CCR Groundwater Monitoring System Certification

Unit 3 Landfill

Sherburne County (Sherco) Generating Plant
Becker, Minnesota

Prepared for:

Northern States Power Company, a Minnesota Corporation

October, 2017

Carlson McCain

15650 36th Ave N. Suite 110
Plymouth, MN 55446
Tel 952-346-3900
Fax 952-346-3901
www.carlsonmccain.com

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CCR GROUNDWATER MONITORING SYSTEM CERTIFICATION

Sherco Unit 3 Landfill
Becker, Minnesota

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the laws of the State of Minnesota.

Additionally, I certify that the groundwater monitoring system identified in this report 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.

NICHOLAS BONOW
LICENSED PROFESSIONAL ENGINEER
47510
STATE OF MINNESOTA

Signature of Preparer:

Nicholas Bonow, P.E., P.G. #47510
Carlson McCain, Inc.

Date: October 16, 2017

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1. INTRODUCTION

This report presents documentation and certification of the groundwater monitoring system for the Unit 3 Dry Ash Landfill (Landfill) at the Sherburne County Generating Plant (Sherco) located in Becker, Minnesota. The Sherco plant is owned and operated by Northern States Power Company, a Minnesota Corporation (NSPM). The Landfill location is shown on Figure 1 and an aerial photograph and site layout map for Landfill are shown on Figure 2.

The Landfill is an existing coal combustion residuals (CCR) landfill and is required to comply with provisions of the U.S. Code of Federal Regulations (CFR), Title 40, Parts 257 and 261 relating to disposal of coal combustion residuals from electric utilities. In particular, this report addresses the requirements of 40 CFR Section 257.91, Groundwater Monitoring Systems.

1.1 Groundwater Monitoring System §257.91(a)

According to §257.91(a), CCR units must comply with the following 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 down-gradient 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."

Additionally, §257.91 includes specific requirements in subparts (b) through (g) relating to the development and implementation of the groundwater monitoring system, which must be satisfied in order to demonstrate compliance with the performance standard listed in subpart (a).

NSPM has installed a groundwater monitoring system at the Landfill as described in Table 1 and shown in Figure 5 that complies with the standard set forth in §257.91(a). The system includes twelve monitoring wells that monitor up-gradient, down-gradient and side-gradient locations.

The following sections describe the system in further detail, and address the requirements of subparts (b) through (g).

2. SITE CHARACTERIZATION

The hydrogeologic setting of the Landfill has been characterized in accordance with §257.91(b) which states *"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."*

Several hydrogeologic investigations have previously been performed at the Landfill to characterize the site's hydrogeology for permitting and compliance with the Minnesota Pollution Control Agency (MPCA) rules. Pertinent reports include the following:

- NSP, 1991a. SHERCO Plant, Unit 3 Dry Ash Landfill Site Expansion, Phase I Hydrogeologic Summary, January 1991;
- NSP, 1991b. SHERCO Plant, Unit 3 Dry Ash Landfill – Cell 2, Phase II Hydrogeologic Investigation, May 11, 1991;
- Xcel, 2007. SHERCO Unit #3 Dry Ash Landfill Expansion, Phase I Hydrogeologic Report and Phase II Work Plan, October 2007;
- NSP, 2008. Sherco Dry Ash Disposal Facility, Hydrogeologic Evaluation, Phase II – Field Investigation, prepared by Xcel Energy; March 2008;
- Xcel, 2009. SHERCO AQCS Landfill – Cell #3, Phase III Hydrogeologic Investigation – EMS Installation, November 16, 2009.

Carlson McCain has reviewed these investigation reports in detail and the data and information contained in the reports has been adapted for use in this report.

2.1 Compliance with §257.91(b)(2) - Geology

General notes:

1) The requirements in §257.91(b)(2) will be discussed prior to §257.91(b)(1) in Sections 2.1 and 2.2 respectively since the geology and stratigraphy requirements in §257.91(b)(2) are generally the basis for the hydrogeologic requirements in §257.91(b)(1).
2) Of the reports listed in the previous section, the reports for Cell 2 (NSP, 1991b) and the landfill expansion (NSP, 2008) in particular discuss the geology, stratigraphy, and distinctive textural classifications of the stratigraphic units beneath the Landfill. For consistency in reading this section, the discussion in this section will reference data mainly from NSP (2008). In general, unless otherwise cited, specific data on soil types, thicknesses, spatial distribution, etc. are credited to NSP (2008).

Three major stratigraphic materials have been encountered at the Landfill and include, from top to bottom, outwash sand (alluvium), a discontinuous layer of glacial till, and granitic bedrock. The major stratigraphic materials encountered at the Landfill are illustrated on cross-sections from soil borings conducted during previous hydrogeologic investigations at the site.

2.1.1 Outwash Material (Alluvium)

Outwash material, or alluvium, is the upper-most stratigraphic unit at the Landfill. The alluvium generally extends from the ground surface to bedrock though it is interrupted by glacial till as described in Section 2.1.2. over a large portion of the site.

Description/Classification
The alluvium consists primarily of fine to coarse sand, densities of medium dense to very dense, typically less than 10% fines, and is well to poorly sorted. Soils are typically classified as SP or SP-SM under the United Soil Classification System (USCS). The sand color was primarily tan to brown in color. The texture and color of the material is fairly consistent across the site.

Spatial Distribution
The alluvium consists of the material between the ground surface extending to bedrock though, as discussed Sections 2.1 and 2.1.2, the alluvium is interrupted by a layer of glacial till that exists over a large portion of the site. The alluvium below the till has also been referred to as deep alluvium (Carlson McCain, 2016). The alluvium ranges from 30 to 75 feet thick with maximum thicknesses found in areas that the alluvial deposits extend uninterrupted from the ground surface to bedrock.

Grain Size and Permeability
Using the Hazen method (Fetter, 1994) and slug testing, the permeabilities for the alluvium beneath the Landfill ranges from 2.2×10^{-2} cm/sec to 7.7×10^{-2} cm/sec. The porosity of the alluvium was estimated to be 0.25.

2.1.2 Glacial Till

Grantsburg sublobe and Superior lobe glacial tills have been identified at the Landfill and have been characterized by their geologic origins in order to highlight their differences in classification, grain size and permeability. Since the permeability of the glacial tills are four to six orders of magnitude lower than the outwash, they have been mapped as a single unit on maps and cross-sections in previous reports.

Description/Classification
Grantsburg till is described to be from the Grantsburg sublobe glacial ice advancement, color is brown to gray, is classified as a clayey sand under the USCS, is calcareous in nature, and contains fragments of shale. Superior till is described to be from the Superior lobe glacial ice advancement, color is reddish-brown due to scouring of iron rich sandstones, and is classified as a silty sand under the USCS.

Spatial Distribution
The glacial till exists within the alluvium over a large portion of the Landfill site, and was typically present at elevations ranging from 923 to 937 feet above mean sea level (MSL). Although it was present in the majority of the borings advanced during the landfill expansion hydrogeologic investigation,

discontinuities in the till were observed beneath the Landfill. Where present, the till thickness typically ranged from 1 to 12 feet thick, with a thicker area present beneath a portion of Cell 2.

Grain Size and Permeability
Using the Hazen method (Fetter, 1994) and slug testing, the permeabilities for the Grantsburg and Superior tills ranged from 1.0×10^{-6} to 3.4×10^{-8} cm/sec and from 1.1×10^{-7} to 8.5×10^{-7} cm/sec respectively. The porosity of the glacial till was estimated to be 0.15.

2.1.3 Bedrock

Nineteen borings were extended to bedrock during previous investigations and middle Precambrian granitic bedrock is the first bedrock encountered at the Landfill. The depth to bedrock ranged from 50 to 83 feet below ground surface (BGS) at elevations ranging from of 896 to 919 feet MSL. The upper portion of bedrock was weathered to various degrees; however, the bedrock is considered impermeable beneath the weathered veneer.

2.2 Compliance with §257.91(b)(1) - Hydrogeology

2.2.1 Aquifer Thickness

The water table beneath the Landfill typically occurs above the top of the glacial till identified in Section 2.1.2. Therefore, the uppermost aquifer is the alluvium discussed in Section 2.1.1, which ranges from 30 to 75 feet thick.

2.2.2 Groundwater Elevation and Flow Direction

As shown in the hydrograph in Figure 3, the groundwater fluctuates between one and three feet on an annual basis and by as much as seven feet from a wet year to a drought year at the Landfill. The hydrograph also indicates that, from 1986 to the present, groundwater elevations at the facility have ranged from approximately 931.0 to 947.0 feet MSL and are typically five to ten feet above the glacial till described in Section 2.1.2.

Groundwater elevations and flow direction at the Landfill during February, 2017 are shown on the water table contour elevation map in Figures 4. The contours were derived from a Sherco site-wide water level gathering effort which included wells in the CCR monitoring system as wells as additional wells and piezometers on the Sherco plant site. As shown in Figure 4, groundwater flow direction is primarily to the south-southwest. This flow direction is generally consistent with historical data at the facility and is also consistent with the regional groundwater flow direction towards the Mississippi river.

2.2.3 Groundwater Flow Gradients

Based on the groundwater elevation contours shown in Figure 4, the average horizontal groundwater gradient at the Landfill was calculated at 0.0032 (units of vertical feet per horizontal foot). The horizontal gradient appeared to be fairly consistent across the entire facility and is also consistent with values previously reported for the facility.

Vertical gradients were calculated from four nested well pairs (P-73A-1 and P-73B-1, P-76A-1 and P-76B-1, P-137A and P-137B and P-138A and P-138B) based on water level measurements collected during April of 2017, and results are shown below:

- 0.0018 downward for P-76A-1/ P-76B-1,
- 0.030 downward at the P-137A/P-137B,
- 0.0007 downward for P-138A/P-138B, and
- 0.0013 upward for P-73A-1/ P-73B-1.

In general, the overall low magnitude opposing results indicates no apparent vertical flow regime and vertical flow is nearly negligible at these locations. The stronger gradient observed at the P-137A/B well nest is anomalous compared to other well nests at the Landfill and across the Sherco plant site. The difference in head at these locations is less than 0.03 feet, which is on the same order of magnitude as the error associated with the surveyed elevations. At the P-137A/B well nest, the calculated vertical gradient does not appear to be consistent or representative of the overall gradient at the Landfill due to the proximity of well nests P-137A/P-137B and P-138A/P-138B to each other and the presence of a very permeable aquifer with a dis-continuous till layer. It does not appear that this anomalous value is indicative of a pattern of significant downward gradients in the vicinity of the Landfill.

2.2.4 Groundwater Flow Velocity

Average linear groundwater flow velocity was calculated using Darcy's equation:

$$v = Kh \times i / ne$$

where Kh = horizontal hydraulic conductivity (length/time)
i = horizontal gradient (dimensionless)
ne = effective porosity

As discussed in Section 2.1.1, the outwash sand at the facility exhibited a range of average Kh values from 2.2×10^{-2} to 7.7×10^{-2} cm/sec and 0.25 for n_e (estimated). Section 2.2.3 indicated the value for i is 0.0032 (calculated).

Resulting groundwater velocity values at the Site range from approximately 291 to 1020 feet per year.

3. CONCEPTUAL MODEL AND MONITORING WELL LOCATIONS

§257.91(c) states that *"The groundwater monitoring system must include the minimum number of monitoring wells necessary to meet the performance standards specified in paragraph (a) of this* section (discussed in Section 1.1 of this report), *based on the site-specific information specified in paragraph (b) of this section* (discussed in Section 2.0 of this report)."

Section 3.1 below integrates existing data into a geologic and hydrogeologic framework, or conceptual model, for the Landfill site. The conceptual model offers a simplified representation of the geologic media and serves as the basis for identifying the primary monitoring units.

The conceptual model also facilitates a description of the fate and transport of a hypothetical release from the proposed facility. It provides a rationale for predicting the most likely flow paths that a release might follow and provides the basis for an effective monitoring network that can intercept the potential release.

Sections 3.2 and 3.3 below discuss the selection of monitoring well locations based on the rule requirements and the conceptual model for the Landfill site.

3.1 Conceptual Model

The conceptual model for the release of a constituent of concern (COC) from the Landfill focuses on groundwater as the transport mechanism. As discussed in Section 2.2.2, the water table beneath Pond 3 is typically 5 to 10 feet above the glacial till layer identified in Section 2.1.2. Exfiltration from Landfill area is anticipated to move vertically downward from the base until it reaches the water table contact. No glacial till has been identified in the vadose zone, which would impede or redirect the infiltrating leachate. Upon reaching the water table, a COC will likely travel mainly horizontally toward the west-southwest and to the Mississippi River.

Based on this conceptual model, the groundwater monitoring network should target the water table as the primary monitoring zone; and downgradient wells should be located on the south and/or west sides of the Landfill in order to detect a potential release.

3.2 Groundwater Monitoring System

As discussed in Section 1.1, NSPM has installed a groundwater monitoring system at the Landfill that complies with the standard set forth in §257.91(a). The system includes twelve water table monitoring wells that include up-gradient, down-gradient, and side-gradient wells as follows:

Up-Gradient	Down-Gradient	Side-Gradient
P-125, P-134, P-141	P-75-1, P-97, P-98, P-117, P-120, P-137A, P-138A	P-73A-1, P-74

Well locations relative to the Landfill are shown in Figure 5; and well construction data, including unique well number and installation date, are summarized in Table 1.

3.2.1 Compliance with §257.91(c)(1)

As described above in Section 3.2, seven monitoring wells are located down-gradient, three are up-gradient and two are side-gradient of the Landfill. This exceeds the minimums of one up-gradient and three down-gradient monitoring wells required in §257.91(c)(1).

3.2.2 Compliance with §257.91(c)(2)

Based on the conceptual model for the Landfill, monitoring wells in addition to the minimums described in Section 3.2.1 have been located in up-gradient, down-gradient and side-gradient locations at the Landfill. Monitoring well P-141 was installed in 2016 (Carlson McCain, 2016) to combine with previously existing wells P-125 and P-134 to accurately represent the background groundwater quality at the site. Previously existing monitoring wells are evenly spaced along the down-gradient and side-gradient edges of the Landfill and are well-situated to detect a potential release.

4. GROUNDWATER MONITORING SYSTEM PERFORMANCE

The Landfill is not a multi-unit facility and, therefore, compliance with §257.91(d) is not required. Given that, Section 4.1 below discusses compliance with §257.91(e) which states that *"Monitoring wells must be cased in a manner that maintains the integrity of the monitoring well borehole. This casing must be screened or perforated and packed with gravel or sand, where necessary, to enable collection of groundwater samples. The annular space (i.e., the space between the borehole and well casing) above the sampling depth must be sealed to prevent contamination of samples and the groundwater."*

4.1 Compliance with §257.91(e)

Monitoring well completion logs that were reviewed indicate that wells included in the monitoring network have casings that are screened and packed with sand to enable collection of groundwater samples (NSP, 1991b, Xcel, 2008 and Xcel, 2009). The monitoring well completion logs also indicate the annular spaces above the sand packs in the monitoring wells have been sealed to prevent contamination of samples and the groundwater. Further, previous sampling at all wells in the monitoring network have proven that the wells are sampleable and provide acceptable and consistent results.

4.1.1 Compliance with §257.91(e)(1)

As required in §257.91(e)(1):

1. The design, installation, development and decommissioning of any monitoring wells, piezometers, and any other measurement, sampling and analytical devices that are part of groundwater monitoring system will be kept as part of the operating record;
2. The operating record for the facility consists of electronic reports found on NSPM's data network; and
3. Access to the operating record was provided for the completion of this groundwater monitoring system certification.

4.1.2 Compliance with §257.91(e)(2)

As required in §257.91(e)(2), monitoring wells, piezometers, and any other measurement, sampling and analytical devices that are part of the groundwater monitoring system will be operated and maintained so that they perform to the design specifications throughout the life of the monitoring program.

4.1.3 Ground Water Sampling Plan

A Ground Water Sampling Plan (GWSP) and Statistical Methods Certification have been completed for the wells in the CCR groundwater monitoring network at Landfill (NSPM, 2017). The GWSP provides the methods and procedures that will be used to collect, ship, analyze, and report groundwater monitoring data from the facility is intended to comply the requirements of §257.93.

5.0 REFERENCES

Carlson McCain, 2016. Monitoring Well Installation Report, Unit #3 AQCS Landfill – Sherco Generating Plant, October 13, 2016.

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NSPM, 2017. CCR Ground Water Sampling Plan, Sherco Unit 3 Landfill. Northern States Power Company, a Minnesota Corporation. October, 2017.

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Xcel, 2009. SHERCO AQCS Landfill – Cell #3, Phase III Hydrogeologic Investigation – EMS Installation. Xcel Energy, November 16, 2009.

Tables

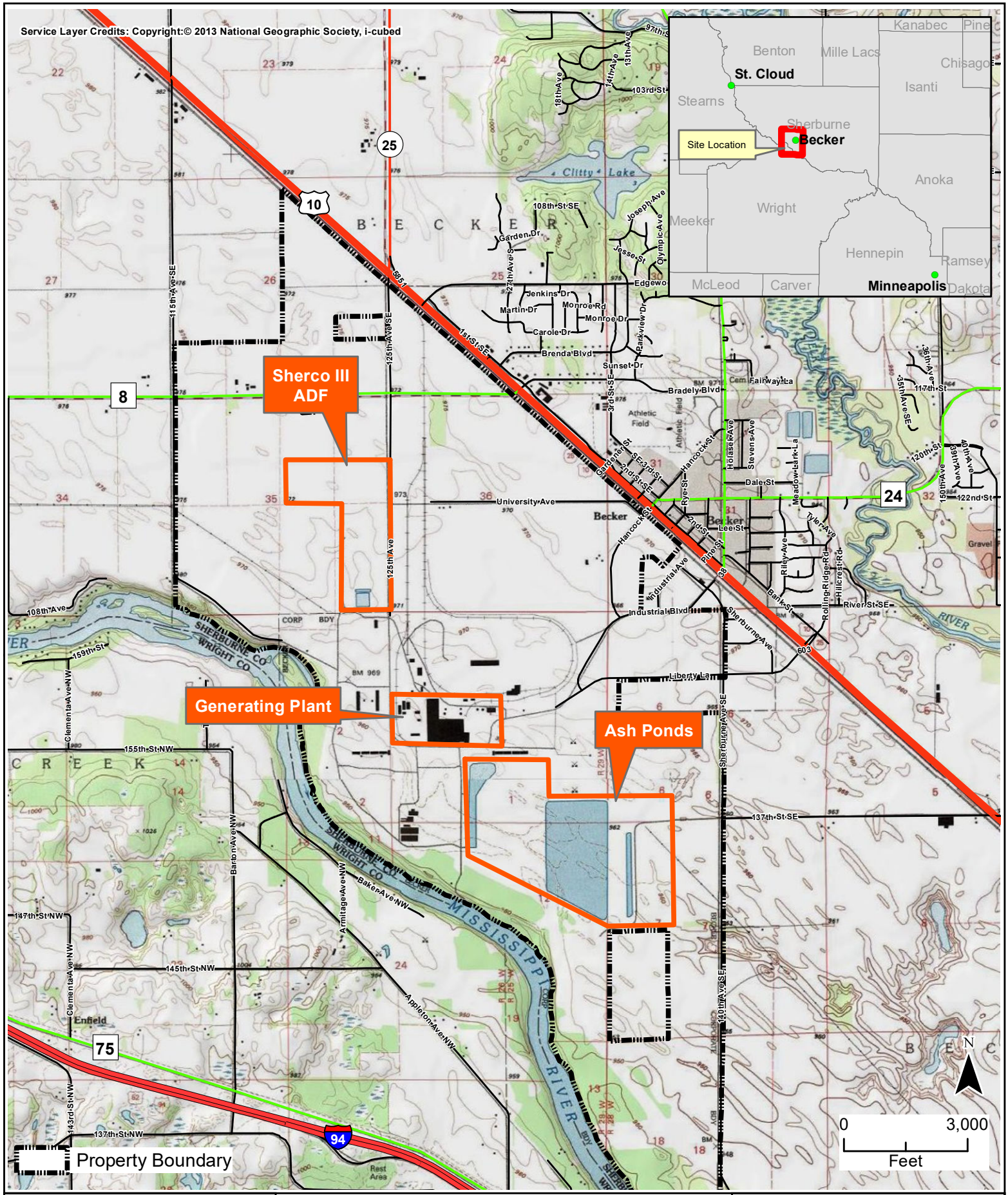
TABLE 1
CCR GROUNDWATER MONITORING SYSTEM
Sherco Unit 3 Landfill

Well ID	Minnesota Unique Well ID	Date Installed	Location Site Coordinates (ft)		Elevation Top of Riser Pipe	Screen Length (ft)	Elevation Top of Screen	Elevation Bottom of Screen	Monitoring Status	Hydrologic Location
			Easting	Northing						
P-73A-1	429451	9/25/86	2025348	872626	973	10	947	937	Routine Semiannual	Side-Gradient
P-74-1	429457	9/25/86	2025237	870732	970.66	10	943	933	Routine Semiannual	Side-Gradient
P-75-1	429454	9/29/86	2023946	871250	972.89	10	943	933	Routine Semiannual	Down-Gradient
P-97	426839	10/13/86	2023990	870840	974.65	10	944	934	Routine Semiannual	Down-Gradient
P-98	426838	10/14/86	2024683	870531	973.37	10	940	930	Routine Semiannual	Down-Gradient
P-117	474026	2/8/91	2023987	872256	973.41	10	940	930	Routine Semiannual	Down-Gradient
P-120	474023	2/11/91	2024299	870529	973.33	10	933	923	Routine Semiannual	Down-Gradient
P-125	517548	4/1/93	2024679	873649	972.2	10	933	923	Routine Semiannual	Up-gradient
P-134	747065	12/6/08	2022754	873698	973.85	10	946	936	Routine Semiannual	Up-gradient
P-137A	768518	7/29/09	2023473	872511	972.64	10	941	931	Routine Semiannual	Down-Gradient
P-138A	768520	7/27/09	2022968	872512	969.27	10	942	932	Routine Semiannual	Down-Gradient
P-141	822160	7/22/16	2023787	873696	975.17	10	947	937	Routine Semiannual	Up-gradient

*Notes:

Elevation is feet above mean sea level

Figures



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Sherco Unit 3 Landfill

Sherburne County Generating Plant
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FIGURE 1

SITE LOCATION MAP

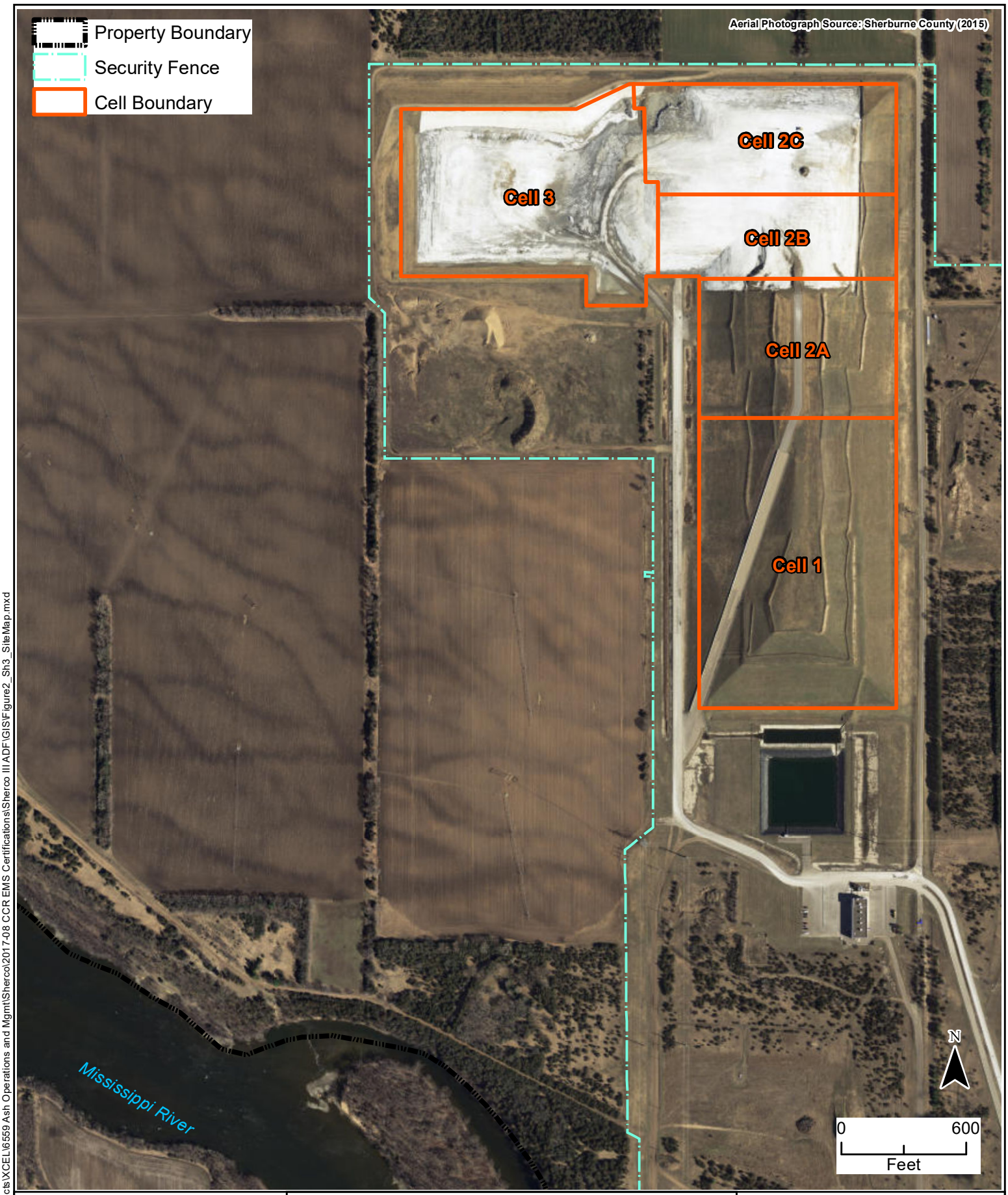

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FIGURE 2
SITE LAYOUT

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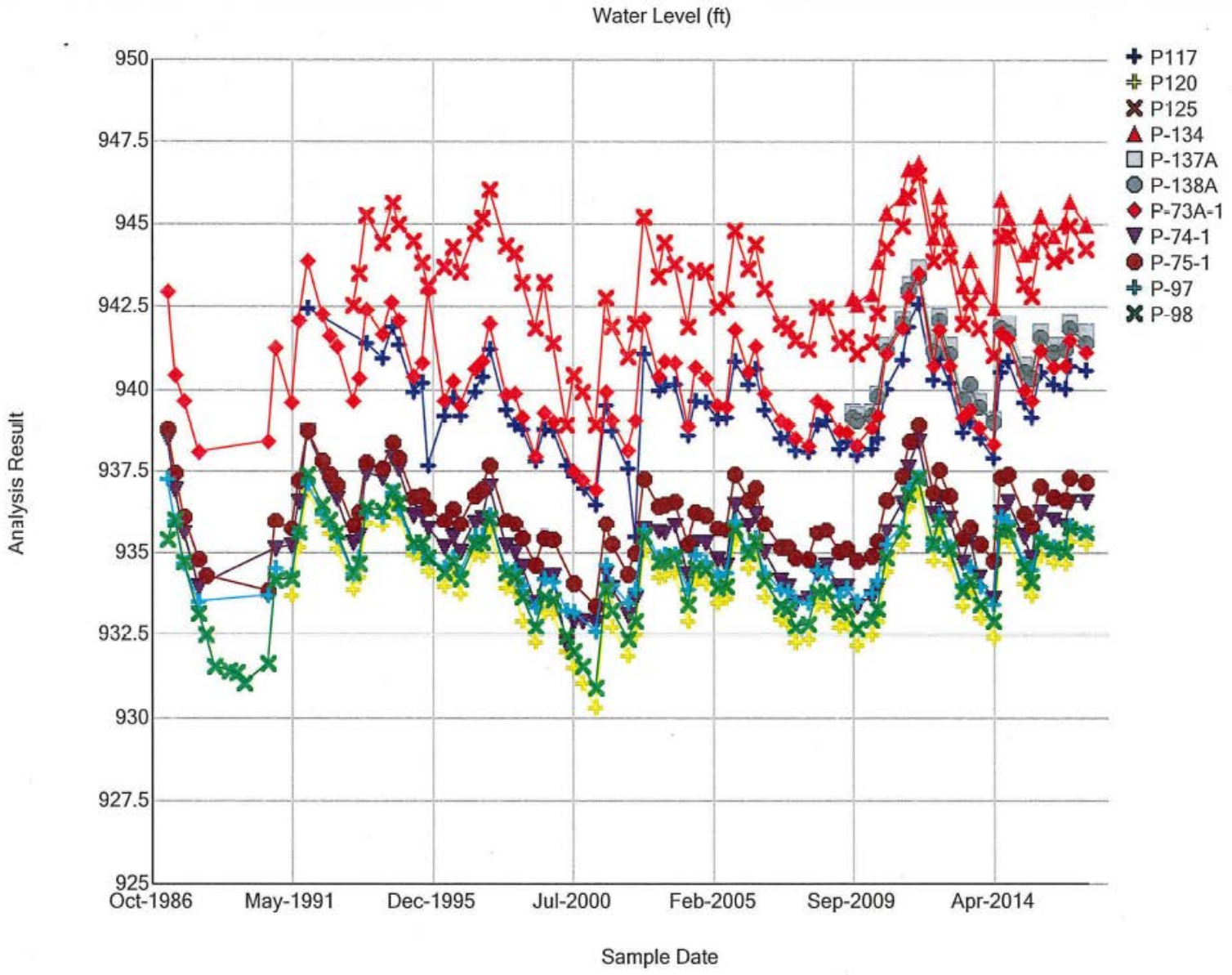

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FIGURE 3

HYDROGRAPH
(1986 – Present)

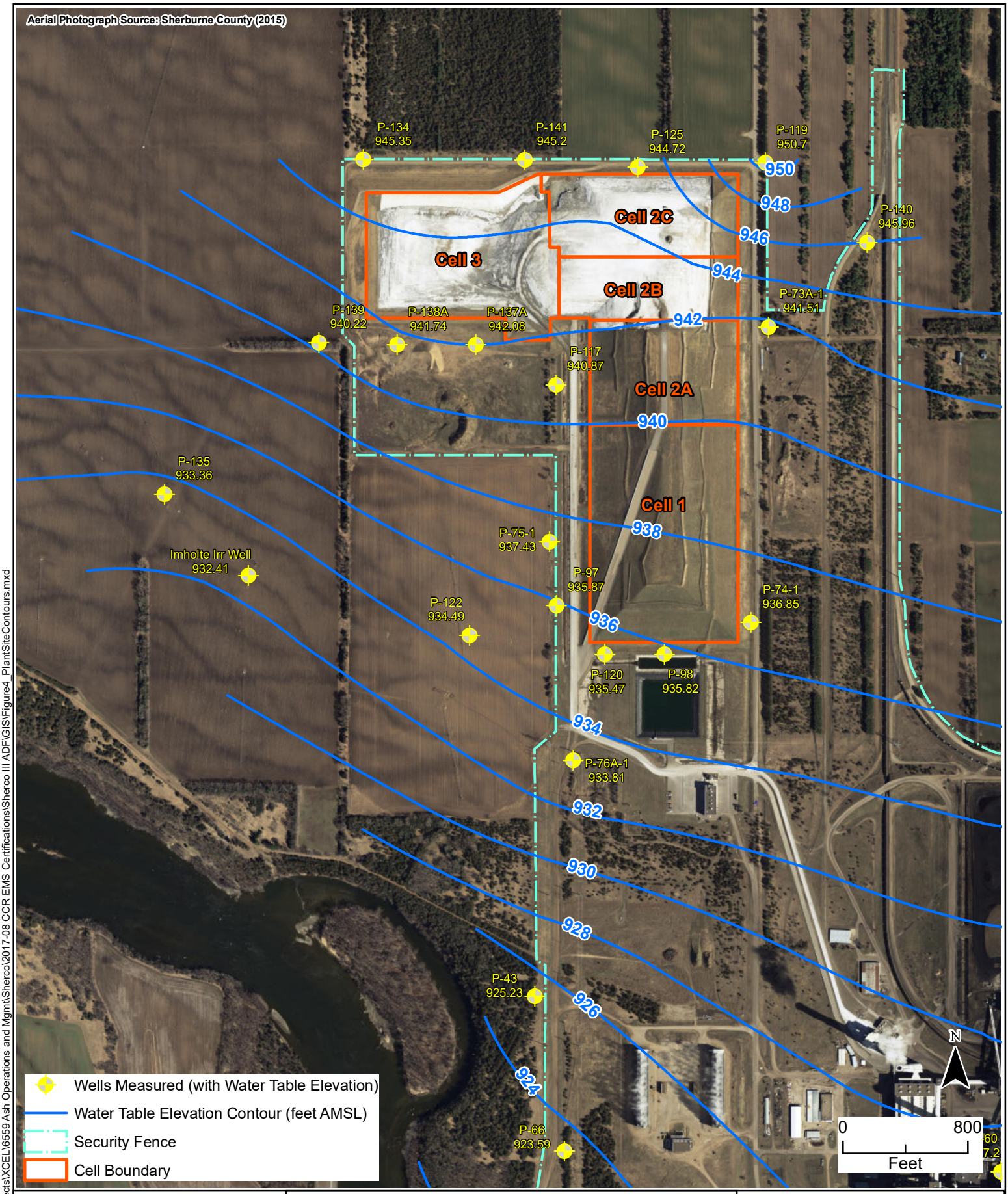

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FIGURE 4
WATER TABLE ELEVATION CONTOUR MAP (02/20-23/2017)

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FIGURE 5

CCR GROUNDWATER MONITORING SYSTEM