REPORT

40 CFR PART 257 GROUNDWATER MONITORING PLAN

SCL4A - Sioux Energy Center

St. Charles County, Missouri, USA

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1.0 INTRODUCTION

This Groundwater Monitoring Plan (GMP) presents information on the design of the groundwater monitoring system, groundwater sampling and analysis procedures, and groundwater statistical analysis methods for the Utility Waste Landfill (UWL) Cell SCL4A (Cell 4a) at Ameren Missouri's (Ameren) Sioux Energy Center (Facility) in St. Charles County, Missouri (see location on **Figure 1**). The SCL4A manages Coal Combustion Residuals (CCR) from the Facility. The SCL4A is approximately 15 acres in size and is located at the UWL south of the generating plant across Highway 94.

This GMP was developed to meet the requirements of United States Environmental Protection Agency (USEPA) 40 CFR Part 257 "Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals From Electric Utilities; Final Rule" (the CCR Rule). The CCR Rule requires owners or operators of an existing CCR Surface Impoundment or landfill to install a groundwater monitoring system and develop a sampling and analysis program (§§ 257.90 - 257.94). Ameren Missouri has determined that the SCL4A is subject to the requirements of the CCR Rule. For this GMP, the Sioux Energy Center generating plant is referred to as the SEC and the SEC and its surrounding facilities, including the UWL, are referred to as the Facility or Site.

2.0 SITE SETTING

Ameren owns and operates the Facility in St. Charles County, Missouri located approximately 12 miles west-northwest of the confluence of the Mississippi and Missouri Rivers. **Figure 1** depicts the location of the Facility and property boundaries relative to local topographic features. **Figure 2** depicts Facility structures referenced to the site boundaries as well as the Mississippi and Missouri Rivers. The Facility encompasses approximately 1,025 acres and is located within the floodplain between the Mississippi and Missouri Rivers. The Facility is bounded to the north by wooded areas associated with the Mississippi River. The property is bounded to the south by a railroad. The Facility is bounded to the east and west by agricultural fields.

The UWL cell SCL4A is located to the south of the SEC. The UWL is bounded immediately on all sides by low lying agricultural land. The SCL4A has a berm elevation of approximately 446 feet above mean sea level (MSL), about 12 to 18 feet above the surrounding low lying farmland. The SCL4A is approximately 15 acres in size as shown in **Figures 1** and **2**. A generalized cross-section through the UWL and surrounding area is shown as **Figure 3**. Directly to the north of the UWL is highway 94, followed by the CCR units called the Bottom Ash Surface Impoundment (SCPA) and the Fly Ash Surface Impoundment (SCPB). Beyond the SCPA and SCPB Surface Impoundments to the north lies the generating plant followed by the Mississippi River. Approximately 3,500 feet to the south of the UWL lies the Missouri River.

2.1 Coal Combustion Residuals (CCR) UWL

Collectively, the UWL consists of a series of CCR Surface Impoundment cells (3 cells) and CCR Landfill cells (4 cells). Most of the information provided in the following paragraphs about the construction and use of the UWL is based on an August 2014 revision entitled “Ameren Missouri Sioux Power Plant – Utility Waste Landfill – Proposed Construction Permit Modification – Construction Permit Number 0918301 – St. Charles County, Missouri” by Reitz & Jens, Inc., and GREDELL Engineering Resources Inc. The UWL is in current operation in accordance with Solid Waste Disposal Area Operating Permit Number 0918301 issued by MDNR on July 30th, 2010.

The UWL is located within an approximately 400 acre tract of land, of which 183.5 acres is planned to be used as an active disposal area. Of these 183.5 acres, 96.9 acres (Cells 1 (SCPC), 2, and 3) are to be constructed as a gypsum stack using wet disposal methods of Wet Flue Gas Desulphurization (WFGD) by-products. The other 86.6 acres (Cells 4 (SCL4A), 5, 6 and 7) are to be used for dry disposal of fly ash, bottom ash, slag, and flue gas wastes generated from the combustion of coal or other fossil fuels. In addition to these two disposal areas, a 19.6 acre process water recycle pond (Recycle Pond) is located on the northern side of the UWL footprint. The Recycle Pond is to be permitted as a waste water facility only. Currently, only the Recycle Pond Cell 1 (SCPC) and Cell 4A (SCL4A) are in use.

The perimeter berm surrounding the cells and Recycle Pond will be built up to an elevation of 446 feet MSL (Mean Sea Level), which is approximately 5 feet above 100-year flood elevation of 441.2 feet MSL. Additionally, the cells as well as the Recycle Pond are (or will be) lined with a bottom composite liner system consisting of two feet of compacted clay soil and a flexible geomembrane liner. This liner system will have a base elevation (top of liner/base of CCR) of 422 feet MSL at its lowest point.

2.2 Geology

Much of the following information was derived from previous studies completed onsite which are described in the following paragraph. In 2005-2006, a Detailed Site Investigation (DSI) report was conducted by GREDELL Engineering Resources, Inc. (GREDELL, August 2006) in which 114 borings and piezometers were installed in order to characterize the geology and hydrogeology of the proposed UWL located just south of the SEC (Figure 1). Since 2008, a monitoring well network used for monitoring the UWL south of Highway 94 provides hydrogeological information from its 16 monitoring wells. In 2015 and 2016, 24 monitoring wells were installed for CCR groundwater monitoring for all CCR Units at the SEC as required by the CCR Rule. These wells provided hydrogeological and geological information about the SEC. Additional site specific information on the sites hydrogeology and geology is provided in EPRI, 1998.

2.2.1 Physiographic Setting and Regional Geology

The Facility is located in the extreme southeastern corner of the Central Lowland Physiographic Province and the Dissected Till Plains (DSI). However, because the Facility lies between two major river systems in an area that has been mostly deposited by flow and deposition of river deposits, the regional physiographic setting is not representative of local Site geology.

2.2.2 Local Geology

Based on the site specific borings, (**Appendix A**), alluvial deposits associated with the Missouri and Mississippi Rivers overlie older sedimentary bedrock. These alluvial deposits comprise the surficial alluvial aquifer, which lies unconformably on top of bedrock and is typically 100 to 120 feet thick. Overall, this aquifer is described as a fining-upward sequence of stratified sands and gravels with varying amounts of silts and clays. Drilling in the alluvial aquifer identified different sub-units, including flood basin deposits, floodplain deposits, natural levee deposits, and channel deposits along with volumetrically less important loess deposits. Grain sizes of the alluvial deposits are highly variable.

According to the DSI, bedrock below the alluvial aquifer includes Mississippian-aged rocks of the Meramecian Series. Formations include primarily limestone, dolomite, and shale and are comprised of the Salem Formation, Warsaw Formation, and the Osagean aged Burlington-Keokuk Formation.

2.3 Site Hydrogeology

2.3.1 Uppermost Aquifer

The CCR Rule requires that a groundwater monitoring system be completed in the uppermost aquifer around each CCR Unit (§257.91(a)). As shown on **Figure 3**, the uppermost aquifer beneath all of the CCR impoundments and landfills is the alluvial deposits consisting primarily of alluvial sands with some silt, clay, and gravel associated with the Missouri and Mississippi River Valley alluvium. This alluvium overlies Mississippian-aged sedimentary bedrock formations. As generally described above, these alluvial deposits typically exhibit a fining-upward sequence with some silts and clays present within the shallow zone and mostly coarse sands and gravels present at depth. The thickness of the alluvial aquifer typically ranges from approximately 100 to 120 feet BGS with base elevations of approximately 300 to 330 feet MSL.

2.3.2 Surface Water and Groundwater Elevations

2.3.2.1 CCR Landfill Water

The SCL4A is a lined CCR landfill that uses dry disposal techniques resulting in no ponding of water within the CCR Unit. The landfill cell also has a leachate and stormwater collection management systems in order to maintain dry conditions (Reitz & Jens, GREDELL, 2014). To the northwest of the SCL4A lies the SCPA which is an unlined surface impoundment. SCPA pond levels in this facility typically range from 12 to 20 feet above the natural groundwater level of the surrounding aquifer.

2.3.2.2 Alluvial Aquifer

During the DSI investigation in the area around the UWL, groundwater in the shallow alluvial aquifer had a relatively flat hydraulic gradient. Maximum groundwater elevation variation at any piezometer location was approximately three feet (3’). Over the year-long groundwater monitoring period, the maximum and minimum groundwater elevations were approximately 417 feet MSL and 411 feet MSL, respectively. Groundwater potentiometric surface maps from the DSI are included in **Appendix B**.

Golder obtained groundwater elevation measurements from March 2016 through June 2017 within the alluvial aquifer for the CCR monitoring wells. For each of the 8 background sampling events, groundwater elevations were measured at monitoring wells within a 24-hour timeframe and a potentiometric map was generated from these data (**Appendix C** and **Table 1**). Groundwater elevations throughout the aquifer ranged during this period from approximately 414 to 424 feet MSL. However, during any specific sampling event, site wide groundwater elevations ranged from 1 to 4 feet difference across the site.

2.3.3 Groundwater Flow Directions

Site groundwater conditions are directly controlled by river stages of the Mississippi and Missouri Rivers since the alluvial aquifer is hydraulically connected to these water bodies. These rivers display large seasonal changes in elevation. Under normal aquifer conditions, groundwater flow in the alluvial aquifer would be expected to have a flow direction component parallel to the river and a flow component from the higher of the two rivers towards the lower of the two rivers.

Although the movement of groundwater within the alluvial aquifer at the Facility is complex, the movement has been characterized by frequent groundwater elevation measurements and the generation of potentiometric surface maps generated by GREDELL and Golder (**Appendix B, Appendix C** and **Table 1**). The potentiometric surface maps display variability in the groundwater flow direction. These changes in flow direction are related to the water levels within the adjacent Missouri and Mississippi Rivers.

Beginning in August 2005, DSI groundwater measurements were taken every month to determine the changes in groundwater flow (**Appendix B**). During the year-long monitoring period, the direction of groundwater flow was always southward from the Mississippi River toward the Missouri River. In this study, groundwater level is mostly controlled by the elevation of the Mississippi River with minor fluctuations in gradients caused by changes in elevation of the Missouri River. The majority of the time, the elevation of the Mississippi River to the north of the Facility was a higher water elevation than the Missouri River to the south of the Facility. The DSI reports that the Missouri River elevation exceeded the Mississippi River elevation less than 5% of the time.

Quarterly groundwater level measurements are obtained as part of the groundwater monitoring program performed in accordance with the Missouri Department of Natural Resources (MDNR) UWL permit. These data indicate similar trends in groundwater gradients and flow directions to DSI results and support the predominant flow direction towards the Missouri River. However, temporary reverse gradients and near flat gradient conditions have been rarely observed due to high water conditions in the Missouri River. According to this study, in 2008 the Missouri River elevation exceeded the Mississippi River elevation 1 of the 4 sampling events (**Appendix B**).

Potentiometric surface maps generated as a part of the initial baseline sampling events for SCL4A display similar results to those completed for the UWL (**Appendix C**). Of the 8 baseline events, the Missouri River level was higher than the Mississippi River level for 5 of the 8 events. However, localized flow directly around the SCL4A typically demonstrates southward flow direction towards the Missouri River.

Groundwater flow direction and hydraulic gradient were estimated for the CCR wells using the EPA's On-line Tool for Site Assessment (USEPA, 2016). Estimated results from this analysis using groundwater elevations within the CCR monitoring wells are provided in **Table 2**. These results indicate that while groundwater flow direction is variable, overall net groundwater flow during the baseline sampling period for the compliance wells surrounding the SCL4A was overall toward the south, flowing toward the Missouri River.

2.3.3.1 Horizontal Gradients

Horizontal groundwater gradients in the alluvial aquifer are typically low and flat. The gradients are very dependent on river water levels (bank recharge and bank discharge conditions described earlier). Horizontal flow gradients calculated for the UWL DSI ranged from 0.0004 to 0.0013 feet/foot near the UWL. Gradients calculated as a part of the UWL sampling display similar results to the DSI, with groundwater gradients ranging from 0.0001 to 0.0008 feet/foot.

Site-wide horizontal gradients were also calculated for each of the CCR groundwater baseline sampling events and the results of these are displayed on **Table 2**. The horizontal groundwater gradients are low, ranging from 0.0001 to 0.0012 feet/foot.

A review of the potentiometric surface maps confirms the gradient estimates for a larger scale, but also demonstrates that localized horizontal gradients can be higher especially in areas near the Mississippi and Missouri Rivers.

2.3.3.2 Vertical Gradients

A review of downward gradients observed in piezometers was completed by comparing groundwater elevations obtained by Golder's initial baseline sampling data. This analysis was completed between shallow and intermediate/deep zone piezometers locations where the piezometers are nested (two or more piezometers in close proximity, screened at different elevations). From the review of these data, variable vertical gradients that fluctuate between upward and downward with no consistent vertical gradient present between shallow and deeper zones of the alluvial aquifer.

2.3.4 Hydraulic Conductivities

In-situ hydraulic conductivity tests (slug tests) were conducted as part of the DSI within the shallow portion of the alluvial aquifer to the south of the existing Surface Impoundments in the area of the UWL. The hydraulic conductivity in the area is highly dependent of the geology present within the screening interval of the piezometer. Estimates of the hydraulic conductivity within the aquifer were made using data acquired from slug tests from the DSI piezometers. The calculated average hydraulic conductivity of the fluvial channel sediments was 4.2×10^{-2} centimeters per second (cm/sec), Natural levee deposits was 1.8×10^{-2} cm/sec, and floodplain deposits were 7.0×10^{-3} cm/sec. Generally, there is a tendency toward higher hydraulic conductivity values where the screened interval intersects with relatively coarse-grained sands interpreted as channel deposits. For relatively homogenous flood plain/levee sequences containing fine-grained sediments, calculated values are demonstrably lower. Similarly, in piezometers where the screen interval intersects finer-grained, clayey backswamp/cut-off deposits, lower hydraulic conductivity values were measured.

Groundwater flow velocities were calculated as a part of the DSI using these hydraulic conductivity values, hydraulic gradients, and an estimated value for effective porosity (Figure 33 of the DSI). The DSI suggests a representative range of prevailing groundwater movement at the Site is between 14 to 188 feet per year, depending on hydraulic conductivity and effective porosity.

Golder also performed rising head hydraulic conductivity tests on the 15 newly installed CCR monitoring wells used to monitor the alluvial aquifer in order to estimate the hydraulic conductivities in February and November, 2016. The tests were conducted using a pneumatic slug (Hi-K slug) and a downhole pressure transducer. The results of Golder's hydraulic conductivity testing estimated the geometric mean of hydraulic conductivity to be approximately 2 x 10^{-2} cm/sec for the CCR groundwater monitoring wells around the SCL4A and throughout the shallow alluvial aquifer. Golder's findings for hydraulic conductivity values are summarized below in **Table 3** and are consistent with the conductivities calculated in the DSI.

Estimated groundwater flow velocities were calculated using the CCR monitoring well hydraulic conductivity, hydraulic gradients and an estimated value for effective porosity (**Table 2**). Using these values, groundwater flow velocities were estimated to range between 0.01 and 0.19 feet per day at the SCL4A.

Table 3: CCR Monitoring Well Hydraulic Conductivities

Well ID	Total Depth (feet BTOC)	Well Screen Interval (feet BTOC)	Well Screen interval (feet MSL)	Estimated Hydraulic Conductivity (feet/day)	Estimated Hydraulic Conductivity (cm/sec)
Background Monitoring Wells					
BMW-1S	26.0	15.8 - 25.6	402.2 - 412.0	16	5.5E-03
BMW-3S	26.7	16.5 - 26.3	400.4 - 410.2	53	1.9E-02
SCPB Fly Ash Surface Impoundment Monitoring Wells					
LMW-1S	42.5	32.3 - 42.1	405.0 - 414.8	31	1.1E-02
LMW-2S	42.7	32.5 - 42.3	404.9 - 414.7	56	2.0E-02
LMW-3S	26.2	16.0 - 25.8	404.4 - 414.2	35	1.2E-02
LMW-4S	27.2	17.0 - 26.8	402.6 - 412.4	28	9.9E-03
LMW-5S	47.5	37.3 - 47.1	400.3 - 410.1	56	2.0E-02
LMW-6S	42.1	31.9 - 41.7	404.3 - 414.1	56	2.0E-02
LMW-7S	42.2	32.0 - 41.8	402.5 - 412.3	45	1.6E-02
LMW-8S	47.2	37.0 - 46.8	400.0 - 409.8	75	2.6E-02
LMW-9S	41.6	31.4 - 41.2	404.4 - 414.2	22	7.9E-03
SCL4A Utility Waste Landfill Monitoring Wells					
UG-3*	30.0	19.8 - 30.0	399.7 - 410.0	51	1.8E-02
TMW-1	28.9	18.7 - 28.5	399.6 - 409.4	75	2.6E-02
TMW-2	30.4	20.2 - 30.0	398.2 - 408.0	45	1.6E-02
TMW-3	30.1	19.9 - 29.7	398.2 - 408.0	56	2.0E-02
SCPC Utility Waste Landfill Monitoring Wells					
UG-1A*	28.5	18.3 - 28.5	399.2 - 409.5	51	1.8E-02
UG-2*	30.0	19.8 - 30.0	399.3 - 409.5	51	1.8E-02
DG-1*	35.0	24.7 - 35.0	396.8 - 407.1	51	1.8E-02
DG-2*	34.5	24.3 - 34.5	397.3 - 407.5	51	1.8E-02
DG-3*	35.0	24.7 - 35.0	398.9 - 409.1	51	1.8E-02
DG-4*	34.7	24.4 - 34.7	398.1 - 408.4	51	1.8E-02

Notes
1. feet BTOC - feet below top of casing
2. feet MSL - feet above mean sea level.
3. cm/sec - centimeters per second.
4. Rising head tests were completed by Golder Associates using a Pneumatic Hi-K Slug®.
5. * - Hydraulic conductivity values based on results from the UWL DSI.

2.3.5 Porosity and Effective Porosity

Porosities were estimated based on the grain size distributions of an aquifer soil sample collected during monitoring well drilling. Representative grain size distributions were collected from the screen intervals at LMW-3S and LMW-8S using the ASTM D6912 Method B and the results are provided in **Appendix D**. The samples from LMW-3S and LMW-8S were similar in field classification to other well drilling samples and the results indicate that the screened interval of the alluvial aquifer are mostly comprised of sand (at least 90%) with lesser amounts of gravel, silt and clay. Also, the typical grain size of the sand ranges from fine to coarse sand. Textbook values of porosities for sands and sand/gravel mixes range from 25-50% (Fetter, 2000 and Freeze and Cherry, 1979) and fine sands typically range from 29-46%, whereas coarse sands typically range from 26-43% (Das, 2008). An average porosity of 35% is estimated for the alluvial aquifer based on the site data.

Effective porosity is the porosity that is available for fluid flow. Studies completed in unconsolidated sediments have determined that water molecules pass through all pores and the effective porosity is approximately equal to the total porosity (Fetter, 2000). Therefore, the effective porosity of the alluvial aquifer is also estimated to be 0.35.

3.0 GROUNDWATER MONITORING NETWORK

3.1 Monitoring Network Design Criteria

§257.91 of the CCR Rule sets out the requirements for development of a groundwater monitoring system for both new and existing CCR landfills and Surface Impoundments. The performance standard in the CCR Rule (§257.91(a)) states that the groundwater monitoring system must consist of a sufficient number of wells at appropriate locations to yield groundwater samples in the uppermost aquifer that accurately represent:

- The quality of background groundwater
- The quality of groundwater passing the waste boundary of the CCR unit

3.2 Design of the Groundwater Monitoring System

The detection monitoring well network for the Facility is depicted on **Figure 2**. The network consists of Six (6) monitoring wells screened in the uppermost aquifer for the purpose of monitoring the SCL4A. The monitoring well network includes 2 background groundwater monitoring wells (BMW-1S and BMW-3S) that are located approximately 5,000 to 5,500 feet northwest of the SCL4A in areas unaffected by CCR disposal. Four (4) of the groundwater monitoring wells are placed ringing the SCL4A and are considered to be the compliance wells. The groundwater monitoring well locations were selected based on site-specific technical information presented in section 2.0 of this document, as well as the preferential migration pathway analysis below.

3.2.1 Preferential Migration Pathway Analysis

After detailed review of the information outlined in section 2.0 of this document, a preferential migration pathway for potential groundwater impacts coming from the SCL4A Landfill was determined. The SCL4A is lined and has a bottom elevation of approximately 422 feet MSL. Potential constituent migration pathways are likely to be downward to groundwater level then laterally in the direction of groundwater flow in the alluvial aquifer. Groundwater flow within the alluvial aquifer is variable depending on levels within the Missouri and Mississippi Rivers and can flow in a variety of directions, however, overall net flow near SCL4A is towards the Missouri River. Based on water level readings, the groundwater surface in the alluvial aquifer can range from approximately 414 to 424 feet MSL. In order to place monitoring well screens within the migration pathway from the unit, monitoring wells were installed with screen interval elevations that range below the seasonal low groundwater levels so that the well screen is submerged below the water table surface to allow for groundwater sampling.

3.3 Groundwater Monitoring Well Placement

3.3.1 Background/Upgradient Monitoring Well Locations

As described above, the flow of groundwater in the alluvial aquifer is generally from either the Mississippi River towards the Missouri River or from the Missouri River towards the Mississippi River. Alluvial aquifer flow is also locally influenced by water levels in the SCPA and the Mississippi and Missouri River levels. The CCR Rule (§257.91(a)(1)) requires that background groundwater samples from the uppermost aquifer;

- *"Accurately represent the quality of background groundwater that has not been affected by leakage from a CCR unit."*

At SCL4A, groundwater typically flows south towards the Missouri River. Two background monitoring well locations were placed to the north and west of SCL4A, in upgradient locations. As shown in **Figure 2**, the background monitoring wells BMW-1S and BMW-3S are northwest of the SCL4A at a location south of the Mississippi River. These wells provide background groundwater quality for SCL4A monitoring.

3.3.2 Downgradient Monitoring Well Locations

As discussed above, downgradient monitoring wells are located adjacent to the SCL4A to monitor potential migration pathways. **Figure 2** shows that the downgradient well network consists of four groundwater monitoring wells (UG-3, TMW-1, TMW-2, and TMW-3) around the SCL4A at locations that are located as close to the waste boundary as practical.

3.3.1 Groundwater Monitoring Well Screen Intervals

The system of monitoring wells ringing the SCL4A are screened in the shallow alluvial aquifer zone. Details on the construction of the groundwater monitoring wells are provided in **Table 4**, **Appendix E** and **Appendix G**. Screen intervals range from approximately 397 **-** 412 feet MSL in alluvial deposits.

3.3.2 Future Cell Construction for the SCL4A

As Cells 5-7 of the UWL's SCL4A are being constructed, the monitoring well network will need to be adjusted to incorporate these cells. This may include the abandonment of various wells and the installation of several new wells. An initial set of 8 samples will need to be collected in both the background and compliance wells either: (1) prior to the receipt of ash in the CCR unit or (2) within the first 6 months of sampling and placement of ash. After collecting the initial eight background samples, SSI evaluation must then be completed during the first semi-annual sampling event. When new cells are added, this Groundwater Monitoring Plan will need to be updated to reflect the changes in the Groundwater Monitoring System.

4.0 INSTALLATION OF THE GROUNDWATER MONITORING SYSTEM

The CCR Rule Groundwater Monitoring System for the SCL4A was installed by GREDELL Engineering Resources, Inc. (December 2007) and Golder (December 2015, April 2016, and November 2016). The installation of monitoring wells installed by Golder is described in the following subsections. Information on the monitoring wells installed by GREDELL is provided in **Appendix G**.

4.1 Drilling Methods and Monitoring Well Constructions

Cascade Drilling LP installed the Golder monitoring wells using a rotosonic drill rig (Mini Sonic CDD 1415 and Geoprobe 8040) under direct supervision of a Golder Geologist or Engineer. Continuous soil core samples were obtained at each Golder well borehole location and were logged in the field by Golder. Soils were classified according to the Unified Soil Classification System. Boring logs and well construction diagrams for the Golder wells are provided in **Appendix A** and **Appendix E**, respectively.

Groundwater monitoring wells were installed in accordance with Missouri Department of Natural Resources (MDNR) Well Construction Rules (10 CSR 23-4.060 Construction Standards for Monitoring Wells). All groundwater monitoring wells were installed with 2-inch diameter PVC well riser pipe and 10-foot long, 0.010-inch machine slotted well screens. Wells were installed with a sand filter pack, bentonite seal, and annular space in accordance with MDNR Well Construction Rules. Details on the construction of the groundwater monitoring wells are provided in **Table 4** and **Appendix E**.

Monitoring wells were completed with an aluminum protective cover with a locking lid that extends approximately 2 to 3 feet above ground surface and a small concrete pad. Yellow protective posts (concrete filled steel bollards) have been installed around each monitoring well surface completion.

4.2 Groundwater Monitoring Well Development

After well construction, a Golder geologist or engineer developed Golder groundwater monitoring wells using surging and purging techniques. During development, field parameters (pH, conductivity, temperature, and turbidity) were recorded and development was complete once a minimum of three well-bore volumes of water were purged, turbidity was typically less than 20 nephelometric turbidity units (NTU) or ± 10% and consecutive measurements of field parameter values were within 10 percent difference. Groundwater monitoring wells were developed using an inertial pump with a surge block ring attached to a foot valve to surge and purge the well. Well development forms are attached in **Appendix F**.

4.3 Dedicated Pump Installation

A dedicated pump was installed in BMW-1S and BMW-3S groundwater monitoring wells after development and hydraulic conductivity testing. The dedicated pumps provide a consistent, repeatable sampling method to reduce likelihood of cross contamination, reduce water sample turbidity, and expedite sampling. For the purposes of this groundwater monitoring network, low-flow QED brand PVC MicroPurge bladder pumps with Dura-Flex Teflon bladders were installed in each well. Monitoring wells UG-3, TMW-1, TMW-2, and TMW-3 are sampled using peristaltic pumping methods and dedicated tubing.

4.4 Surveying and Well Registration

Zahner and Associates, Inc., a Professional Land Surveyor licensed in Missouri, surveyed the location and top of casing elevation of the Golder monitoring wells. A drawing showing the location of the groundwater monitoring wells is shown in **Figure 2** and a summary of survey information is provided in **Table 4**. Upon completion of monitoring well installation and surveying, MDNR Well Construction Registration Forms were prepared for each well and submitted to MDNR. Copies of these forms are provided in **Appendix G**.

5.0 GROUNDWATER MONITORING PROGRAM

The groundwater monitoring program for the SCL4A is described in the following sections.

5.1 Baseline Sampling Events

In accordance with section 257.94(b) of the CCR Rule, before starting detection monitoring, eight baseline (or background) samples were collected for all Appendix III and Appendix IV parameters at all downgradient and upgradient/background monitoring wells prior to October 17, 2017. These samples establish initial baseline datasets that are used for the statistical evaluation of groundwater results.

5.2 Detection Monitoring

The Detection Monitoring Program is defined in the CCR Rule in section 257.94 and the following sections outline the procedures for the detection monitoring program.

5.2.1 Sampling Constituents and Monitoring Frequency

Detection monitoring should be completed at a minimum of semi-annually (approximately every 6 months) for all Appendix III constituents (**Table 5**)**,** unless a demonstration that the need for an alternative monitoring schedule is required. **Table 6**, lists the analytical methods and practical quantitation limits used for the monitoring program.

5.2.2 Data Evaluation and Response

As required in the CCR Rule, a statistical evaluation of the groundwater data must be completed within 90 days of receiving data from the laboratory. The data will be analyzed using the methods and procedures outlined in the statistical analysis plan (**Appendix H.**).

5.3 Assessment Monitoring

Assessment monitoring is outlined in section 257.95 of the CCR Rule and is initiated after a confirmed SSI has been identified and no alternate source demonstration has been completed. In accordance with the CCR Rule, a notification must be prepared and placed within the Facility operating record and on the publically available website stating that an Assessment Monitoring program has been initiated. The purpose of Assessment Monitoring is to determine whether or not groundwater concentrations are at a Statistically Significant Level (SSL) compared to Groundwater Protection Standards (GWPS). Detection Monitoring sampling continues during Assessment Monitoring.

5.3.1 Sampling Constituents and Monitoring Frequency

As outlined in section 257.95 of the CCR Rule, Assessment Monitoring groundwater sampling must begin within 90 days of a confirmed SSI determination. Sampling must be completed at all monitoring wells used in the detection monitoring program, for all Appendix IV analytes (**Table 5**). Within 90 days of receiving data from this initial Assessment Monitoring sampling event, a second sampling event must be completed analyzing the Appendix IV constituents detected in groundwater during the initial sampling event.

Following this initial phase of the Assessment Monitoring Program, the CCR Rule requires sampling of the full list of Appendix IV constituents on an annual basis (Annual Assessment Event). During the other semi-annual Assessment Sampling Event, only those Appendix IV constituents that are detected during the annual sampling event are to be analyzed and reported. Additionally, verification resampling will be performed within 90 days of receiving data from the laboratory for all detected Appendix IV constituents for each event.

5.3.2 Data Evaluation and Response

As required in the CCR Rule, a statistical evaluation of the groundwater data must be completed within 90 days of receiving data from the laboratory. The data will be analyzed using the methods and procedures outlined in the Statistical Analysis Plan (**Appendix H**).

A GWPS is required for each Appendix IV constituent and must be included in the annual report. The GWPS will be either the MCL or a value based on background data, whichever is higher. The generation of the GWPS is discussed in more detail in the Statistical Analysis Plan (**Appendix H**). Statistical analysis must be completed within 90 days of receiving data from the laboratory. The statistical analysis will determine if any constituents are SSLs greater than the GWPS.

In order to discontinue Assessment Monitoring and return to Detection Monitoring, the concentration of all Appendix III and Appendix IV constituents for all compliance wells must be at levels statistically lower than background levels for two consecutive sampling events (257.95(e)). If any constituent is present at a statistical level above background levels, but below the GWPS, then Assessment Monitoring continues.

5.3.2.1 Responding to a SSL

If the Assessment Monitoring statistical evaluations demonstrate that a SSL has been triggered, then the owner/operator of the CCR unit must complete the following four actions as described in 257.95(g):

1. Prepare a notification identifying the constituents in Appendix IV that have exceeded a CCR Unit specific GWPS. This notification must be placed in the facility operating record within 30 days of identifying the SSL (257.95(g)) and 257.105(h)). Additionally, within 30 days of placing the notification in the operating record, the notification must be posted to the internet site (257.107(h)).
2. Define the character and extent of the release and any relevant site conditions that may affect the corrective action remedy that is ultimately selected. The characterization must be sufficient to support a complete and accurate assessment of the corrective measures necessary to effectively clean up releases from the CCR Unit and must include at least the following: (No timeframe is specified in the CCR Rule for this action)

   A. Installation of additional monitoring wells that are necessary to define the contaminant plume
   B. Collect data on the nature and estimated quantity of the material released
   C. Install and sample at least one additional monitoring well at the facility boundary in the direction of the contaminant plume migration

3. Notify off-site property owners if the contamination plume has migrated offsite on to their property within 30 days of this determination.
4. If possible, provide an alternate source demonstration that determines that the SSL is not caused by a release at the facility within 90 days of completing the statistical evaluation. If no alternate source demonstration can be made and the plume is determined to have originated from the CCR Unit, then proceed to corrective action steps in the CCR Rule.
   D. If no alternate source demonstration is made, and the CCR Unit is an unlined surface impoundment, the closure or retrofit must be initiated.

Actions 1-3 must be completed regardless of whether or not an alternate source demonstration can be made.

5.3.3 Annual Reporting Requirements

In addition to the periodical reporting listed above, an annual groundwater monitoring report will be prepared according to the requirements of 40 CFR §257.90(e). At a minimum, the annual groundwater monitoring report will contain the following information:

- The current status of the groundwater monitoring program
- A projection of key activities planned for the upcoming year
- A map showing the CCR unit and all background (or upgradient) and downgradient monitoring wells included in this monitoring plan
- A discussion of any monitoring wells that were installed or decommissioned during the preceding year or any other changes made to the groundwater monitoring system
- Analytical results from groundwater sampling
- The monitoring data obtained under §§ 257.90 through 257.98, including a summary of the number of groundwater samples that were collected for analysis for each background and downgradient well, the dates the samples were collected, and whether the sample was required by the detection monitoring or assessment monitoring programs
- A narrative discussion of any transition between monitoring programs (e.g., the date and circumstances for transitioning from detection monitoring to assessment monitoring in addition to identifying the constituent(s) detected at a statistically significant increase over background levels)
- If required, an alternate source demonstration that is certified by a professional engineer
- If required, a demonstration that an alternate sampling frequency is needed
- If assessment monitoring is required, a listing of GWPS for each Appendix IV constituent

6.0 GROUNDWATER SAMPLING METHODOLOGY

Sampling will be performed in accordance with accepted practices within the industry and with the provisions of Missouri regulations. The following sections provide details regarding procedures that will be used to collect groundwater samples. Although this section provides reference to specific forms, the use of other equivalent forms to record the necessary data is permissible.

6.1 Equipment Calibration

Equipment used to record field water quality parameters will be calibrated each day prior to use following manufacturers' recommendations. Calibration solutions for standardization materials will be freshly prepared or from non-expired stock. In the absence of manufacturer or regulatory guidance, field equipment should be calibrated to within +/- 10 percent of the standard (or 0.1 standard units for pH meters). Equipment that fails calibration may not be used. Calibration records will be maintained. A sample field Instrument Calibration Form is included in **Appendix I**.

6.2 Monitoring Well Inspection

Prior to performing any water purging or sampling, each monitoring well will be inspected to assess its integrity. The condition of each monitoring well will be evaluated for any physical damage or other breach of integrity. The security of each monitoring well will be assessed in order to confirm that no outside source constituents have been introduced to the monitoring well.

6.3 Water Level Measurement

To meet the requirements of §257.93(c), water level measurements will be taken at all monitoring wells and prior to the start of any groundwater purging. These measurements will be taken within a 24 hour period and will be recorded on the Record of Water Level Readings form or Groundwater Sample Collection Form (included in **Appendix I**). Static water levels will be measured in each monitoring well prior to purging using an electric meter accurate to 0.01-foot. The measuring probe will be rinsed with distilled or deionized water before and after use at each well.

6.4 Monitoring Well Purging

Prior to collecting samples, each monitoring well will be purged. Purging will be accomplished using either:

- Low-flow (a.k.a., minimal drawdown, or Micropurge) techniques
- Traditional purging techniques where at least three well volumes are evacuated before samples are collected

6.4.1 Low-Flow Sampling Technique

Low-flow groundwater sampling procedures will be used for purging and sampling monitoring wells that are equipped with dedicated pumps and will sustain a pumping rate of at least 100 milliliters per minute (ml/min).

Water will be purged from these wells at low rates in order to minimize drawdown in the well during purging and sampling. Depth to water measurements and field water quality parameters (temperature, pH, turbidity, and conductivity) recorded during purging will be used as criteria to determine when purging has been completed. Sample collection will be initiated immediately after purging at each well.

During water purging, wells will be pumped at rates that minimize drawdown in the well. Purging rates in the range of 100-500 ml/min typically will be used; however, higher rates may be used if sustained by the well. Stabilization of the water column will be considered achieved when three consecutive water level measurements vary by 0.3-foot or less at a pumping rate of no less than 100 ml/min.

At a minimum, field water quality parameter measurements of temperature, pH, turbidity, and conductivity, will be measured during purging at each well. Prior to collecting the initial set of field water quality parameters, the water in the sampling pump and discharge tubing (i.e., pump system volume) remaining from the previous sampling event will be removed.

After evacuating the water in the pump system, collecting field measurements will begin. Depth to water measurements and field water quality parameter measurements will be made during purging. If a field meter equipped with a flow cell is used, an amount of water equal to the volume of the flow cell should be allowed to pass through the flow cell between individual field stabilization measurements. Stabilization will be attained and purging considered complete when three consecutive measurements of each field parameter vary within the following limits:

- ± 0.2 for pH
- ± 3% for Conductivity
- ± 10% for Temperature
- Less than 10 nephelometric turbidity units (NTU) or ± 10% for Turbidity

All data gathered during monitoring well purging will be recorded on a form, an example of which is included in **Appendix I**.

6.4.2 *Traditional Purge Techniques*

If low-flow sampling is not performed, wells will be purged a minimum of 3 well volumes before collecting a sample. Purging procedures will generally follow those for low-flow sampling including measurement of the field parameters listed above with two exceptions:

- Higher flow rate may be used during purging
- Purging is completed after a minimum of 3 well volumes have been removed (see below)

Even where low-flow sampling is not performed, the sampling goals are to:

- Stabilize field parameters (listed in previous section) prior to collecting samples
- Minimize drawdown in the well

When traditional purge techniques are used, field stabilization measurements will be collected at the beginning of purging and between each well volume purged. The stability criteria will be those described above for low-flow sampling.

6.4.3 Low Yielding Wells

If a monitoring well purges dry, it will be allowed to recover up to 24 hours before samples are collected. No additional purging will be performed after initially purging the monitoring well dry. If recharge is insufficient to fill all necessary sample bottles, samplers will note this on the field form, and fill as many sample bottles as possible.

6.5 Sample Collection

Sampling should take place immediately after purging is complete. Samples will be transferred directly from field sampling equipment into containers supplied by the analytical laboratory appropriate for the constituents being monitored as listed in **Table 6**. Sample containers will be kept closed until the time each set of sample containers is filled.

6.6 Equipment Decontamination

All non-dedicated field equipment that is used for purging or sample collection shall be cleaned with a phosphate-free detergent and triple-rinsed, inside and out, with deionized or distilled water prior to use and between each monitoring well. Decontamination water shall be disposed of at an Ameren approved location. Any disposable tubing used with non-dedicated pumps should be discarded after use at each monitoring well. Clean latex gloves will be worn by sampling personnel during monitoring well purging and sample collection.

6.7 Sample Preservation and Handling

In accordance with §257.93 of the CCR Rule, groundwater samples collected as part of the monitoring program will not be filtered prior to analysis. Once groundwater samples have been collected and preserved in laboratory supplied containers, they will be packed into insulated, ice-filled coolers to be maintained at a temperature as close as possible to 4 degrees Celsius. Groundwater samples will be collected in the designated size and type of containers required for specific parameters. Sample containers will be filled in such a manner as not to lose preservatives by spilling or overfilling. Samples will be delivered to the laboratory or sent via overnight courier following chain-of-custody procedures.

6.8 Chain-of-Custody Program

The chain-of-custody (COC) program will allow for tracing sample possession and handling from the time of field collection through laboratory analysis. The COC program includes sample labels, sample seals, field Groundwater Sample Collection Forms, and COC record. A sample Chain-of-Custody (COC) form is provided in **Appendix I**.

Each sample will be assigned a unique sample identification number to be recorded on the sample label. The sample identification number for all samples will be designated differently based on the nature of the samples. Each sample identification number and description will be recorded on the field Groundwater Sample Collection Form and on the COC document.

6.8.1 Sample Labels

Sample labels will be sufficiently durable to remain legible when wet and will contain the following information, written with indelible ink:

- Site and sample identification number
- Monitoring well number or other location
- Date and time of collection
- Name of collector
- Parameters to be analyzed
- Preservative, if applicable

6.8.2 Sample Seal

The shipping container will be sealed to prevent the samples from being disturbed during transport to the laboratory.

6.8.3 Field Forms

All field information must be completely and accurately documented to become part of the final report for the groundwater monitoring event. Example field forms are included in **Appendix I**. The field forms will document the following information:

- Identification of the monitoring well
- Sample identification number
- Field meter calibration information
- Static water level depth
- Purge volume
- Time monitoring well was purged
- Date and time of collection
- Parameters requested for analysis
- Preservative used
- Field water quality parameter measurements

- Field observations on sampling event
- Name of collector(s)
- Weather conditions including air temperature and precipitation

6.8.4 Chain-of-Custody Record

The COC record is required for tracing sample possession from time of collection to time of receipt at the laboratory. The National Enforcement Investigations Center (NEIC) of USEPA considers a sample to be in custody under any of the following conditions:

- It is in the individual's possession
- It is in the individual's view after being in his possession
- It was in the individual's possession and he locked it up
- It is in a designated secure area

All environmental samples will be handled under strict COC procedures beginning in the field. The field team leader will be the field sample custodian and will be responsible for ensuring that COC procedures are followed. A COC record will accompany each individual shipment. The record will contain the following information:

- Sample destination and transporter
- Sample identification numbers
- Signature of collector
- Date and time of collection
- Sample type
- Identification of monitoring well
- Number of sample containers in shipping container
- Parameters requested for analysis
- Signature of person(s) involved in the chain of possession
- Inclusive dates of possession

A copy of the completed COC form will be placed in a water resistant bag and accompany the shipment and will be returned to the shipper after the shipping container reaches its destination. The COC record will also be used as the analysis request sheet. When shipping by courier, the courier does not sign the COC record: copies of shipping forms are retained to document custody.

6.9 Temperature Control and Sample Transportation

After collection, sample preservation, and labeling, sample containers will be placed in coolers containing water-ice with the goal of reducing the groundwater samples to a temperature of approximately 4°C or less.

All samples included in the shipping container will be packed in such a manner to minimize the potential for container breakage. Samples will be either hand-delivered or shipped via commercial carrier to the certified analytical laboratory. Custody seals will be placed on the shipping containers if a third party courier is used.

7.0 ANALYTICAL AND QUALITY CONTROL PROCEDURES

7.1 Data Quality Objectives

As part of the evaluation component of the Quality Assurance (QA) program, analytical results will be evaluated for precision, accuracy, representativeness, completeness, and comparability (PARCC). These are defined as follows:

- Precision is the agreement or reproducibility among individual measurements of the same property, usually made under the same conditions
- Accuracy is the degree of agreement of a measurement with the true or accepted value
- Representativeness is the degree to which a measurement accurately and precisely represents a characteristic of a population, parameter, or variations at a sampling point, a process condition, or an environmental condition
- Completeness is a measure of the amount of valid data obtained from a measurement system compared with the amount that was expected to be obtained under correct normal conditions
- Comparability is an expression of the confidence with which one data set can be compared with another data set in regard to the same property

The accuracy, precision and representativeness of data will be functions of the sample origin, analytical procedures and the specific sample matrices. Quality Control (QC) practices for the evaluation of these data quality indicators include the use of accepted analytical procedures, adherence to hold time, and analysis of QC samples (e.g., blanks, replicates, spikes, calibration standards and reference standards).

Quantitative QA objectives for precision and accuracy, along with sensitivity (detection limits) are established in accordance with the specific analytical methodologies, historical data, laboratory method validation studies, and laboratory experience with similar samples. The Representativeness of the analytical data is a function of the procedures used to process the samples.

Completeness is a qualitative characteristic which is defined as the fraction of valid data obtained from a measurement system (e.g., sampling and analysis) compared to that which was planned. Completeness can be less than 100 percent due to poor sample recovery, sample damage, or disqualification of results which are outside of control limits due to laboratory error or matrix-specific interferences. Completeness is documented by including sufficient information in the laboratory reports to allow the data user to assess the quality of the results. The overall completeness goal for each task is difficult to determine prior to data acquisition. For this project, all reasonable attempts will be made to attain 90% completeness or better (laboratory).

Comparability is a qualitative characteristic which allows for comparison of analytical results with those obtained by other laboratories. This may be accomplished through the use of standard accepted methodologies, traceability of standards to the National Bureau of Standards (NBS) or USEPA sources, use of appropriate levels of quality control, reporting results in consistent, standard units of measure, and participation in inter-laboratory studies designed to evaluate laboratory performance.

Data quality and the standard commercial report package will be evaluated with respect to PARCC criteria using the laboratory's QA practices, use of standard analytical methods, certifications, participation in inter-laboratory studies, temperature control, adherence to hold times, and COC documentation (also called Data Validation).

7.2 Quality Assurance/Quality Control Samples

This section describes the various Quality Assurance/Quality Control (QA/QC) samples that will be collected in the field and analyzed in the laboratory and the frequency at which they will be performed.

7.2.1 Field Equipment Rinsate Blanks

In cases where sampling equipment is not dedicated or disposable, an equipment rinsate blank will be collected. The equipment rinsate blanks are prepared in the field using laboratory-supplied analyte-free water. The water is poured over and through each type of sampling equipment following decontamination and submitted to the laboratory for analysis of target constituents. **One rinsate blank will be collected for every 10 samples.**

7.2.2 Field Duplicates

Field duplicates are collected by sampling the same location twice, but the field duplicate is assigned a unique sample identification number. Samplers will document which location is used for the duplicate sample. **One field duplicate will be collected for every 10 samples.**

7.2.3 Field Blank

Field blanks are collected in the field using laboratory-supplied analyte-free water. The water is poured directly into the supplied sample containers in the field and submitted to the laboratory for analysis of target constituents. **One field blank will be collected for every 10 samples.**

7.2.4 Laboratory Quality Control Samples

The laboratory will have an established QC check program using procedural (method) blanks, laboratory control spikes, matrix spikes, and duplicates. Details of the internal QC checks used by the laboratory will be found in the laboratory QAP and the published analytical methods. These QC samples will be used to determine if results may have been affected by field activities or procedures used in sample transportation or if matrix interferences are an issue. **One (1) Matrix Spike (MS)/ Matrix Spike Duplicate (MSD) set** (i.e. one sample plus one MS, and one MSD sample at one location) **will be collected per 20 samples.** MS/MSD samples will have a naming convention as follows:

- Sample: S-UWL-TMW-1
- MS: S-UWL-TMW-1-MS
- MSD: S-UWL-TMW-1-MSD

8.0 DATA EVALUATION AND STATISTICAL ANALYSIS

The following sections describe the evaluation and analysis procedures that are followed upon receipt of the analytical report.

8.1 Evaluation of Rate and Direction of Groundwater Flow

Groundwater elevations will be determined for each sampling event and will be used to develop a groundwater elevation contour map that will be submitted with reports. The direction of groundwater flow will be determined from upgradient and downgradient relationships as depicted on the potentiometric surface map. Based on these maps, groundwater flow velocities will be estimated for each event.

8.2 Data Validation

Before the data are used for statistical analysis, they will be evaluated by examining the quality control data accompanying the data report from the laboratory. Relevant quality control data could include measures of accuracy (percent recovery), precision (relative percent difference, RPD), and sample contamination (blank determinations). Data that fail any of these checks will be flagged for further evaluation. A Data Quality Review (DQR) may be initiated with the laboratory for any anomalous data.

8.3 Statistical Analysis

Upon completion of the data validation, the data will be submitted for statistical analysis in compliance with 40 CFR §257.93. The detailed statistical analysis plan for the Facility will be included in **Appendix H**.

9.0 REFERENCES

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TABLES

Table 1
Groundwater Level Data
SCL4A - UWL Landfill Cell 4A
Sioux Energy Center, St. Charles County, MO

	Location[6]		Top of Casing[7]	Ground Surface[7]	Background Event 1 5/9/2016		Background Event 2 6/13/2016		Background Event 3 7/5/2016		Background Event 4 9/14/2016		Background Event 5 11/7/2016		Background Event 6 1/3/2017		Background Event 7 3/8/2017		Background Event 8 6/5/2017	
Well ID	Northing	Easting	Feet MSL[5]	Feet MSL[5]	DTW[3]	GWE[4]	DTW[3]	GWE[4]	DTW[3]	GWE[4]	DTW[3]	GWE[4]	DTW[3]	GWE[4]	DTW[3]	GWE[4]	DTW[3]	GWE[4]	DTW[3]	GWE[4]
UG-3[8]	1118608.5	880519.4	429.71	427.1	10.21	419.50	9.77	419.94	10.88	418.83	11.58	418.13	11.95	417.76	13.31	416.40	13.80	415.91	5.96	423.75
TMW-1	1117385.1	880121.2	428.08	425.9	8.60	419.48	8.12	419.96	9.76	418.32	10.45	417.63	11.40	416.68	13.24	414.84	13.53	414.55	4.34	423.74
TMW-2	1117320.7	880442.9	428.17	425.9	8.73	419.44	8.25	419.92	9.86	418.31	10.57	417.60	11.49	416.68	13.29	414.88	13.59	414.58	4.03	424.14
TMW-3	1117259.2	880762.4	427.88	425.7	8.48	419.40	7.98	419.90	9.60	418.28	10.31	417.57	11.21	416.67	12.98	414.90	13.30	414.58	4.16	423.72
BMW-1S[1]	1121709.2	876755.6	427.77	426.0	9.31	418.46	NA	NA	9.62	418.15	10.25	417.52	9.77	418.00	9.98	417.79	10.82	416.95	5.30	422.47
BMW-2S[1,12]	1122772.1	880524.1	437.86	436.1	20.52	417.34	NA	NA	20.43	417.43	21.19	416.67	20.33	417.53	19.90	417.96	21.07	416.79	16.00	421.86
BMW-3S[1]	1121792.9	875809.5	426.69	424.1	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	8.65	418.04	9.76	416.93	4.17	422.52
Mississippi River	1124029 [2]	879444 [2]	NA	NA	NA	416.80	NA	416.10	NA	417.30	NA	416.50	NA	417.80	NA	418.50	NA	416.90	NA	422.00
Missouri River	1112870 [2]	878170 [2]	NA	NA	NA	420.30	NA	419.80	NA	421.19	NA	418.20	NA	415.39	NA	415.39	NA	413.90	NA	422.94

Notes:
1.) Groundwater monitoring wells surveyed by Zahner & Associates, Inc. on January 14, 2016 and April 29, 2016.
2.) Mississippi and Missouri River gauge locations are estimated.
3.) DTW - Depth to water measured in feet below top of casing.
4.) GWE - Groundwater elevation measured in feet above mean sea level.
5.) MSL - Feet above mean sea level.
6.) Horizontal Datum: State Plane Coordinates NAD83 (2000) Missouri East Zone feet.
7.) Vertical Datum: NAVD88 feet.
8.) Groundwater monitoring wells installed by GREDELL Engineering Resources and surveyed by KdG.
9.) River Elevation for the Mississippi River is provided by Ameren.
10.) River Elevation for the Missouri River are calculated based on nearby USGS (United States Geological Survey) river elevation gauges.
11.) NA - Not Applicable.
12.) BMW-2S is used as a groundwater elevation piezometer only and is not used for CCR groundwater sampling.

Prepared JSI
Check JS/RJF
Reviewed MNH

Table 2
Generalized Hydraulic Properties of Uppermost Aquifer
SCL4A - UWL Landfill Cell 4A
Sioux Energy Center, St. Charles County, Missouri

SCL4A Compliance Wells (UG-3, TMW-1, TMW-2, TMW-3)							
Baseline Sampling Event	Baseline Sampling Event Date	Average Groundwater Flow Direction (Azimuth)	Estimated Hydraulic Gradient (Feet/Foot)	Mean Hydraulic Conductivity (Feet/Day)	Mean Hydraulic Conductivity (cm/sec)	Estimated Effective Porosity	Estimated Groundwater Velocity (Feet/Day)
1	5/9/2016	115.1	0.0001	55.78	2.0E-02	0.35	0.02
2	6/13/2016	99.9	0.0001	55.78	2.0E-02	0.35	0.01
3	7/5/2016	182.5	0.0004	55.78	2.0E-02	0.35	0.07
4	9/14/2016	178.3	0.0004	55.78	2.0E-02	0.35	0.07
5	11/7/2016	190.1	0.0008	55.78	2.0E-02	0.35	0.13
6	1/3/2017	195.5	0.0012	55.78	2.0E-02	0.35	0.19
7	3/8/2017	193.6	0.0011	55.78	2.0E-02	0.35	0.17
8	6/5/2017	28.1	0.0001	55.78	2.0E-02	0.35	0.02

Estimated Results (USEPA Tool)	
Resultant Groundwater Flow Direction (Azimuth)	189
Estimated Annual Net Groundwater Movement (Feet/Year)	34

Prepared By: JSI
Checked By: RJF
Reviewed By: MNH

Notes:

1. Azimuth and Hydraulic Gradient calculated using the United States Environmental Protection Agency (USEPA) On-Line Tools for Site Assessment Calculation for Hydraulic Gradient (magnitude and direction) available at https://www3.epa.gov/ceampubl/learn2model/part-two/onsite/gradient4plus-ns.html
2. Hydraulic conductivity value is the geometric mean of slug test results for the SCL4A monitoring wells.
3. An effective porosity of 0.35 was used based on grain size distributions and published values (Fetter 2000, Cohen 1953, and Johnson 1967) .
4. Azimuth is measured clockwise in degrees from north.
5. cm/sec - centimeters per second.

Table 4
Monitoring Well Construction Details
SCL4A - UWL Landfill Cell 4A
Sioux Energy Center, St. Charles County, MO

Well ID	Date Installed	Location[4] Northing	Location[4] Easting	Top of Casing Elevation (FT MSL)[5]	Ground Surface Elevation (FT MSL)[5]	Top of Screen (FT MSL)[5]	Bottom of Screen (FT MSL)[5]	Base of Well (FT MSL)[5]	Total Depth (FT BGS)[5]
UG-3*	12/16/2007	1118608.5	880519.4	429.71	427.1	410.0	399.7	399.7	27.4
TMW-1	4/5/2016	1117385.1	880121.2	428.08	425.9	409.4	399.6	399.2	26.7
TMW-2	4/5/2016	1117320.7	880442.9	428.17	425.9	408.0	398.2	397.8	28.1
TMW-3	4/5/2016	1117259.2	880762.4	427.88	425.7	408.0	398.2	397.8	27.9
BMW-1S	12/8/2015	1121709.2	876755.6	427.77	426.0	412.0	402.2	401.8	24.2
BMW-3S	11/8/2016	1121792.9	875809.5	426.69	424.1	410.2	400.4	400.0	24.2

Notes:
1.) All elevations and coordinates were surveyed on January 14, 2016 and December 8, 2016 by Zahner and Associates, Inc.
2.) FT MSL = Feet Above Mean Sea Level.
3.) FT BGS = Feet Below Ground Surface.
4.) Horizontal Datum: State Plane Coordinates NAD83 (2000) Missouri East Zone Feet.
5.) Vertical Datum: NAVD88 Feet.
6.) *Groundwater monitoring wells installed by GREDELL Engineering Resources and surveyed by KdG.

Prepared By: JSI
Checked By: JS
Reviewed By: MNH

Table 5
Groundwater Quality Monitoring Parameters
SCL4A - UWL Landfill Cell 4A
Sioux Energy Center, St. Charles County, MO

Monitoring Parameter		Background[2]	Detection[3]	Assessment[4]
Field Parameters	Temperature, pH, Conductivity and Dissolved Oxygen	X	X	X
Appendix III[1]	Boron	X	X	X
	Calcium	X	X	X
	Chloride	X	X	X
	Fluoride	X	X	X
	Sulfate	X	X	X
	pH	X	X	X
	Total Dissolved Solids (TDS)	X	X	X
Appendix IV[1]	Antimony	X		X
	Arsenic	X		X
	Barium	X		X
	Beryllium	X		X
	Cadmium	X		X
	Chromium	X		X
	Cobalt	X		X
	Fluoride	X		X
	Lead	X		X
	Lithium	X		X
	Mercury	X		X
	Molybdenum	X		X
	Selenium	X		X
	Thallium	X		X
	Radium 226 & 228	X		X

Notes:
1.) Analyte lists match requirements for monitoring from USEPA Rule 40 CFR parts 257 and 261.
2.) Background will be performed through October 2017 until at least 8 samples are collected.
3.) Approximately 6 months will separate each semi-annual sampling event.
4.) If necessary, assessment monitoring will be performed in accordance with USEPA Rule.

Prepared By: JS
Checked By: MWD
Reviewed By: MNH

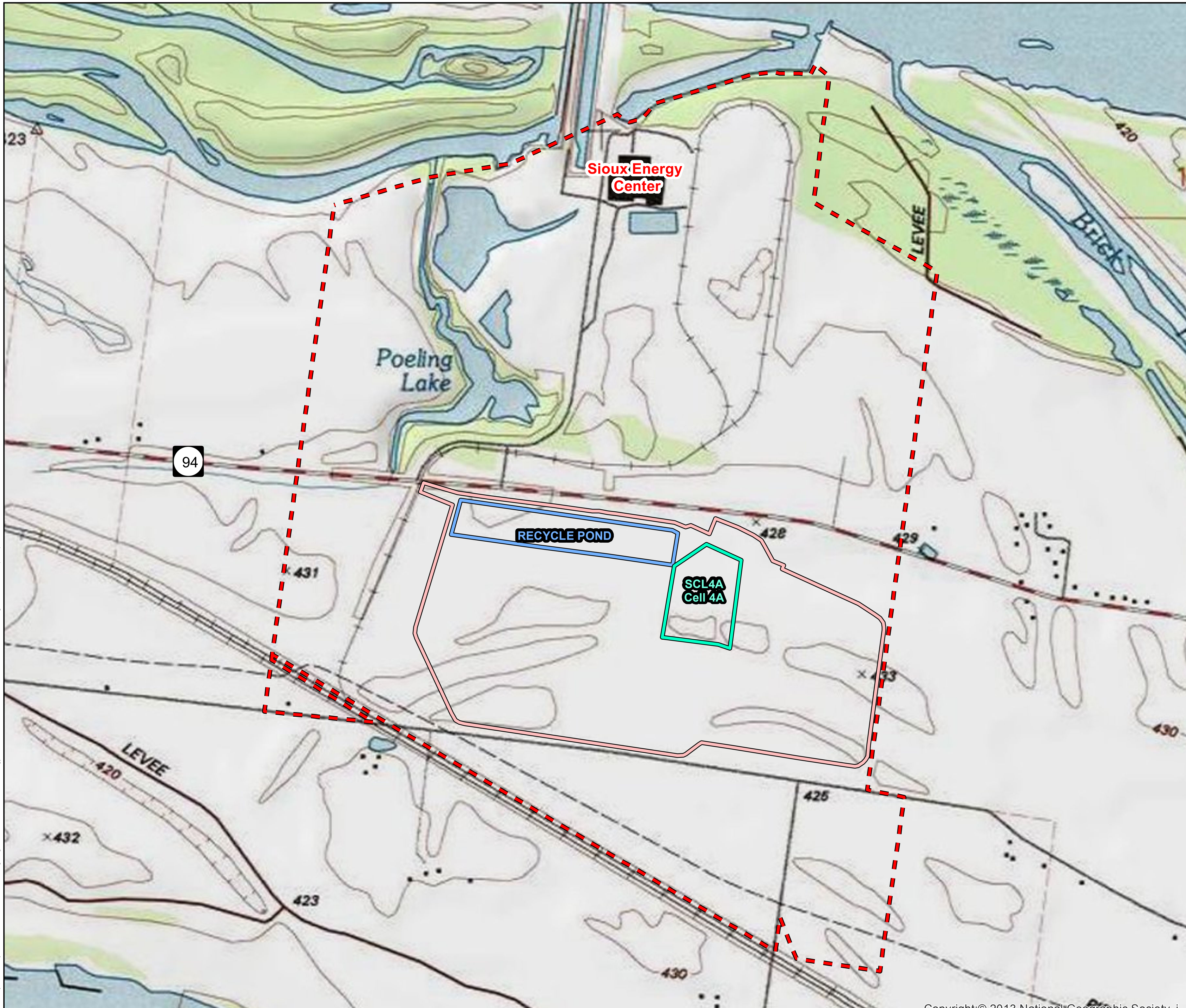
Table 6
Analytical Methods and Practical Quantitation Limits
SCL4A - UWL Landfill Cell 4A
Sioux Energy Center, St. Charles County, MO

Analyte	Method Reference	Preservative	Hold Times	PQL (µg/L)	MCL (mg/L)
Appendix III - Detection Monitoring					
Boron	SW-846 6010/MCAWW 200.7	HNO3	6 months	20.0	NA
Calcium	SW-846 6010/MCAWW 200.7	HNO3	6 months	500.0	NA
Chloride	EPA 300.0/325.5/MCAWW 300/SW8463 9251/9056	NA	28 days	500.0	NA
Fluoride	EPA 300.0, 300.1	NA	28 days	-	4
pH	4500 H+B-2000	NA	NA	-	NA
Sulfate	EPA 300.0/SW8463 300	NA	28 days	2000.0	NA
Total Dissolved Solids (TDS)	2540 C-1997/SM18-20 2540 C	NA	7 days	10000.0	NA
Appendix IV - Assessment Monitoring					
Antimony	SW-846 6010/6020/MCAWW 200.7/200.8	HNO3	6 months	1.0	0.006
Arsenic	SW-846 6010/6020/MCAWW 200.7/200.8	HNO3	6 months	1.0	0.01
Barium	SW-846 6010/6020/MCAWW 200.7/200.8	HNO3	6 months	2.0	2
Beryllium	SW-846 6010/6020/MCAWW 200.7/200.8	HNO3	6 months	1.0	0.004
Cadmium	SW-846 6010/6020/MCAWW 200.7/200.8	HNO3	6 months	0.5	0.005
Chromium	SW-846 6010/6020/MCAWW 200.7/200.8	HNO3	6 months	1.5	0.1
Cobalt	SW-846 6010/6020/MCAWW 200.7/200.8	HNO3	6 months	4.0	NP
Fluoride	EPA 300.0	N/A	28 days	-	4
Lead	SW-846 6020	HNO3	6 months	0.005	0.015
Lithium	SW-846 6010	HNO3	6 months	-	NA
Mercury	SW-846 7470	HNO3	28 days	-	0.002
Molybdenum	SW-846 6010	HNO3	6 months	-	NP
Selenium	SW-846 6010/6020/MCAWW 200.7/200.8	HNO3	6 months	1.0	0.05
Thallium	SW-846 6010/6020/MCAWW 200.7/200.8	HNO3	6 months	0.2	0.002
Radium 226 & 228	SW-846 903.1/SM 6500 904	-	-	1.0 (pCi/L)	5.0 (pCi/L)

Notes:
1.) NA - not applicable.
2.) Analyte lists matches requirements for detection and assessment monitoring from United States Environmental Protection Agency (USEPA) Rule 40 CFR parts 257 and 261.
3.) SW-846 3rd denotes Test Methods for Evaluating Solid Waste, Physical- Chemical Methods, EPA publication SW-846, 3rd edition, and subsequent updates.
4.) MCAWW denotes Methods for the Chemical Analysis of Water and Wastes (MCAWW), United States Environmental Protection Agency (USEPA) published in the 1983.
5.) EPA 300 denotes Methods for the Determination of Organic Compounds in Drinking Water Environmental Monitoring Systems Laboratory, Office of Research and Development, USEPA, Cincinnati, Ohio 45268. EPA-300/4-88/039, December 1988 (Revised July 1991).
6.) SM18-20 denotes Standard Methods for the Examination of Water and Wastewater, 18th, 19th, and 20th Editions, published by the American Public Health Association, Water Environment Federation, and the American Water Works Association.
7.) Other industry-used or agency-approved methods may be used provided that they produce the necessary level of precision and accuracy for data use and reporting.
8.) Updates to the methods listed here are approved for use.
9.) PQL - Practical Quantitation Limit.
10.) MCL - Maximum Contaminant Level from USEPA 2014 Edition of the Drinking Water Standards and Health Advisories. October 2014. http://water.epa.gov/drink/contaminants/index.cfm.
11.) Dash (-) - Indicates no information available.
12.) µg/L - Micrograms per liter.
13.) pCi/L - Picocuries per liter.
14.) NP - Not Promulgated.
15.) mg/L - Milligrams per liter.

Prepared By: JS
Checked By: MWD
Reviewed By: MNH

FIGURES



LEGEND

Sioux Energy Center Property Boundary

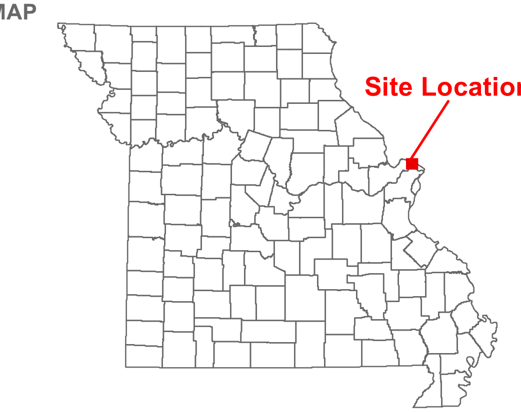
Utility Waste Landfill (UWL)

SCL4A - Landfill Cell 4A

Water Recycle Pond

UWL Final Perimeter Fence

KEY MAP



NOTES

1.) ALL LOCATIONS AND BOUNDARIES ARE APPROXIMATE.

REFERENCES

1.) AMEREN MISSOURI SIOUX ENERGY CENTER, SIOUX PROPERTY CONTROL MAP, FEBRUARY 2011.
2.) COORDINATE SYSTEM: NAD 1983 STATE PLANE MISSOURI EAST FIPS 2401 FEET.
3.) AMEREN MISSOURI DRAWING SX-8420-X-182001.
4.) UWL BOUNDARIES, DESIGNATIONS AND EXISTING MONITORING WELL LOCATIONS BASED ON DRAWINGS IN THE UWL PROPOSED LANDFILL PERMIT (#0918301).

0 500 1,000 2,000 3,000 4,000 Feet

CLIENT
AMEREN MISSOURI
SIOUX ENERGY CENTER

PROJECT
GROUNDWATER MONITORING PROGRAM

TITLE
SITE LOCATION TOPOGRAPHIC MAP

CONSULTANT

YYYY-MM-DD	2017-08-28
PREPARED	JSI
DESIGN	JSI
REVIEW	JS
APPROVED	MNH

PROJECT No.	PHASE	Rev.	FIGURE
153-1406	0003D	0	1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

AMEREN_00001498

LEGEND

Sioux Energy Center Property Boundary

Utility Waste Landfill (UWL)

SCL4A - Landfill Cell 4A

Water Recycle Pond

UWL Final Perimeter Fence

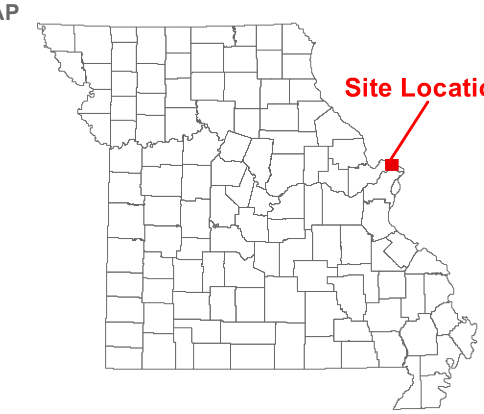
Ground/Surface Elevation Measurement

SCL4A Monitoring Well

Background Monitoring Well

Groundwater Elevation Piezometer

KEY MAP



NOTES

1.) ALL LOCATIONS AND BOUNDARIES ARE APPROXIMATE.
2.) GOLDER GROUNDWATER MONITORING WELLS (BMW-1S, BMW-2S, BMW-3S, TMW-1, TMW-2 AND TMW-3) SURVEYED BY ZAHNER AND ASSOCIATES, INC. ON JANUARY 14 AND DECEMBER 8, 2016.
3.) UWL BOUNDARIES, DESIGNATIONS AND STATE MONITORING WELL LOCATIONS (UG-3) BASED ON DRAWINGS IN THE UWL PROPOSED LANDFILL PERMIT (#0918301).

REFERENCES

1.) AMEREN MISSOURI SIOUX ENERGY CENTER, SIOUX PROPERTY CONTROL MAP, FEBRUARY 2011.
2.) COORDINATE SYSTEM: NAD 1983 STATE PLANE MISSOURI EAST FIPS 2401 FEET.
3.) AMEREN MISSOURI DRAWING SX-8420-X-182001.
4.) GOOGLE EARTH®.

0 500 1,000 2,000 3,000 4,000 Feet

CLIENT
AMEREN MISSOURI
SIOUX ENERGY CENTER

Ameren

PROJECT
GROUNDWATER MONITORING PROGRAM

TITLE
SITE LOCATION AERIAL MAP

CONSULTANT

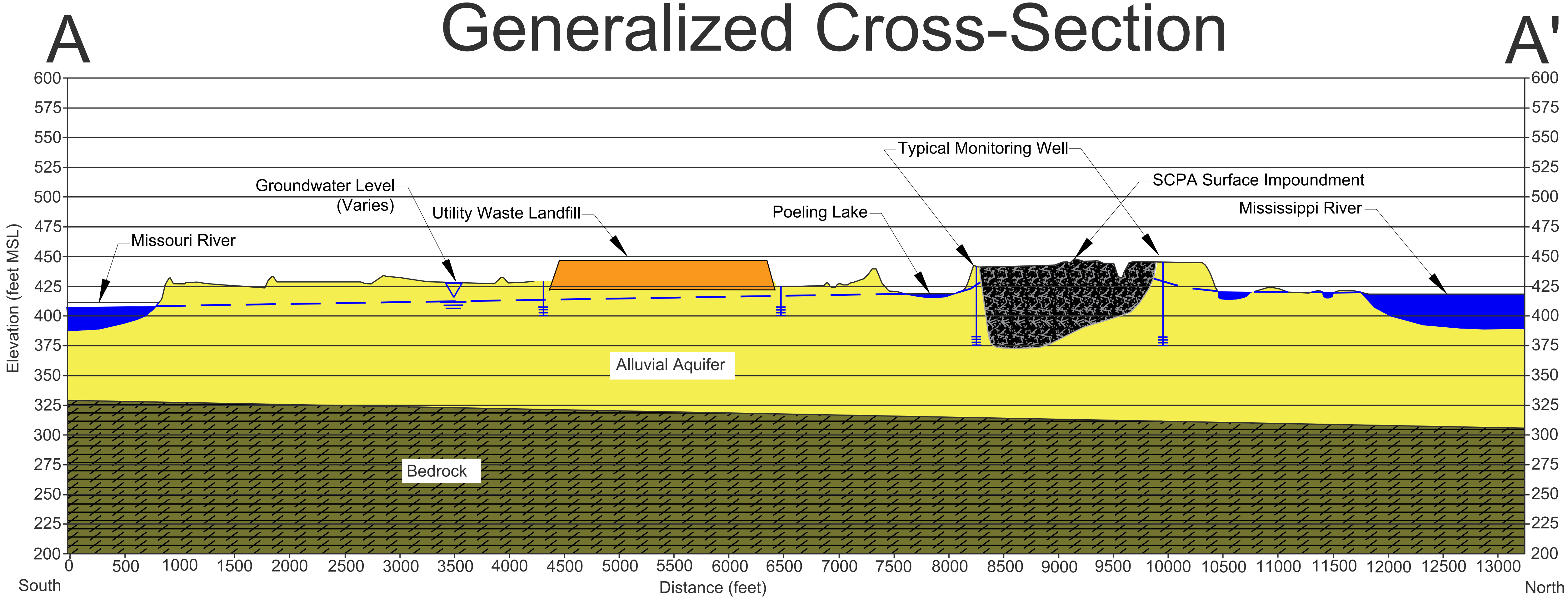
Golder Associates

YYYY-MM-DD	2017-08-29
PREPARED	JSI
DESIGN	JSI
REVIEW	JS
APPROVED	MNH

PROJECT No.	PHASE	Rev.	FIGURE
153-1406	0003D	0	2

AMEREN_00001499

Generalized Cross-Section



Overview Map

Not To Scale

NOTES
1.) ALL LOCATIONS AND BOUNDARIES ARE APPROXIMATE.
2.) CROSS-SECTION IS NOT TO SCALE AND IS ONLY A VISUAL REPRESENTATION OF THE SUBSURFACE GEOLOGY.
3.) MSL - MEAN SEA LEVEL.

REFERENCES
1.) AMEREN, 2011. AMEREN MISSOURI SIOUX ENERGY CENTER, SIOUX PROPERTY CONTROL MAP, FEBRUARY 2011.
2.) GREDELL ENGINEERING RESOURCES, INC. 2006. DETAILED GEOLOGIC AND HYDROLOGIC SITE INVESTIGATION REPORT. AMEREN UE SIOUX POWER PLANT PROPOSED UTILITY WASTE DISPOSAL AREA. ST. CHARLES COUNTY, MISSOURI. AUGUST 2006.
3.) EPRI, 1998. FIELD EVALUATION OF THE COMANAGEMENT OF UTILITY LOW-VOLUME WASTES WITH HIGH-VOLUME COAL COMBUSTION BY-PRODUCTS: SX SITE. TR-108409.
4.) REITZ & JENS, INC., AND GREDELL ENGINEERING RESOURCES, INC. 2014. AMEREN MISSOURI SIOUX POWER PLANT UTILITY WASTE LANDFILL PROPOSED CONSTRUCTION PERMIT MODIFICATION CONSTRUCTION PERMIT NUMBER 0918301 ST, CHARLES COUNTY, MISSOURI.

CLIENT
AMEREN MISSOURI
SIOUX ENERGY CENTER

CONSULTANT

YYYY-MM-DD	2017-08-29
DESIGNED	JSI
PREPARED	JSI
REVIEWED	JS
APPROVED	MNH

PROJECT
GROUNDWATER MONITORING PROGRAM

TITLE
GENERALIZED CROSS-SECTION

PROJECT NO.	PHASE	REV.	FIGURE
153-1406	0003D	0.0	3

APPENDIX A
CCR MONITORING WELL BORING LOGS

RECORD OF BOREHOLE TMW-1

PROJECT: Ameren CCR GW Monitoring
PROJECT NUMBER: 153-1406.0003D
LOCATION: Sioux Energy Center

DRILLING METHOD: 6" Sonic
DRILLING DATE: 4/5/2016
DRILL RIG: Mini Sonic (CDD1415)

DATUM: NAVD88
AZIMUTH: N/A
COORDINATES: N: 1,117,385.10 E: 880,121.20

ELEVATION: 425.86
INCLINATION: -90

DEPTH (feet)	BORING METHOD	DESCRIPTION	USCS	GRAPHIC LOG	ELEVATION / DEPTH (ft)	NUMBER	TYPE	REC / ATT	REMARKS
0	6" Sonic	(0.0-0.9) (CL) sandy SILTY CLAY, non-plastic to low plasticity fines, fine to medium sub-rounded sand, some organics (roots); dark yellowish brown (10YR 4/2); cohesive, w<PL, soft	CL		425.0 / 0.9				
		(0.9-2.4) (CL) SILTY CLAY, medium to high plasticity; dark yellowish brown (10YR 4/2); cohesive, w>PL, firm	CL		423.5 / 2.4	1	SO	2.4 / 5.0	
5		(2.4-7.5) (ML) sandy CLAYEY SILT, low to medium plasticity fines, fine sand; dark yellowish brown (10YR 4/2); cohesive, w<PL, soft	ML		418.4 / 7.5	2	SO	4.1 / 5.0	
		(7.5-10.0) (CL) sandy SILTY CLAY, medium plasticity fines, some fine sand seams (less than 1.0 inches thick); dark yellowish brown (10YR 4/2); cohesive, w~PL, firm	CL		415.9 / 10.0				Water Level 8.60 ft bgs 5/9/2016
10 / 15		(10.0-28.7) (SP) SAND, fine sand, trace non-plastic fines; moderate yellowish brown (10YR 5/4); non-cohesive, wet, compact	SP		405.9 / 20.0	3	SO	10.0 / 10.0	
20 / 25		(20.0) SAA (Same As Above) except, fine to medium sub-rounded sand, trace fine sub-rounded gravel, no fines; light olive gray (5Y 5/2)	SP		397.2 / 28.7	4	SO	9.7 / 10.0	
30		(28.7-30.0) (SW) SAND, fine to coarse sub-rounded sand, trace fine sub-rounded gravel; light olive gray (5Y 5/2) to pale yellowish brown (10YR 6/2); non-cohesive,	SW		395.9				

Log continued on next page

SCALE: 1 in = 3.8 ft
DRILLING CONTRACTOR: Cascade
DRILLER: J. Drabek

LOGGED: JSI/JS
CHECKED: JSI
REVIEWED: PJJ/MNH

Golder Associates

GOLDER STL RECORD OF BOREHOLE MWD SEC LOGS.GPJ GLDR_CO.GDT 10/9/17

RECORD OF BOREHOLE TMW-1

PROJECT: Ameren CCR GW Monitoring
PROJECT NUMBER: 153-1406.0003D
LOCATION: Sioux Energy Center

DRILLING METHOD: 6" Sonic
DRILLING DATE: 4/5/2016
DRILL RIG: Mini Sonic (CDD1415)

DATUM: NAVD88
AZIMUTH: N/A
COORDINATES: N: 1,117,385.10 E: 880,121.20

ELEVATION: 425.86
INCLINATION: -90

DEPTH (feet)	BORING METHOD	SOIL/ROCK PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	ELEVATION / DEPTH (ft)	SAMPLES: NUMBER	TYPE	REC / ATT	REMARKS
30		wet, compact END OF BORING AT 30.0 FT BELOW GROUND SURFACE. FOR WELL DETAILS, SEE WELL CONSTRUCTION LOG TMW-1.			30.0				
35									
40									
45									
50									
55									
60									

SCALE: 1 in = 3.8 ft
DRILLING CONTRACTOR: Cascade
DRILLER: J. Drabek

LOGGED: JSI/JS
CHECKED: JSI
REVIEWED: PJJ/MNH

Golder Associates

GOLDER STL RECORD OF BOREHOLE MWD SEC LOGS.GPJ GLDR_CO.GDT 10/9/17

RECORD OF BOREHOLE TMW-2

PROJECT: Ameren CCR GW Monitoring
PROJECT NUMBER: 153-1406.0003D
LOCATION: Sioux Energy Center

DRILLING METHOD: 6" Sonic
DRILLING DATE: 4/5/2016
DRILL RIG: Mini Sonic (CDD1415)

DATUM: NAVD88
AZIMUTH: N/A
COORDINATES: N: 1,117,320.70 E: 880,442.90

ELEVATION: 425.85
INCLINATION: -90

DEPTH (feet)	BORING METHOD	DESCRIPTION	USCS	GRAPHIC LOG	ELEVATION / DEPTH (ft)	NUMBER	TYPE	REC / ATT	REMARKS
0	6" Sonic	(0.0-0.6) (ML) sandy CLAYEY SILT, non-plastic to low plasticity fines, fine to medium sub-rounded sand, trace fine sub-rounded gravel, some organics (roots); dark yellowish brown (10YR 4/2); cohesive, w<PL, soft	ML		425.3 / 0.6	1	SO	2.0 / 5.0	
		(0.6-2.0) (CL) SILTY CLAY, medium to high plasticity; dark yellowish brown (10YR 4/2); cohesive, w~PL, firm	CL		423.9 / 2.0				
		(2.0-6.0) (CL) SILTY CLAY, medium to high plasticity, some fine sand lenses (<1.0 inches thick); dark yellowish brown (10YR 4/2) to moderate yellowish brown (10YR 5/4); cohesive, w>PL, soft	CI		419.9 / 6.0				
5		(6.0-6.5) (SC) CLAYEY SAND, fine sand, medium plasticity fines; dark yellowish brown (10YR 4/2); non-cohesive, moist, compact	SC		419.4 / 6.5	2	SO	3.3 / 5.0	
		(6.5-10.0) (CL) SILTY CLAY, medium to high plasticity, some fine sand lenses (<1.0 inches thick); moderate yellowish brown (10YR 5/4); cohesive, w~PL, soft	CL		415.9 / 10.0				Water Level 8.73 ft bgs 5/9/2016
10		(10.0-11.9) sandy SILTY CLAY, medium plasticity fines, fine sand, trace fine sub-rounded gravels; moderate yellowish brown (10YR 5/4); cohesive, w~PL, firm	CL		414.0 / 11.9	3	SO	5.0 / 5.0	
		(11.9-30.0) (SP) SAND, fine sand, trace non-plastic fines; moderate yellowish brown (10YR 5/4); non-cohesive, wet, compact	SP						
15						4	SO	5.0 / 5.0	
20		(20.0) SAA (Same As Above) except, no fines, fine to medium sub-rounded sand			405.9 / 20.0	5	SO	9.7 / 10.0	
25		(26.0) SAA except, color to medium gray (N5)			399.9 / 26.0				
30					395.9				

Log continued on next page

SCALE: 1 in = 3.8 ft
DRILLING CONTRACTOR: Cascade
DRILLER: J. Drabek

LOGGED: JSI/JS
CHECKED: JSI
REVIEWED: PJJ/MNH

Golder Associates

GOLDER STL RECORD OF BOREHOLE MWD SEC LOGS.GPJ GLDR_CO.GDT 10/9/17

RECORD OF BOREHOLE TMW-2

PROJECT: Ameren CCR GW Monitoring
PROJECT NUMBER: 153-1406.0003D
LOCATION: Sioux Energy Center

DRILLING METHOD: 6" Sonic
DRILLING DATE: 4/5/2016
DRILL RIG: Mini Sonic (CDD1415)

DATUM: NAVD88
AZIMUTH: N/A
COORDINATES: N: 1,117,320.70 E: 880,442.90

ELEVATION: 425.85
INCLINATION: -90

DEPTH (feet)	BORING METHOD	SOIL/ROCK PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	ELEVATION / DEPTH (ft)	SAMPLES: NUMBER	TYPE	REC / ATT	REMARKS
30		END OF BORING AT 30.0 FT BELOW GROUND SURFACE. FOR WELL DETAILS, SEE WELL CONSTRUCTION LOG TMW-2.			30.0				
35									
40									
45									
50									
55									
60									

SCALE: 1 in = 3.8 ft
DRILLING CONTRACTOR: Cascade
DRILLER: J. Drabek

LOGGED: JSI/JS
CHECKED: JSI
REVIEWED: PJJ/MNH

Golder Associates

RECORD OF BOREHOLE TMW-3

PROJECT: Ameren CCR GW Monitoring
PROJECT NUMBER: 153-1406.0003D
LOCATION: Sioux Energy Center

DRILLING METHOD: 6" Sonic
DRILLING DATE: 4/5/2016
DRILL RIG: Mini Sonic (CDD1415)

DATUM: NAVD88
AZIMUTH: N/A
COORDINATES: N: 1,117,259.20 E: 880,762.40

ELEVATION: 425.66
INCLINATION: -90

DEPTH (feet)	BORING METHOD	DESCRIPTION	USCS	GRAPHIC LOG	ELEVATION / DEPTH (ft)	NUMBER	TYPE	REC / ATT	REMARKS
0	6" Sonic	(0.0-0.6) (CL) sandy SILTY CLAY, low to medium plasticity, fine sand, some organics (roots), trace fine sub-rounded gravel; brownish gray (5YR 4/1) to moderate brown (5YR 4/4); cohesive, w<PL, soft	CL		425.1 / 0.6	1	SO	2.1 / 5.0	
		(0.6-2.1) (CL) SILTY CLAY, medium to high plasticity fines; moderate yellowish brown (10YR 5/4); cohesive, w~PL, soft	CL		423.6 / 2.1				
		(2.1-5.0) (CL) SILTY CLAY, medium to high plasticity, trace fine sand; light brownish gray (5YR 6/1) to moderate yellowish brown (10YR 5/4); cohesive, w~PL, soft	CL		420.7 / 5.0				
5		(5.0-5.5) (MH) CLAYEY SILT, medium plasticity fines, some fine sand; moderate yellowish brown (10YR 5/4); cohesive, w<PL, very soft	MH		420.2 / 5.5	2	SO	5.0 / 5.0	
		(5.5-6.7) (CL) SILTY CLAY, medium to high plasticity, trace fine sand; light brownish gray (5YR 6/1) to moderate yellowish brown (10YR 5/4); cohesive, w~PL, soft	CL		419.0 / 6.7				
		(6.7-6.9) (MH) CLAYEY SILT, medium plasticity fines, some fine sand; moderate yellowish brown (10YR 5/4); cohesive, w<PL, very soft	MH		418.8 / 6.9				
		(6.9-9.8) (CL) SILTY CLAY, medium to high plasticity, trace fine sand; light brownish gray (5YR 6/1) to moderate yellowish brown (10YR 5/4); cohesive, w~PL, soft	CL		415.9 / 9.8				∇ Water Level 8.48 ft bgs 5/9/2016
10		(9.8-10.0) (MH) CLAYEY SILT, medium plasticity fines, some fine sand; moderate yellowish brown (10YR 5/4); cohesive, w<PL, very soft	MH		415.7 / 10.0	3	SO	4.3 / 5.0	
		(10.0-12.0) (ML) sandy CLAYEY SILT, low to medium plasticity, fine sand, some high plasticity clay zones (<2.0 inches thick); light brownish gray (5YR 6/1) to moderate yellowish brown (10YR 5/4) with some medium gray (N5), some <0.5 cm thick laminations; cohesive, w<PL, soft	ML		413.7 / 12.0				
		(12.0-27.5) (SP) SAND, fine sand, trace non-plastic fines; moderate yellowish brown (10YR 5/4); non-cohesive, wet, compact	SP						
15		(15.0) SAA (Same As Above) except, fine to medium sub-rounded sand, trace fine subrounded gravel			410.7 / 15.0	4	SO	4.7 / 5.0	
20		(19.5-20.0) SAA except, with some black (N1) organics (native coal)			406.2 / 19.5	5	SO	10.0 / 10.0	
25					398.2 / 27.5				
		(27.5-30.0) (SW) SAND, fine to coarse sub-rounded sand, trace fine sub-rounded gravel; moderate yellowish brown (10YR 5/4); non-cohesive, wet, compact	SW		397.7 / 28.0				
		(28.0) SAA except, medium gray (N5)			395.7				
30									

Log continued on next page

SCALE: 1 in = 3.8 ft
DRILLING CONTRACTOR: Cascade
DRILLER: J. Drabek

LOGGED: JSI/JS
CHECKED: JSI
REVIEWED: PJJ/MNH

Golder Associates

RECORD OF BOREHOLE TMW-3

PROJECT: Ameren CCR GW Monitoring
PROJECT NUMBER: 153-1406.0003D
LOCATION: Sioux Energy Center

DRILLING METHOD: 6" Sonic
DRILLING DATE: 4/5/2016
DRILL RIG: Mini Sonic (CDD1415)

DATUM: NAVD88
AZIMUTH: N/A
COORDINATES: N: 1,117,259.20 E: 880,762.40

ELEVATION: 425.66
INCLINATION: -90

DEPTH (feet)	BORING METHOD	SOIL/ROCK PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	ELEVATION / DEPTH (ft)	SAMPLES: NUMBER	TYPE	REC / ATT	REMARKS
30		END OF BORING AT 30.0 FEET BELOW GROUND SURFACE. FOR WELL DETAILS, SEE WELL CONSTRUCTION LOG TMW-3.			30.0				
35									
40									
45									
50									
55									
60									

SCALE: 1 in = 3.8 ft
DRILLING CONTRACTOR: Cascade
DRILLER: J. Drabek

LOGGED: JSI/JS
CHECKED: JSI
REVIEWED: PJJ/MNH

Golder Associates

RECORD OF BOREHOLE BMW-1S

PROJECT: Ameren CCR GW Monitoring
PROJECT NUMBER: 153-1406.003B
LOCATION: Sioux Energy Center

DRILLING METHOD: 6" Sonic
DRILLING DATE: 12/8/2015
DRILL RIG: Mini Sonic (CDD1415)

DATUM: NAVD88
AZIMUTH: N/A
COORDINATES: N: 1,121,709.18 E: 876,755.57

ELEVATION: 425.98
INCLINATION: -90

DEPTH (feet)	BORING METHOD	DESCRIPTION	USCS	GRAPHIC LOG	ELEVATION / DEPTH (ft)	NUMBER	TYPE	REC / ATT	REMARKS
0	6" Sonic	(0.0-8.5) (ML) sandy SILT, non-plastic to very low plasticity fines, fine sand, trace organics (roots); brownish gray (5YR 4/1); non-cohesive, moist, loose	ML			1	SO	2.4 / 5.0	
5		(5.0) SAA (Same As Above), no organics			421.0 / 5.0	2	SO	3.7 / 5.0	Water Level 6.33 ft bgs 2/16/2016
		(8.5-15.6) (CL) SILTY CLAY, medium plasticity fines, trace fine sand; light brownish gray (5YR 6/1); cohesive, w~PL, firm	CL		417.5 / 8.5	3	SO	2.8 / 5.0	
15		(15.6-17.5) (SP-SM) SAND, fine sand, some non-plastic fines; light brown (5YR 5/6); non-cohesive, wet, compact	SP-SM		410.4 / 15.6	4	SO	7.5 / 10.0	Run #4, Sample appears to be compacted while being extruded into sample bags. Measured field recovery: 5.2/10.0. Estimated actual recovery: 7.5/10.0.
		(17.5-18.5) (CL) SILTY CLAY, medium plasticity fines, trace fine sand; medium dark gray (N4); cohesive, w~PL, firm	CL		408.5 / 17.5				
		(18.5-25.0) (SP-SM) SAND, fine sand, some non-plastic fines; medium dark gray (N4); non-cohesive, wet, compact	SP-SM		407.5 / 18.5				
25		END OF BORING AT 25.0 FEET BELOW GROUND SURFACE. FOR WELL DETAILS, SEE WELL CONSTRUCTION LOG BMW-1S.			401.0 / 25.0				
30									

SCALE: 1 in = 3.8 ft
DRILLING CONTRACTOR: Cascade
DRILLER: J. Drabek

LOGGED: JSI/JS
CHECKED: JSI
REVIEWED: PJJ/MNH

Golder Associates

RECORD OF BOREHOLE BMW-3S

PROJECT: Ameren CCR GW Monitoring
PROJECT NUMBER: 153-1406.003B
LOCATION: Sioux Energy Center

DRILLING METHOD: 6" Sonic
DRILLING DATE: 11/8/2016
DRILL RIG: Geoprobe (8140CC)

DATUM: NAVD88
AZIMUTH: N/A
COORDINATES: N: 1,121,792.93 E: 875,809.46

ELEVATION: 424.12
INCLINATION: -90

DEPTH (feet)	BORING METHOD	DESCRIPTION	USCS	ELEVATION / DEPTH (ft)	NUMBER	TYPE	REC / ATT	REMARKS
0	6" Sonic	(0.0-1.2) (CH) CLAY, high plasticity fines, some organics; dusky brown (5YR 2/2); cohesive, w~PL, firm	CH	422.9 / 1.2				
		(1.2-12.0) (CL) SILTY CLAY, medium plasticity fines; pale brown (5YR 5/2); cohesive, w~PL, moist	CL		1	SO	4.4 / 5.0	
5					2	SO	3.2 / 5.0	
10				412.1 / 12.0				
		(12.0-22.2) (SP) SAND, fine to medium sub-angular sand, trace non-plastic fines; light brown (5YR 6/4); non-cohesive, wet, compact	SP		3	SO	3.7 / 5.0	
15		(15.0) Same As Above (SAA) excpet color to pale brown (5YR 5/2)		409.1 / 15.0	4	SO	3.4 / 5.0	
20				401.9 / 22.2	5	SO	3.3 / 4.0	
		(22.2-24.0) (SM) SILTY SAND, fine to medium sand, some non-plastic fines; medium gray (N5); non-cohesive, wet, compact	SM	400.1 / 24.0				
25		END OF BORING AT 24.2 FEET BELOW GROUND SURFACE. FOR WELL DETAILS, SEE WELL CONSTRUCTION LOG BMW-3S.						
30								

SCALE: 1 in = 3.8 ft
DRILLING CONTRACTOR: Cascade
DRILLER: M. Rodrigues

LOGGED: MSG
CHECKED: JS
REVIEWED: MNH

Golder Associates

APPENDIX B
HISTORIC POTENTIOMETRIC SURFACE MAPS

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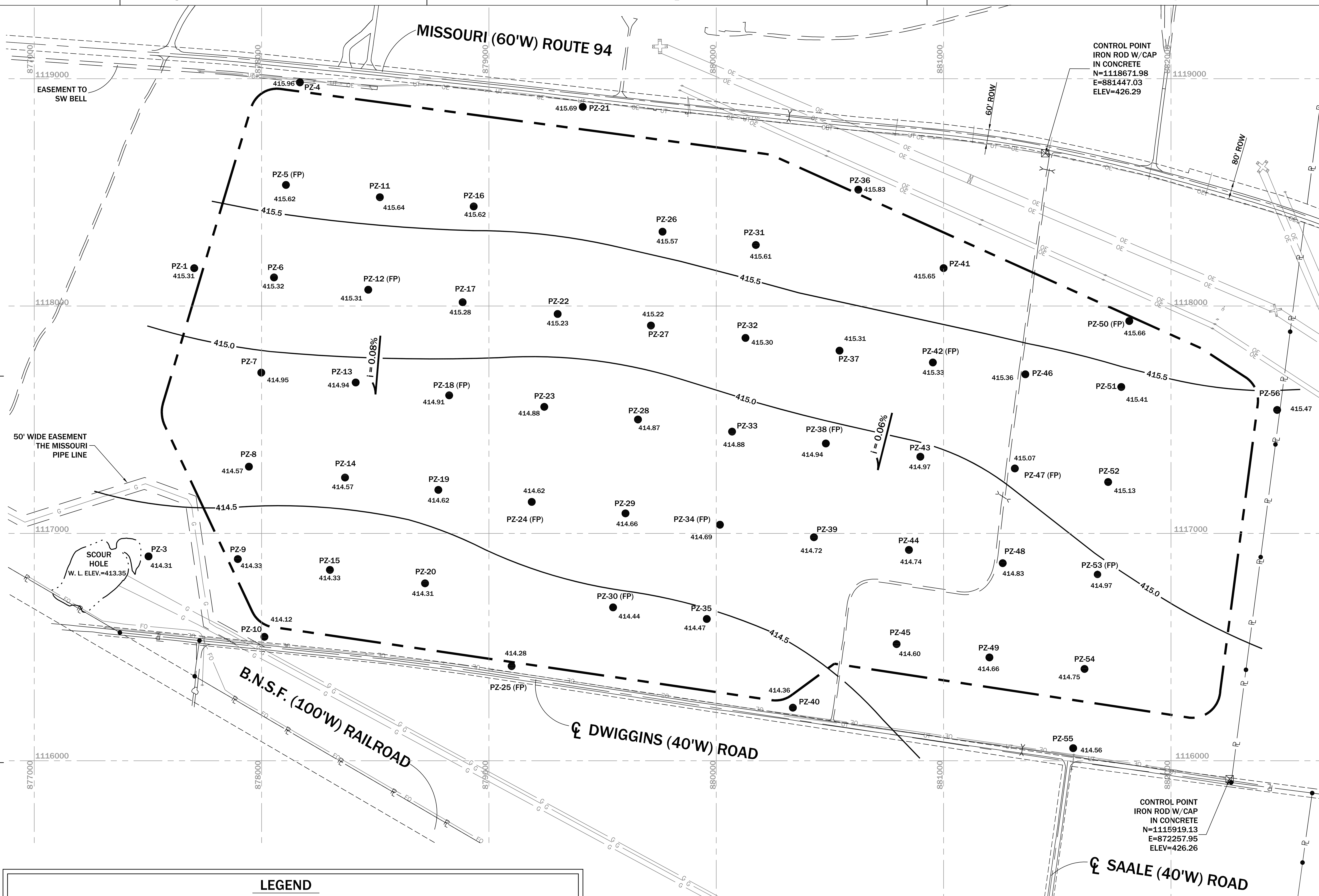

LEGEND

PZ	PIEZOMETER BORING (57)		PAVED ROAD
B	TEMPORARY BORING (54)	i = 0.08%	HYDRAULIC GRADIENT (%)
B	TEMPORARY BORING (DEEP) (3)		GROUNDWATER FLOW DIRECTION
(FP)	FIELD PERMEABILITY TEST LOCATION		ACCESS ROAD
	CONTROL POINT	℞	PROPERTY LINE (APPROX.)
℞	SURVEY POINT		CENTERLINE OF EXISTING ROAD
	METAL TRANSMISSION TOWER		PROPOSED UTILITY WASTE DISPOSAL AREA FOOTPRINT
	EXISTING POWER POLE	G	EXISTING MISSOURI PIPELINE
	CULVERT	UT	EXISTING UNDERGROUND UTILITIES
415.0	GROUND WATER ELEVATION (FT.)	FO	EXISTING FIBER OPTIC
415.0	GROUNDWATER CONTOUR NOTE: CONTOUR INTERVAL (C.I.)=0.5 FT.	OE	EXISTING OVERHEAD ELECTRIC

NOTES

1. GROUNDWATER DATA NOT AVAILABLE FOR TEMPORARY BORINGS.
2. MEASUREMENTS RECORDED BY REITZ & JENS.
3. USE OF SMALL CONTOUR INTERVAL (0.5 FT.) EXAGGERATES APPARENT "SLOPE" OF WATER TABLE SURFACE.
4. MAP REPRESENTATIVE OF GROUNDWATER CONDITIONS OCCURRING ON DATE OF MEASUREMENT: SEPTEMBER 13, 2005.
5. GROUNDWATER ELEVATION READINGS FOR PZ-2 AND PZ-57 WERE BELIEVED TO BE ANOMALOUS AND THEREFORE WERE NOT INCLUDED IN WATER TABLE SURFACE MAP.
6. HYDRAULIC GRADIENTS CALCULATED USING GROUNDWATER ELEVATIONS MEASURED IN PIEZOMETERS PZ-4, PZ-21, PZ-10, PZ-36, PZ-50 AND PZ-40.

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REITZ & JENS, INC. CONSULTING ENGINEERS
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GREDELL Engineering Resources, Inc.
ENVIRONMENTAL ENGINEERING
LAND AIR WATER

PREPARED FOR AmerenUE

DRAWN 080806 W.J.A. (G.E.R.)	FIGURE 21 DETAILED SITE INVESTIGATION PROPOSED UTILITY WASTE DISPOSAL AREA WATER TABLE SURFACE MAP - SEPTEMBER 2005
CHKD. A.R.C. (G.E.R.)	
SUPV. D.E.K. (G.E.R.)	
APPD. D.E.K. (G.E.R.)	LOCATION 001009 — SIOUX PLANT — CLASS 02010
AmerenUE ST. LOUIS, MISSOURI	8430-Y-0168601-22 — REV.

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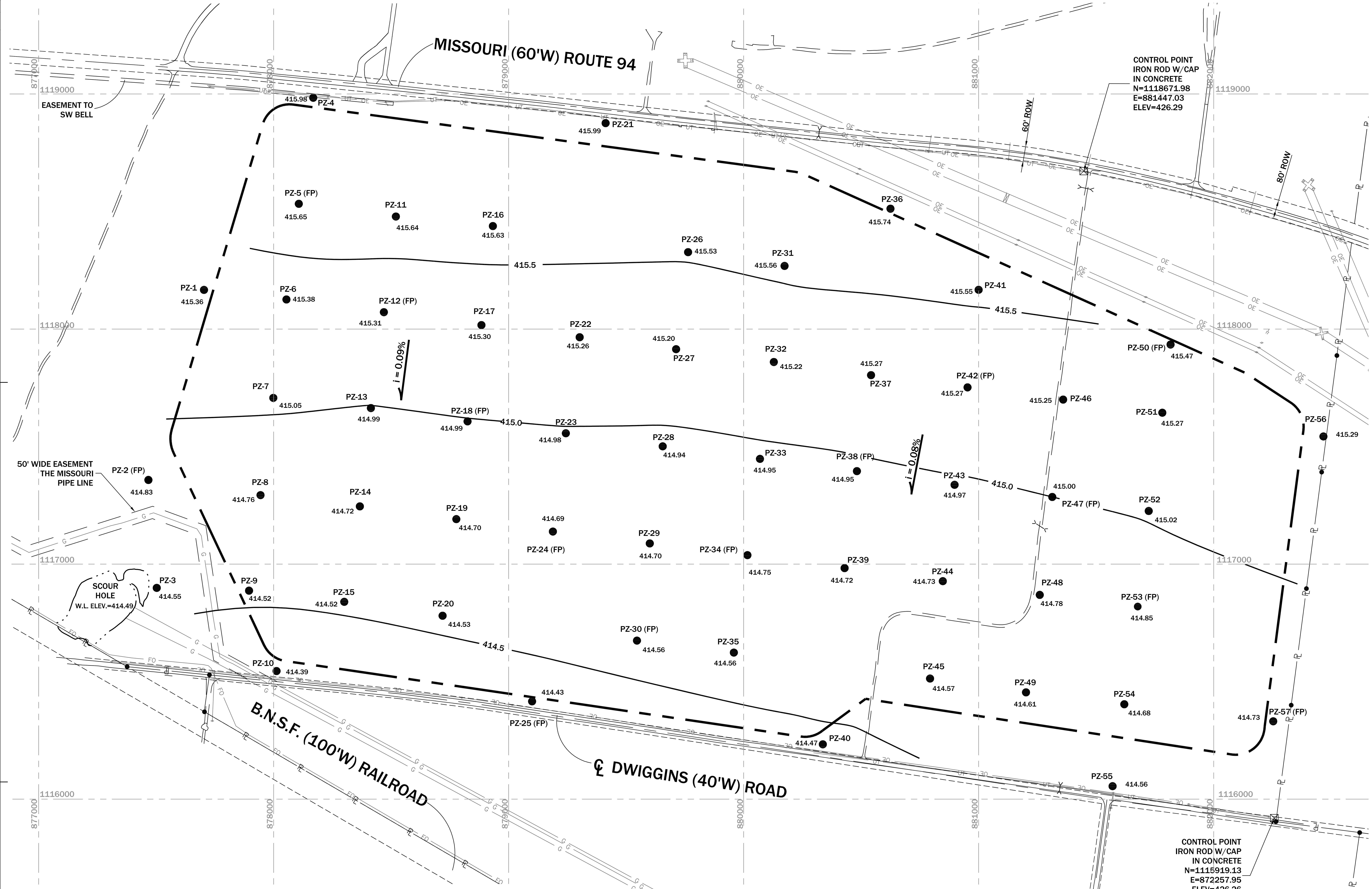

LEGEND

PZ ●	PIEZOMETER BORING (57)		PAVED ROAD
B	TEMPORARY BORING (54)	i = 0.08%	HYDRAULIC GRADIENT (%)
B	TEMPORARY BORING (DEEP) (3)		GROUNDWATER FLOW DIRECTION
(FP) ●	FIELD PERMEABILITY TEST LOCATION		ACCESS ROAD
	CONTROL POINT	℞	PROPERTY LINE (APPROX.)
	℞ SURVEY POINT		CENTERLINE OF EXISTING ROAD
	METAL TRANSMISSION TOWER		PROPOSED UTILITY WASTE DISPOSAL AREA FOOTPRINT
	EXISTING POWER POLE	G	EXISTING MISSOURI PIPELINE
	CULVERT	UT	EXISTING UNDERGROUND UTILITIES
415.0	GROUND WATER ELEVATION (FT.)	FO	EXISTING FIBER OPTIC
415.0	GROUNDWATER CONTOUR NOTE: CONTOUR INTERVAL (C.I.)=0.5 FT.	OE	EXISTING OVERHEAD ELECTRIC

NOTES

1. GROUNDWATER DATA NOT AVAILABLE FOR TEMPORARY BORINGS.
2. MEASUREMENTS RECORDED BY REITZ & JENS, INC.
3. USE OF SMALL CONTOUR INTERVAL (0.5 FT.) EXAGGERATES APPARENT "SLOPE" OF WATER TABLE SURFACE.
4. MAP REPRESENTATIVE OF GROUNDWATER CONDITIONS OCCURRING ON DATE OF MEASUREMENT: OCTOBER 11, 2005.
5. HYDRAULIC GRADIENTS CALCULATED USING GROUNDWATER ELEVATIONS MEASURED IN PIEZOMETERS PZ-4, PZ-21, PZ-10, PZ-36, PZ-50 AND PZ-40.

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GREDELL Engineering Resources, Inc. ENVIRONMENTAL ENGINEERING LAND AIR WATER

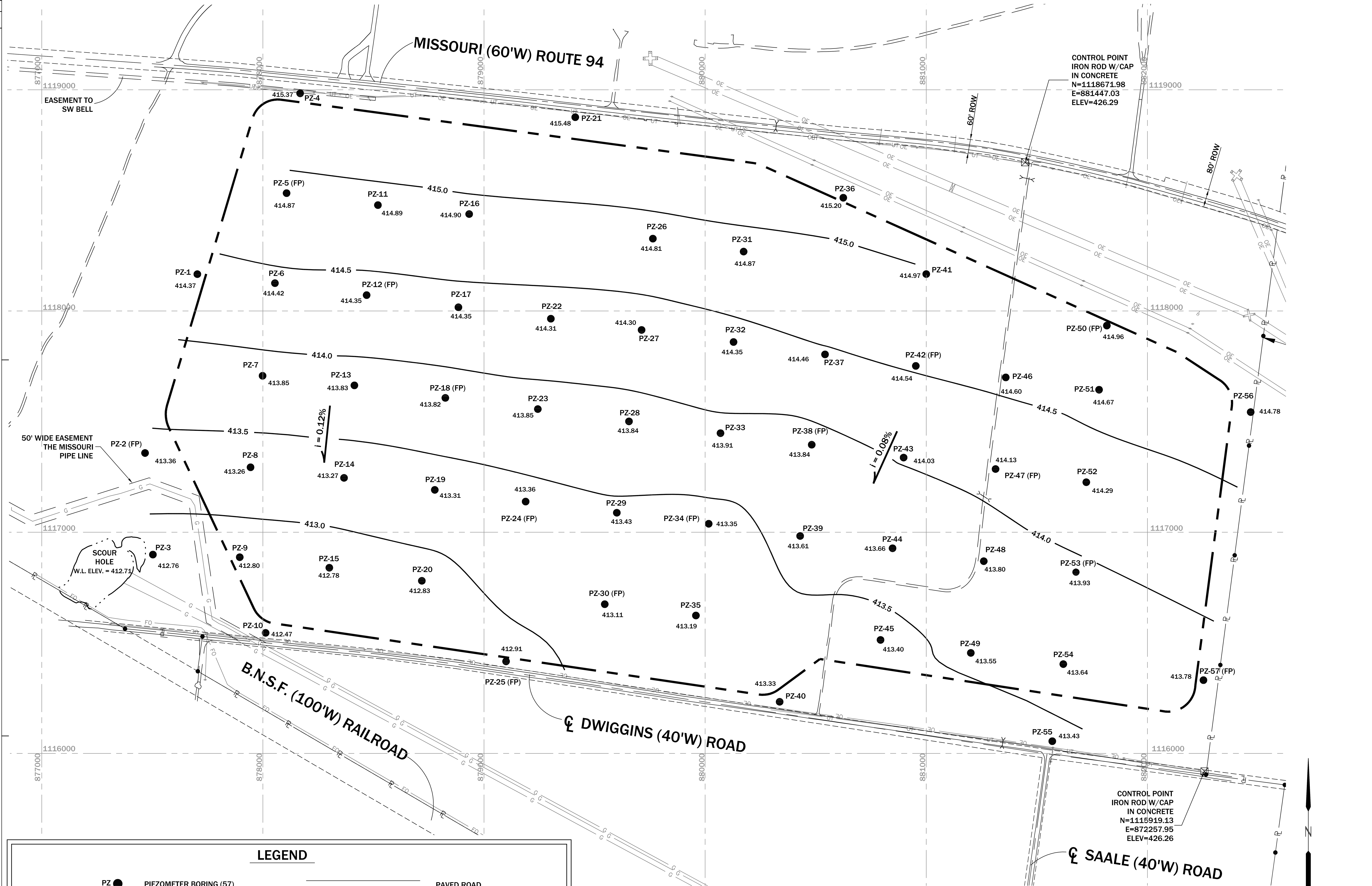
PREPARED FOR AmerenUE

DRAWN 080806 W.J.A. (G.E.R.)
CHKD. A.R.C. (G.E.R.)
SUPV. D.E.K. (G.E.R.)
APPD. D.E.K. (G.E.R.)

FIGURE 22
DETAILED SITE INVESTIGATION
PROPOSED UTILITY WASTE DISPOSAL AREA
WATER TABLE SURFACE MAP - OCTOBER 2005

LOCATION 001009 SIOUX PLANT CLASS 02010

AmerenUE ST. LOUIS, MISSOURI 8430-Y-0168601-23 REV.



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LEGEND

- PZ ● PIEZOMETER BORING (57)
- B TEMPORARY BORING (54)
- B TEMPORARY BORING (DEEP) (3)
- (FP) ● FIELD PERMEABILITY TEST LOCATION
- CONTROL POINT
- ℞ SURVEY POINT
- METAL TRANSMISSION TOWER
- EXISTING POWER POLE
- CULVERT
- 415.0 GROUND WATER ELEVATION (FT.)
- 415.0 GROUNDWATER CONTOUR NOTE: CONTOUR INTERVAL (C.I.)=0.5 FT.
- PAVED ROAD
- i = 0.08% HYDRAULIC GRADIENT (%)
- GROUNDWATER FLOW DIRECTION
- ACCESS ROAD
- ℞ PROPERTY LINE (APPROX.)
- CENTERLINE OF EXISTING ROAD
- PROPOSED UTILITY WASTE DISPOSAL AREA FOOTPRINT
- G EXISTING MISSOURI PIPELINE
- UT EXISTING UNDERGROUND UTILITIES
- FO EXISTING FIBER OPTIC
- OE EXISTING OVERHEAD ELECTRIC

NOTES

1. GROUNDWATER DATA NOT AVAILABLE FOR TEMPORARY BORINGS.
2. MEASUREMENTS RECORDED BY REITZ & JENS.
3. USE OF SMALL CONTOUR INTERVAL (0.5 FT.) EXAGGERATES APPARENT "SLOPE" OF WATER TABLE SURFACE.
4. MAP REPRESENTATIVE OF GROUNDWATER CONDITIONS OCCURRING ON DATE OF MEASUREMENT: NOVEMBER 10, 2005.
5. HYDRAULIC GRADIENTS CALCULATED USING GROUNDWATER ELEVATIONS MEASURED IN PIEZOMETERS PZ-4, PZ-21, PZ-10, PZ-36, PZ-50 AND PZ-40.

THE GEOLOGIST WHO REVIEWED AND APPROVED THIS REPORT ASSUMES RESPONSIBILITY ONLY FOR GEOLOGIC INTERPRETATIONS OF DATA APPEARING ON THE PAGE AND DISCLAIMS PURSUANT TO SECTION 256.456 RSMO ANY RESPONSIBILITY FOR ALL OTHER PLANS, SPECIFICATIONS, ESTIMATES, REPORTS OR OTHER DOCUMENTS OR INSTRUMENTS NOT PREPARED UNDER THE SUPERVISION OF THE GEOLOGIST RELATING TO OR INTENDED TO BE USED FOR ANY PART OR PARTS OF THE PROJECT TO WHICH THIS FIGURE REFERS.

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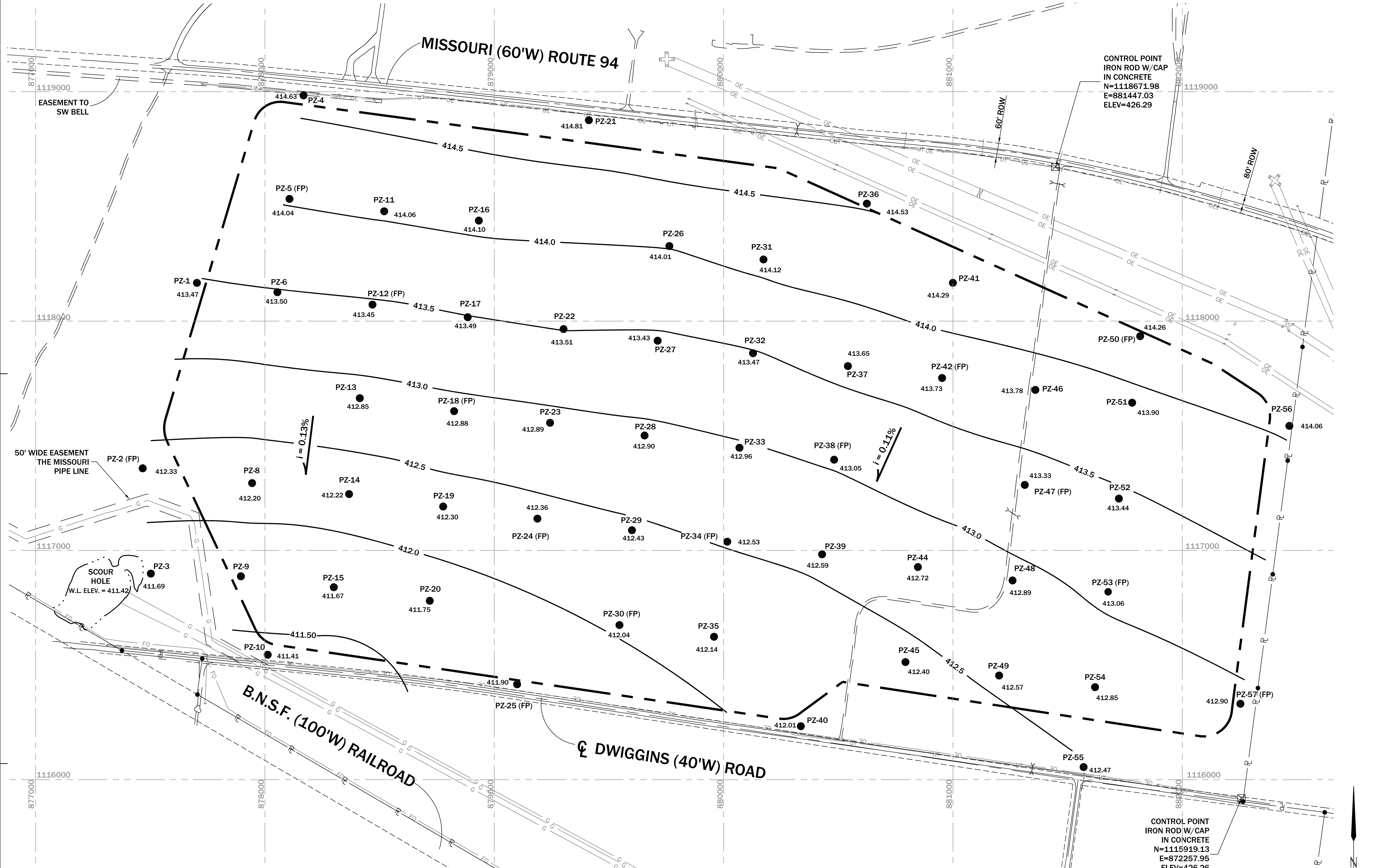
Facsimile: (573) 659-9079

PREPARED FOR AmerenUE

DRAWN 080806 W.J.A. (G.E.R.)	FIGURE 23 DETAILED SITE INVESTIGATION PROPOSED UTILITY WASTE DISPOSAL AREA WATER TABLE SURFACE MAP - NOVEMBER 2005
CHKD. A.R.C. (G.E.R.)	
SUPV. D.E.K. (G.E.R.)	
APPD. D.E.K. (G.E.R.)	LOCATION 001009 — SIOUX PLANT — CLASS 02010
AmerenUE ST. LOUIS, MISSOURI	8430-Y-0168601-24 — REV.



LEGEND

PZ ●	PIEZOMETER BORING (57)		PAVED ROAD
B	TEMPORARY BORING (54)	i = 0.08%	HYDRAULIC GRADIENT (%)
B	TEMPORARY BORING (DEEP) (3)		GROUNDWATER FLOW DIRECTION
(FP) ●	FIELD PERMEABILITY TEST LOCATION		ACCESS ROAD
⊠	CONTROL POINT	℞	PROPERTY LINE (APPROX.)
•	℞ SURVEY POINT		CENTERLINE OF EXISTING ROAD
	METAL TRANSMISSION TOWER		PROPOSED UTILITY WASTE DISPOSAL AREA FOOTPRINT
	EXISTING POWER POLE	G	EXISTING MISSOURI PIPELINE
	CULVERT		
415.0	GROUND WATER ELEVATION (FT.)	UT	EXISTING UNDERGROUND UTILITIES
		FO	EXISTING FIBER OPTIC
415.0	GROUNDWATER CONTOUR NOTE: CONTOUR INTERVAL (C.I.)=0.5 FT.	OE	EXISTING OVERHEAD ELECTRIC

NOTES

1. GROUNDWATER DATA NOT AVAILABLE FOR TEMPORARY BORINGS.
2. MEASUREMENTS RECORDED BY REITZ & JENS.
3. USE OF SMALL CONTOUR INTERVAL (0.5 FT.) EXAGGERATES APPARENT "SLOPE" OF WATER TABLE SURFACE.
4. MAP REPRESENTATIVE OF GROUNDWATER CONDITIONS OCCURRING ON DATE OF MEASUREMENT: DECEMBER 9, 2005.
5. HYDRAULIC GRADIENTS CALCULATED USING GROUNDWATER ELEVATIONS MEASURED IN PIEZOMETERS PZ-4, PZ-21, PZ-10, PZ-36, PZ-50 AND PZ-40.
6. GROUNDWATER ELEVATION READINGS FOR PZ-7 AND PZ-43 WERE BELIEVED TO BE ANOMALOUS AND THEREFORE WERE NOT INCLUDED IN WATER TABLE SURFACE MAP.

THE GEOLOGIST WHO REVIEWED AND APPROVED THIS REPORT ASSUMES RESPONSIBILITY ONLY FOR GEOLOGIC INTERPRETATIONS OF DATA APPEARING ON THE PAGE AND DISCLAIMS PURSUANT TO SECTION 256.456 RSMO ANY RESPONSIBILITY FOR ALL OTHER PLANS, SPECIFICATIONS, ESTIMATES, REPORTS OR OTHER DOCUMENTS OR INSTRUMENTS NOT PREPARED UNDER THE SUPERVISION OF THE GEOLOGIST RELATING TO OR INTENDED TO BE USED FOR ANY PART OR PARTS OF THE PROJECT TO WHICH THIS FIGURE REFERS.

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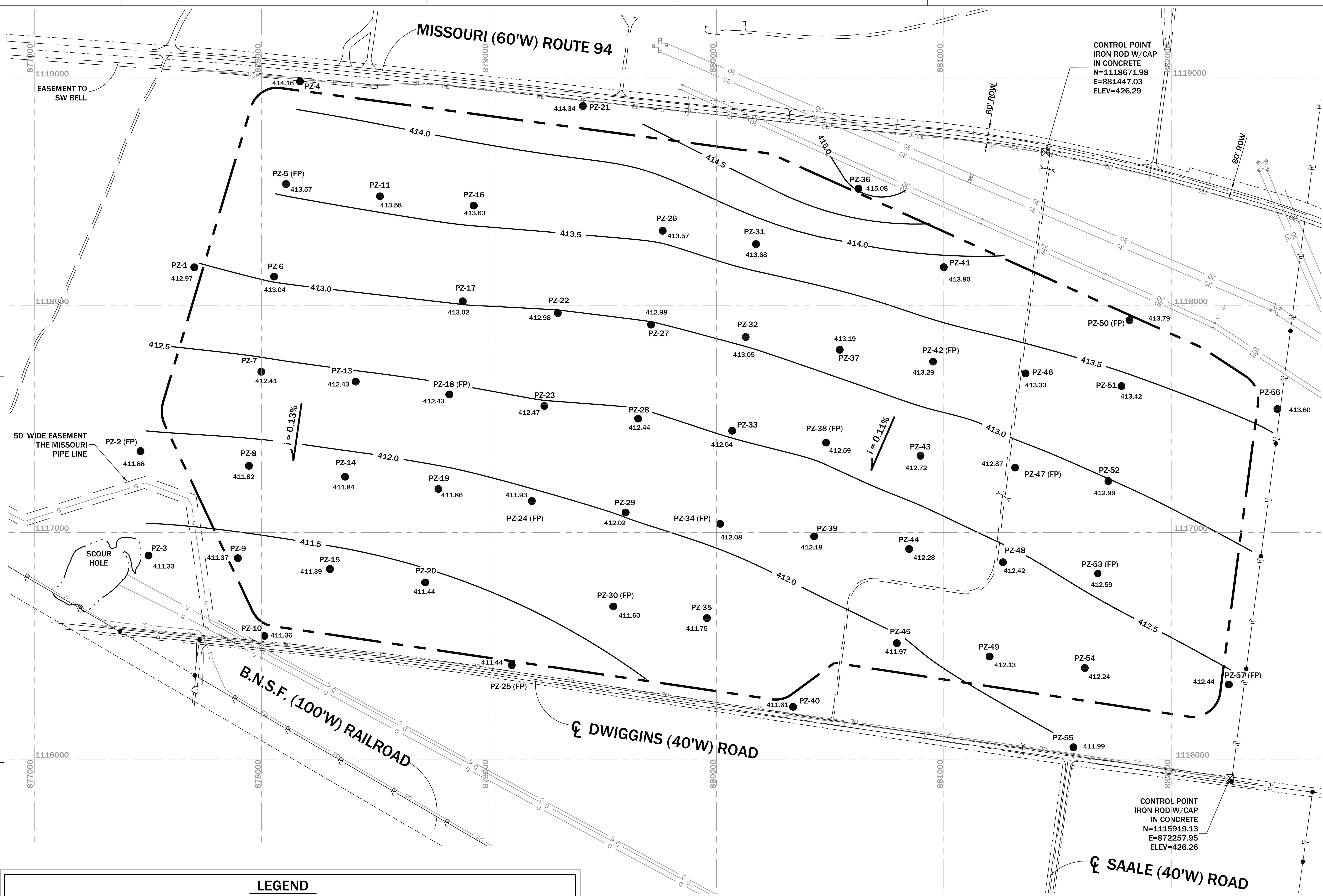
DRAWN 080806 W.J.A. (G.E.R.)	FIGURE 24 DETAILED SITE INVESTIGATION PROPOSED UTILITY WASTE DISPOSAL AREA WATER TABLE SURFACE MAP - DECEMBER 2005
CHKD. A.R.C. (G.E.R.)	
SUPV. D.E.K. (G.E.R.)	
APPD. D.E.K. (G.E.R.)	LOCATION 001009 — SIOUX PLANT — CLASS 02010
AmerenUE ST. LOUIS, MISSOURI	8430-Y-0168601-25 — REV.



LEGEND

PZ ●	PIEZOMETER BORING (57)		PAVED ROAD
B	TEMPORARY BORING (54)	i = 0.08%	HYDRAULIC GRADIENT (%)
B	TEMPORARY BORING (DEEP) (3)		GROUNDWATER FLOW DIRECTION
(FP) ●	FIELD PERMEABILITY TEST LOCATION		ACCESS ROAD
⊠	CONTROL POINT	℞	PROPERTY LINE (APPROX.)
●	℞ SURVEY POINT		CENTERLINE OF EXISTING ROAD
	METAL TRANSMISSION TOWER		PROPOSED UTILITY WASTE DISPOSAL AREA FOOTPRINT
	EXISTING POWER POLE	G	EXISTING MISSOURI PIPELINE
	CULVERT	UT	EXISTING UNDERGROUND UTILITIES
415.0	GROUND WATER ELEVATION (FT.)	FO	EXISTING FIBER OPTIC
415.0	GROUNDWATER CONTOUR NOTE: CONTOUR INTERVAL (C.I.)=0.5 FT.	OE	EXISTING OVERHEAD ELECTRIC

NOTES

1. GROUNDWATER DATA NOT AVAILABLE FOR TEMPORARY BORINGS.
2. MEASUREMENTS RECORDED BY REITZ & JENS.
3. USE OF SMALL CONTOUR INTERVAL (0.5 FT.) EXAGGERATES APPARENT "SLOPE" OF WATER TABLE SURFACE.
4. MAP REPRESENTATIVE OF GROUNDWATER CONDITIONS OCCURRING ON DATE OF MEASUREMENT: JANUARY 6, 2006.
5. GROUNDWATER ELEVATION READING FOR PZ-12 WAS BELIEVED TO BE ANOMALOUS AND THEREFORE WAS NOT INCLUDED IN WATER TABLE SURFACE MAP.
6. HYDRAULIC GRADIENTS CALCULATED USING GROUNDWATER ELEVATIONS MEASURED IN PIEZOMETERS PZ-4, PZ-21, PZ-10, PZ-36, PZ-50 AND PZ-40.
7. ELEVATION DATA FOR "SCOUR HOLE" WAS NOT AVAILABLE FOR DATE OF GROUNDWATER MEASUREMENTS.

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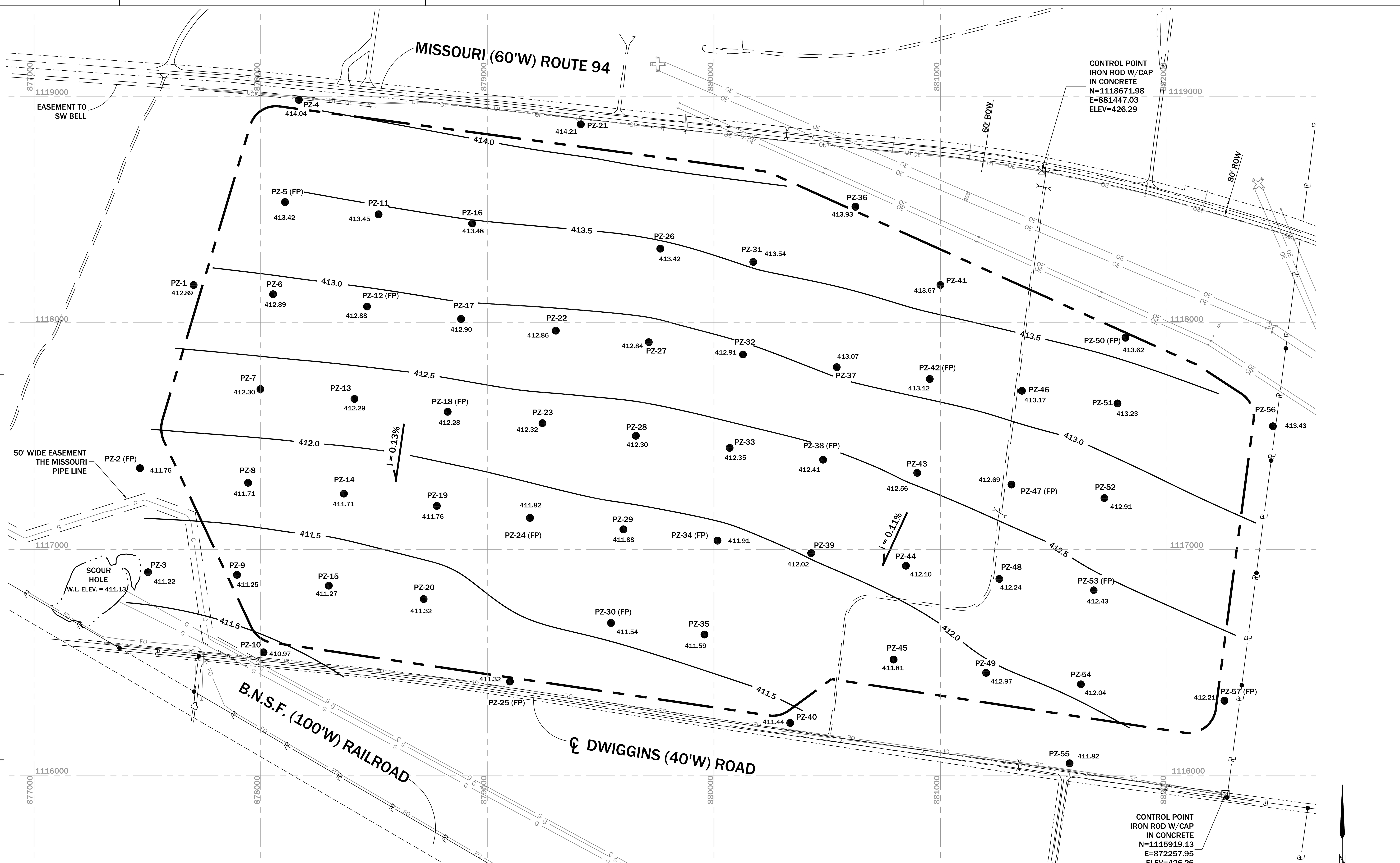
DRAWN 080806 W.J.A. (G.E.R.)	FIGURE 25 DETAILED SITE INVESTIGATION PROPOSED UTILITY WASTE DISPOSAL AREA WATER TABLE SURFACE MAP - JANUARY 2006
CHKD. A.R.C. (G.E.R.)	
SUPV. D.E.K. (G.E.R.)	
APPD. D.E.K. (G.E.R.)	LOCATION 001009 — SIOUX PLANT — CLASS 02010
AmerenUE ST. LOUIS, MISSOURI	8430-Y-0168601-26 — REV.



LEGEND

PZ ●	PIEZOMETER BORING (57)		PAVED ROAD
B	TEMPORARY BORING (54)	i = 0.08%	HYDRAULIC GRADIENT (%)
B	TEMPORARY BORING (DEEP) (3)		GROUNDWATER FLOW DIRECTION
(FP) ●	FIELD PERMEABILITY TEST LOCATION		ACCESS ROAD
	CONTROL POINT	℄	PROPERTY LINE (APPROX.)
℄	SURVEY POINT		CENTERLINE OF EXISTING ROAD
	METAL TRANSMISSION TOWER		PROPOSED UTILITY WASTE DISPOSAL AREA FOOTPRINT
	EXISTING POWER POLE	G	EXISTING MISSOURI PIPELINE
	CULVERT	UT	EXISTING UNDERGROUND UTILITIES
415.0	GROUND WATER ELEVATION (FT.)	FO	EXISTING FIBER OPTIC
415.0	GROUNDWATER CONTOUR NOTE: CONTOUR INTERVAL (C.I.)=0.5 FT.	OE	EXISTING OVERHEAD ELECTRIC

NOTES

1. GROUNDWATER DATA NOT AVAILABLE FOR TEMPORARY BORINGS.
2. MEASUREMENTS RECORDED BY REITZ & JENS.
3. USE OF SMALL CONTOUR INTERVAL (0.5 FT.) EXAGGERATES APPARENT "SLOPE" OF WATER TABLE SURFACE.
4. MAP REPRESENTATIVE OF GROUNDWATER CONDITIONS OCCURRING ON DATE OF MEASUREMENT: FEBRUARY 2, 2006.
5. HYDRAULIC GRADIENTS CALCULATED USING GROUNDWATER ELEVATIONS MEASURED IN PIEZOMETERS PZ-4, PZ-21, PZ-10, PZ-36, PZ-50 AND PZ-40.

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PREPARED FOR AmerenUE

DRAWN 080806 W.J.A. (G.E.R.)	FIGURE 26 DETAILED SITE INVESTIGATION PROPOSED UTILITY WASTE DISPOSAL AREA WATER TABLE SURFACE MAP - FEBRUARY 2006
CHKD. A.R.C. (G.E.R.)	
SUPV. D.E.K. (G.E.R.)	
APPD. D.E.K. (G.E.R.)	LOCATION 001009 — SIOUX PLANT — CLASS 02010

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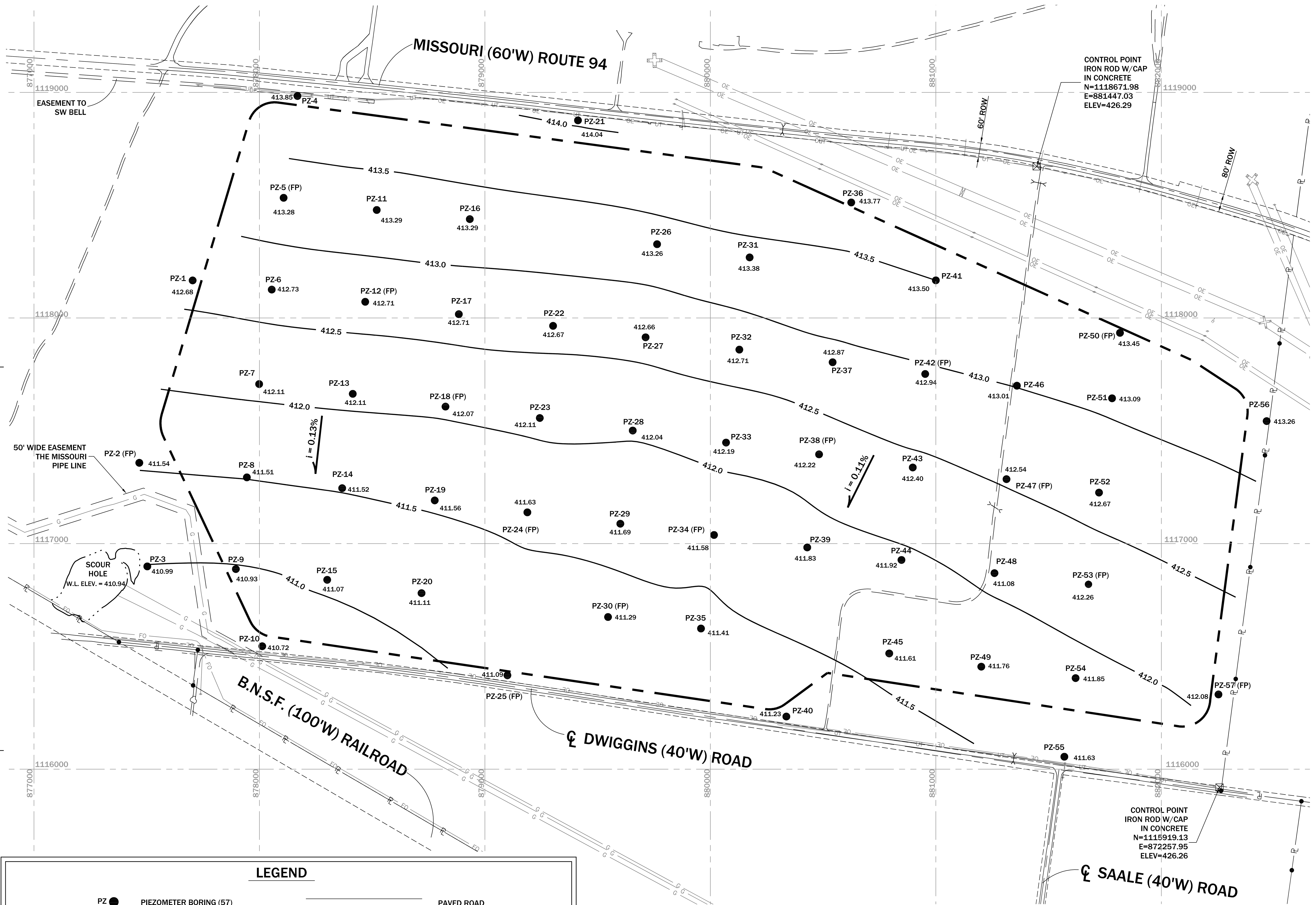

LEGEND

PZ ●	PIEZOMETER BORING (57)		PAVED ROAD
B	TEMPORARY BORING (54)	i = 0.08%	HYDRAULIC GRADIENT (%)
B	TEMPORARY BORING (DEEP) (3)		GROUNDWATER FLOW DIRECTION
(FP) ●	FIELD PERMEABILITY TEST LOCATION		ACCESS ROAD
	CONTROL POINT	℄	PROPERTY LINE (APPROX.)
℄	SURVEY POINT		CENTERLINE OF EXISTING ROAD
	METAL TRANSMISSION TOWER		PROPOSED UTILITY WASTE DISPOSAL AREA FOOTPRINT
	EXISTING POWER POLE	G	EXISTING MISSOURI PIPELINE
	CULVERT	UT	EXISTING UNDERGROUND UTILITIES
415.0	GROUND WATER ELEVATION (FT.)	FO	EXISTING FIBER OPTIC
415.0	GROUNDWATER CONTOUR NOTE: CONTOUR INTERVAL (C.I.)=0.5 FT.	OE	EXISTING OVERHEAD ELECTRIC

NOTES

1. GROUNDWATER DATA NOT AVAILABLE FOR TEMPORARY BORINGS.
2. MEASUREMENTS RECORDED BY REITZ & JENS.
3. USE OF SMALL CONTOUR INTERVAL (0.5 FT.) EXAGGERATES APPARENT "SLOPE" OF WATER TABLE SURFACE.
4. MAP REPRESENTATIVE OF GROUNDWATER CONDITIONS OCCURRING ON DATE OF MEASUREMENT: MARCH 6, 2006.
5. HYDRAULIC GRADIENTS CALCULATED USING GROUNDWATER ELEVATIONS MEASURED IN PIEZOMETERS PZ-4, PZ-21, PZ-10, PZ-36, PZ-50 AND PZ-40.

SCALE: 1" = 200'

0 100 200 400

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DRAWN 080806 W.J.A. (G.E.R.)	FIGURE 27 DETAILED SITE INVESTIGATION PROPOSED UTILITY WASTE DISPOSAL AREA WATER TABLE SURFACE MAP - MARCH 2006
CHKD. A.R.C. (G.E.R.)	
SUPV. D.E.K. (G.E.R.)	
APPD. D.E.K. (G.E.R.)	LOCATION 001009 — SIOUX PLANT — CLASS 02010
AmerenUE ST. LOUIS, MISSOURI	8430-Y-0168601-28 — REV.

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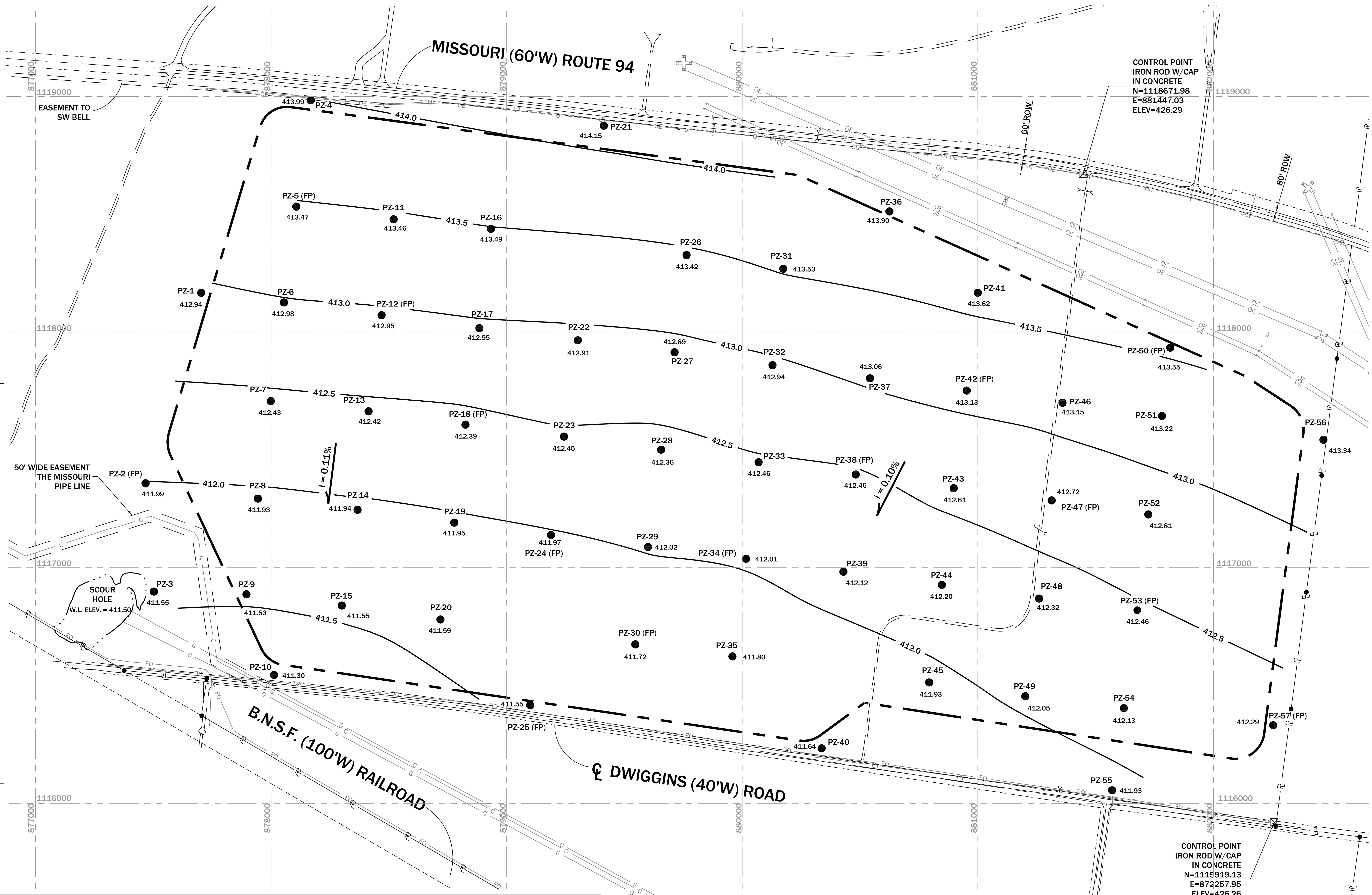

LEGEND

PZ ●	PIEZOMETER BORING (57)		PAVED ROAD
B	TEMPORARY BORING (54)	i = 0.08%	HYDRAULIC GRADIENT (%)
B ◎	TEMPORARY BORING (DEEP) (3)		GROUNDWATER FLOW DIRECTION
(FP) ●	FIELD PERMEABILITY TEST LOCATION		ACCESS ROAD
⊠	CONTROL POINT	℄	PROPERTY LINE (APPROX.)
•	℄ SURVEY POINT		CENTERLINE OF EXISTING ROAD
	METAL TRANSMISSION TOWER		PROPOSED UTILITY WASTE DISPOSAL AREA FOOTPRINT
	EXISTING POWER POLE	G	EXISTING MISSOURI PIPELINE
	CULVERT	UT	EXISTING UNDERGROUND UTILITIES
415.0	GROUND WATER ELEVATION (FT.)	FO	EXISTING FIBER OPTIC
415.0	GROUNDWATER CONTOUR NOTE: CONTOUR INTERVAL (C.I.)=0.5 FT.	OE	EXISTING OVERHEAD ELECTRIC

NOTES

1. GROUNDWATER DATA NOT AVAILABLE FOR TEMPORARY BORINGS.
2. MEASUREMENTS RECORDED BY REITZ & JENS.
3. USE OF SMALL CONTOUR INTERVAL (0.5 FT.) EXAGGERATES APPARENT "SLOPE" OF WATER TABLE SURFACE.
4. MAP REPRESENTATIVE OF GROUNDWATER CONDITIONS OCCURRING ON DATE OF MEASUREMENT: APRIL 4, 2006.
5. HYDRAULIC GRADIENTS CALCULATED USING GROUNDWATER ELEVATIONS MEASURED IN PIEZOMETERS PZ-4, PZ-21, PZ-10, PZ-36, PZ-50 AND PZ-40.

SCALE: 1" = 200'
0 100 200 400

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DRAWN 080806 W.J.A. (G.E.R.)	FIGURE 28 DETAILED SITE INVESTIGATION PROPOSED UTILITY WASTE DISPOSAL AREA WATER TABLE SURFACE MAP - APRIL 2006
CHKD. A.R.C. (G.E.R.)	
SUPV. D.E.K. (G.E.R.)	
APPD. D.E.K. (G.E.R.)	LOCATION 001009 — SIOUX PLANT — CLASS 02010
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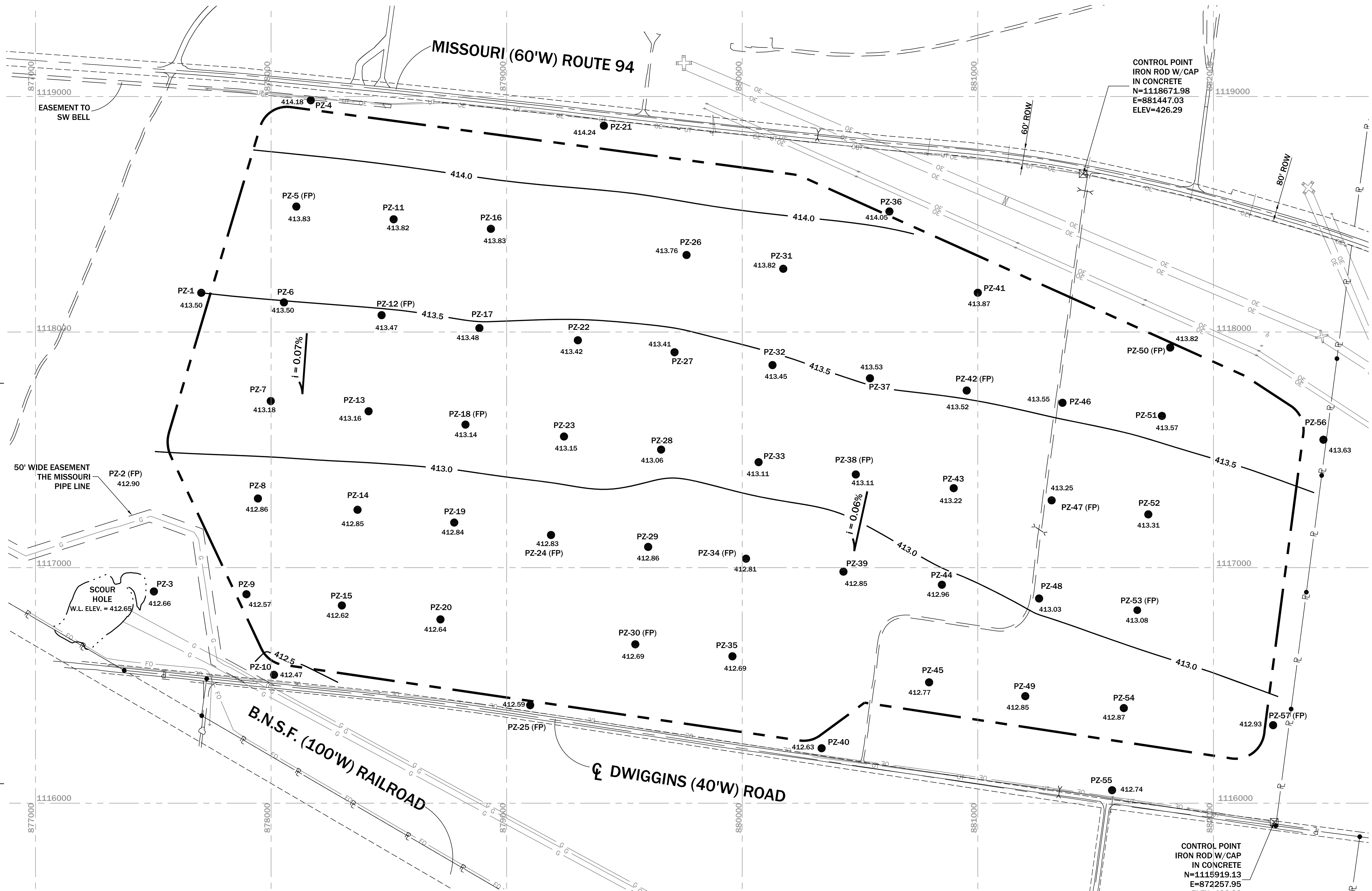

LEGEND

PZ ●	PIEZOMETER BORING (57)		PAVED ROAD
B	TEMPORARY BORING (54)	i = 0.08%	HYDRAULIC GRADIENT (%)
B	TEMPORARY BORING (DEEP) (3)		GROUNDWATER FLOW DIRECTION
(FP) ●	FIELD PERMEABILITY TEST LOCATION		ACCESS ROAD
	CONTROL POINT	℄	PROPERTY LINE (APPROX.)
•	℄ SURVEY POINT		CENTERLINE OF EXISTING ROAD
	METAL TRANSMISSION TOWER		PROPOSED UTILITY WASTE DISPOSAL AREA FOOTPRINT
	EXISTING POWER POLE	G	EXISTING MISSOURI PIPELINE
	CULVERT	UT	EXISTING UNDERGROUND UTILITIES
415.0	GROUND WATER ELEVATION (FT.)	FO	EXISTING FIBER OPTIC
415.0	GROUNDWATER CONTOUR NOTE: CONTOUR INTERVAL (C.I.)=0.5 FT.	OE	EXISTING OVERHEAD ELECTRIC

NOTES

1. GROUNDWATER DATA NOT AVAILABLE FOR TEMPORARY BORINGS.
2. MEASUREMENTS RECORDED BY REITZ & JENS.
3. USE OF SMALL CONTOUR INTERVAL (0.5 FT.) EXAGGERATES APPARENT "SLOPE" OF WATER TABLE SURFACE.
4. MAP REPRESENTATIVE OF GROUNDWATER CONDITIONS OCCURRING ON DATE OF MEASUREMENT: MAY 1, 2006.
5. HYDRAULIC GRADIENTS CALCULATED USING GROUNDWATER ELEVATIONS MEASURED IN PIEZOMETERS PZ-4, PZ-21, PZ-10, PZ-36, PZ-50 AND PZ-40.

SCALE: 1" = 200'
0 100 200 400

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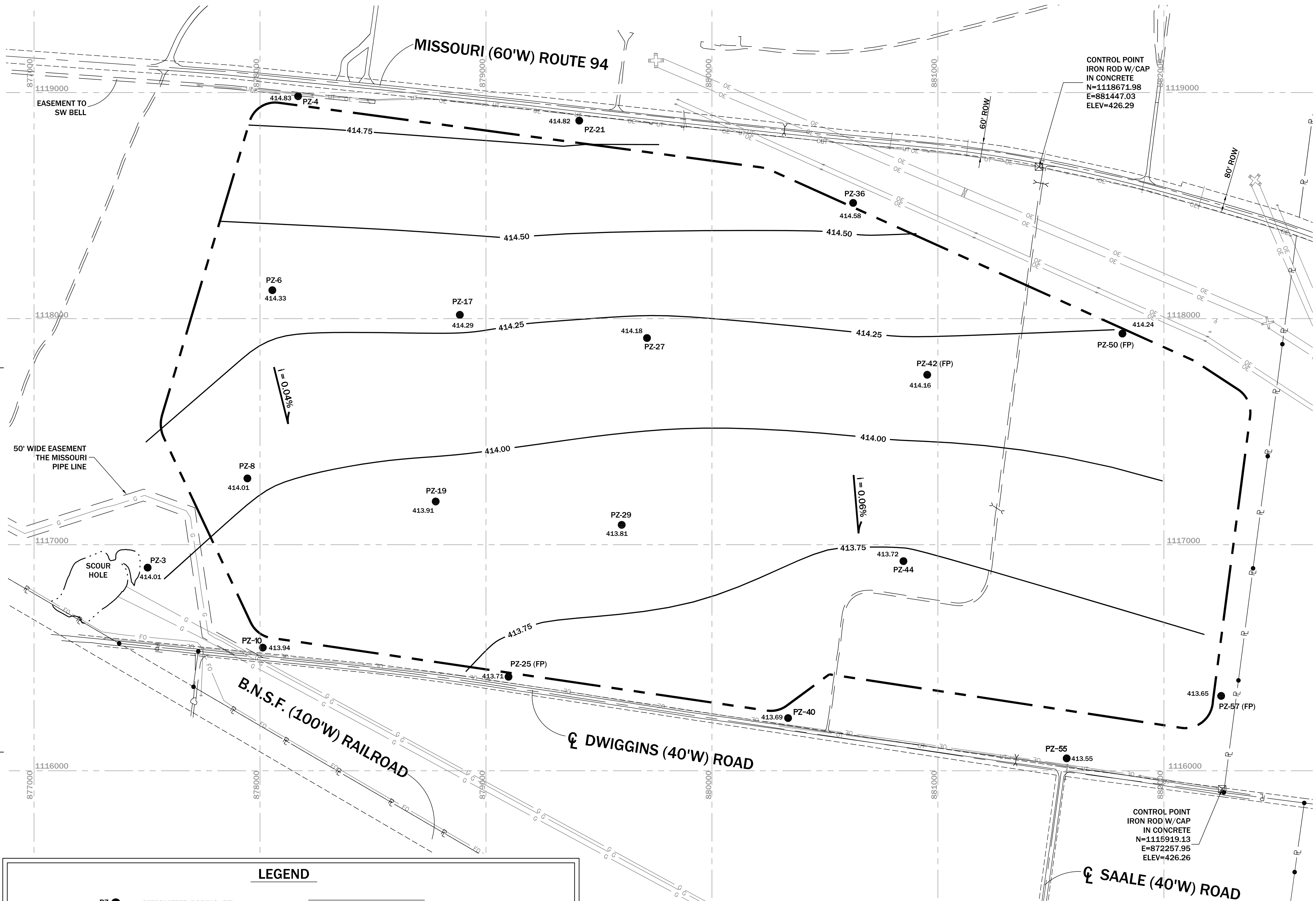
DRAWN 080806 W.J.A. (G.E.R.)	FIGURE 29 DETAILED SITE INVESTIGATION PROPOSED UTILITY WASTE DISPOSAL AREA WATER TABLE SURFACE MAP - MAY 2006		
CHKD. A.R.C. (G.E.R.)			
SUPV. D.E.K. (G.E.R.)			
APPD. D.E.K. (G.E.R.)	LOCATION 001009	SIOUX PLANT	CLASS 02010
AmerenUE ST. LOUIS, MISSOURI	8430-Y-0168601-30		REV.



LEGEND

PZ	PIEZOMETER BORING (57)		PAVED ROAD
B	TEMPORARY BORING (54)	i = 0.08%	HYDRAULIC GRADIENT (%)
B	TEMPORARY BORING (DEEP) (3)		GROUNDWATER FLOW DIRECTION
(FP)	FIELD PERMEABILITY TEST LOCATION		ACCESS ROAD
	CONTROL POINT	℞	PROPERTY LINE (APPROX.)
℞	SURVEY POINT		CENTERLINE OF EXISTING ROAD
	METAL TRANSMISSION TOWER		PROPOSED UTILITY WASTE DISPOSAL AREA FOOTPRINT
	EXISTING POWER POLE	G	EXISTING MISSOURI PIPELINE
	CULVERT	UT	EXISTING UNDERGROUND UTILITIES
415.0	GROUND WATER ELEVATION (FT.)	FO	EXISTING FIBER OPTIC
415.0	GROUNDWATER CONTOUR NOTE: CONTOUR INTERVAL (C.I.)=0.25 FT.	OE	EXISTING OVERHEAD ELECTRIC

NOTES

1. GROUNDWATER DATA NOT AVAILABLE FOR TEMPORARY BORINGS.
2. MEASUREMENTS RECORDED BY REITZ & JENS.
3. USE OF SMALL CONTOUR INTERVAL (0.25 FT.) EXAGGERATES APPARENT "SLOPE" OF WATER TABLE SURFACE.
4. MAP REPRESENTATIVE OF GROUNDWATER CONDITIONS OCCURRING ON DATE OF MEASUREMENT: MAY 15, 2006.
5. HYDRAULIC GRADIENTS CALCULATED USING GROUNDWATER ELEVATIONS MEASURED IN PIEZOMETERS PZ-4, PZ-21, PZ-10, PZ-36, PZ-50 AND PZ-40.
6. ELEVATION DATA FOR "SCOUR HOLE" WAS NOT AVAILABLE FOR DATE OF GROUNDWATER MEASURMENTS.

SCALE: 1" = 200'
0 100 200 400

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DRAWN 080806 W.J.A. (G.E.R.)	FIGURE 30 DETAILED SITE INVESTIGATION PROPOSED UTILITY WASTE DISPOSAL AREA ACCELERATED GROUNDWATER MONITORING
CHKD. A.R.C. (G.E.R.)	
SUPV. D.E.K. (G.E.R.)	
APPD. D.E.K. (G.E.R.)	LOCATION 001009 — SIOUX PLANT — CLASS 02010
AmerenUE ST. LOUIS, MISSOURI	8430-Y-0168601-31 — REV.

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LEGEND

PZ ●	PIEZOMETER BORING (57)		PAVED ROAD
B	TEMPORARY BORING (54)	i = 0.08%	HYDRAULIC GRADIENT (%)
B	TEMPORARY BORING (DEEP) (3)		GROUNDWATER FLOW DIRECTION
(FP) ●	FIELD PERMEABILITY TEST LOCATION		ACCESS ROAD
	CONTROL POINT	℄	PROPERTY LINE (APPROX.)
℄	SURVEY POINT		CENTERLINE OF EXISTING ROAD
	METAL TRANSMISSION TOWER		PROPOSED UTILITY WASTE DISPOSAL AREA FOOTPRINT
	EXISTING POWER POLE	G	EXISTING MISSOURI PIPELINE
	CULVERT	UT	EXISTING UNDERGROUND UTILITIES
415.0	GROUND WATER ELEVATION (FT.)	FO	EXISTING FIBER OPTIC
415.0	GROUNDWATER CONTOUR NOTE: CONTOUR INTERVAL (C.I.)=0.5 FT.	OE	EXISTING OVERHEAD ELECTRIC

NOTES

1. GROUNDWATER DATA NOT AVAILABLE FOR TEMPORARY BORINGS.
2. MEASUREMENTS RECORDED BY REITZ & JENS.
3. USE OF SMALL CONTOUR INTERVAL (0.5FT.) EXAGGERATES APPARENT "SLOPE" OF WATER TABLE SURFACE.
4. MAP REPRESENTATIVE OF GROUNDWATER CONDITIONS OCCURRING ON DATE OF MEASUREMENT: JUNE 1, 2006.
5. HYDRAULIC GRADIENTS CALCULATED USING GROUNDWATER ELEVATIONS MEASURED IN PIEZOMETERS PZ-4, PZ-21, PZ-10, PZ-36, PZ-50 AND PZ-40.
6. GROUNDWATER ELEVATION READING FOR PZ-1 WAS BELIEVED TO BE ANOMALOUS AND THEREFORE WAS NOT INCLUDED IN WATER TABLE SURFACE MAP.

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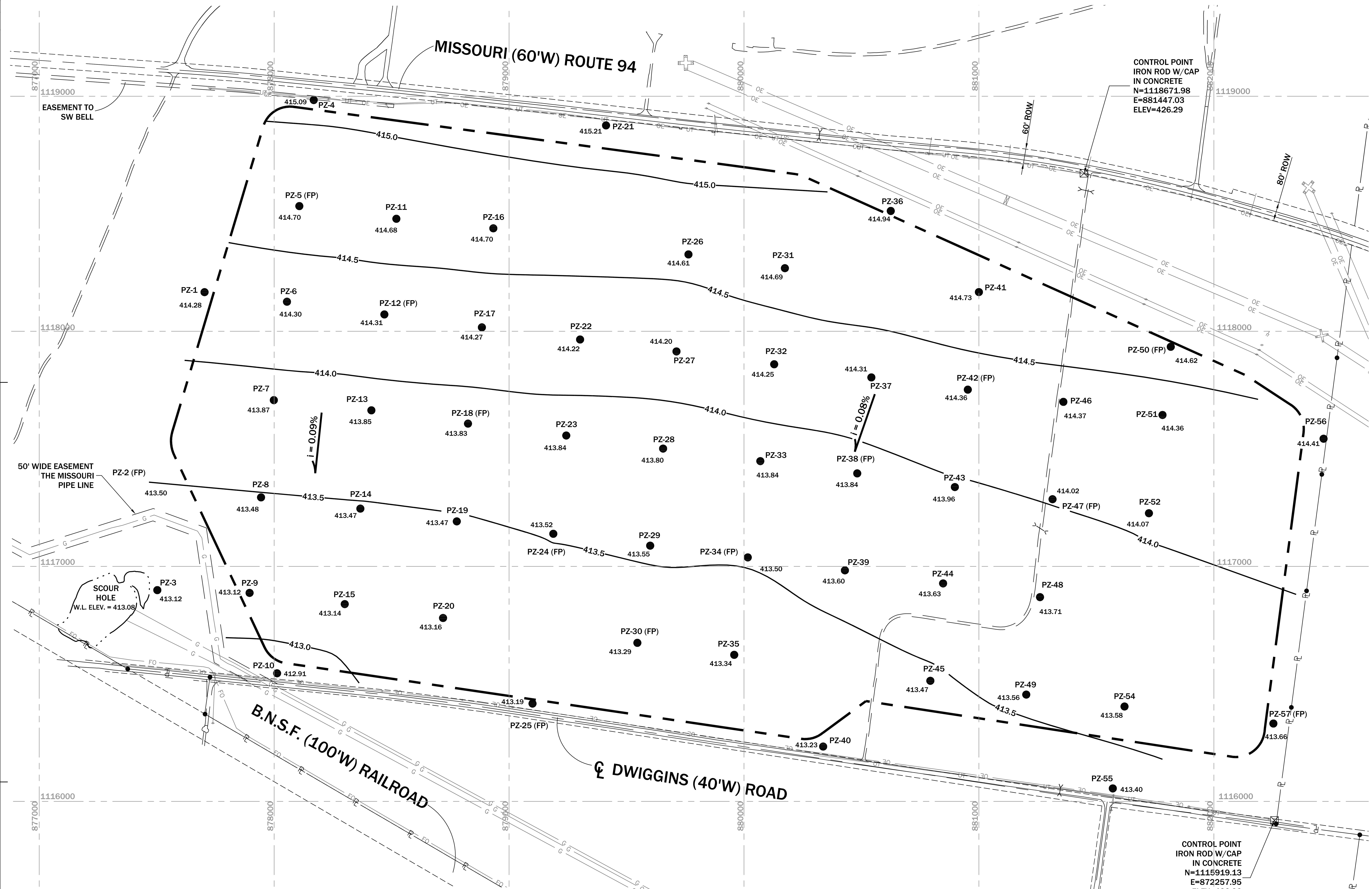
DRAWN 080806 W.J.A. (G.E.R.)	FIGURE 31 DETAILED SITE INVESTIGATION PROPOSED UTILITY WASTE DISPOSAL AREA WATER TABLE SURFACE MAP - JUNE 2006
CHKD. A.R.C. (G.E.R.)	
SUPV. D.E.K. (G.E.R.)	
APPD. D.E.K. (G.E.R.)	LOCATION 001009 — SIOUX PLANT — CLASS 02010
AmerenUE ST. LOUIS, MISSOURI	8430-Y-0168601-32 — REV.



LEGEND

PZ	PIEZOMETER BORING (57)		PAVED ROAD
B	TEMPORARY BORING (54)	i = 0.08%	HYDRAULIC GRADIENT (%)
B	TEMPORARY BORING (DEEP) (3)		GROUNDWATER FLOW DIRECTION
(FP)	FIELD PERMEABILITY TEST LOCATION		ACCESS ROAD
	CONTROL POINT	℄	PROPERTY LINE (APPROX.)
℄	SURVEY POINT		CENTERLINE OF EXISTING ROAD
	METAL TRANSMISSION TOWER		PROPOSED UTILITY WASTE DISPOSAL AREA FOOTPRINT
	EXISTING POWER POLE	G	EXISTING MISSOURI PIPELINE
	CULVERT	UT UT	EXISTING UNDERGROUND UTILITIES
415.0	GROUND WATER ELEVATION (FT.)	FO	EXISTING FIBER OPTIC
415.0	GROUNDWATER CONTOUR NOTE: CONTOUR INTERVAL (C.I.)=0.5 FT.	OE OE	EXISTING OVERHEAD ELECTRIC

NOTES

1. GROUNDWATER DATA NOT AVAILABLE FOR TEMPORARY BORINGS.
2. MEASUREMENTS RECORDED BY REITZ & JENS.
3. USE OF SMALL CONTOUR INTERVAL (0.5 FT.) EXAGGERATES APPARENT "SLOPE" OF WATER TABLE SURFACE.
4. MAP REPRESENTATIVE OF GROUNDWATER CONDITIONS OCCURRING ON DATE OF MEASUREMENT: JULY 3, 2006.
5. HYDRAULIC GRADIENTS CALCULATED USING GROUNDWATER ELEVATIONS MEASURED IN PIEZOMETERS PZ-4, PZ-21, PZ-10, PZ-36, PZ-50 AND PZ-40.
6. GROUNDWATER ELEVATION READING FOR PZ-53 WAS BELIEVED TO BE ANOMALOUS AND THEREFORE WAS NOT INCLUDED IN WATER TABLE SURFACE MAP.

SCALE: 1" = 200'
0 100 200 400

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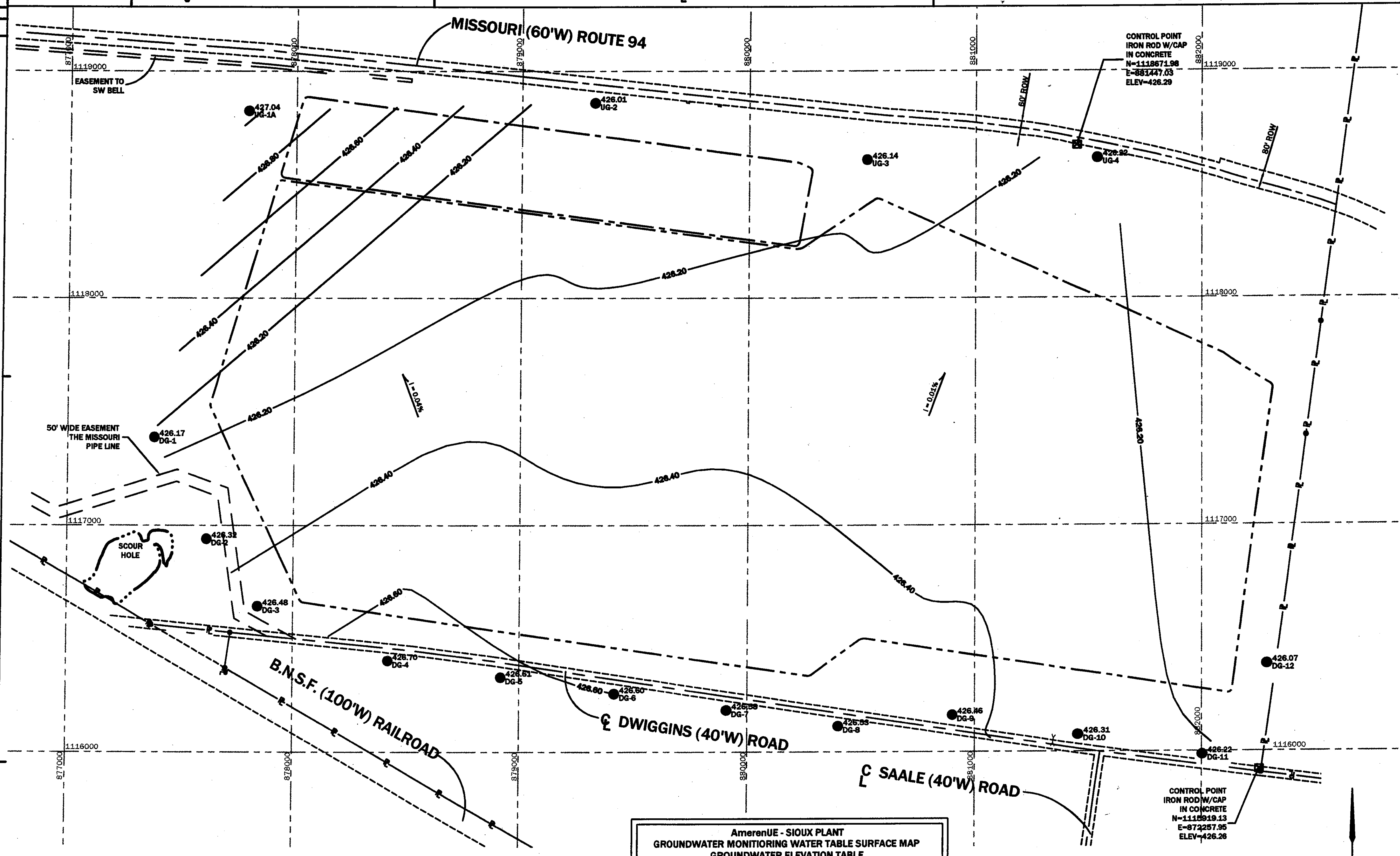
FIGURE 32
DETAILED SITE INVESTIGATION
PROPOSED UTILITY WASTE DISPOSAL AREA
WATER TABLE SURFACE MAP - JULY 2006

DRAWN 080806 W.J.A. (G.E.R.)			
CHKD. A.R.C. (G.E.R.)			
SUPV. D.E.K. (G.E.R.)			
APPD. D.E.K. (G.E.R.)	LOCATION 001009	SIOUX PLANT	CLASS 02010
AmerenUE ST. LOUIS, MISSOURI		8430-Y-0168601-33	REV.



LEGEND

- UG-XX PIEZOMETER LOCATIONS DG-XX
- CONTROL POINT
- ℞ SURVEY POINT
- METAL TRANSMISSION TOWER
- EXISTING POWER POLE
- CULVERT
- 415.0 GROUND WATER ELEVATION (FT.)
- 415.0 GROUNDWATER CONTOUR NOTE: CONTOUR INTERVAL (C.I.)=0.5 FT.
- FO EXISTING FIBER OPTIC
- OE EXISTING OVERHEAD ELECTRIC
- PAVED ROAD
- i = 0.08% HYDRAULIC GRADIENT (%)
- GROUNDWATER FLOW DIRECTION
- ACCESS ROAD
- ℞ PROPERTY LINE (APPROX.)
- CENTERLINE OF EXISTING ROAD
- PROPOSED UTILITY WASTE DISPOSAL AREA FOOTPRINT
- PROPOSED NPDES RECYCLE POND PERMIT
- G EXISTING MISSOURI PIPELINE
- UT UT EXISTING UNDERGROUND UTILITIES

AmerenUE - SIOUX PLANT
GROUNDWATER MONITIORING WATER TABLE SURFACE MAP
GROUNDWATER ELEVATION TABLE

Ameren Sioux Power Plant Elevations for Contour Map

Well ID	Groundwater Elevation NGVD 2Q08	Groundwater Elevation NGVD 3Q08	Groundwater Elevation NGVD 4Q08	Groundwater Elevation NGVD 1Q09
DG-1	426.17	418.75	418.31	415.52
DG-2	426.32	418.34	418.09	415.06
DG-3	426.48	418.14	417.90	414.84
DG-4	426.70	417.89	417.83	414.72
DG-5	426.61	418.01	417.84	414.79
DG-6	426.60	418.15	417.86	414.87
DG-7	426.58	418.31	418.04	415.01
DG-8	426.53	418.44	418.12	415.10
DG-9	426.46	418.85	418.15	415.36
DG-10	426.31	418.85	418.24	415.54
DG-11	426.22	419.03	418.24	415.60
DG-12	426.07	419.44	418.40	415.90
UG-1A	427.04	419.92	419.12	416.95
UG-2	426.01	419.66	418.69	416.67
UG-3	426.14	420.25	419.19	417.15
UG-4	426.22	420.44	419.30	417.39

NOTES

1. USE OF SMALL CONTOUR INTERVAL (0.2 FT.) EXAGGERATES APPARENT "SLOPE" OF WATER TABLE SURFACE.
2. MAP REPRESENTATIVE OF GROUNDWATER CONDITIONS OCCURRING ON DATE OF MEASUREMENT: JUNE 28, 2008.
3. ELEVATION DATA FOR "SCOUR HOLE" NOT AVAILABLE FOR DATE OF GROUNDWATER MEASUREMENTS.

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SUPV. J.B.F. (G.E.R.)
APPD. J.B.F. (G.E.R.)

GROUNDWATER CONTOUR MAP
PROPOSED UTILITY WASTE DISPOSAL AREA
WATER TABLE SURFACE MAP
JUNE 28, 2008

LOCATION 001009 | SIOUX PLANT | CLASS 02010

AmerenUE | ST. LOUIS, MISSOURI | FIGURE 2 | REV.

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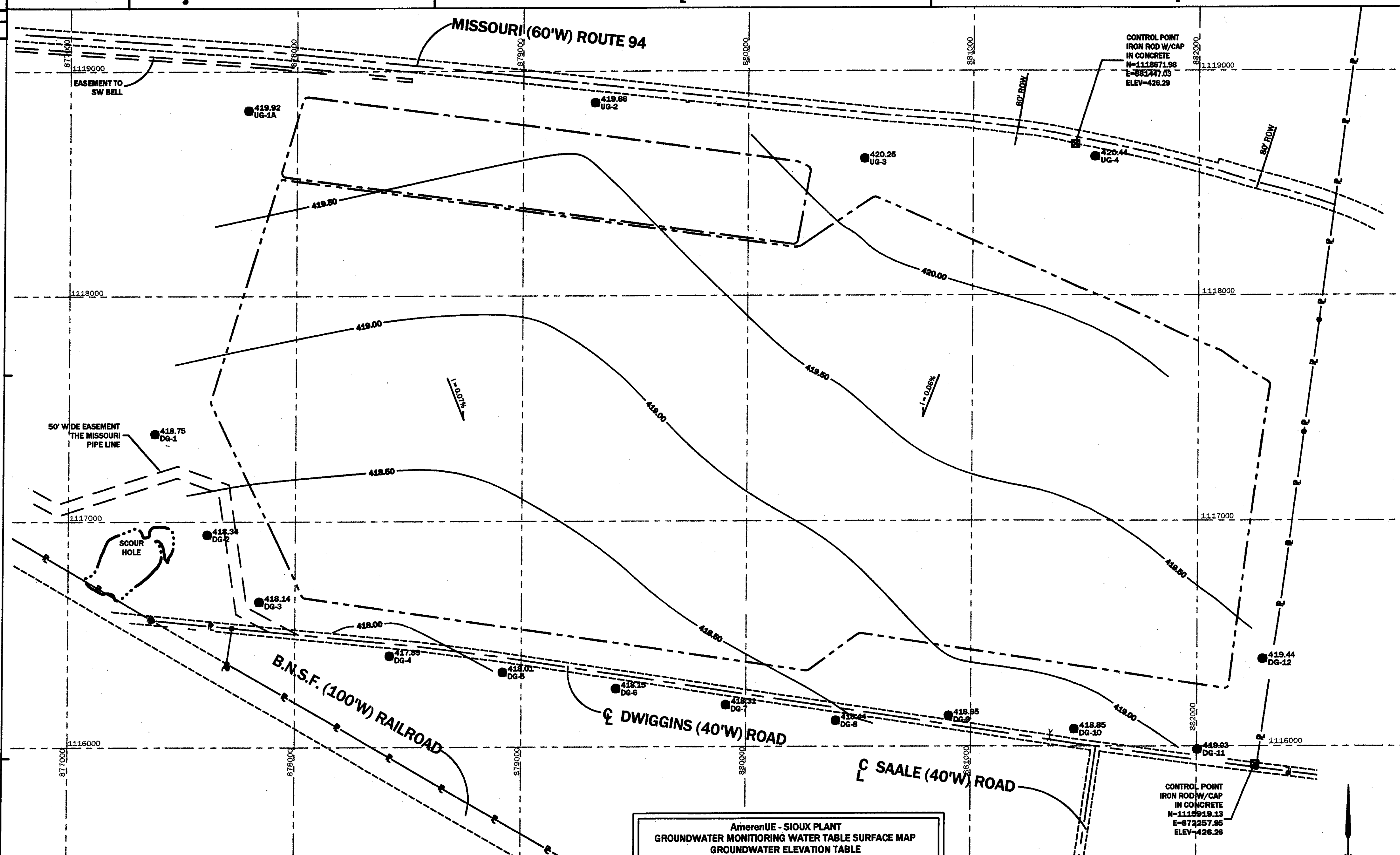

AmerenUE - SIOUX PLANT
GROUNDWATER MONITIORING WATER TABLE SURFACE MAP
GROUNDWATER ELEVATION TABLE

Ameren Sioux Power Plant Elevations for Contour Map

Well ID	Groundwater Elevation NGVD 2Q08	Groundwater Elevation NGVD 3Q08	Groundwater Elevation NGVD 4Q08	Groundwater Elevation NGVD 1Q09
DG-1	426.17	418.75	418.31	415.52
DG-2	426.32	418.34	418.09	415.06
DG-3	426.48	418.14	417.90	414.84
DG-4	426.70	417.89	417.83	414.72
DG-5	426.61	418.01	417.84	414.79
DG-6	426.60	418.15	417.86	414.87
DG-7	426.58	418.31	418.04	415.01
DG-8	426.53	418.44	418.12	415.10
DG-9	426.46	418.85	418.15	415.36
DG-10	426.31	418.85	418.24	415.54
DG-11	426.22	419.03	418.24	415.60
DG-12	426.07	419.44	418.40	415.90
UG-1A	427.04	419.92	419.12	416.95
UG-2	426.01	419.66	418.69	416.67
UG-3	426.14	420.25	419.19	417.15
UG-4	426.22	420.44	419.30	417.39

LEGEND

- UG-XX PIEZOMETER LOCATIONS DG-XX
- CONTROL POINT
- ℄ SURVEY POINT
- METAL TRANSMISSION TOWER
- EXISTING POWER POLE
- CULVERT
- 415.0 GROUND WATER ELEVATION (FT.)
- 415.0 GROUNDWATER CONTOUR NOTE: CONTOUR INTERVAL (C.I.)=0.5 FT.
- FO EXISTING FIBER OPTIC
- OE EXISTING OVERHEAD ELECTRIC
- PAVED ROAD
- i = 0.08% HYDRAULIC GRADIENT (%)
- GROUNDWATER FLOW DIRECTION
- ACCESS ROAD
- ℄ PROPERTY LINE (APPROX.)
- CENTERLINE OF EXISTING ROAD
- PROPOSED UTILITY WASTE DISPOSAL AREA FOOTPRINT
- PROPOSED NPDES RECYCLE POND PERMIT
- G EXISTING MISSOURI PIPELINE
- UT UT EXISTING UNDERGROUND UTILITIES

NOTES

1. USE OF SMALL CONTOUR INTERVAL (0.5 FT.) EXAGGERATES APPARENT "SLOPE" OF WATER TABLE SURFACE.
2. MAP REPRESENTATIVE OF GROUNDWATER CONDITIONS OCCURRING ON DATE OF MEASUREMENT:AUGUST 28, 2008.
3. ELEVATION DATA FOR "SCOUR HOLE" NOT AVAILABLE FOR DATE OF GROUNDWATER MEASUREMENTS.

SCALE: 1" = 200'
0 100 200 400

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REITZ & JENS, INC. CONSULTING ENGINEERS
1055 CORPORATE SQUARE DRIVE
ST. LOUIS, MISSOURI 63132
314.993.4132 (voice) 314.993.4177 (fax)

GREDELL Engineering Resources, Inc.
ENVIRONMENTAL ENGINEERING
LAND AIR WATER

PREPARED FOR AmerenUE

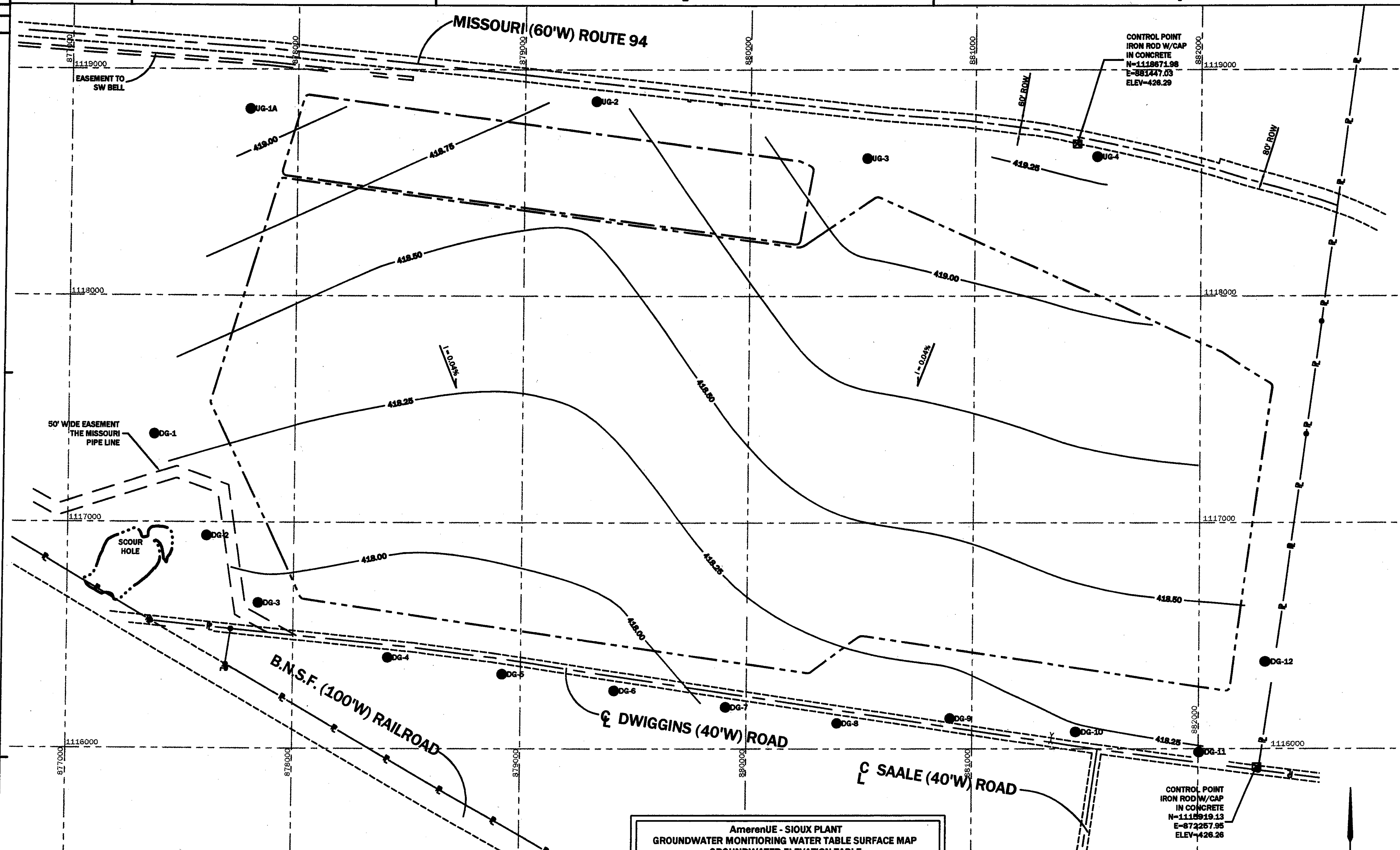
DRAWN 081308 W.J.A. (G.E.R.)
CHKD. A.R.C. (G.E.R.)
SUPV. J.B.F. (G.E.R.)
APPD. J.B.F. (G.E.R.)

GROUNDWATER CONTOUR MAP
PROPOSED UTILITY WASTE DISPOSAL AREA
WATER TABLE SURFACE MAP
AUGUST 28, 2008

LOCATION 001009 | SIOUX PLANT | CLASS 02010

AmerenUE | ST. LOUIS, MISSOURI | FIGURE 3 | REV.

AMEREN_00001524



LEGEND

- UG-XX DG-XX — PIEZOMETER LOCATIONS
- CONTROL POINT
- ℄ SURVEY POINT
- METAL TRANSMISSION TOWER
- EXISTING POWER POLE
- CULVERT
- 415.0 — GROUND WATER ELEVATION (FT.)
- 415.0 — GROUNDWATER CONTOUR NOTE: CONTOUR INTERVAL (C.I.)=0.5 FT.
- FO — EXISTING FIBER OPTIC
- OE — EXISTING OVERHEAD ELECTRIC
- PAVED ROAD
- I = 0.08% — HYDRAULIC GRADIENT (%)
- GROUNDWATER FLOW DIRECTION
- ACCESS ROAD
- ℄ — PROPERTY LINE (APPROX.)
- CENTERLINE OF EXISTING ROAD
- PROPOSED UTILITY WASTE DISPOSAL AREA FOOTPRINT
- PROPOSED NPDES RECYCLE POND PERMIT
- G — EXISTING MISSOURI PIPELINE
- UT — EXISTING UNDERGROUND UTILITIES

AmerenUE - SIOUX PLANT
GROUNDWATER MONITIORING WATER TABLE SURFACE MAP
GROUNDWATER ELEVATION TABLE

Ameren Sioux Power Plant Elevations for Contour Map

Well ID	Groundwater Elevation NGVD 2Q08	Groundwater Elevation NGVD 3Q08	Groundwater Elevation NGVD 4Q08	Groundwater Elevation NGVD 1Q09
DG-1	426.17	418.75	418.31	415.52
DG-2	426.32	418.34	418.09	415.06
DG-3	426.48	418.14	417.90	414.84
DG-4	426.70	417.89	417.83	414.72
DG-5	426.61	418.01	417.84	414.79
DG-6	426.60	418.15	417.86	414.87
DG-7	426.58	418.31	418.04	415.01
DG-8	426.53	418.44	418.12	415.10
DG-9	426.46	418.85	418.15	415.36
DG-10	426.31	418.85	418.24	415.54
DG-11	426.22	419.03	418.24	415.60
DG-12	426.07	419.44	418.40	415.90
UG-1A	427.04	419.92	419.12	416.95
UG-2	426.01	419.66	418.69	416.67
UG-3	426.14	420.25	419.19	417.15
UG-4	426.22	420.44	419.30	417.39

NOTES

1. USE OF SMALL CONTOUR INTERVAL (0.25 FT.) EXAGGERATES APPARENT "SLOPE" OF WATER TABLE SURFACE.
2. MAP REPRESENTATIVE OF GROUNDWATER CONDITIONS OCCURRING ON DATE OF MEASUREMENT: NOVEMBER 5, 2008.
3. ELEVATION DATA FOR "SCOUR HOLE" NOT AVAILABLE FOR DATE OF GROUNDWATER MEASUREMENTS.

SCALE: 1" = 200'

0 100 200 400

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REITZ & JENS, INC. CONSULTING ENGINEERS
1055 CORPORATE SQUARE DRIVE
ST. LOUIS, MISSOURI 63132

GREDELL Engineering Resources, Inc.
ENVIRONMENTAL ENGINEERING
LAND AIR WATER

PREPARED FOR AmerenUE

DRAWN 081308 W.J.A. (G.E.R.)
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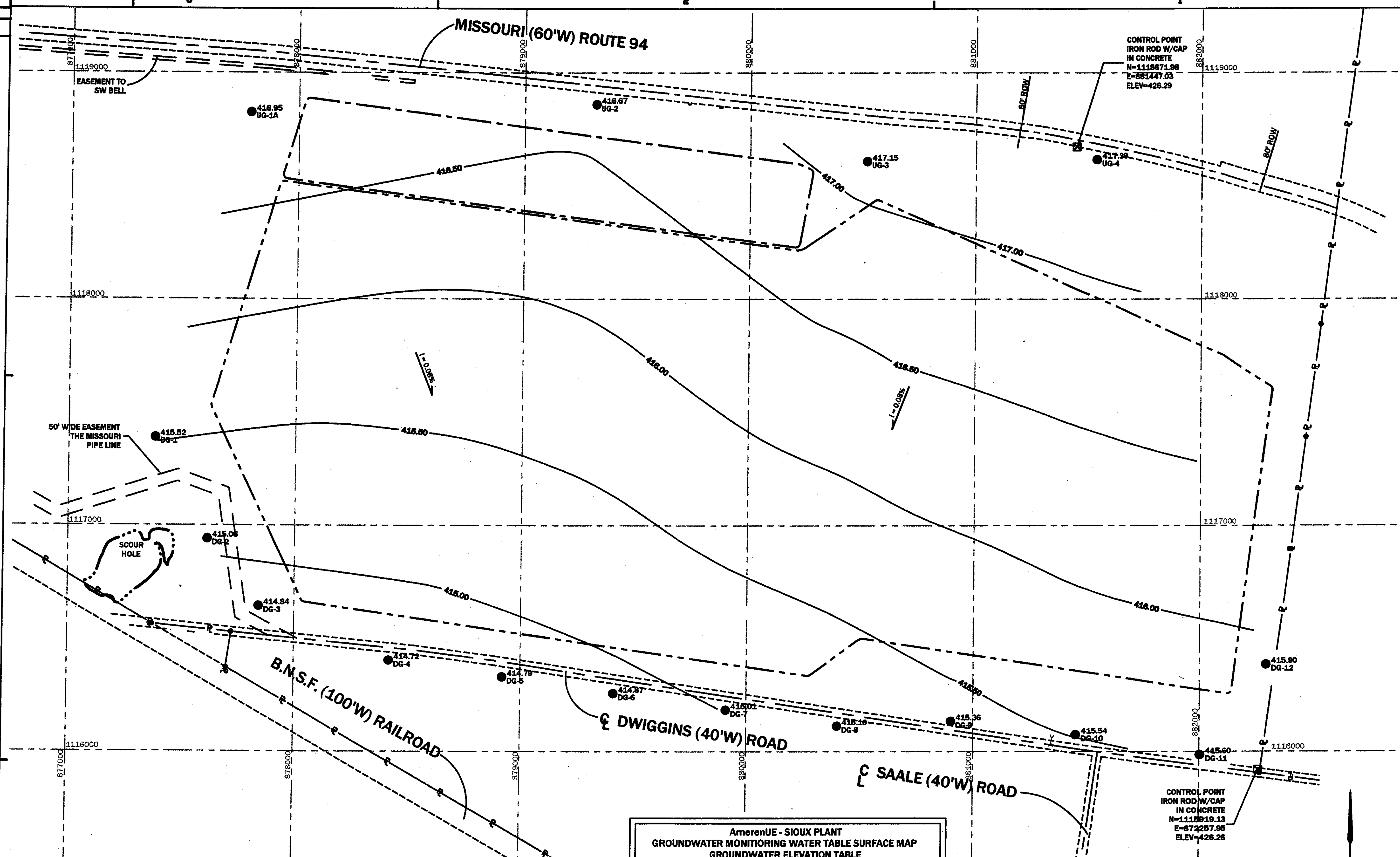
SUPV. J.B.F. (G.E.R.)
APPD. J.B.F. (G.E.R.)

GROUNDWATER CONTOUR MAP
PROPOSED UTILITY WASTE DISPOSAL AREA
WATER TABLE SURFACE MAP
NOVEMBER 5, 2008

LOCATION 001009 | SIOUX PLANT | CLASS 02010

AmerenUE | ST. LOUIS, MISSOURI | FIGURE 4 | REV.

AMEREN_00001525



LEGEND

●	UG-XX PIEZOMETER LOCATIONS DG-XX		PAVED ROAD
⊠	CONTROL POINT	i = 0.08%	HYDRAULIC GRADIENT (%)
•	℄ SURVEY POINT		GROUNDWATER FLOW DIRECTION
	METAL TRANSMISSION TOWER		ACCESS ROAD
	EXISTING POWER POLE	℄	PROPERTY LINE (APPROX.)
	CULVERT		CENTERLINE OF EXISTING ROAD
415.0	GROUND WATER ELEVATION (FT.)		PROPOSED UTILITY WASTE DISPOSAL AREA FOOTPRINT
415.0	GROUNDWATER CONTOUR NOTE: CONTOUR INTERVAL (C.I.)=0.5 FT.		PROPOSED NPDES RECYCLE POND PERMIT
FO	EXISTING FIBER OPTIC	G	EXISTING MISSOURI PIPELINE
OE	EXISTING OVERHEAD ELECTRIC	UT	EXISTING UNDERGROUND UTILITIES

AmerenUE - SIOUX PLANT
GROUNDWATER MONITIORING WATER TABLE SURFACE MAP
GROUNDWATER ELEVATION TABLE

Ameren Sioux Power Plant Elevations for Contour Map				
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DG-5	426.61	418.01	417.84	414.79
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UG-1A	427.04	419.92	419.12	416.95
UG-2	426.01	419.66	418.69	416.67
UG-3	426.14	420.25	419.19	417.15
UG-4	426.22	420.44	419.30	417.39

NOTES

1. USE OF SMALL CONTOUR INTERVAL (0.5 FT.) EXAGGERATES APPARENT "SLOPE" OF WATER TABLE SURFACE.
2. MAP REPRESENTATIVE OF GROUNDWATER CONDITIONS OCCURRING ON DATE OF MEASUREMENT: FEBRUARY 5, 2009
3. ELEVATION DATA FOR "SCOUR HOLE" NOT AVAILABLE FOR DATE OF GROUNDWATER MEASUREMENTS.

SCALE: 1" = 200'
0 100 200 400

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REITZ & JENS, INC. CONSULTING ENGINEERS 1055 CORPORATE SQUARE DRIVE ST. LOUIS, MISSOURI 63132

GREDELL Engineering Resources, Inc. ENVIRONMENTAL ENGINEERING LAND AIR WATER

PREPARED FOR AmerenUE

DRAWN 081308 W.J.A. (G.E.R.)	**GROUNDWATER CONTOUR MAP PROPOSED UTILITY WASTE DISPOSAL AREA WATER TABLE SURFACE MAP FEBRUARY 5, 2009**
CHKD. A.R.C. (G.E.R.)	
SUPV. J.B.F. (G.E.R.)	
APPD. J.B.F. (G.E.R.)	LOCATION 001009 — SIOUX PLANT — CLASS 02010
AmerenUE — ST. LOUIS, MISSOURI	FIGURE 5 — REV.

AMEREN_00001526

APPENDIX C
POTENTIOMETRIC SURFACE MAPS FROM BACKGROUND CCR SAMPLING EVENTS

Path: G:\Projects\150 Projects\1531406 - Ameren GW Monitoring Program - MO\Phase 0003 - Sioux Energy\800 - FIGURES-DRAWINGS\PRODUCTION\GMP\Updated Pot Maps\Final\Updated Shallow\SCPC-E1.mxd

LEGEND

- Sioux Energy Center Property Boundary
- SCPB - Fly Ash Surface Impoundment

Ground/Surface Water Measurement Locations

- SCL4A - UWL Cell 4A Monitoring Well
- Groundwater Elevation Piezometer
- Background Monitoring Well
- SCPB - Fly Ash Surface Impoundment Monitoring Well
- SCPC - WFGD Surface Impoundment Monitoring Well
- SPCA Pond Gauge
- River Elevation

Utility Waste Landfill (UWL)

- SCL4A - UWL Cell 4A
- SCPC - WFGD Surface Impoundment
- Water Recycle Pond
- UWL Future Perimeter Fence

Groundwater Elevation Contours

- Groundwater Elevation Contour (FT MSL)
- Inferred Groundwater Elevation Contour (FT MSL)
- Groundwater Flow Direction

NOTES

1.) ALL LOCATIONS AND BOUNDARIES ARE APPROXIMATE.
2.) GOLDER GROUNDWATER MONITORING WELLS SURVEYED BY ZAHNER AND ASSOCIATES, INC. ON JANUARY 14, APRIL 29, AND DECEMBER 8, 2016.
3.) GROUNDWATER AND SURFACE WATER ELEVATIONS DISPLAYED IN FT MSL (FEET ABOVE MEAN SEA LEVEL).
4.) GROUNDWATER MEASUREMENTS OBTAINED BY GOLDER.
5.) MISSOURI RIVER ELEVATION ESTIMATED BASED ON NEARBY USGS (UNITED STATES GEOLOGICAL SURVEY) RIVER GAUGING LOCATIONS.
6.) MISSISSIPPI RIVER ELEVATION PROVIDED BY AMEREN MISSOURI.
7.) POND GAUGE LEVEL OBTAINED ONSITE BY GOLDER.
8.) UWL BOUNDARIES, DESIGNATIONS AND STATE MONITORING WELL LOCATIONS BASED ON DRAWINGS IN THE UWL PROPOSED LANDFILL PERMIT (#0918301).
9.) WFGD - WET FLUE GAS DESULFURIZATION.

REFERENCE

1.) AMEREN MISSOURI SIOUX ENERGY CENTER, SIOUX PROPERTY CONTROL MAP, FEBRUARY 2011.
2.) COORDINATE SYSTEM: NAD 1983 STATE PLANE MISSOURI EAST FIPS 2,401 FEET.
3.) USGS NATIONAL WATER INFORMATION SYSTEM, USGS GAUGES 06935965 (ST. CHARLES), 07010000 (ST. LOUIS), 05587498 (ALTON), GRAFTON (05587450).
4.) AMEREN MISSOURI SIOUX POWER PLANT UTILITY WASTE LANDFILL PROPOSED CONSTRUCTION PERMIT MODIFICATION (#0918301), AUGUST 2014.

CLIENT
AMEREN MISSOURI
SIOUX ENERGY CENTER

Ameren

PROJECT
CCR GROUNDWATER MONITORING PROGRAM

TITLE
SCL4A POTENTIOMETRIC SURFACE MAP
BACKGROUND EVENT 1 - MAY 9, 2016

CONSULTANT

Golder Associates

YYYY-MM-DD	2016-05-25
PREPARED	JSI
DESIGN	JSI
REVIEW	JS
APPROVED	MNH

PROJECT No.	PHASE	FIGURE
153-1406	0003D	P1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

Path: G:\Projects\150 Projects\1531406 - Ameren GW Monitoring Program - MO\Phase 0003 - Sioux Energy\800 - FIGURES-DRAWINGS\PRODUCTION\GMP\Updated Pot Maps\Final\Updated Shallow\SCPC-E2.mxd

LEGEND

- Sioux Energy Center Property Boundary

Ground/Surface Water Measurement Locations

- SCL4A - UWL Cell 4A
- SCPC - WFGD Surface Impoundment
- River Elevation

Utility Waste Landfill (UWL)

- SCL4A - UWL Cell 4A
- SCPC - WFGD Surface Impoundment
- Water Recycle Pond
- UWL Future Perimeter Fence

Groundwater Elevation Contours

- Groundwater Elevation Contour (FT MSL)
- Inferred Groundwater Elevation Contour (FT MSL)
- Groundwater Flow Direction

NOTES

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REFERENCE

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4.) AMEREN MISSOURI SIOUX POWER PLANT UTILITY WASTE LANDFILL PROPOSED CONSTRUCTION PERMIT MODIFICATION (#0918301), AUGUST 2014.

CLIENT
AMEREN MISSOURI
SIOUX ENERGY CENTER

Ameren

PROJECT
CCR GROUNDWATER MONITORING PROGRAM

TITLE
SCL4A POTENTIOMETRIC SURFACE MAP
BACKGROUND EVENT 2 - JUNE 13, 2016

CONSULTANT

Golder Associates

YYYY-MM-DD	2016-05-25
PREPARED	JSI
DESIGN	JSI
REVIEW	JS
APPROVED	MNH

PROJECT No. 153-1406
PHASE 0003D
FIGURE P2

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

0 1 in

AMEREN_00001529

Path: G:\Projects\150 Projects\1531406 - Ameren GW Monitoring Program - MO\Phase 0003 - Sioux Energy\800 - FIGURES-DRAWINGS\PRODUCTION\GMP\Updated Pot Maps\Final\Updated Shallow\SCPC-E3.mxd

LEGEND

- Sioux Energy Center Property Boundary
- SCPB - Fly Ash Surface Impoundment

Ground/Surface Water Measurement Locations

- SCL4A - UWL Cell 4A Monitoring Well
- Groundwater Elevation Piezometer
- Background Monitoring Well
- SCPB - Fly Ash Surface Impoundment Monitoring Well
- SCPC - WFGD Surface Impoundment Monitoring Well
- SPCA Pond Gauge
- River Elevation

Utility Waste Landfill (UWL)

- SCL4A - UWL Cell 4A
- SCPC - WFGD Surface Impoundment
- Water Recycle Pond
- UWL Future Perimeter Fence

Groundwater Elevation Contours

- Groundwater Elevation Contour (FT MSL)
- Inferred Groundwater Elevation Contour (FT MSL)
- Groundwater Flow Direction

NOTES

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6.) MISSISSIPPI RIVER ELEVATION PROVIDED BY AMEREN MISSOURI.
7.) POND GAUGE LEVEL OBTAINED ONSITE BY GOLDER.
8.) UWL BOUNDARIES, DESIGNATIONS AND STATE MONITORING WELL LOCATIONS BASED ON DRAWINGS IN THE UWL PROPOSED LANDFILL PERMIT (#0918301).
9.) WFGD - WET FLUE GAS DESULFURIZATION.

REFERENCE

1.) AMEREN MISSOURI SIOUX ENERGY CENTER, SIOUX PROPERTY CONTROL MAP, FEBRUARY 2011.
2.) COORDINATE SYSTEM: NAD 1983 STATE PLANE MISSOURI EAST FIPS 2,401 FEET.
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4.) AMEREN MISSOURI SIOUX POWER PLANT UTILITY WASTE LANDFILL PROPOSED CONSTRUCTION PERMIT MODIFICATION (#0918301), AUGUST 2014.

CLIENT
AMEREN MISSOURI
SIOUX ENERGY CENTER

Ameren

PROJECT
CCR GROUNDWATER MONITORING PROGRAM

TITLE
SCL4A POTENTIOMETRIC SURFACE MAP
BACKGROUND EVENT 3 - JULY 5, 2016

CONSULTANT

Golder Associates

YYYY-MM-DD	2016-08-16
PREPARED	JS
DESIGN	JS
REVIEW	JSI
APPROVED	MNH

PROJECT No.	PHASE	FIGURE
153-1406	0003D	P3

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

Path: G:\Projects\150 Projects\1531406 - Ameren GW Monitoring Program - MO\Phase 0003 - Sioux Energy\800 - FIGURES-DRAWINGS\PRODUCTION\GMP\Updated Pot Maps\Final\Updated Shallow\SCPC-E4.mxd

LEGEND

- Sioux Energy Center Property Boundary
- SCPB - Fly Ash Surface Impoundment

Ground/Surface Water Measurement Locations

- SCL4A - UWL Cell 4A Monitoring Well
- Groundwater Elevation Piezometer
- Background Monitoring Well
- SCPB - Fly Ash Surface Impoundment Monitoring Well
- SCPC - WFGD Surface Impoundment Monitoring Well
- SPCA Pond Gauge
- River Elevation

Utility Waste Landfill (UWL)

- SCL4A - UWL Cell 4A
- SCPC - WFGD Surface Impoundment
- Water Recycle Pond
- UWL Future Perimeter Fence

Groundwater Elevation Contours

- Groundwater Elevation Contour (FT MSL)
- Inferred Groundwater Elevation Contour (FT MSL)
- Groundwater Flow Direction

NOTES

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6.) MISSISSIPPI RIVER ELEVATION PROVIDED BY AMEREN MISSOURI.
7.) POND GAUGE LEVEL OBTAINED ONSITE BY GOLDER.
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9.) WFGD - WET FLUE GAS DESULFURIZATION.

REFERENCE

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CLIENT
AMEREN MISSOURI
SIOUX ENERGY CENTER

Ameren

PROJECT
CCR GROUNDWATER MONITORING PROGRAM

TITLE
SCL4A POTENTIOMETRIC SURFACE MAP
BACKGROUND EVENT 4 - SEPTEMBER 14, 2016

CONSULTANT

Golder Associates

YYYY-MM-DD	2016-09-27
PREPARED	JSI
DESIGN	JSI
REVIEW	JS
APPROVED	MNH

PROJECT No. 153-1406 | PHASE 0003D | FIGURE P4

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

AMEREN_00001531

Path: G:\Projects\150 Projects\1531406 - Ameren GW Monitoring Program - MO\Phase 0003 - Sioux Energy\800 - FIGURES-DRAWINGS\PRODUCTION\GMP\Updated Pot Maps\Final\Updated Shallow\SCPC-E5.mxd

LEGEND

- Sioux Energy Center Property Boundary
- SCPB - Fly Ash Surface Impoundment

Ground/Surface Water Measurement Locations

- SCL4A - UWL Cell 4A Monitoring Well
- Groundwater Elevation Piezometer
- Background Monitoring Well
- SCPB - Fly Ash Surface Impoundment Monitoring Well
- SCPC - WFGD Surface Impoundment Monitoring Well
- SPCA Pond Gauge
- River Elevation

Utility Waste Landfill (UWL)

- SCL4A - UWL Cell 4A
- SCPC - WFGD Surface Impoundment
- Water Recycle Pond
- UWL Future Perimeter Fence

Groundwater Elevation Contours

- Groundwater Elevation Contour (FT MSL)
- Inferred Groundwater Elevation Contour (FT MSL)
- Groundwater Flow Direction

NOTES

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6.) MISSISSIPPI RIVER ELEVATION PROVIDED BY AMEREN MISSOURI.
7.) POND GAUGE LEVEL OBTAINED ONSITE BY GOLDER.
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9.) WFGD - WET FLUE GAS DESULFURIZATION.

REFERENCE

1.) AMEREN MISSOURI SIOUX ENERGY CENTER, SIOUX PROPERTY CONTROL MAP, FEBRUARY 2011.
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4.) AMEREN MISSOURI SIOUX POWER PLANT UTILITY WASTE LANDFILL PROPOSED CONSTRUCTION PERMIT MODIFICATION (#0918301), AUGUST 2014.

CLIENT
AMEREN MISSOURI
SIOUX ENERGY CENTER

Ameren

PROJECT
CCR GROUNDWATER MONITORING PROGRAM

TITLE
SCL4A POTENTIOMETRIC SURFACE MAP
BACKGROUND EVENT 5 - NOVEMBER 7, 2016

CONSULTANT

Golder Associates

YYYY-MM-DD	2016-11-07
PREPARED	JSI
DESIGN	JSI
REVIEW	MSG
APPROVED	MNH

PROJECT No. 153-1406

PHASE 0003D

FIGURE **P5**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

Path: G:\Projects\150 Projects\1531406 - Ameren GW Monitoring Program - MO\Phase 0003 - Sioux Energy\800 - FIGURES-DRAWINGS\PRODUCTION\GMP\Updated Pot Maps\Final\Updated Shallow\SCPC-E6.mxd

LEGEND

- Sioux Energy Center Property Boundary
- SCPB - Fly Ash Surface Impoundment

Ground/Surface Water Measurement Locations

- SCL4A - UWL Cell 4A Monitoring Well
- Groundwater Elevation Piezometer
- Background Monitoring Well
- SCPB - Fly Ash Surface Impoundment Monitoring Well
- SCPC - WFGD Surface Impoundment Monitoring Well
- SPCA Pond Gauge
- River Elevation

Utility Waste Landfill (UWL)

- SCL4A - UWL Cell 4A
- SCPC - WFGD Surface Impoundment
- Water Recycle Pond
- UWL Future Perimeter Fence

Groundwater Elevation Contours

- Groundwater Elevation Contour (FT MSL)
- Inferred Groundwater Elevation Contour (FT MSL)
- Groundwater Flow Direction

NOTES

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6.) MISSISSIPPI RIVER ELEVATION PROVIDED BY AMEREN MISSOURI.
7.) POND GAUGE LEVEL OBTAINED ONSITE BY GOLDER.
8.) UWL BOUNDARIES, DESIGNATIONS AND STATE MONITORING WELL LOCATIONS BASED ON DRAWINGS IN THE UWL PROPOSED LANDFILL PERMIT (#0918301).
9.) WFGD - WET FLUE GAS DESULFURIZATION.

REFERENCE

1.) AMEREN MISSOURI SIOUX ENERGY CENTER, SIOUX PROPERTY CONTROL MAP, FEBRUARY 2011.
2.) COORDINATE SYSTEM: NAD 1983 STATE PLANE MISSOURI EAST FIPS 2,401 FEET.
3.) USGS NATIONAL WATER INFORMATION SYSTEM, USGS GAUGES 06935965 (ST. CHARLES), 07010000 (ST. LOUIS), 05587498 (ALTON), GRAFTON (05587450).
4.) AMEREN MISSOURI SIOUX POWER PLANT UTILITY WASTE LANDFILL PROPOSED CONSTRUCTION PERMIT MODIFICATION (#0918301), AUGUST 2014.

CLIENT
AMEREN MISSOURI
SIOUX ENERGY CENTER

Ameren

PROJECT
CCR GROUNDWATER MONITORING PROGRAM

TITLE
SCL4A POTENTIOMETRIC SURFACE MAP
BACKGROUND EVENT 6 - JANUARY 3, 2017

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-01-03
PREPARED	JS
DESIGN	JSI
REVIEW	JSI
APPROVED	MNH

PROJECT No.	PHASE	FIGURE
153-1406	0003D	P6

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

Path: G:\Projects\150 Projects\1531406 - Ameren GW Monitoring Program - MO\Phase 0003 - Sioux Energy\800 - FIGURES-DRAWINGS\PRODUCTION\GMP\Updated Pot Maps\Final\Updated Shallow\SCPC-E7.mxd

LEGEND

- Sioux Energy Center Property Boundary
- SCPB - Fly Ash Surface Impoundment

Ground/Surface Water Measurement Locations

- SCL4A - UWL Cell 4A Monitoring Well
- Groundwater Elevation Piezometer
- Background Monitoring Well
- SCPB - Fly Ash Surface Impoundment Monitoring Well
- SCPC - WFGD Surface Impoundment Monitoring Well
- SPCA Pond Gauge
- River Elevation

Utility Waste Landfill (UWL)

- SCL4A - UWL Cell 4A
- SCPC - WFGD Surface Impoundment
- Water Recycle Pond
- UWL Future Perimeter Fence

Groundwater Elevation Contours

- Groundwater Elevation Contour (FT MSL)
- Inferred Groundwater Elevation Contour (FT MSL)
- Groundwater Flow Direction

NOTES

1.) ALL LOCATIONS AND BOUNDARIES ARE APPROXIMATE.
2.) GOLDER GROUNDWATER MONITORING WELLS SURVEYED BY ZAHNER AND ASSOCIATES, INC. ON JANUARY 14, APRIL 29, AND DECEMBER 8, 2016.
3.) GROUNDWATER AND SURFACE WATER ELEVATIONS DISPLAYED IN FT MSL (FEET ABOVE MEAN SEA LEVEL).
4.) GROUNDWATER MEASUREMENTS OBTAINED BY GOLDER.
5.) MISSOURI RIVER ELEVATION ESTIMATED BASED ON NEARBY USGS (UNITED STATES GEOLOGICAL SURVEY) RIVER GAUGING LOCATIONS.
6.) MISSISSIPPI RIVER ELEVATION PROVIDED BY AMEREN MISSOURI.
7.) POND GAUGE LEVEL OBTAINED ONSITE BY GOLDER.
8.) UWL BOUNDARIES, DESIGNATIONS AND STATE MONITORING WELL LOCATIONS BASED ON DRAWINGS IN THE UWL PROPOSED LANDFILL PERMIT (#0918301).
9.) WFGD - WET FLUE GAS DESULFURIZATION.

REFERENCE

1.) AMEREN MISSOURI SIOUX ENERGY CENTER, SIOUX PROPERTY CONTROL MAP, FEBRUARY 2011.
2.) COORDINATE SYSTEM: NAD 1983 STATE PLANE MISSOURI EAST FIPS 2,401 FEET.
3.) USGS NATIONAL WATER INFORMATION SYSTEM, USGS GAUGES 06935965 (ST. CHARLES), 07010000 (ST. LOUIS), 05587498 (ALTON), GRAFTON (05587450).
4.) AMEREN MISSOURI SIOUX POWER PLANT UTILITY WASTE LANDFILL PROPOSED CONSTRUCTION PERMIT MODIFICATION (#0918301), AUGUST 2014.

CLIENT
AMEREN MISSOURI
SIOUX ENERGY CENTER

Ameren

PROJECT
CCR GROUNDWATER MONITORING PROGRAM

TITLE
SCL4A POTENTIOMETRIC SURFACE MAP
BACKGROUND EVENT 7 - MARCH 8, 2017

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-03-14
PREPARED	JSI
DESIGN	JSI
REVIEW	JS
APPROVED	MNH

PROJECT No.	PHASE	FIGURE
153-1406	0003D	P7

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

1 in

AMEREN_00001534

Path: G:\Projects\150 Projects\1531406 - Ameren GW Monitoring Program - MO\Phase 0003 - Sioux Energy\800 - FIGURES-DRAWINGS\PRODUCTION\GMP\Updated Pot Maps\Final\Updated Shallow\SCPC-E8.mxd

LEGEND

- Sioux Energy Center Property Boundary
- SCPB - Fly Ash Surface Impoundment

Ground/Surface Water Measurement Locations

- SCL4A - UWL Cell 4A Monitoring Well
- Groundwater Elevation Piezometer
- Background Monitoring Well
- SCPB - Fly Ash Surface Impoundment Monitoring Well
- SCPC - WFGD Surface Impounment Monitoring Well
- SPCA Pond Gauge
- River Elevation

Utility Waste Landfill (UWL)

- SCL4A - UWL Cell 4A
- SCPC - WFGD Surface Impoundment
- Water Recycle Pond
- UWL Future Perimeter Fence

Groundwater Elevation Contours

- Groundwater Elevation Contour (FT MSL)
- Inferred Groundwater Elevation Contour (FT MSL)
- Groundwater Flow Direction

NOTES

1.) ALL LOCATIONS AND BOUNDARIES ARE APPROXIMATE.
2.) GOLDER GROUNDWATER MONITORING WELLS SURVEYED BY ZAHNER AND ASSOCIATES, INC. ON JANUARY 14, APRIL 29, AND DECEMBER 8, 2016.
3.) GROUNDWATER AND SURFACE WATER ELEVATIONS DISPLAYED IN FT MSL (FEET ABOVE MEAN SEA LEVEL).
4.) GROUNDWATER MEASUREMENTS OBTAINED BY GOLDER.
5.) MISSOURI RIVER ELEVATION ESTIMATED BASED ON NEARBY USGS (UNITED STATES GEOLOGICAL SURVEY) RIVER GAUGING LOCATIONS.
6.) MISSISSIPPI RIVER ELEVATION PROVIDED BY AMEREN MISSOURI.
7.) POND GAUGE LEVEL OBTAINED ONSITE BY GOLDER.
8.) UWL BOUNDARIES, DESIGNATIONS AND STATE MONITORING WELL LOCATIONS BASED ON DRAWINGS IN THE UWL PROPOSED LANDFILL PERMIT (#0918301).
9.) WFGD - WET FLUE GAS DESULFURIZATION.

REFERENCE

1.) AMEREN MISSOURI SIOUX ENERGY CENTER, SIOUX PROPERTY CONTROL MAP, FEBRUARY 2011.
2.) COORDINATE SYSTEM: NAD 1983 STATE PLANE MISSOURI EAST FIPS 2,401 FEET.
3.) USGS NATIONAL WATER INFORMATION SYSTEM, USGS GAUGES 06935965 (ST. CHARLES), 07010000 (ST. LOUIS), 05587498 (ALTON), GRAFTON (05587450).
4.) AMEREN MISSOURI SIOUX POWER PLANT UTILITY WASTE LANDFILL PROPOSED CONSTRUCTION PERMIT MODIFICATION (#0918301), AUGUST 2014.

CLIENT
AMEREN MISSOURI
SIOUX ENERGY CENTER

Ameren

PROJECT
CCR GROUNDWATER MONITORING PROGRAM

TITLE
SCL4A POTENTIOMETRIC SURFACE MAP
BACKGROUND EVENT 8 - JUNE 5, 2017

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-07-05
PREPARED	JSI
DESIGN	JSI
REVIEW	RJF
APPROVED	MNH

PROJECT No. 153-1406
PHASE 0003D
FIGURE P8

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM:

AMEREN_00001535

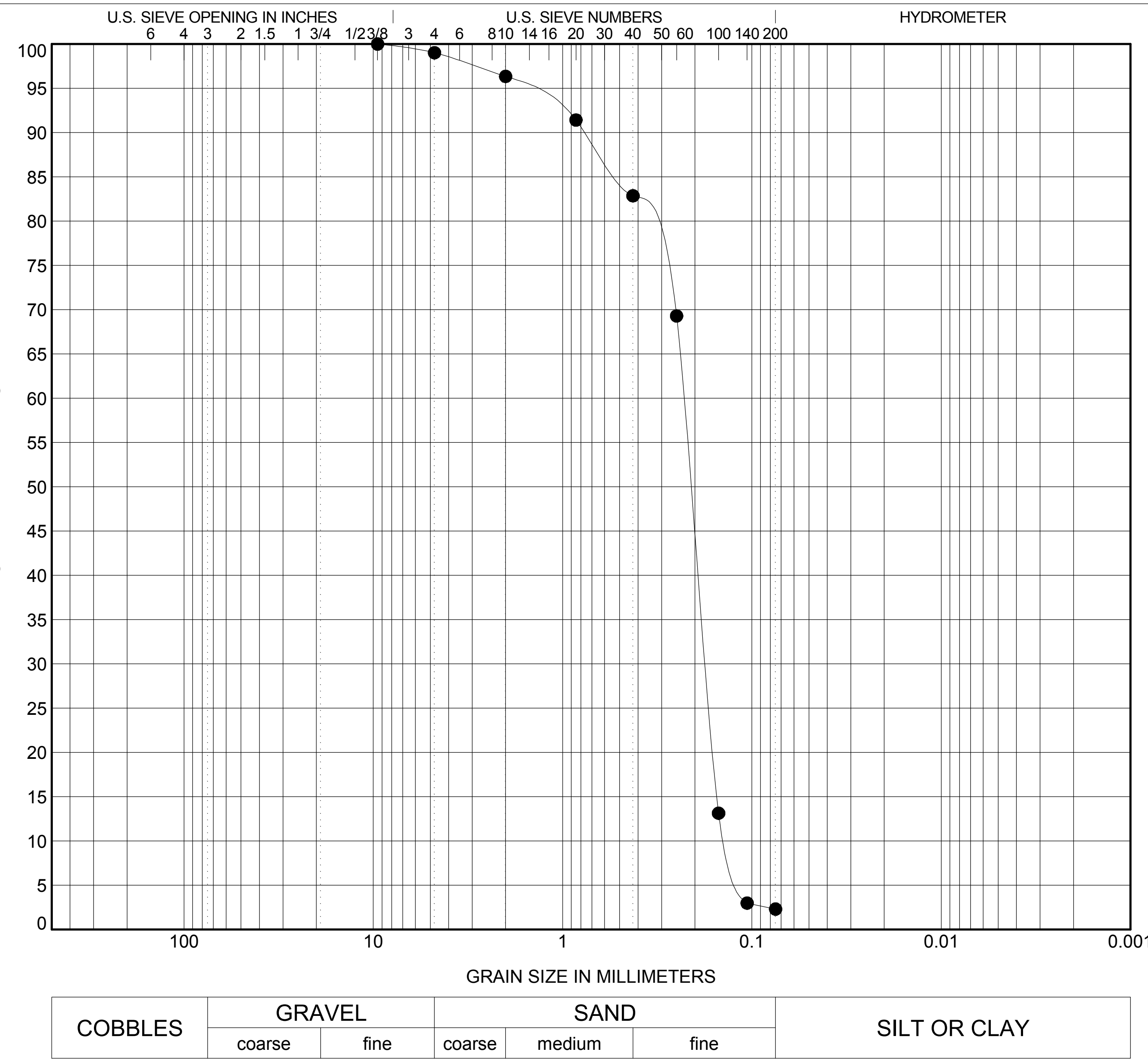
APPENDIX D
GRAIN SIZE DISTRIBUTION

Golder Associates
500 Century Plaza Drive, Suite 190
Houston, Texas 77073
Telephone: (281) 821-6868
Fax: (281) 821-6870

GRAIN SIZE DISTRIBUTION
ASTM D6913
Method B

CLIENT AMEREN SERVICES **PROJECT NAME** Ameren/GW Monitoring Program/MO

PROJECT NUMBER 153-1406.0002 **PROJECT LOCATION**



	BOREHOLE	DEPTH	Classification	LL	PL	PI
●	LMW-3S	15-25 ft	POORLY GRADED SAND (SP)			

	BOREHOLE	DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	LMW-3S	15-25 ft	9.5	0.23	0.175	0.135	1.0	96.7	2	

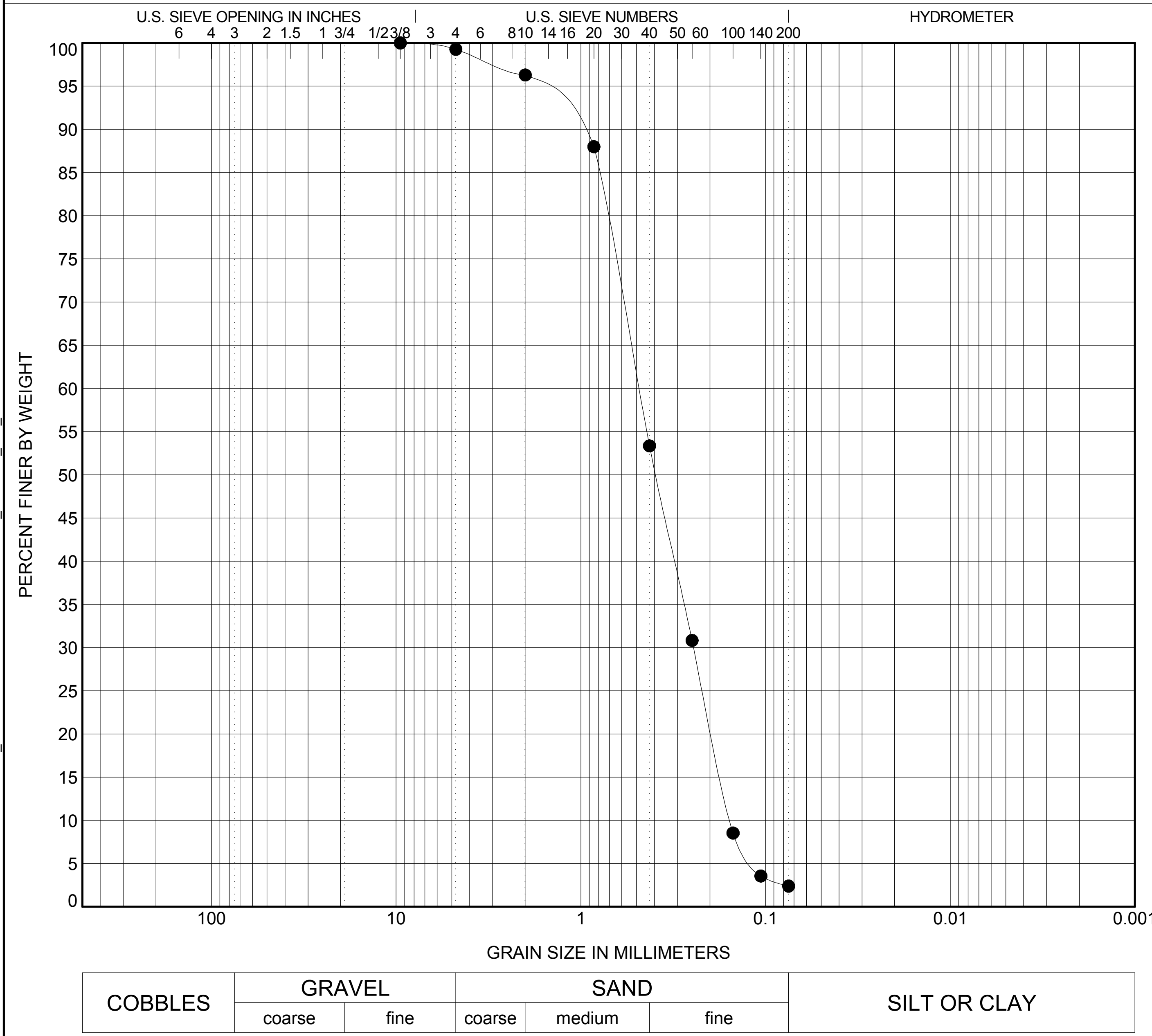
GRAIN SIZE (FULL SIEVE) - GINT STD US LAB.GDT - 12/18/15 08:56 - L:\15 - 2015 FILE FOLDER\1531406.0002_AMEREN GW MONITORING\1531405_AMEREN_GW_MONITORING.GPJ

Golder Associates
500 Century Plaza Drive, Suite 190
Houston, Texas 77073
Telephone: (281) 821-6868
Fax: (281) 821-6870

GRAIN SIZE DISTRIBUTION
ASTM D6913
Method B

CLIENT AMEREN SERVICES **PROJECT NAME** Ameren/GW Monitoring Program/MO

PROJECT NUMBER 153-1406.0002 **PROJECT LOCATION**



	BOREHOLE	DEPTH	Classification	LL	PL	PI
●	LMW-8S	35-45 ft	POORLY GRADED SAND (SP)			

	BOREHOLE	DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	LMW-8S	35-45 ft	9.5	0.485	0.245	0.155	0.7	96.9	2	

GRAIN SIZE (FULL SIEVE) - GINT STD US LAB.GDT - 12/18/15 08:58 - L:\15 - 2015 FILE FOLDER\1531406.0002_AMEREN GW MONITORING\1531405_AMEREN_GW_MONITORING.GPJ

APPENDIX E
CCR MONITORING WELL CONSTRUCTION DIAGRAMS

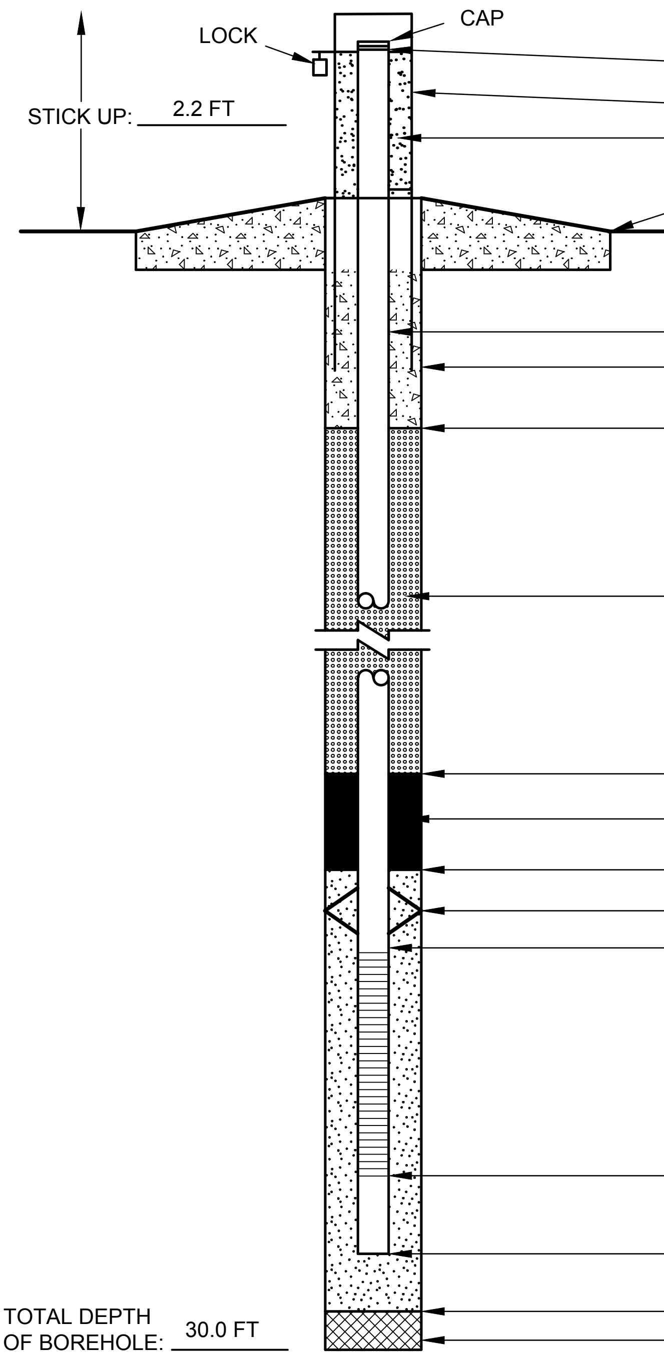
ABOVE GROUND MONITORING WELL CONSTRUCTION LOG TMW-1

Golder Associates

PROJECT NAME: AMEREN CCR GW MONITORING	PROJECT NUMBER: 153-1406.0003D
SITE NAME: SIOUX ENERGY CENTER	LOCATION: TMW-1
CLIENT: AMEREN MISSOURI	SURFACE ELEVATION: 425.9 FT MSL

GEOLOGIST: J. INGRAM	NORTHING: 1117385.1	EASTING: 880121.2
DRILLER: J. DRABEK	STATIC WATER LEVEL: 10.87 FT BTOC	COMPLETION DATE: 4/5/2016

DRILLING COMPANY: CASCADE	DRILLING METHODS: SONIC



STICK UP: 2.2 FT

TOP OF CASING ELEVATION: 428.08 FT MSL

PROTECTIVE CASING (yes / no): 4" X 5' ALUMINUM

PEA GRAVEL OR SAND

GROUND SURFACE ELEVATION: 425.9 FT MSL

DIAMETER OF RISER PIPE (in.): 2.0

DIAMETER OF BOREHOLE (in.): 6.0

CONCRETE SEAL DEPTH (ft. bgs): 2.5

TYPE AND AMOUNT OF ANNULAR SEAL: NONE

TOP OF BENTONITE SEAL DEPTH (ft. bgs): 2.5

TYPE AND AMOUNT OF BENTONITE SEAL: $\frac{3}{8}$" BENTONITE CHIPS - 3 BAG

TOP OF SAND PACK DEPTH (ft. bgs): COARSE: 14.0 FINE: 13.0

CENTRALIZER (yes / no) - TYPE: NONE

TOP OF SCREEN DEPTH (ft. bgs): 16.5

TYPE OF SCREEN: 2" X 9.8' SCHEDULE 40 PVC

SCREEN SLOT SIZE (in.): 0.010 IN

SIZE OF SAND PACK: COARSE: #1 FINE: #0

AMOUNT OF SAND: COARSE: 3 BAGS FINE: $\frac{1}{2}$ BAG

BOTTOM OF SCREEN DEPTH (ft. bgs): 26.3

BOTTOM OF WELL DEPTH (ft. bgs): 26.7

BOTTOM OF FILTER PACK (ft. bgs): 28.0

TYPE AND AMOUNT OF BACKFILL: 2.0 FT NATURAL CAVE IN

TOTAL DEPTH OF BOREHOLE: 30.0 FT

ADDITIONAL NOTES: FT BGS = FEET BELOW GROUND SURFACE. FT MSL = FEET ABOVE MEAN SEA LEVEL.
50 GALLONS OF H2O USED DURING DRILLING. HORIZONTAL DATUM: STATE PLANE COORDINATES NAD83 US SURVEY FEET (2000)
MISSOURI EAST ZONE. VERTICAL DATUM: NAVD88. WELL SURVEYED BY ZAHNER AND ASSOCIATES, INC ON APRIL 29, 2016.
FT BTOC = FEET BELOW TOP OF CASING. SAND AND BENTONITE BAGS WEIGH 50 LBS EACH.

CHECKED BY: J. INGRAM

DATE CHECKED: 6/2/2016

PREPARED BY: J. SUOZZI

AMEREN_00001547

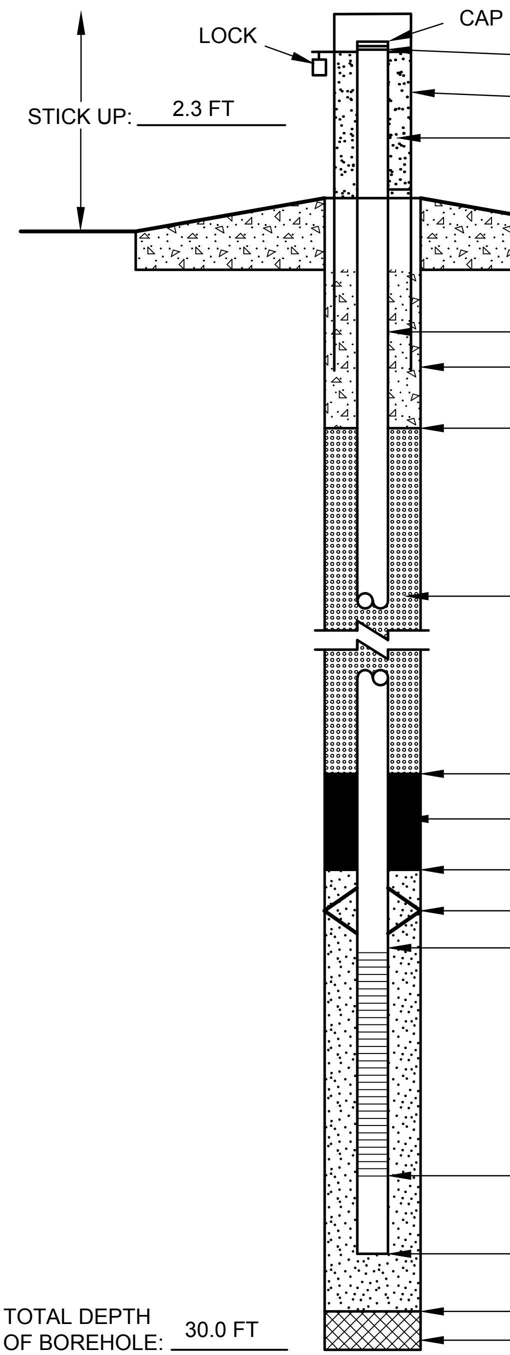
ABOVE GROUND MONITORING WELL CONSTRUCTION LOG TMW-2

Golder Associates

PROJECT NAME: AMEREN CCR GW MONITORING	PROJECT NUMBER: 153-1406.0003D
SITE NAME: SIOUX ENERGY CENTER	LOCATION: TMW-2
CLIENT: AMEREN MISSOURI	SURFACE ELEVATION: 425.9 FT MSL

GEOLOGIST: J. INGRAM	NORTHING: 1117320.7	EASTING: 880442.9
DRILLER: J. DRABEK	STATIC WATER LEVEL: 11.00 FT BTOC	COMPLETION DATE: 4/5/2016

DRILLING COMPANY: CASCADE	DRILLING METHODS: SONIC



STICK UP: 2.3 FT

TOP OF CASING ELEVATION: 428.17 FT MSL

PROTECTIVE CASING (yes / no): 4" X 5' ALUMINUM

PEA GRAVEL OR SAND

GROUND SURFACE ELEVATION: 425.9 FT MSL

DIAMETER OF RISER PIPE (in.): 2.0

DIAMETER OF BOREHOLE (in.): 6.0

CONCRETE SEAL DEPTH (ft. bgs): 2.5

TYPE AND AMOUNT OF ANNULAR SEAL: NONE

TOP OF BENTONITE SEAL DEPTH (ft. bgs): 2.5

TYPE AND AMOUNT OF BENTONITE SEAL: $\frac{3}{8}$" BENTONITE CHIPS - 2 $\frac{1}{2}$ BAGS

TOP OF SAND PACK DEPTH (ft. bgs): COARSE: 15.0 FINE: 14.0

CENTRALIZER (yes / no) - TYPE: NONE

TOP OF SCREEN DEPTH (ft. bgs): 17.9

TYPE OF SCREEN: 2" X 9.8' SCHEDULE 40 PVC

SCREEN SLOT SIZE (in.): 0.010 IN

SIZE OF SAND PACK: COARSE: #1 FINE: #0

AMOUNT OF SAND: COARSE: 3 BAGS FINE: $\frac{1}{2}$ BAG

BOTTOM OF SCREEN DEPTH (ft. bgs): 27.7

BOTTOM OF WELL DEPTH (ft. bgs): 28.1

TOTAL DEPTH OF BOREHOLE: 30.0 FT

BOTTOM OF FILTER PACK (ft. bgs): 28.1

TYPE AND AMOUNT OF BACKFILL: 1.9 FT NATURAL CAVE IN

ADDITIONAL NOTES: FT BGS = FEET BELOW GROUND SURFACE. FT MSL = FEET ABOVE MEAN SEA LEVEL. 50 GALLONS OF H2O USED DURING DRILLING. HORIZONTAL DATUM: STATE PLANE COORDINATES NAD83 US SURVEY FEET (2000) MISSOURI EAST ZONE. VERTICAL DATUM: NAVD88. WELL SURVEYED BY ZAHNER AND ASSOCIATES, INC ON APRIL 29, 2016. FT BTOC = FEET BELOW TOP OF CASING. SAND AND BENTONITE BAGS WEIGH 50 LBS EACH.

CHECKED BY: J. INGRAM

DATE CHECKED: 6/2/2016

PREPARED BY: J. SUOZZI

AMEREN 0001547

ABOVE GROUND MONITORING WELL CONSTRUCTION LOG TMW-3

Golder Associates

PROJECT NAME: AMEREN CCR GW MONITORING | PROJECT NUMBER: 153-1406.0003D

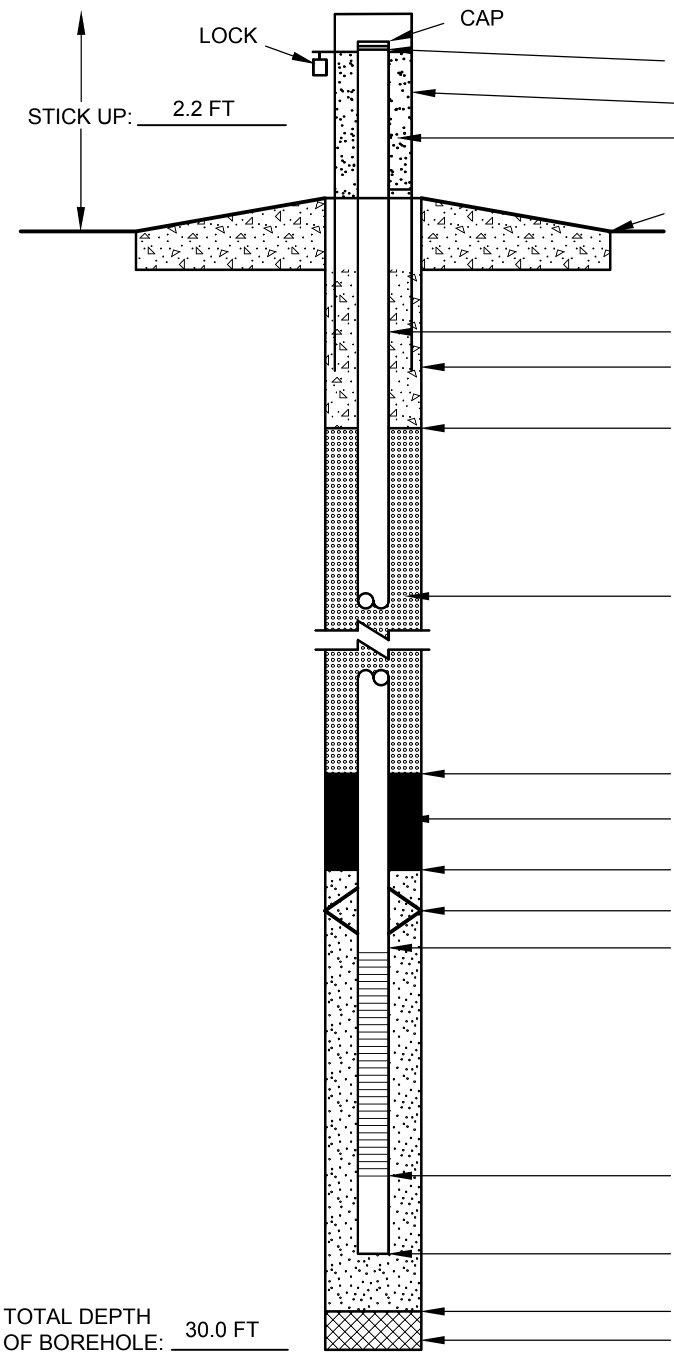
SITE NAME: SIOUX ENERGY CENTER | LOCATION: TMW-3

CLIENT: AMEREN MISSOURI | SURFACE ELEVATION: 425.7 FT MSL

GEOLOGIST: J. INGRAM | NORTHING: 1117259.2 | EASTING: 880762.4

DRILLER: J. DRABEK | STATIC WATER LEVEL: 10.69 FT BTOC | COMPLETION DATE: 4/5/2016

DRILLING COMPANY: CASCADE | DRILLING METHODS: SONIC



TOP OF CASING ELEVATION: 427.88 FT MSL

PROTECTIVE CASING (yes / no): 4" X 5' ALUMINUM

PEA GRAVEL OR SAND

GROUND SURFACE ELEVATION: 425.7 FT MSL

DIAMETER OF RISER PIPE (in.): 2.0

DIAMETER OF BOREHOLE (in.): 6.0

CONCRETE SEAL DEPTH (ft. bgs): 2.5

TYPE AND AMOUNT OF ANNULAR SEAL: NONE

TOP OF BENTONITE SEAL DEPTH (ft. bgs): 2.5

TYPE AND AMOUNT OF BENTONITE SEAL: $\frac{3}{8}$" BENTONITE CHIPS - 1 $\frac{1}{2}$ BAGS

TOP OF SAND PACK DEPTH (ft. bgs): COARSE: 14.0 FINE: 13.0

CENTRALIZER (yes / no) - TYPE: NONE

TOP OF SCREEN DEPTH (ft. bgs): 17.7

TYPE OF SCREEN: 2" X 9.8' SCHEDULE 40 PVC

SCREEN SLOT SIZE (in.): 0.010 IN

SIZE OF SAND PACK: COARSE: #1 FINE: #0

AMOUNT OF SAND: COARSE: 2 $\frac{3}{4}$ BAGS FINE: $\frac{1}{2}$ BAG

BOTTOM OF SCREEN DEPTH (ft. bgs): 27.5

BOTTOM OF WELL DEPTH (ft. bgs): 27.9

BOTTOM OF FILTER PACK (ft. bgs): 28.0

TOTAL DEPTH OF BOREHOLE: 30.0 FT

TYPE AND AMOUNT OF BACKFILL: 2.0 FT NATURAL CAVE IN

ADDITIONAL NOTES: FT BGS = FEET BELOW GROUND SURFACE. FT MSL = FEET ABOVE MEAN SEA LEVEL.
40 GALLONS OF H2O USED DURING DRILLING. HORIZONTAL DATUM: STATE PLANE COORDINATES NAD83 US SURVEY FEET (2000)
MISSOURI EAST ZONE. VERTICAL DATUM: NAVD88. WELL SURVEYED BY ZAHNER AND ASSOCIATES, INC ON APRIL 29, 2016.
FT BTOC = FEET BELOW TOP OF CASING. SAND AND BENTONITE BAGS WEIGH 50 LBS EACH.

CHECKED BY: J. INGRAM

DATE CHECKED: 6/2/2016

PREPARED BY: J. SUOZZI

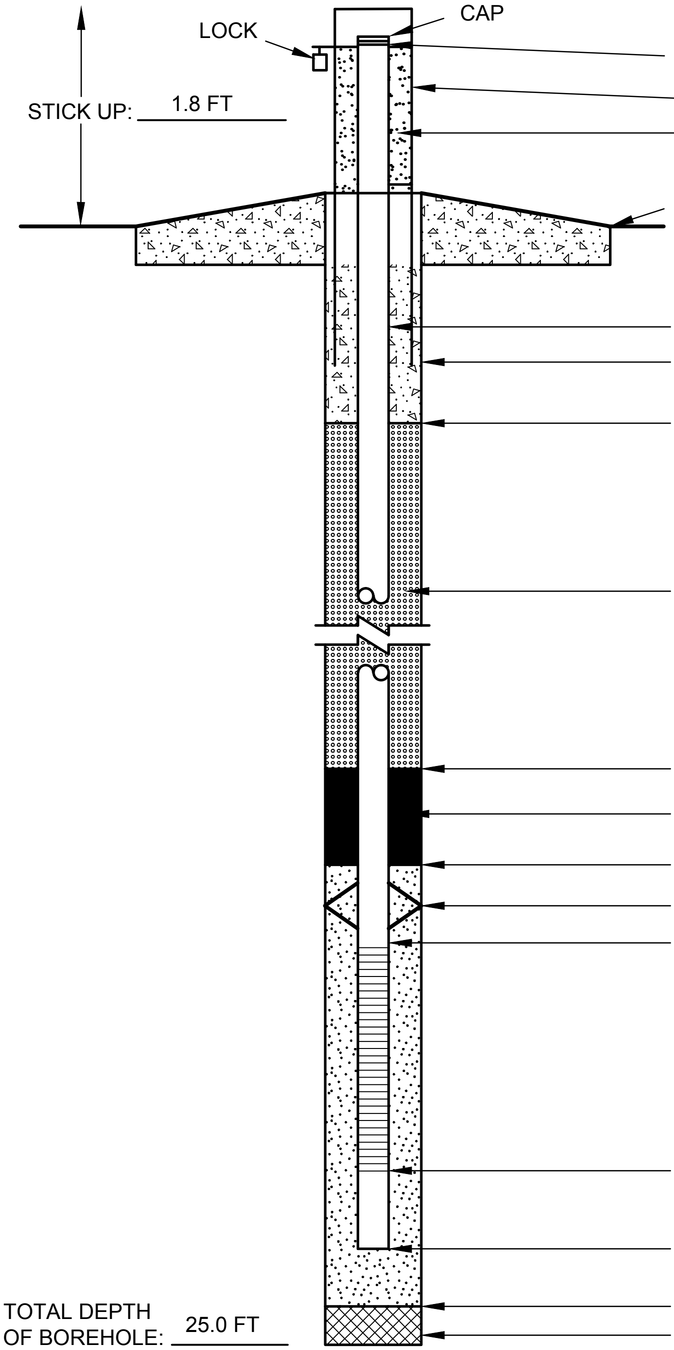
Golder Associates

ABOVE GROUND MONITORING WELL CONSTRUCTION LOG BMW-1S

PROJECT NAME: AMEREN CCR GW MONITORING	PROJECT NUMBER: 153-1406.0003B
SITE NAME: SIOUX ENERGY CENTER	LOCATION: BMW-1S
CLIENT: AMEREN MISSOURI	SURFACE ELEVATION: 426.0 FT MSL

GEOLOGIST: J. INGRAM	NORTHING: 1121709.2	EASTING: 876755.6
DRILLER: J. DRABEK	STATIC WATER LEVEL: 7.35 FT BTOC	COMPLETION DATE: 12/8/2015

DRILLING COMPANY: CASCADE	DRILLING METHODS: SONIC



STICK UP: 1.8 FT

TOP OF CASING ELEVATION: 427.77 FT MSL

PROTECTIVE CASING (yes / no): 4" X 5' ALUMINUM

PEA GRAVEL OR SAND

GROUND SURFACE ELEVATION: 426.0 FT MSL

DIAMETER OF RISER PIPE (in.): 2.0

DIAMETER OF BOREHOLE (in.): 6.0

CONCRETE SEAL DEPTH (ft. bgs): 2.5

TYPE AND AMOUNT OF ANNULAR SEAL: NONE

TOP OF BENTONITE SEAL DEPTH (ft. bgs): 2.5

TYPE AND AMOUNT OF BENTONITE SEAL: $\frac{3}{8}$" BENTONITE CHIPS - 2 BAGS

TOP OF SAND PACK DEPTH (ft. bgs): COARSE: 12.5 FINE: 12.0

CENTRALIZER (yes / no) - TYPE: NONE

TOP OF SCREEN DEPTH (ft. bgs): 14.0

TYPE OF SCREEN: 2" X 9.8' SCHEDULE 40 PVC

SCREEN SLOT SIZE (in.): 0.010 IN

SIZE OF SAND PACK: COARSE: #1 FINE: #0

AMOUNT OF SAND: COARSE: 3.5 BAGS FINE: $\frac{1}{3}$ BAG

BOTTOM OF SCREEN DEPTH (ft. bgs): 23.8

BOTTOM OF WELL DEPTH (ft. bgs): 24.2

TOTAL DEPTH OF BOREHOLE: 25.0 FT

BOTTOM OF FILTER PACK (ft. bgs): 24.2

TYPE AND AMOUNT OF BACKFILL: 0.8 FT - NATURAL CAVE IN

ADDITIONAL NOTES: FT BGS = FEET BELOW GROUND SURFACE. FT MSL = FEET ABOVE MEAN SEA LEVEL.
50 GALLONS OF H2O USED DURING DRILLING. HORIZONTAL DATUM: STATE PLANE COORDINATES NAD83 US SURVEY FEET (2000)
MISSOURI EAST ZONE. VERTICAL DATUM: NAVD88. WELL SURVEYED BY ZAHNER AND ASSOCIATES, INC ON JANUARY 14, 2016.
FT BTOC = FEET BELOW TOP OF CASING. SAND AND BENTONITE BAGS WEIGH 50 LBS EACH.

CHECKED BY: J. INGRAM

DATE CHECKED: 4/20/2016

PREPARED BY: J. SUOZZI

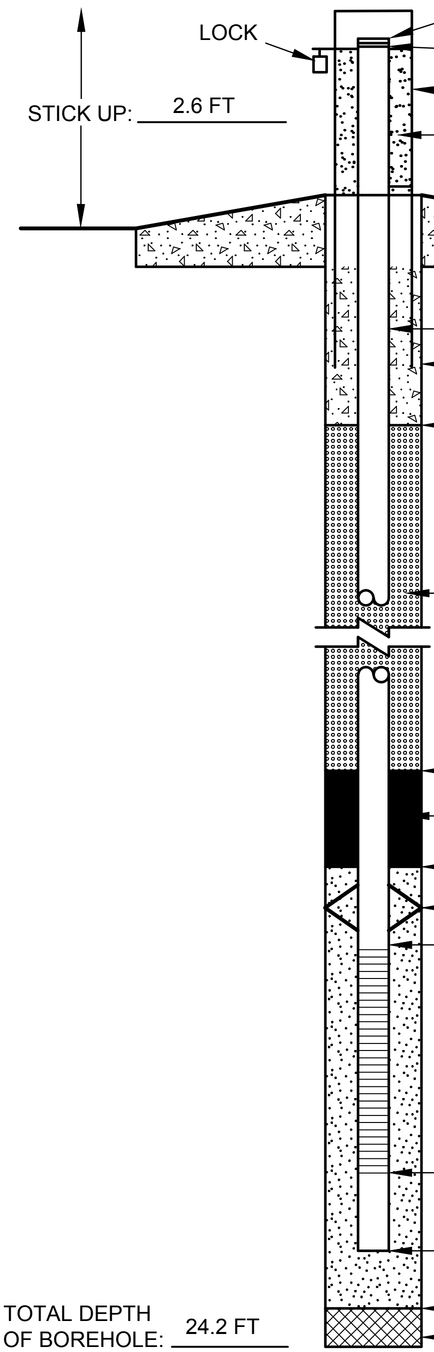
ABOVE GROUND MONITORING WELL CONSTRUCTION LOG BMW-3S

Golder Associates

PROJECT NAME: AMEREN CCR GW MONITORING	PROJECT NUMBER: 153-1406.0003B
SITE NAME: SIOUX ENERGY CENTER	LOCATION: BMW-3S
CLIENT: AMEREN MISSOURI	SURFACE ELEVATION: 424.1 FT MSL

GEOLOGIST: J. INGRAM/M. GORE	NORTHING: 1121792.9	EASTING: 875809.5
DRILLER: M. RODRIGUES	STATIC WATER LEVEL: 8.65 FT BTOC	COMPLETION DATE: 11/8/2016

DRILLING COMPANY: CASCADE	DRILLING METHODS: SONIC



TOP OF CASING ELEVATION: 426.69 FT MSL

PROTECTIVE CASING (yes / no): 4" X 5' ALUMINUM

PEA GRAVEL OR SAND

GROUND SURFACE ELEVATION: 424.1 FT MSL

DIAMETER OF RISER PIPE (in.): 2.0

DIAMETER OF BOREHOLE (in.): 6.0

CONCRETE SEAL DEPTH (ft. bgs): 2.5

TYPE AND AMOUNT OF ANNULAR SEAL: HIGH SOLIDS BENTONITE

TOP OF BENTONITE SEAL DEPTH (ft. bgs): 2.5

TYPE AND AMOUNT OF BENTONITE SEAL: $\frac{3}{8}$" BENTONITE CHIPS - 1 BUCKET

TOP OF SAND PACK DEPTH (ft. bgs): COARSE: 11.6 FINE: 10.8

CENTRALIZER (yes / no) - TYPE: NONE

TOP OF SCREEN DEPTH (ft. bgs): 14.0

TYPE OF SCREEN: 2" X 9.8' SCHEDULE 40 PVC

SCREEN SLOT SIZE (in.): 0.010 IN

SIZE OF SAND PACK: COARSE: #1 (20-30) FINE: #0 (30/65)

AMOUNT OF SAND: COARSE: 4 BAGS FINE: $\frac{1}{2}$ BAG

BOTTOM OF SCREEN DEPTH (ft. bgs): 23.8

BOTTOM OF WELL DEPTH (ft. bgs): 24.2

BOTTOM OF FILTER PACK (ft. bgs): 24.2

TYPE AND AMOUNT OF BACKFILL: NONE

ADDITIONAL NOTES: FT BGS = FEET BELOW GROUND SURFACE. FT MSL = FEET ABOVE MEAN SEA LEVEL. 50 GALLONS OF H2O USED DURING DRILLING. HORIZONTAL DATUM: STATE PLANE COORDINATES NAD83 US SURVEY FEET (2000) MISSOURI EAST ZONE. VERTICAL DATUM: NAVD88. WELL SURVEYED BY ZAHNER AND ASSOCIATES, INC ON DECEMBER 8, 2016. FT BTOC = FEET BELOW TOP OF CASING. SAND AND BENTONITE BAGS WEIGH 50 LBS EACH.

CHECKED BY: J. INGRAM

DATE CHECKED: 8/3/2017

PREPARED BY: J. SUOZZI

AMEREN_00001547

APPENDIX F
WELL DEVELOPMENT FORMS

Sheet 1 of 1

Golder Associates WELL DEVELOPMENT/PURGING FORM

Project Ref: Ameren GW Monitoring **Project No.:** 153-1406.0003

Location
4MW-1

Monitored By: JS Date 4/13/16 Time 0830

Well Piezometer Data

(circle one)

Depth of Well (from top of PVC or ground)	29.93	feet
Depth of Water (from top of PVC or ground)	10.72	feet
Radius of Casing	2	inches
	—	feet
Casing Volume	—	cubic feet
	7.4·3 = 23 gal	gallons

+ 50 gal from drilling
= 73 gal total

Development / Purging Discharge Data

Purging Method	Waterra			
Start Purging	Date	4/13/16	Time	0838
Stop Purging	Date	4/13/16	Time	0952

Monitoring

Date	Time	Volume Discharge (gals)	Temp (°__)	pH	Spec.Cond. (__S/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/L)	Redox Potential (+/- mV)	WL (ft BTOC)	Appearance of Water and Comments
4/13/16	0910	50	10.85	6.30	0.774	307	2.40	195.7	11.01	Cloudy
	0920	67	10.43	6.63	0.784	71000	1.33	159.6	11.00	cloudy/muddy
	0930	85	10.62	6.69	0.771	87.4	1.58	139.4	11.15	cloudy Remove surge block
	0940	110	10.58	6.66	0.773	15.6	1.28	136.1	11.15	Clear
	0950	125	10.68	6.72	0.771	11.0	1.08	126.5	11.15	Clear

post Dev'l TD: 29.95

DI water reads: 4 NTU

AMEREN_00001546

Sheet 1 of 1

Golder Associates WELL DEVELOPMENT/PURGING FORM

Project Ref: Ameren GW Monitoring **Project No.:** 153-1406. 000 3

Location

TMW-2

Monitored By: JS Date 4/13/16 Time 1033

Well Piezometer Data

(circle one)

Depth of Well (from top of PVC or ground) 30.49 feet

Depth of Water (from top of PVC or ground) 10.82 feet

Radius of Casing 2 inches
— feet

Casing Volume — cubic feet
7.1 · 3 = 21.3 gallons - + 50 gal from drilling
= 72 gal total

Development / Purging Discharge Data

Purging Method Waterra

Start Purging Date 4/13/16 Time 1040

Stop Purging Date 4/13/16 Time 1241

Monitoring

Date	Time	Volume Discharge (gals)	Temp (°__)	pH	Spec.Cond. (__S/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/L)	Redox Potential (+/- mV)	WL (ft BTOC)	Appearance of Water and Comments
4/13/16	1045	15	10.51	6.86	0935	>1000	2.60	175.9	11.40	muddy
	1055	30	10.64	6.81	0.911	>1000	2.18	109.6	11.41	muddy
	1105	56	10.62	6.73	0.894	>1000	1.47	41.6	11.41	muddy
	1115	70	10.37	6.76	0.894	>1000	1.46	11.9	11.30	muddy
	1125	84	10.61	6.72	0.880	>1000	1.87	5.6	11.30	muddy
	1135	97	10.55	6.71	0.883	316	1.30	14.2	11.40	v. cloudy, Remove surge block
	1150	130	10.59	6.70	0.868	70.8	1.87	5.2	11.41	cloudy
	1200	150	10.62	6.75	0.870	52.8	1.30	-7.8	11.40	cloudy
	1210	170	10.64	6.72	0.869	35.6	1.43	-20.7	11.40	clear
	1220	200	10.31	6.86	0.870	24.2	1.68	-24.6	11.36	clear
	1230	210	10.64	6.74	0.868	20.7	1.23	-28.4	11.35	clear
	1240	217	10.62	6.68	0.868	12.5	1.67	-24.5	11.32	clear

post Dev't TD: 30.50

DI water reads: 4 NTU

Golder Associates WELL DEVELOPMENT/PURGING FORM

Project Ref: Ameren GW Monitoring **Project No.:** 153-1406. 0003D

Location

TMW-3

Monitored By: JS Date 4/13/16 Time 1310

Well Piezometer Data

(*circle one*)

Depth of Well (from top of PVC or ground): 30.14 feet

Depth of Water (from top of PVC or ground): 10.39 feet

Radius of Casing: 2 inches; — feet

Casing Volume: — cubic feet; 8.3 = 24 gallons + 40 gal H_2O from drilling = 64 gal total

Development / Purging Discharge Data

Purging Method: Waterra

Start Purging Date 4/13/16 Time 1324

Stop Purging Date 4/13/16 Time 1502

Monitoring

Date	Time	Volume Discharge (gals)	Temp (°__)	pH	Spec.Cond. (__S/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/L)	Redox Potential (+/- mV)	WL (ft BTOC)	Appearance of Water and Comments
4/13/16	1330	20	10.71	8.23	1.168	>1000	6.18	19.4	10.85	muddy
	1340	30	10.43	7.24	1.041	>1000	3.20	-9.1	10.90	muddy
	1350	40	10.58	6.90	0.984	>1000	6.88	-12.1	10.91	muddy
	1400	60	10.70	6.89	0.952	>1000	7.66	-11.7	10.91	muddy
	1410	77	10.63	6.90	0.930	>1000	2.18	-13.3	10.91	muddy
	1420	90	10.64	6.77	0.949	128	1.12	-0.7	11.02	Remove surge block, cloudy
	1430	105	10.59	6.77	0.916	61.4	1.20	1.0	10.89	cloudy
	1440	125	10.56	6.78	0.910	23.0	0.92	6.5	10.90	clear
	1450	140	10.56	6.76	0.907	16.7	1.11	9.5	10.91	Clear
	1500	160	10.58	6.76	0.905	10.6	0.90	10.3	10.91	Clear

post Dev't TD: 30.14

DI Water reads: 4 NTU

Sheet 1 of 2

Golder Associates WELL DEVELOPMENT/PURGING FORM

Project Ref: Ameren GW Monitoring **Project No.:** 153-1406.

Location BMW-1S

Monitored By: JSE Date 1/22/16 Time 0800

0.163

Well Piezometer Data

(circle one)

Depth of Well (from top of PVC or ground)	25.95	feet
Depth of Water (from top of PVC or ground)	7.35	feet BTOR
Radius of Casing	2.00	inches
	4.00	feet
Casing Volume	6.5X3 = 14.5	cubic feet
	+ 50 =	gallons

69.5 total gallons

Development / Purging Discharge Data

Purging Method	Waterra.			
Start Purging	Date	1/21/16	Time	0821
Stop Purging	Date	1/22/16	Time	1544

Monitoring

STARTED very muddy – [illegible] with Cav[illegible]

Date	Time	Volume Discharge (gals)	Temp (°C)	pH	Spec.Cond. (mS/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/L)	Redox Potential (+/- mV)	WL (ft BTOC)	Appearance of Water and Comments
1/22	900	55	12.84	7.21	0.804	>1000	1.61	124.4	9.30	Cloudy / Brownish – muddy upon [illegible]
	930	65	13.20	7.46	0.764	>1000	1.52	153.9	9.15	
	940	80	13.12	7.45	0.763	>1000	1.47	166.0	9.20	~~[illegible]~~ Cloudy
	950	86	13.54	7.40	0.763	>1000	0.86	168.9	9.21	
	1000	95	13.54	7.39	0.765	>1000	0.83	170.3	9.22	Cloudy
	1010	104	13.29	7.38	0.766	>1000	1.06	170.5	9.23	
	1020	120	13.04	7.36	0.760	>1000	1.07	174.3	9.23	– Less [illegible] for 10 min [illegible]
	1040	130	13.07	7.34	0.770	>1000	0.66	171.7	9.25	
	1050	145	13.07	7.33	0.732	>1000	0.76	170.7	9.25	
	1100	155	13.01	7.33	0.764	>1000	0.65	170.4	9.25	St[illegible] less cloudy
	1110	165	13.00	7.3	0.764	373	0.45	170.4	9.25	Clearer
	1120	175	13.00	7.31	0.718	198	0.58	170.7	8.80	Clearer S[illegible]
	1130	185	12.96	7.31	0.763	138	0.68	168.3	8.73	
	1140	195	13.12	7.33	0.717	98.4	0.59	168.2	8.73	– OUT of Sclean [illegible]
	1150	198	10.33	7.29	0.718	204	1.52	171.9	7.50	
	1200	200	10.40	7.33	0.726	147	1.25	173.7	7.51	Break – Lunch [illegible]
	1230	203	11.05	7.16	0.757	113	1.26	173.1	7.52	– Restart
	1240	206	10.84	7.36	0.757	125	1.25	166.9	7.52	
	1250	209	10.76	7.32	0.759	113	1.23	168.1	7.52	
	1300	212.	10.42	7.12	0.732	128	1.22	174.1	7.52	STOP w/ Waterra. continue by [illegible]
	1310	214	10.40	7.10	0.724	132	1.23	180.5	7.46	
	1320	216	10.57	7.27	0.726	112	1.24	175.9	7.41	
	1333	220	12.48	7.87	0.756	>1000	1.46	-59.3	~~[illegible]~~	Muddy
	1345	225	12.42	7.62	0.765	374	0.99	-33.2	7.41	
	1408	230	12.31	7.74	0.762	>1000	1.08	-84.8	7.41	
	1435	235	12.37	7.71	0.756	[illegible]	1.10	-83.2	7.45	Clear
	1451	237	12.78	7.54	0.771	29.7	1.15	-91.2	7.40	Slow flow water @ 1445 low flow
	1456	239	12.78			79.6				

Sheet 2 of 2

Golder Associates WELL DEVELOPMENT/PURGING FORM

Project Ref: Ameren GW Monitoring　　**Project No.:** 153-1406.

Location BMW-15

Monitored By: JSI　Date 1/22/16　Time 0800.

PAGE 2

Well Piezometer Data

(circle one)

Depth of Well (from top of PVC or ground)	25.95	feet
Depth of Water (from top of PVC or ground)	7.35	feet
Radius of Casing	2.00	inches
	6.50	feet
Casing Volume	6.5 x 3 = 19.5	cubic feet
	19.5 total	gallons

SEE PAGE 1

49.5 total gals

Development / Purging Discharge Data

Purging Method: Waterra

Start Purging　Date 1/22/16　Time 0821

Stop Purging　Date 1/22/16　Time 1544

Monitoring

Date	Time	Volume Discharge (gals)	Temp (°C)	pH	Spec.Cond. (mS/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/L)	Redox Potential (+/- mV)	WL (ft BTOC)	Appearance of Water and Comments
1/22	1500	239	10.39	7.44	0.761	71.6	1.26	-63.9	7.45	Clear
1/22	1510	241	10.37	7.40	0.752	27.8	1.31	-60.3	7.45	Clear
1/22	1520	243	10.32	7.41	0.743	12.6	1.33	-57.2	7.46	Clear.
1/22	1530	245	10.31	7.38	0.760	10.1	1.35	-59.2	7.46	
1/22	1540	247	10.32	7.33	0.754	4.2	1.36	-57.4	7.46	

END 23.97

Sheet 1 of 2

Golder Associates WELL DEVELOPMENT/PURGING FORM

Project Ref: Ameren GW Monitoring **Project No.:** 153-1406.

Location

BMW-3S

Monitored By: M-GORE Date 11/10/2016 11/11/2016 Time 1300 — 1700 1030 —

Stickup 2.6'

Well Piezometer Data

(circle one)

Depth of Well (from top of PVC or ground)	26.74	feet
Depth of Water (from top of PVC or ground)	8.65	feet
Radius of Casing	2	inches
		feet
Casing Volume	[illegible]	cubic feet
	6.7	gallons

$\boxed{27.0}$

Need to remove

$40 + 6.7 = \boxed{47 \text{ gall}}$

Development / Purging Discharge Data

Purging Method	Watera			
Start Purging	Date 11/10/2016	Time 1300	11/11/16 1030	
Stop Purging	Date 11/10/2016	Time 1700	11/11/16	

Monitoring

	Date	Time	Volume Discharge (gals)	Temp (°C)	pH	Spec.Cond. (mS/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/L)	Redox Potential (+/- mV)	WL (ft BTOC)	Appearance of Water and Comments	
		1300								8.95	START	
0	11/10	1320	40	17.21	7.49	0.638	>1000	4.59	-202	8.96	Cloudy	
1		1330	20/60	17.30	7.39	0.744	>1000	5.37	-271	8.99	Cloudy	
2		1340	20/80	17.01	7.19	0.739	>1000	3.22	-418	8.94	Cloudy	
3		1350	20/100	16.73	6.96	0.725	>1000	3.03	-324	8.93	Cloudy	
4		1400	20/120	16.81	7.22	[illegible]	>1000	1.90	-451	8.94	Cloudy	
5		1410	20/140	16.45	7.69	0.613	>1000	3.02	-438	8.95	Cloudy	
6		1420	20/160	16.75	7.54	0.613	>1000	3.31	-483	8.94	Cloudy	
7		1430	20/180	16.33	7.69	0.606	>1000	3.76	-492	8.94	Cloudy	
8		1440	20/200	16.39	7.51	0.603	>1000	4.75	-486	8.96	Cloudy	
9		1450	20/220	16.73	7.21	0.602	>1000	2.99	-484	8.93	Cloudy	
10		1500	20/240	16.48	7.70	0.595	897	3.74	-478	8.91	Cloudy	
Above Screen	1550	~~1505~~	10/250	16.43	7.73	0.608	776	5.30	-455	8.90	Cloudy	← Decrease Flow rate by 1/2
		1600	10/260	14.70	7.51	0.577	478	7.02	-413	8.91	Cloudy	
		1610	10/270	15.26	7.38	0.580	600	6.54	-401	8.90	Cloudy	
		1620	10/280	14.49	7.36	0.569	435	6.21	-412	8.92	Cloudy	
		1630	10/290	14.33	7.34	0.560	324	6.43	-406	8.91	Cloudy	
		1640	10/300	13.99	7.39	0.555	264	5.93	-416	8.91	Cloudy	
		1650	10/310	13.61	7.36	0.549	212	4.61	-414	8.90	Cloudy Stopped @	1650
recalibrated equipment	11/11	~~1700~~	10/320	~~18~~							Started 11/11	
	1050	1030	20/340	18.43	6.75	0.768	182	4.53	-220	8.92	Cloudy	
		1100	10/350	18.61	7.41	0.768	167	5.25	-237	8.91	Cloudy	
		1110	10/360	18.78	7.25	0.761	139	4.66	-291	8.90	Cloudy	
		1130	20/380	18.91	7.26	0.740	131	4.51	-309	8.91	Cloudy	
removed surge block →		1150	20/400	18.65	7.26	0.720	132	4.80	-264	8.93	Cloudy	
		1210	20/420	18.73	7.60	0.733	69	5.22	-255	8.91	Cloudy	
		1230	20/440	18.93	7.21	0.714	62	4.42	-287	8.92	Cloudy	

Sheet 2 of 2

Golder Associates WELL DEVELOPMENT/PURGING FORM

Project Ref: Ameren GW Monitoring **Project No.:** 153-1406.

Location BMW-35

Monitored By: M. GORE Date 11/10/2016 11/11/2016 Time 1300-1700 1030-

Well Piezometer Data

(circle one)

Depth of Well (from top of PVC or ground)	26.74	feet
Depth of Water (from top of PVC or ground)	8.65	feet
Radius of Casing	2	inches
	—	feet
Casing Volume	—	cubic feet
	6.7	gallons

27.0'

stickup 2.6'

Development / Purging Discharge Data

Purging Method: Watera

Start Purging Date 11/10/2016 Time 1300 11/11/2016 1030

Stop Purging Date 11/10/2016 Time 1700 11/11/2016

Monitoring

Date	Time	Volume Discharge (gals)	Temp (°C)	pH	Spec.Cond. (mS/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/L)	Redox Potential (+/- mV)	WL (ft BTOC)	Appearance of Water and Comments
cont'd 11/11/16	1230	20/440	18.93	7.21	0.714	62	4.42	-287	8.92	Cloudy
	1250	20/460	18.67	7.25	0.703	52.3	4.56	-284	8.91	Cloudy
	1310	20/480	16.45	7.66	0.713	64.2	4.32	-327	8.92	Cloudy
	~~1330~~	~~20/~~								Pause to cool pump
	1350	20/500	17.37	7.61	0.723	46.2	5.02	-277	8.90	Cloudy
	~~1400~~		16.			131			8.92	1380 - 1400 Flushed screen @ highest Flow rate followed by a 10 minute break
	1410	START AGAIN								
	1420	10/510	16.44	7.61	0.714	131	4.55	-250	8.92	Cloudy
	1440	20/530	15.94	7.56	0.711	70	5.97	-283	8.91	Cloudy
	1450	10/540	15.23	7.39	0.704	107	2.36	-316	8.90	Cloudy Slowed down rate
550	1510	~~20/560~~	14.10	7.46	0.694	77	4.09	-265	8.93	Cloudy
560	1530	~~20/580~~	13.75	6.96	0.674	50.6	3.41	-320	8.91	Cloudy
	1550	10/570	13.36	7.42	0.677	35.1	5.10	-239	8.90	Cloudy
	1620	10/580	13.24	7.52	0.682	19.7	6.22	-187	8.92	Cloudy
	1650	10/590	13.03	7.39	0.683	16.3	6.73	-151		Cloudy

APPENDIX G
CCR MDNR WELL CERTIFICATION FORMS

MISSOURI DEPARTMENT OF NATURAL RESOURCES
DIVISION OF GEOLOGY AND LAND SURVEY
(573) 368-2165

MONITORING WELL CERTIFICATION RECORD

REF NO	DATE RECEIVED
00305963	05/26/2016
CR NO	CHECK NO. 170099
STATE WELL NO A206737 05/31/2016	REVENUE NO. 052616
ENTERED NRBASSM PH1 PH2 PH3 05/26/2016 05/26/2016 05/26/2016	APPROVED BY / ROUTE

INFORMATION SUPPLIED BY PRIMARY CONTRACTOR OR DRILLING CONTRACTOR

NOTE: THIS FORM IS NOT TO BE USED FOR NESTED WELLS

OWNER NAME AMEREN MISSOURI C/O BILL KUTOSKY	CONTACT NAME AMEREN MISSOURI C/O BILL KUTOSKY			VARIANCE GRANTED BY DNR
OWNER ADDRESS 370 S LINDBERGH BLVD	CITY ST LOUIS	STATE MO	ZIP 63127	NUMBER ________
SITE NAME SIOUX ENERGY CENTER		WELL NUMBER TMW 1		COUNTY ST CHARLES
SITE ADDRESS 8501 N STATE ROUTE 94		CITY WEST ALTON		STATIC WATER LEVEL 10.87 FT

SURFACE COMPLETION
TYPE
[X] ABOVE GROUND
[ ] FLUSH MOUNT

LENGTH AND DIAMETER OF SURFACE COMPLETION
LENGTH 5.0 FT.
DIAMETER 4.0 IN.

DIAMETER AND DEPTH OF THE HOLE SURFACE COMPLETION WAS PLACED
DIAMETER 12.0 IN.
LENGTH 2.5 FT.

SURFACE COMPLETION GROUT
[X] CONCRETE
[ ] OTHER

COPY

LOCATION OF WELL
LAT. 38 ° 54' 7.41"
LONG. 90 ° 17' 22.08"

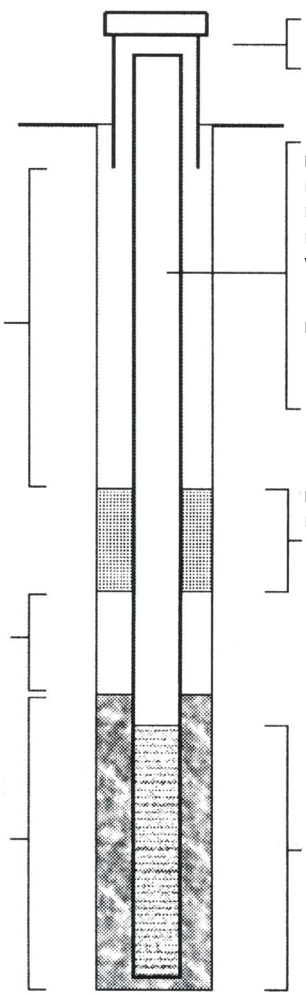
SMALLEST ____ 1/4 ____ 1/4 ____ 1/4 LARGEST

SEC. LG001838 TWN. ____ NORTH
RANGE ____ Direction

MONITORING FOR:
[ ] RADIONUCLIDES [ ] PETROLEUM PRODUCTS ONLY
[ ] EXPLOSIVES [ ] METALS [ ] VOC
[ ] SVOCS [ ] PESTICIDES/HERBICIDESS

PROPOSED USE OF WELL
[ ] GAS MIGRATION WELL [ ] OBSERVATION
[ ] EXTRACTION WELL [ ] OPEN HOLE
[X] PIEZOMETERS
[ ] DIRECT PUSH

[ ] LOCKING CAP
[ ] WEEP HOLE



SURFACE COMPLETTION
[ ] STEEL [X] ALUMINUM [ ] PLASTIC

ELEVATION ____ FT.

RISER
RISER PIPE DIAMETER 2.0 IN.
RISER PIPE LENGTH 18.7 FT.
HOLE DIAMETER 6.0 IN.
WEIGHT OR SDR# SCH40

ANNULAR SEAL
LENGTH 0.0 FT.
[ ] SLURRY [ ] CHIPS
[ ] PELLETS [ ] GRANULAR
[ ] CEMENT/SLURRY

MATERIAL
[ ] STEEL [X] THERMOPLASTIC (PVC)
[ ] OTHER ____

IF CEMENT/BENTONITE MIX:
BAGS OF CEMENT USED:
%OF BENTONITE USED:
WATER USED/BAG: GAL.

BENTONITE SEAL
LENGTH: 10.5
[ ] CHIPS [ ] PELLETS [ ] GRANULAR
[ ] SLURRY
[ ] SATURATED ZONE [ ] HYDRATED

SECONDARY FILTER PACK
LENGTH: 1.0 FT.

SCREEN
SCREEN DIAMETER: 2.0 IN.
SCREEN LENGTH: 9.8 FT.
DIAMETER OF DRILL HOLE: 6.0 IN.
DEPTH TO TOP 20.2 FT.

DEPTH TO TOP OF PRIMARY
FILTER PACK: 17.3 FT.

SCREEN MATERIAL
[ ] STEEL [X] THERMOPLASTIC (PVC)
[ ] OTHER

LENGTH OF PRIMARY FILTER PACK: **12.7 FT.**

DEPTH FROM	DEPTH TO	FORMATION DESCRIPTION
0.0	0.9	SDY CLY SLT
0.9	2.4	STY CLY
2.4	7.5	CLY SLT
7.5	10.0	SDY STY CLY
10.0	28.7	SND
28.7	30.0	SND

TOTAL DEPTH: 30.0 FEET

FOR CASED WELLS, SUBMIT ADDITIONAL AS BUILT DIAGRAMS SHOWING WELL CONSTRUCTION DETAILS INCLUDING TYPE AND SIZE OF ALL CASING, HOLE DIAMETER AND GROUT USED.

SIGNATURE (PRIMARY COUNTRACTOR) x JEFFREY INGRAM	PERMIT NUMBER 006124	DATE WELL DRILLING WAS COMPLETED 04/05/2016

I HEREBY CERTIFY THAT THE MONITORING WELL HEREIN DESCRIBED WAS CONSTRUCTED IN ACCORDANCE WITH MISSOURI DEPARTMENT OF NATURAL RESOURCES REQUIREMENTS FOR THE CONSTRUCTION OF MONITORING WELLS

[ ] PUMP INSTALLED

SIGNATURE (WELL DRILLER) x JASON DRABEK	PERMIT NUMBER 004484	SIGNATURE (APPRENTICE) x ________	APPRENTICE PERMIT NUMBER ________

MISSOURI DEPARTMENT OF NATURAL RESOURCES
DIVISION OF GEOLOGY AND LAND SURVEY
(573) 368-2165

MONITORING WELL CERTIFICATION RECORD

REF NO 00305964	DATE RECEIVED 05/26/2016	
CR NO	CHECK NO. 170099	
STATE WELL NO A206738 05/31/2016	REVENUE NO. 052616	
ENTERED NRBASSM PH1 PH2 PH3 05/26/2016 05/26/2016 05/26/2016	APPROVED BY	ROUTE

INFORMATION SUPPLIED BY PRIMARY CONTRACTOR OR DRILLING CONTRACTOR

NOTE: THIS FORM IS NOT TO BE USED FOR NESTED WELLS

OWNER NAME AMEREN MISSOURI C/O BILL KUTOSKY	CONTACT NAME AMEREN MISSOURI C/O BILL KUTOSKY			VARIANCE GRANTED BY DNR
OWNER ADDRESS 370 S LINDBERGH BLVD	CITY ST LOUIS	STATE MO	ZIP 63127	NUMBER ________
SITE NAME SIOUX ENERGY CENTER		WELL NUMBER TMW 2		COUNTY ST CHARLES
SITE ADDRESS 8501 N STATE ROUTE 94		CITY WEST ALTON		STATIC WATER LEVEL 11.0 FT

SURFACE COMPLETION

TYPE
- [X] ABOVE GROUND
- [ ] FLUSH MOUNT

LENGTH AND DIAMETER OF SURFACE COMPLETION
LENGTH 5.0 FT.
DIAMETER 4.0 IN.

DIAMETER AND DEPTH OF THE HOLE SURFACE COMPLETION WAS PLACED
DIAMETER 12.0 IN.
LENGTH 2.5 FT.

SURFACE COMPLETION GROUT
- [X] CONCRETE
- [ ] OTHER

COPY

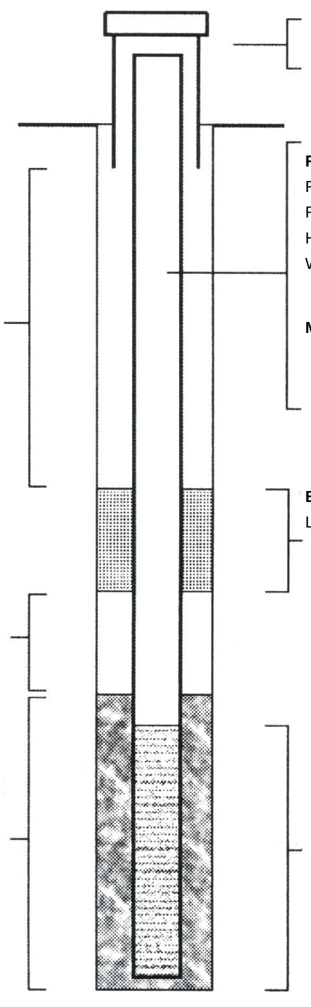
LOCATION OF WELL
LAT. 38 ° 54' 6.76"
LONG. 90 ° 17' 18.01"

SMALLEST ______ 1/4 ______ 1/4 LARGEST ______ 1/4

SEC. LG001838 TWN. ______ NORTH
RANGE ______ Direction E

MONITORING FOR:
- [ ] RADIONUCLIDES
- [ ] EXPLOSIVES
- [ ] SVOCS
- [ ] PETROLEUM PRODUCTS ONLY
- [ ] METALS
- [ ] VOC
- [ ] PESTICIDES/HERBICIDESS

- [ ] LOCKING CAP
- [ ] WEEP HOLE



SURFACE COMPLETTION
- [ ] STEEL
- [X] ALUMINUM
- [ ] PLASTIC

ELEVATION ______FT.

ANNULAR SEAL
LENGTH ______0.0FT.
- [ ] SLURRY
- [ ] PELLETS
- [ ] CEMENT/SLURRY
- [ ] CHIPS
- [ ] GRANULAR

IF CEMENT/BENTONITE MIX:
BAGS OF CEMENT USED:
%OF BENTONITE USED:
WATER USED/BAG: GAL.

RISER
RISER PIPE DIAMETER ______2.0IN.
RISER PIPE LENGTH ______20.2FT.
HOLE DIAMETER ______6.0IN.
WEIGHT OR SDR# ______SCH40

MATERIAL
- [ ] STEEL
- [ ] OTHER ______
- [X] THERMOPLASTIC (PVC)

PROPOSED USE OF WELL
- [ ] GAS MIGRATION WELL
- [ ] EXTRACTION WELL
- [X] PIEZOMETERS
- [ ] DIRECT PUSH
- [ ] OBSERVATION
- [ ] OPEN HOLE

BENTONITE SEAL
LENGTH: 11.5
- [ ] CHIPS
- [ ] PELLETS
- [ ] GRANULAR
- [ ] SLURRY
- [ ] SATURATED ZONE
- [ ] HYDRATED

SECONDARY FILTER PACK
LENGTH: ______1.0FT.

SCREEN
SCREEN DIAMETER: ______2.0IN.
SCREEN LENGTH: ______9.8FT.
DIAMETER OF DRILL HOLE: 6.0IN.
DEPTH TO TOP ______20.2FT.

DEPTH TO TOP OF PRIMARY
FILTER PACK: ______16.9FT.

SCREEN MATERIAL
- [ ] STEEL
- [ ] OTHER
- [X] THERMOPLASTIC (PVC)

LENGTH OF PRIMARY FILTER PACK: ______13.1FT.

DEPTH FROM	DEPTH TO	FORMATION DESCRIPTION
0.0	0.6	SND SLTY
0.6	6.0	STY CLY
6.0	6.5	CLY SND
6.5	10.0	STY CLY
10.0	11.9	SDY SLTY CLY
11.9	30.0	SND

TOTAL DEPTH: ______30.0 FEET

FOR CASED WELLS, SUBMIT ADDITIONAL AS BUILT DIAGRAMS SHOWING WELL CONSTRUCTION DETAILS INCLUDING TYPE AND SIZE OF ALL CASING, HOLE DIAMETER AND GROUT USED.

SIGNATURE (PRIMARY COUNTRACTOR) x JEFFREY INGRAM	PERMIT NUMBER 006124	DATE WELL DRILLING WAS COMPLETED 04/05/2016

I HEREBY CERTIFY THAT THE MONITORING WELL HEREIN DESCRIBED WAS CONSTRUCTED IN ACCORDANCE WITH MISSOURI DEPARTMENT OF NATURAL RESOURCES REQUIREMENTS FOR THE CONSTRUCTION OF MONITORING WELLS

- [ ] PUMP INSTALLED

SIGNATURE (WELL DRILLER) x JASON DRABEK	PERMIT NUMBER 004484	SIGNATURE (APPRENTICE) x ________	APPRENTICE PERMIT NUMBER ________

MISSOURI DEPARTMENT OF NATURAL RESOURCES
DIVISION OF GEOLOGY AND LAND SURVEY
(573) 368-2165

MONITORING WELL CERTIFICATION RECORD

REF NO	DATE RECEIVED
00305965	05/26/2016
CR NO	CHECK NO. 170099
STATE WELL NO A206739 05/31/2016	REVENUE NO. 052616

ENTERED NRBASSM	APPROVED BY	ROUTE
PH1 PH2 PH3 05/26/2016 05/26/2016 05/26/2016		

INFORMATION SUPPLIED BY PRIMARY CONTRACTOR OR DRILLING CONTRACTOR

NOTE: THIS FORM IS NOT TO BE USED FOR NESTED WELLS

OWNER NAME AMEREN MISSOURI C/O BILL KUTOSKY	CONTACT NAME AMEREN MISSOURI C/O BILL KUTOSKY			VARIANCE GRANTED BY DNR
OWNER ADDRESS 370 S LINDBERGH BLVD	CITY ST LOUIS	STATE MO	ZIP 63127	NUMBER ________________
SITE NAME SIOUX ENERGY CENTER		WELL NUMBER TMW 3		COUNTY ST CHARLES
SITE ADDRESS 8501 N STATE ROUTE 94		CITY WEST ALTON		STATIC WATER LEVEL FT

SURFACE COMPLETION

TYPE
[X] ABOVE GROUND
[ ] FLUSH MOUNT

LENGTH AND DIAMETER OF SURFACE COMPLETION
LENGTH 5.0 FT.
DIAMETER 4.0 IN.

DIAMETER AND DEPTH OF THE HOLE SURFACE COMPLETION WAS PLACED
DIAMETER 12.0 IN.
LENGTH 2.5 FT.

SURFACE COMPLETION GROUT
[X] CONCRETE
[ ] OTHER

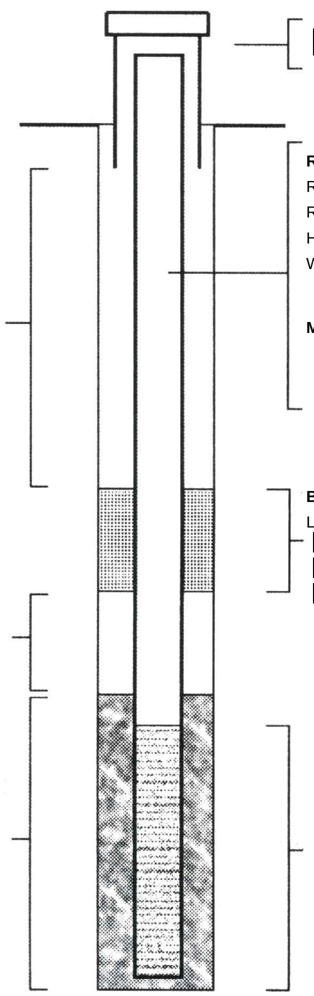
COPY

LOCATION OF WELL
LAT. 38 ° 54' 6.15"
LONG. 90 ° 17' 13.97"

SMALLEST ________ 1/4 ________ 1/4 ________ 1/4 LARGEST

SEC. 19 TWN. 48 NORTH
RANGE 6 Direction E

[ ] LOCKING CAP
[ ] WEEP HOLE



SURFACE COMPLETTION
[ ] STEEL [X] ALUMINUM [ ] PLASTIC

MONITORING FOR:
[ ] RADIONUCLIDES [ ] PETROLEUM PRODUCTS ONLY
[ ] EXPLOSIVES [ ] METALS [ ] VOC
[ ] SVOCS [ ] PESTICIDES/HERBICIDESS

ELEVATION ________FT.

RISER
RISER PIPE DIAMETER 2.0 IN.
RISER PIPE LENGTH 19.9 FT.
HOLE DIAMETER 6.0 IN.
WEIGHT OR SDR# SCH40

ANNULAR SEAL
LENGTH 0.0 FT.
[ ] SLURRY [ ] CHIPS
[ ] PELLETS [ ] GRANULAR
[ ] CEMENT/SLURRY

PROPOSED USE OF WELL
[ ] GAS MIGRATION WELL [ ] OBSERVATION
[ ] EXTRACTION WELL [ ] OPEN HOLE
[X] PIEZOMETERS
[ ] DIRECT PUSH

MATERIAL
[ ] STEEL [X] THERMOPLASTIC (PVC)
[ ] OTHER ______

IF CEMENT/BENTONITE MIX:
BAGS OF CEMENT USED:
%OF BENTONITE USED:
WATER USED/BAG: GAL.

BENTONITE SEAL
LENGTH: 10.5
[ ] CHIPS [ ] PELLETS [ ] GRANULAR
[ ] SLURRY
[ ] SATURATED ZONE [ ] HYDRATED

DEPTH FROM	DEPTH TO	FORMATION DESCRIPTION
0.0	0.6	SND STY CLY
0.6	10.0	STY CLY
10.0	12.0	CLY SLT
12.0	27.5	SND
27.5	30.0	SND

SECONDARY FILTER PACK
LENGTH: 1.0 FT.

SCREEN
SCREEN DIAMETER: 2.0 IN.
SCREEN LENGTH: 9.8 FT.
DIAMETER OF DRILL HOLE: 6.0 IN.
DEPTH TO TOP 20.2 FT.

DEPTH TO TOP OF PRIMARY
FILTER PACK: 16.1 FT.

SCREEN MATERIAL
[ ] STEEL [X] THERMOPLASTIC (PVC)
[ ] OTHER

LENGTH OF PRIMARY FILTER PACK: 13.9 FT.

TOTAL DEPTH: 30.0 FEET

FOR CASED WELLS, SUBMIT ADDITIONAL AS BUILT DIAGRAMS SHOWING WELL CONSTRUCTION DETAILS INCLUDING TYPE AND SIZE OF ALL CASING, HOLE DIAMETER AND GROUT USED.

SIGNATURE (PRIMARY COUNTRACTOR) x JEFFREY INGRAM	PERMIT NUMBER 006124		DATE WELL DRILLING WAS COMPLETED 04/05/2016
I HEREBY CERTIFY THAT THE MONITORING WELL HEREIN DESCRIBED WAS CONSTRUCTED IN ACCORDANCE WITH MISSOURI DEPARTMENT OF NATURAL RESOURCES REQUIREMENTS FOR THE CONSTRUCTION OF MONITORING WELLS			[ ] PUMP INSTALLED
SIGNATURE (WELL DRILLER) x JASON DRABEK	PERMIT NUMBER 004484	SIGNATURE (APPRENTICE) x ________________	APPRENTICE PERMIT NUMBER ________

MISSOURI DEPARTMENT OF NATURAL RESOURCES
DIVISION OF GEOLOGY AND LAND SURVEY
(573) 368-2165

MONITORING WELL CERTIFICATION RECORD

REF NO	DATE RECEIVED	
00512903	02/04/2016	
CR NO	CHECK NO. 170079	
STATE WELL NO A206275 02/09/2016	REVENUE NO. 020416	
ENTERED NRBASSM PH1 PH2 PH3 02/08/2016 02/08/2016 02/08/2016	APPROVED BY	ROUTE

INFORMATION SUPPLIED BY PRIMARY CONTRACTOR OR DRILLING CONTRACTOR

NOTE: THIS FORM IS NOT TO BE USED FOR NESTED WELLS

OWNER NAME	CONTACT NAME			VARIANCE GRANTED BY DNR
AMEREN MISSOURI C/O BILL KUTOSKY	AMEREN MISSOURI C/O BILL KUTOSKY			
OWNER ADDRESS 3750 S LINDBERGH BLVD.	CITY ST LOUIS	STATE MO	ZIP 63127	NUMBER ________
SITE NAME SIOUX ENERGY CENTER		WELL NUMBER BMW 1S		COUNTY ST CHARLES
SITE ADDRESS 8501 N STATE ROUTE 94		CITY WEST ALTON		STATIC WATER LEVEL 7.4 FT

SURFACE COMPLETION

TYPE
[X] ABOVE GROUND
[ ] FLUSH MOUNT

LENGTH AND DIAMETER OF SURFACE COMPLETION
LENGTH 5.0 FT.
DIAMETER 4.0 IN.

DIAMETER AND DEPTH OF THE HOLE SURFACE COMPLETION WAS PLACED
DIAMETER 12.0 IN.
LENGTH 2.5 FT.

SURFACE COMPLETION GROUT
[X] CONCRETE
[ ] OTHER

COPY

LOCATION OF WELL
LAT. 38 ° 54' 50.22"
LONG. 90 ° 18' 4.54"

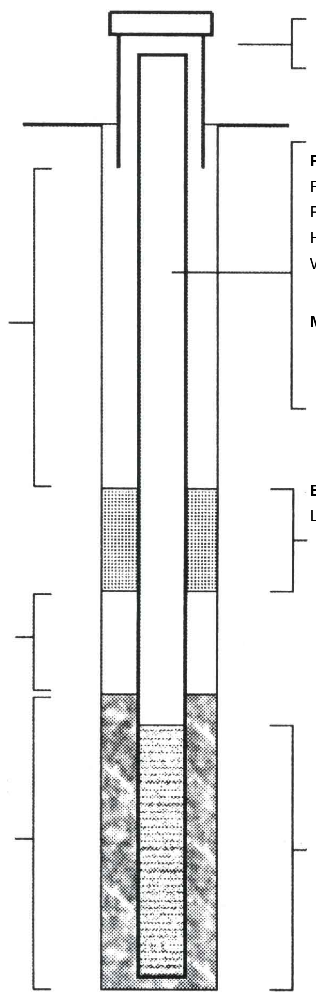
SMALLEST ______ 1/4 ______ 1/4 LARGEST ______ 1/4

SEC. 19 TWN. 48 NORTH
RANGE 6 Direction E

MONITORING FOR:
[ ] RADIONUCLIDES [ ] PETROLEUM PRODUCTS ONLY
[ ] EXPLOSIVES [X] METALS [ ] VOC
[ ] SVOCS [ ] PESTICIDES/HERBICIDESS

PROPOSED USE OF WELL
[ ] GAS MIGRATION WELL [X] OBSERVATION
[ ] EXTRACTION WELL [ ] OPEN HOLE
[ ] PIEZOMETERS
[ ] DIRECT PUSH

[ ] LOCKING CAP
[ ] WEEP HOLE



SURFACE COMPLETTION
[ ] STEEL [X] ALUMINUM [ ] PLASTIC

ELEVATION ______FT.

RISER
RISER PIPE DIAMETER 2.0IN.
RISER PIPE LENGTH 15.8FT.
HOLE DIAMETER 6.0IN.
WEIGHT OR SDR# SCH40

ANNULAR SEAL
LENGTH 0.0FT.
[ ] SLURRY [ ] CHIPS
[ ] PELLETS [ ] GRANULAR
[ ] CEMENT/SLURRY

MATERIAL
[ ] STEEL [X] THERMOPLASTIC (PVC)
[ ] OTHER ______

IF CEMENT/BENTONITE MIX:
BAGS OF CEMENT USED:
%OF BENTONITE USED:
WATER USED/BAG: GAL.

BENTONITE SEAL
LENGTH: 9.5
[ ] CHIPS [ ] PELLETS [ ] GRANULAR
[ ] SLURRY
[ ] SATURATED ZONE [ ] HYDRATED

SECONDARY FILTER PACK
LENGTH: 0.1FT.

SCREEN
SCREEN DIAMETER: 2.0IN.
SCREEN LENGTH: 9.8FT.
DIAMETER OF DRILL HOLE: 6.0IN.
DEPTH TO TOP 15.2FT.

DEPTH TO TOP OF PRIMARY
FILTER PACK: 12.5FT.

SCREEN MATERIAL
[ ] STEEL [X] THERMOPLASTIC (PVC)
[ ] OTHER

LENGTH OF PRIMARY FILTER PACK: 12.5FT.

DEPTH FROM	DEPTH TO	FORMATION DESCRIPTION
0.0	8.5	SDY SLT
8.5	15.6	STY CLY
15.6	17.5	SND
17.5	18.5	STY CLY
18.5	25.0	SND

TOTAL DEPTH: 25.0 FEET

FOR CASED WELLS, SUBMIT ADDITIONAL AS BUILT DIAGRAMS SHOWING WELL CONSTRUCTION DETAILS INCLUDING TYPE AND SIZE OF ALL CASING, HOLE DIAMETER AND GROUT USED.

SIGNATURE (PRIMARY COUNTRACTOR)	PERMIT NUMBER		DATE WELL DRILLING WAS COMPLETED
x JOHN SUOZZI	006284		12/08/2015
I HEREBY CERTIFY THAT THE MONITORING WELL HEREIN DESCRIBED WAS CONSTRUCTED IN ACCORDANCE WITH MISSOURI DEPARTMENT OF NATURAL RESOURCES REQUIREMENTS FOR THE CONSTRUCTION OF MONITORING WELLS			[ ] PUMP INSTALLED
SIGNATURE (WELL DRILLER) x JASON DRABEK	PERMIT NUMBER 004484	SIGNATURE (APPRENTICE) x ________	APPRENTICE PERMIT NUMBER ________

MISSOURI DEPARTMENT OF NATURAL RESOURCES
GEOLOGICAL SURVEY PROGRAM

MONITORING WELL CERTIFICATION RECORD

NOTE: This form is not to be used for nested wells

OFFICE USE ONLY		DATE RECEIVED	
REFERENCE NO.		CHECK NO.	
STATE WELL NO.		REVENUE NO.	
ENTERED	APPROVED	DATE	ROUTE / /

OWNER AND SITE INFORMATION

PROPERTY OWNER NAME WHERE WELL IS LOCATED: Sioux Energy Center	PRIMARY PHONE NUMBER WITH AREA CODE:	WELL NUMBER: BMW-3S	WELL COMPLETION DATE: 11/08/2016
PROPERTY OWNER MAILING ADDRESS: 8501 N State Rd 94	CITY: West Alton	STATE: MO	ZIP CODE: 63386
PHYSICAL ADDRESS OF PROPERTY WHERE WELL IS LOCATED: 8501 N State Rd 94	CITY: West Alton	COUNTY: St Charles	
NAME OF SITE OR CLEANUP PROJECT: Ameren CCR GW Monitoring	DNR/EPA PROJECT NUMBER OR REGULATORY SITE ID NUMBER (IF APPLICABLE): 153-1406.0003B	VARIANCE NUMBER (IF ISSUED):	
PRIMARY CONTRACTOR NAME (PLEASE PRINT):	PERMIT NUMBER:	*Section 256.607(3), RSMo, requires all primary contractors to comply with all rules and regulations promulgated pursuant to Sections 256.600 to 256.640 RSMo.*	

SURFACE COMPLETION

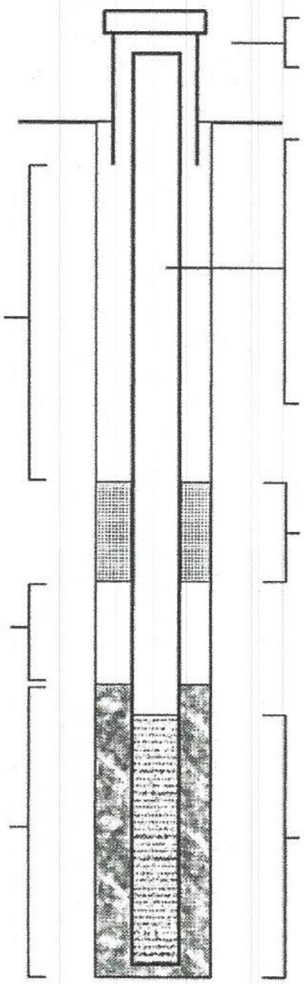
TYPE
- ☑ Above Ground
- ☐ Flush Mount

LENGTH AND DIAMETER OF SURFACE COMPLETION
Length 2.57 FT.
Diameter 4 IN.

DIAMETER AND DEPTH OF THE HOLE SURFACE COMPLETION WAS PLACED
Diameter 12 IN.
Length 24.17 FT.

SURFACE COMPLETION GROUT
- ☑ Concrete
- ☐ Other ____

- ☑ Locking Cap
- ☐ Weep Hole



Elevation 424.12 FT.

ANNULAR SEAL
Length 9 FT.
☑ Slurry ☐ Chips
☐ Pellets ☐ Granular
☐ Cement/Slurry

IF CEMENT/BENTONITE MIX:
Bags of Cement Used ____
% of Bentonite Used ____
Water Used Per Bag ____ GAL.

SECONDARY FILTER PACK LENGTH
0.8 FT.

DEPTH TO TOP OF PRIMARY FILTER PACK
11.6 FT.

LENGTH OF PRIMARY FILTER PACK
12.57 FT.

SURFACE COMPLETION
☐ Steel ☑ Aluminum ☐ Plastic

RISER OR CASING (IF OPEN HOLE COMPLETION)
Riser/Casing Diameter 2 IN.
Riser/Casing Length 16.5 FT.
Diameter Of Drill Hole 6 IN.
Weight Or SDR# S40

MATERIAL
☐ Steel ☑ Thermoplastic (PVC)
☐ Other ____

BENTONITE SEAL
Length 2.5
☑ Chips ☐ Pellets ☐ Granular
☐ Saturated Zone ☐ Hydrated

SCREEN
Screen Diameter 2 IN.
Screen Length 9.8 FT.
Diameter Of Drill Hole 6 IN.
Depth To Top 24.1 FT.

SCREEN MATERIAL
☐ Steel ☑ Thermoplastic (PVC)
☐ Other ____

LOCATION OF WELL (D/M/S FORMAT ONLY)
Latitude 38 ° 54 ' 50.93N "
Longitude 90 ° 18 ' 16.53W "

SMALLEST ____ ¼ ____ ¼ LARGEST ____ ¼
Section ____ Township ____ North
Range ____ ☐ E ☐ W

TYPE OF WELL (CHECK ONE)
☐ Direct Push ☐ Extraction ☐ Inclinometer
☐ Gas Migration ☐ Injection Lysimeter
☑ Observation ☐ Open Hole ☐ Other (specify)
☐ Piezometer ☐ Standard ____

MONITORING FOR (CHECK ALL THAT APPLY)
☐ Explosives ☐ Metals
☐ Pesticides/Herbicides ☐ Petroleum
☐ Radionuclides ☐ SVOCS
☐ VOCS (non-petroleum) ☐ Geotechnical Data

DEPTH FROM	DEPTH TO	FORMATION DESCRIPTION (OR ATTACH BORING LOG*)

TOTAL DEPTH: FT.
☐ *Boring Log Attached

STATIC WATER LEVEL 8.65 FT.
PUMP INSTALLED ☐ Yes ☑ No

For cased wells, submit additional as-built diagrams showing well construction details including type and size of all casing, hole diameter and grout used.

I hereby certify that the monitoring well herein described was constructed in accordance with Missouri Department of Natural Resources requirements.

MONITORING WELL INSTALLATION CONTRACTOR	PERMIT NUMBER	DATE	MONITORING WELL INSTALLATION CONTRACTOR APPRENTICE (IF APPLICABLE)	PERMIT NUMBER
[signature]	4398	8-28-17		

MO 780-1415 (8-16) **SEND COMPLETED FORM ALONG WITH $100 CERTIFICATION FEE TO: MISSOURI DEPARTMENT OF NATURAL RESOURCES, MISSOURI GEOLOGICAL SURVEY, WELLHEAD PROTECTION SECTION, PO BOX 250, ROLLA, MO 65402 PHONE: 573-368-2165 FAX: 573-368-2317 EMAIL: welldrillers@dnr.mo.gov RECORD (AND FEE) MAY BE SUBMITTED ONLINE: dnr.mo.gov/mowells**

AMEREN_00001558

APPENDIX H
STATISTICAL ANALYSIS PLAN

Statistical Analysis Plan

STATISTICAL ANALYSIS PLAN

Prepared in accordance with the United States Environmental Protection Agencies Coal Combustion Rule, part 40 CFR 257.93 for Ameren Missouri's Utility Waste Landfill Cell SCL4A at the Sioux Energy Center, St. Charles County, Missouri

Submitted To: Ameren Missouri
1901 Chouteau Avenue
St. Louis, Missouri 63103

Submitted By: Golder Associates Inc.
820 S. Main Street, Suite 100
St. Charles, MO 63301 USA

Date: October 12, 2017 **Project No.153-1406**

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EXECUTIVE SUMMARY

This Statistical Analysis Plan (SAP) was developed to meet the requirements of United States Environmental Protection Agency (USEPA) 40 CFR Part 257 "Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals From Electric Utilities; Final Rule" (the Rule or CCR Rule). The Rule requires owners or operators of an existing Coal Combustion Residuals (CCR) Surface Impoundment to install a groundwater monitoring system and develop a sampling and analysis program (§§ 257.90 - 257.94). Ameren Missouri has determined that the Utility Waste Landfill's (UWL) SCL4A at the Sioux Energy Center in St. Charles County, Missouri is subject to the requirements of the CCR Rule.

As a part of the groundwater sampling and analysis requirements of the Rule, statistical methods as described in Section §257.93(f) of the Rule need to be implemented to statistically evaluate groundwater quality. The selected statistical method must then be certified by a qualified professional engineer stating that the statistical method is appropriate for evaluating the groundwater monitoring data for the CCR Unit. Detailed descriptions of the acceptable statistical data methods are provided in the USEPA's *Statistical Analysis of Groundwater Data at RCRA Facilities, Unified Guidance* (USEPA, 2009) (Unified Guidance). The Unified Guidance is also recommended in the CCR Rule to be used for guidance in the selection of the appropriate statistical evaluation method.

This SAP details the statistical procedures to be used to establish background conditions, to implement detection monitoring, and to implement assessment monitoring (if needed) for Ameren Missouri at the above mentioned CCR Unit. Detailed information on collection, sampling techniques, preservation, etc. are provided in the Groundwater Monitoring Plan (GMP) for the CCR Unit specified above. This SAP is a companion documents to the GMP and assumes that data analyzed by the procedures described in this SAP are from samples that were collected in accordance with the GMP.

This SAP was prepared by Golder Associates, Inc. (Golder) on behalf of Ameren in order to document appropriate method of groundwater data evaluation in compliance with CCR Rules. The methods and groundwater data evaluation techniques used in this SAP are appropriate for evaluation of the groundwater monitoring data for the above mentioned CCR Unit and are in compliance with performance standards outlined in Section §257.93(g) of the CCR Rule.

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1.0 BASELINE STATISTICS

This section discusses the procedures, methods, and processes that will be implemented as part of the Detection Monitoring statistical evaluation. Detection Monitoring will begin after eight rounds of sampling are completed at each monitoring well for each of the Appendix III and Appendix IV parameters. This background monitoring period provides baseline data for each monitoring well which can be used as the basis of the statistical evaluation. Detection monitoring will be completed on a semiannual basis unless adequate groundwater flow is not available for semiannual sampling and proper documentation as outlined in §257.94(d) is completed. Detection monitoring will analyze for Appendix III analytes as outlined in the Groundwater Monitoring Plan for this CCR Unit.

1.1 STATISTICAL DATA PREPARATION AND INITIAL REVIEW

Many of the statistical comparison tests used in detection, and assessment monitoring require various analyses to be completed prior to the data being used for the calculation of statistical limits. This section discusses the methods and procedures for completing this initial review of the data. The analyses required include testing for statistical independence, physical independence, and procedures to evaluate potential outliers.

1.1.1 Physical and Statistical Independence of Groundwater Samples

Detection, and Assessment Monitoring statistical evaluations assume that background and downgradient sampling results are statistically independent. The Unified Guidance states that *"Physical independence of samples does not guarantee statistical independence, but it increases the likelihood of statistical independence."* (Section 14.1, Unified Guidance). Physical independence is most likely achieved when consecutive groundwater samples are collected from independent volumes of water within a given aquifer zone. Using the Darcy Equation, minimum time intervals between sampling events can be calculated in order to confirm the minimum time interval for groundwater to travel through the borehole is less than the time between sampling events (**Table 1, Physical Independence**). This minimum time can be calculated as displayed in Section *14.3.2* of the Unified Guidance.

Table 1: Physical Independence

Well ID	Hydraulic Conductivity	Average Hydraulic Gradient	Effective Porosity	Well Bore Volume	Minimum Time
Symbol	K	I	n	D	T_{min}
Units	Feet/Day	Feet/Foot	%	Feet	Days
UG-3	51	0.00053	0.35	0.5	6.5
TMW-1	75	0.00053	0.35	0.5	4.4
TMW-2	45	0.00053	0.35	0.5	7.3
TMW-3	56	0.00053	0.35	0.5	5.9
BMW-1S	16	0.00053	0.35	0.5	21.0
BMW-3S	53	0.00053	0.35	0.5	6.2

Notes:
1. Average hydraulic gradient and effective porosity taken from table 2 in the Groundwater Monitoring Plan (GMP)
2. Hydraulic Conductivity taken from table 3 of the Groundwater Monitoring Plan (GMP)
3. Calculation completed using the Darcy Equation as outlined in section 14.3.2 of the Unified Guidance.

1.1.2 Data Review – Testing For Outliers

Careful review of the data is critical for verifying that there is an accurate representation of the groundwater conditions. Early identification of anomalous data (outliers) helps play a key role in a successful SAP. Possible causes for outliers include:

- Sampling error or field contamination;
- Analytical errors or laboratory contamination;
- Recording or transcription errors;
- Faulty sample preparation, preservation, or shelf-life exceedance; or
- Extreme, but accurately detected environmental conditions (e.g., spills, migration from the facility).

The following sections outline a few graphical and statistical tests that should be completed prior to the data being used to calculate statistical limits.

1.1.2.1 Time Series Plots

Time Series plots are a quick and simple method to check for possible outliers. Time series plots should be generated with the concentration of the analyte on the Y-axis and the sample date (time) on the X-axis. If any data points look to be potential outliers, the data should be flagged and further evaluated as described in Section 1.1.2.2 below.

1.1.2.2 Dixon's and Rosner's Tests

If graphical methods demonstrate that potential outliers exist, further investigation of these data points can be completed using Dixon's test for datasets with fewer than 25 samples and Rosner's test with datasets greater than 20 samples. Formal testing should only be performed if an observation seems particularly high compared to the rest of the dataset. If statistical testing is to be completed to whether an outlier exists, it should be cautioned that these outlier tests assume that the rest of the data (other than the outlier) are normally distributed. Additionally, because log-normally distributed data often contain one or more values that appear high relative to the rest, it is recommended that the outlier test be run on the transformed values instead of their original observations. This way, one can avoid classifying a high log-normal measurement as an outlier just because the test assumptions were violated. Most groundwater statistical packages can complete Dixon's and Rosner's tests and more information about Dixon's and Rosner's tests is provided in Sections 12.3 and 12.4 of the Unified Guidance. If the test designates an observation as a statistical outlier, the source of the abnormal measurement should be investigated. In general, if a data point is found to be a statistical outlier, it should not be used for statistical evaluation. However, outlier removal should be performed carefully, and typically only when a specific cause for the outlier can be identified.

In some cases where a specific cause for an outlier cannot be identified, professional judgment can be used to determine whether the outlier significantly affects the statistical results to the extent that removal is deemed necessary. If an outlier value with much higher concentration than other background observations is not removed from background prior to statistical testing, it will tend to increase both the background sample mean and standard deviation. In turn, this may substantially raise the magnitude of the prediction limit or control limit calculated from that data set. Thus, experience shows that it is a good practice to remove obvious outliers from the database even when independent evidence of the source of the outlier does not exist. The removal of outliers tends to normalize the data and therefore produce a more robust statistical limit. Outlier removal also tends to produces a more conservative statistical limit, since the data variability is decreased, thereby decreasing the standard deviation.

1.2 Upgradient Monitoring Wells

Following the identification and removal of outliers, the upgradient data are further reviewed to determine appropriate methods for statistical evaluation to maintain adequate statistical power while minimizing the chance of false positives. The following sections describe the procedures and methods that should be used, based on the background dataset, to compare the background datasets, to calculate the data distribution, to handle non-detect (ND) data, and to select appropriate statistical evaluation methods (interwell vs intrawell).

1.2.1 Calculate for Mean and Standard Deviation

Following outlier removal, initial summary statistics including mean and standard deviation should be calculated for the background monitoring well datasets. While these summary statistics are easily completed in many groundwater statistical software packages, it is important to account for values that have low or zero values as described below.

1.2.1.1 Reporting of Low and Zero Values

1.2.1.1.1 Estimated Values (J Flag)

Estimated values are values that have a concentration between the method detection limit (MDL[1]) and the practical quantitation limit (PQL[2]) for any given compound. These values are typically displayed with a J flag in laboratory report packages and are often referred to as "J-values". In most cases, The Unified Guidance recommends using the estimated value provided for statistical evaluation. Estimated values are typically used because the accuracy and power of most statistical evaluations lose power as the percentage of non-detects increases. While they are below the PQL, estimated values are considered detectable concentrations for statistical calculations, which has the effect of lowering the percentage of non-detects.

This "rule" should be applied with care, as there is an exception. Estimated values are not considered detectable concentrations if all values for a single constituent are less than the PQL. This is discussed in more detail in Section 1.3.5 of this document.

1.2.1.1.2 Non-Detects Values (ND)

Non-Detect Values (ND) are concentrations that were not detected at a concentration above the MDL. ND values are typically displayed with a "U" or "ND" flag in laboratory data report packages. The following approaches for managing ND values are based on recommendations in the Unified Guidance and are applicable for use with the statistical evaluation procedures that will be further discussed and used in this SAP (prediction intervals, confidence intervals, and tolerance intervals):

- If <15% ND, substitute ½ the PQL;
- If between 15% to 50% ND, use the Kaplan-Meier or robust regression on ordered statistics to estimate the mean and standard deviation;
- If >50% but less than 100% ND, use a non-parametric test; or
- If 100% of values are less than the PQL, use the Double Quantification Rule.

1.2.2 Data Distribution

Statistical evaluations of groundwater data require an understanding of the data distribution for each analyte in each monitoring well. Data typically fall into one of the following distributions:

[1] MDL = lowest level of an analyte (substance) that the laboratory can reliably detect with calibrated instrumentation; generally based on results of an annual "MDL study" performed in accordance with 40 CFR Part 136, Appendix B; MDLs are generally set using laboratory grade deionized water spiked with a known concentration and thus do not account for effects of matrix interference inherent in typical groundwaters.

[2] PQL = minimum concentration of an analyte (substance) that can be measured with a high degree of confidence that the analyte is present at or above that concentration (typically 5-10x higher than the MDL).

- Normal distribution – Sometimes referred to as Gaussian distribution, a normal distribution is a common continuous distribution where data form a symmetrical bell-shaped curve around a mean. Normally distributed data are tested using parametric methods.
- Transformed-normal distribution – Similar to a normal distribution, however, data are asymmetrical until transformation is applied to all data which then causes it to form a bell-curve. Transformed-normal data distributions are also tested use parametric methods.
- Non-Normal Distribution – When the data are not or cannot be transformed into a symmetrical distribution. Non-normal data distributions are tested using Non-parametric methods.

Testing for data distributions can be completed in several different ways including the skewness coefficient, probability plots with Filliben's test, or the Shapiro-Wilk/Shapiro-Francia Test. All of these methods may be employed, however, the Shapiro-Wilk and Shapiro-Francia tests are generally considered the best method according to the Unified Guidance. The Shapiro-Wilk test is best for sample sizes under 50 while the Shapiro-Francia test is best with larger datasets of 50 or more observations. Most groundwater statistical software packages can complete both Shapiro-Wilk and Shapiro-Francia tests and a detailed discussion of the testing procedures is provided in Section *10.5.1* of the Unified Guidance.

Based on the outcome of the data distribution testing, data will use either Parametric or Non-parametric tests. It is important to note that non-parametric testing usually requires larger datasets in order to minimize the Site Wide False Positive Rate (SWFPR) therefore when the raw data are not normally distributed, a transformed-normal distribution is preferred when possible.

1.2.3 Temporal Trend

Most statistical tests assume that the sample data are statistically independent and identically distributed. Therefore, samples collected over a period of time should not exhibit a time dependence. A time dependence could include the presence of trends or cyclical patterns when observations are graphed on a time series plot. Trend analysis methodologies test to see whether the dataset displays an increasing, decreasing, or seasonal trend. A statistically significant increasing or decreasing trend could indicate a release from the CCR unit (or alternative source) and further investigation of the cause of the trend may be necessary.

If a trend is suspected, a Theil-Sen trend line should be used to estimate slope and the Mann-Kendall Trend Test should be used to evaluate the slope significance (Chapter 14, Unified Guidance). If a statistically significant trend is reported, based on a Sen's slope/Mann-Kendall trend test, the source of the trend should be investigated. If the trend can be shown to be a result of an upgradient or off-site source, the data can be de-trended and used to calculated statistical limits. De-trending can be accomplished by computing a linear regression on the data (see Section 17.3.1 of the Unified Guidance) and then using the regression residuals instead of the original measurements in subsequent statistical analysis.

1.2.4 Comparing Background Datasets (Spatial Variation)

After physical independence, outlier, trend, and summary statistical testing is completed, the datasets from the background monitoring wells should be compared to one another for each individual constituent. The comparison of these background datasets is useful for determining whether spatial variability exists in the background dataset, and can also be used to decide whether an interwell or intrawell approach is more appropriate for statistical evaluation.

Box and whisker plots can be used to perform side by side comparison for each well and can be completed for each individual analyte to determine if the variance is equal across the background datasets. If the box plots appear to be staggered and do not appear to be from the same population (same variance) then a Lavene's test using an α of 0.01 should be used as a check to determine if the background datasets have spatial variation. Testing methods and procedures are provided in Section 11.2 of the Unified Guidance.

The preferred method for comparing background datasets is a Mann-Whitney (or Wilcoxon Rank Sum) Test, which evaluates the ranked medians of both the historical and new dataset populations. An α of 0.05 should be used for this evaluation. After calculation, if the Mann-Whitney statistic does not exceed the critical point, the test assumes that the two data populations have equal medians, and therefore are likely from the same statistical distribution. The testing methods and procedures for this analysis are provided in Section 16.2 of the Unified Guidance.

If spatial variability is identified within the background dataset, an additional investigation may be needed in order to confirm that the variability is not caused by impacts from the CCR unit. If there is spatial variability and it is not caused by impacts from the CCR Unit, then an intrawell approach to statistical evaluation may be appropriate.

1.3 Compliance Monitoring Wells and Statistically Significant Increases

After completing the previously described analyses of the background data, a statistical evaluation of the compliance monitoring data should be completed to determine if there are any Statistically Significant Increases[3] (SSIs) that could trigger assessment monitoring. Section §257.93(F) of the CCR Rule specifies the list of methods that can be used for statistical evaluation. These specific methods to be used for statistical evaluation of data from the RMSGS are detailed below. Further, the Unified Guidance is recommended in the CCR Rule to be used for guidance in the selection of the appropriate statistical evaluation method. This section provides a guide to choosing the correct statistical evaluation to analyze the compliance wells for SSIs, the basic principles of each method, and response activities for identified SSIs.

[3] SSI = a verified statistical exceedance; under compliance monitoring programs, the first time an exceedance is reported it is an initial statistical exceedance and is only considered an SSI if a confirmatory result verifies the initial exceedance.

1.3.1 Interwell vs Intrawell Statistical Analysis

1.3.1.1 Interwell Statistical Analysis

An interwell statistical evaluation compares the groundwater results from the compliance (downgradient) monitoring wells to a pool of background (typically upgradient) monitoring well results. If results from the downgradient wells are statistically higher (or significant) than the background dataset then an exceedance is triggered. This upgradient verses downgradient method typically assumes that:

- Naturally, un-impacted groundwater characteristics in the compliance monitoring wells is comparable and equal on average to the background monitoring wells.
- Upgradient and downgradient monitoring well samples are drawn from the same aquifer and are screened in essentially the same hydrostratigraphic position.
- The aquifer unit is homogeneous and isotropic.
- Groundwater flow is in a definable pathway from upgradient to downgradient wells beneath the CCR Unit.

An interwell approach is preferable for statistical evaluation because it compares data to a background dataset that is not influenced by the CCR Unit. Interwell methods should be used with two exceptions: (1) there are significant differences in the datasets of the background wells (as indicated by methods described in Section 1.2.4) or (2) it can be demonstrated that groundwater geochemistry at all wells (background and compliance) is not impacted by the SCL4A.

1.3.1.2 Intrawell Statistical Analysis

An intrawell statistical evaluation compares the groundwater results from a compliance monitoring well to historical data collected from that same compliance monitoring well. This method can be used for CCR monitoring when groundwater data from the background monitoring wells is statistically different than that of the compliance monitoring wells or when it can be shown that there is no impact from the SCL4A in either upgradient or downgradient/compliance wells.

1.3.2 Statistical Power

As discussed above, one of the primary goals of the selection of a proper statistical evaluation method is to limit the potential for results to falsely trigger a SSI while also maintaining sufficient statistical power to detect a true SSI. Falsely triggering a SSI when no release from the CCR unit has occurred is referred to as a false positive. The False Positive Rate (FPR), typically denoted by the Greek letter α, is also known as the “significance level”. The FPR is the probability that a future compliance observation will be declared to be from a different statistical distribution than the background data. If the FPR is set too high, it can lead to the conclusion that there is evidence of impact when none exists. Conversely, if the FPR is set too low, it can lead to a false conclusion that no contamination exists, when it actually does exist (also known as a “false negative”). Ultimately, the ability to accurately identify SSIs depends on the selection of an appropriate FPR, which is referred to as the statistical power. FPRs are set for each parameter (or for each parameter in each well for intrawell analysis). However, statistical analysis programs and the resulting decision making do not depend on each individual measurement/comparison error rates, but are dependent on the collective error rate from all of the individual comparisons. When the individual FPRs are integrated over the entire statistical monitoring program, it is referred to as the site-wide false positive rate (SWFPR), which is a better measure of the ability of the entire statistical program to detect false positive observations.

1.3.2.1 Site-Wide False Positive Rate

For CCR monitoring, detection monitoring events are based on multiple comparisons, which include the seven (7) Appendix III parameters, at each compliance monitoring well. The SWFPR can be calculated based on several input parameters, including the assumed FPR, the number of downgradient monitoring wells (n), the number of parameters, and the number of statistical comparisons events in a given year for the CCR Unit. The Unified Guidance recommends that a statistical evaluation program be designed with an annual, cumulative SWFPR of approximately 10%.

The Unified Guidance recommends measuring statistical power using power curves which display the probability that an individual comparison will detect a concentration increase relative to background results. After determining the statistical method based on the background data, a power curve can be generated in order to determine the statistical power of the compliance monitoring program. The methods and procedures for calculating the SWFPR are described in Section 6.2.2 of the Unified Guidance.

1.3.2.2 Verification Sampling

Verification Sampling is an important aspect of the SAP as it improves statistical power while maintaining the SWFPR. Most statistical evaluations incorporate verification sampling mathematically into their determination of the SWFPR. Verification sampling is typically completed at a 1 of 2 pass strategy. As described above if an initial statistical exceedance is reported, then verification sampling will be performed to confirm the initial exceedance. Verification samples should be collected on a schedule that allows for physical independence of the samples. In a 1 of 2 pass strategy, if the concentration of the verification sample is less than the calculated compliance limit, then no SSI is triggered. If the initial and subsequent verification observation are above the calculated compliance limit, a SSI is triggered.

Due to the time constraints for reporting put forth in the CCR rule, it is suggested that verification sampling not be completed at the next regularly scheduled sampling event, but instead be collected prior to the next sampling event. Verification sampling within 90 days (assuming a 1 of 2 pass verification sampling strategy) will typically allow sufficient time to complete laboratory and statistical analysis in accordance with the timeframes set forth in the CCR Rules.

1.3.3 Statistical Evaluation Methods

As outlined above, the CCR rule list 5 possible methods for statistical evaluation. The different methods that can be employed for CCR monitoring as outlined in §257.93(F) are:

- ***§257.93(F)(1)*** *"A parametric analysis of variance followed by multiple comparison procedures to identify statistically significant evidence of contamination. The method must include estimation and testing of the contrasts between each compliance well's mean and the background mean levels for each constituent."*
- ***§257.93(F)(2)*** *"An analysis of variance based on ranks followed by multiple comparison procedures to identify statistically significant evidence of contamination. The method must include estimation and testing of the contrasts between each compliance well's median and the background median levels for each constituent."*
- ***§257.93(F)(3)*** *"A tolerance or prediction interval procedure, in which an interval for each constituent is established from the distribution of the background data and the level of each constituent in each compliance well is compared to the upper tolerance or prediction limit."*
- ***§257.93(F)(4)*** *"A control chart approach that gives control limits for each constituent."*
- ***§257.93(F)(5)*** *"Another statistical test method that meets the performance standards of paragraph (g) of this section."*

1.3.4 Prediction Intervals

Section §257.93(F)(3) outlines using prediction intervals or tolerance intervals for statistical evaluation. Based on recommendation from the Unified Guidance, prediction limits are the preferred method for calculating detection monitoring compliance limits and will be used to calculate compliance limits for the seven Appendix III constituents. In addition, the Unified Guidance suggests using prediction limits with verification sampling (Chapter 19 of the Unified Guidance), because prediction limits help to maintain low SWFPR while still providing high statistical power. Tolerance intervals, which are a backward looking procedure, should not be used for detection monitoring, but will likely be used in assessment monitoring, as further described in Section 2.0 below. If, at any point in the future, a different statistical method becomes more applicable to the site conditions, this document may be modified to include that method as recommended by the Unified Guidance.

Prediction interval methods can be used for parametric and non-parametric datasets as well as for intrawell or interwell statistical analysis. Prediction limits use background data from either background monitoring wells for interwell analysis or from historical data for intrawell analysis calculate a concentration that represents an upper limit of expected future concentrations for a particular population. In contrast to tolerance limits, prediction intervals are a forward looking, predictive analysis, which incorporate uncertainty in future measurements, and are thus the most appropriate method for detection monitoring programs. Typically, a one-sided upper prediction limit is used to evaluate detection monitoring observations. Observations must be lower than the prediction limit (or within the upper and lower prediction limits for pH) to be considered "in control". Parametric methods are generally preferred over non-parametric methods, because they result in lower SWFPRs and higher statistical power.

For detection monitoring, if parametric testing is required, the procedures outlined in Section 19.3.1 of the Unified Guidance should be used to calculate prediction limits for the statistical analysis. If non-parametric testing is required, the procedures outlined in Section 19.4.1 of the Unified Guidance should be used to calculate prediction limits. Most groundwater statistical software includes algorithms for calculating either parametric or non-parametric prediction limits.

1.3.5 Double Quantification Rule

In situations where the entire background dataset is reported as ND or Estimated (J-flag), the Double Quantification Rule (DQR) will be used to supplement the prediction limit analyses. Generally, the Appendix III constituents occur at detectable concentrations in natural groundwater; however, if ND results are encountered for a given constituent, the DQR can be implemented. A demonstration that this statistical evaluation is as least as effective as any other test and results as described in §257.93(f)(5) can be made. The DQR is recommended by the Unified Guidance as a supplement to prediction limits because it reduces the number of non-detects used for statistical analysis and provides a lower SWFPR while maintaining statistical power.

Under the DQR, a SSI is triggered if a compliance well observation is higher than the reporting limit (RL)/PQL in either (1) both a detection monitoring sample and its verification resample, or (2) two consecutive sampling events in a program were resampling is not utilized.

1.4 Responding to SSIs

If the statistical evaluation for an Appendix III analyte triggers a SSI, the data must be evaluated to determine if the cause of the SSI is due to a release from the CCR Unit or from an alternative source. Possible alternative sources may include laboratory causes, sampling causes, statistical evaluation causes, or natural variation. If the SSI can be attributed to one of these sources and the SSI was not caused by the CCR Unit, an alternate source demonstration (ASD) can be completed. An ASD must be certified by a qualified professional engineer and completed in writing within 90 days of completing the statistical evaluation for a particular sampling event. If the SSI cannot be attributed to an alternative source and is from the CCR Unit, then Assessment Monitoring is triggered.

1.5 Updating Background Values

The Unified Guidance suggests that updating statistical limits should only be completed after a minimum of 4 to 8 new measurements are available (i.e., every 2 to 4 years of semiannual monitoring, assuming no verification sampling). The periodic update of background, during which additional data are incorporated into the background, improves statistical power and accuracy by providing a more conservative estimate of the true background population. Prior to incorporating new data into the background dataset, a test should be performed to demonstrate that the "new data" are from the same statistical population as the existing background results. Below are three methods that can be used in determining if the “new” data should be included in the background:

- Time Series Graphs – As described in Section 1.1.2.1, time series graphs can be used as a qualitative test to assist with the determination whether a new group of data match the historical data or if there is a concentration trend that could be indicative of a release or evolving groundwater conditions.
- Box-Whisker plots can also be used to determine whether or not the datasets are similar.
- Mann-Whitney (or Wilcoxon Rank) Test – Used to evaluate the ranked medians of both the historical and new dataset populations. An α of 0.05 should be used for this evaluation. After calculation, if the Mann-Whitney statistic does not exceed the critical point, the test assumes that the two data populations have equal medians, and therefore are likely similar.

Ultimately, the Mann-Whitney (Wilcoxon Rank Sum) Test is the statistical test that is used to determine whether new observations should be included in the background dataset. It is important to note that a difference in background datasets does not automatically prevent the new data from being used; however, if differences are noted, a review of the new data will be conducted to determine if the noted difference is a result of a change in the natural conditions of the groundwater or if it is the result of a potential release from the CCR Unit. If the new data are included in the background dataset, the prediction limits will be recalculated, as described in Section 1.3.4 above.

2.0 ASSESSMENT MONITORING STATISTICAL EVALUATION

This section discusses the procedures, methods, and processes that will be implemented as part of the assessment monitoring statistical evaluation, if required. Assessment monitoring will be initiated if a SSI is triggered during detection monitoring. As per the CCR Rule in Section §257.95(b), assessment monitoring must be initiated within 90 days of identifying an SSI (not the sample event which provided the data that resulted in the SSI). This 90-day period includes sampling the groundwater monitoring network for the Appendix IV constituents. Following the initial sampling event for all Appendix IV constituents, the monitoring network is then sampled again within 90 days of receiving the results from the initial Appendix IV sampling event. Following these initial assessment monitoring events, assessment monitoring is performed on a semiannual basis. During one of the two semiannual events, the full list of Appendix IV constituents must be tested. During the second assessment monitoring event of each year, only the Appendix IV constituents that are detected during the previous semiannual event are required to be monitored. Assessment monitoring is terminated if concentrations for all Appendix III and Appendix IV constituents in all compliance wells are statistically lower than background for two consecutive sampling events (§257.95(e)). The following sections discuss the procedures, methods, and processes that will be implemented as part of the assessment monitoring statistical evaluation. As discussed in Section 1.1 of this document, many of the statistical comparisons used in assessment monitoring require various analyses to be completed prior to the data being accepted into the statistical evaluation. Before using the results from assessment monitoring, the steps outlined in Sections 1.1 and 1.2 will be completed. Please refer to those sections for descriptions on the methods and techniques required to complete these analyses.

2.1 Establishing a Ground Water Protection Standard (GWPS)

Following the removal of outliers and the performance of general statistics described in Sections 1.1 and 1.2, GWPS will be developed for use in the assessment monitoring program. The GWPS is a key element to the assessment monitoring process. GWPS must be generated for each of the detected Appendix IV analytes. If interwell methods are utilized (preferred method), a site-wide GWPS will be generated for each analyte based on Appendix IV results reported for background/hydraulically upgradient wells. If intrawell methods are utilized, a well specific GWPS will be generated for each analyte.

For Appendix IV parameters that have a maximum contaminant level (MCL), as established by the United States Environmental Protection Agency, the GWPS is set equal to the MCL. For those constituents whose background concentration are greater than the MCL, the GWPS will be calculated from the background data. Finally, for those constituents that do not have an established MCL, the GWPS will be calculated. Several analytes (cobalt, lead, lithium, and molybdenum) do not have MCLs established and therefore the GWPS must be calculated based on their background concentrations.

2.1.1 Maximum Contaminant Level (MCL) Based GWPS

Many of the Appendix IV analytes have USEPA MCL levels. As specified in the CCR Rule in Section §257.95(b), the GWPS must either be the MCL, or a limit based on background data, whichever is greater. This section describes the methods to be used for statistical analysis when the MCL is to be used as the GWPS.

For Assessment Monitoring, the Unified Guidance recommends the confidence interval method to evaluate for potential exceedances, which are referred to as "statistically significant levels" (SSLs) (Chapter 21, Unified Guidance). Using confidence intervals, SSLs are identified by comparing the calculated confidence interval against the GWPS. A confidence interval statistically defines the upper and lower bounds of a specified population within a stipulated level of significance. Confidence intervals are required to be calculated based on a minimum of 4 independent observations, but a more representative confidence interval can be developed when all of the available data are utilized.

The specific type of confidence interval should be based the attributes of the data being analyzed, including: (1) the data distribution, (2) the detection frequency, and (3) potential trends in the data. Table 1 below is based on Table 4-4 from the Electric Power Research Institute's *Groundwater Monitoring Guidance for the Coal Combustion Residual Rule* (2015), which displays the criteria for selecting an appropriate confidence interval. The method and procedure for calculating the Upper Confidence Limit (UCL) and Lower Confidence Limit (LCL) is provided in the section reference from the Unified Guidance, which is listed in the last column of Table 1, below.

Table 2- Confidence Interval Method Selection

Data Distribution	Non-detect Frequency	Data Trend	Confidence Interval Method
Normal	Low	Stable	Confidence Interval Around Normal Mean (Section 21.1.1)
Transformed Normal (Log-Normal)	Low	Stable	Confidence Interval Around Lognormal Arithmetic Mean (Section 21.1.3)
Non-normal	N/A	Stable	Nonparametric Confidence Interval Around Median (Section 21.2)
Cannot Be Determined	High	Stable	Nonparametric Confidence Interval Around Median (Section 21.2)
Residuals After Subtracting Trend are Normal (with equal variance)	Low	Trend	Confidence Band Around Linear Regression (Section 21.3.1)
Residuals after Subtracting Trend are Non-Normal	Low	Trend	Confidence Band Around Theil-Sen Line (Section 21.3.2)

In an assessment monitoring program the LCL is of prime interest. If the LCL exceeds the GWPS, there is statistical evidence that a SSL has been triggered. An initial SSL should be confirmed by verification sampling. If only the UCL exceeds the GWPS while the LCL is below the GWPS, the test is considered inconclusive and the Unified Guidance recommends that this situation be interpreted as "in compliance". If both the UCL and the LCL are below the GPWS, the data are also "in compliance" with the GWPS.

It is important to note that a slightly different set of criteria are used to determine whether assessment monitoring can be terminated. Additional discussion of the criteria used for exiting assessment monitoring and returning to detection monitoring is provided below in Section 2.2.

During Assessment Monitoring, a per test FPR (α) of 0.05 will be used as an initial error level for calculating the two-tailed confidence intervals for the compliance wells (which actually means 2.5% FPR per tail). In some cases based on recommendations from the Unified Guidance, it is appropriate to adjust the FPR of the confidence interval based on the number of data points available as well as the distribution of the data being evaluated. If deemed necessary based on recommendations from the Unified Guidance, an approach is provided in Section 22 of the Unified Guidance for determining an appropriate per test FPR based on the data characteristics.

When performing assessment monitoring statistical evaluations, it is important to evaluate the compliance data for shifts. If no shifts have occurred, then all of the available Appendix IV data for a particular constituent can be used in the statistical evaluation. If shifts are noted (typically based on qualitative evaluation of a time series plot), only the data collected after the shift should be used in the statistical evaluation.

2.1.2 Non-MCL Based GWPS

Background or historical concentration limits should be assessed using the following techniques for all Appendix IV analytes. These concentration limits should then be compared with the MCL, if available, and the higher of these two values will be used as the GWPS.

The Unified Guidance provides two acceptable approaches for establishing a non-MCL based GWPS (unless all values are ND, in which case the Double Quantification Rule as described above in Section 1.3.5 should be used). The two methods include the tolerance interval approach or the prediction interval approach.

2.1.2.1 Tolerance Interval Approach

If the background dataset is normally or transformed normally distributed, the Unified Guidance recommends Tolerance Intervals over the Prediction Intervals for establishing a GWPS. The GWPS should be based on a 95 percent coverage/95 percent confidence tolerance interval. If the background data are non-normal (even after transformation), then a large number of background observations are required to calculate a non-parametric tolerance interval (typically a minimum of 60 background observations are required to meet these requirements). If there is an insufficient number of background observations to calculate a non-parametric tolerance interval, then a non-parametric Prediction Interval approach should be used, as described in Section 2.1.2.2 below.

The Upper Tolerance Limit (UTL) is calculated for each detected Appendix VI constituent. Tolerance Limits, as outlined in the Unified Guidance (Section 17.2), are a concentration limit that is designed to contain a pre-specified percentage of the dataset population. Two coefficients associated tolerance intervals are (1) the specified population proportion and (2) the statistical confidence. The coverage coefficient (γ), which is used to contain the population portion, and the tolerance coefficient (or confidence level ($1-\alpha$)), which is used to set the confidence of the test. Typically, the UTL is calculated to have a coverage and confidence of 95%. When an MCL does not exist or the background concentrations are greater than the MCL, the calculated UTL for each constituent is used as the GWPS. The confidence interval for each compliance well is then compared with the GWPS.

In order to calculate a valid confidence interval, a minimum of four data points are necessary for each of the detected Appendix IV constituents in each compliance monitoring well (or four “new” assessment monitoring observations in each well when intrawell statistical methods are employed). Using the Tolerance Interval Approach, a statistically significant level (SSL) is triggered when calculated lower confidence limit (LCL) for each compliance well is greater than the GWPS.

Tolerance limits can be completed using both parametric (Section 17.2.1 of Unified Guidance) or non-parametric methods (Section 17.2.2 of Unified Guidance). However, as described above, the non-parametric method requires at least 60 background (or historical) measurements in order to achieve 95% confidence with 95% coverage. Tolerance Intervals can be calculated using most groundwater statistical software packages.

2.1.2.2 Prediction Interval Approach

If Tolerance Intervals cannot be used to calculate the GWPS (based on recommendation from the Unified Guidance, such as non-parametric datasets, ect.), then a Prediction Interval method should be used. This method is very similar to Section 1.3.4 of this document, however, for assessment monitoring, the Unified Guidance suggests using a prediction interval about a future mean for normally/transfomred-normally distributed datasets or a prediction interval about a future median for datasets with a high percent of ND or non-normally distributed data.

When using prediction intervals to calculate for a GWPS, a one-sided prediction interval is calculated using background (or historical) datasets based on a specified number of future comparisons - four future comparisons is typical. The Upper Prediction Limit that is calculated as a product of this method then becomes the GWPS, and is compared against the confidence interval for the compliance data, as described in Section 2.1.2.1, above. As also described above, if the LCL is greater than the calculated prediction limit then an SSL is triggered.

2.2 Returning to Background Detection Monitoring

As specified in 257.95(e) of the CCR Rule, in order to return to detection monitoring, the concentration of all constituents listed in Appendix III and Appendix IV must be shown to be at or below calculated “background (or historical) values” for two consecutive semiannual sampling events. This determination of background values is based on the statistical evaluation procedure established for detection monitoring. Therefore, if prediction limits (with the double quantification rule for analytes with all non-detects) are used for detection monitoring, prediction limits should be calculated and used for all Appendix III and IV analytes to determine when the monitoring program can return to Detection Monitoring. It is important to remember that Appendix IV constituents are only required to be sampled annually with only those Appendix IV constituents that are detected during the previous semiannual event being required to be analyzed during the second semiannual event of a given year. If statistical results demonstrate that concentrations for all constituents are below background levels for a particular event, all Appendix IV constituents should be sampled during the next event in order to achieve this goal of returning to Detection Monitoring. If this statistical evaluation demonstrates that any of the Appendix III or Appendix IV are at a concentration above background levels, but no SSLs have been triggered, then the CCR unit will remain in assessment monitoring (257.95(f)).

2.3 Response to a SSL

If the assessment monitoring statistical evaluation demonstrates that a SSL has been triggered, then the owner/operator of the CCR unit must complete the following four actions as described in 257.95(g):

1. Prepare a notification identifying the constituents in Appendix IV that have exceeded a CCR Unit specific GWPS. This notification must be placed in the facilities operating record within 30 days of identifying the SSL
2. Define the nature and extent of the release and any relevant site conditions that may affect the corrective action remedy that is ultimately selected. The characterization must be sufficient to support a complete and accurate assessment of the corrective measures necessary to effectively clean up releases from the CCR Unit and must include at least the following;
    A. Installation of additional monitoring wells that are necessary to define the contaminant plume,
    B. Collect data on the nature and estimated quantity of the material released,
    C. Install and sample at least one additional monitoring well at the facility boundary in the direction of the contaminant plume migration,
3. Notify off-site property owners if the contamination plume has migrated offsite on to their property, and
4. If possible, provide an alternative source demonstration that determines that the SSL is not caused by a release at the facility within 90 days of completing the statistical evaluation. If no alternative source demonstration can be made and the plume is determined to have come from the CCR Unit then initiate corrective action.

Actions 1-3 must be completed regardless of whether or not an alternate source demonstration can be made.

2.4 Updating Background Values

The background for Assessment Monitoring Parameters should be updated using the same methods and techniques described in Section 1.5 for updating detection monitoring background data.

3.0 REFERENCES

EPRI. 2015. Groundwater Monitoring Guidance for the Coal Combustion Residual Rule. Electric Power Research Institute. November.

USEPA. 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities, Unified Guidance. Office of Resource Conservation and Recovery – Program Implementation and Information Division. March

USEPA. 2015. Federal Register. Volume 80. No. 74. Friday April 17, 2015. Part II. Environmental Protection Agency. 40 CFR Parts 257 and 261. Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals from Electric Utilities; Final Rule/ [EPA-HQ-RCRA-2009-0640; FRL-9919-44-OSWER]. RIN-2050-AE81. April.

APPENDIX I
EXAMPLE FIELD FORMS

Golder Associates WELL DEVELOPMENT/PURGING FORM

Project Ref: ______________________ **Project No.:** ______________________

Location

Monitored By: Date Time

Well Piezometer Data

(*circle one*)

Depth of Well (from top of PVC or ground) feet

Depth of Water (from top of PVC or ground) feet

Radius of Casing inches
feet

Casing Volume cubic feet
gallons

Development / Purging Discharge Data

Purging Method

Start Purging Date Time

Stop Purging Date Time

Monitoring

Date	Time	Volume Discharge (gals)	Temp (°__)	pH	Spec.Cond. (__S/cm)	Turbidity (NTU)	Dissolved Oxygen (mg/L)	Redox Potential (+/- mV)	WL (ft TOC)	Appearance of Water and Comments

GROUNDWATER SAMPLE COLLECTION FORM

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Project Ref: __ ______________________________ **Project No. :**________________

WEATHER CONDITIONS

Temperature ____________________ Weather ______________________________

SAMPLE INFORMATION

Sample Location ______________________ Sample No. ____________________

Sample Date ________________ Time __________ Sample By____________________

Sample Method ______________________ Sample Type____________________

Water Level Before Purging: ______________________

Well Volume: ______________________

Volume Water Removed Before Sampling: ______________

Water Level Before Sampling: ______________________

Water Level After Sampling: ______________________

Appearance of Sample: ______________________

FIELD MEASUREMENTS

Parameter	Units	Measurement	Measurement	Measurement	Measurement	Sample
Time	hhmm					
Volume Discharge	gals					
pH	Standard					
Spec. Cond.	___S/CM					
Turbidity	NTU					
Temperature	°___					
Dissolved Oxygen	mg/l					
Redox Potential	+/- mV					

LABORATORY CONTAINERS

Sub-Sample	Analysis Requested	Type and Size of Sample Container	Filtered (Yes or No)	Type of Preservative
1				
2				
3				
4				
5				
6				
7				
8				

REMARKS: ______________________________

NA = Not applicable

SAMPLING METHODS:

Bailer: PVC/PE; Stainless Steel; Teflon

Peristaltic Pump; Submersible Pump; Hand Pump

Air-Lift Pump; Other__________

ABOVE GROUND MONITORING WELL CONSTRUCTION LOG ____________

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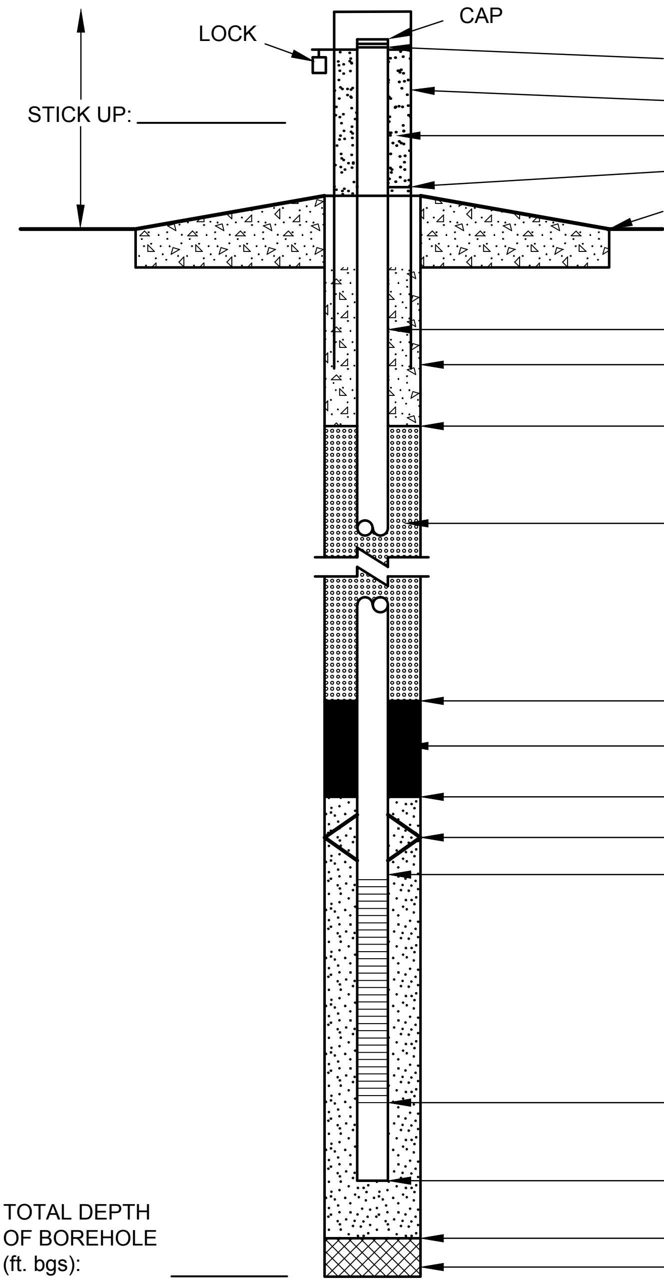
PROJECT NAME:	PROJECT NUMBER:
SITE NAME:	LOCATION:
CLIENT:	SURFACE ELEVATION:

GEOLOGIST:	NORTHING:	EASTING:
DRILLER:	STATIC WATER LEVEL:	COMPLETION DATE:

DRILLING COMPANY:	DRILLING METHODS:



TOP OF CASING ELEVATION: ____________

PROTECTIVE CASING (yes ☐no): ____________

PEA GRAVEL OR SAND

WEEP HOLE

GROUND SURFACE ELEVATION: ____________

DIAMETER OF RISER PIPE (in.): ____________

DIAMETER OF BOREHOLE (in.): ____________

CONCRETE SEAL DEPTH (ft. bgs): ____________

TYPE AND AMOUNT OF ANNULAR SEAL: ____________

TOP OF BENTONITE SEAL DEPTH (ft. bgs): ____________

TYPE AND AMOUNT OF BENTONITE SEAL: ____________

TOP OF SAND PACK DEPTH (ft. bgs): ____________

CENTRALIZER (yes ☐no) - TYPE: ____________

TOP OF SCREEN DEPTH (ft. bgs): ____________

TYPE OF SCREEN: ____________

SCREEN SLOT SIZE (in.): ____________

SIZE OF SAND PACK: ____________

AMOUNT OF SAND: ____________

BOTTOM OF SCREEN DEPTH (ft. bgs): ____________

BOTTOM OF WELL DEPTH (ft. bgs): ____________

TOTAL DEPTH OF BOREHOLE (ft. bgs): ____________

BOTTOM OF FILTER PACK (ft. bgs): ____________

TYPE AND AMOUNT OF BACKFILL: ____________

ADDITIONAL NOTES: ____________

CHECKED BY: ____________

DATE CHECKED: ____________

PREPARED BY: ____________

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RECORD OF WATER LEVEL READINGS

Project Name: ______________________ **Location:** _____________________________ **Project No.:** ________________________

Borehole No.	Date	Time	Measuring Device / Serial No.	Measurement Point (M.P)	Water Level Below M.P.	Correction To Survey Mark	Survey Mark Elevation	Water Level Elevation	By	Comments

Sheet ___ of ___

INSTRUCTIONS CALIBRATION FORM

Project Name: ____________________________ **Project No:** ______________________

Calibration By:

Instrument Details

Instrument Name	
Serial No.	
Model No.	

Calibration Details

Required Calibration Frequency/Last Calibration	
Calibration Standard	
Calibration Standard(s) Expiration Date	

Calibration:

Date	Time	**Calibration Standard** Units: ___________	**Instrument Reading** Units: _________

Comments:

>>> Select a Laboratory <<<

#N/A
#N/A
#N/A
#N/A

Chain of Custody Record

Regulatory Program: ☐ DW ☐ NPDES ☐ RCRA ☐ Other:

Client Contact	**Project Manager:**	**Site Contact:**	**Date:**	COC No:
Your Company Name here	**Tel/Fax:**	**Lab Contact:**	**Carrier:**	_______ of ______ COCs
Address	**Analysis Turnaround Time**			Sampler:
City/State/Zip	☐ CALENDAR DAYS ☐ WORKING DAYS			**For Lab Use Only:**
(xxx) xxx-xxxx Phone	TAT if different from Below _________			Walk-in Client:
(xxx) xxx-xxxx FAX	☐ 2 weeks			Lab Sampling:
Project Name:	☐ 1 week			
Site:	☐ 2 days			Job / SDG No.:
P O #	☐ 1 day			

Sample Identification	**Sample Date**	**Sample Time**	**Sample Type** (C=Comp, G=Grab)	**Matrix**	**# of Cont.**	Filtered Sample (Y / N)	Perform MS / MSD (Y / N)																	Sample Specific Notes:

Preservation Used: 1= Ice, 2= HCl; 3= H2SO4; 4=HNO3; 5=NaOH; 6= Other ____________

Possible Hazard Identification:
Are any samples from a listed EPA Hazardous Waste? Please List any EPA Waste Codes for the sample in the Comments Section if the lab is to dispose of the sample.

☐ Non-Hazard ☐ Flammable ☐ Skin Irritant ☐ Poison B ☐ Unknown

Sample Disposal (A fee may be assessed if samples are retained longer than 1 month)

☐ Return to Client ☐ Disposal by Lab ☐ Archive for__________ Months

Special Instructions/QC Requirements & Comments:

Custody Seals Intact: ☐ Yes ☐ No | Custody Seal No.: | Cooler Temp. (^{o}C): Obs'd:_________ Corr'd:__________ Therm ID No.:____________

Relinquished by:	Company:	Date/Time:	Received by:	Company:	Date/Time:
Relinquished by:	Company:	Date/Time:	Received by:	Company:	Date/Time:
Relinquished by:	Company:	Date/Time:	Received in Laboratory by:	Company:	Date/Time:

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Field Boring Log

DEPTH HOLE ____________ PROJ. NO. ____________ PROJECT ______________________________ BORING NO. ____________
DEPTH SOIL DRILL ________ GA INSP. ____________ DRILLING METHOD ______________________________ SHEET ________ OF ________
DEPTH ROCK CORE ________ WEATHER ____________ DRILLING COMPANY ______________________________ SURFACE ELEV. ____________
ABANDONMENT ______________________________ DRILL RIG ____________________ DRILLER ____________ DATUM ____________
DEPTHS ________ / ________ / ________ / ________ (WATER LEVEL / CAVE-IN / DATE-TIME / NOTE) SAMPLER HAMMER TYPE ____________ WT. ________ DROP ________ STARTED ________ / ________ (TIME / DATE)
DEPTHS (DELAYED) ________ / ________ / ________ / ________ (WATER LEVEL / CAVE-IN / DATE-TIME / NOTE) HOLE LOCATION ______________________________ COMPLETED ________ / ________ (TIME / DATE)

SAMPLE TYPES

- A.S. AUGER SAMPLE
- C.S. CHUNK SAMPLE
- * D.O. DRIVE OPEN (SPT)
- D.S. DENISON SAMPLE
- F.S. FOIL SAMPLE
- P.S. PITCHER SAMPLE
- S.C. SOIL CORE
- * T.O. THIN-WALLED, OPEN
- * T.P. THIN-WALLED, PISTON
- W.S. WASH SAMPLE
- * ____ ____________
- * ____ ____________
- * ____________
- * NOTE SIZE

ABBREVIATIONS

ANG	ANGULAR	GR	GRAY	R	RED		
BL	BLACK	HE	HETEROGENEOUS	RES	RESIDUAL		
BR	BROWN	HO	HOMOGENEOUS	RX	ROCK		
C	COARSE	LYD	LAYERED	RND	ROUNDED		
CIN	CAVE-IN	M	MEDIUM	SAT	SATURATED		
CO	COHESIVE	MIC	MICACEOUS	SD	SAND		
CL	CLAY	MOT	MOTTLED	SI	SILT		
CLY	CLAYEY	MST	MOIST	SIY	SILTY		
D	DRY	NC	NON-COHESIVE	SM	SOME		
EL	ELONGATED	NP	NON-PLASTIC	TR	TRACE		
F	FINE	OG	ORANGE	WL	WATER LEVEL		
FL	FLAT	ORG	ORGANIC	WH	WEIGHT OF HAMMER		
FRAG	FRAGMENTS	PP	POCKET PEN.	WR	WEIGHT OF RODS		
GL	GRAVEL	PL	PLASTIC LIMIT	Y	YELLOW		

ORDER OF DESCRIPTION

CONSTITUENTS
1) GROUP SYMBOL
2) SOIL GROUP NAME
3) PRIMARY COMPONENTS
4) SECONDARY COMPONENTS
5) MINOR COMPONENTS ;

PLUS DESCRIPTION: CL/SI: PLASTICITY; SD: SIZE, GRADING; GL: SIZE, GRADING, SHAPE, ROCK TYPE

GENERAL
6) COLOR
7) WEATHERING
8) STRUCTURE
9) SENSITIVITY
10) CONTAMINATION
11) MINEROLOGY
12) ORIGIN ;

BEHAVIOR
13) BEHAVIOR (CO/NC)
14) MOISTURE/WATER CONTENT
15) DENSITY/CONSISTENCY

PROPORTIONS

"TRACE"	0 – 5%
"SOME"	5 – 12%
PREFIX "-Y"	12 – 35%
"AND"	35 – 50%

NON-COHESIVE SOILS

RELATIVE DENSITY		BLOWS
VERY LOOSE	VLS	0 – 4
LOOSE	LS	4 – 10
COMPACT	CP	10 – 30
DENSE	DN	30 – 50
VERY DENSE	VDN	>50

MOISTURE CONDITION

DRY	SOIL FLOWS
MOIST	FEELS COOL
WET	WITH FREE WATER

COHESIVE SOILS

CONSISTENCY		PP(TSF)	FINGER PRESSURE
VERY SOFT	VS	<0.25	EXTRUDES
SOFT	S	0.25 - 0.5	MOLDS EASILY
FIRM	FM	0.5 – 1	MOLDS
STIFF	ST	1 – 2	THUMB INDENTS
VERY STIFF	VST	2 – 4	THUMBNAIL INDENTS
HARD	H	>4	RESISTS THUMBNAIL

WATER CONTENT - W

W < PL	CANNOT ROLL 4 mm THREAD
W ~ PL	CAN ROLL THREAD 2 – 4 mm
W > PL	CAN ROLL THREAD <2 mm

ELEV. / DEPTH	LITHOLOGY	SAMPLES: NO.	TYPE	DEPTH	SPT N / PP(TSF)	BLOWS PER 6 IN	REC / ATT	CONSTITUENTS: GL	SD	CL/SI	BEHAVIOR: CO or NC	MOIST. or W	DENS./CONS.	USCS	SAMPLE DESCRIPTION AND DRILLING NOTES

(Constituents: PROPORTION, SIZE, SHAPE, GRADING, PLASTICITY)

Dec 2012

Golder Associates

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Established in 1960, Golder Associates is a global, employee-owned organization that helps clients find sustainable solutions to the challenges of finite resources, energy and water supply and management, waste management, urbanization, and climate change. We provide a wide range of independent consulting, design, and construction services in our specialist areas of earth, environment, and energy. By building strong relationships and meeting the needs of clients, our people have created one of the most trusted professional services organizations in the world.

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