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Kincaid Generation, LLC

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1940101010-006

GROUNDWATER MODELING REPORT

ASH POND
KINCAID POWER PLANT
KINCAID, ILLINOIS

GROUNDWATER MODELING REPORT
KINCAID POWER PLANT ASH POND

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ACRONYMS AND ABBREVIATIONS

§	Section
35 I.A.C.	Title 35 of the Illinois Administrative Code
AP	Ash Pond
BCU	bedrock confining unit
Cabeno	Cabeno Field Services
CBR	closure by removal
CIP	closure in place
CCR	coal combustion residuals
cm/s	centimeters per second
CSM	conceptual site model
ft/d	feet/foot per day
GMP	Groundwater Monitoring Plan
GMR	Groundwater Modeling Report
GWPS	Groundwater Protection Standard
HCR	Hydrogeologic Site Characterization Report
HELP	Hydrologic Evaluation of Landfill Performance
ID	identification
IEPA	Illinois Environmental Protection Agency
Kd	soil adsorption coefficient
K_d	linear partition coefficients
K_{dF}	Frendlich partition coefficients
Kh/Kv	vertical anisotropy
KPP	Kincaid Power Plant
L/kg	liters per kilogram
LCU	lower confining unit
mg/L	milligrams per liter
mL/g	milliliters per gram
MNA	monitored natural attenuation
NAVD88	North American Vertical Datum of 1988
No.	number

Part 845	35 I.A.C. § 845: Standards for the Disposal of Coal Combustion Residuals in Surface Impoundments
PMP	potential migration pathway
R2	correlation coefficient
Ramboll	Ramboll Americas Engineering Solutions, Inc.
TDS	total dissolved solids
TVD	total-variation-diminishing
UA	uppermost aquifer
USCU	upper semi-confining unit
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey

EXECUTIVE SUMMARY

Ramboll Americas Engineering Solutions, Inc. (Ramboll) has prepared this Groundwater Modeling Report (GMR) on behalf of the Kincaid Power Plant (KPP), operated by Kincaid Generation, LLC, in accordance with requirements of Title 35 of the Illinois Administrative Code (35 I.A.C.) Section (§) 845: Standards for the Disposal of Coal Combustion Residuals in Surface Impoundments (Part 845) (Illinois Environmental Protection Agency [IEPA], 2021). This document presents the results of predictive groundwater modeling simulations for proposed closure scenarios for the Ash Pond (AP; Vistra identification [ID] number [No.] 141, IEPA ID No. W0218140002-01).

The AP coal combustion residuals (CCR) unit is located between two lobes of Sangchris Lake, which was formed in 1964 by damming Clear Creek, a tributary to the south fork of the Sangamon River. Sangchris Lake was created to provide a source of cooling water for the KPP. The western lobe of Sangchris Lake forms part of the western and the northern border of the AP and is connected to an intake flume for the KPP on the western edge of the AP. A discharge flume from the KPP forms the southern border of the AP and is connected to the eastern lobe of Sangchris Lake. The KPP property is surrounded by the lobes of Sangchris Lake and Sangchris Lake State Park to the north and east, and a combination of undeveloped land and surface support facilities associated with the former Peabody Coal Company #10 mine to the south and west.

A detailed summary of site conditions was provided in the Hydrogeologic Site Characterization Report (HCR; Ramboll, 2021a). Five distinct water-bearing units have been identified in the vicinity of the AP based on stratigraphic relationships and common hydrogeologic characteristics. The units are described as follows:

- **CCR**: Saturated CCR, consisting primarily of bottom ash, and boiler slag.
- **Upper Semi-Confining Unit (USCU)**: Low-permeability clay with some silt and minor sand, silt layers, and occasional discontinuous sand lenses. Includes the lithologic layers identified as the Cahokia Formation. Sand lenses with higher permeability within the USCU have a higher probability of contaminant transport and these materials are referred to as the potential migration pathways (PMP).
- **Uppermost Aquifer (UA)**: Thin (generally less than 4 feet), moderate permeability sand, silty sand, and clayey sand and gravel units, which include the clays and silts of the Upper Cahokia Formation, where saturated, and the thin, moderate permeability sands and gravels of the Lower Cahokia Formation, which, at some locations, also includes the interface with the Vandalia Till.
- **Lower Confining Unit (LCU):** Underlying the aquifer unit is dense grey clay till; this till is easily distinguished during investigation by difficult drilling and/or refusal and is apparent on boring logs. The till was encountered at elevations ranging from approximately 570 to 583.5 feet (referenced to North American Vertical Datum of 1988 [NAVD88]. The LCU is comprised of low permeability silt and clay with minor sand, silt layers, and occasional discontinuous sand lenses (more frequently near the top of the unit). Includes the lithologic layers identified as the Vandalia Till.

- **Bedrock Confining Unit (BCU):** The water-bearing layer referred to as the BCU is composed of interbedded shale and limestone of the Pennsylvanian Age Bond Formation that underlie the Vandalia Till, and underlies the entire AP.

Groundwater flow in the UA is to the northwest toward Sangchris Lake. Groundwater elevations are primarily controlled by the surface water levels in the lobes of Sangchris Lake and the water level within the AP. An apparent groundwater divide trending southwest to northeast has been observed beneath the AP.

A review and summary of data collected from 2015 through 2021 for parameters with groundwater protection standards (GWPS) listed in 35 I.A.C. § 845.600 is provided in the HCR (Ramboll, 2021a). Groundwater concentrations presented in HCR Table 4-1 and summarized in the History of Potential Exceedances (Ramboll, 2021b) are considered potential exceedances because the methodology used to determine them is proposed in the Groundwater Monitoring Plan (GMP; Ramboll, 2021c) and has not been reviewed or approved by IEPA at the time of this submittal. The following constituents with potential exceedances of the GWPS listed in 35 I.A.C. § 845.600 were identified: boron, sulfate, and total dissolved solids (TDS) (Ramboll, 2021b).

Statistically significant correlations between boron concentrations and concentrations of other parameters identified as potential exceedances of the GWPS indicate boron is an acceptable surrogate for sulfate and TDS in the groundwater model. It was assumed that boron would not significantly sorb or chemically react with aquifer solids (soil adsorption coefficient [Kd] was set to 0 milliliters per gram [mL/g]) which is a conservative estimate for predicting contaminant transport times. Boron, sulfate, and TDS transport is likely to be affected by both chemical and physical attenuation mechanisms (*i.e.,* adsorption and/or precipitation reactions as well as dilution and dispersion).

Data collected from previous field investigations, as well as the 2021 field investigations, were used to develop a groundwater model for the AP. The MODFLOW and MT3DMS models were then used to evaluate two closure scenarios, including CCR consolidation and closure in place (CIP), and closure by removal (CBR) scenarios, using information provided in the Draft CCR Final Closure Plan (Burns & McDonnell, 2022):

- Scenario 1: CIP (CCR removal from the north and west areas of the AP, consolidation to the central and southeast portions of the AP, and construction of a cover system over the remaining CCR); and,
- Scenario 2: CBR (CCR removal from the AP)

Prior to the simulation of these scenarios, a dewatering simulation was included for the removal of free liquids from the AP prior to the implementation of the two scenarios. Predictive simulations of closure conservatively indicate groundwater in the UA will achieve the GWPS in site monitoring wells for Scenarios 1 and 2 in 17 and 16.5 years after implementation of the closure scenarios, respectively. From a modeling perspective, the difference between the predicted time to reach the GWPS for boron (2 mg/L) in Scenario 1 (17 years) versus Scenario 2 (16.5 years) is negligible. In other words, both scenarios are predicted to reach the GWPS after approximately 17 years, the simulated difference between these two scenarios is not significant.

Results of groundwater fate and transport modeling estimate that groundwater will attain the GWPS for all constituents identified as potential exceedances of the GWPS within 17 years of closure implementation for both Scenarios. In both scenarios residual boron exceedances from the calibrated model remain in close proximity to the ash pond and/or calibrated extent of exceedances as the plumes recede.

1. INTRODUCTION

1.1 Overview

In accordance with requirements of Part 845 (IEPA, 2021), Ramboll has prepared this GMR on behalf of KPP, operated by Kincaid Generation, LLC. This report will apply specifically to the CCR Unit referred to as the AP (**Figure 1-1**). The KPP operates as a coal-fired power plant and has a single CCR management unit, the AP (**Figure 1-2**), a 172-acre, unlined surface impoundment used to manage CCR and non-CCR waste streams at the KPP with a total storage capacity of approximately 3,560 acre-feet. This GMR presents and evaluates the results of predictive groundwater modeling simulations for two scenarios:

- Scenario 1: CIP (CCR removal from the north and west areas of the AP, consolidation to the central and southeast portions of the AP, and construction of a cover system over the remaining CCR)
- Scenario 2: CBR (CCR removal from the AP)

1.2 Site Location and Background

The KPP is located in the southwest quarter of Section 1, and the northeast quarter of Section 12, Township 13 North, Range 4 West, along West Route 104, Christian County, Illinois and approximately four miles west of the Village of Kincaid. The AP is located between two lobes of Sangchris Lake (**Figure 1-1**), which was formed in 1964 by damming Clear Creek, a tributary to the south fork of the Sangamon River. Sangchris Lake was created to provide a source of cooling water for the KPP. The western lobe of Sangchris Lake forms part of the western and northern border of the AP and is connected to an intake flume for the KPP on the western edge of the AP. A discharge flume from the KPP forms the southern border of the AP and is connected to the eastern lobe of Sangchris Lake. The KPP property is surrounded by the lobes of Sangchris Lake and Sangchris Lake State Park to the north and east, and a combination of undeveloped land and surface support facilities associated with the former Peabody Coal Company #10 mine to the south and west.

1.3 Site History and Unit Description

Construction of the AP began in 1964 and it was commissioned for use in 1967. The AP primarily contains bottom ash and boiler slag, and other minor materials, including water and wastewater treatment solids, excavation spoils, and dredge spoils. The discharge for the AP is located at the southeast corner of the unit. The approximate dates of construction of each successive stage of the AP are summarized in **Table A** on the following page (AECOM, 2016).

Table A. History of Construction

Date	Event
1964-1965	Construction of AP
1967	AP was put into service
1978-1980	Installation of AP recycle water intake structures and associated piping
Mid-1980's	Erosion repair along north embankment adjacent to Sangchris Lake
2006	Replacement of emergency outlet piping
2009-2010	Tree removal, grading, and vegetation re-established along the north and east embankment
2010	Riprap placement along the northwest AP embankment adjacent to Sangchris Lake

2. SITE GEOLOGY AND HYDROGEOLOGY

AP hydrogeologic and groundwater quality data was presented in the HCR (Ramboll, 2021a) and used to establish a conceptual site model (CSM) for this GMR, and is summarized below. There are three principal types of unlithified materials present overlying bedrock at the KPP, consisting of the following in descending order:

- Fill, the constructed AP consists of fill (predominantly coal ash within the AP, but also including constructed berms and railroad embankments around the AP).
- Clays and silts of the Cahokia Formation, interbedded with thin sand lenses, most of which are laterally discontinuous, but a thin bed of sand was observed at the bottom of the Cahokia Formation in the majority of soil borings advanced near the AP. This sand unit comprises the UA. The Cahokia materials extend to depths of less than 44 feet.
- Clay and silt with varying amounts of sand and gravel of the Vandalia Till, which extend to depths of up to 52 feet.

Bedrock beneath the AP consists of the Pennsylvanian-age Bond Formation, comprised mainly of limestone with lesser amounts of shale and sandstone.

Prior to 2021, there were 12 monitoring wells (MW-1 through MW-12) around the AP for monitoring groundwater. Nineteen additional monitoring wells (MW-7S, MW-8S, MW-11S, MW-12S, MW-12D, MW-20S, MW-20, MW-22, MW-23, MW-24, MW-25, MW-26, MW-27, MW-28, MW-29, MW-30, MW-31, MW-32, and MW-31S) were installed in 2021 around the perimeter of the AP to meet the requirements of Part 845. Construction details for monitoring wells and piezometers are provided in **Table 2-1** and depicted in **Figure 2-1**. Boring logs, monitoring well and piezometer construction forms are provided in Appendix B of the HCR.

Five distinct water-bearing units have been identified in the vicinity of the AP based on stratigraphic relationships and common hydrogeologic characteristics. The units are described as follows:

- **CCR**: Saturated CCR, consisting primarily of bottom ash, and boiler slag.
- **USCU**: Low-permeability clay with some silt and minor sand, silt layers, and occasional discontinuous sand lenses. Includes the lithologic layers identified as the Cahokia Formation. Sand lenses with higher permeability within the USCU have a higher probability of contaminant transport and these materials are referred to as the PMP.
- **UA**: Thin (generally less than 4 feet), moderate permeability sand, silty sand, and clayey sand and gravel units, which include the clays and silts of the Upper Cahokia Formation, where saturated, and the thin, moderate permeability sands and gravels of the Lower Cahokia Formation, which, at some locations, also includes the interface with the Vandalia Till.
- **LCU:** Underlying the aquifer unit is dense grey clay till; this till is easily distinguished during investigation by difficult drilling and/or refusal and is apparent on boring logs. The till was encountered at elevations ranging from approximately 570 to 583.5 feet NAVD88. The LCU is comprised of low permeability silt and clay with minor sand, silt layers, and occasional discontinuous sand lenses (more frequently near the top of the unit). Includes the lithologic layers identified as the Vandalia Till.

- **BCU:** The water-bearing layer referred to as the BCU is composed of interbedded shale and limestone of the Pennsylvanian Age Bond Formation that underlie the Vandalia Till, and underlies the entire AP.

Groundwater flow direction (**Figure 2-2 and Figure 2-3**) and gradients have not changed significantly since the first hydrogeologic study of the AP was completed, and recent data supports the existing CSM which has been refined to incorporate additional data as follows:

- Due to the downgradient location and proximity of Sangchris Lake to the AP, Sangchris Lake is likely to be hydraulically connected to the UA beneath the AP. Flow of groundwater from the KPP to Sangchris Lake through the UA is the primary pathway for contaminant migration.
- The elevations of water within the AP are greater than groundwater elevations in the surrounding areas, and, depending on the hydraulic connection between the AP and the surrounding aquifer, water may flow radially from the AP toward the lobes of Sangchris Lake.
- Horizontal groundwater flow in the USCU in the area of the AP is toward the north and northwest toward the western lobe of Sangchris Lake. There also appears to be a component of groundwater flow to the south and east toward the discharge flume that flows to the eastern lobe of Sangchris Lake, as evidenced by groundwater elevations on the southern side of the AP. These two components of groundwater flow suggest a groundwater divide beneath the AP.
- The groundwater divide beneath the AP is further supported by horizontal groundwater flow in the UA, which is to the northwest and southeast toward the western and eastern lobes of Sangchris Lake, respectively.
- Groundwater elevations are primarily controlled by the surface water level in Sangchris Lake, and the water level within the AP. Typically, groundwater from the AP flows from east to west and discharges to Sangchris Lake.
- Vertical gradients calculated between the bedrock and UA are generally upward, consistent with previous vertical gradient calculations (HCR, Ramboll, 2021a).

3. GROUNDWATER QUALITY

Groundwater at the AP does not meet the definition of Class I - Potable Resource Groundwater (35 I.A.C. § 620.210), based on the following criteria provided in the HCR:

- Site investigations have determined that water bearing lenses contain more than 12 percent fines and are less than five feet in thickness (Cabeno Field Services [Cabeno], 2013),
- Sustained groundwater yield from a 12-inch borehole of less than 150-gallons per day from a thickness of 15-feet or less.
- Field (horizontal) hydraulic conductivity tests and laboratory (vertical) hydraulic conductivity tests from wells screened within the UA resulted in an overall (geometric mean) of 5.07×10^{-5} centimeters per second (cm/s) and 1.07×10^{-7} cm/s, respectively (see Table 2-1 and Table 3-4 in the HCR; Ramboll, 2021a).

As set forth in 35 I.A.C. § 620.220, any geologic material with a hydraulic conductivity of less than 1×10^{-4} cm/s, and which does not meet the provisions of 35 I.A.C. § 620.210 (Class I), 35 I.A.C. § 620.230 (Class III), or 35 I.A.C. § 620.240 (Class IV), meets the definition of Class II: General Resource Groundwater. Based on the detailed geologic information provided for the unlithified materials and bedrock encountered at the AP and the hydrogeologic data, the groundwater in the UA can be classified as Class II: General Resource Groundwater. This is supported by results of the hydrogeologic study completed in 2013 (Cabeno, 2013), which concluded that the AP does not meet most criteria of Class I groundwater and the data collected supported a Class II groundwater classification.

Groundwater quality investigations were completed at the AP starting in 2010. In 2021, additional wells were installed to comply with Part 845 requirements, specifically to reduce the lateral spacing between monitoring points and to further characterize the PMPs. Wells were sampled for the parameters listed in 35 I.A.C. § 845.600. A review and summary of data collected from 2015 through 2021 for parameters with GWPSs listed in 35 I.A.C. § 845.600 is provided in the HCR (Ramboll, 2021a).

Concentration results presented in the HCR were compared directly to 35 I.A.C. § 845.600 GWPSs to determine potential exceedances. The results are considered potential exceedances because the results were compared directly to the standard and did not include an evaluation of background groundwater quality or utilize the statistical methodologies proposed in the GMP (Ramboll, 2021c) attached to the operating permit application.

Groundwater concentrations from 2015 to 2021 are summarized in the History of Potential Exceedances (Ramboll, 2021b) (attached to the operating permit application) and are considered potential exceedances because the methodology used to determine them is proposed in the Statistical Analysis Plan (Appendix A to the GMP, Ramboll 2021c), which has not been reviewed or approved by IEPA at the time of submittal of the Part 845 operating permit application.

The History of Potential Exceedances attached to the operating permit application summarizes all potential groundwater exceedances following the proposed Statistical Analysis Plan. The following potential exceedances were identified:

- Boron – determined at monitoring wells MW-7S, MW-12, and MW-28
- Sulfate – determined at monitoring wells MW-28 and MW-32
- TDS – determined at monitoring well MW-28

4. GROUNDWATER MODEL

4.1 Overview

Data collected at the site from the 2021 field investigation were used to develop a groundwater model for the AP. The MODFLOW and MT3DMS models were then used to evaluate two closure scenarios, including CCR consolidation and CIP using information provided in the Draft CCR Final Closure Plan (Burns & McDonnell, 2022), and CBR scenarios. The results of the CIP and CBR closure scenarios are summarized and evaluated in this GMR. Associated model files are included as **Appendix A**.

4.2 Conceptual Site Model

The HCR (Ramboll, 2021a) is the foundation of the site setting and CSM that describes groundwater flow at the site. The AP overlies the recharge area for the underlying transmissive geologic media, which are composed of moderate permeability sand, silty sand, and clayey sand and gravel units, which include the clays and silts of the Upper Cahokia Formation, where saturated, and the thin, moderate permeability sands and gravels of the Lower Cahokia Formation, which, at some locations, also includes the interface with the Vandalia Till deposits (*i.e.*, the UA). Groundwater enters the model domain vertically via recharge. The groundwater from the UA flows into the forks of Sangchris Lake.

Boron was selected for transport modeling. Boron is commonly used as an indicator parameter for contaminant transport modeling for CCR because: (i) it is commonly present in coal ash leachate; (ii) it is mobile and typically not very reactive but conservative (*i.e.*, low rates of sorption or degradation) in groundwater; and (iii) it is less likely than other constituents to be present in background groundwater from natural or other anthropogenic sources. The only significant source of boron is the AP. Mass (boron) is added to groundwater via vertical recharge through CCR, and horizontal groundwater flow through CCR where it is in contact with the water table. Mass flows with groundwater toward Sangchris Lake. The primary transport pathway is the UA as indicated by groundwater observations. The USCU is also a PMP, although the sands in this unit are discontinuous which limit migration potential.

4.3 Model Approach

4.3.1 Potential Groundwater Exceedances

Comparisons of observed sulfate and TDS concentrations to boron (**Figure A** on the following page) indicate statistically significant correlations between these parameters within wells screened in the UA. Observed concentrations were transformed into Log10 concentrations for evaluation. The correlation coefficient (R2) and p values (indicator of statistical significance) are also provided on **Figure A**. Higher R2 values (*i.e.*, closer to 1) indicate stronger correlation between parameters. A correlation is considered statistically significant when the p value is lower than 0.05. Both correlations have p values less than the target of 0.05, indicating correlations are statistically significant. The correlation is slightly stronger between TDS and boron. The statistically significant correlations associated with boron concentrations indicate boron is an acceptable surrogate for sulfate, and TDS in the groundwater model, and concentrations of these parameters are expected to change along with model predicted boron concentrations.

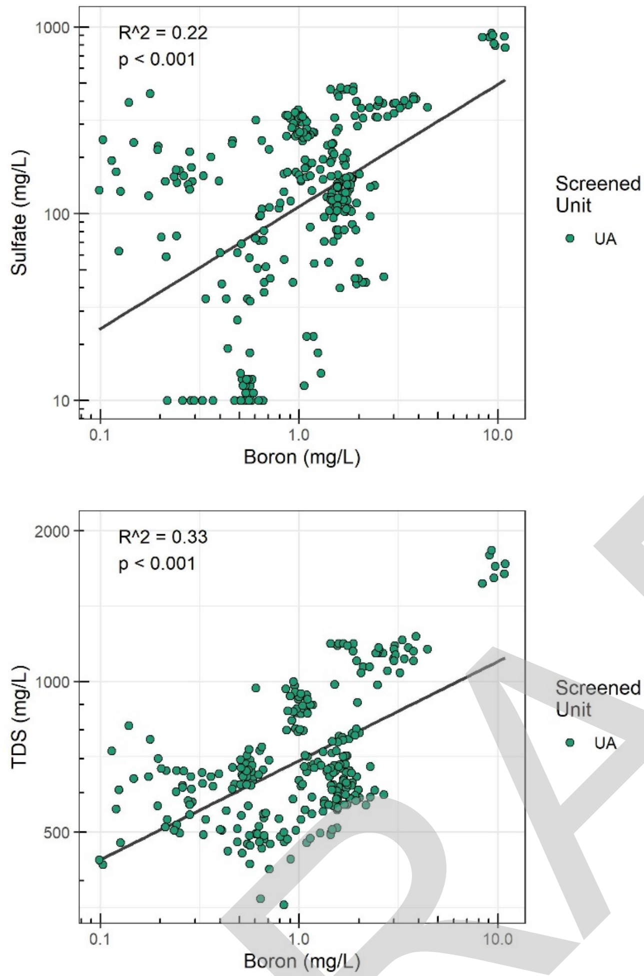

Figure A. Boron Correlation with Sulfate and TDS in UA Wells

4.3.2 Summary of Modeling Activities

A three-dimensional groundwater flow and transport model was calibrated to represent the conceptual flow system described above. Initial modeling was performed for a sufficient period (27.5 years) to allow modeled boron concentrations in the primary transport layer (*i.e.,* UA) to achieve steady concentrations. The model was calibrated to match the mean groundwater elevation and median concentration observed at individual monitoring wells. Prediction simulations were then performed to evaluate the effects of CBR and CIP closure scenarios on groundwater quality for a period of 30 years following corrective action measures, which include dewatering of the AP for 1 year, consolidation of CCR and cover system construction or removal of CCR. The calibration and prediction model timelines are illustrated in **Figure 4-1**.

Three model codes were used to simulate groundwater flow and contaminant transport:

- Groundwater flow was modeled in three dimensions using MODFLOW 2005
- Contaminant transport was modeled in three dimensions using MT3DMS
- Percolation (recharge) after removal at the AP was modeled using the results of the Hydrologic Evaluation of Landfill Performance (HELP) model.

Modeling steps are a summarized below:

- A steady state model was created in MODFLOW 2005 and used to simulate the general groundwater flow conditions at the site. The model was calibrated to match mean groundwater elevations observed between 2015 to 2021.
- A transient flow model based off of the calibrated steady state model was used to simulate groundwater flow and transport for 27.5 years using MODFLOW 2005 and MT3DMS to simulate boron entering the system through time and allow concentrations to match currently observed concentrations of boron in groundwater (**Table 4-1**).
- Prediction simulations began with a 1-year dewatering period simulated in MODFLOW 2005 and MT3DMS where heads were reduced within the CCR unit and concentrations were removed from CCR removal areas.
- Prediction simulations resumed for CIP and CBR following the 1-year dewatering period using the results of HELP modeling as input values for recharge rates in the construction areas.
- The prediction simulations were run using MODFLOW 2005 and MT3DMS to estimate the time for boron concentrations to meet the GWPS in the compliance wells; and, to evaluate the differences between the two closure scenarios.

5. MODEL SETUP AND CALIBRATION

5.1 Model Descriptions

For the construction and calibration of the numerical groundwater flow model for the site, Ramboll selected the model code MODFLOW, a publicly-available groundwater flow simulation program developed by the United States Geological Survey (USGS) (McDonald and Harbaugh, 1988). MODFLOW is thoroughly documented, widely used by consultants, government agencies and researchers, and is consistently accepted in regulatory and litigation proceedings. MODFLOW uses a finite difference approximation to solve a three-dimensional head distribution in a transient, multi-layer, heterogeneous, anisotropic, variable-gradient, variable-thickness, confined or unconfined flow system—given user-supplied inputs of hydraulic conductivity, aquifer/layer thickness, recharge, wells, and boundary conditions. The program also calculates water balance at wells, rivers, and drains.

MODFLOW was developed by USGS (McDonald and Harbaugh, 1988) and has been updated several times. Major assumptions of the code are: (i) groundwater flow is governed by Darcy's law; (ii) the formation behaves as a continuous porous medium; (iii) flow is not affected by chemical, temperature, or density gradients; and (iv) hydraulic properties are constant within a grid cell. Other assumptions concerning the finite difference equation can be found in McDonald and Harbaugh (1988). MODFLOW 2005 was used for these simulations with Groundwater Vistas 7 software for model pre- and post- processing tasks (Environmental Simulations, Inc., 2017).

MT3DMS (Zheng and Wang, 1998) is an update of MT3D. It calculates concentration distribution for a single dissolved solute as a function of time and space. Concentration is distributed over a three-dimensional, non-uniform, transient flow field. Solute mass may be input at discrete points (wells, drains, river nodes, constant head cells), or distributed evenly or unevenly over the land surface (recharge).

MT3DMS accounts for advection, dispersion, diffusion, first-order decay, and sorption. Sorption can be calculated using linear, Freundlich, or Langmuir isotherms. First-order decay terms may be differentiated for the adsorbed and dissolved phases.

The program uses the standard finite difference method, the particle-tracking-based Eulerian-Lagrangian methods and the higher-order finite-volume total-variation-diminishing (TVD) method for the solution schemes. The finite difference solution has numerical dispersion for low-dispersivity transport scenarios but conserves good mass balance. The particle-tracking method avoids numerical dispersion but was not accurate in conserving mass. The TVD solution is not subject to significant numerical distribution and adequately conserves mass, but is numerically intensive, particularly for long-term models such as developed for the AP. The finite difference solution was used for this simulation.

Major assumptions of MT3DMS are: (i) changes in the concentration field do not affect the flow field; (ii) changes in the concentration of one solute do not affect the concentration of another solute; (iii) chemical and hydraulic properties are constant within a grid cell; and (iv) sorption is instantaneous and fully reversible, while decay is not reversible.

The HELP model was developed by the United States Environmental Protection Agency (USEPA). HELP is a one-dimensional hydrologic model of water movement across, into, through, and out of a landfill or soil column based on precipitation, evapotranspiration, runoff, and the geometry and hydrogeologic properties of a layered soil and waste profile. For this modeling, results of the HELP model, HELP Version 4.0 (Tolaymat and Krause, 2020), were used to estimate the hydraulic conditions from closure conditions.

5.2 Flow and Transport Model Setup

The modeled area was approximately 6,520 feet by 7,780 feet. The north, west, and south edges of the model are bounded by the forks of Sangchris Lake. The eastern edge of the model is selected to maintain sufficient distance from the AP to reduce boundary interference with model calculations, while not extending too far past the extent of available calibration data. The middle of the AP is an approximate topographic high and surface water divide in the model. The model grid and boundary conditions are displayed in **Figure 5-1 through Figure 5-4**.

Evaluation of monitoring well data has not identified statistically significant seasonal trends in groundwater quality which could affect model applicability for prediction of boron transport. The MODFLOW model was calibrated to mean groundwater elevation collected from June 2015 to September 2021 presented in **Table 5-1**. MT3DMS was run on the calibrated flow model and model-simulated concentrations were calibrated to the median observed boron concentration values at the monitoring wells calculated from boron concentrations results from March to July 2021 presented in **Table 5-2**. Multiple iterations of MODFLOW and MT3DMS calibration were performed to achieve an acceptable match to observed flow and transport data. The calibrated flow and transport models were used in predictive modeling to evaluate the CBR closure scenario by removing saturated ash cells and CIP closure scenario by removing ash cells from the northern part and capping ash cells in the southern part as demonstrated in the closure plan. The HELP model is used to estimate recharge values to simulate changes proposed in the closure scenarios.

5.2.1 Grid and Boundary Conditions

A five-layer, 326 x 389 node grid was established with 20 foot grid spacing (**Figure 5-1**). Boundary conditions are illustrated in **Figure 5-2 through Figure 5-4**. The north, south and west edges of the model are bounded by Sangchris Lake. To simulate the lake, a constant head (Dirichlet) boundary was imposed on layer 3. For water in the AP, a constant head boundary was also used. Constant concentration boundary conditions were imposed in layer 1 and a small wedge in northwest of layer 2 upgradient of MW-28. The observed boron concentrations at well MW-28 are two times greater than observed concentrations in other monitoring wells and the porewater samples collected from within the AP (**Table 5-2**). These elevated concentrations in MW-28 suggests that materials with higher concentrations than bottom ash may have been deposited in that area in the past. The historical survey map of 1966 (Appendix A in Ramboll, 2021) shows lower surface elevation extending into the AP footprint from the lake. This low area would have been filled during construction of the AP berm and have been interpreted to contain CCR material with higher boron concentrations than the rest of the AP to match observed elevated concentrations at MW-28.

5.2.2 Flow Model Input Values and Sensitivity

Flow model input values and sensitivity analyses results are presented in **Table 5-3** and described below.

The flow model calibration targets (*i.e.*, mean groundwater elevations from June 2015 to September 2021 and target well locations) are summarized in **Table 5-1**. Groundwater elevations measured at wells MW1, MW-2, MW-9, and MW-10 were not included as flow model calibration targets because they were on the other side of the lake channels and were outside the immediate vicinity of the AP.

Sensitivity analysis was conducted by changing input values and observing changes in the sum of squared residuals. Horizontal and vertical conductivities were varied between one-tenth- and ten-times calibrated values. Recharge terms were varied between one-half and two times calibrated values. When the calibrated model was tested, the sum of squared residuals was 81.1. Sensitivity test results were categorized into negligible, low, moderate, moderately high, and high sensitivity based on the change in the sum of squared residuals as summarized in the notes in **Table 5-3**.

5.2.2.1 Model Layers

Model layer elevations were generated through spatial interpolation of boring log data in Surfer software, with the use of pilot points as needed to maintain consistency with the conceptual site model for each of the five distinct water-bearing units described in **Section 2**. The bottom elevation of the LCU in layer 5 was generated by kriging with pilot points. Its thickness in the model is 50 feet. The contacts between the overlying layers were approximated from hydrostratigraphic unit thicknesses presented in the HCR (Ramboll, 2021a), including the bottom of the fill (ash) layer. The approximate base of ash surface was developed from information presented in the HCR (Ramboll, 2021a). The resulting surfaces were imported as layers into the model to represent the distribution and change in thickness of each water-bearing unit across the model domain.

5.2.2.2 Hydraulic Conductivity

Hydraulic conductivity values and sensitivity results are summarized in **Table 5-3**. When available, these values were derived from field or laboratory measured values reported in the HCR (Ramboll, 2021a). No horizontal anisotropy was assumed. Vertical anisotropy (presented as Kh/Kv in **Table 5-3**) was applied to conductivity zones to simulate preferential flow in the horizontal direction in these materials. Permeability tests discussed in the HCR (Ramboll, 2021a) indicate vertical conductivity values that are generally lower than horizontal.

The spatial distribution of the hydraulic conductivity zones (**Figure 5-5 through Figure 5-9**) in each layer simulates the distribution of hydrostratigraphic units as reported in the HCR (Ramboll, 2021a). The limits of the fill unit hydraulic conductivity zone (zone 1) in the model reflect the limits of the ash fill as presented in the HCR (Ramboll, 2021a). The distribution of other hydraulic conductivity zones was determined through analysis of each of the five distinct water-bearing unit layer surfaces. The USCU and UA are both exhibiting presence of each other's lenses which makes them relatively heterogenous, especially along the western and northern AP boundaries where historical survey map of 1966 (Appendix A in Ramboll, 2021) shows a lower topographic surface elevation extending into the AP footprint from the lake. Based on boring logs and measured hydraulic conductivities, zones of different hydraulic conductivity were defined to improve the flow calibration (**Figure 5-5 and Figure 5-8**).

The model displayed moderately high sensitivity to changes in horizontal conductivity in zones 1 (CCR), 2 (USCU) and 3 (UA), where the model was moderately sensitive to horizontal conductivity in the remaining zones. The model was highly sensitive to changes in vertical conductivity in zones 1 (CCR), 2 (USCU) and 3 (UA), while the model exhibited a low sensitivity in the remaining zones.

5.2.2.3 Recharge

Recharge rates were determined through calibration and spatial distribution of recharge zones were based on the location and type of material present at land surface (**Figure 5-10**). Four different zones were created to simulate recharge in the model area. The recharge occurring through the AP area was split into four different values. The recharge zone of 1.314 (inches per year [in/yr]) corresponds to approximate limits of ash based on the 1995 topographic map, which also matches with the current area of open water. The recharge zone 8.76 (in/yr) corresponds to the approximate extent of CCR present on a 1971 aerial image. The northern zone of 4.38 (in/yr) recharge zone approximates the extent of ash present on a 1983 aerial image and the same recharge rate was used in areas that have been disturbed along the western portion of the pond and south of the pond where the plant is present. The recharge zone of 0.22 (in/yr) represents ambient recharge through the USCU at the land surface and portions of the berms around the AP. In the model, zones with the same recharge rates that are divided by the implementation boundary of CBR and CIP were given different zone numbers for the purpose of calibration runs and closure scenarios setup (i.e. zone 3, 5 and zone 4, 7 and 8)

The model had a high sensitivity to changes in recharge in zones with high recharge rates (zones 4, 7 and 8). The model varied from moderately high to negligible sensitivity to changes in recharge in the remaining zones.

5.2.2.4 Storage and Specific Yield

The current calibration model did not use these terms because it was run at steady state. For the transport model, which was run in transient, no field data defining these terms were available so published values were used consistent with Fetter (1988). Specific yield was set to equal effective porosity values described in **Section 5.2.3.3**. The spatial distribution of the storage and specific yield zones were consistent with those of the hydraulic conductivity zones. The sensitivity of these parameters was tested by evaluating their effect on the transport model as described in **Section 5.2.3.4**.

5.2.2.5 Constant Head Boundary

Constant head boundary conditions were used for the lake and water impoundment in the AP area (**Figure 5-4**). Based on digital elevation model (DEM), constant head for the lake is set to 584.35 feet and 603.48 feet for the impoundment inside the AP domain. The flow calibration model had moderately high sensitivity to changes in constant head values.

5.2.3 Transport Model Input Values and Sensitivity

MT3DMS input values are listed in **Table 5-4** and described below. Sensitivity of the transport model is summarized in **Table 5-5**.

The model was calibrated to groundwater boron concentration ranges at each well as measured from June 2015 to September 2021. The transport model calibration targets are summarized in **Table 5-2**.

Sensitivity analysis was conducted by changing input values and observing percent change in boron concentration at each well from the calibrated model boron concentration. Effective porosity was varied by decreasing and increasing calibrated model values by 0.05. Storage values were multiplied and divided by a factor of 10, and specific yield by a factor of 2.

5.2.3.1 Initial Concentrations

No initial concentrations were placed in the calibration model. The flow model was run as transient and concentration was added to the model through constant concentration cells starting at the same time as flow simulation. Modeling was performed for a sufficient period (27.5 years, **Figure 4-1**) to allow modeled concentrations to match currently observed concentrations of boron in groundwater.

5.2.3.2 Source Concentrations

Two concentration sources in the form of constant concentration boundary cells were simulated in fill unit layer 1 and one small wedge of fill in layer 2 upgradient of MW-28 for calibration as discussed in **Section 5.2.1**. The locations of the boundary cells are illustrated in **Figures 5-2 and 5-3** and input values are summarized in **Table 5-4**. Water that comes into contact with CCR in the northern and eastern portions of the AP (constant concentration zones 31, 401 and 402) were given a concentration of 3.1 mg/L. Water that comes into contact with CCR in the western and southern portion of the AP (constant concentration zones 351 and 352) was given a concentration of 3.5. The observed boron concentrations at well MW-28 are two times greater than observed concentrations in other monitoring wells and the porewater samples collected from within the AP (**Table 5-2**). These elevated concentrations in MW-28 suggest that materials with higher concentrations than bottom ash may have been deposited in that area in the past. The historical survey map of 1966 (Appendix A in Ramboll, 2021) shows a lower topographic surface elevation extending into the AP footprint from the lake. This low area would have been filled during construction of the AP berm and has been interpreted to contain fill/CCR material with higher boron concentrations than the rest of the AP to match observed elevated concentrations at MW-28. All sources were simulated by assigning constant concentration cells placed in layer 1 and layer 2 to simulate saturated ash conditions. From the model perspective, this means that when the simulated water level is above the base of these cells, water that passes through the cell will take on the assigned concentration. All source concentrations were calibrated to the boron concentration data collected in from 2015 to 2021.

Because these are the sources of concentration in the model, the model will be highly sensitive to changes in the input values. For that reason, sensitivity testing was not completed for the source values.

5.2.3.3 Effective Porosity

Effective porosity for each modeled hydrostratigraphic unit were calibrated in the model and derived from literature values, 0.21 for silt and clay, 0.25 for sand, silt and gravel and 0.1 for clay from Morris and Johnson (1967) and Heath (1983) and presented in **Table 5-4**.

The model had a negligible to high sensitivity to changes in porosity values, not including monitoring location where the calibration concentration was 0.0 mg/L (i.e., MW-8S) (**Table 5-5**). The greatest sensitivity for porosity was high for the low porosity sensitivity test at monitoring locations MW-8, MW-20 and MW-20S. Computed concentrations is these locations are very small (1.2E-3 to 2.3E-3 mg/L) and are prone to numerical errors and therefore their high sensitivity can be considered over-predicted.

5.2.3.4 Storage and Specific Yield Sensitivity

The model had negligible sensitivity to changes in storage and specific yield values (**Table 5-5**).

5.2.3.5 Dispersivity

Physical attenuation (dilution and dispersion) of contaminants is simulated in MT3DMS. Dispersion in porous media refers to the spreading of contaminants over a greater region than would be predicted solely from the average groundwater velocity vectors (Anderson, 1979; Anderson, 1984). Dispersion is caused by both mechanical dispersion, a result of deviations of actual velocity at a microscale from the average groundwater velocity, and molecular diffusion driven by concentration gradients. Molecular diffusion is generally secondary and negligible compared to the effects of mechanical dispersion and only becomes important when groundwater velocity is very low. The sum of mechanical dispersion and molecular diffusion is termed hydrodynamic dispersion, or simply dispersion (Zheng and Wang, 1998).

Dispersivity values were applied to the entire model domain and determined during calibration. Longitudinal dispersivity was set at 5 feet. The transverse and vertical dispersivity were set at 1/10 and 1/100 of longitudinal dispersivity. These input values were determined during model calibration. With an approximate travel distance of 50 feet for groundwater from the source to the receiving body of water, the model is not expected to be sensitive to dispersivity inputs and the sensitivity of the model to dispersivity was not tested.

5.2.3.6 Retardation

It was assumed that boron would not significantly sorb or chemically react with aquifer solids (distribution coefficient [Kd] was set to 0 mL/g) which is a conservative estimate for estimating contaminant transport times. Boron, sulfate, and TDS transport is likely to be affected by both chemical and physical attenuation mechanisms (i.e., adsorption and/or precipitation reactions as well as dilution and dispersion). Batch adsorption testing was conducted to generate site specific partition coefficient results for boron and sulfate (Golder, 2022, **Appendix B**) for locations MW-12S and MW-28. Results of the testing are summarized below:

- Boron: Calculated linear partition coefficient (K_D) values for MW-12S and MW-28 were 0.05 and 1.81 liters per kilogram (L/kg), respectively. Langmuir partition coefficient (K_L) values were 1.4×10^6 and -1.5×10^4 L/kg, respectively. Freundlich partition coefficients (K_F) values were 112 and 27.5 L/kg, respectively. For comparison, in Strenge and Peterson (1989) the partition coefficients for boron range from 0.19 to 1.3 L/kg, depending on pH conditions and the amount of sorbent (*i.e.*, clay, organic matter, and iron and aluminum oxyhydroxide) present.

- Sulfate: Calculated K_D values for MW-12S and MW-28 were 0.23 and 15.5 L/kg, respectively. K_L values were 454 and -750 L/kg, respectively. K_F values were 1.87 and 0.13 L/kg, respectively. In Strenge and Peterson (1989), partition coefficients for sulfate are 0.0 L/kg, regardless of pH conditions and the amount of sorbent present.

The results from site samples have a high degree of variation and little correlation with the literature values provided for comparison. The potential exceedances identified in groundwater (boron, sulfate, and TDS) are affected by natural attenuation processes in multiple ways and to varying degrees. Further assessment of these processes and how they may be applied as a potential groundwater remedy will be completed as part of future remedy selection evaluations, as necessary. For the purposes of this GMR, and as mentioned at the beginning of this section, no retardation was applied to boron transport in the model (i.e., Kd was set to 0).

5.3 Flow and Transport Model Assumptions and Limitations

Simplifying assumptions were made while developing this model:

- Leading up to 2022, the groundwater flow system can be simulated as steady state.
- Natural recharge is constant over the long term.
- No fluctuations are assumed for the lake stage.
- Hydraulic conductivity is consistent within hydrostratigraphic zones
- The approximate base of ash surface was developed from information presented in the HCR (Ramboll, 2021a).
- Observed concentrations in groundwater exhibit no long-term trend.
- Source concentrations are assumed to remain constant over time.
- Boron is not adsorbed and does not decay, and mixing and dispersion are the only attenuation mechanisms.

The model is limited by the data used for calibration, which adequately define the local groundwater flow system and the source and extent of the plume. Since data used for calibration are near the monitoring wells, model predictions of transport distant spatially and temporally from the calibrated conditions at the CCR units will not be as reliable as predictions closer to the CCR units and concentrations observed in 2021.

5.4 Calibration Flow and Transport Model Results

Results of the MODFLOW/MT3DMS modeling are presented below. Electronic copies of the model files are attached to this report in **Appendix A**.

Flow model calibration results are presented in **Figure 5-11 through Figure 5-18**. The mass balance error for the flow model was -0.02 percent and the ratio of the residual standard deviation to the range was 8.0 percent; these values are within the targets for these criteria of 1 percent and 10 percent, respectively. Another flow model calibration goal is that residuals are evenly distributed such that there is no bias affecting modeled flow. The observed heads are plotted versus the simulated heads in **Figure 5-16**. The near-linear relationship between observed and simulated values indicates that the model adequately represents the calibration dataset. The residual mean was -0.08 feet and absolute residual mean was 1.31 feet; in general the simulated residuals were evenly distributed above and below the observed values as presented in **Figure 5-17**.

The range of observed boron concentrations in 2021 for transport calibration locations are summarized in **Table 5-2**. The goals of the transport model calibration were to have predicted concentrations fall within the range of observed concentrations, and/or have predicted concentrations above and below the GWPS for boron (2 mg/L) match observed concentrations above or below the standard at each well. One or both of these goals were achieved at all but 8 of the transport calibration location wells, including MW-5, MW-7, MW-12S, MW-23, MW-24, MW-27, MW-29, and MW-31S (**Figure 5-18**). Deviations from the observed ranges are discussed below.

- Simulated concentration at UA well MW-23 (0.72 mg/L) was slightly less than the observed minimum of 0.93. The median observed boron concentration at MW-23 is equal to the GWPS of 2.0 mg/L, so the simulated concentration below 2.0 mg/L was not far off the calibration goals. This is the only calibration location to not meet both goals where simulated concentration was lower than observed.
- Co-located wells are challenging to simulate accurately unless very detailed vertical discretization is being implemented in the model, which will cost performance and run time issues. Well MW-12S in the USCU did not meet the calibration goals because the simulated concentration (2.65 mg/L) is slightly above the observed maximum concentration of 2.63 mg/L and is also above the median observed concentration of 1.51 mg/L. The elevated concentrations in this well are acceptable because accurate calibration to UA well MW-12 (one of the UA wells with the highest observed boron concentrations) was a greater priority for calibration than wells MW-12S and MW-12D, which are nested in lower permeability materials at the same location. The model simulates MW-12 very accurately, which results in over simulation of concentrations at MW-12S and MW-12D. Over simulation of concentrations in these wells is also more conservative given the objectives of the modeling to estimate time to reach the GWPS (*i.e.,* there is more boron mass to be removed in the modeled system leading to longer predicted timelines to reach the GWPS).
- Similarly, the model simulates higher concentrations of boron (2.12 mg/L) at UA well MW-7 because the model was calibrated to simulate elevated boron concentrations observed in USCU well MW-7S at the same location. To be conservative, the model was calibrated to meet the goals at the nested well with higher observed concentrations.
- Wells MW-5 and MW-31S have simulated concentrations that are greater than observed and greater than the GWPS of 2.0 mg/L along the northern berm of the AP. These wells are in close proximity to the modeled source areas. Other wells along this berm met the calibration goals; over simulation in these wells makes the model more conservative.
- Similarly, wells MW-24, MW-27, and MW-29 have simulated concentrations that are greater than observed and greater than the GWPS of 2.0 mg/L along the eastern and southern berm. These wells are in close proximity to the source areas and other wells located on either side of these locations met the calibration goals. Over simulation of boron concentration in these wells makes the model more conservative.

The remaining calibration locations had predicted concentrations that fall within the range of observed concentrations and/or have predicted concentrations above and below the GWPS for boron (2.0 mg/L) that match observed concentrations above or below the standard at each well. MW-28, located downgradient of the CCR unit, where the highest concentrations downgradient of the CCR unit were observed, was also calibrated near the median concentration of the observed values from June 2015 to September 2021. Similarly, MW-12 was calibrated near the median concentration of observed values. The calibration result for wells MW-28 and MW-12 indicate the transport calibration model was able to simulate the highest observed concentrations downgradient of the AP in the UA.

The simulated extents of boron concentrations greater than the GWPS (2.0 mg/L) are presented by layer in **Figures 5-19 to 5-22**. Boron exceedances are in close proximity to the limits of the

Ash Pond with the exception of areas to the west, where the plume is simulated as present beneath Sangchris Lake.

6. SIMULATION OF CLOSURE SCENARIOS

6.1 Overview and Prediction Model Development

Prediction simulations were performed to evaluate the effects of source control measures (CIP and CBR) for the AP on groundwater quality, which include removal of free liquids from the AP prior to construction (**Figure 4-1**). As discussed in **Sections 5.2.3.5**, physical attenuation (dilution and dispersion) of contaminants in groundwater is simulated in MT3DMS, which captures the physical process of natural attenuation as part of corrective actions for both of the closure scenarios simulated. No retardation was applied to boron transport in the model (*i.e.,* Kd was set to 0) as discussed in **Section 5.2.3.6**. The following methods were used to develop the prediction models and simulate the CIP and CBR closure scenarios:

- Define ash fill material removal and consolidation areas based on designs provided in the Draft CCR Final Closure Plan (Burns & McDonnell, 2022).
- A 1-year dewatering period was simulated in MODFLOW 2005 and MT3DMS where heads were reduced within the CCR unit using constant heads and concentrations were removed from CCR removal areas.
- In the two closure scenarios, HELP-calculated average annual percolation rates were developed from a 30-year HELP model run. This 30-year HELP-calculated percolation rate remained constant over duration of the closure scenario prediction model runs following CBR.
- Changes in recharge resulting from dewatering (assumed decrease calibration model recharge rates by 90 percent) and ash fill removal/ ash consolidation areas (recharge rates are based on HELP-calculated average annual percolation rates) have an instantaneous effect on recharge and percolation through surface materials.
- Boron source concentrations were assumed to remain constant as a function of time following the end of the calibration simulation in the ash consolidation area. Boron concentration in the ash fill removal areas was assumed to be 0 mg/L following construction to simulate removal of ash.
- The start of each closure prediction simulation was initiated at the end of the calibration model period of 27.5 years plus 1 year to complete dewatering and closure. The prediction modeling timeline for each scenario is illustrated in **Figure 4-1**.
- Ash fill removal areas were assumed to be graded following placement of soil backfill based on the design drawings provided in the Draft CCR Final Closure Plan (Burns & McDonnell, 2022).
- Apply drain cells (drain input parameters approximated designs provided in the Draft CCR Final Closure Plan) to simulate storm water management within CCR removal areas following closure.
- All saturated ash (constant concentration cells) in the transport calibration model were removed instantaneously in all prediction models following ash fill removal/final soil backfill grading. Local fill materials assumed to be sourced from surrounding USCU materials (clay) replaced ash fill in areas of removal.
- Local fill materials applied to the prediction models have similar hydraulic properties as the USCU materials used in the transport calibration models.

6.2 HELP Model Setup and Results

HELP (Version 4.0; Tolaymat and Krause, 2020) was used to estimate percolation through the AP areas for two ash fill removal scenarios. HELP input and output files are included electronically and attached to this report.

HELP input data and results are provided in **Table 5-6**. All scenarios were modeled for a period of 30 years. Climatic inputs were synthetically generated using default equations developed for Springfield, Illinois (the closest weather station included in the HELP database). Precipitation, temperature, and solar radiation was simulated based on the latitude of the Ash Pond. Thickness of soil backfill and soil runoff input parameters were developed for the ash fill removal scenarios using data provided the CCR Final Closure Plan (Burns & McDonnell, 2022).

HELP model results (**Table 5-6**) indicated 5.83 inches of percolation per year for the Ash Pond closure by removal and backfill area, 5.82 inches of percolation per year for the Ash Pond closure in place removal and backfill area, and 0.0041 inches of percolation per year for the Ash Pond closure in place consolidation and cover system area. The differences in HELP model runs for each area included the following parameters: area, soil backfill thickness, and soil runoff slope length; all other HELP model input parameters were the same for each simulated area.

6.3 Simulation of Closure Scenarios

The calibrated model was used to evaluate the effectiveness of the two closure scenarios by decreasing recharge to simulate dewatering of the ash fill prior to removal, applying drains to simulate stormwater management, and changing recharge rates to simulate ash fill removal areas at the AP. Removal of leachate inputs from the ash removal areas (source control) was simulated by deactivation constant concentration cell.

Each prediction scenario was started after the 1-year dewatering simulation to remove free liquids from the AP (27.5 years calibration plus 1 year of dewatering). The prediction model input values are summarized in **Table 6-2** and changes to the recharge zones for ash removal and consolidation areas and placement of drain for stormwater management for each closure scenario are illustrated in **Figures 6-1 and 6-7**. The two closure scenarios are discussed in this report based on predicted changes in boron concentrations as described below.

6.3.1 Closure Scenario 1 (CIP) Predicted Boron Concentrations

The design for Scenario 1: CIP includes CCR removal from the north and west areas of the AP, consolidation to the central and southeast portions of the AP, and construction of a cover system over the remaining CCR.

Predicted concentrations start to decline within approximately 2 years (**Figure 6-2**). These declines occur as recharge is reduced from dewatering. As a result of dewatering, downward percolation of solute mass from the AP is reduced, which decreases the boron concentration entering the model domain. The southern part of the AP was capped with a cover system which further reduces recharge and decreases the amount of boron mass entering the model domain. At all downgradient wells in the UA and USCU, concentrations in Scenario 1: CIP were predicted to decrease rapidly following initial dewatering and completion of closure construction (**Figure 6-2**).

At well MW-23, the model indicates concentrations will continue to increase for a brief period of time following closure construction before concentrations decrease. MW-28 shows the highest concentration and it falls below the GWPS for boron approximately 17 years after closure construction, at which time concentrations in all wells are predicted to be below the GWPS. Boron is predicted to decrease below the GWPS in all wells approximately 17 years after implementation of CIP.

Residual boron concentrations at approximately 17 years are presented in **Figures 6-3 through 6-6**. Note that boron is not present in layer 5 of the calibrated or prediction models so there are no figures of boron concentrations in model layer 5. By year 17, the residual boron plume has significantly receded when compared to the calibrated model plume (**Figures 5-19 to 5-22**).

6.3.2 Closure Scenario 2 (CBR) Predicted Boron Concentrations

The design for Scenario 2: CBR includes removal of all CCR. Predicted concentrations start to decline rapidly following closure (**Figure 6-8**). These declines occur as recharge is reduced from dewatering and constant concentration cells are removed to simulate removal of CCR. The decrease of concentration in the CBR scenario is slightly faster than the CIP scenario because in the CBR scenario all the fill material is being removed from the site. However, the decline in concentration in wells located north of the AP is almost identical with the CIP scenario, where ash is removed for consolidation. Following CBR, boron concentrations are no longer entering the model domain from recharge or from saturated ash cells (constant concentration cells). A very similar pattern of concentration decrease is observed in MW-23, where concentration starts to increase initially but then declines. The simulated increase of concentration at MW-23 is slightly less in the CBR scenario due to the absence of the consolidation and cover system which has lower recharge rates in the CIP scenario. MW-28 with the highest concentration falls below the GWPS for boron approximately 16.5 years after closure. Boron is also predicted to decrease below the GWPS in all wells approximately 16.5 years after implementation of CBR.

Residual boron concentrations after approximately 16.5 years are presented in **Figures 6-9 through 6-12**. Note that boron is not present in layer 5 of the calibrated or prediction models, so there are no figures of boron concentrations in model layer 5. By year 16.5 the residual boron plume has significantly receded when compared to the calibrated model plume (**Figures 5-19 to 5-22**). When compared to CIP (**Figures 6-3 to 6-6**) the residual boron plumes show similar distribution of boron greater than 2 mg/L. Differences are present in layers 2, 3, and 4 of the CIP scenario, where boron is present within the footprint of the AP near the area of CCR consolidation due to the lower infiltration rates beneath the cover system. In both scenarios residual boron exceedances remain in close proximity to the ash pond and/or calibrated extent of exceedances as the plumes recede.

From a modeling perspective, the difference between the predicted time to reach the GWPS for boron (2 mg/L) in Scenario 1 (17 years) versus Scenario 2 (16.5 years) is negligible. In other words, both scenarios are predicted to reach the GWPS after approximately 17 years.

7. CONCLUSIONS

This GMR has been prepared to evaluate how proposed closure scenarios will achieve compliance with the applicable groundwater standards at the KPP. Data collected from the 2021 field investigation were used to develop a groundwater model for the AP. Statistically significant correlations between boron concentrations and concentrations of other parameters identified as potential exceedances of the GWPS indicate boron is an acceptable surrogate for sulfate and TDS in the groundwater model. It was assumed that boron would not significantly sorb or chemically react with aquifer solids (soil adsorption coefficient [Kd] was set to 0 milliliters per gram [mL/g]) which is a conservative estimate for predicting contaminant transport times. Boron, sulfate, and TDS transport is likely to be affected by both chemical and physical attenuation mechanisms (i.e., adsorption and/or precipitation reactions as well as dilution and dispersion). MODFLOW and MT3DMS models were then used to evaluate two closure scenarios:

- Scenario 1: CIP (CCR removal from the north and west areas of the AP, consolidation to the central and southeast portions of the AP, and construction of a cover system over the remaining CCR); and,
- Scenario 2: CBR (CCR removal from the AP)

Prior to the simulation of these scenarios, a dewatering simulation was included for the removal of free liquids from the AP prior to the implementation of the two scenarios. Predictive simulations of closure conservatively indicate groundwater in the UA will achieve the GWPS in site monitoring wells for Scenarios 1 and 2 in 17 and 16.5 years after implementation of the closure scenarios, respectively. From a modeling perspective, the difference between the predicted time to reach the GWPS for boron (2 mg/L) in Scenario 1 (17 years) versus Scenario 2 (16.5 years) is negligible. In other words, both scenarios are predicted to reach the GWPS after approximately 17 years, the simulated difference between these two scenarios is not significant.

Results of groundwater fate and transport modeling estimate that groundwater will attain the GWPS for all constituents identified as potential exceedances of the GWPS within 17 years of closure implementation for both Scenarios. In both scenarios residual boron exceedances from the calibrated model remain in close proximity to the ash pond and/or calibrated extent of exceedances as the plumes recede.

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TABLES

TABLE 2-1. MONITORING WELL LOCATIONS AND CONSTRUCTION DETAILS
GROUNDWATER MODELING REPORT
KINCAID POWER PLANT
ASH POND
KINCAID, ILLINOIS

Well Number	HSU	Date Constructed	Top of PVC Elevation (ft)	Measuring Point Elevation (ft)	Measuring Point Description	Ground Elevation (ft)	Screen Top Depth (ft BGS)	Screen Bottom Depth (ft BGS)	Screen Top Elevation (ft)	Screen Bottom Elevation (ft)	Well Depth (ft BGS)	Bottom of Boring Elevation (ft)	Screen Length (ft)	Screen Diameter (inches)	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)
MW-1	UA	04/20/2010	604.71	604.71	Top of PVC	602.60	15.00	25.00	587.60	577.60	25.00	568.10	10	2	39.592051	-89.490283
MW-2	UA	04/21/2010	601.10	601.10	Top of PVC	598.88	10.00	20.00	588.90	578.90	20.00	541.40	10	2	39.590698	-89.488916
MW-3	UA	04/15/2010	601.46	601.46	Top of PVC	599.24	14.00	24.00	585.20	575.20	24.00	552.70	10	2	39.594458	-89.487173
MW-4	UA	04/14/2010	600.88	600.88	Top of PVC	598.46	12.00	22.00	586.50	576.50	22.00	560.50	10	2	39.600751	-89.487354
MW-5	UA	04/22/2010	619.44	619.44	Top of PVC	617.77	30.00	40.00	587.80	577.80	40.00	541.80	10	2	39.601296	-89.490402
MW-6	UA	04/16/2010	600.46	600.46	Top of PVC	598.44	10.00	20.00	588.40	578.40	20.00	572.90	10	2	39.598638	-89.498944
MW-7	UA	04/16/2010	597.75	597.75	Top of PVC	596.00	10.00	20.00	586.00	576.00	20.00	569.50	10	2	39.597637	-89.498959
MW-7S	USCU	02/02/2021	597.64	597.64	Top of PVC	595.59	6.00	11.00	589.59	584.59	11.00	580.59	5	2	39.59766	-89.498978
MW-8	UA	04/13/2010	603.14	603.14	Top of PVC	601.14	12.00	22.00	589.10	579.10	22.00	563.10	10	2	39.594399	-89.496829
MW-8S	USCU	02/02/2021	603.30	603.30	Top of PVC	600.57	4.00	7.00	596.57	593.57	7.00	580.57	3	2	39.594381	-89.496822
MW-9	UA	04/19/2010	599.39	599.39	Top of PVC	597.63	10.00	20.00	587.60	577.60	20.00	573.10	10	2	39.595204	-89.500968
MW-10	UA	04/19/2010	600.11	600.11	Top of PVC	598.22	10.00	20.00	588.20	578.20	20.00	575.20	10	2	39.590652	-89.503745
MW-11	UA	06/17/2015	601.81	601.81	Top of PVC	599.27	11.00	21.00	588.30	578.30	21.00	578.30	10	2	39.593104	-89.491115
MW-11S	USCU	01/26/2021	601.76	601.76	Top of PVC	599.43	4.00	8.00	595.43	591.43	8.00	591.43	4	2	39.593122	-89.491102
MW-12	UA	07/23/2015	591.40	591.40	Top of PVC	589.04	15.00	25.00	573.90	563.90	25.00	563.90	10	2	39.600208	-89.496381
MW-12S	USCU	01/27/2021	591.10	591.10	Top of PVC	588.62	5.00	9.00	583.62	579.62	9.00	579.12	4	2	39.600208	-89.496412
MW-12D	BCU	01/26/2021	590.96	590.96	Top of PVC	589.08	50.00	55.00	539.08	534.08	55.00	489.08	5	2	39.600194	-89.496418
MW-20	UA	01/26/2021	600.77	600.77	Top of PVC	598.52	14.00	24.00	584.52	574.52	24.00	547.52	10	2	39.598653	-89.48728
MW-20S	USCU	01/26/2021	600.64	600.64	Top of PVC	598.43	4.00	10.00	594.43	588.43	10.00	588.43	6	2	39.598665	-89.487279
MW-22	UA	02/03/2021	601.77	601.77	Top of PVC	599.51	15.00	19.00	584.51	580.51	19.00	579.51	4	2	39.593235	-89.487638
MW-23	UA	02/02/2021	610.32	610.32	Top of PVC	608.05	23.00	28.00	585.05	580.05	28.00	558.05	5	2	39.593293	-89.489352
MW-24	UA	02/02/2021	615.48	615.48	Top of PVC	613.01	27.00	32.00	586.01	581.01	32.00	581.01	5	2	39.593271	-89.493267
MW-25	USCU	02/02/2021	607.20	607.20	Top of PVC	604.60	9.00	14.00	595.60	590.60	14.00	579.60	5	2	39.594397	-89.495062

TABLE 2-1. MONITORING WELL LOCATIONS AND CONSTRUCTION DETAILS
GROUNDWATER MODELING REPORT
KINCAID POWER PLANT
ASH POND
KINCAID, ILLINOIS

Well Number	HSU	Date Constructed	Top of PVC Elevation (ft)	Measuring Point Elevation (ft)	Measuring Point Description	Ground Elevation (ft)	Screen Top Depth (ft BGS)	Screen Bottom Depth (ft BGS)	Screen Top Elevation (ft)	Screen Bottom Elevation (ft)	Well Depth (ft BGS)	Bottom of Boring Elevation (ft)	Screen Length (ft)	Screen Diameter (inches)	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)
MW-26	UA	02/02/2021	596.16	596.16	Top of PVC	593.33	7.00	12.00	586.33	581.33	12.00	573.33	5	2	39.595584	-89.497582
MW-27	USCU	02/02/2021	600.05	600.05	Top of PVC	597.35	10.00	15.00	587.35	582.35	15.00	577.35	5	2	39.596694	-89.497927
MW-28	UA	02/02/2021	601.40	601.40	Top of PVC	598.33	12.00	22.00	586.33	576.33	22.00	573.33	10	2	39.599258	-89.497962
MW-29	UA	02/01/2021	599.94	599.94	Top of PVC	596.86	14.00	19.00	582.86	577.86	19.00	576.86	5	2	39.599691	-89.497249
MW-30	UA	02/03/2021	618.47	618.47	Top of PVC	616.00	35.00	40.00	581.00	576.00	40.00	571.00	5	2	39.601262	-89.493996
MW-31	UA	02/03/2021	617.34	617.34	Top of PVC	615.02	35.00	40.00	580.02	575.02	40.00	565.02	5	2	39.601301	-89.491702
MW-31S	USCU	02/03/2021	617.54	617.54	Top of PVC	615.13	25.00	30.00	590.13	585.13	30.00	585.13	5	2	39.601303	-89.491681
MW-32	UA	02/03/2021	619.49	619.49	Top of PVC	617.20	32.00	37.00	585.20	580.20	37.00	577.20	5	2	39.601279	-89.488643
PZ-4C	UA	03/30/2016	600.57	600.57	Top of PVC	597.89	15.50	20.50	582.39	577.39	20.50	577.39	5	2	39.596398	-89.487207
XPW01	CCR	02/01/2021	627.84	627.84	Top of PVC	625.48	22.00	32.00	603.48	593.48	32.00	593.48	10	2	39.594417	-89.493104
XPW02	CCR	01/26/2021	620.19	620.19	Top of PVC	617.91	13.00	23.00	604.91	594.91	23.00	595.91	10	2	39.597918	-89.49687
XPW03	CCR	01/26/2021	616.08	616.08	Top of PVC	616.08	10.00	20.00	606.08	596.08	20.00	596.08	10	2	39.599588	-89.495765
XPW04	CCR	01/26/2021	606.53	606.53	Top of PVC	604.57	13.00	23.00	591.57	581.57	23.00	580.57	10	2	39.600737	-89.492276
XSG-01	CCR	--	--	608.43	Staff gauge	--	--	--	--	--	--	--	--	--	39.593401	-89.48768
SG-02	SW	--	--	564.80	Staff gauge	--	--	--	--	--	--	--	--	--	39.593106	-89.498155

Notes:
All elevation data are presented relative to the North American Vertical Datum 1988 (NAVD88), GEOID 12A
-- = data not available
BCU = bedrock confining unit
BGS = below ground surface
CCR = Coal Combustion Residual
ft = foot or feet
HSU = Hydrostratigraphic Unit
PVC = polyvinyl chloride
SW = surface water
UA = uppermost aquifer
USCU = upper semi-confining unit
generated 10/05/2021, 4:22:06 PM CDT

TABLE 5-1. FLOW MODEL CALIBRATION TARGETS

GROUNDWATER MODELING REPORT

KINCAID POWER PLANT

ASH POND

KINCAID, ILLINOIS

				Flow Targets							
Well Name	**Easting**	**Northing**	**HSU**	**Number of Samples**	**median GWL[1] (feet)**	**mean GWL[1] (feet)**	**std dev GWL[1] (feet)**	**min GWL[1] (feet)**	**max GWL[1] (feet)**	**Earliest Sample Date**	**Latest Sample Date**
MW-1	2487193	1065989	UA	33	589.6	589.0	2.7	587.6	604.7	06/16/2015	09/01/2021
MW-2	2487582	1065499	UA	33	594.6	594.9	1.5	592.4	601.1	06/16/2015	09/01/2021
MW-4	2487995	1069164	UA	30	593.4	593.4	1.1	590.8	597.1	12/14/2015	09/01/2021
MW-5	2487135	1069356	UA	32	593.8	594.1	4.6	590.6	619.4	06/16/2015	09/01/2021
MW-6	2484735	1068370	UA	33	592.2	592.0	2.3	588.2	600.5	06/16/2015	09/01/2021
MW-7	2484734	1068005	UA	35	589.2	589.5	3.1	586.6	597.8	06/17/2015	09/01/2021
MW-7S	2484728.09	1068011.16	USCU	11	587.3	587.2	0.2	587.1	587.9	02/23/2021	08/11/2021
MW-8	2485342	1066831	UA	34	594.7	595.5	2.0	593.2	603.1	06/17/2015	09/01/2021
MW-8S	2485344.57	1066821.52	USCU	8	594.9	595.0	1.0	593.9	597.5	02/23/2021	06/10/2021
MW-9	2484174	1067115	UA	27	590.2	590.7	3.7	583.2	596.8	12/14/2015	09/01/2021
MW-10	2483403	1065451	UA	27	588.2	588.7	2.0	585.0	592.3	12/14/2015	09/01/2021
MW-11	2486956	1066371	UA	30	590.2	590.2	0.3	589.9	591.7	12/14/2015	09/01/2021
MW-12	2485452.88	1068944.67	UA	30	585.1	584.1	0.6	583.2	586.6	12/14/2015	09/01/2021
MW-12S	2485444.27	1068944.79	USCU	11	585.4	584.8	0.6	584.8	587.2	02/23/2021	08/11/2021
MW-12D	2485442.58	1068939.69	LCU	11	586.2	584.6	0.9	584.6	587.2	02/23/2021	08/11/2021
MW-20	2488021.74	1068397.57	UA	11	595.1	594.8	1.2	594.2	598.9	02/23/2021	08/10/2021
MW-20S	2488021.76	1068402.07	USCU	11	595.0	594.8	1.2	594.2	599.1	02/23/2021	08/10/2021
MW-22	2487935.62	1066423.38	UA	11	595.7	596.1	0.7	594.9	597.5	02/23/2021	08/10/2021
MW-23	2487452.37	1066440.78	UA	11	594.0	594.2	0.6	593.5	595.9	02/23/2021	08/10/2021
MW-24	2486349.15	1066424.59	UA	10	593.4	592.2	1.1	590.5	594.4	02/23/2021	07/22/2021
MW-25	2485840.34	1066830.95	USCU	11	601.2	601.4	5.0	584.0	602.1	02/23/2021	08/11/2021
MW-26	2485127.12	1067258.09	UA	11	589.0	588.9	2.2	585.0	592.5	02/23/2021	08/10/2021
MW-27	2485026.71	1067661.72	USCU	11	586.1	586.1	3.2	583.4	594.4	02/23/2021	08/11/2021
MW-28	2485010.02	1068595.29	UA	11	595.4	595.4	1.0	593.5	597.6	02/23/2021	08/11/2021

TABLE 5-1. FLOW MODEL CALIBRATION TARGETS
GROUNDWATER MODELING REPORT
KINCAID POWER PLANT
ASH POND
KINCAID, ILLINOIS

				Flow Targets							
Well Name	Easting	Northing	HSU	Number of Samples	median GWL[1] (feet)	mean GWL[1] (feet)	std dev GWL[1] (feet)	min GWL[1] (feet)	max GWL[1] (feet)	Earliest Sample Date	Latest Sample Date
MW-29	2485209.8	1068754.64	UA	11	595.7	595.7	0.6	594.9	597.1	02/23/2021	08/11/2021
MW-30	2486122	1069336	UA	11	594.0	594.0	0.6	593.4	595.7	02/23/2021	08/10/2021
MW-31	2486768.38	1069352.71	UA	11	587.9	587.7	2.0	586.7	594.2	02/23/2021	08/10/2021
MW-31S	2486774.19	1069353.41	USCU	11	590.9	591.2	1.5	588.3	592.8	02/23/2021	08/10/2021
MW-32	2487630	1069354	UA	11	596.9	596.9	0.7	596.1	598.7	02/23/2021	08/10/2021
XPW01	2486392.09	1066842.23	CCR	11	603.4	603.5	0.1	603.1	603.5	02/23/2021	08/11/2021
XPW02	2485321.31	1068109.66	CCR	11	603.8	603.8	0.1	603.5	603.9	02/23/2021	08/11/2021
XPW03	2485628.19	1068720.21	CCR	11	601.0	601.0	0.2	600.8	601.6	02/23/2021	08/11/2021
XPW04	2486608.19	1069145.99	CCR	11	603.2	603.4	0.2	602.8	603.4	02/23/2021	08/10/2021

[O: PR 05/05/22; C: EGP 5/6/22]

Notes:
[1] Groundwater Elevation
std dev = standard deviation from the mean
min = minimum
max = maximum

HSU: Hydrostratigraphic Unit
CCR = coal combustion residual
USCU = upper semi-confining unit
UA = uppermost aquifer
LCU = lower confining unit

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TABLE 5-2. TRANSPORT MODEL CALIBRATION TARGETS

GROUNDWATER MODELING REPORT

KINCAID POWER PLANT

ASH POND

KINCAID, ILLINOIS

				Transport Targets							
Well Name	**Easting**	**Northing**	**HSU**	**Number of Samples**	**median Boron (mg/L)**	**mean Boron (mg/L)**	**std dev Boron (mg/L)**	**min Boron (mg/L)**	**max Boron (mg/L)**	**Earliest Sample Date**	**Latest Sample Date**
MW-3	2488063	1066873	UA	20	1.62	1.68	0.28	1.02	2.40	06/03/2015	08/10/2021
MW-4	2487995	1069164	UA	17	0.57	0.57	0.12	0.34	0.84	06/03/2015	06/09/2021
MW-5	2487135	1069356	UA	24	0.55	0.55	0.04	0.47	0.66	06/04/2015	09/01/2021
MW-6	2484735	1068370	UA	24	1.06	1.11	0.33	0.63	1.91	06/04/2015	09/01/2021
MW-7	2484734	1068005	UA	24	0.26	0.28	0.14	0.10	0.65	06/04/2015	09/01/2021
MW-7S	2484728.09	1068011.16	USCU	8	4.03	4.33	0.75	3.56	5.51	02/24/2021	08/11/2021
MW-8	2485342	1066831	UA	24	1.01	1.03	0.13	0.86	1.51	06/04/2015	09/01/2021
MW-8S	2485344.57	1066821.52	USCU	4	1.04	0.98	0.14	0.74	1.10	02/24/2021	05/21/2021
MW-9	2484174	1067115	UA	13	0.10	0.10	0.03	0.06	0.18	06/04/2015	06/10/2021
MW-11	2486956	1066371	UA	23	1.65	1.65	0.21	1.34	2.28	12/15/2015	09/01/2021
MW-12	2485452.88	1068944.67	UA	23	2.78	2.87	0.65	1.95	4.42	12/15/2015	09/01/2021
MW-12S	2485444.27	1068944.79	USCU	8	1.51	1.60	0.52	0.86	2.63	02/25/2021	08/11/2021
MW-12D	2485442.58	1068939.69	LCU	8	0.84	0.86	0.10	0.71	1.08	02/25/2021	08/11/2021
MW-20	2488021.74	1068397.57	UA	8	0.45	0.46	0.06	0.34	0.56	02/26/2021	08/10/2021
MW-20S	2488021.76	1068402.07	USCU	8	1.29	1.24	0.50	0.06	1.89	02/26/2021	08/10/2021
MW-22	2487935.62	1066423.38	UA	4	1.46	1.48	0.04	1.44	1.55	02/26/2021	05/18/2021
MW-23	2487452.37	1066440.78	UA	8	2.00	1.96	0.45	0.93	2.67	02/26/2021	08/10/2021
MW-24	2486349.15	1066424.59	UA	--	--	--	--	--	--	--	--
MW-25	2485840.34	1066830.95	USCU	5	1.08	1.09	0.04	1.04	1.14	02/25/2021	08/11/2021
MW-26	2485127.12	1067258.09	UA	4	1.10	1.15	0.10	1.07	1.32	02/25/2021	05/21/2021
MW-27	2485026.71	1067661.72	USCU	8	1.23	1.19	0.24	0.77	1.50	02/24/2021	08/11/2021
MW-28	2485010.02	1068595.29	UA	8	9.49	9.64	0.80	8.35	10.90	02/24/2021	08/11/2021
MW-29	2485209.8	1068754.64	UA	8	1.66	1.72	0.14	1.57	2.01	02/25/2021	08/11/2021
MW-30	2486122	1069336	UA	8	1.19	1.22	0.16	1.06	1.60	02/25/2021	08/10/2021
MW-31	2486768.38	1069352.71	UA	8	0.29	0.29	0.04	0.22	0.37	02/24/2021	08/10/2021

TABLE 5-2. TRANSPORT MODEL CALIBRATION TARGETS

GROUNDWATER MODELING REPORT

KINCAID POWER PLANT

ASH POND

KINCAID, ILLINOIS

				Transport Targets							
Well Name	**Easting**	**Northing**	**HSU**	**Number of Samples**	**median Boron (mg/L)**	**mean Boron (mg/L)**	**std dev Boron (mg/L)**	**min Boron (mg/L)**	**max Boron (mg/L)**	**Earliest Sample Date**	**Latest Sample Date**
MW-31S	2486774.19	1069353.41	USCU	8	0.05	0.05	0.00	0.04	0.06	02/24/2021	08/11/2021
MW-32	2487630	1069354	UA	8	1.65	1.67	0.14	1.44	1.88	02/25/2021	08/10/2021
PZ-4C	1067576.48	2488048.39	UA	8	1.56	1.57	0.17	1.34	1.93	02/25/2021	08/11/2021
XPW01*	2486392.09	1066842.23	CCR	8	1.46	1.40	0.15	1.18	1.58	03/01/2021	08/11/2021
XPW02*	2485321.31	1068109.66	CCR	8	3.73	3.78	0.39	3.11	4.23	03/01/2021	08/11/2021
XPW03*	2485628.19	1068720.21	CCR	8	2.89	3.06	0.46	2.69	4.21	03/02/2021	08/11/2021
XPW04*	2486608.19	1069145.99	CCR	8	1.54	1.68	0.30	1.26	2.28	03/02/2021	08/10/2021

[O: PR 05/05/22; C: EGP 5/6/22]

Notes:

mg/L = milligrams per liter
std dev = standard deviation from the mean
min = minimum
max = maximum
* Porewater samples used for boundary condition estimate and not as target

HSU = Hydrostratigraphic Unit
CCR = coal combustion residuals
USCU = upper semi-confining unit
UA = uppermost aquifer
LCU = lower confining unit

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TABLE 5-3. FLOW MODEL INPUT AND SENSITIVITY ANALYSIS RESULTS
GROUNDWATER MODELING REPORT
KINCAID POWER PLANT
ASH POND
KINCAID, ILLINOIS

Zone	Hydrostratigraphic Unit	Materials	ft/d	cm/s	Kh/Kv	Value Source	Sensitivity[1]
Horizontal Hydraulic Conductivity						**Calibration Model**	
1	CCR	Bottom Ash and boiler slag	243	8.57E-02	NA	Calibrated - Within Range of Field Test Results (Ramboll, 2021a)	High
2	USCU	Clay with silt and sand lenses	0.45	1.59E-04	NA	Calibrated - Conductivity Value to Allow Groundwater Flow from UD to Riverand Drain Boundary Conditions	High
3	UA	Sand, silty sand, and clayey sand and gravel	0.5	1.76E-04	NA	Calibrated - Within Range of Field Test Results (Ramboll, 2021a)	High
4	LCU	Clay till	4.79	1.69E-03	NA	Calibrated - Within Range of Field Test Results (Ramboll, 2021a)	High
5	CL	Clay lens	0.05	1.76E-05	NA	Calibrated - Within Range of Field Test Results (Ramboll, 2021a)	High
6	SGL	Sand and gravel lens	25	8.82E-03	NA	Calibrated - Within Range of Field Test Results (Ramboll, 2021a)	Moderately High
Vertical Hydraulic Conductivity[2]						**Calibration Model**	
1	CCR	Bottom Ash and boiler slag	1.20E+01	4.23E-03	20	Calibrated - Within Range Laboratory Test Results and near Geomean of Laboratory Test Results (Ramboll, 2021a)	High
2	USCU	Clay with silt and sand lenses	4.50E-02	1.59E-05	10	Calibrated - Conductivity Value to Allow Groundwater Flow from UD to Riverand Drain Boundary Conditions	High
3	UA	Sand, silty sand, and clayey sand and gravel	5.00E-02	1.76E-05	10	Calibrated - Within Range Laboratory Test Results and near Geomean of Laboratory Test Results (Ramboll, 2021a)	High
4	LCU	Clay till	4.79E-01	1.69E-04	10	Calibrated - Within Range Laboratory Test Results and near Geomean of Laboratory Test Results (Ramboll, 2021a)	High
5	CL	Clay lens	5.00E-03	1.76E-06	10	Calibrated - Within Range Laboratory Test Results and near Geomean of Laboratory Test Results (Ramboll, 2021a)	High
6	SGL	Sand and gravel lens	2.50E+00	8.82E-04	10	Calibrated - Within Range Laboratory Test Results and near Geomean of Laboratory Test Results (Ramboll, 2021a)	Moderately High
Zone	**Hydrostratigraphic Unit**	**Materials**	**ft/d**	**in/yr**	**Kh/Kv**	**Value Source**	**Sensitivity[1]**
Recharge						**Calibration Model**	
1	USCU	Clay with silt and sand lenses	5.00E-05	0.22	NA	Calibrated	Low
2	CCR	Bottom Ash and boiler slag	1.00E-03	4.38	NA	Calibrated	Negligible
3, 5	CCR - 1971/1983 area	Bottom Ash and boiler slag	2.00E-03	8.76	NA	Calibrated	Moderate
6	USCU - developed area	Clay with silt and sand lenses	1.00E-03	4.38	NA	Calibrated	Moderately High
4, 7, 8	CCR - 1995 area	Bottom Ash and boiler slag	3.00E-04	1.31	NA	Calibrated	High
Storage							
1	CCR	Bottom Ash and boiler slag				*Not used in steady-state calibration model*	
2	USCU	Clay with silt and sand lenses					
3	UA	Sand, silty sand, and clayey sand and gravel					
4	LCU	Clay till					

TABLE 5-3. FLOW MODEL INPUT AND SENSITIVITY ANALYSIS RESULTS
GROUNDWATER MODELING REPORT
KINCAID POWER PLANT
ASH POND
KINCAID, ILLINOIS

Zone	Hydrostratigraphic Unit	Materials		Value Source	Sensitivity[1]
Constant Head					
	Relative Location	**Head (feet)**	---	---	
5 (Lake)	Northwest and southern model boundary	*584.35*			High
4, 6, 7 (Pond)	Inside the Ash Pond domain	603.48			High

[O: PR 5/08/22; C: EGP 5/6/22]

Notes:
[1] Sensitivity Explanation:
Negligible - SSR changed by less than 1%
Low - SSR change between 1% and 10%
Moderate - SSR change between 10% and 50%
Moderately High - SSR change between 50% and 100%
High - SSR change greater than 100%
[2] For sensitivity analysis vertical conductivities maintained the same anisotropy.
RMSE = root of the mean squared error
--- = not tested
cm/s = centimeters per second
ft/d = feet per day
ft^2/day = feet squared per day
in/yr = inches per year
Kh/Kv = anisotropy ratio
NA = not applicable

Hydrostratigraphic Unit
CCR = coal combustion residuals
USCU = upper semi-confining unit
UA = uppermost aquifer

TABLE 5-4. TRANSPORT MODEL INPUT VALUES (CALIBRATION)
GROUNDWATER MODELING REPORT
KINCAID POWER PLANT
ASH POND
KINCAID, ILLINOIS

Zone	Hydrostratigraphic Unit	Materials	Calibration Model				
			Boron Concentration (mg/L)			Value Source	Sensitivity
Initial Concentration							
Entire Domain	NA	NA	0			NA	- - -
Source Concentration (Constant Concentration Cells)							
			pre-1983	**post 1983**			
351, 352	CCR	Bottom Ash and boiler slog	3.5	--		Boron concentration data from XWP01, XWP02, XWP03 and XWP04 - calibrated	- - -
31, 401, 402	CCR	Bottom Ash and boiler slog	--	3.1		Boron concentration data from XWP01, XWP02, XWP03 and XWP04 - calibrated	- - -
11	USCU	Other high concentration ash materials	14	14		Calibrated to meet MW-28 observed concentration	
Storage, Specific Yield and Effective Porosity			**Calibration Model**				
Zone	**Hydrostratigraphic Unit**	**Materials**	**Storage**	**Specific Yield**	**Effective Porosity**	**Value Source**	**Sensitivity**
1	CCR	Bottom Ash and boiler slog	0.003	0.15	0.15	Calibrated	see Table 5-5
2	USCU	Clay with silt and sand lenses	0.003	0.21	0.21	Calibrated	see Table 5-5
3	UA	Sand, silty sand, and clayey sand and gravel	0.003	0.25	0.25	Calibrated	see Table 5-5
4	LCU	Clay till	0.003	0.1	0.1	Calibrated	see Table 5-5
Dispersivity							
Applicable Region	**Hydrostratigraphic Unit**	**Materials**	**Longitudinal (feet)**	**Transverse (feet)**	**Vertical (feet)**	**Value Source**	**Sensitivity**
Entire Domain	NA	NA	5	0.5	0.05	calibrated	- - -

[O: PR 5/4/22; C: EGP 5/6/22]

Notes:
[1] The concentrations from the end of the calibrated transport model were imported as initial concentrations for the prediction model runs.
- - - = not tested
mg/L = milligrams per liter
NA = not applicable

Hydrostratigraphic Unit
CCR = coal combustion residuals
USCU = upper semi-confining unit
UA = uppermost aquifer

TABLE 5-5. TRANSPORT MODEL INPUT SENSITIVITY (CALIBRATION)
GROUNDWATER MODELING REPORT
KINCAID POWER PLANT
ASH POND
KINCAID, ILLINOIS

			Storage and Specific Yield				Effective Porosity			
Well ID	**HSU**	**Calibration on Boron Concentration (mg/L)**	**Boron Concentration (mg/L)**	**Sensitivity [1]**	**Boron Concentration (mg/L)**	**Sensitivity [1]**	**Boron Concentration (mg/L)**	**Sensitivity [1]**	**Boron Concentration (mg/L)**	**Sensitivity [1]**
MW-3	UA	0.20	0.20	Negligible	0.20	Negligible	0.20	Low	0.19	Low
MW-4	UA	0.05	0.05	Negligible	0.05	Negligible	0.13	High	0.02	Moderately High
MW-5	UA	2.72	2.72	Negligible	2.72	Negligible	2.77	Low	2.63	Low
MW-6	UA	1.71	1.71	Negligible	1.71	Negligible	1.71	Negligible	1.70	Negligible
MW-7	UA	2.12	2.12	Negligible	2.12	Negligible	2.14	Negligible	2.09	Low
MW-7S	USCU	2.12	2.12	Negligible	2.12	Negligible	2.14	Negligible	2.09	Low
MW-8	UA	2.3E-03	2.3E-03	Negligible	2.3E-03	Negligible	5.2E-03	High	7.7E-04	Moderately High
MW-11	UA	1.90	1.90	Negligible	1.90	Negligible	1.90	Negligible	1.90	Negligible
MW-12	UA	2.72	2.72	Negligible	2.72	Negligible	2.89	Low	2.55	Low
MW-12S	USCU	2.65	2.65	Negligible	2.65	Negligible	2.75	Low	2.36	Low
MW-12D	LCU	1.78	1.78	Negligible	1.78	Negligible	2.48	Moderate	1.28	Moderate
MW-20	UA	1.2E-03	1.2E-03	Negligible	1.2E-03	Negligible	5.5E-03	High	3.0E-04	Moderately High
MW-20S	USCU	1.5E-03	1.5E-03	Negligible	1.5E-03	Negligible	6.9E-03	High	3.8E-04	Moderately High
MW-22	UA	1.39	1.39	Negligible	1.39	Negligible	1.39	Negligible	1.39	Negligible
MW-23	UA	0.72	0.72	Negligible	0.72	Negligible	0.72	Negligible	0.72	Negligible
MW-24	UA	3.45	3.45	Negligible	3.45	Negligible	3.45	Negligible	3.45	Negligible
MW-25	USCU	0.52	0.52	Negligible	0.52	Negligible	0.59	Moderate	0.43	Moderate
MW-26	UA	1.19	1.19	Negligible	1.19	Negligible	1.24	Low	1.11	Low
MW-27	USCU	3.11	3.11	Negligible	3.11	Negligible	3.12	Negligible	3.10	Negligible
MW-28	UA	9.06	9.06	Negligible	9.06	Negligible	9.06	Negligible	9.06	Negligible
MW-29	UA	2.38	2.38	Negligible	2.38	Negligible	2.39	Negligible	2.38	Negligible
MW-30	UA	1.89	1.89	Negligible	1.89	Negligible	1.90	Negligible	1.88	Negligible
MW-31	UA	1.71	1.71	Negligible	1.71	Negligible	1.71	Negligible	1.70	Negligible
MW-31S	USCU	2.42	2.42	Negligible	2.42	Negligible	2.42	Negligible	2.42	Negligible
MW-32	UA	1.15	1.15	Negligible	1.15	Negligible	1.15	Negligible	1.14	Negligible
PZ-4C	UA	0.52	0.52	Negligible	0.52	Negligible	0.59	Moderate	0.41	Moderate
			S*0.1 Sy*0.5[2]		S*10 Sy*2[2]		Porosity-0.05		Porosity+0.05	

[O: PR 5/09/22; C: EGP 5/11/22]

Notes:
[1] Sensitivity Explanation:
Negligible = concentration changed by less than 1%
Low = concentration change between 1% and 10%
Moderate = concentration change between 10% and 50%
Moderately High = concentration change between 50% and 100%
High = concentration change greater than 100%
[2] sensitivity test used steady state flow and transient transport
ID = identification
mg/L = milligrams per liter
S = storativity
Sy = specific yield
Disp = dispersivity

TABLE 6-1. HELP MODEL INPUT AND OUTPUT VALUES
GROUNDWATER MODELING REPORT
KINCAID POWER PLANT
ASH POND
KINCAID, ILLINOIS

Closure Scenario - Area Description	CBR - Removal Area	CIP - Removal Area	CIP - Consolidation and Cover System Area	Notes
Input Parameter				
Climate-General				
City	Kincaid, IL	Kincaid, IL	Kincaid, IL	Nearby city to the Site within HELP database
Latitude	39.59	39.59	39.59	Site latitude
Evaporative Zone Depth	18	18	18	Estimated based on geographic location (Illinois) and uppermost soil type (Tolaymat, T. and Krause, M, 2020)
Maximum Leaf Area Index	4.5	4.5	4.5	Maximum for geographic location (Illinois) (Tolaymat, T. and Krause, M, 2020)
Growing Season Period, Average Wind Speed, and Quarterly Relative Humidity	Springfield, IL	Springfield, IL	Springfield, IL	Nearby city to the Kincaid Ash Pond within HELP database
Number of Years for Synthetic Data Generation	30	30	30	
Temperature, Evapotranspiration, and Precipitation	Precipitation, temperature, and solar radiation was simulated based on HELP V4 weather simulation for: Lat/Long: 39.59/-89.50	Precipitation, temperature, and solar radiation was simulated based on HELP V4 weather simulation for: Lat/Long: 39.59/-89.50	Precipitation, temperature, and solar radiation was simulated based on HELP V4 weather simulation for: Lat/Long: 39.59/-89.50	
Soils-General				
% where runoff possible	100	100	100	
Area (acres)	172	88	84	CBR - Removal Area based on HCR (Ramboll, 2021); CIP - Consolidation and Cover System Area based on construction drawing for Kincaid Ash Pond; CIP -Removal Area equals the difference
Specify Initial Moisture Content	No	No	No	
Surface Water/Snow	Model Calculated	Model Calculated	Model Calculated	
Soils-Layers				
1	Unsaturated Backfill Material (HELP Final Cover Soil [topmost layer])	Unsaturated Backfill Material (HELP Final Cover Soil [topmost layer])	Vegetative Soil Layer (HELP Final Cover Soil [topmost layer])	Layer details for CBR and CIP areas based on grading plans, construction drawings, and cover system design for Kincaid Ash Pond
2	Protective Soil Layer (HELP Vertical Percolation Layer)	Protective Soil Layer (HELP Vertical Percolation Layer)	Protective Soil Layer (HELP Vertical Percolation Layer)	
3	--	--	Geotextile Liner (HELP Drainage Net)	
4	--	--	Geomembrane Liner	
5	--	--	Unsaturated CCR Material (HELP Waste)	
6	--	--	Unsaturated Material (HELP Vertical Percolation Layer)	
Soil Parameters--Layer 1, Unsaturated Backfill Material (HELP Final Cover Soil [topmost layer]) or Vegetative Soil Layer (HELP Final Cover Soil [topmost layer])				
Type	1	1	1	Vertical Percolation Layer (Cover Soil)
Thickness (in)	30	30	6	For CBR and CIP removal areas, layer 1 thickness is the average thickness of unsaturated backfill material placed after removal
Texture	12	12	12	defaults used
Description	Silty Clay Loam	Silty Clay Loam	Silty Clay Loam	
Saturated Hydraulic Conductivity (cm/s)	4.20E-05	4.20E-05	4.20E-05	defaults used

TABLE 6-1. HELP MODEL INPUT AND OUTPUT VALUES
GROUNDWATER MODELING REPORT
KINCAID POWER PLANT
ASH POND
KINCAID, ILLINOIS

Closure Scenario - Area Description	CBR - Removal Area	CIP - Removal Area	CIP - Consolidation and Cover System Area	Notes
Soil Parameters--Layer 2, Protective Soil Layer (HELP Vertical Percolation Layer)				
Type	1	1	1	Vertical Percolation Layer
Thickness (in)	72	72	18	design thickness
Texture	43	43	43	Custom layer, adjusted for site specific hydraulic conductivity
Description	Silty Clay	Silty Clay	Sandy Silty Clay	
Saturated Hydraulic Conductivity (cm/s)	1.20E-07	1.20E-07	1.00E-05	Design vertical hydraulic conductivity for backfill
Soil Parameters--Layer 3, Geotextile Liner (HELP Drainage Net)				
Type	--	--	2	Geotextile Protective Layer
Thickness (in)	--	--	0.11	design thickness
Texture	--	--	123	custom layer
Description	--	--	10 oz Nonwoven Geotextile	
Saturated Hydraulic Conductivity (cm/s)	--	--	3.00E-01	custom design hydraulic conductivity
Soil Parameters--Layer 4, Geomembrane Liner				
Type	--	--	4	Flexible Membrane Liner
Thickness (in)	--	--	0.04	design thickness
Texture	--	--	36	defaults used
Description	--	--	Geomembrane	
Saturated Hydraulic Conductivity (cm/s)			4.00E -13	defaults used
Soil Parameters--Layer 5, Unsaturated CCR Material (HELP Waste)				
Type	--	--	1	Vertical Percolation Layer (Waste)
Thickness (in)	--	--	372	Estimated unsaturated CCR thickness within CIP Consolidation and Cover System Area
Texture	--	--	83	Custom layer, adjusted for site specific hydraulic conductivity
Description	--	--	Electric Plant Coal Bottom Ash	
Saturated Hydraulic Conductivity (cm/s)	--	--	1.40E-03	calibrated flow model vertical hydraulic conductivity for CCR
Soil Parameters--Layer 6, Unsaturated Material (HELP Vertical Percolation Layer)				
Type	--	--	1	Vertical Percolation Layer
Thickness (in)	--	--	84	Estimated unsaturated Silty Clay thickness within CIP Consolidation and Cover System Area
Texture	--	--	44	Custom layer, adjusted for site specific hydraulic conductivity
Description	--	--	Silty Clay	
Saturated Hydraulic Conductivity (cm/s)	--	--	1.20E-07	calibrated flow model vertical hydraulic conductivity for Silty Clay
Soils--Runoff				
Runoff Curve Number	85.7	85.9	87.2	HELP-computed curve number
Slope	0.5%	0.5%	2.5%	Estimated average from construction design drawings for Kincaid Ash Pond
Length (ft)	3000	2300	800	estimated maximum flow path
Texture	10	10	10	uppermost layer texture
Vegetation	fair	fair	fair	fair indicating fair stand of grass on surface of soil backfill

TABLE 6-1. HELP MODEL INPUT AND OUTPUT VALUES
GROUNDWATER MODELING REPORT
KINCAID POWER PLANT
ASH POND
KINCAID, ILLINOIS

Closure Scenario - Area Description	CBR - Removal Area	CIP - Removal Area	CIP - Consolidation and Cover System Area	Notes
Execution Parameters				
Years	30	30	30	
Report Daily	No	No	No	
Report Monthly	No	No	No	
Report Annual	Yes	Yes	Yes	
Output Parameter				
Percolation Rate (in/yr)	**5.83**	**5.82**	**0.0041**	

[O: EGP 4/25/22 C: JJW 5/11/22]

Notes:
% = percent
cm/s = centimeters per second
ft = feet
HELP = Hydrologic Evaluation of Landfill Performance
in = inches
in/yr = inches per year
Lat/Long = latitude/longitude
CBR = closure by removal
CIP = closure in place
HCR = Hydrogeologic Site Characterization Report

References:

Tolaymat, T. and Krause, M, 2020. *Hydrologic Evaluation of Landfill Performance: HELP 4.0 User Manual*. United States Environmental Protection Agency, Washington, DC, EPA/600/B 20/219.
Ramboll Americas Engineering Solutions, Inc. (Ramboll), 2021. Hydrogeologic Site Characterization Report. Kincaid Ash Pond. Kincaid Power Plant. Kincaid, Illinois.

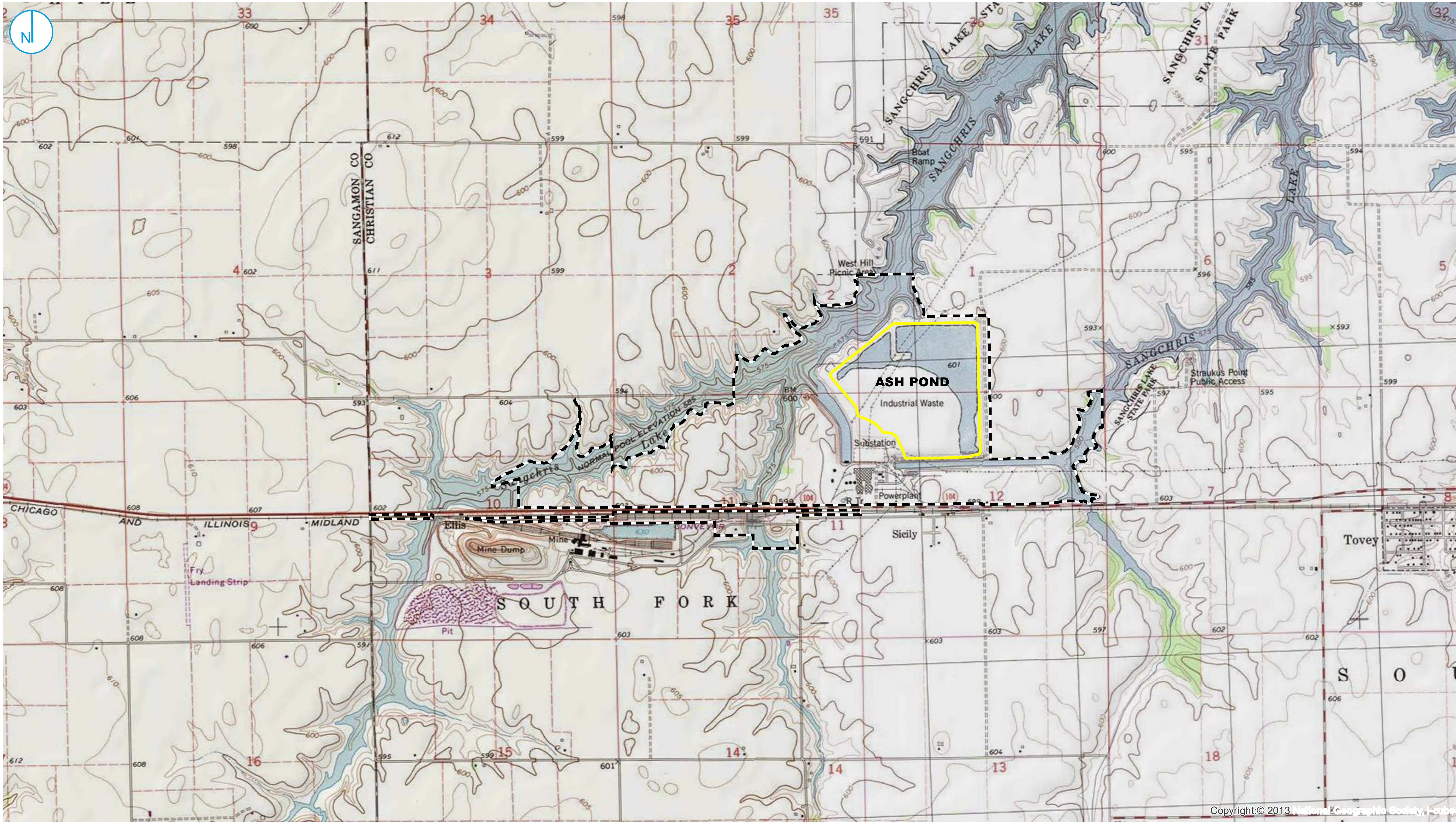
TABLE 6-2. PREDICTION MODEL INPUT VALUES
GROUNDWATER MODELING REPORT
KINCAID POWER PLANT
ASH POND
KINCAID, ILLINOIS

Hydrostratigraphic Unit/Recharge Area	Notes	Recharge Zone	Recharge (ft/day)	Recharge (inches/yr)	Stormwater Drain Stage	Constant Concentration Layer	Constant Concentration (mg/L)
Scenario 1: CIP							
Removal Area North	CCR	2, 4, 5, 7	1.3E-03	5.82	585	--	--
Removal Area South	CCR	3, 8	6.26E-08	4.10E-03	585	1	3.1, 3.5[1]
Scenario 2: CBR							
Removal Area North	CCR	2, 4, 5, 7	1.3E-03	5.82	585	--	--
Removal Area South	CCR	3, 8	1.3E-03	5.82	585	--	--

[O: PR 05/09/22; C: EGP 5/10/22]

Notes:
[1] See **Figure 5-2**
- - = not included
CCR = coal combustion residuals
ft/day = feet per day
inches/yr = inches per year
mg/L = milligrams per liter

FIGURES



PART 845 REGULATED UNIT FACILITY BOUNDARY

PROPERTY BOUNDARY

0 1,000 2,000 Feet

DRAFT

SITE LOCATION MAP

GROUNDWATER MODELING REPORT
ASH POND
KINCAID POWER PLANT
KINCAID, ILLINOIS

FIGURE 1-1

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL

PART 845 REGULATED UNIT (SUBJECT UNIT)
CLOSURE IN PLACE BOUNDARY
PROPERTY BOUNDARY

0 250 500 Feet

DRAFT

SITE MAP

GROUNDWATER MODELING REPORT
ASH POND
KINCAID POWER PLANT
KINCAID, ILLINOIS

FIGURE 1-2

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL

Y:\Mapping\Projects\22\2285\MXD\Model_Figures\Kincaid\Figure 1-2_Site_Map.mxd

PROJECT: 169000XXXX | DATED: 5/10/2022 | DESIGNER: galarnmc

BACKGROUND WELL
COMPLIANCE WELL
MONITORING WELL
PORE WATER WELL
STAFF GAGE, CCR UNIT
STAFF GAGE, LAKE
PART 845 REGULATED UNIT (SUBJECT UNIT)
PROPERTY BOUNDARY

0 250 500 Feet

MONITORING WELL LOCATION MAP

GROUNDWATER MODELING REPORT
ASH POND
KINCAID POWER PLANT
KINCAID, ILLINOIS

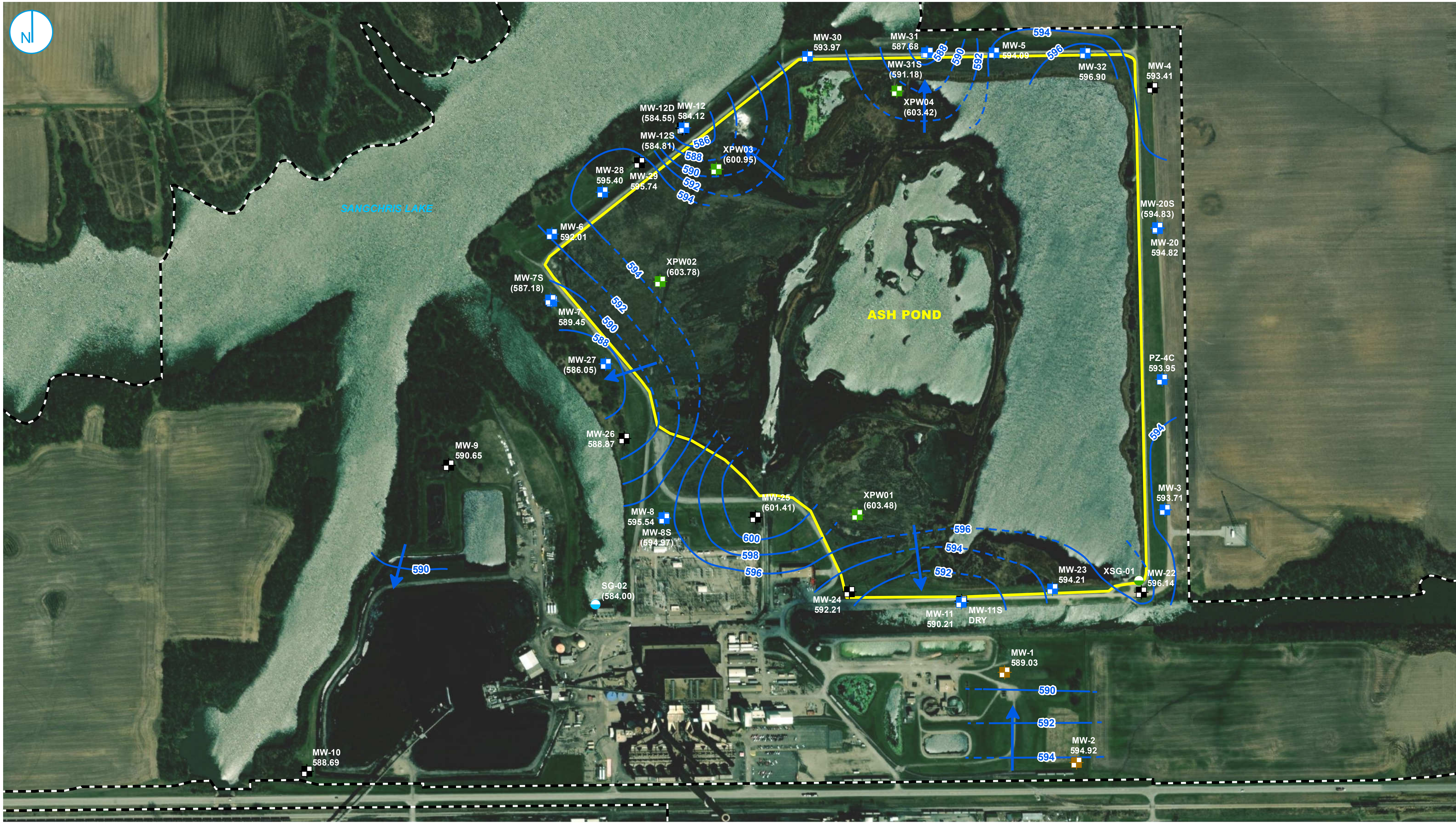
FIGURE 2-1

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL

PROJECT: 169000XXXX | DATED: 5/10/2022 | DESIGNER: galarnmc

Y:\Mapping\Projects\22\2285\MXD\Model_Figures\Kincaid\Figure 2-1_Monitoring Well Location Map.mxd



BACKGROUND WELL
COMPLIANCE WELL
PORE WATER WELL
MONITORING WELL
STAFF GAGE, CCR UNIT
STAFF GAGE, RIVER
PART 845 REGULATED UNIT (SUBJECT UNIT)
PROPERTY BOUNDARY
GROUNDWATER ELEVATION CONTOUR (2-FT CONTOUR INTERVAL, NAVD88)
INFERRED GROUNDWATER ELEVATION CONTOUR
GROUNDWATER FLOW DIRECTION

0 250 500 Feet

NOTES
1. PARENTHESES INDICATES WELL NOT USED FOR CONTOURING

DRAFT

POTENTIOMETRIC SURFACE MAP
FEBRUARY 23, 2021

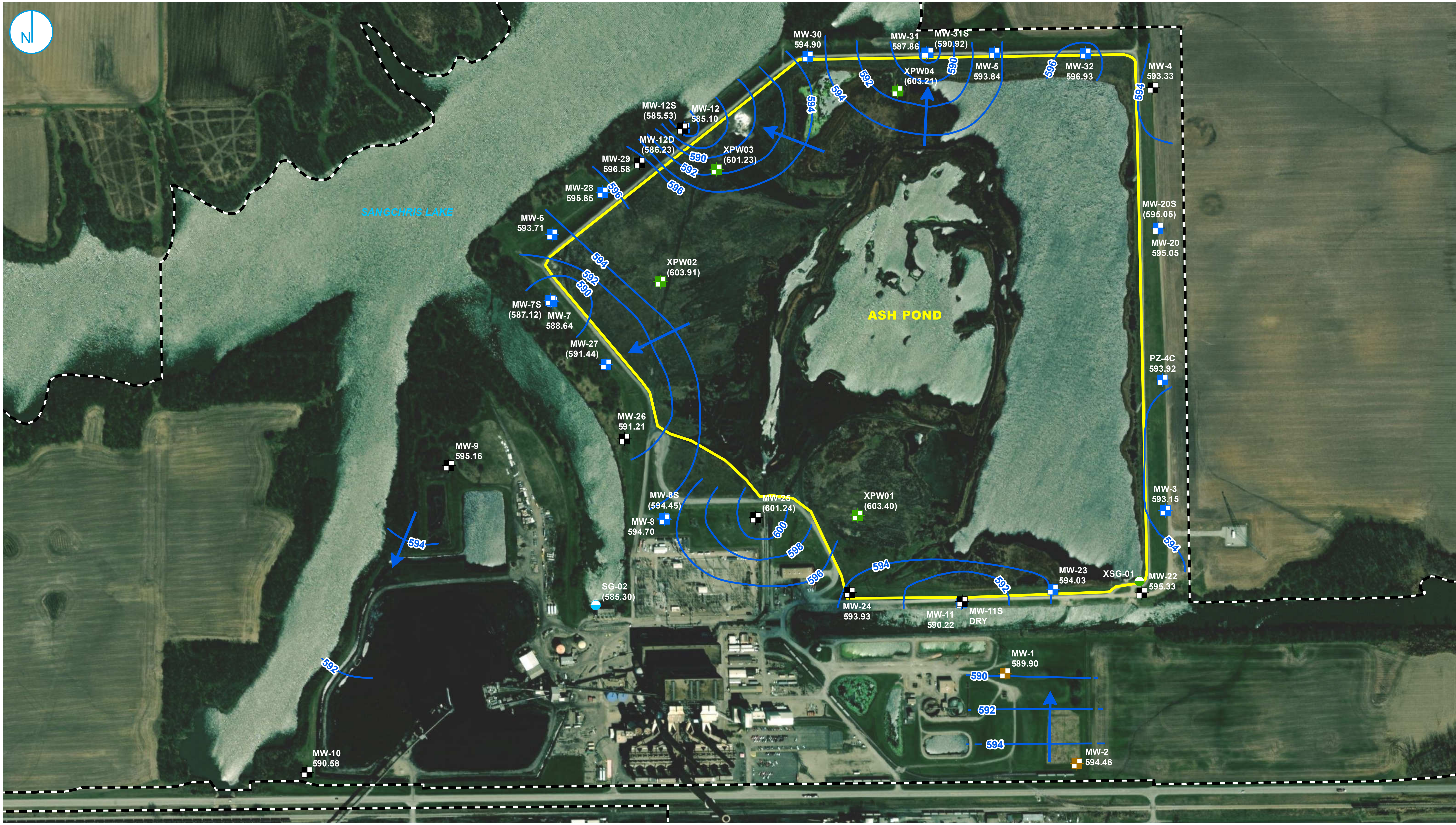
GROUNDWATER MODELING REPORT
ASH POND
KINCAID POWER PLANT
KINCAID, ILLINOIS

FIGURE 2-2

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL

PROJECT: 169000XXXX | DATED: 5/10/2022 | DESIGNER: galarmmc
Y:\Mapping\Projects\22\2285\MXD\Model_Figures\Kincaid\Figure 2-2_Pot Surface 20210223.mxd



BACKGROUND WELL	STAFF GAGE, CCR UNIT
COMPLIANCE WELL	STAFF GAGE, RIVER
PORE WATER WELL	PART 845 REGULATED UNIT (SUBJECT UNIT)
MONITORING WELL	PROPERTY BOUNDARY

GROUNDWATER ELEVATION CONTOUR (2-FT CONTOUR INTERVAL, NAVD88)
INFERRED GROUNDWATER ELEVATION CONTOUR
GROUNDWATER FLOW DIRECTION

0 250 500 Feet

DRAFT

NOTES
1. PARENTHESES INDICATES WELL NOT USED FOR CONTOURING

POTENTIOMETRIC SURFACE MAP
APRIL 5, 2021

GROUNDWATER MODELING REPORT
ASH POND
KINCAID POWER PLANT
KINCAID, ILLINOIS

FIGURE 2-3

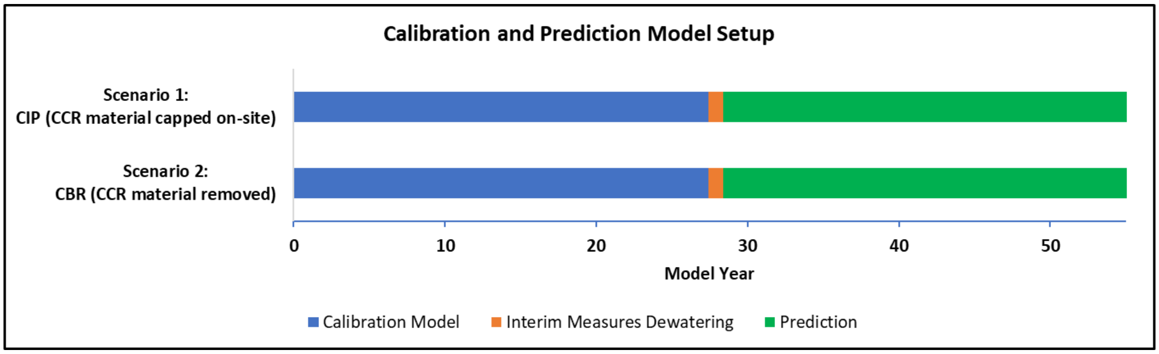
RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL

PROJECT: 169000XXXX | DATED: 5/10/2022 | DESIGNER: galarnmc

Y:\Mapping\Projects\22\2285\MXD\Model_Figures\Kincaid\Figure 2-3_Pot Surface 20210405.mxd

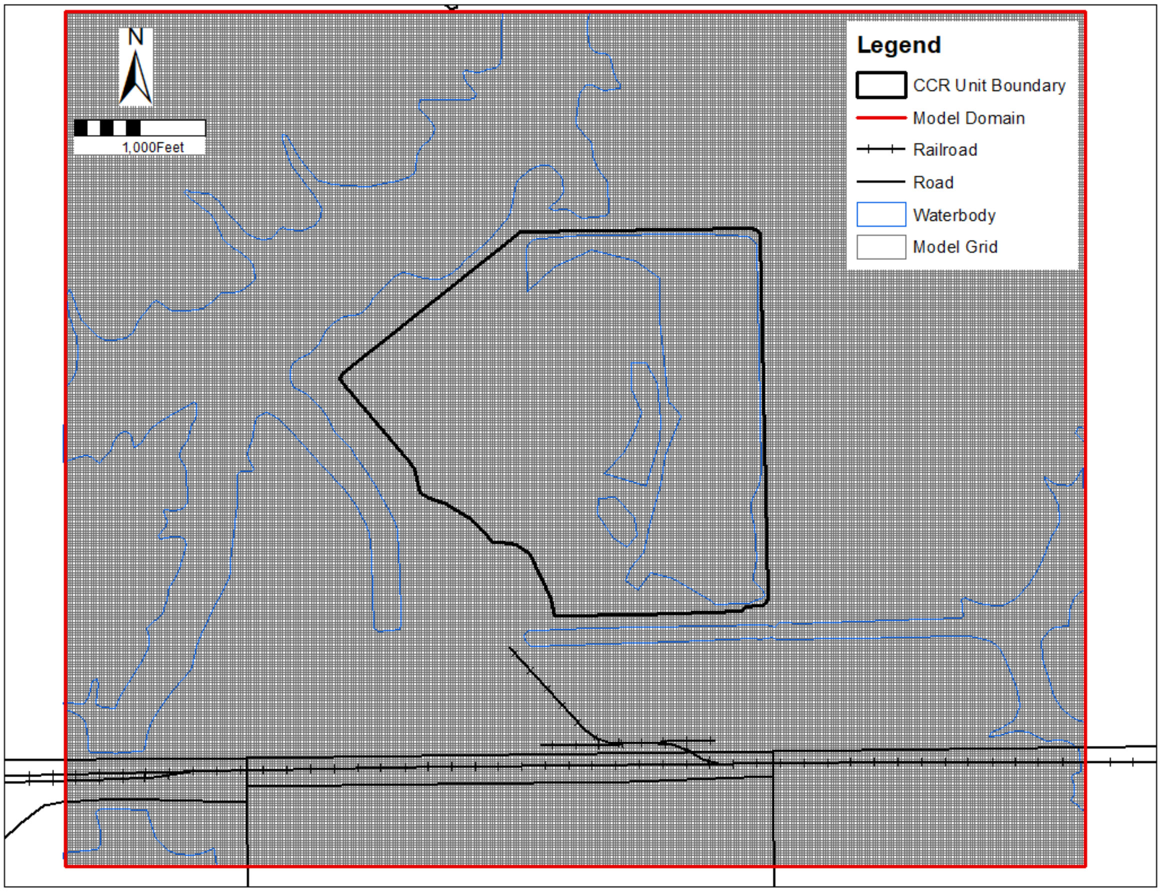
FIGURE 4-1



CALIBRATION AND PREDICTIVE TIMELINE

GROUNDWATER MODELING REPORT
KINCAID CCR ASH POND
KINCAID POWER PLANT
KINCAID, ILLINOIS

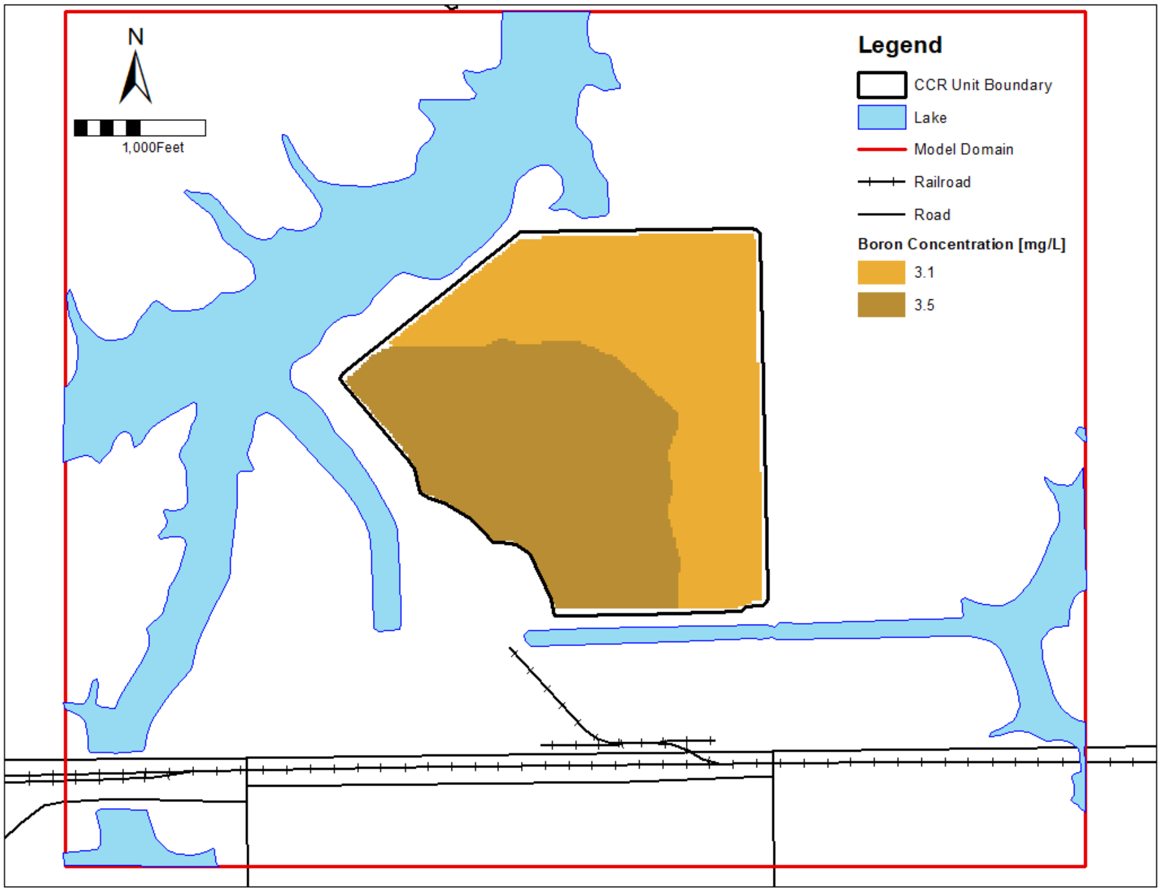
RAMBOLL



MODEL GRID FOR LAYERS 1 THROUGH 5

GROUNDWATER MODELING REPORT
KINCAID CCR ASH POND
KINCAID POWER PLANT
KINCAID, ILLINOIS

RAMBOLL

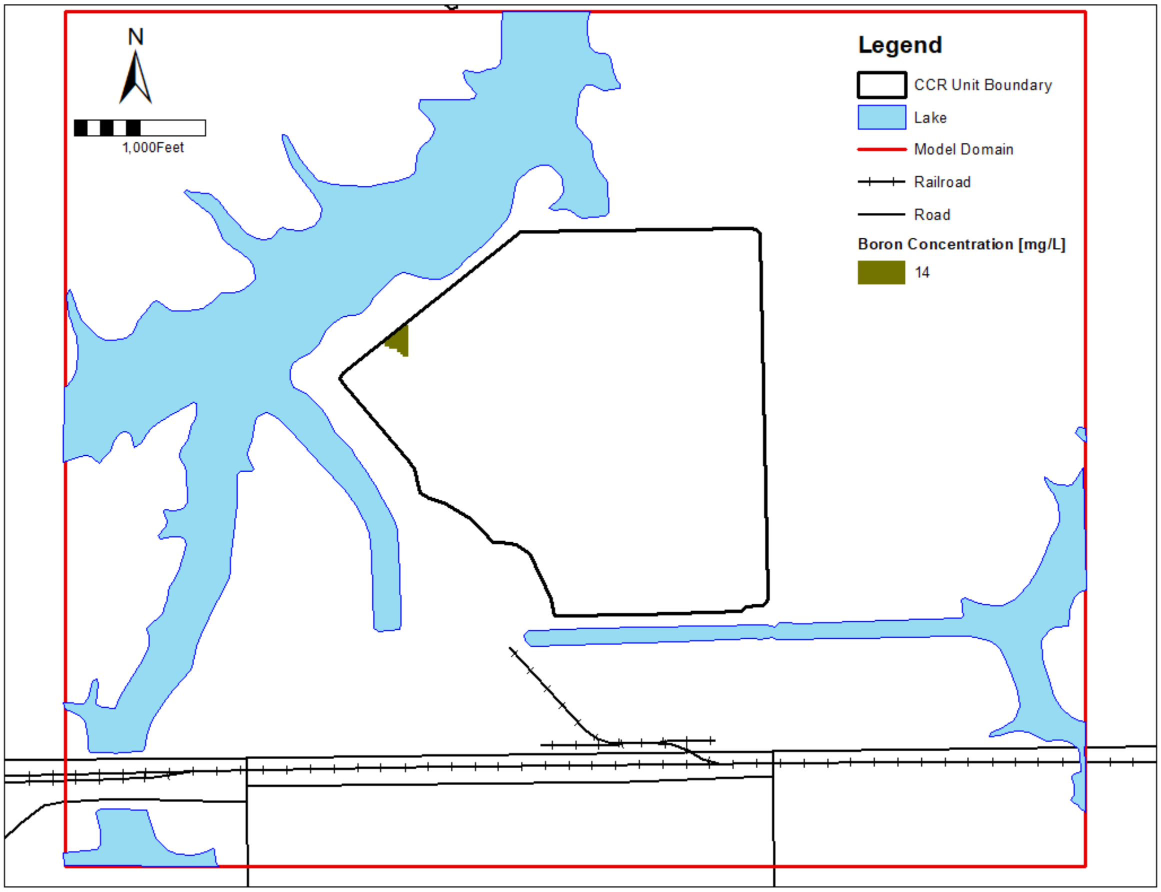


BOUNDARY CONDITIONS FOR LAYER 1

GROUNDWATER MODELING REPORT
KINCAID CCR ASH POND
KINCAID POWER PLANT
KINCAID, ILLINOIS

RAMBOLL

FIGURE 5-3

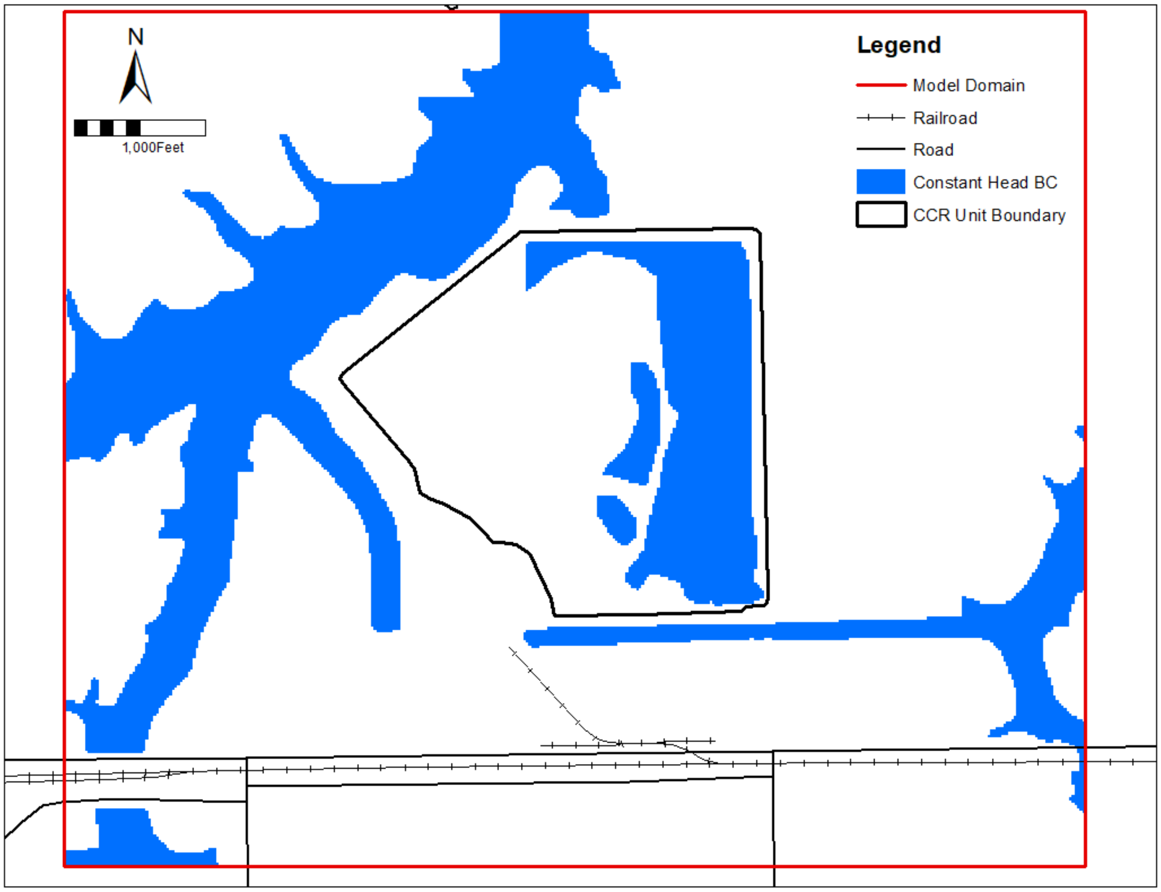


BOUNDARY CONDITIONS FOR LAYER 2

GROUNDWATER MODELING REPORT
KINCAID CCR ASH POND
KINCAID POWER PLANT
KINCAID, ILLINOIS

RAMBOLL

FIGURE 5-4

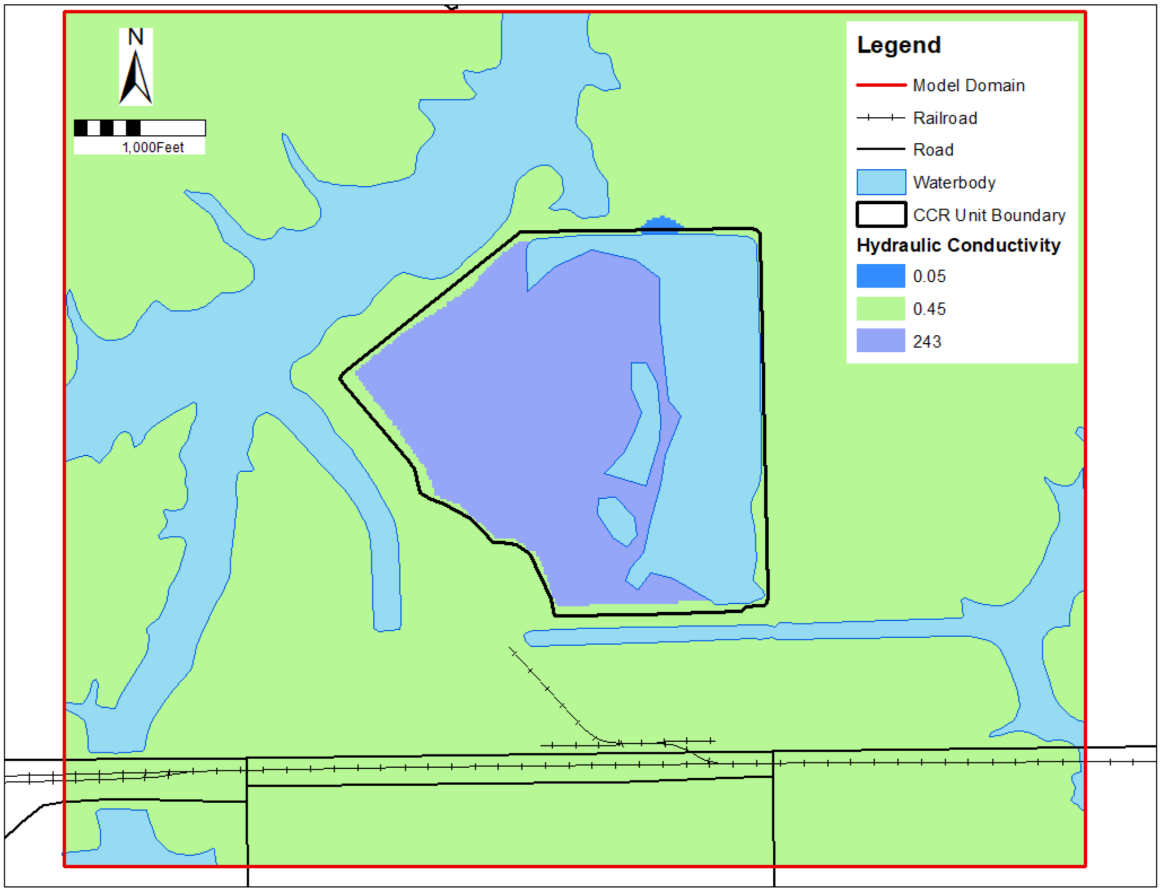


BOUNDARY CONDITIONS FOR LAYER 3

GROUNDWATER MODELING REPORT
KINCAID CCR ASH POND
KINCAID POWER PLANT
KINCAID, ILLINOIS

RAMBOLL

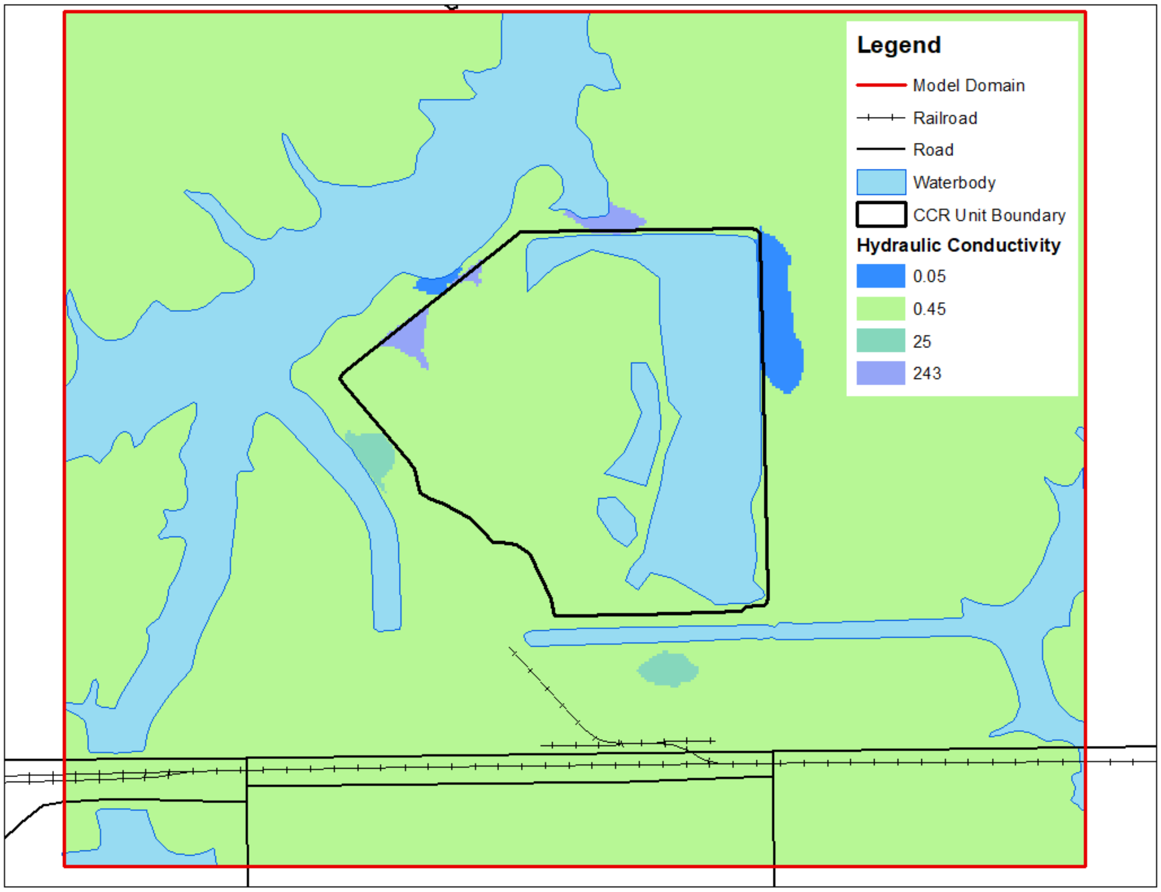
FIGURE 5-5



DISTRIBUTION OF HYDRAULIC CONDUCTIVITY ZONES (ft/d) FOR LAYER 1

GROUNDWATER MODELING REPORT
KINCAID CCR ASH POND
KINCAID POWER PLANT
KINCAID, ILLINOIS

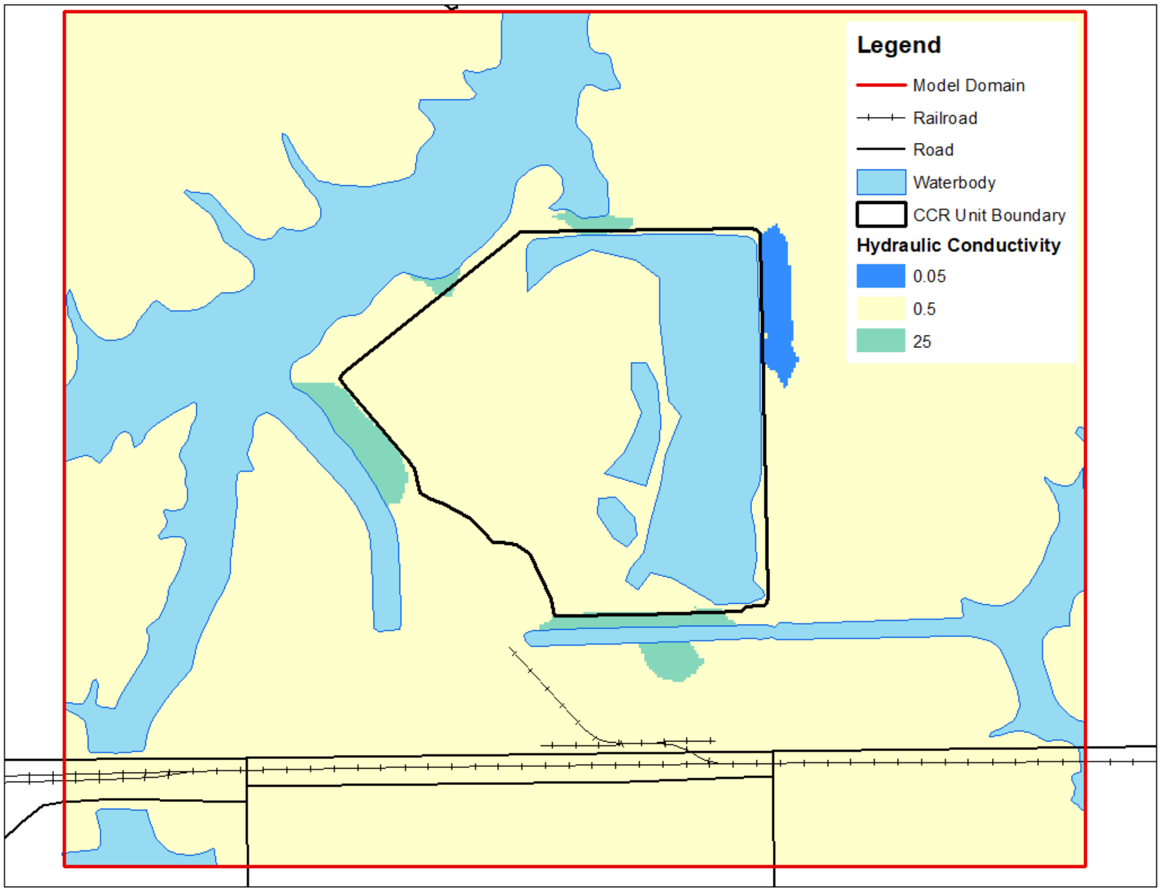
RAMBOLL



DISTRIBUTION OF HYDRAULIC CONDUCTIVITY ZONES (ft/d) FOR LAYER 2

GROUNDWATER MODELING REPORT
KINCAID CCR ASH POND
KINCAID POWER PLANT
KINCAID, ILLINOIS

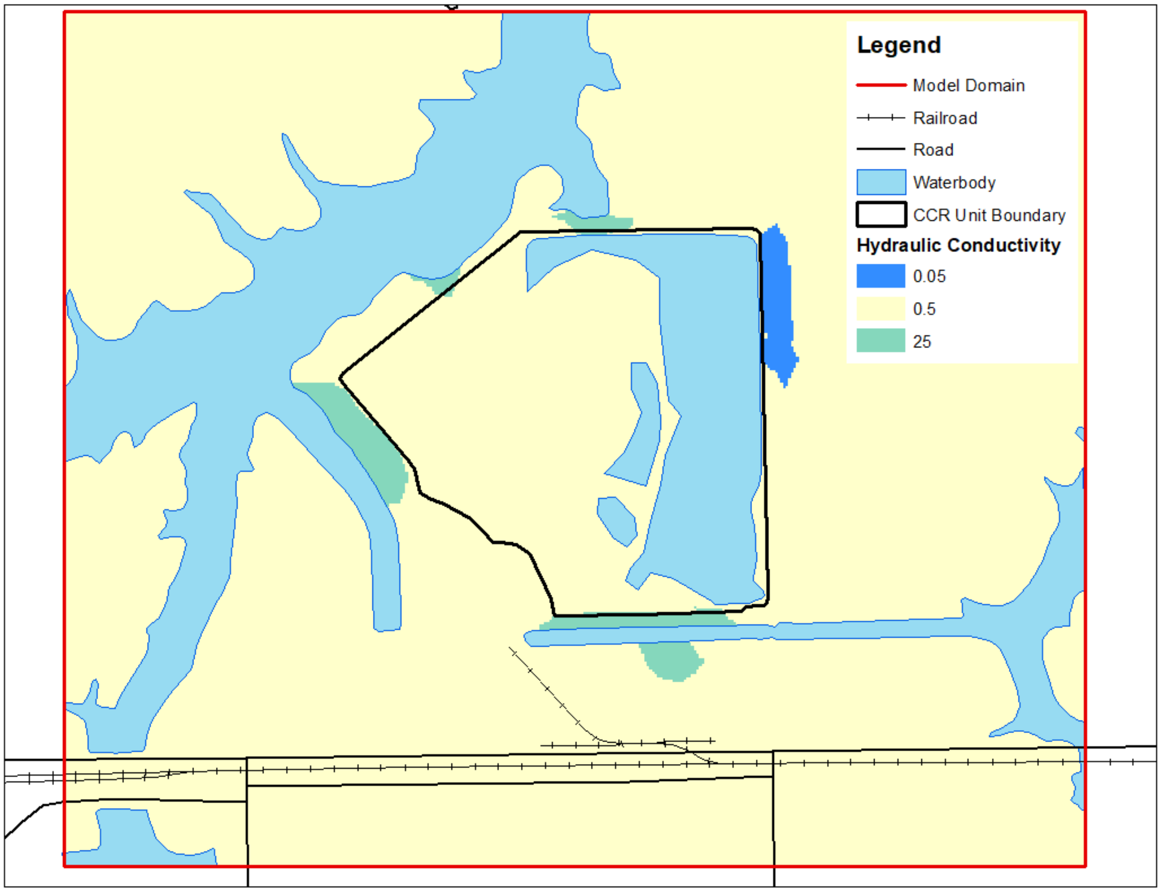
RAMBOLL



DISTRIBUTION OF HYDRAULIC CONDUCTIVITY ZONES (ft/d) FOR LAYER 3

GROUNDWATER MODELING REPORT
KINCAID CCR ASH POND
KINCAID POWER PLANT
KINCAID, ILLINOIS

RAMBOLL

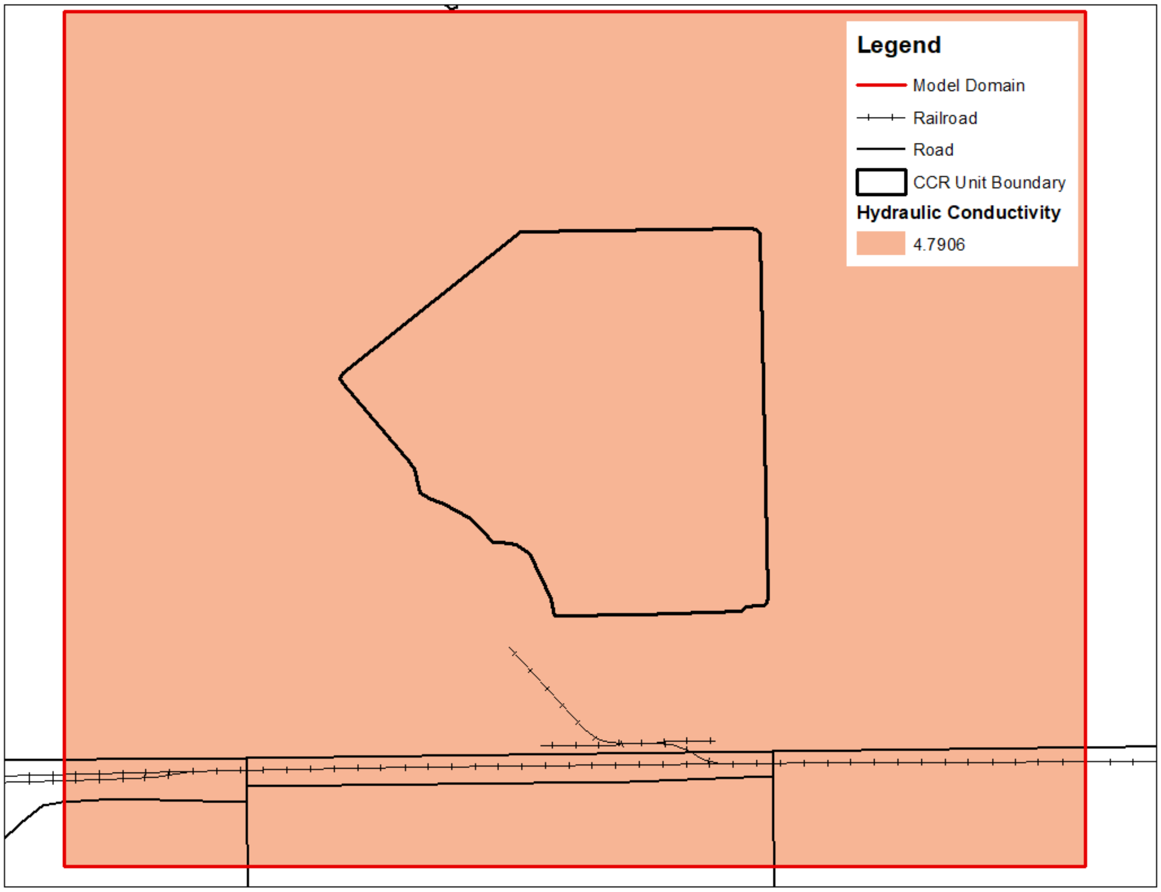


DISTRIBUTION OF HYDRAULIC CONDUCTIVITY ZONES (ft/d) FOR LAYER 4

GROUNDWATER MODELING REPORT
KINCAID CCR ASH POND
KINCAID POWER PLANT
KINCAID, ILLINOIS

RAMBOLL

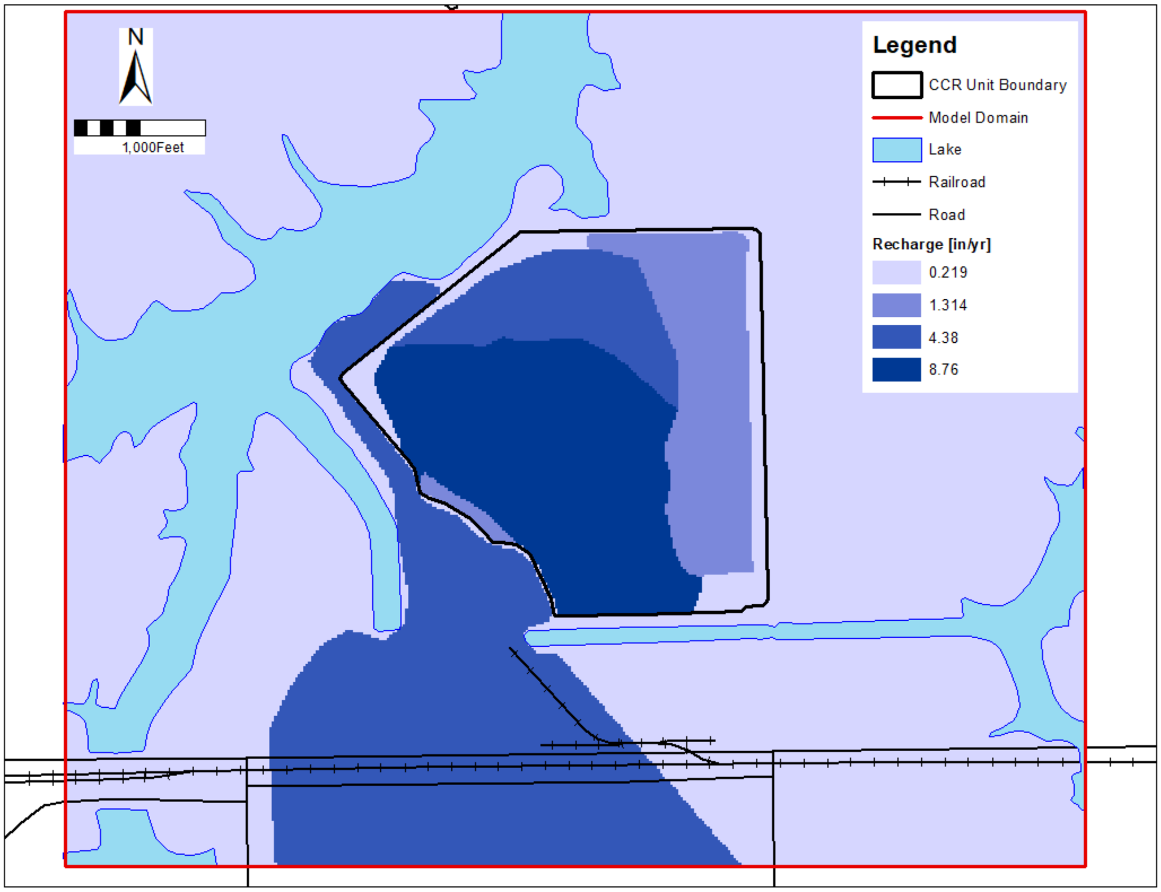
FIGURE 5-9



DISTRIBUTION OF HYDRAULIC CONDUCTIVITY ZONES (ft/d) FOR LAYER 5

GROUNDWATER MODELING REPORT
KINCAID CCR ASH POND
KINCAID POWER PLANT
KINCAID, ILLINOIS

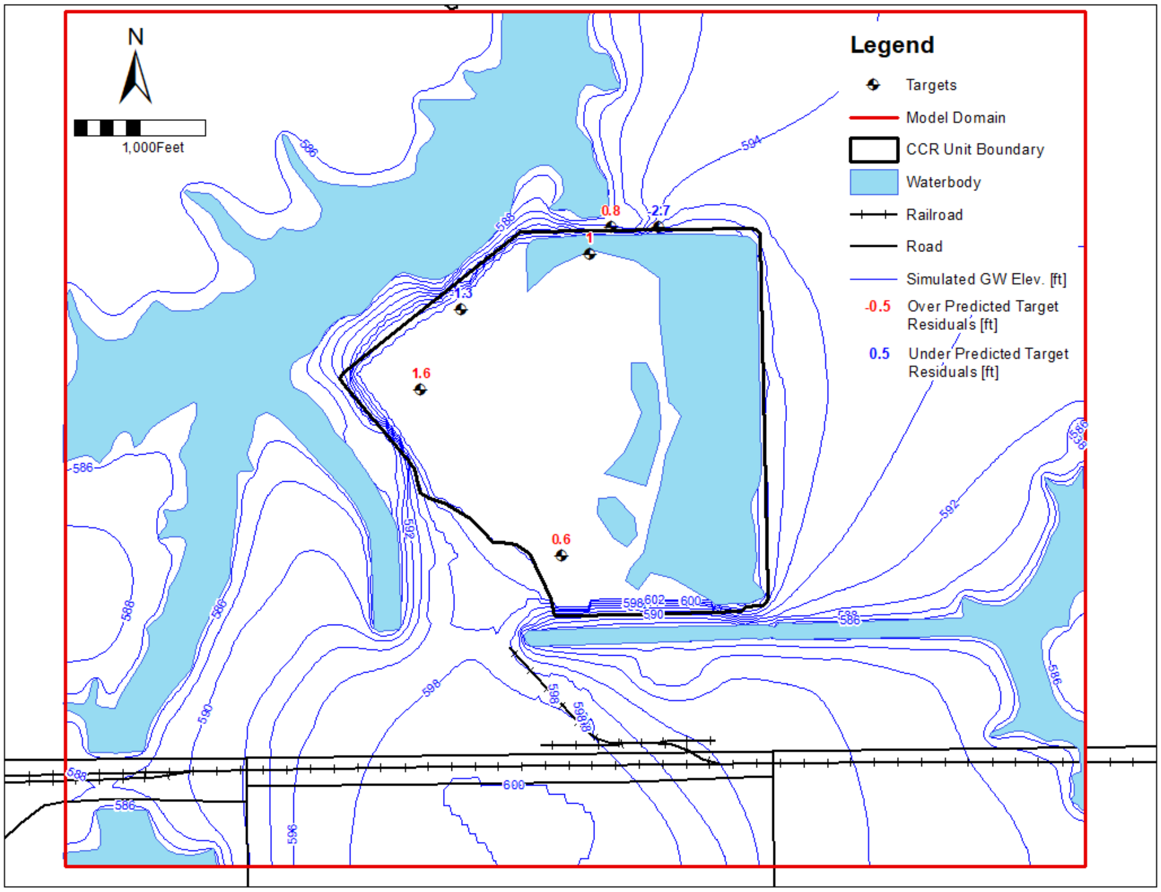
RAMBOLL



DISTRIBUTION OF RECHARGE ZONES (in/yr)

GROUNDWATER MODELING REPORT
KINCAID CCR ASH POND
KINCAID POWER PLANT
KINCAID, ILLINOIS

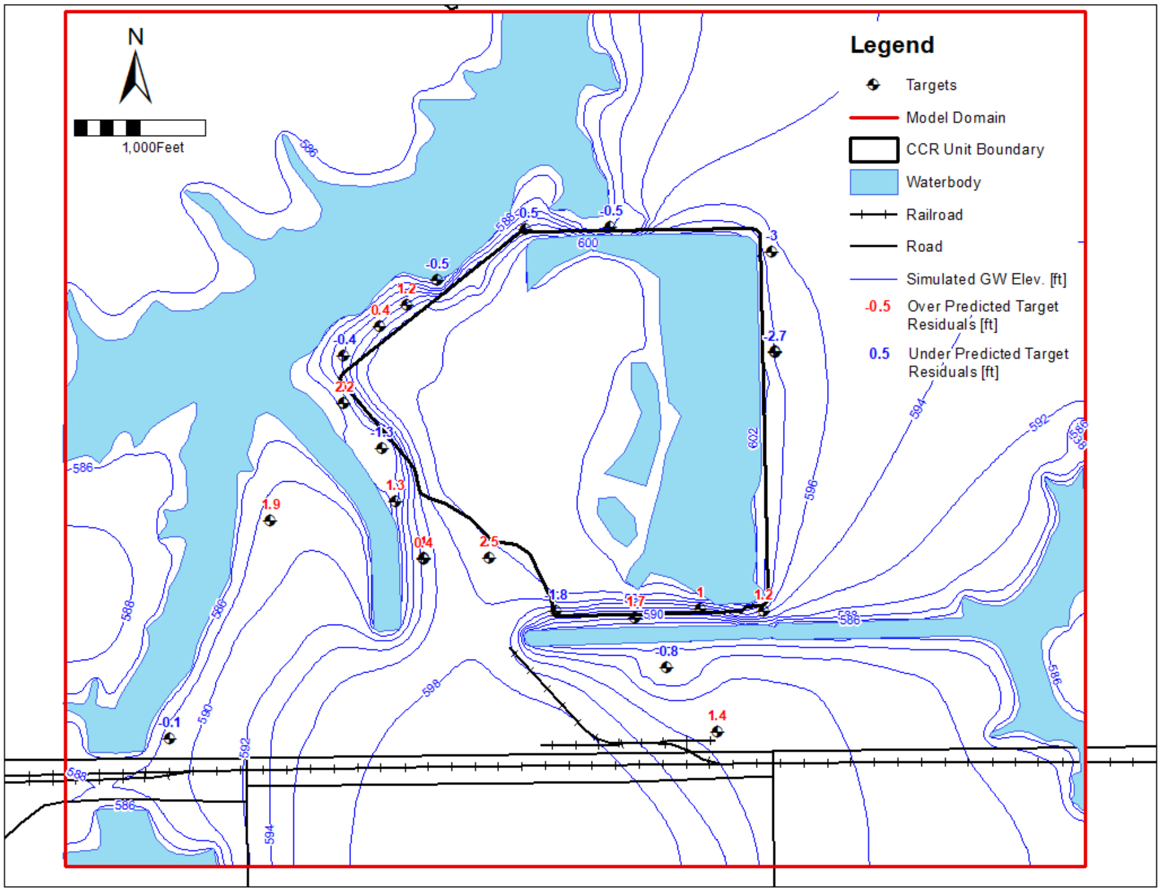
RAMBOLL



OBSERVED VERSUS SIMULATED GROUNDWATER ELEVATIONS LAYER 1

GROUNDWATER MODELING REPORT
KINCAID CCR ASH POND
KINCAID POWER PLANT
KINCAID, ILLINOIS

FIGURE 5-12

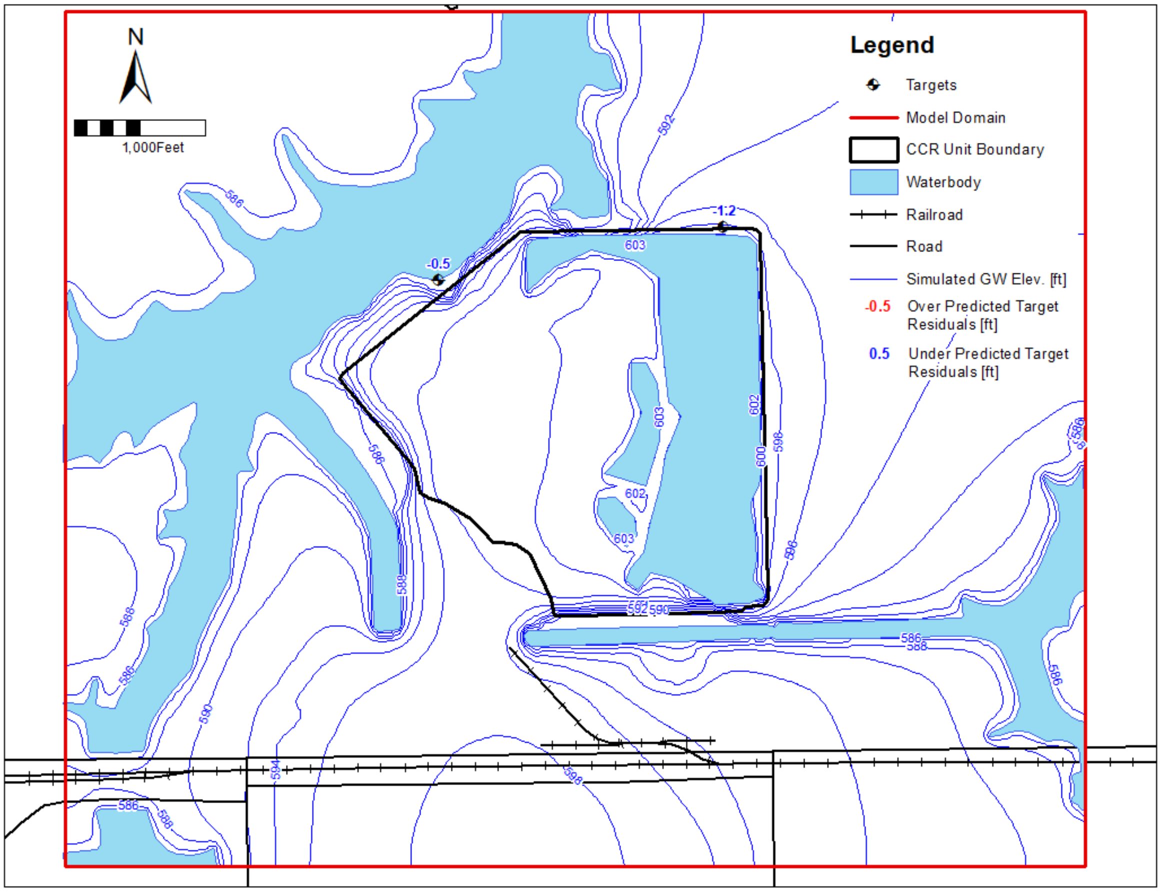


OBSERVED VERSUS SIMULATED GROUNDWATER ELEVATIONS LAYER 2

GROUNDWATER MODELING REPORT
KINCAID CCR ASH POND
KINCAID POWER PLANT
KINCAID, ILLINOIS

RAMBOLL

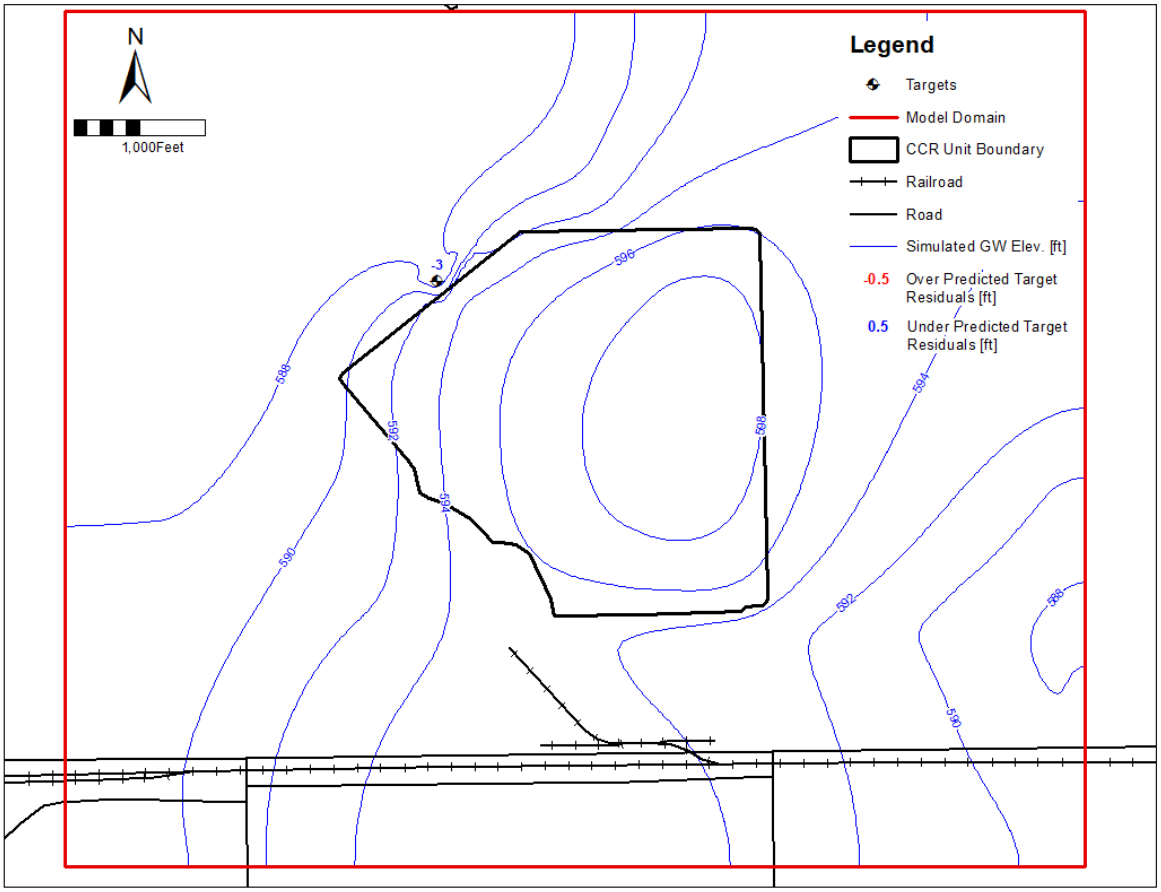
FIGURE 5-13



OBSERVED VERSUS SIMULATED GROUNDWATER ELEVATIONS LAYER 3

GROUNDWATER MODELING REPORT
KINCAID CCR ASH POND
KINCAID POWER PLANT
KINCAID, ILLINOIS

RAMBOLL

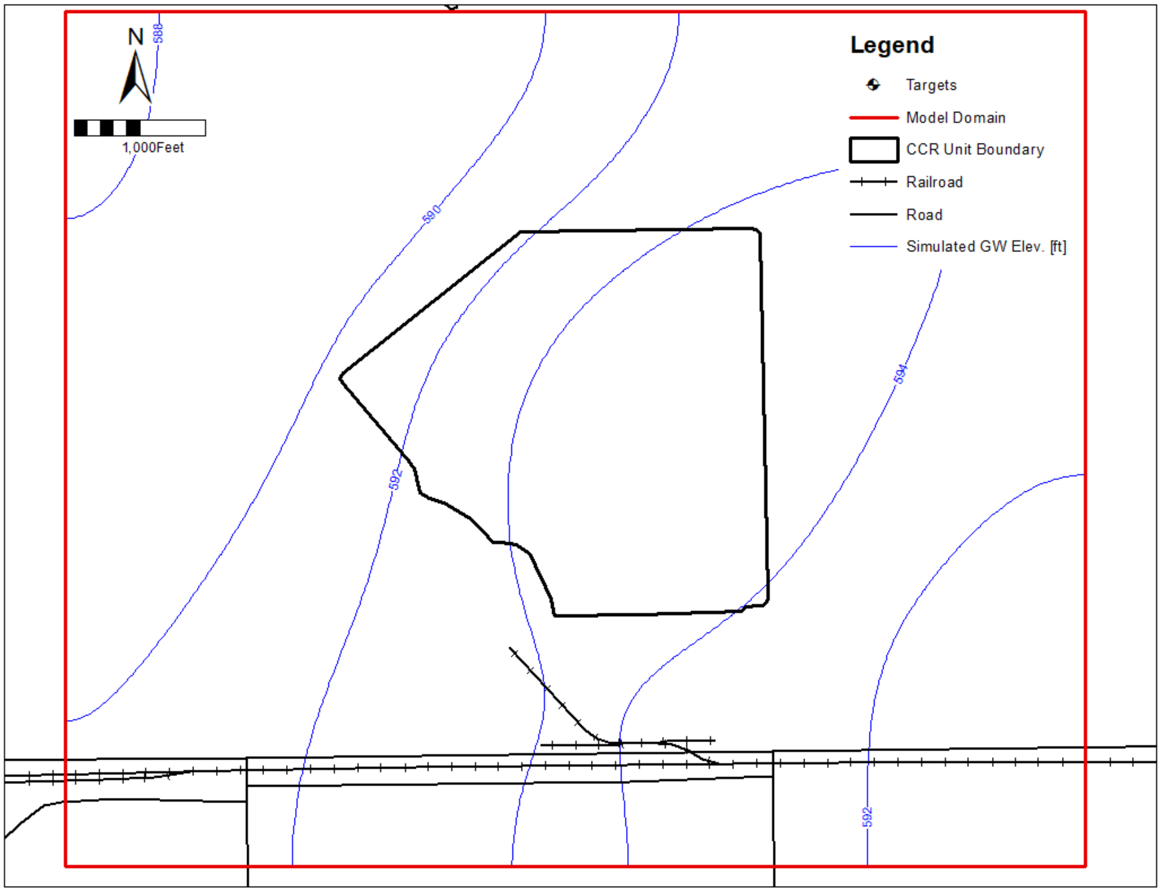


OBSERVED VERSUS SIMULATED GROUNDWATER ELEVATIONS LAYER 4

GROUNDWATER MODELING REPORT
KINCAID CCR ASH POND
KINCAID POWER PLANT
KINCAID, ILLINOIS

RAMBOLL

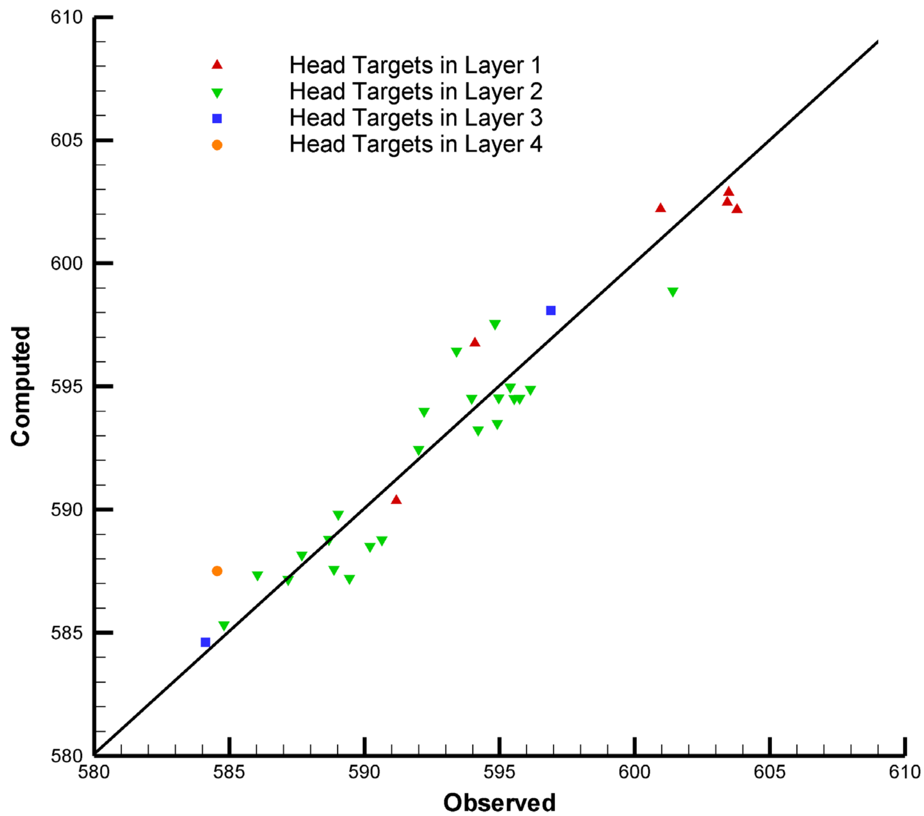
FIGURE 5-15



OBSERVED VERSUS SIMULATED GROUNDWATER ELEVATIONS LAYER 5

GROUNDWATER MODELING REPORT
KINCAID CCR ASH POND
KINCAID POWER PLANT
KINCAID, ILLINOIS

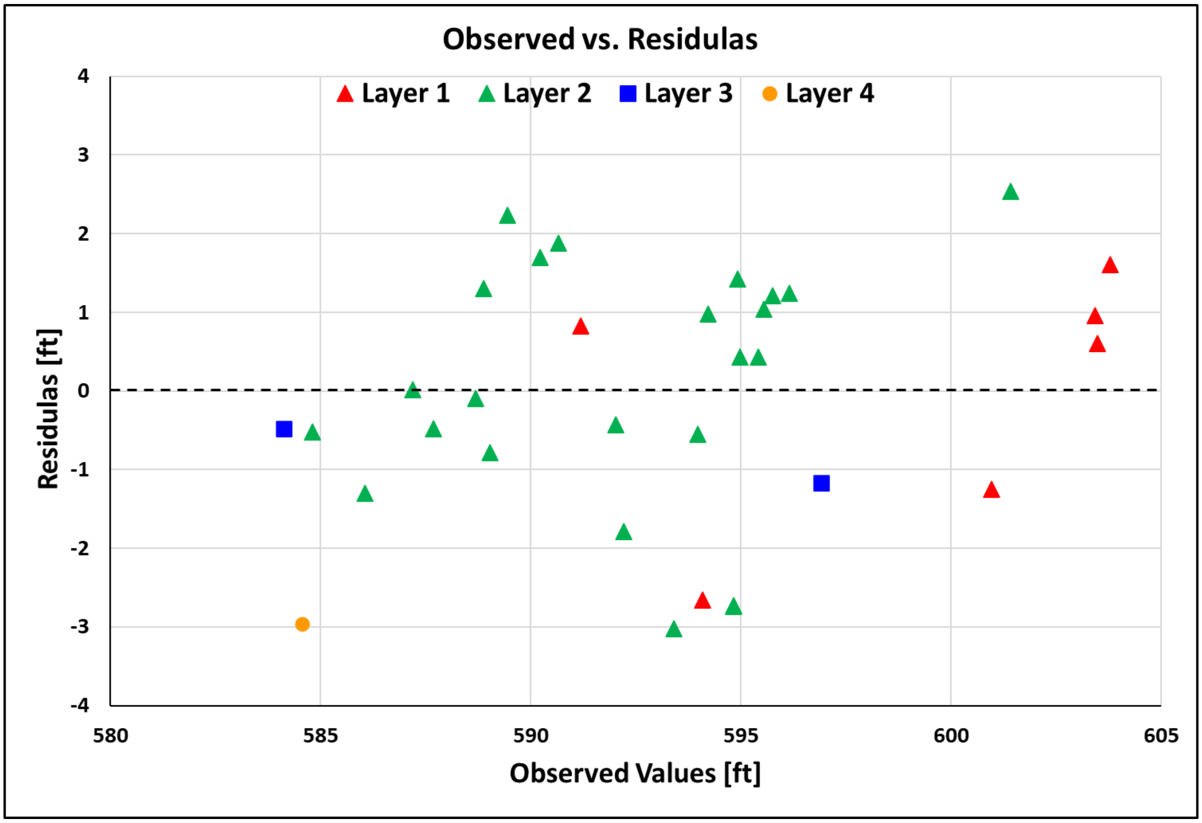
RAMBOLL



STEADY STATE MODFLOW CALIBRATION RESULTS – OBSERVED VERSUS SIMULATED (ft)

GROUNDWATER MODELING REPORT
KINCAID CCR ASH POND
KINCAID POWER PLANT
KINCAID, ILLINOIS

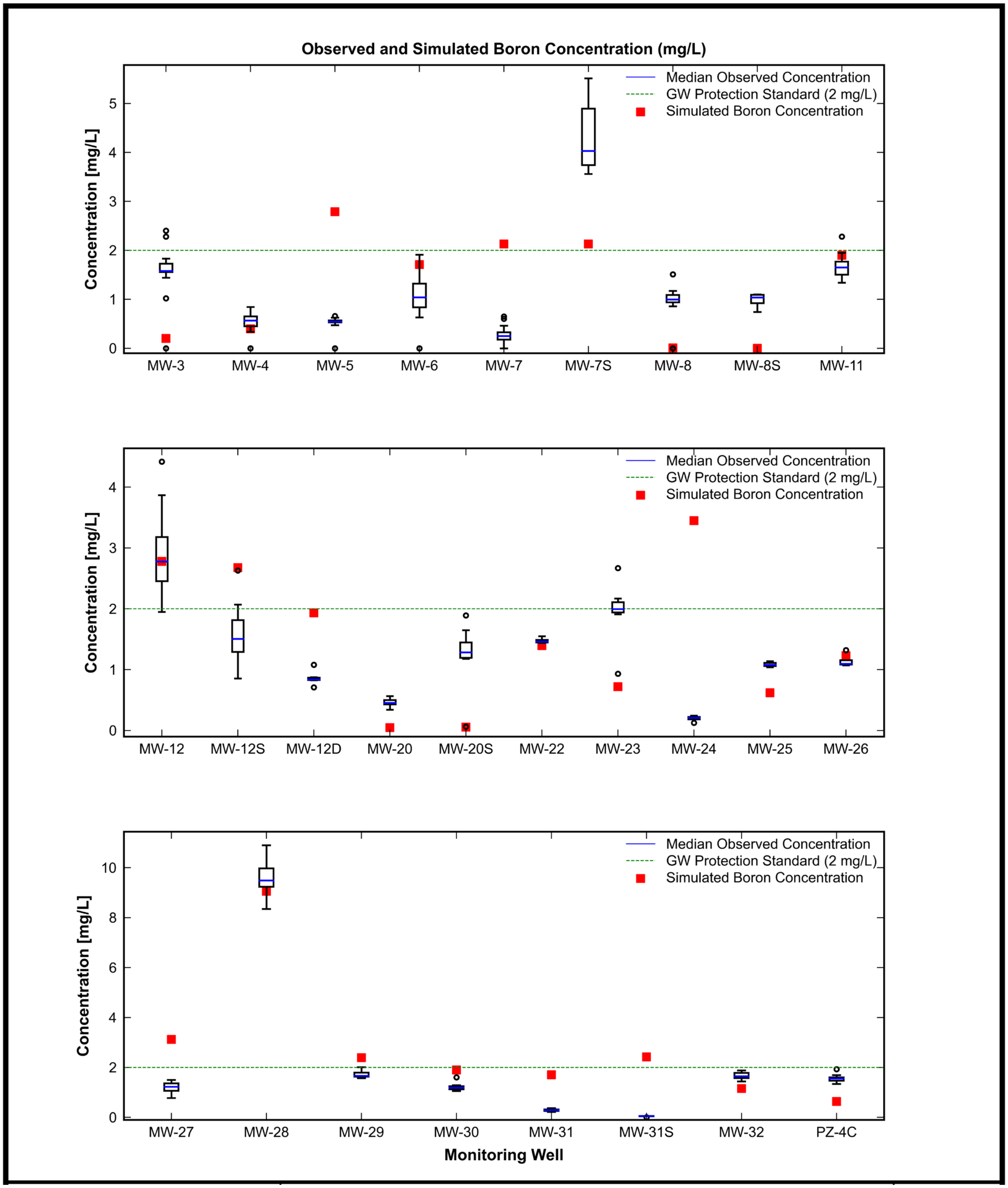
RAMBOLL



SIMULATED GROUNDWATER LEVEL RESIDUAL FROM THE CALIBRATED MODEL

GROUNDWATER MODELING REPORT
KINCAID CCR ASH POND
KINCAID POWER PLANT
KINCAID, ILLINOIS

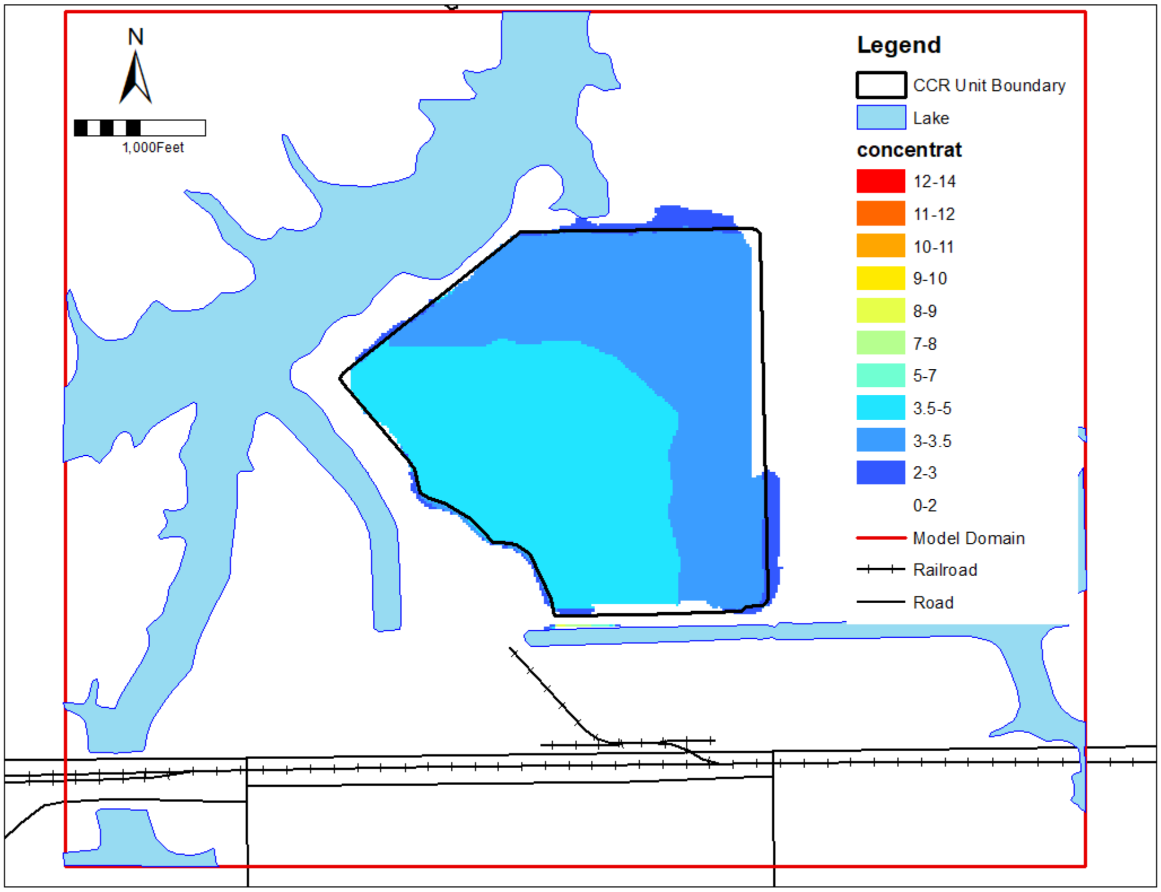
RAMBOLL



OBSERVED AND SIMULATED BORON CONCENTRATIONS (mg/L)

GROUNDWATER MODELING REPORT
KINCAID CCR ASH POND
KINCAID POWER PLANT
KINCAID, ILLINOIS

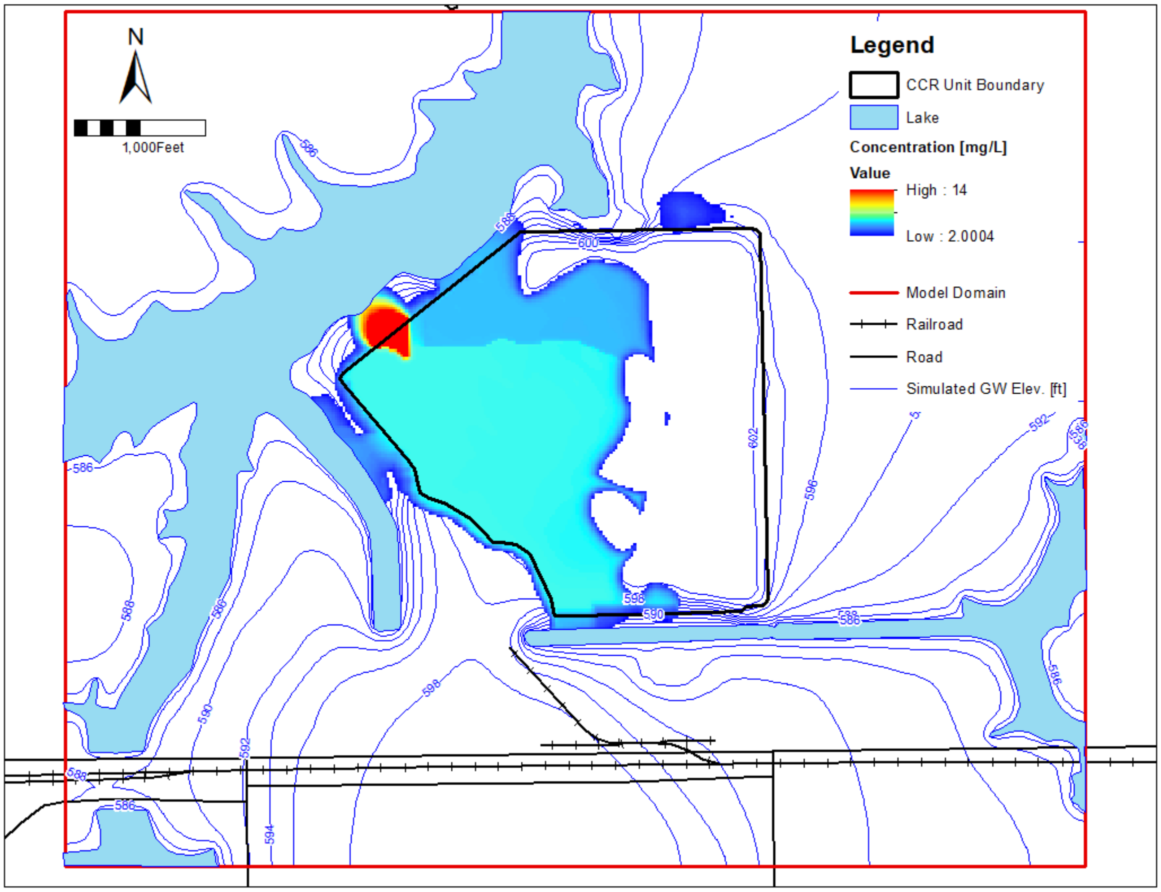
RAMBOLL



DISTRIBUTION OF BORON CONCENTRATION (mg/L) IN THE CALIBRATED MODEL LAYER 1

GROUNDWATER MODELING REPORT
KINCAID CCR ASH POND
KINCAID POWER PLANT
KINCAID, ILLINOIS

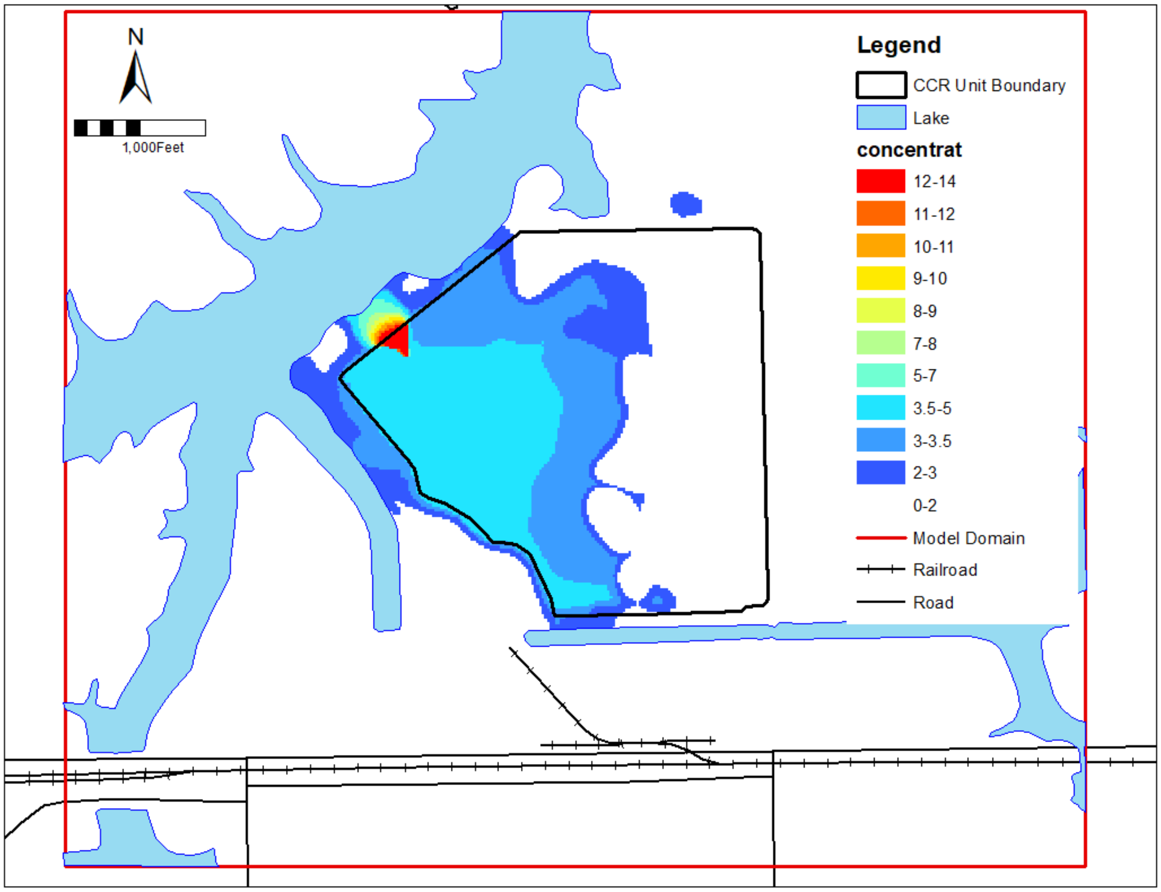
RAMBOLL



DISTRIBUTION OF BORON CONCENTRATION (mg/L) IN THE CALIBRATED MODEL LAYER 2

GROUNDWATER MODELING REPORT
KINCAID CCR ASH POND
KINCAID POWER PLANT
KINCAID, ILLINOIS

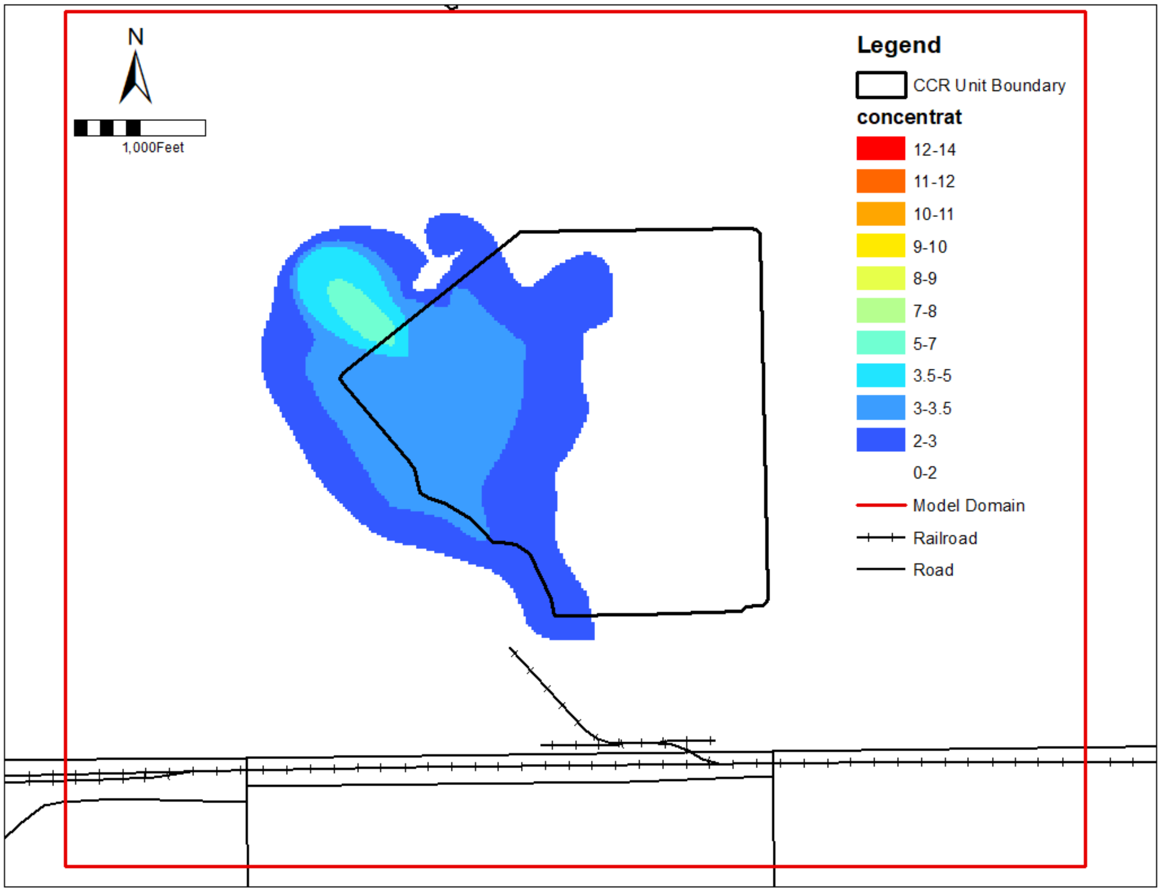
RAMBOLL



DISTRIBUTION OF BORON CONCENTRATION (mg/L) IN THE CALIBRATED MODEL LAYER 3

GROUNDWATER MODELING REPORT
KINCAID CCR ASH POND
KINCAID POWER PLANT
KINCAID, ILLINOIS

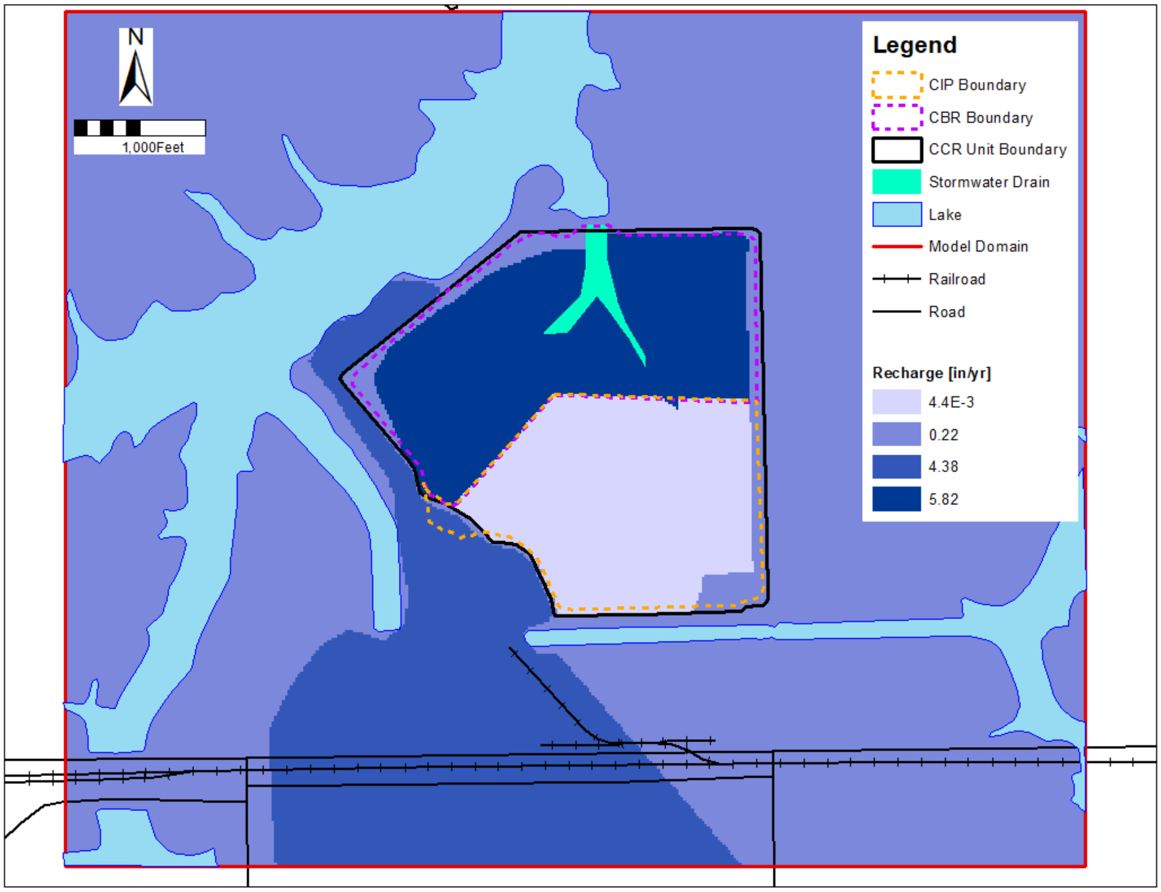
RAMBOLL



DISTRIBUTION OF BORON CONCENTRATION (mg/L) IN THE CALIBRATED MODEL LAYER 4

GROUNDWATER MODELING REPORT
KINCAID CCR ASH POND
KINCAID POWER PLANT
KINCAID, ILLINOIS

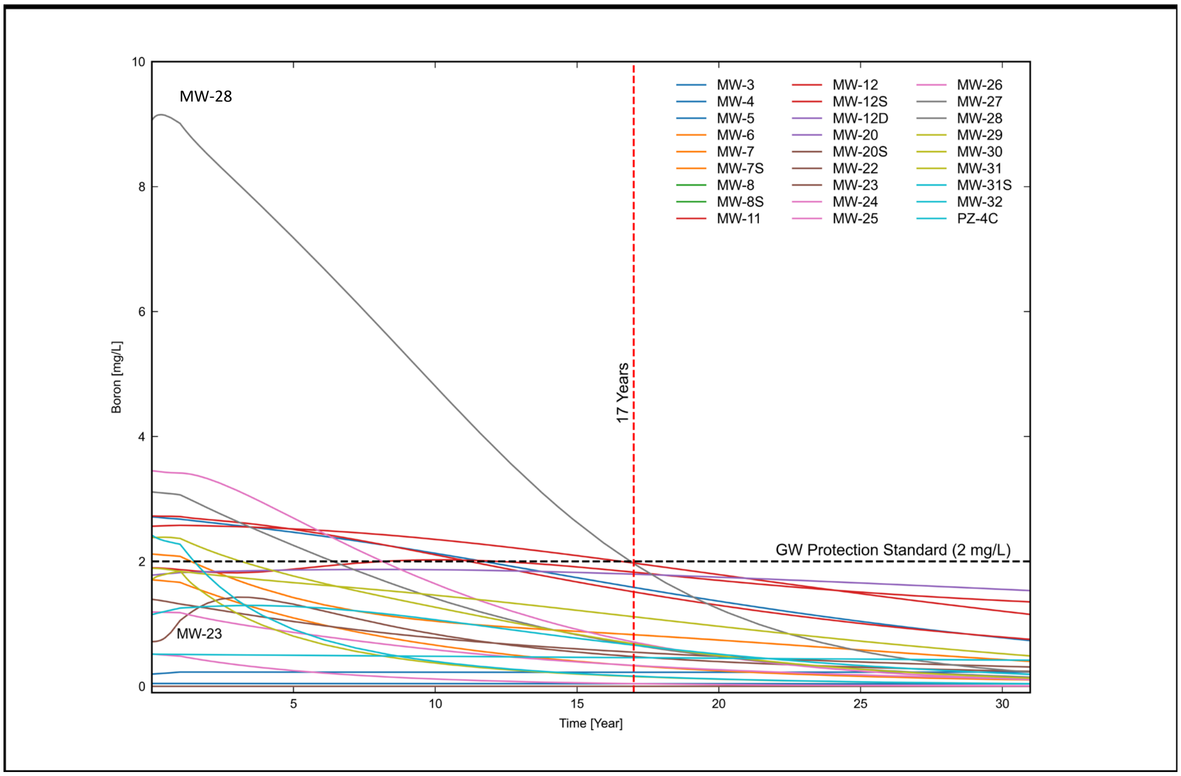
RAMBOLL



CIP RECHARGE DISTRIBUTION AND STORMWATER DRAIN

GROUNDWATER MODELING REPORT
KINCAID CCR ASH POND
KINCAID POWER PLANT
KINCAID, ILLINOIS

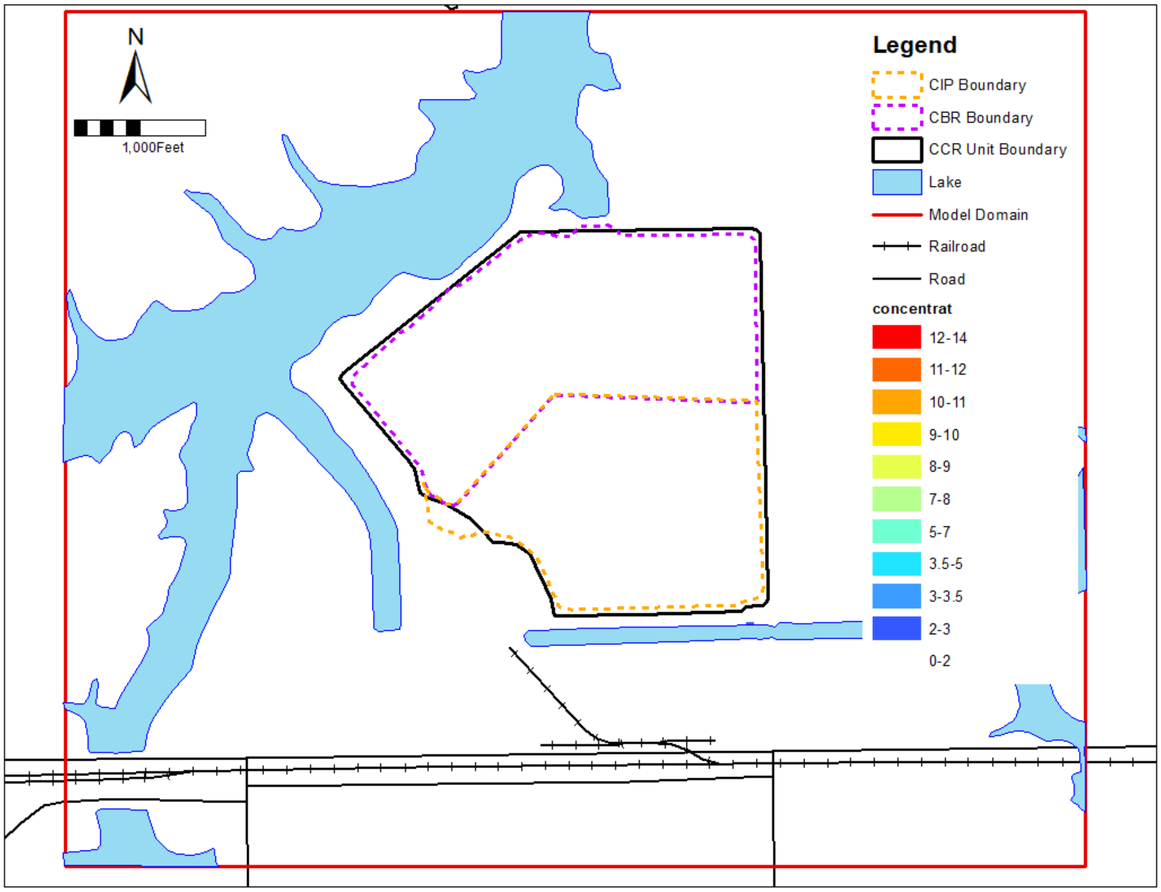
RAMBOLL



CIP (SCENARIO 1) - MODEL PREDICTED BORON CONCENTRATION

GROUNDWATER MODELING REPORT
KINCAID CCR ASH POND
KINCAID POWER PLANT
KINCAID, ILLINOIS

RAMBOLL

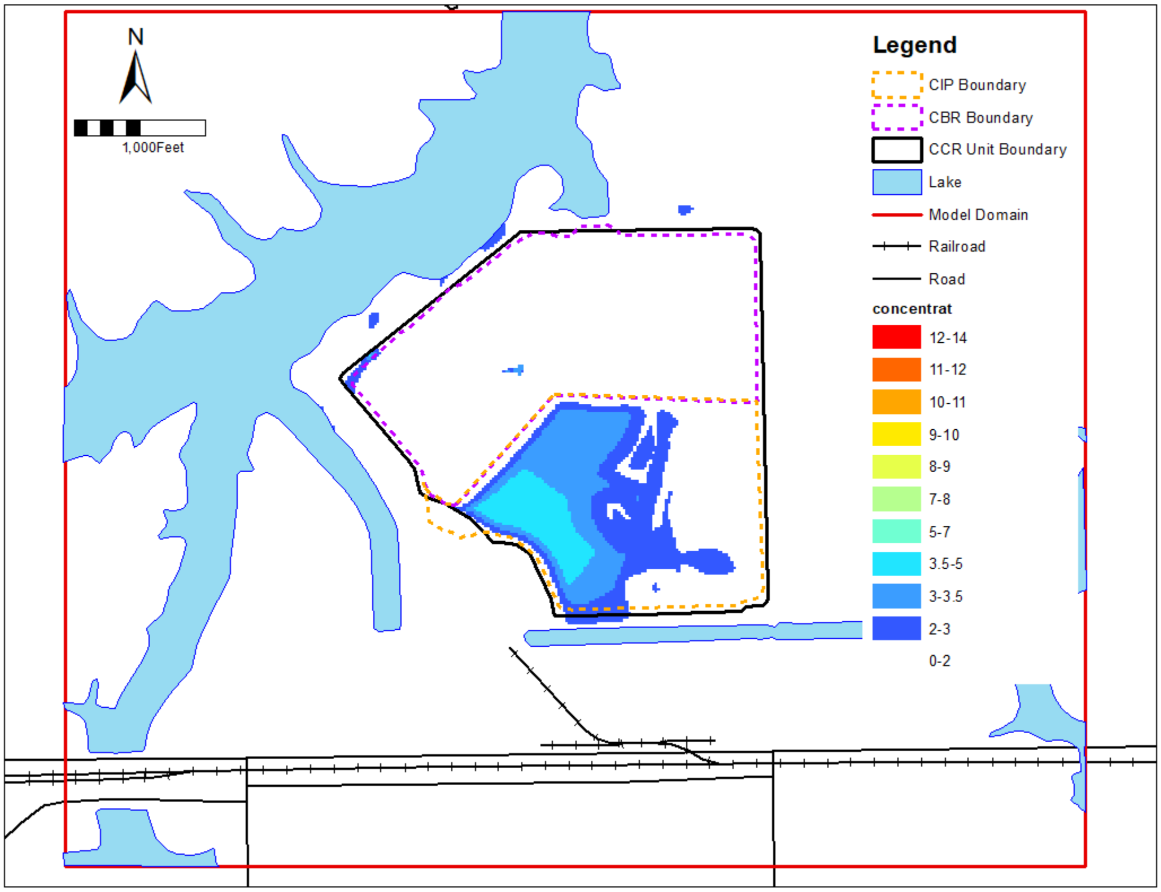


DISTRIBUTION OF BORON CONCENTRATION (mg/L) IN CIP SCENARIO LAYER 1 (17 YEARS)

GROUNDWATER MODELING REPORT
KINCAID CCR ASH POND
KINCAID POWER PLANT
KINCAID, ILLINOIS

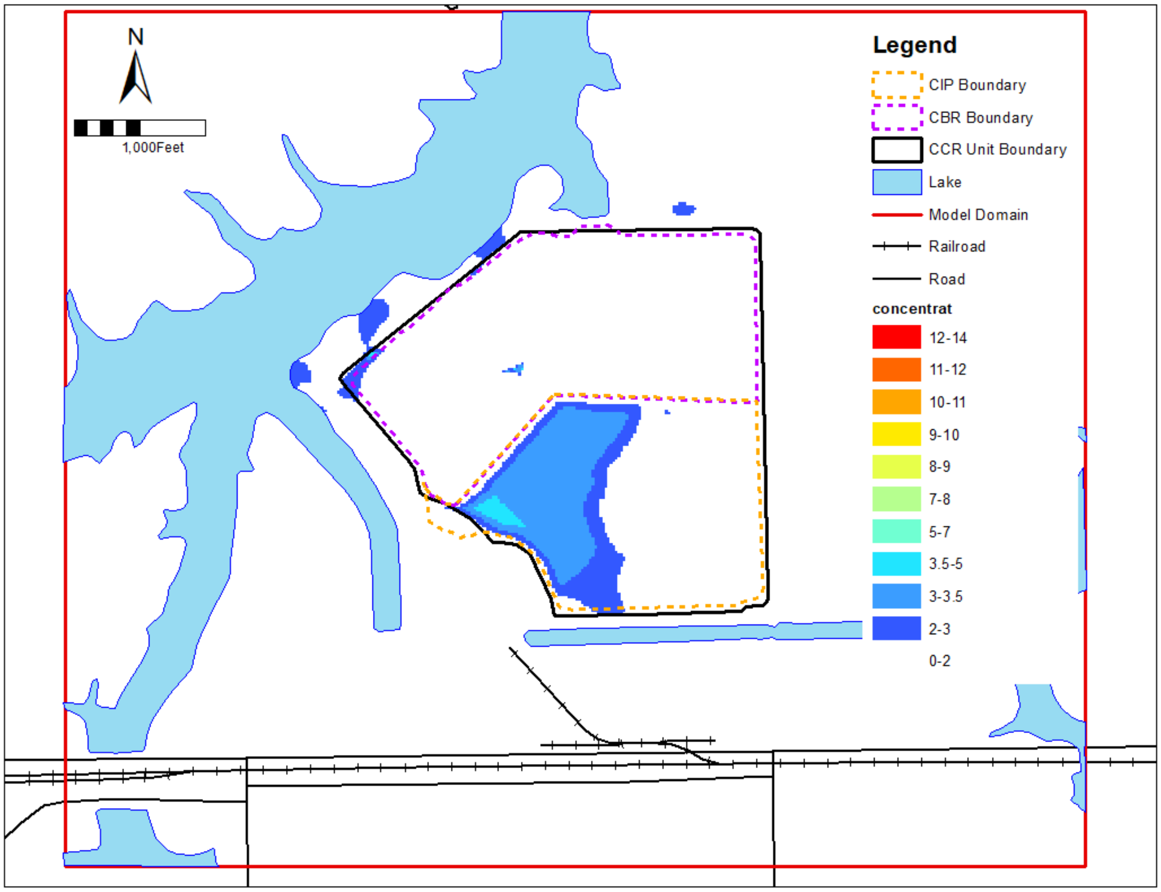
RAMBOLL

FIGURE 6-4



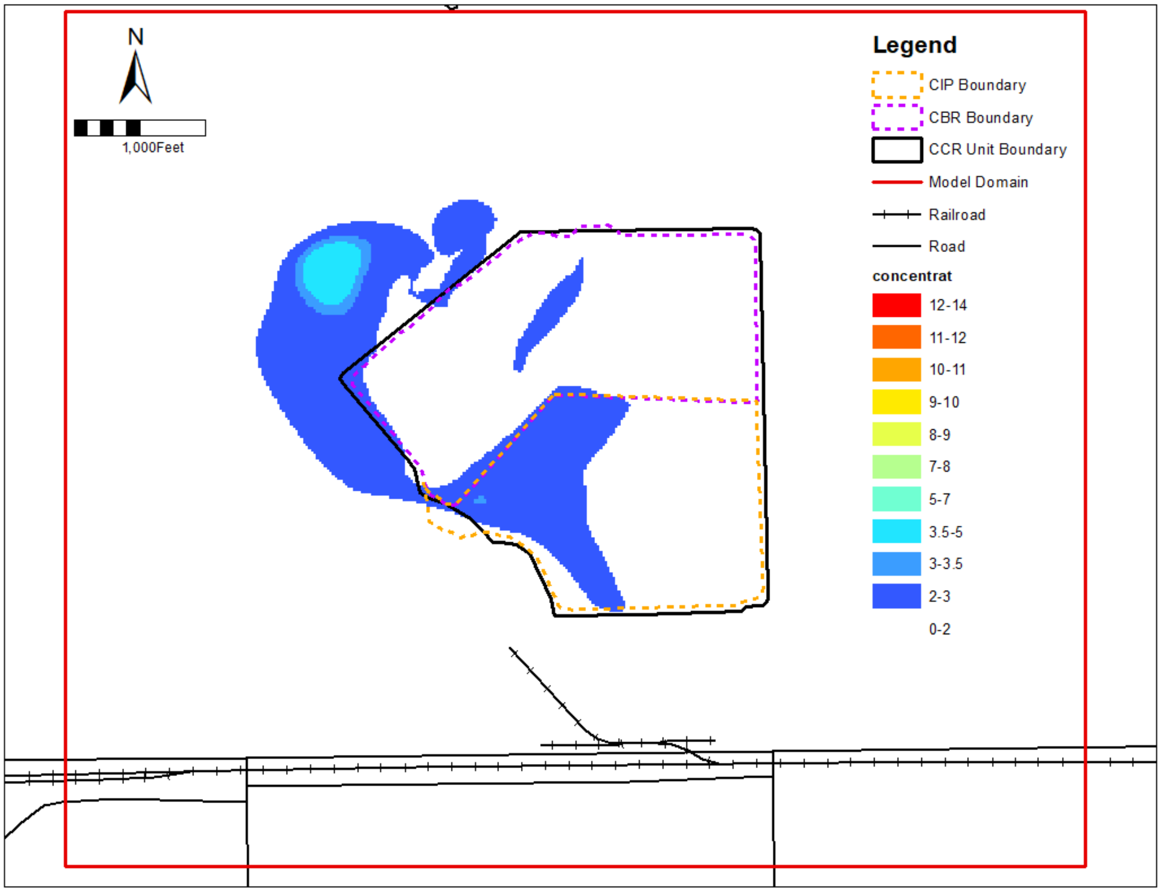
DISTRIBUTION OF BORON CONCENTRATION (mg/L) IN CIP SCENARIO LAYER 2 (17 YEARS)

GROUNDWATER MODELING REPORT
KINCAID CCR ASH POND
KINCAID POWER PLANT
KINCAID, ILLINOIS



DISTRIBUTION OF BORON CONCENTRATION (mg/L) IN CIP SCENARIO LAYER 3 (17 YEARS)

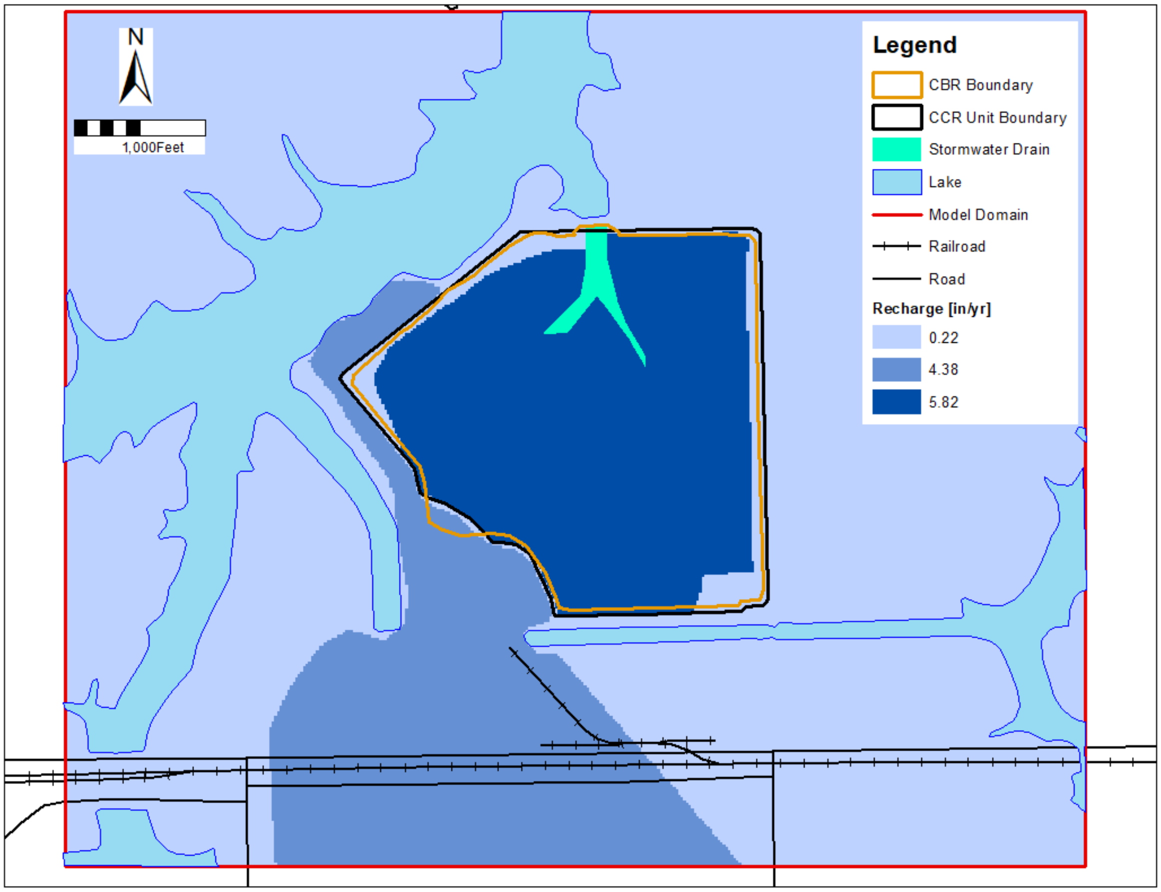
GROUNDWATER MODELING REPORT
KINCAID CCR ASH POND
KINCAID POWER PLANT
KINCAID, ILLINOIS



DISTRIBUTION OF BORON CONCENTRATION (mg/L) IN CIP SCENARIO LAYER 4 (17 YEARS)

GROUNDWATER MODELING REPORT
KINCAID CCR ASH POND
KINCAID POWER PLANT
KINCAID, ILLINOIS

RAMBOLL

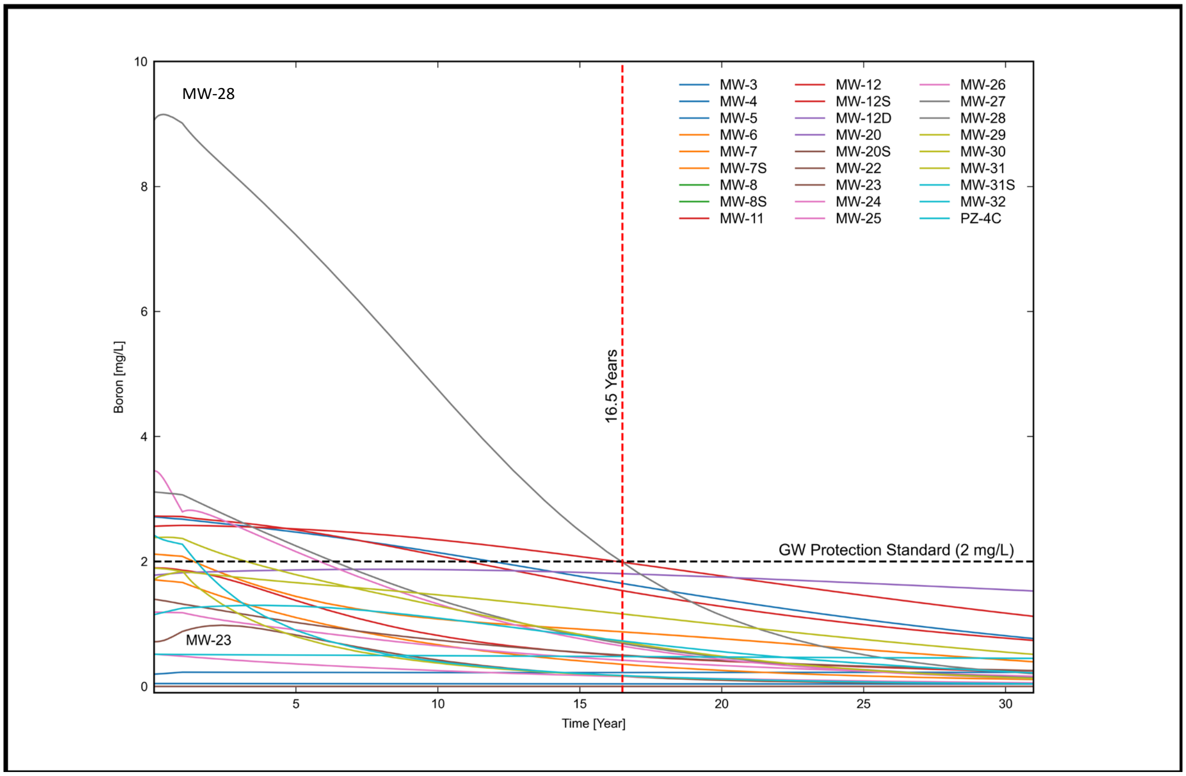


CBR RECHARGE DISTRIBUTION AND STORMWATER DRAIN

GROUNDWATER MODELING REPORT
KINCAID CCR ASH POND
KINCAID POWER PLANT
KINCAID, ILLINOIS

RAMBOLL

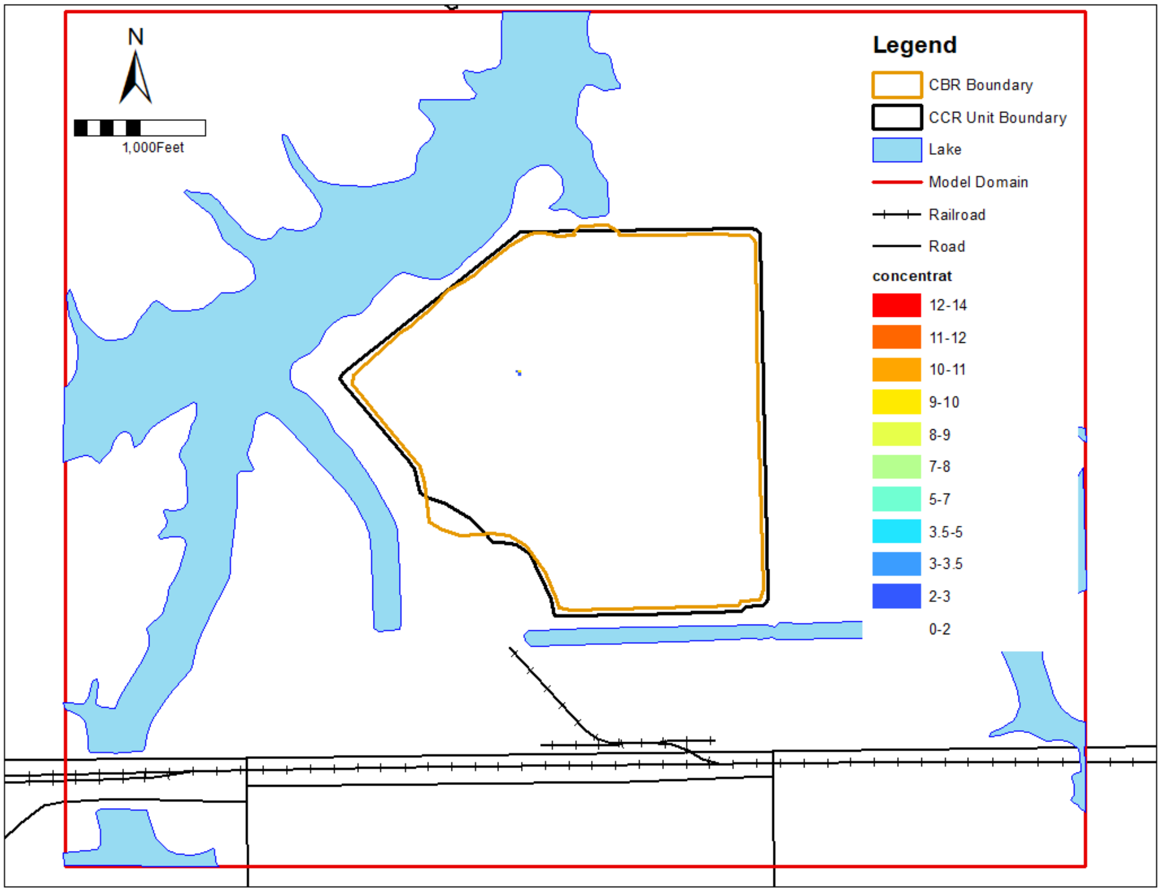
FIGURE 6-8



CBR (SCENARIO 2) - MODEL PREDICTED BORON CONCENTRATION

GROUNDWATER MODELING REPORT
KINCAID CCR ASH POND
KINCAID POWER PLANT
KINCAID, ILLINOIS

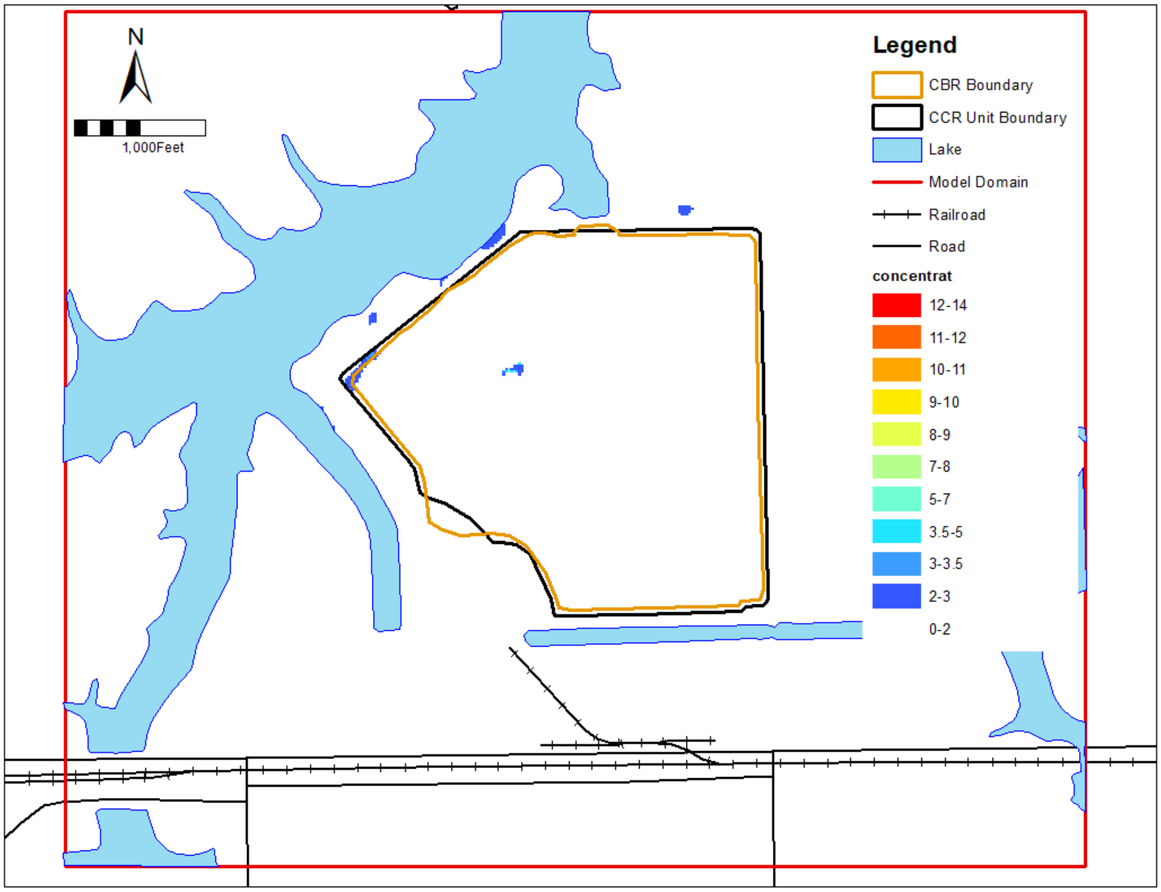
RAMBOLL



DISTRIBUTION OF BORON CONCENTRATION (mg/L) IN CBR SCENARIO LAYER 1 (17 YEARS)

GROUNDWATER MODELING REPORT
KINCAID CCR ASH POND
KINCAID POWER PLANT
KINCAID, ILLINOIS

RAMBOLL

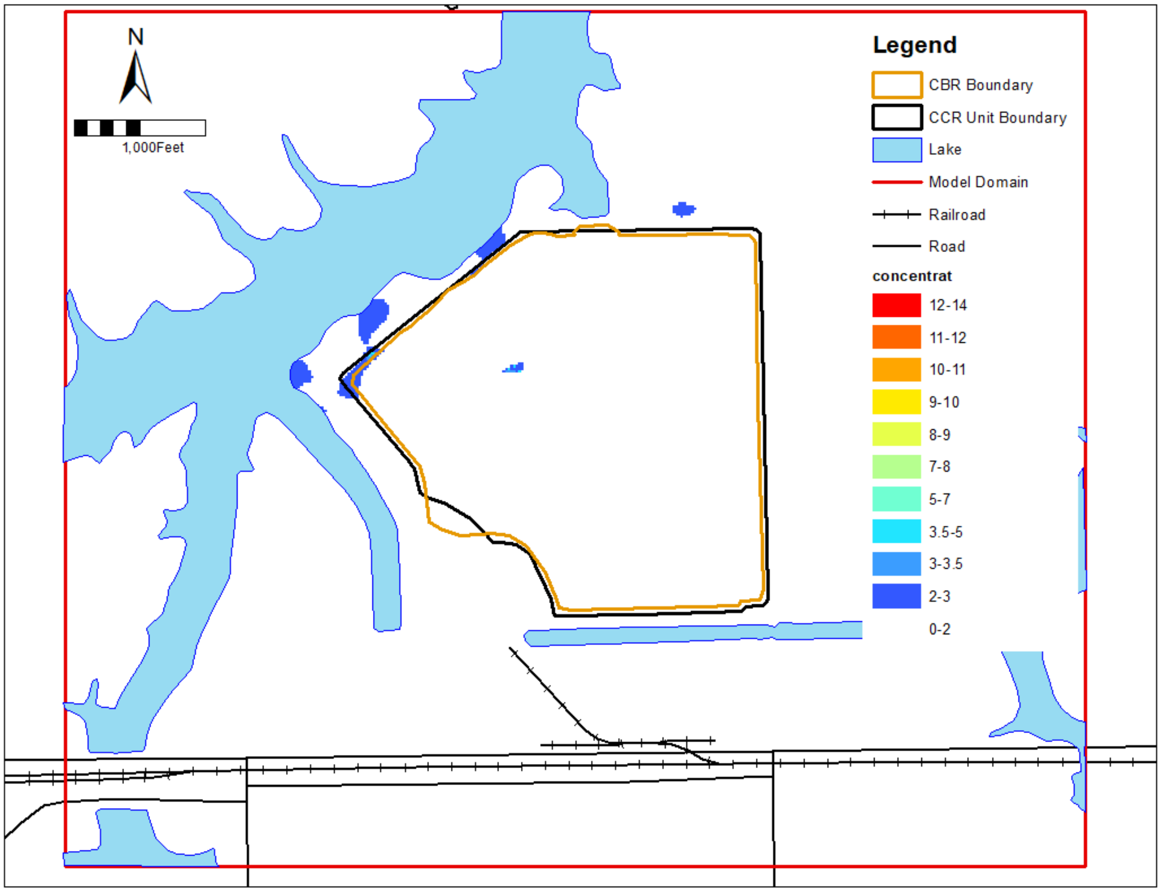


DISTRIBUTION OF BORON CONCENTRATION (mg/L) IN CBR SCENARIO LAYER 2 (17 YEARS)

GROUNDWATER MODELING REPORT
KINCAID CCR ASH POND
KINCAID POWER PLANT
KINCAID, ILLINOIS

RAMBOLL

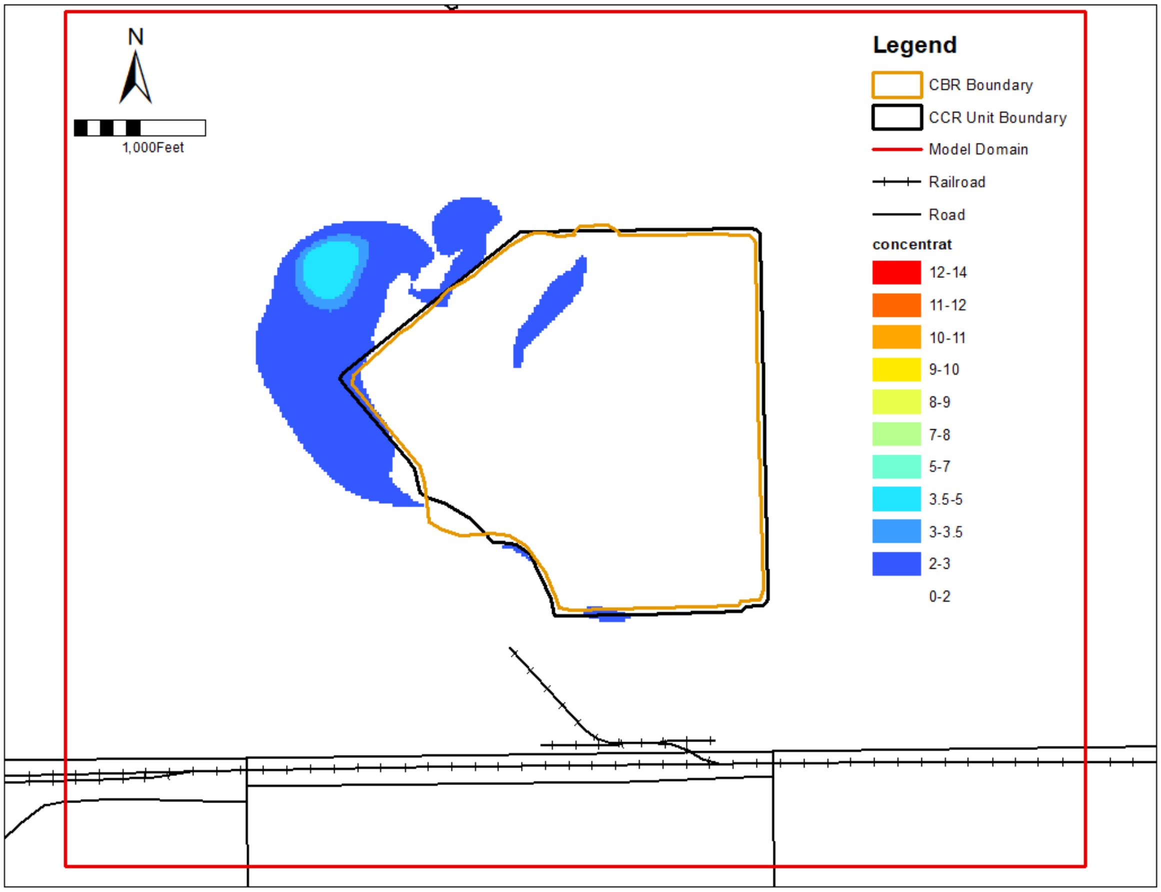
FIGURE 6-11



DISTRIBUTION OF BORON CONCENTRATION (mg/L) IN CBR SCENARIO LAYER 3 (17 YEARS)

GROUNDWATER MODELING REPORT
KINCAID CCR ASH POND
KINCAID POWER PLANT
KINCAID, ILLINOIS

RAMBOLL



DISTRIBUTION OF BORON CONCENTRATION (mg/L) IN CBR SCENARIO LAYER 4 (17 YEARS)

GROUNDWATER MODELING REPORT
KINCAID CCR ASH POND
KINCAID POWER PLANT
KINCAID, ILLINOIS

RAMBOLL

APPENDICES

APPENDIX A
MODFLOW, MT3DMS, and HELP MODEL FILES
(ELECTRONIC ONLY)

APPENDIX B
EVALUATION OF PARTITION COEFFICIENT RESULTS (GOLDER, 2022)

WSP GOLDER

TECHNICAL MEMORANDUM

DATE March 30, 2022 **Project No.** 21454831

TO David Mitchell, Stu Cravens, Vic Modeer
Kincaid Generation, LLC

CC Brian Henning - Ramboll

FROM Golder Associates USA Inc. **EMAIL** **Jeffrey_Ingram@golder.com**

EVALUATION OF PARTITION COEFFICIENT RESULTS, KINCAID POWER PLANT ASH POND (CCR UNIT 141), KINCAID POWER PLANT, CHRISTIAN COUNTY, ILLINOIS

1.0 INTRODUCTION

Kincaid Generation, LLC (KG) operates the Kincaid Power Plant (KPP) located in Christian County, Illinois. The Ash Pond (AP or Site), Illinois Environmental Protection Agency [IEPA] ID No. W0218140002 - 01 is a 178-acre unlined surface impoundment used to manage coal combustion residuals (CCRs) at the KPP. The AP is regulated under Part 845 *"Standards for the Disposal of Coal Combustion Residuals in Surface Impoundments"* (State CCR Rule or Part 845) which was promulgated by the Illinois Pollution Control Board (IPCB) on April 21, 2021. WSP Golder (Golder) is assisting KG with Part 845 compliance at the Site.

KG is currently preparing a Construction Permit application for the AP as required under Section 845.220. As a part of the Construction Permit application, groundwater modeling is being conducted for known potential exceedances of groundwater protection standards (GWPS) as outlined in the Operating Permit application for the AP (Burns and McDonnell 2021). In the Operating Permit (October 2021), Ramboll Americas Engineering Solutions, Inc. (Ramboll) identified potential GWPS exceedances for several compounds potentially associated with the AP, including boron and sulfate. Batch adsorption testing was performed to generate site-specific partition coefficient results for these parameters for use in the groundwater models. This Technical Memorandum summarizes the results of the batch adsorption testing.

2.0 OVERVIEW

In August 2021, Golder conducted a field investigation at the KPP which included the completion of eight (8) soil/rock borings ranging in depth from 20 to 40 feet below ground surface (ft bgs). As a part of that investigation, soil and groundwater samples were submitted to SiREM laboratories (Guelph, ON) for batch solid/liquid partitioning testing. A summary of the soil samples used for the batch testing is provided in Table 1.

Table 1: Batch Attenuation Testing Data Summary

Groundwater Sample ID	Soil Sample ID	Soil: Water Ratio
MW-12S	K-SB-02 (10.0-14.7 ft bgs)	2:1
		1:1

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18300 NE Union Hill Road, Suite 200, Redmond, Washington, USA 98052 T: +1 425 883-0777 F: +1 425 882-5498

Groundwater Sample ID	Soil Sample ID	Soil: Water Ratio
		1:5
		1:10
		1:20
MW-28	K-SB-02 (14.7-17.5 ft bgs)	2:1
		1:1
		1:5
		1:10
		1:20

Notes:

1) ft bgs – Feet below ground surface

Site-specific partitioning coefficients were determined for constituents of interest (COIs) boron and sulfate, which were identified based on statistical evaluation of potential groundwater exceedances calculated at the Site (Burns and McDonnell 2021). Two groundwater samples (MW-12S and MW-28) and two soil samples (K-SB-02 (10.0-14.7) and K-SB-02 (14.7-17.5)) were used for batch attenuation testing at various ratios (Table 1). For each treatment, 0.1 L of groundwater was brought in contact with an amount of soil (0.003 to 0.17 kg, depending on the ratio) over a seven-day period. Each contact water/soil microcosm was amended (spiked) with meta-arsenite, boric acid, lithium chloride, and sodium sulfate to a target concentration of arsenic, boron, lithium, and sulfate, respectively (Table 2). Arsenic and lithium are not currently COIs at the Site and, therefore, were not evaluated as part of this report. However, arsenic and lithium may be revisited in the future, thus meta-arsenite and lithium chloride were included as additional amendments. After the seven-day contact period, COI concentrations were analyzed in the contact water. The control samples (i.e., groundwater samples MW-12S and MW-28) were only analyzed at the initiation of testing. The oxidation/reduction potential (redox) and pH were measured for each batch test at the beginning and end of the contact period and in the control samples.

Table 2: Microcosm amendment and target concentration for COIs

COI	Groundwater Sample	Amendment	Target Concentration (mg/L)
Arsenic	MW-12S	67.45 µL of a 2 g/L As(III) solution	0.04
	MW-28	68.67 of a 2 g/L As(III) solution	
Boron	MW-12S	17.78 mL of a 10 g/L H_3BO_3 solution	16.8
	MW-28	9.61 mL of a 10 g/L H_3BO_3 solution	
Lithium	MW-12S	2.42 mL of a 1 g/L LiCl solution	0.2

	MW-28	2.39 mL of a 1 g/L LiCl solution	
Sulfate	MW-12S	51.56 mL of a 100 g/L Na_2SO_4 solution	1,748
	MW-28	27.56 mL of a 100 g/L Na_2SO_4 solution	

Notes:

1) g/L – grams per liter
2) mL – milliliter
3) µg/L – micrograms per liter
4) mg/L – miligrams per liter
5) As(III) – arsenite
6) H_3BO_3 – boric acid
7) LiCl – lithium chloride
8) Na_2SO_4 – sodium sulfate

The results of batch attenuation testing (Tables 3 and 4) were used to calculate the following adsorption isotherms for each COI:

- Linear: $q_e = K_D * C_e$
- Langmuir: $C_e/q_e = 1/(K_L * q_m) + C_e/q_m$
- Freundlich: $\log(q_e) = \log(K_F) + (1/n)\log(C_e)$

Where

K_D, K_L, and K_F = the linear, Langmuir, and Freundlich partition coefficients, respectively (in liters per kilogram; L/kg).

q_e = concentration of the adsorbate in soil

C_e = aqueous concentration of the adsorbate

q_m = 1/slope in the linear expression of the isotherm

n = non-linearity constant

3.0 SUMMARY OF RESULTS

Figures that show the linear, Langmuir, and Freundlich isotherms for the two COIs are provided in Appendix A. The partition coefficient values for MW-12S and MW-28 are presented in Tables 5 and 6, respectively. The results of the batch adsorption testing can be summarized as follows:

- **Boron**: Calculated K_D values for MW-12S and MW-28 were 0.05 and 1.81 L/kg, respectively, K_L values -1.4E+6 and -1.5E+4 L/kg, respectively, and K_F values 112 and 27.5 L/kg, respectively. For comparison, in Strenge and Peterson (1989), partition coefficients for boron range from 0.19 to 1.3 L/kg, depending on pH conditions and the amount of sorbent (i.e. clay, organic matter, and iron and aluminum oxyhydroxide) present.
- **Sulfate**: Calculated K_D values for MW-12S and MW-28 were 0.23 and 15.5 L/kg, respectively, K_L values -454 and -750 L/kg, respectively, and K_F values 1.87 and 0.13 L/kg, respectively. In Strenge and Peterson (1989), partition coefficients for sulfate are 0.0 L/kg, regardless of pH conditions and the amount of sorbent present.

- **pH and Redox**: Generally, after the seven-day contact time, the pH of each contact water was consistent with the pH of the control samples (6.94 for MW-12S and 6.90 for MW-28, respectively), ranging from 6.93 to 6.97 across the batch tests. The redox values of the control samples after the seven-day contact time were -54 mV and 116 mV for MW-12S and MW-28, respectively. The redox value of contact water ranged from -131 to +236 mV across treatments.

4.0 REFERENCES

Burns and McDonnell, 2021. Initial Operating Permit Kincaid Power Plant Ash Pond.

Strenge, D. and Peterson, S. 1989. Chemical Data Bases for the Multimedia Environmental Pollutant Assessment System (MEPAS) (No. PNL-7145). Pacific Northwest Lab., Richland, WA (USA).

5.0 CLOSING

Golder appreciates the opportunity to serve as your consultant on this project. If you have any questions concerning this technical memorandum or need additional information, please contact the undersigned.

Golder Associates USA Inc.

Jeffrey Ingram
Senior Consultant, Geologist

Pat Behling
Practice Leader

CK/JSI/PJB

Attachments Appendix A – Partition Coefficient Graphs

Table 3: Batch Attenuation Testing Results, MW-12S

Geologic Material Sample ID	Treatment	Date	Day	Replicate	Dissolved Boron (mg/L)	Dissolved Sulfate (mg/L)	pH (SU)	ORP (mV)
	Groundwater Only Control	2/10/2022	0	MW-12S-1a	17	1,700	6.96	13
				MW-12S-2a	18	1,513	6.95	8
				Average Concentration (mg/L)	17	1,606	6.96	11
		2/17/2022	7	MW-12S-1	16	964	6.94	-59
				MW-12S-2	17	1,059	6.94	-48
				Average Concentration (mg/L)	16	1,012	6.94	-54
MW-12S K-SB-02 (10.0-14.7)	2:1 Soil:Water Ratio	2/10/2022	0					
		2/17/2022	7	K-SB-02-(10.0-14.7) :MW-12S 2:1-1	8.9	878	6.94	-110
				K-SB-02-(10.0-14.7) :MW-12S 2:1-2	8.0	921	6.92	-127
				Average Concentration (mg/L)	8.4	899	6.93	-119
	1:1 Soil:Water Ratio	2/10/2022	0					
		2/17/2022	7	K-SB-02-(10.0-14.7) :MW-12S 1:1-1	12	1,137	6.92	-131
				K-SB-02-(10.0-14.7) :MW-12S 1:1-2	12	1,284	7.01	--
				Average Concentration (mg/L)	12	1,211	6.97	-131
	1:5 Soil:Water Ratio	2/10/2022	0					
		2/17/2022	7	K-SB-02-(10.0-14.7) :MW-12S 1:5-1	16	1,268	6.95	-4
				K-SB-02-(10.0-14.7) :MW-12S 1:5-2	15	1,568	6.94	16
				Average Concentration (mg/L)	16	1,418	6.95	6
	1:10 Soil:Water Ratio	2/10/2022	0					
		2/17/2022	7	K-SB-02-(10.0-14.7) :MW-12S 1:10-1	16	1,216	6.93	53
				K-SB-02-(10.0-14.7) :MW-12S 1:10-2	17	1,527	6.95	22
				Average Concentration (mg/L)	17	1,372	6.94	38
	1:20 Soil:Water Ratio	2/10/2022	0					
		2/17/2022	7	K-SB-02-(10.0-14.7) :MW-12S 1:20-1	19	981	6.96	42
				K-SB-02-(10.0-14.7) :MW-12S 1:20-2	18	1,381	6.95	53
				Average Concentration (mg/L)	19	1,181	6.96	48

Notes:
1) mg/L- Miligrams per liter
2) SU - Standard Units
3) mV - milivolts
4) ORP - Oxidation Reduction Potential
5) ND - non-detect

Table 4: Batch Attenuation Testing Results, MW-28

Geologic Material Sample ID	Treatment	Date	Day	Replicate	Dissolved Boron	Dissolved Sulfate	pH	ORP
					mg/L	mg/L	SU	mV
	Groundwater Only Control	2/10/2022	0	MW-28-1a	18	1,515	6.92	-3
				MW-28-2a	17	1,582	6.93	3
				Average Concentration (mg/L)	18	1,549	6.93	0
		2/17/2022	7	MW-28-1	16	1,397	6.88	183
				MW-28-2	17	624	6.91	48
				Average Concentration (mg/L)	17	1,010	6.90	116
MW-12S K-SB-02 (14.7-17.5)	2:1 Soil:Water Ratio	2/10/2022	0					
		2/17/2022	7	K-SB-02-(14.7-17.5):MW-28 2:1-1	8.5	546	6.94	239
				K-SB-02-(14.7-17.5):MW-28 2:1-2	9.2	<1.4	6.92	232
				Average Concentration (mg/L)	8.8	546	6.93	236
	1:1 Soil:Water Ratio	2/10/2022	0					
		2/17/2022	7	K-SB-02-(14.7-17.5):MW-28 1:1-1	12	761	6.96	139
				K-SB-02-(14.7-17.5):MW-28 1:1-2	12	1,026	6.95	89
				Average Concentration (mg/L)	12	893	6.96	114
	1:5 Soil:Water Ratio	2/10/2022	0					
		2/17/2022	7	K-SB-02-(14.7-17.5):MW-28 1:5-1	17	1,023	6.99	106
				K-SB-02-(14.7-17.5):MW-28 1:5-2	16	999	6.95	107
				Average Concentration (mg/L)	16	1,011	6.97	107
	1:10 Soil:Water Ratio	2/10/2022	0					
		2/17/2022	7	K-SB-02-(14.7-17.5):MW-28 1:10-1	16	1,182	6.94	70
				K-SB-02-(14.7-17.5):MW-28 1:10-2	16	949	6.95	79
				Average Concentration (mg/L)	16	1,066	6.95	75
	1:20 Soil:Water Ratio	2/10/2022	0					
		2/17/2022	7	K-SB-02-(14.7-17.5):MW-28 1:20-1	17	1,112	6.94	73
				K-SB-02-(14.7-17.5):MW-28 1:20-2	17	915	6.93	41
				Average Concentration (mg/L)	17	1,013	6.94	57

Notes:
1) mg/L- Miligrams per liter
2) SU - Standard Units
3) mV - milivolts
4) ORP - Oxidation Reduction Potential
5) ND - non-detect

Table 5: Partition Coefficient Results, MW-12S

Analyte	Isotherm	Variable	With Soil Mass
Boron	Raw Data R^2		0.01
	Linear K_D (L/kg)		0.05
	Langmuir	R^2	0.63
		q_m (mg/g)	0.007
		K_L (L/kg)	-1.43E+06
	Freundlich	R^2	0.01
		1/n	0.049
		K_F (L/kg)	111.65
Sulfate	Raw Data R^2		0.00
	Linear K_D (L/kg)		0.23
	Langmuir	R^2	0.08
		q_m (mg/g)	-0.883
		K_L (L/kg)	-4.54E+02
	Freundlich	R^2	0.08
		1/n	2.111
		K_F (L/kg)	1.87

Note(s):

K_D: linear partition coefficient

K_L: Langmuir partition coefficient

K_F: Freundlich partition coefficient

q_m: 1/slope in the linear expression of the isotherm

n: non-linearity constant

Table 6: Partition Coefficient Results, MW-28

Analyte	Isotherm	Variable	With Soil Mass
Boron	Raw Data R^2		0.41
	Linear K_D (L/kg)		1.81
	Langmuir	R^2	0.02
		q_m (mg/g)	-0.043
		K_L (L/kg)	-1.54E+04
	Freundlich	R^2	0.43
		1/n	1.495
		K_F (L/kg)	27.53
Sulfate	Raw Data R^2		0.26
	Linear K_D (L/kg)		15.50
	Langmuir	R^2	0.34
		q_m (mg/g)	-1.013
		K_L (L/kg)	-7.50E+02
	Freundlich	R^2	0.50
		1/n	3.198
		K_F (L/kg)	0.13

Note(s):

K_D: linear partition coefficient

K_L: Langmuir partition coefficient

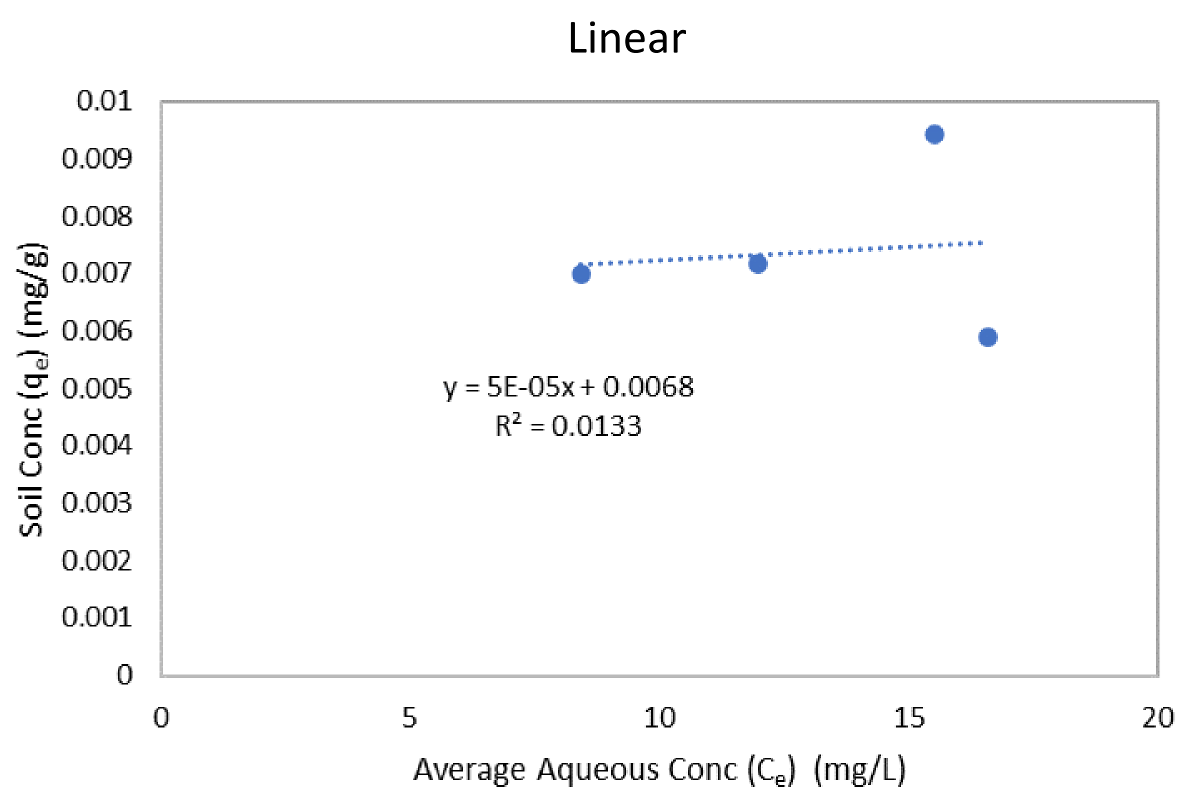
K_F: Freundlich partition coefficient

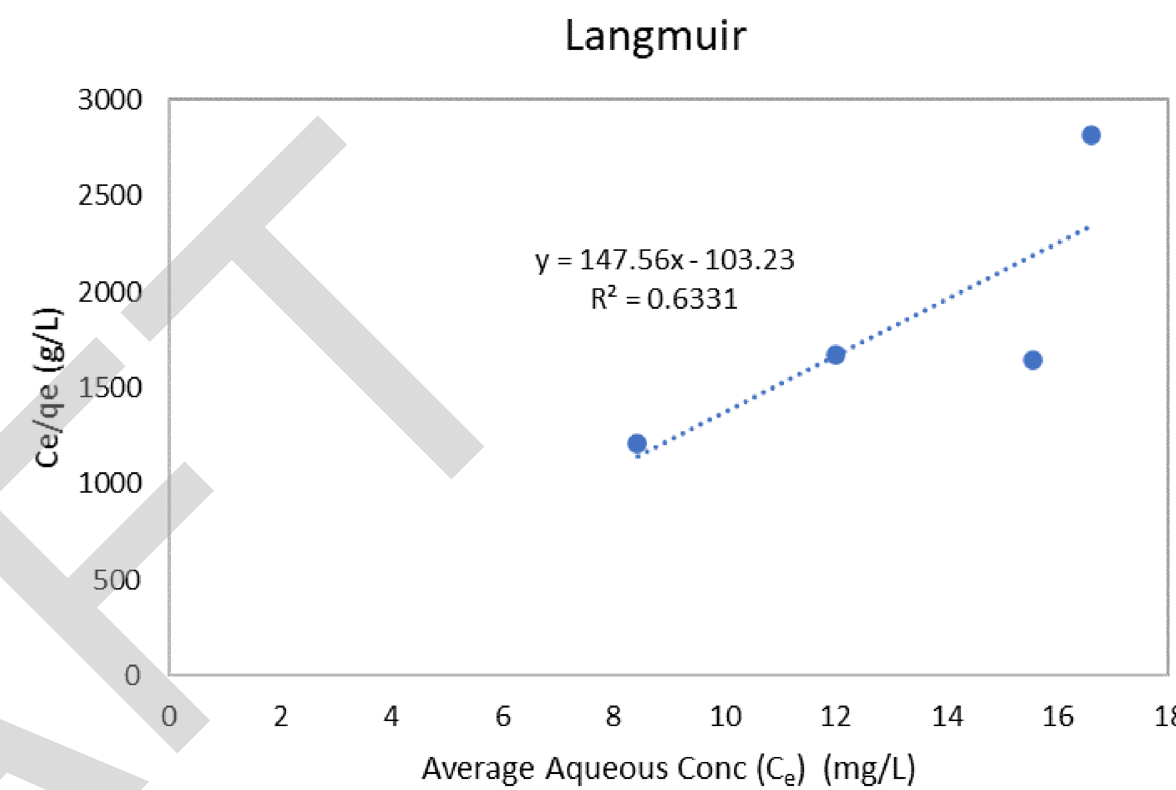
q_m: 1/slope in the linear expression of the isotherm

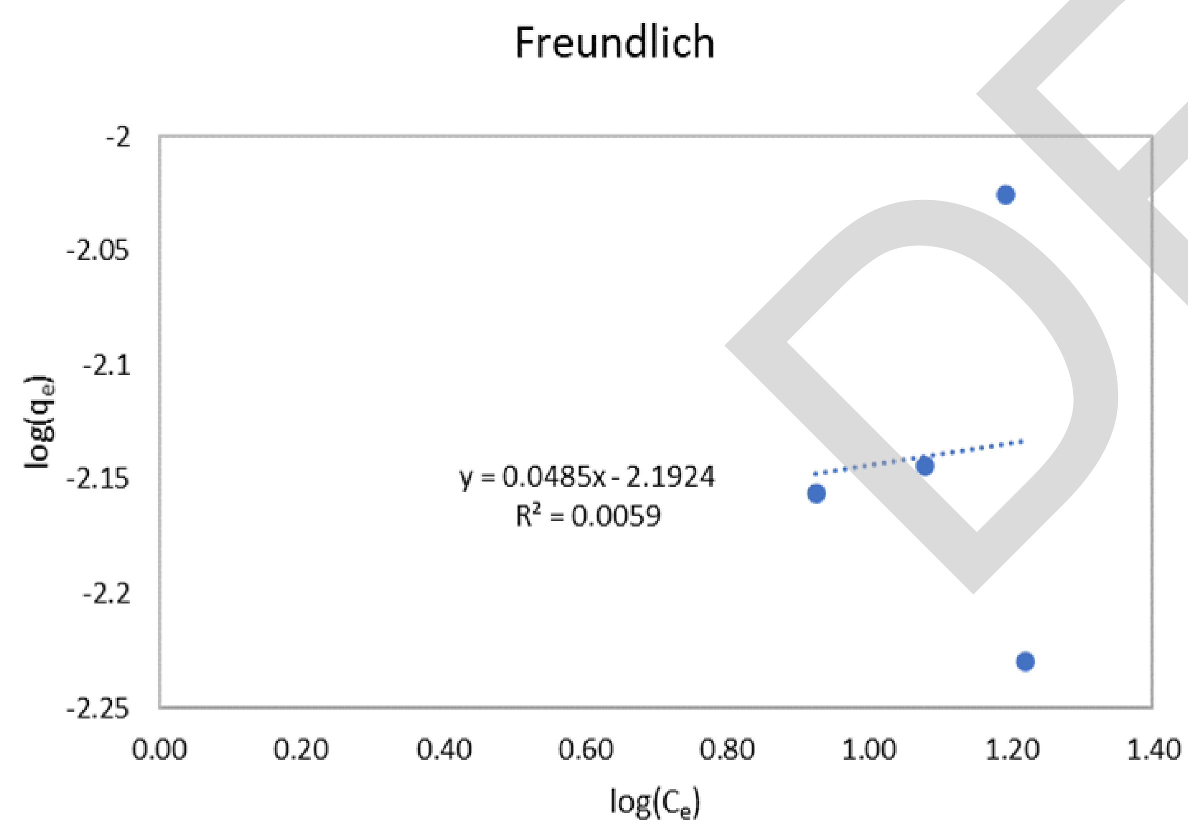
n: non-linearity constant

APPENDIX A

Partition Coefficient Graphs







Note(s):
mg/L: milligrams per liter
mg/g: milligrams per gram
g/L: grams per liter
Ce: aqueous concentration of the adsorbate
qe: concentration of the adsorbate in soil

CLIENT
KINCAID GENERATION, LLC
KINCAID POWER PLANT ASH POND (CCR UNIT 141)

PROJECT
EVALUATION OF PARTITION COEFFICIENT RESULTS AP

CONSULTANT
WSP GOLDER

TITLE
MW-12S BORON PARTITION COEFFICIENTS

PROJECT NO.	PHASE	REV.	FIGURE
21454831	0003	0	A-1

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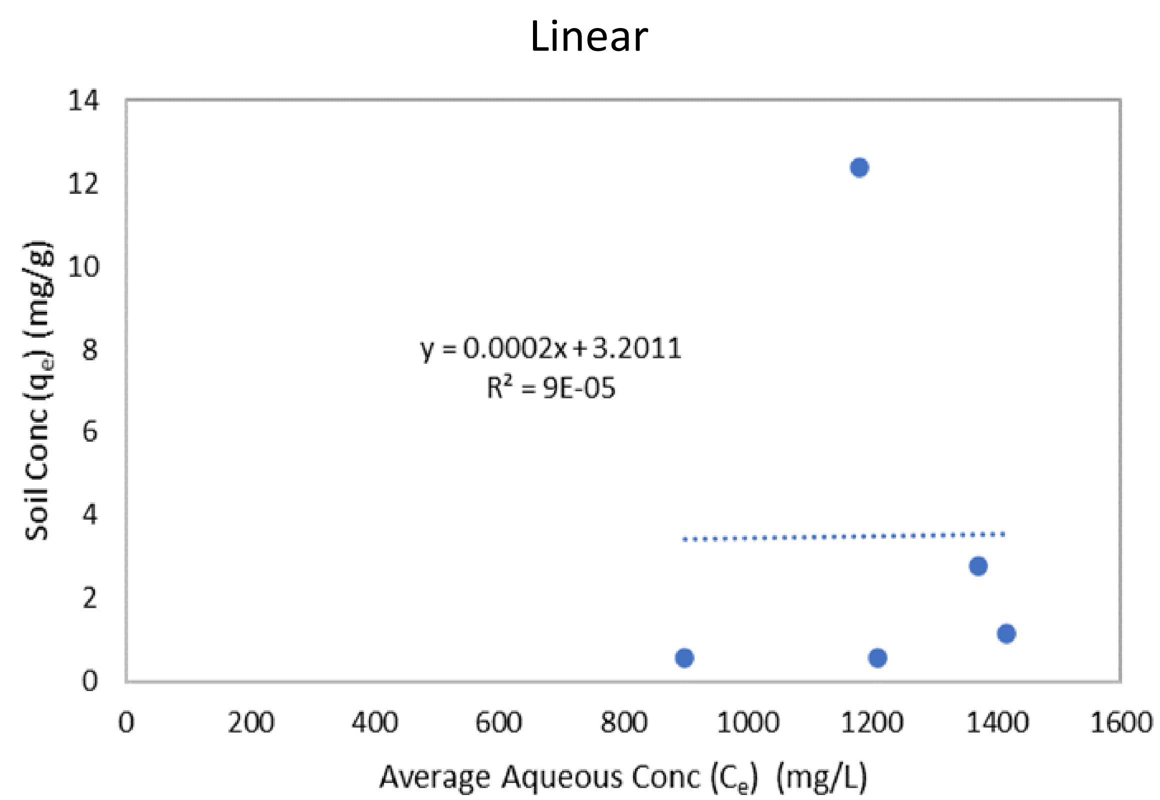

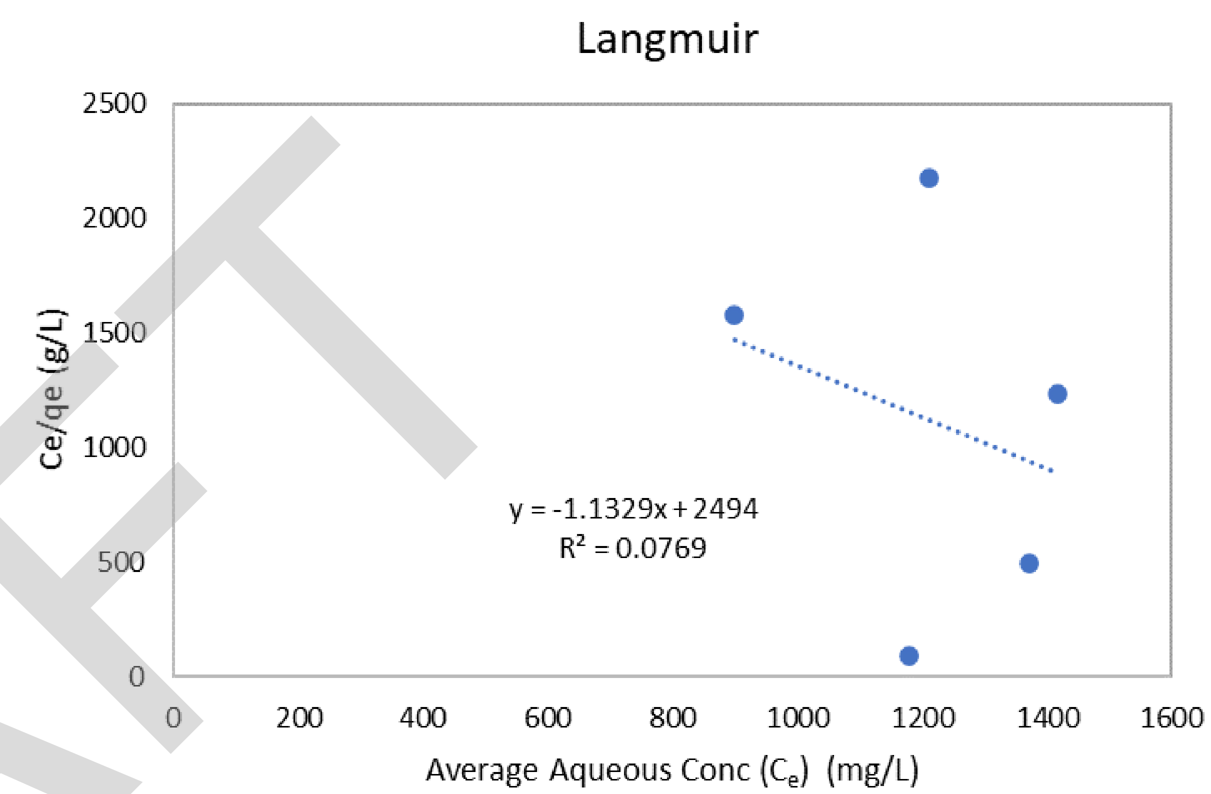

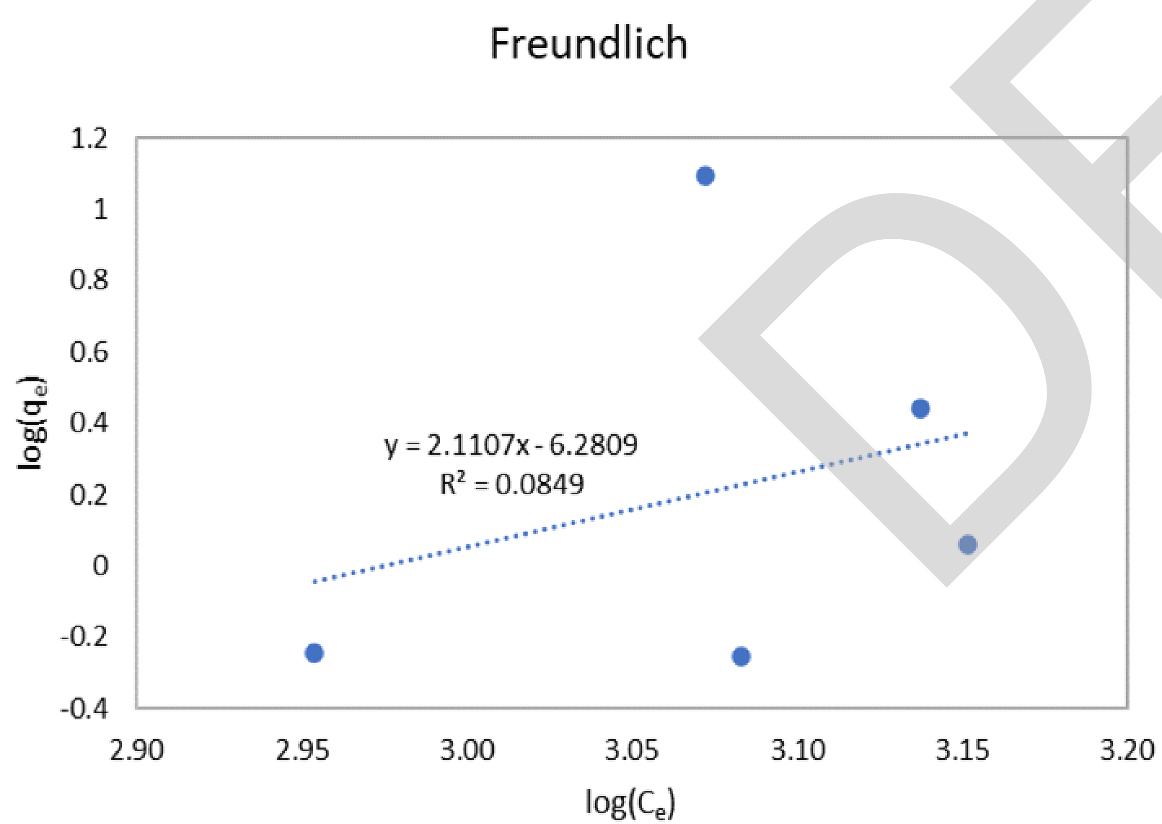

Note(s):
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mg/g: milligrams per gram
g/L: grams per liter
Ce: aqueous concentration of the adsorbate
qe: concentration of the adsorbate in soil

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PROJECT
EVALUATION OF PARTITION COEFFICIENT RESULTS AP

CONSULTANT
WSP GOLDER

TITLE
MW-12S SULFATE PARTITION COEFFICIENTS

PROJECT NO.	PHASE	REV.	FIGURE
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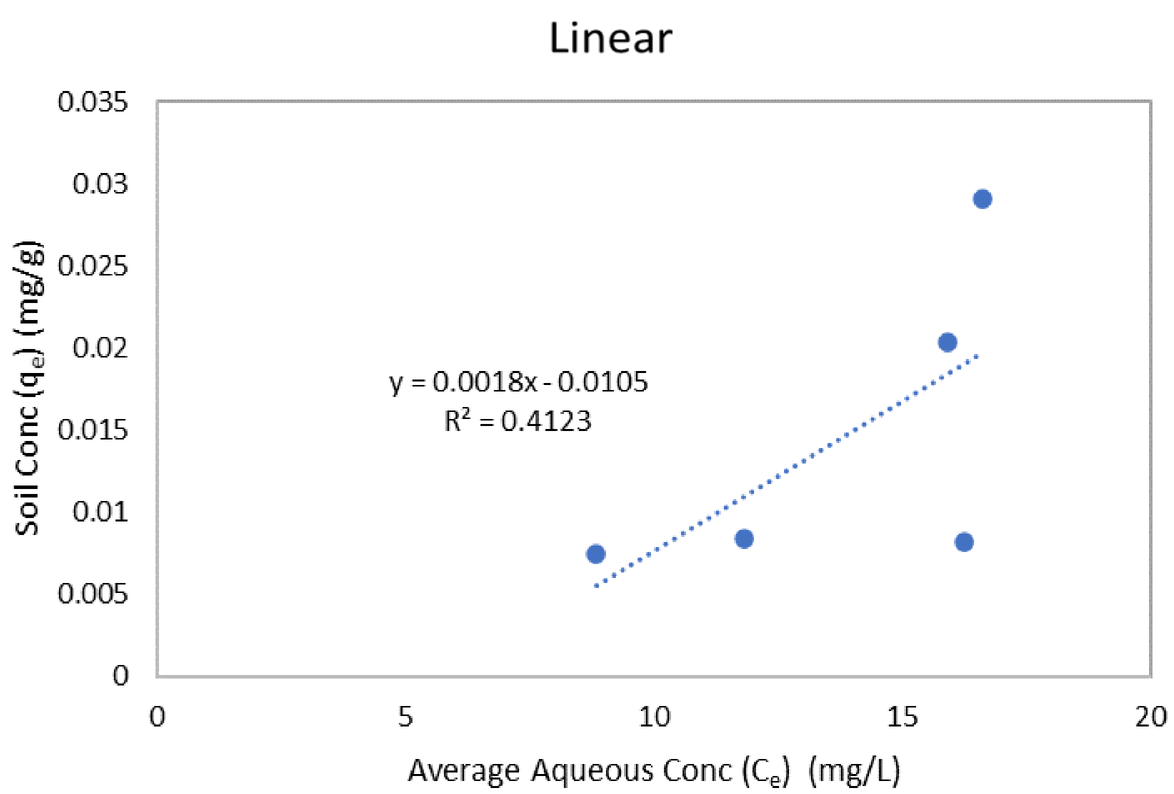

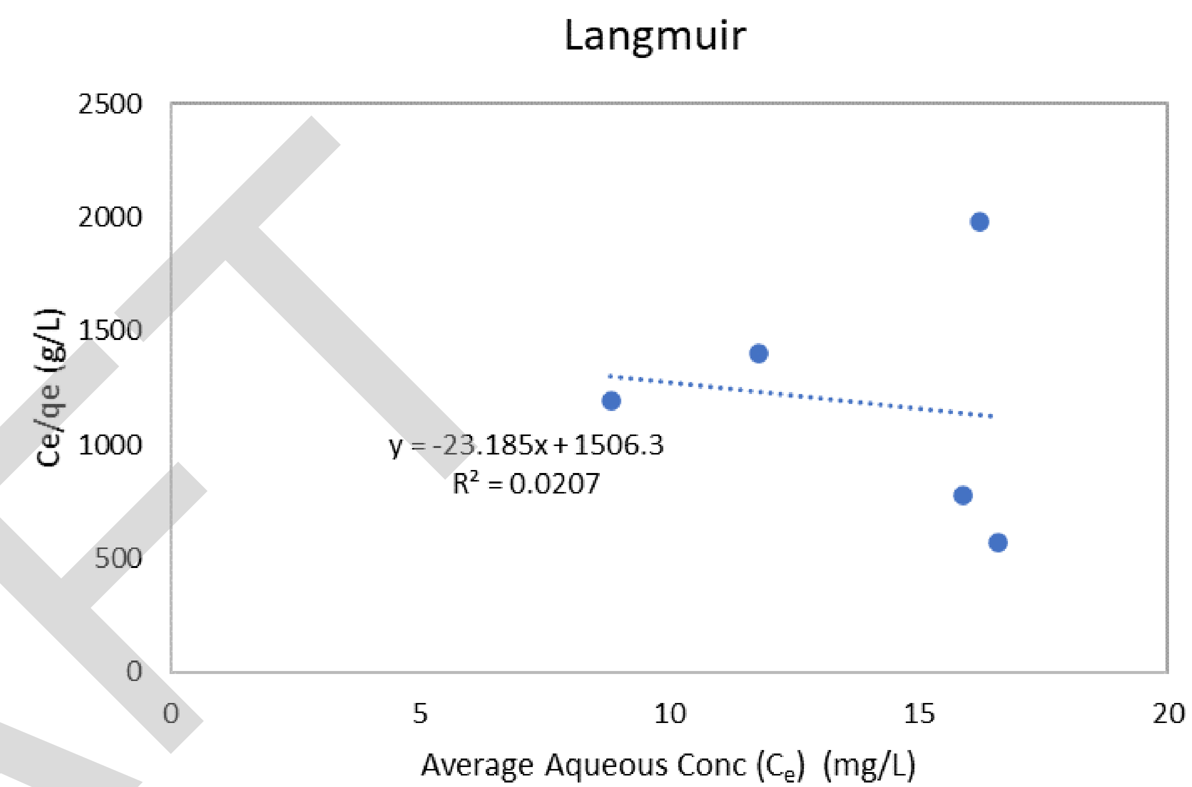

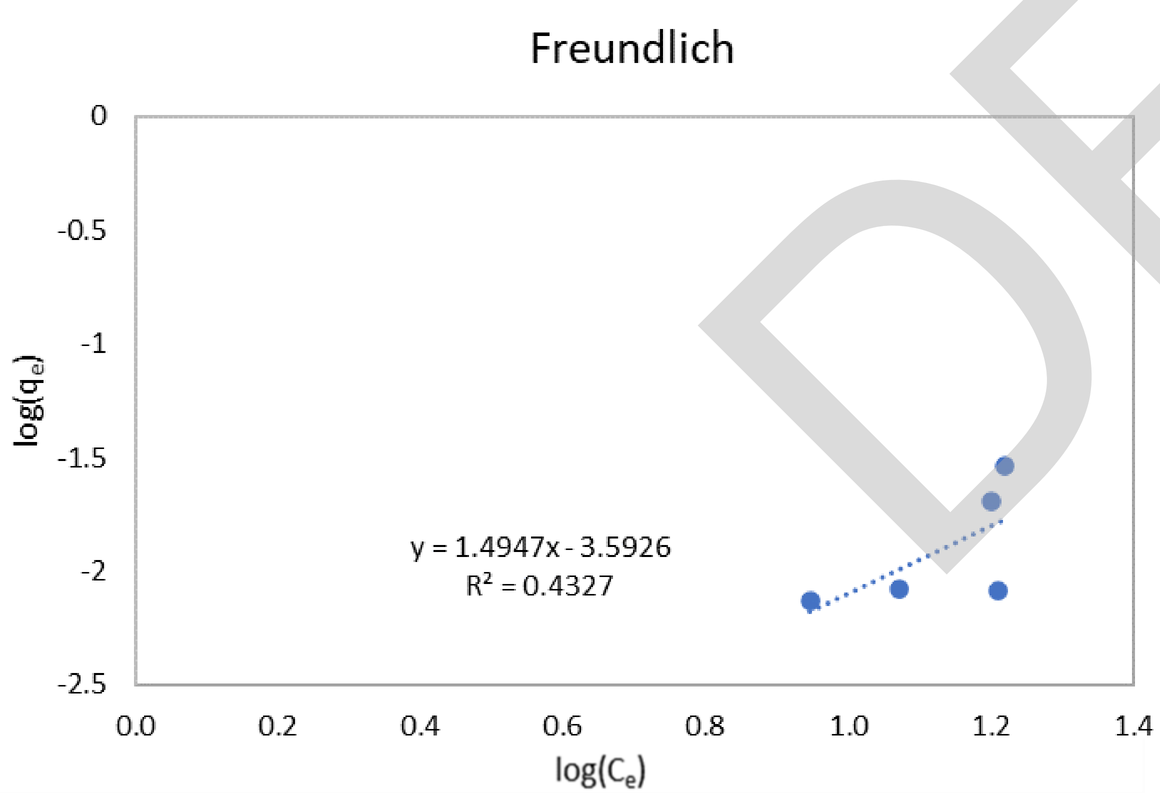

Note(s):
mg/L: milligrams per liter
mg/g: milligrams per gram
g/L: grams per liter
Ce: aqueous concentration of the adsorbate
qe: concentration of the adsorbate in soil

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PROJECT
EVALUATION OF PARTITION COEFFICIENT RESULTS AP

TITLE
MW-28 BORON PARTITION COEFFICIENTS

PROJECT NO.	PHASE	REV.	FIGURE
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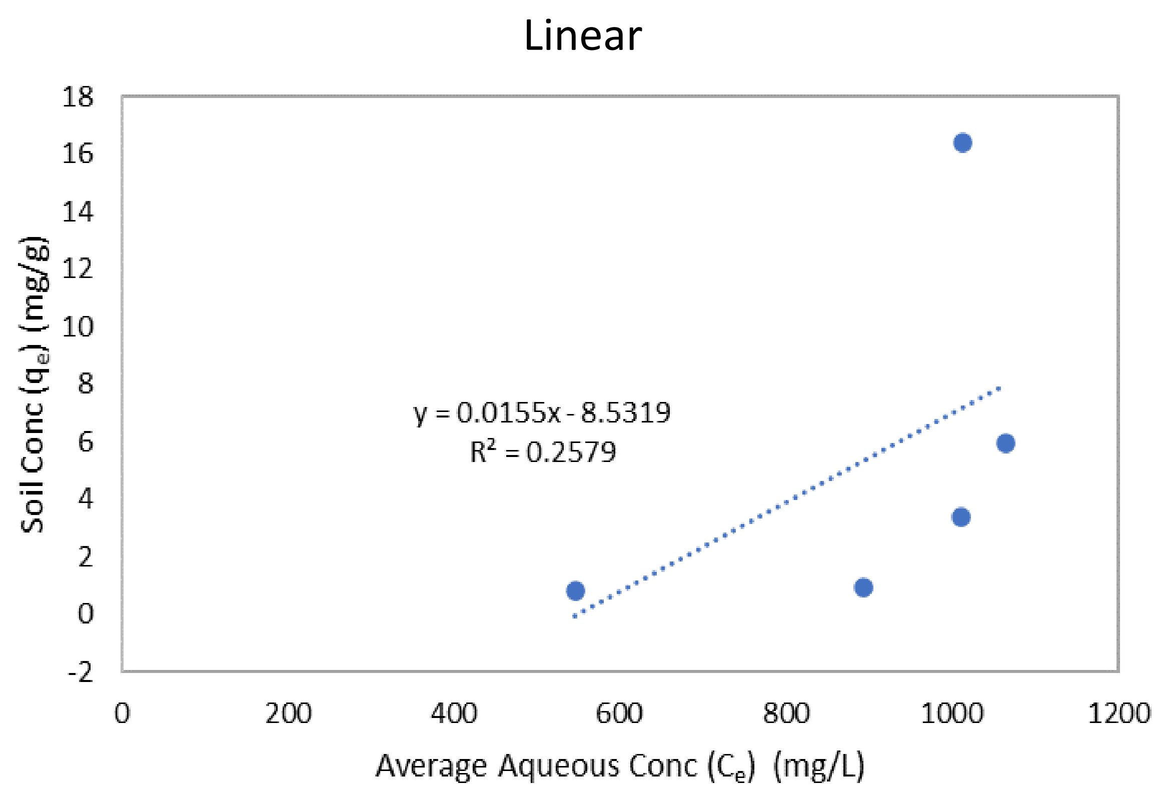

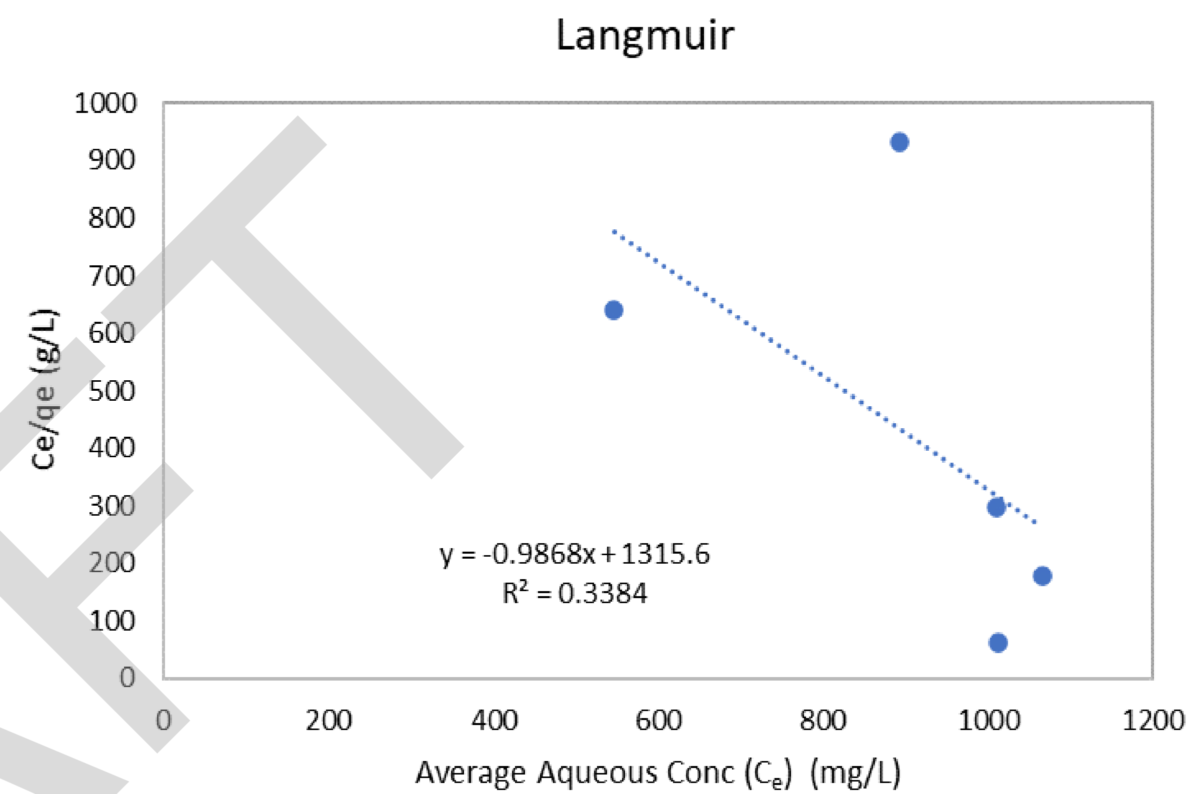

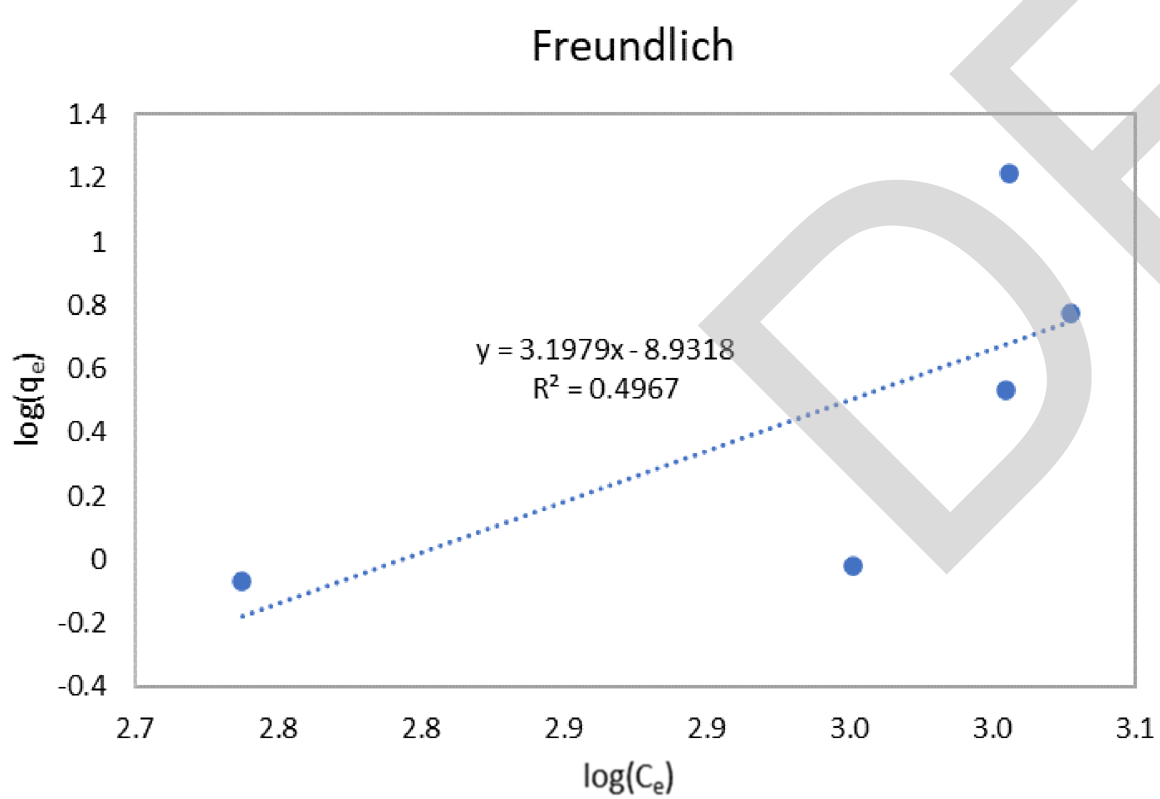

Note(s):
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mg/g: milligrams per gram
g/L: grams per liter
Ce: aqueous concentration of the adsorbate
qe: concentration of the adsorbate in soil

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EVALUATION OF PARTITION COEFFICIENT RESULTS AP

CONSULTANT
WSP GOLDER

TITLE
MW-28 SULFATE PARTITION COEFFICIENTS

PROJECT NO.	PHASE	REV.	FIGURE
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