REPORT

40 CFR PART 257 GROUNDWATER MONITORING PLAN

Utility Waste Landfill Cell LCL1, Labadie Energy Center

Franklin County, Missouri, USA

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Date: October 10, 2017

Project No.153-1406

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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) at Ameren Missouri's (Ameren) Labadie Energy Center (Facility) in Franklin County, Missouri (see location on **Figure 1**). The UWL currently only operates Cell LCL1 which is an on-site landfill cell and manages Coal Combustion Residuals (CCR) from the Facility. The LCL1 is approximately 31 acres in size and is located to the east of the generating plant.

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 landfill to install a groundwater monitoring system and develop a sampling and analysis program (§§ 257.90 - 257.94). Ameren Missouri has determined that the UWL is subject to the requirements of the CCR Rule. For this GMP, the Labadie Energy Center generating plant is referred to as the LEC and the LEC 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 Franklin County, Missouri located approximately 35 miles west of downtown St. Louis. **Figure 1** depicts the location of the Facility and property boundaries referenced to local topographic features and the Missouri River. **Figure 2** depicts Facility structures relative to site property boundaries and the Missouri River. The Facility is encompasses 2,400 acres and is located within the Missouri River Valley. The Facility is bounded to the north by the Missouri River, to the west by Labadie Creek, to the northeast and east by agricultural land and to the south by a railroad line and bedrock bluffs.

The UWL is bounded immediately on all four sides by lower elevation agricultural fields. The floodplain is approximately 15 to 25 feet lower than the UWL berm which is at approximately 488 feet MSL. 3,000 feet north of the UWL lies the Missouri River which trends in a northeasterly direction. South of the railroad, bedrock bluffs rise to an elevation of over 550 feet MSL.

2.1 Coal Combustion Residuals (CCR) UWL LCL1

Collectively, the UWL once fully constructed will consist of a series of 4 CCR landfill cells that are shown on **Figure 2**. As part of the permitting of the construction of the UWL, a Construction Permit Application has been prepared for Ameren by Reitz & and Jens, Inc., and GREDELL Engineering Resources, Inc. The information in this section about the construction and use of the UWL is based on a January 2014 revision of this permit entitled "*Ameren Missouri – Labadie Energy Center – Construction Permit Application for a Proposed Utility Waste Landfill – Franklin County, Missouri."* The UWL will operate in accordance with Solid Waste Disposal Area Operating Permit Number 0907101 that is currently in draft stage and will be issued by Missouri Department of Natural Resources (MDNR).

The UWL is located to the east of the LEC and the existing surface impoundments as shown in **Figures 1** and **2**. The UWL and associated areas have an approximate 400 acre footprint, of which 166.5 acres will be used for CCR disposal. The UWL will be used to dispose of fly ash, bottom ash and byproducts from a future planned FGD (Flue Gas Desulfurization) system at the LEC. The construction of the UWL is to be completed in four different phases. Phase 1 will consist of a 31.4 acre disposal area with a 5.7-acre storm water pond. Phase 2 will consist of a 35.2-acre disposal area, phase 3 will consist of a 57.1-acres disposal area and a 4.4-acre storm water pond, and phase 4 will consist of a 42.8-acre disposal area with a 3.4-acre storm water pond.

The perimeter berm surrounding the cells and storm water ponds will be built to an elevation of 488.0 feet above mean sea level (MSL), which is approximately 4 feet above the 100-year flood elevation of 484 feet MSL. Additionally, the waste disposal cells will be lined with a bottom liner system consisting of two feet of compacted clay soil and a flexible geomembrane liner. The liner system will have a base elevation (top of liner) of 468 feet MSL or greater.

2.2 Geology

2.2.1 Physiographic Setting and Regional Geology

The Facility area lies along the northeast margin of the Salem Plateau, a subsection of the Ozark Physiographic Province (USGS, 1994). In this region, the Salem Plateau is mainly comprised of Ordovician dolomite, limestone, and sandstone formations. To the northwest of the Labadie Bottoms area, the Salem plateau transitions into the geologically younger Mississippian and Pennsylvanian subsystems that are regionally known as glaciated plains (GREDELL Engineering Resources, Inc. (GREDELL) and Reitz & Jens, Inc. (Reitz & Jens), 2011). The approximate boundary between these two systems is the Missouri River, which is interpreted as being an ice-margin stream during the latest glacial epoch and defined the approximate southernmost progression of glaciation.

2.2.2 Local Geology

The geology immediately surrounding the Facility is composed of two distinctly different geological terrains; (1) floodplain deposits of the Missouri River Valley and (2) older sedimentary bedrock formations. Most of the Facility, including all of the plant infrastructure, the Surface Impoundments, and UWL lies within the Missouri River Valley, locally referred to as the Labadie Bottoms. The Missouri River Valley in this region is an approximately 2 to 3 mile wide area of floodplain with alluvial deposits (alluvium) that are the result of the water flow and deposition from the Missouri River. Based on the Surficial Material Geologic Map of the Labadie 7.5' quadrangle (Butler and Siemens, 2010), borings logged by Golder during the installation of the CCR monitoring well network and borings conducted during the Detailed Site Investigation (DSI) (GREDELL and Rietz & Jens, 2011), the alluvial deposits are typically comprised of sands and gravels with lesser amounts of silts and clays, generally resulting in an overall fining-upward sequence. Boring logs for the CCR monitoring well network are provided in Appendix A.

The depth of the alluvial deposits near the surface impoundment typically range from approximately 90 to 110 feet below ground surface (BGS) (365 to 385 feet MSL) with total depths in the area as deep as 135 feet BGS and becoming shallower towards the bluffs to the south based on site specific borings. Sedimentary bedrock underlies the alluvial deposits.

Bluffs to the south, as well as bedrock underlying the floodplain alluvial deposits, are comprised of relatively flat-lying Ordovician-aged limestones, sandstones and dolomites. In progression from youngest to oldest, these deposits consist of the Plattin Group, Joachim Dolomite, St. Peter Sandstone, Powell Dolomite, and the Cotter/Jefferson City Dolomites (Starbuck, 2010; GREDELL and Reitz & Jens, 2011). In deep wells, the Roubidoux Formation and the underlying Gasconade Dolomite can be found at depths of approximately 530-764 feet BGS (GREDELL and Reitz & Jens, 2011).

2.3 Site Hydrogeology

Site hydrogeology has been characterized based on information obtained from 127 piezometers and borings installed by GREDELL and Reitz & Jens (2011) to support a DSI conducted for the Labadie UWL, the CCR groundwater monitoring wells installations completed by Golder, and 36 monitoring wells installed around the perimeter of the UWL in 2013 and 2014 by Reitz & Jens for state required UWL groundwater monitoring. **Figure 3** provides a generalized cross-section of the nearby LCPA Surface Impoundment referenced to local geology, groundwater, and the Missouri River.

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 River Valley alluvium. This alluvium overlies Ordovician-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.

2.3.2 Surface Water and Groundwater Elevations

2.3.2.1 CCR Landfill and Surface Impoundment Water

Cell LCL1, as well as the future cells at the UWL, will use dry CCR landfill disposal methods. The UWL will not have ponded surface water in the cells.

2.3.2.2 Alluvial Aquifer

Groundwater elevations within the alluvial aquifer in the Labadie Bottoms area have been obtained in several different studies. As a part of the DSI for the UWL, groundwater elevations were obtained in 100 piezometers located within the alluvial aquifer within the footprint of the UWL from December 2009 to November 2010. These piezometers were all located in the shallow portion of the alluvial aquifer and had screen intervals ranging from approximately 428 to 452 feet MSL. Groundwater elevation measurements ranged from approximately 456 to 469 feet MSL during this time period. However, during any single round of groundwater level measurements, the aquifer potentiometric surface was relatively flat, with the surface variability in any round of groundwater level measurements, ranging from approximately 1 to 4 feet across all of the piezometers. Potentiometric Surface Maps displaying these results are provided in **Appendix B**.

Water level measurements were also collected at 36 monitoring wells during four background sampling events for the UWL from 2013-2014 (GREDELL and Reitz & Jens, 2013a, 2013b, 2013c, and 2014). During this timeframe, groundwater elevations ranged from approximately 448 to 459 feet MSL.

Golder obtained groundwater elevation measurements from March 2016 through May 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 ranged from approximately 453 feet MSL to 465 feet MSL.

2.3.3 Groundwater Flow Directions

Groundwater flow within the alluvial aquifer is dynamic and is influenced by seasonal changes in the water level in the adjacent Missouri River. River water levels measured at the Facility display large seasonal changes in the elevation of the Missouri River water surface. For example, from April 2015 to July 2017, river water levels fluctuated between approximately 451 and 474 feet MSL. Water flows into and out of the alluvial aquifer as a result of fluctuating river water levels that produce "bank recharge" and "bank discharge" conditions. Under normal aquifer conditions, groundwater flow in the alluvial aquifer would be expected to have a flow direction component toward the river and a flow component away from the bluffs, with a likely net flow direction generally to the north.

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, Rietz & Jens and Golder (**Appendix B**, **Appendix C and Table 1**). The potentiometric surface maps display some variability in the groundwater flow direction. These changes in flow direction are related to the level within the adjacent Missouri River.

In addition to the DSI potentiometric surface maps, additional groundwater analysis was also completed as a part of the UWL Construction Permit Application (GREDELL and Rietz & Jens, 2014). These analyses calculated the net groundwater flow velocity and direction from December 2009 until November 2010. During this timeframe, groundwater located near proposed UWL cells 1 & 2 was calculated to have a net annual velocity of approximately 12 feet per year with a bearing of 33° (North-northeast). Groundwater located near UWL cells 3 & 4 was calculated to have a net annual flow velocity of approximately 15 feet per year with a bearing of approximately 67° (East-northeast). These analysis also displayed that groundwater flow direction was highly variable from month to month depending on Missouri River conditions with overall flow directions ranging from a west-northwesterly direction to a southeasterly direction.

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 was generally towards the north, flowing from the bluffs toward the river.

Based on the potentiometric surface maps, a general flow direction from the south (bluffs area) to the north (Missouri River) under normal river conditions is expected. However, during periods of high river levels, groundwater flow can temporarily reverse and flow southward. During these times of high river stage and temporary flow direction changes, horizontal groundwater gradients generally decrease and little net movement of groundwater to the south occurs.

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 0.000002 to 0.0035 feet/foot. The DSI indicates that the higher gradients were observed closer to the Missouri River and reflect localized river influence and are not representative of site-wide conditions farther from the river.

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 0.0002 to 0.0006 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 Missouri River.

2.3.3.2 Vertical Gradients

A review of downward gradients observed in piezometers was completed by comparing groundwater elevations obtained by GREDELL and Rietz & Jens DSI, as well as by Golder's initial baseline sampling data. This analysis was completed between shallow and intermediate/deep zone piezometer 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 exist that fluctuate between upward and downward with no consistent vertical gradient present between shallow and deeper zones of the alluvial aquifer.

Downward gradients within the nearby LCPA pond and the underlying alluvial groundwater zone are much greater, based on a review of water elevation measurements and the pond gauge levels. This downward gradient changes seasonally based on river levels and fluctuating alluvial aquifer groundwater levels.

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 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 in 25 piezometers. The calculated hydraulic conductivity of the fluvial sediments ranges from 1.01 x 10^{-2} to 4.81 x 10^{-2} centimeters/second with an average value of 2.49 x 10^{-2} centimeters/second. Sandy channel deposits displayed a similar average value of 2.79 x 10^{-2} centimeters/second. 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, the DSI indicates 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 (Table 8 of the DSI). The DSI suggests a representative range of prevailing groundwater movement at the Site is between 0.1 and 10 feet per year, depending on hydraulic conductivity and effective porosity.

Golder also performed rising head hydraulic conductivity tests on the 12 newly installed CCR monitoring wells used to monitor the shallow alluvial aquifer, in order to estimate the hydraulic conductivities in February to April, 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 1.8 x 10^{-2} cm/sec for CCR groundwater monitoring wells screened in 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 are estimated to range between 0.05 and 0.17 feet per day and average approximately 20 feet per year.

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)
LCPB Fly Ash Surface Impoundment Monitoring Wells					
LMW-1S	25.75	15.6 - 25.4	444.7 - 454.5	97	3.4E-02
LMW-2S	56.07	50.9 - 55.7	441.0 - 445.8	31	1.1E-02
LMW-3S	71.80	61.6 - 71.4	421.2 - 431.0	37	1.3E-02
LMW-4S	34.83	24.6 - 34.4	438.5 - 448.3	76	2.7E-02
LMW-5S	23.96	13.8 - 23.6	445.2 - 455.0	56	2.0E-02
LMW-6S	25.09	14.9 - 24.7	444.9 - 454.7	56	2.0E-02
LMW-7S	25.27	15.1 - 24.9	443.6 - 453.4	41	1.4E-02
LMW-8S	25.20	15.0 - 24.8	442.4 - 452.2	56	2.0E-02
Background Monitoring Wells					
BMW-1S	33.03	22.8 - 32.6	440.9 - 450.7	128	4.5E-02
BMW-2S	30.17	20.0 - 29.8	444.8 - 454.6	112	4.0E-02
UWL Monitoring Wells					
MW-26*	23.00	12.8 - 22.6	446.6 - 456.4	79	2.8E-02
TMW-1*	21.58	11.3 - 21.1	448.2 - 458.0	79	2.8E-02
TMW-2	27.77	17.6 - 27.4	443.0 - 452.8	56	2.0E-02
TMW-3	27.61	17.4 - 27.2	442.2 - 452.0	78	2.7E-02

Notes
1. feet MSL - feet above mean sea level
2. cm/sec - centimeters per second
3. Rising head tests were completed by Golder Associates on February 18, and April 19, 2016 using a Pneumatic Hi-K Slug®
4. feet BTOC - feet below top of casing
5. * - Hydraulic conductivity values represent average hydraulic conductivity for channel deposits 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. A representative grain size distribution was collected from the screen interval at LMW-1S using the ASTM D6912 Method B and the results are provided in Appendix D. The sample from LMW-1S was similar in field classification to other shallow alluvial aquifer 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 medium 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 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 6 monitoring wells screened in the uppermost aquifer for the purpose of monitoring the UWL's LCL1. The monitoring well network includes 2 background groundwater monitoring wells (BMW-1S and BMW-2S) that are located approximately 2.5 miles west of the UWL in areas unaffected by CCR disposal. Four (4) of the groundwater monitoring wells are placed ringing the LCL1 and are considered to be the downgradient wells. The groundwater monitoring well locations were selected based on site-specific 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 LCL1 was determined. The LCL1 has a bottom elevation of approximately 468 feet MSL. Potential constituent migration pathways are likely to be downward then laterally in the direction of groundwater flow in the shallow alluvial aquifer. Groundwater flow within the alluvial aquifer can also be variable depending on levels within the Missouri River and can flow in a variety of directions. Groundwater monitoring wells were placed around the unit in order to capture flow in variable directions. Based on water level readings, the groundwater in the shallow alluvial aquifer can range from approximately 448 to 469 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 the bluffs area located south of the site toward the Missouri River to the north, however, alluvial aquifer flow is locally influenced by water levels in the LCPA and the Missouri River level. 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."*

As shown in **Figure 2**, the background monitoring wells BMW-1S and BMW-2S are west of the UWL at a location approximately 2,000 to 3,000 feet from the Missouri River. These wells provide background groundwater quality representative of upgradient conditions in the alluvial aquifer.

3.3.2 Downgradient Monitoring Well Locations

As discussed above, downgradient monitoring wells are located ringing the LCL1 to monitor potential migration pathways. **Figure 2** shows that the downgradient well network consists of 4 groundwater monitoring wells (TMW-1, TMW-2, TMW-3, and MW-26) around the LCL1 at locations that are located as close to the waste boundary as practical.

3.3.3 Groundwater Monitoring Well Screen Intervals

The system of monitoring wells ringing the LCL1 is screened in the alluvial aquifer zone as close to the landfill base elevation as possible. Details on the construction of the groundwater monitoring wells are provided in **Table 4** and **Appendix E**. Screen intervals range from approximately 396 to 413 feet MSL in sandy alluvial deposits

3.3.4 Future Cell Construction for the UWL

As Cells 2-4 of the UWL are being constructed, the monitoring well network will need to be adjusted to incorporate these cells. This will likely include the abandonment of some wells and the installation of several new wells. An initial set of 8 baseline samples will need to be collected 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 UWL's LCL1 was installed in March 2013, February 2016 and April 2016. The monitoring system includes groundwater monitoring wells installed by Rietz & Jens (TMW-1 and MW-26) and Golder (TMW-2, TMW-3, BMW-1S, BMW-2S). Monitoring wells installed in 2013 were installed as described in more detail in Rietz & Jens, 2013.

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) under direct supervision of a Golder Geologist or Engineer. Continuous soil core samples were obtained at each well borehole location and were logged in the field by Golder. Soils were classified according to the Unified Soil Classification System. Monitoring well installed by Rietz & Jens were installed using hollow stem auger (HSA) drilling methods using a Dietrich D-50 Turbo Drill rig. Boring logs and well construction diagrams for the monitoring wells used in the monitoring well network are provided in **Appendix A**, and **Appendix E**, respectively.

Groundwater monitoring wells were installed in accordance with MDNR Well Construction Rules (10 CSR 23-4.060 Construction Standards for Monitoring Wells). 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 installed by Golder 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.

4.2 Groundwater Monitoring Well Development

After well construction, a Golder geologist or engineer developed newly installed 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. Wells installed by Rietz & Jens were developed by Rietz & Jens using airlifting and submersible pumps. Well development forms are attached in **Appendix F**.

4.3 Dedicated Pump Installation

A dedicated pump was installed in BMW-1S and BMW-2S 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. Monitoring wells TMW-1, TMW-2, TMW-3 and MW-26 are sampled using peristaltic pumping methods with dedicated tubing and do not have dedicated bladder pumps installed.

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 installed monitoring wells. Monitoring wells installed by Reitz & Jens were surveyed by Keuhlmann Design Group (KDG). 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 UWL LCL1 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 generally 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 (USEPA, 2010).

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 sufficiently durable to remain legible when wet 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: L-TMW-1
- MS: L-TMW-1-UWL-MS
- MSD: L-TMW-1-UWL-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 up-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**.

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TABLES

Table 1
Groundwater Level Data
LCL1 - Utility Waste Landfill
Labadie Energy Center, Franklin County, MO

Well ID	Location[5]		Top of Casing[6]	Ground Surface[6]	Background Event 1 5/3/2016		Background Event 2 6/15/2016		Background Event 3 7/11/2016		Background Event 4 9/8/2016		Background Event 5 11/11/2016		Background Event 6 1/16/2017		Background Event 7 3/1/2017		Background Event 8 5/31/2017	
	Northing	Easting	Feet MSL[4]	Feet MSL[4]	DTW[2]	GWE[3]	DTW[2]	GWE[3]	DTW[2]	GWE[3]	DTW[2]	GWE[3]	DTW[2]	GWE[3]	DTW[2]	GWE[3]	DTW[2]	GWE[3]	DTW[2]	GWE[3]
MW-26*	993976.5	726910.9	469.20	466.7	9.20	460.00	6.77	462.43	8.27	460.93	11.61	457.59	12.46	456.74	15.19	454.01	15.59	453.61	4.17	465.03
TMW-1*	993782.9	728656.8	469.34	466.9	10.12	459.22	6.92	462.42	8.83	460.51	11.74	457.60	12.08	457.26	14.94	454.40	15.61	453.73	4.74	464.60
TMW-2	994513.1	728663.8	470.40	468.0	10.40	460.00	8.24	462.16	10.05	460.35	13.02	457.38	13.61	456.79	16.51	453.89	17.04	453.36	5.82	464.58
TMW-3	994635.7	727842.0	469.41	467.1	9.35	460.06	7.10	462.31	8.84	460.57	12.11	457.30	12.89	456.52	15.54	453.87	16.07	453.34	4.62	464.79
BMW-1S	988310.0	715131.6	473.49	471.2	9.40	464.09	NA	NA	11.89	461.60	16.30	457.19	18.26	455.23	20.53	452.96	19.74	453.75	6.61	466.88
BMW-2S	987210.1	715104.3	474.56	472.5	11.77	462.79	NA	NA	12.44	462.12	16.83	457.73	18.84	455.72	21.32	453.24	20.64	453.92	7.42	467.14
Missouri River	995047.6	723234.9	NA	NA	NA	464.69	NA	460.21	NA	458.15	NA	453.85	NA	451.84	NA	450.11	NA	451.37	NA	464.22

Notes:
1.) Groundwater monitoring wells installed by Golder Associates were surveyed by Zahner & Associates, Inc. on February 11 and April 28, 2016.
2.) DTW - Depth to water measured in feet below top of casing.
3.) GWE - Groundwater elevation measured in feet above mean sea level.
4.) MSL - Feet above mean sea level.
5.) Horizontal Datum: State Plane Coordinates NAD83 (2000) Missouri East Zone feet.
6.) Vertical Datum: NAVD88 feet.
7.) * - Groundwater monitoring wells installed by Reitz and Jens, Inc. and surveyed by KdG.
8.) NA - Not Applicable.
9.) Missouri River level obtained from United States Geological Survey (USGS) gauge 06935550.

Prepared JSI
Check JS/RJF
Reviewed MNH

Table 2

Generalized Hydraulic Properties of Uppermost Aquifer
LCL1 - Utility Waste Landfill
Labadie Energy Center, Franklin County, MO

LCL1 Compliance Wells Only (TMW-1, TMW-2, TMW-3, and MW-26)							
Baseline Sampling Event	Baseline Sampling Event Date	Average Groundwater flow Direction (Azimuth)	Estimated Hydraulic Gradient (Feet/Foot)	Hydraulic Conductivity (Feet/Day)	Mean Hydraulic Conductivity (cm/sec)	Estimated Effective Porosity	Estimated Groundwater Velocity (Feet/Day)
1	5/3/2016	160.2	0.0008	72.29	2.6E-02	0.35	0.17
2	6/15/2016	16.1	0.0002	72.29	2.6E-02	0.35	0.05
3	7/11/2016	54.4	0.0003	72.29	2.6E-02	0.35	0.07
4	9/8/2016	3.1	0.0004	72.29	2.6E-02	0.35	0.07
5	11/11/2016	340.8	0.0007	72.29	2.6E-02	0.35	0.14
6	1/16/2017	347.4	0.0006	72.29	2.6E-02	0.35	0.12
7	3/1/2017	359.3	0.0005	72.29	2.6E-02	0.35	0.10
8	5/31/2017	85.9	0.0003	72.29	2.6E-02	0.35	0.05

Estimated Results (USEPA Tool)	
Resultant Groundwater Flow Direction (Azimuth)	12
Estimated Annual Net Groundwater Movement (Feet/Year)	20

Prepared By: JS
Checked By: JSI
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 LCL1 compliance 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

LCL1 - Utility Waste Landfill

Labadie Energy Center, Franklin County, MO

Well ID	Date Installed	Location[4]		Top of Casing Elevation	Ground Surface Elevation	Top of Screen	Bottom of Screen	Base of Well	Total Depth
		Northing	Easting	(FT MSL)[5]	(FT MSL)[5]	(FT MSL)[5]	(FT MSL)[5]	(FT MSL)[5]	(FT BGS)[5]
MW-26*	3/20/2013	993976.5	726910.9	469.20	466.7	456.4	446.6	446.2	20.5
TMW-1*	3/19/2013	993782.9	728656.8	469.34	466.9	458.0	448.2	447.8	19.2
TMW-2	4/6/2016	994513.1	728663.8	470.40	468.0	452.8	443.0	442.6	25.4
TMW-3	4/6/2016	994635.7	727842.0	469.41	467.1	452.0	442.2	441.8	25.3
BMW-1S	2/1/2016	988310.0	715131.6	473.49	471.2	450.7	440.9	440.5	30.7
BMW-2S	2/2/2016	987210.1	715104.3	474.56	472.5	454.6	444.8	444.4	28.1

Notes:

1.) All elevations and coordinates were surveyed on February 11, 2016 and April 28th, 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 Reitz and Jens, Inc. and surveyed by KdG.

Prepared By: JSI

Checked By: JS

Reviewed By: MNH

Table 5

Groundwater Quality Monitoring Parameters

LCL1 - Utility Waste Landfill

Labadie Energy Center, Franklin 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 completed by 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 the USEPA Rule.

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

Table 6

Analytical Methods and Practical Quantitation Limits

LCL1 - Utility Waste Landfill

Labadie Energy Center, Franklin 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/SW846 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/SW846 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 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.

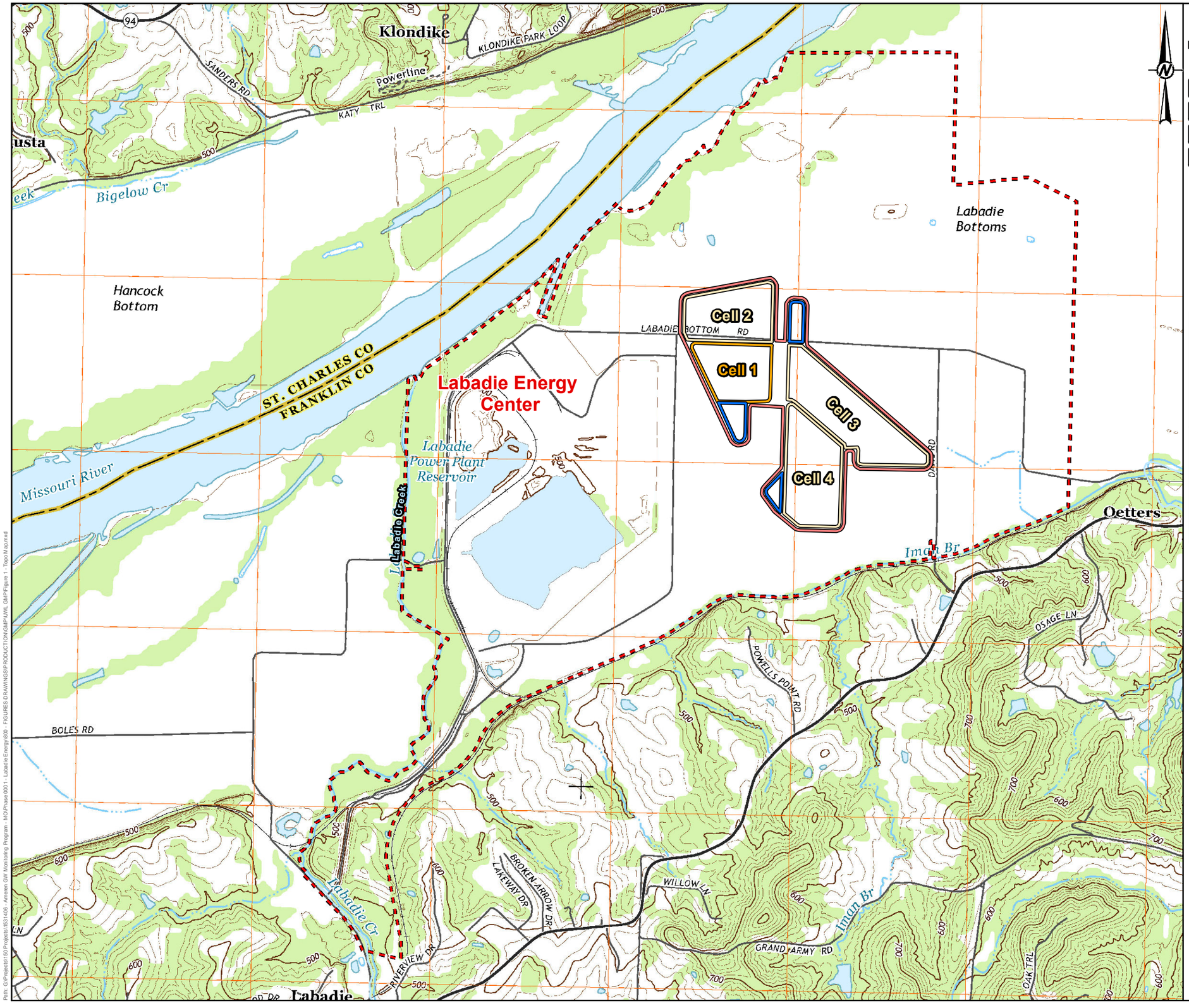
15.) mg/L - Milligrams per liter.

Prepared By: JS

Checked By: MWD

Reviewed By: MRS

FIGURES



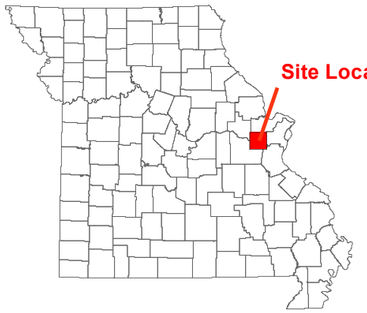
LEGEND

- Labadie Energy Center Property Boundary

Utility Waste Landfill (UWL)

- Proposed Fence Perimeter
- Cell LCL1
- Proposed Stormwater Pond
- Proposed Future Cell

KEY MAP



NOTES

1. ALL LOCATIONS AND BOUNDARIES ARE APPROXIMATE.

REFERENCES

1. ZAHNER AND ASSOCIATES, INC. 2016. LOT CONSOLIDATION PLAT OF "LABADIE ENERGY CENTER" - PREPARED FOR AMEREN MISSOURI. REVISED JUNE 15, 2016.
2.) COORDINATE SYSTEM: NAD 1983 STATEPLANE MISSOURI EAST FIPS 2,401 FEET.

0 5001,000 2,000 3,000 4,000 Feet

CLIENT
AMEREN MISSOURI
LABADIE ENERGY CENTER

PROJECT
GROUNDWATER MONITORING PROGRAM

TITLE
SITE LOCATION TOPOGRAPHIC MAP

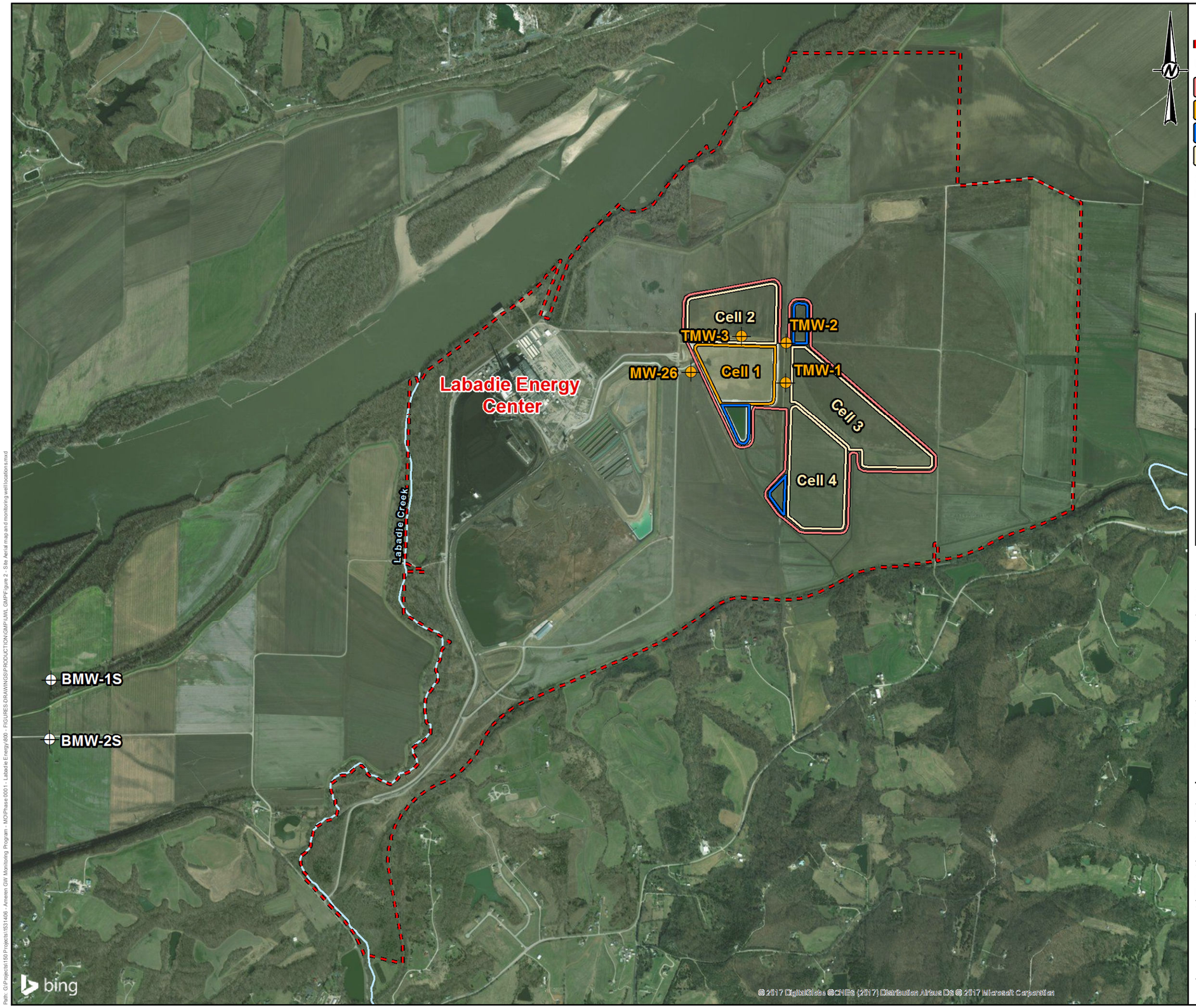
CONSULTANT
Golder Associates

YYYY-MM-DD	2017-07-08
PREPARED	JSI
DESIGN	JSI
REVIEW	JS
APPROVED	MRS

PROJECT No. 153-1406 | PHASE 0001C | Rev. 0 | FIGURE 1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 1 in

Path: G:\Projects\153\Projects\1531406 - Ameren GW Monitoring Program - MO\Phase 0001 - Labadie Energy\800 - FIGURES\DRAWINGS\PRODUCTION\GMP\UWL GMP Figure 1 - Topo Map.mxd



LEGEND

Labadie Energy Center Property Boundary

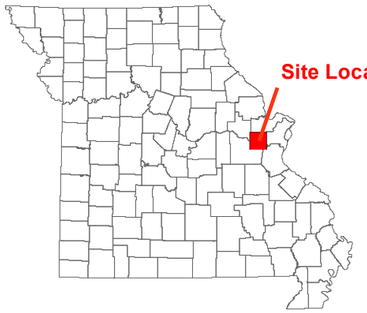
Utility Waste Landfill (UWL)

- Proposed Fence Perimeter
- Cell LCL1
- Proposed Stormwater Pond
- Proposed Future Cell

Ground/Surface Elevation Measurement Location

- UWL Monitoring Well
- Background Monitoring Well

KEY MAP



NOTES

1. ALL LOCATIONS AND BOUNDARIES ARE APPROXIMATE.
2. GROUNDWATER MONITORING WELLS INSTALLED BY GOLDER ASSOCIATES WERE SURVEYED BY ZAHNER & ASSOCIATES, INC. ON FEBRUARY 11 AND APRIL 28, 2016.
3. GROUNDWATER MONITORING WELLS INSTALLED BY REITZ AND JENS, INC. WERE SURVEYED BY KDG.

REFERENCES

1. ZAHNER AND ASSOCIATES, INC. 2016. LOT CONSOLIDATION PLAT OF "LABADIE ENERGY CENTER" - PREPARED FOR AMEREN MISSOURI. REVISED JUNE 15, 2016.
2.) COORDINATE SYSTEM: NAD 1983 STATEPLANE MISSOURI EAST FIPS 2,401 FEET.

0 5001,000 2,000 3,000 4,000 Feet

CLIENT
AMEREN MISSOURI
LABADIE ENERGY CENTER

PROJECT
GROUNDWATER MONITORING PROGRAM

TITLE
SITE LOCATION AERIAL MAP AND MONITORING WELL LOCATION

CONSULTANT
Golder Associates

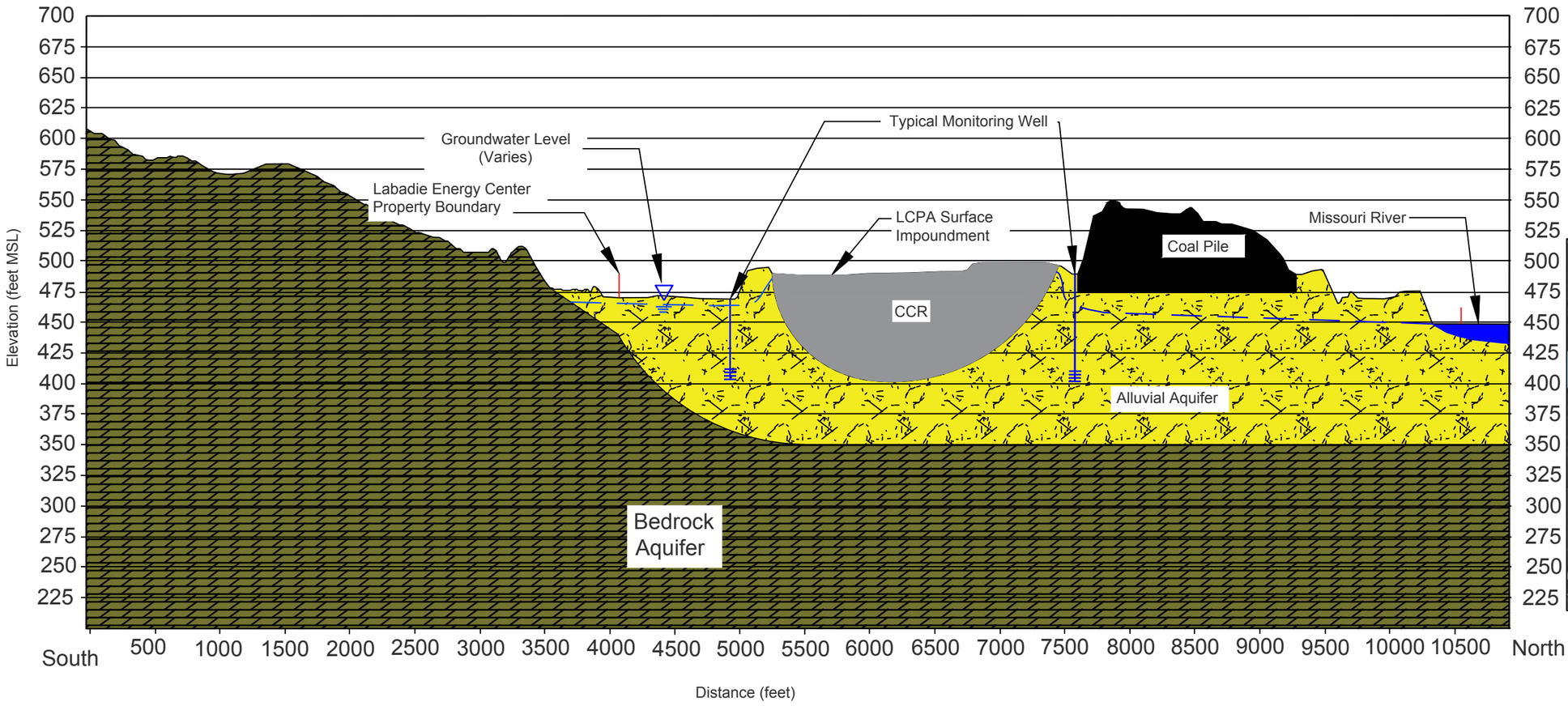
YYYY-MM-DD	2017-07-08
PREPARED	JSI
DESIGN	JSI
REVIEW	JS
APPROVED	MRS

PROJECT No.	PHASE	Rev.	FIGURE
153-1406	0001C	0	2

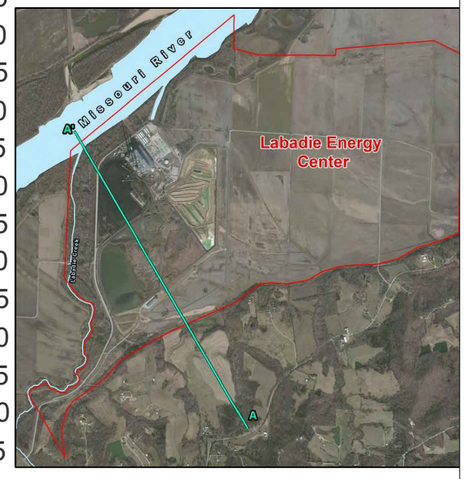
IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 1in

Path: G:\Projects\153\Projects\1531406 - Ameren GW Monitoring Program - MO\Phase 0001 - Labadie Energy\800 - FIGURES.DRAWINGS\PRODUCTION\GMP\UWL GMP\Figure 2 - Site Aerial map and monitoring well locations.mxd

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 AND FEATURES.
3.) MSL - MEAN SEA LEVEL.

REFERENCES
1.) AMEREN, 2011. AMEREN MISSOURI LABADIE ENERGY CENTER, LABADIE PROPERTY CONTROL MAP, NOVEMBER 2011
2.) GREDELL ENGINEERING RESOURCES, INC., AND REITZ & JENS. 2011. DETAILED SITE INVESTIGATION REPORT FOR: AMEREN MISSOURI LABADIE POWER PLANT PROPOSED UTILITY WASTE DISPOSAL AREA FRANKLIN COUNTY, MISSOURI.

CLIENT
AMEREN MISSOURI
LABADIE ENERGY CENTER

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-07-31
DESIGNED	JSI
PREPARED	JSI
REVIEWED	JS
APPROVED	MRS

PROJECT
GROUNDWATER MONITORING PROGRAM

TITLE
GENERALIZED CROSS-SECTION

PROJECT NO.	PHASE	REV.	FIGURE
153-1406	0001	0.0	3

AMEREN_00002566

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

1 in

0

Path: \\atlout\common\Projects\150 Projects\1531406 - Ameren GW Monitoring Program - MO\Phase 0001 - Labadie Energy\800 - FIGURES-DRAWINGS\PRODUCTION\Generalized Cross Section\ | File Name: Generalized Cross Section.dwg

APPENDIX A
CCR MONITORING WELL BORING LOGS

RECORD OF BOREHOLE TMW-2

SHEET 1 of 1

PROJECT: Ameren CCR GW Monitoring
PROJECT NUMBER: 153-1406.0001C
LOCATION: Labadie Energy Center

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

DATUM: NAVD88
AZIMUTH: N/A
COORDINATES: N: N/A E: N/A

ELEVATION: 468
INCLINATION: -90

DEPTH (feet)	BORING METHOD	SOIL/ROCK PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	ELEVATION / DEPTH (ft)	SAMPLES: NUMBER	TYPE	REC / ATT	REMARKS
0	6" Sonic	(0.0-1.4) TOPSOIL - (ML) SILT, non-plastic to low plasticity fines, some fine sand, some organics (roots); dark yellowish brown (10YR 4/2); non-cohesive, moist, loose	ML		466.6 / 1.4				
		(1.4-5.0) (CL) SILTY CLAY, medium plasticity fines, some fine sand; dark yellowish brown (10YR4/2); cohesive, w<PL, soft	CL		463.0 / 5.0	1	SO	2.6 / 5.0	
5		(5.0-6.8) (ML) sandy CLAYEY SILT, low plasticity fines, fine sand; brownish gray (5YR 6/1); cohesive, w<PL, soft	ML		461.2 / 6.8				
		(6.8-10.0) (SP-SM) SAND, fine sand, some non-plastic fines; moderate yellowish brown (10YR 5/4); non-cohesive, wet, compact	SP-SM		458.0 / 10.0	2	SO	4.2 / 5.0	▽ Water Level 9.0 ft bgs 4/6/2016
10		(10.0-25.4) (SP) SAND, fine sand, trace non-plastic fines; moderate yellowish brown (10YR 5/4); non-cohesive, wet, compact	SP			3	SO	10.0 / 10.0	
15									
20		(20.0) SAA (Same As Above), less fines, fine to medium sub-rounded sand, trace fine sub-rounded gravel; light olive gray (5Y 5/2)			448.0 / 20.0	4	SO	4.3 / 5.4	
25		END OF BORING AT 25.4 FEET BELOW GROUND SURFACE. FOR WELL DETAILS, SEE WELL CONSTRUCTION LOG TMW-2.			442.6 / 25.4				
30									

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 LEC LOGS.GPJ GLDR_CO.GDT 10/9/17

RECORD OF BOREHOLE TMW-3

SHEET 1 of 1

PROJECT: Ameren CCR GW Monitoring
PROJECT NUMBER: 153-1406.0001C
LOCATION: Labadie Energy Center

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

DATUM: NAVD88
AZIMUTH: N/A
COORDINATES: N: N/A E: N/A

ELEVATION: 468
INCLINATION: -90

DEPTH (feet)	BORING METHOD	SOIL/ROCK PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	ELEVATION / DEPTH (ft)	SAMPLES: NUMBER	TYPE	REC / ATT	REMARKS
0	6" Sonic	(0.0-1.2) (ML) SILT, low plasticity fines, some organics (roots), some fine sand; dark yellowish brown (10YR 4/2); cohesive, w<PL, soft	ML		466.8				
		(1.2-5.9) (CL) SILTY CLAY, medium plasticity fines, some fine sand; dark yellowish brown (10YR 4/2); cohesive, w<PL, soft	CL		1.2	1	SO	1.8 / 5.0	
5					462.1				
		(5.9-12.7) (ML) sandy CLAYEY SILT, low plasticity fines, fine sand; brownish gray (5YR 4/1); cohesive, w<PL, firm	ML		5.9	2	SO	3.2 / 5.0	▽ Water Level 9.0 ft bgs 4/6/2016
10		(10.0) SAA (Same As Above) except, ~1-2 cm thick laminations, dark yellowish orange layers (10YR 6/6)			458.0 10.0				
		(12.7-17.6) (SP-SM) SAND, fine sand, some non-plastic fines; moderate olive brown (5Y 4/6); non-cohesive, wet, compact	SP-SM		455.3 12.7	3	SO	10.0 / 10.0	
15					450.4				
		(17.6-20.0) (SP) SAND, fine to medium sub-rounded sand, trace non-plastic fines; moderate olive brown (5Y 4/6); non-cohesive, wet, compact	SP		17.6				
20					448.0				
		(20.0-25.3) (SW) SAND, fine to coarse sub-rounded sand; medium gray (N5) to light olive gray (5Y 5/2); non-cohesive, wet, compact	SW		20.0	4	SO	3.9 / 5.3	
25					442.7				
		END OF BORING AT 25.3 FEET BELOW GROUND SURFACE. FOR WELL DETAILS, SEE WELL CONSTRUCTION LOG TMW-3.			25.3				
30									

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 LEC LOGS.GPJ GLDR_CO.GDT 10/9/17

RECORD OF BOREHOLE BMW-1S

SHEET 1 of 2

PROJECT: Ameren CCR GW Monitoring
PROJECT NUMBER: 153-1406.0001B
LOCATION: Labadie Energy Center

DRILLING METHOD: 6" Sonic
DRILLING DATE: 2/1/2016
DRILL RIG: Mini Sonic (CDD1415)

DATUM: NAVD88
AZIMUTH: N/A
COORDINATES: N: 988,310.02 E: 715,131.61

ELEVATION: 471.17
INCLINATION: -90

DEPTH (feet)	BORING METHOD	SOIL/ROCK PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	ELEVATION / DEPTH (ft)	SAMPLES: NUMBER	TYPE	REC / ATT	REMARKS
0	6" Sonic	(0.0-6.5) (ML) CLAYEY SILT, low to medium plasticity fines, some organics (roots), some fine sand; brownish gray (5YR 4/1); cohesive, w<PL, firm	ML			1	SO	2.1 / 5.0	
5		(5.0) SAA (Same As Above) except, no organics			466.2 / 5.0				
		(6.5-9.3) (CL) SILTY CLAY, medium plasticity fines, trace fine sand, trace iron staining; brownish gray (5YR 4/1) mottled with dark yellowish orange (10YR 6/6) and moderate yellowish brown (10YR 5/4); cohesive, w~PL, firm	CL		464.7 / 6.5	2	SO	5.0 / 5.0	
		(9.3-10.0) (SP-SM) SAND, fine sand, some non-plastic fines; brownish gray (5YR 4/1); non-cohesive, moist, compact	SP-SM		461.9 / 9.3				
10		(10.0-17.9) (SM) SILTY SAND, fine sand, low to non-plastic fines; brownish gray (5YR 4/1); non-cohesive, wet, compact	SM		461.2 / 10.0	3	SO	8.2 / 10.0	▽ Water Level 13.93 ft bgs 3/14/2016
15		(16.3) SAA except, color to medium gray (N5)			454.9 / 16.3				
		(17.9-18.6) (CL) SILTY CLAY, medium plasticity, some fine sand; medium gray (N5); cohesive, w~PL, firm	CL		453.3 / 17.9				
		(18.6-30.7) (SP) SAND, fine sand, trace non-plastic fines; medium gray (N5); non-cohesive, wet, compact			452.6 / 18.6				
20						4	SO	7.3 / 10.7	Run #4, Sample appears to be compacted while being extruded into sample bags. Measured field recovery: 4.2/10.71 Estimated actual recovery: 7.3/10.71.
25		(25.0) SAA except, trace subrounded gravels, some medium grained subrounded sand	SP		446.2 / 25.0				
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

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

RECORD OF BOREHOLE BMW-1S

PROJECT: Ameren CCR GW Monitoring
PROJECT NUMBER: 153-1406.0001B
LOCATION: Labadie Energy Center

DRILLING METHOD: 6" Sonic
DRILLING DATE: 2/1/2016
DRILL RIG: Mini Sonic (CDD1415)

DATUM: NAVD88
AZIMUTH: N/A
COORDINATES: N: 988,310.02 E: 715,131.61

ELEVATION: 471.17
INCLINATION: -90

DEPTH (feet)	BORING METHOD	SOIL/ROCK PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	ELEVATION / DEPTH (ft)	SAMPLES: NUMBER	TYPE	REC / ATT	REMARKS
30			SP		440.5	4	SO	7.3 / 10.7	
		END OF BORING AT 30.7 FT BELOW GROUND SURFACE. FOR WELL DETAILS, SEE WELL CONSTRUCTION LOG BMW-1S.			30.7				
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 LEC LOGS.GPJ GLDR_CO.GDT 10/9/17

RECORD OF BOREHOLE BMW-2S

SHEET 1 of 2

PROJECT: Ameren CCR GW Monitoring
PROJECT NUMBER: 153-1406.0001B
LOCATION: Labadie Energy Center

DRILLING METHOD: 6" Sonic
DRILLING DATE: 2/2/2016
DRILL RIG: Mini Sonic (CDD1415)

DATUM: NAVD88
AZIMUTH: N/A
COORDINATES: N: 987,210.08 E: 715,104.29

ELEVATION: 472.48
INCLINATION: -90

DEPTH (feet)	BORING METHOD	SOIL/ROCK PROFILE: DESCRIPTION	USCS	GRAPHIC LOG	ELEVATION / DEPTH (ft)	SAMPLES: NUMBER	TYPE	REC / ATT	REMARKS
0	6" Sonic	(0.0-4.0) (ML) CLAYEY SILT, low plasticity fines, some fine to coarse sub-angular sand, some organics (roots); brownish gray (5YR 4/1); cohesive, w<PL, firm	ML		468.5 / 4.0	1	SO	2.3 / 5.0	Run #1, Sand in last foot of run appears to have washed out.
5		(4.0-30.0) (SP) SAND, fine sand, trace non-plastic fines; moderate yellowish brown (10YR 5/4); non-cohesive, dry, loose	SP			2	SO	5.0 / 5.0	
10						3	SO	5.0 / 5.0	
15		(15.0) SAA (Same As Above) except, wet, fine to medium sub-rounded sand			457.5 / 15.0	4	SO	5.0 / 5.0	▽ Water Level 14.84 ft bgs 3/14/2016
20		(22.0-27.0) SAA except, trace coarse sand			450.5 / 22.0				
25		(25.0) SAA except, mottled dark yellowish orange (10YR 6/6) and dark yellowish brown (10YR 4/2)			447.5 / 25.0	5	SO	10.0 / 10.0	
		(28.0) SAA except, color to light olive gray (5Y 5/2)			444.5 / 28.0				
30					442.5				

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 LEC LOGS.GPJ GLDR_CO.GDT 10/9/17

RECORD OF BOREHOLE BMW-2S

PROJECT: Ameren CCR GW Monitoring
PROJECT NUMBER: 153-1406.0001B
LOCATION: Labadie Energy Center

DRILLING METHOD: 6" Sonic
DRILLING DATE: 2/2/2016
DRILL RIG: Mini Sonic (CDD1415)

DATUM: NAVD88
AZIMUTH: N/A
COORDINATES: N: 987,210.08 E: 715,104.29

ELEVATION: 472.48
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 BMW-2S.			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 LEC LOGS.GPJ GLDR_CO.GDT 10/9/17

REITZ & JENS, INC.
CONSULTING ENGINEERS

BORING LOG MW-26

Labadie UWL Permanent Monitoring Wells
Labadie Energy Center, Franklin Co., MO
CLIENT: **Ameren Missouri**

LOCATION: N 993976.451 E 726910.923
ELEVATION: 466.66 DATUM: NAVD 88
DATE DRILLED: 03-20-2013

DEPTH (FEET)	ELEVATION	WATER TABLE	GRAPHIC LOG	SAMPLE TYPE	PERCENT RECOVERY	MATERIAL DESCRIPTION	DRY UNIT WEIGHT (PCF) BLOWS PER 6 INCHES RQD= ROCK QUALITY DES.	MOISTURE CONTENT PERCENT BY WEIGHT
0	465					CLAY (CH), brownish gray, high plastic		
5	460				100	Silty SAND (SM), light brown, fine		
10	455				100	SAND (SP), tan, fine		
15	450				100			
20	445				100	Becoming fine- to medium-grain with fine gravel		
25	440					Boring terminated at 20.0 feet Hole surged with 13 gallons water		
30								

SHEAR STRENGTH, tsf
△ QU/2 ■ PP □ SV ◇ TV
1 2 3
STANDARD PENETRATION TEST
▲ N-VALUE (BLOWS PER LAST FOOT)
● MOISTURE CONTENT, %
○ % FINES (SILTS & CLAYS)
PL LL
20 40 60

DRILLER: Brotcke Well & Pump
METHOD: 8-1/4" OD HSA
TYPE OF SPT HAMMER: None
HAMMER EFFICIENCY (%):
LOGGED BY: C. Cook

STRATIFICATION LINES ARE APPROXIMATE SOIL BOUNDARIES ONLY; ACTUAL CHANGES MAY BE GRADUAL OR MAY OCCUR BETWEEN SAMPLES.

WATER LEVELS: DURING DRILLING Unk. FEET
N BORING DRY AT COMPLETION OF DRILLING
AT 13.96 FEET AFTER 552 HOURS
AT 15.50 FEET AFTER 634 HOURS
PIEZOMETER: INSTALLED AT 20.0 FEET

File: 2008012455

REITZ & JENS, INC.
CONSULTING ENGINEERS

BORING LOG TMW-1

Labadie UWL Permanent Monitoring Wells
Labadie Energy Center, Franklin Co., MO
CLIENT: **Ameren Missouri**

LOCATION: N 993782.879 E 728656.811
ELEVATION: 466.91 DATUM: NAVD 88
DATE DRILLED: 03-19-2013

DEPTH (FEET)	ELEVATION	WATER TABLE	GRAPHIC LOG	SAMPLE TYPE	PERCENT RECOVERY	MATERIAL DESCRIPTION	DRY UNIT WEIGHT (PCF) BLOWS PER 6 INCHES RQD= ROCK QUALITY DES.	MOISTURE CONTENT PERCENT BY WEIGHT
0	465					CLAY (CH), gray brown, high plastic		
5	460				100	Clayey SILT (ML), brown Silty SAND (SM), tan, fine		
10	455				100			
15	450	▼			100	SAND (SP), tan, fine, trace silt Without silt		
20	445				100	Boring terminated at 19.0' Hole surged with 15 gallons water		
25	440							
30								

SHEAR STRENGTH, tsf
△ QU/2 ■ PP □ SV ◇ TV
1 2 3
STANDARD PENETRATION TEST
▲ N-VALUE (BLOWS PER LAST FOOT)
● MOISTURE CONTENT, %
○ % FINES (SILTS & CLAYS)
PL LL
20 40 60

DRILLER: Brotcke Well & Pump
METHOD: 8-1/4" OD HSA
TYPE OF SPT HAMMER: None
HAMMER EFFICIENCY (%):
LOGGED BY: C. Cook

STRATIFICATION LINES ARE APPROXIMATE SOIL BOUNDARIES ONLY; ACTUAL CHANGES MAY BE GRADUAL OR MAY OCCUR BETWEEN SAMPLES.

WATER LEVELS: DURING DRILLING Unk. FEET
N BORING DRY AT COMPLETION OF DRILLING
AT 15.37 FEET AFTER 574 HOURS
AT 16.21 FEET AFTER 659 HOURS
PIEZOMETER: INSTALLED AT 19.0 FEET

File: 2008012455

APPENDIX B
HISTORIC POTENTIOMETRIC SURFACE MAPS

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MISSOURI RIVER ELEVATION:
December 21, 2009
451.3 ft Ameren Missouri - Labadie Power Plant Gauging Station

LEGEND

- 2007 PIEZOMETER
- 2" PIEZOMETER
- 4" PIEZOMETER
- SURVEY MONUMENT
- 459.23 GROUNDWATER ELEVATION (FT.)
- GROUNDWATER FLOW DIRECTION
- 465 EXISTING GROUND CONTOURS (C.I. = 1 FT.)
- 460.00 GROUNDWATER CONTOUR NOTE: CONTOUR INTERVAL (C.I.) = 0.5 FT. (DASHED WHERE INFERRED)
- PROPOSED UTILITY WASTE DISPOSAL AREA FOOTPRINT

NOTES

1. MAP DEVELOPED BASED ON CONTOURS GENERATED BY SURFER® SOFTWARE.
2. GROUNDWATER DATA NOT AVAILABLE FOR TEMPORARY AND CPT BORINGS.
3. MEASUREMENTS RECORDED BY GREDELL ENGINEERING RESOURCES FIELD PERSONNEL.
4. MAP REPRESENTATIVE OF GROUNDWATER CONDITIONS OCCURRING ON DATE OF MEASUREMENT.
5. USE OF SMALL CONTOUR INTERVAL (0.5 FT.) EXAGGERATES APPARENT "SLOPE" OF WATER TABLE SURFACE.
6. RANGE OF GROUNDWATER FLOW GRADIENT AS DETERMINED BY SURFER® SOFTWARE 0.00006161 FT./FT. TO 0.001912 FT./FT.
7. MISSOURI RIVER GAUGE ELEVATION = 451.3 FT. ON DATE OF WATER LEVEL MONITORING AS MEASURED AT LABADIE POWER PLANT. THIS REPRESENTS AN APPROXIMATE 14.5 FT. DECREASE IN RIVER ELEVATION BEGINNING ON NOVEMBER 20, 2009.

SURVEY MONUMENTS

MONUMENT ID	NORTHING	EASTING	ELEVATION
AUELBE-001	990484.82	726569.81	467.19
AUELBE-002	996166.50	727588.30	470.70
AUELBE-003	989921.39	728508.32	467.59
AUELBE-004	994487.78	729353.29	467.02
AUELBE-005	991746.97	731438.29	462.78
AUELBE-006	996728.98	731621.69	467.67

Missouri State Plane Coordinate System Datum:
Horizontal Datum NAD 1983;
Vertical Datum NAVD 1988

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LAND AIR WATER
1991 Ewell Rd. Town & Country, MO 63131 Telephone: (573) 458-9676
Jefferson City, Missouri 65101 Telefax: (573) 635-7879

PREPARED FOR Ameren

DRAWN 020411 W.J.A. (GER)	FIGURE 18 DETAILED SITE INVESTIGATION PROPOSED UTILITY WASTE DISPOSAL AREA WATER TABLE SURFACE MAP - DECEMBER 21, 2009		
CHKD. M.C.C. (GER)			
SUPV. M.C.C. (GER)			
APPD. M.C.C. (GER)	LOCATION 001004	LABADIE PLANT	CLASS 02010
Ameren MISSOURI	ST. LOUIS, MISSOURI	FIGS (18) THRU (29)(33).DWG	REV.

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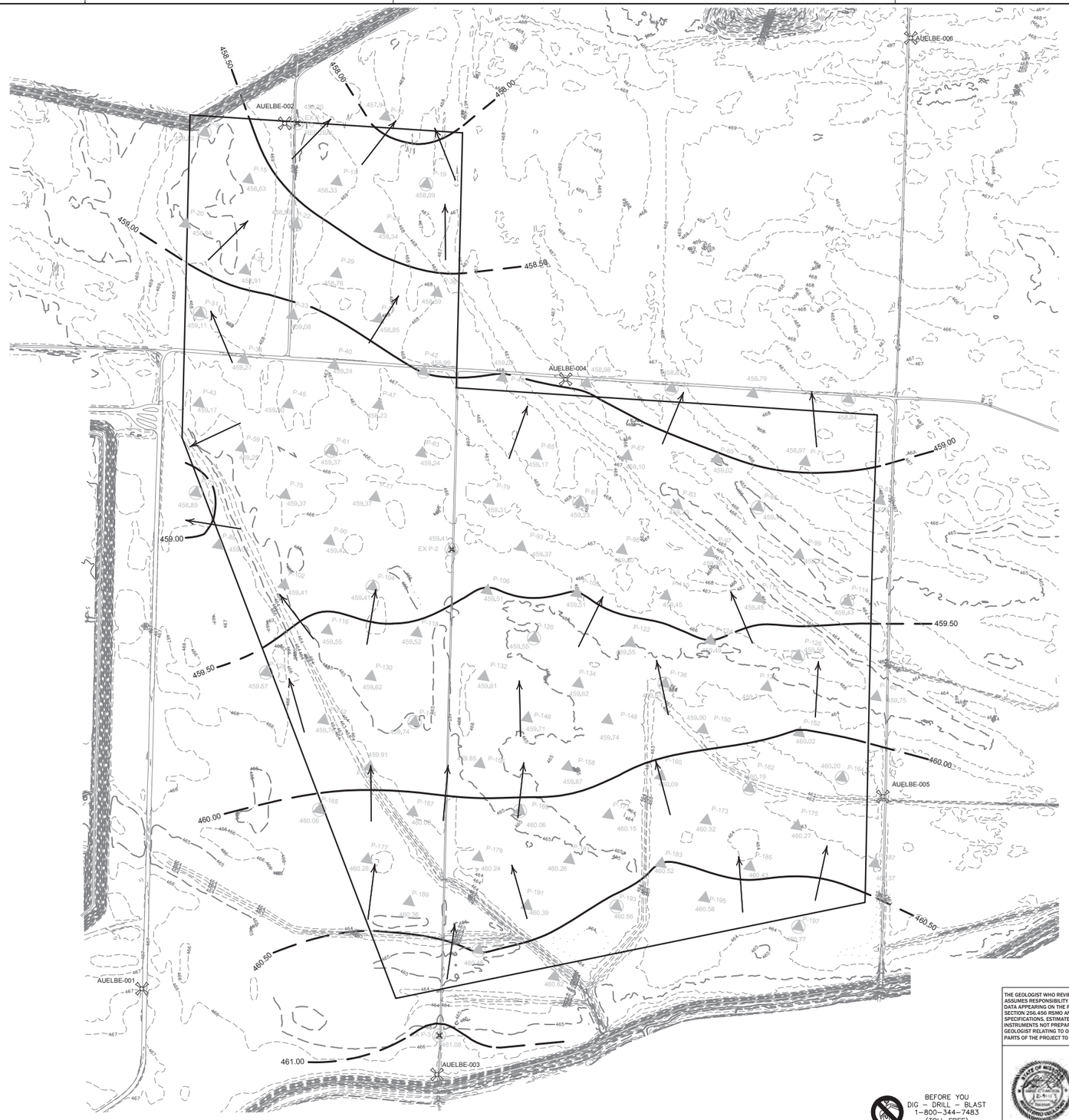

N

SCALE: 1" = 300'

0 150 300 600

MISSOURI RIVER ELEVATION:
January 25, 2010
465.9 ft Ameren Missouri - Labadie Power Plant Gauging Station

LEGEND

- 2007 PIEZOMETER
- 2" PIEZOMETER
- 4" PIEZOMETER
- SURVEY MONUMENT
- 459.23 GROUNDWATER ELEVATION (FT.)
- GROUNDWATER FLOW DIRECTION
- EXISTING GROUND CONTOURS (C.I. = 1 FT.)
- 460.00 GROUNDWATER CONTOUR NOTE: CONTOUR INTERVAL (C.I.) = 0.5 FT. (DASHED WHERE INFERRED)
- PROPOSED UTILITY WASTE DISPOSAL AREA FOOTPRINT

NOTES

1. MAP DEVELOPED BASED ON CONTOURS GENERATED BY SURFER® SOFTWARE.
2. GROUNDWATER DATA NOT AVAILABLE FOR TEMPORARY AND CPT BORINGS.
3. MEASUREMENTS RECORDED BY GREDELL ENGINEERING RESOURCES AND REITZ AND JENS FIELD PERSONNEL.
4. MAP REPRESENTATIVE OF GROUNDWATER CONDITIONS OCCURRING ON DATE OF MEASUREMENT.
5. USE OF SMALL CONTOUR INTERVAL (0.5 FT.) EXAGGERATES APPARENT "SLOPE" OF WATER TABLE SURFACE.
6. RANGE OF GROUNDWATER FLOW GRADIENT AS DETERMINED BY SURFER® SOFTWARE 0.00004573 FT./FT. TO 0.00106 FT./FT.
7. MISSOURI RIVER GAUGE ELEVATION = 465.9 FT. ON DATE OF WATER LEVEL MONITORING AS MEASURED AT LABADIE POWER PLANT. THIS REPRESENTS AN APPROXIMATE 13.5 FT. RISE IN RIVER ELEVATION BEGINNING ON JANUARY 18, 2010.

SURVEY MONUMENTS

MONUMENT ID	NORTHING	EASTING	ELEVATION
AUELBE-001	990484.82	726569.81	467.19
AUELBE-002	996166.50	727588.30	470.70
AUELBE-003	989921.39	728508.32	467.59
AUELBE-004	994487.78	729353.29	467.02
AUELBE-005	991746.97	731438.29	462.78
AUELBE-006	996728.98	731621.69	467.67

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1905 East High Street Telephone (573) 635-9078
Jefferson City, Missouri 65101 Facsimile (573) 635-9079

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DRAWN 020411 W.J.A. (GER)	FIGURE 19 DETAILED SITE INVESTIGATION PROPOSED UTILITY WASTE DISPOSAL AREA WATER TABLE SURFACE MAP - JANUARY 25, 2010	
CHKD. M.C.C. (GER)		
SUPV. M.C.C. (GER)		
APPD. M.C.C. (GER)	LOCATION 001004 — LABADIE PLANT	CLASS 02010
Ameren ST. LOUIS, MISSOURI	FIGS (18) THRU (29)(33).DWG	REV.

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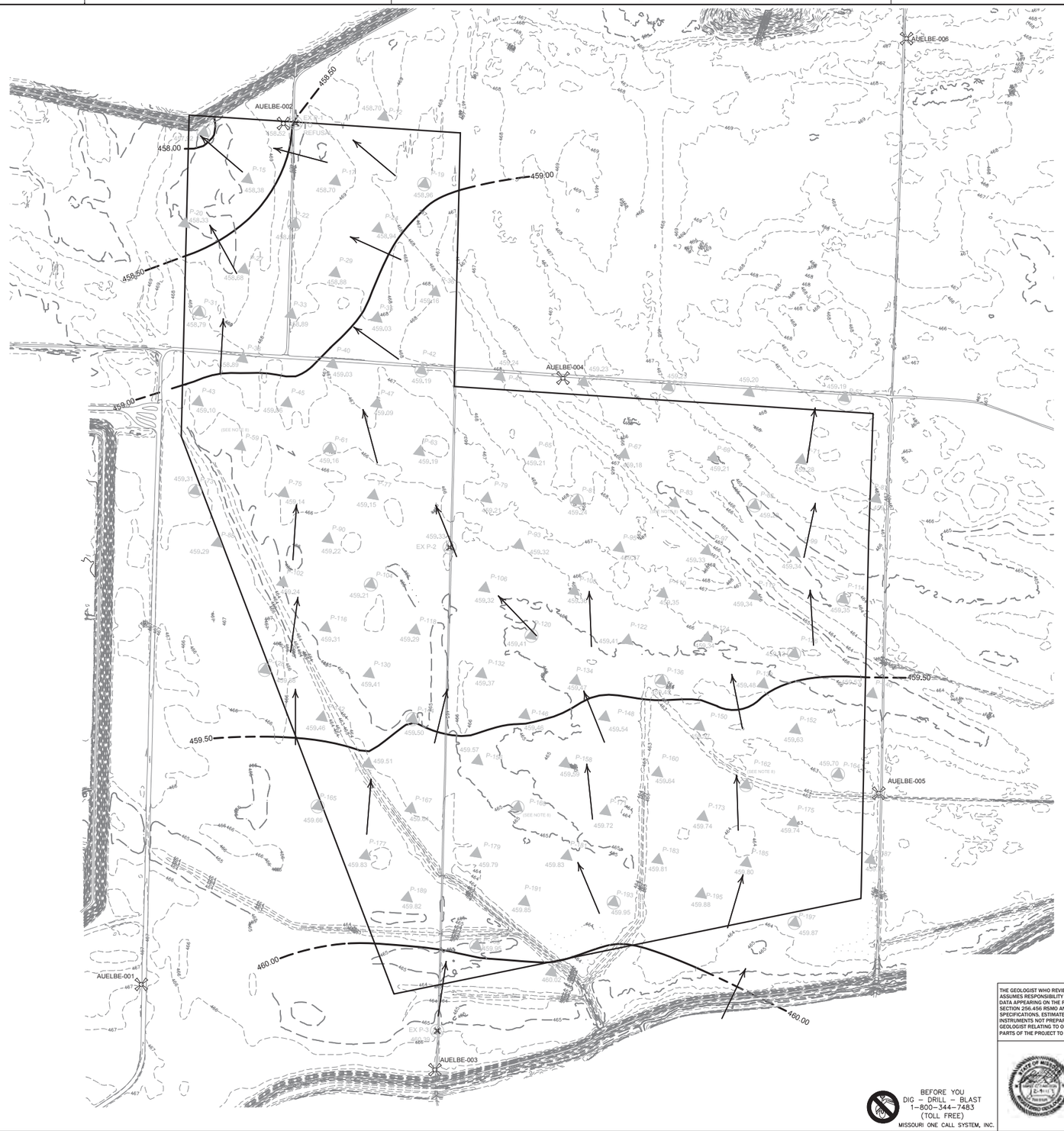

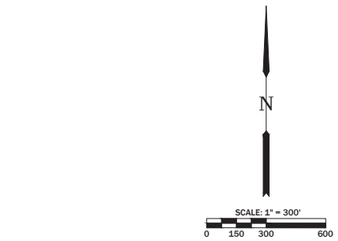

MISSOURI RIVER ELEVATION:
February 16, 2010
454.0 ft Ameren Missouri - Labadie Power Plant Gauging Station

LEGEND

- 2007 PIEZOMETER
- 2" PIEZOMETER
- 4" PIEZOMETER
- SURVEY MONUMENT
- 459.23 GROUNDWATER ELEVATION (FT.)
- GROUNDWATER FLOW DIRECTION
- EXISTING GROUND CONTOURS (C.I. = 1 FT.)
- 460.00 GROUNDWATER CONTOUR NOTE: CONTOUR INTERVAL (C.I.) = 0.5 FT. (DASHED WHERE INFERRED)
- PROPOSED UTILITY WASTE DISPOSAL AREA FOOTPRINT

NOTES

1. MAP DEVELOPED BASED ON CONTOURS GENERATED BY SURFER® SOFTWARE.
2. GROUNDWATER DATA NOT AVAILABLE FOR TEMPORARY AND CPT BORINGS.
3. MEASUREMENTS RECORDED BY GREDELL ENGINEERING RESOURCES AND REITZ AND JENS FIELD PERSONNEL.
4. MAP REPRESENTATIVE OF GROUNDWATER CONDITIONS OCCURRING ON DATE OF MEASUREMENT.
5. USE OF SMALL CONTOUR INTERVAL (0.5 FT.) EXAGGERATES APPARENT "SLOPE" OF WATER TABLE SURFACE.
6. RANGE OF GROUNDWATER FLOW GRADIENT AS DETERMINED BY SURFER® SOFTWARE 0.00000349 FT./FT. TO 0.005547 FT./FT.
7. MISSOURI RIVER GAUGE ELEVATION = 454.0 FT. ON DATE OF WATER LEVEL MONITORING AS MEASURED AT LABADIE POWER PLANT. THIS REPRESENTS AN APPROXIMATE 4.2 FT. DECREASE IN RIVER ELEVATION BEGINNING ON FEBRUARY 11, 2010.
8. GROUNDWATER ELEVATION READINGS FOR P-59, P-83, P-162, AND P-169 ARE SUSPECTED MEASUREMENT ERRORS. VALUES NOT CONSIDERED REPRESENTATIVE OF TRUE GROUNDWATER CONDITIONS (SEE TABLE 3).

SURVEY MONUMENTS

MONUMENT ID	NORTHING	EASTING	ELEVATION
AUELBE-001	990484.82	726569.81	467.19
AUELBE-002	996166.50	727588.30	470.70
AUELBE-003	989921.39	728508.32	467.59
AUELBE-004	994487.78	729353.29	467.02
AUELBE-005	991746.97	731438.29	462.78
AUELBE-006	996728.98	731621.69	467.67

Missouri State Plane Coordinate System Datum:
Horizontal Datum NAD 1983;
Vertical Datum NAVD 1988

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DRAWN 020411 W.J.A. (GER)	FIGURE 20
CHKD. M.C.C. (GER)	DETAILED SITE INVESTIGATION
SUPV. M.C.C. (GER)	PROPOSED UTILITY WASTE DISPOSAL AREA
APPD. M.C.C. (GER)	WATER TABLE SURFACE MAP - FEBRUARY 16, 2010
LOCATION 001004	LABADIE PLANT
CLASS 02010	
Ameren ST. LOUIS, MISSOURI	FIGS (18) THRU (29)(33).DWG
REV.	

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M:\Ameren\GWMon\AMERIBull LABADIE\GW Groundwater\FIGS (18) THRU (29)(33).DWG, 8.5 X 29.3 11:07 AM, Mark Tu PDF.pc5

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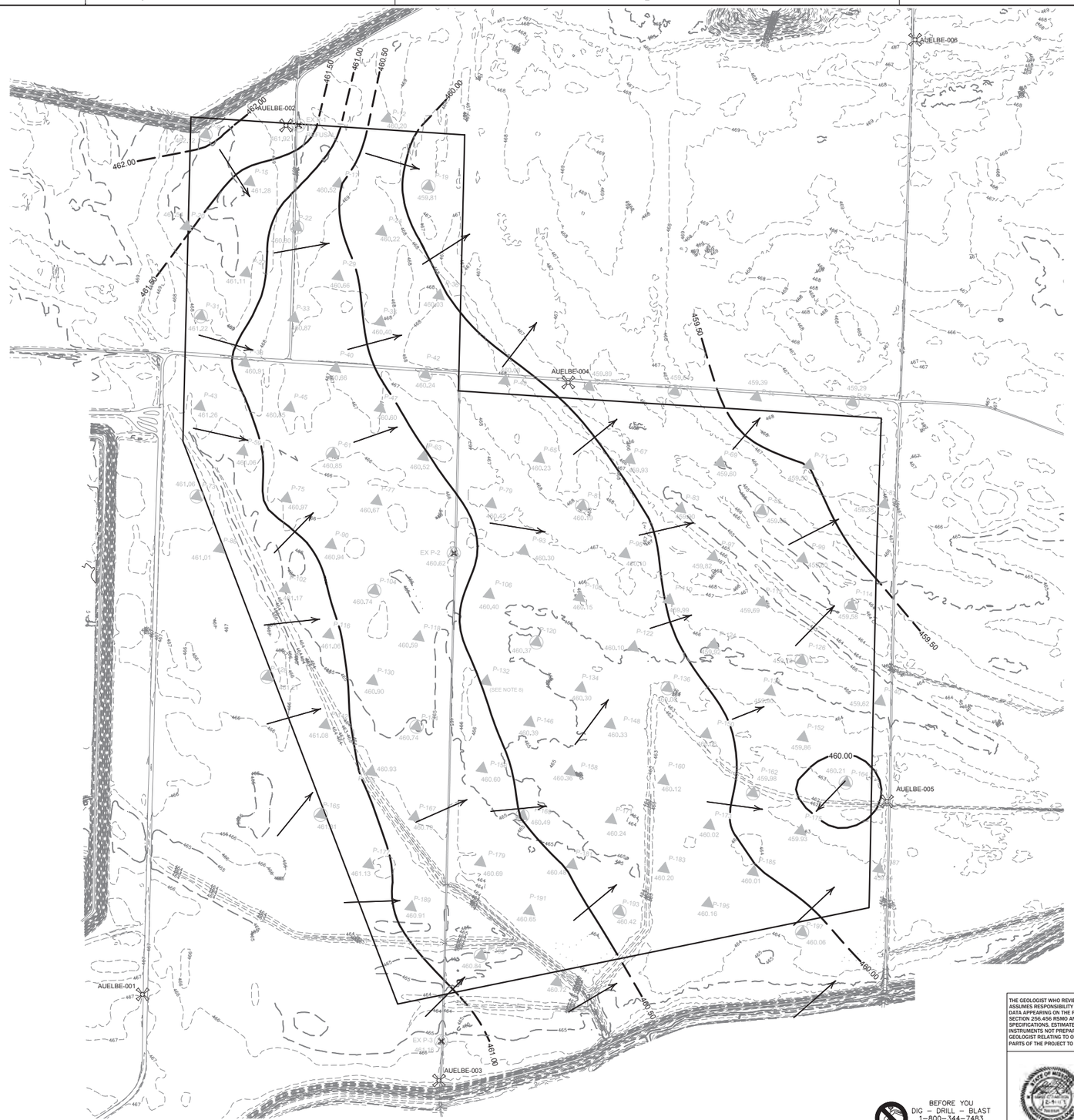

MISSOURI RIVER ELEVATION:
March 16, 2010
468.2 ft Ameren Missouri - Labadie Power Plant Gauging Station

LEGEND

- 2007 PIEZOMETER
- 2" PIEZOMETER
- 4" PIEZOMETER
- SURVEY MONUMENT
- 459.23 GROUNDWATER ELEVATION (FT.)
- GROUNDWATER FLOW DIRECTION
- EXISTING GROUND CONTOURS (C.I. = 1 FT.)
- 460.00 GROUNDWATER CONTOUR NOTE: CONTOUR INTERVAL (C.I.) = 0.5 FT. (DASHED WHERE INFERRED)
- PROPOSED UTILITY WASTE DISPOSAL AREA FOOTPRINT

NOTES

1. MAP DEVELOPED BASED ON CONTOURS GENERATED BY SURFER® SOFTWARE.
2. GROUNDWATER DATA NOT AVAILABLE FOR TEMPORARY AND CPT BORINGS.
3. MEASUREMENTS RECORDED BY GREDELL ENGINEERING RESOURCES AND REITZ AND JENS FIELD PERSONNEL.
4. MAP REPRESENTATIVE OF GROUNDWATER CONDITIONS OCCURRING ON DATE OF MEASUREMENT.
5. USE OF SMALL CONTOUR INTERVAL (0.5 FT.) EXAGGERATES APPARENT "SLOPE" OF WATER TABLE SURFACE.
6. RANGE OF GROUNDWATER FLOW GRADIENT AS DETERMINED BY SURFER® SOFTWARE 0.000006952 FT./FT. TO 0.003517 FT./FT.
7. MISSOURI RIVER GAUGE ELEVATION = 468.2 FT. ON DATE OF WATER LEVEL MONITORING AS MEASURED AT LABADIE POWER PLANT. THIS REPRESENTS AN APPROXIMATE 13.5 FT. RISE IN RIVER ELEVATION BEGINNING ON MARCH 8, 2010.
8. GROUNDWATER ELEVATION READING FOR P-132 IS SUSPECTED MEASUREMENT ERROR. VALUE NOT CONSIDERED REPRESENTATIVE OF TRUE GROUNDWATER CONDITIONS (SEE TABLE 3).

SURVEY MONUMENTS

MONUMENT ID	NORTHING	EASTING	ELEVATION
AUELBE-001	990484.82	726569.81	467.19
AUELBE-002	996166.50	727588.30	470.70
AUELBE-003	989921.39	728508.32	467.59
AUELBE-004	994487.78	729353.29	467.02
AUELBE-005	991746.97	731438.29	462.78
AUELBE-006	996728.98	731621.69	467.67

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DRAWN 020411 W.J.A. (GER)	FIGURE 21 DETAILED SITE INVESTIGATION PROPOSED UTILITY WASTE DISPOSAL AREA WATER TABLE SURFACE MAP - MARCH 16, 2010	
CHKD. M.C.C. (GER)		
SUPV. M.C.C. (GER)		
APPD. M.C.C. (GER)	LOCATION 001004	LABADIE PLANT — CLASS 02010
Ameren ST. LOUIS, MISSOURI	FIGS (18) THRU (29)(33).DWG	REV.

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SCALE: 1" = 300'

0 150 300 600

MISSOURI RIVER ELEVATION:
April 13, 2010
462.4 ft Ameren Missouri - Labadie Power Plant Gauging Station

LEGEND

- 2007 PIEZOMETER
- 2" PIEZOMETER
- 4" PIEZOMETER
- SURVEY MONUMENT
- 459.23 GROUNDWATER ELEVATION (FT.)
- GROUNDWATER FLOW DIRECTION
- 465 EXISTING GROUND CONTOURS (C.I. = 1 FT.)
- 460.00 GROUNDWATER CONTOUR NOTE: CONTOUR INTERVAL (C.I.) = 0.5 FT. (DASHED WHERE INFERRED)
- PROPOSED UTILITY WASTE DISPOSAL AREA FOOTPRINT

NOTES

1. MAP DEVELOPED BASED ON CONTOURS GENERATED BY SURFER® SOFTWARE.
2. GROUNDWATER DATA NOT AVAILABLE FOR TEMPORARY AND CPT BORINGS.
3. MEASUREMENTS RECORDED BY GREDELL ENGINEERING RESOURCES AND REITZ AND JENS FIELD PERSONNEL.
4. MAP REPRESENTATIVE OF GROUNDWATER CONDITIONS OCCURRING ON DATE OF MEASUREMENT.
5. USE OF SMALL CONTOUR INTERVAL (0.5 FT.) EXAGGERATES APPARENT "SLOPE" OF WATER TABLE SURFACE.
6. RANGE OF GROUNDWATER FLOW GRADIENT AS DETERMINED BY SURFER® SOFTWARE 0.000009415 FT./FT. TO 0.0006961 FT./FT.
7. MISSOURI RIVER GAUGE ELEVATION = 462.4 FT. ON DATE OF WATER LEVEL MONITORING AS MEASURED AT LABADIE POWER PLANT. THIS REPRESENTS AN APPROXIMATE 4.3 FT. DECREASE IN RIVER ELEVATION BEGINNING ON APRIL 13, 2010.
8. GROUNDWATER ELEVATION READING FOR P-35 IS SUSPECTED MEASUREMENT ERROR. VALUE NOT CONSIDERED REPRESENTATIVE OF TRUE GROUNDWATER CONDITIONS (SEE TABLE 3).

SURVEY MONUMENTS

MONUMENT ID	NORTHING	EASTING	ELEVATION
AUELBE-001	990484.82	726569.81	467.19
AUELBE-002	996166.50	727588.30	470.70
AUELBE-003	989921.39	728508.32	467.59
AUELBE-004	994487.78	729353.29	467.02
AUELBE-005	991746.97	731438.29	462.78
AUELBE-006	996728.98	731621.69	467.67

Missouri State Plane Coordinate System Datum:
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DRAWN 020411	W.J.A. (GER)
CHKD.	M.C.C. (GER)
SUPV.	M.C.C. (GER)
APPD.	M.C.C. (GER)

FIGURE 22
DETAILED SITE INVESTIGATION
PROPOSED UTILITY WASTE DISPOSAL AREA
WATER TABLE SURFACE MAP - APRIL 13, 2010

LOCATION		CLASS
001004	LABADIE PLANT	02010

Ameren MISSOURI ST. LOUIS, MISSOURI

FIGS (18) THRU (29)(33).DWG

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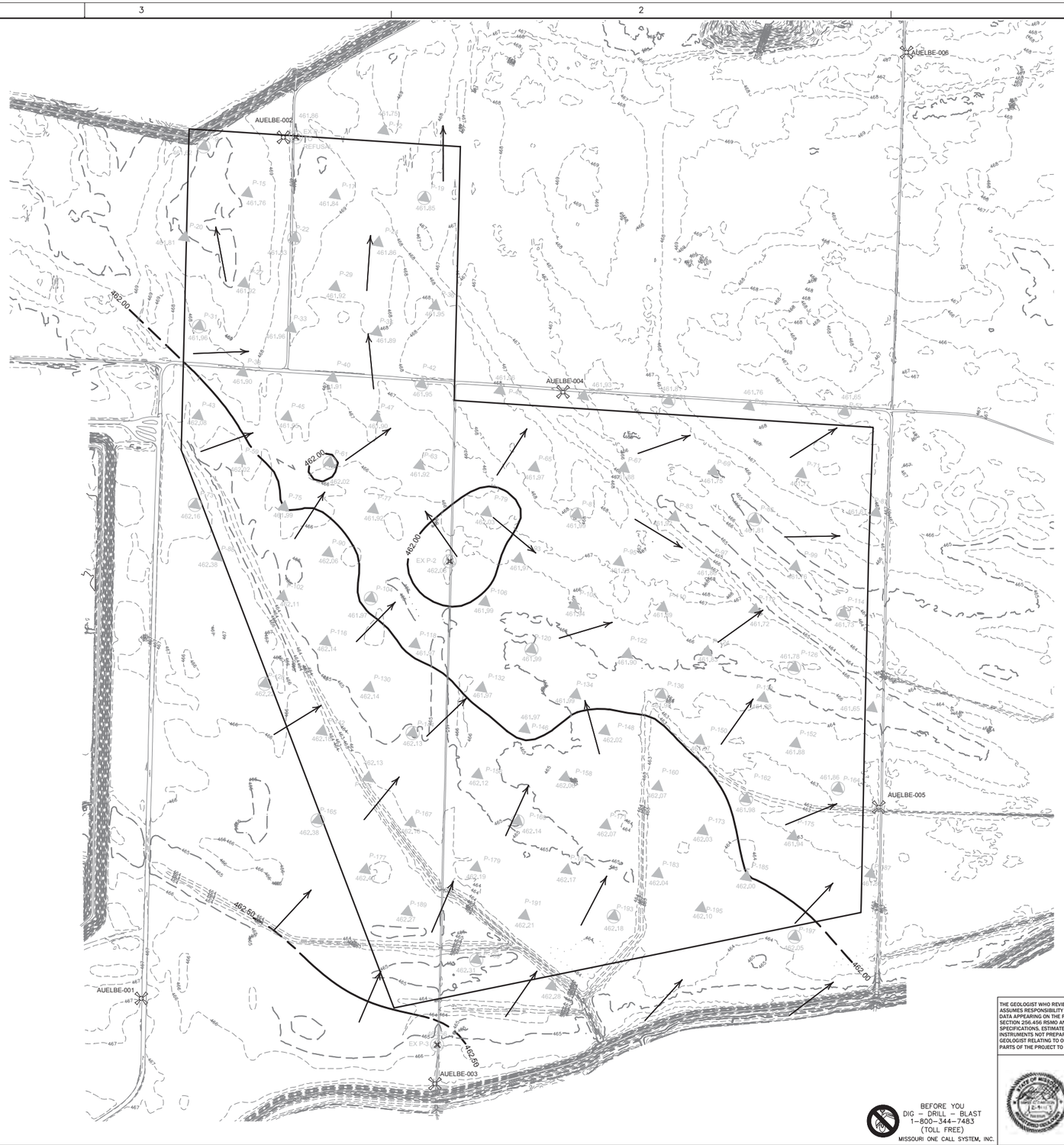

N

SCALE: 1" = 300'

0 150 300 600

MISSOURI RIVER ELEVATION:
May 11, 2010
460.7 ft Ameren Missouri - Labadie Power Plant Gauging Station

LEGEND

- 2007 PIEZOMETER
- 2" PIEZOMETER
- 4" PIEZOMETER
- SURVEY MONUMENT
- 459.23 GROUNDWATER ELEVATION (FT.)
- GROUNDWATER FLOW DIRECTION
- EXISTING GROUND CONTOURS (C.I. = 1 FT.)
- 460.00 GROUNDWATER CONTOUR NOTE: CONTOUR INTERVAL (C.I.) = 0.5 FT. (DASHED WHERE INFERRED)
- PROPOSED UTILITY WASTE DISPOSAL AREA FOOTPRINT

NOTES

1. MAP DEVELOPED BASED ON CONTOURS GENERATED BY SURFER® SOFTWARE.
2. GROUNDWATER DATA NOT AVAILABLE FOR TEMPORARY AND CPT BORINGS.
3. MEASUREMENTS RECORDED BY GREDELL ENGINEERING RESOURCES FIELD PERSONNEL.
4. MAP REPRESENTATIVE OF GROUNDWATER CONDITIONS OCCURRING ON DATE OF MEASUREMENT.
5. USE OF SMALL CONTOUR INTERVAL (0.5 FT.) EXAGGERATES APPARENT "SLOPE" OF WATER TABLE SURFACE.
6. RANGE OF GROUNDWATER FLOW GRADIENT AS DETERMINED BY SURFER® SOFTWARE 0.00000529 FT./FT. TO 0.0007999 FT./FT.
7. MISSOURI RIVER GAUGE ELEVATION = 460.7 FT. ON DATE OF WATER LEVEL MONITORING AS MEASURED AT LABADIE POWER PLANT. THIS REPRESENTS AN APPROXIMATE 8.7 FT. DECREASE IN RIVER ELEVATION BEGINNING ON APRIL 28, 2010.

SURVEY MONUMENTS

MONUMENT ID	NORTHING	EASTING	ELEVATION
AUELBE-001	990484.82	726569.81	467.19
AUELBE-002	996166.50	727588.30	470.70
AUELBE-003	989921.39	728508.32	467.59
AUELBE-004	994487.78	729353.29	467.02
AUELBE-005	991746.97	731438.29	462.78
AUELBE-006	996728.98	731621.69	467.67

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DRAWN 020411 W.J.A. (GER)	FIGURE 23 DETAILED SITE INVESTIGATION PROPOSED UTILITY WASTE DISPOSAL AREA WATER TABLE SURFACE MAP - MAY 11, 2010		
CHKD. M.C.C. (GER)			
SUPV. M.C.C. (GER)			
APPD. M.C.C. (GER)	LOCATION 001004	LABADIE PLANT	CLASS 02010
Ameren ST. LOUIS, MISSOURI	FIGS (18) THRU (29)(33).DWG		REV.

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SCALE: 1" = 300'

0 150 300 600

MISSOURI RIVER ELEVATION:
June 8, 2010
465.9 ft Ameren Missouri - Labadie Power Plant Gauging Station

LEGEND

- 2007 PIEZOMETER
- 2" PIEZOMETER
- 4" PIEZOMETER
- SURVEY MONUMENT
- 459.23 GROUNDWATER ELEVATION (FT.) (★SEE NOTE 9)
- GROUNDWATER FLOW DIRECTION
- 465 EXISTING GROUND CONTOURS (C.I. = 1 FT.)
- 460.00 GROUNDWATER CONTOUR NOTE: CONTOUR INTERVAL (C.I.) = 0.5 FT. (DASHED WHERE INFERRED)
- PROPOSED UTILITY WASTE DISPOSAL AREA FOOTPRINT

NOTES

1. MAP DEVELOPED BASED ON CONTOURS GENERATED BY SURFER® SOFTWARE.
2. GROUNDWATER DATA NOT AVAILABLE FOR TEMPORARY AND CPT BORINGS.
3. MEASUREMENTS RECORDED BY GREDELL ENGINEERING RESOURCES FIELD PERSONNEL.
4. MAP REPRESENTATIVE OF GROUNDWATER CONDITIONS OCCURRING ON DATE OF MEASUREMENT.
5. USE OF SMALL CONTOUR INTERVAL (0.5 FT.) EXAGGERATES APPARENT "SLOPE" OF WATER TABLE SURFACE.
6. RANGE OF GROUNDWATER FLOW GRADIENT AS DETERMINED BY SURFER® SOFTWARE 0.00003298 FT./FT. TO 0.0009193 FT./FT.
7. MISSOURI RIVER GAUGE ELEVATION = 465.9 FT. ON DATE OF WATER LEVEL MONITORING AS MEASURED AT LABADIE POWER PLANT. THIS REPRESENTS AN APPROXIMATE 1.0 FT. DECREASE IN RIVER ELEVATION BEGINNING ON JUNE 6, 2010.
8. NO MEASUREMENT. PIEZOMETER COULD NOT BE ACCESSED.
9. GROUNDWATER ELEVATIONS ABOVE APPARENT GROUND SURFACE ELEVATIONS IN P-102, P-150, P-155, P-165, P-167, AND P-177 (SEE ALSO TABLE 3).

SURVEY MONUMENTS

MONUMENT ID	NORTHING	EASTING	ELEVATION
AUELBE-001	990484.82	726569.81	467.19
AUELBE-002	996166.50	727588.30	470.70
AUELBE-003	989921.39	728508.32	467.59
AUELBE-004	994487.78	729353.29	467.02
AUELBE-005	991746.97	731438.29	462.78
AUELBE-006	996728.98	731621.69	467.67

Missouri State Plane Coordinate System Datum:
Horizontal Datum NAD 1983;
Vertical Datum NAVD 1988

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Jefferson City, Missouri 65101 Facsimile (573) 635-9679

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DRAWN 020411 W.J.A. (GER)	FIGURE 24 DETAILED SITE INVESTIGATION PROPOSED UTILITY WASTE DISPOSAL AREA WATER TABLE SURFACE MAP - JUNE 8, 2010		
CHKD. M.C.C. (GER)			
SUPV. M.C.C. (GER)			
APPD. M.C.C. (GER)	LOCATION 001004	LABADIE PLANT	CLASS 02010
Ameren ST. LOUIS, MISSOURI	FIGS (18) THRU (29)(33).DWG		REV.

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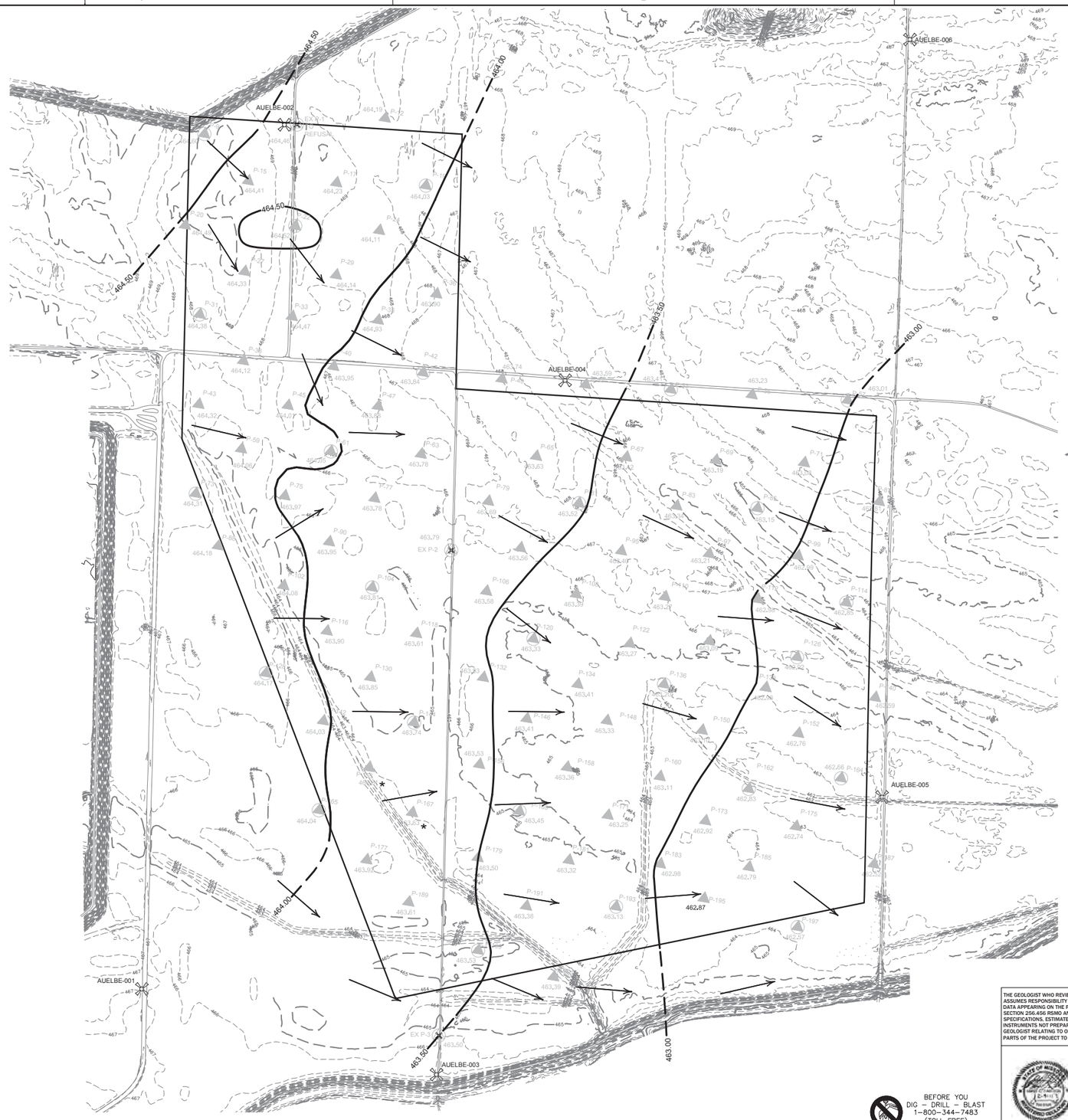

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SCALE: 1" = 300'

0 150 300 600

MISSOURI RIVER ELEVATION:
July 7, 2010
465.0 ft Ameren Missouri - Labadie Power Plant Gauging Station

LEGEND

- 2007 PIEZOMETER
- 2" PIEZOMETER
- 4" PIEZOMETER
- SURVEY MONUMENT
- 459.23 GROUNDWATER ELEVATION (FT.) (★SEE NOTE 8)
- GROUNDWATER FLOW DIRECTION
- 465 EXISTING GROUND CONTOURS (C.I. = 1 FT.)
- 460.00 GROUNDWATER CONTOUR NOTE: CONTOUR INTERVAL (C.I.) = 0.5 FT. (DASHED WHERE INFERRED)
- PROPOSED UTILITY WASTE DISPOSAL AREA FOOTPRINT

NOTES

1. MAP DEVELOPED BASED ON CONTOURS GENERATED BY SURFER® SOFTWARE.
2. GROUNDWATER DATA NOT AVAILABLE FOR TEMPORARY AND CPT BORINGS.
3. MEASUREMENTS RECORDED BY GREDELL ENGINEERING RESOURCES AND REITZ AND JENS FIELD PERSONNEL.
4. MAP REPRESENTATIVE OF GROUNDWATER CONDITIONS OCCURRING ON DATE OF MEASUREMENT.
5. USE OF SMALL CONTOUR INTERVAL (0.5 FT.) EXAGGERATES APPARENT "SLOPE" OF WATER TABLE SURFACE.
6. RANGE OF GROUNDWATER FLOW GRADIENT AS DETERMINED BY SURFER® SOFTWARE 0.00001928 FT./FT. TO 0.001323 FT./FT.
7. MISSOURI RIVER GAUGE ELEVATION = 465.0 FT. ON DATE OF WATER LEVEL MONITORING AS MEASURED AT LABADIE POWER PLANT. THIS REPRESENTS AN APPROXIMATE 3.9 FT. DECREASE IN RIVER ELEVATION BEGINNING ON JUNE 30, 2010.
8. GROUNDWATER ELEVATIONS ABOVE APPARENT GROUND SURFACE ELEVATIONS IN P-155 AND P-167 (SEE ALSO TABLE 3).

SURVEY MONUMENTS

MONUMENT ID	NORTHING	EASTING	ELEVATION
AUELBE-001	990484.82	726569.81	467.19
AUELBE-002	996166.50	727588.30	470.70
AUELBE-003	989921.39	728508.32	467.59
AUELBE-004	994487.78	729353.29	467.02
AUELBE-005	991746.97	731438.29	462.78
AUELBE-006	996728.98	731621.69	467.67

Missouri State Plane Coordinate System Datum:
Horizontal Datum NAD 1983;
Vertical Datum NAVD 1988

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DRAWN 020411 W.J.A. (GER)	FIGURE 25 DETAILED SITE INVESTIGATION PROPOSED UTILITY WASTE DISPOSAL AREA WATER TABLE SURFACE MAP - JULY 7, 2010		
CHKD. M.C.C. (GER)			
SUPV. M.C.C. (GER)			
APPD. M.C.C. (GER)	LOCATION 001004	LABADIE PLANT	CLASS 02010
Ameren ST. LOUIS, MISSOURI	FIGS (18) THRU (29)(33).DWG		REV.

H:\Revit CAD\Rev Labadie\Rev LABADIE CAD\Groundwater\FIGS (18) THRU (29)(33).DWG, 8.5"X11.0"(1:48 PM, 2/4/11) PDF.plt 8

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SCALE: 1" = 300'

0 150 300 600

MISSOURI RIVER ELEVATION:
August 5, 2010
462.9 ft Ameren Missouri - Labadie Power Plant Gauging Station

LEGEND

- 2007 PIEZOMETER
- 2" PIEZOMETER
- 4" PIEZOMETER
- SURVEY MONUMENT
- 459.23 GROUNDWATER ELEVATION (FT.)
- GROUNDWATER FLOW DIRECTION
- EXISTING GROUND CONTOURS (C.I. = 1 FT.)
- 460.00 GROUNDWATER CONTOUR NOTE: CONTOUR INTERVAL (C.I.) = 0.5 FT. (DASHED WHERE INFERRED)
- PROPOSED UTILITY WASTE DISPOSAL AREA FOOTPRINT

NOTES

1. MAP DEVELOPED BASED ON CONTOURS GENERATED BY SURFER® SOFTWARE.
2. GROUNDWATER DATA NOT AVAILABLE FOR TEMPORARY AND CPT BORINGS.
3. MEASUREMENTS RECORDED BY GREDELL ENGINEERING RESOURCES AND REITZ AND JENS FIELD PERSONNEL.
4. MAP REPRESENTATIVE OF GROUNDWATER CONDITIONS OCCURRING ON DATE OF MEASUREMENT.
5. USE OF SMALL CONTOUR INTERVAL (0.5 FT.) EXAGGERATES APPARENT "SLOPE" OF WATER TABLE SURFACE.
6. RANGE OF GROUNDWATER FLOW GRADIENT AS DETERMINED BY SURFER® SOFTWARE 0.000006144 FT./FT. TO 0.001152 FT./FT.
7. MISSOURI RIVER GAUGE ELEVATION = 462.9 FT. ON DATE OF WATER LEVEL MONITORING AS MEASURED AT LABADIE POWER PLANT. THIS REPRESENTS AN APPROXIMATE 2.5 FT. DECREASE IN RIVER ELEVATION BEGINNING ON AUGUST 1, 2010.

SURVEY MONUMENTS

MONUMENT ID	NORTHING	EASTING	ELEVATION
AUELBE-001	990484.82	726569.81	467.19
AUELBE-002	996166.50	727588.30	470.70
AUELBE-003	989921.39	728508.32	467.59
AUELBE-004	994487.78	729353.29	467.02
AUELBE-005	991746.97	731438.29	462.78
AUELBE-006	996728.98	731621.69	467.67

Missouri State Plane Coordinate System Datum:
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Vertical Datum NAVD 1988

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SUPV. M.C.C. (GER)
APPD. M.C.C. (GER)

FIGURE 26
DETAILED SITE INVESTIGATION
PROPOSED UTILITY WASTE DISPOSAL AREA
WATER TABLE SURFACE MAP - AUGUST 5, 2010

LOCATION 001004 | LABADIE PLANT | CLASS 02010

Ameren ST. LOUIS, MISSOURI | FIGS (18) THRU (29)(33).DWG | REV.

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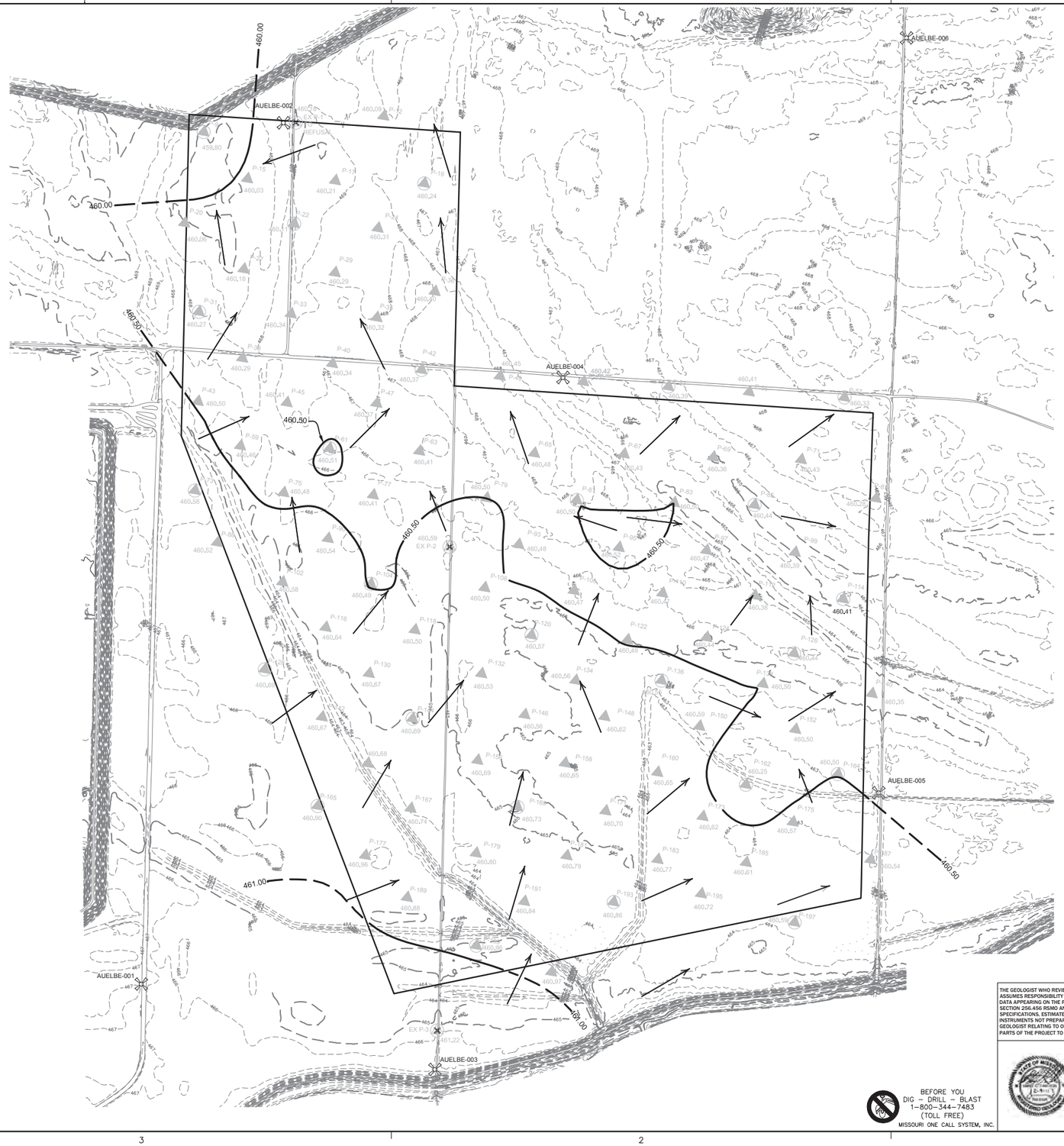

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SCALE: 1" = 300'

0 150 300 600

MISSOURI RIVER ELEVATION:
September 8, 2010
458.5 ft Ameren Missouri - Labadie Power Plant Gauging Station

LEGEND

- 2007 PIEZOMETER
- 2" PIEZOMETER
- 4" PIEZOMETER
- SURVEY MONUMENT
- 459.23 GROUNDWATER ELEVATION (FT.)
- GROUNDWATER FLOW DIRECTION
- EXISTING GROUND CONTOURS (C.I. = 1 FT.)
- 460.00 GROUNDWATER CONTOUR NOTE: CONTOUR INTERVAL (C.I.) = 0.5 FT. (DASHED WHERE INFERRED)
- PROPOSED UTILITY WASTE DISPOSAL AREA FOOTPRINT

NOTES:

1. MAP DEVELOPED BASED ON CONTOURS GENERATED BY SURFER® SOFTWARE.
2. GROUNDWATER DATA NOT AVAILABLE FOR TEMPORARY AND CPT BORINGS.
3. MEASUREMENTS RECORDED BY GREDELL ENGINEERING RESOURCES AND RIETZ AND JENS FIELD PERSONNEL.
4. MAP REPRESENTATIVE OF GROUNDWATER CONDITIONS OCCURRING ON DATE OF MEASUREMENT.
5. USE OF SMALL CONTOUR INTERVAL (0.5 FT.) EXAGGERATES APPARENT "SLOPE" OF WATER TABLE SURFACE.
6. RANGE OF GROUNDWATER FLOW GRADIENT AS DETERMINED BY SURFER® SOFTWARE 0.00000395 FT./FT. TO 0.001044 FT./FT.
7. MISSOURI RIVER GAUGE ELEVATION = 458.5 FT. ON DATE OF WATER LEVEL MONITORING AS MEASURED AT LABADIE POWER PLANT. THIS REPRESENTS AN APPROXIMATE 3.1 FT. DECREASE IN RIVER ELEVATION BEGINNING ON SEPTEMBER 4, 2010.

SURVEY MONUMENTS

MONUMENT ID	NORTHING	EASTING	ELEVATION
AUELBE-001	990484.82	726569.81	467.19
AUELBE-002	996166.50	727588.30	470.70
AUELBE-003	989921.39	728508.32	467.59
AUELBE-004	994487.78	729353.29	467.02
AUELBE-005	991746.97	731438.29	462.78
AUELBE-006	996728.98	731621.69	467.67

Missouri State Plane Coordinate System Datum:
Horizontal Datum NAD 1983;
Vertical Datum NAVD 1988

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DRAWN 020411 W.J.A. (GER)	FIGURE 27 DETAILED SITE INVESTIGATION PROPOSED UTILITY WASTE DISPOSAL AREA WATER TABLE SURFACE MAP - SEPTEMBER 8, 2010		
CHKD. M.C.C. (GER)			
SUPV. M.C.C. (GER)			
APPD. M.C.C. (GER)	LOCATION 001004	LABADIE PLANT	CLASS 02010
Ameren MISSOURI	ST. LOUIS, MISSOURI	FIGS (18) THRU (29)(33).DWG	REV.

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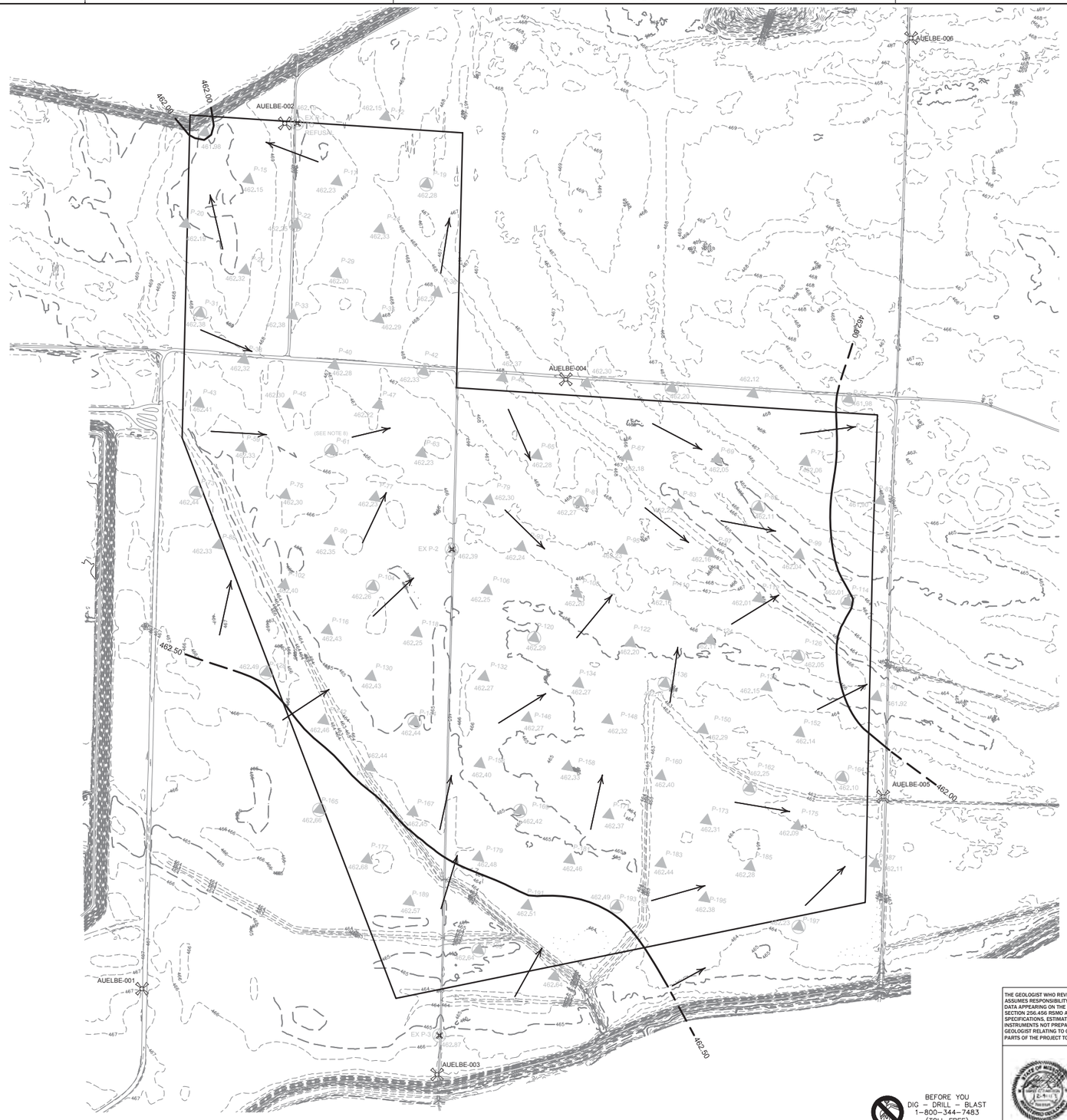

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SCALE: 1" = 300'

0 150 300 600

MISSOURI RIVER ELEVATION:
October 7, 2010
460.3 ft Ameren Missouri - Labadie Power Plant Gauging Station

LEGEND

- 2007 PIEZOMETER
- 2" PIEZOMETER
- 4" PIEZOMETER
- SURVEY MONUMENT
- 459.23 GROUNDWATER ELEVATION (FT.)
- GROUNDWATER FLOW DIRECTION
- EXISTING GROUND CONTOURS (C.I. = 1 FT.)
- 460.00 GROUNDWATER CONTOUR NOTE: CONTOUR INTERVAL (C.I.) = 0.5 FT. (DASHED WHERE INFERRED)
- PROPOSED UTILITY WASTE DISPOSAL AREA FOOTPRINT

NOTES:

1. MAP DEVELOPED BASED ON CONTOURS GENERATED BY SURFER® SOFTWARE.
2. GROUNDWATER DATA NOT AVAILABLE FOR TEMPORARY AND CPT BORINGS.
3. MEASUREMENTS RECORDED BY GREDELL ENGINEERING RESOURCES FIELD PERSONNEL.
4. MAP REPRESENTATIVE OF GROUNDWATER CONDITIONS OCCURRING ON DATE OF MEASUREMENT.
5. USE OF SMALL CONTOUR INTERVAL (0.5 FT.) EXAGGERATES APPARENT "SLOPE" OF WATER TABLE SURFACE.
6. RANGE OF GROUNDWATER FLOW GRADIENT AS DETERMINED BY SURFER® SOFTWARE 0.00002977 FT./FT. TO 0005534 FT./FT.
7. MISSOURI RIVER GAUGE ELEVATION = 460.3 FT. ON DATE OF WATER LEVEL MONITORING AS MEASURED AT LABADIE POWER PLANT. THIS REPRESENTS AN APPROXIMATE 8.5 FT. DECREASE IN RIVER ELEVATION BEGINNING ON SEPTEMBER 25, 2010.
8. GROUNDWATER ELEVATION READING FOR P-61 IS SUSPECTED MEASUREMENT ERROR. VALUE NOT CONSIDERED REPRESENTATIVE OF TRUE GROUNDWATER CONDITIONS (SEE TABLE 3).

SURVEY MONUMENTS

MONUMENT ID	NORTHING	EASTING	ELEVATION
AUELBE-001	990484.82	726569.81	467.19
AUELBE-002	996166.50	727588.30	470.70
AUELBE-003	989921.39	728508.32	467.59
AUELBE-004	994487.78	729353.29	467.02
AUELBE-005	991746.97	731438.29	462.78
AUELBE-006	996728.98	731621.69	467.67

Missouri State Plane Coordinate System Datum:
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DRAWN 020411 W.J.A. (GER)	FIGURE 28
CHKD. M.C.C. (GER)	DETAILED SITE INVESTIGATION
SUPV. M.C.C. (GER)	PROPOSED UTILITY WASTE DISPOSAL AREA
APPD. M.C.C. (GER)	WATER TABLE SURFACE MAP - OCTOBER 7, 2010
LOCATION 001004	LABADIE PLANT — CLASS 02010
Ameren Missouri ST. LOUIS, MISSOURI	FIGS (18) THRU (29)(33).DWG — REV.

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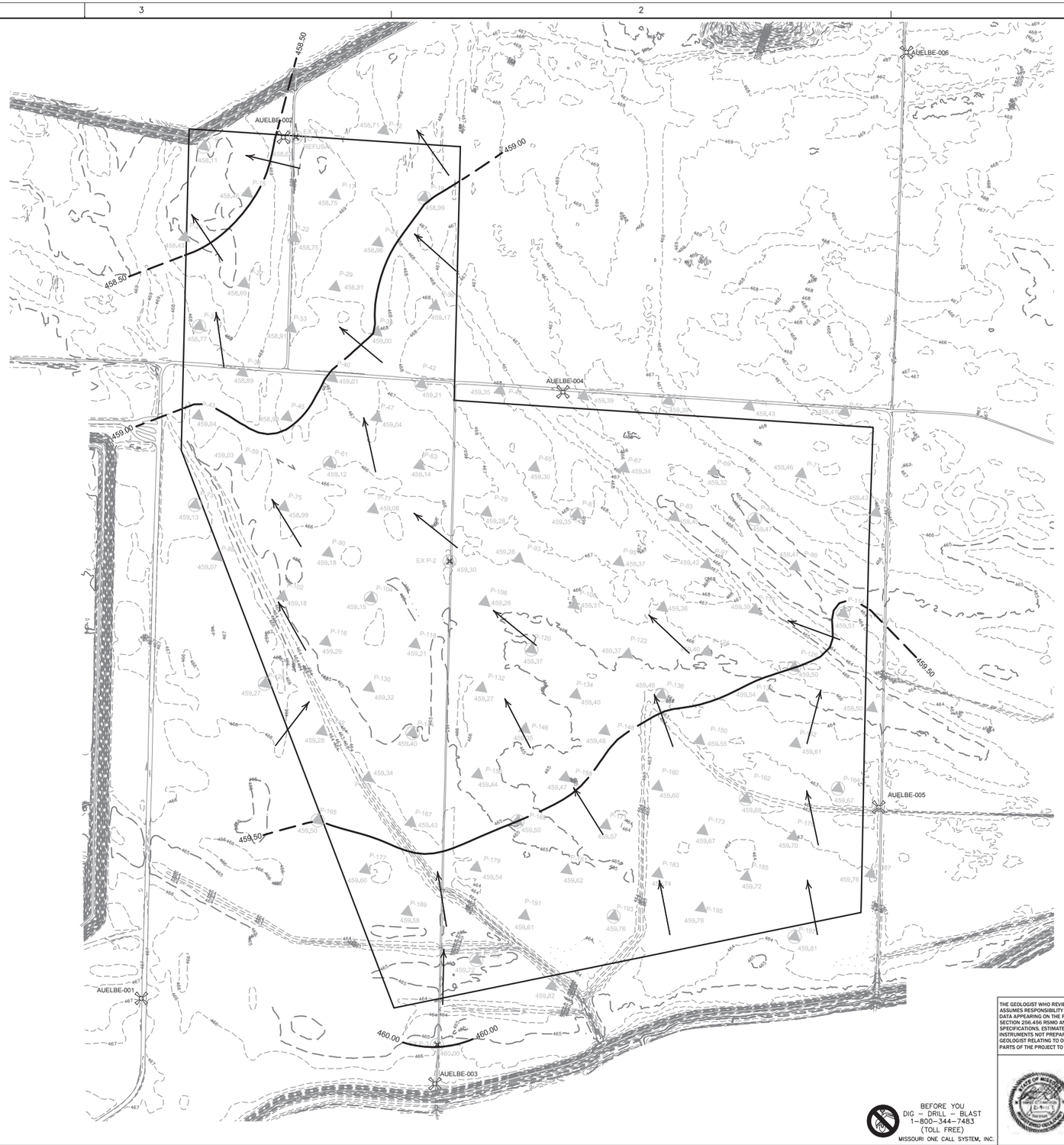

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SCALE: 1" = 300'

0 150 300 600

MISSOURI RIVER ELEVATION:
November 4, 2010
456.8 ft Ameren Missouri - Labadie Power Plant Gauging Station

LEGEND

- 2007 PIEZOMETER
- 2" PIEZOMETER
- 4" PIEZOMETER
- SURVEY MONUMENT
- 459.23 GROUNDWATER ELEVATION (FT.)
- GROUNDWATER FLOW DIRECTION
- 465 EXISTING GROUND CONTOURS (C.I. = 1 FT.)
- 460.00 GROUNDWATER CONTOUR NOTE: CONTOUR INTERVAL (C.I.) = 0.5 FT. (DASHED WHERE INFERRED)
- PROPOSED UTILITY WASTE DISPOSAL AREA FOOTPRINT

NOTES:

1. MAP DEVELOPED BASED ON CONTOURS GENERATED BY SURFER® SOFTWARE.
2. GROUNDWATER DATA NOT AVAILABLE FOR TEMPORARY AND CPT BORINGS.
3. MEASUREMENTS RECORDED BY GREDELL ENGINEERING RESOURCES FIELD PERSONNEL.
4. MAP REPRESENTATIVE OF GROUNDWATER CONDITIONS OCCURRING ON DATE OF MEASUREMENT.
5. USE OF SMALL CONTOUR INTERVAL (0.5 FT.) EXAGGERATES APPARENT "SLOPE" OF WATER TABLE SURFACE.
6. RANGE OF GROUNDWATER FLOW GRADIENT AS DETERMINED BY SURFER® SOFTWARE 0.00000199 FT./FT. TO 0.0008934 FT./FT.
7. MISSOURI RIVER GAUGE ELEVATION = 456.8 FT. ON DATE OF WATER LEVEL MONITORING AS MEASURED AT LABADIE POWER PLANT. THIS REPRESENTS AN APPROXIMATE 3.5 FT. DECREASE IN RIVER ELEVATION BEGINNING ON OCTOBER 7, 2010.

SURVEY MONUMENTS

MONUMENT ID	NORTHING	EASTING	ELEVATION
AUELBE-001	990484.82	726569.81	467.19
AUELBE-002	996166.50	727588.30	470.70
AUELBE-003	989921.39	728508.32	467.59
AUELBE-004	994487.78	729353.29	467.02
AUELBE-005	991746.97	731438.29	462.78
AUELBE-006	996728.98	731621.69	467.67

Missouri State Plane Coordinate System Datum:
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DRAWN 020411 W.J.A. (GER)	FIGURE 29 DETAILED SITE INVESTIGATION PROPOSED UTILITY WASTE DISPOSAL AREA WATER TABLE SURFACE MAP - NOVEMBER 4, 2010		
CHKD. M.C.C. (GER)			
SUPV. M.C.C. (GER)			
APPD. M.C.C. (GER)	LOCATION 001004	LABADIE PLANT	CLASS 02010
Ameren ST. LOUIS, MISSOURI	FIGS (18) THRU (29)(33).DWG		REV.

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M:\Jobs\GRDRes\AMEREN\Fall LABADIE\DWG\Groundwater\FIGS (18) THRU (29)(33).DWG, 8.5 X 29.3 LO #1 PM, Wed, Fri, Phil Lyn

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LEGEND

- 2" MONITORING WELL
- SURVEY MONUMENT
- 453.45 GROUNDWATER ELEVATION (FT.)
- GROUNDWATER FLOW DIRECTION REFERENCE VECTOR. SIZE OF ARROW PROPORTIONAL TO MAGNITUDE OF GROUNDWATER FLOW GRADIENT.
- EXISTING GROUND CONTOURS (C.I. = 1 FT.)
- 454 GROUNDWATER CONTOUR NOTE: CONTOUR INTERVAL (C.I.) = 0.5 FT. (DASHED WHERE INFERRED)
- PROPOSED UTILITY WASTE DISPOSAL AREA FOOTPRINT

SURVEY MONUMENTS

MONUMENT ID	NORTHING	EASTING	ELEVATION
AUELBE-001	990484.82	726569.81	467.19
AUELBE-002	996166.50	727588.30	470.70
AUELBE-003	989921.39	728508.32	467.59
AUELBE-004	994487.78	729353.29	467.02
AUELBE-005	991746.97	731438.29	462.78
AUELBE-006	996729.00	731621.70	467.67

Missouri State Plane Coordinate System Datum:
Horizontal Datum NAD 1983;
Vertical Datum NAVD 1988

NOTES

1. MAP DEVELOPED BASED ON CONTOURS GENERATED BY SURFER® SOFTWARE.
2. MEASUREMENTS RECORDED BY GREDELL ENGINEERING RESOURCES, INC. FIELD PERSONNEL ON APRIL 16 AND 17, 2013
3. MAP REPRESENTATIVE OF GROUNDWATER CONDITIONS OCCURRING ON DATE OF MEASUREMENT.
4. USE OF SMALL CONTOUR INTERVAL (0.5 FT.) EXAGGERATES APPARENT "SLOPE" OF WATER TABLE SURFACE.
5. RANGE OF GROUNDWATER FLOW GRADIENT AS DETERMINED BY SURFER® SOFTWARE 9.65×10^{-6} FT./FT. TO 7.56×10^{-3} FT./FT.

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(TOLL FREE)
MISSOURI ONE CALL SYSTEM, INC.

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REITZ & JENS, INC. CONSULTING ENGINEERS
1005 CORPORATE SQUARE DRIVE
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GREDELL Engineering Resources, Inc.
ENVIRONMENTAL ENGINEERING
LAND AIR WATER
1000 East 45th Street, Jefferson City, Missouri 65101
Telephone: (573) 635-6570
Facsimile: (573) 635-6573

PREPARED FOR AMEREN MISSOURI

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

FIGURE 1
1st BACKGROUND SAMPLING EVENT - APRIL 2013
WATER TABLE SURFACE CONTOUR MAP
PROPOSED UTILITY WASTE LANDFILL

LOCATION		CLASS
001009	LABADIE ENERGY CENTER	02010

AMEREN MISSOURI — ST. LOUIS, MISSOURI | MAY 2013 | REV. 0

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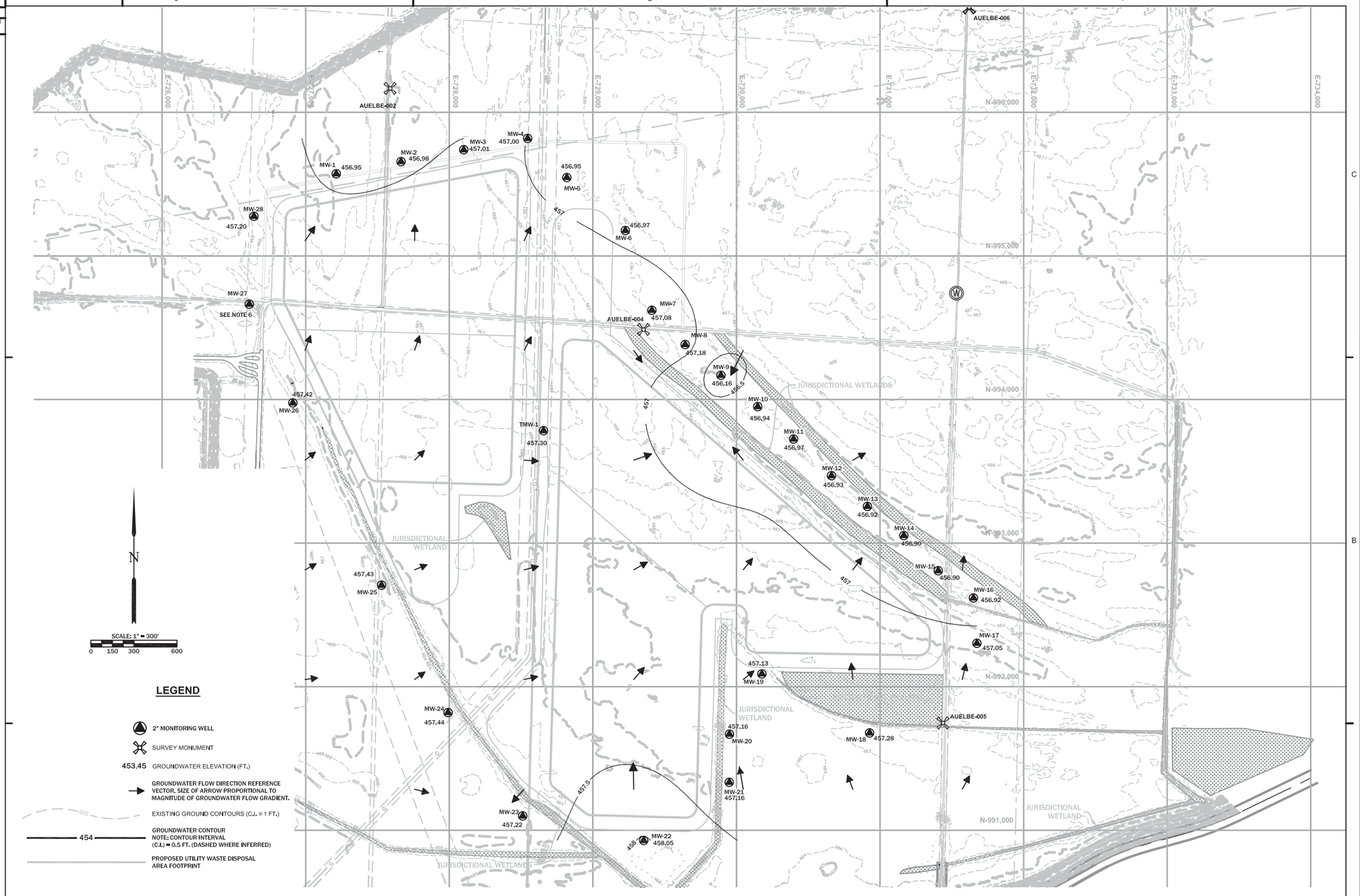
REVISIONS		
REV.	W.O.	SYM



N

SCALE: 1" = 300'

0 150 300 600

LEGEND

- 2" MONITORING WELL
- SURVEY MONUMENT
- 453.45 GROUNDWATER ELEVATION (FT.)
- GROUNDWATER FLOW DIRECTION REFERENCE VECTOR, SIZE OF ARROW PROPORTIONAL TO MAGNITUDE OF GROUNDWATER FLOW GRADIENT.
- EXISTING GROUND CONTOURS (C.I. = 1 FT.)
- 454 GROUNDWATER CONTOUR NOTE: CONTOUR INTERVAL (C.I.) = 0.5 FT. (DASHED WHERE INFERRED)
- PROPOSED UTILITY WASTE DISPOSAL AREA FOOTPRINT

SURVEY MONUMENTS

MONUMENT ID	NORTHING	EASTING	ELEVATION
AUELBE-001	990484.82	726569.81	467.19
AUELBE-002	996166.50	727588.30	470.70
AUELBE-003	989921.39	728508.32	467.59
AUELBE-004	994487.78	729353.29	467.02
AUELBE-005	991746.97	731438.29	462.78
AUELBE-006	996729.00	731621.70	467.67

Missouri State Plane Coordinate System Datum:
Horizontal Datum NAD 1983;
Vertical Datum NAVD 1988

NOTES

1. MAP DEVELOPED BASED ON CONTOURS GENERATED BY SURFER® SOFTWARE.
2. MEASUREMENTS RECORDED BY GREDELL ENGINEERING RESOURCES, INC. FIELD PERSONNEL ON AUGUST 19, 20, AND 21, 2013
3. MAP REPRESENTATIVE OF GROUNDWATER CONDITIONS OCCURRING ON DATE OF MEASUREMENTS.
4. USE OF SMALL CONTOUR INTERVAL (0.5 FT.) EXAGGERATES APPARENT "SLOPE" OF WATER TABLE SURFACE.
5. RANGE OF GROUNDWATER FLOW GRADIENT AS DETERMINED BY SURFER® SOFTWARE 1.57×10^{-6} FT./FT. TO 3.00×10^{-3} FT./FT.
6. GROUNDWATER ELEVATION READING FOR MW-27 IS SUSPECTED MEASUREMENT ERROR, VALUE NOT CONSIDERED REPRESENTATIVE OF TRUE GROUNDWATER CONDITIONS (SEE TABLE 2).

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REITZ & JENS, INC. CONSULTING ENGINEERS
3105 CORPORATE SQUARE DRIVE
ST. LOUIS, MISSOURI 63132
314.993.4132 (VOICE) 314.993.4177 (fax)

GREDELL Engineering Resources, Inc.
ENVIRONMENTAL ENGINEERING
LAND ABI WATER
1005 East High Street Telephone (573) 659-9078
Jefferson City, Missouri 65101 Facsimile (573) 659-9079

PREPARED FOR AMEREN MISSOURI

DRAWN M.J.W. (G.E.R.)	FIGURE 1	
CHKD. M.C.C. (G.E.R.)	2nd BACKGROUND SAMPLING EVENT - AUGUST 2013	
SUPV. M.C.C. (G.E.R.)	WATER TABLE SURFACE CONTOUR MAP	
APPD. T.A.D. (G.E.R.)	PROPOSED UTILITY WASTE LANDFILL	
LOCATION 001009	LABADIE ENERGY CENTER	CLASS 02010
AMEREN MISSOURI	ST. LOUIS, MISSOURI	SEPTEMBER 2013
		REV. 0

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REVISIONS		
REV.	W.O.	SYM

LEGEND

- 2" MONITORING WELL
- SURVEY MONUMENT
- 453.45 GROUNDWATER ELEVATION (FT.)
- GROUNDWATER FLOW DIRECTION REFERENCE VECTOR. SIZE OF ARROW PROPORTIONAL TO MAGNITUDE OF GROUNDWATER FLOW GRADIENT.
- EXISTING GROUND CONTOURS (C.I. = 1 FT.)
- 453 GROUNDWATER CONTOUR NOTE: CONTOUR INTERVAL (C.I.) = 0.5 FT. (DASHED WHERE INFERRED)
- PROPOSED UTILITY WASTE DISPOSAL AREA FOOTPRINT

SURVEY MONUMENTS

Missouri State Plane Coordinate System Datum:
Horizontal Datum NAD 1983;
Vertical Datum NAVD 1988

NOTES

1. MAP DEVELOPED BASED ON CONTOURS GENERATED BY SURFER® SOFTWARE.
2. MEASUREMENTS RECORDED BY GREDELL ENGINEERING RESOURCES, INC. FIELD PERSONNEL ON NOVEMBER 19 AND 20, 2013.
3. MAP REPRESENTATIVE OF GROUNDWATER CONDITIONS OCCURRING ON DATE OF MEASUREMENTS.
4. USE OF SMALL CONTOUR INTERVAL (0.5 FT.) EXAGGERATES APPARENT "SLOPE" OF WATER TABLE SURFACE.
5. RANGE OF GROUNDWATER FLOW GRADIENT AS DETERMINED BY SURFER® SOFTWARE 3.11×10^{-5} FT./FT. TO 6.38×10^{-4} FT./FT.

CALL BEFORE YOU DIG - DRILL - BLAST
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(TOLL FREE)
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REITZ & JENS, INC. ENGINEERING CONSULTANTS 13408 CORPORATE SQUARE DRIVE ST. LOUIS, MISSOURI 63133 314.993.4133 (voice) 314.993.4177 (fax)

GREDELL Engineering Resources, Inc. ENVIRONMENTAL ENGINEERING

PREPARED FOR AMEREN

DRAWN	A.J.K. (G.E.R.)
CHKD.	T.A.D. (G.E.R.)
SUPV.	T.R.O. (G.E.R.)
APVD.	M.C.C. (G.E.R.)

FIGURE 1
3rd BACKGROUND SAMPLING EVENT - NOVEMBER 2013
WATER TABLE SURFACE CONTOUR MAP
PROPOSED UTILITY WASTE LANDFILL

LOCATION		CLASS
001009	LABADIE ENERGY CENTER	02010
AMEREN	ST. LOUIS, MISSOURI	DECEMBER 2013

REV. 0

M:\Share\CADDFiles\AMEREN-UE\LABADIE\GWMonitoring\GROUNDWATER 2013 NOVEMBER.dwg, SHEET 3, 12/13/2013 3:37:36 PM

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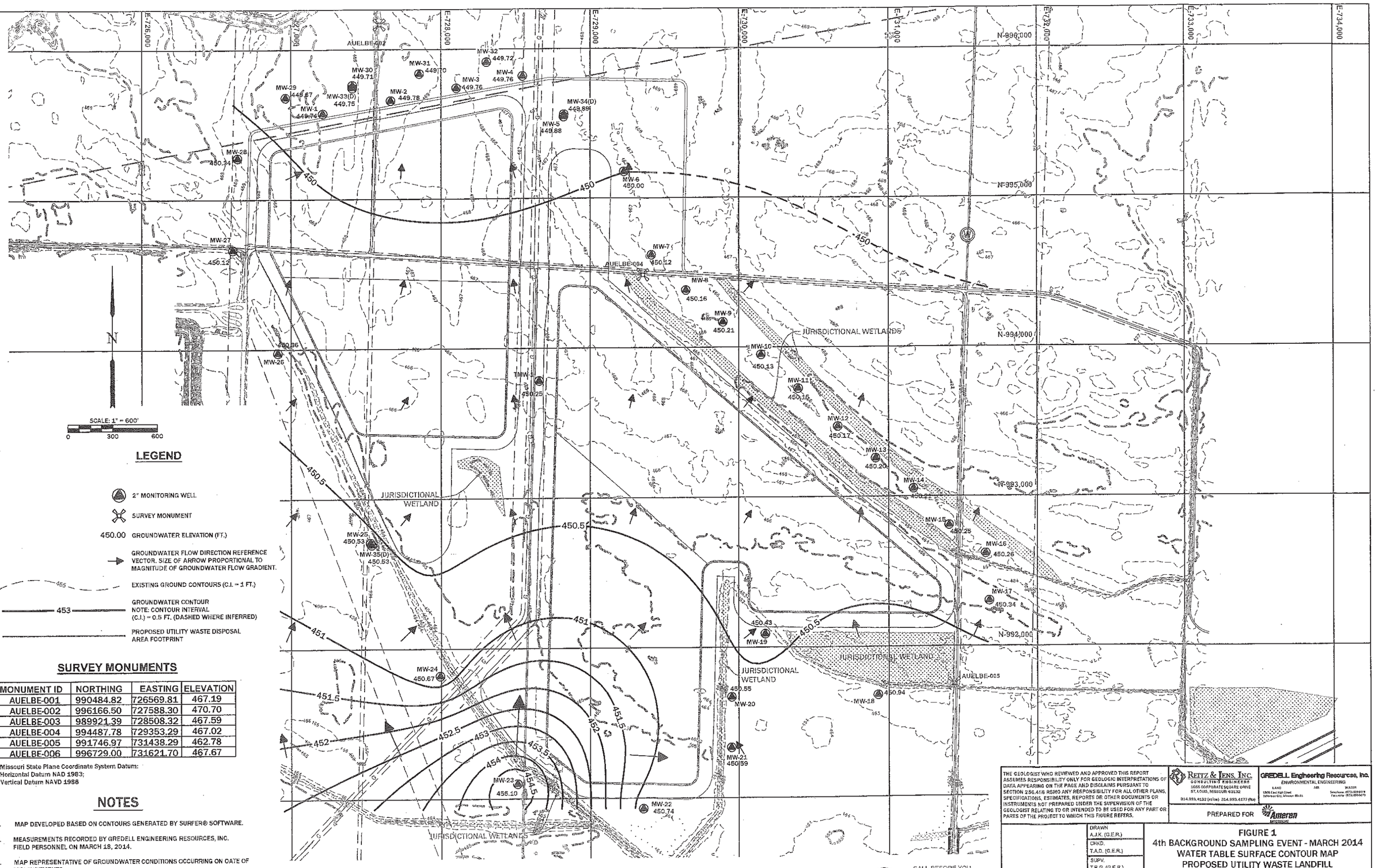
REVISIONS		
REV.	W.O.	SYM



LEGEND

- 2" MONITORING WELL
- SURVEY MONUMENT
- 450.00 GROUNDWATER ELEVATION (FT.)
- GROUNDWATER FLOW DIRECTION REFERENCE VECTOR. SIZE OF ARROW PROPORTIONAL TO MAGNITUDE OF GROUNDWATER FLOW GRADIENT.
- 465 EXISTING GROUND CONTOURS (C.I. = 1 FT.)
- 453 GROUNDWATER CONTOUR NOTE: CONTOUR INTERVAL (C.I.) = 0.5 FT. (DASHED WHERE INFERRED)
- PROPOSED UTILITY WASTE DISPOSAL AREA FOOTPRINT

SURVEY MONUMENTS

MONUMENT ID	NORTHING	EASTING	ELEVATION
AUELBE-001	990484.82	726569.81	467.19
AUELBE-002	996166.50	727588.30	470.70
AUELBE-003	989921.39	728508.32	467.59
AUELBE-004	994487.78	729353.29	467.02
AUELBE-005	991746.97	731438.29	462.78
AUELBE-006	996729.00	731621.70	467.67

Missouri State Plane Coordinate System Datum:
Horizontal Datum NAD 1983;
Vertical Datum NAVD 1988

NOTES

1. MAP DEVELOPED BASED ON CONTOURS GENERATED BY SURFER® SOFTWARE.
2. MEASUREMENTS RECORDED BY GREDELL ENGINEERING RESOURCES, INC. FIELD PERSONNEL ON MARCH 18, 2014.
3. MAP REPRESENTATIVE OF GROUNDWATER CONDITIONS OCCURRING ON DATE OF MEASUREMENTS.
4. USE OF SMALL CONTOUR INTERVAL (0.5 FT.) EXAGGERATES APPARENT "SLOPE" OF WATER TABLE SURFACE.
5. RANGE OF GROUNDWATER FLOW GRADIENT AS DETERMINED BY SURFER® SOFTWARE 1.52×10^{-3} FT./FT. TO 5.84×10^{-3} FT./FT.

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314.993.4122 (voice) 314.993.4177 (fax)

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Telephone: (573) 893-9379
Fax/voice: (573) 893-9479

PREPARED FOR Ameren Missouri

DRAWN	A.J.K. (G.E.R.)
CHKD.	T.A.D. (G.E.R.)
SUPV.	T.R.G. (G.E.R.)
APPD.	M.C.C. (G.E.R.)

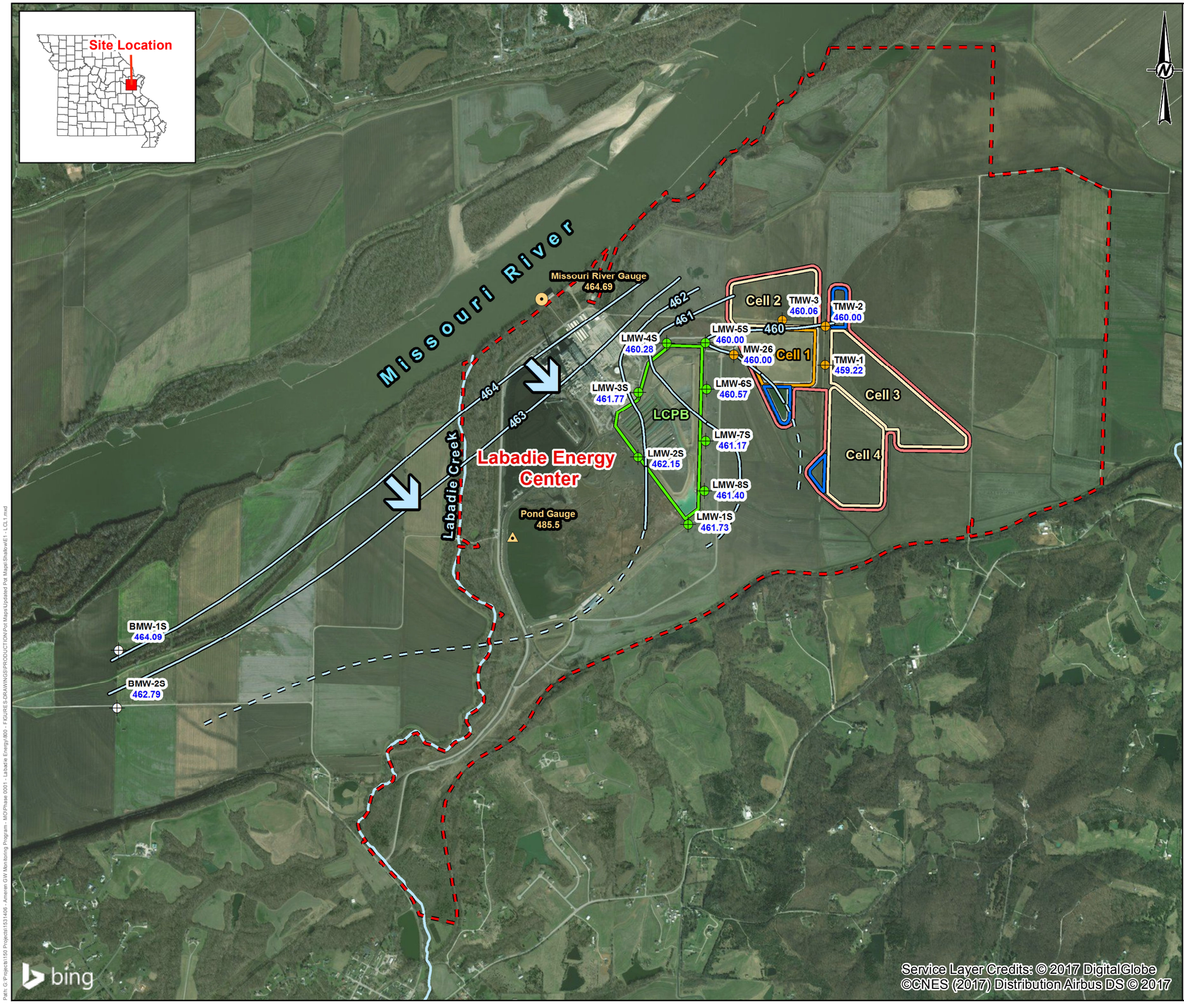
FIGURE 1
4th BACKGROUND SAMPLING EVENT - MARCH 2014
WATER TABLE SURFACE CONTOUR MAP
PROPOSED UTILITY WASTE LANDFILL

LOCATION		CLASS
001009	LABADIE ENERGY CENTER	02010

Ameren Missouri — ST. LOUIS, MISSOURI — APRIL 2014 — REV. 0

AMEREN_00002592

APPENDIX C
POTENTIOMETRIC SURFACE MAPS FROM BACKGROUND CCR SAMPLING EVENTS



LEGEND

- Labadie Energy Center Property Boundary

Utility Waste Landfill (UWL)

- Proposed Fence Perimeter
- Cell LCL1
- Proposed Stormwater Pond
- Proposed Future Cell

Surface Impoundment

- LCPB - Fly Ash Surface Impoundment

Groundwater Elevation Contours

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

Ground/Surface Water Measurement Locations

- LCPB Fly Ash Surface Impoundment Monitoring Well
- Background Monitoring Well
- UWL Monitoring Well
- Missouri River Gauge
- LCPA Bottom Ash Surface Impoundment Gauge
- Groundwater Flow Direction

NOTES

1. ALL LOCATIONS AND BOUNDARIES ARE APPROXIMATE.
2. GROUNDWATER ELEVATION MEASUREMENTS OBTAINED BY GOLDER.
3. GROUNDWATER MONITORING WELLS (EXCEPT TMW-1 AND MW-26) SURVEYED BY ZAHNER AND ASSOCIATES, INC. ON JANUARY 13 AND FEBRUARY 11, 2016.
4. GROUNDWATER MONITORING WELLS TMW-1 AND MW-26 INSTALLED BY RIETZ & JENS, INC. AND SURVEYED BY KDG INC.
5. GROUNDWATER ELEVATIONS DISPLAYED IN FT MSL (FEET ABOVE MEAN SEA LEVEL).
6. MISSOURI RIVER LEVEL OBTAINED FROM USGS LABADIE GAUGE 06935550.
7. POND GAUGE LEVEL OBTAINED ONSITE BY GOLDER.
8. THE UWL BOUNDARIES AND DESIGNATIONS ARE BASED ON AMEREN LABADIE CONSTRUCTION PERMIT APPLICATION DRAWINGS.

REFERENCES

1. ZAHNER AND ASSOCIATES, INC. 2016. LOT CONSOLIDATION PLAT OF "LABADIE ENERGY CENTER" - PREPARED FOR AMEREN MISSOURI. REVISED JUNE 15, 2016.
2. COORDINATE SYSTEM: NAD 1983 STATEPLANE MISSOURI EAST FIPS 2,401 FEET.
3. USGS (UNITED STATES GEOLOGICAL SURVEY), NATIONAL WATER INFORMATION SYSTEM, USGS GAUGE 06935550 MISSOURI RIVER NEAR LABADIE, MO.
4. REITZ & JENS, INC. 2014. ADDITIONAL GROUND WATER DETECTION MONITORING WELLS INSTALLATION REPORT.

0 5001,000 2,000 3,000 4,000 5,000 6,000 Feet

CLIENT
AMEREN MISSOURI
LABADIE ENERGY CENTER

PROJECT
CCR GROUNDWATER MONITORING PROGRAM

TITLE
LCL1 POTENTIOMETRIC SURFACE MAP
BACKGROUND EVENT 2 - MAY 3, 2016

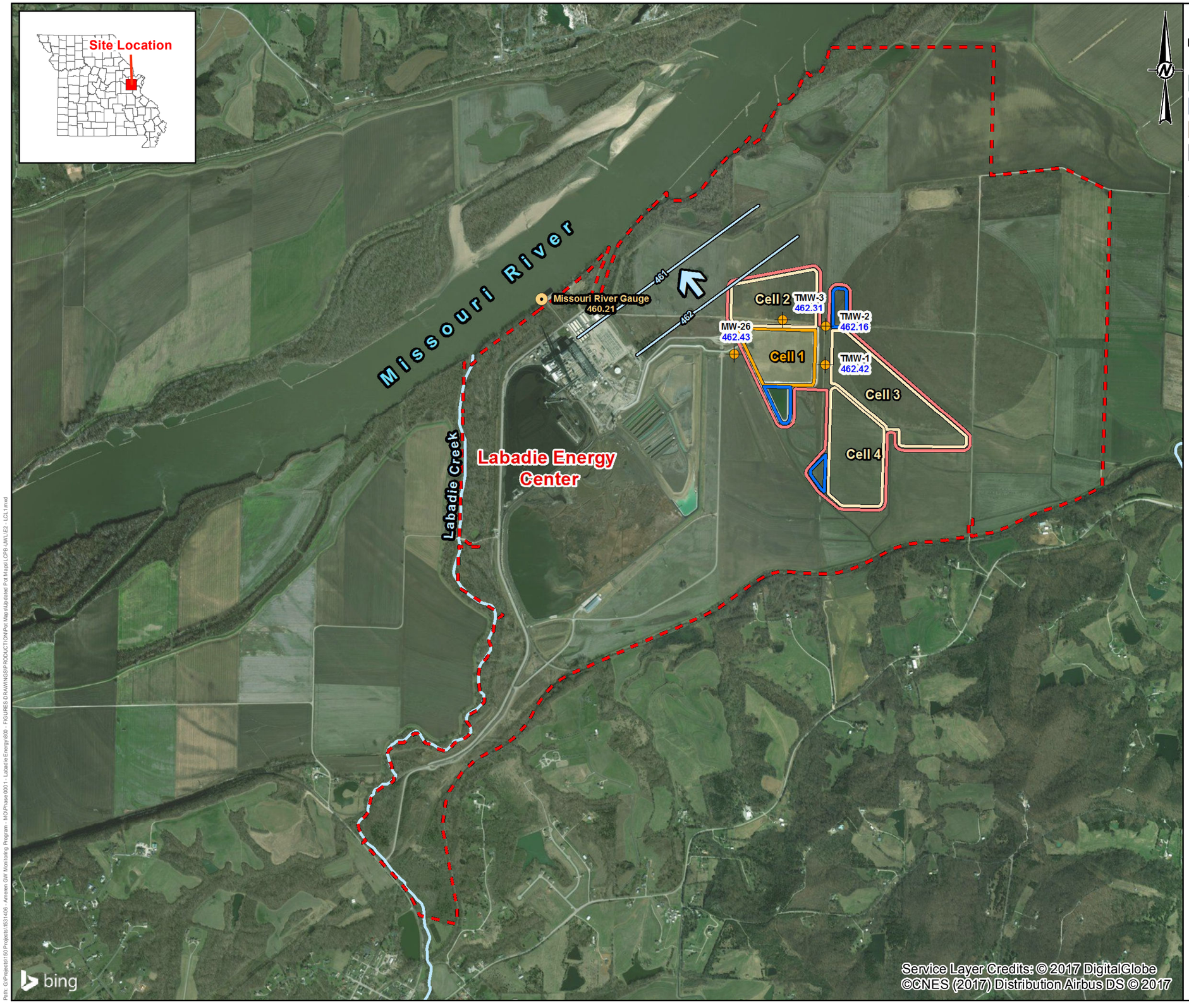
CONSULTANT
Golder Associates

YYYY-MM-DD	2016-05-31
PREPARED	JSI
DESIGN	JSI
REVIEW	JS
APPROVED	MNH

PROJECT No. 153-1406 | PHASE 0001C | Rev. 0.0 | FIGURE **P1**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 1 in 0

Path: G:\Projects\1501 Projects\1531406 - Ameren GW Monitoring Program - MO\Phase 0001 - Labadie Energy\800 - FIGURES-DRAWINGS\PRODUCTION\Pot Maps\Updated Pot Maps\ShallowVE1 - LCL1.mxd



LEGEND

- Labadie Energy Center Property Boundary

Utility Waste Landfill (UWL)

- Proposed Fence Perimeter
- Cell LCL1
- Proposed Stormwater Pond
- Proposed Future Cell

Groundwater Elevation Contours

- Groundwater Elevation Contour (FT MSL)
- Inferred Groundwater Elevation Contour (FT MSL)
- UWL Monitoring Well
- Missouri River Gauge
- Groundwater Flow Direction

NOTES

1. ALL LOCATIONS AND BOUNDARIES ARE APPROXIMATE.
2. GROUNDWATER ELEVATION MEASUREMENTS OBTAINED BY GOLDER.
3. GROUNDWATER MONITORING WELLS (EXCEPT TMW-1 AND MW-26) SURVEYED BY ZAHNER AND ASSOCIATES, INC. ON JANUARY 13 AND FEBRUARY 11, 2016.
4. GROUNDWATER MONITORING WELLS TMW-1 AND MW-26 INSTALLED BY RIETZ & JENS, INC. AND SURVEYED BY KDG INC.
5. GROUNDWATER ELEVATIONS DISPLAYED IN FT MSL (FEET ABOVE MEAN SEA LEVEL).
6. MISSOURI RIVER LEVEL OBTAINED FROM USGS LABADIE GAUGE 06935550.
7. THE UWL BOUNDARIES AND DESIGNATIONS ARE BASED ON AMEREN LABADIE CONSTRUCTION PERMIT APPLICATION DRAWINGS.

REFERENCES

1. ZAHNER AND ASSOCIATES, INC. 2016. LOT CONSOLIDATION PLAT OF "LABADIE ENERGY CENTER" - PREPARED FOR AMEREN MISSOURI. REVISED JUNE 15, 2016.
2. COORDINATE SYSTEM: NAD 1983 STATEPLANE MISSOURI EAST FIPS 2,401 FEET.
3. USGS (UNITED STATES GEOLOGICAL SURVEY), NATIONAL WATER INFORMATION SYSTEM, USGS GAUGE 06935550 MISSOURI RIVER NEAR LABADIE, MO.
4. REITZ & JENS, INC. 2014. ADDITIONAL GROUND WATER DETECTION MONITORING WELLS INSTALLATION REPORT.

0 5001,000 2,000 3,000 4,000 5,000 6,000

Feet

CLIENT
AMEREN MISSOURI
LABADIE ENERGY CENTER

PROJECT
CCR GROUNDWATER MONITORING PROGRAM

TITLE
LCL1 POTENTIOMETRIC SURFACE MAP
BACKGROUND EVENT 2 - JUNE 15, 2016

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-08-07
PREPARED	JSI
DESIGN	JSI
REVIEW	RJF
APPROVED	MNH

PROJECT No.	PHASE	Rev.	FIGURE
153-1406	0001C	0.0	**P2**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 11in 0

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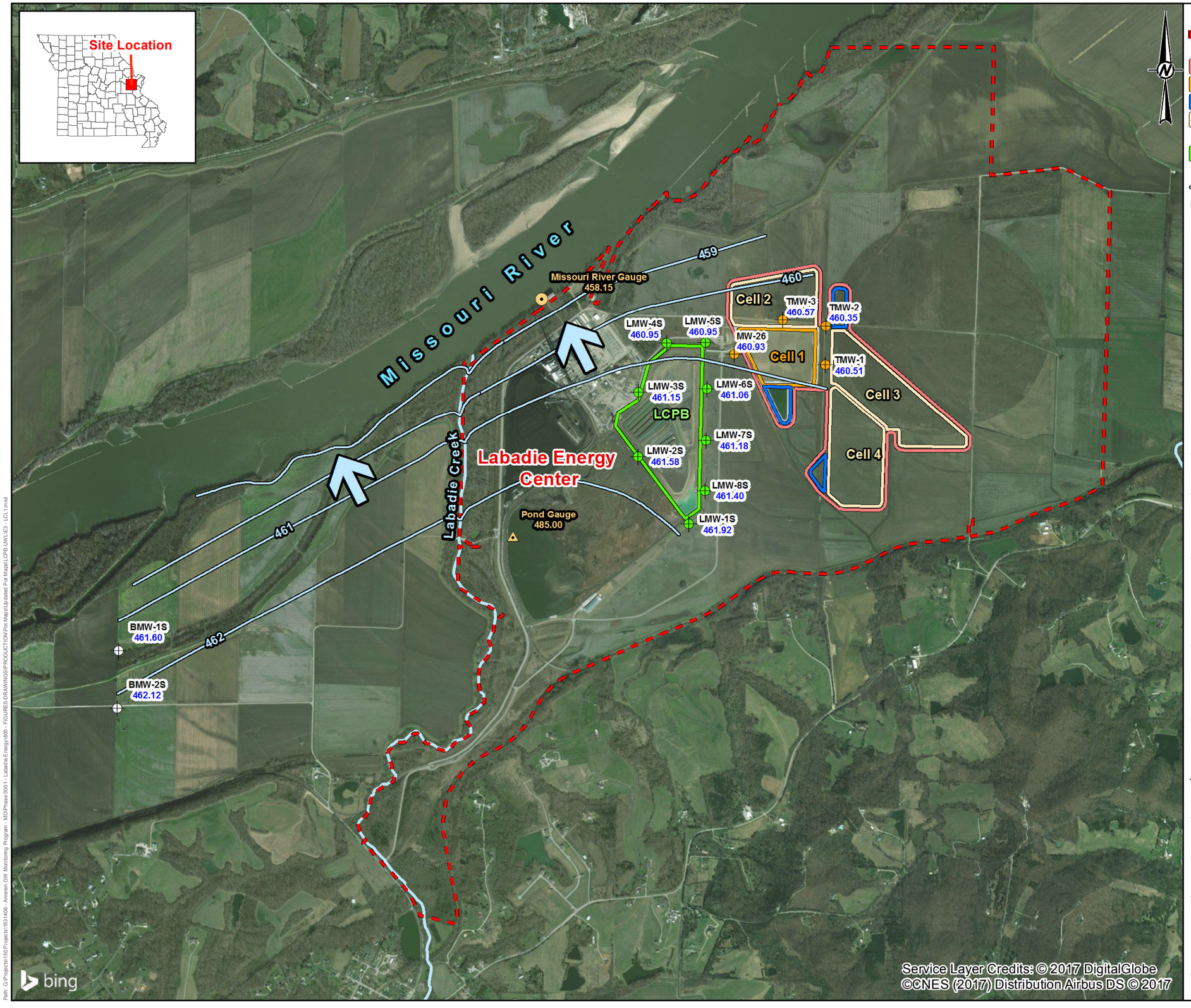


LEGEND

- Labadie Energy Center Property Boundary

Utility Waste Landfill (UWL)

- Proposed Fence Perimeter
- Cell LCL1
- Proposed Stormwater Pond
- Proposed Future Cell

Surface Impoundment

- LCPB - Fly Ash Surface Impoundment

Groundwater Elevation Contours

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

Ground/Surface Water Measurement Locations

- LCPB Fly Ash Surface Impoundment Monitoring Well
- Background Monitoring Well
- UWL Monitoring Well
- Missouri River Gauge
- LCPA Bottom Ash Surface Impoundment Gauge
- Groundwater Flow Direction

NOTES

1. ALL LOCATIONS AND BOUNDARIES ARE APPROXIMATE.
2. GROUNDWATER ELEVATION MEASUREMENTS OBTAINED BY GOLDER.
3. GROUNDWATER MONITORING WELLS (EXCEPT TMW-1 AND MW-26) SURVEYED BY ZAHNER AND ASSOCIATES, INC. ON JANUARY 13 AND FEBRUARY 11, 2016.
4. GROUNDWATER MONITORING WELLS TMW-1 AND MW-26 INSTALLED BY RIETZ & JENS, INC. AND SURVEYED BY KDG INC.
5. GROUNDWATER ELEVATIONS DISPLAYED IN FT MSL (FEET ABOVE MEAN SEA LEVEL).
6. MISSOURI RIVER LEVEL OBTAINED FROM USGS LABADIE GAUGE 06935550.
7. POND GAUGE LEVEL OBTAINED ONSITE BY GOLDER.
8. THE UWL BOUNDARIES AND DESIGNATIONS ARE BASED ON AMEREN LABADIE CONSTRUCTION PERMIT APPLICATION DRAWINGS.

REFERENCES

1. ZAHNER AND ASSOCIATES, INC. 2016. LOT CONSOLIDATION PLAT OF "LABADIE ENERGY CENTER" - PREPARED FOR AMEREN MISSOURI. REVISED JUNE 15, 2016.
2. COORDINATE SYSTEM: NAD 1983 STATEPLANE MISSOURI EAST FIPS 2,401 FEET.
3. USGS (UNITED STATES GEOLOGICAL SURVEY), NATIONAL WATER INFORMATION SYSTEM, USGS GAUGE 06935550 MISSOURI RIVER NEAR LABADIE, MO.
4. REITZ & JENS, INC. 2014. ADDITIONAL GROUND WATER DETECTION MONITORING WELLS INSTALLATION REPORT.

0 5001,000 2,000 3,000 4,000 5,000 6,000

Feet

CLIENT
AMEREN MISSOURI
LABADIE ENERGY CENTER

PROJECT
CCR GROUNDWATER MONITORING PROGRAM

TITLE
LCL1 POTENTIOMETRIC SURFACE MAP
BACKGROUND EVENT 3 - JULY 11, 2016

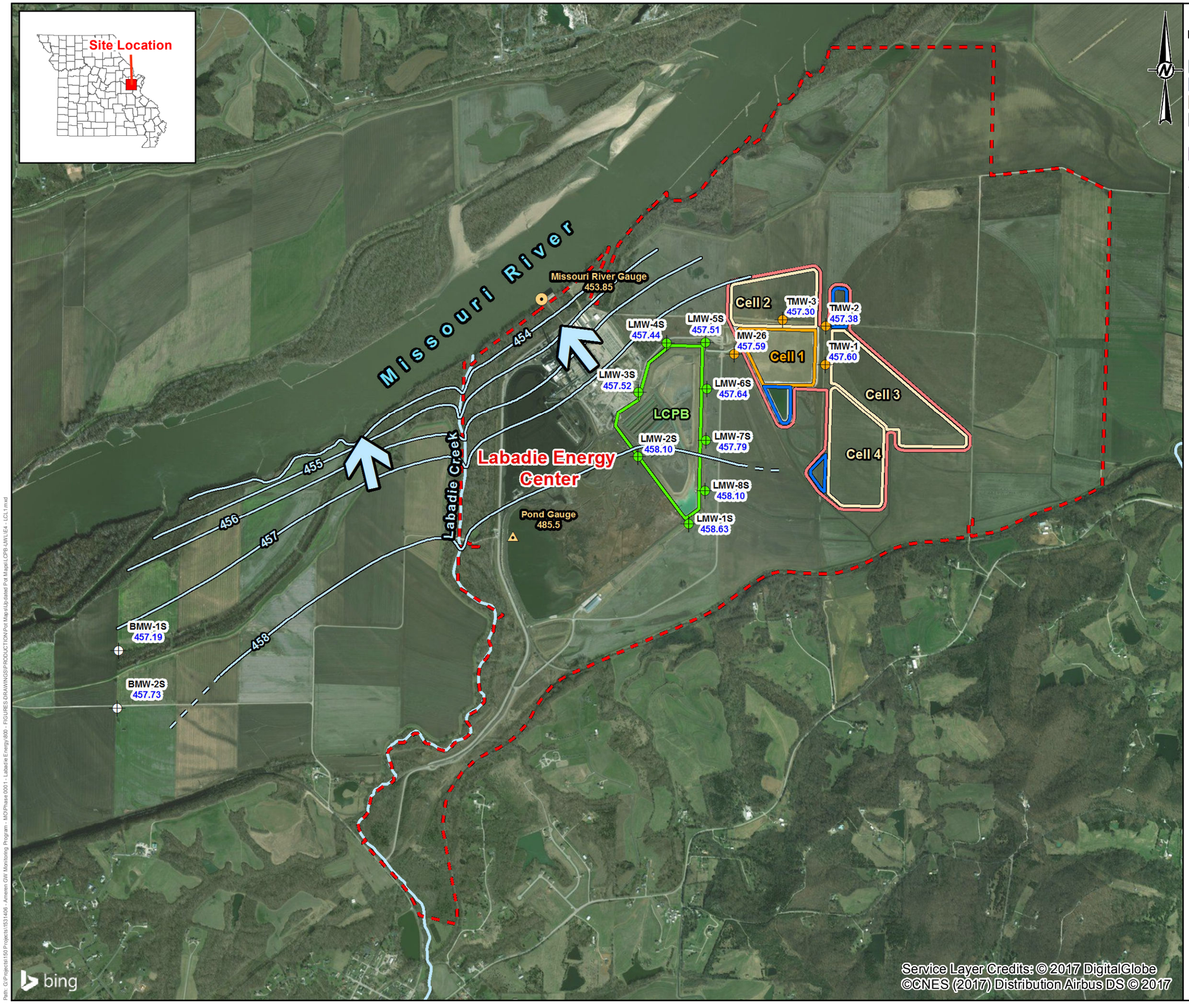
CONSULTANT
Golder Associates

YYYY-MM-DD	2016-09-28
PREPARED	JS
DESIGN	JSI
REVIEW	RJF/JSI
APPROVED	MNH

PROJECT No.	PHASE	Rev.	FIGURE
153-1406	0001C	0.0	**P3**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 1 in 0

Path: G:\Projects\1530 Projects\1531406 - Ameren GW Monitoring Program - MO\Phase 0001 - Labadie Energy\800 - FIGURES\DRAWINGS\PRODUCTION\Pot Maps\Updated Pot Maps\LCPB-UWL\E3 - LCL1.mxd



LEGEND

- Labadie Energy Center Property Boundary

Utility Waste Landfill (UWL)

- Proposed Fence Perimeter
- Cell LCL1
- Proposed Stormwater Pond
- Proposed Future Cell

Surface Impoundment

- LCPB - Fly Ash Surface Impoundment

Groundwater Elevation Contours

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

Ground/Surface Water Measurement Locations

- LCPB Fly Ash Surface Impoundment Monitoring Well
- Background Monitoring Well
- UWL Monitoring Well
- Missouri River Gauge
- LCPA Bottom Ash Surface Impoundment Gauge
- Groundwater Flow Direction

NOTES

1. ALL LOCATIONS AND BOUNDARIES ARE APPROXIMATE.
2. GROUNDWATER ELEVATION MEASUREMENTS OBTAINED BY GOLDER.
3. GROUNDWATER MONITORING WELLS (EXCEPT TMW-1 AND MW-26) SURVEYED BY ZAHNER AND ASSOCIATES, INC. ON JANUARY 13 AND FEBRUARY 11, 2016.
4. GROUNDWATER MONITORING WELLS TMW-1 AND MW-26 INSTALLED BY RIETZ & JENS, INC. AND SURVEYED BY KDG INC.
5. GROUNDWATER ELEVATIONS DISPLAYED IN FT MSL (FEET ABOVE MEAN SEA LEVEL).
6. MISSOURI RIVER LEVEL OBTAINED FROM USGS LABADIE GAUGE 06935550.
7. POND GAUGE LEVEL OBTAINED ONSITE BY GOLDER.
8. THE UWL BOUNDARIES AND DESIGNATIONS ARE BASED ON AMEREN LABADIE CONSTRUCTION PERMIT APPLICATION DRAWINGS.

REFERENCES

1. ZAHNER AND ASSOCIATES, INC. 2016. LOT CONSOLIDATION PLAT OF "LABADIE ENERGY CENTER" - PREPARED FOR AMEREN MISSOURI. REVISED JUNE 15, 2016.
2. COORDINATE SYSTEM: NAD 1983 STATEPLANE MISSOURI EAST FIPS 2,401 FEET.
3. USGS (UNITED STATES GEOLOGICAL SURVEY), NATIONAL WATER INFORMATION SYSTEM, USGS GAUGE 06935550 MISSOURI RIVER NEAR LABADIE, MO.
4. REITZ & JENS, INC. 2014. ADDITIONAL GROUND WATER DETECTION MONITORING WELLS INSTALLATION REPORT.

0 5001,000 2,000 3,000 4,000 5,000 6,000 Feet

CLIENT
AMEREN MISSOURI
LABADIE ENERGY CENTER

PROJECT
CCR GROUNDWATER MONITORING PROGRAM

TITLE
LCL1 POTENTIOMETRIC SURFACE MAP
BACKGROUND EVENT 4 - SEPTEMBER 8, 2016

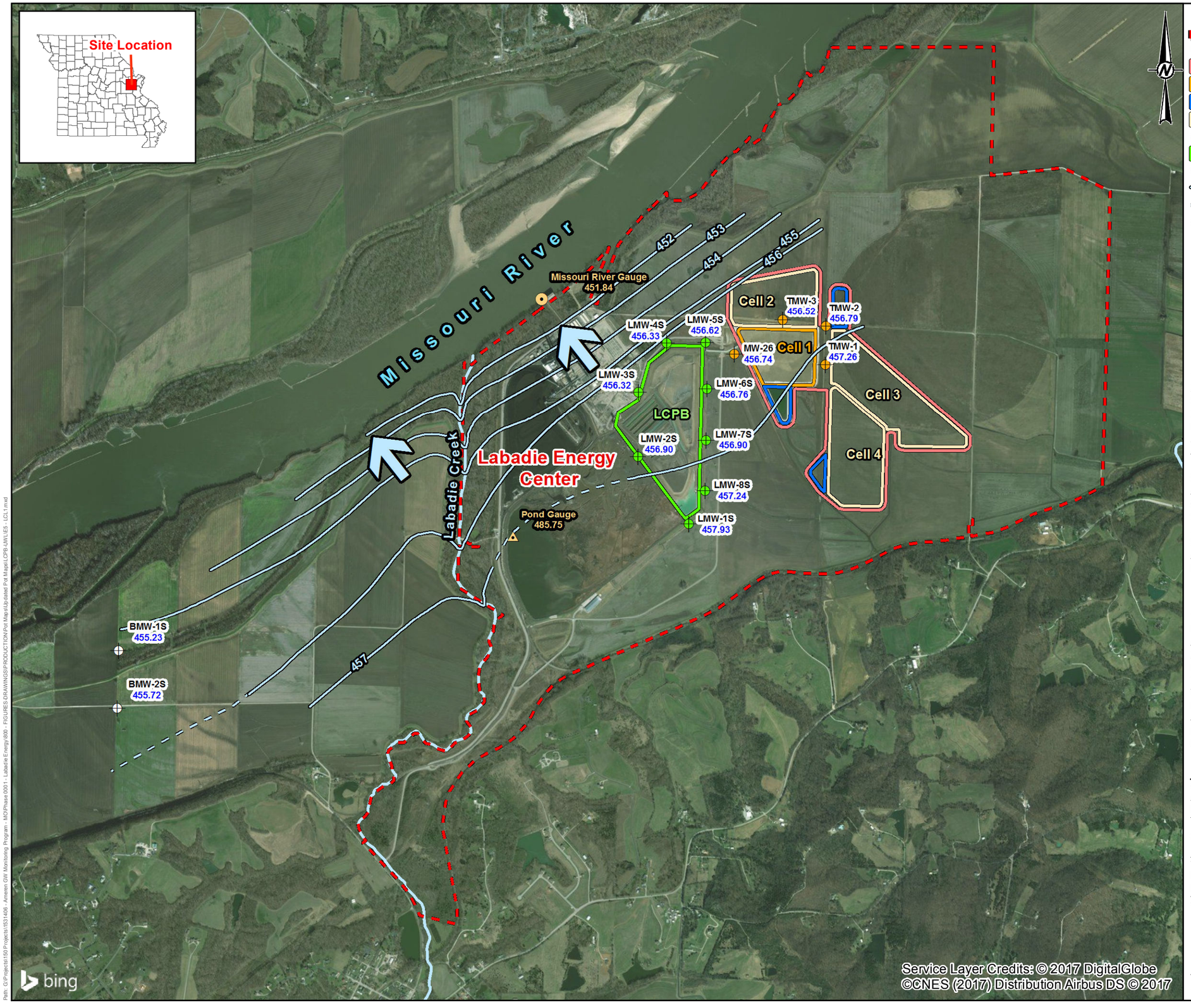
CONSULTANT
Golder Associates

YYYY-MM-DD	2016-09-28
PREPARED	JSI
DESIGN	JSI
REVIEW	JS
APPROVED	MNH

PROJECT No.	PHASE	Rev.	FIGURE
153-1406	0001C	0.0	**P4**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 1in 0

Path: G:\Projects\153 Projects\15531406 - Ameren GW Monitoring Program - MO\Phase 0001 - Labadie Energy\800 - FIGURES DRAWINGS\PRODUCTION\Pot Maps\Updated Pot Maps\LCPB-UWLE4 - LCL1.mxd



LEGEND

- Labadie Energy Center Property Boundary

Utility Waste Landfill (UWL)

- Proposed Fence Perimeter
- Cell LCL1
- Proposed Stormwater Pond
- Proposed Future Cell

Surface Impoundment

- LCPB - Fly Ash Surface Impoundment

Groundwater Elevation Contours

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

Ground/Surface Water Measurement Locations

- LCPB Fly Ash Surface Impoundment Monitoring Well
- Background Monitoring Well
- UWL Monitoring Well
- Missouri River Gauge
- LCPA Bottom Ash Surface Impoundment Gauge
- Groundwater Flow Direction

NOTES

1. ALL LOCATIONS AND BOUNDARIES ARE APPROXIMATE.
2. GROUNDWATER ELEVATION MEASUREMENTS OBTAINED BY GOLDER.
3. GROUNDWATER MONITORING WELLS (EXCEPT TMW-1 AND MW-26) SURVEYED BY ZAHNER AND ASSOCIATES, INC. ON JANUARY 13 AND FEBRUARY 11, 2016.
4. GROUNDWATER MONITORING WELLS TMW-1 AND MW-26 INSTALLED BY RIETZ & JENS, INC. AND SURVEYED BY KDG INC.
5. GROUNDWATER ELEVATIONS DISPLAYED IN FT MSL (FEET ABOVE MEAN SEA LEVEL).
6. MISSOURI RIVER LEVEL OBTAINED FROM USGS LABADIE GAUGE 06935550.
7. POND GAUGE LEVEL OBTAINED ONSITE BY GOLDER.
8. THE UWL BOUNDARIES AND DESIGNATIONS ARE BASED ON AMEREN LABADIE CONSTRUCTION PERMIT APPLICATION DRAWINGS.

REFERENCES

1. ZAHNER AND ASSOCIATES, INC. 2016. LOT CONSOLIDATION PLAT OF "LABADIE ENERGY CENTER" - PREPARED FOR AMEREN MISSOURI. REVISED JUNE 15, 2016.
2. COORDINATE SYSTEM: NAD 1983 STATEPLANE MISSOURI EAST FIPS 2,401 FEET.
3. USGS (UNITED STATES GEOLOGICAL SURVEY), NATIONAL WATER INFORMATION SYSTEM, USGS GAUGE 06935550 MISSOURI RIVER NEAR LABADIE, MO.
4. REITZ & JENS, INC. 2014. ADDITIONAL GROUND WATER DETECTION MONITORING WELLS INSTALLATION REPORT.

0 5001,000 2,000 3,000 4,000 5,000 6,000 Feet

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 11in 0

CLIENT
AMEREN MISSOURI
LABADIE ENERGY CENTER

PROJECT
CCR GROUNDWATER MONITORING PROGRAM

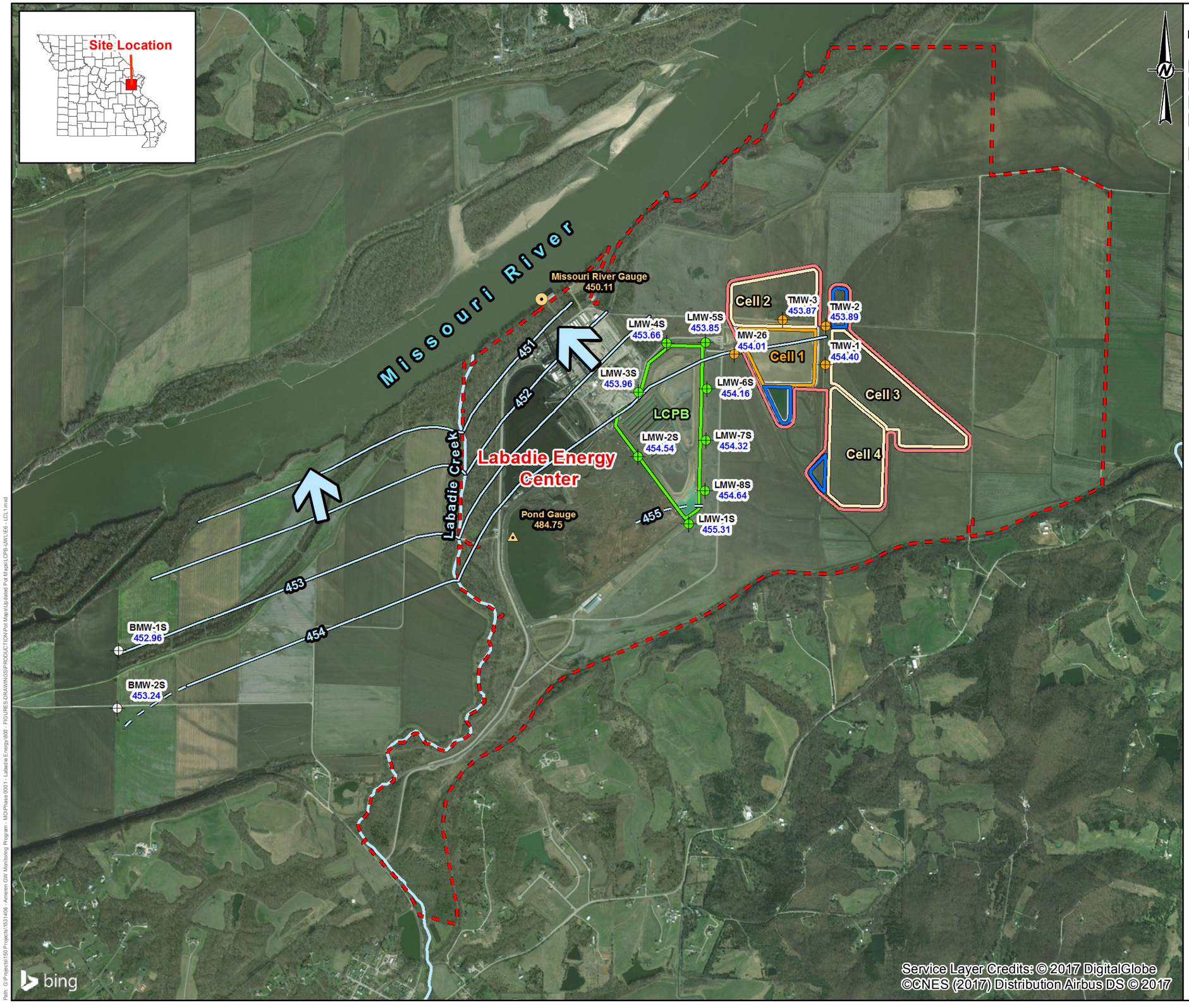
TITLE
LCL1 POTENTIOMETRIC SURFACE MAP
BACKGROUND EVENT 5 - NOVEMBER 11, 2016

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-11-18
PREPARED	JSI
DESIGN	JSI
REVIEW	MSG
APPROVED	MNH

PROJECT No. 153-1406 | PHASE 0001C | Rev. 0.0 | FIGURE **P5**

Path: G:\Projects\1530 Projects\1531406 - Ameren GW Monitoring Program - MO\Phase 0001 - Labadie Energy\800 - FIGURES\DRAWINGS\PRODUCTION\Pot Maps\Updated Pot Maps\LCPB-UWLIES - LCL1.mxd



LEGEND

- Labadie Energy Center Property Boundary

Utility Waste Landfill (UWL)

- Proposed Fence Perimeter
- Cell LCL1
- Proposed Stormwater Pond
- Proposed Future Cell

Surface Impoundment

- LCPB - Fly Ash Surface Impoundment

Groundwater Elevation Contours

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

Ground/Surface Water Measurement Locations

- LCPB Fly Ash Surface Impoundment Monitoring Well
- Background Monitoring Well
- UWL Monitoring Well
- Missouri River Gauge
- LCPA Bottom Ash Surface Impoundment Gauge
- Groundwater Flow Direction

NOTES

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4. GROUNDWATER MONITORING WELLS TMW-1 AND MW-26 INSTALLED BY RIETZ & JENS, INC. AND SURVEYED BY KDG INC.
5. GROUNDWATER ELEVATIONS DISPLAYED IN FT MSL (FEET ABOVE MEAN SEA LEVEL).
6. MISSOURI RIVER LEVEL OBTAINED FROM USGS LABADIE GAUGE 06935550.
7. POND GAUGE LEVEL OBTAINED ONSITE BY GOLDER.
8. THE UWL BOUNDARIES AND DESIGNATIONS ARE BASED ON AMEREN LABADIE CONSTRUCTION PERMIT APPLICATION DRAWINGS.

REFERENCES

1. ZAHNER AND ASSOCIATES, INC. 2016. LOT CONSOLIDATION PLAT OF "LABADIE ENERGY CENTER" - PREPARED FOR AMEREN MISSOURI. REVISED JUNE 15, 2016.
2. COORDINATE SYSTEM: NAD 1983 STATEPLANE MISSOURI EAST FIPS 2,401 FEET.
3. USGS (UNITED STATES GEOLOGICAL SURVEY), NATIONAL WATER INFORMATION SYSTEM, USGS GAUGE 06935550 MISSOURI RIVER NEAR LABADIE, MO.
4. REITZ & JENS, INC. 2014. ADDITIONAL GROUND WATER DETECTION MONITORING WELLS INSTALLATION REPORT.

0 5001,000 2,000 3,000 4,000 5,000 6,000 Feet

CLIENT
AMEREN MISSOURI
LABADIE ENERGY CENTER

PROJECT
CCR GROUNDWATER MONITORING PROGRAM

TITLE
LCL1 POTENTIOMETRIC SURFACE MAP
BACKGROUND EVENT 6 - JANUARY 16, 2017

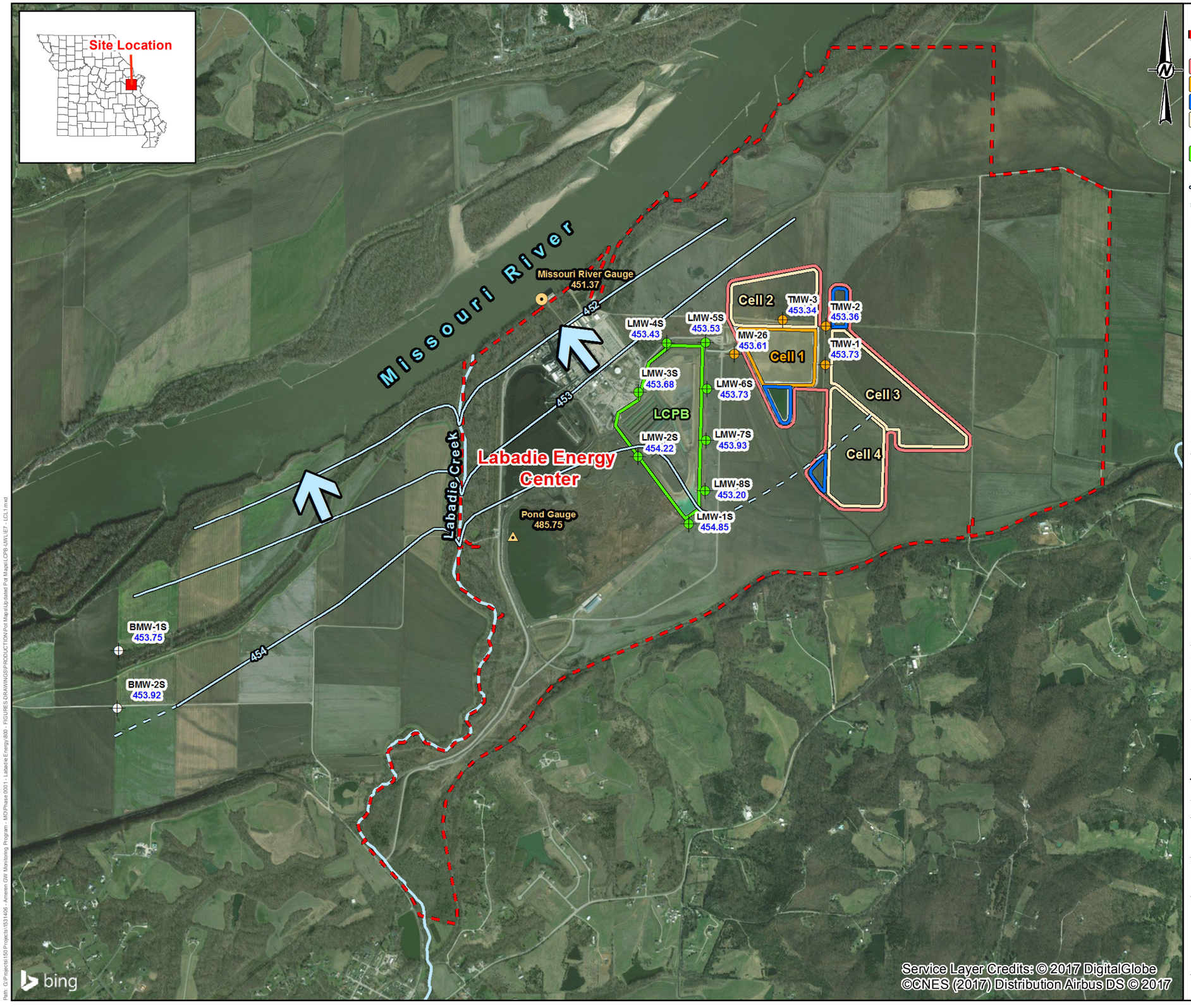
CONSULTANT
Golder Associates

YYYY-MM-DD	2017-01-20
PREPARED	JS
DESIGN	JSI
REVIEW	BEF
APPROVED	MNH

PROJECT No.	PHASE	Rev.	FIGURE
153-1406	0001C	0.0	**P6**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 1in 0

Path: G:\Projects\150 Projects\15314406 - Ameren GW Monitoring Program - MO\Phase 0001 - Labadie Energy\800 - FIGURES DRAWINGS\PRODUCTION\Pot Maps\Updated Pot Maps\LCPB-UWLE8 - LCL1.mxd



LEGEND

- Labadie Energy Center Property Boundary

Utility Waste Landfill (UWL)

- Proposed Fence Perimeter
- Cell LCL1
- Proposed Stormwater Pond
- Proposed Future Cell

Surface Impoundment

- LCPB - Fly Ash Surface Impoundment

Groundwater Elevation Contours

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

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- Background Monitoring Well
- UWL Monitoring Well
- Missouri River Gauge
- LCPA Bottom Ash Surface Impoundment Gauge
- Groundwater Flow Direction

NOTES

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REFERENCES

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4. REITZ & JENS, INC. 2014. ADDITIONAL GROUND WATER DETECTION MONITORING WELLS INSTALLATION REPORT.

0 5001,000 2,000 3,000 4,000 5,000 6,000 Feet

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 11 in

CLIENT
AMEREN MISSOURI
LABADIE ENERGY CENTER

PROJECT
CCR GROUNDWATER MONITORING PROGRAM

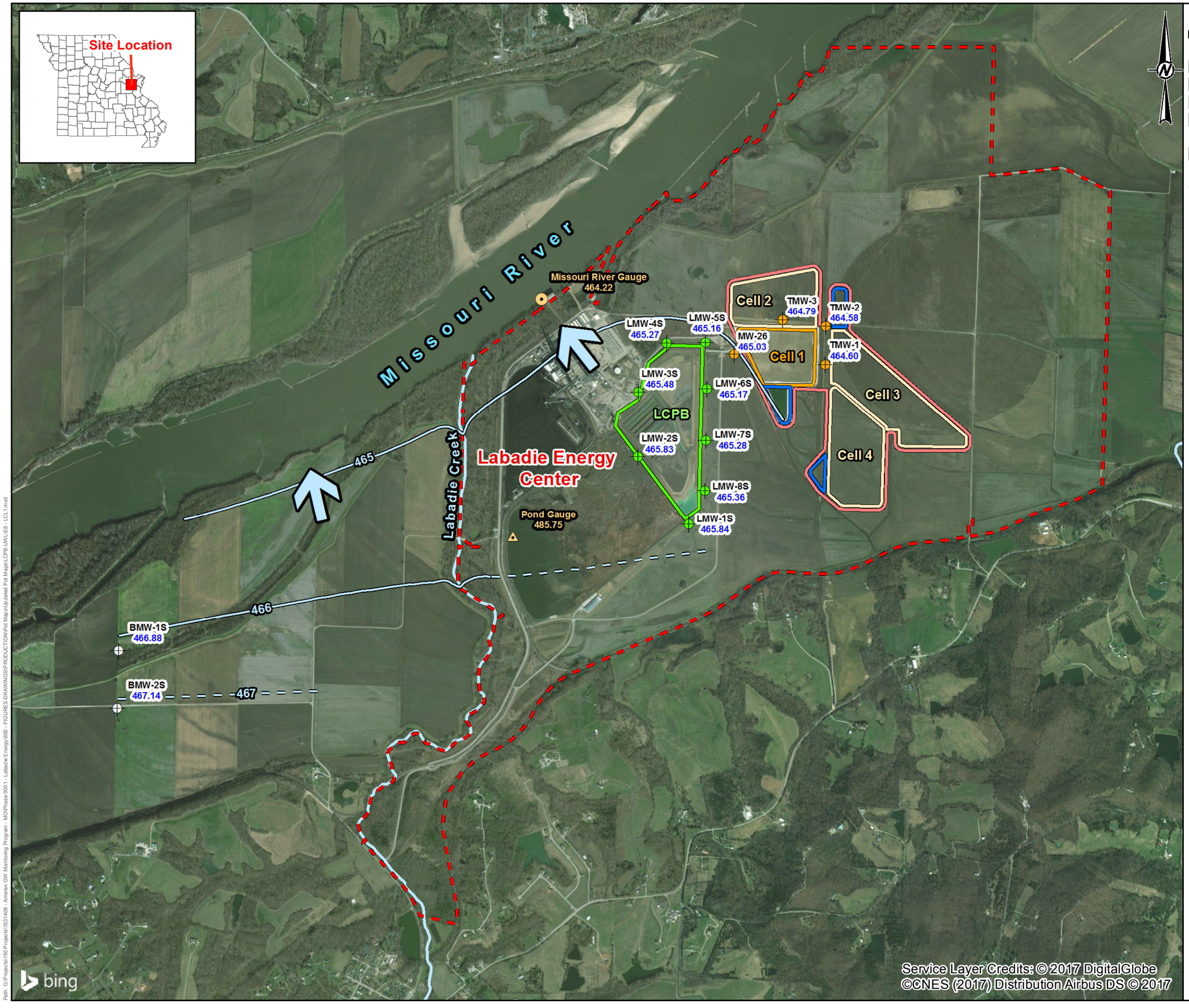
TITLE
LCL1 POTENTIOMETRIC SURFACE MAP
BACKGROUND EVENT 7 - MARCH 1, 2017

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-06-14
PREPARED	JSI
DESIGN	JSI
REVIEW	JS
APPROVED	MNH

PROJECT No.	PHASE	Rev.	FIGURE
153-1406	0001C	0.0	**P7**

Path: G:\Projects\1530 Projects\1531406 - Ameren GW Monitoring Program - MO\Phase 0001 - Labadie Energy\800 - FIGURES\DRAWINGS\PRODUCTION\Pot Maps\Updated Pot Maps\LCPB-UWL\E7 - LCL1.mxd



LEGEND

- Labadie Energy Center Property Boundary

Utility Waste Landfill (UWL)

- Proposed Fence Perimeter
- Cell LCL1
- Proposed Stormwater Pond
- Proposed Future Cell

Surface Impoundment

- LCPB - Fly Ash Surface Impoundment

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- UWL Monitoring Well
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3. USGS (UNITED STATES GEOLOGICAL SURVEY), NATIONAL WATER INFORMATION SYSTEM, USGS GAUGE 06935550 MISSOURI RIVER NEAR LABADIE, MO.
4. REITZ & JENS, INC. 2014. ADDITIONAL GROUND WATER DETECTION MONITORING WELLS INSTALLATION REPORT.

0 5001,000 2,000 3,000 4,000 5,000 6,000 Feet

CLIENT
AMEREN MISSOURI
LABADIE ENERGY CENTER

PROJECT
CCR GROUNDWATER MONITORING PROGRAM

TITLE
LCL1 POTENTIOMETRIC SURFACE MAP
BACKGROUND EVENT 8 - MAY 31, 2017

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-06-14
PREPARED	JS
DESIGN	JSI
REVIEW	RJF
APPROVED	MNH

PROJECT No.	PHASE	Rev.	FIGURE
153-1406	0001C	0.0	**P8**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 11in

Path: G:\Projects\153 Projects\15314406 - Ameren GW Monitoring Program - MO\Phase 0001 - Labadie Energy\800 - FIGURES DRAWINGS\PRODUCTION\Pot Maps\Updated Pot Maps\LCPB-UWLE8 - LCL1.mxd

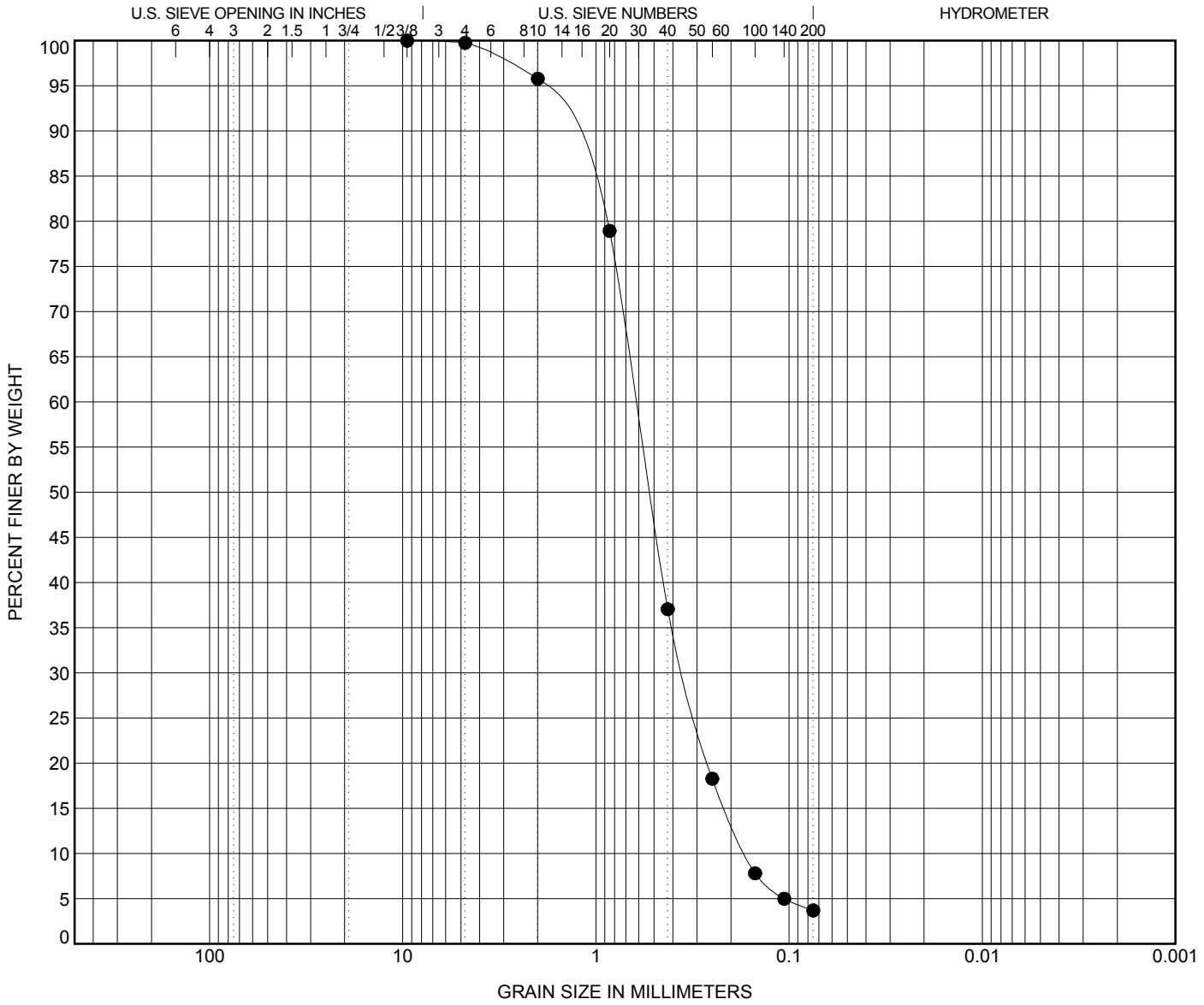
APPENDIX D
GRAIN SIZE DISTRIBUTION

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**



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	BOREHOLE	DEPTH	Classification	LL	PL	PI
●	LMW-1S	15-25 ft	POORLY GRADED SAND (SP)			

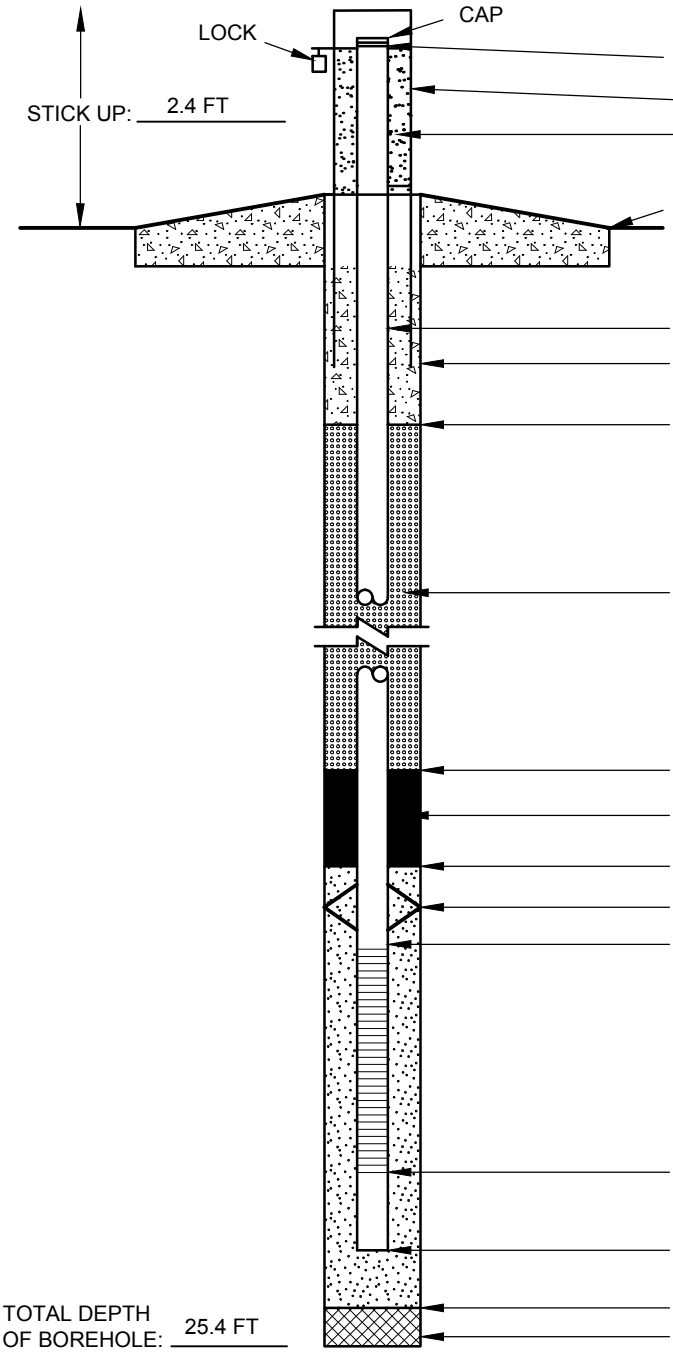
	BOREHOLE	DEPTH	D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	LMW-1S	15-25 ft	9.5	0.621	0.348	0.167	0.2	96.1	4	

GRAIN SIZE (FULL SIEVE) - GINT STD US LAB.GDT - 11/25/15 09:40 - 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-2

PROJECT NAME: AMEREN CCR GW MONITORING		PROJECT NUMBER: 153-1406.0001C
SITE NAME: LABADIE ENERGY CENTER		LOCATION: TMW-2
CLIENT: AMEREN MISSOURI		SURFACE ELEVATION: 468.0 FT MSL
GEOLOGIST: J. INGRAM	NORTHING: 994513.1	EASTING: 728663.8
DRILLER: J. DRABEK	STATIC WATER LEVEL: 12.57 FT BTOC	COMPLETION DATE: 4/6/2016
DRILLING COMPANY: CASCADE		DRILLING METHODS: SONIC



TOP OF CASING ELEVATION: 470.40 FT MSL

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

PEA GRAVEL OR SAND

GROUND SURFACE ELEVATION: 468.0 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: 3/8" BENTONITE CHIPS - 2 BAGS

TOP OF SAND PACK DEPTH (ft. bgs): COARSE: 12.0 FINE: 11.0

CENTRALIZER (yes / no) - TYPE: NONE

TOP OF SCREEN DEPTH (ft. bgs): 15.2

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: 1/2 BAG

BOTTOM OF SCREEN DEPTH (ft. bgs): 25.0

BOTTOM OF WELL DEPTH (ft. bgs): 25.4

BOTTOM OF FILTER PACK (ft. bgs): 25.4

TYPE AND AMOUNT OF BACKFILL: NONE

ADDITIONAL NOTES: FT BGS = FEET BELOW GROUND SURFACE. FT MSL = FEET ABOVE MEAN SEA LEVEL.
30 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 28, 2016. FT BTOC = FEET BELOW TOP OF CASING. SAND AND BENTONITE BAGS WEIGH 50 LBS EACH.

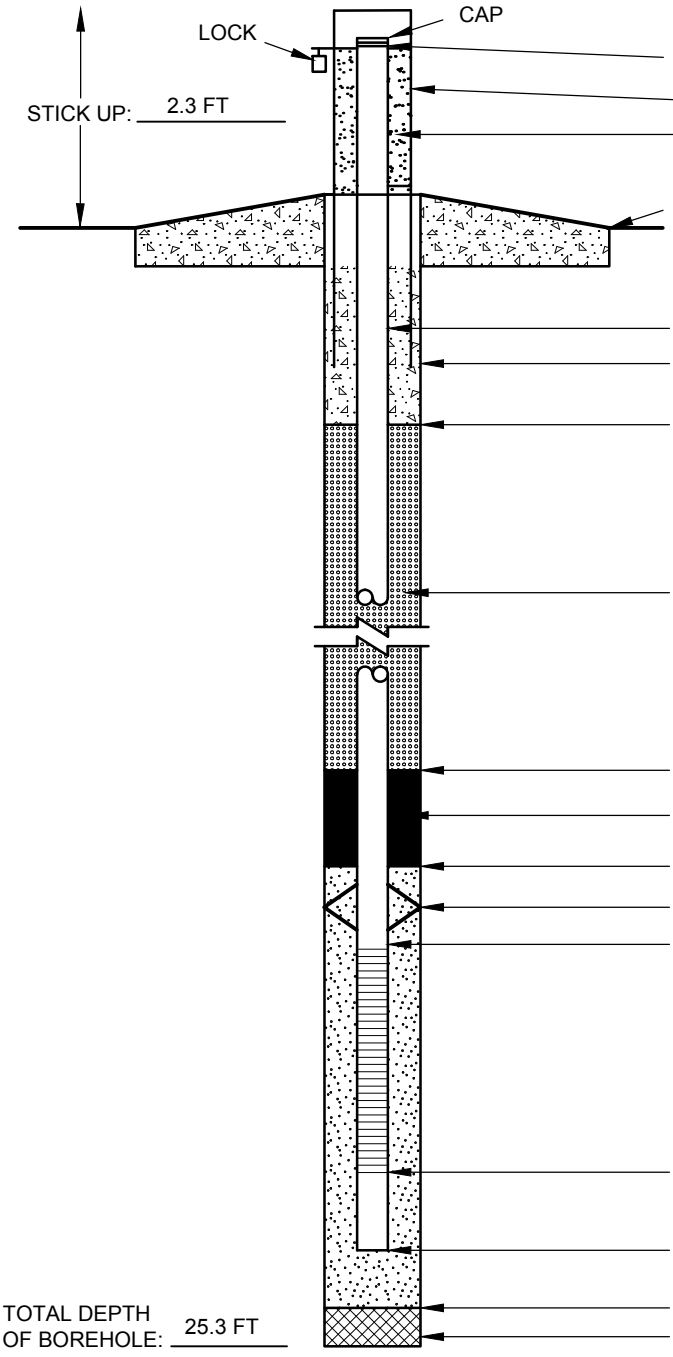
CHECKED BY: J. INGRAM

DATE CHECKED: 6/2/2016

PREPARED BY: J. SUOZZI

ABOVE GROUND MONITORING WELL CONSTRUCTION LOG TMW-3

PROJECT NAME: AMEREN CCR GW MONITORING	PROJECT NUMBER: 153-1406.0001C	
SITE NAME: LABADIE ENERGY CENTER	LOCATION: TMW-3	
CLIENT: AMEREN MISSOURI	SURFACE ELEVATION: 467.1 FT MSL	
GEOLOGIST: J. INGRAM	NORTHING: 994635.7	EASTING: 727842.0
DRILLER: J. DRABEK	STATIC WATER LEVEL: 9.35 FT BTOC	COMPLETION DATE: 4/6/2016
DRILLING COMPANY: CASCADE	DRILLING METHODS: SONIC	



TOP OF CASING ELEVATION: 469.41 FT MSL

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

PEA GRAVEL OR SAND

GROUND SURFACE ELEVATION: 467.1 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: NONE

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

TYPE AND AMOUNT OF BENTONITE SEAL: 3/8" BENTONITE CHIPS - 2 BAGS

TOP OF SAND PACK DEPTH (ft. bgs): COARSE: 12.5 FINE: 11.5

CENTRALIZER (yes / (no) - TYPE: NONE

TOP OF SCREEN DEPTH (ft. bgs): 15.1

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: 1/2 BAG

BOTTOM OF SCREEN DEPTH (ft. bgs): 24.9

BOTTOM OF WELL DEPTH (ft. bgs): 25.3

BOTTOM OF FILTER PACK (ft. bgs): 25.3

TYPE AND AMOUNT OF BACKFILL: NONE

ADDITIONAL NOTES: FT BGS = FEET BELOW GROUND SURFACE. FT MSL = FEET ABOVE MEAN SEA LEVEL.
30 GALLONS OF H2O USED DURING DRILLING. HORIZONTAL DATUM: STATE PLANE COORDINATES NAD83 (2000) MISSOURI EAST ZONE.
VERTICAL DATUM: NAVD88. WELL SURVEYED BY ZAHNER AND ASSOCIATES, INC ON APRIL 28, 2016.
FT BTOC = FEET BELOW TOP OF CASING. SAND AND BENTONITE BAGS WEIGH 50 LBS EACH.

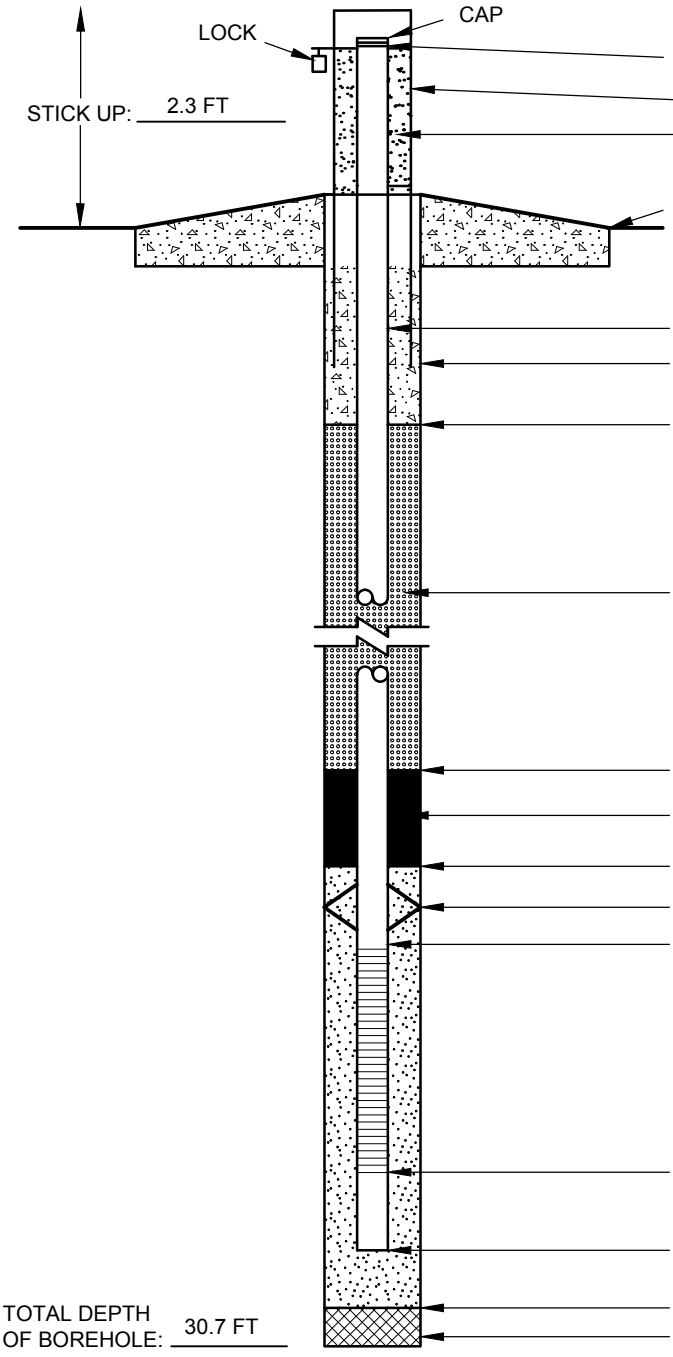
CHECKED BY: J. INGRAM

DATE CHECKED: 6/2/2016

PREPARED BY: J. SUOZZI

ABOVE GROUND MONITORING WELL CONSTRUCTION LOG BMW-1S

PROJECT NAME: AMEREN CCR GW MONITORING	PROJECT NUMBER: 153-1406.0001B	
SITE NAME: LABADIE ENERGY CENTER	LOCATION: BMW-1S	
CLIENT: AMEREN MISSOURI	SURFACE ELEVATION: 471.2 FT MSL	
GEOLOGIST: J. INGRAM	NORTHING: 988310.0	EASTING: 715131.6
DRILLER: J. DRABEK	STATIC WATER LEVEL: 13.60 FT BTOC	COMPLETION DATE: 2/01/2016
DRILLING COMPANY: CASCADE	DRILLING METHODS: SONIC	



TOP OF CASING ELEVATION: 473.49 FT MSL

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

PEA GRAVEL OR SAND

GROUND SURFACE ELEVATION: 471.2 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: 3/8" BENTONITE CHIPS - 3 BAGS

TOP OF SAND PACK DEPTH (ft. bgs): COARSE: 17.5 FINE: 16.5

CENTRALIZER (yes / no) - TYPE: NONE

TOP OF SCREEN DEPTH (ft. bgs): 20.5

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: 1/2 BAG

BOTTOM OF SCREEN DEPTH (ft. bgs): 30.3

BOTTOM OF WELL DEPTH (ft. bgs): 30.7

BOTTOM OF FILTER PACK (ft. bgs): 30.7

TYPE AND AMOUNT OF BACKFILL: NONE

TOTAL DEPTH OF BOREHOLE: 30.7 FT

ADDITIONAL NOTES: FT BGS = FEET BELOW GROUND SURFACE. FT MSL = FEET ABOVE MEAN SEA LEVEL.
100 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 FEBRUARY 11, 2016. FT BTOC = FEET BELOW TOP OF CASING. SAND AND BENTONITE BAGS WEIGH 50 LBS EACH.

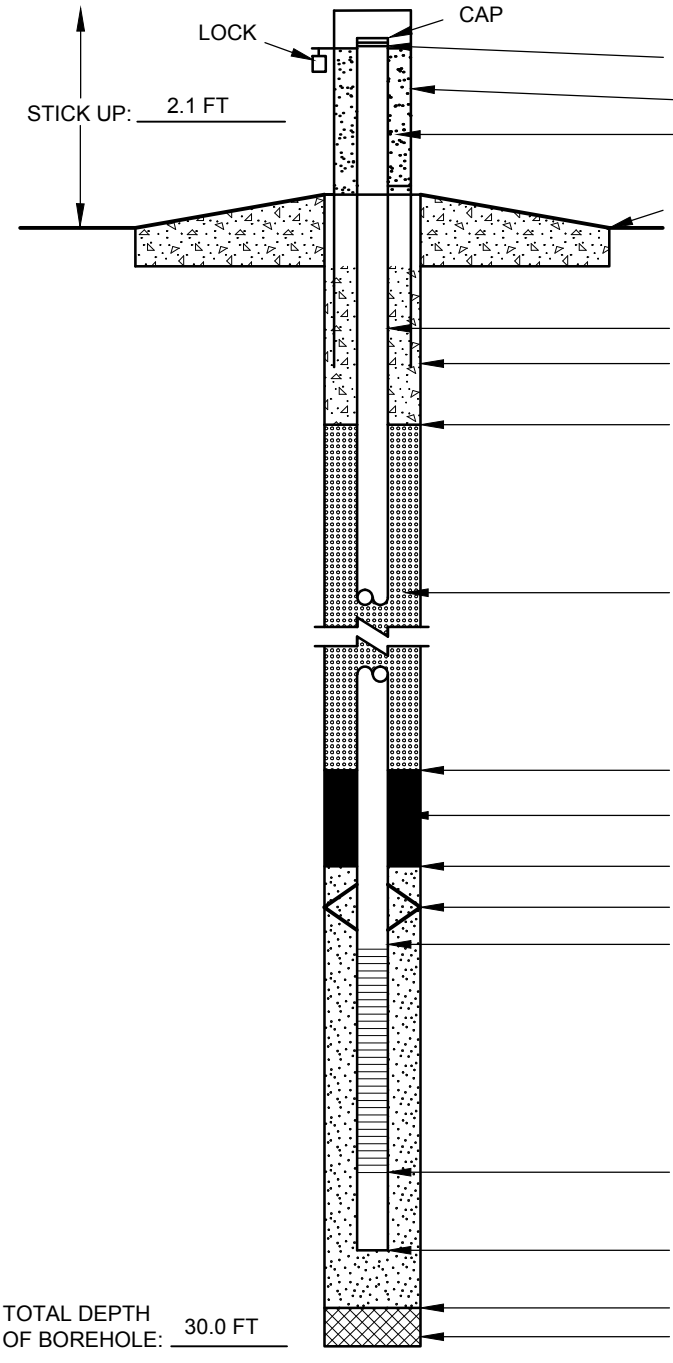
CHECKED BY: J. INGRAM

DATE CHECKED: 4/19/2016

PREPARED BY: AMEREN_J.SCOZZI

ABOVE GROUND MONITORING WELL CONSTRUCTION LOG BMW-2S

PROJECT NAME: AMEREN CCR GW MONITORING	PROJECT NUMBER: 153-1406.0001B	
SITE NAME: LABADIE ENERGY CENTER	LOCATION: BMW-2S	
CLIENT: AMEREN MISSOURI	SURFACE ELEVATION: 472.5 FT MSL	
GEOLOGIST: J. INGRAM	NORTHING: 987210.1	EASTING: 715104.3
DRILLER: J. DRABEK	STATIC WATER LEVEL: 14.30 FT BTOC	COMPLETION DATE: 2/02/2016
DRILLING COMPANY: CASCADE	DRILLING METHODS: SONIC	



TOP OF CASING ELEVATION: 474.56 FT MSL

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

PEA GRAVEL OR SAND

GROUND SURFACE ELEVATION: 472.5 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: 3/8" BENTONITE CHIPS - 4 BAGS

TOP OF SAND PACK DEPTH (ft. bgs): COARSE: 15.5 FINE: 15.0

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: 1/2 BAG

BOTTOM OF SCREEN DEPTH (ft. bgs): 27.7

BOTTOM OF WELL DEPTH (ft. bgs): 28.1

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.
100 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 FEBRUARY 11, 2016.
FT BTOC = FEET BELOW TOP OF CASING. SAND AND BENTONITE BAGS WEIGH 50 LBS EACH.

CHECKED BY: J. INGRAM

DATE CHECKED: 4/19/2016

PREPARED BY: J. SUOZZI

APPENDIX F
WELL DEVELOPMENT FORMS

Golder Associates WELL DEVELOPMENT/PURGING FORM

Project Ref: Ameren GW Monitoring **Project No.:** 153-1406.0001

Location TMW-2

Monitored By: JS Date 4/12/16 Time 0854

Well Piezometer Data

(circle one)

Depth of Well (from top of PVC or ground)	27.70	feet
Depth of Water (from top of PVC or ground)	13.07	feet
Radius of Casing	2	inches
	—	feet
Casing Volume	—	cubic feet
	≈6 gal · 3 = 18 gal	gallons

+30 gal from refilling
≈60 gal total

Development / Purging Discharge Data

Purging Method: waterra

Start Purging Date ~~4/12/16~~ 4/12/16 Time 0914

Stop Purging Date 4/12/16 Time 1140

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
	0935	40	9.97	6.00	1.128	71000	1.49	234.4	13.42	muddy
	0945	60	10.15	6.79	1.161	71000	2.47	162.8	13.31	muddy
	0955	80	10.47	6.64	1.145	71000	1.24	135.9	13.40	muddy, Remove surge block ★
	1005	90	10.35	6.72	1.157	493	1.05	76.0	13.41	muddy
	1015	105	10.47	6.75	1.166	208	0.73	86.4	13.39	cloudy
	1025	120	10.45	6.70	1.163	81.7	0.84	84.6	13.40	cloudy
	1035	130	10.44	6.69	1.162	50.6	0.99	68.8	13.40	cloudy
	1045	145	10.42	6.67	1.164	35.3	0.88	55.7	13.31	slightly cloudy
	1055	160	10.47	6.76	1.126	31.3	4.30	41.3	13.30	slightly cloudy
	1105	180	10.59	6.69	1.175	24.9	1.26	41.4	13.30	clear
	1115	195	10.43	6.76	1.173	19.9	1.68	37.8	13.30	clear
	1125	215	10.49	6.68	1.169	19.5	1.36	34.8	13.30	clear
	1135	230	10.52	6.69	1.167	20.0	1.89	31.5	13.28	clear

post Devt TD: 27.75

Dt water levels: 4.65 NTU

Golder Associates WELL DEVELOPMENT/PURGING FORM

Project Ref: Ameren GW Monitoring **Project No.:** 153-1406. 0001

Location TMW-3

Monitored By: JS Date 4/12/16 Time 1200

Well Piezometer Data

(circle one)

Depth of Well (from top of PVC or ground)	27.52	feet
Depth of Water (from top of PVC or ground)	12.18	feet
Radius of Casing	2	inches
	—	feet
Casing Volume	—	cubic feet
	6.4 · 3 = 21 gal	gallons

+30 gal H_2O from drilling = 51 gal total

Development / Purging Discharge Data

Purging Method: Waterra

Start Purging Date 4/12/16 Time 1217

Stop Purging Date 4/12/16 Time 1728

Monitoring

DI water reads: 4.95 NTU

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
4/12/16	1230	15	10.62	6.62	1.199	71000	4.19	55.4	12.48	muddy
	1240	20	11.14	6.84	1.195	71000	1.44	-47.4	12.39	muddy
	1250	30	11.06	6.99	1.212	71000	3.61	-59.9	12.40	muddy
	1300	37	11.42	6.89	1.203	71000	2.10	-57.6	12.39	muddy
	1310	47	11.16	6.84	1.218	71000	1.75	-49.5	12.35	muddy
	1320	62	11.50	6.70	1.220	71000	1.86	-47.9	12.34	muddy
	1330	72	11.55	6.85	1.202	71000	1.94	-46.4	12.35	muddy
	1340	80	11.60	6.78	1.247	71000	1.86	-49.6	12.33	Remove surge block
	1350	86	11.34	6.72	1.245	71000	3.23	-50.3	12.34	muddy
	1400	96	11.38	6.71	1.274	317	1.80	-54.7	12.34	cloudy
	1414	108	11.56	6.72	1.246	217	1.06	-52.8	12.33	cloudy
	1424	120	11.34	6.63	1.250	167	1.23	-41.3	12.33	cloudy
	1435	130	11.31	6.72	1.249	154	1.28	-57.8	12.33	cloudy
	1445	140	11.45	6.73	1.247	135	1.41	-55.0	12.33	cloudy
	1455	150	11.43	6.78	1.252	107	1.05	-61.9	12.32	cloudy
	1505	161	11.60	6.71	1.248	76.5	1.29	-58.6	12.32	cloudy
	1515	168	11.61	6.72	1.251	55.1	1.43	-63.1	12.32	cloudy
	1525	174	11.69	6.69	1.250	56.7	1.30	-56.0	12.31	cloudy
	1535	180	11.66	6.77	1.251	50.9	1.70	-58.4	12.32	cloudy
	1545	190	11.71	6.69	1.250	47.5	1.42	-56.7	12.32	cloudy
	1555	195	11.71	6.76	1.252	49.8	1.68	-57.3	12.32	cloudy
	1605	202	11.47	6.74	1.254	50.7	0.73	-59.3	12.31	cloudy
	1615	208	11.39	6.67	1.267	530	1.49	-55.9	12.32	cloudy
	1625	216	11.28	6.67	1.264	393	2.75	-54.5	12.31	very cloudy
	1655	225	11.14	6.40	1.257	184	3.11	-10.9	12.30	cloudy
	1705	245	11.35	6.77	1.264	147	2.97	-48.0	12.30	cloudy
	1715	252	11.25	6.80	1.267	143	1.28	-63.8	12.30	cloudy
	1725	261	11.29	6.68	1.266	136	1.60	-56.0	12.30	cloudy

Golder Associates WELL DEVELOPMENT/PURGING FORM

Project Ref: Ameren GW Monitoring **Project No.:** 153-1406.0001

Location BMW-15

Monitored By: JS Date 2/11/16 Time 1200

Well Piezometer Data

(circle one)

Depth of Well (from top of PVC or ground)	33.03	feet
Depth of Water (from top of PVC or ground)	13.52	feet
Radius of Casing	2	inches
	—	feet
Casing Volume	—	cubic feet
	7.3 · 3 = 22	gallons

+100 gal H_2O from drilling

122 gal H_2O

Development / Purging Discharge Data

Purging Method: Waterra

Start Purging Date 2/11/16 Time 1202

Stop Purging Date 2/11/16 Time 1437

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
2/11/16	1220	30	12.40	6.94	1.267	259	1.70	-57.0	13.60	v. cloudy
	1226	—	—	—	—	—	—	—		survey well
	1230	40	10.78	6.97	1.274	138	2.94	-46.1	13.65	cloudy
	1240	65	12.81	6.91	1.247	161	1.94	-45.1	13.71	cloudy
	1250	90	12.85	6.92	1.277	108	1.25	-47.2	13.71	cloudy
	1300	110	12.71	6.90	1.289	71000	4.33	-43.5	13.68	v. cloudy
	1320	145	11.48	6.89	1.078	467	6.72	+6.1	13.60	v. cloudy, remove surge block
	1340	150	9.41	6.81	1.214	71000	5.40	+4.7	13.53	v. cloudy, slow flow
	1350	154	8.68	6.76	1.229	71000	3.74	+7.6	13.54	v. cloudy
	1405	155	9.01	6.91	1.283	125	2.97	-3.0	13.55	cloudy
	1415	165	11.54	6.91	1.247	24.0	2.34	-9.2	13.59	clear
	1425	170	11.52	6.95	1.250	10.5	1.74	-14.6	13.60	clear
	1435	174	11.40	6.95	1.254	5.34	1.69	-17.3	13.63	clear

Post Dev't TD: 33.06

Golder Associates WELL DEVELOPMENT/PURGING FORM

Project Ref: Ameren GW Monitoring **Project No.:** 153-1406.0001

Location BMW-2S

Monitored By: JS Date 2/12/16 Time 0730

Well Piezometer Data

(circle one)

Depth of Well (from top of PVC or ground)	30.17	feet
Depth of Water (from top of PVC or ground)	14.34	feet
Radius of Casing	2	inches
	—	feet
Casing Volume	—	cubic feet
	6.4 • 3 = 25.2	gallons

+100 gal H_2O from drilling = 126 gal H_2O total

Development / Purging Discharge Data

Purging Method: Waterra

Start Purging Date 2/12/16 Time 0749

Stop Purging Date 2/12/16 Time 1152

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
2/12/16	0829	30	12.98	7.09	0.763	71000	2.30	144.9	14.40	muddy
	0840	40	13.04	7.37	0.755	71000	2.22	128.4	14.44	muddy
	0850	50	13.00	7.36	0.741	71000	2.24	104.7	14.43	muddy
	0900	60	13.31	7.32	0.741	71000	1.33	104.2	14.60	slightly muddy
	0910	70	13.27	7.29	0.737	71000	2.03	104.7	14.61	slightly muddy
	0920	80	12.89	7.26	0.739	71000	2.27	106.7	14.61	v. cloudy, remove surge block
	0930	90	13.56	7.28	0.730	71000	1.92	103.8	14.61	v. cloudy
	0940	100	13.76	7.28	0.731	71000	1.79	102.9	14.76	v. cloudy
	0950	120	12.56	7.17	0.731	22.1	1.78	111.2	14.62	clear
	1005	145	13.17	7.30	0.733	21.3	1.72	108.1	14.63	clear
	1012	150	11.10	7.32	0.751	84.1	1.78	106.9	14.39	cloudy, low flow
	1022	153	9.40	7.31	0.733	79.1	1.76	80.1	14.40	cloudy, low flow
	1032	156	10.91	7.33	0.737	150	2.04	103.4	14.49	v. cloudy, low flow
	1042	157	11.85	7.31	0.734	86.1	2.45	101.4	14.50	v. cloudy, low flow
	1052	159	12.32	7.31	0.729	69.9	2.31	99.1	14.45	cloudy, low flow
	1115	163	12.31	7.30	0.733	38.5	2.38	98.9	14.50	clear, low flow
	1130	170	12.32	7.32	0.727	21.6	2.30	96.0	14.54	clear, low flow
	1140	173	12.79	7.31	0.732	11.4	2.31	95.8	14.55	clear, low flow
	1150	176	12.87	7.31	0.733	7.25	2.43	92.2	14.55	clear, low flow

post Dev't TD: 30.15

Well Development Record

Location: Ameren Labadie Energy Center UWL						Date: 4/12/2013				
Well: MW-26						Initial Depth to Groundwater (ft, btoc):			16.5 ft	
Borehole Diameter: 8.25 in.						Base of Well (ft, btoc):			23.00 ft	
Casing Diameter: 2 in. ID (2.375 in. OD)						Filter Pack Height (ft, btoc):			10.5 ft	
Development method: Air lifted/ submersible pump						Screened Interval Lithology: Sand				
Date	Time	Purge Volume (cumulative) (gallons)	Casing Volume (gallons)	Annular Volume (gallons)	Tremie Volume (gallons)	pH (s.u.)	Specific Conductance (umhos/cm)	Temperature (^{o}C)	Initial Water Level (ft., btoc)	Water Clarity
4/12/13		5	1.0	5.1	13					Turbid
4/12/13	14:38	10				6.99	804	52.8	16.5	Clear
4/12/13	14:43	15				7.15	866	81.4		Clear
4/12/13	14:48	20				7.17	825	52.5		Clear
4/12/13	14:53	25				7.08	800	54.1		Clear
4/12/13	14:57	30				7.17	786	54.1		Clear
4/12/13	15:02	35				7.11	804	53.9		Clear
4/12/13	15:05	40				7.13	802	54.1	16.5	Clear
Comments: Air lifted 5 gallons, pumped 35 gallons										
Gallons Necessary: 31.3										
Gallons Extracted: 40										
Name: Christopher Cook, P.E.						Company: Reitz & Jens, Inc / Brotcke Well & Pump, Inc.				

Well Development Record

Location: Ameren Labadie Energy Center UWL						Date: 4/12/13				
Well: TMW-1						Initial Depth to Groundwater (ft, btoc):			17.8 ft	
Borehole Diameter: 8.25 in.						Base of Well (ft, btoc):			21.58 ft	
Casing Diameter: 2 in. ID (2.375 in. OD)						Filter Pack Height (ft, btoc):			9.3 ft	
Development method: Air Lift/ Submersible Pump						Screened Interval Lithology: Sand and silty sand				
Date	Time	Purge Volume (cumulative) (gallons)	Casing Volume (gallons)	Annular Volume (gallons)	Tremie Volume (gallons)	pH (s.u.)	Specific Conductance (umhos/cm)	Temperature (^{o}C)	Initial Water Level (ft., btoc)	Water Clarity
4/12/13		5	0.6	2.9	15					Turbid
4/12/13	11:26	10				7.25	1147	49.8	17.8	Clear
4/12/13	11:30	15				7.20	1100	51.9		Clear
4/12/13	11:39	20				7.20	1107	52.5		Clear
4/12/13	11:45	25				7.19	1112	51.9		Clear
4/12/13	11:52	30				7.21	1113	52.3	17.8	Clear
Comments: Air lifted 5 gallons, pumped 25 gallons										
Gallons Necessary: 25.7										
Gallons Extracted: 30										
Name: Christopher Cook, P.E.						Company: Reitz & Jens, Inc / Brotcke Well & Pump, Inc.				

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 00305961	DATE RECEIVED 05/26/2016
CR NO	CHECK NO. 170099
STATE WELL NO A206735 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 NUMBER
OWNER ADDRESS 370 S LINDBERGH BLVD	CITY ST LOUIS	STATE MO	ZIP 63127	
SITE NAME LABADRE ENERGY CNETER		WELL NUMBER TMW 2		COUNTY FRANKLIN
SITE ADDRESS 226 LABADRE POWER POINT RD		CITY LABADIE		STATIC WATER LEVEL 12.57 FT

SURFACE COMPLETION

TYPE	LENGTH AND DIAMETER OF SURFACE COMPLETION	DIAMETER AND DEPTH OF THE HOLE SURFACE COMPLETION WAS PLACED	SURFACE COMPLETION GROUT
[X] ABOVE GROUND	LENGTH 5.0 FT.	DIAMETER 12.0 IN.	[X] CONCRETE
[ ] FLUSH MOUNT	DIAMETER 4.0 IN.	LENGTH 2.5 FT.	[ ] OTHER

LOCATION OF WELL

LAT. 38 ° 33' 51.9"
LONG. 90 ° 49' 12.62"

SMALLEST 1/4 1/4 NW 1/4 LARGEST

SEC. 17 TWN. 44 NORTH
RANGE 2 Direction E

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

ELEVATION _____FT.

ANNULAR SEAL
LENGTH 0.0FT.

[ ] SLURRY [ ] CHIPS
[ ] PELLETS [ ] GRANULAR
[ ] CEMENT/SLURRY

IF CEMENT/BENTONITE MIX:

BAGS OF CEMENT USED:

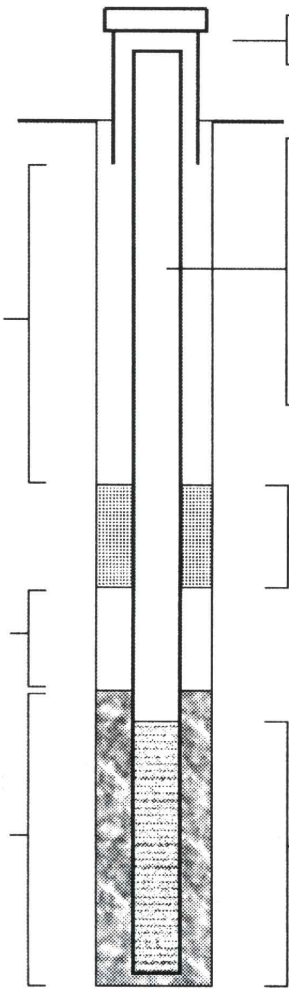
%OF BENTONITE USED:

WATER USED/BAG: GAL.

SECONDARY FILTER PACK
LENGTH: 1.0FT.

DEPTH TO TOP OF PRIMARY
FILTER PACK: 11.6FT.

LENGTH OF PRIMARY FILTER PACK: 13.4FT.



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

RISER
RISER PIPE DIAMETER 2.0IN.
RISER PIPE LENGTH 17.6FT.
HOLE DIAMETER 6.0IN.
WEIGHT OR SDR# SCH40

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

BENTONITE SEAL
LENGTH: 8.5
[ ] CHIPS [ ] PELLETS [ ] GRANULAR
[ ] SLURRY
[ ] SATURATED ZONE [ ] HYDRATED

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

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

DEPTH FROM	DEPTH TO	FORMATION DESCRIPTION
0.0	1.4	SLT
1.4	5.0	STY CLY
5.0	6.5	SND SLY SLT
6.5	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) x JEFFREY INGRAM	PERMIT NUMBER 006124	DATE WELL DRILLING WAS COMPLETED 04/06/2016

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 00305962	DATE RECEIVED 05/26/2016
CR NO	CHECK NO. 170099
STATE WELL NO A206736 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 NUMBER
OWNER ADDRESS 370 S LINDBERGH BLVD	CITY ST LOUIS	STATE MO	ZIP 63127	
SITE NAME LABADRE ENERGY CNETER		WELL NUMBER TMW 3		COUNTY FRANKLIN
SITE ADDRESS 226 LABADRE POWER POINT RD		CITY LABADIE		STATIC WATER LEVEL 9.35 FT

SURFACE COMPLETION

TYPE	LENGTH AND DIAMETER OF SURFACE COMPLETION	DIAMETER AND DEPTH OF THE HOLE SURFACE COMPLETION WAS PLACED	SURFACE COMPLETION GROUT
[X] ABOVE GROUND	LENGTH 5.0 FT.	DIAMETER 12.0 IN.	[X] CONCRETE
[ ] FLUSH MOUNT	DIAMETER 4.0 IN.	LENGTH 2.5 FT.	[ ] OTHER

LOCATION OF WELL

LAT. 38 ° 33' 53.09"
LONG. 90 ° 49' 22.97"

SMALLEST 1/4 1/4 NW 1/4 LARGEST

SEC. 17 TWN. 44 NORTH
RANGE 2 Direction E

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

ELEVATION _____FT.

ANNULAR SEAL
LENGTH 0.0FT.

[ ] SLURRY [ ] CHIPS
[ ] PELLETS [ ] GRANULAR
[ ] CEMENT/SLURRY

IF CEMENT/BENTONITE MIX:

BAGS OF CEMENT USED:

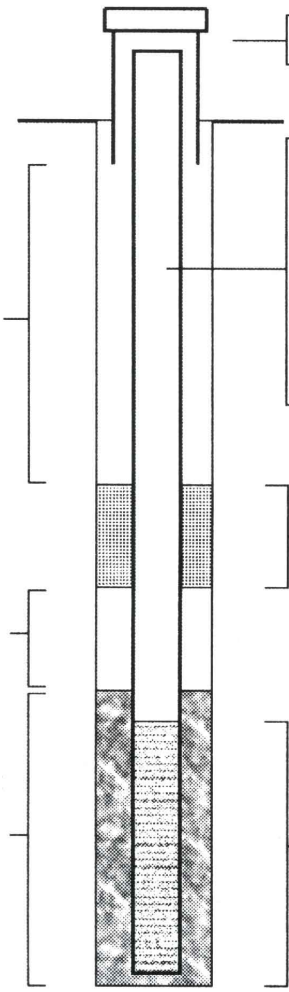
%OF BENTONITE USED:

WATER USED/BAG: GAL.

SECONDARY FILTER PACK
LENGTH: 1.0FT.

DEPTH TO TOP OF PRIMARY
FILTER PACK: 12.2FT.

LENGTH OF PRIMARY FILTER PACK: 12.8FT.



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

RISER
RISER PIPE DIAMETER 2.0IN.
RISER PIPE LENGTH 17.4FT.
HOLE DIAMETER 6.0IN.
WEIGHT OR SDR# SCH40

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

BENTONITE SEAL
LENGTH: 8.5
[ ] CHIPS [ ] PELLETS [ ] GRANULAR
[ ] SLURRY
[ ] SATURATED ZONE [ ] HYDRATED

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

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

DEPTH FROM	DEPTH TO	FORMATION DESCRIPTION
0.0	1.2	SLT
1.2	5.4	STY CLY
5.4	12.7	SDY CLY SLT
12.7	17.6	SND
17.6	20.0	SND
20.0	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) x JEFFREY INGRAM	PERMIT NUMBER 006124	DATE WELL DRILLING WAS COMPLETED 04/06/2016
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 00304710	DATE RECEIVED 03/14/2016
CR NO	CHECK NO. 170083
STATE WELL NO A206410 03/15/2016	REVENUE NO. 031416
ENTERED NRBASSM PH1 PH2 PH3 03/14/2016 03/15/2016 03/15/2016	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 NUMBER
OWNER ADDRESS 3750 S LINDEBERGH BLVD	CITY ST LOUIS	STATE MO	ZIP 63127	
SITE NAME LABADIE ENERGY CNETER		WELL NUMBER BMW1S		COUNTY ST LOUIS CITY
SITE ADDRESS BOLES RD		CITY ST LOUIS		STATIC WATER LEVEL 13.6 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

LOCATION OF WELL

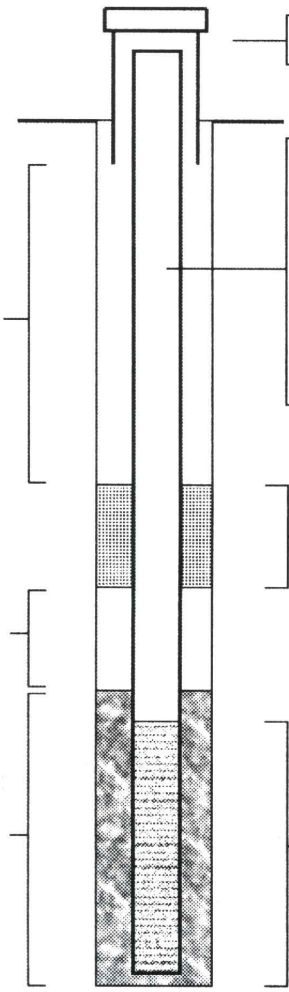
LAT. 38 ° 32' 50.0"
LONG. 90 ° 52' 2.68"

SMALLEST _____ 1/4 _____ 1/4 _____ 1/4 LARGEST

SEC. LG002577 TWN. _____ NORTH
RANGE _____ Direction E

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

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



- [ ] LOCKING CAP
- [ ] WEEP HOLE

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.

SECONDARY FILTER PACK
LENGTH: 1.0FT.

DEPTH TO TOP OF PRIMARY
FILTER PACK: 17.8FT.

LENGTH OF PRIMARY FILTER PACK: 13.2FT.

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

RISER
RISER PIPE DIAMETER 2.0IN.
RISER PIPE LENGTH 22.8FT.
HOLE DIAMETER 6.0IN.
WEIGHT OR SDR# SCH40

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

BENTONITE SEAL
LENGTH: 14.0
- [ ] CHIPS
- [ ] PELLETS
- [ ] GRANULAR
- [ ] SLURRY
- [ ] SATURATED ZONE
- [ ] HYDRATED

SCREEN
SCREEN DIAMETER: 2.0IN.
SCREEN LENGTH: 9.8FT.
DIAMETER OF DRILL HOLE: 6.0IN.
DEPTH TO TOP 21.2FT.

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

DEPTH FROM	DEPTH TO	FORMATION DESCRIPTION
0.0	6.5	CLY SLT
6.5	9.3	STY CLY
9.3	10.0	SND
10.0	17.6	STY SND
17.6	18.6	STY CLY
18.6	31.0	SND
		TOTAL DEPTH: 31.0 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 02/01/2016
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 _____

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DIVISION OF GEOLOGY AND LAND SURVEY
(573) 368-2165

MONITORING WELL CERTIFICATION RECORD

REF NO 00304712	DATE RECEIVED 03/14/2016
CR NO	CHECK NO. 170083
STATE WELL NO A206412 03/15/2016	REVENUE NO. 031416
ENTERED NRBASSM PH1 PH2 PH3 03/14/2016 03/15/2016 03/15/2016	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 NUMBER
OWNER ADDRESS 3750 S LINDEBERGH BLVD	CITY ST LOUIS	STATE MO	ZIP 63127
SITE NAME LABADIE ENERGY CNETER		WELL NUMBER BMW2S	COUNTY ST LOUIS CITY
SITE ADDRESS BOLES RD		CITY ST LOUIS	STATIC WATER LEVEL 14.3 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

LOCATION OF WELL

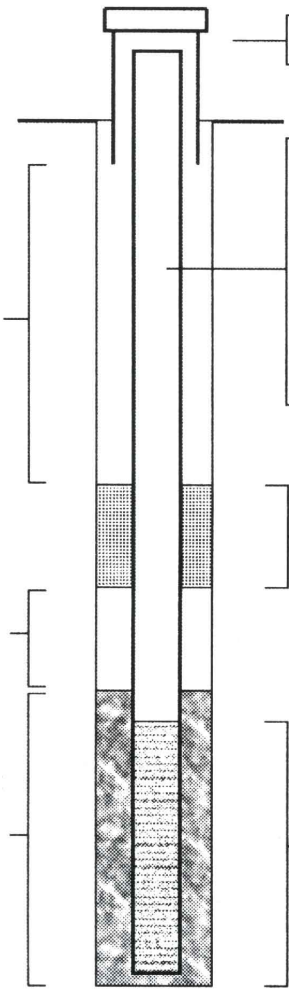
LAT. 38 ° 32' 39.4"
LONG. 90 ° 52' 2.97"

SMALLEST 1/4 1/4 LARGEST 1/4

SEC. LG002577 TWN. NORTH
RANGE Direction E

MONITORING FOR:
- [ ] RADIONUCLIDES
- [X] PETROLEUM PRODUCTS ONLY
- [ ] EXPLOSIVES
- [ ] 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

ELEVATION _____FT.

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

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

SECONDARY FILTER PACK
LENGTH: 0.5FT.

DEPTH TO TOP OF PRIMARY
FILTER PACK: 17.4FT.

LENGTH OF PRIMARY FILTER PACK: 12.6FT.

DEPTH FROM	DEPTH TO	FORMATION DESCRIPTION
0.0	4.0	CLY SLT
4.0	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 02/02/2016

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
00482866	05/09/2013
CR NO	CHECK NO.
	36619
STATE WELL NO	REVENUE NO.
A191668 05/30/2013	050913
ENTERED NRSMITK4	APPROVED BY / ROUTE
PH1 PH2 PH3	
05/10/2013 05/10/2013 05/10/2013	

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	CRAIG GIESMANN			
OWNER ADDRESS	CITY	STATE	ZIP	NUMBER
3700 SOUTH LINDBERGH BLVD	SUNSET HILLS	MO	63127	
SITE NAME		WELL NUMBER		COUNTY
AMEREN MISSOURI LABADIE ENERGY CTR		MW-26		FRANKLIN
SITE ADDRESS		CITY		STATIC WATER LEVEL
PROPOSED UTILITY WASTE LANDFIL 226 LABADIE POWER PLANT ROAD		LABADIE		14.0 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 24.0 IN.
- LENGTH 1.5 FT.

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

LOCATION OF WELL

LAT. 38 ° 33' 46.5"
LONG. 90 ° 49' 34.7"

SMALLEST 1/4 1/4 LARGEST NW 1/4

SEC. 17 TWN. 44 NORTH
RANGE 2 Direction E

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

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

- [ ] LOCKING CAP
- [ ] WEEP HOLE

ELEVATION _____FT.

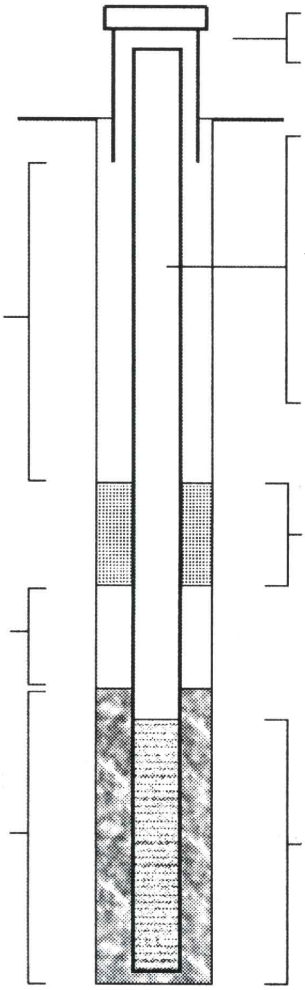
ANNULAR SEAL
LENGTH 0.0FT.
- [ ] SLURRY
- [ ] PELLETS
- [ ] CEMENT/SLURRY
- [ ] CHIPS
- [ ] GRANULAR

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

SECONDARY FILTER PACK
LENGTH: 0.0FT.

DEPTH TO TOP OF PRIMARY
FILTER PACK: 7.3FT.

LENGTH OF PRIMARY FILTER PACK: 12.7FT.



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

RISER
RISER PIPE DIAMETER 2.0IN.
RISER PIPE LENGTH 12.8FT.
HOLE DIAMETER 8.25IN.
WEIGHT OR SDR# SCH40

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

BENTONITE SEAL
LENGTH: 6.0
- [X] CHIPS
- [ ] PELLETS
- [ ] GRANULAR
- [ ] SLURRY
- [ ] SATURATED ZONE
- [ ] HYDRATED

SCREEN
SCREEN DIAMETER: 2.0IN.
SCREEN LENGTH: 10.2FT.
DIAMETER OF DRILL HOLE: 8.25IN.
DEPTH TO TOP 9.8FT.

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

DEPTH FROM	DEPTH TO	FORMATION DESCRIPTION
0.0	4.0	CLY
4.0	7.0	SLTY SND
7.0	20.0	SND

TOTAL DEPTH: 20.0 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 PAUL BROTCKE	002370	03/20/2013

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)	PERMIT NUMBER	SIGNATURE (APPRENTICE)	APPRENTICE PERMIT NUMBER
x JERRY HANCOCK	004497	x	

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

MONITORING WELL CERTIFICATION RECORD

REF NO 00482863	DATE RECEIVED 05/09/2013
CR NO	CHECK NO. 36619
STATE WELL NO A191665 05/30/2013	REVENUE NO. 050913
ENTERED NRSMITK4 PH1 PH2 PH3 05/10/2013 05/10/2013 05/10/2013	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	CONTACT NAME: CRAIG GIESMANN		VARIANCE GRANTED BY DNR NUMBER:
OWNER ADDRESS: 3700 SOUTH LINDBERGH BLVD	CITY: SUNSET HILLS	STATE: MO / ZIP: 63127	
SITE NAME: AMEREN MISSOURI LABADIE ENERGY CTR	WELL NUMBER: TMW-1		COUNTY: FRANKLIN
SITE ADDRESS: PROPOSED UTILITY WASTE LANDFIL 226 LABADIE POWER PLANT ROAD	CITY: LABADIE		STATIC WATER LEVEL: 15.3 FT

SURFACE COMPLETION

TYPE	LENGTH AND DIAMETER OF SURFACE COMPLETION	DIAMETER AND DEPTH OF THE HOLE SURFACE COMPLETION WAS PLACED	SURFACE COMPLETION GROUT
[X] ABOVE GROUND	LENGTH 5.0 FT.	DIAMETER 24.0 IN.	[X] CONCRETE
[ ] FLUSH MOUNT	DIAMETER 4.0 IN.	LENGTH 1.5 FT.	[ ] OTHER

LOCATION OF WELL

LAT. 38 ° 33' 44.7"
LONG. 90 ° 49' 12.7"

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

SEC. 17 TWN. 44 NORTH
RANGE 2 Direction E

MONITORING FOR:
[ ] RADIONUCLIDES [X] 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

ELEVATION ____ FT.

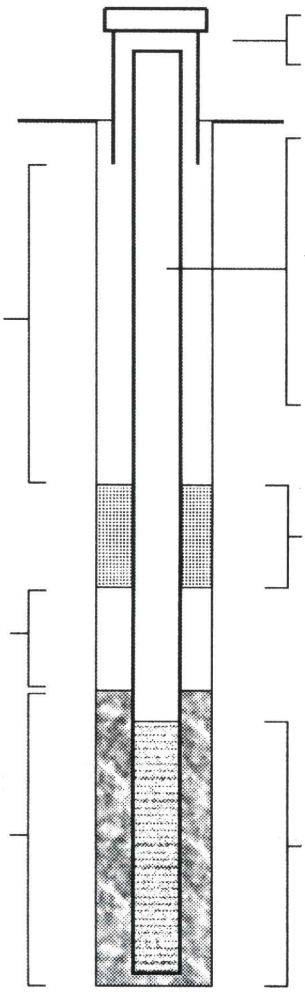
ANNULAR SEAL
LENGTH 0.0 FT.
[ ] SLURRY [ ] CHIPS
[ ] PELLETS [ ] GRANULAR
[ ] CEMENT/SLURRY

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

SECONDARY FILTER PACK
LENGTH: 0.0 FT.

DEPTH TO TOP OF PRIMARY
FILTER PACK: 6.4 FT.

LENGTH OF PRIMARY FILTER PACK: 12.6 FT.



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

RISER
RISER PIPE DIAMETER 2.0 IN.
RISER PIPE LENGTH 11.4 FT.
HOLE DIAMETER 8.25 IN.
WEIGHT OR SDR# SCH40

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

BENTONITE SEAL
LENGTH: 4.9
[X] CHIPS [ ] PELLETS [ ] GRANULAR
[ ] SLURRY
[ ] SATURATED ZONE [ ] HYDRATED

SCREEN
SCREEN DIAMETER: 2.0 IN.
SCREEN LENGTH: 10.2 FT.
DIAMETER OF DRILL HOLE: 8.25 IN.
DEPTH TO TOP 8.8 FT.

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

DEPTH FROM	DEPTH TO	FORMATION DESCRIPTION
0.0	6.0	CLY
6.0	7.0	CLY SLT
7.0	13.0	SLTY SND
13.0	19.0	SND

TOTAL DEPTH: 19.0 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 PAUL BROTCKE	PERMIT NUMBER 002370	DATE WELL DRILLING WAS COMPLETED 03/19/2013
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 JERRY HANCOCK	PERMIT NUMBER 004497	SIGNATURE (APPRENTICE) x ____ / APPRENTICE PERMIT NUMBER ____

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 LCL1 at the Labadie Energy Center, Franklin 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 10, 2017

Project No.153-1406

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) LCL1 at the Labadie Energy Center in Franklin 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.

Table of Contents

List of Tables

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
TMW-1	79	0.00047	0.35	0.5	4.7
TMW-2	79	0.00047	0.35	0.5	4.7
TMW-2	56	0.00047	0.35	0.5	6.6
TMW-3	78	0.00047	0.35	0.5	4.8
BMW-1S	128	0.00047	0.35	0.5	2.9
BMW-2S	112	0.00047	0.35	0.5	3.3

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:

- 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.

[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).

- 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 LCL1.

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 LCL1 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

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:

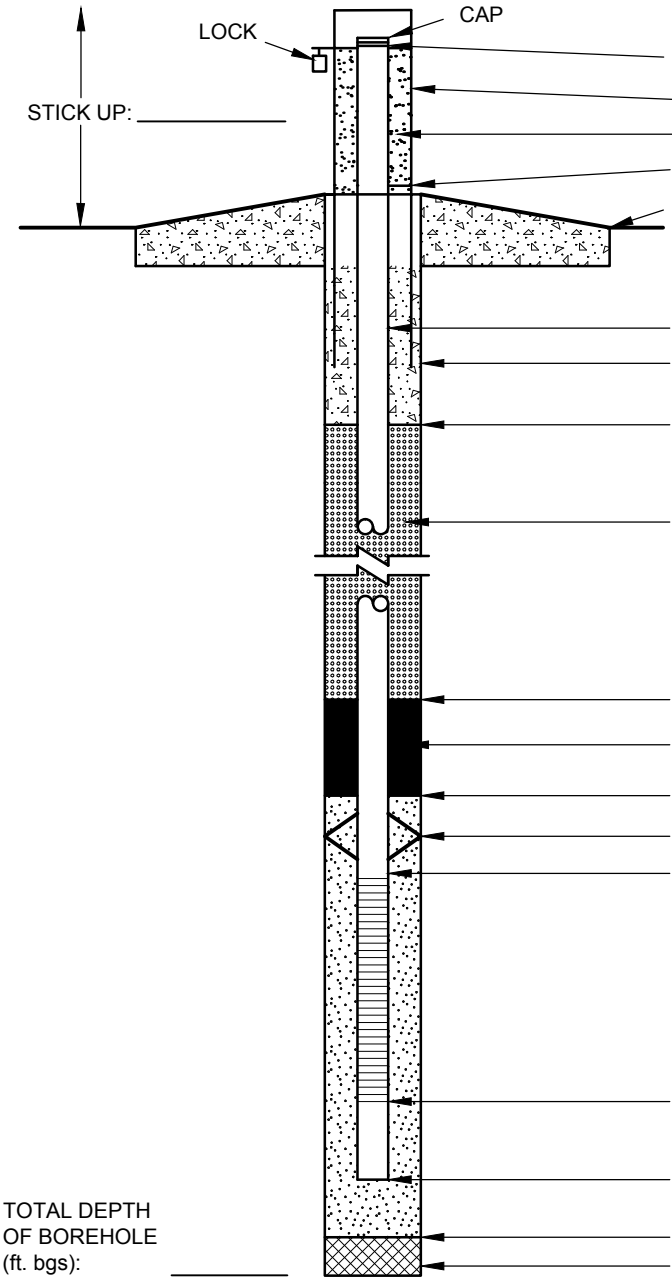
Bailer: PVC/PE Peristaltic Pump Air-Lift Pump

Stainless Steel Submersible Pump Other_____

Teflon Hand Pump

ABOVE GROUND MONITORING WELL CONSTRUCTION LOG _____

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: _____

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 ___

INSTRUMENT 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. (°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 _____/_____/_____/_____ **SAMPLER HAMMER TYPE** _____ **WT.** _____ **DROP** _____ **STARTED** _____/_____
WATER LEVEL CAVE-IN DATE-TIME NOTE TIME DATE

DEPTHS _____/_____/_____/_____ **HOLE LOCATION** _____ **COMPLETED** _____/_____
(DELAYED) WATER LEVEL CAVE-IN DATE-TIME NOTE 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 (PROPORTION; SIZE, SHAPE, GRADING; PLASTICITY)	BEHAVIOR CO or NC	MOIST. or W	DENS./ CONS.	USCS	SAMPLE DESCRIPTION AND DRILLING NOTES

Dec 2012

Golder Associates

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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Golder Associates

Engineering Earth's Development, Preserving Earth's Integrity