Groundwater Monitoring System Report

Blue Pit Area
Coyote Station
Beulah, North Dakota

Prepared for
Otter Tail Power Company

November 2016

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Certifications

I hereby certify that the monitoring system identified herein has been designed and constructed to meet the requirements of § 257.91, Groundwater monitoring systems, as included in 40 CFR Part 257, Subpart D, Disposal of Coal Combustion Residuals from Electric Utilities.

I hereby certify that this report was prepared by me or under my direct supervision, and that I am a duly registered Professional Engineer under the laws of the State of North Dakota.

Scott F. Korom, P.E.
PE #: 3835

November 15, 2016
Date

Scott F. Korom
2016.11.15 15:55:03
-06'00'

Acronyms

Acronym	Description
bgs	Below Ground Surface
Blue Pit Area	Blue Pit and surrounding area
BMP	Below Measuring Point
B-Z	Beulah-Zap
CCR	Coal Combustion Residuals
EPA	Environmental Protection Agency
Facility	Coyote Station
FGD	Flue Gas Desulfurization
Lower B-Z	Lower Beulah-Zap lignite bed
NDAC	North Dakota Administrative Code
NTU	Nephelometric Turbidity Units
OTP	Otter Tail Power
SCM	Site Conceptual Model
Site	Ponds (Slag Pond, Sluice Outfall, and Nelsen Pond), landfills (Green Pit, Black Pit, and Blue Pit), and Plant
Slag Pond Area	Slag Pond, Sluice Outfall, Nelsen Pond, and surrounding area
TOR	Top of Riser

1.0 Introduction

Otter Tail Power Company (OTP) owns and operates Coyote Station, a coal-fired generation unit in Beulah, North Dakota. The Site location is shown on Figure 1, which includes ponds (Slag Pond, Sluice Outfall, and Nelsen Pond) and landfills (Green Pit, Black Pit, Purple Pit, and Blue Pit).

The Slag Pond, Sluice Outfall, and Nelsen Pond are existing CCR surface impoundments and the Blue Pit is an existing CCR landfill at Coyote Station that are required to comply with the provisions of the US EPA Coal Combustion Residuals (CCR) Rule (40 CFR Parts 257 and 261 Disposal of Coal Combustion Residuals From Electric Utilities). The Green Pit, Purple Pit and Black Pit landfills are not regulated by the CCR Rule. The Slag Pond Area, which includes the Slag Pond, Sluice Outfall, Nelsen Pond, and surrounding area is discussed in a separate report.

The Blue Pit Area consists of the landfill and the area around the landfill in which the monitoring system is located. The Blue Pit Area is shown on Figure 2.

This report has been prepared to document hydrogeologic and monitoring system information as required by the CCR Rule. It describes:

- July, August, and September 2016 field activities
- The site hydrogeology
- The CCR groundwater monitoring system meeting the requirements of the CCR Rule (40 CFR Part 257, US EPA, 2015) at Coyote Station (Facility)

1.1 Purpose

This document has been prepared to describe the groundwater monitoring system for the Coyote Station Blue Pit Landfill and how it has been designed to meet the requirements of the CCR Rule (Rule). Specific requirements for groundwater monitoring systems are established in § 257.91, "Groundwater monitoring systems," as follows:

> *(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.

(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.

1.2 Scope of Work

The scope of work performed for this project includes:

- Collect and review existing information regarding each CCR unit to provide the information required by the Rule.
- Establish and document the groundwater site conceptual model (SCM) that can be used to evaluate site data and design the monitoring system.
- Identify gaps in the existing data and perform additional field tasks to establish a monitoring system as required by the Rule.
- Observe field investigation consisting of the following subtasks:
    - Installation of monitoring wells BLUE 14, BLUE 15, and BLUE 16 at the Blue Pit, along with the abandonment of BLUE 12 and completion of a pilot boring near BLUE 7 at the Blue Pit Area
    - Develop monitoring wells proposed to become part of the CCR monitoring system
    - Collect geotechnical samples for analysis of parameters such as grain size analysis, vertical hydraulic conductivity, and horizontal hydraulic conductivity

- Collect water level data to document groundwater flow directions
- Perform slug tests on select wells to estimate horizontal hydraulic conductivity

1.3 Report Contents

Based on the requirements of the CCR Rule, this report contains:

- Section 1.0 Introduction (this section) which provides an overview
- Section 2.0 Site Background which provides background information on the Site, including Site operations and setting, and geologic and hydrogeological information
- Section 3.0 Conceptual Models provides a summary of the site conceptual model for the Blue Pit Area
- Section 4.0 Groundwater Monitoring Well System which provides a description of the CCR monitoring system
- Section 5.0 References

2.0 Site Background

2.1 Coyote Station

Coyote Station (Facility; Figure 1) burns lignite coal to operate its 454-megawatt generating unit.

Boiler slag and economizer ash are sluiced into the Sluice Outfall (Figure 1). Some of the fines overflow with the sluice water to the Slag Pond. Boiler slag is removed from the Sluice Outfall and utilized beneficially in accordance with the CCR Rule or disposed of in the Blue Pit.

The Slag Pond fines are dredged once every two to three years. The dredged material is dewatered in Nelsen Pond. The water drains by gravity back into the Slag Pond system, while the solid portion remains in Nelsen Pond (Figure 1). After dewatering is complete, the solids are transported by mobile equipment and placed in the Blue Pit (Figure 1).

The Blue Pit is an active CCR disposal area located southeast of the plant area and is primarily used for disposal of flue gas desulfurization (FGD) waste, as well as solids from Nelsen Pond.

2.1.1 Blue Pit Area History and Construction

The Blue Pit is permitted as an industrial landfill by the North Dakota Department of Health. It is constructed with a compacted clay liner, and it does not have a leachate collection system. Landfill permit documents were not reviewed for this report.

Historically, filling of Phase 1 (north part) of the Blue Pit began in 1999. Filling progressed from north to south in Phase 2 through Phase 8, from 2001 through today (Figure 2).

2.2 Site Setting

The Site lies on a portion of the Missouri Plateau, which consists of rolling to hummocky terrain incised by the Knife River. The region has historically been mined for lignite coal. Because of past mining activities, most of the native soil and geologic materials within and adjacent to the Site have been exposed, mined, and/or reclaimed with mine soils and mixed overburden materials. The subsurface units around the Facility have remained largely intact. Information on the geology and hydrogeology surrounding the Site is summarized in the sections below.

2.2.1 Regional Geology

The surface geology underlying most of the Site is the Coleharbor and Sentinel Butte Formations. Mine spoils primarily consist of a mixture of these two units in varying quantities.

The uppermost and youngest deposits consist of late Pleistocene glacial till of the Coleharbor Formation. This formation was deposited over older formations and generally fills in pre-existing valleys and erosional channels. The Coleharbor Formation generally consists of an unbedded, unsorted mixture (till) of clay, silt,

sand, pebbles, and a few cobbles and boulders, with a thickness up to 100 feet (Clayton, 1980). Sorted glaciofluvial sediments derived from meltwater are also par to the Coleharbor Formation.

The geological unit below the Coleharbor Formation is the Sentinel Butte Formation, which consists of brown to gray silt, sand, clay, sandstone, and lignite mixtures, along with river, lake, and swamp sediment with a thickness of up to 550 feet (Carlson, 1973). The Sentinel Butte Formation is subdivided into several intervals corresponding to associated lignite beds, which are separated by discontinuous low-permeability silts, clays, and sand. The School House (upper-most lignite bed) and Beulah-Zap (B-Z) lignite bed are mined in the area. The Spaer and Hazen "B" lignite beds are lignite beds located below the B-Z lignite bed and are not mined in the area because they are too deep below the ground surface to mine economically.

2.2.2 Regional Hydrogeology

Groundwater results primarily from infiltration into the ground within topographically higher upland areas consisting of the geological strata described above. Regional groundwater flow is toward the Knife River located approximately one mile north of the Site.

2.2.3 Site Geology

Figure 3 shows the surface geology at the Site as mapped by the State of North Dakota 1:500,000 Geologic Map, (Clayton, 1980). Due to the scale of this map, the geologic contacts shown when enlarged to the Site scale are not accurate. However, the map does show the general geological context.

The Oahe Formation is shown to the northwest of the Site on Figure 3, but it is not believed to be in the vicinity of the Blue Pit Area and is not discussed further.

Coleharbor Formation

The Coleharbor Formation consists primarily of clay with a few laterally discontinuous lenses of silt, sand, and gravel. A lens is defined in this report as a deposit that is thick in the middle and thins at the edges, but it may be truncated abruptly by erosion. In many cases, this formation has been stripped or partially removed as overburden above the mine deposits. The Coleharbor Formation (till) is a continuous lithostratigraphic unit, but it is divided into two separate hydrostratigraphic units for the purpose of this report as described below.

The Upper Coleharbor is the uppermost oxidized (weathered) clay till of the Coleharbor Formation.

The Lower Coleharbor is located below the Upper Coleharbor and is defined as typically less oxidized and grayer in color than the more oxidized Upper Coleharbor. The Lower Coleharbor is also less fractured and less permeable than the Upper Coleharbor, except where sand seams are present (Barr, 2013). The Lower Coleharbor may exhibit higher moisture content which may result in higher apparent plasticity (Barr, 2013).

Sentinel Butte Formation

As mentioned in Section 2.2.1, the Sentinel Butte Formation underlies the Coleharbor Formation. The Sentinel Butte Formation consists largely of gray consolidated clay (i.e. claystone) and some discontinuous low-permeability silts, clays, and sand. The formation is subdivided into several lignite intervals corresponding to associated lignite beds, which are separated by claystone and discontinuous low-permeability silts, clays, and sand. A thin lignite bed (2–5 feet thick) located in most cases 7 to 13 feet below the B-Z lignite bed is not mined likely because of economic reasons (i.e., quality, thickness, and/or depth). The thin lignite bed in this report is called the Lower B-Z.

2.2.3.1 Blue Pit Area

Available soil boring logs and monitoring well completion logs for the monitoring wells shown on Figure 2 were provided by OTP. Appendix A includes the following information:

- Soil boring and monitoring well completion logs for monitoring system wells discussed in Section 4.0, except that there is no known soil boring log available for well BLUE 6-93.
- Soil boring logs for new boring BLUE 7 (pilot boring) and monitoring well logs for BLUE 14, BLUE 15, and BLUE 16, which were installed in July 2016.
- Available soil logs and monitoring well completion logs used to create cross-sections presented in Section 3.0, except that there is no known soil boring log or monitoring well completion log available for well BLUE 4-93 and BLUE 6-93.

Generally, the soil boring logs and historical aerial photography from 1995 (Google Earth; Historical Photographs) show much of the area underlying and surrounding the Blue Pit Area has been disturbed by mining, except the geology under Highway 49 is believed to be undisturbed. Because of past mining activities, the surface topography has been extensively modified and most of the native soil and geologic materials have been exposed, mined, and/or reclaimed with mine soils and mixed with overburden materials.

Soil borings show that the surface and shallow geology from 0 to approximately 65–80 feet below ground surface (bgs) consist of mine spoils that are a mixture of Coleharbor Formation and Sentinel Butte Formation clay, silt, and sand that extend to the depth of mining.

The Sentinel Butte Formation is present below the mine spoil. The uppermost subunit is a claystone that is 7–13 feet thick and overlies the Lower B-Z lignite bed. The Lower B-Z lignite bed is 2–5 feet thick, brown to black, generally water bearing, and highly fractured. As shown on Figure 4, the Lower B-Z lignite bed dips to the west-southwest at about 0.01 ft/ft. The monitoring well logs show the majority of wells are screened across the Lower B-Z lignite bed.

2.2.4 Site Hydrogeology

The movement of groundwater within the geologic formations occurs within more permeable material (e.g., fractured lignite, sand or silty sand) within an otherwise fine-grained geologic media (e.g., claystone, clay till).

2.2.4.1 Blue Pit Area

The primary hydrostratigraphic unit for the Blue Pit Area is the Lower B-Z lignite bed of the Sentinel Butte Formation. Groundwater is relatively deep occurring at 50 to over 100 feet bgs with the shallower depths generally found in areas upgradient of the landfill.

Groundwater Flow

Figure 5 shows the temporal groundwater elevations (hydrograph) for monitoring wells included in the monitoring well system, which is described in more detail in Section 4.0. There are currently limited groundwater elevation data for monitoring wells BLUE 8-93, BLUE 14, BLUE 15, and BLUE 16 because these wells were either newly-installed or not routinely monitored. The figure shows monitoring well BLUE 7 had significant (i.e., ~10-foot) groundwater elevation flucations through time that are generally not obsevered in other Blue Pit Area monitoring wells (i.e., BLUE 8 and BLUE 13). Both BLUE 7 and BLUE 13 show increasing groundwater elevations over time. This may represent climatic factors or may be related to equilibration of the flow system from past mining hydrologic conditions.

Figure 6 shows the Blue Pit Area groundwater contours on August 16, 2016, and indicates that groundwater flow is northwest towards the valley between the Blue Pit and Black Pit (Figure 1). Groundwater flow appears to be strongly influenced by the dip of the Lower B-Z lignite bed. As mentioned in Section 2.2.3.1, the top of the Lower B-Z lignite bed map shown on Figure 4 illustrates a generally westward dip direction of the Lower B-Z lignite bed. Based on the groundwater elevations, groundwater enters the CCR unit boundary east of the Blue Pit and flows northwest. Appendix D provides a map of the bottom elevation of the Lower B-Z lignite bed, which was provided to OTP in a letter dated July 30, 2002, from Water Supply Inc. (Water Supply). The Water Supply map shows there is a strong northwest dip direction and Figure 4 (top of the Lower B-Z lignite bed map) shows the dip to be more westward; however, the source of data used to make the Water Supply map is unclear.

Laboratory Permeability and Hydraulic Conductivity

Table 1 and Table 2 summarize laboratory permeability test results from the Blue Pit Area. Laboratory data are available in Appendix B.

Table 1 Blue Pit Area Laboratory Values (Sentinel Butte Formation - Claystone)

Boring/ Well	Depth (ft)	Sample Description	USCS	Test Type	Hydraulic Conductivity (cm/s)
BLUE 7 (pilot boring)	88-89'	Fat Clay	CH	Vertical	$6.8x10^{-9}$
BLUE 7 (pilot boring)	126-127'	Fat Clay	CH	Vertical	$2x10^{-8}$
BLUE 7 (pilot boring)	126-127'	Fat Clay	CH	Horizontal	$1.7x10^{-8}$
BLUE 16	93.6-94.6'	Fat Clay	CH	Vertical	$5.1x10^{-8}$

Laboratory testing was not conducted on lignite from the Lower B-Z lignite bed because in-situ samples could not be obtained due to the hardness of the lignite.

Two sets of slug-in/out test pairs were performed at BLUE 15; however the slug-in test data for BLUE 15 were not analyzed due to significant noise in the data. Slug test analysis results are summarized in Table 2 and additional details pertaining to the data analysis are included in Appendix C.

A slug test consists of monitoring the water-level recovery in a well following an "instantaneous" change in water level. For this work, displacement of the water level in the well was achieved by adding and removing a solid piece of PVC pipe with a known volume. A slug test in which the displacement is initiated by rapidly lowering the slug below the water level is referred to as a slug-in or falling-head test; a slug-out or rising-head test is one in which the slug is rapidly removed. At least two slug tests—slug-in and slug-out—were performed sequentially at each well listed in Table 2. The resulting water-level recovery to static, pre-test condition was monitored using a data-logging pressure transducer (InSitu LevelTroll 700).

Hydraulic conductivity values were estimated using the AQTESOLV software package (Duffield, 2007) to match the Bouwer-Rice (1976) analytical solution against the water-level recovery data. Aquifer and well construction parameter values required for the analysis were obtained from the available boring logs and well-construction records.

Table 2 Blue Pit Slug Test Values

Well	Monitored Unit	Hydraulic Conductivity Slug-In (cm/s)	Hydraulic Conductivity Slug-Out (cm/s)
BLUE 13	Lower B-Z, upgradient	$4.2x10^{-6}$	$7.2x10^{-6}$
BLUE 15	Lower B-Z, downgradient	Not done	$4.6x10^{-3}$

The horizontal hydraulic conductivity of the Lower B-Z ranges from $4.2x10^{-6}$ to $4.6x10^{-3}$ cm/s based on single-well slug tests (Table 2), with a geometric mean of $5.2x10^{-5}$ cm/s. These slug test-derived values for hydraulic conductivity are similar to the values of $4.2x10^{-5}$ cm/s found in the Hagel Bed near Center, North Dakota (Rehm et. al., 1980). Hydraulic conductivity values vary within fractured lignite due to variability of fractures. A decrease in the size or number of fractures, at times due to increased depth or confining pressures, results in decreased permeability and thus decreased hydraulic conductivity (Rehm et. al., 1980).

The groundwater velocity is calculated using Darcy's equation, where the assumed porosity of the fractured Lower B-Z lignite aquifer is 0.2.:

$$Vt = K * i/n = 0.005 \text{ ft/day or } 2 \text{ ft/year}$$

Where: Vt = average linear velocity
K = hydraulic conductivity (geometric mean = $5.2x10^{-5}$ cm/s)
i = gradient (BLUE 13 to BLUE 15 =0.007; calculated from water levels)
n = effective porosity (0.2)

Confining Unit Characteristics

As mentioned above, the primary hydrostratigraphic unit for the Blue Pit Area is the Lower B-Z lignite bed of the Sentinel Butte Formation. The claystone located above and below the Lower B-Z lignite bed appears to be unsaturated and the thickness of the Sentinel Butte is estimated at over 500 feet thick. According to (Rehm et al., 1980, pg. 553) fractures are the "only cause" of permeability in coal. Therefore, it is likely that groundwater flow occurs mainly within fractures within the Lower B-Z lignite bed.

The vertical and horizontal conductivity results of the claystone tested above and below the Lower B-Z lignite bed show the material has a very low conductivity. Therefore, groundwater is expected to travel primarily horizontally within fractures of the Lower B-Z lignite bed at a velocity of 0.005 ft/day.

2.2.5 Potential Groundwater Flow Receptors

There are no known groundwater flow receptors (e.g., private water wells) within a 1-mile radius of the Blue Pit Area.

2.3 Well Development

Well development was completed to remove fines from the water column in the sand pack adjacent to the well screen and to improve formation permeability near the borehole that may have been influenced by drilling activities. Monitoring wells were surged several times initially by raising the pump up and down within the casing to settle the sand pack and collapse voids in the filter pack caused by bridging. Monitoring wells identified to be within the monitoring well system discussed in Section 4.0 were then developed by a combination of higher-rate pumping followed by lower-rate pumping without significant surging.

Volume of purge water removed, relative clarity and turbidity were measured at each well during development. Monitoring well development continued until the water from the well was relatively sediment free, appeared clear, and yielded consistent turbidity values. Table 3 provides the approximate lowest turbidity measurements, total volumes purged, and the approximate well recharge rates for each well developed.

Table 3 Blue Pit Area Turbidity, Purge, and Recharge Field Measurements

Well ID	Lowest Obtained Turbidity Measurement (NTU)	Approx. Total Amount Volume Purged (gal)	Approx. Most Recent Recharge Rate (ft.) [date]
BLUE 13	50	18	35 minutes to recharge 2 ft [7/15/16]
BLUE 6-93	53	24	25 minutes to recharge 1.5 ft [7/14/16]
BLUE 7-93	30	70	>3/4 gpm [7/14/16]
BLUE 14	90	30	4 hours to recharge 6 ft [7/15/16]
BLUE 15	5	40	5 minutes to recharge 1 ft [7/14/16]
BLUE 16	21	70	>1 gpm [7/14/16]

Table 3 also shows the approximate recharge rate measured by pumping the well dry and then measuring the recovery. In instances where the pump discharge could be matched to a recovery rate, the pumping rate is provided.

3.0 Conceptual Models

3.1 Blue Pit Area Site Conceptual Model

Cross section locations for the Blue Pit Area are shown on Figure 7 and include the locations of cross section A-A' and B-B'. Cross section A-A' is shown on Figure 8; cross section B- B' is shown on Figure 9. Monitoring well BLUE 12 was abandoned in July 2016 and is shown on Figure 7, Figure 8, and Figure 9 as an abandoned monitoring well.

Monitoring well BLUE 13 is near Highway 49 in an area that was not previously mined. The well completion log for monitoring well BLUE 13 shows two thick lignite beds above of the Lower B-Z lignite bed, which presumably are the School House and B-Z lignite beds.

The conceptual model for the Blue Pit Area shows that the subsurface materials consist primarily of spoil material and Sentinel Butte Formation. Groundwater is shown to be located within the Lower B-Z lignite bed. Groundwater flow is believed to occur within fractures of the lower B-Z lignite bed.

The groundwater flow map and the cross section on Figure 8 show that groundwater flows from the southeast to northwest towards a natural valley between the Black Pit and Blue Pit. The Lower B-Z lignite dips in the same general direction. Both cross sections shown on Figure 7 and Figure 8 assume the materials underneath Highway 49 have not been mined and the presumed target of mining excluded the Lower B-Z lignite interval.

3.2 Release Conceptual Model

A release conceptual model uses the groundwater flow direction and geologic information of the site conceptual model to predict the likely pathway of a release from a CCR unit to groundwater would travel so that a monitoring system can be positioned properly to intercept it.

3.2.1.1 Release Conceptual Model for the Blue Pit Area

As stated in Section 3.1, the groundwater flows from southeast to northwest, towards a valley near the Black Pit.

A hypothetical release from the Blue Pit would likely be transported northwest towards the valley between the Blue Pit and Black Pit in the downgradient direction of the water table shown on Figure 5. The downgradient wells discussed in the next section are positioned to ensure detection of any contaminants from such a release.

4.0 CCR Groundwater Monitoring System

Figure 10 shows and Table 4 describe the CCR groundwater monitoring system for the Blue Pit Area.

Table 4 Blue Pit Area Monitoring Well System Summary

Well ID	Well Placement	Rationale
BLUE 13	Upgradient	To account for geologic and hydrogeologic variability upgradient of the Blue Pit Area and to establish a sufficient number of upgradient monitoring wells at appropriate locations and depths to yield groundwater samples of the uppermost aquifer not impacted by the CCR unit (257.91(a) (1) and (2)).
BLUE 6-93, BLUE 7-93, BLUE 14, BLUE 15, and BLUE 16	Downgradient	To detect a release from the Blue Pit Area and to account for geologic and hydrogeologic variability, establish sufficient number of downgradient monitoring wells at appropriate locations and depths to yield groundwater samples of the uppermost aquifer accurately representing the quality of groundwater passing through the waste boundary (257.91(a) (1) and (2)).

As mentioned in Section 2.2.3.1, available soil boring logs and monitoring well completion logs for the monitoring well system are provided in Appendix A, except that there are no known soil boring log available for well BLUE 6-93.

Based on our observations during sampling and well-development activities, the upgradient and downgradient monitoring wells included in the monitoring system will be able to provide representative groundwater samples. Based on the monitoring well completion logs available, each well has a casing that is screened; the annular space between the screen and borehole is filled with sand and the annular space above the sand pack is sealed. The downgradient wells listed in Table 4 are positioned to ensure detection of any contaminants from a hypothetical release in the Blue Pit Area.

In summary, the groundwater monitoring system identified in Table 4 and on Figure 10 is deemed to be adequate for groundwater monitoring under the CCR Rule requirements. Table 5 provides construction details of the CCR groundwater monitoring wells.

Table 5 **Blue Pit Area CCR Monitoring Well Details**

Well	Installation Date	TOR	Total Depth BMP (ft)	Screen Length (ft)/ Diameter (in)	Casing/ Screen/Slot
BLUE 6-93	8/19/1993	1982.23	82.07	5/2.0	PVC/PVC/#10
BLUE 7-93	NA	1998.33	97.42	18.5/2.0	PVC/PVC/#10
BLUE 13	9/4/1998	2045.27	116.72	5/2.0	PVC/PVC/#10
BLUE 14	7/11/2016	1999.55	86.97	10/2.0	PVC/PVC/#8
BLUE 15	7/10/2016	1995.88	87.91	10/2.0	PVC/PVC/#8
BLUE 16	7/12/2016	1995.94	97.63	10/2.0	PVC/PVC/#8

NA = Not Available

5.0 References

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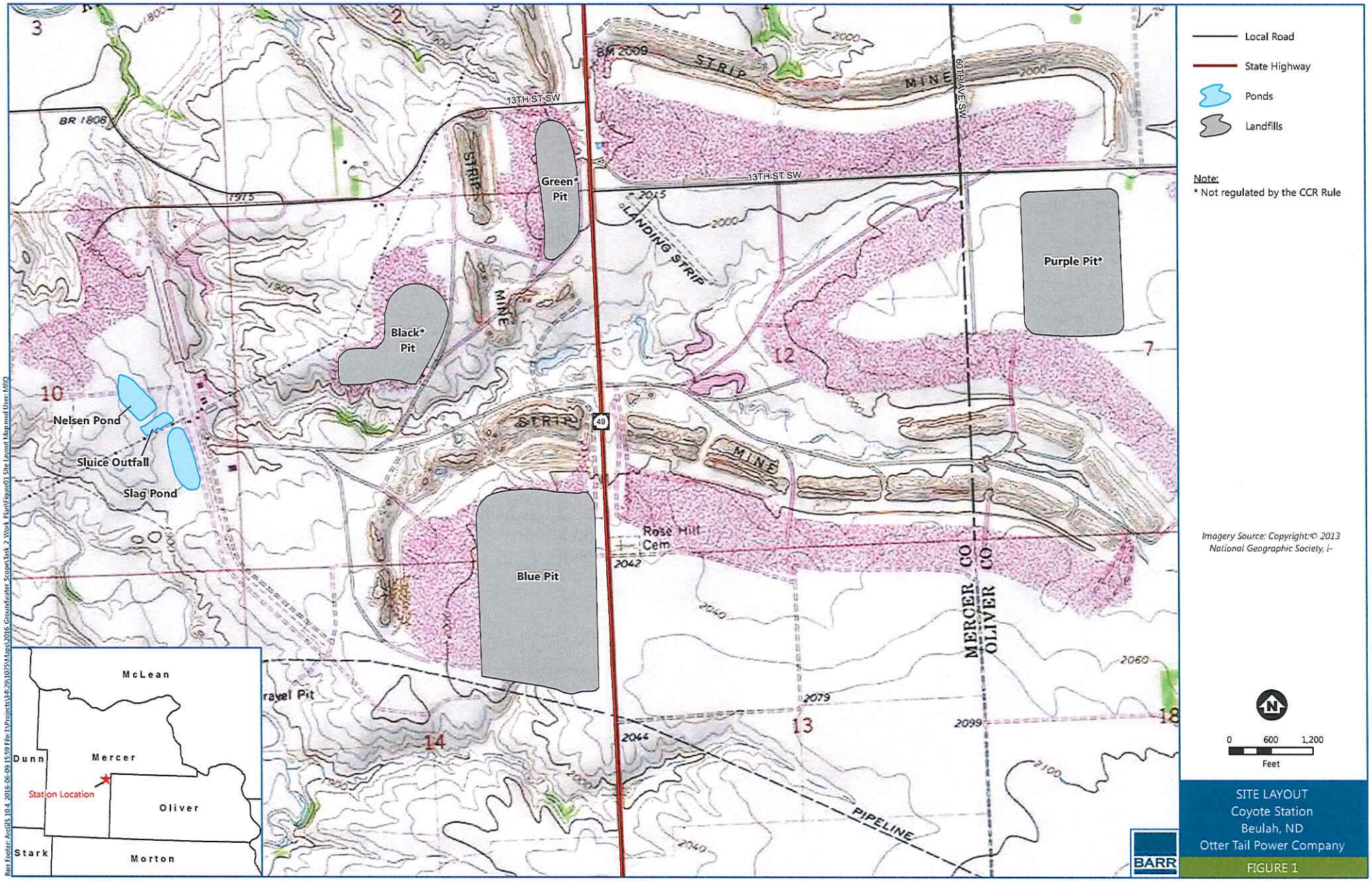
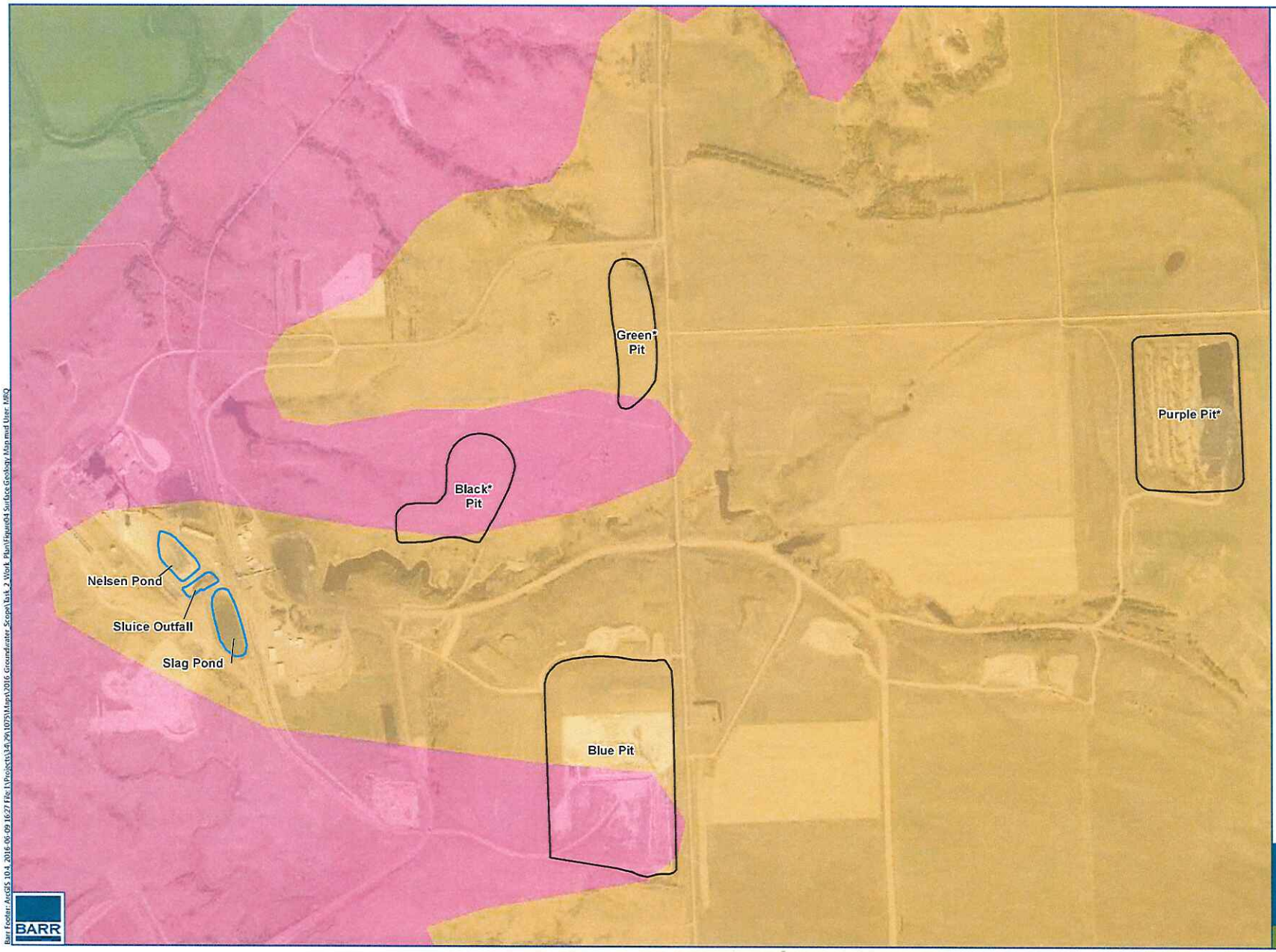
Figures



SITE LAYOUT
Coyote Station
Beulah, ND
Otter Tail Power Company

FIGURE 1


BLUE 4-93
49
BLUE 14
BLUE 7-93
Covered Landfill
BLUE 15
BLUE 5-93
BLUE 6-93
BLUE 1-93
Active Landfill
BLUE 16
BLUE 13
BLUE 3-93
BLUE 8-93
Monitoring Well Location
Active Landfill
Blue Pit Area
Imagery Source: USDA-FSA-APFO
NAIP 2015
0
250
500
Feet
BLUE PIT AREA
Coyote Station
Beulah, ND
Otter Tail Power Company
FIGURE 2
BARR
Ben Foster; ArcGIS 10.4; 2016-09-13 14:19; File: \\Projects\34\26\105\Maps\2016 Groundwater Scope\Task 5 Certification\Figure03 Blue Pit Area.mxd User: MFQ



Pond Areas

Landfill Areas

Geologic Unit

Coleharbor Formation

Oahe Formation

Sentinel Butte Formation

Geologic Terms

Coleharbor Formation - unbedded, unsorted mixture of clay, silt, sand, pebbles, and a few cobbles and boulders. Thickness may be up to 100 feet.

Oahe Formation - dark bedded clay and silt generally overlaying cross-bedded sand. Thickness may be up to 100 feet. On flood plains of modern streams.

Sentinel Butte Formation - Gray brown silt, sand, clay, sandstone, and lignite mixture. River, lake, and swamp sediment. Thickness may be up to 550 feet.

Note:

* Not regulated by the CCR Rule

Imagery Source: USDA-FSA-AFPO NAIP 2015

Surface geology data derived from the State of North Dakota 1:500,000 Geologic Map by Lee Clayton, 1980

N

0 600 1,200

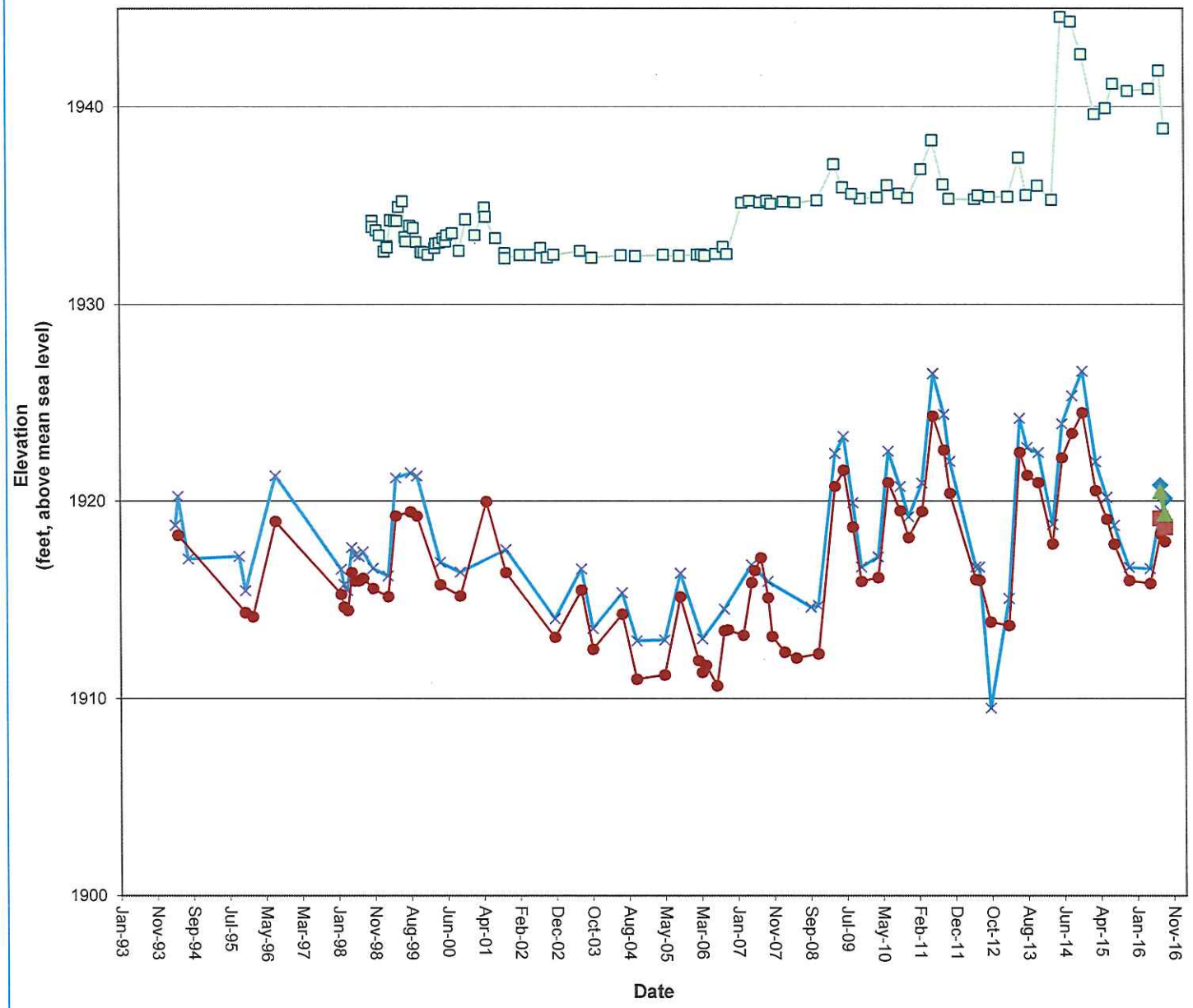
Feet

SURFACE GEOLOGY
Coyote Station
Beulah, ND
Otter Tail Power Company

FIGURE 3

BARR


BLUE 4-93
NA
BLUE 14
1920.20
BLUE 7-93
NA
BLUE 15
1915.60
Covered Landfill
BLUE 5-93
NA
BLUE 6-93
NA
Active Landfill
BLUE 1-93
NA
BLUE 16
1908.50
BLUE 12
1920.90
BLUE 13
1931.10
1910
1920
1930
BLUE 3-93
NA
BLUE 8-93
NA
49
Abandoned Monitoring Well
Monitoring Well
Top of Beulah-Zap Lignite Bed
Active Landfill
Blue Pit Area
Note:
NA - Not Available
Imagery Source: USDA-FSA-APFO NAIP 2015
N
0
250
500
Feet
TOP OF LOWER
BEULAH-ZAP LIGNITE
BLUE PIT AREA
Coyote Station
Beulah, ND
Otter Tail Power Company
FIGURE 4
BARR
Barr Footer: ArcGIS 10.4 2016-10-10 13:41 File: I:\Projects\23\Active\2015\Maps\2016 Groundwater Scope\Task 5 Certification\Figure05 Top of B-Z Lignite Bed (Blue Pit Area).mxd User: MRO

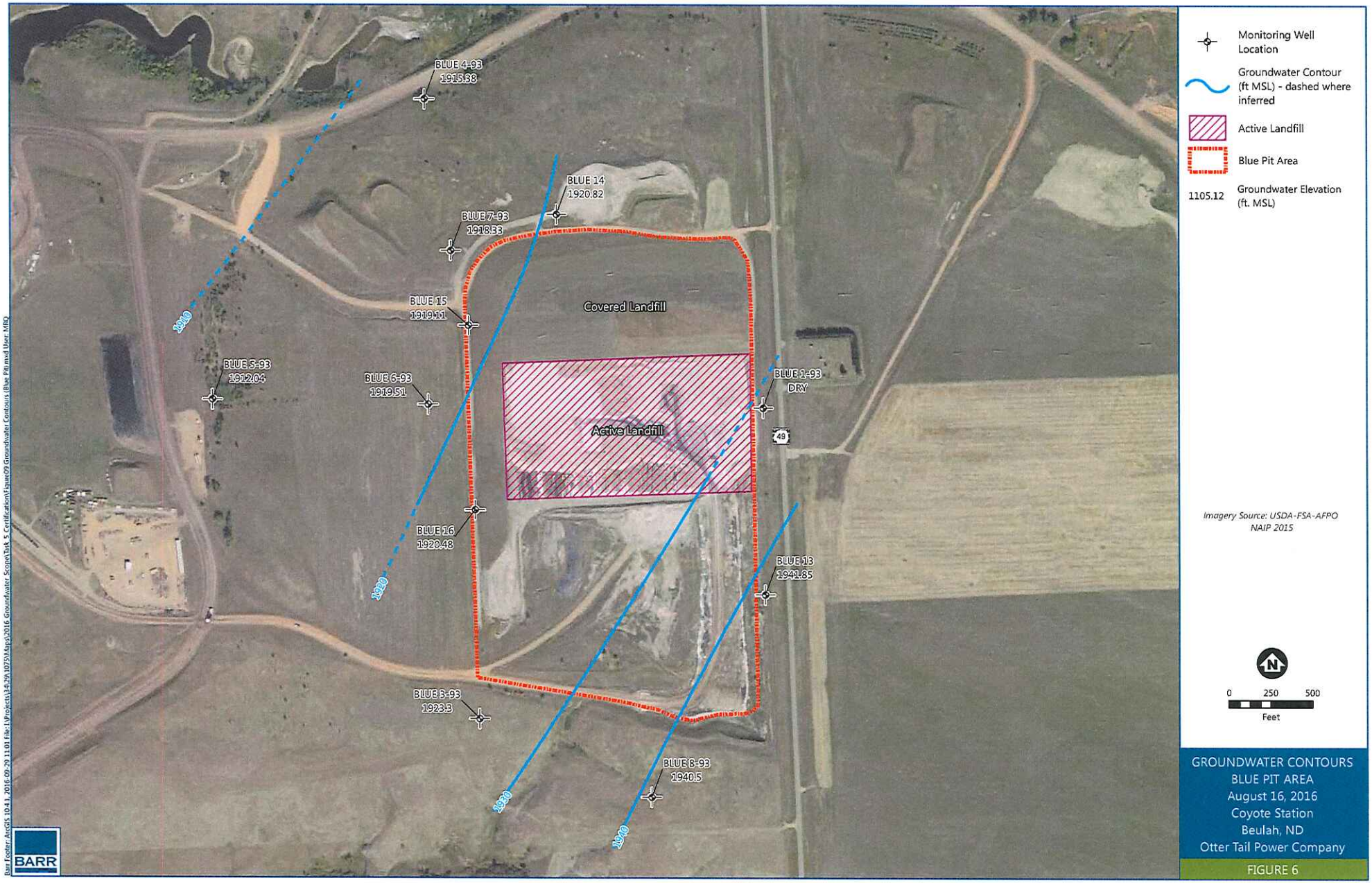


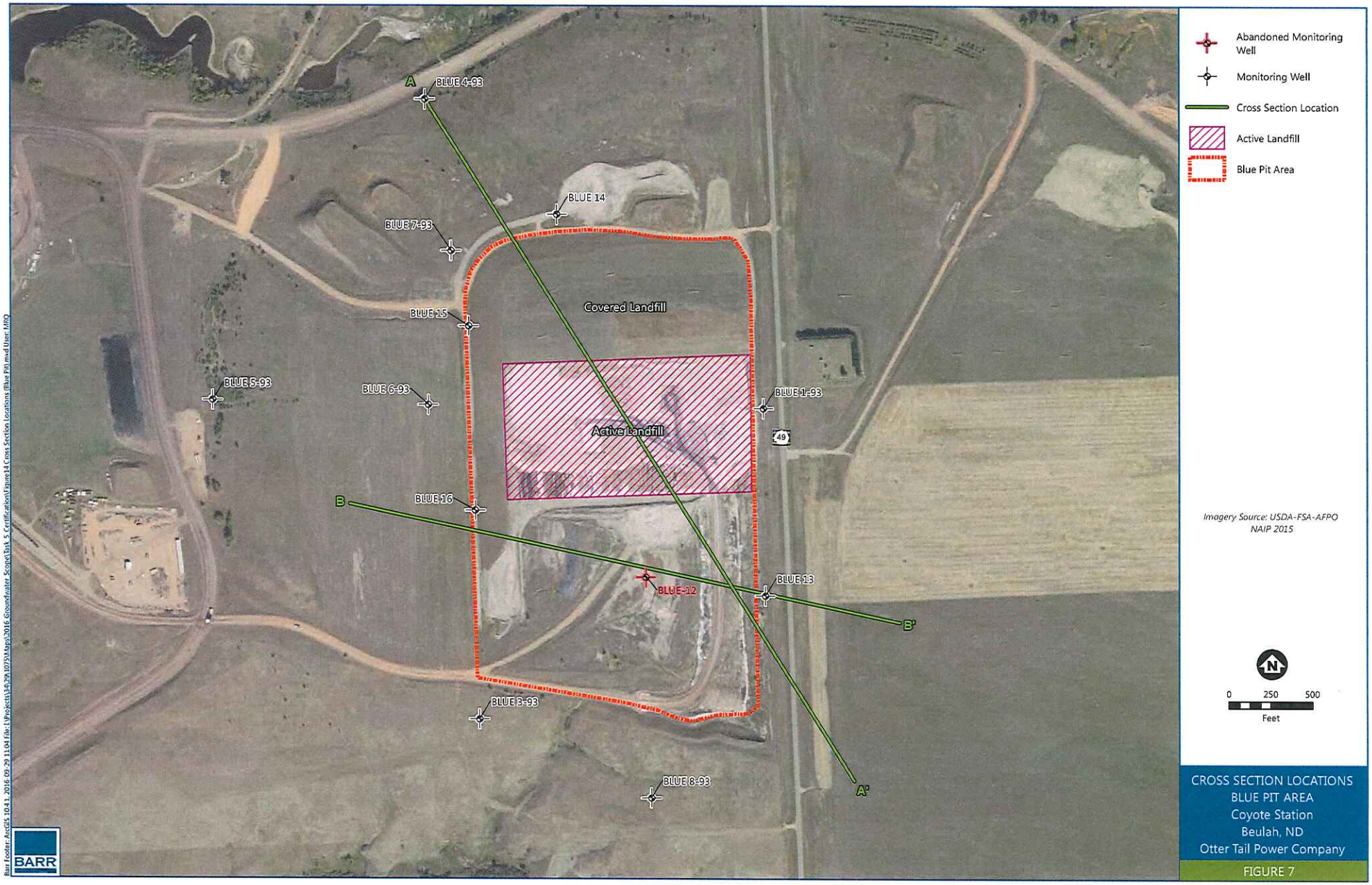
Note:
Monitoring Wells were resurveyed in 2013. Water levels from June 2013 onward reflect this change.

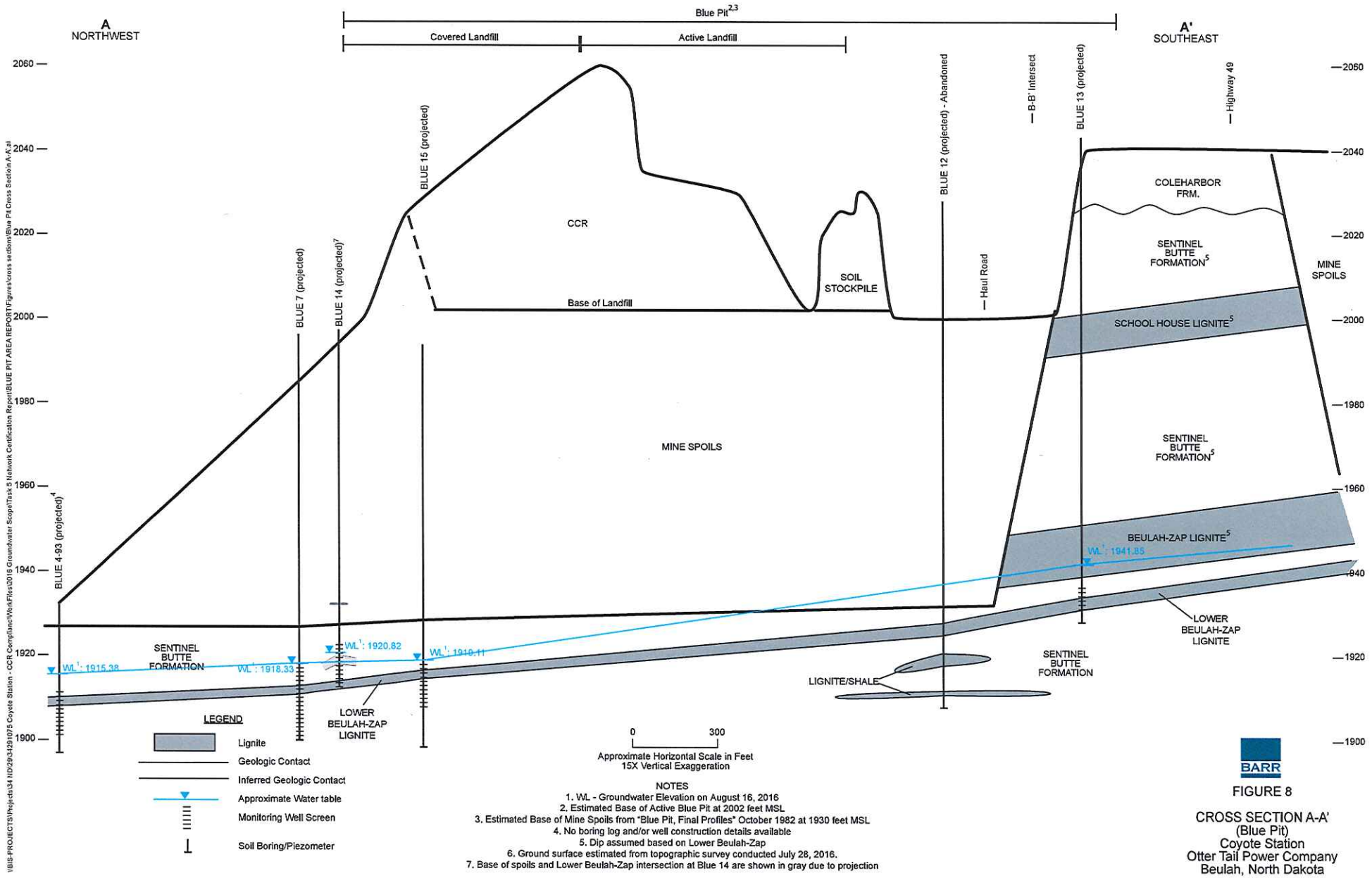
BARR

WELL HYDROGRAPH (BLUE PIT AREA)
Coyote Station
Beulah, ND
Otter Tail Power Company

FIGURE 5


BLUE 4-93
1915.38
BLUE 14
1920.82
BLUE 7-93
1918.33
BLUE 15
1919.11
Covered Landfill
BLUE 5-93
1912.04
BLUE 6-93
1919.51
BLUE 1-93
DRY
Active Landfill
49
BLUE 16
1920.48
BLUE 13
1941.85
BLUE 3-93
1923.3
BLUE 8-93
1940.5
1910
1920
1930
1940
Monitoring Well Location
Groundwater Contour (ft MSL) - dashed where inferred
Active Landfill
Blue Pit Area
1105.12
Groundwater Elevation (ft. MSL)
Imagery Source: USDA-FSA-APFO NAIP 2015
N
0
250
500
Feet
GROUNDWATER CONTOURS
BLUE PIT AREA
August 16, 2016
Coyote Station
Beulah, ND
Otter Tail Power Company
FIGURE 6
BARR
Barr Footer ArcGIS 10.4.1, 2016-09-29 11:01 File:\Projects\34.29107\5\Maps\2016 Groundwater Scope\Task 5 Certification\Figure09 Groundwater Contours Blue Pit.mxd User: MKC


A
BLUE 4-93
BLUE 14
BLUE 7-93
Covered Landfill
BLUE 15
BLUE 5-93
BLUE 6-93
BLUE 1-93
Active Landfill
49
B
BLUE 16
BLUE 12
BLUE 13
B'
BLUE 3-93
BLUE 8-93
A'
Abandoned Monitoring Well
Monitoring Well
Cross Section Location
Active Landfill
Blue Pit Area
Imagery Source: USDA-FSA-APFO NAIP 2015
N
0
250
500
Feet
CROSS SECTION LOCATIONS
BLUE PIT AREA
Coyote Station
Beulah, ND
Otter Tail Power Company
FIGURE 7
BARR



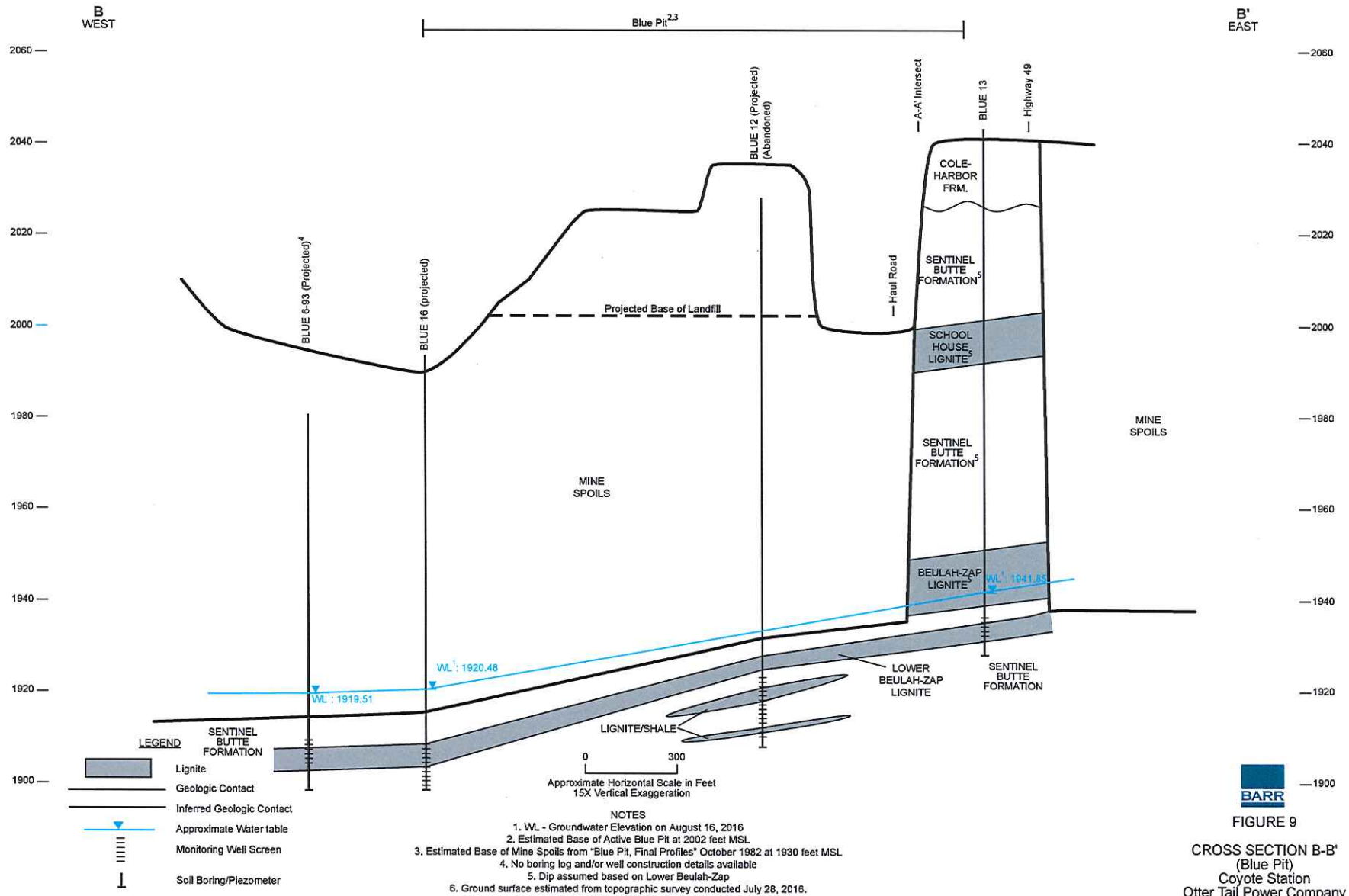
NOTES
1. WL - Groundwater Elevation on August 16, 2016
2. Estimated Base of Active Blue Pit at 2002 feet MSL
3. Estimated Base of Mine Spoils from "Blue Pit, Final Profiles" October 1982 at 1930 feet MSL
4. No boring log and/or well construction details available
5. Dip assumed based on Lower Beulah-Zap
6. Ground surface estimated from topographic survey conducted July 28, 2016.
7. Base of spoils and Lower Beulah-Zap intersection at Blue 14 are shown in gray due to projection

BARR

FIGURE 8

CROSS SECTION A-A'
(Blue Pit)
Coyote Station
Otter Tail Power Company
Beulah, North Dakota

\\BIS-PROJECTS\Projects\34 ND\29-34291075 Coyote Station - CCR Compliance\Work Files\2016 Groundwater Sampling\Task 5 Network Certification Report\BLUE PIT AREA REPORT\Figures\cross sections\Blue Pit Cross Section A-A'.ai



NOTES
1. WL - Groundwater Elevation on August 16, 2016
2. Estimated Base of Active Blue Pit at 2002 feet MSL
3. Estimated Base of Mine Spoils from "Blue Pit, Final Profiles" October 1982 at 1930 feet MSL
4. No boring log and/or well construction details available
5. Dip assumed based on Lower Beulah-Zap
6. Ground surface estimated from topographic survey conducted July 28, 2016.

BARR

FIGURE 9

CROSS SECTION B-B'
(Blue Pit)
Coyote Station
Otter Tail Power Company
Beulah, North Dakota

Monitoring Well Location

Active Landfill

Blue Pit Area

Imagery Source: USDA-FSA-APFO NAIP 2015

0 250 500

Feet

MONITORING WELL SYSTEM
BLUE PIT AREA
Coyote Station
Beulah, ND
Otter Tail Power Company

FIGURE 10

BARR

Barr Footer: ArcGIS 10.4 2016-10-10 13:58 File:\\Projects\\342\29\1095\Mxd\2016 Groundwater Scope\Task 5 Certification\Figure18 Monitoring Well System (Blue Pit Area).mxd User: MPO

Appendix A

Boring Logs (Blue Pit)

07/16/2002 WELL COMPLETION REPORT Well Number: 6-93

Owner: OTPC Project: Coyote Blue
Well Coordinates: S-21 W-2108
Location: 143 -088 -14ABB
Aquifer: Lower BZ
County: Mercer State: ND

Drilling Company: WSI
Method Drilled: Rotary
Bit Size: 5.25
Depth Drilled: 80'

Drilled: 19 August 1993
Completed: 19 August 1993
Destroyed:

Well Head Elevation (MP): 1980.18
Ground Elevation (GL): 1978.16

CASING Type: PVC Diameter: 2"

SCREEN Type: PVC Diameter: 2"
Slot Size: 010
Top (from GL): 73 Bottom (from GL): 78
Top Elevation: 1905.16 Bottom Elevation: 1900.16

Shdown Valve: YES
Formation Packer: NO

GRAVEL Type: 20-40 silica sand Volume: 100#
Top (from GL): 70 Bottom (from GL): 80
Top Elevation: 1908.16 Bottom Elevation: 1898.16
Tremied: YES

GROUT Type: neat cement
Volume: 940#
Top (from GL): 2 Bottom (from GL): 65
Top Elevation: 1976.16 Bottom Elevation: 1913.16
Tremied: YES

BACKFILL Type: Med. Bentonite Chips
Top: 65 Bottom: 70
Type:
Top: Bottom:

COMMENTS

07/16/2002 WELL COMPLETION REPORT Well Number: 7

Owner: OTPC Project: Coyote Blue
Well Coordinates: N-900 W-1932
Location: 143N-088W-11DCA
Aquifer: Lower BZ
County: Mercer State: ND

Drilling Company:
Method Drilled:
Bit Size:
Depth Drilled: '

Drilled:
Completed:
Destroyed:

Well Head Elevation (MP): 1996.15
Ground Elevation (GL): 1994.04

CASING Type: PVC Diameter: 2

SCREEN Type: Diameter:
Slot Size:
Top (from GL): 80 Bottom (from GL): 98.5
Top Elevation: 1914.04 Bottom Elevation: 1895.54

Shutdown Valve: NO
Formation Packer: NO

GRAVEL Type: Volume:
Top (from GL): Bottom (from GL):
Top Elevation: Bottom Elevation:
Tremied: NO

GROUT Type:
Volume:
Top (from GL): Bottom (from GL):
Top Elevation: Bottom Elevation:
Tremied: NO

BACKFILL Type:
Top: Bottom:
Type:
Top: Bottom:

COMMENTS

State of North Dakota

BOARD OF WATER WELL CONTRACTORS

900 E. BOULEVARD * BISMARCK, NORTH DAKOTA 58505

MONITORING WELL REPORT

State law requires that this report be filed with the State Board of Water Well Contractors within 30 days after completion or abandonment of the well.

1. WELL OWNER

Name Coyote Station

Address Box 339

Beulah, ND 58631

2. WELL LOCATION

Address (if in City)

#13, Blue Pit Monitoring Well

143-88-14ADA

County Mercer

NE1/4 SE1/4 NE1/4 Sec. 14 Twp. 143N. Rge. 88W

Lat.:

Long.:

Altitude:

3. METHOD DRILLED

Auger Other Mud Rotary

4. WELL CONSTRUCTION

Diameter of Hole 5.5 inches Depth 115 feet

Riser: X PVC Other

Threaded Solvent X Other

Riser rating SDR 21 Schedule

Diameter 2 inches

From 2.5 ft. to 109 ft.

Was a well screen installed? Yes No

Material PVC Diameter 2 inches

Slot Size 10 set from 109 ft to 114 ft

Sand packed from 105 to 115

Depth grouted from surface to 105

Grouting material

Bentonite HiSolids Grt Other &

If other explain: Quikrete w/4" sq steel vertical protective casing

Well head completion:

24" above grade X Other

If other, specify

Was protective casing installed? X yes No

Was well disinfected upon completion? yes X No

5. WATER LEVEL

Static water level Feet below surface

if flowing: closed-in pressure psi or

ft. above land surface

6. WELL LOG

Formation	Depth (Ft.) To
Clay silty	1
Limestone rock	2
Clay, mottled yellow and gray	17
Clay, silty medium gray	32
Clay, silty, dark gray	34
Clay, silty to sandy, medium gray	42
Lignite	51
Clay, sandy, medium gray	59
Clay, silty to sandy, medium gray	92
Lignite, taking water	104
Clay	109
Lignite	112
Clay	115

(use separate sheet if necessary)

7. WAS THE HOLE PLUGGED OF ABANDONED?

Yes X No

if so, how?

8. REMARKS Silica sand to 105', 200# high solids bentonite grout to 30' 250# bentonite chips to 2', Quikrete w/4" sq steel vertical PC at surface

9. DATE COMPLETED 9/3/98

10. CONTRACTOR CERTIFICATION

This well was drilled under my jurisdiction and this report is true to the best of my knowledge

Water Supply, Inc. 96

Monitoring Well Contractor Certificate No.

Box 1191, Bismarck, ND 58501-1191

Address

Signature WSIKP/MWR02 9/4/98 Date

Barr Engineering Company
234 West Century Avenue
Bismarck, ND 58503
Telephone: 701-255-5460

LOG OF BORING BLUE 7 (Pilot)

Project:Coyote Station CCR Rule
Project No.:34291075.01
Location:Mercer County, North Dakota
Coordinates:N 567,315.4 ft E 1,647,060.2 ft
Datum:NAD83 ND State Plane South

Surface Elevation:1995.9 ft
Drilling Method:Rotasonic
Sampling Method:Continuous
Completion Depth:135.0 ft

Unique Well No.: BLUE 7

Depth, feet	Sample Type & Recovery	Sample No.	USCS	Graphic Log	LITHOLOGIC DESCRIPTION	MAJOR UNIT	Elevation, feet
0			CH		TOPSOIL: (FAT CLAY) (CH): olive gray; moist; roots; high plasticity; weak HCl reaction; 0% gravel, 5% sand, 95% fines.		1995
					FAT CLAY (CH): olive gray; moist; some silt; high plasticity; weak HCl reaction; 5% gravel, 5% sand, 90% fines. 1 ft: trace lignite and scoria granules. 2 to 2.5 ft: siltier. 4 to 5 ft: siltier.		
5							1990
					7 to 9 ft: Clayey gravel (GC), gray, moist, rounded gravel with white gray clay, high plasticity, strong HCL recation, 60% gravel, 5% sand, 35% fines.		
10							1985
15					15.2 to 15.4 ft: siltier, oranger; no HCl reaction. 15.4 to 15.5 ft: some lignite granules; no HCl reaction. 17 ft: large rock (plugged casing); no HCl reaction.		1980
20							1975
25							1970
30							1965
					32 to 40 ft: 2" siltier zone, more orange; no HCl reaction.	Mine Spoils	
35			CH				1960
40					40 ft: grayer; no HCl reaction.		1955
45							1950
50							1945
55					55 to 56.5 ft: very fine red orange sand; no HCl reaction.		1940
60							1935
65					66 to 67.5 ft: black, clayey sand, roots, damp; no HCl reaction.		1930
70			CH				

Date Boring Started: 7/9/16 7:10 am
Date Boring Completed: 7/9/16 1:50 pm
Logged By: AMK2
Drilling Contractor: Cascade
Drill Rig: Truck

Remarks:

Additional data may have been collected in the field which is not included on this log.

Barr Engineering Company
234 West Century Avenue
Bismarck, ND 58503
Telephone: 701-255-5460

LOG OF BORING BLUE 7 (Pilot)

Project:Coyote Station CCR Rule
Project No.:34291075.01
Location:Mercer County, North Dakota
Coordinates:N 567,315.4 ft E 1,647,060.2 ft
Datum:NAD83 ND State Plane South

Surface Elevation:1995.9 ft
Drilling Method:Rotasonic
Sampling Method:Continuous
Completion Depth:135.0 ft

Unique Well No.: BLUE 7

Depth, feet	Sample Type & Recovery	Sample No.	USCS	Graphic Log	LITHOLOGIC DESCRIPTION	MAJOR UNIT	Elevation, feet
70					CLAYSTONE (CH): dark gray; moist; firm, thinly bedded with silt; high plasticity; no HCl reaction; 0% gravel, 5% sand, 95% fines. *(continued)*		1925
75			CH		75 to 82 ft: siltier, bluer; no HCl reaction.	Sentinel Butte Formation	1920
80					82 to 83 ft: abundant thin lignite seams; no HCl reaction.		1915
			OL		LIGNITE (OL): brown to black; moist; no HCl reaction.	Lower B-Z Lignite	
85					CLAYSTONE (CH): dark gray; moist; firm, thinly bedded with silt; high plasticity; no HCl reaction; 0% gravel, 5% sand, 95% fines.		1910
90					88 to 89 ft: Sample taken for grain-size analysis. Lab analysis done by Terracon. Results: Silty Sand (SM) 35 to 40 ft: Sample taken for grain-size analysis. Lab analysis done by Terracon. Result: Fat Clay (CH).		1905
95					93 to 95 ft: darker; no HCl reaction. Moist to wet; 95 to 95.4 ft: lignite clay mix,; no HCl reaction.		1900
100					99 to 100 ft: bedded thicker, trace lignite granules, bluer; no HCl reaction. 100 to 102 ft: siltier; no HCl reaction.		1895
105					102 ft: darker; no HCl reaction. 103 to 108: lignite clay mix; no HCl reaction.		1890
110			CH		109 to 112 ft: lighter gray; no HCl reaction.	Sentinel Butte Formation	1885
115					115 to 117 ft: siltier; weak HCl reaction.		1880
120							1875
125					124 to 125 ft: clayey gravel; strong HCl reaction. 125 ft: trace lignite seam; weak HCl reaction. 126 to 127 ft: Sample taken for grain-size analysis. Lab analysis done by Terracon. Results: Silty Sand (SM) 35 to 40 ft: Sample taken for grain-size analysis. Lab analysis done by Terracon. Result: Fat Clay (CH).		1870
130							1865
135					End of boring 135.0 feet		
140							

Date Boring Started: 7/9/16 7:10 am
Date Boring Completed: 7/9/16 1:50 pm
Logged By: AMK2
Drilling Contractor: Cascade
Drill Rig: Truck

Remarks:

Additional data may have been collected in the field which is not included on this log.

O:\GINT\PROJECTS\34291075\COYOTE BORING LOGS.GPJ BARRLIBRARY.GLB ENVIRO LOG BARR TEMPLATE.GDT

Barr Engineering Company
234 West Century Avenue
Bismarck, ND 58503
Telephone: 701-255-5460

LOG OF BORING BLUE 14

Project:Coyote Station CCR Rule
Project No.:34291075.01
Location:Mercer County, North Dakota
Coordinates:N 567,497.4 ft E 1,647,704.6 ft
Datum:NAD83 ND State Plane South

Surface Elevation:1997.2 ft
Drilling Method:Rotasonic
Sampling Method:Continuous
Completion Depth:85.0 ft

Unique Well No.: BLUE 14

Depth, feet	Sample Type & Recovery	Sample No.	USCS	Graphic Log	LITHOLOGIC DESCRIPTION	MAJOR UNIT	WELL OR PIEZOMETER CONSTRUCTION DETAIL	Elevation, feet
0			CH		ROAD (CH): dark grayish brown; moist; (same as below); 10% gravel, 25% sand, 65% fines.			1995
					SANDY FAT CLAY WITH GRAVEL: very dark gray; moist; rounded; trace lignite and scoria granules, very fine to fine sand, some white/gray silt, mustard yellow silt, trace rounded gravel; weak HCl reaction; 10% gravel, 25% sand, 65% fines.		PRO. CASING Diameter: 4" Type: Square Steel Interval:	
5					5 to 10 ft: trace orange oxidized staining.			1990
10					10 to 15 ft: more purple than gray; no HCl reaction.		RISER CASING Diameter: 2" Type: PVC Sch 40 Interval:	1985
15					15 ft: firmer; no HCl reaction.			1980
20							GROUT Type: Neat Cement Interval: 0-67' bgs	1975
25							SEAL Type: Bentonite Interval: 67-72' bgs	1970
30					31 to 31.5 ft: some thin lignite seams; no HCl reaction.	Mine Spoils		1965
35					31.5 to 50 ft: some very fine sandy clay fill to silty clay fill, gray, softer; no HCl reaction.		SANDPACK Type: Silica 30/50 Interval: 72-85' bgs	1960
40					41 ft: abundant oxidized staining; no HCl reaction.		SCREEN Diameter: 2" (Slot Size 8) Type: PVC Sch 40 Interval: 75-85' bgs	1955
45								1950
50					51 ft: trace oxidized staining; no HCl reaction.			1945
55								1940
60					60.5 ft: 6" of silty gray clay; no HCl reaction. 61 to 62 ft: Lignite/clay mixed with roots; no HCl reaction.			1935
65					64 ft: roots; no HCl reaction.			1930
70					CLAYSTONE: FAT CLAY: very dark greenish gray; moist; thin to thick silt laminations, firm; no HCl reaction; massive; 0% gravel, 10% sand, 90% fines.			

Date Boring Started: 7/11/16 9:00 am
Date Boring Completed: 7/11/16 12:30 pm
Logged By: AMK2
Drilling Contractor: Cascade
Drill Rig: Truck

Remarks:

Additional data may have been collected in the field which is not included on this log.

O:\GINT\PROJECTS\34291075\COYOTE BORING LOGS.GPJ BARRLIBRARY.GLB ENVIRO LOG BARR TEMPLATE.GDT

Barr Engineering Company
234 West Century Avenue
Bismarck, ND 58503
Telephone: 701-255-5460

LOG OF BORING BLUE 14

Project:Coyote Station CCR Rule
Project No.:34291075.01
Location:Mercer County, North Dakota
Coordinates:N 567,497.4 ft E 1,647,704.6 ft
Datum:NAD83 ND State Plane South

Surface Elevation:1997.2 ft
Drilling Method:Rotasonic
Sampling Method:Continuous
Completion Depth:85.0 ft

Unique Well No.: BLUE 14

Depth, feet	Sample Type & Recovery	Sample No.	USCS	Graphic Log	LITHOLOGIC DESCRIPTION	MAJOR UNIT	WELL OR PIEZOMETER CONSTRUCTION DETAIL	Elevation, feet
70					CLAYSTONE: FAT CLAY: very dark greenish gray; moist; thin to thick silt laminations, firm; no HCl reaction; massive; 0% gravel, 10% sand, 90% fines. *(continued)*	Sentinel Butte Fm	PRO. CASING Diameter: 4" Type: Square Steel Interval:	1925
75			OL		LIGNITE (OL): brown to black; no HCl reaction.	Lower B-Z Lignite		1920
80					CLAYSTONE: FAT CLAY: very dark greenish gray; moist; thin to thick silt laminations, firm. 79 ft: damp purple fat clay; no HCl reaction. 81 to 82': Siltier; no HCl reaction. 83 to 84': Damp clayey very fine grained sand.	Sentinel Butte Fm	RISER CASING Diameter: 2" Type: PVC Sch 40 Interval:	1915
85					End of boring 85.0 feet		GROUT Type: Neat Cement Interval: 0-67' bgs SEAL Type: Bentonite Interval: 67-72' bgs SANDPACK Type: Silica 30/50 Interval: 72-85' bgs SCREEN Diameter: 2" (Slot Size 8) Type: PVC Sch 40 Interval: 75-85' bgs	
90								
95								
100								
105								
110								
115								
120								
125								
130								
135								
140								

Date Boring Started: 7/11/16 9:00 am
Date Boring Completed: 7/11/16 12:30 pm
Logged By: AMK2
Drilling Contractor: Cascade
Drill Rig: Truck

Remarks:

Additional data may have been collected in the field which is not included on this log.

O:\GINT\PROJECTS\34291075\COYOTE BORING LOGS.GPJ BARRLIBRARY.GLB ENVIRO LOG BARR TEMPLATE.GDT

Barr Engineering Company
234 West Century Avenue
Bismarck, ND 58503
Telephone: 701-255-5460

LOG OF BORING BLUE 15

Project:Coyote Station CCR Rule
Project No.:34291075.01
Location:Mercer County, North Dakota
Coordinates:N 566,856.5 ft E 1,647,138.1 ft
Datum:NAD83 ND State Plane South

Surface Elevation:1993.6 ft
Drilling Method:Rotasonic
Sampling Method:Continuous
Completion Depth:90.0 ft

Unique Well No.: BLUE 15

Depth, feet	Sample Type & Recovery	Sample No.	USCS	Graphic Log	LITHOLOGIC DESCRIPTION	MAJOR UNIT	WELL OR PIEZOMETER CONSTRUCTION DETAIL	Elevation, feet
0					SCORIA/GRAVEL ROAD: moist; weak HCl reaction.			1990
5					SANDY FAT CLAY WITH GRAVEL: brown; moist; angular small scoria, rounded small to large gravel, rounded fine to coarse sand, some black lignite granules and dust, some gray clay; medium to high plasticity; weak HCl reaction; 10% gravel, 30% sand, 60% fines.		PRO. CASING Diameter: 4" Type: Square Steel Interval:	1985
10								
15					12.9 ft: 6" lignite; no HCl reaction.		RISER CASING Diameter: 2" Type: PVC Sch 40 Interval:	1980
20					18 ft: some silty sand; no HCl reaction. CLAYEY GRAVEL: gray; moist; rounded to subangular large gravel, whitish gray fat clay; strong HCl reaction; 60% gravel, 5% sand, 35% fines.		GROUT Type: Neat Cement Interval: 0-66' bgs	1975
25					CLAYSTONE: dark gray; moist; firm fat clay, trace gravel at 24.5 ft,; high plasticity; no HCl reaction; massive; 5% gravel, 5% sand, 90% fines.			1970
30					SANDY FAT CLAY WITH GRAVEL: moist; rounded small to large gravel, rounded fine to coarse sand; no HCl reaction. CLAYSTONE: dark gray; moist; firm fat clay, massive, some mustard yellow silt, disturbed Sentinal Butte; high plasticity; no HCl reaction; 5% gravel, 5% sand, 90% fines.	Mine Spoils	SEAL Type: Bentonite Interval: 66-72.5' bgs	1965
35					35 ft: trace lignite granules; no HCl reaction.		SANDPACK Type: Silica 30/50 Interval: 72.5-85.4' bgs	1960
40							SCREEN Diameter: 2" (Slot Size 8) Type: PVC Sch 40 Interval: 75.4-85.4' bgs	1955
45					45 to 49 ft: grayer; no HCl reaction.			1950
50					49 to 55 ft: more orange; weak HCl reaction. 52 ft: 3" lignite.			1945
55					55 to 65 ft: grayer; no HCl reaction.			1940
60								1935
65					CLAYSTONE: dark gray; moist; fat, abundant light gray silt lenses, thinly bedded; weak HCl reaction; massive; 0% gravel, 5% sand, 95% fines.			1930
70								1925

Date Boring Started: 7/8/16 9:40 am
Date Boring Completed: 7/8/16 2:30 pm
Logged By: AMK2
Drilling Contractor: Cascade
Drill Rig: Truck

Remarks: Water added down hole at 65 feet to help with drilling

Additional data may have been collected in the field which is not included on this log.

O:\GINT\PROJECTS\34291075\COYOTE BORING LOGS.GPJ BARRLIBRARY.GLB ENVIRO LOG BARR TEMPLATE.GDT

Barr Engineering Company
234 West Century Avenue
Bismarck, ND 58503
Telephone: 701-255-5460

LOG OF BORING BLUE 15

Project:Coyote Station CCR Rule
Project No.:34291075.01
Location:Mercer County, North Dakota
Coordinates:N 566,856.5 ft E 1,647,138.1 ft
Datum:NAD83 ND State Plane South

Surface Elevation:1993.6 ft
Drilling Method:Rotasonic
Sampling Method:Continuous
Completion Depth:90.0 ft

Unique Well No.: BLUE 15

Depth, feet	Sample Type & Recovery	Sample No.	USCS	Graphic Log	LITHOLOGIC DESCRIPTION	MAJOR UNIT	WELL OR PIEZOMETER CONSTRUCTION DETAIL	Elevation, feet
70					CLAYSTONE: dark gray; moist; fat, abundant light gray silt lenses, thinly bedded; weak HCl reaction; massive; 0% gravel, 5% sand, 95% fines. *(continued)*	Sentinel Butte Formation	PRO. CASING Diameter: 4" Type: Square Steel Interval:	1920
75					73 ft: Lignite, 1" thick, brown to black ,wet, thickly bedded, no HCL reaciton. 73 to 75 ft: damp.			1915
					LIGNITE: brown to black; moist; brown to black; no HCl reaction.	Lower B-Z Lignite		
80					CLAYSTONE: dark gray; moist; fat, abundant silt lenses (light gray), thinly bedded; no HCl reaction; 0% gravel, 5% sand, 95% fines.	Sentinel Butte Formation	RISER CASING Diameter: 2" Type: PVC Sch 40 Interval:	1910
85					85 to 90 ft: sandier; no HCl reaction. 87 to 90 ft: thickly bedded; weak HCl reaction.			1905
90					End of boring 90.0 feet		GROUT Type: Neat Cement Interval: 0-66' bgs SEAL Type: Bentonite Interval: 66-72.5' bgs SANDPACK Type: Silica 30/50 Interval: 72.5-85.4' bgs SCREEN Diameter: 2" (Slot Size 8) Type: PVC Sch 40 Interval: 75.4-85.4' bgs	
95								
100								
105								
110								
115								
120								
125								
130								
135								
140								

Date Boring Started: 7/8/16 9:40 am
Date Boring Completed: 7/8/16 2:30 pm
Logged By: AMK2
Drilling Contractor: Cascade
Drill Rig: Truck

Remarks: Water added down hole at 65 feet to help with drilling

Additional data may have been collected in the field which is not included on this log.

O:\GINT\PROJECTS\34291075\COYOTE BORING LOGS.GPJ BARRLIBRARY.GLB ENVIRO LOG BARR TEMPLATE.GDT

Barr Engineering Company
234 West Century Avenue
Bismarck, ND 58503
Telephone: 701-255-5460

LOG OF BORING BLUE 16

Project:Coyote Station CCR Rule
Project No.:34291075.01
Location:Mercer County, North Dakota
Coordinates:N 565,749.1 ft E 1,647,112.6 ft
Datum:NAD83 ND State Plane South

Surface Elevation:1993.5 ft
Drilling Method:Rotasonic
Sampling Method:Continuous
Completion Depth:95.0 ft

Unique Well No.: BLUE 16

Depth, feet	Sample Type & Recovery	Sample No.	USCS	Graphic Log	LITHOLOGIC DESCRIPTION	MAJOR UNIT	WELL OR PIEZOMETER CONSTRUCTION DETAIL	Elevation, feet
0			CH		SANDY FAT CLAY WITH GRAVEL (CH): dark grayish brown; moist; rounded small to large gravel, rounded fine sand, trace lignite and scoria granules, light gray silty clay; high plasticity; no HCl reaction; 10% gravel, 30% sand, 60% fines.	Mine Spoils	PRO. CASING Diameter: 4" Type: Square Steel Interval: RISER CASING Diameter: 2" Type: PVC Sch 40 Interval: GROUT Type: Neat Cement Interval: 0-76' bgs SEAL Type: Bentonite Interval: 76-82' bgs SANDPACK Type: Silica 30/50 Interval: 82-95' bgs SCREEN Diameter: 2" (Slot Size 8) Type: PVC Sch 40 Interval: 85-95' bgs	1990
5								1985
10								1980
15								1975
20			CH		CLAYSTONE (CH): greenish black; moist; fat, disturbed, some mustard yellow and gray silty clay, trace lignite, firm; high plasticity; no HCl reaction; massive; 0% gravel, 5% sand, 95% fines. 23 to 25 ft: less disturbed. 23.5 ft: 2cm lignite seam; no HCl reaction. 24.4 ft: 0.1' damp clayey sand. 24.5 ft: 0.5' clayey lignite; no HCl reaction.			1970
25					SANDY FAT CLAY WITH GRAVEL: no HCl reaction. 25 ft: more orange.			1965
30					32 to 33 ft: disturbed Sentinel Butte claystone; no HCl reaction.			1960
35								1955
40					43.5 ft to 44 ft: very fine clayey sand. 44.5 ft: 2" damp purple fat clay; no HCl reaction.			1950
45								1945
50					52 ft: 1.5' of very fine clayey sand.			1940
55					56.5 ft: 2" lignite seam; no HCl reaction. 58 ft: 0.5' lignite.			1935
60					59 to 60 ft: clayey gravel fill, whitish gray; strong HCl reaction.			1930
65					65.5 to 67 ft: whitish gray clay, trace gravel; strong HCl reaction. 67 to 70 ft: bluer.			1925
70								

Date Boring Started: 7/12/16
Date Boring Completed: 7/12/16 11:15 am
Logged By: AMK2
Drilling Contractor: Cascade
Drill Rig: Truck

Remarks:

Additional data may have been collected in the field which is not included on this log.

O:\GINT\PROJECTS\34291075\COYOTE BORING LOGS.GPJ BARRLIBRARY.GLB ENVIRO LOG BARR TEMPLATE.GDT

Barr Engineering Company
234 West Century Avenue
Bismarck, ND 58503
Telephone: 701-255-5460

LOG OF BORING BLUE 16

Project:Coyote Station CCR Rule
Project No.:34291075.01
Location:Mercer County, North Dakota
Coordinates:N 565,749.1 ft E 1,647,112.6 ft
Datum:NAD83 ND State Plane South

Surface Elevation:1993.5 ft
Drilling Method:Rotasonic
Sampling Method:Continuous
Completion Depth:95.0 ft

Unique Well No.: BLUE 16

Depth, feet	Sample Type & Recovery	Sample No.	USCS	Graphic Log	LITHOLOGIC DESCRIPTION	MAJOR UNIT	WELL OR PIEZOMETER CONSTRUCTION DETAIL	Elevation, feet
70					SANDY FAT CLAY WITH GRAVEL: no HCl reaction. *(continued)* 72 ft: trace scoria; no HCl reaction.	Mine Spoils	PRO. CASING Diameter: 4" Type: Square Steel Interval:	1920
75								
80			CH		CLAYSTONE (CH): very dark greenish gray; moist; fat, very firm, thinly bedded; no HCl reaction; massive; 0% gravel, 0% sand, 100% fines. 83 ft: trace pyrite.	Sentinel Butte Fm	RISER CASING Diameter: 2" Type: PVC Sch 40 Interval:	1915 1910
85			OL		LIGNITE (OL): brown to black; moist; brown to black; no HCl reaction.	Lower B-Z Lignite		1905
			OL		LIGNITE (OL): brown to black; wet; brown to black.			
90					CLAYSTONE: very dark greenish gray; fat, very firm, thinly bedded. 90 to 92 ft: less firm. 91 and 94 ft: some tan clay; no HCl reaction. 93.6 to 94.6 ft: Sample taken for grain-size analysis. Lab analysis done by Terracon. Results: Silty Sand (SM) 35 to 40 ft: Sample taken for grain-size analysis. Lab analysis done by Terracon. Result: Fat Clay (CH).	Sentinel Butte Fm	GROUT Type: Neat Cement Interval: 0-76' bgs	1900
95					End of boring 95.0 feet		SEAL Type: Bentonite Interval: 76-82' bgs SANDPACK Type: Silica 30/50 Interval: 82-95' bgs SCREEN Diameter: 2" (Slot Size 8) Type: PVC Sch 40 Interval: 85-95' bgs	
100								
105								
110								
115								
120								
125								
130								
135								
140								

Date Boring Started: 7/12/16
Date Boring Completed: 7/12/16 11:15 am
Logged By: AMK2
Drilling Contractor: Cascade
Drill Rig: Truck

Remarks:

Additional data may have been collected in the field which is not included on this log.

C:\GINT\PROJECTS\34291075\COYOTE BORING LOGS.GPJ BARRLIBRARY.GLB ENVIRO LOG BARR TEMPLATE.GDT

State of North Dakota

BOARD OF WATER WELL CONTRACTORS

900 E. BOULEVARD * BISMARCK, NORTH DAKOTA 58505

MONITORING WELL REPORT

State law requires that this report be filed with the State Board of Water Well Contractors within 30 days after completion or abandonment of the well.

1. WELL OWNER

Name Coyote Station

Address Box 339

Beulah, ND 58631

2. WELL LOCATION

Address (if in City)

#12, Blue Pit Monitoring Well

143-88-14AAC

County Mercer

SW1/4 NE1/4 NE1/4 Sec. 14 Twp. 143N. Rge. 88W

Lat.:

Long.:

Altitude:

3. METHOD DRILLED

Auger Other Mud Rotary

4. WELL CONSTRUCTION

Diameter of Hole 5.5 inches Depth 120 feet

Riser: X PVC Other

Threaded Solvent X Other

Riser rating SDR 21 Schedule

Diameter 2 inches

From 1.9 ft. to 107 ft.

Was a well screen installed? Yes No

Material PVC Diameter 2 inches

Slot Size 10 set from 107 ft to 120 ft

Sand packed from 105 to 120

Depth grouted from ~30 to 105

Grouting material

Bentonite HiSolids Grt Other &

If other explain: Quikrete w/4" sq steel vertical protective casing

Well head completion:

24" above grade X Other

If other, specify

Was protective casing installed? X yes No

Was well disinfected upon completion? yes X No

5. WATER LEVEL

Static water level Feet below surface

if flowing: closed-in pressure psi or

ft. above land surface

6. WELL LOG

Formation	Depth (Ft.) To
Clay silty, brown and gray, spoil*	96
Clay, bedrock?	100
Lignite or hard shale	103
Clay	107
Lignite or hard shale	110
Clay	116
Lignite	117
Clay	120

* Lost circulation at ~20', no samples, log based on drill action

(use separate sheet if necessary)

7. WAS THE HOLE PLUGGED OF ABANDONED?

Yes X No

if so, how?

8. REMARKS 325# silica sand to 105', 150# high solids bentonite grout to about 30', 235# bentonite chips to 2.5', Quikrete w/4" sq steel vertical PC at surface

9. DATE COMPLETED 9/3/98

10. CONTRACTOR CERTIFICATION

This well was drilled under my jurisdiction and this report is true to the best of my knowledge

Water Supply, Inc. 96

Monitoring Well Contractor Certificate No.

Box 1191, Bismarck, ND 58501-1191

Address

Signature WSIKP/MWR02 9/4/98 Date

Appendix B

Geotechnical Laboratory Data

Terracon
1805 Hancock Dr / PO Box 2084 / Bismarck, North Dakota 58502
Telephone (701) 258-2833 / Fax (701) 258-2857

REPORT OF: TESTS OF SOILS

PROJECT: Coyote Station Project
6240 13th St SW
Beulah, North Dakota

DATE: August 4, 2016

REPORTED TO: Otter Tail Power Company
Attn: Paul Vukonich
PO Box 496
Fergus Falls, MN 56538-0496

COPIES: Barr Engineering Company
Attn: Scott Korom

PROJECT NO: M2165099

SAMPLE IDENTIFICATION:	Blue 7, Depth 88-89' Vertical	Blue 7, Depth 126-127' Vertical	Blue 7, Depth 126-127' Horizontal
CLASSIFICATION:	FAT CLAY (CH)	FAT CLAY (CH)	FAT CLAY (CH)
COLOR:	Dark gray	Dark gray	Dark gray

PARTICLE DISTRIBUTION (see attached curves):

Gravel (%)			
Sand (%)	1.5	2.4	
Fines (%)			
Silt (.074-.005 mm)	57.2	11.1	
Clay (.005-.001 mm)	41.3	86.6	

LABORATORY PERMEABILITY:

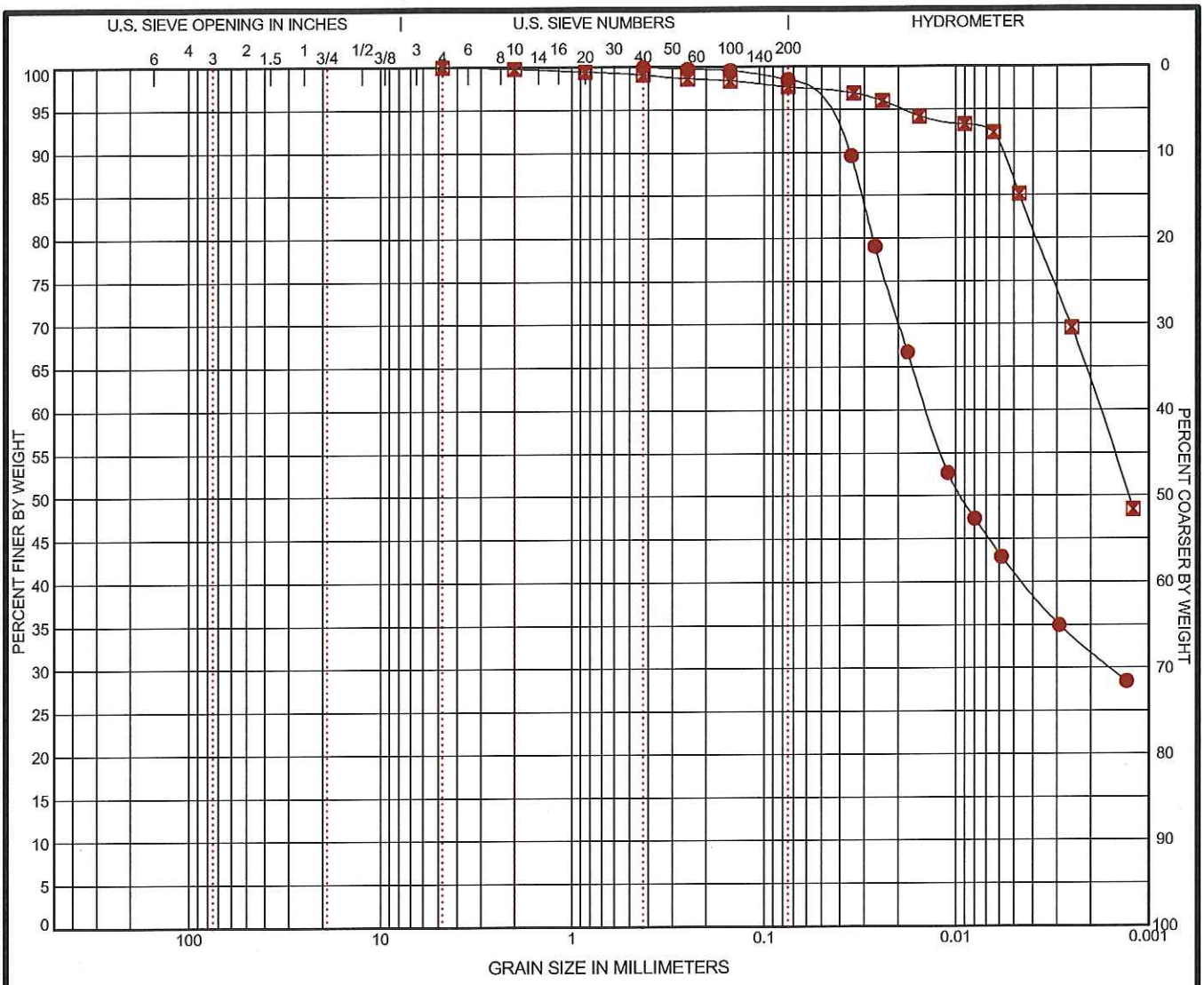
Method	US Army Corps of Engineers, EM1110-2-1906, Appendix VII-Permeability Tests (modified)		
Initial Moisture Content (%)	18.4	25.4	24.8
Final Moisture Content (%)	21.7	31.8	32.4
Coefficient of Permeability (cm/sec)	6.8×10^{-9}	2.0×10^{-8}	1.7×10^{-8}

REMARKS: Samples were submitted to and received here at the laboratory for test on July 25, 2016.

Signed: _____
Chad A. Cowley, P.E.

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	BORING ID	DEPTH	% COBBLES	% GRAVEL	% SAND	% SILT	% FINES	% CLAY	USCS
●	Blue 7	88 - 89	0.0	0.0	1.5	57.2		41.3	
⊠	Blue 7	126 - 127	0.0	0.0	2.4	11.1		86.6	

	GRAIN SIZE		
	●	⊠	
D_{60}	0.014	0.002	
D_{30}	0.002		
D_{10}			
	COEFFICIENTS		
C_C			
C_U			

SIEVE (size)	PERCENT FINER ●	PERCENT FINER ⊠	
1 1/2"			
1"			
3/4"			
1/2"			
3/8"			
#4		100.0	
#10		99.82	
#20		99.45	
#40	100.0	99.08	
#60	99.75	98.62	
#100	99.58	98.38	
#200	98.51	97.64	

SOIL DESCRIPTION
● FAT CLAY (CH)
⊠ FAT CLAY (CH)

REMARKS
●
⊠

PROJECT: Coyote Station

SITE: Mercer County, North Dakota

Terracon
1805 Hancock Dr PO Box 2084
Bismarck, ND

PROJECT NUMBER: M2165099

CLIENT: Otter Tail Power Company

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS 1 M2165099 LAB TESTING ONLY.GPJ 35159097 - ATTERBERG ISSUE.GPJ 8/3/16

Terracon
1805 Hancock Dr / PO Box 2084 / Bismarck, North Dakota 58502
Telephone (701) 258-2833 / Fax (701) 258-2857

REPORT OF: TESTS OF SOILS

PROJECT:	Coyote Station Project 6240 13th St SW Beulah, North Dakota	DATE:	August 4, 2016
REPORTED TO:	Otter Tail Power Company Attn: Paul Vukonich PO Box 496 Fergus Falls, MN 56538-0496	COPIES:	Barr Engineering Company Attn: Scott Korom
PROJECT NO:	M2165099		

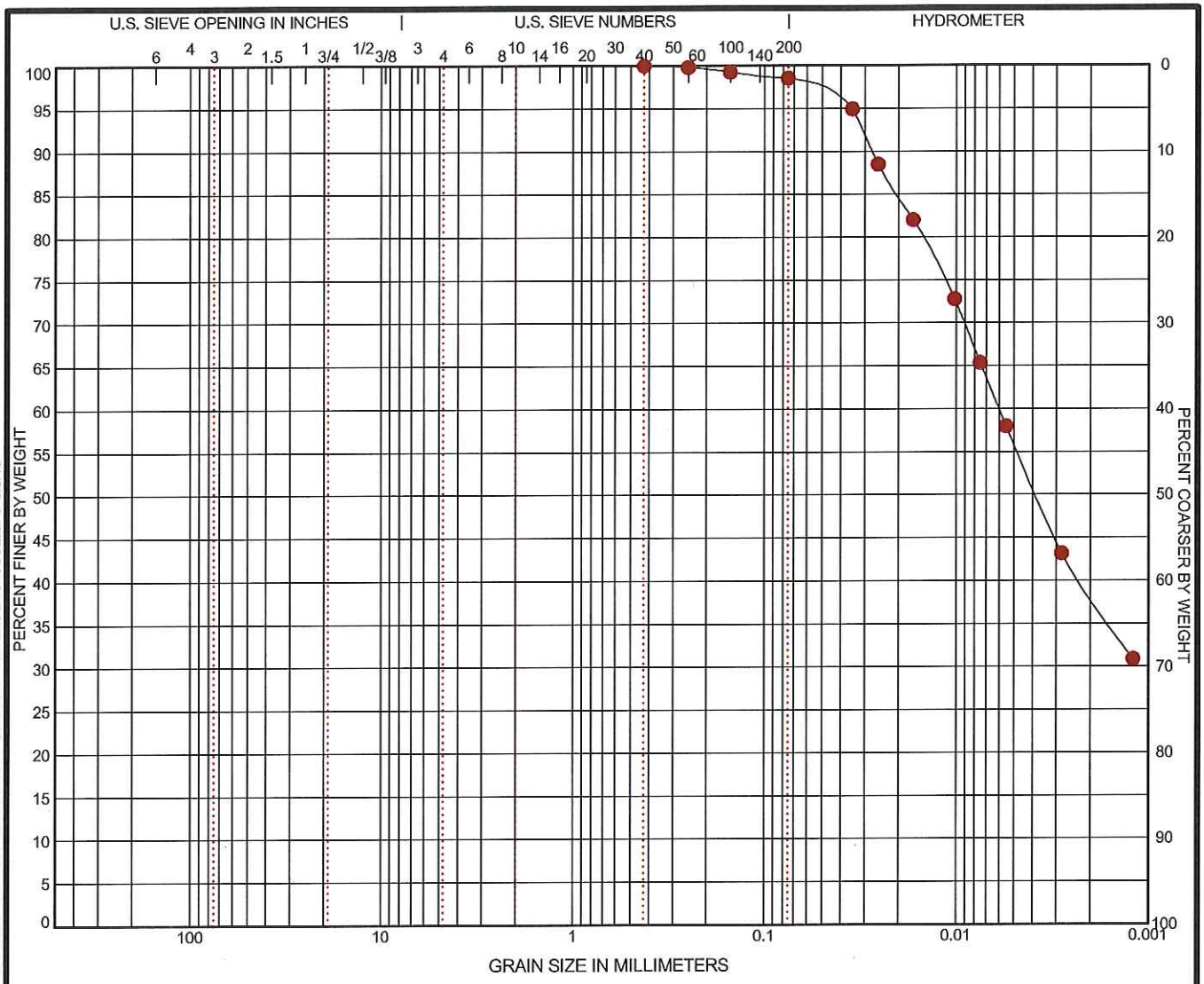
SAMPLE IDENTIFICATION:	Blue 16, Depth 93.6-94.6' Vertical
CLASSIFICATION:	FAT CLAY (CH)
COLOR:	Dark gray
PARTICLE DISTRIBUTION (see attached curve):	
Gravel (%)	
Sand (%)	1.4
Fines (%)	
Silt (.074-.005 mm)	42.6
Clay (.005-.001 mm)	55.9
LABORATORY PERMEABILITY:	
Method	US Army Corps of Engineers, EM1110-2-1906, Appendix VII-Permeability Tests (modified)
Initial Moisture Content (%)	16.2
Final Moisture Content (%)	30.1
Coefficient of Permeability (cm/sec)	5.1×10^{-8}

REMARKS: Sample was submitted to and received here at the laboratory for test on July 25, 2016.

Signed: _____
Chad A. Cowley, P.E.

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	BORING ID	DEPTH	% COBBLES	% GRAVEL	% SAND	% SILT	% FINES	% CLAY	USCS
●	**Blue 16**	**93.6 - 94.6**	**0.0**	**0.0**	**1.4**	**42.6**		**55.9**	

	GRAIN SIZE
	●
D_{60}	**0.006**
D_{30}	
D_{10}	
	COEFFICIENTS
C_C	
C_U	

SIEVE (size)	PERCENT FINER ●		
1 1/2"			
1"			
3/4"			
1/2"			
3/8"			
#4			
#10			
#20			
#40	**100.0**		
#60	**99.82**		
#100	**99.28**		
#200	**98.55**		

SOIL DESCRIPTION
● FAT CLAY (CH)

REMARKS
●

PROJECT: Coyote Station

SITE: Mercer County, North Dakota

Terracon
1805 Hancock Dr PO Box 2084
Bismarck, ND

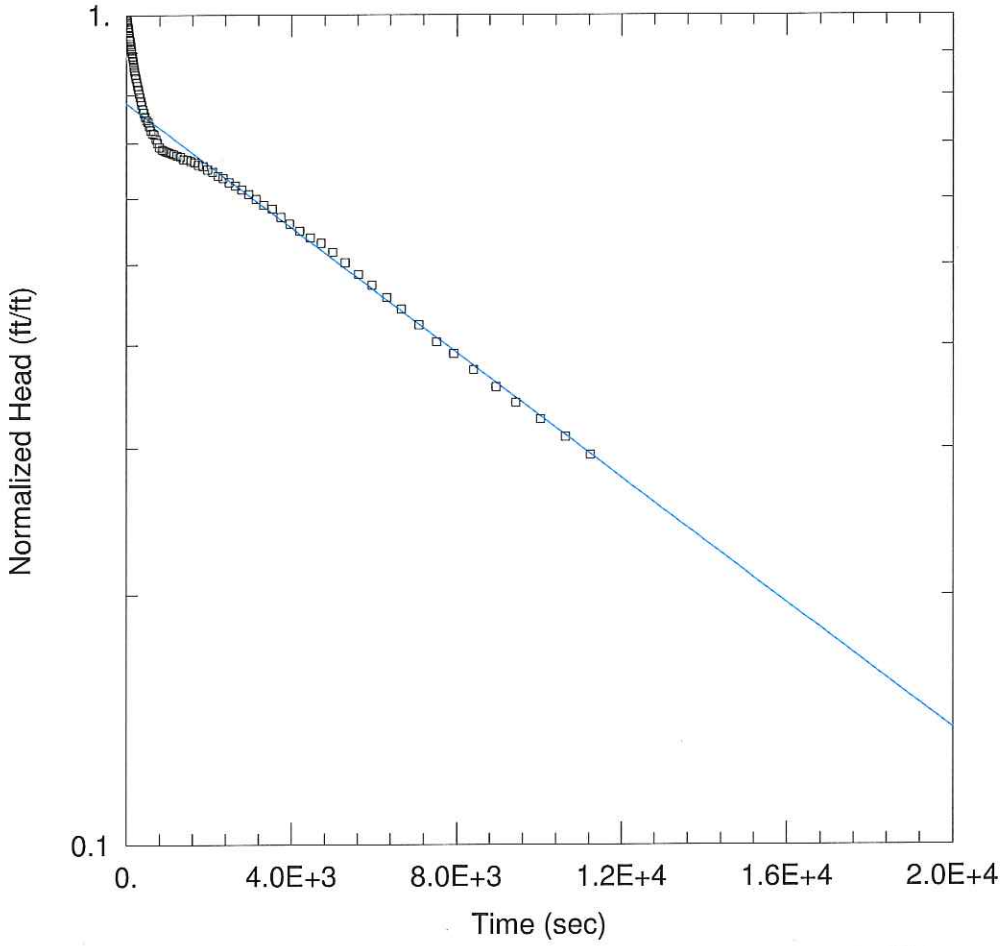
PROJECT NUMBER: M2165099

CLIENT: Otter Tail Power Company

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS 1 M2165099 LAB TESTING ONLY.GPJ 35159097 - ATTERBERG ISSUE.GPJ 8/3/16

Appendix C

Slug Test Results



BLUE 13 FALLING HEAD SLUG TEST (SLUG-IN)

Data Set: \...\Blue 13 Slug In BR.aqt
Date: 09/14/16 Time: 09:45:55

PROJECT INFORMATION

Company: Barr Engineering Co.
Client: OtterTail Power Company
Project: 34291075
Location: Beulah, ND
Test Well: Blue-13
Test Date: July 22, 2016

AQUIFER DATA

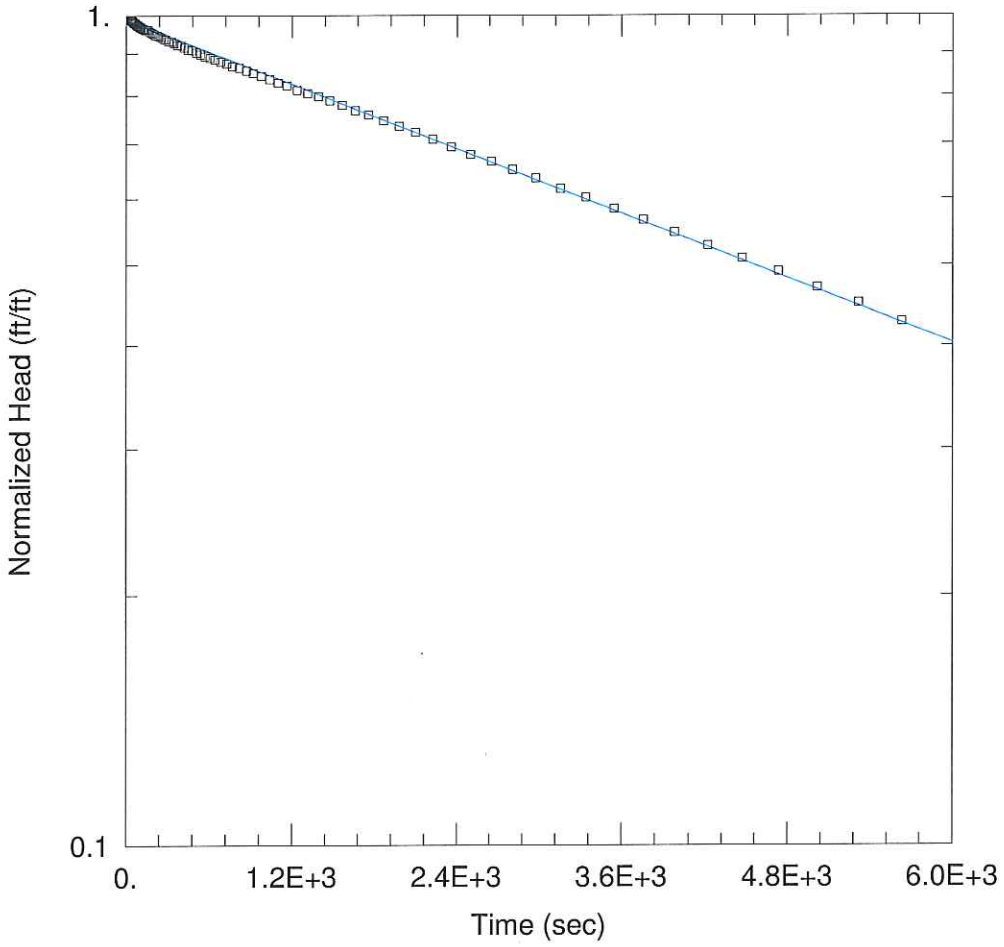
Saturated Thickness: 5. ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (Blue 13)

Initial Displacement: 1.32 ft
Total Well Penetration Depth: 5. ft
Casing Radius: 0.083 ft
Static Water Column Height: 12.06 ft
Screen Length: 5. ft
Well Radius: 0.23 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice
K = 4.174E-6 cm/sec
y0 = 1.033 ft



BLUE 13 RISING HEAD SLUG TEST (SLUG-OUT)

Data Set: \...\Blue 13 Slug Out BR.aqt
Date: 09/14/16 Time: 09:45:45

PROJECT INFORMATION

Company: Barr Engineering Co.
Client: OtterTail Power Company
Project: 34291075
Location: Beulah, ND
Test Well: Blue-13
Test Date: July 22, 2016

AQUIFER DATA

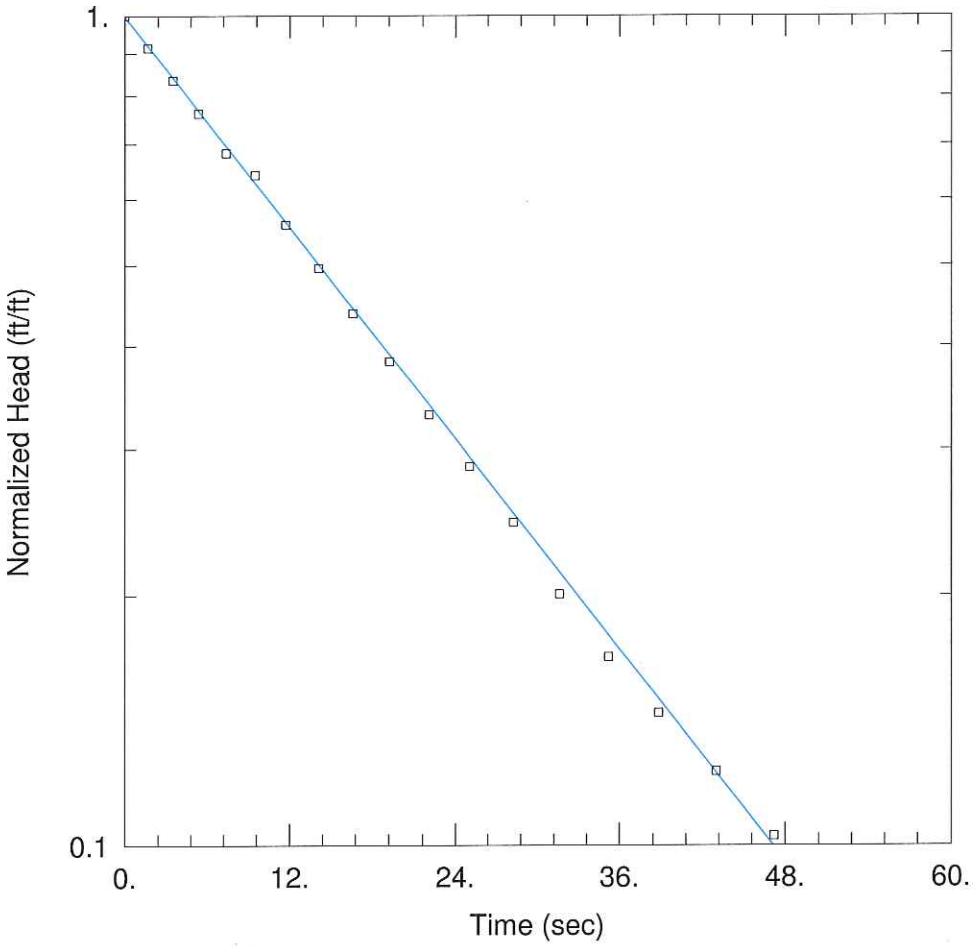
Saturated Thickness: 5. ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (Blue 13)

Initial Displacement: 1.32 ft
Total Well Penetration Depth: 5. ft
Casing Radius: 0.083 ft
Static Water Column Height: 12.06 ft
Screen Length: 5. ft
Well Radius: 0.23 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice
K = 7.202E-6 cm/sec
y0 = 1.305 ft



BLUE 15 RISING HEAD (SLUG-OUT) SLUG TEST #1

Data Set: \...\Blue 15 Slug Out 1 BR.aqt
Date: 09/14/16 Time: 08:56:28

PROJECT INFORMATION

Company: Barr Engineering Co.
Client: OtterTail Power Company
Project: 34291075
Location: Beulah, ND
Test Well: Blue-15
Test Date: July 21, 2016

AQUIFER DATA

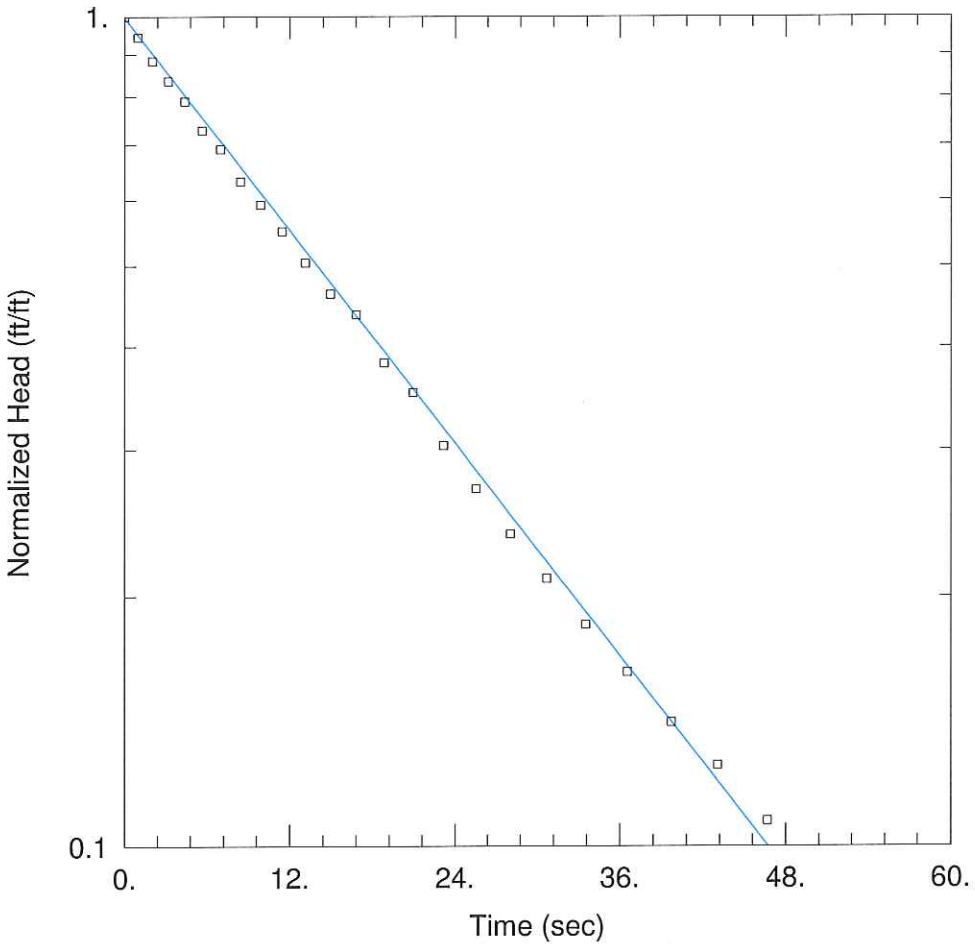
Saturated Thickness: 2. ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (Blue 15)

Initial Displacement: 1.41 ft
Total Well Penetration Depth: 2. ft
Casing Radius: 0.083 ft
Static Water Column Height: 2. ft
Screen Length: 2. ft
Well Radius: 0.167 ft

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice
K = 0.00459 cm/sec
y0 = 1.407 ft



BLUE 15 RISING HEAD (SLUG OUT) SLUG TEST #2

Data Set: \...\Blue 15 Slug Out 2 BR.aqt
Date: 09/14/16 Time: 08:56:15

PROJECT INFORMATION

Company: Barr Engineering Co.
Client: OtterTail Power Company
Project: 34291075
Location: Beulah, ND
Test Well: Blue-15
Test Date: July 21, 2016

AQUIFER DATA

Saturated Thickness: 2. ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (Blue 15)

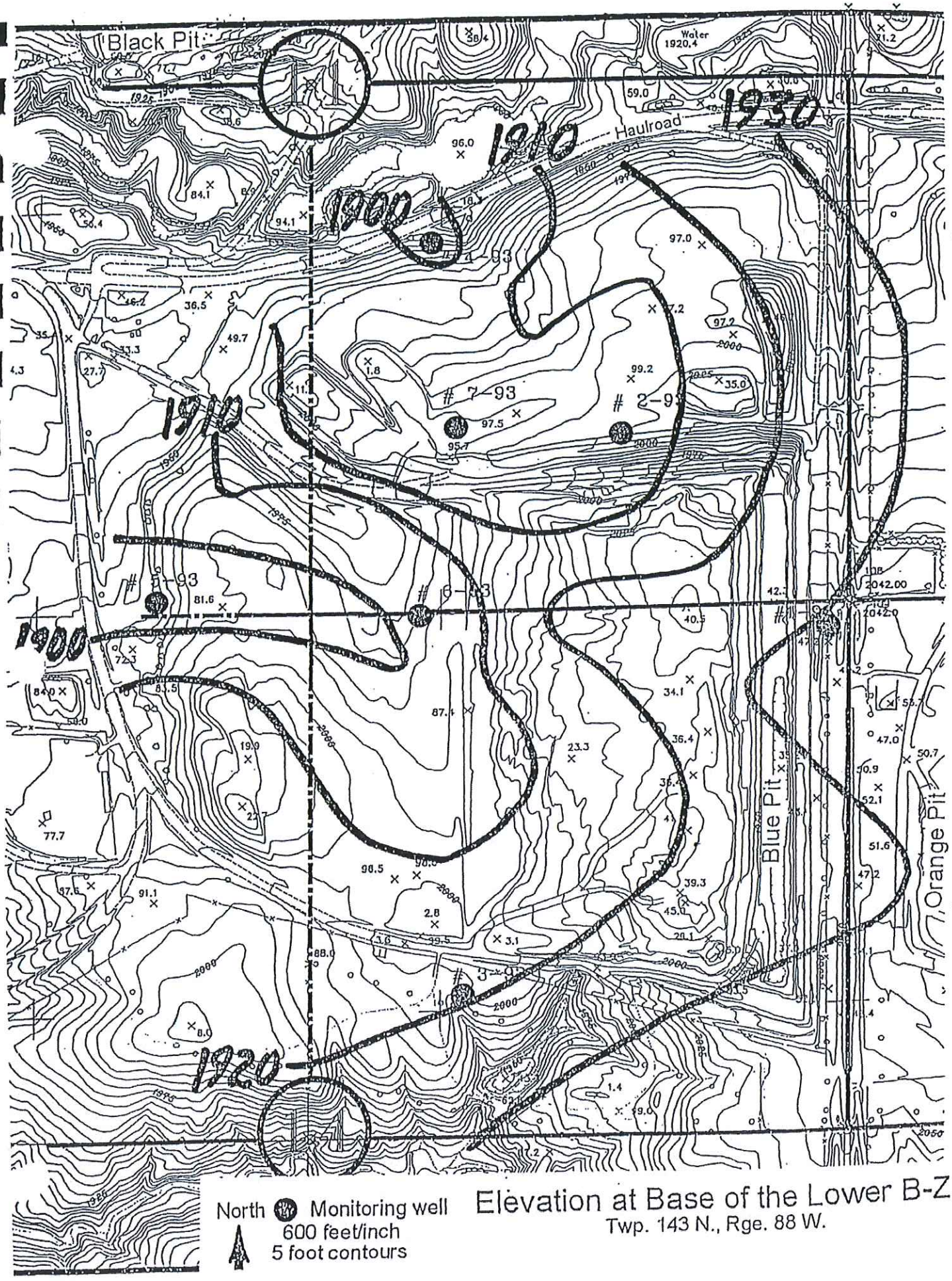
Initial Displacement: 1.47 ft
Total Well Penetration Depth: 2. ft
Casing Radius: 0.083 ft
Static Water Column Height: 1. ft
Screen Length: 2. ft
Well Radius: 0.167 ft

SOLUTION

Aquifer Model: Confined
K = 0.00463 cm/sec
Solution Method: Bouwer-Rice
y0 = 1.466 ft

Appendix D

Top of Lower B-Z Lignite Bed Map (Water Supply)



Elevation at Base of the Lower B-Z

Twp. 143 N., Rge. 88 W.