40 CFR Part 257.98
Corrective Action Groundwater Monitoring Plan

Meramec Surface Impoundments, Meramec Energy Center, St. Louis County, Missouri

Submitted to:

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Revision History

Version	Date	Description
0	November 2019	Corrective Action Groundwater Monitoring Plan
1	May 1, 2020	Added MW-9 and MW-10 to Corrective Action Monitoring Well Network. Removed proposed MW-12S and MW-12D from Monitoring Well Network. Changed location of MW-11S and MW-11D.

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1.0 INTRODUCTION

On August 30th, 2019, Ameren Missouri (Ameren) posted the "Selection of Remedy Report – 40 CFR § 257.97 Rush Island, Labadie, Sioux and Meramec CCR Basins" report to its publicly available website (Ameren 2019). This report selected the final remedy to be implemented to address groundwater contamination from the Meramec Surface Impoundments at Ameren's Meramec Energy Center (MEC or Facility) in St. Louis County, Missouri (see location on **Figure 1**).

This Corrective Action Groundwater Monitoring Plan (GMP) was developed pursuant to § 257.98(a)(1) of "Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals From Electric Utilities; Final Rule" (the CCR Rule). This section of the CCR Rule requires owners or operators establish and implement a Corrective Action GMP within 90 days of selecting a remedy. This Corrective Action GMP presents information on the design of the groundwater monitoring system, groundwater sampling and analysis procedures, groundwater statistical analysis methods, and data evaluation methods needed to complete the selected remedy of source control through installation of a low permeability cover system and use of Monitored Natural Attenuation (MNA) for groundwater impacts.

1.1 Overview of CCR Rule Activities for the Meramec Surface Impoundments

The CCR Rule was published in the Federal Register on April 17, 2015. This rule required CCR surface impoundments and landfills to monitor groundwater around these CCR units. Prior to the first major deadline of October 17, 2017, Ameren completed the following tasks: (1) installation of a groundwater monitoring well system; (2) a Statistical Method Certification; (3) a Groundwater Monitoring Plan (GMP) that details design, installation, development, sampling procedures, as well as statistical methods; and (4) eight baseline groundwater sampling events for all Appendix III and Appendix IV parameters of the CCR Rule. In November 2017, the first Detection Monitoring event was completed. Results from this event demonstrated some Appendix III parameters were present at concentrations that were a Statistically Significant Increase (SSI) over background and were then verified in January 2018 testing. In accordance with the CCR Rule, Ameren placed a "Notification of the Establishment of a CCR Assessment Monitoring Program" and began Assessment Monitoring within 90 Days.

Results from the Assessment Monitoring Events for the MEC surface impoundments indicated the presence of molybdenum, lithium and arsenic at a Statistically Significant Level (SSL) over the site Groundwater Protection Standard (GWPS) in several of the compliance wells. As required, Ameren placed a "Notification of the Detection of Statistically Significant Levels Above CCR Groundwater Protection Standards" on its website and commenced an assessment of potential Corrective Measures. On August 30th, 2019 subsequent to a public meeting held to discuss those findings, Ameren selected a final remedy of source control through installation of a low permeability cover system and use of MNA. Ameren has posted a "Notification of intent to Close a CCR Unit and Certification for Final Cover Design" and has commenced closure of the MEC surface impoundments and intends to complete closure by the end of 2023.

This Corrective Action GMP is designed to support the final remedy selection. At this time, molybdenum, lithium, and arsenic are the only parameters that were detected at an SSL above a site GWPS and are the focus of the MNA analysis.

2.0 SITE SETTING

The MEC is located approximately 18 miles southwest of downtown St. Louis in St. Louis County, Missouri. **Figure 1** depicts the location of the Facility and property boundaries referenced to local features, as well as the Meramec and Mississippi Rivers. The Facility encompasses approximately 480 acres and is primarily located in the topographical low area north of the confluence of the Mississippi and Meramec Rivers. The property is bounded to the northeast by wooded and partially developed land, to the southeast by the Mississippi River, to the southwest and west by the Meramec River and to the northwest by wooded and partially developed land.

2.1 Meramec Coal Combustion Residuals (CCR) Surface Impoundments

The MEC currently manages and has historically managed Coal Combustion Residuals (CCR) generated from the Facility at a number of surface impoundments. The surface impoundments onsite consist of:

- Active Surface Impoundments
  - Surface Impoundment 492 (MCPA), approximately 6 acres
  - Surface Impoundment 493 (MCPB), approximately 6 acres
  - Surface Impoundment 496 (MCPC), approximately 10 acres
  - Surface Impoundment 498 (MCPD), approximately 17 acres
- Closed Surface Impoundments
  - Surface Impoundment 489 (MCPE), approximately 24 acres
- Excluded Surface Impoundments
  - Surface Impoundment 490 (MOPF), approximately 23 acres
  - Surface Impoundment 491 (MOPG), approximately 12 acres
  - Surface Impoundment 494 (MOPH), approximately 31 acres
  - Surface Impoundment 495 (MOPI), approximately 16 acres (this unit is also partially closed)

According to the CCR Rule, all of the Meramec surface impoundments are considered to be unlined. However, Surface Impoundments 489 and 498 do have a liner in place. Since all the surface impoundments lie very close to one another and dividing berms were constructed with locally derived alluvial material and Coal Combustion Residuals (CCR), the groundwater monitoring network monitors the Meramec surface impoundments as one multi-unit system.

The present site grade is as much as 20 feet above the original ground surface. As part of the MEC plant construction project, the original grade of the plant was raised by using fill material. The ash ponds were reportedly made by excavating on-site silts and clays and using the materials as construction fill beneath the plant, as well as for surface impoundment berms (CH2MHILL, 1997). Reportedly, the Meramec surface impoundments were excavated approximately 10-20 feet below the original grade and then were used to contain the CCR. Therefore, present day ash thickness is reported to be typically 20 to 30 feet below the present site grade, which is considered to be nominally at approximately 420 feet above mean sea level (feet MSL)

(CH2MHILL, 1997). Based on this information, the generalized elevation of the base of the coal ash is estimated to be approximately 390 feet MSL.

CCR thickness was directly measured at three locations in Surface Impoundment 494 (MOPH) to be at least 26.5 feet thick (Golder, 2008) and at an elevation as low as approximately 387 feet MSL. CCR thickness was measured at two locations in Surface Impoundment 489 (Woodward-Clyde Consultants, 1988). The bottom of ash elevations were estimated to be 387.3 and 389.1 feet MSL.

2.2 Geology

2.2.1 Physiographic Setting and Regional Geology

The Facility is located in the extreme southeastern corner of the Central Lowland Physiographic Province and the Dissected Till Plains (Miller et al., 1974). However, the Facility lies between two major river systems near their confluence and within the floodplain of the Mississippi and Meramec Rivers in an area that contains alluvial river deposits. Therefore, the local site is characterized by alluvial floodplain landforms.

2.2.2 Local Geology

The geology immediately surrounding the Facility is comprised of two distinctly different geological terrains; (1) floodplain deposits of the Mississippi and Meramec River Valleys and (2) older sedimentary bedrock formations. Most of the Facility, including all the plant infrastructure and the Meramec surface impoundments, lie within these floodplain deposits. The river valley area is comprised of floodplain and alluvial deposits that are the result of the water flow and deposition of the Mississippi and Meramec Rivers.

Based on previous investigations, the alluvial materials on the east side of the Facility tend to have more clayey silts, silty clays, and fine sands (CH2MHILL, 1997). Alluvial materials to the west, closer to the Meramec River, include coarser materials, including fine- to medium-grained sand with clay, silt, and some gravels (CH2MHILL, 1997). The depth of the alluvial deposits near the MEC range from approximately 105 to 120 feet below ground surface (bgs) and become shallower towards the bluffs to the northeast.

Shannon and Wilson (1979) completed a geotechnical investigation in the area directly around the MEC. Sixteen (16) geotechnical borings were completed as a part of this investigation. Based on borings and cross sections from this report, the local geology directly adjacent to the MEC is as follows:

- Approximately 420-410 feet MSL – Fill Materials
- Approximately 410-375 feet MSL – Clays, Clayey Silts, and Silty Clays
- Approximately 375-340 feet MSL – Silts, Sandy Silts, Silty Sands, and Sands that thicken to the southeast towards the Mississippi River
- Approximately 340-320 feet MSL – Clays and Silty Clays
- Approximately 320-310 feet MSL – Intermittent Sands, Gravels, and Clayey Gravels
- Approximately 310 feet MSL and below – Limestone and Shale Bedrock

Drilling completed for the CCR Rule monitoring show similar results to previous studies. Borings located to the southwest of the MEC (MW-5, MW-6 and MW-7) encounter poorly and well graded sands that are likely associated with paleo channels and meanders of the adjacent Mississippi and Meramec Rivers. The sand in these wells becomes more prevalent at locations closer to the Mississippi River to the south/southeast. Drilling completed further from the Mississippi River to the northwest encountered more fine-grained materials such as silts, clays and silty clays with occasional sandy/gravelly lens deposits. These deposits are typical for low energy floodplain deposits with occasional sandy/gravel units from historical Meramec River channel meanders.

Bedrock beneath the Facility consists of the Warsaw Formation, of the Mississippian-aged Meramecian Series and consists of shales and fine-grained shaley limestone (CH2MHILL, 1997). The bluff area on the east side of the Facility consists of the Salem Formation at lower elevations and St. Louis Limestone at higher elevations (Middendorf and Brill, 2002).

2.3 Site Hydrogeology

Site hydrogeology has been characterized based on data collected during several different investigations. In 1988, 5 monitoring wells were installed around the MEC by Woodward-Clyde Consultants (Woodward-Clyde). Observations from these 5 monitoring wells is summarized below. CH2MHill (1997) also completed a hydrogeological assessment using the monitoring wells installed by Woodward Clyde.

Golder (2008) installed 5 piezometers both in and directly adjacent to Surface Impoundment 494. This effort provides information on the depth of ash in the Meramec surface impoundments, geotechnical data of the soil in and around the Meramec surface impoundments, and water level information in and around the Meramec surface impoundments.

Golder has completed over 20 monitoring wells, piezometers and borings as a part of the CCR Rule program (Golder 2017, Golder 2018, Golder 2019). **Figure 2** provides a generalized west-east depiction of the MEC surface impoundments referenced to local geology and the Meramec River.

2.3.1 Uppermost Aquifer

The CCR Rule requires that a groundwater monitoring system be completed in the uppermost aquifer around each Active CCR Surface Impoundment (§257.91(a)). The uppermost aquifer is the alluvial silt, sand and gravel deposits associated with the Meramec and Mississippi River Valley alluvium (CH2MHILL, 1997; Shannon & Wilson, 1979; Golder 2017). These channel deposits are intermixed with a wide variety of clay/silty clay floodplain deposits and, therefore, can appear at varying depths. However, sandy/gravelly units were encountered at many locations at approximately 360-370 feet MSL, likely deposited from a meandering paleo channel of the Meramec River. These alluvial deposits overlie Mississippian-age limestone and shale of the Meramecian Series. The depth of the alluvial aquifer typically ranges from approximately 105 to 120 feet bgs (approximately 255 to 331 feet MSL) but thins to the east toward the bluff (CH2MHILL, 1997), where it is not present at higher elevations above the floodplain.

2.3.2 CCR Surface Impoundments Water Elevations

Meramec pond gauge measurements were provided by Ameren for Surface Impoundments 492, 493, 496, and 498. These measurements were obtained during a similar timeframe as the groundwater measurements from each of the CCR Rule groundwater sampling events. Surface Impoundment 498 (MCPD) has had pond water levels ranging from approximately 415 to 418 feet MSL. This pond has a liner system in place and does not connect with the underlying aquifer or surrounding surface impoundments. The pond water level in Surface Impoundments 492, 493 and 496 (MCPA, MCPB and MCPC, respectively) ranged between approximately 408 and 412 feet MSL. These water levels ranged between 8 to 40 feet above the natural groundwater elevations in the surrounding aquifer. The difference between the pond level and the natural groundwater elevation is greatest when the Mississippi River level is low. Data show water mounding within the Meramec surface impoundments without a liner regardless of the river level; however, the mounding is less pronounced at times of high river level.

It is anticipated that after closure, the static water level in these CCR units will drop and will equilibrate with the surrounding alluvial aquifer static groundwater levels, thus eliminating the mounding effects of the active operating conditions.

2.3.3 Alluvial Aquifer Groundwater Elevations

Groundwater elevations within the alluvial aquifer in the Facility area have been obtained in several different studies. Historical groundwater measurements come from 5 monitoring wells installed in 1988 by Woodward-Clyde and then re-analyzed in 1997 by CH2MHILL. Three of the monitoring wells (B-4, B-5 and B-6) were installed with total depths ranging from 90 and 101 feet bgs. These three monitoring wells were located near Surface Impoundment 489 at the southwest corner of the Facility, near the Meramec River. Groundwater elevations in the downgradient monitoring wells near Surface Impoundment 489 ranged between approximately 377 and 385 feet MSL, and were similar to the concurrent Mississippi River level. Monitoring wells B-1 and B-2 were installed on the east (upgradient) side of the Facility with total depths ranging from 41 to 56 feet bgs. Groundwater elevations in these monitoring wells ranged from approximately 403 to 415 feet MSL and were typically 20 to 30 feet higher in elevation than the Mississippi River. Additionally, one monitoring well (B-7) was installed into the coal ash to an elevation of approximately 389 feet MSL and was dry in all readings (Woodward-Clyde, 1988).

Golder obtained groundwater elevation measurements from March 2016 through October 2019 within the alluvial aquifer for the CCR monitoring wells. For each of the sampling events, groundwater elevations were measured at monitoring wells within a 24-hour timeframe and a potentiometric map was generated from the data (**Appendix A**). Groundwater elevations ranged from approximately 370 feet MSL to 400 feet MSL excluding MW-1.

2.3.4 Alluvial Aquifer Groundwater Flow Direction

Groundwater flow within the alluvial aquifer is dynamic and is influenced by seasonal changes in the water level in the adjacent Mississippi and Meramec Rivers. River water levels measured at the Facility display large seasonal changes in the elevation of the Mississippi River water surface. For example, since April 2015 river water levels fluctuated between approximately 367 to 414 feet MSL (**Figure 3**). 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 Mississippi and Meramec Rivers, with a net flow direction generally to the southwest.

Figure 3: Mississippi River Elevation at MEC

Notes:

1) Mississippi River Elevations provided by Ameren.

Although the movement of groundwater within the alluvial aquifer at the Facility can be complex, the movement has been characterized by frequent groundwater elevation measurements and the generation of potentiometric surface maps generated by Golder (**Appendix A** and **Table 1**). The potentiometric surface maps display minor variability in the groundwater flow direction. These changes in flow direction are related to the level within the adjacent Mississippi and Meramec Rivers.

Groundwater flow direction and hydraulic gradient were estimated for the alluvial aquifer wells (Devlin 2002). Estimated results from this analysis are provided in **Table 2**. These results indicate that while groundwater flow direction is somewhat variable, overall net groundwater flow from 2015 to 2019 was generally toward the west/southwest, flowing from the bluffs toward the rivers.

Based on the potentiometric surface maps and groundwater calculations, a general flow direction from the northeast (bluffs) to the southwest (Mississippi and Meramec Rivers) under normal river conditions is expected. However, during periods of high river levels, groundwater flow can temporarily reverse in localized areas. 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 north and east occurs.

Horizontal and vertical groundwater flow within the uppermost aquifer has been locally influenced by operation of the Meramec surface impoundments. Ponding of water in the Meramec surface impoundments that do not have a liner in place at elevations greater than the static water levels in the underlying alluvial aquifer groundwater creates a localized mounding effect, resulting in localized downward gradients and localized radial groundwater flow downward and outward from these impoundments. It is anticipated that after closure, these downward gradients will be greatly reduced and effectively eliminated. The full effects of the closure on groundwater elevations will continue to be monitored after closure of the CCR units is completed, to see if there are any major changes to groundwater flow.

2.3.4.1 Horizontal Gradient

Horizontal groundwater gradients in the alluvial aquifer are typically low and flat. Site-wide horizontal gradients were also calculated for each of the CCR groundwater sampling events and the results of these are displayed on **Table 2**. The horizontal groundwater gradients are low, ranging from 0.0001 to 0.004 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 or lower especially in areas near the Mississippi and Meramec Rivers.

2.3.4.2 Vertical Gradient

A review of downward gradients observed in piezometers was completed by comparing groundwater elevations obtained by Golder during CCR Rule monitoring. This analysis was completed by comparing water levels from shallow and intermediate/deep zone piezometer locations where the piezometers are nested (two or more piezometers in close proximity, screened at different elevations). **Figure 4** displays the vertical gradients over time from the different well pairs. From the review of the data, areas away from the active MEC surface impoundments show relatively variable vertical gradients that fluctuate between upward and downward with no consistent vertical gradient present between shallow and deeper zones of the alluvial aquifer. The average vertical gradient in these wells is 0.0036 (very slightly upward), which further demonstrates the relatively flat gradient. There are no nested piezometers directly adjacent to the active CCR Units at the MEC, however based on the difference between the pond elevation and the groundwater elevations in the alluvial aquifer, there is likely a downward gradient from the mounding effect associated with the ponds in active condition. It is anticipated that once the MEC surface impoundments no longer receive CCR or water, the gradients will stabilize and will reflect those of the surrounding aquifer.

2.3.5 Hydraulic Conductivity and Groundwater Velocity

Golder performed rising head hydraulic conductivity tests on the 10 original CCR Rule monitoring wells in order to estimate the hydraulic conductivities. The tests were conducted using a pneumatic slug (Hi-K slug) and a downhole pressure transducer. Results from this testing demonstrate an average hydraulic conductivity of 2.35 x 10^{-2} centimeters per second (cm/sec) with a geometric mean of 1.4 x 10^{-2} cm/sec, a maximum of 6.52 x 10^{-2} cm/sec and a minimum of 9.91 x 10^{-4} cm/sec.

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 0.02 and 0.5 feet per day, and average approximately 79 feet (net) per year in the prevailing downgradient direction.

2.3.6 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 MW-6 and MW-8 using the ASTM D6912 Method B and the results are provided in the Detection/Assessment GMP for the MEC. MW-6 represents monitoring wells that were located closer to the Mississippi River and had more sandy environments, whereas MW-8 represents wells that contained gravel/silty sand environments that were further from the Mississippi River and are historical Meramec River channels. The results indicate that the screened intervals of the alluvial aquifer near the Mississippi River 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 PROGRAM

3.1 Groundwater Monitoring Well Network

For Corrective Action, the CCR Rule requires a demonstration that compliance with the GWPS has been achieved at all points within the plume of contamination that lie beyond the initial Detection and Assessment Monitoring well networks (§ 257.98(c)(1)). To meet with these requirements, a Corrective Action Monitoring Well Network has been established. Monitoring wells to be used for this network are identified below in **Table 3** and their locations, in addition to the wells used for Detection and Assessment Monitoring networks are provided in **Figure 5**.

Table 3 –Corrective Action Groundwater Monitoring Well Network

Shallow Zone of the Alluvial Aquifer	Intermediate/Deep Zone of the Alluvial Aquifer
MW-9	TP-1
MW-10	TP-2
MW-11S	MW-11D

3.2 Groundwater Sampling Frequency and Parameters

3.2.1 CCR Rule Minimum Requirements

The CCR Rule has specific minimum requirements for sampling frequency and parameters. At a minimum, sampling must meet the requirements of an Assessment Monitoring Program (§257.95). Therefore, the minimum monitoring well sampling frequency would be three sampling events the first year, followed by semi-annual sampling thereafter. Minimum requirements for sampling parameters are that all Appendix IV parameters must be tested at least annually, with only detected Appendix IV parameters required for subsequent events. Appendix III parameters must also be tested at least semi-annually. **Table 4** displays the parameters associated with Appendix III and IV, as well as other MNA parameters.

Table 4 – Sampling Parameters List

Groundwater Parameters			
Parameter	**Method**	**Parameter**	**Method**
Appendix III Parameters		**Cations & Anions**	
Boron	200.7	Alkalinity	SM 2320B
Calcium	200.7	Iron	200.7
Chloride	EPA 300.0	Magnesium	200.7
Fluoride	EPA 300.0	Manganese	200.7
pH	NA	Potassium	200.7
Sulfate	EPA 300.0	Sodium	200.7
Total Dissolved Solids	SM2540C	**Other Parameters**	
Appendix IV Parameters		Sulfide	SM4500-S2D
Antimony	200.8	**Iron Speciation**	
Arsenic	200.8	Ferrous Iron	SM3500-Fe-D
Barium	200.7	Ferric Iron	Calculation
Beryllium	200.7		
Cadmium	200.8		
Chromium	200.8		
Cobalt	200.7		
Fluoride	EPA 300.0		
Lead	200.7		
Lithium	200.7		
Mercury	EPA7470A		
Molybdenum	200.7		
Radium 226	EPA 903.1		
Radium 228	EPA 904.0		
Selenium	200.8		
Thallium	200.8		

Notes:

1) The methods provided are those currently used for Detection/Assessment Monitoring. Methods may be adjusted in the future as analytical methods evolve and detection limit adjustments are needed.

3.2.2 Prior to Completion of Source Control

The first step in the selected remedy is to provide source control through the installation of a low permeability cover system. In the time prior to the cap completion, the requirements of the CCR Rule will be met with completion of three sampling events for the Corrective Action monitoring wells in 2020 and the subsequent years as follows:

1) Q2 2020 (~April) – An initial sampling event for all Appendix IV parameters at all monitoring wells.

2) Q2 2020 (~May) – Sampling event within 90 days for all detected Appendix IV parameters and all Appendix III parameters.

3) Q4 2020 (~November) – Semi-annual sampling event for all detected Appendix IV parameters and all Appendix III parameters.

4) Q2 2021+ (~May) – Semi-annual sampling event for all Appendix III and IV parameters at all monitoring wells.

5) Q4 2021+ (~November) - Semi-annual sampling event for all detected Appendix IV parameters and all Appendix III parameters.

These sampling events are subject to change depending on unforeseen conditions such as flooding, etc.

In addition to the requirements of the CCR Rule, in order to complete Corrective Action statistical analysis, a minimum of 4 samples are required and 8 samples are recommended by the Unified Guidance (USEPA 2009). Parameters that have been detected at an SSL should have a minimum of 8 sample results for analysis prior to MEC pond closure completion.

Also, several parameters such as major cations/anions, iron speciation and sulfide are very beneficial for MNA analysis and are needed to demonstrate that MNA is occurring. Major cations and anions will be tested from each Corrective Action monitoring well sample during each sampling events. Iron speciation and sulfide will be tested annually along with the sampling event for all Appendix IV and III parameters. **Table 4** provides a list of the parameters to be sampled for groundwater sampling.

3.2.3 Long-Term Performance Monitoring

Once source control is completed, long-term monitoring of MNA and statistical compliance will be initiated. In order to comply with the requirements of the CCR Rule, sampling will be completed on a semi-annual basis. For this sampling, the first sampling event each year will test for all Appendix III and IV parameters. Additionally, for MNA evaluation, major cations, anions, iron speciation, and sulfide will be tested. During the second event of each year, samples will be tested for Appendix IV parameters that were detected during that year’s first sampling event, as well as all Appendix III parameters and major cations/anions will be tested.

3.3 Groundwater Level Measurements

To meet the requirements of §257.93(c), water level measurements will be taken at all monitoring wells to be sampled and prior to the start of any groundwater purging at the monitoring well. 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. 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. In addition, other monitoring wells or piezometers that may be beneficial for groundwater elevation mapping may also be measured.

3.4 Groundwater Sampling Methods and Procedures

Sampling will be performed in accordance with generally accepted practices within the industry and Missouri requirements. **Appendix B** provides details of procedures used to collect groundwater samples.

4.0 DATA EVALUATION AND REPORTING

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

4.1 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, as well as groundwater flow directions. Additional software or analysis (Modflow, USEPA gradient calculator, etc.) may also be used as applicable for groundwater flow analysis.

4.2 Data Validation

Before the data are used for statistical analysis, they will be evaluated by examining the quality control data in the laboratory report. 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 anomalous data.

4.3 Statistical Evaluations for Corrective Action

Upon completion of the data validation, Corrective Action statistical analysis will be completed to determine if groundwater concentrations are present at a level statistically above or below the site-specific GWPS. 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. Once the statistical evaluation is completed, the results will be placed in the operating record. The data will be analyzed using the methods and procedures outlined in the Statistical Analysis Plan (**Appendix C**).

As specified in 257.98(C) of the CCR Rule, in order to complete Corrective Action monitoring the following must be demonstrated:

- Compliance with the GWPS at all points within the plume of contamination that lie beyond the Detection/Assessment Monitoring groundwater monitoring well system.
- Compliance with the GWPS where concentrations of constituents listed in Appendix IV to this part have not exceeded the GWPS for a period of three consecutive years.

Additionally, because Corrective Action and its effects on the groundwater regime should result in changes in plume concentrations and size over time, individual monitoring wells may be removed from Corrective Action monitoring once concentrations are below the GWPS for three consecutive years. As outlined in the CCR Rule, the Corrective Action Program will be deemed complete once all points within the plume beyond the Detection/Assessment Monitoring groundwater monitoring well system are statistically within compliance of the GWPS for three consecutive years. Once this demonstration can be made, a notification stating that the remedy has been completed is required to be posted to the operating record and the publicly available website. This notification must be certified by a Professional Engineer.

4.4 Data Evaluation to Demonstrate MNA

The CCR Rule (§ 257.98(a)(1)(ii)) requires that the Corrective Action GMP provide a way to document the effectiveness of the Corrective Action remedy. The statistical analysis is required by the CCR Rule in order to determine when monitoring wells are in compliance with the GWPS and are the basis of removing the CCR unit from Corrective Action, however, these statistical methods do not directly indicate if MNA is occurring. Multiple lines of evidence and analysis can be used to evaluate the effectiveness of the remedy. Methods that may be used for evaluating and demonstrating the MNA is occurring are as follows:

1) **Well Specific Constituent Trend Graphs:** Constituent concentration versus time graphs can be used to determine if concentrations are behaving as anticipated or if unexpected conditions are occurring. Decreasing trends of constituents over time can be used to assess the progress of MNA. Increasing trends could represent a new source, unanticipated plume behavior, a change in ambient conditions, or a possible increase of transformation products.

2) **Concentration Maps:** Concentrations of constituents plotted in 2D, 3D, or cross-sectional view can be used to define the extents and concentrations within the plume at a given time. Comparison of the plume extents, location, size, configuration, concentrations, and center of mass which will allow for an assessment of MNA progress and an identification of potential migration patterns.

3) **Geochemical Analysis:** Completion of geochemical analysis such as Piper and Stiff diagrams can provide information on water chemistry changed over time and/or spatial area. Changes in chemistry over time can show that MNA is occurring. Changes may also identify possible changes in ambient conditions, which may change estimates of MNA timeframes, etc.

These methods are examples of initial methods to evaluate MNA and remedy effectiveness. Other methods may be used in the evaluation as the monitoring program progresses.

4.5 Verify no Adverse Impacts to Downgradient Receptors

One key objective in any MNA program is to verify that there are no adverse impacts to downgradient receptors. A human health risk assessment for the site was completed by Haley & Aldrich in 2018. From this assessment, the potential downgradient receptors are:

1. Users of the Mississippi and Meramec Rivers including people who used the rivers for recreational activities that may bring them into direct contact with the rivers.
2. The drinking water intake located approximately 51.2 miles downstream from the MEC at the Chester Intake.

Multiple rounds of surface water samples collected from the Mississippi and Meramec Rivers adjacent to the MEC have shown no impact from the MEC to these rivers. Calculated Risk-Based Screening Levels for the Mississippi River were generated in the Haley & Aldrich 2018 report that provides a conservative groundwater target level (or threshold) that is protective of the rivers. For each constituent, the lowest of the human health drinking water, recreational, and ecological screening levels is used. A dilution factor (100,000 for the Mississippi River and 700 for the Meramec River) is then applied to the lowest screening level for surface water and results in the Calculated Risk-Based Screening Level.

In order to verify that there are no adverse impacts to downgradient receptors, groundwater concentrations adjacent to the Meramec and Mississippi Rivers will continue to be monitored, and if concentrations in these monitoring wells reach the calculated risk-based thresholds, the following actions will be taken:

- The monitoring well that displayed the impacts will be re-sampled for verification.
- If verified, a surface water sampling plan will be prepared and surface water sampling in the Mississippi and/or Meramec Rivers will be completed.

4.6 Monitoring Well Network Review and Long-Term Monitoring Well Network Optimization

Annual review of the monitoring well network will be completed to evaluate if the current network is still accurately monitoring MNA at the site. This review will be completed to determine if any monitoring wells should be added or removed from the network. This review will be based on data reviews completed above, as well as professional judgment. In addition, monitoring well network optimization programs may be used to determine if any changes to the network are warranted.

4.7 Supplemental Corrective Measures

Groundwater treatment technologies are being evaluated to determine if treatment may be able to supplement the selected remedy. Pilot studies and additional treatment testing may be performed at the MEC as a supplemental corrective measure. If treatment is to be used as a supplemental corrective measure, this monitoring plan may be updated to include the groundwater monitoring requirements and methods associated with evaluating and monitoring the supplemental corrective measure.

4.8 Annual Groundwater Monitoring and Corrective Action Report

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), compliance monitoring wells installed under § 257.91 of the CCR Rule (MEC GMP, Detection and Assessment Monitoring well network), and the Corrective Action Monitoring well network discussed in this GMP
- 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 required by Detection, Assessment and Corrective Action Monitoring
- A demonstration, if appropriate, for an alternative groundwater sampling frequency for Detection, Assessment or Corrective Action Monitoring
- 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, Assessment or Corrective Action Monitoring

- 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 demonstrating that any new Detection or Assessment Monitoring SSIs or SSLs over background are not due to the release from the Facility
- A listing of GWPS for both Assessment and Corrective Action Monitoring

In addition to the requirements of the CCR Rule, additional information on the evaluation of MNA, treatability studies, or risk assessments may also be included in the Annual Report, if applicable.

5.0 REFERENCES

Ameren Missouri, 2018. Remedy Selection Report – 40 CFR §257.97 Rush Island, Labadie, Sioux and Meramec CCR Basins.

CH2MHILL, 1997. Hydrogeologic Assessment of Potential Impacts of Meramec Ash Ponds on Local Groundwater and Surface Water. Prepared for Union Electric Company, Meramec Plant, and December 16, 1997.

Das, B. 2008. Advanced Soil Mechanics. Taylor & Francis, London & New York.

Devlin, 2002. A Spreadsheet Method for Estimating Hydraulic Gradient With Heads From Multiple Wells" submitted to Ground Water.

Electric Power Research Institute (EPRI), 2015. Monitored Natural Attenuation for Inorganic Constituents in Coal Combustion Residuals. Technical Report.

Fetter, C.W. 2000. Applied Hydrogeology, Fourth Edition. Pearson Education.

Freeze, R. Allan and Cherry, John A. 1979. Groundwater. Prentice-Hall Inc.

Golder Associates Inc. 2008. Ash Pond #494 Drilling and Piezometer Installation – Meramec Plant, St. Louis County, Missouri. Prepared for AmerenUE, February 26, 2008.

Golder Associates Inc. 2017. 40 CFR Part 257 Groundwater Monitoring Plan, Meramec Surface Impoundments, Meramec Energy Center- St. Louis County, Missouri, USA.

Golder Associates Inc. 2018. 2017 Annual Groundwater Monitoring Report, Meramec Surface Impoundments, Meramec Energy Center- St. Louis County, Missouri, USA.

Golder Associates Inc. 2019. 2018 Annual Groundwater Monitoring Report, Meramec Surface Impoundments, Meramec Energy Center- St. Louis County, Missouri, USA.

Haley and Aldrich, 2018. Human Health and Ecological Assessment of the Meramec Energy Center.

Haley and Aldrich, 2019. Corrective Measures Assessment – Ameren Missouri Meramec Energy Center St. Louis County, Missouri.

ITRC, 2010. A Decision Framework for Applying Monitored Natural Attenuation Processes to Metals and Radionuclides in Groundwater. Technical/Regulatory Guidance.

Johnson, A.I. 1967. Specific Yield – Compilation of Specific Yields for Various Materials: U.S. Geological Survey Water-Supply Paper 1662-D. Available at: https://pubs.er.usgs.gov/publication/wsp1662D.

MDNR. 2011. Missouri Well Construction Rules. Missouri Department of Natural Resources Division of Geology and Land Survey. Rolla, MO. August 2011.

Middendorf, M.A., and Brill, K.G. 2002. Bedrock Geologic Map of the Oakville 7 1/2' Quadrangle, Missouri. Missouri Department of Natural Resources, Division of Geology and Land Survey.

Miller et al., 1974. Water Resources of the St. Louis Area, Missouri. Missouri Geological Survey and water Resources and U.S. Geological Survey.

Shannon & Wilson, INC. 1979. Geotechnical Investigation – Meramec Plant Retrofit – Union Electric Company – St. Louis, Missouri. Prepared for Union Electric Company, April 1979.

USEPA, 2007a. Monitored Natural Attenuation of Inorganic Contaminants in Ground Water. Volume 1. Technical Basis for Assessment. EPA/600/R-07/139.

USEPA. 2010. Low Stress (Low Flow) Purging and Sampling Procedure for the Collection of Groundwater Samples From Monitoring Wells., U.S. Environmental Protection Agency, Revised January 19, 2010.

USEPA. 2015. 40 CFR Parts 257 and 261 Hazardous and Solid Waste Management System: Disposal of Coal Combustion Residuals From Electric Utilities. Environmental Protection Agency. April 17, 2015.

Woodward-Clyde Consultants, 1988. Report of Hydrogeological Investigation and Monitor Well Installation Program Meramec Power Plant. Prepared for Union Electric Company, April 5, 1988.

Tables

Table 1
Groundwater Elevation Measurements
Meramec Energy Center
St. Louis County, Missouri

	Well ID	Location		Top of Casing	Ground Surface Elevation	Date Installed	3/28/2016		5/13/2016		7/18/2016		9/7/2016		11/10/2016		1/6/2017		3/7/2017		6/14/2017		11/6/2017	
		Northing	Easting	FT MSL	FT MSL		DTW	GWE	DTW	GWE	DTW	GWE	DTW	GWE	DTW	GWE	DTW	GWE	DTW	GWE	DTW	GWE	DTW	GWE
CCR Rule Groundwater Monitoring Wells	MW-1	937676.9	865954.1	406.43	404.10	1/23/2016	4.83	401.60	2.61	403.82	5.57	400.86	4.72	401.71	5.36	401.07	7.08	399.35	5.55	400.88	2.46	403.97	7.43	399.00
	MW-2	937325.1	864864.5	398.62	396.13	1/23/2016	12.76	385.86	3.54	395.08	14.79	383.83	11.69	386.93	16.42	382.20	19.10	379.52	13.25	385.37	7.72	390.90	19.29	379.33
	MW-3	936750.8	864447.2	397.12	394.63	1/22/2016	11.30	385.82	2.07	395.05	13.27	383.85	10.15	386.97	14.93	382.19	17.62	379.50	11.81	385.31	6.23	390.89	17.78	379.34
	MW-4	935618.0	864629.8	404.10	402.03	1/22/2016	18.17	385.93	9.13	394.97	20.02	384.08	16.48	387.62	21.65	382.45	24.43	379.67	18.93	385.17	13.08	391.02	24.50	379.60
	MW-5	934874.4	864781.0	402.93	400.83	1/22/2016	16.94	385.99	7.93	395.00	18.67	384.26	15.65	387.28	20.27	382.66	23.14	379.79	17.83	385.10	11.69	391.24	23.13	379.80
	MW-6	933905.2	865153.5	418.12	415.84	1/21/2016	32.26	385.86	23.33	394.79	33.56	384.56	30.56	387.56	35.11	383.01	38.29	379.83	33.64	384.48	26.49	391.63	37.99	380.13
	MW-7	934334.4	866242.5	417.94	415.67	1/24/2016	32.01	385.93	23.04	394.90	33.32	384.62	30.37	387.57	34.68	383.26	37.79	380.15	33.52	384.42	26.39	391.55	37.53	380.41
	MW-8	935303.6	866797.8	423.37	421.03	1/24/2016	36.68	386.69	27.46	395.91	38.07	385.30	35.14	388.23	39.60	383.77	42.59	380.78	37.57	385.80	31.27	392.10	42.59	380.78
	BMW-1	935220.4	867989.4	419.08	416.79	4/7/2016	24.40	394.68	19.78	399.30	28.16	390.92	24.96	394.12	27.41	391.67	32.64	386.44	28.51	390.57	22.49	396.59	34.14	384.94
	BMW-2	937927.1	866342.2	409.02	406.80	1/25/2016	14.21	394.81	11.22	397.80	15.45	393.57	14.58	394.44	15.36	393.66	17.29	391.73	15.71	393.31	11.39	397.63	17.85	391.17
Temporary Piezometers	MW-9 (AMW-1)	935106.5	864425.3	393.71	391.12	6/20/2018	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	MW-10 (AMW-2)	934137.4	867158.9	405.62	402.83	6/19/2018	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	TP-1	935109.7	864437.0	393.71	390.68	6/20/2018	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	TP-2	934151.5	867171.1	405.22	402.35	6/18/2018	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Background Investigation	BMW-3	938110.9	865000.6	396.16	393.45	1/24/2019	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	BMW-4	938425.9	864543.5	396.34	393.52	1/23/2019	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	BMW-5	938750.3	864082.0	402.05	399.53	1/23/2019	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
River Level	Mississippi River	934893	868520	NA	NA	NA	NA	386.59	NA	395.52	NA	384.25	NA	387.53	NA	382.37	NA	380.70	NA	385.77	NA	390.10	NA	379.80
Pond Gauges	MCPA, MCPB, MCPC	937490	865938	NA	NA	NA	NA	408.30	NA	408.20	NA	409.00	NA	409.00	NA	410.10	NA	409.00	NA	410.60	NA	411.50	NA	409.60
	MCPD	936384	865935	NA	NA	NA	NA	417.05	NA	417.15	NA	417.20	NA	417.20	NA	417.30	NA	417.50	NA	417.20	NA	417.20	NA	NA

Notes:
1.) CCR - Coal Combustion Residuals.
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.) NA - Not Applicable.
6.) Horizontal Datum: State Plane Coordinates NAD83 (2000) Missouri East Zone feet.
7.) Vertical Datum: NAVD88 feet.
8.) Mississippi River Level and Pond Gauge elevations are provided by Ameren.
9.) Mississippi River gauge location is estimated.
10.) BG - Below gauge.

Prepared By: JSI
Checked By: EMS
Reviewed By: MNH

Table 1
Groundwater Elevation Measurements
Meramec Energy Center
St. Louis County, Missouri

	Well ID	1/2/2018		4/3/2018		5/17/2018		7/23/2018		8/21/2018		9/25/2018		11/19/2018		1/9/2019		1/28/2019		2/26/2019		8/12/2019		10/3/2019	
		DTW	GWE	DTW	GWE	DTW	GWE	DTW	GWE	DTW	GWE	DTW	GWE	DTW	GWE	DTW	GWE	DTW	GWE	DTW	GWE	DTW	GWE	DTW	GWE
CCR Rule Groundwater Monitoring Wells	MW-1	10.58	395.85	4.00	402.43	4.02	402.41	4.64	401.79	6.80	399.63	4.74	401.69	3.96	402.47	3.66	402.77	3.72	402.71	3.59	402.84	2.54	403.89	1.18	405.25
	MW-2	27.44	371.18	10.36	388.26	7.22	391.40	11.49	387.13	18.90	379.72	11.21	387.41	9.54	389.08	10.97	387.65	16.71	381.91	6.86	391.76	9.65	388.97	NA	NA
	MW-3	26.18	370.94	8.91	388.21	5.75	391.37	10.01	387.11	17.39	379.73	9.67	387.45	8.03	389.09	9.44	387.68	15.18	381.94	5.45	391.67	8.02	389.10	NA	NA
	MW-4	33.50	370.60	15.72	388.38	12.75	391.35	16.92	387.18	24.22	379.88	16.47	387.63	14.87	389.23	16.23	387.87	21.70	382.40	12.64	391.46	14.80	389.30	5.54	398.56
	MW-5	32.28	370.65	14.44	388.49	11.60	391.33	15.67	387.26	22.95	379.98	15.17	387.76	13.54	389.39	14.82	388.11	20.17	382.76	11.50	391.43	13.44	389.49	4.55	398.38
	MW-6	47.26	370.86	29.51	388.61	27.07	391.05	30.74	387.38	38.09	380.03	30.17	387.95	28.52	389.60	29.56	388.56	34.59	383.53	27.23	390.89	28.47	389.65	20.22	397.90
	MW-7	47.53	370.41	29.23	388.71	26.98	390.96	30.66	387.28	38.05	379.89	30.12	387.82	28.53	389.41	29.55	388.39	34.24	383.70	27.01	390.93	28.41	389.53	20.17	397.77
	MW-8	52.23	371.14	34.14	389.23	31.56	391.81	35.22	388.15	42.45	380.92	34.91	388.46	33.37	390.00	34.46	388.91	39.42	383.95	31.71	391.66	33.04	390.33	24.80	398.57
	BMW-1	41.55	377.53	23.08	396.00	23.97	395.11	26.14	392.94	31.64	387.44	25.98	393.10	24.64	394.44	25.72	393.36	28.90	390.18	24.21	394.87	24.71	394.37	20.64	398.44
	BMW-2	20.18	388.84	12.51	396.51	12.54	396.48	13.51	395.51	16.28	392.74	13.57	395.45	12.82	396.20	12.11	396.91	12.44	396.58	12.34	396.68	11.52	397.50	10.30	398.72
Temporary Piezometers	MW-9 (AMW-1)	NA	NA	NA	NA	NA	NA	6.41	387.30	13.82	379.89	6.10	387.61	4.40	389.31	5.75	387.96	11.32	382.39	NA	NA	4.01	389.70	NA	NA
	MW-10 (AMW-2)	NA	NA	NA	NA	NA	NA	18.58	387.04	25.97	379.65	18.26	387.36	16.49	389.13	17.93	387.69	23.53	382.09	13.94	391.68	16.00	389.62	6.83	398.79
	TP-1	NA	NA	NA	NA	NA	NA	6.22	387.49	13.55	380.16	5.70	388.01	4.14	389.57	5.28	388.43	10.40	383.31	NA	NA	3.90	389.81	NA	NA
	TP-2	NA	NA	NA	NA	NA	NA	18.16	387.06	25.53	379.69	17.81	387.41	16.03	389.19	17.47	387.75	23.07	382.15	13.57	391.65	15.53	389.69	6.47	398.75
Background Investigation	BMW-3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	14.26	381.90	4.44	391.72	7.10	389.06	NA	NA
	BMW-4	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	14.52	381.82	4.02	392.32	7.27	389.07	NA	NA
	BMW-5	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	20.37	381.68	9.61	392.44	13.00	389.05	NA	NA
River Level	Mississippi River	NA	367.89	NA	388.40	NA	392.25	NA	387.73	NA	380.35	NA	388.13	NA	389.35	NA	388.04	NA	381.93	NA	392.75	NA	389.88	NA	399.62
Pond Gauges	MCPA, MCPB, MCPC	NA	410.10	NA	BG	NA	NA	NA	408.63	NA	408.63	NA	409.13	NA	408.63	NA	BG	NA	408.72	NA	NA	NA	BG	NA	409.05
	MCPD	NA	417.00	NA	417.20	NA	NA	NA	417.30	NA	415.30	NA	417.40	NA	417.40	NA	417.30	NA	417.30	NA	NA	NA	417.50	NA	417.40

Notes:
1.) CCR - Coal Combustion Residuals.
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.) NA - Not Applicable.
6.) Horizontal Datum: State Plane Coordinates NAD83 (2000) Missouri East Zone feet.
7.) Vertical Datum: NAVD88 feet.
8.) Mississippi River Level and Pond Gauge elevations are provided by Ameren.
9.) Mississippi River gauge location is estimated.
10.) BG - Below gauge.

Prepared By: JSI
Checked By: EMS
Reviewed By: MNH

Table 2
Generalized Hydraulic Properties of Uppermost Aquifer
Meramec Energy Center
St. Louis County, Missouri

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)
3/28/2016	242	0.00280	37.02	1.3E-02	0.35	0.30
5/13/2016	249	0.00122	37.02	1.3E-02	0.35	0.13
7/18/2016	240	0.00253	37.02	1.3E-02	0.35	0.27
9/7/2016	245	0.00220	37.02	1.3E-02	0.35	0.23
11/10/2016	242	0.00317	37.02	1.3E-02	0.35	0.34
1/6/2017	234	0.00295	37.02	1.3E-02	0.35	0.31
3/7/2017	231	0.00225	37.02	1.3E-02	0.35	0.24
6/14/2017	244	0.00187	37.02	1.3E-02	0.35	0.20
11/6/2017	233	0.00260	37.02	1.3E-02	0.35	0.28
1/2/2018	224	0.00397	37.02	1.3E-02	0.35	0.42
4/3/2018	243	0.00247	37.02	1.3E-02	0.35	0.26
5/17/2018	234	0.00145	37.02	1.3E-02	0.35	0.15
7/23/2018	223	0.00188	37.02	1.3E-02	0.35	0.20
8/21/2018	221	0.00279	37.02	1.3E-02	0.35	0.29
9/25/2018	224	0.00173	37.02	1.3E-02	0.35	0.18
11/19/2018	225	0.00157	37.02	1.3E-02	0.35	0.17
1/9/2019	223	0.00186	37.02	1.3E-02	0.35	0.20
1/28/2019	245	0.00226	37.02	1.3E-02	0.35	0.24
2/26/2019	234	0.00127	37.02	1.3E-02	0.35	0.13
8/12/2019	246	0.00142	37.02	1.3E-02	0.35	0.15
10/3/2019	223	0.00016	37.02	1.3E-02	0.35	0.02

Estimated Results	
Resultant Groundwater Flow Direction (Azimuth)	235
Estimated Annual Net Groundwater Movement (Feet/Year)	79

Prepared By: JSI
Checked By: TJG
Reviewed By: MNH

Notes:
1. Azimuth and Hydraulic Gradient calculated using the spreadsheet tool from the 2005 report entitled "A Spreadsheet Method For Estimating Hydraulic Gradient With Heads From Multiple Wells" submitted to Ground Water" by J.F. Devlin.
2. Hydraulic conductivity value is the geometric mean of slug test results for the CCR 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.

Figures

LEGEND

- Meramec Energy Center Property Boundary
- Active Surface Impoundment
- Capped and Closed Surface Impoundment
- Exempt Surface Impoundment

0 500 1,000 1,500 2,000 2,500
Feet

NOTE(S)

1.) ALL BOUNDARIES AND LOCATIONS ARE APPROXIMATE.
2. SI - SURFACE IMPOUNDMENT.
3. EXEMPT SURFACE IMPOUNDMENTS ARE EXCLUDED FROM COAL COMBUSTION RESIDUALS MONITORING.

REFERENCE(S)

1.) AMEREN MISSOURI MERAMEC ENERGY CENTER, MERAMEC PROPERTY CONTROL MAP, FEBRUARY 2011.
2.) COORDINATE SYSTEM: NAD 1983 STATE PLANE MISSOURI EAST FIPS 2,401 FEET.

CLIENT
AMEREN MISSOURI
MERAMEC ENERGY CENTER

Ameren

PROJECT
GROUNDWATER MONITORING PROGRAM

TITLE
SITE LOCATION MAP

CONSULTANT

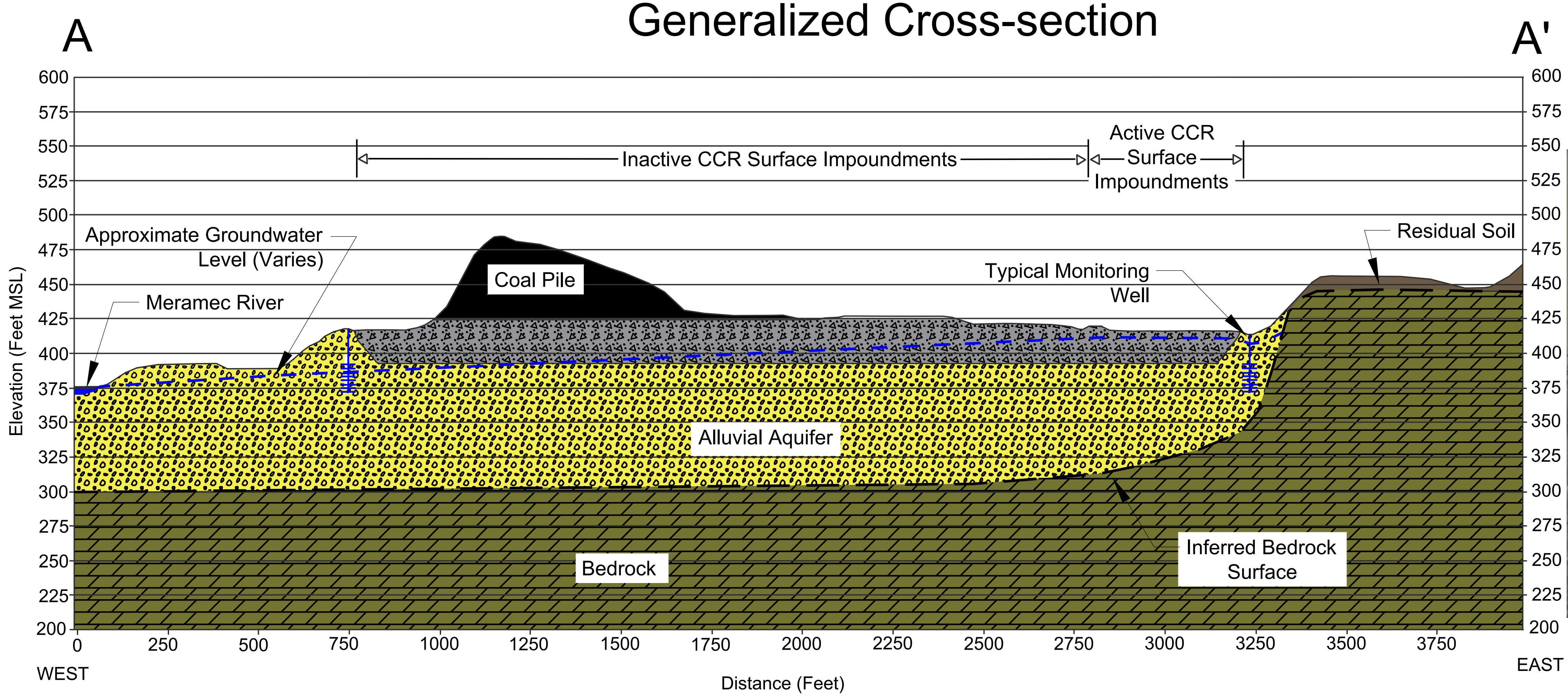
GOLDER

YYYY-MM-DD	2019-11-15
DESIGNED	JSI
PREPARED	JSI
REVIEWED	TJG
APPROVED	MNH

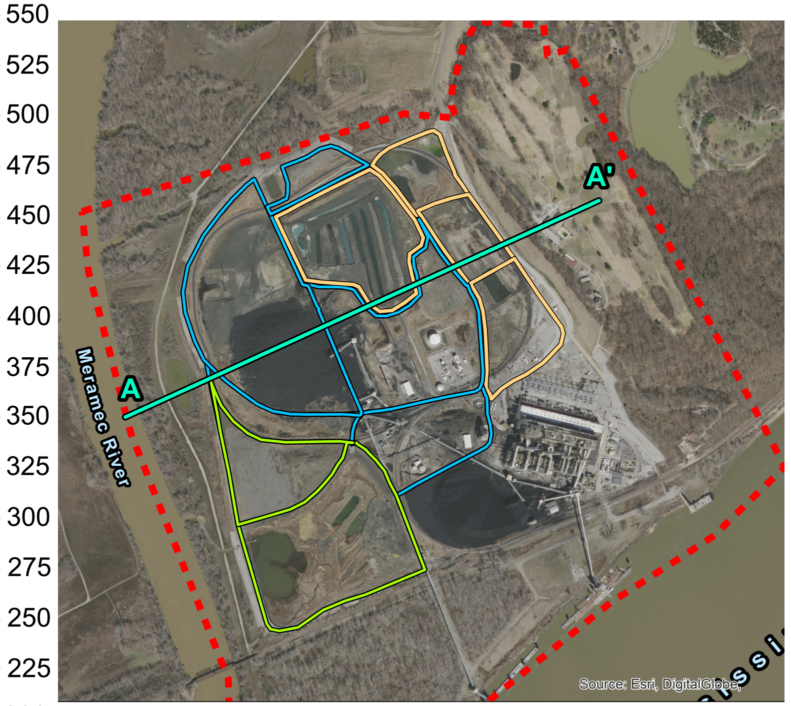
PROJECT NO. 153140602 REV. 0 FIGURE 1

AMEREN_00000793

Generalized Cross-section



Overview Map



NOT TO SCALE

NOTES
1.) ALL LOCATIONS AND BOUNDARIES ARE APPROXIMATE.
2.) CROSS-SECTION IS NOT TO SCALE AND IS ONLY A VISUAL REPRESENTATION OF THE SUBSURFACE GEOLOGY.
3.) MSL - MEAN SEA LEVEL.
4.) DEPTH OF CCR IS ESTIMATED BASED ON DRAWINGS. ACTUAL DEPTH OF CCR IS UNKNOWN.
5.) CCR - COAL COMBUSTION RESIDUALS.
6.) BEDROCK SURFACE IS ESTIMATED; INFERRED FROM AVAILABLE INFORMATION.

REFERENCES
1.) AMEREN MISSOURI MERAMEC ENERGY CENTER, MERAMEC PROPERTY CONTROL MAP, FEBRUARY 2011.
2.) CH2MHILL, 1997, HYDROGEOLOGIC ASSESSMENT OF POTENTIAL IMPACTS OF MERAMEC ASH PONDS ON LOCAL GROUNDWATER AND SURFACE WATER.
3.) SHANNON & WILSON, INC., 1979. GEOTECHNICAL INVESTIGATION - MERAMEC PLANT RETROFIT - UNION ELECTRIC COMPANY - ST. LOUIS, MISSOURI.

CLIENT
AMEREN MISSOURI
MERAMEC ENERGY CENTER

CONSULTANT
GOLDER

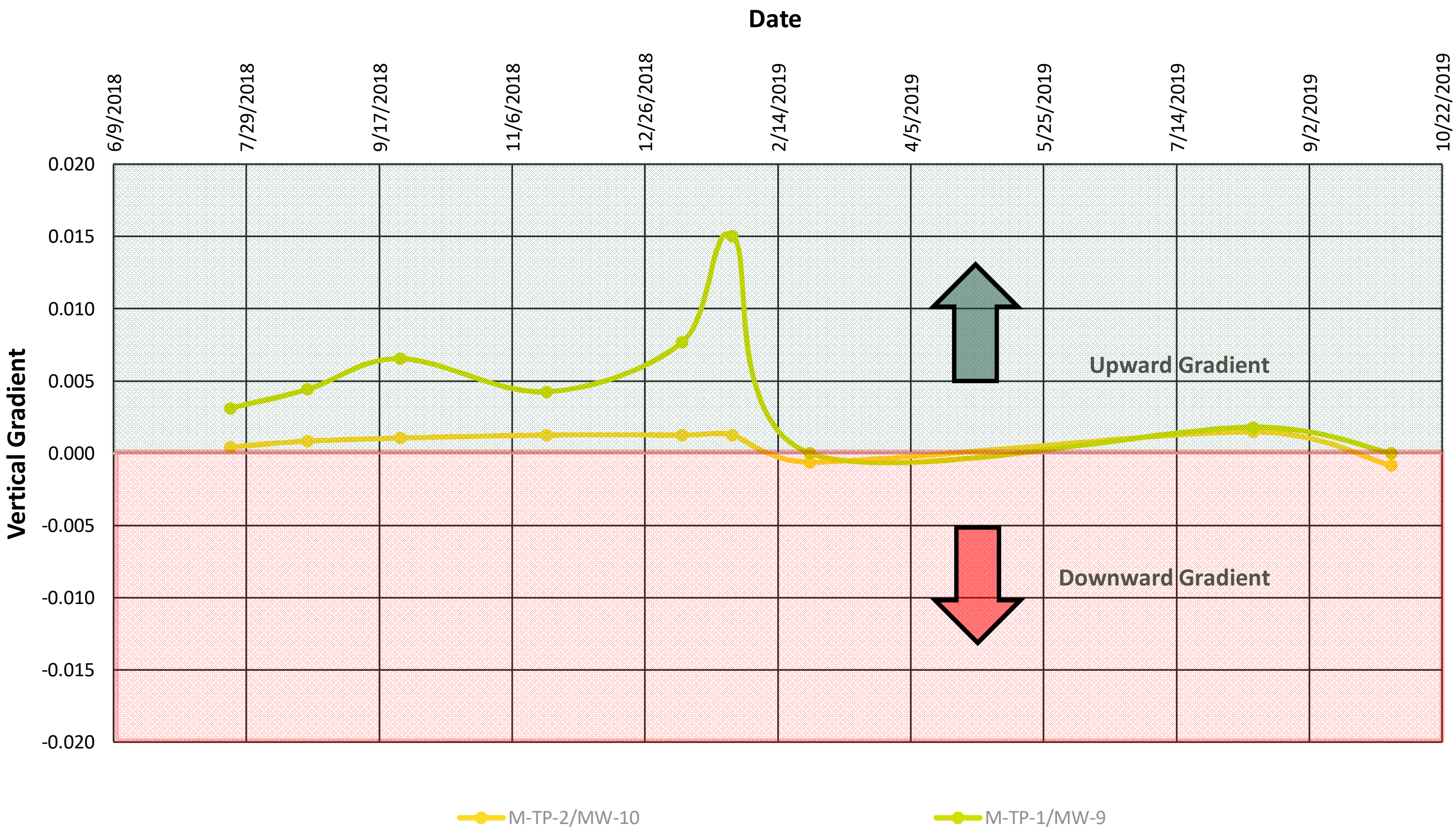
YYYY-MM-DD	2015-12-11
DESIGNED	JSI
PREPARED	JSI
REVIEWED	JS
APPROVED	MNH

PROJECT
GROUNDWATER MONITORING PROGRAM

TITLE
GENERALIZED CROSS-SECTION

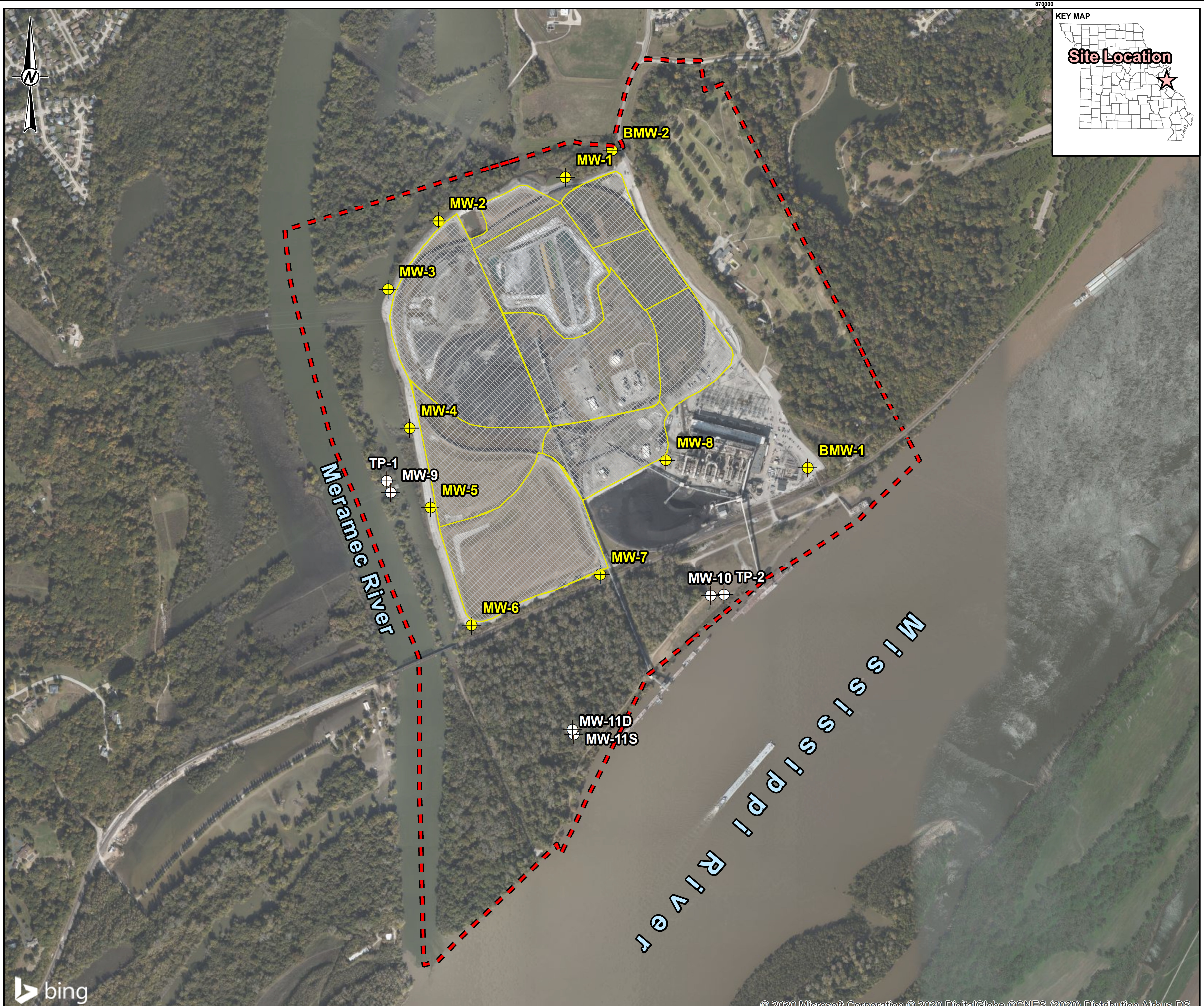
PROJECT NO.	PHASE	REV.	FIGURE
153140602	0004	0.0	2

Figure 4: Vertical Gradients



Notes:
1) A positive gradient indicates upward flow and is in the green zone.
2) A negative gradient indicates downward flow and is in the red zone.

Prepared By: EMS 11/20/2019
Checked By: AMM 11/20/2019
Reviewed By: MNH 11/27/2019



LEGEND

- Meramec Energy Center Property Boundary
- Meramec Surface Impoundments

Groundwater Monitoring Wells

- Detection/Assessment Monitoring Well Network
- Corrective Action Monitoring Well Network

0 500 1,000 1,500 2,000 2,500

Feet

NOTE(S)

1.) ALL BOUNDARIES AND LOCATIONS ARE APPROXIMATE.
2.) LOCATION OF NESTED WELL PAIRS MAY BE OFFSET FOR CLARITY.

REFERENCE(S)

1.) AMEREN MISSOURI MERAMEC ENERGY CENTER, MERAMEC PROPERTY CONTROL MAP, FEBRUARY 2011.
2.) COORDINATE SYSTEM: NAD 1983 STATE PLANE MISSOURI EAST FIPS 2,401 FEET.

CLIENT
AMEREN MISSOURI
MERAMEC ENERGY CENTER

Ameren

PROJECT
GROUNDWATER MONITORING PROGRAM

TITLE
MERAMEC ENERGY CENTER GROUNDWATER MONITORING PROGRAMS MONITORING WELL LOCATION MAP

CONSULTANT

GOLDER

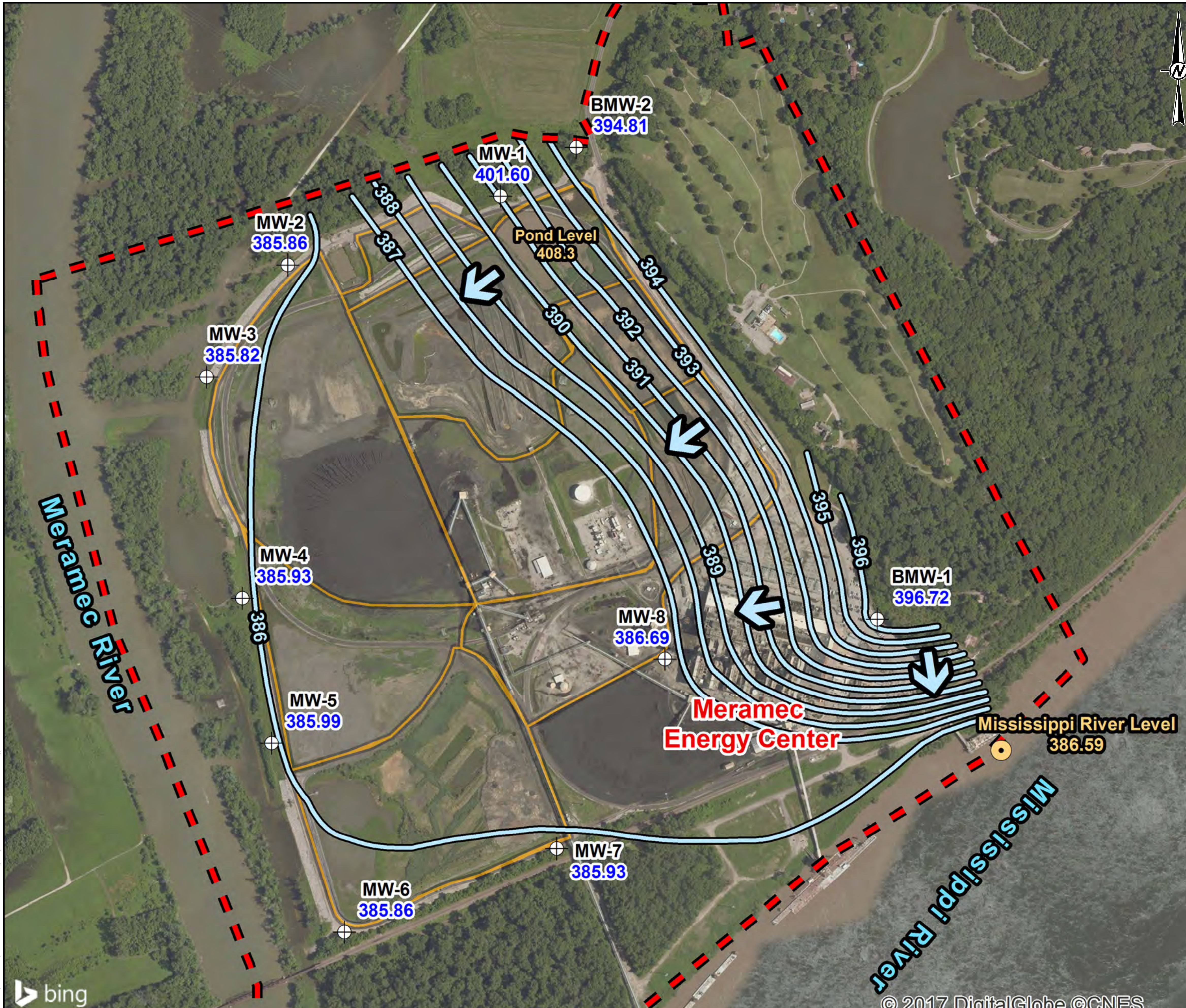
YYYY-MM-DD	2020-04-23
DESIGNED	JSI
PREPARED	JSI
REVIEWED	BTT
APPROVED	CMR

PROJECT NO. 153140602 REV. 1 FIGURE 5

AMEREN_00000796

APPENDIX A

CCR Rule Program Potentiometric Surface Maps



LEGEND

Meramec Energy Center Property Boundary

All Surface Impoundments

Groundwater Elevation Contours

Groundwater Elevation Contour (FT MSL)

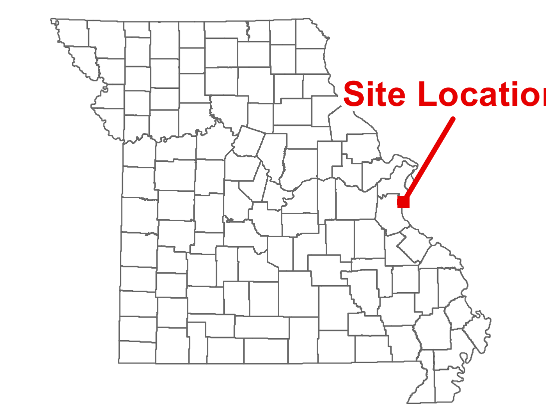
Ground/Surface Water Measurement Locations

Groundwater Monitoring Well

Mississippi River Gauge

Groundwater Flow Direction

KEY MAP



NOTES
1. ALL LOCATIONS AND BOUNDARIES ARE APPROXIMATE.
2. GROUNDWATER ELEVATION MEASUREMENTS OBTAINED BY GOLDER.
3. GROUNDWATER MONITORING WELLS SURVEYED BY ZAHNER AND ASSOCIATES, INC. ON FEBRUARY 4 AND APRIL 28, 2016.
4. WELL MW-1 NOT USED FOR POTENTIOMETRIC SURFACE MAP CONTOURING.
5. GROUNDWATER ELEVATIONS DISPLAYED IN FT MSL (FEET ABOVE MEAN SEA LEVEL).
6. MISSISSIPPI RIVER AND POND LEVELS PROVIDED BY AMEREN.

REFERENCES
1.) AMEREN MISSOURI MERAMEC ENERGY CENTER, MERAMEC PROPERTY CONTROL MAP, FEBRUARY 2011.
2.) COORDINATE SYSTEM: NAD 1983 STATEPLANE MISSOURI EAST FIPS 2401 FEET.

0 250 500 1,000 1,500 Feet

CLIENT
AMEREN MISSOURI
MERAMEC ENERGY CENTER

Ameren

PROJECT
CCR GROUNDWATER MONITORING PROGRAM

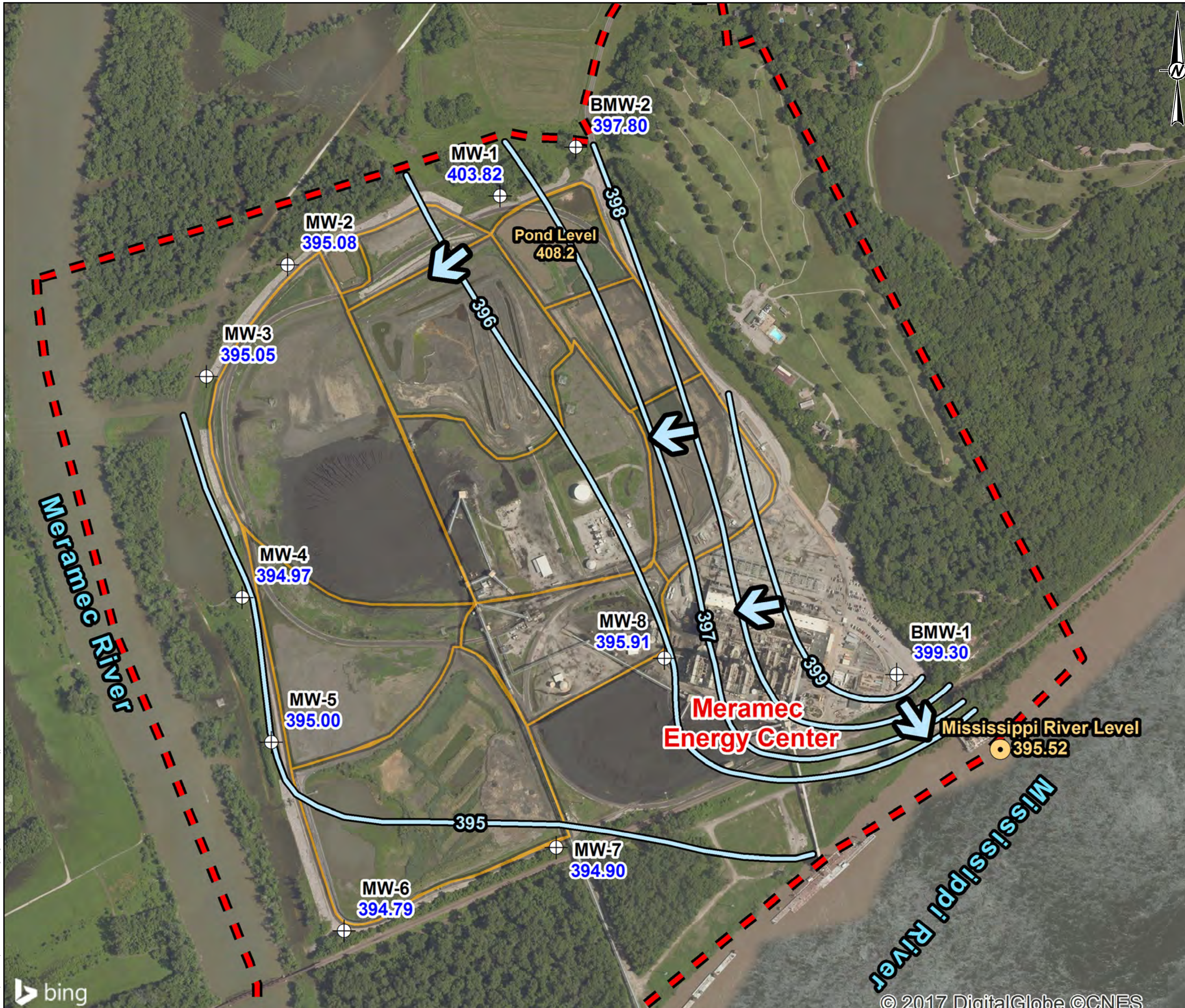
TITLE
POTENTIOMETRIC SURFACE MAP
BACKGROUND EVENT 1 - MARCH 28, 2016

CONSULTANT
Golder Associates

YYYY-MM-DD	2016-03-31
PREPARED	JSI
DESIGN	JSI
REVIEW	JS
APPROVED	MNH

PROJECT No.	PHASE	Rev.	FIGURE
153-1406	0004A	0.0	A1

AMEREN_00000798



LEGEND

Meramec Energy Center Property Boundary

All Surface Impoundments

Groundwater Elevation Contours

Groundwater Elevation Contour (FT MSL)

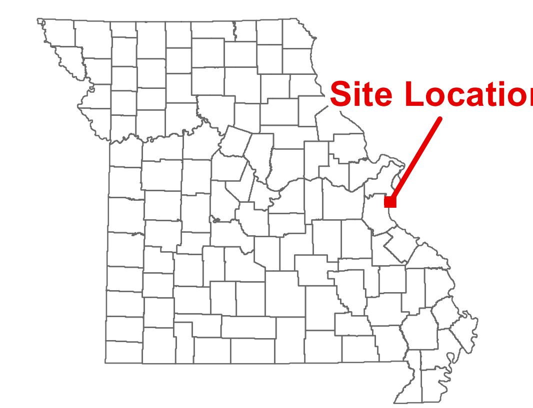
Ground/Surface Water Measurement Locations

Groundwater Monitoring Well

Mississippi River Gauge

Groundwater Flow Direction

KEY MAP



NOTES
1. ALL LOCATIONS AND BOUNDARIES ARE APPROXIMATE.
2. GROUNDWATER ELEVATION MEASUREMENTS OBTAINED BY GOLDER.
3. GROUNDWATER MONITORING WELLS SURVEYED BY ZAHNER AND ASSOCIATES, INC. ON FEBRUARY 4 AND APRIL 28, 2016.
4. WELL MW-1 NOT USED FOR POTENTIOMETRIC SURFACE MAP CONTOURING.
5. GROUNDWATER ELEVATIONS DISPLAYED IN FT MSL (FEET ABOVE MEAN SEA LEVEL).
6. MISSISSIPPI RIVER AND POND LEVELS PROVIDED BY AMEREN.

REFERENCES
1.) AMEREN MISSOURI MERAMEC ENERGY CENTER, MERAMEC PROPERTY CONTROL MAP, FEBRUARY 2011.
2.) COORDINATE SYSTEM: NAD 1983 STATEPLANE MISSOURI EAST FIPS 2401 FEET.

0 250 500 1,000 1,500 Feet

CLIENT
AMEREN MISSOURI
MERAMEC ENERGY CENTER

Ameren

PROJECT
CCR GROUNDWATER MONITORING PROGRAM

TITLE
POTENTIOMETRIC SURFACE MAP
BACKGROUND EVENT 2 - MAY 13, 2016

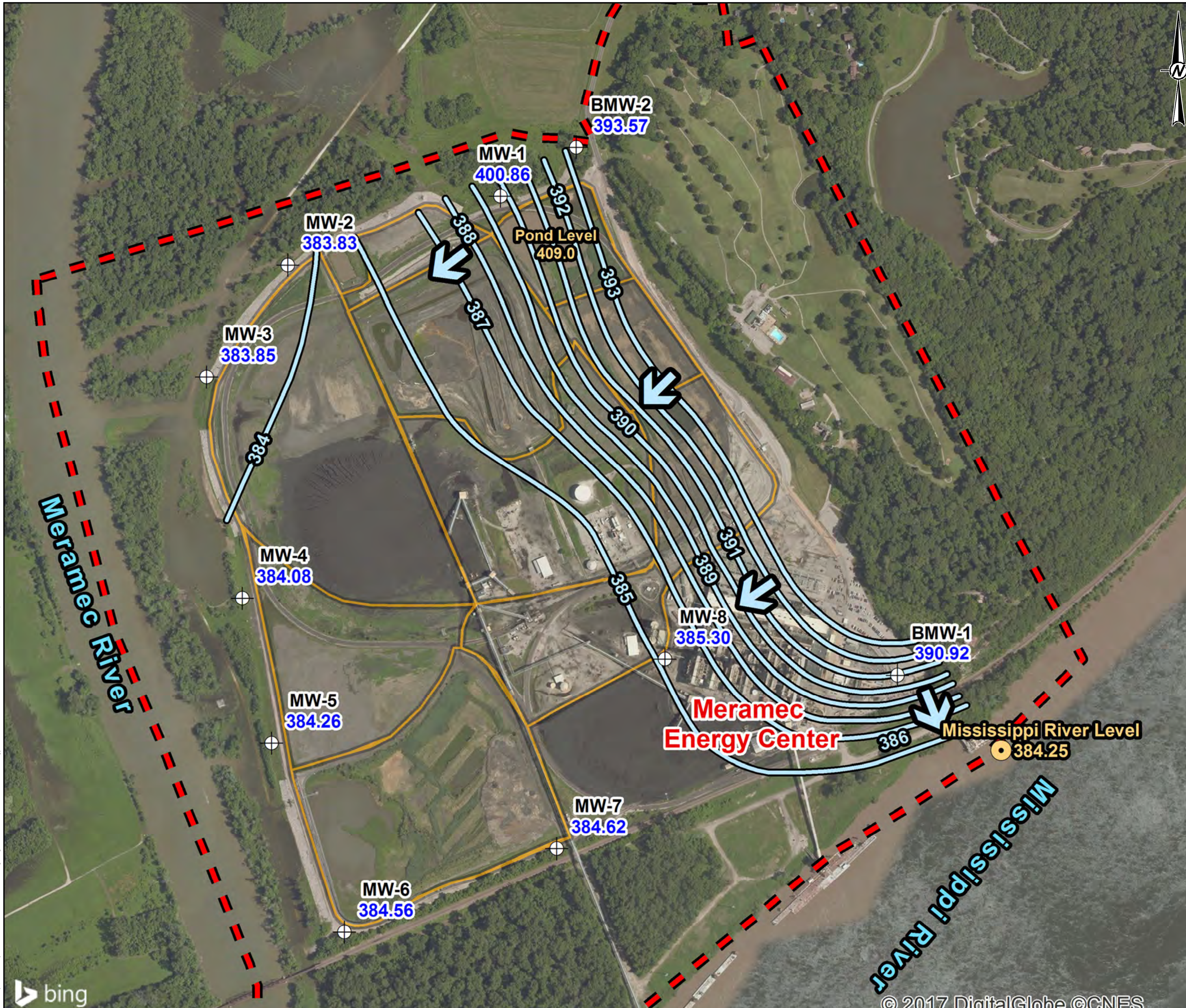
CONSULTANT

Golder Associates

YYYY-MM-DD	2016-05-24
PREPARED	JSI
DESIGN	JSI
REVIEW	JS
APPROVED	MNH

PROJECT No.	PHASE	Rev.	FIGURE
153-1406	0004A	0.0	A2

AMEREN_00000799



LEGEND

Meramec Energy Center Property Boundary

All Surface Impoundments

Groundwater Elevation Contours

Groundwater Elevation Contour (FT MSL)

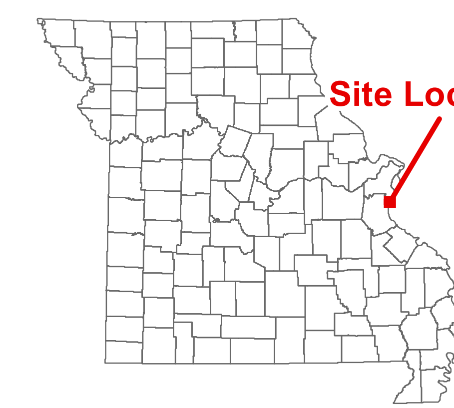
Ground/Surface Water Measurement Locations

Groundwater Monitoring Well

Mississippi River Gauge

Groundwater Flow Direction

KEY MAP



NOTES
1. ALL LOCATIONS AND BOUNDARIES ARE APPROXIMATE.
2. GROUNDWATER ELEVATION MEASUREMENTS OBTAINED BY GOLDER.
3. GROUNDWATER MONITORING WELLS SURVEYED BY ZAHNER AND ASSOCIATES, INC. ON FEBRUARY 4 AND APRIL 28, 2016.
4. WELL MW-1 NOT USED FOR POTENTIOMETRIC SURFACE MAP CONTOURING.
5. GROUNDWATER ELEVATIONS DISPLAYED IN FT MSL (FEET ABOVE MEAN SEA LEVEL).
6. MISSISSIPPI RIVER AND POND LEVELS PROVIDED BY AMEREN.

REFERENCES
1.) AMEREN MISSOURI MERAMEC ENERGY CENTER, MERAMEC PROPERTY CONTROL MAP, FEBRUARY 2011.
2.) COORDINATE SYSTEM: NAD 1983 STATEPLANE MISSOURI EAST FIPS 2401 FEET.

0 250 500 1,000 1,500 Feet

CLIENT
AMEREN MISSOURI
MERAMEC ENERGY CENTER

Ameren

PROJECT
CCR GROUNDWATER MONITORING PROGRAM

TITLE
POTENTIOMETRIC SURFACE MAP
BACKGROUND EVENT 3 - JULY 18, 2016

CONSULTANT

Golder Associates

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

PROJECT No.	PHASE	Rev.	FIGURE
153-1406	0004A	0.0	A3

AMEREN_00000800

LEGEND

Meramec Energy Center Property Boundary

All Surface Impoundments

Groundwater Elevation Contours

Groundwater Elevation Contour (FT MSL)

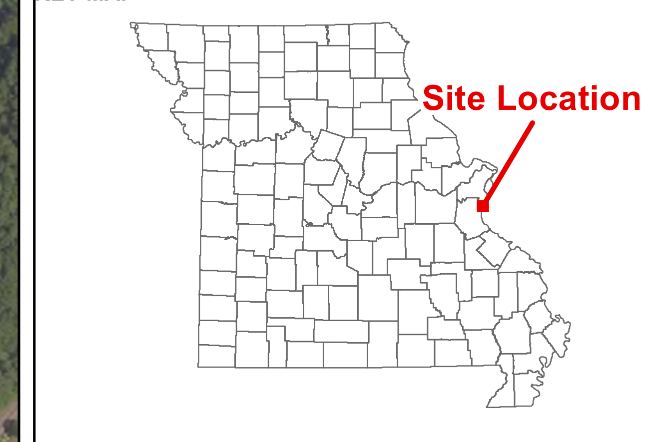
Ground/Surface Water Measurement Locations

Groundwater Monitoring Well

Mississippi River Gauge

Groundwater Flow Direction

KEY MAP



NOTES
1. ALL LOCATIONS AND BOUNDARIES ARE APPROXIMATE.
2. GROUNDWATER ELEVATION MEASUREMENTS OBTAINED BY GOLDER.
3. GROUNDWATER MONITORING WELLS SURVEYED BY ZAHNER AND ASSOCIATES, INC. ON FEBRUARY 4 AND APRIL 28, 2016.
4. WELL MW-1 NOT USED FOR POTENTIOMETRIC SURFACE MAP CONTOURING.
5. GROUNDWATER ELEVATIONS DISPLAYED IN FT MSL (FEET ABOVE MEAN SEA LEVEL).
6. MISSISSIPPI RIVER AND POND LEVELS PROVIDED BY AMEREN.

REFERENCES
1.) AMEREN MISSOURI MERAMEC ENERGY CENTER, MERAMEC PROPERTY CONTROL MAP, FEBRUARY 2011.
2.) COORDINATE SYSTEM: NAD 1983 STATEPLANE MISSOURI EAST FIPS 2401 FEET.

0 250 500 1,000 1,500 Feet

CLIENT
AMEREN MISSOURI
MERAMEC ENERGY CENTER

Ameren

PROJECT
CCR GROUNDWATER MONITORING PROGRAM

TITLE
POTENTIOMETRIC SURFACE MAP
BACKGROUND EVENT 4 - SEPTEMBER 7, 2016

CONSULTANT

Golder Associates

YYYY-MM-DD	2017-09-27
PREPARED	JSI
DESIGN	JSI
REVIEW	JS
APPROVED	MNH

PROJECT No.	PHASE	Rev.	FIGURE
153-1406	0004A	0.0	A4

AMEREN_00000801

LEGEND

- Meramec Energy Center Property Boundary
- All Surface Impoundments

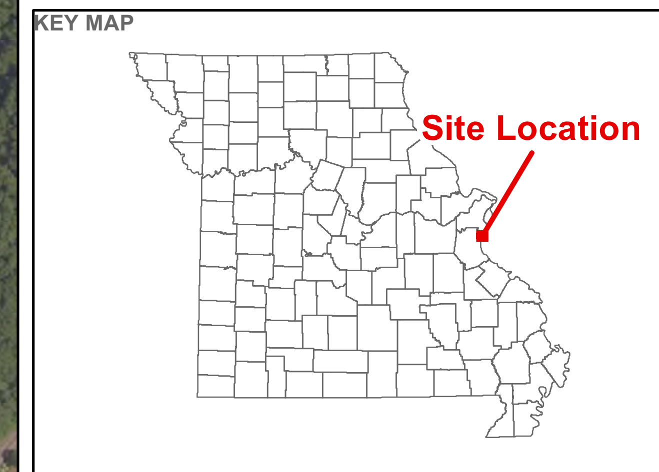
Groundwater Elevation Contours

- Groundwater Elevation Contour (FT MSL)

Ground/Surface Water Measurement Locations

- Groundwater Monitoring Well
- Mississippi River Gauge
- Groundwater Flow Direction

KEY MAP



NOTES

1. ALL LOCATIONS AND BOUNDARIES ARE APPROXIMATE.
2. GROUNDWATER ELEVATION MEASUREMENTS OBTAINED BY GOLDER.
3. GROUNDWATER MONITORING WELLS SURVEYED BY ZAHNER AND ASSOCIATES, INC. ON FEBRUARY 4 AND APRIL 28, 2016.
4. WELL MW-1 NOT USED FOR POTENTIOMETRIC SURFACE MAP CONTOURING.
5. GROUNDWATER ELEVATIONS DISPLAYED IN FT MSL (FEET ABOVE MEAN SEA LEVEL).
6. MISSISSIPPI RIVER AND POND LEVELS PROVIDED BY AMEREN.

REFERENCES

1.) AMEREN MISSOURI MERAMEC ENERGY CENTER, MERAMEC PROPERTY CONTROL MAP, FEBRUARY 2011.
2.) COORDINATE SYSTEM: NAD 1983 STATEPLANE MISSOURI EAST FIPS 2401 FEET.

0 250 500 1,000 1,500 Feet

CLIENT
AMEREN MISSOURI
MERAMEC ENERGY CENTER

Ameren

PROJECT
CCR GROUNDWATER MONITORING PROGRAM

TITLE
POTENTIOMETRIC SURFACE MAP
BACKGROUND EVENT 5 - NOVEMBER 10, 2016

CONSULTANT

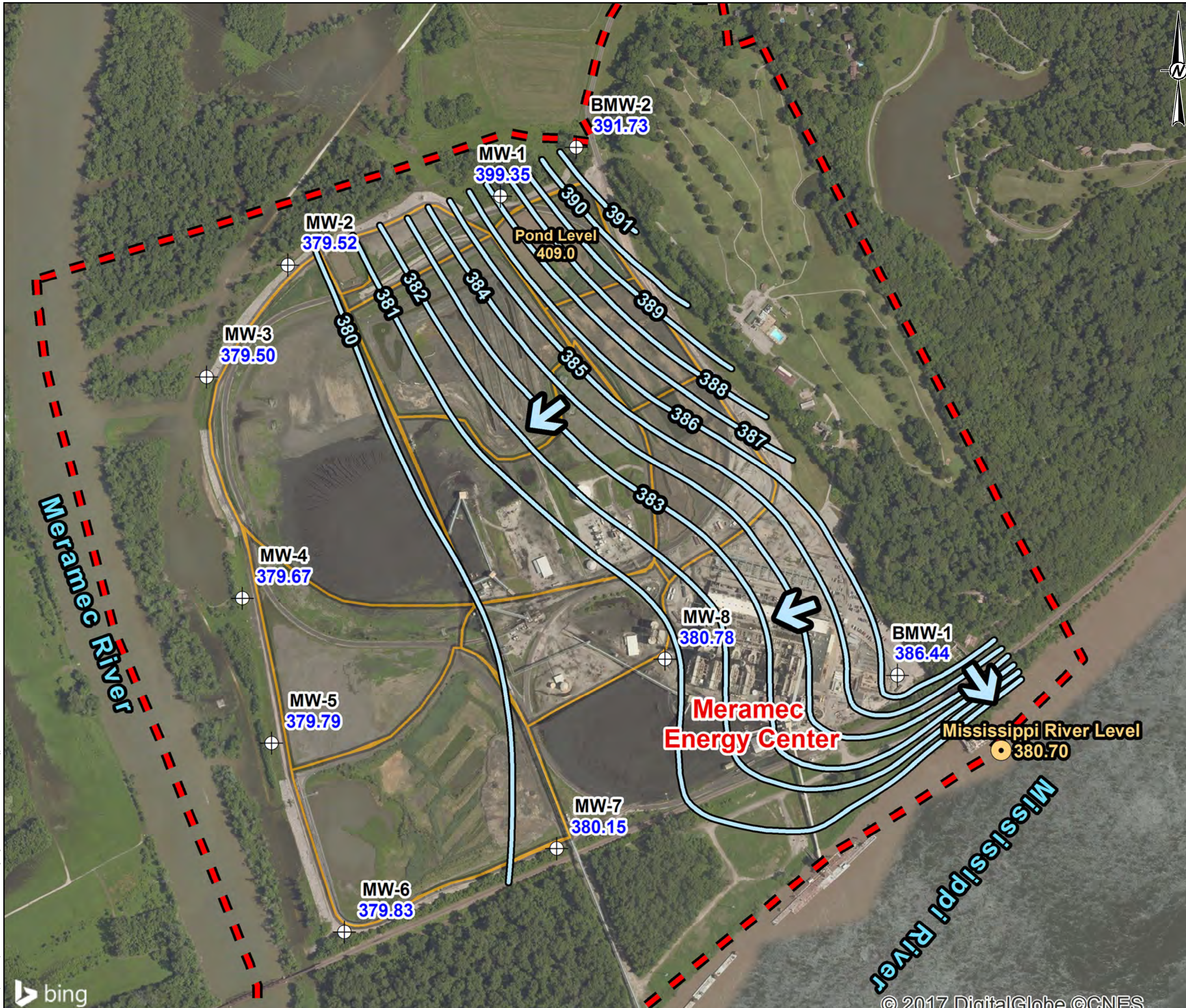
Golder Associates

YYYY-MM-DD	2017-11-21
PREPARED	JSI
DESIGN	JSI
REVIEW	MSG
APPROVED	MNH

PROJECT No.	PHASE	Rev.	FIGURE
153-1406	0004A	0.0	A5

AMEREN_00000802

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



LEGEND

Meramec Energy Center Property Boundary

All Surface Impoundments

Groundwater Elevation Contours

Groundwater Elevation Contour (FT MSL)

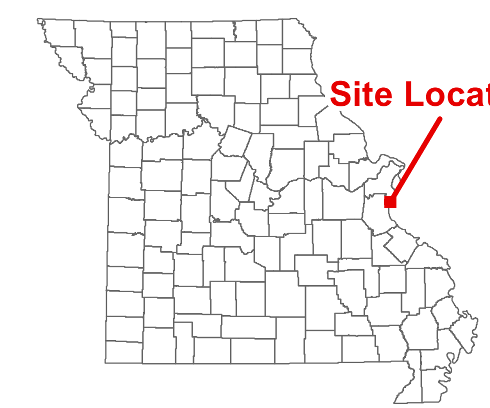
Ground/Surface Water Measurement Locations

Groundwater Monitoring Well

Mississippi River Gauge

Groundwater Flow Direction

KEY MAP



NOTES
1. ALL LOCATIONS AND BOUNDARIES ARE APPROXIMATE.
2. GROUNDWATER ELEVATION MEASUREMENTS OBTAINED BY GOLDER.
3. GROUNDWATER MONITORING WELLS SURVEYED BY ZAHNER AND ASSOCIATES, INC. ON FEBRUARY 4 AND APRIL 28, 2016.
4. WELL MW-1 NOT USED FOR POTENTIOMETRIC SURFACE MAP CONTOURING.
5. GROUNDWATER ELEVATIONS DISPLAYED IN FT MSL (FEET ABOVE MEAN SEA LEVEL).
6. MISSISSIPPI RIVER AND POND LEVELS PROVIDED BY AMEREN.

REFERENCES
1.) AMEREN MISSOURI MERAMEC ENERGY CENTER, MERAMEC PROPERTY CONTROL MAP, FEBRUARY 2011.
2.) COORDINATE SYSTEM: NAD 1983 STATEPLANE MISSOURI EAST FIPS 2401 FEET.

0 250 500 1,000 1,500 Feet

CLIENT
AMEREN MISSOURI
MERAMEC ENERGY CENTER

Ameren

PROJECT
CCR GROUNDWATER MONITORING PROGRAM

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

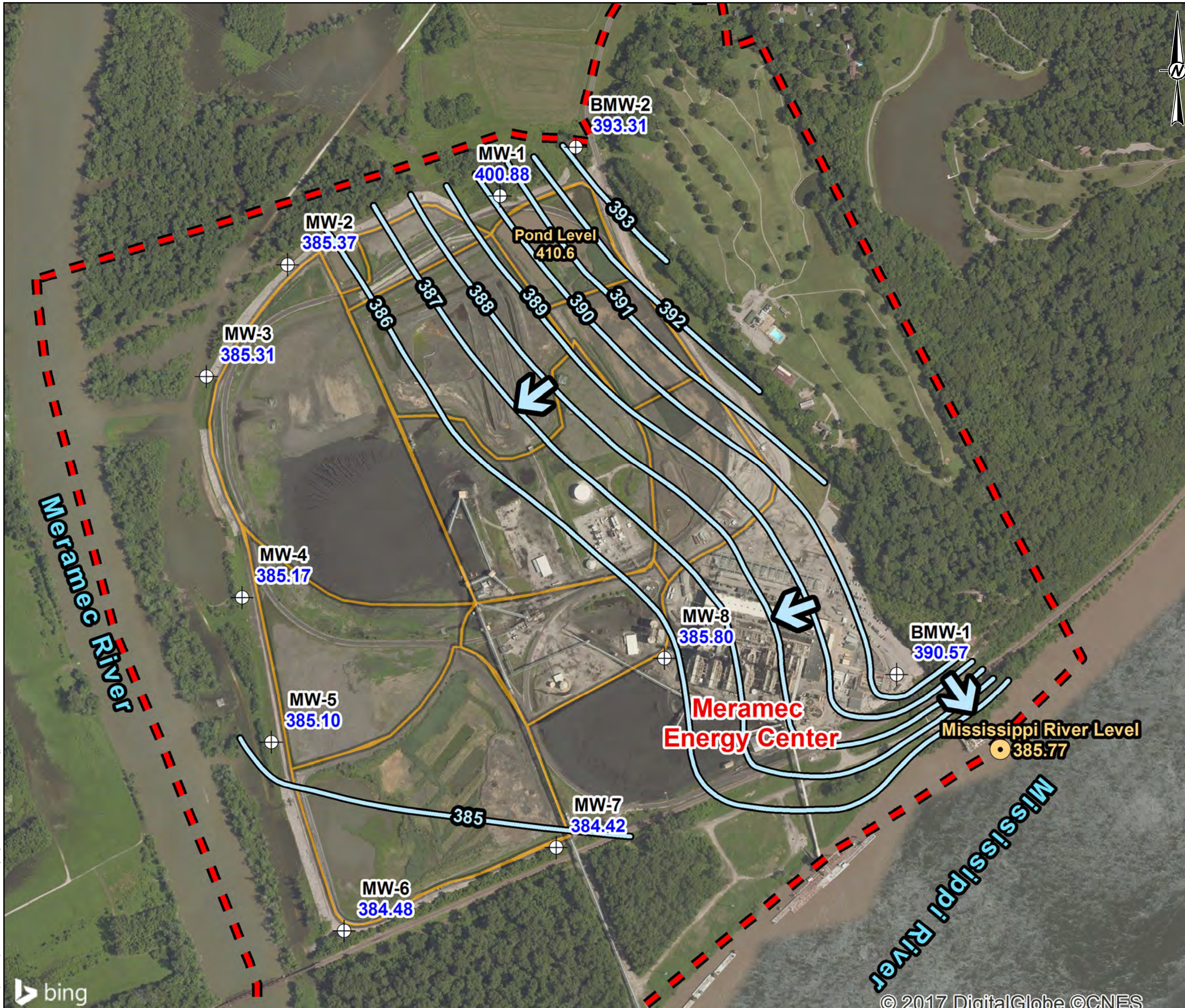
CONSULTANT

Golder Associates

YYYY-MM-DD	2017-01-23
PREPARED	JS
DESIGN	JSI
REVIEW	BEF
APPROVED	MNH

PROJECT No.	PHASE	Rev.	FIGURE
153-1406	0004A	0.0	A6

AMEREN_00000803



LEGEND

- Meramec Energy Center Property Boundary
- All Surface Impoundments

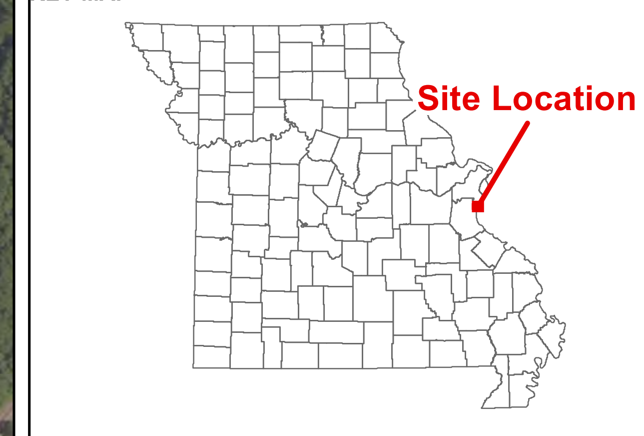
Groundwater Elevation Contours

- Groundwater Elevation Contour (FT MSL)

Ground/Surface Water Measurement Locations

- Groundwater Monitoring Well
- Mississippi River Gauge
- Groundwater Flow Direction

KEY MAP



NOTES

1. ALL LOCATIONS AND BOUNDARIES ARE APPROXIMATE.
2. GROUNDWATER ELEVATION MEASUREMENTS OBTAINED BY GOLDER.
3. GROUNDWATER MONITORING WELLS SURVEYED BY ZAHNER AND ASSOCIATES, INC. ON FEBRUARY 4 AND APRIL 28, 2016.
4. WELL MW-1 NOT USED FOR POTENTIOMETRIC SURFACE MAP CONTOURING.
5. GROUNDWATER ELEVATIONS DISPLAYED IN FT MSL (FEET ABOVE MEAN SEA LEVEL).
6. MISSISSIPPI RIVER AND POND LEVELS PROVIDED BY AMEREN.

REFERENCES

1.) AMEREN MISSOURI MERAMEC ENERGY CENTER, MERAMEC PROPERTY CONTROL MAP, FEBRUARY 2011.
2.) COORDINATE SYSTEM: NAD 1983 STATEPLANE MISSOURI EAST FIPS 2401 FEET.

0 250 500 1,000 1,500 Feet

CLIENT
AMEREN MISSOURI
MERAMEC ENERGY CENTER

Ameren

PROJECT
CCR GROUNDWATER MONITORING PROGRAM

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

CONSULTANT
Golder Associates

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

PROJECT No.	PHASE	Rev.	FIGURE
153-1406	0004A	0.0	A7

AMEREN_00000804

LEGEND

Meramec Energy Center Property Boundary

All Surface Impoundments

Groundwater Elevation Contours

Groundwater Elevation Contour (FT MSL)

Ground/Surface Water Measurement Locations

Groundwater Monitoring Well

Mississippi River Gauge

Groundwater Flow Direction

KEY MAP

NOTES
1. ALL LOCATIONS AND BOUNDARIES ARE APPROXIMATE.
2. GROUNDWATER ELEVATION MEASUREMENTS OBTAINED BY GOLDER.
3. GROUNDWATER MONITORING WELLS SURVEYED BY ZAHNER AND ASSOCIATES, INC. ON FEBRUARY 4 AND APRIL 28, 2016.
4. WELL MW-1 NOT USED FOR POTENTIOMETRIC SURFACE MAP CONTOURING.
5. GROUNDWATER ELEVATIONS DISPLAYED IN FT MSL (FEET ABOVE MEAN SEA LEVEL).
6. MISSISSIPPI RIVER AND POND LEVELS PROVIDED BY AMEREN.

REFERENCES
1.) AMEREN MISSOURI MERAMEC ENERGY CENTER, MERAMEC PROPERTY CONTROL MAP, FEBRUARY 2011.
2.) COORDINATE SYSTEM: NAD 1983 STATEPLANE MISSOURI EAST FIPS 2401 FEET.

0 250 500 1,000 1,500 Feet

CLIENT
AMEREN MISSOURI
MERAMEC ENERGY CENTER

Ameren

PROJECT
CCR GROUNDWATER MONITORING PROGRAM

TITLE
POTENTIOMETRIC SURFACE MAP
BACKGROUND EVENT 8 - JUNE 14, 2017

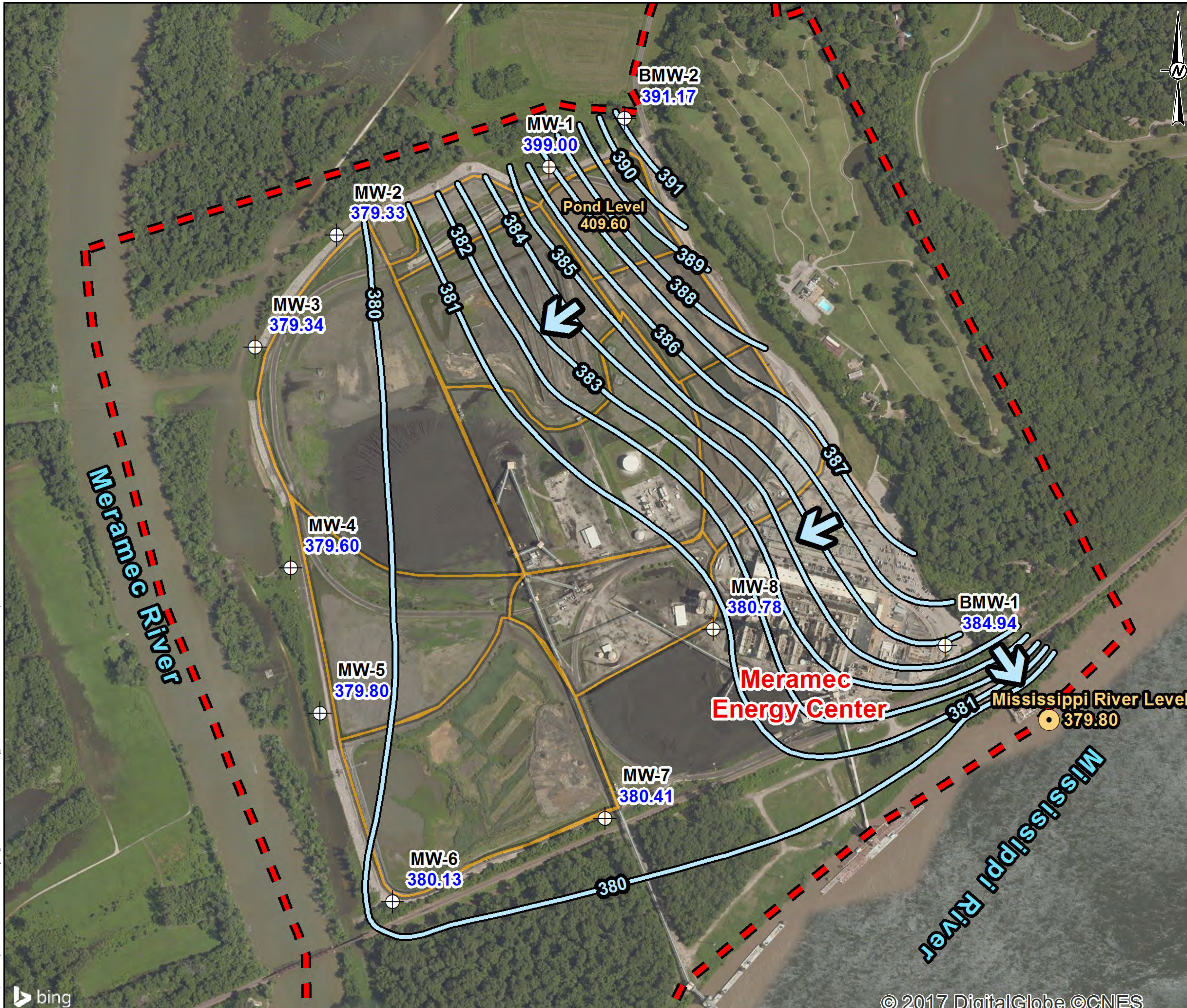
CONSULTANT

Golder Associates

YYYY-MM-DD	2017-07-06
PREPARED	JS
DESIGN	JSI
REVIEW	RJF
APPROVED	MNH

PROJECT No.	PHASE	Rev.	FIGURE
153-1406	0004A	0.0	A8

AMEREN_00000805



LEGEND

Meramec Energy Center Property Boundary

All Surface Impoundments

Groundwater Elevation Contours

Groundwater Elevation Contour (FT MSL)

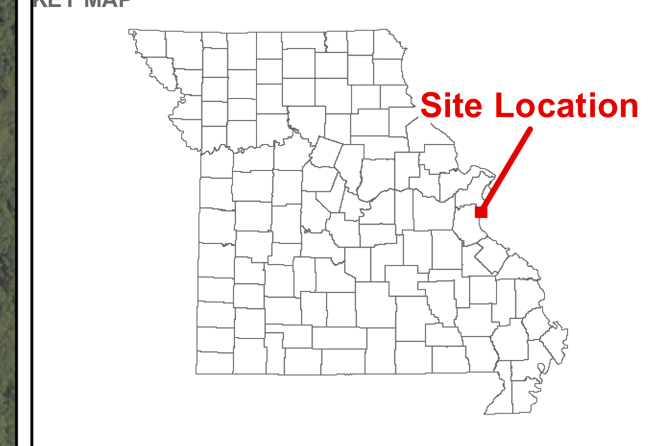
Ground/Surface Water Measurement Locations

Groundwater Monitoring Well

Mississippi River Gauge

Groundwater Flow Direction

KEY MAP



NOTES

1. ALL LOCATIONS AND BOUNDARIES ARE APPROXIMATE.
2. GROUNDWATER ELEVATION MEASUREMENTS OBTAINED BY GOLDER.
3. GROUNDWATER MONITORING WELLS SURVEYED BY ZAHNER AND ASSOCIATES, INC. ON FEBRUARY 4 AND APRIL 28, 2016.
4. WELL MW-1 NOT USED FOR POTENTIOMETRIC SURFACE MAP CONTOURING.
5. GROUNDWATER ELEVATIONS DISPLAYED IN FT MSL (FEET ABOVE MEAN SEA LEVEL).
6. MISSISSIPPI RIVER AND POND LEVELS PROVIDED BY AMEREN.

REFERENCES

1.) AMEREN MISSOURI MERAMEC ENERGY CENTER, MERAMEC PROPERTY CONTROL MAP, FEBRUARY 2011.
2.) COORDINATE SYSTEM: NAD 1983 STATEPLANE MISSOURI EAST FIPS 2401 FEET.

0 250 500 1,000 1,500 Feet

CLIENT
AMEREN MISSOURI
MERAMEC ENERGY CENTER

Ameren

PROJECT
CCR GROUNDWATER MONITORING PROGRAM

TITLE
POTENTIOMETRIC SURFACE MAP
DETECTION MONITORING - NOVEMBER 6, 2017

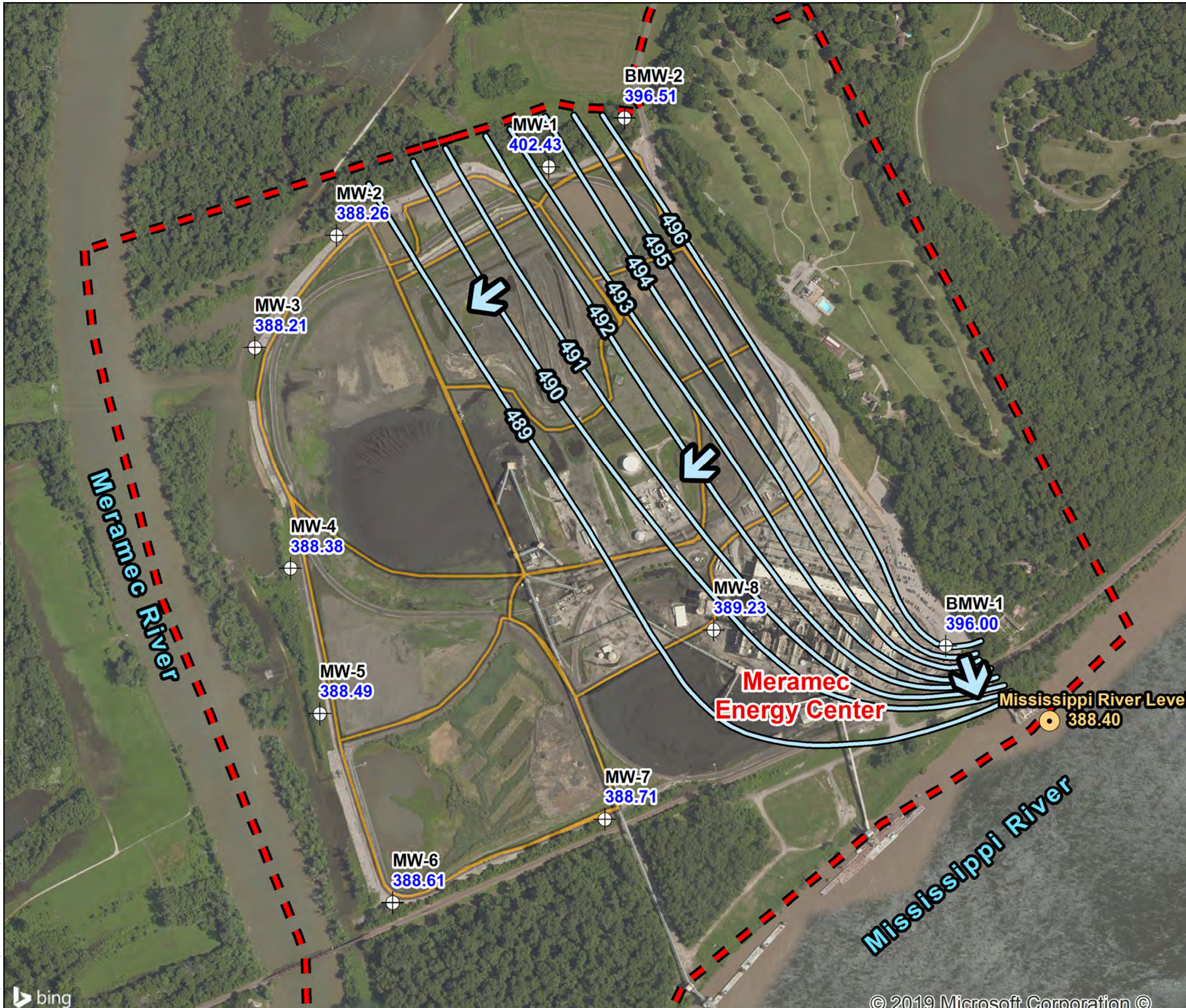
CONSULTANT
Golder Associates

YYYY-MM-DD	2017-11-20
PREPARED	RJF
DESIGN	JSI
REVIEW	JS/JSI
APPROVED	MNH

PROJECT No.	PHASE	Rev.	FIGURE
153-1406	0004A	0.0	A9

AMEREN_00000806

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



LEGEND

- Meramec Energy Center Property Boundary
- All Surface Impoundments

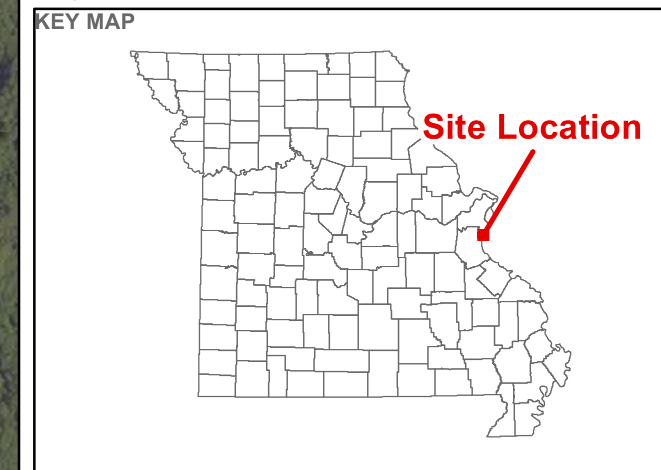
Groundwater Elevation Contours

- Groundwater Elevation Contour (FT MSL)

Ground/Surface Water Measurement Locations

- Groundwater Monitoring Well
- Mississippi River Gauge
- Groundwater Flow Direction

KEY MAP



NOTES

1. ALL LOCATIONS AND BOUNDARIES ARE APPROXIMATE.
2. GROUNDWATER ELEVATION MEASUREMENTS OBTAINED BY GOLDER.
3. GROUNDWATER MONITORING WELLS SURVEYED BY ZAHNER AND ASSOCIATES, INC. ON FEBRUARY 4 AND APRIL 28, 2016.
4. WELL MW-1 NOT USED FOR POTENTIOMETRIC SURFACE MAP CONTOURING.
5. GROUNDWATER ELEVATIONS DISPLAYED IN FT MSL (FEET ABOVE MEAN SEA LEVEL).
6. MISSISSIPPI RIVER AND POND LEVELS PROVIDED BY AMEREN.

REFERENCES

1.) AMEREN MISSOURI MERAMEC ENERGY CENTER, MERAMEC PROPERTY CONTROL MAP, FEBRUARY 2011.
2.) COORDINATE SYSTEM: NAD 1983 STATEPLANE MISSOURI EAST FIPS 2401 FEET.

0 500 1,000 Feet

CLIENT
AMEREN MISSOURI
MERAMEC ENERGY CENTER

Ameren

PROJECT
CCR GROUNDWATER MONITORING PROGRAM

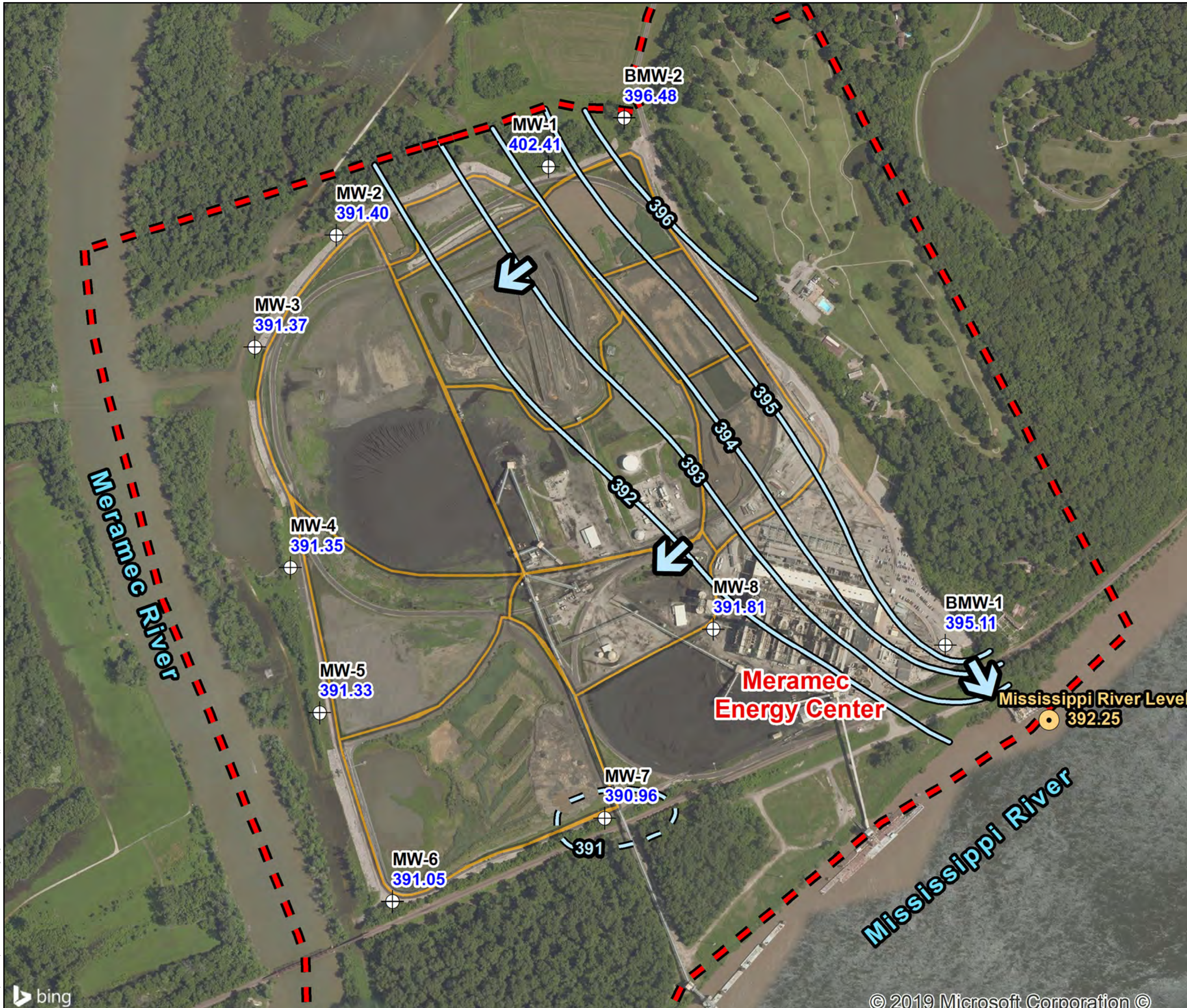
TITLE
POTENTIOMETRIC SURFACE MAP - APRIL 3, 2018

CONSULTANT
GOLDER

YYYY-MM-DD	2018-05-03
PREPARED	EFT
DESIGN	JSI
REVIEW	EMS/JSI
APPROVED	MNH

PROJECT No.	PHASE	Rev.	FIGURE
153-1406	0004	0.0	A10

AMEREN_00000807



LEGEND

Meramec Energy Center Property Boundary

All Surface Impoundments

Groundwater Elevation Contours

Groundwater Elevation Contour (FT MSL)

Inferred Groundwater Elevation Contour (FT MSL)

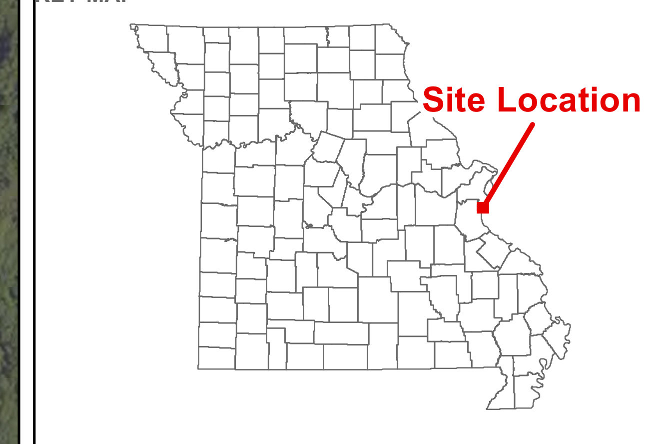
Ground/Surface Water Measurement Locations

Groundwater Monitoring Well

Mississippi River Gauge

Groundwater Flow Direction

KEY MAP



NOTES

1. ALL LOCATIONS AND BOUNDARIES ARE APPROXIMATE.
2. GROUNDWATER ELEVATION MEASUREMENTS OBTAINED BY GOLDER.
3. GROUNDWATER MONITORING WELLS SURVEYED BY ZAHNER AND ASSOCIATES, INC. ON FEBRUARY 4 AND APRIL 28, 2016.
4. WELL MW-1 NOT USED FOR POTENTIOMETRIC SURFACE MAP CONTOURING.
5. GROUNDWATER ELEVATIONS DISPLAYED IN FT MSL (FEET ABOVE MEAN SEA LEVEL).
6. MISSISSIPPI RIVER AND POND LEVELS PROVIDED BY AMEREN.

REFERENCES

1.) AMEREN MISSOURI MERAMEC ENERGY CENTER, MERAMEC PROPERTY CONTROL MAP, FEBRUARY 2011.
2.) COORDINATE SYSTEM: NAD 1983 STATEPLANE MISSOURI EAST FIPS 2401 FEET.

0 500 1,000 Feet

CLIENT
AMEREN MISSOURI
MERAMEC ENERGY CENTER

Ameren

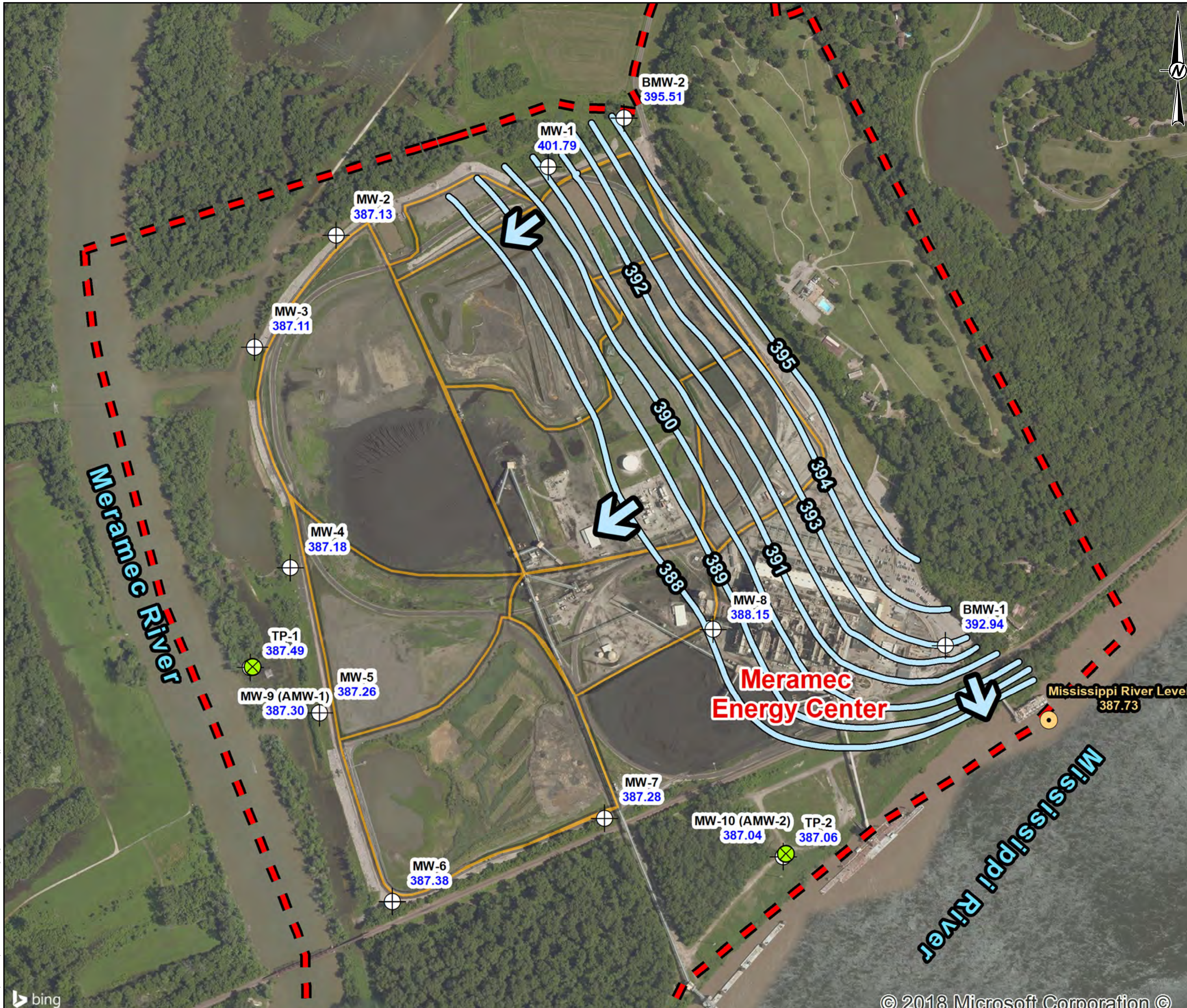
PROJECT
CCR GROUNDWATER MONITORING PROGRAM

TITLE
POTENTIOMETRIC SURFACE MAP - MAY 17, 2018

CONSULTANT
GOLDER

YYYY-MM-DD	2018-06-20
PREPARED	EFT
DESIGN	JSI
REVIEW	EMS/JSI
APPROVED	MNH

PROJECT No. 153-1406
PHASE 0004
AMEREN_00000808
FIGURE A11



LEGEND

- Meramec Energy Center Property Boundary
- All Surface Impoundments

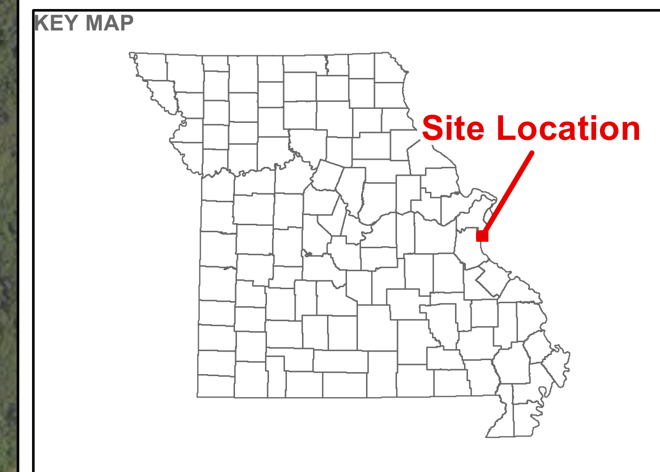
Groundwater Elevation Contours

- Groundwater Elevation Contour (FT MSL)

Ground/Surface Water Measurement Locations

- CCR Groundwater Monitoring Wells
- Temporary Nature and Extent Piezometer
- Mississippi River Gauge
- Groundwater Flow Direction

KEY MAP



NOTES
1. ALL LOCATIONS AND BOUNDARIES ARE APPROXIMATE.
2. GROUNDWATER ELEVATION MEASUREMENTS OBTAINED BY GOLDER.
3. WELL MW-1 NOT USED FOR POTENTIOMETRIC SURFACE MAP CONTOURING.
4. GROUNDWATER ELEVATIONS DISPLAYED IN FT MSL (FEET ABOVE MEAN SEA LEVEL).
5. MISSISSIPPI RIVER LEVEL PROVIDED BY AMEREN.

REFERENCES
1.) AMEREN MISSOURI MERAMEC ENERGY CENTER, MERAMEC PROPERTY CONTROL MAP, FEBRUARY 2011.
2.) COORDINATE SYSTEM: NAD 1983 STATEPLANE MISSOURI EAST FIPS 2401 FEET.

0 250 500 1,000 1,500 Feet

CLIENT
AMEREN MISSOURI
MERAMEC ENERGY CENTER

Ameren

PROJECT
CCR GROUNDWATER MONITORING PROGRAM

TITLE
JULY 2018 POTENTIOMETRIC SURFACE MAP

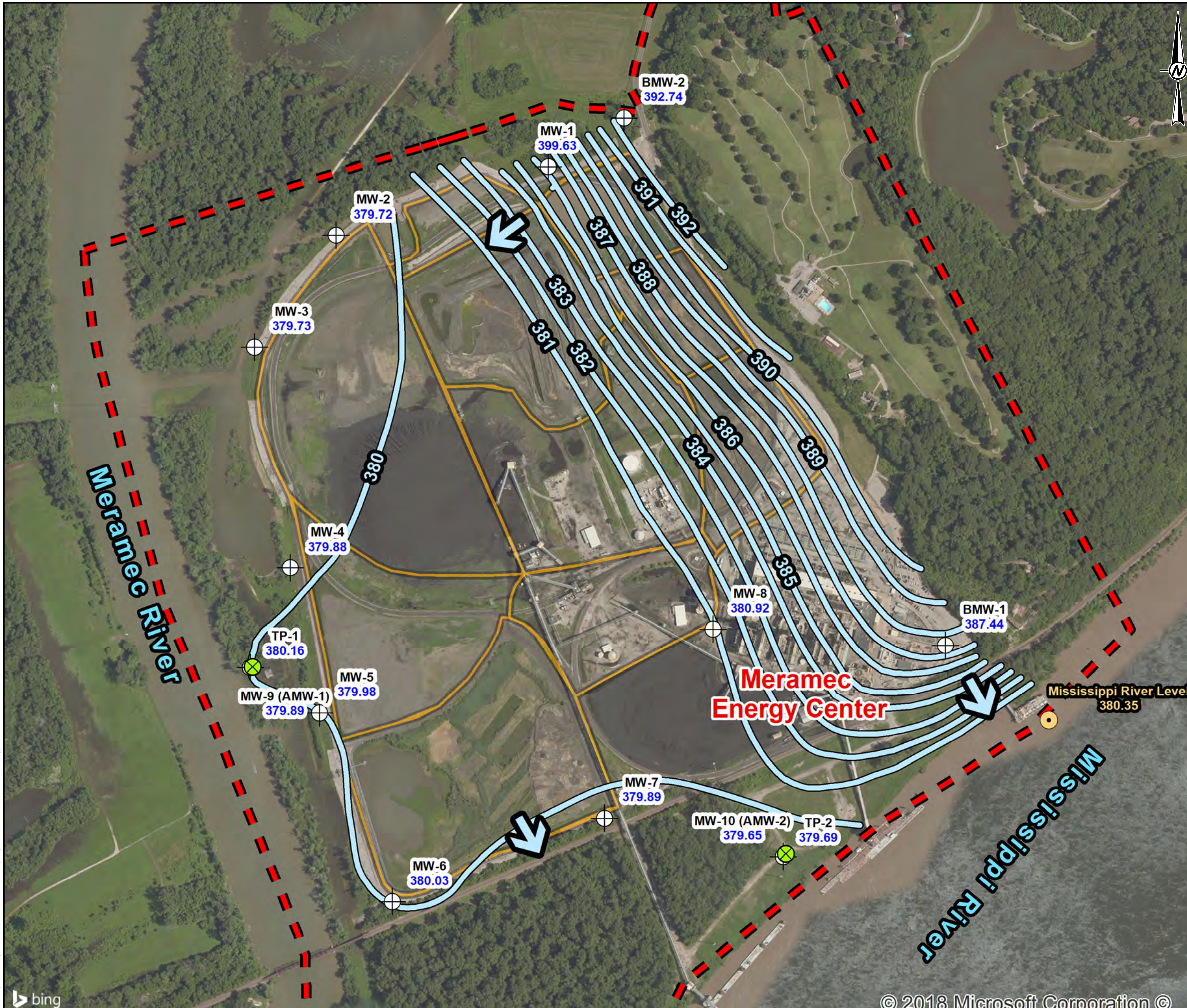
CONSULTANT

GOLDER

YYYY-MM-DD	2018-09-05
PREPARED	JS
DESIGN	JSI
REVIEW	TJG/JSI
APPROVED	MNH

PROJECT No.	PHASE	Rev.	FIGURE
153-1406	0004	0.0	A12

AMEREN_00000809



LEGEND

- Meramec Energy Center Property Boundary
- All Surface Impoundments

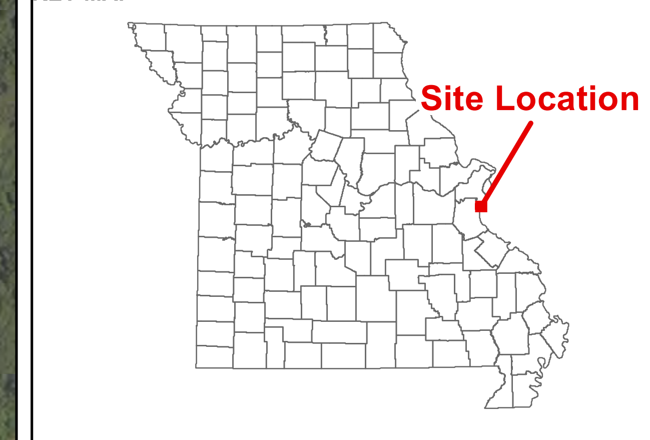
Groundwater Elevation Contours

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

Ground/Surface Water Measurement Locations

- CCR Groundwater Monitoring Wells
- Temporary Nature and Extent Piezometer
- Mississippi River Gauge
- Groundwater Flow Direction

KEY MAP



NOTES

1. ALL LOCATIONS AND BOUNDARIES ARE APPROXIMATE.
2. GROUNDWATER ELEVATION MEASUREMENTS OBTAINED BY GOLDER.
3. WELL MW-1 NOT USED FOR POTENTIOMETRIC SURFACE MAP CONTOURING.
4. GROUNDWATER ELEVATIONS DISPLAYED IN FT MSL (FEET ABOVE MEAN SEA LEVEL).
5. MISSISSIPPI RIVER LEVEL PROVIDED BY AMEREN.

REFERENCES

1.) AMEREN MISSOURI MERAMEC ENERGY CENTER, MERAMEC PROPERTY CONTROL MAP, FEBRUARY 2011.
2.) COORDINATE SYSTEM: NAD 1983 STATEPLANE MISSOURI EAST FIPS 2401 FEET.

0 250 500 1,000 1,500 Feet

CLIENT
AMEREN MISSOURI
MERAMEC ENERGY CENTER

PROJECT
CCR GROUNDWATER MONITORING PROGRAM

TITLE
AUGUST 2018 POTENTIOMETRIC SURFACE MAP

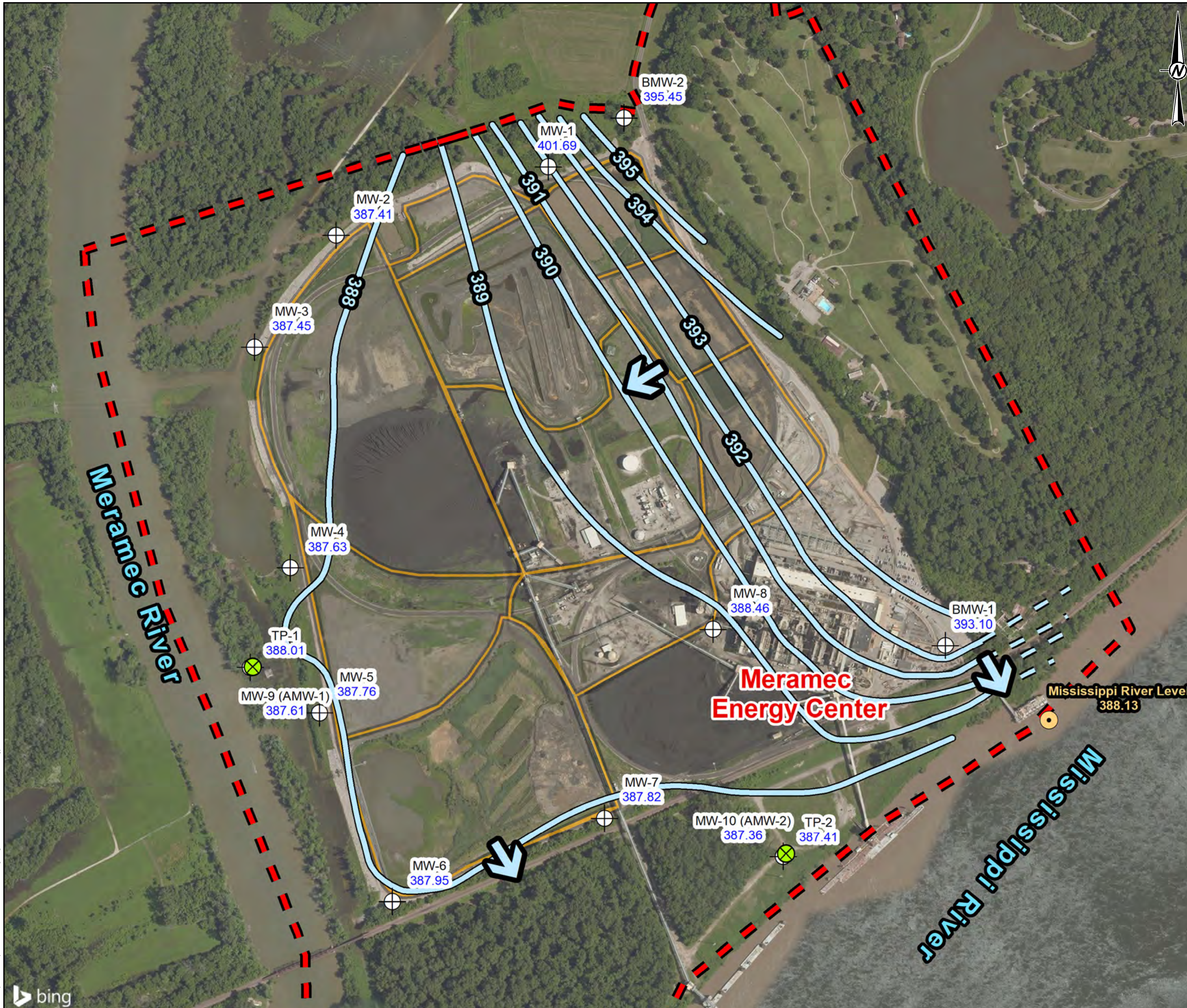
CONSULTANT

YYYY-MM-DD	2018-09-05
PREPARED	JS
DESIGN	JSI
REVIEW	TJG/JSI
APPROVED	MNH

PROJECT No.	PHASE	Rev.	FIGURE
153-1406	0004	0.0	A13

AMEREN_00000810

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



LEGEND

- Meramec Energy Center Property Boundary
- All Surface Impoundments

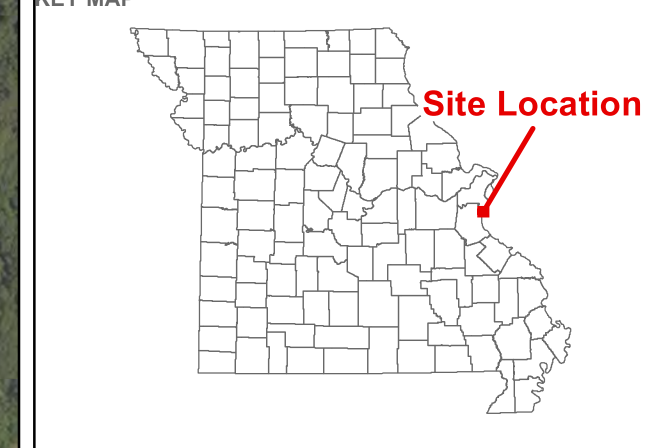
Groundwater Elevation Contours

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

Ground/Surface Water Measurement Locations

- CCR Groundwater Monitoring Wells
- Temporary Nature and Extent Piezometer
- Mississippi River Gauge
- Groundwater Flow Direction

KEY MAP



NOTES
1. ALL LOCATIONS AND BOUNDARIES ARE APPROXIMATE.
2. GROUNDWATER ELEVATION MEASUREMENTS OBTAINED BY GOLDER.
3. WELL MW-1 AND PIEZOMETER TP-1 WERE NOT USED FOR POTENTIOMETRIC SURFACE MAP CONTOURING.
4. GROUNDWATER ELEVATIONS DISPLAYED IN FT MSL (FEET ABOVE MEAN SEA LEVEL).
5. MISSISSIPPI RIVER LEVEL PROVIDED BY AMEREN.

REFERENCES
1.) AMEREN MISSOURI MERAMEC ENERGY CENTER, MERAMEC PROPERTY CONTROL MAP, FEBRUARY 2011.
2.) COORDINATE SYSTEM: NAD 1983 STATEPLANE MISSOURI EAST FIPS 2401 FEET.

0 250 500 1,000 1,500
Feet

CLIENT
AMEREN MISSOURI
MERAMEC ENERGY CENTER

Ameren

PROJECT
CCR GROUNDWATER MONITORING PROGRAM

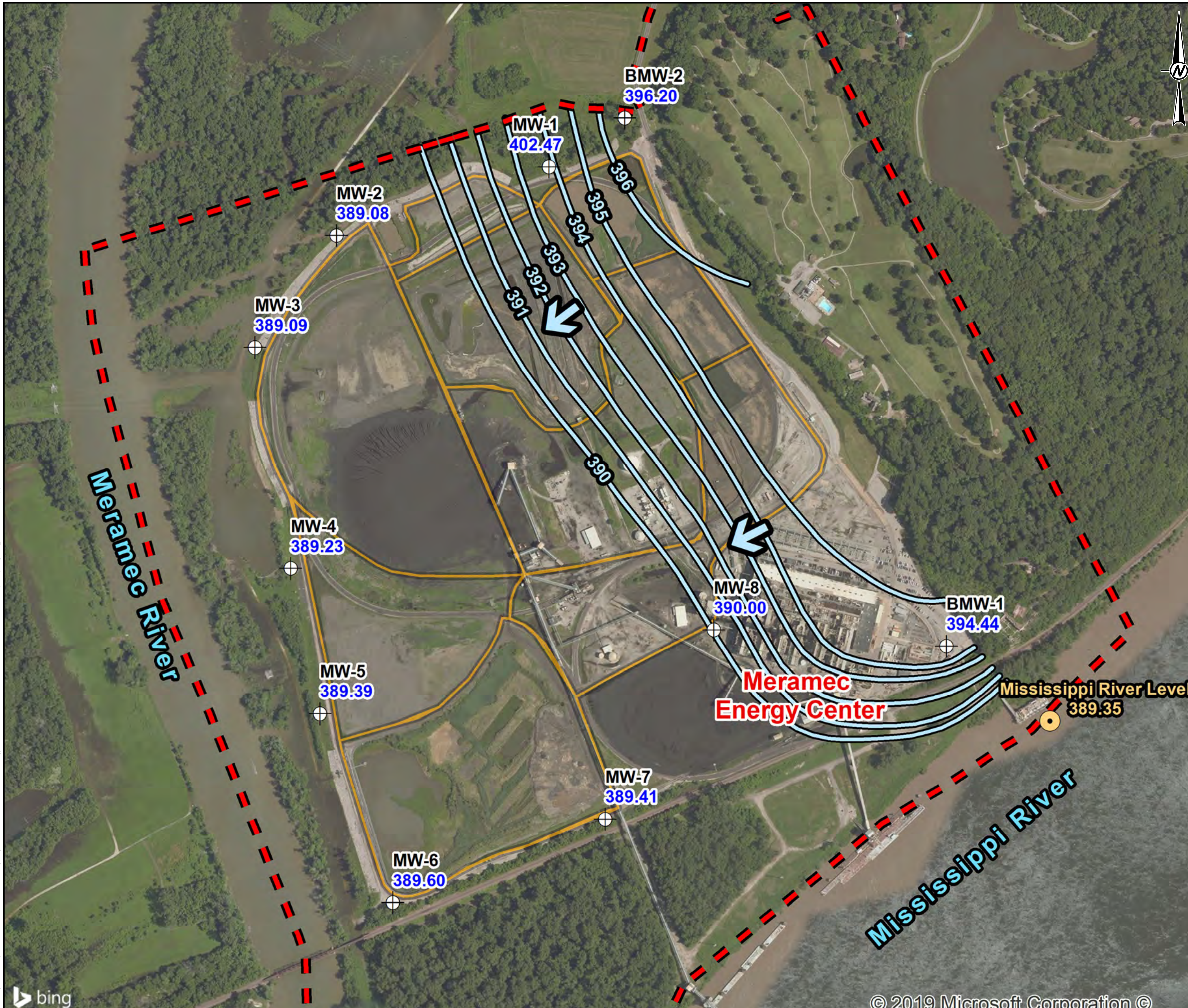
TITLE
SEPTEMBER 2018 POTENTIOMETRIC SURFACE MAP

CONSULTANT

GOLDER

YYYY-MM-DD	2018-10-11
PREPARED	RJF
DESIGN	JSI
REVIEW	EMS/JSI
APPROVED	MNH

PROJECT No.	PHASE	Rev.	FIGURE
153-1406	0004	0.0	A14



LEGEND

- Meramec Energy Center Property Boundary
- All Surface Impoundments

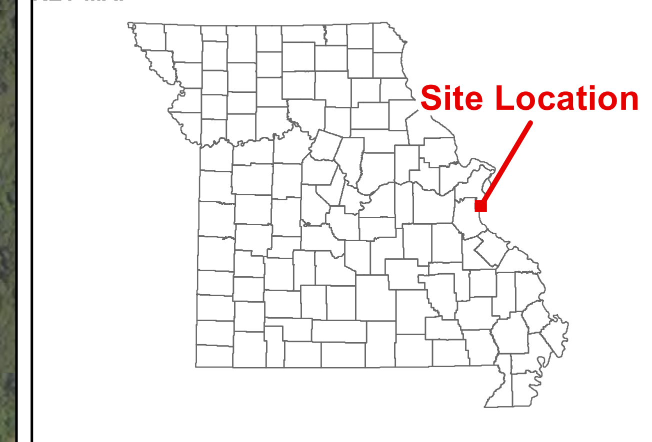
Groundwater Elevation Contours

- Groundwater Elevation Contour (FT MSL)

Ground/Surface Water Measurement Locations

- Groundwater Monitoring Well
- Mississippi River Gauge
- Groundwater Flow Direction

KEY MAP



NOTES
1. ALL LOCATIONS AND BOUNDARIES ARE APPROXIMATE.
2. GROUNDWATER ELEVATION MEASUREMENTS OBTAINED BY GOLDER.
3. GROUNDWATER MONITORING WELLS SURVEYED BY ZAHNER AND ASSOCIATES, INC.
4. WELL MW-1 NOT USED FOR POTENTIOMETRIC SURFACE MAP CONTOURING.
5. GROUNDWATER ELEVATIONS DISPLAYED IN FT MSL (FEET ABOVE MEAN SEA LEVEL).
6. MISSISSIPPI RIVER LEVEL PROVIDED BY AMEREN.

REFERENCES
1.) AMEREN MISSOURI MERAMEC ENERGY CENTER, MERAMEC PROPERTY CONTROL MAP, FEBRUARY 2011.
2.) COORDINATE SYSTEM: NAD 1983 STATEPLANE MISSOURI EAST FIPS 2401 FEET.

0 500 1,000 Feet

CLIENT
AMEREN MISSOURI
MERAMEC ENERGY CENTER

PROJECT
CCR GROUNDWATER MONITORING PROGRAM

TITLE
POTENTIOMETRIC SURFACE MAP - NOVEMBER 19, 2018

CONSULTANT
GOLDER

YYYY-MM-DD	2018-12-21
PREPARED	EFT
DESIGN	JSI
REVIEW	JAP
APPROVED	MNH

PROJECT No. 153-1406 PHASE 0004 FIGURE A15

AMEREN_00000812

LEGEND

Meramec Energy Center Property Boundary

All Surface Impoundments

Groundwater Elevation Contours

Groundwater Elevation Contour (FT MSL)

Inferred Groundwater Elevation Contour (FT MSL)

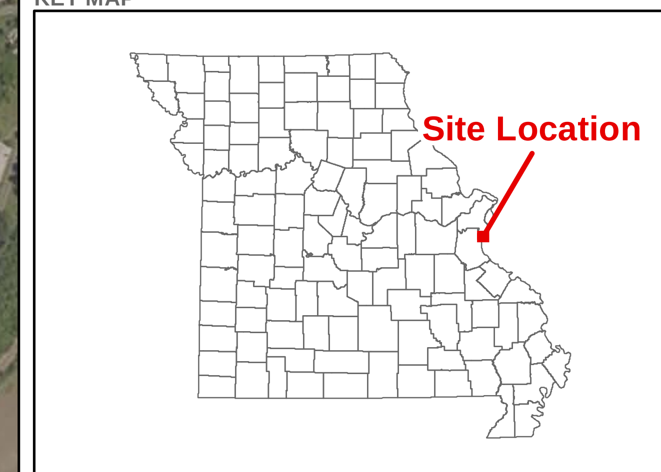
Ground/Surface Water Measurement Locations

Groundwater Monitoring Well

Mississippi River Gauge

Groundwater Flow Direction

KEY MAP



NOTES

1. ALL LOCATIONS AND BOUNDARIES ARE APPROXIMATE.
2. GROUNDWATER ELEVATION MEASUREMENTS OBTAINED BY GOLDER.
3. GROUNDWATER MONITORING WELLS SURVEYED BY ZAHNER AND ASSOCIATES, INC.
4. WELL MW-1 NOT USED FOR POTENTIOMETRIC SURFACE MAP CONTOURING.
5. GROUNDWATER ELEVATIONS DISPLAYED IN FT MSL (FEET ABOVE MEAN SEA LEVEL).
6. MISSISSIPPI RIVER LEVEL PROVIDED BY AMEREN.

REFERENCES

1.) AMEREN MISSOURI MERAMEC ENERGY CENTER, MERAMEC PROPERTY CONTROL MAP, FEBRUARY 2011.
2.) COORDINATE SYSTEM: NAD 1983 STATEPLANE MISSOURI EAST FIPS 2401 FEET.

0 500 1,000 Feet

CLIENT
AMEREN MISSOURI
MERAMEC ENERGY CENTER

Ameren

PROJECT
CCR GROUNDWATER MONITORING PROGRAM

TITLE
POTENTIOMETRIC SURFACE MAP - JANUARY 9, 2019

CONSULTANT
GOLDER

YYYY-MM-DD	2018-12-21
PREPARED	RJF
DESIGN	JSI
REVIEW	KAB
APPROVED	MNH

PROJECT No. 153-140601 PHASE 0004 AMEREN_00000813 FIGURE A16

LEGEND

Meramec Energy Center Property Boundary

All Surface Impoundments

Groundwater Elevation Contours

Groundwater Elevation Contour (FT MSL)

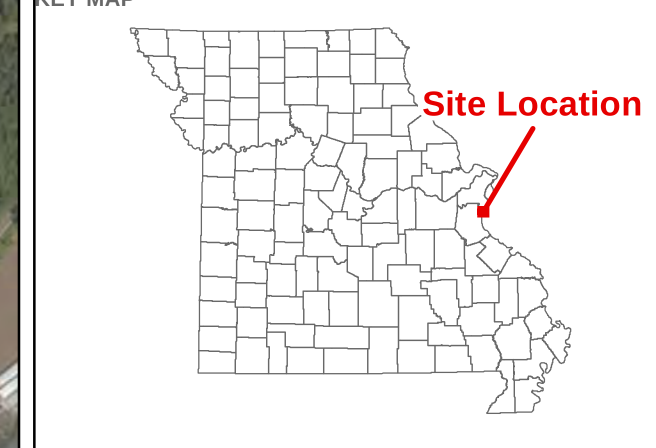
Ground/Surface Water Measurement Locations

Groundwater Monitoring Well

Mississippi River Gauge

Groundwater Flow Direction

KEY MAP



NOTES

1. ALL LOCATIONS AND BOUNDARIES ARE APPROXIMATE.
2. GROUNDWATER ELEVATION MEASUREMENTS OBTAINED BY GOLDER.
3. GROUNDWATER MONITORING WELLS SURVEYED BY ZAHNER AND ASSOCIATES, INC.
4. WELL MW-1 NOT USED FOR POTENTIOMETRIC SURFACE MAP CONTOURING.
5. GROUNDWATER ELEVATIONS DISPLAYED IN FT MSL (FEET ABOVE MEAN SEA LEVEL).
6. MISSISSIPPI RIVER AND POND LEVELS PROVIDED BY AMEREN.

REFERENCES

1.) AMEREN MISSOURI MERAMEC ENERGY CENTER, MERAMEC PROPERTY CONTROL MAP, FEBRUARY 2011.
2.) COORDINATE SYSTEM: NAD 1983 STATEPLANE MISSOURI EAST FIPS 2401 FEET.

0 500 1,000 Feet

CLIENT
AMEREN MISSOURI
MERAMEC ENERGY CENTER

Ameren

PROJECT
CCR GROUNDWATER MONITORING PROGRAM

TITLE
JANUARY 28, 2019 POTENTIOMETRIC SURFACE MAP

CONSULTANT

GOLDER

YYYY-MM-DD	2019-02-19
PREPARED	EMS
DESIGN	JSI
REVIEW	TJG
APPROVED	MNH

PROJECT No.	PHASE	Rev.	FIGURE
153-1406	0004D	0.0	A17

AMEREN_00000814

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

LEGEND

- Meramec Energy Center Property Boundary
- All Surface Impoundments

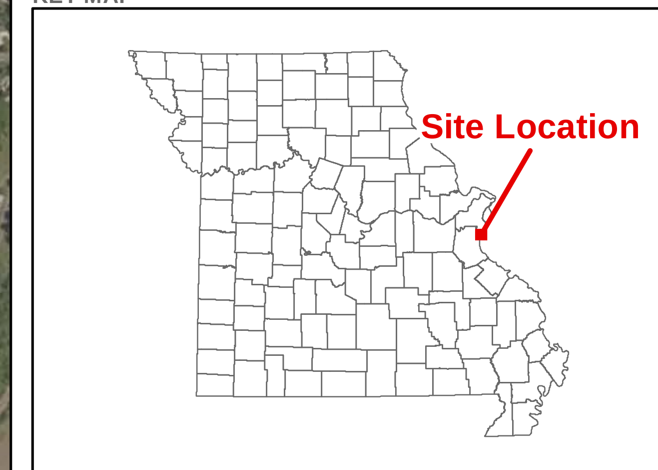
Groundwater Elevation Contours

- Groundwater Elevation Contour (FT MSL)

Ground/Surface Water Measurement Locations

- Groundwater Monitoring Well
- Mississippi River Gauge
- Groundwater Flow Direction

KEY MAP



NOTES
1. ALL LOCATIONS AND BOUNDARIES ARE APPROXIMATE.
2. GROUNDWATER ELEVATION MEASUREMENTS OBTAINED BY GOLDER.
3. GROUNDWATER MONITORING WELLS SURVEYED BY ZAHNER AND ASSOCIATES, INC.
4. WELL MW-1 NOT USED FOR POTENTIOMETRIC SURFACE MAP CONTOURING.
5. GROUNDWATER ELEVATIONS DISPLAYED IN FT MSL (FEET ABOVE MEAN SEA LEVEL).
6. MISSISSIPPI RIVER LEVEL PROVIDED BY AMEREN.
7. MW-9 (AMW-1) AND TP-1 ACCESS BLOCKED DUE TO HIGH WATER, NO GROUNDWATER ELEVATION DATA RECORDED.

REFERENCES
1.) AMEREN MISSOURI MERAMEC ENERGY CENTER, MERAMEC PROPERTY CONTROL MAP, FEBRUARY 2011.
2.) COORDINATE SYSTEM: NAD 1983 STATEPLANE MISSOURI EAST FIPS 2401 FEET.

0 500 1,000 Feet

CLIENT
AMEREN MISSOURI
MERAMEC ENERGY CENTER

Ameren

PROJECT
CCR GROUNDWATER MONITORING PROGRAM

TITLE
POTENTIOMETRIC SURFACE MAP - FEBRUARY 26, 2019

CONSULTANT
GOLDER

YYYY-MM-DD	2019-11-27
PREPARED	EMS
DESIGN	JSI
REVIEW	RJF/JSI
APPROVED	MNH

PROJECT No.	PHASE	Rev.	FIGURE
153-140601	0004	0.0	A18

AMEREN_00000815

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

LEGEND

Meramec Energy Center Property Boundary

All Surface Impoundments

Groundwater Elevation Contours

Groundwater Elevation Contour (FT MSL)

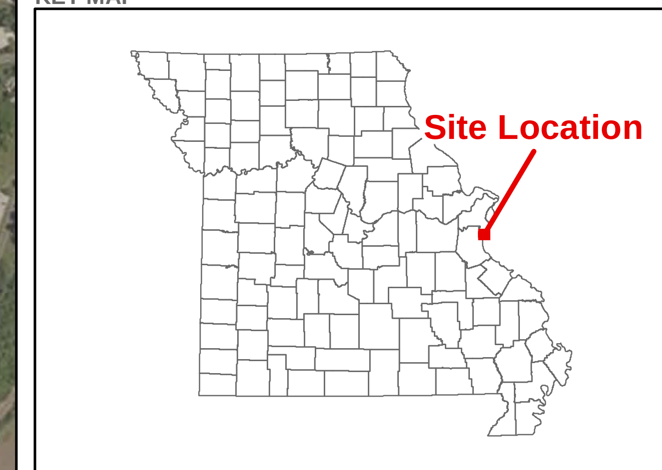
Ground/Surface Water Measurement Locations

Groundwater Monitoring Well

Mississippi River Gauge

Groundwater Flow Direction

KEY MAP



NOTES
1. ALL LOCATIONS AND BOUNDARIES ARE APPROXIMATE.
2. GROUNDWATER ELEVATION MEASUREMENTS OBTAINED BY GOLDER.
3. GROUNDWATER MONITORING WELLS SURVEYED BY ZAHNER AND ASSOCIATES, INC.
4. WELL MW-1 NOT USED FOR POTENTIOMETRIC SURFACE MAP CONTOURING.
5. GROUNDWATER ELEVATIONS DISPLAYED IN FT MSL (FEET ABOVE MEAN SEA LEVEL).
6. MISSISSIPPI RIVER LEVEL PROVIDED BY AMEREN.

REFERENCES
1.) AMEREN MISSOURI MERAMEC ENERGY CENTER, MERAMEC PROPERTY CONTROL MAP, FEBRUARY 2011.
2.) COORDINATE SYSTEM: NAD 1983 STATEPLANE MISSOURI EAST FIPS 2401 FEET.

0 500 1,000 Feet

CLIENT
AMEREN MISSOURI
MERAMEC ENERGY CENTER

Ameren

PROJECT
CCR GROUNDWATER MONITORING PROGRAM

TITLE
POTENTIOMETRIC SURFACE MAP - AUGUST 12, 2019

CONSULTANT

GOLDER

YYYY-MM-DD	2019-08-29
PREPARED	JSI
DESIGN	JSI
REVIEW	KAB/EMS
APPROVED	MNH

PROJECT No.	PHASE	Rev.	FIGURE
153-140601	0004	0.0	A19

AMEREN_00000816

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

LEGEND

- Meramec Energy Center Property Boundary
- All Surface Impoundments

Groundwater Elevation Contours

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

Ground/Surface Water Measurement Locations

- Groundwater Monitoring Well
- Mississippi River Gauge
- Groundwater Flow Direction

KEY MAP

NOTES

1. ALL LOCATIONS AND BOUNDARIES ARE APPROXIMATE.
2. GROUNDWATER ELEVATION MEASUREMENTS OBTAINED BY GOLDER.
3. GROUNDWATER MONITORING WELLS SURVEYED BY ZAHNER AND ASSOCIATES, INC.
4. WELL MW-1 NOT USED FOR POTENTIOMETRIC SURFACE MAP CONTOURING.
4. GROUNDWATER ELEVATION MEASUREMNTS COULD NOT BE COLLECTED AT MW-2, MW-3, MW-9 (AMW-1), BMW-3, BMW-4, AND BMW-5 DUE TO FLOODING.
6. GROUNDWATER ELEVATIONS DISPLAYED IN FT MSL (FEET ABOVE MEAN SEA LEVEL).
7. MISSISSIPPI RIVER LEVEL PROVIDED BY AMEREN.

REFERENCES

1.) AMEREN MISSOURI MERAMEC ENERGY CENTER, MERAMEC PROPERTY CONTROL MAP, FEBRUARY 2011.
2.) COORDINATE SYSTEM: NAD 1983 STATEPLANE MISSOURI EAST FIPS 2401 FEET.

0 500 1,000
Feet

CLIENT
AMEREN MISSOURI
MERAMEC ENERGY CENTER

Ameren

PROJECT
CCR GROUNDWATER MONITORING PROGRAM

TITLE
POTENTIOMETRIC SURFACE MAP - OCTOBER 3, 2019

CONSULTANT

GOLDER

YYYY-MM-DD	2019-10-18
PREPARED	AMM
DESIGN	JSI
REVIEW	RJF
APPROVED	MNH

PROJECT No.	PHASE		FIGURE
153-140601	0004	AMEREN_00000817	A20

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

APPENDIX B

Groundwater Sampling Methods and Procedures

Groundwater Sampling Methodology and Procedures

Groundwater Monitoring Plan

Ameren Missouri
1901 Chouteau Avenue, St. Louis, Missouri 63103

Golder Associates Inc.
13515 Barrett Parkway Drive, Suite 260, Ballwin, Missouri, USA 63021

+1 314 984-8800

153140601

November 2019

Table of Contents

1.0 INTRODUCTION

Sampling will be performed in accordance with generally accepted practices within the industry and with the provisions of Missouri regulations. This document is an appendix to the Groundwater Monitoring Plan and provides details regarding the procedures that will be used to collect groundwater samples. Although this appendix provides references to specific forms, the use of other equivalent forms to record the necessary data is permissible.

2.0 GROUNDWATER SAMPLING METHODOLOGY

2.1 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.

2.2 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

2.2.1 Low-Flow Sampling Technique

Low-flow groundwater sampling procedures will be used for purging and sampling monitoring wells that are equipped with dedicated pumps/tubing 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 is 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 (United States Environmental Protection Agency [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, 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 A**.

2.3 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.

2.3.1 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 containers, samplers will note this on the field form, and fill as many sample containers as possible.

3.0 CALIBRATION, FIELD DOCUMENTATION, AND LABORATORY DOCUMENTATION

3.1 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 A.**

3.1.1 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. Sample containers will be kept closed until the time each set of sample containers is filled.

3.1.2 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 or nitrile gloves will be worn by sampling personnel during monitoring well purging and sample collection.

3.1.3 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.

3.1.4 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 A**.

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.

3.1.5 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

3.1.6 Sample Seal

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

3.1.7 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 A**. The field forms will document the following information:

- Identification of the monitoring well
- Sample identification number
- Field meter calibration information
- 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

3.1.8 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 their possession
- It was in the individual’s possession and they 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.

3.1.9 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.

4.0 ANALYTICAL AND QUALITY CONTROL PROCEDURES

4.1.1 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).

4.1.2 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.

4.1.2.1 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.**

4.1.2.2 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.**

4.1.2.3 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.**

4.1.2.4 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: MW-1
- MS: MW-1-MS
- MSD: MW-1-MSD

5.0 REFERENCES

MDNR. 2011. Missouri Well Construction Rules. Missouri Department of Natural Resources Division of Geology and Land Survey. Rolla, MO. August 2011.

USEPA. 2010. Low Stress (Low Flow) Purging and Sampling Procedure for the Collection of Groundwater Samples From Monitoring Wells., U.S. Environmental Protection Agency, Revised January 19, 2010.

APPENDIX A

Example Field Forms

GOLDER

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 BTOC)	Appearance of Water and Comments

GROUNDWATER SAMPLE COLLECTION FORM

GOLDER

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	º___					
Dissolved Oxygen	mg/l					
Redox Potential	+/- mV					

LABORATORY CONTAINERS

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

REMARKS: ____

NA = Not applicable

SAMPLING METHODS:

Bailer: PVC/PE, Stainless Steel, Teflon

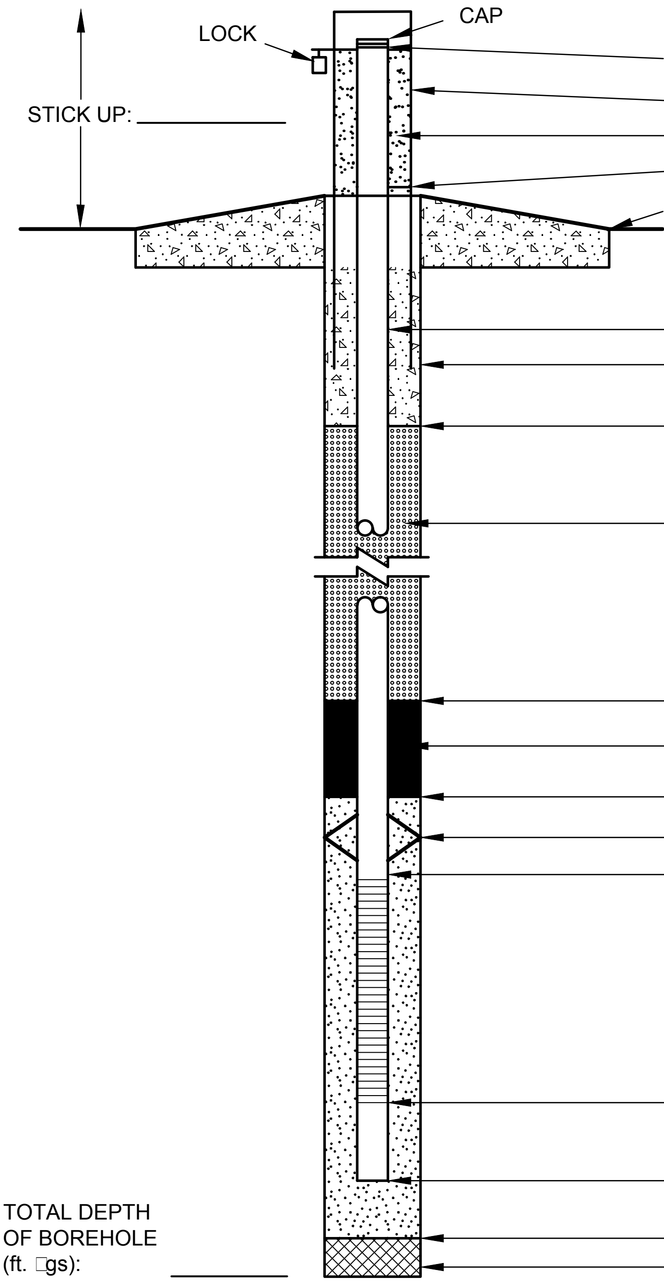
Peristaltic Pump, Submersible Pump, Hand Pump

Air-Lift Pump, Other__________

GOLDER

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. □gs): ____________

TYPE AND AMOUNT OF ANNULAR SEAL: ____________

TOP OF BENTONITE SEAL DEPTH (ft. □gs): ____________

TYPE AND AMOUNT OF BENTONITE SEAL: ____________

TOP OF SAND PACK DEPTH (ft. □gs): ____________

CENTRALIZER (yes □no) - TYPE: ____________

TOP OF SCREEN DEPTH (ft. □gs): ____________

TYPE OF SCREEN: ____________

SCREEN SLOT SIZE (in.): ____________

SIZE OF SAND PACK: ____________

AMOUNT OF SAND: ____________

BOTTOM OF SCREEN DEPTH (ft. □gs): ____________

BOTTOM OF WELL DEPTH (ft. □gs): ____________

TOTAL DEPTH OF BOREHOLE (ft. □gs): ____________

BOTTOM OF FILTER PACK (ft. □gs): ____________

TYPE AND AMOUNT OF BACKFILL: ____________

ADDITIONAL NOTES: ____________

CHECKED BY: ____________

DATE CHECKED: ____________

PREPARED BY: ____________

GOLDER

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 ___

GOLDER

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:

AMEREN_00000833

Golder Associates

Field Boring Log

DEPTH HOLE _____________ PROJ. NO. _____________ PROJECT ______________________________ BORING NO. _______________

DEPTH SOIL DRILL ________ GA INSP. _____________ DRILLING METHOD ______________________________ SHEET ________ OF ________

DEPTH ROCK CORE_______ WEATHER _____________ DRILLING COMPANY ______________________________ SURFACE ELEV. _____________

ABANDONMENT______________________________ DRILL RIG ______________________ DRILLER _______________ DATUM _____________________

DEPTHS_________/_________/_________/_________ (WATER LEVEL / CAVE-IN / DATE-TIME / NOTE) SAMPLER HAMMER TYPE ______________ WT. ________ DROP_______ STARTED ________/________ (TIME / DATE)

DEPTHS_________/_________/_________/_________ ((DELAYED) WATER LEVEL / CAVE-IN / DATE-TIME / NOTE) HOLE LOCATION ______________________________ COMPLETED ________/________ (TIME / DATE)

SAMPLE TYPES

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

* NOTE SIZE

ABBREVIATIONS

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

ORDER OF DESCRIPTION

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

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

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

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

PROPORTIONS

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

NON-COHESIVE SOILS

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

MOISTURE CONDITION

DRY	SOIL FLOWS
MOIST	FEELS COOL
WET	WITH FREE WATER

COHESIVE SOILS

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

WATER CONTENT - W

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

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

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

GOLDER

APPENDIX C

Statistical Analysis Plan

GOLDER

Corrective Action Statistical Analysis Plan

Meramec Energy Center - St. Louis County, Missouri

Submitted to:

Ameren Missouri

1901 Chouteau Avenue, St. Louis, Missouri 63103

Submitted by:

Golder Associates Inc.

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153140601

November 2019

Executive Summary

This Corrective Action 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), specifically § 257.98(a)(1) on the Implementation of a Corrective Action Program. This section of the CCR Rule requires owners or operators establish and implement a Corrective Action Groundwater Monitoring Plan (GMP) within 90 days of selecting a remedy. On August 30, 2019 Ameren Missouri (Ameren) selected the remedy of source control through installation of a low permeability cover system and use of Monitored Natural Attenuation (MNA) for groundwater impacts from the Meramec Surface Impoundments at the Meramec Energy Center (MEC).

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 for Corrective Action monitoring for Ameren Missouri at the above mentioned CCR Unit. Details on statistical analysis for detection monitoring and assessment monitoring are provided in the GMP for the MEC and are not included in this document. Detailed information on collection, sampling techniques, preservation, etc. are provided in the Corrective Action Groundwater Monitoring Plan (GMP) for the CCR Unit specified above. This SAP is a companion document 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 Corrective Action GMP.

This SAP was prepared by Golder Associates Inc. (Golder), on behalf of Ameren, to document appropriate methods 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 the CCR Rule.

Table of Contents

1.0 INTRODUCTION

This SAP discusses the procedures, methods, and processes that will be implemented as part of the Corrective Action statistical evaluation. Corrective Action statistical analysis will begin once source control through the installation of a low permeability cover system is complete. Additionally, as specified in the Corrective Action GMP, a minimum of eight rounds of sampling for all constituents present at a Statistically Significant Level (SSL) from Assessment Monitoring will be collected prior to initiating statistical analysis. This background monitoring period provides baseline data for each monitoring well which can be used as the basis of the statistical evaluation.

2.0 STATISTICAL DATA PREPARATION AND INITIAL REVIEW

Many of the statistical comparison tests used in Corrective Action 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 the initial review of the data. The analyses required include testing for statistical independence, physical independence, and procedures to evaluate potential outliers.

2.1.1 Physical and Statistical Independence of Groundwater Samples

Corrective Action 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 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. This table displays the range of conductivities collected onsite. If a sampling frequency less than those provided below are to be used, then well specific calculations will need to be completed to ensure that the samples will be physically independent.

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
CCR Rule Monitoring Wells					
Minimum	3	0.0021	0.35	0.5	29.4
Geomean	40	0.0021	0.35	0.5	2.1
Maximum	185	0.0021	0.35	0.5	0.4

Notes:

1. Average hydraulic gradient and effective porosity obtained from GMP
2. Hydraulic conductivity obtained from ranges provided in GMP
3. Calculation completed using the Darcy Equation as outlined in section 14.3.2 of the Unified Guidance.

2.1.2 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 using the data to calculate statistical limits.

2.1.2.1 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 2.1.2.2 below.

2.1.2.2 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 produce a more conservative statistical limit, since the data variability is decreased, thereby decreasing the standard deviation.

2.1.3 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.

2.1.3.1 Reporting of Low and Zero Values

2.1.3.1.1 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 (NDs) 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 NDs.

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. In these cases, the Double Quantification Rule (DQR) as described in this CCR Units GMP should be used.

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

[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).

2.1.4 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.
- **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.

2.1.5 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.

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). Following implementation of a successful remediation strategy, it is expected that CCR-related groundwater constituents concentrations will decrease with time. If a statistically significant trend is reported, based on a Sen's slope/Mann-Kendall trend test, it is inappropriate to perform "normal" statistical calculations (see Section 21.3 of the Unified Guidance). In such cases, an adjustment or an alternate method is required.

3.0 CORRECTIVE ACTION STATISTICAL EVALUATION

Following the removal of outliers and the performance of general statistics described in Section 2.0, the specific Corrective Action Statistical Evaluation will be completed. This evaluation is very similar to the Assessment Monitoring statistical procedures except the null hypothesis for the confidence intervals is reversed. For Corrective Action, the Unified Guidance states that the appropriate null hypothesis is that the groundwater population (mean) exceeds the GWPS for those constituents that exceed the GWPS under Assessment Monitoring program. Therefore, in Corrective Action the Upper Confidence Limit (UCL) is compared to the Groundwater Protection Standard (GWPS) instead of the Lower Confidence Limit (LCL) [as was used during Assessment Monitoring].

3.1 Statistical Power

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 compliance while also maintaining sufficient statistical power to detect when compliance is achieved. Falsely triggering compliance when groundwater concentrations are still statistically above the GWPS occurred is referred to as a false positive in corrective action. 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 compliance depends on the selection of an appropriate FPR, which is referred to as the statistical power. 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.

In Corrective Action monitoring, it is not possible to calculate a FPR or a site-wide false positive rate, as is calculated during Detection Monitoring. The Unified Guidance gives two methods for determining the statistical power in Corrective Action monitoring, both methods are dependent on the minimizing the FPR and at the same time minimizing the false negative rate. As stated in the Unified Guidance, ultimately, the statistical power of the confidence interval test will increase as the sample size increases, as long as the FPR is held constant. For this CCR Unit, an initial FPR of 0.05 is proposed for the confidence interval test methodology. Initially, when sample sizes are low, the overall power of the test will also be relatively low, but the power (and thus the confidence in making sound judgements relative to the success of the remedial efforts) will increase over time, as the sample size increases.

Ultimately, the goal of Corrective Action monitoring is to determine whether the selected remedy has been effective in cleaning up the groundwater to a point at which continued monitoring is no longer required. In that sense, the power of the statistical approach is important for confirming that the statistical method is accurately determining the end point of the remedial effort. Thus, particular caution will be exercised in situations where the compliance statistic (in this case, the upper confidence level (UCL), is at or near the compliance limit (in this case, the groundwater protection standard [GWPS]). Corrective Action monitoring will only be discontinued if it can be clearly demonstrated that the UCL is and will remain below the GWPS. Additional discussion is provided below regarding the specifics of the confidence interval method that will be used in Corrective Action monitoring.

3.2 Confidence Interval Approach

The statistical method for evaluating data in Correction Action is similar to the method that was used during Assessment Monitoring. Thus, intrawell confidence intervals will be calculated for each detected Appendix IV constituent in each well and the resulting confidence intervals will be compared with the appropriate Groundwater Protection Standard (GWPS). During the Assessment Monitoring phase of the program, a site wide GWPS generated for each detected Appendix IV constituent. Over time, as additional background data are collected, the GWPS will be updated accordingly, as described in Section 3.2.2, below.

3.2.1 Maximum Contaminant Level (MCL) Based GWPS

All the Appendix IV analytes have either an USEPA MCL or a health based GWPS that was adopted for Appendix IV parameters without an MCL (i.e. cobalt, lithium, molybdenum, and lead). As specified in Section §257.95(b) of the CCR Rule, the GWPS must either be the MCL (or adopted heath based standard), or a limit based on site-specific background data, whichever is greater. This section describes the methods to be used for statistical analysis when the MCL (or adopted heath based standard) is to be used as the GWPS. Additional discussion is provided below in Section 3.2.2 for situations where the site-specific background is greater than the MCL or health based standard.

For Corrective Action, the Unified Guidance recommends the confidence interval method to evaluate for potential compliance under the GWPS (Chapter 22, Unified Guidance). Using confidence intervals, potential compliance under the GWPS is 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 used. As discussed in Section 3.1, above, the statistical power of the method increases with an increasing number of observations, so it is generally preferred that all available data be used to calculate the confidence interval. However, if trends are noted in the data, it may be necessary to exclude historical data prior to the trend, so that the confidence interval can be more accurately calculated. As described in preceding sections, it is expected that trends will develop following the implementation of remedial actions, and thus, it is likely that the well specific data sets will require adjustment over time to account for trends.

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 2** below is based on Table 4-5 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 UCL and LCL is provided in the section reference from the Unified Guidance, which is listed in the last column of **Table 2**, 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)
Statistical Trend Noted in Well Specific Data Set	Low	Trend	Confidence Band Around Theil-Sen Line (Section 21.3.2)

In a Corrective Action monitoring program, the UCL is of primary interest. If the UCL exceeds the GWPS, the constituent is still present at a concentration that is statistically above the GWPS; however, if the UCL is less than the GWPS, the constituent is below the GWPS. If the UCL is lower than the GWPS for three consecutive years, then the monitoring well is in considered to be in full compliance.

As discussed above in Section 3.1, during Corrective Action, 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 Corrective Action 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.

3.2.2 Updating the GWPS

In general, the GWPS have already been established for each Appendix IV constituent at this CCR Unit. However, it may be necessary to update the GWPS in the future to account for changes in background constituent concentrations. Recalculating the GWPS by incorporating additional background data over time typically results in a more robust value for the GWPS. During Corrective Action monitoring, background or historical concentration limits should be assessed using the following techniques for each of the detected

Appendix IV analytes. These concentration limits should then be compared with the MCL or health-based value, and the higher of these two values will be used as the GWPS. Updates to the GWPS will only apply to those constituents whose site-specific background concentration is above the established MCL or health-based value. Additional details regarding the timeframes for updating the GWPS are provided in Section 3.4, below.

The Unified Guidance provides two acceptable approaches for establishing a non-MCL based GWPS. As described in the SAP of the this CCR Units GMP, for situations where the site-specific background is greater than the MCL/health base limit, the two methods for calculating the GWPS include the tolerance interval approach or the prediction interval approach, described further below.

3.2.2.1 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 3.2.2.2 below.

The Upper Tolerance Limit (UTL) is calculated for each required 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 with 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 both a coverage and a confidence of 95%. When the background concentrations are greater than the MCL, the calculated UTL for each constituent is used as the GWPS. The intrawell confidence interval for each required Appendix IV constituent 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 required Appendix IV constituents in each compliance monitoring well; however a dataset of at least eight samples is recommended by the Unified Guidance. Using the Tolerance Interval Approach, a monitoring well is considered “in compliance” when the calculated UCL for each parameter in that well is less than the GWPS for three consecutive years.

Tolerance Intervals 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.

3.2.2.2 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, etc.), then a Prediction Interval method should be used. This method is very similar to the methods used for Detection Monitoring as specified in the SAP of the GMP for this CCR Unit; however, for Corrective Action, the Unified Guidance suggests using a prediction interval about a future mean for normally/transformed-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 3.2.2.1 above. As also described above, if the UCL is less than the calculated prediction limit for each constituent for three consecutive years then the monitoring well is "in compliance".

3.3 Completing Corrective Action Monitoring

As specified in 257.98(C) of the CCR Rule, because the selected remedy (capping and closure) depends on a monitored natural attenuation approach, in order to complete corrective action monitoring and declare the remedial efforts completed the following must be demonstrated:

- Compliance with the GWPS at all points within the plume of contamination that lie beyond the Detection/Assessment Groundwater Monitoring Well Network.
- Compliance with the GWPS where concentrations of constituents listed in Appendix IV have not exceeded the GWPS for a period of three consecutive years.

Additionally, because Corrective Action can be a dynamic process, with frequent changes in plume concentrations and size, individual monitoring wells may be removed from corrective action once they are under the GWPS for three consecutive years. The Corrective Action Program, however, will only be deemed competed once all points within the plume beyond the detection/assessment monitoring groundwater monitoring well system are statistically within compliance of the GWPS.

3.4 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). 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 whether the "new" data should be included in the background:

- Time Series Graphs – As described in Section 2.1.2.1, 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 will be 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 GWPS will be recalculated, as described above.

3.5 Alternative Source Demonstrations

If the Corrective Action statistical evaluation for detected Appendix IV parameters determines that a constituent has a UCL above the GWPS that was not identified as an SSL in Assessment Monitoring, then the data must be evaluated to determine if the cause of elevated UCL is due to a release from the CCR Unit or from an alternative source. Possible alternative sources may include new or previously unknown CCR constituent sources, nearby source areas, laboratory or sampling causes, statistical evaluation causes, or natural variation. If the value can be attributed to one of these alternative sources and was not caused by an SSL directly related to impacts from the CCR Unit, then 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.

4.0 REFERENCES

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

Golder Associates Inc., 2017. 40 CFR Part 257 Groundwater Monitoring Plan, Meramec Surface Impoundments, Meramec Energy Center-St. Louis County, Missouri, USA.

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.

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