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GROUNDWATER MODELING REPORT

PRIMARY ASH POND

NEWTON POWER PLANT

NEWTON, ILLINOIS

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NEWTON POWER PLANT PRIMARY ASH POND

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ACRONYMS AND ABBREVIATIONS

§	Section
±	plus or minus
35 I.A.C.	Title 35 of the Illinois Administrative Code
BCU	bedrock confining unit
bgs	below ground surface
CBR	closure by removal
CCR	coal combustion residuals
CIP	closure in place
cm/s	centimeters per second
CSM	conceptual site model
DEM	Digital Elevation Model
ft/ft	feet per foot
ft^2	square feet
ft/d	feet per day
GHB	general head boundary conditions
GMP	Groundwater Monitoring Plan
GMR	Groundwater Modeling Report
Golder	Golder Associates USA Inc.
GWL	groundwater elevation
GWPS	groundwater protection standard
HCR	Hydrogeologic Site Characterization Report
HDPE	high-density polyethylene
HDR	HDR, Inc.
HELP	Hydrologic Evaluation of Landfill Performance
HUC	Hydrologic Unit Code
ID	identification
IEPA	Illinois Environmental Protection Agency
IPGC	Illinois Power Generating Company
ISGS	Illinois State Geological Survey
K	hydraulic conductivity
Kd	distribution coefficient
Kh/Kv	anisotropy ratio
LCU	lower confining unit
LF1	Phase 1 Landfill
LF2	Phase 2 Landfill
LVW	low volume wastewater
m	meter
mg/L	milligrams per liter
mL/g	milliliters per gram
NAVD88	North American Vertical Datum of 1988
NID	National Inventory of Dams
No.	Number

NPDES	National Pollutant Discharge Elimination System
NPP	Newton Power Plant
NRT/OBG	Natural Resource Technology, an OBG Company
Part 845	Standards for the Disposal of Coal Combustion Residuals in Surface Impoundments: 35 I.A.C. § 845
PAP	Primary Ash Pond
PMP	potential migration pathway
Ramboll	Ramboll Americas Engineering Solutions, Inc
Rapps	Rapps Engineering and Applied Science
RMSE	root mean squared error
SI	surface impoundment
std	standard deviation
TDS	total dissolved solids
TVD	total-variation-diminishing
UA	uppermost aquifer
UCU	upper confining unit
UD	upper drift
USEPA	United States Environmental Protection Agency
USDA/NRCS	United States Department of Agriculture/Natural Resources Conservation Service
USGS	United States Geological Survey

EXECUTIVE SUMMARY

Ramboll Americas Engineering Solutions, Inc. (Ramboll) has prepared this Groundwater Modeling Report (GMR) on behalf of the Newton Power Plant (NPP), operated by Illinois Power Generating Company (IPGC), 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], April 15, 2021). This document presents the results of predictive groundwater modeling simulations for proposed closure scenarios for the Primary Ash Pond (PAP), Vistra identification (ID) number (No.) 501, IEPA ID No. W0798070001-01, and National Inventory of Dams (NID) No. IL50719.

The NPP is located in Jasper County in the southeastern part of central Illinois, approximately seven miles southwest of the town of Newton (**Figure 1-1**). The PAP is located south of the NPP and situated in a predominantly agricultural area. The PAP is surrounded by Newton Lake on the west, south, and east. Beyond the lake is additional agricultural land.

A detailed summary of site conditions was provided in the Hydrogeologic Site Characterization Report (HCR; Ramboll, 2021a). This report integrates existing site data and information with the latest hydrogeology and groundwater quality data to generate a conceptual and numerical model of the PAP. The conceptual site model (CSM) includes hydrogeologic and groundwater quality data specific to the PAP, which has been collected between 2015 and 2021. The PAP is a 9,715 acre-feet earthen berm coal combustion residuals (CCR) surface impoundment (SI) located south of the power plant. In addition to the CCR within the PAP, there are six layers of unlithified material present above the Pennsylvanian-Age bedrock. These materials have been categorized into five hydrostratigraphic units presented below in descending order:

- **Upper Drift (UD)/Potential Migration Pathway (PMP):** The UD is composed of the low permeability silts and clays of the Peoria Silt and Sangamon Soil and the sandier soils of the Hagarstown Member (*i.e.,* PMP).
  - **Hagarstown Member/PMP**: The Hagarstown Member consists of the discontinuous, sandier deposits of the UD where present and overlies the Vandalia Till.
- **Upper Confining Unit (UCU):** The UCU consists of a thick package of low permeability clays and silts of the Vandalia Till. This unit is a laterally continuous layer between the base of the CCR unit and the top of the uppermost aquifer (UA).
- **Uppermost Aquifer (UA)**: The UA is composed of the Mulberry Grove Member, which has been classified as poorly graded sand, silty sand, clayey sand, and gravel.
- **Lower Confining Unit (LCU)**: The LCU is comprised of low permeability silt and clay of the Smithboro Till Member and the Banner Formation.
- **Bedrock Confining Unit (BCU):** The low permeability bedrock underlying the PAP is the Pennsylvanian-Age Mattoon Formation, which consists of a complex sequence of thin limestones, coals, black fissile shales, underclay, thick gray shales, and several well-developed sandstones. The Mattoon Formation has a maximum thickness of more than 600 feet in the central part of the Illinois Basin in Jasper County.

The Cahokia Formation, described in the regional geology of the HCR, occurs in modern river valleys and floodplains. These deposits (which may contain sand, silt, or clay with wood and shell fragments) are expected to occur along the southeastern boundary of the PAP associated with the east branch of Newton Lake and may be difficult to distinguish from the deposits of the UD and the top of the UCU given the observed heterogeneity in the Cahokia, UD, and UCU.

Groundwater migrates downward through the UD and UCU into the UA. Groundwater in the UA flows from north to south/southwest and converges near a former drainage feature located west of the PAP. Groundwater elevations vary seasonally, although generally less than one foot per year. The surface water elevation at Newton Lake (at location SG02) measured between February 15 and March 9, 2021 ranged from 504.42 to 504.84 feet North American Vertical Datum of 1988 (NAVD88). Groundwater elevations in the UA at downgradient wells were observed around 491 feet NAVD88 (approximately 15 feet lower than the lake elevation). The separation between measured groundwater elevations and lake elevations (and observed downward vertical gradients in wells) indicates groundwater does not flow into Newton Lake from the UA. As indicated by the observed heads and groundwater flow directions in the UA, surface water from Newton Lake is entering the UA. The UA also approaches the former land surface east of the PAP, now beneath Newton Lake, as illustrated in geologic cross section B'-B" (Figure 2-7 of the HCR). The CSM for modeling the PAP is as follows:

- Most hydrostratigraphic layers are laterally continuous across the area. The flat to gently rolling uplands are dissected by deeply incised streams (into the materials of the UD, UCU, and UA) that are tributaries to river systems in the area. Cahokia formation deposits are also located within the incised streams. Newton Lake was created by damming one of these tributary streams for use by the NPP. Increased water levels within Newton Lake induced flow of surface water into the UA through discrete and limited areas north and east of the PAP, creating the potentiometric surface observed beneath the PAP.
- The UA is separated from the bottom of the PAP by a minimum of 14 feet of low-permeability glacial till that comprises the UCU. This laterally continuous confining unit is a barrier to vertical migration of groundwater from the PAP to the UA. Erosion caused by incised streams and deposition of Cahokia formation deposits has occurred along the southeast corner of the PAP.
- Groundwater in the UA flows from north to south/southwest and converges near a former drainage feature located west of the PAP.
- Surface recharge and groundwater migrate vertically through the low permeability sediments of the UD and Cahokia deposits. Groundwater migrates horizontally through the higher permeability sediments of the PMP and the UA.
- The UA is heterogenous, with materials ranging from clayey sand to coarse gravels. The highly transmissive sands and gravel are prominent in close proximity to the PAP.
- The separation between measured groundwater elevations and lake elevations (and observed downward vertical gradients) indicates groundwater does not flow into Newton Lake from the UA. The connection between the UA and Newton Lake is spatially discrete and limited to areas northeast of the PAP.
- The PAP is constructed such that the earthen berm and base are in contact with the UCU.
- The stage within the PAP is managed with minimal (less than 3 feet) variability throughout the year.

Groundwater quality parameters were monitored in the shallow sands of the PMP and UA monitoring wells at the PAP as part of the groundwater quality investigations performed between

2015 and 2021. 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 Table 4-1 of the HCR 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: lithium, pH, sulfate, and total dissolved solids (TDS) (Ramboll, 2021b).

Multiple lines of evidence that limited potential GWPS exceedances of pH in the PMP are not related to the PAP are provided in the technical memorandum (**Appendix A**), *Evaluation of Potential GWPS Exceedances* (Golder Associates USA Inc. [Golder], 2022a). Statistically significant correlations between sulfate concentrations and concentrations of lithium and TDS indicate sulfate is an acceptable surrogate for lithium and TDS in the groundwater model. Concentrations of these parameters are expected to change along with model predicted sulfate concentrations.

It was assumed that sulfate would not significantly sorb or chemically react with aquifer solids (distribution coefficient [Kd] was set to 0 milliliters per gram [mL/g]), which is a conservative estimate for estimating contaminant transport times in the model. Lithium, 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).

All available hydrological information were used to construct a CSM and numerical model of the PAP. A steady state, 7-layer numerical model was constructed to characterize the long-term groundwater flow conditions at the site. The hydrostratigraphic units included in the model were the UD, PMP, UCU, UA, and LCU. The BCU was not included in the model. Calibration of the model focused on simulating mean groundwater elevations for 30 wells at the site by modifying hydraulic parameters for the different hydrostratigraphic units, alongside river and general head boundary conductance. The calibrated model represents a reasonable match to the observed head and sulfate concentration data.

The calibrated model was used to predict the sulfate concentration for two closure scenarios described in the Draft Final Closure Plan (HDR, 2022), including:

- **Scenario 1:** closure in place (CIP) including removal of CCR from the southern portion of the PAP, consolidation into the northern portion of the PAP, and construction of a cover system over the remaining CCR, and;
- **Scenario 2:** closure by removal (CBR) including removal of all CCR and regrading of the removal area.
- Prior to the simulation of these scenarios, a dewatering simulation was included which simulated the removal of free liquids from the PAP prior to the implementation of the two scenarios.

Predictive simulations of pond closure indicate simulated groundwater concentrations in the monitoring wells within the two transport zones, namely the UD/PMP and UA, will achieve the GWPS in 20 years and 16 years for the CIP and CBR closure scenarios, respectively. This indicates that both scenarios are predicted to reach the GWPS for the monitoring wells after approximately 20 years; the simulated four-year difference between these two scenarios is not significant. The four-year difference in time to reach the GWPS between CIP and CBR is expected to be further reduced because the estimated duration of construction activities presented in the Draft Closure Alternatives Analysis (Gradient, 2022) indicates CBR will take between 2.6 and 4.9 years longer to complete than CIP.

The prediction simulations indicate that although the groundwater wells reach the GWPS, sulfate remains within the model beyond 100 years. This is due to the sulfate mass retained within the thick UCU which underlies the PAP. The low vertical hydraulic conductivity of this thick unit leads to low flow rates through the unit which will require time to release the sulfate mass. However, in both the CIP and CBR scenarios, the plume footprint continues to recede with time and remains within the property boundaries, indicating these closure options are equally protective.

Results of groundwater fate and transport modeling conservatively estimate that groundwater concentrations will attain the GWPS for all constituents identified as potential exceedances of the GWPS in the UD/PMP and UA monitoring wells within 20 years of closure implementation for both CIP and CBR. Within the property boundary, residual sulfate will be present within the clay confining unit above the GWPS due to the slow release of sulfate from the UCU.

1. INTRODUCTION

1.1 Overview

In accordance with the requirements of Part 845 (IEPA, 2021), Ramboll has prepared this GMR on behalf of the NPP, operated by IPGC. This report applies specifically to the CCR unit referred to as the PAP. However, information gathered to evaluate other CCR units in the vicinity regarding geology, hydrogeology, and groundwater quality is included, where appropriate. This GMR presents and evaluates the results of predictive groundwater modeling simulations for two proposed closure scenarios: 1) CIP and 2) CBR.

1.2 Previous Groundwater Reports

Numerous hydrogeologic investigations have been performed at the NPP. The information presented in this GMR includes data collected as part of a 2021 field investigation and previous investigations summarized and presented in the HCR (Ramboll, 2021a) which was provided as an attachment to the initial operating permit application required by 35 I.A.C. § 845.230.

1.3 Site Location and Background

The NPP is located in Jasper County, Illinois approximately 7.5 miles southwest of the town of Newton. The PAP is located in Section 26 and the western half of Section 25, Township 6 North, Range 8 East (**Figure 1-1**). The PAP is located south of the power plant and situated in a predominantly agricultural area. The PAP is surrounded by Newton Lake on the west, south, and east. Beyond the lake is additional agricultural land. The region is characterized by relatively flat to gently rolling topography.

1.4 Site History and CCR Units

Three CCR units are present on the NPP property, including the PAP and two landfills: the Phase 1 Landfill (LF1) is located northwest and west of the PAP, and the Phase 2 Landfill (LF2) is located west of the PAP (**Figure 1-2**). The PAP was constructed in 1977 and has a design capacity of approximately 9,715 acre-feet. There is also a non-CCR 83.6 acre-feet Secondary Pond located immediately south of the PAP. The PAP has a surface area of 404 acres and the Secondary Pond has an area of 9.3 acres. The PAP currently receives stormwater runoff, bottom ash, fly ash, and low-volume wastewater (LVW) from the plant's two coal-fired boilers. The PAP is operated per National Pollutant Discharge Elimination System (NPDES) Permit No. IL0049191, Outfall 001 (located at the Secondary Pond).

Prior to PAP construction, an incised stream gully existed at the site of the PAP. Areas within the impoundment were excavated during construction for native materials used to build the containment berms (AECOM, 2016).

2. SITE GEOLOGY AND HYDROGEOLOGY

The geology and hydrogeology of the PAP is described in detail in the HCR (Ramboll, 2021a). A short summary is provided below.

2.1 Stratigraphy

The unlithified stratigraphy within and immediately surrounding the PAP consists of the following in descending order: fill material and CCR; silt and clayey silt loess (Peoria Loess); weathered till of the Sangamon Soil; discontinuous gravel and sand (Hagarstown Member), sandy/silty till with discontinuous lenses of sand and gravel (Vandalia Till); sands of the UA (Mulberry Grove Member); and clay till (Smithboro Till and Banner Formation) (Rapps Engineering and Applied Science [Rapps], 1997). The Cahokia Formation, described in the regional geology of the HCR, occurs in modern river valleys and floodplains. These deposits (which may contain sand, silt, or clay with wood and shell fragments) are expected to occur along the southeastern boundary of the PAP associated with the east branch of Newton Lake and may be difficult to distinguish from the deposits of the UD and the top of the UCU given the observed heterogeneity in the Cahokia, UD, and UCU. Unlithified units overlay Pennsylvanian-age shaley bedrock (Mattoon Formation).

CCR is present within most of the PAP at thicknesses between 17 to 19.5 feet thick as observed in porewater wells XPW01 through XPW04. The lowest bottom of ash elevation observed is approximately 486 feet in the center of a former drainage feature oriented north-south through the center of the PAP, whereas ash is potentially highest in elevation at approximately 550 feet along the outer edges of the PAP. The bottom of ash surface appears to mirror the former drainage feature. Comparison of the bottom of ash contours and topographic contours indicate CCR fill may be 40 feet or greater within the former drainage feature.

The Peoria Silt and Sangamon Soils extends from beneath the topsoil to depths ranging from 3 to 46 feet. The Peoria Silt and Sangamon Soils consist predominantly of low permeability lean clay.

The Hagarstown Member of the Pearl Formation underlies the Peoria Silt and Sangamon Soils. This is a discontinuous sandy unit composed of poorly graded sand with silt, with thicknesses up to approximately 7 feet but generally the thickness is less than 2 feet.

The Hagarstown Member is generally underlain by a relatively thick till sequence consisting of the Vandalia Till. The till sequence is encountered at thicknesses up to 59 feet in the area of the PAP, while the average thickness is 26 feet. This thick glacial deposit is laterally continuous beneath the NPP. The Vandalia Till primarily consists of lean clay and silty clay. Alluvial deposits belonging to the Cahokia Formation, which is a Holocene stage deposit in floodplains and channels of modern rivers and streams are expected to occur along the southeastern corner of the PAP. Generally, the Cahokia Formation consists of poorly sorted sand, silt, and clay with wood and shell fragments with local deposits of sandy gravel which is similar in composition to the deposits that comprise the UD and UCU.

The Mulberry Grove Member is a thin to moderately thick (3 to 17 feet) unit composed of silty sand, poorly graded sand with silt and well graded sand with silt. The Mulberry Member generally slopes from approximately 483 feet NAVD88 in the northeast portion of the PAP to 462 feet NAVD88 in the southwest portion of PAP. The maximum observed thickness of this member was 30 feet, while the average thickness is approximately 10 feet.

Till sequences underlying the Mulberry Grove Member consist of clay and silt of the Smithboro Till Member and Banner Formation. These laterally continuous till units are encountered at thicknesses up to 36 feet, while the average thickness is 32 feet. The till sequences are typically composed of lean clay and silty clay.

The Pennsylvanian Age Mattoon Formation consists of a complex sequence of thin limestones, coals, black fissile shales, underclays, thick gray shales, and several well-developed sandstones. The bedrock is dipping to the southwest at the site.

2.2 Hydrogeology

Five distinct hydrostratigraphic units have been identified at the site based on stratigraphic relationships and common hydrogeologic characteristics, which are summarized below:

- **UD/PMP:** this unit includes the lower permeability silts and clays of the Peoria Silt and Sangamon Soil, and the sandier soils of the Hagarstown Member (*i.e.,* PMP). These units are hydraulically connected and underlain by a thick till sequence of Vandalia Till.
- **UCU:** underlying the UD till sequence, the laterally continuous low permeability silts and clays of the Vandalia Till and Cahokia Formation are 26 feet thick on average.
- **UA:** this unit consisting of sands and gravels of the Mulberry Grove Formation is on average 10 feet thick and can be up to 30 feet thick. These sandy deposits are the first laterally continuous sands observed beneath the PAP.
- **LCU:** underlying the UA are the low permeability silts and clays of the Smithboro Till and the Banner Formation. This unit is approximately 5 to 36 feet thick.
- **BCU:** The low permeability bedrock underlying the PAP is the Pennsylvanian Age Mattoon Formation, which consists of a complex sequence of thin limestones, coals, black fissile shales, underclays, thick gray shales, and several well-developed sandstones. The Mattoon Formation has a maximum thickness of more than 600 feet in the central part of the Illinois Basin in Jasper County.
- Holocene alluvial deposits of the Cahokia formation are expected to replace UD and UCU deposits along the southeastern boundary of the PAP.

2.2.1 Groundwater Flow

Monitoring well locations are illustrated in **Figure 2-1**. The elevations of water within the PAP (as observed in XPW01 through XPW04 and XSG01) are greater than the surrounding areas (**Figures 2-2** and **2-3**). The phreatic surface within the PAP between February and August 2021 averaged 542 feet NAVD88, ranging from 546.69 feet NAVD88 in XPW02 (located along the northern portion of the PAP) to 535.40 feet NAVD88 in XSG01 (located along the southern portion of the PAP). Groundwater elevations in PMP wells are above those in the UA and range from approximately 518 feet NAVD88 (APW05S) to 535 feet NAVD88 (APW05S).

Groundwater flow in the UA is generally from north to south. However, the UA wells also display flow converging towards a former surface drainage feature located west of the PAP (**Figure 2-2** and **Figure 2-3**) and an area where the UA has the greatest thickness. Groundwater elevations vary seasonally, generally less than one foot per year, while across the PAP they range from approximately 490 to 530 feet NAVD88, although flow directions are generally consistent.

2.2.2 Hydraulic Properties

Hydraulic field tests were conducted on multiple wells within the CCR, UD, PMP, and UA at NPP and are summarized below:

- Hydraulic properties for the CCR ranged from 1.0 x 10^{-3} to 2.3 x 10^{-1} centimeters per second (cm/s) (2.8 to 652 feet per day [ft/d]), with a geometric mean hydraulic conductivity of 2.0 x 10^{-2} cm/s (56.7 ft/d), based on hydraulic tests on four wells.
- Hydraulic field tests conducted on three wells provided hydraulic properties of the UD unit, which ranged from 5.14 x 10^{-6} to 4.53 x 10^{-5} cm/s (0.01 to 128.4 ft/d) with a geometric mean of 1.5 x 10^{-5} cm/s (0.04 ft/d).
- Hydraulic properties for the PMP ranged from 6.1 x 10^{-4} to 1.5 x 10^{-2} cm/s (1.7 to 42.5 ft/d) with a geometric mean hydraulic conductivity of 3.1 x 10^{-3} cm/s (8.8 ft/d), based on hydraulic tests on two wells.
- Hydraulic properties for the UA ranged from 2.0 x 10^{-4} to 1.5 x 10^{-1} cm/s (0.57 to 425.0 ft/d) with a geometric mean of 6.8 x 10^{-3} cm/s (19.3 ft/d), based on field tests conducted on seven wells.

The absence of wells screened within the UCU, LCU, and BCU at the NPP means that no field based hydraulic data are available for these units.

Additional laboratory analysis of samples from the CCR, UD, PMP, UCU, UA, and LCU provided vertical hydraulic conductivities summarized below:

- Laboratory falling head permeability test results for the six CCR samples indicated a geometric mean vertical hydraulic conductivity of 3.1 x 10^{-4} cm/s (0.88 ft/d) with a range of 1.6 x 10^{-5} to 1.3 x 10^{-3} cm/s (0.05 to 3.7 ft/d).
- Laboratory falling head permeability test results in the UD indicated a geometric mean vertical hydraulic conductivity of 5.9 x 10^{-8} cm/s (0.0002 ft/d) and ranged from 3.1 x 10^{-8} to 8.6 x 10^{-8} cm/s (0.0001 to 0.00024 ft/d). These values are less than previous samples collected in 2017, with a geometric mean hydraulic conductivity of 1.3 x 10^{-5} cm/s (0.04 ft/d) (Natural Resource Technology, an OBG Company [NRT/OBG], 2017).
- Laboratory falling head permeability test results from three samples collected from the Hagarstown Member (i.e., PMP) within the UD, indicated a geometric mean vertical hydraulic conductivity of 3.5 x 10^{-5} cm/s (0.1 ft/d) and ranged from 1.1 x 10^{-7} to 9.6 x 10^{-5} cm/s (0.0003 to 0.27 ft/d).
- Laboratory falling head permeability test results from four samples collected from the Vandalia Till indicated that the UCU has a geometric mean vertical hydraulic conductivity of 6.7 x 10^{-8} cm/s (0.0002 ft/d) and ranged from 3.3 x 10^{-8} to 9.7 x 10^{-8} cm/s (0.0001 to 0.0003 ft/d).
- Laboratory falling head permeability test results from five samples collected from the Mulberry Grove Formation indicated that the UA has a geometric mean vertical hydraulic conductivity of 3.2 x 10^{-4} cm/s (0.9 ft/d) and ranged from 3.5 x 10^{-6} to 7.2 x 10^{-4} cm/s (0.01 to 2.04 ft/d) (NRT/OBG, 2017).
- Laboratory falling head permeability test results from eight samples collected from the glacial tills of the Smithboro Till indicated a geometric mean vertical hydraulic conductivity of 9.3 x 10^{-8} cm/s (0.0003 ft/d) and ranged from 2.4 x 10^{-8} to 2.7 x 10^{-7} cm/s (0.0001 to 0.0008 ft/d).

2.2.3 Groundwater Elevation Data

There are 30 wells located around the PAP with most wells located adjacent to the perimeter of the PAP. In most of these wells, water level measurements are available from 2015 to 2021. The well construction details are summarized in **Table 2-1** and groundwater elevation readings are summarized in **Table 2-2**. The observed range in groundwater elevation (GWL) within the PMP wells data set is 17.3 feet and 44.3 feet in the UA wells. For all wells, the mean variation in GWL within each well is 0.8 feet (mean GWL variation), with an observed minimum and maximum variation of 0.2 and 2.5 feet, respectively. The UA approaches the former land surface, now beneath Newton Lake, northeast of the PAP. The UA may intersect the base of Newton Lake allowing groundwater within the UA to mix with surface water from the lake, upgradient of the PAP. Groundwater flow in the UA generally flows southwest across the PAP with potentiometric surface elevations at downgradient wells around 491 feet NAVD88 (approximately 15 feet lower than the Newton Lake elevation). The elevation of water in Newton Lake ranges from 504.42 to 504.84 feet NAVD88. This separation in groundwater and lake elevations (and observed downward vertical gradients) indicates groundwater within the UA does not flow into Newton Lake.

2.2.4 Mining Activity

The areas immediately surrounding the facility have never been mined. Based on the directory of coal mines for Jasper County (Illinois State Geological Survey [ISGS], 2021), the nearest coal mines in the vicinity of the PAP are located approximately 6.7 miles to the northeast.

3. GROUNDWATER QUALITY

3.1 Groundwater Classification

Per 35 I.A.C. § 620.210, groundwater within the UA at the PAP meets the definition of Class I – Potable Resource Groundwater based on the following criteria:

- Groundwater is located more than 10 feet below ground surface (bgs) and within an unconsolidated silty sand and gravel unit which is five feet or more in thickness.
- Hydraulic conductivity exceeds the 1 x 10^{-4} cm/s criterion.
- Groundwater is not downgradient of or underlying previously mined out areas.

Testing of the unconsolidated materials of the Mulberry Grove Member averaged 21 percent fines, which is greater than the 12 percent fines criterion; however, this was not deemed prohibitive of the Class I Classification (Ramboll, 2021a).

3.2 Potential Groundwater Exceedances

There are potential groundwater exceedances of applicable GWPS attributable to the PAP as described below. Groundwater concentrations from 2015 to 2021 are presented in the HCR Table 4-1 (Ramboll, 2021a), were evaluated and summarized in the History of Potential Exceedance tables (Ramboll, 2021b), and are considered potential exceedances because the methodology used to determine them is proposed in the Statistical Analysis Plan (Appendix A to GMP; Ramboll, 2021c), which has not been reviewed or approved by IEPA at the time of submittal of 35 I.A.C. § 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:

- Lithium – UD well APW02;
- pH – UD wells APW04 and APW12;
- Sulfate – UA well APW10 and UD wells APW02 and APW04; and
- TDS – UD wells APW02, APW04, and AP05S

Multiple lines of evidence that limited potential GWPS exceedances of pH are not related to the GMF Pond is provided in the *Evaluation of potential GWPS Exceedances* (**Appendix A**, Golder, 2022a) and summarized below:

- The pH of CCR porewater is significantly higher than the pH in monitoring wells APW04 and APW12.
- The pH ranges recorded in the PMP are likely naturally occurring.

Since potential GWPS exceedances for pH are not related to the Ash Pond, these parameters will not be discussed further in this GMR.

4. GROUNDWATER MODEL

4.1 Overview

Data collected at the Site from 2004 to the recent 2021 field investigation were used to construct a groundwater model of the PAP. The model was then used to evaluate how the proposed closure options (CIP and CBR) would achieve compliance with the applicable groundwater standards following the closure construction. The modeling results are summarized and evaluated in this GMR. The associated model files are included as **Appendix B**.

4.2 Conceptual Model

The HCR (Ramboll, 2021a) forms the foundation of the PAP hydrogeological setting. The PAP overlies the recharge area for the underlying transmissive geologic media, which are composed of unlithified deposits.

4.2.1 Hydrogeology

As discussed in **Section 2.2**, groundwater flow around the PAP is generally in a southwest direction. The silts of the UD and sands of the PMP are hydraulically connected. The groundwater flow in the silts and clays of the UD and confining units of the UCU, LCU, and BCU are expected to be primarily vertical. The Hagarstown member PMP and sands of the UA are where the majority of the horizontal migration is expected to occur. The geological conceptual model for the site consists of the following layers:

- Silts and Clays (UD) – silt and clayey silt of the Peoria Silt and Sangamon Soil which extends beneath the topsoil.
- Discontinuous sands (PMP) - sandier soils of the Hagarstown Member.
- Vandalia Till (UCU) – a thick layer of low permeability till consisting of the Vandalia Till.
- Sands (UA) – sands and gravels of the Mulberry Grove Formation, laterally continuous sand and gravel deposit identified beneath the site.
- Smithboro Till (LCU) – composed of lean clay Smithboro Till and Banner Formation.
- BCU – lowermost unit identified at the site and underlies all unlithified deposits. This unit, composed of low permeability shale of the Mattoon Formation.
- Alluvial deposits of the Cahokia formation may replace UD and UCU deposits along the southeastern boundary of the PAP.

Surfaces for each of the six major geological units (Silts/Clays, discontinuous sand, Vandalia Till, shallow sand, Smithboro Till and Bedrock) were made by interpolating contacts between the units interpreted from boring logs. Alluvial deposits of the Cahokia formation were represented by zones within the horizontal layers of the major geologic units. Boring log information is centered around the pond and CCR units; the surfaces were extended to the full model domain by extrapolation and verified with off-site well logs, where available.

4.2.2 Extent and Boundaries

The United States Geological Survey (USGS) National Map places the NPP within the upper Illinois-Little Wabash watershed subbasin (Hydrologic Unit Code [HUC] 05120114).

The PAP CSM extent is bounded by a hydrological catchment (watershed) divide to the east based on watershed data from USGS. Along the north, south, and east the model boundary has been placed along known waterbodies as much as possible. As such, it is assumed groundwater inflow from adjacent watersheds is negligible through both the UA and LCU.

The Newton Lake water levels are managed such that they remain at an elevation between 504.23 and 504.82 feet NAVD88. Newton Lake is the receiving body of water for surface water in the area encompassed by the CSM.

Infiltration of precipitation to the groundwater table is applied as recharge at the site. Groundwater in the UD migrates downward into the discontinuous sands of the Hagarstown Formation. As discussed in **Section 2.2.1**, the Hagarstown Formation is considered a PMP for groundwater adjacent to the PAP. The sands of the UA are separated from the Hagarstown Formation PMP and the base of ash in the PAP by the laterally continuous UCU. The UA receives water from connection with Newton Lake.

4.2.3 Primary Ash Pond

The PAP is constructed with an earthen berm which acts as a low permeability interface between the CCR contained within the PAP and the ambient groundwater system. Findings from the HCR (Ramboll, 2021a) indicate that the PAP does not appear to impact groundwater flow directions in the UA via recharge to groundwater. The PAP does influence the shallower UD/PMP flow system, where there is a component of radial flow from the pond to the thin Hagarstown Formation.

Sulfate was selected for transport modeling. Sulfate is commonly used as an indicator parameter for contaminant transport modeling for CCR because: (i) it is commonly present in coal ash leachate; and (ii) it is mobile and typically not very reactive but conservative (*i.e.*, low rates of sorption or degradation) in groundwater.

4.3 Model Approach

Comparisons of observed lithium and TDS concentrations to sulfate (Figure A and Figure B, respectively, below) indicate statistically significant correlations between these parameters in UD wells where these potential exceedances were observed. 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 and Figure B. 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 correlations are strongest between sulfate and TDS. The statistically significant correlations associated with sulfate concentrations indicate sulfate is an acceptable surrogate for lithium and TDS in the groundwater model, and concentrations of these parameters are expected to change along with model predicted sulfate concentrations.

Figure A. Sulfate Correlation with Lithium in UD Wells

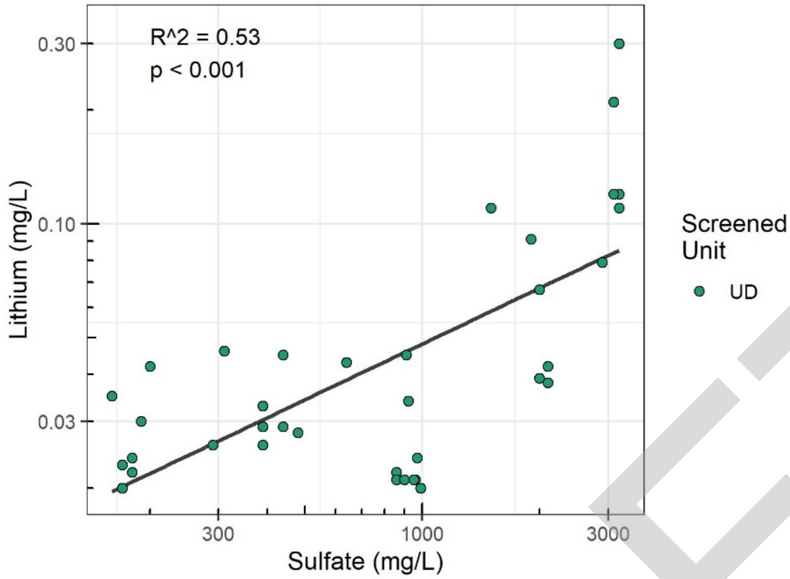
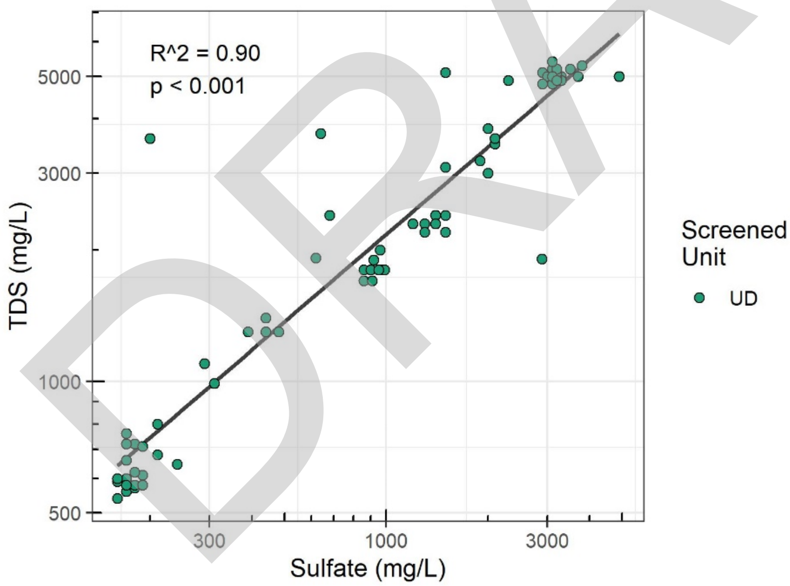


Figure B. Sulfate Correlation with TDS in UD Wells



A three-dimensional groundwater flow model was calibrated to represent the conceptual flow system described above. A steady state model was used to simulate the mean groundwater flow conditions at the site. The model was calibrated to match mean groundwater elevations observed between 2015 to 2021 (**Table 2-2**). Prediction simulations were then performed to evaluate the potential impacts to groundwater from CIP as presented in the *Draft Final Closure Plan for the PAP, Newton Power Plant* (HDR, 2022) which is an appendix to the Construction Permit Application to which this report is also attached. **Figure 4-1** shows the calibration and predictive modeling timeline.

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) was modeled using the results of the Hydrologic Evaluation of Landfill Performance (HELP) model.

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 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 since. 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 PAP. 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) completed for the groundwater model were used to estimate the hydraulic flux from beneath the PAP.

5.2 Flow and Transport Model Setup

The modeled area was approximately 7,900 feet by 9,950 feet (382,955,000 square feet [ft^2]) with the PAP located in the southern quadrant (**Figure 5-1**). The model boundaries along the northern, southern and eastern edges of the model were selected to maintain sufficient distance from the PAP to reduce boundary interference with model calculations, while not extending too far past the extent of available calibration data. The east and west edges of the model also approximate topographic highs, surface water divides, watershed boundaries.

The MODFLOW model was calibrated to mean groundwater elevation collected from 2015 to 2021 presented in **Table 2-2**. MT3DMS was run on the calibrated flow model and model-simulated concentrations were calibrated to observed sulfate concentration values at the monitoring wells from March to July 2021 presented in **Table 2-2**. Multiple iterations of MODFLOW and MT3DMS calibration were performed to achieve an acceptable match to observed flow and transport data. For the PAP, the calibrated flow and transport models were used in predictive modeling to evaluate the CIP and CBR closure scenarios. Prior to simulation of CIP and CBR, a dewatering phase, which simulated the removal of free liquid from the CCR material in the PAP was completed. Closure scenarios were simulated by removing saturated ash cells and using HELP modeled recharge values to simulate changes proposed in the closure scenarios.

5.2.1 Grid and Boundary Conditions

A seven-layer, 451 x 508 node grid was established with a variable grid spacing of between 25 and 100 feet (**Figure 5-2 through Figure 5-8**), with a total number of 1,546,703 active cells. The grid is rotated 25 degrees to the east to align the model boundary with the orientation of Newton Lake and Sandy Creek.

The northern boundaries for layers 1, 2, 3, and 4 are general head boundaries placed to simulate flow in the Peoria Silt, Sangamon Soil, and sandier soils of the Hagarstown Member composing the UD, PMP, and UCU. The general head boundaries along the northern and southern model boundaries for layer 6 represents the regional flow conditions within this unit. The eastern and western edges are no flow boundaries in all model layers.

Newton Lake is represented as a constant head boundary based on a reasonably constant surface water elevation measured from February 15 to March 9, 2021 of between 504.42 to 504.84 feet NAVD88. The constant head boundary was simulated with an elevation equal to 504.6 feet. The lake is in hydraulic connection with multiple layers within the model.

The bottom of the model was also a no-flow boundary. The top of the model was a time-dependent specified flux boundary, with specified flux rates equal to the recharge rate. A specified mass flux boundary was used to simulate downward percolation of solute mass from the PAP. This boundary condition assigns a specified concentration to recharge water entering the cells within the PAP, and the resulting concentration in the PAP cells is a function of the relative rate and concentration of recharge water (water percolating from the impoundments) compared to the rate and concentration of other water entering the node.

Natural (streams) drainage features are present in the modeled area; these are represented as rivers and drains depending on available information in the model.

5.2.2 Flow Model Input Values and Sensitivity

Evaluation of monitoring well data for the PAP has not identified statistically significant seasonal trends in groundwater flow or quality which could affect model applicability for prediction of transport. The MODFLOW model was calibrated to mean groundwater elevations from 2015 to 2021. Multiple iterations of MODFLOW calibration were performed to achieve an acceptable match to observed flow data.

Sensitivity analysis was conducted by changing input values and observing changes in the sum of squared residuals (SSR). Horizontal conductivity, vertical conductivity, and river and general head conductance terms were all varied by one order of magnitude (*i.e.*, between one-tenth and ten times) of the calibrated values. Recharge terms were varied between one-half and two times calibrated values. River stage and drain bottom elevations were obtained from the 10 meter (m) Digital Elevation Model (DEM) from the United States Department of Agriculture/Natural Resources Conservation Service National Geospatial Center of Excellence (USDA/NRCS, 2022). The vertical error of the 10 m DEM is 0.82 m (2.7 feet); therefore, the stream stage and drain bases were varied by adding and subtracting 2.7 feet. General head boundary head terms were varied between 90 and 110 percent of calibrated values. When the calibrated model was tested, the SSR was 794. Sensitivity test results were categorized into negligible, low, moderate, moderately high, and high sensitivity based on the change in the SSR as summarized in the notes in **Table 5-1**.

5.2.2.1 Layer Top/Bottom

A digital elevation model of the area was used to assign the top of layer one. The elevations for the base of each hydrostratigraphic layer were interpolated from boring log data primarily from logs provided in the HCR (Ramboll, 2021a) utilizing Surfer® software for each of the six distinct water-bearing units described in **Section 2** (excluding the BCU). The resulting surfaces were imported into MODFLOW. The silts, clays, and sands of the UD unit (Peoria Silt, Sangamon Soil and Hagarstown Member) were divided into three layers to accommodate the explicit inclusion of the PAP ash deposits and the PMP. The thick UCU comprised of Vandalia Till was divided into two layers for contaminant transport; the Mulberry Grove Formation and Smithboro Till were represented as single layers within the model. **Figures 5-9** to **Figure 5-15** show the seven model layer elevations. 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. Flow model layer descriptions are summarized in **Table A** below.

Table A. Flow Model Layer Descriptions

Layer	Hydrostratigraphic unit name	Hydrostratigraphic unit used to determine layer thickness	Top Elevation [1]	Bottom Elevation [1]	Thickness (feet)
			Mean (Minimum – Maximum)		
1&2	UD	Silty clay and clay	535.6 (503.71-564.0)	511.1 (472.0-532.5)	24.5 (4.0-76.4)
3	PMP	Sand, silty clay, and clay	511.1 (472.0-532.5)	508.8 (470.0-530.1)	2.3 (2.0-25.56)
4&5	UCU	Silts and lean clays of the Vandalia member	508.8 (470.0-530.1)	472.0 (425.4-486.9)	36.8 (10.7-57.6)
6	UA	Sands and gravels within silty clay	472.0 (425.4-486.9)	465.3 (418.1-483.9)	6.7 (2.0-29.9)
7	LCU	lean clays of the Smithboro Till	465.3 (418.1-483.9)	438.3 (412.2-458.1)	26.9 (5.9-37.8)

Notes:
[1] Elevation is measured in feet, referenced to NAVD88.

5.2.2.2 Hydraulic Conductivity

Hydraulic conductivity values and sensitivity results are summarized in **Table 5-1.** The spatial distribution of the hydraulic conductivities within the UD, UCU, and LCU was considered homogenous. A zone representing the Cahokia deposits was included in UCE layers 4 and 5. The hydraulic properties of this zone is equivalent to those of the rest of the UCU, this zone is discussed further in **Section 5.2.3.5**. In both the PMP and UA layers (model layers 3 and 6, respectively), well log data indicated the presence of silt, sand, and gravel lenses. These were included in the model as zones within these two layers. The spatial extent of these zones was determined using well log data for areas of silt within the PMP, and silt/sand and gravel within the UA. Hydraulic properties within these zones do not vary. **Figures 5-16 through 5-22** show the spatial distribution of the hydrostratigraphic units, PAP and other units on site for each of the seven model layers.

Where available, hydraulic conductivity values were derived from field measured or laboratory tested values reported in the HCR (Ramboll, 2021a) (**Section 2.2.2**). No horizontal anisotropy was assumed. Vertical anisotropy was applied to conductivity zones to simulate preferential flow in the horizontal direction in these materials, and are presented as anisotropy ratio (Kh/Kv) in **Table 5-1**.

The model was highly sensitive to changes in horizontal conductivity in UD (zone 1), UD-PMP sand (zone 5), UA (zone 7), UA-gravel (zone 9), and moderately high sensitivity to the sand deposit in the UA (zone 8). The calibrated model has low to moderate sensitivity to horizontal conductivity in the remaining hydrostratigraphic units. The model was highly sensitive to changes in the vertical conductivity in the UD (zone 1), and the UCU and UCU-Cahokia (zone 6 and 11, respectively). The model had a moderately high sensitivity to changes in vertical conductivity in the UA (zone 7) and the sand deposit in the UA (zone 8), and moderate sensitivity to changes in vertical conductivity in UD-PMP sand (zone 5) and UA-gravel (zone 9). The UD fill (zone 2), CCR (zone 3), UD-PMP (zone 4), and LCU (zone 10) exhibited low sensitivity.

5.2.2.3 Recharge

Recharge rates were determined through calibration of the model to observed groundwater elevations. For the calibration model, recharge was applied to the upper most active layer and the rates varied based on different units, namely the PAP, LF1, LF2, Secondary Pond, NPP, and Cooling Pond. Model inputs are summarized in **Table 5-1**. The distribution of recharge is show in **Figure 5-23**.

The calibrated flow model is highly sensitive to recharge to the PAP, moderately sensitive to recharge to the UD, and has negligible sensitivity to all other zones within the model (**Table 5-1**).

5.2.2.4 Storage and Specific Yield

The flow calibration model did not use these terms because it was run at steady state. For the transport model, which was run as a transient simulation, 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 General Head Boundary Parameters

General head boundary conditions (GHB) were used along the northern boundary of the model for layer 1 through 4 and layer 6. GHB were also used along the southern boundary for layer 6 only (**Figures 5-2** to **5-7**). The GHB at the northern limit of the model in layers 1 through 4 was used to simulate groundwater flow into the model via the UD, PMP, and UCU. The UCU was included in the GHB due to its hydraulic connection to Newton Lake even though it has a low hydraulic conductivity. The groundwater levels used for the northern boundary of the model in layers 1 through 4 were estimated using the Dupuit equation for steady state flow in an unconfined aquifer with recharge.

The DEM of the site provided estimates of the surface water levels for Newton Lake on the east of the model domain (504.6 feet) and the Sandy Creek (525 feet) located 6,500 feet west of Newton Lake. The calibrated ambient recharge to the UD was used in the calculation of the groundwater level distribution at the northern boundary. The hydraulic conductivity value K used in the Dupuit equation was estimated during model calibration.

This GHB was only applied to cells along the northern boundary where the base of the cell was below the calculated groundwater head for a given distance from the constant head boundaries, the head was determined by the Dupuit equation. Cell conductance was then calculated using the calibrated hydraulic conductivity and the cells' saturated thickness and cell width.

The CSM for NPP (layer 6) describes a potential hydraulic connection between the UA and either Big Muddy Creek or Newton Lake dam, both of which are located approximately 14,000 feet southwest of the model domain. The elevation of both Big Muddy Creek and Newton Lake dam at this distance is approximately 460 feet. Therefore, the GHB elevation and distance at the southern limits of the model in the UA was set to 460 feet and 14,000 feet. The conductance was determined using the cells calibrated hydraulic conductivity, cell width and thickness (cells were assumed to be fully saturated).

The GHB elevation for northern boundary in the UA was established during calibration (**Table 5-1**). The distance to the GHB head was set to 1, and the GHB conductivity was calculated using the cell width, cell thickness, and calibrated hydraulic conductivity from the model.

The sensitivity to changes in specified head was negligible to moderate for both the northern GHB in layer 1-4, and in the UA (layer 6), and high for the southern GHB in the UA. The flow calibration model had low sensitivity to changes in the conductance for both the northern GHBs (layer 1-4 and layer 6), and high sensitivity in the southern GHB in layer 6 (UA).

5.2.2.6 River Parameters

The Cooling Flume transports water from the Cooling Pond north of the PAP to Newton Lake. The flume consists of three sections, where the surface water elevation is controlled via weirs with decreasing elevation as the flume approaches Newton Lake. The most upstream section is maintained at 530.98 feet, the intermediate section has a surface water elevation of 515.66 feet, and the surface water elevation in the final section is maintained at 499.0 feet. Sandy Creek is the primary natural surface water feature which discharges into Newton Lake west of the PAP.

Both the Cooling Flume and Sandy Creek are included in the model as head dependent flux boundaries that required inputs for elevation of the surface water, bottom of the stream, width, bed thickness, and bed hydraulic conductivity (**Table 5-1**). A total of three river reaches are included in the model; in the absence of river geometry information the DEM was used to estimate stream stage at the upstream and downstream limits of each reach. For Sandy Creek the slope of the river was then linearly interpolated along the reach, providing an estimation of stream stage along the length of each reach for each model grid cell though which the river flows. Bed thickness was set at 1 foot and river width was set at 10 feet.

The width of the Cooling Flume (approximately 32 feet) is larger than the grid cell dimensions (25 feet by 25 feet), therefore the conductance term for the Cooling Flume was based on the area of the cells which coincide with the flume. The DEM provided surface water elevation estimations of the three sections of the Cooling Flume, and the bed thickness was set to 1 foot.

River width, bed thickness, and bed hydraulic conductivity parameters were used to calculate a conductance term for the river cells. This conductance term was determined by adjusting hydraulic conductivity during model calibration.

The river boundaries were placed in layers 1 through 4, corresponding with simulated river elevation and base of the river (**Figure 5-2 through Figure 5-5**).

The calibrated flow model has negligible sensitivity to changes in either river stage or conductance.

Table B. River and Drain Information

Name	Boundary Type	Length (feet)	Slope (ft/ft)
Cooling Flume	River	7891.0	-
Sandy Creek	River	13082.7	-0.0019
Sandy Creek Tributary 1	Drain	2420.5	-0.0076
Sandy Creek Tributary 2	Drain	6326.4	-0.0038
Sandy Creek Tributary 3A	Drain	4359.1	-0.0015
Sandy Creek Tributary 3B	Drain	4088.8	-0.0058
Landfill Stream	Drain	2706.7	-0.0057
PAP Stream	Drain	5658.5	-0.0038
PAP drain north	Drain	2055.2	-0.0102
Newton Lake Tributary 1	Drain	6854.6	-0.0057
Newton Lake Tributary 2	Drain	3414.8	-0.0083
Newton Lake Tributary 3	Drain	2369.0	-0.0090
Newton Lake Tributary 4	Drain	1603.0	-0.0029
Newton Lake Tributary 5	Drain	2448.4	-0.0078
Newton Lake Tributary 6	Drain	2556.7	-0.0107
Newton Lake Tributary 7	Drain	3002.7	-0.0061
Tributary South 1	Drain	1839.0	-0.0021
Tributary South 2	Drain	4364.0	-0.0041
Tributary South 3	Drain	1200.9	-0.0083
PAP drain north	Drain	2051.2	-0.0137

Notes:
ft/ft = feet per foot

5.2.2.7 Drains

The model contains numerous small tributaries which discharge into both Sandy Creek and Newton Lake. Limited hydrological data are available for these surface water features; therefore, it is uncertain how these interact with the groundwater levels. However, these features are all first-order streams (or headwater streams) and therefore it is highly likely that they are fed by a combination of groundwater discharge and surface runoff (Horton, 1945). Therefore, these streams are included in the model as head dependent flux boundaries (drain) that required inputs for elevation of the bottom on the stream, width, bed thickness, and bed hydraulic conductivity (**Table 5-1**). By using the drain head-dependent flux boundary it is assumed that these streams only act as groundwater discharge features and makes the fewest assumptions regarding stream geometry.

A total of 18 drain reaches are included in the model. In the absence of river geometry information the DEM was used to estimate stream stage at the upstream and downstream limits of each reach. The slope of the river was then linearly interpolated along the reach, which provided an estimate of stream stage along the length of each reach for each model grid cell though which the stream flows.

The drain boundaries were placed in layers 1 through 4 corresponding with simulated drain depth (**Figure 5-2 through Figure 5-5**).

The calibrated flow model has negligible to low sensitivity to both drain elevation and conductance for most drains. Only the Landfill drain (reach 6) had moderate sensitivity to drain elevation.

5.2.3 Transport Model Input Values and Sensitivity

MT3DMS input values are listed in **Table 5-2** and described below. Sensitivity of the transport model is summarized in **Table 5-3**.

Groundwater transport was calibrated to groundwater sulfate concentration ranges at each well as measured from the monitoring wells between 2015 (where available) and 2021. The transport model calibration targets are summarized in **Table 2-2**.

Sensitivity analysis was conducted by changing input values and observing percent change in sulfate concentration at each well from the calibrated model sulfate 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. Dispersivity in the Cahokia Alluvium was varied by decreasing and increasing calibrated model dispersivity by 50 percent. The transport model had a negligible sensitivity to changes in storage and specific yield (**Table 5-3**). The transport model ranged from negligible to high sensitivity to effective porosity and negligible to moderately high sensitivity to dispersivity as discussed in **Sections 5.2.3.3** and **5.2.3.5**.

5.2.3.1 Initial Concentrations

No initial concentrations were placed in the steady state flow calibration model. The flow model was run as transient and concentration was added to the model through recharge starting at the same time as flow simulation. Modeling was performed for a sufficient period (45 years) to allow modeled concentrations in the primary transport layer (*i.e.,* UD/PMP and UA) to reach recently observed levels.

5.2.3.2 Source Concentrations

Based on review of CCR placement, initial source concentrations for the pond were set to observed concentrations from porewater samples collected from earlier placement areas (XPW02 and XPW03) with a sulfate concentration of 130 milligrams per liter (mg/L) (**Figure 5-24**). This was applied throughout the pond until 1985, after which discoloration becomes apparent in the CCR deposits and source areas were added using porewater results from XPW01 and XPW04. Three concentration sources in the form of vertical percolation (recharge) through CCR were simulated within the PAP for calibration (**Table 5-2**): (i) percolation through CCR in the northeastern portion of the PAP, (ii) percolation through CCR in the northwestern portion of the PAP, and (iii) percolation through CCR in the remaining area of the PAP (**Figure 5-24**).

Porewater chemistry from within the PAP indicated that the distribution of sulfate concentrations is spatially variable, ranging on average between 19,000 mg/L (XPW01) and 99 mg/L (XPW03). Therefore, zonation of the PAP concentration sources was used to delineate areas with differing sulfate source inputs. The zonation was based on evidence provided by Ramboll (2020) and AECOM's (2016) History of Construction of the PAP. The CCR materials within the PAP shows zones of discoloration, suggestive of additional chemical processes occurring within the CCR and/or the presence of deposits other than CCR (Burns & McDonnell Engineering Company, Inc., 2020). Analysis of aerial imagery of the PAP indicates that the zones of discoloration around XWP01 and XPW04 are present from 1998 onwards. The CCR around XWP02 and XWP03 shows no discoloration and are located within the oldest CCR deposits. The sulfate concentration in these wells are similar and possibly more indicative of the sulfate concentrations within the CCR in general. Therefore, the CCR sulfate concentration (excluding the 2 zones) was set to the average concentration from XWP02 and XPW03 (130 mg/L).

All three source areas were simulated by assigning concentration to the recharge input. All source concentrations in the transport model were based on sulfate concentration data collected in 2021. The source concentrations applied to the recharge zones and saturated ash cells immediately below the recharge zones have the same concentration values. 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 obtained from the HCR (Ramboll, 2021a) and based on the porosity and are presented in **Table 5-2**.

The model had a negligible to high sensitivity to changes in porosity values, not including monitoring locations where the calibration concentration was less than 10.0 mg/L (*i.e.*, AWP05, APW06, APW08, APW11, APW15, and APW16) (**Table 5-3**). For wells with calibration concentrations greater than 10.0 mg/L, the greatest sensitivity for porosity was high for the low porosity sensitivity test at monitoring locations APW07, AWP09, APW17, and APW18.

5.2.3.4 Storage and Specific Yield Sensitivity

Estimates of storage and specific yield for each modeled hydrostratigraphic unit were obtained from the HCR (Ramboll, 2021a) and based on the porosity and are presented in **Table 5-2**.

The model had a negligible sensitivity to changes in storage and specific yield values (**Table 5-3**).

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 and 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 1 foot. The transverse and vertical dispersivity were set at 1/10 and 1/100 of longitudinal dispersivity. The Cahokia Alluvial deposits are represented in layer 4 a distinct zone within the UCU, there is no evidence to indicate that the hydraulic properties of this unit differ from those of the UCU; however, there is evidence that there is preferred transport through this unit. Therefore, this unit (**Figure 5-19** and **5-20**) has been included as an area of increased dispersivity. The calibrated longitudinal dispersivity for the Cahokia Alluvium was 20 feet, with the transverse and vertical dispersivity set at 1/10 and 1/100 of longitudinal dispersivity. Changes in hydraulic conductivity within this zone have negative impacts on the flow calibration in the UA. The increased dispersivity allows for migration of mass to wells where elevated sulfate concentrations have been observed and are coincident with the Cahokia deposits illustrated on Figure 2 of the HCR (Ramboll, 2021a) while preserving flow calibration.

The model had a negligible to moderately high sensitivity to changes in the Cahokia Alluvium dispersivity in wells, not including monitoring locations where the calibrated concentration was less than 10 mg/L. For wells with calibration concentrations greater than 10.0 mg/L, the greatest sensitivity for dispersivity was moderately high for the low dispersivity sensitivity test at monitoring locations APW07, APW09, APW17, and APW18.

5.2.3.6 Retardation

It was assumed that sulfate would not significantly sorb or chemically react with aquifer solids (distribution coefficient [Kd] was set to 0 milliliters per gram [mL/g]), which is a conservative estimate for estimating contaminant transport times. Lithium, 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 lithium and sulfate (Golder, 2022b, **Appendix C**) for locations APW-04 and APW-14. Results of the testing are summarized below:

- Lithium: Calculated linear partition coefficient (K_D) values for APW-04 and APW-14 were 4.49 and 5.58 liters per kilogram (L/kg) respectively, Langmuir partition coefficient (K_L) values were 6.2×10^7 and 1.6×10^8 L/kg, respectively, and Freundlich partition coefficients (K_F) values were 135 and 230 L/kg, respectively. In Strenge and Peterson (1989), partition coefficients for lithium range from 0 to 0.8 L/kg, depending on pH conditions and the amount of sorbent present.
- Sulfate: Calculated K_D values for APW-04 and APW-14 were 3.58 and -25.6 L/kg, respectively, K_L values were -626 and -2,200 L/kg, respectively, and K_F values were 4.11 and 2.14×10^{11} 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 (lithium, 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 modeling report, and as mentioned at the beginning of this section, no retardation was applied to sulfate 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:

- Natural recharge is constant over the long term.
- Fluctuations in lake stage do not affect groundwater flow and transport over the long term.

- Hydraulic conductivity is consistent within hydrostratigraphic units and delineated zones.
- The approximate base of ash surface in the PAP was developed with HDR using soil borings and bathymetric survey results.
- Source concentrations are assumed to remain constant over time.
- Sulfate 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 PAP, 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 Model

The groundwater model was manually calibrated to best approximate the mean groundwater elevations in 30 wells at the site. The mean elevations used for calibration and locations of wells within the flow model are summarized in **Table 2-2**. Well locations are shown in **Figure 2-1**. This involved modifying the hydraulic conductivities of the different hydrostratigraphic units, recharge rate, and conductance of the drains, rivers, and general head boundaries within the model to minimize the difference between the mean observed groundwater elevation and simulated groundwater elevation. Where possible, the range of the parameter values used during calibration were based on observed values (*i.e.,* for the range in hydraulic conductivity estimates from the HCR). Where this was not possible, such as for the drain and general head boundary conductance, the range of parameter values were based on other site information or inferred from knowledge from similar sites. Where data were limited, the parameter values were less constrained during calibration (*e.g.,* parameter values had wider ranges). The RMSE was used as a metric to identify the optimal values for the different parameters.

5.5 Calibration Flow Model Results

Results of the MODFLOW modeling are presented below. The model files accompany this report (**Attachment A**). **Table 5-1** shows the calibrated hydraulic conductivity for the different units shown in **Figures 5-16** to **5-22**.

Groundwater model calibration results are presented in **Figure 5-25** and **Figure 5-26**, which shows the observed GWL and simulated groundwater elevations and the observed GWL versus residuals. The near-linear relationship between observed and simulated values presented on **Figure 5-25** indicates that the model adequately represents the calibration dataset. The RMSE of the GWL across all wells was 5.14 feet. The mass balance error for the flow model was 0.00 percent and the ratio of the residual std to the range of heads was 9.2 percent, which is just below the desired target value of 10 percent. 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 **5-26** and simulated values are evenly distributed above and below observed values. The residual mean was also near zero with a value of 1.12 feet, indicating a small bias towards overestimating the GWL in the calibrated model; this is also illustrated in the observed versus residuals plot in **Figure 5-26**. The simulated groundwater elevations within the UD/PMP (layer 3) and the UA (layer 6) are shown in **Figure 5-27** and **Figure 5-28**.

In general, the model is able to simulate the groundwater flow patterns the UA (**Figure 2-2** and **Figure 2-3**) interpreted from the site well data for May and July 2021 respectively. The notable exceptions are 1) those wells located to the north of the PAP, close to the boundary between the UA and UA- sand, and 2) those wells to the east of the PAP close to the boundary between the UA, UA-sand and UA-gravel. The groundwater level is underestimated in both of these areas. The underestimation in groundwater heads suggests that the subsurface heterogeneity (the uppermost aquifer is located in glacial deposits that grade from sand to silt with gravel deposits) is not optimally represented by the zoned layers used in the model. The interpretation of both the UA-sand and UA-gravel areas were based on well log data available near the PAP. These sand and gravel deposits may or may not be present beyond the available well information. Based on the objective of the model to estimate potential impacts from the PAP, and the model's ability to simulate flow within the UA, the zoned representation in hydraulic properties within the UA is suitable.

5.6 Transport Model Results

The range of observed sulfate concentrations for transport calibration locations are summarized in **Table 2-2**. The goals of the transport model calibration were to have predicted concentrations fall within the range of observed concentrations; and, to have predicted concentrations above and below the GWPS for sulfate (400 mg/L) match observed concentrations above or below the standard at each well.

Both these goals were achieved in three of the transport calibration location wells (**Figure 5-29**), and all but two wells achieved the second goal of matching observed concentrations above or below 2 mg/L. Deviations from the observed ranges are discussed below.

- The model over predicts concentration in wells APW02, APW04, and APW12, which are screened in the UD/PMP. The modeled and observed concentration are both above 400 mg/L, so one of the two calibration goals was satisfied.
- The model under predicts concentrations in APW05S, which is screened in the UD/PMP; however, the difference between the lower limit of the range of observed concentrations (200 mg/L) and the predicted concentration of 116.3 mg/L is small. APW05S is located upgradient of the pond and may also be influenced by other factors, notwithstanding the PAP. The modeled and minimum observed concentration are both below 400 mg/L, so one of the two calibration goals was satisfied.
- The model under predicts concentrations in APW03, which is screened in the UD/PMP; however, the difference between the lower limit of the range of observed concentrations (160 mg/L) and the predicted concentration of 128.9.3 mg/L is small. Both the observed and predicted concentrations are below the GWPS, so one of the two calibration goals was satisfied.
- The model slightly under predicts the concentration in APW10, which is screened in the UA. The minimum observed concentration at APW10 is 390 mg/L and simulated sulfate concentration is 340 mg/L. The modeled and minimum observed concentration are both below 400 mg/L, so one of the two calibration goals was satisfied.
- The model under predicts concentrations in APW05, APW06, APW11, APW13, APW14, APW15 and APW17 which are screened in the UA. The range in observed sulfate concentrations in these wells is very small, with an average range of 35 mg/L. The maximum observed

concentrations in these wells are 15 mg/L, 9.9 mg/L, 300 mg/L, 230 mg/L, 340 mg/L, 1 mg/L and 41 mg/L, respectively. The predicted concentrations are 0.3 mg/L, 0 mg/L, 2.5 mg/L, 85.2 mg/L, 96.8 mg/L, 9 mg/L and 87.6 mg/L for APW05, APW06, APW11, APW13, APW14, APW15 and APW17, respectively. However, observed and predicted concentrations did not exceed the GWPS, satisfying one of the calibration goals.

- The model over predicts the concentration at APW18, which is screened in the UA. The maximum observed sulfate concentration at APW18 is 26 mg/L and the simulated concentration is 87.6 mg/L, which is an overprediction of 61.6 mg/L. However, observed and predicted concentrations did not exceed the GWPS, satisfying one of the calibration goals.

The remaining calibration locations (APW07, APW09, APW16) have predicted concentrations that were within range of the observed sulfate concentration and simulated GWPS exceedances. The UD/PMP well APW02, where the highest concentrations were observed (3,200 mg/L), was also calibrated to the median concentration of the observed values in 2021, indicating the transport calibration model was able to simulate the highest observed concentrations (**Figure 5-29**). The sulfate plume at the end of the transient model simulation of 500 years for the UD/PMP is shown in **Figure 5-30.** There are no simulated exceedances in the UA at the end of the transient model; however, sulfate is approaching the GWPS of 400 mg/L near APW-10 where exceedances of the GWPS have been observed.

6. SIMULATION OF CLOSURE SCENARIOS

6.1 Overview and Prediction Model Development

Prediction simulations were performed to evaluate the effects of Closure (source control measures) for the PAP on groundwater quality. The prediction simulations evaluated changes in groundwater sulfate concentrations from Scenario 1: CIP (removal of CCR from the southern portion of the PAP and consolidation into the northern portion of the PAP and Scenario 2: CBR (removal of all CCR material from the PAP). As discussed in **Section 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 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**.

Closure scenarios were simulated by initially removing free liquid from the CCR material over the course of 1 year by placing constant head cells with an elevation of 520 feet above the base of the CCR material and applying zero recharge to simulate dewatering of the PAP.

HELP-calculated percolation rates, based on removal and final soil backfill grading designs also provided in the Draft Final Closure Plan for the PAP (HDR, 2022), were applied for the different closure scenarios. HELP modeling input and output values are summarized in **Table 6-1** and described in detail below.

The CIP and CBR scenarios were simulated for a 500-year period. The following simplifying assumptions were made during the simulations:

- Removal of free liquids from CCR takes place prior to the CIP and CBR closure scenarios. Constant head cells were placed within the PAP to simulate the target water elevation within the ponds; and recharge was set to zero.
- In the CIP and CBR 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 CCR dewatering period.
- Changes in recharge resulting from removal of free liquids (decrease calibration model recharge rates to zero) and CCR fill removal/ final soil backfill grading (recharge rates are based on HELP-calculated average annual percolation rates) have an instantaneous effect on recharge and percolation through surface materials.
- Sulfate source concentrations were assumed to be negligible (0 mg/L) in CCR removal areas in both the CIP and CBR scenarios. The spatial distribution of CCR concentrations within the consolidation area for the CIP scenario were maintained from the initial transport simulation.
- Cap construction in CIP scenario was assumed to be completed with a cover system consisting of the following (listed from ground surface down): a vegetative cover (6 inches thick), rooting zone (18 inches thick), a 200-mil geocomposite drainage layer and a 40-mil linear low-density polyethylene (LLDPE) geomembrane.
- The start of each closure prediction simulation was initiated at the end of the calibration model period of 45 years plus 1 year to complete removal of free liquid. For example, the

simulation of Scenario 1: CIP begins at 46 years (45 years for calibration plus 1 year). The prediction modeling timeline for each scenario is illustrated in Figure 4-1.

- CCR removal areas were assumed to be graded following placement of soil backfill based on the design drawings provided in the Draft Final Closure Plan for the PAP (HDR, 2022).
- CCR consolidation/removal areas were assumed to be graded and include proper storm water controls to remove excess water from the surface using the design drawings provided (HDR, 2022).
- The CIP scenario includes the placement of a stormwater drain within the removal area. The outflow elevation of this stormwater pond is 525 feet, which will discharge into Newton Lake adjacent to the PAP. This is represented as a drain in the model whose elevation is equal to the stormwater pond outflow elevation.
- All saturated CCR (constant concentration cells) in the transport calibration model were removed instantaneously in all CCR removal areas for all prediction models.
- Local fill materials applied to the prediction models have similar hydraulic properties as the UD materials used in the transport calibration models. However, the local fill materials were assumed to have reduced vertical anisotropy ratios, approaching isotropic, due to reworking of the material as it is placed as backfill (Kh/Kv decreased from measured values of 100 to 1 for reworked material).

6.2 HELP Model Setup and Results

HELP (Version 4.0; Tolaymat and Krause, 2020) was used to estimate percolation through the PAP in areas of CCR removal with soil backfill, and areas of CCR consolidation with final cover system. HELP input and output files are included electronically and attached to this report.

HELP input data and results are provided in **Table 6-1**. All scenarios were modeled for a period of 30 years. Climatic inputs were synthetically generated using default equations developed for Terra Haute, Indiana (the closest weather station included in the HELP database). Precipitation, temperature, and solar radiation was simulated based on the latitude of the PAP. Thickness of soil backfill and soil runoff input parameters were developed for the ash fill removal scenarios using data provided the Draft Final Closure Plan for the PAP (HDR, 2022).

HELP model results (**Table 6-1**) indicated 4.29 inches of percolation per year for the PAP CCR removal and soil backfill area in the CIP scenario, 0.042 inches of percolation per year through the CCR and final cover system for the CIP scenario, 4.38 inches of percolation per year for the PAP CCR removal and soil backfill area in the CBR scenario. HELP model simulations were also completed to estimate the percolation for the proposed closure of LF2. Model results indicated 0.000003 inches of percolation per year for LF1 and LF2 through the cover system. The differences in HELP model runs for each area included the following parameters: area, soil backfill thickness, slopes, and soil runoff slope length; all other HELP model input parameters were the same for each simulated area. HELP input data and results are provided in **Appendix B.**

6.3 Simulation of Closure Scenarios

The calibrated model was used to evaluate the effectiveness of the two closure scenarios by adding constant head cells within the PAP, decreasing recharge to simulate removal of free liquid within the ash fill prior to removal, and changing recharge rates to simulate ash fill removal areas at the PAP. Removal of source inputs from the ash removal areas was simulated by reducing the sulfate concentrations associated with recharge in the areas to 0 mg/L. Constant concentration cells that represent areas with potentially saturated CCR were also removed from the ash removal areas.

Each prediction scenario was simulated as a continuation of the PAP dewatering simulation which followed the transient calibrated model. The prediction model input values are summarized in **Table 6-2,** and the modifications to the recharge zones and drain placement for the CIP scenario are illustrated in **Figure 6-1**. **Figure 6-2** illustrates the CCR removal area for the CBR at the PAP. The two closure scenarios are discussed in this report based on predicted changes in sulfate concentrations as described below.

6.3.1 Closure in Place Model Results

In the CIP scenario, the predicted concentrations in the UD/PMP start to decline once the closure actions are implemented within the prediction model. The reduced recharge rate in the northern area of the PAP leads to an increasing number of saturated ash cells (constant concentration cells) becoming inactive. These inactive cells are no longer contributing sulfate source concentration to the model domain. Sulfate concentration continues to be introduced in the CIP consolidation area via recharge, although only at a low rate. In addition, as a result of removal of free liquid and low recharge rate, downward percolation of solute mass from the PAP is reduced.

As previously discussed, the calibrated model over predicts sulfate concentrations in monitoring wells APW02, APW04, and APW12, which are screened in the UD/PMP. The predictive model indicates that these wells will reach the GWPS (400 mg/L) in 15 years, 20 years, and 4 years respectively, after the corrective measures are in place. All UD/PMP groundwater monitoring wells are below the GWPS within 20 years (**Figure 6-3**). The predicted footprint of the sulfate plume within the UD/PMP (Layer 3) shown in **Figure 6-3** is considerably reduced from that at the end of the transient model simulation (**Figure 5-30**).

The predicted concentrations in UA groundwater monitoring wells increase for various periods of time after corrective measures are implemented (**Figure 6-4**). However, only APW10 exceeds the GWPS following closure. The predicted concentration in APW10 rises for approximately 10 years after closure is completed, after which it declines such that the concentrations fall below the GWPS after 20 years.

Most of the UA wells show a delayed response to the implementation of closure, with the concentrations continuing to rise for up to 200 years in the case of APW17 while remaining below the GWPS. This delay can be attributed to the thick layer of UCU materials present between the UA and the CCR. Due to its low vertical hydraulic conductivity (0.0001 ft/d), sulfate will very slowly percolate through the UCU into the UA. The reduced recharge rate in the CIP scenario further reduces the vertical gradient across this unit, thereby slowing the movement of the sulfate within it. This results in the slow rise and fall of sulfate in many of the UA wells.

The predicted footprint of the sulfate plume within the UA (Layer 6) is shown in **Figure 6-4.** Only a small area to the east of the pond (in close proximity to APW10) shows sulfate concentrations above the GWPS.

6.3.2 Closure by Removal Model Results

In the CBR scenario, predicted concentrations in the UD/PMP start to decline once the closure actions are implemented within the prediction model. These declines are due to removal of the CCR and a small reduction in recharge within the PAP. Predicted sulfate concentrations for APW02, APW03, APW04, APW05S, and APW12 are below the GWPS within 14 years (**Figure 6-3**).

As previously discussed, the model over predicts sulfate concentrations in monitoring wells APW02, APW04, and APW12, which are screened in the UD/PMP. The predictive model indicates that these wells will reach the GWPS 14 years, 10 years, and 13 years respectively, after closure.

Similar to the CIP scenario, the predicted footprint of the sulfate plume for the CBR within the UD/PMP (Layer 3) shown in **Figure 6-3** is considerately reduced from that of the transient model simulation (**Figure 5-30**). In comparison to the CIP scenario, the CBR simulation has a smaller plume at both the eastern boundary and western boundary of the PAP.

The simulated sulfate concentrations in the UA wells display a similar lagged response to closure as observed in the CIP scenario. Only APW10 exceeds the GWPS following closure. The predicted concentrations in APW10 continue to rise approximately 9 years after closure is completed, after which it declines such the concentrations fall below the GWPS after 16 years.

Like the CIP scenario, most of the UA wells show a delayed response to the implementation of closure, the concentrations continue to rise for up to 50 years in the case of APW18 while remaining below the GWPS.

The predicted footprint of the sulfate plume within the UA (Layer 6) is shown in **Figure 6-4**. Only a small area to the east of the pond (in close proximity to APW10) shows sulfate concentrations above the GWPS and is not significantly different from the CIP simulated plume footprint.

6.3.3 Sulfate Composite Plume for CIP and CBR

The maximum footprint of the plume, based on the simulated sulfate concentrations in all model layers 20 years after corrective measures, is shown in **Figure 6-5**. The footprint of the plume includes the sulfate concentrations retained within the UCU and is therefore greater in area than those plumes in either the UD/PMP or UA. As mentioned above, the sulfate within the thick UCU will slowly percolate through the unit, the rate of which is governed by the hydraulic gradient across the unit. **Figure 6-6** shows the maximum plume extent after 100 years for both the CIP and CBR scenarios. The reduced recharge rate in the CIP scenario leads to a slightly larger plume for the CIP scenario than for the CBR scenario.

The maximum plume footprint in both the CIP and CBR scenarios continues to reduce through time and remains within the property boundaries.

7. CONCLUSIONS

This GMR has been prepared to evaluate how proposed CIP and CBR scenarios will achieve compliance with the applicable groundwater standards at the NPP. Data collected from the recent 2021 field investigations were used to develop a groundwater model to predict the impacts of the closure scenarios on groundwater quality at the NPP. The MODFLOW and MT3DMS models were used to evaluate two scenarios using information provided in the Draft CCR Final Closure Plan (HDR, 2022):

- Scenario 1: CIP (consolidation of CCR in the north of the unit with cover system)
- Scenario 2: CBR (CCR is removed)

Predictive simulations of pond closure indicate simulated groundwater concentrations in the monitoring well within the two transport zones, namely the UD/PMP and UA, will achieve the GWPS in 20 years and 16 years for the CIP and CBR closure scenarios, respectively. This indicates that both scenarios are predicted to reach the GWPS for the monitoring wells after approximately 20 years; the simulated four-year difference between these two scenarios is not significant. The four-year difference in time to reach the GWPS between CIP and CBR is expected to be further reduced because the estimated duration of construction activities presented in the Draft Closure Alternatives Analysis (Gradient, 2022) indicates CBR will take between 2.6 and 4.9 years longer to complete than CIP.

The prediction simulations indicate that although the groundwater wells reach the GWPS, sulfate remains within the model beyond 100 years. This is due to the sulfate mass retained within the thick UCU which underlies the PAP. The low vertical hydraulic conductivity of this thick unit leads to low flow rates through the unit which will require time to release the sulfate mass. However, in both the CIP and CBR scenarios, the plume footprint continues to recede with time and remains within the property boundaries indicating these closure options are equally protective.

Results of groundwater fate and transport modeling conservatively estimate that groundwater concentrations will attain the GWPS for all constituents identified as potential exceedances of the GWPS in the UD/PMP and UA monitoring wells within 20 years of closure implementation for both CIP and CBR. Within the property boundary, residual sulfate will be present within the clay confining unit above the GWPS due to the slow release of sulfate from the UCU.

8. REFERENCES

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TABLES

TABLE 2-1. MONITORING WELL LOCATIONS AND CONSTRUCTION DETAILS
GROUNDWATER MODELING REPORT
NEWTON POWER PLANT
PRIMARY ASH POND
NEWTON, 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)
APW02	UD	06/19/2010	533.61	533.61	Top of Riser	529.90	9.70	19.70	520.20	510.20	20.00	509.90	10	2	38.925918	-88.293907
APW03	UD	06/18/2010	532.41	532.41	Top of Riser	528.37	9.70	19.70	518.67	508.67	20.00	508.40	10	2	38.922322	-88.281567
APW04	UD	06/19/2010	525.06	525.06	Top of Riser	521.45	7.70	17.70	513.75	503.75	18.00	503.50	10	2	38.927444	-88.273113
APW05	UA	10/22/2015	544.07	544.07	Top of Riser	541.08	62.64	67.44	478.44	473.64	67.84	473.10	4.8	2	38.933958	-88.280983
APW05S	UD	01/19/2021	543.94	543.94	Top of PVC	541.05	10.00	20.00	531.05	521.05	20.00	518.10	10	2	38.933958	-88.281033
APW06	UA	10/21/2015	546.07	546.07	Top of Riser	542.89	67.67	72.48	475.22	470.41	72.88	468.90	4.8	2	38.933746	-88.286276
APW07	UA	11/05/2015	538.37	538.37	Top of Riser	535.72	77.89	82.70	457.83	453.02	83.10	452.60	4.8	2	38.928233	-88.292076
APW08	UA	10/28/2015	528.97	528.97	Top of Riser	526.26	71.40	81.06	454.86	445.20	81.53	444.30	9.7	2	38.923154	-88.292286
APW09	UA	11/03/2015	531.52	531.52	Top of Riser	528.33	56.66	61.46	471.67	466.87	61.85	466.30	4.8	2	38.922319	-88.281585
APW10	UA	11/06/2015	524.25	524.25	Top of Riser	521.49	40.74	45.54	480.75	475.95	45.94	475.60	4.8	2	38.927435	-88.273127
APW11	UA	01/23/2021	538.63	538.63	Top of PVC	536.05	60.00	65.00	476.05	471.05	65.00	436.10	5	2	38.932811	-88.27545
APW12	UD	02/21/2021	546.29	546.29	Top of PVC	543.33	20.00	30.00	523.33	513.33	30.00	456.30	10	2	38.92975	-88.272058
APW13	UA	01/22/2021	537.99	537.99	Top of PVC	535.16	58.50	63.50	476.66	471.66	63.50	445.20	5	2	38.92566	-88.274416
APW14	UA	01/23/2021	526.29	526.29	Top of PVC	523.85	50.00	55.00	473.85	468.85	55.00	428.90	5	2	38.924057	-88.277994
APW15	UA	01/22/2021	524.69	524.69	Top of PVC	522.06	98.00	103.00	424.06	419.06	103.00	412.10	5	2	38.921593	-88.285226
APW16	UA	01/20/2021	531.18	531.18	Top of PVC	529.16	80.50	85.50	448.66	443.66	85.50	419.20	5	2	38.920317	-88.291291
APW17	UA	01/22/2021	532.52	532.52	Top of PVC	529.84	87.00	92.00	442.84	437.84	92.00	429.80	5	2	38.925916	-88.293928
APW18	UA	01/21/2021	543.27	543.27	Top of PVC	540.55	75.00	80.00	465.55	460.55	80.00	433.60	5	2	38.930979	-88.290122
G48MG	UA	10/20/2015	545.53	545.53	Top of Riser	542.68	71.80	76.65	470.88	466.03	77.06	465.60	4.9	2	38.939248	-88.296012
G202	UA	10/16/1996	539.69	539.69	Top of Riser	536.85	64.00	74.00	472.85	462.85	74.00	462.90	10	2	38.930876	-88.290559
G203	UA	11/15/1996	533.13	533.13	Top of Riser	530.73	62.50	72.50	468.23	458.23	72.50	458.20	10	2	38.928597	-88.292217
G208	UA	10/13/2011	535.03	535.03	Top of Riser	533.19	74.93	94.71	458.26	438.48	94.80	438.20	19.8	2	38.929632	-88.298182
G217S	UD	08/26/1997	537.98	537.98	Top of Riser	535.54	9.00	19.00	526.54	516.54	19.00	510.50	10	2	38.932171	-88.290041

TABLE 2-1. MONITORING WELL LOCATIONS AND CONSTRUCTION DETAILS
GROUNDWATER MODELING REPORT
NEWTON POWER PLANT
PRIMARY ASH POND
NEWTON, 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)
G217D	UA	12/09/2014	537.92	537.92	Top of Riser	535.51	--	--	--	--	69.30	--	--	--	38.932174	-88.29008
G222	UA	10/25/2011	534.32	534.32	Top of Riser	532.38	64.57	79.24	467.81	453.14	79.30	452.40	14.7	2	38.927194	-88.299669
G223	UA	10/11/2011	533.60	533.60	Top of Riser	531.68	79.09	88.75	452.59	442.93	89.10	442.60	9.7	2	38.93016	-88.293451
G224	UA	10/05/2011	534.31	534.31	Top of Riser	532.31	63.51	73.17	468.80	459.14	73.50	458.30	9.7	2	38.931767	-88.292396
R202	UA	--	--	--	--	--	--	--	--	--	--	--	--	--	38.930879	-88.290581
R217D	UA	09/26/2017	538.18	538.18	Top of Riser	535.60	60.10	65.03	475.50	470.57	65.24	470.40	4.9	2	38.932191	-88.290118
XPW01	CCR	01/20/2021	551.76	551.76	Top of PVC	548.62	7.00	17.00	541.62	531.62	17.00	528.60	10	2	38.932212	-88.285525
XPW02	CCR	01/19/2021	554.43	554.43	Top of PVC	551.97	6.00	16.00	545.97	535.97	16.00	532.00	10	2	38.932343	-88.28289
XPW03	CCR	01/19/2021	553.65	553.65	Top of PVC	550.81	10.00	20.00	540.81	530.81	20.00	530.80	10	2	38.931062	-88.27641
XPW04	CCR	01/19/2021	554.51	554.51	Top of PVC	551.90	10.00	20.00	541.90	531.90	20.00	531.90	10	2	38.929888	-88.274073
XSG01	CCR	--	--	536.17	Staff gauge	--	--	--	--	--	--	--	--	--	38.923218	-88.29067
SG02	SW	--	--	506.89	Staff gauge	--	--	--	--	--	--	--	--	--	38.921234	-88.292057

Notes:
All elevation data are presented relative to the North American Vertical Datum 1988 (NAVD88), GEOID 12A
-- = data not available
bgs = below ground surface
CCR = coal combustion residuals
ft = foot or feet
HSU = Hydrostratigraphic Unit
PVC = polyvinyl chloride
SW = surface water
UA = uppermost aquifer
UD = upper drift

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TABLE 2-2. FLOW AND TRANSPORT MODEL CALIBRATION TARGETS

GROUNDWATER MODELING REPORT
NEWTON POWER PLANT
PRIMARY ASH POND
NEWTON, ILLINOIS

				Flow Targets								Transport Targets						
Well Name	Easting	Northing	HSU	Number of Samples	median GWL[1] (ft)	mean GWL[1] (ft)	std GWL[1] (ft)	min GWL[1] (ft)	max GWL[1] (ft)	Earliest Sample Date	Latest Sample Date	Number of Samples	mean Sulfate (mg/L)	std Sulfate (mg/L)	min Sulfate (mg/L)	max Sulfate (mg/L)	Earliest Sample Date	Latest Sample Date
APW02	995466.245	822683.473	UD	34	528.6	528.6	1.0	524.9	530.4	10/07/2015	08/02/2021	8	2913	579	1500	3200	01/13/2015	07/15/2021
APW03	998977.669	821375.539	UD	33	524.4	524.7	1.5	520.8	528.2	10/07/2015	08/02/2021	8	174	9	160	190	01/13/2015	07/15/2021
APW04	1001381.684	823242.504	UD	33	520.1	520.0	0.7	518.2	521.1	10/07/2015	08/02/2021	8	933	43	860	990	01/13/2015	07/15/2021
APW05	999141.384	825613.581	UA	37	529.5	529.5	0.5	528.0	530.8	12/14/2015	08/02/2021	25	3	4	1	15	12/15/2015	07/15/2021
APW05S	999127.161	825613.573	UD	15	533.6	533.1	0.8	531.7	534.4	02/04/2021	07/15/2021	7	1563	794	200	2100	02/17/2021	07/15/2021
APW06	997635.757	825535.544	UA	36	526.5	526.9	1.1	525.4	530.6	12/14/2015	08/02/2021	25	4	3	1	9.9	12/15/2015	07/15/2021
APW07	995986.774	823526.85	UA	29	492.5	492.8	1.4	491.3	497.6	12/14/2015	08/02/2021	17	12	20	1	66	12/15/2015	02/10/2021
APW08	995927.867	821677.002	UA	29	492.2	492.4	0.9	491.3	494.9	12/14/2015	08/02/2021	17	40	5	30	48	12/15/2015	02/10/2021
APW09	998972.548	821374.443	UA	29	505.1	505.7	1.9	503.4	510.9	12/14/2015	08/02/2021	17	19	22	1	62	12/15/2015	02/11/2021
APW10	1001377.703	823239.224	UA	32	506.6	506.8	0.9	505.1	509.4	12/14/2015	08/02/2021	19	422	34	390	540	12/16/2015	07/29/2021
APW11	1000715.588	825196.787	UA	13	514.1	514.2	0.3	513.9	514.7	02/04/2021	07/15/2021	8	266	52	140	300	02/18/2021	07/15/2021
APW12	1001681.255	824082.573	UD	14	532.0	532.0	0.6	531.3	533.1	02/04/2021	07/15/2021	8	391	65	290	480	02/17/2021	07/15/2021
APW13	1001011.414	822592.511	UA	17	505.8	505.8	0.3	505.2	506.5	02/04/2021	07/15/2021	8	216	7	210	230	02/22/2021	07/15/2021
APW14	999993.839	822008.042	UA	16	505.6	505.5	0.3	504.9	506.3	02/04/2021	07/15/2021	8	325	9	310	340	02/22/2021	07/15/2021
APW15	997936.787	821109.457	UA	15	502.4	501.9	0.9	500.5	502.8	02/04/2021	07/14/2021	8	1	0	1	1	02/23/2021	07/14/2021
APW16	996211.429	820643.869	UA	16	491.4	491.4	0.2	491.1	492.1	02/04/2021	07/15/2021	8	1	0	1	1.9	02/23/2021	07/15/2021
APW17	995460.271	822682.742	UA	16	491.7	491.8	0.3	491.4	492.6	02/04/2021	07/15/2021	8	35	6	25	41	02/23/2021	07/15/2021
APW18	996542.186	824527.23	UA	16	491.9	492.0	0.3	491.7	492.7	02/04/2021	07/15/2021	8	7	9	1	26	02/23/2021	07/15/2021
G48MG	994865.387	827538.141	UA	28	526.4	526.6	0.7	525.5	528.5	12/14/2015	08/02/2021	-	-	-	-	-	-	-
G202	996417.888	824489.657	UA	43	492.8	493.1	1.3	491.6	496.7	04/21/2015	07/14/2021	-	-	-	-	-	-	-
G203	995946.602	823659.404	UA	43	492.8	493.2	1.2	491.0	496.4	04/21/2015	08/02/2021	-	-	-	-	-	-	-
G208	994249.502	824035.648	UA	46	509.5	510.1	2.5	504.9	516.0	04/21/2015	08/02/2021	-	-	-	-	-	-	-
G217S	996565.022	824961.379	UD	30	531.5	531.8	1.4	528.6	535.4	04/21/2015	08/02/2021	-	-	-	-	-	-	-
G223	995595.297	824228.508	UA	47	500.4	500.4	1.2	495.6	504.2	04/21/2015	08/02/2021	-	-	-	-	-	-	-
G224	995895.159	824813.927	UA	47	492.7	492.4	1.4	486.5	495.0	04/21/2015	08/02/2021	-	-	-	-	-	-	-
R202	996411.629	824490.747	UA	2	493.1	493.1	0.2	492.9	493.3	05/21/2020	02/08/2021	-	-	-	-	-	-	-
XPW01	997849.684	824976.957	CCR	11	539.6	539.6	0.2	539.3	539.9	02/15/2021	07/14/2021	5	15000	3807.9	11000	19000	02/17/2021	07/14/2021
XPW02	998599.238	825025.074	CCR	12	545.9	545.9	0.6	544.9	546.7	02/04/2021	07/14/2021	5	164	15.2	150	190	02/17/2021	07/14/2021
XPW03	1000442.897	824559.611	CCR	12	544.1	543.9	0.4	543.3	544.4	02/04/2021	07/14/2021	5	99	11.8	92	120	02/17/2021	07/14/2021
XPW04	1001107.994	824132.454	CCR	11	542.2	542.1	0.2	541.8	542.5	02/04/2021	07/14/2021	5	1920	1196.7	600	3800	02/17/2021	07/14/2021

Notes:

[1] Groundwater Elevation (feet)
GWL = groundwater elevation
ft = feet
std = standard deviation from the mean
min = minimum
max = maximum

HSU: Hydrostratigraphic Unit
CCR = coal combustion residual
UD/PMP = upper drift/potential migration pathway
UA = uppermost aquifer

TABLE 5-1. FLOW MODEL INPUT AND SENSITIVITY ANALYSIS RESULTS
GROUNDWATER MODELING REPORT
NEWTON POWER PLANT
PRIMARY ASH POND
NEWTON, ILLINOIS

Zone	Hydrostratigraphic Unit	Materials	ft/d	cm/s	Kh/Kv	Value Source	Sensitivity[1]
Horizontal Hydraulic Conductivity			**Calibration Model**				
1	UD	clay and silt	0.41	1.45E-04	NA	Calibrated - Within Range of Field Test Results (Ramboll, 2021a)	High
2	UD -Fill (abover riv/drn)	NA	7	2.47E-03	NA	Calibrated - Conductivity Value to Allow Groundwater Flow from UD to Riverand Drain Boundary Conditions	Low
3	CCR	CCR	17.6	6.21E-03	NA	Calibrated - Within Range of Field Test Results (Ramboll, 2021a)	Moderate
4	UD-PMP	clay and silt	1.5	5.29E-04	NA	Calibrated - Within Range of Field Test Results (Ramboll, 2021a)	Low
5	UD-PMP Sand	mixed alluvial deposits in the vicinity of the PAP	28	9.88E-03	NA	Calibrated - Within Range of Field Test Results (Ramboll, 2021a)	High
6	UCU	lean clay/Cahokia alluvium	0.001	3.53E-07	NA	Calibrated - Within Range of Field Test Results (Ramboll, 2021a)	Low
7	UA	clay and silt	3	1.06E-03	NA	Calibrated - Within Range of Field Test Results (Ramboll, 2021a)	High
8	UA-Sand	sand	3	1.06E-03	NA	Calibrated - Within Range of Field Test Results (Ramboll, 2021a)	Moderately High
9	UA-Gravel	gravel	50	1.76E-02	NA	Calibrated - Within Range of Field Test Results (Ramboll, 2021a)	High
10	LCU	lean clay	0.001	3.53E-07	NA	Calibrated - Within Range of Field Test Results (Ramboll, 2021a)	Low
11	UCU-cahokia	alluvial deposits	0.001	3.53E-07	NA	Calibrated - Within Range of Field Test Results (Ramboll, 2021a)	Low
Vertical Hydraulic Conductivity			**Calibration Model**				
1	UD	clay and silt	0.0041	1.45E-06	100	Calibrated - Within Range Laboratory Test Results and near Geomean of Laboratory Test Results (Ramboll, 2021a)	High
2	UD -Fill (abover riv/drn)	NA	7	2.47E-03	1	Calibrated - Conductivity Value to Allow Groundwater Flow from UD to Riverand Drain Boundary Conditions	Low
3	CCR	CCR	0.2750	9.70E-05	64	Calibrated - Within Range Laboratory Test Results and near Geomean of Laboratory Test Results (Ramboll, 2021a)	Low
4	UD-PMP	clay and silt	0.0150	5.29E-06	100	Calibrated - Within Range Laboratory Test Results and near Geomean of Laboratory Test Results (Ramboll, 2021a)	Low
5	UD-PMP Sand	mixed alluvial deposits in the vicinity of the PAP	0.2800	9.88E-05	100	Calibrated - Within Range Laboratory Test Results and near Geomean of Laboratory Test Results (Ramboll, 2021a)	Moderate
6	UCU	lean clay/Cahokia alluvium	0.0001	3.53E-08	10	Calibrated - Within Range Laboratory Test Results and near Geomean of Laboratory Test Results (Ramboll, 2021a)	High
7	UA	clay and silt	0.0010	3.53E-07	10	Calibrated - Within Range Laboratory Test Results and near Geomean of Laboratory Test Results (Ramboll, 2021a)	Moderately High
8	UA-Sand	sand	0.1000	3.53E-05	21	Calibrated - Within Range Laboratory Test Results and near Geomean of Laboratory Test Results (Ramboll, 2021a)	Moderately High
9	UA-Gravel	gravel	0.1000	3.53E-05	208	Calibrated - Within Range Laboratory Test Results and near Geomean of Laboratory Test Results (Ramboll, 2021a)	Moderate
10	LCU	lean clay	0.0001	3.53E-08	10	Calibrated - Within Range Laboratory Test Results and near Geomean of Laboratory Test Results (Ramboll, 2021a)	Low
11	UCU-cahokia	alluvial deposits	0.0001	3.53E-08	10	Calibrated - Within Range Laboratory Test Results and near Geomean of Laboratory Test Results (Ramboll, 2021a)	High

TABLE 5-1. FLOW MODEL INPUT AND SENSITIVITY ANALYSIS RESULTS
GROUNDWATER MODELING REPORT
NEWTON POWER PLANT
PRIMARY ASH POND
NEWTON, ILLINOIS

Zone	Hydrostratigraphic Unit	Materials	ft/d	cm/s	Kh/Kv	Value Source	Sensitivity[1]
Recharge			**Calibration Model**				
1	UD	clay and silt	1.15E-04	0.50	NA	Calibrated	Moderate
2	Fill Unit - PAP	CCR	1.80E-03	7.88	NA	Calibrated	High
3	Fill Unit - Newton Phase II North Landfill	CCR	8.00E-05	0.35	NA	Calibrated	Negligible
4	Fill Unit - Newton Phase II West Landfill	CCR	8.00E-05	0.35	NA	Calibrated	Negligible
5	Fill Unit - Secondary Pond	CCR	8.00E-05	0.35	NA	Calibrated	Negligible
6	Fill Unit - PAP pond north	CCR	8.00E-05	0.35	NA	Calibrated	Negligible
7	Fill Unit - North Pond	CCR	8.00E-05	0.35	NA	Calibrated	Negligible
8	Fill Unit - South Pond	CCR	8.00E-05	0.35	NA	Calibrated	Negligible
9	Fill Unit - Cooling Pond	CCR	8.00E-05	0.35	NA	Calibrated	Negligible
10	NPP	Power Plant footprint	1.00E-05	0.04	NA	Calibrated	Negligible
Storage			**Calibration Model**				
1	UD	clay and silt					
2	UD -Fill (abover riv/drn)	NA					
3	CCR	CCR					
4	UD-PMP	clay and silt					
5	UD-PMP Sand	mixed alluvial deposits in the vicinity of the PAP	*Not used in steady-state calibration model*				
6	UCU	lean clay/Cahokia alluvium					
7	UA	clay and silt					
8	UA-Sand	sand					
9	UA-Gravel	gravel					
10	LCU	lean clay					
River Parameters	**Relative Location**	**River Width (feet)**	**River depth (feet)**	**Bed Thickness (feet)**	**Hydraulic Conductivity (ft/d)**	**Head (feet)**	**River Boundary Conductance (ft^2/d)**
Reach 0	Cooling Flume-0	varaible	5	1	0.9	535.98	5
Sensitivity[1]	NA	- - -	- - -	- - -	- - -	Negligible	Negligible
Reach 1	Cooling Flume-1	varaible	5	1	0.9	520.66	5
Sensitivity[1]	NA	- - -	- - -	- - -	- - -	Negligible	Negligible
Reach 2	Cooling Flume-2	varaible	5	1	0.9	504.60	5
Sensitivity[1]	NA	- - -	- - -	- - -	- - -	Negligible	Negligible
Reach 3	Sandy Creek	10	6	1	7.5	530.0-504.6	2500
Sensitivity[1]	NA	- - -	- - -	- - -	- - -	Negligible	Negligible
Value Source	NA	Calibrated	Calibrated	Calibrated	Calibrated	Estimated based on DEM	Calibrated

TABLE 5-1. FLOW MODEL INPUT AND SENSITIVITY ANALYSIS RESULTS
GROUNDWATER MODELING REPORT
NEWTON POWER PLANT
PRIMARY ASH POND
NEWTON, ILLINOIS

Drain Parameters	Name	Drain Width (feet)	Drain depth (feet)	Bed Thickness (feet)	Hydraulic Conductivity (ft/d)	Stage (feet)	Drain Conductance (ft^2/d)
Reach 1	Sandy Creek Trib 1	5	3	1	7.5	525.6-548.9	36.8-5161
Sensitivity[1]	NA	- - -	- - -	- - -	- - -	Negligible	Negligible
Reach 2	Sandy Creek Trib 2	5	3	1	7.5	524.2-548	16.6-4541
Sensitivity[1]		- - -	- - -	- - -	- - -	Negligible	Negligible
Reach 3	Sandy Creek Trib 3A	5	3	1	7.5	521-544	129-3988
Sensitivity[1]		- - -	- - -	- - -	- - -	Negligible	Negligible
Reach 4	Sandy Creek Trib 3B	5	3	1	7.5	516-521	2.5-4037.2
Sensitivity[1]		- - -	- - -	- - -	- - -	Low	Negligible
Reach 5	Landfill Stream	5	3	1	7.5	508.6-511	8.7-1153.3
Sensitivity[1]		- - -	- - -	- - -	- - -	Low	Negligible
Reach 6	Landfill Drain	5	3	1	7.5	511-525.9	58.3-769.4
Sensitivity[1]		- - -	- - -	- - -	- - -	Moderate	Low
Reach 7	PAP Stream	5	3	1	7.5	508.6-530	3.3-1325.3
Sensitivity[1]		- - -	- - -	- - -	- - -	Low	Low
Reach 8	Newton Lake Trib 1	5	3	1	7.5	508.6-548	24.7-2282.3
Sensitivity[1]		- - -	- - -	- - -	- - -	Negligible	Negligible
Reach 9	Newton Lake Trib 2	5	3	1	7.5	508.6-537	5.1-1196.7
Sensitivity[1]		- - -	- - -	- - -	---	Negligible	Negligible
Reach 10	Newton Lake Trib 3	5	3	1	7.5	508.6-529.8	54.8-1982.7
Sensitivity[1]		- - -	- - -	- - -	- - -	Negligible	Negligible
Reach 11	Newton Lake Trib 4	5	3	1	7.5	508.6-518	101.98-2895
Sensitivity[1]	NA	- - -	- - -	- - -	- - -	Negligible	Negligible
Reach 12	Newton Lake Trib 5	5	3	1	7.5	5086.-527.3	20.3-4147.1
Sensitivity[1]	NA	- - -	- - -	- - -	- - -	Negligible	Negligible
Reach 13	Newton Lake Trib 6	5	3	1	7.5	508.6-535.5	212.5-5306.7
Sensitivity[1]	NA	- - -	- - -	- - -	- - -	Negligible	Negligible
Reach 14	Newton Lake Trib 7	5	3	1	7.5	508.6-526.9	196.8-3828.5
Sensitivity[1]	NA	- - -	- - -	- - -	- - -	Low	Low
Reach 15	Trib South 1	5	3	1	7.5	523-526.9	515.9-4076.7
Sensitivity[1]	NA	- - -	- - -	- - -	- - -	Negligible	Negligible
Reach 16	Trib South 2	5	3	1	7.5	514-532	5.6-4441.4
Sensitivity[1]	NA	- - -	- - -	- - -	- - -	Negligible	Negligible
Reach 17	Trib South 3	5	3	1	7.5	519-528.6	607.0-4191.6
Sensitivity[1]	NA	- - -	- - -	- - -	- - -	Negligible	Negligible
Reach 18	PAP North drain	5	3	1	7.5	517-537.6	1.48-1998.7
Sensitivity[1]	NA	- - -	- - -	- - -	- - -	Low	Negligible
Value Source	NA	Calibrated	Calibrated	Calibrated	Calibrated	Estimated based on DEM	Calibrated

TABLE 5-1. FLOW MODEL INPUT AND SENSITIVITY ANALYSIS RESULTS
GROUNDWATER MODELING REPORT
NEWTON POWER PLANT
PRIMARY ASH POND
NEWTON, ILLINOIS

General Head Parameters	Relative Location	Width of General Head Boundary Cell (feet)	Distance to General Head Boundary Head (feet)	Saturated Thickness of Cell (feet)	Hydraulic Conductivity (ft/d)	Head (feet)	General Head Boundary Conductance (ft^2/d)
Reach 0	Northern Model Boundary in UD & PMP	*variable*	1	variable	variable	variable	2.5-18325
Sensitivity[1]	NA	- - -	- - -	- - -	- - -	Negligible	Low
Reach 1	Northern Model Boundary in UA	variable	1	variable	3	490	229-935
Sensitivity[1]	NA	- - -	- - -	- - -	- - -	Moderate	Low
Reach 2	Southern Model Boundary in UA (silt,sand,gravel)	variable	14000	variable	3,3,50	460	0.033-3.4
Sensitivity[1]	NA	- - -	- - -	- - -	- - -	High	High
Value Source	NA	Calibrated	Calibrated	Calibrated	Calibrated	Estimated based on Groundwater Elevation Targets in UD-PMP and UA around the PAP	Calibrated

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%
SSR = sum of squared residuals
- - - = not tested
CCR = coal combustion residuals
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
PAP = Primary Ash Pond

Hydrostratigraphic Unit
UD = upper drift
LCU = lower confining unit
UA = uppermost aquifer
UCU = upper confining unit
PMP = potential migration pathway

TABLE 5-2. TRANSPORT MODEL INPUT VALUES (CALIBRATION)
GROUNDWATER MODELING REPORT
NEWTON POWER PLANT
PRIMARY ASH POND
NEWTON, ILLINOIS

Zone	Hydrostratigraphic Unit	Materials	Calibration Model				
			Sulfate Concentration (mg/L)			Value Source	Sensitivity
Initial Concentration							
Entire Domain	NA	NA	0			NA	- - -
Source Concentration (recharge)							
			pre-1985	post 1985			
1	UD	clay and silt	0	0		NA	- - -
2	Fill Unit - PAP	CCR	130	130		Sulfate concentration data from XWP02 and XWP03	- - -
3	Fill Unit - Newton Phase II North Landfill	CCR	0	0		NA	- - -
4	Fill Unit - Newton Phase II West Landfill	CCR	0	0		NA	- - -
5	Fill Unit - Secondary Pond	CCR	0	0		NA	- - -
6	Fill Unit - PAP pond north	CCR	0	0		NA	- - -
7	Fill Unit - North Pond	CCR	0	0		NA	- - -
8	Fill Unit - South Pond	CCR	0	0		NA	- - -
9	Fill Unit - Cooling Pond	CCR	0			NA	- - -
10	NPP	NPP	0	0		NA	- - -
11	Fill Unit - PAP	CCR	130	11,000		Sulfate concentration data from XWP01	- - -
12	Fill Unit - PAP	CCR	130	3,000		Sulfate concentration data from XWP04 - calibrated	- - -
Storage, Specific Yield and Effective Porosity			Calibration Model				
Zone	**Hydrostratigraphic Unit**	**Materials**	**Storage**	**Specific Yield**	**Effective Porosity**	**Value Source**	**Sensitivity**
1	UD	clay and silt	0.003	0.18	0.18	Ramboll (2021a) HCR	see Table 5-3
2	UD -Fill (abover riv/drn)	NA	0.003	0.5	0.5	Ramboll (2021a) HCR	see Table 5-3
3	CCR	CCR	0.003	0.21	0.21	Ramboll (2021a) HCR	see Table 5-3
4	UD-PMP	clay and silt	0.003	0.18	0.18	Ramboll (2021a) HCR	see Table 5-3
5	UD-PMP Sand	mixed alluvial deposits in the vicinity of the PAP	0.003	0.18	0.18	Ramboll (2021a) HCR	see Table 5-3
6	UCU	lean clay/Cahokia alluvium	0.003	0.15	0.15	Ramboll (2021a) HCR	see Table 5-3
7	UA	clay and silt	0.003	0.11	0.11	Ramboll (2021a) HCR	see Table 5-3
8	UA-Sand	sand	0.003	0.11	0.11	Ramboll (2021a) HCR	see Table 5-3
9	UA-Gravel	gravel	0.003	0.11	0.11	Ramboll (2021a) HCR	see Table 5-3
10	LCU	lean clay	0.003	0.155	0.155	Ramboll (2021a) HCR	see Table 5-3
Dispersivity							
Applicable Region	**Hydrostratigraphic Unit**	**Materials**	**Longitudinal (feet)**	**Transverse (feet)**	**Vertical (feet)**	**Value Source**	**Sensitivity**
Cahokia Alluvium	UCU	alluvial deposits	20	2	0.2	calibrated	see Table 5-3
Entire Domain	NA	NA	1	0.1	0.01	calibrated	- - -

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

Hydrostratigraphic Unit
UD = upper drift
LCU = lower confining unit
UA = uppermost aquifer
UCU = upper confining unit
PMP = potential migration pathway

TABLE 5-3. TRANSPORT MODEL INPUT SENSITIVITY (CALIBRATION)
GROUNDWATER MODELING REPORT
NEWTON POWER PLANT
PRIMARY ASH POND
NEWTON, ILLINOIS

		Storage and Specific Yield				Effective Porosity				Dispersivity			
Well ID	**Calibration on Concentration (mg/L)**	**Concentration (mg/L)**	**Sensitivity [1]**	**Concentration (mg/L)**	**Sensitivity [1]**	**Concentration (mg/L)**	**Sensitivity [1]**	**Concentration (mg/L)**	**Sensitivity [1]**	**Concentration (mg/L)**	**Sensitivity [1]**	**Concentration (mg/L)**	**Sensitivity [1]**
APW02	3960.7	3960.5	Negligible	3960.8	Negligible	3982.6	Negligible	3947.1	Negligible	3947.1	Negligible	3960.7	Negligible
APW03	128.9	128.9	Negligible	128.9	Negligible	129.1	Negligible	128.7	Negligible	128.7	Negligible	128.7	Negligible
APW04	1676.9	1676.9	Negligible	1677.0	Negligible	1684.9	Negligible	1664.8	Negligible	1664.8	Negligible	1669.8	Negligible
APW05	0.3	0.3	Negligible	0.3	Negligible	0.8	High	0.2	Moderate	0.2	Moderately High	0.3	Negligible
APW05S	116.3	116.4	Negligible	116.3	Negligible	119.5	Low	113.6	Low	113.6	Low	116.3	Negligible
APW06	0.0	0.0	Negligible	0.0	Negligible	0.0	High	0.0	Moderately High	0.0	Moderately High	0.0	Negligible
APW07	15.7	15.7	Negligible	15.7	Negligible	45.5	High	6.9	Moderately High	6.9	Moderately High	15.7	Negligible
APW08	9.9	9.9	Negligible	9.9	Negligible	38.2	High	3.8	Moderately High	3.8	Moderately High	11.7	Moderate
APW09	16.3	16.3	Negligible	16.3	Negligible	54.8	High	7.0	Moderately High	7.0	Moderately High	22.0	Moderate
APW10	340.4	340.3	Negligible	340.3	Negligible	522.1	Moderately High	226.6	Moderate	226.6	Moderate	467.7	Moderate
APW11	2.5	2.5	Negligible	2.5	Negligible	5.8	High	1.2	Moderately High	1.2	Moderately High	2.5	Negligible
APW12	984.8	984.8	Negligible	984.8	Negligible	1205.2	Moderate	733.7	Moderate	733.7	Moderate	954.4	Low
APW13	85.2	85.2	Negligible	85.1	Negligible	150.5	Moderately High	48.8	Moderate	48.8	Moderate	118.5	Moderate
APW14	96.8	96.8	Negligible	96.7	Negligible	165.0	Moderately High	57.1	Moderate	57.1	Moderate	131.5	Moderate
APW15	9.0	9.0	Negligible	9.0	Negligible	37.9	High	2.0	Moderately High	2.0	Moderately High	11.6	Moderate
APW16	1.8	1.8	Negligible	1.8	Negligible	7.7	High	0.8	Moderately High	0.8	Moderately High	2.8	Moderately High
APW17	15.9	15.9	Negligible	15.9	Negligible	51.7	High	6.2	Moderately High	6.2	Moderately High	15.9	Negligible
APW18	87.6	87.6	Negligible	87.6	Negligible	209.9	High	41.0	Moderately High	41.0	Moderately High	87.7	Negligible
		S*0.1 Sy*0.5[2]		S*10 Sy*2[2]		Porosity-0.05		Porosity+0.05		Disp zone 11*0.5		Disp zone 11*1.5	

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

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

Closure Scenario Number (Drainage Length)	Primary and Secondary AP- CBR	Primary and Secondary AP - CIP Removal Area	Primary Ash Pond - CIP Consolidation and Cover System Area	Landfill Consolidation Area 1 and 2	Notes
Input Parameter					
Climate-General					
City	Newton, IL	Newton, IL	Newton, IL	Newton, IL	Nearby city to the Site within HELP database
Latitude	38.93	38.93	38.93	38.93	Site latitude
Evaporative Zone Depth	18	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	4.5	Maximum for geographic location (Illinois) (Tolaymat, T. and Krause, M, 2020)
Growing Season Period, Average Wind Speed, and Quarterly Relative Humidity	Terre Haute, IN	Terre Haute, IN	Terre Haute, IN	Terre Haute, IN	Nearby city to the Newton Ash Pond within HELP database
Number of Years for Synthetic Data Generation	30	30	30	30	
Temperature, Evapotranspiration, and Precipitation	Precipitation, temperature, and solar radiation was simulated based on HELP V4 weather simulation for: Lat/Long: 38.93/-88.28	Precipitation, temperature, and solar radiation was simulated based on HELP V4 weather simulation for: Lat/Long: 38.93/-88.28	Precipitation, temperature, and solar radiation was simulated based on HELP V4 weather simulation for: Lat/Long: 38.93/-88.28	Precipitation, temperature, and solar radiation was simulated based on HELP V4 weather simulation for: Lat/Long: 38.93/-88.29	
Soils-General					
% where runoff possible	100	100	100	100	
Area (acres)	413.3	148.3	265	11.7	CBR - Removal Area based on HCR (Ramboll, 2021); CIP - Consolidation and Cover System Area based on construction drawing for Newton Primary and Secondary Ash Pond; CIP -Removal Area equals the difference; Landfill Consolidation Area based on HDR drawings
Specify Initial Moisture Content	No	No	No	No	
Surface Water/Snow	Model Calculated	Model Calculated	Model Calculated	Model Calculated	
Soils-Layers					
1	Unsaturated UD Material (HELP Final Cover Soil)	Unsaturated UD Material (HELP Final Cover Soil)	Vegetative Soil Layer (HELP Final Cover Soil [topmost layer])	Protective Cover Layer (HELP Final Cover Soil [topmost layer])	Layers details for CBR, CIP, and Landfill areas based on grading plans, construction drawings, and cover system design for Newton Ash Pond and Landfill
2			Protective Soil Layer (HELP Vertical Percolation Layer)	Protective Cover Layer (HELP Vertical Percolation Layer)	
3			Geocomposite Drainage Layer(HELP Geosynthetic Drainage Net)	Geocomposite Drainage Layer(HELP Geosynthetic Drainage Net)	
4			Geomembrane Liner	Geomembrane Liner	
5			Unsaturated CCR Material (HELP Waste)	Unsaturated CCR Material (HELP Waste)	
6				Geocomposite Drainage Layer	
7				Geomembrane Liner	
8				Clay Liner	

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

Closure Scenario Number (Drainage Length)	Primary and Secondary AP- CBR	Primary and Secondary AP - CIP Removal Area	Primary Ash Pond - CIP Consolidation and Cover System Area	Landfill Consolidation Area 1 and 2	Notes
Soil Parameters--Layer 1					
Type	1	1	1	1	Vertical Percolation Layer (Cover Soil)
Thickness (in)	60	60	6	4	For CBR and CIP removal areas, layer 1 thickness is the average thickness of unsaturated backfill material placed after removal
Texture	43	43	10	10	Defaults used
Description	Silty Clay	Silty Clay	Sandy Clay Loam	Sandy Clay Loam	
Saturated Hydraulic Conductivity (cm/s)	1.45E-06	1.45E-06	1.20E-04	1.20E-04	Hydraulic conductivity supplied by HDR construction plans
Soil Parameters--Layer 2					
Type	--	--	1	1	Vertical Percolation Layer (PAP) and Cover Soil (Landfill)
Thickness (in)	--	--	18	32	design thickness
Texture	--	--	43	43	Custom for Ash Pond - CIP Consolidation and Cover System Area and default for landfill
Description	--	--	Sandy Silty Clay	Sandy Silty Clay	
Saturated Hydraulic Conductivity (cm/s)	--	--	1.00E-05	1.00E-05	Custom for PAP and default for landfill
Soil Parameters--Layer 3					
Type	--	--	2	2	Lateral Drainage Layer
Thickness (in)	--	--	0.2	0.2	design thickness
Texture	--	--	20	20	Defaults used
Description	--	--	Drainage Net (0.5cm)	Drainage Net (0.5cm)	
Saturated Hydraulic Conductivity (cm/s)	--	--	1.00E+01	1.00E+01	Defaults used
Soil Parameters--Layer 4					
Type	--	--	4	4	Flexible Membrane Liner
Thickness (in)	--	--	0.04	0.04	design thickness
Texture	--	--	36	36	Defaults used
Description	--	--	LDPE Membrane	LDPE Membrane	
Saturated Hydraulic Conductivity (cm/s)		--	4.00E -13	4.00E-13	Defaults used
Soil Parameters--Layer 5					
Type	--	--	1	1	Vertical Percolation Layer (Waste)
Thickness (in)	--	--	156	768	design thickness
Texture	--	--	30	30	Defaults used
Description	--	--	High-Density Electric Plant Coal Fly Ash	High-Density Electric Plant Coal Fly Ash	
Saturated Hydraulic Conductivity (cm/s)		--	5.00E-05	5.00E-05	defaults used

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

Closure Scenario Number (Drainage Length)	Primary and Secondary AP- CBR	Primary and Secondary AP - CIP Removal Area	Primary Ash Pond - CIP Consolidation and Cover System Area	Landfill Consolidation Area 1 and 2	Notes
Soil Parameters--Layer 6					
Type	--	--	--	2	Drainage Liner
Thickness (in)	--	--	--	12	design thickness
Texture	--	--	--	44	Defaults used
Description	--	--	--	Drainage Layer	
Saturated Hydraulic Conductivity (cm/s)		--	--	1.00E-01	Defaults used
Soil Parameters--Layer 7					
Type	--	--	--	4	Flexible Membrane Liner
Thickness (in)	--	--	--	0.06	design thickness
Texture	--	--	--	35	Defaults used
Description	--	--	--	HDPE Membrane	
Saturated Hydraulic Conductivity (cm/s)		--	--	2.00E-13	Defaults used
Soil Parameters--Layer 8					
Type	--	--	--	3	Drainage Liner
Thickness (in)	--	--	--	36	design thickness
Texture	--	--	--	16	Defaults used
Description	--	--	--	Liiner Soil (High)	
Saturated Hydraulic Conductivity (cm/s)	--	--	--	1.00E-07	Defaults used
Soils--Runoff					
Runoff Curve Number	88.7	88.9	84.4	89.8	HELP-computed curve number
Slope	1.00%	1.00%	2.00%	2.00%	Estimated from construction design drawings
Length (ft)	3600	2300	1500	600	estimated maximum flow path
Vegetation	fair	fair	fair	fair	fai rindicating fair stand of grass on sruface of soil backfill
Execution Parameters					
Years	30	30	30	30	
Report Daily	No	No	No	No	
Report Monthly	No	No	No	No	
Report Annual	Yes	Yes	Yes	Yes	
Output Parameter					
Unsaturated Percolation Rate (in/yr)	**4.38**	**4.29**	**0.042**	**0.000003**	

Notes:
% = percent
ft = feet
HELP = Hydrologic Evaluation of Landfill Performance
in = inches
in/yr = inches per year
Lat = latitude
Long = longitude
CBR = Closure By Removal
CIP = Closure In Place
HCR = Hydrogeologic 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. Newton Primary Ash Pond. Newton Power Plant. Newton, Illinois.

TABLE 6-2. PREDICTION MODEL INPUT VALUES

GROUNDWATER MODELING REPORT

NEWTON POWER PLANT

PRIMARY ASH POND

NEWTON, ILLINOIS

Hydrostratigraphic Unit/Recharge Area	Notes	Recharge Zone	Sulfate Concentration (mg/L)	Recharge (ft/day)	Recharge (in/yr)	Constant Concentration Layer	Constant Concentration (mg/L)
Scenario 1: CIP							
Fill Unit - PAP	CCR	2	130	8.90E-06	0.039	2&3	130.0
Fill Unit - PAP	CCR	3	11,000	8.90E-06	0.039	-	-
Fill Unit - PAP	CCR	4	3,000	8.90E-06	0.039	-	-
Removal Area - PAP	FILL	7	0	9.93E-04	4.35	-	
Scenario 2: CBR							
Removal Area - PAP	FILL	2	0	1.00E-03	4.38	-	-
Removal Area - PAP	FILL	3	0	1.00E-03	4.38	-	-
Removal Area - PAP	FILL	4	0	1.00E-03	4.38	-	-

Notes:

CCR = coal combustion residuals

mg/L = milligrams per liter

ft/day = feet per day

in/yr = inches per year

PAP = Primary Ash Pond

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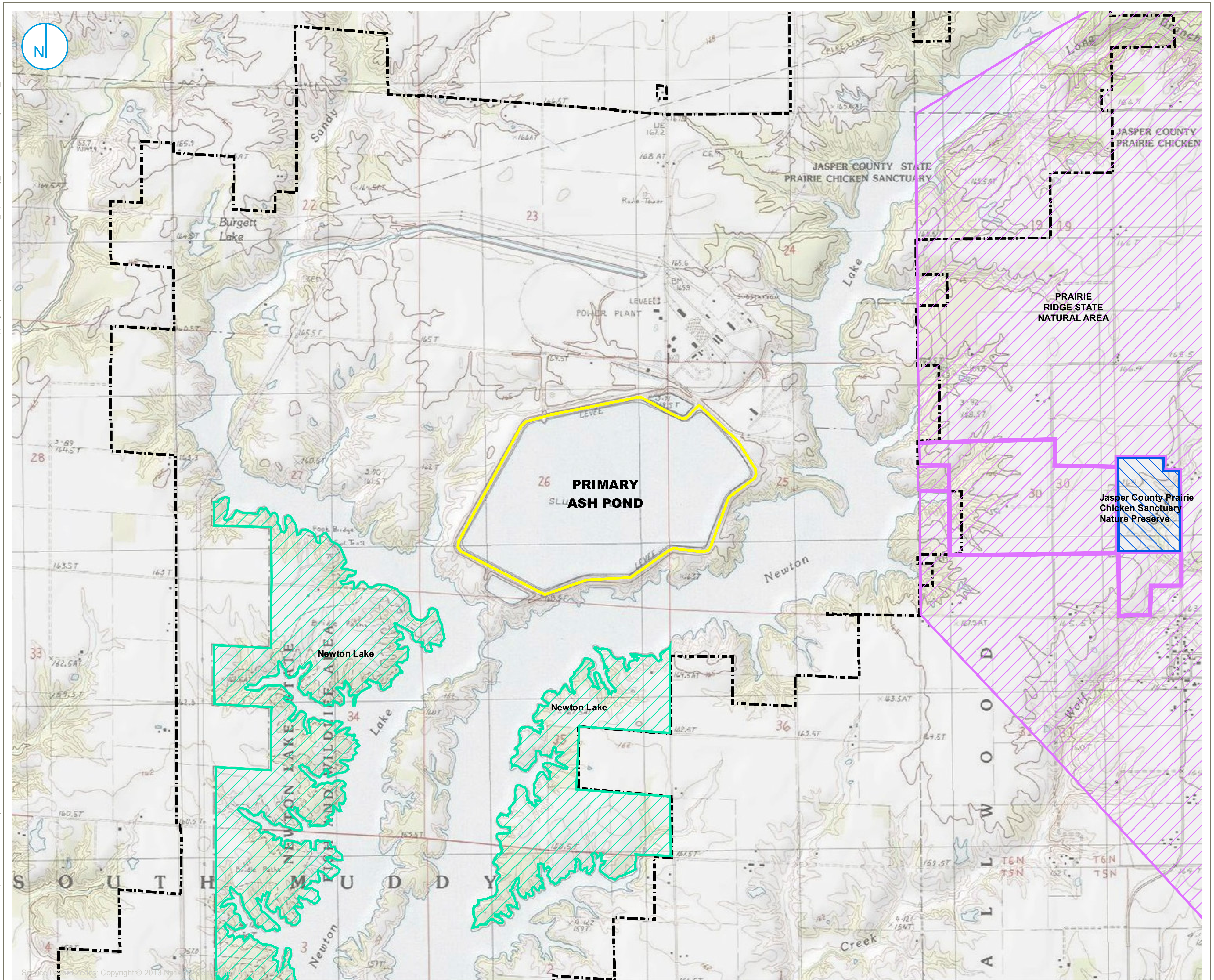
FIGURES



DRAFT

SITE LOCATION MAP

GROUNDWATER MODELING REPORT
PRIMARY ASH POND

NEWTON POWER PLANT
NEWTON, ILLINOIS

FIGURE 1-1

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

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Y:\Mapping\Projects\22\2285\MXD\845_Operating_Permit\Newton\Figure 1-1_Site Location Map.mxd

PROJECT: 194010101 0-007 | DATED: 4/11/2022 | DESIGNER: STOLZSD

PART 845 REGULATED UNIT (SUBJECT UNIT)
SITE FEATURE
PROPERTY BOUNDARY

0 500 1,000 Feet

SITE MAP

GROUNDWATER MODELLING REPORT
PRIMARY ASH POND
NEWTON POWER PLANT
NEWTON, ILLINOIS

FIGURE 1-2

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

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Y:\Mapping\Projects\22\2285\MXD\Model_Figures\Newton\Groundwater_Modelling_Report_2022\Figure 1_Site Map.mxd

PROJECT: 194010010-007 | DATED: 3/29/2022 | DESIGNER: galammc

PORE WATER WELL

MONITORING WELL

STAFF GAGE, CCR UNIT

STAFF GAGE, RIVER

PART 845 REGULATED UNIT (SUBJECT UNIT)

SITE FEATURE

0 400 800 Feet

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MONITORING WELL LOCATION MAP

GROUNDWATER MODELLING REPORT
PRIMARY ASH POND
NEWTON POWER PLANT
NEWTON, ILLINOIS

FIGURE 2-1

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

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Y:\Mapping\Projects\22\2285\MXD\Model_Figures\Newton\Groundwater_Modelling_Report_2022\Figure 3_Monitoring Well Location Map.mxd

PROJECT: 1940101010-007 | DATED: 3/29/2022 | DESIGNER: galammc

Y:\Mapping\Projects\23\2285\MXD\845_Operating_Permit\Newton\Figure 3-3_GWE_Contours_20210427.mxd

PROJECT: 194010101O-007 | DATED: 10/19/2021 | DESIGNER: STOLZSD

BACKGROUND WELL
MONITORING WELL
SOURCE SAMPLE LOCATION
STAFF GAGE
GROUNDWATER ELEVATION CONTOUR (5-FT CONTOUR INTERVAL, NAVD88)
INFERRED GROUNDWATER ELEVATION CONTOUR
GROUNDWATER FLOW DIRECTION
PART 845 REGULATED UNIT (SUBJECT UNIT)
SITE FEATURE

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NOTES:

1. ELEVATIONS IN PARENTHESES WERE NOT USED FOR CONTOURING.
2. NM = NOT MEASURED
3. ELEVATION CONTOURS SHOWN IN FEET, NORTH AMERICAN VERTICAL DATUM OF 1988

0 400 800 Feet

UPPERMOST AQUIFER GROUNDWATER ELEVATION CONTOURS APRIL 27, 2021

GROUNDWATER MODELING REPORT
PRIMARY ASH POND
NEWTON POWER PLANT
NEWTON, ILLINOIS

FIGURE 2-2

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL

Y:\Mapping\Projects\23\2285\MXD\845_Operating_Permit\Newton\Figure 3-4_GWE_Contours_20210714.mxd

PROJECT: 1940101010-007 | DATED: 10/19/2021 | DESIGNER: STOLZSD

BACKGROUND WELL
MONITORING WELL
SOURCE SAMPLE LOCATION
STAFF GAGE
GROUNDWATER ELEVATION CONTOUR (5-FT CONTOUR INTERVAL, NAVD88)
INFERRED GROUNDWATER ELEVATION CONTOUR
GROUNDWATER FLOW DIRECTION
PART 845 REGULATED UNIT (SUBJECT UNIT)
SITE FEATURE

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NOTES:

1. ELEVATIONS IN PARENTHESIS WERE NOT USED FOR CONTOURING.
2. NM = NOT MEASURED
3. ELEVATION CONTOURS SHOWN IN FEET, NORTH AMERICAN VERTICAL DATUM OF 1988

0 400 800 Feet

UPPERMOST AQUIFER GROUNDWATER ELEVATION CONTOURS JULY 14, 2021

GROUNDWATER MODELING REPORT
PRIMARY ASH POND
NEWTON POWER PLANT
NEWTON, ILLINOIS

FIGURE 2-3

RAMBOLL AMERICAS ENGINEERING SOLUTIONS, INC.

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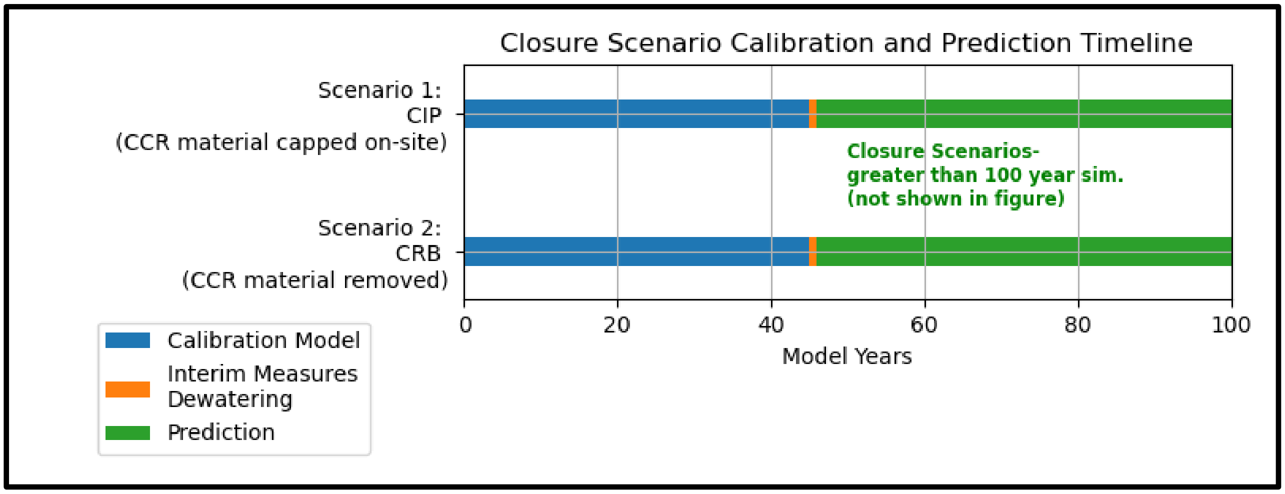
FIGURE 4-1



CLOSURE SCENARIO CALIBRATION AND PREDICTION MODEL

GROUNDWATER MODELING REPORT
PRIMARY ASH POND
NEWTOWN POWER PLANT
NEWTOWN, ILLINOIS

RAMBOLL

CCR
UD
UA
RIVER
LAKE
COOLING FLUME
MODEL DOMAIN
PART 845 REGULATED UNIT (SUBJECT UNIT)
SITE FEATURE

0 0.25 0.5 Miles

DRAFT

MODEL AREA MAP

GROUNDWATER MODELLING REPORT
PRIMARY ASH POND
NEWTON POWER PLANT
NEWTON, ILLINOIS

FIGURE 5-1

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

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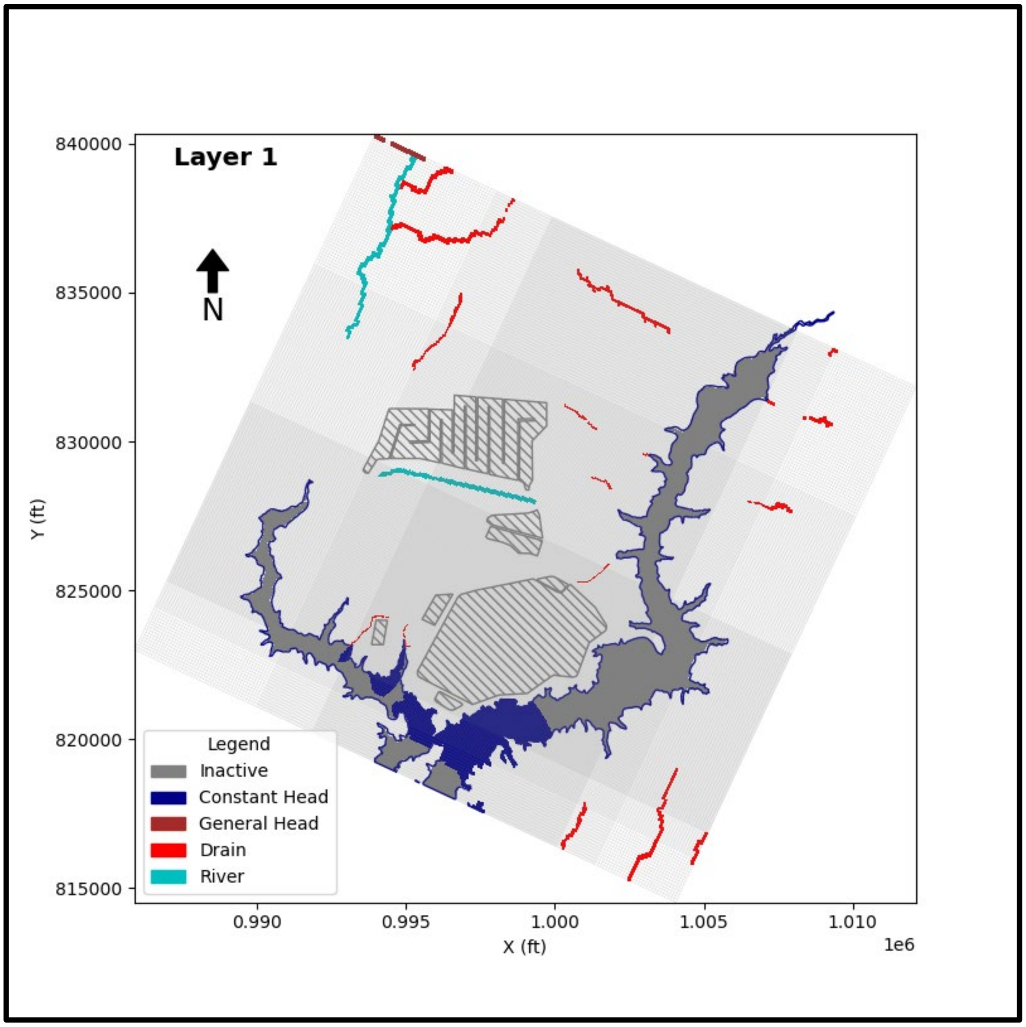
Y:\Mapping\Projects\22\2285\MXD\Model_Figures\Newton\Groundwater_Modelling_Report_2022\Figure 4_Model Domain.mxd

PROJECT: 194010010-007 | DATED: 3/29/2022 | DESIGNER: galarmc

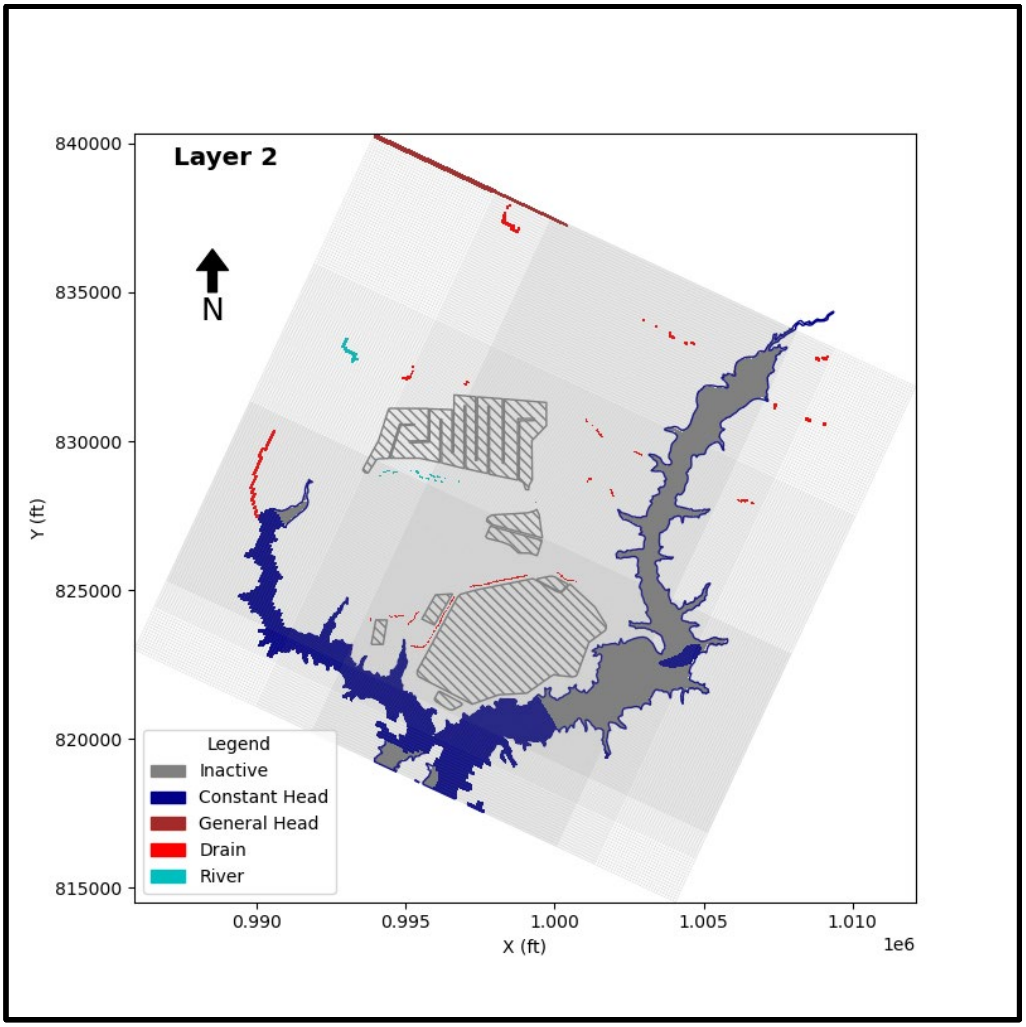
FIGURE 5-2



BOUNDARY CONDITIONS FOR LAYER 1 OF THE CALIBRATED NUMERICAL MODEL

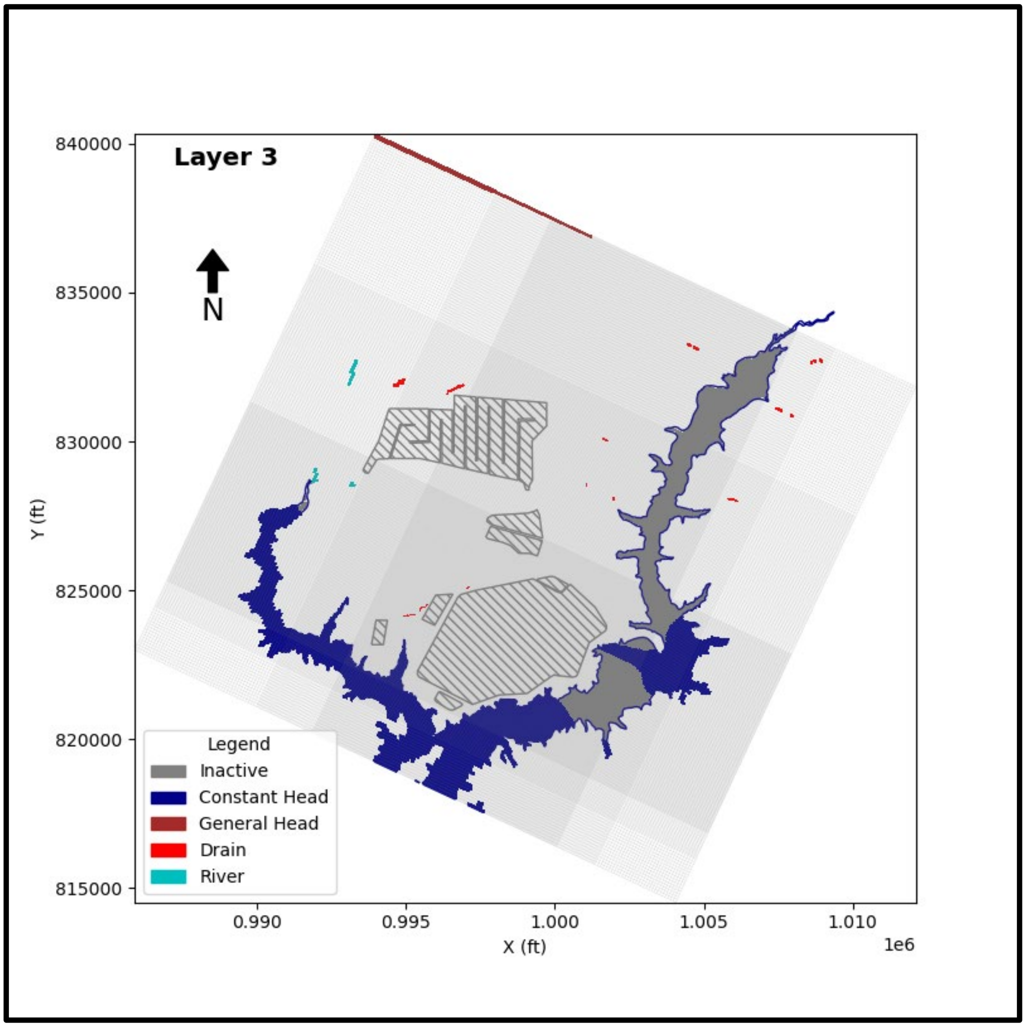
GROUNDWATER MODELING REPORT
PRIMARY ASH POND
NEWTON POWER PLANT
NEWTON, ILLINOIS

RAMBOLL



BOUNDARY CONDITIONS FOR LAYER 2 OF THE CALIBRATED NUMERICAL MODEL

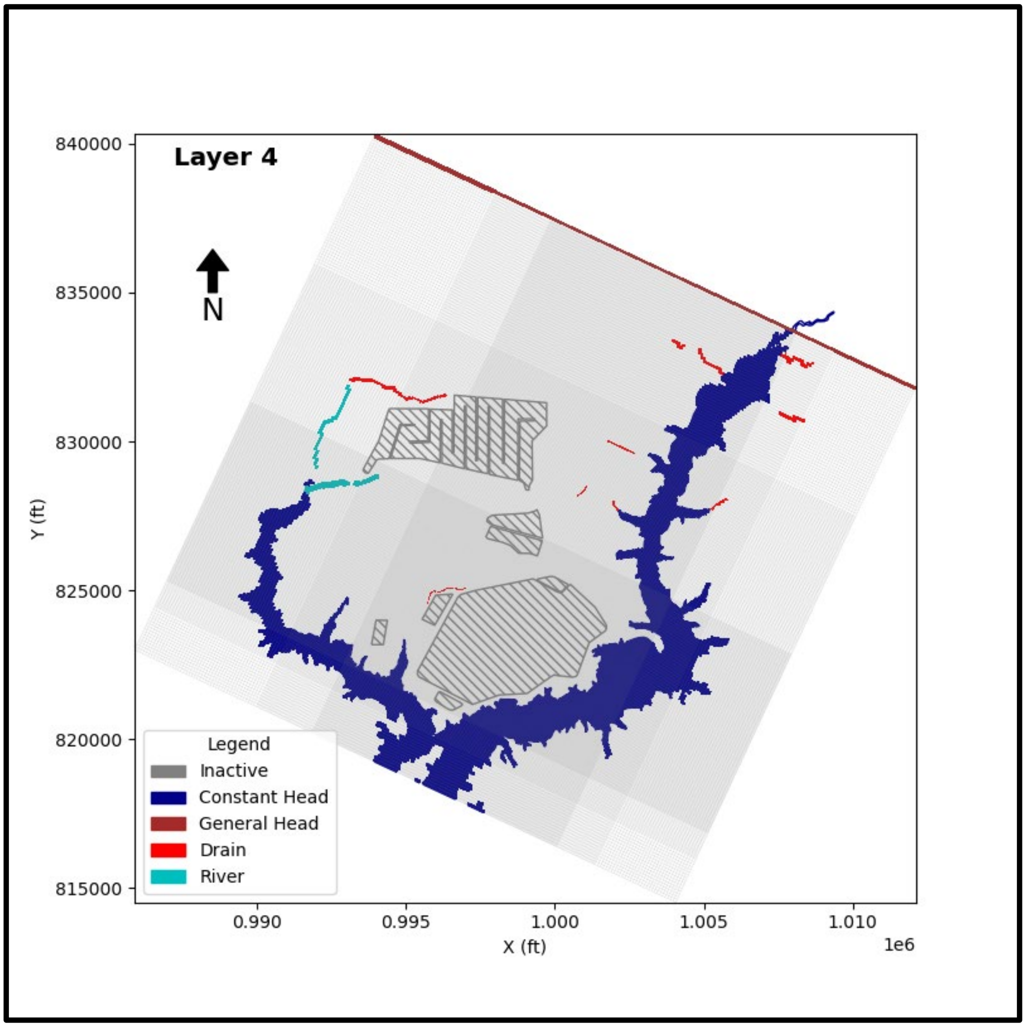
GROUNDWATER MODELING REPORT
PRIMARY ASH POND
NEWTON POWER PLANT
NEWTON, ILLINOIS



BOUNDARY CONDITIONS FOR LAYER 3 OF THE CALIBRATED NUMERICAL MODEL

GROUNDWATER MODELING REPORT
PRIMARY ASH POND
NEWTON POWER PLANT
NEWTON, ILLINOIS

RAMBOLL

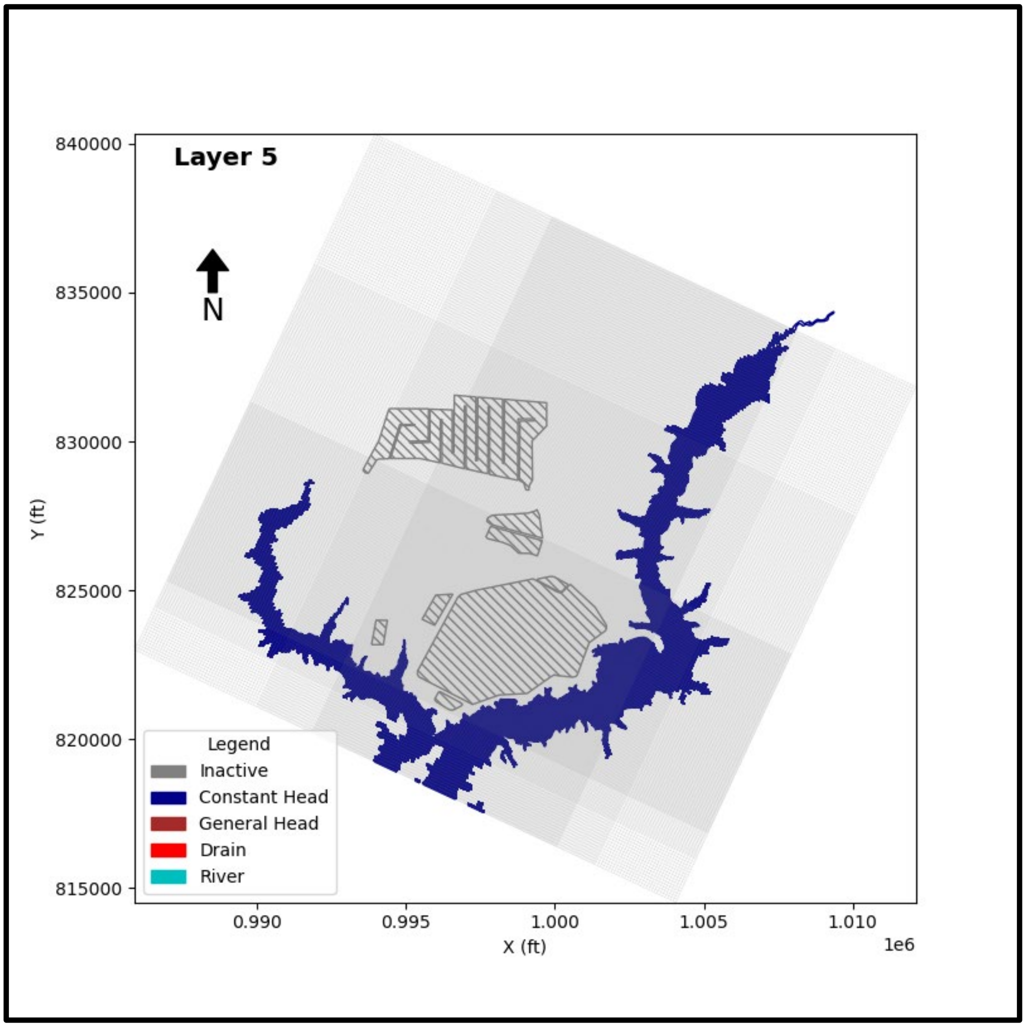


BOUNDARY CONDITIONS FOR LAYER 4 OF THE CALIBRATED NUMERICAL MODEL

GROUNDWATER MODELING REPORT
PRIMARY ASH POND
NEWTON POWER PLANT
NEWTON, ILLINOIS

RAMBOLL

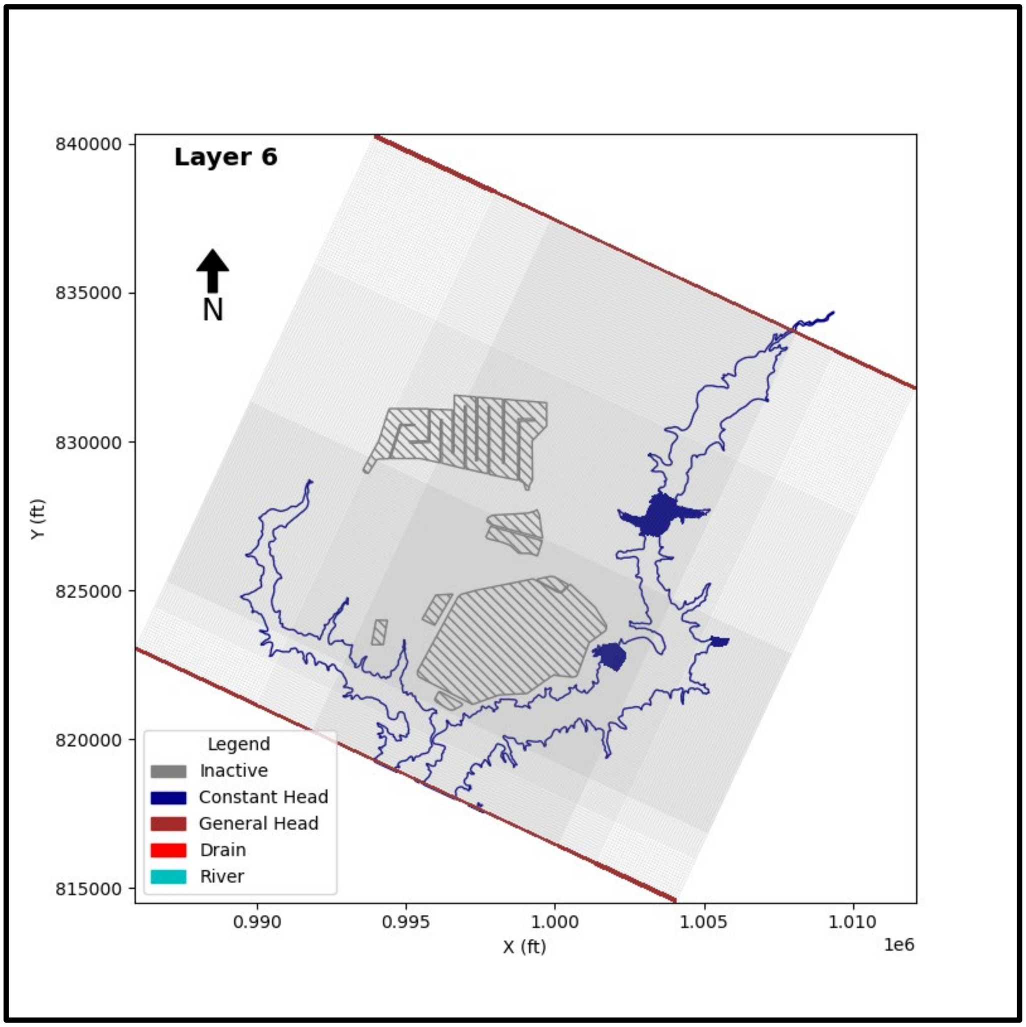
FIGURE 5-6



BOUNDARY CONDITIONS FOR LAYER 5 OF THE CALIBRATED NUMERICAL MODEL

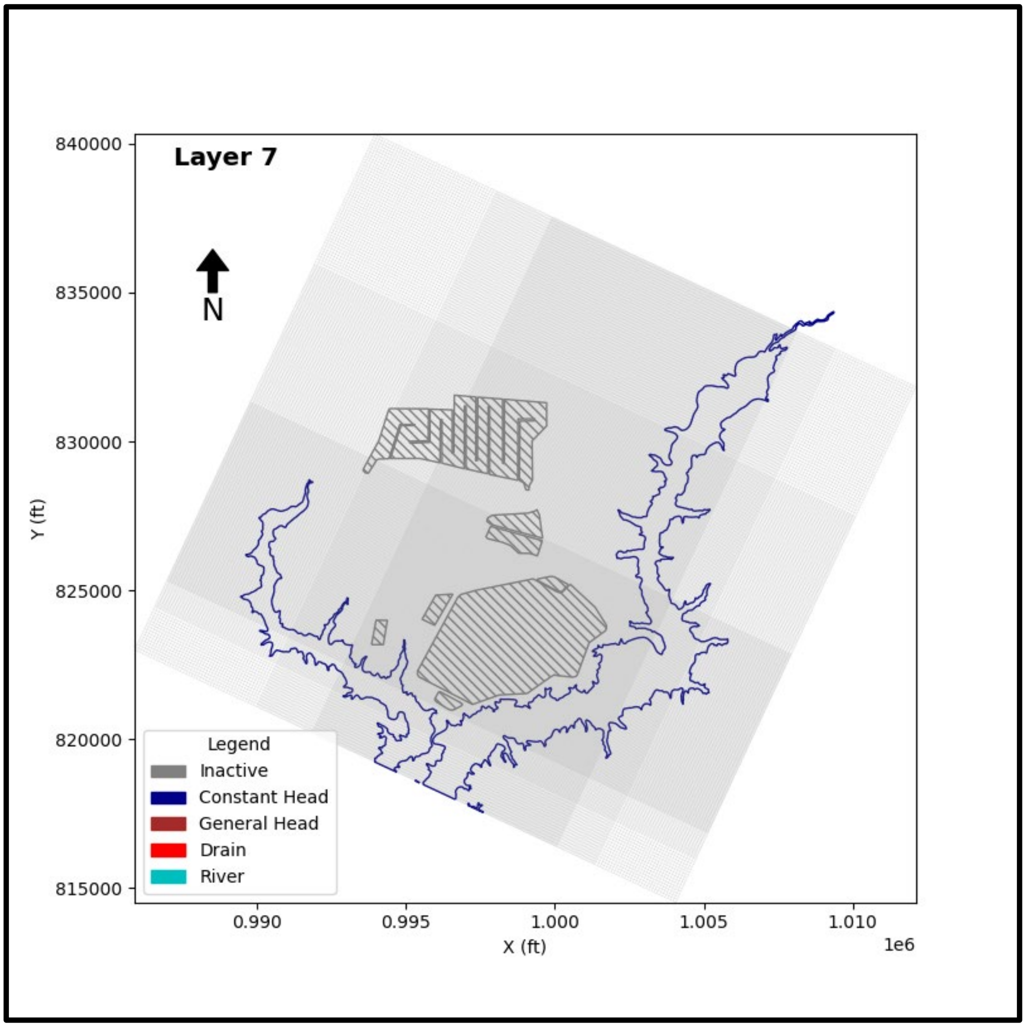
GROUNDWATER MODELING REPORT
PRIMARY ASH POND
NEWTON POWER PLANT
NEWTON, ILLINOIS

RAMBOLL



BOUNDARY CONDITIONS FOR LAYER 6 OF THE CALIBRATED NUMERICAL MODEL

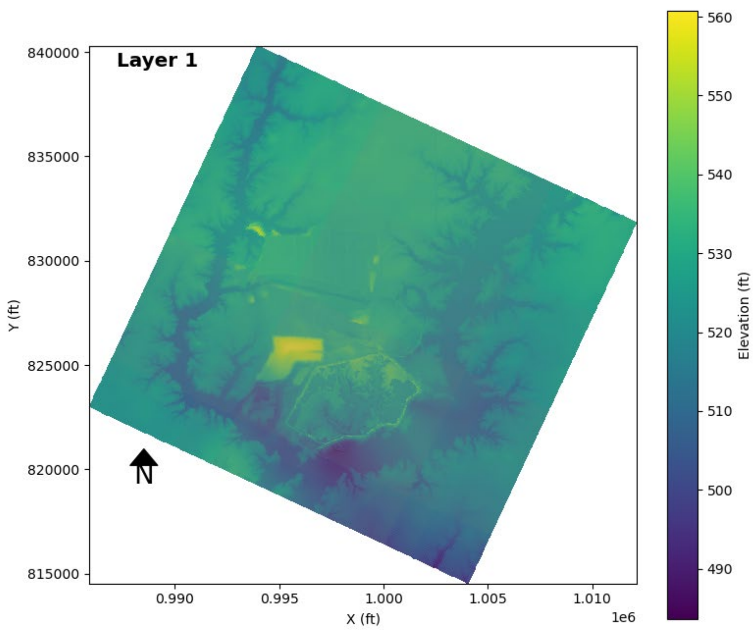
GROUNDWATER MODELING REPORT
PRIMARY ASH POND
NEWTON POWER PLANT
NEWTON, ILLINOIS



BOUNDARY CONDITIONS FOR LAYER 7 OF THE CALIBRATED NUMERICAL MODEL

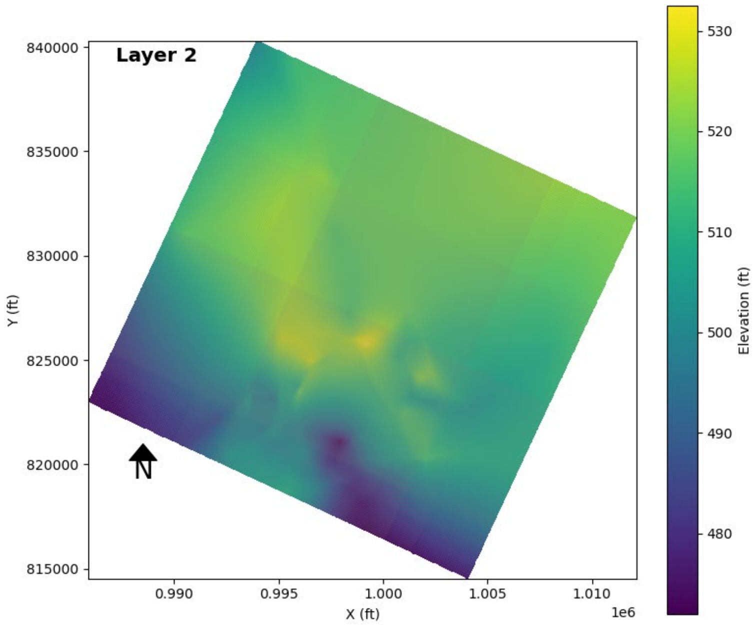
GROUNDWATER MODELING REPORT
PRIMARY ASH POND
NEWTON POWER PLANT
NEWTON, ILLINOIS

RAMBOLL



BASE OF MODEL LAYER 1

GROUNDWATER MODELING REPORT
PRIMARY ASH POND
NEWTON POWER PLANT
NEWTON, ILLINOIS

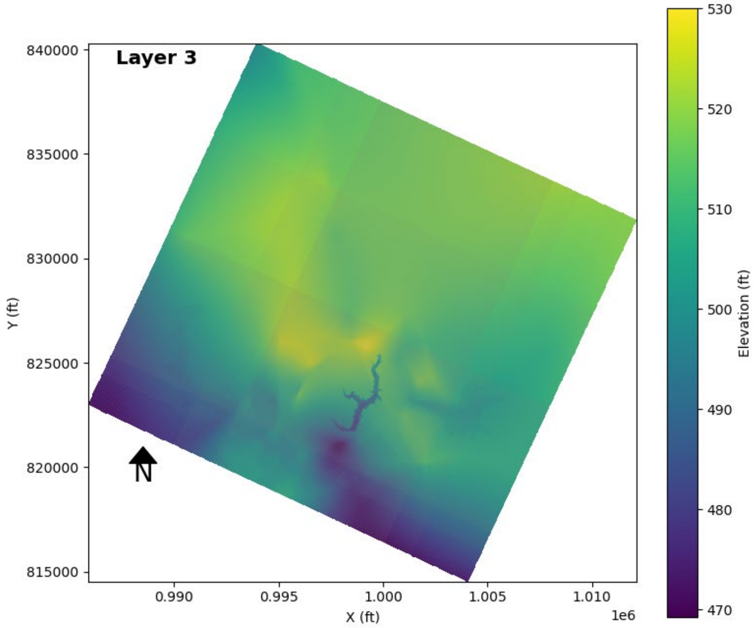


BASE OF MODEL LAYER 2

GROUNDWATER MODELING REPORT
PRIMARY ASH POND
NEWTON POWER PLANT
NEWTON, ILLINOIS

RAMBOLL

FIGURE 5-11

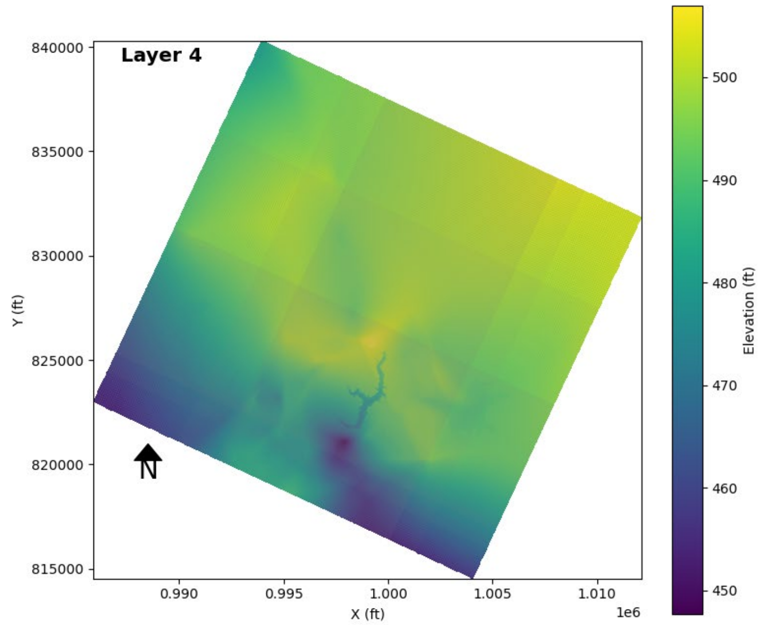


DRAFT

BASE OF MODEL LAYER 3

GROUNDWATER MODELING REPORT
PRIMARY ASH POND
NEWTON POWER PLANT
NEWTON, ILLINOIS

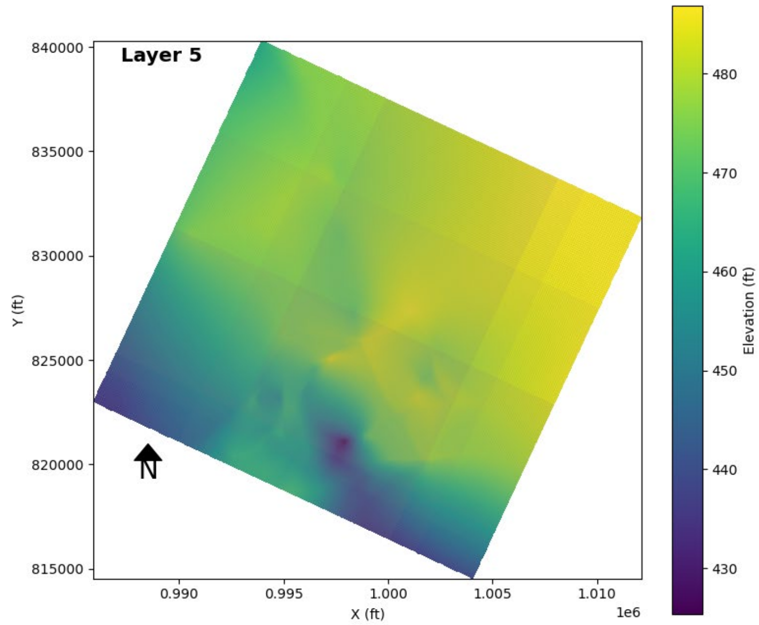
RAMBOLL



BASE OF MODEL LAYER 4

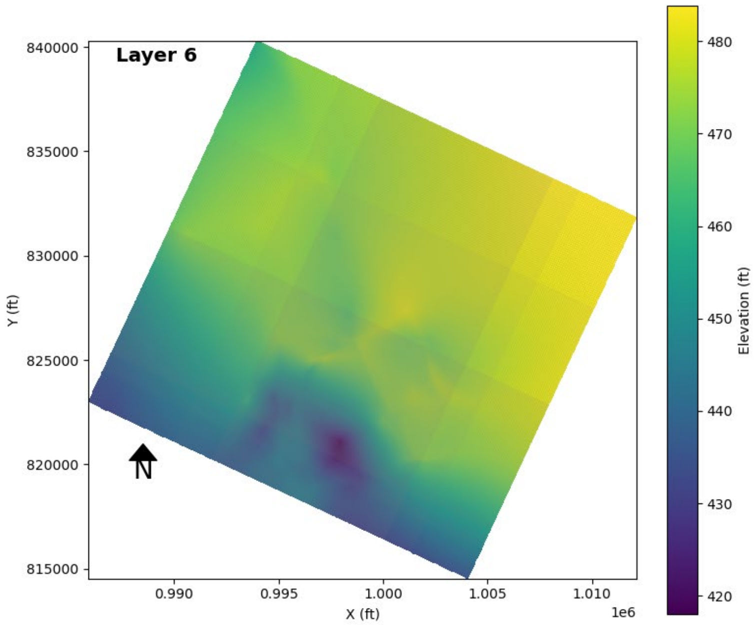
GROUNDWATER MODELING REPORT
PRIMARY ASH POND
NEWTON POWER PLANT
NEWTON, ILLINOIS

RAMBOLL



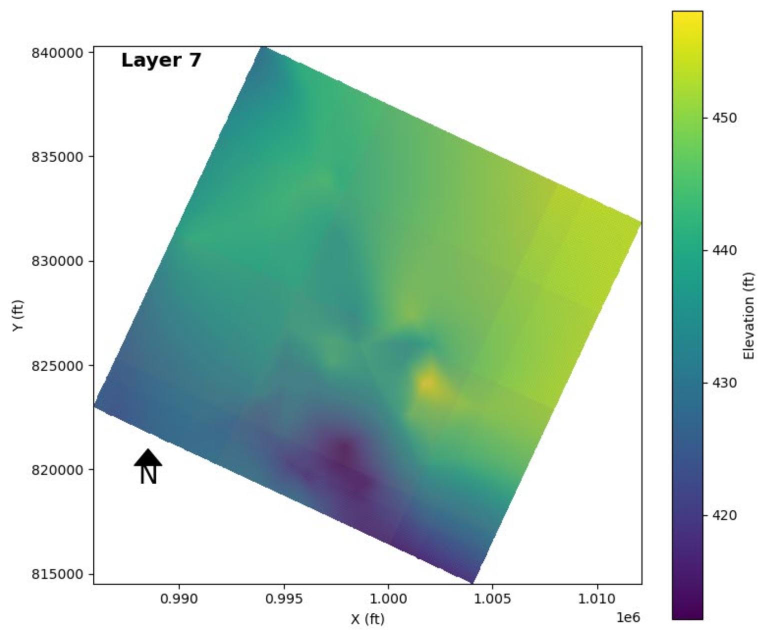
BASE OF MODEL LAYER 5

GROUNDWATER MODELING REPORT
PRIMARY ASH POND
NEWTON POWER PLANT
NEWTON, ILLINOIS



BASE OF MODEL LAYER 6

GROUNDWATER MODELING REPORT
PRIMARY ASH POND
NEWTON POWER PLANT
NEWTON, ILLINOIS

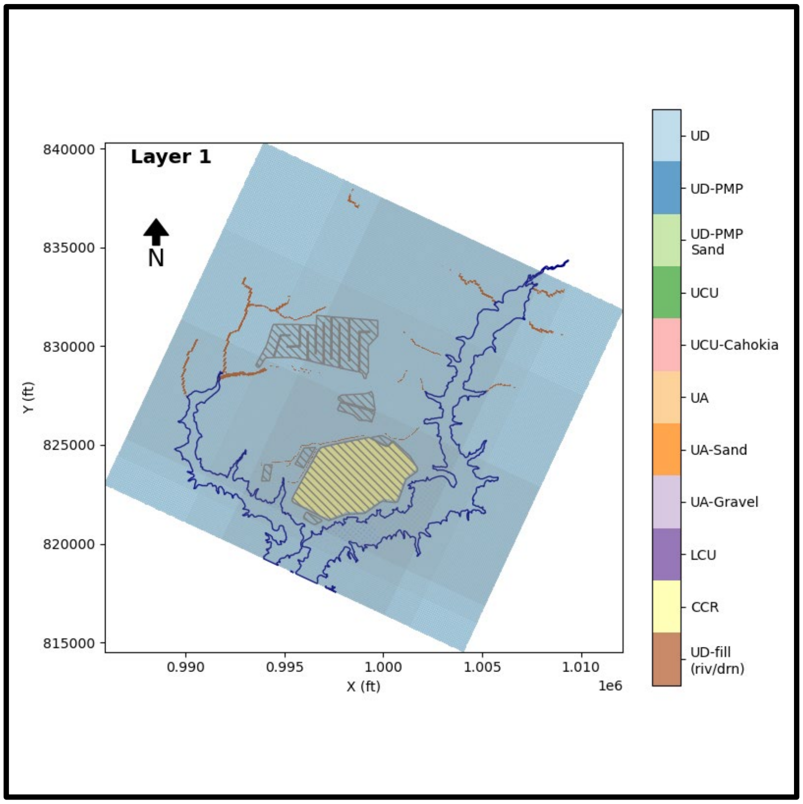


BASE OF MODEL LAYER 7

GROUNDWATER MODELING REPORT
PRIMARY ASH POND
NEWTON POWER PLANT
NEWTON, ILLINOIS

RAMBOLL

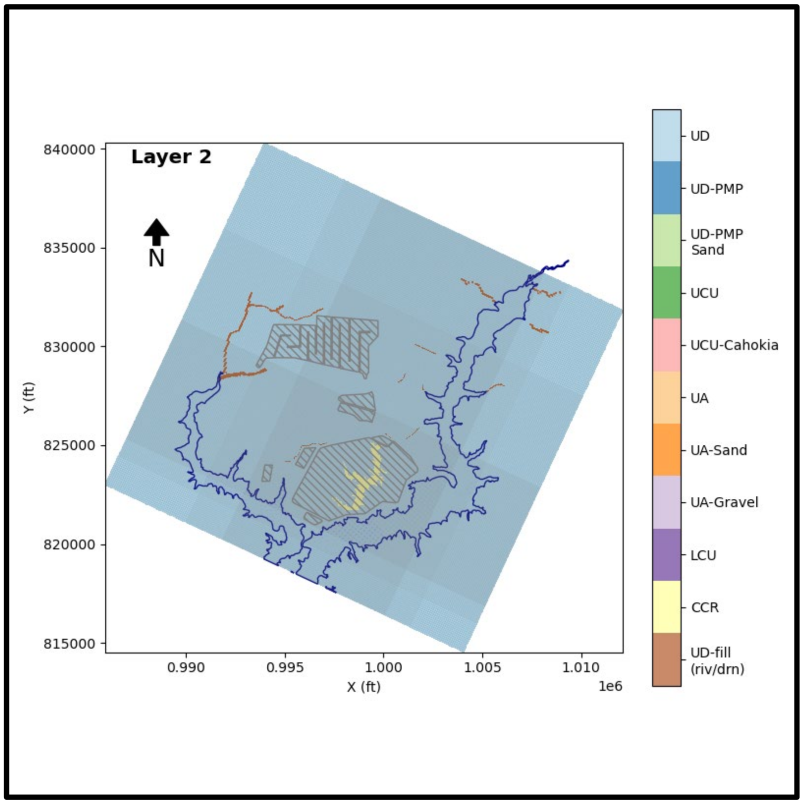
FIGURE 5-16



SPATIAL DISTRIBUTION OF HYDROSTRATIGRAPHIC LAYERS FOR LAYER 1 IN THE NUMERICAL MODEL

GROUNDWATER MODELING REPORT
PRIMARY ASH POND
NEWTON POWER PLANT
NEWTON, ILLINOIS

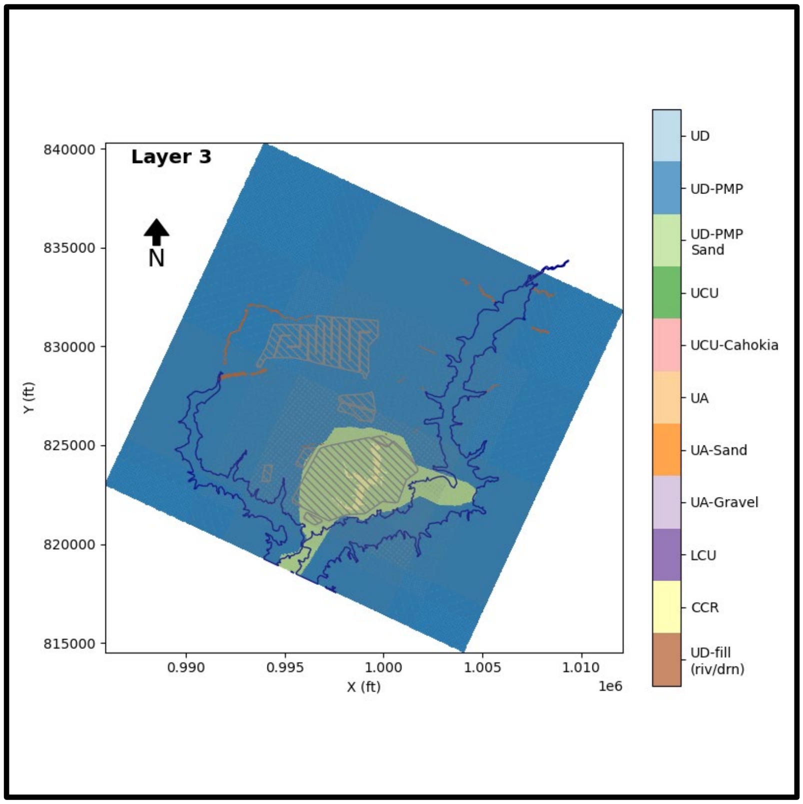
RAMBOLL



SPATIAL DISTRIBUTION OF HYDROSTRATIGRAPHIC LAYERS FOR LAYER 2 IN THE NUMERICAL MODEL

GROUNDWATER MODELING REPORT
PRIMARY ASH POND
NEWTON POWER PLANT
NEWTON, ILLINOIS

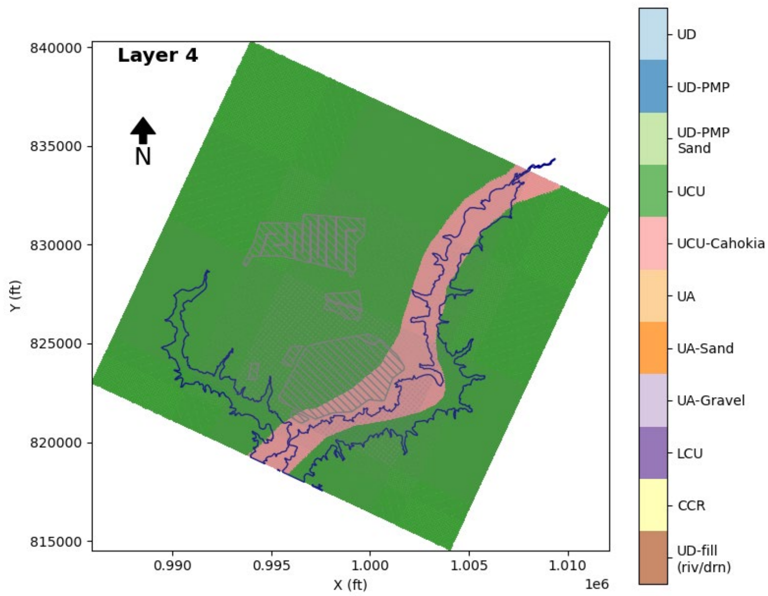
RAMBOLL



SPATIAL DISTRIBUTION OF HYDROSTRATIGRAPHIC LAYERS FOR LAYER 3 IN THE NUMERICAL MODEL

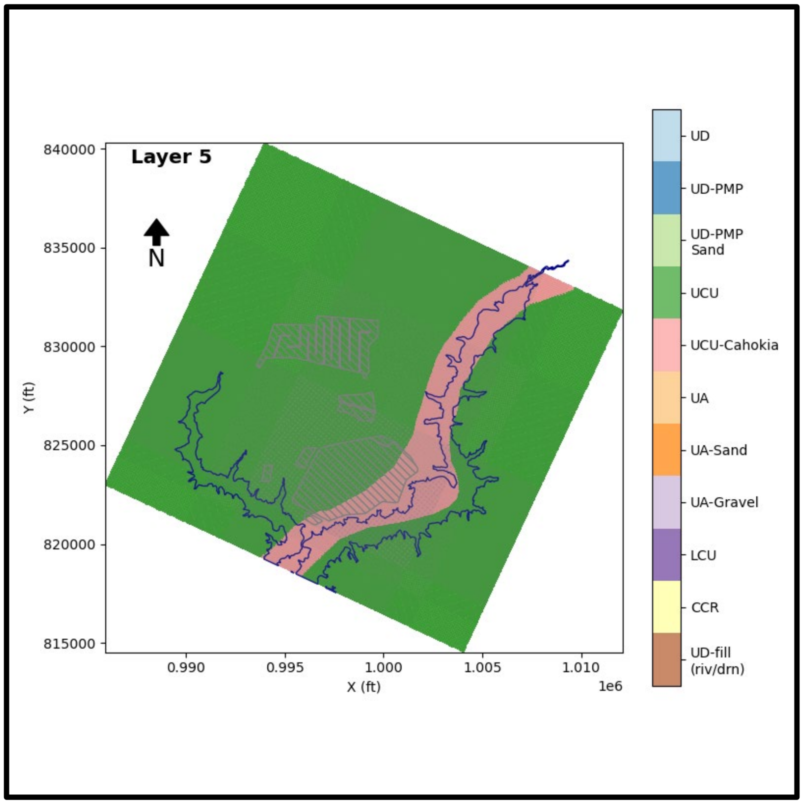
GROUNDWATER MODELING REPORT
PRIMARY ASH POND
NEWTON POWER PLANT
NEWTON, ILLINOIS

RAMBOLL



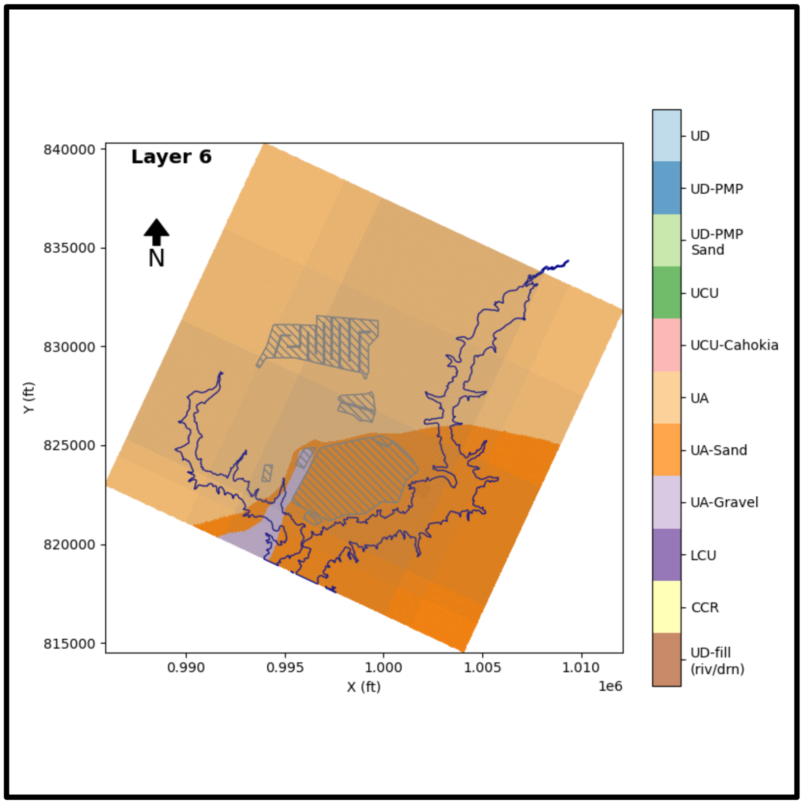
SPATIAL DISTRIBUTION OF HYDROSTRATIGRAPHIC LAYERS FOR LAYER 4 IN THE NUMERICAL MODEL

GROUNDWATER MODELING REPORT
PRIMARY ASH POND
NEWTON POWER PLANT
NEWTON, ILLINOIS



SPATIAL DISTRIBUTION OF HYDROSTRATIGRAPHIC LAYERS FOR LAYER 5 IN THE NUMERICAL MODEL

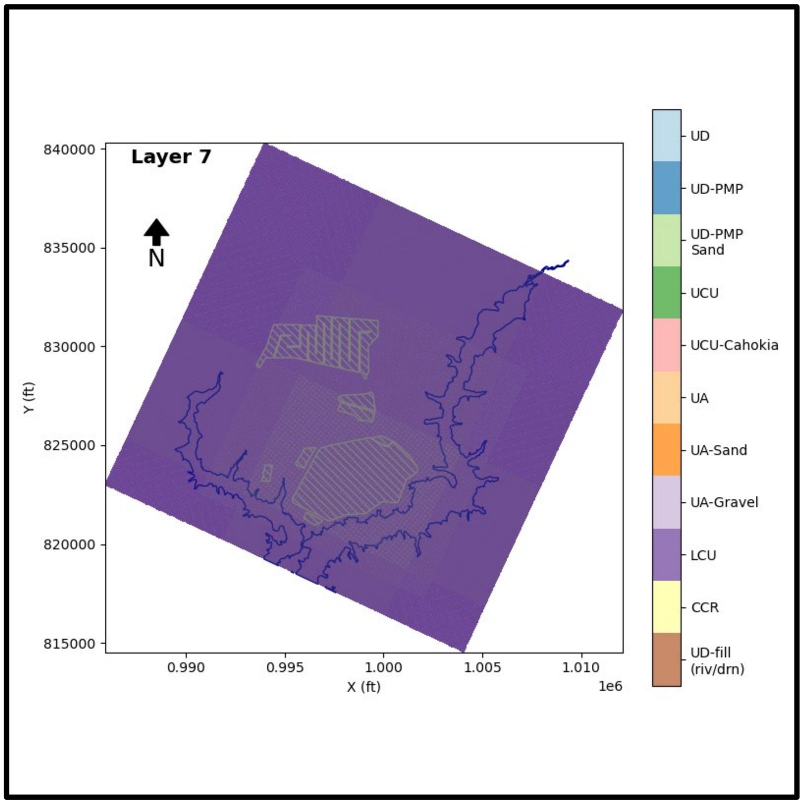
GROUNDWATER MODELING REPORT
PRIMARY ASH POND
NEWTON POWER PLANT
NEWTON, ILLINOIS



SPATIAL DISTRIBUTION OF HYDROSTRATIGRAPHIC LAYERS FOR LAYER 6 IN THE NUMERICAL MODEL

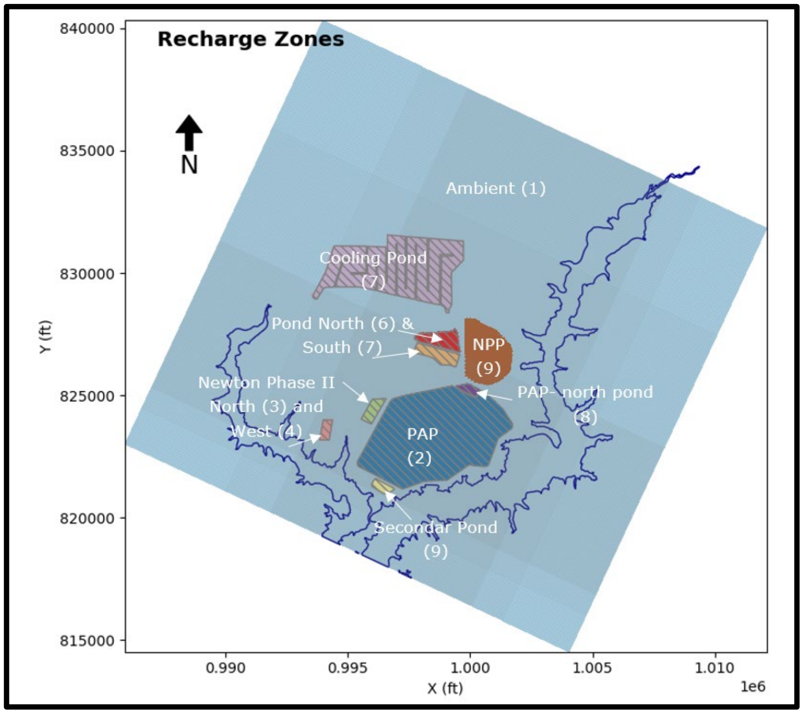
GROUNDWATER MODELING REPORT
PRIMARY ASH POND
NEWTON POWER PLANT
NEWTON, ILLINOIS

RAMBOLL



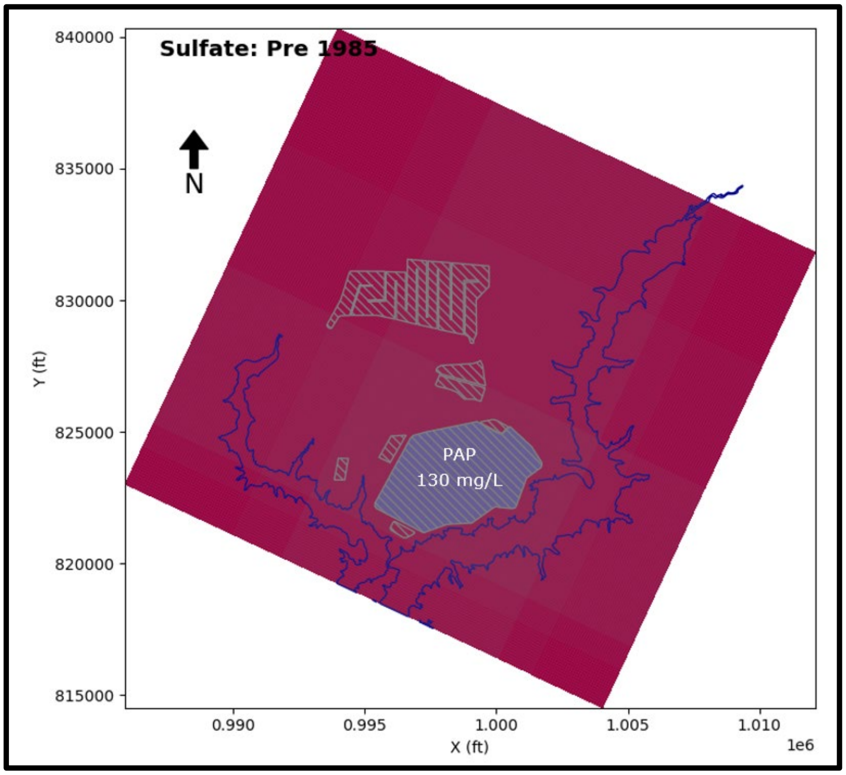
SPATIAL DISTRIBUTION OF HYDROSTRATIGRAPHIC LAYERS FOR LAYER 7 IN THE NUMERICAL MODEL

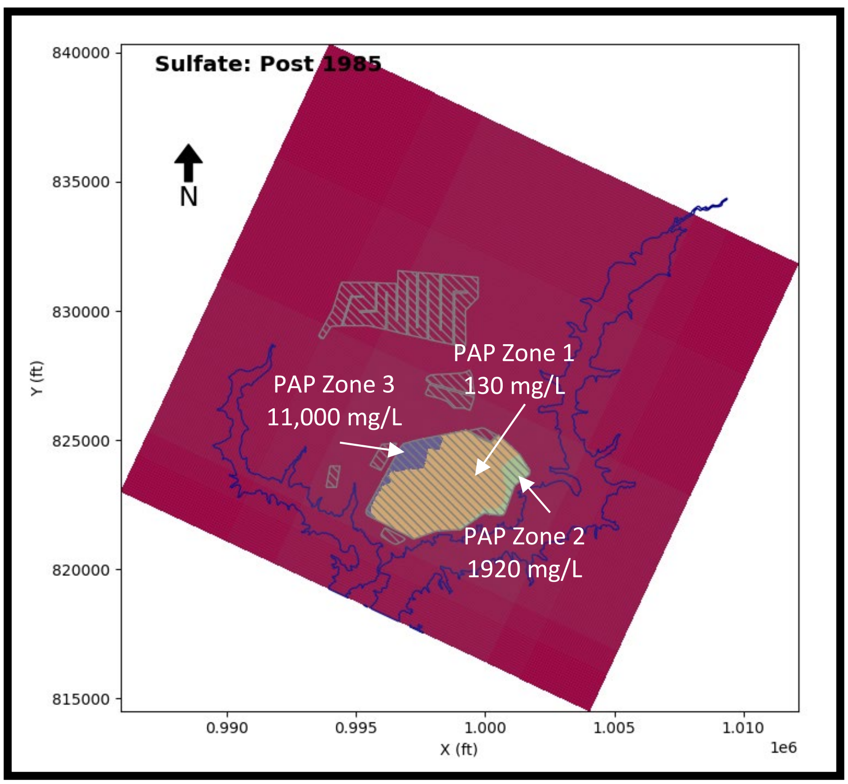
GROUNDWATER MODELING REPORT
PRIMARY ASH POND
NEWTON POWER PLANT
NEWTON, ILLINOIS



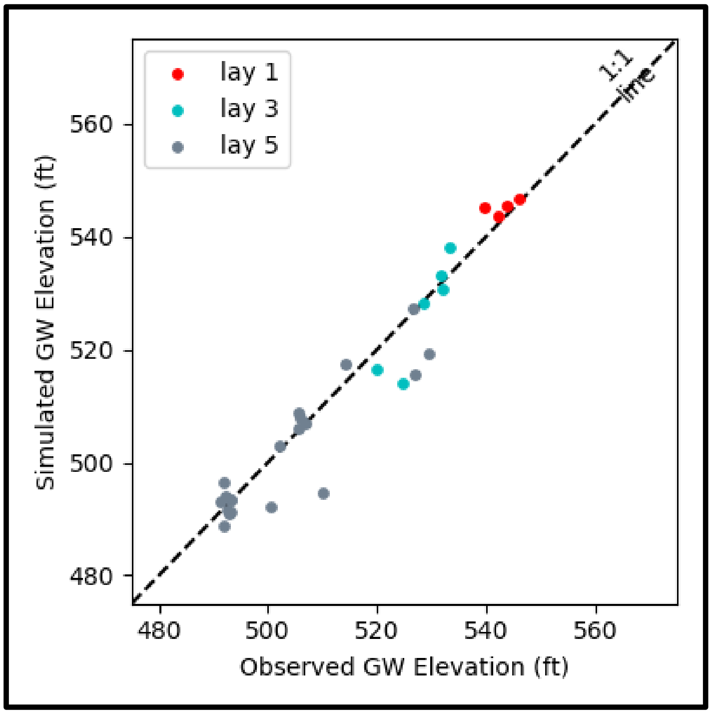
MODEL RECHARGE DISTRIBUTION (STEADY STATE CALIBRATION MODEL)

GROUNDWATER MODELING REPORT
PRIMARY ASH POND
NEWTON POWER PLANT
NEWTON, ILLINOIS





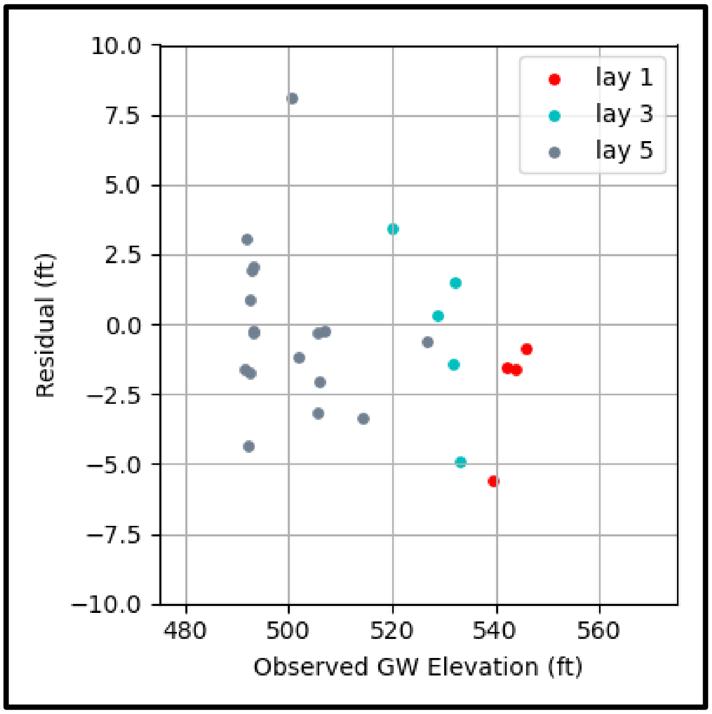
MODEL RECHARGE DISTRIBUTION FOR TRANSPORT MODEL FOR PRE AND POST 1985



OBSERVED VERSUS SIMULATED STEADY STATE GROUNDWATER LEVELS FROM THE CALIBRATION MODEL

GROUNDWATER MODELING REPORT
PRIMARY ASH POND
NEWTON POWER PLANT
NEWTON, ILLINOIS

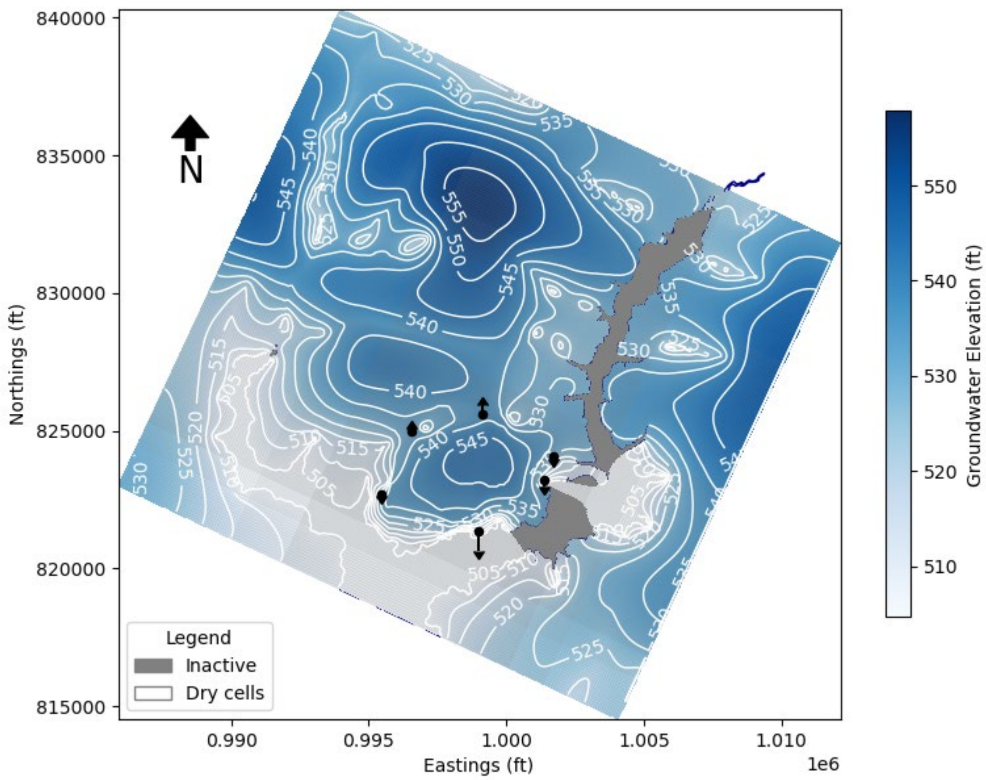
RAMBOLL



SIMULATED GROUNDWATER LEVEL RESIDUALS FROM THE CALIBRATED MODEL

GROUNDWATER MODELING REPORT
PRIMARY ASH POND
NEWTON POWER PLANT
NEWTON, ILLINOIS

RAMBOLL

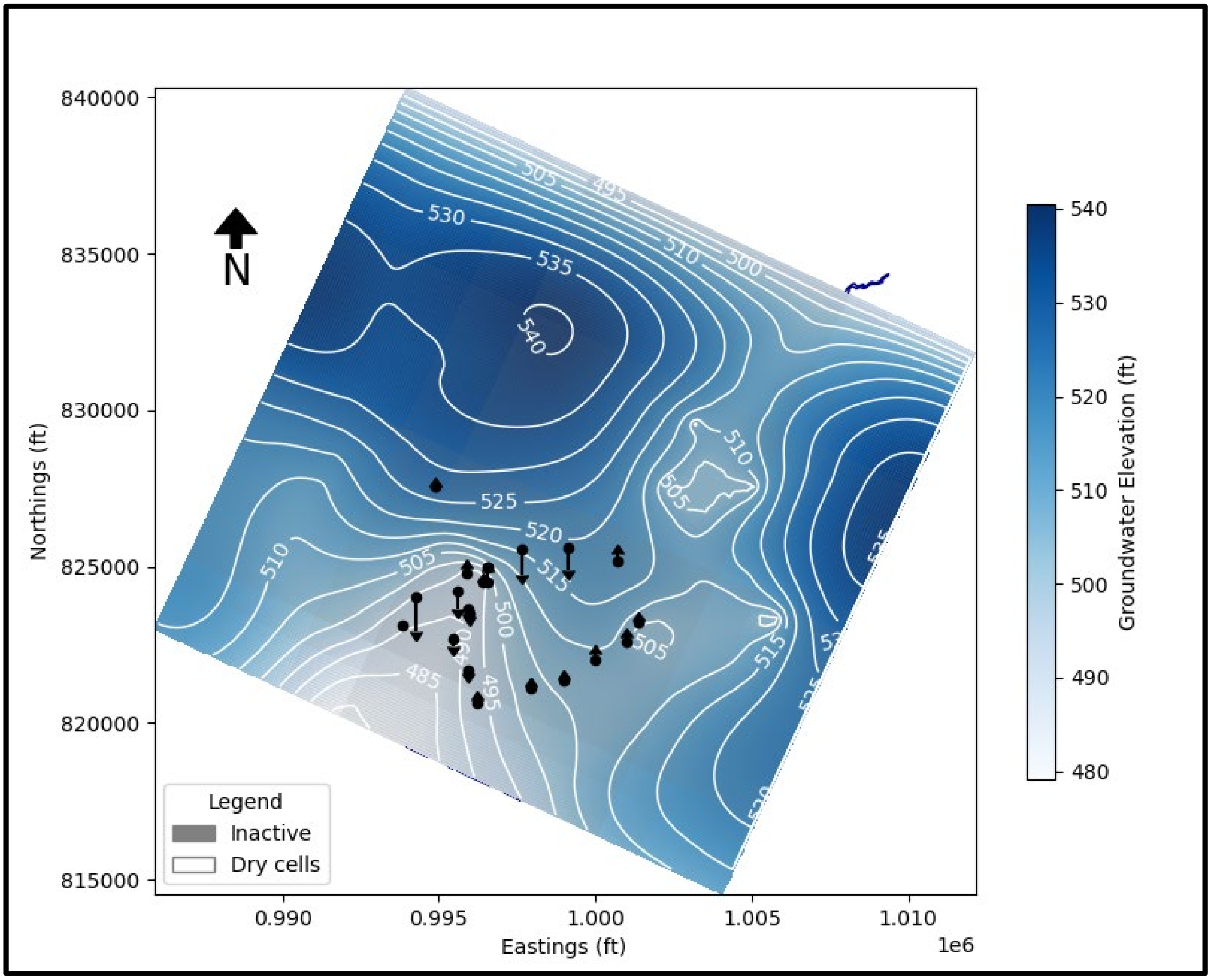


NOTE: BLACK DOTS INDICATE WELLS AND ARROW DIRECTION INDICATES BIAS IN SIMULATED GROUNDWATER LEVEL (NORTH ARROW = OVERESTIMATION, SOUTH ARROW = UNDERESTIMATION)

SIMULATED STEADY STATE GROUNDWATER LEVEL CONTOURS FROM UD/PMP (LAYER 3) FROM THE CALIBRATED MODEL

GROUNDWATER MODELING REPORT
PRIMARY ASH POND
NEWTON POWER PLANT
NEWTON, ILLINOIS

RAMBOLL

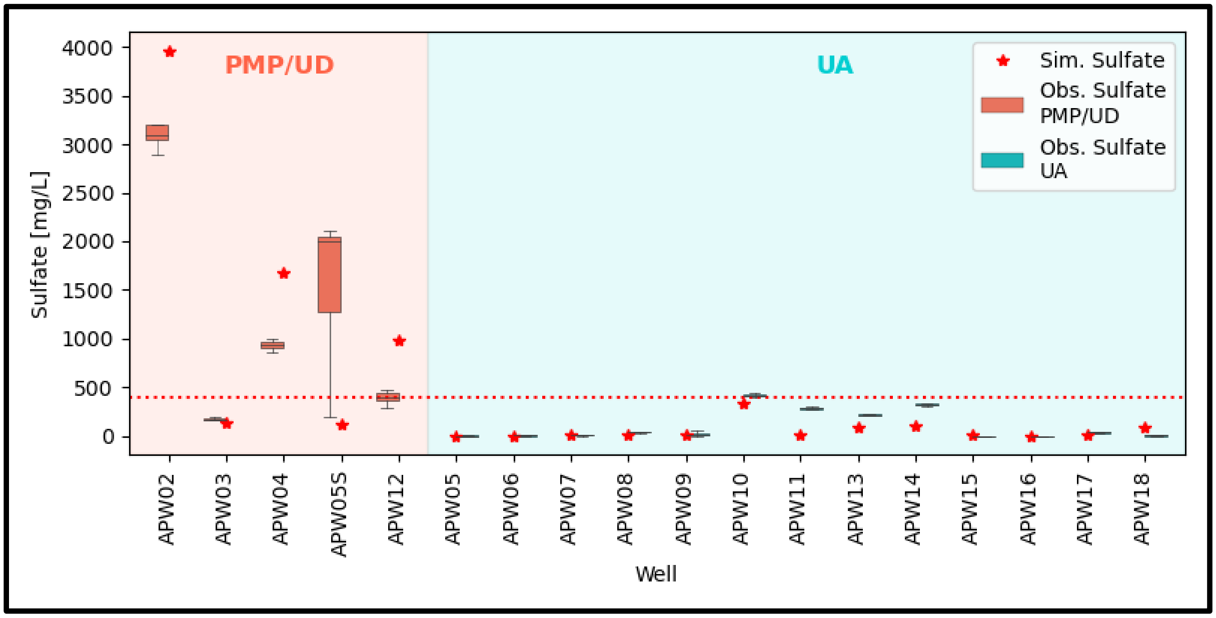


NOTE: BLACK DOTS INDICATE WELLS AND ARROW DIRECTION INDICATES BIAS IN SIMULATED GROUNDWATER LEVEL (NORTH ARROW = OVERESTIMATION, SOUTH ARROW = UNDERESTIMATION)

SIMULATED STEADY STATE GROUNDWATER LEVEL CONTOURS FROM UA (LAYER 6) FROM THE CALIBRATED MODEL

GROUNDWATER MODELING REPORT
PRIMARY ASH POND
NEWTON POWER PLANT
NEWTON, ILLINOIS

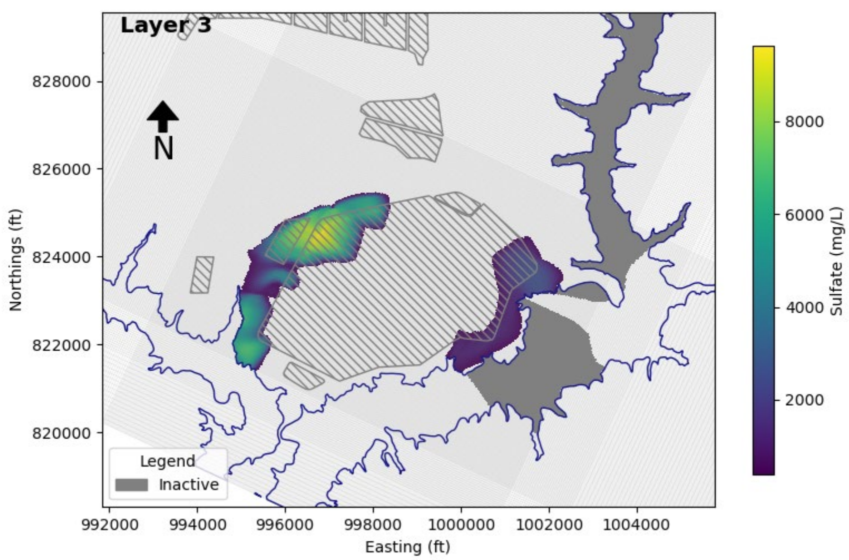
RAMBOLL



OBSERVED VERSUS SIMULATED SULFATE CONCENTRATIONS (mg/L)
(Obs. = Observed and Sim. = Simulated)

GROUNDWATER MODELING REPORT
PRIMARY ASH POND
NEWTON POWER PLANT
NEWTON, ILLINOIS

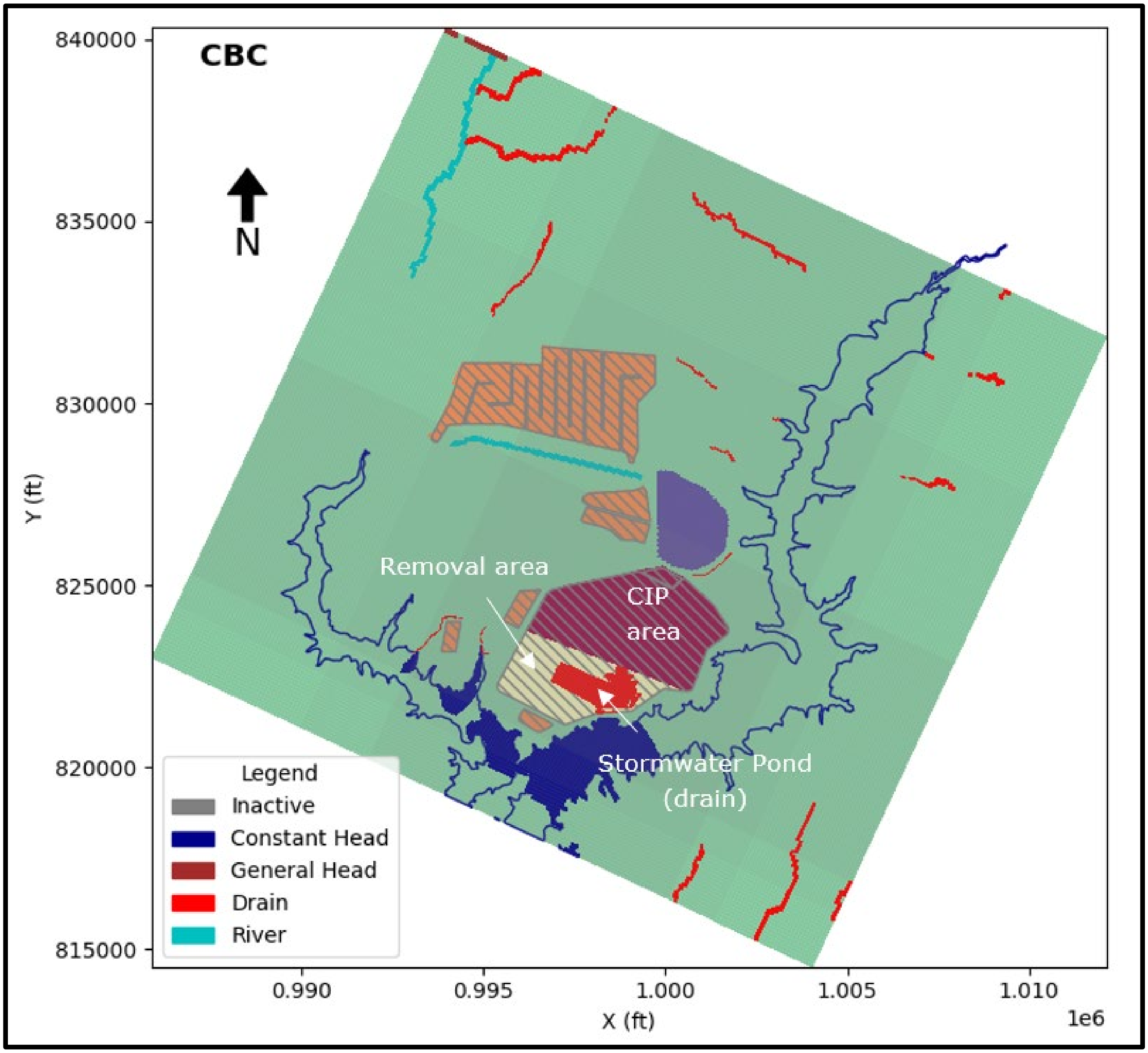
RAMBOLL



SIMULATED SULFATE PLUME OF THE UD/PMP FROM THE TRANSIENT MODEL

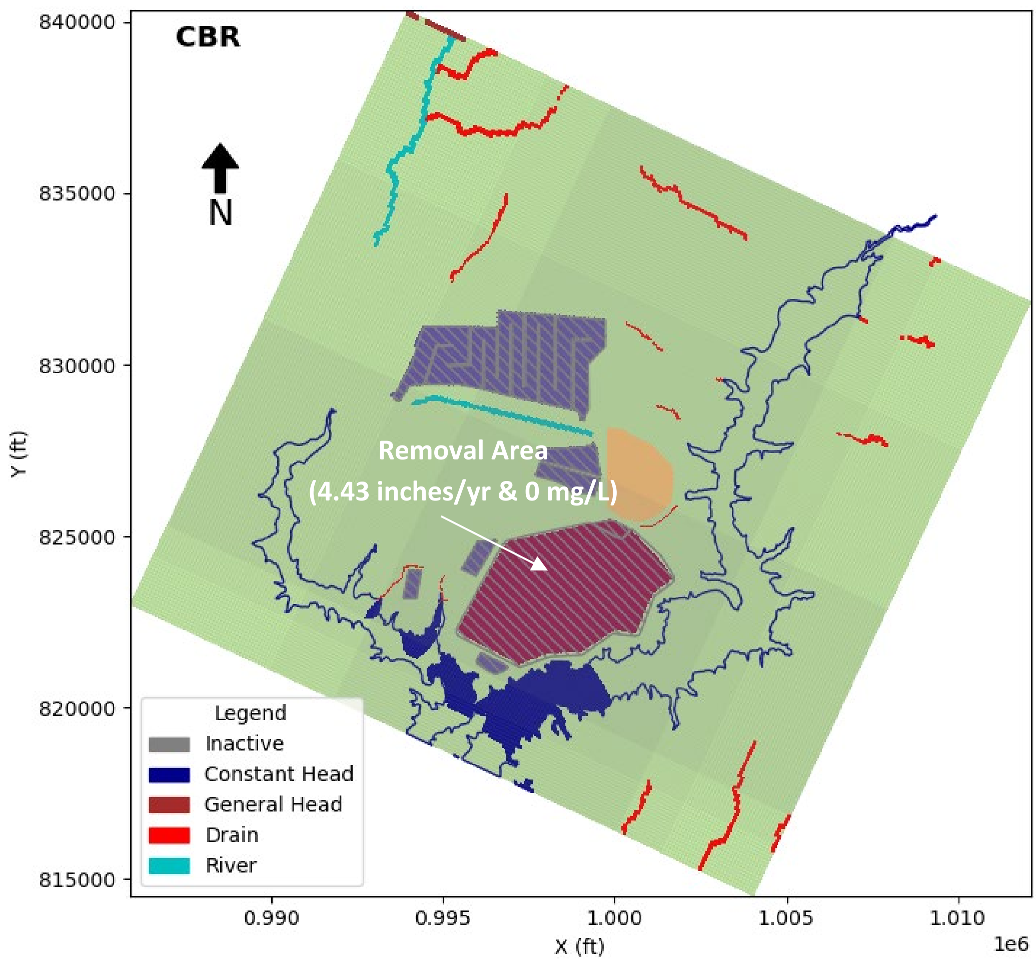
GROUNDWATER MODELING REPORT
PRIMARY ASH POND
NEWTON POWER PLANT
NEWTON, ILLINOIS

RAMBOLL



CIP RECHARGE AND STORMWATER POND MODIFICATIONS

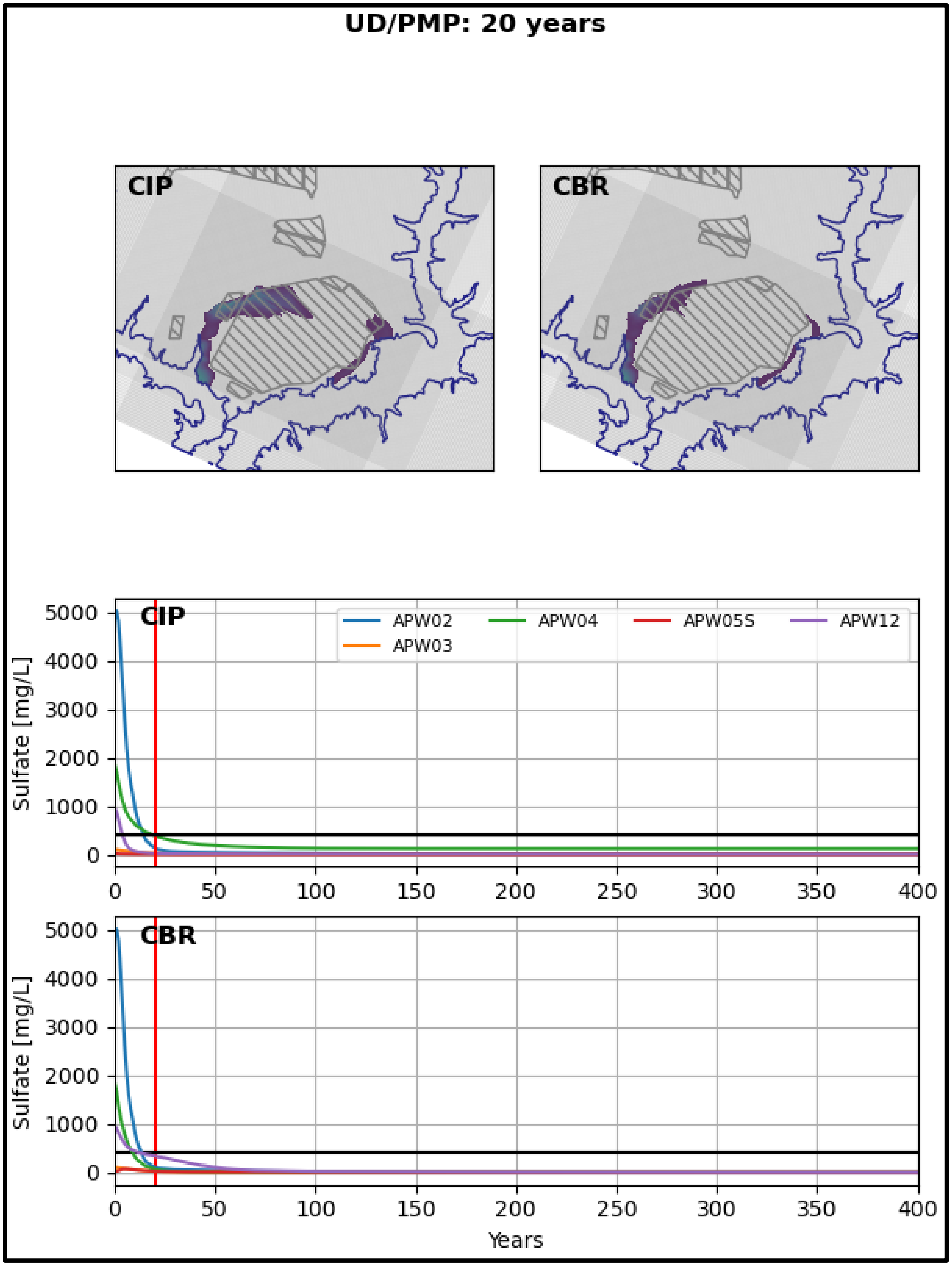
GROUNDWATER MODELING REPORT
PRIMARY ASH POND
NEWTON POWER PLANT
NEWTON, ILLINOIS



CBR RECHARGE MODIFICATIONS AND REMOVAL AREA

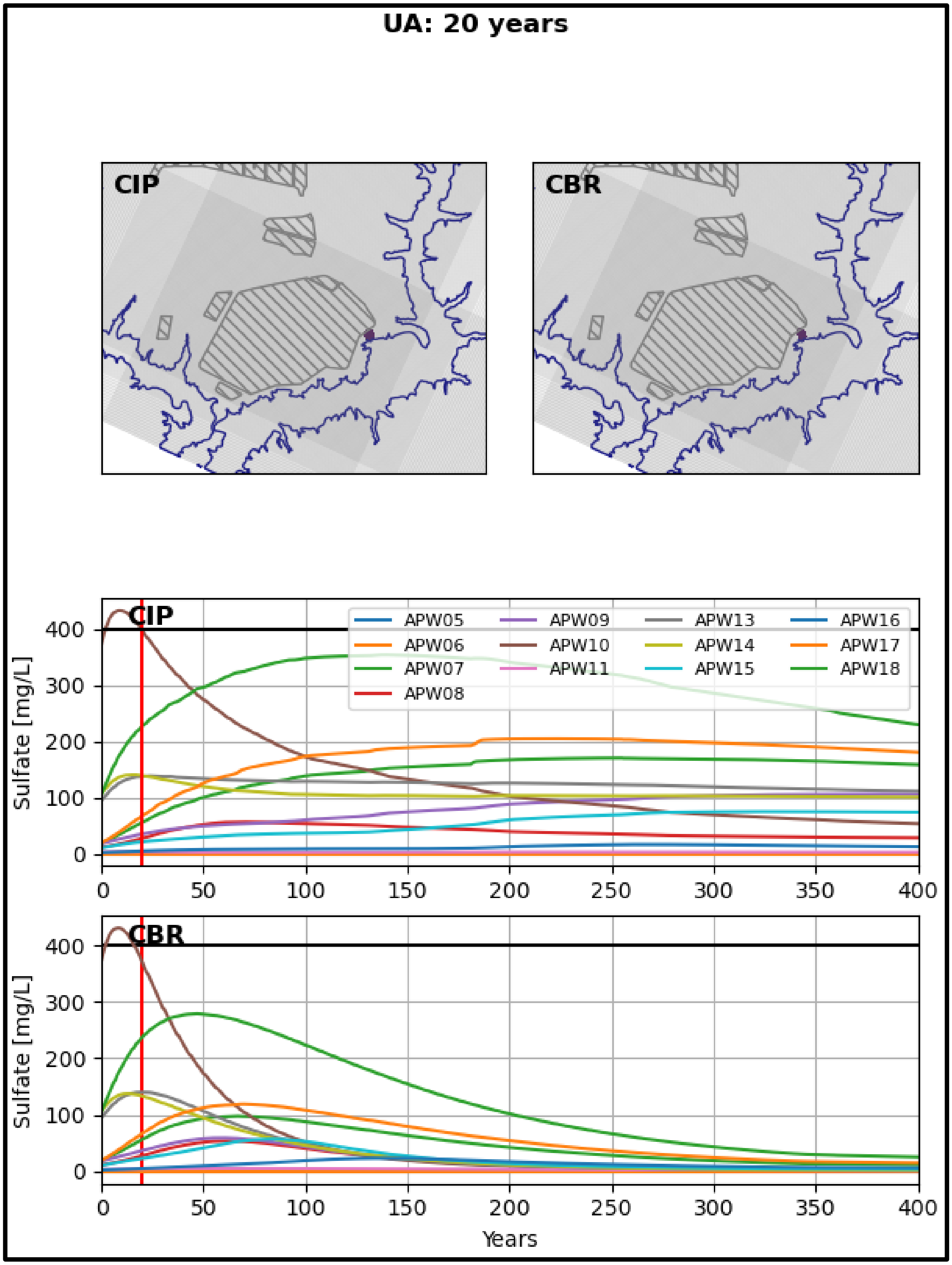
GROUNDWATER MODELING REPORT
PRIMARY ASH POND
NEWTON POWER PLANT
NEWTON, ILLINOIS

RAMBOLL



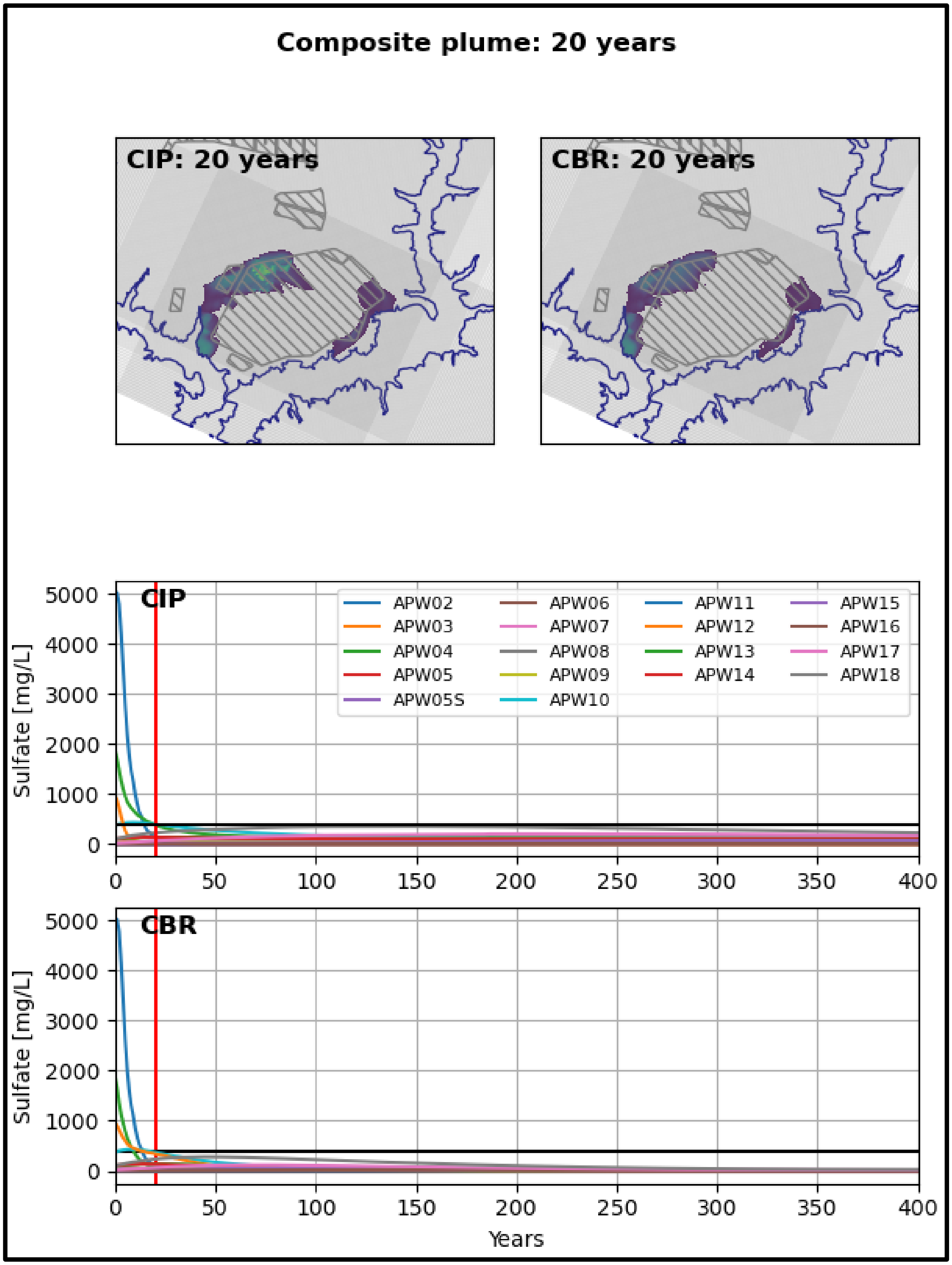
SIMULATED SULFATE PLUME OF THE UD/PMP FOR THE CIP AND CBR SCENARIOS AFTER 20 YEARS

GROUNDWATER MODELING REPORT
PRIMARY ASH POND
NEWTON POWER PLANT
NEWTON, ILLINOIS



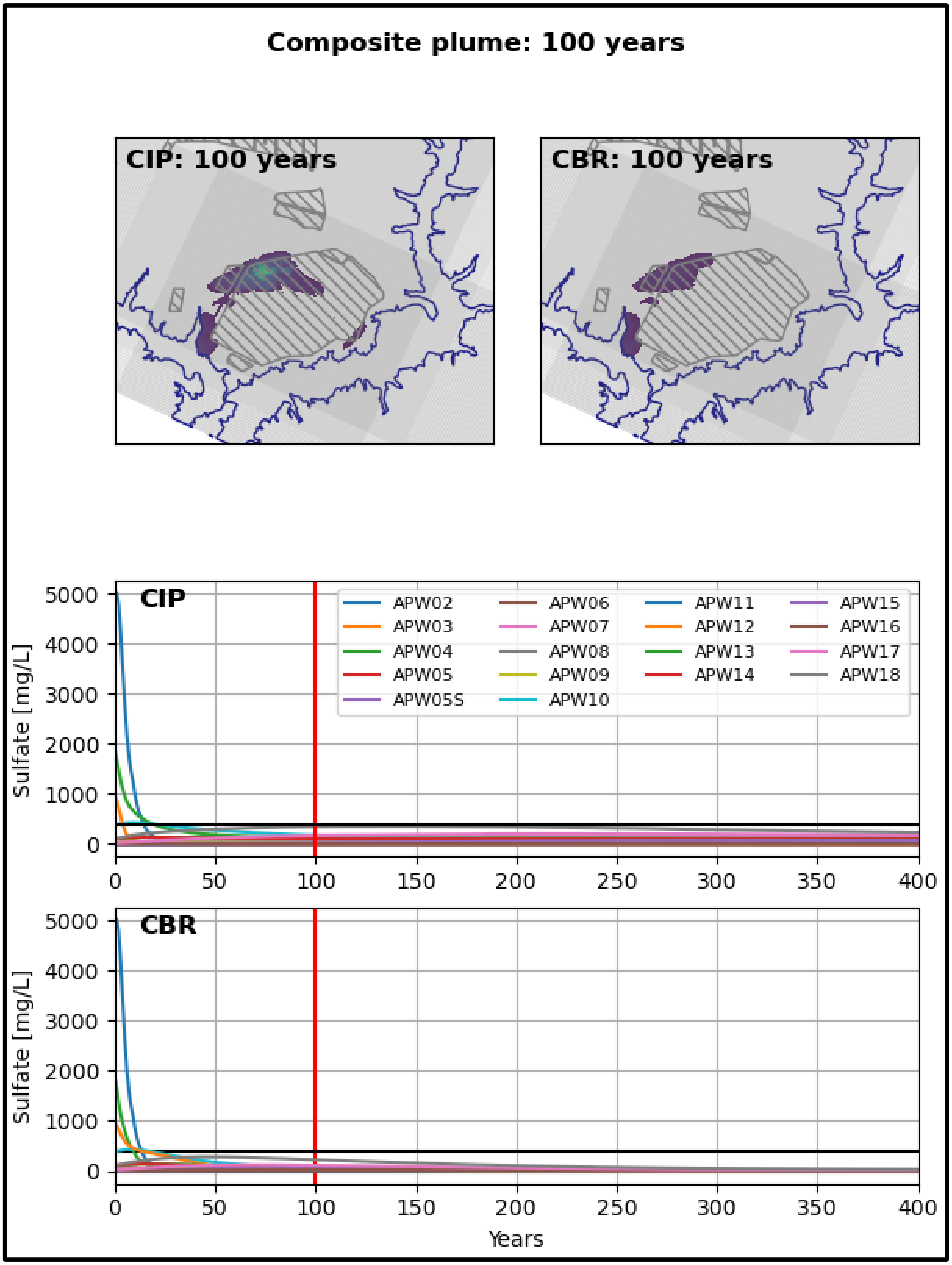
SIMULATED SULFATE PLUME OF THE UA FOR THE CIP AND CBR SCENARIOS AFTER 20 YEARS

GROUNDWATER MODELING REPORT
PRIMARY ASH POND
NEWTON POWER PLANT
NEWTON, ILLINOIS



MAXIMUM EXTENT OF THE SULFATE PLUME FOR THE CIP AND CBR SCENARIOS AFTER 20 YEARS

GROUNDWATER MODELING REPORT
PRIMARY ASH POND
NEWTON POWER PLANT
NEWTON, ILLINOIS



MAXIMUM EXTENT OF THE SULFATE PLUME FOR THE CIP AND CBR SCENARIOS AFTER 100 YEARS

GROUNDWATER MODELING REPORT
PRIMARY ASH POND
NEWTON POWER PLANT
NEWTON, ILLINOIS

APPENDIX A
EVALUATION OF POTENTIAL GWPS EXCEEDANCES
(GOLDER ASSOCIATES USA INC., 2022)

TECHNICAL MEMORANDUM

DATE April 15, 2022 21454831

TO David Mitchell, Stu Cravens, Vic Modeer
Illinois Power Generating Company

CC Brian Hennings - Ramboll

FROM Roberta Russell, Jeffrey Ingram, Pat Behling - Golder **EMAIL** jingram@golder.com

EVALUATION OF POTENTIAL GWPS EXCEEDANCES, PRIMARY ASH POND, NEWTON POWER PLANT, JASPER COUNTY, ILLINOIS

1.0 INTRODUCTION

Illinois Power Generating Company (IPGC) currently operates the Newton Power Plant (NPP or Site) located in Jasper County, Illinois. The Primary Ash Pond (PAP, Illinois Environmental Protection Agency [IEPA] ID No. W0798070001-01) is a surface impoundment used to manage coal combustion residuals (CCRs) at the NPP. The PAP 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.

IPGC is currently preparing a Construction Permit application for the PAP as required under Section 845.220 which requires groundwater modelling be completed for the known potential exceedances of groundwater protection standards (GWPS) as outlined in the Operating Permit application (Burns and McDonnell 2021). In October 2021, Ramboll Americas Engineering Solutions, Inc. (Ramboll) identified potential GWPS exceedances for pH in certain monitoring wells in the vicinity of the PAP (Ramboll 2021a). This Technical Memorandum was developed to further evaluate these potential GWPS exceedances.

1.1 Site Setting

The NPP is located in Jasper County Illinois, approximately 20 miles southeast of Effingham and 7 miles southwest of Newton, in Section 26 and 25, Township 6 North, Range 8 East. The NPP has one CCR surface impoundment (the PAP) with a surface area of 404 acres and a non-CCR Secondary Pond with a surface area of 9.3 acres. The PAP currently receives bottom ash, fly ash, and low-volume wastewater from the plant's two coal-fired boilers.

The NPP is situated in a predominantly agricultural area with fields located on the north, west and southern boarders of the property. The eastern border of the property is the Prairie Ridge State Natural Area. The PAP is adjacent to Newton Lake on the southern and eastern sides, with the NPP generating station located to the north of the PAP, and the site's Utility Waste Landfills located to the west.

Six hydrogeologic units are present at the NPP. They are described as follows in the Hydrogeologic Site Characterization Report (Ramboll 2021b), in downward order:

- **CCR:** CCR, consisting mostly of bottom and fly ash. CCR is present from the surface (approximately 545 to 555 feet above mean sea level (ft MSL) down to approximately 475 feet msl at its deepest portions.
- **Upper Drift (UD) / Potential Migration Pathway (PMP):** The UD consists of low-permeability silts and clays of the Peoria Silt and Sangamon Soil units. In some areas, discontinuous lenses of the sandier Hagarstown Member are also present, making up the PMP.
- **Upper Confining Unit (UCU):** the UCU comprises a thick sequence of low-permeability clays and silts of the Vandalia Till Unit. This unit is laterally continuous and is present from the base of the PAP down to the top of the uppermost aquifer.
- **Uppermost Aquifer (UA):** the UA comprises the Mulberry Grove Formation and generally consists of fine to coarse, poorly- to well-graded sands, with occasional clayey sand layers and gravels.
- **Lower Confining Unit (LCU):** This unit consists of the Smithboro Till Member and is generally made up of compact glacial till consisting of low-permeability silty clays and clayey silts with trace sand and gravel.
- **Bedrock Confining Unit (BCU):** Bedrock below the unconsolidated deposits, consisting of shale of the Mattoon Formation.

Groundwater elevations within the PAP are high when compared to the surrounding aquifer, creating a downward gradient between the PAP and the surrounding aquifer. Below the PAP, groundwater migrates downward and laterally through the UD and UCU into the UA. Additionally, as displayed in **Figure 1**, groundwater in the UA flows from the north to the southeast in the eastern portion of the pond and to the south/southwest in the western portion of the pond (Ramboll 2021a).

2.0 POTENTIAL GWPS EXCEEDANCES AND MONITORING WELL DETAILS

As required by Section 845.230 (d)(2)(M), an evaluation of the history of potential GWPS exceedances was completed for the Operating Permit application (Burns and McDonnell 2021; Ramboll 2021b). Data collected since 2015 from the PAP monitoring well network were evaluated using statistical methods described in the Statistical Analysis Plan included in the Operating Permit application (Appendix I, Ramboll 2021c). The following monitoring wells and potential exceedances of the GWPSs are evaluated in this Technical Memorandum:

- **pH at APW04:** For pH, a lower confidence limit (LCL) of 6.1 (in Standard Units; SU) was calculated below the lower GWPS of 6.4. APW04 is located to the east/southeast of the PAP, downgradient of the PAP based on typical flow directions within the UD and UCU. The well is screened in sandy clays of the UD (PMP) from 7.7 to 17.7 FT BGS (513.75 to 503.75 FT MSL).
- **pH at APW12:** For pH, a lower confidence limit (LCL) of 6.2 was calculated below the lower GWPS of 6.4. APW12 is located to the east/northeast of the PAP, typically upgradient of the general groundwater flow direction within the UD and PMP. The well is screened in a mixture of silty clays and sands of the UD (PMP) from 20.0 to 30.0 FT BGS (523.33 to 513.33 FT MSL).

3.0 EVIDENCE THAT POTENTIAL GWPS EXCEEDANCES ARE NOT RELATED TO THE PAP

Groundwater data for monitoring wells that exhibited potential pH GWPS exceedances, background monitoring wells and porewater samples from the PAP were evaluated. The review of these data indicates that the GWPS exceedances are not related to the PAP, as described in the following line of evidence.

- **The pH of CCR porewater is significantly higher than the pH in monitoring wells APW12 and APW04 and the pH ranges recorded in the PMP are likely naturally occurring.**

The pH of porewater within the PAP ranges from approximately 8.6 to 12.2 with an average of 10.7, while pH in all PMP wells (APW02, APW03, APW04, APW5S, APW12) ranges from 6.0 to 7.2, with an average of 6.7 (Table 1). The pH of groundwater in background wells within the UA ranges from 6.4 to 7.8. Due to the high pH values within the PAP, it would be expected that any releases from the PAP would increase the pH in downgradient wells. However, as demonstrated in **Table** 1, downgradient wells within the PMP report pH values significantly lower than in the PAP.

	Background Wells	Upper Drift Wells	PAP Porewater
pH Average	7.5	6.7	10.7
pH Min	6.4	6.0	8.6
pH Max	7.8	7.2	12.4

Table 1. Summary of average, minimum and maximum pH values (in SU) in background wells (APW05, APW06), UD wells (APW02, APW03, APW04, APW05S and APW12) and the PAP.

In addition, pH is consistently slightly lower in all PMP wells compared to background wells (Tables 1 and 2). The average pH values across the PMP wells are similar, i.e. within 0.5 SU of one another. Given the consistency of average pH values across the PMP, it is likely that the slightly lower pH is naturally occurring in the PMP.

Sample Date	APW05	APW06	APW02	APW03	APW04	APW05S	APW12
Well Formation	**UA**	**UA**	**UD/PMP**	**UD/PMP**	**UD/PMP**	**UD/PMP**	**UD/PMP**
2/17/2021	7.20	6.40	6.60	6.70	6.50	6.60	6.20
3/10/2021	7.70	7.70	7.00	7.20	6.90	7.00	6.50
3/30/2021	7.20	7.10	6.60	6.30	6.10	--	6.00
4/28/2021	7.49	7.69	6.68	7.00	6.86	6.84	6.40
5/25/2021	7.54	7.71	6.67	7.05	6.90	6.86	6.54
6/17/2021	7.73	7.69	6.62	6.98	6.81	6.82	6.45
6/30/2021	7.55	7.61	6.58	7.03	6.80	6.73	6.29
7/15/2021	7.78	7.49	6.55	6.93	6.76	6.77	6.54
Average	**7.52**	**7.42**	**6.66**	**6.90**	**6.70**	**6.80**	**6.37**

Table 2. pH data (in SU) for 2021 sampling events for background wells (APW05, APW06) and PMP wells (APW02, APW03, APW04, APW05S, APW12).

Therefore, the CCR unit is not the cause of the pH values statistically below the lower pH GWPS at APW12 and APW04.

4.0 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.

Roberta Russell
Senior Consultant, Geologist

Patrick J. Behling
Principal, Practice Leader

JSI/RR/PJB

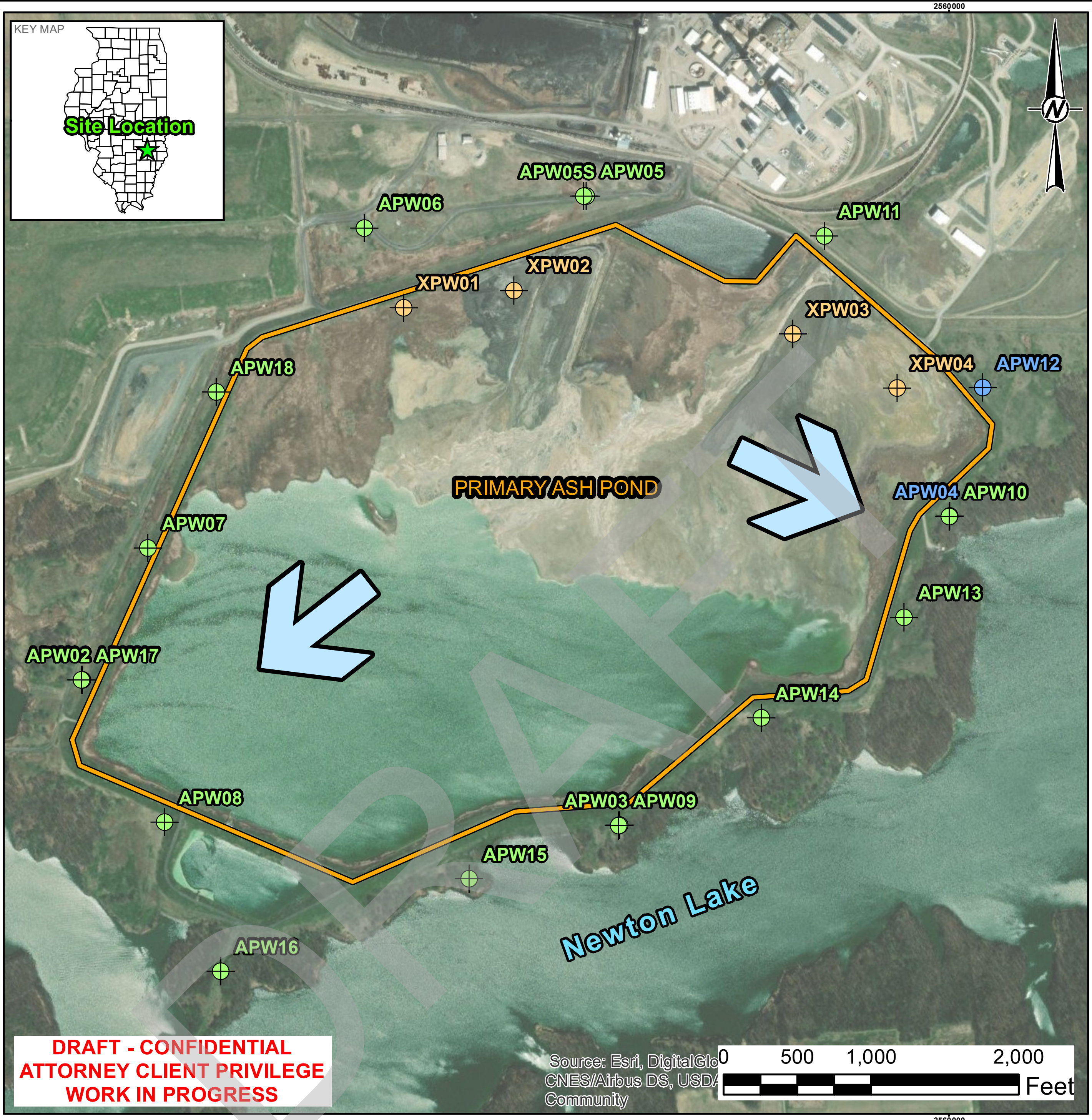
5.0 REFERENCES

Burns and McDonnell 2021. Initial Operating Permit, Newton Ash Pond. October 25.

Ramboll 2021a. History of Potential Exceedances, Newton Ash Pond, Newton Power Plant. October 17.

Ramboll 2021b. Hydrogeologic Site Characterization Report, Primary Ash Pond, Newton Power Plant. October 25.

Ramboll 2021c. Statistical Analysis Plan, Primary Ash Pond, Newton Power Plan. October 25.



LEGEND

- Primary Ash Pond - CCR Unit ID
- Part 845 Groundwater Sample Location With no Potential pH Exceedance
- CCR Pore Water Sample Location
- Part 845 Groundwater Sample Location With a Potential pH Exceedance
- Typical Groundwater Flow Directions

NOTE(S)

1. ALL LOCATIONS AND BOUNDARIES ARE APPROXIMATE.

REFERENCE(S)

1. RAMBOLL 2021, TABLE 2 SUMMARY OF POTENTIAL EXCEEDANCES.
2. RAMBOLL 2021. GROUNDWATER MONITORING PLAN, PRIMARY ASH POND, NEWTON POWER PLANT, NEWTON ILLINOIS.

CLIENT
ILLINOIS POWER GENERATING COMPANY

PROJECT
NEWTON POWER PLANT - EVALUATION OF POTENTIAL GWPS EXCEEDANCES

TITLE
NEWTON MONITORING WELL LOCATIONS AND TYPICAL GROUNDWATER FLOW DIRECTION

CONSULTANT
WSP GOLDER

YYYY-MM-DD	2022-02-01
DESIGNED	BTT
PREPARED	BTT
REVIEWED	JSI
APPROVED	PJB

PROJECT NO.	PHASE	FIGURE
21454831	0004	1

APPENDIX B
MODFLOW, MT3DMS, AND HELP MODEL FILES (ELECTRONIC ONLY)

APPENDIX C
EVALUATION OF PARTITION COEFFICIENT RESULTS
(GOLDER ASSOCIATES USA INC., 2022)

TECHNICAL MEMORANDUM

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

TO David Mitchell, Stu Cravens, Vic Modeer
Illinois Power Generating Company

CC Brian Henning - Ramboll

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

EVALUATION OF PARTITION COEFFICIENT RESULTS, PRIMARY ASH POND (CCR UNIT 501), NEWTON POWER PLANT, JASPER COUNTY, ILLINOIS

1.0 INTRODUCTION

Illinois Power Generating Company (IPGC) operates the Newton Power Plant (NPP) located in Jasper County, Illinois. The Primary Ash Pond (PAP or Site), Illinois Environmental Protection Agency [IEPA] ID No. W0798070001-01 is a 404-acre unlined surface impoundment used to manage coal combustion residuals (CCRs) at the NPP. The PAP 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 IPGC with Part 845 compliance at the Site.

IPGC is currently preparing a Construction Permit application for the PAP as required under Section 845.220. As a part of the Construction Permit application, groundwater modeling is being completed for known potential exceedances of groundwater protection standards (GWPS) as outlined in the Operating Permit application for the PAP (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 PAP, including lithium and sulfate. Batch adsorption testing was conducted to generate site-specific partition coefficient results for these parameters for use in the groundwater models. Site-specific partition coefficients were also developed for boron for its use in groundwater modeling. This Technical Memorandum summarizes the results of the batch adsorption testing.

2.0 OVERVIEW

In August 2021, Golder conducted a field investigation at the PAP which included the completion of seven (7) soil/rock borings ranging in depth from 15 to 90 feet below ground surface (ft bgs; Golder 2021). 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
APW-04	N-SB-05 (60.0-67.1 ft bgs)	2:1
		1:1
		1:5
		1:10
		1:20
APW-14	N-SB-04 (12.0-18.0 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) lithium and sulfate, identified based on statistical evaluation of potential groundwater exceedances calculated at the Site (Burns and McDonnell 2021). Site-specific partitioning coefficients were also determined for boron for its potential use in groundwater modeling, despite not being detected at statistically significant levels above the site GWPS. Two groundwater samples (APW-04 and APW-14) and two soil samples (N-SB-05 60.0-67.1 ft bgs and N-SB-04 12.0-18.0 ft bgs) 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 (0.004 to 0.2 kg, dependent 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). After the seven-day contact period, COI and boron concentrations were analyzed in the contact water. The control samples (i.e., groundwater samples APW-04 and APW-14) 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. Arsenic is not currently a COI at the Site and, therefore, was not evaluated as part of this report. However, arsenic may be revisited in the future, thus meta-arsenite was included as an amendment (Table 2).

Table 2: Microcosm amendment and target concentration for COIs

COI	Groundwater Sample	Amendment	Target Concentration (mg/L)
Arsenic	APW-04	346.80 µL of a 2 g/L As(III) solution	0.2
	APW-14	344.72 µL of a 2 g/L As(III) solution	
Boron	APW-04	11.40 mL of a 10 g/L H_3BO_3 solution	10

	APW-14	11.32 mL of a 10 g/L H_3BO_3 solution	
Lithium	APW-04	3.40 mL of a 1 g/L LiCl solution	0.3
	APW-14	3.39 mL of a 1 g/L LiCl solution	
Sulfate	APW-04	12.20 mL of a 100 g/L Na_2SO_4 solution	774
	APW-14	24.41 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 – milligrams 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 each COI are provided in Appendix A. The partition coefficient values for APW-04 and APW-14 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 APW-04 and APW-14 were -1.35 and -0.89 L/kg, respectively, K_L values -6.2E+4 and -1.6E+5 L/kg, respectively, and K_F values 57.4 and 68.7 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.

- **Lithium:** Calculated K_D values for APW-04 and APW-14 were 4.49 and 5.58 L/kg, respectively, K_L values 6.2E+7 and 1.6E+8 L/kg, respectively, and K_F values 135 and 230 L/kg, respectively. In Strenge and Peterson (1989), partition coefficients for lithium range from 0 to 0.8 L/kg, depending on pH conditions and the amount of sorbent present.

- **Sulfate**: Calculated K_D values for APW-04 and APW-14 were 3.58 and -25.6 L/kg, respectively, K_L values -626 and -2,200 L/kg, respectively, and K_F values 4.11 and 2.14E+11 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 (7.03 and 7.00 for APW-04 and APW-14, respectively), ranging from 7.02 to 7.06 across the batch tests. The average redox values of the control samples after the seven-day contact time were 40 mV and -26 mV for APW-04 and APW-14, respectively. The redox value of contact water ranged from -111 to +40 mV across treatments.

4.0 REFERENCES

Burns and McDonnell, 2021. Initial Operating Permit Newton Ash Pond.

Golder Associates Inc. 2021. Technical Memorandum: Monitored Natural Attenuation Field Investigation Status Update, Primary Ash Pond (CCR Unit 501) Newton Power Plant, Jasper County, Illinois.

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.

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Pat Behling
Practice Leader

CK/JSI/PJB

Attachments Appendix A – Partition Coefficient Graphs

Table 3: Batch Attenuation Testing Results, APW-04

Geologic Material Sample ID	Treatment	Date	Day	Replicate	Dissolved Boron	Dissolved Lithium	Dissolved Sulfate	pH	ORP
					mg/L	mg/L	mg/L	SU	mV
	Groundwater Only Control	2/15/2022	0	APW-04-1a	9.2	0.28	1,097	6.92	2
				APW-04-2a	9.5	0.29	1,077	6.92	29
				Average Concentration (mg/L)	9.3	0.28	1,087	6.92	16
		2/22/2022	7	APW-04-1	9.2	0.26	721	7.02	67
				APW-04-2	9.4	0.25	407	7.04	13
				Average Concentration (mg/L)	9.3	0.26	564	7.03	40
N-SB-05 (60.0-67.1 ft bgs)	2:1 Soil:Water Ratio	2/15/2022	0						
		2/22/2022	7	N-SB-05-(60.0-67.1) :APW-04 2:1-1	5.9	<0.10	440	7.02	-20
				N-SB-05-(60.0-67.1) :APW-04 2:1-2	5.8	<0.10	463	7.02	-43
				Average Concentration (mg/L)	5.9	ND	451	7.02	-32
	1:1 Soil:Water Ratio	2/15/2022	0						
		2/22/2022	7	N-SB-05-(60.0-67.1) :APW-04 1:1-1	7.2	0.13	807	7.02	-49
				N-SB-05-(60.0-67.1) :APW-04 1:1-2	7.4	0.14	740	7.02	-48
				Average Concentration (mg/L)	7.3	0.14	773	7.02	-49
	1:5 Soil:Water Ratio	2/15/2022	0						
		2/22/2022	7	N-SB-05-(60.0-67.1) :APW-04 1:5-1	8.6	0.17	813	7.04	-40
				N-SB-05-(60.0-67.1) :APW-04 1:5-2	9.6	0.24	788	7.02	-70
				Average Concentration (mg/L)	9.1	0.21	800	7.03	-55
	1:10 Soil:Water Ratio	2/15/2022	0						
		2/22/2022	7	N-SB-05-(60.0-67.1) :APW-04 1:10-1	10	0.26	889	7.02	-92
				N-SB-05-(60.0-67.1) :APW-04 1:10-2	9.6	0.25	996	7.02	-52
				Average Concentration (mg/L)	10	0.26	943	7.02	-72
	1:20 Soil:Water Ratio	2/15/2022	0						
		2/22/2022	7	N-SB-05-(60.0-67.1) :APW-04 1:20-1	9.2	0.24	776	7.03	-27
				N-SB-05-(60.0-67.1) :APW-04 1:20-2	8.9	0.23	1,212	7.02	-5
				Average Concentration (mg/L)	9.1	0.24	994	7.03	-16

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, APW-14

Geologic Material Sample ID	Treatment	Date	Day	Replicate	Dissolved Boron (mg/L)	Dissolved Lithium (mg/L)	Dissolved Sulfate (mg/L)	pH (SU)	ORP (mV)
	Groundwater Only Control	2/15/2022	0	APW-14-1a	9.5	0.28	1,010	6.99	17
				APW-14-2a	9.6	0.28	1,004	6.99	4
				Average Concentration (mg/L)	9.5	0.28	1,007	6.99	11
		2/22/2022	7	APW-14-1	9.2	0.25	1,366	7.00	-28
				APW-14-2	10.0	0.25	773	7.00	-24
				Average Concentration (mg/L)	9.6	0.25	1,069	7.00	-26
N-SB-04 (12.0-18.0 ft bgs)	2:1 Soil:Water Ratio	2/15/2022	0						
		2/22/2022	7	N-SB-04-(12.0-18.0) :APW-14 2:1-1	5.6	<0.10	773	7.02	-72
				N-SB-04-(12.0-18.0) :APW-14 2:1-2	5.6	<0.10	938	7.02	-150
				Average Concentration (mg/L)	5.6	ND	856	7.02	-111
	1:1 Soil:Water Ratio	2/15/2022	0						
		2/22/2022	7	N-SB-04-(12.0-18.0) :APW-14 1:1-1	7.2	0.15	853	7.03	-47
				N-SB-04-(12.0-18.0) :APW-14 1:1-2	7.0	0.13	630	7.04	35
				Average Concentration (mg/L)	7.1	0.14	741	7.04	-6
	1:5 Soil:Water Ratio	2/15/2022	0						
		2/22/2022	7	N-SB-04-(12.0-18.0) :APW-14 1:5-1	10.2	0.26	716	7.06	53
				N-SB-04-(12.0-18.0) :APW-14 1:5-2	8.9	0.20	1,081	7.05	17
				Average Concentration (mg/L)	9.6	0.23	899	7.06	35
	1:10 Soil:Water Ratio	2/15/2022	0						
		2/22/2022	7	N-SB-04-(12.0-18.0) :APW-14 1:10-1	10	0.22	914	7.05	21
				N-SB-04-(12.0-18.0) :APW-14 1:10-2	9.7	0.23	998	7.06	34
				Average Concentration (mg/L)	10	0.23	956	7.06	28
	1:20 Soil:Water Ratio	2/15/2022	0						
		2/22/2022	7	N-SB-04-(12.0-18.0) :APW-14 1:20-1	9.8	0.26	650	7.08	41
				N-SB-04-(12.0-18.0) :APW-14 1:20-2	9.0	0.24	724	7.04	38
				Average Concentration (mg/L)	9.4	0.25	687	7.06	40

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, APW-04

Analyte	Isotherm	Variable	With Soil Mass
Boron	Raw Data R^2		0.16
	Linear K_D (L/kg)		-1.35
	Langmuir	R^2	0.03
		q_m (mg/g)	-0.003
		K_L (L/kg)	-6.23E+04
	Freundlich	R^2	0.01
		1/n	0.379
		K_F (L/kg)	57.39
Lithium	Raw Data R^2		0.20
	Linear K_D (L/kg)		4.49
	Langmuir	R^2	0.94
		q_m (mg/g)	0.009
		K_L (L/kg)	6.16E+07
	Freundlich	R^2	0.23
		1/n	0.101
		K_F (L/kg)	135.83
Sulfate	Raw Data R^2		0.62
	Linear K_D (L/kg)		3.58
	Langmuir	R^2	0.13
		q_m (mg/g)	-0.999
		K_L (L/kg)	-6.26E+02
	Freundlich	R^2	0.53
		1/n	1.924
		K_F (L/kg)	4.11

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, APW-14

Analyte	Isotherm	Variable	With Soil Mass
Boron	Raw Data R^2		0.37
	Linear K_D (L/kg)		-0.89
	Langmuir	R^2	0.18
		q_m (mg/g)	0.000
		K_L (L/kg)	-1.56E+05
	Freundlich	R^2	0.99
		1/n	0.280
		K_F (L/kg)	68.65
Lithium	Raw Data R^2		0.57
	Linear K_D (L/kg)		5.58
	Langmuir	R^2	1.00
		q_m (mg/g)	0.034
		K_L (L/kg)	1.55E+08
	Freundlich	R^2	0.54
		1/n	0.031
		K_F (L/kg)	230.83
Sulfate	Raw Data R^2		0.47
	Linear K_D (L/kg)		-25.60
	Langmuir	R^2	0.07
		q_m (mg/g)	0.166
		K_L (L/kg)	-2.20E+03
	Freundlich	R^2	0.33
		1/n	-6.626
		K_F (L/kg)	2.14E+11

Note(s):

K_D: linear partition coefficient

K_L: Langmuir partition coefficient

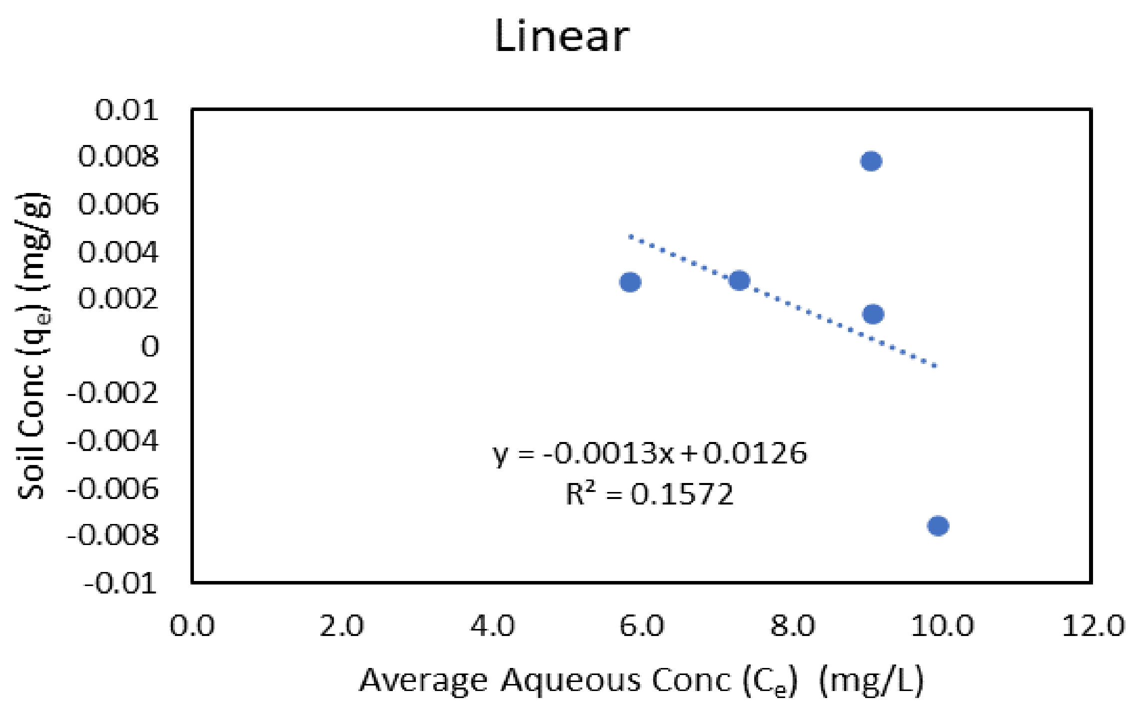
K_F: Freundlich partition coefficient

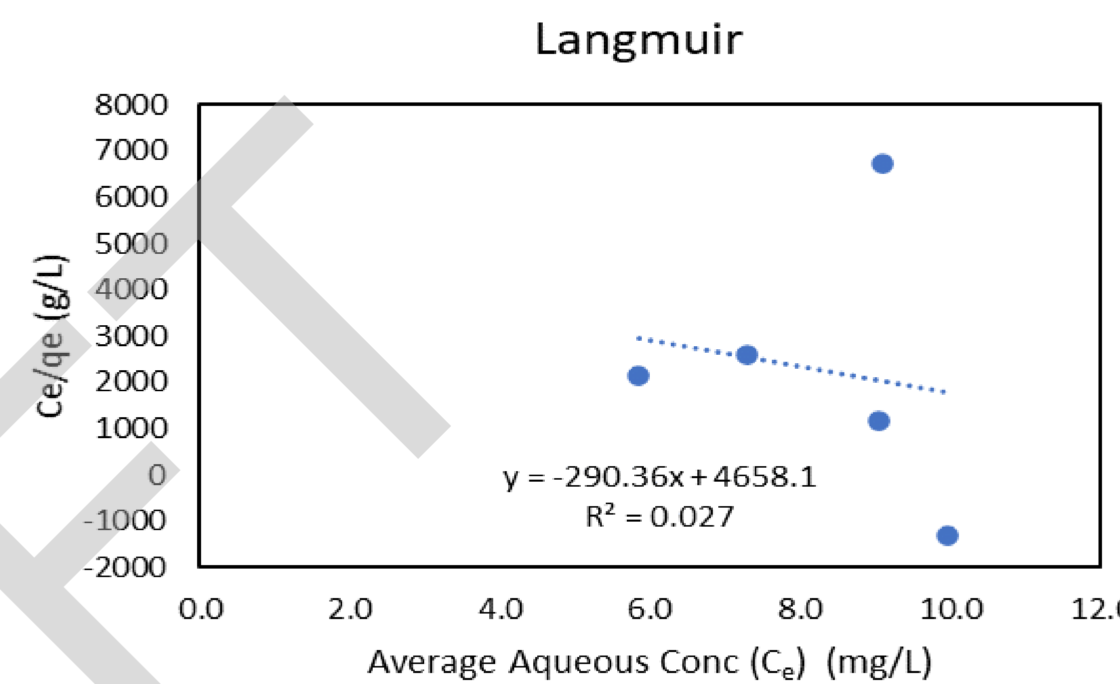
q_m: 1/slope in the linear expression of the isotherm

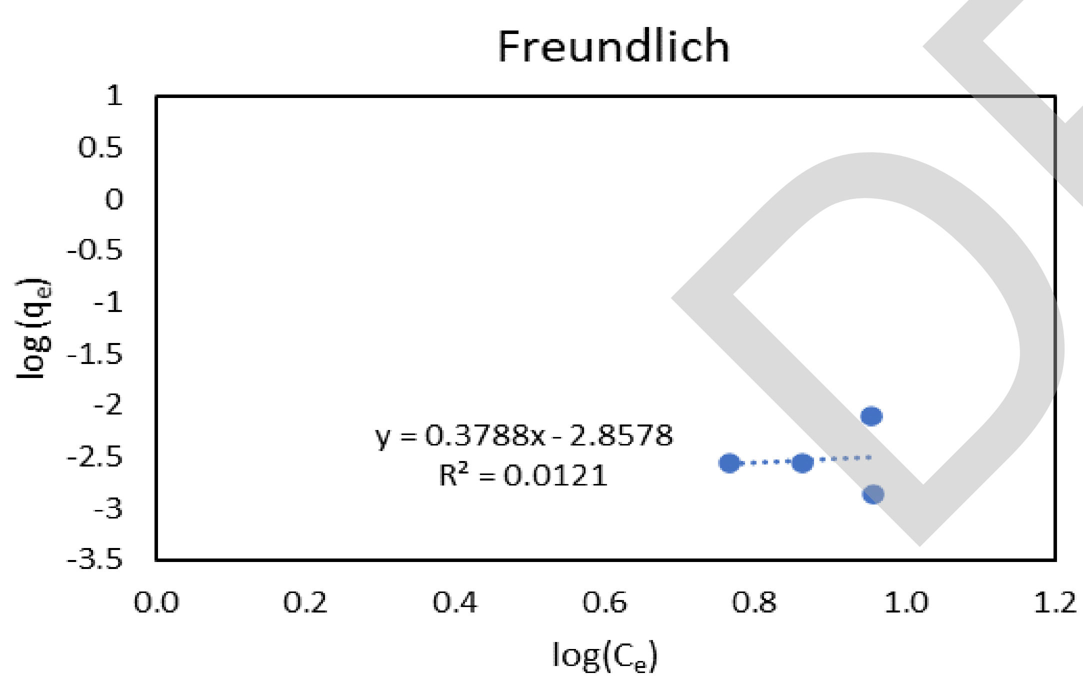
n: non-linearity constant

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

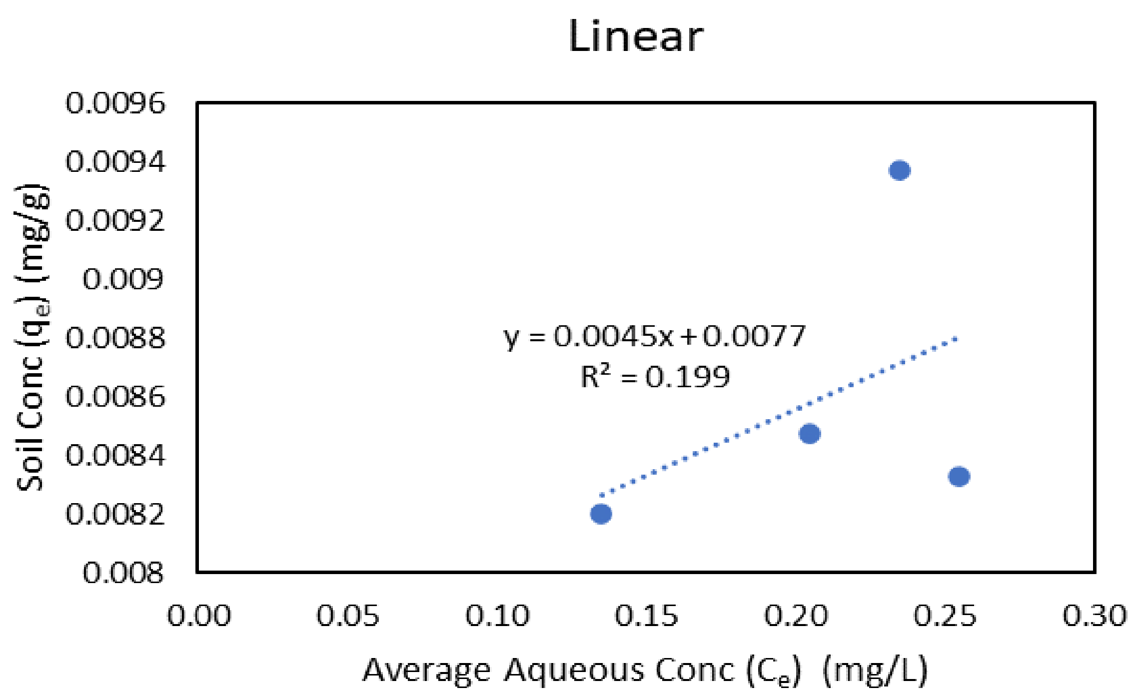
CLIENT
ILLINOIS POWER GENERATING COMPANY
NEWTON PRIMARY ASH POND (CCR UNIT 501)

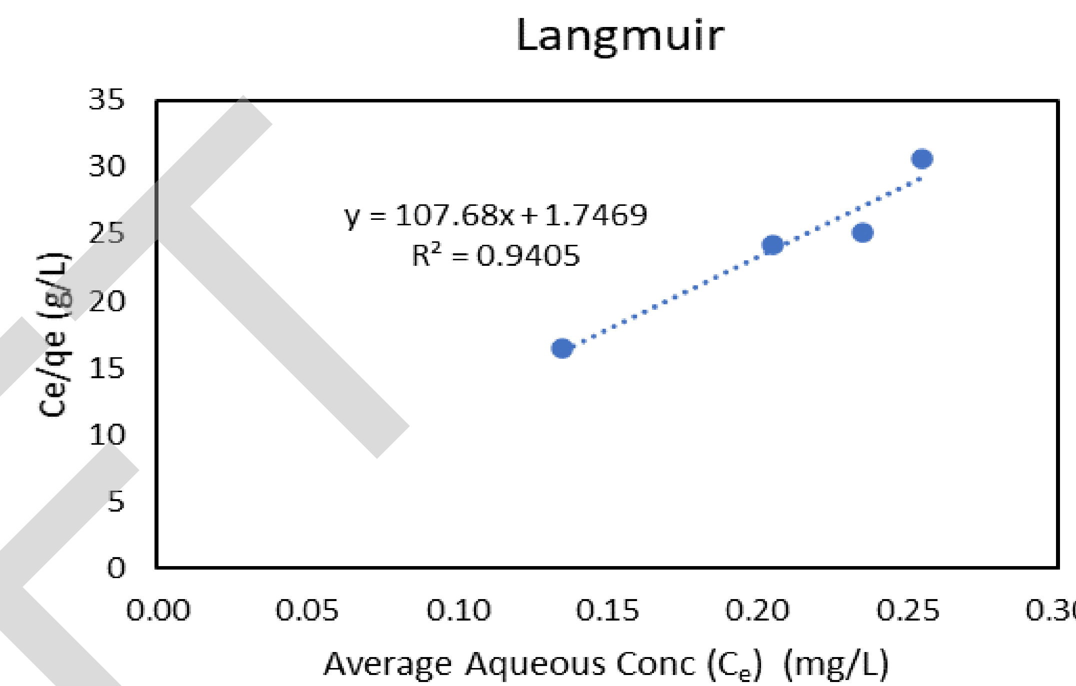
PROJECT
EVALUATION OF PARTITION COEFFICIENT RESULTS PAP

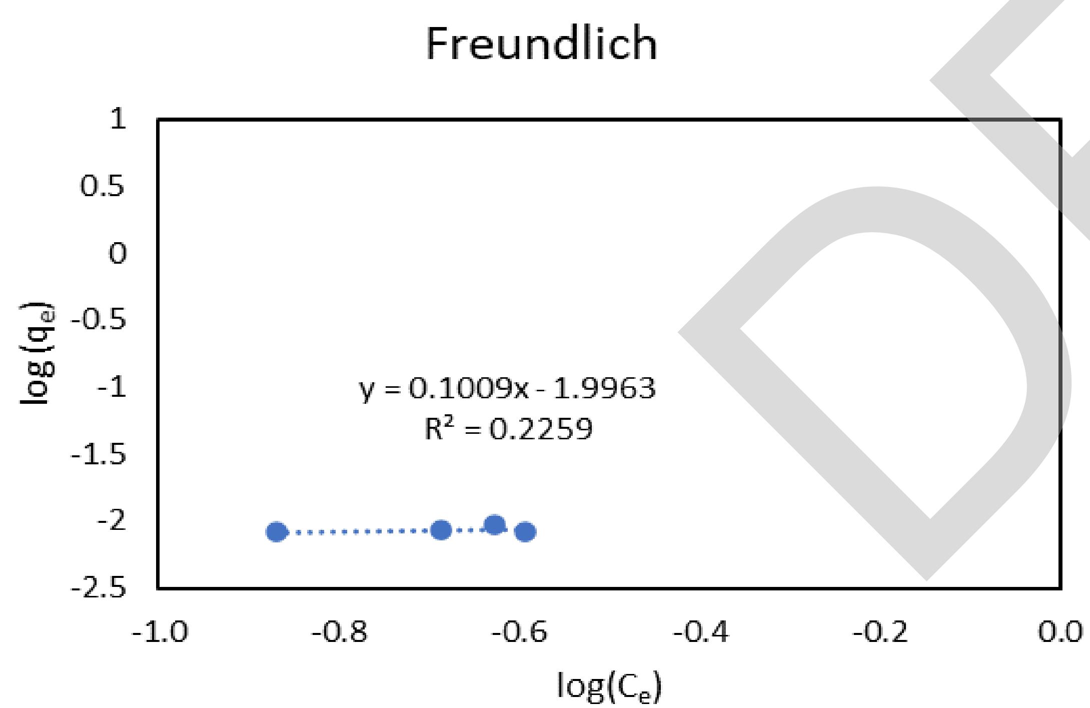
CONSULTANT
WSP GOLDER

TITLE
APW-04 BORON PARTITION COEFFICIENTS

PROJECT NO.	PHASE	REV.	FIGURE
21454831	0004	0	A-1







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g/L: grams per liter
Ce: aqueous concentration of the adsorbate
qe: concentration of the adsorbate in soil

CLIENT
ILLINOIS POWER GENERATING COMPANY
NEWTON PRIMARY ASH POND (CCR UNIT 501)

PROJECT
EVALUATION OF PARTITION COEFFICIENT RESULTS PAP

CONSULTANT
WSP GOLDER

TITLE
APW-04 LITHIUM PARTITION COEFFICIENTS

PROJECT NO.	PHASE	REV.	FIGURE
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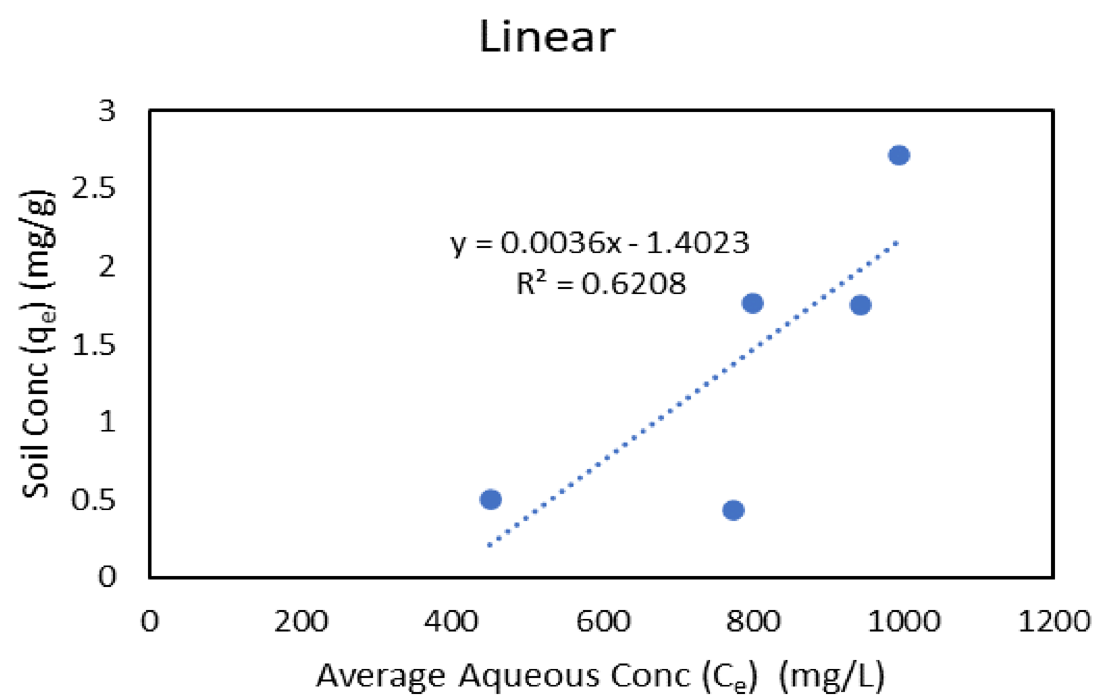

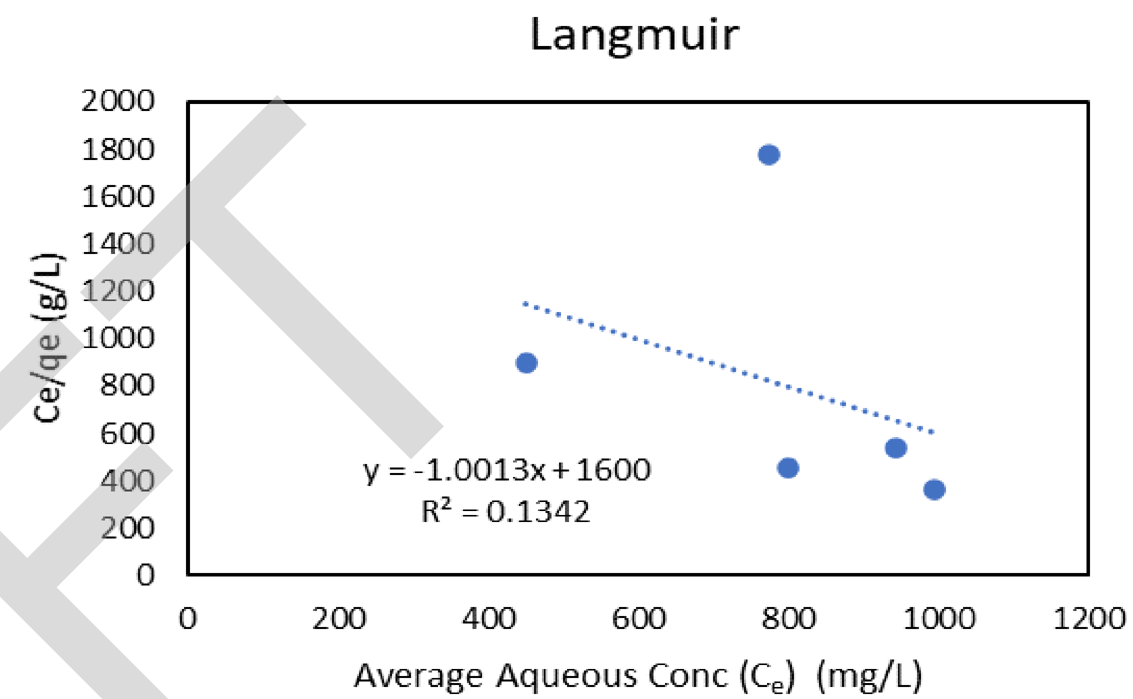

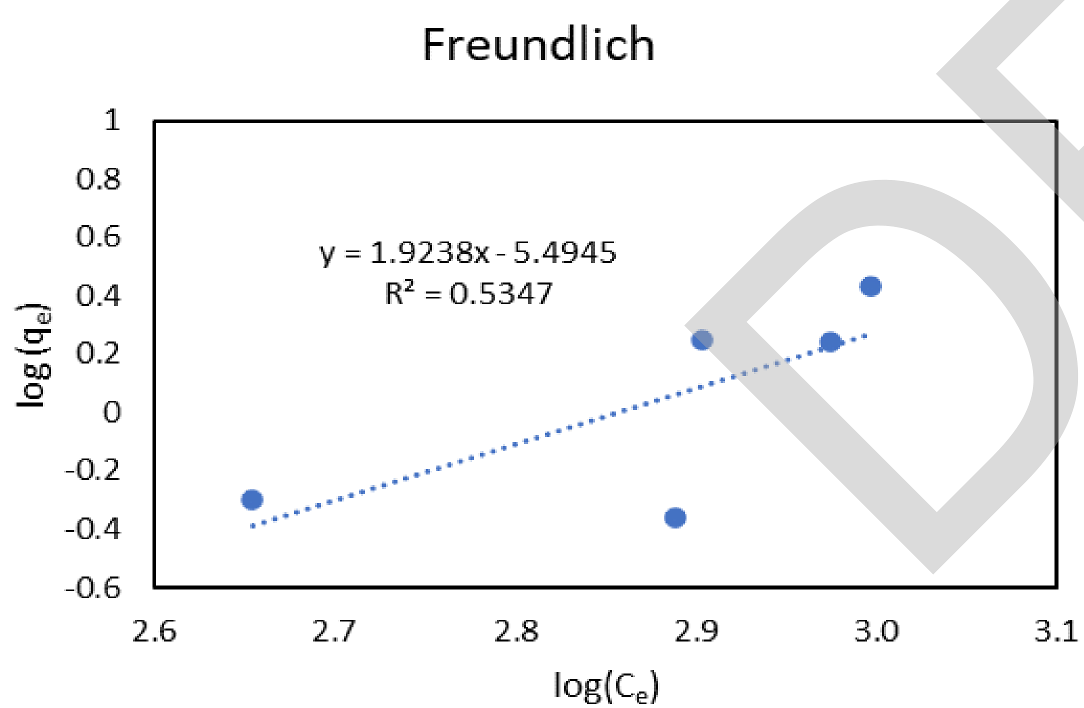

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Ce: aqueous concentration of the adsorbate
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CLIENT
ILLINOIS POWER GENERATING COMPANY
NEWTON PRIMARY ASH POND (CCR UNIT 501)

PROJECT
EVALUATION OF PARTITION COEFFICIENT RESULTS PAP

CONSULTANT
WSP GOLDER

TITLE
APW-04 SULFATE PARTITION COEFFICIENTS

PROJECT NO.	PHASE	REV.	FIGURE
21454831	0004	0	A-3

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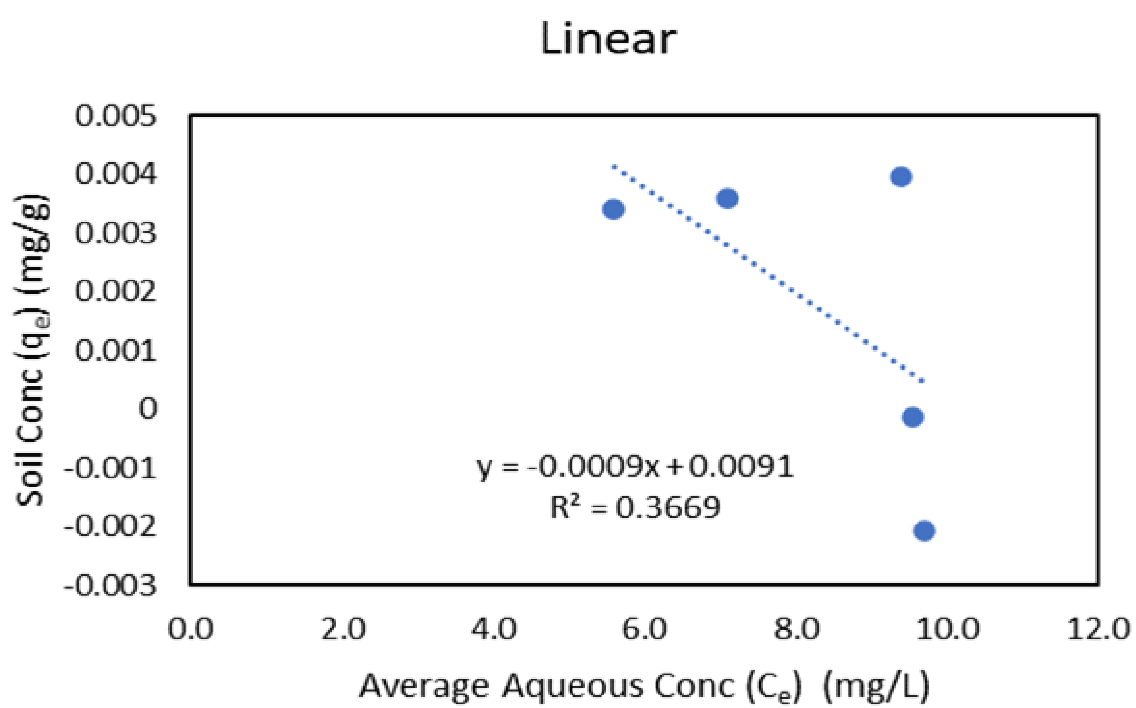
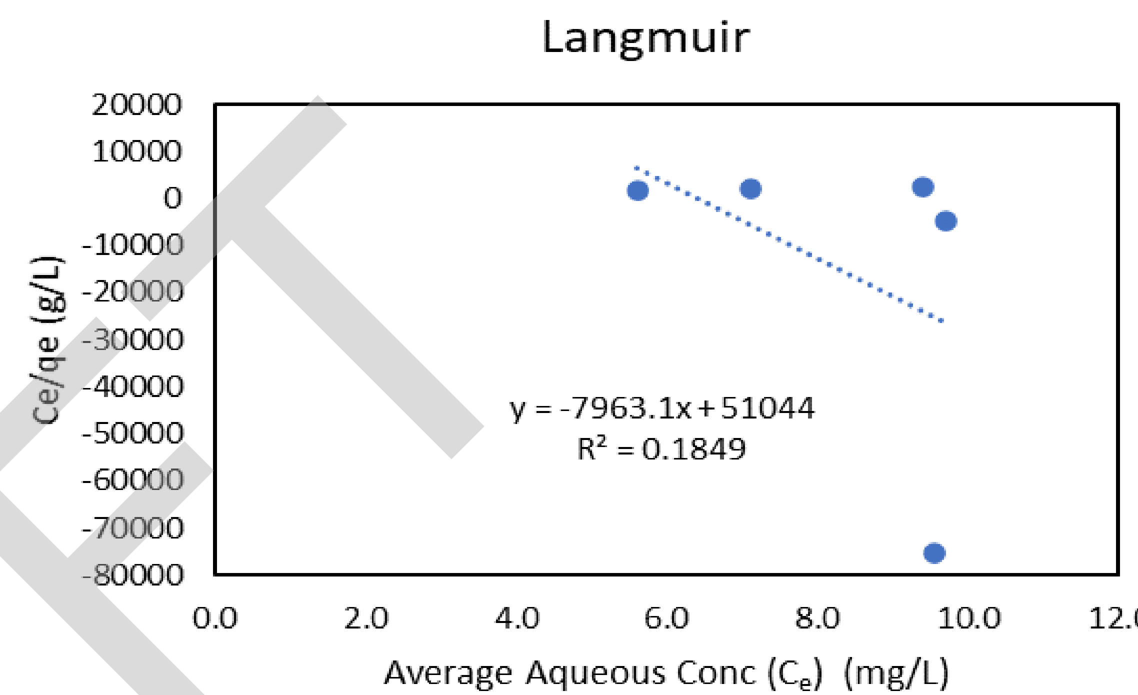
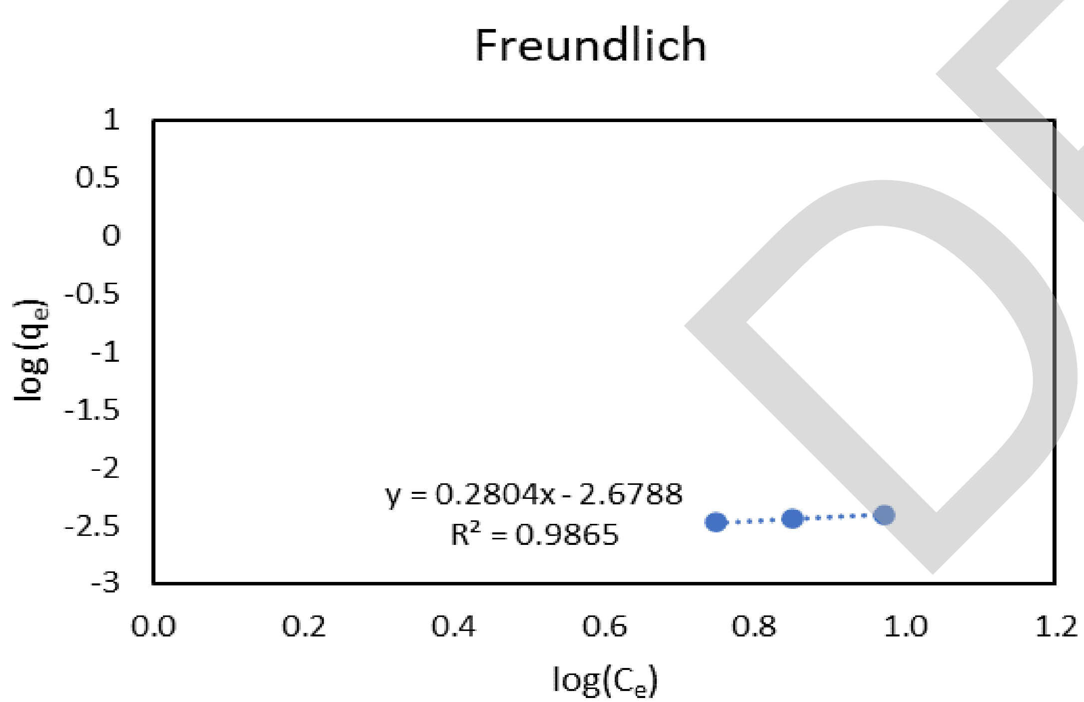






Note(s):
mg/L: milligrams per liter
mg/g: milligrams per gram
g/L: grams per liter
Ce: aqueous concentration of the adsorbate
qe: concentration of the adsorbate in soil

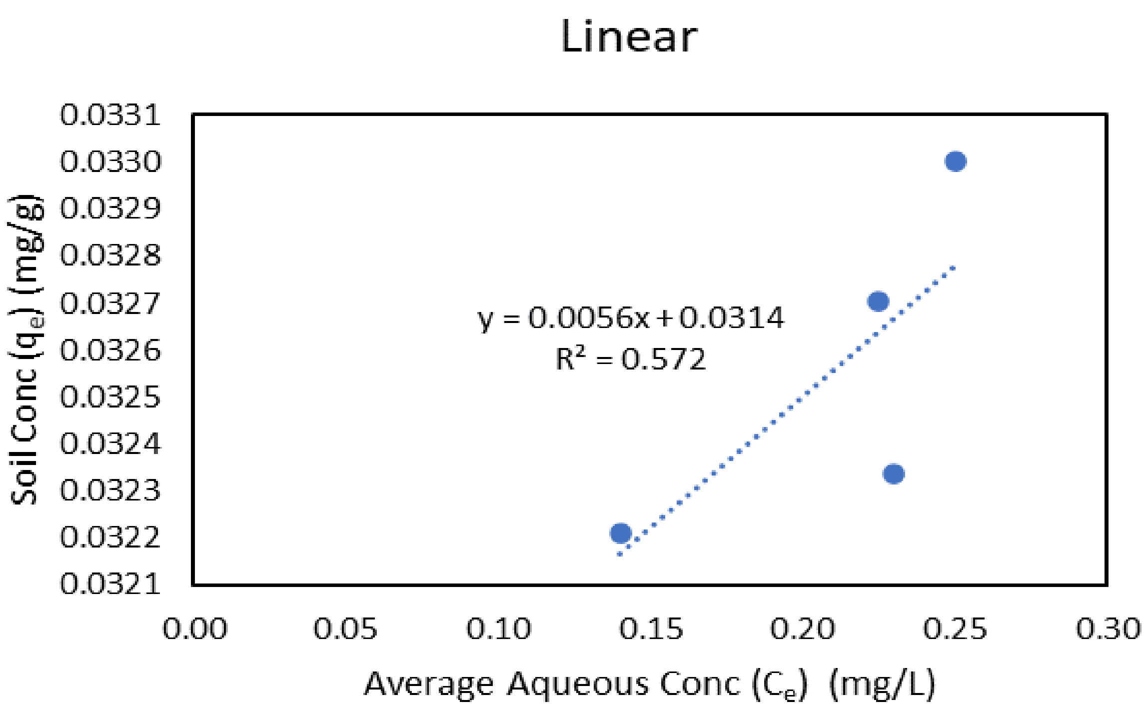
CLIENT
ILLINOIS POWER GENERATING COMPANY
NEWTON PRIMARY ASH POND (CCR UNIT 501)

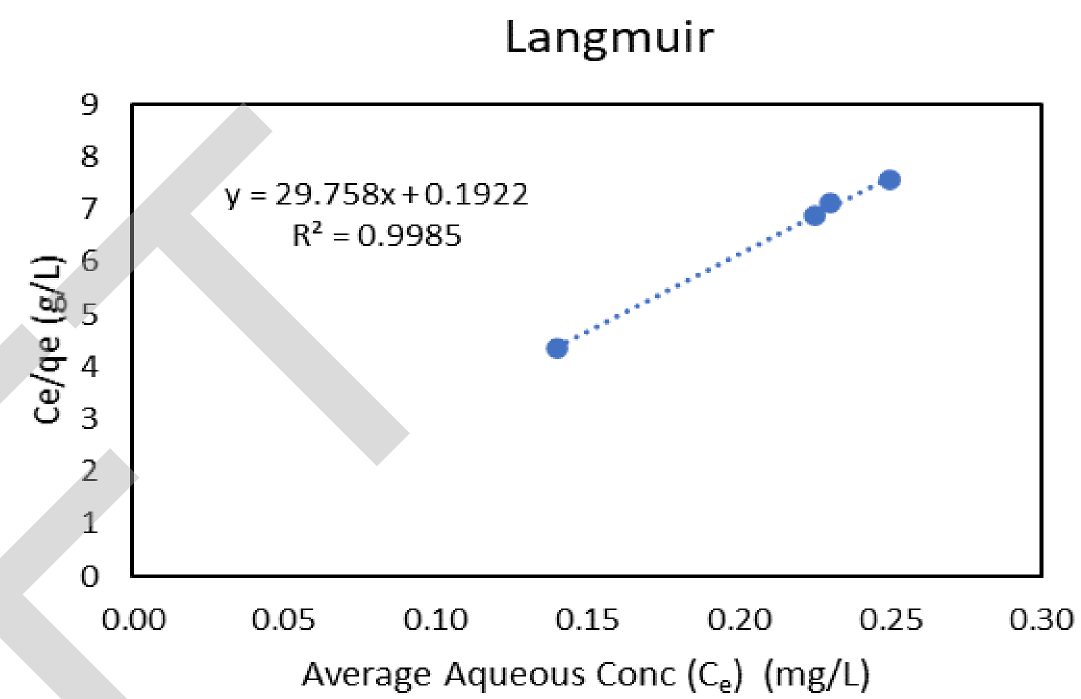
PROJECT
EVALUATION OF PARTITION COEFFICIENT RESULTS PAP

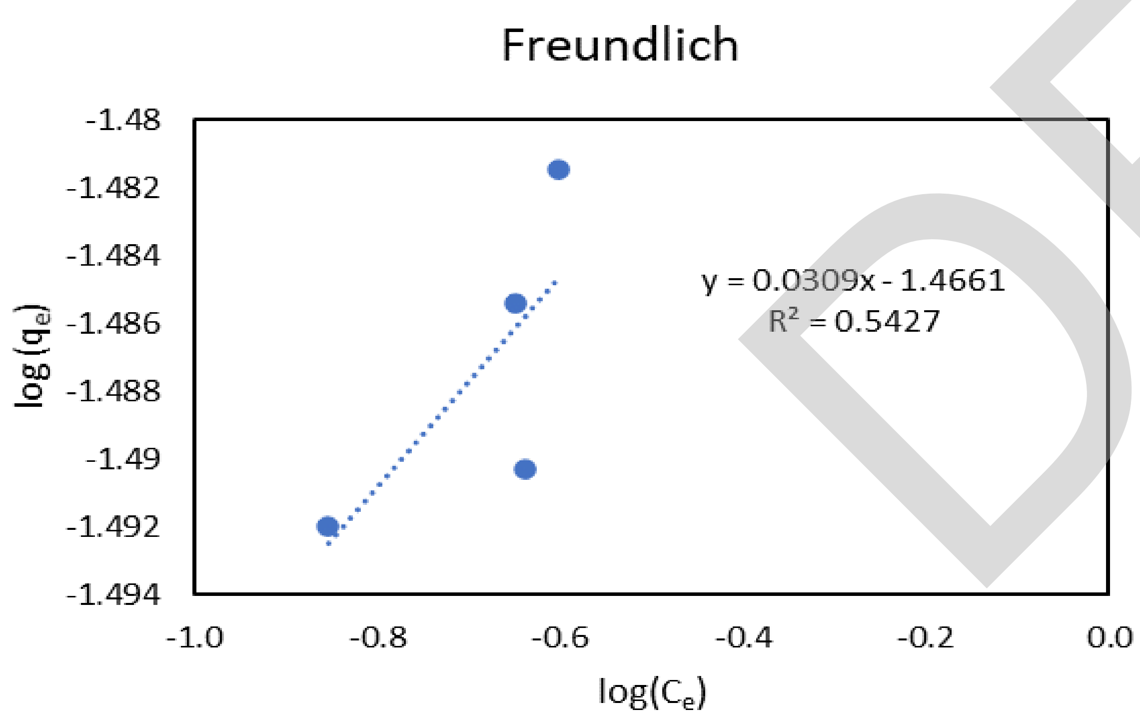
CONSULTANT
WSP GOLDER

TITLE
APW-14 BORON PARTITION COEFFICIENTS

PROJECT NO.	PHASE	REV.	FIGURE
21454831	0004	0	A-4







Note(s):
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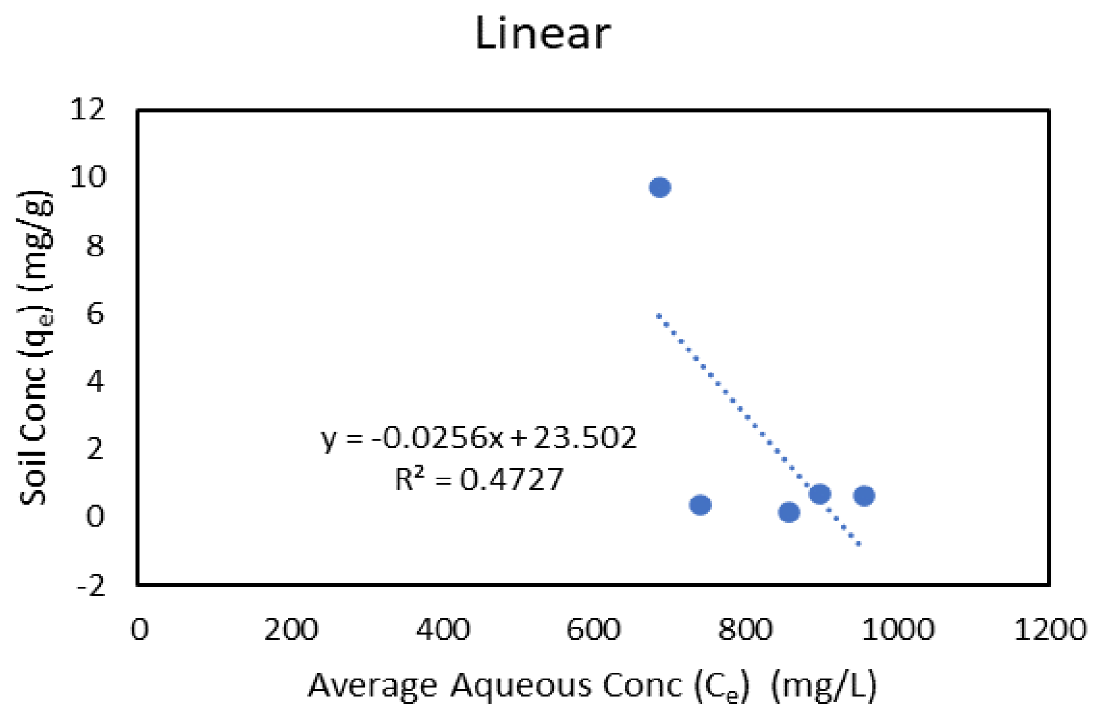
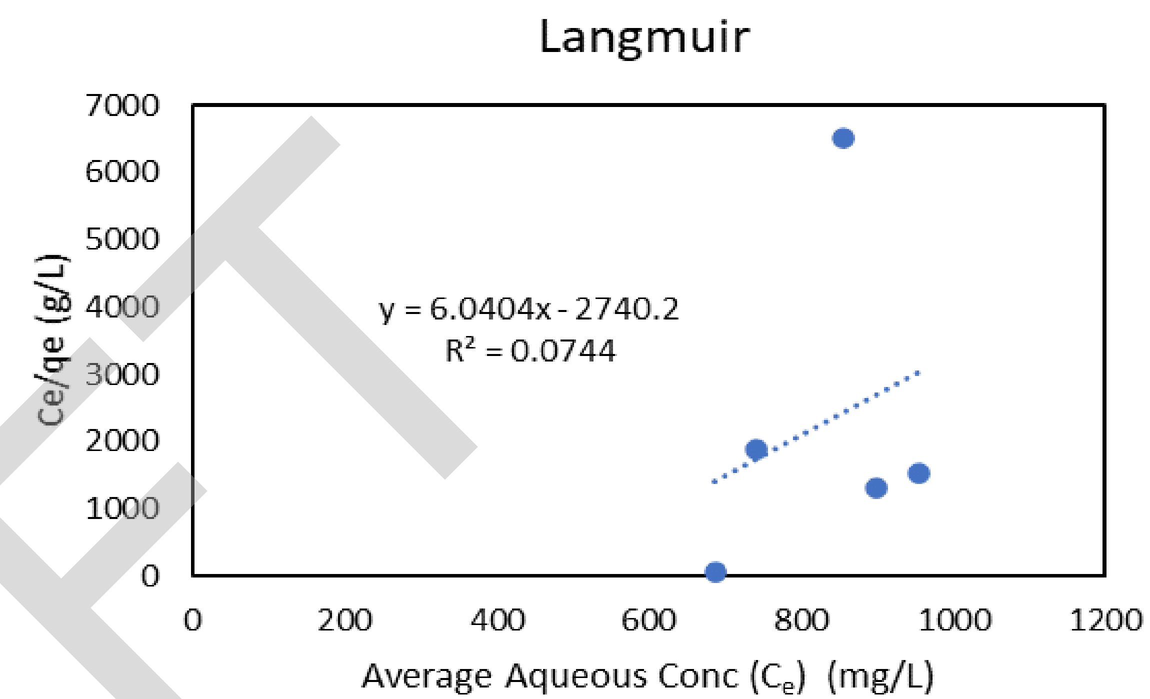
PROJECT
EVALUATION OF PARTITION COEFFICIENT RESULTS PAP

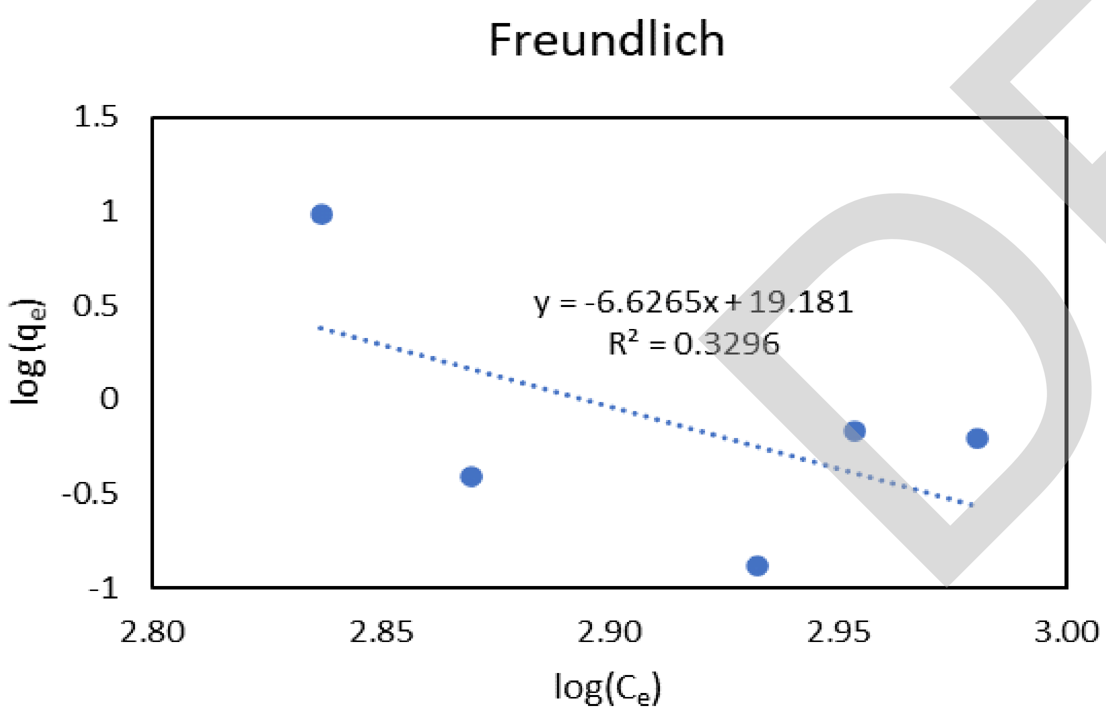
CONSULTANT
WSP GOLDER

TITLE
APW-14 LITHIUM PARTITION COEFFICIENTS

PROJECT NO.	PHASE	REV.	FIGURE
21454831	0004	0	A-5







Note(s):
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g/L: grams per liter
Ce: aqueous concentration of the adsorbate
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ILLINOIS POWER GENERATING COMPANY
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PROJECT
EVALUATION OF PARTITION COEFFICIENT RESULTS PAP

CONSULTANT
WSP GOLDER

TITLE
APW-14 SULFATE PARTITION COEFFICIENTS

PROJECT NO.	PHASE	REV.	FIGURE
21454831	0004	0	A-6