to the northeast across the site towards the South Platte River; however, a bedrock high, trending northwest to southeast, is present beneath the landfill area, resulting in a radial flow away from the landfill on the eastern side (PSCo, 2015; shown in **Figure 2**).

The three new monitoring wells installed at Pawnee Station (PNMW-12, -13, -14; **Figure 2**) were sited based on monitoring requirements in the CCR Rule, facility design, and existing hydrogeologic data for the vicinity, as described in the Groundwater Monitoring System Certification (HDR, 2015).

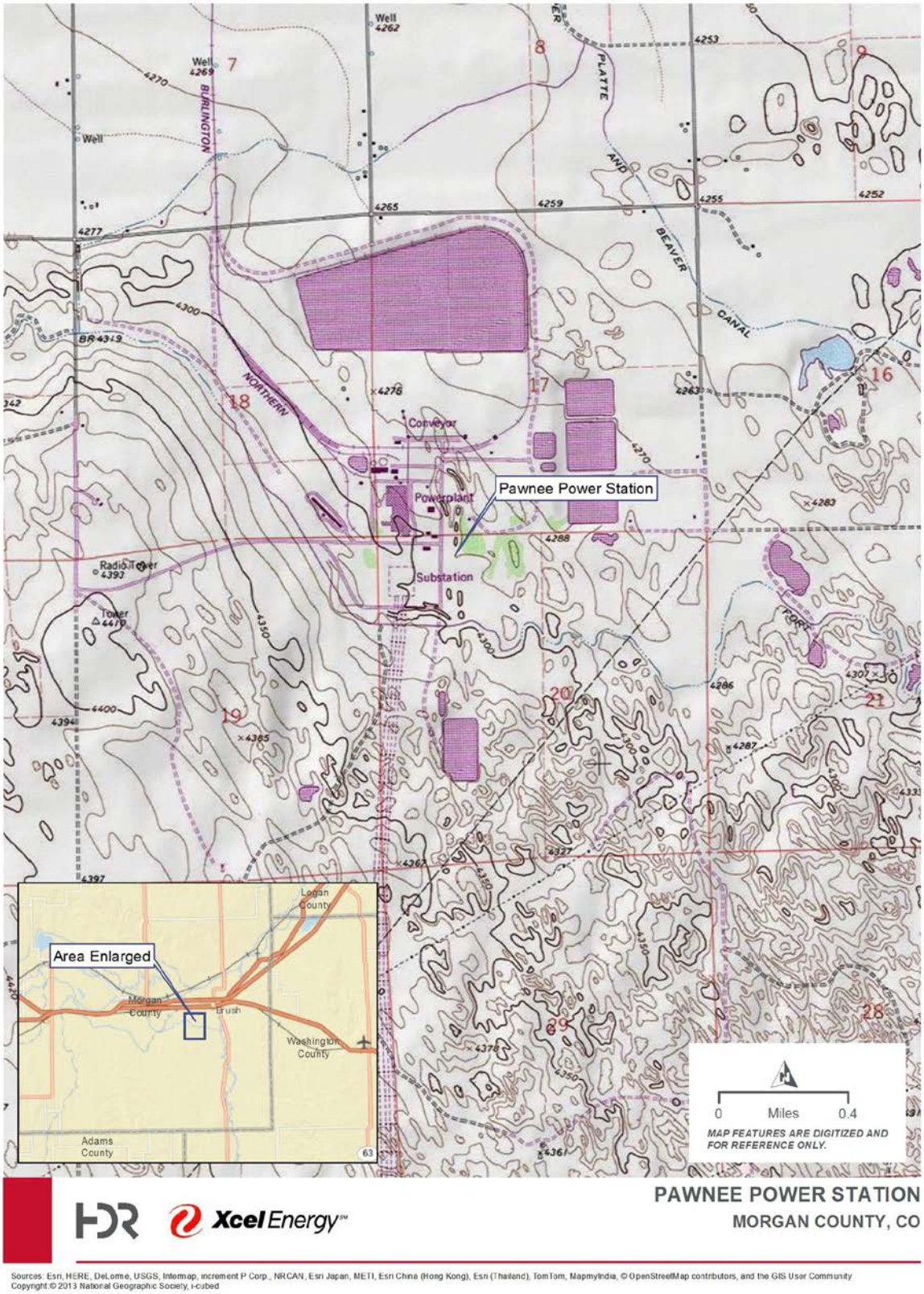


Figure 1. Vicinity Map for Pawnee Station

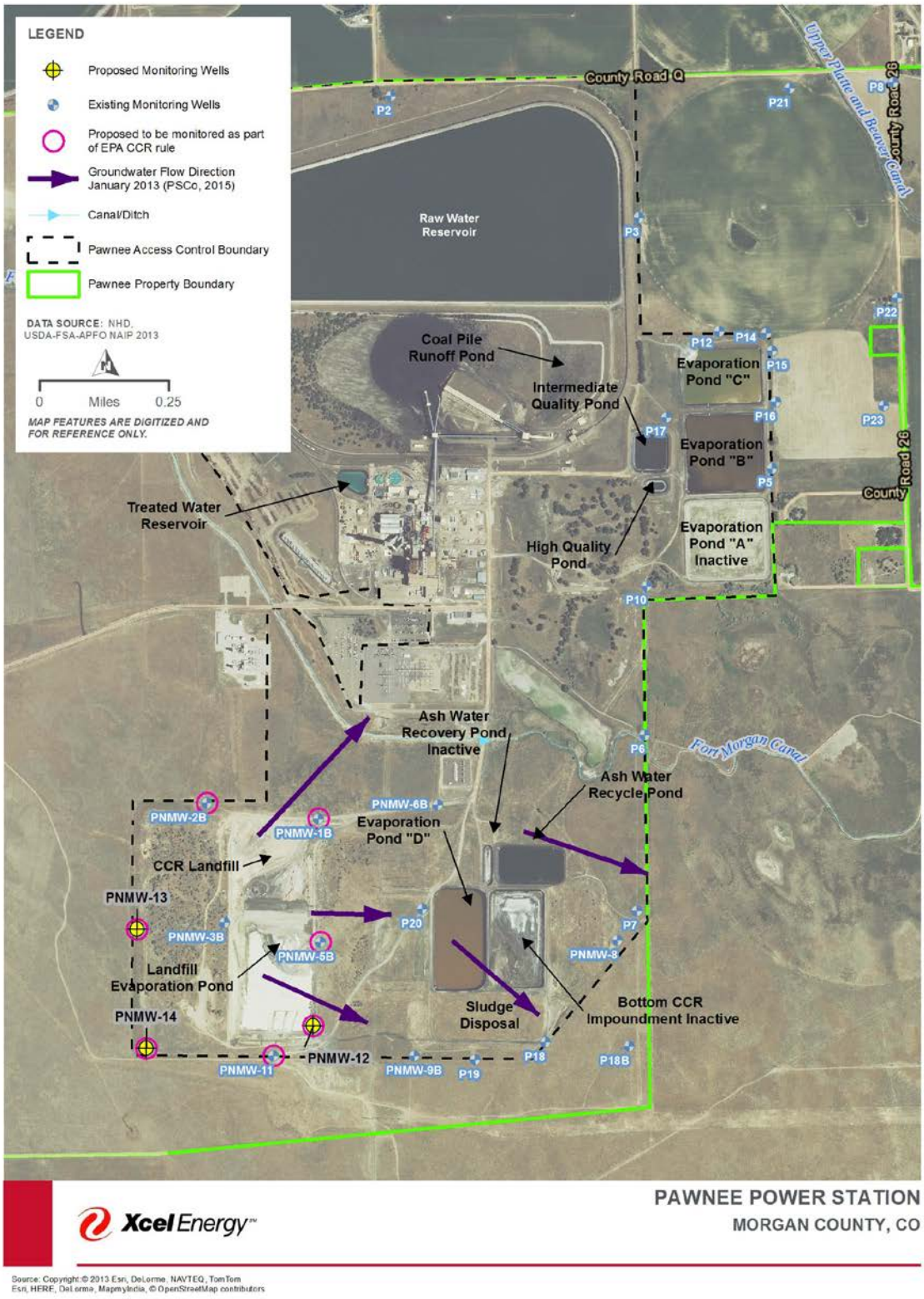


Figure 2. Well Location Map, Pawnee Station

3.0 Field and Laboratory Methods

3.1 Borehole Drilling

The boreholes for each well were drilled by HP Geotech using a hollow stem auger drilling method between November 16 and 18, 2015. Utility locations were identified prior to beginning drilling operations. However, to ensure the absence of any buried utilities, the driller advanced soil borings from the ground surface to a minimum depth of 8 feet using a pot-holing technique prior to drilling. The borehole was then advanced using the hollow stem auger drilling method with a CME-55 drill rig. The nominal borehole diameter was 6 inches to accommodate construction of 2-inch diameter wells.

Similar to the previously constructed groundwater monitoring wells on site[1], screen depth was targeted for placement above the Pierre Shale bedrock within the dune deposits. Therefore, as described in the Monitoring Well Installation Plan (HDR, 2015), all boreholes were drilled to the top of the Pierre Shale or to a depth of at least 10 feet below the water table, whichever was shallower. This resulted in boreholes with total depths of 50 and 70 feet below ground surface (bgs), as further described in **Section 4.3**.

An HDR geologist was present during drilling operations to collect samples and log the subsurface material, in addition to overseeing site safety and proper well construction. Soil samples from boreholes were collected in plastic bags and logged every 5 feet by the field geologist during drilling to document lithologic soil characteristics. The geologist visually classified soil type, consistency/relative density, color, and water content in accordance with the Unified Soil Classification System (USCS) as well as grain size, mineralogy, sorting, rounding, hardness, and matrix/clast support, among other textural properties. Samples were placed in sample bags labeled with the borehole identification and depth interval. One undisturbed soil sample from each well was collected within the well screen depth interval and submitted to a lab for hydraulic properties analysis, as described below in **Section 3.2**. Boring logs for each borehole are provided in **Appendix A**.

Soil cuttings, fluids, and potholing slurry generated during drilling were transported to and disposed of at the existing evaporation pond within the on-site ash landfill. Drilling equipment was decontaminated with potable water before moving to the next bore hole.

3.2 Soil Samples – Geotechnical Analysis

Soils were logged from the cutting returns during drilling and classified based on the USCS. During drilling, one undisturbed soil sample was obtained from each borehole at a depth coinciding with the interval of the well screen depth. An 18-inch long California Modified Style Split-Spoon Sampler was

[1] The existing wells on site are screened above the Pierre Shale bedrock. The screened intervals at these existing wells capture the higher of either the residual soil/dune sand contact or the residual soil/weathered bedrock, up to the maximum historic groundwater elevation. This screening interval intercepts potential seepage from the landfill through either the dune sand or transition zone bedrock (PSCo, 2015). This approach has worked well for the groundwater monitoring program conducted on the site and wells for this project were therefore similarly constructed.

used to collect the undisturbed core of sediment. The undisturbed soil samples (one from each well) were submitted to HP Geotech for analysis of the following parameters:

- Grain-size: Sieve and Hydrometer (ASTM D421/422)
- Total Porosity (SW9100)
- Bulk Density (ASTM D2937)
- Moisture Content (ASTM D2216)
- Specific Gravity (ASTM D854)

Analysis was completed in accordance with the method for grain-size analysis using sieve and hydrometer described in ASTM D421/422 (ASTM D421-85, 1998 and ASTM D422-63, 2007). Chain of custody documentation is provided in **Appendix B**.

3.3 Well Construction

Once the target drilling depth was reached at each location, 2-inch diameter, Schedule 40 PVC casing and well screens (0.010-inch slots) were assembled and lowered into each borehole. Approximately 30 feet of screen was installed in PNMW-12, -13, and -14.

After pvc casing and screen placement in the borehole, the filter pack sand and the bentonite pellet seal were placed via gravity feed from the surface into the annular space. The filter pack consisted of 10-20 (sieve size) washed silica sand emplaced from the bottom of the hole to approximately 5 feet above the well screen. An annular seal of bentonite pellets was placed to 5 feet above the top of the filter pack and hydrated for 12 hours after placement. HP Geotech then used a tremie pipe to place bentonite grout above the bentonite seal to within approximately two feet of the surface.

An annular surface seal consisting of neat cement was installed from the top of the bentonite grout to the surface. All wells were finished with a 2-foot-by-2-foot concrete pad. Each well included between 3 and 4 feet of PVC stick-up. Three bollards were installed at PNMW-12, and no bollards were installed at PNMW-13 or PNMW-14. Each well was secured with a protective steel casing and lock. Well construction is further described in **Section 4.3**.

3.4 Well Development

Wells were developed over several days to improve hydraulic connectivity in the area immediately surrounding the well and remove any fluids introduced during drilling. Well development involves removing as much of the introduced drilling fluids, cuttings, and particulates from within and adjacent to the well as possible. Development did not begin until at least 12 hours after the wells had been grouted to ensure grout had sufficiently set.

Wells were developed by surge blocking and pumping. This method involves moving a surge block up and down the well screen and casing which alternately forces water in and out of the screen, loosens sediment, and draws fine-grained materials into the well, then removing the purge water and fine sediment from the well using a pump.

The duration of development; initial water level; well depth; method; and field parameter measurements of pH, specific conductance, temperature, and turbidity were recorded on the

development record for each well. The amount of purge water removed from each well was estimated in the field. Field parameters were recorded approximately every 5 minutes of discharge and checked more often for wells with slow recharge. Well development continued until field parameters stabilized. Stabilized field parameters were defined as three consecutive readings where temperatures were within 1°C, pH readings were within 0.2 standard units, and conductivity within 10 percent, and turbidity values were less than 10 nephelometric turbidity units (NTU). The field manager was notified when field parameters stabilized, and development ceased when the water was visually free of suspended solids. Purge water was placed into drums and/or buckets and disposed of at the CCR landfill. All three wells took considerable time to develop, between four and six days. All non-dedicated down-well equipment used during development was decontaminated.

3.5 Well Survey

Surveying of the monitoring wells was performed by professional surveyor, Edward-James Surveying, Inc. after well completion. The surveyor recorded elevations of the top of PVC casing (point at notch on the north side of the casing top) and ground surface using a level loop. The northing and easting coordinates of the wells were also surveyed.

3.6 Groundwater Level Measurement and Aquifer (Slug) Testing

HDR performed slug tests on monitoring wells PNMW-12, PNMW-13, and PNMW-14 on December 9, 2015 to calculate hydraulic conductivity for the shallow unconfined aquifer. A 1.5-inch diameter by 2.7-foot long watertight slug was used. Given a 2-inch diameter well, an expected slug displacement of 1.52 feet is estimated for the slug. A transducer was suspended on a communications cable near the bottom of the well, and recorded water level measurements at 1-second intervals. Both slug-in and slug-out tests were performed. Slug-in tests were completed by dropping the slug into the water column as quickly as possible, and measuring the falling water level that followed. Slug-out tests were completed after each slug-in test by removing the slug from the water column as quickly as possible and measuring the rising water level that followed. Well-specific testing details are summarized below:

- PNMW-12: One slug-in and one slug-out test were performed on December 9, 2015. The depth to water in the well was 33.00 feet below top of casing. With a well screen interval of 20-50 feet bgs and a casing stick-up of 3.86 feet, 9.14 feet of the well screen was exposed to the vadose zone.

- PNMW-13: One slug-in and one slug-out test were performed on December 9, 2015. The depth to water in the well was 42.68 feet below top of casing. With a well screen interval of 20-50 feet bgs and a casing stick-up of 3.89 feet, 18.79 feet of the well screen was exposed to the vadose zone.

- PNMW-14: One slug-in and one slug-out test were performed on December 9, 2015. The depth to water in the well was 59.32 feet below top of casing. With a well screen interval of 40-70 feet bgs and a casing stick-up of 4.00 feet, 15.32 feet of the well screen was exposed to the vadose zone.

Slug test data was downloaded from the Rugged Reader at the end of each working day and saved locally to a laptop. All non-dedicated down-well equipment used during slug testing was decontaminated.

3.7 Decontamination of Field Equipment

Field instrumentation (such as interface probes or water quality meters) was decontaminated between sample locations by rinsing with an Alconox/distilled water solution followed by a potable water rinse and a final rinse with deionized water.

4.0 Field and Laboratory Results

4.1 Borehole Drilling

Boring logs for each borehole are provided in **Appendix A**. Soil cuttings from the borehole samples, which consisted primarily of fine to medium grained sand and silty sand, were dry at all three wells from the ground surface to approximately 50 to 55 feet. At two boreholes, PNMW-12 and -13, silty sand and sand, respectively, were encountered with shale at approximately 45 to 50 feet, respectively. This was presumed to be the top of the Pierre Shale formation. Moist sediment was encountered at only one boring, well PNMW-14, during drilling, at a depth of approximately 55 feet bgs. Shale was encountered at PNMW-14 at approximately 69 feet bgs.

4.2 Soil Samples – Geotechnical Analysis

The undisturbed soil samples collected from the well screen depth interval of each borehole were analyzed for grain size and porosity by HP Geotech, and are summarized in **Table 1**. The soils laboratory results are presented in **Appendix B**.

Laboratory results show the wells are screened in sandy silt, with porosities between 32 and 40 percent, which is consistent with the silty sand material noted in the drilling logs.

Table 1. Summary of Geotechnical Testing Results

Well I.D.	Sample Depth (ft BGS)	Gradation			Total Porosity (%)	Moisture Content (%)
		Gravel (%)	Sand (%)	Silt and Clay (%)		
PNMW-12	44	0	34	66	39.5	20.4
PNMW-13	34	0	38	62	31.7	14.7
PNMW-14	69	0	31	69	39.7	21.4

Note:
BGS = below ground surface

4.3 Well Construction

A diagram for each well documenting well construction is provided in **Appendix C**. Approximately 30 feet of screen was installed in each well. The screen was placed from approximately 20 to 50 feet bgs in wells PNMW-12 and PNMW-13, directly above the Pierre Shale formation. In well PNMW-14, the water table was encountered at approximately 55 feet bgs during drilling, and shale was encountered at approximately 69 feet bgs. The screen was placed from approximately 40 to 70 bgs at PNMW-14. Well construction details for all three wells are summarized in **Table 2**. State well construction permits are included in **Appendix D**.

Table 2. Well Construction Details for Groundwater Monitoring Wells PNMW-12, PNMW-13, PNMW-14 at Pawnee Station									
Well I.D.	**Northing (State Plane, NAD 1983 UTM Zone 13 N meters)**	**Easting (State Plane, NAD 1983 UTM Zone 13 N meters)**	**Elevation TOC (feet AMSL)**	**Well Total Depth (feet BGS)**	**Depth of Screen Interval (feet BGS)**	**Well Stickup (feet)**	**Casing Type**	**Depth to Water (feet BTOC)**	**Static Water Level (feet AMSL)**
PNMW-12	612111.7569	4451517.214	4348.34	50	20-50	3.83	2-inch Sch. 40 PVC	32.89	4315.45
PNMW-13	611555.4201	4451735.628	4378.11	50	20-50	3.90	2-inch Sch. 40 PVC	42.78	4335.33
PNMW-14	611555.2833	4451488.609	4376.96	70	40-70	4.00	2-inch Sch. 40 PVC	59.34	4317.62

Notes:
TOC = top of casing
BTOC = below top of casing
BGS = below ground surface
AMSL = above mean sea level

4.4 Well Development

Wells were developed over several weeks (November 19 through December 7, 2015). Development was considered relatively difficult for all three wells, due primarily to high turbidity readings and relatively slow recharge rates. On December 4, 2015, parameters stabilized after approximately 70 gallons of water was removed from PNMW-12. On December 7, 2015 the field parameters stabilized at PNMW-13 after 64 gallons of water had been removed. Development of PNMW-14 was completed on December 4, 2015 after 127 gallons of water had been removed. Water quality parameters measured in the field after development are noted in **Table 3**.

Table 3. Field Water Quality After Well Development

Well I.D.	Conductivity (µS/cm)	pH	Temperature (degrees C)	Turbidity (NTU)
PNMW-12	621	7.30	14.3	0.9
PNMW-13	583	7.61	14.1	9.4
PNMW-14	377.3	7.78	14.3	3.0

Notes:
µS/cm = microsiemens per centimeter
NTU = nephelometric turbidity unit

4.5 Well Survey

Survey coordinates and elevations are provided in **Table 2**.

4.6 Groundwater Level Measurement and Aquifer (Slug) Testing

All slug-in and slug-out tests were analyzed using the Dagan (1978) slug test solution for unconfined aquifers, and implemented using Aqtesolv® v4.5. Each well screen intersected the water table (i.e., was partially submerged) during the slug testing. An effective casing radius correction was applied using Aqtesolv® to account for drainage to and from the filter pack. For this correction, a well radius of 0.25 foot was used and an equipment radius of 0.005 foot was specified for the transducer cable. The aquifer at each location was represented with the following estimates of saturated thickness: 20.83 feet (MW-12), 11.22 feet (MW-13), and 14.68 feet (MW-14). An anisotropy ratio of 1 (unitless) was assigned to the aquifer at each well location.

Initial displacement created by the slug, and hydraulic conductivity results for the slug testing are shown in **Table 4**. In all but one test, the initial displacement was less than the expected displacement of 1.52 feet; it is suspected that this is attributable either to filter pack effects or to the transducer not recording quickly enough to read the initial displacement at the moment it reached maximum. Plots of the analyses are included in **Appendix E**. The geometric mean of the hydraulic conductivity calculated at PNMW-12, PNMW-13, and PNMW-14 is 3.51×10^{-3} cm/sec (9.95 feet per day). This value corresponds with the textbook range of 10^{-5} to 10^{-1} cm/sec for silty sand by Freeze and Cherry (1979), which generally agrees with the range of formation materials noted in the boring logs (very fine to fine silty sand at PNMW-12, medium silty sand at PNMW-13, and fine silty sand at PNMW-14) and the geotechnical sediment sampling.

Table 4. Slug Testing Results			
Well	**Test Name**	**Initial Displacement (feet)**	**Hydraulic Conductivity (cm/sec)**
PNMW-12	Slug In	1.72	2.22E-03
PNMW-12	Slug Out	1.16	2.39E-03
PNMW-13	Slug In	0.99	3.45E-03
PNMW-13	Slug Out	1.26	5.90E-03
PNMW-14	Slug In	1.22	2.06E-02
PNMW-14	Slug Out	1.47	8.33E-04
		Geometric Mean	**3.51E-03**

5.0 References

Dagan, G., 1978. A note on packer, slug, and recovery tests in unconfined aquifers, Water Resources Research, vol. 14, no. 5. pp. 929-934.

HDR, 2015. Monitoring Well Installation Plan for Compliance with the Coal Combustion Residuals (CCR) Rule, Xcel Energy Pawnee Station. November 30, 2015.

Fetter, C. W., 1994. Applied Hydrogeology, 3rd ed. Upper Saddle River, NJ: Prentice Hall, Inc.

Freeze, R.A. and J.A. Cherry, 1979. Groundwater, Prentice-Hall, Inc., Englewood Cliffs, NJ.

Public Service Company of Colorado, 2015. PSCo Pawnee Station Landfill 2014 Annual Groundwater Monitoring Report. January 31, 2015.

Xcel Energy, 2011. Pawnee Station Landfill Ground Water Monitoring Plan. February, 2011.

Appendix A

Borehole Logs

Boring Log

Project Name	Project No.	Drilling Company
Xcel CCR	266180-006	HP Geotech
Boring No.	**Location**	**Drilling Rig Type and Drilling Method**
PNMW-12	Pawnee Station	CME-55 Hollow Stem Auger (6-inch diameter)

Sample No.	Blow Count	Depth (feet)	Description (USCS)	Elevation (feet)	Remarks
1	N/A		Brown yellow 10YR 6/8; Fine-medium SAND (SP); Dry		Pothole to 8 ft
2	N/A	5	Pale brown 10YR 6/3; Fine-medium SAND (SP); Dry		
3	7-10-12 (SS)	10	Pale brown 10YR 6/3; Fine silty SAND (SM); Dry		SS=Split spoon sampler
4	7-10-14 (SS)	15	Yellow brown 10YR 5/4; Fine silty SAND (SM); Dry		
5	7-12-16 (SS)	20	As above		
6	8-15-19 (SS)	25	Light yellow brown 10YR 6/4; Fine silty SAND (SM); Dry		
7	6-13-21 (SS)	30	Light olive gray 5Y 6/2; Silty SAND (SM) with trace carbonates; Dry		
8	50/10"	35	Olive yellow 2.5Y 6/6; Very fine SAND (SP) with trace SHALE; Dry		
9	50/10"	40	Light yellow brown 2.5Y 6/4; Very fine SAND (SP); Dry		
MW-12: 44' bgs	50/10"	45	Light yellow brown 7.5Y 6/4; Silty SAND (SM) w/SHALE; Dry		Soil sample submitted for geotech analysis
		50			

Total Depth (feet)	Water Level (feet)		Logged/Sampled By:	Drilled By:
	After Drilling:	Hours After:	Matthew Keaveney	HP Geotech
50	--	--	Date Started: 11/16/2015	Date Completed: 11/16/2015

Boring Log

Project Name	Project No.	Drilling Company
Xcel CCR	266180-006	HP Geotech

Boring No.	Location	Drilling Rig Type and Drilling Method
PNMW-13	Pawnee Station	CME-55 Hollow Stem Auger (6-inch diameter)

Sample No.	Blow Count	Depth (feet)	Description (USCS)	Elevation (feet)	Remarks
1	N/A		Brown 10YR 4/3; Fine-medium SAND (SP); Dry		Pothole to 8 ft
2	N/A	5	Light yellow brown 2.5Y 6/4; Fine-medium SAND (SP); Dry		
3	2-2-3	10	Yellow brown 10YR 5/4; ; Fine-medium SAND (SP); Dry		
4	3-3-5	15	As above		
5	7-14-12	20	Light yellow-brown 10YR 6/4; Fine-medium SAND (SP); Dry		
6	8-15-19 (SS)	25	Light yellow-brown 2.5YR 6/4; Fine SAND (SP); Dry		SS=Split spoon sampler
7	13-15-13	30	Light yellow-brown 2.5YR 6/4; Medium SAND (SP); Dry		
MW-13: 34' bgs	12-20-2	35	Light olive brown 2.5Y 5/4; Fine-medium SAND (SP); Dry		Soil sample submitted for geotech analysis
9	50/11"	40	Light olive brown 2.5Y 5/3; Fine-medium SAND (SP); Dry		
10	50/9"	45	Light olive brown 2.5Y 5/3; Silty SAND (SM); Dry		
11	5/4"	50	Light olive brown 7.5Y 5/3; Fine SAND (SP) and Shale; Dry		

Total Depth (feet)	Water Level (feet)		Logged/Sampled By:	Drilled By:
	After Drilling:	Hours After:	Matthew Keaveney	HP Geotech
50	--	--	Date Started: 11/18/2015	Date Completed: 11/18/2015

Boring Log

Project Name	Project No.	Drilling Company
Xcel CCR	266180-006	HP Geotech

Boring No.	Location	Drilling Rig Type and Drilling Method
PNMW-14	Pawnee Station	CME-55 Hollow Stem Auger (6-inch diameter)

Sample No.	Blow Count	Depth (feet)	Description (USCS)	Elevation (feet)	Remarks
1	N/A		Brown 10YR 4/3; Fine Silty SAND (SM); Dry		Pothole to 8 ft
2	N/A		Brown 10YR 4/3; Fine SAND (SP); Dry		
3	4-6-6 (SS)	10	Light yellowish brown 2.5Y 6/4; Fine SAND (SP); Dry		SS=Split spoon sampler
4	5-8-8 (SS)		As above		
5	9-12-13 (SS)	20	Yellowish brown 10YR 5/6; Fine-medium Silty SAND (SM); Dry		
6	50/10"		Light yellowish brown 2.5Y 6/3; Fine SAND (SP); Dry		
7	50/11"	30	Light yellowish brown 2.5Y 6/4; Very fine SAND (SP); Dry		
8	50/11"		As above		
9	10-15-18(SS)	40	As above		
10	10-14-15(SS)		As above		
11	8-14-17 (SS)	50	Light yellowish brown 10YR 6/4; Very fine SAND (SP); Dry		
12	9-13-13 (SS)		Light olive brown 2.5Y 5/4; Very fine SAND (SP); Moist		Moist
13	5-9-12 (SS)	60	Light olive brown 2.5Y 5/4; Silty SAND (SM); Wet		Wet
14	5-7-10 (SS)		As above		
MW-14: 69' bgs	50/9"	70	Light olive brown 2.5Y 5/4; Silty SAND (SP) with trace SHALE; Wet		Undisturbed sample submitted for geotech analysis

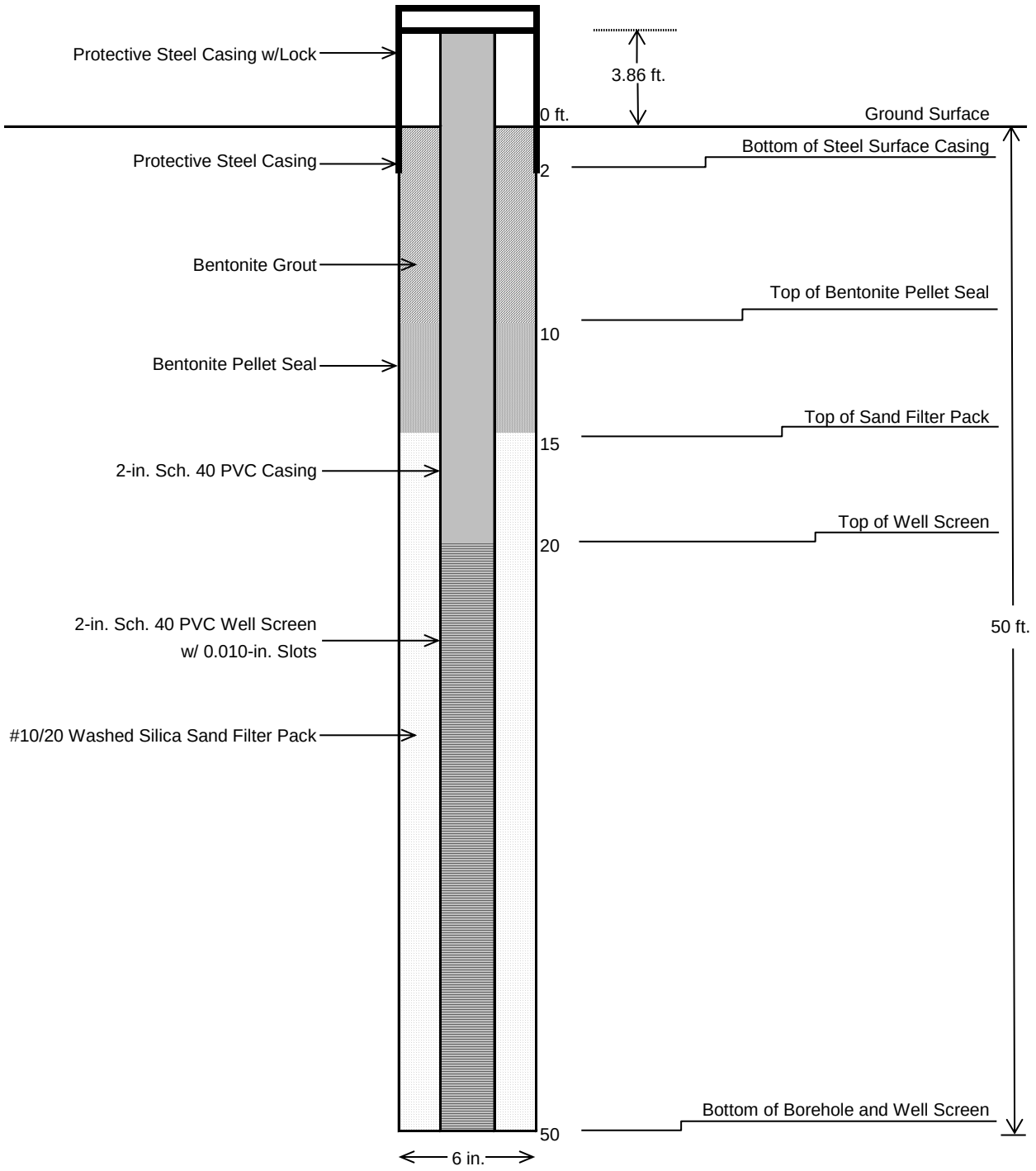
Total Depth (feet)	Water Level (feet)		Logged/Sampled By:	Drilled By:
	After Drilling:	Hours After:	Date Started:	Date Completed:
70	59.00	24	11/18/2015	11/18/2015

Matthew Keaveney

HP Geotech

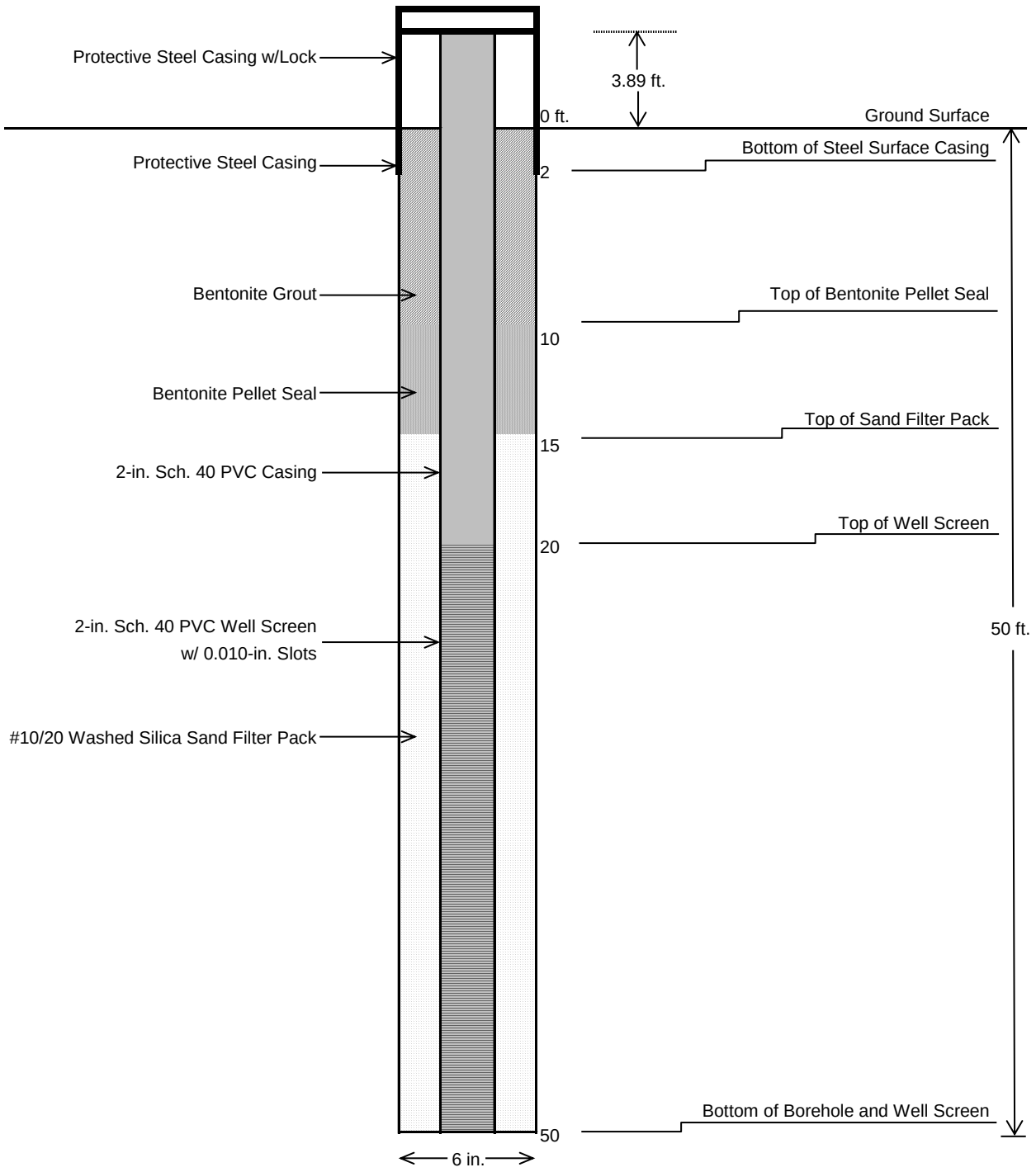
Appendix B

Well Construction Diagrams



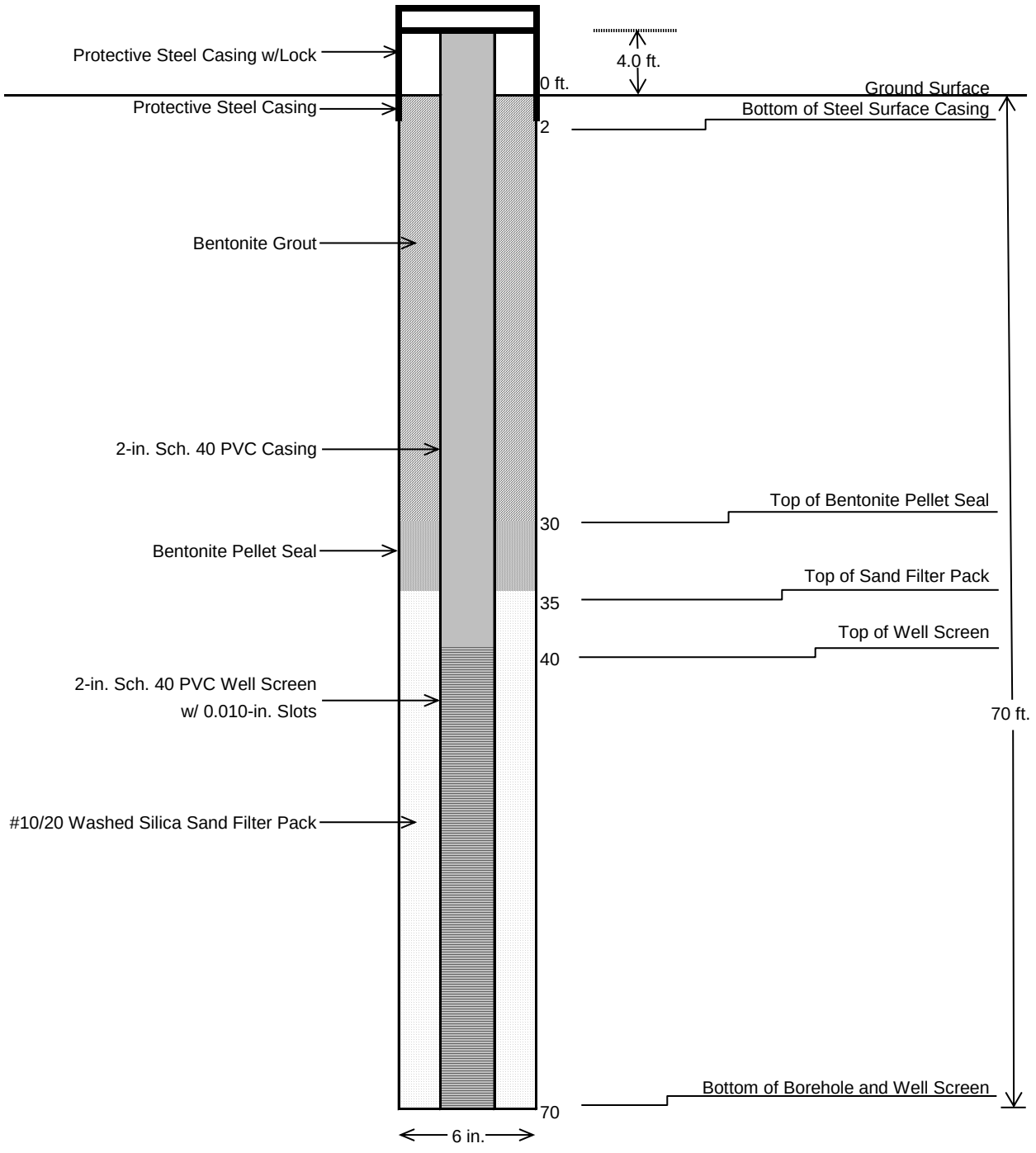
Constructed: **11/16/2015**
Drilled By: **HP Geotech**
PVC Casing EL: **4348.34 ft amsl**
Water EL: **4315.45 ft amsl (December 2015)**

Monitoring Well Construction Diagram
PNMW-12
Pawnee Station
Xcel Energy



Constructed: **11/18/2015**
Drilled By: **HP Geotech**
PVC Casing EL: **4378.11 ft amsl**
Water EL: **4335.33 ft amsl (December 2015)**

Monitoring Well Construction Diagram
PNMW-13
Pawnee Station
Xcel Energy



Constructed: **11/16/2015**
Drilled By: **HP Geotech**
PVC Casing EL: **4376.96 ft amsl**
Water EL: **4317.62 ft amsl (December 2015)**

Monitoring Well Construction Diagram
PNMW-14
Pawnee Station
Xcel Energy

Appendix C

Geotechnical Analysis Laboratory Reports

Hepworth-Pawlak Geotechnical, Inc.
10302 South Progress Way
Parker, Colorado 80134
Phone: 303-841-7119
Fax: 303-841-7556
www.hpgeotech.com

December 14, 2015

Anna Lundin
HDR
1670 Broadway, Suite 3400
Denver, CO 80202

215333B
Anna.Lundin@HDRinc.com

Subject: Laboratory Tests Results – Xcel Coal Combustion Residuals Rule Compliance Project, Pawnee Power Station.

Dear Ms. Lundin:

This letter presents the results of laboratory tests performed on samples submitted for the subject project. The test results are presented on the attached Figures 1-3 and Table 1.

If there are any questions, please feel free to contact us.

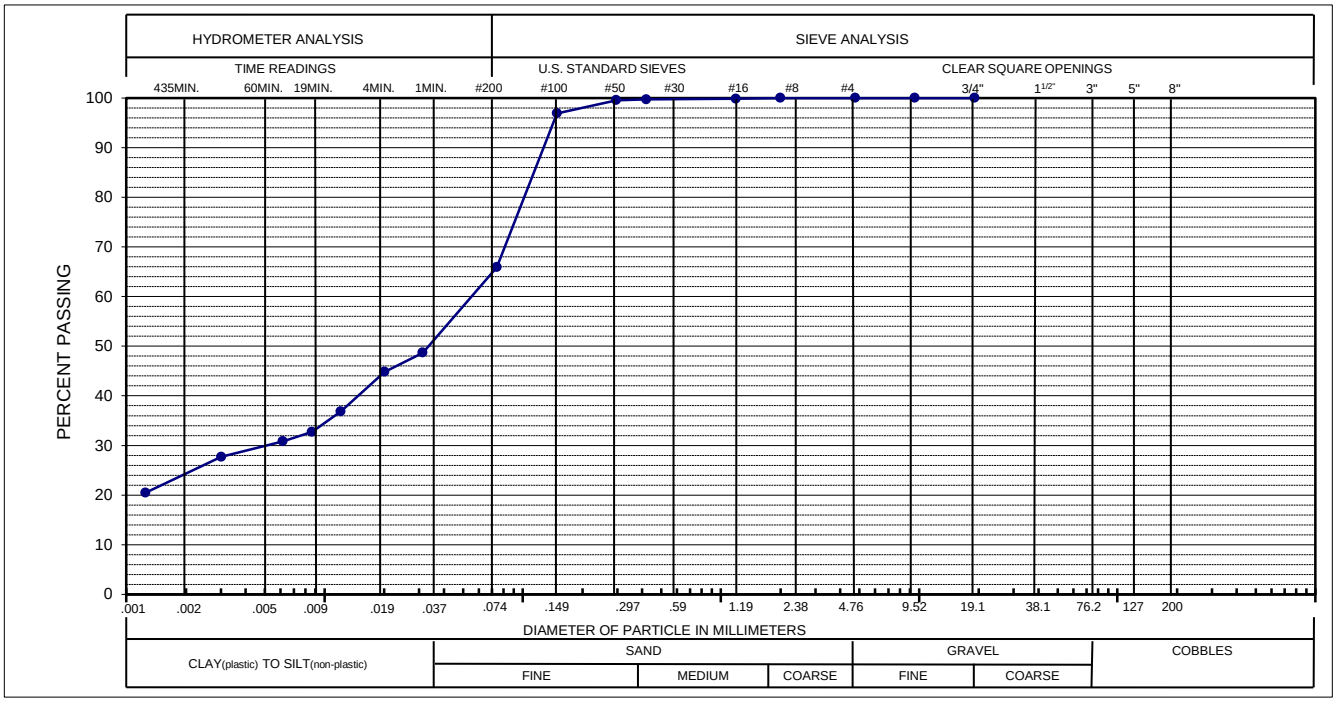
Sincerely,

HEPWORTH-PAWLAK GEOTECHNICAL, Inc.

Cuong Vu, Ph.D., P.E.

Reviewed by: Arben Kalaveshi, P.E.

215333B (Pawnee) xmittal.doc



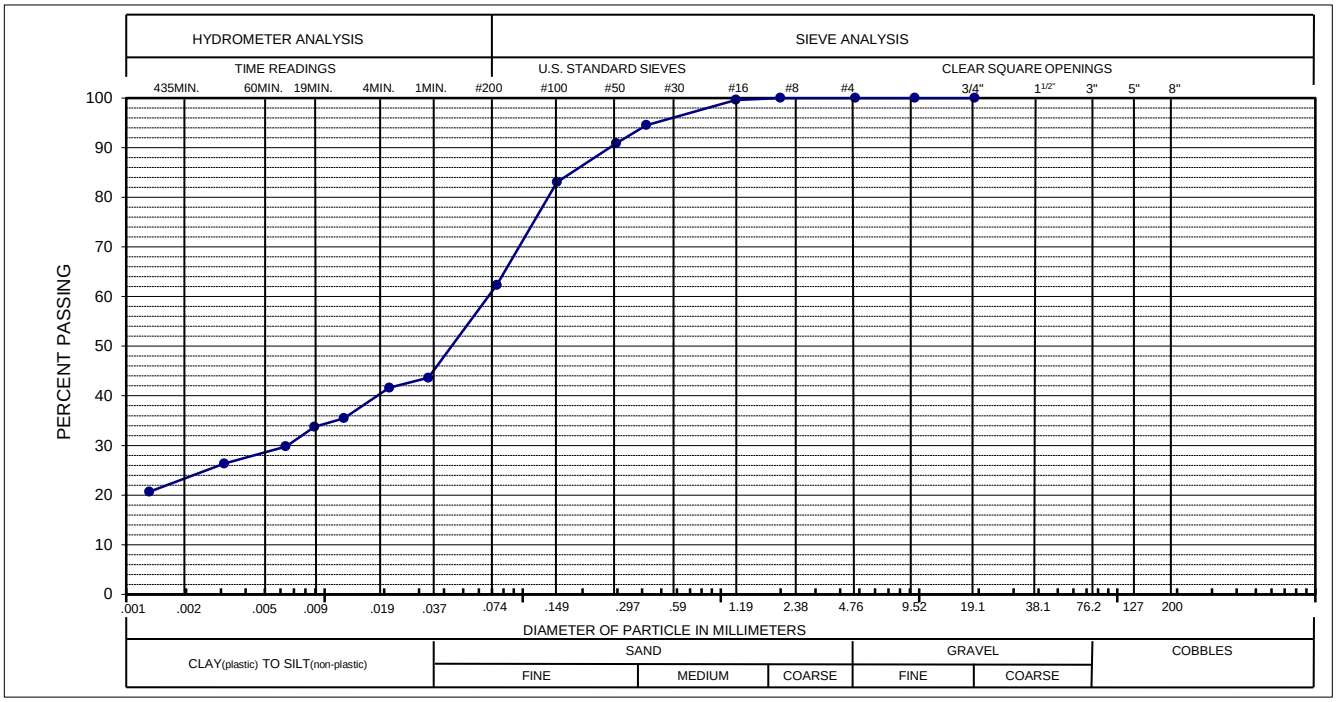
GRAVEL: 0%
BORING : MW12
DEPTH : 44 feet

SAND: 34%

SILT / CLAY: 66%
Specific Gravity: 2.83
Porosity : 39.5%

Sieve Size / Particle Diameter	Percent Passing
(1")	100
(3/4")	100
(1/2")	100
(3/8")	100
(#4)	100
(#10)	100
(#16)	100
(#40)	100
(#50)	100
(#100)	97
(#200)	66
0.0313	49
0.0201	45
0.0121	37
0.0086	33
0.0062	31
0.0030	28
0.0013	20

215333B	HEPWORTH-PAWLAK GEOTECHNICAL, INC.	HDR PAWNEE HYDROMETER AND SIEVE ANALYSIS	FIG. 1



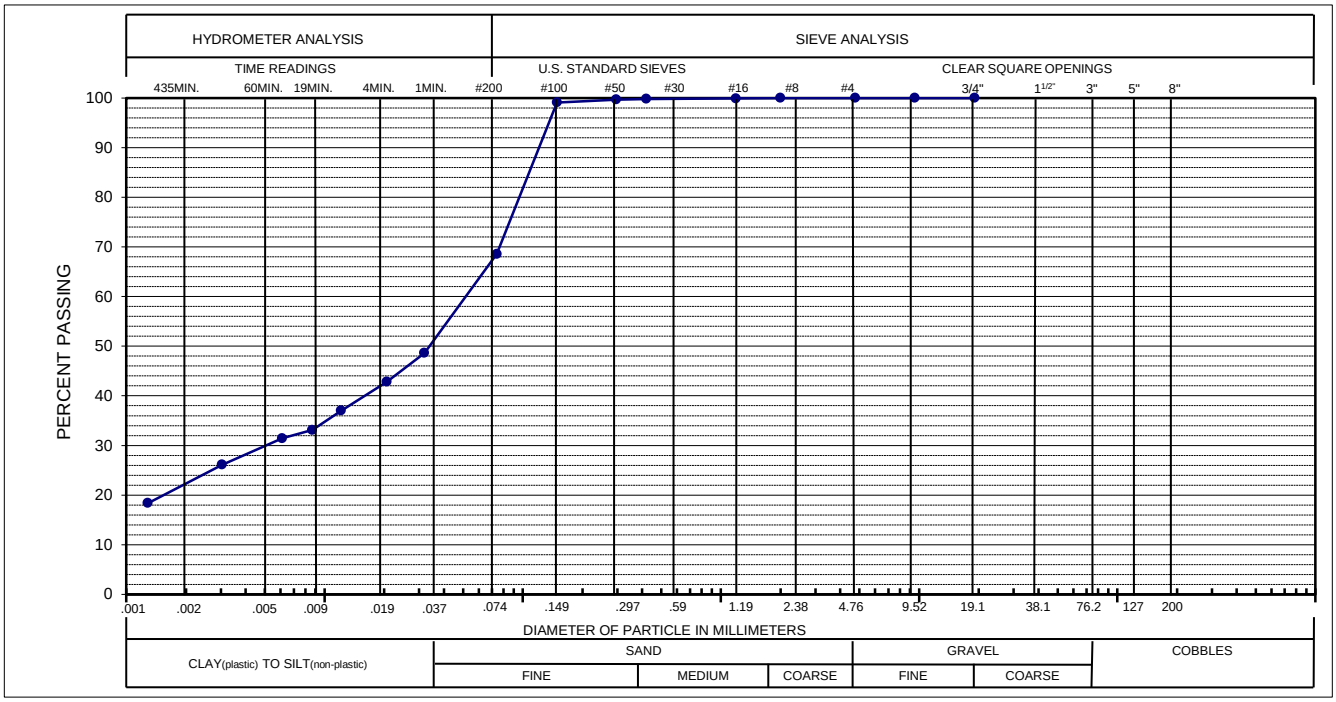
GRAVEL: 0% SAND: 38% SILT / CLAY: 62%

BORING : MW13 Specific Gravity: 2.72

DEPTH : 34 feet Porosity : 31.7%

Sieve Size / Particle Diameter	Percent Passing
(1")	100
(3/4")	100
(1/2")	100
(3/8")	100
(#4)	100
(#10)	100
(#16)	100
(#40)	95
(#50)	91
(#100)	83
(#200)	62
0.0334	44
0.0212	42
0.0125	35
0.0089	34
0.0064	30
0.0031	26
0.0013	21

215333B	HEPWORTH-PAWLAK GEOTECHNICAL, INC.	HDR PAWNEE HYDROMETER AND SIEVE ANALYSIS	FIG. 2



GRAVEL: 0%
SAND: 31%
SILT / CLAY: 69%
BORING : MW14
Specific Gravity: 2.81
DEPTH : 69 feet
Porosity : 39.7%

Sieve Size / Particle Diameter	Percent Passing
(1")	100
(3/4")	100
(1/2")	100
(3/8")	100
(#4)	100
(#10)	100
(#16)	100
(#40)	100
(#50)	100
(#100)	99
(#200)	69
0.0319	49
0.0206	43
0.0121	37
0.0087	33
0.0061	31
0.0030	26
0.0013	18

215333B	HEPWORTH-PAWLAK GEOTECHNICAL, INC.	HDR PAWNEE HYDROMETER AND SIEVE ANALYSIS	FIG. 3

HEPWORTH-PAWLAK GEOTECHNICAL, INC.

JOB NO. 215333B

PROJECT: PAWNEE

TABLE 1

SUMMARY OF LABORATORY TEST RESULTS

SAMPLE LOCATION		NATURAL MOISTURE CONTENT (%)	NATURAL DRY UNIT WEIGHT (PCF)	GRADATION			SPECIFIC GRAVITY	POROSITY (%)
BORING	DEPTH feet			GRAVEL (%)	SAND (%)	SILT & CLAY (%)		
MW12	44	20.4	107	0	34	66	2.83	39.5
MW13	34	14.7	116	0	38	62	2.72	31.7
MW14	69	21.4	106	0	31	69	2.81	39.7

Appendix D

State Well Permits

Form No.
GWS-25

OFFICE OF THE STATE ENGINEER
COLORADO DIVISION OF WATER RESOURCES

818 Centennial Bldg., 1313 Sherman St., Denver, Colorado 80203
(303) 866-3581

EXST

WELL PERMIT NUMBER 299821 -_____-____
DIV. 1 WD 1 DES. BASIN MD

APPLICANT

PUBLIC SERVICE COMPANY OF COLORADO
14940 CR 24
BRUSH, CO 80723-

(303) 571-7340

APPROVED WELL LOCATION
MORGAN COUNTY
SE 1/4 SE 1/4 Section 19
Township 3 N Range 56 W Sixth P.M.

DISTANCES FROM SECTION LINES
1129 Ft. from South Section Line
944 Ft. from East Section Line

UTM COORDINATES (Meters,Zone:13,NAD83)
Easting: Northing:

PERMIT TO USE AN EXISTING WELL

ISSUANCE OF THIS PERMIT DOES NOT CONFER A WATER RIGHT

CONDITIONS OF APPROVAL

1) This well shall be used in such a way as to cause no material injury to existing water rights. The issuance of this permit does not ensure that no injury will occur to another vested water right or preclude another owner of a vested water right from seeking relief in a civil court action.
2) The construction of this well shall be in compliance with the Water Well Construction Rules 2 CCR 402-2, unless approval of a variance has been granted by the State Board of Examiners of Water Well Construction and Pump Installation Contractors in accordance with Rule 18.
3) Approved pursuant to CRS 37-92-602(3)(b)(I) for uses as described in CRS 37-92-602(1)(f). Use of this well is limited to monitoring water levels and/or water quality sampling.
4) Approved for the use of an existing well known as PNMW-12.
5) This well must be equipped with a locking cap or seal to prevent well contamination or possible hazards as an open well. The well must be kept capped and locked at all times except during sampling or measuring.
6) Records of water level measurements and water quality analyses shall be maintained by the well owner and submitted to the Division of Water Resources upon request.
7) Upon conclusion of the monitoring program the well owner shall plug this well in accordance with Rule 16 of the Water Well Construction Rules. A Well Abandonment Report must be completed and submitted to the Division of Water Resources within 60 days of plugging.
8) The owner shall mark the well in a conspicuous place with the well permit number and name of aquifer as appropriate, and shall take necessary means and precautions to preserve these markings.
9) This well must have been constructed by or under the supervision of a licensed well driller or other authorized individual according to the Water Well Construction Rules.
10) This well must be located not more than 200 feet from the location specified on this permit.

NOTE: Issuance of this permit does not guarantee that this well can be converted to a production well under a future permit. Additionally, pursuant to Rule 14.2 of the Water Well Construction Rules (2 CCR 402-2), monitoring holes constructed pursuant to a monitoring hole notice shall not be converted to a production well. (Upon obtaining a permit from the State Engineer, a monitoring hole may be converted to a monitoring well, recovery well for remediation of the aquifer, or a dewatering system for dewatering the aquifer.)

NOTICE: This permit has been approved subject to the following changes: The UTM coordinate values provided with the permit application were not used and the well location was determined from the PLSS coordinates provided. In addition MH-54630 was not referenced on this permit since it is not located in the SE 1/4 of the SE 1/4 of Sec 19, Twp 3N, Rng 56W. You are hereby notified that you have the right to appeal the issuance of this permit, by filing a written request with this office within sixty (60) days of the date of issuance, pursuant to the State Administrative Procedures Act. (See Section 24-4-104 through 106, C.R.S.)

APPROVED
DG2

Dick Wolfe
State Engineer

By

Receipt No. 3672804A DATE ISSUED 01-05-2016 EXPIRATION DATE N/A

Form No.
GWS-25

OFFICE OF THE STATE ENGINEER
COLORADO DIVISION OF WATER RESOURCES

818 Centennial Bldg., 1313 Sherman St., Denver, Colorado 80203
(303) 866-3581

EXST

WELL PERMIT NUMBER 299822 - - -
DIV. 1 WD 1 DES. BASIN MD

APPLICANT

PUBLIC SERVICE COMPANY OF COLORADO
14940 CR 24
BRUSH, CO 80723-

(303) 571-7340

APPROVED WELL LOCATION
MORGAN COUNTY
NE 1/4 SW 1/4 Section 19
Township 3 N Range 56 W Sixth P.M.

DISTANCES FROM SECTION LINES
2230 Ft. from South Section Line
2722 Ft. from East Section Line

UTM COORDINATES (Meters,Zone:13,NAD83)
Easting: Northing:

PERMIT TO USE AN EXISTING WELL

ISSUANCE OF THIS PERMIT DOES NOT CONFER A WATER RIGHT

CONDITIONS OF APPROVAL

1) This well shall be used in such a way as to cause no material injury to existing water rights. The issuance of this permit does not ensure that no injury will occur to another vested water right or preclude another owner of a vested water right from seeking relief in a civil court action.
2) The construction of this well shall be in compliance with the Water Well Construction Rules 2 CCR 402-2, unless approval of a variance has been granted by the State Board of Examiners of Water Well Construction and Pump Installation Contractors in accordance with Rule 18.
3) Approved pursuant to CRS 37-92-602(3)(b)(I) for uses as described in CRS 37-92-602(1)(f). Use of this well is limited to monitoring water levels and/or water quality sampling.
4) Approved for the use of an existing well known as PNMW-13.
5) This well must be equipped with a locking cap or seal to prevent well contamination or possible hazards as an open well. The well must be kept capped and locked at all times except during sampling or measuring.
6) Records of water level measurements and water quality analyses shall be maintained by the well owner and submitted to the Division of Water Resources upon request.
7) Upon conclusion of the monitoring program the well owner shall plug this well in accordance with Rule 16 of the Water Well Construction Rules. A Well Abandonment Report must be completed and submitted to the Division of Water Resources within 60 days of plugging.
8) The owner shall mark the well in a conspicuous place with the well permit number and name of aquifer as appropriate, and shall take necessary means and precautions to preserve these markings.
9) This well must have been constructed by or under the supervision of a licensed well driller or other authorized individual according to the Water Well Construction Rules.
10) This well must be located not more than 200 feet from the location specified on this permit.

NOTE: Issuance of this permit does not guarantee that this well can be converted to a production well under a future permit. Additionally, pursuant to Rule 14.2 of the Water Well Construction Rules (2 CCR 402-2), monitoring holes constructed pursuant to a monitoring hole notice shall not be converted to a production well. (Upon obtaining a permit from the State Engineer, a monitoring hole may be converted to a monitoring well, recovery well for remediation of the aquifer, or a dewatering system for dewatering the aquifer.)

NOTICE: This permit has been approved subject to the following changes: The UTM coordinate values provided with the permit application were not used and the well location was determined from the PLSS coordinates provided. In addition MH-54630 was not referenced on this permit since it is not located in the NE 1/4 of the SW 1/4 of Sec 19, Twp 3N, Rng 56W. You are hereby notified that you have the right to appeal the issuance of this permit, by filing a written request with this office within sixty (60) days of the date of issuance, pursuant to the State Administrative Procedures Act. (See Section 24-4-104 through 106, C.R.S.)

APPROVED
DG2

Dick Wolfe
State Engineer

By

Receipt No. 3672804B DATE ISSUED 01-05-2016 EXPIRATION DATE N/A

Form No.
GWS-25

OFFICE OF THE STATE ENGINEER
COLORADO DIVISION OF WATER RESOURCES

818 Centennial Bldg., 1313 Sherman St., Denver, Colorado 80203
(303) 866-3581

EXST

WELL PERMIT NUMBER 299823 - - -
DIV. 1 WD 1 DES. BASIN MD

APPLICANT

PUBLIC SERVICE COMPANY OF COLORADO
14940 CR 24
BRUSH, CO 80723-

(303) 571-7340

APPROVED WELL LOCATION
MORGAN COUNTY
SE 1/4 SW 1/4 Section 19
Township 3 N Range 56 W Sixth P.M.

DISTANCES FROM SECTION LINES
1063 Ft. from South Section Line
2459 Ft. from East Section Line

UTM COORDINATES (Meters,Zone:13,NAD83)
Easting: 611580 Northing: 4451458

PERMIT TO USE AN EXISTING WELL

ISSUANCE OF THIS PERMIT DOES NOT CONFER A WATER RIGHT

CONDITIONS OF APPROVAL

1) This well shall be used in such a way as to cause no material injury to existing water rights. The issuance of this permit does not ensure that no injury will occur to another vested water right or preclude another owner of a vested water right from seeking relief in a civil court action.
2) The construction of this well shall be in compliance with the Water Well Construction Rules 2 CCR 402-2, unless approval of a variance has been granted by the State Board of Examiners of Water Well Construction and Pump Installation Contractors in accordance with Rule 18.
3) Approved pursuant to CRS 37-92-602(3)(b)(I) for uses as described in CRS 37-92-602(1)(f). Use of this well is limited to monitoring water levels and/or water quality sampling.
4) Approved for the use of an existing well acknowledged for construction under monitoring hole notice MH-54630, and known as PNMW-14.
5) This well must be equipped with a locking cap or seal to prevent well contamination or possible hazards as an open well. The well must be kept capped and locked at all times except during sampling or measuring.
6) Records of water level measurements and water quality analyses shall be maintained by the well owner and submitted to the Division of Water Resources upon request.
7) Upon conclusion of the monitoring program the well owner shall plug this well in accordance with Rule 16 of the Water Well Construction Rules. A Well Abandonment Report must be completed and submitted to the Division of Water Resources within 60 days of plugging.
8) The owner shall mark the well in a conspicuous place with the well permit number and name of aquifer as appropriate, and shall take necessary means and precautions to preserve these markings.
9) This well must have been constructed by or under the supervision of a licensed well driller or other authorized individual according to the Water Well Construction Rules.
10) This well must be located not more than 200 feet from the location specified on this permit.

NOTE: Issuance of this permit does not guarantee that this well can be converted to a production well under a future permit. Additionally, pursuant to Rule 14.2 of the Water Well Construction Rules (2 CCR 402-2), monitoring holes constructed pursuant to a monitoring hole notice shall not be converted to a production well. (Upon obtaining a permit from the State Engineer, a monitoring hole may be converted to a monitoring well, recovery well for remediation of the aquifer, or a dewatering system for dewatering the aquifer.)

NOTICE: This permit has been approved subject to the following changes: The distances from section lines were calculated from UTM coordinate values provided with the permit application. You are hereby notified that you have the right to appeal the issuance of this permit, by filing a written request with this office within sixty (60) days of the date of issuance, pursuant to the State Administrative Procedures Act. (See Section 24-4-104 through 106, C.R.S.)

APPROVED
DG2

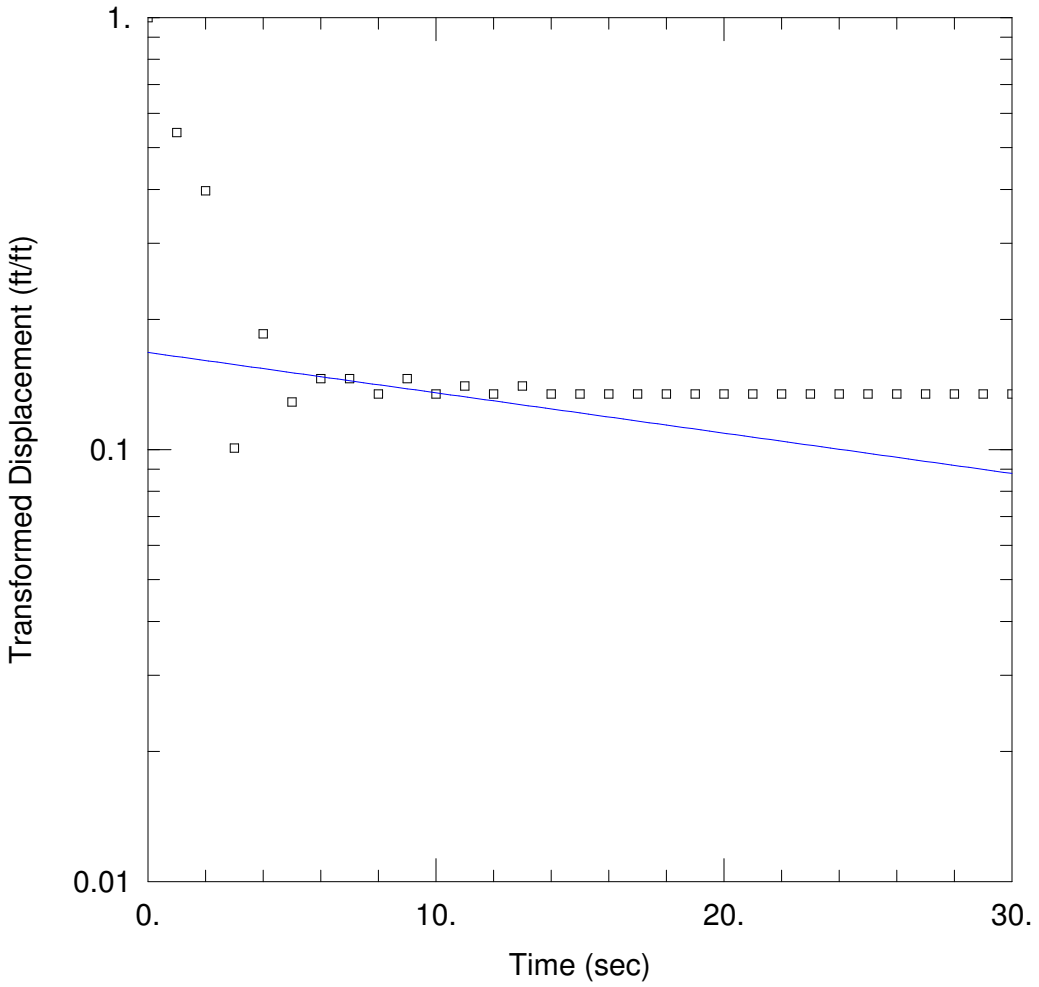
Dick Wolfe
State Engineer

By

Receipt No. 3672804C DATE ISSUED 01-05-2016 EXPIRATION DATE N/A

Appendix E

Slug Test Analyses



PNMW-12 SLUG IN

Data Set: P:\...\Pawnee_PNMW-12_Slug_In_Dagan.aqt
Date: 02/01/16 Time: 13:43:15

PROJECT INFORMATION

Company: HDR
Client: Xcel Energy
Project: 266180
Location: Pawnee Station
Test Well: PNMW-12
Test Date: 12/9/2015

AQUIFER DATA

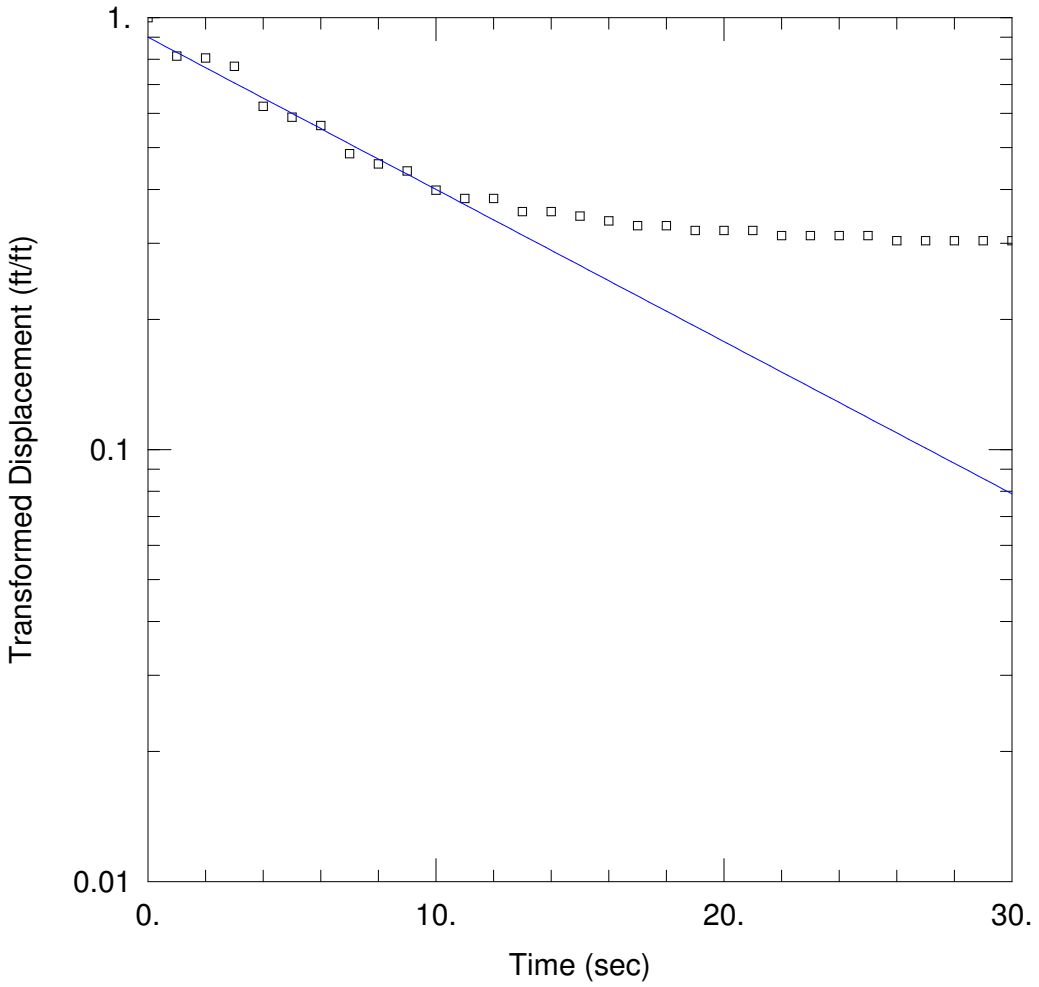
Saturated Thickness: 20.83 ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (PNMW-12)

Initial Displacement: 1.72 ft
Total Well Penetration Depth: 20.83 ft
Casing Radius: 0.083 ft
Static Water Column Height: 20.83 ft
Screen Length: 20.83 ft
Well Radius: 0.25 ft
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
Solution Method: Dagan
K = 0.002222 cm/sec
y0 = 0.2988 ft



PNMW-12 SLUG OUT

Data Set: P:\...\Pawnee_PNMW-12_Slug_Out_Dagan.aqt
Date: 02/01/16 Time: 14:33:36

PROJECT INFORMATION

Company: HDR
Client: Xcel Energy
Project: 266180
Location: Pawnee Station
Test Well: PNMW-12
Test Date: 12/9/2015

AQUIFER DATA

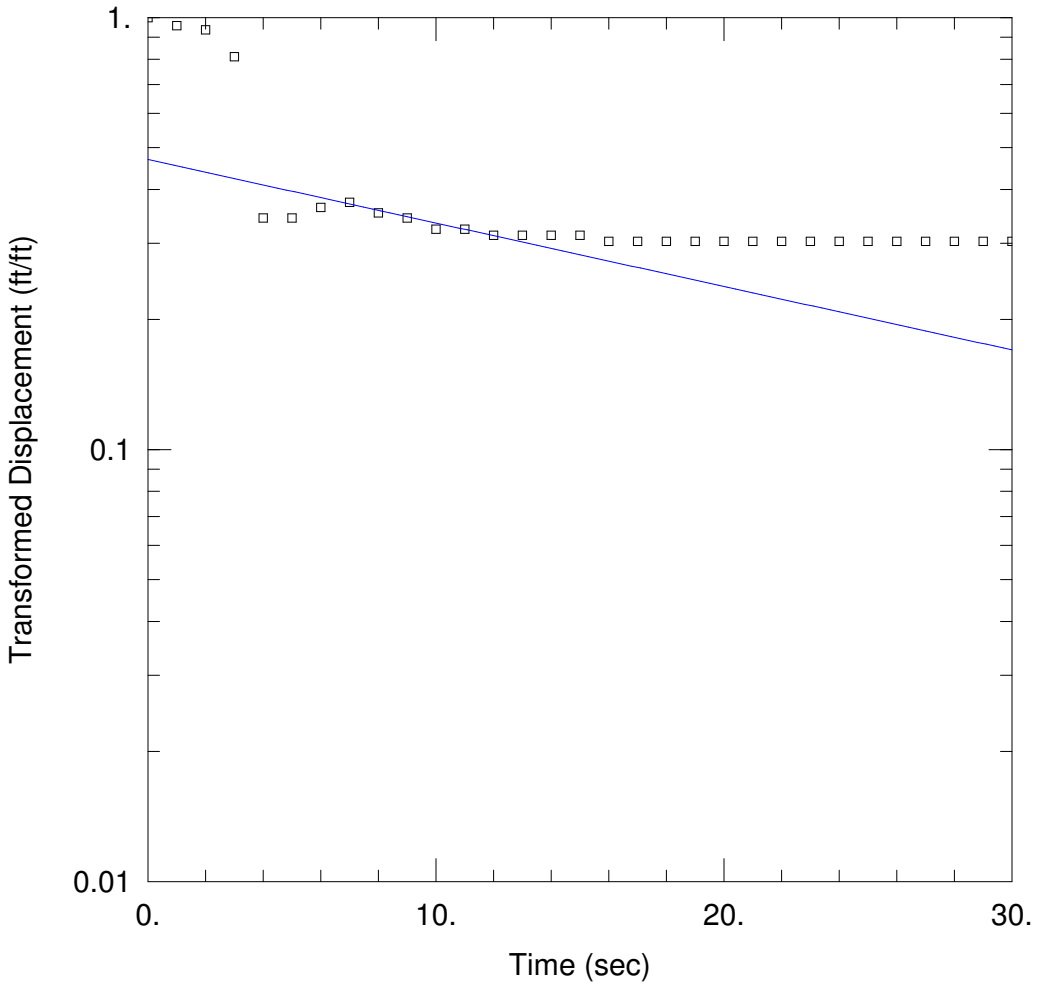
Saturated Thickness: 20.83 ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (PNMW-12)

Initial Displacement: 1.16 ft
Total Well Penetration Depth: 20.83 ft
Casing Radius: 0.083 ft
Static Water Column Height: 20.83 ft
Screen Length: 20.83 ft
Well Radius: 0.25 ft
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
Solution Method: Dagan
K = 0.002392 cm/sec
y0 = 1.047 ft



PNMW-13 SLUG IN

Data Set: P:\...\Pawnee_PNMW-13_Slug_In_Dagan.aqt
Date: 02/01/16 Time: 14:35:10

PROJECT INFORMATION

Company: HDR
Client: Xcel Energy
Project: 266180
Location: Pawnee Station
Test Well: PNMW-13
Test Date: 12/9/2015

AQUIFER DATA

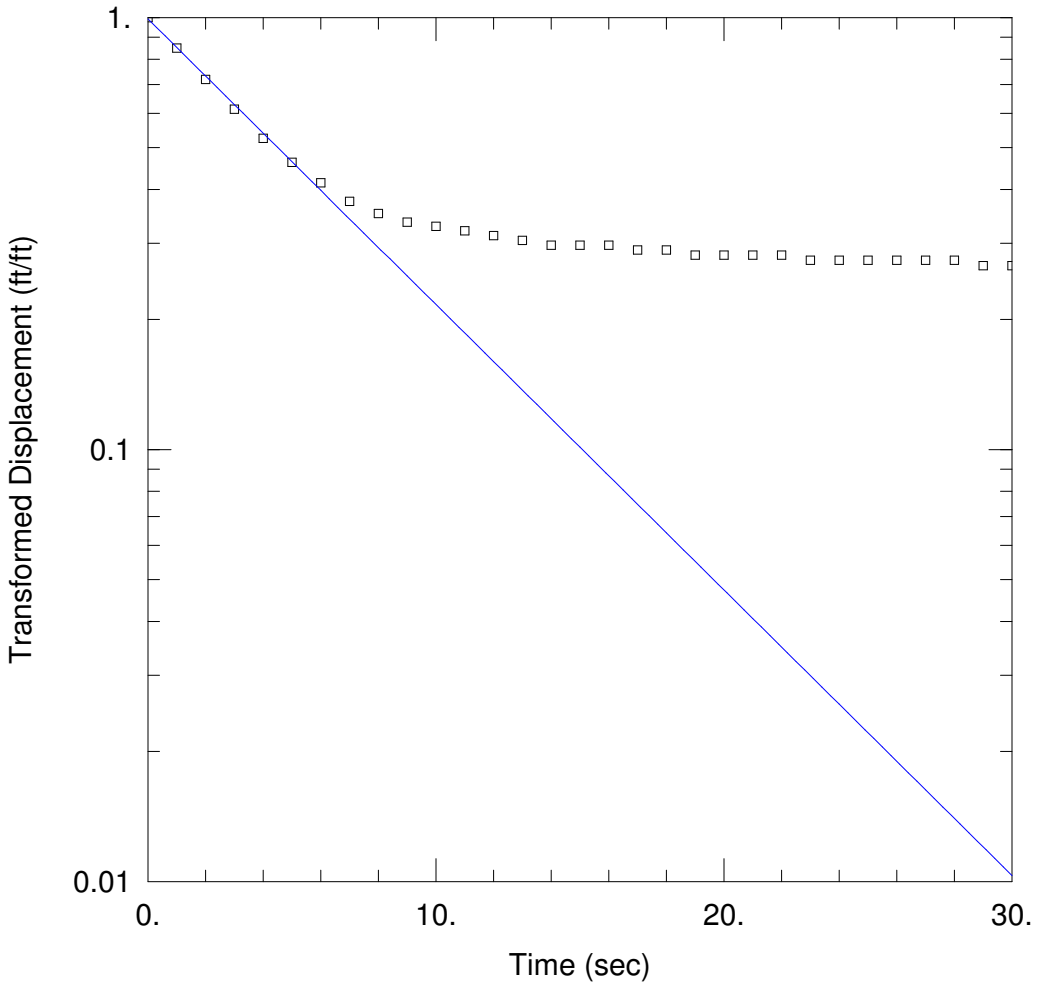
Saturated Thickness: 11.22 ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (PNMW-13)

Initial Displacement: 0.99 ft
Total Well Penetration Depth: 11.22 ft
Casing Radius: 0.083 ft
Static Water Column Height: 11.22 ft
Screen Length: 11.22 ft
Well Radius: 0.25 ft
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
Solution Method: Dagan
K = 0.003451 cm/sec
y0 = 0.4755 ft



PNMW-13 SLUG OUT

Data Set: P:\...\Pawnee_PNMW-13_Slug_Out_Dagan.aqt
Date: 02/01/16 Time: 14:36:00

PROJECT INFORMATION

Company: HDR
Client: Xcel Energy
Project: 266180
Location: Pawnee Station
Test Well: PNMW-13
Test Date: 12/9/2015

AQUIFER DATA

Saturated Thickness: 11.22 ft Anisotropy Ratio (Kz/Kr): 1.

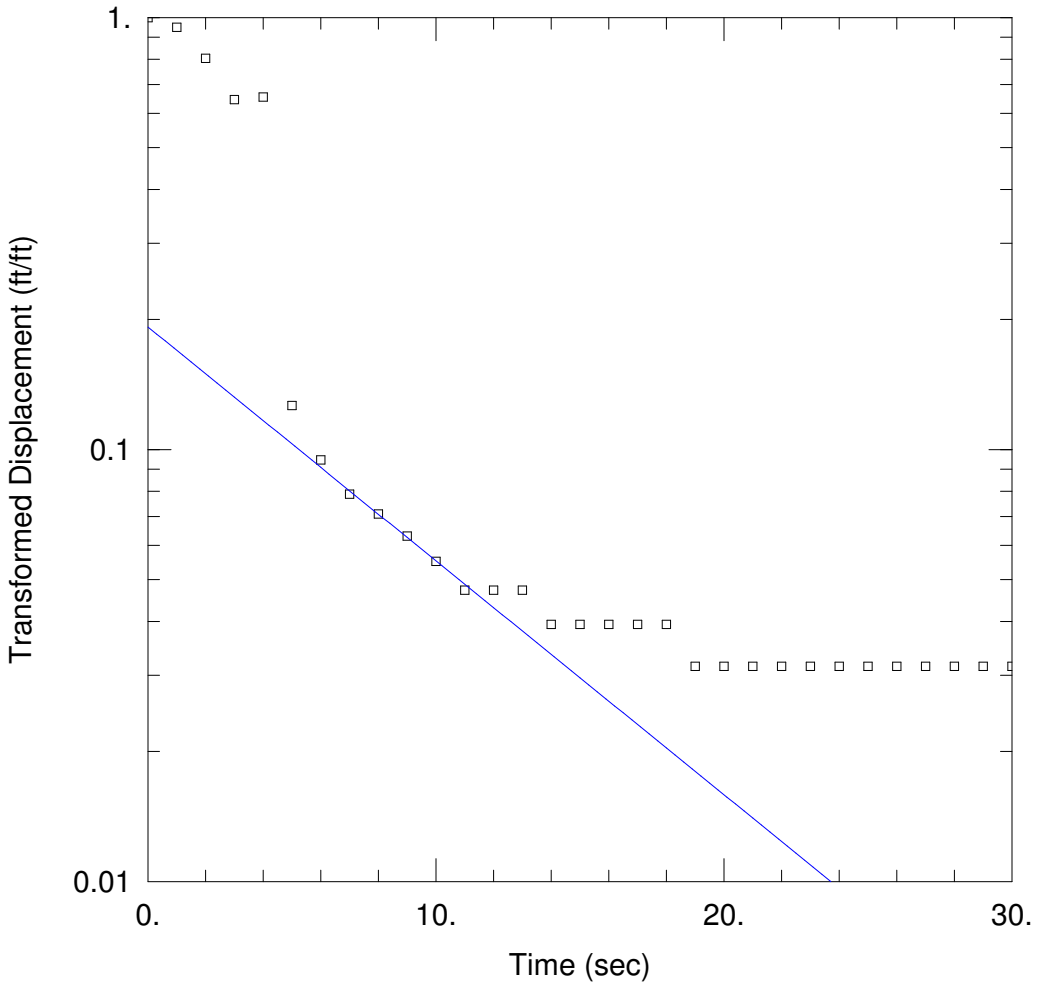
WELL DATA (PNMW-13)

Initial Displacement: 1.26 ft
Total Well Penetration Depth: 11.22 ft
Casing Radius: 0.083 ft
Static Water Column Height: 11.22 ft
Screen Length: 11.22 ft
Well Radius: 0.25 ft
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined Solution Method: Dagan

K = 0.005901 cm/sec y0 = 1.251 ft



PNMW-14 SLUG IN

Data Set: P:\...\Pawnee_PNMW-14_Slug_In_Dagan.aqt
Date: 02/01/16 Time: 14:36:47

PROJECT INFORMATION

Company: HDR
Client: Xcel Energy
Project: 266180
Location: Pawnee Station
Test Well: PNMW-14
Test Date: 12/9/2015

AQUIFER DATA

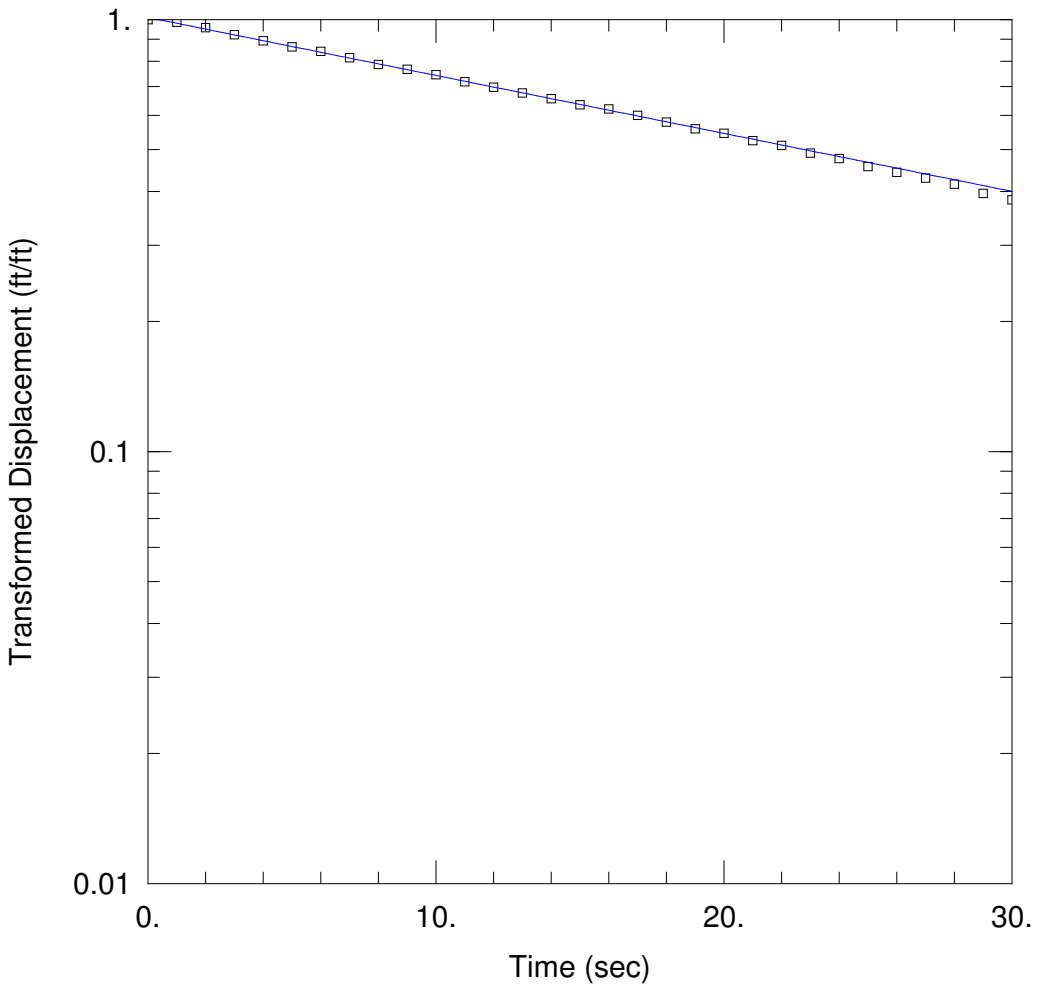
Saturated Thickness: 14.68 ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (PNMW-14)

Initial Displacement: 1.22 ft
Total Well Penetration Depth: 14.68 ft
Casing Radius: 0.083 ft
Static Water Column Height: 14.68 ft
Screen Length: 14.68 ft
Well Radius: 0.25 ft
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
Solution Method: Dagan
K = 0.02059 cm/sec
y0 = 0.2426 ft



PNMW-14 SLUG OUT

Data Set: P:\...\Pawnee_PNMW-14_Slug_Out_Dagan.aqt
Date: 02/01/16 Time: 14:37:42

PROJECT INFORMATION

Company: HDR
Client: Xcel Energy
Project: 266180
Location: Pawnee Station
Test Well: PNMW-14
Test Date: 12/9/2015

AQUIFER DATA

Saturated Thickness: 14.68 ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (PNMW-14)

Initial Displacement: 1.47 ft
Total Well Penetration Depth: 14.68 ft
Casing Radius: 0.083 ft
Static Water Column Height: 14.68 ft
Screen Length: 14.68 ft
Well Radius: 0.25 ft
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
Solution Method: Dagan
K = 0.0008333 cm/sec
y0 = 1.485 ft