



Groundwater Monitoring System Report

Ash Landfill

Hoot Lake Plant

Fergus Falls, Minnesota

Prepared for
Otter Tail Power Company

November 2016

Groundwater Monitoring System Report Ash Landfill, Hoot Lake Plant

November 2016

Contents

1.0	Introduction	1
1.1	Purpose.....	1
1.1.1	Distance from Waste Boundary.....	2
1.1.2	Lateral Spacing	2
1.2	Report Contents.....	3
2.0	Site Background	4
2.1	Hoot Lake Plant	4
2.2	Delineation of the CCR Facility.....	4
2.3	Site Setting	4
2.3.1	Regional Geology	4
2.3.2	Regional Hydrogeology.....	5
2.3.3	Site Geology	6
2.3.4	Site Hydrogeology	6
2.3.5	Potential Groundwater Flow Receptors.....	9
3.0	Conceptual Models.....	10
3.1	Site Conceptual Model	10
3.2	Release Conceptual Model	12
4.0	CCR Groundwater Monitoring System.....	13
5.0	References	15

List of Tables

Table 1	Otter Tail surficial aquifer characteristics.....	6
Table 2	Laboratory Values for Permeability.....	8
Table 3	Slug Test Values for Permeability	8
Table 4	CCR Monitoring Well Details.....	14

List of Figures

Figure 1	Site Location Map
Figure 2	Site Map
Figure 3	Site Surficial Geology Map
Figure 4	Groundwater Contours
Figure 5	Upgradient Groundwater Levels Over Time
Figure 6	Downgradient Groundwater Levels Over Time
Figure 7	Groundwater Levels Over Time in CCR Monitoring Wells
Figure 8	Cross Section and Conceptual Site Model
Figure 9	Conceptual Release Model
Figure 10	Proposed CCR Groundwater Monitoring System

List of Appendices

Appendix A	Boring and Well Logs
------------	----------------------

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 Minnesota.



James Berkas, P.E.
PE #44916

November 21, 2016

Date

1.0 Introduction

Otter Tail Power Company owns and operates the Hoot Lake Plant, a coal-fired generation unit in Fergus Falls, Minnesota. Coal combustion residuals (CCR) from plant operations are placed in a landfill, referred to as the Hoot Lake Ash Landfill, on the plant property. The Site location is shown on Figure 1 and the layout is shown on Figure 2. The Ash Landfill is the CCR Unit at the Hoot Lake Plant that is required to comply with the provisions of the US EPA Coal Combustion Residuals (CCR) rule (40 CFR Parts 257 and 261 Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals From Electric Utilities). The Site includes the Ash Landfill itself and the area around the landfill in which the monitoring system is located.

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

- The Site hydrogeology
- The CCR groundwater monitoring system meeting the requirements of the CCR Rule (40 CFR Part 257, US EPA, 2015) at the Otter Tail Power Company (OTP) Hoot Lake Plant Ash Landfill (Site).

1.1 Purpose

This document has been prepared to describe the groundwater monitoring system for the Hoot Lake Plant Ash Landfill and how it has been designed to meet the requirements of the CCR rule. Specific requirements for the groundwater monitoring system 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.

The monitoring system has been designed based on the site conceptual model (SCM) as it is currently understood, which is also presented herein, with the intent of obtaining representative samples of groundwater so that a release from the CCR unit can be detected.

The CCR rule has three primary requirements addressing the locations of wells in the network. These include:

- The wells must be placed near enough to the waste boundary to provide timely detection of a release
- There must be a minimum of three downgradient wells and one upgradient well
- The wells must be spaced appropriately to provide a reasonable opportunity to intersect a plume resulting from a hypothetical release

Each of these requirements is discussed below.

1.1.1 Distance from Waste Boundary

The industry practice is to place the monitoring downgradient of the waste disposal area and within the property boundary (EPA, 2015, p. 21324). The Minnesota Rules require a compliance boundary no more than 200 feet from the waste, so existing monitoring wells were generally placed 200 feet or less from the waste to be compliant. This distance is also based on the presumed flow directions and the need to allow sufficient space between the waste boundary and the monitoring network to allow for hydrodynamic dispersion which increases the probability of detection.

1.1.2 Lateral Spacing

Monitoring well spacing satisfies part 257.91 (a)(2) of the Coal Combustion Rule.

1.2 Report Contents

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

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

2.0 Site Background

2.1 Hoot Lake Plant

The Hoot Lake Plant operates its 54 MW Unit 2, on line since 1959, and 75 MW Unit 3, on line since 1964. Coal ash is generated by combustion of subbituminous coal for the production of electricity. Coal ash is either utilized for a beneficial use or placed in an on-site ash landfill that has been in use since 1980. The ash landfill is located on approximately 43 acres within the Otter Tail Power Company Hoot Lake Plant property in the N 1/2 of the SE 1/4 of Section 36, Township 133N, Range 43W, within the city limits of Fergus Falls, Otter Tail County, Minnesota.

2.2 Delineation of the CCR Facility

The Minnesota Pollution Control Agency (MPCA) Permit SW-211 for the Site defines two waste activity areas:

- Closed Industrial Waste Disposal Area IL001
- Industrial Waste Disposal Area IL002

While not directly applicable to the CCR rules, the MPCA-defined areas align with the CCR rules in that the MPCA IL001 area ceased receiving CCR prior to October 19, 2015. 40 CFR Parts 257.50 (d) states "This subpart does not apply to CCR landfills that have ceased receiving CCR prior to October 19, 2015." Area IL001 was closed in 2011. Therefore, the CCR rules do not apply to IL001. The CCR rules do apply to the IL002 area as it is an existing CCR landfill. Figure 2 is a map showing these areas.

2.3 Site Setting

The Site is underlain by several hundred feet of glacial deposits. Figure 3 shows the surficial geology of the Site. The following sections provide a description of regional and Site geology and hydrogeology, as well as potential groundwater flow receptors.

2.3.1 Regional Geology

The surficial geology is composed of Late Wisconsin Des Moines Lobe glacial till. The surficial units are the upper Goose River Group. From Harris (1999):

Glacial sediment deposited in and adjacent to the Red River lowland by unnamed phases of the Des Moines (Red River) lobe. The sediment is derived from a northwestern-source area (Riding Mountain area of western Manitoba). Sand and gravel were deposited on older stratigraphic units by coalescing, anastomosing meltwater streams to form undulating outwash plains. The deposits are generally collapsed (pitted) due to melting of buried ice blocks.

The pitting from melted ice blocks is apparent in the many lakes and ponds. Generally, this area is described as being covered by a hummocky moraine (Ekman, 2002).

Per Harris (1999), the Site is in an area covered by glacial sediment deposited by glacial ice on ice-cored glaciated landscape that later collapsed due to the melting of the buried ice. These sediments are interspersed with glacial outwash deposits.

The upper Goose River Group is generally underlain by the lower Goose River Group and other older deposits from earlier glacial advances.

2.3.2 Regional Hydrogeology

Ekman and Berg (2002) describe the hydrogeology of the region just east of the site, which is underlain by the same deposits as are found at the site. They note that the surficial hydrogeology is generally characterized as a two-layer system, with the upper system recharged by spring and fall rains and interacting with surface water bodies, whereas the lower system has little interaction with surface water and is more regionally recharged.

In a USGS report, Reppe (2005) defines a roughly oval area approximately 50 miles north to south and 20 miles east to west around Fergus Falls as being underlain by the Otter Tail surficial aquifer:

"The Otter Tail surficial aquifer consists of ice-contact and outwash deposits, primarily well-sorted sand with varying gradations of fine- to coarse-grained sand and gravel and lenses of clay. Although bedrock is 200 ft below land surface near Perham, Minnesota, and Big Pine Lake, north and northwest of Little Pine Lake bedrock is more than 400 ft below land surface. The aquifer is predominantly unconfined although some parts may be confined locally by clay lenses. The depth to the aquifer's water table ranges from 0 to 70 ft below land surface depending on local topography. The aquifer has a saturated thickness of at least 20 ft across 95 mi² and varies up to 5 ft with fluctuations in the water table."

Reppe (2005) also notes:

"Ground-water flow in the aquifer is towards the Otter Tail River (and the lakes along the river) and south and west along the axis of the river. In the southern one-third of the aquifer, ground water flows north-northwest toward the Otter Tail and Leaf Rivers. The water table has a maximum slope of approximately 25 ft/mi and a mean slope of 9 ft/mi."

Table 1 summarizes the Otter Tail surficial aquifer characteristics.

Table 1 Otter Tail surficial aquifer characteristics

Parameter	Value
Thickness	Maximum – 100 feet Mean – 50 feet
Transmissivity	Maximum – 26,800 ft ² /day (290 cm ² /sec) Mean – 14,500 ft ² /day (156 cm ² /sec) Minimum – 6,700 ft ² /day (72 cm ² /sec)
Hydraulic conductivity	Maximum – 410 ft/day (0.14 cm/sec) Minimum – 86 ft/day (0.03 cm/sec)

(extracted in part from Reppe, 2005)

On the basis of available water-quality data, the concentrations of selected constituents were generally relatively low in the Otter Tail surficial aquifer relative to the other surficial aquifers in the region (Reppe, 2005). On the basis of characteristics and hydraulic properties, estimated water budgets, theoretical well yields, groundwater storage and use, and water quality, the Otter Tail surficial aquifer has near the greatest potential for additional development of groundwater resources compared to the other surficial aquifers in the region (Reppe, 2005). The estimated travel times from the surface to the aquifer is characterized as moderate, years to decades, for the higher elevations and as high, weeks to years, for the low-lying area along the river (Ekman, 2002).

2.3.3 Site Geology

Figure 3 shows the surface geology at the Site as mapped by the Minnesota Geological Survey to be Quaternary undivided. Per Wenck (2010):

"...all borings have shown an interbedded profile of coarse and fine alluvium, as well as clay till strata (the upper 30-50 feet is dominated by till). These strata are largely intermittent with undulating surfaces and varying thicknesses. Below the till, fine and medium sands with gravel predominate. Many of the previous site borings showed an intermediate clay or silt strata at or near elevation 1250 ft MSL.

"Below the majority of the site a deep lean, gray clay strata is present at an elevation of 1190 ft and is 20 feet thick or greater. This was found in all site borings that went deep enough (9 borings spread across the site), with the sole exception of B-3. At historical boring B-3, from elevation 1207-1195 ft, dense layers of gray silts and clayey sands were encountered."

Subsequent borings (see boring and well logs in Appendix A) have found consistent conditions.

2.3.4 Site Hydrogeology

Groundwater recharge at the Site is likely from the higher regional water table to the south and precipitation and infiltration in the local area. As shown on Figure 4, groundwater flow is generally from southeast to northwest under the facility.

The multiple clay and silt till units interbedded with sand and gravel outwash units under the Site create multiple saturated zones. Some are intermittent, and some are above the lined landfill space. The pond west of the landfill appears to be perched above the aquifer on a low permeability unit.

Four persistent saturated sand and gravel outwash aquifer units separated by leaky confining clayey till units have been identified in the area under and around the Ash Landfill:

- Upper perched zone – Well S-3 (upgradient of water table aquifer) – water elevation 1260-1270 feet. This aquifer is very limited in lateral extent and above the lined landfill space (outside of the waste boundary), so is not relevant to CCR monitoring.
- Intermediate aquifer – Wells S-4, S-50, and S-51 (upgradient of water table aquifer) – water elevation 1238-1260 feet. This aquifer extends an unknown distance south of facility and extends partway under the facility and apparently “merges” with or drains away into the underlying water table aquifer. It is important for upgradient water quality monitoring but does not exist downgradient.
- Water table aquifer – All other wells not identified in other aquifers – water elevation 1196-1220 feet. This aquifer appears to be continuous under the Site and for an unknown extent off Site and is considered the upper aquifer at the Site. It may be confined south of the Site.
- Deep aquifer – Wells M-1 and M-3 (upgradient of water table) – water elevation 1215-1219 feet. This aquifer appears to be continuous under the Site and for an unknown extent off Site. As it is not downgradient of the facility and is separated from the water table aquifer by a relatively thick gray till, it is not part of the CCR monitoring.

The adjacent Otter Tail River varies from a high of Elevation 1202 feet MSL upstream to Elevation 1193 feet MSL downstream. Groundwater generally flows toward and discharges into the Otter Tail River north of the Site.

Table 2 and Table 3 summarize hydrogeological test results from the Site.

Table 2 Laboratory Values for Permeability

Boring/ Well	Depth	Sample Description	USCS	Test Type	Hydraulic Conductivity, cm/sec
S-2A*	33-34.5	Clayey sand w/gravel	CL	Vertical	3.3×10^{-7}
B-7*	21.5-23	Clayey sand with gravel	CL	Vertical	1.8×10^{-6}
B-7*	46-50	Sand w/ silt and gravel	SP-SM	Recompacted	7.6×10^{-6}
B-7*	50-55	Sand w/ silt and gravel	SP-SM	Recompacted	6.4×10^{-4}
S-1*	72.5-77.5	Silty sand	SM	Recompacted	3.5×10^{-5}
S-1*	80-87.5	Sand w/ silt and gravel	SP-SM	Recompacted	2.8×10^{-5}
B-5**	11-12.5	Clayey sand w/ gravel	SC	Vertical	1.9×10^{-7}
B-5**	26-28	Clayey sand w/ gravel	SC	Vertical	4.5×10^{-7}
B-6**	21-22	Lean clay	CL	Vertical	1.4×10^{-7}
B-3**	65-66 & 70-71	Sand w/silt and gravel	SP-SM	Recompacted	7.6×10^{-4}

*TKDA, 1989

**TKDA, 1988

Table 3 Slug Test Values for Permeability

Well	Monitored Unit	Hydraulic Conductivity
S-1*	Water table, upgradient	1.0×10^{-4} cm/sec
S-4**	Water table, upgradient	8.0×10^{-4} cm/sec
S-5*	Water table, downgradient	8.0×10^{-6} cm/sec
S-10R***	Water table, downgradient	2.5×10^{-2} cm/sec
S-14R***	Water table, downgradient	7.7×10^{-3} cm/sec
S-2014***	Water table, downgradient	2.5×10^{-2} cm/sec
S-10	Water table, downgradient, abandoned 2015	1.2×10^{-1} cm/sec

*TKDA, 1989

**TKDA, 1988

***Barr, 2015

The hydraulic conductivity of the uppermost aquifer ranges from 8.0×10^{-6} to 1.2×10^{-1} cm/sec based on single-well slug tests, with a geometric mean of 2.3×10^{-3} cm/sec.

The water table aquifer is described as

- poorly graded sand to poorly graded sand with gravel (S-10R)
- poorly graded sand (S-10R)
- coarse sand and gravel (S-3AR)
- sand with a little gravel (S-13)
- sand with a little gravel (S-2A)

Porosity of sands range from 0.25 to 0.5 (Freeze and Cherry, 1979). Porosities of glacial outwash aquifers in the region range from 0.2 to 0.3 (Reppe, 2005). The assumed porosity of the Site aquifer is 0.25.

The groundwater velocity is calculated using Darcy's equation:

$$V_t = k * i / n = 0.3\text{-}0.5 \text{ ft/day or } 100\text{-}200 \text{ ft/year}$$

Where: V_t = true velocity

K = hydraulic conductivity (2.3×10^{-3} cm/sec)

i = gradient (S52-S2A – 0.20, S52-S13 – 0.12; calculated from water levels)

n = effective porosity (0.25)

Figure 4 shows the groundwater contours in the mid-level perched aquifer and the water table aquifer. These contours are consistent with historical measurements at the Site. Based on the groundwater elevations, groundwater enters the existing CCR landfill boundary in the southeast corner and flows radially to the north to west-northwest, toward the river.

Figure 5 shows a hydrograph of groundwater elevations over time in two of the wells upgradient of the IL001 unit and in the two wells upgradient of the existing CCR landfill. This graph indicates the groundwater elevations in the new wells are consistent with what had been anticipated. The water level in well S-51 is about 20 feet higher than the water level in well S-52, indicating that these wells are screened in two different hydrogeological units.

Figure 6 shows the groundwater elevations over time in the wells downgradient of the existing CCR landfill. Discounting a few outliers, the trends over time are reasonably consistent from well to well, indicating these wells are all in the same aquifer. For comparison, Figure 7 shows the groundwater elevations over time in all the existing CCR landfill wells.

2.3.5 Potential Groundwater Flow Receptors

Per the Minnesota County Well Index (accessed 6/29/16), the nearest domestic well is about 1,800 feet west (sidegradient) of the Site. There are no water supply wells downgradient of the Site. The primary discharge area for groundwater is the Otter Tail River.

3.0 Conceptual Models

In order to solve any hydrogeologic problem, it is necessary to assemble relevant field data and synthesize what is known about a site into a site hydrogeological conceptual model (Anderson et al., 2015).

3.1 Site Conceptual Model

Figure 4 shows the approximate orientation of conceptual cross section A-A' which is illustrated on Figure 8 illustrating the conceptual model at the Site. The Site is underlain by a complex mix of interlayered till and outwash deposits deposited in a stagnation moraine setting. The area around the Site has a hummocky and collapsed topography characteristic of stagnation moraines formed from differential melting of glacial ice blocks. Stagnation moraines have a complicated distribution of soil materials composed of glacial till, outwash, and water-laid sediments. Layers of different sediment types can form complex vertical and lateral sequences as outwash sediments are deposited in meltwater channels concurrently as till is deposited from melting ice blocks. Outwash deposits are generally sandy and till deposits are composed of clay to silt loam in the area. Gravel and boulders are also present in the deposits.

The surficial geology at the Site is generally composed of an upper outwash deposit consisting of sandy material with discontinuous layers of silty and clayey till material at various depths within approximately 100 to 110 feet of the ground surface. The discontinuous till layers within this upper deposit do not appear to extend laterally across the Site. A continuous layer of clayey till approximately 10 to 30 feet thick is present below the upper sequence of outwash and till at depths generally greater than 100 feet. A deeper layer of sandy outwash deposits is present below the continuous till layer. Cross section A-A', extending across the Site from well S-2A in the northwest to well S-50 in the southeast, shows the surficial geology of the interlayered upper deposits over the continuous clay layer.

The Otter Tail River has cut a surficial channel across the glacial sediments with a general east-west trend to the north of the Site. Post-glacial fluvial deposits are likely present in the river valley (Figure 4). The elevation of the river is approximately 70 to 95 feet below the surficial elevation of the Site. The river elevation ranges from approximately 1202 feet MSL to the east of the Site to 1193 feet MSL to the west of the Site.

The Site geology is consistent with the regional geology described in Section 2.3.1. In general the surficial geology of the Site consists of the following sequence:

- The uppermost layer across most of the Site consists of a unit of sandy outwash material which contains discrete layers of silty and/or clayey material to depths of approximately 100 to 110 feet. The base of this layer is at an elevation of approximately 1190 to 1200 feet MSL in the Site area.
- The surficial layer in the northwest corner of the Site in the vicinity of wells S-2, S-2A, S-3, S-3A-R, S-10-R, S-13, and S-14-R consists dominantly of till composed of clayey sand to sandy clay with discontinuous interlayered sand lenses to depths of approximately 37 to 60 feet. A layer of sandy

material is present below the surficial clay deposit which is consistent with the geology in other areas of the Site.

- Individual layers of fine-grained material within the upper outwash sand in the east-southeast portion of the Site do not extend laterally across the Site, range in length/width from approximately 100 to 1,500 feet, and are approximately 1 to 25 feet thick (see cross section A-A'). The elevation of the base of this upper outwash unit (1190 to 1200) is generally below the elevation of the Otter Tail River.
- A consistent layer of clay and sandy clay material is present below the interlayered outwash material. This layer of clayey material ranges from approximately 10 to over 30 feet thick and appears to be laterally extensive across the Site. The top of this clay layer is the contact with the base of the upper outwash sand with interlayered clay and silt at an elevation of approximately 1190 to 1200 feet at the Site.
- A layer of sandy material is present below the extensive clay layer.

Details of the Site hydrology and hydrogeology are presented in Section 2.3.4. Monitoring wells are screened within multiple intervals of the geologic sequence described above. The general hydrogeology consists of the following:

- **Upper Perched Zones.** Zones of perched water are present on discrete fine-grained soil layers within the upper sandy outwash deposits. Perched water was encountered in several borings. The layers of fine-grained material that perch water in these zones are not laterally extensive, tend to terminate within the Site area, and do not extend completely below the lined facility (see cross section A-A'). Water will eventually drain from the discrete perched units to lower portions of the sandy deposit. Well S-3 is screened in one such zone but, because it is isolated from the existing CCR landfill, it is not included in the CCR monitoring.

The pond located to the west of the Site appears to be perched on the clayey surficial soil observed in borings on the western portion of the Site (S-10R and S-14R).

- **Intermediate Aquifer Zone.** Wells S-4, S-50, and S-51 are screened in a saturated zone that extends from approximately Elevation 1220 feet MSL to Elevation 1260 feet MSL. Laterally this zone extends off site to the south and west but does not extend as far west as well S-1 nor as far north as well S-6 (Figure 4). While this intermediate aquifer does not extend under the CCR facility, the groundwater in the intermediate aquifer drains down into the underlying water table aquifer, which then extends under the CCR facility. As such the intermediate aquifer is an important component of the upgradient water quality.
- **Water Table Aquifer Zone.** Groundwater is continuously present in the lower sandy outwash deposit underlying the Site. This unit is referred to as the water table aquifer, despite the fact that it appears to be confined south of the facility and despite the fact that the intermediate aquifer described above is the water table south of the Site. Head elevations in the lower sand unit are

higher than the elevation of the overlying clay indicating flow is upward from the lower sand toward the surficial unconfined aquifer.

The groundwater elevation ranges from approximately 1196 to 1220 feet MSL in the water table aquifer. This unconfined saturated zone is consistent across the Site. The flow direction of the water table aquifer is toward the Otter Tail River and the river is at a lower elevation than the water table. The lower boundary of the saturated outwash deposit is the surface of the underlying continuous clay layer at an elevation of approximately 1190 to 1200 feet.

Water infiltrating into the soil from the ground surface at the Site will migrate vertically downward until reaching the water table within the unconfined outwash deposits (water table elevation of approximately 1196 to 1200 feet), then flow laterally toward the Otter Tail River. Water may become perched on the discrete layers of fine-grained soil until sufficient water is present in the perched layer to drain to lower portions of the deposit. There do not appear to be other outlets for perched water other than eventually draining to the lower water table aquifer. Flow in the water table aquifer is expected to be toward the north-northwest from the Site to the Otter Tail River. Perched water does not appear to be present below the lined facility or potentially below only a portion of the lined facility. Therefore, the water table aquifer at elevations of approximately 1196 to 1200 feet will receive water infiltrating at the lined facility location. The lower confined aquifer is recharged at upgradient locations, and water from the Site will not flow to the lower confined aquifer as the hydraulic gradient is vertically upward from the deeper confined aquifer to the overlying unconfined aquifer.

3.2 Release Conceptual Model

A release conceptual model uses the flow and geologic information of the site conceptual model to predict the likely pathway that a release to groundwater would travel so that a monitoring network can be properly sited. In order for a hypothetical release from the facility to occur it would need to breach the compacted clay and geomembrane composite liner system at the base of the landfill and slowly seep through the base of lined footprint into the unsaturated zone under the landfill. The release would then drain with gravity primarily vertically downward. Some lateral dispersion would be anticipated as the release encounters layers of lesser or greater permeability. Eventually the release would reach the water table in the Monitoring Zone which consists of the lower saturated outwash.

Assuming predominantly horizontal flow, the release would then move toward the Otter Tail River which is the discharge area for groundwater. Long before the release would reach the river, the leading edge of the release would disperse laterally as the constituents of the release move into well screens within the monitoring well network (e.g., S-13 on Figure 9). Samples of groundwater from the network wells would then detect the concentrations of constituents in groundwater. If the concentrations exceed statistical thresholds as described in the Sampling and Analysis Plan for the Site, it would indicate that a release has occurred unless otherwise demonstrated to be unrelated to the landfill. This release conceptual model is illustrated on Figure 9.

4.0 CCR Groundwater Monitoring System

USEPA guidance (1991) is the basis for determining the adequacy of the wells. The CCR groundwater monitoring system for the Ash Landfill is shown on Figure 10. The CCR groundwater monitoring system well network consists of the following:

- upgradient water table aquifer wells:
 - S-51. This well was recently installed in the intermediate aquifer. It is adequately constructed and well placed for upgradient monitoring of the existing CCR landfill because, based on the conceptual model, groundwater from this area flows past the upgradient waste boundary and then to downgradient wells.
 - S-52. This well was recently installed in the water table aquifer upgradient of the existing CCR landfill. It is adequately constructed and well placed for upgradient monitoring of the existing CCR landfill because, based on the conceptual model, this water is likely to move past the upgradient waste boundary to reach downgradient wells. The downgradient groundwater is a mixture of both the intermediate and lower upgradient groundwater.
- downgradient water table aquifer wells:
 - S-2A. This well is adequately constructed and screened within the Monitoring Zone downgradient of the existing CCR landfill.
 - S-3A-R. This well is adequately constructed and screened within the Monitoring Zone downgradient of the existing CCR landfill.
 - S-13. This well is adequately constructed and screened within the Monitoring Zone downgradient of the existing CCR landfill.
 - S-14-R. This well is adequately constructed and screened within the Monitoring Zone downgradient of the existing CCR landfill.
 - S-10R. This well is adequately constructed and screened within the Monitoring Zone downgradient of the existing CCR landfill.

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

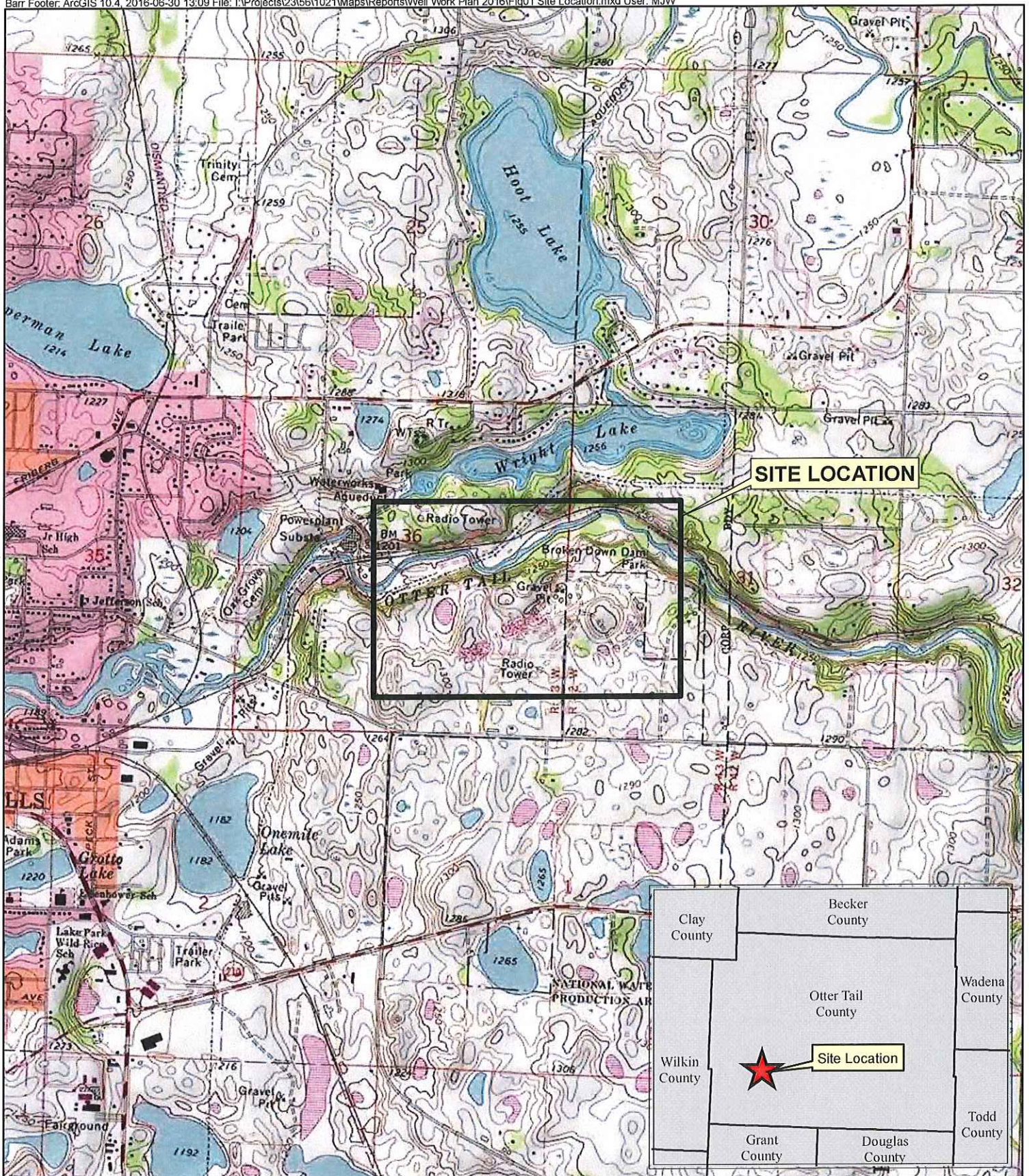
Table 4 CCR Monitoring Well Details

Well	Unique No.	Installation Date	TOR	Depth	Screen Length/ Diameter (ft/in)	Materials
Upgradient Wells						
S-51	814830	6/3/2016	1286.90	53	10/2.0	black steel/SS/#10
S-52	822155	7/6/2016	1286.62	100	10/2.0	black steel/SS/#10
Downgradient Wells						
S-2A	444350	5/9/1989	1272.9	77	10/2.0	PVC/PVC/#10
S-3AR	674671	9/27/2005	1271.56	77	10/2.0	PVC/PVC/#10
S-10R	806341	4/23/2015	1281.47	78	10/2.0	black steel/SS/#10
S-13	632810	4/9/2001	1296.42	96.5	10/2.0	SS/SS/#15
S-14R	806342	4/21/2015	1280.61	84.5	10/2.0	black steel/SS/#10

5.0 References

- Anderson, M.P., Woessner, WW, and Hunt, R.J., 2015 *Applied Groundwater Monitoring Simulation of Flow and Advective Transport*, Second Edition, Elsevier Inc. 564 pp.
- Barr, 2015. Monitoring Well Installation Report. Hoot Lake Plant Industrial Solid Waste Landfill Permit No. SW-211. Prepared for Otter Tail Power Company.
- Bouwer, H. and R.C. Rice, 1976. A slug test method for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells, *Water Resources Research*, vol. 12, no. 3, pp. 423-428.
- Ekman JC and JA Berg, 2002. Part B Plate 2 Geologic Sensitivity to Pollution of Near-surface Groundwater, Regional Hydrogeologic Assessments RHA-5. Minnesota Department of Natural Resources. http://www.dnr.state.mn.us/waters/programs/gw_section/mapping/platesum/rha_ot.html
- Ekman JC, 2002. Part B Plate 1 Surficial Hydrogeology, Regional Hydrogeologic Assessments RHA-5. Minnesota Department of Natural Resources. http://www.dnr.state.mn.us/waters/programs/gw_section/mapping/platesum/rha_ot.html
- Freeze, R. Allen and John A. Cherry, 1979. *Groundwater*. Prentice Hall.
- Harris, K.L., 1999. Quaternary geology-Otter Tail area, west-central Minnesota [Part A]. Minnesota Geological Survey. Regional Hydrogeologic Assessments RHA-5. Minnesota Geological Survey. Retrieved from the University of Minnesota Digital Conservancy, <http://hdl.handle.net/11299/59783>.
- Minnesota County Well Index (accessed 6/29/16).
- Reppe, Thomas H.C., 2005. Ground-Water Availability from Surficial Aquifers in the Red River of the North Basin, Minnesota. USGS Scientific Investigations Report 2005-5204. <http://pubs.usgs.gov/sir/2005/5204/pdf/SIR20055204.pdf>.
- TKDA, 1989. Phase II Geotechnical Investigation Report and Environmental Monitoring System Plan, Hoot Lake Ash Disposal Landfill, Otter Tail Power Company, Fergus Falls, Minnesota.
- TKDA, 1988. Geotechnical Investigation Report and Environmental Monitoring System Work Plan, Hoot Lake Ash Disposal Landfill, Otter Tail Power Company, Fergus Falls, Minnesota.
- US EPA, 2015. Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals From Electric Utilities; Final Rule, Federal Register vol. 80, no. 74.
- US EPA, 1991. Handbook of Suggested Practices for the Design and Installation of Ground-Water Monitoring Wells. EPA 600/4-89/034 March 1991. 221 pp.
- Wenck, 2010. Supplemental Phase II/III Hydrogeologic Investigation Report, Hoot Lake Ash Disposal Facility, Otter Tail Power Company, Permit SW-211.

Figures



Background: USGS Topographic quadrangle maps and National Park Service (NPS) Natural Earth physical map from ArcGIS Online

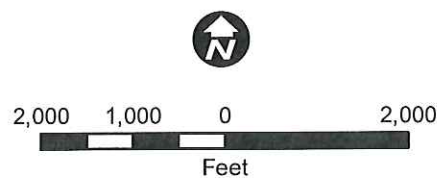
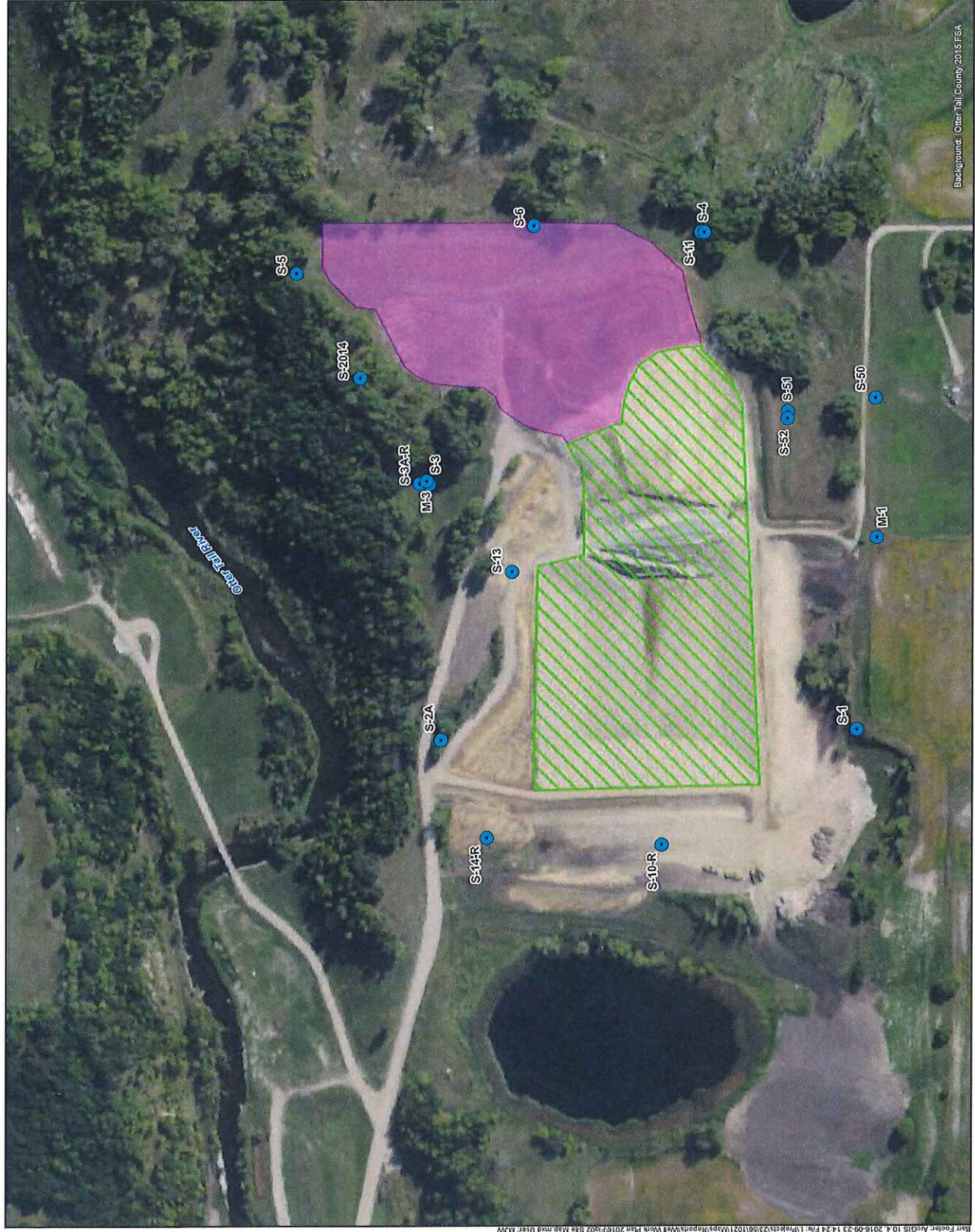


Figure 1

SITE LOCATION MAP
Hoot Lake Ash Disposal Facility
Otter Tail Power Company
Fergus Falls, MN



- Industrial Solid Waste Unit IL001
- Existing CCR Landfill (IL002)
- Existing Monitoring Well

Minnesota industrial solid waste unit IL001 was closed prior to the effective date of the CCR Rule and is therefore not subject to the rule.



Figure 2
SITE MAP
Hoot Lake Ash Disposal Facility
Otter Tail Power Company
Fergus Falls, MN

Figure 5
Upgradient Groundwater Levels Over Time

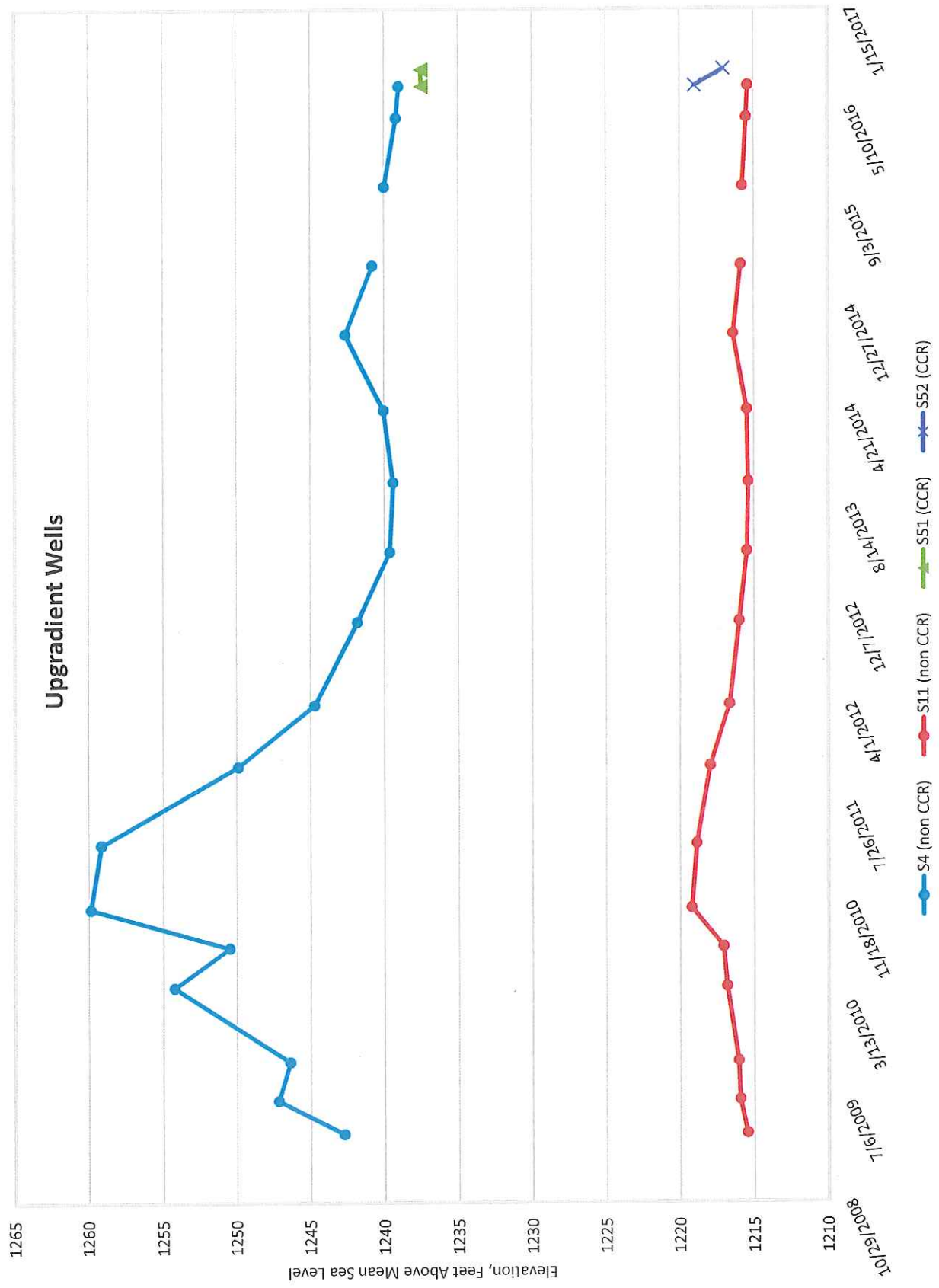


Figure 6
Downgradient Groundwater Levels Over Time

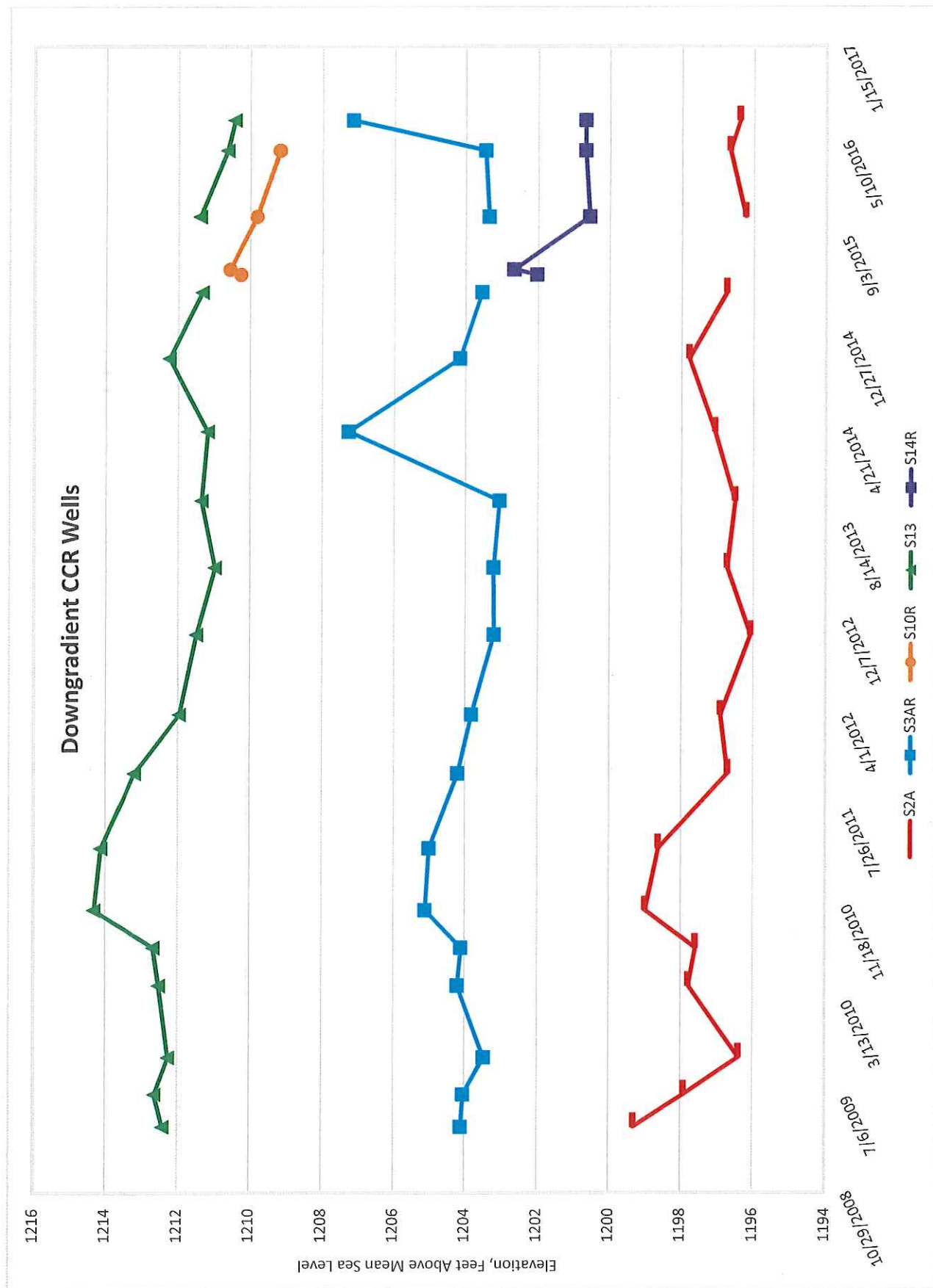
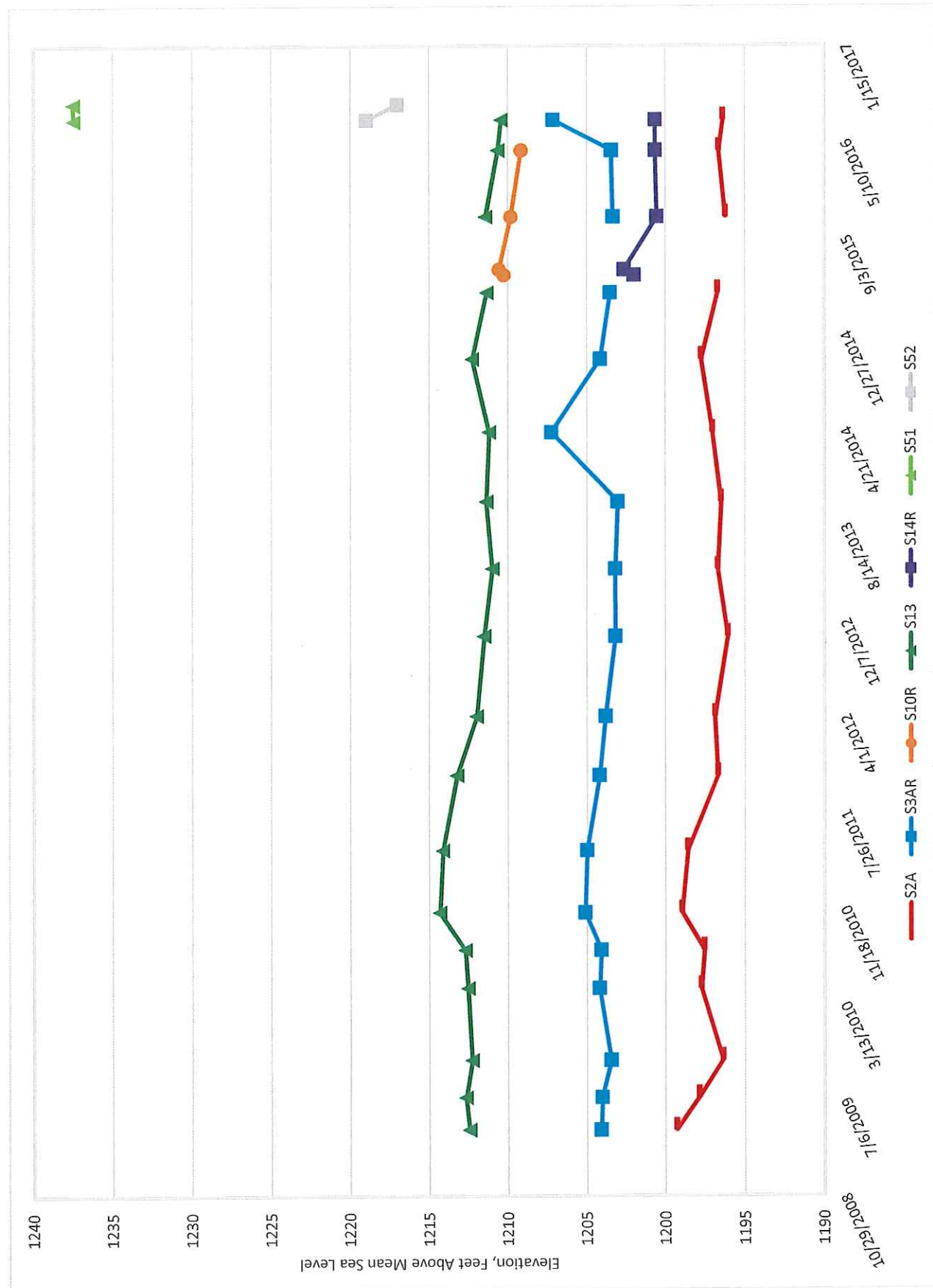


Figure 7
Groundwater Levels Over Time in Existing CCR Landfill Monitoring Wells



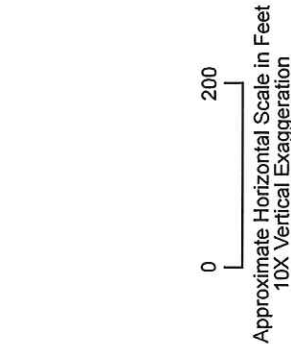
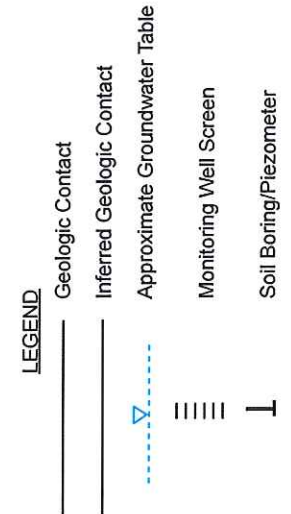
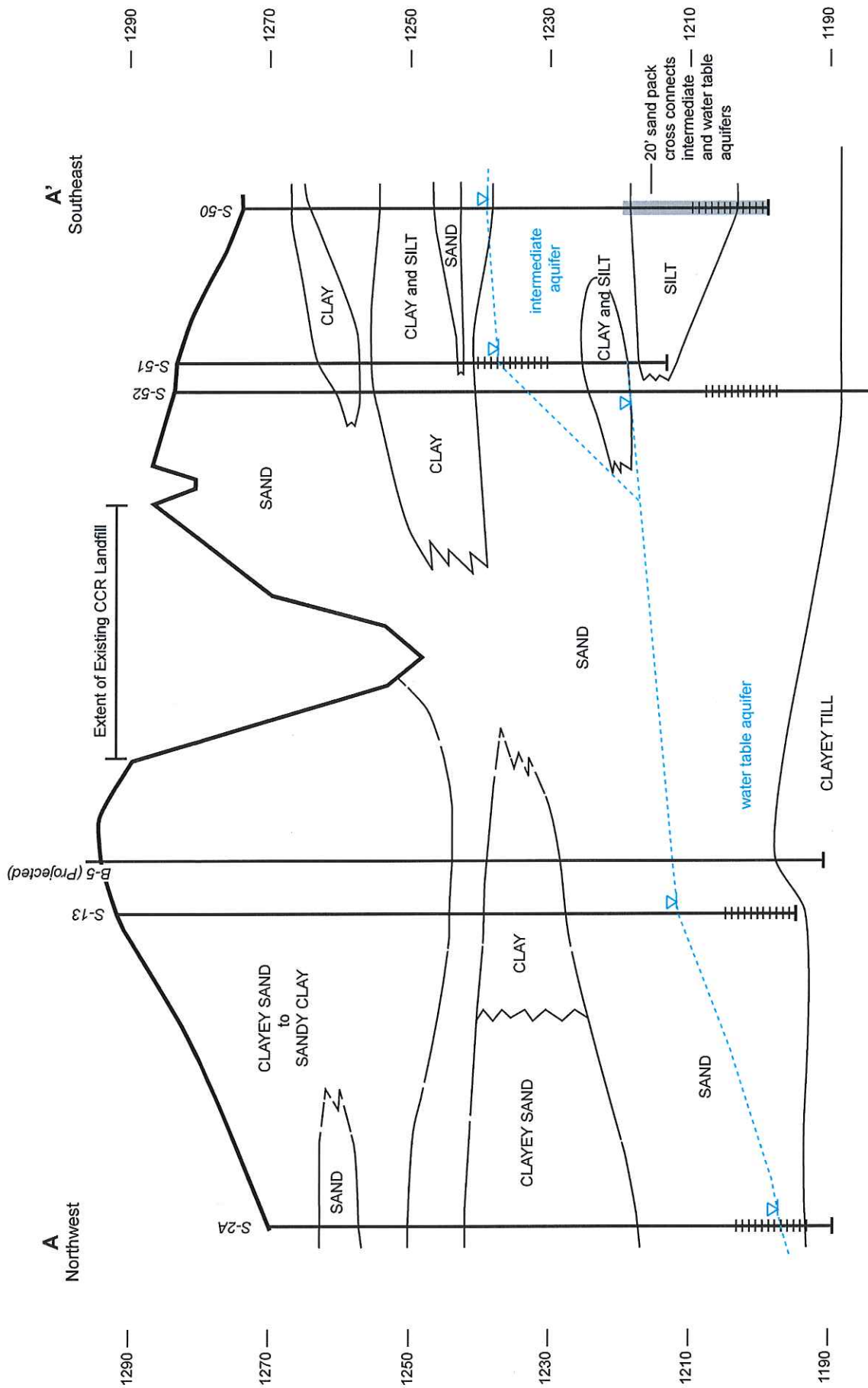


Figure 8

CROSS SECTION AND
CONCEPTUAL SITE MODEL
Hoot Lake Ash Disposal Facility
Otter Tail Power Company
Fergus Falls, MN

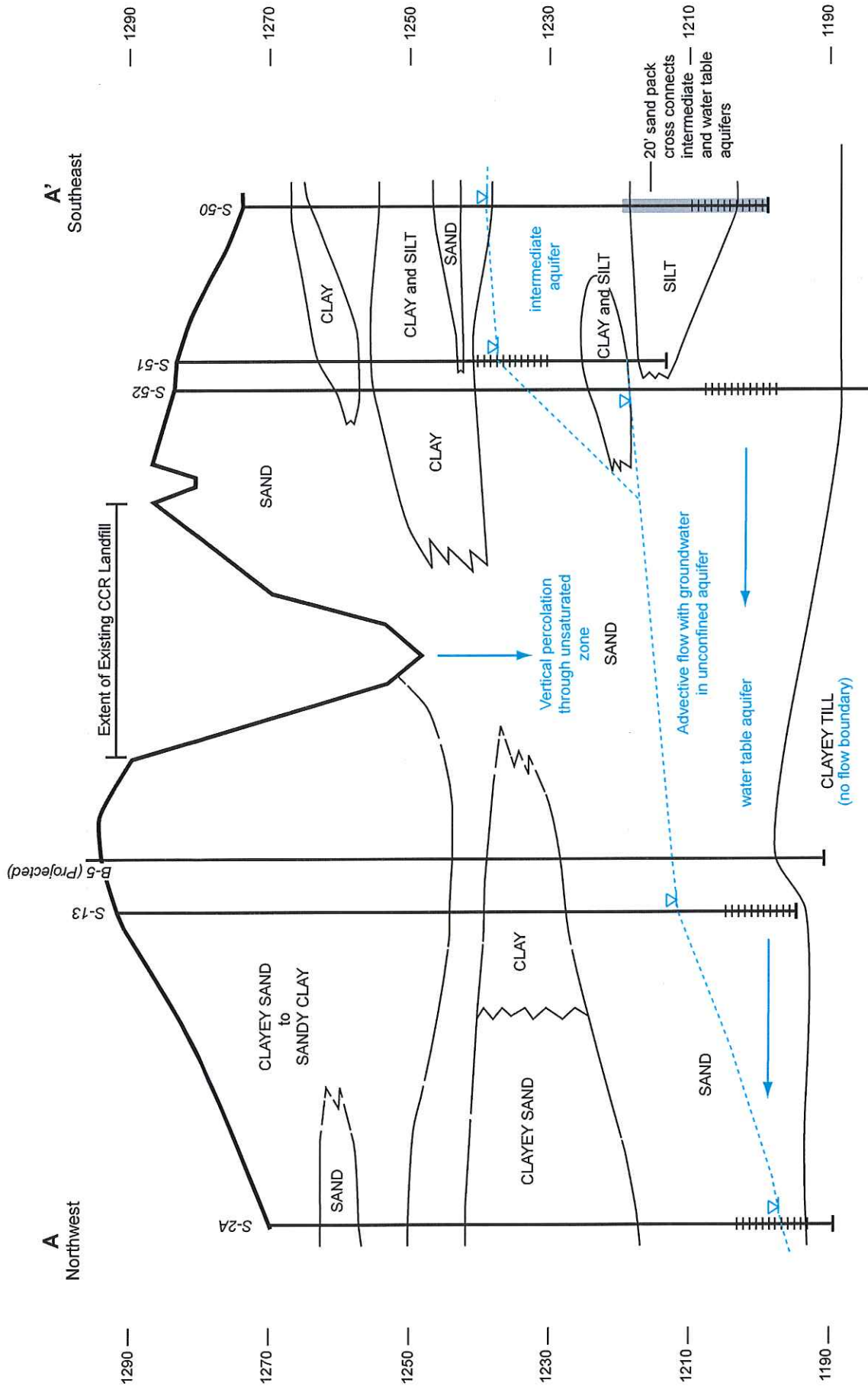


Figure 9

CONCEPTUAL RELEASE MODEL
Conceptual Release Migration Pathway
Hoot Lake Ash Disposal Facility
Otter Tail Power Company
Fergus Falls, MN



- CCR Monitoring Program Well
- Industrial Solid Waste Unit IL001 Monitoring Program Well
- Industrial Solid Waste Unit IL001
- Existing CCR Landfill (IL002)



Figure 10

CCR GROUNDWATER
MONITORING SYSTEM
Hoot Lake Ash Disposal Facility
Otter Tail Power Company
Fergus Falls, MN

Background: Otter Tail County 2015 FSA

Appendices

Appendix A

Boring and Well Logs

Appendix A Boring and Well Logs

upgradient well S-52

MINNESOTA UNIQUE WELL
AND BORING NO.MINNESOTA DEPARTMENT OF HEALTH
WELL AND BORING CONSTRUCTION RECORD
Minnesota Statutes, Chapter 103I

822155

WELL OR BORING LOCATION

County Name

Fergus Falls

Township Name

Township No.

Range No.

Section No.

Fraction

NE SE

1/4 1/4

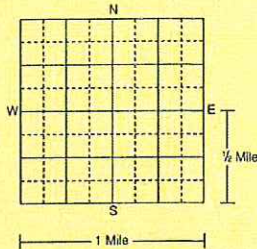
GPS LOCATION — decimal degrees (to four decimal places).

Latitude Longitude

House Number, Street Name, City, and ZIP Code of Well Location

1012 Water Plant Road, Fergus Falls, MN 56537

Show exact location of well/boring in section grid with "X".

Sketch map of well/boring location.
Showing property lines,
roads, buildings, and direction.

See Map

PROPERTY OWNER'S NAME/COMPANY NAME

1012 Water Plant Road, Fergus Falls, MN 56537

Property owner's mailing address if different than well location address indicated above.
PO Box 496
Fergus Falls, MN 56538

WELL OWNER'S NAME/COMPANY NAME

Overtail Power Company

Well/boring owner's mailing address if different than property owner's address indicated above.

-Same as above-

GEOLOGICAL MATERIALS	COLOR	HARDNESS OF MATERIAL	FROM	TO
Topsoil	B	5	0	10
Clay	R	5	10	25
SAND/SILT	B	10S	25	60
Silty/Sand	B	5	60	85

Use a second sheet, if needed.

REMARKS, ELEVATION, SOURCE OF DATA, etc.

117-16-7819

Well 552

IMPORTANT - FILE WITH PROPERTY PAPERS WELL OWNER COPY

822155

WELL/BORING DEPTH (completed)

85'

DATE WORK COMPLETED

7-5-16

DRILLING METHOD

- ☐ Cable Tool ☐ Driven
☐ Auger ☐ Rotary
☒ Other SONIC

DRILLING FLUID

N/A

WELL HYDROFRACTURED? ☐ Yes ☒ No

From ft. To ft.

USE

- ☐ Domestic ☒ Monitoring ☐ Heating/Cooling
☐ Noncommunity PWS ☐ Environ. Bore Hole ☐ Industry/Commercial
☐ Community PWS ☐ Irrigation ☐ Remedial
☐ Elevator ☐ Dewatering ☐

CASING MATERIAL

Drive Shoe? ☐ Yes ☒ No

HOLE DIAM.

- ☒ Steel ☐ Threaded ☐ Welded
☐ Plastic ☐

CASING

Diameter

Weight

Specifications

2 in. To

75 ft. To

365 lbs./ft.

S.P.H. 40

6 in. To

85 ft.

in. To

ft.

lbs./ft.

in. To

ft.

in. To

ft.

lbs./ft.

in. To

ft.

SCREEN Yes

Make

Johnson

Type

SS

OPEN HOLE

From

ft. To

ft.

Slot/Gauze

.010

Length

10'

Set between

85 ft. and

75 ft.

Fittings

T + C

STATIC WATER LEVEL

15

ft. Below

☐ Above land surface

Measured from

Ground

Date measured

7-5-16

PUMPING LEVEL (below land surface)

N/A

ft. after

hrs. pumping

g.p.m.

WELLHEAD COMPLETION

☐ Pileless/adaptor manufacturer

Model

☒ Casing protection 6" Protop☐ 12 in. above grade☐ At-grade☐ Well House☐ Hand Pump

GROUT INFORMATION (specify bentonite, cement-sand, neat-cement, concrete, cuttings, or other)

Material

NEAT Cement

From

65

To

0 ft.

12

☐ Yds. ☒ Bags

Material

From

To

ft.

☐ Yds. ☐ Bags

Material

From

To

ft.

☐ Yds. ☐ Bags

Driven casing seal

From

To

Bags

NEAREST KNOWN SOURCE OF CONTAMINATION

N/A

feet

direction

type

Well disinfected upon completion?

☐ Yes ☒ No

PUMP

☒ Not installed

Date installed

Manufacturer's name

Model Number

HP

Volts

Length of drop pipe

ft.

Capacity

g.p.m.

Type: ☐ Submersible ☐ L.S. Turbine ☐ Reciprocating ☐ Jet ☐

ABANDONED WELLS

Does property have any not in use and not sealed well(s)?

☐ Yes ☒ No

VARIANCE

Was a variance granted from the MDH for this well?

☐ Yes ☒ No

TN#

WELL CONTRACTOR CERTIFICATION

This well was drilled under my supervision and in accordance with Minnesota Rules, Chapter 4725.

The information contained in this report is true to the best of my knowledge.

Cascade Drilling

Licensee Business Name

Lic. or Reg. No.

Dale Ruck

Certified Representative Signature

2856

Certified Rep. No.

7-29-16

Date

Roy Buckenberger

Name of Driller



Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING S-52

SHEET 1 OF 2

Project: Hoot Lake CCR Compliance

Project No.: 23/56-1021

Location: Hoot Lake, MN

Coordinates: Lat: 46.28647° Long: -96.03146°

Datum:

Surface Elevation: 1284.1 ft

Drilling Method: Rotasonic

Sampling Method: Rotasonic core

Completion Depth: 100.0 ft

Unique Well No.:

Depth, feet	Sample Type & Recovery	Sample No.	Graphic Log	LITHOLOGIC DESCRIPTION	WELL OR PIEZOMETER CONSTRUCTION DETAIL	Elevation, feet
0			CH	TOPSOIL: FAT CLAY WITH SAND (CH): fine grained; dark yellowish brown; moist; roots; medium plasticity; weak HCl reaction; 5% gravel, 20% sand, 95% fines.		
5			SW-SC	WELL GRADED SAND WITH GRAVEL AND CLAY (SW-SC): dark yellowish brown; moist; subrounded, fine to coarse sand, rounded gravel, loose; weak HCl reaction; 20% gravel, 70% sand, 10% fines. 8 ft: 7.5YR 3/4 (more red).	PRO. CASING Diameter: 6" Type: Sch 40 Steel Interval: 3' ags-4' bgs	1280
10					RISER CASING Diameter: 2" Type: Sch 10 304 s.s./Sch 40 Steel Interval: 2.7' ags - 75.5' bgs	1275
15			SW	WELL GRADED SAND (SW): light olive brown; moist; subrounded to rounded, very fine grained; weak HCl reaction; 0% gravel, 95% sand, 5% fines.	GROUT Type: Neat Cement Interval: 0-67.5' bgs	1270
20			SW-SC	WELL GRADED SAND WITH CLAY AND GRAVEL (SW-SC): dark grayish brown; moist; rounded, fine to coarse grained, loose; 20% gravel, 70% sand, 10% fines.	SEAL Type: Bentonite Interval: 67.5-71.5' bgs	1265
25			ML	SILT (ML): olive brown; moist to wet; black organic laminations (1 mm thick), somewhat cohesive, trace orange oxidation laminations, very fine sand; low plasticity; slow dilatancy; weak HCl reaction; 0% gravel, 10% sand, 90% fines.	SANDPACK Type: #40 Red Flint Interval: 71.5-85.5' bgs	1260
30			SW-SC	WELL GRADED SAND WITH CLAY AND GRAVEL (SW-SC): dark grayish brown; moist to wet; rounded, fine to coarse grained, loose; no HCl reaction; 20% gravel, 70% sand, 10% fines.		
35			ML	SILT (ML): gray; moist; light gray laminations; low plasticity; rapid dilatancy; weak HCl reaction; 0% gravel, 0% sand, 100% fines.	SCREEN Diameter: 2" Type: Stainless Steel Interval: 75.5-85.5' bgs	1255
40			SW-SC/CL	WELL GRADED SAND WITH CLAYEY GRAVEL (SW-SC): dark grayish brown; moist to wet; rounded, fine to coarse grained, loose; no HCl reaction.		
45			SW-SC	LEAN CLAY (CL): very dark gray; moist; medium plasticity.		
50			CL	WELL GRADED SAND WITH CLAYEY GRAVEL (SW-SC): dark grayish brown; wet; rounded, fine to coarse grained, loose; no HCl reaction. 32.5 to 33 ft: wet, very fine sandy silt, red brown. SANDY LEAN CLAY WITH GRAVEL (CL): dark gray; moist; fine to very fine grained, lean, at times more clay and less sand; weak HCl reaction; 10% gravel, 30% sand, 60% fines.		1250
			SW-SM	WELL GRADED SAND WITH SILT (SW-SM): dark yellowish brown; moist to wet; trace rounded gravel, fine grained, rounded to subangular; weak HCl reaction. 43 ft: large cobble.		1245
						1240
						1235

Date Boring Started: 7/5/16 4:05 pm

Date Boring Completed: 7/6/16 8:30 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.
Weather: 82 F, 8mph NE winds, cloudy

C:\GINT\PROJECTS\23561021 HOOT LAKE CCR COMPLIANCE\23561021 HOOT LAKE CCR.GPJ BARR\BARR LOG BARR TEMPLATE.GDT

Project: Hoot Lake CCR Compliance

Surface Elevation: 1284.1 ft

Project No.: 23/56-1021

Drilling Method: Rotasonic

Unique Well No.:

Location: Hoot Lake, MN

Sampling Method: Rotasonic core

Coordinates: Lat: 46.28647° Long: -96.03146°

Completion Depth: 100.0 ft

Datum:

Depth, feet	Sample Type & Recovery	Sample No.	SSU	Graphic Log	LITHOLOGIC DESCRIPTION	WELL OR PIEZOMETER CONSTRUCTION DETAIL	Elevation, feet
55			SW-SM		WELL GRADED SAND WITH SILT (SW-SM): dark yellowish brown; moist to wet; trace rounded gravel, fine grained, rounded to subangular; weak HCl reaction. <i>(continued)</i> 51 to 54 ft: more gravel.	PRO. CASING Diameter: 6" Type: Sch 40 Steel Interval: 3' ags-4' bgs RISER CASING Diameter: 2" Type: Sch 10 304 s.s./Sch 40 Steel Interval: 2.7' ags - 75.5' bgs GROUT Type: Neat Cement Interval: 0-67.5' bgs SEAL Type: Bentonite Interval: 67.5-71.5' gbs SANDPACK Type: #40 Red Flint Interval: 71.5-85.5' bgs SCREEN Diameter: 2" Type: Stainless Steel Interval: 75.5-85.5' bgs	1230
60			SM		SILTY SAND (SM): dark greenish gray; moist to wet; somewhat cohesive; medium to fast dilatancy; low plasticity; weak HCl reaction. 57 ft: trace 1mm laminations; no HCl reaction. 61 to 64 ft: lean clay; no HCl reaction; 0% gravel, 40% sand, 60% fines.		1225
65							1220
70							1215
75							1210
80			SW-SC		WELL GRADED SAND WITH CLAY AND GRAVEL (SW-SC): olive brown; moist to wet; rounded to subrounded, fine grained, loose, gravel, small to large; no HCl reaction. 75 ft: color change to gray; no HCl reaction. 79 to 79.51 ft: very fine sand; no HCl reaction. 83 ft: more clay; no HCl reaction. 85 ft: end of day 7/5/16; no HCl reaction.		1205
85							1200
90							1195
95			CL		SANDY LEAN CLAY (CL): dark gray; moist to wet; lean, rounded fine to coarse sand, rounded small gravel; no HCl reaction.		1190
100					End of boring 100.0 feet		1185

Date Boring Started: 7/5/16 4:05 pm

Remarks:

Date Boring Completed: 7/6/16 8:30 am

Logged By: AMK2

Drilling Contractor: Cascade

Drill Rig: Truck

Additional data may have been collected in the field which is not included on this log.
Weather: 82 F, 8mph NE winds, cloudy

O:\GINT\PROJECTS\23561021 HOOT LAKE CCR COMPLIANCE\23561021 HOOT LAKE CCR.GPJ BARR\LIBRARY.GLB ENVIRO LOG BARR TEMPLATE.GDT



Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING S-51 DRAFT

SHEET 1 OF 3

Project: Hoot Lake CCR Compliance

Project No.: 23/56-1021

Location: Hoot Lake, MN

Coordinates:

Datum:

Surface Elevation:

Drilling Method: Geoprobe

Sampling Method:

Completion Depth: 70.0 ft

Depth, feet	Sample Type & Recovery	Sample No.	SSUS	Graphic Log	LITHOLOGIC DESCRIPTION	Elevation, feet
0				OL	(OL): ORGANIC SOIL; Black; moist; black topsoil with grass.	
1		1			(SP): POORLY GRADED SAND; fine to medium grained; Tan; moist.	
5				SP		
10		2			More fine-grained from 10 ft.	
15		3				
20		4		SM	(SM): SILTY SAND; fine to medium grained; tan/brown; moist to wet.	
25				CL	(CL): SANDY LEAN CLAY; brown; wet; low plasticity, fine-grained sand.	
30		5		CL	(CL): LEAN CLAY; gray; moist; medium plasticity.	
				SP	(SP): POORLY GRADED SAND with GRAVEL; coarse grained; tan; moist to wet.	
		6		ML	(ML): SANDY SILT; brown; moist; trace gravel.	

Date Boring Started:

6/2/16

Date Boring Completed:

6/2/16

Logged By:

ECL

Drilling Contractor:

Dakota

Drill Rig:

Remarks:

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

O:\GINT\PROJECTS\23561021 HOOT LAKE CCR COMPLIANCE\23561021 HOOT LAKE CCR.GPJ BARR\LIBRARY.GLB ENVIRO LOG BARR TEMPLATE.GDT



Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING S-51 DRAFT

SHEET 2 OF 3

Project: Hoot Lake CCR Compliance

Project No.: 23/56-1021

Location: Hoot Lake, MN

Coordinates:

Datum:

Surface Elevation:

Drilling Method: Geoprobe

Sampling Method:

Completion Depth: 70.0 ft

Depth, feet	Sample Type & Recovery	Sample No.	USCS	Graphic Log	LITHOLOGIC DESCRIPTION	Elevation, feet
30					(CL): LEAN CLAY; gray; moist; low plasticity.	
		7	CL		(ML): SILT; gray; moist; few gravel at 32 ft.	
35			ML			
		8	CL		(CL): SANDY LEAN CLAY; gray; moist to wet; low to medium plasticity, fine-grained sand.	
40			SP-SM		(SP-SM): POORLY GRADED SAND with SILT; medium grained; brown; moist.	
			ML		(ML): SILT; brown; moist.	
		9			(SP): POORLY GRADED SAND with GRAVEL; fine to coarse grained; tan/brown; moist.	
45					Saturated at 46 ft.	
		10				
50			SP			
		11			Gray from 52.5 ft. Silty sand lens (6) at 53 ft.	
55					Increasing fines content from 56 - 58 ft.	
		12				
			CL		(CL): SANDY LEAN CLAY; gray; moist to wet; low plasticity.	
			ML		(ML): SANDY SILT; gray; moist; fine-grained sand.	
60						

Date Boring Started: 6/2/16

Date Boring Completed: 6/2/16

Logged By: ECL

Drilling Contractor: Dakota

Drill Rig:

Remarks:

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

O:\GINT\PROJECTS\23561021 HOOT LAKE CCR COMPLIANCE\23561021 HOOT LAKE CCR.GPJ BARR\LIBRARY\GLB ENVIRO LOG BARR TEMPLATE.GDT



Barr Engineering Company
4300 MarketPointe Drive Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING S-51 DRAFT

SHEET 3 OF 3

Project:Hoot Lake CCR Compliance

Project No.:23/56-1021

Location:Hoot Lake, MN

Coordinates:

Datum:

Surface Elevation:

Drilling Method:Geoprobe

Sampling Method:

Completion Depth:70.0 ft

Depth, feet	Sample Type & Recovery	Sample No.	USCS	Graphic Log	LITHOLOGIC DESCRIPTION	Elevation, feet
60		13	ML		(ML): SANDY SILT; gray; moist; fine-grained sand. <i>(continued)</i>	
65			SM		(SM): SILTY SAND; very fine to fine grained; gray; wet.	
		14	ML		(ML): SANDY SILT; gray.	
70					End of boring 70.0 feet	
75						
80						
85						
90						

Date Boring Started: 6/2/16

Date Boring Completed: 6/2/16

Logged By: ECL

Drilling Contractor: Dakota

Drill Rig:

Remarks:

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

ORIGINAL PROJECTS\23561021 HOOT LAKE CCR COMPLIANCE\23561021 HOOT LAKE CCR.GPJ BARR\LIBRARY.GLB ENVIRO LOG BARR TEMPLATE.GDT



Wenck

Wenck Associates, Inc.
1800 Pioneer Creek Center
Maple Plain, MN 55359
Telephone: 763-479-4200
Fax: 763-479-4242

WELL NUMBER S-3A-R

PAGE 1 OF 4

CLIENT <u>Otter Tail Power Company</u>		PROJECT NAME <u>Environmental Monitoring System</u>	
PROJECT NUMBER <u>0909-50</u>		PROJECT LOCATION <u>Fergus Falls, Minnesota</u>	
DATE STARTED <u>9/26/05</u>	COMPLETED <u>9/27/05</u>	GROUND ELEVATION _____	HOLE SIZE <u>8-Inch</u>
DRILLING CONTRACTOR <u>Interstate Drilling Services</u>		GROUND WATER LEVELS:	
DRILLING METHOD <u>Hollow-stem auger</u>		AT TIME OF DRILLING <u>---</u>	
LOGGED BY <u>Nick Christensen</u>		AT END OF DRILLING <u>---</u>	
CHECKED BY <u>Paul Turner</u>		AFTER DRILLING <u>---</u>	
NOTES _____			

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	WELL DIAGRAM
0							
	SS 9	83	1-4-4-6 (8)	OH		0.5 Black sandy clay topsoil Light brown and tan coarse sand and gravel	
5				SW			
10	SS 10	42	3-6-7-7 (13)	SC		8.0 Brown to gray clayey sand with some gravel	
15							
20							

GENERAL BH / TP / WELL / GINT FILES.GPJ WENCK.GDT 10/3/05

(Continued Next Page)



Wenck

Wenck Associates, Inc.
1800 Pioneer Creek Center
Maple Plain, MN 55359
Telephone: 763-479-4200
Fax: 763-479-4242

WELL NUMBER S-3A-R

PAGE 2 OF 4

CLIENT Otter Tail Power Company

PROJECT NAME Environmental Monitoring System

PROJECT NUMBER 0909-50

PROJECT LOCATION Fergus Falls, Minnesota

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	WELL DIAGRAM
20							
	SS 11	33	1-5-7-9 (12)			Brown to gray clayey sand with some gravel (continued)	
25							
				SC			
30	SS 12	100	2-6-8-11 (14)				
35							
						37.0	
						Gray sandy lean clay with discrete 1-inch saturated sand layers occurring in the bottom 10-feet	
40	SS 13	100	2-7-10-15 (17)	CL			

← High solids bentonite grout

← 2-inch black steel riser pipe

GENERAL BH / TP / WELL GINT FILES.GPJ WENCK.GDT 10/3/05

(Continued Next Page)



Wenck

Wenck Associates, Inc.
1800 Pioneer Creek Center
Maple Plain, MN 55359
Telephone: 763-479-4200
Fax: 763-479-4242

WELL NUMBER S-3A-R

PAGE 3 OF 4

CLIENT Otter Tail Power Company

PROJECT NAME Environmental Monitoring System

PROJECT NUMBER 0909-50

PROJECT LOCATION Fergus Falls, Minnesota

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	WELL DIAGRAM
45						Gray sandy lean clay with discrete 1-inch saturated sand layers occurring in the bottom 10-feet (continued)	
50	SS 14	100	3-9-11-15 (20)	CL			
55							
60	SS 15	75	22-58-34- 31 (92)	SW		60.0 Tan fine to coarse sand	
	SS 16	92	7-10-13-21 (23)	CL- ML		63.0 Tan sandy silt and clay	
65				GP		65.0 Tan with rust stained coarse sand and gravel	

2-inch
stainless
steel riser
pipe

(Continued Next Page)



Wenck

Wenck Associates, Inc.
1800 Pioneer Creek Center
Maple Plain, MN 55359
Telephone: 763-479-4200
Fax: 763-479-4242

WELL NUMBER S-3A-R

PAGE 4 OF 4

CLIENT Otter Tail Power Company

PROJECT NAME Environmental Monitoring System

PROJECT NUMBER 0909-50

PROJECT LOCATION Fergus Falls, Minnesota

DEPTH (ft)	SAMPLE TYPE NUMBER	RECOVERY %	BLOW COUNTS (N VALUE)	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION	WELL DIAGRAM
	SS 17	83	3-18-26-23 (44)			Tan with rust stained coarse sand and gravel (<i>continued</i>)	
	SS 18	50	4-14-18-20 (32)				
70	SS 19	50	1-16-22-30 (38)				
	SS 20	50	1-7-14-18 (21)	GP			
75							
	AU 21						
80						80.0	
						Bottom of hole at 80.0 feet.	

Natural collapse of sand and gravel

2-inch stainless steel #10-slot screen

Natural collapse of sand and gravel

S-3AR

MINNESOTA DEPARTMENT OF HEALTH
WELL AND BORING RECORD
Minnesota Statutes Chapter 1031

MINNESOTA UNIQUE WELL NO.

674671

WELL LOCATION

County Name

Otter Tail

Township Name

Fergus Falls

Township No.

133N

Range No.

43W

Section No.

36

Fraction
NW NE SE
1/4 1/4 1/4

WELL DEPTH (completed)

77 ft.

Date Work Completed

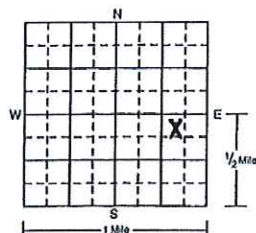
9-27-05

House Number, Street Name, City, and Zip Code of Well Location

Hoot Lake Plant, 1012 Water Plant Rd., Fergus Falls 56537

or Fire Number

Show exact location of well in section grid with "X".

Sketch map of well location.
Showing property lines,
roads and buildings.

PLEASE SEE ATTACHED MAP

PROPERTY OWNER'S NAME

Otter Tail Power Company

Property owner's mailing address if different than well location address indicated above.

215 Cascade Street
Fergus Falls, MN 56537

WELL OWNER'S NAME

Otter Tail Power Company

Well owner's mailing address if different than property owner's address indicated above.

DRILLING METHOD

☐ Cable Tool☐ Auger☒ 4" HSA☐ Driven☐ Rotary☐ Dug☐ Jetted

DRILLING FLUID

NA

WELL HYDROFRACTURED?

☐ YES ☒ NO

FROM _____ ft. to _____ ft.

USE

☐ Domestic☐ Irrigation☐ Environ. Bore Hole☒ Monitoring☐ Community PWS☐ Noncommunity PWS☐ Dewatering☐ Heating/Cooling☐ Industry/Commercial☐ Remedial

CASING

Drive Shoe?

☐ Yes ☒ No☒ Steel☐ Threaded☐ Welded

HOLE DIAM.

CASING DIAMETER

62

in. to

67

ft.

WEIGHT

304 Stainless Steel

lbs./ft.

8

in. to

77

ft.

0

in. to

62

ft.

Sch. 40

lbs./ft.

in. to

in. to

SCREEN

Stainless Steel

Make

Johnson

Type

Flush Thread

Slot/Gauze

.01

Set between

67

ft. and

77

ft.

OPEN HOLE

from _____ ft. to _____ ft.

Diam.

2"

Length

10'

STATIC WATER LEVEL

NA

ft.

☐ below☐ above land surface

Date measured _____

PUMPING LEVEL (below land surface)

NA

ft. after

hrs. pumping

g.p.m.

WELL HEAD COMPLETION

☐ Pileless adapter manufacturer

Model

☒ Casing Protection

4" Protap/30" Stickup

☐ At-grade (Environmental Wells and Borings ONLY)

GROUTING INFORMATION

Well grouted? ☒ Yes ☐ NoGrout Material ☐ Neat cement ☐ Bentonite ☐ Concrete☒ High Solids Bentonite

Concrete

Quick Grout

from

0

to

5

ft.

5

yds.

☒ bags

from

5

to

58

ft.

☐ yds.☐ bags

NEAREST KNOWN SOURCE OF CONTAMINATION

_____ feet _____ direction _____ type

Well disinfected upon completion? ☐ Yes ☐ No

PUMP

XX Not installed

Date installed _____

Manufacturer's name _____

Model number _____

HP _____

Volts _____

Length of drop pipe _____

ft.

Capacity _____

g.p.m.

Type: ☐ Submersible ☐ L.S. Turbine ☐ Reciprocating ☐ Jet ☐ _____

ABANDONED WELLS

Does property have any not in use and not sealed well(s)? ☐ Yes ☒ No

VARIANCE

Was a variance granted from the MDH for this well? ☐ Yes ☒ No

TN# _____

WELL CONTRACTOR CERTIFICATION

This well was drilled under my supervision and in accordance with Minnesota Rules, Chapter 4725. The information contained in this report is true to the best of my knowledge.

Interstate Drilling Services, LLP

M0148

Licensee Business Name

Lic. or Reg. No.

Authorized Representative Signature

10-6-05

Date

Michael Zak

10-6-05

Name of Driller

Date

Well ID No.: S-3A-R

IDS Project No.: 205121

IMPORTANT - FILE WITH PROPERTY PAPERS

WELL OWNER COPY

674671

HE-01205-07 (Rev. 2/99)



Barr Engineering Company
4700 West 77th St. Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING S-10-R

SHEET 1 OF 3

Project: Otter Tail Power Company

Project No.: 23/56-0038.03

Location: Fergus Falls, MN

Coordinates: Lat: 46° 17' 14.20554" Long: 96° 02' 07.14990"

Datum:

Surface Elevation: 1279.0 ft

Drilling Method: Rotasonic

Sampling Method: Rotasonic core

Completion Depth: 85.0 ft

Top of Casing Elev.: 1281.5 ft

Unique Well No.: 806341

Depth, feet	Sample Type & Recovery	Sample No.	ENVIRONMENTAL DATA	U S C S	Graphic Log	LITHOLOGIC DESCRIPTION	WELL OR PIEZOMETER CONSTRUCTION DETAIL	Elevation, feet
0		1	No odors noted/	SC		CLAYEY SAND (SC): fine to coarse grained; dark yellowish brown (10YR 4/4); moist; subangular to subrounded; with ~5% fine to coarse gravel; ~40% clayey fines, abundant carbonates with granitic and mafic lithology, soft, cohesive.	PRO. CASING Diameter: 6" Type: sch 40 steel Interval: 3' ags-4' bgs	1275
5						SANDY LEAN CLAY (CL): brown (10YR 5/3); moist; subangular to subrounded; medium plasticity; no dilatancy; medium toughness; massive; soft to firm; 30-35% fine to medium-grained sand; 5-10% mostly fine gravel with few some coarse fraction; mostly carbonates with granitic and mafic lithology.	RISER CASING Diameter: 2" Type: 5' sch10 304 s.s/ sch40 steel Interval: 62-68' bgs 2.5 ags-62' bgs	
						From 5-8.5' bgs, brown (10YR 5/3).		
10		2	No odors noted/	CL		From 8.5-10' bgs, mottled with dark gray (2.5Y 4/1) and strong brown (7.5YR 5/6).	GROUT Type: neat Interval: cement/concrete 0-59.5' bgs	1270
						From 10-14.9' bgs, dark gray (2.5Y 4/1).	SEAL Type: bentonite Interval: 59.5-64.5' bgs	
						At 10.2' bgs, fine-grained gray sand lens (2.5Y 5/1).		
						At 12.8' bgs, fine-grained gray sand lens (2.5Y 5/1).		
15				CL		SANDY LEAN CLAY (CL): yellowish brown (10YR 5/6); moist; medium plasticity; no dilatancy; medium toughness; ~40% fine to medium-grained sand; trace coarse sand; trace to 5% gravel, subangular to subrounded.	SANDPACK Type: #40 red flint Interval: 64.5-78' bgs	1265
				GM		SILTY GRAVEL WITH SAND (GM): dark yellowish brown (10YR 4/4); saturated; subangular to subrounded; fine to coarse gravel, trace cobble; subangular to subrounded; mostly carbonates/granitic material; 15-25% fine to coarse-grained sand; 15% fines.	SCREEN Diameter: 2" Type: stainless steel Interval: 10 slot 68-78' bgs	1260
20		3	No odors noted/	CL		SANDY LEAN CLAY (CL): dark grayish brown (10YR 4/2); moist; low to medium plasticity; no dilatancy; low toughness; firm to hard; ~40% fine to medium-grained sand with ~10% coarse-grained total sand; trace to 5% fine gravel; subangular to subrounded grains/clasts mottled dark grayish brown (10YR 4/2) and yellowish brown (10YR 5/4).		1255
				SP		POORLY GRADED SAND (SP): fine grained; light olive brown (2.5Y 5/3); moist; mostly quartz; no gravel; with ~15% medium-grained and trace coarse-grained sand; trace fines.		
25				CL		SANDY LEAN CLAY (CL): dark grayish brown (10YR 4/2); moist; low to medium plasticity; no dilatancy; low toughness; firm to hard; ~40% fine to medium-grained sand with ~10% coarse-grained total sand; trace 5% fine gravel; subangular to subrounded grains/clasts mottled dark gray brown (10YR 4/2) and yellow-brown (10YR 5/4).		
				CL		LEAN CLAY WITH SAND (CL): dark gray (5Y 4/1); moist; medium plasticity; no dilatancy; medium toughness; strong HCl reaction; massive; 30% fine to coarse-grained sand; 5% mostly fine gravel, trace coarse gravel, subangular to subrounded.		1250

Date Boring Started:

4/22/15

Date Boring Completed:

4/23/15

Logged By:

KAM

Drilling Contractor:

Cascade Drilling L.P.

Drill Rig:

Remarks: Samples collected with a 4" core barrel, 6" overide casing.

PID = Headspace; D/O/S = Discoloration/Odor/Sheen; FID/MC = FID/Methane Corrected
Additional data may have been collected in the field which is not included on this log.
Weather:

M:\GINT\PROJECTS\23560038.03 OTTER_TAIL_POWER_COMPANY\23560038.03 OTTER TAIL POWER COMPANY.GPJ BARR\LIBRARY\GLB ENVIRO LOG BARR TEMPLATE.GDT



Barr Engineering Company
4700 West 77th St. Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING S-10-R

SHEET 2 OF 3

Project: Otter Tail Power Company
Project No.: 23/56-0038.03
Location: Fergus Falls, MN
Coordinates: Lat: 46° 17' 14.20554"° Long: 96° 02' 07.14990"°
Datum:

Surface Elevation: 1279.0 ft
Drilling Method: Rotasonic
Sampling Method: Rotasonic core
Completion Depth: 85.0 ft

Top of Casing Elev.: 1281.5 ft
Unique Well No.: 806341

Depth, feet	Sample Type & Recovery	Sample No.	ENVIRONMENTAL DATA	USCS	Graphic Log	LITHOLOGIC DESCRIPTION	WELL OR PIEZOMETER CONSTRUCTION DETAIL	Elevation, feet
30		4	No odors noted/	CL		LEAN CLAY WITH SAND (CL): dark gray (5Y 4/1); moist; medium plasticity; no dilatancy; medium toughness; strong HCl reaction; massive; 30% fine to coarse-grained sand; 5% mostly fine gravel, trace coarse gravel, subangular to subrounded. (continued) From 30-33' bgs, firm to soft.	PRO. CASING Diameter: 6" Type: sch 40 steel Interval: 3' ags-4' bgs	1245
35				SC		CLAYEY SAND (SC): fine to medium grained; yellowish brown (10YR 5/4); moist; trace coarse and fine gravel, subangular to subrounded; ~30% clayey fines, cohesive; mottled with yellow-brown (10YR 5/4).	RISER CASING Diameter: 2" Type: 5' sch10 304 s.s./sch40 steel Interval: 62-68' bgs 2.5 ags-62' bgs	
40		5	No odors noted/	SM		SILTY SAND (SM): fine grained; brown (10YR 5/3); moist; ~10% medium to coarse-grained sand; trace fine gravel, subangular to subrounded; 15% fines. Moist.	GROUT Type: neat Interval: cement/concrete 0-59.5' bgs	1240
				CL		LEAN CLAY WITH SAND (CL): dark gray (5Y 4/1); moist; mostly carbonates with some mafic and granitic grains/clasts.	SEAL Type: bentonite Interval: 59.5-64.5' bgs	
				SP		POORLY GRADED SAND (SP): fine to medium grained; light olive brown (2.5Y 5/3); with 10% coarse-grained sand, ; trace to 5% fines; subangular to subrounded. From 39-40' bgs, 20% fine to coarse gravel. From 40-41' bgs, no gravel.	SANDPACK Type: #40 red flint Interval: 64.5-78' bgs	1235
				GP-GM		POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM): grayish brown (2.5Y 5/2); moist; fine to coarse gravel, angular to subangular; mostly granitic with some mafic with some carbonates; 15% fines; ~35% fine to coarse-grained sand.	SCREEN Diameter: 2" Type: stainless steel Interval: 10 slot 68-78' bgs	1230
45				SP		POORLY GRADED SAND WITH GRAVEL (SP): fine to coarse grained; dark grayish brown (2.5Y 4/2); moist; ~30% fine to coarse gravel, subangular to subrounded; 5% fines.		
50		6	No odors noted/	ML		SILT WITH VERY FINE SAND (ML): brown (10YR 5/3); moist; non-plastic; rapid dilatancy; noncohesive; ~15% very fine-grained sand. At 53' bgs.		1225
55				GP-GM		POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM): yellowish brown (10YR 5/4); moist; fine to coarse gravel, angular to subangular, % gravel and fines decrease to 20% and 5% respectively with depth; 30% fine to coarse-grained sand, 10% fines.		
60		7	No odors noted/	SP				1220

Date Boring Started: 4/22/15
Date Boring Completed: 4/23/15
Logged By: KAM
Drilling Contractor: Cascade Drilling L.P.
Drill Rig:

Remarks: Samples collected with a 4" core barrel, 6" overide casing.

PID = Headspace; D/O/S = Discoloration/Odor/Sheen; FID/MC = FID/Methane Corrected
Additional data may have been collected in the field which is not included on this log.
Weather:

M:\GINT\PROJECTS\23560038.03 OTTER_TAIL_POWER_COMPANY\GPJ_BARR\LIBRARY.GLB ENVIRO LOG BARR TEMPLATE.GDT



Barr Engineering Company
4700 West 77th St. Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING S-10-R

SHEET 3 OF 3

Project: Otter Tail Power Company
Project No.: 23/56-0038.03
Location: Fergus Falls, MN
Coordinates: Lat: 46° 17' 14.20554" Long: 96° 02' 07.14990"
Datum:

Surface Elevation: 1279.0 ft
Drilling Method: Rotasonic
Sampling Method: Rotasonic core
Completion Depth: 85.0 ft

Top of Casing Elev.: 1281.5 ft
Unique Well No.: 806341

Depth, feet	Sample Type & Recovery	Sample No.	ENVIRONMENTAL DATA	Graphic Log	LITHOLOGIC DESCRIPTION	WELL OR PIEZOMETER CONSTRUCTION DETAIL	Elevation, feet
60					POORLY GRADED SAND (SP): fine to medium grained; olive brown (2.5Y 4/3); moist; 15-20% coarse-grained sand; trace to 5% fine gravel, subangular to subrounded; mostly quartz sand with carbonates and granitic minerals, some mafics; trace fines. (continued) From 61-65' bgs, gravel is absent.	PRO. CASING Diameter: 6" Type: sch 40 steel Interval: 3' ags-4' bgs	1215
65		8	No odors noted/	SP	Below 65' bgs, gravel increases to ~15% and 5% fines (poorly graded sand with gravel); moist.	RISER CASING Diameter: 2" Type: 5' sch10 304 s.s./ sch40 steel Interval: 62-68' bgs 2.5 ags-62' bgs	1210
70					Appears saturated below 69' bgs.	GROUT Type: neat Interval: cement/concrete 0-59.5' bgs	
75		9	No odors noted/	GP	POORLY GRADED GRAVEL WITH SAND (GP): fine to coarse grained; olive brown (2.5Y 4/3); saturated; subrounded; fine to coarse gravel; 30% fine to coarse-grained sand; trace fines; mostly granitic lithology and carbonates.	SEAL Type: bentonite Interval: 59.5-64.5' bgs	1205
				SP	POORLY GRADED SAND WITH GRAVEL (SP): gray (5Y 5/1); saturated; ~15% fine to coarse gravel, subangular to subrounded; trace fines; carbonates, mafics, granitic minerals.	SANDPACK Type: #40 red flint Interval: 64.5-78' bgs	
		10	No odors noted/		At 76.5' bgs, one 4-inch cobble present; saturated.	SCREEN Diameter: 2" Type: stainless steel Interval: 10 slot 68-78' bgs	1200
80				CL	SANDY LEAN CLAY (CL): very dark gray (5Y 3/1); moist; medium plasticity; medium toughness; strong HCl reaction; firm to soft, 30% fine to coarse-grained sand; 5% fine to coarse gravel, subangular to subrounded; cohesive; mostly carbonates with some granitic lithology and mafics. From 79-80' bgs, firm.		
85		11	No odors noted/		End of Boring 85' bgs.		1195

Date Boring Started: 4/22/15
Date Boring Completed: 4/23/15
Logged By: KAM
Drilling Contractor: Cascade Drilling L.P.
Drill Rig:

Remarks: Samples collected with a 4" core barrel, 6" override casing.

PID = Headspace; D/O/S = Discoloration/Odor/Sheen; FID/MC = FID/Methane Corrected
Additional data may have been collected in the field which is not included on this log.
Weather:

M:\GINT\PROJECTS\23560038.03_OTTER_TAIL_POWER_COMPANY\23560038.03_OTTER_TAIL_POWER_COMPANY.GPJ_BARR\BARR\LOG BARR TEMPLATE.GDT

S-10R

MINNESOTA UNIQUE WELL
AND BORING NO.

806341

MINNESOTA DEPARTMENT OF HEALTH
WELL AND BORING RECORD
Minnesota Statutes, Chapter 103I

WELL OR BORING LOCATION

County Name

Otter Tail

Township Name

Fergus Falls

Township No.

133N

Range No.

43W

Section No.

36

Fraction

NW NE SE

WELL/BORING DEPTH (completed)

78 ft.

DATE WORK COMPLETED

4-22-15

GPS

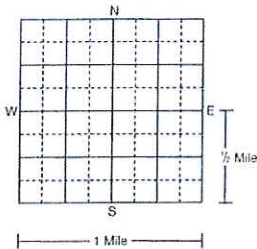
LOCATION:

Latitude _____ degrees _____ minutes _____ seconds _____
Longitude _____ degrees _____ minutes _____ seconds _____

House Number, Street Name, City, and ZIP Code of Well Location

1012 Water Plant Road Fergus Falls 56537

Show exact location of well/boring in section grid with "X."

Sketch map of well/boring location.
Showing property lines,
roads, buildings, and direction.

See Map

DRILLING METHOD

☐ Cable Tool ☐ Driven
☐ Auger ☐ Rotary
☒ Other Sonic

DRILLING FLUID

None

WELL HYDROFRACTURED? ☐ Yes ☒ No

From _____ ft. To _____ ft.

USE

☐ Domestic ☒ Monitoring ☐ Heating/Cooling
☐ Noncommunity PWS ☐ Environ. Bore Hole ☐ Industry/Commercial
☐ Community PWS ☐ Irrigation ☐ Remedial
☐ Elevator ☐ Dewatering ☐ _____

CASING MATERIAL

☒ Steel ☒ Threaded ☐ Welded
☐ Plastic ☐ _____
Drive Shoe? ☐ Yes ☒ No

HOLE DIAM.

CASING

Diameter

Weight

Specifications

2 in. To 68 ft. _____ lbs./ft. _____

6 in. To 78 ft.

_____ in. To _____ ft. _____ lbs./ft. _____

_____ in. To _____ ft.

_____ in. To _____ ft. _____ lbs./ft. _____

_____ in. To _____ ft.

SCREEN

yes

Make

S.S. Johnson

Type

S.S. 010

OPEN HOLE

From _____ ft. To _____ ft.

Diam. 2' ft.

Slot/Gauze

68 010

Length

10'

Set between

68 ft. and 78 ft.

Fittings

T+C

STATIC WATER LEVEL

71

ft. Below ☒ Above land surface

Measured from

Ground

Date measured 4-27-15

PUMPING LEVEL (below land surface)

N/A

ft. after _____

hrs. pumping _____

g.p.m. _____

WELLHEAD COMPLETION

☐ Pileless/adaptor manufacturer

Model

☒ Casing protection 6" Protup☒ 12 in. above grade☐ At-grade☐ Well House☐ Hand Pump

GROUTING INFORMATION (specify bentonite, cement-sand, neat-cement, concrete, cuttings, or other)

Material Cement

From 0

To 59

ft. 6

☐ Yds. ☒ Bags

Material _____

From _____

To _____

ft. _____

☐ Yds. ☐ Bags

Material _____

From _____

To _____

ft. _____

☐ Yds. ☐ Bags

Driven casing seal

From _____

To _____

Bags _____

NEAREST KNOWN SOURCE OF CONTAMINATION

unknown

feet _____

direction _____

type _____

Well disinfected upon completion? ☐ Yes ☒ No

PUMP

☒ Not installed

Date installed _____

Manufacturer's name _____

Model Number _____

HP _____

Volts _____

Length of drop pipe _____

ft. _____

Capacity _____

g.p.m. _____

Type: ☐ Submersible ☐ L.S. Turbine ☐ Reciprocating ☐ Jet ☐ _____

ABANDONED WELLS

Does property have any not in use and not sealed well(s)? ☐ Yes ☒ No

VARIANCE

Was a variance granted from the MDH for this well? ☐ Yes ☒ No

TN# _____

WELL CONTRACTOR CERTIFICATION

This well was drilled under my supervision and in accordance with Minnesota Rules, Chapter 4725.

The information contained in this report is true to the best of my knowledge.

Cascade Drilling, L.P. 3267

Licensee Business Name

Lic. or Reg. No.

Pete Dursel

2856

5-15-15

Certified Representative Signature

Certified Rep. No.

Date

Mark Biermaier

Name of Driller

MINN. DEPT. OF HEALTH COPY

806341

S-13

F8.B.I.i

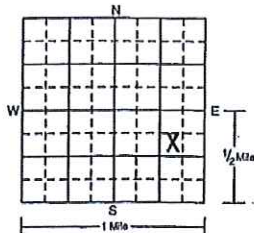
WELL LOCATION

County Name
Otter TailMINNESOTA DEPARTMENT OF HEALTH
WELL AND BORING RECORD
Minnesota Statutes Chapter 103I

MINNESOTA UNIQUE WELL NO.

632810Township Name
Fergus FallsTownship No.
133NRange No.
43WSection No.
36Fraction
SW NE SEWELL DEPTH (completed) **97** ft.Date Work Completed
4-9-01House Number, Street Name, City, and Zip Code of Well Location
Hoot Lake Plant, 1012 Water Plant Rd., Fergus Falls 56537DRILLING METHOD
☐ Cable Tool
☐ Auger
☒ **4 1/2 HSA**
☐ Driven
☐ Rotary
☐ Dug
☐ Jetted

Show exact location of well in section grid with "X".

Sketch map of well location.
Showing property lines,
roads and buildings.**SEE
ATTACHED
MAP**DRILLING FLUID
NoneWELL HYDROFRACTURED? ☐ YES ☒ NO
FROM _____ ft. to _____ ft.USE
☐ Domestic
☐ Irrigation
☐ Environ. Bore Hole
☒ Monitoring
☐ Community PWS
☐ Noncommunity PWS
☐ Dewatering
☐ Heating/Cooling
☐ Industry/Commercial
☐ RemedialCASING
☒ Steel
☐ Plastic
Drive Shoe? ☐ Yes ☒ No
☒ Threaded
☐ Welded

HOLE DIAM.

CASING DIAMETER
2 in. to **81.5** ft.
2 in. to **87** ft.
WEIGHT
Sch. 40 lbs./ft.
Flush Thread S.S. lbs./ft.
8 in. to **97** ft.
8 in. to _____ ft.SCREEN **304 Stainless Steel**
Make **Stainless Steel**
Type **Stainless Steel**
Slot/Gauze **.015**
Set between **87** ft. and **97** ft. FITTINGS: **Flush**
OPEN HOLE
from _____ ft. to _____ ft.
Diam. **2"**
Length **10'**STATIC WATER LEVEL
5 ft. ☒ below ☐ above land surface Date measured **3-21-01**PUMPING LEVEL (below land surface) **NA**
ft. after _____ hrs. pumping _____ g.p.m.WELL HEAD COMPLETION
☐ Pile adapter manufacturer
☒ Casing Protection **4" Steel** Model **30"** ☒ in. above grade
☐ At-grade (Environmental Wells and Borings ONLY)GROUTING INFORMATION
Well grouted? ☒ Yes ☐ No
Grout Material ☒ Neat cement ☐ Bentonite ☐ Concrete ☐ High Solids Bentonite
from **2** to **82** ft. **15** yds. ☒ bags
from _____ to _____ ft. _____ yds. ☐ bags
from _____ to _____ ft. _____ yds. ☐ bagsNEAREST KNOWN SOURCE OF CONTAMINATION
200 feet **SE** direction **Ash** type
Well disinfected upon completion? ☐ Yes ☒ NoPUMP
☒ Not installed Date installed _____
Manufacturer's name _____
Model number _____ HP _____ Volts _____
Length of drop pipe _____ ft. Capacity _____ g.p.m.
Type: ☐ Submersible ☐ L.S. Turbine ☐ Reciprocating ☐ Jet ☐ABANDONED WELLS **NA**
Does property have any not in use and not sealed well(s)? ☐ Yes ☐ NoVARIANCE **NA**
Was a variance granted from the MDH for this well? ☐ Yes ☐ No TN# _____

WELL CONTRACTOR CERTIFICATION

This well was drilled under my supervision and in accordance with Minnesota Rules, Chapter 4725.
The information contained in this report is true to the best of my knowledge.**Interstate Drilling Services, LLP M0148**

Licensee Business Name

Lic. or Reg. No.

Michael Zak **5-3-01**

Authorized Representative Signature Date

Michael Zak **5-3-01**

Name of Driller

Date

GEOLOGICAL MATERIALS	COLOR	HARDNESS OF MATERIAL	FROM	TO
SANDY LEAN CLAY (FILL)	Dark Brown	Soft	0	7
SANDY LEAN CLAY	BROWN	Medium	7	29
SANDY LEAN CLAY	Gray	Medium	29	72
SAND, Medium-grained, a little gravel	BROWN	Dense	72	97

Use a second sheet, if needed

REMARKS, ELEVATION, SOURCE OF DATA, etc.

Well ID #S-13
IDS Project #201025IMPORTANT - FILE WITH PROPERTY PAPERS
WELL OWNER COPY**632810**



Barr Engineering Company
4700 West 77th St. Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING S-14R

SHEET 1 OF 3

Project: Otter Tail Power Company
Project No.: 23/56-0038.03
Location: Fergus Falls, MN
Coordinates: Lat: 46° 17' 18.33531" Long: 96° 2' 06.94320"
Datum:

Surface Elevation: 1278.1 ft
Drilling Method: Rotasonic
Sampling Method: Rotasonic core
Completion Depth: 90.0 ft

Top of Casing Elev.: 1280.6 ft
Unique Well No.: 806342

Depth, feet	Sample Type & Recovery	Sample No.	ENVIRONMENTAL DATA	USCS	Graphic Log	LITHOLOGIC DESCRIPTION	WELL OR PIEZOMETER CONSTRUCTION DETAIL	Elevation, feet
0				OL/OH		ORGANIC SOIL (OL/OH): black (10YR 2/1); moist; clayey; abundant roots.		
		1	No odors noted/	SP-SM		POORLY GRADED SAND WITH SILT (SP-SM): fine to medium grained; very dark grayish brown (10YR 3/2); moist; 10% coarse-grained sand; trace to 5% fine gravel, subangular to subrounded; 10% fines.	PRO. CASING Diameter: 6" Type: sch 40 steel Interval: 3' ags-4' bgs	1275
5				SP		POORLY GRADED SAND (SP): fine to medium grained; brown (10YR 5/3); 40-45% fine to medium-grained sand; 10% gravel-mostly fine with few coarse, subangular to subrounded; a little bit of lean clay at bottom; trace to 5% fines.		
		2	No odors noted/	CL		SANDY LEAN CLAY TO CLAYEY SAND (CL): yellowish brown (10YR 5/4); moist; low plasticity; low toughness; massive; 40-45% fine to medium-grained sand with some coarse-grained sand; ~5 to 10% fine gravel, trace coarse gravel, subangular to subrounded; predominately carbonate, few to some granitic/mafic.	RISER CASING Diameter: 2" Type: sch10 304 s.s./sch40 steel Interval: 69.5-74.5' bgs 2.5 ags-69.5' bgs	1270
10				CL			GROUT Type: neat cement Interval: 0-65' bgs	
15				CL		SANDY LEAN CLAY (CL): brown (10YR 5/2); moist; medium plasticity; medium dry strength; massive; soft to firm; 30-35% fine to medium-grained sand with some coarse-grained sand interbedded; ~5-10% fine gravel with some coarse; abundant carbonate grains/clasts; with some granitic/mafic; grades to brown (10YR 4/3).	SEAL Type: bentonite Interval: 65-70' bgs	1265
20		3	No odors noted/	CL			SANDPACK Type: #40 red flint Interval: 70.5-84.5' bgs	
				CL		LEAN CLAY WITH SAND (CL): dark gray (5Y 4/1); moist; medium plasticity; high dry strength; medium toughness; strong HCl reaction; massive; 30% fine to coarse-grained sand; 5% fine gravel, trace coarse gravel; mostly carbonate grains/clasts with some granitic and mafic.	SCREEN Diameter: 2" Type: stainless steel Interval: 10 slot 74.5-84.5' bgs	1260
25				CL		From 25-27' bgs, very soft and very moist.		1255
30		4	No odors noted/	CL				1250

Date Boring Started: 4/21/15
Date Boring Completed: 4/22/15
Logged By: KAM
Drilling Contractor: Cascade Drilling L.P.
Drill Rig:

Remarks: Samples collected with 4" core barrel, 6" override casing.

PID = Headspace; D/O/S = Discoloration/Odor/Sheen; FID/MC = FID/Methane Corrected
Additional data may have been collected in the field which is not included on this log.
Weather:

M:\GINT\PROJECTS\23560038.03_OTTER_TAIL_POWER_COMPANY\GPJ_BARR\LIBRARY\GLB_ENVIRO LOG_BARR TEMPLATE.GDT

Project: Otter Tail Power Company
Project No.: 23/56-0038.03
Location: Fergus Falls, MN
Coordinates: Lat: 46° 17' 18.33531" Long: 96° 2' 06.94320"
Datum:

Surface Elevation: 1278.1 ft
Drilling Method: Rotasonic
Sampling Method: Rotasonic core
Completion Depth: 90.0 ft

Top of Casing Elev.: 1280.6 ft
Unique Well No.: 806342

Depth, feet	Sample Type & Recovery	Sample No.	ENVIRONMENTAL DATA	SSC	Graphic Log	LITHOLOGIC DESCRIPTION	WELL OR PIEZOMETER CONSTRUCTION DETAIL	Elevation, feet
35		5	No odors noted/	CL		LEAN CLAY WITH SAND (CL): dark gray (5Y 4/1); moist; medium plasticity; high dry strength; medium toughness; strong HCl reaction; massive; 30% fine to coarse-grained sand; 5% fine gravel, trace coarse gravel; mostly carbonate grains/clasts with some granitic and mafics. (continued) At 34' bgs, possible perched water; fine-grained 0.5 cm sand lens.	PRO. CASING Diameter: 6" Type: sch 40 steel Interval: 3' ags-4' bgs RISER CASING Diameter: 2" Type: sch10 304 s.s./ sch40 steel Interval: 69.5-74.5' bgs 2.5 ags-69.5' bgs GROUT Type: neat cement Interval: 0-65' bgs SEAL Type: bentonite Interval: 65-70' bgs SANDPACK Type: #40 red flint Interval: 70.5-84.5' bgs SCREEN Diameter: 2" Type: stainless steel Interval: 10 slot 74.5-84.5' bgs	1245
40								1240
45		6	No odors noted/	CL		Below 43' bgs, very moist; soft; facets of gravel clasts in broken core were wet.		1235
50								1230
55		7	No odors noted/	GP		POORLY GRADED GRAVEL WITH SAND (GP): light olive brown (2.5Y 5/3); moist; fine to coarse gravel, subangular to subrounded; 5% fines, 45% fine to coarse-grained sand; about 1/2 carbonate, 1/2 granitic/mafic.		1225
60				SP		POORLY GRADED SAND WITH GRAVEL (SP): light olive brown (2.5Y 5/3); moist; fine to coarse gravel, subangular to subrounded, 15-20% fine gravel; trace coarse gravel, subangular to subrounded; about 1/2 carbonate, 1/2 granitic/mafic; 5% fines. Moist; From 55-61.5' bgs, moist; slightly fines with depth to ~15% gravel. At 56' bgs, 4" cobble.		1220
				SP		At 61' bgs, 3.5" cobble.		

Date Boring Started: 4/21/15
Date Boring Completed: 4/22/15
Logged By: KAM
Drilling Contractor: Cascade Drilling L.P.
Drill Rig:

Remarks: Samples collected with 4" core barrel, 6" override casing.

PID = Headspace; D/O/S = Discoloration/Odor/Sheen; FID/MC = FID/Methane Corrected
Additional data may have been collected in the field which is not included on this log.
Weather:

M:\GINT\PROJECTS\23560038.03_OTTER_TAIL_POWER_COMPANY\23560038.03_OTTER_TAIL_POWER_COMPANY.GPJ BARR\LIBRARY.GLB ENVIRO LOG BARR TEMPLATE.GDT



Barr Engineering Company
4700 West 77th St. Suite 200
Minneapolis, MN 55435
Telephone: 952-832-2600

LOG OF BORING S-14R

SHEET 3 OF 3

Project: Otter Tail Power Company

Project No.: 23/56-0038.03

Location: Fergus Falls, MN

Coordinates: Lat: 46° 17' 18.33531" Long: 96° 2' 06.94320"

Datum:

Surface Elevation: 1278.1 ft

Drilling Method: Rotasonic

Sampling Method: Rotasonic core

Completion Depth: 90.0 ft

Top of Casing Elev.: 1280.6 ft

Unique Well No.: 806342

Depth, feet	Sample Type & Recovery	Sample No.	ENVIRONMENTAL DATA	U C S S	Graphic Log	LITHOLOGIC DESCRIPTION	WELL OR PIEZOMETER CONSTRUCTION DETAIL	Elevation, feet
65		8	No odors noted/	SP		POORLY GRADED SAND (SP): fine grained; grayish brown (2.5Y 5/2); trace medium to coarse-grained sand; no gravel; mostly quartz sand; trace to 5% fines. (continued)	PRO. CASING Diameter: 6" Type: sch 40 steel Interval: 3' ags-4' bgs	1215
70				SP-SM		POORLY GRADED SAND WITH GRAVEL (SP-SM): fine to coarse grained; dark gray brown (2.5Y 4/2); moist; subangular to subrounded; 5-10% fines; 15-20% fine to coarse-grained sand.	RISER CASING Diameter: 2" Type: sch10 304 s.s./ sch40 steel Interval: 69.5-74.5' bgs 2.5 ags-69.5' bgs	1210
75				SM		At 70' bgs, a few cobbles up to 3.5".	GROUT Type: neat cement Interval: 0-65' bgs	1205
80		9	No odors noted/	SP		From 73-74' bgs, 5-10% fines, 5% fine gravel.	SEAL Type: bentonite Interval: 65-70' bgs	
85						From 74-75.5' bgs, a fine to medium-grained sand lens; strong brown (7.5YR 5/6); oxidation; hard and slightly cemented.	SANDPACK Type: #40 red flint Interval: 70.5-84.5' bgs	1200
90		10	No odors noted/			SILTY SAND WITH GRAVEL (SM): fine to coarse grained; brown (10YR 5/3); moist; ~15% fine gravel; firm; 15% fines.	SCREEN Diameter: 2" Type: stainless steel Interval: 10 slot 74.5-84.5' bgs	1195
						POORLY GRADED SAND (SP): fine to medium grained; dark gray (2.5 4/1); moist; subangular to subrounded; with 20% coarse-grained sand; 5-10% fine gravel, abundant carbonates, mafic and granitic material; 5% fines.		1190
						At 76.5' bgs, fine-gravel lens; saturated below.		
						From 83-84' bgs, coarse-grained sand decreases to ~10% of total sand.		
						From 84-85' bgs, coarse-grained sand increases to ~20% of total sand.		
						From 88.7-89.2' bgs, coarse-grained sand and gravel lens; gravel is mostly fine with a few coarse gravel; subangular to subrounded grains/clasts; carbonates, mafics, granitic materials.		
						End of Boring 90' bgs.		

Date Boring Started:

4/21/15

Date Boring Completed:

4/22/15

Logged By:

KAM

Drilling Contractor:

Cascade Drilling L.P.

Drill Rig:

Remarks: Samples collected with 4" core barrel, 6" override casing.

PID = Headspace; D/O/S = Discoloration/Odor/Sheen; FID/MC = FID/Methane Corrected
Additional data may have been collected in the field which is not included on this log.
Weather:

MA\GINT\PROJECTS\23560038.03 - OTTER TAIL POWER COMPANY.GPJ BARR\BARR\BARR TEMPLATE.GDT

S-14R

MINNESOTA DEPARTMENT OF HEALTH
WELL AND BORING RECORD
Minnesota Statutes, Chapter 103I

MINNESOTA UNIQUE WELL
AND BORING NO.

806342

WELL OR BORING LOCATION

County Name

Otter Tail

Township Name

Fergus Falls

Township No.

133N

Range No.

43W

Section No.

36

Fraction

NW NE SE
1/4 1/4 1/4

GPS

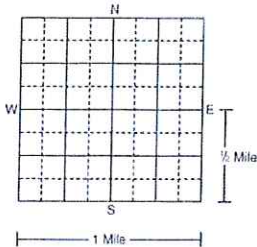
LOCATION:

Latitude _____ degrees _____ minutes _____ seconds _____
Longitude _____ degrees _____ minutes _____ seconds _____

House Number, Street Name, City, and ZIP Code of Well Location

1012 Water Plant Road Fergus Falls 56537

Show exact location of well/boring in section grid with "X."

Sketch map of well/boring location.
Showing property lines,
roads, buildings, and direction.

See Map

PROPERTY OWNER'S NAME/COMPANY NAME

Otter Tail Power Company

Property owner's mailing address if different than well location address indicated above

215 South Cascade St.
Fergus Falls, MN 56537

WELL OWNER'S NAME/COMPANY NAME

Otter Tail Power Company

Well/boring owner's mailing address if different than property owner's address indicated above

-Same as above-

WELL/BORING DEPTH (completed)

84.5

DATE WORK COMPLETED

4-21-15

DRILLING METHOD

☐ Cable Tool ☐ Driven
☐ Auger ☐ Rotary
☒ Other *Sonic*

DRILLING FLUID

None

WELL HYDROFRACTURED? ☐ Yes ☒ No

From _____ ft. To _____ ft.

USE

☐ Domestic ☒ Monitoring ☐ Heating/Cooling
☐ Noncommunity PWS ☐ Environ. Bore Hole ☐ Industry/Commercial
☐ Community PWS ☐ Irrigation ☐ Remedial
☐ Elevator ☐ Dewatering ☐ _____

CASING MATERIAL

☒ Steel ☐ Drive Shoe? ☐ Yes ☒ No
☐ Plastic ☐ Threaded ☐ Welded

HOLE DIAM.

CASING

Diameter

2 in. To 74.5 ft. _____ lbs./ft. _____

Weight

Specifications

6 in. To 84.5 ft. _____

SCREEN

yes

Make

Johnson

Type

S.S.

OPEN HOLE

From _____ ft. To _____ ft.

Slot/Gauze

1010

Length

10'

Set between

74.5 ft. and 84.5 ft.

FITTINGS

T & F

STATIC WATER LEVEL

79

Measured from Ground

ft.

Below ☐ Above land surface

Date measured 4-27-15

PUMPING LEVEL (below land surface)

N/A

ft. after _____

hrs. pumping _____

g.p.m. _____

WELLHEAD COMPLETION

☐ Pitless/adaptor manufacturer _____ Model _____
☒ Casing protection 6" Protrop ☒ 12 in. above grade
☐ At-grade ☐ Well House ☐ Hand Pump

GROUTING INFORMATION (specify bentonite, cement-sand, neat-cement, concrete, cuttings, or other)

Material Cement From 0 To 65 ft. 6 Yds. ☒ BagsMaterial _____ From _____ To _____ ft. _____ Yds. ☐ BagsMaterial _____ From _____ To _____ ft. _____ Yds. ☐ Bags

Driven casing seal From _____ To _____ Bags

NEAREST KNOWN SOURCE OF CONTAMINATION

Unknown feet _____ direction _____ type _____

Well disinfected upon completion? ☐ Yes ☒ No

PUMP

☒ Not installed Date installed _____

Manufacturer's name _____

Model Number _____ HP _____ Volts _____

Length of drop pipe _____ ft. Capacity _____ g.p.m.

Type: ☐ Submersible ☐ L.S. Turbine ☐ Reciprocating ☐ Jet ☐ _____

ABANDONED WELLS

Does property have any not in use and not sealed well(s)? ☐ Yes ☒ No

VARIANCE

Was a variance granted from the MDH for this well? ☐ Yes ☒ No TN# _____

WELL CONTRACTOR CERTIFICATION

This well was drilled under my supervision and in accordance with Minnesota Rules, Chapter 4725.

The information contained in this report is true to the best of my knowledge.

Cascade Drilling, L.P. 3267

Licensee Business Name Lic. or Reg. No.

Dale Paul 2856 5-15-15

Certified Representative Signature Certified Rep. No. Date

Mark Biermaier

Name of Driller

MINN. DEPT. OF HEALTH COPY

806342