Pawnee Station, Morgan County, Colorado

Groundwater Monitoring System Certification

For Compliance with the Coal Combustion Residuals (CCR) Rule

Pawnee Station

Xcel Energy

April 28, 2016

Rev 1: October 16, 2017

Rev 2: December 27, 2018

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Table of Abbreviations and Acronyms

Abbreviation	Definition
cm/sec	centimeters per second
CCR	Coal Combustion Residuals
EPA	U.S. Environmental Protection Agency
ft/ft	feet per foot
TSS	Total Suspended Solids

Certification

Groundwater Monitoring System for Compliance

With the Coal Combustion Residuals Rule

Public Service Company of Colorado, an Xcel Energy Company

Pawnee Station, Morgan County, Colorado

I hereby certify that the groundwater monitoring system at Pawnee Station is designed to meet the performance standard in Sections 257.91(a)(1) and (2) of the Federal Coal Combustion Residuals Rule, and that the groundwater monitoring system has been designed and constructed to ensure that the groundwater monitoring will meet this performance standard for the CCR units located at Pawnee Station.

I am a duly licensed Professional Engineer under the laws of the State of Colorado.

Matthew M Rohr
Colorado PE License 0053467
License Renewal Date October 31, 2019

1.0 Introduction

The U.S. Environmental Protection Agency's (EPA's) final Coal Combustion Residuals (CCR) Rule establishes a comprehensive set of requirements for the management and disposal of CCR (or coal ash) in landfills and surface impoundments by electric utilities. Pawnee Station, located 90 miles northeast of Denver in Morgan County, Colorado (**Figure 1**), has two active CCR units subject to the CCR Rule: the North CCR Landfill and East CCR Landfill. There are also two former CCR Impoundments (Ash Water Recovery Pond and Bottom Ash Storage Pond) that are subject to the CCR Rule (**Figure 2**).

This document supports compliance with the CCR Rule by demonstrating that the groundwater monitoring system at Pawnee Station meets the requirements outlined in Section § 257.91 of the Rule, which states:

- Section § 257.91(f): *'The owner or operation must obtain a certification from a qualified professional engineer stating that the groundwater monitoring system has been designed and constructed to meet requirements of this section* [§257.91]. *If the groundwater monitoring system includes the minimum number of monitoring wells specified in paragraph (c)(1) of this section* [Section § 257.91], *the certification must document the basis supporting this determination*.'

Table 1 summarizes components required by groundwater monitoring systems, per the CCR Rule and the professional engineer's certification of compliance with these requirements. The remainder of this document provides information to support certification for the groundwater monitoring system for the CCR units at the Pawnee Station.

Table 1. Summary of 40 CFR Section § 257.91 Groundwater Monitoring System Requirements and Site-Specific Compliance

Groundwater Monitoring System Requirements	Compliance with Requirement
(a) *Performance standard.* The owner or operator of a CCR unit must install a groundwater monitoring system that consists of a sufficient number of wells, installed at appropriate locations and depths, to yield groundwater samples from the uppermost aquifer that: (1) Accurately represent the quality of background groundwater that has not been affected by leakage from a CCR unit. A determination of background quality may include sampling of wells that are not hydraulically upgradient of the CCR management area where: (i) Hydrogeologic conditions do not allow the owner or operator of the CCR unit to determine what wells are hydraulically upgradient; or (ii) Sampling at other wells will provide an indication of background groundwater quality that is as representative or more representative than that provided by the upgradient wells; and (2) Accurately represent the quality of groundwater passing the waste boundary of the CCR unit. The downgradient monitoring system must be installed at the waste boundary that ensures detection of groundwater contamination in the uppermost aquifer. All potential contaminant pathways must be monitored.	**Yes.** The direction of groundwater flow has been determined at the site; the groundwater monitoring system includes the minimum number of wells at appropriate locations and depths to yield groundwater samples necessary to meet performance standards (a)(1) and (a)(2). See Sections 3 and 4.

Table 1. Summary of 40 CFR Section § 257.91 Groundwater Monitoring System Requirements and Site-Specific Compliance	
Groundwater Monitoring System Requirements	**Compliance with Requirement**
(b) The number, spacing, and depths of monitoring systems shall be determined based upon site-specific technical information that must include thorough characterization of: (1) Aquifer thickness, groundwater flow rate, groundwater flow direction including seasonal and temporal fluctuations in groundwater flow; and (2) Saturated and unsaturated geologic units and fill materials overlying the uppermost aquifer, materials comprising the uppermost aquifer, and materials comprising the confining unit defining the lower boundary of the uppermost aquifer, including, but not limited to, thicknesses, stratigraphy, lithology, hydraulic conductivities, porosities and effective porosities.	**Yes.** The monitoring system was designed based on results of technical, site-specific data, including (b)(1) and (b)(2). See Sections 3 and 4.
(c) The groundwater monitoring system must include the minimum number of monitoring wells necessary to meet the performance standards specified in paragraph (a) of this section, based on the site-specific information specified in paragraph (b) of this section. The groundwater monitoring system must contain: (1) A minimum of one upgradient and three downgradient monitoring wells; and (2) Additional monitoring wells as necessary to accurately represent the quality of background groundwater that has not been affected by leakage from the CCR unit and the quality of groundwater passing the waste boundary of the CCR unit.	**Yes.** The groundwater monitoring system includes a minimum of one upgradient and three downgradient wells at each of the CCR Units that meet the performance standards are being monitored in compliance with the CCR Rule. See Section 4.
(d) The owner or operator of multiple CCR units may install a multiunit groundwater monitoring system instead of separate groundwater monitoring systems for each CCR unit. (1) The multiunit groundwater monitoring system must be equally as capable of detecting monitored constituents at the waste boundary of the CCR unit as the individual groundwater monitoring system specified in paragraphs (a) through (c) of this section for each CCR unit based on the following factors:(i) Number, spacing, and orientation of each CCR unit; (ii) Hydrogeologic setting; (iii) Site history; and (iv) Engineering design of the CCR unit. (2) If the owner or operator elects to install a multiunit groundwater monitoring system, and if the multiunit system includes at least one existing unlined CCR surface impoundment as determined by §257.71(a), and if at any time after October 19, 2015 the owner or operator determines in any sampling event that the concentrations of one or more constituents listed in appendix IV to this part are detected at statistically significant levels above the groundwater protection standard established under §257.95(h) for the multiunit system, then all unlined CCR surface impoundments comprising the multiunit groundwater monitoring system are subject to the closure requirements under §257.101(a) to retrofit or close.	**N/A.** A multiunit system was not necessary.
(e) Monitoring wells must be cased in a manner that maintains the integrity of the monitoring well borehole. This casing must be screened or perforated and packed with gravel or sand, where necessary, to enable collection of groundwater samples. The annular space (*i.e.,* the space between the borehole and well casing) above the sampling depth must be sealed to prevent contamination of samples and the groundwater. (1) The owner or operator of the CCR unit must document and include in the operating record the design, installation, development, and decommissioning of any monitoring wells, piezometers and other measurement, sampling, and analytical devices. The qualified professional engineer must be given access to this documentation when completing the groundwater monitoring system certification required under paragraph (f) of this section. (2) The monitoring wells, piezometers, and other measurement, sampling, and analytical devices must be operated and maintained so that they perform to the design specifications throughout the life of the monitoring program.	**Yes.** Well design meets requirements (e). See Section 4. Groundwater monitoring system will be operated and maintained per (e)(2).

Table 1. Summary of 40 CFR Section § 257.91 Groundwater Monitoring System Requirements and Site-Specific Compliance	
Groundwater Monitoring System Requirements	**Compliance with Requirement**
(f) The owner or operator must obtain a certification from a qualified professional engineer stating that the groundwater monitoring system has been designed and constructed to meet the requirements of this section. If the groundwater monitoring system includes the minimum number of monitoring wells specified in paragraph (c)(1) of this section, the certification must document the basis supporting this determination.	**Yes.** System designed and constructed to meet the requirements of Section §257.91. Technical information to support certification and number of wells, per (c)(1). See Sections 2.0, 3.0 and 4.0.

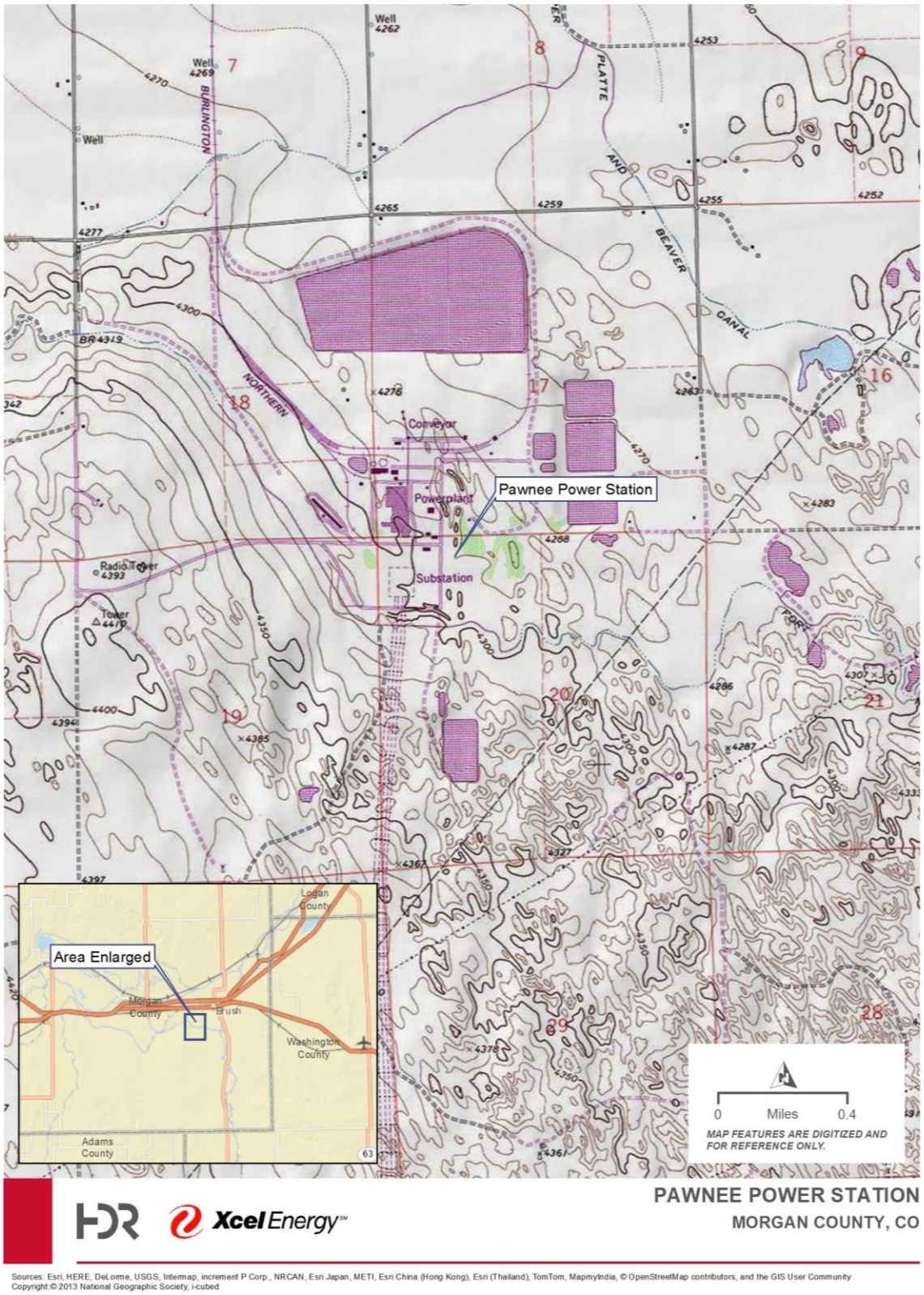

Figure 1. Vicinity Map for Pawnee Station

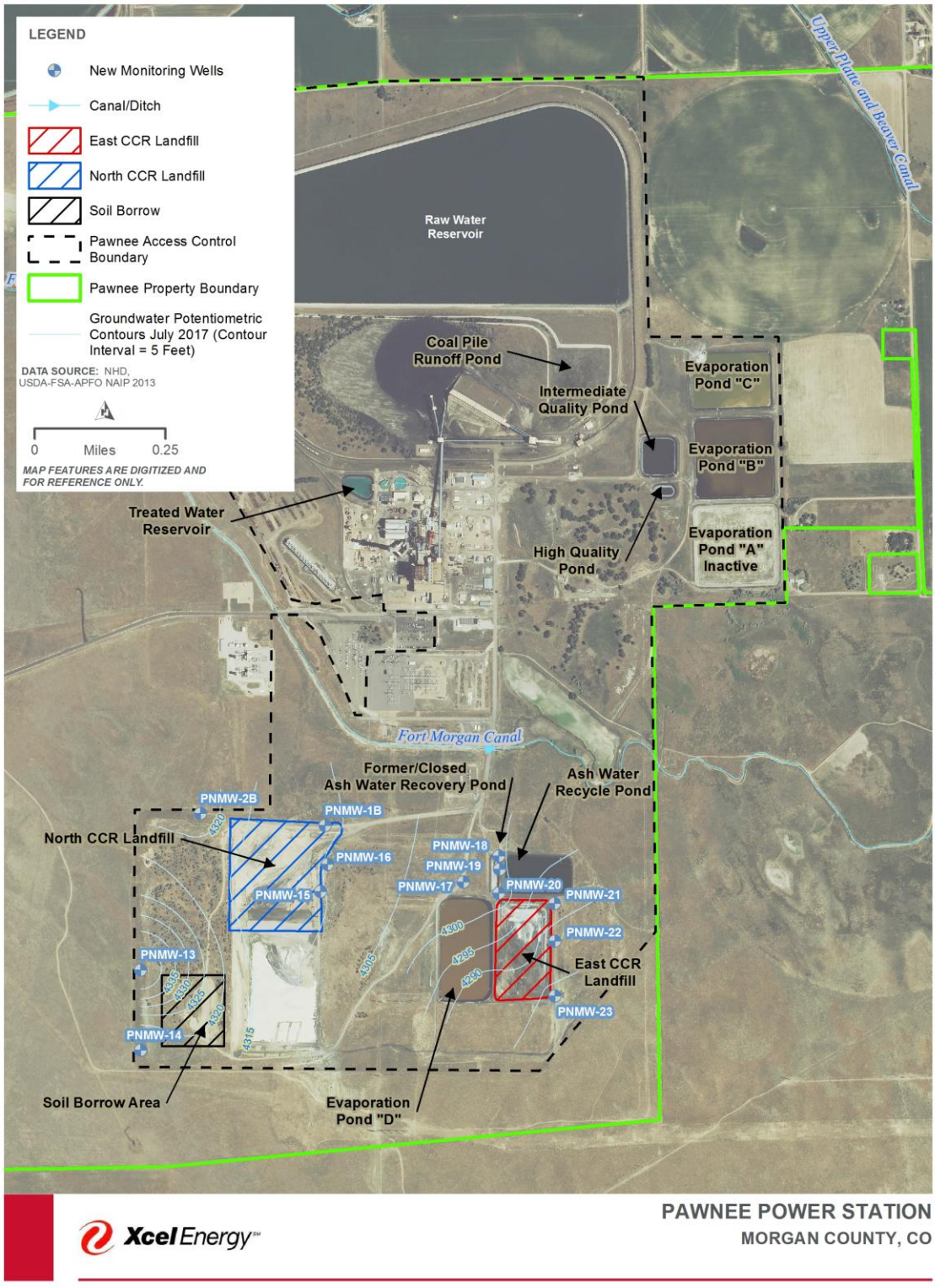

Figure 2. Pawnee Station – CCR Landfill and Monitoring Well Location Map

2.0 Facility Description

Pawnee Station is a coal-fired, steam turbine electric generating station; the fuel source for the existing coal-fired units is sub-bituminous, low-sulfur coal from the Eagle Butte Mine near Gillette, Wyoming. Pawnee Station currently has two active CCR landfills: the unlined North CCR Landfill and the lined East CCR Landfill. There are also two former CCR Impoundments (Ash Water Recovery Pond and Bottom Ash Storage Pond). The sections that follow provide a brief description of the CCR units.

The facility also operates a number of non-CCR impoundments/units including raw water, treated water, coal pile runoff, South Landfill, ash water recycle, and evaporation ponds. These units do not hold CCR, and therefore are not considered CCR units, in compliance with the CCR Rule:

> *"CCR surface impoundments do not include units generally referred to as cooling water ponds, process water ponds, wastewater treatment ponds, storm water holding ponds, or aeration ponds. These units are not designed to hold an accumulation of CCR, and in fact, do not generally contain significant amounts of CCR."*

2.1 CCR Landfill - North CCR Landfill

The Pawnee Station North CCR Landfill is located approximately ½ mile south-southwest of the power plant. The North CCR Landfill has been used for storage of CCR and has been in use since operations began in 1981 **(Figure 2)**. Historically, landfill operations consist primarily of management of CCR bottom ash and fly ash and disposal of minor amounts of other approved non-CCR waste.

2.2 CCR Landfill - East CCR Landfill

The Pawnee Station East CCR Landfill is located approximately ½ mile south-southeast of the power plant **(Figure 2)**. The East CCR Landfill was constructed in the footprint of the former Bottom Ash Storage Pond after the pond was closed in 2017 by removal of all CCR and liner material and certified by a Professional Engineer. Construction of the lined East CCR Landfill was completed in October 2018. Background groundwater monitoring was also completed in 2018. The East CCR Landfill will be used for disposal of bottom ash, fly ash and other approved non-CCR waste beginning in early 2019.

2.3 CCR Impoundments - Former Ash Water Recovery Pond and Bottom Ash Storage Pond

The former Ash Water Recovery Pond was built in 1980, as part of the original site construction. It was constructed with a composite liner system, and was inactive since 2005. During active operation, it was used to recycle ash transport water from the Bottom Ash Storage Pond back to the plant. The pond was approximately 400 feet long by 100 feet wide and encompassed 0.92 acre. The inactive CCR impoundment was closed in 2017 by removal of all CCR and liner material and certified by a Professional Engineer. The footprint of the former CCR impoundment is located immediately northwest of the East CCR Landfill (former Bottom Ash Storage Pond) and will be used as a non-contact stormwater pond (**Figure 2**).

The Bottom Ash Storage Pond was built in 1980, as part of the original site construction. It was constructed with a composite liner system, and was inactive since 2005. During active operation, it

was used to receive and settle sluiced bottom ash and recycle the transport water back to the plant via the Ash Water Recovery Pond. The inactive CCR impoundment was closed in 2017 by removal of all CCR and liner material and certified by a Professional Engineer. The new East CCR Landfill was subsequently constructed within the footprint of the former impoundment. Therefore, the monitoring is described in terms of monitoring the East CCR Landfill rather than the Bottom Ash Pond throughout this document; however the monitoring locations are the same for both units. The monitoring wells will be used for post closure monitoring of the former Bottom Ash Storage Pond and detection monitoring of the East CCR Landfill.

3.0 Site Hydrogeology/Geology

Prior hydrogeologic and geotechnical investigations have been conducted at Pawnee as documented in the following reports and summarized in the text below:

- Pawnee Station Landfill Ground Water Monitoring Plan (Xcel, 2011)
- Pawnee Station Landfill 2014 Annual Groundwater Monitoring Report (PSCo, 2015)

Dune sand deposits are present under all of these facilities, which overlie a fine-grained soil and shale bedrock (the Pierre Shale Formation).

- The dune sand deposit is a well-sorted fine sand and ranges from approximately 8 to 70 feet thick from the land surface (PSCo, 2015).
- The fine-grained soil underlying the dune sand is unconsolidated very fine sand, silt, and clay derived from in-situ weathering of the Pierre Shale and is approximately 8 to 125 feet thick (PSCo, 2015). The thickness of the residual soil is greatest in the northeast portion of the property. The base of the residual soil is characterized by a transition zone from partially weathered bedrock to the underlying competent bedrock that is typically less than 5 feet.
- The Pierre Shale underlies the units described above and consists of shale to sandy shale (claystones and siltstones), and is approximately 4,500 to 5,000 feet thick in this region of Colorado. The depth to the Pierre Shale at the site ranges from approximately 40 to 80 feet in the southern portion of the site to approximately 110 to 140 feet in the northeastern portion of the property (PSCo, 2015).

Groundwater flows primarily within the transition zone bedrock located at the base of the residual soil and above the consolidated shale bedrock. Groundwater is recharged from infiltration from above and is confined below by the competent, very low conductivity, Pierre Shale bedrock. Dune sands in the North 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 in the vicinity of the North CCR Landfill towards the South Platte River; however, a bedrock high, trending northwest to southeast, is present beneath the North CCR Landfill area, resulting in an eastern radial flow such that groundwater beneath the North CCR Landfill flows east northeast, east, and east southeast (PSCo, 2015) (**Figure 2**). Groundwater beneath the East CCR Landfill primarily flows east. Groundwater beneath the former Ash Water Recovery Pond flows east northeast.

4.0 Monitoring Wells

The CCR Rule requires, at a minimum, one upgradient and three downgradient monitoring wells per CCR unit to be completed in the uppermost aquifer. In addition, the CCR Rule states that downgradient monitoring wells should be installed to: *"accurately represent the quality of groundwater passing the waste boundary of the CCR unit. The downgradient monitoring system must be installed at the waste boundary that ensures detection of groundwater contamination in the uppermost aquifer."*

Based on the CCR requirements, hydrogeological data, and site visits, thirteen wells were sited for CCR compliance to serve as four upgradient and nine downgradient monitoring wells **(Figure 2)**.

Upgradient Monitoring Wells

Three upgradient wells are located west of the North CCR Landfill to monitor background water quality conditions for the North Landfill and also serve as background wells for the entire southern portion of Pawnee Station. Monitoring wells PNMW-2B, PNMW-13, and PNMW-14 are representative of background groundwater quality in the vicinity of the North CCR Landfill due to the upgradient location west of the North CCR Landfill, proximity to the North CCR Landfill, and because the wells are screened in the residual soil/dune sand. The open area between the west edge of the North CCR Landfill configuration and the locations for PNMW-13 and PNMW-14 is a soil borrow area (**Figure 2**).

PNMW-17 is sited to be upgradient specifically for the two facilities being monitored to the east – the former Ash Water Recovery Pond and the East CCR Landfill. PNMW-17 is located approximately 300 feet due west from the center of the west edge of the Ash Water Recovery Pond and is representative of background groundwater quality in the vicinity of the Ash Water Recovery Pond as well as the East CCR Landfill due to the upgradient location west and northwest of both CCR units, proximity to both CCR units, and because PNMW-17 is screened in the residual sand.

Downgradient Monitoring Wells

Groundwater in the vicinity of the facilities flows predominantly east. Based upon flow direction, nine groundwater monitoring wells were installed for downgradient monitoring (PNMW-1B, PNMW-15, PNMW-16, PNMW-18, PNMW-19, PNMW-20, PNMW-21, PNMW-22, and PNMW-23). Wells PNMW-1B, PNMW-15, and PNMW16 are located at the downgradient waste boundary of the North CCR Landfill. Monitoring wells PNMW-18, PNMW-19, and PNMW-20 are located at the downgradient limit of the former Ash Water Recovery Pond. At the East CCR Landfill (and former Bottom Ash Pond), monitoring wells PNMW-21, PNMW-22, and PNMW-23 are located along the downgradient eastern boundary of the CCR unit (**Figure 2**).

4.1 Well Construction

All of the CCR monitoring wells were drilled by a licensed well driller. All wells were drilled to a depth of 10 feet below the water table, or to the top of the Pierre Shale, whichever was shallower. The placement of the monitoring well screens just above the bedrock will monitor shallow groundwater. Wells were designed to capture the uppermost groundwater, which could be impacted by the CCR landfill. Shallow groundwater will primarily flow within the dune sands, residual soil, and upper

weathered bedrock. Therefore, screens were designed to capture the shallow groundwater above the very thick, low permeability bedrock.

Monitoring wells are constructed with 2-inch diameter, Schedule 40 PVC casing and screen with 0.010-inch screen slots. Wells have between 20 and 35 feet of screen and are located immediately above the Pierre Shale contact. Well construction included 10-20 washed silica sand for the filter pack approximately 5 feet above the well screen. Annular seals of coated bentonite pellets extend from the top of the filter pack to the surface and were hydrated after placement. Monitoring wells were developed and surveyed by a professional licensed surveyor.

Table 2. Monitoring Well Construction											
Well I.D.	**Northing**	**Easting**	**Elevation TOC (ft. AMSL)**	**U/G or D/G**	**Well Total Depth (ft. BGS)**	**Screen Interval (ft. BGS)**	**Well Stickup (ft.)**	**Well Type**	**Static Water Level (ft. AMSL) December 2015**	**Well Permit Number**	**Approximate Depth of Pierre Shale if encountered (ft. BGS)**
	(State Plane, NAD 83 Zone 13, meters)										
PNMW-1B	612122.5206	4452179.266	4332.23	D/G	40	20-40	2.01	4-inch Sch. 40 PVC	4310.07	285095	39.5
PNMW-2B	611739.3229	4452216.075	4359.76	U/G	62	27-62	1.82	4-inch Sch. 40 PVC	4320.76	285096	59
PNMW-13	611555.4201	4451735.628	4378.11	U/G	50	20-50	3.89	2-inch Sch. 40 PVC	4335.33	299822	50
PNMW-14	611555.2833	4451488.609	4376.96	U/G	70	40-70	4.00	2-inch Sch. 40 PVC	4317.62	299823	69
PNMW-15	612108.6655	4451975.9531	4341.57	D/G	55	25−55	2.18	2-inch Sch. 40 PVC	4312.67	56328	28
PNMW-16	612130.9766	4452060.4886	4322.73	D/G	35	5−35	2.45	2-inch Sch. 40 PVC	4307.14	56329	>35
PNMW-17	612548.5390	4452006.0495	4314.78	U/G	35	5-35	2.23	2-inch Sch. 40 PVC	4305.85	56330	>35
PNMW-18	612658.3353	4452085.1461	4331.21	D/G	55	20-55	2.35	2-inch Sch. 40 PVC	4300.85	56331	>40

PNMW-19	612660.9447	4452044.6224	4330.82	D/G	53	23-53	2.17	2-inch Sch. 40 PVC	4299.82	306576	46
PNMW-20	612657.88384	4451971.2478	4330.83	D/G	50	20-50	2.15	2-inch Sch. 40 PVC	4301.72	306577	44
PNMW-21	612828.8799	4451939.3059	4331.06	D/G	60	30−60	2.35	2-inch Sch. 40 PVC	4291.81	306578	55
PNMW-22	612830.1897	4451823.4324	4331.05	D/G	60	30−60	2.59	2-inch Sch. 40 PVC	4289.73	306579	70
PNMW-23	612830.8628	4451655.4639	4331.48	D/G	60	30−60	2.24	2-inch Sch. 40 PVC	4283.97	306580	45

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

5.0 Groundwater Quality Sampling

5.1 Schedule

Sampling is conducted at a frequency compliant with CCR Part 257.94. Eight rounds of upgradient and downgradient monitoring well sampling were completed before the October 17, 2017 deadline for the North CCR Landfill, before the end of 2018 for the former Ash Water Recovery Pond, and before the East CCR Landfill accepts the first placement of CCR. These samples will represent background water quality. After eight rounds of sampling to establish background water quality, semi-annual (twice per year) groundwater detection monitoring will be initiated. Groundwater quality sampling will be conducted in all upgradient and downgradient monitoring wells unless wells are dry. In accordance with the CCR Rule, groundwater samples will not be field filtered. The field parameters of turbidity, pH, and temperature will be measured using a YSI Professional Plus (or an equivalent) portable water quality instrument that has been calibrated prior to use.

5.2 Analytical testing

Analytical testing of groundwater samples will be performed by TestAmerica. Samples will be analyzed for the parameters shown on **Table 3**, which include all of the parameters in Appendices III and IV of Part 257 for the initial eight background sample events, plus Total Suspended Solids (TSS). For subsequent events, it is anticipated the parameters listed in Appendix III will be analyzed, unless assessment monitoring is required. For quality control, one field duplicate sample and one field equipment blank sample will be collected for each sample event. The laboratory will analyze matrix spike/matrix spike duplicates at a rate of 5 percent, per laboratory quality control standards.

Table 3. Groundwater Quality Parameters

Appendix III Constituents for Detection Monitoring*
Boron
Calcium
Chloride
Fluoride
pH
Sulfate
Total Dissolved Solids (TDS)
Appendix IV Constituents for Assessment Monitoring*
Antimony
Arsenic
Barium
Beryllium
Cadmium
Chromium
Cobalt
Fluoride
Lead
Lithium

Mercury
Molybdenum
Selenium
Thallium
Radium 226 and 228 combined
Additional Parameters
Total Suspended Solids (TSS)

**note that total metals will be measured (not dissolved metal concentrations)*

6.0 Reporting

The CCR Rule 297.90(e) identifies the reporting requirements for the groundwater monitoring program for the CCR units. The annual reporting documents will be developed no later than January 31, 2018 and annually thereafter. The annual reports will be placed in the Pawnee operating record. The data validation, verification, and statistical methods used to analyze each specified constituent in each monitoring well are described in a separate Data Management and Statistical Procedures Plan.

Annual reports will summarize key monitoring actions completed, describe any problems encountered, discuss actions to resolve the problems, and project key activities for the upcoming year. For CCR compliance, Xcel Energy will file the report in the facility operating records.

Xcel Energy will comply with the CCR Rule recordkeeping requirements specified in § 257.105(h), notification requirements specified in § 257.106(h), and internet requirements specified in § 257.107(h).

7.0 References

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

URS, 2009. Pawnee Landfill Evaluation, Pawnee Station Brush, Colorado, July 14, 2009.

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