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SUPPLEMENTAL REMEDY SELECTION REPORT
AMEREN MISSOURI MERAMEC ENERGY CENTER
ST. LOUIS COUNTY, MISSOURI

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for
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1. Introduction

1.1 PURPOSE

This Supplemental Remedy Selection Report (RSR) was prepared by Haley & Aldrich, Inc. on behalf of Union Electric Company d/b/a Ameren Missouri (Ameren) for five Coal Combustion Residuals (CCR) surface impoundments located at the Meramec Energy Center (MEC, Site) located in St. Louis County, Missouri. The five subject CCR surface impoundments – MCPA, MCPB, MCPC, MCPD, and MCPE (collectively referred to as the MEC CCR Surface Impoundments) – are subject to requirements of the United States Environmental Protection Agency rule entitled *Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals from Electric Utilities* (CCR Rule) effective 17 April 2015, including subsequent revisions. Under the CCR Rule, a Corrective Measure Assessment (CMA) report for MEC was prepared in May 2019 to evaluate four remedial alternatives against threshold criteria and balancing criteria outlined in the CCR Rule. An RSR for four of Ameren's CCR facilities, including MEC, was prepared on 30 August 2019 and posted to the MEC publicly available CCR website.[1] Ameren indicated in the 2019 RSR that it was actively exploring various groundwater treatment methodologies based on site-specific data and bench scale testing. Since preparation of the 2019 RSR, such technologies (in the form of groundwater extraction, ex-situ treatment, and re-injection systems) have been installed and are operational at Ameren's Rush Island Energy Center (RIEC) and Sioux Energy Center (SEC).

The National Pollutant Discharge Elimination System (NPDES) Permit MO-0000361 for MEC (effective 1 June 2024), issued by the Missouri Department of Natural Resources (MDNR), allows subsurface discharges of impacted groundwater to surface waters and indicates that MDNR has chosen monitored natural attenuation (MNA) as Best Available Technology for the Site. In the NPDES permit, MDNR also established a compliance schedule along with compliance points for various parameters. Ameren is evaluating various supplemental corrective measures to comply with both MDNR and federal CCR Rule requirements, including groundwater treatment systems such as those employed at the RIEC and SEC facilities.

The intent of this Supplemental RSR is to document the corrective measures implemented since development of the 2019 RSR, the results of implementing those measures, and any additional supplemental measures that may be anticipated in the future.

1.2 FACILITY DESCRIPTION

The MEC property encompasses approximately 480 acres along the Mississippi River at its confluence with the Meramec River in southeastern St. Louis County, Missouri. MEC began coal-fired electric-generating operations in 1953, and the coal-fired power plant was retired at the end of 2022. CCR produced as a byproduct of the coal combustion process was historically managed in a series of nine surface impoundments, of which five have been subject to the CCR Rule since its effective date (the MEC CCR Surface Impoundments) and four have been historically exempt from the CCR Rule (MOPF, MOPG, MOPH, and MOPI). The previously prepared MEC CMA report and 2019 RSR did not include the four historically exempt surface impoundments, and those impoundments are not the subject of this Supplemental RSR. The five MEC CCR Surface Impoundments (Figure 1) that have been previously evaluated are the subject of this report have been closed using a closure in place (CIP) methodology that

[1] Documents referenced in this report as posted to the Ameren MEC publicly available CCR website may be obtained at the following website address: https://www.ameren.com/company/environment-and-sustainability/managing-coal-combustion/ccr-compliance-reports/meramec-energy-center

involved dewatering in support of closure, general stabilization of existing CCR, placement of general fill, and the installation of a low-permeability geomembrane final cover system over the CCR to minimize erosion and infiltration. A summary of key information regarding the size and closure details for each of the five MEC CCR Surface Impoundments is provided in in-text Table 1 below.

Table 1 – Summary of MEC CCR Surface Impoundments				
CCR Unit	Approximate Acreage*	Estimated CCR Volume (cy)*	Closure Completion Date	Closure Methodology
MCPA	7	187,000	15 October 2023	CIP with cap
MCPB	7	59,000	15 October 2023	CIP with cap
MCPC	10	274,000	15 October 2023	CIP with cap
MCPD	21	1,017,000	7 October 2021	CIP with cap
MCPE	25	900,000	11 April 2018	CIP with cap

Note: The approximate acreage and estimate CCR volume in cubic yards (cy) for each of the MEC CCR Surface Impoundments was taken from the respective Closure Plan for each impoundment posted to the MEC publicly available CCR website.

As of October 2023, each of the five MEC CCR Surface Impoundments has been closed. Upon completion of closure, each of the surface impoundments transitioned into the post-closure care requirements of the CCR Rule outlined in the Code of Federal Regulations Title 40 (40 CFR) §257.104.

1.3 CCR RULE COMPLIANCE SUMMARY

CCR Rule groundwater monitoring has been performed in accordance with CCR Rule requirements outlined in 40 CFR §257.90 through §257.95. The monitoring has been completed through a phased approach to allow for a graduated response [i.e., detection monitoring followed by assessment monitoring and then nature and extent (N&E) investigation, as applicable]:

- The CCR groundwater monitoring network includes two background wells and eight downgradient monitoring wells located around the perimeter of the Site's surface impoundments (Figure 1) and generally screened in the alluvial aquifer zone. These monitoring wells were installed in January 2016 and April 2016.
- Detection monitoring events occurred in 2017 and 2018, and results indicated concentrations of Appendix III constituents above Site-specific background values (i.e., statistically significant increases). As a result, an Assessment Monitoring Program was initiated for the MEC CCR Surface Impoundments.
- Assessment monitoring events initially occurred in April 2018 and subsequently in May 2018 and November 2018. Those results indicated concentrations of Appendix IV constituents arsenic, lithium, and molybdenum above Site-specific Groundwater Protection Standards (GWPSs) (i.e., at statistically significant levels [SSLs]). As a result, a notification of the detection of SSLs above GWPSs was placed in the operating record and on the publicly available CCR website, and an investigation into the N&E of impacts to groundwater was initiated.
- N&E monitoring events occurred in November 2018 and August 2019. Results from the N&E investigation were summarized in the *2019 Annual Groundwater Monitoring and Corrective Action Report*. Those results formed the basis for the CMA report and original RSR and were used to select the Corrective Action Monitoring Well Network.

Two different groundwater monitoring networks are currently used to collect groundwater samples near the MEC CCR Surface Impoundments: the Detection and Assessment Monitoring Well Network (established under 40 CFR §257.91) and the Corrective Action Monitoring Well Network (established under 40 CFR §257.98). Monitoring of the two networks is conducted on a semiannual basis each year, generally simultaneously during the second and fourth quarters. A map displaying the locations of groundwater monitoring wells is provided as Figure 1.

Based on monitoring data available at the time, a CMA report for MEC was prepared in May 2019, and a public meeting was held on 30 May 2019. A summary of verbal comments received during the public meeting and written comments received after the meeting is provided in Appendix A. After completion of the CMA report and solicitation of public comment, an RSR that identified the selected remedy for the MEC CCR Surface Impoundments (and CCR surface impoundments at three other Ameren facilities) was prepared in August 2019. Section 1.4 provides an overview of the 2019 RSR.

1.4 2019 SELECTION OF REMEDY REPORT SUMMARY

On 30 August 2019, Ameren prepared a report entitled *Remedy Selection Report - 40 CFR § 257.97 - Rush Island, Labadie, Sioux, and Meramec CCR Basins* (2019 RSR) that outlined the remedy selected for the MEC CCR Surface Impoundments and CCR surface impoundments at other sites (Appendix B). The 2019 RSR indicated that numerous technical evaluations informed the final remedy selection, including groundwater modeling; human health and ecological risk assessments; groundwater treatment assessments; onsite and offsite monitoring data; rail, barge, and truck transportation studies; and a deep excavation study report. The remedy selected for the MEC CCR Surface Impoundments was outlined in the CMA report as Alternative 1 (CIP with low permeability capping and MNA). The 2019 RSR outlined three phases to the selected remedy:

1. Source control, stabilization, and containment of CCR by installation of a low-permeability geomembrane cap (a minimum 1×10^{-7} centimeters per second [cm/sec] versus 1×10^{-5} cm/sec required by the CCR Rule).
2. Implement MNA of groundwater concentrations upon completion of source control to address limited and localized CCR-related impacts, including modeling evaluations.
3. Preparation of Annual Groundwater Monitoring and Corrective Action Reports that address the following:
   - Demonstration that the groundwater plume(s) are stable or decreasing and not expanding.
   - An ongoing summary of baseline and periodic geochemical analysis including groundwater chemistry, subsurface soils chemical composition, and mineralogy.
   - Determine Site-specific attenuation factors and rate of attenuation process.
   - Design a long-term performance monitoring program based on the specific attenuation mechanism to confirm concentration reductions and document trends.

In addition, the 2019 RSR also outlined potential supplemental corrective measures that may be considered to supplement groundwater concentration reductions that are expected to result from source control (including dewatering in support of closure and installation of a low-permeability cover system) and MNA. The 2019 RSR indicated those supplemental corrective measures may include groundwater treatment and summarized results from ongoing treatment studies. The 2019 RSR also concluded that the laboratory results indicate reduction of arsenic and molybdenum concentrations may be supported by pH level adjustment in soils and groundwater, use of chemical reduction (e.g., zero valence iron), and/or bioremediation.

No supplemental corrective measures have been implemented at MEC to-date. Implementation of supplemental corrective measures at two other Ameren facilities in Missouri (RIEC and SEC) has followed an iterative process, ultimately resulting in construction and operation of groundwater extraction, ex-situ treatment, and re-injection systems at those facilities. Additional groundwater investigations are planned at MEC, as required by MDNR in the MEC NPDES permit, to evaluate concentrations of boron at or near the property boundary. The results from such investigations will be used to inform future supplemental corrective measures at the Site.

Since completion of the four-site 2019 RSR, annual groundwater monitoring and corrective action reports have continued to document the status of the MEC CCR Surface Impoundments groundwater monitoring and corrective action program, in accordance with 40 CFR §257.90(e). Since 2019, substantial progress has been made in completing closure for the MEC CCR Surface Impoundments (from 2018 through October 2023) and implementing post-closure MNA (starting with the November 2023 sampling event). Consideration of supplemental corrective measures for the MEC CCR Surface Impoundments is ongoing, including consideration of groundwater extraction and treatment technologies implemented at other Ameren facilities, as discussed in Section 2.3. Section 2 documents remedy implementation progress achieved to-date, including remedy activities completed and the results of those completed activities.

2. Remedy Implementation Progress

2.1 SUMMARY OF IMPLEMENTED REMEDIAL ACTIVITIES

As summarized in Section 1.4, the selected remedy for the MEC CCR surface impoundments included source control through dewatering in support of closure and CIP using a low-permeability geomembrane final cover system, MNA, preparation of Annual Groundwater Monitoring and Corrective Action Reports, and potential supplemental corrective measures. In-text Table 2 below summarizes the timeline of remedial activities that have been implemented to-date for the MEC CCR Surface Impoundments.

Table 2 – Timeline of Remedy Implementation

Date	Activity
April 2018	MCPE closure completed (Appendix C)
August 2019	2019 RSR completed (Appendix B)
December 2019	Preliminary treatability study results report developed to document findings from a three-phase treatability study for the remediation of arsenic, molybdenum, and other metals of concern. The treatability testing focused on refining the ex-situ remedial approach in order to finalize the pilot test design. (Appendix D)
January 2020	*2019 Groundwater Monitoring and Corrective Action Report* completed[1]
October 2020	CCR sluicing to the MCPD ceased
January 2021	*2020 Groundwater Monitoring and Corrective Action Report* completed[1]
October 2021	MCPD closure completed (Appendix C)
January 2022	*2021 Groundwater Monitoring and Corrective Action Report* completed[1]
December 2022	Active sluicing to the MCPA, MCPB, and MCPC ceased
January 2023	*2022 Groundwater Monitoring and Corrective Action Report* completed[1]
October 2023	MCPA, MCPB, and MCPC closure completed (Appendix C)
November 2023	Post-closure MNA initiated, as documented in *2023 Groundwater Monitoring and Corrective Action Report*[1]
January 2024	*2023 Groundwater Monitoring and Corrective Action Report* completed[1]

[1] Annual groundwater monitoring and corrective action reports for the MEC CCR Surface Impoundments can be found on the Ameren MEC publicly available CCR website

In addition to development of routine annual reports that summarize groundwater monitoring and corrective action progress, the primary remedial activities that have been completed to-date include:

- MEC CCR Surface Impoundment source control through dewatering and CIP using a low-permeability geomembrane final cover system
  - Initiated: Prior to 2018 through 2022
  - Completed: From 2018 through 2023
- Post-closure MNA
  - Initiated: November 2023
  - Ongoing

An overview of the selected remedy, including locations at the Site where the selected remedy has been implemented, is provided in Figure 2.

Table 3 below summarizes pertinent details of the remedial activities implemented to-date for the MEC CCR Surface Impoundments.

Table 3 – Summary of Implemented Remedial Activity Details	
Remedial Activity	**Details**
MEC CCR Surface Impoundments Source Control	Ameren began closure of the MCPE surface impoundment and placed a "Notice of Intent to Initiate Closure" onto its publicly available CCR website on 9 December 2015. A "Notification of Intent to Close a CCR Unit and Certification for Final Cover Design System" for the MCPD surface impoundment was placed onto its publicly available CCR website on 15 January 2021, and similar notifications for the MCPA, MCPB, and MCPC surface impoundments [which were previously subject to a CCR Part A Final Rule alternative closure demonstration under 40 CFR §257.103(f)(2) that was withdrawn in December 2022] were placed onto the website on 25 October 2022. Source control of the five MEC CCR Surface Impoundments entailed dewatering in support of closure, closing the impoundments in-place, and installing an engineered low-permeability geomembrane cover system over the impoundments to prevent infiltration and promote stormwater drainage. Closure was completed for the MCPE in April 2018, for the MCPD in October 2021, and for the MCPA, MCPB, and MCPC in October 2023. As certified in the closure certifications, closure for each of the five MEC CCR Surface Impoundments was completed in general conformance with the plans and specifications issued for construction and in accordance with requirements of the CCR Rule. Notifications of intent to close, Closure Plans, Post-Closure Plans, and closure completion statements for the MEC CCR Surface Impoundments are available on the MEC publicly available CCR website and are attached to this report as Appendix C.
Post-Closure MNA	After closure of the MCPA, MCPB, and MCPC surface impoundments was completed in October 2023, post-closure MNA began with the November 2023 sampling event to address CCR-related impacts. Post-closure MNA includes monitoring of the Corrective Action Monitoring Well Network (Figure 1), and monitoring is ongoing semi-annually, generally during the second and fourth quarters of each year.

Supplemental corrective measures, including potential groundwater extraction and treatment, are being considered for implementation at MEC. As referenced in Appendix D, although treatability studies at Ameren CCR facilities were initially conducted under the assumption that results may be incorporated into in-situ groundwater treatment design considerations, evaluation of the potential for clogging from metals precipitation and considerations for treating boron led to a transition from an in-situ to an ex-situ concept for groundwater treatment at Ameren CCR surface impoundments.

Ameren recently announced plans to construct a natural gas-fired power plant at the Site. The construction of such a facility will entail an evaluation of stormwater flow and drainage across the Site, along with the capping of former CCR management units (MOPF, MOPG, MOPH, and MOPI). In conjunction with those efforts, Ameren will continue its evaluation of hydrogeologic conditions, groundwater flow direction, MNA efficacy, and technological and/or engineering measures to accelerate compliance with applicable federal and state requirements.

Evaluation of groundwater monitoring results indicate generally positive results, as described in Section 2.2.

2.2 SUMMARY OF REMEDIAL RESULTS

Based on available monitoring data, source control completed for the MEC CCR Surface Impoundments (including dewatering in support of closure, closure-in-place of CCR, and installation of a low-permeability cover system) and ongoing natural attenuation processes appear to be collectively contributing to a general reduction in most constituent concentrations in groundwater near the MEC CCR Surface Impoundments.

Since the remedy for the MEC CCR Surface Impoundments was selected in 2019, annual groundwater monitoring and corrective action reports have documented progress in remedy implementation and summarized groundwater monitoring results. As discussed in annual groundwater monitoring and corrective measures reports posted to the MEC publicly available CCR website, completed source control and ongoing natural attenuation processes are anticipated to positively influence groundwater near the MEC CCR Surface Impoundments over time.

Based on statistical evaluations documented in annual CCR groundwater monitoring and corrective action reports[2], stable or decreasing constituent concentrations have been recorded in groundwater at many monitoring wells directly adjacent to the MEC CCR Surface Impoundments since initiation of impoundment closure. Site groundwater monitoring data collected since MCPE was closed in April 2018 indicate general downward trends in average concentrations in groundwater for most key constituents at assessment and detection monitoring wells with consistent Appendix IV SSLs (i.e. MW-4, MW-5, MW-6, MW-7, and MW-8). Calculations and plotting of groundwater monitoring data collected from April 2018 through October 2023 in MW-4 through MW-8 were performed to further evaluate how constituent concentrations have changed over time as the MEC CCR Surface Impoundments have progressed through initiation and completion of closure. For purposes of the evaluation, calculations and plotting were performed using monitoring data for primary Appendix III (i.e., indicator) constituents boron and sulfate as well as Appendix IV constituents with SSLs (arsenic, lithium, and molybdenum)[3].

Plots were created illustrating average concentrations from April 2018 through October 2023 for the constituents and monitoring wells described above. The plots for Appendix IV constituents arsenic (Figure 4A), lithium (Figure 4B), and molybdenum (Figure 4C) include reference to the GWPSs applicable to each constituent. Each of the fives plots also includes reference (i.e., vertical lines) to five milestone dates:

- Completion of MCPE closure – April 2018
- Cessation of sluicing to MCPD – October 2020
- Completion of MCPD closure – October 2021

[2] Individual monitoring well statistical evaluations are conducted for semiannual assessment and corrective action monitoring results for Appendix IV constituents. Those statistical analyses are documented in annual groundwater monitoring and corrective action reports posted on the publicly available CCR website.

[3] Calculations used comprehensive data provided by Ameren. The following assumptions were made when calculating average results for each monitoring event for the five monitoring wells (MW-4 through MW-8):

- Available data from non-routine monitoring events performed in January 2019, February 2022, January 2023, and February 2024 were not considered because only a minor subset of the wells was sampled.
- Lithium concentrations for MW-7 and MW-8 were recorded as non-detect at an elevated laboratory method detection limit (MDL) on 15 November 2021 and subsequently recorded above at more normative MDLs on 16 November 2021. In those instances, the results from 16 November 2021 were used for purposes of calculations and plotting.
- Occasionally, non-detect values were recorded, often in cases where the laboratory method detection limit was greater than historically recorded concentrations for the constituent. In other rare instances, an individual well may not have been sampled during a sampling event. In such instances, the average of the concentrations from the immediately preceding sampling event and the immediately following sampling event was used. In cases where a result from the most recent (October 2023) sampling event was not available for a specific well-constituent pair, the result from the next most recent sampling event was used for purposes of calculations and plotting.

- Cessation of sluicing to MCPA, MCPB, and MCPC – December 2022
- Completion of MCPA, MCPB, and MCPC closure – October 2023

Boron and Sulfate (Appendix III Constituents)

Based on evaluation of data from monitoring wells MW-4 through MW-8 from April 2018 to October 2023, average concentrations of key Appendix III constituents boron and sulfate have decreased. The average concentration reductions from April 2018 results compared to October 2023 results are as follows:

- boron – decreased by approximately 23 percent
- sulfate – decreased by approximately 32 percent

As shown in Figure 3A for boron and Figure 3B for sulfate, average concentrations in groundwater at MW-4 through MW-8 have fluctuated over time but appear to be trending downward based on the last two and a half years of data collected (since April 2021). This timing generally corresponds with the completion of substantial dewatering and closure of MCPD and, more recently, the cessation of sluicing to MCPA, MCPB, and MCPC. These downward trends in concentrations of two key indicator constituents (boron and sulfate) may provide an early indication of the decreasing trends of constituent trends that are ultimately anticipated to occur in the long-term as a result of source control and ongoing natural attenuation. Data are not currently available for sampling completed since October 2023 to evaluate how concentrations may be changing since completion of MCPA, MCPB, and MCPC closure.

Figure 3A – Average Boron Concentrations in MW-4 through MW-8

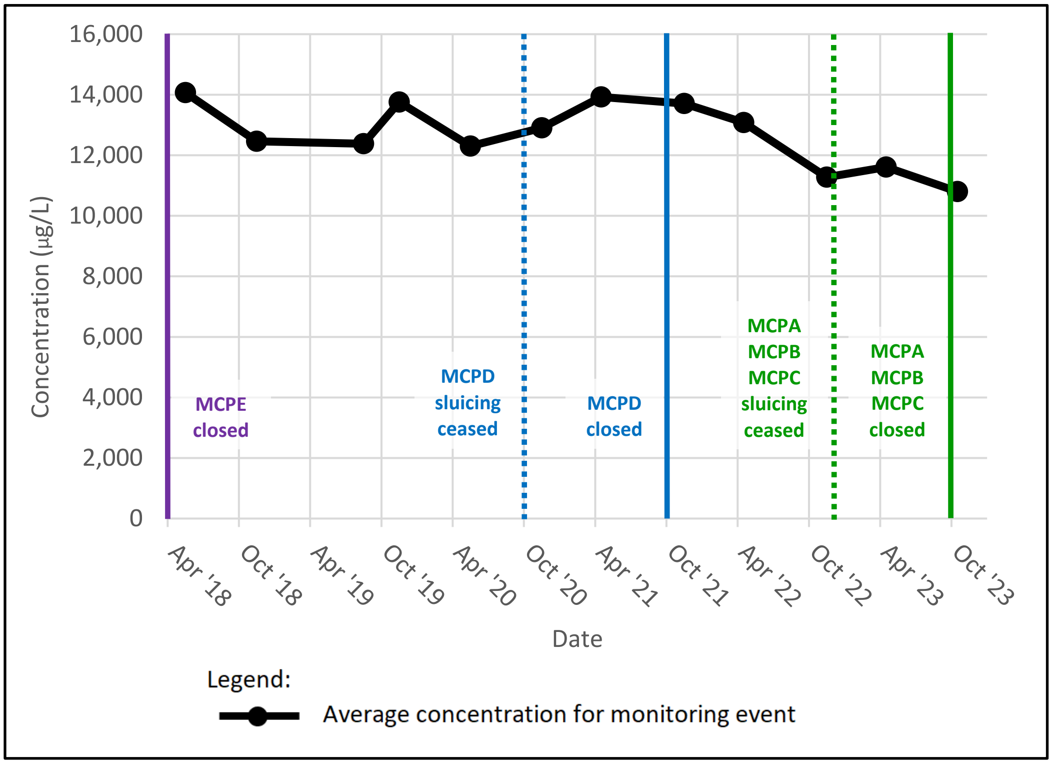
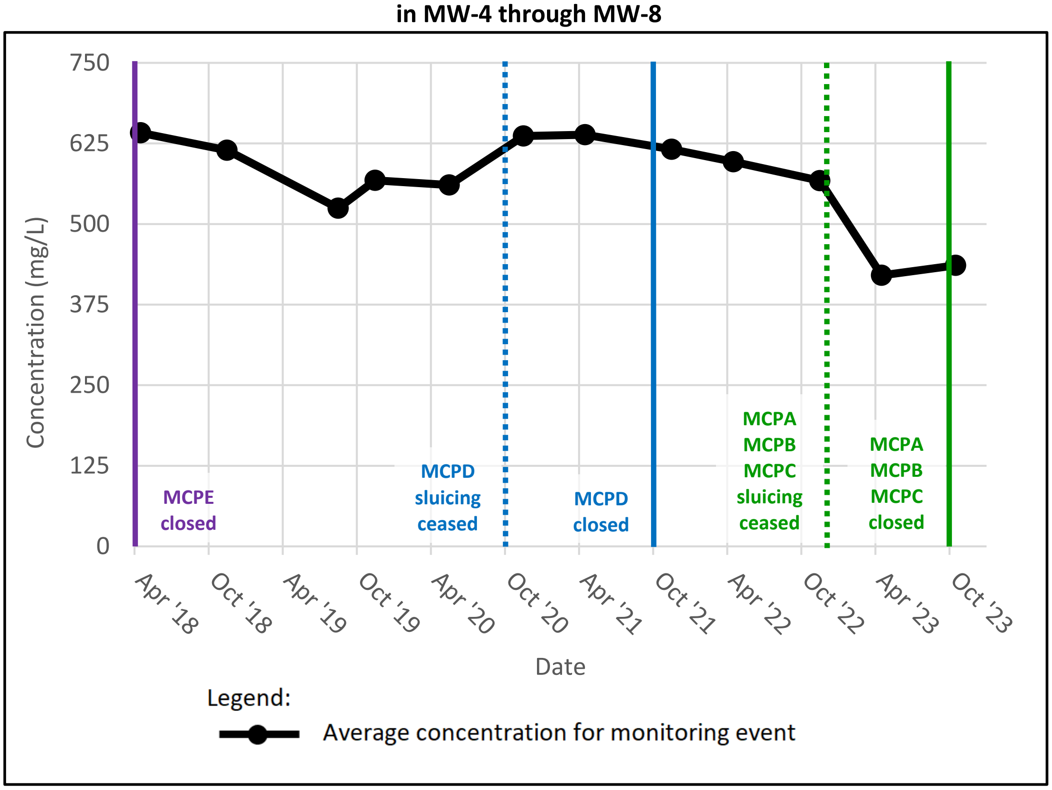


Figure 3B – Average Sulfate Concentrations in MW-4 through MW-8



Arsenic, Lithium, and Molybdenum (Appendix IV Constituents)

Based on evaluation of data from monitoring wells MW-4 through MW-8 from April 2018 to October 2023, average concentrations of Appendix IV constituents arsenic, lithium, and molybdenum (the constituents with SSLs) have decreased or remained stable. The average concentration reductions from April 2018 results compared to October 2023 results are as follows:

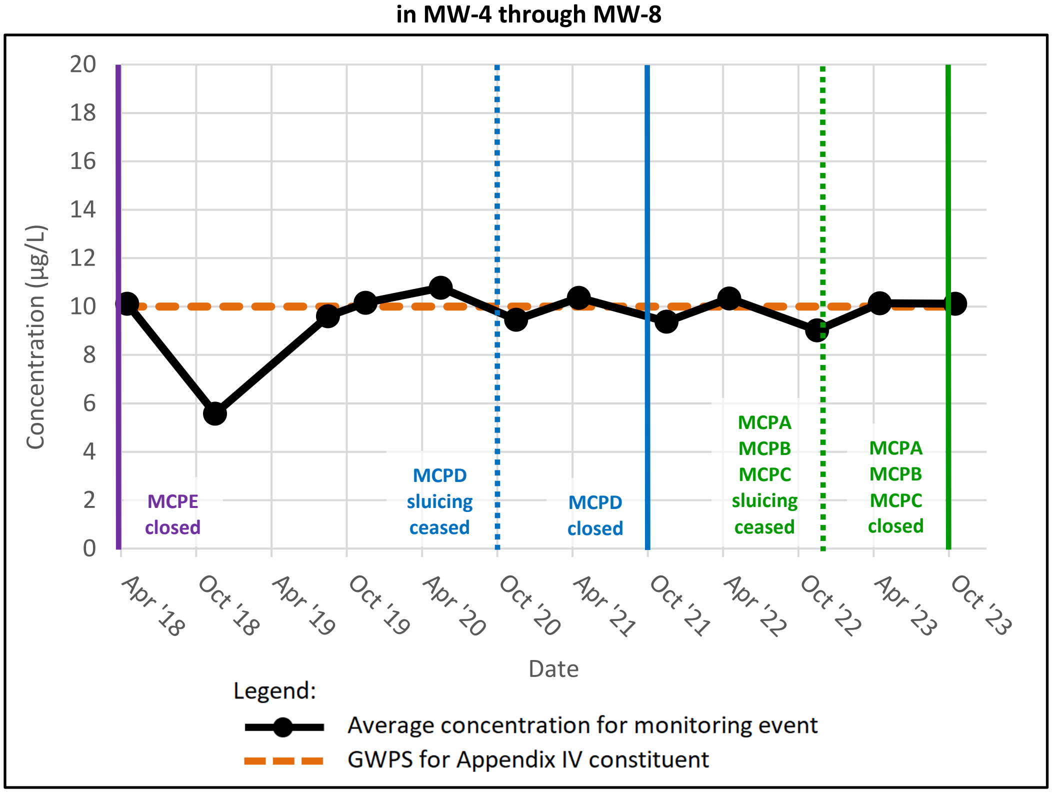
- arsenic – decreased by 0 percent (neither decreased nor increased)
- lithium – decreased by approximately 20 percent
- molybdenum – decreased by approximately 15 percent

More detailed observations from the averaging evaluations are provided for arsenic, lithium, and molybdenum below.

Arsenic

As shown in Figure 4A for arsenic, average concentrations in groundwater at MW-4 through MW-8 have fluctuated to a limited degree over time, with averages typically similar to the 10 µg/L arsenic GWPS. Of the five wells evaluated, arsenic concentrations are consistently greater than the GWPS in MW-4 and MW-5 (Appendix E), with concentrations relatively higher in MW-5. Arsenic concentrations in MW-5 have generally decreased from a maximum of 24.1 micrograms per liter (µg/L) in May 2020 to a most recent result of 20.2 µg/L (an approximate 16 percent decrease over that period). The relatively lower average arsenic concentration calculated for November 2018 (Figure 4A) is caused by an anomalously low concentration recorded in MW-5 (1.8 µg/L). Arsenic concentrations in MW-4 have fluctuated without a clear trend and a potential seasonal relationship of relatively lower concentrations often recorded in the fall (generally drier) months and relatively higher concentrations often recorded in the spring (generally wetter) months. Arsenic is typically a less mobile and more geochemically reactive constituent, meaning changes in arsenic concentrations often occur relatively slower over time compared to other constituents.

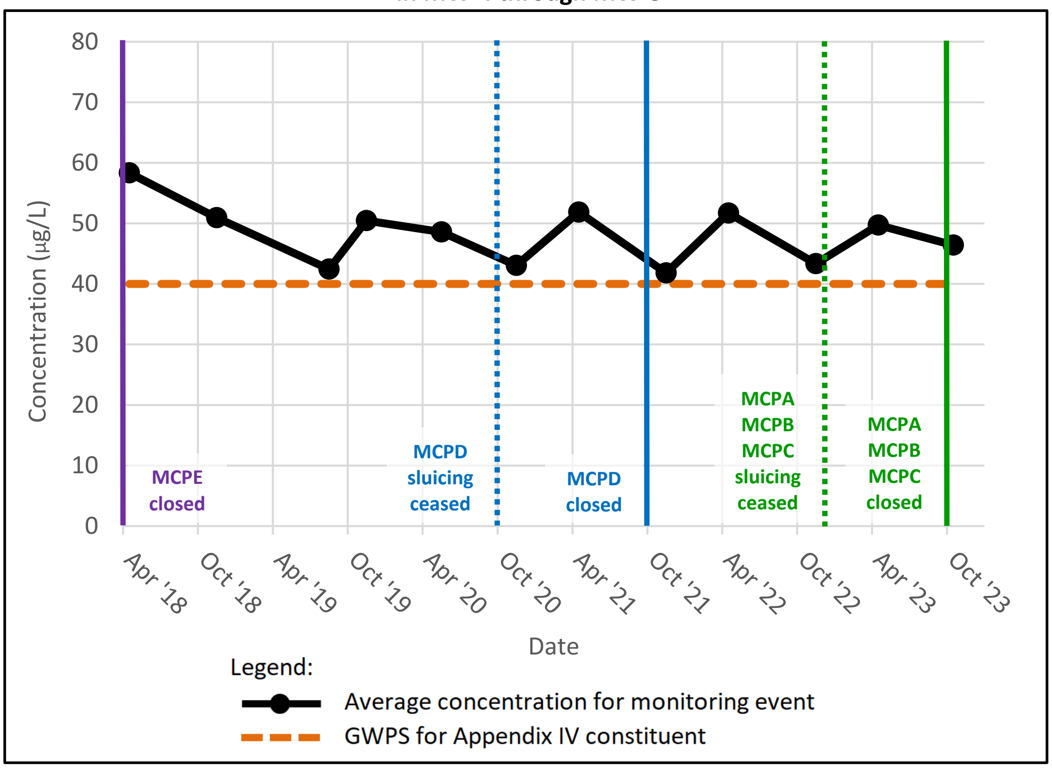
Figure 4A – Average Arsenic Concentrations in MW-4 through MW-8



Lithium

As shown in Figure 4B for lithium, average concentrations in groundwater at MW-4 through MW-8 decreased from a historical maximum in April 2018 and have otherwise fluctuated over time, with averages typically between 41 µg/L to 52 µg/L and greater than the 40 µg/L lithium GWPS. Of the five wells evaluated, lithium concentrations are consistently greater than the GWPS in MW-6 and typically greater than the GWPS in MW-7 (Appendix E), with concentrations relatively higher in MW-6. Lithium concentrations in MW-6 have fluctuated without a clear trend and a potential seasonal relationship of relatively lower concentrations often recorded in the fall (generally drier) months and relatively higher concentrations often recorded in the spring (generally wetter) months. Lithium concentrations in MW-7 also fluctuate but have generally decreased from a concentration of 55.1 µg/L in May 2020 to a most recent result of 40.9 µg/L (an approximate 26 percent decrease over that period). Lithium is typically a more mobile and less geochemically reactive constituent compared to arsenic, meaning changes in lithium concentrations often occur relatively more quickly over time compared to arsenic.

Figure 4B – Average Lithium Concentrations in MW-4 through MW-8

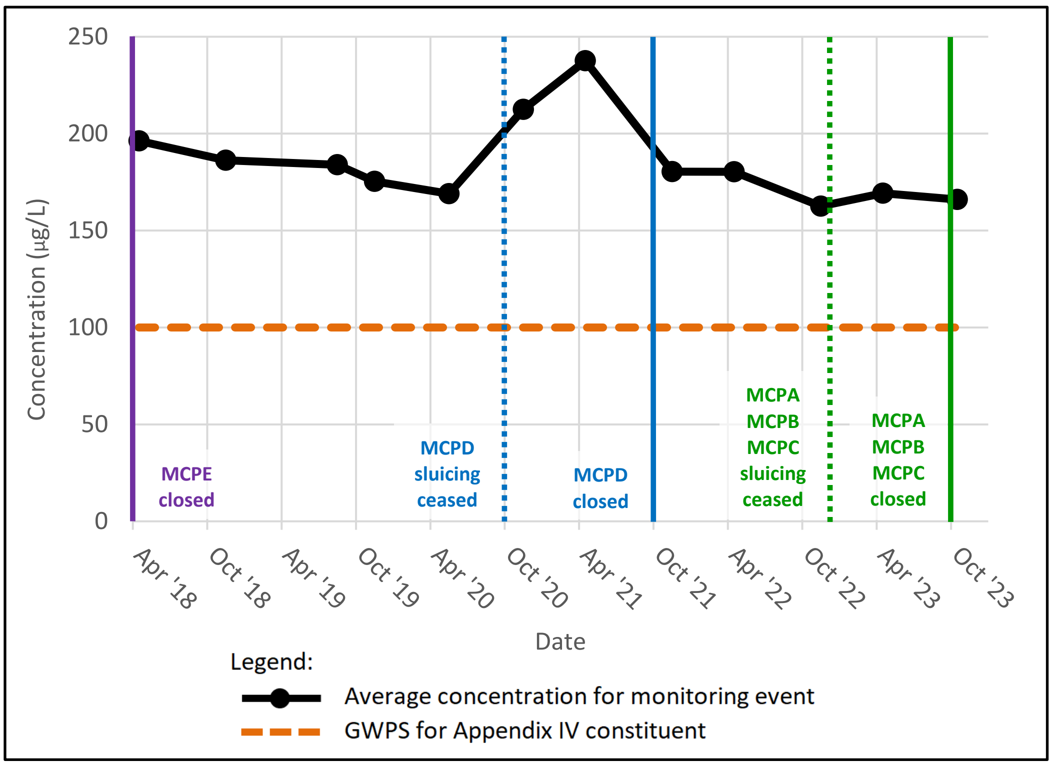


Molybdenum

As shown in Figure 4C for molybdenum, average concentrations in groundwater at MW-4 through MW-8 have fluctuated over time, with averages typically between 150 µg/L to 200 µg/L and greater than the 100 µg/L molybdenum GWPS. The average molybdenum concentrations generally decreased from April 2018 to May 2020, increased markedly during November 2020 and April 2021, and decreased again from April 2021 to October 2023, resulting in an approximately 15 percent overall decrease in average concentrations from April 2018 compared to October 2023. Molybdenum concentrations in MW-7 were the primary contributor to the temporary increase in average molybdenum concentrations during November 2020 and April 2021.

Of the five wells evaluated, molybdenum concentrations are consistently greater than the GWPS in MW-6, MW-7, and MW-8 (Appendix E), with concentrations highest in MW-7. At MW-7, molybdenum concentrations reached a maximum concentration of 697 µg/L in April 2021 and have since generally decreased, with the three most recent results being three of the four lowest historically recorded concentrations in the well. The most recent result of 313 µg/L represents an approximate 55 percent decrease in concentration since the maximum recorded concentration in April 2021. At MW-6, molybdenum concentrations reached a maximum concentration of 164 µg/L in November 2020 and have since generally decreased, with the two most recent results being the two lowest historically recorded concentrations in the well. The most recent result of 117 µg/L represents an approximate 29 percent decrease in concentration since the maximum recorded concentration in April 2021. The timing of molybdenum concentration decreases in MW-7 and MW-6 generally correspond with the completion of substantial dewatering and closure of MCPD and, more recently, the cessation of sluicing to MCPA, MCPB, and MCPC. At MW-8, molybdenum concentrations have not exhibited a clear trend over time, although the most recent result was the highest recorded concentration recorded for the well. Like lithium, molybdenum is typically a more mobile and less geochemically reactive constituent compared to arsenic, meaning changes in molybdenum concentrations often occur relatively more quickly over time compared to arsenic.

Figure 4C – Average Molybdenum Concentrations in MW-4 through MW-8



Results from these averaging evaluations for boron, sulfate, arsenic, lithium, and molybdenum in monitoring wells MW-4 through MW-8 indicate that closure of the MEC CCR Surface Impoundments and natural attenuation processes are likely beginning to contribute to constituent concentration reductions in groundwater immediately downgradient of the impoundments. As additional time passes since completion of source control (i.e., closure) for MEC CCR Surface Impoundments, constituent concentrations in downgradient groundwater are anticipated to continue decreasing.

Although these averaging evaluations provide helpful insight into how constituent concentrations are changing over time in the most impacted downgradient portion of the waste boundary for the MEC CCR

Surface Impoundments, consideration of concentration changes over time for individual downgradient well-constituent pairs provides additional insight into changing conditions over time. Appendix E contains time-series plots using data for individual well-constituent pairs downgradient of the MEC CCR Surface Impoundments. Plots were produced for boron, sulfate, arsenic, lithium, and molybdenum for each of the following downgradient monitoring wells:

- Assessment/detection monitoring wells: MW-4, MW-5, MW-6, MW-7, and MW-8
- Corrective action monitoring wells: MW-9, MW-10, MW-11S, MW-11D, TP-1, and TP-2

The monitoring wells listed above were selected for inclusion in Appendix E because they are monitoring wells with consistent or frequent Appendix IV SSLs or are co-located with a monitoring well with consistent SSLs (e.g., MW-11S, co-located with MW-11D). Key evaluation conclusions related to SSLs and constituent trends for the five assessment and detection monitoring wells were provided earlier in this section. Key additional observations resulting from the evaluation of SSLs and constituent trends for the six corrective action monitoring wells are as follows (Appendix E):

- Boron concentrations appear to be generally increasing in MW-11S and MW-11D and decreasing in TP-1; the highest boron concentrations are recorded in MW-11D (approximately 8,000 µg/L to 12,000 µg/L) and MW-9 (approximately 2,500 µg/L to 10,000 µg/L). Sulfate concentrations appear to be generally increasing in MW-9 and MW-11S, although concentrations in MW-11S remain less than 100 mg/L; the highest sulfate concentrations are typically recorded in MW-11D (approximately 500 mg/L to 600 mg/L) and TP-2 (approximately 400 mg/L to 600 mg/L).
- Arsenic concentrations have remained relatively stable during the last three years; the highest arsenic concentrations are typically recorded in MW-9 and TP-1 (approximately 20 µg/L for recent results in both wells).
- Lithium concentrations have remained relatively stable over time; the highest lithium concentrations are typically recorded in MW-11D and TP-2 (approximately 40 µg/L to 50 µg/L for recent results in both wells).
- Molybdenum concentrations are consistently greater than the GWPS in one well: MW-11D; those concentrations appear to have generally increased slightly over time, with recent concentrations typically near 300 µg/L.

Furthermore, groundwater modeling for the Site (produced in May 2019 by Burns & McDonnell Engineering Company, Inc.) indicates constituent concentrations will decrease in magnitude downgradient of the MEC CCR Surface Impoundments in the long-term. The 2019 modeling assumed CIP for the MEC CCR Surface Impoundments (which has been completed) and did not incorporate potential supplemental corrective measures. The 2019 modeling report included model-predicted arsenic, lithium, and molybdenum future concentration trend plots for current CCR monitoring well locations as well as plan-view isoconcentration maps for GWPSs at 0, 5, 10, 20, and 30 years post-closure.

Results from the 2019 modeling indicate concentrations of arsenic, lithium, and molybdenum are anticipated to decrease to less than GWPSs in groundwater at current CCR monitoring well locations within 30 years post-closure. The modeling results also indicate persistence of arsenic, lithium, and molybdenum concentrations above applicable GWPSs beyond the 30-year post-closure modeled timeframe in areas of groundwater along and downgradient of the western boundary of the MCPE surface impoundment, indicating that supplemental corrective measures likely will be necessary. Monitoring data from MW-11D (a corrective action monitoring well installed after modeling was last updated in 2019) indicate concentrations of arsenic, lithium, and molybdenum are greater than GWPSs south of the MCPE surface impoundment, with arsenic and lithium concentrations only slightly above

GWPSs and molybdenum concentrations typically about three times greater than the GWPS. Based on concentrations in MW-11D and the model-predicted persistence of molybdenum west of the MCPE surface impoundment, it is also likely that modeling using currently available data would predict persistence of molybdenum concentrations above the GWPS south of the MCPE surface impoundment.

2.3 SUMMARY OF ANTICIPATED SUPPLEMENTAL CORRECTIVE MEASURES

Post-closure MNA is ongoing at MEC, and closure of the MEC CCR Surface Impoundments was completed from 2018 through 2023. Ameren is evaluating various supplemental corrective measures to comply with both MDNR and federal CCR Rule requirements, including groundwater treatment systems such as those employed at the RIEC and SEC facilities. In addition, Ameren is evaluating potential locations to install additional groundwater monitoring wells to supplement the existing Detection and Assessment Monitoring Well Network and Corrective Action Monitoring Well Network.

2.4 DEMONSTRATION OF 40 CFR §257.97(B) REQUIREMENTS

In accordance with 40 CFR §257.97(b), a remedy must meet the following requirements (i.e., "threshold criteria"):

> *(1) Be protective of human health and the environment;*
>
> *(2) Achieve the groundwater protection standard pursuant to 40 CFR §257.95(h);*
>
> *(3) Control the source(s) of releases so as to reduce or eliminate, to the maximum extent feasible, further releases of constituents in Appendix IV [of the CCR Rule] into the environment;*
>
> *(4) Remove from the environment as much of the contaminated material that was released from the CCR unit as is feasible, taking into account factors such as avoiding inappropriate disturbance of sensitive ecosystems; and*
>
> *(5) Comply with certain standards for management of wastes as specified in [40 CFR] §257.98(d).*

In May 2019, Ameren completed the CMA Report for the five MEC CCR Surface Impoundments and posted the report to its publicly available CCR website. The CMA Report considered four corrective measures alternatives, all of which were demonstrated to meet the threshold criteria listed above. The CMA Report also included the summary results of the assessment of numerous technical evaluations conducted, which include groundwater and geochemical modeling, human health and ecological risk assessments, and N&E of CCR constituents in groundwater assessments. Results of these technical evaluations indicated each of the four corrective measures alternatives effectively satisfied the requirements under 40 CFR §257.97(b), listed above.

In its 2019 RSR, Ameren selected CMA Alternative 1 (CIP with capping and MNA), noting that supplemental corrective measures were being evaluated and may be implemented as part of an iterative remedial strategy. Since completion of the CMA Report and 2019 RSR, Ameren has completed closure of the five MEC CCR Surface Impoundments and initiated post-closure MNA in November 2023. The remedy implemented to-date for each of the MEC CCR Surface Impoundments aligns with the CMA Report's Alternative 1, which was considered to effectively satisfy the requirements under 40 CFR §257.97(b) in the CMA Report.

Based on the prior CMA evaluation, the remedy implemented for the MEC CCR Surface Impoundments meets the requirements of the 40 CFR §257.97(b) threshold criteria.

Supplemental corrective measures in the form of groundwater extraction, ex-situ treatment, and re-injection systems have been constructed and are operating at Ameren's RIEC and SEC. Ameren is in the process of evaluating future supplemental corrective measures at MEC to comply with both MDNR and federal CCR Rule requirements. Supplemental corrective measures would serve to supplement, or enhance, constituent concentration reductions already promoted by completed closure of the MEC CCR Surface Impoundments and ongoing natural attenuation processes. Assuming supplemental corrective measures are implemented in the future, the implemented remedy (like Alternative 1 and Alternative 3 in the CMA Report) would be expected to effectively satisfy the requirements under 40 CFR §257.97(b).

2.5 DEMONSTRATION OF 40 CFR §257.97(C) CONSIDERATIONS

In accordance with 40 CFR §257.97(c), the owner of a CCR unit must consider the following evaluation factors (i.e., "balancing criteria") when selecting a remedy that satisfies the threshold criteria under 40 CFR §257.97(b):

> *(1) The long- and short-term effectiveness and protectiveness of the potential remedy(s), along with the degree of certainty that the remedy will prove successful based on consideration of the following:*
>
> > *(i) Magnitude of reduction of existing risks;*
> >
> > *(ii) Magnitude of residual risks in terms of likelihood of further releases due to CCR remaining following implementation of a remedy;*
> >
> > *(iii) The type and degree of long-term management required, including monitoring, operation, and maintenance;*
> >
> > *(iv) Short-term risks that might be posed to the community or the environment during implementation of such a remedy, including potential threats to human health and the environment associated with excavation, transportation, and re-disposal of contaminant;*
> >
> > *(v) Time until full protection is achieved;*
> >
> > *(vi) Potential for exposure of humans and environmental receptors to remaining wastes, considering the potential threat to human health and the environment associated with excavation, transportation, re-disposal, or containment;*
> >
> > *(vii) Long-term reliability of the engineering and institutional controls; and*
> >
> > *(viii) Potential need for replacement of the remedy.*
>
> *(2) The effectiveness of the remedy in controlling the source to reduce further releases based on consideration of the following factors:*
>
> > *(i) The extent to which containment practices will reduce further releases; and*
> >
> > *(ii) The extent to which treatment technologies may be used.*
>
> *(3) The ease or difficulty of implementing a potential remedy(s) based on consideration of the following types of factors:*
>
> > *(i) Degree of difficulty associated with constructing the technology;*
> >
> > *(ii) Expected operational reliability of the technologies;*
> >
> > *(iii) Need to coordinate with and obtain necessary approvals and permits from other agencies;*
> >
> > *(iv) Availability of necessary equipment and specialists; and*
> >
> > *(v) Available capacity and location of needed treatment, storage, and disposal services.*
>
> *(4) The degree to which community concerns are addressed by a potential remedy(s).*

The CMA Report compared the four corrective measures alternatives relative to one another with respect to the first three primary balancing criteria identified in the CCR Rule: long-term and short-term effectiveness, source control, and implementability. The fourth balancing criterion, community concerns, was considered after the public meeting was held on 30 May 2019 and the period of public comment was completed.

Similar to consideration of the threshold criteria under 40 CFR §257.97(b) discussed in Section 2.4, appropriate consideration of the balancing criteria under 40 CFR §257.97(c) for the remedy implemented for the MEC CCR Surface Impoundments should consider how the CMA Report evaluated Alternative 1. In the CMA Report, Alternative 1 received a "favorable" or "less favorable" rating for each of the balancing criteria, and the alternative received no "unfavorable" ratings under any of the balancing criteria. Based on the CMA favorability ratings for Alternative 1, the implemented remedy is considered relatively highly favorable.

Table 4 provides an evaluation of the implemented remedy against each of the balancing criteria outlined under 40 CFR §257.97(c). Based on the prior CMA evaluation and consideration of the corrective measures implemented to-date, the remedy implemented for the MEC CCR Surface Impoundments effectively addresses the 40 CFR §257.97(c) balancing criteria, as documented in Table 4.

Assuming supplemental corrective measures are implemented in the future, the implemented remedy (like Alternative 1 and Alternative 3 in the CMA Report) would be expected to be relatively highly favorable based on evaluation against the balancing criteria outlined in 40 CFR §257.97(c). Ameren plans to perform additional groundwater investigations and potentially install additional groundwater monitoring wells to supplement the existing Detection and Assessment Monitoring Well Network and Corrective Action Monitoring Well Network. An MNA evaluation report summarizing MNA efficacy, including pertinent conclusions from the additional groundwater investigations, is anticipated to be developed in 2025. Ameren will also periodically consider the potential need for performing future modeling updates to predict the timeframe for attaining the constituent GWPSs based on the implemented remedy.

2.6 SCHEDULE FOR IMPLEMENTING AND COMPLETING REMEDIAL ACTIVITIES

Section 2.1 summarizes remedial activities that have been implemented for MEC. Closure of the MEC CCR Surface Impoundments was completed from 2018 through 2023. Evaluation of monitoring results and documentation of remedy implementation progress have been included in annual groundwater monitoring and corrective action reports. Preparation of annual reports will continue.

In accordance with 40 CFR §257.97(d), the owner of a CCR unit must specify schedule(s) for implementing and completing remedial activities, requiring completion of remedial activities within a reasonable timeframe that considers the following factors:

> *(1) Extent and nature of contamination, as determined by the characterization required under §257.95(g);*
>
> *(2) Reasonable probabilities of remedial technologies in achieving compliance with the groundwater protection standards established under §257.95(h) and other objectives of the Remedy;*
>
> *(3) Availability of treatment or disposal capacity for CCR managed during implementation of the remedy;*
>
> *(4) Potential risks to human health and the environment from exposure to contamination prior to completion of the remedy;*
>
> *(5) Resource value of the aquifer including:*
>
> > *(i) Current and future uses;*

(ii) Proximity and withdrawal rate of users;

(iii) Groundwater quantity and quality;

(iv) The potential damage to wildlife, crops, vegetation, and physical structures caused by exposure to CCR constituents;

(v) The hydrogeologic characteristic of the facility and surrounding land; and

(6) Other relevant factors.

Implementation of CCR surface impoundment closure has been performed in an expeditious fashion, as summarized in Section 2.1. As of the date of the 2019 CMA report, the MCPA, MCPB, MCPC, and MCPD still actively received sluiced CCR inflows. Closure of MCPD was completed in approximately 12 months after final receipt of CCR into the impoundment. Closure of the MCPA, MCPB, and MCPC was completed in approximately 10 months after final receipt of CCR into the impoundments. Closure of the MEC CCR Surface Impoundments by CIP allowed source control to be completed much sooner (approximately 20 or more years sooner, based on the CMA Report) than would have been possible with an alternative closure by removal method, especially given the technical and logistical challenges with excavating near the Mississippi and Meramec Rivers.

The risk assessment report developed for the Site in 2018 concluded no unacceptable risk to human health or the environment associated with groundwater at the MEC CCR Surface Impoundments (Appendix F). Since completion of the risk assessment report, closure of the MEC CCR Surface Impoundments is complete, constituent concentration reductions have been observed, and supplemental corrective measures are being evaluated. The potential for exposure of humans and the environment to CCR material that existed prior to closure of MEC CCR Surface Impoundments has been mitigated by completion of closure and installation of an engineered final cover system. The final cover system was constructed quickly and allowed CCR material to remain onsite, thereby limiting the duration of potential exposure of humans or the environment to the CCR. Based on improved Site conditions since completion of the 2018 risk assessment report, conclusions from that risk assessment are validated.

The 2018 risk assessment report also noted that eight private and three public water supply wells located within a one-mile radius of the Site. The private and public water supply wells are upgradient of the Site or located on the opposite side of the Meramec River and are, therefore, beyond the extent of CCR constituent migration from the MEC CCR Surface Impoundments.

Groundwater modeling performed to-date has evaluated post-closure conditions and predicted arsenic, lithium, and molybdenum concentration decreases over time under an MNA scenario. Results from the 2019 modeling indicate concentrations of arsenic, lithium, and molybdenum are anticipated to decrease to less than GWPSs in groundwater at current CCR monitoring well locations within 30 years post-closure. The modeling results also indicate persistence of arsenic, lithium, and molybdenum concentrations above applicable GWPSs beyond the 30-year post-closure modeled timeframe in areas of groundwater along and downgradient of the western boundary of the MCPE surface impoundment. Based on currently modeled persistence of constituent concentrations above GWPSs beyond the waste boundary, Ameren plans to perform additional groundwater investigations, potentially install additional groundwater monitoring wells, develop an MNA evaluation report, and evaluate supplemental corrective measures. Ameren will also periodically consider the potential need for performing modeling updates.

Anticipated future remedy-related activities and approximate timeframes include:

- Semiannual corrective action monitoring (ongoing).

- Evaluation of corrective action effectiveness on CCR constituent concentrations in groundwater (ongoing).
- Annual groundwater monitoring and corrective action report development (ongoing).
- Evaluation of supplemental corrective measures (ongoing).
- Additional groundwater investigations and monitoring well installations (late 2024/early 2025).
- Development of an MNA evaluation report (in 2025).

Annual groundwater monitoring and corrective action reports will continue to document groundwater analytical results and constituent concentration trends over time. Updated Site data and available modeling results will be used to confirm model-predicted durations for achievement of GWPSs. Supplemental or alternative corrective measures may continue to be considered if results or modeling indicate constituent concentration reductions are not occurring sufficient to achieve GWPSs within a reasonable timeframe. In such a case, the array of potential supplemental or alternative corrective measures that may be considered would likely be similar to the measures and alternatives developed and evaluated in the CMA report.

Based on the information outlined above, the remedy has been implemented and is anticipated to be completed in a manner consistent with consideration of the factors listed in 40 CFR §257.97(d).

3. Supplemental Remedy Selection Report Certification Statement

I, Steven F. Putrich, am a professional engineer and licensed in the state of Missouri. I have reviewed this Selection of Remedy report for the five coal combustion residuals surface impoundments (MCPA, MCPB, MCPC, MCPD, and MCPE) at the Ameren Missouri Meramec Energy Center located in St. Louis County, Missouri. I hereby certify that this report has been prepared in general conformance with and meets the requirements of Title 40 Code of Federal Regulations (40 CFR) § 257.97 of the U. S. Environmental Protection Agency's Rule entitled "Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals from Electric Utilities." 80 Fed. Reg. 21302 (17 April 2015) (promulgating 40 CFR § 257.61); 83 Fed. Reg. 36435 (30 July 2018) (amending 40 CFR § 257.61) (the CCR Rule).

Signed:______________________________
Certifying Engineer

Print Name:	Steven F. Putrich, P.E.
Missouri License No.:	2014035813
Title:	Project Principal
Company:	Haley & Aldrich, Inc.

Professional Engineers Seal:

7/16/2024

TABLES

TABLE 4
EVALUATION OF IMPLEMENTED REMEDY – 40 CFR §257.97(c) REQUIREMENTS
SUPPLEMENTAL REMEDY SELECTION REPORT – MEC CCR SURFACE IMPOUNDMENTS
MERAMEC ENERGY CENTER – ST. LOUIS COUNTY, MISSOURI

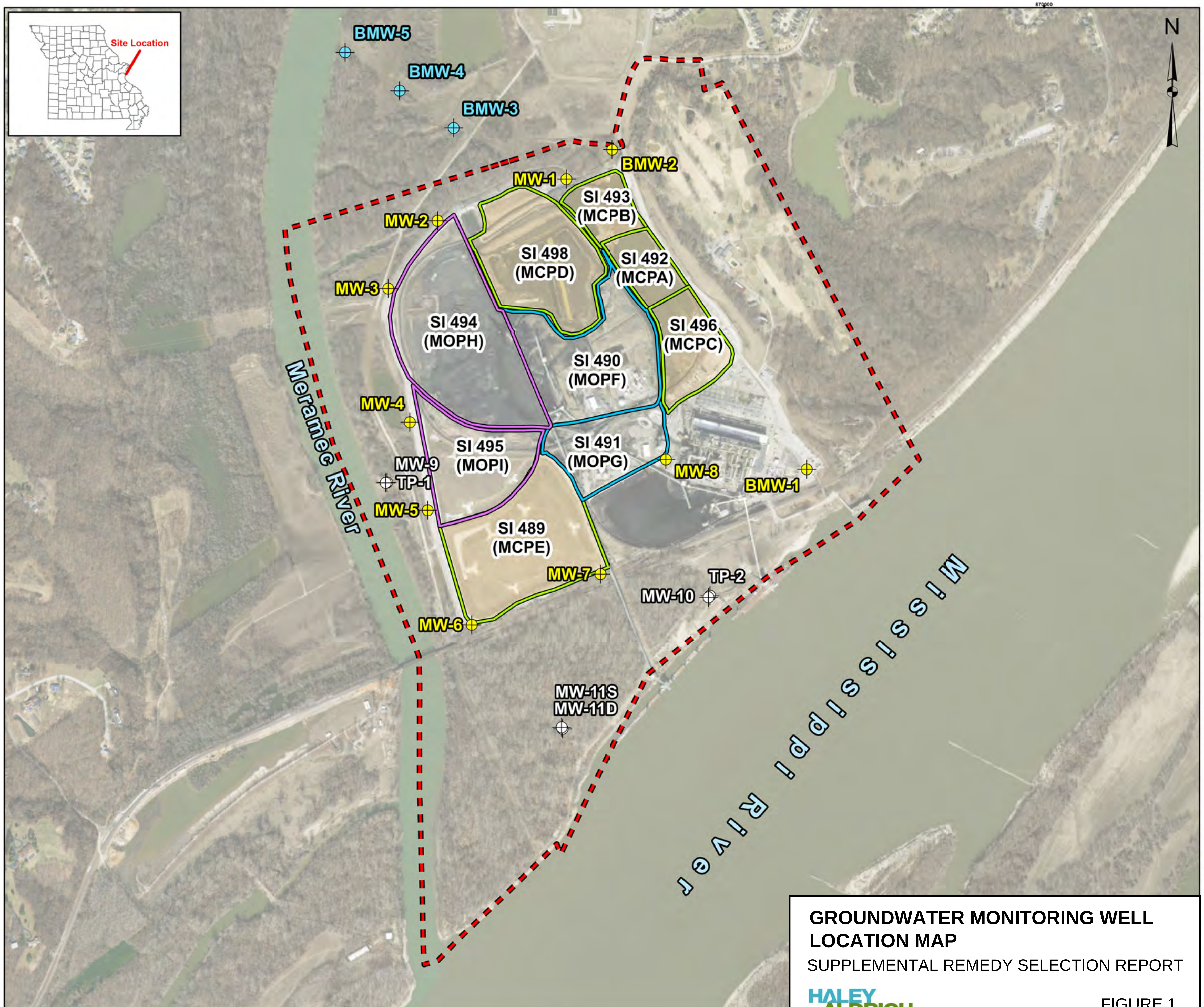
General Description	Implemented Remedy[1] CIP with Capping and MNA with Supplemental Corrective Measures[1]
257.97(c)(1) The long and short term effectiveness and protectiveness of the remedy(s), along with the degree of certainty that the remedy will prove successful	
(i) Magnitude of reduction of existing risk	No unacceptable risk to human health and the environment exists based on the risk assessment in Appendix E and included in the CMA Report. The MEC CCR Surface Impoundments have been closed in place with a low-permeability engineered final cover system. The final cover system further contains the CCR material in the impoundments and reduces the risk of the CCR entering the environment.
(ii) Magnitude of residual risks in terms of likelihood of further releases due to CCR remaining following implementation of a remedy	The low-permeability final cover systems for the MEC CCR Surface Impoundments contain the underlying CCR material and significantly reduce the infiltration of precipitation into the CCR. Therefore, the residual risks in terms of likelihood of further releases due to CCR remaining is considered low.
(iii) The type and degree of long-term management required, including monitoring, operation, and maintenance	Long-term management of the implemented remedy includes limited O&M of the final cover systems and monitoring wells. The degree of long-term management required for the closed MEC CCR Surface Impoundments is generally limited to routine vegetative maintenance (e.g., mowing/trimming) of the final cover systems during the growing season and the potential for non-routine maintenance of the final cover systems (e.g., limited soil regrading in the event of side-slope erosion caused by stormwater runoff). Post-closure MNA involves relatively limited long-term management, including routine groundwater monitoring and the potential for non-routine monitoring well maintenance (e.g., repair or replacement in the event that damage occurs to a monitoring well).
(iv) Short-term risks that might be posed to the community or the environment during implementation of such a remedy	Since closure construction activities have already been completed, potential short-term risks to the community or the environment are very limited. Also, the implemented remedy is entirely contained within the Site boundary, which greatly reduces any potential risks to the community or environment. Closure of the MEC CCR Surface Impoundments was completed via CIP from 2018 through 2023. CIP involves a relatively lower degree of short-term risks posed to the community or environment.
(v) Time until full protection is achieved	No unacceptable risk to human health or the environment exists based on the risk assessment in Appendix E and included in the CMA Report. Therefore, protection is already achieved. Based on modeling, completed source control in conjunction with ongoing natural attenuation processes are expected to result in reductions in constituent concentrations in groundwater over time. Current modeling indicates concentrations of arsenic, lithium, and molybdenum are anticipated to decrease to less than GWPSs in groundwater at current CCR monitoring well locations within 30 years post-closure. Current modeling results also indicate persistence of arsenic, lithium, and molybdenum concentrations above applicable GWPSs beyond the 30-year post-closure modeled timeframe in areas of groundwater along and downgradient of the western boundary of the MCPE surface impoundment, indicating that supplemental corrective measures likely will be necessary. Based on currently modeled persistence of constituent concentrations above GWPSs beyond the waste boundary, Ameren plans to perform additional groundwater investigations, potentially install additional groundwater monitoring wells, develop an MNA evaluation report, and evaluate supplemental corrective measures. Ameren will also periodically consider the potential need for performing modeling updates.
(vi) Potential for exposure of humans and environmental receptors to remaining wastes, considering the potential threat to human health and the environment associated with excavation, transportation, re-disposal, or containment	Closure of the MEC CCR Surface Impoundments was completed in October 2023 via CIP, which substantially reduced the potential for exposure of humans and environmental receptors to remaining wastes during closure activities compared to CBR. The remaining CCR material is contained within a low-permeability engineered final cover system, which greatly limits the potential for post-closure exposure to the CCR.
(vii) Long-term reliability of the engineering and institutional controls	Closure of the MEC CCR Surface Impoundments by CIP has already been completed, and CIP is a proven long-term solution for CCR management.
(viii) Potential need for replacement of the remedy	The CIP method used to close the MEC CCR Surface Impoundments is considered permanent and effective at preventing CCR release into the environment and reducing infiltration of precipitation into the CCR. Although groundwater modeling indicates constituent concentrations are predicted to reduce over time, the system could be modified in the future if remedial objectives are not being met as expected.
257.97(c)(2) The Effectiveness of the Remedy in Controlling the Source to Reduce Further Releases	
(i) The extent to which containment practices will reduce further releases	Closure of the MEC CCR Surface Impoundments was completed in October 2023 via CIP using a low-permeability final cover system that limits infiltration of precipitation into underlying CCR material and protects from future CCR releases through engineered containment of the underlying CCR material.
(ii) The extent to which treatment technologies may be used	Treatment technologies are not currently used for the implemented remedy. Ameren is evaluating various supplemental corrective measures to comply with both MDNR and federal CCR Rule requirements, including groundwater treatment systems such as those employed at the RIEC and SEC facilities.
257.97(c)(3) The Ease or Difficulty of Implementing a Potential Remedy	
(i) Degree of difficulty associated with constructing the technology	The CIP method used to close the MEC CCR Surface Impoundments was substantially less difficult to implement than the alternative CBR method that was considered unfavorable under this balancing criterion in the CMA Report due to technical and logistical challenges.
(ii) Expected operational reliability of the technologies	Closure of the MEC CCR Surface Impoundments is complete, and only ongoing O&M of the final cover system is necessary.
(iii) Need to coordinate with and obtain necessary approvals and permits from other agencies	Closure-related permitting and approvals were obtained to support closure of the MEC CCR Surface Impoundments by CIP, which required less permitting and approvals than the alternative CBR method that was considered unfavorable under this balancing criterion in the CMA Report.
(iv) Availability of necessary equipment and specialists	Equipment and specialist needs were less to support closure of the MEC CCR Surface Impoundments by CIP relative to the alternative CBR method that was considered unfavorable under this balancing criterion in the CMA Report.
(v) Available capacity and location of needed treatment, storage, and disposal services	CIP of the MEC CCR Surface Impoundments allowed CCR material to remain onsite and in-place, which would not have been possible under a CBR scenario.

Notes:
[1] - The currently implemented remedy is a combination of source control and post-closure MNA. Ameren is evaluating various supplemental corrective measures to comply with both MDNR and federal CCR Rule requirements, including groundwater treatment systems such as those employed at the RIEC and SEC facilities. This table only evaluates the discrete components of the remedy that has been implemented at the Site to-date and does not consider potential supplemental corrective measures that may be implemented in the future.

Abbreviations:
CBR = closure by removal
CCR = coal combustion residuals
CIP = closure in place
CMA = Corrective Measures Assessment
GWPS = Groundwater Protection Standard
MDNR = Missouri Department of Natural Resources
MEC = Meramec Energy Center
MNA = monitored natural attenuation
O&M = operations and maintenance
RIEC = Rush Island Energy Center
SEC = Sioux Energy Center

FIGURES

MERAMEC ENERGY CENTER GROUNDWATER MONITORING PROGRAMS AND MONITORING WELL LOCATION MAP



LEGEND

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

Monitoring Well Networks

- Detection/Assessment Monitoring Well
- Corrective Action Monitoring Well
- Monitoring Well Used for Water Elevation Measurements Only

NOTES

1.) ALL BOUNDARIES AND LOCATIONS ARE APPROXIMATE.
2.) SI - SURFACE IMPOUNDMENT.
3.) EXEMPT SURFACE IMPOUNDMENTS ARE EXCLUDED FROM COAL COMBUSTION RESIDUALS MONITORING.
4.) GROUNDWATER MONITORING WELLS SURVEYED BY ZAHNER AND ASSOCIATES, INC.

REFERENCES

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

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

GROUNDWATER MONITORING WELL LOCATION MAP

SUPPLEMENTAL REMEDY SELECTION REPORT

HALEY ALDRICH

FIGURE 1

PROJECT
CCR RULE GROUNDWATER MONITORING PROGRAM

CLIENT
AMEREN MISSOURI
MERAMEC ENERGY CENTER

Ameren

ROCKSMITH GEOENGINEERING

DESIGN	GTM	YYYY-MM-DD	2024-01-04
PREPARED	GTM	PROJECT No.	23010
REVIEW	JSI		
APPROVED	MNH		

FIGURE 1

LEGEND

- DETECTION/ASSESSMENT MONITORING WELL
- CORRECTIVE ACTION MONITORING WELL
- MERAMEC ENERGY CENTER PROPERTY BOUNDARY
- CAPPED AND CLOSED REGULATED SURFACE IMPOUNDMENT
- EXEMPT SURFACE IMPOUNDMENT
- CAPPED AND CLOSED EXEMPT SURFACE IMPOUNDMENT

NOTES

1. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE.
2. SEE FIGURE 1 FOR INDIVIDUAL MONITORING WELL IDENTIFICATION INFORMATION.
3. SEE FIGURE 3 FOR INDIVIDUAL EXTRACTION AND INJECTION WELL IDENTIFICATION INFORMATION.
4. SUPPLEMENTAL CORRECTIVE MEASURES FOR THE MERAMEC SURFACE IMPOUNDMENTS HAVE NOT BEEN IMPLEMENTED TO-DATE.
5. AERIAL IMAGERY SOURCE: NEARMAP, 13 FEBRUARY 2024

0 525 1,050
SCALE IN FEET

HALEY ALDRICH

MERAMEC ENERGY CENTER
ST. LOUIS COUNTY, MISSOURI
SUPPLEMENTAL REMEDY SELECTION REPORT

SELECTED REMEDY OVERVIEW MAP

JUNE 2024

FIGURE 2

GIS FILE PATH: \\haleyaldrich\share\CF\Projects\132002\GIS\132002_AMEREN_ASH_WELLS.aprx - USER: mmjones - LAST SAVED: 5/29/2024 11:07 AM

APPENDIX A
Response to 2019 CMA Public Comments

Response To Community Comments On Ameren Missouri Corrective Measures Assessments For Rush Island, Labadie, Sioux And Meramec Energy Centers

Contents

SUMMARY OVERVIEW

In May 2019, Ameren Missouri held public meetings regarding Corrective Measures Assessment (CMA) Reports for the Rush Island, Labadie, Meramec and Sioux Energy Centers. At those meetings and afterwards in written comments, the public raised a variety of concerns regarding CCR basins located at the energy centers. This Response to Community Comments addresses those concerns. In addition, Ameren Missouri ("Ameren") has performed additional technical analysis which has been posted on Ameren's CCR website along with this Response. Ameren summarizes key response items below:

- *Groundwater Impacts are Limited and No Risk to Public Health Exists.* Groundwater impacts at Ameren's energy centers are limited and localized in nature. Drinking water supplies, whether residential wells or adjacent rivers, are not impacted by the energy centers. Suggestions that Ameren has somehow "skewed" or misrepresented the data are inaccurate. *See* Section 2 and 3 and Attachments 1 and 2.

- *Excavation Delays Compliance with Groundwater Standards*. Several commenters argue that the only way to comply with the CCR Rule is to excavate the ash. Not true. Concentration levels will diminish over time due to installation of a geomembrane cap, the water table lowers, and pH conditions stabilize. Excavation requires the basins to remain open to ongoing infiltration. To address such comments, Ameren performed additional modeling analysis to assess groundwater impact at Rush Island under both containment and excavation scenarios. Containment results in a predicted return to standards in 2027, approximately 6-7 years post-closure, as compared to 2057 under an excavation scenario. *See* Section 11 and in Attachments 6 and 7. Concerns relating to groundwater compliance are addressed more expeditiously by promply closing and capping the ash basins and cutting off infiltration.

- *Trucking is Less Burdensome than Rail but Neither is Fast.* The Lochmueller Extraction & Transportation Study (CMA, Appendix C) described the logistics behind hauling CCR from the energy centers to a commercial landfill. Certain commenters took issue with that analysis and instead contend that railroad carrier CSX provides such services. Connecting to the CSX railroad would require multiple carriers, installation of onsite storage yards, nine dedicated, 100-car unit trains, and commercial landfill unloading facilites. No Illinois or Missouri landfill was identified as having adequate rail facilities. *See* Section 4 and Attachment 3.

- *The CCR Basins are Structurally Sound, Built to Withstand Extreme Weather Events*. Several commenters expressed concerns regarding the risk of "wash out" or "liquefaction" of the stored material should a flood or seismic event occur. All of Ameren's CCR units are protected by massive embankments designed to prevent failure. The potential for extreme events has been specifically considered and we have provided a stability analysis summary chart. *See* Section 5.

GENERAL COMMENTS

To the extent a number of commenters raised identical or similar issues, such comments are grouped by subject matter.

1. The Public Meetings Facilitated One-on-One Discussions and Were Designed to Foster Collaboration

The public meetings provided a forum to define the community concerns; promote one-on-one communication between Ameren and the community; and to foster collaboration. Ameren and its experts presented information about the CMAs and made themselves available to discuss questions and concerns expressed by those in attendance. Importantly, the CCR Rule does not specify a format for the public meeting nor does the rule require that specific responses be provided. The rule simply states that the remedy selection by the owner should consider the "degree to which community concerns are addressed by a potential remedy(s)." Nevertheless, Ameren believes responses to the concerns are important.

Ameren organized the public meetings with much thought and consideration. The meetings featured technical experts located at discrete stations who were available to discuss a number of topics relevant to the corrective measures options; groundwater data collection; risk assessment analysis; modeling analysis; the corrective measures assessment process; and dam safety issues. The goal was to maximize for the community one-on-one time with company representatives and the experts so the community could provide their input and present questions.

A number of commenters expressed frustration with the meeting time, a perceived lack of notice and a perceived lack of time to review the CMAs. Ameren wishes to address these concerns. First, as to notice, Ameren placed notices of the meeting on its CCR website and in a variety of media outlets (***St. Louis Community News, Festus Jefferson Leader and the Washington Missourian***) during the weeks of May 1 and May 9, 2019. Second, as to the CMAs, Ameren posted the CMA reports on its CCR webpage starting on May 16, 2019, with printed copies available at the meetings.[1] We note that there is no requirement to make the CMAs available prior to the meeting but Ameren chose to do so regardless. Indeed, social media postings by the Labadie Environmental Organization (LEO) and Sierra Club clearly reflect that local environmental activists were not only well aware of the meeting dates and times, but also of the CMA posting. In fact, activist groups had members attend each of the meetings. Lastly, as to the time of day, Ameren selected the afternoon and all of the meetings were well attended. For those who could not attend, Ameren received comments through a dedicated email address box and, as requested, posted the exhibits used at the meetings to the Ameren website following the meetings. Again, all of this is more than is required by the CCR Rule.

[1] The CMA reports were removed temporarily from the website on May 30, 2019, during an IT system migration but were re-posted the next day.

While the format did not include or facilitate speechmaking, the format was informational and not a "public relations event." The amount of direct questioning and explanation clearly resonated with many members of the community. Again, Ameren chose the format to provide the greatest amount of direct contact with company representatives and the technical experts. Videos taken by the environmental activists during the meetings demonstrate that attendees effectively utilized the question and answer approach.

2. <u>CCR Constituents Do Not Threaten Human Health or Drinking Water</u>

Some commenters expressed concern that CCR constituents in groundwater at Ameren's energy centers present a risk to drinking water sources and to public health. **Public or private drinking water supplies are not at risk from Ameren's CCR units.** As depicted in the charts below and as presented in numerous technical reports including the CMAs, the CCR units have not affected the bedrock aquifer that serves as a water source to residences located within the general vicinity of the Labadie and Rush Island energy centers. To the extent impacts from coal ash exist on Ameren's property and immediately adjacent to surface impoundments, the public has no direct or indirect access to such groundwater. Further, as presented in numerous technical reports including the CMAs, sampling results demonstrate that public drinking water sources that draw from the Meramec, Mississippi and Missouri Rivers are not impacted by Ameren's CCR units. As made clear in published risk assessments, where there is no exposure, there can be no risk.

More specifically, in calendar years 2012-2014, going beyond then existing or current regulatory requirements, Ameren installed offsite monitoring well networks at both Labadie and Rush Island in an effort to provide the community with data to address concerns about the sites' impact on their drinking water wells. Through these monitoring networks, Ameren evaluated groundwater quality, flow direction and water column height within the bedrock aquifers. So that representative samples were taken, the monitoring wells mirrored the actual depths of the residential wells. Groundwater elevations in residential wells are at a higher elevation than groundwater levels near the ash basins. Groundwater moves from the bluffs to the river valleys and **no physical mechanism exists** through which groundwater from Ameren's coal ash basins could travel uphill to domestic water supplies. This is true even under an extreme flood; hypothetically assuming river levels match the highest flood of record for 55 straight days. *See Golder Technical Memorandum dated June 26, 2019* attached hereto as **<u>Attachment 1</u>**.

Labadie – No Impact to Bedrock Aquifer

Do values from offsite well network exceed CCR Rule GWPS (Yes or No)

Analyte	UNITS	GWPS	September/October 2014 Samples							
			TGP-A	TGP-B	TGP-C	TGP-D	TGP-E	TGP-F	TGP-G	BW-1
Sample Date			9/9/2014	9/8/2014	10/3/2014	10/6/2014	9/8/2014	9/30/2014	9/3/2014	9/9/2014
ARSENIC, TOTAL	µg/L	42.6	NO	NO	NO	NO	NO	NO	NO	NO
BARIUM, TOTAL	µg/L	2,000	NO	NO	NO	NO	NO	NO	NO	NO
BERYLLIUM, TOTAL	µg/L	4	NO	NO	NO	NO	NO	NO	NO	NO
CADMIUM, TOTAL	µg/L	5	NO	NO	NO	NO	NO	NO	NO	NO
CHROMIUM, TOTAL	µg/L	100	NO	NO	NO	NO	NO	NO	NO	NO
COBALT, TOTAL	µg/L	6	NO	NO	NO	NO	NO	NO	NO	NO
FLUORIDE, TOTAL	µg/L	4	NO	NO	NO	NO	NO	NO	NO	NO
LEAD, TOTAL	µg/L	15	NO	NO	NO	NO	NO	NO	NO	NO
MERCURY, TOTAL	µg/L	2	NO	NO	NO	NO	NO	NO	NO	NO
MOLYBDENUM, TOTAL	µg/L	100	NO	NO	NO	NO	NO	NO	NO	NO
SELENIUM, TOTAL	µg/L	50	NO	NO	NO	NO	NO	NO	NO	NO
THALLIUM, TOTAL	µg/L	2	NO	NO	NO	NO	NO	NO	NO	NO

Notes:
1) µg/L – micrograms per liter, mg/L – milligrams per liter,
2) GWPS – Site-specific Groundwater Protection Standard applicable to Labadie CCR units

Rush Island – No Impact to Bedrock Aquifer

Do values from offsite well network exceed CCR Rule GWPS (Yes or No)

Analyte	UNITS	GWPS	TBW-1	TBW-2	TBW-3
Samples Collected in 2014					
ARSENIC, TOTAL	µg/L	30	NO	NO	NO
BARIUM, TOTAL	µg/L	2,000	NO	NO	NO
BERYLLIUM, TOTAL	µg/L	4	NO	NO	NO
CADMIUM, TOTAL	µg/L	5	NO	NO	NO
CHROMIUM, TOTAL	µg/L	100	NO	NO	NO
COBALT, TOTAL	µg/L	6	NO	NO	NO
FLUORIDE, TOTAL	µg/L	4,000	NO	NO	NO
LEAD, TOTAL	µg/L	15	NO	NO	NO
MERCURY, TOTAL	µg/L	2	NO	NO	NO
MOLYBDENUM, TOTAL	µg/L	100	NO	NO	NO
SELENIUM, TOTAL	µg/L	50	NO	NO	NO
THALLIUM, TOTAL	µg/L	2	NO	NO	NO

Notes:
1) µg/L – micrograms per liter.
2) GWPS – Site Specific Groundwater Protection Standard applicable to Rush CCR Unit.

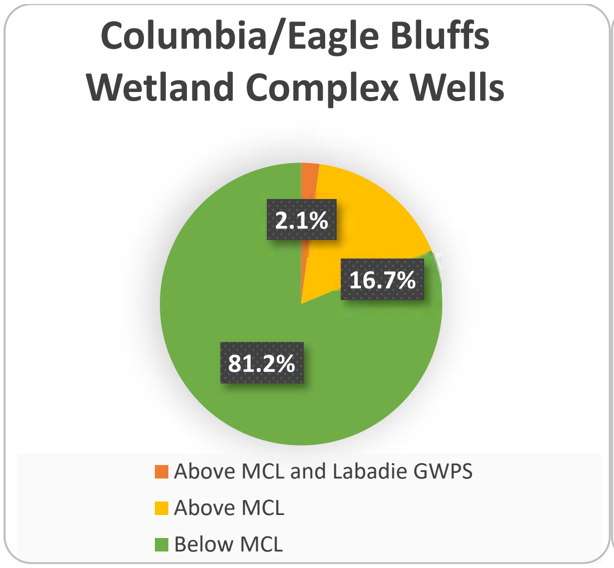
With respect to St. Charles and St. Louis County communities located near the Sioux and Meramec energy centers, all residences are connected to public water suppliers that draw from drinking water intakes located within the Missouri, Mississippi or Meramec Rivers and are miles away from the facilities. Extensive river sampling immediately adjacent, downstream and upstream from Ameren's facilities (again this sampling is over and above what is required by any rule), confirms that all such surface water samples (more than 250 sample locations and over 16,000 individual analyses) comply with federal and state drinking water standards. **Ameren's energy centers do not adversely impact those surface waterbodies.**

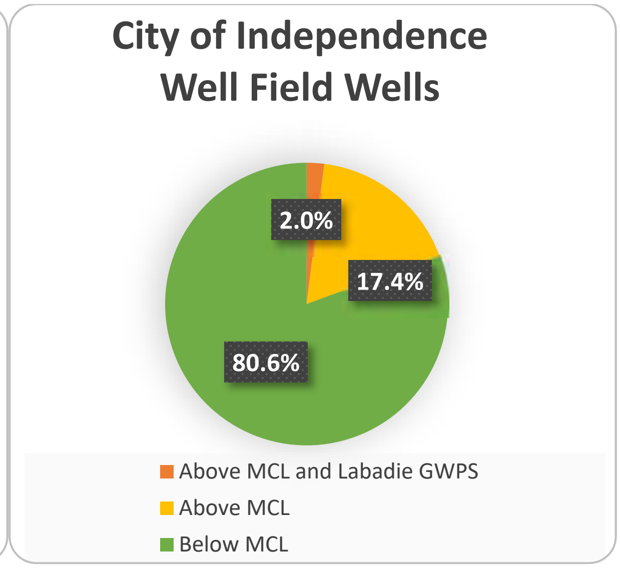
3. The Groundwater Protection Standards Set by Ameren are Protective and Comply with the CCR Rule

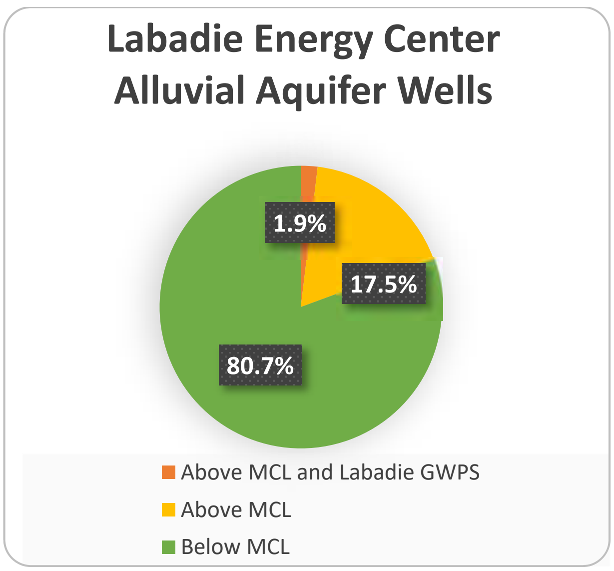
Groundwater impacts at Ameren's energy centers are limited in nature with more than 95% of assessment monitoring results statistically **below** site groundwater protection standards. This is good news. And yet, rather than being reassured by such results, activists instead argue in comments that Ameren "skewed" the data and calculated "abnormally high" background levels and, consequently, protection standards. Nothing could be further from the truth. The CCR Rule prescribes a specific process for the siting of wells, collecting data, and then statistically analyzing the results to calculate the Groundwater Protection Standards (GWPS) used in the CCR process. The CCR Rule requires that a licensed professional engineer certify all critical steps of the process and EPA has issued a Unified Guidance for determining the applicable statistical methodology, *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities*, (Unified Guidance) EPA-530-F-09-020 (March 2009). The GWPS calculated for each site fully comply with the CCR Rule and Unified Guidance. Ameren’s independent licensed professional engineer and hydrogeologist who certified the standards prepared an additional technical memorandum to address comments received from the Washington University Environmental Law Clinic (WUELC), **Attachment 2** to this response document.

Ameren also responds to additional more specific comments received on two naturally occurring constituents, arsenic and molybdenum. Those comments relate to the setting of GWPS for those constituents at Labadie and Rush Island. As to arsenic, contrary to the WUELC's claims that arsenic present in background wells emanates from Ameren’s CCR units, naturally occurring levels of arsenic with concentrations above EPA standards are widespread within the Missouri River alluvial aquifer. In fact, the National Water Quality Monitoring Council (NWQMC) reports in a publicly available database that approximately 20% of groundwater samples collected near groundwater municipal well fields in Missouri (Columbia and Independence), have ambient arsenic levels above the MCL. As the charts below reflect (prepared using the NWQMC data), the data closely align with sampling results collected in the alluvial aquifer at Labadie. In other words, naturally occurring levels of arsenic are found within various locations in Missouri and such levels are consistent with background conditions found upgradient from Ameren's sites. But putting aside data from other locations in Missouri, it is important to note that the background wells at Labadie are ***more than one-mile upgradient/cross-gradient*** from the facility and located in an agricultural field ***unimpacted*** by CCR. Additionally, background wells at Rush Island are located north of the power plant building and upgradient/cross-gradient of the CCR unit.

Naturally Occurring/Non-CCR Arsenic Exist At Labadie and Other Municipal Sites







Golder calculated the arsenic GWPS using sixteen (16) data points per site, consisting of eight (8) baseline samples from each of the two background wells. Due to the spatial variability in the arsenic samples between the background wells (one with high results and one with low results), Golder used a statistical method consistent with EPA's Unified Guidance to calculate the GWPS. The remainder of this paragraph describes the statistical test used to determine a single background level where measured results vary. The terms used are standard statistical language, perhaps not familiar to the reader. Where spatial variability exists, Golder performed statistical outlier analysis, removed any outliers and then calculated a tolerance level. Because the background data varied spatially at both sites, the resulting GWPS is equal to the highest background value in each data set. Because the background data were not normally distributed for either site, the concentrations of 42.6 µg/L (Labadie) and 30 µg/L (Rush Island), respectively, are from observed values, not outliers, and therefore are statistically part of the background population. In addition, it is clear from well logs that the selected background locations are not influenced by site operations due to their upgradient/cross-gradient locations and the limited groundwater concentrations of either boron or molybdenum, indicating the lack of CCR impact. As a result, and notwithstanding differences between the sample populations of the two wells at each site, the background data from the higher concentration wells must be considered. The higher concentrations in background wells at each site demonstrate that arsenic exists, unrelated to plant operations, representing a background condition that must be included in the statistical analysis of data.

As to molybdenum and based upon their comments, the Missouri Confluence Water-keeper (Waterkeeper) seems to have misunderstood the purpose behind the Molybdenum Fact Sheet provided by Ameren at the public meetings. Molybdenum, while naturally occurring, is not a commonly known element and Ameren thought it would be helpful to provide a separate background fact sheet with each of its CMA reports to provide context for the public. The fact sheet notes that the Institute of Medicine of the National Academy of Sciences (NAS) defines molybdenum as an essential nutrient for human health. In addition to developing a Recommended Daily Allowance (RDA) that defines the amount of molybdenum needed to maintain good health, the NAS also developed an Upper Tolerable Limit for molybdenum, a limit that equates to a safe drinking water level of 600 µg/L. The Fact Sheet presented this value purely as a point of context; **Ameren knows and acknowledges that it is the GWPS that is used as the basis of decision making under the CCR Rule.**

Further, in 2018, EPA revised its regulations to designate a specific protection standard for molybdenum and adopted 100 ug/L for molybdenum. 83 Fed. Reg. 36435,36444 (June 30, 2018) (Emphasis added.) Importantly, EPA went on to say:

> "These levels were derived using the same methodology that EPA proposed to require States to use to establish alternative GWPS (*See* 83 Fed. Reg. 11598–11599, 11613). The methodology follows Agency guidelines for assessment of human health risks of an environmental pollutant. This means that **these GWPSs are expected to be concentrations to which the human population could be exposed to on a daily basis without an appreciable risk of deleterious effects during a lifetime**." *Id.* (Emphasis added.)

Ameren used the GWPS of 100 µg/L for molybdenum at all four of its facilities. While we agree with the Waterkeeper that EPA included molybdenum on its 2009 Contaminant Candidate List, 74 Fed. Reg. 51850,51852 (Oct. 8, 2009), no regulatory action has occurred in the intervening ***10-year period*** and where the EPA may go with this rulemaking is unknown.

4. Railing or Barging CCR from Ameren's Energy Centers is Neither Reliable Nor Economical

WUELC argues, seemingly based on a CSX marketing brochure that it references, that rail transport would avoid local impacts to the community inherent in truck hauling and therefore rail is a viable option for transporting CCR for the offsite disposal. However, as the brochure notes, "CSX offers direct connections to numerous cement producers, fly ash and slag locations, and cement terminals **throughout the East Coast."** Ameren Missouri's energy centers are all located west of the Mississippi River.

Ameren receives coal via rail delivery and has extensive experience with the challenges associated with such transport mode. Ameren asked its transportation expert to expand its consideration of rail and barge in response to comments received. Set forth below are key considerations based on Ameren's experience and the Lochmueller Group review (**Attachment 3**):

- *Multiple Carriers.* Neither CSX nor its short-line rail partners have direct access to Ameren's energy centers. To connect to CSX at its Rose Lake Yard in East St. Louis, a unit train (a set of similar railcars that typically remain together in a dedicated train), would need to first transfer to the Terminal Railroad Association in St. Louis via the Burlington Northern (BNSF: Rush Island, Sioux) or Union Pacific railroads (UP: Meramec, Labadie).

- *Coal Trains Can't Be Repurposed.* Dedicated coal unit trains leave the the Powder River Coal Basin on a near-daily basis and travel directly to the energy centers via the UP or BN railroads, unload, and then return in a near-continuous loop. The train cars are specifically designed to carry and unload coal and are NOT designed to carry CCR.

- *Single Loop Rail Tracks Require Coal Delivery Prioritization.* The energy centers have single loop rail tracks that, in order to maintain reliable generating operations, must prioritize coal deliveries. The hauling of large volumes of CCR woud require separate onsite car storage areas known as "ladder tracks" and specialized, covered rail cars traveling in a "unit train". Sufficient or adequate property for ladder tracks may not be available at all locations such as Rush Island.

- *Carriers Control Haul Cycles, Not Shippers.* Unlike truck hauling, the carrier, not the shipper, controls the availability of locomotives and timing of shipments. In order to get to the CSX, the unit train would need to be staged on ladder tracks at the energy center until the originator carrier (UP or BNSF) is available to transport the unit train to a rail yard in St. Louis where a terminal railroad would then move the loaded unit train to CSX's Rose Lake yard located in East St. Louis. From there, the CSX would take possession of the unit cars and haul to a landfill with proper rail unloading facilities large enough to accommodate a unit train. Alternatively, the loaded unit train could be delivered to a train-to-truck transfer station located close to the disposal site where the CCR would be unloaded from rail cars and then hauled via truck to a landfill. Once emptied, the unit train cars would return via the reverse route (CSX, Terminal, and UP/BNSF railroads). The entire process entails multiple railroad crew exchanges.

- *Logistical Issues Impact Reliability of Rail*. Due to the haul cycles and load/unload times, a single unit, 100-car train is capable of transporting at most one load per week.

Nine (9) unit trains would be required to to maintain parity with trucking estimates of 5,000 tons per day. The cost of procuring such trainsets is approximately $90M ($100,000 per car x 9 unit trains). Interruptions with multiple railroad crews or service anywhere along the haul routes, rail yards or energy centers would disrupt shipments. Based on Ameren's experience with coal deliveries, it is highly unlikely that the rail carriers could consistently maintain such productivity.

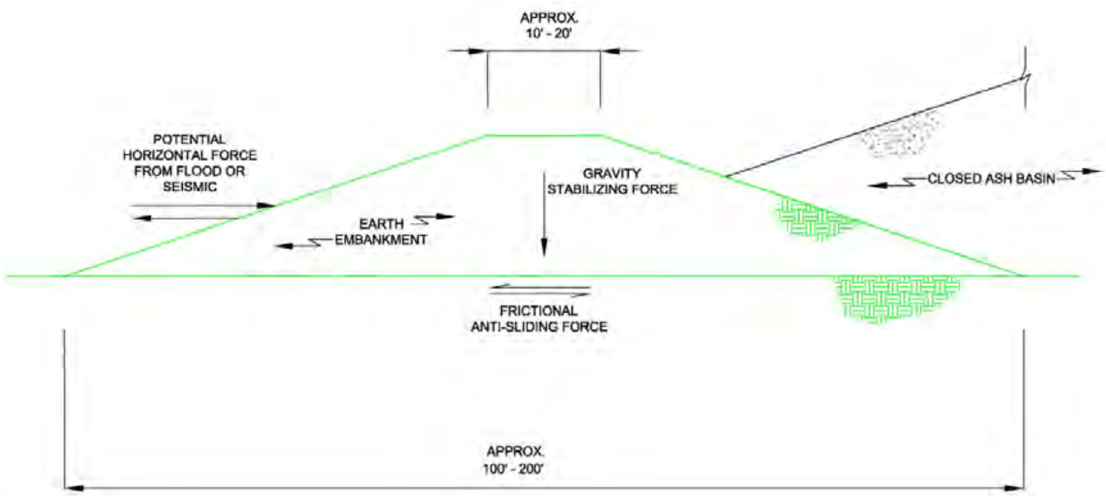
- Shipment via barge is not a viable option due to a lack of existing loading/unloading facilities and environmental concerns associated with large scale, long term shipments on unpredictable waterways.

5. <u>Ameren Ash Basins: Sound Structural Integrity Even Under Flood Conditions</u>

Several commenters expressed concerns that the in-place closure of CCR units could increase the risk of "wash out" or "liquefaction" of the stored material should a flood or seismic event occur. We understand these concerns. The CCR Rule specifically requires owners of ash basins and landfills to perform extensive structural and geotechnical analyses to verify the stability of such units during both normal operations and natural disasters. All of Ameren's CCR units have been inspected, evaluated and verified by third-party geotechnical engineering firms and are inspected weekly by specially-trained plant personnel and annually by Dam Safety specialists.

Ameren's coal ash basins are protected by massive embankments and designed to prevent failure. The potential for extreme events has been specifically considered. The embankment slopes have undergone rigorous evaluations as part of the CCR Rule's structural integrity requirements and are subject to weekly surveillance and monthly maintenance protocols. Engineering evaluations calculate the slope stability of the embankments and compare the driving forces within a cross-section of slope to the resisting forces and determining a factor of safety (FOS). Slope stability analysis includes multiple geotechnical borings and laboratory analysis to assess soil properties. Gravity forces tend to move the slope downward (driving force), while resisting forces derived from soil shear strength, tend to keep the slope in place. When the driving force on a slope is greater than the resisting force, sliding can occur. Ameren's embankments have broad foundations that are at least 4 to 6 times as wide as their height and narrow to a minimum of approximately 10 to 20 feet at their crests. This slope configuration functions as a solid pyramid designed to withstand flooding and seismic events. The diagram below depicts a typical configuration and illustrates the shear mass that would need to erode or otherwise be compromised before a "wash out" of compacted ash stored within the basin could occur.

EMBANKMENT SLOPES & FORCES



Lastly, the embankments surrounding the basins can withstand an estimated 7.0 to 8.0 magnitude earthquake. Both EPA and the Missouri Department of Natural Resources (MDNR) have published target safety factors for a variety of potential structural conditions and all of Ameren's CCR units meet or exceed those requirements.[2] The calculated FOS are expected to increase post-closure as surface waters are removed reducing internal force and pressures. In addition, an engineered cap and stormwater measures will prevent pooling on and within the basins.

SLOPE STABILITY ANALYSIS

	Condition	Target FOS	Minimum Calculated FOS
Labadie	**Major Flood Event**	1.40	1.52
	Steady State	1.50	1.64
	Liquefaction	1.20	1.27
	Slope with Seismic Forces	1.00	1.08

	Condition	Target FOS	Minimum Calculated FOS
Rush Island	**Major Flood Event**	1.40	1.42
	Steady State	1.50	1.51
	Liquefaction	1.20	1.29
	Slope with Seismic Forces	1.00	1.07

[2] 80 Fed. Reg. 214755-77

Sioux	Condition	Target FOS	Minimum Calculated FOS
	Major Flood Event	1.40	1.42
	Steady State	1.50	1.50
	Liquefaction	1.20	1.26
	Slope with Seismic Forces	1.00	1.12

Meramec	Condition	Target FOS	Minimum Calculated FOS
	Major Flood Event	1.4	1.62
	Steady State	1.5	1.71
	Liquefaction	1.2	1.62
	Slope with Seismic Forces	1.0	1.18

Lastly, closure design includes armoring the riverside of embankment slopes to mitigate erosion from floodwater rises and rapid draw down conditions. In addition to routine examinations, qualified Dam and Safety personnel inspect embankments before, during and after flood conditions to ensure proper ongoing maintenance. All of Ameren's ash pond embankments remain structurally sound following the recent 2019 floods crests.

6. <u>The WUELC Misconstrues the CCR Rule and Seeks to Create a New Standard</u>

WUELC's interpretation of the federal CCR rule as those rules relate to elimination of *"free liquids"* is simply misplaced. The requirement cited by WUELC is located within the closure provisions of the regulations that address the activity of drainage or dewatering, and subsequent stabilization of the CCR, to allow for the construction and installation of the final cover system. EPA specifically defined "f*ree liquids"* in relation to ambient pressure and temperature, a clear reference to removal of standing water as part of the draining/dewatering of a CCR basin in preparation for installation of a closure capping system in accordance with best engineering practices. Nowhere does the CCR Rule require draining or dewatering CCR impoundments at depth to meet the closure in place requirements.

The CCR rule requires that owners of CCR units meet two main performance criteria: contain the CCR waste mass in a covered, stabilized unit; and address impacted groundwater outside of the CCR unit boundaries. *See* 40 CFR §257.102 and §257.97, respectively. The rule does not require a compliance monitoring point *within* the waste that is contained in place. EPA specifically authorized two closure options: removal or closure in place and EPA does not select, or even prefer, one to the other.[3]

By conflating CCR Rule performance standards, WUELC attempts to create a *new* performance standard, one that does not exist in the rule and in effect would mandate excavation regardless of environmental impact. WUELC's position is also in direct contradiction to the actual language of the rule and RCRA's governing standards of *"no reasonable probability of adverse effect on health or the environment.*" EPA found that monitoring groundwater throughout the active and post-closure periods and requiring the owner to perform appropriate corrective measures adequately addresses any groundwater impacts.

7. <u>The Estimated Timeline for Excavation is Reasonable Given the Volumes and Complexity of an Excavation Project</u>

Estimated timelines contained in the Lochmueller report are based on a number of factors including transportation related factors. Using Rush Island as an example, such factors include: volume of stored material including soil amendments; travel time and distance to disposal site; maximum daily haul rate (5,000 tons); 8-hour daily operation and a range of 115-192 days per year of operation (adjusted for equipment breakdown, weather, holidays, vacation, imperfect execution, etc.). The daily haul rate assumes a fleet of trucks making multiple roundtrips per day and that the landfill has capacity, manpower, and authority to accept the maximum daily load of trucks (192). Haul trucks leaving the site every 2.5 minutes would still take decades upon decades to complete the project. Even assuming a constant stream of available trucks, there is simply a practical limitation on how quickly an excavator can load a truck even if there were multiple trucks and multiple excavators onsite.

Furthermore, in addition to the transportation challenges outlined by Lochmueller, there are a number of construction-related issues associated with excavating large volumes of material adjacent to large river systems in alluvial (i.e., river deposited) sands and up to depths of approzimately 100 feet. To further explain the timeline for excavation, Reitz & Jens, a geotechnical engineering firm, examined the construction related issues identified by Lochmueller and supplemented the analysis. Reitz & Jens prepared a white paper outlining its analysis found here in **<u>Attachment 4</u>**. In its *Study of Deep Excavation*, Reitz & Jens notes the following:

- *Excavation Methods.* There are two principal methods of removal or excavation of the CCRs from the basins: 1) excavation in the "dry" by first pumping out the water to some depth below the excavation; or 2) excavation in the "wet" by dredging. Other

[3] "In practice, EPA does not routinely require complete removal of all contamination (that is, cleanup to 'background') from a closing unit even for hazardous waste units. Requiring CCR units to clean up soils to levels before the site was contaminated, would be more stringent than current hazardous waste policies. There is no basis in the current record to impose provisions for the remediation of CCR units that are more stringent than those imposed on hazardous wastes." 80 Fed. Reg. 21302, 21412.

than at the top 20-30 feet, the location of the basins would preclude large-scale excavation via "dry" techniques and the use of conventional equipment.

- *Conventional Dredging has an Adverse Impact on Groundwater.* Dredging with an open bucket (i.e., backhoe, dragline or clamshell) could result in suspension of particles in the remaining groundwater, and an increase in the hydraulic conductivity of the remaining CCR, both potentially causing additional release of contaminants to groundwater.

- *Specially Designed Equipment*. Due to these concerns, the only viable method identified by Reitz & Jens for deep excavation is a cutter-head dredge that would need to be specifically designed and manufactured for Ameren's sites. The unique dredge may pump approximately 14,000 gallons per minute and could remove up to 650 cubic yards of CCR per hour. A suction dredge may be used for depths up to 20 to 30 feet.

- *Construction and Permitting of Settling Basins.* To use the specially designed dredge, a large volume of water would need to be routed from the CCR unit to multiple lined settling ponds. These ponds currently do not exist and would require permitting from MDNR. After CCR settles in the ponds, the dredged material is excavated and dried to allow for overland hauling to a commercial landfill. This double-handling and drying process takes substantial space and time, increasing the costs substantially as well. Remaining water would need to be monitored, potentially treated, and discharged in accordance with regulatory requirements.

- *Dredging Operations Could Take a Decade or More.* It would take more than a decade of full-time dredging operation to remove the CCRs from the largest of Ameren Missouri's CCR units—this time estimate does not take into account permitting, construction activities, drying, double-handling of CCR, weather, maintenance, transportation of the CCR for disposal off-site and handling of the water that remains in the settling ponds.

With all of these considerations taken into account, Reitz & Jens' conclusions are consistent with the time estimates determined by Lochmueller in its transportation study. In no sense are Ameren's basins (total system in-place volume 31M tons) similar to the City of Columbia's three year, 90,000 ton excavation from a single, four (4) acre former farmer's pond. WUELC erroneously relies on this example to demonstrate the ease by which such a project could be executed without disclosing the dissimilarities between that site and Ameren's sites.

8. <u>Closure Plans Posted on Ameren's Website Were Required by the CCR Rule and Do Not Indicate a Final Remedy has been Selected</u>

Several commenters suggested that Ameren is disingenuous in even requesting comments on the CMAs because Ameren has announced previously its plans to close the CCR basins. Such comments ignore the fact that the CCR Rule required Ameren to post on its CCR website closure and post-closure plans by October 2016, one year from the effective date of the CCR Rule. This federal requirement applied even though investigatory efforts were ongoing. (In fact, closure plans are required to be included with *applications* for *new* CCR units.)

Moreover, Ameren's approach continues to evolve through ongoing investigation and analysis, risk assessments and the corrective action options, including groundwater treatment, as outlined in the CMAs. The groundwater impacts observed at the CCR basins are few and localized in nature and do not pose a risk to human health even if the units were to remain open. Preliminary indications are that geochemical conditions within the alluvium are such that concentrations will reduce over time as pH levels stabilize.[4] In addition, Ameren is exploring a variety of treatment techniques that may reduce the amount of time needed to achieve groundwater protection standards at the designated compliance point (that is, the toe of the berm). That analysis will continue for several months.

In the meantime, Ameren has constructed wastewater treatment facilities at Rush Island and Labadie that isolate the ash basin systems and allow for the removal of surface waters from the basins. In fact, MDNR in a recently issued permit required Ameren to remove all standing surface water from the Rush Island CCR basin by this summer. The CCR Rule requires closure to commence shortly after the known final receipt of CCR. *40 CFR 257 §102.* For Labadie, Rush Island and Sioux, such "known final receipt" date is linked to the in-service dates for waste water treatment facilities. Even the most ardent environmental activist would have to concede that removing surface water reduces recharge into groundwater and that by eliminating the exposure of ponded ash to the elements, the environment benefits immensely. Having been very vocal about the ash basins for years, Ameren is surprised that activists now accuse it of moving too quickly.

SPECIFIC ISSUES RASIED BY COMMENTORS

9. “Litigation Risk” is not a CCR Rule Remedy Selection Factor

The first seven pages of the Waterkeeper's public comment contains a lengthy discussion on its view of legal issues that the United States Supreme Court may or may not entertain and the applicability or non-applicability of the Clean Water Act to CCR basins. None of that is relevant to CCR Rule requirements for remedy selection. No litigation has been brought by any person or entity regarding Ameren's CCR Units.

Furthermore, to the extent Waterkeeper suggests that Ameren should have solicited public comments before issuing its CMAs, they have clearly misread the CCR Rule requirements.

[4] A discussion of the behavior of metals in soil and groundwater can be found at **Attachment 5**.

10. <u>Closure of the CCR Basins Will Control Source Material and Mitigate Groundwater Impacts</u>

WUELC suggests that the only way Ameren can comply with the CCR Rule's closure performance standards is to excavate and remove all CCR, a positon rejected by EPA. In fact, EPA explicitly did not choose closure by removal over closure in place, indicating that both options, when done properly, are acceptable.

> *EPA did not propose to require clean closure nor to establish restrictions on the situations in which clean closure would be appropriate. As EPA acknowledged in the proposal, most facilities will likely not clean close their CCR units given the expense and difficulty of such an operation. Because <u>clean closure</u> is generally preferable <u>from the standpoint of land re-use and redevelopment</u>, EPA has explicitly identified this as an <u>acceptable means</u> of closing a CCR unit. However*, ***both methods*** *of closure (i.e., clean closure and closure with waste in place) can be* ***equally protective, provided they are conducted properly****. Thus, consistent with the proposal, the final rule* ***allows the owner or operator to determine*** *whether clean closure or closure with the waste in place is appropriate for their particular unit. EPA agrees that the RBCA [risk based corrective action] process, using recognized and generally accepted good engineering practices such as the ASTM Eco–RBCA process, can be a useful tool to evaluate whether waste removal is appropriate at the site. It is, however, not a prerequisite.*

80 Fed Reg at 21411-12 (emphasis added); *See also 80* Fed Reg at 21407.[5]

The CMAs step through the regulatory criteria for each of the considered remedial alternatives, all of which meets the requirements of 40 CFR §257.97. In addition, geochemical conditions across the sites indicate that concentration levels of the few parameters that exceed GWPS will reduce over time as infiltration is eliminated by installation of a cap, the water table lowers and pH conditions stabilize through a variety of natural in situ processes.[6] To optimize this process, Ameren is evaluating groundwater treatment options particularly for arsenic. Treatment methods for arsenic are well established.[7] While metals (unlike organics) cannot be destroyed, by changing the environmental conditions of the soil and groundwater, the leaching or dissolution of such metals can be reduced through the formation of stable minerals or by

[5] Contrary to WUELC assertions, the CCR Rule does not require returning CCR units to pre-construction conditions. EPA itself determined that was inappropriate, unnecessary, and would result in stricter standards than at hazardous waste sites. 80 Fed. Reg. 21302, 21412 **("There is no basis in the current record to impose provisions for the remediation of CCR units that are more stringent than those imposed on hazardous wastes.")**

[6] EPA specifically discussed that its lack of pH-specific data could impact its risk assessment. In its response to comments on the risk assessment, EPA indicates that pH-specific data, as well as other site-specific factors could yield site-specific remediation alternatives that cannot be addressed in a nationwide risk assessment. 80 Fed. Reg. 21302, 21434-37. Ameren is using site-specific data in the CMAs to make remedy comparisons that fit the unique nature of these surface impoundments.

[7] https://www.epa.gov/remedytech/arsenic-treatment-technologies-soil-waste-and-water.

binding such metals more strongly to other minerals. XDD has prepared a short description of this process, appended hereto as **Attachment 5**, *Behavior of Metals in Soil and Groundwater*.

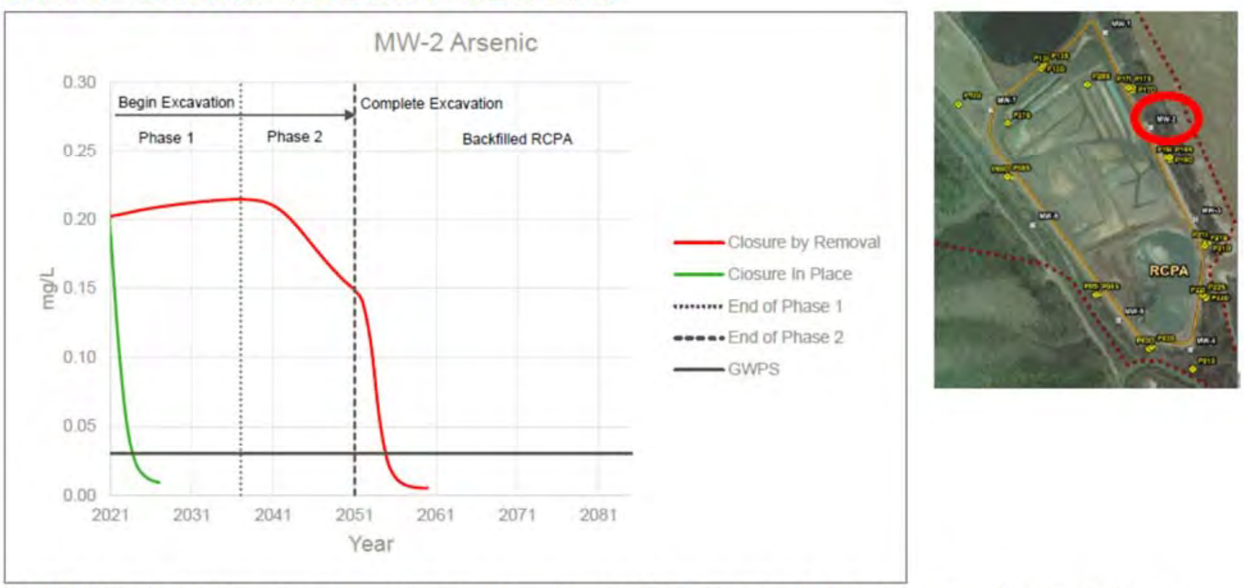
Predictive modeling also indicates that compliance with GWPS at the designated compliance point is achievable. Once that occurs and is confirmed by three years of groundwater monitoring, corrective actions are complete.

11. Excavation Would Delay Compliance Until After 2050

Several commenters believe that excavation is the only way to ensure compliance with GWPS. As the Lochmueller and Reitz & Jens reports make clear, excavation projects at these sites are complex, take decades to execute and will be a burden on local communities. During the entirety of the process, the ash basins remain open to weather, and recharge (contaminant loading due to infiltration from precipitation) to groundwater would continue during this entire period. Using Rush Island as an example, Ameren performed additional predictive modeling to illustrate the timeframe needed to come into compliance under an excavation scenario. (*See Golder Rush Island Closure by Removal Modeling,* **Attachment 6**). Under a containment/capping scenario, compliance with GWPS is predicted to occur in approximately 6-7 years post-closure (2027) as compared to thirty (30) or more years (2057) after beginning the excavation.

Modeling Results Indicate Excavation Delays Groundwater Compliance

RUSH ISLAND ENERGY CENTER



MW-2 (highest arsenic value in CCR Rule Well) is estimated to reach the GWPS 30 years sooner using closure in place vs closure by removal (Excavation)

12. Evaluation of Climate Change is Not Required by EPA

One commentor suggested that Ameren should have evaluated climate-related issues as part of its corrective measures assessment. EPA did not designate consideration of climate change as a requirement of the CCR Rule. However, to the extent precipitation events increase in severity or number as some climate models suggest, maintaining the proper Factors of Safety and structural stability of ash basins effectively counters those risks. Ameren addressed these issues in Section 5.

13. Transportation of Waste from Westlake Landfill has Less Impact on Community Due to Access Route and Volume

At the Westlake Landfill CERCLA Site in St. Louis, EPA recently ordered the **limited** excavation of **radioactive** material improperly sent to a sanitary landfill that due to its chemical composition set off subsurface fires. The proposed excavation is limited to approximately 1.5M in-place cubic yards (cy), located up to depths of 16 feet with deeper materials left in place at depths up to 89 feet below ground surface. EPA estimates the excavation will cost approximately $274M*. See Proposed Record of Decision Amendment Westlake Landfill Superfund Site (EPA, 2018).* The volumes proposed for excavation at Westlake are a fraction (5%) of the CCR material stored in Ameren's ash ponds (30M in-place cy; 41.3M with soil amendments) and would very likely also take the fraction of the time to transport off-site. Westlake Landfill is located in close proximity to interstate highways that function as major regional transportation arteries, thus minimizing disruption to local communities and neighborhoods. To Ameren's knowledge, specific transportation plans for Westlake have not been published.

Attachment List

1. **Golder Technical Memorandum dated June 26, 2019**

2. **Golder Response to CMA Public Comments Regarding Groundwater Protection Standards and Background Water Quality**

3. **Lochmueller Group Rail & Barge Transportation Assessment**

4. **Reitz & Jenz, Inc. Deep Excavation Analysis**

5. **XDD Behavior of Metals in Soil and Groundwater**

6. **Golder Rush Island Closure by Removal Groundwater Modeling**

TECHNICAL MEMORANDUM

DATE June 26, 2019 **Project No.** 153140601

TO Ameren Missouri

CC

FROM Mark Haddock, PE, RG **EMAIL mark_haddock@golder.com**

GROUNDWATER MODELING INDICATES NO IMPACT FROM LABADIE ENERGY CENTER CCR BASINS ON RESIDENTIAL WELLS EVEN UNDER EXTREME FLOOD CONDITIONS

Ameren Missouri (Ameren) recently held public meetings to discuss its Corrective Measures Assessment (CMA) as required under the United States Environmental Protection Agency's Coal Combustion Residual (CCR) Rule. In public comments raised either at these meetings or submitted to Ameren, members of the public questioned whether groundwater used by residential supply wells could be adversely impacted by CCR basins located at the Labadie Energy Center. The results of the modeling and testing conclude that bedrock groundwater quality in the residential areas of the bluffs is unaffected by CCR impacts to the alluvial aquifer based upon the following:

- The bedrock groundwater flow direction is consistently from high elevation areas (i.e. the bluffs) to low elevation areas (river bottoms).
- The closest community water supply well is located approximately two miles south of the LEC. Some individual wells are located within a mile of the LEC and all draw water from the bedrock aquifer in the bluffs area.
- Groundwater in the bedrock beneath the bluffs flows from the bluffs to the river valley areas, even under extreme river flood stage conditions. The higher groundwater levels in the bluffs prevent groundwater impacted by CCR on Ameren's property from travelling upgradient to residential water supplies.
- To assess groundwater flow under flood conditions, Golder modeled a worst case scenario (i.e. the 1993 flood of record (486.6 feet at the LEC), at a constant elevation and lasting for 55 straight days)[1]. The modeling results indicate that groundwater in the bluffs still flows in a northward direction, towards the Bottoms, and not vice versa.
- Multiple bedrock groundwater quality samples collected from wells in the bluffs area near the existing residential wells confirm that water quality is unaffected by CCR.

[1] In 1993, this peak elevation level lasted one day at Labadie.

Below is a reproduction of a technical memorandum originally produced on August 5, 2015 regarding Golder's groundwater modeling analysis.

August 5, 2015 Golder Technical Memorandum on flood conditions groundwater modeling at LEC

1.0 INTRODUCTION AND BACKGROUND

At the request of Ameren Missouri (Ameren), Golder performed limited groundwater modeling for the Labadie Bottoms area in the vicinity of the Labadie Energy Center (LEC) located in Labadie, Missouri. The modeling was primarily intended to investigate movement of groundwater near the LEC for a flood condition in the Missouri River. The intent of the modeling was to investigate the potential for reversal of groundwater hydraulic gradient from the alluvial aquifer toward the bedrock aquifer located in the Bluffs area south of the LEC during and following a significant flood event. Specifically, the intent was to investigate the potential that groundwater flow in the alluvial aquifer was significantly reversed toward the bedrock aquifer due to flood conditions.

1.1 Modeling Software

Groundwater modeling was accomplished using MODFLOW 2000, a finite-difference numerical modeling code developed by the United States Geological Survey, and the most widely accepted groundwater modeling platform. MODFLOW 2000 is an updated version of the original MODFLOW code and incorporates improved functionality. Model development was facilitated by Groundwater Vistas, a graphical user interface used to develop the model domain, grid, properties, and to visualize model results.

1.2 Conceptual Model, Domain and Grid

The model domain was intended to model conditions in the alluvial aquifer under and near the LEC and the adjacent limestone bedrock aquifer to the south. The domain was approximately 47,000 feet by 35,000 feet, and was developed roughly parallel to the Missouri River (Figure 1). The model domain was rotated such that the northern model boundary corresponded approximately to the Missouri River. The southern boundary was set in the bedrock aquifer a sufficient distance away from the river so as to minimize boundary effects to the model output. The direction of groundwater flow has been determined to be generally from the bedrock aquifer toward the alluvial aquifer.

The total model thickness for the alluvial aquifer was set at 100 feet based on subsurface drilling information. The individual grid cells were 500 feet by 500 feet, and the model was split into four layers, each 25 feet thick, for increased computational resolution. The model layers were sloped with the top of the model set to 600 feet at the southern model boundary and to approximately 454 feet at the Missouri River, based on general topographic trends in both areas. Initial modeling was conducted with the model layers both horizontal and sloped as a comparison. However, early model runs indicated that preliminary results for the sloped layer configuration were more conservative (i.e., greater effect at the area of interest).

1.3 Boundary Conditions

The eastern and western boundaries of the domain were treated as essentially parallel to groundwater flow and therefore were considered to be no-flow boundaries. The southern and northern boundaries of the model domain were considered to be constant head boundaries. The model boundaries are shown on Figure 2.

Groundwater elevations in the bedrock aquifer near the bluffs and the alluvial aquifer were used to extrapolate the hydraulic gradient throughout the model domain to the south. The intent was that the model emulate the approximate groundwater elevations determined in the installed bedrock wells. In order to do this, the southern constant head boundary was set to 590 feet. It is important to note that the actual groundwater elevations at the southern domain boundary are not expected to be 590 feet at all locations, but this was done as a convenience to generate the anticipated groundwater elevations in the middle of the model and avoid boundary effects.

The northern constant head boundary was set to 455.4 feet to represent a typical stage of the Missouri River. This constant head boundary was increased to 486.6 feet to represent the flood event, as observed during the flood event of 1993. This was a historic severe flood event with water in the Missouri River above flood stage for 55 days, primarily at modest elevations. The peak elevation of the flood near the LEC was 486.6 feet and only lasted one day. However, the intent was to model a worst case flood scenario so the peak elevation was extended for the entire 55-day flood event.

The alluvial aquifer was modeled as a single unit with a hydraulic conductivity of 70 feet per day (ft/d) based on a mean value for the alluvial aquifer from the Detailed Site Investigation (DSI) (GREDELL Engineering Resources and Reitz & Jens, Inc., 2011) for the LEC. The bedrock aquifer was modeled as a single unit with a hydraulic conductivity of 3 ft/d, based on a published value for limestone from Todd (1980). Specific yield for the alluvium and bedrock aquifers were set at 0.3 and 0.14, respectively, based on published estimates from Anderson and Woessner (1992), and were also used to approximate porosity. Specific storage for the alluvium and bedrock aquifers was set to 2.3E-04 ft^{-1} and 1.1E-05 ft^{-1}, respectively, based on published estimates from Anderson and Woessner (1992).

2.0 STEADY STATE GROUNDWATER MODELING RESULTS

The model was initially run in steady state to generate the typical groundwater gradient and movement from the bedrock aquifer to the alluvial aquifer toward the Missouri River, as observed from direct measurements. A general comparison was made between the model estimated groundwater elevations in the bedrock aquifer and the measured groundwater elevations in the area of the bluffs. The model estimated groundwater elevations at the edge of the bluffs were approximately 460 feet, which closely approximates the measured groundwater elevations in this area (Figure 3).

3.0 TRANSIENT GROUNDWATER MODELING RESULTS

Golder was asked to model the effects of a significant flood event, comparable to the 1993 flood event of the Missouri River, on the groundwater movement in the alluvial aquifer. The 1993 flood saw an increase in river flows and levels above flood stage for a period of 55 days. The maximum river stage in the Missouri River near the Labadie Plant during this flood was 486.6 feet, an increase of approximately 31 feet over typical flows in the Missouri River in this area. Use of the peak flood elevation for the entire length of the flood was conducted to represent an extreme worst case scenario.

A transient model run was conducted in which the southern constant head boundary, representing the Missouri River, was set to 486.6 feet for 55 days, then was returned to the same level as in the steady state model run (455.4 feet). Three stress periods were simulated in the model run: Period 1 is the steady state condition with the Missouri River set to 455.4 feet, Period 2 is a transient, 55-day period with the Missouri River set to 486.6 feet, and Period 3 is a transient, 100-year period with the Missouri River returned to 455.4 feet. Changes to water levels near a location of interest were monitored throughout the model run. This location of interest is a hypothetical monitoring well as shown on Figure 4.

Figure 4 shows the modeled groundwater level contours after the 55 day flood event. Modeled groundwater elevations near the limestone bluffs remained at approximately 460 feet at the end of the 55 day flood event, rising less than 0.5 foot (Figure 5). The groundwater divide, the area where the original hydraulic gradient from the bedrock aquifer and the hydraulic gradient from the alluvial aquifer meet, was located well north of the northern edge of the bluff area demonstrating no reversal of flow at the location of interest.

3.1 Particle Tracking

Particle tracking was conducted using the computer code MODPATH (Polluck, 1989). With this analysis, particles are placed in an area of the model to represent points in the groundwater system, and their flow paths through the groundwater system are traced by moving the particles along the vector of maximum velocity within each model cell. In this way, particle tracking can estimate the movement of groundwater under a simulated condition, in this case, a flood event on the Missouri River. Particles were started within the area of the Labadie Plant and tracked throughout the flood event and during the subsequent recovery period. The particles moved in toward the bedrock aquifer during the flood event, and for a period of about 100 days after the event, until the hydraulic gradient reversed again toward the Missouri River in response to the decrease in river stage. The total distance traveled in toward the bedrock aquifer is small (about 50 feet). This is consistent with independent calculations of the average groundwater flow velocity assuming the same parameters used in the model (Darcy's law equation for advection, Fetter, 1988).

4.0 SENSITIVITY ANALYSIS

Numerical modeling always involves a certain level of uncertainty in assigning model parameters. A sensitivity analysis was conducted in which model parameters were systematically varied to determine the variability in the model estimated response to the flood event, as shown in Table 1. The structure of the model runs remained unchanged, only the parameters indicated in Table 1 were modified. The model presented above in this report, model 1, is the preferred model because the model parameters are considered the most likely for the aquifer systems near the LEC. Four sensitivity runs, models 2 through 5, were conducted in which the hydraulic conductivity, storage, and porosity were deliberately altered to facilitate greater movement of groundwater. The results for all of these sensitivity runs were not consistent with reversal of flow at the location of interest.

The particle tracking analysis was repeated for sensitivity model run 5 because this model had the largest response at the monitoring well location. Particles released in the area of the Labadie Plant travel toward the bedrock aquifer for approximately 60 days and travel approximately 235 feet before the hydraulic gradient is again reversed back toward the Missouri River.

5.0 CONCLUSIONS

Groundwater modeling was conducted for an extreme worst case flood event, using the maximum elevation of the 1993 flood and carrying this elevation for the entire 55 days of this flood. The results of groundwater modeling did not indicate any reversal of groundwater flow at the location of interest. Groundwater flow was consistently from the bedrock aquifer to the alluvial aquifer based on the results of this model.

Attachments or Enclosures:

Table 1 – Groundwater Model Parameters

Figure 1 – Groundwater Model Domain Boundary and Model Grid

Figure 2 – No-flow and Constant Head Boundaries

Figure 3 – Pre-flood Groundwater Elevations

Figure 4 – Groundwater Model Domain Boundary and Resulting Groundwater Elevations

Figure 5 – Water Level Changes at Point of Interest

References

Anderson, Mary P., and Woessner, William W., 1992. Applied Groundwater Modeling – Simulation of Flow and Advective Transport.

Fetter, C.W., 1988. Applied Hydrogeology, Second Edition.

GREDELL Engineering Resources and Reitz & Jens, Inc. 2011. Detailed Site Investigation. Ameren Missouri Labadie Power Plant Proposed Utility Waste Disposal Area. Franklin County, Missouri. February 4, 2011.

Todd, David Keith, 1980. Groundwater Hydrology, Second Edition.

USGS 2000, Modflow-2000, the U.S. Geological Survey Modular Ground-Water Model – User Guide to Modularization Concepts and the Ground-Water Flow Process.

TABLES

Table 1
Groundwater Model Parameters
Labadie Energy Center, Franklin County, MO
Ameren Missouri

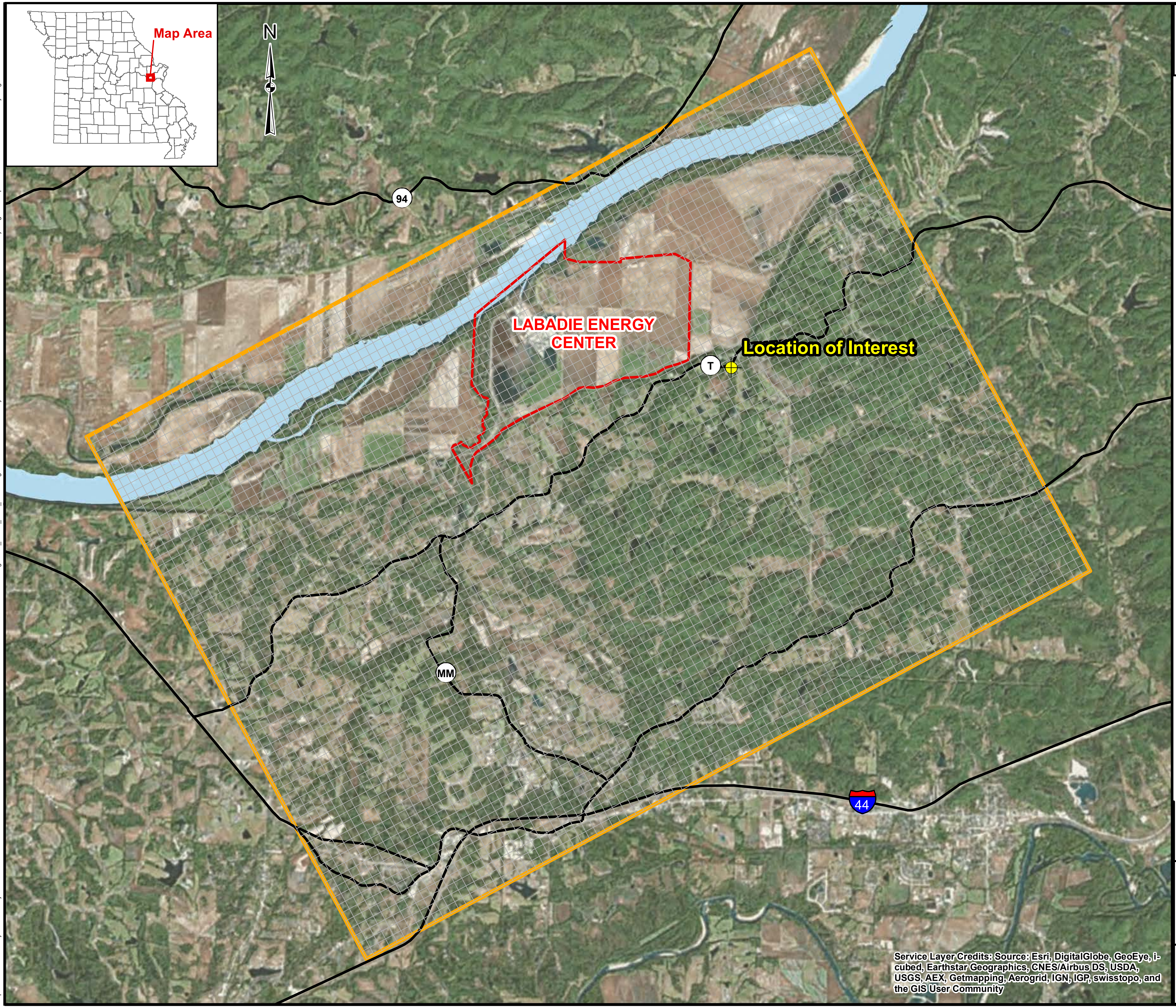
Model Number	Conductivity of Alluvium (feet/day)	Conductivity of Limestone (feet/day)	Specific Yield of Alluvium	Specific Yield of Limestone	Storativity of Alluvium ($feet^{-1}$)	Storativity of Limestone ($feet^{-1}$)	Model Results
1	70	3	0.3	0.14	2.30E-04	1.10E-05	Preferred
2	70	3	0.15	0.05	2.30E-04	1.10E-05	Sensitivity
3	70	10	0.15	0.05	2.30E-04	1.10E-05	Sensitivity
4	70	10	0.1	0.01	2.30E-04	1.10E-05	Sensitivity
5	120	10	0.1	0.01	2.30E-04	1.10E-05	Sensitivity

Prepared By: BS/JSI
Checked By: JS
Review By: JRS

FIGURES

GROUNDWATER MODEL DOMAIN BOUNDARY AND MODEL GRID

TITLE



LEGEND

- Labadie Energy Center Property Boundary
- Groundwater Model Domain
- Location of Interest

NOTES

1.) All boundaries and locations are approximate.

REFERENCES

1.) Ameren, 2011. Ameren Missouri Labadie Energy Center, Labadie Property Control Map, November 2011.
2.) MSDIS (Missouri Spatial Data Information Service) Database, 2014.
3.) MODFLOW groundwater modeling program.
4.) COORDINATE SYSTEM: NAD 1983 StatePlane Missouri East FIPS 2401 Feet.

0 5,000 10,000 Feet

PROJECT

Ameren

AMEREN MISSOURI LABADIE ENERGY CENTER
FRANKLIN COUNTY, MISSOURI

Golder Associates

PROJECT No. 130-1560			Figure 1 - Domain Boundary and Model Grid.mxd	
DESIGN	-	-	SCALE: AS SHOWN	REV. 0
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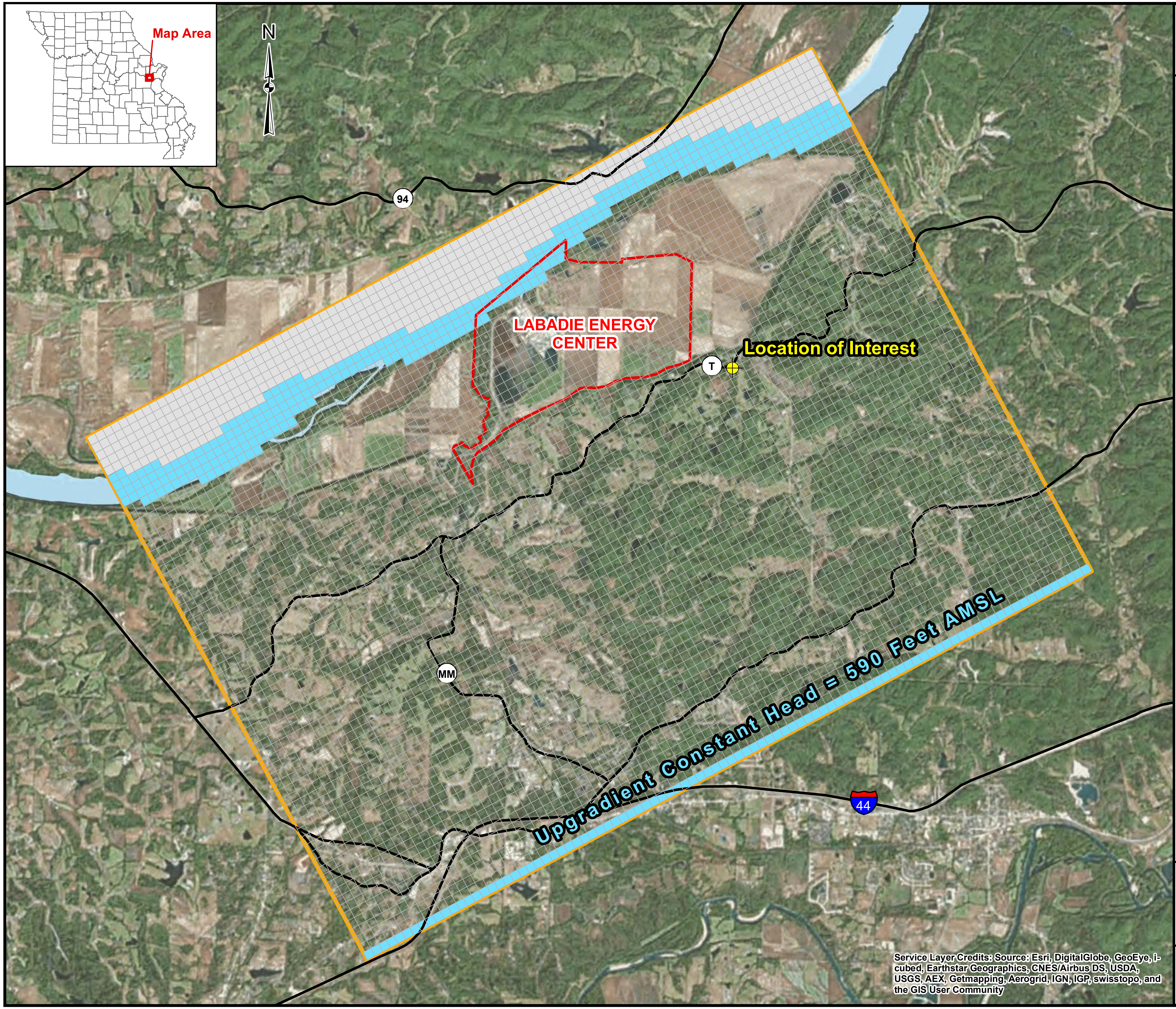
CHECK	JS	7/10/2015		
REVIEW	JRS	7/10/2015		



Map Document: G:\Projects\130 Projects\1301560 - Ameren Ash Ponds - MO\800 - FIGURES-DRAWINGS\PRODUCTION\Phase 0001 - Labadie\Arcgis\GW_Model_Tech_Memo\Figure 2 - Domain Boundary and Model Grid.mxd / Modified 7/10/2015 4:21:17 PM by JIngram / Exported 7/10/2015 4:21:24 PM by JIngram

TITLE

NO-FLOW AND CONSTANT HEAD BOUNDARIES

LEGEND

- Labadie Energy Center Property Boundary
- Groundwater Model Domain
- Location of Interest
- Constant Head Boundaries
- No-Flow Boundaries

NOTES

1.) All boundaries and locations are approximate.
2.) Constant Head Boundaries are 455.4 feet AMSL under average conditions, 486.6 ft AMSL under extreme flood conditons (peak of the 1993 flood), and are 590 feet AMSL upgradient.
3.) AMSL - Above Mean Sea Level.

REFERENCES

1.) Ameren, 2011. Ameren Missouri Labadie Energy Center, Labadie Property Control Map, November 2011.
2.) MSDIS (Missouri Spatial Data Information Service) Database, 2014.
3.) MODFLOW groundwater modeling program.
4.) COORDINATE SYSTEM: NAD 1983 StatePlane Missouri East FIPS 2401 Feet.

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Feet

PROJECT

Ameren

AMEREN MISSOURI LABADIE ENERGY CENTER
FRANKLIN COUNTY, MISSOURI

Golder Associates

PROJECT No. 130-1560			Figure 2 - Domain Boundary and Model Grid.mxd	
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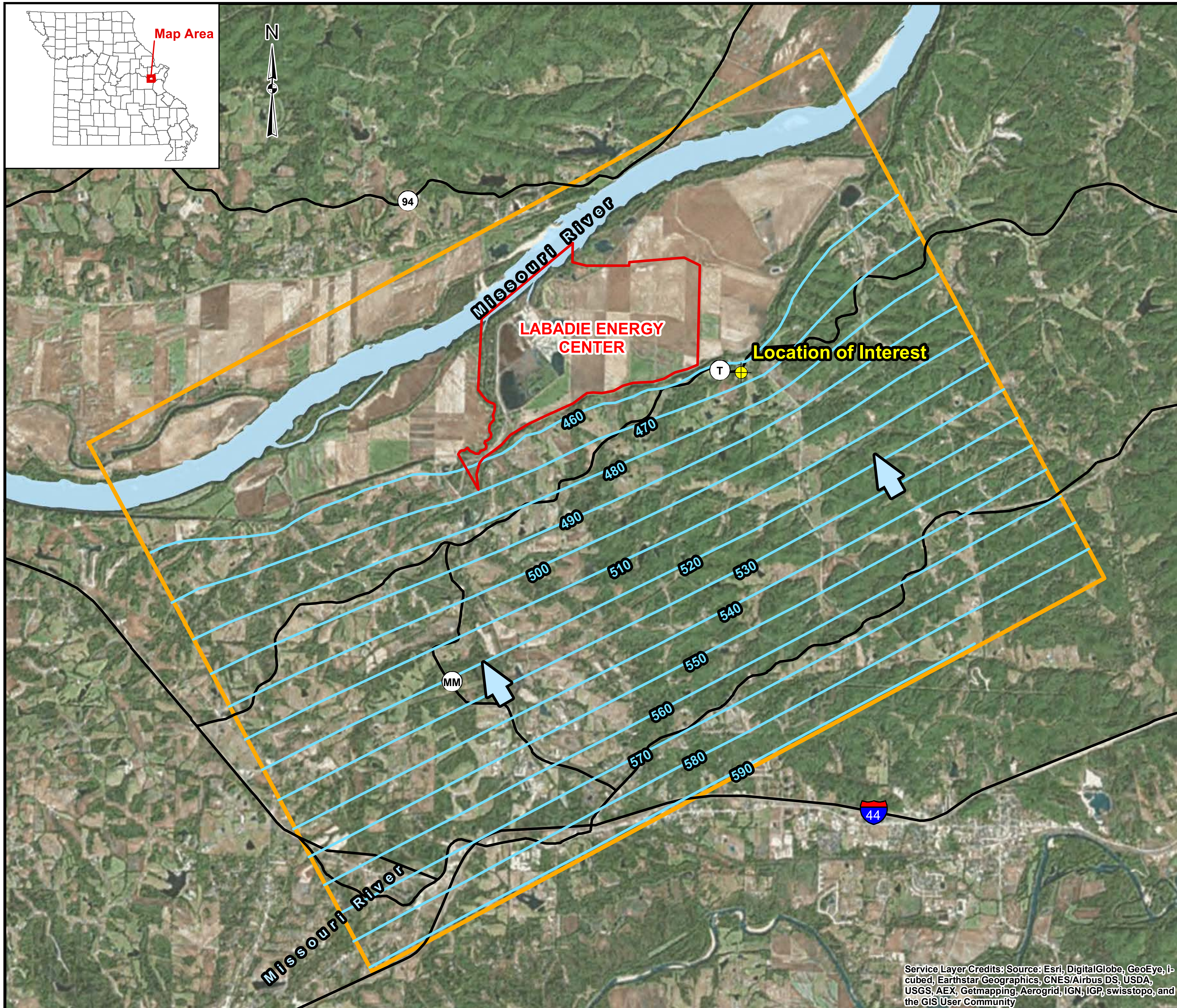

TITLE

PRE-FLOOD GROUNDWATER ELEVATIONS

LEGEND

- Labadie Energy Center Property Boundary
- Groundwater Model Domain
- Location of Interest
- Model Groundwater Elevation Contours
- Groundwater Flow Direction

NOTES

1.) All boundaries and locations are approximate.
2.) Model contour interval is 10 feet.
3.) Upgradient contours are used for generalized gradient and are not considered locally accurate.
4.) Model results reflect pre-flood river conditions.

REFERENCES

1.) Ameren, 2011. Ameren Missouri Labadie Energy Center, Labadie Property Control Map, November 2011.
2.) MSDIS (Missouri Spatial Data Information Service) Database, 2014.
3.) MODFLOW groundwater modeling program.
4.) COORDINATE SYSTEM: NAD 1983 StatePlane Missouri East FIPS 2401 Feet.

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Feet

PROJECT

Ameren

AMEREN MISSOURI LABADIE ENERGY CENTER
FRANKLIN COUNTY, MISSOURI

Golder Associates

PROJECT No. 130-1560			Figure 3 - Pre-flood groundwater elevations .mxd	
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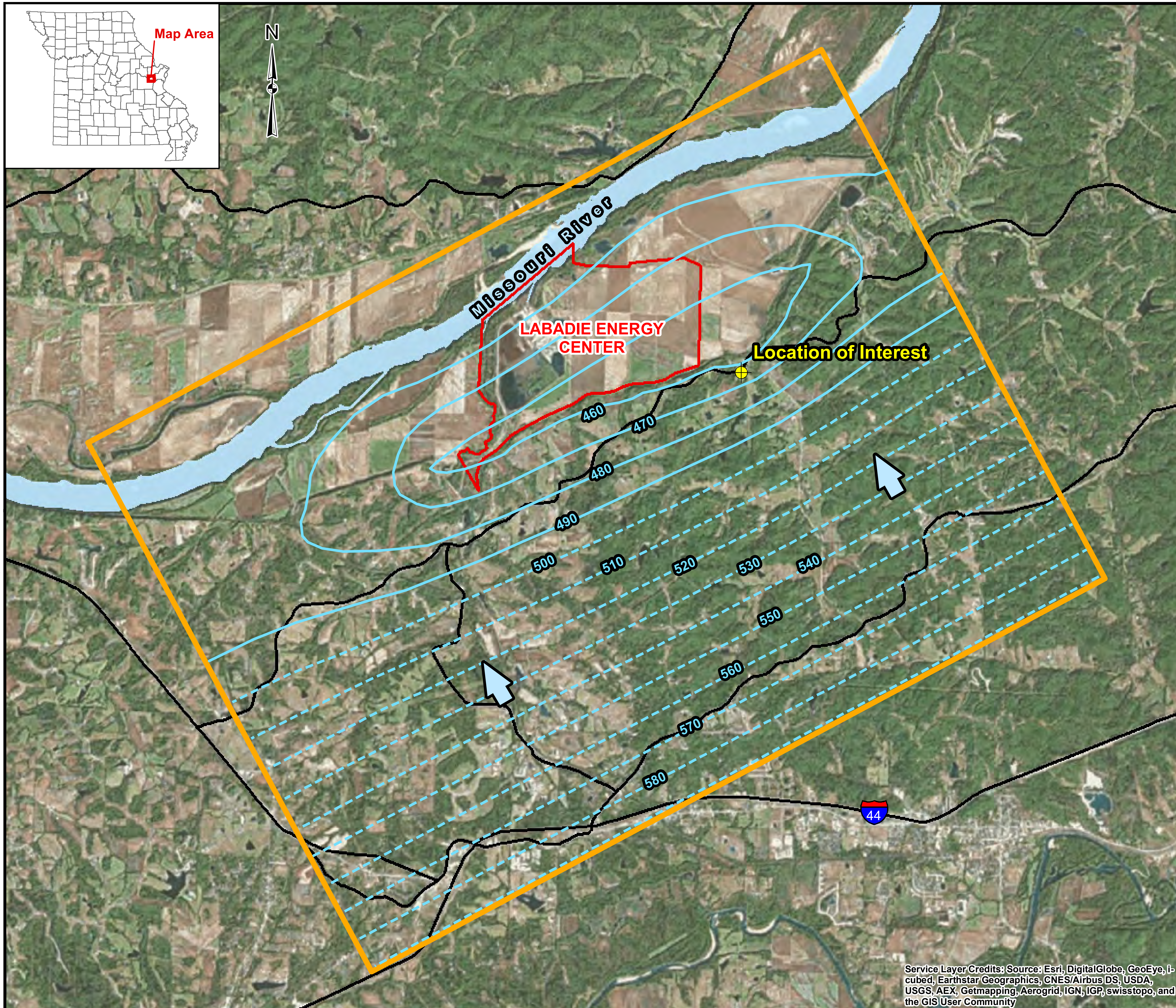
CHECK	JS	7/10/2015		
REVIEW	JRS	7/10/2015		

Map Document: G:\Projects\130 Projects\1301560 - Ameren Ash Ponds - MO\800 - FIGURES-DRAWINGS\PRODUCTION\Phase 0001 - Labadie\Arcgis\GW_Model_Tech_Memo\Figure 3 - Pre-flood groundwater elevations .mxd / Modified 7/10/2015 4:22:03 PM by Jingram / Exported 7/10/2015 4:22:11 PM by Jingram



TITLE

GROUNDWATER MODEL DOMAIN BOUNDARY AND RESULTING GROUNDWATER ELEVATIONS DURING FLOOD

LEGEND

- Labadie Energy Center Property Boundary
- Groundwater Model Domain
- Location of Interest
- Model Groundwater Elevation Contours
- Model Estimated Groundwater Elevation Contours
- Groundwater Flow Direction

NOTES

1.) All boundaries and locations are approximate.
2.) Model contour interval is 10 feet.
3.) Upgradient contours are used for generalized gradient and are not considered locally accurate.
4.) Model results reflect 55 continuous days of river level at 486.6 feet above mean sea level (peak level of the 1993 flood).

REFERENCES

1.) Ameren, 2011. Ameren Missouri Labadie Energy Center, Labadie Property Control Map, November 2011.
2.) MSDIS (Missouri Spatial Data Information Service) Database, 2014.
3.) MODFLOW groundwater modeling program.
4.) COORDINATE SYSTEM: NAD 1983 StatePlane Missouri East FIPS 2401 Feet.

0 5,000 10,000 Feet

PROJECT

AMEREN MISSOURI LABADIE ENERGY CENTER
FRANKLIN COUNTY, MISSOURI

PROJECT No. 130-1560		Figure-4 - Groundwater Elevation after 55 days.mxd		
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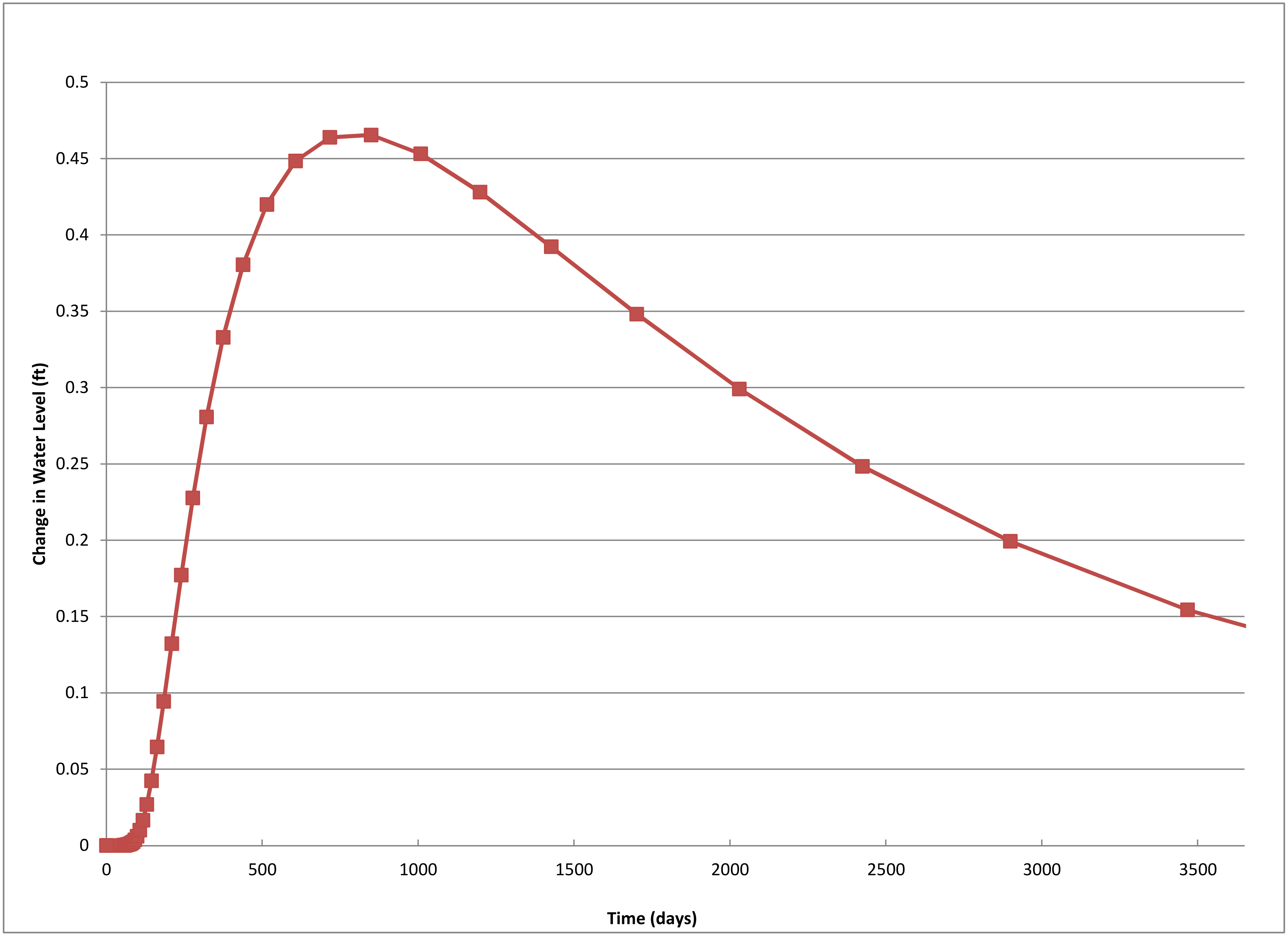
CHECK	JRS	6/16/2015		
REVIEW	MNH	6/17/2015		

Map Document: G:\Projects\130 Projects\1301560 - Ameren Ash Ponds - MO\800 - FIGURES-DRAWINGS\PRODUCTION\Phase 0001 - Labadie\Arcgis\GW_Model_Tech_Memo\Figure-4 - Groundwater Elevation after 55 days.mxd / Modified 8/5/2015 4:45:37 PM by JIngram / Exported 8/5/2015 4:45:44 PM by JIngram

Figure 5
Water Level Changes at Point of Interest
Labadie Energy Center, Franklin County, MO
Ameren Missouri



GOLDER

TECHNICAL MEMORANDUM

DATE June 20, 2019 **Project No.** 1531410601

TO Ameren Missouri

CC

FROM Golder Associates Inc. **EMAIL Mhaddock@golder.com**

RESPONSE TO CMA PUBLIC COMMETNS REGARDING GROUNDWATER PROTECTION STANDARDS AND BACKGROUND WATER QUALITY

1.0 INTRODUCTION

This Technical Memorandum discusses the methods, procedures, and reasoning used to calculate the Groundwater Protection Standards (GWPS) at the Rush Island Energy Center (RIEC) and the Labadie Energy Center (LEC), as well as a brief review of publicly available data regarding arsenic in the alluvial aquifer of the Missouri River in Missouri. Recent public comments to the Corrective Measures Assessment reports (CMAs) have suggested that the calculation of the GWPS for arsenic have "skewed" the results of the monitoring evaluation and rendered the groundwater monitoring networks incapable of detecting arsenic contamination, biasing the CMAs against clean closure. This Technical Memorandum discusses the specific requirements of the CCR Rule that Golder has followed, the best practices for statistical evaluation as outlined in the United States Environmental Protection Agency's (USEPA) Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities (Unified Guidance), the locations of the background monitoring wells at the Labadie Energy Center (LEC) and Rush Island Energy Center (RIEC), and the presence of existing and naturally occurring arsenic in the alluvial aquifers of the Missouri and Mississippi River valleys.

2.0 LOCATION OF BACKGROUND MONITORING WELLS

The location of background wells is one of the most important factors in developing an effective monitoring well network. Section 257.91(a)(1) of the CCR Rule outlines the location requirements of background monitoring wells for a monitoring well network. The requirements are as follows:

(1) Accurately represent the quality of background groundwater that has not been affected by leakage from a CCR unit. A determination of background quality may include sampling of wells that are not hydraulically upgradient of the CCR management area where: (i) Hydrogeologic conditions do not allow the owner or operator of the CCR unit to determine what wells are hydraulically upgradient; or (ii) Sampling at other wells will provide an indication of background groundwater quality that is as representative or more representative than that provided by the upgradient wells;

The CCR Rule requirements have been carefully followed and the locations selected for background monitoring wells accurately represent quality of background groundwater that has not been affected by a CCR unit.

2.1 Background Wells at the Labadie Energy Center

The background monitoring wells for the LCPA ash basin at the LEC are BMW-1D and BMW-2D and two other wells, BMW-1S and BMW-2S provide background monitoring for the LCPB ash basin. An aerial image with the

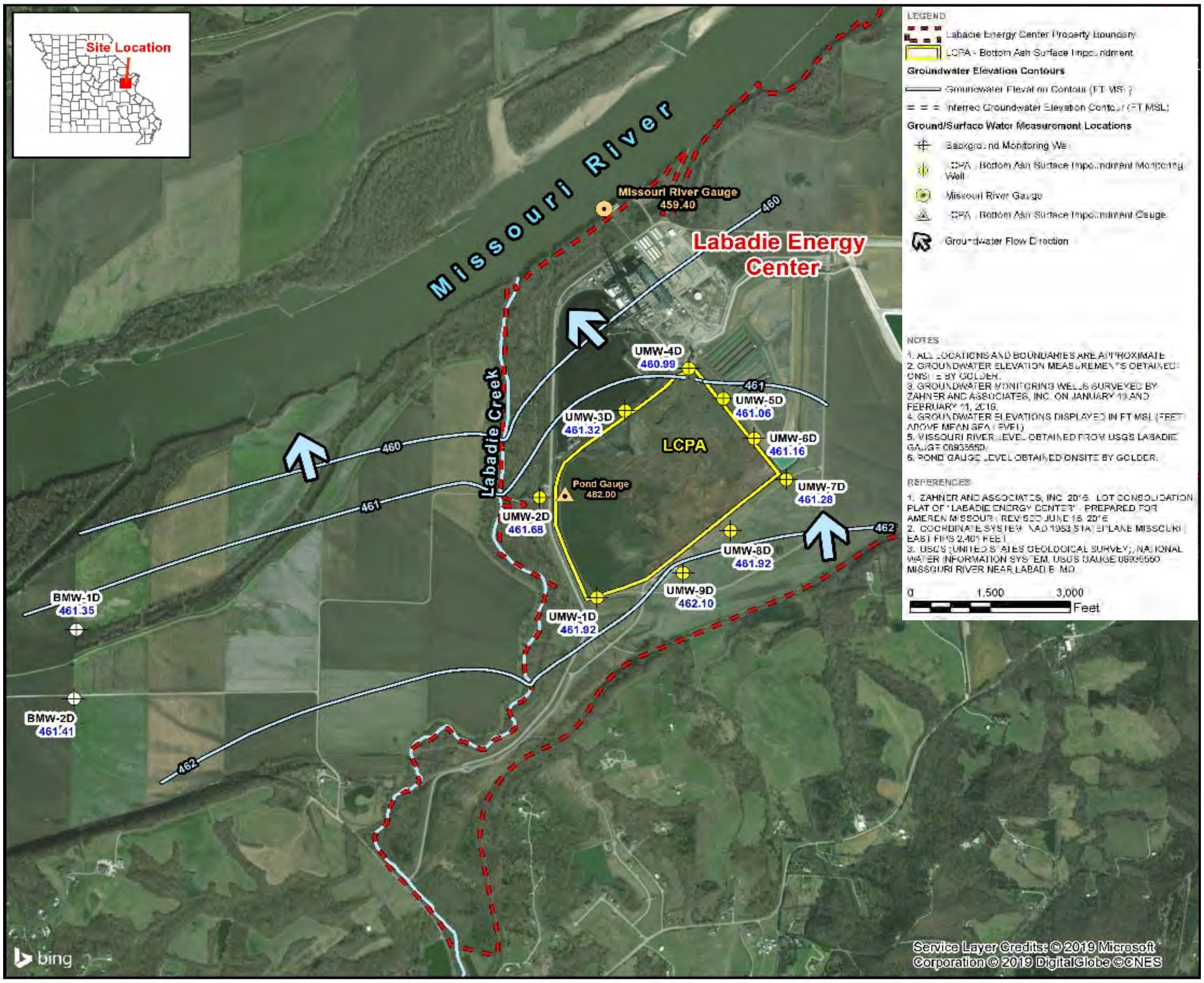


Figure 1: Labadie Monitoring Well Location and Groundwater Flow Map

location of the LCPA, the monitoring wells, and a representative groundwater flow map from 2018 is provided in Figure 1. The background monitoring wells are located approximately 1.5 miles west/southwest of the LCPA and 2,000 to 3,000 feet south of the Missouri River. These locations are upgradient and cross-gradient from the CCR at LCPA. Each of these two locations have shallow and deep zone wells (4 total) used for LCPB and LCPA monitoring purposes.

Groundwater flow within the alluvial aquifer is dynamic and can be influenced by seasonal changes in the water level of the Missouri River. Overall, as discussed in the annual reports (publicly available on Ameren website at https://www.ameren.com/company/environment-and-sustainability/managing-coal-combustion/ccr-compliance-reports), groundwater flows from the bluffs area toward the Missouri River at a rate of approximately 20 feet per year. Based on the upgradient/cross-gradient location of the background wells at LEC and the sampling results from these wells, there are no CCR impacts from the LCPA or the operation of the LEC in these wells and they are representative of un-impacted, background groundwater quality.

Background concentrations of arsenic in these wells have ranged from 0.12 µg/L to 42.6 µg/L and the spatial variability of concentrations is evident - at one location the deep well exhibits the highest concentration and at the other well-pair location the shallow well has the highest arsenic value. Spatial variability in these concentrations is the result of the heterogeneous makeup of the alluvial aquifer porous media and geochemical interactions of the aquifer media with groundwater. The alluvial aquifer is naturally composed of fine to coarse-grained sediments and clasts derived from soil and rock sources up the river basin that can contain arsenic and metallic minerals, as described in Section 4 below.

2.2 Background Wells at the Rush Island Energy Center

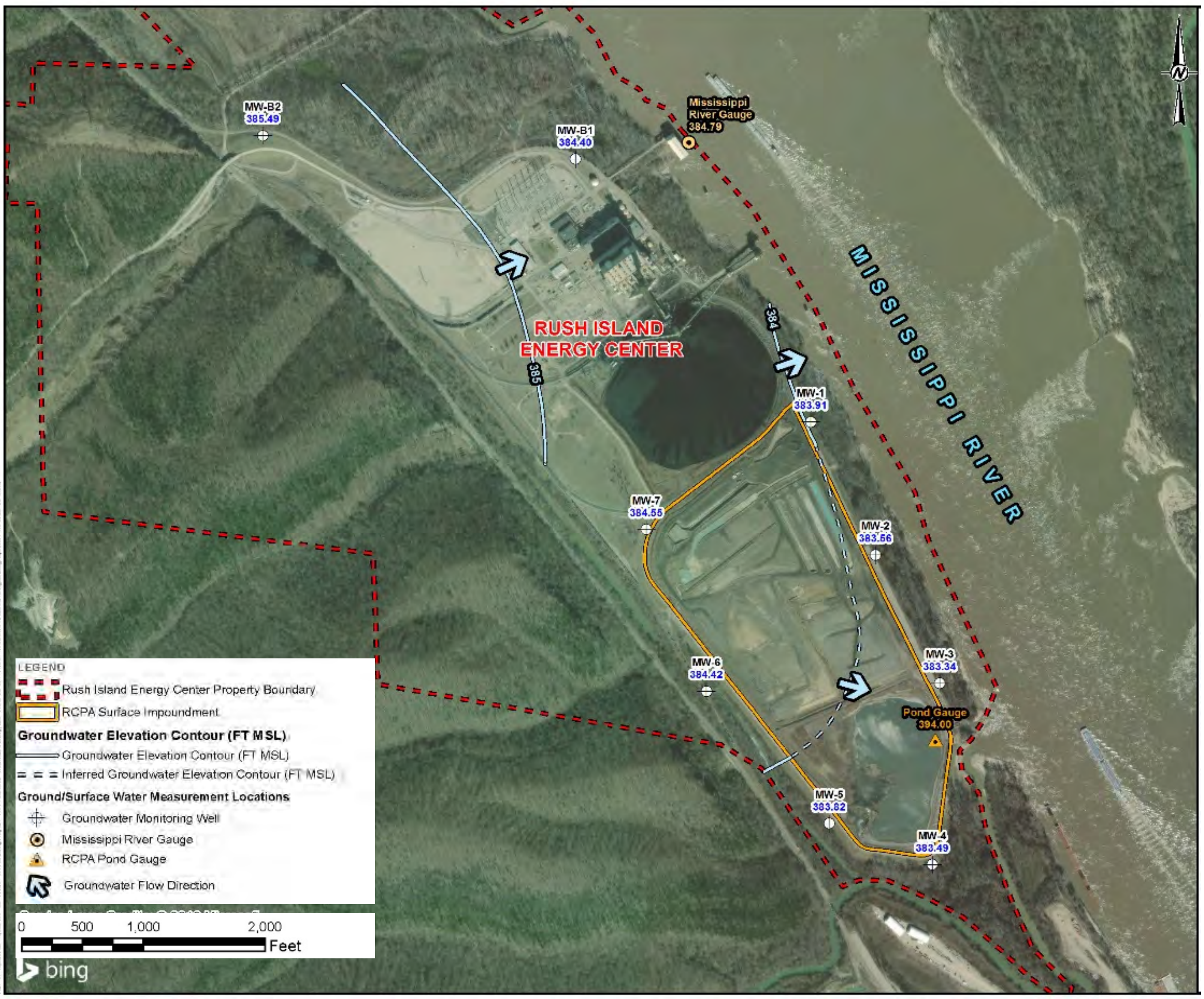


Figure 2: Rush Island Monitoring Well Location and Groundwater Flow Map

The background monitoring wells for the RCPA ash basin are MW-B1 and MW-B2. In addition, two monitoring wells from the 2014 Detailed Site Investigation (DSI) are present within 50 feet of MW-B2. These two wells include a shallow zone well (P29S) and a deep zone well (P29D). An aerial image of the location of the RCPA, the monitoring wells, and a representative groundwater flow map from 2018 are provided in Figure 2. The background monitoring wells are located approximately 2,500 to 4,500 feet north/northwest of the RCPA and 600 to 2,000 feet west of the Mississippi River. These wells are upgradient and cross-gradient from the CCR at RCPA.

Groundwater flow within the alluvial aquifer at the RIEC is also dynamic and can be influenced by seasonal changes in the water level of the Mississippi River. Overall, as discussed in the annual reports (publicly available on Ameren website at https://www.ameren.com/company/environment-and-sustainability/managing-coal-combustion/ccr-compliance-reports), groundwater flows easterly toward the Mississippi River. Based on the upgradient/cross-gradient location of the background wells at RIEC and the sampling results from these wells, there are no impacts from the RCPA or the operation of the RIEC in these wells and they are representative of un-impacted, background groundwater quality.

Background concentrations of arsenic in these wells have ranged from 1.9 to 30 µg/L in CCR Rule wells (MW-B1 and MW-B2) and from 1.1 to 51.7 µg/L in the DSI wells (P29S and P29D). Spatial variability in these concentrations is evident as the highest and lowest concentrations are in nested wells (P29S, and P29D) located 4,500 feet north of the RCPA. This variability in background concentrations is the result of the heterogeneous makeup of the alluvial aquifer porous media and geochemical interactions of the aquifer media with groundwater. The alluvial aquifer is naturally composed of fine to coarse-grained sediments and clasts derived from soil and rock sources upriver that can contain arsenic and metallic minerals, as further described in Section 4 below.

3.0 STATISTICAL METHODS AND CALCULATION OF THE GWPS

As required by the CCR Rule, prior to October 17th, 2017 Ameren posted a Statistical Method Certification (SMC) to its publicly available website for each of its CCR Units. These SMC's describe the statistical methods to be used for each CCR Unit for Detection and Assessment Monitoring. The methods included in the SMCs were selected because they comply with the requirements of the CCR Rule and are consistent with methods recommended in the USEPA Unified Guidance, which is specifically referenced as a statistical guidance document in the CCR Rule.

As required by the CCR Rule, once assessment monitoring is triggered at a site, site-specific GWPS must be calculated for each of the detected Appendix IV parameters. Following standard practice, the CCR Rule also requires that the site-specific GWPS be derived from either: (1) the United States Environmental Protection Agency's (USEPA) maximum contaminant levels (MCL), (2) health-based standards which were adopted by USEPA in July 2018 for Cobalt, Lead, Lithium, and Molybdenum, or (3) un-impacted background concentrations, for situations where the un-impacted background concentrations are higher than the MCL. Using these methods, the GWPS for arsenic at the LCPA was set at 42.6 µg/L, while the arsenic GWPS for the RCPA is 30.0 µg/L.

As outlined in the SMCs for both the LCPA and the RCPA, following the establishment of the GWPS, assessment monitoring statistics were performed using an interwell confidence interval method to compare results from downgradient/compliance monitoring wells with the GWPS. The confidence interval method used to evaluate Appendix IV results from both the LCPA and RCPA are consistent with the methods recommended in the Unified Guidance.

In summary, the methods used for the calculation of the GWPS at the LEC and RIEC, as well as the resulting GWPS values, follow standard practice in groundwater monitoring and are consistent with the CCR Rule and the USEPA Unified Guidance.

4.0 EXAMPLES OF NATURALLY OCCURING ARSENIC IN MISSOURI

There are numerous reports and publications that discuss the presence of naturally occurring arsenic in Missouri. Arsenic has been reported to occur in groundwater in Missouri from both naturally occurring and anthropogenic sources (https://health.mo.gov/living/environment/ privatedrinkingwater /contaminants.php). Additionally, as provided in the risk assessment reports for Labadie and Rush Island, United States Geological Survey (USGS) soil and groundwater maps by the United States Geological Survey (USGS) for arsenic in the groundwater and soils shows that arsenic is naturally present in our environment (USGS Reports available at https://mrdata.usgs. gov/geochem/doc/ averages/ countydata.htm and http://water.usgs.gov/nawqa/trace/pubs/ geo_v46n11 /fig2.html, Ameren risk assessment report available at https://www.ameren. com/company/environment-and-sustainability/managing-coal-combustion/water-quality).

The National Water Quality Monitoring Council's (NWQMC) Water Quality Portal (available at https://www.waterqualitydata.us/) summarizes data from the USGS, the USEPA, and the NWQMC databases. The NWQMC database includes arsenic results from a total of 1,215 groundwater samples for wells located upgradient of the LEC within the Missouri River alluvial aquifer. These 1,215 samples are from wells located just upstream of the LEC to the confluence of the Kansas and Missouri River in Kansas City, Missouri. The 1,215 samples consist of: 351 samples from the Independence Well Field near Independence Missouri, 852 samples are from the Columbia/Eagle Bluffs Wetland Complex wells, and the remaining 12 samples from various locations in the identified area. This is an extensive dataset. A USGS report on the data for Independence Missouri is available at https://pubs.er.usgs.gov/publication/sir20105232 and USGS Reports for the Columbia/Eagle Bluffs Wetland Complex wells are available at https://pubs.er.usgs.gov/publication/wri024227. Arsenic values within these samples ranged from non-detect (<0.022 ug/L) to 72 µg/L, with an average concentration of 6.7 µg/L.

Figure 3: Comparison of Missouri River Alluvial Aquifer Groundwater Arsenic Concentrations – Public Data and Labadie Results

Figure 3 compares the publicly available groundwater arsenic data in upgradient Missouri River alluvial aquifer settings to the Labadie background and monitoring well results, which ranged from non-detect (<0.052 µg/L) to 69.5 µg/L in CCR Rule monitoring wells, with an average concentration of 6.6 µg/L. Overall, the results at the upgradient locations in Missouri are nearly identical to those at the LEC with around 80% of the samples being below the MCL and 20% above the MCL. These data demonstrate that arsenic concentrations above the MCL are not unusual in the Missouri River alluvial aquifer and are primarily from naturally occurring sources or, potentially, from anthropogenic sources that are unrelated to CCR and power plant operations.

Additionally, using the NWQMC Water Quality Portal (available at https://www.waterqualitydata.us/) from the confluence of the Mississippi and Missouri Rivers to the RIEC there are 99 arsenic groundwater sampling locations with published data from the alluvial aquifer of the Mississippi River. Arsenic test results from these published well samples range from non-detect (<1.0 µg/L) to 39 µg/L with 4 sampling locations reporting arsenic concentrations greater than the MCL and 2 locations with concentrations over the site-specific GWPS for the RIEC. These levels are similar to background arsenic concentrations at the RIEC and further support that the concentrations in background wells are derived from naturally occurring or non-CCR anthropogenic sources of arsenic in the Mississippi River alluvial aquifer.

Additional comments to the CMA's make note that boron is a clear indicator of CCR impacts, which is acknowledged by EPRI (2012) documentation that boron is "*Typically present in leachate, non-reactive and mobile in common hydrogeological environments, and not a common anthropogenic contaminant*." The public comments also attempt to draw a correlation between the arsenic concentrations present onsite and boron concentrations. Since boron is not detected in background groundwater wells, this absence further supports the case that the arsenic observed in background wells is not from a CCR source and is naturally occurring, likely derived from sulfide minerals present in the aquifer.

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ADDENDUM

Rush Island, Meramec, Labadie and Sioux Ash Pond Closure: Rail & Barge Transportation Assessment July 9, 2019

Lochmueller Group previously completed a planning-level assessment of the costs and logistics associated with extracting, stabilizing, and transporting coal combustion residuals (CCR) from existing ash ponds at the Rush Island, Meramec, Labadie, and Sioux Energy Centers to offsite landfills. Trucking is the most flexible and cost-effective mode of transporting CCR, given the relatively short distances (50 miles or less) between each energy center and the preferred landfill locations. The purpose of this addendum is to evaluate in detail the rail and barge transportation modes.

Rail and Barge Overview

Rail and barge typically become more cost-efficient than trucking over longer distances. In fact, the average barge trip length along the Mississippi River waterway system is 513 miles, which is indicative of the long distances that waterway freight commonly travels.

As compared to the highway network, the geographical reach of the rail and barge networks is limited. As such, payloads transported by rail and barge are commonly picked up by truck at the origin and delivered by truck to the destination, with intermediate transloads on and off trains and barges. Over short distances, the cost and time for these transloads renders rail and barge non-competitive with truck hauling.

To maintain parity with truck hauling, CCR transport by rail would require specialized rail cars fully lined with covers to prevent material escape (coal delivery trains are not suited for CCR removal). As such, these trains would be dedicated for CCR transportation and would run full to landfills and return empty. Such specialized rail cars are expensive and cost approximately $100,000 per car. Rail cars for each 100-car unit train are estimated to cost $10M.

CSX is a Class 1 railroad with acknowledged CCR transport capabilities. However, CSX does not directly serve any of Ameren's energy centers. For CSX to be a CCR hauler for Ameren, carrier transfers would be required involving the Class 1 serving each site (UP or BNSF). This would probably occur using the St. Louis Terminal Railroad (TRRA) as an intermediary to transfer train cars from UP and BNSF yards in Missouri to the CSX Rose Lake Yard in East St. Louis, Illinois. In total, the use of three separate carriers and multiple train yards would increase the complexity, cost, and haul cycle under the CSX option. Service disruptions would also be a concern, as Ameren would have little control over the means or methods of rail transport.

Given the carrier transfer process described above, a single 100-car unit train is assumed to be capable of transporting approximately one load every two weeks, although the actual timeframe depends on the landfill destination. To maintain the previously assumed CCR removal rates and assuming the 2-week roundtrip haul, unit trains would need to be loaded at each energy center one to four times per week dictating two to eight CCR unit trains in the cycle for each site. The capital expense to acquire a sufficient number of rail cars to support such haul cycles at Ameren's four energy centers would be approximately $90M.

Rail and barge transportation is more susceptible to disruptions, particularly due to flooding events that can close rivers and rail lines for extended periods. In addition, congestion on rail lines and in rail yards and at lock and dams affects the reliability of these modes. Barges also present a unique environmental and safety concern. In 2018, 15 coal barges broke loose on the Monongahela River near Pittsburg with two of the barges sinking and at least one spilling coal into the river. The leakage or spillage of CCR into waterways would have environmental ramifications. Given the sensitivities surrounding CCR generally, barging is simply not a desirable transport mode.

Ameren Energy Centers

As previously noted, each energy center has the potential for direct rail and barge loading. However, there are site constraints at each location that would hamper rail or barge operations, as follows:

Rush Island

The site currently has a rail loop off the BNSF line for unloading coal trains. A full 12-hours is required to unload a coal train and the site receives about one train per day. Hence, the existing rail spur is fully utilized and does not have capacity to temporarily store or load CCR trains.

It would be necessary to construct dedicated tracks for loading CCR unit trains known as "ladder track". The site does not have space for such a facility, so land would need to be acquired or leased from an adjacent property owner or from the BNSF itself to construct a loading area. Since the loading would occur off-site, CCR would need to be trucked to the rail loading area.

Additionally, the BNSF mainline consists of a flood-prone single track. The line has been inoperable due to multiple flooding events in 2019 alone. Due to the single track, northbound and southbound trains must pass at sidings to maintain two-way operation. This significantly diminishes the capacity of the line. It is uncertain if existing BNSF operations can accommodate additional train volume. The addition of CCR train operations could disrupt coal delivery, impacting power generation and ultimately service to customers.

Rush Island does not presently have barge loading capabilities. Ameren would need to construct barge-loading facilities in the Mississippi River along with conveyors to transport the CCR from land to the barge loading area. This would require permits from multiple agencies, including the Army Corps of Engineers and US Coast Guard. This section of the Mississippi River is very active and the ability to obtain regulatory approvals for CCR removal by barge is uncertain.

Meramec

Similar to Rush Island, Meramec is located along a single-track mainline, which is operated by the UP. It is uncertain if existing UP operations can accommodate additional train volume, as this line has the same challenges maintaining two-way operations as the BNSF line. This line is also prone to closure due to flooding.

Concerning barge transportation, Meramec has barge loading facilities in place. However, environmental and safety concerns with barge transportation persist, in terms of the potential for CCR to leak or spill from barges into waterways or for barges to break away.

Labadie

Both the UP (and BNSF via trackage rights) and Central Midland Railroad (CMR) – a short line railroad running between St. Louis and Union – operate in proximity to the Labadie site. However, CMR's line sale contract contains a service restriction prohibiting the CMR line from serving the Labadie facility. That restriction was upheld by the Surface Transportation Board (STB Dockets NOR 42126, FD 33508, FD 33537, served Feb. 27, 2013). The UP presently delivers two loaded coal trains per day to Labadie.

The site's existing rail infrastructure is fully committed to unloading coal trains and would not have capacity to temporarily store or load CCR trains. Therefore, it would be necessary to construct dedicated tracks for loading CCR unit trains on site. Given the site's location in the Missouri River flood plain, such a facility would be subject to permitting and approval from numerous regulatory authorities, which could delay or prohibit construction.

Barge transportation on the Missouri River is considerably less reliable than on the Mississippi River. There are no lock and dams along the Missouri River; water levels are highly susceptible to rainfall and spring snowpack melt in the Rocky Mountains; and the Army Corps of Engineers has not consistently maintained a navigation channel. In recent years, the barging "season" has been at most six months per year. Given these issues, barge transportation would not be a reliable mode for removing CCR from Labadie.

In addition, the Labadie site does not presently have barge loading capabilities. Ameren would need to construct docking facilities along with conveyors to transport the CCR from land to the barge loading area. This would require permits from multiple agencies, including the Army Corps of Engineers and US Coast Guard. With the river not being navigable for half of the year, pursuit of permits and capital expenditures for barge loading facilities would not be economically viable.

Sioux

The site is located along a single-track BNSF line, which is also prone to closure due to flooding and two-way volume constrained. Similar to the other sites, existing on-site rail infrastructure is dedicated to unloading coal trains. Dedicated tracks for loading a CCR unit train would need to be constructed to facilitate removal of CCR by rail.

The Sioux site does not presently have barge-loading capabilities and Ameren would need to construct docking facilities along with conveyors to transport the CCR from land to the barge loading area. This would require permits from multiple agencies, including the Army Corps of Engineers and US Coast Guard. The environmentally sensitive nature of this section of the Mississippi River – influenced by the presence of wetlands, recreation and parks along the river, and eagle habitats – would further encumber the permitting process.

Potential Landfill Destinations

To avoid the need to transload CCR from rail or barge to trucks to reach the final destination, Lochmueller reviewed landfills located in proximity to rail lines or waterways to determine if facilities are in place to enable direct unloading of CCR from rail or barge. Sites across Missouri and Illinois (excluding the Chicago area) were reviewed using location information provided by each state's environmental agency.

While several landfills were discovered along active rail lines, none appears to have active rail unloading capabilities in place. The Five Oaks Recycling and Disposal located near Taylorville, Illinois had a rail unloading spur at one time, although it seems to have fallen into disuse. Moreover, if reactivated, it would not have the ability to store long CCR unit trains and would need to be extended.

Similarly, no landfills were discovered with unloading capabilities along waterways. It is our understanding that such facilities may exist in other states. However, the increase in travel distance to access those facilities would likely render them cost-prohibitive for purposes of CCR removal from these four sites.

Study of Deep Excavation at Ameren Missouri Energy Centers

INTRODUCTION

In response to questions raised at recent public meetings held by Ameren Missouri (Ameren), Reitz & Jens was asked to prepare a white paper that discusses the methods and implications of deep excavation and removal of Coal Combustion Residuals (CCRs) from the surface impoundments ("basins") located at Ameren's four coal-fired energy centers. The technical review presented in this paper is applicable in general to a deep excavation below the water table at the Sioux, Labadie and Rush Island Energy Centers[1]; specific characteristics of each individual energy center or CCR unit are not addressed.

GENERAL DESCRIPTION OF CCR BASINS

The principal characteristics of the CCR basins at each of Ameren Missouri's energy centers are:

1. The basins are built both below and above grade (that is "partially-incised") in alluvial sands in close proximity to a major river (Mississippi River or Missouri River). The basins were created by dredging the sands in the vicinity of each plant to obtain fill material to raise the actual area of the power plant building and appurtenant facilities to above flood levels of the adjacent river. The excavation was then repurposed to manage CCRs generated from the plant. The CCRs were generally placed in the excavation by sluicing (deposited by flowing water). At some point in the history of each plant, large perimeter berms were constructed around the basins. This is illustrated below:

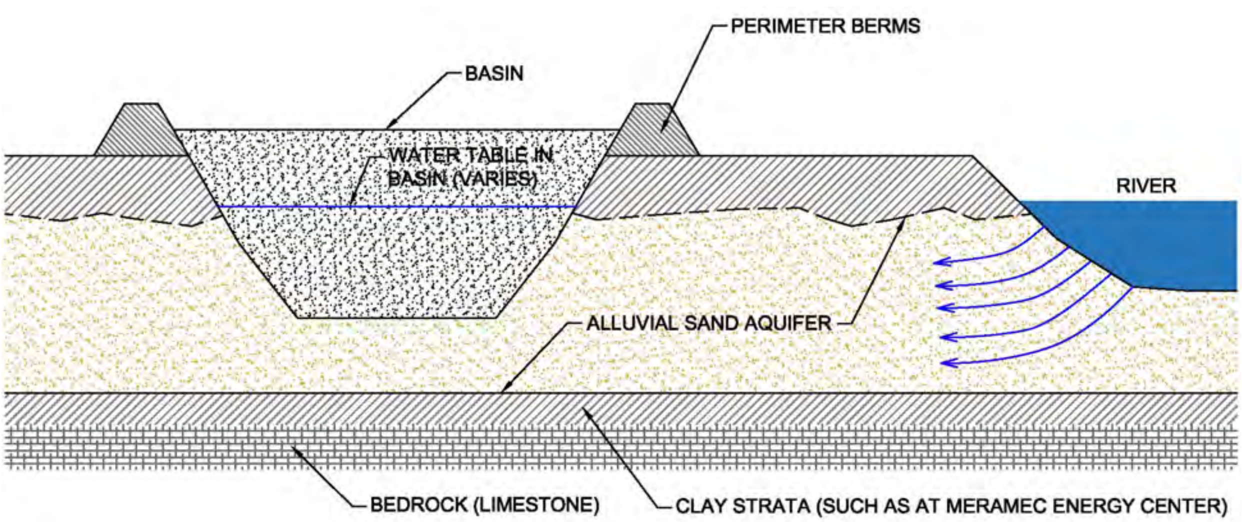


Figure 1 – Illustration of General Construction of CCR Basins (not to scale)

2. The size, depth and proximity to large rivers all impact the method of potential excavation. These basins are relatively large – up to 165 acres – compared to many CCR units at other power plants.

[1] At normal river levels, most of the CCR basins at the Meramec Energy Center are above the water table and are excluded from this description.

The basins are relatively deep – up to 100 feet. Some basins, such as at the Rush Island Energy Center, extend close to the underlying bedrock.

3. The removal process of the ponded CCR is more difficult than traditional soils and would require specialized equipment and management prior to transport to a landfill. The characteristics of the CCRs vary from plant to plant and also depend upon the nature of the CCR – fly ash, bottom ash, and other coal combustion byproducts. Fly ash tends to hold water and will not drain by gravity alone such as in a pile; it typically requires some mechanical grading or agitation. Bottom ash is more like sand and will drain more freely. In addition, CCRs are lighter in weight than soils and compressible. Near the surface of the basins CCRs are generally in a loose state due to their placement via sluicing. At greater depths within the basins, CCRs generally compress and become more dense due to settlement from the weight of the upper CCRs. CCRs become less permeable with increasing density, that is, limiting the volume and velocity of water that may move through the CCRs. Eventually, fly ash may become as impermeable as fine-grain soils.

The principal characteristics of the CCR basins listed above are the determining factors in the feasibility of excavation at Ameren's Energy Centers and could differ from that observed at other power plants which may have burned coal or built basins with different characteristics.

PRINCIPAL METHODS OF EXCAVATION

There are two principal methods of removal or excavation of the CCRs from the basins: 1) excavation in the "dry" by first pumping out the water (i.e. "dewatering") to some depth below the excavation; or 2) excavation in the "wet" by dredging, which is how the basins were excavated originally. The "dredge" may be a backhoe with an extended arm and bucket, a crane with a dragline bucket, or a crane with a clam-shell bucket. Another type of dredge is the suction dredge which pumps the material and water to a disposal site. Small suction dredges have been used in CCR basins at other power plants, but they are limited to about 20 to 30 feet deep. Because of the greater depths, removing CCRs from Ameren's basins would require a cutter-head dredge, such as pictured below.

Figure 2 – Illustration of Cutter-Head Suction Dredge

The cutter-head dredge is designed to break through and remove compacted or cemented CCRs and, due to the depths of Ameren's basins, would need to be specially manufactured. The dredge would pump approximately 14,000 gallons per minute and could remove up to about 650 cubic yards of CCR per hour.

EXCAVATION IN THE "DRY"

Complete removal of water from the CCR basin prior to excavation may not be practical or technically feasible using either deep wells or cutoff walls. The volume of water requiring handling would be tremendous because the basins are in a sand aquifer near a major river as illustrated in Figure 1.

To keep water from filling the excavation would require concentric rectangles or "rings" of deep wells installed at close spacings and completely encircling each basin, with each well pumping hundreds of gallons per minute. The use of a deep well system to dewater the basins creates a number of technical and environmental problems:

1. Space limitations around the basins could impede or preclude the installation of such a large system of concentric wells around each basin. Each concentric system of wells must be separated from the next system by 15 feet or more for equipment and maintenance. Also, a stable slope must be maintained in the sand between each system as the excavation progresses. Therefore, the outside limits of the wells and excavation would need to extend well beyond the existing limits of the basin. The basins are in close proximity to each plant and operational facilities, such as railroad tracks, tanks, and buildings.

2. The drawdown would pull CCR-impacted water from the basin; therefore, a tremendous volume of water would have to be managed and/or treated, requiring a large water treatment plant to be constructed on site[2].

3. Depending upon location, the drawdown of the groundwater table could potentially impact the surrounding environment, such as surrounding vegetation and crops, and potential settlement of the natural soils surrounding the basins. This could cause settlement of shallow foundations, roads, railroad tracks, adjacent river banks or levees, and utilities.

Therefore, in lieu of a concentric well system, a cutoff wall would need to be designed and constructed around each CCR basin to prevent the surrounding groundwater from flowing into the basin as it is pumped dry and excavated. For the Labadie Energy Center, the cutoff wall would have to be up to two (2) miles long and would extend to the bottom of the aquifer, up to 100 feet deep or deeper. Construction of the cutoff wall alone could take up to a year. The water removed during excavation of CCRs inside the cutoff wall would need to be treated.

Structural Stability: Cutoff Walls and Cofferdams

Slurry cutoffs, structural panel cutoffs or sheetpile walls alone would not be structurally adequate due to the tremendous hydrostatic pressure and lateral earth pressures that would occur on the outside of the cutoff wall as the interior CCRs are dewatered and excavated. Installation of deep wells around the outside of the

[2] Existing waste water treatment facilities are inadequate to manage the volume of water generated by a deep excavation project discussed here.

cutoff wall to reduce the hydrostatic pressure would create some of the same problems discussed above. A potential solution would be to install rows of tie-backs through the wall and into the underlying bedrock as the excavation progresses. This is illustrated in Figure 3 below:

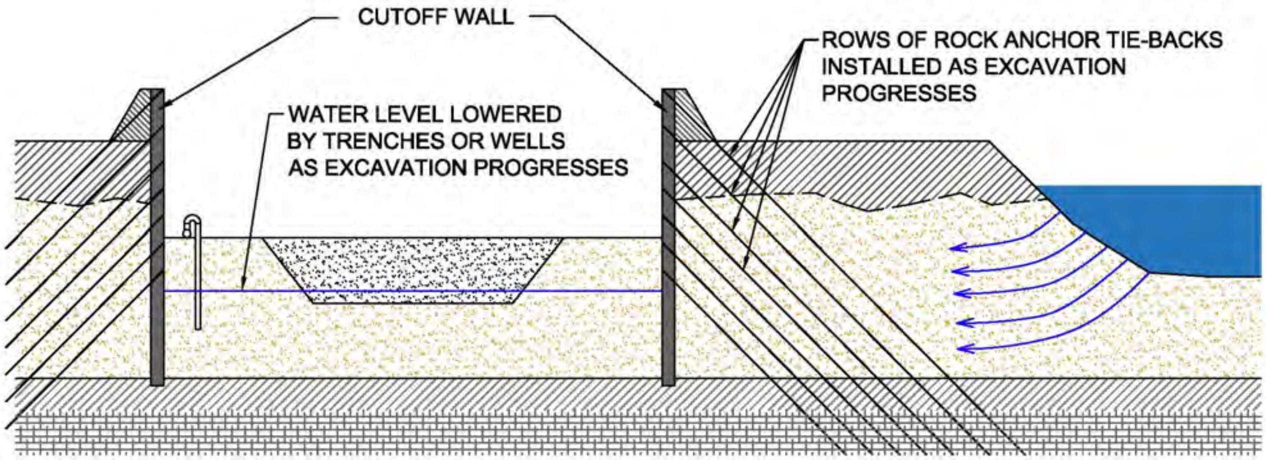


Figure 3 – Illustration of Cutoff Wall with Tie-Backs

There are several different methods of installing a structural concrete cutoff wall. One method is to excavate a deep trench, using a heavy mud slurry to keep the trench open in the sands. Reinforcing steel is then inserted into the trench, and the slurry is displaced by pumping concrete up from the bottom. An example is the structural concrete cutoff wall installed for the construction of the World Trade Center to hold back the water of the Hudson River.

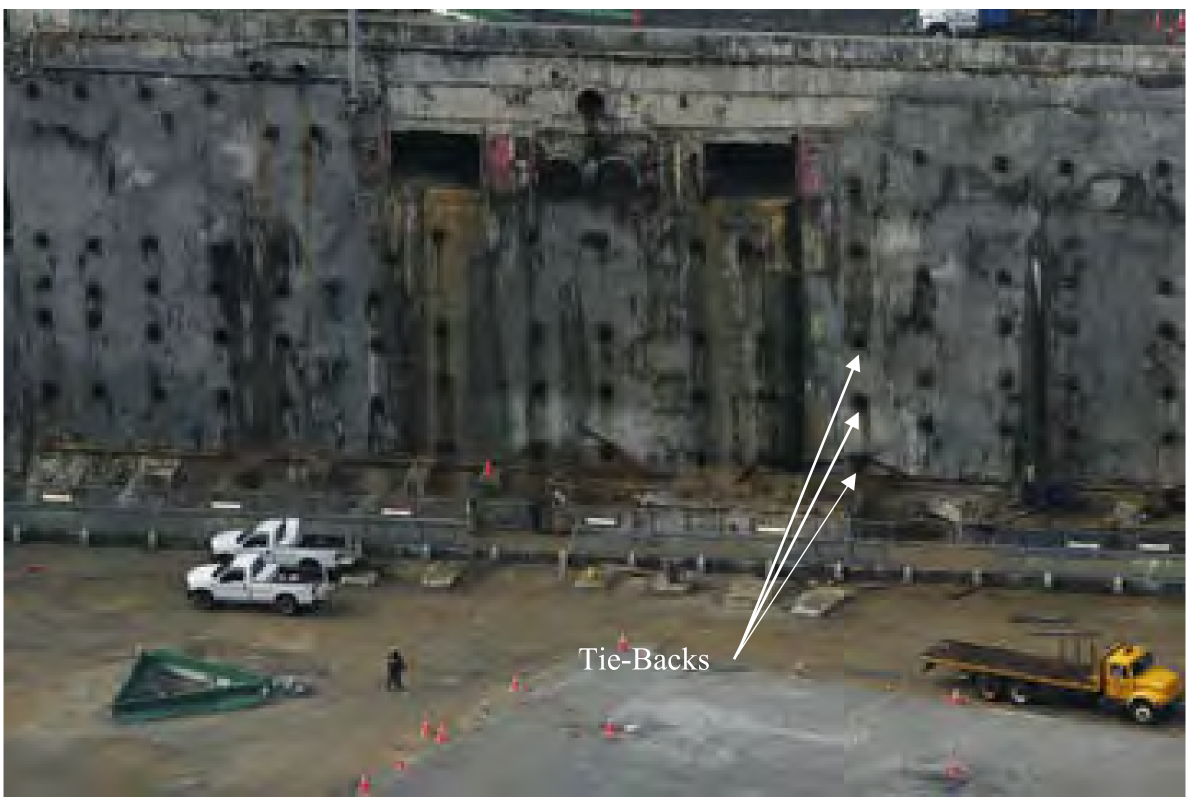


Figure 4 – Structural Concrete Cutoff Wall for the World Trade Center

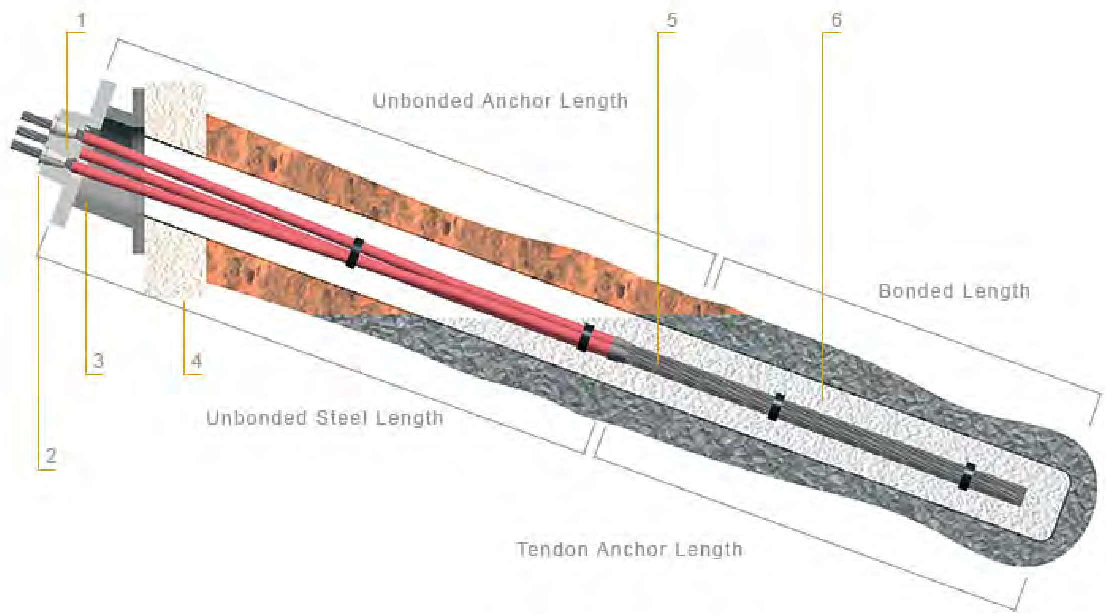


Figure 5 – Illustration of a Typical Rock Anchor Tie-Back

An illustration of a typical multi-stand rock anchor tie-back is shown in Figure 5. Tie-backs are installed by drilling in horizontal rows as the excavation progresses downward. Tie-backs ends can be seen in the photo of the cutoff wall in Figure 4. At some locations, the lengths of the upper tie-backs would need to be well over 100 feet to penetrate into the bedrock, such as at Labadie and Rush Island. The cost per tie-back could range from $10,000 to $40,000.

The construction of a structural concrete cutoff wall is problematic due to both the depths and the presence of large cobbles and boulders near the bedrock, such as at Labadie and Sioux Energy Centers. It is critical that the cutoff extend into the underlying clays where present, such as at Meramec, or into the bedrock, such as at Labadie and Rush Island. The cutoff has to be more than 90% sealed to have real effect at stopping the inflow of groundwater. Installation of hundreds to thousands of tie-backs as the excavation of the CCRs progresses would add years to the construction of the cutoff and the removal of the CCRs. The installation of the cutoff wall and tie-back rock anchors alone will add millions to tens of millions of dollars to the cost of removal of the CCRs by excavation in the dry.

Another type of cutoff sometimes used adjacent to a major river is a “cellular cofferdam.” This technique typically requires deep soil mixing, compaction grouting or drilled holes to make continuous lines of cylindrical columns to form a row of boxes or cells completely around each CCR basin. The width of the cells would have to be large to withstand the hydrostatic pressure and lateral earth pressures. This construction method requires a sufficient open area that may not exist at each energy center and is equally as expensive as a cutoff wall. The close proximity of the plant and appurtenances could be a limiting factor.

Treatment and Management of Water

As the excavation inside the cutoff walls progresses, water from the basin would need to be removed by temporary wells and trenches. This includes existing water and precipitation that falls over the years it would take to complete the project. The water would have to be evaluated to determine regulatory status before the pumped water could be discharged. Assuming such water exceeds regulatory standards, a water treatment plant would need to be constructed on site to handle the volume.

Summary

Since removal and treatment of sufficient volumes of water would be very problematic, extremely time consuming, and exceedingly costly, excavation of CCRs in the basins in the "dry" is not practically feasible.

EXCAVATION BY DREDGING

Excavation by dredging eliminates many issues associated with the removal of the water from an area of deep alluvial sands adjacent to a major river. There are, however, a number of technical challenges that remain with dredging. First, excavation by dredging is done blindly under water. Therefore, removal of CCRs from a basin with a bottom liner should not be done because there would be a very high probability that the bottom liner would be damaged, causing more environmental harm than if the basin were closed with the CCRs in place. Secondly, dredging with an open bucket – such as with a backhoe, dragline or clamshell – could result in suspension of contaminants and an increase in the hydraulic conductivity of the CCRs, resulting in an increase in release from the unlined basin. Because of these limitations, the only viable method is a suction dredge. As stated above, a cutter-head dredge would be necessary for the deep basins.

A suction dredge discharges a slurry of water and CCRs from the basin. The volume is tremendous – on the order of 14,000 gallons per minute for a large cutter-head dredge. Due to the volume, and to allow the CCRs to settle out, the slurry would be piped into one or more lined settling ponds constructed on site. The settling ponds would need to be located adjacent to the CCR basin so that the decanted water could flow by gravity or pumped back into the CCR basin. Excess water, such as from precipitation, would have to be tested and evaluated to determine the treatment that would be required before the water could be discharged. However, at all of the energy centers, space immediately adjacent to the basins is limited. Accordingly, settling basins would need to be located away from the CCR basins complicating ongoing excavation activities with delays inherent to the pumping and settling process.

The dredged material would need to be excavated and dried sufficiently to allow overland hauling to a commercial landfill. This double-handling and drying processes requires substantially more space and time, as well as cost, to complete. We estimate that it would take 10 years or more of a continuous dredging operation to remove the CCRs from the largest of Ameren Missouri's CCR basins. This time estimate does not take into account permitting and construction of the settling ponds which would further delay the completion schedule. Delays for weather, equipment maintenance, double-handing, drying, and transporting the CCRs to a landfill have the potential to further increase project duration.

Stability of Interior Slopes

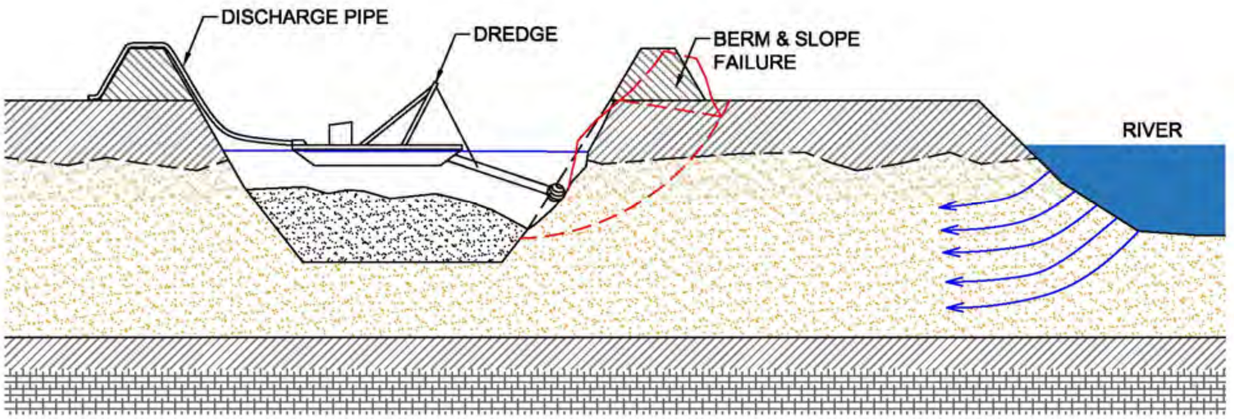


Figure 6 – Illustration of Problems with Stability of Interior Slopes

During an excavation project, the interior slopes of the basins have the potential to become unstable as illustrated in Figure 6. Instability is particularly problematic during a flood when water would be pushing on the perimeter berms. The basins were originally excavated by dredging, and the interior slopes were stable at that time. However, over time perimeter berms were constructed around the basins, in some cases after the deposition of the CCRs, to increase capacities and to protect against flooding. As excavation occurs, the interior slopes would become unstable unless the berms were removed. Removing the perimeter berms increases the risk that the basins would become flooded at high river stages. To prevent environmental risk associated with a flooded and unsecured CCR basin, new perimeter berms would need to be constructed far enough from the edge of the basin to prevent a slope failure and an uncontrolled release of CCR. Sufficient room may not exist at all energy centers to construct new temporary perimeter berms.

To ensure that all of the CCRs are removed, it is inevitable that some excavation will penetrate below the original bottom of the excavated basin and below the original interior side slopes. This would also cause instability of the interior side slopes. A failure of the perimeter of the partially-excavated basin has the potential to result in an uncontrolled release of CCR, particularly on the side adjacent to the river. An unstable slope would also be a major safety hazard for the construction and possibly for the adjacent energy center and operations. To mitigate such risks, temporary retaining walls with tie-backs may need to be constructed.

Completion of Project

Following completion of the excavation, the water remaining in each basin would have to be evaluated for compliance with regulatory water quality standards (GWPS) and some remedial clean-up activities would probably be required for each of the settling basins. After the water in each basin meets the required regulatory standards, the hole could be filled. Dredged sand from the adjacent river would likely be used for fill material because the excavation would contain water.

TECHNICAL MEMORANDUM

TO: AMEREN MISSOURI

FROM: XDD ENVIRONMENTAL, GOLDER ASSOCIATES INC.

SUBJECT: BEHAVIOR OF METALS IN SOIL AND GROUNDWATER

DATE: JULY 9, 2019

CC: SCHIFF HARDIN LLP

Metals are found naturally at varying concentrations in the minerals that make up our soil. As groundwater comes in contact with the soil, some metals leach from the soil, into the groundwater. The metals cannot be destroyed, but by changing environmental conditions of the soil and groundwater, the leaching (dissolution) can be reduced through the formation of more stable minerals or by being bound more strongly to other minerals.

Two major factors that affect the dissolved concentrations of metals in are the pH and the oxidation-reduction potential (ORP) of the water. pH is a measure of the acidic or alkaline nature of the water; strongly acidic water has a low pH (e.g., less than 4), while strong alkaline water has a pH typically greater than 10. ORP is a measurement of the tendency of a substance to oxidize or reduce another substance. Highly oxygenated water typically has a high ORP (greater than +200 millivolts), and highly reduced groundwater typically has an ORP less than 200 millivolts. The pH and ORP of the groundwater strongly influence the form of the metal present and the associated dissolution of the metals into groundwater.

Many metals increase in dissolved concentration when the groundwater is more acidic or more alkaline, because the minerals in the soils can dissolve under these conditions and the metals are released. Similarly, extremes in the ORP can also cause increases in dissolved metals due to the impact on the minerals. By optimizing pH and/or ORP levels, minerals within the groundwater and surrounding soils stabilize thereby reducing the dissolved concentrations of metals and creating more stable minerals that resist leaching / dissolution of the metals.

Groundwater conditions at Rush Island provide a useful illustration of this process. Upgradient of the ash basins, pH ranges from 6.0 to 8.5 in the shallow and deep groundwater zones to the north and west of the CCR unit (RCPA). On the downgradient side of the RCPA (eastern side), where pH is neutral, there are limited concentrations above the arsenic GWPS. However, as shown in Figures 1 and 2, on the downgradient side of the RCPA where the pH is higher than normal neutral conditions, arsenic concentrations are also present at elevated concentrations.

By optimizing natural processes, as one would do with a swimming pool, such as adjusting the pH level within the intermediate zone, a stabilization zone is created, and concentration levels are predicted to drop. Installation of an engineered cap system with a nearly impermeable geomembrane will effectively eliminate precipitation infiltration through the ash, which is a driving force behind the physical process that causes metal impacts to groundwater.

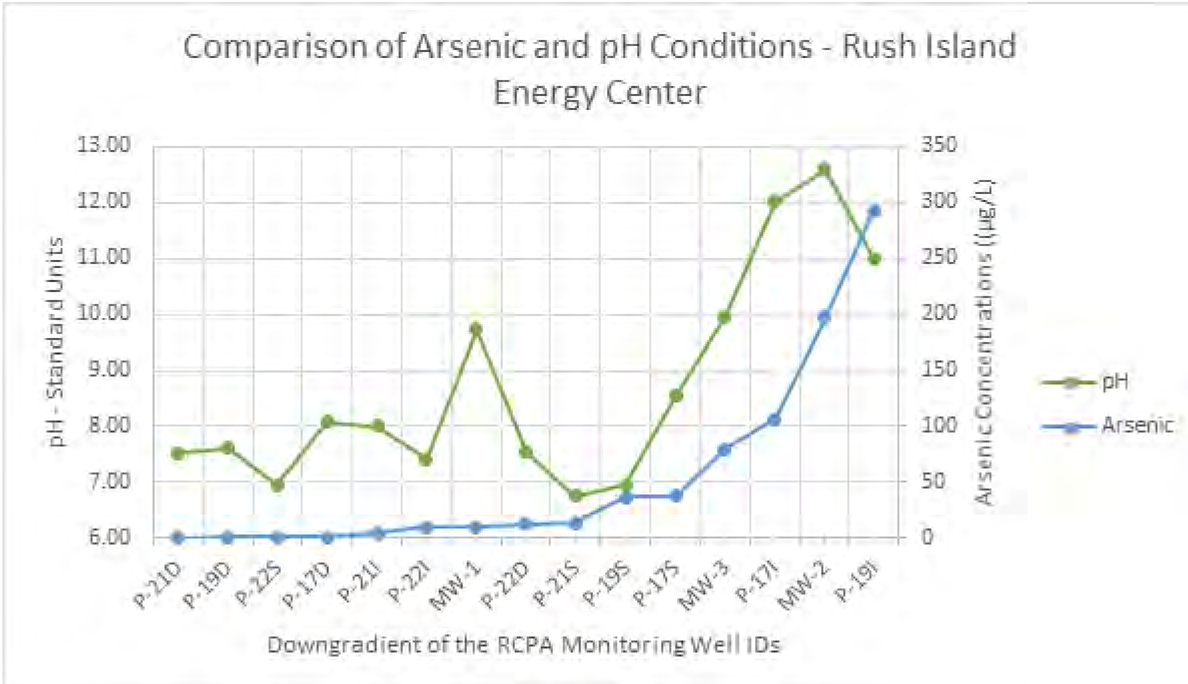
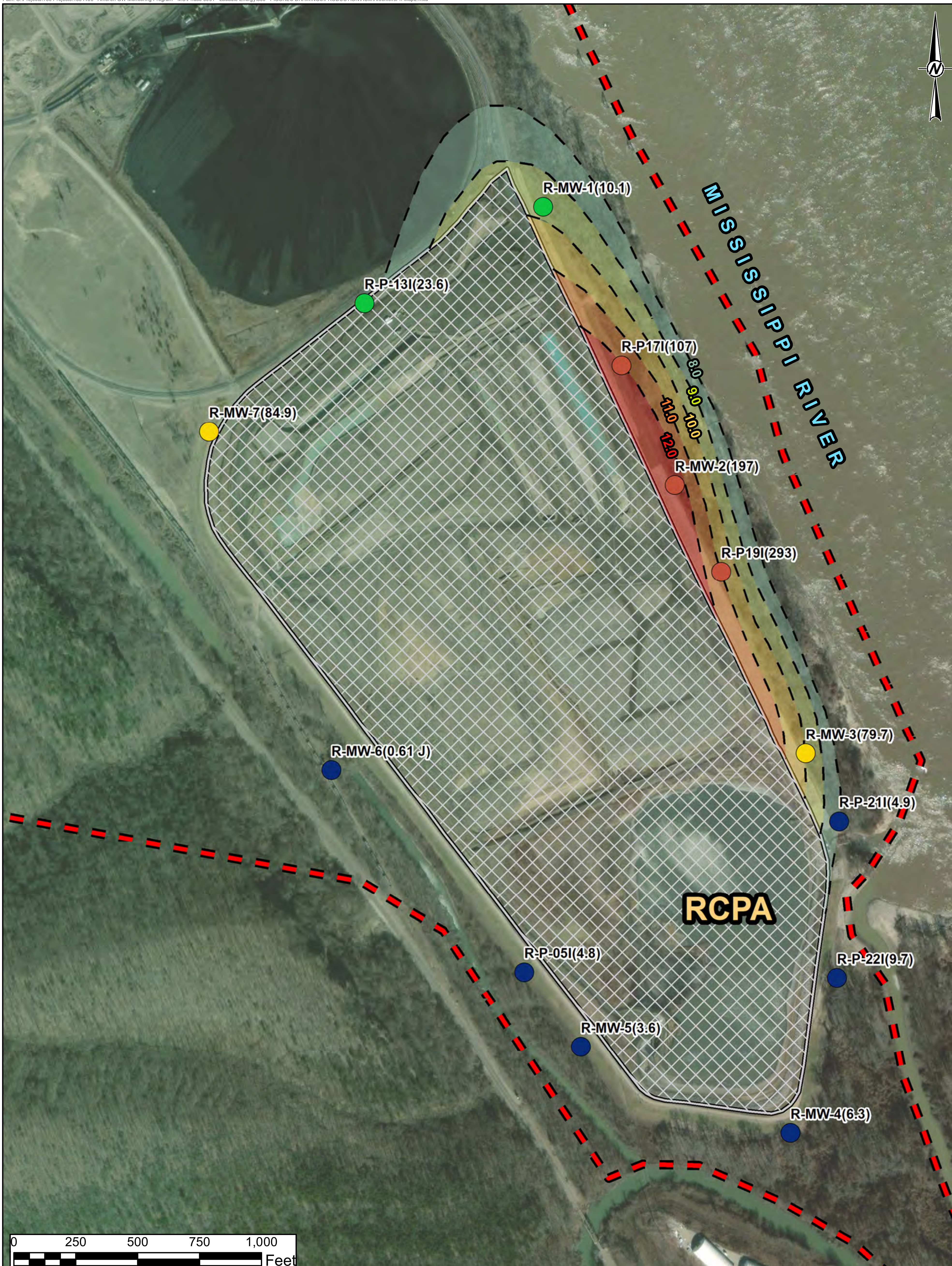


Figure 1 - Comparison of Arsenic and pH Conditions - Rush Island Energy Center

Path: G:\Projects\150 Projects\1531406 - Ameren GW Monitoring Program - MO\Phase 0001 - Labadie Energy\800 - FIGURES-DRAWINGS\PRODUCTION\ACM\ArsenicvsPh Map2.mxd



LEGEND

Rush Island Energy Center Property Boundary

RCPA Surface Impoundment

November 2018 Arsenic Concentrations (µg/L)

- Greater than 100 µg/L (Above Site GWPS)
- Greater than 30 µg/L (Above Site GWPS)
- Greater than 10 µg/L (Above MCL, Below GWPS)
- Less than 10 µg/L (Below MCL)

pH concentration Zones (Standard Units)

- pH values less than 8.0 are not colored
- pH between 8.0 - 9.0
- pH between 9.0 - 10.0
- pH between 10.0 - 11.0
- pH between 11.0 - 12.0
- pH above 12.0

NOTES

1. ALL LOCATIONS AND BOUNDARIES ARE APPROXIMATE.
2. J - ESTIMATED CONCENTRATION ABOVE THE ADJUSTED METHOD DETECTION LIMIT AND BELOW THE ADJUSTED REPORTING LIMIT.
3. GWPS - GROUND WATER PROTECTION STANDARD (SITE SPECIFIC).

REFERENCE

1. AMEREN MISSOURI RUSH ISLAND ENERGY CENTER, RUSH ISLAND PROPERTY CONTROL MAP, JANUARY 2012.

CLIENT
AMEREN MISSOURI
RUSH ISLAND ENERGY CENTER

Ameren

PROJECT
GROUNDWATER MONITORING PROGRAM

TITLE
NOVEMBER 2018 ARSENIC VS PH CONCENTRATION MAP
INTERMEDIATE ZONE OF THE ALLUVIAL AQUIFER

CONSULTANT

GOLDER

YYYY-MM-DD	2019-07-02
PREPARED	JSI
DESIGN	JSI
REVIEW	EMS
APPROVED	MNH

PROJECT No.	PHASE	FIGURE
153-140601	0002	2

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

Rush Island Closure by Removal Groundwater Modeling

June 27, 2019

AGENDA

Objective of Modeling 01

Construction/Assumptions of the Model 02

Modeling Results 03

Objective of the Model

RUSH ISLAND ENERGY CENTER

This modeling effort compared the estimated time to achieve groundwater concentrations below the Groundwater Protection Standard (GWPS) at monitoring wells around the RCPA. Modeling included updating the previous model(s) to simulate the effects of Closure by Removal (CBR) on the groundwater quality around the RCPA. These results were then compared with Closure in Place (CIP) to compare how long it would take to achieve GWPS at compliance wells in both scenarios.

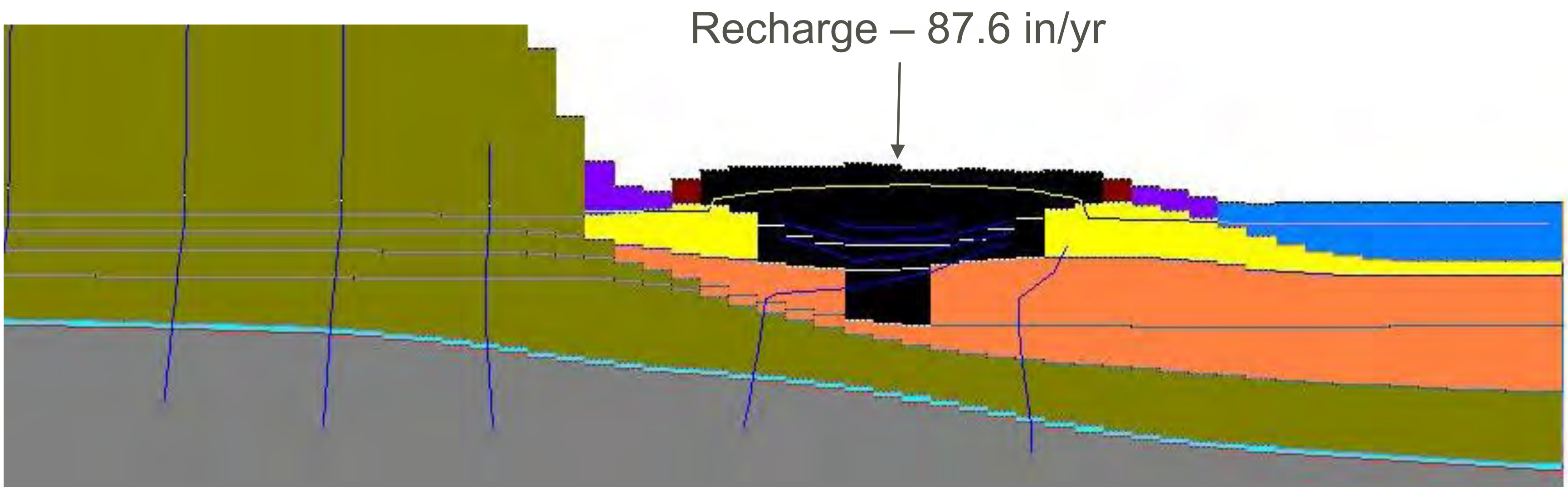
Closure by Removal Modeling - Phases

Rush Island Energy Center

Phase 1 – Active Conditions	Active conditions were modeled the same way as previously reported. Assumed constant slurry recharge to the RCPA
Phase 2 – Dry CCR Removal	Removal of the top portion of the RCPA that would be above the static groundwater level after dewatering to static conditions.
Phase 3 – Wet CCR Removal	Removal of deeper portions of the RCPA were the CCRs are fully submerged.
Phase 4 – All CCR Removed and Backfilled	Modeling conditions after all CCR has been removed from the RCPA. Assumes fluvial sands/silts from the Mississippi River are to be used as backfill.

Phase – 1 Active Conditions

RUSH ISLAND ENERGY CENTER

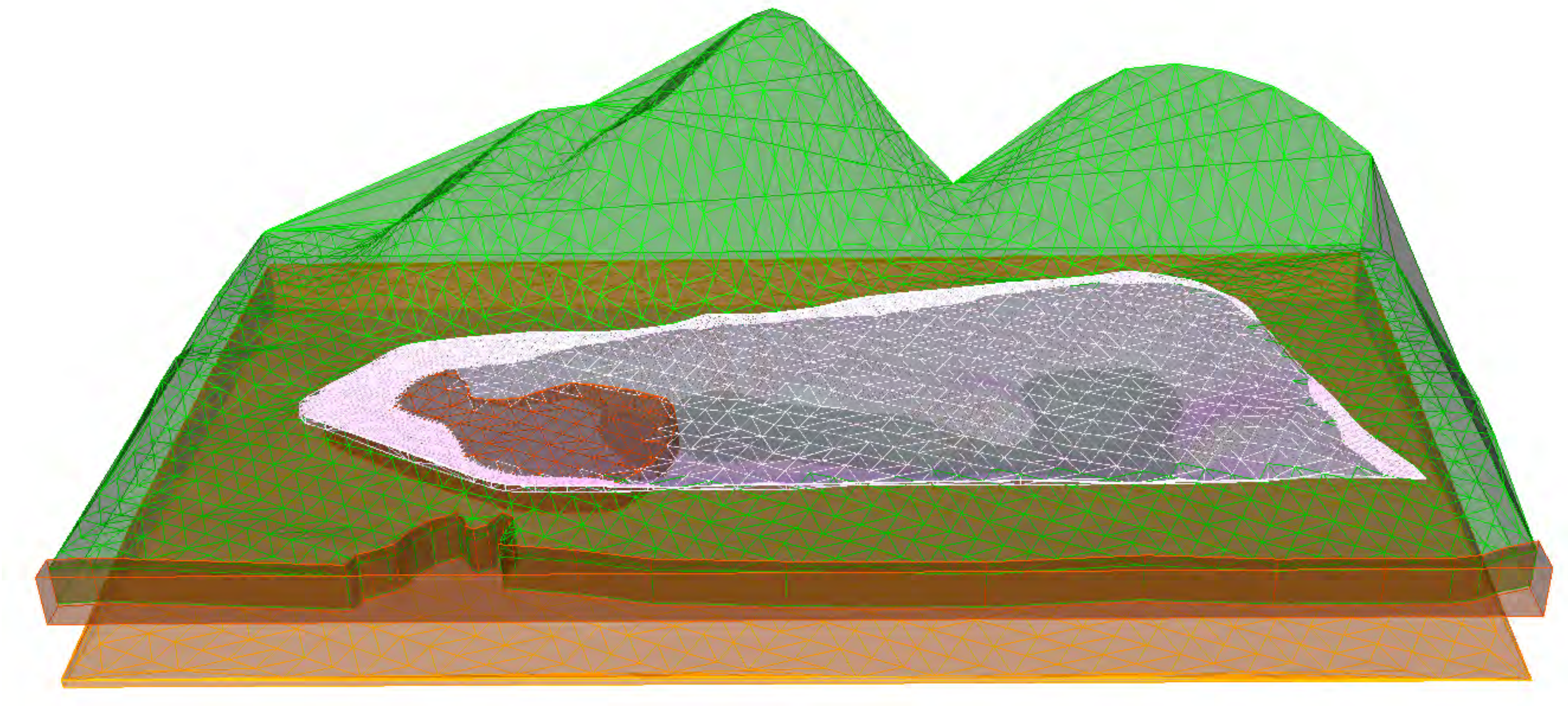


Active Conditions Assumptions

1. Same model(s) used as described in previous modeling report.
2. Recharge into RCPA 87.6 inches per year (i.e. Active Conditions).
3. Results in predicted mound in RCPA as measured in present conditions.

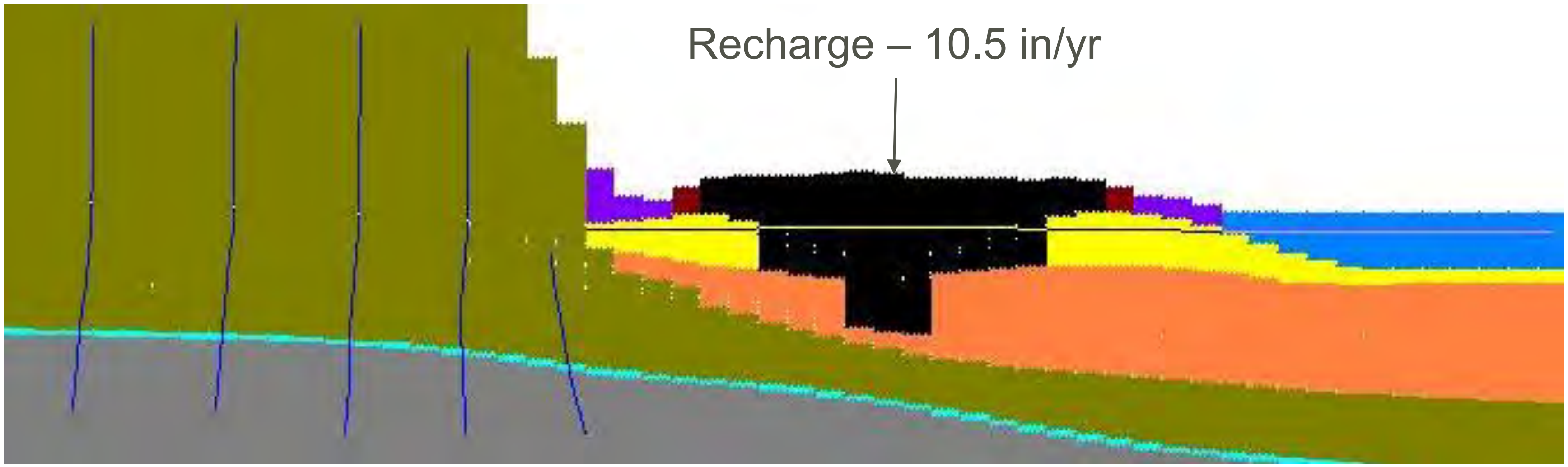
Phase 1 – 3D Model Design

RUSH ISLAND ENERGY CENTER



Phase 2 – Dry CCR Removal

RUSH ISLAND ENERGY CENTER

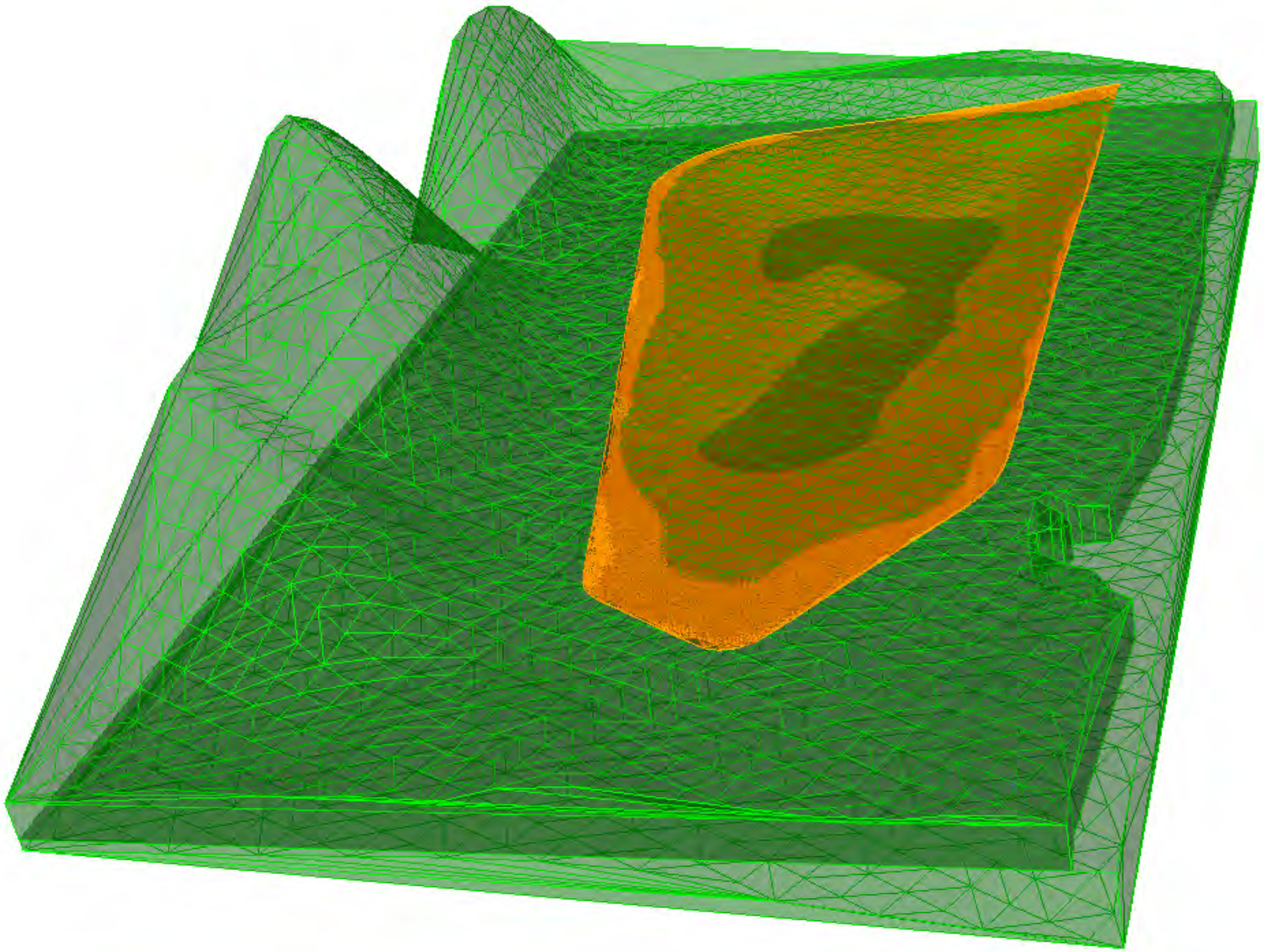


Dry CCR Removal Assumptions

1) Based on volume of CCR, it will take 16 years to excavate down the top 28 feet (dry excavation and partially wet excavation, based on lochmuller (2019) report).
2) Recharge into the pond will be less than active conditions, but higher than cap and closed conditions. The vertical conductivity (Kz) of the ash is estimated to be 1×10^{-5} cm/sec, so for a conservative approach, the value calculated in the help model for a 1×10^{-5} cm/s cap was used for recharge (10.5 in/yr) during this stage. This recharge rate causes a small mound in the RCPA of ~1-3 feet during this phase.
3) Removed polishing pond from southern portion of the RCPA.

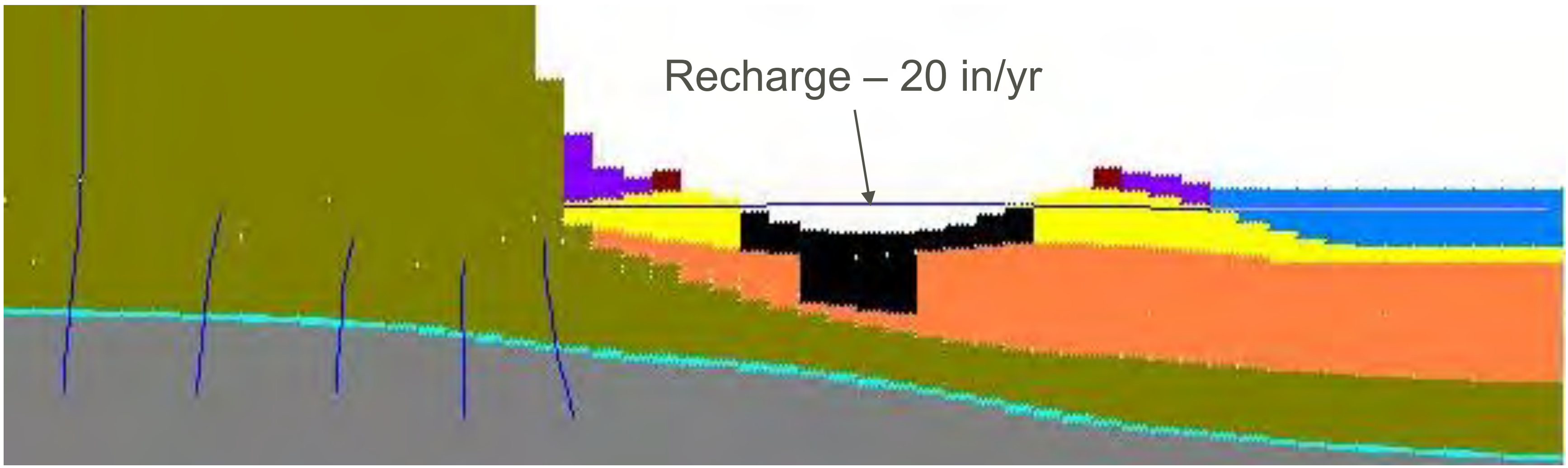
Phase 2 – Model Design

RUSH ISLAND ENERGY CENTER



Phase 3 – Wet CCR Removal

RUSH ISLAND ENERGY CENTER



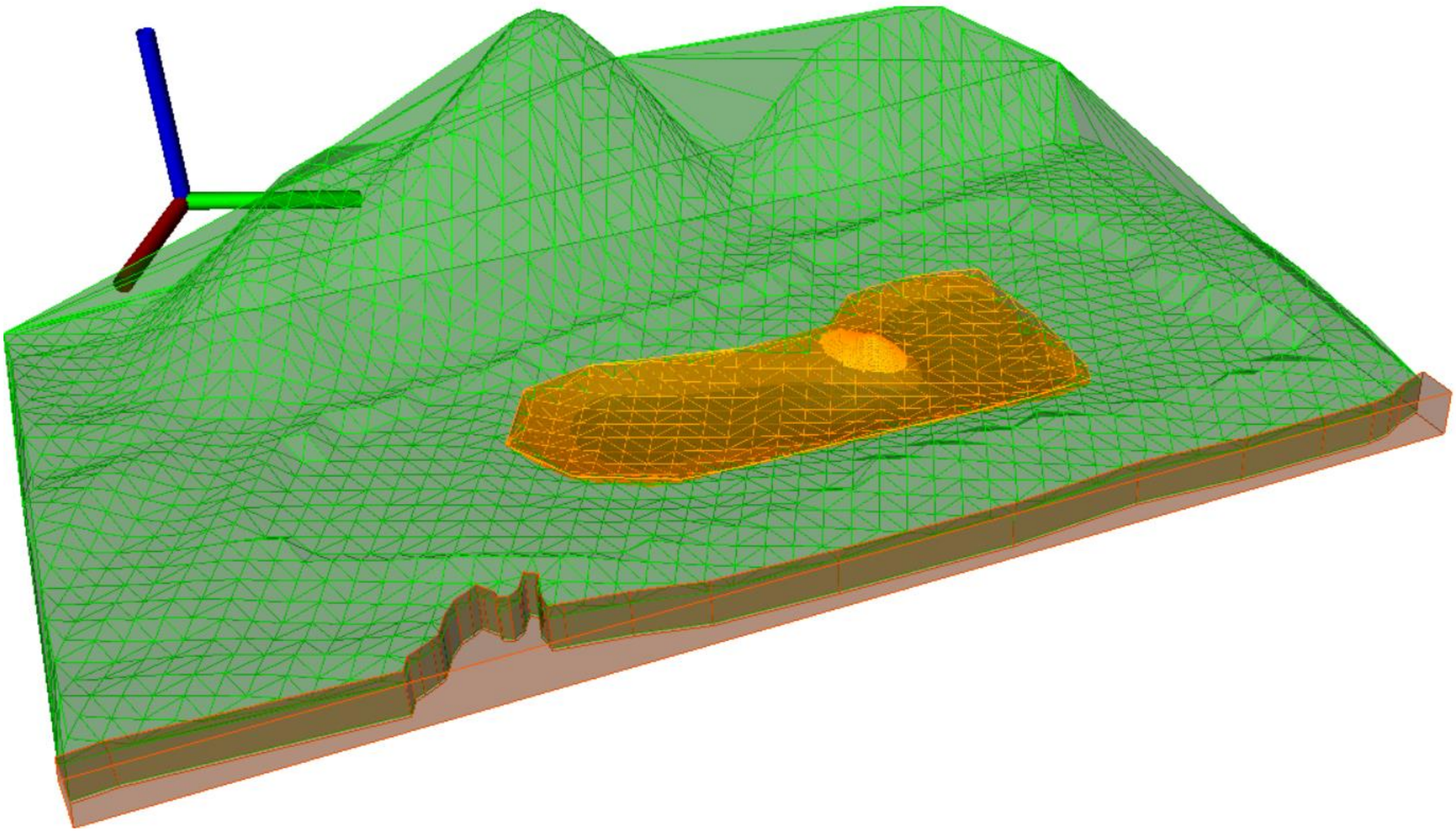
Wet CCR Removal Assumptions

1) Removed the upper portion of the CCR and treated resulting pit as an open hole.

2) Recharge was higher than the dry excavation stage, but less than the active conditions. It was assumed that there would be 43 in/year of rainfall (U.S. Climate Data, Festus). It was also assumed that the RCPA would evaporate similar to a lake, which according to U.S. Department of Commerce report, *Evaporation From Pans and Lakes*, a lake in Missouri can have ~23 inches a year in evaporation. Therefore, net annual recharge is expected to be ~20 inches/year. The rest of the water used for hydraulic dredging is assumed to be in a “closed” loop, and water used to pump the CCR out of the pond will be directed back to the RCPA after the materials are extracted.

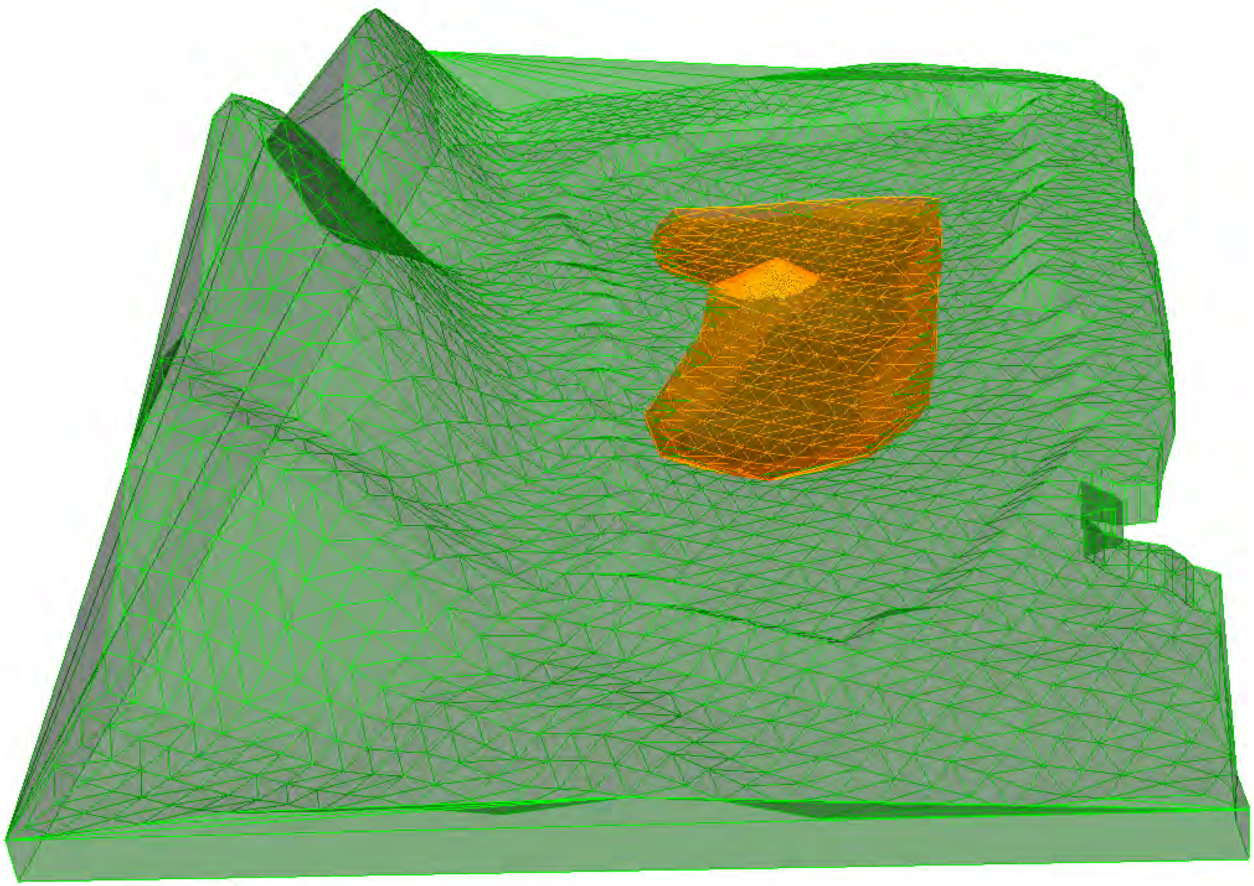
Phase 3 – Wet CCR Removal

RUSH ISLAND ENERGY CENTER



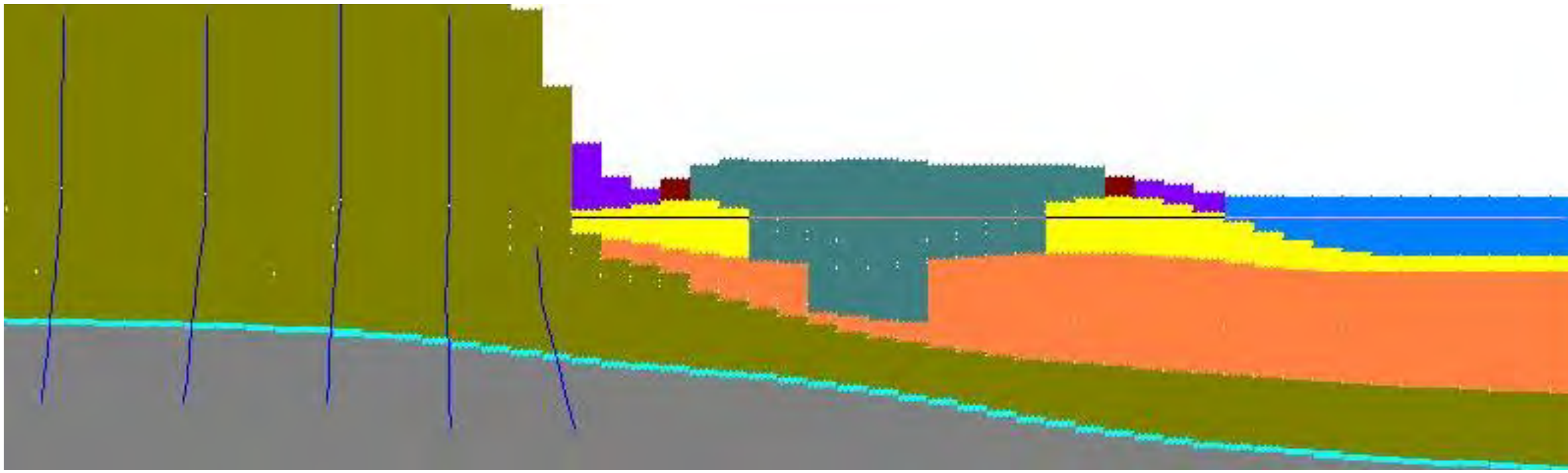
Phase 3 – Wet CCR Removal

RUSH ISLAND ENERGY CENTER



Phase 4 – Backfilled RCPA

RUSH ISLAND ENERGY CENTER



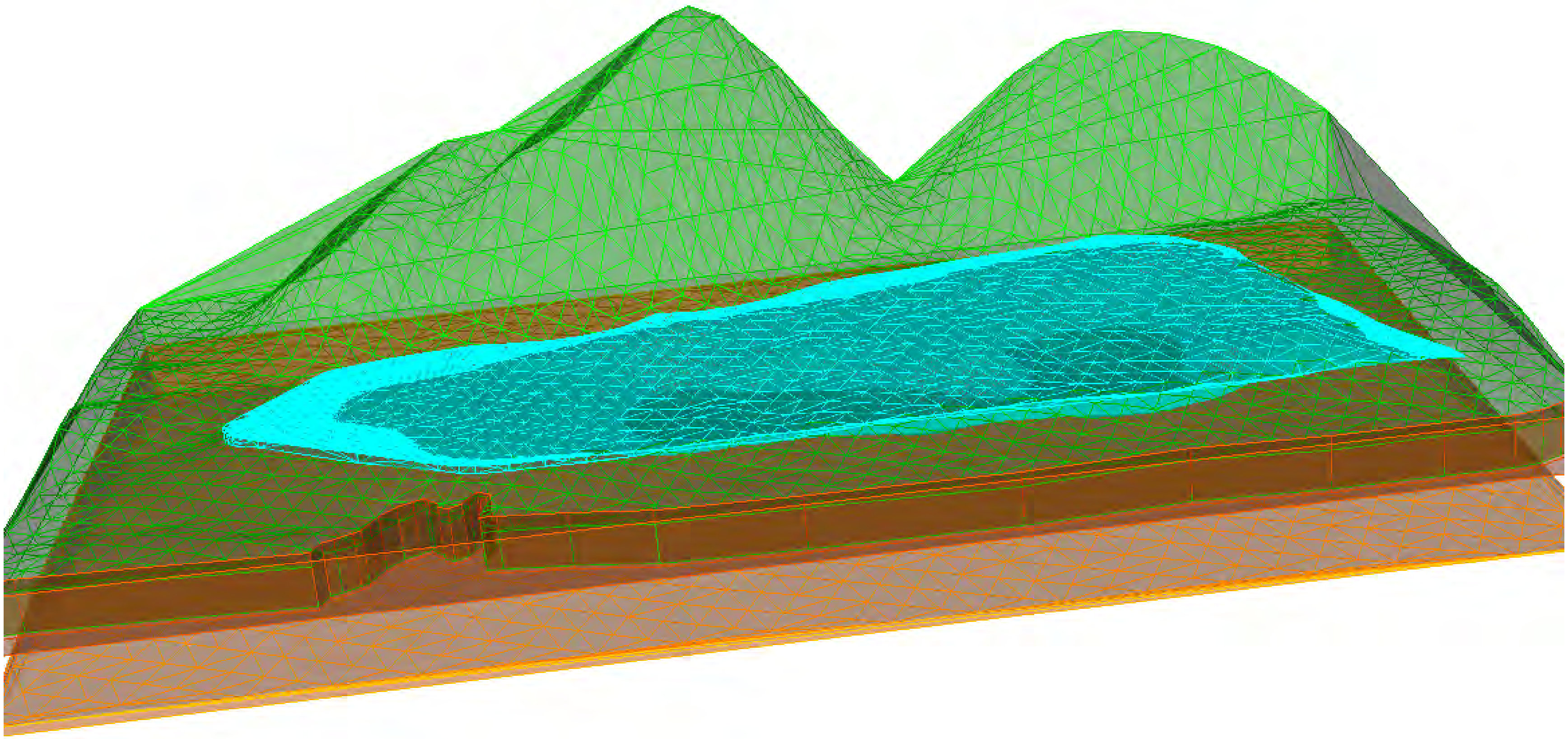
Backfilled RCPA Assumptions

1) Entire former RCPA backfilled with materials similar to the shallow alluvium onsite from dredging the Mississippi River (Lochmueller 2019). Material assumed to have a conductivity of 2.1×10^{-3} cm/sec (6 feet/day).

2) Recharge into the backfilled area was set equal to that estimated for the surrounding alluvial aquifer.

Phase 4 – Backfilled RCPA

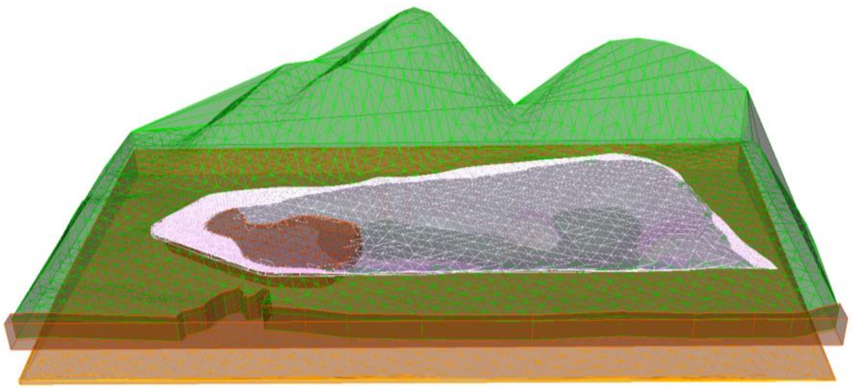
RUSH ISLAND ENERGY CENTER



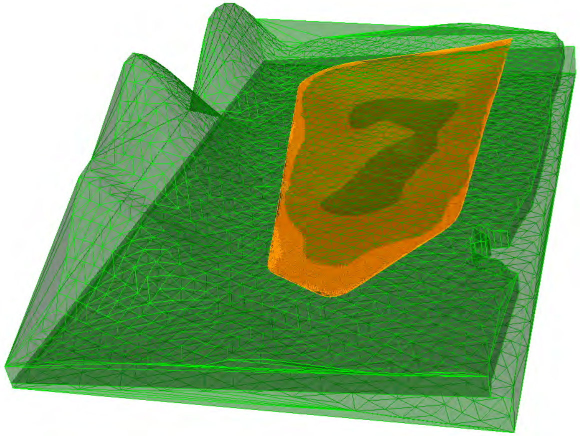
Phases of the Model

RUSH ISLAND ENERGY CENTER

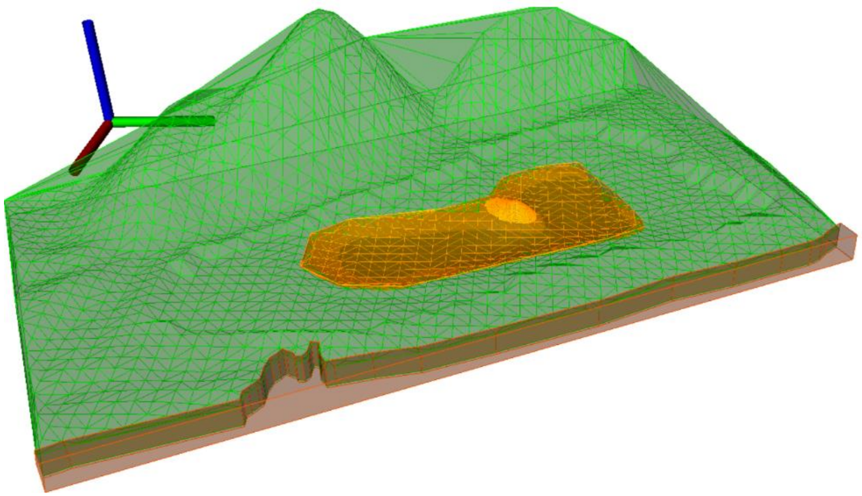
Phase 1 - Active



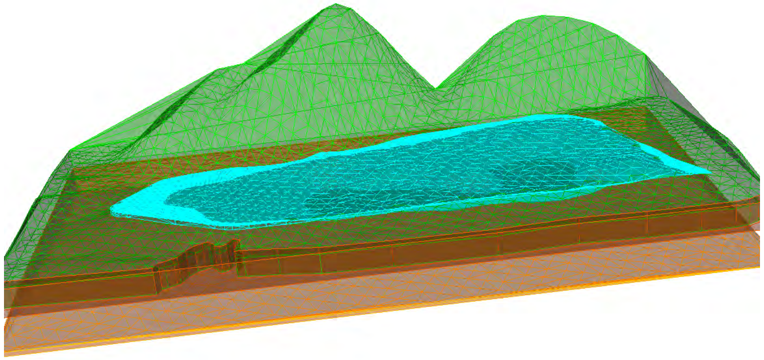
Phase 2 – Dry Removal



Phase 3 – Wet Removal

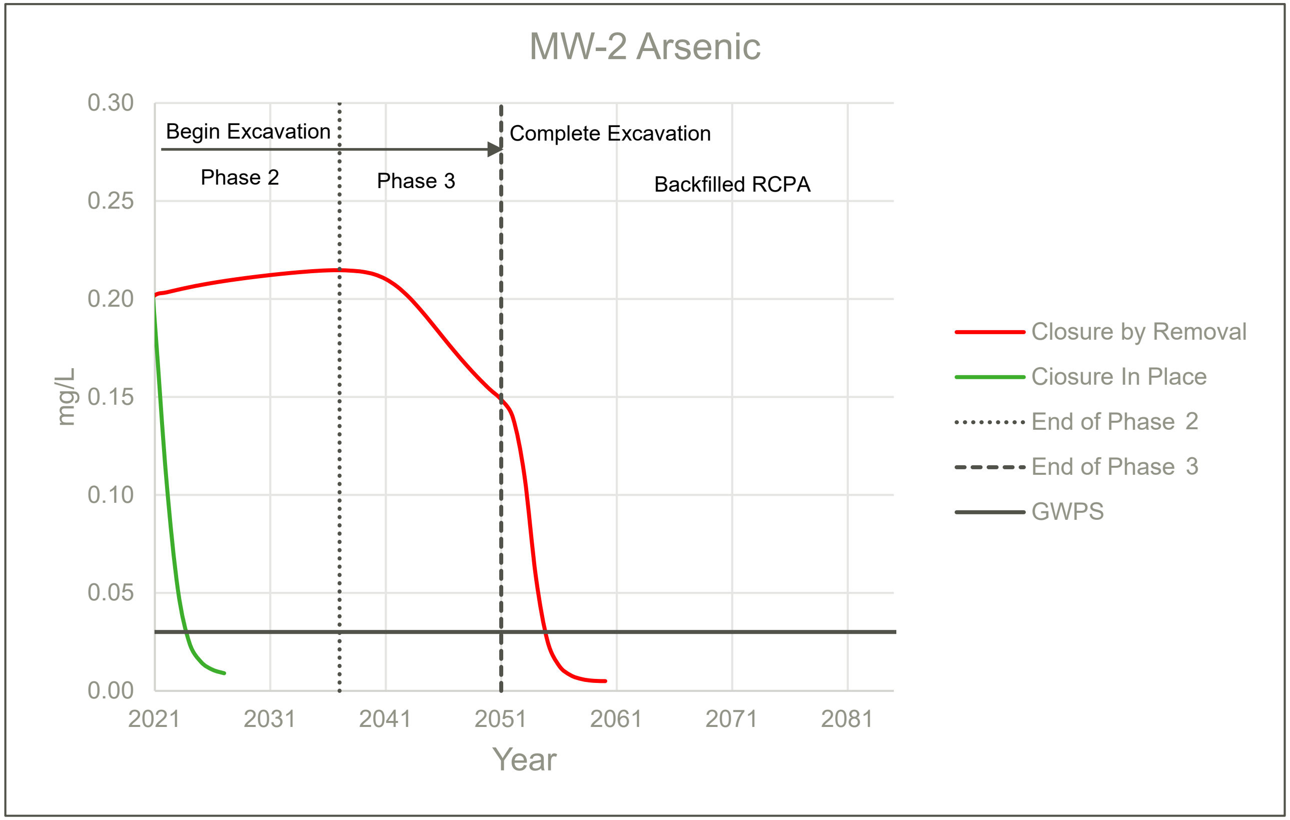


Phase 4 – Backfilled



Modeling Results Indicate Excavation Delays Groundwater Compliance

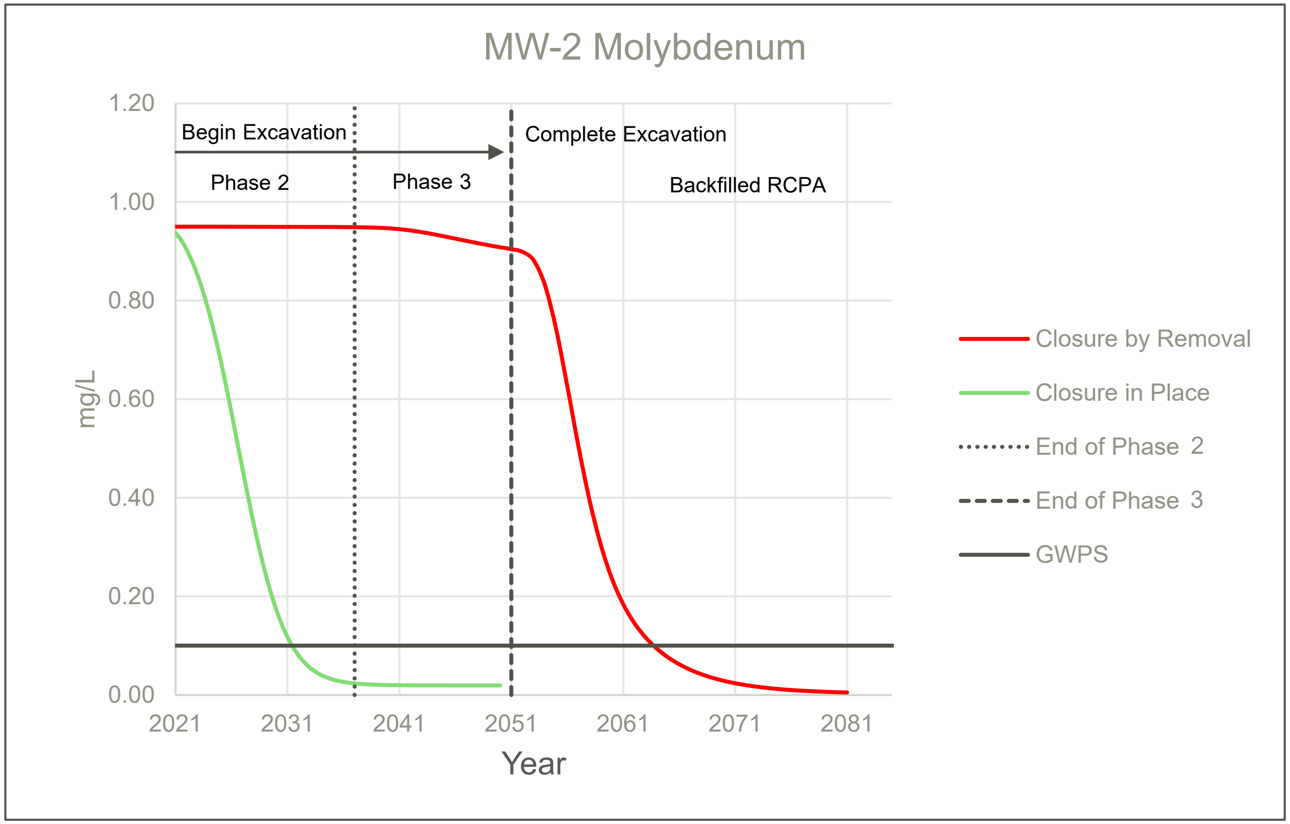
RUSH ISLAND ENERGY CENTER



MW-2 (highest arsenic value in CCR Rule Well) is estimated to reach the GWPS 30 years sooner using closure in place vs closure by removal (Excavation)

Modeling Results Indicate Excavation Delays Groundwater Compliance

RUSH ISLAND ENERGY CENTER



MW-2 is estimated to reach the GWPS 31 years sooner using closure in place vs closure by removal (Excavation)

Information on the closure by removal process is available in the Lochmueller (2019) and the Reitz & Jens (2019) reports

Explanation of Results

RUSH ISLAND ENERGY CENTER

Closure in Place reduces downgradient concentrations faster than Closure by Removal because:

- The 31-year time for CBR ash removal, during which rainfall drives outward migration of CCR impacts, adds contaminant loading and delays groundwater cleanup

APPENDIX B
2019 Remedy Selection Report

August 30, 2019

REMEDY SELECTION REPORT - 40 CFR § 257.97
RUSH ISLAND, LABADIE, SIOUX AND MERAMEC CCR BASINS

In May 2019, Ameren Missouri completed Corrective Measures Assessment (CMA) Reports for certain coal ash (CCR) basins located at the Rush Island, Labadie, Meramec, and Sioux energy centers. For each site, the CMAs considered a series of alternatives, all of which are protective of human health and the environment, control source material, minimize the potential for further releases and, over time, will attain site-specific groundwater protection standards. After sharing the CMAs publicly, Ameren Missouri solicited public input. In addition to the CMAs, Ameren Missouri and its consultants performed numerous technical evaluations, all of which help to inform the Company's remedy selection. Those evaluations include groundwater modeling; human health and ecological risk assessments; groundwater treatment assessments; onsite and offsite monitoring data; rail, barge and truck transportation studies; and a deep excavation study report.[1] The technical assessments, data and public input inform the evaluation of selection factors that has led to this final remedy selection.

Set forth below is a summary of Ameren Missouri's remedial plan that, when fully implemented and completed, will achieve CCR Rule requirements. As previously announced, Ameren Missouri intends to expeditiously close CCR basins at its energy centers by completing necessary steps to remove the basins from service and then installing an engineered cap system that exceeds, by more than two orders of magnitude, the federal regulatory requirements and, as modeling indicates, will minimize the limited and localized impact to groundwater observed at the CCR basins. In time, the sites will attain site-specific groundwater protection standards. As conditions stabilize after cover system installation, groundwater evaluations and monitoring will continue, and, as necessary, be modified. Ameren Missouri intends to implement the following corrective action measures in conjunction with the closure of CCR basins.

CORRECTIVE MEASURES REMEDIAL PLAN

CMA Reports Alternative 1: Source Control Through Installation of Low Permeable Cover System & Monitored Natural Attenuation

1. Source control, stabilization and containment of CCR by installation of a low-permeability geomembrane cap (a minimum 1 x 10 -7 centimeters per second (cm/sec) versus 1 x 10 -5 cm/sec required by the CCR Rule).

2. Once source control is achieved, monitor the natural attenuation (MNA) of groundwater concentrations to address limited and localized CCR-related impacts. Ongoing monitoring and modeling evaluations will document that concentrations are

[1] Technical assessments are appended to the CMA reports and/or to Ameren Missouri's Response to Public Concerns and all have been posted to Ameren's CCR website.

decreasing as modeled. MNA occurs due to naturally occurring processes within the aquifer.

3. Annual Groundwater *Monitoring and Corrective Action Reports* for each site will address the following:

    - Demonstrate that groundwater plume(s) are stable or decreasing and not expanding;

    - Contain an ongoing summary of baseline and periodic geochemical analysis including groundwater chemistry, subsurface soils chemical composition and mineralogy;

    - Determine site-specific attenuation factors and rate of attenuation process; and

    - Design a long-term performance monitoring program based on the specific attenuation mechanism to confirm concentration reductions and document trends.

The installation of a low-permeability, geomembrane cap system satisfies both the CCR Rule's basin closure requirements and can constitute an appropriate remedial corrective measure for groundwater impacts, as recently confirmed by the Missouri Department of Natural Resources (MDNR). A properly engineered and installed cap will practically eliminate the infiltration of water into the stored ash material. As summarized in the CMA reports, concentrations will reduce once the cap system stops recharge into the ash and groundwater conditions, such as pH levels, stabilize. Ameren Missouri will establish a long-term performance monitoring plan in accordance with the CCR Rule to document and confirm such reductions. MNA encompasses a variety of physical and chemical processes (biodegradation, sorption, dilution, chemical reactions and evaporation), which, under the right conditions, can immobilize metals in aquifer sediments. In addition to capping as a remedial corrective measure, both EPA and MDNR recognize MNA as a corrective action component for addressing inorganics (metals) in groundwater. *EPA Directive 9283.1-36 (2015); Section 644.143 RSMo (1999).* As MDNR notes, MNA is not a "no action" alternative and is complementary to source control measures. *(See Fact Sheet: MNA of Groundwater at Brownfields/Voluntary Cleanup Program Sites.)*

IMPLEMENTATION OF REMEDY

Under its current schedule, Ameren Missouri will close more than 67% (428 acres) of its CCR units by the end of 2020, with the remaining 33% by December 2023. Installation of a geomembrane cap at the energy centers will practically eliminate infiltration. Site preparation activities are underway at Rush Island and Labadie, with construction of the cap/cover systems occurring over the next 12 -18 months. Closure of additional basins at Meramec will occur in 2020 and 2021, with closure of remaining basins following the retirement of the energy center in 2023. At Sioux, use of the ash basins will terminate once wastewater and dry ash handling facilities are completed in 2020. Set forth below are key milestones in the implementation of Ameren's remedial plans. Such schedule is subject to revision based upon each energy center's construction schedule, ongoing field investigations and, if needed, regulatory approvals.

Facility	Ash Basin Removed from Service	Ash Basin Cap System Completed	Performance Review: Groundwater & Cap System
Rush Island	04/2019	12/2020	Annual - Commencing 2021
Labadie	09/2019	12/2020	Annual - Commencing 2021
Sioux	12/2020	2021	Annual - Commencing 2023
Meramec	12/2022	2023	Annual - Commencing 2024

SUPPLEMENTAL CORRECTIVE MEASURES

In its laboratories, XDD, Ameren Missouri's environmental consultant, reproduced existing (i.e. pre-closure) groundwater and soil conditions so as to evaluate potential treatment methods to accelerate existing natural attenuation processes. Under appropriate conditions, metals can attenuate through precipitation, co-precipitation and/or sorption processes with subsurface soil minerals. XDD is evaluating potential treatment methods such as the use of pH adjustment, zero valent iron (ZVI), and bio-augmentation.[2] Laboratory results for arsenic and molybdenum, the primary contaminants of concern (COC) at some of Ameren's energy centers, indicate that through the adjustment of pH levels in subsurface soils and groundwater, groundwater protection standards (GWPS) can be met for each site[3] and that the use of chemical reduction (ZVI) and bioremediation may be helpful in the reduction process for these and other compounds.

Set forth below is a summary chart reflecting results from ongoing treatment studies. Boron is included for evaluation purposes even though under the Federal CCR Rule it is not currently an Appendix IV parameter.

[2] Ameren Missouri and XDD have experience with the use of ZVI and bio-augmentation at its Huster Substation property, a groundwater remediation project supervised by USEPA and MDNR, (CERCLA-07-2017-0129). Using a drill rig, XDD injected a slurry comprised of water and ZVI into subsurface soils and groundwater forming a reactive barrier that successfully contained groundwater contaminants that had migrated from the substation. In addition, ongoing degradation of source contaminants continues to occur through a bio-augmentation process consisting of the injection of feedstock into the sands of the aquifer.

[3] The slow groundwater flow rate at the Sioux energy center has allowed for the concentration of molybdenum at levels higher than those observed at the other energy centers. Such conditions however may be particularly conducive to the use of ZVI or bioremediation.

SUMMARY OF LABORATORY TREATMENT STUDIES

	Arsenic	Molybdenum	Boron	Lithium	Attenuation Mechanism
	mg/L				
pH 10		R/M5/M6		M6	P,C
pH 9	R				P,C
pH 8	R	M6			P,C
pH 7	R				P,C
pH 6	R/M5*/M6*	R/M5/M6/L/S			P,C
CaSx	R	R/M5/M6/L	M6	M5	P,C
Dissolved Iron (Anaerobic)	R	L			P,C
Dissolved Iron (Aerobic)	R	L			P,C
ZVI Injectable	R	R/M5/M6/L/S	L/S R/M5/M6	M5/M6	P,C
ZVI PRB	R	R/M5/M6/L	R/M5/M6	M5/M6	P,C
ZVI Injectable + Bio	R	R/M5/M6/L/S	R/M5/M6	M5/M6	P,C
ZVI Injectable pH 8 + Bio	R	R/L	R		P,C
ZVI PRB + Bio	R	M5/M6/L/S	S	M5/M6 L/S	P,C
ZVI PRB pH 8 + Bio	R	R/L	R	M6 L/S	P,C

Notes: -

No Effect

Reduce

Increase

Attains Standard

Non-Detect

L = Labadie

S = Sioux

R = Rush Island

M5/M6 =Meramec monitoring wells

PRB = permeable reactive barrier

Injectable = iron particles at micro-scale; potentially applied through injection

Dissolved iron = 50 mg/L Iron(II) sulfate

CaSx = calcium polysulfide

P = Precipitation

C = Co-precipitation

* = arsenic was not detected in M5/M6 baseline despite being detected during quarterly sampling at M5. Results indicate arsenic would likely be removed under pH 6 conditions.

Additional pilot studies are needed to confirm that laboratory results can be replicated and appropriately scaled under field conditions. Assuming such confirmation, corrective action Measures may also include groundwater treatment to facilitate reductions. Field demonstrations and groundwater treatment applications could require a state-issued permit pursuant to *10 CSR 20-6.010*. Remedial actions are iterative in nature and Ameren Missouri (as part of the long-term performance monitoring program) will periodically evaluate then-existing groundwater conditions relative to GWPS and determine whether additional treatment measures are warranted.

APPENDIX C
Closure Completion Documentation for the MEC CCR Surface Impoundments

Meramec Energy Center
Notification of Intent to Close a CCR Unit
and Certification for Final Cover System Design

In accordance with 40 CFR §257.102(g), this is notification of Ameren Missouri's (the Owner) intent to close CCR surface impoundment MCPA (Pond 492) at their Meramec Energy Center. This closure will be performed in accordance with 40 CFR §257.102(d) by leaving CCR in place.

CERTIFICATION:

As a Professional Engineer in the state of Missouri, I hereby certify that to the best of my knowledge, information, and belief, the final cover system design for surface impoundment MCPA (Pond 492) at Ameren Missouri's Meramec Energy Center meets the final cover system requirements of 40 CFR §257.102(d)(3).

Signature:

Name: Eric J. Karch

Date: 25 October 2022

Missouri License Number: 2007005040

Expiration Date: December 31, 2022

Meramec Energy Center
CCR Surface Impoundment MCPA
(Pond 492)
CCR Unit Closure Plan

Meramec Energy Center CCR Surface Impoundment MCPA (Pond 492) CCR Unit Closure Plan

Prepared for

Ameren Missouri
Project No. 90683
Ameren, Missouri

Revision 1
November 2016

Prepared by

Burns & McDonnell Engineering Company, Inc.
Kansas City, Missouri

INDEX AND CERTIFICATION

Ameren Missouri
Meramec Energy Center
CCR Surface Impoundment MCPA (Pond 492)
CCR Unit Closure Plan

Report Index

Certification

I hereby certify, as a Professional Engineer in the state of Missouri, that the information in this document was assembled under my direct personal charge. This report is not intended or represented to be suitable for reuse by Ameren Missouri or others without specific verification or adaptation by the Engineer. I certify that this Closure Plan and the Final Cover System specified herein satisfy the requirements presented in 40 CFR §257.102(b).

Scott A. Martin, P.E.
License Number 2010019572
License renewal date: December 31, 2016.

Pages or sheets covered by this seal: As noted above

TABLE OF CONTENTS

Page No.

LIST OF FIGURES

Page No.

LIST OF ABBREVIATIONS

Abbreviation	Term/Phrase/Name
Ameren	Ameren Missouri
BMcD	Burns & McDonnell
CCR	Coal Combustion Residual
CCR Rule	EPA Coal Combustion Rule Published April 17, 2015
CFR	Code of Federal Regulations
Cm/sec	Centimeters per second
CQA	Construction Quality Assurance
CY	Cubic yard
EPA	Environmental Protection Agency
EPDM	Ethylene propylene diene monomer
HDPE	High-density polyethylene
HELP	Hydrologic Evaluation of Landfill Performance
LLDPE	Low-density polyethylene
MCPA	CCR Surface Impoundment MCPA or Pond 492
Meramec	Meramec Energy Center

1.0 INTRODUCTION

On April 17, 2015, the Environmental Protection Agency (EPA) issued the federal Coal Combustion Residual Rule (CCR Rule) to regulate the disposal of coal combustion residual (CCR) materials generated by electric utilities and independent power producers.

Ameren Missouri (Ameren) is subject to the CCR Rule and is required to develop a Closure Plan for existing CCR surface impoundments per 40 Code of Federal Regulations (CFR) §257.102. This document serves as Ameren's Closure Plan for the existing CCR Surface Impoundment MCPA (Pond 492) at the Meramec Energy Center (Meramec). The Closure Plan is required to contain the following, as required in §257.102(b)(1):

- A description of how the CCR Unit will be closed.
  - For in-place closure: A description of the final cover system, methods for installing final cover system, and methods for achieving compliance with the standards outlined in §257.102(d).
- An estimate of the maximum inventory of CCR material ever stored in the CCR Unit over its active life.
- An estimate of the largest area requiring a final cover as required by §257.102(d) at any time during the active life of the CCR Unit.
- A schedule for completing CCR Unit closure activities, including the anticipated year of closure and major milestones for permitting and construction activities.

2.0 CLOSURE PLAN

2.1 Facility and Surface Impoundment Description

Meramec is located in southeastern St. Louis County, Missouri and consists of four generating units (a site aerial figure is included as Appendix A). Units 1 and 2 are fired on natural gas (fuel switching from coal to natural gas was completed in April 2016), and Units 3 and 4 are fired on coal. CCR generated at the facility includes fly ash and bottom ash.

Surface Impoundment MCPA (Pond 492), referred to herein as MCPA, is located on the northeast side of the Meramec facility. As-built construction documents are not available to document that a liner system was installed; therefore, MCPA has been classified as an existing, unlined CCR surface impoundment.

2.1.1 CCR Inventory and Extent

MCPA has an approximate surface area of 7 acres, as measured within the perimeter dikes, which represents the largest area that would require a final cover. The estimated maximum inventory of CCR in MCPA over its active life is approximately 187,000 cubic yards (CY) of CCR material. Ameren periodically removes CCR from MCPA for beneficial use (primarily used for cement kiln raw feed).

2.2 Closure Method

The CCR Rule allows for CCR Units to be closed through removal of CCR or by leaving CCR material in-place. MCPA is planned to be closed with CCR material in-place, and accordingly, will follow the closure performance standards referenced in 40 CFR §257.102(d). If the design or use changes in the future, this Closure Plan will be updated accordingly (see Section 3.0).

2.2.1 Drainage / Stabilization of CCR Material

Prior to installing the final cover system, Ameren will perform the following activities outlined in §257.102(d) of the CCR Rule:

- Eliminate free liquids by removing liquid wastes or solidifying the remaining wastes and waste residues.
- Stabilize remaining wastes sufficiently in order to support the final cover system.

Free liquids will be removed, with excess water discharged under the current NPDES Permit. Free liquid removal will be performed throughout construction, as necessary, to manage surface water and storm water runoff. Once stabilized, the CCR will be compacted and graded to promote drainage.

2.2.2 Final Cover System

The final cover system will be designed and constructed to meet the following criteria pursuant to §257.102(d)(3)(i):

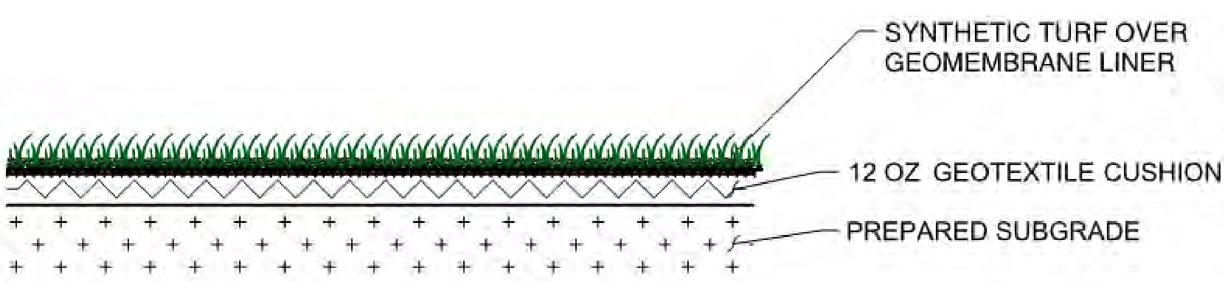
- Have a permeability less than or equal to the permeability of any bottom liner system or natural subsoils present, or a permeability no greater than $1x10^{-5}$ centimeters per second (cm/sec), whichever is less.
- The infiltration of liquids through the closed CCR Unit must be minimized by the use of an infiltration layer that contains a minimum of 18 inches of earthen material.
- The erosion of the final cover system must be minimized by the use of an erosion layer that contains a minimum of six inches of earthen material that is capable of sustaining native plant growth.
- The disruption of the integrity of the final cover system must be minimized through a design that accommodates settling and subsidence.
- The owner or operator may select an alternative final cover system design, provided the alternative final cover system meets the above requirements.

MCPA will be capped and closed in-place as described herein, and in accordance with the requirements of the CCR Rule. MCPA will be closed using an alternative cover system, which will consist of (from bottom to top):

- Geotextile cushion (to protect the overlying geomembrane),
- 40-mil (minimum) linear low-density polyethylene (LLDPE), high-density polyethylene (HDPE), or ethylene propylene diene monomer (EPDM) geomembrane,
- Synthetic turf.

A typical cross section of this alternative cover system is shown in Figure 2-1.

Figure 2-1: Final Cover System



A construction quality assurance (CQA) plan will be compiled prior to the commencement of construction, and the CQA program will be implemented during construction of the cover system.

2.2.2.1 Permeability and Infiltration

The federal minimum standard requires MCPA's cover system permeability to be less than or equal to that of the bottom liner, natural underlying subsoils, or $1x10^{-5}$ cm/sec, whichever is less. As discussed above, MCPA construction documents are not available. MCPA was reportedly constructed by excavating soils within MCPA (silts and clays), and the excavated materials were utilized for pond berms. Site specific permeability information of the pond base and/or natural subsoils is not available at this time.

The proposed cover system will feature a geomembrane component which has a permeability of 2.0×10^{-12} cm/sec, which represents the maximum permeability value of the potential geomembrane material types planned to be utilized for closure[1]. The alternative final cover system uses a geomembrane component to achieve the minimum permeability requirements of the CCR Rule, rather than relying on the permeability of an 18-inch of infiltration layer.

2.2.2.2 Geometry and Stormwater Management

The geometry and stormwater management controls of MCPA following closure will allow the CCR Unit to meet the following requirements as outlined in §257.102(d) of the CCR Rule:

- Control, minimize, or eliminate, to the maximum extent feasible, post-closure infiltration of liquids into the waste and releases of CCR, leachate, or contaminated run-off to the ground or surface waters or to the atmosphere.
- Prevent future impoundment of water.
- Provide for slope stability to protect against sloughing or movement of the final cover system.

The closure system will be designed to provide adequate drainage during storm events. Intermediate swales will be utilized to limit the maximum overland flow distance, thereby minimizing ponded water, as well as limiting the infiltration of run-off.

2.2.2.3 Integrity of the Final Cover

Settling and subsidence of the final cover system is expected to be minimal. Settlement would potentially be caused by consolidation of the CCR material, general fill material, or underlying natural subsoils due

[1] Per the Hydrologic Evaluation of Landfill Performance (HELP) Model User's Guide for Version 3 - EPA/600/R-94/168a.

to the dynamic loads typically resulting from construction activities; consequently, this settlement is expected to be minimal following final cover installation activities. General fill will be installed in a controlled manner to minimize post-fill installation settlement. Maintenance will be conducted as necessary to maintain the integrity of the final cover, as outlined in the Post-Closure Plan for MCPA (separate document).

2.2.3 Final Cover Schedule

According to §257.101 of the CCR Rule, closure of the MCPA will commence no later than six months following the date on which a closure event is triggered. For the purposes of this Plan, closure of MCPA is assumed to have commenced when Ameren has ceased placing CCR material into MCPA and has completed any of the following actions or activities:

- Taken any steps necessary to implement the written Closure Plan.
- Submitted a completed application for any required state or agency permit or permit modification.
- Taken any steps necessary to comply with any state or other agency standards that are a prerequisite, or are otherwise applicable, to initiating or completing the closure of a CCR Unit.

In the event that closure of MCPA is required due to a location restriction or groundwater impacts, but not a safety factor assessment, the CCR unit may continue to receive CCR material beyond the six-month maximum duration, provided that MCPA satisfies the criteria specified in §257.103(a) or §257.103(b).

No later than the date Ameren initiates closure of MCPA, a Notification of Intent to Close the CCR Unit will be prepared. The notification is considered completed when it has been placed in the facility's CCR Operating Record. The notification will then be posted on Ameren's CCR public website within 30 days.

2.2.3.1 Closure Completion

Closure for MCPA shall be completed within five years of commencing closure activities per the CCR Rule. The timeframe for completing closure of the CCR Unit may be extended if Ameren demonstrates that it is not feasible to complete closure of the CCR Unit within the required timeframe due to factors beyond the facility's control. A demonstration for an extension of the closure timeframe shall be completed pursuant to §257.102(f)(2).

For the purpose of this Closure Plan, closure of MCPA is considered complete when the final cover system is installed and applicable construction completion documentation is finalized. Based on the closure schedule provided in Appendix B, it is estimated that the closure of MCPA will be completed in less than five years. The estimated closure year is 2026.

Within 30 days of completion of closure of MCPA, Ameren will prepare a notification of closure and post it on the facility's CCR Operating Record and on Ameren's CCR public website. This notification shall include certification by a qualified professional engineer, registered in the State of Missouri, verifying that closure has been completed in accordance with this Closure Plan and the requirements of §257.102.

Following closure, Ameren will record a notation on the deed of the Meramec property, and within 30 days of the deed notation, Ameren will prepare a notification stating that the notation has been recorded per §257.102(i) and place within facility's CCR Operating Record.

In accordance with §257.102(i), Ameren will record a notation on the deed to the property, following completion of closure. This notation is inform any potential future owner of the property of the previous use of the land, and that the land is restricted by post-closure care requirements.

3.0 REVISIONS AND AMENDMENTS

The MCPA Closure Plan will be amended whenever there is a change in operation of the CCR unit that affects the current or planned closure operations. The Closure Plan will be amended 60 days prior to a planned change in operation, or within 60 days following an unplanned change in operation. If a written Closure Plan is revised after closure activities have commenced, the written Closure Plan will be amended no later than 30 days following the triggering event. The initial Closure Plan and any amendment will be certified by a qualified professional engineer in the State of Missouri for meeting the requirements of §257.102 of the CCR Rule. All amendments and revisions will be posted on the CCR public website within 30 days following placement in the facility's CCR Operating Record. A record of revisions made to this document is included in Section 4.0 of this document.

4.0 RECORD OF REVISIONS AND UPDATES

Revision Number	Date	Revisions Made	By Whom
0	10/13/2016	Initial Closure Plan	Burns & McDonnell
1	11/14/2016	Revisions to cover page to use Ameren's standard cover page, and Section 2.2.3.1 to include estimated year of MCPA closure	Burns & McDonnell

APPENDIX A – SITE AERIAL FIGURE

NORTH

0 150' 300'
SCALE IN FEET

BURNS McDONNELL

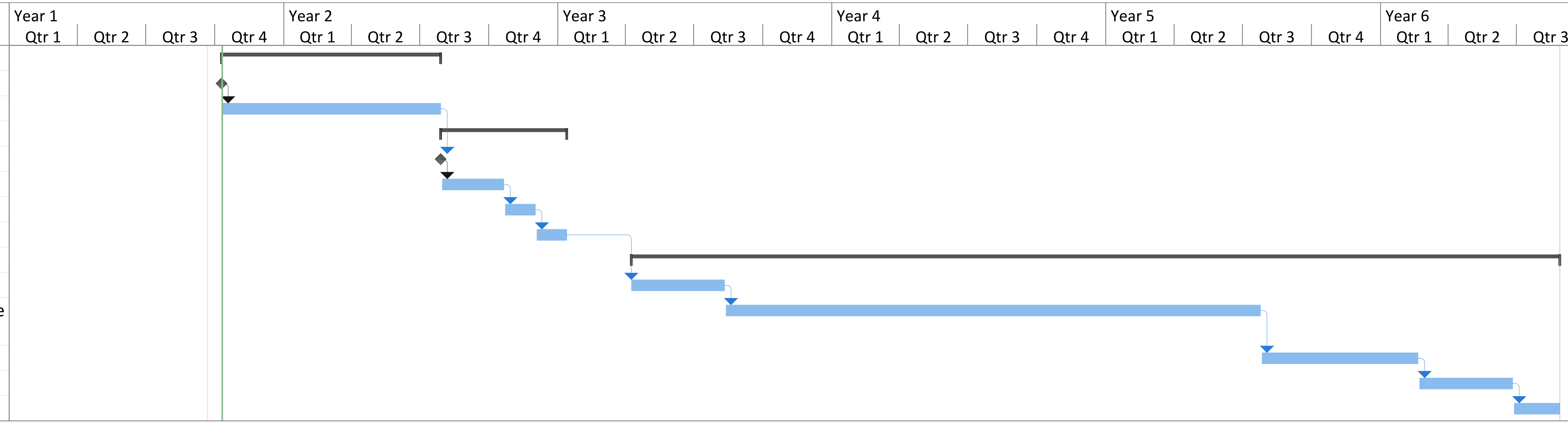
Figure 1

AMEREN MISSOURI
SURFACE IMPOUNDMENT MCPA
SITE AERIAL

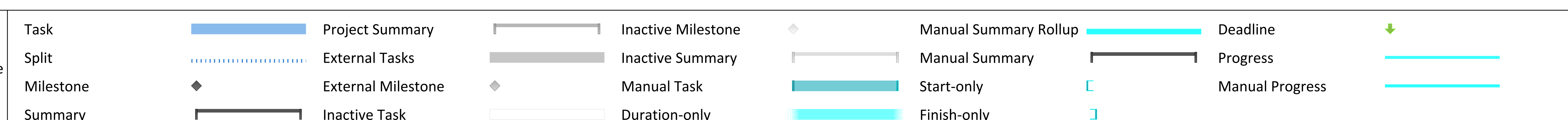
Z:\CLIENTS\ENR\AMERENMO\90683_MERAMECCLOSURE\DESIGN\ENVIRO\SOLID_WASTE\MERAMEC CLOSURE PLANS\492 CLOSURE AND POSTCLOSURE\90683 - MCPA CLOSURE.DWG 9/22/2016 1:41 PM MGONZALES

APPENDIX B – CLOSURE SCHEDULE

ID	Task Name
1	**Permitting & Design Support**
2	Closure Trigger
3	Permitting and Design
4	**Preparation for Closure**
5	Design Documents Issued for Bid
6	Bid Period
7	Bid Evaluation
8	Contract Award
9	**Construction**
10	Dewater and Unwater CCR Material
11	Grading CCR Material and Prepare Surface for Cover
12	Placement of Alternative Cover System
13	Topsoil and Seeding
14	Site Cleanup and Demobilization



Project: MCPA Impoundment Closure



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Meramec Energy Center
CCR Surface Impoundment MCPA (Pond 492)
CCR Unit Post-Closure Plan

Ameren Missouri

Project No. 90683

Revision 0
October 2016

Meramec Energy Center
CCR Surface Impoundment MCPA (Pond 492)
CCR Unit Post-Closure Plan

Prepared for

Ameren Missouri
Project No. 90683
Ameren, Missouri

Revision 0
October 2016

Prepared by

Burns & McDonnell Engineering Company, Inc.
Kansas City, Missouri

INDEX AND CERTIFICATION

Ameren Missouri
Meramec Energy Center
CCR Surface Impoundment MCPA (Pond 492)
CCR Unit Post-Closure Plan

Report Index

Certification

I hereby certify, as a Professional Engineer in the state of Missouri, that the information in this document was assembled under my direct personal charge. This report is not intended or represented to be suitable for reuse by the Ameren Missouri or others without specific verification or adaptation by the Engineer. I certify that this Post-Closure Plan document satisfies the requirements presented in 40 CFR §257.104(d).

Scott A. Martin, P.E.
License Number 2010019572
License renewal date: December 31, 2016.
Pages or sheets covered by this seal: As noted above

TABLE OF CONTENTS

Page No.

LIST OF ABBREVIATIONS

Abbreviation	**Term/Phrase/Name**
Ameren	Ameren Missouri
BMcD	Burns & McDonnell
CCR	Coal Combustion Residual
CCR Rule	EPA Coal Combustion Rule Published April 17, 2015
CFR	Code of Federal Regulations
EPA	Environmental Protection Agency
MCPA	CCR Surface Impoundment MCPA or Pond 492
Meramec	Meramec Energy Center

1.0 INTRODUCTION

On April 17, 2015, the Environmental Protection Agency (EPA) issued the final version of the federal Coal Combustion Residual Rule (CCR Rule) to regulate the disposal of coal combustion residual (CCR) materials generated by electric utilities and independent power producers.

Ameren Missouri (Ameren) is subject to the CCR Rule and is required to develop a Post-Closure Plan for existing CCR surface impoundments per 40 Code of Federal Regulations (CFR) §257.104. This document serves as Ameren's Post-Closure Care Plan for the existing CCR Surface Impoundment MCPA (Pond 492) at the Meramec Energy Center (Meramec). The Post-Closure Plan is required to contain the following per §257.104(d)(1):

- A description of post-closure care maintenance activities (and frequency of these activities) including the following:
  - Maintaining the integrity and effectiveness of the final cover system (if capped in place), including making repairs to the final cover as necessary to correct the effects of settlement, subsidence, erosion, or other events, and preventing run-on and run-off from eroding or otherwise damaging the final cover.
  - Maintaining the groundwater monitoring system and monitoring the groundwater in accordance with the requirements of §257.90 through §257.98.
- The name, address, telephone number, and email address of the person or office to contact about the facility during the post-closure care period.
- A description of the planned uses of the property during the post-closure period.
  - Post-closure use of the property shall not disturb the integrity of the final cover, liner(s), or any other component of the containment system, or the function of the monitoring system unless necessary to comply with §257.104, or if the owner or operator of the CCR unit demonstrates that the disturbance (including any removal of CCR) will not increase the potential threat to human health or the environment.

2.0 DETAILS OF POST-CLOSURE

Meramec is located in southeast St. Louis County, Missouri and consists of four generating units (a site aerial figure is included as Appendix A). Units 1 and 2 are fired on natural gas (fuel switching from coal to natural gas was completed in April 2016), and Units 3 and 4 are fired on coal. CCR generated at the facility includes fly ash and bottom ash.

Surface Impoundment MCPA (Pond 492) is located on the northeast side of the Meramec facility. As-built construction documents are not available to document that a liner system was installed; therefore, MCPA has been classified as an existing, unlined CCR surface impoundment. A Closure Plan was prepared by Burns & McDonnell per section §257.102(b)(1) of the Federal CCR Rule. MCPA will be closed and capped in place as described in the Closure Plan, which will be available on Ameren's CCR website.

2.1 Post-Closure Compliance

Post-closure maintenance shall be as described in §257.104(b) of the CCR Rule. The requirements consist of the following:

- Maintaining the integrity and effectiveness of the final cover system, including making repairs to the final cover as necessary to correct the effects of settlement, subsidence, erosion, or other events, and preventing run-on and run-off from eroding or otherwise damaging the final cover.
- Maintaining the groundwater monitoring system.

Ameren will achieve compliance with the above requirements through final cover inspection and maintenance of MCPA, which will be conducted for a period of 30 years after the completion of closure activities. Inspection and maintenance activities will be monitored during annual inspections that will occur throughout the post-closure care period. Inspection activities are discussed further in Section 2.1.2.

2.1.1 Groundwater Monitoring

Ameren will conduct sampling, analysis and reporting of the MCPA groundwater monitoring network per §257.90 through §257.98, for the entire 30 years of post-closure care. Per §257.104(c)(2), should any of the groundwater monitoring results cause MCPA to enter or remain in an Assessment Monitoring Program (§257.95) at the end of the 30-year post-closure care period, Ameren will continue monitoring the groundwater until MCPA is able to return to the Detection Monitoring Program (§257.94).

2.1.2 Site Inspections

Site inspections will be performed annually (at minimum) during the post-closure care period to confirm that the integrity and effectiveness of the final cover system is maintained per Section §257.104(b)(1). Maintenance of the final cover will include making repairs, as necessary, to correct the effects of settlement, subsidence, erosion, or other events, and to prevent run-on and run-off from eroding or otherwise damaging the final cover. During the site inspections, Ameren will also inspect groundwater monitoring wells to confirm that they are structurally intact and appear to be in good working condition.

2.2 Post-Closure Contact

Ameren will designate and list a contact person during the post-closure care period per §257.104 (d)(ii). The following individual will be Ameren's designated contact person for post-closure care of MCPA:

Contact	Ameren Missouri
Address	1901 Chouteau Avenue St. Louis, MO 63103
Phone No.	(800) 552-7583
Email	CCR@ameren.com

2.3 Property Use During Post-Closure Care Period

MCPA is located within a secured power plant facility, and access and use will be limited to inspection and groundwater monitoring activities.

2.4 Completion of Post-Closure Care

No later than 60 days following the completion of the post-closure care period, Ameren shall prepare a notification verifying that post-closure care has been completed and place the notification in the facility's CCR Operating Record. The notification shall include the certification by a qualified professional engineer in the State of Missouri, that post-closure care has been completed in accordance with the written Post-Closure Plan in effect and the requirements of §257.104.

3.0 REVISIONS AND AMENDMENTS

This initial MCPA Post-Closure Plan shall be placed in the CCR Operating Record by October 17, 2016. The plan is required to be amended whenever there is a change in the operation of the CCR Unit that affects the current or planned post-closure activities.

The Post-Closure Plan shall be amended 60 days prior to a planned change in operation, or within 60 days following an unplanned change in operation. If a written Post-Closure Plan is revised after post-closure activities have commenced, it shall be amended no later than 30 days following the triggering event. The Post-Closure Plan and any amendments shall be certified by a qualified professional engineer in the State of Missouri for meeting the requirements of §257.104 of the CCR Rule. All amendments and revisions must be posted on the CCR public website within a reasonable amount of time following placement in the facility's CCR Operating Record. A record of revisions made to this document is included in Section 4.0 of this document. A record of revisions made to this document is included in Section 4.0.

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NORTH

0 150' 300'
SCALE IN FEET

BURNS McDONNELL

Figure 1

AMEREN MISSOURI
SURFACE IMPOUNDMENT MCPA
SITE AERIAL

CREATE AMAZING.

Burns & McDonnell World Headquarters
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Kansas City, MO 64114
O 816-333-9400
F 816-333-3690
www.burnsmcd.com

Meramec Energy Center
Certification of Completion for Final Cover System

As a Professional Engineer in the state of Missouri, I hereby certify that the closure of Surface Impoundment MCPA (Pond 492) at Ameren Missouri's Meramec Energy Center was completed on October 15, 2023 in general conformance with the plans and specifications issued for construction, and in accordance with the closure plan specified in 40 CFR §257.102(b) and the requirements of 40 CFR §257.102

Signature: ______________________

Name:	Eric J. Karch
Date:	December 14, 2023
Missouri License Number:	2007005040
Expiration Date:	December 31, 2023

Meramec Energy Center
Notification of Intent to Close a CCR Unit
and Certification for Final Cover System Design

In accordance with 40 CFR §257.102(g), this is notification of Ameren Missouri's (the Owner) intent to close surface impoundment MCPB (Pond 493) at their Meramec Energy Center. This closure will be performed in accordance with 40 CFR §257.102(d) by leaving CCR in place.

CERTIFICATION:

As a Professional Engineer in the state of Missouri, I hereby certify that to the best of my knowledge, information, and belief, the final cover system design for surface impoundment MCPB (Pond 493) at Ameren Missouri's Meramec Energy Center meets the final cover system requirements of 40 CFR §257.102(d)(3).

Signature: ____________________

Name: Eric J. Karch

Date: 25 October 2022

Missouri License Number: 2007005040

Expiration Date: December 31, 2022

Meramec Energy Center
CCR Surface Impoundment MCPB
(Pond 493)
CCR Unit Closure Plan

Meramec Energy Center
CCR Surface Impoundment MCPB (Pond 493)
CCR Unit Closure Plan

Prepared for

Ameren Missouri
Project No. 90683
Ameren, Missouri

Revision 1
November 2016

Prepared by

Burns & McDonnell Engineering Company, Inc.
Kansas City, Missouri

INDEX AND CERTIFICATION

Ameren Missouri
Meramec Energy Center
CCR Surface Impoundment MCPB (Pond 493)
CCR Unit Closure Plan

Report Index

Certification

I hereby certify, as a Professional Engineer in the state of Missouri, that the information in this document was assembled under my direct personal charge. This report is not intended or represented to be suitable for reuse by Ameren Missouri or others without specific verification or adaptation by the Engineer. I certify that this Closure Plan and the Final Cover System specified herein satisfy the requirements presented in 40 CFR §257.102(b).

Scott A. Martin, P.E.
License Number 2010019572
License renewal date: December 31, 2016.
Pages or sheets covered by this seal: As noted above

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LIST OF FIGURES

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Cm/sec	Centimeters per second
CQA	Construction Quality Assurance
CY	Cubic yard
EPA	Environmental Protection Agency
EPDM	Ethylene propylene diene monomer
HDPE	High-density polyethylene
HELP	Hydrologic Evaluation of Landfill Performance
LLDPE	Low-density polyethylene
MCPB	CCR Surface Impoundment MCPB or Pond 493
Meramec	Meramec Energy Center

1.0 INTRODUCTION

On April 17, 2015, the Environmental Protection Agency (EPA) issued the final version of the federal Coal Combustion Residual Rule (CCR Rule) to regulate the disposal of coal combustion residual (CCR) materials generated by electric utilities and independent power producers.

Ameren Missouri (Ameren) is subject to the CCR Rule and is required to develop a Closure Plan for existing CCR surface impoundments per 40 Code of Federal Regulations (CFR) §257.102. This document serves as Ameren's Closure Plan for the existing CCR Surface Impoundment MCPB (Pond 493) at the Meramec Energy Center (Meramec). The Closure Plan is required to contain the following, as required in §257.102(b)(1):

- A description of how the CCR Unit will be closed.
  - For in-place closure: A description of the final cover system, methods for installing final cover system, and methods for achieving compliance with the standards outlined in §257.102(d).
- An estimate of the maximum inventory of CCR material ever stored in the CCR Unit over its active life.
- An estimate of the largest area requiring a final cover as required by §257.102(d) at any time during the active life of the CCR Unit.
- A schedule for completing CCR Unit closure activities, including the anticipated year of closure and major milestones for permitting and construction activities.

Additionally, the CCR Unit will be subject to the post-closure care requirements contained in §257.104, and a Post-Closure Plan has been prepared as a separate, stand-alone document.

2.0 CLOSURE PLAN

2.1 Facility and Surface Impoundment Description

Meramec is located in southeast St. Louis County, Missouri and consists of four generating units (a site aerial figure is included as Appendix A). Units 1 and 2 are fired on natural gas (fuel switching from coal to natural gas was completed in April 2016), and Units 3 and 4 are fired on coal. CCR generated at the facility includes fly ash and bottom ash.

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2.1.1 CCR Inventory and Extent

MCPB has an approximate surface area of 7 acres, as measured within the perimeter dikes, which represents the largest area that would require a final cover. The estimated maximum inventory of CCR in MCPB over its active life is approximately 59,000 cubic yards (CY) of CCR material. Ameren periodically removes CCR from MCPB for beneficial use (primarily used for cement kiln raw feed).

2.2 Closure Method

The CCR Rule allows for CCR Units to be closed through removal of CCR or by leaving CCR material in-place. MCPB is planned to be closed with CCR material in-place, and accordingly, will follow the closure performance standards referenced in 40 CFR §257.102(d). If the design or use changes in the future, this Closure Plan will be updated accordingly (see Section 3.0).

2.2.1 Drainage / Stabilization of CCR Material

Prior to installing the final cover system, Ameren will perform the following activities outlined in §257.102(d) of the CCR Rule:

- Eliminate free liquids by removing liquid wastes or solidifying the remaining wastes and waste residues.
- Stabilize remaining wastes sufficiently in order to support the final cover system.

Free liquids will be removed, with excess water discharged under the current NPDES Permit. Free liquid removal will be performed throughout construction, as necessary, to manage surface water and storm water runoff. Once stabilized, the CCR will be compacted and graded to promote drainage.

2.2.2 Final Cover System

The final cover system will be designed and constructed to meet the following criteria pursuant to §257.102(d)(3)(i):

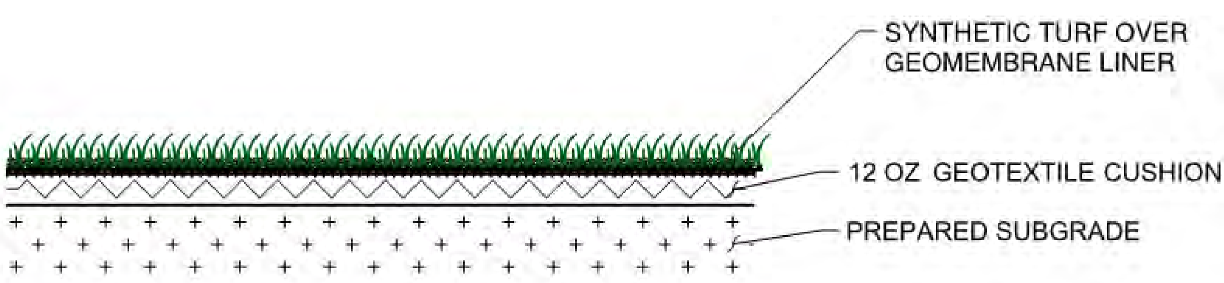
- Have a permeability less than or equal to the permeability of any bottom liner system or natural subsoils present, or a permeability no greater than $1x10^{-5}$ centimeters per second (cm/sec), whichever is less.
- The infiltration of liquids through the closed CCR Unit must be minimized by the use of an infiltration layer that contains a minimum of 18 inches of earthen material.
- The erosion of the final cover system must be minimized by the use of an erosion layer that contains a minimum of six inches of earthen material that is capable of sustaining native plant growth.
- The disruption of the integrity of the final cover system must be minimized through a design that accommodates settling and subsidence.
- The owner or operator may select an alternative final cover system design, provided the alternative final cover system meets the above requirements.

MCPB will be capped and closed in-place as described herein, and in accordance with the requirements of the CCR Rule. MCPB will be closed using an alternative cover system, which will consist of (from bottom to top):

- Geotextile cushion (to protect the overlying geomembrane),
- 40-mil (minimum) linear low-density polyethylene (LLDPE), high-density polyethylene (HDPE), or ethylene propylene diene monomer (EPDM) geomembrane,
- Synthetic turf.

A typical cross section of this alternative cover system is shown in Figure 2-1.

Figure 2-1: Final Cover System



A construction quality assurance (CQA) plan will be compiled prior to the commencement of construction, and the CQA program will be implemented during construction of the cover system.

2.2.2.1 Permeability and Infiltration

The federal minimum standard requires MCPB's cover system permeability to be less than or equal to that of the bottom liner, natural underlying subsoils, or $1x10^{-5}$ cm/sec, whichever is less. As discussed above, MCPB construction documents are not available. MCPB was reportedly constructed by excavating soils within MCPB (silts and clays), and the excavated materials were utilized for pond berms. Site specific permeability information of the pond base and/or natural subsoils is not available at this time.

The proposed cover system will feature a geomembrane component which has a permeability of 2.0×10^{-12} cm/sec, which represents the maximum permeability value of the potential geomembrane material types planned to be utilized for closure[1]. The alternative final cover system uses a geomembrane component to achieve the minimum permeability requirements of the CCR Rule, rather than relying on the permeability of an 18-inch infiltration layer.

2.2.2.2 Geometry and Stormwater Management

The geometry and stormwater management controls of MCPB following closure will allow the CCR Unit to meet the following requirements as outlined in §257.102(d) of the CCR Rule:

- Control, minimize, or eliminate, to the maximum extent feasible, post-closure infiltration of liquids into the waste and releases of CCR, leachate, or contaminated run-off to the ground or surface waters or to the atmosphere.
- Prevent future impoundment of water.
- Provide for slope stability to protect against sloughing or movement of the final cover system.

The closure system will be designed to provide adequate drainage during storm events. Intermediate swales will be utilized to limit the maximum overland flow distance, thereby minimizing ponded water, as well as limiting the infiltration of run-off.

2.2.2.3 Integrity of the Final Cover

Settling and subsidence of the final cover system is expected to be minimal. Settlement would potentially be caused by consolidation of the CCR material, general fill material, or underlying natural subsoils due

[1] Per the Hydrologic Evaluation of Landfill Performance (HELP) Model User's Guide for Version 3 - EPA/600/R-94/168a.

to the dynamic loads typically resulting from construction activities; consequently, this settlement is expected to be minimal following final cover installation activities. General fill will be installed in a controlled manner to minimize post-fill installation settlement. Maintenance will be conducted as necessary to maintain the integrity of the final cover, as outlined in the Post-Closure Plan for MCPB (separate document).

2.2.3 Final Cover Schedule

According to §257.101 of the CCR Rule, closure of the MCPB will commence no later than six months following the date on which a closure event is triggered. For the purposes of this Plan, closure of MCPB is assumed to have commenced when Ameren has ceased placing CCR material into MCPB and has completed any of the following actions or activities:

- Taken any steps necessary to implement the written Closure Plan.
- Submitted a completed application for any required state or agency permit or permit modification.
- Taken any steps necessary to comply with any state or other agency standards that are a prerequisite, or are otherwise applicable, to initiating or completing the closure of a CCR Unit.

In the event that closure of MCPB is required due to a location restriction or groundwater impacts, but not a safety factor assessment, the CCR unit may continue to receive CCR material beyond the six-month maximum duration, provided that MCPB satisfies the criteria specified §257.103(a) or §257.103(b).

No later than the date Ameren initiates closure of MCPB, a Notification of Intent to Close the CCR Unit will be prepared. The notification is considered completed when it has been placed in the facility's CCR Operating Record. The notification will then be posted on Ameren's CCR public website within 30 days.

2.2.3.1 Closure Completion

Closure for MCPB shall be completed within five years of commencing closure activities per the CCR Rule. The timeframe for completing closure of the CCR Unit may be extended if Ameren demonstrates that it is not feasible to complete closure of the CCR Unit within the required timeframe due to factors beyond the facility's control. A demonstration for an extension of the closure timeframe shall be completed pursuant to §257.102(f)(2).

For the purpose of this Closure Plan, closure of MCPB is considered complete when the final cover system is installed and applicable construction completion documentation is finalized. Based on the closure schedule provided in Appendix B, it is estimated that the closure of MCPB will be completed in less than 5 years. The estimated closure year is 2026.

Within 30 days of completion of closure of MCPB, Ameren will prepare a notification of closure and post it on the facility's CCR Operating Record and on Ameren's CCR public website. This notification shall include certification by a qualified professional engineer, registered in the State of Missouri, verifying that closure has been completed in accordance with this Closure Plan and the requirements of §257.102.

In accordance with §257.102(i), Ameren will record a notation on the deed to the property, following completion of closure. This notation is inform any potential future owner of the property of the previous use of the land, and that the land is restricted by post-closure care requirements.

3.0 REVISIONS AND AMENDMENTS

The MCPB Closure Plan will be amended whenever there is a change in operation of the CCR unit that affects the current or planned closure operations. The Closure Plan will be amended 60 days prior to a planned change in operation, or within 60 days following an unplanned change in operation. If a written Closure Plan is revised after closure activities have commenced, the written Closure Plan will be amended no later than 30 days following the triggering event. The initial Closure Plan and any amendment will be certified by a qualified professional engineer in the State of Missouri for meeting the requirements of §257.102 of the CCR Rule. All amendments and revisions will be posted on the CCR public website within 30 days following placement in the facility's CCR Operating Record. A record of revisions made to this document is included in Section 4.0 of this document.

4.0 RECORD OF REVISIONS AND UPDATES

Revision Number	Date	Revisions Made	By Whom
0	10/13/2016	Initial Closure Plan	Burns & McDonnell
1	11/14/2016	Revisions to cover page to use Ameren's standard cover page, and Section 2.2.3.1 to include estimated year of MCPB closure	Burns & McDonnell

APPENDIX A – SITE AERIAL FIGURE

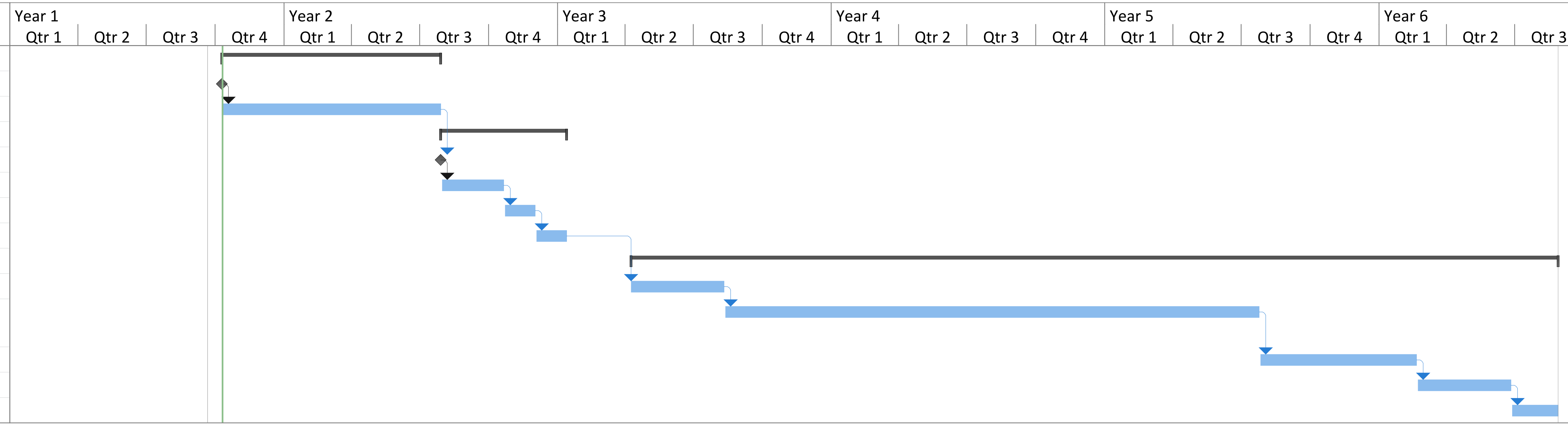
BURNS McDONNELL

Figure 1

AMEREN MISSOURI
SURFACE IMPOUNDMENT MCPB
SITE AERIAL

APPENDIX B – CLOSURE SCHEDULE

ID	Task Name
1	**Permitting & Design Support**
2	Closure Trigger
3	Permitting and Design
4	**Preparation for Closure**
5	Design Documents Issued for Bid
6	Bid Period
7	Bid Evaluation
8	Contract Award
9	**Construction**
10	Dewater and Unwater CCR Material
11	Grading CCR Material and Prepare Surface for Cover
12	Placement of Alternative Cover System
13	Topsoil and Seeding
14	Site Cleanup and Demobilization



Project: MCPB Impoundment Closure

Task	Project Summary	Inactive Milestone	Manual Summary Rollup	Deadline
Split	External Tasks	Inactive Summary	Manual Summary	Progress
Milestone	External Milestone	Manual Task	Start-only	Manual Progress
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Meramec Energy Center
CCR Surface Impoundment MCPB (Pond 493)
CCR Unit Post-Closure Plan

Ameren Missouri

Project No. 90683

Revision 0
October 2016

Meramec Energy Center
CCR Surface Impoundment MCPB (Pond 493)
CCR Unit Post-Closure Plan

Prepared for

Ameren Missouri
Project No. 90683
Ameren, Missouri

Revision 0
October 2016

Prepared by

Burns & McDonnell Engineering Company, Inc.
Kansas City, Missouri

INDEX AND CERTIFICATION

Ameren Missouri
Meramec Energy Center
CCR Surface Impoundment MCPB (Pond 493)
CCR Unit Post-Closure Plan

Report Index

Certification

I hereby certify, as a Professional Engineer in the state of Missouri, that the information in this document was assembled under my direct personal charge. This report is not intended or represented to be suitable for reuse by the Ameren Missouri or others without specific verification or adaptation by the Engineer. I certify that this Post-Closure Plan document satisfies the requirements presented in 40 CFR §257.104(d).

Scott A. Martin, P.E.
License Number 2010019572
License renewal date: December 31, 2016.
Pages or sheets covered by this seal: As noted above

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LIST OF ABBREVIATIONS

Abbreviation	**Term/Phrase/Name**
Ameren	Ameren Missouri
BMcD	Burns & McDonnell
CCR	Coal Combustion Residual
CCR Rule	EPA Coal Combustion Rule Published April 17, 2015
CFR	Code of Federal Regulations
EPA	Environmental Protection Agency
MCPB	CCR Surface Impoundment MCPB or Pond 493
Meramec	Meramec Energy Center

1.0 INTRODUCTION

On April 17, 2015, the Environmental Protection Agency (EPA) issued the final version of the federal Coal Combustion Residual Rule (CCR Rule) to regulate the disposal of coal combustion residual (CCR) materials generated by electric utilities and independent power producers.

Ameren Missouri (Ameren) is subject to the CCR Rule and is required to develop a Post-Closure Plan for existing CCR surface impoundments per 40 Code of Federal Regulations (CFR) §257.104. This document serves as Ameren's Post-Closure Care Plan for the existing CCR Surface Impoundment MCPB (Pond 493) at the Meramec Energy Center (Meramec). The Post-Closure Plan is required to contain the following per §257.104(d)(1):

- A description of post-closure care maintenance activities (and frequency of these activities) including the following:
    - Maintaining the integrity and effectiveness of the final cover system (if capped in place), including making repairs to the final cover as necessary to correct the effects of settlement, subsidence, erosion, or other events, and preventing run-on and run-off from eroding or otherwise damaging the final cover.
    - Maintaining the groundwater monitoring system and monitoring the groundwater in accordance with the requirements of §257.90 through §257.98.
- The name, address, telephone number, and email address of the person or office to contact about the facility during the post-closure care period.
- A description of the planned uses of the property during the post-closure period.
    - Post-closure use of the property shall not disturb the integrity of the final cover, liner(s), or any other component of the containment system, or the function of the monitoring system unless necessary to comply with §257.104, or if the owner or operator of the CCR unit demonstrates that the disturbance (including any removal of CCR) will not increase the potential threat to human health or the environment.

2.0 DETAILS OF POST-CLOSURE

Meramec is located in southeast St. Louis County, Missouri and consists of four generating units (a site aerial figure is included as Appendix A). Units 1 and 2 are fired on natural gas (fuel switching from coal to natural gas was completed in April 2016), and Units 3 and 4 are fired on coal. CCR generated at the facility includes fly ash and bottom ash.

Surface Impoundment MCPB (Pond 493) is located on the northeast side of the Meramec facility. As-built construction documents are not available to document that a liner system was installed; therefore, MCPB has been classified as an existing, unlined CCR surface impoundment. A Closure Plan was prepared by Burns & McDonnell per section §257.102(b)(1) of the Federal CCR Rule. MCPB will be closed and capped in place as described in the Closure Plan, which will be available on Ameren's CCR website.

2.1 Post-Closure Compliance

Post-closure maintenance shall be as described in §257.104(b) of the CCR Rule. The requirements consist of the following:

- Maintaining the integrity and effectiveness of the final cover system, including making repairs to the final cover as necessary to correct the effects of settlement, subsidence, erosion, or other events, and preventing run-on and run-off from eroding or otherwise damaging the final cover.
- Maintaining the groundwater monitoring system.

Ameren will achieve compliance with the above requirements through final cover inspection and maintenance of MCPB, which will be conducted for a period of 30 years after the completion of closure activities. Inspection and maintenance activities will be monitored during annual inspections that will occur throughout the post-closure care period. Inspection activities are discussed further in Section 2.1.2.

2.1.1 Groundwater Monitoring

Ameren will conduct sampling, analysis and reporting of the MCPB groundwater monitoring network per §257.90 through §257.98, for the entire 30 years of post-closure care. Per §257.104(c)(2), should any of the groundwater monitoring results cause MCPB to enter or remain in an Assessment Monitoring Program (§257.95) at the end of the 30-year post-closure care period, Ameren will continue monitoring the groundwater until MCPB is able to return to the Detection Monitoring Program (§257.94).

2.1.2 Site Inspections

Site inspections will be performed annually during the post-closure care period to confirm that the integrity and effectiveness of the final cover system is maintained per Section §257.104(b)(1). Maintenance of the final cover will include making repairs, as necessary, to correct the effects of settlement, subsidence, erosion, or other events, and to prevent run-on and run-off from eroding or otherwise damaging the final cover. During the site inspections, Ameren will also inspect groundwater monitoring wells to confirm that they are structurally intact and appear to be in good working condition.

2.2 Post-Closure Contact

Ameren will designate and list a contact person during the post-closure care period per §257.104 (d)(ii). The following individual will be Ameren's designated contact person for post-closure care of MCPB:

Contact	Ameren Missouri
Address	1901 Chouteau Avenue St. Louis, MO 63103
Phone No.	(800) 552-7583
Email	CCR@ameren.com

2.3 Property Use During Post-Closure Care Period

MCPB is located within a secured power plant facility, and access and use will be limited to inspection and groundwater monitoring activities.

2.4 Completion of Post-Closure Care

No later than 60 days following the completion of the post-closure care period, Ameren shall prepare a notification verifying that post-closure care has been completed and place the notification in the facility's CCR Operating Record. The notification shall include the certification by a qualified professional engineer in the State of Missouri, that post-closure care has been completed in accordance with the written Post-Closure Plan in effect and the requirements of §257.104.

3.0 REVISIONS AND AMENDMENTS

This initial MCPB Post-Closure Plan shall be placed in the CCR Operating Record by October 17, 2016. The plan is required to be amended whenever there is a change in the operation of the CCR Unit that affects the current or planned post-closure activities.

The Post-Closure Plan shall be amended 60 days prior to a planned change in operation, or within 60 days following an unplanned change in operation. If a written Post-Closure Plan is revised after post-closure activities have commenced, it shall be amended no later than 30 days following the triggering event. The Post-Closure Plan and any amendments shall be certified by a qualified professional engineer in the State of Missouri for meeting the requirements of §257.104 of the CCR Rule. All amendments and revisions must be posted on the CCR public website within a reasonable amount of time following placement in the facility's CCR Operating Record. A record of revisions made to this document is included in Section 4.0 of this document. A record of revisions made to this document is included in Section 4.0.

4.0 RECORD OF REVISIONS AND UPDATES

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APPENDIX A – SITE AERIAL FIGURE

BURNS McDONNELL

Figure 1

AMEREN MISSOURI
SURFACE IMPOUNDMENT MCPB
SITE AERIAL

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Meramec Energy Center
Certification of Completion for Final Cover System

As a Professional Engineer in the state of Missouri, I hereby certify that the closure of Surface Impoundment MCPB (Pond 493) at Ameren Missouri's Meramec Energy Center was completed on October 15, 2023 in general conformance with the plans and specifications issued for construction, and in accordance with the closure plan specified in 40 CFR §257.102(b) and the requirements of 40 CFR §257.102

STATE OF MISSOURI
ERIC
KARCH
NUMBER
PE-2007005040
PROFESSIONAL ENGINEER

Signature: ______________

Name: Eric J. Karch

Date: December 14, 2023

Missouri License Number: 2007005040

Expiration Date: December 31, 2023

Meramec Energy Center
Notification of Intent to Close a CCR Unit and Certification for Final Cover System Design

In accordance with 40 CFR §257.102(g), this is notification of Ameren Missouri's (the Owner) intent to close surface impoundment MCPC (Pond 496) at their Meramec Energy Center. This closure will be performed in accordance with 40 CFR §257.102(d) by leaving CCR in place.

CERTIFICATION:

As a Professional Engineer in the state of Missouri, I hereby certify that to the best of my knowledge, information, and belief, the final cover system design for surface impoundment MCPC (Pond 496) at Ameren Missouri's Meramec Energy Center meets the final cover system requirements of 40 CFR §257.102(d)(3).

STATE OF MISSOURI
ERIC KARCH
NUMBER PE-2007005040
PROFESSIONAL ENGINEER

Signature:

Name:	Eric J. Karch
Date:	25 October 2022
Missouri License Number:	2007005040
Expiration Date:	December 31, 2022

Meramec Energy Center
CCR Surface Impoundment MCPC
(Pond 496)
CCR Unit Closure Plan

Meramec Energy Center
CCR Surface Impoundment MCPC (Pond 496)
CCR Unit Closure Plan

Prepared for

Ameren Missouri
Project No. 90683
Ameren, Missouri

Revision 1
November 2016

Prepared by

Burns & McDonnell Engineering Company, Inc.
Kansas City, Missouri

INDEX AND CERTIFICATION

Ameren Missouri
Meramec Energy Center
CCR Surface Impoundment MCPC (Pond 496)
CCR Unit Closure Plan

Report Index

Certification

I hereby certify, as a Professional Engineer in the state of Missouri, that the information in this document was assembled under my direct personal charge. This report is not intended or represented to be suitable for reuse by Ameren Missouri or others without specific verification or adaptation by the Engineer. I certify that this Closure Plan and the Final Cover System specified herein satisfy the requirements presented in 40 CFR §257.102(b).

Scott A. Martin, P.E.
License Number 2010019572
License renewal date: December 31, 2016.
Pages or sheets covered by this seal: As noted above

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LIST OF FIGURES

LIST OF ABBREVIATIONS

Abbreviation	Term/Phrase/Name
Ameren	Ameren Missouri
BMcD	Burns & McDonnell
CCR	Coal Combustion Residual
CCR Rule	EPA Coal Combustion Rule Published April 17, 2015
CFR	Code of Federal Regulations
Cm/sec	Centimeters per second
CQA	Construction Quality Assurance
CY	Cubic yard
EPA	Environmental Protection Agency
EPDM	Ethylene propylene diene monomer
HDPE	High-density polyethylene
HELP	Hydrologic Evaluation of Landfill Performance
LLDPE	Low-density polyethylene
MCPC	CCR Surface Impoundment MCPC or Pond 496
Meramec	Meramec Energy Center

1.0 INTRODUCTION

On April 17, 2015, the Environmental Protection Agency (EPA) issued the final version of the federal Coal Combustion Residual Rule (CCR Rule) to regulate the disposal of coal combustion residual (CCR) materials generated by electric utilities and independent power producers.

Ameren Missouri (Ameren) is subject to the CCR Rule and is required to develop a Closure Plan for existing CCR surface impoundments per 40 Code of Federal Regulations (CFR) §257.102. This document serves as Ameren's Closure Plan for the existing CCR Surface Impoundment MCPC (Pond 496) at the Meramec Energy Center (Meramec). The Closure Plan is required to contain the following, as required in §257.102(b)(1):

- A description of how the CCR Unit will be closed.
    - For in-place closure: A description of the final cover system, methods for installing final cover system, and methods for achieving compliance with the standards outlined in §257.102(d).
- An estimate of the maximum inventory of CCR material ever stored in the CCR Unit over its active life.
- An estimate of the largest area requiring a final cover as required by §257.102(d) at any time during the active life of the CCR Unit.
- A schedule for completing CCR Unit closure activities, including the anticipated year of closure and major milestones for permitting and construction activities.

Additionally, the CCR Unit will be subject to the post-closure care requirements contained in §257.104, and a Post-Closure Plan has been prepared as a separate, stand-alone document.

2.0 CLOSURE PLAN

2.1 Facility and Surface Impoundment Description

Meramec is located in southeast St. Louis County, Missouri and consists of four generating units (a site aerial figure is included as Appendix A). Units 1 and 2 are fired on natural gas (fuel switching from coal to natural gas was completed in April 2016), and Units 3 and 4 are fired on coal. CCR generated at the facility includes fly ash and bottom ash.

Surface Impoundment MCPC (Pond 496), referred to herein as MCPC, is located on the northeast side of the Meramec facility. As-built construction documents are not available to document that a liner system was installed; therefore, MCPC has been classified as an existing, unlined CCR surface impoundment.

2.1.1 CCR Inventory and Extent

MCPC has an approximate surface area of 10 acres, as measured within the perimeter dikes, which represents the largest area that would require a final cover. The estimated maximum inventory of CCR in MCPC over its active life is approximately 274,000 cubic yards (CY) of CCR material. Ameren periodically removes CCR from MCPC for beneficial use (primarily used for cement kiln raw feed).

2.2 Closure Method

The CCR Rule allows for CCR Units to be closed through removal of CCR or by leaving CCR material in-place. MCPC is planned to be closed with CCR material in-place, and accordingly, will follow the closure performance standards referenced in 40 CFR §257.102(d). If the design or use changes in the future, this Closure Plan will be updated accordingly (see Section 3.0).

2.2.1 Drainage / Stabilization of CCR Material

Prior to installing the final cover system, Ameren will perform the following activities outlined in §257.102(d) of the CCR Rule:

- Eliminate free liquids by removing liquid wastes or solidifying the remaining wastes and waste residues.
- Stabilize remaining wastes sufficiently in order to support the final cover system.

Free liquids will be removed, with excess water discharged under the current NPDES Permit. Free liquid removal will be performed throughout construction, as necessary, to manage surface water and storm water runoff. Once stabilized, the CCR will be compacted and graded to promote drainage.

2.2.2 Final Cover System

The final cover system will be designed and constructed to meet the following criteria pursuant to §257.102(d)(3)(i):

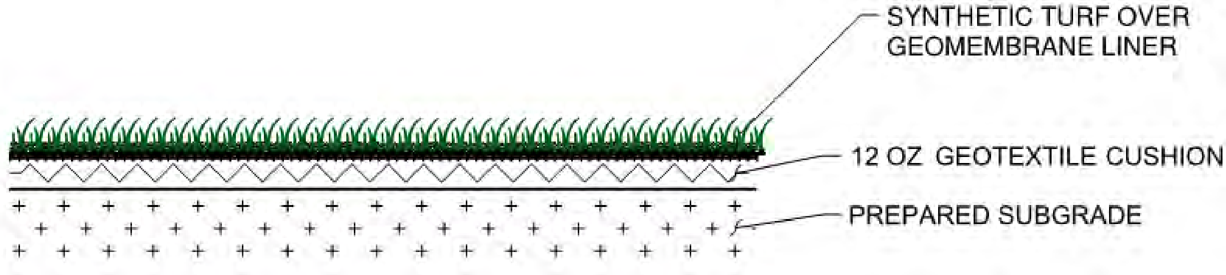
- Have a permeability less than or equal to the permeability of any bottom liner system or natural subsoils present, or a permeability no greater than 1×10^{-5} centimeters per second (cm/sec), whichever is less.
- The infiltration of liquids through the closed CCR Unit must be minimized by the use of an infiltration layer that contains a minimum of 18 inches of earthen material.
- The erosion of the final cover system must be minimized by the use of an erosion layer that contains a minimum of six inches of earthen material that is capable of sustaining native plant growth.
- The disruption of the integrity of the final cover system must be minimized through a design that accommodates settling and subsidence.
- The owner or operator may select an alternative final cover system design, provided the alternative final cover system meets the above requirements.

MCPC will be capped and closed in-place as described herein, and in accordance with the requirements of the CCR Rule. MCPC will be closed using an alternative cover system, which will consist of (from bottom to top):

- Geotextile cushion (to protect the overlying geomembrane),
- 40-mil (minimum) linear low-density polyethylene (LLDPE), high-density polyethylene (HDPE), or ethylene propylene diene monomer (EPDM) geomembrane,
- Synthetic turf.

A typical cross section of this alternative cover system is shown in Figure 2-1.

Figure 2-1: Final Cover System



A construction quality assurance (CQA) plan will be compiled prior to the commencement of construction, and the CQA program will be implemented during construction of the cover system.

2.2.2.1 Permeability and Infiltration

The federal minimum standard requires MCPC's cover system permeability to be less than or equal to that of the bottom liner, natural underlying subsoils, or $1x10^{-5}$ cm/sec, whichever is less. As discussed above, MCPC construction documents are not available. MCPC was reportedly constructed by excavating soils within MCPC (silts and clays), and the excavated materials were utilized for pond berms. Site specific permeability information of the pond base and/or natural subsoils is not available at this time.

The proposed cover system will feature a geomembrane component which has a permeability of 2.0×10^{-12} cm/sec, which represents the maximum permeability value of the potential geomembrane material types planned to be utilized for closure[1].The alternative final cover system uses a geomembrane component to achieve the minimum permeability requirements of the CCR Rule, rather than relying on the permeability of an 18-inch infiltration layer.

2.2.2.2 Geometry and Stormwater Management

The geometry and stormwater management controls of MCPC following closure will allow the CCR Unit to meet the following requirements as outlined in §257.102(d) of the CCR Rule:

- Control, minimize, or eliminate, to the maximum extent feasible, post-closure infiltration of liquids into the waste and releases of CCR, leachate, or contaminated run-off to the ground or surface waters or to the atmosphere.
- Prevent future impoundment of water.
- Provide for slope stability to protect against sloughing or movement of the final cover system.

The closure system will be designed to provide adequate drainage during storm events. Intermediate swales will be utilized to limit the maximum overland flow distance, thereby minimizing ponded water, as well as limiting the infiltration of run-off.

2.2.2.3 Integrity of the Final Cover

Settling and subsidence of the final cover system is expected to be minimal. Settlement would potentially be caused by consolidation of the CCR material, general fill material, or underlying natural subsoils due

[1] Per the Hydrologic Evaluation of Landfill Performance (HELP) Model User's Guide for Version 3 - EPA/600/R-94/168a.

to the dynamic loads typically resulting from construction activities; consequently, this settlement is expected to be minimal following final cover installation activities. General fill will be installed in a controlled manner to minimize post-fill installation settlement. Maintenance will be conducted as necessary to maintain the integrity of the final cover, as outlined in the Post-Closure Plan for MCPC (separate document).

2.2.3 Final Cover Schedule

According to §257.101 of the CCR Rule, closure of the MCPC will commence no later than six months following the date on which a closure event is triggered. For the purposes of this Plan, closure of MCPC is assumed to have commenced when Ameren has ceased placing CCR material into MCPC and has completed any of the following actions or activities:

- Taken any steps necessary to implement the written Closure Plan.
- Submitted a completed application for any required state or agency permit or permit modification.
- Taken any steps necessary to comply with any state or other agency standards that are a prerequisite, or are otherwise applicable, to initiating or completing the closure of a CCR Unit.

In the event that closure of MCPC is required due to a location restriction or groundwater impacts, but not a safety factor assessment, the CCR unit may continue to receive CCR material beyond the six-month maximum duration, provided that MCPC satisfies the criteria specified §257.103(a) or §257.103(b).

No later than the date Ameren initiates closure of MCPC, a Notification of Intent to Close the CCR Unit will be prepared. The notification is considered completed when it has been placed in the facility's CCR Operating Record. The notification will then be posted on Ameren's CCR public website within 30 days.

2.2.3.1 Closure Completion

Closure for MCPC shall be completed within five years of commencing closure activities per the CCR Rule. The timeframe for completing closure of the CCR Unit may be extended if Ameren demonstrates that it is not feasible to complete closure of the CCR Unit within the required timeframe due to factors beyond the facility's control. A demonstration for an extension of the closure timeframe shall be completed pursuant to §257.102(f)(2).

For the purpose of this Closure Plan, closure of MCPC is considered complete when the final cover system is installed and applicable construction completion documentation is finalized. Based on the closure schedule provided in Appendix B, it is estimated that the closure of MCPC will be completed in less than five years. The estimated closure year is 2026.

Within 30 days of completion of closure of MCPC, Ameren will prepare a notification of closure and post it on the facility's CCR Operating Record and on Ameren's CCR public website. This notification shall include certification by a qualified professional engineer, registered in the State of Missouri, verifying that closure has been completed in accordance with this Closure Plan and the requirements of §257.102.

In accordance with §257.102(i), Ameren will record a notation on the deed to the property, following completion of closure. This notation is inform any potential future owner of the property of the previous use of the land, and that the land is restricted by post-closure care requirements.

3.0 REVISIONS AND AMENDMENTS

The MCPC Closure Plan will be amended whenever there is a change in operation of the CCR unit that affects the current or planned closure operations. The Closure Plan will be amended 60 days prior to a planned change in operation, or within 60 days following an unplanned change in operation. If a written Closure Plan is revised after closure activities have commenced, the written Closure Plan will be amended no later than 30 days following the triggering event. The initial Closure Plan and any amendment will be certified by a qualified professional engineer in the State of Missouri for meeting the requirements of §257.102 of the CCR Rule. All amendments and revisions will be posted on the CCR public website within 30 days following placement in the facility's CCR Operating Record. A record of revisions made to this document is included in Section 4.0 of this document.

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APPENDIX A – SITE AERIAL FIGURE

BURNS McDONNELL

Figure 1

AMEREN MISSOURI
SURFACE IMPOUNDMENT MCPC
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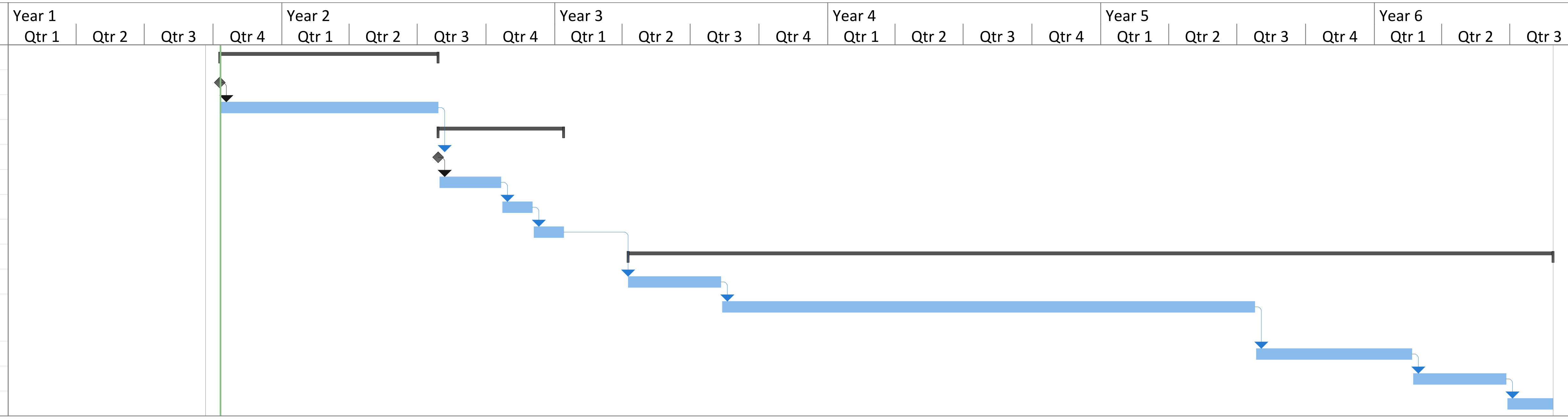

Project: MCPC Impoundment Closure

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Meramec Energy Center
CCR Surface Impoundment MCPC (Pond 496)
CCR Unit Post-Closure Plan

Ameren Missouri

Project No. 90683

Revision 0
October 2016

Meramec Energy Center CCR Surface Impoundment MCPC (Pond 496) CCR Unit Post-Closure Plan

Prepared for

Ameren Missouri
Project No. 90683
Ameren, Missouri

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Report Index

Certification

I hereby certify, as a Professional Engineer in the state of Missouri, that the information in this document was assembled under my direct personal charge. This report is not intended or represented to be suitable for reuse by the Ameren Missouri or others without specific verification or adaptation by the Engineer. I certify that this Post-Closure Plan document satisfies the requirements presented in 40 CFR §257.104(d).

Scott A. Martin, P.E.
License Number 2010019572
License renewal date: December 31, 2016.
Pages or sheets covered by this seal: As noted above

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LIST OF ABBREVIATIONS

Abbreviation	**Term/Phrase/Name**
Ameren	Ameren Missouri
BMcD	Burns & McDonnell
CCR	Coal Combustion Residual
CCR Rule	EPA Coal Combustion Rule Published April 17, 2015
CFR	Code of Federal Regulations
EPA	Environmental Protection Agency
MCPC	CCR Surface Impoundment MCPC or Pond 496
Meramec	Meramec Energy Center

1.0 INTRODUCTION

On April 17, 2015, the Environmental Protection Agency (EPA) issued the final version of the federal Coal Combustion Residual Rule (CCR Rule) to regulate the disposal of coal combustion residual (CCR) materials generated by electric utilities and independent power producers.

Ameren Missouri (Ameren) is subject to the CCR Rule and is required to develop a Post-Closure Plan for existing CCR surface impoundments per 40 Code of Federal Regulations (CFR) §257.104. This document serves as Ameren's Post-Closure Care Plan for the existing CCR Surface Impoundment MCPC (Pond 496) at the Meramec Energy Center (Meramec). The Post-Closure Plan is required to contain the following per §257.104(d)(1):

- A description of post-closure care maintenance activities (and frequency of these activities) including the following:
    - Maintaining the integrity and effectiveness of the final cover system (if capped in place), including making repairs to the final cover as necessary to correct the effects of settlement, subsidence, erosion, or other events, and preventing run-on and run-off from eroding or otherwise damaging the final cover.
    - Maintaining the groundwater monitoring system and monitoring the groundwater in accordance with the requirements of §257.90 through §257.98.
- The name, address, telephone number, and email address of the person or office to contact about the facility during the post-closure care period.
- A description of the planned uses of the property during the post-closure period.
    - Post-closure use of the property shall not disturb the integrity of the final cover, liner(s), or any other component of the containment system, or the function of the monitoring system unless necessary to comply with §257.104, or if the owner or operator of the CCR unit demonstrates that the disturbance (including any removal of CCR) will not increase the potential threat to human health or the environment.

2.0 DETAILS OF POST-CLOSURE

Meramec is located in southeast St. Louis County, Missouri and consists of four generating units (a site aerial figure is included as Appendix A). Units 1 and 2 are fired on natural gas (fuel switching from coal to natural gas was completed in April 2016), and Units 3 and 4 are fired on coal. CCR generated at the facility includes fly ash and bottom ash.

Surface Impoundment MCPC (Pond 496) is located on the northeast side of the Meramec facility. As-built construction documents are not available to document that a liner system was installed; therefore, MCPC has been classified as an existing, unlined CCR surface impoundment. A Closure Plan was prepared by Burns & McDonnell per section §257.102(b)(1) of the Federal CCR Rule. MCPC will be closed and capped in place as described in the Closure Plan, which will be available on Ameren's CCR website.

2.1 Post-Closure Compliance

Post-closure maintenance shall be as described in §257.104(b) of the CCR Rule. The requirements consist of the following:

- Maintaining the integrity and effectiveness of the final cover system, including making repairs to the final cover as necessary to correct the effects of settlement, subsidence, erosion, or other events, and preventing run-on and run-off from eroding or otherwise damaging the final cover.
- Maintaining the groundwater monitoring system.

Ameren will achieve compliance with the above requirements through final cover inspection and maintenance of MCPC, which will be conducted for a period of 30 years after the completion of closure activities. Inspection and maintenance activities will be monitored during annual inspections that will occur throughout the post-closure care period. Inspection activities are discussed further in Section 2.1.2.

2.1.1 Groundwater Monitoring

Ameren will conduct sampling, analysis and reporting of the MCPC groundwater monitoring network per §257.90 through §257.98, for the entire 30 years of post-closure care. Per §257.104(c)(2), should any of the groundwater monitoring results cause MCPC to enter or remain in an Assessment Monitoring Program (§257.95) at the end of the 30-year post-closure care period, Ameren will continue monitoring the groundwater until MCPC is able to return to the Detection Monitoring Program (§257.94).

2.1.2 Site Inspections

Site inspections will be performed annually during the post-closure care period to confirm that the integrity and effectiveness of the final cover system is maintained per Section §257.104(b)(1). Maintenance of the final cover will include making repairs, as necessary, to correct the effects of settlement, subsidence, erosion, or other events, and to prevent run-on and run-off from eroding or otherwise damaging the final cover. During the site inspections, Ameren will also inspect groundwater monitoring wells to confirm that they are structurally intact and appear to be in good working condition.

2.2 Post-Closure Contact

Ameren will designate and list a contact person during the post-closure care period per §257.104 (d)(ii). The following individual will be Ameren's designated contact person for post-closure care of MCPC:

Contact	Ameren Missouri
Address	1901 Chouteau Avenue St. Louis, MO 63103
Phone No.	(800) 552-7583
Email	CCR@ameren.com

2.3 Property Use During Post-Closure Care Period

MCPC is located within a secured power plant facility, and access and use will be limited to inspection and groundwater monitoring activities.

2.4 Completion of Post-Closure Care

No later than 60 days following the completion of the post-closure care period, Ameren shall prepare a notification verifying that post-closure care has been completed and place the notification in the facility's CCR Operating Record. The notification shall include the certification by a qualified professional engineer in the State of Missouri, that post-closure care has been completed in accordance with the written Post-Closure Plan in effect and the requirements of §257.104.

3.0 REVISIONS AND AMENDMENTS

This initial MCPC Post-Closure Plan shall be placed in the CCR Operating Record by October 17, 2016. The plan is required to be amended whenever there is a change in the operation of the CCR Unit that affects the current or planned post-closure activities.

The Post-Closure Plan shall be amended 60 days prior to a planned change in operation, or within 60 days following an unplanned change in operation. If a written Post-Closure Plan is revised after post-closure activities have commenced, it shall be amended no later than 30 days following the triggering event. The Post-Closure Plan and any amendments shall be certified by a qualified professional engineer in the State of Missouri for meeting the requirements of §257.104 of the CCR Rule. All amendments and revisions must be posted on the CCR public website within a reasonable amount of time following placement in the facility's CCR Operating Record. A record of revisions made to this document is included in Section 4.0 of this document. A record of revisions made to this document is included in Section 4.0.

4.0 RECORD OF REVISIONS AND UPDATES

Revision Number	Date	Revisions Made	By Whom
0	10/13/2016	Initial Post-Closure Plan	Burns & McDonnell

APPENDIX A – SITE AERIAL FIGURE

BURNS McDONNELL

Figure 1

AMEREN MISSOURI
SURFACE IMPOUNDMENT MCPC
SITE AERIAL

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CREATE AMAZING.

Burns & McDonnell World Headquarters
9400 Ward Parkway
Kansas City, MO 64114
O 816-333-9400
F 816-333-3690
www.burnsmcd.com

Meramec Energy Center
Certification of Completion for Final Cover System

As a Professional Engineer in the state of Missouri, I hereby certify that the closure of Surface Impoundment MCPC (Pond 496) at Ameren Missouri's Meramec Energy Center was completed on October 15, 2023 in general conformance with the plans and specifications issued for construction, and in accordance with the closure plan specified in 40 CFR §257.102(b) and the requirements of 40 CFR §257.102

STATE OF MISSOURI
ERIC
KARCH
NUMBER
PE-2007005040
PROFESSIONAL ENGINEER

Signature: ______________________

Name: Eric J. Karch

Date: December 14, 2023

Missouri License Number: 2007005040

Expiration Date: December 31, 2023

Meramec Energy Center
Notification of Intent to Close a CCR Unit
and Certification for Final Cover System Design

In accordance with 40 CFR §257.102(g), this is notification of Ameren Missouri's (the Owner) intent to close the lined portion of CCR surface impoundment MCPD (Pond 498) at their Meramec Energy Center. This closure will be performed in accordance with 40 CFR §257.102(d) by leaving CCR in place.

CERTIFICATION:

As a Professional Engineer in the state of Missouri, I hereby certify that to the best of my knowledge, information, and belief, the final cover system design for surface impoundment MCPD at Ameren Missouri's Meramec Energy Center meets the final cover system requirements of 40 CFR §257.102(d)(3).

STATE OF MISSOURI
ERIC KARCH
NUMBER PE-2007005040
PROFESSIONAL ENGINEER

Signature: [signature]

Name: Eric J. Karch

Date: 15 January 2021

Missouri License Number: 2007005040

Expiration Date: December 31, 2021

Meramec Energy Center
CCR Surface Impoundment MCPD
(Pond 498)
CCR Unit Closure Plan

Prepared for

Ameren MISSOURI

Prepared by

Reitz & Jens, Inc.
Consulting Engineers

1055 Corporate Square Drive
St. Louis, Missouri 63132

Revised
February 2021

Ameren Missouri
Meramec Energy Center
CCR Surface Impoundment MCPD (Pond 498)
CCR Unit Closure Plan

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CERTIFICATION

I hereby certify, as a Professional Engineer in the state of Missouri, that the Closure Plan and the Final Cover System discussed herein satisfy the requirements of 40 CFR §257.102(b). I assume responsibility only for what appears in this Closure Plan and disclaim (pursuant to Section 327.411 RSMo) any responsibility for all other plans, estimates, specifications, reports, or other documents or instruments not sealed by me relating to or intended to be used for any part or parts of the project to which this Closure Plan refers.

Name: Eric J. Karch, P.E.
Date: February 2, 2021
Missouri License Number: 2007005040
Expiration Date: December 31, 2021

Ameren Missouri
Meramec Energy Center
CCR Surface Impoundment MCPD (Pond 498)
CCR Unit Closure Plan

1.0 INTRODUCTION

On April 17, 2015, the Environmental Protection Agency (EPA) issued the final version of the federal Coal Combustion Residual Rule (CCR Rule) to regulate the disposal of coal combustion residual (CCR) materials generated by electric utilities and independent power producers.

In compliance with the CCR Rule, Ameren Missouri (Ameren) is required to develop a Closure Plan for existing CCR surface impoundments per 40 Code of Federal Regulations (CFR) §257.102. This document presents Ameren's Closure Plan for the existing CCR Unit/Surface Impoundment MCPD (Pond 498) at the Meramec Energy Center (Meramec). As required in §257.102(b)(1), this Closure Plan contains the following:

- A description of how the CCR Unit will be closed. For in-place closure, a description of the final cover system, methods for installing final cover system, and methods for achieving compliance with the performance standards outlined in §257.102(d).
- An estimate of the maximum inventory of CCR material ever stored in the CCR Unit over its active life.
- An estimate of the largest area requiring a final cover as required by §257.102(d) at any time during the active life of the CCR Unit.
- A schedule for completing CCR Unit closure activities, including the anticipated year of closure and major milestones for permitting and construction activities.

The CCR Unit will also be subject to the post-closure care requirements contained in §257.104. A separate Post-Closure Plan has been developed.

2.0 CLOSURE PLAN

2.1. Facility and Surface Impoundment Description

The Meramec Energy Center is located near Oakville, Missouri and consists of four generating units (a site aerial is included as Appendix A). Units 1 and 2 are fired with natural gas (fuel was switched from coal to natural gas in April 2016), and Units 3 and 4 are fired with coal. CCRs generated at the facility include fly ash and bottom ash.

Surface Impoundment MCPD (Pond 498) is located on the north central portion of the Meramec facility. As-built construction documents are not available to document that a liner system was installed as part of the original construction of MCPD; therefore, MCPD has been classified as an existing, unlined CCR surface impoundment. A portion of MCPD was modified in 2001 by adding a 60-mil high-density polyethylene (HDPE) bottom liner. The modified portion is also considered unlined per the CCR Rule.

2.1.1. CCR Inventory and Extent

The lined portion of MCPD has an approximate surface area of 21 acres which represents the largest area that would require a final cover. The estimated maximum inventory of CCR in MCPD over its active life is approximately 1,017,000 cubic yards (CY) of CCR material.

2.2. Closure Method

The CCR Rule allows for CCR Units to be closed through removal of CCR or by leaving CCR material in-place. MCPD is planned to be closed with CCR material remaining in-place, and accordingly, will follow the closure performance standards referenced in 40 CFR §257.102(d).

2.2.1. Drainage / Stabilization of CCR Material

Prior to installing the final cover system, Ameren will complete the following activities outlined in §257.102(d) of the CCR Rule:

- Eliminate free liquids by removing liquid wastes or solidifying the remaining wastes and waste residues.
- Stabilize remaining wastes sufficiently in order to support the final cover system.

Free liquids will be removed, with excess water discharged under the Meramec Energy Center's existing NPDES Permit. Free liquid removal will be performed throughout construction, as necessary to manage surface water and storm water runoff. Once stabilized, the CCR will be compacted and graded to promote drainage.

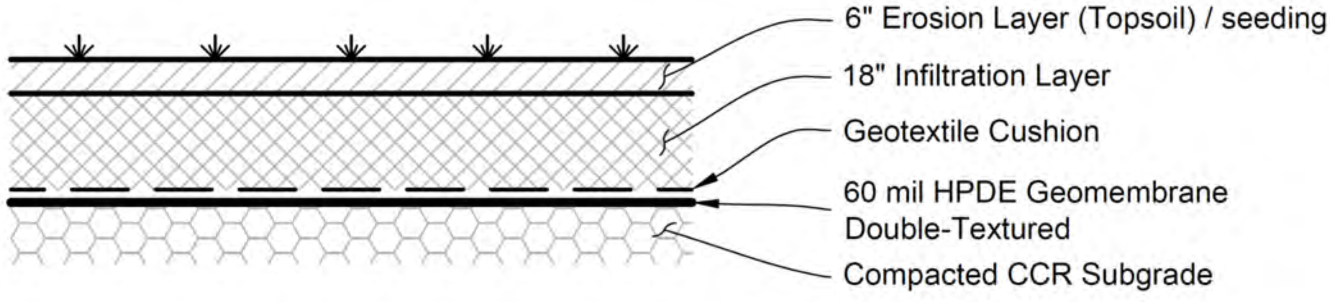
2.2.2. Final Cover System

The final cover system will be designed and constructed to meet the following criteria pursuant to §257.102(d)(3)(i) and (ii):

- Permeability of the final cover system must be less than or equal to the permeability of any bottom liner system or natural subsoils present, or a permeability no greater than $1x10^{-5}$ centimeters per second (cm/sec), whichever is less.
- Infiltration of liquids through the closed CCR Unit must be minimized by the use of an infiltration layer that contains a minimum of 18 inches of earthen material.
- Erosion of the final cover system must be minimized by the use of an erosion layer that contains a minimum of six inches of earthen material that is capable of sustaining vegetation.
- Disruption of the integrity of the final cover system must be minimized through a design that accommodates settling and subsidence.
- The owner or operator may select an alternative final cover system design, provided the alternative final cover system meets the above requirements.

MCPD will be capped and closed in-place as described herein in accordance with the requirements of the CCR Rule. MCPD will be closed using an alternative cover system, which includes (from bottom to top): a 60-mil high density polyethylene (HDPE) flexible geomembrane liner, a geotextile cushion, a nominally compacted 18-inch infiltration soil layer, and a 6-inch erosion layer that is capable of sustaining vegetation. A typical cross section of this alternative cover system is shown in Figure 1.

Figure 1 – Final Cover System



A construction quality assurance (CQA) plan will be developed and the CQA program will be implemented during construction of the cover system.

2.2.2.1. Permeability and Infiltration

The CCR Rule requires that the permeability of the MCPD's cover system be less than or equal to that of the bottom liner, natural underlying subsoils, or 1x10-5 cm/sec, whichever is less. As discussed above, documents for the original construction of MCPD are not available. MCPD was reportedly constructed by excavating soils within MCPD (silts and clays), and the excavated materials were utilized for pond berms. The lined portion of MCPD included a 60-mil HDPE bottom liner. The proposed cover system will include a 60-mil HDPE liner, 18-inch infiltration soil layer, and a 6-inch erosion layer which has equivalent or less permeability than the existing bottom liner, and meets or exceeds the requirements of the CCR Rule.

2.2.2.2. Geometry and Stormwater Management

The geometry and stormwater management controls of MCPD following closure will allow the CCR Surface Impoundment to meet the following requirements outlined in §257.102(d) of the CCR Rule:

- Control, minimize, or eliminate, to the maximum extent feasible, post-closure infiltration of liquids into the waste and releases of CCR, leachate, or contaminated run-off to the ground or surface waters or to the atmosphere.
- Prevent future impoundment of water.
- Provide for slope stability to protect against sloughing or movement of the final cover system.

The closure system will be designed to provide adequate drainage during storm events. Intermediate swales will be utilized to limit the maximum overland flow distance, thereby minimizing ponded water, as well as limiting the infiltration of run-off.

2.2.2.3. Integrity of the Final Cover

Settling and subsidence of the final cover system is expected to be minimal. Settlement would potentially be caused by consolidation of the CCR material, general fill material, or underlying natural subsoils due to the dynamic loads typically resulting from construction activities; consequently, this settlement is expected to be minimal following final cover installation activities. General fill will be installed in a controlled manner to minimize post-fill installation settlement. Maintenance will be conducted as necessary to maintain the integrity of the final cover, as outlined in the Post-Closure Plan for MCPD (a separate document).

2.2.3. Final Cover Schedule

According to §257.101 of the CCR Rule, closure of the MCPD will commence no later than six months following the date on which a closure event is triggered. For the purposes of this Plan, closure of the lined portion of MCPD will assumed to have commenced when Ameren has ceased placing CCR material into MCPD and has completed any of the following actions or activities:

- Taken any steps necessary to implement the written Closure Plan.
- Submitted a completed application for any required state or agency permit or permit modification.
- Taken any steps necessary to comply with any state or other agency standards that are a prerequisite, or are otherwise applicable, to initiating or completing the closure of a CCR Unit.

In the event that closure of MCPD is required due to a location restriction or groundwater impacts, but not a safety factor assessment, the CCR unit may continue to receive CCR material beyond the six-month maximum duration, provided that MCPD satisfies the criteria specified in §257.103(a) or §257.103(b).

No later than the date Ameren initiates closure of MCPD, a Notification of Intent to Close the CCR Unit will be prepared. The notification will be considered to be completed when it has been placed in the facility's CCR Operating Record. The notification will then be placed on Ameren's CCR public website within 30 days.

2.2.3.1. Closure Completion

Closure for MCPD shall be completed within five years of commencing closure activities per the CCR Rule. The timeframe for completing closure of the CCR Unit may be extended if Ameren demonstrates that it is not feasible to complete closure of the CCR Unit within the required timeframe due to factors beyond the facility's control. A demonstration for an extension of the closure timeframe shall be completed pursuant to §257.102(f)(2).

For the purpose of this Closure Plan, closure of MCPD is considered complete when the final cover system is installed and applicable construction completion documentation is finalized. Based on the closure schedule provided in Appendix B, it is estimated that the closure of MCPD will be completed in less than five years. Closure of the approximate 21-acre lined portion of MCPD is expected to be completed in 2021.

Within 30 days of completion of closure of MCPD, Ameren will prepare a notification of closure and post it on the facility's CCR Operating Record and on Ameren's CCR public website. This notification will include certification by a professional engineer, registered in the State of Missouri verifying, that closure has been completed in accordance with this Closure Plan and the requirements of §257.102.

In accordance with §257.102(i), Ameren will record a notation on the deed to the property, following completion of closure. This notation is to inform any potential future owner of the property of the previous use of the land, and that the land is restricted by post-closure care requirements.

3.0 REVISIONS AND AMENDMENTS

The MCPD Closure Plan will be amended whenever there is a change in operation of the CCR unit that affects the current or planned closure operations. The Closure Plan will be amended 60 days prior to a planned change in operation, or within 60 days following an unplanned change in operation. If a written Closure Plan is revised after closure activities have commenced, the written Closure Plan will be amended no later than 30 days following the triggering event. The initial Closure Plan and any amendment will be certified by a professional engineer in the State of Missouri for meeting the requirements of §257.102 of the CCR Rule. All amendments and revisions will be posted on the CCR public website within 30 days following placement in the facility's CCR Operating Record. A record of revisions made to this document is included in Section 4.0 of this document.

4.0 REVISIONS AND AMENDMENTS

Revision	Date	Revisions Made	By Whom
0	10/13/2016	Initial Closure Plan	Burns & McDonnell
1	11/14/2016	Revisions to cover page to use Ameren's standard cover page, and Section 2.2.3.1 to include estimated year of MCPD closure	Burns & McDonnell
2	02/02/2021	Revisions to final cover system in Section 2.2.2 and other sections to reflect closure schedule	Reitz & Jens, Inc.

Appendix A

Site Aerial Figure

REITZ & JENS, INC.
CONSULTING ENGINEERS
1055 Corporate Square Drive
St. Louis, Missouri 63132
(314) 993-4132

SITE AERIAL

MERAMEC ENERGY CENTER
SURFACE IMPOUNDMENT MCPD
LINED PORTION CLOSURE

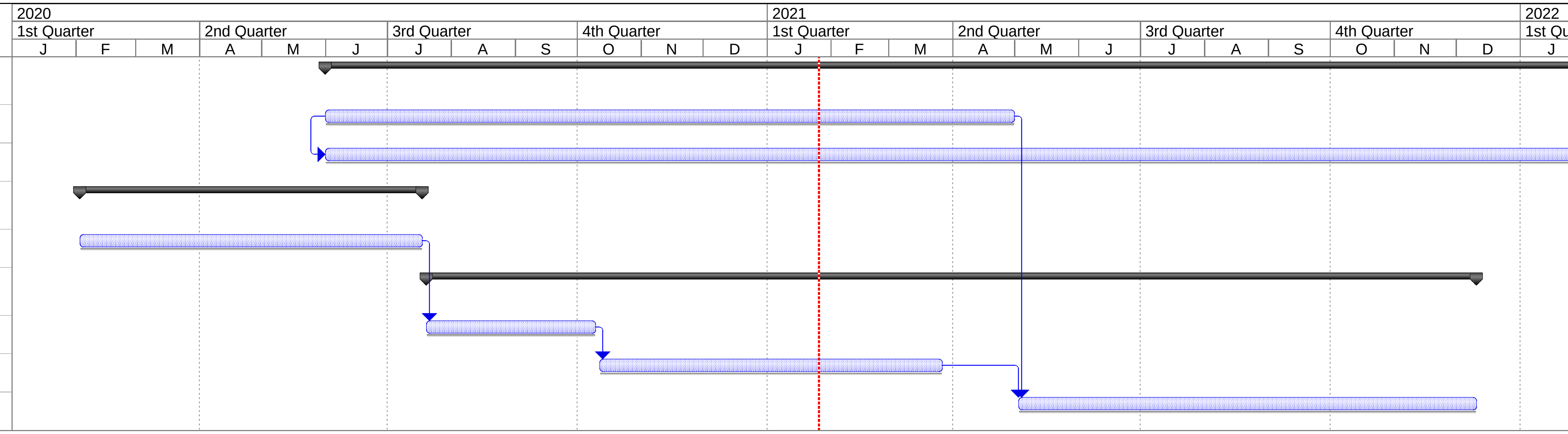
AMEREN MISSOURI
3700 S. Lindbergh
St. Louis, MO 63127

Appendix B

Closure Schedule

Meramec Energy Center
CCR Surface Impoundment MCPD (Pond 498)
Closure Schedule

ID	Task Name
1	**Energy Center Operation**
2	Disposal of CCRs in active portion of MCPD
3	Generation of Power and CCRs
4	**Permitting & Design (Lined Portion of MCPD)**
5	Permitting & Design
6	**Bidding & Construction (Lined Portion of MCPD)**
7	Issue/Obtain Bids
8	Review/Approval of Bid and Issuance of Purchase Order
9	Installation/Construction of Cover System



Task		Progress		Summary		External Tasks		Deadline	
Split		Milestone		Project Summary		External Milestone			

Tue 1/26/21 8:47 AM

Ameren MEC-MCPD(498) Closure Schedule.mpp

Meramec Energy Center
CCR Surface Impoundment MCPD (Pond 498)
CCR Unit Post-Closure Plan

Ameren Missouri

Project No. 90683

Revision 0
October 2016

Meramec Energy Center
CCR Surface Impoundment MCPD
(Pond 498)
CCR Unit Post-Closure Plan

Prepared for

Ameren Missouri
Project No. 90683
Ameren, Missouri

Revision 0
October 2016

Prepared by

Burns & McDonnell Engineering Company, Inc.
Kansas City, Missouri

INDEX AND CERTIFICATION

Ameren Missouri
Meramec Energy Center
CCR Surface Impoundment MCPD (Pond 498)
CCR Unit Post-Closure Plan

Report Index

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  - Maintaining the groundwater monitoring system and monitoring the groundwater in accordance with the requirements of §257.90 through §257.98.
- The name, address, telephone number, and email address of the person or office to contact about the facility during the post-closure care period.
- A description of the planned uses of the property during the post-closure period.
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2.1 Post-Closure Compliance

Post-closure maintenance shall be as described in §257.104(b) of the CCR Rule. The requirements consist of the following:

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Ameren will designate and list a contact person during the post-closure care period per §257.104 (d)(ii). The following individual will be Ameren's designated contact person for post-closure care of MCPD:

Contact	Ameren Missouri
Address	1901 Chouteau Avenue St. Louis, MO 63103
Phone No.	(800) 552-7583
Email	CCR@ameren.com

2.3 Property Use During Post-Closure Care Period

MCPD is located within a secured power plant facility, and access and use will be limited to inspection and groundwater monitoring activities.

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No later than 60 days following the completion of the post-closure care period, Ameren shall prepare a notification verifying that post-closure care has been completed and place the notification in the facility's CCR Operating Record. The notification shall include the certification by a qualified professional engineer in the State of Missouri, that post-closure care has been completed in accordance with the written Post-Closure Plan in effect and the requirements of §257.104.

3.0 REVISIONS AND AMENDMENTS

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The Post-Closure Plan shall be amended 60 days prior to a planned change in operation, or within 60 days following an unplanned change in operation. If a written Post-Closure Plan is revised after post-closure activities have commenced, it shall be amended no later than 30 days following the triggering event. The Post-Closure Plan and any amendments shall be certified by a qualified professional engineer in the State of Missouri for meeting the requirements of §257.104 of the CCR Rule. All amendments and revisions must be posted on the CCR public website within a reasonable amount of time following placement in the facility's CCR Operating Record. A record of revisions made to this document is included in Section 4.0 of this document. A record of revisions made to this document is included in Section 4.0.

4.0 RECORD OF REVISIONS AND UPDATES

Revision Number	Date	Revisions Made	By Whom
0	10/13/2016	Initial Post-Closure Plan	Burns & McDonnell

APPENDIX A – SITE AERIAL FIGURE

NORTH

0 150' 300'
SCALE IN FEET

BURNS McDONNELL

Figure 1

AMEREN MISSOURI
SURFACE IMPOUNDMENT MCPD
SITE AERIAL

Z:\CLIENTS\ENR\AMERENMO\90683_MERAMECCLOSURE\DESIGN\ENVIRO\SOLID_WASTE\MERAMEC CLOSURE PLANS\498 CLOSURE AND POSTCLOSURE\90683 - MCPD CLOSURE.DWG 9/22/2016 11:37 AM MGONZALES

BURNS & McDONNELL

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Burns & McDonnell World Headquarters
9400 Ward Parkway
Kansas City, MO 64114
O 816-333-9400
F 816-333-3690
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Meramec Energy Center
Certification of Completion for Final Cover System

As a Professional Engineer in the state of Missouri, I hereby certify that the closure of Surface Impoundment MCPD (Pond 498) at Ameren Missouri's Meramec Energy Center was completed on October 7, 2021 in general conformance with the plans and specifications issued for construction, and in accordance with the closure plan specified in 40 CFR §257.102(b) and the requirements of 40 CFR §257.102

Signature: ____________________

Name: Eric J. Karch

Date: October 7, 2021

Missouri License Number: 2007005040

Expiration Date: December 31, 2021

AMEREN MISSOURI: Meramec Energy Center

Notice of Intent to Initiate Closure of the Inactive Surface Impoundment MCPE (Pond 489)

Rev	Date	Revisions	Originator	Reviewer	Approver
0	12-09-15	Initial Issue	C. J. Giesmann		RCS 12-9-15

In 2000, Ameren Missouri constructed a 25-acre surface impoundment (denominated as pond #489 on technical drawings), for the management of coal ash materials generated at the Meramec Energy Center. While a synthetic (HPDE) liner was used in the construction of pond # 489, such liner system does not comply with the performance requirements set forth in the CCR Rule. Ameren Missouri intends to complete closure activities no later than April 17, 2018, effectively exempting the impoundment from all other CCR requirements. §40 CFR 257.100(b).

A closure plan encompassing technical analysis and engineering drawings is under development. Closure of Unit #489 will follow the engineering design and construction processes required by §40 CFR 257 and include the following elements:

1. CCR material will be left in place.
2. CCR material within the unit # 489 will be exposed to precipitation events until such time as the cap system is installed. Closure activities will include an assessment of saturation within the unit and whether additional dewatering activities are necessary to remove free liquids or to compact and stabilize the underlying ash material to support the final cover system. Measures will be taken to minimize post-closure infiltration of liquids.
3. Storm water will be routed to newly designed drainage systems so as to minimize water infiltration.
4. Material within the impoundment will be sloped and graded. Site specific slopes will be determined for the exterior embankment and the cap.
5. The impoundment will be covered with a cap system comprised of earthen materials (or other approved materials) and a synthetic liner designed to a performance standard of no less than 1×10^{-5} permeability. The cap will be covered with soil sufficient to support vegetative growth or other approved materials so as to minimize erosion. Excess embankment materials, if any, will be evaluated for use within the vegetative cover on the final cap.
6. Structural integrity analyses of the impoundment in the closed condition will be performed. Appropriate factors of safety will be defined to the following stability criteria: short and long term slope stability analysis (exterior berm and capping materials); seismic event slope stability (exterior embankment and cover materials); bearing capacity and maximum induced settlement.
7. A construction quality assurance (CQA) plan will be developed to verify construction occurs in accordance with project plans and specifications.

Set forth below is a preliminary schedule for the development and execution of a closure plan encompassing the above elements.

2016 – Detailed Engineering Design, Bidding

2017 – Construction

- Dewatering
- Drainage Improvement Installation
- Site Contouring
- Cap and Cover Installation

2018 – Project Completion prior to April 17th

PROFESSIONAL ENGINEER CERTIFICATION

The following PE Certification is certifying that the design of the final cover system will meet the requirements of 40 CFR 257.100(b)(3)(ii) and that the closure in place, 40 CFR 257.100(b)(1) through (4), of the inactive surface impoundment is technically feasible to be completed by April 17, 2018.

CRAIG J. GIESMANN

Printed Name of Professional Engineer

Signature

E-2001004593 MO 12-9-15

Registration No. **Registration State** **Date**

Meramec Energy Center
CCR Surface Impoundment MCPE
(Pond 489)
CCR Unit Closure Plan

Meramec Energy Center
CCR Surface Impoundment MCPE
(Pond 489)
CCR Unit Closure Plan

Prepared for

Ameren Missouri
Project No. 90683
Ameren, Missouri

Revision 1
April 2018

Prepared by

Burns & McDonnell Engineering Company, Inc.
Kansas City, Missouri

INDEX AND CERTIFICATION

Ameren Missouri
Meramec Energy Center
CCR Surface Impoundment MCPE (Pond 489)
CCR Unit Closure Plan

Report Index

Certification

I hereby certify, as a Professional Engineer in the state of Missouri, that the information in this document was assembled under my direct personal charge. This report is not intended or represented to be suitable for reuse by Ameren Missouri or others without specific verification or adaptation by the Engineer. I certify that this Closure Plan and the Final Cover System specified herein satisfy the requirements presented in 40 CFR §257.102(b).

04/11/18 5:58 PM

Scott A. Martin, P.E.
License Number 2010019572
License renewal date: December 31, 2018.
Pages or sheets covered by this seal: As noted above

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LIST OF FIGURES

Page No.

LIST OF ABBREVIATIONS

Abbreviation	Term/Phrase/Name
Ameren	Ameren Missouri
BMcD	Burns & McDonnell
CCR	Coal Combustion Residual
CCR Rule	EPA Coal Combustion Rule
CFR	Code of Federal Regulations
cm/sec	Centimeters per second
CQA	Construction Quality Assurance
CY	Cubic yard
EPA	Environmental Protection Agency
EPDM	Ethylene propylene diene monomer
HDPE	High-density polyethylene
HELP	Hydrologic Evaluation of Landfill Performance
LLDPE	Low-density polyethylene
MCPE	CCR Surface Impoundment MCPE or Pond 489
Meramec	Meramec Energy Center

1.0 INTRODUCTION

Ameren Missouri (Ameren) is subject to the CCR Rule and is required to develop a Closure Plan for CCR surface impoundments per 40 Code of Federal Regulations (CFR) §257.102. This document serves as Ameren's Closure Plan for the CCR Surface Impoundment MCPE (Pond 489) at the Meramec Energy Center (Meramec), which was affected by the August 5, 2016 CCR Rule revisions.

The Closure Plan is required to contain the following, as required in §257.102(b)(1):

- A description of the final cover system, methods for installing final cover system, and a discussion on how the final cover system is achieving compliance with the standards outlined in §257.102(d).
- An estimate of the maximum inventory of CCR material ever stored in the CCR Unit over its active life.
- An estimate of the largest area requiring a final cover as required by §257.102(d) at any time during the active life of the CCR Unit.
- A schedule for completing CCR Unit closure activities, including the anticipated year of closure and major milestones for permitting and construction activities.

2.0 CLOSURE PLAN

2.1 Facility and Surface Impoundment Description

Meramec is located in southeastern St. Louis County, Missouri and consists of four generating units (a site aerial figure is included as Appendix A). Units 1 and 2 are fired on natural gas (fuel switching from coal to natural gas was completed in April 2016), and Units 3 and 4 are fired on coal. CCR generated at the facility includes fly ash and bottom ash.

Surface Impoundment MCPE (Pond 489), referred to herein as MCPE, is located on the southwest side of the Meramec facility. MCPE contains an existing high density polyethylene (HDPE) geomembrane liner with a nominal 60-mil thickness; however, the liner system is not in compliance with the CCR Rule as it does not contain a compacted soil liner, or approved equivalent base liner below the geomembrane. MCPE has been classified as an unlined CCR surface impoundment.

2.1.1 CCR Inventory and Extent

MCPE has an approximate surface area of 25 acres, as measured within the perimeter dikes, which represents the largest area that would require a final cover. The estimated maximum inventory of CCR in MCPE is approximately 900,000 cubic yards (CY) of CCR material.

2.2 Closure Method

The CCR Rule allows for CCR Units to be closed by leaving CCR material in-place. MCPE is planned to be closed with CCR material in-place, and accordingly, will follow the closure performance standards referenced in 40 CFR §257.102(d). If the design or use changes in the future, this Closure Plan will be updated accordingly (see Section 3.0).

2.2.1 Drainage / Stabilization of CCR Material

Prior to installing the final cover system, Ameren will perform the following activities outlined in §257.102(d) of the CCR Rule:

- Eliminate free liquids by removing liquid wastes or solidifying the remaining wastes and waste residues.
- Stabilize remaining wastes sufficiently in order to support the final cover system.

Free liquids will be removed using constructed drainage channels and a pumping system, with excess water discharged under the current NPDES Permit. Free liquid removal will be performed throughout construction, as necessary, to manage surface water and storm water runoff. Prior to installing the final cover system, CCR materials will be graded to promote drainage and compacted in a controlled manner to stabilize CCR to sufficiently support the final cover system.

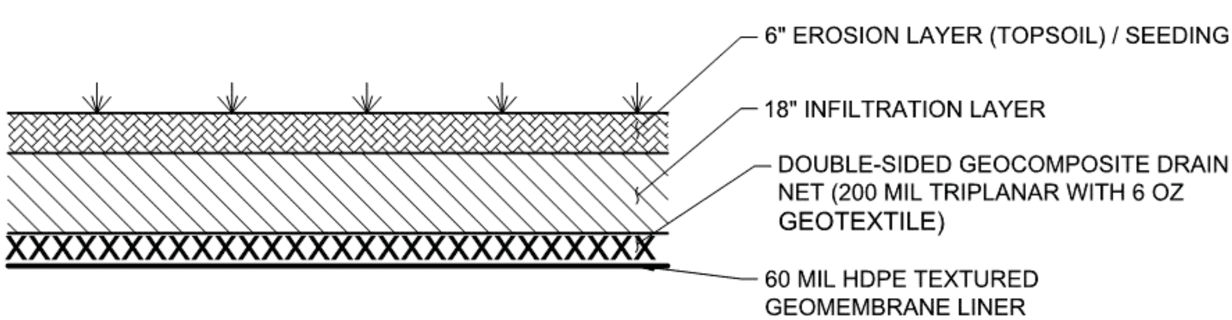
2.2.2 Final Cover System

The final cover system will be designed and constructed to meet the following criteria pursuant to §257.102(d)(3)(i):

- Have a permeability less than or equal to the permeability of any bottom liner system or natural subsoils present, or a permeability no greater than $1x10^{-5}$ centimeters per second (cm/sec), whichever is less.
- The infiltration of liquids through the closed CCR Unit must be minimized by the use of an infiltration layer that contains a minimum of 18 inches of earthen material.
- The erosion of the final cover system must be minimized by the use of an erosion layer that contains a minimum of six inches of earthen material that is capable of sustaining native plant growth.
- The disruption of the integrity of the final cover system must be minimized through a design that accommodates settling and subsidence.
- The owner or operator may select an alternative final cover system design, provided the alternative final cover system meets the above requirements.

MCPE will be capped and closed in-place as described herein, and in accordance with the requirements of the CCR Rule. MCPE will be closed using an alternative cover system, which will consist of (from bottom to top): a 60-mil high density polyethylene (HDPE) flexible geomembrane material, a geocomposite drainage layer, a nominally compacted 18-inch infiltration soil layer, and 6-inch erosion layer that is capable of sustaining native plant growth. A typical cross section of this alternative cover system is shown in Figure 2-1.

Figure 2-1: Final Cover System



A construction quality assurance (CQA) plan has been prepared, and the CQA program will be implemented during construction of the cover system.

2.2.2.1 Permeability and Infiltration

The federal minimum standard requires MCPE's cover system permeability to be less than or equal to that of the bottom liner, natural underlying subsoils, or $1x10^{-5}$ cm/sec, whichever is less.

The final cover system has an equivalent permeability to the existing liner system, and conforms to the closure requirements of the CCR Rule.

2.2.2.2 Geometry and Stormwater Management

The geometry and stormwater management controls of MCPE, following closure, will allow the CCR Unit to meet the following requirements as outlined in §257.102(d) of the CCR Rule:

- Control, minimize, or eliminate, to the maximum extent feasible, post-closure infiltration of liquids into the waste and releases of CCR, leachate, or contaminated run-off to the ground or surface waters or to the atmosphere.
- Prevent future impoundment of water.
- Provide for slope stability to protect against sloughing or movement of the final cover system.

The closure system will be designed to provide adequate drainage during storm events. Intermediate swales will be utilized to limit the maximum overland flow distance, thereby minimizing ponded water, and limiting the infiltration of run-off.

2.2.2.3 Integrity of the Final Cover

Materials will be placed and compacted in a controlled manner to minimize post-fill installation settlement. Settlement would potentially be caused by consolidation of the CCR material, general fill material, or underlying natural subsoils due to the dynamic loads typically resulting from construction activities; consequently, this settlement is expected to be minimal following final cover installation activities. Maintenance will be conducted as necessary to maintain the integrity of the final cover, as outlined in the Post-Closure Plan for MCPE (separate document).

2.2.3 Final Cover Schedule

Closure activities commenced in 2017 as per the December 9, 2015 Notification of Intent to Close MCPE. The notification has been placed in the facility's CCR Operating Record, and is posted on Ameren's CCR public website.

2.2.3.1 Closure Completion

Closure for MCPE shall be completed within five years of commencing closure activities per the CCR Rule. The timeframe for completing closure of the CCR Unit may be extended if Ameren demonstrates that it is not feasible to complete closure of the CCR Unit within the required timeframe due to factors beyond the facility's control. A demonstration for an extension of the closure timeframe can be completed pursuant to §257.102(f)(2).

For the purpose of this Closure Plan, closure of MCPE is considered complete when the final cover system is installed. Per the closure schedule provided in Appendix B, the closure of MCPE was completed in less than five years.

Within 30 days of completion of closure of MCPE, Ameren will prepare a notification of closure and post it on the facility's CCR Operating Record and on Ameren's CCR public website. This notification shall include certification by a qualified professional engineer, registered in the State of Missouri, verifying that closure has been completed in accordance with this Closure Plan and the requirements of §257.102.

Following closure, Ameren will record a notation on the deed of the Meramec property, and within 30 days of the deed notation, Ameren will prepare a notification stating that the notation has been recorded per §257.102(i) and placed within the CCR Unit's Operating Record.

In accordance with §257.102(i), Ameren will record a notation on the deed to the property, following completion of closure. This notation is inform any potential future owner of the property of the previous use of the land, and that the land is restricted by post-closure care requirements.

3.0 REVISIONS AND AMENDMENTS

This initial MCPE Closure Plan shall be placed in the CCR Operating Record by April 17, 2018. The MCPE Closure Plan will be amended whenever there is a change in operation of the CCR unit that affects the current or planned closure operations. The Closure Plan will be amended 60 days prior to a planned change in operation, or within 60 days following an unplanned change in operation. If a written Closure Plan is revised after closure activities have commenced, the written Closure Plan will be amended no later than 30 days following the triggering event. The initial Closure Plan and any amendment will be certified by a qualified professional engineer in the State of Missouri for meeting the requirements of §257.102 of the CCR Rule. All amendments and revisions will be posted on the CCR public website within 30 days following placement in the facility's CCR Operating Record. A record of revisions made to this document is included in Section 4.0 of this document.

4.0 RECORD OF REVISIONS AND UPDATES

Revision Number	Date	Revisions Made	By Whom
0	4/27/17	Initial Closure Plan	Burns & McDonnell
1	4/11/18	Updated the closure schedule and associated narrative in Sections 2.2.3 and 2.2.3.1	Burns & McDonnell

APPENDIX A – SITE AERIAL FIGURE

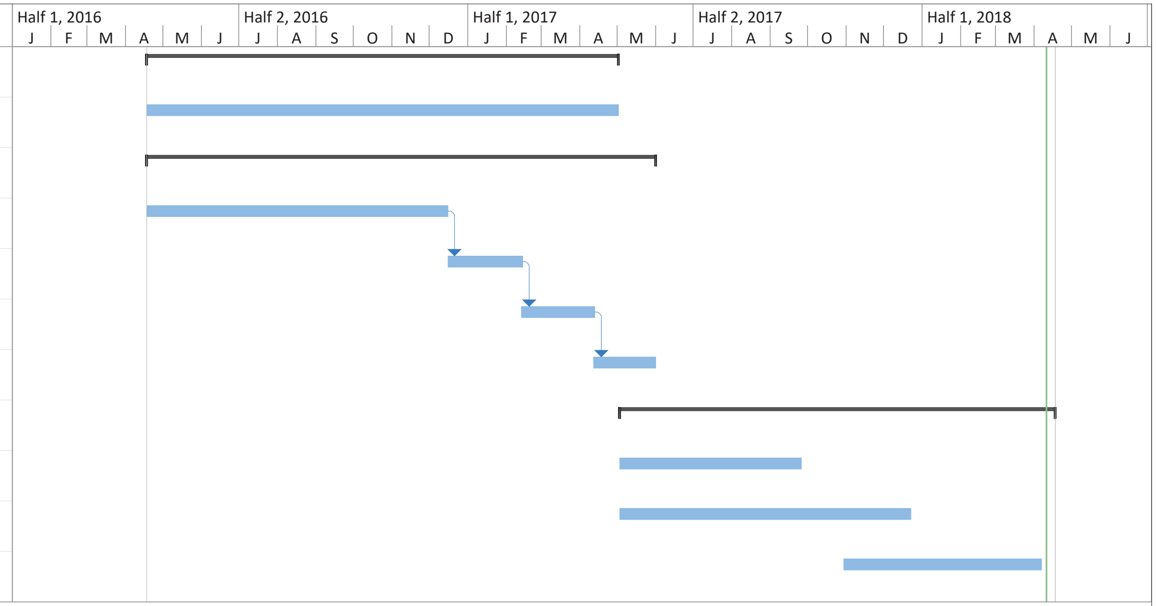
BURNS McDONNELL

FIGURE 1

AMEREN MISSOURI
SURFACE IMPOUNDMENT MCPE
SITE AERIAL

APPENDIX B – CLOSURE SCHEDULE

ID	Task Name	Start	Finish
1	**Permitting & Design Support**	**Mon 4/18/16**	**Mon 5/1/17**
2	Permitting and Design	Mon 4/18/16	Mon 5/1/17
3	**Preparation for Closure**	**Mon 4/18/16**	**Wed 5/31/17**
4	Design Documents Issued for Bid	Mon 4/18/16	Thu 12/15/16
5	Bid Period	Fri 12/16/16	Mon 2/13/17
6	Bid Evaluation	Mon 2/13/17	Wed 4/12/17
7	Contract Award	Wed 4/12/17	Wed 5/31/17
8	**Construction**	**Wed 5/3/17**	**Tue 4/17/18**
9	Remove Free Liquids	Wed 5/3/17	Mon 9/25/17
10	Grading CCR Material and Prepare Surface for Cover	Wed 5/3/17	Fri 12/22/17
11	Placement of Final Cover System	Mon 10/30/17	Fri 4/6/18



Project: MCPE Impoundment Closure

Task
Split
Milestone
Summary
Project Summary
External Tasks
External Milestone
Inactive Task
Inactive Milestone
Inactive Summary
Manual Task
Duration-only
Manual Summary Rollup
Manual Summary
Start-only
Finish-only
Deadline
Progress
Manual Progress

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Meramec Energy Center
CCR Surface Impoundment MCPE
(Pond 489)
CCR Unit Post-Closure Plan

Meramec Energy Center
CCR Surface Impoundment MCPE
(Pond 489)
CCR Unit Post-Closure Plan

Prepared for

Ameren Missouri
Project No. 90683
Ameren, Missouri

Revision 0
April 2017

Prepared by

Burns & McDonnell Engineering Company, Inc.
Kansas City, Missouri

INDEX AND CERTIFICATION

Ameren Missouri
Meramec Energy Center
CCR Surface Impoundment MCPE (Pond 489)
CCR Unit Post-Closure Plan

Report Index

Chapter Number	Chapter Title	Number of Pages
1.0	Introduction	1
2.0	Details of Post-Closure	2
3.0	Revisions and Amendments	1
4.0	Record of Revisions and Updates	1
Appendix A	Site Aerial Figure	1

Certification

I hereby certify, as a Professional Engineer in the state of Missouri, that the information in this document was assembled under my direct personal charge. This report is not intended or represented to be suitable for reuse by Ameren Missouri or others without specific verification or adaptation by the Engineer. I certify that this Post-Closure Plan document satisfies the requirements presented in 40 CFR §257.104(d).

04/27/17 1:35 PM

Scott A. Martin, P.E.
License Number 2010019572
License renewal date: December 31, 2018.
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LIST OF ABBREVIATIONS

Abbreviation	**Term/Phrase/Name**
Ameren	Ameren Missouri
BMcD	Burns & McDonnell
CCR	Coal Combustion Residual
CCR Rule	EPA Coal Combustion Rule
CFR	Code of Federal Regulations
EPA	Environmental Protection Agency
MCPE	CCR Surface Impoundment MCPE or Pond 489
Meramec	Meramec Energy Center

1.0 INTRODUCTION

Ameren Missouri (Ameren) is subject to the CCR Rule and is required to develop a Post-Closure Plan for existing CCR surface impoundments per 40 Code of Federal Regulations (CFR) §257.104. This document serves as Ameren's Post-Closure Care Plan for the CCR Surface Impoundment MCPE (Pond 489) at the Meramec Energy Center (Meramec), which was affected by the August 5, 2016 CCR Rule revisions. The Post-Closure Plan is required to contain the following per §257.104(d)(1):

- A description of post-closure care maintenance activities (and frequency of these activities) including the following:
  - Maintaining the integrity and effectiveness of the final cover system (if capped in place), including making repairs to the final cover as necessary to correct the effects of settlement, subsidence, erosion, or other events, and preventing run-on and run-off from eroding or otherwise damaging the final cover.
  - Maintaining the groundwater monitoring system and monitoring the groundwater in accordance with the requirements of §257.90 through §257.98.
- The name, address, telephone number, and email address of the person or office to contact about the facility during the post-closure care period.
- A description of the planned uses of the property during the post-closure period.
  - Post-closure use of the property shall not disturb the integrity of the final cover, liner(s), or any other component of the containment system, or the function of the monitoring system unless necessary to comply with §257.104, or if the owner or operator of the CCR unit demonstrates that the disturbance (including any removal of CCR) will not increase the potential threat to human health or the environment.

2.0 DETAILS OF POST-CLOSURE

Meramec is located in southeast St. Louis County, Missouri and consists of four generating units (a site aerial figure is included as Appendix A). Units 1 and 2 are fired on natural gas (fuel switching from coal to natural gas was completed in April 2016), and Units 3 and 4 are fired on coal. CCR generated at the facility includes fly ash and bottom ash.

Surface Impoundment MCPE (Pond 489) is located on the southwest side of the Meramec facility. MCPE has an existing high density polyethylene (HDPE) geomembrane liner with a nominal 60-mil thickness; however, the liner system is not in compliance with the CCR Rule as it does not contain a compacted soil liner, or approved equivalent base liner below the geomembrane. MCPE has been classified as an unlined CCR surface impoundment. A Closure Plan was prepared by Burns & McDonnell per section §257.102(b)(1) of the Federal CCR Rule. MCPE will be closed and capped in place as described in the Closure Plan, which will be available on Ameren's CCR website.

2.1 Post-Closure Compliance

Post-closure maintenance shall be as described in §257.104(b) of the CCR Rule. The requirements consist of the following:

- Maintaining the integrity and effectiveness of the final cover system, including making repairs to the final cover as necessary to correct the effects of settlement, subsidence, erosion, or other events, and preventing run-on and run-off from eroding or otherwise damaging the final cover.
- Maintaining the groundwater monitoring system.

Ameren will achieve compliance with the above requirements through final cover inspection and maintenance of MCPE, which will be conducted for a period of 30 years after the completion of closure activities. Inspection and maintenance activities will be monitored during annual inspections that will occur throughout the post-closure care period. Inspection activities are discussed further in Section 2.1.2.

2.1.1 Groundwater Monitoring

Ameren will conduct sampling, analysis and reporting of the MCPE groundwater monitoring network per §257.90 through §257.98, for the entire 30 years of post-closure care. Per §257.104(c)(2), should any of the groundwater monitoring results cause MCPE to enter or remain in an Assessment Monitoring Program (§257.95) at the end of the 30-year post-closure care period, Ameren will continue monitoring the groundwater until MCPE is able to return to the Detection Monitoring Program (§257.94).

2.1.2 Site Inspections

Site inspections will be performed annually (at minimum) during the post-closure care period to confirm that the integrity and effectiveness of the final cover system is maintained per Section §257.104(b)(1). Maintenance of the final cover will include making repairs, as necessary, to correct the effects of settlement, subsidence, erosion, or other events, and to prevent run-on and run-off from eroding or otherwise damaging the final cover. During the site inspections, Ameren will also inspect groundwater monitoring wells to confirm that they are structurally intact and appear to be in good working condition.

2.2 Post-Closure Contact

Ameren will designate and list a contact person during the post-closure care period per §257.104 (d)(ii). The following individual will be Ameren's designated contact person for post-closure care of MCPE:

Contact	Ameren Missouri
Address	1901 Chouteau Avenue St. Louis, MO 63103
Phone No.	(800) 552-7583
Email	CCR@ameren.com

2.3 Property Use During Post-Closure Care Period

MCPE is located within a secured power plant facility, and access and use will be limited to inspection and groundwater monitoring activities. Future additional uses of the area can be evaluated for purposes that maintain the final cover and do not increase the potential threat to human health or the environment.

2.4 Completion of Post-Closure Care

No later than 60 days following the completion of the post-closure care period, Ameren shall prepare a notification verifying that post-closure care has been completed and place the notification in the facility's CCR Operating Record. The notification shall include the certification by a qualified professional engineer in the State of Missouri, that post-closure care has been completed in accordance with the written Post-Closure Plan in effect and the requirements of §257.104.

3.0 REVISIONS AND AMENDMENTS

This initial MCPE Post-Closure Plan shall be placed in the CCR Operating Record by April 17, 2018. The plan is required to be amended whenever there is a change in the operation of the CCR Unit that affects the current or planned post-closure activities.

The Post-Closure Plan shall be amended 60 days prior to a planned change in operation, or within 60 days following an unplanned change in operation. If a written Post-Closure Plan is revised after post-closure activities have commenced, it shall be amended no later than 30 days following the triggering event. The Post-Closure Plan and any amendments shall be certified by a qualified professional engineer in the State of Missouri for meeting the requirements of §257.104 of the CCR Rule. All amendments and revisions must be posted on the CCR public website within a reasonable amount of time following placement in the facility's CCR Operating Record. A record of revisions made to this document is included in Section 4.0 of this document. A record of revisions made to this document is included in Section 4.0.

4.0 RECORD OF REVISIONS AND UPDATES

Revision Number	Date	Revisions Made	By Whom
0	4/27/17	Initial Post-Closure Plan	Burns & McDonnell

APPENDIX A – SITE AERIAL FIGURE

BURNS McDONNELL

FIGURE 1

AMEREN MISSOURI
SURFACE IMPOUNDMENT MCPE
SITE AERIAL

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BURNS & McDONNELL

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Kansas City, MO 64114
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F 816-333-3690
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BURNS McDONNELL

I hereby certify, as a Professional Engineer in the State of Missouri, that the closure of Surface Impoundment MCPE (Pond 489) at Ameren Missouri's Meramec Energy Center was completed on April 6, 2018 in accordance with the closure plan specified in 40 CFR §257.102(b) and the requirements of 40 CFR §257.102.

04/11/18 6:01 PM

Scott A. Martin, P.E.
License Number 2010019572
License renewal date: December 31, 2018.

9400 Ward Parkway \ Kansas City, MO 64114
O 816-333-9400 \ **F** 816-333-3690 \ burnsmcd.com

APPENDIX D
Treatability Study Documentation

December 31, 2019 *Via e-Mail* (bmiller2@ameren.com)

Ameren Services
1901 Chouteau Avenue
PO Box 66149, MC 6
St. Louis, MO 63166-6149

RE: Ashpond Metals Treatability Study Results

XDD Project No. 19005.00, 19005.01, 19010.00, and 19011.0

XDD ENVIRONMENTAL, LLC (XDD) appreciates the opportunity to provide Ameren Services (Ameren) with the results of the data evaluation, bench-scale treatability testing, and remedial technology evaluation to address elevated levels of arsenic (As), molybdenum (Mo), lithium (Li), boron (B), and other site metals in ashponds leachate / groundwater from the Rush Island Energy Center (RIEC), the Meramec Energy Center (MEC), the Labadie Energy Center (LEC), and the Sioux Energy Center (SEC). The bench-scale testing was performed in accordance with the scope of work described in XDD's *Proposal for Metals Treatability Study* dated February 12, 2019, *Proposal for Metals Treatability at the Labadie Energy Center* dated April 23, 2019, and *Proposal for Metals Treatability at the Sioux Energy Center* dated April 23, 2019, with modifications as noted in this report. The report herein includes preliminary results of the treatability testing for all sites with a final pilot study design approach for RIEC.

If you have any questions regarding the information presented in this report, please do not hesitate to call me at 314.609.3065.

Sincerely,

DEREK INGRAM

XDD Environmental

cc:

Michael Marley
Laurel Crawford
Bridget Cavanagh

ASHPOND METALS TREATABILITY STUDY RESULTS

Ameren Services

Prepared For:

AMEREN SERVICES
1901 CHOUTEAU AVENUE
PO BOX 66149, MC6
ST. LOUIS, MO 63166-6149

Prepared By:

22 MARIN WAY
STRATHAM, NH 03885
TEL: (603) 778-1100
FAX: (603) 778-2121

December 31, 2019

EXECUTIVE SUMMARY

XDD Environmental (XDD) was retained by Ameren Services (Ameren) to perform metals treatability studies for the remediation of arsenic, molybdenum, lithium, boron, and other metals of concern (MOC) from ashpond leachate / groundwater. Phase 1 of the three phases of treatability studies included a review of geological conditions and existing metals in leachate from four sites [Rush Island Energy Center (RIEC), Meramec Energy Center (MEC), Labadie Energy Center (LEC), and Sioux Energy Center (SEC)]. In addition, the Phase 1 involved literature research on possible treatment trains and chemical conditions favorable for the MOC remediation. The results from the Phase 1 study identified several possible in situ treatment technologies for further evaluation, including: pH adjustment, iron precipitation / coprecipitation, zero valent iron (ZVI), metals reducing geochemical conditions, and biological stimulation as possible approaches to be tested in the Phase 2 studies.

The Phase 2 studies evaluated the Phase 1 identified treatment approaches effectiveness for MOC remediation using site groundwaters and soils, mimicking an in situ treatment application. The primary objective of the Phase 2 testing was to determine which treatment approaches / changes to geochemical conditions would promote adsorption, precipitation, or coprecipitation of the MOC, without adversely affecting the dissolved and total MOC concentrations in groundwater or other metals present at the site. The tests were carried out for periods of one to eight weeks (depending on the technology under evaluation). Of the remedial approaches tested in Phase 2, microscale ZVI and pH reduction (to pH 6) were the only methods that treated arsenic and molybdenum (the two metals of greatest regulatory concern at RIEC) to the required criteria. The other remedial approaches tested had limited to no impact on the MOC in groundwater.

The results from the Phase 2 testing were to be used to refine Phase 3 testing and to develop the pilot test design for the RIEC site. However, prior to the Phase 3 testing, boron was changed from a secondary to a primary MOC. Microscale ZVI was the only technology that had been shown to remove boron from groundwater in the Phase 2 testing; additional research identified an ion-specific resin (resin) that could treat boron to the required criteria using an ex situ remedial approach. The addition of boron as a primary MOC, along with concerns with clogging of the aquifer from precipitation of site metals, and the complexity of in situ treatment of boron, resulted in a transition from an in situ to an ex situ treatment system conceptual treatment approach for all sites MOC. The primary concern /difference in the transition from in situ to ex situ treatment is the decreased treatment time; the available in situ treatment time based on site hydraulics is weeks to a month or more; ex situ treatment requires a few minutes to hours of reaction time to permit a practical and cost-effective remedial approach.

Accordingly, for the Phase 3 treatability studies, pH adjustment, microscale ZVI, and ferric chloride addition (added due to additional literature research on the decreased available reaction timeframes for ex situ treatment) were tested for the treatment of arsenic and molybdenum in the RIEC groundwater, with polishing of the treated groundwater using resin for boron removal. The results of the Phase 3 testing identified pH adjustment, ferric chloride aided precipitation, sand filtration, and resin polishing as the most effective and reliable ex situ treatment option for RIEC groundwater.

Going forward, the results of the Phase 3 treatability testing for the RIEC groundwater will be used to guide the finalization of the treatability testing of the other sites ashpond leachate / groundwaters. Each of the individual sites unique water geochemical conditions, MOC, and hydraulics will require evaluation to ensure a reliable treatment approach design for each site.

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1.0 INTRODUCTION

XDD Environmental (XDD) was retained by Ameren Services (Ameren) to perform metals treatability studies on ashpond leachate / groundwater from four sites: Rush Island Energy Center (RIEC), Meramec Energy Center (MEC), Labadie Energy Center (LEC), and Sioux Energy Center (SEC). The primary objective of the studies was to evaluate potential remedial technologies for metals of concern (MOC) identified as part of the requirements of United States Environmental Protection Agency (USEPA) 40 CFR Part 257 "Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals From Electric Utilities; Final Rule" (the CCR Rule). The CCR Rule requires owners or operators of existing CCR units to produce an Annual Groundwater Monitoring and Corrective Action Report (Annual Report) each year (§§ 257.90(e)). XDD was provided, through a third party, data from the annual reports, samples from compliance wells with previously identified elevated MOC concentrations, and applicable statistically determined action levels (target goals for MOC treatment) for each site.

The treatability studies were developed and completed using a conservative approach of testing groundwaters from the areas of highest MOC concentrations, with the understanding that proposed engineered caps for each site should result in reduced MOC groundwater concentrations over time. Though the MOC and regulatory concerns are similar at each site, site-specific groundwater geochemistry's and varying MOC concentrations required XDD to approach treatment for each site separately. This approach ensures certainty in the MOC treatment effectiveness based on the differing site conditions and MOC concentrations for each site. It also provides for information needed in developing a treatment train specific to each site to address the differing geochemical conditions.

Initially, the primary MOC at the sites (though not all present at all sites) were arsenic, molybdenum, and lithium. Other potential MOC carried through the studies for each site (though again not all present at all sites) included boron, lead, cobalt, and selenium. A key component of the study was to determine if a potential MOC treatment approach would affect other metals in site groundwater and soil in either a positive (reduced concentration) or negative (increased concentration) manner. Baseline MOC / metals concentrations for all four sites (five locations; two sample sets being studied at MEC due to the presence of localized lithium) are presented in **Table 1**. The initial conceptual remedial approach was to treat the metals in situ, taking advantage of the slow moving groundwaters at the sites (allowing weeks of treatment time for MOC removal to occur), and for the potential for the most cost-effective treatment.

Around June 2019, during the performance of the treatability studies, per direction from Ameren, boron was transitioned from a potential MOC to a primary MOC, to account for an anticipated revision in the CCR Rule compliance. With this transition, any remedial option would be required to include boron treatment to below the applicable action. The complexity of in situ treatment of boron and its limited treatability options became a primary driver to change the conceptual treatment approach to ex situ treatment for the sites groundwaters.

This report focuses on the initial literature research conducted for all sites, initial treatability testing of the leachate / groundwater for all sites (for in situ treatment), then a refocus of the studies to consider ex situ treatment of the MOC (with boron added as a MOC), and finally the refinement of the treatment effectiveness and development of a MOC remedial approach for pilot testing at RIEC. The results from the additional treatability studies performed for RIEC will be used to guide refinement of the treatability studies and pilot test design for the other three sites (MEC, LEC, and SEC).

The three primary approaches for metals removal from groundwater are:

- **Precipitation**: Transformation of a dissolved species to a solid form, which can then settle out of suspension.
- **Coprecipitation with other minerals**: Transformation of a dissolved species to a solid form that combines with another material (such as iron), which can then then settle out of suspension.
- **Adsorption**: Introduction or production of a solid that will absorb the MOC from the groundwater.

The treatability studies for each site consisted of two phases; with a final / third phase conducted on RIEC only, at this time, each of the three phases of testing are described below:

- Phase 1 – Site Review and Data Evaluation for Preparation of the Treatability Study Design (**Appendix A**)
    - o Compare site-specific data to each site's MOC target goals and develop a conceptual MOC remedial approach based on a summary of the site-specific geochemical and hydrological conditions.
    - o Evaluate existing literature to identify potential remedial options for the MOC to be tested for each site.
- Phase 2 – Bench-Scale Treatability Study for In Situ Remediation of MOCs
    - o Based on the literature review results from Phase 1, bench-scale reactors were developed, using site soil and groundwater, to evaluate promising in situ treatment technologies or treatment trains. Treatment options identified in the Phase 1 review included (**Table 2**):
        - pH adjustment

      - Addition of calcium polysulfide (CaSx)
      - Addition of dissolved iron
      - Addition of microscale zero valent iron (ZVI)
      - Addition of particle size ZVI
      - Biodegradation / biostimulation in conjunction with ZVI.
  - The focus of Phase 2 testing was to identify specific MOC removal methods from site groundwater over the course of a one month treatment period without adversely affecting other MOCs in the groundwater (e.g., mobilizing MOCs present on site soils). The one month treatment period was selected based on the groundwater flow rates from the proposed in situ treatment application area to the regulatory point of compliance; actual site-specific treatment periods will have some variance greater than this selected period.
- Phase 3 –Treatment Train Development for Ex Situ Remediation of the MOCs at RIEC
  - Per above, boron was added as a primary MOC during the Phase 2 testing timeframe. The limitation to the availability and the complexity of in situ remedial options for boron removal, along with concern for long-term aquifer clogging from MOC precipitation / coprecipitation, caused a change in the conceptual remedial approach for the sites from an in situ to an ex situ treatment train process. The primary consequence of the change was the available time for treatment of metals in an above-surface treatment train. For in situ remediation, a one month MOC treatment period was readily available for the sites; however, for practical and cost-effective ex situ MOC remediation, the treatment period would need to be reduced to minutes to a few hours, dependent upon groundwater extraction rates and storage limitations of the ex situ treatment processes.
  - Additional literature research suggested that the most reliable approach for removal of boron from groundwater was boron selective ion-exchange resins (resin)
  - Based on the RIEC Phase 2 treatability study results, ZVI and pH adjustment were identified as potential effective in situ remedial options for the initial MOCs at RIEC. One of the ZVI products tested in Phase 2 was effective on boron, though pH adjustment had no effect. Accordingly, the following column tests were conducted in the Phase 3 testing:
      - Initial groundwater pH adjustment, followed by passing groundwater through a column filled with a ZVI/sand mixture for treatment of arsenic

and molybdenum, with evaluation of the treatment effectiveness of that system for boron

- pH adjustment of groundwater to approximately pH 6, followed by passing the groundwater through a sand column for treatment of arsenic and molybdenum only
- Addition of a column filled with resin after the ZVI/sand column and the pH followed by sand column tests, for additional treatment of boron

- Based on the change to an ex situ remedial approach, requiring fast treatment periods (faster reaction kinetics), additional literature research identified the addition of ferric chloride to the groundwater as a potential approach for rapid arsenic removal through coagulation / flocculation / precipitation. The following additional tests were conducted to further evaluate ex situ treatment of arsenic and molybdenum:
  - Initial groundwater pH adjustment, followed by the addition of ferric chloride, followed by settling of the developed precipitants and filtration to remove the suspended precipitants from the groundwater
  - A resin filled column after the above filtration step for treatment of boron

Details on each of these three phases of treatment are provided in the following sections of this report.

2.0 PHASE 1 LITERATURE REVIEW

An extensive literature review was conducted for in situ treatment and general chemical behavior of the MOC prior to the selection of remedial options for consideration for the sites. The results of the literature review are presented in **Appendix A**. The literature review was necessary since the MOC precipitate, co-precipitate, or adsorb under varying geochemical conditions; however, these preferred MOC treatment geochemical conditions may result in increased mobility of other metals / MOC at the sites. The literature review identified the geochemical conditions that were either favorable for the MOC to be removed from the groundwater or would not negatively affect other MOC present. From this research, potential treatment trains were identified for remediating site MOC and for Phase 2 treatability testing.

3.0 PHASE 2 – TREATABILITY TESTING

3.1 Phase 2 Experimental Procedures

Based on the initial literature review, five mechanisms were identified as possible treatment approaches for the in situ removal of arsenic, molybdenum, and lithium from the sites groundwaters. The selection of arsenic, molybdenum, and lithium as the MOC was based on detections above the provided statistically-derived action levels for at least one of the four sites evaluated (**Table 1**). Boron was initially not on the list of primary MOC but as a metal being analyzed for since it does not have a current regulatory required action level. Boron was added as a primary MOC in the Phase 3 testing, per the request of Ameren and as a statistically-derived action level for each site was provided.

Below is a summary of each of the Phase 2 potential in situ approaches tested. A breakdown of the experimental setup for the approaches tested are presented in **Table 2**.

1. pH adjustment (7-day test)
    - For the pH adjustment, a range of pH of 6 to 10 was evaluated for RIEC to determine how the MOC concentrations would change as the pH decreased (at RIEC the initial pH in groundwater from monitoring well MW-2 was 11). Reduction and maintaining a pH of 6 resulted in arsenic and molybdenum removal after a week of treatment, without adversely affecting the concentrations of the other MOC present; therefore, this approach was maintained for testing of the other sites groundwaters.
2. Addition of calcium polysulfide (CaSx) (7-day test)
    - CaSx has been proven to reduce certain dissolved metal concentrations through forcing of reduced groundwater chemistry and subsequent metal sulfide formation. The dosage of CaSx used in these tests was based on a 1:2 mass of metals to mass of CaSx, with a 100 percent (%) safety factor (**Table 2**).
3. Addition of ferrous iron (4-week test)
    - The RIEC site groundwater samples have low concentrations of dissolved iron; dissolved iron is beneficial for the coprecipitation of certain MOC and as a sorbent for MOC. Dissolved iron (ferrous sulfate at 50 mg/L) was added to the site groundwater and soil. The test was conducted under both aerobic and anaerobic groundwater chemistries to determine if coprecipitation or sorption of the MOC can be induced.

4. Addition of ZVI (4-week test)
    - ZVI can also introduce dissolved iron, under anaerobic conditions, into groundwater for coprecipitation and possible adsorption of the MOC.
    - Two ZVI products were evaluated as potential remedial options: a microscale (7 micron) product, which is typically injected into the subsurface, and granular ZVI, which is commonly used in permeable reactive barriers (PRBs) (SR.25 particle size). Given the MOC concentrations present in site groundwater, ZVI dosages were established for the RIEC and MEC (MW-5 and MW-6) sites, based on manufacturer recommendations. While preliminary results from this approach suggested ZVI as a promising method for MOC removal, the required ZVI dosage was determined to be impractical for full-scale implementation. The ZVI dosage for the LEC and SEC site treatability tests were reduced to more practical dosage levels (see **Table 2**).
5. Biostimulation with ZVI addition (8-week test)
    - Test conditions, described in Test 4 above, were duplicated with the addition of food and nutrients, which are typically lacking in site groundwater and soils, to promote biotransformation of metals from a soluble to an insoluble form. Since biological processes are often slower than chemical processes, the biostimulated reactors were maintained for twice as long a treatment period as the ZVI only reactors (8 weeks vs. 4 weeks).

<u>**3.2 Phase 2 – Treatability Testing - Results**</u>

The results of the metals in groundwater analyses for the Phase 2 testing are presented in **Table 3** (RIEC), **Table 4** (MEC, MW-5), **Table 5** (MEC, MW-6), **Table 6** (LEC), and **Table 7** (SEC) for the in situ treatment approaches tested. The Phase 2 testing results suggest:

- A pH adjustment to 6 resulted in the reduction of arsenic and molybdenum to near action levels at all sites (Test 1).
- There was some benefit to using the granular size ZVI and a pH adjustment (reduction to 6) for the removal of arsenic and molybdenum (Test 4). Granular ZVI achieved action levels for arsenic and molybdenum for all sites, with the exception of molybdenum at SEC.
- There was minimal reduction in total metals concentrations for the tests conducted at a pH greater than 8 (Test 1).

- There was minimal reduction in MOCs as a result of treatment with CaSx, dissolved ferrous iron, or biostimulation (Tests 2, 3, and 5, respectively).
- Microscale ZVI was the only product tested that reduced boron to action levels for all sites, except for SEC.

Upon completion of the Phase 2 testing, per the request of Ameren, boron was added as a primary MOC with an action level of 4 mg/L. Of the approaches tested, microscale ZVI was the only approach that had a positive impact in reducing boron levels in groundwater. The literature research, supported by the phase 2 test results, suggests boron is most efficiently and reliably treated via ex situ filtration through a ion-selective resin. Given the addition of boron as a primary MOC and with concerns of long-term clogging of the site aquifers from metals precipitation, it was collectively decided to change the conceptual remedial approaches from an in situ to an ex situ treatment process. At this point in the testing (entering Phase 3), it was suggested by XDD and presented to Ameren, to focus on developing an ex situ remedial approach for RIEC to expedite the design and testing of a pilot scale system. The proposed Phase 3 treatability work and developed pilot test approach for RIEC would then be used to guide future Phase 3 testing and pilot test designs for the other sites (MEC, LEC, and SEC). An additional advantage of an ex situ remedial approach is the flexibility and ease of adjustment of an ex situ treatment system, given the variability in the groundwater geochemistry's and hydraulics across the four sites under evaluation. In addition, changes in site groundwater conditions are expected over time as both the consequences of the engineered cap placement and the potential ex situ treatment implementations stabilize, with respect to groundwater MOC concentrations.

4.0 PHASE 3 – TREATABILITY TESTING - RIEC

4.1 Phase 3 Experimental Procedures

The Phase 3 treatability testing focused on refining the ex situ remedial approach for RIEC and to finalize the RIEC pilot test design. The initial results from the Phase 2 testing for the in situ treatment of the MOC at RIEC, conducted in batch reactors with site groundwater and soil, supported that pH adjustment and the addition of ZVI were the most promising remedial options for treatment of arsenic and molybdenum (the primary MOC at RIEC) to action levels. The phase 3 testing consisted of a treatment train that was scaled, for the bench testing, using an ex situ conceptual pilot test design sized to fit within single or double Conex box (portable storage unit) treatment units, that could be positioned above ground at any of the sites.

The major design issue, refined in the Phase 3 testing, was the transition from the Phase 2 test results developed for an in situ treatment approach, to a reliable ex situ treatment train. For ex situ treatment to be practical and cost-effective the time of reaction (kinetics) to create precipitants needs to be on the order of minutes to a few hours. For the in situ approaches tested in Phase 2, a month-long contact time was available between amendments addition and for precipitation of metals to occur (based on the site groundwater velocity and distance from the remedial implementation area to the compliance sampling locations). For the in situ reaction timeframe, batch reactors were ideal. The required reaction timeframes for the Phase 3 testing made it necessary to use columns in the test procedures and to scale the reactor sizes and groundwater flow rates to match the conceptual field pilot and full-scale Conex box remedial systems sizing.

The Phase 3 treatability tests were also scaled for site hydraulics, assuming a 200-ft long cross-sectional treatment length, perpendicular to impacted groundwater flow, at the RIEC. Site-specific groundwater modeling was performed to determine the full-scale groundwater capture / flow rates required to permit an approximate 6 to 12-month pilot test duration to demonstrate the effectiveness of the treatment train. The pilot test treatment results need to be reflected both within the ex situ treatment process sampling points but also in existing compliance monitoring wells located within and downgradient of the treatment system hydraulic capture zone. For the RIEC site, the projected pilot test groundwater flow rate was estimated at 8 gallons per minute (gpm) (2 gpm per well) which is approximately four times the projected full-scale required groundwater flow rate.

It was also initially estimated that the ex situ treatment vessels (either filters or settling tanks) within the proposed Conex box system would have to be on the order of 750 to 1,000 gallons maximum capacity to fit in the unit, and that the Phase 3 testing would need to have reaction timeframes (kinetics) that would match the available vessel sizing. To scale the pilot test treatment train conceptual design to the Phase 3 treatability study design, the treatability study columns were made 3-inch (in) long and 1.5-in in diameter, with a groundwater flow rate of 0.7 milliliters per minute (mL/min).

Based on the results of the literature research and the Phase 2 testing, the initial Phase 3 tests were conducted with pH adjustment to pH 6 for the RIEC groundwater. The pH adjusted groundwater was then passed through a sand filter (with a residence time of 40 minutes) for arsenic and molybdenum removal. The pH adjusted groundwater was also tested by adding dissolved iron either via a ZVI/sand filter or by the addition of ferric chloride. Ferric chloride was incorporated into the Phase 3 testing due to the potential faster reactions times to create metal precipitates, per the discussion in Section 1 of this report. The ferric chloride was added to the groundwater to a concentration of 40 mg/L, the ferric chloride treated groundwater was passed into a settling vessel with a residence time of 1.25 hours, the metals were allowed to precipitate and settle, and the treated groundwater was passed through either a bag or a sand filter.

Since pH adjustment and iron addition had proved ineffective at boron removal in the Phase 2 testing, a resin filter was added to the effluent of the pH and iron addition ex situ treatment processes tested to evaluate the resins effectiveness for boron removal given the RIEC groundwater geochemistry. The resin was added post pH and ferric chloride addition as the resin is relatively expensive and focusing its use on the boron only is considered an overall more cost-effective approach for the groundwater treatment.

4.2 Phase 3 – Treatability Testing – RIEC – Results

Ferric Chloride ($FeCl_3$) Addition

The ex situ treatment method that proved most successful and reliable in the Phase 3 testing for pilot and full-scale implementation at the RIEC site is the pH adjusted, $FeCl_3$ aided flocculation / removal of arsenic and molybdenum. Preliminary testing with the ZVI and pH adjustment, discussed below, helped guide the design of the $FeCl_3$ treatment train. Understanding that the resin can be successful at removing boron at the concentrations present at the RIEC, Phase 3 testing focused on arsenic and molybdenum removal and developing a removal approach that worked effectively in the available ex situ treatment timeframes.

A preliminary Phase 3 test was performed to evaluate varying dosages of $FeCl_3$ and pH adjustment specific to the treatment of the arsenic in the RIEC groundwater. A kinetics / rate of treatment / reaction test was conducted where $FeCl_3$ was added to the groundwater and allowed to react, flocculate / precipitate and settle out of the groundwater for periods of 1 hour, 3 hours, and 6 hours, prior to flowing the groundwater through a sand filter column (**Table 8**). Since arsenic(V) is the form of arsenic that coprecipitates more readily with iron, hydrogen peroxide was tested as an oxidizer to transform any arsenic(III) in the groundwater to arsenic(V), prior to removal with the $FeCl_3$ addition. The results from the preliminary $FeCl_3$ tests suggested that:

- Both arsenic and molybdenum can be reduced to concentrations at or below action levels, using $FeCl_3$ addition.
- An initial pH of 6 (prior to the addition of $FeCl_3$) caused faster settling of the precipitants than an initial pH of 4 (also, pH 6 was determined to be a more favorable pH for RIEC groundwater treatment, based on the Phase 2 test results).
- Higher $FeCl_3$ dosage (40 mg/L vs. 20 mg/L) provided greater removal of arsenic and molybdenum. Though the difference in $FeCl_3$ dosage performance for the RIEC groundwater was not significant, based on the concentrations detected in the groundwater and the applicable action levels for the MOC at the RIEC site. The dosage evaluation results were however considered beneficial for refinement of Phase 3 testing for the other sites.

- The additional of hydrogen peroxide did not improve the arsenic removal efficiency. However, a check on the arsenic form in groundwater at RIEC showed the arsenic to be predominantly arsenic(V), so the pre-oxidation step was not needed for RIEC.

The reaction time determined for the $FeCl_3$ coagulation and flocculation / precipitation and associated removal of arsenic and molybdenum from groundwater in the preliminary testing was adequate for the conceptual ex situ treatment approach.

Following the preliminary testing it was considered beneficial to run further testing to confirm the preliminary test results, and to optimize the pilot test design. Based on additional literature research, aeration of the groundwater prior to $FeCl_3$ addition was added as a treatment step. Additional treatability tests were conducted using pH adjustment of the RIEC groundwater to approximately 6, followed by addition of 40 mg/L of $FeCl_3$, followed by settling and filtration of precipitants using either sand or bag filters. The treated groundwater was then passed through the resin filter for boron removal. Results of these additional tests are presented in **Table 9**. Key observations and conclusions from the additional $FeCl_3$ testing are:

- Aeration of the groundwater prior to the addition of $FeCl_3$ accelerates the formation of precipitants.
- Influent pH should be close to pH of 6 at RIEC for optimal precipitant settling times.
- Higher $FeCl_3$ concentrations added to the groundwater appear to provide larger precipitant particles that settle faster. However, the higher dosage of $FeCl_3$ will also increase the sludge volume that will require additional disposal and may increase maintenance needs.
- 100-micron bag filters are insufficient to remove the arsenic particles in the groundwater (and reduce total arsenic concentrations to below action levels). Though 10-micron filters work effectively to meet action levels, the 10-micron filter is likely to cause operational issues in a pilot and full-scale system and is therefore not a preferred treatment option. Also, bag filters are unlikely to remove iron in the treated groundwater to below 2 mg/L, which may negatively impact the resin filter longevity.
- The sand filter was effective as a polishing step to reduce total arsenic and molybdenum concentrations to below action levels, while also decreasing total iron concentrations to approximately 0.3 mg/L. Sand filtration is therefore recommended for the pilot scale system.
- The resin filter is needed to remove boron from the groundwater to action levels. The resin operates optimally between a pH of 4 and 10. The $FeCl_3$ addition reduces the

groundwater pH to approximately 4 so pH adjustment back to pH 6 is recommended prior to resin treatment.

- Though total lead is reported in groundwater at RIEC below action levels, the $FeCl_3$ addition reduced the total lead concentration from 0.0057 mg/L to 0.0026 mg/L or lower, suggesting that $FeCl_3$ is a potential option at other sites for treatment of total lead levels which exceed action levels.

pH Adjustment followed by Resin Column Treatment

The Phase 2 pH adjustment only bench testing had proven effective for arsenic and molybdenum removal (though not boron) over a week-long treatment period in the presence of site soils. The Phase 3 tests included an evaluation of pH adjustment followed by the resin as an alternative RIEC treatment train. Since the resin is specially designed for boron removal, the manufacturer could not provide insight into its effectiveness, performance or sustainability for arsenic or molybdenum treatment, so it was assumed that pre-treatment to remove arsenic and molybdenum was still needed.

The columns tests were conducted by decreasing the pH of the RIEC groundwater to pH 5 then passing the pH adjusted groundwater through a sand filter sized to provide a hydraulic residence time of 40 minutes. The filtered groundwater was then passed through a resin column. Groundwater exiting the resin column were collected for analysis of MOC (**Table 10**). The analysis results showed that MOC action levels were achieved after Days 1 and 3 of treatment for all MOCs; however, breakthrough of arsenic occurred by Day 7.

Groundwater samples collected between the sand filter and the resin columns showed that the pH adjustment by itself did not effectively treat the arsenic or molybdenum in the groundwater, over the short treatment period available in the scaled ex situ treatment train. Consequently, it was determined that the resin was responsible for the removal of arsenic, molybdenum, and boron in the RIEC groundwater. A further review of the data and the procedures used in this test suggests that for pH adjustment to be successful for removing arsenic and molybdenum from the RIEC groundwater, the groundwater needs to be maintained at a reduced pH for longer than 40 minutes (the residence time in the tested columns). Hence, pH adjustment alone would not be a viable ex situ treatment approach as an ex situ treatment system design.

Further, while the resin was successful at temporarily removing arsenic, molybdenum, and boron, it was not designed for arsenic and molybdenum treatment, and the arsenic concentration reduction could not be sustained below REIC action levels for up to a week. This indicates that a large resin vessel and / or frequent regeneration of the resin would be needed for resin to be considered as a stand-alone treatment approach. Also, since the resin was not designed to remove arsenic and molybdenum, it is unknown if the metals will desorb during the resin regeneration, in which case, the resin could be ineffective for further arsenic and molybdenum removal. The adsorption capacity of the resin for arsenic and molybdenum should only be considered as a safety factor in the final pilot test design, if the pretreatment for arsenic and molybdenum failed, but not as a stand-alone remedial option.

ZVI Column Testing

Since the microscale ZVI was identified in the Phase 2 tests as a possible approach for removing boron, arsenic, and molybdenum from the RIEC site groundwater, test columns were constructed using a mixture of the microscale ZVI and commercial sand (to allow the required flow through the column / ZVI, without clogging due to the ZVI microscale particle size). The columns were prepared using a 5:1 ratio of sand to microscale ZVI, and a 2:1 ratio of sand to microscale ZVI. The columns were operated for 7 days, with treated groundwater samples collected from the column effluent after 1, 3, and 7 days of treatment time (simulating groundwater treatment over a one week period through a pilot or full-scale 1,000-gallon capacity column / filter).

Table 11 presents the results of the ZVI column testing. The results show partial treatment of arsenic and molybdenum, though not to action levels. Both the 5:1 and 2:1 sand to ZVI dosed columns showed some treatment occurred the first day, but treatment effectiveness decreased by Days 3 and 7. Results for both the columns showed that concentrations did not decrease to action levels for arsenic, and results for only one column sample showed that molybdenum concentrations decreased to action levels (Day 1 of the 5:1 dose column). Boron concentrations did not change passing through the ZVI columns.

From the Phase 3 test results, it was determined that the ZVI treatment effectiveness (at the design sand to ZVI dosages) and the associated treatment longevity was questionable, and likely not reliable as a sustainable remedial option. To ensure the ZVI was being adequately evaluated, XDD had additional discussions with the ZVI vendor on the system design and effectiveness. It was determined that the recommendations by the vendor on how to use ZVI in an ex situ process was impractical for the site given the conceptual pilot test design constraints (action levels, MOC, flow rates, vessel sizing, etc.).

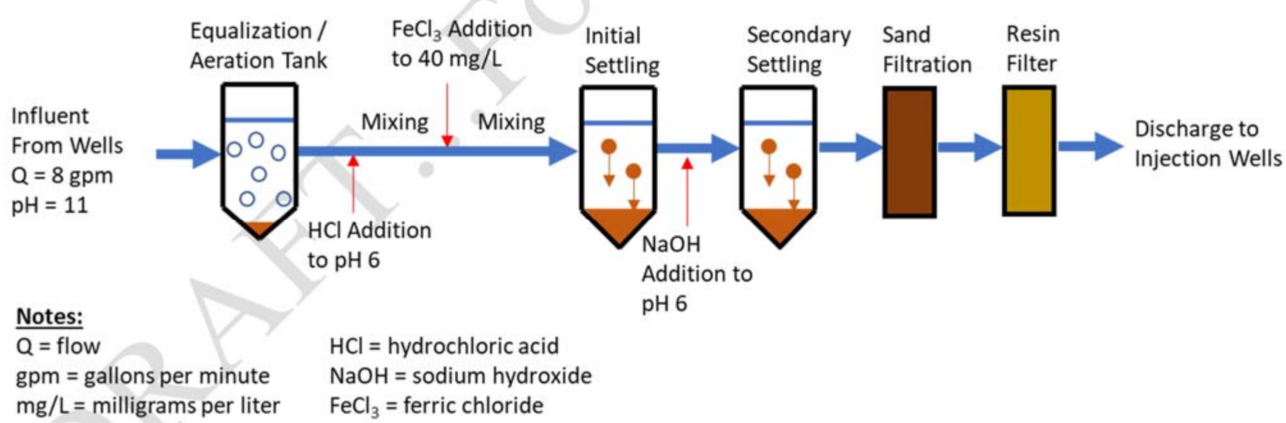
5.0 CONCLUSIONS AND RECOMMENDATIONS FROM TREATABILITY TESTING

Several potential treatment technologies were evaluated for the MOC at the sites. While ZVI and pH adjustment were the most promising remedial approaches from the Phase 2 testing for in situ treatment of the initially identified primary MOC, the subsequent addition of boron as a primary

MOC resulted in the requirement to transition to an ex situ remedial approach. Added benefits of the transition to an ex situ remedial approach are concerns with potential aquifer clogging from in situ MOC precipitation and the benefits of the flexibility in ex situ system design for varying site groundwater geochemistry's. The difference in available and practical treatment times (reaction kinetics) for in situ treatment versus ex situ treatment systems resulted in the elimination of the ZVI and pH adjustment alone technologies as viable ex situ remedial options and the evaluation of additional technologies for the MOC treatment.

Based on the results of the Phase 1 through Phase 3 treatability testing, the proposed treatment train identified for the RIEC pilot test is presented below in **Figure 1**. Modifications and optimizations to the treatment train will be evaluated during the pilot scale startup. The Phase 3 remedial approach refinement testing demonstrated that pH adjustment, followed by $FeCl_3$ aided coagulation/flocculation for arsenic and molybdenum treatment of the RIEC groundwater was effective and reliable. Boron removal requires the addition of an ion-specific resin following the $FeCl_3$ treatment. To expedite the arsenic and molybdenum removal, aeration of the groundwater prior to pH adjustment and the addition of 40 mg/L of $FeCl_3$ is required. The $FeCl_3$ reduces the groundwater pH to approximately 4 so pH adjustment back to pH 6 is recommended prior to resin treatment for boron removal.

Figure 1: Conceptual Treatment Train for Pilot Scale System at RIEC



Going forward, MEC, LEC, and SEC have similar MOC to RIEC (primarily molybdenum and boron) but with a few distinct deviations from the RIEC groundwater quality. The main points of difference that need to be considered in subsequent Phase 3 testing for the individual sites are:

- At MEC (monitoring well MW-6), lithium has been detected above action levels. The literature review performed during Phase 1 (**Appendix A**) suggests ZVI is a viable remediation approach for lithium; it is suspected that $FeCl_3$ may also be effective at lithium removal.

- The boron concentration at SEC is above the manufacturer's maximum concentration recommendation for the resin (10 mg/L maximum vs. 22 to 25 mg/L measured at SEC). A recirculation method or resin vessels in series may be needed to reduce the boron concentration in SEC groundwater to meet action levels in the resin treated groundwater.
- SEC also has significantly higher molybdenum concentrations (3.05 mg/L) than RIEC (0.16 mg/L) so testing is needed to ensure $FeCl_3$ can be effective at removing molybdenum to action levels at these higher groundwater concentrations.
- Higher remediation system flow rates are likely to be encountered at some of the sites (in particular LEC) so refinement of the system hydraulics and available treatment timeframes need to be evaluated.
- The high pH at RIEC resulted in the need for an initial pH adjustment. This may not be necessary at the other locations, but confirmation tests should be performed.
- $FeCl_3$ flocculation / precipitation is facilitated with increased groundwater alkalinity. Additional alkalinity may be needed to be added to the treatment systems at the other sites to increase the rates of formation and settling of the precipitants.
- General groundwater geochemistry's are also likely to have subtle differences for the other sites. Testing is needed to provide confidence in the effectiveness of the treatment train at the other sites / locations.

The information gathered in the Phase 3 RIEC treatability testing will be used to guide the design of treatability testing and remedial approaches for the other three sites.

APPENDIX A: PHASE 1 LITERATURE REVIEW

Primary Metals of Concern

Arsenic

- Detected at 0.22 milligrams per liter (mg/L) (RIEC) and 0.02 mg/L (MEC, monitoring well MW-5). Arsenic was not detected at LEC, SEC, or at monitoring well MW-6 at MEC.
- Action levels are 0.030 mg/L (RIEC), 0.01 mg/L (MEC and SEC), and 0.0426 mg/L (LEC).
- Potential treatment methods include precipitation/coprecipitation, pH adjustment, adsorption, and ZVI/ZVI with carbon:
  - Speciation – trivalent arsenite [As (III)] is more soluble and mobile than pentavalent arsenate [As(V)].
  - Redox – arsenic is more readily mobilized under reducing conditions.
  - pH – mobility is lowest at pH 3 to 7, increases under very acidic or alkaline pH conditions.
  - Competing ions – phosphate and sulfate can limit arsenic adsorption and increase mobility.
  - Adsorption – iron oxides sorb arsenic and can greatly limit arsenic mobility.
  - Precipitation – formation of insoluble calcium arsenates can reduce leaching and mobility.
- Application of ferrous sulfate to soils has shown promise in reducing arsenic concentrations in groundwater at utility substation sites (EPRI, 2010).
  - Data review has shown that both RIEC and MEC lack iron – this indicates ZVI treatment may be promising.
- pH adjustment in trench application case study: The pH was raised from 1.93 to 7.9, leading to a reduction in groundwater arsenic concentrations from 35,000 micrograms per liter (µg/L) to <4 µg/L (EPRI, 2006).
- Summary of favorable conditions for arsenic removal:
  - pH range of 3 to 7, oxidizing conditions
  - Addition of Iron and calcium complexes
  - Low phosphate and sulfate concentrations

Molybdenum

- Detected at 0.16 mg/L (RIEC), 0.11 mg/L (MEC, monitoring well MW-5), 0.15 mg/L (MEC, monitoring well MW-6), 0.155 mg/L (LEC), and 3.05 mg/L (SEC).
- Action Level is 0.1 mg/L for all sites.
- Potential treatment methods include precipitation/coprecipitation, pH adjustment, adsorption, and ZVI/ZVI with carbon

- Molybdenum adsorption is highly pH-dependent. Peak adsorption for most sorbents (except maghemite nanoparticles) occurs at pH < 5 and limited adsorption occurs at pH > 8. In alkaline conditions, molybdenum behaves conservatively, and its dissolved concentration is controlled by precipitation, not adsorption, reactions (EPRI, 2011).
- Permeable Reactive Barrier (PRB)/ZVI/pH adjustment case study: Molybdenum was sequestered under reducing/oxidizing conditions with pH 7.3 to 10; effective for 15 months (reducing conditions sustained for 5 to 9 months) (Bellantoni, 2014).
- Summary of potential treatment options for molybdenum removal:
  - Maintaining a neutral or slightly alkaline pH with ZVI addition.

Lithium

- Detected at 0.12 mg/L (MEC, monitoring well MW-6), and either non-detect or below action levels at the other sites.
- Action Levels are 0.0647 mg/L (RIEC), 0.04 mg/L (MEC and SEC), and 0.055 mg/L (LEC).
- Potential treatment is limited to precipitation using ZVI PRBs.
- "Additional research is needed to evaluate, and possibly develop, in situ groundwater treatment technologies for lithium, specifically reagents for in situ injection or media for a permeable reactive barrier. Zeolites such as clinoptilolite and clays such as bentonite and kaolinite have been shown to exhibit lithium-sorbing characteristics in a laboratory setting, making these candidates for future in situ injection and PRB application studies" (EPRI, 2018).
- Summary of potential treatment options for lithium removal:
  - ZVI

Boron

- Detected at 3.85 mg/L (RIEC), 5.2 mg/L (MEC, monitoring well MW-5), 7.9 mg/L (MEC, monitoring well MW-6), 7.9 mg/L (LEC), 23.5 mg/L (SEC).
- Action Level is 4 mg/L for all sites.
- "Additional research is needed on the mechanisms of boron attenuation, both precipitation and adsorption, for a wider range of soil and mineral types, and in hydrogeologic environments typical of CCP management sites. While the literature suggests nonlinear sorption and some dependence on general soil type and pH, these relationships are not well understood. The same is true for competing ion effects, such as sulfate and fluoride. In addition, there are few field studies documenting boron attenuation at utility sites" (EPRI, 2005).

- "There is a need to measure boron sorption in the alkaline pH range associated with ash leachate, and to make these measurements with a wider range of soil and mineral types. Moreover, there are relatively few field-scale studies available on the fate and transport of boron derived from coal ash in groundwater. Studies based on site-specific sorption, hydrogeologic, and leaching data may yield a better understanding of the long-term impacts of boron from coal-combustion residues (EPRI, 2005)."
- Case study: pH adjustment to > 9.1 and the addition of proprietary ionizing agents resulted in 99% removal (sorption of boron complexes) (Kreinberg, 2017).
- Summary of potential treatment options for boron removal:
  - ZVI or boron specific ion-exchange resin (ex situ)

<u>Metals of Concern Potentially Released as a Result of Treatment:</u>

<u>Cobalt</u>

- Not detected in baseline samples collected at any of the sites.
- Action Level is 0.006 mg/L for all sites.
- Potential treatment methods include ZVI PRB and carbon substrate injections
  - Ontario ZVI case study: sulfate-reducing conditions (anaerobic, ORP <-250 mV), cobalt remediation achieved (reduction of ~260 parts per billion [ppb] to 40 ppb) (Pare, 2014, RPIC).

<u>Lead</u>

- Either reported below action levels or not detected in baseline samples collected at all sites.
- Action Level is 0.015 mg/L for all sites.
- Potential treatment methods include metal cation precipitation as sulfides, adsorption to iron corrosion products, pH adjustment using Acid-B Extra™ reagent (10%) (EPRI, 2006).
  - Success Mine PRB case study: Lead was reduced from 0.658 mg/L upgradient of the PRB to <0.002 mg/L downgradient of the PRB. The pH was buffered from 4.9 to 6.9 throughout the thickness of the barrier wall. PRB is anaerobic and creates conditions optimal for sulfate-reducing bacteria. Expected to provide treatment for 30 years (EPRI, 2006).
  - Case study at Gilt Edge Mine, SD: leachate pH was raised from 1.93 to 7.9, resulting in the following reductions in metals concentrations: arsenic from 35,000 µg/L to <4 µg/L, antimony from 500 µg/L to 10 µg/L, and lead from 390 µg/L to <10 µg/L (EPRI, 2006).

Selenium

- Not detected in baseline samples from any of the sites.
- Action Level is 0.05 mg/L for all sites.
- Potential treatment methods include reductive precipitation with oxidized iron minerals, adsorption to iron oxides, ZVI, and ZVI/carbon – many positive case studies (EPRI, 2006)
- Oxyanions (e.g., arsenic, chromium, selenium, molybdenum, vanadium, and sulfate) adsorb most strongly at low pH levels and cations (e.g., lead, cadmium, and nickel) adsorb most strongly at high pH levels.
- Like arsenic, selenium is generally present in predominantly two oxyanion forms in natural waters: Se (IV) as selenite ion SeO_3^{-2}, and Se (VI) as selenate ion SeO_4^{-2}. Selenite tends to dominate in impoundment settings when the source coal is bituminous or a mixture of bituminous and subbituminous, while selenate tends to predominate in landfill settings and when the source coal is subbituminous/lignite (EPRI, 2006). Selenate is generally soluble and mobile and is readily taken up by organisms and plants. Selenite is less soluble and mobile than selenate; therefore, reductive precipitation/coprecipitation of selenium could serve as a viable remediation approach. However, re-oxidation is a potential problem. Phytoremediation has also been reported and adsorption has been used.

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Tables

Table 1
Baseline Metal Concentrations and Action Levels
Ameren Services, Missouri

	Rush Island			Meramec MW-5			Meramec MW-6		
	Action Levels	Baseline/Baseline Dup		Action Levels	Baseline/Baseline Dup		Action Levels	Baseline/Baseline Dup	
	Total Metals (mg/L)								
Arsenic	0.03	0.22	0.22	0.01	0.020	0.020	0.01	0.005 U	0.005 U
Molybdenum	0.1	0.16	0.16	0.1	0.11	0.11	0.1	0.15	0.15
Boron	4	4.0	3.7	4	5.2	5.2	4	7.8	8.0
Lead	0.015	0.007	0.007	0.015	0.005 U	0.005 U	0.015	0.005 U	0.005 U
Cobalt	0.006	0.01 U	0.01 U	0.006	0.01 U	0.01 U	0.006	0.01 U	0.01 U
Selenium	0.05	0.01 U	0.01 U	0.05	0.01 U	0.01 U	0.05	0.01 U	0.01 U
Lithium	0.0647	0.06 U	0.06 U	0.04	0.06 U	0.06 U	0.04	0.12	0.12

	Labadie			Sioux		
	Action Levels	Baseline/Baseline Dup		Action Levels	Baseline/Baseline Dup	
	Total Metals (mg/L)					
Arsenic	0.0426	0.025 U	0.025 U	0.01	0.025 U	0.025 U
Molybdenum	0.1	0.15 J	0.16 J	0.1	3.20 J	2.90 J
Boron	4	7.7	8.1	4	25.0	22.0
Lead	0.015	0.025 U	0.025 U	0.015	0.025 U	0.025 U
Cobalt	0.006	0.05 U	0.05 U	0.006	0.05 U	0.05 U
Selenium	0.05	0.05 U	0.05 U	0.05	0.05 U	0.05 U
Lithium	0.055	0.019 J	0.016 J	0.04	0.029 J	0.020 J

Notes:

mg/L = milligrams per liter

U = not detected above the indicated reporting limit concentration

J = estimated value

(green) Concentrations are at or below action level

(grey) Concentrations are between action level and reporting limit

Table 2
Summary of In Situ Test Conditions for Metal Treatability Study
Ameren Services, Missouri

Test Conditions				Rush Island			Meramec MW-5			Meramec MW-6		
Test condition	Soil (g)	Addition	Duration (week)	Amount	pH	Aerobic or Anaerobic	Amount	pH	Aerobic or Anaerobic	Amount	pH	Aerobic or Anaerobic
pH adjusted	48	HCl 36%	1	Varied	10, 9, 8, 7, 6	Aerobic	Varied	10, 8, 6	Aerobic	Varied	10, 8, 6	Aerobic
CaSx- No pH change	48	CaSx	1	2.1 mg		Aerobic	3.1 mg		Aerobic	5.5 mg		Aerobic
CaSx- pH adjusted	48	CaSx	1	2.1 mg	8	Aerobic		NA			NA	
Fe- anaerobic	48	Fe(II) sulfate	4	12 mg		Anaerobic	12 mg		Anaerobic	12 mg		Anaerobic
Fe -anaerobic- pH adjusted	48	Fe(II) sulfate	4	12 mg	8	Anaerobic		NA			NA	
Fe - aerobic	48	Fe(II) sulfate	4	12 mg		Aerobic	12 mg		Aerobic	12 mg		Aerobic
Fe - aerobic- pH adjusted	48	Fe(II) sulfate	4	12 mg	8	Aerobic		NA			NA	
ZVI (SR.2S)	48	SR.2S	4	96 mg		Anaerobic	96 mg		Anaerobic	96 mg		Anaerobic
ZVI (SR.2S)- pH adjusted	48	SR.2S + HCl	4	96 mg	8	Anaerobic		NA			NA	
ZVI (SR.2S)-Food	48	SR.2S + Food	8	96 mg		Anaerobic	96 mg		Anaerobic	96 mg		Anaerobic
ZVI (SR.2S)-Food- pH adjusted	48	SR.2S + Food + HCl	8	96 mg	8	Anaerobic		NA			NA	
ZVI (7 micron)	48	7 micron	4	96 mg		Anaerobic	96 mg		Anaerobic	96 mg		Anaerobic
ZVI (7 micron)- pH adjusted	48	7 micron + HCl	4	96 mg	8	Anaerobic		NA			NA	
ZVI (7 micron)- Food	48	7 micron + Food	8	96 mg		Anaerobic	96 mg		Anaerobic	96 mg		Anaerobic
ZVI (7 micron)- Food- pH adjusted	48	7 micron + Food + HCl	8	96 mg	8	Anaerobic		NA			NA	

Test Conditions				Labadie			Sioux		
Test condition	Soil (g)	Addition	Duration (week)	Amount	pH	Aerobic or Anaerobic	Amount	pH	Aerobic or Anaerobic
pH adjusted	48	HCl 36%	1	Varied	6	Aerobic	Varied	6	Aerobic
CaSx- No pH change	48	CaSx	1	0.09 mg		Aerobic	0.09 mg		Aerobic
CaSx- pH adjusted	48	CaSx	1	0.09 mg	7	Aerobic		NA	
Fe- anaerobic	48	Fe(II) sulfate	4	13.8 mg		Anaerobic	13.8 mg		Anaerobic
Fe -anaerobic- pH adjusted	48	Fe(II) sulfate	4	13.8 mg	7	Anaerobic		NA	
Fe - aerobic	48	Fe(II) sulfate	4	13.8 mg		Aerobic	13.8 mg		Aerobic
Fe - aerobic- pH adjusted	48	Fe(II) sulfate	4	13.8 mg	7	Aerobic		NA	
ZVI (SR.2S)	48	SR.2S	4	11 mg		Anaerobic	11mg		Anaerobic
ZVI (SR.2S)- pH adjusted	48	SR.2S + HCl	4	11 mg	7	Anaerobic		NA	
ZVI (SR.2S)-Food	48	SR.2S + Food	8	11 mg		Anaerobic	11mg		Anaerobic
ZVI (SR.2S)-Food- pH adjusted	48	SR.2S + Food + HCl	8	11 mg	7	Anaerobic		NA	
ZVI (7 micron)	48	7 micron	4	11 mg		Anaerobic	11mg		Anaerobic
ZVI (7 micron)- pH adjusted	48	7 micron + HCl	4	11 mg	7	Anaerobic		NA	
ZVI (7 micron)- Food	48	7 micron + Food	8	11 mg		Anaerobic	11mg		Anaerobic
ZVI (7 micron)- Food- pH adjusted	48	7 micron + Food + HCl	8	11 mg	7	Anaerobic		NA	

Notes:

SR.2S = particle size ZVI
ZVI = zero valent iron
7 micron = microscale ZVI
Food = lactate, EOL, cornsweet, and nutrients
NA = test condition not run
HCl = hydrochloric acid
CaSx = calcium polysulfide
Fe = iron (dissolved)

Table 3
Summary of Rush Island In Situ Total Metals Removal Performance
Rush Island Energy Center, Missouri

	Arsenic	Molybdenum	Boron	Lead	Cobalt	Selenium	Lithium
	mg/L						
Action Levels	0.03	0.1	4	0.015	0.006	0.05	0.065
Average of All Controls[1]	0.18	0.12	3.10	0.13	0.03 J*	0.03 J*	0.13
pH 10	0.17	0.12	3.05	0.08	0.02	0.02	0.07
pH 9	0.12	0.12	2.80	0.08	0.02	0.02	0.09
pH 8	0.10	0.13	3.15	0.05	0.01 J*	0.01 J*	0.06
pH 7	0.07	0.11	3.05	0.06	0.02	0.01	0.08
pH 6	0.02 J*	0.08	3.80	0.03 U	0.06 U	0.06 U	0.06 U
CaSx	0.23	0.12	3.60	0.08	0.07 U	0.07 U	0.07
CaSx pH7	0.05	0.14	3.75	0.03 U	0.06 U	0.06 U	0.04 J*
Dissolved Iron (Anaerobic)	0.20	0.13	3.20	0.11	0.05 U	0.05 U	0.11
Dissolved Iron pH 8 (Anaerobic)	0.11	0.14	3.20	0.08	0.05 U	0.05 U	0.06
Dissolved Iron (Aerobic)	0.19	0.13	3.05	0.13	0.05 U	0.05 U	0.10
Dissolved Iron pH 8 (Aerobic)	0.06	0.14	3.45	0.04 J*	0.05 U	0.05 U	0.13
ZVI Injectable	0.03 U	0.05 U	0.30	0.03 U	0.05 U	0.05 U	0.08 U
ZVI Injectable pH 8	0.03 U	0.05 U	0.13 J*	0.03 U	0.05 U	0.05 U	0.09 U
ZVI PRB	0.02 J*	0.39	3.60	0.03 U	0.05 U	0.05 U	0.04 U
ZVI PRB pH 8	0.03 U	0.04 J*	2.55	0.03 U	0.05 U	0.05 U	0.02 J
ZVI Injectable + Bio	0.025 U	0.05 U	0.32 J	0.025 U	0.05 U	0.05 U	0.06 U
ZVI Injectable pH 8 + Bio	0.025 U	0.05 U	0.07 J	0.025 U	0.05 U	0.05 U	NS
ZVI PRB + Bio	0.03 U	0.32 J	4.45 J	0.03 U	0.05 U	0.05 U	0.02 J
ZVI PRB pH 8 + Bio	0.03 U	0.05 U	2.20 J	0.03 U	0.05 U	0.05 U	0.04 J

Notes:

U = not detected above the indicated concentration

PRB = permeable reactive barrier

Injectable = iron particles at micro-scale; potentially applied through injection

Dissolved iron = 50 mg/L Iron(II) sulfate

NS = not sampled

CaSx = calcium polysulfide

J* = half the detection limit was used for non-detect when duplicates had a detection and a non-detect.

pH adjustment testing was conducted over a 7-day test period. The native pH in monitoring well MW-2 was pH 11.

1) Average of All Controls = average of all controls used in the Phase 2 testing for Rush Island Energy Center

At or below action level

Approaching action level

Above action level and increase relative to control

Non-detect but detection limit greater than action level

NA = no action level

mg/L = milligrams per liter

Table 4
Summary of Meramec MW-5 In Situ Total Metals Removal Performance
Meramec Energy Center, Missouri

	Arsenic	Molybdenum	Boron	Lead	Cobalt	Selenium	Lithium
	mg/L						
Action Levels	0.01	0.1	4	0.015	0.006	0.05	0.040
Average of All Controls[1]	0.034 J*	0.174	5.5	0.028 J*	0.062 U	0.062 U	0.028 J
pH 10	0.031	0.18	5.55	0.013	0.01 U	0.01 U	0.0285 J
pH 8	0.03	0.16	5.30	0.02	0.01 U	0.01 U	0.04 J
pH 6	0.029	0.11	5.6	0.027	0.01	0.01 U	0.049 J
CaSx	0.05 U	0.17	5.3	0.05 U	0.1 U	0.1 U	0.026 J
Dissolved Iron (Anaerobic)	0.039	0.18 J	4.8	0.035	0.05 U	0.05 U	0.029 J
Dissolved Iron (Aerobic)	0.031	0.17 J	4.6	0.03	0.05 U	0.05 U	0.03
ZVI Injectable	0.025 U	0.05 U	0.33	0.025 U	0.05 U	0.05 U	0.06 U
ZVI PRB	0.025 U	0.08	3.7	0.025 U	0.05 U	0.05 U	0.035 J
ZVI Injectable + Bio	0.05 U	0.1 U	0.31	0.05 U	0.1 U	0.1 U	NS
ZVI PRB + Bio	0.05 U	0.1 U	4.8 J	0.05 U	0.1 U	0.1 U	0.032 J

Notes:

U = not detected above the indicated concentration

PRB = permeable reactive barrier

Injectable = iron particles at micro-scale; potentially applied through injection

Dissolved iron = 50 mg/L Iron(II) sulfate

NS = not sampled

CaSx = calcium polysulfide

J* = half the detection limit was used for non-detect when duplicates had a detection and a non-detect.

pH adjustment testing was conducted over a 7-day test period. The native pH in monitoring well MW-6 was approximately pH 7.5.

1) Average of All Controls = average of all controls used in the Phase 2 testing for Merimec Energy Center MW-5

At or below action level (green)

Approaching action level (blue)

Above action level and increase relative to control (orange)

Non-detect but detection limit greater than action level (grey)

NA = no action level

mg/L = milligrams per liter

Table 5
Summary of Meramec MW-6 In Situ Total Metals Removal Performance
Meramec Energy Center, Missouri

	Arsenic	Molybdenum	Boron	Lead	Cobalt	Selenium	Lithium
	mg/L						
Action Levels	0.01	0.1	4	0.015	0.006	0.05	0.040
Average of All Controls[1]	0.0259 J*	0.22 J	10.24 J	0.027 J*	0.062 U	0.062 U	0.128
pH 10	0.0285	0.215	10.5	0.0135	0.01 U	0.01 U	0.12
pH 8	0.013	0.18	11	0.016	0.01 U	0.01 U	0.15
pH 6	0.03	0.14	10	0.027	0.01	0.01 U	0.16
CaSx	0.05 U	0.19	10	0.05 U	0.1 U	0.1 U	0.12
Dissolved Iron (Anaerobic)	0.032	0.26 J	8.5	0.041	0.05 U	0.05 U	0.13
Dissolved Iron (Aerobic)	0.027	0.22 J	8.6	0.033	0.05 U	0.05 U	0.13
ZVI Injectable	0.025 U	0.05 U	0.69	0.025 U	0.05 U	0.05 U	0.5 U
ZVI PRB	0.025 U	0.05	6.5	0.025 U	0.05 U	0.05 U	0.11
ZVI Injectable + Bio	0.05 U	0.1 U	0.72	0.05 U	0.1 U	0.1 U	NS
ZVI PRB + Bio	0.05 U	0.1 U	8.5 J	0.05 U	0.1 U	0.1 U	0.1

Notes:

U = not detected above the indicated concentration

PRB = permeable reactive barrier

Injectable = iron particles at micro-scale; potentially applied through injection

Dissolved iron = 50 mg/L Iron(II) sulfate

CaSx = calcium polysulfide

mg/L = milligrams per liter

half the detection limit was used for non-detect when duplicates had a detection and a non-detect.

pH adjustment testing was conducted over a 7-day test period. The native pH in monitoring well MW-6 was approximately pH 7.6.

1) Average of All Controls = average of all controls used in the Phase 2 testing for Merimec Energy Center MW-6

(green) At or below action level

(blue) Approaching action level

(orange) Above action level and increase relative to control

(grey) Non-detect but detection limit greater than action level

NA = no action level

Table 6
Summary of Labadie In Situ Total Metals Removal Performance
Labadie Energy Center, Missouri

	Arsenic	Molybdenum	Boron	Lead	Cobalt	Selenium	Lithium
	mg/L						
Action Levels	0.0426	0.1	4	0.015	0.006	0.05	0.055
Average of All Controls[1]	0.042 U	0.162 J	9.133 J	0.042 U	0.083 U	0.083 U	0.022 J*
pH 6	0.025 U	0.13 J	7.6	0.025 U	0.05 U	0.05 U	0.018 J
CaSx	0.025 U	0.16 J	7.5	0.025 U	0.05 U	0.05 U	0.016 J
CaSx pH7	0.025 U	0.13 J	7.6	0.025 U	0.05 U	0.05 U	0.017 J
Dissolved Iron (Anaerobic)	0.05 U	0.17	9.5	0.05 U	0.1 U	0.1 U	0.06 U
Dissolved Iron (Aerobic)	0.05 U	0.17	9.6	0.05 U	0.1 U	0.1 U	0.023 J
Dissolved Iron pH 7 (Anaerobic)	0.05 U	0.15	9.5	0.05 U	0.1 U	0.1 U	0.06 U
Dissolved Iron pH 7 (Aerobic)	0.05 U	0.16	9.7	0.05 U	0.1 U	0.1 U	0.06 U
ZVI Injectable	0.05 U	0.1 U	6.5	0.05 U	0.1 U	0.1 U	0.06 U
ZVI Injectable pH 7	0.05 U	0.1 U	6.3	0.05 U	0.1 U	0.1 U	0.06 U
ZVI PRB	0.05 U	0.1	9.3	0.05 U	0.1 U	0.1 U	0.06 U
ZVI PRB pH 7	0.05 U	0.1 U	8.9	0.05 U	0.1 U	0.1 U	0.022 J
ZVI Injectable + Bio	0.05 U	0.1 U	10 J	0.05 U	0.1 U	0.1 U	0.016 J
ZVI Injectable pH 7 + Bio	0.05 U	0.1 U	8.9 J	0.05 U	0.1 U	0.1 U	0.019 J
ZVI PRB + Bio	0.05 U	0.1 U	9.9 J	0.05 U	0.1 U	0.1 U	0.063 J
ZVI PRB pH 7 + Bio	0.05 U	0.1 U	9.2 J	0.05 U	0.1 U	0.1 U	0.038 U

Notes:

U = not detected above the indicated concentration

PRB = permeable reactive barrier

Injectable = iron particles at micro-scale; potentially applied through injection

Dissolved iron = 50 mg/L Iron(II) sulfate

CaSx = calcium polysulfide

mg/L = milligrams per liter

J* = half the detection limit was used for non-detect when duplicates had a detection and a non-detect.

pH adjustment testing was conducted over a 7-day test period. The native pH at Labadie was approximately pH 8.3.

1) Average of All Controls = average of all controls used in the Phase 2 testing for Labadie Energy Center

(green)	At or below action level
(blue)	Approaching action level
(orange)	Above action level and increase relative to control
(gray)	Non-detect but detection limit greater than action level

NA = no action level

Table 7
Summary of Sioux In Situ Total Metals Removal Performance
Sioux Energy Center, Missouri

	Arsenic	Molybdenum	Boron	Lead	Cobalt	Selenium	Lithium
	mg/L						
Action Levels	0.01	0.1	4	0.015	0.006	0.05	0.040
Average of All Controls[1]	0.033 J*	2.867 J	26.7 J	0.065 J*	0.052 J*	0.083 U	0.049
pH 6	0.025 U	1.7 J	23	0.025 U	0.05 U	0.05 U	0.028 J
CaSx	0.025 U	2.7 J	21	0.025 U	0.05 U	0.05 U	0.025 J
Dissolved Iron (Anaerobic)	0.05 U	2.7	28	0.05 U	0.1 U	0.1 U	0.028 J
Dissolved Iron (Aerobic)	0.05 U	2.6	27	0.069	0.1 U	0.1 U	0.085
ZVI Injectable	0.05 U	0.1 U	23	0.05 U	0.1 U	0.1 U	0.06 U
ZVI PRB	0.05 U	0.81	26	0.05 U	0.1 U	0.1 U	0.024 J
ZVI Injectable + Bio	0.05 U	0.5 J	19 J	0.05 U	0.1 U	0.1 U	0.029 J
ZVI PRB + Bio	0.05 U	0.1 U	27 J	0.05 U	0.1 U	0.1 U	0.021 J

Notes:

U = not detected above the indicated concentration

PRB = permeable reactive barrier

Injectable = iron particles at micro-scale; potentially applied through injection

Dissolved iron = 50 mg/L Iron(II) sulfate

CaSx = calcium polysulfide

mg/L = milligrams per liter

J* = half the detection limit was used for non-detect when duplicates had a detection and a non-detect.

pH adjustment testing was conducted over a 7-day test period. The native pH at Sioux was approximately pH 7.8.

1) Average of All Controls = average of all controls used in the Phase 2 testing for Sioux Energy Center

(green) At or below action level

(blue) Approaching action level

(orange) Above action level and increase relative to control

(gray) Non-detect but detection limit greater than action level

NA = no action level

Table 8

Summary of Preliminary Ferric Chloride Treatability Testing - Rush Island

Rush Island Energy Center, Missouri

	Arsenic			Molybdenum		
	1 hour [1]	3 hour [2]	6 hour [3]	1 hour [1]	3 hour [2]	6 hour [3]
	mg/L					
Action Level	0.03			0.1		
Total Metals						
Baseline	0.224			0.146		
20 mg/L $FeCl_3$, pH 6[4]	0.0072	0.0109	0.0126	0.0205	0.0241	0.0283
40 mg/L $FeCl_3$, pH 6[4]	0.0049	0.0059	0.0062	0.01 U	0.01 U	0.01 U
40 mg/L $FeCl_3$, pH 4[5]	0.0056	0.0085	0.0105	0.01 U	0.01 U	0.01 U
40 mg/L $FeCl_3$, 3% H_2O_2, pH 6[4,6]	0.0269	NM	NM	0.188	NM	NM

Notes:

U = not detected above the indicated concentration

mg/L = milligrams per liter

NM = not measured

$FeCl_3$ = ferric chloride

Green: At or below action level

Blue: Approaching action level

Orange: Above action level and increase relative to baseline

Grey: Non-detect but detection limit greater than action level

1) 1 hour sample started collecting 1.5 hours after $FeCl_3$ added (flow through column started 0.5 hours after $FeCl_3$). Ended collection 3 hours after $FeCl_3$ added.

2) 3 hour sample started collecting 3.5 hours after $FeCl_3$ added. Ended collection 5 hours after $FeCl_3$ added.

3) 6 hour sample started collecting 5.5 hours after $FeCl_3$ added. Ended collection 7 hours after $FeCl_3$ added.

4) pH of 6 was the goal but after adding the $FeCl_3$, the 20 mg/L test was a pH of 4.65 and the 40 mg/L was a pH of 3.66. Did not measure the final pH of the H_2O_2 test.

5) pH of 4 was the goal but after adding the $FeCl_3$, the 0 mg/L test was a pH of 3.45.

6) this was the only sample that had a brownish tent to it in the effluent. The flocks had formed faster and seemed to settle out better than those without the H_2O_2. Bubbles noted in effluent of column.

Table 9

Summary of Ferric Chloride Continuous Flow Test - Rush Island

Rush Island Energy Center, Missouri

	Action Level	Influent	Sand Filter – Intermediate 19 hr	Intermediate 2 day	Intermediate 8 day*	Effluent Sand Filter Ave first 19 hr	Effluent 19 hr	Effluent 2 day	Effluent 7 day
Total mg/L									
Arsenic	0.03	0.212	NM	NM	0.0288	0.0013	0.001	0.001 U	0.0107
Molybdenum	0.1	0.156	NM	NM	0.0267	0.01 U	0.01 U	0.01 U	0.0151
Lead	0.015	0.0057	NM	NM	0.0016	0.0026	0.0023	0.001 U	0.001 U
Lithium	0.0647	0.005 U	NM	NM	NM	0.005 U	0.005 U	0.005 U	NM
Iron	NA	0.0769	NM	NM	1.15	NM	NM	NM	0.299
Boron	4	4**	NM	NM	NM	NM	NM	NM	NM
Dissolved mg/L									
Arsenic	0.03	0.198	0.0019	0.0032	0.0219	0.001 U	0.001 U	0.001 U	0.0094
Molybdenum	0.1	0.144	0.01 U	0.01 U	0.0224	0.01 U	0.01 U	0.01 U	0.0136
Lead	0.015	0.0052	0.0022	0.0035	0.0014	0.0029	0.0027	0.001 U	0.001 U
Lithium	0.0647	0.005 U	0.005 U	0.005 U	NM	0.005 U	0.005 U	0.005 U	NM
Iron	NA	0.0552	NM	NM	0.831	NM	NM	NM	0.204
Boron	4	NM	NM	NM	NM	NM	NM	NM	NM

Filters - Mimic Resin Filtration Followed By Resin

	Action Level	Influent	Effluent 100 micron filter - 3 Days	Effluent 10 micron filter - 3 Days	filter pH to 7.5 adjusted - 3 Days	Post Resin
Total mg/L						
Arsenic	0.03	0.212	0.0363	0.0023	NM	0.0016
Molybdenum	0.1	0.156	0.0257	0.01 U	NM	0.01 U
Lead	0.015	0.0057	NM	NM	NM	NM
Lithium	0.0647	0.005 U	NM	NM	NM	NM
Iron	NA	0.0769	4.41	2.69	NA	5.11
Boron	4	4**	NM	4**	NA	0.02 U
Dissolved mg/L						
Arsenic	0.03	0.198	0.0032	0.0016	0.001 U	0.0012
Molybdenum	0.1	0.144	0.01 U	0.01 U	0.01 U	0.01 U
Lead	0.015	0.0052	NM	NM	NM	NM
Lithium	0.0647	0.005 U	NM	NM	NM	NM
Iron	NA	0.0552	1.92	2.33	0.951	0.503
Boron	4	NM	NM	NM	NM	0.02 U

Notes:

U = not detected above the indicated concentration

mg/L = milligrams per liter

$FeCl_3$ = ferric chloride at 40 mg/L

NM = not measured

NA = not applicable. Not a metal of concern

hr = hour

Ave = average of the flow collected in the first 19 hours

Intermediate = collected after $FeCl_3$ has been added and mixed, and the flocculants are being settled

Rush Island water was adjusted to a pH of 5.8-6.0 prior to adding the $FeCl_3$ and had a final pH of 4.0-4.3.

Effluent water was adjusted to a pH of 6-8 prior to passing through the resin.

* = the total intermediate sample was passed through a 5 micron filter to simulate a bag filter.

** = results are internal XDD measurements using colorimetric Hach testing

Legend (cell shading):
- Green: At or below action level
- Blue: Approaching action level
- Orange: Above action level and increase relative to baseline
- Gray: Non-detect but detection limit greater than action level

Table 10

Summary of pH Adjustment and Resin Column Testing - Rush Island

Rush Island Energy Center, Missouri

	Arsenic	Boron	Molybdenum
	mg/L		
Action Level	0.03	4	0.1
Total Metals			
Baseline	0.224	3.72	0.146
Day 1	0.0261	0.02 U	0.01 U
Day 3	0.0042	0.02 U	0.01 U
Day 7 - pH only	0.198	3.64	0.153
Day 7	0.0568	0.02 U	0.01 U
Dissolved Metals			
Baseline	0.211	3.39	0.14
Day 1	0.0242	0.02 U	0.01 U
Day 3	0.0032	0.02 U	0.01 U
Day 7 - pH only	0.189	3.27	0.142
Day 7	0.0525	0.02 U	0.01 U

Notes:

U = not detected above the indicated concentration

mg/L = milligrams per liter

pH was adjusted to 5

pH only = sample collected after pH adjustment and flowing through sand, but before the ion-specific resin

(green)	At or below action level
(blue)	Approaching action level
(orange)	Above action level and increase relative to baseline
(gray)	Non-detect but detection limit greater than action level

Table 11
Summary of Zero Valent Iron Column Metals Removal - Rush Island
Rush Island Energy Center, Missouri

	Column Construction: 5 Parts Sand per 1 Part ZVI				Column Construction: 2 Parts Sand per 1 Part ZVI			
	Arsenic	**Boron**	**Iron**	**Molybdenum**	**Arsenic**	**Boron**	**Iron**	**Molybdenum**
	mg/L							
Action Level	0.03	4	--	0.1	0.03	4	--	0.1
Total Metals								
Baseline	0.195	3.84	0.0721	0.143	0.211	3.51	0.0817	0.148
Day 1	0.034	3.48	0.357	0.0954	0.0419	3.47	0.503	0.145
Day 3	0.114	3.86	0.0959	0.15	0.082	3.4	0.166	0.134
Day 7	0.113	3.9	0.15	0.151	0.089	3.51	0.11	0.143
Dissolved Metals								
Baseline	0.18	3.71	0.0614	0.139	0.212	3.47	0.0489	0.143
Day 1	0.025 U	3.117	0.047	0.0792	0.0439	3.42	0.04 U	0.143
Day 3	0.104	3.59	0.0569	0.134	0.0836	3.36	0.0702	0.133
Day 7	0.101	3.61	0.114	0.135	0.0898	3.34	0.0805	0.138

Notes:

U = not detected above the indicated concentration

ZVI = zero valent iron - micro-scale size

mg/L = milligrams per liter

At or below action level

Approaching action level

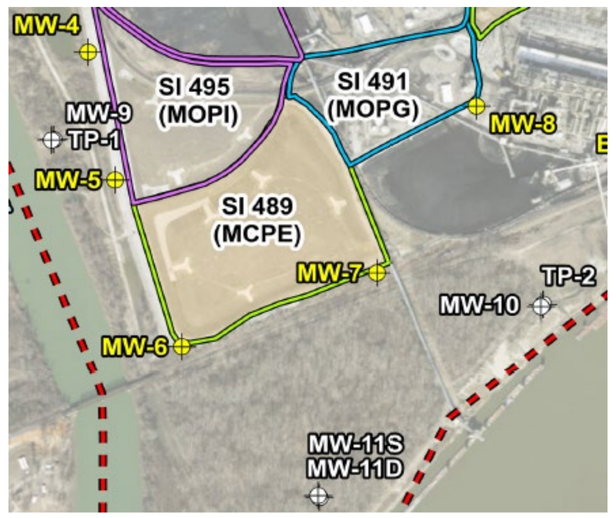
Above action level and increase relative to baseline

Non-detect but detection limit greater than action level

APPENDIX E
Time-Series Plots for Key Downgradient Well-Constituent Pairs

Arsenic Time-Series Plots for Key Downgradient Well Constituent Pairs

Detection and Assessment Monitoring Wells



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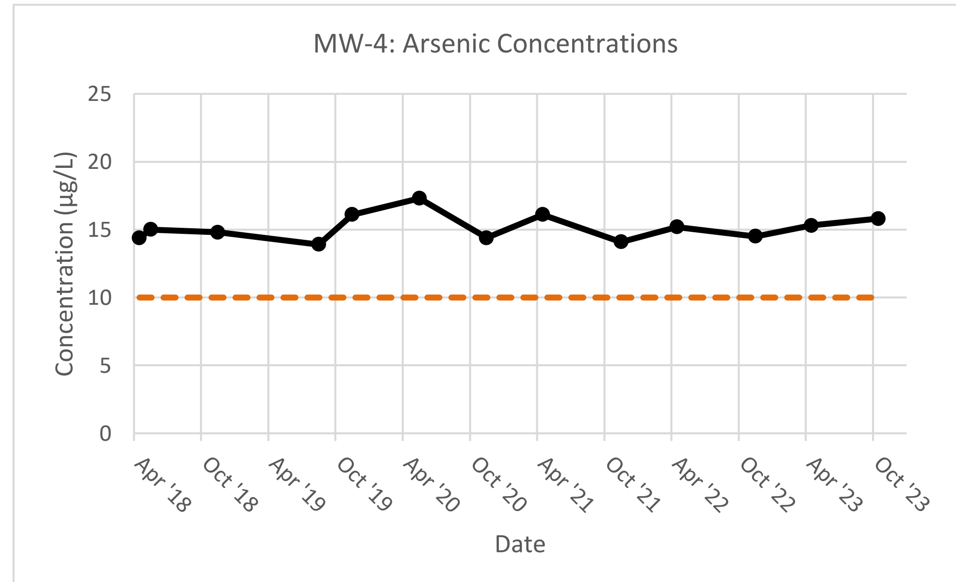
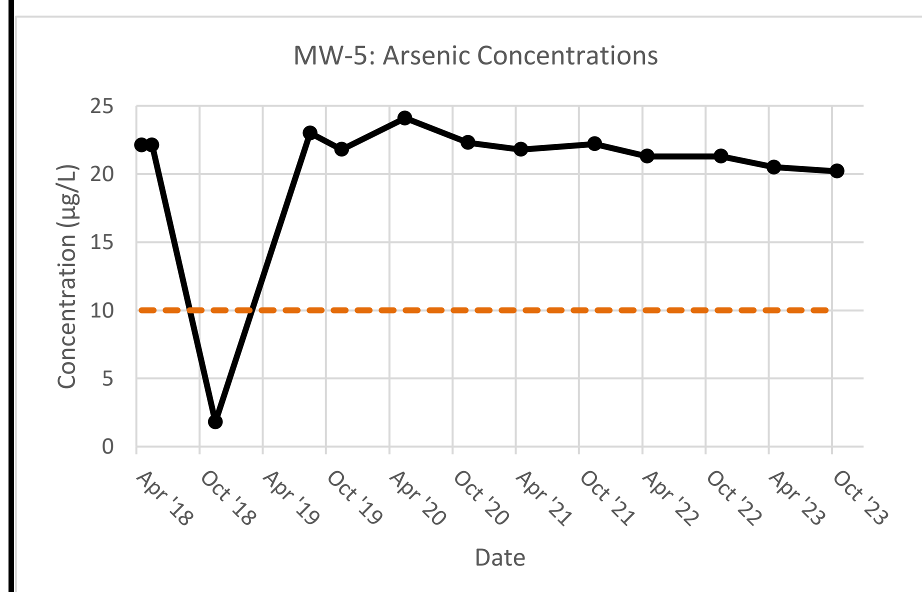
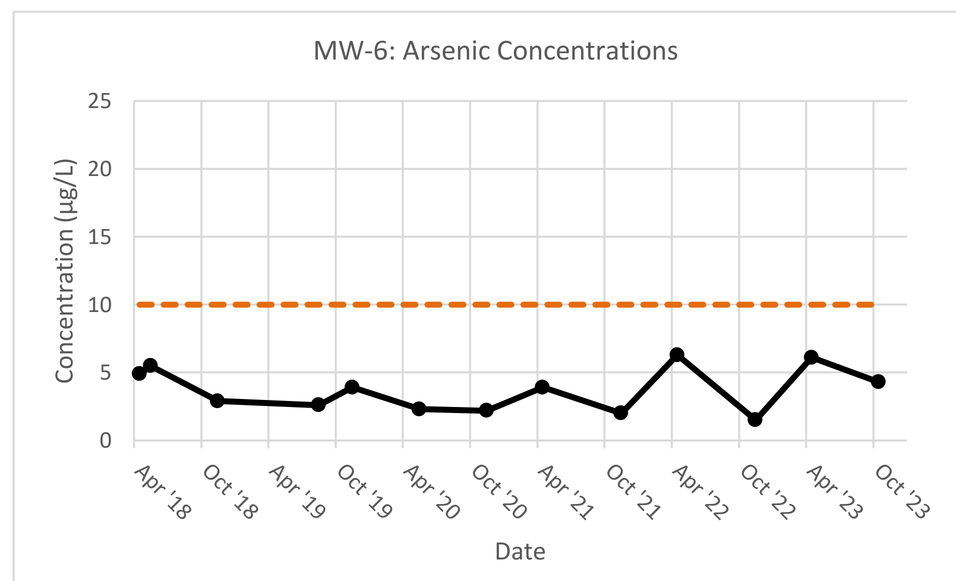
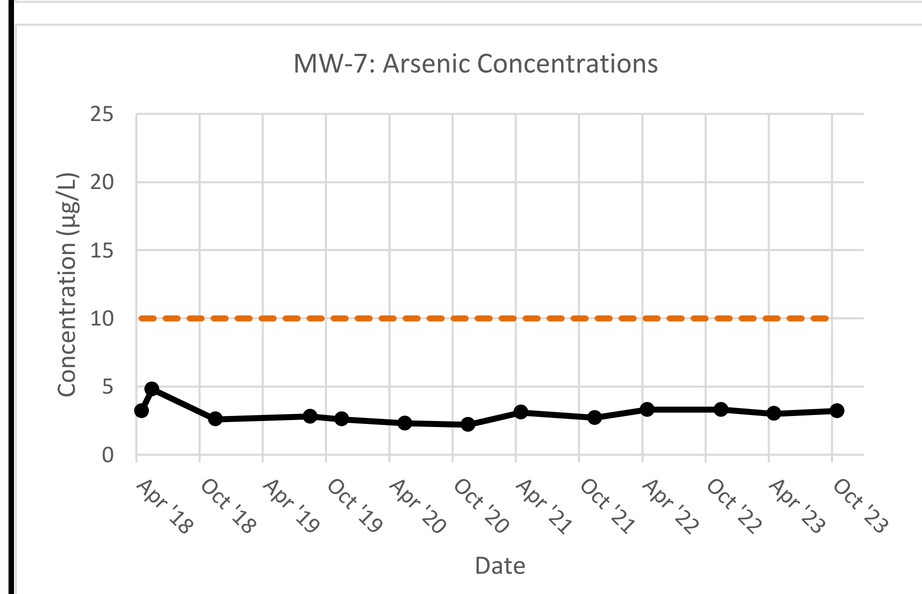
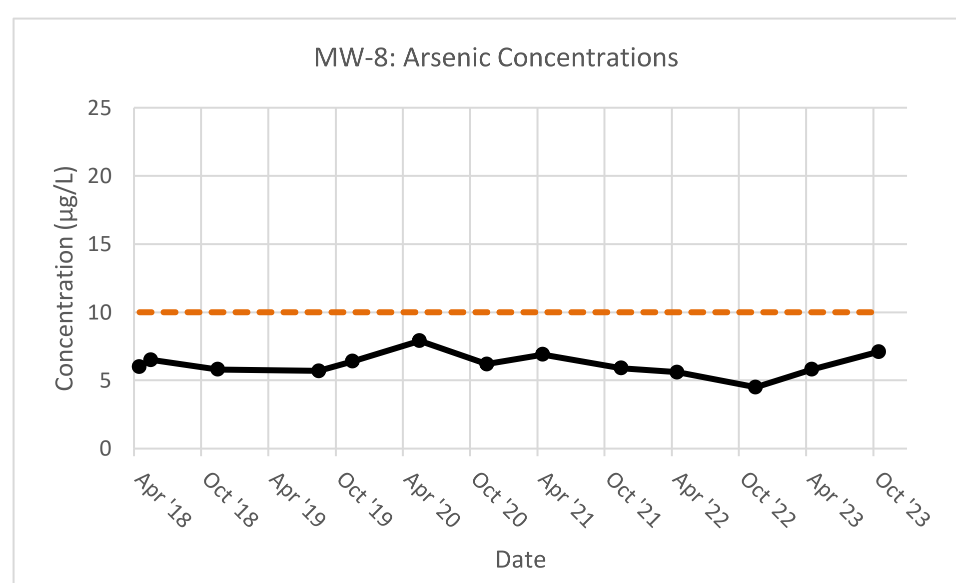


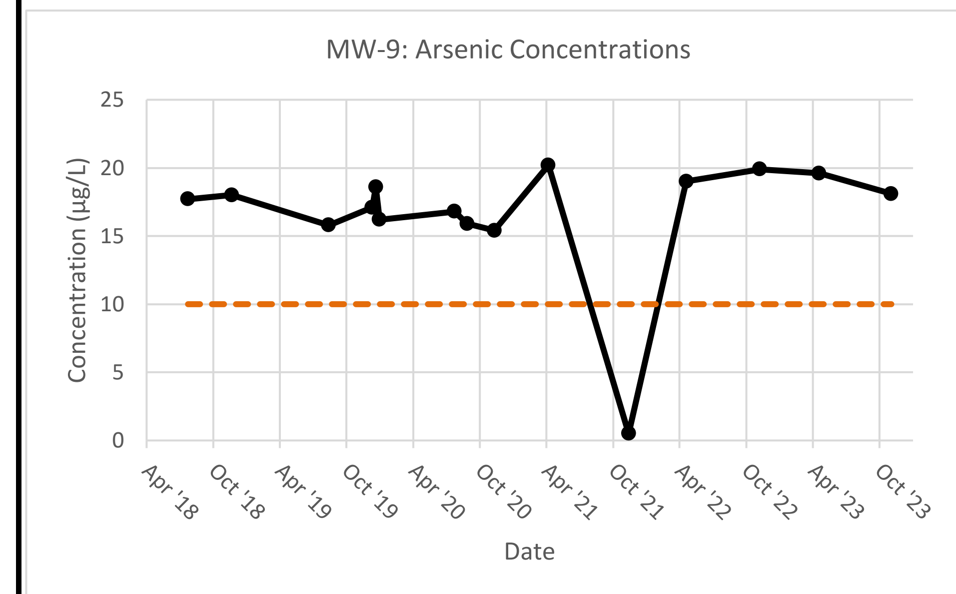


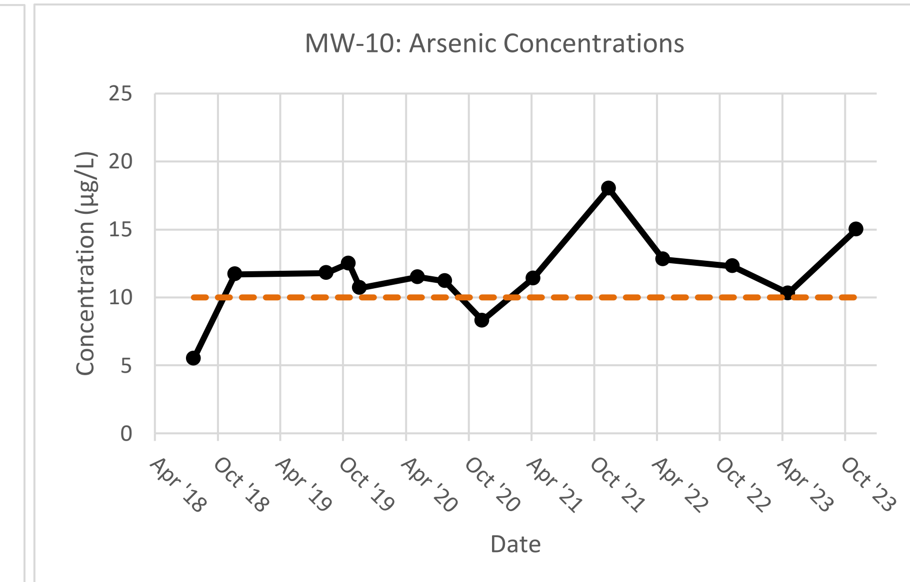


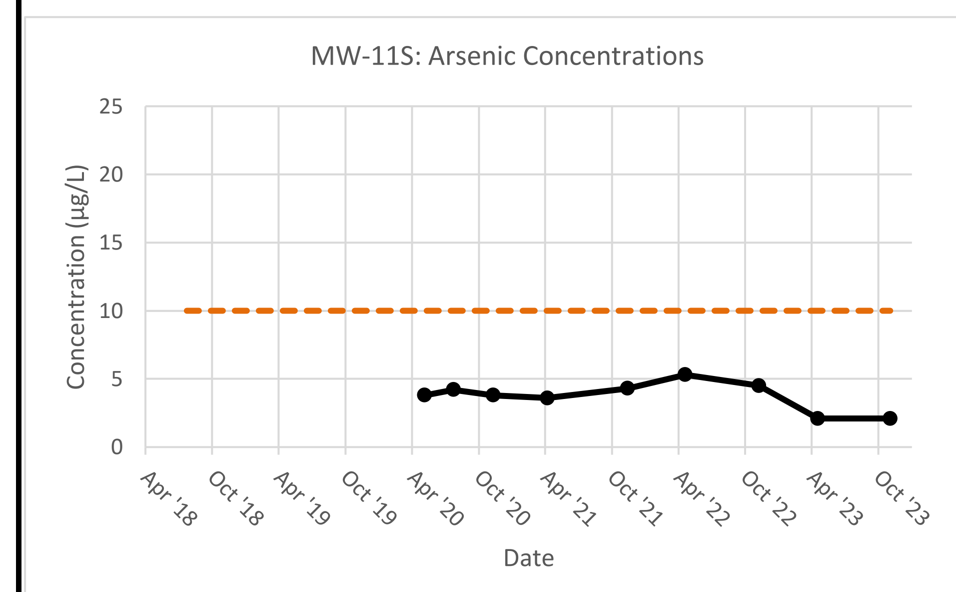


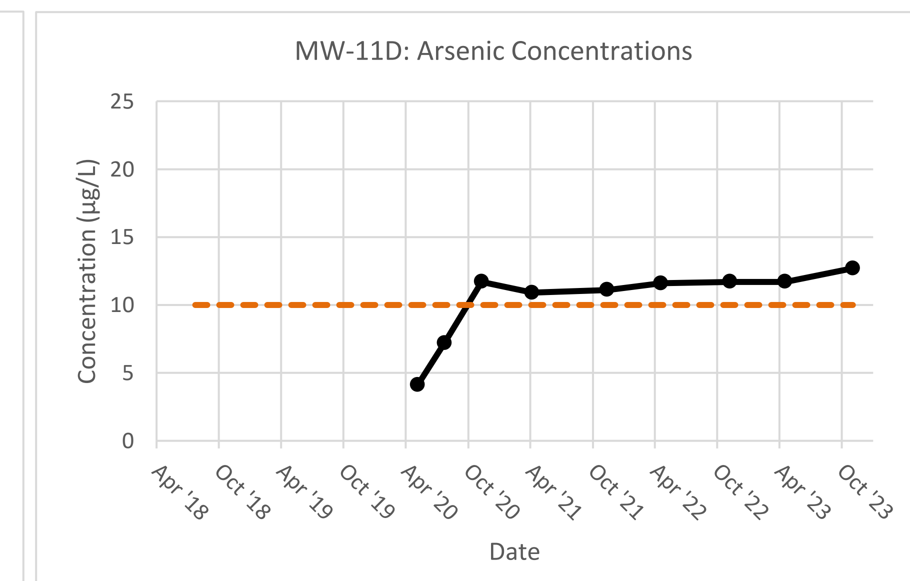


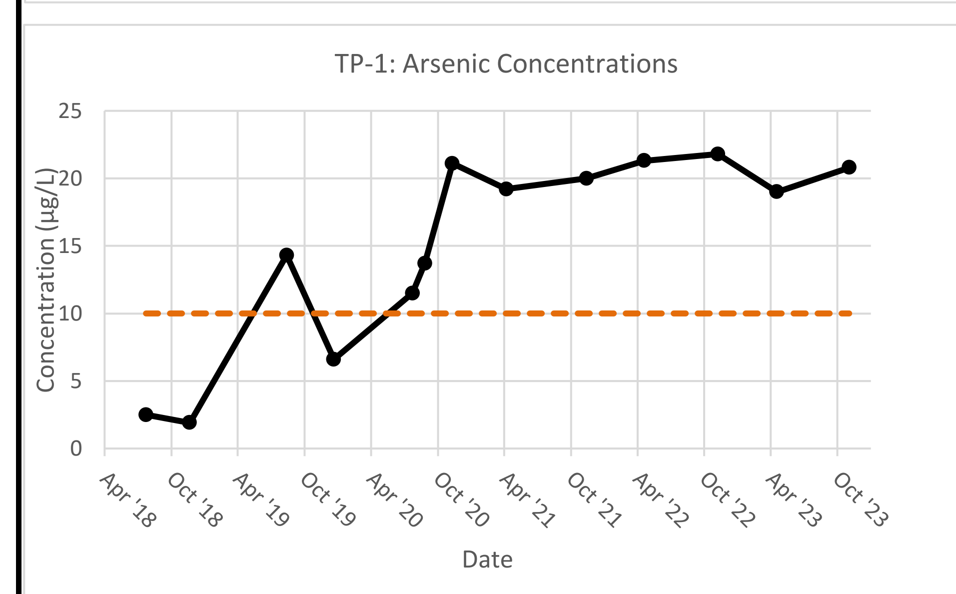
Corrective Action Monitoring Wells

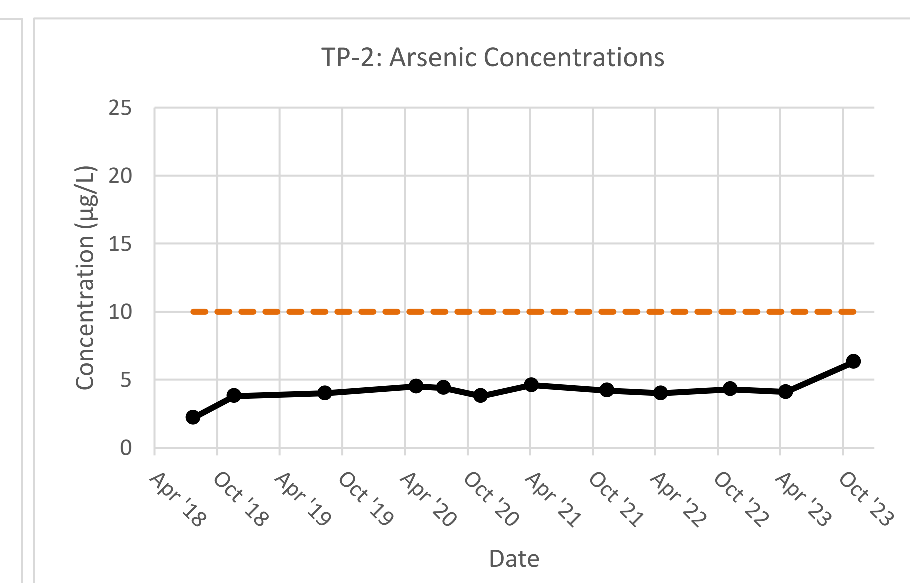








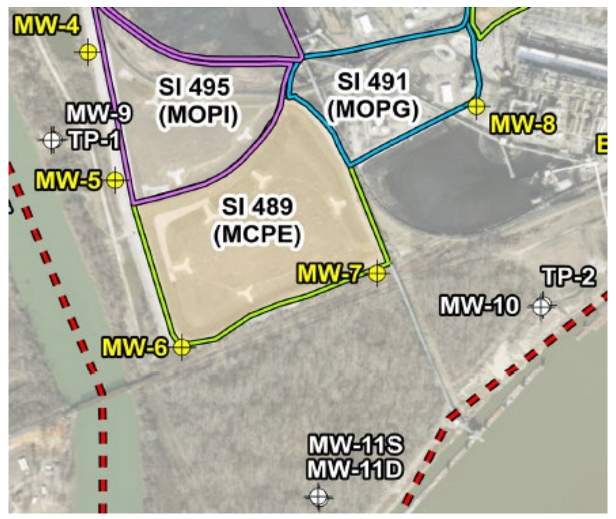




Legend:
- Concentration for monitoring event
- Non-detect result - value averaged from proximate event(s)
- GWPS for Appendix IV constituent

Boron Time-Series Plots for Key Downgradient Well Constituent Pairs

Detection and Assessment Monitoring Wells



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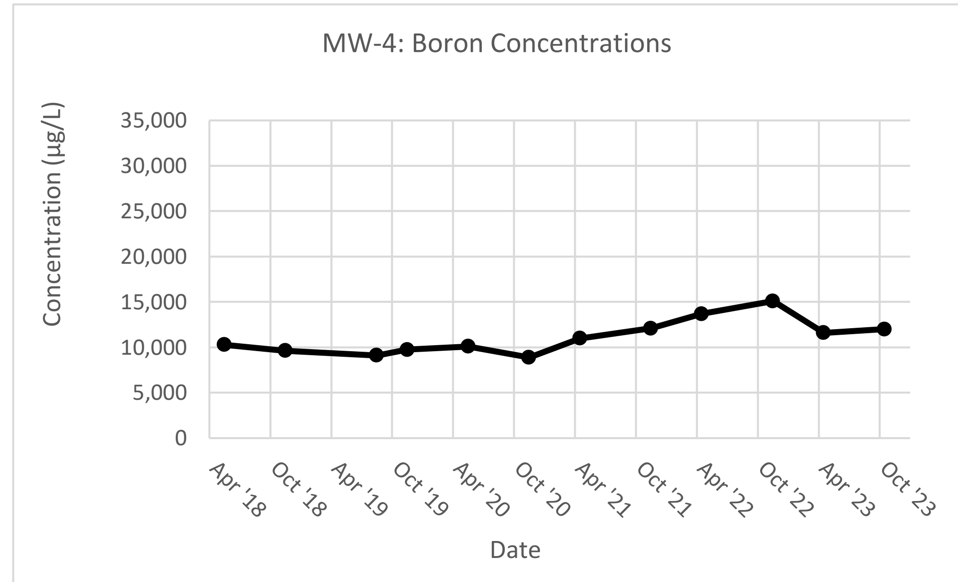
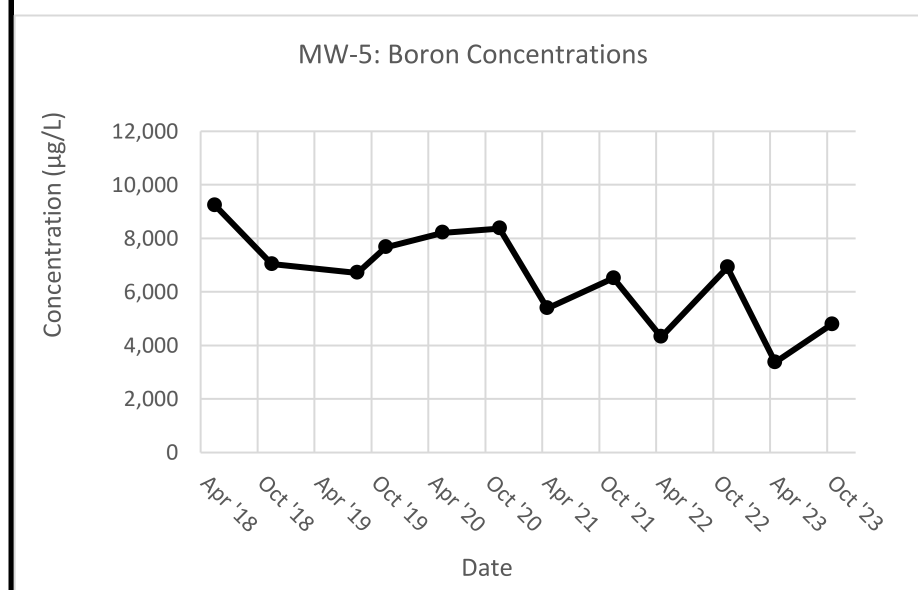
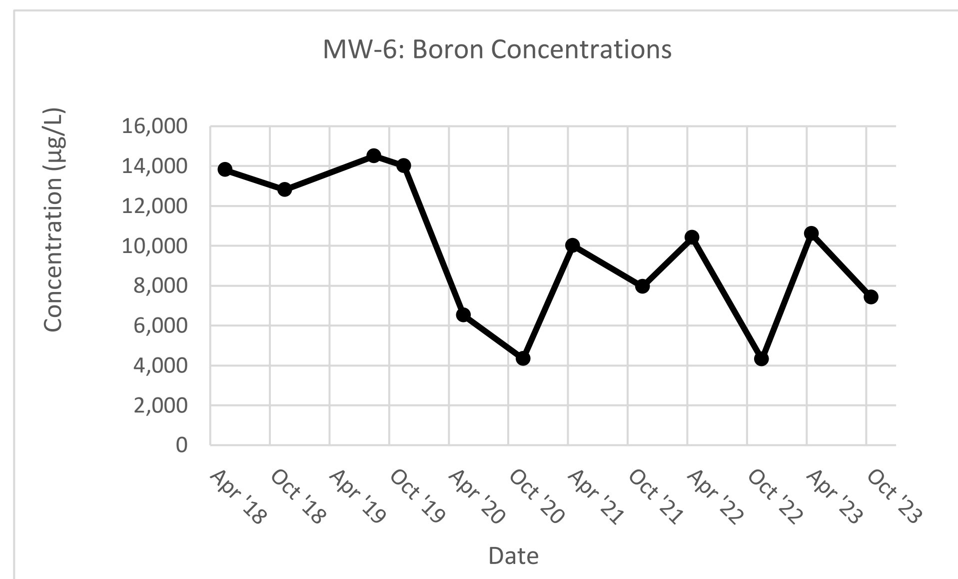
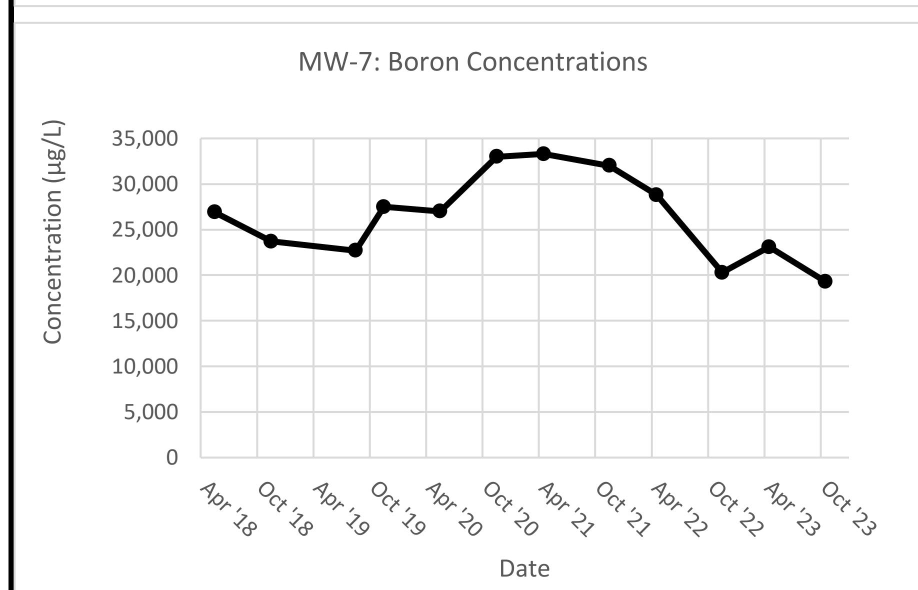
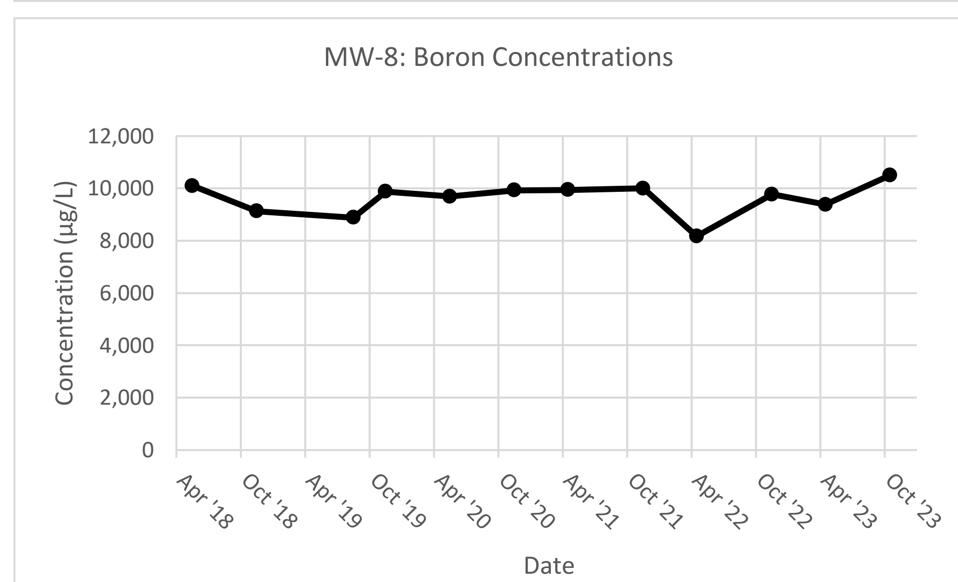


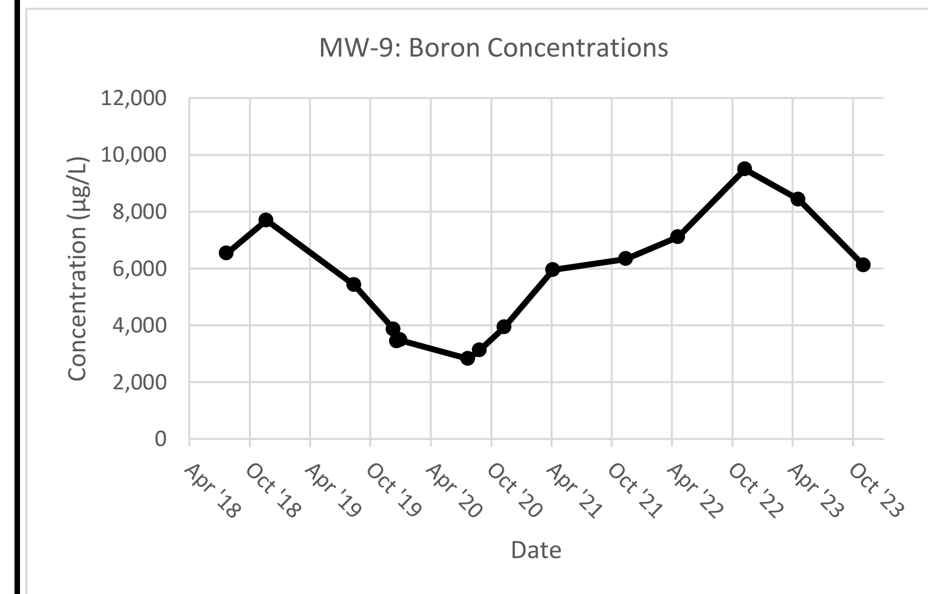


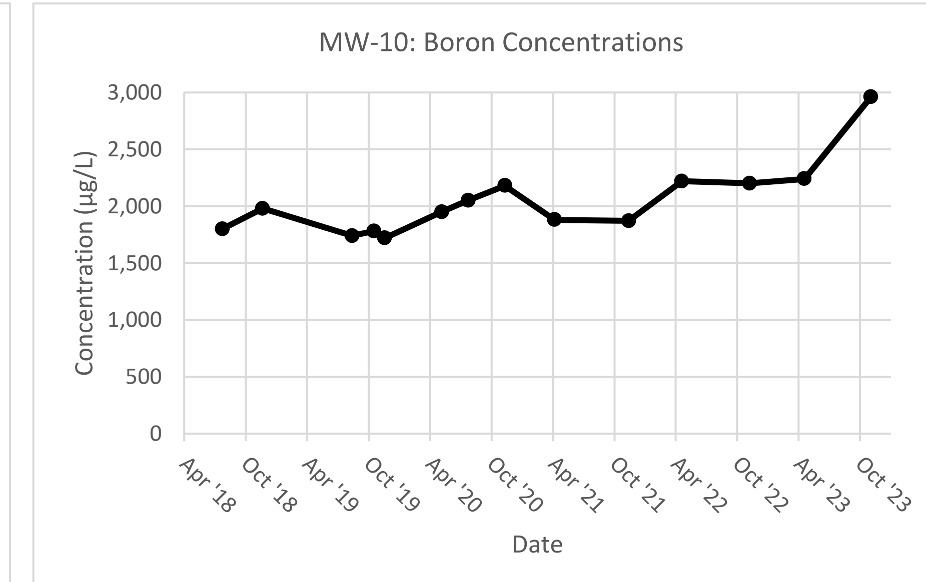


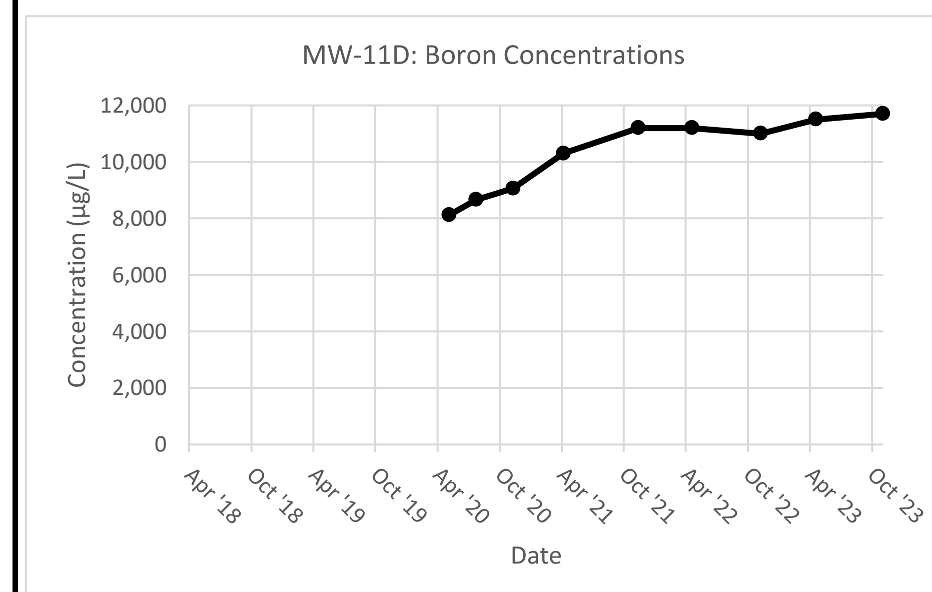


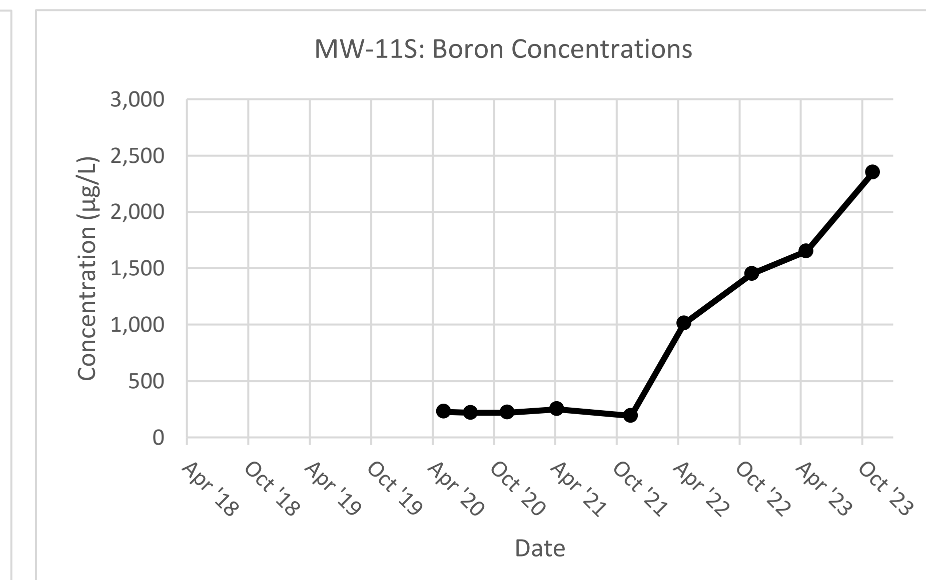


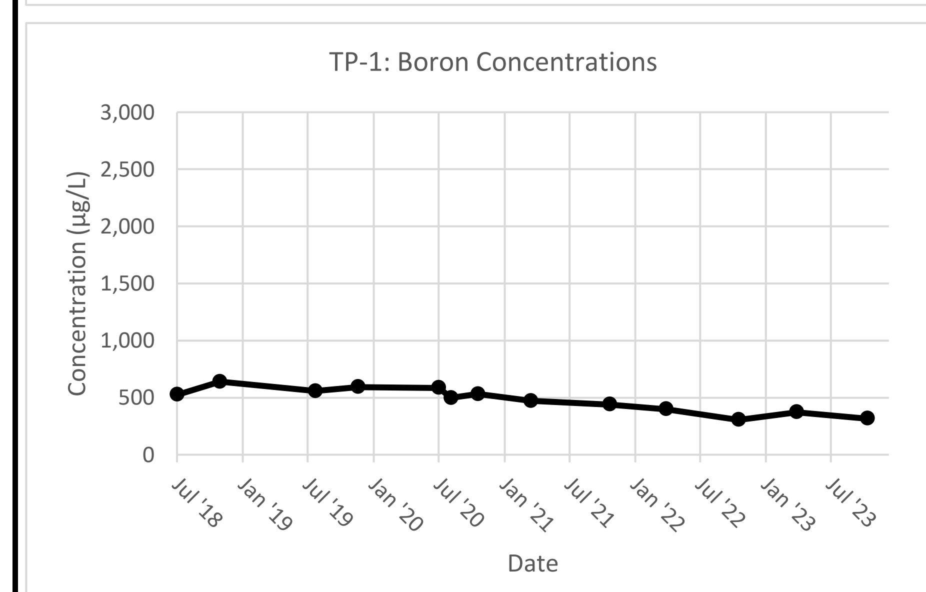
Corrective Action Monitoring Wells

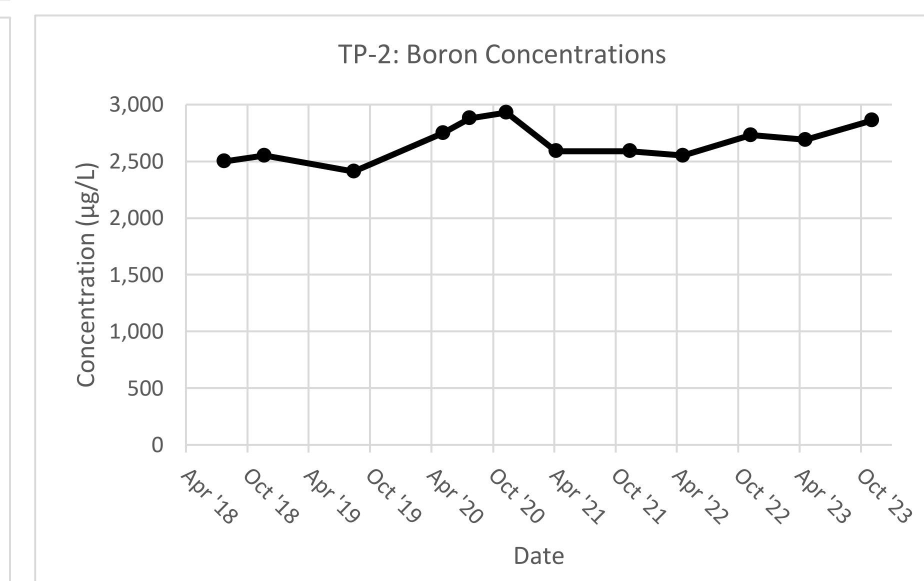






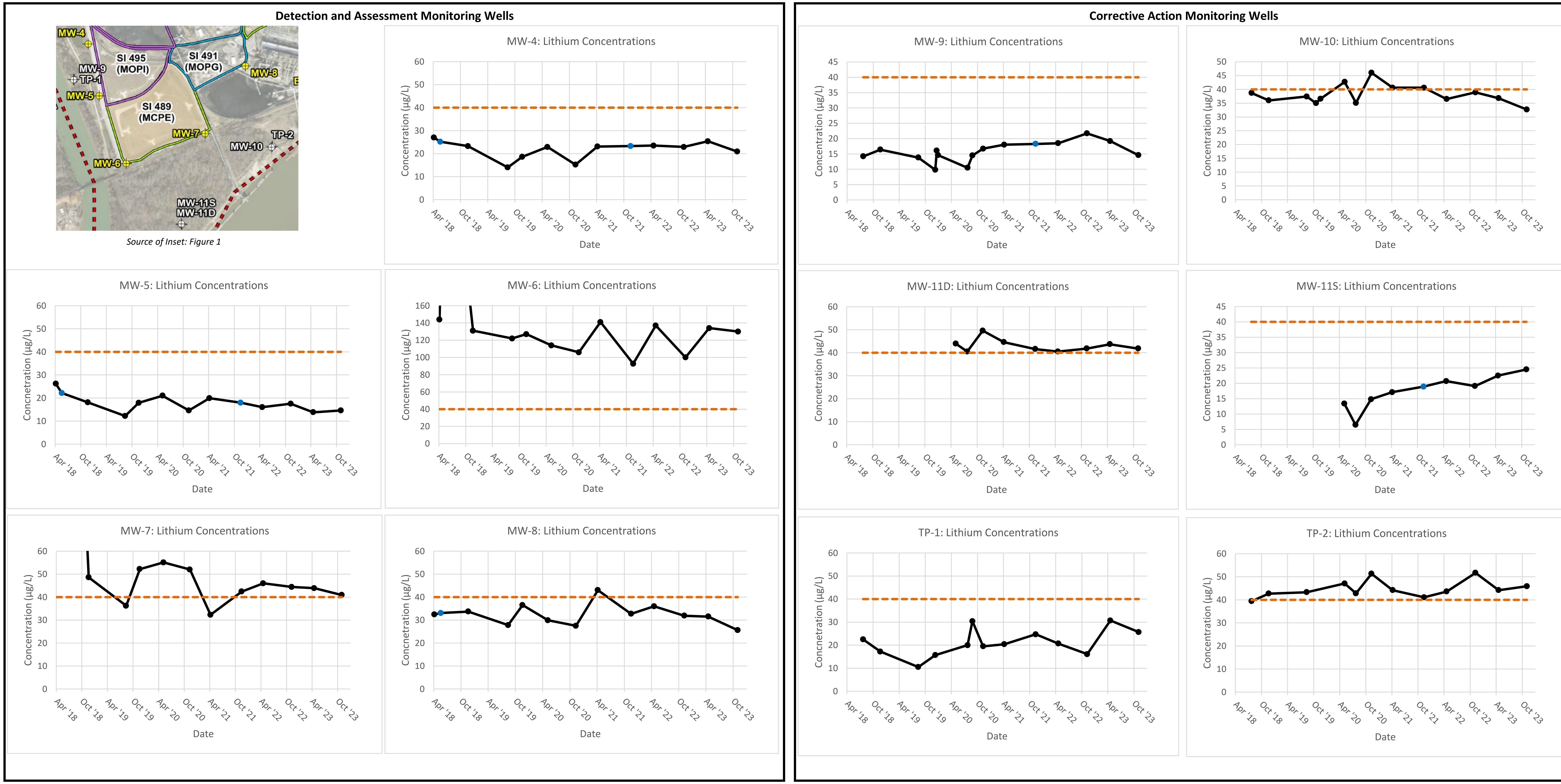






Legend:
- Concentration for monitoring event
- Non-detect result - value averaged from proximate event(s)

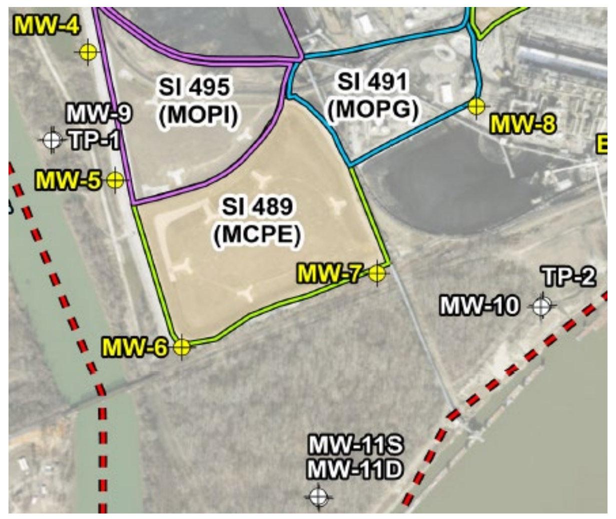
Lithium Time-Series Plots for Key Downgradient Well Constituent Pairs



Legend:
- Concentration for monitoring event
- Non-detect result - value averaged from proximate event(s)
- GWPS for Appendix IV constituent

Molybdenum Time-Series Plots for Key Downgradient Well Constituent Pairs

Detection and Assessment Monitoring Wells



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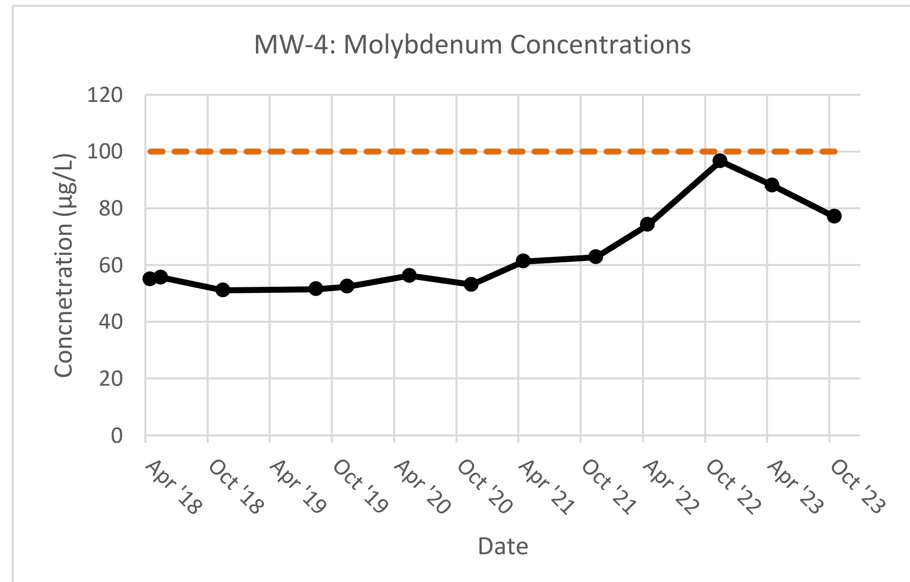
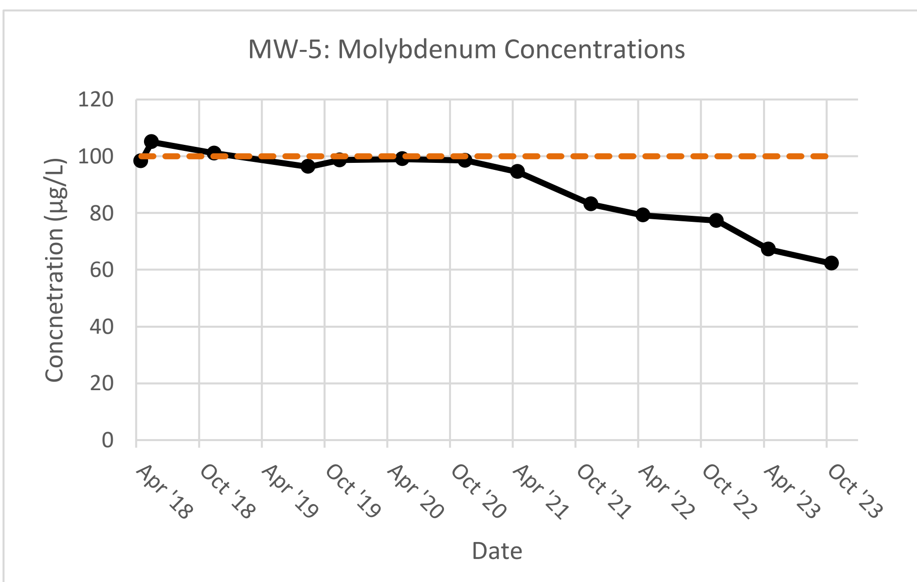
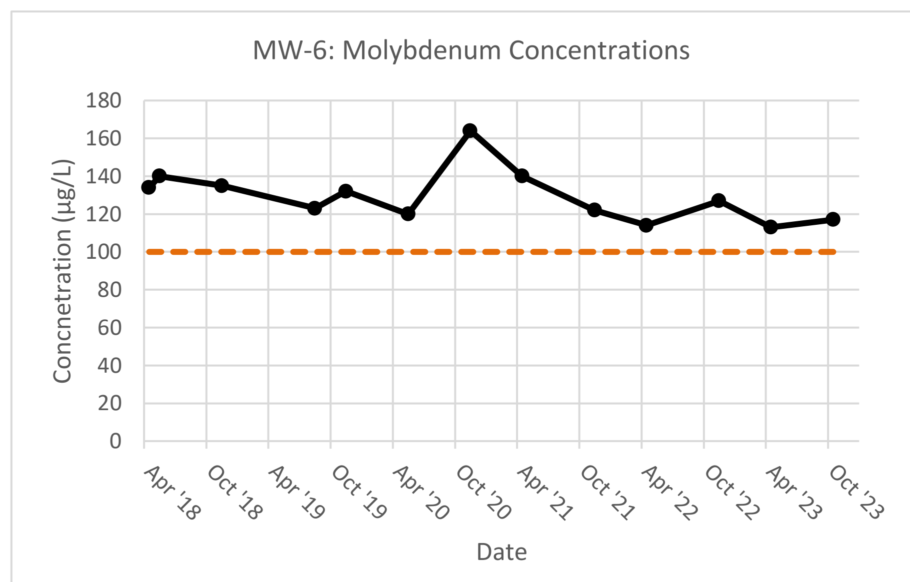
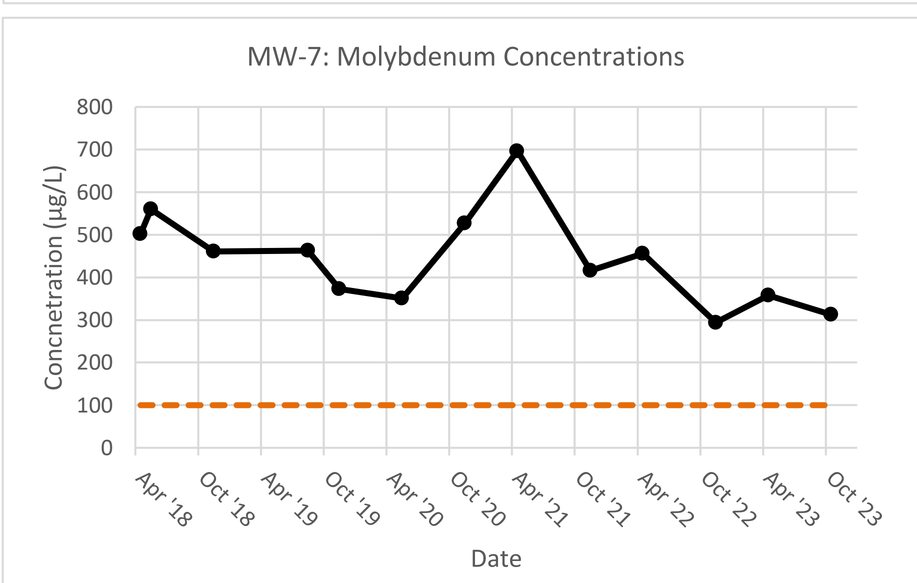
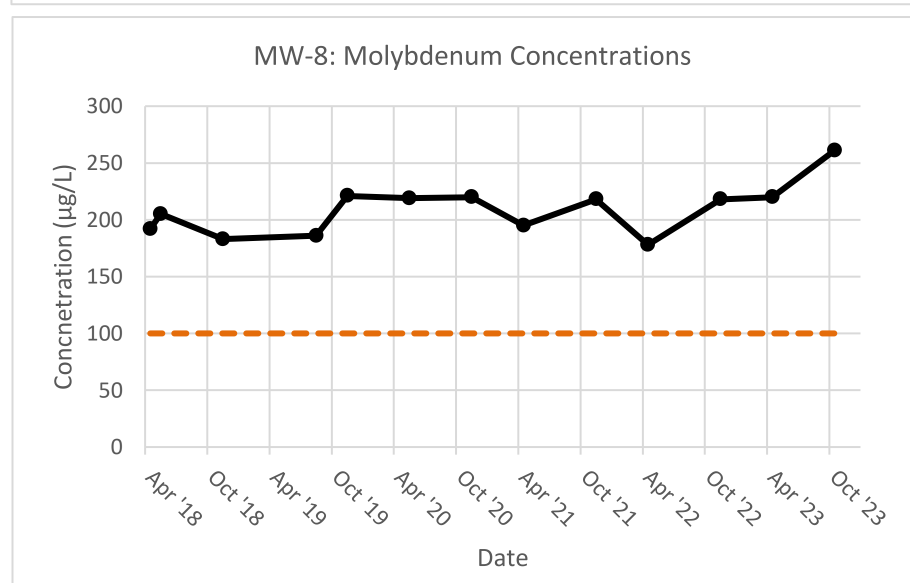


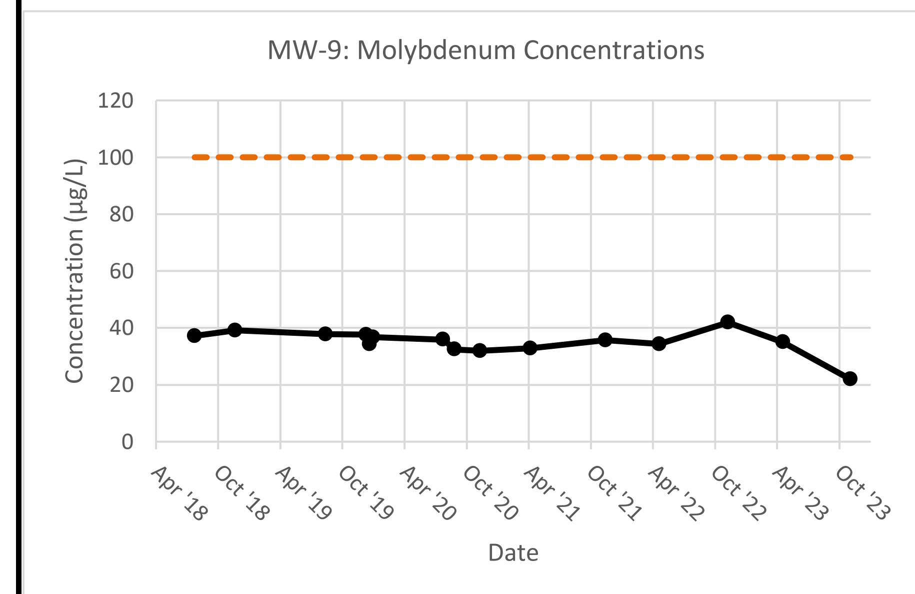


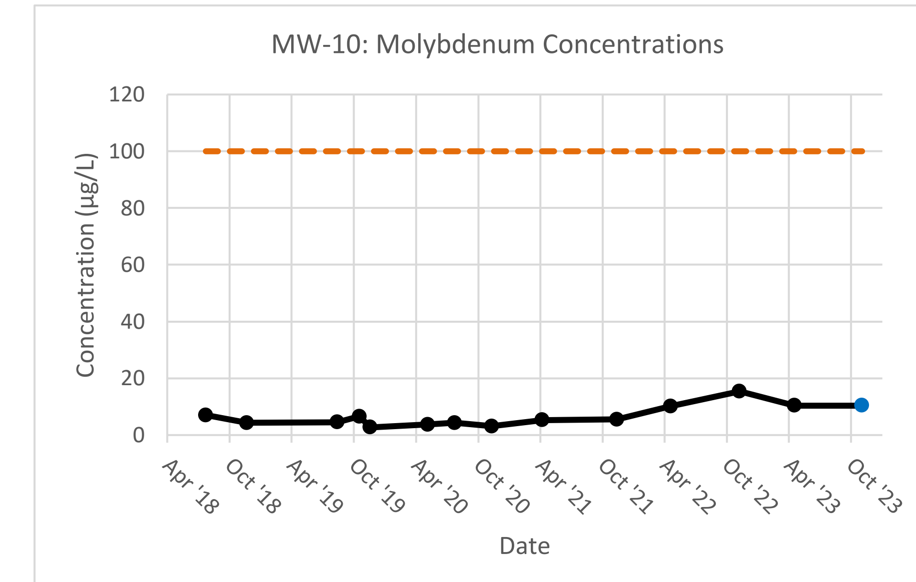


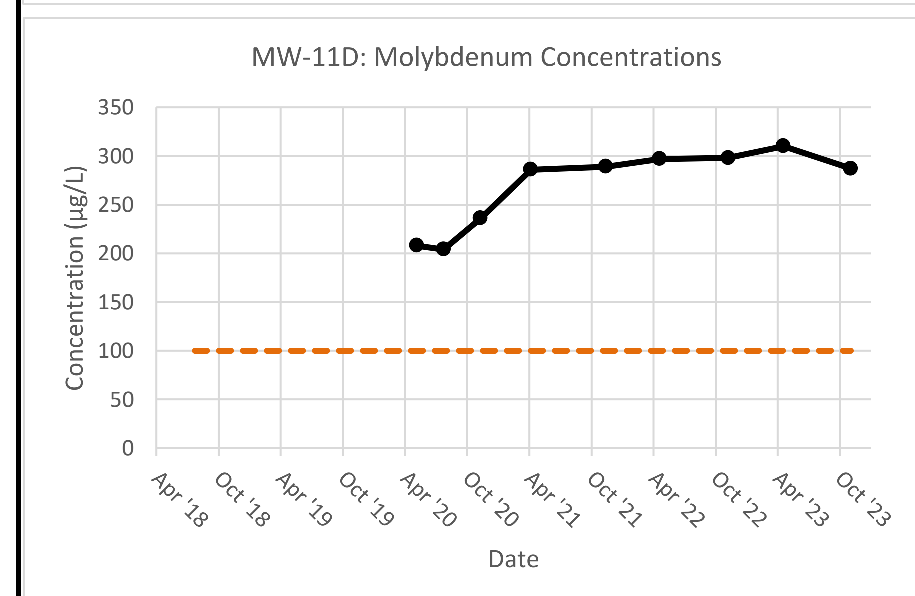


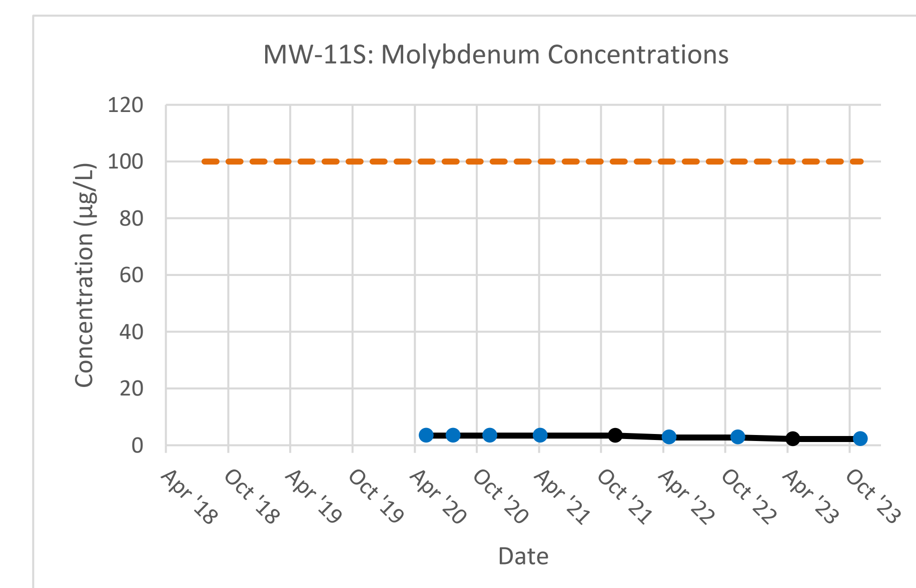


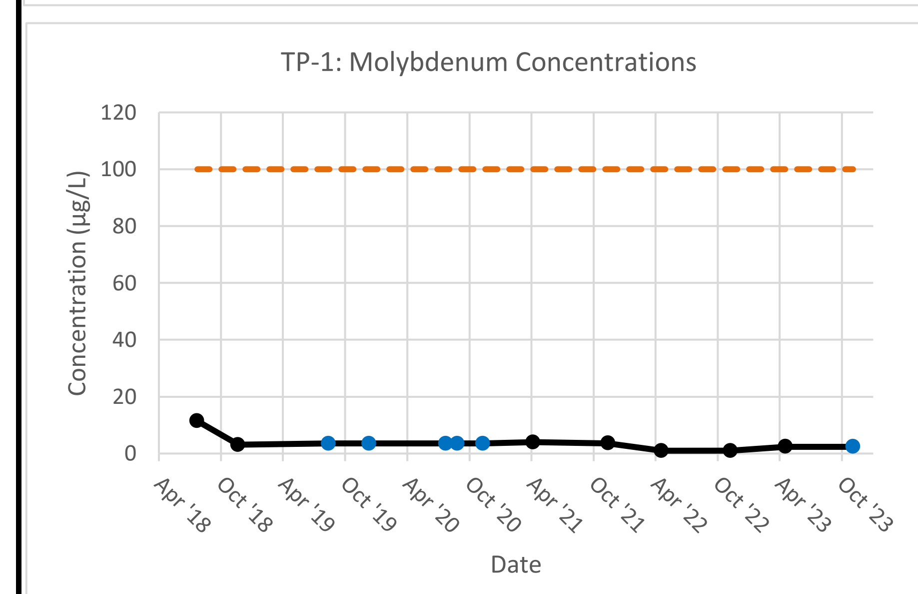
Corrective Action Monitoring Wells

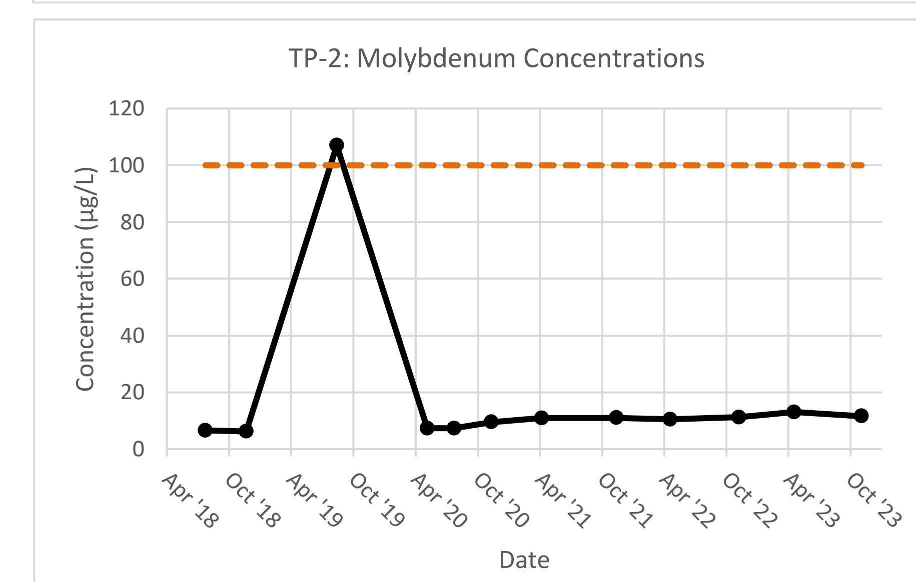








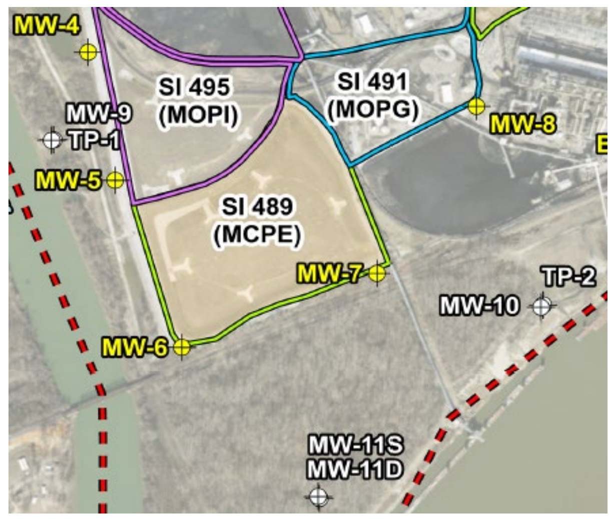




Legend:
- Concentration for monitoring event
- Non-detect result - value averaged from proximate event(s)
- GWPS for Appendix IV constituent

Sulfate Time-Series Plots for Key Downgradient Well Constituent Pairs

Detection and Assessment Monitoring Wells



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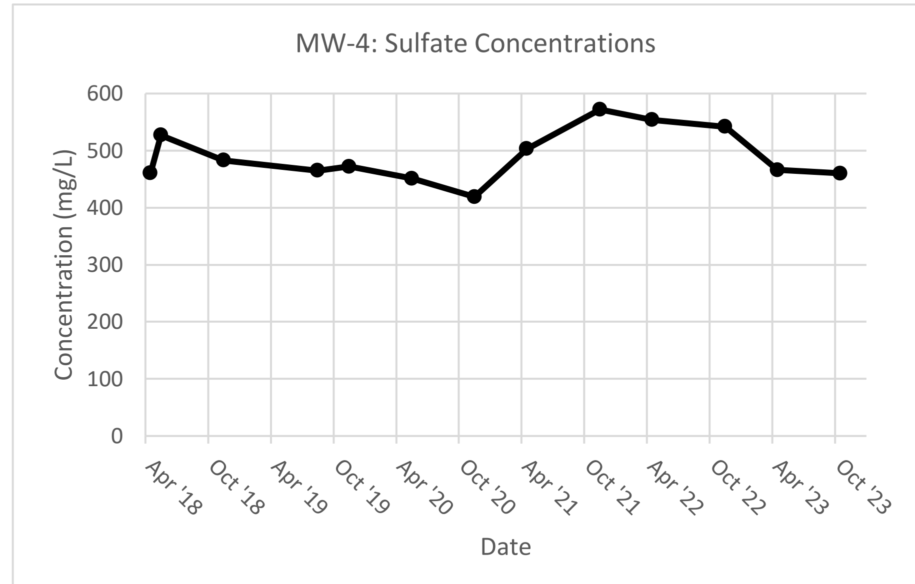
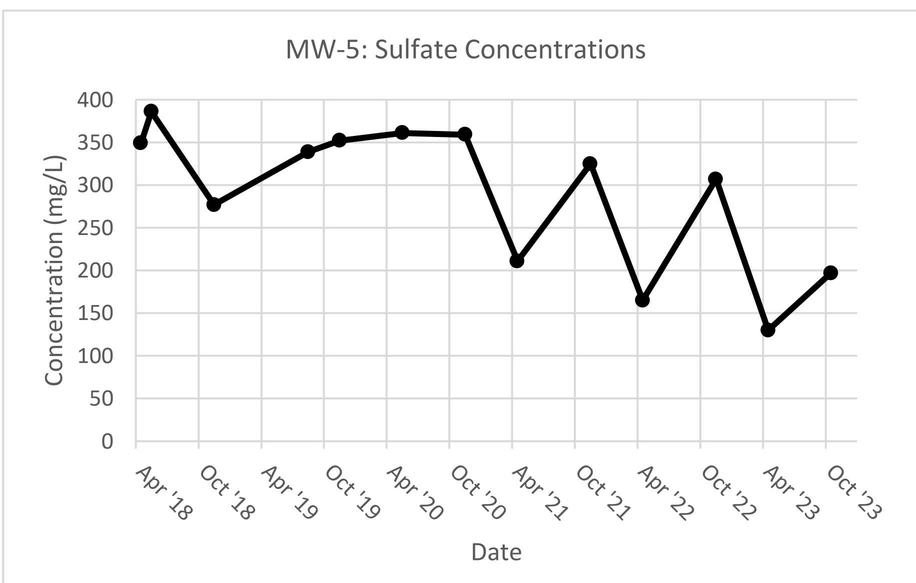
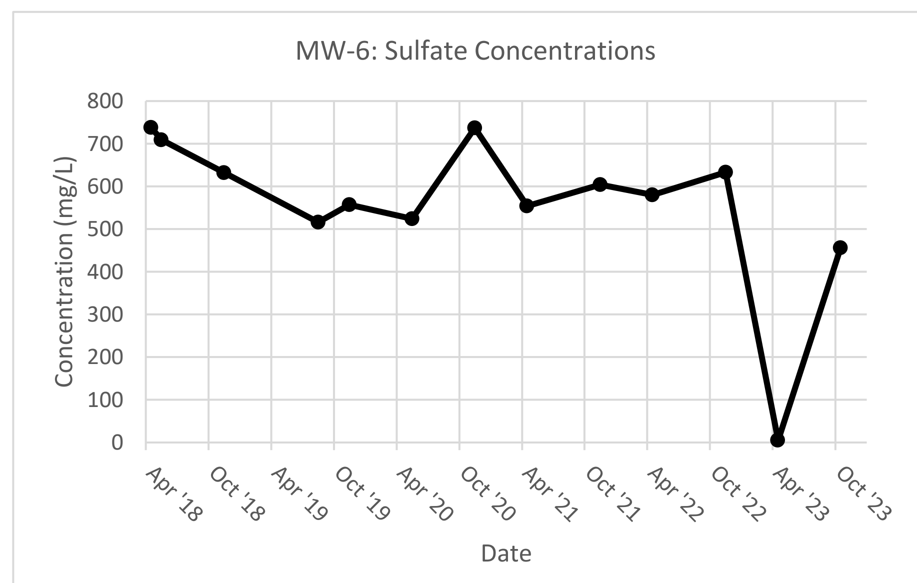
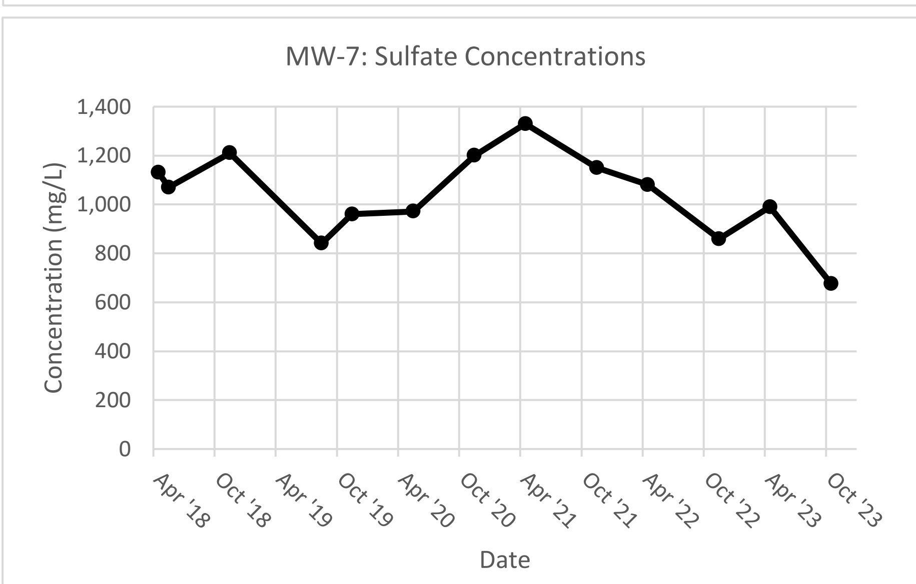
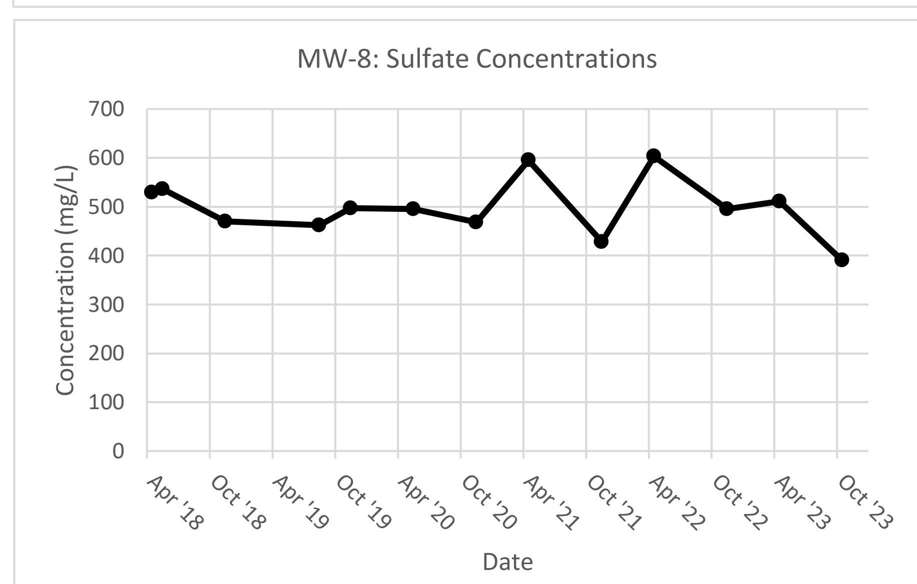


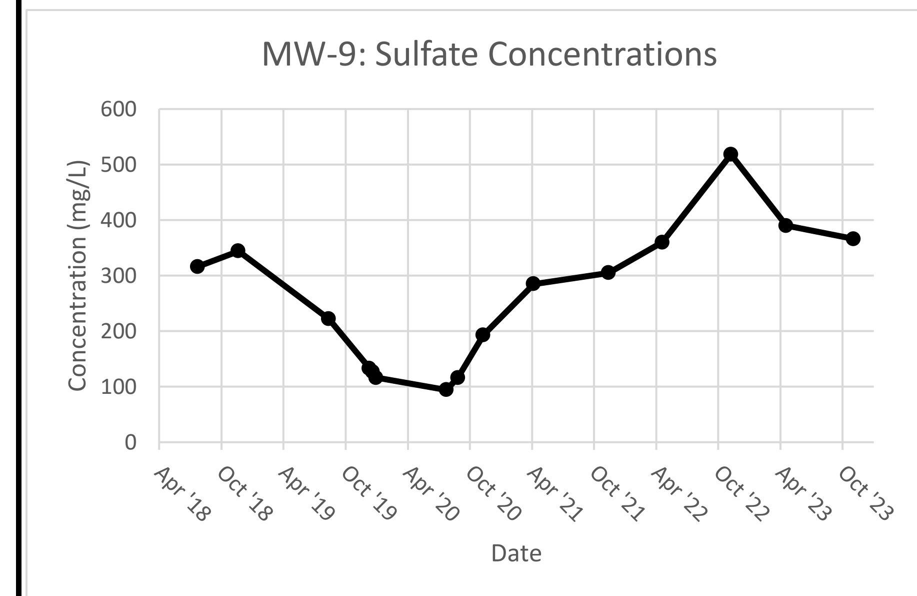


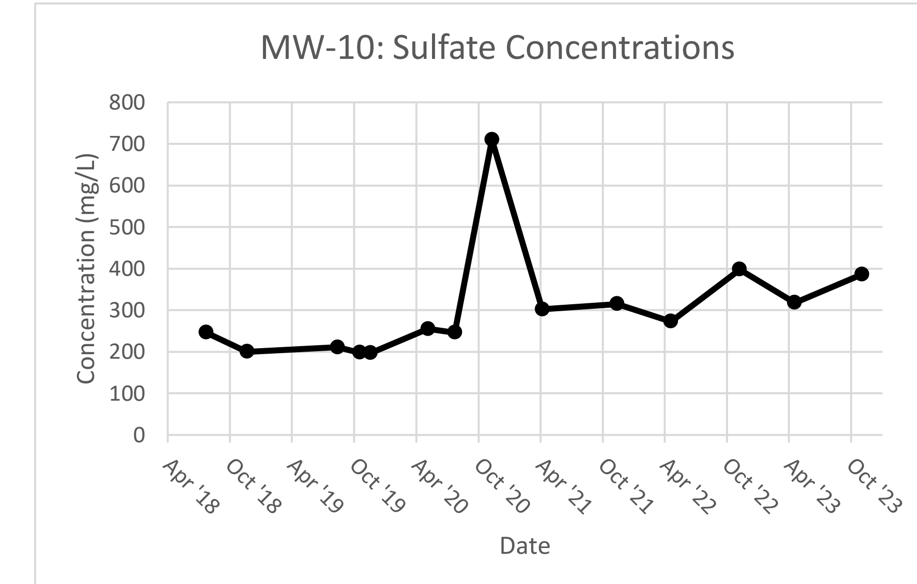


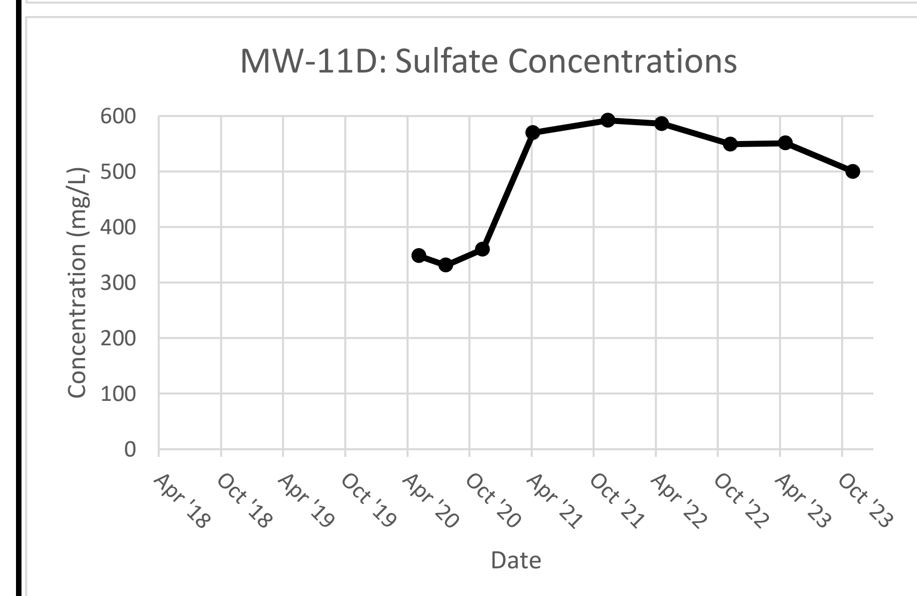


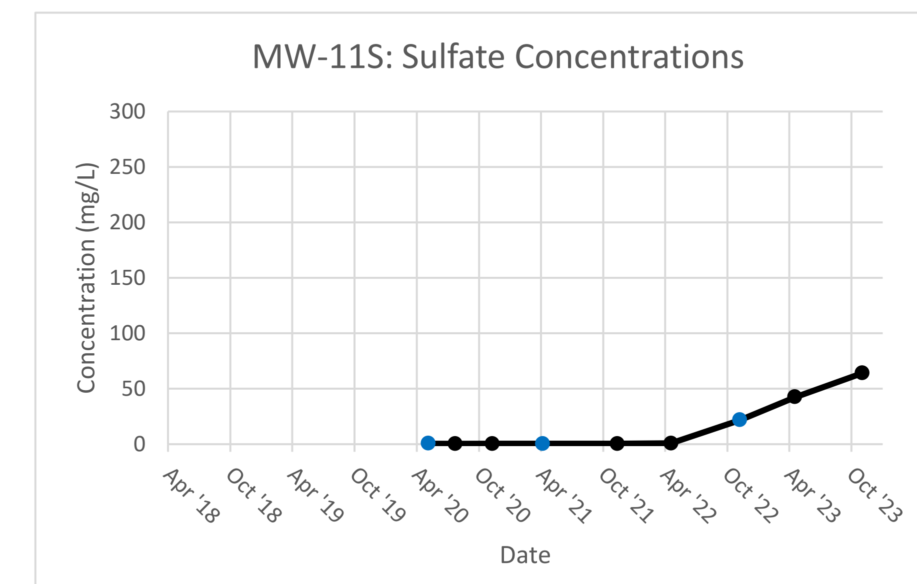


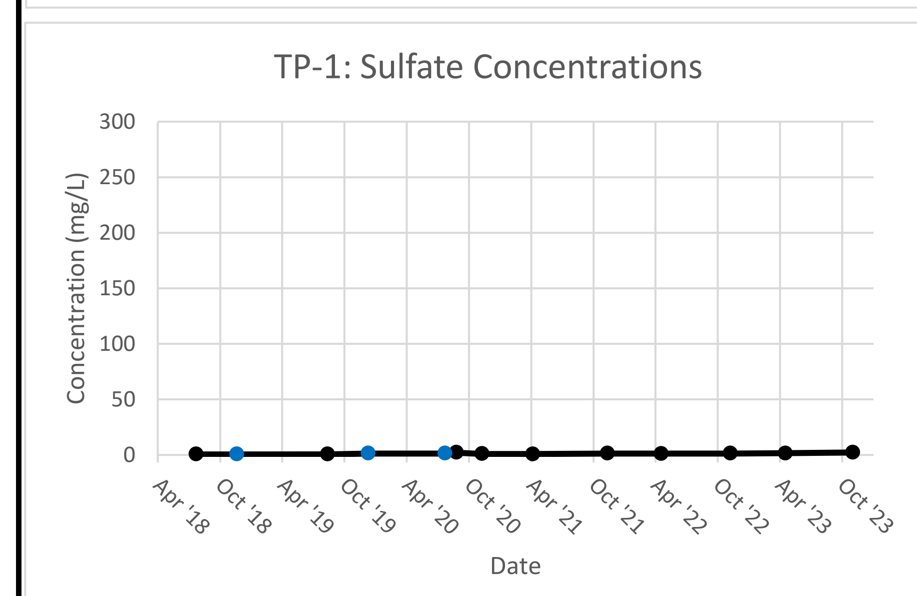
Corrective Action Monitoring Wells

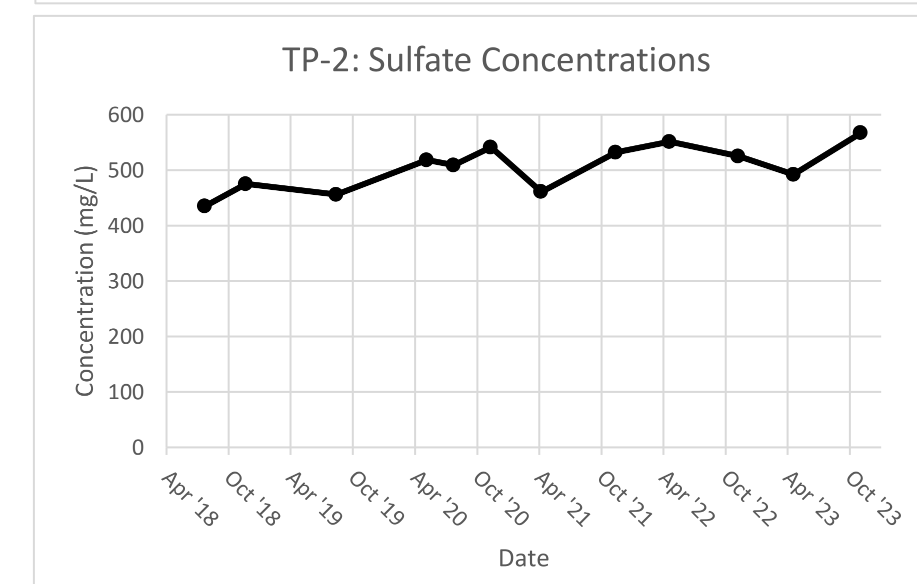












Legend:
- Concentration for monitoring event
- Non-detect result - value averaged from proximate event(s)

APPENDIX F
2018 Risk Assessment Report

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REPORT ON

HUMAN HEALTH AND ECOLOGICAL ASSESSMENT OF THE MERAMEC ENERGY CENTER

AMEREN MISSOURI
ST. LOUIS, MISSOURI

by Haley & Aldrich, Inc.
Boston, Massachusetts

for Ameren Missouri
St. Louis, Missouri

File No. 130182-002
February 2018

1. Introduction

The Meramec Energy Center (MEC) is a 831 MW natural gas and coal-fueled steam electrical power generating facility located along the Mississippi River at the confluence of the Meramec River, in St. Louis County, Missouri. The facility began operations in 1953 and historically Ameren Missouri managed coal ash in a series of nine (9) on-site surface impoundments. The Company has commenced closure of certain impoundments and closure activities will continue over the next several years. The facility is scheduled to be retired in 2022 at which point the remaining active ash ponds will be closed. Figure 1 shows the location of the facility, and the location of the surface impoundments.

The U.S. Environmental Protection Agency (USEPA) issued a final rule for “Disposal of Coal Combustion Residuals from Electric Utilities” in 2015 (the CCR Rule). One of the requirements in the CCR Rule is that utilities monitor groundwater at coal ash management facilities, and that the data be reported publicly. Ameren Missouri is complying with the CCR Rule, and has posted the required information on their publicly-available website: *https://www.ameren.com/Environment/ccr-rule-compliance*.

This Haley & Aldrich report is a companion document to the recently published 2017 Annual Groundwater Monitoring Report prepared by Golder Associates Inc. ("Golder") to provide interested reviewers with the information needed to interpret and meaningfully understand the groundwater monitoring data. Beyond the specific monitoring requirements of the CCR Rule, Ameren Missouri has also voluntarily taken the additional steps to determine if there has been any off-site impact to surface water from the operation of the surface impoundments. In this report, Haley & Aldrich examines groundwater data reported under the CCR Rule, and the results of surface water samples collected from the Mississippi River and Meramec River, which border the Meramec Energy Center.

Ameren Missouri's comprehensive evaluation demonstrates that there are no adverse impacts resulting from coal ash management practices at the Meramec Energy Center on human health or the environment from either surface water or groundwater uses. In fact, as described in Sections 6 and 7, concentration levels of constituents detected in the groundwater would need to be multiple orders of magnitude higher before such a risk could exist. Details about the evaluation are provided below.

2. Approach

The analysis presented in this report was conducted by evaluating the environmental setting of the Meramec Energy Center, including its location and where ash management has occurred at the facility. Information on where groundwater is located at the facility, the rate(s) of groundwater flow, the direction(s) of groundwater flow, and where waterbodies may intercept groundwater flow was prepared by Golder, and is reviewed and summarized here.

A conceptual model was developed based on this physical setting information, and the model was used to identify what human populations could contact groundwater and/or surface water in the area of the facility. This information was also used to identify where ecological populations could come into contact with surface water. This conceptual model approach was used to identify where to collect surface water samples to allow evaluation of potential impact to the environment. Groundwater and surface water data are evaluated on a human health risk basis and an ecological risk basis.

Human health risk assessment is a process used to estimate the chance that contact with constituents in the environment may result in harm to people. Generally, there are four components to the process: (1) Hazard Identification, (2) Toxicity Assessment, (3) Exposure Assessment, and (4) Risk Characterization.

The USEPA develops "screening levels" of constituent concentrations in groundwater (and other media) that are considered to be protective of specific human exposures. These screening levels are referred to as "Risk-Based Screening Levels" or RSLs, and are published by USEPA and updated twice yearly[1]. In developing the screening levels, USEPA uses a specific target risk level (component 4) combined with an assumed exposure scenario (component 3) and toxicity information from USEPA (component 2) to derive an estimate of a concentration of a constituent in an environmental medium, for example groundwater, (component 1) that is protective of a person in that exposure scenario (for example, drinking water). Similarly, ecological screening levels for surface water are developed by Federal and State agencies to be protective of the wide range of potential aquatic ecological resources, or receptors.

Risk-based screening levels are designed to provide a conservative estimate of the concentration to which a receptor (human or ecological) can be exposed without experiencing adverse health effects. Due to the conservative methods used to derive risk-based screening levels, it can be assumed with reasonable certainty that concentrations below screening levels will not result in adverse health effects, and that no further evaluation is necessary. Concentrations above conservative risk-based screening levels do not necessarily indicate that a potential risk exists, but indicate that further evaluation may be warranted.

The surface water and groundwater data were evaluated using human health risk-based and ecological risk-based screening levels drawn from Federal and State sources. The screening levels are used to determine if the concentration levels of constituents could pose a risk to human health or the environment. The evaluation also considers whether constituents are present in groundwater and surface water above screening levels, and if so, if the results could be due to the ash management operations.

Conceptual Site Model

A conceptual site model (CSM) is used to evaluate the potential for human or ecological exposure to constituents that may have been released to the environment. Some of the questions posed during the CSM evaluation include:

> What is the source? How can constituents be released from the source? What environmental media may be affected by constituent release? How and where do constituents travel within a medium? Is there a point where a receptor (human or ecological) could contact the constituents in the medium? Are the constituent concentrations high enough to potentially exert a toxic effect?

For the evaluation of the ash management operations at the Meramec Energy Center, the coal ash stored at surface impoundments on site is the potential source. Constituents present in the coal ash can be dissolved into infiltrating water (either from precipitation or from groundwater intrusion) and those constituents may then be present in shallow groundwater, also referred to as the alluvial aquifer. Constituents could move with groundwater as it flows, usually in a downgradient/downhill direction.

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[1] USEPA Risk-Based Screening Levels (November 2017).
http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/index.htm

The constituents derived from the coal ash could then be introduced to adjacent surface water bodies; here, that could be the Mississippi River and/or Meramec River. Figure 1 shows the facility location and layout, and identifies direction of groundwater flow and the adjacent surface water bodies. Thus, the environmental media of interest for this evaluation are:

- Groundwater on the facility;
- Mississippi River surface water;
- Meramec River surface water; and
- Creek/Drainage surface water along the northern boundary of the facility.

The direction of groundwater flow has been cataloged for many years at the Meramec Energy Center. The direction and rate of flow can vary with Mississippi and Meramec River stages but as Figure 1 shows, the direction of groundwater flow is mainly from the bluff area on the northern side to the southwest towards the Meramec River and to a lesser extent to the Mississippi River.

The facility is located in a metropolitan area and surrounded by bluffs. Its immediate neighbors include the Metropolitan Sewer District (MSD) wastewater treatment facility and a golf course owned by Ameren Missouri. There are no users of shallow groundwater that are present between the surface impoundments and the Mississippi River and Meramec River. According to a well survey database maintained by the Missouri Department of Natural Resources (MDNR), there are approximately eight (8) private wells and three (3) public wells recorded within a one-mile radius of the facility (see Figure 2). Five of the private wells are located between the Mississippi and Meramec Rivers and are upgradient of the facility. The three public wells and five of the private wells are located in a bluff area on the west side of the Meramec River and the Mississippi River.

American Water and the City of St. Louis provide drinking water to the majority of residents located within the metropolitan area. Water intake locations include the Mississippi River (Chain of Rocks), the Missouri River (Howard Bend), both upstream from the facility, and the Meramec River at a location approximately 5 miles upstream from the Meramec Energy Center. The Mississippi is a source of drinking water for the City of Chester, Illinois; the drinking water intake is located approximately 51.2 miles downstream from the facility.

The Mississippi and Meramec Rivers can be used for human recreation – wading, swimming, boating, fishing. The creek/drainage along the northern portion of the facility is small in size and would be limited mostly to wading.

Both rivers serve as habitat for aquatic species – fish, amphibians, etc.

A depiction of the conceptual site model is shown in Figure 3.

Based on this conceptual site model and the facility setting shown in Figure 1, samples have been collected from each of these environmental media – groundwater, Mississippi River, and Meramec River, as well as the creek/drainage along the northern portion of the facility. The samples have been analyzed for constituents that are commonly associated with coal ash, as discussed below. However, it is recognized by the USEPA that all of these constituents are naturally occurring and can be found in rocks, soils, water and sediments; thus, the challenge is to understand what the naturally occurring background levels are for these constituents. [See Attachment A for a more detailed discussion of the constituents present in coal ash and in our natural environment.] The CCR Rule requires sampling and analysis of upgradient and/or background groundwater just for this reason. The same reasoning applies to the surface water, thus, when sampling surface water for this evaluation, samples were collected upstream to assess background conditions, and downstream to assess whether the facility may be having an impact on surface water quality. The sampling is detailed in the next section.

To answer the question, "Are the constituent concentrations high enough to potentially exert a toxic effect?" health risk-based screening levels from Federal and State sources are used for comparison to the data. To be conservative, all data are compared to risk-based drinking water screening level levels, even though the closest downgradient drinking water intake in the Mississippi River is 51.5 miles downstream near Chester, Illinois. The surface water data is compared to risk-based human recreational screening levels, and to ecological screening levels.

Thus, this conceptual site model has guided the sample collection, sample analysis, and the risk-based sample results evaluation that are provided in the following sections.

3. Sample Collection

Alluvial Aquifer Groundwater

Ten (10) groundwater monitoring wells were installed to evaluate groundwater at the surface impoundments under the CCR Rule. Eight (8) monitoring wells were installed along the perimeter of the surface impoundments to assess groundwater conditions at the ash management area, and two (2) monitoring wells were installed north and east of the facility to assess background groundwater conditions. Figure 1 shows the locations and groundwater elevations of the monitoring wells. Each well is identified by a unique name. MW-1 through MW-8 are located around the perimeter of the surface impoundments, and BMW-1 and BMW-2 are the two background wells.

Each groundwater monitoring well was sampled nine (9) times in 2016 and 2017[2].

Mississippi River

In September 2017, Golder collected surface water samples (not required by the CCR Rule for compliance) from twelve (12) locations in the Mississippi River. These locations are shown on Figure 4. At each sample location, shallow samples were collected near the surface of the river. Where the depth of water was greater than four (4) feet, a second sample was collected mid-depth in the river (referred to here as a deep sample).

To assess water conditions unaffected by facility operations, Golder sampled the Mississippi River at three (3) locations approximately 0.25 miles upstream of the facility (M-MIS-10S through -12S). Five (5) samples were collected to represent the following environments:

- Nearshore on the side closest to the Meramec Energy Center (M-MIS-10S), shallow depth;
- Midstream (M-MIS-12S/D), shallow depth, and deep depth; and
- Near midstream (M-MIS-11S/D), shallow depth, and deep depth.

Golder also sampled the Mississippi River at six (6) locations adjacent to the facility (M-MIS-4S through -9S). The data from these locations are used to assess whether there is potential impact by the facility to river water quality. Similar to the upstream location, ten (10) samples were collected to represent the following environments:

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[2] The CCR Rule requires eight (8) rounds of sampling events to establish baseline conditions in each well. Under the CCR Rule, the ninth sampling round is defined as the "Detection" sampling round.

- Nearshore on the side closest to the Meramec Energy Center (M-MIS-4S and M-MIS-7S), shallow depth;
- Midstream (M-MIS-6S/D and M-MIS-9S/D), shallow depth, and deep depth; and
- Near midstream (M-MIS-5S/D and M-MIS-8S/D), shallow depth, and deep depth.

Three (3) locations are approximately 0.25 miles downstream of the facility (M-MIS-1S through -3S). The data from these locations are used to assess whether there is potential impact by the facility to river water quality. Similar to the upstream location, five (5) samples were collected to represent the following environments:

- Nearshore on the side closest to Meramec Energy Center (M-MIS-1S), shallow depth;
- Midstream (M-MIS-3S/D), shallow depth, and deep depth; and
- Near midstream (M-MIS-2S/D), shallow depth, and mid-depth.

Thus, a total of twenty (20) samples were collected from the Mississippi River.

Meramec River

The western border of the Meramec Energy Center is adjacent to Meramec River. Golder collected surface water samples from nine (9) locations in the river in September 2017. These locations are shown on Figure 4.

Three (3) locations are upstream of the facility (M-MEC-7S to -9S), and represent water conditions unaffected by facility operations. Four (4) samples were collected to represent the following environments:

- Nearshore on the side closest to the Meramec Energy Center (M-MEC-7S), shallow depth;
- Midstream (M-MEC-9S/D), shallow depth, and deep depth; and
- Near midstream (M-MEC-8S), shallow depth (this location was not deep enough to collect a deep sample).

Six (6) sampling locations (in two groups) are adjacent to the facility. The data from these locations are used to assess whether there is potential impact by the facility to river water quality. Similar to the upstream location, nine (9) samples were collected to represent the following environments:

- Nearshore on the side closest to the Meramec Energy Center (M-MEC-4S and M-MEC-1S), shallow depth;
- Midstream (M-MEC-5S, and M-MEC-2S/D), shallow depth, and deep depth (location M-MEC-5 was not deep enough to collect a deep sample); and
- Near midstream (M-MEC-6S/D and M-MEC-3S/D), shallow depth, and deep depth.

Thus, a total of thirteen (13) surface water samples were collected from the Meramec River.

Creek/Drainage

A creek/drainage bed runs along the northwestern boundary of Meramec Energy Center. Shallow surface water samples were collected from three (3) locations in the creek in September 2017. These locations are shown on Figure 4. One location is upstream of the facility (M-C-1), one location is adjacent (M-C-2), and one location is downstream of the facility (M-C-3), near the confluence with the

Meramec River. Thus, a total of three (3) surface water samples were collected from the creek/drainage area.

4. Sample Analysis

The CCR Rule identifies the constituents that are included for groundwater testing; these are:

Boron	Antimony	Lead
Calcium	Arsenic	Lithium
Chloride	Barium	Mercury
pH	Beryllium	Molybdenum
Sulfate	Cadmium	Selenium
Total Dissolved Solids (TDS)	Chromium	Thallium
Fluoride	Cobalt	Radium 226/228

The CCR Rule requires eight (8) rounds of groundwater sampling and analysis. However, nine (9) rounds of groundwater samples collected through June 2017 were analyzed for all constituents. The samples from an additional tenth round from November 2017 were analyzed for the constituents listed in the first column above (these are the Appendix III constituents under the CCR Rule – the remaining are referred to as Appendix IV constituents). The CCR Rule requires statistical methods be used to determine whether a statistically significant increase (SSI) above background exists for the first column constituents. If so, additional assessment monitoring could be required.

So as to create an appropriate dataset for comparison, the above parameters were also used for the surface water sample analysis except for pH and radium 226/228[3]. Two sets of analyses were conducted on the surface water samples. The samples were analyzed for the list above (referred to as the “total (unfiltered)” results), and then an aliquot of each sample was filtered to remove sediments/particulates and then analyzed (referred to as the “dissolved (filtered)” results). This is an important step for the analysis of surface water samples for two reasons:

- Surface water, especially in large rivers, can carry a large sediment load – the total (unfiltered results) include constituent concentrations that are associated with the sediment from upstream locations and not the water; and
- Some of the ecological screening levels used to evaluate the results apply only to dissolved (filtered) data.

The surface water samples were also analyzed for hardness, as some of the ecological screening levels are calculated based on site-specific hardness levels.

5. Risk-Based Screening Levels

A comprehensive set of risk-based screening levels have been compiled for this evaluation for the three types of potential exposures identified in the conceptual site model discussion above:

- Human health drinking water consumption;
- Human health recreational use of surface water; and
- Aquatic ecological receptors for surface water.

[3] As discussed in Section 6, radium-226/228 was not detected above risk-based screening levels in the CCR Rule monitoring wells.

Table 1 provides the human health drinking water and recreational screening levels available from the State of Missouri sources and from Federal sources. Table 2 provides the ecological screening levels.

Drinking Water Screening Levels

The Missouri State drinking water supply levels are essentially the same as the Federal primary drinking water standards, also known as Maximum Contaminant Levels or MCLs. The Missouri State groundwater screening levels provide some additional screening levels not included on their list of drinking water screening levels.

In addition to the MCLs that are enforceable for municipal drinking water supplies, there are Federal secondary MCLs, or SMCLs, that are generally based on aesthetics (taste, color) and are not risk-based. The USEPA also provides risk-based screening levels (RSLs) for tapwater (drinking water).

The selected screening levels used to evaluate potential drinking water exposures are shown on Table 1. Missouri drinking water supply screening levels were used and supplemented with Federal MCLs, then the USEPA risk-based levels for tapwater (RSLs), and finally the Federal SMCLs.

It is important to note that the CCR Rule limits the evaluation of groundwater monitoring data of ash management areas to Federal MCLs or to a comparison with site-specific background. That comparison and evaluation is provided in the CCR Rule Groundwater Monitoring Report prepared by Golder, which this report supplements. The use of a more comprehensive set of screening levels in this evaluation provides a broader risk-based evaluation of the groundwater data than would be provided by the CCR Rule requirements.

Recreational Screening Levels

Table 1 provides the State of Missouri human health recreational screening levels, based on fish consumption. The Federal Ambient Water Quality Criteria (AWQC) for consumption of organisms are also provided. Both sources were used to identify the screening levels used in this analysis, as listed on Table 1. The drinking water screening levels used to evaluate surface water are protective for other recreational uses of the river such as swimming, wading, and boating. Note that this evaluation of other uses of surface water are above and beyond the requirements of the CCR Rule.

Ecological Screening Levels

The ecological risk-based screening levels for surface water are provided in Tables 2. As noted above, some of the screening levels are based on the hardness of the water. Therefore, Table 2 provides the screening levels for both the Mississippi River and the Meramec River as the hardness data for the two rivers are similar. Note that this ecological evaluation of surface water is above and beyond the requirements of the CCR Rule.

6. Results

The level of analysis and comparison to risk-based screening levels presented below is above and beyond the requirements of the CCR Rule. The analysis of the groundwater results required by the CCR Rule is presented in the 2017 Groundwater Monitoring Annual Report prepared by Golder: *https://www.ameren.com/Environment/managing-ccrs/ash-pond-closure*. This report serves to supplement that report by providing the risk-based analysis of groundwater and surface water, so that the groundwater results can be understood in their broader environmental context.

Alluvial Aquifer Groundwater – CCR Rule Evaluation

Ameren Missouri has filed on its website reports and notification required by the federal CCR Rule, as noted above, and additional reports will be prepared and posted on Ameren's website per the CCR Rule. The statistical analysis of the data has indicated an SSI for samples collected from monitoring wells M-MW-1 through MW-8 (see Figure 1). Analytes exhibiting an SSI include boron, calcium, sulfate, and TDS.

The SSI values reflect a statistical evaluation that compares mathematically the results of the various rounds of samples to background water quality as required under the CCR rule. However, such values without further evaluation do not establish that there is an actual adverse impact to human health or the environment. The CSM process and screening analysis described in this report provides the relevant context for such groundwater monitoring results and whether the MEC poses a true risk to human health and the environment. As explained in the remaining sections of this report, based upon surface water sampling data and the application of risk assessment principles uniformly adopted by USEPA and state environmental regulators including the Missouri Department of Natural Resources (MDNR), no such risk exists.

Alluvial Aquifer Groundwater – Risk-Based Evaluation

Groundwater data from all nine (9) rounds of groundwater monitoring were compared to the human health risk-based drinking water screening levels. Figure 1 shows that the monitoring wells are located at the edge of the surface impoundments and, therefore, provide worst-case groundwater results.

Table 3 compares the results of all sampling rounds to human health drinking water screening levels. Analytical results greater than the screening level are provided; analytical results below the risk-based drinking water screening levels are indicated by "<". The vast majority of the results are below the human health risk-based drinking water screening levels.

A limited number of parameters are above screening values for some, but not all, sampling events. MW-6 has the most results above the screening levels: these are for boron, sulfate, TDS, cobalt, lithium, and molybdenum. MW-7 also has a majority of results for boron, sulfate, TDS, lithium, and molybdenum above the screening levels. Note that shallow groundwater in the vicinity of the ash management areas is not used as a source of drinking water. The drinking water wells within the 1-mile radius of the facility are upgradient and, therefore, not impacted by facility operations.

The striking aspect of the analysis shown in Table 3 is how few results are above a conservative risk-based drinking water screening level for human health, given that the wells are located at the base of the ash management area, and the facility has been in operation for 65 years[4]. Even for the very few results that may be above screening values for some of the sampling events, including the SSI results identified under the CCR Rule, there is no complete drinking water exposure pathway to groundwater. Where there is no exposure, there is no risk.

Mississippi River

The comparison to risk-based screening levels of the analytical results for the Mississippi River are presented in Tables 4 through 6.

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[4] Out of the 1660 groundwater analyses conducted, only 242 results are above a drinking water screening level (see Table 3). Put another way, approximately 85% of the groundwater results for the CCR Rule monitoring wells located at the edge of the MEC impoundments are below drinking water screening levels.

- Table 4 – Comparison to drinking water screening levels – No results are above risk-based screening levels for drinking water.
- Table 5 – Comparison to human health recreational screening levels – Only total and dissolved concentrations of arsenic are above their screening levels. The arsenic results upstream and downstream are similar, thus, indicative of normal river conditions. In addition, groundwater samples on-site indicate that arsenic is either below screening levels or non-detected, thus, indicating that arsenic in the river is not attributable to the surface impoundments.
- Table 6 – Comparison to ecological screening levels – No results are above risk-based ecological screening levels, with the exception of a single result for selenium that was just slightly above the screening level. Selenium was not detected in on-site groundwater above drinking water screening levels thus indicated the selenium in the river is not likely attributable to the surface impoundments.

There are no analytical results for the Mississippi River that above drinking water screening levels. While arsenic concentrations in the river are slightly above the human health recreational screening levels, the concentrations are similar upstream and downstream indicating that the facility is not the source of the arsenic detected in the river. In fact, the concentrations of arsenic in all of the rivers sampled by Ameren for this evaluation (the Mississippi at Sioux, Meramec, and Rush Island; the Missouri River at Labadie and Sioux; and the Meramec River at Meramec) are all very similar with total results ranging from 0.0012 to 0.005 mg/L. This underscores the fact that arsenic is naturally occurring in our environment, as discussed in more detail in Attachment A.

Thus, the Mississippi River sampling results do not show evidence of impact of constituents derived from the MEC. This is important in that the absence of concentrations above risk-based screening levels means that there is not a significant pathway of exposure.

Meramec River

The comparison to risk-based screening levels of the analytical results for Meramec River are presented in:

- Table 7 – Comparison to drinking water screening levels – All results are below the risk-based screening levels with the exception of lead. The total lead results upstream and downstream are similar and, thus, indicative of normal river conditions. All dissolved concentrations of lead are below the screening level, indicating that lead is associated with particulate in the river. In addition, groundwater samples on-site indicate that lead is either below screening levels or non-detected, thus, indicating that lead in the river is not attributable to the surface impoundments.
- Table 8 – Comparison to human health recreational screening levels – All results are below the risk-based screening levels with the exception of arsenic. The total and dissolved arsenic results upstream and downstream are similar and, thus, indicative of normal river conditions. In addition, groundwater samples on-site indicate that arsenic is either below screening levels or non-detected, thus, indicating that arsenic in the river is not likely attributable to the surface impoundments.
- Table 9 – Comparison to ecological screening levels – All results are below the risk-based screening levels with the exception of lead. The total lead results upstream and downstream are similar and, thus, likely represent normal river conditions. As noted above, groundwater samples on-site indicate that lead is either below screening levels or non-detected, thus, indicating that the lead in the river is not likely attributable to the surface impoundments.

Total lead concentrations are above drinking water and ecological screening levels in the Meramec River. However, the concentrations are similar upstream and downstream. Lead is not present above drinking water screening levels in site groundwater. Arsenic concentrations in the creek are slightly above the human health recreational screening levels, the concentrations are similar upstream and downstream. Arsenic is not present above drinking water screening levels in site groundwater.

Thus, the Meramec River sampling results do not show evidence of impact of constituents derived from the surface impoundments.

Creek/Drainage

The comparison to risk-based screening levels of the analytical results for Creek/Drainage are presented in:

- Table 10 – Comparison to drinking water screening levels – All results are below risk-based screening levels for drinking water.
- Table 11 – Comparison to human health recreational screening levels – Only total concentrations of arsenic are above the screening level. The total arsenic results upstream and downstream are similar, thus indicative of represent normal creek conditions. In addition, groundwater samples on-site indicate that arsenic is either below screening levels or non-detected, thus, indicating that arsenic in the river is not likely attributable to the surface impoundments.
- Table 12 – Comparison to ecological screening levels – All results are below risk-based screening levels for ecological risk.

There are no analytical results for the creek/drainage that above drinking water screening levels. While arsenic concentrations in the creek/drainage are slightly above the human health recreational screening levels, arsenic is not present above drinking water screening levels in site groundwater, the concentrations are similar upstream and downstream and, thus, likely represent normal conditions and not attributable to the surface impoundments.

Thus, even this small water body immediately adjacent to the impoundments does not show evidence of risk to human health or the environment from ash management operations at the MEC. This is important in that the absence of concentrations above risk-based screening levels means that there is not a significant pathway of exposure.

NPDES Outfall WET Testing Results

Two permitted outfalls under the National Pollutant Discharge Elimination System (NPDES) program are tested for toxicity on a periodic basis as required by the permit. WET (whole effluent toxicity) testing involves mixing Mississippi River water collected upstream with the effluent water from Outfall 003 and from Outfall 009 to simulate mixing of the effluent upon discharge to the river. The tests are conducted on a 10% effluent mixture. Tests are also conducted on the upstream Mississippi River water and on laboratory reconstituted control water. If the effluent treatment results are not statistically different from the control results, then the effluent is considered to have passed the WET test. Table 13 shows the results of the direct aquatic organism toxicity testing that is conducted using the outfall effluents from 2013 through 2017[5]. The results indicate no evidence of aquatic toxicity of the outfall effluent. This is a direct biological measure demonstrating the lack of toxicity of the Outfall 003 and Outfall 009 effluent.

7. Derivation of Risk-Based Screening Levels for Groundwater

The results presented here demonstrate that the 65-year history of ash management activities at the surface impoundments have not had an adverse effect on human health or the environment. While some groundwater results are above drinking water screening levels, there is no pathway of exposure to the on-site groundwater (i.e., the shallow alluvial groundwater is not used as a source of drinking water). For those waters where a theoretical pathway of exposure exists (i.e., the Mississippi River, the Meramec River, and the adjacent creek-drainage area), there is no evidence of impact and all samples are either below screening levels or consistent with background.

Ameren's facilities are located on major river systems with a massive and rapid river flow. In this section, we have attempted to illustrate how the groundwater – which is a fraction of the volume and flow rate of the river – may interact with a surface body under an assumed set of criteria and conditions. (see Attachment B). Such an exercise in assumptions can help put in context whether a theoretical risk to public water supplies exists, particularly where, as here, actual surface water samples have been collected and evaluated.

However, impacts to groundwater does not mean that surface waters are impaired. The degree of interface between groundwater and surface waters is variable and complex and dependent upon a variety of factors including gradient and flow rate. It is possible, however, to determine the maximum concentration level that would need to be present on-site in groundwater and still be protective of the surface water environment, assuming gradient and flow rates are such that groundwater flows into the surface water. Groundwater and surface waters flow at very different rates and volumes. The Mississippi River is the largest river system in North America and as depicted on Table 14 and Attachment B, when compared to groundwater, its dilution factor is greater than 100,000.

It is possible to calculate a protective screening level for groundwater based upon the amount of dilution that occurs under the above assumption. This calculated risk-based screening level for groundwater can be used to determine whether an on-site groundwater concentration level is protective of the river. Stated differently, at what concentration level does groundwater entering the river system pose a human health or ecological risk?

Table 14 and Table 15 are summarized below and show the application of the dilution factor to calculate risk-based screening levels for the following parameters: boron, sulfate, TDS, cobalt, lithium, and molybdenum. These Table 3 constituents have one or more monitoring well concentrations above the drinking water screening levels. For each constituent, the human health drinking water and recreational screening levels are presented as well as the ecological screening level. The lowest of the three screening levels is then identified for surface water and the dilution factor applied to this lowest screening level. The resulting calculation indicates the concentration level that would have to be present in groundwater for there to be a corresponding ecological or human health risk to either Mississippi River or Meramec River bodies.

[5] Note that presently effluent is discharged only from Outfall 003.

This evaluation is not limited to only those constituents for which SSIs have been identified. The constituents listed here are those for which there is one or more groundwater result above a risk-based screening level[6].

DERIVATION OF RISK-BASED SCREENING LEVELS FOR GROUNDWATER BASED ON THE MISSISSIPPI RIVER (see Table 14)

	Estimated Dilution Factor for the Mississippi River	100,000			
Constituents	**Lowest of the Human Health and Ecological Screening Levels (mg/L)**	**Groundwater Risk-Based Screening Level* (mg/L)**	**Maximum MEC Groundwater Concentration (mg/L)**		**Ratio Between Groundwater Risk-Based Screening Level and the Maximum MEC Groundwater Concentration**
Boron**	2	200000	30.3	M-MW-7	>6,000
Sulfate**	250	25000000	1250	M-MW-7	>20,000
TDS**	500	50000000	2320	M-MW-7	>21,000
Cobalt	0.006	600	0.0078	M-MW-6	>76,000
Lithium	0.04	4000	0.164	M-MW-6	>24,000
Molybdenum	0.1	10000	0.717	M-MW-7	>13,000

CALCULATING RISK-BASED SCREENING LEVELS FOR GROUNDWATER BASED ON THE MERAMEC RIVER (see Table 15)

	Estimated Dilution Factor for the Meramec River	700			
Constituents	**Lowest of the Human Health and Ecological Screening Levels (mg/L)**	**Groundwater Risk-Based Screening Level* (mg/L)**	**Maximum MEC Groundwater Concentration (mg/L)**		**Ratio Between Groundwater Target Level and the Maximum MEC Groundwater Concentration**
Boron**	2	1400	30.3	M-MW-7	>40
Sulfate**	250	175000	1250	M-MW-7	>100
TDS**	500	350000	2320	M-MW-7	>100
Cobalt	0.006	4.2	0.0078	M-MW-6	>500
Lithium	0.04	28	0.164	M-MW-6	>100
Molybdenum	0.1	70	0.717	M-MW-7	>90

*** Where the Groundwater Risk-Based Screening Level = Screening Level x Dilution Factor.**

**** Constituents for which an SSI has been identified. Note that although an SSI was identified for boron, sulfate, and TDS, these constituents are not present in surface water at concentrations above the risk-based screening levels.**

[6] Note that under the CCR Rule, statistically significant levels of Appendix IV constituents are determined after Assessment Monitoring has been conducted.

The groundwater alternative risk-based screening levels are calculated in units of milligrams of constituent per liter of water (mg/L). One mg/L is equivalent to one million parts per million.[7]

The table identifies the maximum groundwater concentration of each constituent detected in the MEC monitoring wells. The comparison between the target levels and the maximum concentrations indicates that there is a wide margin of safety between the two values for both the Mississippi River and the Meramec River. This margin is shown in the last column of each table. To illustrate, concentration levels of boron and molybdenum would need to be more than 40 and 90 times higher, respectively, than currently measured levels before an adverse impact in the Meramec River could occur. Similarly, the concentration levels of boron and molybdenum would need to be more than 6,000 and 13,000 times higher, respectively, than currently measured levels before an adverse impact in the Mississippi River could occur.

This means that not only do the present concentrations of constituents in groundwater at the RCPA not pose a risk to human health or the environment, but even much higher concentrations would not be harmful.

8. Closure of the Surface Impoundments

Ameren Missouri has commenced the closure of inactive surface impoundments[8]. Closure of the CCR units will continue in series until the remaining surface impoundments are closed following the retirement of the facility in 2022. Closure is estimated to reduce the movement of CCR constituents from the surface impoundments discharge (or flux) of water into the alluvial aquifer groundwater by 90% or more. This reduction is the result of several factors: closure will cease the flow of water and ash to the surface impoundments, a cap will be installed that will limit infiltration of precipitation, and the closure plan includes stormwater run-on and run-off controls to route stormwater off of the capped area and away from the surface impoundments. It is likely that concentrations of constituents in groundwater at the surface impoundments will decrease post-closure.

9. Summary

This comprehensive evaluation demonstrates that there are no adverse impacts on human health from either surface water or groundwater uses resulting from coal ash management practices at the Meramec Energy Center.

10. Attachments

<u>TABLES</u>

1 HUMAN HEALTH SCREENING LEVELS

2 ECOLOGICAL SCREENING LEVELS

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[7] A million parts per million is equivalent to 1 penny in $10,000 worth of pennies, 1 second in 11.5 days, or 1 inch in 15.8 miles.

[8] Importantly, the CCR Rule promulgated by USEPA in 2015 is both under appeal [Utility Solid Waste Activities, et al v. EPA, Docket No. 15-01219, DC Circuit Court of Appeals Sept 13, 2017, Letter from Pruitt to reconsider.] and is being reconsidered by the current Administration. Notwithstanding any proposed changes to the federal CCR Rule, Ameren Missouri intends to implement its closure plan and schedule.

<u>FIGURES</u>

<u>ATTACHMENTS</u>

TABLES

TABLE 1
HUMAN HEALTH SCREENING LEVELS
MERAMEC ENERGY CENTER, ST. LOUIS COUNTY, MO
AMEREN MISSOURI

			Missouri State Water Quality Screening Levels (mg/L)			Federal Water Quality Screening Levels (mg/L)				Selected Screening Level (mg/L)	
Constituent	**Abbreviation**	**CASRN**	**Human Health Fish Consumption (a)**	**Drinking Water Supply (a)**	**Groundwater (a)**	**USEPA AWQC Human Health Consumption of Organism Only (b)**	**MCLs (c)**	**SMCLs (c)**	**November 2017 USEPA Tapwater RSLs (d)**	**Drinking Water (e)**	**Recreational Use (f)**
Antimony	Sb	7440-36-0	4.3	0.006	0.006	0.64	0.006	NA	0.0078 (m)	0.006	4.3
Arsenic	As	7440-38-2	NA	0.05	0.05	0.00014 (i)	0.01	NA	0.000052	0.05	0.00014
Barium	Ba	7440-39-3	NA	2	2	NA	2	NA	3.8	2	NA
Beryllium	Be	7440-41-7	NA	0.004	0.004	NA	0.004	NA	0.025	0.004	NA
Boron	B	7440-42-8	NA	NA	2	NA	NA	NA	4	4 (q)	NA
Cadmium	Cd	7440-43-9	NA	0.005	0.005	NA	0.005	NA	0.0092	0.005	NA
Calcium	Ca	7440-70-2	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chloride	Cl	7647-14-5	NA	250	NA	NA	NA	250	NA	250	NA
Chromium	Cr	16065-83-1 (g)	NA	0.1	0.1	NA	0.1 (j)	NA	22 (n)	0.1	NA
Cobalt	Co	7440-48-4	NA	NA	1	NA	NA	NA	0.006	0.006	NA
Fluoride	Fl	16984-48-8	NA	4	4	NA	4	2	0.8	4	NA
Lead	Pb	7439-92-1	NA	0.015	0.015	NA	0.015 (k)	NA	0.015	0.015	NA
Lithium	Li	7439-93-2	NA	NA	NA	NA	NA	NA	0.04	0.04	NA
Mercury	Hg	7487-94-7 (h)	NA	0.002	0.002	NA	0.002 (l)	NA	0.0057 (o)	0.002	NA
Molybdenum	Mo	7439-98-7	NA	NA	NA	NA	NA	NA	0.1	0.1	NA
Radium 226/228 (pCi/L)	Ra 226/228	RADIUM226228	NA	NA	NA	NA	5	NA	NA	5	NA
Selenium	Se	7782-49-2	NA	0.05	0.05	4.2	0.05	NA	0.1	0.05	4.2
Sulfate	SO4	7757-82-6	NA	250	NA	NA	NA	250	NA	250	NA
Thallium	Tl	7440-28-0	0.0063	0.002	0.002	0.00047	0.002	NA	0.0002 (p)	0.002	0.0063
Total Dissolved Solids	TDS	TDS	NA	NA	NA	NA	NA	500	NA	500	NA
pH (std)	--	PHFLD	NA	NA	NA	NA	NA	6.5 - 8.5	NA	6.5 - 8.5	NA

Notes:

AWQC - Ambient Water Quality Criteria.
CASRN - Chemical Abstracts Service Registry Number.
HI - Hazard Index (noncancer child).
MCL - Maximum Contaminant Level.
mg/L - milligram per liter.
NA - not available.
pCi/L - picoCurie per liter.
RSL - Risk-based Screening Levels (USEPA).
TR - Target Risk (carcinogenic).
USEPA - United States Environmental Protection Agency.

(a) - 10 Missouri Code of State Regulations Division 20 Chapter 7 Table A. Updated January 29, 2014. Per 10 CSR 20-7.031(4)(B)(2), the criteria for Human Protection Fish Consumption apply to dissolved metals data. All other criteria apply to total concentrations.
http://www.sos.mo.gov/adrules/csr/current/10csr/10c20-7a.pdf
(b) - USEPA National Recommended Water Quality Criteria. USEPA Office of Water and Office of Science and Technology. Accessed November 2014.
https://www.epa.gov/wqc/national-recommended-water-quality-criteria-human-health-criteria-table
USEPA AWQC Human Health for the Consumption of Organism Only apply to total concentrations.
(c) - USEPA 2012 Edition of the Drinking Water Standards and Health Advisories. Spring 2012.
http://water.epa.gov/drink/contaminants/index.cfm
(d) - USEPA Risk-Based Screening Levels (November 2017). Values for tapwater. HI = 1.0, TR = 1E-06.
http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/index.htm
(e) - The hierachy for selecting the Human Health Screening Level for Drinking Water is: Missouri State Water Quality Criteria for Drinking Water Supply (a); Federal USEPA MCL for Drinking Water (c); Federal June 2017 USEPA Tapwater RSL (d); Federal USEPA SMCL for Drinking Water (c).
(f) - The hierachy for selecting the Human Health Screening Level for Recreational Use is: Missouri State Water Quality Criteria for Human Health Fish Consumption (a); Federal USEPA AWQC for Human Health Consumption of Organism Only (b).
(g) - CAS number for Trivalent Chromium.
(h) - CAS number for Mercuric Chloride.
(i) - Value applies to inorganic form of arsenic only.
(j) - Value for Total Chromium.
(k) - Lead Treatment Technology Action Level is 0.015 mg/L.
(l) - Value for Inorganic Mercury.
(m) - RSL for Antimony (metallic) used for Antimony.
(n) - RSL for Chromium (III), Insoluble Salts used for Chromium.
(o) - RSL for Mercuric Chloride used for Mercury.
(p) - RSL for Thallium (Soluble Salts) used for Thallium.
(q) - RSL selected for Boron as the Missouri State Water Quality Groundwater screening level is based on irrigation.

TABLE 2
ECOLOGICAL SCREENING LEVELS
MERAMEC ENERGY CENTER, ST. LOUIS COUNTY, MO
AMEREN MISSOURI

		Missouri State Water Quality Criteria (mg/L)						Federal Water Quality Criteria (mg/L)			
		Site-Specific Protection of Aquatic Life Acute (a)		Site-Specific Protection of Aquatic Life Chronic (a)		Irrigation (a)	Livestock Wildlife Watering (a)	Site-Specific USEPA Aquatic Life AWQC Freshwater Acute (b)		Site-Specific USEPA Aquatic Life AWQC Freshwater Chronic (b)	
Constituent	**CASRN**	**Total**	**Dissolved**	**Total**	**Dissolved**	**Total**	**Total**	**Total**	**Dissolved**	**Total**	**Dissolved**
Antimony (c)	7440-36-0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic	7440-38-2	NA	NA	NA	0.02	0.1	NA	0.34	0.34	0.15	0.15
Barium (c)	7440-39-3	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Beryllium	7440-41-7	NA	NA	NA	0.005	0.1	NA	NA	NA	NA	NA
Boron	7440-42-8	NA	NA	NA	NA	2	NA	NA	NA	NA	NA
Cadmium	7440-43-9	0.011	0.010	0.00049	0.0004	NA	NA	0.0042 (f)	0.0038 (g)	0.0015 (f)	0.0013 (g)
Calcium (c)	7440-70-2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Chloride	16887-00-6	NA	NA	NA	NA	NA	NA	860	NA	230	NA
Chromium	7440-47-3	3.5	1.1	0.17	0.14	0.1 (e)	NA	3.5 (e,g)	1.1 (e,h)	0.17 (e,g)	0.14 (e,h)
Cobalt	7440-48-4	NA	NA	NA	NA	NA	1	NA	NA	NA	NA
Fluoride	16984-48-8	NA	NA	NA	NA	NA	4	NA	NA	NA	NA
Lead	7439-92-1	0.23	0.15	0.0089	0.0060	NA	NA	0.23 (f)	0.15 (g)	0.0089 (f)	0.0060 (g)
Lithium (c)	7439-93-2	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mercury	7439-97-6	0.0024	0.0024	0.0005	0.0005	NA	NA	0.0016	0.0014	0.00091	0.00077
Molybdenum (c)	7439-98-7	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Selenium	7782-49-2	NA	NA	NA	0.005	NA	NA	0.013 (d)	0.013 (d)	0.005 (d)	0.005 (d)
Sulfate	14808-79-8	NA	NA	1608 (g,i)	NA	NA	NA	NA	NA	NA	NA
Thallium (c)	7440-28-0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Total Dissolved Solids (c)	TDS	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Notes:

AWQC - USEPA Ambient Water Quality Criteria.
CASRN - Chemical Abstracts Service Registry Number.
CMC - Criterion Maximum Concentration.
mg/L - milligram per liter.
NA - Not Available.
USEPA - United States Environmental Protection Agency.

(a) - 10 Missouri Code of State Regulations Division 20 Chapter 7 Table A. January 29, 2014.
http://www.sos.mo.gov/adrules/csr/current/10csr/10c20-7a.pdf. Total values provided.
Missouri State Protection of Aquatic Life Acute and Chronic values apply only to dissolved results (except mercury);
irrigation, livestock/wildlife watering, and mercury Aquatic Life Acute and Chronic values apply only to totals results.
(b) - USEPA National Recommended Water Quality Criteria. USEPA Office of Water and Office of Science and Technology. Accessed December 2014.
http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm
Total values provided. Values adjusted for site-specific hardness - see note (f).
USEPA provides AWQC for both total and dissolved results.
(c) - Water quality criteria from the presented sources are not available for this constituent.
(d) - The selenium value is based on the 1999 selenium criterion document for screening purposes.
Acute AWQC is equal to 1/[(f1/CMC1) + (f2/CMC2)] where f1 and f2 are the fractions of total selenium that are treated as selenite and selenate, respectively, and CMC1 and CMC2 are 185.9 ug/L and 12.82 ug/L, respectively. Calculated assuming that all selenium is present as selenate, a likely overly conservative assumption.
(e) - Value for trivalent chromium used.
(f) - Hardness dependent value for total metals. Site-specific total recoverable mean hardness value for Meramec River and Mississippi River of 224 mg/L as CaCO3 used.
(g) - Hardness dependent value for total metals adjusted for dissolved fraction. Site-specific total recoverable mean hardness value for the Meramec River and Mississippi River of 224 mg/L as CaCO3 used.
(h) - Chloride dependent value (default chloride value of 25 mg/L is assumed) for Meramec River and Mississippi River.
When chloride is greater than or equal to 25 and less than or equal to 500 mg/L and hardness is between 100 and 500 mg/L,
sulfate limit in mg/L = [1276.7 + 5.508 (hardness) − 1.457 (chloride)] * 0.65.

TABLE 3
SUMMARY OF MERAMEC SURFACE IMPOUNDMENT GROUNDWATER MONITORING RESULTS COMPARISON TO HUMAN HEALTH DRINKING WATER SCREENING LEVELS
MERAMEC ENERGY CENTER, ST. LOUIS COUNTY, MO
AMEREN MISSOURI

		Human Health Drinking Water Screening (a)																				
	Constituent	Boron	Calcium	Chloride	pH	Sulfate	TDS	Fluoride	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Lead	Lithium	Mercury	Molybdenum	Selenium	Thallium	Radium-226/228
	HH DW SL	4	NA	250	6.5-8.5	250	500	4	0.006	0.05	2	0.004	0.005	0.1	0.006	0.015	0.04	0.002	0.1	0.05	0.002	5
Monitoring Well ID	**Sampling Event Date**	mg/L	mg/L	mg/L	S.U.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	pCi/L
M-BMW-1 (b)	May-16	<	<	<	<	<	832	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	Jun-16	<	<	<	<	<	755	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	Jul-16	<	<	<	<	<	772	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	Sep-16	<	<	<	<	<	817	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	Nov-16	<	<	<	<	<	751	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	Jan-17	<	<	<	<	<	752	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	Mar-17	<	<	<	<	<	728	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	Jun-17	<	<	<	<	<	723	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	Nov-17	<	<	<	NA	<	764	<	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
M-BMW-2 (b)	Mar-16	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	May-16	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	Jul-16	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	Sep-16	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	Nov-16	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	Jan-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	Mar-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	Jun-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	Nov-17	<	<	<	NA	<	<	<	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
M-MW-1	Mar-16	<	<	<	<	<	611	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	May-16	<	<	<	<	<	663	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	Jul-16	<	<	<	<	<	675	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	Sep-16	<	<	<	<	<	623	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	Nov-16	<	<	<	<	<	609	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	Jan-17	<	<	<	<	<	608	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	Mar-17	<	<	<	<	<	632	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	Jun-17	<	<	<	<	<	643	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	Nov-17	<	<	<	NA	<	612	<	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
M-MW-2	Mar-16	4.53	<	<	<	313	716	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	May-16	5.4	<	<	<	329	847	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	Jul-16	4.06	<	<	<	299	811	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	Sep-16	4.74	<	<	<	312	802	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	Nov-16	<	<	<	<	290	756	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	Jan-17	5.88	<	<	<	352	750	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	Mar-17	6.6	<	<	<	399	850	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	Jun-17	6.04	<	<	<	317	809	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	Nov-17	5.08	<	<	NA	330	<	<	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
M-MW-3	Mar-16	5.61	<	<	<	<	682	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	May-16	5.96	<	<	<	264	755	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	Jul-16	8.28	<	<	<	309	872	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	Sep-16	9.39	<	<	<	344	957	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	Nov-16	8.41	<	<	<	348	854	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	Jan-17	6.75	<	<	<	<	729	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	Mar-17	6.8	<	<	<	315	832	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	Jun-17	6.63	<	<	<	278	816	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	Nov-17	6.66	<	<	NA	318	809	<	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
M-MW-4	Mar-16	8.98	<	<	<	370	918	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	May-16	8.36	<	<	<	380	1030	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	Jul-16	8.71	<	<	<	366	993	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	Sep-16	8.54	<	<	<	378	995	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	Nov-16	8.58	<	<	<	402	908	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	Jan-17	8.66	<	<	<	403	925	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	Mar-17	8.89	<	<	<	404	976	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	Jun-17	9	<	<	<	378	964	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	Nov-17	8.54	<	<	NA	404	928	<	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
M-MW-5	Mar-16	7.3	<	<	<	374	918	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	May-16	6.9	<	<	<	355	940	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	Jul-16	7.07	<	<	<	341	1030	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	Sep-16	7.13	<	<	<	391	1050	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	Nov-16	7.97	<	<	<	438	1010	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	Jan-17	8.97	<	<	<	446	1000	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	Mar-17	9.24	<	<	<	425	1060	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	Jun-17	9.04	<	<	<	410	1090	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
	Nov-17	8.72	<	<	NA	426	1030	<	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
M-MW-6	Mar-16	18.8	<	<	<	580	1280	<	<	<	<	<	<	<	<	<	0.129	<	0.137	<	<	<
	May-16	25.9	<	<	<	631	1310	<	<	<	<	<	<	<	<	<	0.164	<	0.124	<	<	<
	Jul-16	14.7	<	<	<	555	1370	<	<	<	<	<	<	<	<	<	0.13	<	0.129	<	<	<
	Sep-16	14.8	<	<	<	547	<	<	<	<	<	<	<	<	<	<	0.123	<	0.12	<	<	<
	Nov-16	13.8	<	<	<	610	1290	<	<	<	<	<	<	<	0.0061	<	0.13	<	0.135	<	<	<
	Jan-17	9.8	<	<	<	672	1500	<	<	<	<	<	<	<	0.0065	<	0.138	<	0.163	<	<	<
	Mar-17	11.1	<	<	<	656	1510	<	<	<	<	<	<	<	<	<	0.14	<	0.157	<	<	<
	Jun-17	10.9	<	<	<	504	1320	<	<	<	<	<	<	<	0.0078	<	0.129	<	0.147	<	<	<
	Nov-17	8.6	<	<	NA	696	1590	<	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

TABLE 3
SUMMARY OF MERAMEC SURFACE IMPOUNDMENT GROUNDWATER MONITORING RESULTS COMPARISON TO HUMAN HEALTH DRINKING WATER SCREENING LEVELS
MERAMEC ENERGY CENTER, ST. LOUIS COUNTY, MO
AMEREN MISSOURI

		Human Health Drinking Water Screening (a)																				
	Constituent	Boron	Calcium	Chloride	pH	Sulfate	TDS	Fluoride	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Lead	Lithium	Mercury	Molybdenum	Selenium	Thallium	Radium-226/228
	HH DW SL	4	NA	250	6.5-8.5	250	500	4	0.006	0.05	2	0.004	0.005	0.1	0.006	0.015	0.04	0.002	0.1	0.05	0.002	5
Monitoring Well ID	**Sampling Event Date**	mg/L	mg/L	mg/L	S.U.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	pCi/L
M-MW-7	Mar-16	21.5	<	<	<	911	1590	<	<	<	<	<	<	<	<	<	<	<	0.451	<	<	<
	May-16	18.7	<	<	<	941	1660	<	<	<	<	<	<	<	<	<	0.0403	<	0.338	<	<	<
	Jul-16	21.1	<	<	<	881	1780	<	<	<	<	<	<	<	<	<	0.0509	<	0.359	<	<	<
	Sep-16	20.3	<	<	<	1000	1740	<	<	<	<	<	<	<	<	<	0.0436	<	0.351	<	<	<
	Nov-16	21.4	<	<	<	756	1690	<	<	<	<	<	<	<	<	<	0.0583	<	0.331	<	<	<
	Jan-17	30.3	<	<	<	999	2060	<	<	<	<	<	<	<	<	<	0.0711	<	0.297	<	<	<
	Mar-17	25.5	<	<	<	1250	2220	<	<	<	<	<	<	<	<	<	0.0742	<	0.314	<	<	<
	Jun-17	19.3	<	<	<	896	1630	<	<	<	<	<	<	<	<	<	<	<	0.717	<	<	<
	Nov-17	25.6	<	<	NA	1220	2320	<	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
M-MW-8	Mar-16	9.94	<	<	<	469	875	<	<	<	<	<	<	<	<	<	<	<	0.229	<	<	<
	May-16	9.56	<	<	<	449	959	<	<	<	<	<	<	<	<	<	<	<	0.204	<	<	<
	Jul-16	9.05	<	<	<	437	985	<	<	<	<	<	<	<	<	<	<	<	0.215	<	<	<
	Sep-16	8.64	<	<	<	455	<	<	<	<	<	<	<	<	<	<	<	<	0.211	<	<	<
	Nov-16	8.89	<	<	<	478	881	<	<	<	<	<	<	<	<	<	<	<	0.212	<	<	<
	Jan-17	8.91	<	<	<	448	886	<	<	<	<	<	<	<	<	<	<	<	0.207	<	<	<
	Mar-17	9.39	<	<	<	456	908	<	<	<	<	<	<	<	<	<	<	<	0.213	<	<	<
	Jun-17	8.39	<	<	<	407	957	<	<	<	<	<	<	<	<	<	<	<	0.19	<	<	<
	Nov-17	7.6	<	<	NA	435	917	<	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Summary Ratio of # Results above the SL : Total # Results		62:90	0:90	0:90	0:80	61:90	78:90	0:90	0:80	0:80	0:80	0:80	0:80	0:80	3:80	0:80	14:80	0:80	24:80	0:80	0:80	0:80

Notes:

< - less than the Human Health Drinking Water Screening Level
DW - Drinking Water.
HH - Human Health.
MCL - Maximum Contaminant Level
mg/L - milligram per liter.

NA - Not Applicable/Not Analyzed
RSL - Risk-Based Screening Level
SL - Screening Level
TDS - Total Dissolved Solids
USEPA - United States Environmental Protection Agency

(a) - Drinking Water Screening Levels selected in Table 1 following the following hierarchy
Missouri State Water Quality Criteria for Drinking Water Supply
Federal USEPA MCL for Drinking Water.
Federal November 2017 USEPA Tapwater RSL.
Federal USEPA SMCL for Drinking Water.
(b) - Background wells

TABLE 4
SUMMARY OF MISSISSIPPI RIVER SURFACE WATER TOTAL (UNFILTERED) AND DISSOLVED (FILTERED) RESULTS COMPARISON TO HUMAN HEALTH DRINKING WATER SCREENING LEVELS
MERAMEC ENERGY CENTER, ST. LOUIS COUNTY, MO
AMEREN MISSOURI

Sample Location ID		Human Health Drinking Water Screening (a)																				
	Constituent	Boron		Calcium		Chloride	pH	Sulfate	TDS	Fluoride	Antimony		Arsenic		Barium		Beryllium		Cadmium		Chromium	
	Fraction	Total	Dissolved	Total	Dissolved	Total	Total	Total	Total	Total	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
	HH DW SL	4	4	NA	NA	250	6.5-8.5	250	500	4	0.006	0.006	0.05	0.05	2	2	0.004	0.004	0.005	0.005	0.1	0.1
	Sampling Event Date	mg/L	mg/L	mg/L	mg/L	mg/L	S.U.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
UPSTREAM																						
M-MIS-10S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MIS-11D	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MIS-11S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MIS-12D	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MIS-12S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
ADJACENT																						
M-MIS-4S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MIS-5D	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MIS-5S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MIS-6D	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MIS-6S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MIS-7S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MIS-8D	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MIS-8S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MIS-9D	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MIS-9S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
DOWNSTREAM																						
M-MIS-1S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MIS-2D	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MIS-2S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MIS-3D	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MIS-3S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<

Notes:

< - less than the Human Health Drinking Water Screening Level.
DW - Drinking Water.
HH - Human Health.
MCL - Maximum Contaminant Level.
mg/L - milligram per liter.
NA - Not Applicable/Not Analyzed.
pCi/L - picoCurie per liter.
RSL - Risk-Based Screening Level.
SL - Screening Level.
S.U. - Standard Units.
TDS - Total Dissolved Solids.
USEPA - United States Environmental Protection Agency.

(a) - Drinking Water Screening Levels selected in Table 1 following the following hierarchy:
Missouri State Water Quality Criteria for Drinking Water Supply.
Federal USEPA MCL for Drinking Water.
Federal November 2017 USEPA Tapwater RSL.
Federal USEPA SMCL for Drinking Water.

TABLE 4
SUMMARY OF MISSISSIPPI RIVER SURFACE WATER TOTAL (UNFILTERED) AND DISSOLVED (FILTERED) RESULTS COMPARISON TO HUMAN HEALTH DRINKING WATER SCREENING LEVELS
MERAMEC ENERGY CENTER, ST. LOUIS COUNTY, MO
AMEREN MISSOURI

Sample Location ID		Human Health Drinking Water Screening (a)															
	Constituent	Cobalt		Lead		Lithium		Mercury		Molybdenum		Selenium		Thallium		Radium-226/228	Hardness
	Fraction	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Total
	HH DW SL	0.006	0.006	0.015	0.015	0.04	0.04	0.002	0.002	0.1	0.1	0.05	0.05	0.002	0.002	5	NA
	Sampling Event Date	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	pCi/L	mg/L
UPSTREAM																	
M-MIS-10S	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MIS-11D	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MIS-11S	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MIS-12D	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MIS-12S	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
ADJACENT																	
M-MIS-4S	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MIS-5D	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MIS-5S	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MIS-6D	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MIS-6S	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MIS-7S	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MIS-8D	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MIS-8S	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MIS-9D	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MIS-9S	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
DOWNSTREAM																	
M-MIS-1S	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MIS-2D	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MIS-2S	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MIS-3D	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MIS-3S	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<

Notes:
< - less than the Human Health Drinking Water Screening Level.
DW - Drinking Water.
HH - Human Health.
MCL - Maximum Contaminant Level.
mg/L - milligram per liter.
NA - Not Applicable/Not Analyzed.
pCi/L - picoCurie per liter.
RSL - Risk-Based Screening Level.
SL - Screening Level.
S.U. - Standard Units.
TDS - Total Dissolved Solids.
USEPA - United States Environmental Protection Agency.

(a) - Drinking Water Screening Levels selected in Table 1 following the following hierarchy:
Missouri State Water Quality Criteria for Drinking Water Supply.
Federal USEPA MCL for Drinking Water.
Federal November 2017 USEPA Tapwater RSL.
Federal USEPA SMCL for Drinking Water.

TABLE 5
SUMMARY OF MISSISSIPPI RIVER SURFACE WATER TOTAL (UNFILTERED) AND DISSOLVED (FILTERED) RESULTS COMPARISON TO HUMAN HEALTH RECREATIONAL USE SCREENING LEVELS
MERAMEC ENERGY CENTER, ST. LOUIS COUNTY, MO
AMEREN MISSOURI

		Human Health Recreational Use Screening (a)																				
	Constituent	Boron		Calcium		Chloride	pH	Sulfate	TDS	Fluoride	Antimony		Arsenic		Barium		Beryllium		Cadmium		Chromium	
	Fraction	Total	Dissolved	Total	Dissolved	Total	Total	Total	Total	Total	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
Sample	**HH REC SL**	NA	NA	NA	NA	NA	6.5-8.5	NA	NA	NA	4.3	4.3	0.00014	0.00014	NA	NA	NA	NA	NA	NA	NA	NA
Location ID	**Sampling Event Date**	mg/L	mg/L	mg/L	mg/L	mg/L	S.U.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
UPSTREAM																						
M-MIS-10S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	0.003	0.0028	<	<	<	<	<	<	<	<
M-MIS-11D	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	0.0028	0.0026	<	<	<	<	<	<	<	<
M-MIS-11S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	0.003	0.0025	<	<	<	<	<	<	<	<
M-MIS-12D	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	0.0024	0.0019	<	<	<	<	<	<	<	<
M-MIS-12S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	0.0022	0.0019	<	<	<	<	<	<	<	<
ADJACENT																						
M-MIS-4S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	0.0032	0.0028	<	<	<	<	<	<	<	<
M-MIS-5D	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	0.0028	0.0024	<	<	<	<	<	<	<	<
M-MIS-5S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	0.0027	0.0024	<	<	<	<	<	<	<	<
M-MIS-6D	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	0.0024	0.0019	<	<	<	<	<	<	<	<
M-MIS-6S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	0.0023	0.002	<	<	<	<	<	<	<	<
M-MIS-7S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	0.0035	0.0027	<	<	<	<	<	<	<	<
M-MIS-8D	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	0.0029	0.0024	<	<	<	<	<	<	<	<
M-MIS-8S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	0.0027	0.0025	<	<	<	<	<	<	<	<
M-MIS-9D	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	0.0022	0.0018	<	<	<	<	<	<	<	<
M-MIS-9S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	0.0022	0.0021	<	<	<	<	<	<	<	<
DOWNSTREAM																						
M-MIS-1S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	0.0028	0.0024	<	<	<	<	<	<	<	<
M-MIS-2D	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	0.003	0.0025	<	<	<	<	<	<	<	<
M-MIS-2S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	0.003	0.0024	<	<	<	<	<	<	<	<
M-MIS-3D	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	0.0024	0.0021	<	<	<	<	<	<	<	<
M-MIS-3S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	0.0026	0.0021	<	<	<	<	<	<	<	<

Notes:

< - less than the Human Health Recreational Use Screening Level.
HH - Human Health.
mg/L - milligram per liter.
NA - Not Applicable/Not Analyzed.
pCi/L - picoCurie per liter.
REC - Recreational Use.
SL - Screening Level.
S.U. - Standard Units.
TDS - Total Dissolved Solids.
USEPA - United States Environmental Protection Agency.

(a) - Recreational Use Screening Levels selected in Table 1 following the following hierarchy:
Missouri State Water Quality Criteria for Human Health Fish Consumption.
USEPA Ambient Water Quality Criteria for Human Health Consumption of Organism Only.

TABLE 5
SUMMARY OF MISSISSIPPI RIVER SURFACE WATER TOTAL (UNFILTERED) AND DISSOLVED (FILTERED) RESULTS COMPARISON TO HUMAN HEALTH RECREATIONAL USE SCREENING LEVELS
MERAMEC ENERGY CENTER, ST. LOUIS COUNTY, MO
AMEREN MISSOURI

		Human Health Recreational Use Screening (a)															
	Constituent	Cobalt		Lead		Lithium		Mercury		Molybdenum		Selenium		Thallium		Radium-226/228	Hardness
	Fraction	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Total
	HH REC SL	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	4.2	4.2	0.0063	0.0063	NA	NA
Sample Location ID	**Sampling Event Date**	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	pCi/L	mg/L
UPSTREAM																	
M-MIS-10S	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MIS-11D	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MIS-11S	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MIS-12D	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MIS-12S	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
ADJACENT																	
M-MIS-4S	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MIS-5D	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MIS-5S	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MIS-6D	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MIS-6S	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MIS-7S	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MIS-8D	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MIS-8S	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MIS-9D	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MIS-9S	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
DOWNSTREAM																	
M-MIS-1S	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MIS-2D	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MIS-2S	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MIS-3D	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MIS-3S	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<

Notes:

< - less than the Human Health Recreational Use Screening Level.
HH - Human Health.
mg/L - milligram per liter.
NA - Not Applicable/Not Analyzed.
pCi/L - picoCurie per liter.
REC - Recreational Use.
SL - Screening Level.
S.U. - Standard Units.
TDS - Total Dissolved Solids.
USEPA - United States Environmental Protection Agency.

(a) - Recreational Use Screening Levels selected in Table 1 following the following hierarchy:
Missouri State Water Quality Criteria for Human Health Fish Consumption.
USEPA Ambient Water Quality Criteria for Human Health Consumption of Organism Only.

TABLE 6
SUMMARY OF MISSISSIPPI RIVER SURFACE WATER TOTAL (UNFILTERED) AND DISSOLVED (FILTERED) RESULTS COMPARISON TO ECOLOGICAL SCREENING LEVELS
MERAMEC ENERGY CENTER, ST. LOUIS COUNTY, MO
AMEREN MISSOURI

		Ecological Screening (a)																				
	Constituent	Boron		Calcium		Chloride	pH	Sulfate	TDS	Fluoride	Antimony		Arsenic		Barium		Beryllium		Cadmium		Chromium	
	Fraction	Total	Dissolved	Total	Dissolved	Total	Total	Total	Total	Total	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
Sample	**ECO SL**	2	2	NA	NA	230	6.5-8.5	1608	NA	4	NA	NA	0.15	0.15	NA	NA	0.1	0.1	0.0015	0.0015	0.167	0.167
Location ID	**Sampling Event Date**	mg/L	mg/L	mg/L	mg/L	mg/L	S.U	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
UPSTREAM																						
M-MIS-10S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MIS-11D	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MIS-11S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MIS-12D	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MIS-12S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
ADJACENT																						
M-MIS-4S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MIS-5D	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MIS-5S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MIS-6D	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MIS-6S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MIS-7S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MIS-8D	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MIS-8S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MIS-9D	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
DOWNSTREAM																						
M-MIS-9S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MIS-1S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MIS-2D	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MIS-2S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MIS-3D	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MIS-3S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<

Notes:
- < - Less than the Ecological Screening Level.
- ECO - Ecological.
- mg/L - milligram per liter.
- NA - Not Applicable/Not Analyzed.
- pCi/L - picoCurie per liter.
- SL - Screening Level.
- S.U. - Standard Units.
- TDS - Total Dissolved Solids.
- USEPA - United States Environmental Protection Agency.

Qualifiers:
- J - Value is estimated.

(a) - Ecological Screening Levels selected in Table 2 following the following hierarchy:
- Missouri State Water Quality Criteria for the Protection of Aquatic Life (Chronic).
- USEPA Aquatic Life Ambient Water Quality Criteria (Chronic).
- Missouri State Water Quality Criteria for the Protection of Aquatic Life (Acute).
- USEPA Aquatic Life Ambient Water Quality Criteria (Acute).
- Missouri State Water Quality Criteria for Irrigation.
- Missouri State Water Quality Criteria for Livestock Wildlife Watering.

TABLE 6
SUMMARY OF MISSISSIPPI RIVER SURFACE WATER TOTAL (UNFILTERED) AND DISSOLVED (FILTERED) RESULTS COMPARISON
TO ECOLOGICAL SCREENING LEVELS
MERAMEC ENERGY CENTER, ST. LOUIS COUNTY, MO
AMEREN MISSOURI

		Ecological Screening (a)															
	Constituent	Cobalt		Lead		Lithium		Mercury		Molybdenum		Selenium		Thallium		Radium-226/228	Hardness
	Fraction	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Total
	ECO SL	1	1	0.0089	0.0089	NA	NA	0.0005	0.0005	NA	NA	0.005	0.005	NA	NA	NA	NA
Sample Location ID	**Sampling Event Date**	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	pCi/L	mg/L
UPSTREAM																	
M-MIS-10S	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MIS-11D	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MIS-11S	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MIS-12D	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MIS-12S	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
ADJACENT																	
M-MIS-4S	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MIS-5D	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MIS-5S	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MIS-6D	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MIS-6S	Sep-17	<	<	<	<	<	<	<	<	<	<	<	0.0051 J	<	<	NA	<
M-MIS-7S	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MIS-8D	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MIS-8S	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MIS-9D	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
DOWNSTREAM																	
M-MIS-9S	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MIS-1S	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MIS-2D	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MIS-2S	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MIS-3D	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MIS-3S	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<

Notes:
< - Less than the Ecological Screening Level.
ECO - Ecological.
mg/L - milligram per liter.
NA - Not Applicable/Not Analyzed.
pCi/L - picoCurie per liter.
SL - Screening Level.
S.U. - Standard Units.
TDS - Total Dissolved Solids.
USEPA - United States Environmental Protection Agency.

Qualifiers:
J - Value is estimated.

(a) - Ecological Screening Levels selected in Table 2 following the following hierarchy:
Missouri State Water Quality Criteria for the Protection of Aquatic Life (Chronic).
USEPA Aquatic Life Ambient Water Quality Criteria (Chronic).
Missouri State Water Quality Criteria for the Protection of Aquatic Life (Acute).
USEPA Aquatic Life Ambient Water Quality Criteria (Acute).
Missouri State Water Quality Criteria for Irrigation.
Missouri State Water Quality Criteria for Livestock Wildlife Watering.

TABLE 7
SUMMARY OF MERAMEC RIVER SURFACE WATER TOTAL (UNFILTERED) AND DISSOLVED (FILTERED) RESULTS COMPARISON TO HUMAN HEALTH DRINKING WATER SCREENING LEVELS
MERAMEC ENERGY CENTER, ST. LOUIS COUNTY, MO
AMEREN MISSOURI

		Human Health Drinking Water Screening (a)																				
	Constituent	Boron		Calcium		Chloride	pH	Sulfate	TDS	Fluoride	Antimony		Arsenic		Barium		Beryllium		Cadmium		Chromium	
	Fraction	Total	Dissolved	Total	Dissolved	Total	Total	Total	Total	Total	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
Sample	**HH DW SL**	4	4	NA	NA	250	6.5-8.5	250	500	4	0.006	0.006	0.05	0.05	2	2	0.004	0.004	0.005	0.005	0.1	0.1
Location ID	**Sampling Event Date**	mg/L	mg/L	mg/L	mg/L	mg/L	S.U.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
UPSTREAM																						
M-MEC-7S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MEC-8S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MEC-9D	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MEC-9S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
ADJACENT																						
M-MEC-4S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MEC-5S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MEC-6D	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MEC-6S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
DOWNSTREAM																						
M-MEC-1S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MEC-2D	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MEC-2S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MEC-3D	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MEC-3S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<

Notes:
< - less than the Human Health Drinking Water Screening Level.
DW - Drinking Water.
HH - Human Health.
MCL - Maximum Contaminant Level.
mg/L - milligram per liter.
NA - Not Applicable/Not Analyzed.
pCi/L - picoCurie per liter.
RSL - Risk-Based Screening Level.
SL - Screening Level.
S.U. - Standard Units.
TDS - Total Dissolved Solids.
USEPA - United States Environmental Protection Agency.

(a) - Drinking Water Screening Levels selected in Table 1 following the following hierarchy:
Missouri State Water Quality Criteria for Drinking Water Supply.
Federal USEPA MCL for Drinking Water.
Federal November 2017 USEPA Tapwater RSL.
Federal USEPA SMCL for Drinking Water.

TABLE 7
SUMMARY OF MERAMEC RIVER SURFACE WATER TOTAL (UNFILTERED) AND DISSOLVED (FILTERED) RESULTS COMPARISON
TO HUMAN HEALTH DRINKING WATER SCREENING LEVELS
MERAMEC ENERGY CENTER, ST. LOUIS COUNTY, MO
AMEREN MISSOURI

		Human Health Drinking Water Screening (a)															
	Constituent	Cobalt		Lead		Lithium		Mercury		Molybdenum		Selenium		Thallium		Radium-226/228	Hardness
	Fraction	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Total
	HH DW SL	0.006	0.006	0.015	0.015	0.04	0.04	0.002	0.002	0.1	0.1	0.05	0.05	0.002	0.002	5	NA
Sample Location ID	**Sampling Event Date**	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	pCi/L	mg/L
UPSTREAM																	
M-MEC-7S	Sep-17	<	<	0.0172	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MEC-8S	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MEC-9D	Sep-17	<	<	0.0205	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MEC-9S	Sep-17	<	<	0.0196	<	<	<	<	<	<	<	<	<	<	<	NA	<
ADJACENT																	
M-MEC-4S	Sep-17	<	<	0.0175	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MEC-5S	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MEC-6D	Sep-17	<	<	0.018	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MEC-6S	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
DOWNSTREAM																	
M-MEC-1S	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MEC-2D	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MEC-2S	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MEC-3D	Sep-17	<	<	0.0155	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MEC-3S	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<

Notes:
< - less than the Human Health Drinking Water Screening Level.
DW - Drinking Water.
HH - Human Health.
MCL - Maximum Contaminant Level.
mg/L - milligram per liter.
NA - Not Applicable/Not Analyzed.
pCi/L - picoCurie per liter.
RSL - Risk-Based Screening Level.
SL - Screening Level.
S.U. - Standard Units.
TDS - Total Dissolved Solids.
USEPA - United States Environmental Protection Agency.

(a) - Drinking Water Screening Levels selected in Table 1 following the following hierarchy:
Missouri State Water Quality Criteria for Drinking Water Supply.
Federal USEPA MCL for Drinking Water.
Federal November 2017 USEPA Tapwater RSL.
Federal USEPA SMCL for Drinking Water.

TABLE 8
SUMMARY OF MERAMEC RIVER SURFACE WATER TOTAL (UNFILTERED) AND DISSOLVED (FILTERED) RESULTS COMPARISON TO HUMAN HEALTH RECREATIONAL USE SCREENING LEVELS
MERAMEC ENERGY CENTER, ST. LOUIS COUNTY, MO
AMEREN MISSOURI

		Human Health Recreational Use Screening (a)																				
	Constituent	Boron		Calcium		Chloride	pH	Sulfate	TDS	Fluoride	Antimony		Arsenic		Barium		Beryllium		Cadmium		Chromium	
	Fraction	Total	Dissolved	Total	Dissolved	Total	Total	Total	Total	Total	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
Sample	**HH REC SL**	NA	NA	NA	NA	NA	6.5-8.5	NA	NA	NA	4.3	4.3	0.00014	0.00014	NA	NA	NA	NA	NA	NA	NA	NA
Location ID	**Sampling Event Date**	mg/L	mg/L	mg/L	mg/L	mg/L	S.U.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
UPSTREAM																						
M-MEC-7S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	0.0018	0.0016	<	<	<	<	<	<	<	<
M-MEC-8S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	0.0014	0.0013	<	<	<	<	<	<	<	<
M-MEC-9D	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	0.0013	0.0011	<	<	<	<	<	<	<	<
M-MEC-9S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	0.0012	0.0011	<	<	<	<	<	<	<	<
ADJACENT																						
M-MEC-4S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	0.0018	0.0014	<	<	<	<	<	<	<	<
M-MEC-5S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	0.0016	0.0013	<	<	<	<	<	<	<	<
M-MEC-6D	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	0.0014	0.0012	<	<	<	<	<	<	<	<
M-MEC-6S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	0.0013	0.0011	<	<	<	<	<	<	<	<
DOWNSTREAM																						
M-MEC-1S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	0.0016	0.0013	<	<	<	<	<	<	<	<
M-MEC-2D	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	0.0014	0.0012	<	<	<	<	<	<	<	<
M-MEC-2S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	0.0015	0.0011	<	<	<	<	<	<	<	<
M-MEC-3D	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	0.0014	0.0011	<	<	<	<	<	<	<	<
M-MEC-3S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	0.0015	0.0012	<	<	<	<	<	<	<	<

Notes:
< - Less than the Human Health Recreational Use Screening Level.
HH - Human Health.
mg/L - milligram per liter.
NA - Not Applicable/Not Analyzed.
pCi/L - picoCurie per liter.
REC - Recreational Use.
SL - Screening Level.
S.U. - Standard Units.
TDS - Total Dissolved Solids.
USEPA - United States Environmental Protection Agency.

(a) - Recreational Use Screening Levels selected in Table 1 following the following hierarchy:
Missouri State Water Quality Criteria for Human Health Fish Consumption.
USEPA Ambient Water Quality Criteria for Human Health Consumption of Organism Only.

TABLE 8
SUMMARY OF MERAMEC RIVER SURFACE WATER TOTAL (UNFILTERED) AND DISSOLVED (FILTERED) RESULTS COMPARISON
TO HUMAN HEALTH RECREATIONAL USE SCREENING LEVELS
MERAMEC ENERGY CENTER, ST. LOUIS COUNTY, MO
AMEREN MISSOURI

		Human Health Recreational Use Screening (a)															
	Constituent	Cobalt		Lead		Lithium		Mercury		Molybdenum		Selenium		Thallium		Radium-226/228	Hardness
	Fraction	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Total
	HH REC SL	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	4.2	4.2	0.0063	0.0063	NA	NA
Sample Location ID	**Sampling Event Date**	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	pCi/L	mg/L
UPSTREAM																	
M-MEC-7S	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MEC-8S	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MEC-9D	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MEC-9S	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
ADJACENT																	
M-MEC-4S	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MEC-5S	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MEC-6D	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MEC-6S	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
DOWNSTREAM																	
M-MEC-1S	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MEC-2D	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MEC-2S	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MEC-3D	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MEC-3S	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<

Notes:

< - Less than the Human Health Recreational Use Screening Level.
HH - Human Health.
mg/L - milligram per liter.
NA - Not Applicable/Not Analyzed.
pCi/L - picoCurie per liter.
REC - Recreational Use.
SL - Screening Level.
S.U. - Standard Units.
TDS - Total Dissolved Solids.
USEPA - United States Environmental Protection Agency.

(a) - Recreational Use Screening Levels selected in Table 1 following the following hierarchy:
Missouri State Water Quality Criteria for Human Health Fish Consumption.
USEPA Ambient Water Quality Criteria for Human Health Consumption of Organism Only.

TABLE 9
SUMMARY OF MERAMEC RIVER SURFACE WATER TOTAL (UNFILTERED) AND DISSOLVED (FILTERED) RESULTS COMPARISON TO ECOLOGICAL SCREENING LEVELS
MERAMEC ENERGY CENTER, ST. LOUIS COUNTY, MO
AMEREN MISSOURI

		Ecological Screening (a)																				
	Constituent	Boron		Calcium		Chloride	pH	Sulfate	TDS	Fluoride	Antimony		Arsenic		Barium		Beryllium		Cadmium		Chromium	
	Fraction	Total	Dissolved	Total	Dissolved	Total	Total	Total	Total	Total	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
Sample	**ECO SL**	2	2	NA	NA	230	6.5-8.5	1608	NA	4	NA	NA	0.15	0.15	NA	NA	0.1	0.1	0.0015	0.0015	0.167	0.167
Location ID	**Sampling Event Date**	mg/L	mg/L	mg/L	mg/L	mg/L	S.U	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
UPSTREAM																						
M-MEC-7S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MEC-8S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MEC-9D	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MEC-9S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
ADJACENT																						
M-MEC-4S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MEC-5S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MEC-6D	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MEC-6S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
DOWNSTREAM																						
M-MEC-1S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MEC-2D	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MEC-2S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MEC-3D	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
M-MEC-3S	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<

Notes:
< - Less than the Ecological Screening Level.
ECO - Ecological.
mg/L - milligram per liter.
NA - Not Applicable/Not Analyzed.
pCi/L - picoCurie per liter.
SL - Screening Level.
S.U. - Standard Units.
TDS - Total Dissolved Solids.
USEPA - United States Environmental Protection Agency.

(a) - Ecological Screening Levels selected in Table 2 following the following hierarchy:
Missouri State Water Quality Criteria for the Protection of Aquatic Life (Chronic).
USEPA Aquatic Life Ambient Water Quality Criteria (Chronic).
Missouri State Water Quality Criteria for the Protection of Aquatic Life (Acute).
USEPA Aquatic Life Ambient Water Quality Criteria (Acute).
Missouri State Water Quality Criteria for Irrigation.
Missouri State Water Quality Criteria for Livestock Wildlife Watering.

TABLE 9
SUMMARY OF MERAMEC RIVER SURFACE WATER TOTAL (UNFILTERED) AND DISSOLVED (FILTERED) RESULTS COMPARISON TO ECOLOGICAL SCREENING LEVELS
MERAMEC ENERGY CENTER, ST. LOUIS COUNTY, MO
AMEREN MISSOURI

		Ecological Screening (a)															
	Constituent	Cobalt		Lead		Lithium		Mercury		Molybdenum		Selenium		Thallium		Radium-226/228	Hardness
	Fraction	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Total
Sample	**ECO SL**	1	1	0.0089	0.0089	NA	NA	0.0005	0.0005	NA	NA	0.005	0.005	NA	NA	NA	NA
Location ID	**Sampling Event Date**	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	pCi/L	mg/L
UPSTREAM																	
M-MEC-7S	Sep-17	<	<	0.0172	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MEC-8S	Sep-17	<	<	0.0112	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MEC-9D	Sep-17	<	<	0.0205	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MEC-9S	Sep-17	<	<	0.0196	<	<	<	<	<	<	<	<	<	<	<	NA	<
ADJACENT																	
M-MEC-4S	Sep-17	<	<	0.0175	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MEC-5S	Sep-17	<	<	0.0139	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MEC-6D	Sep-17	<	<	0.018	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MEC-6S	Sep-17	<	<	0.0121	<	<	<	<	<	<	<	<	<	<	<	NA	<
DOWNSTREAM																	
M-MEC-1S	Sep-17	<	<	0.014	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MEC-2D	Sep-17	<	<	0.0142	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MEC-2S	Sep-17	<	<	0.0146	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MEC-3D	Sep-17	<	<	0.0155	<	<	<	<	<	<	<	<	<	<	<	NA	<
M-MEC-3S	Sep-17	<	<	0.0143	<	<	<	<	<	<	<	<	<	<	<	NA	<

Notes:
< - Less than the Ecological Screening Level.
ECO - Ecological.
mg/L - milligram per liter.
NA - Not Applicable/Not Analyzed.
pCi/L - picoCurie per liter.
SL - Screening Level.
S.U. - Standard Units.
TDS - Total Dissolved Solids.
USEPA - United States Environmental Protection Agency.

(a) - Ecological Screening Levels selected in Table 2 following the following hierarchy:
Missouri State Water Quality Criteria for the Protection of Aquatic Life (Chronic).
USEPA Aquatic Life Ambient Water Quality Criteria (Chronic).
Missouri State Water Quality Criteria for the Protection of Aquatic Life (Acute).
USEPA Aquatic Life Ambient Water Quality Criteria (Acute).
Missouri State Water Quality Criteria for Irrigation.
Missouri State Water Quality Criteria for Livestock Wildlife Watering.

TABLE 10
SUMMARY OF CREEK/DRAINAGE SURFACE WATER TOTAL (UNFILTERED) AND DISSOLVED (FILTERED) RESULTS COMPARISON TO HUMAN HEALTH DRINKING WATER SCREENING LEVELS
MERAMEC ENERGY CENTER, ST. LOUIS COUNTY, MO
AMEREN MISSOURI

		Human Health Drinking Water Screening (a)																				
	Constituent	Boron		Calcium		Chloride	pH	Sulfate	TDS	Fluoride	Antimony		Arsenic		Barium		Beryllium		Cadmium		Chromium	
	Fraction	Total	Dissolved	Total	Dissolved	Total	Total	Total	Total	Total	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
Sample	**HH DW SL**	4	4	NA	NA	250	6.5-8.5	250	500	4	0.006	0.006	0.05	0.05	2	2	0.004	0.004	0.005	0.005	0.1	0.1
Location ID	**Sampling Event Date**	mg/L	mg/L	mg/L	mg/L	mg/L	S.U	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
UPSTREAM																						
M-C-1	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
ADJACENT																						
M-C-2	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
DOWNSTREAM																						
M-C-3	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<

Notes:
- < - Less than the Human Health Drinking Water Screening Level.
- CCR - Coal Combustion Residuals.
- DW - Drinking Water.
- HH - Human Health.
- MCL - Maximum Contaminant Level.
- mg/L - milligram per liter.
- NA - Not Applicable/Not Analyzed.
- pCi/L - picoCurie per liter.
- RSL - Risk-Based Screening Level.
- SL - Screening Level.
- S.U. - Standard Units.
- TDS - Total Dissolved Solids.
- USEPA - United States Environmental Protection Agency.

(a) - Drinking Water Screening Levels selected in Table 1 following the following hierarchy:
- Missouri State Water Quality Criteria for Drinking Water Supply.
- Federal USEPA MCL for Drinking Water.
- Federal November 2017 USEPA Tapwater RSL.
- Federal USEPA SMCL for Drinking Water.

TABLE 10
SUMMARY OF CREEK/DRAINAGE SURFACE WATER TOTAL (UNFILTERED) AND DISSOLVED (FILTERED) RESULTS COMPARISON TO HUMAN HEALTH DRINKING WATER SCREENING LEVELS
MERAMEC ENERGY CENTER, ST. LOUIS COUNTY, MO
AMEREN MISSOURI

		Human Health Drinking Water Screening (a)															
	Constituent	Cobalt		Lead		Lithium		Mercury		Molybdenum		Selenium		Thallium		Radium-226/228	Hardness
	Fraction	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Total
	HH DW SL	0.006	0.006	0.015	0.015	0.04	0.04	0.002	0.002	0.1	0.1	0.05	0.05	0.002	0.002	5	NA
Sample Location ID	**Sampling Event Date**	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	pCi/L	mg/L
UPSTREAM																	
M-C-1	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
ADJACENT																	
M-C-2	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
DOWNSTREAM																	
M-C-3	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<

Notes:
< - Less than the Human Health Drinking Water Screening Level.
CCR - Coal Combustion Residuals.
DW - Drinking Water.
HH - Human Health.
MCL - Maximum Contaminant Level.
mg/L - milligram per liter.
NA - Not Applicable/Not Analyzed.
pCi/L - picoCurie per liter.
RSL - Risk-Based Screening Level.
SL - Screening Level.
S.U. - Standard Units.
TDS - Total Dissolved Solids.
USEPA - United States Environmental Protection Agency.

(a) - Drinking Water Screening Levels selected in Table 1 following the following hierarchy:
Missouri State Water Quality Criteria for Drinking Water Supply.
Federal USEPA MCL for Drinking Water.
Federal November 2017 USEPA Tapwater RSL.
Federal USEPA SMCL for Drinking Water.

TABLE 11
SUMMARY OF CREEK/DRAINAGE SURFACE WATER TOTAL (UNFILTERED) AND DISSOLVED (FILTERED) RESULTS COMPARISON TO HUMAN HEALTH RECREATIONAL SCREENING LEVELS
MERAMEC ENERGY CENTER, ST. LOUIS COUNTY, MO
AMEREN MISSOURI

		Human Health Recreational Use Screening (a)																				
	Constituent	Boron		Calcium		Chloride	pH	Sulfate	TDS	Fluoride	Antimony		Arsenic		Barium		Beryllium		Cadmium		Chromium	
	Fraction	Total	Dissolved	Total	Dissolved	Total	Total	Total	Total	ecreational U	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
Sample	**HH REC SL**	NA	NA	NA	NA	NA	6.5-8.5	NA	NA	NA	4.3	4.3	0.00014	0.00014	NA	NA	NA	NA	NA	NA	NA	NA
Location ID	**Sampling Event Date**	mg/L	mg/L	mg/L	mg/L	mg/L	S.U.	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
UPSTREAM																						
M-C-1	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	0.00077 J	0.00084 J	<	<	<	<	<	<	<	<
ADJACENT																						
M-C-2	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	0.0022	0.0023	<	<	<	<	<	<	<	<
DOWNSTREAM																						
M-C-3	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	0.0025	0.0024	<	<	<	<	<	<	<	<

Notes:
< - Less than the Human Health Recreational Use Screening Level.
HH - Human Health.
mg/L - milligram per liter.
pCi/L - picoCurie per liter.
NA - Not Applicable/Not Analyzed.
REC - Recreational Use.
SL - Screening Level.
S.U. - Standard Units.
TDS - Total Dissolved Solids.
USEPA - United States Environmental Protection Agency.

Qualifiers:
J - Value is estimated.

(a) - Recreational Use Screening Levels selected in Table 1 following the following hierarchy:
Missouri State Water Quality Criteria for Human Health Fish Consumption.
USEPA Ambient Water Quality Criteria for Human Health Consumption of Organism Only.

TABLE 11
SUMMARY OF CREEK/DRAINAGE SURFACE WATER TOTAL (UNFILTERED) AND DISSOLVED (FILTERED) RESULTS COMPARISON
TO HUMAN HEALTH RECREATIONAL SCREENING LEVELS
MERAMEC ENERGY CENTER, ST. LOUIS COUNTY, MO
AMEREN MISSOURI

		Human Health Recreational Use Screening (a)															
	Constituent	Cobalt		Lead		Lithium		Mercury		Molybdenum		Selenium		Thallium		Radium-226/228	Hardness
	Fraction	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Total
	HH REC SL	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	4.2	4.2	0.0063	0.0063	NA	NA
Sample Location ID	**Sampling Event Date**	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	pCi/L	mg/L
UPSTREAM																	
M-C-1	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
ADJACENT																	
M-C-2	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
DOWNSTREAM																	
M-C-3	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<

Notes:
< - Less than the Human Health Recreational Use Screening Level.
HH - Human Health.
mg/L - milligram per liter.
pCi/L - picoCurie per liter.
NA - Not Applicable/Not Analyzed.
REC - Recreational Use.
SL - Screening Level.
S.U. - Standard Units.
TDS - Total Dissolved Solids.
USEPA - United States Environmental Protection Agency.

Qualifiers:
J - Value is estimated.

(a) - Recreational Use Screening Levels selected in Table 1 following the following hierarchy:
Missouri State Water Quality Criteria for Human Health Fish Consumption.
USEPA Ambient Water Quality Criteria for Human Health Consumption of Organism Only.

TABLE 12
SUMMARY OF CREEK/DRAINAGE SURFACE WATER TOTAL (UNFILTERED) AND DISSOLVED (FILTERED) RESULTS COMPARISON TO ECOLOGICAL SCREENING LEVELS
MERAMEC ENERGY CENTER, ST. LOUIS COUNTY, MO
AMEREN MISSOURI

		Ecological Screening (a)																				
	Constituent	Boron		Calcium		Chloride	pH	Sulfate	TDS	Fluoride	Antimony		Arsenic		Barium		Beryllium		Cadmium		Chromium	
	Fraction	Total	Dissolved	Total	Dissolved	Total	Total	Total	Total	Total	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
Sample	**ECO SL**	2	2	NA	NA	230	6.5-8.5	1608	NA	4	NA	NA	0.15	0.15	NA	NA	0.1	0.1	0.0015	0.0015	0.167	0.167
Location ID	**Sampling Event Date**	mg/L	mg/L	mg/L	mg/L	mg/L	S.U	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
UPSTREAM																						
M-C-1	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
ADJACENT																						
M-C-2	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
DOWNSTREAM																						
M-C-3	Sep-17	<	<	<	<	<	NA	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<

Notes:
< - Less than the Ecological Screening Level.
ECO - Ecological.
mg/L - milligram per liter.
NA - Not Applicable/Not Analyzed.
pCi/L - picoCurie per liter.
SL - Screening Level.
S.U. - Standard Units.
TDS - Total Dissolved Solids.
USEPA - United States Environmental Protection Agency.

(a) - Ecological Screening Levels selected in Table 2 following the following hierarchy:
Missouri State Water Quality Criteria for the Protection of Aquatic Life (Chronic).
USEPA Aquatic Life Ambient Water Quality Criteria (Chronic).
Missouri State Water Quality Criteria for the Protection of Aquatic Life (Acute).
USEPA Aquatic Life Ambient Water Quality Criteria (Acute).
Missouri State Water Quality Criteria for Irrigation.
Missouri State Water Quality Criteria for Livestock Wildlife Watering.

TABLE 12
SUMMARY OF CREEK/DRAINAGE SURFACE WATER TOTAL (UNFILTERED) AND DISSOLVED (FILTERED) RESULTS COMPARISON TO ECOLOGICAL SCREENING LEVELS
MERAMEC ENERGY CENTER, ST. LOUIS COUNTY, MO
AMEREN MISSOURI

		Ecological Screening (a)															
	Constituent	Cobalt		Lead		Lithium		Mercury		Molybdenum		Selenium		Thallium		Radium-226/228	Hardness
	Fraction	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Total
	ECO SL	1	1	0.0089	0.0089	NA	NA	0.0005	0.0005	NA	NA	0.005	0.005	NA	NA	NA	NA
Sample Location ID	**Sampling Event Date**	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	pCi/L	mg/L
UPSTREAM																	
M-C-1	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
ADJACENT																	
M-C-2	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<
DOWNSTREAM																	
M-C-3	Sep-17	<	<	<	<	<	<	<	<	<	<	<	<	<	<	NA	<

Notes:
< - Less than the Ecological Screening Level.
ECO - Ecological.
mg/L - milligram per liter.
NA - Not Applicable/Not Analyzed.
pCi/L - picoCurie per liter.
SL - Screening Level.
S.U. - Standard Units.
TDS - Total Dissolved Solids.
USEPA - United States Environmental Protection Agency.

(a) - Ecological Screening Levels selected in Table 2 following the following hierarchy:
Missouri State Water Quality Criteria for the Protection of Aquatic Life (Chronic).
USEPA Aquatic Life Ambient Water Quality Criteria (Chronic).
Missouri State Water Quality Criteria for the Protection of Aquatic Life (Acute).
USEPA Aquatic Life Ambient Water Quality Criteria (Acute).
Missouri State Water Quality Criteria for Irrigation.
Missouri State Water Quality Criteria for Livestock Wildlife Watering.

TABLE 13
SUMMARY OF WHOLE EFFLUENT TOXICITY TESTING RESULTS FOR NPDES OUTFALL 003 AND 009
MERAMEC ENERGY CENTER, ST. LOUIS COUNTY, MO
AMEREN MISSOURI

Sampling Event	Treatment	Percent Survival at 48 hours	
		Pimephales promelas	***Ceriodaphnia dubia***
Outfall 003 (Ash Retention Pond)			
January 2013	10% Effluent	100%	100%
	Reconstituted Control	100%	100%
	Upstream Control	100%	100%
January 2014	10% Effluent	100%	100%
	Reconstituted Control	100%	100%
	Upstream Control	100%	100%
January 2015	10% Effluent	100%	100%
	Reconstituted Control	100%	100%
	Upstream Control	98%	100%
January 2016	10% Effluent	100%	100%
	Reconstituted Control	100%	100%
	Upstream Control	100%	100%
January 2017	10% Effluent	100%	100%
	Reconstituted Control	100%	100%
	Upstream Control	100%	100%
Outfall 009 (489 Pond)			
July 2016	10% Effluent	100%	100%
	Reconstituted Control	100%	100%
	Upstream Control	100%	100%

Notes:
NPDES - Natual Pollutant Discharge Elimination System.

No significant difference (alpha = 0.05) between effluent and control survival data for the above test.
Effluent passes in all tests conducted from 2013 through 2017.
10% Effluent - Outfall 003 and Outfall 009 effluent mixed with Mississippi River water.
Reconstituted Control - Laboratory reconstituted water.
Upstream Control - Mississippi River water.

TABLE 14
DERIVATION OF RISK-BASED SCREENING LEVELS FOR GROUNDWATER BASED ON THE MISSISSIPPI RIVER
MERAMEC ENERGY CENTER, ST. LOUIS COUNTY, MO
AMEREN MISSOURI

Constituents	HH DW SL (a) (mg/L)	HH REC SL (b) (mg/L)	ECO SL (c) (mg/L)	Lowest of the Human Health and Ecological Screening Levels (mg/L)	Groundwater Risk-Based Screening Level* (mg/L)	Maximum MEC Groundwater Concentration (mg/L)		Ratio Between Groundwater Risk-Based Screening Level and the Maximum MEC Groundwater Concentration
				Estimated Dilution Factor (d) =	100,000			
Boron	4	NA	2	2	200000	30.3	M-MW-7	>6,000
Sulfate	250	NA	1773	250	25000000	1250	M-MW-7	>20,000
TDS	500	NA	NA	500	50000000	2320	M-MW-7	>21,000
Cobalt	0.006	NA	1	0.006	600	0.0078	M-MW-6	>76,000
Lithium	0.04	NA	NA	0.04	4000	0.164	M-MW-6	>24,000
Molybdenum	0.1	NA	NA	0.1	10000	0.717	M-MW-7	>13,000

Notes:
* Where the Groundwater Risk-Based Screening Level = Screening Level x Dilution Factor.
ECO SL - Ecological Screening Level.
HH DW SL - Human Health Drinking Water Screening Level.
HH REC SL - Human Health Recreational Use Screening Level.
mg/L - milligram per liter.
NA - Not Available.

(a) - Drinking Water Screening Levels selected in Table 1 following the following hierarchy:
Missouri State Water Quality Criteria for Drinking Water Supply.
Federal USEPA MCL for Drinking Water.
Federal November 2017 USEPA Tapwater RSL.
Federal USEPA SMCL for Drinking Water.
(b) - Recreational Use Screening Levels selected in Table 1 following the following hierarchy:
Missouri State Water Quality Criteria for Human Health Fish Consumption.
USEPA Ambient Water Quality Criteria for Human Health Consumption of Organism Only.
(c) - Ecological Screening Levels selected in Table 2 following the following hierarchy:
Missouri State Water Quality Criteria for the Protection of Aquatic Life (Chronic).
USEPA Aquatic Life Ambient Water Quality Criteria (Chronic).
Missouri State Water Quality Criteria for the Protection of Aquatic Life (Acute).
USEPA Aquatic Life Ambient Water Quality Criteria (Acute).
Missouri State Water Quality Criteria for Irrigation.
Missouri State Water Quality Criteria for Livestock Wildlife Watering.
(d) - Estimated value, see text and Attachment B for derivation.

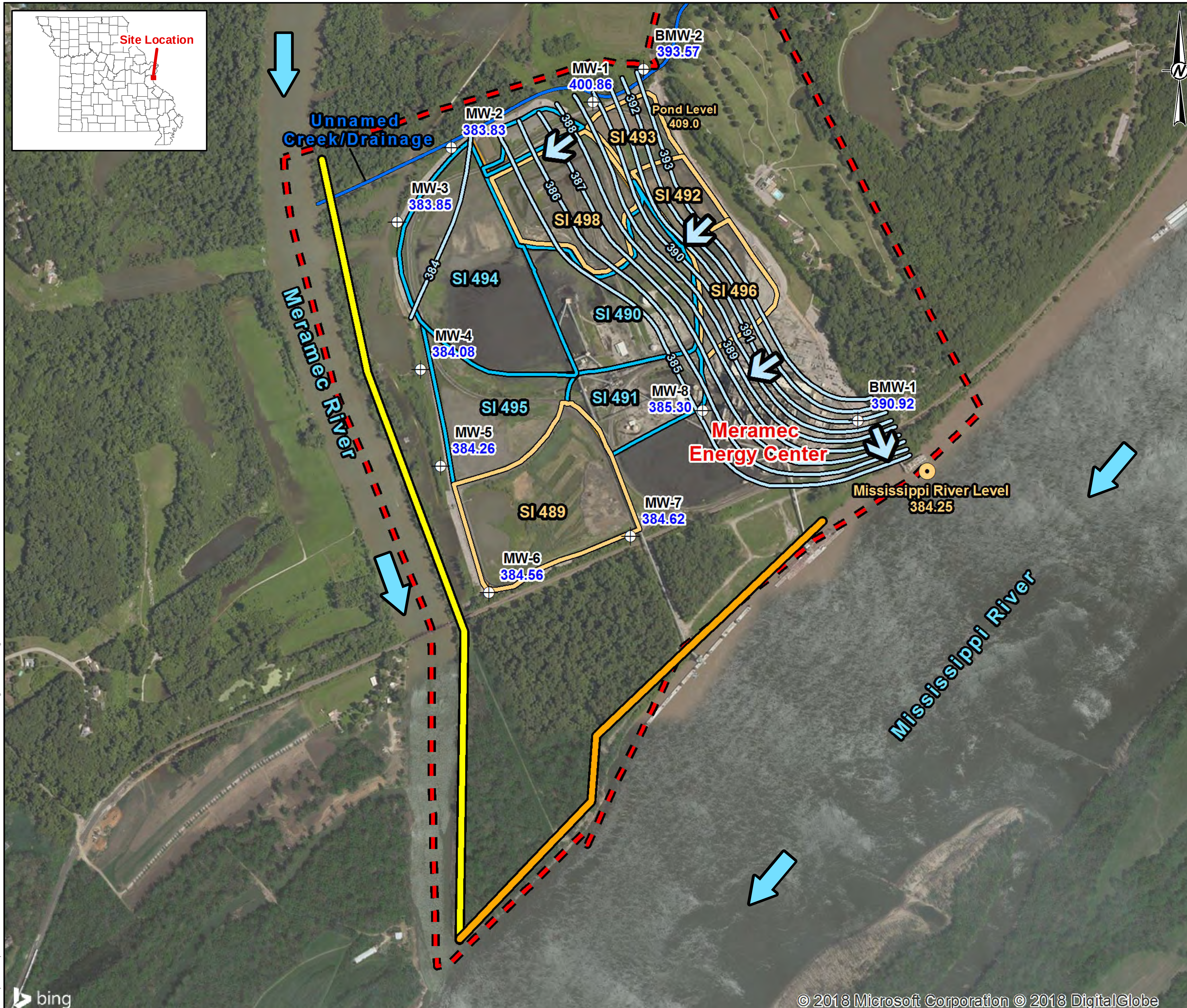
TABLE 15
DERIVATION OF RISK-BASED SCREENING LEVELS FOR GROUNDWATER BASED ON THE MERAMEC RIVEF
MERAMEC ENERGY CENTER, ST. LOUIS COUNTY, MO
AMEREN MISSOURI

				Estimated Dilution Factor (d) =	700			
Constituents	**HH DW SL (a) (mg/L)**	**HH REC SL (b) (mg/L)**	**ECO SL (c) (mg/L)**	**Lowest of the Human Health and Ecological Screening Levels (mg/L)**	**Groundwater Risk-Based Screening Level* (mg/L)**	**Maximum MEC Groundwater Concentration (mg/L)**		**Ratio Between Groundwater Risk-Based Screening Level and the Maximum MEC Groundwater Concentration**
Boron	4	NA	2	2	1400	30.3	M-MW-7	>40
Sulfate	250	NA	1773	250	175000	1250	M-MW-7	>100
TDS	500	NA	NA	500	350000	2320	M-MW-7	>100
Cobalt	0.006	NA	1	0.006	4.2	0.0078	M-MW-6	>500
Lithium	0.04	NA	NA	0.04	28	0.164	M-MW-6	>100
Molybdenum	0.1	NA	NA	0.1	70	0.717	M-MW-7	>90

Notes:
* Where the Groundwater Risk-Based Screening Level = Screening Level x Dilution Factor.
ECO SL - Ecological Screening Level.
HH DW SL - Human Health Drinking Water Screening Level.
HH REC SL - Human Health Recreational Use Screening Level.
mg/L - milligram per liter.
NA - Not Available.

(a) - Drinking Water Screening Levels selected in Table 1 following the following hierarchy:
Missouri State Water Quality Criteria for Drinking Water Supply.
Federal USEPA MCL for Drinking Water.
Federal November 2017 USEPA Tapwater RSL.
(b) - Recreational Use Screening Levels selected in Table 1 following the following hierarchy:
Missouri State Water Quality Criteria for Human Health Fish Consumption.
USEPA Ambient Water Quality Criteria for Human Health Consumption of Organism Only.
(c) - Ecological Screening Levels selected in Table 2 following the following hierarchy:
Missouri State Water Quality Criteria for the Protection of Aquatic Life (Chronic).
USEPA Aquatic Life Ambient Water Quality Criteria (Chronic).
Missouri State Water Quality Criteria for the Protection of Aquatic Life (Acute).
USEPA Aquatic Life Ambient Water Quality Criteria (Acute).
Missouri State Water Quality Criteria for Irrigation.
Missouri State Water Quality Criteria for Livestock Wildlife Watering.
(d) - Estimated value, see text and Attachment B for derivation.

FIGURES



LEGEND

- Meramec Energy Center Property Boundary
- Active Surface Impoundment
- Exempt Surface Impoundment
- Length of Groundwater Discharge Used in the Dilution Factor Calculations for the Meramec River
- Length of Groundwater Discharge Used in the Dilution Factor Calculations for the Mississippi River
- Unnamed Creek/Drainage

Groundwater Elevation Contours

- Groundwater Elevation Contour (FT MSL)

Ground/Surface Water Measurement Locations

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

NOTES
1. ALL LOCATIONS AND BOUNDARIES ARE APPROXIMATE.
2. GROUNDWATER ELEVATION MEASUREMENTS OBTAINED BY GOLDER ON JULY 18, 2016.
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 2,000 Feet

CLIENT
AMEREN MISSOURI
MERAMEC ENERGY CENTER

Ameren

PROJECT
AMEREN HYDROGEOLOGICAL CONSULTING

TITLE
ESTIMATED LENGTH OF DISCHARGE AND EXAMPLE GROUNDWATER FLOW MAP

CONSULTANT

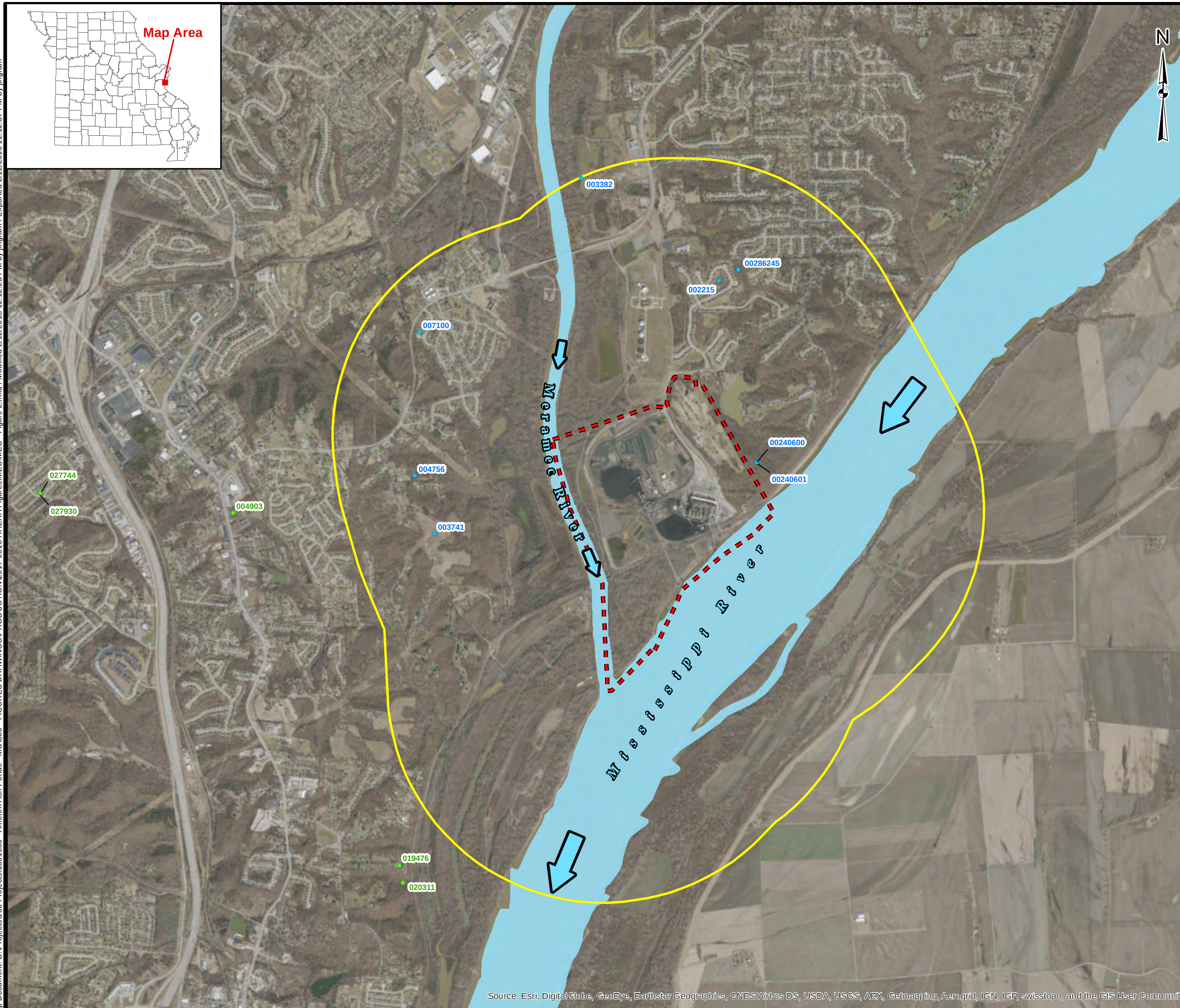
Golder Associates

YYYY-MM-DD	2017-12-19
PREPARED	JS
DESIGN	JS
REVIEW	RJF
APPROVED	MNH

PROJECT No.
130-1560

FIGURE
1

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



LEGEND

- Meramec Energy Center Property Boundary
- Approximate 1-Mile Radius
- Private Well
- Public Well
- Surface Water Flow Direction

NOTES

1.) Wells are labeled with state issued reference number or log ID.
2.) Search radius is approximately one mile beyond the Ameren property boundary line.
3.) Wells in Illinois are not shown.
4.) See Table 1 for details on wells within the 1-mile radius.
5.) Private wells outside of the approximate 1-mile radius are not shown for clarity.

REFERENCES

1.) MDNR - Missouri Department of Natural Resources
2.) MSDIS - Missouri Spatial Data Information Service
3.) University of Missouri - Columbia - Department of Geography - MSDIS Database
4.) Missouri Department of Natural Resources - Water Resources Center - Geologic Well Logs
5.) Missouri Environmental Geology Atlas 2007 (MEGA)
6.) MDNR Wellhead Protection Program
7.) COORDINATE SYSTEM: NAD 1983 UTM Zone 15N

0 2,000 4,000 Feet

PROJECT

Ameren

AMEREN MISSOURI COAL FIRED POWER PLANTS
ST. LOUIS COUNTY, MISSOURI

TITLE

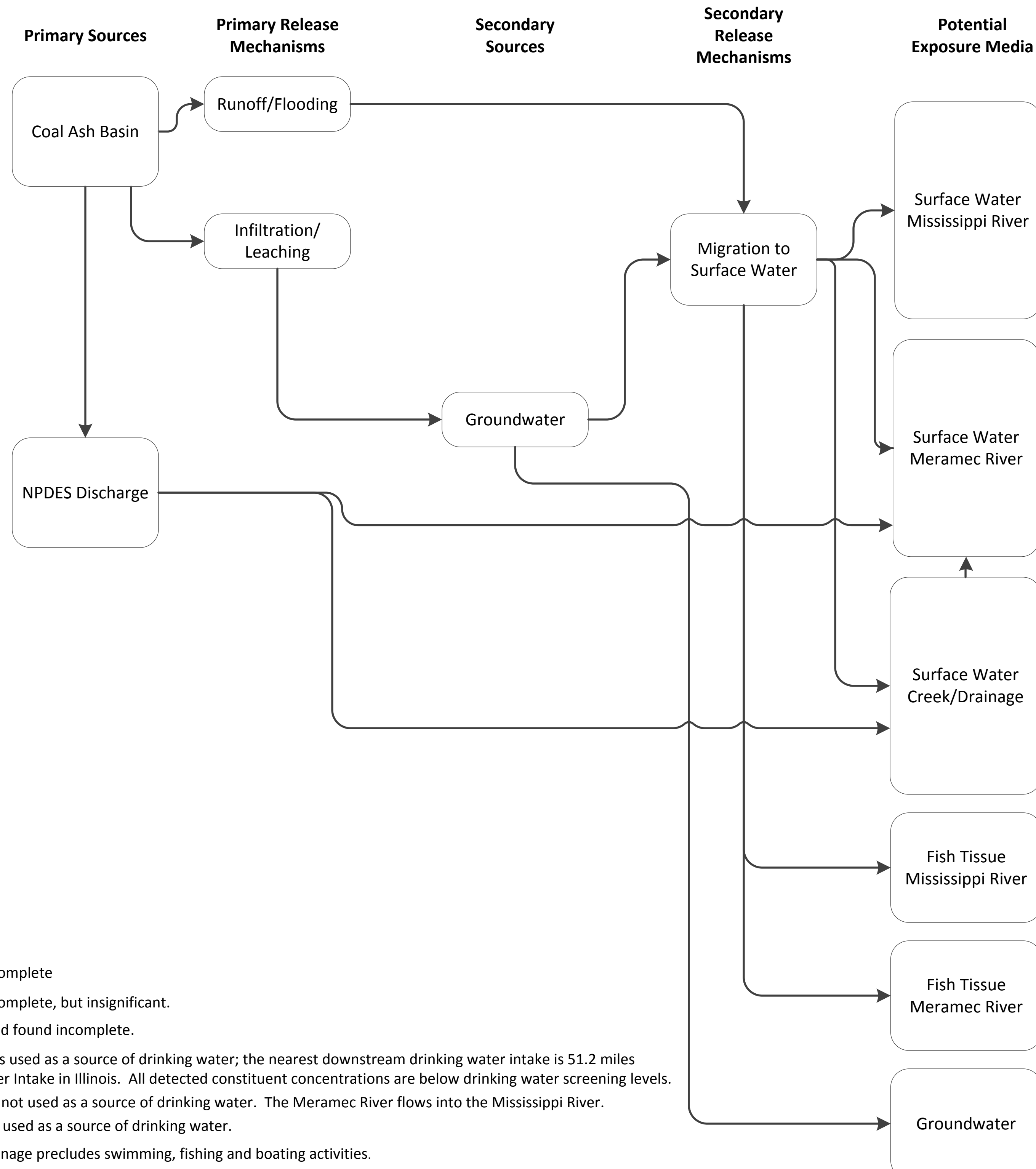
PRIVATE WELL LOCATION WITHIN 1-MILE RADIUS OF FACILITY BOUNDARY

Golder Associates

PROJECT No. 130-1560			FILE No. MEC - Figure 2.mxd	
DESIGN	-	-	SCALE: AS SHOWN	REV. 0
GIS	JSI	2/12/2018		
CHECK	MWD	2/12/2018	FIGURE 2	
REVIEW	MNH	2/12/2018		

Map Document: G:\Projects\130 Projects\1301560 - Ameren Ash Ponds - MO\800 - FIGURES-DRAWINGS\PRODUCTION\2017-2018 HHERA Figures\MEC\MEC - Figure 2.mxd / Modified 2/12/2018 12:12:23 PM by jingram / Exported 2/12/2018 12:12:37 PM by jingram

FIGURE 3
CONCEPTUAL SITE MODEL
MERAMEC ENERGY CENTER, ST. LOUIS COUNTY, MO
AMEREN MISSOURI



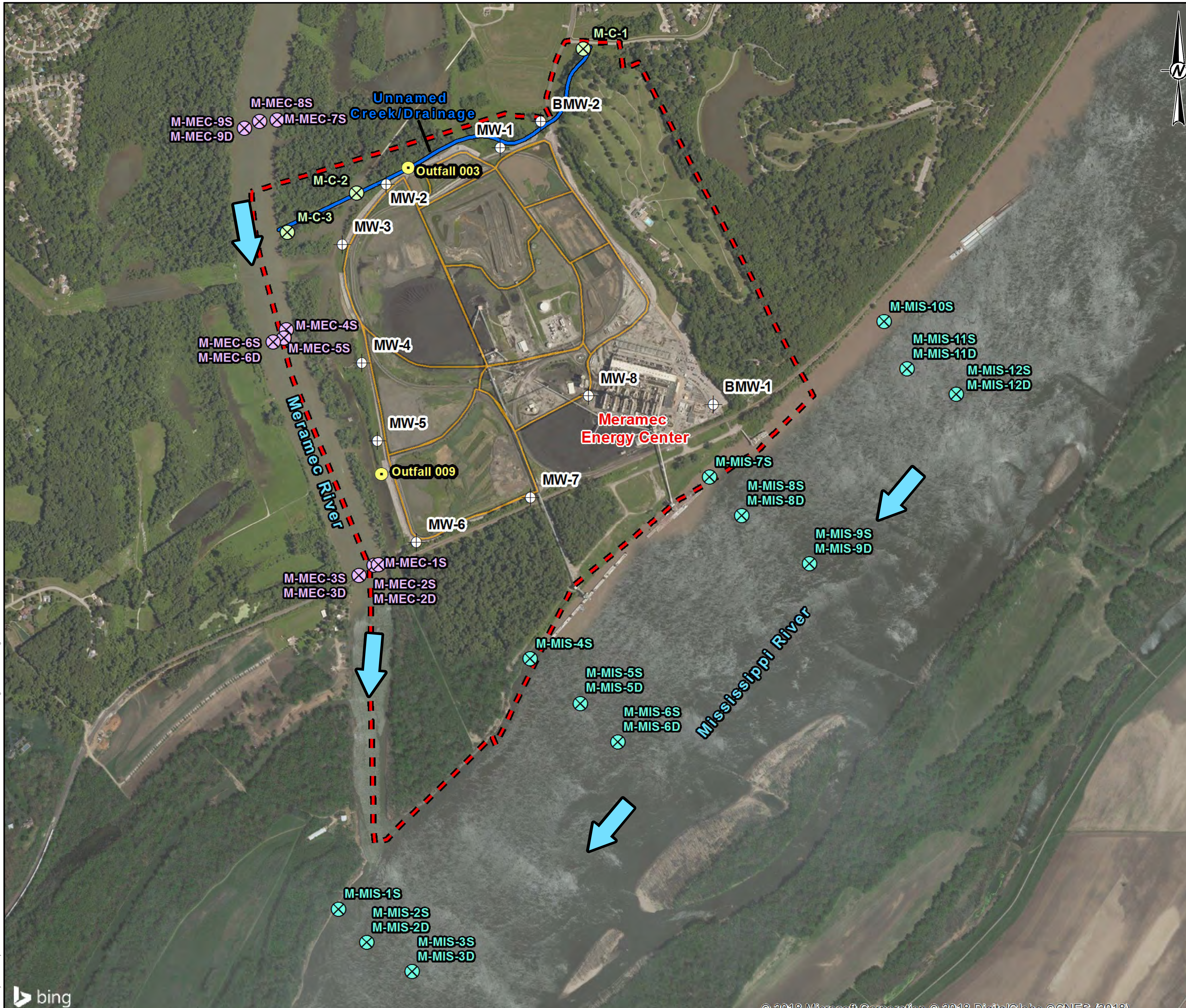
	Potential Human Health Receptors					Potential Ecological Receptors
Potential Exposure Route	**Current/Future Off-Site Resident Adult/Child**	**Current/Future Off-Site Recreational Swimmer**	**Current/Future Off-Site Recreational Wader**	**Current/Future Off-Site Recreational Boater**	**Current/Future Off-Site Recreational Fisher**	**Aquatic Receptors**
Drinking Water Use	⊙ (a)	○	○	○	○	NA
Incidental Ingestion	○	⊙	⊙	⊙	⊙	NA
Dermal Contact	○	⊙	⊙	⊙	⊙	NA
Aquatic Exposure	NA	NA	NA	NA	NA	⊙
Drinking Water Use	⊙ (b)	○	○	○	○	NA
Incidental Ingestion	○	⊙	⊙	⊙	⊙	NA
Dermal Contact	○	⊙	⊙	⊙	⊙	NA
Aquatic Exposure	NA	NA	NA	NA	NA	⊙
Drinking Water Use	○ (c)	○	○	○	○	NA
Incidental Ingestion	○	○	⊙	○	○	NA
Dermal Contact	○	○ (d)	⊙	○ (d)	○ (d)	NA
Aquatic Exposure	NA	NA	NA	NA	NA	⊙
Ingestion	○	○	○	○	●	NA
Aquatic Exposure	NA	NA	NA	NA	NA	⊙
Ingestion	○	○	○	○	●	NA
Aquatic Exposure	NA	NA	NA	NA	NA	⊙
Drinking Water Use	○ (e)	○	○	○	○	NA
Aquatic Exposure	NA	NA	NA	NA	NA	○ (f)

Notes:
- ● Pathway potentially complete
- ⊙ Pathway potentially complete, but insignificant.
- ○ Pathway evaluated and found incomplete.

(a) The Mississippi River is used as a source of drinking water; the nearest downstream drinking water intake is 51.2 miles downstream at Chester Intake in Illinois. All detected constituent concentrations are below drinking water screening levels.
(b) The Meramec River is not used as a source of drinking water. The Meramec River flows into the Mississippi River.
(c) Creek/Drainage is not used as a source of drinking water.
(d) The size of Creek/Drainage precludes swimming, fishing and boating activities.
(e) The shallow alluvial aquifer in the vicinity of the coal ash management area is not used for drinking water purposes.
(f) Ecological Receptors are not exposed to groundwater.

NA – Not Applicable.
NPDES - National Pollutant Discharge Elimination System.

HALEY ALDRICH



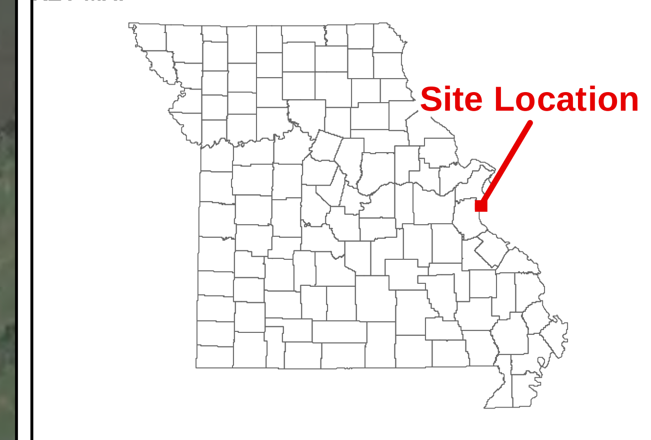
LEGEND

- Meramec Energy Center Property Boundary
- All Surface Impoundments
- Unnamed Creek/Drainage

Ground/Surface Water Measurement Locations

- Groundwater Monitoring Well
- Creek/Drainage Sample Location
- Meramec River Sample Location
- Mississippi River Sample Location
- NPDES Outfall Location
- Surface Water Flow Direction

KEY MAP



NOTES
1. ALL LOCATIONS AND BOUNDARIES ARE APPROXIMATE.
2. GROUNDWATER MONITORING WELLS SURVEYED BY ZAHNER AND ASSOCIATES, INC. ON FEBRUARY 4 AND APRIL 28, 2016.
3. SAMPLE LOCATIONS BASED ON HANDHELD TRIMBLE GPS UNIT.
4. SAMPLE LOCATIONS REPRESENT MIDPOINT BETWEEN STARTING AND ENDING LOCATIONS.
5. NPDES - NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM.

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 2,000 2,500 3,000 Feet

CLIENT
AMEREN MISSOURI
MERAMEC ENERGY CENTER

Ameren

PROJECT
AMEREN HYDROGEOLOGICAL CONSULTING

TITLE
SURFACE WATER SAMPLING LOCATIONS
MERAMEC ENERGY CENTER

CONSULTANT
Golder Associates

YYYY-MM-DD	2017-09-28
PREPARED	JSI
DESIGN	JSI
REVIEW	JS
APPROVED	MNH

PROJECT No.	PHASE	Rev.	FIGURE
130-1560	0004	0.0	4

ATTACHMENT A

Constituents Present in Coal Ash and in Our Natural Environment

Attachment A

Constituents Present in Coal Ash and in Our Natural Environment

It is important to understand what constituents are present in coal ash, which can be released to the environment, and to understand the natural occurrence of these constituents in our environment.

Coal is a type of sedimentary rock that is a natural component of the earth's crust and the inorganic minerals and elements it contains are also naturally occurring. It is the organic component of coal that burns and produces energy, and it is the inorganic minerals and elements that remain after combustion the make up the coal ash, or coal combustion products (CCPs).

A.1 Major, Minor and Trace Constituents in Coal Ash

All of the inorganic minerals and elements that are present in coal ash are also present in our natural environment. This is one fact that that the public seems either not to understand or will not acknowledge. **Figure A-1** shows the major and minor components of fly ash, bottom ash, volcanic ash, and shale. It is important to understand that the constituents that are the focus of many of the concerns expressed by the public about the toxicity of coal ash (e.g., lead, arsenic, mercury, cadmium, selenium, etc.) are trace elements, so called because they are present in such low concentrations (in the mg/kg or part per million (ppm) range). Together, the trace elements generally make up less than 1 percent of the total mass of these materials. To put these concentrations into context, a mg/kg or ppm is equivalent to:

- 1 penny in a large container holding $10,000 worth of pennies, or
- 1 second in 11.5 days, or
- 1 inch in 15.8 miles

These trace elements have been referred to by the public and even in the popular press as "toxic"—without any context provided for what this means. Moreover, claims have been made that there is no safe level of exposure to any of these elements.

This is simply not true, and there are two important facts that must be understood to put this in context. The first relates to background levels of constituents in our environment and the second relates to toxicity.

A.2 Background Levels in Soils

The first fact that must be understood is that all of the constituents present in coal ash occur naturally in our environment. U.S. Geological Survey (USGS) data demonstrate the presence of these constituents in the soils across the U.S. Prime examples include arsenic, lead, mercury and selenium. With respect to arsenic, **Figure A-2** shows the range of background levels of arsenic in soils across the U.S., as published by the USGS. The USGS is conducting a "national geochemical survey" to identify background levels of elements in soils in the U.S. (USGS, 2013). **Figures A-3 – A-6** provide maps prepared by the USGS demonstrating the naturally-occurring presence of other trace elements in soils in the U.S., including aluminum and copper (**Figure A-3**), iron and lead (**Figure A-4**), manganese and mercury (**Figure A-5**), and selenium and zinc (**Figure A-6**).

These soils are found in our backyards, schools, parks, etc., and because of their presence in soil, these constituents are also present in the foods we eat. Some of these constituents are present in our vitamins, such as manganese and selenium. Thus, we are exposed to these trace elements in our natural environment every day, and in many ways.

A.3 Toxicity and Risk

The second fact is that all constituents and materials that we encounter in our natural environment can be toxic, but what determines whether a toxic effect actually occurs is how one is exposed to the constituent, the amount of material to which one may be exposed, and the timing and duration of that exposure. Without sufficient exposure the science tells us that there are no toxic effects. Put another way, when a toxic effect is demonstrated by a particular constituent, it is generally caused by high levels of exposure over a long-term duration. The fundamental principles here are:

- All constituents can exert toxic effects (from aspirin[1] to table salt to water to minerals).
- For such toxic effects to occur, exposure must occur at a sufficiently high level for a sufficiently long period of time.
- If there is no exposure, there is no risk.

A.4 Risk-Based Screening Levels

The U.S. Environmental Protection Agency (USEPA) uses information on the potential toxicity of constituents to identify concentrations of trace elements in soil in a residential setting that are considered by USEPA to be protective for humans (including sensitive groups) over a lifetime (USEPA, 2014c). Specifically, residential soil screening levels are levels that are protective of a child and adult's daily exposure to constituents present in soil or a solid matrix over a residential lifetime. In the context of regulatory decision making, at sites where constituent concentrations fall below these screening levels, no further action or study is warranted under the federal Superfund program. Missouri Department of Natural Resources also applies this concept to the development of screening levels in its Risk-Based Corrective Action program (MDNR, 2006).

Figure A-7 shows USEPA's residential soil screening levels for a variety of trace elements that are present in coal ash. USEPA considers it to be safe for children to be exposed to these concentrations of each of these trace elements in soils on a daily basis, throughout their lifetime. What this tells us is that by developing these residential soil screening levels, USEPA considers the presence of these levels of these constituents in soils to be safe for humans, even for exposure on a daily basis. It is, therefore, simply not true that there are no safe levels of exposure to these constituents.

A.5 Comparison of Coal Ash Constituent Concentrations to Risk-Based Screening Levels and Background

A comparison of constituent concentrations in coal ash, as reported by the USGS (USGS, 2011a) to USEPA's risk-based screening levels for residential soil indicates that with only a few exceptions, constituent concentrations in coal ash are below screening levels developed by the USEPA for residential soils, and are similar in concentration to background U.S. soils. Details of this evaluation are provided in the report titled "Coal Ash Material Safety: A Health Risk-Based Evaluation of USGS

[1] For example, if one takes two aspirin every four hours as directed, aspirin is not toxic. If one takes the entire bottle at once, the aspirin is very toxic.

Coal Ash Data from Five US Power Plants" (AECOM, 2012). The study is available at: http://www.acaa-usa.org/associations/8003/files/ACAA_CoalAshMaterialSafety_June2012.pdf.

Figure A-8 is an updated chart from this study comparing ranges of trace element concentrations in fly ash produced from coal from the Powder River Basin in Wyoming (the same type of coal used at Rush Island Energy Center) to USEPA screening levels, and to background levels in soils in the U.S. The USEPA screening levels for residential soils (USEPA, 2014c) are shown as the green vertical bars, the ranges for the Wyoming coal fly ash are shown in purple on top of the green vertical bars, and the ranges of background levels in U.S. soils are shown in the grey bars. What this figure shows is that all but one of the constituents are present in the Wyoming fly ash at concentrations that are below the USEPA residential soil screening levels; and for cobalt, the concentration range is only marginally above the screening level. As noted in detail in the report itself, the toxicity value upon which the USEPA soil screening level for cobalt is based is two levels of magnitude lower than what has been derived by other regulatory agencies; thus a much higher health protective soil screening level for cobalt exists. What the data also show is that constituent concentrations in coal ash are not that different from concentrations in soils in the U.S.

The results are similar for all of the coal ashes evaluated in the report (AECOM, 2012). The evaluation in the report included not only the simple comparison of constituent concentrations in coal ash to USEPA screening levels, but also provided a detailed cumulative risk screen for each coal ash data set to account for potential additive effects of combined exposures to the trace elements in coal ash. The results confirm the simple screening results, which indicate that no significant risk would be posed by direct exposure to coal ash in a residential setting.

Thus, by considering the levels of trace elements in coal ash in comparison to the background levels in soils in the U.S., and in comparison to the USEPA screening levels for these constituents in residential soil, screening levels that are protective of daily exposure to soils by children and adults, including sensitive subgroups, it is concluded that even daily direct contact to trace elements in coal ash would not pose a significant risk to human health.

A.6 Background Levels in Groundwater

Because these constituents are naturally present in soils and rocks, they are also naturally present in our groundwaters and surface waters. The USGS has published a report titled "Trace Elements and Radon in Groundwater Across the United States" (USGS, 2011b). Just as for soil, it is important to understand that there are background levels of constituents in groundwater. Constituent concentrations in groundwater that is upgradient of a source represent background conditions. To demonstrate a release to groundwater by a source, concentrations downgradient of the source must be greater than the background/upgradient concentrations at a statistically significant level for a consistent period of time.

The same concept applies to surface water. These same constituents are naturally present in surface water due to discharge of groundwater to surface water and the effect of erosion of soil into our surface waters. To demonstrate an effect of a source on surface water, the concentrations downgradient/downstream of the source must be greater than the background/upstream concentrations at a statistically significant level for a consistent period of time.

Constituents in groundwater and surface water can be in a dissolved form, or they can be adhered to or part of a soil or sediment particle. Movement of these particles in groundwater is generally more difficult because of the presence of the soil and rock that the groundwater must move through. Surface water is constantly impacted by erosion of soils, thus in surface water, it is much more common for constituents to be bound to particles rather than dissolved in the water. For this reason, it is important to evaluate both total concentrations of constituents in water (which represents constituents dissolved in the water and as part of a soil or sediment particle) and the dissolved component (by filtering out the soil/sediment particles).

A.7 Toxicity Evaluation for Cobalt and Chromium

A.7.1 Cobalt

Cobalt is the only constituent in the Powder River Basin coal ash (the coal that is used at the Rush Island Energy Center) with concentrations above the USEPA screening level for residential soils. There is much uncertainty associated with the USEPA dose-response value for cobalt, and with the resulting screening level for residential soil. The World Health Organization (WHO) indicates that "there are no suitable data with which to derive a tolerable intake for chronic ingestion of cobalt" (WHO, 2006). Agency for Toxic Substances and Disease Registry (ATSDR, 2004) states that "adequate chronic studies of the oral toxicity of cobalt or cobalt compounds in humans and animals are not presently available." However, using a short-term study in six human volunteers, ATSDR (2004) derived an intermediate-term (15–364 days) minimal risk level (MRL) of 0.05 mg/kg-day. The "adverse" effect was identified as increased red blood cell count, although it is also noted that cobalt is used as a treatment for anemia (low red blood cell count). ATSDR also notes that "Since cobalt is naturally found in the environment, people cannot avoid being exposed to it. However, the relatively low concentrations present do not warrant any immediate steps to reduce exposure." WHO notes that the largest source of exposure to cobalt for the general population is the food supply; the estimated intake from food is 5–40 ug/day, most of which is inorganic cobalt (WHO, 2006). Expressed on a mg/kg-day basis, this is 0.00007–0.0005 mg/kg-day from the diet.

USEPA however has derived a Provisional Peer-Reviewed Toxicity Value (PPRTV) for cobalt of 0.0003 mg/kg-day, this is two orders of magnitude lower than the ATSDR intermediate term MRL, and is higher that most dietary intake estimates. Thus the RSL for cobalt for residential soil is much lower than values derived by other regulatory bodies.

A.7.2 Hexavalent Chromium

The data provided by USGS (2011a) for chromium is for total chromium in the samples; the Ameren data for groundwater and surface water are also based on analysis of total chromium. Many metals can exist in different oxidation states; for some metals, the oxidation state can have different toxicities. This is the case for chromium. Chromium exists in two common oxidation states: trivalent chromium (chromium-3, Cr(III) or Cr+3), and hexavalent chromium (chromium-6, Cr(VI) or Cr+6). Trivalent chromium is essentially nontoxic, as evidenced by its RSL of 120,000 mg/kg. It can be bought over-the-counter as a supplement, and is included in most vitamins. Hexavalent chromium has been concluded to be a human carcinogen by the inhalation route of exposure (USEPA, 2014a).

Currently on USEPA's toxicity database, the Integrated Risk Information System (IRIS) (USEPA, 2014a), the primary source of dose-response information for risk assessment and for the RSL tables, an oral reference dose is available for trivalent chromium, and IRIS provides an inhalation IUR for potential inhalation carcinogenic effects and an oral reference dose and inhalation reference concentration for hexavalent chromium. The oral noncancer dose-response value for hexavalent chromium is based on a study where no adverse effects were reported; thus the target endpoint is identified as "none reported."

Recent studies by the National Toxicology Program (NTP) have shown that when present in high concentrations in drinking water, hexavalent chromium can cause gastrointestinal tract tumors in mice (NTP, 2008). IRIS does not present an oral CSF for hexavalent chromium; a value developed by the New Jersey Department of Environmental Protection (NJDEP, 2009) was used in the development of the RSLs. USEPA developed a draft oral cancer dose-response value for hexavalent chromium, based on the same study and was the same as the NJDEP value. However, it should be noted that USEPA's Science Advisory Board (SAB) provided comments in July 2011 on the draft USEPA derivation of the oral CSF for hexavalent chromium and indicated many reservations with the assumptions of mode of action, and in the derivation itself. The SAB review can be accessed at http://cfpub.epa.gov/ncea/iris_drafts/recordisplay.cfm?deid=221433. Thus, the value used to develop the RSLs for hexavalent chromium has been called into question by USEPA's peer review panel. Currently there is much scientific debate about whether the mode of action of hexavalent chromium in very high concentrations in drinking water is relevant to the low concentrations most likely to be encountered in environmental situations (Proctor, et al., 2012).

Therefore, for this evaluation of chromium in the Powder River Basin coal ash, total chromium is evaluated assuming the total concentration is hexavalent chromium and using RSLs calculated using USEPA's on-line RSL calculator (USEPA, 2014b), based on the primary dose-response values provided in the IRIS database (USEPA, 2014a) for both potential carcinogenic and noncarcinogenic endpoints.

The assumption that all chromium in CCPs is in the hexavalent form is very conservative, and in fact unrealistic. Data for the Alaska Power Plant indicate that hexavalent chromium comprises 0.25% of the total chromium concentration in the combined fly ash/bottom ash material from that facility. Literature data for analyses of CCPs from US coals (total CCPs) indicate that hexavalent chromium can comprise up to 5% of the total chromium (Huggins, et al., 1999); thus over 95% of the total chromium is present in the nontoxic trivalent form. This is consistent with data from USEPA, though there are some single higher results (USEPA, 2009).

A.8 Summary

Constituents present in coal ash are also present in our natural environment, and we are exposed to them every day, in the soils that we contact and the food that we eat. All of these constituents have USEPA-derived risk-based screening levels for residential soils. The constituent concentrations in coal ash from the Powder River Basin, the source of the coal used at the Rush Island Energy Center, are below risk-based screening levels for residential soils (with one exception) and the concentrations are similar to background levels in U.S. soils.

A.9 References

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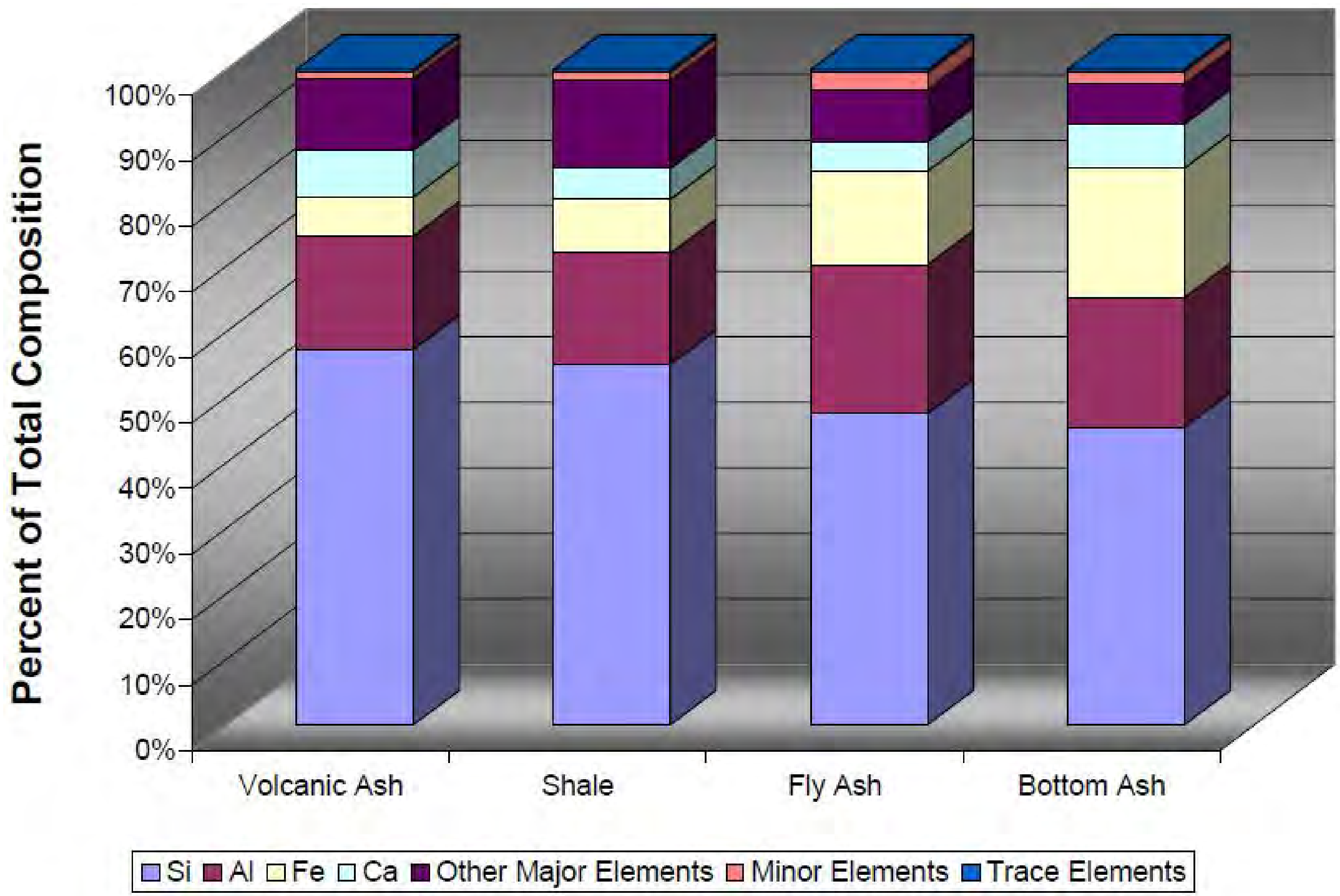
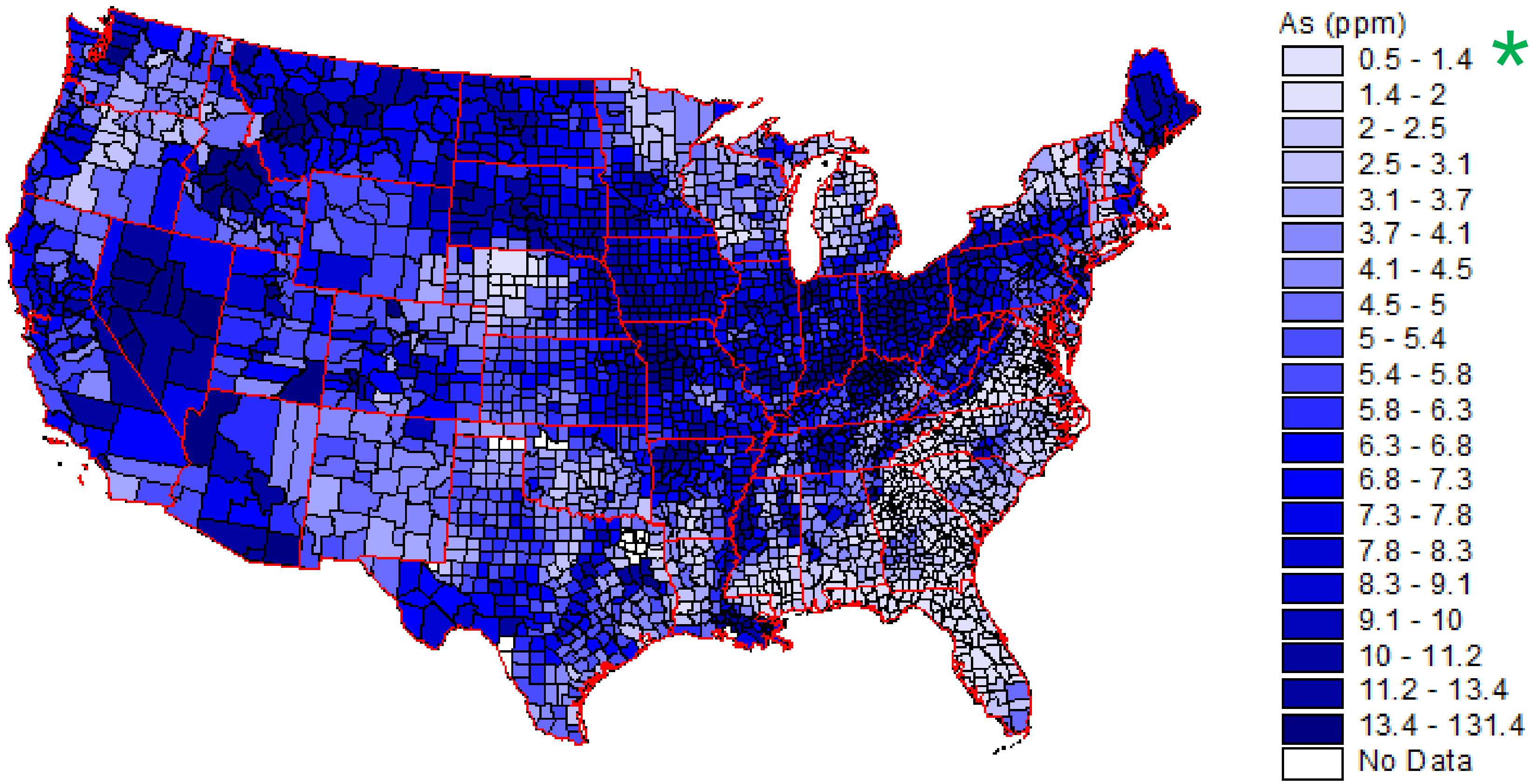
Attachment A – Figures

Figure A-1
Composition of Coal Ash and Other Natural Materials



Source: EPRI. 2010. Comparison of Coal Combustion Products to Other Common Materials – Chemical Characteristics. Report No. 1020556. Available for download at www.epri.com.

Figure A-2
Arsenic is Present in our Natural Environment –
Background Levels in Soils in the U.S.

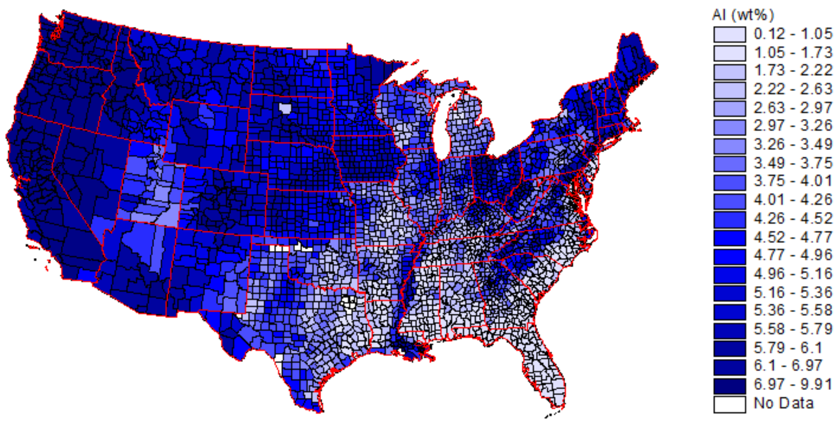


***The USEPA regional screening level for arsenic in residential soil at a one in one million risk level is 0.67 mg/kg. USEPA. 2014c.**
http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/index.htm
Thus the arsenic concentration in the majority of the soils in the U.S. are above the one in one million risk level.

Source: USGS. 2013. National Geochemical Survey. http://mrdata.usgs.gov/geochem/doc/averages/countydata.htm

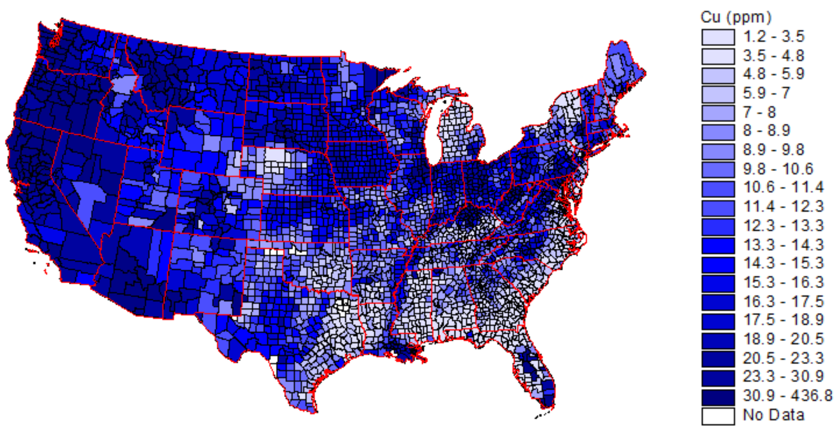
Figure A-3

Aluminum is Present in our Natural Environment –
Background Levels in Soils in the U.S.



Source: USGS. 2013. National Geochemical Survey. http://mrdata.usgs.gov/geochem/doc/averages/countydata.htm

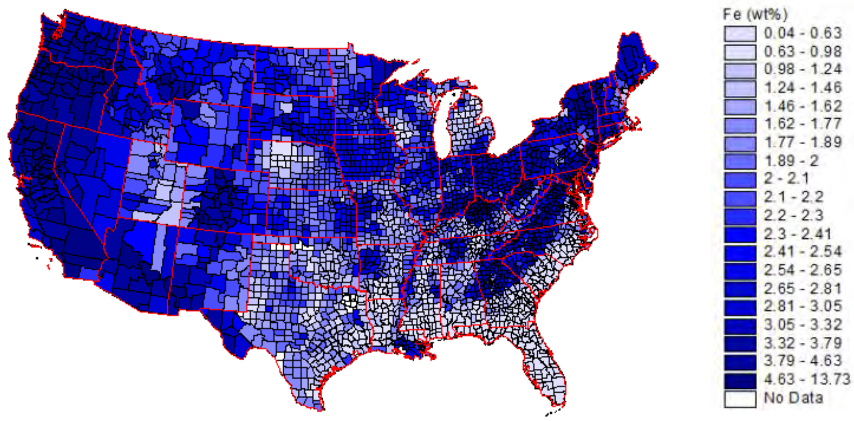
Copper is Present in our Natural Environment –
Background Levels in Soils in the U.S.



Source: USGS. 2013. National Geochemical Survey. http://mrdata.usgs.gov/geochem/doc/averages/countydata.htm

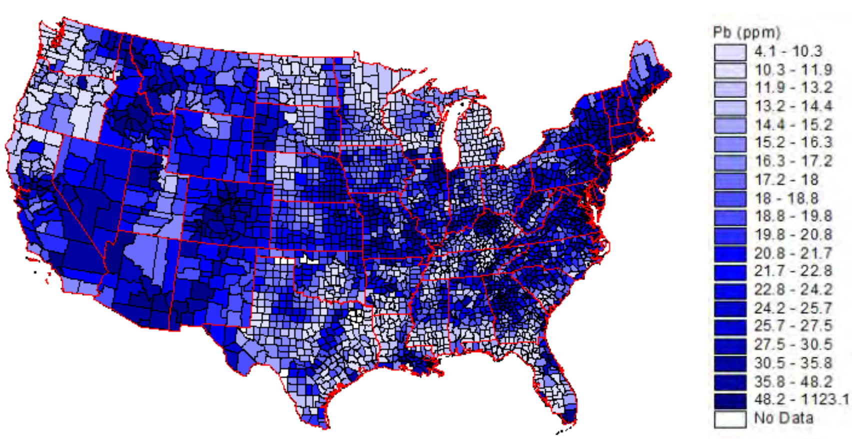
Figure A-4

Iron is present in our natural environment –
Background levels in soils in the U.S.



Source: USGS. 2013. National Geochemical Survey. http://mrdata.usgs.gov/geochem/doc/averages/countydata.htm

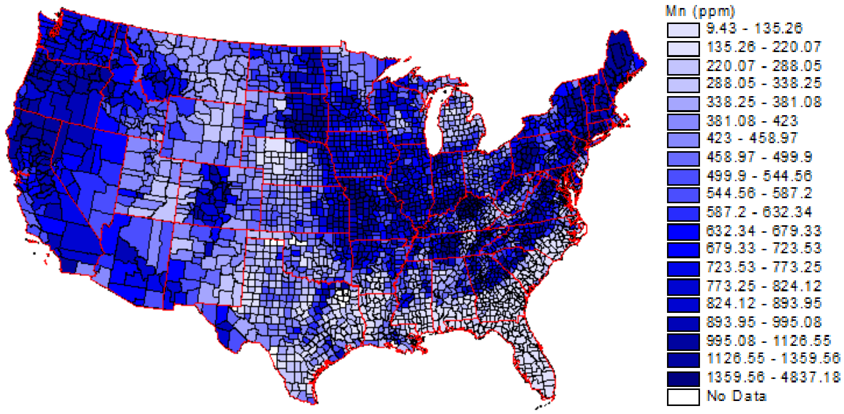
Lead is present in our natural environment –
Background levels in soils in the U.S.



Source: USGS. 2013. National Geochemical Survey. http://mrdata.usgs.gov/geochem/doc/averages/countydata.htm

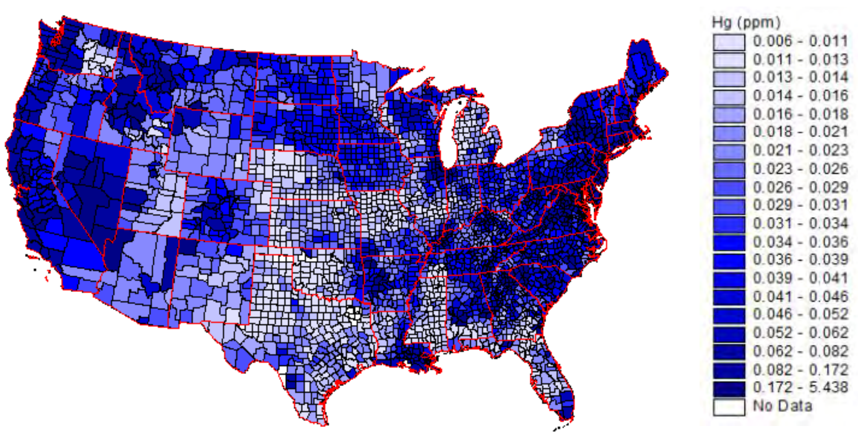
Figure A-5

Manganese is present in our natural environment –
Background levels in soils in the U.S.



Source: USGS. 2013. National Geochemical Survey. http://mrdata.usgs.gov/geochem/doc/averages/countydata.htm

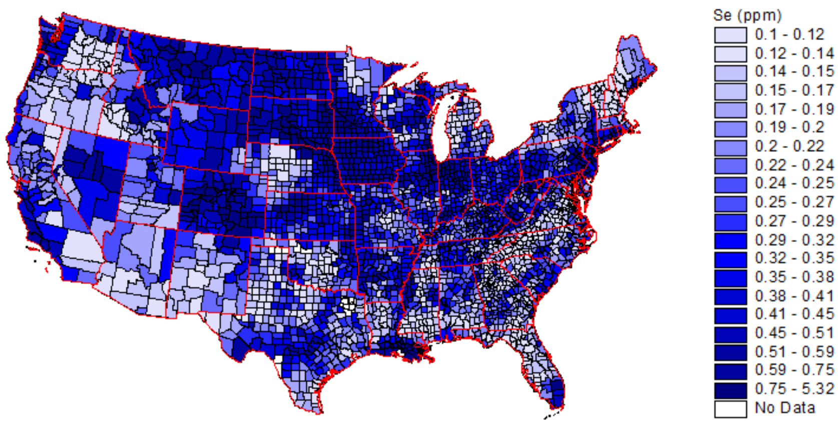
Mercury is present in our natural environment –
Background levels in soils in the U.S.



Source: USGS. 2013. National Geochemical Survey. http://mrdata.usgs.gov/geochem/doc/averages/countydata.htm

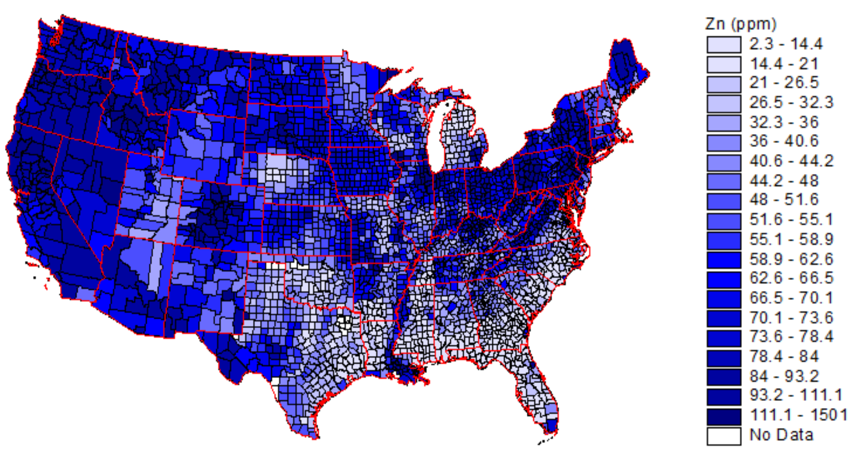
Figure A-6

Selenium is present in our natural environment –
Background levels in soils in the U.S.



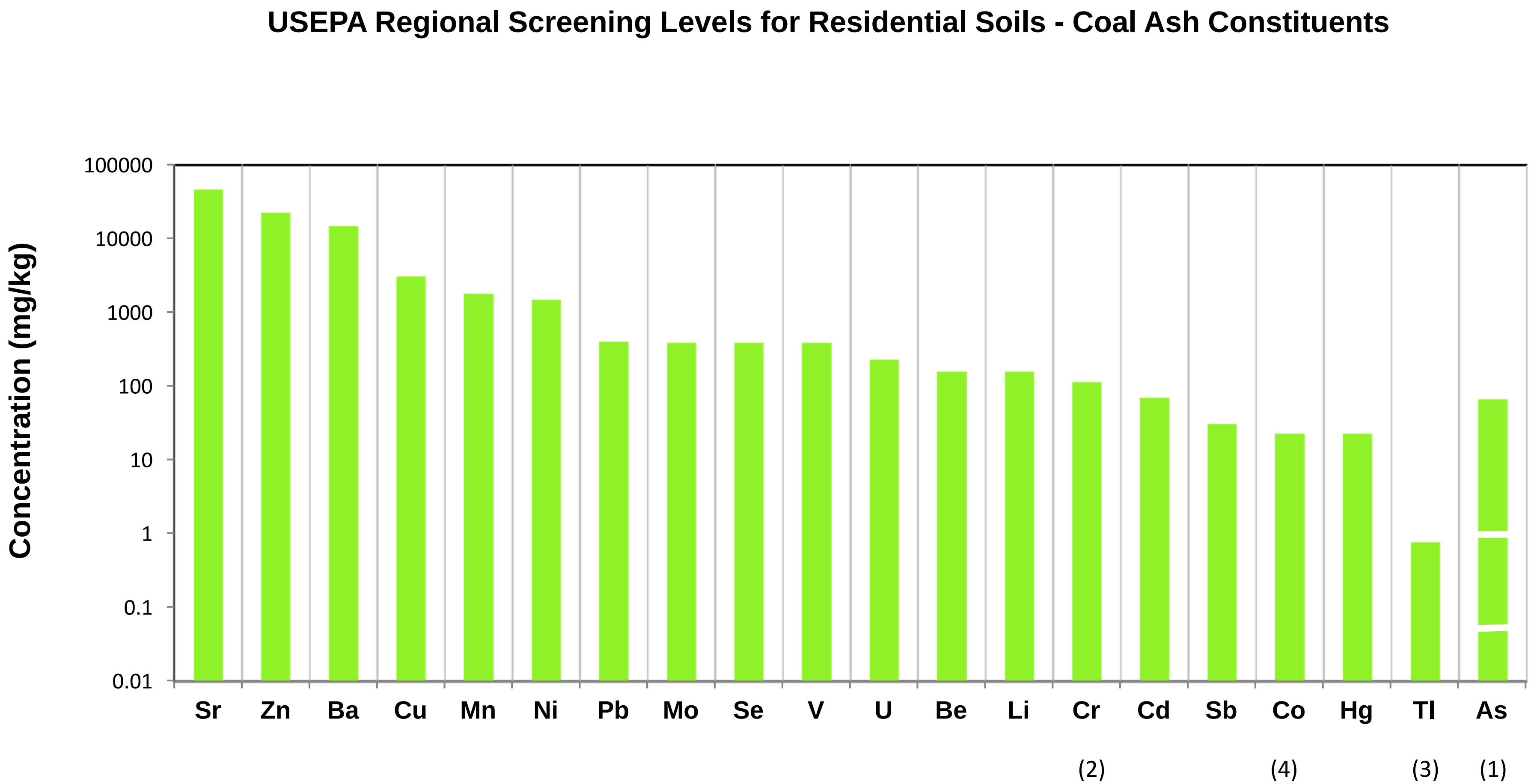
Source: USGS. 2013. National Geochemical Survey. http://mrdata.usgs.gov/geochem/doc/averages/countydata.htm

Zinc is present in our natural environment –
Background levels in soils in the U.S.



Source: USGS. 2013. National Geochemical Survey. http://mrdata.usgs.gov/geochem/doc/averages/countydata.htm

Figure A-7



Top of bar corresponds to the USEPA Regional Screening Level (RSL) - Residential Soil (May 2014)

http://www.epa.gov/region9/superfund//prg/index.html

Notes:

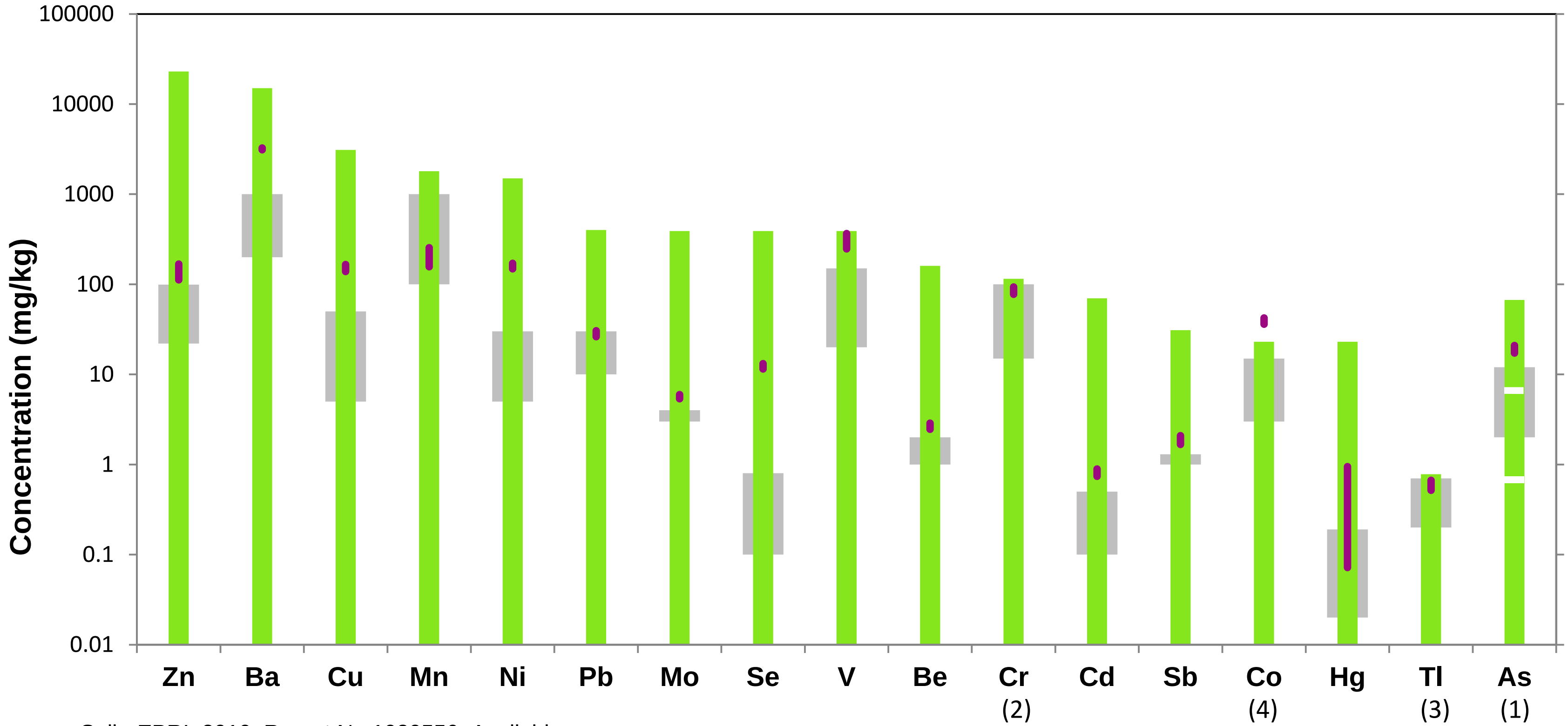
(1) Arsenic RSLs for target risk level of 10^{-4} (top of green bar), 10^{-5} (middle white bar), 10^{-6} (lower white bar.

(2) The screening level shown for chromium is the value calculated using toxicity information for hexavalent chromium currently available on USEPA's IRIS database [http://www.epa.gov/iris/subst/0144.htm]. The screening level for trivalent chromium is 120,000 mg/kg.

(3) The RSL for thallium is identified by USEPA as a "provisional value" of "limited usefulness" that was developed for information purposes although USEPA states "it is inappropriate to derive a provisional subchronic or chronic [toxicity value] for thallium" [http://hhpprtv.ornl.gov/issue_papers/ThalliumandCompounds.pdf]

(4) The RSL for cobalt is based on a provisional dose-response value that is two orders of magnitude lower than values from other regulatory sources, and higher than most dietary intake estimates. Thus, a more realistic RSL could be more than an order of magnitude higher than the value shown here.

Figure A-8 **Comparison of 10th and 90th percentile USGS Database Constituent Concentrations in Fly Ash from the Wyoming Coal Power Plant and Background Levels in US Soils to the USEPA Regional Screening Levels for Residential Soils**



Soil - EPRI, 2010. Report No.1020556. Available for download at www.epri.com.

USEPA Regional Screening Level (RSL) - Residential Soil (May 2014)

http://www.epa.gov/region9/superfund//prg/index.html

Concentration Range (10th - 90th Percentile) in Wyoming Fly Ash; USGS, 2011.

http://pubs.usgs.gov/ds/635/

Notes:
(1) Arsenic RSLs for target risk level of 10^{-4} (top of green bar), 10^{-5} (middle white bar), 10^{-6} (lower white bar).
(2) The screening level shown for chromium is the value calculated using toxicity information for hexavalent chromium currently available on USEPA's IRIS database [http://www.epa.gov/iris/subst/0144.htm]. The screening level for trivalent chromium is 120,000 mg/kg.
(3) The RSL for thallium is identified by USEPA as a "provisional value" of "limited usefulness" that was developed for information purposes although USEPA states "it is inappropriate to derive a provisional subchronic or chronic [toxicity value] for thallium" [http://hhpprtv.ornl.gov/issue_papers/ThalliumandCompounds.pdf]
(4) The RSL for cobalt is based on a provisional dose-response value that is two orders of magnitude lower than values from other regulatory sources, and higher than most dietary intake estimates. Thus, a more realistic RSL could be more than an order of magnitude higher than the value shown here.

ATTACHMENT B

Meramec Energy Center Dilution Factor Calculations

CALCULATIONS

Date: February 8, 2018 | **Made by:** J. Ingram

Project No.: 130-1560 | **Checked by:** E. Kidner

Subject: Meramec Energy Center Dilution Factor Calculations - Mississippi River | **Reviewed by:** M.Haddock

1.0 Introduction

The Mississippi River is a large, flowing water body and daily flow at the Meramec Energy Center (MEC) is estimated to range between 36 and 538 billion gallons per day, depending upon the river stage. In contrast, during low river flow conditions, average daily groundwater flow into the river is a fraction (estimated to be 131.000 gallons or 0.0004%) of the receiving water body. This ratio of flow is referred to as a "dilution factor" and is useful when assessing the relationship between smaller and larger water bodies. Set forth below is a calculation of a dilution factor based on specific criteria and assumptions delineated in Section 1.6.

1.1 Low River Conditions

Date	St. Louis Gauge Height	St. Louis Gauge Elevation	Mississippi River Elevation at St. Louis Gauge	Chester Gauge Height	Chester Gauge Elevation	Mississippi River Elevation at Chester Gauge
Units	**ft above gauge**	**ft MSL**	**ft MSL**	**ft above gauge**	**ft MSL**	**ft MSL**
1/1/2013 12:00	-4.55	379.58	375.03	-1.12	341.05	339.93
1/2/2013 19:00	-4.35	379.58	375.23	-1.28	341.05	339.77

Notes:
1) ft - feet
2) ft MSL - feet above mean sea level
3) Information and Data for the St. Louis gauge available at https://waterdata.usgs.gov/usa/nwis/uv?07010000.
4) Information and Data for the Chester gauge available at https://waterdata.usgs.gov/nwis/uv?site_no=07020500.

Mississippi River Elevation at St. Louis Gauge	Mississippi River Elevation at Chester Gauge	Distance Between St. Louis and Chester Gauges	Calculated Mississippi River Gradient	Distance from St. Louis Gauge to MEC	Estimated Mississippi River Elevation at MEC
ft MSL	**ft MSL**	**River Miles**	**foot/foot**	**River Miles**	**ft MSL**
375.03	339.93	70.1	0.00009	18.5	366

Notes
1) Estimated Mississippi River Elevation at the MEC calculated by subtracting the gradient of the Mississippi River multiplied distance from the St. Louis gauge (in river feet) from the St. Louis gauge.

1.2 Aquifer Discharge Length and Area

Description	Value	Units
Estimated length of discharge zone	4,400	feet
Estimated top of discharge zone (1Q10 river level)	366	feet above mean sea level
Estimated bottom of discharge zone (Bedrock)	310	feet above mean sea level
Estimated thickness of discharge zone (Top - Bottom)	56	feet
Estimated area of discharge zone (length x thickness)	246,400	$feet^2$

1.3 Groundwater Properties

Description	Symbol	Value	Units
Average Hydraulic Conductivity (includes MW-6, MW-7, MW-8	K	31	feet/day
Average Groundwater Gradient (from GMP)	I	0.0023	feet/feet
Effective Porosity (from GMP)	n	35	%
Average linear groundwater velocity (V=KI/n)	*V*	0.2	feet/day

1.4 Groundwater Discharge

Description	*Symbol*	Value	Units
Average linear groundwater velocity	*V*	0.2	feet/day
Estimated Discharge zone area	*A*	246,400	$feet^2$
Effective Porosity (from GMP)	*n*	35	%
Estimated total GW Discharge (Q=V*A*n)	*Q*	17,568	$feet^3$/day

1.5 Mississippi River Flow

Description	*Value*	Units
Estimated low Mississippi River Conditions (1/1/2013)	366	feet MSL
Corresponding STL Discharge (1/1/2013)	56,400	$feet^3$/sec
Seconds per Day	86,400	seconds/day
Estimated low Flow Daily Discharge (Average Discharge * seconds per day)	4,872,960,000	$feet^3$/day

Golder Associates

CALCULATIONS

Date: February 8, 2018 | **Made by:** J. Ingram

Project No.: 130-1560 | **Checked by:** E. Kidner

Subject: Meramec Energy Center Dilution Factor Calculations - Mississippi River | **Reviewed by:** M.Haddock

1.5 Dilution Factor

Description	Values	Units
Estimated Daily Groundwater Discharge	17,568	$feet^3/day$
Estimated Daily Groundwater Discharge	131,420	gallons/day
Estimated Daily River Flow	4,872,960,000	$feet^3/day$
Estimated Daily River Flow	36,452,274,739	gallons/day
Estimated Dilution Factor (River / GW)	**277,372 or >100,000**	Unitless

1.6 List of Conservative Assumptions Used

1) Calculations are based on estimated flow rates under low flow river conditions. As an example, low flow values used for Meramec are from January 1, 2013 which is the lowest value since 1989 and the 9th lowest in recorded history at the St. Louis Mississippi River gauge. Using river flow averages would greatly increase the dilution by an order of magnitude. Mississippi River data is available at http://water.weather.gov/ahps2/hydrograph.php?wfo=lsx&gage=EADM7.

2) To simplify the calculations, the alluvial aquifer was assumed to consist of higher permeability sands, resulting in conservative (higher) estimates of groundwater discharge.

3) The calculations do not take into account any dilution from the alluvial aquifer itself. The river locally recharges the aquifer at varying rates depending on river stage. In addition, on a near continuous basis, groundwater flows from the bedrock aquifer into the shallow alluvial aquifer. All of these sources increase dilution within the alluvial aquifer.

Although these calculations use conservative assumptions which would serve to increase the dilution factor ratio, the calculated value for the dilution factor has been rounded down. This dilution factor ratio represents a worst case scenario and actual dilution factors are likely greater.

CALCULATIONS

Date: February 8, 2018	**Made by:** J. Ingram
Project No.: 130-1560	**Checked by:** E. Kidner
Subject: Meramec Energy Center Dilution Factor Calculations - Meramec River	**Reviewed by:** M. Haddock

1.0 Introduction

The Meramec River is a large, flowing water body and daily flow at the Meramec Energy Center (MEC) is estimated to range between 171 million and 103 billion gallons per day, depending upon the river stage. In contrast, during low river flow conditions, average daily groundwater flow into the river is a fraction (estimated to be 231,000 gallons or 0.13%) of the receiving water body. This ratio of flow is referred to as a "dilution factor" and is useful when assessing the relationship between smaller and larger water bodies. Set forth below is a calculation of a dilution factor based on specific criteria and assumptions delineated in Section 1.6.

1.1 Low River Conditions

Date	Arnold Gauge Height	Arnold Gauge Elevation	Meramec River Elevation at Arnold Gauge	Valley Park Gauge Height	Valley Park Gauge Elevation	Meramec River Elevation at Valley Park Gauge
Units	ft above gauge	ft MSL	ft MSL	ft above gauge	ft MSL	ft MSL
7/28/2012 21:00	5.47	373.21	378.68	-3.88	391.22	387.34

Notes:
1) ft - feet
2) ft MSL - feet above mean sea level
3) Information and Data for the Arnold gauge available at https://waterdata.usgs.gov/nwis/uv?site_no=07019300,
4) Information and Data for the Valley Park gauge available at https://waterdata.usgs.gov/nwis/uv?site_no=07019130,

Meramec River Elevation at Arnold Gauge	Meramec River Elevation at Valley Park Gauge	Distance Between Arnold and Valley Park Gauges	Calculated Meramec River Gradient	Distance from Arnold Gauge to MEC	Estimated Meramec River Elevation at MEC
ft MSL	ft MSL	River Miles	foot/foot	River Miles	ft MSL
378.68	387.34	15.5	0.00011	5.6	376

Notes
1) Estimated Meramec River Elevation at the MEC calculated by subtracting the gradient of the Meramec River multiplied distance from the Arnold gauge (in river feet) from the Arnold gauge.

Date: February 8, 2018 | **Made by:** J. Ingram

Project No.: 130-1560 | **Checked by:** E. Kidner

Subject: Meramec Energy Center Dilution Factor Calculations - Meramec River | **Reviewed by:** M. Haddock

1.2 Alluvial Aquifer Geological Properties

Description	Value	Units
Estimated length of discharge zone	6,200	feet
Estimated top of discharge zone (low river level)	376	feet above mean sea level
Estimated bottom of discharge zone (Bedrock)	310	feet above mean sea level
Estimated thickness of discharge zone (Top - Bottom)	66	feet
Estimated area of discharge zone (length x thickness)	409,200	$feet^2$
Estimated percentage of discharge area that consists of channel deposits (mostly sands and gravels)	34	%
Estimated percentage of discharge area that consists of floodplain deposits (mostly Silty Clay, Silt or Clay)	66	%
Estimated channel deposits discharge area	139,128	$feet^2$
Estimated floodplain deposits discharge area	270,072	$feet^2$

1.3 Groundwater Properties

Description	Symbol	Value	Units
Channel Deposits (Sand, Silty Sand, Gravel)			
Average Hydraulic Conductivity (includes MW-3, MW-4, and MW-5)	K	96	feet/day
Average Groundwater Gradient (from GMP)	I	0.0023	feet/feet
Effective Porosity (from GMP)	n	35	%
Average linear groundwater velocity (V=KI/n)	*V*	0.6	feet/day
Floodplain Deposits (Silt, Clay, Sitly Clay)			
Estimated Average Hydraulic Conductivity (inorganic silts, Geotechdata.info (see below))	K	0.284	feet/day
Average Groundwater Gradient (from GMP)	I	0.0023	feet/feet
Effective Porosity (from GMP)	n	35	%
Average linear groundwater velocity (V=KI/n)	*V*	0.002	feet/day

Hydraulic Conductivity for floodplain deposits based on data for inorganic silts, silty or clayey fine sands, with slight plasticity available at http://www.geotechdata.info/parameter/permeability.html.

1.4 Groundwater Discharge

Description	*Symbol*	Value	Units
Channel Deposits (Sand, Silty Sand, Gravel)			
Average linear groundwater velocity	*V*	0.6	feet/day
Estimated Discharge zone area	*A*	139,128	$feet^2$
Effective Porosity (from GMP)	*n*	35	%
Estimated total GW Discharge (Q=V*A*n)	*Q*	30,719	$feet^3$/day
Floodplain Deposits (Silt, Clay, Sitly Clay)			
Average linear groundwater velocity	*V*	0.002	feet/day
Estimated Discharge zone area	*A*	270,072	$feet^2$
Effective Porosity (from GMP)	*n*	35	%
Estimated total GW Discharge (Q=V*A*n)	*Q*	176	$feet^3$/day

CALCULATIONS

Date: February 8, 2018		**Made by:**	J. Ingram
Project No.: 130-1560		**Checked by:**	E. Kidner
Subject: Meramec Energy Center Dilution Factor Calculations - Meramec River		**Reviewed by:**	M. Haddock

1.4 Meramec River Flow

Description	*Value*	Units
Estimated low Meramec River Conditions (7/28/2012)	376	feet MSL
Corresponding Discharge for Eureka Gauge (7/28/2012)	265	$feet^3$/sec
Seconds per Day	86,400	seconds/day
Estimated low Flow Daily Discharge (Average Discharge * seconds per day)	22,896,000	$feet^3$/day

Nearest upstream gauge with discharge data is the Eureka gauge. No discharge data is available for the Arnold, Fenton, or Valley Park gauges. Information and data for the Eureka gauge is available at https://waterdata.usgs.gov/nwis/uv?site_no=07019000.

1.5 Dilution Factor

Description	Values	Units
Estimated Daily Channel Deposit Groundwater Discharge	30,719	$feet^3$/day
Estimated Daily Floodplain Deposit Groundwater Discharge	176	$feet^3$/day
Estimated Daily Groundwater Discharge	30,896	$feet^3$/day
Estimated Daily Groundwater Discharge	231,117	gallons/day
Estimated Daily River Flow	22,896,000	$feet^3$/day
Estimated Daily River Flow	171,273,986	gallons/day
Estimated Dilution Factor (River / GW)	**741 or >700**	Unitless

1.6 List of Conservative Assumptions Used

1) Calculations are based on estimated flow rates under low flow river conditions. As an example, low flow values used for Meramec are from July 28, 2012 which is the lowest value since 2001 at the Meramec Arnold Gauge. Using river flow averages would greatly increase the dilution by an order of magnitude. Meramec River data is available at http://water.weather.gov/ahps2/hydrograph.php?gage=arnm7&wfo=lsx.
2) The calculations do not take into account any dilution from the alluvial aquifer itself. The river locally recharges the aquifer at varying rates depending on river stage. In addition, on a near continuous basis, groundwater flows from the bedrock aquifer into the shallow alluvial aquifer. All of these sources increase dilution within the alluvial aquifer.
3) The nearest Meramec River gauge with discharge values for July 28, 2012 is the Eureka gauge, which is located approximately 34 river miles upstream. The discharge as the river flows downstream is greater as it approaches the Mississippi River. Additionally, under low Meramec conditions, the Mississippi River can also flow upstream, causing additional dilution of the area near the MEC, which was not accounted for in the calculation.

Although these calculations use conservative assumptions which would serve to increase the dilution factor ratio, the calculated value for the dilution factor has been rounded down. This dilution factor ratio represents a worst case scenario and actual dilution factors are likely greater.