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CORRECTIVE MEASURES ASSESSMENT
AMEREN MISSOURI RUSH ISLAND ENERGY CENTER
JEFFERSON COUNTY, MISSOURI

by
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for
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Overview

This Corrective Measures Assessment (CMA) was prepared by Haley & Aldrich, Inc. (Haley & Aldrich) for Union Electric Company d/b/a Ameren Missouri (Ameren) for the Coal Combustion Residual (CCR) surface impoundment (RCPA) located at the Rush Island Energy Center (RIEC). The RIEC is a coal-fired power plant located along the Mississippi River in Jefferson County, Missouri. The CMA was completed in accordance with requirements stated in the U.S. Environmental Protection Agency's (USEPA) rule entitled *Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals from Electric Utilities*. 80 Fed. Reg. 21302 (Apr. 17, 2015) (promulgating 40 CFR §257.61); 83 Fed. Reg. 36435 (July 30, 2018) (amending 40 CFR §257.61) (CCR Rule).

Ameren implemented groundwater monitoring under the CCR Rule through a phased approach to allow for a graduated response and evaluation of steps to address groundwater quality associated with a CCR unit. Assessment monitoring completed in 2018 evaluated the presence and concentration of constituents in groundwater specified in the CCR Rule (i.e. Appendix IV). Of the 23 CCR parameters evaluated, only two constituents of concern (COC), arsenic and molybdenum, exceed to a very limited extent, the Groundwater Protection Standards (GWPS) established for the RCPA. In fact, as described in ***Section 3.3.1,*** 96% of Appendix IV parameters tested complied with CCR Rule requirements. Arsenic excursions occurred to a limited extent in only three wells.

Ameren completed a detailed environmental evaluation of the RCPA and surrounding area, including voluntary, supplemental surface water sampling and bedrock sampling. Two risk evaluations (conducted in 2014 and 2018), were undertaken to identify whether current groundwater conditions pose an unacceptable risk to human health and the environment, and whether corrective measures mitigate such an unacceptable risk, if present. The risk evaluations concluded that there are **no adverse effects on human health or the environment currently or under reasonably anticipated future uses** from either surface water or groundwater due to CCR management practices at RIEC.

In performing this CMA, Haley & Aldrich considered the following: presence and distribution of arsenic and molybdenum, RCPA configuration, hydrogeologic setting, and the results of the detailed risk evaluation. Within the RCPA, CCR is managed in an impoundment that extends to a depth of approximately 100 feet (ft) below ground surface (bgs). Groundwater within the Mississippi River valley ranges in thickness from not present west of the energy center where bedrock bluffs are present, to greater than 100 feet thick beneath the eastern boundary of the RCPA. Although flow direction is influenced by the elevation of surface water in the Mississippi River, groundwater generally flows west to east beneath the RCPA, towards the Mississippi River.

To provide a comprehensive CMA, this effort included six CCR unit closure and groundwater remediation alternatives, including:

- Alternative 1: Closure in place (CIP) with low permeability capping and monitored natural attenuation (MNA);
- Alternative 2: CIP with in-situ stabilization (ISS), low permeability capping and MNA;
- Alternative 3: CIP with low permeability capping and in-situ groundwater treatment;
- Alternative 4: CIP with low permeability capping, hydraulic containment (HC) of groundwater, and ex-situ groundwater treatment;

- Alternative 5: CIP with low permeability capping, HC of groundwater, ex-situ groundwater treatment, and subsurface barrier wall; and
- Alternative 6: Closure by removal (CBR) with MNA.

These six alternatives were evaluated based on the threshold criteria provided in the CCR rule and then compared to three of the four balancing criteria stated in the CCR Rule. The four balancing criteria consider:

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;
2. The effectiveness of the remedy in controlling the source to reduce further releases;
3. The ease or difficulty of implementing a potential remedy; and
4. The degree to which community concerns are addressed by a potential remedy.

Balancing criteria four, which considers community concerns, will be evaluated following a public information session scheduled for May 2019.

The following observations are made regarding closure scenarios and groundwater remedial alternatives for the RCPA and are described more fully in this report:

- **Cap Integrity and Hydrogeologic Conditions:** For all CIP alternatives, Ameren intends to install a synthetic cap and cover system that exceeds by two orders-of-magnitude the performance criteria set forth in the CCR Rule and is referred to in this CMA as a "low permeability cap." Vertical infiltration via precipitation is virtually eliminated following installation of the synthetic cap system. Modelling predicts that post-closure, 94% of groundwater travels horizontally around the CCR unit via a preferential pathway in the surrounding soils.

- **No Risk:** Risk assessment evaluations confirm that the RCPA, even prior to closure, presents **no unacceptable risk** to human health or the environment. In fact, concentration levels of arsenic and molybdenum would need to be **more than 50 and more than 10,000 times higher**, respectively, than currently measured levels before an adverse impact in the Mississippi River could occur. Therefore, since no adverse risk currently exists, implementation of any of the remedies considered will not result in a meaningful reduction in risk.

- **Groundwater Compliance**: Post-closure, and due to current geochemical conditions, arsenic and molybdenum concentrations are predicted to reduce below GWPS in eight and fourteen years, respectively. Based on laboratory testing, such timeframes could accelerate to four to ten years following in-situ treatment. See **Figures 4-2, 4-3.** Ameren has retained XDD Environmental (XDD), to evaluate and develop groundwater treatment methods to address both arsenic and molybdenum.

- **Excavation Timeframe:** As described in an Extraction & Transportation Study prepared by the Lochmueller Group, the excavation of, transportation to, and disposal of ponded ash at an off-site commercial landfill would require approximately 28 to 34 years to complete. As detailed in the report, there is simply a limit to how much material can be excavated and hauled away during a work day. See **Appendix C.** In addition, implementation of Alternative 6, CBR, would require the impoundment to remain open for decades while impacts to the community –through increased truck traffic and associated hazards – could increase dramatically.

- **Groundwater Treatment:** Laboratory testing performed by XDD has resulted in arsenic concentration decreases ranging from between 30 to 85% once pH levels within the groundwater are modified. Bench-scale testing and in-situ treatment evaluations for arsenic and molybdenum will be completed later this summer.

In accordance with §257.98, Ameren will implement a groundwater monitoring program to document the effectiveness of the selected remedial alternative. Corrective measures are considered complete when monitoring reflects groundwater downgradient of the RCPA has fallen to below Appendix IV GWPS for three consecutive years. USEPA is in the process of modifying certain CCR Rule requirements and, depending upon the nature of such changes, assessments made herein could be modified or supplemented to reflect such future regulatory revisions. See *Federal Register (March 15, 2018; 83 FR 11584*).

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List of Acronyms and Abbreviations

Ameren	Ameren Missouri
AMSL	Above Mean Sea Level
bgs	Below Ground Surface
CBR	Closure by Removal
CCR	Coal Combustion Residuals
CIP	Closure In-Place
CMA	Corrective Measures Assessment
cm/sec	Centimeters per Second
COC	Constituents of Concern
CSM	Conceptual Site Model
DSI	Detailed Site Investigation
ft	Feet
Golder	Golder Associates Inc.
GMP	Groundwater Monitoring Plan
GWPS	Groundwater Protection Standards
Haley & Aldrich	Haley & Aldrich, Inc.
HC	Hydraulic Containment
ISS	In-Situ Stabilization
Lochmueller	Lochmueller Group
MM	Million
MM CY	Million Cubic Yards
MCL	Maximum Contaminant Level
mg/kg	Milligrams per kilogram
mg/l	Milligrams per liter
MNA	Monitored Natural Attenuation
N&E	Nature and Extent
NAS	U.S. National Academy of Sciences
O&M	Operations and Maintenance
ORP	Oxidation Reduction Potential
ppm	Parts per Million
PRB	Permeable Reactive Barrier
RCPA	Rush Island Surface Impoundment
RDA	Recommended Daily Allowance
RIEC	Rush Island Energy Center
RO	Reverse Osmosis
SSI	Statistically Significant Increase
SSL	Statistically Significant Level
ug/L	Micrograms per liter
UL	Tolerable Upper Limit
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
XDD	XDD Environmental
ZVI	Zero Valent Iron

1. Introduction

Haley & Aldrich, Inc. (Haley & Aldrich) has prepared this Corrective Measures Assessment (CMA) for the Coal Combustion Residual (CCR) surface impoundment (RCPA) located at the Ameren Missouri (Ameren) Rush Island Energy Center (RIEC) located in Festus, Missouri. Ameren has conducted detailed geologic and hydrogeologic investigations under Missouri's utility and solid waste landfill requirements as well as the USEPA rule entitled *Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals from Electric Utilities*. 80 Fed. Reg. 21302 (Apr. 17, 2015) (promulgating 40 CFR §257.61); 83 Fed. Reg. 36435 (July 30, 2018) (amending 40 CFR §257.61) (CCR Rule). These investigations were, in part, related to determination of requirements related to the potential for both RCPA closure and groundwater corrective action.


Rush Island Energy Center

This CMA includes a summary of the results of groundwater and site investigations at the RIEC. Groundwater impacted by the RCPA exceeds statistically-derived GWPS for only two constituents: arsenic and molybdenum at only three monitoring locations. Of these parameters, USEPA has developed drinking water standards only for arsenic. This report evaluates potential corrective measures to address these limited exceedances of the GWPS.

1.1 FACILITY DESCRIPTION/BACKGROUND

The RIEC property encompasses approximately 960-acres and manages CCR in an on-site surface impoundment located in the south-southeast portion of the Site (**Figure 1-1**). The RCPA was constructed in the mid-1970s, concurrent with development of the RIEC Site. Native soil from designated borrow areas and shallow excavations at the Site were used to build the earthen berms that encircle the RCPA. The surface impoundment was constructed by excavating alluvial deposits, which were used as fill material for the power block footprint and construction of related power plant structures.

Historically, RIEC utilized the RCPA to actively manage approximately 65,000+/- tons of bottom ash and 150,000+/- tons of fly ash produced annually. Active wet sluicing of CCR to the RCPA terminated in 2018 following the facility's conversion to dry ash handling. All standing surface waters will be drained from the pond by June 2019, as required by the facility's Missouri Water Operating Permit. The estimated volume of CCR currently within the limits of the RCPA is approximately 12.7 million cubic yards (MM CY).

1.2 SITE CHARACTERIZATION WORK SUMMARY

Extensive subsurface investigations have occurred pursuant to Missouri's utility and solid waste landfill requirements as well as the CCR Rule. A Detailed Site Investigation (DSI) Report prepared by Natural Resource Technology in September 2015 delineated the site-specific geology and hydrogeology to support the development of a hydrogeologic Conceptual Site Model (CSM). The DSI also incorporated the findings of various historical investigation activities at the RIEC including:

- Soil borings and sampling;
- Geotechnical testing;
- Rock coring;
- Downhole geophysics;
- Packer testing;
- Well and piezometer installation;
- Slug testing;
- Groundwater sampling; and
- Borehole abandonment.

The CSM has been further enhanced with ongoing CCR groundwater monitoring and supplemental subsurface investigation activities performed by Golder Associates Inc. (Golder). Findings from these extensive and updated series of geologic, geotechnical, and hydrogeologic investigations (over a period of the last 15 years) have produced a robust CSM that supports the CMA activities discussed in this report.

1.3 GROUNDWATER MONITORING

Groundwater monitoring under the CCR Rule occurs through a phased approach to allow for a graduated response (i.e., baseline, detection, and assessment monitoring as applicable) and evaluation of steps to address groundwater quality associated with a CCR unit. Golder prepared a Groundwater Monitoring Plan (GMP) as required by the CCR Rule. The GMP presents the design of the groundwater monitoring system, groundwater sampling and analysis procedures, and groundwater statistical analysis methods.

CCR Rule Monitoring Constituents			
Appendix III	Boron	Appendix IV	Antimony
	Calcium		Arsenic
	Chloride		Barium
	Fluoride		Beryllium
	Sulfate		Cadmium
	pH		Chromium
	Tot. Dissolved Solids		Cobalt
			Fluoride
			Lead
			Lithium
			Mercury
			Molybdenum
			Selenium
			Thallium
			Radium 226 & 228

Monitoring wells were installed in October and November 2015 to support compliance with the CCR Rule (see insert plan map showing CCR well locations for the RCPA). The CCR groundwater monitoring network includes two background wells (MW-B1 and MW-B2) in areas unaffected by the CCR unit and seven downgradient monitoring wells (MW-1 through MW-7) located around the perimeter of the RCPA. In general, the monitoring wells are screened in the alluvial aquifer zone near the base elevation of the RCPA.

Detection monitoring sampling events occurred in 2017 and 2018. The results of the sampling events were then compared to background, or natural groundwater values, using statistical methods to determine if Appendix III constituents at the base of the ash basin are present at concentrations above background, called statistically significant increases (SSI). Detection of Appendix III analytes triggered a verification sampling event in January 2018 and verified SSIs. The results of this analysis indicated SSIs necessitating the establishment of an Assessment Monitoring Program and respective notification of the same.

During the Assessment Monitoring phase, CCR groundwater monitoring well samples were collected during April, May and November 2018 and subsequently analyzed for Appendix IV constituents. Appendix IV analytical results for the baseline and Assessment Monitoring events are summarized in **Table I**.

Groundwater Monitoring Well Locations
Image from Figure 2, Groundwater Monitoring Plan (Golder 2017)

1.4 CORRECTIVE MEASURES ASSESSMENT PROCESS

The CMA process involves development of groundwater remediation technologies that will result in the following threshold criteria: protection of human health and the environment, attainment of GWPS, source control, COC removal and compliance with standards for waste management. Once these technologies are demonstrated to meet these criteria, they are then compared to one another with respect to long- and short-term effectiveness, source control, and implementability. Input from the community on such proposed measures will occur as part of a public meeting scheduled for May 2019.

1.5 RISK REDUCTION AND REMEDY

The CCR Rule at §257.97 (Selection of Remedy) at (b)(1) requires that remedies must be protective of human health and the environment. Further, at (c) the CCR Rule requires that in selecting a remedy, the owner or operator of the CCR unit shall consider specific evaluation factors, including the risk reduction achieved by each of the proposed corrective measures. Each of the evaluation factors listed here and discussed in **Section 4** are those that consider risk to human health or the environment.

(1)(i) Magnitude of reduction of existing risks;

(1)(ii) Magnitude of residual risks in terms of likelihood of further releases due to CCR remaining following implementation of a remedy;

(1)(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;

(1)(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;

(4) Potential risks to human health and the environment from exposure to contamination prior to completion of the remedy[1];

(5)(i) Current and future uses of the aquifer;

(5)(ii) Proximity and withdrawal rate of users; and

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

[1] Factors 4 and 5 are not part of the CMA evaluation process as described in §257.97(d)(4), §257.97(d)(5)(i)(ii)(iv); rather they are factors the owner or operator must consider as part of the schedule for remedy implementation.

2. Groundwater Conceptual Site Model

To evaluate the magnitude of risk reduction, the degree of existing risk must first be identified. Prior risk evaluations and data collected are summarized below.

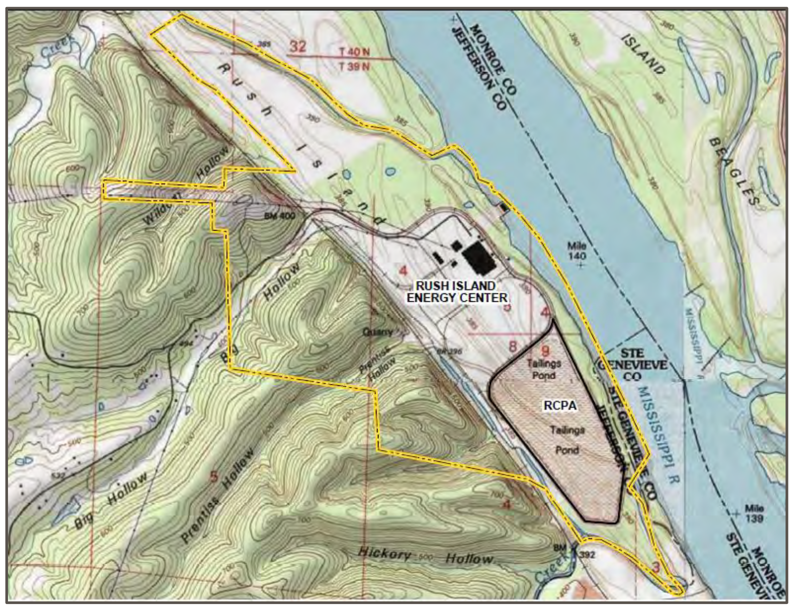
2.1 SITE SETTING

The RIEC Site is located in Jefferson County and adjacent to the Mississippi River. The area around the facility is sparsely populated with residential homes located in the bluffs area located to the west and an industrial facility located to the south. Residences within the bluffs area draw water from private supply wells drilled deep into the bedrock aquifer.

A contiguous strip of forested area runs between the RCPA and the Mississippi River, which can be inundated during high river water levels. The Isle du Bois Creek is located approximately 100 ft from the southern toe of the RCPA perimeter dike. The western side of the Site is bounded by a small drainage creek that is approximately 100 to 300 ft west of the RCPA.

2.2 SITE TOPOGRAPHY

Ground surface elevation increases from roughly 385 ft above mean sea level (AMSL) along bottomlands at the river's edge to approximately 410 ft AMSL along embankments above the river, including the impoundment perimeter berms, railroad embankments, and the platform on which the power plant was constructed. The site is bounded to the west by bedrock bluffs that rise some 300-ft above the elevation of the site. The intermittent streams and creeks that cut valleys in the bluffs enter the floodplain through water gaps eroded in the bedrock hills at elevations 390 to 400 ft AMSL.



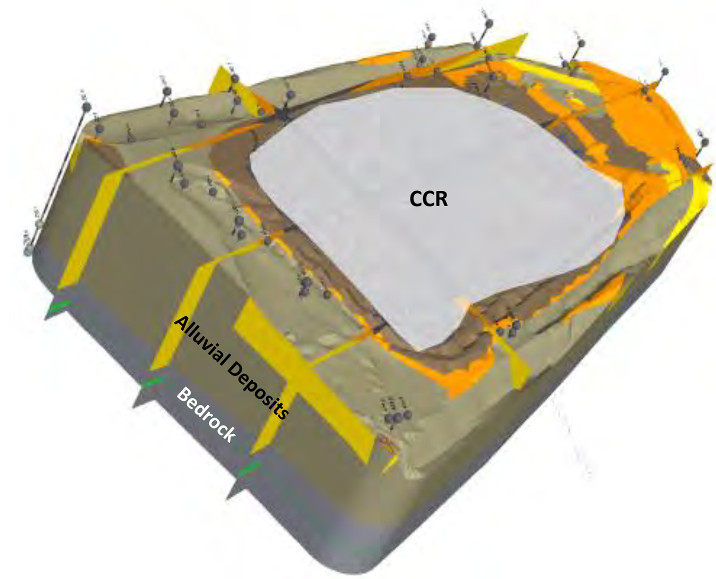
Topographic Map

2.3 GEOLOGY AND HYDROGEOLOGY

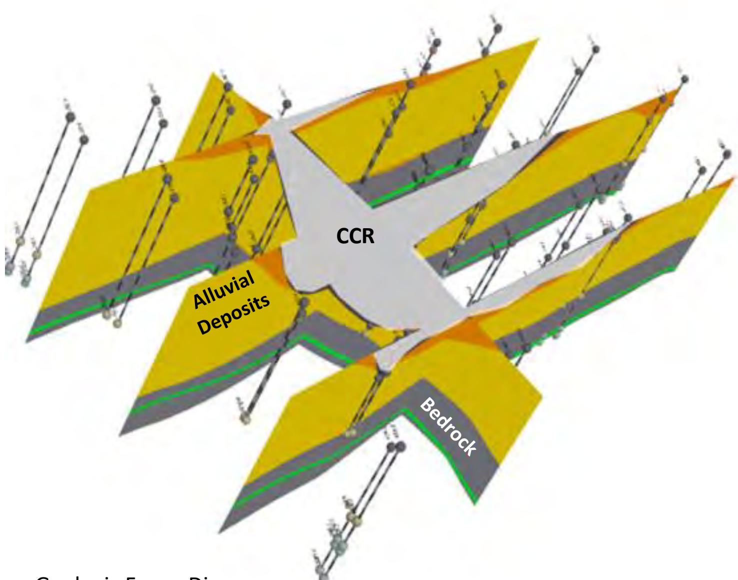
The geology immediately surrounding the Site is comprised of two distinctly different geological terrains; (1) alluvial deposits and (2) sedimentary bedrock formations. Most of the Site, including all the power plant infrastructure and the RCPA, lies within the Mississippi River Valley on floodplain and alluvial soil deposits.

The alluvial deposits are typically comprised of sands and gravels with lesser amounts of silts and clays, with an overall fining upward sequence. The depth of the alluvial deposits near the RCPA ranges from approximately 50 to 150 ft+/- bgs, approximately 255 to 330+/- ft AMSL.

The alluvial deposits are underlain by bedrock within the lower part of the Ordovician-aged Plattin group. This bedrock unit is comprised of massive, gray to brown, micritic, fossiliferous limestone with shale interbeds. The depth to bedrock typically increases towards the Mississippi River and bedrock beneath the RCPA dips towards the east-northeast. The Plattin group is stratigraphically underlain by the Joachim Dolomite. The higher portions of the bluffs to the west of the Site are comprised of Mississippian-age limestone and shales, which are exposed along the eastern portions of the bluffs.



Generalized 3-Dimensional Model of Geologic Conditions



Geologic Fence Diagram

The alluvial aquifer is the primary water-bearing unit at the RIEC. The bottom of this aquifer is defined by the presence of low hydraulic conductivity bedrock. Across the Site, the alluvial aquifer extends to depths of up to 150 ft bgs. Historically, ponded water levels in the surface impoundment above created a localized "mounding" effect inside the footprint of the RCPA, resulting in radial groundwater flow both downward (vertically) and outward (horizontally) from the RCPA.

Horizontal hydraulic gradients in the alluvial aquifer are typically low and flat and are dependent on river water levels. Groundwater flow direction and hydraulic gradient were estimated for the downgradient CCR monitoring wells using the USEPA's On-line Tool for Site Assessment Calculation for Hydraulic Gradient (Magnitude and Direction) (USEPA, 2016). Horizontal gradients calculated by the program ranged from 0.0001 to 0.0015 ft/ft with an estimated net annual groundwater velocity of approximately 34 ft per year under current conditions[2].

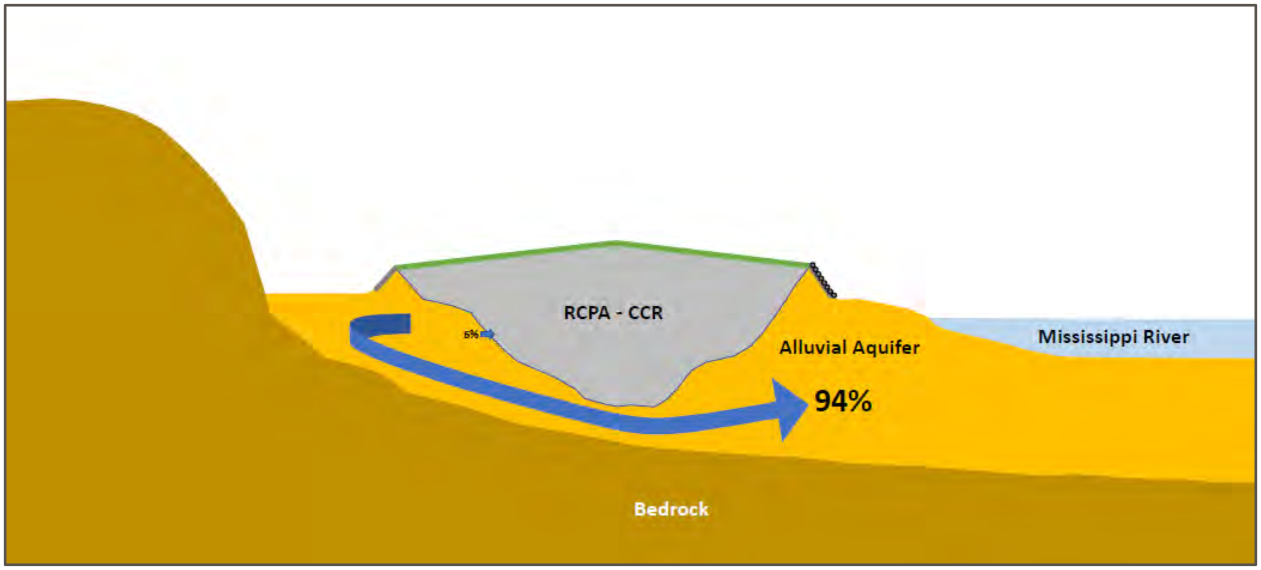
Vertical hydraulic gradients reflect low downward gradients, with groundwater elevations between the shallow and intermediate/deep groundwater monitoring zones typically differing less than 0.01 ft. This illustrates that the shallow and deeper zones are interconnected, however, the majority of groundwater flow in the alluvium is lateral/horizontal.

Groundwater Flow Map-November 1, 2018
Image from Figure C3, 2018 Annual Groundwater Monitoring and Corrective Action Report (Golder 2019)

Groundwater flow modeling completed by Golder evaluated the flux of groundwater passing through the CCR, following closure and dewatering of the RCPA. As shown in the figure on the following page, the model results indicated 94% of groundwater moving laterally through the alluvial aquifer preferentially flows under (and around) the RCPA, due to the notably lower horizontal hydraulic conductivity of the CCR.

[2] 2018 Annual Groundwater Monitoring and Corrective Action Report, RCPA Surface Impoundment, RIEC, Jefferson County, Missouri (Golder 2019)

Groundwater Preferentially Flows Under/Around the RCPA



Mississippi River levels typically rise from low water conditions in fall and winter to seasonal high-water levels in spring and summer. Mississippi River levels in excess of 385 ft AMSL will reach ground surface at the base of the RCPA perimeter berms. The drainage swale on the west side of the Site (formerly the course of Saline Creek) captures runoff from intermittent streams that drain Prentiss Hollow and Big Hollow and directs surface water south to Isle du Bois Creek. Surface water flow in the swale is intermittent. Mississippi River elevations above 380 ft AMSL will begin to flood the mouth of Isle du Bois Creek and the swale. Flow reversals in Isle du Bois Creek and the west swale are common, and the swale is often slow to recede after a flooding event. Under normal aquifer conditions, groundwater flow in the aquifer is eastward toward the Mississippi River.

2.4 GROUNDWATER PROTECTION STANDARDS

Golder completed a statistical evaluation of groundwater samples using the methods and procedures outlined in the Groundwater Monitoring Plan's *Statistical Analysis Plan* (Golder 2017) to develop site-specific GWPS for each Appendix IV constituents.

Groundwater results were compared to the site-specific GWPS. As shown on **Figure 2-1,** statistically significant levels (SSL) above the GWPS are limited to three monitoring wells (MW-2, MW-3, and MW-7) for arsenic and molybdenum only.

Parameter	Site GWPS	Units
Antimony	6	µg/L
Arsenic	30	µg/L
Barium	2000	µg/L
Beryllium	4	µg/L
Cadmium	5	µg/L
Chromium	100	µg/L
Cobalt	6	µg/L
Fluoride	4	mg/l
Lead	15	µg/L
Lithium	64.7	µg/L
Mercury	2	µg/L
Molybdenum	100	µg/L
Radium 226+228	5	pCi/L
Selenium	50	µg/L
Thallium	2	µg/L

Groundwater Protection Standards
ug/L – micrograms per liter
mg/l – milligrams per liter
pCi/L – picoCuries per liter

2.5 NATURE AND EXTENT OF GROUNDWATER IMPACTS

Ameren initiated a nature and extent (N&E) investigation as required by the CCR Rule in 2018 by evaluating existing piezometers and monitoring wells (N&E wells) that previously installed near the RCPA (**Figure 2-2**). The N&E wells are screened in three different, generalized zones of the alluvial aquifer: shallow zone, middle/intermediate zone, and deep zone. Well screen lengths range from 5 to 20 ft long and total depths range from approximately 25 to 143 ft bgs.

Analytical results from the N&E wells indicate that arsenic concentrations are limited in their extent and diminish at depth in the alluvial aquifer. Arsenic concentrations from the N&E wells are similar to Assessment Monitoring results in the shallow to intermediate depths and decrease to less than the GWPS and the Maximum Contaminant Level (MCL) in the deep alluvial aquifer well groundwater samples.

Results from the N&E wells indicate that molybdenum concentrations in the alluvial aquifer are also limited in areal extent and are below the GWPS along the west and south side of the RCPA, with similar concentrations to Assessment Monitoring results along the northern and eastern sides of the basin. Concentrations of molybdenum are highest in the intermediate and deep alluvial aquifer well groundwater samples.

The extent of the arsenic and molybdenum concentrations are limited to the alluvial aquifer and do not extend into the bedrock beneath and adjacent to the RCPA or to off-site bedrock wells installed previously by Ameren. Results from the N&E wells were used to develop corrective measures alternatives.

2.6 SURFACE WATER SAMPLING

The limited elevated levels of arsenic or molybdenum have not adversely impacted surface waters. Prior to the CCR Rule, Ameren voluntarily collected samples of surface water from the Mississippi River and Isle du Bois Creek to evaluate whether ash management operations at the RIEC have impacted these the two adjacent surface water bodies.

Golder collected surface water samples from six locations in the Mississippi River in April 2014 and 12 locations in May 2018. At each sample location, samples were collected near the surface of the river. Where the depth of water was greater than four feet, a second sample was collected mid-depth in the river. Surface water samples were also collected by Golder from nine locations in Isle du Bois Creek in April 2014 and May 2018. These locations are shown on **Figure 2-3**.

Samples were analyzed for the same Appendix III and Appendix IV constituents listed in **Section 1.3**, with the exception of radium (all CCR monitoring well data are below the GWPS for radium). There are no analytical results for the Mississippi River that are above drinking water screening levels[3].

Sample results were also compared to human health and ecological risk-based screening levels. The screening levels and comparison of the surface water results to the screening levels are provided in **Appendix A** and are more fully explained in **Section 3**.

[3] Similarly, while arsenic concentrations in the river are slightly above the human health recreational screening levels, the concentrations are statistically **no different** in upstream and downstream samples indicating that the facility is not the source of the arsenic detected in the river. The data for Isle du Bois Creek are similar.

In summary, the results of this investigation demonstrate that the Mississippi River and Isle du Bois Creek sampling do not show evidence of impact of constituents derived from the RCPA.

2.7 BEDROCK GROUNDWATER INVESTIGATION

To address potential community concerns, Ameren installed an off-site well network to evaluate water quality within the bedrock aquifer and confirm groundwater flow direction. In 2014, Golder installed three monitoring wells (TBM-1 through TBM-3) with screened intervals in bedrock at similar depths to residential water wells closest to the RIEC property boundary (west of the RIEC). **Figure 2-4** shows the locations of the bedrock monitoring wells and residential water wells within a one-mile radius of the RIEC along with an illustration of the groundwater flow. Based on the groundwater measurements, the groundwater flow in this area demonstrates that residential wells are located upgradient of the RCPA and thus cannot be impacted by the RCPA. In fact, sampling results indicated that the bedrock groundwater upon which residents rely fully complies with federal and state drinking water standards. Furthermore, the bedrock aquifer underlying the alluvial aquifer at the RIEC has not been impacted by CCR.

3. Risk Assessment and Exposure Evaluation

As described in this report, Ameren has conducted detailed environmental evaluations of the RIEC and its environs. These investigations have been detailed in two risk evaluation reports available to the public on the Ameren website:

- August 2014: Groundwater and Surface Water Data Demonstrate No Off-Site Impact from Rush Island Energy Center. Available at: https://www.ameren.com/-/media/corporate-site/files/environment/reports/rushislandreport.ashx?la=en&hash=B0C49A936DE7E3119F6FAD36EDF9F26287EFEE9F
- February 2018: Human Health and Ecological Assessment of the Rush Island Energy Center. Available at: https://www.ameren.com/-/media/corporate-site/files/environment/ccr-rule/2017/groundwater-monitoring/rush-island-haley-aldrich-report.ashx?la=en&hash=B27EDADC095FE0E08073B8158F50EB8B97019D8A

The purpose of these risk evaluations were to identify whether current groundwater conditions pose a risk to human health and the environment and, if so, whether the corrective measures identified in this report mitigate such risk.

3.1 APPROACH

The risk evaluation provided in the 2014 and 2018 risk assessment reports evaluated the environmental setting of the RIEC, which has been in operation for over 40 years, including its location and ash management operations at the facility. Golder provided information on groundwater location and direction, the rate(s) of groundwater flow, and where waterbodies may intercept groundwater flow.

A conceptual model was then developed based on this physical setting information and 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 locations where ecological populations could come into contact with surface water. Based on this conceptual model approach, Ameren's environmental consultants and risk assessors identified sampling locations to evaluate potential impact to the environment. Sampling results were then evaluated, as appropriate, on both a human health and 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 (USEPA, 1989): (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 protective of specific human exposures. These screening levels are referred to as "Regional Screening Levels" and are published by USEPA and updated twice yearly (USEPA, 2018a). 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 sources. The screening levels are used to determine if the concentration levels of constituents could pose an unacceptable 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.

3.2 CONCEPTUAL SITE MODEL

There are no on-site users of alluvial groundwater adjacent to the RCPA. As documented in the 2014 and 2018 risk assessment reports, there are approximately 16 private wells recorded within a one-mile radius of the facility, and all are located west and upgradient of the facility. There are **no users** of groundwater impacted by molybdenum, arsenic or any other CCR constituent in the vicinity of the RIEC ash management area and sampling results from the off-site network demonstrate that bedrock groundwater fully complies with federal and state drinking water standards.

3.3 RESULTS

3.3.1 Alluvial Aquifer

A summary of the screening results is presented in the table below:

Table: Assessment Monitoring Reflects High Percentage Compliance

	Rush Island Energy Center RCPA – Shallow Alluvial Aquifer
Percent of Assessment Monitoring Parameter Compliance	96%
Percent of Assessment Monitoring Parameter Results Requiring Corrective Action (Constituents)	4% Molybdenum Arsenic

The striking aspect of the analysis is how few CCR monitoring well results are above a conservative GWPS based on MCLs, health-based GWPS, or background levels, given that the wells are located directly adjacent to and at the base of the ash management area, and the facility has been in operation for over 40 years. Note that out of the 1773 groundwater analyses conducted for the RCPA, only 71 results are above the GWPS. Put another way, approximately 96% of the groundwater results for the CCR Rule monitoring wells located at the edge of the RCPA are below the GWPS.

3.3.2 Surface Water

There are no analytical results for the Mississippi River that are above drinking water screening levels. Similarly, while arsenic concentrations in the river are slightly above the human health recreational screening levels, the concentrations are statistically **no different** in upstream and downstream samples indicating that the facility is not the source of the arsenic detected in the river. The data for Isle du Bois Creek are similar.

Thus, the Mississippi River and Isle du Bois Creek sampling results do not show evidence of impact of constituents derived from the RCPA.

3.3.3 National Pollutant Discharge Elimination System Outfall

The outfall for the RCPA impoundment is identified as 002 and, shown on **Figure 2-3**, is located near where Isle du Bois Creek meets the Mississippi River. This is a permitted outfall under the National Pollutant Discharge Elimination System program. The outfall effluent water is tested for toxicity on a periodic basis as required by the permit. The biological toxicity testing results for Outfall 002 at the RCPA show no evidence of aquatic toxicity in the outfall effluent.

3.3.4 Off-Site Bedrock Groundwater

The deep groundwater at locations west of the Site is upgradient of the RIEC, as shown on **Figure 2-4**. All results meet drinking water standards and do not show evidence of impact from coal ash. This confirms that the coal ash management practices at the RIEC have not had an impact on groundwater used as a source of drinking water.

3.4 CONCLUSION

The sampling results for the Mississippi River and Isle du Bois creek are important. Although groundwater at the edge of the impoundment shows that two constituents in some wells are above the GWPS, only 4% of the results are above a GWPS, and the adjacent surface water bodies do not show evidence of impact of constituents derived from the RCPA. This is important because the absence of concentrations above risk-based screening levels means that there is not a significant pathway of exposure.

Impacts to groundwater do 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 groundwater at the facility flows into the river, it is diluted by more than 100,000 times.

This conservative estimate of dilution is used to further understand how high an arsenic or molybdenum groundwater concentration would have to be to potentially have an adverse impact on the Mississippi River. The following table shows how this factor is applied to the most conservative of the human health and ecological risk-based screening levels for surface water.

CALCULATING RISK-BASED SCREENING LEVELS FOR GROUNDWATER AT RIEC BASED ON THE MISSISSIPPI RIVER

	Estimated Dilution Factor for Mississippi River	100,000			
Constituents*	**Lowest of the Human Health and Ecological Screening Levels (mg/L)**	**Groundwater Risk-Based Screening Level (mg/L)****	**Maximum RIEC Groundwater Concentration (mg/L)**		**Ratio Between Groundwater Screening Level and the Maximum RIEC Groundwater Concentration**
Arsenic	0.00014	14	0.257	R-MW-2	>50
Molybdenum	0.1	10000	0.943	R-MW-3	>10,000

*A dilution factor is not directly applicable to pH, thus it is not included in this analysis.
**Where the Groundwater Risk-Based Screening Level = Screening Level x Dilution Factor.

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 part per one million parts.

The table identifies the maximum groundwater concentration of arsenic and of molybdenum detected in the RCPA 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. This margin is shown in the last column of the table. To illustrate, concentration levels of arsenic and molybdenum would need to be **more than 50 and more than 10,000 times higher**, respectively, than currently measured levels before an adverse impact in the river could occur.

The comprehensive evaluation summarized here 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 RIEC.

3.4.1 Trace Elements in Coal Ash

All of the inorganic minerals and elements that are present in coal ash are also present naturally in our environment. Arsenic and molybdenum are referred to as trace elements, so called because they are present in soils (and in coal ash) at such low concentrations (in the milligrams per kilogram (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:

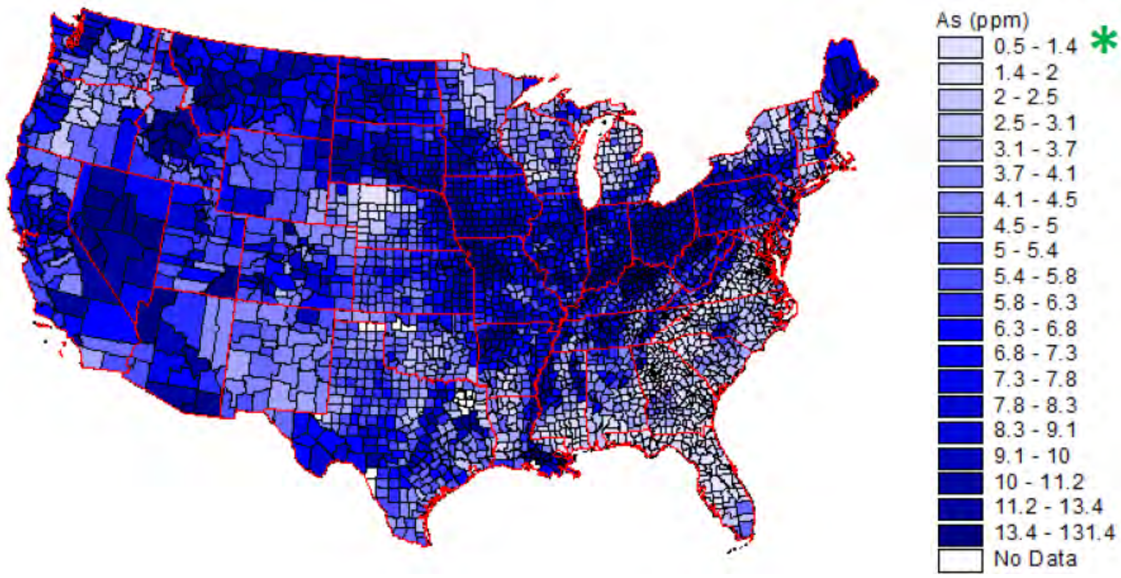
- 1 penny in a large container holding $10,000 worth of pennies, or
- 1 second in 11.5 days, or
- 1 inch in 15.8 miles

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. 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 molybdenum. Thus, we are exposed to these trace elements in our natural environment every day, and in many ways.

3.4.2 Arsenic

Arsenic is present in soils across the U.S. The USGS map of arsenic in surface soils in the U.S. is shown below.

Arsenic 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

*The USEPA regional screening level for arsenic in residential soil at a one in one million risk level is 0.61 mg/kg (USEPA, 2018a). Thus, the arsenic concentration in the majority of the soils in the U.S. are above the one in one million risk level.

Because arsenic is naturally present in soils and rocks, it is also naturally present in our groundwaters and surface waters. Just as for soil, 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 for a consistent period of time. Thus, it is not surprising that arsenic is present in both of the CCR background wells for the RCPA.

3.4.3 Molybdenum

Haley & Aldrich has prepared a fact sheet (**Appendix B)** that provides information on molybdenum so that the groundwater data can be considered in context. There is no public exposure to groundwater at the RIEC and concentration levels of molybdenum in adjacent surface waters are all well below health-based regulatory standards.

As discussed in more detail in **Appendix B**, molybdenum is an essential nutrient for humans, and the Institute of Medicine of the U.S. National Academy of Sciences (NAS) has provided recommended daily allowances (RDA) and tolerable upper limits (UL) to be used as guidelines for vitamins and supplements and other exposures (NAS, 2001).

The RDA for a nutrient is "the average daily dietary nutrient intake level sufficient to meet the nutrient requirement of nearly all (97 to 98 percent) health individuals" (NAS, 2001). The RDA for molybdenum for adults set by the NAS in 2001 is 0.045 mg/day and is based on the amount of molybdenum needed to achieve a steady healthy balance in the body for the majority of the population.

The UL for molybdenum set by the NAS is 2 mg/day. This level is based on an evaluation of the potential toxicity of molybdenum at high levels of intake. Based on the UL, a safe drinking water level for molybdenum is 0.6 mg/L or 600 ug/L, or six-times higher than the level set by USEPA of 0.1 mg/L or 100 ug/L in the CCR Rule. This difference serves to underscore the conservatism of the USEPA value when evaluating groundwater under the CCR Rule. As reflected in the chart, over 90% of the GW results across all four energy centers and all but **11 samples** at Rush Island are within the standard the National Academy of Science developed for vitamins and supplements.

	Labadie	Meramec	Rush Island	Sioux
Groundwater				
Number of Samples	208	88	77	244
Molybdenum greater than CCR GWPS of 0.1 mg/L (a)	81	35	38	77
Molybdenum greater than NAS standard of 0.6 mg/L (b)	3	1	11	49
Surface Water				
Number of Samples	67	74	50	80
Molybdenum greater than 0.1 mg/L (a)	0	0	0	0

Notes:
mg/L - milligrams per liter.
(a) - Drinking water-based on GWPS specified in the CCR Rule.
(b) - Alternative health-protective drinking water screening level based on the NAS review of molybdenum.

3.5 EVALUATION OF RISK IN THE CORRECTIVE MEASURES ASSESSMENT

In summary, there are no adverse impacts resulting from coal ash management practices at the RIEC on human health or the environment from either surface water or groundwater uses. There are no users of groundwater impacted by CCR near RCPA. In fact, as described above, concentrations of arsenic and molybdenum detected in the groundwater would need to be more than **50 and more than 10,000 times higher**, respectively, before such an unacceptable risk could exist under current and reasonably anticipated future uses.

Although the purpose of this CMA is to evaluate remedies to address assumed risks from the SSLs, the current conditions at the RCPA, even prior to closure, do not pose an unacceptable risk to human health or the environment. Therefore, the risk-based evaluation provides additional support for the selection of a remedy moving forward.

4. Corrective Measures Alternatives

4.1 CORRECTIVE MEASURES ASSESSMENT GOALS

The overall goal of this CMA is to identify and evaluate the appropriateness of potential corrective measures to prevent further releases of Appendix IV constituents above their GWPS, to remediate releases of Appendix IV constituents detected during groundwater monitoring above their GWPS that have already occurred, and to restore groundwater in the affected area to conditions that are below the GWPS for these Appendix IV constituents. The corrective measures evaluation that is discussed below and subsequent sections provides an analysis of the effectiveness of six potential corrective measures in meeting the requirements and objectives of remedies as described under §257.97 (also shown graphically on **Figure 4-1**). This assessment also meets the requirements promulgated in §257.96 which require the assessment to evaluate:

- The performance, reliability, ease of implementation, and potential impacts of appropriate potential remedies, including safety impacts, cross-media impacts, and control of exposure to residual contamination;
- The time required to complete the remedy; and
- The institutional requirements, such as state or local permit requirements or other environmental or public health requirements that may substantially affect implementation of the remedy.

The criteria listed above are included in the balancing criteria considered during the corrective measures evaluation, described in **Section 5**.

4.2 GROUNDWATER MODELING

Modeling is an analytical tool used to create estimates based on computer-simulated conditions. Groundwater flow and geochemical modeling[4] performed by Golder evaluated the hydrogeologic and geochemical conditions at the RCPA.

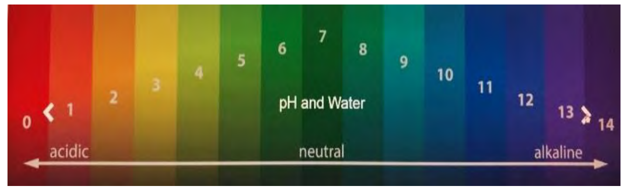
Golder evaluated the fate and transport of arsenic and molybdenum through a geochemical modeling that used PHAST V.3, a program developed by the USGS that simulates multicomponent reactive transport in three-dimensional groundwater flow systems. The geochemical reactions in PHAST, including attenuation mechanisms such as mineral precipitation and sorption of constituents to the aquifer matrix, are simulated using the geochemical model, PHREEQC, which is an integral component of PHAST.

4.3 GROUNDWATER TREATMENT EVALUATION

In-situ treatment to reduce the concentrations of dissolved metals in groundwater can occur via stabilization of metals through precipitation of a metal compound, co-precipitation of the target metal within the structure of another compound, and/or sorption of the target metal onto other compounds in the subsurface. In simple terms, groundwater amendments are injected into the aquifer to create a

[4] Groundwater flow modeling was performed using MODFLOW 2000 supported by Groundwater Vistas as the graphical user interface.

chemical reaction that attenuates metals through precipitation or sorption. Chemical precipitation is an available and demonstrated groundwater treatment technology recognized by USEPA [5]. Groundwater geochemistry (including oxidation reduction potential (ORP)) can greatly impact metals mobility at a site, where some metal compounds may be more soluble under highly oxidative (positive ORP) conditions while others are more soluble under reduced conditions (negative ORP). Also, the solubilities of many metal compounds are highly dependent on pH. For example, iron is more soluble under acidic conditions (pH less than 6), while arsenic is more soluble under extremely acidic (pH < 2) or extremely alkaline (pH > 9) conditions. This is an important consideration when evaluating remedial approaches for arsenic and molybdenum in groundwater. Field monitoring data collected from groundwater monitoring wells associated with the RCPA showed a positive ORP (129 millivolts) and an elevated pH (11 pH units).



pH and Water (USGS - Water Science School publication).

Ameren has retained XDD Environmental (XDD) to research and develop appropriate treatment options for molybdenum and arsenic and is performing bench-scale treatability studies to demonstrate the effectiveness of treatment options on site-specific soils and groundwater. Treatment options under evaluation include pH stabilization and the application of the following treatment reagents: calcium polysulfide, dissolved iron, zero valent iron (ZVI), granulated activated carbon, phosphate and nutrient amendments and potential combination of these reagents.

4.3.1 Arsenic Treatment

Reduction in arsenic concentrations ranging from approximately 30 to 85% were measured in laboratory testing following the adjustment of pH. Based on those results, in-situ treatment for arsenic may be feasible for groundwater immediately downgradient from the RCPA. Underlying conditions that may be supportive of arsenic treatment are described below.

Based on measured dissolved oxygen and iron concentrations in site groundwater, the saturated zone is characterized as a mild iron-reducing condition with both ferric Fe(III) and ferrous Fe(II) iron present in groundwater. The alluvial soil beneath the site appears to be rich in iron; the metal extraction results indicate that the iron concentrations in soil are generally between 5 and 20 grams per liter (i.e., 0.5% - 2% weight of solids; Golder 2019). The observed dissolved oxygen concentrations range from approximately 0.5 mg/L to 3 mg/L, indicating that suboxic and micro-aerobic conditions are present in groundwater, which is consistent with the mild iron-reducing conditions based on the dissolved iron data. Based on the foregoing, an arsenic-specific treatment option would be to introduce a mild acid or alkaline solution into the groundwater and subsurface alluvial soils to alter pH levels. Further, treatment options such as adding additional iron or oxygen sources to enhance precipitation, co-precipitation and sorption are being evaluated.

4.3.2 Chemistry and Precipitation: Molybdenum

As a preliminary step in the treatment option evaluation, XDD evaluated the effects of altering the pH in bench-scale reactors containing site soil and groundwater. Because the sample from RIEC well MW-2

[5] EPA, "Effluent Limitations Guidelines and Standards for the Steam Electric Power Generating Point Source Category: EPA's Response to Public Comments; Part 7 of 10", SE05958A6, p. 7-20.

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had a high pH (greater than 10), the tests were conducted at lower pH values (pH 10, 9, 8, and 7). The RIEC pH testing showed minor effects on the molybdenum concentration in groundwater (though arsenic was greatly reduced by 85% at pH 7). These preliminary pH adjustment results suggest that creating a pH condition of 6 *may* aid in the reduction of molybdenum and arsenic in groundwater so additional testing of the RIEC groundwater and soils at pH 6 is currently underway and will be completed this summer. However, any treatment method to reduce the groundwater concentration of molybdenum needs to avoid altering conditions to a point where other metals of concern dissolve to concentrations above the applicable site action levels.

Precipitation, occurring in the form of a low solubility metal compound, is a preferred approach to reduce metals concentrations in groundwater to below action levels due to the stability of the formed precipitant. The possible molybdenum species formed under varying ORP and pH conditions in typical groundwaters include:

- Molybdenum dioxide;
- Hydroxy(oxido)dioxomolybdenum;
- Molybdate;
- Trimolybdenum octaoxide; and
- Molybdenum disulfide.

Molybdenum disulfide is a solid/precipitant form of molybdenum that can occur at mildly reducing and oxidizing conditions over a wide pH range. However, while this can be promoted to occur in-situ through both biological (biotic) and non-biological (abiotic) processes, the resulting molybdenum concentrations in groundwater may exceed a low action level of 0.1 mg/L; therefore, additional co-precipitation and sorption of molybdenum are being considered in an overall remedial approach to meet the site-specific action level or at sites with concentrations just below the applicable action level.

4.3.3 Additional Treatment of Molybdenum through Co-Precipitation and/ or Sorption

Available research findings describing in-situ reduction in dissolved molybdenum concentrations in groundwater has focused on sorption processes (Pare, 2014; EPRI, 2011; Goldemun and Robb, 2018; Morrison et al., 2006; Bellantoni, 2014). Of those studies, a majority have evaluated ZVI as a media to promote both sorption and precipitation of the molybdenum. Other research also suggests bioremediation can be used to promote the sorption and precipitation processes (Goldemun and Robb, 2018). Both processes create iron compounds that can act to co-precipitate and/or sorb the molybdenum or promote the formation of molybdenum disulfide (if sulfate is present in the groundwater, which is the case for RIEC). Groundwater at RIEC is deficient in dissolved iron and iron supplementation is being evaluated as a component of an overall remedial approach. Treatability studies using the above technologies are underway.

4.4 CORRECTIVE MEASURES ALTERNATIVES

Corrective measures can terminate when groundwater impacted by the RCPA does not exceed the Appendix IV GWPS for three consecutive years of groundwater monitoring. In accordance with §257.97, the groundwater corrective measures to be considered must meet, at a minimum, the following threshold criteria:

1. Be protective of human health and the environment;
2. Attain the GWPS;

3. Control the source(s) of releases so as to reduce or eliminate, to the maximum extent feasible, further releases of COCs to the environment;
4. Remove from the environment as much of the contaminated material that was released from the CCR unit as is feasible, considering factors such as avoiding inappropriate disturbance of sensitive ecosystems; and
5. Comply with standards (regulations) for waste management.

Each of the remedial alternatives assembled as part of this CMA meet the requirements of the threshold criteria listed above.

The remedial alternatives presented below contemplate both CIP (Alternatives 1 through 5) and CBR (Alternative 6) of the RCPA. Both closure methods are expressly authorized under the CCR Rule. Ameren has submitted engineering drawings and closure plans with state (Missouri Department of Natural Resources) and local (Jefferson County) regulatory agencies and is currently in the process of closing the RCPA in place.

4.4.1 Alternative 1 – Closure in Place with Capping and Monitored Natural Attenuation

The RCPA would be closed in place with a low-permeability, synthetic cap to reduce infiltration of surface water to groundwater thereby isolating source material. This cap selection exceeds regulatory requirements by more than two orders of magnitude (<1 x 10^{-7} centimeters per second (cm/sec) planned versus 1 x 10^{-5} cm/sec required by the CCR Rule). Over time, depletion of COCs in CCR would allow the concentration of COCs in downgradient groundwater to decline and overall groundwater concentrations of COCs to attenuate. Geochemical modeling described in **Section 4.2** above predicts the limited concentrations of arsenic and molybdenum that are above the GWPS would be reduced to below the standards in 7 to 8 years for arsenic and 12 to 14 years for molybdenum.

CIP can be completed safely, in compliance with applicable federal and state regulations, and be protective of public health and the environment. In general, CIP consists of installing a cap/cover designed to significantly reduce infiltration from surface water or rainwater, resist erosion, contain CCR materials, and prevent exposures to CCR. For this alternative, Ameren would install a cover system with a permeability that is 100 times lower than what the CCR Rule requires thus further reducing infiltration. At the RIEC, CIP construction activities will take approximately 18-24 months and are expected to be completed in 2020. By using a synthetic cap at RIEC, Ameren will reduce the amount of soil needed for closure with corresponding reduction in external truck traffic and use of public roadways.

MNA is a viable remedial technology recognized by both state and federal regulators that is applicable to inorganic compounds in groundwater. The USEPA defines MNA as "the reliance on natural attenuation processes to achieve site-specific remediation objectives within a time frame that is reasonable compared to that offered by other more active methods". The 'natural attenuation processes' that are at work in such a remediation approach include a variety of physical, chemical, or biological processes that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater. These in-situ processes include biodegradation; dispersion; dilution; sorption; volatilization; radioactive decay; and chemical or biological stabilization, transformation, or destruction of contaminants (USEPA, 2015). When combined with a low-permeability cap to address the source by limiting the infiltration of precipitation into and through the CCR, MNA can be effective for, over time, reducing concentrations of molybdenum and arsenic in groundwater at the RCPA boundary.

Following the installation of the cap system, Ameren would implement post-closure care activities. Post closure care includes long-term groundwater monitoring until such time that groundwater conditions return to below regulatory levels and cap system maintenance. Future development of the capped surface could be used for solar photovoltaic arrays or other site staging/ancillary operational needs.

The geochemical modeling performed by Golder indicates that capping and CIP of the RCPA would result in a lowering of concentrations of arsenic and molybdenum in groundwater, thereby supporting MNA is viable and appropriate. Using the geometric mean to characterize the source area, simulated concentrations of arsenic and molybdenum are predicted to decrease to below GWPSs (0.03 mg/l for arsenic and 0.1 mg/l for molybdenum) following capping and closure.

Geochemical model results indicate a pronounced reduction in arsenic concentrations post-closure. The model results predict concentrations of arsenic are expected to decline to below the target level of 0.03 mg/l in 7 to 8 years.

Geochemical model results for molybdenum predict a pronounced reduction in concentrations during the 14-year period following capping and closure. This reduction in concentrations is attributable solely to dilution and mixing through hydrodynamic dispersion. The model results predict a reduction of molybdenum to below the target level of 0.1 mg/l in 12 to 14 years. Predicted results will be verified and calibrated based on post-closure groundwater sampling.

4.4.2 Alternative 2 – CIP with In-Situ Stabilization, Capping and Monitored Natural Attenuation

In-situ stabilization is a technique that uses mixing of the CCR with amendments to solidify the material in place. Amendments typically include Portland Cement and the solidification is completed in-situ using large diameter augers. CCR located beneath the water table would be isolated by ISS, followed by capping of the surface impoundment. Groundwater impacts would be addressed through the processes of natural attenuation. This alternative would isolate the source and over time, allow the concentrations of COCs in downgradient groundwater to decline and overall groundwater concentrations of COCs to attenuate.

In-situ stabilization of the RCPA is predicted to take several years to complete, depending on the availability of specialized contractors and equipment. Implementation of ISS will require a detailed design effort with bench scale testing to determine the appropriate amendment mix. Pilot testing will be needed to verify the ability of equipment to solidify material at depth. ISS has not been commonly used to stabilize entire ash units as part of a closure strategy. Changes to groundwater chemistry relative to the mobility of Appendix IV constituents following completion of ISS, where large volumes of amendments (typically Portland cement) are added to the subsurface, are unknown and would require pilot testing.

Following the ISS completion and low-permeability final cover system ($<1 \times 10^{-7}$ cm/sec), Ameren would implement post-closure care activities that includes long-term groundwater monitoring and cover system maintenance. Future development of the capped surface could be used for solar photovoltaic arrays or other site staging/ancillary operational needs.

4.4.3 Alternative 3 – CIP with Capping and In-Situ Groundwater Treatment

Similar to Alternative 1, the RCPA would be CIP with a low-permeability ($<1 \times 10^{-7}$ cm/sec) cap to reduce infiltration of surface water to groundwater and to isolate source material. COCs would be addressed through in-situ injection of groundwater amendments downgradient of the RCPA, or through the installation of a permeable reactive barrier (PRB). Over time, leaching and depletion of COCs in CCR in contact with groundwater would allow the concentration of COCs to attenuate and active remediation (injections or PRB replenishment) could cease.

Following the installation of the low-permeability cover and in-situ treatment system (via a trench or injection wells), Ameren would implement post-closure care activities that include periodic amendment injections or periodic replenishment of the treatment reagents within the PRB, long-term groundwater sampling to monitor treatment system performance, and cover system maintenance. Based upon laboratory testing performed by XDD, the timeline for in-situ treatment is expected to be less than Alternative 1 as shown on **Figures 4-2 and 4-3**.

Future development of the capped surface could be used for solar photovoltaic arrays or other site staging/ancillary operational needs.

4.4.4 Alternative 4 – CIP with Capping and Hydraulic Containment Through Groundwater Pumping and Ex-Situ Treatment

The RCPA would be closed in place with a low-permeability (<1 x 10^{-7} cm/sec) cap to reduce infiltration and isolate source material. Pumping wells would be used to hydraulically control the downgradient migration of constituents. However, pumping wells would generate large volumes of effluent that would require ex-situ treatment, likely with an ion exchange or a reverse osmosis (RO) treatment system. Both treatment systems are complex with ongoing operation and maintenance and would generate a secondary waste stream – including regeneration/replacement of the ion exchange media or concentration reject water from the RO system. Approvals and permitting would be required for the discharge of the treated groundwater.

Implementation of a large-scale hydraulic containment (HC) system will require a detailed design effort with bench scale testing to verify groundwater treatment. Pilot testing, such as pumping tests and additional groundwater modeling, will be needed to verify the hydraulic capture zone. While HC is a widely used remediation technology, it has not been commonly used as part of a large-scale CCR unit closure strategy.

Once implemented, leaching and depletion of COCs in CCR in contact with groundwater would allow the concentration of COCs to attenuate and pumping would cease over time. The timeline for active treatment is expected to be comparable to Alternatives 1 and 3 because treatment would continue until source concentrations attenuate to levels less than the GWPS. With active groundwater pumping along the boundary of the RCPA, such process creates waste stream that must be permitted and managed prior to discharge back into the Mississippi River.

Following the installation of the low-permeability cover, groundwater pumping well network, and ex-situ treatment system, Ameren would implement post-closure care activities that includes operation and maintenance of the HC system, long-term groundwater sampling to monitor HC system performance, and cover system maintenance. Future development of the capped surface could be used for solar photovoltaic arrays or other site staging/ancillary operational needs.

4.4.5 Alternative 5 – CIP with Capping and Hydraulic Containment through Groundwater Pumping with Ex-Situ Treatment and Barrier Wall

The configuration of this alternative would be identical to Alternative 4, with the addition of a low-permeability barrier wall between the pumping wells and the Mississippi River. The purpose of the wall is to reduce the flux of groundwater moving downgradient west to east from the RCPA and minimize the intake of groundwater from the east during groundwater pumping, therefore improving the pumping efficiency of the HC system. Approvals and permitting would be required for the barrier wall installation adjacent to the Mississippi River in addition to permits required for discharge of the treated groundwater.

Similar to Alternative 4, implementation of a large-scale HC system will require a detailed design effort with bench scale testing to verify groundwater treatment. Pilot testing, such as long-duration pumping tests and additional groundwater modeling, will be needed to verify the hydraulic capture zone. A detailed design will also be required for the deep barrier wall, given the target depth and horizontal length of the wall. Implementation of the barrier wall and HC system will be particularly challenging given the proximity of the Mississippi River and limited work area. Installation of the barrier wall would also likely require extensive permitting.

Once implemented, the timeline for active treatment is expected to be comparable to Alternatives 1, 3, and 4, as treatment would continue until groundwater concentrations attenuate to levels less than the GWPS.

Following the installation of the low-permeability cover, subsurface barrier wall, groundwater pumping well network, and ex-situ treatment system, Ameren would implement post-closure care activities that includes operation and maintenance of the HC system, long-term groundwater sampling to monitor HC system performance, and cover system maintenance. No ongoing maintenance would be required for the subsurface barrier wall. Future development of the capped surface could be used for solar photovoltaic arrays or other site staging/ancillary operational needs.

4.4.6 Alternative 6 – Closure by Removal with Monitored Natural Attenuation

This alternative consists of removal of RCPA contents followed by natural attenuation of the CCR COCs in groundwater. While this alternative would eliminate (through removal) the source, it takes decades to implement during which time the RCPA would remain open and the ponded ash subject to ongoing infiltration for the duration of the removal activities. As with Alternatives 1, 2, and 3 concentrations of COCs in downgradient groundwater would decline via natural attenuation processes.

There are several potential community impacts, safety concerns and challenges associated with the CBR alternative. Given the magnitude of the total estimated haul tonnage (21.6 MM tons)[6] alone with the travel distance required to transport the CCR to one or more landfills, injuries and fatalities would be likely. A study completed by the Lochmueller Group (Lochmueller) **(Appendix C)** estimated that if 200 truckloads per day **(one every 2.5 minutes)**, hauled excavated material off-site to a commercial landfill, it would take approximately 28 to 34 years to complete the project. The Lochmueller report details various considerations that could impact the overall project. In addition, several of the roads which connect the RIEC to Highway 61 are not suitable for the volume of truck traffic anticipated. The existing

[6] The estimated volume of CCR in the RCPA is approximately 12.7 MM CY. The excavation and disposal tonnage cited here includes the conversion factor for cubic yards to tons plus bulking and stabilization additions as required to achieve complete removal in the CBR approach.

asphalt pavement would not likely withstand the effects of this heavy truck traffic. Improvements to these roads would likely be necessary before large-scale removal of ash could begin and would result in additional traffic flow disruptions due to road construction activities and delay in implementation of this alternative.

Excavated materials from the RCPA would not be suitable for beneficial use applications, due to chemical reactions that occurred during the placement of class C fly ash via wet sluicing. Traditional beneficial use applications for class C fly ash, such as replacement for cement in the production of ready-mix concrete and concrete related products require the materials to be capable of reacting chemically to produce cementitious bonds. The capability to produce these chemical reactions have been expended with the wet-sluicing process of CCR into RCPA. In contrast, the chemistry of class F fly ash, produced at other utility sites, does not react with sluice water to create cementitious bonds, and thus may be suitable for recovery and processing for use in ready mix concrete and concrete related products[7].

Technical and logistical challenges of implementing a large-scale ash removal project also need to be considered (removal of CCR over 100-ft deep adjacent to the Mississippi River). Removal activities will be difficult and require full-time dewatering, implementation of CCR stabilization methods and temporary staging/stockpiling of material for drying prior to transportation off-site; these considerations will affect productivity and increase removal duration. Excavation and construction safety during the removal duration is another major concern due to heavy equipment (bulldozers, excavators, front end loaders, off-road trucks) and dump truck operation within the active RIEC site. Additional community impacts associated with the use of heavy equipment and truck traffic are also a consideration for this alternative.

[7] Information provided by Ameren technical staff, April 29, 2019.

5. Comparison of Corrective Measures Alternatives

The purpose of this section is to evaluate, compare, and rank the six corrective measures alternatives using the balancing criteria described in §257.97.

5.1 EVALUATION CRITERIA

In accordance with §257.97, remedial alternatives that satisfy the threshold criteria are then compared to four balancing (evaluation) criteria. The balancing criteria allow a comparative analysis for each corrective measure, thereby providing the basis for final corrective measure selection. The four balancing criteria include the following:

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;
2. The effectiveness of the remedy in controlling the source to reduce further releases;
3. The ease or difficulty of implementing a potential remedy; and
4. The degree to which community concerns are addressed by a potential remedy.

Public input and feedback will be considered following a public information session.

5.2 COMPARISON OF ALTERNATIVES

This section compares the alternatives to each other based on evaluation of the balancing criteria listed above. The goal of this analysis is to identify the alternative that is technologically feasible, relevant and readily implementable, provides adequate protection to human health and the environment, and minimizes impacts to the community.

A graphic is provided within each subsection below to provide a visual snapshot of the favorability of each alternative, where green represents favorable, yellow represents less favorable, and red represents unfavorable.

5.2.1 The Long- and Short-Term Effectiveness and Protectiveness of the Potential Remedy, along with the Degree of Certainty that the Remedy Will Prove Successful

This balancing criterion takes into consideration the following sub criteria relative to the long-term and short-term effectiveness of the remedy, along with the anticipated success of the remedy.

5.2.1.1 Magnitude of reduction of existing risks

As summarized in **Section 3**, no unacceptable risk to human health and the environment exist under the current configuration of the RCPA. Therefore, none of the remedial alternatives will reduce risk posed by Appendix IV constituents in groundwater because no such adverse risk exists. However, other types of risks can be posed by the various remedial alternatives considered here. The remedial alternative that poses the lowest risk to human health and the environment is Alternative 1 (CIP with MNA) because it involves the least amount of construction, operations and maintenance activities and associated impacts. Alternative 6 (CBR with MNA) has the highest risk to human health and the environment related to excessive and prolonged truck traffic, which increases the likelihood of roadway accidents during the estimated 28 to 34 years needed to complete the CBR project. Construction and material transportation will also be required for Alternative 2 (CIP with ISS) during the process of solidifying the CCR, and during construction of the barrier wall included with Alternative 5 (CIP with HC and barrier). Aside from the cap construction, only minor construction will be required for Alternatives 3 (CIP with in-situ) and 4 (CIP with HC) during treatment system installation.

	Alternative 1 CIP with Cap & MNA	**Alternative 2** CIP with Cap, ISS, & MNA	**Alternative 3** CIP with Cap & In-Situ GW Treatment	**Alternative 4** CIP with Cap & Hydraulic Containment	**Alternative 5** CIP with Cap & Hydraulic Containment & Barrier Wall	**Alternative 6** CBR with MNA
Category 1 - Subcriteria i) Magnitude of reduction of risks						

5.2.1.2 *Magnitude of residual risks in terms of likelihood of further releases due to CCR remaining following implementation of a remedy*

Alternative 6 (CBR with MNA), has the lowest long-term residual risk in that removal of the source material reduces the likelihood of future releases to groundwater. However, implementation of this alternative takes approximately 28 to 34 years during which time the source material (ash) is not controlled, thereby increasing the likelihood of further releases during the implementation period relative to the other alternatives. For Alternatives 1 through 5, the RCPA would be CIP with the installation of a low permeability ($<1 \times 10^{-7}$ cm/s) cap that would significantly reduce the infiltration of precipitation into the RCPA. The source remains in place with Alternatives 1 through 5, although dissolved phase COCs to groundwater are addressed through MNA. Additionally, COCs in groundwater are not significant because they do not threaten human health or the environment even under current conditions. Alternatives 3, 4, and 5 also provide further protection from future releases with in-situ treatment and hydraulic controls, respectively, at the RCPA boundaries. A low risk for further releases exists with Alternative 2 (CIP with ISS) when completed, however implementation will require several years to complete with the potential for ongoing releases during construction. The likelihood of a further release during the ISS construction period is high, relative to the other CIP alternatives.

	Alternative 1 CIP with Cap & MNA	**Alternative 2** CIP with Cap, ISS, & MNA	**Alternative 3** CIP with Cap & In-Situ GW Treatment	**Alternative 4** CIP with Cap & Hydraulic Containment	**Alternative 5** CIP with Cap & Hydraulic Containment & Barrier Wall	**Alternative 6** CBR with MNA
Category 1 - Subcriteria ii) Magnitude of residual risk in terms of likelihood of further release						

5.2.1.3 *The type and degree of long-term management required, including monitoring, operation, and maintenance*

Alternative 1 (CIP with MNA) is the most favorable alternative with respect to this criterion because it requires the least amount of long-term management and involves no mechanical systems as part of the remedy. Alternative 6 (CBR with MNA) is least favorable because the remedy takes 28 to 34 years to complete and is logistically complex with transportation and coordination with off-site disposers (commercial landfills). The remaining alternatives fall between Alternatives 1 and 6 because they involve more intensive systems to implement and/or maintain throughout their remediation life cycle.

	Alternative 1 CIP with Cap & MNA	**Alternative 2** CIP with Cap, ISS, & MNA	**Alternative 3** CIP with Cap & In-Situ GW Treatment	**Alternative 4** CIP with Cap & Hydraulic Containment	**Alternative 5** CIP with Cap & Hydraulic Containment & Barrier Wall	**Alternative 6** CBR with MNA
Category 1 - Subcriteria iii) Type and degree of long-term management required						

5.2.1.4 *Short-term risks that might be posed to the community or the environment during implementation of such a remedy*

The highest short-term impact posed to the community or environment would be during implementation of Alternative 6 (CBR with MNA) followed by Alternative 2 (CIP with ISS), making these alternatives least favorable. Environmental impacts include noise and emissions from heavy equipment, the potential for a release during excavation and dewatering, and fugitive dust emissions. Community impacts include general impacts to the community due to increased truck traffic on public roads during the entire project duration, along with an increased potential for traffic accidents and fatalities, noise, and truck emissions.

For Alternatives 1 (CIP with MNA), 3 (CIP with in-situ treatment), 4 (CIP with HC), and 5 (CIP with HC and barrier) risk to the community during construction is considered the same and would be minimal compared to the other alternatives. Periodic sampling of the monitoring well network to verify treatment system effectiveness will pose no risk to the community.

	Alternative 1 CIP with Cap & MNA	**Alternative 2** CIP with Cap, ISS, & MNA	**Alternative 3** CIP with Cap & In-Situ GW Treatment	**Alternative 4** CIP with Cap & Hydraulic Containment	**Alternative 5** CIP with Cap & Hydraulic Containment & Barrier Wall	**Alternative 6** CBR with MNA
Category 1 - Subcriteria iv) Short term risk to community or environment during implementation						

5.2.1.5 *Time until full protection is achieved*

There is currently no unacceptable risk to human health and the environment associated with groundwater at the RCPA; therefore, protection is already achieved. Based upon modeling, Alternatives 1 (CIP with MNA), 4 (CIP with HC), and 5 (CIP with HC and barrier) source depletion and natural attenuation reduces COCs to concentrations less than GWPS in approximately 12 to 14 years (see **Figures 4-2** and **4-3**). With in-situ groundwater treatment, such time is reduced to four and ten years. Alternative 3 (CIP with in-situ treatment) takes the least amount of time to reduce COCs to concentrations to less than GWPS. Alternatives 4 and 5 also have the potential to reduce concentrations in a similar timeframe as Alternative 3. These alternatives are favorable given the reasonable timeframe.

Alternative 6 (CBR with MNA) is expected to take between 28 to 34 years for construction followed by several years of groundwater monitoring to verify natural attenuation of the groundwater plume, which makes this alternative not only unfavorable but will not achieve compliance with the CCR Rule closure time mandates. The period for construction is limited mainly by the amount of material that can be excavated and hauled during a work day, probable road improvements, disposal facility capacity, and the large volume of ash contained within the RCPA.

Implementation of Alternative 2 (CIP with ISS) would require extensive engineering analysis and field testing. Assuming such studies confirm the viability of ISS technology at the RIEC and equipment availability, field implementation could take approximately five years to complete followed by five years of groundwater monitoring to verify natural attenuation of the groundwater plume. Including a five-year time horizon for planning and regulatory approvals, the total timeframe until achieving the GWPS for this alternative – at least 10 to 15 years – is comparable to the timeframe estimated for the alternatives (1, 3, 4, and 5) that include CIP.

	Alternative 1 CIP with Cap & MNA	Alternative 2 CIP with Cap, ISS, & MNA	Alternative 3 CIP with Cap & In-Situ GW Treatment	Alternative 4 CIP with Cap & Hydraulic Containment	Alternative 5 CIP with Cap & Hydraulic Containment & Barrier Wall	Alternative 6 CBR with MNA
Category 1 - Subcriteria v) Time until full protection is achieved						

5.2.1.6 *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*

Alternatives 1 (CIP with MNA), 3 (CIP with in-situ treatment), 4 (CIP with HC), and 5 (CIP with HC and barrier) all have similar, minimal potential for exposure of humans and environmental receptors during regrading and cap construction; monitoring well system installation; and installation of the in-situ treatment system, HC system, or subsurface barrier wall construction. Alternative 1 (CIP with MNA) is the most favorable alternative since, aside from capping, no additional contact with CCR or impacted groundwater would be needed. Alternative 3 (CIP with in-situ treatment) is also favorable because treatment occurs below ground and no waste stream is generated.

Alternatives 2 (CIP with ISS) and 6 (CBR with MNA) have moderate and high potential for exposure, respectively, which makes them the least favorable remedy for this criterion. A high potential for exposure exists during the excavation and transport of the CCR over local roadways if Alternative 6 is implemented. A moderate potential to exposure exists during ISS construction (Alternative 2), if some CCR needs to be disposed off-site as part of the preliminary removal effort prior to ISS implementation.

	Alternative 1 CIP with Cap & MNA	Alternative 2 CIP with Cap, ISS, & MNA	Alternative 3 CIP with Cap & In-Situ GW Treatment	Alternative 4 CIP with Cap & Hydraulic Containment	Alternative 5 CIP with Cap & Hydraulic Containment & Barrier Wall	Alternative 6 CBR with MNA
Category 1 - Subcriteria vi) Potential for exposure of humans and environmental receptors to remaining wastes						

5.2.1.7 *Long-term reliability of the engineering and institutional controls*

Alternatives 1 (CIP with MNA), 3 (CIP with in-situ treatment), 4 (CIP with HC), and 5 (CIP with HC and barrier) are all expected to have high long-term reliability, as capping and long-term monitoring are common methods for long-term waste management. HC and ex-situ treatment (Alternatives 4 and 5) are considered reliable, proven technologies and would have high long-term reliability. However, implementation of alternatives 2-5 will require bench scale and pilot scale testing to confirm treatability of arsenic and molybdenum or engineering studies and design. Of the CIP alternatives, Alternative 1 (CIP with MNA) is considered the most favorable because no additional ongoing Operations and Maintenance (O&M) would be needed, other than periodic groundwater sampling and verification of decreasing concentrations.

For Alternatives 1 through 5, which include CIP, institutional controls such as the recording of an environmental covenant restricting the use of groundwater can easily be implemented because the RCPA is located on property owned by Ameren.

With Alternative 6 (CBR with MNA) no additional engineering and institutional controls are anticipated because CCR will have been removed. Alternative 2 (CIP with ISS) is also expected to have a high long-term reliability because the CCR would be isolated within the ISS monolith.

	Alternative 1 CIP with Cap & MNA	Alternative 2 CIP with Cap, ISS, & MNA	Alternative 3 CIP with Cap & In-Situ GW Treatment	Alternative 4 CIP with Cap & Hydraulic Containment	Alternative 5 CIP with Cap & Hydraulic Containment & Barrier Wall	Alternative 6 CBR with MNA
Category 1 - Subcriteria vii) Long-term reliability of engineering and institutional controls	(green)	(green)	(yellow)	(yellow)	(yellow)	(green)

5.2.1.8 Potential need for replacement of the remedy

Closure in place of the RCPA with ISS and closure by removal are both considered permanent and can be effective in appropriate circumstances. Detailed engineering assessments would need to be completed before the viability of such approaches could be considered at a site such as the RCPA given its depth, volume and narrow location immediately adjacent to the river. Field pilot testing would be needed for ISS to confirm the ability of equipment to reach the bottom of CCR. From the perspective of needing to replace the remedy, source removal (Alternative 6) is permanent.

Alternatives 1 (CIP with MNA), 3 (CIP with in-situ treatment), 4 (CIP with HC), and 5 (CIP with HC and barrier) are expected to have permanent closures with capping in place. Should monitoring results indicate that the selected remedial alternative is not effective at reducing the concentration of COCs over time, alternate and/or additional active remedial methods for groundwater may be considered.

	Alternative 1 CIP with Cap & MNA	Alternative 2 CIP with Cap, ISS, & MNA	Alternative 3 CIP with Cap & In-Situ GW Treatment	Alternative 4 CIP with Cap & Hydraulic Containment	Alternative 5 CIP with Cap & Hydraulic Containment & Barrier Wall	Alternative 6 CBR with MNA
Category 1 - Subcriteria viii) Potential need for replacement of the remedy	(yellow)	(green)	(yellow)	(yellow)	(yellow)	(green)

5.2.1.9 Long- and short-term effectiveness and protectiveness criterion summary

The graphic below provides a summary of the long- and short-term effectiveness and protectiveness of the potential remedy, along with the degree of certainty that the remedy will prove successful. Alternatives 1 (CIP with MNA) is the most favorable, while Alternative 6 (CBR with MNA) is the least favorable. Alternative 1 is expected to be effective both short- and long-term and does not include additional treatment technology aside from MNA. Alternative 3 (CIP with in-situ treatment) is comparable to Alternative 1 because it has a shorter potential timeframe to meet the GWPS despite requiring treatment. Alternative 6 (CBR with MNA) will require a lengthy construction period, and therefore not effective in the short-term.

	Alternative 1 CIP with Cap & MNA	Alternative 2 CIP with Cap, ISS, & MNA	Alternative 3 CIP with Cap & In-Situ GW Treatment	Alternative 4 CIP with Cap & Hydraulic Containment	Alternative 5 CIP with Cap & Hydraulic Containment & Barrier Wall	Alternative 6 CBR with MNA
CATEGORY 1 Long- and Short Term Effectiveness, Protectiveness, and Certainty of Success	(green)	(yellow)	(green)	(yellow)	(yellow)	(red)

5.2.2 The Effectiveness of the Remedy in Controlling the Source to Reduce Further Releases

This balancing criterion takes into consideration the ability of the remedy to control a future release, and the extensiveness of treatment technologies that will be required.

5.2.2.1 *The extent to which containment practices will reduce further releases*

For remedial Alternatives 1 (CIP with MNA), 3 (CIP with in-situ treatment), 4 (CIP with HC), and 5 (CIP with HC and barrier) installation of the low permeability cap will reduce the infiltration of surface water into the RCPA and decrease the flux of COCs passing from impounded ash porewater to groundwater over time. Groundwater mounding, and associated outward hydraulic gradient, present at the RCPA during operation is expected to dissipate after closure. Alternative 5 is considered the most favorable because three treatment technologies (HC, ex-situ treatment, and a barrier wall) will be implemented to limit down-gradient migration of COCs in groundwater.

Under Alternatives 2 (CIP with ISS) and 6 (CBR with MNA), no further releases are anticipated following removal or stabilization of the CCR material. However, the implementation of each alternative is anticipated to require multiple years to complete (approximately 5 and 28 to 34 years for Alternatives 2 and 6, respectively) with MNA monitoring following completion of construction. During the period of construction for Alternatives 2 and 6, there would be no source control of the Appendix IV constituents.

For Alternatives 3 (CIP with in-situ treatment), 4 (CIP with HC), and 5 (CIP with HC and barrier), additional containment or treatment practices (in-situ treatment and HC with ex-situ treatment) will address COCs in groundwater migrating downgradient from the RCPA, achieving the performance criteria at the waste boundary. Alternative 1 will not have an additional containment technology beyond natural attenuation but is expected to reduce the concentrations below the GWPS in 12 to 14 years. Alternative 3, in-situ treatment, relies on the natural hydraulic gradient to move contaminants through the treatment zone and would be expected to operate for the shortest duration although, depending upon the treatment train, may present other complications.

	Alternative 1 CIP with Cap & MNA	**Alternative 2** CIP with Cap, ISS, & MNA	**Alternative 3** CIP with Cap & In-Situ GW Treatment	**Alternative 4** CIP with Cap & Hydraulic Containment	**Alternative 5** CIP with Cap & Hydraulic Containment & Barrier Wall	**Alternative 6** CBR with MNA
Category 2 - Subcriteria i) Extent to which containment practices will reduce further releases						

5.2.2.2 *The extent to which treatment technologies may be used*

No groundwater treatment technologies, other than natural attenuation, will be used for Alternatives 1 and 6. There would be no ongoing operation and maintenance of a treatment technology, other than periodic groundwater monitoring. Alternative 1 relies only on low-permeability capping, and therefore is the most favorable. Alternative 2 (CIP with ISS) uses solidification of the CCR below the water table to address COCs in groundwater.

Alternative 3 will use one additional technology, in-situ treatment, while Alternatives 4 and 5 will use two additional technologies, HC and ex-situ treatment, for an estimated period of less than 15 years. The operation of an ex-situ treatment system would likely create a secondary waste stream, such as concentrated reject water (RO) requiring off-site disposal, or depleted resin (ion exchange) requiring regeneration or off-site disposal. Alternative 5 is the least favorable because this alternative also includes the installation of a subsurface barrier wall, in addition to HC and ex-situ treatment.

	Alternative 1 CIP with Cap & MNA	**Alternative 2** CIP with Cap, ISS, & MNA	**Alternative 3** CIP with Cap & In-Situ GW Treatment	**Alternative 4** CIP with Cap & Hydraulic Containment	**Alternative 5** CIP with Cap & Hydraulic Containment & Barrier Wall	**Alternative 6** CBR with MNA
Category 2 - Subcriteria ii) Extent to which treatment technologies may be used						

5.2.2.3 Effectiveness of the remedy in controlling the source to reduce further releases summary

The graphic below provides a summary of the effectiveness of the remedial alternatives to control the source to reduce further releases. Alternatives 1 (CIP with MNA) and 3 (CIP with in-situ treatment) are the most favorable, while Alternatives 2 (CIP with ISS) and 4 (CIP with HC) are the least favorable.

	Alternative 1 CIP with Cap & MNA	**Alternative 2** CIP with Cap, ISS, & MNA	**Alternative 3** CIP with Cap & In-Situ GW Treatment	**Alternative 4** CIP with Cap & Hydraulic Containment	**Alternative 5** CIP with Cap & Hydraulic Containment & Barrier Wall	**Alternative 6** CBR with MNA
CATEGORY 2 Effectiveness in controlling the source to reduce further releases						

5.2.3 The Ease or Difficulty of Implementing a Potential Remedy

This balancing criterion takes into consideration technical and logistical challenges required to implement a remedy, including practical considerations such as equipment availability and disposal facility capacity.

5.2.3.1 Degree of difficulty associated with constructing the technology

CIP with a low permeability cap will be straightforward and can be implemented with common construction methods for Alternatives 1 (CIP with MNA), 3 (CIP with in-situ treatment), 4 (CIP with HC), and 5 (CIP with HC and barrier). No construction difficulties are anticipated if Alternatives 1, 3, and 4 are implemented. Specialty equipment or contractors are not required. Alternative 3 may be slightly more difficult to implement should a subsurface trench be required for a permeable barrier. A specialty contractor will likely be needed to complete the low-permeability barrier wall for Alternative 5 since the wall will fully penetrate the alluvial aquifer. For Alternative 1, no additional treatment technology is needed other than monitoring wells for groundwater monitoring.

Alternatives 2 (CIP with ISS) and 6 (CBR with MNA) will be difficult to implement due to technical and logistical challenges. Alternative 6 will include a deep excavation below the water table, ongoing excavation dewatering, and the transportation of 21 MM tons of CCR over local roadways. Under Alternative 2, the successful completion of ISS to target depths will be technically challenging and will require field pilot testing to confirm equipment reach. Alternatives 2 and 6 will both include large-scale construction, specialty equipment and contractors, long project durations, and significant technical challenges.

	Alternative 1 CIP with Cap & MNA	**Alternative 2** CIP with Cap, ISS, & MNA	**Alternative 3** CIP with Cap & In-Situ GW Treatment	**Alternative 4** CIP with Cap & Hydraulic Containment	**Alternative 5** CIP with Cap & Hydraulic Containment & Barrier Wall	**Alternative 6** CBR with MNA
Category 3 - Subcriteria i) Degree of difficulty associated with constructing the technology						

5.2.3.2 *Expected operational reliability of the technologies*

Alternative 1 (CIP with MNA) is considered the most favorable from an operational perspective because capping with MNA has a proven track record and requires limited O&M. While alternative 2 (CIP with ISS) is a proven technology and isolates the ponded material, pilot testing would be required to ensure ISS will be able to solidify CCR at depth. Alternatives 3, 4, and 5 are expected to be reliable, but will utilize additional groundwater treatment technologies. Alternative 6, CBR with MNA is considered a reliable alternative as all CCR material would be removed, although implementation would be challenging.

	Alternative 1 CIP with Cap & MNA	**Alternative 2** CIP with Cap, ISS, & MNA	**Alternative 3** CIP with Cap & In-Situ GW Treatment	**Alternative 4** CIP with Cap & Hydraulic Containment	**Alternative 5** CIP with Cap & Hydraulic Containment & Barrier Wall	**Alternative 6** CBR with MNA
Category 3 - Subcriteria ii) Expected operational reliability of the technologies						

5.2.3.3 *Need to coordinate with and obtain necessary approvals and permits from other agencies*

Alternative 1 (CIP with MNA) is the most favorable since the implementation of the remedy is straightforward and only includes capping and MNA. Alternatives 2 (CIP with ISS) and 6 (CBR with MNA) will require extensive permitting for large-scale construction whereas the permitting is expected to be straightforward for CIP Alternatives 1, 3, and 4. Additional approval and permitting may be required for Alternative 3 (CIP with in-situ treatment) because this alternative may include subsurface treatment via groundwater amendment or PRB, and permitting would likely be required for Alternatives 4 and 5 for the discharge of treated groundwater. Additional approval and permitting will also be required for Alternative 5, which includes the construction of a subsurface barrier wall adjacent to the Mississippi River.

	Alternative 1 CIP with Cap & MNA	**Alternative 2** CIP with Cap, ISS, & MNA	**Alternative 3** CIP with Cap & In-Situ GW Treatment	**Alternative 4** CIP with Cap & Hydraulic Containment	**Alternative 5** CIP with Cap & Hydraulic Containment & Barrier Wall	**Alternative 6** CBR with MNA
Category 3 - Subcriteria iii) Need to coordinate with and obtain necessary approvals and permits from other agencies						

5.2.3.4 *Availability of necessary equipment and specialists*

Alternative 1 (CIP with MNA) is the most favorable since specialty equipment and specialists will not be required to implement the MNA remedy.   Alternatives 2 (CIP with ISS) and 6 (CBR with MNA) are the least favorable since both will require specialty remediation contractors to implement full removal or ISS, respectively, which will include large-scale construction dewatering and effluent management and treatment, deep excavations below the water table, transportation of material to off-site disposal facilities, and implementation of ISS at depth (for Alternative 2 only). Specialty equipment will likely be required to install the low permeability barrier wall under Alternative 5.

	Alternative 1 CIP with Cap & MNA	**Alternative 2** CIP with Cap, ISS, & MNA	**Alternative 3** CIP with Cap & In-Situ GW Treatment	**Alternative 4** CIP with Cap & Hydraulic Containment	**Alternative 5** CIP with Cap & Hydraulic Containment & Barrier Wall	**Alternative 6** CBR with MNA
Category 3 - Subcriteria iv) Availability of necessary equipment and specialists						

5.2.3.5 Available capacity and location of needed treatment, storage, and disposal services

To evaluate the CBR alternative (Alternative 6), a transportation study completed by Lochmueller. In that study, four landfills were identified within 80 miles that could potentially receive CCR for disposal. The closest landfill is approximately 35 miles from RIEC and, based on calculations by Lochmueller, could receive approximately 80% of the CCR. The additional 20% of CCR to be disposed under Alternative 6 could be sent to one of the other three landfills, located approximately 67 to 80 miles from RIEC. Actual disposal capacity, any local zoning or other restrictions and synchronization with current customer base all require further confirmation for Alternative 6. Because of these considerations, Alternative 6 (CBR with MNA) is the least favorable alternative under this criterion.

Alternative 2 (CIP with ISS) includes ISS of CCR below the water table. Amendments such as Portland Cement will be imported to the RIEC to solidify the material in-situ.

Because the RCPA will be CIP for Alternatives 1, 3, 4, and 5, treatment, storage, and disposal services for CCR material will not be needed. Temporary stockpiling of CCR during RCPA regrading and capping can be completed within the current boundaries of the ash unit. Alternative 1 is the most favorable alternative since no active treatment is included. For Alternatives 4 and 5, the ex-situ treatment system may generate a concentrated waste stream which would likely require off-site transportation and disposal that the other alternatives would not require.

	Alternative 1 CIP with Cap & MNA	**Alternative 2** CIP with Cap, ISS, & MNA	**Alternative 3** CIP with Cap & In-Situ GW Treatment	**Alternative 4** CIP with Cap & Hydraulic Containment	**Alternative 5** CIP with Cap & Hydraulic Containment & Barrier Wall	**Alternative 6** CBR with MNA
Category 3 - Subcriteria v) Available capacity and location of needed treatment, storage, and disposal services						

5.2.3.6 Ease or difficulty of implementation summary

The graphic below provides a summary of the ease or difficulty that will be needed to implement each alternative. Alternatives 1 (CIP with MNA) and 3 (CIP with in-situ treatment) are the most favorable, while Alternatives 2 (CIP with ISS) and 6 (CBR with MNA) are the least favorable.

	Alternative 1 CIP with Cap & MNA	**Alternative 2** CIP with Cap, ISS, & MNA	**Alternative 3** CIP with Cap & In-Situ GW Treatment	**Alternative 4** CIP with Cap & Hydraulic Containment	**Alternative 5** CIP with Cap & Hydraulic Containment & Barrier Wall	**Alternative 6** CBR with MNA
CATEGORY 3 Ease of implementation						

6. Summary

This Corrective Measures Assessment has evaluated the following alternatives:

- Alternative 1 – Closure in Place (CIP) with Capping and Monitored Natural Attenuation
- Alternative 2 – CIP with In-Situ Stabilization, Capping and MNA
- Alternative 3 – CIP with Capping and In-Situ Groundwater Treatment
- Alternative 4 – CIP with Capping and Hydraulic Containment Through Groundwater Pumping and Ex-situ Treatment
- Alternative 5 – CIP with Capping and Hydraulic Containment through Groundwater Pumping with Ex-situ Treatment and Barrier Wall
- Alternative 6 – Closure by Removal with Monitored Natural Attenuation

In accordance with §257.97, each of these alternatives has been evaluated in the context of the following threshold criteria:

- Be protective of human health and the environment;
- Attain the GWPS;
- Control the source(s) of releases so as to reduce or eliminate, to the maximum extent feasible, further releases of COCs to the environment;
- Remove from the environment as much of the contaminated material that was released from the CCR unit as is feasible, considering factors such as avoiding inappropriate disturbance of sensitive ecosystems; and
- Comply with standards (regulations) for waste management.

In addition, in accordance with §257.97(c), each of the alternatives has been evaluated in the context of the following balancing criteria:

- 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 eight factors.
- The effectiveness of the remedy in controlling the source to reduce further releases based on consideration of the extent to which containment practices will reduce further releases and the extent to which treatment technologies may be used.
- The ease or difficulty of implementing a potential remedy(s) based on consideration of five types of factors

This Corrective Measures Assessment, and the input received during the public comment period, will be used to identify a final corrective measure for implementation at the RIEC.

References

1. AECOM, August 2014. Groundwater and Surface Water Data Demonstrate No Off-Site Impact from Rush Island Energy Center. https://www.ameren.com/-/media/corporate-site/files/environment/reports/rushislandreport.ashx?la=en&hash=B0C49A936DE7E3119F6FAD36EDF9F26287EFEE9F

2. Golder Associates Inc. 2017. 40 CFR Part 257 Groundwater Monitoring Plan, RCPA Rush Island Energy Center-Jefferson County, Missouri, USA.

3. Golder Associates Inc. 2018. Technical Memorandum Assessment Monitoring Statistical Evaluation for the RCPA Surface Impoundment, Rush Island Energy Center-Jefferson County, Missouri.

4. Golder Associates Inc. 2018. 2017 Annual Groundwater Monitoring Report, RCPA Surface Impoundment, Rush Island Energy Center-Jefferson County, Missouri, USA.

5. Golder Associates Inc. 2019. 2018 Annual Groundwater Monitoring and Corrective Action Report, RCPA Surface Impoundment, Rush Island Energy Center-Jefferson County, Missouri, USA.

6. Golder Associates Inc. 2019. Technical Memorandum, Groundwater and Geochemical Modeling Summary for Ameren Rush Island Energy Center Corrective Measures Assessment.

7. Golder Associates Inc. 2019. Technical Memorandum, Progress Update on RCPA Nature and Extent Investigation, Rush Island Energy Center, Missouri.

8. Haley & Aldrich, Inc. 2018. Human Health and Ecological Assessment of the Rush Island Energy Center, Ameren Missouri, Festus, Missouri. https://www.ameren.com/-/media/corporate-site/files/environment/ccr-rule/2017/groundwater-monitoring/rush-island-haley-aldrich-report.ashx?la=en&hash=B27EDADC095FE0E08073B8158F50EB8B97019D8A

9. Haley & Aldrich, Inc. 2018. 2018 Coal Combustion Residual Pond Characterization Summary Report Ameren Missouri Rush Island Energy Center, Festus, Jefferson County, Missouri.

10. Lochmueller Group 2019. Extraction & Transportation Study: Rush Island Ash Pond Closure Assessment. Rush Island Site, Jefferson County, Missouri.

11. NAS. 2001. Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc. Institute of Medicine. National Academy of Sciences. 2001. National Academy Press. Available at: http://www.nap.edu/catalog/10026.html

12. Natural Resources Technology 2015. Draft Detailed Site Investigation Report, Proposed Utility Waste Landfill, Ameren Missouri Rush Island Energy Center-Jefferson County, Missouri.

13. USEPA. 1989. Risk Assessment Guidance for Superfund: Volume I. Human Health Evaluation Manual (Part A). Interim Final. Office of Emergency and Remedial Response. U.S. Environmental Protection Agency, Washington, D.C. EPA 540/1-89/002. Available at: http://www.epa.gov/oswer/riskassessment/ragsa

14. USEPA. 2009. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities – Unified Guidance.

15. USEPA. 2015. Frequent Questions about the 2015 Coal Ash Disposal Ruel. https://www.epa.gov/coalash/frequent-questions-about-2015-coal-ash-disposal-rule

16. USEPA. 2015a. Final Rule: Disposal of Coal Combustion Residuals (CCRs) for Electric Utilities. 80 FR 21301-21501. U.S. Environmental Protection Agency, Washington, D.C. Available at: https://www.govinfo.gov/content/pkg/FR-2015-04-17/pdf/2015-00257.pdf

17. USEPA. 2015b. Use of Monitored Natural Attenuation for Inorganic Contaminants in Groundwater at Superfund Sites.

18. USEPA. 2018a. USEPA Regional Screening Levels. November 2018, values for tapwater. U.S. Environmental Protection Agency. Available at: https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables

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TABLES

TABLE I
GROUNDWATER ANALYTICAL RESULTS - APPENDIX IV CONSTITUENTS
CORRECTIVE MEASURES ASSESSMENT
AMEREN MISSOURI RUSH ISLAND ENERGY CENTER - FESTUS, MISSOURI

Monitoring Well ID	Date Sampled	Constituents													
		Antimony Total	Arsenic Total	Barium Total	Beryllium Total	Cadmium Total	Chromium Total	Fluoride Total	Cobalt Total	Lead Total	Lithium Total	Mercury Total	Molybdenum Total	Selenium Total	Thallium Total
		ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
	Site GWPS	6	30	2000	4	5	100	4	6	15	64.7	2	100	50	2
	3/10/2016	0.65 J	5.8	33	1 U	0.5 U	0.42 J	0.11 J	5 U	5 U	10 U	0.2 U	69.8	8.1	1 U
	5/2/2016	0.75 J	9.7	21.3	1 U	0.5 U	0.38 J	0.26	5 U	5 U	10 U	0.2 U	73.1	10.2	1 U
	7/25/2016	1	9.3	15.1	1 U	0.5 U	1.4	0.4	5 U	5 U	10 U	0.2 U	57.7	12.7	1 U
	9/7/2016	0.8 J	13.1	12.6	1 U	0.052 J	1 U	0.37	5 U	5 U	10 U	0.2 U	42.8	4.5	1 U
	11/16/2016	0.84 J	12	15.5	1 U	0.045 J	1 U	0.22	5 U	5 U	10 U	0.045 J	32.6	3.8	1 U
R-MW-1	1/19/2017	0.87 J	9.4	18.1	1 U	0.5 U	0.46 J	0.16 J	5 U	5 U	10 U	0.2 U	32.8	3.4	0.12 J
	3/6/2017	0.88 J	12.8	19.2	1 U	0.5 U	2.2	0.24	0.86 J	5 U	10 U	0.2 U	40	3.5	1 U
	6/8/2017	0.73 J	8.9	16.9	1 U	0.5 U	1 U	0.11 J	5 U	5 U	10 U	0.052 J	36.3	1.7	0.11 J
	4/3/2018	1.2	20.8	16.0	1 U	0.5 U	0.086 J	0.51	5 U	10 U	10 U	0.2 U	52.4	6.0	1 U
	5/24/2018	0.95 J	17.1	17.0				0.39			10 U		54	4.1	
	11/2/2018	0.55 J	10.1	15.1	1 U	0.039 J	1 U	0.36	0.92 J	10 U	10 U		**102**	1.8	1 U
	3/10/2016	5.4	**257**	26.2	1 U	0.26 J	1.1	0.61	5 U	14.4	10 U	0.2 U	**150**	1.1	1 U
	5/2/2016	5.2	**231**	18.8	1 U	0.25 J	0.95 J	0.91	5 U	8.8	10 U	0.2 U	**173**	2.1	1 U
	7/26/2016	5	**238**	17	1 U	0.26 J	0.96 J	0.85	5 U	10.2	10 U	0.2 U	**197**	1.5	1 U
	9/6/2016	5.4	**250**	13.7	1 U	0.31 J	1.2	0.89	5 U	**17.7**	10 U	0.2 U	**183**	2.2	1 U
	11/16/2016	**6.4**	**257**	10.4	1 U	0.28 J	0.58 J	0.95	5 U	4.5 J	10 U	0.058 J	**201**	1.6	1 U
R-MW-2	1/19/2017	4.6	**224**	12.2	1 U	0.14 J	0.86 J	1.2	5 U	9.7	10 U	0.2 U	**160**	1.1	1 U
	3/6/2017	4.6	**217**	12	0.23 J	0.2 J	0.94 J	1.3	5 U	9.6	3.5 J	0.2 U	**168**	1.6	1 U
	6/8/2017	5.1	**242**	11	1 U	0.22 J	0.42 J	1.1	5 U	7	10 U	0.055 J	**174**	1.2	0.054 J
	4/2/2018	4.7	**232**	10.2	1 U	0.5 U	0.61 J	0.76	5 U	7.3 J	10 U	0.2 U	**156**	2.8	1 U
	5/24/2018	4	**211**	10				0.82			10 U		**202**	0.84 J	
	11/5/2018	3.8	**197**	9.5	1 U	0.26 J	1 U	1.2	5 U	6.2 J	10 U		**170**	0.88 J	1 U
	3/10/2016	0.16 J	16.8	21	1 U	0.5 U	1	0.78	5 U	5.9	10 U	0.2 U	**943**	0.66 J	1 U
	5/2/2016	0.098 J	**36.2**	18.3	1 U	0.5 U	1.4	0.8	5 U	6.2	10 U	0.2 U	**826**	0.6 J	1 U
	7/25/2016	0.13 J	**64**	16	1 U	0.5 U	1.5	0.74	5 U	3.4 J	10 U	0.2 U	**811**	0.7 J	1 U
	9/6/2016	0.12 J	**74.3**	15.3	1 U	0.13 J	1.9	0.63	5 U	4.2 J	10 U	0.2 U	**804**	0.66 J	1 U
	11/16/2016	0.32 J	28.6	19.7	1 U	0.5 U	0.89 J	0.8	5 U	6.4	10 U	0.046 J	**869**	0.66 J	1 U
R-MW-3	1/19/2017	0.22 J	**72**	16.3	1 U	0.5 U	0.8 J	0.82	5 U	5.3	10 U	0.2 U	**697**	0.55 J	1 U
	3/6/2017	0.13 J	**80**	15	0.26 J	0.5 U	0.92 J	0.81	5 U	4.9 J	10 U	0.2 U	**753**	0.57 J	1 U
	6/8/2017	0.15 J	**85.6**	14.5	1 U	0.049 J	0.47 J	0.8	5 U	3.8 J	10 U	0.054 J	**676**	0.73 J	0.097 J
	4/2/2018	1 U	**86.1**	14.2	1 U	0.5 U	0.49 J	0.86	5 U	4.0 J	10 U	0.2 U	**655**	1 U	1 U
	5/24/2018	1 U	**96.6**	13.2				0.78			10 U		**759**	0.59 J	
	11/2/2018	0.15 J	**79.7**	12.1	1 U	0.33 J	1 U	0.95	5 U	4.6 J	10 U		**736**	0.71 J	1 U
	3/11/2016	1 U	10.3	314	1 U	0.5 U	0.83 J	0.87	5 U	3.1 J	45.8	0.2 U	96.2	1 U	1 U
	5/3/2016	0.12 J	9	275	1 U	0.5 U	0.51 J	0.81	5 U	2.7 J	41.4	0.2 U	91.4	1 U	1 U
	7/25/2016	1 U	7.2	256	1 U	0.5 U	0.66 J	0.75	5 U	5 U	43.1	0.2 U	95.9	1 U	1 U
	9/6/2016	1 U	7.4	268	1 U	0.048 J	0.86 J	0.73	5 U	5 U	44.8	0.2 U	**105**	0.24 J	1 U
	11/16/2016	0.18 J	6.4	256	1 U	0.032 J	0.57 J	0.8	5 U	5 U	39.9	0.044 J	**109**	1 U	1 U
R-MW-4	1/19/2017	0.11 J	6.7	280	1 U	0.5 U	0.41 J	0.82	5 U	5 U	44.6	0.2 U	96.5	0.12 J	1 U
	3/6/2017	0.029 J	6.8	286	1 U	0.5 U	1.6	0.81	0.82 J	5 U	45.7	0.2 U	**103**	0.12 J	1 U
	6/8/2017	0.034 J	6	254	1 U	0.031 J	0.14 J	0.87	0.73 J	5 U	44.1	0.05 J	**133**	0.11 J	0.04 J
	4/2/2018	1 U	6.7	266	1 U	0.5 U	0.24 J	0.79	5 U	10 U	39.6	0.2 U	80.8	1 U	1 U
	5/24/2018	1 U	7.2	283				0.79			47.8		90	1 U	
	11/1/2018	1 U	6.3	237	1 U	0.5 U	1 U	0.92	0.96 J	10 U	40.3		89.6	0.14 J	1 U
	3/11/2016	1 U	5.2	452	1 U	0.5 U	0.55 J	0.1 J	0.84 J	5 U	5.5 J	0.2 U	1 J	1 U	1 U
	5/3/2016	1 U	3.6	395	1 U	0.5 U	0.38 J	0.19 J	5 U	5 U	10 U	0.2 U	0.74 J	1 U	1 U
	7/25/2016	1 U	4.1	383	1 U	0.5 U	1.1	0.12 J	0.93 J	5 U	6.5 J	0.2 U	0.79 J	1 U	1 U
	9/6/2016	1 U	4.1	391	1 U	0.051 J	1.4	0.18 J	5 U	5 U	6.3 J	0.2 U	0.88 J	1 U	1 U
	11/16/2016	0.2 J	4.3	392	1 U	0.048 J	0.51 J	0.14 J	5 U	5 U	10 U	0.041 J	1.5 J	1 U	1 U
R-MW-5	1/19/2017	0.11 J	4.3	413	1 U	0.5 U	0.52 J	0.12 J	5 U	3 J	10 U	0.2 U	0.86 J	1 U	1 U
	3/6/2017	1 U	4.8	384	0.2 J	0.5 U	0.58 J	0.14 J	5 U	3 J	5 J	0.2 U	20 U	1 U	1 U
	6/8/2017	0.048 J	5.1	374	1 U	0.5 U	0.47 J	0.11 J	5 U	5 U	10 U	0.054 J	1.4 J	1 U	1 U
	4/2/2018	1 U	3.6	378	1 U	0.5 U	0.34 J	0.15 J	5 U	10 U	10 U	0.2 U	20 U	1 U	1 U
	5/24/2018	1 U	3.8	371				0.16 J			5.3 J		20 U	1 U	
	11/1/2018	1 U	3.6	378	1 U	0.5 U	0.15 J	0.2 U	5 U	10 U	8.6 J		20 U	1 U	1 U
	3/11/2016	1 U	0.58 J	132	1 U	0.5 U	0.86 J	0.18 J	5 U	3.2 J	10 U	0.2 U	1.6 J	0.26 J	1 U
	5/2/2016	0.071 J	0.14 J	105	1 U	0.5 U	0.73 J	0.22	5 U	5 U	10 U	0.2 U	1.9 J	0.38 J	1 U
	7/25/2016	0.14 J	0.62 J	119	1 U	0.5 U	1.7	0.15 J	5 U	5 U	10 U	0.2 U	1.5 J	0.7 J	1 U
	9/7/2016	0.1 J	0.97 J	252	1 U	0.052 J	1.1	0.14 J	5 U	5 U	10 U	0.2 U	1.5 J	0.42 J	1 U
	11/16/2016	0.22 J	0.75 J	166	1 U	0.048 J	0.6 J	0.23	5 U	5 U	10 U	0.044 J	1 J	0.25 J	1 U
R-MW-6	1/19/2017	0.14 J	0.5 J	190	1 U	0.5 U	0.46 J	0.24	5 U	2.6 J	7 J	0.2 U	1.6 J	0.24 J	0.09 J
	3/6/2017	0.05 J	0.51 J	144	0.48 J	0.5 U	0.6 J	0.24	5 U	5 U	5.3 J	0.2 U	2.4 J	0.25 J	1 U
	6/8/2017	0.16 J	0.61 J	101	1 U	0.5 U	0.19 J	0.16 J	0.88 J	5 U	10 U	0.2 U	2.5 J	0.72 J	1 U
	4/2/2018	1 U	0.38 J	169	1 U	0.5 U	1 U	0.26	5 U	10 U	10 U	0.2 U	2.3 J	1 U	1 U
	5/25/2018	1 U	1 U	123				0.22			10 U		1.5 J	1 U	
	11/6/2018	1 U	1 U	105	1 U	0.5 U	1 U	0.26	5 U	10 U	5.1 J		20 U	1 U	1 U

TABLE I
GROUNDWATER ANALYTICAL RESULTS - APPENDIX IV CONSTITUENTS
CORRECTIVE MEASURES ASSESSMENT
AMEREN MISSOURI RUSH ISLAND ENERGY CENTER - FESTUS, MISSOURI

Monitoring Well ID	Date Sampled	Constituents													
		Antimony Total	Arsenic Total	Barium Total	Beryllium Total	Cadmium Total	Chromium Total	Fluoride Total	Cobalt Total	Lead Total	Lithium Total	Mercury Total	Molybdenum Total	Selenium Total	Thallium Total
		ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
	Site GWPS	6	30	2000	4	5	100	4	6	15	64.7	2	100	50	2
R-MW-7	3/10/2016	0.55 J	**34.5**	308	1 U	0.5 U	0.56 J	0.31	5 U	3.7 J	34.7	0.2 U	**170**	1 U	1 U
	5/3/2016	1 U	**76.3**	286	1 U	0.5 U	0.41 J	0.36	5 U	5 U	31.6	0.2 U	**171**	1 U	1 U
	7/25/2016	1 U	**91.8**	287	1 U	0.5 U	0.7 J	0.29	5 U	5 U	34.4	0.2 U	**185**	1 U	1 U
	9/7/2016	1 U	**96.3**	285	1 U	0.061 J	2.1	0.27	5 U	5 U	32.4	0.2 U	**188**	1 U	1 U
	11/16/2016	0.24 J	**90.7**	284	1 U	0.041 J	0.48 J	0.32	5 U	5 U	29.2	0.056 J	**162**	1 U	1 U
	1/19/2017	0.14 J	**96.6**	328	1 U	0.5 U	0.27 J	0.31	5 U	5 U	38.7	0.2 U	**180**	1 U	0.063 J
	3/6/2017	0.029 J	**92.3**	308	0.21 J	0.5 U	4.8	0.35	5 U	5 U	35.5	0.2 U	**196**	1 U	1 U
	6/8/2017	0.086 J	**105**	289	1 U	0.024 J	0.14 J	0.28	5 U	5 U	28.9	0.2 U	**152**	0.097 J	1 U
	4/2/2018	1 U	**90.8**	307	1 U	0.5 U	0.15 J	0.36	5 U	10 U	33.4	0.2 U	**190**	1 U	1 U
	5/25/2018	1 U	**91.6**	305				0.35			35.1		**187**	1 U	
	11/2/2018	1 U	**84.9**	280	1.2 J	0.065 J	1 U	0.33	1.4 J	10 U	30.1		**162**	1 U	1 U
R-MW-B1	3/10/2016	0.065 J	27.7	551	0.42 J	0.5 U	0.44 J	0.1 J	5 U	3.1 J	64.2	0.2 U	0.97 J	1 U	1 U
	5/2/2016	1 U	19.4	488	1 U	0.5 U	1 U	0.2	5 U	5 U	62.9	0.2 U	0.54 J	1 U	1 U
	7/25/2016	1 U	24.3	496	1 U	0.5 U	1.8	0.14 J	5 U	5 U	62.9	0.2 U	0.55 J	1 U	1 U
	9/6/2016	1 U	22.6	490	1 U	0.049 J	1.4	0.098 J	5 U	3.1 J	61.5	0.2 U	20 U	1 U	1 U
	11/16/2016	0.19 J	30	464	1 U	0.046 J	0.38 J	0.14 J	5 U	5 U	54.7	0.045 J	20 U	1 U	1 U
	1/19/2017	0.13 J	24.3	556	1 U	0.5 U	0.24 J	0.11 J	5 U	5 U	64.7	0.2 U	1.9 J	1 U	0.071 J
	3/6/2017	0.028 J	23.4	514	1 U	0.5 U	2	0.16 J	5 U	5 U	64.4	0.2 U	1.5 J	1 U	1 U
	6/8/2017	1 U	29.5	477	1 U	0.5 U	0.06 J	0.11 J	5 U	5 U	55.6	0.051 J	1.9 J	1 U	1 U
	4/3/2018	1 U	24.3	494	1 U	0.5 U	0.087 J	0.15 J	5 U	10 U	61.1	0.2 U	20 U	1 U	1 U
	5/24/2018	1 U	20.4	456				0.16 J			61.9		20 U	1 U	
	11/2/2018	1 U	24.8	432	1 U	0.5 U	1 U	0.2 U	5 U	10 U	60.2		20 U	1 U	1 U
R-MW-B2	3/11/2016	0.077 J	2.6	434	1 U	0.5 U	0.82 J	0.13 J	5 U	5 U	9.6 J	0.2 U	1.2 J	1 U	1 U
	5/2/2016	1 U	2.6	398	1 U	0.5 U	0.42 J	0.21	5 U	2.9 J	10.8	0.2 U	1 J	1 U	1 U
	7/26/2016	1 U	2.8	382	1 U	0.5 U	0.6 J	0.14 J	5 U	5 U	9.6 J	0.2 U	0.94 J	1 U	1 U
	9/6/2016	1 U	3.1	407	1 U	0.044 J	1.8		5 U	5 U	9.8 J	0.2 U	0.82 J	1 U	1 U
	10/13/2016							0.19 J							
	11/16/2016	0.19 J	3.6	405	1 U	0.048 J	1 U	0.18 J	5 U	5 U	5.5 J	0.044 J	0.57 J	1 U	1 U
	1/19/2017	0.11 J	3.7	448	1 U	0.5 U	0.42 J	0.15 J	5 U	5 U	9.7 J	0.2 U	0.98 J	1 U	1 U
	3/6/2017	1 U	3	450	0.25 J	0.5 U	0.55 J	0.17 J	5 U	5 U	11.8	0.2 U	20 U	1 U	1 U
	6/8/2017	1 U	3.2	435	1 U	0.5 U	0.15 J	0.15 J	5 U	2.8 J	7.1 J	0.05 J	20 U	1 U	1 U
	4/2/2018	1 U	1.9	430	1 U	0.5 U	0.15 J	0.18 J	5 U	10 U	9.6 J	0.2 U	20 U	1 U	1 U
	5/24/2018	1 U	2.1	419				0.18 J			9.3 J		20 U	1 U	
	11/6/2018	1 U	2.2	415	1 U	0.5 U	1 U	0.22	5 U	10 U	14.3		20 U	0.1 J	1 U
R-P-01S	11/1/2018	1 U	19.6	290	1 U	0.5 U	0.11 J	0.23	1.9 J	10 U	27.8	0.2 U	20 U	0.31 J	1 U
R-P-03D	11/5/2018	1 U	0.57 J	471	1 U	0.5 U	1 U	0.2 U	3.7 J	10 U	25.5	0.2 U	20 U	1 U	1 U
R-P-03S	11/5/2018	1 U	**239**	253	1 U	0.5 U	1 U	0.21	5 U	10 U	10.4	0.2 U	5.1 J	0.2 J	1 U
R-P-05I	11/1/2018	1 U	4.8	526	1 U	0.5 U	0.1 J	0.25	1 J	10 U	10 U	0.2 U	20 U	1 U	1 U
R-P-05S	11/1/2018	1 U	**149**	157	1 U	0.5 U	0.37 J	0.36	5 U	10 U	17.6	0.2 U	10.6 J	0.22 J	1 U
R-P-08D	11/5/2018	1 U	1.5	99	1 U	0.5 U	1 U	0.29	5 U	10 U	8.7 J	0.2 U	43.6	1 U	1 U
R-P-08S	11/5/2018	1 U	**209**	220	1 U	0.5 U	1 U	0.45	5 U	10 U	15.7	0.2 U	21.5	0.22 J	1 U
R-P10S	11/5/2018	0.99 J	11.4	89.2	1 U	0.084 J	1 U	0.53	5 U	10 U	10.4	0.2 U	**150**	0.2 J	1 U
R-P-13D	11/5/2018	1 U	0.29 J	86.6	1 U	0.40 J	1 U	0.32	5 U	10 U	**78.7**	0.2 U	**1300**	0.13 J	1 U
R-P-13I	11/5/2018	1 U	23.6	46.9	1 U	0.096 J	1 U	1.1	5 U	10 U	12	0.2 U	**203**	0.34 J	1 U
R-P-13S	11/5/2018	0.11 J	0.78 J	67.7	1 U	0.061 J	1 U	0.4	5 U	10 U	39.1	0.2 U	35.1	0.089 J	1 U
R-P-17D	11/5/2018	1 U	1.3	117	1 U	0.23 J	1 U	0.58	5 U	10 U	41.4	0.2 U	**732**	0.24 J	1 U
R-P-17I	11/2/2018	0.90 J	**107**	13	1 U	1.1	1.4	2.1	5 U	**31.2**	10 U	0.2 U	100	6.5	1 U
R-P-17S	11/2/2018	0.24 J	**38**	57.3	1 U	0.064 J	1 U	1.5	5 U	10 U	21.4	0.2 U	**125**	0.52 J	1 U
R-P-19D	11/5/2018	0.086 J	0.71 J	121	1 U	0.34 J	1 U	1.3	5 U	10 U	24.5	0.2 U	**1040**	0.30 J	1 U
R-P-19I	11/5/2018	**6.4**	**293**	15.9	1 U	0.59	1 U	1.4	5 U	12.5	16.1	0.2 U	**368**	3.4	1 U
R-P-19S	11/5/2018	0.096 J	**37.3**	260	1 U	0.5 U	1 U	0.41	5 U	10 U	42.1	0.2 U	26	0.15 J	1 U

TABLE I
GROUNDWATER ANALYTICAL RESULTS - APPENDIX IV CONSTITUENTS
CORRECTIVE MEASURES ASSESSMENT
AMEREN MISSOURI RUSH ISLAND ENERGY CENTER - FESTUS, MISSOURI

Monitoring Well ID	Date Sampled	Constituents													
		Antimony Total	Arsenic Total	Barium Total	Beryllium Total	Cadmium Total	Chromium Total	Fluoride Total	Cobalt Total	Lead Total	Lithium Total	Mercury Total	Molybdenum Total	Selenium Total	Thallium Total
		ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	mg/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L	ug/L
	Site GWPS	6	30	2000	4	5	100	4	6	15	64.7	2	100	50	2
R-P-21D	11/2/2018	1 U	0.56 J	44.1	1 U	0.14 J	1 U	1.7	5 U	10 U	49.8	0.2 U	**422**	0.23 J	1 U
R-P-21I	11/2/2018	1 U	4.9	33.4	1 U	0.063 J	1 U	1.3	5 U	10 U	18.4	0.2 U	61.2	0.61 J	1 U
R-P-21S	11/2/2018	1 U	14	279	0.24 J	0.5 U	1 U	0.41	5 U	10 U	20.6	0.2 U	5.5 J	0.21 J	1 U
R-P-22D	11/2/2018	0.10 J	12.6	69.4	1 U	0.15 J	1.1 J	2.2	5 U	10 U	20.5	0.2 U	**343**	0.77 J	1 U
R-P-22I	11/2/2018	1 U	9.7	116	1 U	0.036 J	1 U	0.82	5 U	10 U	23.2	0.2 U	33.8	0.087 J	1 U
R-P-22S	11/1/2018	0.096 J	0.81 J	119	1 U	0.070 J	0.078 J	0.51	1.4 J	10 U	36.6	0.2 U	13.5 J	0.20 J	1 U
R-P-29D	11/6/2018	1 U	1.1	152	1 U	0.5 U	1 U	0.28	5 U	10 U	47.9	0.2 U	1.6 J	0.091 J	1 U
R-P-29S	11/6/2018	0.093 J	**51.7**	335	1 U	0.057 J	1 U	0.26	1.4 J	10 U	11.1	0.2 U	1.1 J	0.17 J	1 U
	12/6/2018	1 U	**49**	384	0.25 J	0.053 J	0.14 J	0.2 U	1.7 J	10 U	17	0.2 U	1.8 J	0.12 J	1 U
R-P-30S	11/5/2018	0.12 J	1.1	110	1 U	0.058 J	1 U	0.26	5 U	10 U	47.7	0.2 U	1.3 J	0.32 J	1 U
R-P-31S	11/6/2018	1 U	15.6	141	1 U	0.037 J	1 U	0.39	5 U	10 U	8.3 J	0.2 U	7.8 J	0.14 J	1 U

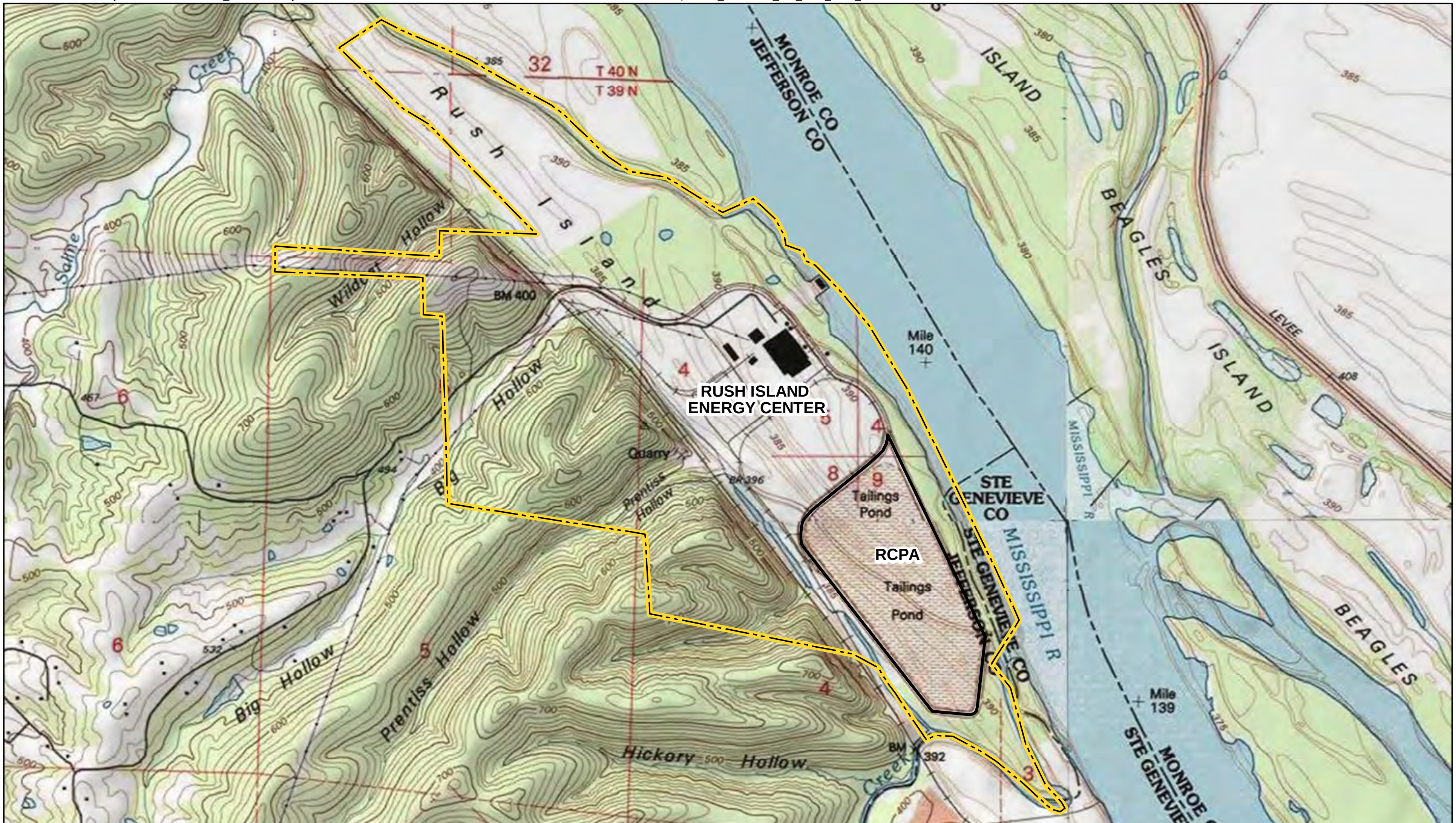
Notes:
49 Bold denotes concentration exceeding the GWPS
Blank cells - Constituent not included in this analysis.
mg/L - milligrams per liter.
ug/L - micrograms per liter.
GWPS - Groundwater Protection Standard.

Qualifiers:
J - Value is estimated.
U - Constituent was not detected, value is the reporting limit.

Site GWPS is either the MCL/Health Based GWPS or based on background levels (calculated as described in the Statistical Analysis Plan for Assessment Monitoring), whichever is higher.
GWPS and background values calculated using baseline sampling results from monitoring wells MW-B1 and MW-B2.

FIGURES

GIS FILE PATH: \\haleyaldrich.com\share\cle_common\Projects\132002 - Ameren Ash Pond Closure Assessment\007-Rush Island\GIS\Maps\2019_04\132002_007_0001_SITE_LOCUS.mxd — USER: hwachholz — LAST SAVED: 4/5/2019 3:41:25 PM



LEGEND

RCPA SURFACE IMPOUNDMENT

RUSH ISLAND ENERGY CENTER PROPERTY BOUNDARY

NOTES
1. ALL LOCATIONS AND BOUNDARIES ARE APPROXIMATE.
2. IMAGERY SOURCE: ESRI

0 1,000 2,000
SCALE IN FEET

HALEY ALDRICH

CORRECTIVE MEASURES ASSESSMENT
AMEREN MISSOURI RUSH ISLAND ENERGY CENTER
FESTUS, MISSOURI

SITE LOCATION MAP

APRIL 2019

FIGURE 1-1

LEGEND

— — — AMEREN PROPERTY LINE

LIMITS OF RCPA SURFACE IMPOUNDMENT

CCR MONITORING WELL LOCATION

As **ARSENIC CONCENTRATION ABOVE GWPS**

Mo **MOLYBDENUM CONCENTRATION ABOVE GWPS**

NOTES

1. AERIAL IMAGE FROM GOOGLE EARTH PRO DATED 12 OCTOBER 2015.
2. ALL BOUNDARIES AND LOCATIONS ARE APPROXIMATE
3. CCR = COAL COMBUSTION RESIDUALS
4. GWPS = GROUNDWATER PROTECTION STANDARDS
5. REFER TO TABLE I FOR GROUNDWATER ANALYTICAL RESULTS.
6. NATURE AND EXTENT WELLS WILL BE ADDED FOLLOWING COMPLETION OF STATISTICAL ANALYSIS.

0 400 800

SCALE IN FEET

HALEY ALDRICH

CORRECTIVE MEASURES ASSESSMENT
AMEREN RUSH ISLAND ENERGY CENTER
FESTUS, MISSOURI

MONITORING WELL LOCATIONS WITH STATISTICALLY SIGNIFICANT LEVELS ABOVE GWPS

SCALE: AS SHOWN

MAY 2019

FIGURE 2-1

VARI, KATALIN \\HALEYALDRICH.COM\SHARE\CLE_COMMON\PROJECTS\129530_AMEREN RUSH ISLAND POND CLOSURE\CAD\FIGURES\CORRECTIVE MEASURES\132002-007_FIG 2-1_MW LOC.DWG

Printed: 4/9/2019 10:02:35 AM Layout: FIGURE 2-1

LEGEND

— — — AMEREN PROPERTY LINE

LIMITS OF RCPA SURFACE IMPOUNDMENT

CCR MONITORING WELL LOCATION

NATURE AND EXTENT MONITORING WELL LOCATION

NOTES

1. AERIAL IMAGE FROM GOOGLE EARTH PRO DATED 12 OCTOBER 2015.
2. ALL BOUNDARIES AND LOCATIONS ARE APPROXIMATE
3. CCR = COAL COMBUSTION RESIDUALS

0 600 1200
SCALE IN FEET

HALEY ALDRICH

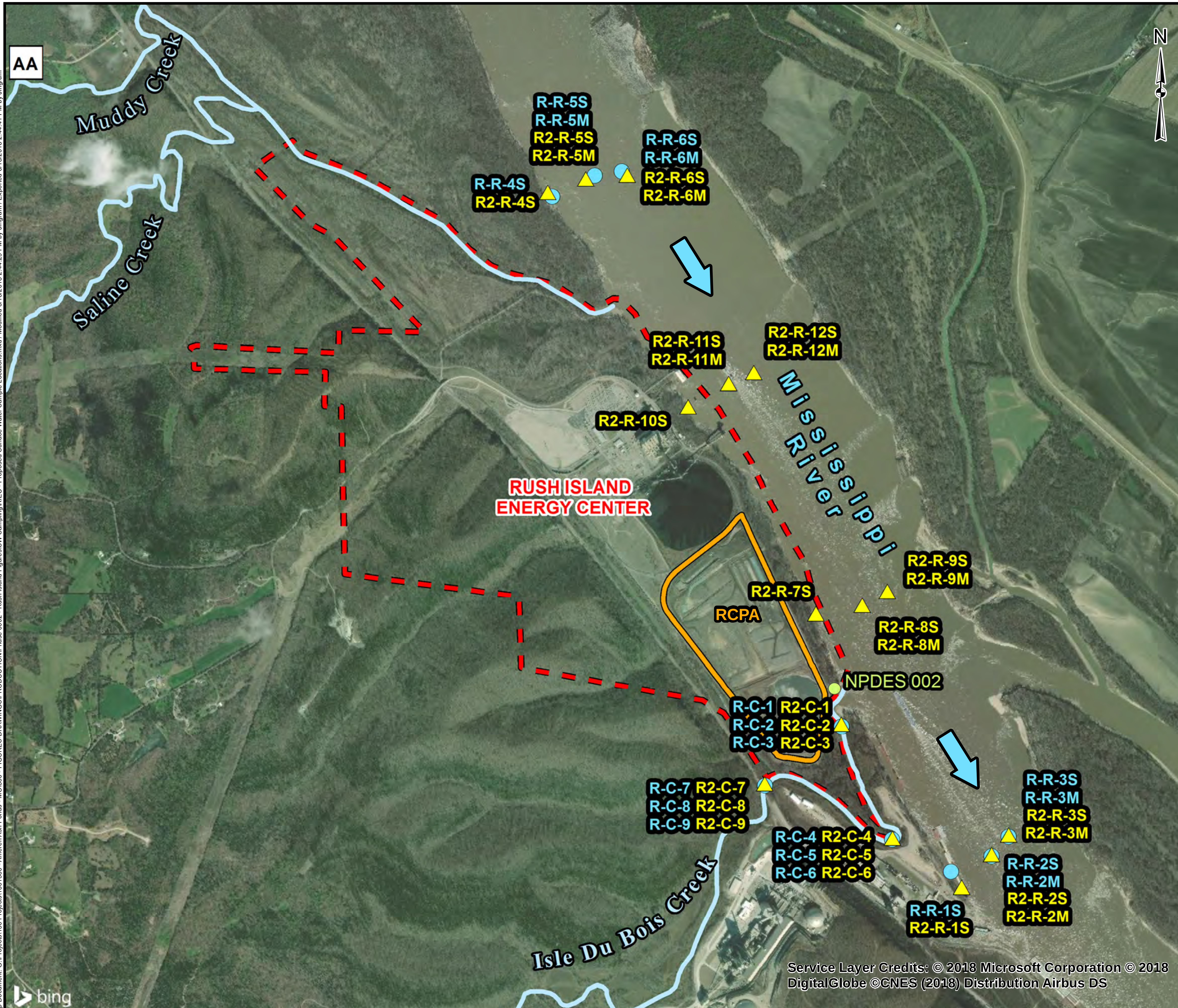
CORRECTIVE MEASURES ASSESSMENT
AMEREN RUSH ISLAND ENERGY CENTER
FESTUS, MISSOURI

SITE FEATURES

SCALE: AS SHOWN

MAY 2019

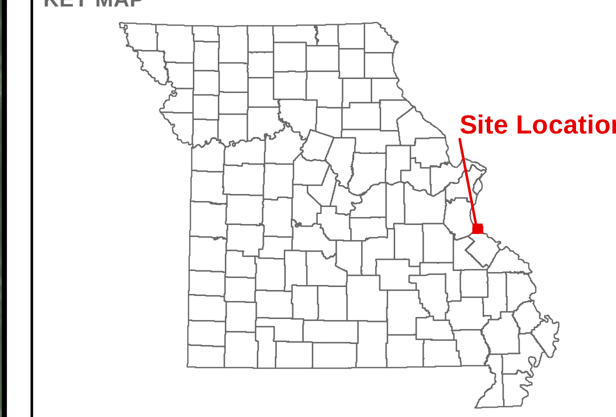
FIGURE 2-2



LEGEND

- Approximate Rush Island Property Boundary
- RCPA Surface Impoundment
- Ameren NPDES Outfall
- April 2014 Surface Water Sample
- May 2018 Surface Water Sample
- Surface Water Flow Direction

KEY MAP



NOTES

1.) ALL LOCATIONS AND BOUNDARIES ARE APPROXIMATE.
2.) SAMPLE LOCATIONS BASED ON HANDHELD TRIMBLE GPS MEASUREMENTS. SAMPLE LOCATION REPRESENTS CENTERPOINT BETWEEN SAMPLE STARTING AND ENDING LOCATION.
3.) NPDES - NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM.
4.) PREFIX R- USED FOR SAMPLES COLLECTED IN APRIL 2014 AND R2- USED FOR SAMPLES COLLECTED IN MAY 2018.

REFERENCES

1.) AMEREN, 2012. AMEREN MISSOURI RUSH ISLAND ENERGY CENTER, RUSH ISLAND PROPERTY CONTROL MAP, JANUARY 2012.
2.) COORDINATE SYSTEM: NAD 1983 STATEPLANE MISSOURI EAST FIPS 2401 FEET.

0 2,000 4,000 Feet

CLIENT
AMEREN MISSOURI
RUSH ISLAND ENERGY CENTER

Ameren

PROJECT
AMEREN HYDROGEOLOGICAL CONSULTING

TITLE
SURFACE WATER SAMPLE LOCATIONS
RUSH ISLAND ENERGY CENTER

CONSULTANT

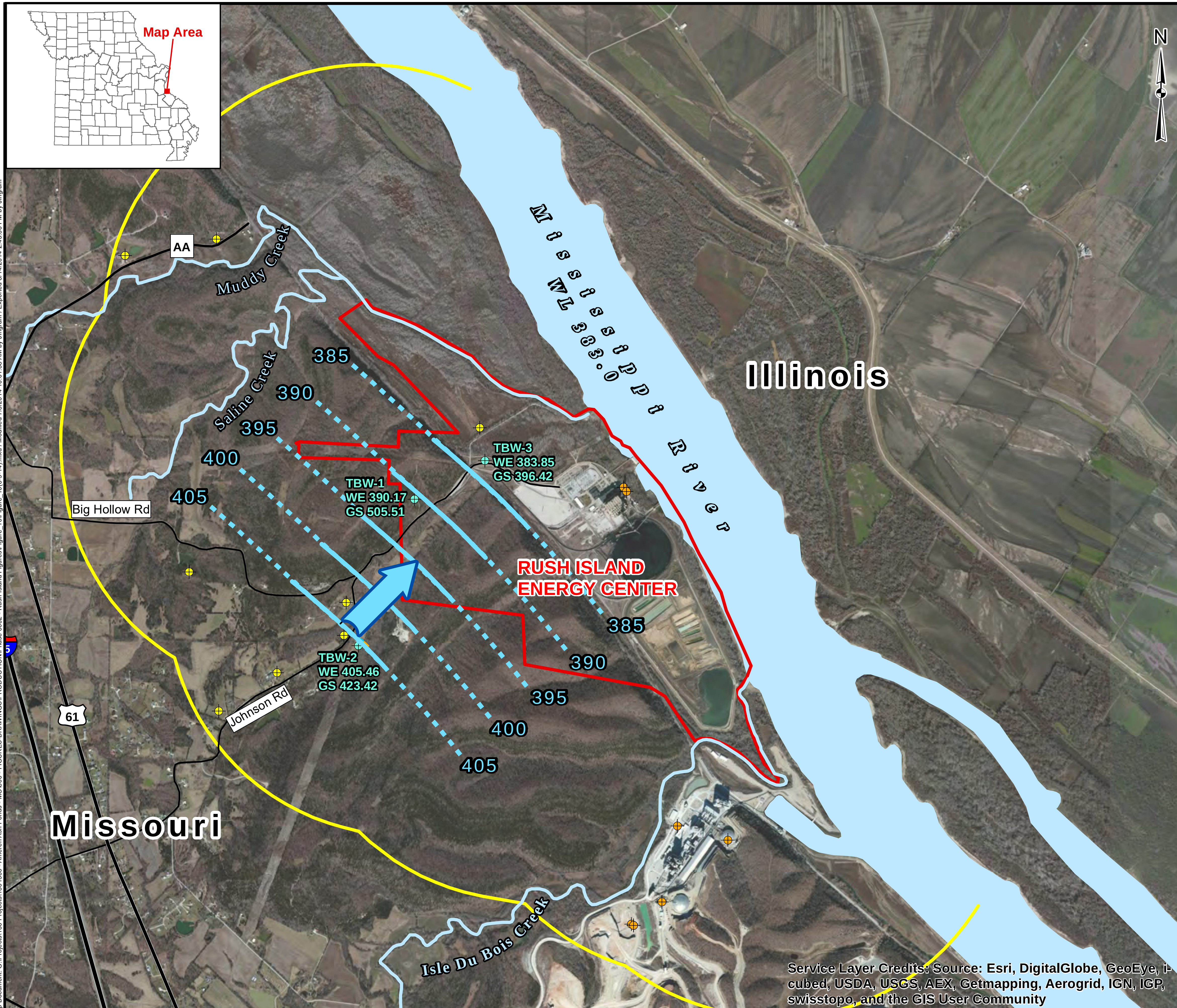
GOLDER

YYYY-MM-DD	2018-05-29
PREPARED	JS
DESIGN	JSI
REVIEW	JSI
APPROVED	MNH

PROJECT No. 130-1560 | Rev. 0 | **Figure 2-3**

TITLE

BEDROCK GROUNDWATER SAMPLING LOCATIONS AND GROUNDWATER FLOW DIRECTION



LEGEND

- Rush Island Property Boundary
- Approximate 1-Mile Radius
- Non-Community Public Well
- Private Well
- TBW-1 WE 390.17 GS 505.51 — Groundwater Sampling Location with Groundwater Elevation (WE) and Ground Surface (GS) Elevation (Feet Above MSL)
- Groundwater Potentiometric Surface Contour (Feet Above MSL) (Dashed Where Inferred)
- Groundwater Flow Direction

NOTES

1.) All boundaries and locations are approximate.
2.) Well locations were surveyed by Zahner & Associates.
3.) Groundwater elevations measured on June 9th, 2014 by Golder.
4.) MSL - mean sea level.
5.) WE - groundwater elevation (feet above MSL).
6.) GS - ground surface elevation (feet above MSL).
7.) Ft - feet.
8.) See Figure 3 and Table 2 for more information on the wells within approximately 1-mile of the Rush Island Energy Center.
9.) Wells outside of the approximate 1-mile radius and those outside of Missouri are not shown.

REFERENCES

1.) Ameren, 2012. Ameren Missouri Rush Island Energy Center, Rush Island Property Control Map, January 2012.
2.) CARES. 2013. Public Drinking Water System Reports. Center for Applied Research and Environmental Systems.
3.) MDNR. 2013a. Missouri Well Information Management System (WIMS), Wellhead Protection Program. Missouri Department of Natural Resources.
4.) MDNR. 2013b. Geologic Well Logs of Missouri, Water Resource Center. Missouri Department of Natural Resources.
5.) MDNR, 2014a. Geosciences Technical Resource Assessment Tool (GeoSTRAT). Missouri Department of Natural Resources.
6.) MEGA. 2007. Missouri Environmental Geology Atlas. A Collection of Statewide Geographic Information System Data.
7.) MSDIS. 2013. Missouri Spatial Data Information Service.
8.) COORDINATE SYSTEM: NAD 1983 StatePlane Missouri East FIPS 2401 Feet.

0 2,000 4,000 Feet

August 2014

PROJECT

AMEREN MISSOURI RUSH ISLAND ENERGY CENTER
JEFFERSON COUNTY, MISSOURI

PROJECT No. 130-1560			Figure_10(6-9-14).mxd
DESIGN	-	-	SCALE: AS SHOWN / REV. 1
GIS	JSI	6/10/2014	FIGURE 2-4
CHECK	LAB	6/10/2014	
REVIEW	MNH	6/15/2014	

Golder Associates

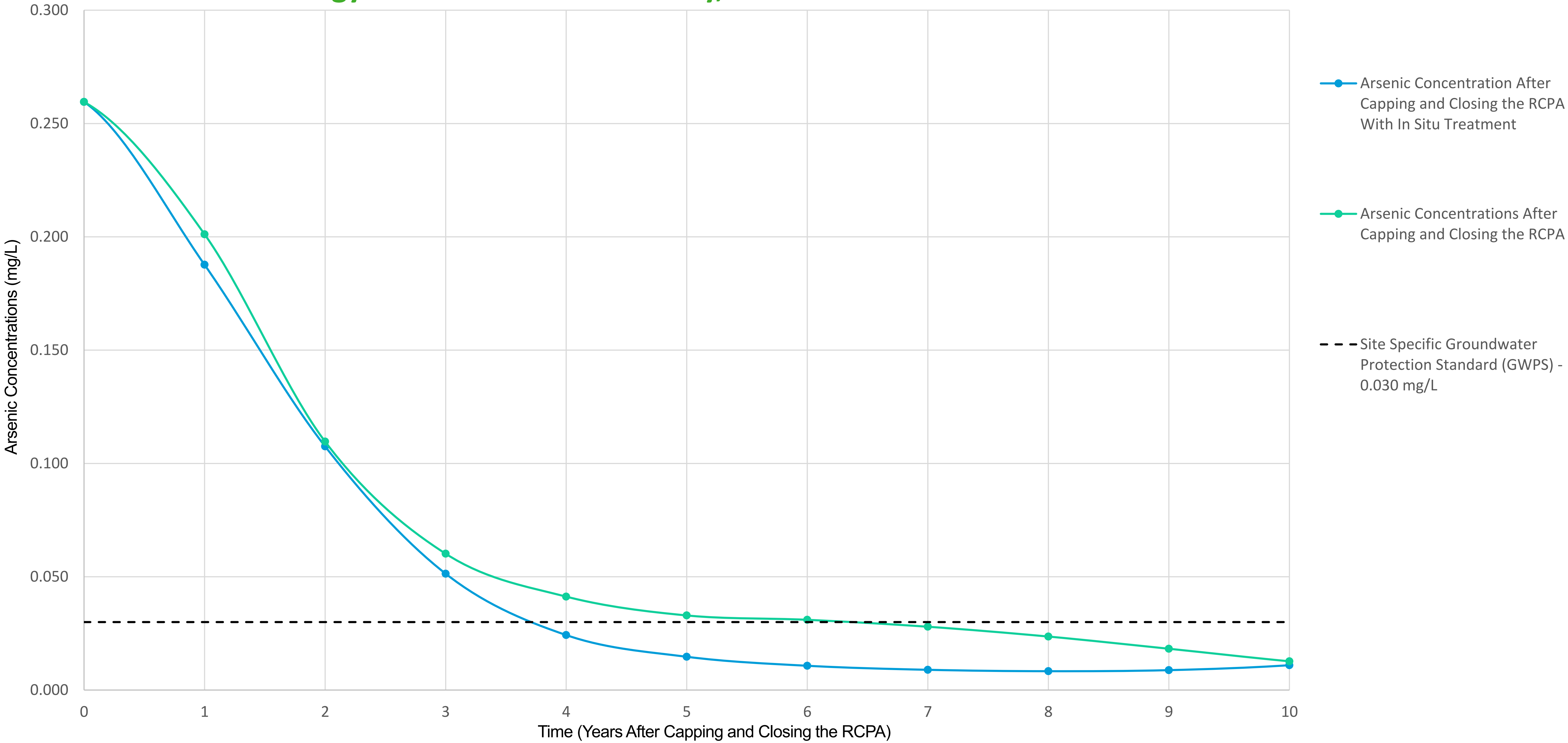
Map Document: G:\Projects\130 Projects\1301560 - Ameren Ash Ponds - MO\800 - FIGURES-DRAWINGS\PRODUCTION\Phase 0002 - Rush Island Figures\Figure_10\Figure_10(6-9-14).mxd / Modified 7/3/2014 10:01:58 AM by JIngram / Exported 8/14/2014 2:45:36 PM by JIngram

FIGURE 4-1
REMEDIAL ALTERNATIVE ROADMAP
CORRECTIVE MEASURES ASSESSMENT
RUSH ISLAND SURFACE IMPOUNDMENT (RCPA)
RUSH ISLAND ENERGY CENTER - JEFFERSON COUNTY, MISSOURI

<table>
<tr><th rowspan="2">Alternative Number</th><th rowspan="2">Remedial Alternative Description</th><th rowspan="2">RCPA Closure Description</th><th colspan="3">Groundwater Remedy Components</th></tr>
<tr><th>A. Groundwater Remedy Approach</th><th>B. Groundwater Treatment Method</th><th>C. Post-Closure Actions</th></tr>
<tr><td>1</td><td>Closure In Place (CIP) with Capping and Monitored Natural Attenuation (MNA)</td><td>CIP with Synthetic Cap</td><td rowspan="2">Natural Attenuation with Monitoring
Mitigate off-site migration of groundwater with CCR constituents above GWPS through process of natural attenuation</td><td rowspan="2">No Active Treatment
No active treatment technologies for groundwater to address CCR constituents</td><td rowspan="2">MNA
Long-term groundwater monitoring to confirm reduction of CCR constituents</td></tr>
<tr><td>2</td><td>CIP with In-Situ Stabilization (ISS), Capping and MNA</td><td>CIP with ISS and Synthetic Cap</td></tr>
<tr><td>3</td><td>CIP with Capping and In-Situ Groundwater Treatment</td><td>CIP with Synthetic Cap</td><td>Subsurface Treatment System
Mitigate off-site migration of groundwater with CCR constituents above GWPS using in-situ amendments</td><td>In-Situ Treatment
Subsurface treatment to reduce Appendix IV constituent concentrations in groundwater</td><td>In-Situ Treatment Long-Term
Continue periodic in-situ treatment of groundwater to maintain reduction of CCR constituents in groundwater</td></tr>
<tr><td>4</td><td>CIP with Capping and Hydraulic Containment through Groundwater Pumping and Ex-Situ Treatment</td><td>CIP with Synthetic Cap</td><td>Hydraulic Containment
Mitigate off-site migration of groundwater with CCR constituents above GWPS using extraction wells</td><td rowspan="2">Ex-Situ Treatment
Treatment system (ion exchange or reverse osmosis) to remove CCR constituents from groundwater and discharge under applicable permits</td><td rowspan="2">Pump & Treat Long-Term
Continue to operate hydraulic containment system to maintain reduction of CCR constituents in groundwater</td></tr>
<tr><td>5</td><td>CIP with Capping and Hydraulic Containment through Groundwater Pumping and Ex-Situ Treatment and Barrier Wall</td><td>CIP with Synthetic Cap</td><td>Barrier Wall with Hydraulic Containment
Mitigate off-site migration of groundwater with CCR constituents above GWPS using extraction wells and a low permeability barrier wall</td></tr>
<tr><td>6</td><td>Closure by Removal (CBR) with MNA</td><td>CBR</td><td>Natural Attenuation with Monitoring
Mitigate off-site migration of groundwater with CCR constituents above GWPS through process of natural attenuation</td><td>No Active Treatment
No active treatment technologies for groundwater to address CCR constituents</td><td>MNA
Long-term groundwater monitoring to confirm reduction of CCR constituents</td></tr>
</table>

Modeled Arsenic Concentrations After Capping and Closing the RCPA

Rush Island Energy Center – Jefferson County, Missouri



NOTE(S)

1.) mg/L – Milligrams per liter
2.) GWPS – Groundwater Protection Standard. This is a site specific value.
3.) Concentrations are representative of the intermediate zone of the alluvial aquifer at CCR Rule Monitoring Well MW-2.

CLIENT
AMEREN MISSOURI
RUSH ISLAND ENERGY CENTER

CONSULTANT
GOLDER

YYYY-MM-DD	2019-04-26
PREPARED	JSI
DESIGN	JSI
REVIEW	EMS
APPROVED	KB

PROJECT
GROUNDWATER MONITORING PROGRAM

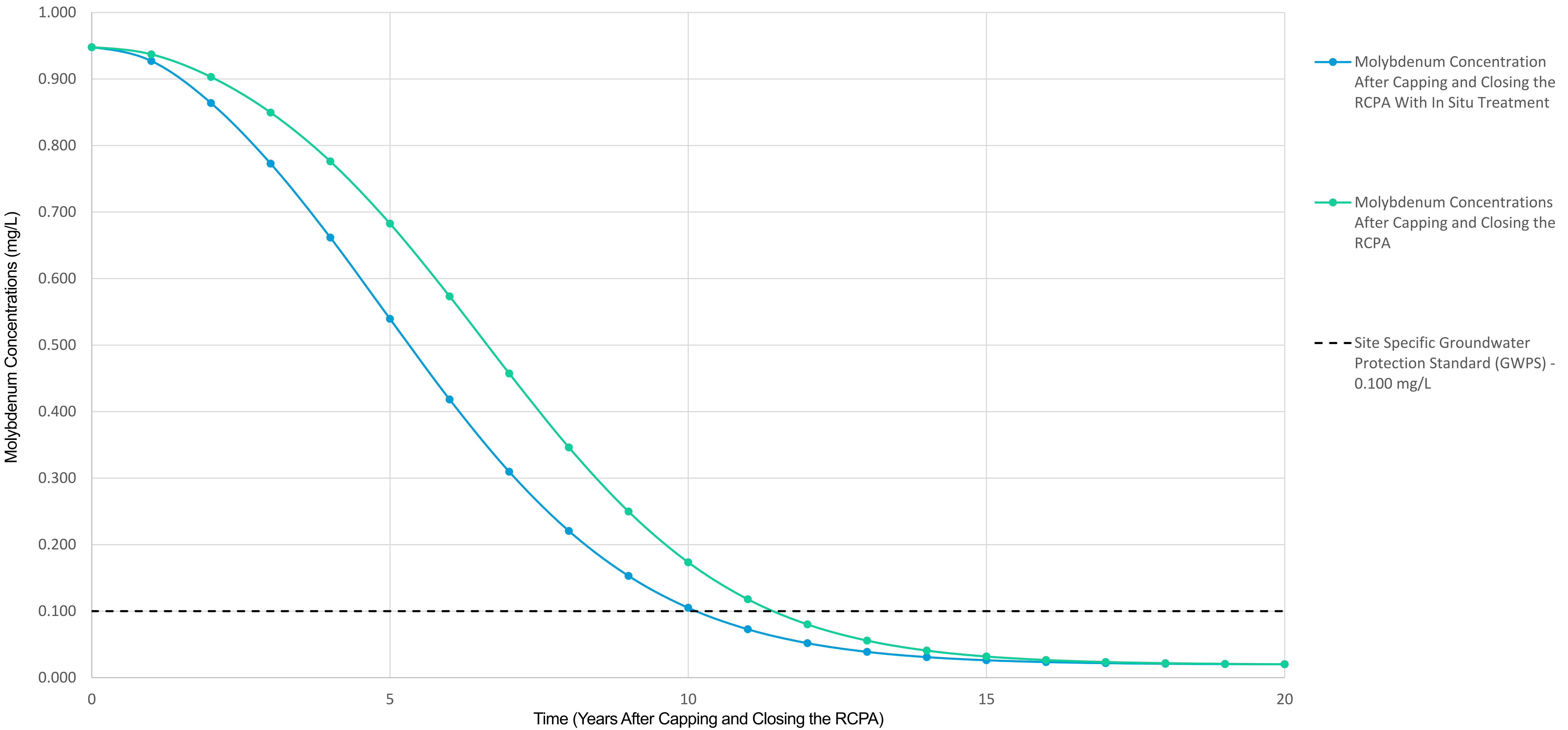
TITLE
Modeled Arsenic Concentrations After Capping and Closing the RCPA

PROJECT No.
153-140601

Figure
Figure 4-2

Modeled Molybdenum Concentrations After Capping and Closing the RCPA

Rush Island Energy Center – Jefferson County, Missouri



NOTE(S)

1.) mg/L – Milligrams per liter
2.) GWPS – Groundwater Protection Standard. This is a site specific value.
3.) Concentrations are representative of the intermediate zone of the alluvial aquifer at CCR Rule Monitoring Well MW-3.

CLIENT
AMEREN MISSOURI
RUSH ISLAND ENERGY CENTER

CONSULTANT
GOLDER

YYYY-MM-DD	2019-04-26
PREPARED	JSI
DESIGN	JSI
REVIEW	EMS
APPROVED	KB

PROJECT
GROUNDWATER MONITORING PROGRAM

TITLE
Modeled Molybdenum Concentrations After Capping and Closing the RCPA

PROJECT No.
153-140601

Figure
Figure 4-3

APPENDIX A

Surface Water Screening Tables

Appendix A
Rush Island Energy Center Surface Water Screening Tables – TOC

TABLES

TABLE 1
HUMAN HEALTH SCREENING LEVELS
RUSH ISLAND ENERGY CENTER, JEFFERSON COUNTY, FESTUS, MO
AMEREN MISSOURI

		Drinking Water Screening Levels (mg/L)				Surface Water Screening Levels (mg/L)	
Constituent	**CASRN**	**MCLs (b)**	**SMCLs (b)**	**November 2018 USEPA Tapwater RSLs (c)**	**Site-Specific Groundwater Protection Standards (d)**	**Drinking Water (e)**	**Recreational Use (a) (f)**
Antimony	7440-36-0	0.006	NA	0.0078 (m)	0.006	0.006	0.64
Arsenic	7440-38-2	0.01	NA	0.000052	0.03	0.01	0.00014 (i)
Barium	7440-39-3	2	NA	3.8	2	2	NA
Beryllium	7440-41-7	0.004	NA	0.025	0.004	0.004	NA
Boron	7440-42-8	NA	NA	4	NA	4	NA
Cadmium	7440-43-9	0.005	NA	0.0092	0.005	0.005	NA
Calcium	7440-70-2	NA	NA	NA	NA	NA	NA
Chloride	7647-14-5	NA	250	NA	NA	250	NA
Chromium	16065-83-1 (g)	0.1 (j)	NA	22 (n)	0.1	0.1	NA
Cobalt	7440-48-4	NA	NA	0.006	0.006	0.006	NA
Fluoride	16984-48-8	4	2	0.8	4	4	NA
Lead	7439-92-1	0.015 (k)	NA	0.015	0.015	0.015	NA
Lithium	7439-93-2	NA	NA	0.04	0.0647	0.04	NA
Mercury	7487-94-7 (h)	0.002 (l)	NA	0.0057 (o)	0.002	0.002	NA
Molybdenum	7439-98-7	NA	NA	0.1	0.1	0.1	NA
Radium 226/228 (pCi/L)	RADIUM226228	5	NA	NA	5	5	NA
Selenium	7782-49-2	0.05	NA	0.1	0.05	0.05	4.2
Sulfate	7757-82-6	NA	250	NA	NA	250	NA
Thallium	7440-28-0	0.002	NA	0.0002 (p)	0.002	0.002	0.00047
Total Dissolved Solids	TDS	NA	500	NA	NA	500	NA
pH (std)	PHFLD	NA	6.5 - 8.5	NA	NA	6.5 - 8.5	NA

Notes:
AWQC - Ambient Water Quality Criteria.
CASRN - Chemical Abstracts Service Re
GWPS - Groundwater Protection Standar
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) - USEPA National Recommended Water Quality Criteria. USEPA Office of Water and Office of Science and Technology.
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.
(b) - USEPA 2018 Edition of the Drinking Water Standards and Health Advisories. Spring 2018.
http://water.epa.gov/drink/contaminants/index.cfm
(c) - USEPA Regional Screening Levels (November 2018). Values for tapwater.
http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/index.htm
(d) - The site GWPS is either the MCL/Health Based GWPS or based on background levels, whichever is higher. GWPS and background values calculated using baseline sampling results from monitoring wells MW-B1 and MW-B2. See text for additional information.
(e) - Selected Drinking Water Screening Level uses the following hierarchy:
Federal USEPA MCL for Drinking Water.
Federal USEPA SMCL for Drinking Water.
Federal November 2018 USEPA Tapwater RSL.
(f) - The selected Human Health Recreational Use Screening Level is the Federal USEPA AWQC for Human Health Consumption of Organism Only.
(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.

TABLE 2
ECOLOGICAL SCREENING LEVELS - MISSISSIPPI RIVER
RUSH ISLAND ENERGY CENTER, JEFFERSON COUNTY, FESTUS, MO
AMEREN MISSOURI

		Federal Water Quality Criteria (mg/L)				Federal Water Quality Criteria (mg/L)			
		Site-Specific USEPA Aquatic Life AWQC - 2018 Hardness Data Freshwater Acute (a)		Site-Specific USEPA Aquatic Life AWQC - 2018 Hardness Data Freshwater Chronic (a)		Site-Specific USEPA Aquatic Life AWQC - 2014 Hardness Data Freshwater Acute (b)		Site-Specific USEPA Aquatic Life AWQC - 2014 Hardness Data Freshwater Chronic (b)	
Constituent	**CASRN**	**Total**	**Dissolved**	**Total**	**Dissolved**	**Total**	**Dissolved**	**Total**	**Dissolved**
Antimony	7440-36-0	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic	7440-38-2	0.34	0.34	0.15	0.15	0.34	0.34	0.15	0.15
Barium	7440-39-3	NA	NA	NA	NA	NA	NA	NA	NA
Beryllium	7440-41-7	NA	NA	NA	NA	NA	NA	NA	NA
Boron	7440-42-8	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	7440-43-9	0.0047 (c)	0.0043 (d)	0.0017 (c)	0.0014 (d)	0.0041 (f)	0.0037 (g)	0.0015 (f)	0.0013 (g)
Calcium	7440-70-2	NA	NA	NA	NA	NA	NA	NA	NA
Chloride	16887-00-6	860	NA	230	NA	860	NA	230	NA
Chromium	7440-47-3	3.9 (e,c)	1.2 (e,d)	0.18 (e,c)	0.16 (e,d)	3.4 (e,f)	1.1 (e,g)	0.16 (e,f)	0.14 (e,g)
Cobalt	7440-48-4	NA	NA	NA	NA	NA	NA	NA	NA
Fluoride	16984-48-8	NA	NA	NA	NA	NA	NA	NA	NA
Lead	7439-92-1	0.27 (c)	0.18 (d)	0.010 (c)	0.0068 (d)	0.22 (f)	0.15 (g)	0.0085 (f)	0.0058 (g)
Lithium	7439-93-2	NA	NA	NA	NA	NA	NA	NA	NA
Mercury	7439-97-6	0.0016	0.0014	0.001	0.00077	0.0016	0.0014	0.00091	0.00077
Molybdenum	7439-98-7	NA	NA	NA	NA	NA	NA	NA	NA
Selenium	7782-49-2	NA	NA	3.1	NA	NA	NA	3.1	NA
Sulfate	14808-79-8	NA	NA	NA	NA	NA	NA	NA	NA
Thallium	7440-28-0	NA	NA	NA	NA	NA	NA	NA	NA
Total Dissolved Solids	TDS	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.

(a) - USEPA National Recommended Water Quality Criteria. USEPA Office of Water and Office of Science and Technology.
http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm
Total values provided. Values adjusted for site-specific hardness using hardness data collected in May 2018 - see note (c).
USEPA provides AWQC for both total and dissolved results.

(a) - USEPA National Recommended Water Quality Criteria. USEPA Office of Water and Office of Science and Technology.
http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm
Total values provided. Values adjusted for site-specific hardness using hardness data collected in April 2014 - see note (f).
USEPA provides AWQC for both total and dissolved results.

(c) - Hardness dependent value for total metals. Site-specific total recoverable mean hardness value for the Mississippi River of 254 mg/L as CaCO3 used.

(d) - Hardness dependent value for total metals adjusted for dissolved fraction. Site-specific total recoverable mean hardness value for the Mississippi River of 254 mg/L as CaCO3 used.

(e) - Value for trivalent chromium used.

(f) - Hardness dependent value for total metals. Site-specific total recoverable mean hardness value for the Mississippi River of 217 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 Mississippi River of 217 mg/L as CaCO3 used.

TABLE 3
ECOLOGICAL SCREENING LEVELS - ISLE DU BOIS CREEK
RUSH ISLAND ENERGY CENTER, JEFFERSON COUNTY, FESTUS, MO
AMEREN MISSOURI

		Federal Water Quality Criteria (mg/L)				Federal Water Quality Criteria (mg/L)			
		Site-Specific USEPA Aquatic Life AWQC - 2018 Hardness Data Freshwater Acute (a)		Site-Specific USEPA Aquatic Life AWQC - 2018 Hardness Data Freshwater Chronic (a)		Site-Specific USEPA Aquatic Life AWQC - 2014 Hardness Data Freshwater Acute (b)		Site-Specific USEPA Aquatic Life AWQC - 2014 Hardness Data Freshwater Chronic (b)	
Constituent	**CASRN**	**Total**	**Dissolved**	**Total**	**Dissolved**	**Total**	**Dissolved**	**Total**	**Dissolved**
Antimony	7440-36-0	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic	7440-38-2	0.34	0.34	0.15	0.15	0.34	0.34	0.15	0.15
Barium	7440-39-3	NA	NA	NA	NA	NA	NA	NA	NA
Beryllium	7440-41-7	NA	NA	NA	NA	NA	NA	NA	NA
Boron	7440-42-8	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	7440-43-9	0.0044 (c)	0.0040 (d)	0.0016 (c)	0.0014 (d)	0.0051 (f)	0.0046 (g)	0.0018 (f)	0.0015 (g)
Calcium	7440-70-2	NA	NA	NA	NA	NA	NA	NA	NA
Chloride	16887-00-6	860	NA	230	NA	860	NA	230	NA
Chromium	7440-47-3	3.7 (e,c)	1.2 (e,d)	0.18 (e,c)	0.15 (e,d)	4.1 (e,f)	1.3 (e,g)	0.20 (e,f)	0.17 (e,g)
Cobalt	7440-48-4	NA	NA	NA	NA	NA	NA	NA	NA
Fluoride	16984-48-8	NA	NA	NA	NA	NA	NA	NA	NA
Lead	7439-92-1	0.25 (c)	0.16 (d)	0.010 (c)	0.0064 (d)	0.29 (f)	0.19 (g)	0.011 (f)	0.0074 (g)
Lithium	7439-93-2	NA	NA	NA	NA	NA	NA	NA	NA
Mercury	7439-97-6	0.0016	0.0014	0.001	0.00077	0.0016	0.0014	0.00091	0.00077
Molybdenum	7439-98-7	NA	NA	NA	NA	NA	NA	NA	NA
Selenium	7782-49-2	NA	NA	3.1	NA	NA	NA	3.1	NA
Sulfate	14808-79-8	NA	NA	NA	NA	NA	NA	NA	NA
Thallium	7440-28-0	NA	NA	NA	NA	NA	NA	NA	NA
Total Dissolved Solids	TDS	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.

(a) - USEPA National Recommended Water Quality Criteria. USEPA Office of Water and Office of Science and Technology.
http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm
Total values provided. Values adjusted for site-specific hardness using hardness data collected in May 2018 - see note (c).
USEPA provides AWQC for both total and dissolved results.
(b) - USEPA National Recommended Water Quality Criteria. USEPA Office of Water and Office of Science and Technology.
http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm
Total values provided. Values adjusted for site-specific hardness using hardness data collected in April 2014 - see note (f).
USEPA provides AWQC for both total and dissolved results.
(c) - Hardness dependent value for total metals. Site-specific total recoverable mean hardness value collected in May 2018 for Isle Du Bois Creek of 238 mg/L as CaCO3 used.
(d) - Hardness dependent value for total metals adjusted for dissolved fraction. Site-specific total recoverable mean hardness value collected in May 2018 for the Isle Du Bois Creek of 238 mg/L as CaCO3 used.
(e) - Value for trivalent chromium used.
(f) - Hardness dependent value for total metals. Site-specific total recoverable mean hardness value collected in April 2014 for the Isle Du Bois Creek of 273 mg/L as CaCO3 used.
(g) - Hardness dependent value for total metals adjusted for dissolved fraction. Site-specific total recoverable mean hardness value collected in April 2014 for the Isle Du Bois Creek of 273 mg/L as CaCO3 used.

TABLE 4
SUMMARY OF SCREENING RESULTS
RUSH ISLAND ENERGY CENTER, JEFFERSON COUNTY, FESTUS, MO
AMEREN MISSOURI

	Mississippi River - Human Health Drinking Water						Mississippi River - Human Health Recreational					
	Dissolved			Total			Dissolved			Total		
Constituent	**Upstream**	**Adjacent**	**Downstream**	**Upstream**	**Adjacent**	**Downstream**	**Upstream**	**Adjacent**	**Downstream**	**Upstream**	**Adjacent**	**Downstream**
Antimony												
Arsenic							9 : 9 100%	5 : 5 100%	15 : 15 100%	10 : 10 100%	4 : 5 80%	14 : 15 93%
Barium												
Beryllium												
Boron												
Cadmium												
Calcium												
Chloride												
Chromium												
Cobalt												
Fluoride												
Lead												
Lithium												
Mercury												
Molybdenum												
pH	3 : 5 60%		4 : 5 80%	3 : 5 60%		4 : 5 80%						
Selenium												
Sulfate												
Thallium												
TDS												
Radium 226/228												

Notes:
Blank cells - no results above screening levels for the specified constituent / media.
Number of exceedences : total number of samples.

TABLE 4
SUMMARY OF SCREENING RESULTS
RUSH ISLAND ENERGY CENTER, JEFFERSON COUNTY, FESTUS, MO
AMEREN MISSOURI

	Mississippi River - Ecological						Isle Du Bois Creek - Human Health Drinking Water					
	Dissolved			Total			Dissolved			Total		
Constituent	Upstream	Adjacent	Downstream	Upstream	Adjacent	Downstream	Upstream	Adjacent	Downstream	Upstream	Adjacent	Downstream
Antimony												
Arsenic												
Barium												
Beryllium												
Boron												
Cadmium												
Calcium												
Chloride												
Chromium												
Cobalt												
Fluoride												
Lead									1 : 6 17%			
Lithium												
Mercury												
Molybdenum												
pH	1 : 5 20%			1 : 5 20%								
Selenium												
Sulfate												
Thallium												
TDS												
Radium 226/228												

Notes:
Blank cells - no results above screening levels for the specified constituent / media.
Number of exceedences : total number of samples.

TABLE 4
SUMMARY OF SCREENING RESULTS
RUSH ISLAND ENERGY CENTER, JEFFERSON COUNTY, FESTUS, MO
AMEREN MISSOURI

	Isle Du Bois Creek - Human Health Recreational						Isle Du Bois Creek - Ecological					
	Dissolved			Total			Dissolved			Total		
Constituent	Upstream	Adjacent	Downstream	Upstream	Adjacent	Downstream	Upstream	Adjacent	Downstream	Upstream	Adjacent	Downstream
Antimony												
Arsenic	3 : 6 50%	3 : 6 50%	3 : 6 50%	6 : 6 100%	5 : 6 83%	6 : 6 100%						
Barium												
Beryllium												
Boron												
Cadmium												
Calcium												
Chloride												
Chromium												
Cobalt												
Fluoride												
Lead												
Lithium												
Mercury												
Molybdenum												
pH												
Selenium												
Sulfate												
Thallium												
TDS												
Radium 226/228												

Notes:
Blank cells - no results above screening levels for the specified constituent / media.
Number of exceedences : total number of samples.

TABLE 5a
COMPARISON OF MAY 2018 MISSISSIPPI RIVER SURFACE WATER RESULTS -
TO HUMAN HEALTH DRINKING WATER SCREENING LEVELS - TOTAL (UNFILTERED) SAMPLE RESULTS (a)
RUSH ISLAND ENERGY CENTER, JEFFERSON COUNTY, FESTUS, MO
AMEREN MISSOURI

			Federal Water Quality Screening Levels			Selected Drinking Water Screening Level (h)	Mississippi River Upstream					Mississippi River Adjacent					Mississippi River Downstream					Mississippi River Further Downstream				
Constituent	CAS	Units	USEPA MCLs (b)	USEPA SMCLs (b)	USEPA Tapwater RSLs (c)		R2-R-4S	R2-R-5M	R2-R-5S	R2-R-6M	R2-R-6S	R2-R-10S	R2-R-11M	R2-R-11S	R2-R-12M	R2-R-12S	R2-R-7S	R2-R-8M	R2-R-8S	R2-R-9M	R2-R-9S	R2-R-1S	R2-R-2M	R2-R-2S	R2-R-3M	R2-R-3S
Antimony*	7440-36-0	mg/L	0.006	NA	0.0078	0.006																				
Arsenic	7440-38-2	mg/L	0.01	NA	0.000052	0.01	0.0031	0.003	0.0029	0.0027	0.0019	0.0042 J	0.0041		0.0034	0.003	0.0044	0.003	0.003	0.0032	0.0029	0.003		0.0028	0.0027	0.0024
Barium	7440-39-3	mg/L	2	NA	3.8	2	0.164	0.143	0.149	0.13	0.125	0.157	0.153	0.154	0.126	0.116	0.132	0.134	0.133	0.115	0.103	0.128	0.146	0.125	0.135	0.117
Beryllium	7440-41-7	mg/L	0.004	NA	0.025	0.004	0.00037 J	0.00022 J	0.00019 J	0.00024 J	0.00038 J	0.0003 J	0.00037 J	0.00034 J	0.00024 J	0.00041 J	0.00028 J	0.00028 J	0.0004 J	0.00032 J	0.00017 J	0.00041 J	0.00038 J	0.00019 J	0.00043 J	0.00032 J
Boron	7440-42-8	mg/L	NA	NA	4	4	0.0603 J	0.0556 J	0.0564 J	0.0448 J	0.0447 J	0.0591 J	0.0552 J	0.0565 J	0.0441 J	0.0392 J	0.0569 J	0.0522 J	0.0562 J	0.0409 J	0.0392 J	0.0595 J	0.0548 J	0.0536 J	0.0495 J	0.0436 J
Cadmium	7440-43-9	mg/L	0.005	NA	0.0092	0.005												0.00057 J							0.00081 J	
Calcium	7440-70-2	mg/L	NA	NA	NA	NA	65.4	64.7	63.8	60	58.9	64.6	63.5	62.9	59.4	56	64.5	62.6	63.7	55.8	56	63.7	62.7	62.9	60	58.8
Chloride	16887-00-6	mg/L	NA	250	NA	250	23.8	24.2	24.5	26.7	27.5	23.8	24.5	24.5	27.2	28.4	23.7	25.5	25.2	28.1	28.4	23.7	24.8	24.8	26.5	27
Chromium	7440-47-3	mg/L	0.1 (e)	NA	22 (f)	0.1	0.006	0.0033 J	0.0045 J	0.0046 J	0.0039 J	0.0056	0.0059	0.0044 J	0.004 J	0.0041 J	0.0016 J	0.0031 J	0.0027 J	0.0044 J		0.0013 J	0.0048 J		0.0049 J	0.0024 J
Cobalt	7440-48-4	mg/L	NA	NA	0.006	0.006	0.0031 J	0.0025 J	0.0024 J	0.003 J	0.0019 J	0.0026 J	0.0036 J	0.0028 J	0.0027 J	0.0018 J	0.0012 J	0.0023 J	0.0024 J	0.0019 J	0.0021 J	0.0013 J	0.0028 J	0.0015 J	0.0025 J	0.0015 J
Fluoride	16984-48-8	mg/L	4	2	0.8	4	0.25	0.25	0.25	0.21	0.21	0.25	0.26	0.24	0.26	0.24	0.3	0.22	0.24	0.21	0.2	0.24	0.25	0.25	0.21	0.21
Lead	7439-92-1	mg/L	0.015 (g)	NA	0.015	0.015	0.0067 J	0.0051 J	0.0045 J	0.0031 J	0.0039 J	0.0067 J	0.0046 J		0.0045 J	0.0032 J		0.0068 J		0.004 J			0.0056 J	0.0041 J	0.006 J	0.0041 J
Lithium	7439-93-2	mg/L	NA	NA	0.04	0.04	0.0262	0.0217	0.0245	0.0168	0.0151	0.0258	0.0223	0.0224	0.0146	0.0152	0.0233	0.0197	0.0211	0.0131	0.0103	0.0214	0.0206	0.0169	0.0161	0.0147
Mercury*	7439-97-6	mg/L	0.002	NA	0.0057 (d)	0.002																				
Molybdenum	7439-98-7	mg/L	NA	NA	0.1	0.1	0.0021 J	0.0016 J	0.0012 J	0.0013 J	0.0015 J	0.0017 J	0.0019 J	0.0018 J	0.0018 J	0.0014 J	0.0015 J	0.0016 J	0.0019 J	0.0013 J	0.0011 J	0.0019 J	0.0014 J	0.001 J	0.0016 J	0.0015 J
Selenium*	7782-49-2	mg/L	0.05	NA	0.1	0.05																				
Sulfate	14808-79-8	mg/L	NA	250	NA	250	103	97.1	97.2	66.9	64.1	103	93.3	99.7	70.7	59.5	109	81.4	84.5	55.2	53.8	103	90.1	89.5	71.5	68.3
Thallium	7440-28-0	mg/L	0.002	NA	0.0002	0.002											0.00011 J									
Total Hardness as CaCO3	471-34-1	mg/L	NA	NA	NA	NA	271	267	264	247	244	268	261	259	245	232	265	258	261	231	231	264	260	257	249	242
Total Dissolved Solids	TDS	mg/L	NA	500	NA	500	232	371	374	336	346	381	363	382	337	307	404	376	361	330	319	378	363	324	326	328

Notes:

Blank cells - Non-detect value.
* - Constituent was not detected in any samples.
CAS - Chemical Abstracts Service.
J - Estimated value.
MCL - Maximum Contaminant Level.

mg/L - milligrams per liter.
NA - Not Available.
RSL - Regional Screening Level.
SMCL - Secondary Maximum Contaminant Level.
USEPA - United States Environmental Protection Agency.

Detected Concentration > Selected Drinking Water Screening Level.

(a) - Surface water samples collected in May 2018.
(b) - USEPA 2018 Edition of the Drinking Water Standards and Health Advisories. Spring 2018.
http://water.epa.gov/drink/contaminants/index.cfm
(c) - USEPA Regional Screening Levels (November 2018). Values for tapwater.
http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/index.htm
(d) - RSL for Mercuric Chloride used for Mercury.
(e) - The drinking water standard or MCL for chromium is based on total chromium.
(f) - Value for trivalent chromium used. USEPA provides a screening level for hexavalent chromium
that is not a drinking water standard, the basis of which has been questioned by USEPA's Science Advisory Board.
(g) - The Action Level presented is recommended in the USEPA Drinking Water Standards.
(h) - Selected Drinking Water Screening Level uses the following hierarchy:
Federal USEPA MCL for Drinking Water.
Federal USEPA SMCL for Drinking Water.
Federal November 2018 USEPA Tapwater RSL.

TABLE 5b
COMPARISON OF MAY 2018 MISSISSIPPI RIVER SURFACE WATER RESULTS -
TO HUMAH HEALTH DRINKING WATER SCREENING LEVELS - DISSOLVED (FILTERED) SAMPLE RESULTS (a)
RUSH ISLAND ENERGY CENTER, JEFFERSON COUNTY, FESTUS, MO
AMEREN MISSOURI

Constituent	CAS	Units	Federal Water Quality Screening Levels			Selected Drinking Water Screening Level (h)	Mississippi River Upstream					Mississippi River Adjacent					Mississippi River Downstream					Mississippi River Further Downstream				
			USEPA MCLs (b)	USEPA SMCLs (b)	USEPA Tapwater RSLs (c)		R2-R-4S	R2-R-5M	R2-R-5S	R2-R-6M	R2-R-6S	R2-R-10S	R2-R-11M	R2-R-11S	R2-R-12M	R2-R-12S	R2-R-7S	R2-R-8M	R2-R-8S	R2-R-9M	R2-R-9S	R2-R-1S	R2-R-2M	R2-R-2S	R2-R-3M	R2-R-3S
Antimony*	7440-36-0	mg/L	0.006	NA	0.0078	0.006																				
Arsenic	7440-38-2	mg/L	0.01	NA	0.000052	0.01	0.0023		0.0022	0.0019	0.0018	0.0021	0.0022	0.0021	0.0017	0.0017	0.0024	0.0021	0.0021	0.0016	0.0016	0.0023	0.0022	0.0021	0.0019	0.0017
Barium	7440-39-3	mg/L	2	NA	3.8	2	0.0942	0.0913	0.0951	0.0832	0.0772	0.095	0.0922	0.0919	0.0756	0.0741	0.0953	0.0888	0.092	0.0735	0.0744	0.0949	0.09	0.088	0.0775	0.0862
Beryllium*	7440-41-7	mg/L	0.004	NA	0.025	0.004																				
Boron	7440-42-8	mg/L	NA	NA	4	4	0.0584 J	0.0531 J	0.0536 J	0.0464 J	0.041 J	0.0548 J	0.0536 J	0.0534 J	0.0368 J	0.0385 J	0.0541 J	0.0489 J	0.0542 J	0.0368 J	0.0374 J	0.0557 J	0.053 J	0.051 J	0.0411 J	0.0434 J
Cadmium	7440-43-9	mg/L	0.005	NA	0.0092	0.005			0.00054 J																	
Calcium	7440-70-2	mg/L	NA	NA	NA	NA	59.6	57.9	59.3	55.5	53.5	59.4	58.6	58.9	53.3	52.2	59.7	58.1	58.9	53	52.1	59.7	58.7	57.5	53.9	54.9
Chromium*	7440-47-3	mg/L	0.1 (e)	NA	22 (f)	0.1																				
Cobalt*	7440-48-4	mg/L	NA	NA	0.006	0.006																				
Lead*	7439-92-1	mg/L	0.015 (g)	NA	0.015	0.015																				
Lithium	7439-93-2	mg/L	NA	NA	0.04	0.04	0.0209	0.0195	0.021	0.0139	0.012	0.021	0.0216	0.0194	0.0122	0.0116	0.0214	0.0169	0.0209	0.0083 J	0.0102	0.0194	0.0189	0.019	0.0131	0.0141
Mercury*	7439-97-6	mg/L	0.002	NA	0.0057 (d)	0.002																				
Molybdenum	7439-98-7	mg/L	NA	NA	0.1	0.1	0.0016 J	0.0018 J	0.0022 J	0.0013 J	0.0013 J	0.0019 J	0.0016 J	0.0016 J	0.0013 J	0.0013 J	0.0014 J	0.0015 J	0.0015 J	0.0012 J	0.0015 J	0.0013 J	0.0016 J	0.0014 J	0.0011 J	0.0012 J
Selenium*	7782-49-2	mg/L	0.05	NA	0.1	0.05																				
Thallium*	7440-28-0	mg/L	0.002	NA	0.0002	0.002																				

Notes:

Blank cells - Non-detect value.
* - Constituent was not detected in any samples.
CAS - Chemical Abstracts Service.
J - Estimated value.
MCL - Maximum Contaminant Level.
mg/L - milligrams per liter.
NA - Not Available.
RSL - Regional Screening Level.
SMCL - Secondary Maximum Contaminant Level.
USEPA - United States Environmental Protection Agency.

[green box] Detected Concentration > Selected Drinking Water Screening Level.

(a) - Surface water samples collected in May 2018.
(b) - USEPA 2018 Edition of the Drinking Water Standards and Health Advisories. Spring 2018.
http://water.epa.gov/drink/contaminants/index.cfm
(c) - USEPA Regional Screening Levels (November 2018). Values for tapwater.
http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/index.htm
(d) - RSL for Mercuric Chloride used for Mercury.
(e) - The drinking water standard or MCL for chromium is based on total chromium.
(f) - Value for trivalent chromium used. USEPA provides a screening level for hexavalent chromium
that is not a drinking water standard, the basis of which has been questioned by USEPA's Science Advisory Board.
(g) - The Action Level presented is recommended in the USEPA Drinking Water Standards.
(h) - Selected Drinking Water Screening Level uses the following hierarchy:
Federal USEPA MCL for Drinking Water.
Federal USEPA SMCL for Drinking Water.
Federal November 2018 USEPA Tapwater RSL.

TABLE 5c
COMPARISON OF APRIL 2014 MISSISSIPPI RIVER SURFACE WATER RESULTS TO DRINKING WATER SCREENING LEVELS - TOTAL (UNFILTERED) SAMPLE RESULTS (a)
RUSH ISLAND ENERGY CENTER, JEFFERSON COUNTY, FESTUS, MO
AMEREN, MISSOURI

			Federal Water Quality Screening Levels			Selected Drinking Water Screening Level (i)	Mississippi River									
							Upstream					Downstream				
Constituent	CAS	Units	USEPA MCLs (b)	USEPA SMCLs (b)	USEPA Tapwater RSLs (c)		RI-R-4S	RI-R-5S	RI-R-5M	RI-R-6S	RI-R-6M	RI-R-1S	RI-R-2S	RI-R-2M	RI-R-3S	RI-R-3M
Antimony*	7440-36-0	mg/L	0.006	NA	0.0078	0.006										
Arsenic	7440-38-2	mg/L	0.01	NA	0.000052	0.01	0.0021	0.0019	0.0025	0.0023	0.0021	0.0028	0.0021	0.0024	0.0024	0.0022
Barium	7440-39-3	mg/L	2	NA	3.8	2	0.104	0.102	0.101	0.0931	0.0932	0.1	0.099	0.0947	0.0801	0.0911
Beryllium*	7440-41-7	mg/L	0.004	NA	0.025	0.004										
Boron	7440-42-8	mg/L	NA	NA	4	4	0.0553	0.0532	0.0532	0.0471	0.0468	0.0543	0.0515	0.0487	0.0418	0.0437
Cadmium*	7440-43-9	mg/L	0.005	NA	0.0092	0.005										
Calcium	7440-70-2	mg/L	NA	NA	NA	NA	56.4	54.3	55.2	54	53.6	53.5	54.1	53.7	52.9	53.7
Chromium	7440-47-3	mg/L	0.1 (e)	NA	22 (h)	0.1	0.0027	0.0027	0.0026	0.0029	0.0031	0.0022	0.0032	0.0034	0.0021	0.0035
Cobalt	7440-48-4	mg/L	NA	NA	0.006	0.006	0.0023	0.0024	0.0026	0.0024	0.0025	0.0023	0.0028	0.0024	0.0021	0.0026
Fluoride	16984-48-8	mg/L	4	2	0.8	4				0.58						
Lead	7439-92-1	mg/L	0.015 (g)	NA	0.015	0.015	0.0025	0.0024	0.0025	0.0026	0.0022	0.0025	0.0025	0.0024	0.0022	0.0022
Mercury*	7439-97-6	mg/L	0.002	NA	0.0057 (f)	0.002										
Molybdenum	7439-98-7	mg/L	NA	NA	0.1	0.1										
Selenium	7782-49-2	mg/L	0.05	NA	0.1	0.05	0.00088	0.00097	0.0011	0.00079	0.00083	0.001	0.00098	0.00079	0.00077	0.00069
Sulfate	14808-79-8	mg/L	NA	250	NA	250	79	73.8	73.2	60.3	59.3	75.5	70.6	63.9	44.1	47
Thallium*	7440-28-0	mg/L	0.002	NA	0.0002	0.002										
pH (d)	NA	SU	NA	6.5-8.5	NA	NA	**6.14**	7.59	**8.88**	8.33	**8.76**	**8.58**	**8.56**	**8.88**	7.78	**8.93**
Total Hardness as CaCO3	471-34-1	mg/L	NA	NA	NA	NA	226	216	220	216	215	214	217	215	213	218

Notes:
Blank cells - Non-detect value.
* Constituent was not detected in any samples.
-- - Constituent not included in this analysis.
CAS - Chemical Abstracts Service.
MCL - Maximum Contaminant Level.
mg/L - milligrams per liter.
NA - Not Available.
RSL - Regional Screening Level.
SMCL - Secondary Maximum Contaminant Level.
SU - Standard Units.
USEPA - United States Environmental Protection Agency.

Highlighted (shown in bold): Detected Concentration > Selected Drinking Water Screening Level

(a) - Surface water samples collected in April 2014.
(b) - USEPA 2018 Edition of the Drinking Water Standards and Health Advisories. Spring 2018.
http://water.epa.gov/drink/contaminants/index.cfm
(c) - USEPA Regional Screening Levels (November 2018). Values for tapwater.
http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/index.htm
(d) - pH values were obtained during the field sampling event and were recorded at the time of sample collection. Data for pH was not provided by the laboratory.
(e) - The drinking water standard or MCL for chromium is based on total chromium.
(f) - The tapwater RSL for mercury is based on mercuric chloride.
(g) - The Action Level presented is recommended in the USEPA Drinking Water Standards.
(h) - Value for trivalent chromium used. USEPA provides a screening level for hexavalent chromium that is not a drinking water standard, the basis of which has been questioned by USEPA's Science Advisory Board.
(i) - Selected Drinking Water Screening Level uses the following hierarchy:
Federal USEPA MCL for Drinking Water.
Federal USEPA SMCL for Drinking Water.
Federal November 2018 USEPA Tapwater RSL.

TABLE 5d
COMPARISON OF APRIL 2014 MISSISSIPPI RIVER SURFACE WATER RESULTS TO DRINKING WATER SCREENING LEVELS - DISSOLVED (FILTERED) SAMPLE RESULTS
(a) RUSH ISLAND ENERGY CENTER, JEFFERSON COUNTY, FESTUS, MO
AMEREN, MISSOURI

			Federal Water Quality Screening Levels			Selected Drinking Water Screening Level (i)	Mississippi River									
							Upstream					Downstream				
Constituent	CAS	Units	USEPA MCLs (b)	USEPA SMCLs (b)	USEPA Tapwater RSLs (c)		RI-R-4S	RI-R-5S	RI-R-5M	RI-R-6S	RI-R-6M	RI-R-1S	RI-R-2S	RI-R-2M	RI-R-3S	RI-R-3M
Antimony*	7440-36-0	mg/L	0.006	NA	0.0078	0.006										
Arsenic	7440-38-2	mg/L	0.01	NA	0.000052	0.01	0.001	0.0015	0.0012	0.0013	0.0014	0.0015	0.0011	0.0012	0.0012	0.0011
Barium	7440-39-3	mg/L	2	NA	3.8	2	0.0776	0.0796	0.0745	0.0677	0.0698	0.078	0.073	0.0662	0.0602	0.0611
Beryllium*	7440-41-7	mg/L	0.004	NA	0.025	0.004										
Boron	7440-42-8	mg/L	NA	NA	4	4	0.053	0.0511	0.0502	0.0449	0.0476	0.0527	0.0499	0.0442	0.0405	0.0412
Cadmium*	7440-43-9	mg/L	0.005	NA	0.0092	0.005										
Calcium	7440-70-2	mg/L	NA	NA	NA	NA	52.5	52.6	52.1	52	51.7	52.5	52.4	51.3	50.9	51
Chromium*	7440-47-3	mg/L	0.1 (e)	NA	22 (h)	0.1										
Cobalt*	7440-48-4	mg/L	NA	NA	0.006	0.006										
Fluoride	16984-48-8	mg/L	4	2	0.8	4	--	--	--	--	--	--	--	--	--	--
Lead	7439-92-1	mg/L	0.015 (g)	NA	0.015	0.015		0.00049								
Mercury*	7439-97-6	mg/L	0.002	NA	0.0057 (f)	0.002										
Molybdenum	7439-98-7	mg/L	NA	NA	0.1	0.1	0.0018					0.0019		0.0017		
Selenium	7782-49-2	mg/L	0.05	NA	0.1	0.05	0.00093	0.00079	0.00084	0.00069	0.00073	0.00087	0.00075	0.00085	0.0008	0.00079
Sulfate	14808-79-8	mg/L	NA	250	NA	250	--	--	--	--	--	--	--	--	--	--
Thallium*	7440-28-0	mg/L	0.002	NA	0.0002	0.002										
pH (d)	NA	SU	NA	6.5-8.5	NA	NA	6.14	7.59	8.88	8.33	8.76	8.58	8.56	8.88	7.78	8.93
Total Hardness as CaCO3	471-34-1	mg/L	NA	NA	NA	NA	--	--	--	--	--	--	--	--	--	--

Notes:
Blank cells - Non-detect value.
* Constituent was not detected in any samples.
-- - Constituent not included in this analysis.
CAS - Chemical Abstracts Service.
MCL - Maximum Contaminant Level.
mg/L - milligrams per liter.
NA - Not Available.
RSL - Regional Screening Level.
SMCL - Secondary Maximum Contaminant Level.
SU - Standard Units.
USEPA - United States Environmental Protection Agency.

Detected Concentration > Selected Drinking Water Screening Level.

(a) - Surface water samples collected in April 2014.
(b) - USEPA 2018 Edition of the Drinking Water Standards and Health Advisories. Spring 2018.
http://water.epa.gov/drink/contaminants/index.cfm
(c) - USEPA Regional Screening Levels (November 2018). Values for tapwater.
http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/index.htm
(d) - pH values were obtained during the field sampling event and were recorded at the time of sample collection. Data for pH was not provided by the laboratory.
(e) - The drinking water standard or MCL for chromium is based on total chromium.
(f) - The tapwater RSL for mercury is based on mercuric chloride.
(g) - The Action Level presented is recommended in the USEPA Drinking Water Standards.
(h) - Value for trivalent chromium used. USEPA provides a screening level for hexavalent chromium that is not a drinking water standard, the basis of which has been questioned by USEPA's Science Advisory Board.
(i) - Selected Drinking Water Screening Level uses the following hierarchy:
Federal USEPA MCL for Drinking Water.
Federal USEPA SMCL for Drinking Water.
Federal November 2018 USEPA Tapwater RSL.

TABLE 6a
COMPARISON OF MAY 2018 MISSISSIPPI RIVER SURFACE WATER RESULTS -
TO HUMAN HEALTH AWQC SCREENING LEVELS - TOTAL (UNFILTERED) SAMPLE RESULTS (a)
RUSH ISLAND ENERGY CENTER, JEFFERSON COUNTY, FESTUS, MO
AMEREN MISSOURI

Constituent	CAS	Units	USEPA AWQC (b)	Mississippi River Upstream					Mississippi River Adjacent					Mississippi River Downstream					Mississippi River Further Downstream				
				R2-R-4S	R2-R-5M	R2-R-5S	R2-R-6M	R2-R-6S	R2-R-10S	R2-R-11M	R2-R-11S	R2-R-12M	R2-R-12S	R2-R-7S	R2-R-8M	R2-R-8S	R2-R-9M	R2-R-9S	R2-R-1S	R2-R-2M	R2-R-2S	R2-R-3M	R2-R-3S
Antimony*	7440-36-0	mg/L	0.64																				
Arsenic	7440-38-2	mg/L	0.00014 (c)	0.0031	0.003	0.0029	0.0027	0.0019	0.0042 J	0.0041		0.0034	0.003	0.0044	0.003	0.003	0.0032	0.0029	0.003		0.0028	0.0027	0.0024
Barium	7440-39-3	mg/L	NA	0.164	0.143	0.149	0.13	0.125	0.157	0.153	0.154	0.126	0.116	0.132	0.134	0.133	0.115	0.103	0.128	0.146	0.125	0.135	0.117
Beryllium	7440-41-7	mg/L	NA	0.00037 J	0.00022 J	0.00019 J	0.00024 J	0.00038 J	0.0003 J	0.00037 J	0.00034 J	0.00024 J	0.00041 J	0.00028 J	0.00028 J	0.0004 J	0.00032 J	0.00017 J	0.00041 J	0.00038 J	0.00019 J	0.00043 J	0.00032 J
Boron	7440-42-8	mg/L	NA	0.0603 J	0.0556 J	0.0564 J	0.0448 J	0.0447 J	0.0591 J	0.0552 J	0.0565 J	0.0441 J	0.0392 J	0.0569 J	0.0522 J	0.0562 J	0.0409 J	0.0392 J	0.0595 J	0.0548 J	0.0536 J	0.0495 J	0.0436 J
Cadmium	7440-43-9	mg/L	NA												0.00057 J							0.00081 J	
Calcium	7440-70-2	mg/L	NA	65.4	64.7	63.8	60	58.9	64.6	63.5	62.9	59.4	56	64.5	62.6	63.7	55.8	56	63.7	62.7	62.9	60	58.8
Chloride	16887-00-6	mg/L	NA	23.8	24.2	24.5	26.7	27.5	23.8	24.5	24.5	27.2	28.4	23.7	25.5	25.2	28.1	28.4	23.7	24.8	24.8	26.5	27
Chromium	7440-47-3	mg/L	NA	0.006	0.0033 J	0.0045 J	0.0046 J	0.0039 J	0.0056	0.0059	0.0044 J	0.004 J	0.0041 J	0.0016 J	0.0031 J	0.0027 J	0.0044 J		0.0013 J	0.0048 J		0.0049 J	0.0024 J
Cobalt	7440-48-4	mg/L	NA	0.0031 J	0.0025 J	0.0024 J	0.003 J	0.0019 J	0.0026 J	0.0036 J	0.0028 J	0.0027 J	0.0018 J	0.0012 J	0.0023 J	0.0024 J	0.0019 J	0.0021 J	0.0013 J	0.0028 J	0.0015 J	0.0025 J	0.0015 J
Fluoride	16984-48-8	mg/L	NA	0.25	0.25	0.25	0.21	0.21	0.25	0.26	0.24	0.26	0.24	0.3	0.22	0.24	0.21	0.2	0.24	0.25	0.25	0.21	0.21
Lead	7439-92-1	mg/L	NA	0.0067 J	0.0051 J	0.0045 J	0.0031 J	0.0039 J	0.0067 J	0.0046 J		0.0045 J	0.0032 J		0.0068 J		0.004 J			0.0056 J	0.0041 J	0.006 J	0.0041 J
Lithium	7439-93-2	mg/L	NA	0.0262	0.0217	0.0245	0.0168	0.0151	0.0258	0.0223	0.0224	0.0146	0.0152	0.0233	0.0197	0.0211	0.0131	0.0103	0.0214	0.0206	0.0169	0.0161	0.0147
Mercury*	7439-97-6	mg/L	NA																				
Molybdenum	7439-98-7	mg/L	NA	0.0021 J	0.0016 J	0.0012 J	0.0013 J	0.0015 J	0.0017 J	0.0019 J	0.0018 J	0.0018 J	0.0014 J	0.0015 J	0.0016 J	0.0019 J	0.0013 J	0.0011 J	0.0019 J	0.0014 J	0.001 J	0.0016 J	0.0015 J
Selenium*	7782-49-2	mg/L	4.2																				
Sulfate	14808-79-8	mg/L	NA	103	97.1	97.2	66.9	64.1	103	93.3	99.7	70.7	59.5	109	81.4	84.5	55.2	53.8	103	90.1	89.5	71.5	68.3
Thallium	7440-28-0	mg/L	0.00047											0.00011 J									
Total Hardness as CaCO3	471-34-1	mg/L	NA	271	267	264	247	244	268	261	259	245	232	265	258	261	231	231	264	260	257	249	242
Total Dissolved Solids	TDS	mg/L	NA	232	371	374	336	346	381	363	382	337	307	404	376	361	330	319	378	363	324	326	328

Notes:
Blank cells - Non-detect value.
* - Constituent was not detected in any samples.
AWQC - Ambient Water Quality Criteria.
CAS - Chemical Abstracts Service.
J - Estimated value.
mg/L - milligrams per liter.
NA - Not Available.
USEPA - United States Environmental Protection Agency.

[green highlight] Detected Concentration > AWQC.

(a) - Surface water samples collected in May 2018.
(b) - USEPA National Recommended Water Quality Criteria.
USEPA Office of Water and Office of Science and Technology.
http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm
USEPA AWQC Human Health for the Consumption of Organism Only
apply to total concentrations.
(c) - Value applies to inorganic form of arsenic only.

TABLE 6b
COMPARISON OF MAY 2018 MISSISSIPPI RIVER SURFACE WATER RESULTS -
TO HUMAN HEALTH AWQC SCREENING LEVELS - DISSOLVED (FILTERED) SAMPLE RESULTS (a)
RUSH ISLAND ENERGY CENTER, JEFFERSON COUNTY, FESTUS, MO
AMEREN MISSOURI

Constituent	CAS	Units	USEPA AWQC (b)	Mississippi River Upstream					Mississippi River Adjacent					Mississippi River Downstream					Mississippi River Further Downstream				
				R2-R-4S	R2-R-5M	R2-R-5S	R2-R-6M	R2-R-6S	R2-R-10S	R2-R-11M	R2-R-11S	R2-R-12M	R2-R-12S	R2-R-7S	R2-R-8M	R2-R-8S	R2-R-9M	R2-R-9S	R2-R-1S	R2-R-2M	R2-R-2S	R2-R-3M	R2-R-3S
Antimony*	7440-36-0	mg/L	0.64																				
Arsenic	7440-38-2	mg/L	0.00014 (c)	0.0023		0.0022	0.0019	0.0018	0.0021	0.0022	0.0021	0.0017	0.0017	0.0024	0.0021	0.0021	0.0016	0.0016	0.0023	0.0022	0.0021	0.0019	0.0017
Barium	7440-39-3	mg/L	NA	0.0942	0.0913	0.0951	0.0832	0.0772	0.095	0.0922	0.0919	0.0756	0.0741	0.0953	0.0888	0.092	0.0735	0.0744	0.0949	0.09	0.088	0.0775	0.0862
Beryllium*	7440-41-7	mg/L	NA																				
Boron	7440-42-8	mg/L	NA	0.0584 J	0.0531 J	0.0536 J	0.0464 J	0.041 J	0.0548 J	0.0536 J	0.0534 J	0.0368 J	0.0385 J	0.0541 J	0.0489 J	0.0542 J	0.0368 J	0.0374 J	0.0557 J	0.053 J	0.051 J	0.0411 J	0.0434 J
Cadmium	7440-43-9	mg/L	NA			0.00054 J																	
Calcium	7440-70-2	mg/L	NA	59.6	57.9	59.3	55.5	53.5	59.4	58.6	58.9	53.3	52.2	59.7	58.1	58.9	53	52.1	59.7	58.7	57.5	53.9	54.9
Chromium*	7440-47-3	mg/L	NA																				
Cobalt*	7440-48-4	mg/L	NA																				
Lead*	7439-92-1	mg/L	NA																				
Lithium	7439-93-2	mg/L	NA	0.0209	0.0195	0.021	0.0139	0.012	0.021	0.0216	0.0194	0.0122	0.0116	0.0214	0.0169	0.0209	0.0083 J	0.0102	0.0194	0.0189	0.019	0.0131	0.0141
Mercury*	7439-97-6	mg/L	NA																				
Molybdenum	7439-98-7	mg/L	NA	0.0016 J	0.0018 J	0.0022 J	0.0013 J	0.0013 J	0.0019 J	0.0016 J	0.0016 J	0.0013 J	0.0013 J	0.0014 J	0.0015 J	0.0015 J	0.0012 J	0.0015 J	0.0013 J	0.0016 J	0.0014 J	0.0011 J	0.0012 J
Selenium*	7782-49-2	mg/L	4.2																				
Thallium*	7440-28-0	mg/L	0.00047																				

Notes:
Blank cells - Non-detect value.
* - Constituent was not detected in any samples.
AWQC - Ambient Water Quality Criteria.
CAS - Chemical Abstracts Service.
J - Estimated value.
mg/L - milligrams per liter.
NA - Not Available.
USEPA - United States Environmental Protection Agency.

Detected Concentration > AWQC.

(a) - Surface water samples collected in May 2018.
(b) - USEPA National Recommended Water Quality Criteria.
USEPA Office of Water and Office of Science and Technology.
http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm
USEPA AWQC Human Health for the Consumption of Organism Only
apply to total concentrations.
(c) - Value applies to inorganic form of arsenic only.

TABLE 6c
COMPARISON OF APRIL 2014 MISSISSIPPI RIVER SURFACE WATER RESULTS TO AWQC SCREENING LEVELS - TOTAL (UNFILTERED) SAMPLE RESULTS
(a) RUSH ISLAND ENERGY CENTER, JEFFERSON COUNTY, FESTUS, MO
AMEREN, MISSOURI

				Mississippi River									
			USEPA	Upstream					Downstream				
Constituent	CAS	Units	AWQC (b)	RI-R-4S	RI-R-5S	RI-R-5M	RI-R-6S	RI-R-6M	RI-R-1S	RI-R-2S	RI-R-2M	RI-R-3S	RI-R-3M
Antimony*	7440-36-0	mg/L	0.64										
Arsenic	7440-38-2	mg/L	0.00014 (c)	0.0021	0.0019	0.0025	0.0023	0.0021	0.0028	0.0021	0.0024	0.0024	0.0022
Barium	7440-39-3	mg/L	NA	0.104	0.102	0.101	0.0931	0.0932	0.1	0.099	0.0947	0.0801	0.0911
Beryllium*	7440-41-7	mg/L	NA										
Boron	7440-42-8	mg/L	NA	0.0553	0.0532	0.0532	0.0471	0.0468	0.0543	0.0515	0.0487	0.0418	0.0437
Cadmium*	7440-43-9	mg/L	NA										
Calcium	7440-70-2	mg/L	NA	56.4	54.3	55.2	54	53.6	53.5	54.1	53.7	52.9	53.7
Chromium	7440-47-3	mg/L	NA	0.0027	0.0027	0.0026	0.0029	0.0031	0.0022	0.0032	0.0034	0.0021	0.0035
Cobalt	7440-48-4	mg/L	NA	0.0023	0.0024	0.0026	0.0024	0.0025	0.0023	0.0028	0.0024	0.0021	0.0026
Fluoride*	16984-48-8	mg/L	NA				0.58						
Lead	7439-92-1	mg/L	NA	0.0025	0.0024	0.0025	0.0026	0.0022	0.0025	0.0025	0.0024	0.0022	0.0022
Mercury*	7439-97-6	mg/L	NA										
Molybdenum	7439-98-7	mg/L	NA										
Selenium	7782-49-2	mg/L	4.2	0.00088	0.00097	0.0011	0.00079	0.00083	0.001	0.00098	0.00079	0.00077	0.00069
Sulfate	14808-79-8	mg/L	NA	79	73.8	73.2	60.3	59.3	75.5	70.6	63.9	44.1	47
Thallium*	7440-28-0	mg/L	0.00047										
pH (d)	NA	SU	NA	6.14	7.59	8.88	8.33	8.76	8.58	8.56	8.88	7.78	8.93
Total Hardness as CaCO3	471-34-1	mg/L	NA	226	216	220	216	215	214	217	215	213	218

Notes:
Blank cells - Non-detect value.
* Constituent was not detected in any samples.
-- - Constituent not included in this analysis.
AWQC - Ambient Water Quality Criteria.
CAS - Chemical Abstracts Service.
mg/L - milligrams per liter.
NA - Not Available.
SU - Standard Units.
USEPA - United States Environmental Protection Agency.

Detected Concentration > AWQC.

(a) - Surface water samples collected in April 2014.
(b) - USEPA National Recommended Water Quality Criteria. USEPA Office of Water and Office of Science and Technology.
http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm
USEPA AWQC Human Health for the Consumption of Organism Only apply to total concentrations.
(c) - Value applies to inorganic form of arsenic only.
(d) - pH values were obtained during the field sampling event and were recorded at the time of sample collection. Data for pH was not provided by the laboratory.

TABLE 6d
COMPARISON OF APRIL 2014 MISSISSIPPI RIVER SURFACE WATER RESULTS TO AWQC SCREENING LEVELS - DISSOLVED (FILTERED) SAMPLE RESULTS (a)
RUSH ISLAND ENERGY CENTER, JEFFERSON COUNTY, FESTUS, MO
AMEREN, MISSOURI

				Mississippi River									
			USEPA	Upstream					Downstream				
Constituent	CAS	Units	AWQC (b)	RI-R-4S	RI-R-5S	RI-R-5M	RI-R-6S	RI-R-6M	RI-R-1S	RI-R-2S	RI-R-2M	RI-R-3S	RI-R-3M
Antimony*	7440-36-0	mg/L	0.64										
Arsenic*	7440-38-2	mg/L	0.00014 (c)	0.001	0.0015	0.0012	0.0013	0.0014	0.0015	0.0011	0.0012	0.0012	0.0011
Barium	7440-39-3	mg/L	NA	0.0776	0.0796	0.0745	0.0677	0.0698	0.078	0.073	0.0662	0.0602	0.0611
Beryllium*	7440-41-7	mg/L	NA										
Boron	7440-42-8	mg/L	NA	0.053	0.0511	0.0502	0.0449	0.0476	0.0527	0.0499	0.0442	0.0405	0.0412
Cadmium*	7440-43-9	mg/L	NA										
Calcium	7440-70-2	mg/L	NA	52.5	52.6	52.1	52	51.7	52.5	52.4	51.3	50.9	51
Chromium	7440-47-3	mg/L	NA										
Cobalt*	7440-48-4	mg/L	NA										
Fluoride	16984-48-8	mg/L	NA	--	--	--	--	--	--	--	--	--	--
Lead*	7439-92-1	mg/L	NA		0.00049								
Mercury*	7439-97-6	mg/L	NA										
Molybdenum	7439-98-7	mg/L	NA	0.0018					0.0019		0.0017		
Selenium	7782-49-2	mg/L	4.2	0.00093	0.00079	0.00084	0.00069	0.00073	0.00087	0.00075	0.00085	0.0008	0.00079
Sulfate	14808-79-8	mg/L	NA	--	--	--	--	--	--	--	--	--	--
Thallium*	7440-28-0	mg/L	0.00047										
pH (d)	NA	SU	NA	6.14	7.59	8.88	8.33	8.76	8.58	8.56	8.88	7.78	8.93
Total Hardness as CaCO3	471-34-1	mg/L	NA	--	--	--	--	--	--	--	--	--	--

Notes:
Blank cells - Non-detect value.
* Constituent was not detected in any samples.
-- - Constituent not included in this analysis.
AWQC Ambient Water Quality Criteria.
CAS - Chemical Abstracts Service.

Detected Concentration > AWQC.

(a) - Surface water samples collected in April 2014.
(b) - USEPA National Recommended Water Quality Criteria. USEPA Office of Water and Office of Science and Technology.
http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm
USEPA AWQC Human Health for the Consumption of Organism Only apply to total concentrations.
(c) - Value applies to inorganic form of arsenic only.
(d) - pH values were obtained during the field sampling event and were recorded at the time of sample collection. Data for pH was not provided by the laboratory.

TABLE 7a
COMPARISON OF MAY 2018 MISSISSIPPI RIVER SURFACE WATER RESULTS
TO ECOLOGICAL SCREENING LEVELS - TOTAL (UNFILTERED) SAMPLE RESULTS (a)
RUSH ISLAND ENERGY CENTER, JEFFERSON COUNTY, FESTUS, MO
AMEREN MISSOURI

			Federal Water Quality Criteria		Mississippi River Upstream					Mississippi River Adjacent					Mississippi River Downstream					Mississippi River Further Downstream				
Constituent	CAS	Units	USEPA Aquatic Life AWQC Freshwater Acute (b)	USEPA Aquatic Life AWQC Freshwater Chronic (b)	R2-R-4S	R2-R-5M	R2-R-5S	R2-R-6M	R2-R-6S	R2-R-10S	R2-R-11M	R2-R-11S	R2-R-12M	R2-R-12S	R2-R-7S	R2-R-8M	R2-R-8S	R2-R-9M	R2-R-9S	R2-R-1S	R2-R-2M	R2-R-2S	R2-R-3M	R2-R-3S
Antimony*	7440-36-0	mg/L	NA	NA																				
Arsenic	7440-38-2	mg/L	0.34	0.15	0.0031	0.003	0.0029	0.0027	0.0019	0.0042 J	0.0041		0.0034	0.003	0.0044	0.003	0.003	0.0032	0.0029	0.003		0.0028	0.0027	0.0024
Barium	7440-39-3	mg/L	NA	NA	0.164	0.143	0.149	0.13	0.125	0.157	0.153	0.154	0.126	0.116	0.132	0.134	0.133	0.115	0.103	0.128	0.146	0.125	0.135	0.117
Beryllium	7440-41-7	mg/L	NA	NA	0.00037 J	0.00022 J	0.00019 J	0.00024 J	0.00038 J	0.0003 J	0.00037 J	0.00034 J	0.00024 J	0.00041 J	0.00028 J	0.00028 J	0.0004 J	0.00032 J	0.00017 J	0.00041 J	0.00038 J	0.00019 J	0.00043 J	0.00032 J
Boron	7440-42-8	mg/L	NA	NA	0.0603 J	0.0556 J	0.0564 J	0.0448 J	0.0447 J	0.0591 J	0.0552 J	0.0565 J	0.0441 J	0.0392 J	0.0569 J	0.0522 J	0.0562 J	0.0409 J	0.0392 J	0.0595 J	0.0548 J	0.0536 J	0.0495 J	0.0436 J
Cadmium	7440-43-9	mg/L	0.0047 (d)	0.0017 (d)												0.00057 J							0.00081 J	
Calcium	7440-70-2	mg/L	NA	NA	65.4	64.7	63.8	60	58.9	64.6	63.5	62.9	59.4	56	64.5	62.6	63.7	55.8	56	63.7	62.7	62.9	60	58.8
Chloride	16887-00-6	mg/L	860	230	23.8	24.2	24.5	26.7	27.5	23.8	24.5	24.5	27.2	28.4	23.7	25.5	25.2	28.1	28.4	23.7	24.8	24.8	26.5	27
Chromium	7440-47-3	mg/L	3.87 (c,d)	0.185 (c,d)	0.006	0.0033 J	0.0045 J	0.0046 J	0.0039 J	0.0056	0.0059	0.0044 J	0.004 J	0.0041 J	0.0016 J	0.0031 J	0.0027 J	0.0044 J		0.0013 J	0.0048 J		0.0049 J	0.0024 J
Cobalt	7440-48-4	mg/L	NA	NA	0.0031 J	0.0025 J	0.0024 J	0.003 J	0.0019 J	0.0026 J	0.0036 J	0.0028 J	0.0027 J	0.0018 J	0.0012 J	0.0023 J	0.0024 J	0.0019 J	0.0021 J	0.0013 J	0.0028 J	0.0015 J	0.0025 J	0.0015 J
Fluoride	16984-48-8	mg/L	NA	NA	0.25	0.25	0.25	0.21	0.21	0.25	0.26	0.24	0.26	0.24	0.3	0.22	0.24	0.21	0.2	0.24	0.25	0.25	0.21	0.21
Lead	7439-92-1	mg/L	0.26805 (d)	0.010 (d)	0.0067 J	0.0051 J	0.0045 J	0.0031 J	0.0039 J	0.0067 J	0.0046 J		0.0045 J	0.0032 J		0.0068 J		0.004 J			0.0056 J	0.0041 J	0.006 J	0.0041 J
Lithium	7439-93-2	mg/L	NA	NA	0.0262	0.0217	0.0245	0.0168	0.0151	0.0258	0.0223	0.0224	0.0146	0.0152	0.0233	0.0197	0.0211	0.0131	0.0103	0.0214	0.0206	0.0169	0.0161	0.0147
Mercury*	7439-97-6	mg/L	0.00165	0.001																				
Molybdenum	7439-98-7	mg/L	NA	NA	0.0021 J	0.0016 J	0.0012 J	0.0013 J	0.0015 J	0.0017 J	0.0019 J	0.0018 J	0.0018 J	0.0014 J	0.0015 J	0.0016 J	0.0019 J	0.0013 J	0.0011 J	0.0019 J	0.0014 J	0.001 J	0.0016 J	0.0015 J
Selenium*	7782-49-2	mg/L	NA	3.1																				
Sulfate	14808-79-8	mg/L	NA	NA	103	97.1	97.2	66.9	64.1	103	93.3	99.7	70.7	59.5	109	81.4	84.5	55.2	53.8	103	90.1	89.5	71.5	68.3
Thallium	7440-28-0	mg/L	NA	NA											0.00011 J									
Total Hardness as CaCO3	471-34-1	mg/L	NA	NA	271	267	264	247	244	268	261	259	245	232	265	258	261	231	231	264	260	257	249	242
Total Dissolved Solids	TDS	mg/L	NA	NA	232	371	374	336	346	381	363	382	337	307	404	376	361	330	319	378	363	324	326	328

Notes:
Blank cells - Non-detect value.
* Constituent was not detected in any samples.
AWQC - USEPA Ambient Water Quality Criteria.
CAS - Chemical Abstracts Service.
J - Estimated value.
mg/L - milligrams per liter.
NA - Not Available.
USEPA - United States Environmental Protection Agency.

Detected Concentration > USEPA Aquatic Life AWQC Chronic.
Detected Concentration > USEPA Aquatic Life AWQC Acute and Chronic.

(a) - Surface water samples collected in May 2018.
(b) - USEPA National Recommended Water Quality Criteria. USEPA Office of Water and Office of Science and Technology.
http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm
Total values provided. Values adjusted for site-specific hardness - see note (d).
USEPA provides AWQC for both total and dissolved results.
(c) - Value for trivalent chromium used.
(d) - Hardness dependent value for total metals. Site-specific total recoverable mean hardness value for the Mississippi River of 254 mg/L as CaCO3 used.

TABLE 7b
COMPARISON OF MAY 2018 MISSISSIPPI RIVER SURFACE WATER RESULTS -
TO ECOLOGICAL SCREENING LEVELS - DISSOLVED (FILTERED) SAMPLE RESULTS (a) RUSH ISLAND ENERGY CENTER, JEFFERSON COUNTY, FESTUS, MO
AMEREN MISSOURI

			Federal Water Quality Criteria		Mississippi River Upstream					Mississippi River Adjacent					Mississippi River Downstream					Mississippi River Further Downstream				
Constituent	CAS	Units	USEPA Aquatic Life AWQC Freshwater Acute (b)	USEPA Aquatic Life AWQC Freshwater Chronic (b)	R2-R-4S	R2-R-5M	R2-R-5S	R2-R-6M	R2-R-6S	R2-R-10S	R2-R-11M	R2-R-11S	R2-R-12M	R2-R-12S	R2-R-7S	R2-R-8M	R2-R-8S	R2-R-9M	R2-R-9S	R2-R-1S	R2-R-2M	R2-R-2S	R2-R-3M	R2-R-3S
Antimony*	7440-36-0	mg/L	NA	NA																				
Arsenic	7440-38-2	mg/L	0.34	0.15	0.0023		0.0022	0.0019	0.0018	0.0021	0.0022	0.0021	0.0017	0.0017	0.0024	0.0021	0.0021	0.0016	0.0016	0.0023	0.0022	0.0021	0.0019	0.0017
Barium	7440-39-3	mg/L	NA	NA	0.0942	0.0913	0.0951	0.0832	0.0772	0.095	0.0922	0.0919	0.0756	0.0741	0.0953	0.0888	0.092	0.0735	0.0744	0.0949	0.09	0.088	0.0775	0.0862
Beryllium*	7440-41-7	mg/L	NA	NA																				
Boron	7440-42-8	mg/L	NA	NA	0.0584 J	0.0531 J	0.0536 J	0.0464 J	0.041 J	0.0548 J	0.0536 J	0.0534 J	0.0368 J	0.0385 J	0.0541 J	0.0489 J	0.0542 J	0.0368 J	0.0374 J	0.0557 J	0.053 J	0.051 J	0.0411 J	0.0434 J
Cadmium	7440-43-9	mg/L	0.0043 (d)	0.0014 (d)			0.00054 J																	
Calcium	7440-70-2	mg/L	NA	NA	59.6	57.9	59.3	55.5	53.5	59.4	58.6	58.9	53.3	52.2	59.7	58.1	58.9	53	52.1	59.7	58.7	57.5	53.9	54.9
Chromium*	7440-47-3	mg/L	1.22 (c,d)	0.16 (c,d)																				
Cobalt*	7440-48-4	mg/L	NA	NA																				
Lead*	7439-92-1	mg/L	0.176 (d)	0.0068 (d)																				
Lithium	7439-93-2	mg/L	NA	NA	0.0209	0.0195	0.021	0.0139	0.012	0.021	0.0216	0.0194	0.0122	0.0116	0.0214	0.0169	0.0209	0.0083 J	0.0102	0.0194	0.0189	0.019	0.0131	0.0141
Mercury*	7439-97-6	mg/L	0.0014	0.00077																				
Molybdenum	7439-98-7	mg/L	NA	NA	0.0016 J	0.0018 J	0.0022 J	0.0013 J	0.0013 J	0.0019 J	0.0016 J	0.0016 J	0.0013 J	0.0013 J	0.0014 J	0.0015 J	0.0015 J	0.0012 J	0.0015 J	0.0013 J	0.0016 J	0.0014 J	0.0011 J	0.0012 J
Selenium*	7782-49-2	mg/L	NA	NA																				
Thallium*	7440-28-0	mg/L	NA	NA																				

Notes:
Blank cells - Non-detect value.
* Constituent was not detected in any samples.
AWQC - USEPA Ambient Water Quality Criteria.
CAS - Chemical Abstracts Service.
J - Estimated value.
mg/L - milligrams per liter.
NA - Not Available.
USEPA - United States Environmental Protection Agency.

Detected Concentration > USEPA Aquatic Life AWQC Chronic.
Detected Concentration > USEPA Aquatic Life AWQC Acute and Chronic.

(a) - Surface water samples collected in May 2018.
(b) - USEPA National Recommended Water Quality Criteria. USEPA Office of Water and Office of Science and Technology.
http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm
Total values provided. Values adjusted for site-specific hardness - see note (d). USEPA provides AWQC for both total and dissolved results.
(c) - Value for trivalent chromium used.
(d) - Hardness dependent value for total metals. Site-specific total recoverable mean hardness value for the Mississippi River of 254 mg/L as CaCO3 used.

TABLE 7c
COMPARISON OF APRIL 2014 MISSISSIPPI RIVER SURFACE WATER RESULTS TO ECOLOGICAL SCREENING LEVELS - TOTAL (UNFILTERED) SAMPLE RESULTS
(a) RUSH ISLAND ENERGY CENTER, JEFFERSON COUNTY, FESTUS, MO
AMEREN MISSOURI

			Federal Water Quality		Mississippi River									
					River Upstream					River Downstream				
Constituent	CAS	Units	USEPA Aquatic Life AWQC Freshwater Acute (b)	USEPA Aquatic Life AWQC Freshwater Chronic (b)	RI-R-4S	RI-R-5S	RI-R-5M	RI-R-6S	RI-R-6M	RI-R-1S	RI-R-2S	RI-R-2M	RI-R-3S	RI-R-3M
Antimony*	7440-36-0	mg/L	NA	NA										
Arsenic	7440-38-2	mg/L	0.34	0.15	0.0021	0.0019	0.0025	0.0023	0.0021	0.0028	0.0021	0.0024	0.0024	0.0022
Barium	7440-39-3	mg/L	NA	NA	0.104	0.102	0.101	0.0931	0.0932	0.1	0.099	0.0947	0.0801	0.0911
Beryllium*	7440-41-7	mg/L	NA	NA										
Boron	7440-42-8	mg/L	NA	NA	0.0553	0.0532	0.0532	0.0471	0.0468	0.0543	0.0515	0.0487	0.0418	0.0437
Cadmium*	7440-43-9	mg/L	0.0041 (e)	0.0015 (e)										
Calcium	7440-70-2	mg/L	NA	NA	56.4	54.3	55.2	54	53.6	53.5	54.1	53.7	52.9	53.7
Chromium	7440-47-3	mg/L	3.4 (d,e)	0.16 (d,e)	0.0027	0.0027	0.0026	0.0029	0.0031	0.0022	0.0032	0.0034	0.0021	0.0035
Cobalt	7440-48-4	mg/L	NA	NA	0.0023	0.0024	0.0026	0.0024	0.0025	0.0023	0.0028	0.0024	0.0021	0.0026
Fluoride	16984-48-8	mg/L	NA	NA				0.58						
Lead	7439-92-1	mg/L	0.22 (e)	0.0085 (e)	0.0025	0.0024	0.0025	0.0026	0.0022	0.0025	0.0025	0.0024	0.0022	0.0022
Mercury*	7439-97-6	mg/L	0.0016	0.00091										
Molybdenum	7439-98-7	mg/L	NA	NA										
Selenium	7782-49-2	mg/L	NA	3.1	0.00088	0.00097	0.0011	0.00079	0.00083	0.001	0.00098	0.00079	0.00077	0.00069
Sulfate	14808-79-8	mg/L	NA	NA	79	73.8	73.2	60.3	59.3	75.5	70.6	63.9	44.1	47
Thallium*	7440-28-0	mg/L	NA	NA										
pH (c)	NA	SU	NA	6.5-9	6.14	7.59	8.88	8.33	8.76	8.58	8.56	8.88	7.78	8.93
Total Hardness as CaCO3	471-34-1	mg/L	NA	NA	226	216	220	216	215	214	217	215	213	218

Notes:
Blank cells - Non-detect value.
* Constituent was not detected in any samples.
AWQC - USEPA Ambient Water Quality Criteria.
CAS - Chemical Abstracts Service.
mg/L - milligrams per liter.
NA - Not Available.
SU - Standard Units.
USEPA - United States Environmental Protection Agency.

Detected Concentration > USEPA Aquatic Life AWQC Chronic, or pH is outside the AWQC Chronic pH range..
Detected Concentration > USEPA Aquatic Life AWQC Acute and Chronic.

(a) - Surface water samples collected in April 2014.
(b) - USEPA National Recommended Water Quality Criteria. USEPA Office of Water and Office of Science and Technology.
http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm
Total values provided. Values adjusted for site-specific hardness - see note (e).
USEPA provides AWQC for both total and dissolved results.
(c) - pH values were obtained and recorded at the time of sample collection. Data for pH was not provided by the laboratory.
(d) - Value for trivalent chromium used.
(e) - Hardness dependent value for total metals and sulfate. Site-specific total recoverable mean hardness value for the Mississippi River of 217 mg/L as CaCO3 used.

TABLE 7d
COMPARISON OF APRIL 2014 MISSISSIPPI RIVER SURFACE WATER RESULTS TO ECOLOGICAL SCREENING LEVELS - DISSOLVED (FILTERED) SAMPLE RESULTS
(a) RUSH ISLAND ENERGY CENTER, JEFFERSON COUNTY, FESTUS, MO
AMEREN MISSOURI

			Federal Water Quality Criteria		Mississippi River									
					River Upstream					River Downstream				
Constituent	CAS	Units	USEPA Aquatic Life AWQC Freshwater Acute (b)	USEPA Aquatic Life AWQC Freshwater Chronic (b)	RI-R-4S	RI-R-5S	RI-R-5M	RI-R-6S	RI-R-6M	RI-R-1S	RI-R-2S	RI-R-2M	RI-R-3S	RI-R-3M
Antimony*	7440-36-0	mg/L	NA	NA										
Arsenic	7440-38-2	mg/L	0.34	0.15	0.001	0.0015	0.0012	0.0013	0.0014	0.0015	0.0011	0.0012	0.0012	0.0011
Barium	7440-39-3	mg/L	NA	NA	0.0776	0.0796	0.0745	0.0677	0.0698	0.078	0.073	0.0662	0.0602	0.0611
Beryllium*	7440-41-7	mg/L	NA	NA										
Boron	7440-42-8	mg/L	NA	NA	0.053	0.0511	0.0502	0.0449	0.0476	0.0527	0.0499	0.0442	0.0405	0.0412
Cadmium*	7440-43-9	mg/L	0.0037 (e)	0.0013 (e)										
Calcium	7440-70-2	mg/L	NA	NA	52.5	52.6	52.1	52	51.7	52.5	52.4	51.3	50.9	51
Chromium*	7440-47-3	mg/L	1.1 (d,e)	0.14 (d,e)										
Cobalt*	7440-48-4	mg/L	NA	NA										
Fluoride	16984-48-8	mg/L	NA	NA	--	--	--	--	--	--	--	--	--	--
Lead	7439-92-1	mg/L	0.15 (e)	0.0058 (e)		0.00049								
Mercury*	7439-97-6	mg/L	0.0014	0.00077										
Molybdenum	7439-98-7	mg/L	NA	NA	0.0018					0.0019		0.0017		
Selenium	7782-49-2	mg/L	NA	NA	0.00093	0.00079	0.00084	0.00069	0.00073	0.00087	0.00075	0.00085	0.0008	0.00079
Sulfate	14808-79-8	mg/L	NA	NA	--	--	--	--	--	--	--	--	--	--
Thallium*	7440-28-0	mg/L	NA	NA										
pH (c)	NA	SU	NA	6.5-9	6.14 [orange]	7.59	8.88	8.33	8.76	8.58	8.56	8.88	7.78	8.93
Total Hardness as CaCO3	471-34-1	mg/L	NA	NA	--	--	--	--	--	--	--	--	--	--

Notes:
Blank cells - Non-detect value.
* Constituent was not detected in any samples.
-- - Constituent not included in this analysis.
AWQC - USEPA Ambient Water Quality Criteria.
CAS - Chemical Abstracts Service.
mg/L - milligrams per liter.
NA - Not Available.
SU - Standard Units.
USEPA - United States Environmental Protection Agency.

[Orange] Detected Concentration > USEPA Aquatic Life AWQC Chronic, or pH is outside the AWQC Chronic pH range..
[Yellow] Detected Concentration > USEPA Aquatic Life AWQC Acute and Chronic.

(a) - Surface water samples collected in April 2014.
(b) - USEPA National Recommended Water Quality Criteria. USEPA Office of Water and Office of Science and Technology.
http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm
Total values provided. Values adjusted for site-specific hardness - see note (e).
USEPA provides AWQC for both total and dissolved results.
(c) - pH values were obtained and recorded at the time of sample collection. Data for pH was not provided by the laboratory.
(d) - Value for trivalent chromium used.
(e) - Hardness dependent value for total metals and sulfate. Site-specific total recoverable mean hardness value for the Mississippi River of 217 mg/L as CaCO3 used.

TABLE 8a
COMPARISON OF MAY 2018 ISLE DU BOIS CREEK CREEK SURFACE WATER RESULTS -
TO HUMAN HEALTH DRINKING WATER SCREENING LEVELS - TOTAL (UNFILTERED) SAMPLE RESULTS (a)
RUSH ISLAND ENERGY CENTER, JEFFERSON COUNTY, FESTUS, MO
AMEREN MISSOURI

Constituent	CAS	Units	Federal Water Quality Screening Levels			Selected Drinking Water Screening Level (h)	Isle Du Bois Creek Upstream			Isle Du Bois Creek Adjacent			Isle Du Bois Creek Downstream		
			USEPA MCLs (b)	USEPA SMCLs (b)	USEPA Tapwater RSLs (c)		R2-C-7S	R2-C-8S	R2-C-9S	R2-C-4S	R2-C-5S	R2-C-6S	R2-C-1S	R2-C-2S	R2-C-3S
Antimony*	7440-36-0	mg/L	0.006	NA	0.0078	0.006									
Arsenic	7440-38-2	mg/L	0.01	NA	0.000052	0.01	0.0014	0.0016	0.0014	0.0019	0.0019	0.0019	0.002	0.002	0.0019
Barium	7440-39-3	mg/L	2	NA	3.8	2	0.0923	0.0934	0.0927	0.0969	0.101	0.0961	0.0988	0.0965	0.0974
Beryllium*	7440-41-7	mg/L	0.004	NA	0.025	0.004									
Boron	7440-42-8	mg/L	NA	NA	4	4	0.0329 J	0.0312 J	0.0318 J	0.04 J	0.0405 J	0.0375 J	0.0447 J	0.0433 J	0.043 J
Cadmium	7440-43-9	mg/L	0.005	NA	0.0092	0.005		0.00046 J				0.00067 J		0.00059 J	0.0005 J
Calcium	7440-70-2	mg/L	NA	NA	NA	NA	58.5	57.7	58.4	56.7	58	56.6	55.3	55.4	56.4
Chloride	16887-00-6	mg/L	NA	250	NA	250	18.6	19.9	19.8	19.7	19.5	19.4	19	19.2	18.8
Chromium*	7440-47-3	mg/L	0.1 (e)	NA	22 (f)	0.1									
Cobalt	7440-48-4	mg/L	NA	NA	0.006	0.006							0.00097 J	0.00092 J	
Fluoride	16984-48-8	mg/L	4	2	0.8	4	0.19 J	0.19 J	0.18 J	0.21	0.24	0.21	0.25	0.25	0.24
Lead*	7439-92-1	mg/L	0.015 (g)	NA	0.015	0.015									
Lithium	7439-93-2	mg/L	NA	NA	0.04	0.04				0.005 J	0.0063 J	0.0054 J	0.0084 J	0.0086 J	0.0092 J
Mercury*	7439-97-6	mg/L	0.002	NA	0.0057 (i)	0.002									
Molybdenum	7439-98-7	mg/L	NA	NA	0.1	0.1	0.0012 J	0.0011 J	0.0011 J	0.0012 J	0.0016 J	0.0011 J	0.0014 J	0.0018 J	0.0016 J
Selenium*	7782-49-2	mg/L	0.05	NA	0.1	0.05									
Sulfate	14808-79-8	mg/L	NA	250	NA	250	47.8	47.8	47.9	56.7	56.2	55.5	65.4	65	63.3
Thallium*	7440-28-0	mg/L	0.002	NA	0.0002	0.002									
Total Hardness as CaCO3	471-34-1	mg/L	NA	NA	NA	NA	248	245	247	235	241	236	229	231	234
Total Dissolved Solids	TDS	mg/L	NA	500	NA	500	324	337	334	344	348	334	341	334	340

Notes:

Blank cells - Non-detect value.
* - Constituent was not detected in any samples.
CAS - Chemical Abstracts Service.
J - Estimated value.
MCL - Maximum Contaminant Level.

mg/L - milligrams per liter.
NA - Not Available.
RSL - Regional Screening Level.
SMCL - Secondary Maximum Contaminant Level.
USEPA - United States Environmental Protection Agency.

Detected Concentration > Selected Drinking Water Screening Level.

(a) - Surface water samples collected in May 2018.
(b) - USEPA 2018 Edition of the Drinking Water Standards and Health Advisories. Spring 2018.
http://water.epa.gov/drink/contaminants/index.cfm
(c) - USEPA Regional Screening Levels (November 2018). Values for tapwater.
http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/index.htm
(d) - RSL for Mercuric Chloride used for Mercury.
(e) - The drinking water standard or MCL for chromium is based on total chromium.
(f) - Value for trivalent chromium used. USEPA provides a screening level for hexavalent chromium that is not a drinking water standard, the basis of which has been questioned by USEPA's Science Advisory Board.
(g) - The Action Level presented is recommended in the USEPA Drinking Water Standards.
(h) - Selected Drinking Water Screening Level uses the following hierarchy:
Federal USEPA MCL for Drinking Water.
Federal USEPA SMCL for Drinking Water.
Federal November 2018 USEPA Tapwater RSL.

TABLE 8b
COMPARISON OF MAY 2018 ISLE DU BOIS CREEK CREEK SURFACE WATER RESULTS -
TO HUMAN HEALTH DRINKING WATER SCREENING LEVELS - DISSOLVED (FILTERED) SAMPLE RESULTS (a)
RUSH ISLAND ENERGY CENTER, JEFFERSON COUNTY, FESTUS, MO
AMEREN MISSOURI

Constituent	CAS	Units	Federal Water Quality Screening Levels			Selected Drinking Water Screening Level (h)	Isle Du Bois Creek Upstream			Isle Du Bois Creek Adjacent			Isle Du Bois Creek Downstream		
			USEPA MCLs (b)	USEPA SMCLs (b)	USEPA Tapwater RSLs (c)		R2-C-7S	R2-C-8S	R2-C-9S	R2-C-4S	R2-C-5S	R2-C-6S	R2-C-1S	R2-C-2S	R2-C-3S
Antimony*	7440-36-0	mg/L	0.006	NA	0.0078	0.006									
Arsenic	7440-38-2	mg/L	0.01	NA	0.000052	0.01	0.0014	0.0014	0.0015	0.0018	0.0013	0.0013	0.0018	0.0019	0.0016
Barium	7440-39-3	mg/L	2	NA	3.8	2	0.094	0.0942	0.0902	0.0904	0.0982	0.0952	0.0847	0.0852	0.0846
Beryllium*	7440-41-7	mg/L	0.004	NA	0.025	0.004									
Boron	7440-42-8	mg/L	NA	NA	4	4	0.0335 J	0.034 J	0.0329 J	0.0386 J	0.0423 J	0.042 J	0.0407 J	0.0411 J	0.0357 J
Cadmium*	7440-43-9	mg/L	0.005	NA	0.0092	0.005									
Calcium	7440-70-2	mg/L	NA	NA	NA	NA	65.5	66	62.7	59.3	62.4	60.8	55.6	56.5	59.3
Chromium*	7440-47-3	mg/L	0.1 (e)	NA	22 (f)	0.1									
Cobalt*	7440-48-4	mg/L	NA	NA	0.006	0.006									
Lead*	7439-92-1	mg/L	0.015 (g)	NA	0.015	0.015									
Lithium	7439-93-2	mg/L	NA	NA	0.04	0.04					0.0057 J	0.0052 J	0.258 J		
Mercury*	7439-97-6	mg/L	0.002	NA	0.0057 (d)	0.002									
Molybdenum	7439-98-7	mg/L	NA	NA	0.1	0.1					0.0015 J	0.0017 J			
Selenium*	7782-49-2	mg/L	0.05	NA	0.1	0.05									
Thallium*	7440-28-0	mg/L	0.002	NA	0.0002	0.002									

Notes:
Blank cells - Non-detect value.
* - Constituent was not detected in any samples.
CAS - Chemical Abstracts Service.
J - Estimated value.
MCL - Maximum Contaminant Level.
mg/L - milligrams per liter.
NA - Not Available.
RSL - Regional Screening Level.
SMCL - Secondary Maximum Contaminant Level.
USEPA - United States Environmental Protection Agency.

[green shading] Detected Concentration > Selected Drinking Water Screening Level.

(a) - Surface water samples collected in May 2018.
(b) - USEPA 2018 Edition of the Drinking Water Standards and Health Advisories. Spring 2018.
http://water.epa.gov/drink/contaminants/index.cfm
(c) - USEPA Regional Screening Levels (November 2018). Values for tapwater.
http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/index.htm
(d) - RSL for Mercuric Chloride used for Mercury.
(e) - The drinking water standard or MCL for chromium is based on total chromium.
(f) - Value for trivalent chromium used. USEPA provides a screening level for hexavalent chromium
that is not a drinking water standard, the basis of which has been questioned by USEPA's Science Advisory Board.
(g) - The Action Level presented is recommended in the USEPA Drinking Water Standards.
(h) - Selected Drinking Water Screening Level uses the following hierarchy:
Federal USEPA MCL for Drinking Water.
Federal USEPA SMCL for Drinking Water.
Federal November 2018 USEPA Tapwater RSL.

TABLE 8c
COMPARISON OF APRIL 2014 ISLE DU BOIS CREEK SURFACE WATER RESULTS TO SCREENING LEVELS - TOTAL (UNFILTERED) SAMPLE RESULTS
(a) RUSH ISLAND ENERGY CENTER, JEFFERSON COUNTY, FESTUS, MO
AMEREN MISSOURI

Constituent	CAS	Units	Federal Water Quality Screening Levels			Selected Drinking Water Screening Level (i)	Isle de Bois Creek								
							Creek Upstream			Creek Adjacent			Creek Downstream		
			USEPA MCLs (b)	USEPA SMCLs (b)	USEPA Tapwater RSLs (c)		RI-C-7	RI-C-8	RI-C-9	RI-C-4	RI-C-5	RI-C-6	RI-C-1	RI-C-2	RI-C-3
Antimony*	7440-36-0	mg/L	0.006	NA	0.0078	0.006									
Arsenic	7440-38-2	mg/L	0.01	NA	0.000052	0.01	0.0011	0.00079	0.0012	0.00091	0.0012		0.0015	0.0017	0.0013
Barium	7440-39-3	mg/L	2	NA	3.8	2	0.0999	0.0919	0.0938	0.0909	0.0935	0.091	0.107	0.0957	0.0987
Beryllium*	7440-41-7	mg/L	0.004	NA	0.025	0.004									
Boron	7440-42-8	mg/L	NA	NA	4	4	0.0208	0.0195	0.0189	0.036	0.0366	0.0343	0.0395	0.039	0.0391
Cadmium*	7440-43-9	mg/L	0.005	NA	0.0092	0.005									
Calcium	7440-70-2	mg/L	NA	NA	NA	NA	70.3	65.8	66	67	66.7	66.5	67.1	65.6	65.8
Chromium	7440-47-3	mg/L	0.1 (e)	NA	22 (f)	0.1	0.0021	0.0017	0.0018			0.002	0.0033	0.0016	0.002
Cobalt	7440-48-4	mg/L	NA	NA	0.006	0.006	0.0023	0.0019	0.0019	0.0017	0.0018	0.002			
Fluoride*	16984-48-8	mg/L	4	2	0.8	4									
Lead	7439-92-1	mg/L	0.015 (g)	NA	0.015	0.015	0.002	0.0016	0.0016	0.0013	0.0013	0.0012	0.0027	0.002	0.002
Mercury*	7439-97-6	mg/L	0.002	NA	0.0057 (i)	0.002									
Molybdenum	7439-98-7	mg/L	NA	NA	0.1	0.1							0.002	0.0018	
Selenium	7782-49-2	mg/L	0.05	NA	0.1	0.05	0.00067								
Sulfate	14808-79-8	mg/L	NA	250	NA	250	43.2	42.4	43.7	41.7	40.8	41.9	40.5	40.2	41.1
Thallium*	7440-28-0	mg/L	0.002	NA	0.0002	0.002									
pH (d)	NA	SU	NA	6.5-8.5	NA	NA	7.65	8.08	7.42	7.35	7.38	7.43	7.89	7.48	7.42
Total Hardness as CaCO3	471-34-1	mg/L	NA	NA	NA	NA	286	273	275	273	272	271	273	265	267

Notes:
Blank cells - Non-detect value.
* Constituent was not detected in any samples.
-- - Constituent not included in this analysis.
CAS - Chemical Abstracts Service.
MCL - Maximum Contaminant Level.
mg/L - milligrams per liter.
NA - Not Available.
RSL - Regional Screening Level.
SU - Standard Units.
SMCL - Secondary Maximum Contaminant Level.
USEPA - United States Environmental Protection Agency.

Detected Concentration > Selected Drinking Water Screening Level.

(a) - Surface water samples collected in April 2014.
(b) - USEPA 2018 Edition of the Drinking Water Standards and Health Advisories. Spring 2018.
http://water.epa.gov/drink/contaminants/index.cfm
(c) - USEPA Regional Screening Levels (November 2018). Values for tapwater.
http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/index.htm
(d) - pH values were obtained during the field sampling event and were recorded at the time of sample collection. Data for pH was not provided by the laboratory.
(e) - The drinking water standard or MCL for chromium is based on total chromium.
(f) - The tapwater RSL for mercury is based on mercuric chloride.
(g) - The Action Level presented is recommended in the USEPA Drinking Water Standards.
(h) - Value for trivalent chromium used. USEPA provides a screening level for hexavalent chromium that is not a drinking water standard, the basis of which has been questioned by USEPA's Science Advisory Board.
(i) - Selected Drinking Water Screening Level uses the following hierarchy:
Federal USEPA MCL for Drinking Water.
Federal USEPA SMCL for Drinking Water.
Federal November 2018 USEPA Tapwater RSL.

TABLE 8d
COMPARISON OF APRIL 2014 ISLE DU BOIS CREEK SURFACE WATER RESULTS TO SCREENING LEVELS - DISSOLVED (FILTERED) SAMPLE RESULTS (a)
RUSH ISLAND ENERGY CENTER, JEFFERSON COUNTY, FESTUS, MO
AMEREN MISSOURI

Constituent	CAS	Units	Federal Water Quality Screening Levels			Selected Drinking Water Screening Level (i)	Isle du Bois Creek								
							Creek Upstream			Creek Adjacent			Creek Downstream		
			USEPA MCLs (b)	USEPA SMCLs (b)	USEPA Tapwater RSLs (c)		RI-C-7	RI-C-8	RI-C-9	RI-C-4	RI-C-5	RI-C-6	RI-C-1	RI-C-2	RI-C-3
Antimony*	7440-36-0	mg/L	0.006	NA	0.0078	0.006									
Arsenic*	7440-38-2	mg/L	0.01	NA	0.000052	0.01									
Barium	7440-39-3	mg/L	2	NA	3.8	2	0.0845	0.0813	0.0829	0.0818	0.0827	0.0821	0.0863	0.0854	0.0868
Beryllium*	7440-41-7	mg/L	0.004	NA	0.025	0.004									
Boron	7440-42-8	mg/L	NA	NA	4	4	0.019	0.0172	0.018	0.0351	0.0348	0.0334	0.0368	0.0375	0.0374
Cadmium*	7440-43-9	mg/L	0.005	NA	0.0092	0.005									
Calcium	7440-70-2	mg/L	NA	NA	NA	NA	67.4	64.4	65.6	66	67.5	66.7	67	66.7	68.1
Chromium	7440-47-3	mg/L	0.1 (e)	NA	22 (f)	0.1					0.0021				
Cobalt*	7440-48-4	mg/L	NA	NA	0.006	0.006									
Fluoride	16984-48-8	mg/L	4	2	0.8	4	--	--	--	--	--	--	--	--	--
Lead*	7439-92-1	mg/L	0.015 (g)	NA	0.015	0.015									
Mercury*	7439-97-6	mg/L	0.002	NA	0.0057 (i)	0.002									
Molybdenum	7439-98-7	mg/L	NA	NA	0.1	0.1							0.004	0.0021	
Selenium	7782-49-2	mg/L	0.05	NA	0.1	0.05	0.00058								
Sulfate	14808-79-8	mg/L	NA	250	NA	250	--	--	--	--	--	--	--	--	--
Thallium*	7440-28-0	mg/L	0.002	NA	0.0002	0.002									
pH (d)	NA	SU	NA	6.5-8.5	NA	NA	7.65	8.08	7.42	7.35	7.38	7.43	7.89	7.48	7.42
Total Hardness as CaCO3	471-34-1	mg/L	NA	NA	NA	NA	--	--	--	--	--	--	--	--	--

Notes:
Blank cells - Non-detect value.
* Constituent was not detected in any samples.
-- - Constituent not included in this analysis.
CAS - Chemical Abstracts Service.
MCL - Maximum Contaminant Level.
mg/L - milligrams per liter.
NA - Not Available.
RSL - Regional Screening Level.
SMCL - Secondary Maximum Contaminant Level.
SU - Standard Units.
USEPA - United States Environmental Protection Agency.

Detected Concentration > Selected Drinking Water Screening Level.

(a) - Surface water samples collected in April 2014.
(b) - USEPA 2018 Edition of the Drinking Water Standards and Health Advisories. Spring 2018.
http://water.epa.gov/drink/contaminants/index.cfm
(c) - USEPA Regional Screening Levels (November 2018). Values for tapwater.
http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/Generic_Tables/index.htm
(d) - pH values were obtained during the field sampling event and were recorded at the time of sample collection. Data for pH was not provided by the laboratory.
(e) - The drinking water standard or MCL for chromium is based on total chromium.
(f) - The tapwater RSL for mercury is based on mercuric chloride.
(g) - The Action Level presented is recommended in the USEPA Drinking Water Standards.
(h) - Value for trivalent chromium used. USEPA provides a screening level for hexavalent chromium that is not a drinking water standard, the basis of which has been questioned by USEPA's Science Advisory Board.
(i) - Selected Drinking Water Screening Level uses the following hierarchy:
Federal USEPA MCL for Drinking Water.
Federal USEPA SMCL for Drinking Water.
Federal November 2018 USEPA Tapwater RSL.

TABLE 9a
COMPARISON OF MAY 2018 ISLE DU BOIS CREEK CREEK SURFACE WATER RESULTS -
TO HUMAN HEALTH AWQC SCREENING LEVELS - TOTAL (UNFILTERED) SAMPLE RESULTS (a)
RUSH ISLAND ENERGY CENTER, JEFFERSON COUNTY, FESTUS, MO
AMEREN MISSOURI

Constituent	CAS	Units	USEPA AWQC (b)	Isle Du Bois Creek Upstream			Isle Du Bois Creek Adjacent			Isle Du Bois Creek Downstream		
				R2-C-7S	R2-C-8S	R2-C-9S	R2-C-4S	R2-C-5S	R2-C-6S	R2-C-1S	R2-C-2S	R2-C-3S
Antimony*	7440-36-0	mg/L	0.64									
Arsenic	7440-38-2	mg/L	0.00014 (c)	0.0014	0.0016	0.0014	0.0019	0.0019	0.0019	0.002	0.002	0.0019
Barium	7440-39-3	mg/L	NA	0.0923	0.0934	0.0927	0.0969	0.101	0.0961	0.0988	0.0965	0.0974
Beryllium*	7440-41-7	mg/L	NA									
Boron	7440-42-8	mg/L	NA	0.0329 J	0.0312 J	0.0318 J	0.04 J	0.0405 J	0.0375 J	0.0447 J	0.0433 J	0.043 J
Cadmium	7440-43-9	mg/L	NA		0.00046 J				0.00067 J		0.00059 J	0.0005 J
Calcium	7440-70-2	mg/L	NA	58.5	57.7	58.4	56.7	58	56.6	55.3	55.4	56.4
Chloride	16887-00-6	mg/L	NA	18.6	19.9	19.8	19.7	19.5	19.4	19	19.2	18.8
Chromium*	7440-47-3	mg/L	NA									
Cobalt	7440-48-4	mg/L	NA							0.00097 J	0.00092 J	
Fluoride	16984-48-8	mg/L	NA	0.19 J	0.19 J	0.18 J	0.21	0.24	0.21	0.25	0.25	0.24
Lead*	7439-92-1	mg/L	NA									
Lithium	7439-93-2	mg/L	NA				0.005 J	0.0063 J	0.0054 J	0.0084 J	0.0086 J	0.0092 J
Mercury*	7439-97-6	mg/L	NA									
Molybdenum	7439-98-7	mg/L	NA	0.0012 J	0.0011 J	0.0011 J	0.0012 J	0.0016 J	0.0011 J	0.0014 J	0.0018 J	0.0016 J
Selenium*	7782-49-2	mg/L	4.2									
Sulfate	14808-79-8	mg/L	NA	47.8	47.8	47.9	56.7	56.2	55.5	65.4	65	63.3
Thallium*	7440-28-0	mg/L	0.00047									
Total Hardness as CaCO3	471-34-1	mg/L	NA	248	245	247	235	241	236	229	231	234
Total Dissolved Solids	TDS	mg/L	NA	324	337	334	344	348	334	341	334	340

Notes:
Blank cells - Non-detect value.
* - Constituent was not detected in any samples.
AWQC - Ambient Water Quality Criteria.
CAS - Chemical Abstracts Service.
J - Estimated value.
mg/L - milligrams per liter.
NA - Not Available.
USEPA - United States Environmental Protection Agency.

Detected Concentration > AWQC.

(a) - Surface water samples collected in May 2018.
(b) - USEPA National Recommended Water Quality Criteria.
USEPA Office of Water and Office of Science and Technology.
http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm
USEPA AWQC Human Health for the Consumption of Organism Only
apply to total concentrations.
(c) - Value applies to inorganic form of arsenic only.

TABLE 9b
COMPARISON OF MAY 2018 ISLE DU BOIS CREEK CREEK SURFACE WATER RESULTS -
TO AWQC SCREENING LEVELS - DISSOLVED (FILTERED) SAMPLE RESULTS (a)
RUSH ISLAND ENERGY CENTER, JEFFERSON COUNTY, FESTUS, MO
AMEREN MISSOURI

Constituent	CAS	Units	USEPA AWQC (b)	Isle Du Bois Creek Upstream			Isle Du Bois Creek Adjacent			Isle Du Bois Creek Downstream		
				R2-C-7S	R2-C-8S	R2-C-9S	R2-C-4S	R2-C-5S	R2-C-6S	R2-C-1S	R2-C-2S	R2-C-3S
Antimony*	7440-36-0	mg/L	0.64									
Arsenic	7440-38-2	mg/L	0.00014 (c)	0.0014	0.0014	0.0015	0.0018	0.0013	0.0013	0.0018	0.0019	0.0016
Barium	7440-39-3	mg/L	NA	0.094	0.0942	0.0902	0.0904	0.0982	0.0952	0.0847	0.0852	0.0846
Beryllium*	7440-41-7	mg/L	NA									
Boron	7440-42-8	mg/L	NA	0.0335 J	0.034 J	0.0329 J	0.0386 J	0.0423 J	0.042 J	0.0407 J	0.0411 J	0.0357 J
Cadmium*	7440-43-9	mg/L	NA									
Calcium	7440-70-2	mg/L	NA	65.5	66	62.7	59.3	62.4	60.8	55.6	56.5	59.3
Chromium*	7440-47-3	mg/L	NA									
Cobalt*	7440-48-4	mg/L	NA									
Lead*	7439-92-1	mg/L	NA									
Lithium	7439-93-2	mg/L	NA					0.0057 J	0.0052 J	0.258 J		
Mercury*	7439-97-6	mg/L	NA									
Molybdenum	7439-98-7	mg/L	NA					0.0015 J	0.0017 J			
Selenium*	7782-49-2	mg/L	4.2									
Thallium*	7440-28-0	mg/L	0.00047									

Notes:

Blank cells - Non-detect value.
* - Constituent was not detected in any samples.
AWQC - Ambient Water Quality Criteria.
CAS - Chemical Abstracts Service.
J - Estimated value.
mg/L - milligrams per liter.
NA - Not Available.
USEPA - United States Environmental Protection Agency.

Detected Concentration > AWQC.

(a) - Surface water samples collected in May 2018.
(b) - USEPA National Recommended Water Quality Criteria.
USEPA Office of Water and Office of Science and Technology.
http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm
USEPA AWQC Human Health for the Consumption of Organism Only
apply to total concentrations.
(c) - Value applies to inorganic form of arsenic only.

TABLE 9c
COMPARISON OF APRIL 2014 ISLE DU BOIS CREEK SURFACE WATER RESULTS TO AWQC SCREENING LEVELS - TOTAL (UNFILTERED) SAMPLE RESULTS (a)
RUSH ISLAND ENERGY CENTER, JEFFERSON COUNTY, FESTUS, MO
AMEREN MISSOURI

			USEPA	Isle de Bois Creek								
				Creek Upstream			Creek Adjacent			Creek Downstream		
Constituent	**CAS**	**Units**	**AWQC (b)**	**RI-C-7**	**RI-C-8**	**RI-C-9**	**RI-C-4**	**RI-C-5**	**RI-C-6**	**RI-C-1**	**RI-C-2**	**RI-C-3**
Antimony*	7440-36-0	mg/L	0.64									
Arsenic	7440-38-2	mg/L	0.00014 (c)	0.0011	0.00079	0.0012	0.00091	0.0012		0.0015	0.0017	0.0013
Barium	7440-39-3	mg/L	NA	0.0999	0.0919	0.0938	0.0909	0.0935	0.091	0.107	0.0957	0.0987
Beryllium*	7440-41-7	mg/L	NA									
Boron	7440-42-8	mg/L	NA	0.0208	0.0195	0.0189	0.036	0.0366	0.0343	0.0395	0.039	0.0391
Cadmium*	7440-43-9	mg/L	NA									
Calcium	7440-70-2	mg/L	NA	70.3	65.8	66	67	66.7	66.5	67.1	65.6	65.8
Chromium	7440-47-3	mg/L	NA	0.0021	0.0017	0.0018			0.002	0.0033	0.0016	0.002
Cobalt	7440-48-4	mg/L	NA	0.0023	0.0019	0.0019	0.0017	0.0018	0.002			
Fluoride*	16984-48-8	mg/L	NA									
Lead	7439-92-1	mg/L	NA	0.002	0.0016	0.0016	0.0013	0.0013	0.0012	0.0027	0.002	0.002
Mercury*	7439-97-6	mg/L	NA									
Molybdenum	7439-98-7	mg/L	NA							0.002	0.0018	
Selenium	7782-49-2	mg/L	4.2	0.00067								
Sulfate	14808-79-8	mg/L	NA	43.2	42.4	43.7	41.7	40.8	41.9	40.5	40.2	41.1
Thallium*	7440-28-0	mg/L	0.00047									
pH (d)	NA	SU	NA	7.65	8.08	7.42	7.35	7.38	7.43	7.89	7.48	7.42
Total Hardness as CaCO3	471-34-1	mg/L	NA	286	273	275	273	272	271	273	265	267

Notes:
Blank cells - Non-detect value.
* Constituent was not detected in any samples.
-- - Constituent not included in this analysis.
AWQC - Ambient Water Quality Criteria.
CAS - Chemical Abstracts Service.
mg/L - milligrams per liter.
NA - Not Available.
SU - Standard Units.
USEPA - United States Environmental Protection Agency.

[green shading] Detected Concentration > AWQC.

(a) - Surface water samples collected in April 2014.
(b) - USEPA National Recommended Water Quality Criteria. USEPA Office of Water and Office of Science and Technology.
http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm
USEPA AWQC Human Health for the Consumption of Organism Only apply to total concentrations.
(c) - Value applies to inorganic form of arsenic only.
(d) - pH values were obtained during the field sampling event and were recorded at the time of sample collection. Data for pH was not provided by the laboratory.

TABLE 9d
COMPARISON OF APRIL 2014 ISLE DU BOIS CREEK SURFACE WATER RESULTS TO AWQC SCREENING LEVELS - DISSOLVED (FILTERED) SAMPLE RESULTS
(a) RUSH ISLAND ENERGY CENTER, JEFFERSON COUNTY, FESTUS, MO
AMEREN MISSOURI

				Isle du Bois Creek								
			USEPA	Creek Upstream			Creek Adjacent			Creek Downstream		
Constituent	CAS	Units	AWQC (b)	RI-C-7	RI-C-8	RI-C-9	RI-C-4	RI-C-5	RI-C-6	RI-C-1	RI-C-2	RI-C-3
Antimony*	7440-36-0	mg/L	0.64									
Arsenic*	7440-38-2	mg/L	0.00014 (c)									
Barium	7440-39-3	mg/L	NA	0.0845	0.0813	0.0829	0.0818	0.0827	0.0821	0.0863	0.0854	0.0868
Beryllium*	7440-41-7	mg/L	NA									
Boron	7440-42-8	mg/L	NA	0.019	0.0172	0.018	0.0351	0.0348	0.0334	0.0368	0.0375	0.0374
Cadmium*	7440-43-9	mg/L	NA									
Calcium	7440-70-2	mg/L	NA	67.4	64.4	65.6	66	67.5	66.7	67	66.7	68.1
Chromium	7440-47-3	mg/L	NA					0.0021				
Cobalt*	7440-48-4	mg/L	NA									
Fluoride	16984-48-8	mg/L	NA	--	--	--	--	--	--	--	--	--
Lead*	7439-92-1	mg/L	NA									
Mercury*	7439-97-6	mg/L	NA									
Molybdenum	7439-98-7	mg/L	NA							0.004	0.0021	
Selenium	7782-49-2	mg/L	4.2	0.00058								
Sulfate	14808-79-8	mg/L	NA	--	--	--	--	--	--	--	--	--
Thallium*	7440-28-0	mg/L	0.00047									
pH (d)	NA	SU	NA	7.65	8.08	7.42	7.35	7.38	7.43	7.89	7.48	7.42
Total Hardness as CaCO3	471-34-1	mg/L	NA	--	--	--	--	--	--	--	--	--

Notes:
Blank cells - Non-detect value.
* Constituent was not detected in any samples.
-- - Constituent not included in this analysis.
AWQC Ambient Water Quality Criteria.
CAS - Chemical Abstracts Service.

mg/L - milligrams per liter.
NA - Not Available.
SU - Standard Units.
USEPA - United States Environmental Protection Agency.

Detected Concentration > AWQC.

(a) - Surface water samples collected in April 2014.
(b) - USEPA National Recommended Water Quality Criteria. USEPA Office of Water and Office of Science and Technology.
http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm
(c) - Value applies to inorganic form of arsenic only.
(d) - pH values were obtained during the field sampling event and were recorded at the time of sample collection. Data for pH was not provided by the laboratory.

TABLE 10a
COMPARISON OF MAY 2018 ISLE DU BOIS CREEK CREEK SURFACE WATER RESULTS -
TO ECOLOGICAL SCREENING LEVELS - TOTAL (UNFILTERED) SAMPLE RESULTS (a)
RUSH ISLAND ENERGY CENTER, JEFFERSON COUNTY, FESTUS, MO
AMEREN MISSOURI

Constituent	CAS	Units	Federal Water Quality Criteria		Isle Du Bois Creek Upstream			Isle Du Bois Creek Adjacent			Isle Du Bois Creek		
			USEPA Aquatic Life AWQC Freshwater Acute (b)	USEPA Aquatic Life AWQC Freshwater Chronic (b)	R2-C-7S	R2-C-8S	R2-C-9S	R2-C-4S	R2-C-5S	R2-C-6S	R2-C-1S	R2-C-2S	R2-C-3S
Antimony*	7440-36-0	mg/L	NA	NA									
Arsenic	7440-38-2	mg/L	0.34	0.15	0.0014	0.0016	0.0014	0.0019	0.0019	0.0019	0.002	0.002	0.0019
Barium	7440-39-3	mg/L	NA	NA	0.0923	0.0934	0.0927	0.0969	0.101	0.0961	0.0988	0.0965	0.0974
Beryllium*	7440-41-7	mg/L	NA	NA									
Boron	7440-42-8	mg/L	NA	NA	0.0329 J	0.0312 J	0.0318 J	0.04 J	0.0405 J	0.0375 J	0.0447 J	0.0433 J	0.043 J
Cadmium	7440-43-9	mg/L	0.0044 (d)	0.0016 (d)		0.00046 J				0.00067 J		0.00059 J	0.0005 J
Calcium	7440-70-2	mg/L	NA	NA	58.5	57.7	58.4	56.7	58	56.6	55.3	55.4	56.4
Chloride	16887-00-6	mg/L	860	230	18.6	19.9	19.8	19.7	19.5	19.4	19	19.2	18.8
Chromium*	7440-47-3	mg/L	3.7 (c,d)	0.176 (c,d)									
Cobalt	7440-48-4	mg/L	NA	NA							0.00097 J	0.00092 J	
Fluoride	16984-48-8	mg/L	NA	NA	0.19 J	0.19 J	0.18 J	0.21	0.24	0.21	0.25	0.25	0.24
Lead*	7439-92-1	mg/L	0.25 (d)	0.010 (d)									
Lithium	7439-93-2	mg/L	NA	NA				0.005 J	0.0063 J	0.0054 J	0.0084 J	0.0086 J	0.0092 J
Mercury*	7439-97-6	mg/L	0.0016	0.001									
Molybdenum	7439-98-7	mg/L	NA	NA	0.0012 J	0.0011 J	0.0011 J	0.0012 J	0.0016 J	0.0011 J	0.0014 J	0.0018 J	0.0016 J
Selenium*	7782-49-2	mg/L	NA	3.1									
Sulfate	14808-79-8	mg/L	NA	NA	47.8	47.8	47.9	56.7	56.2	55.5	65.4	65	63.3
Thallium*	7440-28-0	mg/L	NA	NA									
Total Hardness as CaCO3	471-34-1	mg/L	NA	NA	248	245	247	235	241	236	229	231	234
Total Dissolved Solids	TDS	mg/L	NA	NA	324	337	334	344	348	334	341	334	340

Notes:

Blank cells - Non-detect value.
* Constituent was not detected in any samples.
AWQC - USEPA Ambient Water Quality Criteria.
CAS - Chemical Abstracts Service.

J - Estimated value.
mg/L - milligrams per liter.
NA - Not Available.
USEPA - United States Environmental Protection Agency.

Detected Concentration > USEPA Aquatic Life AWQC Chronic.
Detected Concentration > USEPA Aquatic Life AWQC Acute and Chronic.

(a) - Surface water samples collected in May 2018.
(b) - USEPA National Recommended Water Quality Criteria. USEPA Office of Water and Office of Science and Technology.
http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm
Total values provided. Values adjusted for site-specific hardness - see note (d).
USEPA provides AWQC for both total and dissolved results.
(c) - Value for trivalent chromium used.
(d) - Hardness dependent value for total metals. Site-specific total recoverable mean hardness value for Isle Du Bois Creek of 238 mg/L as CaCO3 used.

TABLE 10b
COMPARISON OF MAY 2018 ISLE DU BOIS CREEK CREEK SURFACE WATER RESULTS -
TO ECOLOGICAL SCREENING LEVELS - DISSOLVED (FILTERED) SAMPLE RESULTS (a) RUSH
ISLAND ENERGY CENTER, JEFFERSON COUNTY, FESTUS, MO
AMEREN MISSOURI

Constituent	CAS	Units	Federal Water Quality Criteria		Isle Du Bois Creek Upstream			Isle Du Bois Creek Adjacent			Isle Du Bois Creek Downstream		
			USEPA Aquatic Life AWQC Freshwater Acute (b)	USEPA Aquatic Life AWQC Freshwater Chronic (b)	R2-C-7S	R2-C-8S	R2-C-9S	R2-C-4S	R2-C-5S	R2-C-6S	R2-C-1S	R2-C-2S	R2-C-3S
Antimony*	7440-36-0	mg/L	NA	NA									
Arsenic	7440-38-2	mg/L	0.34	0.15	0.0014	0.0014	0.0015	0.0018	0.0013	0.0013	0.0018	0.0019	0.0016
Barium	7440-39-3	mg/L	NA	NA	0.094	0.0942	0.0902	0.0904	0.0982	0.0952	0.0847	0.0852	0.0846
Beryllium*	7440-41-7	mg/L	NA	NA									
Boron	7440-42-8	mg/L	NA	NA	0.0335 J	0.034 J	0.0329 J	0.0386 J	0.0423 J	0.042 J	0.0407 J	0.0411 J	0.0357 J
Cadmium*	7440-43-9	mg/L	0.0040 (d)	0.0014 (d)									
Calcium	7440-70-2	mg/L	NA	NA	65.5	66	62.7	59.3	62.4	60.8	55.6	56.5	59.3
Chromium*	7440-47-3	mg/L	1.16 (c,d)	0.15 (c,d)									
Cobalt*	7440-48-4	mg/L	NA	NA									
Lead*	7439-92-1	mg/L	0.164 (d)	0.0064 (d)									
Lithium	7439-93-2	mg/L	NA	NA					0.0057 J	0.0052 J	0.258 J		
Mercury*	7439-97-6	mg/L	0.0014	0.00077									
Molybdenum	7439-98-7	mg/L	NA	NA					0.0015 J	0.0017 J			
Selenium*	7782-49-2	mg/L	NA	NA									
Thallium*	7440-28-0	mg/L	NA	NA									

Notes:
Blank cells - Non-detect value.
* Constituent was not detected in any samples.
AWQC - USEPA Ambient Water Quality Criteria.
CAS - Chemical Abstracts Service.
J - Estimated value.
mg/L - milligrams per liter.
NA - Not Available.
USEPA - United States Environmental Protection Agency.

Detected Concentration > USEPA Aquatic Life AWQC Chronic.
Detected Concentration > USEPA Aquatic Life AWQC Acute and Chronic.

(a) - Surface water samples collected in May 2018.
(b) - USEPA National Recommended Water Quality Criteria. USEPA Office of Water and Office of Science and Technology.
http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm
Total values provided. Values adjusted for site-specific hardness - see note (d). USEPA provides AWQC for both total and dissolved results.
(c) - Value for trivalent chromium used.
(d) - Hardness dependent value for total metals. Site-specific total recoverable mean hardness value for Isle Du Bois Creek of 238 mg/L as CaCO3 used.

TABLE 10c
COMPARISON OF APRIL 2014 ISLE DU BOIS CREEK SURFACE WATER RESULTS TO ECOLOGICAL SCREENING LEVELS - TOTAL (UNFILTERED) SAMPLE RESULTS (a)
RUSH ISLAND ENERGY CENTER, JEFFERSON COUNTY, FESTUS, MO
AMEREN MISSOURI

Constituent	CAS	Units	Federal Water Quality Criteria		Isle Du Bois Creek								
			USEPA Aquatic Life AWQC Freshwater Acute (b)	USEPA Aquatic Life AWQC Freshwater Chronic (b)	Creek Upstream			Creek Adjacent			Creek Downstream		
					RI-C-7	RI-C-8	RI-C-9	RI-C-4	RI-C-5	RI-C-6	RI-C-1	RI-C-2	RI-C-3
Antimony*	7440-36-0	mg/L	NA	NA									
Arsenic	7440-38-2	mg/L	0.34	0.15	0.0011	0.00079	0.0012	0.00091	0.0012		0.0015	0.0017	0.0013
Barium	7440-39-3	mg/L	NA	NA	0.0999	0.0919	0.0938	0.0909	0.0935	0.091	0.107	0.0957	0.0987
Beryllium*	7440-41-7	mg/L	NA	NA									
Boron	7440-42-8	mg/L	NA	NA	0.0208	0.0195	0.0189	0.036	0.0366	0.0343	0.0395	0.039	0.0391
Cadmium*	7440-43-9	mg/L	0.0051 (e)	0.0018 (e)									
Calcium	7440-70-2	mg/L	NA	NA	70.3	65.8	66	67	66.7	66.5	67.1	65.6	65.8
Chromium	7440-47-3	mg/L	4.1 (d,e)	0.20 (d,e)	0.0021	0.0017	0.0018			0.002	0.0033	0.0016	0.002
Cobalt	7440-48-4	mg/L	NA	NA	0.0023	0.0019	0.0019	0.0017	0.0018	0.002			
Fluoride*	16984-48-8	mg/L	NA	NA									
Lead	7439-92-1	mg/L	0.29 (e)	0.011 (e)	0.002	0.0016	0.0016	0.0013	0.0013	0.0012	0.0027	0.002	0.002
Mercury*	7439-97-6	mg/L	0.0016	0.00091									
Molybdenum	7439-98-7	mg/L	NA	NA							0.002	0.0018	
Selenium	7782-49-2	mg/L	NA	3.1	0.00067								
Sulfate	14808-79-8	mg/L	NA	NA	43.2	42.4	43.7	41.7	40.8	41.9	40.5	40.2	41.1
Thallium*	7440-28-0	mg/L	NA	NA									
pH (c)	NA	SU	NA	6.5-9	7.65	8.08	7.42	7.35	7.38	7.43	7.89	7.48	7.42
Total Hardness as CaCO3	471-34-1	mg/L	NA	NA	286	273	275	273	272	271	273	265	267

Notes:
Blank cells - Non-detect value.
* Constituent was not detected in any samples.
AWQC - USEPA Ambient Water Quality Criteria.
CAS - Chemical Abstracts Service.
mg/L - milligrams per liter.
NA - Not Available.
SU - Standard Units.
USEPA - United States Environmental Protection Agency.

Detected Concentration > USEPA Aquatic Life AWQC Chronic, or pH is outside the AWQC Chronic pH range..
Detected Concentration > USEPA Aquatic Life AWQC Acute and Chronic.

(a) - Surface water samples collected in April 2014.
(b) - USEPA National Recommended Water Quality Criteria. USEPA Office of Water and Office of Science and Technology.
http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm
Total values provided. Values adjusted for site-specific hardness - see note (e).
USEPA provides AWQC for both total and dissolved results.
(c) - pH values were obtained and recorded at the time of sample collection. Data for pH was not provided by the laboratory.
(d) - Value for trivalent chromium used.
(e) - Hardness dependent value for total metals and sulfate. Site-specific total recoverable mean hardness value for the Isle Du Bois Creek of 273 mg/L as CaCO3 used.

TABLE 10d
COMPARISON OF APRIL 2014 ISLE DU BOIS CREEK SURFACE WATER RESULTS TO ECOLOGICAL SCREENING LEVELS - DISSOLVED (FILTERED) SAMPLE RESULTS (a)
RUSH ISLAND ENERGY CENTER, JEFFERSON COUNTY, FESTUS, MO
AMEREN MISSOURI

			Federal Water Quality Criteria		Isle Du Bois Creek								
			USEPA Aquatic Life AWQC Freshwater Acute (b)	USEPA Aquatic Life AWQC Freshwater Chronic (b)	Creek Upstream			Creek Adjacent			Creek Downstream		
Constituent	**CAS**	**Units**			**RI-C-7**	**RI-C-8**	**RI-C-9**	**RI-C-4**	**RI-C-5**	**RI-C-6**	**RI-C-1**	**RI-C-2**	**RI-C-3**
Antimony*	7440-36-0	mg/L	NA	NA									
Arsenic*	7440-38-2	mg/L	0.34	0.15									
Barium	7440-39-3	mg/L	NA	NA	0.0845	0.0813	0.0829	0.0818	0.0827	0.0821	0.0863	0.0854	0.0868
Beryllium*	7440-41-7	mg/L	NA	NA									
Boron	7440-42-8	mg/L	NA	NA	0.019	0.0172	0.018	0.0351	0.0348	0.0334	0.0368	0.0375	0.0374
Cadmium*	7440-43-9	mg/L	0.0046 (e)	0.0015 (e)									
Calcium	7440-70-2	mg/L	NA	NA	67.4	64.4	65.6	66	67.5	66.7	67	66.7	68.1
Chromium	7440-47-3	mg/L	1.3 (d,e)	0.17 (d,e)					0.0021				
Cobalt*	7440-48-4	mg/L	NA	NA									
Fluoride	16984-48-8	mg/L	NA	NA	--	--	--	--	--	--	--	--	--
Lead*	7439-92-1	mg/L	0.19 (e)	0.0074 (e)									
Mercury*	7439-97-6	mg/L	0.0014	0.00077									
Molybdenum	7439-98-7	mg/L	NA	NA							0.004	0.0021	
Selenium	7782-49-2	mg/L	NA	NA	0.00058								
Sulfate	14808-79-8	mg/L	NA	NA	--	--	--	--	--	--	--	--	--
Thallium*	7440-28-0	mg/L	NA	NA									
pH (h)	NA	SU	NA	6.5-9	7.65	8.08	7.42	7.35	7.38	7.43	7.89	7.48	7.42
Total Hardness as CaCO3	471-34-1	mg/L	NA	NA	--	--	--	--	--	--	--	--	--

Notes:
Blank cells - Non-detect value.
* Constituent was not detected in any samples.
-- - Constituent not included in this analysis.
AWQC - USEPA Ambient Water Quality Criteria.
CAS - Chemical Abstracts Service.
mg/L - milligrams per liter.
NA - Not Available.
SU - Standard Units.
USEPA - United States Environmental Protection Agency.

Detected Concentration > USEPA Aquatic Life AWQC Chronic, or pH is outside the AWQC Chronic pH range..
Detected Concentration > USEPA Aquatic Life AWQC Acute and Chronic.

(a) - Surface water samples collected in April 2014.
(b) - USEPA National Recommended Water Quality Criteria. USEPA Office of Water and Office of Science and Technology.
http://water.epa.gov/scitech/swguidance/standards/criteria/current/index.cfm
Total values provided. Values adjusted for site-specific hardness - see note (e).
USEPA provides AWQC for both total and dissolved results.
(c) - pH values were obtained and recorded at the time of sample collection. Data for pH was not provided by the laboratory.
(d) - Value for trivalent chromium used.
(e) - Hardness dependent value for total metals and sulfate. Site-specific total recoverable mean hardness value for the Isle Du Bois Creek of 273 mg/L as CaCO3 used.

APPENDIX B

What You Need to Know About Molybdenum

WHAT YOU NEED TO KNOW ABOUT MOLYBDENUM

Molybdenum is the one constituent that is present in at least one groundwater sample at each of the four Ameren energy centers in Missouri above the screening level used by the U.S. Environmental Protection Agency (USEPA) under the Coal Combustion Residuals (CCR) Rule. The purpose of this fact sheet is to provide information on molybdenum so that data can be considered in context. There is no public exposure to groundwater at the Ameren energy centers and concentration levels of molybdenum in adjacent surface waters are all well below health-based regulatory standards.

SOURCES OF INFORMATION ON MOLYBDENUM

Molybdenum had been evaluated by regulatory and health agencies in the U.S. As discussed below, molybdenum is an essential nutrient for humans, and the Institute of Medicine of the U.S. National Academy of Sciences (NAS) has provided recommended daily allowances and tolerable upper limits to be used as guidelines for vitamins and supplements and other exposures (NAS, 2001).

The Agency for Toxic Substances and Disease Registry (ATSDR) is a federal public health agency within the U.S. Department of Health and Human Services. The ATSDR Toxicological Profile for Molybdenum (ATSDR, 2017) provides a comprehensive summary and interpretation of available toxicological and epidemiological information on molybdenum and provides information on the naturally occurring levels in our environment and in our diet.

The U.S. Environmental Protection Agency (USEPA) published an oral toxicity value for molybdenum in 1992 (USEPA, 1992); this value serves as the basis for the tapwater screening level for molybdenum of 0.1 milligrams per liter (mg/L) or 100 micrograms per liter (ug/L) that was included in the Phase 1 Part update to the CCR Rule (USEPA, 2018a).

MOLYBDENUM IS NATURALLY OCCURRING AND AN ESSENTIAL NUTRIENT FOR PLANTS AND HUMANS

Molybdenum is a naturally occurring trace element that can be found extensively in nature. Biologically, molybdenum plays an important role as a micronutrient in plants and animals, including humans.

Molybdenum in Our Natural Environment

Molybdenum naturally accumulates in poorly drained soils and soils with high organic content (for example, peat bogs and wetlands). It is also present at high concentrations in “black shales,” which are shale deposits with high organic content. The U.S. Geological Survey (USGS, 2013) reports that the average concentration in U.S. soils is approximately 1 milligram per kilogram of soil (mg/kg). USGS (2011) estimates the median concentration of molybdenum in groundwater is 0.001 milligrams per liter (mg/L), with most concentrations below 0.008 mg/L.

Molybdenum in Our Diet

Molybdenum is considered an essential nutrient or trace element for living beings. It is required in several mammalian enzyme systems and is present in most adult multi-vitamins. A deficiency syndrome has only been seen in people with a genetic defect that prevents the synthesis of a specific enzyme for which molybdenum is a cofactor. The deficiency leads to severe neurological damage and early death.

Because it is present in soils, it is also present in our diet. Food derived from above ground plants, such as legumes, leafy vegetables, and cauliflower generally has a relatively higher concentration of molybdenum in comparison to food from tubers or animals. Beans, cereal grains, leafy vegetables, legumes, liver, and milk are reported as the richest sources of molybdenum in the average diet (ATSDR, 2017). The amount of molybdenum in plants varies according to the amount in the soil. The National Academy of Sciences (NAS) has estimated that the average dietary intakes of molybdenum by adult men and women are 0.109 and 0.076 milligrams per day (mg/day), respectively. A study of the dietary intake of adult residents in Denver, Colorado reported a mean molybdenum ingestion rate of 180 µg/day (range 120–240 µg/day) (ATSDR, 2017).

Molybdenum for Health

How Much Do You Need - Daily Allowance:

The Institute of Medicine of the NAS sets dietary intake values for essential nutrients. The recommended dietary allowance (RDA) for a nutrient is "the average daily dietary nutrient intake level sufficient to meet the nutrient requirement of nearly all (97 to 98 percent) health individuals" (NAS, 2001). The RDA for molybdenum for adults set by the NAS in 2001 is 0.045 milligram per day (mg/day) and is based on the amount of molybdenum needed to achieve a steady healthy balance in the body for the majority of the population.

How Much is Too Much - Upper Limits:

In addition to the RDA, the NAS also defines a Tolerable Upper Intake Level (UL) for essential nutrients. The UL is "the highest average daily nutrient intake level that is likely to pose no risk of adverse health effects to almost all individuals in the general population." Thus, the RDA is a level that is considered to be sufficient for the health of the general population, while intake can be as high as the UL and pose no adverse health effects.

The UL for molybdenum set by the NAS is 2 mg/day. This level is based on an evaluation of the potential toxicity of molybdenum at high levels of intake. The most sensitive effect in the literature is associated with reproductive outcomes in rats, and the study was used to develop an oral toxicity value for humans of 0.03 milligrams of molybdenum ingested per day per kilogram of body weight (mg/kg-day). This value is used with an average adult body weight of 68-70 kg (154 lbs) to set the UL[1].

[1] The oral toxicity value identifies a level of intake in terms of milligrams of constituent per kilogram of body weight per day (mg/kg-day) that is considered to be safe for daily exposure for a lifetime. The oral toxicity value is used to calculate a safe drinking water level as follows: if the oral toxicity value is 0.03 mg/kg-day, and a 70 kg adult that consumes 2 liters of water per day, then the safe drinking water level = (0.03 mg/kg-day) x (70 kg) ÷ (2 liters water/day) = 1.05 milligrams per liter (mg/L).

USEPA'S ORAL TOXICITY VALUE FOR MOLYBDENUM

USEPA developed a lower oral toxicity value for molybdenum of 0.005 mg/kg-day (USEPA, 1992) based on a 1962 study of a small population (52 exposure subjects) in Armenia that had a high level of molybdenum in their diet. This population had high levels of uric acid and experienced gout. The findings from the Armenian study have not been replicated, and other regulatory bodies such as the NAS and ATSDR have rejected the study due to its many deficiencies. [It is likely that the observance of gout in the Armenian population had some other cause.]

The NAS concluded that there were "serious methodological difficulties with the [Armenian] study" and noted that no other studies in humans or animals have replicated this effect. The NAS toxicity value is 0.03 mg/kg-day, six-fold higher than the USEPA value. Based on the NAS toxicity value and USEPA assumptions (for body weight and drinking water intake) results in a calculated safe drinking water level of 0.6 mg/L or 600 ug/L.

ATSDR noted the study of the Armenian population was not considered suitable for derivation of a chronic-duration oral toxicity value for molybdenum due to deficiencies in the control group size and composition, and a lack of controlling for confounders, such as diet and alcohol, that could affect the results. ATSDR developed an oral toxicity value of 0.008 mg/kg-day, using the same study reproductive outcomes in rats as the NAS, but applying different assumptions, most notably a 3-fold higher uncertainty factor. Based on the ATSDR toxicity value and USEPA assumptions (for body weight and drinking water intake) results in a calculated safe drinking water level of 0.16 mg/L or 160 ug/L.

MOLYBDENUM UNDER THE CCR RULE

When the CCR Rule was published in 2015, groundwater standards were provided only for those Appendix IV constituents that have primary drinking water standards published by the USEPA under the Safe Drinking Water Act – values known as MCLs or maximum contaminant levels. Molybdenum does not have an MCL[2]. In a subsequent 2018 CCR rule-making, USEPA designated a health-based groundwater protection standard for molybdenum of 0.1 mg/L or 100 ug/L. That is the value used to evaluate groundwater at the Ameren facilities. This level is very conservative and could be much higher and still protective of human health, as described above. [Note that in its March 3, 2019 report the Environmental Integrity Project used a screening level for molybdenum of 0.04 mg/L (or 40 ug/L), which is <u>not</u> the level USEPA has required in the CCR Rule.]

However, based on the USEPA toxicity value, the drinking water levels USEPA has developed for molybdenum are:

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[2] USEPA is in the process of gathering information on the occurrence of molybdenum in public drinking water systems. The decision to develop an MCL (which is a multi-year process) is based on occurrence in public drinking water systems, the severity of adverse health effects, whether the constituent is present in public drinking water systems at levels of public health concern, and whether regulation would provide a meaningful opportunity for health risk reduction. No decision has yet been made as to whether molybdenum will be a candidate for the development of a drinking standard. Note that when USEPA included molybdenum for public water supply testing, it cited USEPA 1992, ATSDR 2017, and NAS 2001 as toxicity references. No mention was made of the differences in toxicity studies used or the values developed.

- 0.1 mg/L – The USEPA tapwater value in its Regional Screening Level (RSL) table and the value identified by USEPA for the CCR Rule (USEPA, 2018b). This is the value USEPA uses in the CCR Rule (USEPA, 2018a).
- 0.2 mg/L – The USEPA Office of Water value for the Drinking Water Equivalent Level (DWEL), which is a *lifetime exposure* concentration protective of adverse, non-cancer health effects, that assumes all of the exposure to a constituent is from drinking water (USEPA, 2018c).
- 0.04 mg/L – The USEPA Office of Water value for the Health Advisory Level (HA), which is based on the DWEL, but using a default assumption that only 20% of intake can come from water (USEPA, 2018c).

Therefore, drinking water concentrations of molybdenum up to 0.2 mg/L to are expected to be **without** adverse health effects. Based on the NAS review, daily exposure to drinking water concentrations of molybdenum up to 0.6 mg/L would be **without** adverse health effects.

WHAT THIS MEANS FOR THE AMEREN ENERGY CENTERS

This information from the NAS has been used to evaluate the levels of molybdenum in groundwater at the Ameren Energy Centers and in nearby surface waters. A total of 930 groundwater and surface water samples were collected from the four energy centers. The concentration levels in approximately 866 samples were below the screening level based on the National Academy of Science Tolerable Upper Intake Level (UL), while 241 are above the GWPS established by USEPA in the CCR Rule.

	Labadie	Meramec	Rush Island	Sioux
Groundwater				
Number of Samples	208	88	77	244
Molybdenum greater than CCR GWPS of 0.1 mg/L (a)	81	35	38	77
Molybdenum greater than NAS standard of 0.6 mg/L (b)	3	1	11	49
Surface Water				
Number of Samples	67	74	50	80
Molybdenum greater than 0.1 mg/L (a)	0	0	0	0

Notes:
mg/L - milligrams per liter.
(a) - Drinking water-based groundwater protection standard specified in the Coal Combustion Residuals Rule.
(b) - Alternative health-protective drinking water screening level based on the National Academy of Sciences review of molybdenum.

The groundwater results were collected from monitoring wells placed as close as practical to the ash basins' boundaries and provide near-source groundwater monitoring results. The groundwater downgradient of each of the Ameren ash basins is not used as a source of drinking water. Deep bedrock groundwater used as drinking water in the vicinity of Labadie and in the vicinity of Rush Island was sampled and demonstrated no impacts from CCR.

Surface water adjacent to each of the energy centers was sampled and all results for molybdenum in surface water are well below the USEPA drinking water screening level of 0.1 mg/L.

Thus, although there are some results for molybdenum in groundwater that are above the USEPA drinking water screening level, the groundwater at these facilities is not used as a source of drinking water, and molybdenum is not present in any of the adjacent water bodies above the drinking water screening level. These results confirm that molybdenum does not pose a risk to human health or the environment at any of the Ameren facilities.

REFERENCES

ATSDR. 2017. Toxicological Profile for Molybdenum. Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services. Available at: https://www.atsdr.cdc.gov/ToxProfiles/tp.asp?id=1482&tid=289

NAS. 2001. Dietary Reference Intakes for Vitamin A, Vitamin K, Arsenic, Boron, Chromium, Copper, Iodine, Iron, Manganese, Molybdenum, Nickel, Silicon, Vanadium, and Zinc. Institute of Medicine. National Academy of Sciences. 2001. National Academy Press. Available at: http://www.nap.edu/catalog/10026.html

USEPA. 1992. Chemical Assessment Summary for Molybdenum. Integrated Risk Information System (IRIS). National Center for Environmental Assessment. U.S. Environmental Protection Agency. Available at: https://cfpub.epa.gov/ncea/iris2/chemicalLanding.cfm?&substance_nmbr=425

USEPA. 2018a. Hazardous and Solid Waste Management System: Disposal of Coal Combustion Residuals from Electric Utilities; Amendments to the National Minimum Criteria (Phase One, Part One). Available at: https://www.federalregister.gov/documents/2018/07/30/2018-16262/hazardous-and-solid-waste-management-system-disposal-of-coal-combustion-residuals-from-electric

USEPA. 2018b. USEPA Regional Screening Levels. U.S. Environmental Protection Agency. Available at: https://www.epa.gov/risk/regional-screening-levels-rsls

USEPA. 2018c. 2018 Edition of the Drinking Water Standards and Health Advisories. March 2018. EPA 822-F-18-001. Office of Water. U.S. Environmental Protection Agency Washington, DC. Available at: https://www.epa.gov/sites/production/files/2018-03/documents/dwtable2018.pdf

USGS. 2011. Trace Elements National Synthesis Project: Trace Elements and Radon in Groundwater Across the United States, 1992-2003. U.S. Department of the Interior. U.S. Geological Survey (USGS). Scientific Investigations Report 2011-5059. Available at: https://water.usgs.gov/nawqa/trace/pubs/sir2011-5059/index.html

USGS. 2013. Geochemical and mineralogical data for soils of the conterminous United States: U.S. Geological Survey Data Series 801, 19 p. Available at: http://pubs.usgs.gov/ds/801/

APPENDIX C

Extraction & Transportation Study

APRIL 29, 2019

EXTRACTION & TRANSPORTATION STUDY: Rush Island Ash Pond Closure Assessment

Rush Island Site

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Introduction

Lochmueller Group completed the following planning-level assessment of the costs and logistics associated with extracting, stabilizing, and transporting coal combustion residuals (CCR) from the existing ash pond system at the Rush Island Power Generation Center to existing offsite, commercially available landfill facilities. The Rush Island site is located along the Mississippi River in Jefferson County, Missouri approximately nine (9) miles southeast of Festus, Missouri. The purpose of this assessment is to describe the methods, determine the impacts, and quantify the order-of-magnitude costs associated with removing and transporting all CCR from its current disposal location at the Rush Island site to a private landfill for permanent storage.

Extraction & Stabilization

Description of Method

Extraction and stabilization of the CCR material from the CCR unit at Rush Island Energy Center is complicated due to its depth and location. In addition, the CCR unit contains both Class C and F fly ash that complicates excavation methods. CCR material from the unit would need to be excavated at depths of up to 100 feet, dewatered, dried and conditioned, before being and loaded into trucks and transported offsite.

Removal of the CCR material would require multiple phases including dry extraction, partially wet extraction and fully submerged extraction. The various phases are described below:

Dry Extraction:

This phase includes the handling and removal of the existing CCR material from the current surface elevation down to the groundwater elevation (approximately 18' below the ground surface (BGS) elevation) (Geotechnical Investigation and Report, prepared by CEC and dated December 20, 2011). Generally, it is assumed that this material can be direct loaded and transported without additional drying or conditioning procedures (moisture content between approximately 25% and 35%). The work associated with this phase includes the extraction, on-site transportation to Staging/Loading Areas, storage, and loading onto transportation for off-site removal. Standard earth-moving equipment and procedures would be utilized including dozers, loaders, and excavators. In general, dozers would be used to excavate and move the CCR material into piles and loaders would be used to load the CCR material into the waiting trucks for transport off-site. Excavators would be used in a support role to dig in areas where dozers are not efficient. Sub-areas of the pond area would need to be established to facilitate extraction operations. The general size of these sub-areas, laterally and vertically, will be determined based on on-site conditions as the operation progresses and the CCR material is removed.

Partially Wet Extraction:

This phase includes the handling and removal of the existing CCR material from the groundwater elevation to a point in which hydraulic excavation is feasible (18' below ground surface to 28' below ground surface). This material is assumed to be in acceptable condition for loading and transportation with no additional drying and conditioning after the dewatering procedure described below is completed.

Dewatering of this material would involve excavation of channels to promote material drying prior to excavation and transportation. Water would be diverted from excavated depressions utilizing pumps and piping systems to transport the water away from the material excavation area. After sufficient dewatering and drying time, the CCR materials would be removed using the same means as described for dry excavation.

Fully Submerged Extraction:

CCR materials located further down in the pond (28' below ground surface to 100' below ground surface) may be saturated and would require drying and conditioning prior to off-site transport. Such materials would need to be extracted via hydraulic dredging methods. The complexities and potential costs associated with such dredging efforts are significantly higher per unit volume than the "Dry Extraction" and "Partially Wet Extraction" phases. In fact, successful pond closures at the depths required for the Rush Island site could were not discovered. Removal operations for CCR ponds with depths up to 50 feet were found.

This method employs equipment that removes the CCR material directly from the bottom of the CCR unit and pumps the “slurry” through a piping system to “geotubes” located in nearby drying areas. Geotubes are a geotextile filtration “bag” manufactured by sewing together multiple sheets of geotextiles using polyester or polypropylene. As the dredged water enters the geotubes, the geotextile captures the CCR materials as the water drains. Chemical addition during the pumping and piping operation using coagulants and flocculants will be necessary to aid in the dewatering process. The specific makeup of CCR materials are site specific. Therefore, selection of the most effective and efficient coagulants and flocculants will require bench testing. Maintenance of the dredging equipment, piping system, drying areas, settling ponds, and temporary roads will be necessary to facilitate the operation.

Significantly large drying areas will be required to accommodate the multi-week week drying procedure. After dewatering is complete, the geotubes are opened and the CCR material is loaded onto transportation for off-site removal. The transportation of material for off-site removal was the assumed limiting factor for the overall CCR disposal process flow based on the analysis performed in this study. However, extended, unforeseen weather conditions can contribute to additional lost working time due to icy conditions, mechanical system freeze-ups, or flooding.

Site Restoration:

This phase includes the final restoration of the site. This would include removal of all temporary access roads and residual ash in project area. Backfilling would likely need to occur for at least some volume of the remaining pond in conjunction with excavation activities to minimize infiltration from the Mississippi River. The closest source of backfill material would be sand dredged from the Mississippi River. Stabilization of the site with vegetative practices would be required for erosion control. The river banks and the remaining embankment along the river would require additional analysis and appropriate stabilization, but may include a combination of vegetation, large rocks or manufactured concrete products.

Extraction and Stabilization Impacts

Safety

Accidents

Workforce safety during the operation is a significant risk factor. With several unit processes operating with heavy machinery, proper safety planning is important. Accidents can be minimized during operations, but the planning and implementation of a safety plan will have significant costs associated with the effort.

Exposure

There is not only immediate physical injury risks, but there is also exposure risk to the people working on the site. Proper safety equipment will be necessary to limit exposure to potentially harmful substances in the CCR material removal process such as flocculants and coagulant used for the dewatering process.

Environment

Floodplain

The project area is currently shown within the 100 year floodplain for both the current and pending FIRM maps. The potential for the area to experience flooding during excavation activities creates additional risk to the extraction and stabilization operations.

River Embankment

The existing ash ponds are adjacent to the Mississippi River. There is a strip of land that separates these surface water bodies and serves and an embankment that separates the pond from the river. Proper excavation techniques and monitoring will need to be employed to ensure the land between the two surface water bodies remains stable during excavation and dredging activities. After dredging activities are complete, the embankment will require analysis to confirm stability. Removal of the embankment and/or significant re-stabilization may be necessary for the restoration of the site.

Emissions

The heavy equipment used during the extraction and stabilization phase of the project includes dozers, loaders, excavators, hydraulic dredges, and onsite hauling trucks. These types of equipment typically utilize diesel fuel and would generate emissions during operations. These emissions are in addition to the emissions discussed in the transportation impacts section of this assessment.

Fugitive Ash Particulate

As the CCR material is being extracted and stabilized, fugitive ash particulate will be created and would need to be managed through an ash management plan.

Capital Projects

Onsite Access Roads

The onsite access road utilized for the offsite hauling trucks is discussed in the transportation section of this assessment. The construction of temporary on-site hauling roads will be required throughout the extraction and stabilization process. These haul roads will need to be modified frequently in order to provide efficient transportation of the CCR to the stabilization and loading areas and to maintain dust control.

Geotube Staging Areas

Geotube staging areas will need to be constructed within the project area that are relatively flat to allow for proper dewatering of the CCR. These staging areas will be temporary and will need to be moved throughout the closure process as CCR is removed during different phases of the operation. Filtrate from the geotubes would be directed back to the settling ponds for treatment.

Water Treatment Facilities

The existing ponds could be utilized throughout the CCR removal process for settling any remaining solids from the filtrate from the drying process. There may be a need for the construction of new settling ponds toward the end of the process to fully remove CCR from the existing ponds. The filtrate will likely contain suspended solids and some form of treatment or settling may need to be evaluated depending on the final characteristics of the filtrate.

Loading Areas

Once the CCR is stabilized, the material may require some additional layout and loading area to ensure the material is dry enough for offsite hauling and ultimate placement in a landfill. The loading areas will need to be constructed as appropriate for the CCR removal areas that are active. The loading areas will require the construction of scales for measuring the weight of trucks and truck washing facilities to wash down tires of residual ash material.

Restoration of Former Ash Ponds

The post-CCR-removal condition of the ponds will be dependent on the final planned use of the area. Some options may include backfilling, removing embankment, creating or restoring habitat, etc. Achieving the desired future use may include utilizing the soil material that would remain between the pond and the river to backfill some of the remaining pond area. Sand backfill material could also be dredged from the Mississippi river for additional backfill material. Overall stabilization of the site would be required and would include vegetative, natural rock, and manufactured products to meet regulatory requirements.

Transportation & Disposal

This section addresses the transportation of CCR material from the site and its permanent disposal at a private landfill.

Modal Options (Truck, Rail, Barge)

The Rush Island site is located along the Mississippi River. Additionally, a BNSF rail line runs adjacent to the site. Therefore, the ability to haul CCR by barge and rail from Rush Island may be possible. However, significant infrastructure improvements would be required at the Rush Island site to provide ash loading capabilities for these modes.

The preferred landfill locations are all located within 80 miles of Rush Island. None of the sites have direct water access. Therefore, any CCR transported by barge from Rush Island would need to be transferred from barge to truck to reach the landfill destinations. The inefficiency of this transfer would render barge transportation considerably more costly than truck hauling. Moreover, most of the landfill sites are located further inland (east or west) from Rush Island such that north-south travel along the Mississippi River would not be beneficial.

With regards to rail, none of the preferred landfill sites have direct rail access. Several sites are located adjacent to rail corridors but spurs would need to be constructed to facilitate direct landfill access and allow for the temporary storage and unloading of rail cars. Additionally, three of the four preferred landfill sites are located in Illinois, which would require trains to travel through the congested St. Louis rail network to cross the Mississippi River. Rail is most efficient when transporting bulk materials over long distances. Given the relatively short travel distance to each landfill site, rail would not be cost-competitive with truck hauling.

This assessment assumed truck hauling to be the most cost-effective and feasible mode of transport. All subsequent analyses reflect truck hauling.

Truck Hauling

To determine a timeframe for extraction and removal of all CCR from its current, impounded location, the following was assumed:

- Truck hauling via 40-foot end load dump trucks loaded via conventional equipment – each trailer has a payload capacity of 25 tons based on a typical 80,000 lb. gross loaded maximum;
- 8-hour daily operation and a range of 155 to 193 days of annual operation (accounting for weekends, holidays, and time lost due to weather and imperfect execution);
- Loading operations on the Rush Island site occur adjacent to the impoundment and on the south portion of the site; and
- A maximum daily haul rate of 5,000 tons.

The resulting transportation haul assumptions are summarized in **Table 1**.

Table 1: Transportation Haul Summary

Total Tons of CCR Removed	Annual Tons of CCR Removed	Closure Duration*
21.6 million	742,772 to 928,465	28-34 Years

*Measured from the decision to begin extraction until fully removed

To accommodate the volume of truck traffic identified in **Table 1**, roadways internal to the Rush Island site would need to be improved. Specifically, a heavy-duty concrete roadway would need to be constructed along the western perimeter of the site extending from Big Hollow Road south to the ash pond area. Multiple at-grade railroad crossings with the site's rail spur would be required.

In the vicinity of the pond area, staging would need to be provided to accommodate several trucks in queue for multiple loading stations. Hence, a large loading station would need to be constructed. Once loaded, trucks would need to proceed to a washout area and scaled to verify the truck is loaded properly. A quick route back to the loading pad from the scale area would be needed for any overweight trucks.

Landfill Options

Four preferred landfills were identified as potential destinations for the CCR removed from the Rush Island site as shown in **Table 2**. Landfill disposal costs supplied by Ameren are similar across the four locations. With costs paid to the landfill being essentially equal, transportation costs would drive the landfill location decision. Assumed haul rates per ton to each landfill location were also supplied by Ameren. The lowest cost haul rate would be to the Progressive Waste site in Richwoods, which is also significantly closer to Rush Island than the other sites. Therefore, this assessment prioritized CCR disposal at the Progressive Waste landfill.

Table 2: Preferred Landfill Locations

Landfill Site	Address	Distance to Site (mi)	Travel Time to Site (min)
Progressive Waste	12581 State Hwy H, Richwoods, MO	34.7	44
Republic Services	4601 Cahokia Road, Roxana, IL	67.3	67
Waste Management	10400 Hillstown Road, Marissa, IL	73.4	82
Perry Ridge	6305 Sacred Heart Road, DuQuoin, IL	79.8	97

Capacity calculations were performed to determine the total space available for CCR disposal in aggregate. The annual disposal amount currently received by the landfill was assumed to remain constant over time and the incremental annual disposal amount due to the Rush Island CCR was added. Based on the capacity of the Progressive Waste site, at the combined disposal volume, it was estimated that the Progressive Waste landfill would become full upon receiving approximately 80 percent of the total CCR from Rush Island.

It was also assumed that the Progressive Waste site could feasibly accept the maximum daily load of trucks (192) and that Progressive Waste would be willing to receive the maximum amount of CCR possible and dedicate the necessary space on site for monofill construction to isolate the CCR material from other waste on site.

Given these assumptions, the calculations indicate that a second landfill site with available capacity would need to receive the final 20 percent of Rush Island CCR material once Progressive Waste reaches capacity. However, for purposes of the subsequent routing and transportation evaluations, it was assumed that the entire Rush Island CCR volume would be disposed at Progressive Waste.

Transportation Route

Many factors were considered when establishing a preferred route suitable for the removal of the CCR from the Rush Island site to the Progressive Waste landfill, including roadway functional classification and the available connectivity between the two sites using the existing roadway network. The selected route is approximately 36.5 miles long and utilizes the following roadways:

- Begin at the Rush Island site on Big Hollow Road
- Johnson Road west
- Danby Road west
- Highway 61 south
- Highway TT west
- Interstate 55 north
- Highway 67 south
- MO-110 west
- MO-21 south
- Highway H west
- End off Highway H at Progressive Waste

This route prioritizes roadways with the highest functional classifications along a reasonably direct line of travel. While a shorter route may be possible, it would rely upon roadways less suitable for truck traffic and therefore was not considered. The selected route emphasizes major numbered state routes, with the exception of leaving the Rush Island site (via Big Hollow Road, Johnson Road, and Danby Road) and accessing Progressive Waste (via Highway H).

The egress route from the Rush Island site utilizes Johnson Road and Danby Road instead of remaining on Big Hollow Road to Drury Road. Johnson Road/Danby Road is the designated route for truck traffic in and out of the Rush Island site. This route also promotes use of the half diamond interchange on Interstate 55 at Route TT, which was constructed approximately 10 years ago for purposes of serving truck traffic to/from the nearby Holcim Cement Plant.

Transportation Impacts

The following transportation impacts would be anticipated as a result of the hauling operation.

Traffic Flow

The selected route between Rush Island and Progressive Waste was evaluated in terms of its ability to accommodate the additional truck traffic, including both loaded and unloaded trucks. Overall, the truck volume distributed over the course of the day would not be expected to generate significant traffic flow impacts. The route emphasizes major roadways, which would be capable of handling the additional traffic. In fact, no improvements were assumed for Interstate 55 or Highway 67.

That said, the following transportation improvements would be recommended to mitigate anticipated impacts of the additional truck traffic at select locations:

- Big Hollow Road, Johnson Road, and Danby Road, which connect the Rush Island site with Highway 61, are not suitable for the volume of truck traffic anticipated. These roadways typically have 11-foot lanes and no shoulders. The horizontal and vertical geometry is substandard in places. The existing asphalt pavement would not likely withstand the effects of heavy truck traffic. It is recommended that this corridor be upgraded to provide an appropriate truck route between Rush Island and Highway 61. The assumed improvements consist of heavy-duty concrete pavement and alignment corrections along the existing roadway.
- The intersection of Danby Road with Highway 61 should be improved to include a dedicated northbound right-turn lane on Highway 61 and enlarged right-turn radius. This turn lane would serve trucks en route to Rush Island from Interstate 55. This intersection would be expected to remain unsignalized.
- The intersection of Route TT with Highway 61 should be improved to include a dedicated southbound right-turn lane on Highway 61 and enlarged right-turn radius. This turn lane would serve trucks en route to Progressive Waste. This intersection would be expected to remain unsignalized.
- The intersection of Highway 21 and Highway 110 was recently realigned and upgraded to current standards, so it should be well-equipped to serve truck turning maneuvers. However, the intersection remains unsignalized. Installation of a signal would be recommended in order to safely and efficiently serve trucks turning from westbound Highway 110 to southbound Highway 21 en route to Progressive Waste.
- The intersection of Highway 21 with Route H is signalized and currently includes a dedicated southbound right-turn lane and dedicated eastbound left-turn lane to serve truck turning movements along the selected route. It is recommended that the eastbound left-turn lane be extended to provide additional storage capacity. The existing turn lane is approximately 75 feet in length, which would accommodate only a single truck and possibly one additional vehicle.
- Route H is a low-volume and narrow two-lane highway with lane widths of approximately 10 feet, low shoulders, and substandard alignment in select areas. While upgrades to this corridor would be beneficial, given the length of the route, significant upgrades for purposes of the hauling operation would likely be deemed cost prohibitive.

Safety & Environment

The safety implications of the truck hauling operation were evaluated using information provided in the Highway Safety Manual (HSM), published by the American Association of State Highway and Transportation Officials (AASHTO). The HSM relates traffic volumes and roadway character to crash expectancy. Changes in volumes would then cause an increase or decrease in the crash expectancy. It is anticipated that the additional truck traffic would result in an increase of 6 crashes total on an annual basis along the entirety of the haul route, as follows:

- Net increase of 2 Severe (Fatal or Injury) Crashes per year
- Net increase of 4 PDO (Property Damage Only) Cashes per year

Additional environmental costs would also be incurred as a result of the hauling operation.[1] In total, transportation safety and environmental costs are estimated to be approximately $490 million to $611 million over the duration of the hauling operation. These costs would not be borne directly by Ameren but instead would be incurred by the general population.

Pavement

The additional truck volume would depreciate the pavement design life and accelerate pavement deterioration along the selected route. To compensate for the increased wear, pavement mill and overlay were assumed at 5-year increments along all segments of the route, with the exception of Interstate 55 (which as an interstate should be build to withstand truck traffic) and the upgraded access route to the Rush Island site (which would be reconstructed with heavy duty concrete).

[1] According to the Environmental Protection Agency's (EPA) publication on National Average In-Use Emissions from Heavy-Duty Trucks, semi-tractor trailer rigs are responsible for emitting 12.5 grams of pollutants per mile into the air. The economic cost attributable to truck emissions using EPA's methodology was estimated to be $434M. This accounts for increased healthcare costs, lost productivity, welfare costs, environmental remediation, etc.

Conclusion

Lochmueller Group completed the preceding planning-level assessment of the methods and impacts associated with extracting, stabilizing, and transporting CCR from the existing Rush Island Power Generation Center. The purpose of this assessment was to determine the impacts and quantify the order-of-magnitude costs associate with completely removing all CCR from the Rush Island site and transporting it to a private landfill for permanent storage. The information contained herein is provided at a planning-level.

This study assumed that 12,725,000 cubic yards of coal combustion residuals would ultimately need to be removed from the Rush Island site. This would equate to approximately 21,650,000 tons of material to transport. This transport weight was calculated by multiplying the in place cubic yards by a swell factor to account for the uncompacted volume after excavation. The weight of the uncompacted unit volume was established from geotechnical testing data that provided the pounds per cubic foot and the percent moisture content. Based on a range of operating days per calendar year, it would take from 28 to 34 years to extract all material from the site.

Restoration of the site would include backfilling and stabilization with vegetative and structural practices. Restoration costs could be significant in that the resulting 70 – 100 foot depression may need to be backfilled via a dredging operation within the Mississippi River.

The total cost to extract, stabilize, transport, and dispose of the CCR material is summarized below in 2019 dollars. The total cost to Ameren could range from $1.9 to $2.1 Billion, depending upon the total period of removal operations. This includes transportation infrastructure upgrades both internal and external to the Rush Island site as discussed.

Extraction of CCR and Transport to Offsite Landfill	
Ameren Project Costs	
Extraction, Stabilization, Loading, and Restoration	$773-891 Million
Hauling	$372-375 Million
Landfill Placement Costs	$691-757 Million
Transportation Infrastructure (on and off-site)	$66-77 Million
Project Cost Total	**$1.9-$2.1 Billion**

Costs in 2019 Dollars