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Electric Energy, Inc.

Date
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Project No.
1940101010-012

GROUNDWATER MODELING REPORT

EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

GROUNDWATER MODELING REPORT
JOPPA POWER PLANT EAST ASH POND

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ACRONYMS AND ABBREVIATIONS

§	Section
35 I.A.C.	Title 35 of the Illinois Administrative Code
40 C.F.R.	Title 40 of the Code of Federal Regulations
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
CY	cubic yards
DMM	deep mixing method
EAP	East Ash Pond
EPRI	Electric Power Research Institute
Federal CCR Rule	40 C.F.R. § 257 Subpart D
ft/d	feet/foot per day
ft^2/d	square feet per day
Geosyntec	Geosyntec Consultants, Inc.
GHB	general head boundary
GMP	Groundwater Monitoring Plan
GMR	Groundwater Modeling Report
gpm	gallons per minute
GWPS	Groundwater Protection Standard
HCR	Hydrogeologic Site Characterization Report
HELP	Hydrologic Evaluation of Landfill Performance
HSU	hydrostratigraphic unit
ID	identification
IEPA	Illinois Environmental Protection Agency
in/yr	inches per year
ISGS	Illinois State Geological Survey
JPP	Joppa Power Plant
Kd	soil adsorption coefficient
LAU	lower aquifer unit
LCU	lower confining unit
LLDPE	linear low-density polyethylene
mg/L	milligrams per liter
mL/g	milliliters per gram
NAVD88	North American Vertical Datum of 1988
NGVD27	National Geodetic Vertical Datum of 1927
NID	National Inventory of Dams
No.	number
NPDES	National Pollutant Discharge Elimination System
NRT	Natural Resource Technology, Inc.
Part 845	35 I.A.C. § 845: Standards for the Disposal of Coal Combustion Residuals in Surface Impoundments
R^2	correlation coefficient

Ramboll	Ramboll Americas Engineering Solutions, Inc.
SI	surface impoundment
Silt Unit	Peoria Silt/Roxana Silt/Loveland Silt
SP	stress period
TVD	total-variation-diminishing
UA	uppermost aquifer
UCU	upper confining unit
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
WAP	West Ash Pond

EXECUTIVE SUMMARY

Ramboll Americas Engineering Solutions, Inc. (Ramboll) has prepared this Groundwater Modeling Report (GMR) on behalf of the Joppa Power Plant (JPP), operated by Electric Energy, Inc., in accordance with requirements of Title 35 of the Illinois Administrative Code (35 I.A.C.) Section (§) 845: Standards for the Disposal of Coal Combustion Residuals in Surface Impoundments (Part 845) (Illinois Environmental Protection Agency [IEPA], 2021). This document presents the results of predictive groundwater modeling simulations for proposed closure scenarios for the East Ash Pond (EAP). The two coal combustion residuals (CCR) Units present on the JPP property are the EAP (Vistra identification [ID] number [No.] 401, Illinois Environmental Protection Agency [IEPA] ID No. W1270100004-02, and National Inventory of Dams [NID] No. IL50714), and Landfill (Vistra ID No. 402). In addition, there is a former CCR disposal area, Joppa West, (Vistra ID No. 403, IEPA ID No. W1270100004-01) located west of the EAP. The EAP is the subject of this report and is located at the JPP which is located in Joppa, Illinois (**Figure 1-1**). The JPP property is situated in an agricultural/industrial area, bordered by LaFarge North America cement plant to the west, Trunkline Gas Company-Joppa Compressor Station to the north and west, the Village of Joppa to the east, and the Ohio River to the south (**Figure 1-2**).

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

- **CCR:** CCR consisting of fly ash and bottom ash. Water elevations measured in early March 2021 within the EAP indicate the phreatic surface is approximately 370 to 374 feet North American Vertical Datum of 1988 (NAVD88). A maximum thickness of saturated fill and CCR of approximately 42 feet was observed at location XPW01 in April 2021. The amount of saturated fill and CCR in the EAP is generally consistent, ranging from 35 to 45 feet from March through August 2021, based on an estimated base of ash from 425 to 435 feet NAVD88 and the measured phreatic surface.
- **Upper Confining Unit (UCU):** Low permeability silt and clay of the Equality Formation, silts of the Peoria/Roxana/Loveland, and clay and silt of the Metropolis Formation are considered the UCU. This unit was encountered in all borings advanced on site and limits the vertical migration of CCR impacts into the uppermost aquifer (UA). These deposits are approximately 50 feet thick and extend down to the McNairy Formation. The geometric mean hydraulic conductivity of this unit is 5.9×10^{-6} centimeters per second (cm/s) (Natural Resource Technology, Inc. [NRT], 2013).
- **Uppermost Aquifer (UA):** High permeability sands with gravel, silt, and clay lenses of the Upper McNairy Formation. The UA was encountered at elevations ranging from 222.6 to 318.6 feet NAVD88 and is between 50 and 100 feet thick near the EAP. This aquifer is classified as a Class I groundwater as defined by 35 I.A.C. § 620.110.
- **Lower Confining Unit (LCU):** Clay and silt of the Lower McNairy Formation that was encountered in site borings advanced to bedrock, with thicknesses of 12 to 14 feet. Based on material description, continuous lateral extent, and observed vertical gradients between the lower aquifer unit (LAU) and the UA, this is identified as a confining unit.

- **Lower Aquifer Unit (LAU):** Lowermost unit identified at the site and underlies all unlithified deposits. This unit is comprised of the Salem Limestone, which is the uppermost lithified unit at the site, and used as a potable and non-potable water supply in the vicinity of the JPP. This aquifer is classified as a Class I groundwater as defined by 35 I.A.C. § 620.110.

In general, the Upper McNairy Formation consists of permeable sands and gravels with isolated lenses of finer grained material. The Upper McNairy Formation is more permeable than the overlying Equality and Metropolis Formations and is encountered at its shallowest elevation on the east/southeast edge of the EAP. The Lower McNairy Formation acts as a confining unit, comprised of clay and silt which overlies the Mississippian Aged Salem Limestone. The clay and silt of this unit appears to be laterally continuous in the vicinity of the EAP.

The underlying Salem Limestone Bedrock is interpreted as the LAU. The LAU is present at an elevation of approximately 200 feet NAVD88 below the EAP, and slopes downward toward the east. The LAU is assumed to be continuous in the vicinity of the EAP, and an upward gradient within the LAU supports the conceptual model that the Ohio River is the regional receiving body of water.

The elevation of free liquids (phreatic surface) within the EAP are higher than groundwater elevations in the surrounding area. In general, groundwater flow beneath the EAP is from northwest to southeast in the northern half of the EAP, and flows southwest to southeast in the southern half of the EAP. Groundwater elevations may fluctuate by up to 20 feet. Some variations in groundwater flow directions in the southern part of the EAP have been observed; however, the major component of groundwater flow direction is consistently south toward the Ohio River which is the primary receiving body of water in the vicinity of the JPP (Ramboll, 2021a). Flood events in the Ohio River have the potential to increase groundwater elevations in the UA near the EAP.

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). Concentration results presented in the HCR are considered potential exceedances because the methodology used to determine them is proposed in the Statistical Analysis Plan (Appendix A to the Groundwater Monitoring Plant [GMP], Ramboll 2021b), which has not been reviewed or approved by IEPA at the time of submittal of the Part 845 operating and construction permit application. The following constituents with potential exceedances of the GWPS listed in 35 I.A.C. § 845.600 were identified in the HCR: boron, chloride, lithium, cobalt, pH, radium 226 and 228 combined, sulfate, and thallium (Ramboll, 2021a).

The History of Potential Exceedances (Ramboll, 2021c) attached to the operating permit application were based on an evaluation of background groundwater quality and the statistical methodologies proposed in the groundwater monitoring plan (GMP; Ramboll, 2021b). This evaluation identified the following potential exceedances: boron, pH, and sulfate. The *Evaluation of Potential GWPS Exceedances, Joppa Power Plant, East Ash Pond [CCR Unit 401]* (**Appendix A**) report was prepared to further evaluate potential GWPS exceedances. The results of the evaluation indicate that two of the well locations are not exceeding following more rigorous statistical analysis. At the remaining well locations, pH exceedances are not related to the EAP because porewater in the EAP does not exhibit low pH, and there is a significant downward trend in background wells indicates changing aquifer consditions outside the EAP. As a result, boron and sulfate are the two remaining potential exceedances of the GWPS. Boron was selected for modeling the closure scenarios.

A statistically significant correlation is present between concentrations of boron and sulfate identified as potential exceedances of the GWPS which indicate boron is an acceptable surrogate for sulfate in the groundwater model. Concentrations of these parameters are expected to change along with model predicted boron concentrations.

It was assumed that boron would not significantly sorb or chemically react with aquifer solids (soil adsorption coefficient [Kd] was set to 0 milliliters per gram [mL/g]) which is a conservative estimate for predicting contaminant transport times in the model. Boron and sulfate transport is likely to be affected by both chemical and physical attenuation mechanisms (*i.e.,* adsorption and/or precipitation reactions as well as dilution and dispersion).

Data collected from previous field investigations, as well as the 2021 and 2022 field investigations, were used to develop and calibrate site-specific groundwater flow and transport models for the EAP. The MODFLOW and MT3DMS models were then used to evaluate two closure scenarios, including CCR consolidation and closure in place (CIP), and closure by removal (CBR) scenarios, using information provided in the *Draft CCR Surface Impoundment Final Closure Plan* (Geosyntec Consultants, Inc. [Geosyntec], 2022a):

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

Prior to the simulation of these scenarios, a dewatering simulation was included which simulated the removal of free liquids from the EAP prior to the implementation of the two scenarios.

Results of predictive simulations for the CIP and CBR construction show near-equivalent timeframes for groundwater in the UA to reach GWPS. Simulated concentrations at UA groundwater wells with average boron concentrations that exceed GWPS from 2015 to 2022 decrease to GWPS within 14.2 years of closure for both CIP and CBR. Boron concentrations at all locations within the UA decrease to the GWPS of 2 milligrams per liter (mg/L) within 24 years of closure for both CIP and CBR. The decrease in infiltration rates at the EAP after cessation of sluicing, and following construction (capping and/or excavation) limits the flushing of residual boron concentration within fine-grained UCU materials beneath the EAP; however, the predicted slow migration of the residual boron within the UCU after closure does not result in impacts to the UA above the GWPS after 24 years.

1. INTRODUCTION

1.1 Overview

In accordance with requirements of Part 845 (IEPA, 2021), Ramboll has prepared this GMR on behalf of JPP, operated by Electric Energy, Inc. This report will apply specifically to the CCR unit referred to as the EAP (**Figure 1-1**).

The EAP is a 111-acre unlined CCR surface impoundment (SI) used to manage CCR and non-CCR waste streams prior to discharge in accordance with the plant's National Pollutant Discharge Elimination System (NPDES) permit (IL0001970) at the JPP. This GMR presents and evaluates the results of predictive groundwater modeling simulations for two proposed closure scenarios, including CCR consolidation and CIP, and CBR scenarios:

- **Scenario 1:** CIP (CCR removal from the southeast areas of the EAP, consolidation to the north and western areas of the EAP, and construction of a cover system over the remaining CCR).
- **Scenario 2:** CBR (CCR removal from the EAP).

This document and associated groundwater flow and transport modeling was developed to simulate and evaluate conditions at the EAP. Due to the proximity of the other CCR units at the site, Joppa West and the Joppa Landfill are also incorporated into the groundwater model domain. However, given the objectives for this modeling effort, groundwater model construction and simulation results at the other CCR units and other non-focus areas should be considered approximate and/or coarse. Evaluation of conditions at Joppa West or the Joppa Landfill should not be performed with the model presented in this document without further refinement and calibration.

1.2 Site Location and Background

The JPP is west of the Village of Joppa in Massac County, Illinois, northeast of the Ohio River in Section 14, Township 15 South, Range 3 East (**Figure 1-1**). The JPP property is bordered by LaFarge North America cement plant to the west, Trunkline Gas Company-Joppa Compressor Station to the north and west, the Village of Joppa to the east, and the Ohio River to the south. The EAP is located in the west half of Section 14 directly north of the JPP, and is bounded immediately to the east by the railway right-of-way, which is adjacent to forested portions of residential property in the Village of Joppa.

Figure 1-1 shows the location of the plant; **Figure 1-2** is a site map showing the location of the EAP and other CCR units.

The EAP was investigated in 2013 (NRT, 2013) and exceedances of Class I Groundwater Standards were reported for boron, cobalt, pH, radium, sulfate, and thallium. Additional wells were installed in 2015 to comply with Title 40 of the Code of Federal Regulations (40 C.F.R.) § 257 Subpart D (the Federal CCR Rule), and again in 2021 to collect additional data to meet the requirements of 35 I.A.C. § 845.620.

1.3 Site History and Unit Description

The JPP is a coal-fired power plant that was removed from service in 2019. It began operation in 1953 and is located on the north bank of the Ohio River, approximately 2 miles west of the town of Joppa, Illinois. Three CCR units are associated with the JPP:

- **Joppa East (*i.e.,* EAP):** A 111-acre existing unlined CCR SI which is used to manage both fly ash and bottom ash. The EAP is currently operating to receive sluiced ash; a portion of the footprint is an open water pond, the remainder of the area consists of ash to current ground surface.
- **Joppa West (*i.e.,* West Ash Pond [WAP]):** An 103.5-acre existing inactive SI located in the western portion of the JPP property. The WAP was used from the early 1950's through the 1970's. The WAP consists of two areas, the primary ash impoundment area and a smaller former settlement pond area in the southern portion (settlement area). Currently, Joppa West is capped by a layer of topsoil and clay ranging from 1 to 2 inches (in the forested areas) to several feet along the utility corridors. Natural vegetation was allowed to grow on the surface of Joppa West, which is now covered with dense vegetation, shrubs, and mature trees.
- **Joppa Landfill:** An existing permitted inactive landfill present in the northwestern portion of the JPP property.

The JPP currently operates the EAP for management of CCR waste streams. The EAP is classified as an existing unlined CCR SI which is used to manage both fly ash and bottom ash. The EAP was built in two phases. The northern portion (Phase I) was placed into service in late 1973, while the southern portion (Phase II) was permitted in May 1985, with completion of construction occurring in late 1985. These two sections are separated by a dividing dike (*i.e.,* Central Dike) and were referred to as the Northern and Southern Ponds. The pond embankment has not been raised since its construction in 1973, but material has been added in some areas to increase the width. The Northern Pond is diked over the length of its perimeter and the height of the dike varies from approximately 15 to 45 feet above the outboard toe of slope. The crest is at an approximate elevation of 380 feet NAVD88. The Southern Pond is also a diked earthen embankment structure with a height that varies from approximately 15 to 45 feet above its outboard toe. As with the Northern Pond, the crest is at an approximate elevation of 380 feet NAVD88 (O'Brien and Gere Engineers, Inc. [OBG], 2010).

Ground improvement along the southeastern portion of the EAP was performed in 2016, consisting of wet soil cement deep mixing method (DMM) to an elevation of approximately 305 feet NAVD88. The purpose of the DMM barrier installation was to provide structural stability along this portion of the embankment, with an added benefit of reduction in permeability between the CCR and native material.

1.4 Status of Site Investigations

A report summarizing the geologic and hydrogeologic conditions at the EAP was submitted to IEPA in 2013 (NRT, 2013). Since that submittal, multiple site characterization activities have been performed at the EAP including monitoring network installation in 2015, geotechnical investigations in 2016 (AECOM, 2016), hydraulic conductivity testing in April 2017, and hydrogeologic investigation in 2021 (Ramboll, 2021a). Site investigations are ongoing to delineate and characterize conditions and boron concentrations downgradient of the EAP. A summary of relevant information collected since submittal of the HCR (Ramboll, 2021a) is provided in **Appendix B.**

2. SITE GEOLOGY AND HYDROGEOLOGY

2.1 Site Topography

Topography in the vicinity of the EAP varies from approximately 370 feet NAVD88 along the north end of the site to 330 feet NAVD88 towards the south and east sloping toward the Ohio River (**Figure 2-1**). The embankments are at an elevation of approximately 370 feet NAVD88, while CCR material within the Phase I area of the impoundment ranges from approximately 372 to 380 feet NAVD88, and in the Phase II it ranges from approximately 351 to 363 feet NAVD88. The height of the EAP is approximately 55 feet relative to surrounding grade.

The EAP also contains ponded water in the southeastern portion of the unit which is connected to the CCR material. According to staff gage XSG01 the surface of the pond is at an elevation of approximately 368 feet NAVD88.

Pre-development ground surface contours indicate that a former drainage feature was present in the central portion of the EAP. Elevation contours indicate that the ground surface was approximately 320 feet North American Vertical Datum of 1927 (NAVD27) in the southeast corner of the pond prior to filling with CCR. **Appendix B** presents information used to develop the base of ash surface.

2.2 Site Geology

Four geologic units are present in the vicinity of the EAP, these include the following in descending order: fill material and CCR, silts and clays of multiple formations, the McNairy Formation, and the Salem Limestone (bedrock). The units are described as follows, with further details in the HCR (Ramboll, 2021a):

- **Fill and CCR:** Both CCR and non-CCR fill material are present within and near the EAP. Non-CCR fill material is present at the EAP at depths of up to 5 feet below ground surface (bgs), and is present in the vicinity of the JPPand near the EAP. Non-CCR fill varies in composition and is present in the constructed berms, railroad embankments, and areas near the plant. Soil borings performed within the EAP (XPW01, XPW02, and XPW03) indicate that CCR material consists of both fly and bottom ash and it varies in thickness up to approximately 50 feet. Ash is encountered within the footprint of the EAP, at the WAP, at the landfill, and two areas exterior to the EAP to the south and southeast of the EAP berm, which are described in **Appendix B**.
- **Silts and Clays:** The uppermost native material at the site consists of predominantly silt and clay with some sand and gravel, of the Equality Formation, windblown silts, and the Metropolis Formation. The Equality Formation is the uppermost unlithified material encountered at the EAP, consisting of silt and clay with minor amounts of sand and gravel. Borings advanced at the site indicated formation thicknesses of 14 to 28 feet. The Peoria Silt, Roxana Silt, and Loveland Silt (Silt Units) are primarily loess, and are generally classified in boring logs as silt with limited occurrences of sandy silt. These Silt Units are not encountered at all locations near the EAP and are limited in extent. The Metropolis Formation is composed of clay, sandy clay, and sandy silt with limited occurrences of silty sand and gravel. This unit is encountered across the site, and varies in thickness from approximately 4 to 40 feet. Contacts between these units are typically gradiational and they are grouped together for evaluation of site conditions.

- **McNairy Formation:** The McNairy Formation underlies the superficial silt and clay units and consists of sands, silts, and clay. At the site, the McNairy Formation is primarily sand and gravels, with occasional lenses of silt and clay, with a total thickness of approximately 50 to 100 feet. The McNairy Formation is continuous through the region and outcrops at ground surface upgradient of the site (Nelson and Masters, 2008).

  Site borings penetrating the full thickness of the McNairy Formation have identified a layer of lean clay immediately above the bedrock surface. This material is more generally characterized as clay, silt, or chert gravel residuum in on-site wells (Nelson, 1997), and has been interpreted and characterized as part of the Lower McNairy Formation, Post Creek (Tuscaloosa) Formation, or weathered limestone residuum. Site borings advanced to bedrock identified unit thicknesses of 14 and 12 feet at G09M and G14D, respectively (Ramboll, 2021a; **Appendix B**). This layer is assumed to be continuous atop the bedrock surface and is referred to in the HCR as the Lower McNairy Formation.

- **Salem Limestone Bedrock**: Bedrock at the site consists of Mississippian-age limestone with some shales present in shallower zones. The bedrock dips gently northward toward the center of the Illinois Basin. The top-of-rock elevation is 162 to 236 feet NAVD88 based on site borings and regional geologic information (Nelson and Masters, 2008); the total thickness of Mississipian limestone in the region is greater than 3,200 feet (Ramboll, 2021a).

2.3 Site Hydrogeology

Five hydrostratigraphic units (HSUs) are present at the site and surrounding areas. HSU is defined as a body of rock or unlithified materials that forms a distinct hydrologic unit with respect to the flow of groundwater. The HSUs at the EAP are discussed in detail in the HCR, and consist of the following in descending order:

- **CCR:** CCR consisting of fly ash and bottom ash. Water elevations measured in early March 2021 within the EAP indicate the phreatic surface is approximately 370 to 374 feet NAVD88. The saturated thickness within the CCR varies based upon the base elevation of the ash material and varies from 0 to 45 feet.
- **UCU:** This unit is comprised of the Equality Formation, the Silt Unit, and Metropolis Formation deposits, which are similar in composition and consist primarily of fine-grained silts and clays. The average thickness of this unit is 40 feet with a range of 8 to 58 feet at the site. The UCU underlies the CCR fill and is thinnest beneath the southeast corner of the EAP. This unit is not an aquifer; it is characterized as a confining unit based upon composition, and flow directions with this unit are predominantly vertical.
- **UA:** This unit is composed of the high-permeability sands and gravels of the McNairy Formation, with isolated lenses of finer-grained material. At the site, the UA is 50 to 100 feet thick.
- **LCU:** The LCU consists of the 12- to 14-foot thick clay material encountered between the McNairy Formation and bedrock. This unit is expected to be low permeability with predominantly vertical flow directions between the two high-permeability aquifers above and below.
- **LAU:** This unit, composed of the Salem Limestone Bedrock, is the lowermost HSU identified. The limestone is high permeability and is used as a regional water supply. The LAU has an

upward gradient where monitored near the southern portion of the site, and discharges into the Ohio River.

2.3.1 Hydraulic Parameters and Characteristics

Estimates of hydraulic conductivity and other hydraulic parameters for site HSUs are available from the results of field testing (*i.e.,* slug testing), laboratory testing, and regional or published information.

Field hydraulic conductivity tests were performed on the UA at the EAP as part of the 2021 field investigation (Ramboll, 2021a). Horizontal hydraulic conductivities for the Upper McNairy Formation (*i.e.,* UA) ranged from 4.8×10^{-4} to 1.2×10^{-2} cm/s with a geometric mean of 3.1×10^{-3} cm/s. Field hydraulic conductivity tests were performed at wells completed into the CCR material in 2021 and ranged from 4.5×10^{-3} to 1.7×10^{-1} cm/s, with a geometric mean of 1.3×10^{-2} cm/s. Results of field testing performed in 2010 by Geotechnology and reported by NRT (2013) yield an estimate of 5.9×10^{-6} cm/s for the UCU at Joppa West and Joppa East (geometric mean).

Laboratory falling head permeability tests were conducted on samples collected in CCR material during the 2021 field investigation resulting in a geometric mean vertical hydraulic conductivity of 1.0×10^{-6} cm/s. Additionally, four samples were collected from UCU material for laboratory falling head permeability tests, which resulted in a geometric mean vertical hydraulic conductivity of 1.7×10^{-7} cm/s (Ramboll, 2021a).

A regional geologic study (Brahana and Mesko, 1988) reports a range of estimated hydraulic conductivities for the Salem Limestone of 10 to 75 feet per day (ft/d), and storativity of 0.007 to 0.0008; well yields for this HSU are high. Slug testing performed at well G09M (completed in shallow bedrock) yielded an estimated average hydraulic conductivity of 4.0×10^{-4} cm/s.

2.3.2 Pumping Wells

The bedrock aquifer (*i.e.,* LAU) is a regional source of groundwater for public supply and private wells. There are four currently-operating supply wells completed into the LAU near the EAP, three at JPP and the community water supply (CWS) for the Village of Joppa. The McNairy Formation (*i.e.,* UA) may also be a source of water for private wells. A site visit/windshield survey was conducted in February 2022 for visual identification of potential pumping wells on private property near the site, however no clear link between database records for well locations and observed potential wellheads was identified (Ramboll, 2022a). No active private water supply wells have been identified off property east or south of the EAP near the Village of Joppa, and no known pumping wells in the area utilize the Equality and Metropolis Formations for groundwater.

2.3.3 Ohio River

The Ohio River is the primary receiving body of water for the region. It is a large navigable waterway, approximately 3,500 feet across at the site, with stage managed by several dams including Olmsted, which is 12 miles downgradient from the site. A gauging station is maintained by JPP personnel adjacent to the site. Daily gauge heights and precipitation from January 1, 2021 through March 2022 are shown in **Figure A** below.

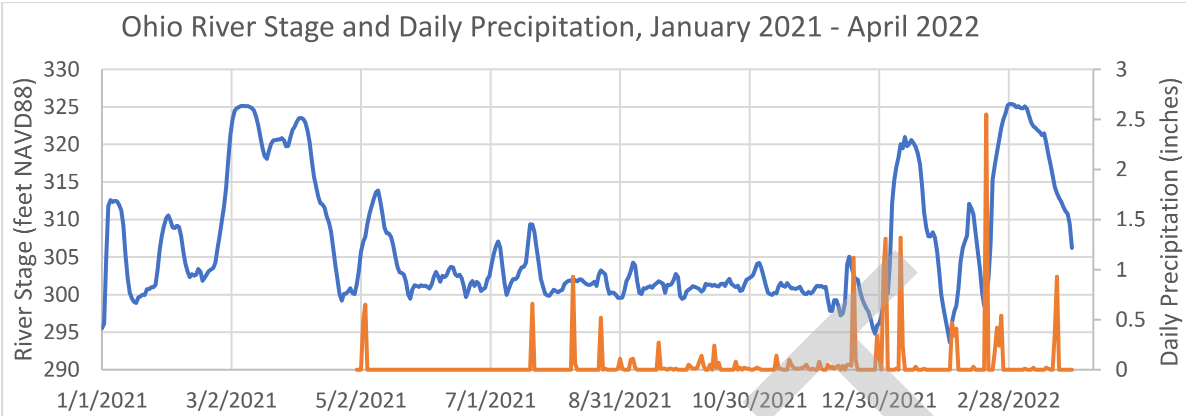

Figure A. Daily Gauge Height (feet) and Daily Precipitation (inches) January 1, 2021 to March 30, 2022 for Joppa Power Plant Gaging Station at the Ohio River at Joppa, Illinois.

Review of available data from the Olmsted gauge and on-site gauge data indicates the following:

- River stage maintains a relatively constant level for most of the time, which represents baseflow conditions in the river and the groundwater system which flows toward the river. This baseflow condition occurs with a site river elevation of approximately 300 feet and represents quasi-equilibrium conditions for the watershed.
- Periodic flood events occur during which the stage in the Ohio River increases by up to 25 feet above baseflow. As shown in **Figure A**, flood events occurred in early 2021 and early 2022.
- Flood events vary with respect to timing/periodicity, the observed pattern of water level changes, severity (*i.e.,* maximum sustained stage), and length. This is unsuprising considering that flooding in the Ohio River is caused by patterns of precipitation and snowmelt, and controlled by multiple dams along its length, which are not constant year-to-year. Review of the longer series of water levels from the Olmsted gauge indicates that the timing of the annual flood varies and should not be characterized as strictly an annualized phenomena.

2.3.4 Conceptual Site Model for Flow

The HCR (Ramboll, 2021a) is the foundation of the site setting and conceptual site model (CSM) that describes groundwater flow at the site. In general, groundwater is recharged from surficial precipitation and from upgradient areas, flowing from north to south within the UA and LAU (bedrock) towards the regional sink of the Ohio River. Groundwater flow is predominantly vertical in the confining units (*i.e.,* UCU and LCU). Groundwater flow in the UA is south towards the river, with an easterly flow component along the east portion of the pond towards the eastern property boundary. Vertical gradients between the bedrock and the UA are upward near the Ohio River.

<u>Discussion of Groundwater Elevations and River Stage</u>

Review of available groundwater elevations from site monitoring wells screened within the UA indicates some variability in groundwater elevations over time. The degree of variability in the groundwater elevation record at each well is not consistent, and varies by location. Evaluation of recent data collected in 2021 and 2022 suggested that the source for variation of groundwater elevations in the UA may be changes in river stage.

A number of site wells were installed in 2021 near the eastern edge of the EAP and along the property boundary to the east. Boring logs, groundwater elevation data, and boron concentrations collected in 2021 and 2022 for these wells are presented in the HCR and **Appendix B**. Data collected from these monitoring wells in early 2022, during flood stage of the Ohio River (**Figure A**), indicate that groundwater elevations within the UA are influenced by stage in the Ohio River.

Generally, evaluation of synoptic (*i.e.*, site-wide) groundwater elevations within the UA indicates that the direction of groundwater flow near the EAP is towards the river from upgradient areas, with some easterly component of flow direction noted near the eastern boundary of the EAP and the site. This is evident in **Figure 2-2**, which presents groundwater elevations measured in the UA on February 1, 2022. The conditions observed in this figure are consistent with the conceptual site model for baseflow conditions at the site, in which the Ohio River has the lowest elevation within the hydrologic watershed and is the receiving body of water for the groundwater system.

Figure 2-3 presents river stage and groundwater elevations collected at site monitoring wells in late 2021 and early 2022, during 2022 flood stages of the Ohio River. This plot shows a clear increase in groundwater elevation during the flooding period, culminating in early March when the flood is at its peak. Elevations at wells for which a pre-flood baseline and March 2, 2022 measurement were collected increased by up to 20 feet during the flood event.

3. GROUNDWATER QUALITY

Per 35 I.A.C. § 620.210, groundwater within the UA and the LAU at the EAP meet the definition of a Class I – Potable Resource Groundwater based on the following criteria:

- Groundwater in the UA extends 10 feet or more below the land surface.
- Hydraulic conductivity exceeds the 1 x 10^{-4} cm/s criterion (Table 3-3 of the HCR [Ramboll, 2021a]).

Field hydraulic conductivity tests performed on the unlithified geologic materials that include high permeability sands of the Upper McNairy Formation (silts, clays, and gravel layers within the unit), and lithified materials (limestone of the Salem Formation) at the JPP had geometric mean hydraulic conductivities exceeding 1 x 10^{-4} cm/s. Based on this information, groundwater is classified as Class I – Potable Resource Groundwater.

A review and summary of data collected from 2015 through 2021 for parameters with GWPSs listed in 35 I.A.C. § 845.600 is provided in the HCR (Ramboll, 2021a). Concentration results presented in the HCR were compared directly to 35 I.A.C. § 845.600 GWPSs to determine potential exceedances. The results indicate the following parameters were greater than the applicable 35 I.A.C. § 845.600 GWPS and are considered potential exceedances: boron, cobalt, pH, radium, sulfate, and thallium. They are considered potential exceedances because the results were compared directly to the standard and did not include an evaluation of background groundwater quality or utilize the statistical methodologies proposed in the GMP (Ramboll, 2021b) attached to the operating permit application.

The History of Potential Exceedances (Ramboll, 2021c) attached to the operating permit application are based on an evaluation of background groundwater quality and the statistical methodologies proposed in the groundwater monitoring plan (GMP; Ramboll, 2021b). This evaluation identified the following potential exceedances: boron, pH, and sulfate. Boron, sulfate, and pH are defined as potential exceedances because the methodology used to determine them is proposed in the Statistical Analysis Plan (Appendix A to GMP), which has not been reviewed or approved by IEPA at the time of submittal of the 35 I.A.C. § 845 operating permit application.

An *Evaluation of Potential GWPS Exceedances, Joppa Power Plant, East Ash Pond [CCR Unit 401]* (**Appendix A**) evaluates the potential GWPS exceedances included in the History of Potential Exceedances (Ramboll, 2021c). The results of the evaluation demonstrated that the potential GWPS exceedances of pH in monitoring wells G06S, G07, G11, G51D, and G151 are not related to the EAP based on several lines of evidence presented in the document. Since potential GWPS exceedances pH are not related to the Ash Pond, this parameter will not be discussed further in this GMR.

Potential exceedances of the GWPS for boron and sulfate are limited to the UA and have not been observed in the lower aquifer unit (LAU, *i.e.,* bedrock aquifer). There is currently one monitoring well present in the LAU (G09M) and no exceedances for boron were observed in the five monitoring events conducted in 2021.

4. MODEL APPROACH

4.1 Overview

Data collected from previous field investigations and those performed in 2021 and early 2022 (Ramboll, 2022a and **Appendix B**) were used to develop groundwater flow and transport models for the EAP (**Section 5**). The MODFLOW and MT3DMS models were then used to evaluate two closure scenarios, including CCR consolidation and CIP, and CBR scenarios, using information provided in the *Draft CCR Surface Impoundment Final Closure Plan* (Geosyntec, 2022a). The results of the CIP and CBR closure scenarios are summarized and evaluated in **Section 6**. Associated model files are included as **Appendix C.**

As discussed in previous sections, investigation of offsite impacts of boron concentrations resulting from the EAP are currently ongoing. Information obtained after April 2022 was not incorporated into the model, and may impact the final closure and/or corrective measures for the site. As such, it is expected that the groundwater models developed and described in this report may be modified as more information becomes available, and for use in simulation of corrective measures in the future.

The groundwater modeling activities documented in this report utilized the following software and model codes:

- Groundwater flow was simulated in three dimensions using MODFLOW
- Contaminant transport was simulated in three dimensions using MT3DMS
- Hydrologic Evaluation of Landfill Performance (HELP) modeling to simulate infiltration
- Use of Groundwater Vistas as a MODFLOW/MT3DMS processing tool

4.2 Description of Site-Specific Groundwater Models

Four specific groundwater flow and transport models were developed to simulate conditions at the EAP consistent with the CSM presented in **Section 2.3.4**, consisting of the following:

- **Current Conditions Flow Model**: A steady-state flow model was developed and calibrated to represent current conditions for groundwater flow at the EAP. This flow model provided the base model for modifications for other phases of modeling and is documented in **Section 5.1**.
- **Historical Transport Calibration:** A transient flow model was developed by modifying the current conditions model to simulate groundwater flow conditions throughout operation of the EAP to the present time. A solute transport model was developed to simulate boron concentrations in groundwater throughout EAP operation to enable comparison of simulated concentrations to observed concentrations (transport calibration) and provide a stable distribution of current boron concentrations as a baseline for predictive modeling. The historical transport model is documented in **Section 5.2**.
- **River Flood Evaluation:** Identification of the potential for transient groundwater flow direction reversals near the Ohio River during periods of river flooding underscored the need for further evaluation of river flooding. The current conditions model was used as a base to construct a transient model to simulate effects of river flooding on groundwater flow directions. The river flood model is documented in **Section 5.3**.

- **Predictive Simulations:** Modifications to the site flow and transport models were made to simulate closure alternatives for the EAP. Simulated groundwater flow and boron concentrations from the historical transport calibration and current conditions models were used to provide baseline conditions for predictive simulations. Predictive simulations are documented in **Section 6.3**.

4.3 Conceptual Site Model for Transport

As discussed in previous sections, investigation of impacts to offsite groundwater from the EAP are ongoing. Although potential exceedances of GWPS have been identified for several COCs, the prevalence of these exceedances (degree and spatial extent) is limited, with the exception of boron, which has been identified in a number of wells within the UA. Concentrations of compounds in leachate potentially migrated downward from the EAP through the silts and clays of the UCU into the sands and gravels of the UA. Groundwater in the UA flows south and southeast (**Figure 2-2**), and boron concentrations have been detected in monitoring wells downgradient of the EAP.

Boron is commonly used as an indicator parameter for contaminant transport of CCR because: (i) it is commonly present at elevated concentrations in coal ash leachate; (ii) it is mobile and typically not very reactive but conservative (*i.e.*, low rates of sorption or degradation) in groundwater; and (iii) it is less likely than other constituents to be present at elevated concentrations in background groundwater from natural or other anthropogenic sources.

Comparisons of observed sulfate to boron concentrations (**Figure B** below) indicate a statistically significant correlation between these parameters in downgradient UA wells. Observed concentrations were transformed into Log10 concentrations for evaluation. The correlation coefficient (R^2) and p values (indicator of statistical significance) are also provided on **Figure B**. Higher R^2 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. The p value is less than the target of 0.05, indicating correlations are statistically significant. The statistically significant correlation between sulfate and boron indicates boron is an acceptable surrogate for sulfate in the groundwater model, and concentrations of sulfate are expected to change along with model predicted boron concentrations. Accordingly, transport modeling was performed for boron and no other constituents at the site at this time.

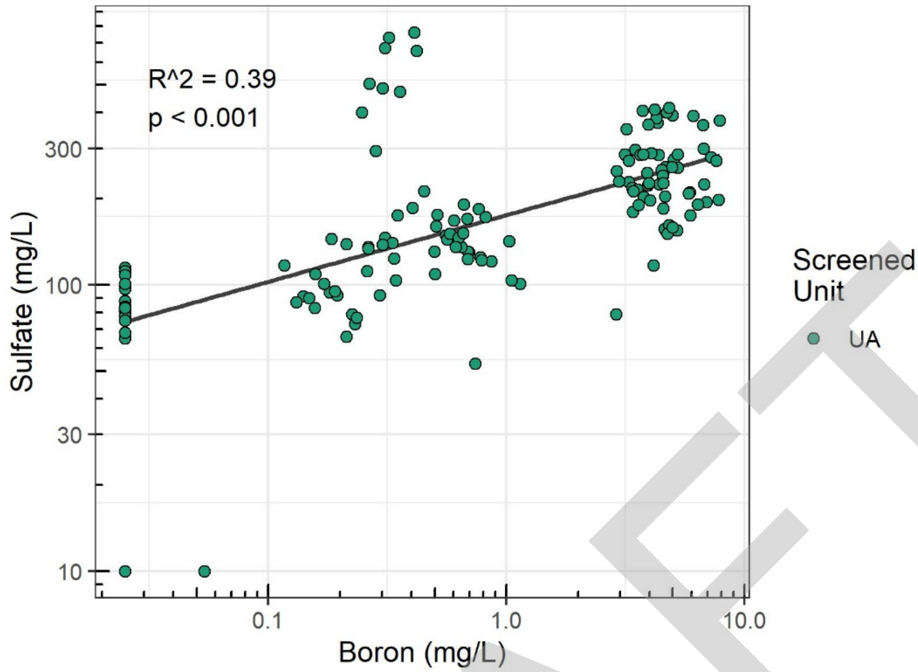

Figure B. Correlation of Observed Sulfate and Boron Concentrations in Downgradient UA Wells.

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

MODFLOW was developed by USGS (McDonald and Harbaugh, 1988) and has been updated several times. Major assumptions of the code are: (i) groundwater flow is governed by Darcy's law; (ii) the formation behaves as a continuous porous medium; (iii) flow is not affected by chemical, temperature, or density gradients; and (iv) hydraulic properties are constant within a grid cell. Other assumptions concerning the finite difference equation can be found in McDonald and Harbaugh (1988). MODFLOW 1996 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 EAP. The finite difference solution was used for this simulation.

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

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

5. MODEL SETUP AND CALIBRATION

This section describes three models which were developed to represent conditions at the site, which consist of the current conditions flow model, the historical calibration transport model, and the river flood evaluation model.

5.1 Current Conditions Flow Model

A steady-state flow model was developed and calibrated to represent current conditions for groundwater flow at the EAP. This flow model provided the base model for flow at the EAP and for modifications for other phases of modeling. Model Files are provided in **Appendix C**.

The development process for a numerical groundwater flow model consists of construction of a finite-difference grid for the model area, specification of model structure, assignment of boundary conditions, specification of hydraulic parameter values and zones, and selection of appropriate water-level measurements for calibration of the model. These features represent elements of the conceptual site model, which provides the basis for the construction and calibration of the numerical model to observed groundwater flow conditions at the site.

Evaluation of available groundwater elevation data for monitoring wells within the model domain indicated that a steady-state current conditions flow calibration was appropriate for this site:

- Groundwater elevation data are generally limited to measurements from the last several years. The dataset that is available for older measurements (wells with longer records) does not indicate the existence of long term water level trends that may require a transient, historical calibration.
- Groundwater elevations for the UA are affected by flooding of the Ohio River, with head increases of up to 20 feet in monitoring wells during periods of flooding (**Section 2.3.3**). However, water levels are generally stable during long periods of baseflow river conditions (stage of approximately 300 feet NAVD88) at the site. The conceptual model for the steady-state flow model is to simulate the stable groundwater elevations and flow directions present during these periods of baseflow (*i.e.,* minimum controlled stage) in the Ohio River to provide a basis for evaluation of long-term, steady-state conditions.

5.1.1 Model Domain and Discretization

The model domain consists of an area 20,000 feet by 15,000 feet (approximately 7,000 acres). The grid was rotated -23.5 degrees to align the southern edge of the model grid with the bank of the Ohio River near the EAP. The model domain is divided into 578 columns (x) and 408 rows (y), with variable grid spacing of 20 feet in areas of interest increasing to 150 feet at the edges of the model domain. **Figure 5-1** presents the model grid.

Seven model layers were assigned to represent subsurface materials. Model layers 1 and 2 were set to represent unconfined flow conditions, with layers 3 through 7 confined. Ground surface elevation within the model domain varies from approximately 300 feet NAVD88 at the Ohio River, to 500 feet NAVD88 in upland areas. Model layer boundaries were interpreted based upon site-specific data (boring logs) and publicly-available information for the area (Nelson and Masters, 2008; Illinois State Geological Survey [ISGS], 2022).

Table A. Flow Model Layer Description

Model Layer	Approximate Layer Bottom Elevation (feet NAVD88)	Layer Description
1	308-surface	CCR material; fill or native materials
2	305-322	UCU – silts and clays
3	273-319	UCU – silts and clays
4	176-250	UA (McNairy formation)
5	162-236 (14 feet uniform thickness)	LCU
6	132-206 (30 feet uniform thickness)	Bedrock
7	-100	Bedrock

Model layer 1 was developed to explicitly represent CCR material, including CCR within the unit boundaries of the EAP and in areas to the southeast of the EAP where ash has been recently identified (and is currently under investigation). Bottom elevations for model layer 1 were set to the base of ash elevation in these areas, with a high base elevation of 375 feet NAVD88 set in areas where no ash is located to ensure these areas would remain dry (inactive) for model simulations. Details regarding ash external to the EAP unit boundaries and elevations of the ash are presented in **Appendix B**.

Model layers 2 and 3 both represent the UCU; two layers were used to represent this HSU to enable greater flexibility in model calibration given the parameter sensivity associated with vertical flow through the thick package of low-permeability material. The base of model layer 3 was set to the top of the McNairy Formation. Model Layer 4 represents the McNairy Formation which comprises the UA. Model layer 5 represents the LCU, and model layers 6 and 7 represent the bedrock. The thickness of the LCU was set to a uniform thickness of 14 feet based upon site data. Simulation of the bedrock as two model layers was selected to enable flexibility in representation of vertical flow through the bedrock. The top of bedrock elevation was set using a handful of data points from site boring logs which penetrated bedrock, well logs for nearby pumping wells, and from the USGS Joppa Geologic Quadrangle Map (Nelson and Masters, 2008).

5.1.2 Boundary Conditions and Hydraulic Parameters

Boundary conditions define the spatial boundaries of the model on the top, bottom, and all sides of the model grid. Additional boundary conditions within the model domain can be specified to represent groundwater sources or sinks, or flow-specified or limiting conditions. This flow model includes five types of boundary conditions: no-flow, recharge (specified flux), and river (head-dependent flux), general head (head-dependent flux), and pumping wells (specified flux). **Figures 5-2 through 5-5** (layer 1, layers 2 and 3, layer 4, layers 6 and 7, respectively) present boundary conditions for the flow model.

Boundary condition parameters and model parameters, chiefly hydraulic conductivity, were varied within appropriate ranges for the site during the model construction and calibration process. Sensitivity testing was performed as necessary to evaluate model construction and adequacy of selected parameters and is documented below where relevant.

5.1.2.1 No-Flow Boundaries

No-flow boundary cells were used to define the edges of the active model area where they do not coincide with the edges of the model grid.

- Model Layer 1 (**Figure 5-2**): Model layer 1 was set as inactive surrounding the EAP extent, since the bottom elevations for model layer 1 represent the base of ash, where present, and are artificially high in other areas to produce dry (unsaturated) model conditions.
- Model Layers 2 and 3 (**Figure 5-3**): No-flow boundaries were defined at the approximate upgradient extends of the local watershed boundaries for the shallow surface units (natural physiographic boundaries). No-flow boundaries were also incorporated above the southern portion of the river as inactive areas.
- No-flow boundaries are not present in model layers 4, 5, 6, and 7; flow in these layers extends to the full model grid extent.

5.1.2.2 River

The Ohio River provides the southern boundary for the model domain. River stage varies based on rainfall/runoff and is also controlled by managing pool level at downstream dams. River elevation data are collected onsite at the JPP and also recorded at the USGS gauging station in Olmsted, Illinois (approximately 12 miles downstream). As shown in **Figure A** in **Section 2.3.3**, plant data indicate that baseflow conditions occur (*i.e.,* consistent minimum elevation) at approximately 300 feet NAVD88, with occasional short-term stage increases of 5 to 10 feet, and periodic (0 to 2 times per year) river flood events of 20 or 25 feet above baseflow conditions. Bathymetry information for the Ohio River near the site indicates a base elevation for the river bottom of approximately 260 feet.

The Ohio River was simulated using river boundary cells in model layer 4 (**Figure 5-4**). A river stage of 300 feet NAVD88 was simulated in the steady-state flow model, with a base of 260 feet. Conductance was increased during sensitivity testing to be sufficiently high to avoid limiting flow into the Ohio River (1.2×10^5 square feet per day [ft^2/d]), as is appropriate per the conceptual model and the function of the river as the primary receiving body of water for the model domain.

5.1.2.3 General Head Boundaries

General head boundaries (GHB) were used to simulate inflow into the upgradient (northern) edge of the model domain in model layers 4, 6, and 7. GHB elevations and conductances were adjusted during calibration to provide an appropriate gradient through the model domain. GHB elevations were simulated at 329 feet NAVD88 in model layer 4, and 332 feet NAVD88 in model layers 6 and 7.

5.1.2.4 Pumping wells

No active private water supply wells have been identified off property east or south of the EAP near the Village of Joppa. Groundwater is pumped for water supply from four bedrock wells located within the model domain. This consists of three supply wells for the plant (JPP1, JPP2, JPP3), and one public water supply well for the town of Joppa (Joppa CWS2). These pumping wells were simulated in the groundwater flow model, within model layer 7 (bedrock) and shown on **Figure 5-5**.

Table B. Pumping Well Summary

Well	Rate (gpm)
Joppa CWS 2	15
JPP1	80
JPP2	410
JPP3	475

Notes:
gpm = gallons per minute

5.1.2.5 Recharge

Recharge is applied as a source of water to the uppermost (top) active layer of the model and represents infiltration of precipitation from the surface to the groundwater table. Recharge can also be used to represent anthropogenic sources of water to groundwater, which in this case consists of sluicing of ash and water into the EAP.

The recharge zones and values specified in the groundwater flow model are identified below and shown in **Figure 5-6**. The model recharge values assigned for each zone described below were selected according to typical recharge values for the site setting, ground cover, and conditions within each zone, and adjusted during model calibration. Sensitivity of model calibration parameters and groundwater elevations in model layers 2 and 3 (flow and transport, described in **Section 5.2**) to changes in recharge values in the EAP and external ash areas was high, due to the large head difference observed between water elevations in the EAP (model layer 1) and the UCU beneath and adjacent to the EAP (model layer 2).

Background recharge of 6.6 inches per year (in/yr) was applied to most of the model domain, which is consistent with typical recharge values for humid temperate climates of the eastern United States. High recharge values were specified for the open water area of the EAP, which receives sluiced ash. A portion of the ash exterior to the EAP was also specified with high recharge due to identification of minimal ground cover and sandy surface fill materials; higher recharge in this location was also consistent with boron concentrations at wells adjacent to this area (Zone 6).

Model settings were applied in MODFLOW for recharge to enter the highest active (saturated) cell; since the area outside of the EAP is inactive (dry or no-flow) in model layer 1, much of the recharge assigned to the model was applied to model layer 2.

Table C. Model Recharge (Current Conditions Flow Model)

Zone	Assigned Recharge (ft/d)	Assigned Recharge (in/yr)	Zone Description
1	0.0015	6.6	Background recharge
2	0.0027	11.8	Ash
3	0.016	70.1	open water ash pond
5	0.0015	6.6	EAP external ash
6	0.007	30.7	EAP external ash, high recharge (limited ground cover)

5.1.2.6 Hydraulic Conductivity

In constructing the model for the site, representative values for horizontal and vertical hydraulic conductivity of hydrogeologic units were selected based on the results of hydraulic testing conducted at the site as well as regional information and literature values for geologic materials where site specific information was not available. **Table 5-1** presents the hydraulic conductivities assigned for the current-conditions flow model, as described below. The hydraulic conductivities specified were selected from site data presented in the HCR and other site reports, and were carefully adjusted during calibration and sensitivity testing.

- **Model Layer 1 (Figure 5-7)**: Given the limited spatial extent of the active area in model layer 1, three conductivity zones were simulated. Zone 1 represents the ash material; hydraulic conductivities for this material were selected from the range of available slug test data for the ash (HCR) and adjusted during calibration. Zone 2 represents the open water area of the EAP and has an artificially high conductivity to produce uniform head across this area. Simulated model layer 1 water elevations were very sensitive to vertical conductivity, and these values were adjusted carefully to produce an adequate calibration. The DMM was represented by a narrow zone with very low hydraulic conductivity (1 x 10^{-4} ft/d).
- **Model Layer 2 (Figure 5-8):** Model layer 2 chiefly represents the silts and clays of the UCU (Zone 2), with calibrated conductivity of 0.2 ft/d, consistent with slug test data for the UCU wells. As presented in Nelson and Masters (2008), the McNairy Formation outcrops at ground surface some distance north of the river. This transition was approximated with Zone 18 in model layers 2 and 3, with a horizontal conductivity of 20 ft/d. A higher conductivity zone was placed above the Ohio River (simulated in model layer 4) to ensure that these cells remained inactive (dry) in model layer 2, consistent with the elevations of each model layer and the CSM. A zone of slightly lower conductivity (zone 13) was assigned south of the EAP and west to the WAP, based upon calibration; and a zone of slightly higher conductivity (zone 11) was assigned along the eastern edge of the EAP during calibration. Since the UCU is a surficial confining unit, flow is predominantly vertical within the unit, and simulated groundwater elevations had high sensitivity to changes in vertical hydraulic conductivity. The DMM was also specified in model layer 2, with a base elevation of 305 feet (specified in the model layer 2 bottom elevation) consistent with its construction.
- **Model Layer 3 (Figure 5-9):** The hydraulic conductivities in model layer 3 were mostly equivalent to those in model layer 2. The vertical hydraulic conductivity of the UCU was adjusted slightly following sensitivity testing, and the zone of elevated permeability to the east of the EAP (zone 11) was removed from model layer 3. The DMM was not simulated for model layer 3 according to its base elevation.
- **Model Layer 4 (Figure 5-10):** The sandy McNairy Formation which comprises the UA was simulated with hydraulic conductivities of 10 ft/d to 100 ft/d. The background hydraulic condcutivity specified for most of the model domain was 40 ft/d, with high and low zones (10 and 100 ft/d) assigned during calibration to reproduce the observed groundwater flow directions and elevations observed in this unit.
- **Model Layers 5, 6 and 7 (Figure 5-11):** Model layers 5, 6, and 7 were simulated with two zones within each layer, one zone representing uniform background hydraulic conductivities for each material, and one zone was placed under the southern portion of the river to provide flexibility for calibration of vertical flow. The alignment of these zones is equivalent in each of the three layers. Background horizontal hydraulic conductivities were specified in model layers

5, 6, and 7 as 0.1, 40, and 70 ft/d, respectively. Site-specific hydraulic conductivities were not available for the LCU (model layer 5), so the value of 0.1 ft/d was selected to represent fine-grained materials. Sensitivity to the horizontal conductivity for model layer 5 is low due to its function as a confining unit with the predominantly vertical flow directions; the vertical hydraulic conductivity of the background zone in model layer 5 was adjusted to 0.008 ft/d during model calibration due to sensitivity of vertical gradients between the LAU and the UC to this value. The hydraulic conductivities for the bedrock layers 6 and 7 were initially identified from regional data cited in the HCR, and adjusted during calibration.

5.1.3 Flow Model Calibration

Calibration of a groundwater flow model refers to the iterative process of adjusting model parameters and boundary conditions to obtain a reasonable match between observed conditions and simulation results. The calibration of a groundwater model should rely on discrete measurements of groundwater elevation to avoid the potential for interpretive bias that may result from attempting to match a contoured potentiometric surface (Konikow, 1978; Anderson and Woessner, 1992).

5.1.3.1 Flow Model Targets and Model Calibration Statistics

The primary criterion for evaluating the calibration of a groundwater flow model is the difference between observed and simulated water levels at a set of calibration targets. Calibration targets are a set of field measurements, typically groundwater elevations. For the calibration of a steady-state (time-invariant) model, the goal in selecting calibration targets is to define a set of water-level measurements that represent the average elevation of the water table or potentiometric surface at locations throughout the site.

To match the conceptual model for development of the flow model, which is simulation of relatively low-elevation conditions in the UA which match periods of lower river stage of approximately 300 feet, available groundwater elevations at each monitoring well were evaluated to identify elevations which represented these baseline conditions, and combined to provide a comprehensive baseline/low-elevation dataset for the model domain. Where feasible, groundwater elevation records were compared to river stage to identify appropriate measurements (*i.e.,* groundwater elevations were selected during periods when river stage was at baseflow). However, in other wells (such as those with an older dataset), generally the minimum values were selected. Insufficient temporal data were available across the model domain to provide a synoptic set of water-level targets. Most of the groundwater monitoring data used for target selection were collected between 2015 and 2022.

Groundwater measurements and elevations have been collected during previous hydrogeologic investigations and characterization to meet requirements of regulatory programs. Water elevations used for calibration were compiled from the HCR (Ramboll, 2021) and supplemented with additional data collected during installation and monitoring of wells installed in September 2021 to delineate the extent of potential impacts (**Appendix B**).

A total of 36 flow model targets were selected from available groundwater level data within the model domain, which includes the Joppa Landfill (3 targets) and the EAP (33 targets). Targets were present in model layers 1 through 4 and 6, with the majority (24) in the UA (model layer 4). Water levels used for targets include the new wells installed along the eastern property boundary in late 2021. Target water levels from these wells were selected from initial well development water levels collected in late 2021 because the synoptic measurements at these locations were collected in early 2022 during a period of high river stage, thus elevated above the levels required for calibration to baseflow (*i.e.,* minimum) conditions.

A number of qualitative, or semi-quantitative, model outputs and results were evaluated and used to adjust calibration as needed to ensure an adequate match to the CSM.

- A calibration target was not defined to represent the level of the open water area within the EAP, however simulation of an elevation close to the observed 368 feet NAVD88 was evaluated during calibration. Use of boundary cells to specify this elevation was considered and discarded in favor of calibration of vertical conductivity and recharge for the ash ponds. The simulated steady-state elevation for this area is 366.7 feet NAVD88.
- The flow balance for the steady-state model was assessed during calibration to ensure that inflow/outflow rates for the model and various boundaries (river and GHBs versus recharge) were reasonable. The flow balance error for the steady-state model was 0.1 percent.
- Vertical gradients upgradient from the site (recharge area) and near the river were assessed during calibration to confirm that vertical flow was reasonably consistent with the CSM and observed vertical gradients at nested wells.
- Flow directions in the UA were carefully evaluated during calibration. Flow directions in the UA from the EAP towards the property boundary to the east show an easterly component of groundwater flow, which is not completely consistent with the expected flow directions directly towards the Ohio River which should be producedby a uniform flow field (hydraulic conductivity/thickness) and linear discharge boundary. Representation of observed flow directions in this area is important for accurate simulation of groundwater flow paths and boron transport from the EAP. The mechanism for the easterly flow component in this area of the UA is the subject of ongoing investigation; flow directions and gradient for the UA were obtained primarily through assignment of hydraulic conductivity zones within model layer 4 during calibration.

5.1.3.2 Model Calibration Results and Statistics

Calibration of the groundwater flow model required numerous individual simulations in an iterative process. During calibration, hydraulic conductivity values, river and GHB boundary components, and recharge were adjusted by trial-and-error and parameter estimation techniques until a reasonable solution was achieved. Calibration targets were used to evaluate the model calibration by analyzing the simulated hydraulic head distributions at the site and the residual statistics.

A model residual is defined as the calculated difference between the observed and simulated hydraulic head at a specific location (observed – simulated). A positive residual indicates that the model is under-predicting observed water levels. Accordingly, a negative residual indicates over-prediction of observed conditions. Residual statistics are used to quantify and evaluate the relative fit of a model simulation to measured water level targets. The mean of model residuals is a representation of overall model bias; a value near zero is desired. The mean residual for this calibration is 0.30. The residual standard deviation indicates the magnitude and spread of the residuals. A residual standard deviation of less than 10 percent of the total range of water level targets is desireable. The residual standard deviation for this calibration is 2.1, which is less than 10 percent of the observation range (67.5).

The residual statistics and simulated hydraulic head distributions indicate a high degree of model calibration and a satisfactory model match to observed groundwater flow conditions. Calibration targets with simulated groundwater elevations, model residuals, and calibration statistics are presented in **Table 5-2**. Simulated groundwater elevations and target residuals are presented on **Figure 5-12 through 5-15**, for model layers 1 through 4.

Another goal of flow model calibration is that residuals are evenly distributed such that there is no bias affecting simulated groundwater elevations across the range of observed values. The observed heads are plotted versus the simulated heads in **Figure 5-16**. The near-linear relationship between observed and simulated values indicates that the model adequately represents the calibration dataset.

5.2 Historical Transport Model

A transient flow model was developed to simulate groundwater flow conditions throughout operation of the EAP to the present time. The current conditions flow model documented in **Section 5.1** was modified to simulate transient, historical flow conditions, and a solute transport model was developed to simulate boron concentrations in groundwater throughout EAP operation. The objective of the historical transport model was to enable comparison of simulated concentrations to observed concentrations (transport calibration) and provide a stable distribution of current boron concentrations as a baseline for predictive modeling.

5.2.1 Transient Model Setup and Changes from the Steady-State Flow Model

A transient flow model was developed to represent conditions of groundwater flow throughout the history of EAP operation and provide the groundwater flow basis for simulation of boron concentrations over time and to the present day. A total of three stress periods (SP) were simulated, to represent 49 years of ash pond operation, as summarized in **Table D** below.

Table D. Time Discretization and Model Timeline (Historic Transport Calibration)

	Years	Description
SP1	1973-1985 (12)	Initial operation of EAP; northern portion only
SP2	1985-2016 (31)	Operation of northern and southern portions
SP3	2016-2022 (6)	Installation of the DMM barrier

Modifications to the steady-state flow model to represent historical conditions of ash pond operation were minimal. One change was to eliminate the DMM barrier from SP1 and SP2 to simulate placement during SP3. The hydraulic conductivities for this thin (1 cell thick) barrier were changed to match the surrounding hydraulic conductivity values in model layers 1 and 2 in SP1 and SP2.

Modifications to recharge zones from the steady-state flow model to reflect changes in ash pond operation are discussed below in **Section 5.2.2.1**.

5.2.1.1 Storage Parameters and Porosity

Simulation of transient flow conditions requires assignment of storage parameters to active model cells, specifically values of storativity, specific yield, and porosity. Limited information was available to define these parameters using site specific values, therefore values were selected based on ranges from literature and assessed during transport model calibration. Uniform storage parameters were specified for each model layer as designated in **Table E** below.

Table E. Transient Model Storage Parameters

Model Layer	Storativity	Specific Yield	Porosity	HSU
1.0	0.003	0.1	0.2	CCR
2.0	0.003	0.1	0.3	UCU
3.0	0.003	0.1	0.3	UCU
4.0	0.003	0.2	0.25	UA
5.0	0.003	0.1	0.3	LCU
6.0	0.001	0.05	0.05	Bedrock
7.0	0.001	0.05	0.1	Bedrock

Note: the storage parameters in the table above do not have units (dimensionless).

5.2.2 Transport Model Construction

The development process for an MT3DMS transport model consists of construction of a finite-difference grid for the model area, specification of model structure, assignment of boundary conditions, specification of hydraulic parameter values and zones, specification of chemical transport parameter values and zones, and selection of appropriate chemical concentrations for calibration of the model. These features represent elements of the conceptual site model, which provides the basis for the construction and calibration of the numerical model to observed groundwater concentration data.

5.2.2.1 Sources of Boron

Migration of boron from the EAP into groundwater was simulated by assigning concentrations of boron to the recharge input. SP1 incorporated boron recharge in the northern portion of the EAP active at that time only, at a concentration of 12 mg/L; SP2 and SP3 incorporated boron recharge consistent with the full area of the EAP (**Table F** below). No initial concentrations were incorporated into the historical transport model prior to construction of the EAP. **Figures 5-17 and 5-18** present the simulated recharge distributions for SP1 and SP2/SP3.

Recharge input of 12 mg/L was selected based upon sample results from monitoring wells completed within the ash (porewater boron concentrations, presented in the HCR). A concentration of 7 mg/L was assigned during calibration to represent dilution of influent within the open water ash pond. Concentrations of 10 and 12 mg/L were assigned for the ash external to the EAP.

Table F. Boron Recharge Concentrations, Historic Transport Calibration, SP2 and SP3

Zone	Recharge	Boron Concentration (mg/L)	Zone Description
1	0.0015	0	Background
2	0.0027	12	Ash
3	0.016	7	open water ash pond
5	0.0015	10	EAP external ash
6	0.007	12	EAP external ash, high recharge (limited ground cover)

5.2.2.2 Transport Parameters

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

Dispersivity was applied to the groundwater model domain with values identified during calibration. A background dispersivity of 1/0.1 feet (longitudinal/transverse) was applied with increased dispersivity of 30/10 feet (longitudinal/transverse) within the observed boron plume location in model layers 2, 3, and 4. Sensitivity of the background dispersivity was high – increases in this value produced overestimation of concentrations of boron to the west and south of the EAP. The increased dispersivity used in the location of the observed plume showed lower sensitivity. **Figure 5-19** presents the dispersivity zonation specified in model layers 2 through 4.

It was assumed that boron would not significantly sorb or chemically react with aquifer solids (Kd was set to 0 mL/g) which is a conservative estimate for estimating contaminant transport times. Boron and sulfate transport is likely to be affected by both chemical and physical attenuation mechanisms (*i.e.,* adsorption and/or precipitation reactions as well as dilution and dispersion). Batch adsorption testing was conducted to generate site specific partition coefficient results for boron (Geosyntec, 2022b; **Appendix D**) for location G07. Results of the testing are summarized below:

- **Boron:** All boron partition coefficients for G07 were calculated using four of the five datapoints provided by batch attenuation testing. The results for the 1:27.3 soil:solution ratio were excluded because they consistently reduced the goodness-of-fit of each isotherm, and resulted in unrealistic values for both the partition coefficients (*i.e.,* negative values) and isotherm fitting parameters (*i.e.,* 1/n). Removal of the 1:27.3 soil:solution ratio also resulted in a more conservative linear partition coefficient. The linear boron partition coefficient of 2.4 L/Kg, calculated using the four-point isotherm, was chosen for G07 based on its goodness-of-fit (R^2 >0.99) and comparability to other values reported in the literature which range from 0.19 to 1.3 L/kg depending on pH conditions and the amount of sorbent present (Electric Power Research Institute [EPRI], 2005; Strenge and Peterson, 1989). Despite their high goodness-of-fit, both the linearized Langmuir and Freundlich isotherms yielded partition coefficients orders of magnitude higher than anticipated relative to values reported in literature.

The results from site specific samples indicate the potential for retardation of boron using a linear isotherm. The potential exceedances identified in groundwater (boron and sulfate) are affected by natural attenuation processes in multiple ways and to varying degrees. Further assessment of these processes and how they may be applied as a potential groundwater remedy will be completed as part of future remedy selection evaluations, as necessary. For the purposes of this GMR, and as mentioned at the beginning of this section, no retardation was applied to boron transport in the model (*i.e.,* Kd was set to 0 mL/g). Sensitivity tests were not run for retardation.

5.2.3 Transport Model Calibration and Targets

Calibration of a transport model is a similar process to calibration of a flow model, in that it consists of the iterative process of adjusting model parameters and boundary conditions to obtain a reasonable match between observed conditions and simulation results.

For the historic transport model, observed boron concentrations at site monitoring wells were used as targets to evaluate adequacy of model simulated boron concentrations. Boron concentrations at site monitoring wells were available from 2016 to 2021, with between 1 and 11 sample results available for each monitoring well. Due to variable numbers of sample results, differences in date of sample results, and interest in capturing average conditions, the average boron concentrations from recent (2016 to 2022) sample results were used to provide targets representing current conditions (2022) for the transport model. Wells with a larger number of observed concentrations were assessed to identify the presence of concentration trends (up or down) which may affect use of average concentrations over a 5-year period to represent current conditions, however no clear trends were identified which would make use of averages inappropriate for model calibration. Boron concentrations and sample results used for calculation of per-well averages are documented in the HCR and **Appendix B**.

A total of 30 boron concentration targets were selected for the EAP, four in the UCU (1 in model layer 2, 3 in model layer 3), one in the bedrock (layer 6) and the remainder within the UA. Five sets of monitoring wells installed in 2021 (G12S/D, G13S/D, G14S/D, G15S/D, G16S/D) are nested pairs within the UA, with one well near the top of the UA and the other completed at a deeper interval. The ”duplicate” target locations were preserved for model calibration to facilitate appropriate averaging of concentrations in the UA, and presented individually for clarity in predicted concentration results; however, simulated boron concentrations for targets in the same model cell are equivalent.

5.2.3.1 Transport Model Calibration Results and Statistics

Calibration of the historical transport model required numerous individual simulations in an iterative process to produce a reasonable solution. Much of the transport calibration process and iterations were performed in tandem with flow model calibration given the sensitivity of simulated boron concentration distributions to flow directions in the UA.

Table 5-3 presents transport model targets and residuals (observed-simulated) for the final transport model calibration. Simulated boron concentrations and transport model target residuals for 2022 (year 49 of the model simulation) are presented on **Figures 5-20 through 5-22**, for model layers 2, 3, and 4. The overall distribution (extent) of simulated boron concentrations in the UA and magnitude are appropriate for observed concentrations, and target locations with concentrations of boron which exceed the GWPS of 2 mg/L are simulated with concentrations above 2 mg/L. Concentrations at G12S/D and G13S/D, along the eastern property boundary, are underpredicted by 1-4 mg/L; underprediction in this portion of the plume is due to slight underrepresentation of easterly flow directions which are observed in this area. Investigations to further characterize the flow directions in this area are ongoing. Simulation of the lower observed concentrations to the west and south of the EAP is consistent with observed concentrations, except for concentrations at G09 which are overpredicted by 2.4 mg/L.

5.3 River Flood Evaluation

Identification of the potential for transient groundwater flow direction reversals near the Ohio River during periods of river flooding highlighted the need for further evaluation of river flooding. As discussed in **Section 2.3.3**, variable stage in the Ohio River, specifically short-term flood events, impacts groundwater elevations measured in the UA. This effect was initially identified in review of groundwater elevation data collected in early 2022, during a flood in the Ohio River with stage of up to 325 feet NAVD88.

As shown in **Figure 2-3**, the early 2022 flood event occured between approximately January 1, 2022, until the end of the record obtained for this report on March 30, 2022. The flood event began with baseline conditions, characterized by an average stage of approximately 300 feet NAVD88 in late December 2021. An initial flood period was characterized by an increase in stage to 321 feet on January, then a return to below baseline conditions of 293 feet NAVD88 on February 1 (stage reduced below baseline likely due to management of pool conditions at the Olmsted Dam to provide capacity for expected future flooding). The greatest flood elevations occured in February and March, reaching an elevation of 325 feet NAVD88 by February 28. Groundwater elevations are grouped by period of the flood event in which they were obtained. The ”Baseline” elevations are aggregated as needed from data extending back in time to June 2021, during which river stage was at baseflow. Elevations shown for 2022 were collected within one day of the assigned date.

Table 5-4 presents a groundwater elevation measurements collected in early 2022 for site monitoring wells. The observed change in groundwater elevations between baseline and the flood elevation (date of maximum flood stage for this event, on 3/1/2022) was calculated for each monitoring well. As shown, elevations at each monitoring well within the UA with sufficient data for this evaluation increased from baseline conditions during the flood event, varying between 0.5 feet at G10 and 18.7 feet at G15D. The average increase in head was 10.9 feet, and the magnitude of head change decreased with distance from the river.

The calibrated groundwater flow model was used as a base to construct a transient groundwater flow model to simulate the observed 2022 flood event. The objectives of this simulation were to evaluate the adequacy of the groundwater model in reproducing observed conditions (qualitative calibration) and evaluate the effects of river flooding at the site on groundwater flow.

5.3.1 Flood Model Construction

A few modifications were made to the current conditions flow model to simulate the 2022 flood event. The model was converted to transient conditions. A total of 60 SPs were specified – 59 of these SPs were 1 day long, to represent daily river stage during the course of the flood event through the end of observed data, from January 3 (stage of 300 feet) to March 2 (stage of 325 feet). The final SP was 300 days in length to simulate conditions following the end of the flood. River stage was specified at the river boundary cells in Layer 4 for each SP according to the stage observed on each day (**Figure 2-3**).

The calibrated steady-state groundwater elevations were used as the initial conditions for the start of the transient model simulation.

5.3.2 Flood Model Results

Figure 5-23 presents simulated groundwater elevations for model layer 4 for the end of the flood period at 59 days elapsed time, which corresponds to the highest river stage (325 feet NAVD88). As shown, groundwater elevations near the river are high, and then decrease moving inland for approximately 2000 feet, where elevations reach a ”saddle” and begin increasing with distance from the river similar to normal conditions. The simulated gradient reversal near the river indicates inflow of water from the river into model layer 4.

Table 5-4 presents the observed and simulated groundwater elevations for each of the flood event monitoring wells, and **Figure 5-24** presents a time-series plot of simulated elevations at a select subset of monitoring wells, and a comparison of observed versus simulated change in groundwater elevation from baseline to flood elevations on March 2, 2022. As shown, the flood model simulation does mimic the changes in groundwater elevation observed in the UA in early 2022. **Figure 5-24** illustrates that groundwater elevations respond to changes in the river stage throughout the flood period, with fluctuations between flood peaks. It is also apparent that the flood model underpredicts the total amount of groundwater elevation increase observed at the monitoring wells onsite –the simulated elevation changes are underpredicted by 25 percent compared to the observed changes, on average. A potential explanation for the underprediction may be the limitations associated with the assignment of hydraulic properties in model layers 2 and 3; specifically, model layers 2 and 3 were simulated with material properties consistent with the UCU through the entire domain, near the river. Under normal flow conditions, application of these properties to materials which are known to be higher in hydraulic conductivity (open space / above ground surface for layer 2, and alluvium for the strip of material closest to the river in layer 3) is not important for accurate representation of flow directions and boron transport near the EAP, since this portion of model layer 2 is typically dry, and both model layers 2 and 3 represent confining units with typically low hydraulic conductivity. Revision of hydraulic properties in this area may be considered for future phases of modeling, as necessary, when additional site investigation activites are completed; however, for the purposes of reviewing the predicted effects of a river flood event, and qualitative assessment of ability to represent observed changes in elevation, this model simulation is adequate for reproduction of flood events.

5.4 Flow and Transport Model Assumptions and Limitations

Simplifying assumptions were made while developing these models:

- Simulation of the groundwater flow system as steady-state is representative of current conditions.
- The approximate base of ash surface in the EAP was developed from information presented in the HCR (Ramboll, 2021a) and in **Appendix B**.
- Observed concentrations of boron in groundwater do not indicate the presence of a trend in concentrations over time.
- Source concentrations are assumed to remain constant over time.
- Boron is not adsorbed and does not decay, and mixing and dispersion are the only attenuation mechanisms.

The model is limited by the data used for calibration, which adequately define the local groundwater flow system and the source and extent of the plume. Since data used for calibration are near the EAP, 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 between 2015 and 2021.

6. SIMULATION OF CLOSURE SCENARIO

6.1 Overview and Prediction Model Development

Prediction simulations were performed to evaluate the effects of closure (source control) measures (CCR consolidation and CIP, and CBR scenarios) for the EAP on groundwater quality.

Modifications were made to the calibrated historical flow and transport model as needed to simulate closure action moving forward from 2022, and are described in detail below. Other parameters and conditions simulated in the calibrated historical flow and transport models were retained for the predictive simulations. Simulations for CIP and CBR consisted of extending the historic transport calibration model to simulate conditions at the beginning of remedy construction (February 1, 2025), simulation of a 2-year construction period consisting of dewatering to remove free liquids from CCR material and construction of the remedy, and a predictive simulation of boron concentrations and groundwater elevations for 50 years following closure.

Model specifications to simulate site closure were selected to be consistent with CIP and CBR remedial designs provided in the *Draft CCR Surface Impoundment Final Closure Plan* (Geosyntec, 2022a), consistent with methodologies used for simulation of site closure at similar units in 2021 and 2022. Model simulations assume all closure or remedial activities specified below were performed instantaneously at the beginning of each model SP.

6.2 HELP Model Setup

HELP (Version 4.0; Tolaymat and Krause, 2020) was used to estimate percolation through the EAP areas for two ash fill closure scenarios and three area types, including CBR removal areas, CIP removal areas, and CIP consolidation and cover system areas. 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 Peducah Barkley Regional Airport in Kentucky (the closest weather station included in the HELP database). Precipitation, temperature, and solar radiation was simulated based on the latitude of the EAP. Thickness and type of the geosynthetic drainage layer, geomembrane liner, soil, and soil runoff input parameters were developed for the ash fill removal and consolidation scenarios using data provided the *Draft CCR Surface Impoundment Final Closure Plan* (Geosyntec, 2022a).

HELP model simulations were performed for the CIP and CBR remedial actions described in the following sections.

6.3 Simulation of Closure Scenarios

6.3.1 Closure Scenario 1 (CIP)

The design for Closure Scenario 1 is presented in the *Draft CCR Surface Impoundment Final Closure Plan* (Geosyntec, 2022a). This EAP closure consists of a consolidation and cap approach, where ash is removed from a portion of the EAP (CBR area) and moved to the portion of the EAP where ash will remain with a protective cover (CIP area). Phases of construction of this remedy consist of a preliminary pre-construction phase for permitting and planning, a dewatering phase in which free liquids will be removed from the ash material, a construction and consolidation phase, and then post-closure care.

The CCR will be consolidated from an area of approximately 128 acres to approximately 74 acres. Approximately 1.5 million cubic yards (CY) of CCR material will be relocated from an approximately 54-acre CBR area in the southeastern portion of the EAP, to the 74-acre CIP area in the north and western portion of the EAP. Approximately 3,000 feet (120,000 CY) of perimeter dikes will be relocated from around the removal area, as it will not be needed after closure, and non-impacted material will be utilized for protective cover soil. Additionally, 230,000 CY of CCR material will be relocated from a 32-acrea area outside of the EAP to the 74-acre CIP area. Approximately 1 foot of native material underlying the CCR material will also be excavated during relocation. Backfill of the CBR area following removal of CCR will not be performed. The footprint of the CIP scenario including final grades are included in the *Draft CCR Surface Impoundment Final Closure Plan* (Geosyntec, 2022a).

After consolidation of the CCR material to the CIP area, a 2,700 feet long, 55-foot high compacted clay soil containment berm will be constructed between the CIP and CBR areas. The CIP area will have a final cover system consisting of the following materials from bottom to top:

- A 40-mil linear low-density polyethylene (LLDPE) geomembrane
- A 10 ounce nonwoven geotextile liner
- A 1.5-foot thick protective layer, utilized from the destruction of the perimeter dikes
- A 0.5-foot thick vegetative topsoil layer

A stormwater detention pond will be constructed in the southeast corner of the EAP with a maintained outfall elevation of 320 feet NAVD88.

6.3.1.1 Model Setup

Closure Scenario 1 (CIP) was simulated using the calibrated historical flow and transport model for the EAP as a base, to be consistent with the specifications and timelines expressed in the *Draft CCR Surface Impoundment Final Closure Plan* (Geosyntec, 2022a). The model was developed to simulate three explicit periods of closure, as described below.

<u>Period 1 – Current Conditions (Extended)</u>

The first period of closure consists of closure plan submittal, approval, and design and bid activities. This period was simulated by using the transport calibration model with no modifications to current model specifications, extended in time to simulate groundwater elevations and boron concentrations from August 1, 2022 (end of historical calibration model) to the anticipated beginning of remedy construction on February 1, 2025 (30 months).

<u>Period 2 – Dewatering and Construction</u>

The second period of closure consists of construction of the CIP remedy and dewatering of free liquids from the CCR in the EAP. Dewatering and construction activities were simulated to occur during a 2 year period; while this is truncated from the expected timeline for CIP, this shorter timeframe is consistent with remedial scenarios simulated for similar sites as part of site closure predictive modeling.

The flow and transport model was modified to represent conditions during dewatering and construction as described below:

- A 2-year period was simulated for dewatering and closure construction, using simulated conditions for February 1, 2025 as initial conditions.
- Dewatering was simulated by adding drain boundary cells within the model cells representing CCR materials within the footprint of the EAP (model layer 1). The drain elevations were set 0.5 feet above the base of each model layer 1 cell where the base of ash elevation was higher than simulated groundwater elevations in model layer 2 (UCU) from the steady-state current conditions flow model. Drain elevations near the southeastern corner of the EAP were set to 315 feet NAVD88, which approximates the expected UCU groundwater elevation level in this area. Drain cells were not simulated in the CBR areas located outside of the EAP unit boundary. The simulated vertical hydraulic conductivity of the CCR materials was increased from the calibrated value of 0.0013 ft/d to 0.03 ft/d to increase draining of the CCR in model layer 1, with the understanding that dewatering of ash materials will incorporate dewatering techniques such as trenching or sumps as necessary to achieve construction timelines.
- Recharge concentrations of boron were eliminated from the EAP to reflect dewatering conditions. Infiltration within the footprint of the EAP was set to be equivalent with background recharge at 6.6 in/yr.

Period 3 – Post-Closure

A fifty-year period was simulated to represent post-closure conditions, with the following changes from the previous SP:

- Drain cells used to dewater free liquids from the ash were removed. Hydraulic conductivities in CBR areas in model layer 1 were set to 1 ft/d (isotropic) with the assumption that most of the CBR area would be open (*i.e.,* above grade). Existing hydraulic conductivities used to represent the CCR material in model layer 1 were retained for the CIP area, with the increased vertical hydraulic conductivity noted above.
- River cells were used to simulate the stormwater detention pond. The stormwater detention pond was simulated with a base of 318 feet NAVD88, stage of 320 feet NAVD88, and no liner. A conductance of value of 40 ft^2/d was used for these cells.
- Boron concentrations remaining after dewatering and construction activities (*i.e.,* simulated at the end of the period 2) were removed from the CBR areas of model layer 1, representing the removal of ash from model layer 1. Boron concentrations present in the groundwater system (model layers 2 through 7) at the end of the dewatering/construction period provided starting concentrations for the post-closure period simulation.
- Recharge concentrations of boron were retained (12 mg/L) within the CIP area to simulate continued leaching from the ash. Recharge concentrations in the CBR areas were eliminated to reflect removal of ash.
- Infiltration rates within the CIP and CBR areas (which included the removal areas outside of the EAP unit footprint) were set to values calculated using HELP model simulations. The HELP model was used to develop two percolation rates for the Closure Scenario 1 (CIP). HELP model results were 1.18 inches of percolation per year for the EAP CIP removal areas, and 0.0044 inches of percolation per year for the EAP consolidation and cover system areas. The differences in HELP model runs for each area included the following parameters: area, layer

construction, soil thickness, 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 C**.

Figure 6-1 presents model layer 1 recharge and boundary conditions for the CIP predictive remedy, which shows the CBR and CIP areas as well as the simulated stormwater detention pond.

6.3.1.2 Model Results

Simulated groundwater elevations and boron concentrations at the end of the current conditions (Period 1) are consistent with conditions presented for 2022 (**Section 5.2**). At the end of the dewatering and construction phase (Period 2), groundwater elevations within the EAP footprint are decreased to the simulated drain elevations, 0.5 feet above the base of model layer 1, or below the base of model layer 1 (dry cells).

Boron concentrations begin to decrease in Period 2, with the removal of boron recharge to the model, and accelerates in Period 3 following completion of closure activities. **Figure 6-2** presents concentrations of boron following closure at 12 of the 30 EAP monitoring wells which have average concentrations exceeding the GWPS of 2 mg/L. As shown, predicted concentrations of boron fall below the GWPS at these locations within 14.2 years of completion of the CIP remedy. Concentrations of most of the monitoring wells are predicted to fall below 2 mg/L within 5 to 10 years, with the exception of concentrations at G09, which was overpredicted in the calibration model (5.5 mg/L versus the target value of 3.1 mg/L). **Table 6-2** presents a summary of observed and simulated boron concentrations at EAP monitoring wells, with predicted time to meet GWPS at each location following closure.

By year 24, no concentrations exceeding 2 mg/L are simulated within the UA (model layer 4). Residual mass remains in the UCU (model layers 2 and 3) after concentrations have decreased in the UA due to the lower permeability (slower transport) of these materials and the decrease in infiltration at the EAP after unit closure. **Figures 6-3 and 6-4** depict concentrations of boron in model layers 2 and 3, respectively, after 24 years. The residual concentrations simulated in these layers remain in close proximity to the EAP as the plume recedes over time. Despite these residual concentrations within the UCU, boron concentrations in the UA remain below 2 mg/L, which indicates continued migration of boron into the UA from the UCU does not adversely impact groundwater quality in the UA. The maximum predicted boron concentration at a site monitoring well 50-years post-closure is 0.03 mg/L.

6.3.2 Closure Scenario 2 (CBR)

This EAP closure scenario consists of approximately 128-acres of CCR material being removed from within the EAP footprint and transported off-site. Additionally, 230,000 CY of CCR material will be relocated from the 32-acrea area south of the EAP and transported to either an on-site or off-site storage facility. Approximately 1 foot of native material underlying the CCR material will also be excavated during relocation of both areas. Backfill following the CCR material removal is not anticipated.

Phases of construction of this remedy consist of a preliminary pre-construction phase for permitting and planning, a dewatering phase in which free liquids will be removed from the ash material, a construction and consolidation phase, and then post-closure care.

Two stormwater detention ponds of maintained elevation will be constructed in the CBR area. The pond in the southeast corner of the EAP is consistent with the pond specified for the CIP remedy, with a maintained outfall elevation of 320 feet NAVD88. A second pond will be located in the northern portion of the CBR area, with a maintained elevation of 332 feet NAVD88.

6.3.2.1 Model Setup

Closure Scenario 1 (CBR) was simulated using the calibrated historical flow and transport model for the EAP as a base, to be consistent with the specifications and timelines expressed in the *Draft CCR Surface Impoundment Final Closure Plan* (Geosyntec, 2022a). The model was developed to simulate three explicit periods of closure, as described below. Periods 1 and 2 are identical to those simulated for the CIP remedy, described above.

Period 1 – Current Conditions (Extended)

The first period of closure consists of closure plan submittal, approval, and design and bid activities. This period was simulated by using the transport calibration model with no modifications to current model specifications, extended in time to simulate groundwater elevations and boron concentrations from August 1, 2022 (end of historical calibration model) to the anticipated beginning of remedy construction on February 1, 2025 (30 months).

Period 2 – Dewatering and Construction

The second period of closure consists of construction of the remedy and dewatering of free liquids from the CCR in the EAP. Dewatering and construction activities were simulated to occur during a 2 year period. The flow and transport model was modified to represent conditions during dewatering and construction as described above, for CIP.

Period 3 – Post-Closure

A fifty-year period was simulated to represent post-closure conditions, with the following changes from the previous SP:

- Drain cells used to dewater free liquids from the ash were removed. Hydraulic conductivities in model layer 1 were set to 1 ft/d (isotropic) with the assumption that the CBR area would be above grade, or open water in the stormwater detention ponds.
- Two stormwater detention ponds were simulated using river cells. The stormwater detention pond in the southeastern portion of the EAP was simulated in the same manner as for the CIP, with a stage of 320 feet and base of 318 feet. The northern stormwater pond was simulated with a stage of 332 feet NAVD88 and a base of 330 feet (conductance of 40 ft^2/d).
- Boron concentrations remaining after dewatering and construction activities (*i.e.,* simluated at the end of the period 2) were removed from the CBR areas of model layer 1, representing the removal of ash from model layer 1. Boron concentrations present in the groundwater system (model layers 2 through 7) at the end of the dewatering/construction period provided starting concentrations for the post-closure period simulation.
- Infiltration rates within the CBR areas (which include the removal areas outside of the EAP unit footprint) were set to values calculated using HELP model simulations. The HELP model was used to develop a percolation rate for the Closure Scenario 2 (CBR). HELP model results

indicated 0.962 inches of percolation per year for the EAP CBR area. HELP input data and results are provided in **Appendix C**.

Figure 6-5 presents model layer 1 recharge and boundary conditions for the CBR predictive remedy, which shows the CBR areas and the 2 simulated stormwater detention ponds.

6.3.2.2 Model Results

Simulated groundwater elevations and boron concentrations at the end of the current conditions (Period 1) are consistent with conditions presented for 2022 (**Section 5.2**). At the end of the dewatering and construction phase (Period 2), groundwater elevations within the EAP footprint are decreased to the simulated drain elevations, 0.5 feet above the base of model layer 1, or below the base of model layer 1 (dry cells).

Boron concentrations begin to decrease in Period 2, with the removal of boron recharge to the model, and accelerates in Period 3 following completion of closure activities. **Figure 6-2** presents concentrations of boron following closure at the 12 of 30 EAP monitoring wells which have average concentrations exceeding the GWPS of 2 mg/L. with current average concentrations over time following closure. As shown, predicted concentrations of boron fall below the GWPS at these locations within 14.2 years of completion of the CBR remedy. Concentrations of most of the monitoring wells are predicted to fall below 2 mg/L with 5 to 10 years, with the exception of concentrations at G09, which was overpredicted in the calibration model (5.5 mg/L versus the target value of 3.1 mg/L in 2022).

By year 24, no concentrations exceeding 2 mg/L are simulated within the UA (model layer 4). As shown for the CIP simulation, residual mass remains in the UCU (model layers 2 and 3) after this time, but migration of boron into the UA does not adversely impact groundwater quality (*i.e.,* groundwater concentrations remain below the GWPS of 2 mg/L. **Figures 6-3 and 6-4** present boron concentrations in model layers 2 and 3 at 24 years, with CIP concentrations shown for comparison. These figures indicate minimal differences in the magnitude of residual mass after 24 years between the two remedies.

7. CONCLUSIONS

This GMR was prepared to evaluate how proposed CIP and CBR closure scenarios will achieve compliance with the applicable groundwater standards at the EAP. Data collected from sampling events between December 2015 and July 2021 were used to develop site-specific groundwater flow and transport models for the JPP EAP. The calibrated MODFLOW and MT3DMS models were then used to evaluate CIP and CBR closure scenarios using information provided in the *Draft CCR Surface Impoundment Final Closure Plan* (Geosyntec, 2022a):

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

Boron and sulfate were identified as potential exceedances of the GWPS in groundwater. Boron was selected for modeling the closure scenarios. A statistically significant correlation is present between concentrations of boron and sulfate identified as potential exceedances of the GWPS which indicate boron is an acceptable surrogate for sulfate in the groundwater model. Concentrations of these parameters are expected to change along with model predicted boron concentrations.

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

Results of predictive simulations for the CIP and CBR construction show near-equivalent timeframes for groundwater in the UA to reach GWPS. Simulated concentrations at UA groundwater wells with average boron concentrations that exceed GWPS from 2015 to 2022 decrease to GWPS within 14.2 years of closure for both CIP and CBR. Boron concentrations at all locations within the UA decrease to the GWPS of 2 milligrams per liter (mg/L) within 24 years of closure for both CIP and CBR. The decrease in infiltration rates at the EAP after cessation of sluicing, and following construction (capping and/or excavation) limits the flushing of residual boron concentration within fine-grained UCU materials beneath the EAP; however, the predicted slow migration of the residual boron within the UCU after closure does not result in impacts to the UA above the GWPS after 24 years.

8. REFERENCES

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TABLES

TABLE 5-1. CURRENT CONDITIONS FLOW MODEL HYDRAULIC CONDUCTIVITY ASSIGNMENTS

GROUNDWATER MODELING REPORT

JOPPA POWER PLANT

EAST ASH POND

JOPPA, ILLINOIS

Zone	Kx/Ky (ft/d) [1]	Kz (ft/d) [1]	Model Layer	Zone Description	Reference / Support
1	0.3	0.0013	1	Ash	within site-specific data range
2	0.2	0.045	2	UCU - silt and clay	within site-specific data range; vertical conductivity adjusted during calibration (high sensitivity)
3	0.2	0.05	3	UCU - silt and clay	within site-specific data range; vertical conductivity adjusted during calibration (high sensitivity)
4	40	4	4	McNairy formation - sand	regional information and literature values
5	0.1	0.002	5	LCU - silt/clay or saprolite	adjusted during calibration
6	40	0.5	6	Shallow bedrock	regional information and literature values
7	70	3.5	7	Limestone bedrock	regional information and literature values
8	0.0001	0.0001	1,2	DMM	insensitive; within literature range for in-situ stabilization
10	100	5	4	Interpreted gravel zone within McNairy formation	regional information and literature values
11	2	0.06	2	higher-permeability zone within UCU	regional information and literature values
12	200	0.01	1	Standing water in EAP (open water)	vertical conductivity adjusted during calibration
13	0.1	0.008	2,3	interpreted less permeable zone within UCU	regional information and literature values
14	10	1	4	interpreted less permeable zone within UA	regional information and literature values
15	50	5	5	vertical communication area under Ohio River	vertical conductivity adjusted during calibration
16	1	0.1	6,7	vertical communication area under Ohio River	vertical conductivity adjusted during calibration
18	20	2	2,3	McNairy formation upgradient surface outcrop	regional information and literature values
19	8	1	2,3	"drain" area above Ohio River in shallow layers	adjusted during calibration; does not represent subsurface material (inactive cells)

[O: KM 05/16/22; C: EGP 5/19/22]

Notes

[1] Isotropic horizontal conductivity was assumed (*i.e.*, Kx=Ky)
ft/d = feet/foot per day
DMM = deep mixing method
EAP = East Ash Pond
Kx = horizontal hydraulic conductivity
Ky = horizontal hydraulic conductivity
Kz = vertical hydraulic conductivity
LCU = lower confining unit
UA = uppermost aquifer
UCU = upper confining unit

TABLE 5-2. CURRENT CONDITIONS FLOW MODEL CALIBRATION TARGETS AND STATISTICS

GROUNDWATER MODELING REPORT

JOPPA POWER PLANT

EAST ASH POND

JOPPA, ILLINOIS

Well ID	Unit	X	Y	Layer	Observed GWE (feet NAVD88)	Simulated GWE (feet NAVD88)	Residual (observed-simulated, feet)
XPW01	Joppa East	833197	200767	1	368.5	372.0	-3.5
XPW02	Joppa East	832343	200371	1	371.2	371.2	0.0
XPW03	Joppa East	832213	199021	1	372.3	371.6	0.7
G151	Joppa East	832154	200439	2	321.4	317.6	3.8
G109	Joppa Landfill	826650	204021	2	321.8	321.8	0.0
G102	Joppa Landfill	826535	205073	2	328.9	323.9	5.0
G105	Joppa Landfill	826290	204659	2	323.5	322.9	0.6
G54S	Joppa East	831609	199074	3	312.7	316.4	-3.7
G153	Joppa East	833979	200068	3	314.7	315.8	-1.1
G101JE	Joppa East	831717	202049	3	318.9	320.5	-1.6
G06S	Joppa East	834117	199303	3	315.1	314.0	1.1
G04	Joppa East	834001	201154	4	319.0	317.5	1.5
G05	Joppa East	834089	200844	4	319.0	316.9	2.1
G54D	Joppa East	831610	199067	4	314.7	314.6	0.1
G01D	Joppa East	831716	202039	4	321.0	320.4	0.6
G11	Joppa East	831953	199843	4	319.7	316.7	3.0
G02D	Joppa East	832843	202137	4	320.6	319.9	0.7
G03	Joppa East	833699	202118	4	320.2	319.6	0.6
G51D	Joppa East	832152	200430	4	320.1	317.5	2.6
G07	Joppa East	834089	198591	4	315.2	312.3	2.9
G10	Joppa East	832089	198700	4	313.5	313.6	-0.1
G09	Joppa East	832589	198357	4	310.4	311.1	-0.7
G06	Joppa East	834115	199293	4	312.4	312.6	-0.2
G08	Joppa East	833493	198423	4	318.7	315.7	3.0
G53D	Joppa East	833980	200075	4	311.8	312.3	-0.5
G12S	Joppa East	834634	198795	4	308.6	307.6	1.0
G12D	Joppa East	834639	198793	4	304.8	307.8	-3.0

TABLE 5-2. CURRENT CONDITIONS FLOW MODEL CALIBRATION TARGETS AND STATISTICS
GROUNDWATER MODELING REPORT
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Well ID	Unit	X	Y	Layer	Observed GWE (feet NAVD88)	Simulated GWE (feet NAVD88)	Residual (observed-simulated, feet)
G13S	Joppa East	834598	198270	4	305.2	308.2	-3.0
G13D	Joppa East	834599	198275	4	311.8	312.3	-0.5
G14S	Joppa East	834653	197097	4	316.8	313.9	2.9
G14D	Joppa East	834653	197104	4	313.7	312.5	1.2
G15S	Joppa East	834108	197189	4	310.8	311.1	-0.3
G15D	Joppa East	834112	197189	4	304.9	308.2	-3.3
G16S	Joppa East	833582	197190	4	306.2	307.6	-1.4
G16D	Joppa East	833584	197196	4	306.8	307.8	-1.0
G09M	Joppa East	832585	198359	6	317.3	316.1	1.2

[O: KM 5/17/22; C: EGP 5/19/22; U: KM 5/24/22]

NOTES:
GWE = groundwater elevation

Calibration Statistics

Residual Mean	0.30
Absolute Residual Mean	1.63
Residual Std. Deviation	2.07
Sum of Squares	157.8
RMS Error	2.1
Min. Residual	-3.7
Max. Residual	5.0
Number of Observations	36.0
Range in Observations	67.5
10% of Range	6.75

TABLE 5-3. HISTORICAL TRANSPORT MODEL CALIBRATION TARGETS AND STATISTICS

GROUNDWATER MODELING REPORT

JOPPA POWER PLANT

EAST ASH POND

JOPPA, ILLINOIS

Well ID	X	Y	Screen Depth (feet bgs)	Model Layer	Boron Concentration (mg/L)		Residual (Observed - Simulated)
					Observed	Simulated	
G54S	831609	199074	(35-45)	3	0.06	0.00	0.1
G54D	831610	199067	(70-80)	4	0.48	0.00	0.5
G53D	833980	200075	(47-57)	4	0.36	3.08	-2.7
G51D	832152	200430	(50-59)	4	0.44	0.00	0.4
G16S	833582	197190	(50-60)	4	7.20	5.15	2.0
G16D	833584	197196	(98-108)	4	4.95	5.15	-0.2
G15S	834108	197189	(50-60)	4	0.98	4.86	-3.9
G15D	834112	197189	(83-93)	4	6.89	4.86	2.0
G153	833979	200068	(30-40)	3	0.02	1.19	-1.2
G151	832154	200439	(32-42)	2	0.12	0.00	1.1
G14S	834653	197097	(53-63)	4	0.03	3.42	-3.4
G14D	834653	197104	(120-130)	4	3.67	3.42	0.3
G13S	834598	198270	(50-60)	4	4.98	3.41	1.6
G13D	834599	198275	(80-90)	4	4.66	3.40	1.3
G12S	834634	198795	(60-70)	4	5.88	2.75	3.1
G12D	834639	198793	(80-90)	4	6.70	2.73	4.0
G11	831953	199843	(56-66)	4	0.33	0.00	0.3
G10	832089	198700	(60-70)	4	4.37	3.48	0.9
G09M	832585	198359	(145-155)	6	0.04	0.00	0.0
G09	832589	198357	(60-70)	4	3.10	5.52	-2.4
G08	833493	198423	(75-85)	4	4.39	5.80	-1.4
G07	834089	198591	(50-60)	4	4.65	5.05	-0.4
G06S	834117	199303	(30-40)	3	0.25	0.61	-0.4
G06	834115	199293	(75-85)	4	3.35	4.21	-0.9
G05	834089	200844	(50-60)	4	0.16	1.52	-1.4
G04	834001	201154	(50-60)	4	0.02	1.02	-1.0
G03	833699	202118	(55-65)	4	0.30	0.00	0.3
G02D	832843	202137	(62-72)	4	0.04	0.00	0.0
G01D	831716	202039	(54-64)	4	0.03	0.00	0.0
Well3	832373	196799	(40-50)	4	0.60	1.79	-1.2

[O: KM 05/16/22; C: EGP 05/20/22]

Notes

Target time is 49 years elapsed time from beginning of simulation, corresponding to early 2022.
Boron concentrations were averaged from available data for 2015-2022
bgs = below ground surface
mg/L = milligrams per Liter
X = latitude
Y = longitude

TABLE 5-4. OBSERVED AND SIMULATED FLOOD EVENT GROUNDWATER ELEVATIONS

GROUNDWATER MODELING REPORT

JOPPA POWER PLANT

EAST ASH POND

JOPPA, ILLINOIS

Well ID	Observed GWE (feet NAVD88)			Simulated GWE (feet NAVD88)		
	Baseline	Flood Elevation	Change in Elevation (feet)	Simulated Baseline Elevation	Simulated Flood Elevation	Simulated Change (feet)
	12/1/2021	3/2/2022		0 days	59 days	
G03	320.2	323.4	3.2	319.5	320.1	0.6
G05	318.6	322.9	4.2	316.9	318.0	1.1
G06	315.4	322.3	6.9	314.0	316.2	2.2
G07	313.6	321.7	8.0	312.3	315.6	3.2
G08	312.5	322.5	10.0	312.5	315.9	3.4
G09	312.3	323.6	11.2	312.6	316.8	4.2
G10	313.5	314.1	0.5	313.7	317.4	3.7
G11	319.2	325.0	5.8	316.8	318.1	1.3
G12D	311.8	321.7	9.9	312.3	315.4	3.0
G12S	311.8	321.7	9.9	312.4	315.4	3.0
G13D	310.8	321.4	10.7	311.1	315.1	4.0
G13S	310.4	321.5	11.1	311.1	315.1	4.0
G14D	306.8	319.9	13.1	307.8	315.8	8.0
G14S	304.8	320.2	15.4	307.8	315.8	8.0
G15D	304.9	323.6	18.7	308.2	316.1	7.9
G15S	305.2	323.7	18.6	308.2	316.1	7.9
G16D	306.2	326.9	20.6	307.6	316.9	9.3
G16S	308.6	327.1	18.5	307.5	316.9	9.4

[O: KM 05/23/22; C: EGP 05/23/22]

Notes

Elevations recorded as "baseline" were collected between June 30, 2021 and January 1, 2022

Elevations are in feet, referenced to North American vertical Datum of 1988 (NAVD88)

GWE = groundwater elevatoin

Change in GWE was calculated by subtracting the Flood Elevation from the Baseline Elevation at each location

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

Closure Scenario - Area Description	EAP CIP - Consolidation Area	EAP CIP - Removal Area	EAP CBR - Removal Area	Notes
Input Parameter				
Climate-General				
City	Joppa, Illinois	Joppa, Illinois	Joppa, Illinois	Nearby city to the Site within HELP database
Latitude	37.21	37.21	37.21	Site latitude
Evaporative Zone Depth	18	18	18	Estimated based on geographic location (Illinois) and uppermost soil type (Tolaymat, T. and Krause, M, 2020)
Maximum Leaf Area Index	4.5	4.5	4.5	Maximum for geographic location (Illinois) (Tolaymat, T. and Krause, M, 2020)
Growing Season Period, Average Wind Speed, and Quarterly Relative Humidity	Paducah Barkley Regional Airport, KY	Paducah Barkley Regional Airport, KY	Paducah Barkley Regional Airport, KY	Nearby city to the Joppa East Ash Pond within HELP database
Number of Years for Synthetic Data Generation	30	30	30	
Temperature, Evapotranspiration, and Precipitation	Precipitation, temperature, and solar radiation was simulated based on HELP V4 weather simulation for: Lat/Long: 37.21/-88.85	Precipitation, temperature, and solar radiation was simulated based on HELP V4 weather simulation for: Lat/Long: 37.21/-88.85	Precipitation, temperature, and solar radiation was simulated based on HELP V4 weather simulation for: Lat/Long: 37.21/-88.85	
Soils-General				
% where runoff possible	100	100	100	
Area (acres)	74	54	128	CBR - Removal Area based on HCR (Ramboll, 2021); CIP - Consolidation and Cover System Area based on construction drawing for Joppa East Ash Pond; CIP -Removal Area equals the difference
Specify Initial Moisture Content	No	No	No	
Surface Water/Snow	Model Calculated	Model Calculated	Model Calculated	
Soils-Layers				
1	Vegetative Soil Layer (HELP Final Cover Soil [topmost layer])	Unsaturated UCU Material (HELP Final Cover Soil)	Unsaturated UCU Material (HELP Final Cover Soil)	Layers details for CBR and CIP areas based on grading plans, construction drawings, and cover system design for Joppa East Ash Pond
2	Protective Soil Layer (HELP Vertical Percolation Layer)	--	--	
3	Geotextile Protective Layer (Custom)	--	--	
4	Geomembrane Liner	--	--	
5	Unsaturated CCR Material (HELP Waste)	--	--	
6	Unsaturated UCU Material (HELP Vertical Percolation Layer)	--	--	

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

Closure Scenario - Area Description	EAP CIP - Consolidation Area	EAP CIP - Removal Area	EAP CBR - Removal Area	Notes
Soil Parameters--Layer 1, Vegetative Soil Layer (HELP Final Cover Soil [topmost layer]) or Unsaturated UCU Material (HELP Final Cover Soil)				
Type	1	1	1	Vertical Percolation Layer (Cover Soil)
Thickness (in)	6	120	180	For CBR and CIP removal areas, layer 1 thickness is the average thickness of unsaturated material after removal
Texture	10	43	43	Default used for CIP Consolidation area, Custom used for CBR areas (UCU Material)
Description	Sandy Clay Loam	Clay	Clay	
Saturated Hydraulic Conductivity (cm/s)	1.20E-04	1.70E-07	1.70E-07	Default used for CIP Consolidation area, Custom used for CBR areas from HCR
Soil Parameters--Layer 2, Protective Soil Layer (HELP Vertical Percolation Layer)				
Type	1	--	--	Vertical Percolation Layer (EAP)
Thickness (in)	18	--	--	design thickness
Texture	15	--	--	Defaults used
Description	Clay (Low Density)	--	--	
Saturated Hydraulic Conductivity (cm/s)	1.70E-05	--	--	Defaults used
Soil Parameters--Layer 3, Geotextile Protective Layer (Custom)				
Type	2	--	--	Geotextile Protective Layer (Custom)
Thickness (in)	0.11	--	--	design thickness
Texture	123	--	--	Defaults used
Description	10 oz Nonwoven Geotextile	--	--	
Saturated Hydraulic Conductivity (cm/s)	3.00E-01	--	--	Defaults used
Soil Parameters--Layer 4, Geomembrane Liner				
Type	4	--	--	Flexible Membrane Liner
Thickness (in)	0.04	--	--	design thickness
Texture	36	--	--	Defaults used
Description	LDPE Membrane	--	--	
Saturated Hydraulic Conductivity (cm/s)	4.00E -13	--	--	Defaults used

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

Closure Scenario - Area Description	EAP CIP - Consolidation Area	EAP CIP - Removal Area	EAP CBR - Removal Area	Notes
Soil Parameters--Layer 5, Unsaturated CCR Material (HELP Waste)				
Type	1	--	--	Vertical Percolation Layer (Waste)
Thickness (in)	600	--	--	design thickness
Texture	83	--	--	Custom used for CCR material
Description	Unsaturated CCR Material (HELP Waste)	--	--	
Saturated Hydraulic Conductivity (cm/s)	1.00E-06	--	--	Custom used for CCR material from HCR
Soil Parameters--Layer 6, Unsaturated UCU Material (HELP Vertical Percolation Layer)				
Type	1	--	--	Vertical Percolation Layer (UCU Material)
Thickness (in)	252	--	--	Unsaturated UCU Thickness
Texture	43	--	--	Custom used
Description	Clay	--	--	
Saturated Hydraulic Conductivity (cm/s)	1.70E-07	--	--	Custom used or UCU material from HCR
Soils--Runoff				
Runoff Curve Number	85.5	89.7	89.6	HELP-computed curve number
Slope	4.67%	3.50%	3.00%	Estimated from construction design drawings
Length (ft)	600	1000	1000	estimated maximum flow path
Texture	10	43	43	uppermost layer texture
Vegetation	fair	fair	fair	fair indicating fair stand of grass on surface of soil backfill
Execution Parameters				
Years	30	30	30	
Report Daily	No	No	No	
Report Monthly	No	No	No	
Report Annual	Yes	Yes	Yes	
Output Parameter				
Percolation Rate (in/yr)	**0.004401**	**1.18**	**0.962**	

[O: EGP 5/20/22, C: JJW 5/19/22]

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

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.
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TABLE 6-2. PREDICTED BORON CONCENTRATIONS AT EAP MONITORING WELLS, CIP AND CBR

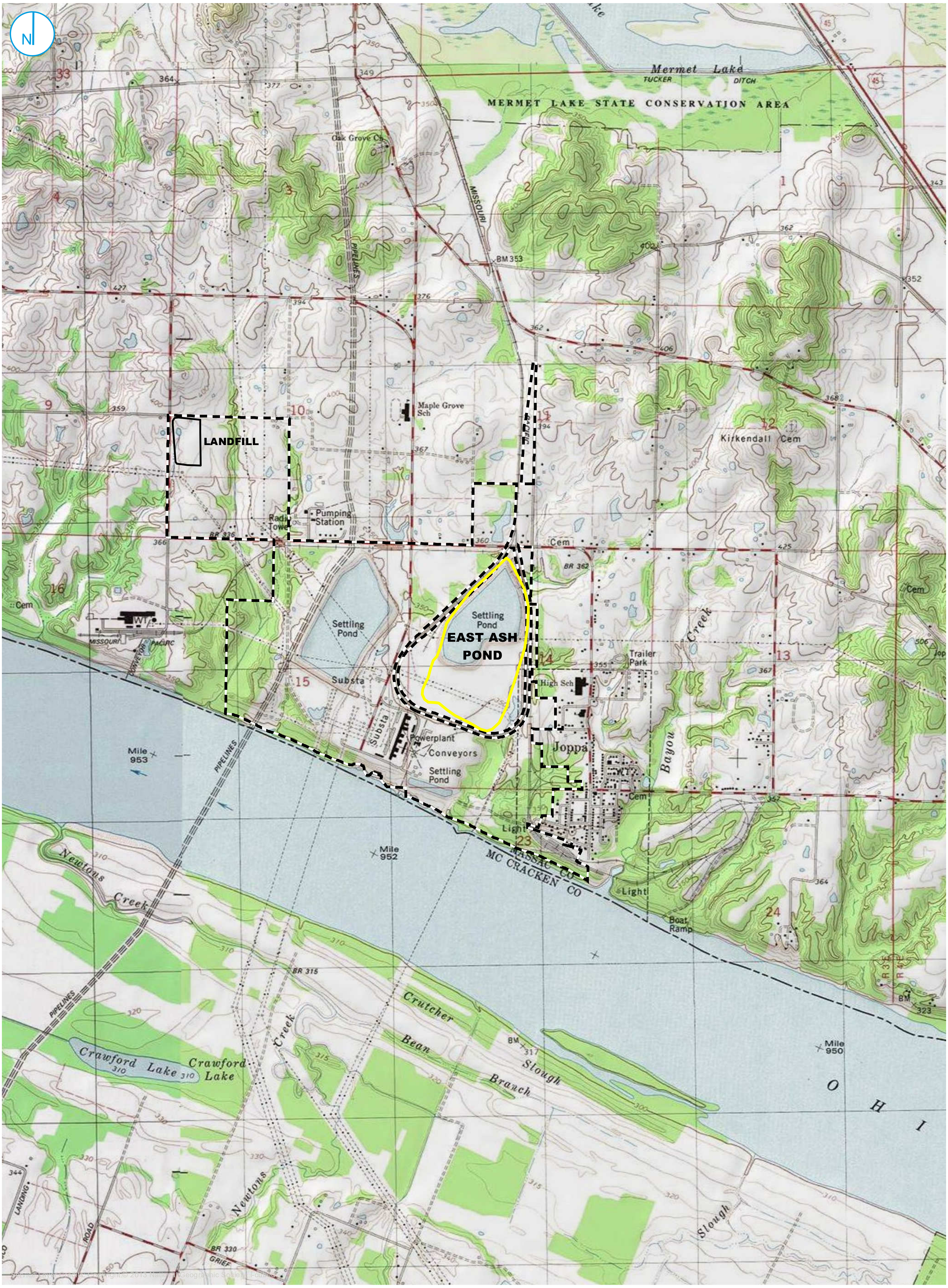
GROUNDWATER MODELING REPORT
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Well ID	2022 Simulated Boron Concentration (mg/L)	Target Value (Average Boron Concentration [mg/L])	Year 0 Predicted Boron Concentration (mg/L)	CIP Years to Meet GWPS	CBR Years to Meet GWPS
G01D	0.00	0.03	0.00		
G02D	0.00	0.04	0.00		
G03	0.00	0.30	0.00		
G04	1.02	0.02	0.60		
G05	1.52	0.16	0.98		
G06	4.21	3.35	3.61	3.8	3.7
G06S	0.61	0.25	0.62		
G07	5.05	4.65	5.19	5.9	5.6
G08	5.80	4.39	5.33	1.9	2.0
G09	5.52	3.10	5.36	14.2	14.2
G09M	0.00	0.04	0.00		
G10	3.48	4.37	3.47	5.2	5.3
G11	0.00	0.33	0.00		
G12D	2.73	6.70	2.43	3.4	3.5
G12S	2.75	5.88	2.43	3.4	3.5
G13D	3.40	4.66	3.20	6.1	6.0
G13S	3.41	4.98	3.20	6.1	6.0
G14D	3.42	3.67	3.33	8.5	8.3
G14S	3.42	0.03	3.25		
G151	0.00	0.12	0.00		
G153	1.19	0.02	1.02		
G15D	4.86	6.89	4.75	9.8	9.3
G15S	4.86	0.98	4.75		
G16D	5.15	4.95	5.02	7.3	7.4
G16S	5.15	7.20	5.02	7.3	7.4
G51D	0.00	0.44	0.00		
G53D	3.08	0.36	2.47		
G54D	0.00	0.48	0.00		
G54S	0.00	0.06	0.00		
Well3	1.79	0.60	2.12		

[O: KM 5/17/22, C: EGP 5/20/22]

Notes:
CBR = closure by removal
CIP = closure in place
GWPS = groundwater protection standard
mg/L = milligrams per liter

FIGURES



PART 845 REGULATED UNIT (SUBJECT UNIT)
OTHER UNIT
PROPERTY BOUNDARY

0 1,000 2,000 Feet

DRAFT

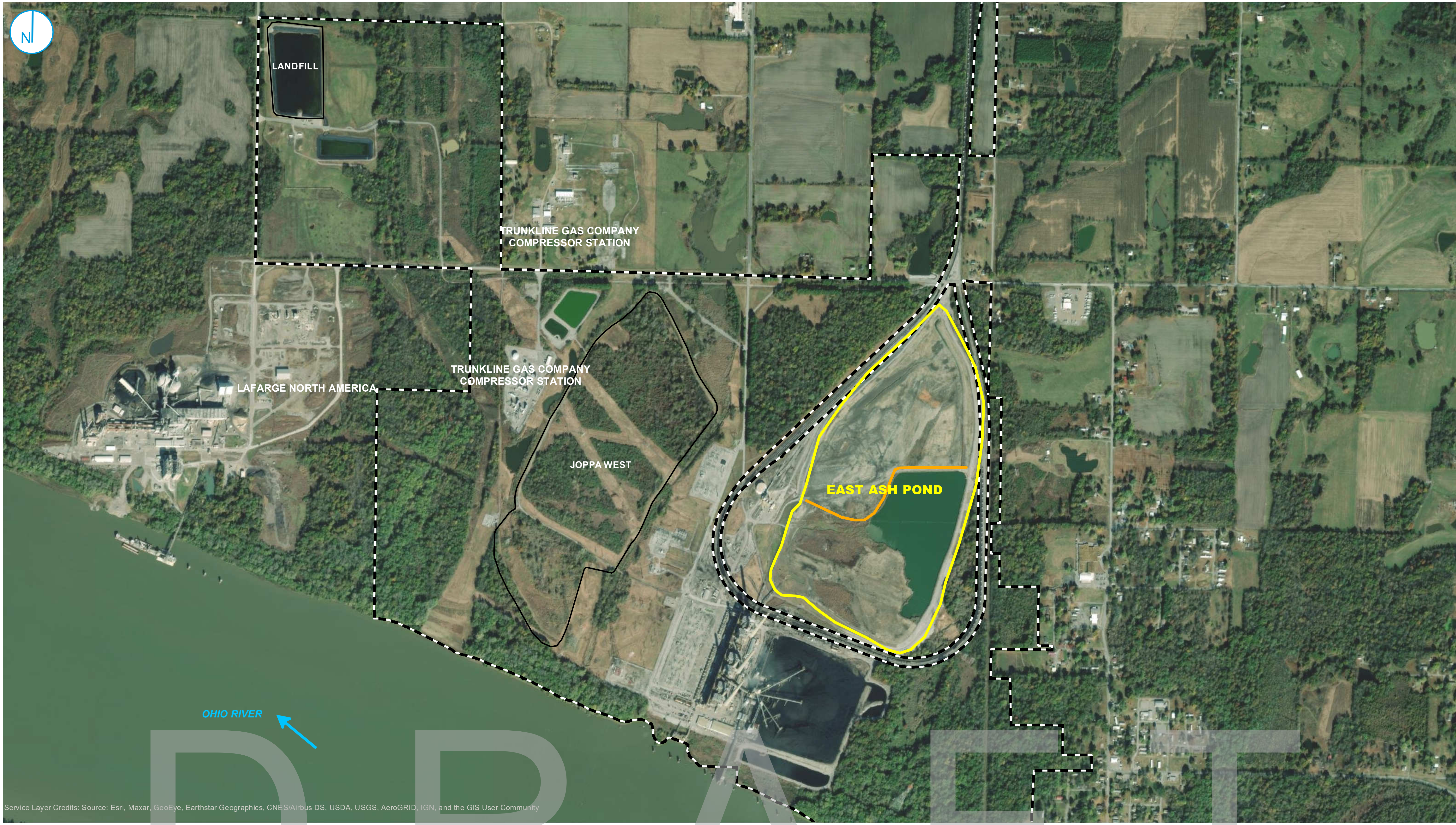
SITE LOCATION MAP

FIGURE 1-1

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL



PART 845 REGULATED UNIT (SUBJECT UNIT)
OTHER UNIT
CENTRAL DIKE
PROPERTY BOUNDARY

0 500 1,000 Feet

Y:\Mapping\Projects\22\2285\MXD\Model_Figures\Joppa\Figure 1-2_Site Map.mxd

PROJECT: 169000XXXX | DATED: 5/18/2022 | DESIGNER: galarmmc

SITE MAP

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

FIGURE 1-2

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL

10FT TOPOGRAPHIC CONTOUR
2FT TOPOGRAPHIC CONTOUR
PART 845 REGULATED UNIT (SUBJECT UNIT)
OTHER UNIT
PROPERTY BOUNDARY

Note:
Elevation contours shown in feet, North American Vertical Datum of 1988 (NAVD88)

0 250 500
Feet

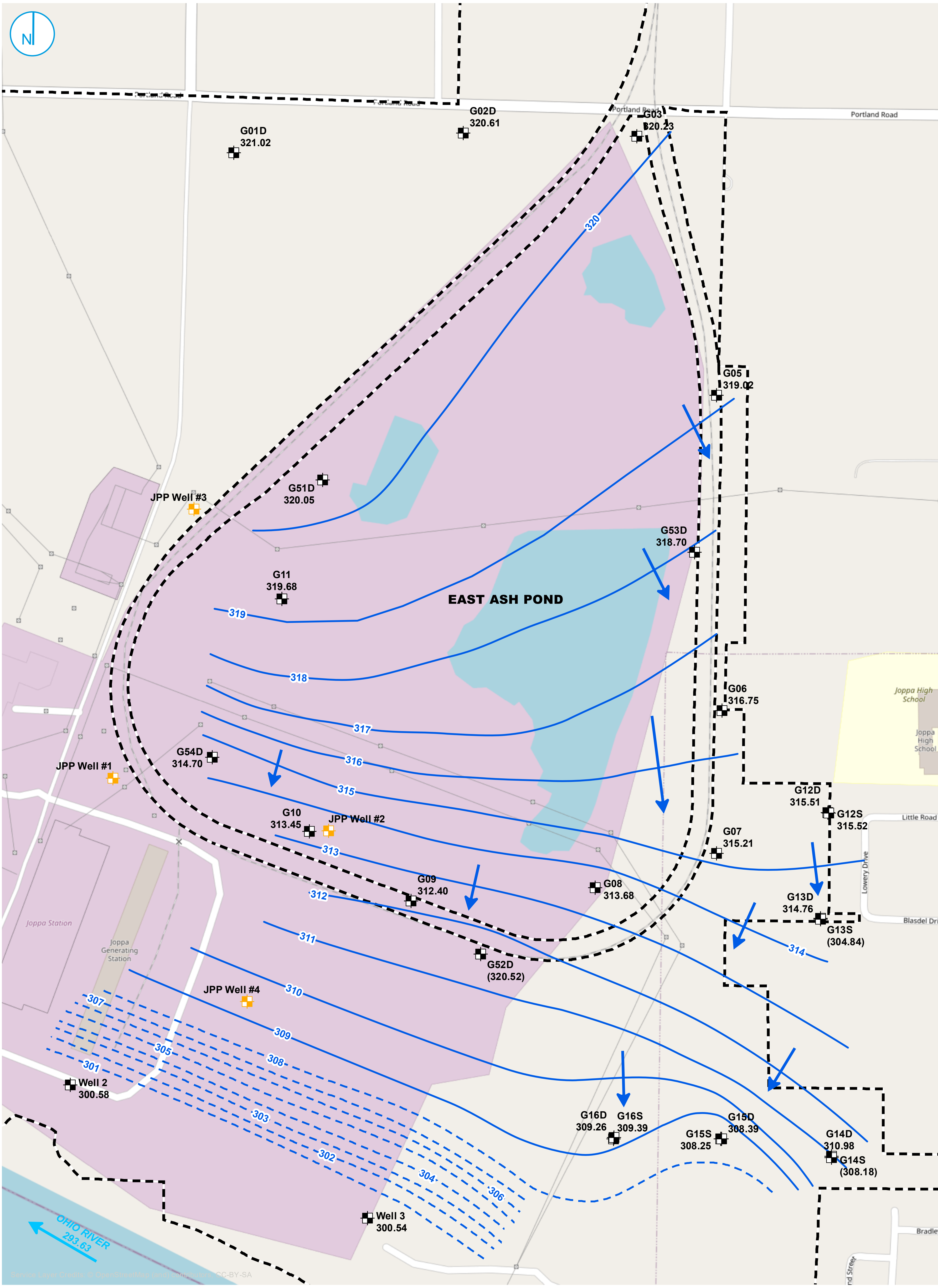
SITE TOPOGRAPHIC MAP

FIGURE 2-1

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL



MONITORING WELL
JOPPA POWER PLANT NON-POTABLE WELLS
PROPERTY BOUNDARY
GROUNDWATER ELEVATION CONTOUR (1-FT CONTOUR INTERVAL, NAVD88)
INFERRED GROUNDWATER ELEVATION CONTOUR
GROUNDWATER FLOW DIRECTION

NOTE:
ELEVATIONS IN PARENTHESIS NOT USED FOR CONTOURING

0 225 450 Feet

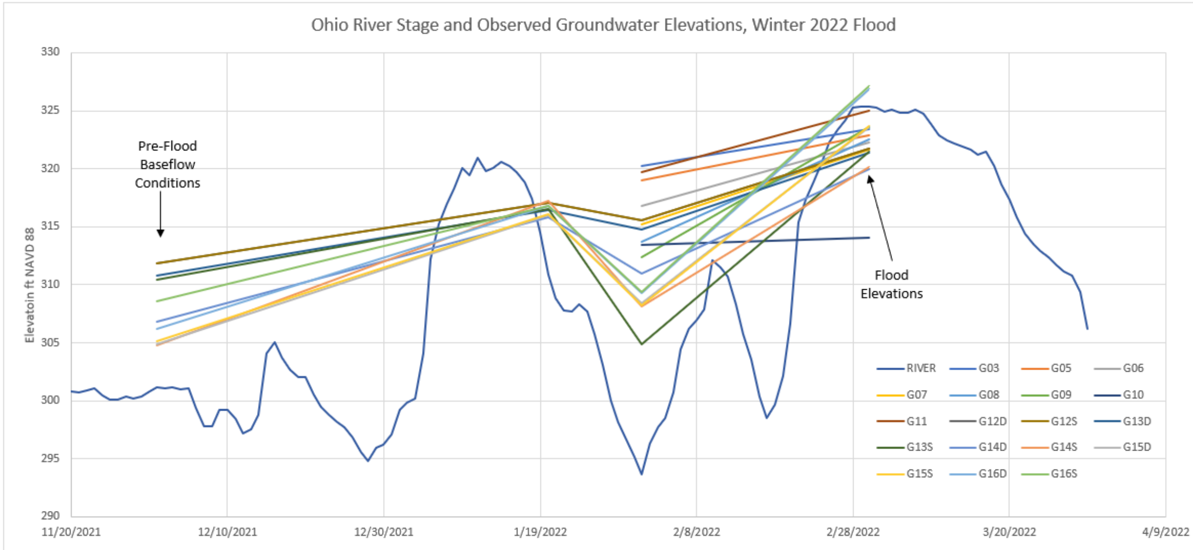
POTENTIOMETRIC SURFACE MAP
FEBRUARY 1, 2022

FIGURE 2-2

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL



Notes

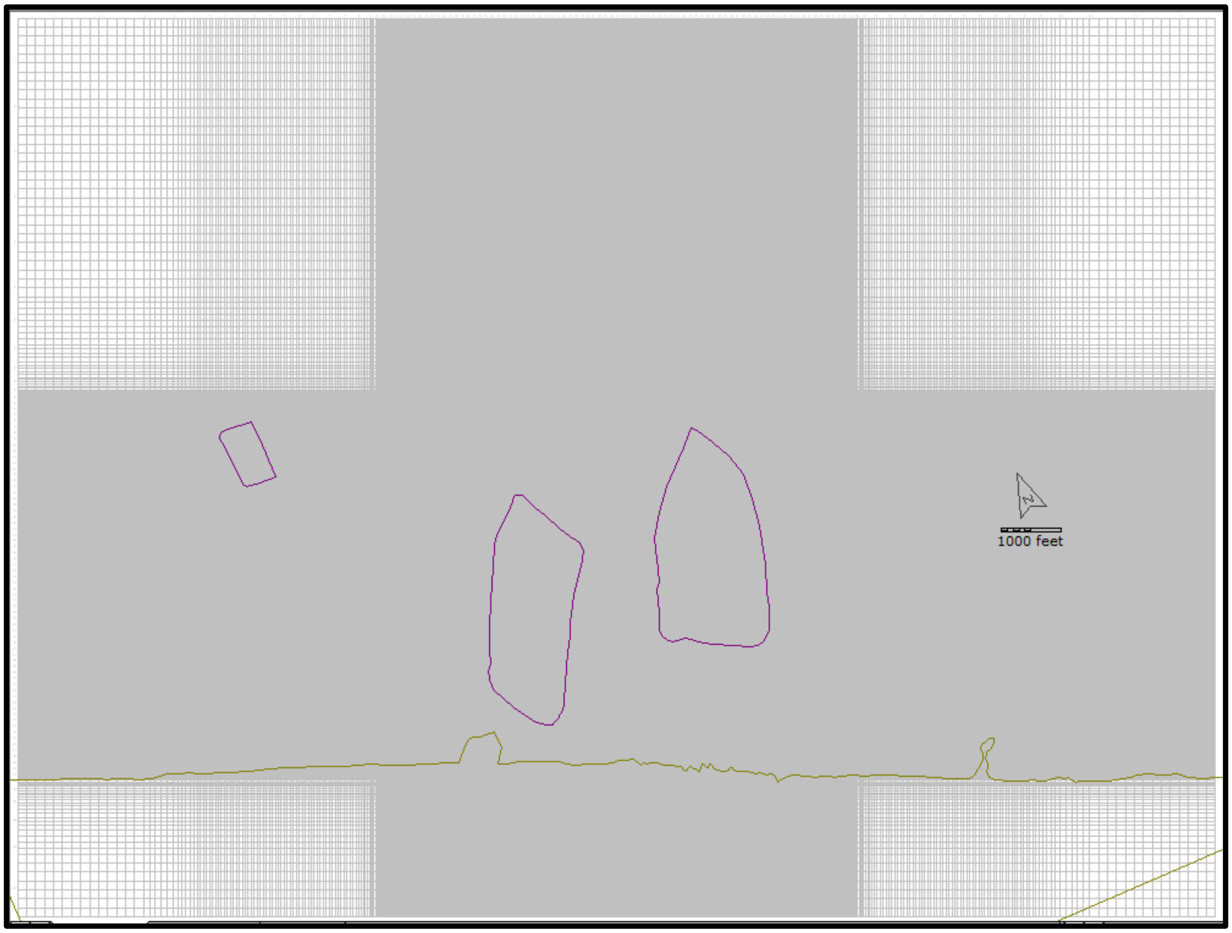
Dates shown for monitoring well elevations are approximate, and were aggregated for analysis purposes, as described below.

Baseline groundwater elevations were aggregated from available data within the baseflow period (*i.e.,* June to mid-December, 2021).

Dates for Flood Period 1 were collected over 2 days (January 19 and 20, 2022).

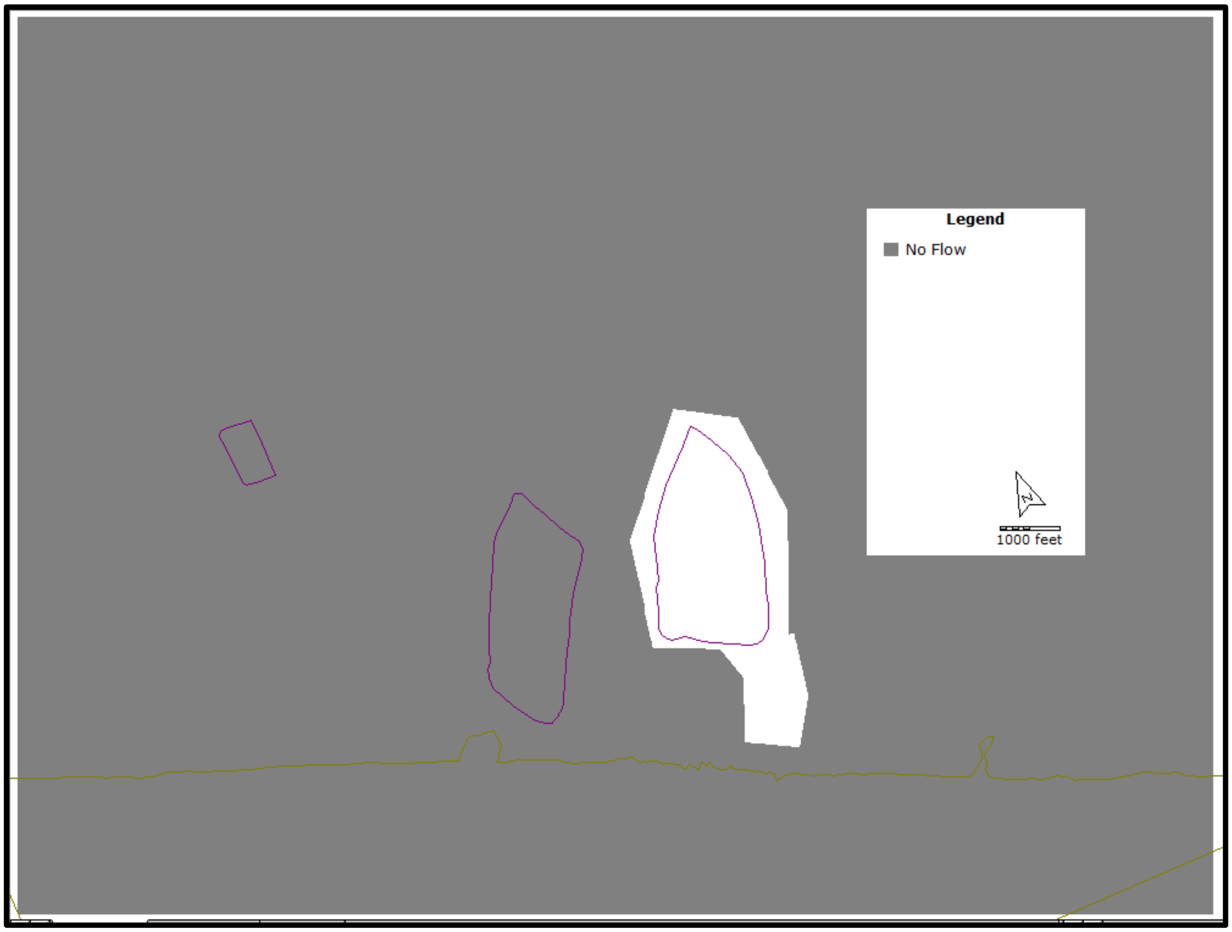
OHIO RIVER STAGE AND OBSERVED GROUNDWATER ELEVATIONS

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS



MODEL GRID

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS



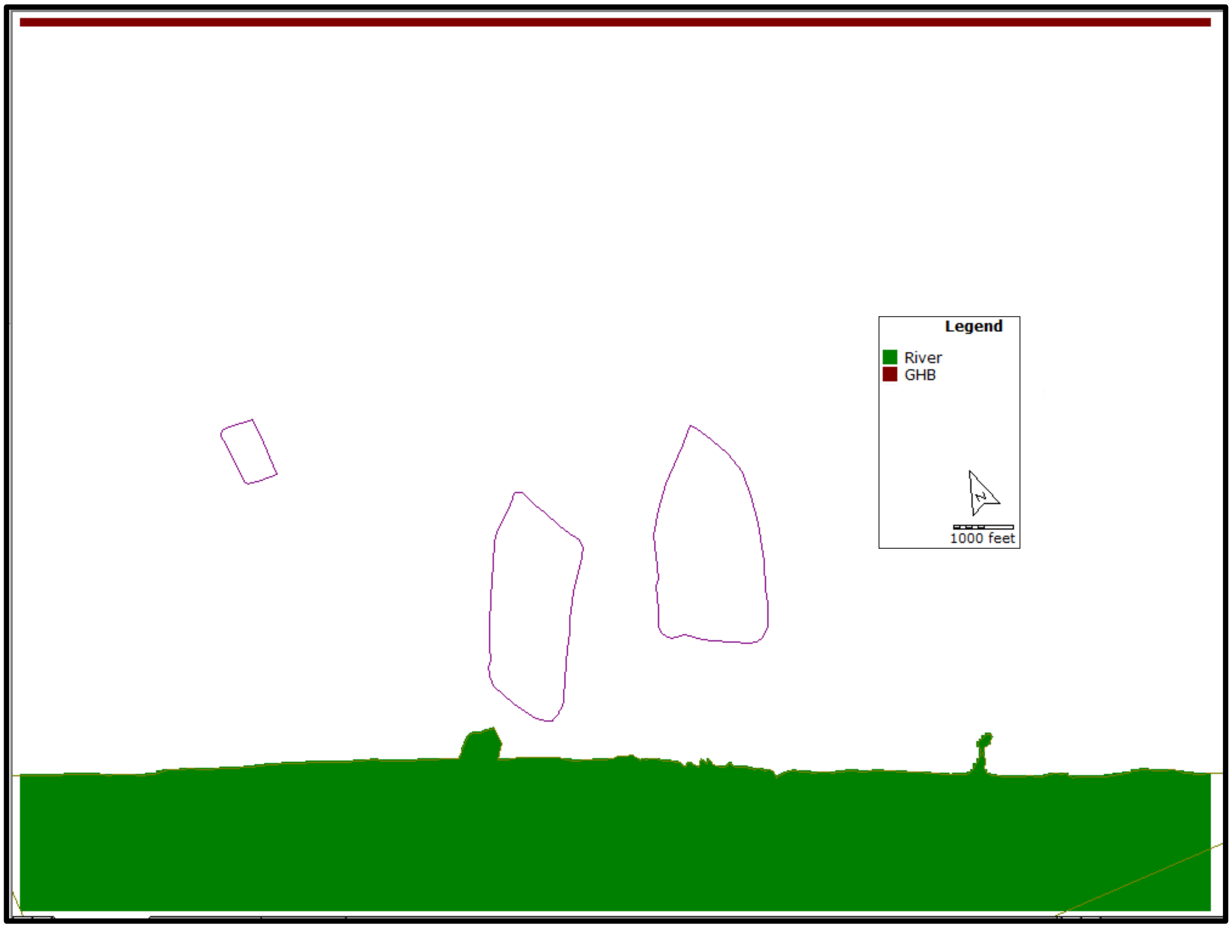
BOUNDARY CONDITIONS, MODEL LAYER 1

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL

BOUNDARY CONDITIONS, MODEL LAYERS 2 AND 3

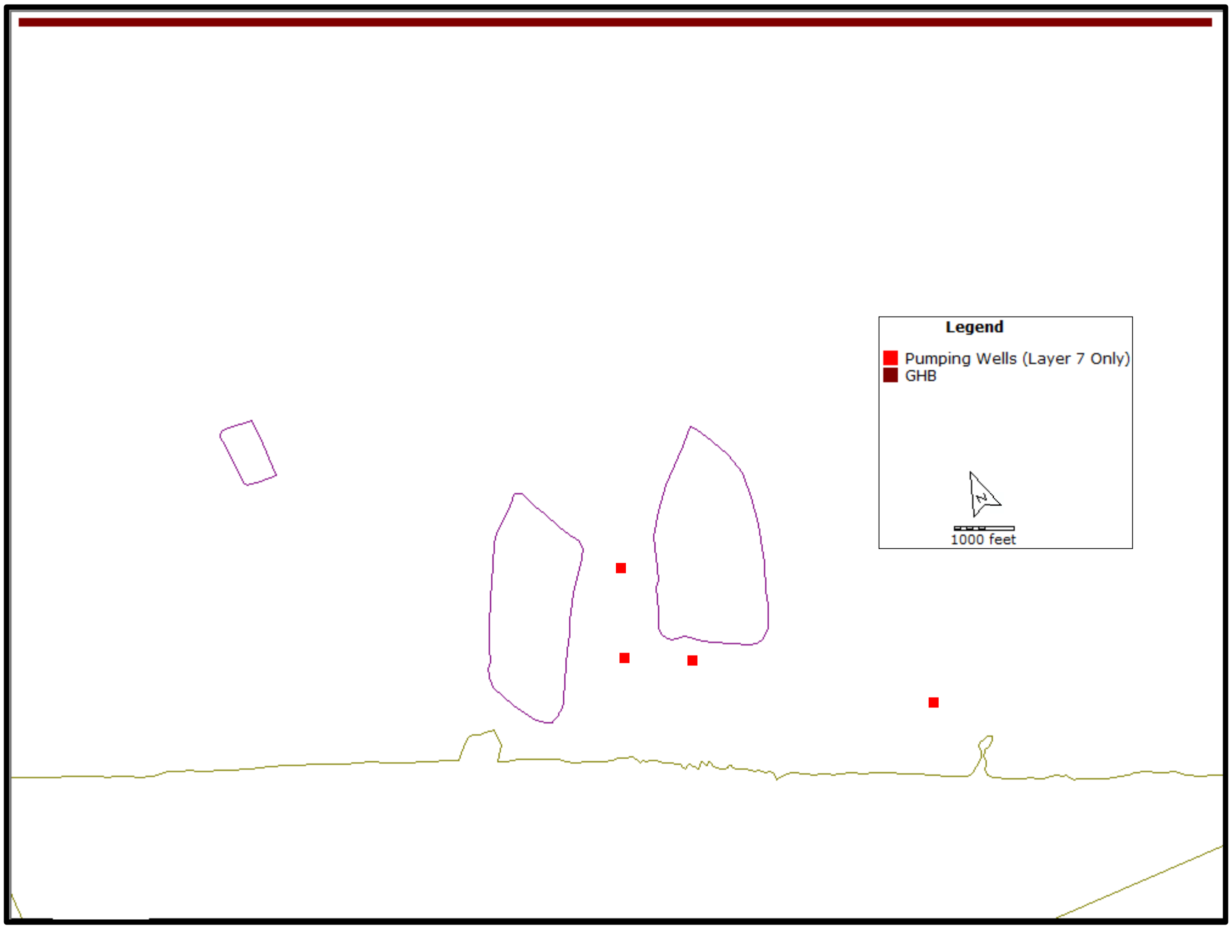
GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS



BOUNDARY CONDITIONS, MODEL LAYER 4

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

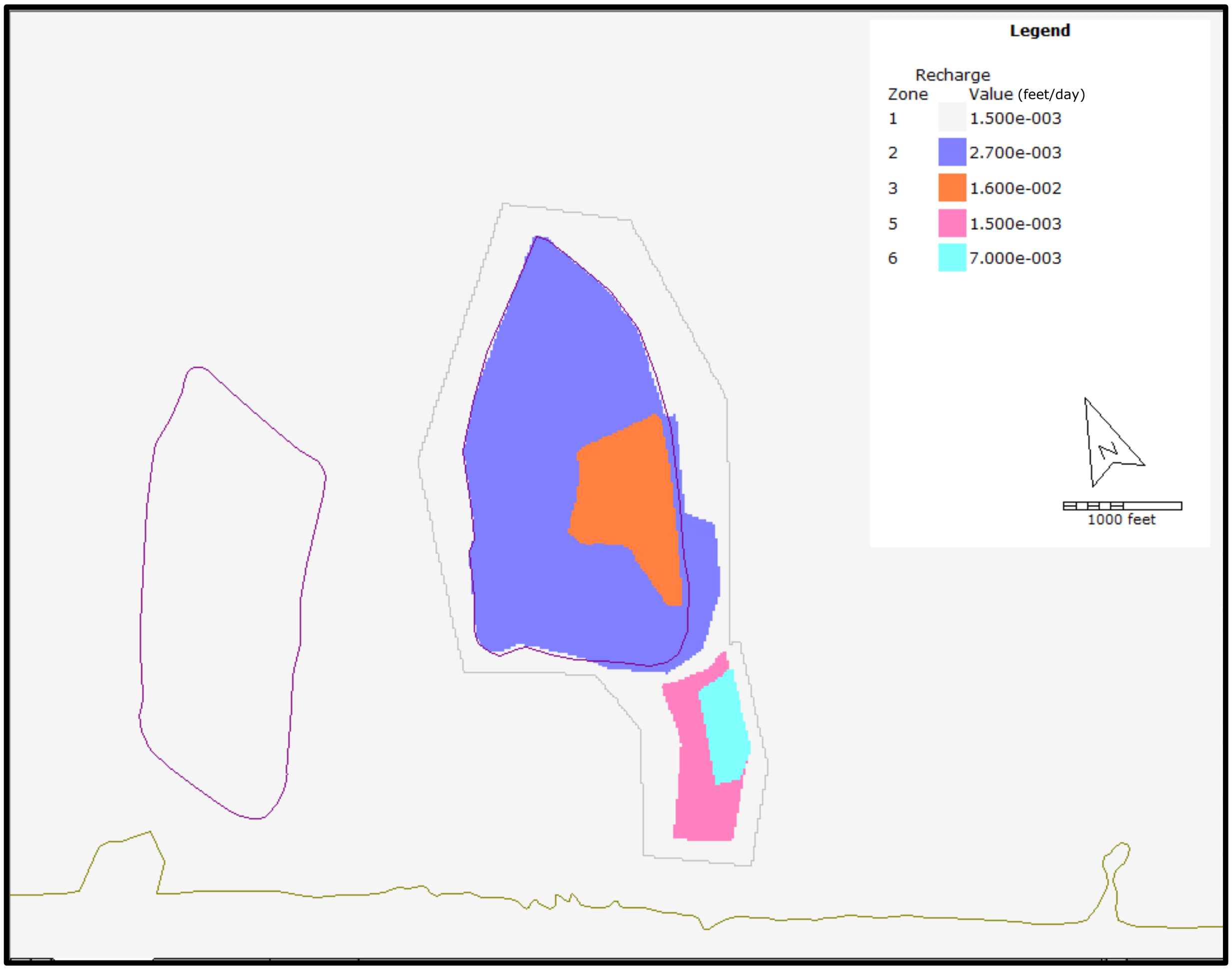
FIGURE 5-5



BOUNDARY CONDITIONS, MODEL LAYERS 6 AND 7

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

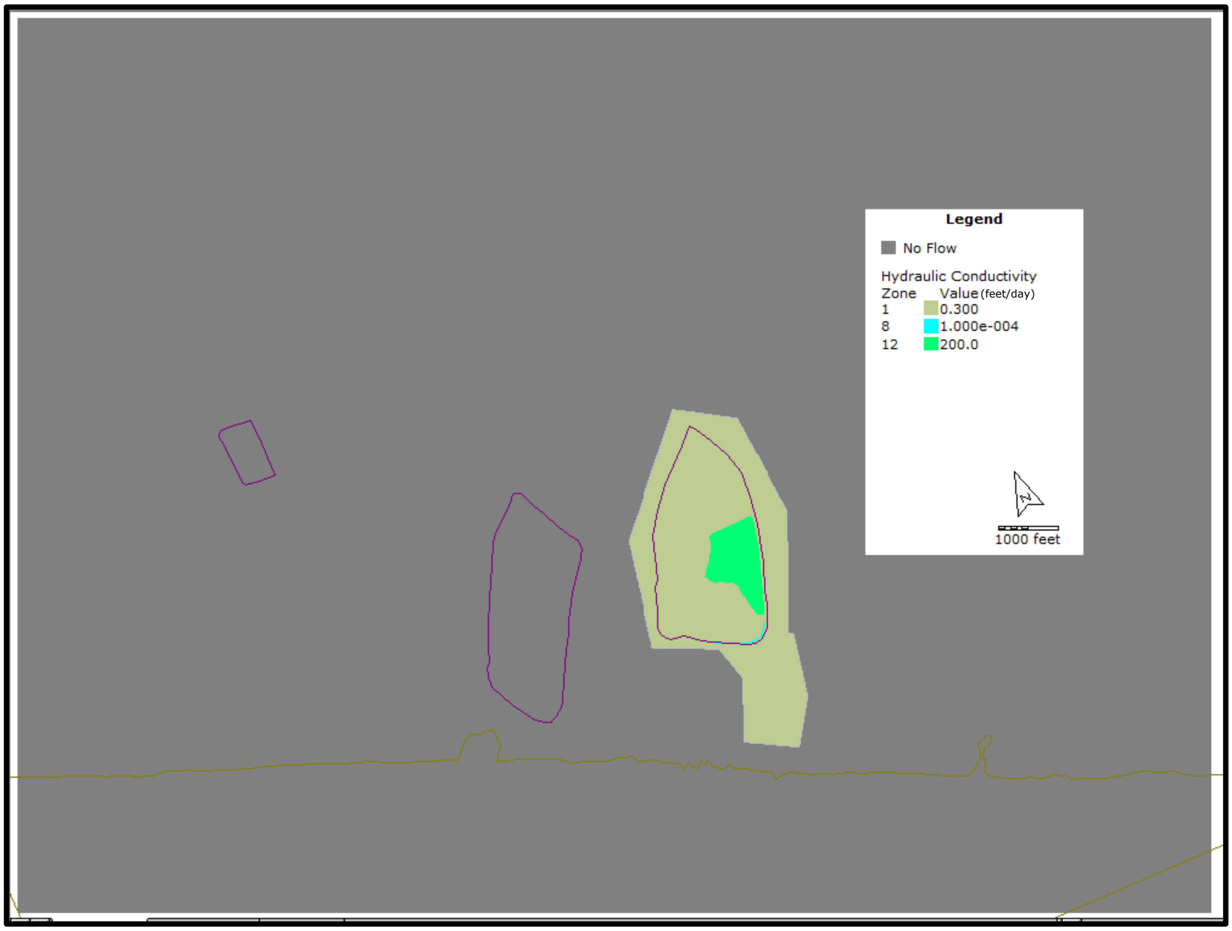
RAMBOLL



MODEL RECHARGE, STEADY-STATE FLOW MODEL

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

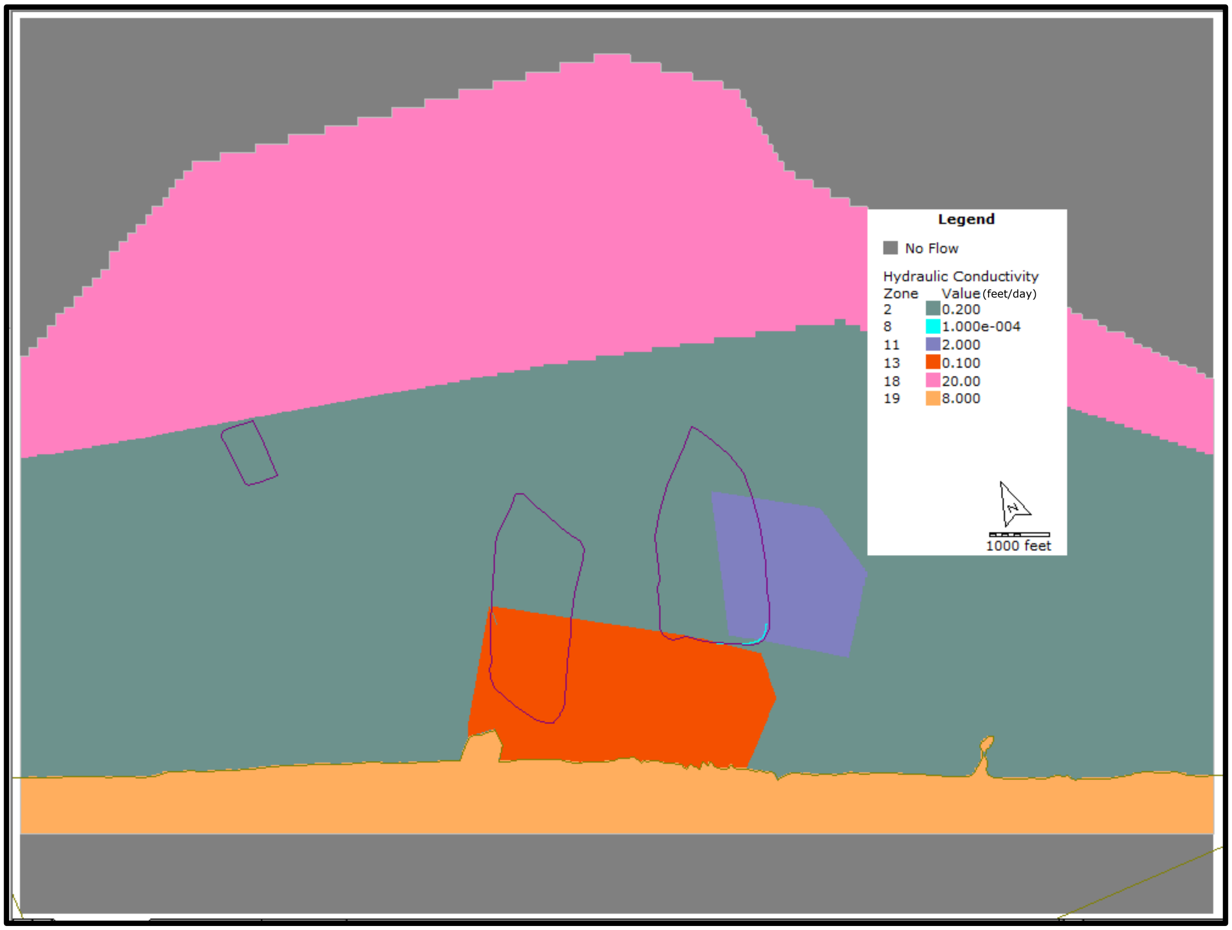
RAMBOLL



ASSIGNED HYDRAULIC CONDUCTIVITIES, MODEL LAYER 1

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

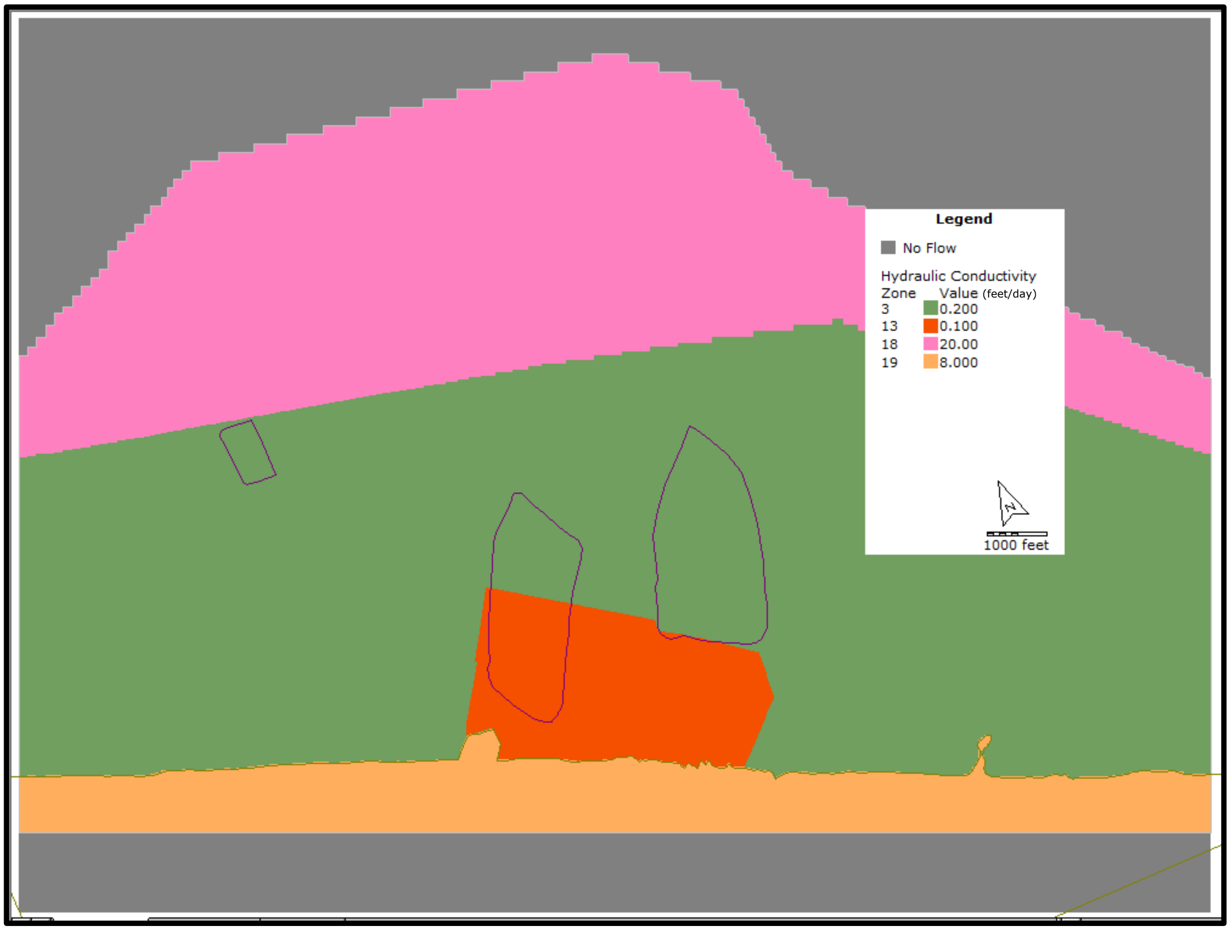
RAMBOLL



ASSIGNED HYDRAULIC CONDUCTIVITIES, MODEL LAYER 2

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL



ASSIGNED HYDRAULIC CONDUCTIVITIES, MODEL LAYER 3

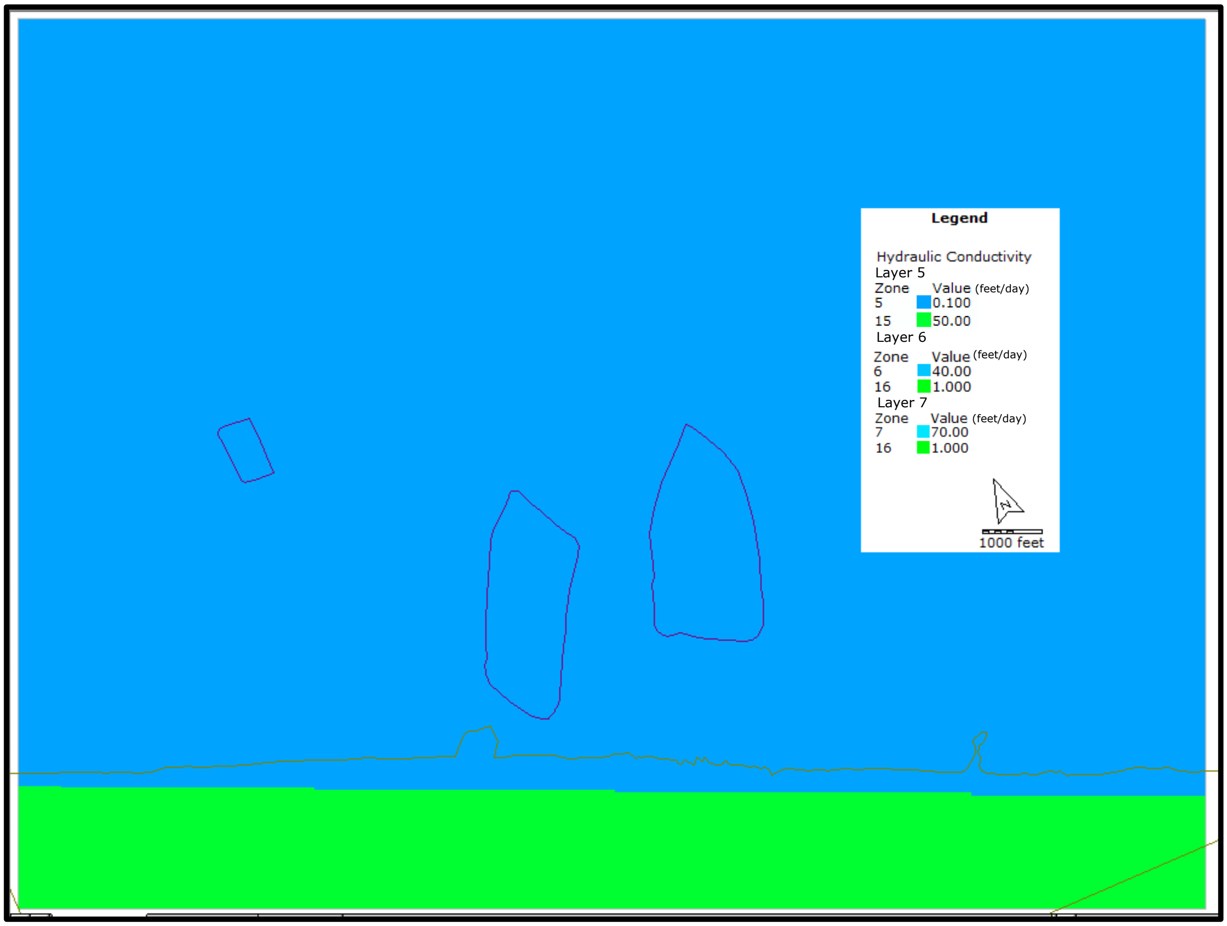
GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL

ASSIGNED HYDRAULIC CONDUCTIVITIES, MODEL LAYER 4

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL

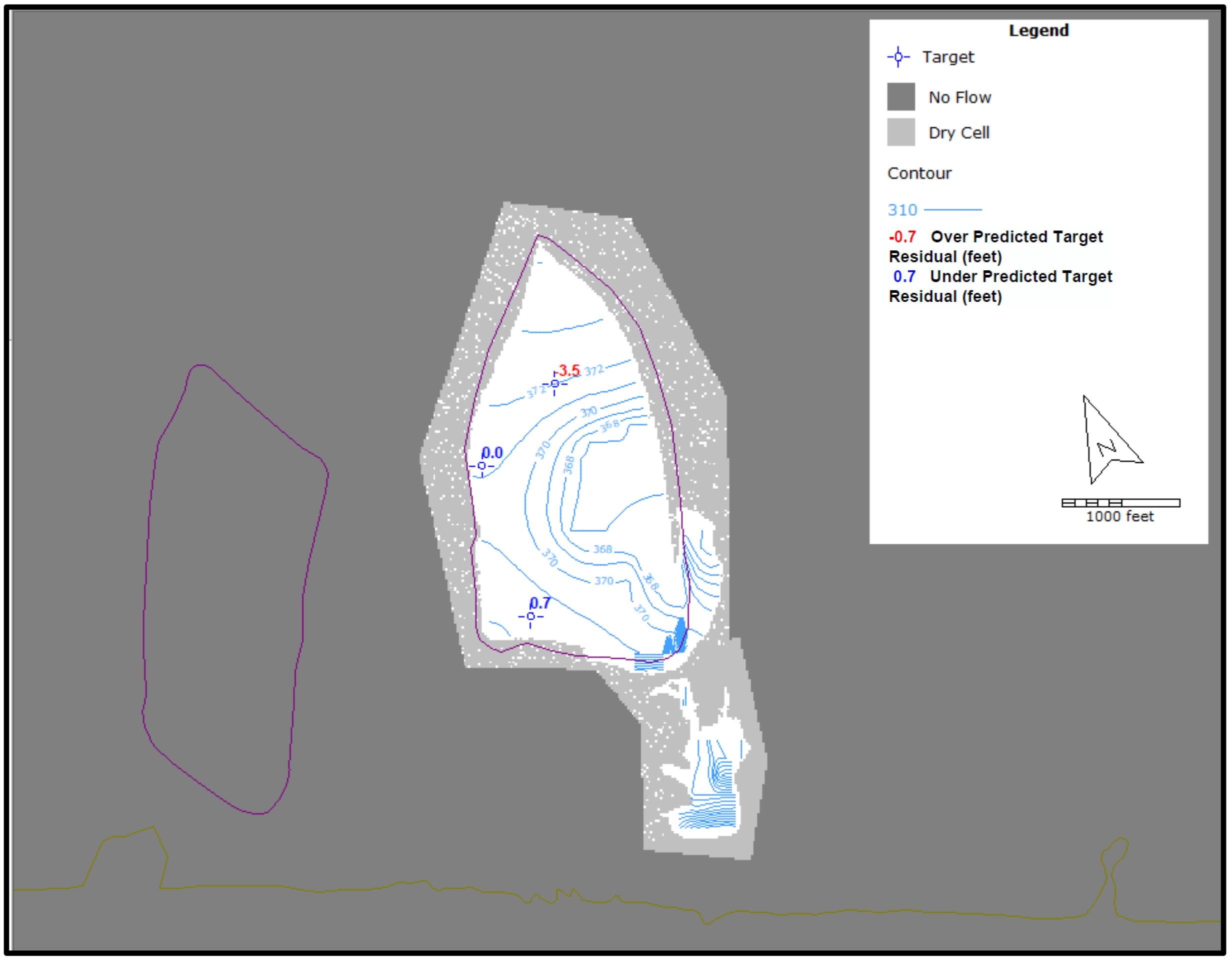


ASSIGNED HYDRAULIC CONDUCTIVITIES, MODEL LAYERS 5, 6, 7

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL

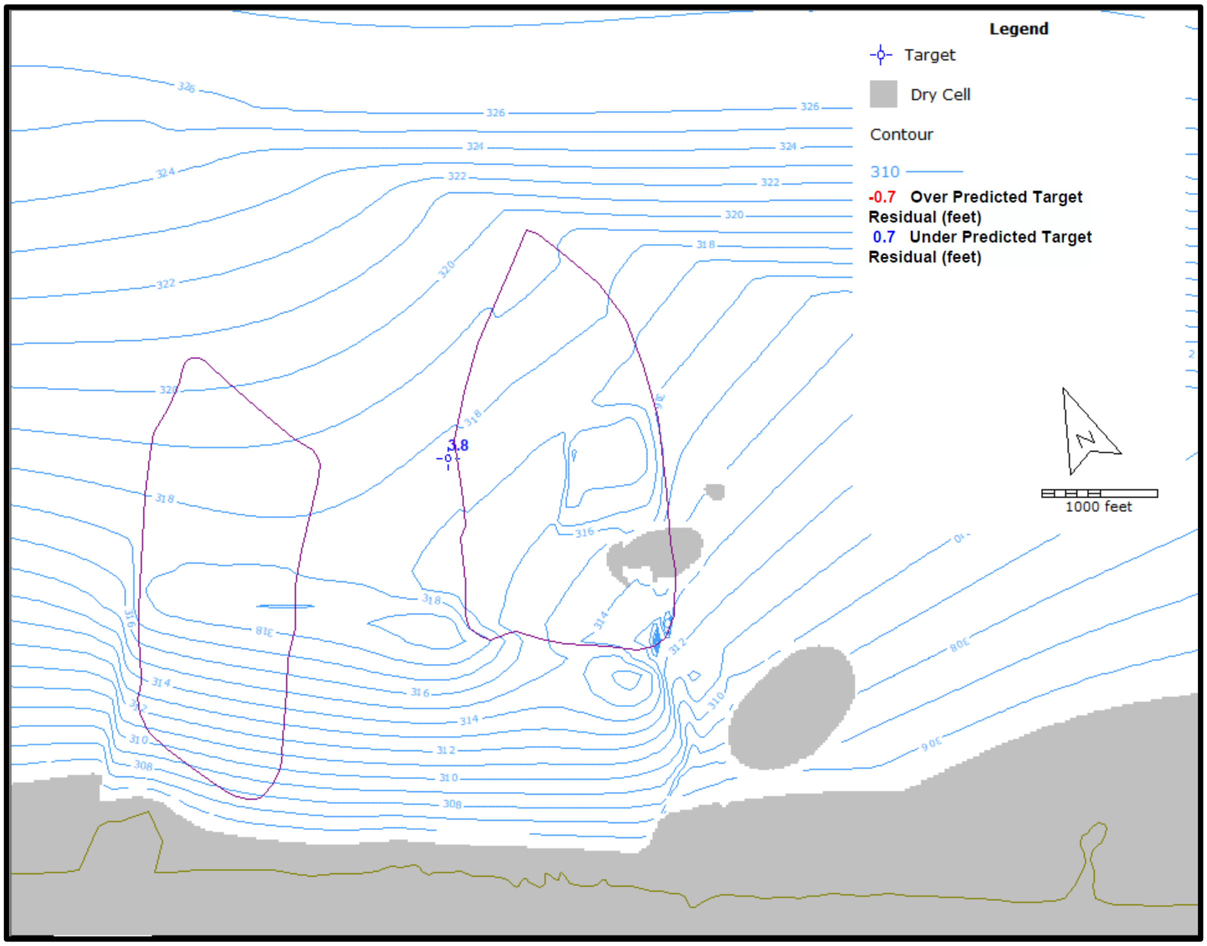
FIGURE 5-12



SIMULATED GROUNDWATER ELEVATIONS AND RESIDUALS, FLOW MODEL, MODEL LAYER 1

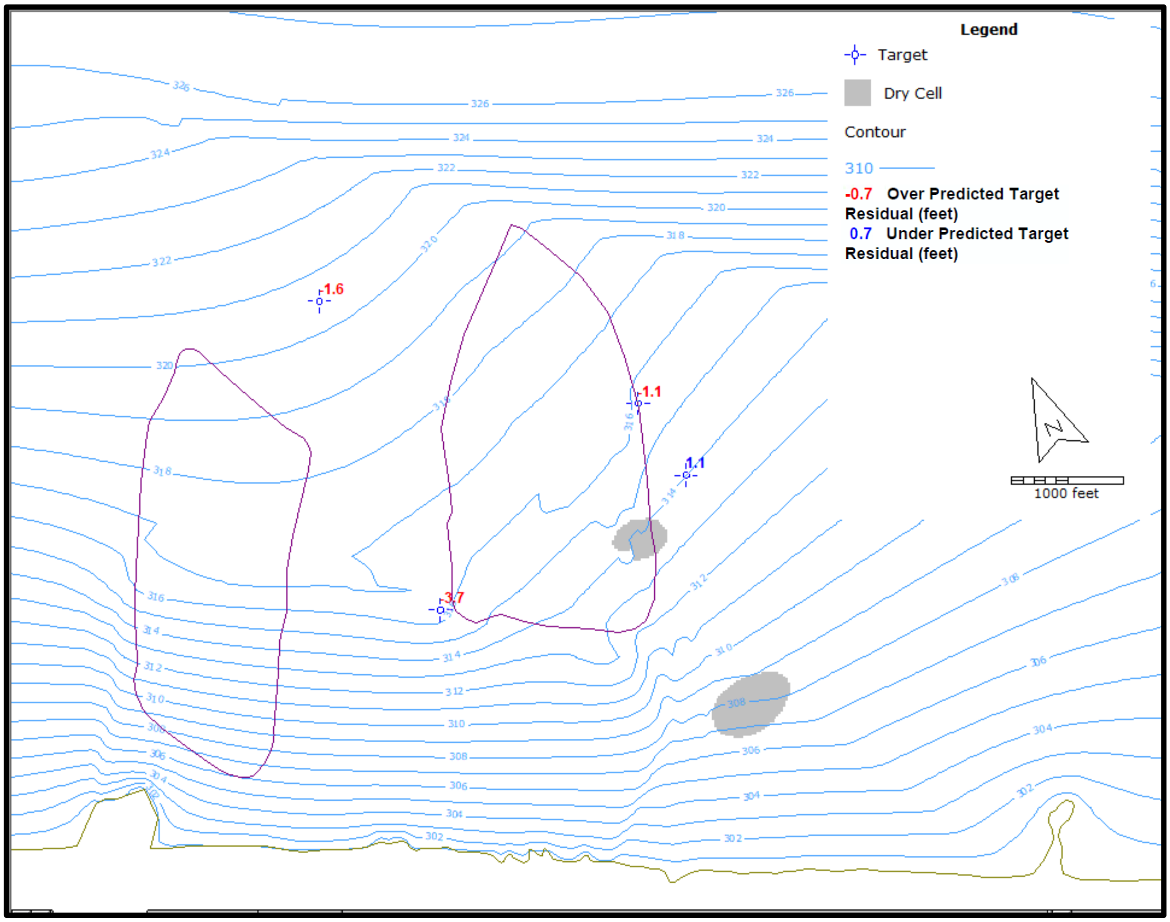
GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL



SIMULATED GROUNDWATER ELEVATIONS AND RESIDUALS, FLOW MODEL, MODEL LAYER 2

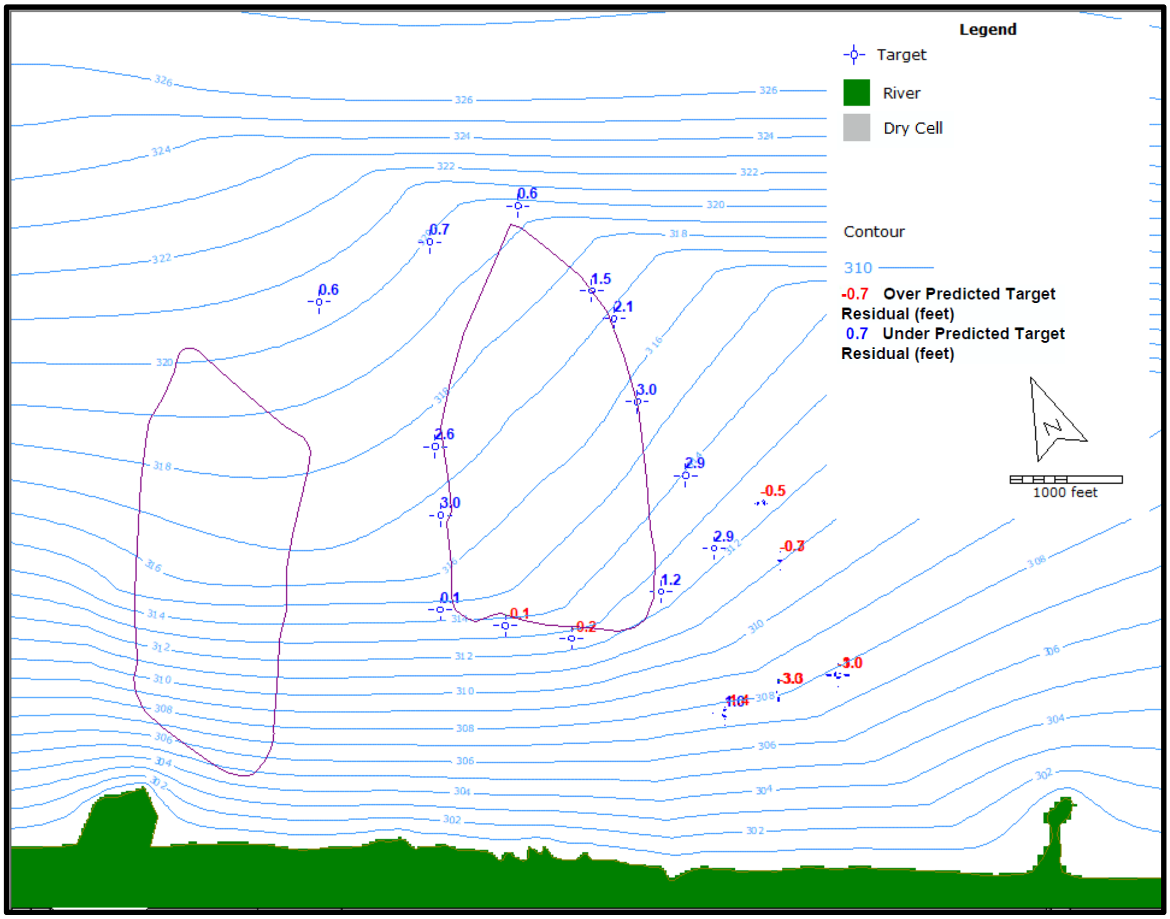
GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS



SIMULATED GROUNDWATER ELEVATIONS AND RESIDUALS, FLOW MODEL, MODEL LAYER 3

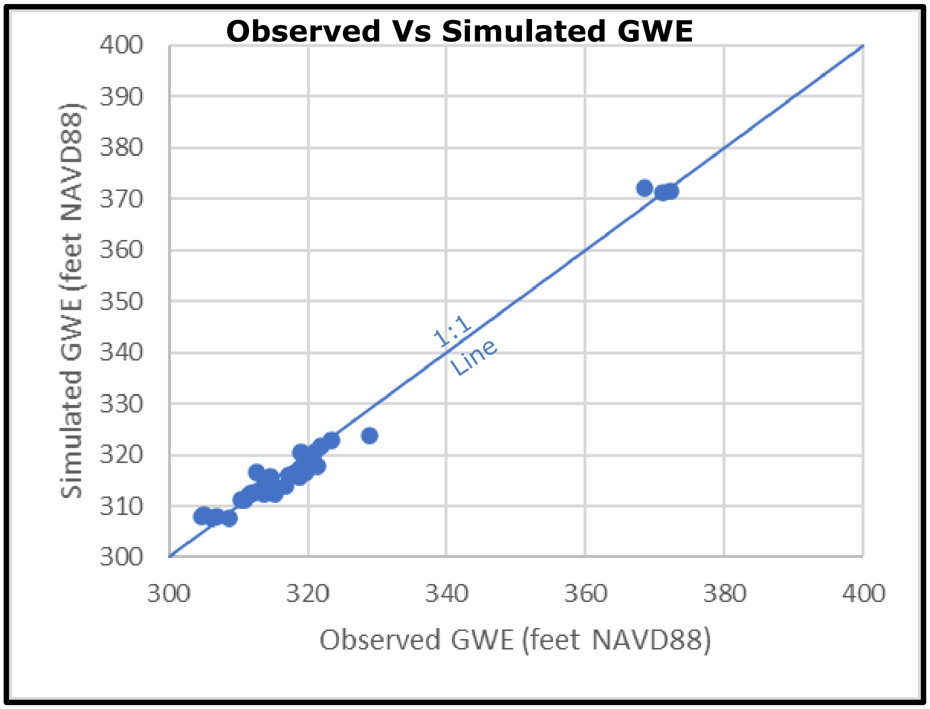
GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

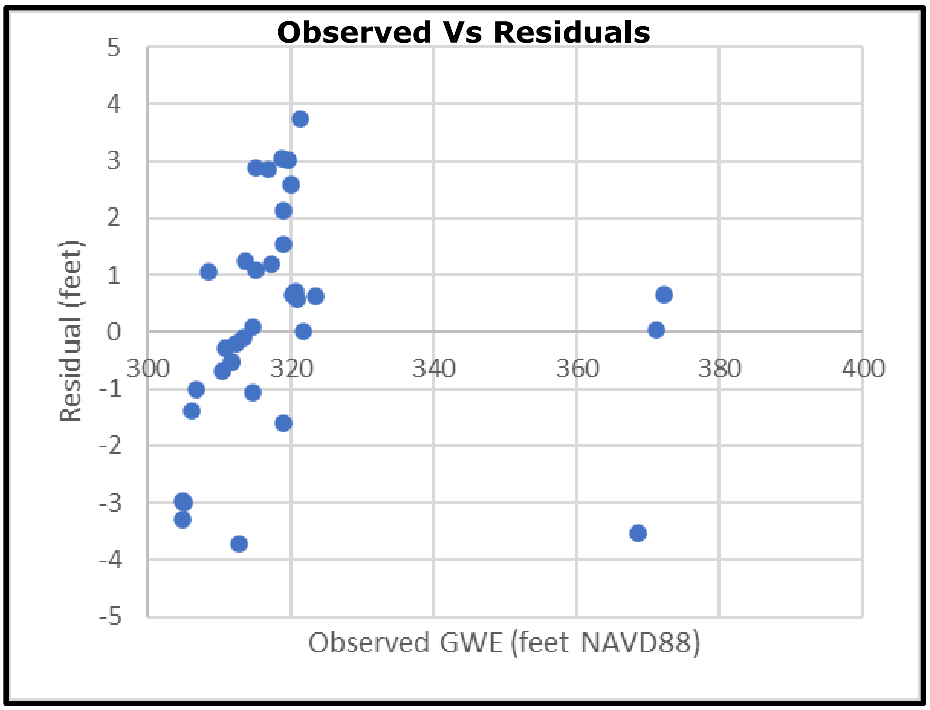
RAMBOLL



SIMULATED GROUNDWATER ELEVATIONS AND RESIDUALS, FLOW MODEL, MODEL LAYER 4

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS



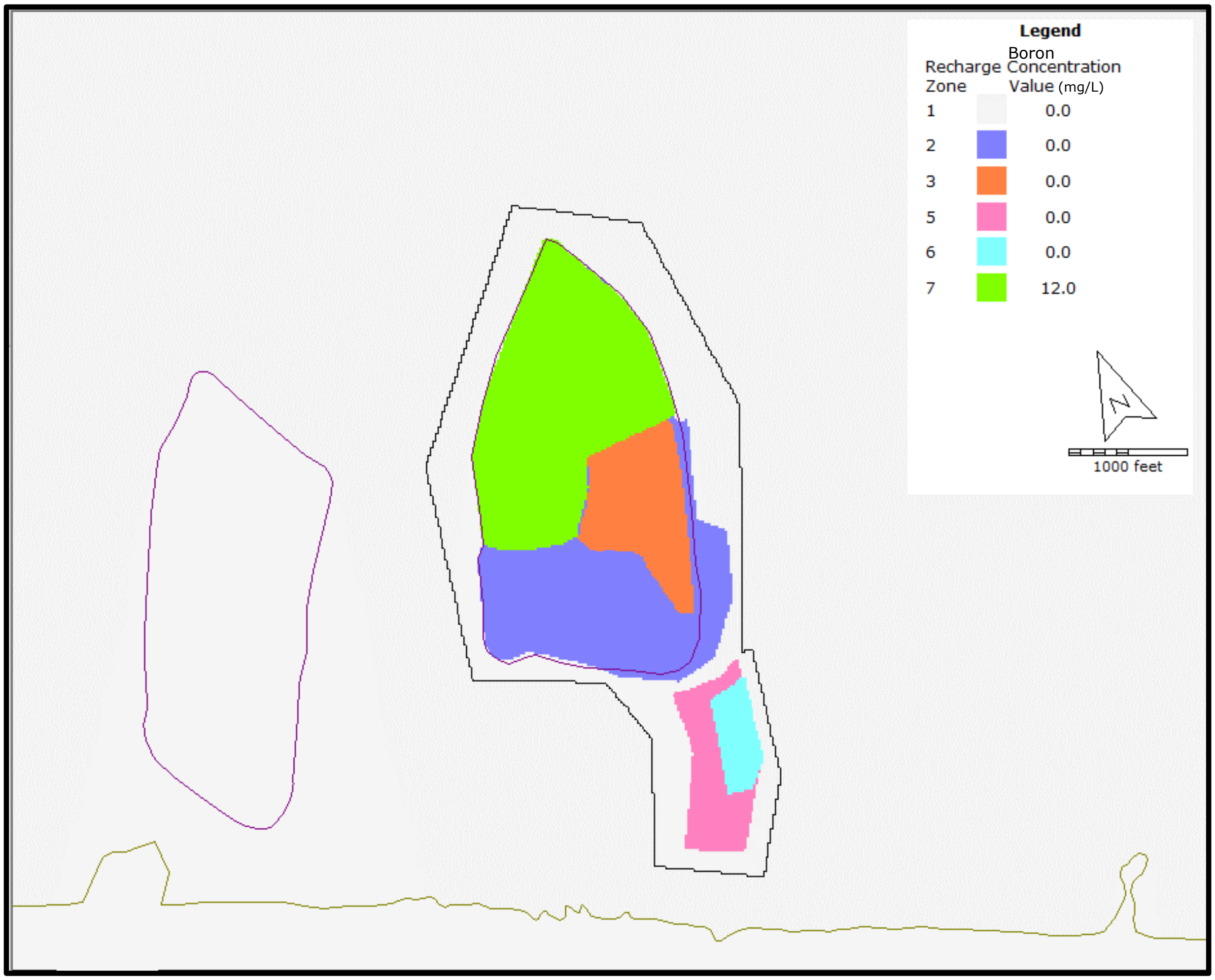


FLOW MODEL CALIBRATION PLOTS, OBSERVED VS SIMULATED GWE AND RESIDUALS

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL

FIGURE 5-17

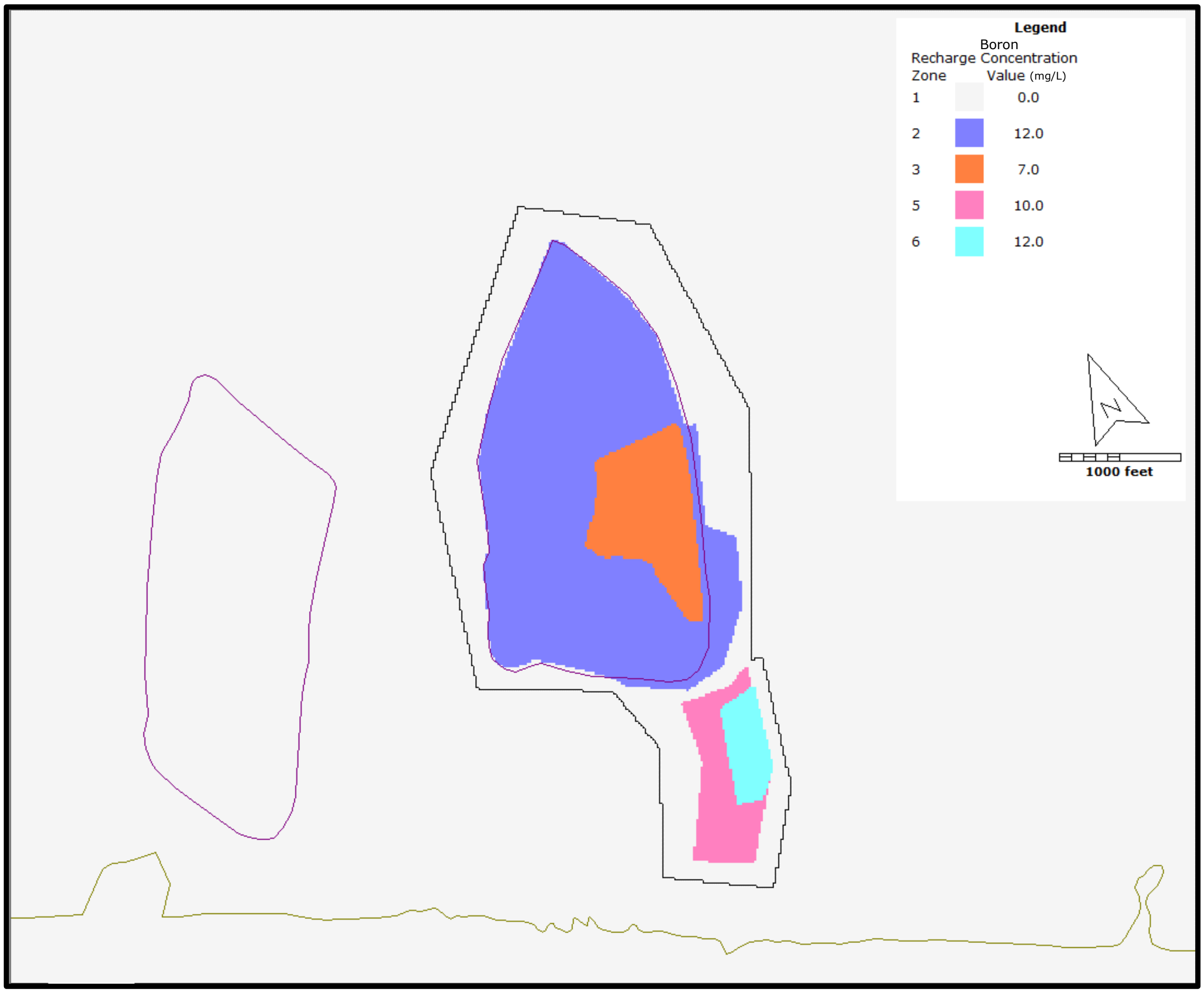


BORON RECHARGE, HISTORIC TRANSPORT MODEL, SP1

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL

FIGURE 5-18

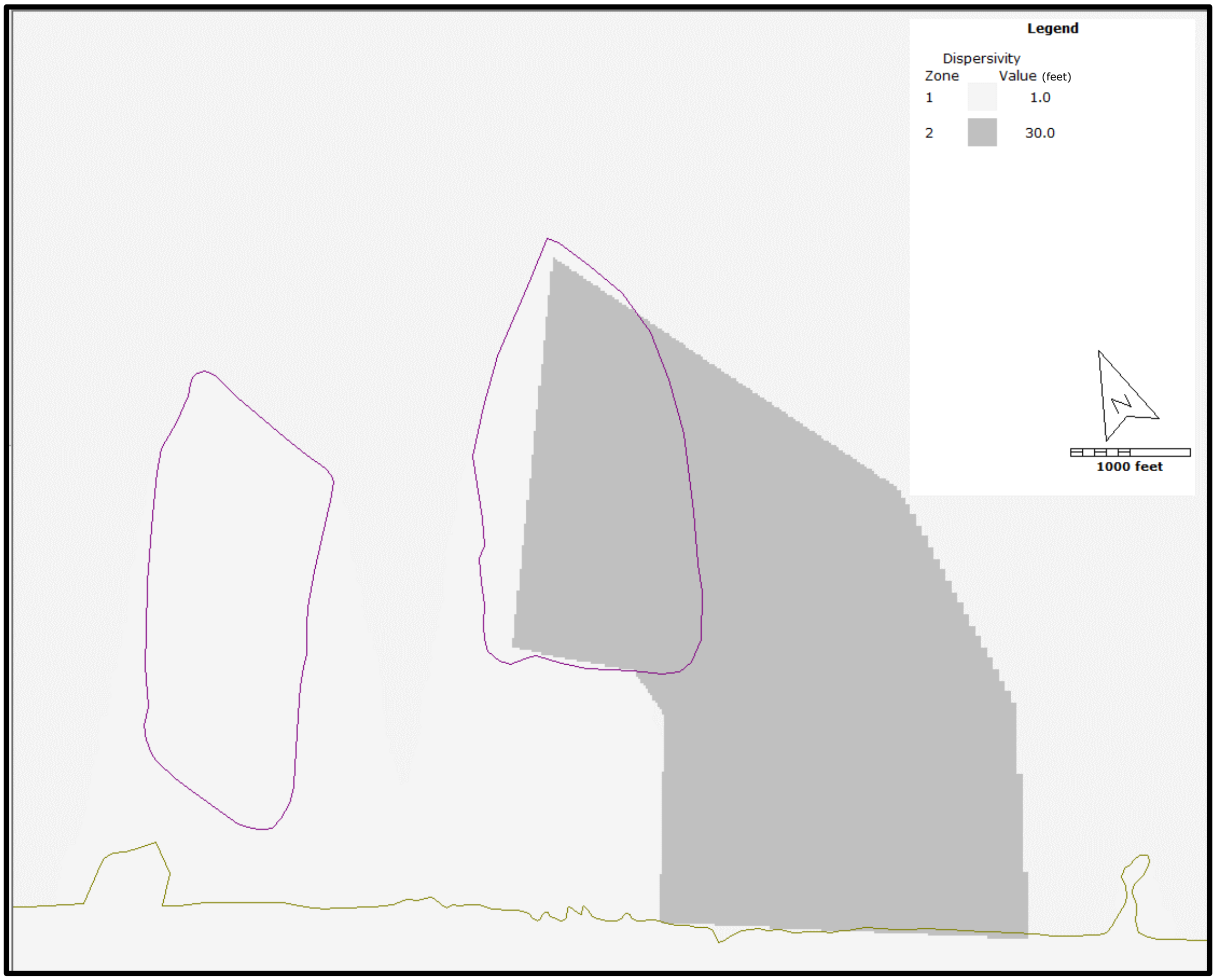


BORON RECHARGE, HISTORIC TRANSPORT MODEL, SP2 AND SP3

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL

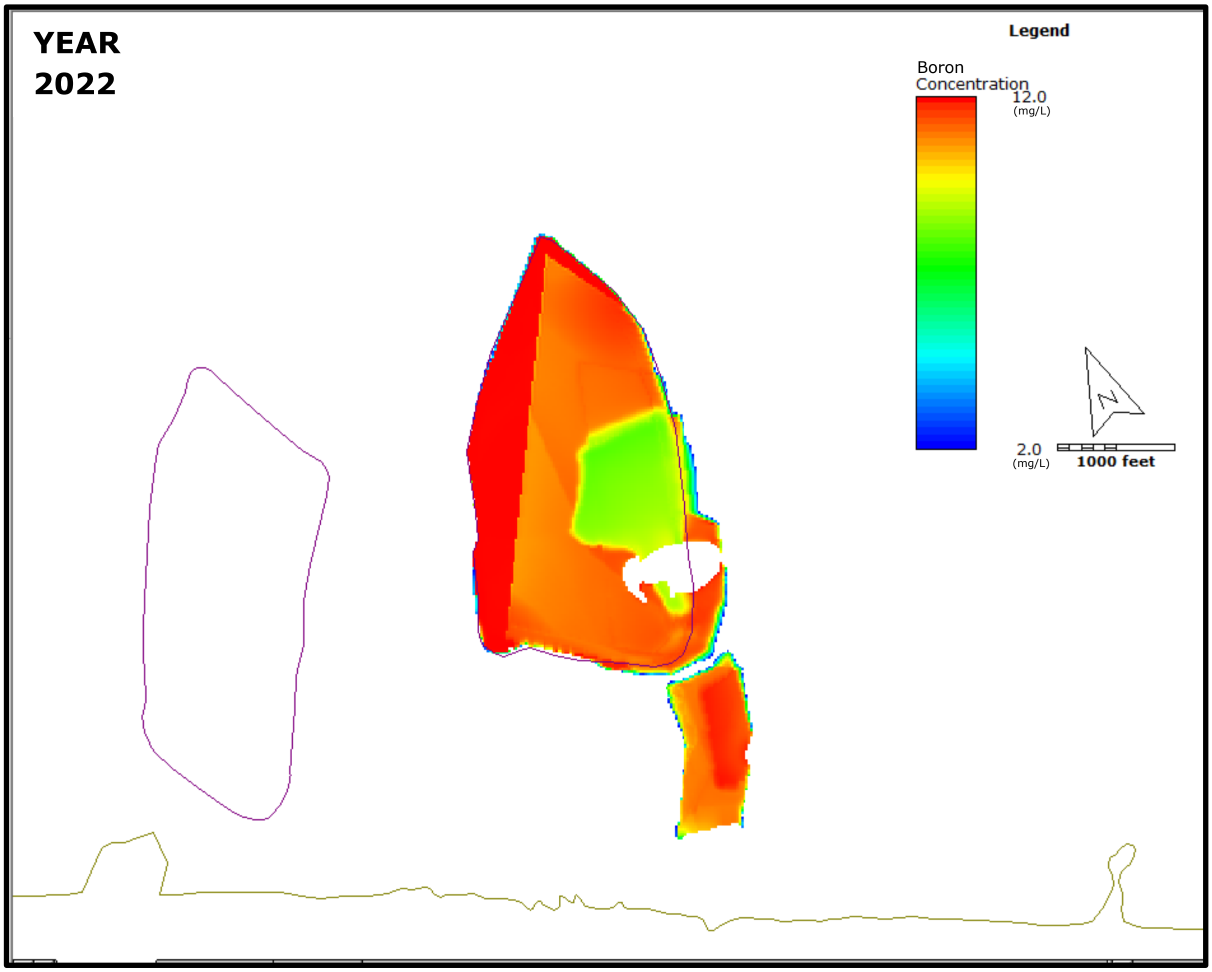
FIGURE 5-19



SIMULATED DISPERSIVITY, TRANSPORT MODEL LAYERS 2 THROUGH 4

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL

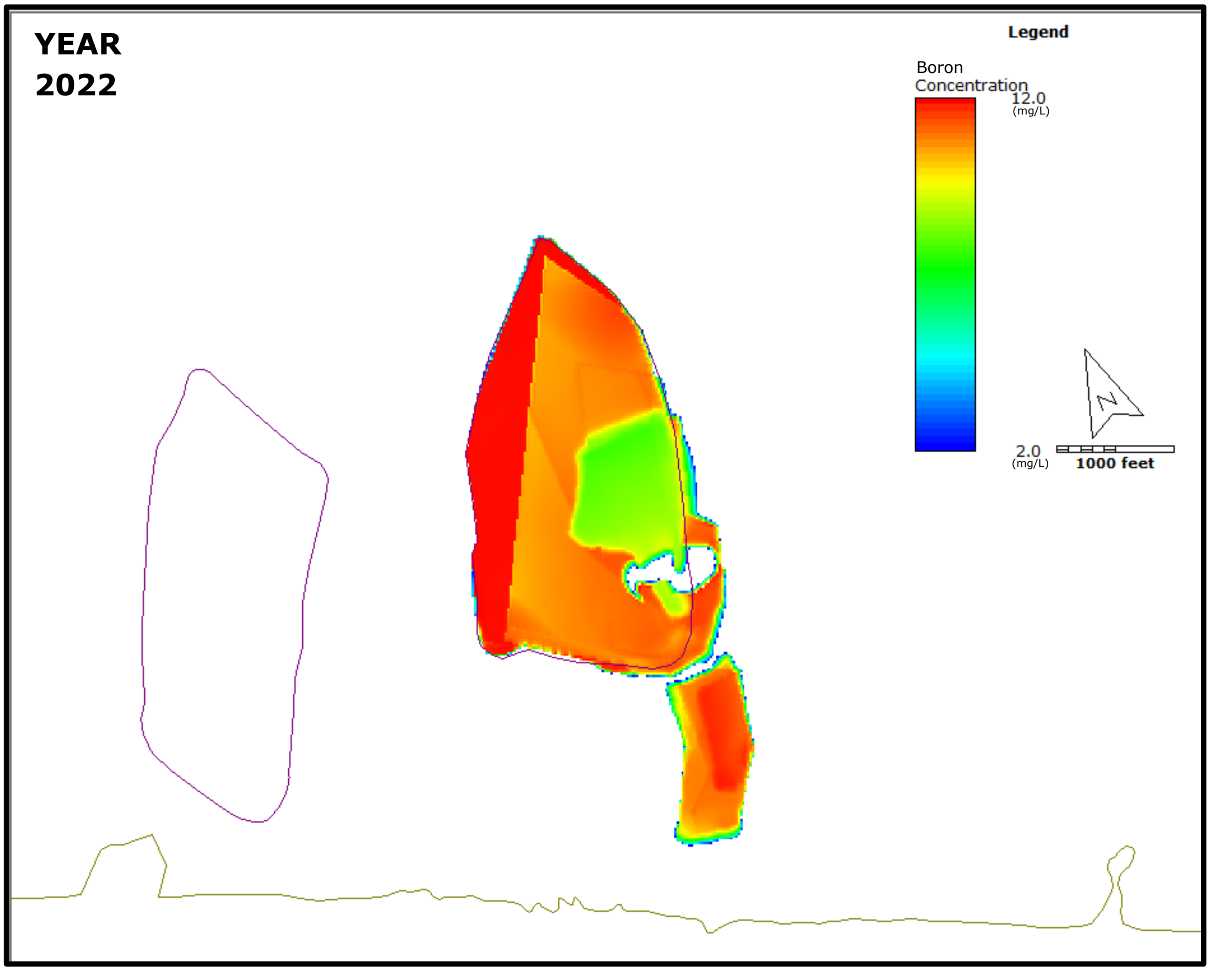


HISTORIC TRANSPORT MODEL SIMULATED BORON CONCENTRATIONS, MODEL LAYER 2

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL

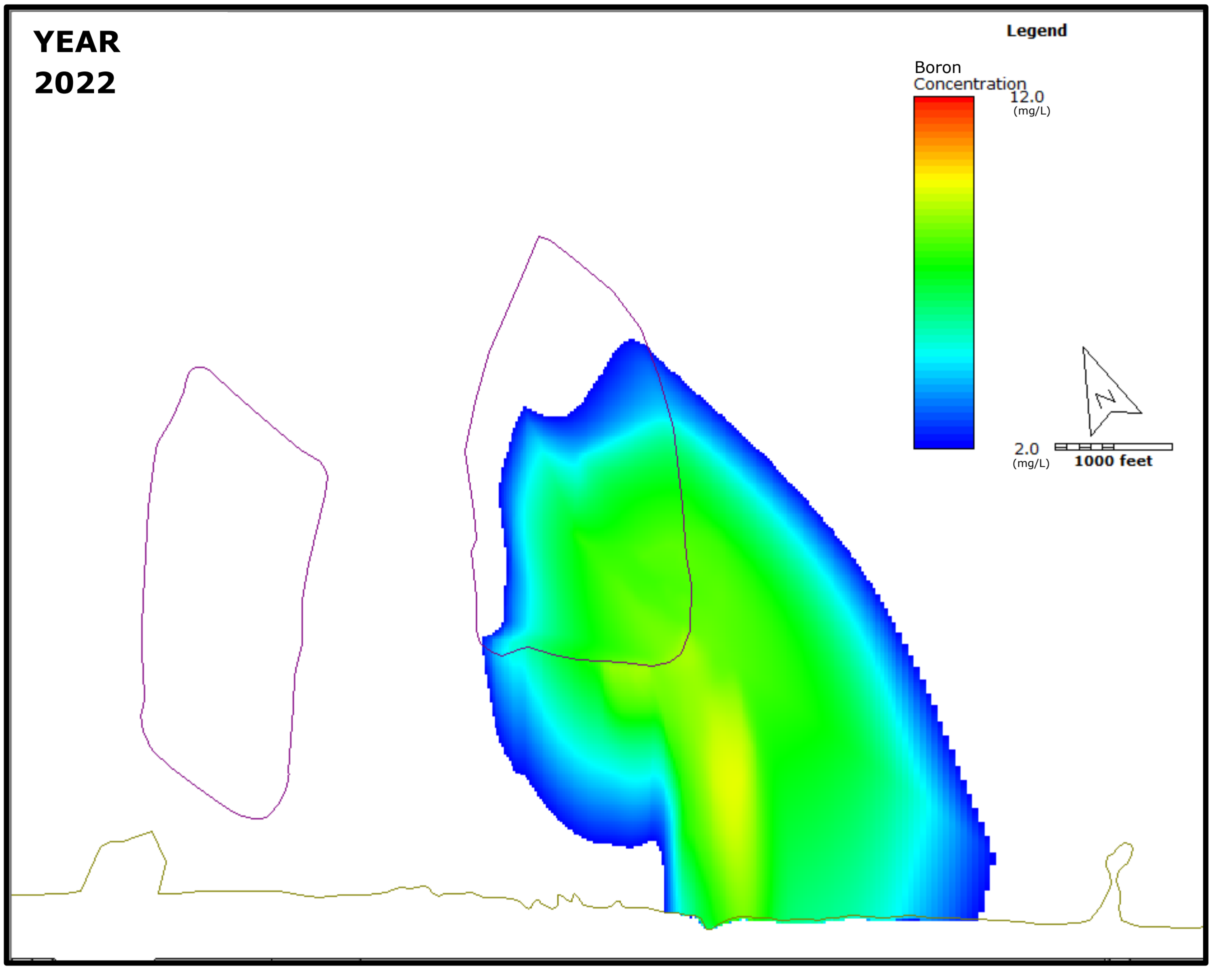
FIGURE 5-21



HISTORIC TRANSPORT MODEL SIMULATED BORON CONCENTRATIONS, MODEL LAYER 3

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

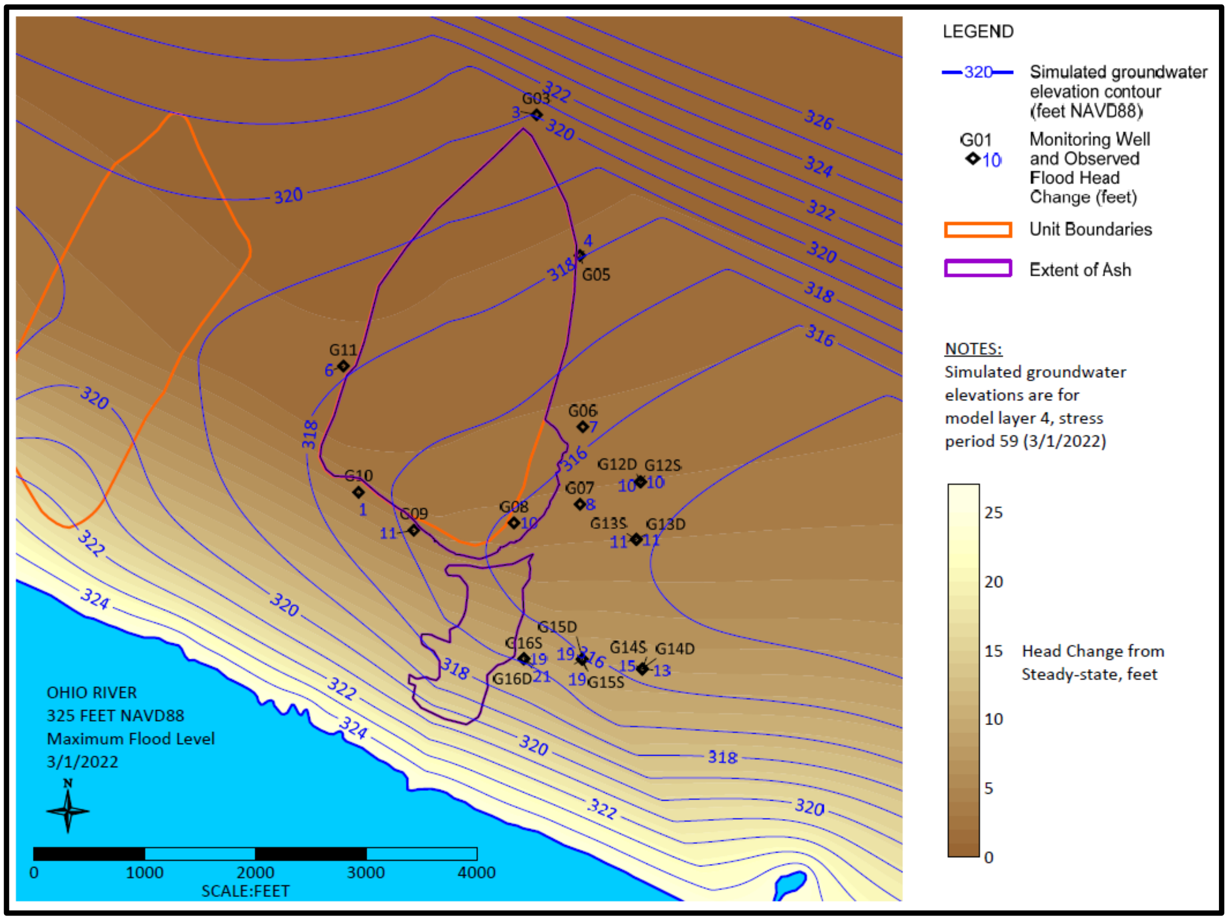
RAMBOLL



HISTORIC TRANSPORT MODEL SIMULATED BORON CONCENTRATIONS, MODEL LAYER 4

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

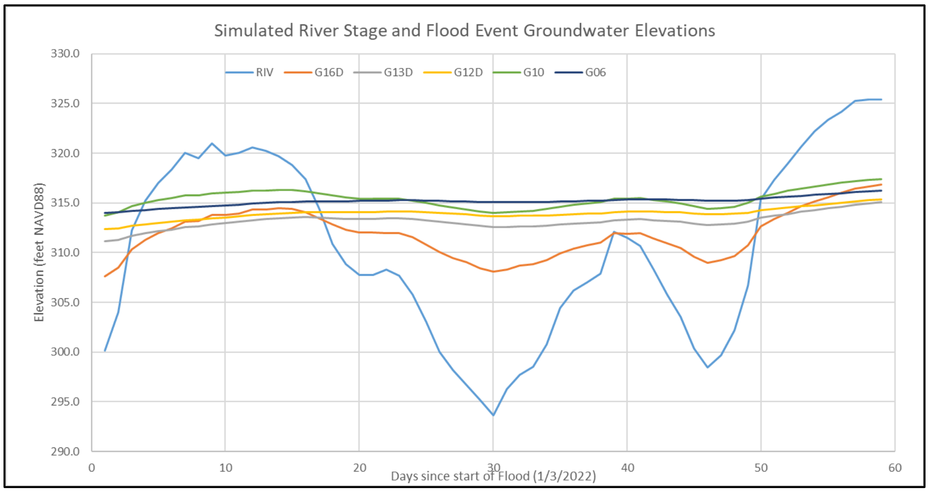
RAMBOLL

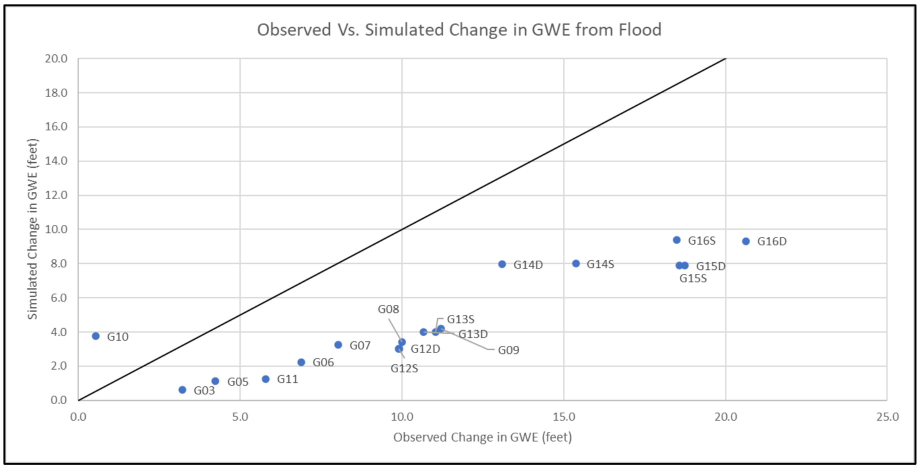


SIMULATED FLOOD EVENT GROUNDWATER ELEVATIONS IN MODEL LAYER 4

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL



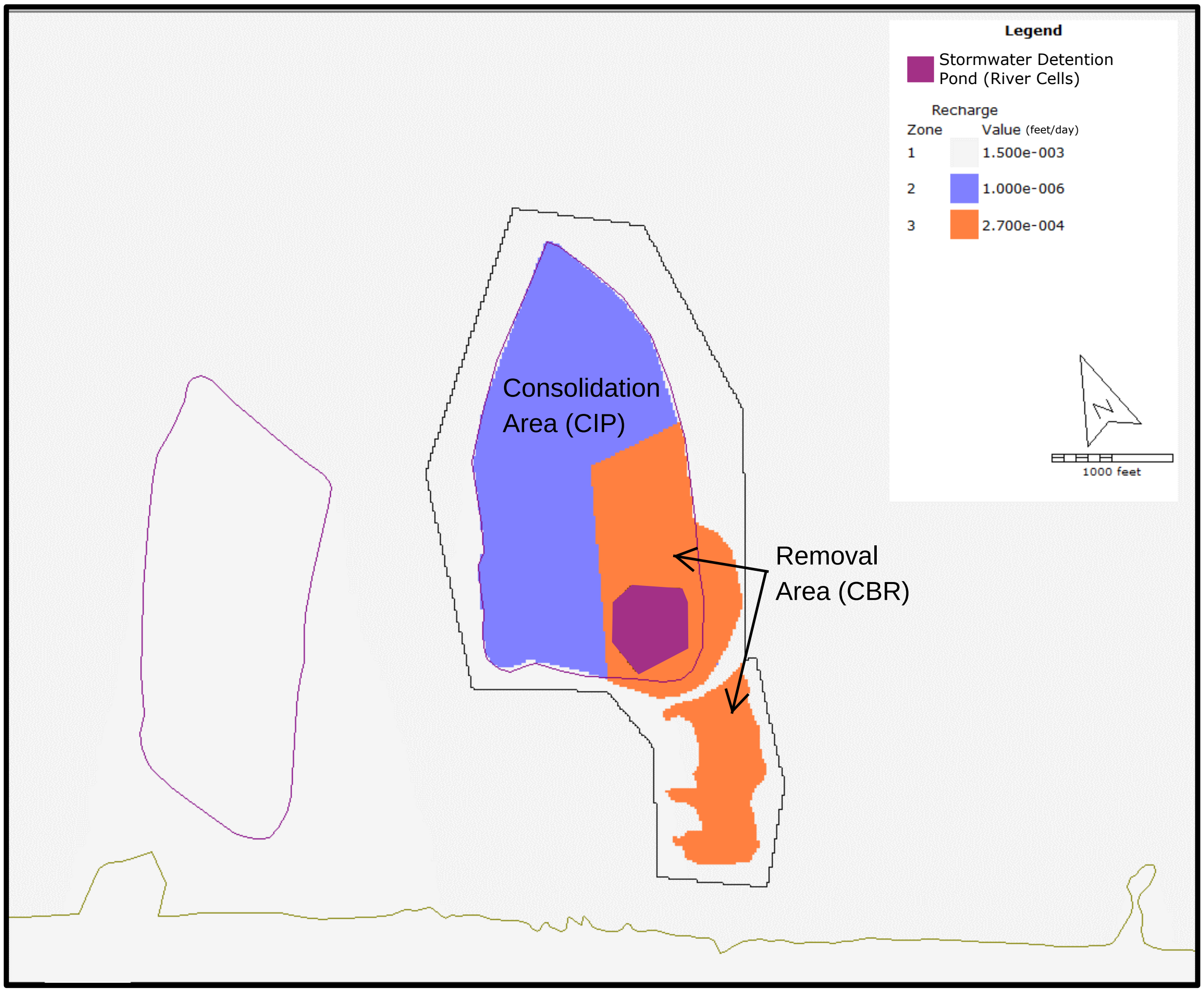


SIMULATED RIVER STAGE AND FLOOD EVENT GROUNDWATER ELEVATIONS

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL

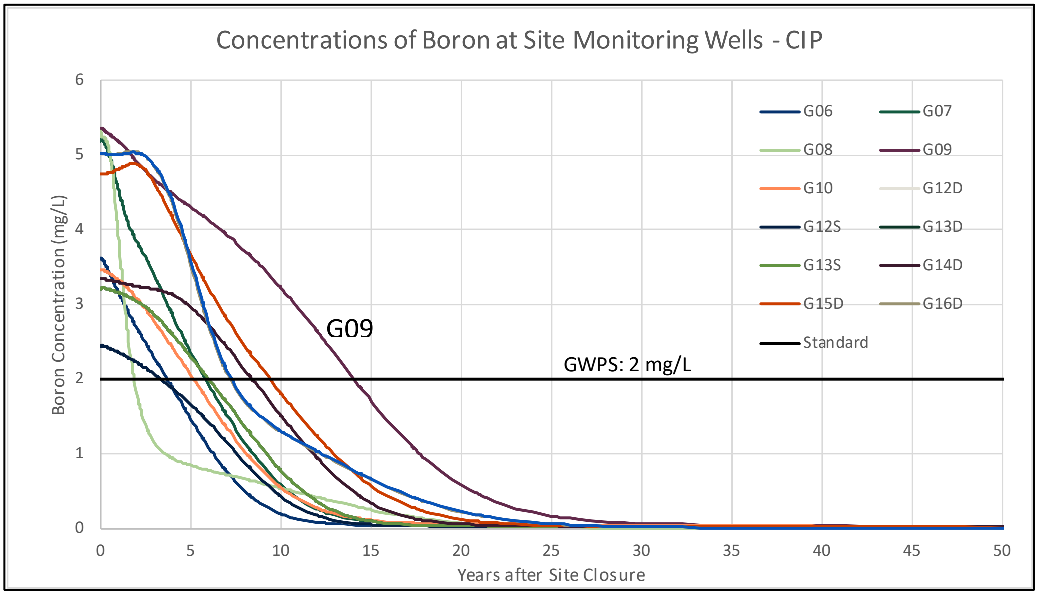
FIGURE 6-1

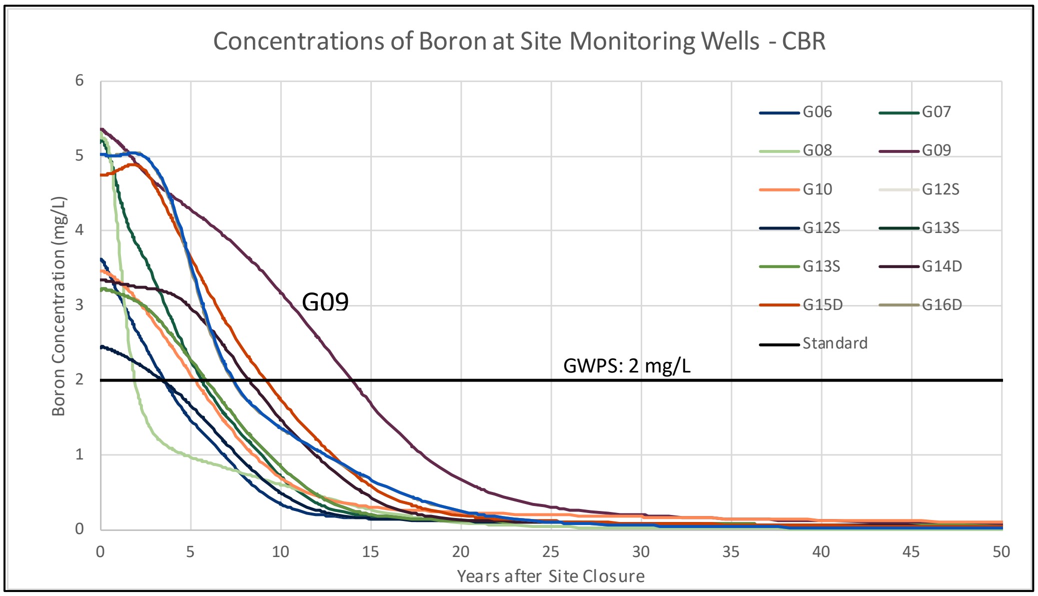


CIP RECHARGE DISTRIBUTION AND BOUNDARY CONDITIONS, MODEL LAYER 1

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL

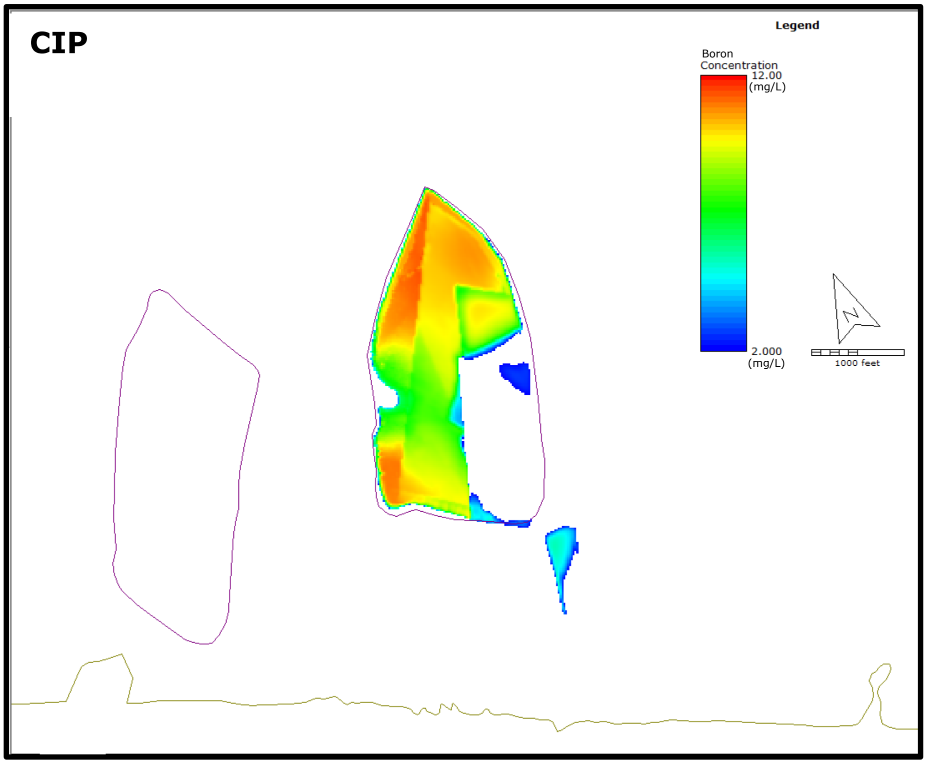


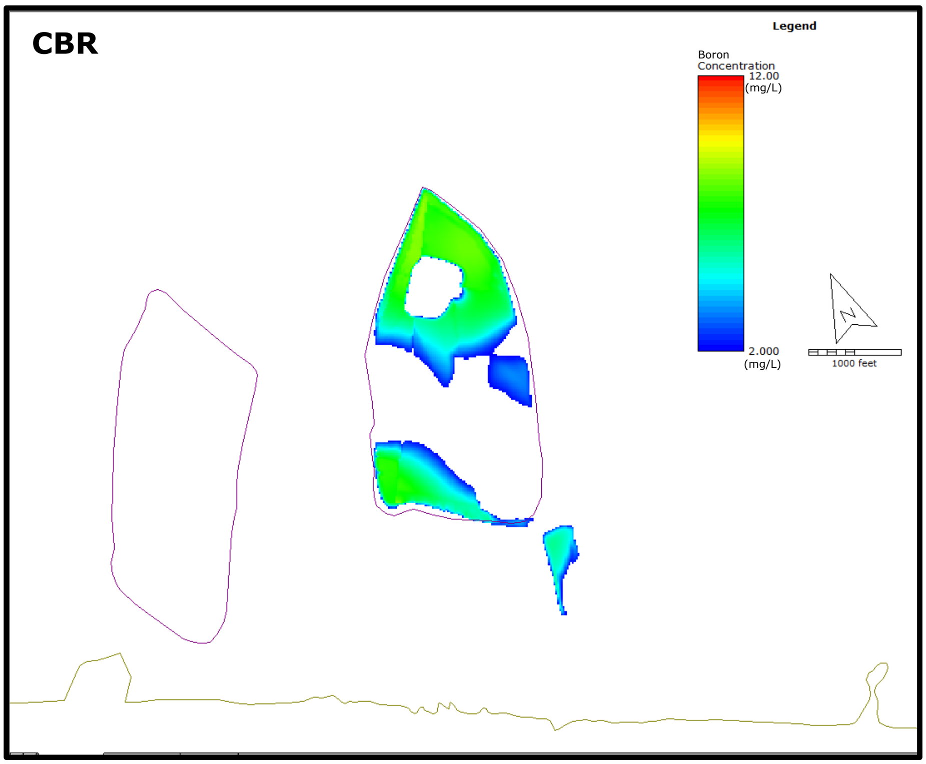


PREDICTED BORON CONCENTRATIONS AT EAP MONITORING WELLS, CIP AND CBR

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL

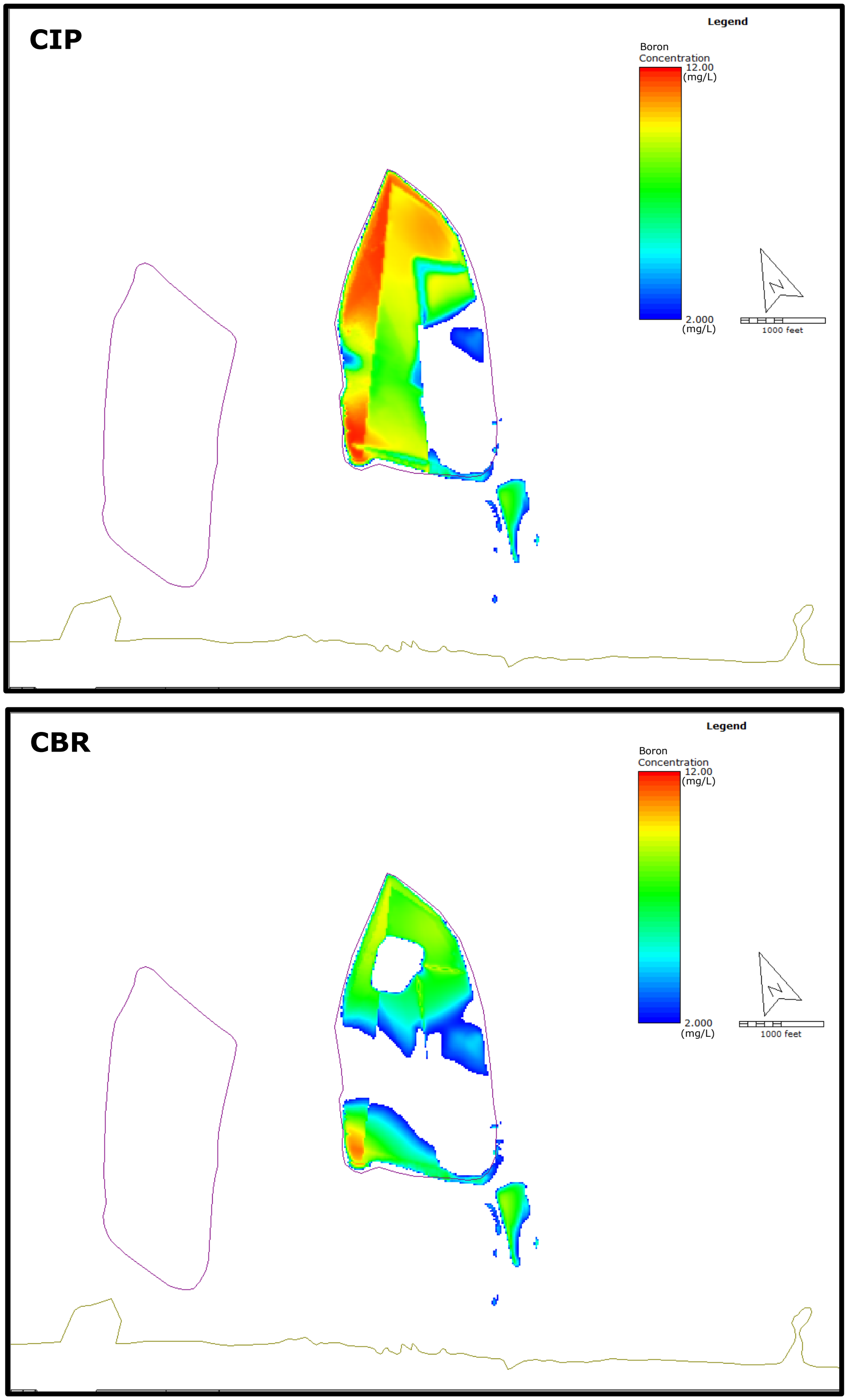




BORON CONCENTRATIONS IN MODEL LAYER 2, 24 YEARS ELAPSED TIME (CIP AND CBR)

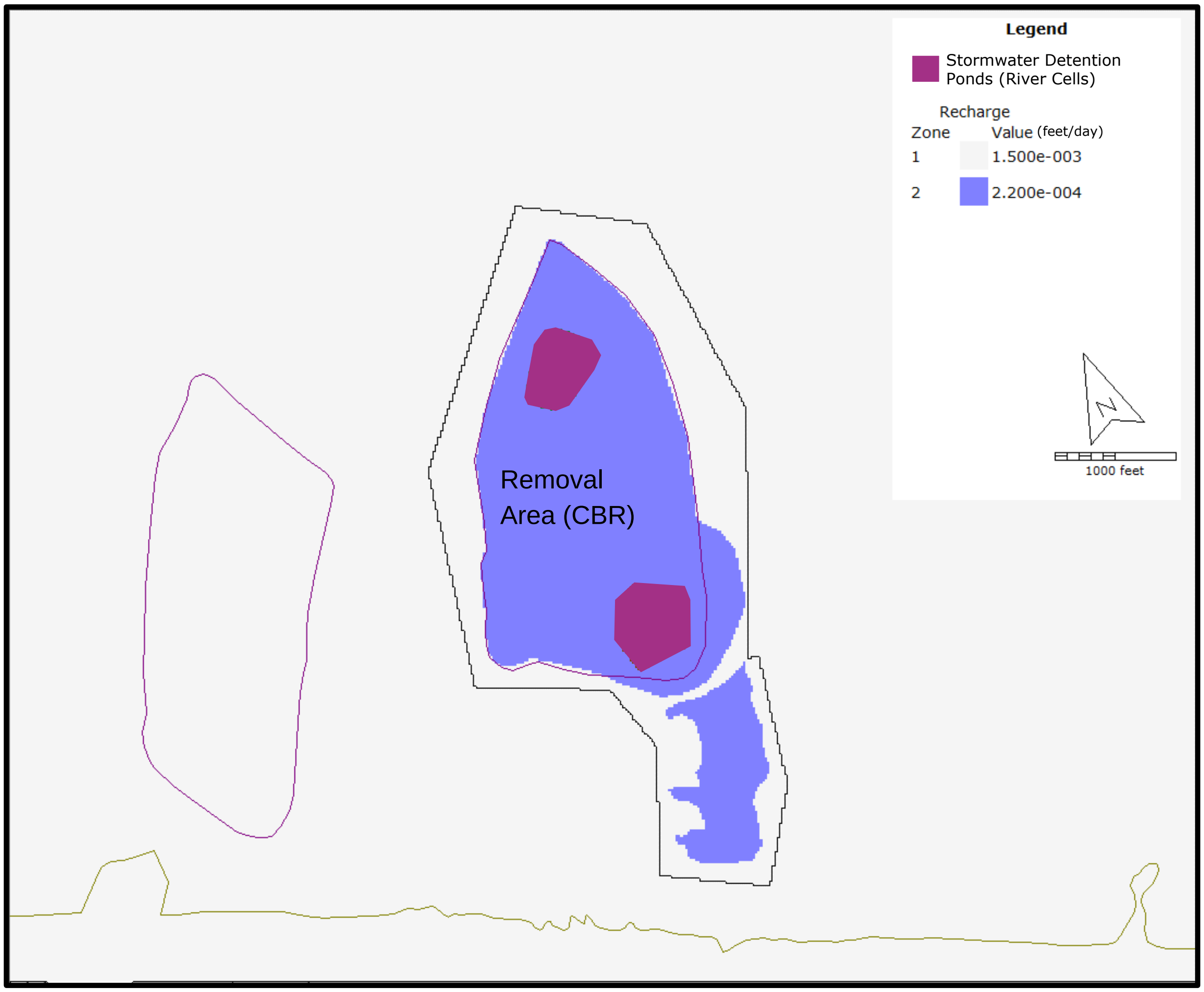
GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL



BORON CONCENTRATIONS IN MODEL LAYER 3, 24 YEARS ELAPSED TIME (CIP AND CBR)

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS



CBR RECHARGE DISTRIBUTION AND BOUNDARY CONDITIONS, MODEL LAYER 1

GROUNDWATER MODELING REPORT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL

APPENDICES

APPENDIX A
EVALUATION OF POTENTIAL GWPS EXCEEDANCES

Intended for
Electric Energy, Inc.

Date
May 23, 2022

Project No.
1940102417

EVALUATION OF POTENTIAL GWPS EXCEEDANCES

JOPPA POWER PLANT
EAST ASH POND
CCR UNIT 401

CONTENTS

FIGURES (IN TEXT)

FIGURES (ATTACHED)

TABLES (IN TEXT)

ACRONYMS AND ABBREVIATIONS

§	section
35 I.A.C.	Title 35 of the Illinois Administrative Code
40 C.F.R.	Title 40 of the Code of Federal Regulations
CCR	coal combustion residuals
GWPS	groundwater protection standard
EAP	East Ash Pond
EEI	Electric Energy, Inc.
ID	identification
IEPA	Illinois Environmental Protection Agency
IQR	interquartile range
JPP	Joppa Power Plant
LAU	lower aquifer unit
LCL	lower confidence limit
LCU	lower confining unit
NAVD88	North American Vertical Datum of 1988
NID	National Inventory of Dams
No.	number
Part 257	40 C.F.R. § 257 Subpart D
Part 845	35 I.A.C. § 845: Standards for the Disposal of Coal Combustion Residuals in Surface Impoundments
PMP	potential migration pathway
Ramboll	Ramboll Americas Engineering Solutions, Inc.
SI	surface impoundment
UA	uppermost aquifer
UCL	upper confidence limit
UCU	upper confining unit
USEPA	United States Environmental Protection Agency

1. INTRODUCTION

Electric Energy, Inc. (EEI) currently operates the Joppa Power Plant (JPP) East Ash Pond (EAP), located in Joppa, Illinois. The EAP is a 111-acre-foot existing unlined coal combustion residuals (CCR) surface impoundment (SI) used to manage CCR and non-CCR waste streams at the JPP. The EAP is regulated under 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). The EAP is identified by Vistra identification (ID) number (No.) 401, Illinois Environmental Protection Agency (IEPA) ID No. W1270100004-02, and National Inventory of Dams (NID) No. IL50714.

EEI is preparing a construction permit application for the EAP as required under Part 845. This application includes groundwater modeling to be completed for the known potential exceedances of groundwater protection standards (GWPS) unless an alternate source can be demonstrated. In October 2021, Ramboll Americas Engineering Solutions, Inc. (Ramboll) identified potential GWPS exceedances for pH in certain monitoring wells in the vicinity of the EAP (Ramboll, 2021a). This document evaluates the source of these potential GWPS exceedances.

2. SITE INFORMATION

The site information has been summarized from the Hydrogeological Site Characterization Report (Ramboll, 2021b). The EAP lies adjacent to and north to northeast of the Ohio River at the southern boundary of the Illinois Basin and the northern edge of the Mississippi Embayment, a relatively low-lying area that is part of the Coastal Plain Physiographic Province. Regionally, the unlithified materials consist of diamictons and lacustrine/alluvial deposits. These deposits may exceed 100 feet in thickness. In addition to CCR material, four principal unlithified deposits exist in the vicinity of the EAP, in descending order: (1) the Equality Formation; (2) Peoria Silt / Roxana Silt / Loveland Silt; (3) Metropolis Formation; and (4) McNairy Formation. The unlithified materials rest on Mississippian-age bedrock. Five water-bearing units have been identified in the vicinity of the EAP based on stratigraphic relationships and common hydrogeologic characteristics. The units are described as follows:

- **CCR:** CCR consisting of fly ash and bottom ash. The amount of saturated fill and CCR in the EAP is generally consistent, ranging from 35 to 45 feet, and the estimated base of ash range from 425 to 435 feet North American Vertical Datum of 1988 (NAVD88).
- **Upper Confining Unit (UCU):** The uppermost hydrostratigraphic unit is comprised of the fine-grained materials from the Equality Formation, the Silt Unit, and Metropolis Formation deposits. The average thickness of this unit is 40.7 feet with a range of 8 to 58 feet. The UCU underlies the CCR fill in all locations and limits the vertical migration of CCR impacts into the uppermost aquifer.
- **Uppermost Aquifer (UA):** This unit consists of the Upper McNairy Formation which is composed of permeable sands and gravels with isolated lenses of finer grained material. This hydrostratigraphic unit at the site was 58 feet thick and is underlain by the LCU.
- **Lower Confining Unit (LCU):** This unit consists of the Lower McNairy Formation which in the vicinity of the EAP is composed of clay and silt overlying the Salem Limestone. Based on material description, continuous lateral extent, and observed vertical gradients, this unit is identified as the LCU.
- **Lower Aquifer Unit (LAU):** This unit is composed of the Salem Limestone bedrock and underlies all unlithified deposits. It is the lowermost hydrostratigraphic unit identified and is considered a potential migration pathway (PMP). The Salem Limestone is used as a potable and non-potable water supply in the vicinity of the JPP.

Groundwater elevations within the EAP are elevated relative to the surrounding area. In general, groundwater flow beneath the EAP is northwest to southeast in the northern half of the EAP, and from southwest and southeast in the southern half of the EAP (Figure 2-1). Groundwater elevations vary seasonally. Slight seasonal variation in groundwater flow directions in the southern part of the EAP have been observed; however, the major component of groundwater flow direction is consistently south toward the Ohio River which is the primary receiving body of water in the vicinity of the JPP (Ramboll, 2021b).

3. POTENTIAL GWPS EXCEEDANCES

As required by Part 845, an evaluation of the history of potential GWPS exceedances was completed for the operating permit application. Data collected since 2015 from the EAP monitoring well network were evaluated using statistical methods described in the Statistical Analysis Plan included in Appendix I of the operating permit application (Ramboll, 2021c). The following monitoring wells and potential exceedances are evaluated in this document:

- pH at wells G06S, G07, G11, and G51D. These wells are screened in the UA. Well G51D was installed in 2015; G06S, G07, and G11 were installed in January 2021.
- pH at well G151. This well is screened in the UCU and was installed in 2010.

The potential exceedances are summarized in Table A below.

Table A. Potential pH exceedances of the GWPS.

Well	Lower Confidence Limit (SU)	Upper Confidence Limit (SU)	Lower GWPS		Upper GWPS	
			Value (SU)	Source	Upper GWPS	Source
G06S	5.5	6.2	6.0	Background	9	Standard
G07	5.9	6.2	6.0	Background	9	Standard
G11	5.8	5.9	6.0	Background	9	Standard
G51D	5.6	5.9	6.2	Background	9	Standard
G151	5.4	5.9	6.0	Background	9	Standard

Monitoring well G51D has been historically monitored in accordance with Title 40 of the Code of Federal Regulations (40 C.F.R.) § 257 Subpart D (Part 257), from 2015 through 2021. The lower confidence limit (LCL) for this well was determined using this data and was compared to the background used in Part 257 compliance monitoring (calculated from data collected between 2015 and 2017). For the other monitoring wells (either newly constructed or not monitored under Part 257), background was determined using data collected from the eight sampling events in 2021 required by Part 845 (Ramboll, 2021a).

4. EVIDENCE THAT POTENTIAL GWPS EXCEEDANCES ARE NOT RELATED TO THE EAP

This document demonstrates that sources other than the EAP (CCR unit) caused the potential GWPS exceedances. Evidence supporting this include the following:

1. The pH exceedances at wells G06S and G07 are not statistically significant.
2. The EAP porewater is not a source of low pH.
3. Background pH is trending downward.

These are described and supported in greater detail below.

4.1 The pH Exceedances at Wells G06S and G07 Are Not Statistically Significant

The preliminary history of potential GWPS exceedances calculation compared the LCL to the lower GWPS for all compounds of concern. However, pH is unique in that it has both a high and a low limit, creating a range of acceptable concentrations. For a pH "exceedance" to occur, the full range of the observed data (characterized by both the LCL and the upper confidence limit [UCL]) would need to fall outside of the GWPS range. Practically, this means that for a pH exceedance to occur, the UCL would fall below the lower GWPS, or the LCL would fall above the upper GWPS. Although the pH LCLs at wells G06S and G07 fall below the lower GWPS (Table A), the UCL remains above the lower GWPS. Therefore, the previously determined pH exceedances at G06S and G07 are not significant.

4.2 The EAP Porewater is Not a Source of Low pH

Box-and-whisker plots graphically represent the range of values of a given dataset using lines to construct a box where the lower line, midline, and upper line of the box represent the values of the first quartile, median, and third quartile values, respectively. The minimum and maximum values of the dataset (excluding outliers) are illustrated by whisker lines extending beyond the first and third quartiles of (*i.e.*, below and above the box). The interquartile range (IQR) is the distance between the first and third quartiles. Outliers (values that are at least 1.5 times the IQR away from the edges of the box) are represented by single points plotted outside of the range of the whiskers. The number in parentheses below each plot is the number of observations (*i.e.,* samples) represented in that dataset.

Figure A below provides a box-and-whisker plot of the pH data collected between 2015 and 2021 at the wells with potential exceedances. The range of pH observed in the CCR porewater is consistently higher than the pH observed in the potential exceedance wells. If the EAP were the source of low pH, the pH would have to be equal to or lower than the pH in the potential exceedance wells. Therefore, the EAP is not the source of the low pH exceedances.

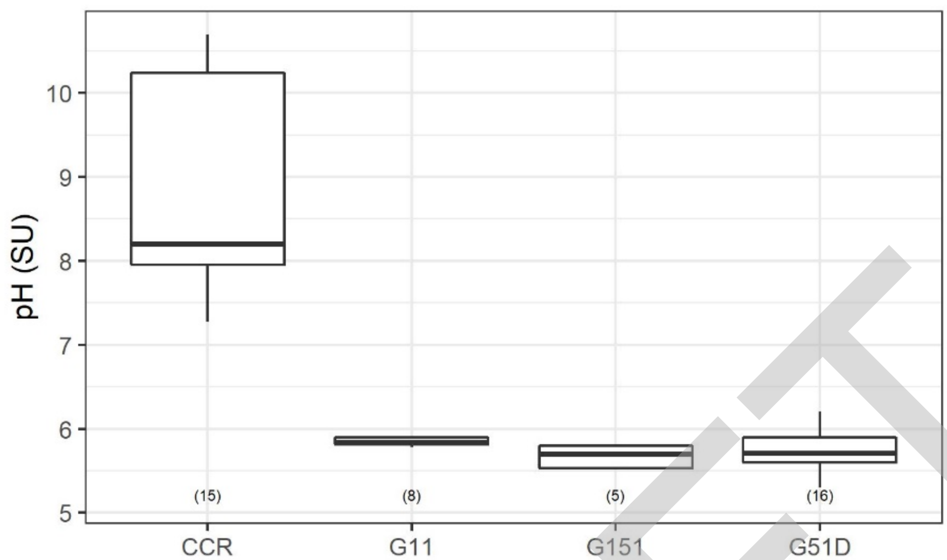


Figure A. pH Ranges Measured in CCR Porewater and Monitoring Wells from 2015 to 2021. The number in parentheses below each box plot represents the sample count.

4.3 Background pH Is Trending Downward

The GWPS used to determine the exceedances at G11 and G151 was based on background data collected during eight sampling events in 2021 conducted for the purpose of establishing a monitoring program compliant with Part 845. Background data was collected from locations G01D and G02D located upgradient from the EAP. The pH at both wells during this sampling period had significant downward trends, determined using a Mann-Kendall trend test with a significance level of 0.05 (Figure B below). As described in the United States Environmental Protection Agency's (USEPA) *Unified Guidance* document, a trend in background data can cause inappropriate determination of background values because the mean of the data is changing over time (USEPA 2009, Section 5.2). In this case, the background would be inappropriately high due to the decreasing mean of the data.

The *Unified Guidance* suggests several possibilities that could cause trends in background data, including contamination of the background or site-wide changes in the aquifer composition. Groundwater flow at the site is generally from the north and west. The site property is bordered by a cement plant to the west and a compressor station to the west and north (Ramboll, 2021c). Therefore, there is a possibility that the decrease in pH is driven by off-site activities. The pH of both background wells decreasing at the same rate (shown by the equivalent slopes of the trend lines) indicates that the change may also indicate a site-wide change in aquifer conditions. In either case, the upgradient decline in pH could influence the determination of exceedances by causing an inappropriately high determination of background.

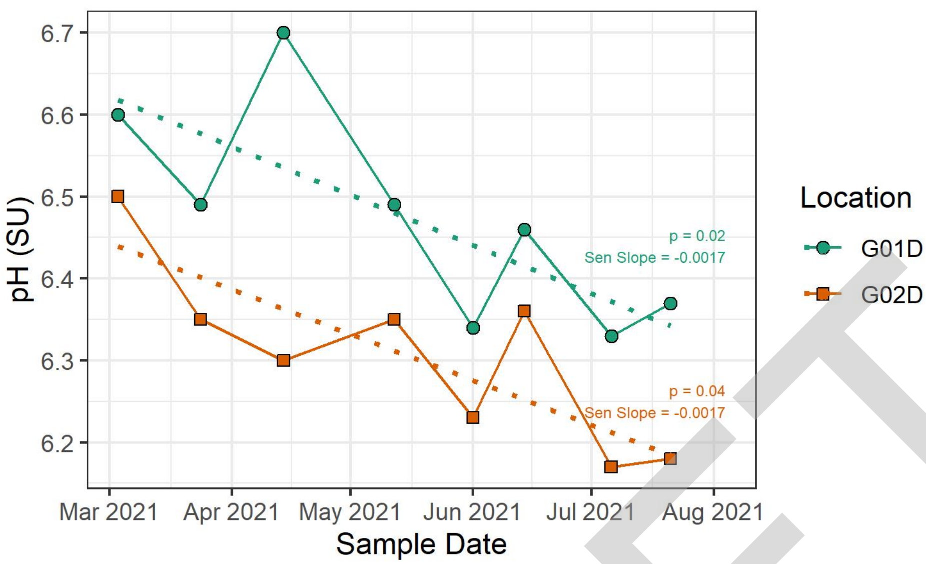


Figure B. 2021 Sampling Data and Mann-Kendall Trend Test Results for pH in Background Wells.

5. CONCLUSIONS

Several lines of evidence indicate that the potential pH exceedances identified are not caused by the EAP. When more rigorous statistical comparison of the data to the GWPS is made, two wells are found to not have a potential pH exceedance. Additionally, the EAP porewater does not have low pH comparable to the potentially affected wells. Finally, the background used for several of the GWPS comparisons has a significant downward trend indicative of changing aquifer conditions outside the influence of the EAP. It is therefore unlikely that the EAP is the cause of the low pH GWPS exceedances.

6. REFERENCES

Ramboll Americas Engineering Solutions, Inc. (Ramboll), 2021a. *History of Potential Exceedances, Joppa East Ash Pond, Joppa Power Plant*. October 25, 2021.

Ramboll Americas Engineering Solutions, Inc. (Ramboll), 2021b. *Hydrogeologic Site Characterization Report, Joppa East Ash Pond, Joppa Power Plant*. October 25, 2021.

Ramboll Americas Engineering Solutions, Inc. (Ramboll), 2021c. *Statistical Analysis Plan, Joppa East Ash Pond, Joppa Power Plant*. October 25, 2021.

United States Environmental Protection Agency (USEPA), 2009. *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities: Unified Guidance*. EPA 530-R-09-007.

FIGURES

PROJECT: 169000XXXX | DATED: 9/28/2021 | DESIGNER: STOLZSD

Y:\Mapping\Projects\22\2285\MXD\845_Operating_Permit\Joppa\Figure 3-5_GWE_Contours_20210511_12.mxd

BACKGROUND WELL

MONITORING WELL

SOURCE SAMPLE LOCATION

STAFF GAGE

GROUNDWATER ELEVATION CONTOUR (1-FT CONTOUR INTERVAL, NAVD88)

PART 845 REGULATED UNIT (SUBJECT UNIT)

PROPERTY BOUNDARY

0 200 400 Feet

NOTES:
1. ELEVATIONS IN PARENTHESIS WERE NOT USED FOR CONTOURING.
2. ELEVATIONS SHOWN IN FEET, NORTH AMERICAN VERTICAL DATUM OF 1988

UPPERMOST AQUIFER POTENTIOMETRIC SURFACE MAP
MAY 11 AND 12, 2021

EVALUATION OF POTENTIAL GWPS EXCEEDANCES

JOPPA POWER PLANT
JOPPA, ILLINOIS

FIGURE 2-1

RAMBOLL AMERICAS ENGINEERING SOLUTIONS, INC.

RAMBOLL

APPENDIX B
HYDROGEOLOGIC UPDATES FOR CONSTRUCTION PERMIT

ENVIRONMENT
& HEALTH

HYDROGEOLOGIC UPDATES FOR CONSTRUCTION PERMIT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, IL

Project name	**Joppa East Construction Permit**
Project no.	**1940102417**
Version	**DRAFT**
Date	**May 31, 2022**
Prepared by	**Nathaniel Keller**
Checked by	
Approved by	
Description	**Evaluation and documentation of recently installed monitoring wells, the base of CCR, the top of the uppermost aquifer and the average water table for use in the Closure Plan and Groundwater Modeling Reports**

CONTENTS

Tables

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Appendices

1. Introduction

1.1 Background

In October 2021, Ramboll Americas Engineering Solutions, Inc. (Ramboll) completed a Hydrogeologic Site Characterization Report (HCR; Ramboll, 2021) for the East Ash Pond (EAP) at Joppa Power Plant (JPP). The report was included in the Operating Permit Application (Burns & McDonnell, 2021) that was submitted to the Illinois Environmental Protection Agency (IEPA). The report was assembled to meet the information and analysis requirements of Title 35 of the Illinois Administrative Code (35 I.A.C.) Section (§) 845.620 and included hydrogeologic and groundwater quality data specific to the EAP, which had been collected between 2015 and 2021.

Additional monitoring wells (G12S, G12D, G13S, G13D, G14S, G14D, G15S, G15D, G16S, and G16D) were installed in the fall of 2021 between the EAP and the JPP property boundary to further evaluate groundwater quality consistent with 35 I.A.C. § 845.600(a)(1). Groundwater samples were collected from the expanded well network in January and February 2022, and confirmed on March 7, 2022. During preparation of the Closure Plan (Geosyntec Consultants, Inc. [Geosyntec], 2022) and groundwater model to evaluate closure scenarios, the conceptual model was updated to include the recent hydrogeologic information, as well as additional evaluations completed to define the bottom/base elevation of the CCR material in the EAP, the top elevation of the uppermost aquifer (UA), and the average water table elevation in the upper confining unit (UCU). This report includes the recent (2022) hydrogeologic information as well as summarizes and documents the results of the additional evaluations.

1.2 Site Location

The JPP is west of the Village of Joppa in Massac County, Illinois, northeast of the Ohio River in Section 14, Township 15 South, Range 3 East (**Figure 1-1**). The JPP property is bordered by LaFarge North America cement plant to the west, Trunkline Gas Company-Joppa Compressor Station to the north and west, the Village of Joppa to the east, and the Ohio River to the south. The EAP is located in the west half of Section 14 directly north of the JPP and is bounded immediately to the east by the railway right-of-way, which is adjacent to forested portions of residential property in the Village of Joppa. **Figure 1-1** shows the location of the plant; **Figure 1-2** is a site map showing the location of the EAP.

2. Hydrogeologic Investigation and Additional Evaluations

2.1 Hydrogeologic Investigation

Ten wells were installed at the JPP property boundary in fall of 2021 to further evaluate groundwater quality consistent with 35 I.A.C. § 845.600(a)(1). Soil boring logs and well construction forms are included in **Appendix A**. Consistent with the HCR (Ramboll, 2021), the additional borings encountered the following hydrostratigraphic units (from ground surface down, **Figure 2-1**):

- **Upper Confining Unit (UCU):** Low permeability silt and clay of the Equality Formation, silts of the Peoria/Roxana/Loveland, and clay and silt of the Metropolis Formation are considered the UCU. This unit was encountered in all borings advanced downgradient of the EAP.
- **Uppermost Aquifer (UA):** High permeability sands with gravel, silt, and clay lenses of the McNairy Formation. The UA was encountered in the downgradient wells at elevations ranging from 226.06 to 312.06 feet North American Vertical Datum of 1988 (NAVD88).

- **Lower Confining Unit (LCU):** Clay, silt, or chert gravel residuum in on-site wells (Nelson, 1997) has been interpreted and characterized as part of the Lower McNairy Formation, Post Creek (Tuscaloosa) Formation, or weathered limestone residuum. This material was encountered in two borings that penetrated the entire thickness of sand (G14D and G15D) at elevations of 214.81 and 233.97 feet NAVD88, respectively. Based on material descriptions (high clay and/or silt content, and partial cementation), continuous lateral extent, and vertical gradients observed between the UA and the LAU, this unit is identified as the LCU.
- **Lower Aquifer Unit (LAU):** Lowermost unit identified at the site and underlies all unlithified deposits. This unit is comprised of the Salem Limestone (bedrock), which is the uppermost lithified unit at the site, and used as a potable and non-potable water supply in the vicinity of the JPP. The LAU was encountered in G14D at approximately 208.31 feet NAVD88.

Following well installation and development, groundwater elevations were measured, and the wells were sampled for 35 I.A.C. § 845.600 parameters during three events (January, February, and March 2022). Results of the groundwater sampling are summarized in **Table 2-1**, groundwater elevations are included in **Table 2-2**. Results from monitoring wells screened within the UA downgradient of the EAP indicate potential exceedances primarily for boron. Boron concentrations above the GWPS of 2 milligrams per liter (mg/L) have been observed in monitoring wells adjacent to the EAP (G06, G07, G08, G09, G10) and downgradient (G12S, G12D, G13S, G13D, G14D, G15S, G15D, G16S, and G16D). Porewater samples collected from within the EAP indicate boron concentrations range from 9.42 to 12.2 mg/L, while boron concentrations in the downgradient wells with potential exceedances range from 2.89 to 7.88 mg/L (**Table 2-1**).

2.2 Base of CCR

Information in the HCR indicated that the base of the CCR material within the EAP extends to an elevation of 327.7 feet NAVD88 (Ramboll, 2021). This elevation provided in the report was the most conservative (lowest) elevation where CCR was observed in the limited number of borings advanced within the footprint of the EAP. To assess closure options, a detailed base of ash surface was required to estimate CCR volumes (for removal or consolidation) and define the geologic layers in the groundwater model.

Geosyntec (2022) evaluated the base of CCR within the EAP using existing soil borings, cone penetrometer data, and the preconstruction historical topographic map and developed a base of CCR surface (**Figure 2-2**) for use in groundwater modeling and evaluation of closure scenarios. Boring logs and cone penetrometer testing results were used in the EAP where available, and the historic topographic contours were used in areas without any investigation to develop a comprehensive base of ash surface. The results are summarized as follows:

- The base of ash ranges in elevation from approximately 310 to 350 feet NAVD88
- CCR is at the lowest elevation (approximately 309 feet NAVD88) in the southeast corner of the EAP and is generally located within the former drainage feature identified on historic topographic maps
- Based on surface elevations, the average thickness of CCR material in the EAP is approximately 50 feet

Review of historic boring logs also indicated the presence of additional CCR material outside the berms and near the southeast corner of the EAP. The extent and base elevations of this CCR material outside the EAP are currently being defined, but preliminary base elevations are illustrated on **Figure 2-3**. Based on preliminary information the elevation of the base of ash in the southeast area ranges from 316 to 334 feet NAVD88, with the lowest elevations occurring in locations within or near the historic drainage feature.

2.3 Top of Uppermost Aquifer

As discussed in the HCR, the UA is comprised of sand and gravel, and was classified as the McNairy Formation. The unit was encountered at its shallowest elevation (approximately 319 feet NAVD88) at C004 located on the east/southeast edge of the EAP. The elevation of G06 that was included in the HCR (Ramboll, 2021) was revised (from approximately 319 to 313 feet NAVD88) following additional evaluation of the boring logs. Descriptions of soil that were dry, cohesive, tight, and/or had elevated fines were not included in the UA definition, as a result the elevation at this location was lowered. The top of the UA (Figure 3-2 in the HCR; Ramboll, 2021) was based on wells installed in 2015 and didn't include information from the 35 I.A.C. § 845 well installation.

Review of boring logs and the cone penetrometer test results was completed to refine the top of UA to construct layers for the groundwater modeling. In areas where there were multiple sources of information for the top of aquifer elevation, data was evaluated for potential errors and uncertainty and a representative elevation was selected. In general, the variability between adjacent points was less than 2 feet. Based on this analysis the top of the UA was refined and contoured (**Figure 2-4**). As illustrated in **Figure 2-4**, the UA is highest (C004, approximately 319 feet NAVD88) along the boundary of the EAP near the southeast corner and generally elevated in an east-west trending ridge across the center of the EAP. The lowest elevation (approximately 278 feet NAVD88) occurs at G52D which is located on the south/southeast corner of the EAP.

2.4 Water Table Evaluation

As presented in the HCR (Ramboll, 2021), the groundwater elevation in wells within the UCU (G101, G151, G152B, G153, and G54S) from March to July 2021 averaged 322.75 feet NAVD88, with a range from 310.25 feet NAVD88 in G54S (southwest corner of the EAP) to 338.96 feet NAVD88 in G152B (southern edge of EAP). Well G152B, located south of the EAP, consistently recorded the highest groundwater elevation, with an average groundwater elevation of 335.58 feet NAVD88. The elevated groundwater here is assumed to be a result of well G152B screen being situated in low conductivity materials. Groundwater elevations at well G151 (along the western edge of the EAP) were also consistently higher than the remaining UCU wells, with an average groundwater elevation of 326.97 feet NAVD88.

A summary of groundwater elevations and averages from the UCU wells during 2021 is provided in **Table 2-3** and the average groundwater elevation at each well is contoured in **Figure 2-5**. The average water table elevation measured in 2021 ranges from 314.1 to 335.9 feet NAVD88 and the flow direction is generally from the west to the east and south, around a groundwater mound that is consistently measured in G152B (as discussed above).

3. Conclusions

The results described above were used to evaluate the proposed closure options and determine separation distances between the base of the CCR and the top of the UA. Evaluation of the water table and CCR was not completed because water elevations measured in the UCU may be influenced by the hydraulic head inside the EAP since the wells are screened in low permeability materials directly adjacent to the EAP. These conditions indicate measurements may not represent the water table following closure of the unit.

The separation distance between the base of CCR and the top of the UA is illustrated on **Figure 3-1**. Separation distance ranges from 0.5 ft to 89 feet with an average of approximately 31 feet. The separation distances are smallest in the southeast corner of the EAP within the former drainage feature where the top of the UA is shallowest.

4. References

Burns & McDonnell, 2021. *Initial Operating Permit Application*, Joppa East Ash Pond. October 25, 2021.

Geosyntec Consultants, Inc. (Geosyntec), 2022. *CCR Surface Impoundment Final Closure Plan, Joppa Power Plant, East Ash Pond, Joppa, Illinois*. April 26, 2022.

Nelson, W. John, 1997. *ISGS Core Study*. January 1997.

Ramboll Americas Engineering Solutions, Inc. (Ramboll), 2021a. *Hydrogeologic Site Characterization Report*. East Ash Pond. Joppa Power Plant, Joppa, Illinois. October 25, 2021.

TABLES

TABLE 2-1. GROUNDWATER ANALYTICAL RESULTS
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Location	Sample Date	Antimony, total (mg/L)	Arsenic, total (mg/L)	Barium, total (mg/L)	Beryllium, total (mg/L)	Boron, total (mg/L)	Cadmium, total (mg/L)	Calcium, total (mg/L)	Chloride, total (mg/L)	Chromium, total (mg/L)	Cobalt, total (mg/L)	Fluoride, total (mg/L)	Lead, total (mg/L)	Lithium, total (mg/L)	Mercury, total (mg/L)	Molybdenum, total (mg/L)	pH (field) (SU)	Radium 226 + Radium 228 (pCi/L)	Selenium, total (mg/L)	Sulfate, total (mg/L)	Thallium, total (mg/L)	Total Dissolved Solids (mg/L)
35 I.A.C. 845.600	Lower	0	0	0	0	0	0	--	0	0	0	0	0	0	0	0	6.5	0	0	0	0	0
	Upper	0.006	0.010	2.0	0.004	2	0.005	--	200	0.1	0.006	4.0	0.0075	0.04	0.002	0.1	9.0	5	0.05	400	0.002	1200
G01D	03/14/2022	<0.001	<0.001	0.128	<0.001	<0.025	<0.001	26.1	8	0.0026	<0.001	0.22	<0.001	<0.003	<0.0002	<0.0015	**6.4**	1.1	0.0012	22	<0.002	318
G02D	03/14/2022	<0.001	<0.001	0.148	<0.001	0.0283	<0.001	38.2	22	<0.0015	<0.001	0.23	<0.001	<0.003	<0.0002	<0.0015	6.5	0.905	0.0012	11	<0.002	260
G12S	01/20/2022	<0.001	<0.001	0.0367	<0.001	**5.91**	<0.001	83.7	19	<0.0015	<0.001	0.28	<0.001	<0.003	<0.0002	<0.0015	**6.3**	0.228	<0.001	175	<0.002	470
G12S	02/10/2022	<0.001	<0.001	0.0343	<0.001	**5.89**	<0.001	78.8	19	<0.0015	<0.001	0.28	<0.001	<0.003	<0.0002	<0.0015	6.6	0.672	<0.001	211	<0.002	432
G12S	03/16/2022	<0.001	<0.001	0.0287	<0.001	**5.83**	<0.001	80.8	19	<0.0015	<0.001	0.27	<0.001	<0.003	<0.0002	<0.0015	6.5	0.329	<0.001	209	<0.002	456
G12D	01/20/2022	<0.001	<0.001	0.0449	<0.001	**6.94**	<0.001	88.4	18	<0.0015	0.0014	0.27	<0.001	<0.003	<0.0002	<0.0015	6.5	1.09	<0.001	195	<0.002	492
G12D	02/10/2022	<0.001	<0.001	0.0361	<0.001	**6.38**	<0.001	85.8	19	<0.0015	<0.001	0.27	<0.001	<0.003	<0.0002	<0.0015	6.7	0.212	<0.001	191	<0.002	458
G12D	03/16/2022	<0.001	<0.001	0.0282	<0.001	**6.79**	<0.001	88.1	19	<0.0015	<0.001	0.26	<0.001	<0.003	<0.0002	<0.0015	6.6	0.33	<0.001	225	<0.002	482
G13S	01/20/2022	<0.001	<0.001	0.0341	<0.001	**5.22**	<0.001	82.2	19	<0.0015	<0.001	0.29	<0.001	<0.003	<0.0002	<0.0015	6.5	0.501	<0.001	155	<0.002	456
G13S	02/10/2022	<0.001	<0.001	0.0297	<0.001	**4.74**	<0.001	79.5	19	<0.0015	<0.001	0.29	<0.001	<0.003	<0.0002	<0.0015	6.5	0.743	<0.001	151	<0.002	428
G13S	03/16/2022	<0.001	<0.001	0.0259	<0.001	**4.99**	<0.001	80.4	20	<0.0015	<0.001	0.28	<0.001	<0.003	<0.0002	<0.0015	**6.3**	0.335	<0.001	159	<0.002	440
G13D	01/20/2022	<0.001	<0.001	0.0376	<0.001	**4.62**	<0.001	84.5	19	<0.0015	<0.001	0.27	<0.001	<0.003	<0.0002	<0.0015	6.6	0.0852	<0.001	157	<0.002	444
G13D	02/10/2022	<0.001	<0.001	0.0346	<0.001	**4.55**	<0.001	83	19	<0.0015	<0.001	0.27	<0.001	<0.003	<0.0002	<0.0015	6.5	0.582	<0.001	185	<0.002	398
G13D	03/16/2022	<0.001	<0.001	0.0302	<0.001	**4.82**	<0.001	81.5	19	<0.0015	<0.001	0.26	<0.001	<0.003	<0.0002	<0.0015	**6.4**	0.438	<0.001	162	<0.002	436
G14S	01/19/2022	<0.001	0.0024	0.106	<0.001	0.054	<0.001	75.9	4	<0.0015	<0.001	0.32	<0.001	0.0086	<0.0002	0.002	7.0	0.53	<0.001	10	<0.002	278
G14S	02/10/2022	<0.001	0.0031	0.0992	<0.001	<0.025	<0.001	77.7	3	<0.0015	<0.001	1.03	<0.001	0.0066	<0.0002	0.0019	7.1	0.835	<0.001	10	<0.002	244
G14S	03/15/2022	<0.001	0.003	0.103	<0.001	<0.025	<0.001	72.1	<4	<0.0015	<0.001	0.3	<0.001	0.0063	<0.0002	0.002	7.1	0.173	<0.001	10	<0.002	278
G14D	01/19/2022	<0.001	<0.001	0.0381	<0.001	**3.4**	<0.001	88	21	<0.0015	<0.001	0.35	<0.001	<0.003	<0.0002	<0.0015	6.6	0.0148	<0.001	180	<0.002	498
G14D	02/10/2022	<0.001	<0.001	0.0348	<0.001	**3.6**	<0.001	85	20	<0.0015	<0.001	0.98	<0.001	<0.003	<0.0002	<0.0015	6.5	0.444	<0.001	190	<0.002	456
G14D	03/15/2022	<0.001	<0.001	0.0314	<0.001	**4.02**	<0.001	85.8	20	<0.0015	<0.001	0.33	<0.001	<0.003	<0.0002	<0.0015	6.5	0.102	<0.001	197	<0.002	472
G15S	01/19/2022	<0.001	<0.001	0.0914	<0.001	1.14	<0.001	55.7	6	<0.0015	**0.0069**	0.25	<0.001	0.0034	<0.0002	<0.0015	**6.2**	0.22	<0.001	101	<0.002	320
G15S	02/10/2022	<0.001	<0.001	0.101	<0.001	1.05	<0.001	56.6	7	<0.0015	0.0042	0.24	<0.001	<0.003	<0.0002	<0.0015	**6.2**	1.07	<0.001	104	<0.002	290
G15S	03/15/2022	<0.001	<0.001	0.0895	<0.001	0.74	<0.001	45.5	3	<0.0015	0.0026	0.25	<0.001	0.0031	<0.0002	<0.0015	**6.2**	0.568	<0.001	53	<0.002	230

TABLE 2-1. GROUNDWATER ANALYTICAL RESULTS
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Location	Sample Date	Antimony, total (mg/L)	Arsenic, total (mg/L)	Barium, total (mg/L)	Beryllium, total (mg/L)	Boron, total (mg/L)	Cadmium, total (mg/L)	Calcium, total (mg/L)	Chloride, total (mg/L)	Chromium, total (mg/L)	Cobalt, total (mg/L)	Fluoride, total (mg/L)	Lead, total (mg/L)	Lithium, total (mg/L)	Mercury, total (mg/L)	Molybdenum, total (mg/L)	pH (field) (SU)	Radium 226 + Radium 228 (pCi/L)	Selenium, total (mg/L)	Sulfate, total (mg/L)	Thallium, total (mg/L)	Total Dissolved Solids (mg/L)
35 I.A.C. 845.600	Lower	0	0	0	0	0	0	--	0	0	0	0	0	0	0	0	6.5	0	0	0	0	0
	Upper	0.006	0.010	2.0	0.004	2	0.005	--	200	0.1	0.006	4.0	0.0075	0.04	0.002	0.1	9.0	5	0.05	400	0.002	1200
G15D	01/19/2022	<0.001	0.0014	0.0506	<0.001	**6.69**	<0.001	134	19	<0.0015	**0.0238**	0.33	<0.001	0.0063	<0.0002	0.0017	6.8	0.726	<0.001	362	<0.002	762
G15D	02/11/2022	<0.001	0.0023	0.0444	<0.001	**6.1**	<0.001	126	19	0.0038	**0.0178**	0.87	<0.001	0.0064	<0.0002	0.0016	6.7	0.00598	<0.001	389	<0.002	726
G15D	03/15/2022	<0.001	0.0023	0.0365	<0.001	**7.88**	<0.001	134	20	0.0017	**0.0217**	0.31	<0.001	0.0082	<0.0002	<0.0015	6.8	0.12	<0.001	375	<0.002	770
G16S	01/19/2022	<0.001	<0.001	0.0421	<0.001	**7.24**	<0.001	147	17	<0.0015	0.0054	0.56	<0.001	<0.003	<0.0002	<0.0015	6.7	0.0657	<0.001	279	<0.002	720
G16S	02/10/2022	<0.001	<0.001	0.0407	<0.001	**7.63**	<0.001	142	17	<0.0015	0.0049	0.64	<0.001	<0.003	<0.0002	<0.0015	6.7	1.45	<0.001	271	<0.002	684
G16S	03/15/2022	<0.001	<0.001	0.0372	<0.001	**6.74**	<0.001	128	17	<0.0015	0.0045	0.54	<0.001	<0.003	<0.0002	<0.0015	6.7	0.99	<0.001	300	<0.002	742
G16D	01/19/2022	<0.001	0.0016	0.0908	<0.001	**2.89**	<0.001	81.8	12	<0.0015	<0.001	0.34	<0.001	0.0053	<0.0002	0.0062	7.1	1.1	<0.001	79	<0.002	400
G16D	02/10/2022	<0.001	<0.001	0.0582	<0.001	**7.79**	<0.001	104	18	<0.0015	<0.001	0.24	<0.001	<0.003	<0.0002	0.0026	6.8	1.12	<0.001	198	<0.002	488
G16D	03/15/2022	<0.001	0.0012	0.0607	<0.001	**4.16**	<0.001	92.3	15	<0.0015	<0.001	0.3	<0.001	<0.003	<0.0002	0.0035	7.0	0.53	<0.001	117	<0.002	430
G51D	03/15/2022	<0.001	<0.001	0.0433	<0.001	0.689	<0.001	31	5	0.0017	0.0016	<0.1	<0.001	0.0055	<0.0002	<0.0015	**5.6**	1.21	0.0049	123	<0.002	324
G52D	03/15/2022	<0.001	0.0018	0.208	<0.001	<0.025	<0.001	48.3	12	<0.0015	**0.0063**	0.29	<0.001	<0.003	<0.0002	<0.0015	**6.2**	0.975	<0.001	68	<0.002	350
G53D	03/15/2022	<0.001	<0.001	0.0922	<0.001	0.332	<0.001	38.1	18	<0.0015	0.0022	0.71	<0.001	<0.003	<0.0002	<0.0015	6.5	0.285	<0.001	74	<0.002	342
G54D	03/15/2022	<0.001	<0.001	0.064	<0.001	0.451	<0.001	83.4	21	<0.0015	**0.011**	0.31	<0.001	<0.003	<0.0002	<0.0015	6.6	0.843	<0.001	213	<0.002	524
Well 3	02/10/2022	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	0.878	--	--	--	--
Well 3	03/15/2022	<0.001	<0.001	0.0435	<0.001	0.588	<0.001	143	20	<0.0015	<0.001	0.45	<0.001	0.0031	<0.0002	0.0016	6.5	1.14	<0.001	233	<0.002	712
XPW01	03/15/2022	<0.001	**0.0529**	0.113	<0.001	**10.4**	<0.001	159	5	<0.0015	<0.001	0.25	<0.001	<0.003	<0.0002	**0.333**	8.3	--	<0.001	360	<0.002	698
XPW02	03/15/2022	<0.001	**0.051**	0.023	<0.001	**16**	<0.001	483	115	<0.0015	<0.001	0.48	<0.004	**0.0841**	<0.0002	**1.06**	7.7	--	<0.001	**2590**	**<0.008**	**4050**
XPW03	03/15/2022	**0.0124**	**0.533**	0.0095	<0.001	**11.1**	<0.001	12.9	25	<0.0015	<0.001	0.27	<0.001	**0.185**	<0.0002	**0.346**	**10.5**	--	0.0266	152	<0.002	414

Notes:
Boron concentrations detected at concentration greater than the GWPS
Exceedance of parameters other than boron
Detected at concentration greater than the GWPS
GWPS = Groundwater protection standard
mg/L = milligrams per liter
pCi/L = picocuries per liter
SU = standard units

TABLE 2-1. GROUNDWATER ANALYTICAL RESULTS
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Location	Sample Date	Antimony, total (mg/L)	Arsenic, total (mg/L)	Barium, total (mg/L)	Beryllium, total (mg/L)	Boron, total (mg/L)	Cadmium, total (mg/L)	Calcium, total (mg/L)	Chloride, total (mg/L)	Chromium, total (mg/L)	Cobalt, total (mg/L)	Fluoride, total (mg/L)	Lead, total (mg/L)	Lithium, total (mg/L)	Mercury, total (mg/L)	Molybdenum, total (mg/L)	pH (field) (SU)	Radium 226 + Radium 228 (pCi/L)	Selenium, total (mg/L)	Sulfate, total (mg/L)	Thallium, total (mg/L)	Total Dissolved Solids (mg/L)
35 I.A.C. 845.600	Lower	0	0	0	0	0	0	--	0	0	0	0	0	0	0	0	6.5	0	0	0	0	0
	Upper	0.006	0.010	2.0	0.004	2	0.005	--	200	0.1	0.006	4.0	0.0075	0.04	0.002	0.1	9.0	5	0.05	400	0.002	1200

< = concentration is less than the concentration shown, which corresponds to the reporting limit for the method. Estimated concentrations below the reporting limit and associated qualifiers are not provided since they are not utilized in statistics to determine exceedances above Part 845 standards.
35 I.A.C. 845.600 = Residuals in Surface Impoundments: Title 35 of the Illinois Administrative Code § 845

TABLE 2-2. GROUNDWATER ELEVATIONS
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Sample Location	Sample Date	Groundwater Elevation (ft NAVD88)
G01D	02/01/2022	321.02
G01D	03/02/2022	324.74
G01D	03/14/2022	325.94
G02D	02/01/2022	320.61
G02D	03/02/2022	323.79
G02D	03/14/2022	325.46
G03	02/01/2022	320.23
G03	03/02/2022	323.42
G05	02/01/2022	319.02
G05	03/02/2022	322.85
G06	02/01/2022	316.75
G06	03/02/2022	322.31
G06S	03/02/2022	322.95
G07	02/01/2022	315.21
G07	03/02/2022	321.66
G08	02/01/2022	313.68
G08	03/02/2022	322.50
G09	02/01/2022	312.40
G09	03/02/2022	323.55
G09M	03/02/2022	324.61
G10	02/01/2022	313.45
G10	03/02/2022	314.07
G11	01/19/2022	321.44
G11	02/01/2022	319.68
G11	03/02/2022	324.98
G12S	01/20/2022	317.06
G12S	02/01/2022	315.52
G12S	03/02/2022	321.74
G12S	03/14/2022	324.04
G12D	01/20/2022	317.05
G12D	02/01/2022	315.51
G12D	03/02/2022	321.73
G12D	03/14/2022	324.04
G13S	01/20/2022	316.50
G13S	02/01/2022	304.84
G13S	03/02/2022	321.49
G13S	03/14/2022	323.78
G13D	01/20/2022	316.44
G13D	02/01/2022	314.76
G13D	03/02/2022	321.42
G13D	03/14/2022	323.81
G14S	01/19/2022	317.23
G14S	02/01/2022	308.18
G14S	03/02/2022	320.19
G14S	03/14/2022	323.55
G14D	01/19/2022	315.81
G14D	02/01/2022	310.98

TABLE 2-2. GROUNDWATER ELEVATIONS
JOPPA POWER PLANT
EAST ASH POND
JOPPA, ILLINOIS

Sample Location	Sample Date	Groundwater Elevation (ft NAVD88)
G14D	03/02/2022	319.94
G14D	03/14/2022	322.44
G15S	01/19/2022	316.13
G15S	02/01/2022	308.25
G15S	03/02/2022	323.72
G15S	03/14/2022	322.82
G15D	01/19/2022	316.00
G15D	02/01/2022	308.39
G15D	03/02/2022	323.62
G15D	03/14/2022	322.62
G16S	01/19/2022	316.82
G16S	02/01/2022	309.39
G16S	03/02/2022	327.12
G16S	03/14/2022	323.50
G16D	01/19/2022	316.75
G16D	02/01/2022	309.26
G16D	03/02/2022	326.86
G16D	03/14/2022	323.49
G51D	02/01/2022	320.05
G51D	03/02/2022	314.10
G51D	03/14/2022	326.13
G52D	02/01/2022	320.52
G52D	03/02/2022	321.80
G52D	03/14/2022	323.13
G53D	02/01/2022	318.70
G53D	03/02/2022	307.79
G53D	03/14/2022	324.84
G54S	03/02/2022	346.60
G54D	02/01/2022	314.70
G54D	03/02/2022	323.70
G54D	03/14/2022	325.19
G151	03/02/2022	329.40
G152B	03/02/2022	337.08
G153	03/02/2022	322.83
Well 3	02/01/2022	300.54
Well 3	03/02/2022	325.64
Well 3	03/14/2022	322.03
XPW01	03/02/2022	370.61
XPW01	03/14/2022	369.57
XPW02	03/02/2022	373.71
XPW02	03/14/2022	372.56
XPW03	03/02/2022	375.05
XPW03	03/14/2022	373.73
XSG01	03/14/2022	367.28

Notes:
ft NAVD88 = feet relative to the North American Vertical Datum 1988, GEOID 12A
generated 05/23/2022, 8:28:24 PM CDT

TABLE 2-3. UPPER CONFINING UNIT GROUNDWATER ELEVATIONS

HYDROGEOLOGIC UPDATE FOR CONSTRUCTION PERMIT

EAST ASH POND

JOPPA POWER PLANT

JOPPA, ILLINOIS

G151		G152B		G153		G54S	
Date	GWE [1]	Date	GWE [1]	Date	GWE [1]	Date	GWE [1]
03/03/21	326.64	03/03/21	338.25	03/03/21	319.04	03/03/21	310.25
03/24/21	330.47	03/25/21	338.38	03/25/21	324.74	03/24/21	311.48
04/14/21	329.35	04/14/21	336.25	04/13/21	324.60	04/14/21	312.84
05/11/21	329.35	05/12/21	338.96	05/11/21	320.59	05/12/21	315.44
06/01/21	325.68	06/01/21	334.71	06/01/21	319.71	06/01/21	312.65
06/14/21	326.03	06/15/21	335.06	06/14/21	320.19	06/14/21	314.30
07/06/21	324.48	07/06/21	332.91	07/06/21	318.17	07/06/21	316.75
07/20/21	324.77	07/20/21	332.91	07/20/21	317.91	07/20/21	318.87
Average GWE [1]	**327.10**		**335.93**		**320.62**		**314.07**

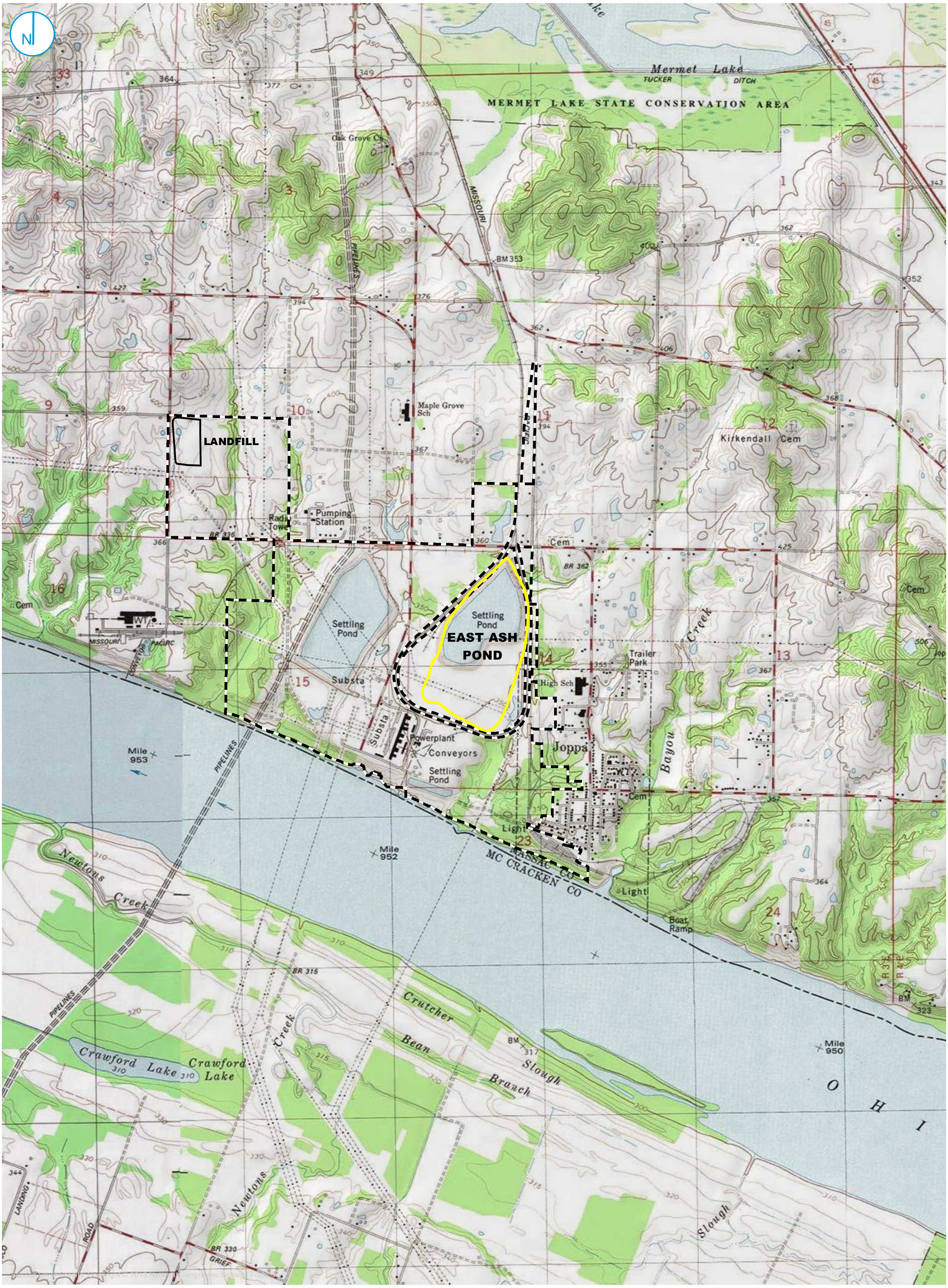
[O: NRK 05/23/22, C: CJC 05/25/22]

Notes:

[1] GWE is in feet referenced to North American Vertical Datum of 1988 (NAVD88)

GWE = groundwater elevation

FIGURES



PART 845 REGULATED UNIT (SUBJECT UNIT)
OTHER UNIT
PROPERTY BOUNDARY

0 1,000 2,000 Feet

DRAFT

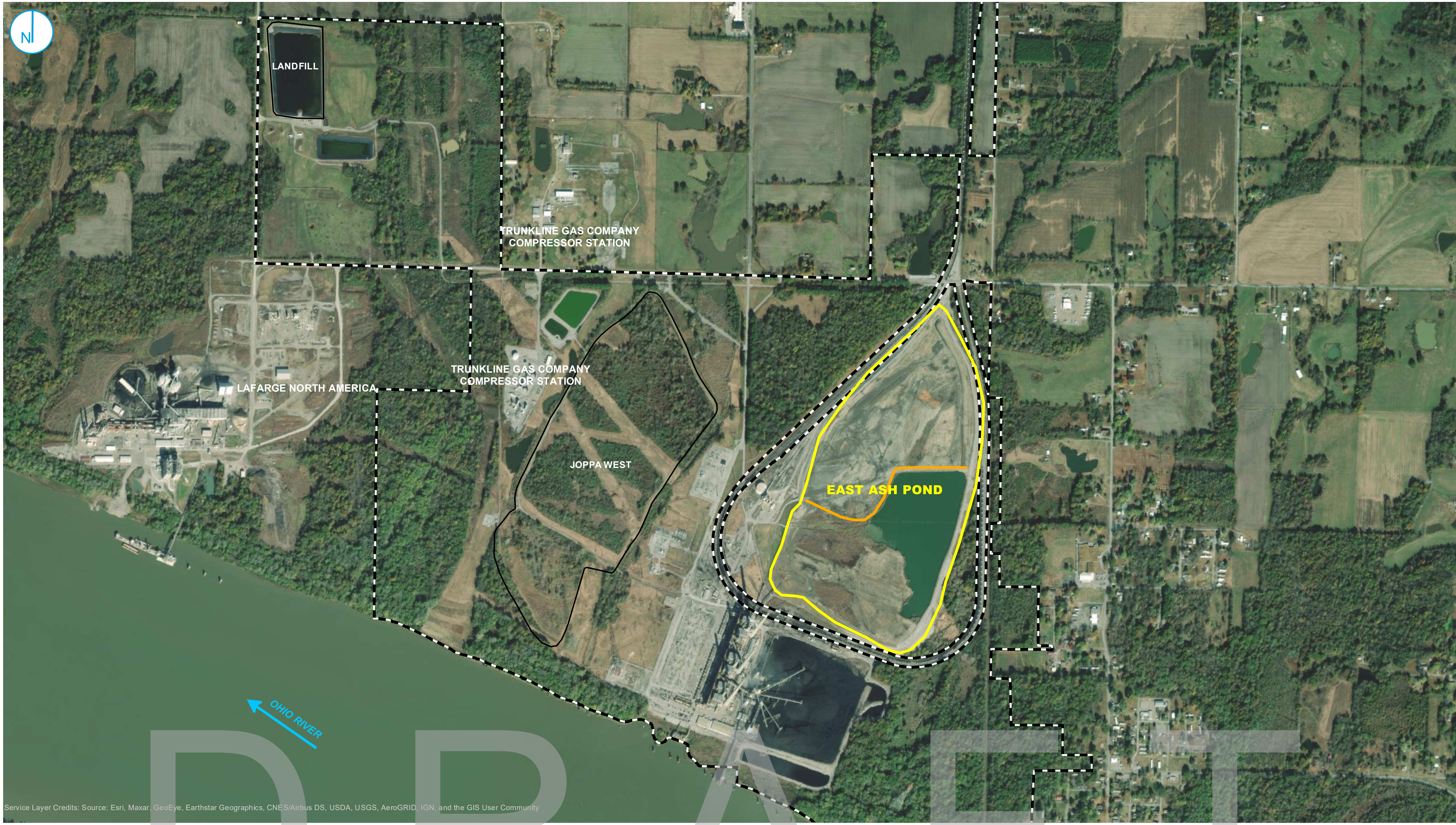
SITE LOCATION MAP

FIGURE 1-1

HYDROGEOLOGIC UPDATES FOR CONSTRUCTION PERMIT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL AMERICAS ENGINEERING SOLUTIONS, INC.

RAMBOLL



PART 845 REGULATED UNIT (SUBJECT UNIT)
OTHER UNIT
CENTRAL DIKE
PROPERTY BOUNDARY

0 500 1,000 Feet

SITE MAP

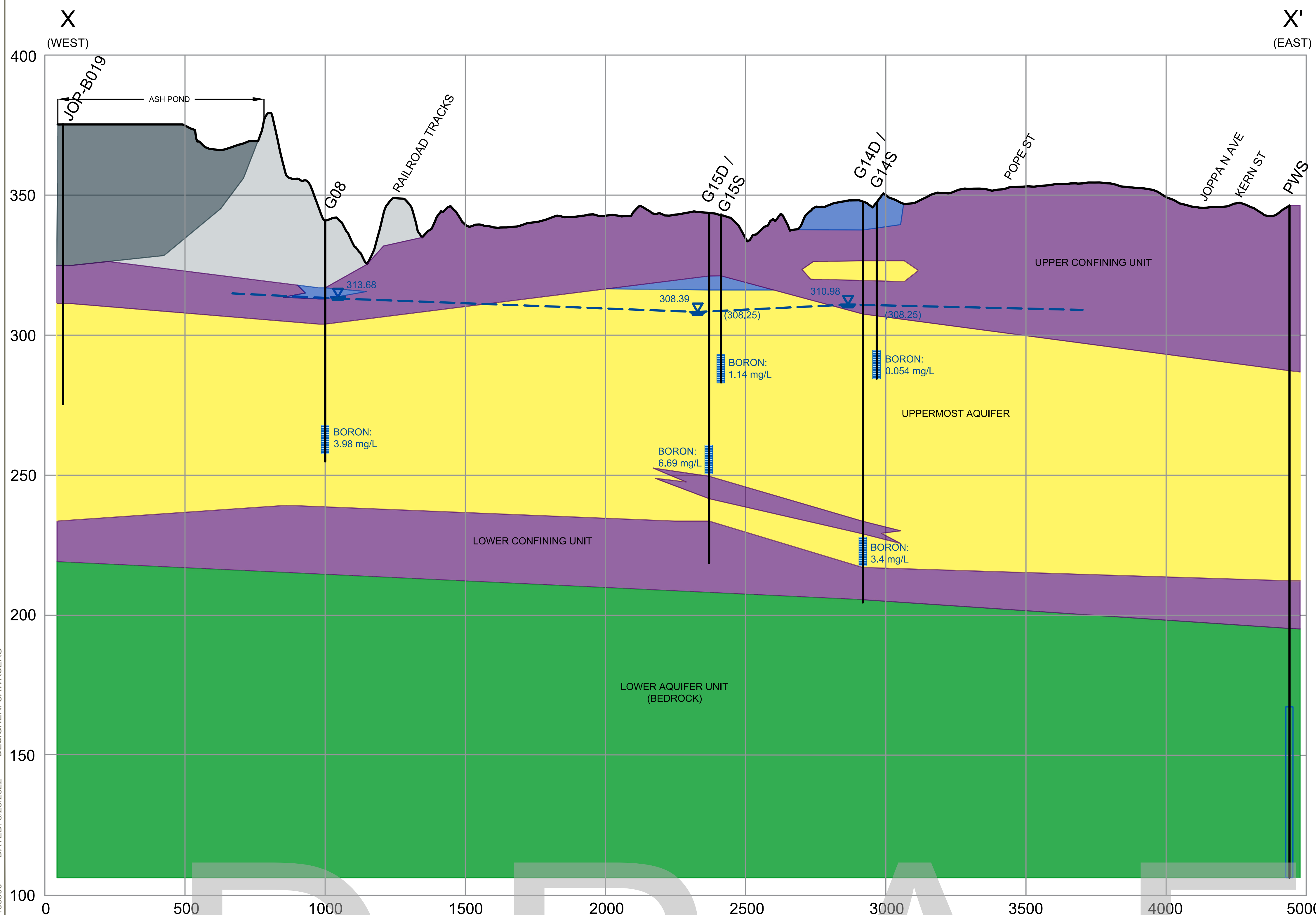
HYDROGEOLOGIC UPDATES FOR CONSTRUCTION PERMIT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

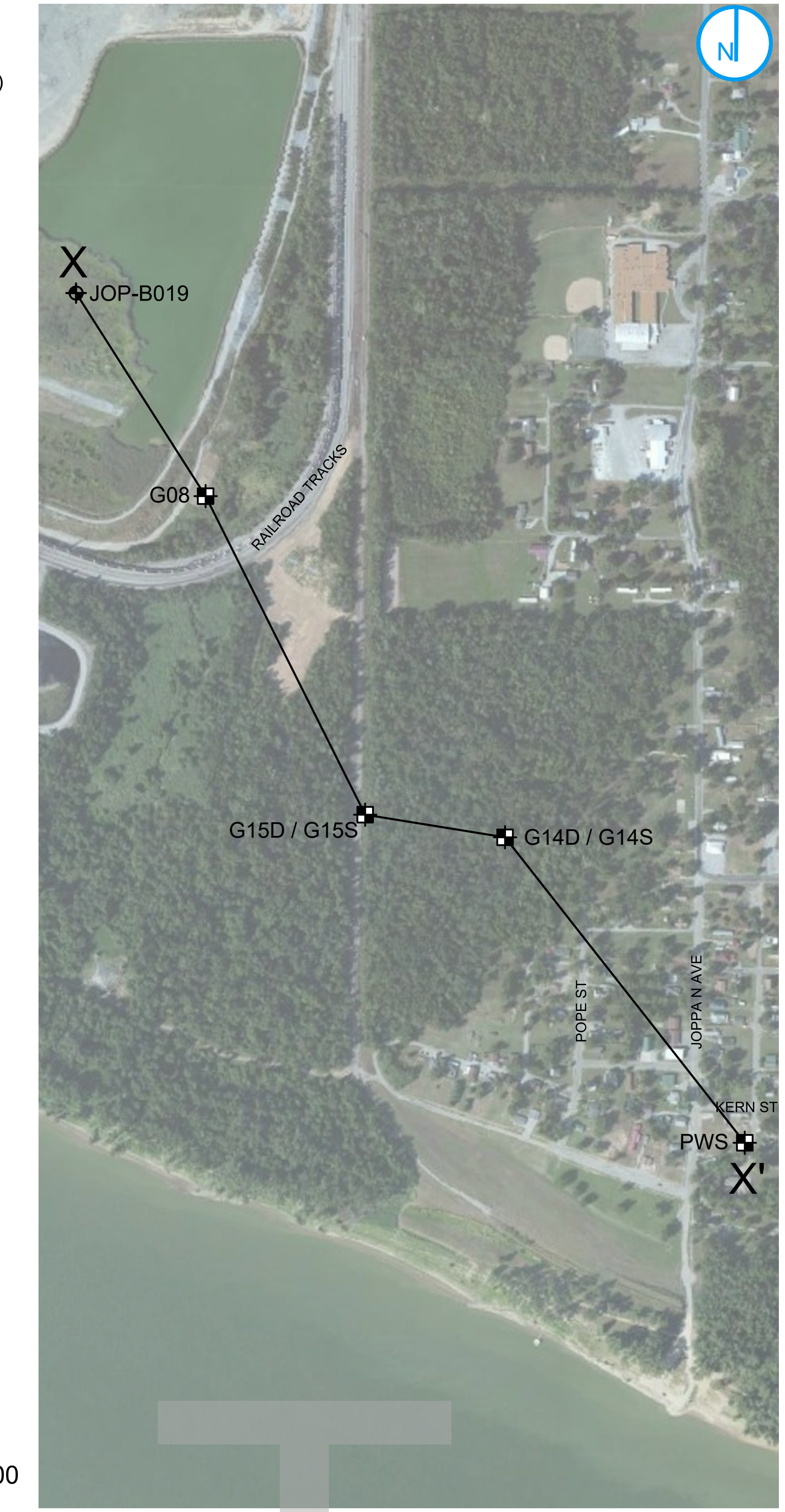
FIGURE 1-2

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL

PROJECT: 169000XXXX | DATED: 5/25/2022 | DESIGNER: galarnmc
Y:\Mapping\Projects\22\2285\MXD\Plume_Delineation\Joppa\JOP_INV_2022\Part845_Construction_Permit\Figure 1-2_Site Map.mxd





LEGEND

- COAL COMBUSTION RESIDUALS (CCR)
- FILL
- SILT
- CLAY
- SAND
- BEDROCK
- WELL SCREEN INTERVAL
- UPPERMOST AQUIFER POTENTIOMETRIC SURFACE
- UPPERMOST AQUIFER GROUNDWATER ELEVATION

NOTES

1. This profile was developed by interpolation between widely spaced boreholes. Only at the borehole location should it be considered as an approximately accurate representation and then only to the degree implied by the notes on the borehole logs.
2. Scale is approximate.
3. Vertical scale is exaggerated 10X.
4. Groundwater elevations measured on February 1, 2022.

40'
0
400'

GEOLOGIC CROSS SECTIONS
X-X'

HYDROGEOLOGIC UPDATES FOR CONSTRUCTION PERMIT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

FIGURE 2-1

RAMBOLL AMERICAS ENGINEERING SOLUTIONS, INC.

RAMBOLL

C:\Users\cawrseag\OneDrive - Ramboll\Desktop\Figure 2-1 Cross Section X-X'.dwg
DESIGNER: CAWRSEAG
DATED: 5/26/2022
PROJECT: 1940100806

BOTTOM OF ASH CONTOUR (5-FT INTERVAL)

PART 257 REGULATED UNIT (SUBJECT UNIT)

PROPERTY BOUNDARY

0 200 400 Feet

DRAFT

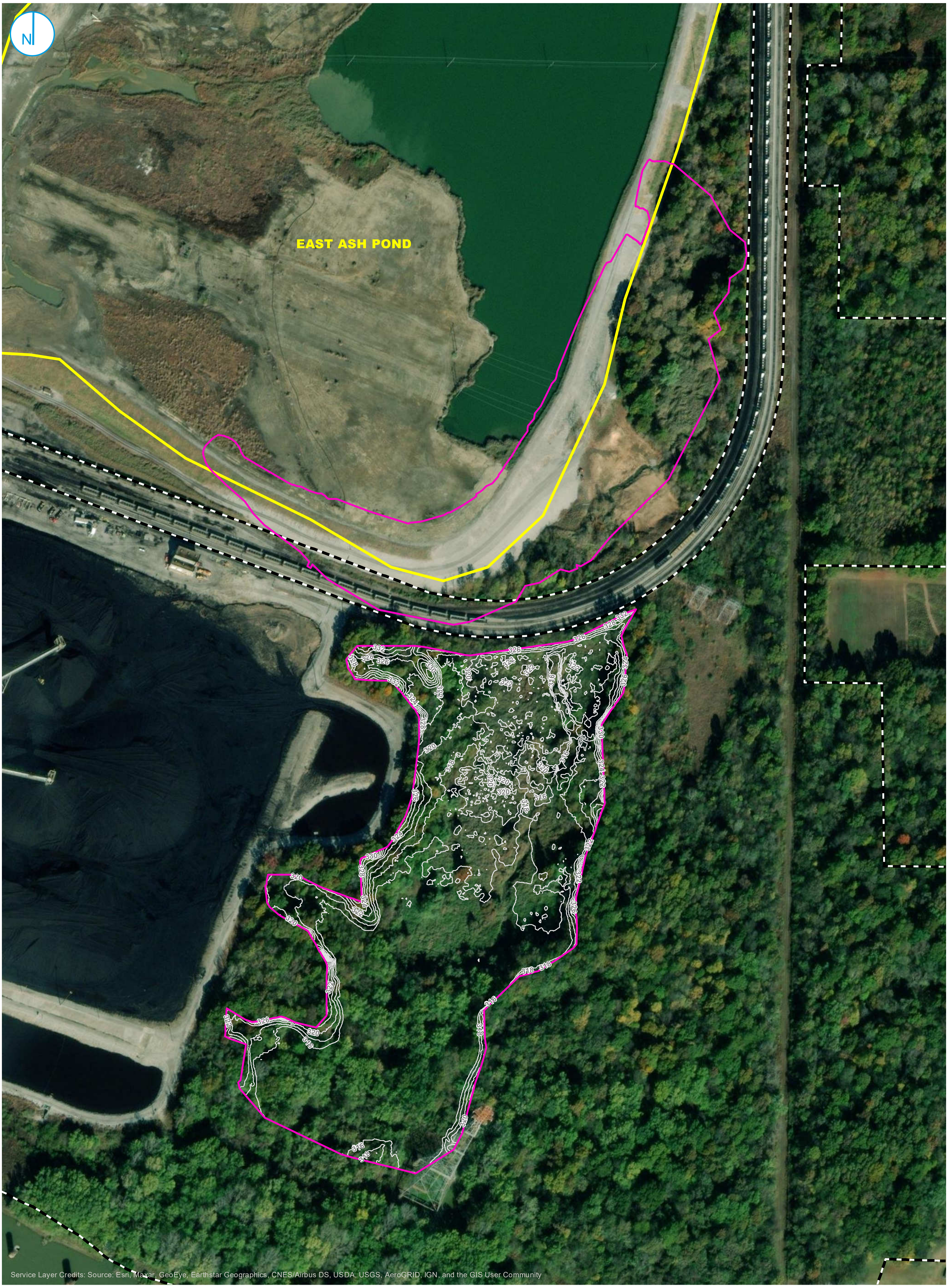
BASE OF CCR (INSIDE EAP)

FIGURE 2-2

HYDROGEOLOGIC UPDATES FOR CONSTRUCTION PERMIT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL AMERICAS ENGINEERING SOLUTIONS, INC.

RAMBOLL



ASH EXTERIOR BOUNDARY
BOTTOM OF ASH CONTOUR (2-FT INTERVAL)
PART 257 REGULATED UNIT (SUBJECT UNIT)
PROPERTY BOUNDARY

0 125 250 Feet

BASE OF CCR (OUTSIDE EAP)

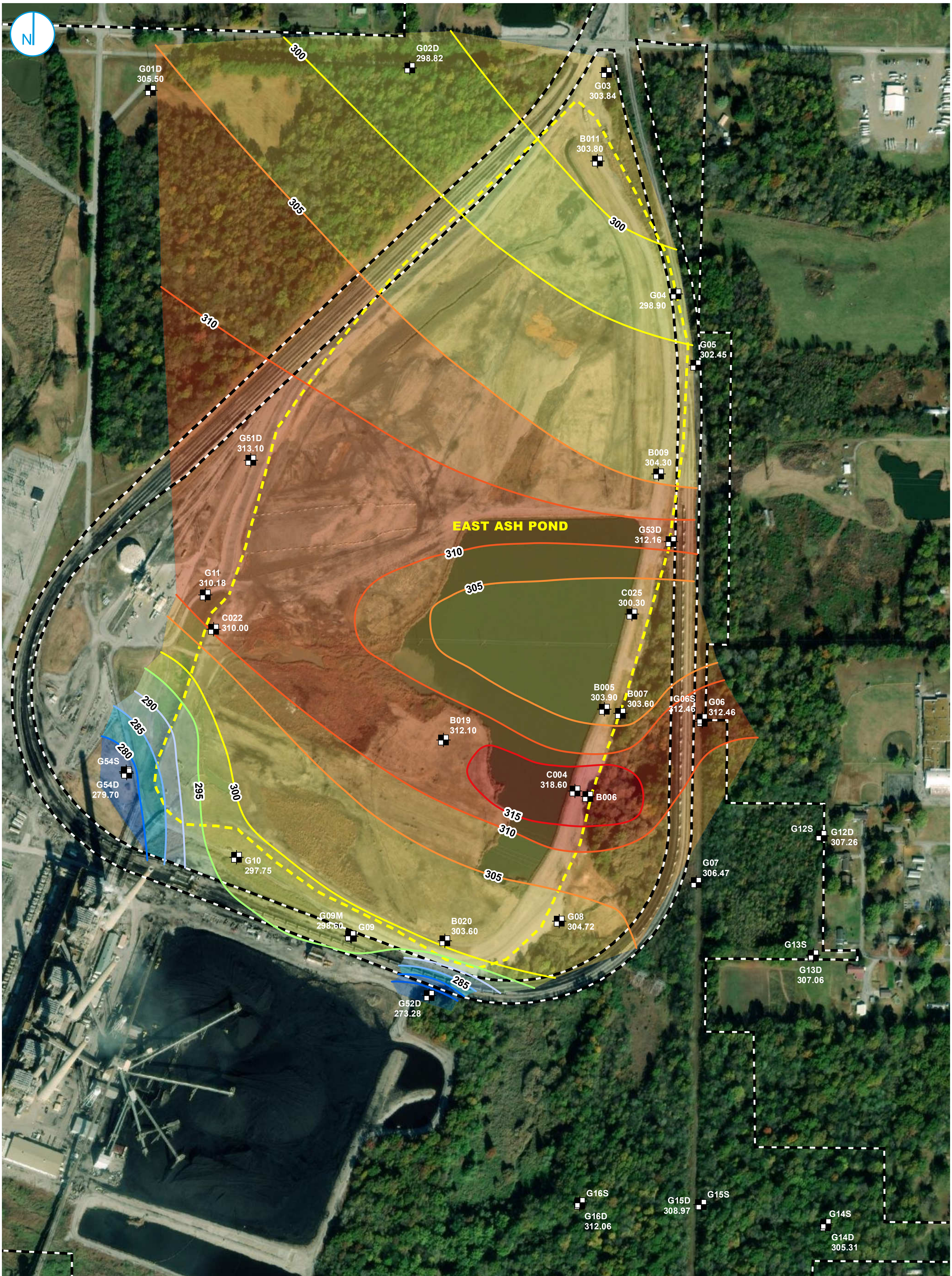
FIGURE 2-3

DRAFT

HYDROGEOLOGIC UPDATES
FOR CONSTRUCTION PERMIT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

RAMBOLL



WELL LOCATION

PART 257 REGULATED UNIT (SUBJECT UNIT)

PROPERTY BOUNDARY

TOP OF UPPER AQUIFER CONTOURS (5-FT CONTOUR INTERVAL)

- 275
- 280
- 285
- 290
- 295
- 300
- 305
- 310
- 315

0 200 400 Feet

DRAFT

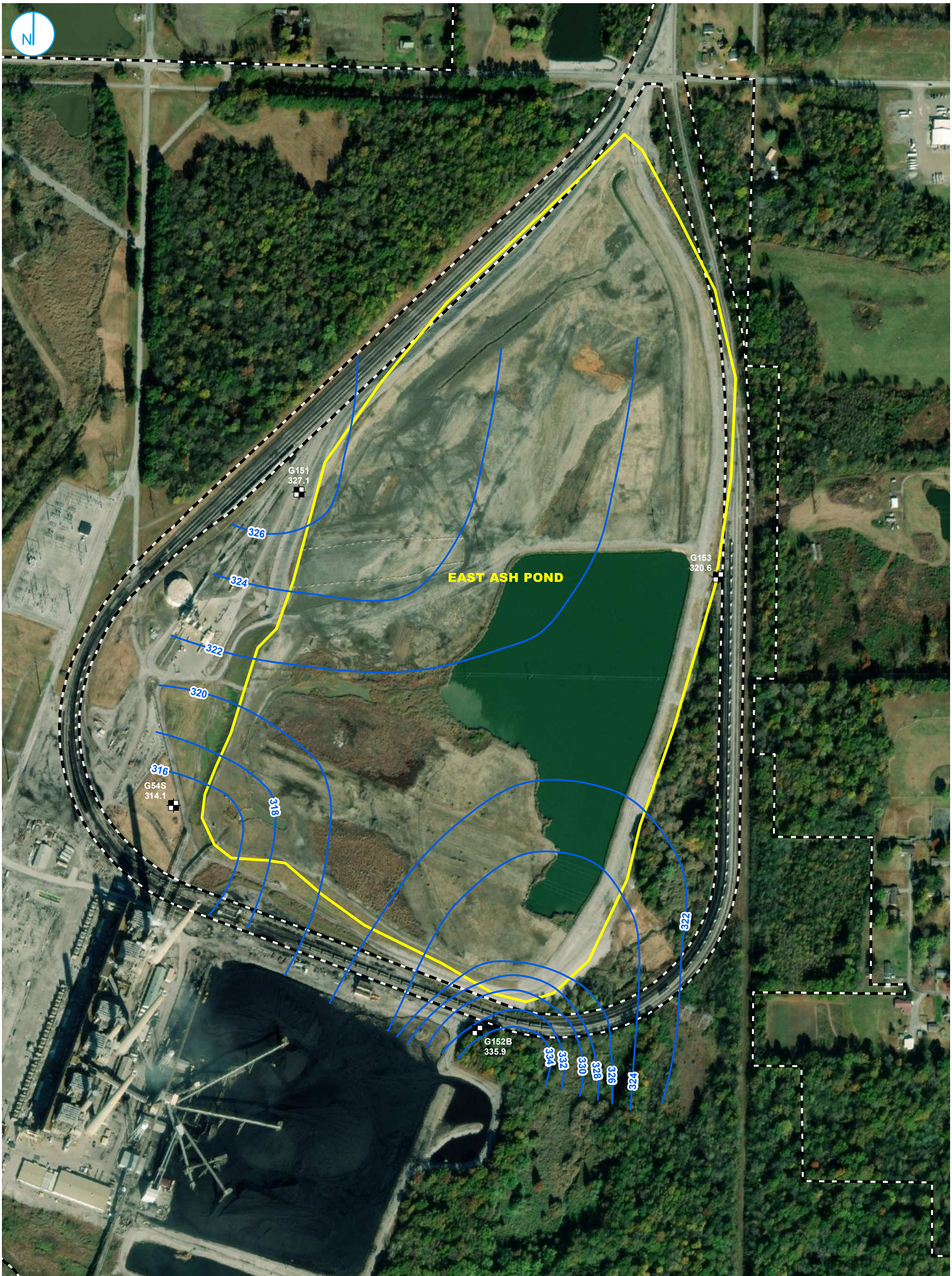
TOP OF UPPERMOST AQUIFER

HYDROGEOLOGIC UPDATES FOR CONSTRUCTION PERMIT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

FIGURE 2-4

RAMBOLL AMERICAS ENGINEERING SOLUTIONS, INC.

RAMBOLL



WELL LOCATION
AVERAGE UCU WATER TABLE ELEVATION CONTOUR 2021
PART 257 REGULATED UNIT (SUBJECT UNIT)
PROPERTY BOUNDARY

0 200 400 Feet

DRAFT

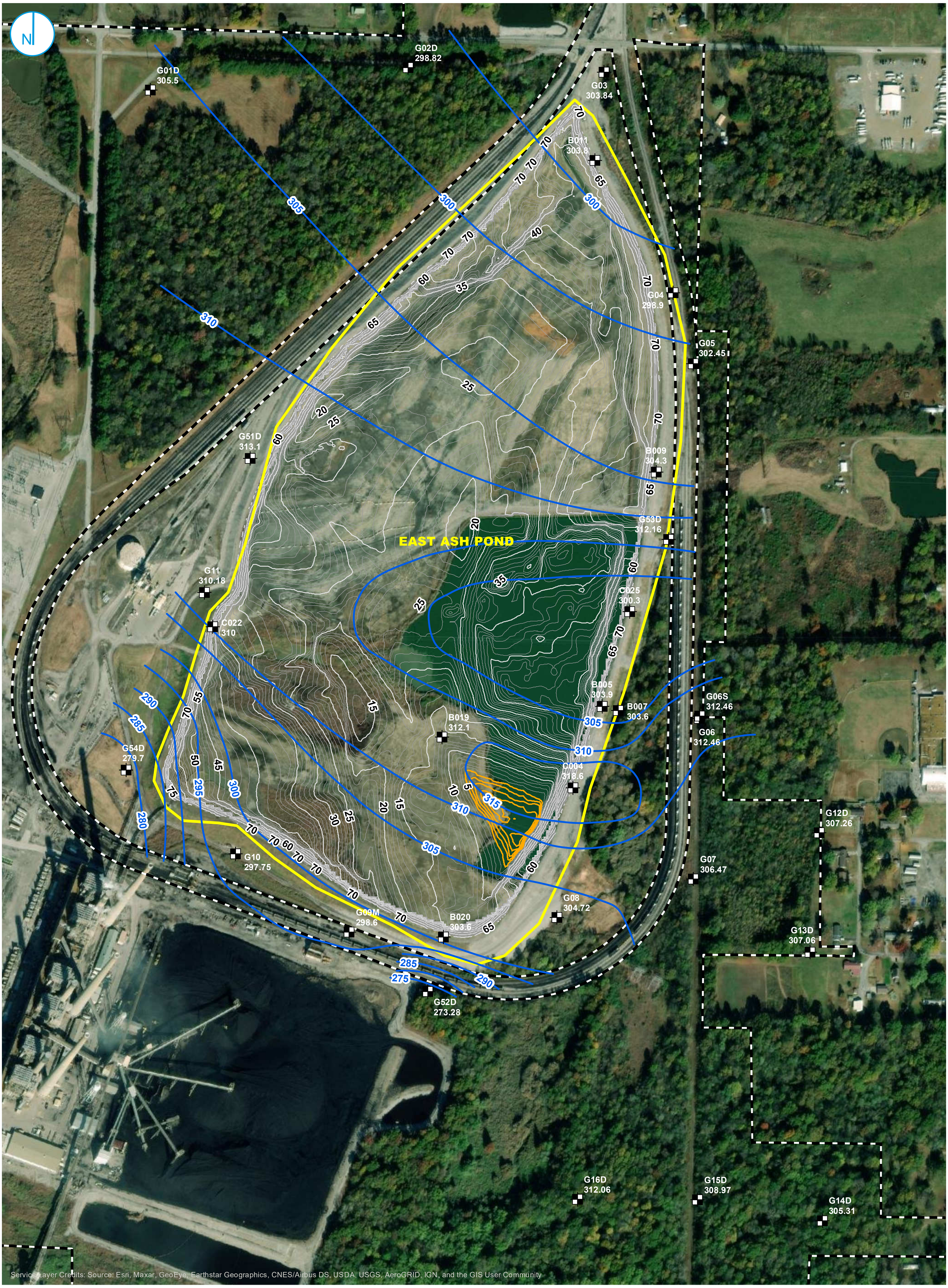
UPPER CONFINING UNIT AVERAGE WATER TABLE ELEVATIONS 2021

FIGURE 2-5

HYDROGEOLOGIC UPDATES FOR CONSTRUCTION PERMIT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL AMERICAS ENGINEERING SOLUTIONS, INC.

RAMBOLL



WELL LOCATION

INTERPRETED TOP OF UPPERMOST AQUIFER (95TH PERCENTILE GROUNDWATER ELEVATION CONTOURS, 2022)

PART 257 REGULATED UNIT (SUBJECT UNIT)

PROPERTY BOUNDARY

SEPARATION BETWEEN BOTTOM OF CCR AND TOP OF AQUIFER LESS THAN 5FT

SEPARATION BETWEEN BOTTOM OF CCR AND TOP OF AQUIFER (5FT CONTOUR INTERVAL)

SEPARATION BETWEEN BOTTOM OF CCR AND TOP OF AQUIFER (1FT CONTOUR INTERVAL)

0 200 400 Feet

DRAFT

BASE OF CCR - TOP OF UPPERMOST AQUIFER SEPARATION

FIGURE 3-1

HYDROGEOLOGIC UPDATES FOR CONSTRUCTION PERMIT
EAST ASH POND
JOPPA POWER PLANT
JOPPA, ILLINOIS

RAMBOLL AMERICAS ENGINEERING SOLUTIONS, INC.

RAMBOLL

APPENDIX A
SOIL BORING LOGS AND WELL CONSTRUCTION FORMS

Geosyntec consultants
engineers | scientists | innovators

Client: Vistra
Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG

Well No. G12D

Drilling Start Date:	09/23/2021	Boring Depth (ft): 100		Well Depth (ft):	90
Drilling End Date:	09/23/2021	Boring Diameter (in): 6		Well Diameter (in):	2
Drilling Company:	Cascade Drilling	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Sonic	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	Truck-mounted	Top of Casing Elev. (ft): 360.22		Screen Material:	Sch 40 PVC
Driller:	Dave Gordon	Ground Elev. (ft): 357.26		Seal Material(s):	NA
Logged By:	Amanda Toye	Northing, Easting (NAD83):		Filter Pack:	NA

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
0								(0') SILT (ML); light brown, fine grained, loose, moist.		0
5										5
10								(10') As above: gray with light brown mottling.		10
15								(14.5') As above: light gray with orange mottling, trace clay, cohesive.		15
								(16.5') Clayey SILT (ML); light gray and orange, cohesive, dry.		
20										20

NOTES:

WELL LOG

Geosyntec consultants — engineers | scientists | innovators	**Client:** Vistra **Project:** GLP8030, Joppa Power Station **Address:** 2100 Portland Rd, Joppa, IL	**Well No.** G12D **Page:** 2 of 5

Drilling Start Date:	**09/23/2021**	Boring Depth (ft):	**100**	Well Depth (ft):	**90**
Drilling End Date:	**09/23/2021**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**360.22**	Screen Material:	**Sch 40 PVC**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**357.26**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
20								(20') CLAY (CL); light gray with trace orange mottling, little silt, medium stiff, high plasticity, moist.		20
25										25
30								(30') Clayey SAND (SC); light gray and orange throughout, fine grained, cohesive, moist.		30
35										35
40										40

NOTES:

Geosyntec consultants — engineers | scientists | innovators	Client: Vistra Project: GLP8030, Joppa Power Station Address: 2100 Portland Rd, Joppa, IL	**WELL LOG** **Well No.** G12D **Page:** 3 of 5

Drilling Start Date:	**09/23/2021**	Boring Depth (ft): **100**		Well Depth (ft):	**90**
Drilling End Date:	**09/23/2021**	Boring Diameter (in): **6**		Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft): **360.22**		Screen Material:	**Sch 40 PVC**
Driller:	**Dave Gordon**	Ground Elev. (ft): **357.26**		Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Recovery (ft)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
40								(40') Silty SAND (SM); reddish orange, fine grained, cohesive, moist.		40
								(42.5') As above: light brown.		
								(44.5') As above: light gray.		
45										45
50								(50') SAND (SP); light brown, fine grained, semi cohesive, saturated.		50
								(51') As above: light gray.		
55										55
								(55.5') As above: light brown to gray, trace gravel.		
								(59') Gravelly SAND (SP); light brown, poorly graded and small gravel, loose, saturated.		
60										60

NOTES:

Geosyntec consultants — engineers | scientists | innovators	Client: Vistra Project: GLP8030, Joppa Power Station Address: 2100 Portland Rd, Joppa, IL	**WELL LOG** Well No. **G12D** Page: **4 of 5**

Drilling Start Date:	**09/23/2021**	Boring Depth (ft):	**100**	Well Depth (ft):	**90**
Drilling End Date:	**09/23/2021**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**360.22**	Screen Material:	**Sch 40 PVC**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**357.26**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
60	Gravel							(60') GRAVEL (GP); various colors, well-graded, loose, saturated.		60
62	Sand							(62') Gravelly SAND (SP); brown, coarse grained, well-graded gravel, loose, saturated.		
64								(64') As above: orange.		
65										65
67.75								(67.75') As above.		
70								(70') As above.		70
75										75
76.25								(76.25') 3" seam of dark brown.		
79								(79') As above: fine grained sand.		
80										80

NOTES:

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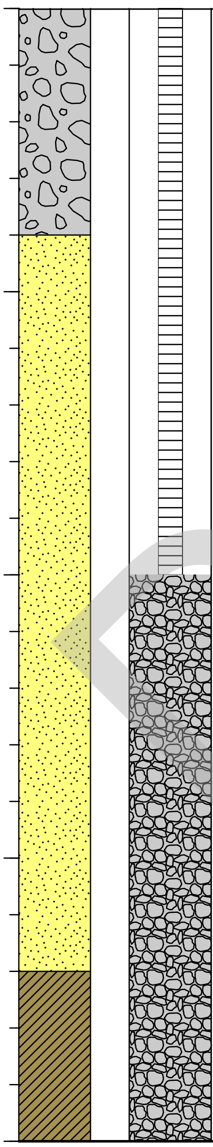
Client:	Vistra
Project:	GLP8030, Joppa Power Station
Address:	2100 Portland Rd, Joppa, IL

WELL LOG

Well No. **G12D**

Drilling Start Date:	**09/23/2021**	Boring Depth (ft):	**100**	Well Depth (ft):	**90**
Drilling End Date:	**09/23/2021**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**360.22**	Screen Material:	**Sch 40 PVC**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**357.26**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
80								(80') GRAVEL (GP); brown, well-graded, loose, saturated.		80
84								(84') SAND (SP); orange, fine grained, cohesive, saturated.		
85										85
90										90
95										95
97								(97') CLAY (CL); light gray, some silt, medium soft, medium plasticity, moist.		
100								(100') Boring terminated. Monitoring well G12D installed at 80-90 ft bgs.		100



NOTES:

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Client: Vistra		**WELL LOG**
Project: GLP8030, Joppa Power Station		**Well No.** G12S
Address: 2100 Portland Rd, Joppa, IL		**Page:** 1 of 4

Drilling Start Date: **09/23/2021**	Boring Depth (ft): **70**	Well Depth (ft): **70**
Drilling End Date: **09/23/2021**	Boring Diameter (in): **4**	Well Diameter (in): **2**
Drilling Company: **Cascade Drilling**	DTW During Drilling (ft):	Screen Slot (in): **0.010**
Drilling Method: **Sonic**	DTW After Drilling (ft):	Riser Material: **Sch 40 PVC**
Drilling Equipment: **Truck-mounted**	Top of Casing Elev. (ft): **360.34**	Screen Material: **Sch 40 PVC Slotted**
Driller: **Dave Gordon**	Ground Elev. (ft): **357.56**	Seal Material(s): **NA**
Logged By: **Amanda Toye**	Northing, Easting (NAD83):	Filter Pack: **NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
0								(0') Blind drill.		0
5										5
10										10
15										15
20										20

NOTES:

Client:	Vistra
Project:	GLP8030, Joppa Power Station
Address:	2100 Portland Rd, Joppa, IL

WELL LOG

Well No. G12S

Drilling Start Date:	09/23/2021	Boring Depth (ft):	70	Well Depth (ft):	70
Drilling End Date:	09/23/2021	Boring Diameter (in):	4	Well Diameter (in):	2
Drilling Company:	Cascade Drilling	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Sonic	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	Truck-mounted	Top of Casing Elev. (ft):	360.34	Screen Material:	Sch 40 PVC Slotted
Driller:	Dave Gordon	Ground Elev. (ft):	357.56	Seal Material(s):	NA
Logged By:	Amanda Toye	Northing, Easting (NAD83):		Filter Pack:	NA

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
20								(20') Blind drill.		20
25										25
30										30
35										35
40										40

NOTES:

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Client: Vistra		**WELL LOG**
Project: GLP8030, Joppa Power Station		**Well No.** G12S
Address: 2100 Portland Rd, Joppa, IL		**Page:** 3 of 4

Drilling Start Date:	**09/23/2021**	Boring Depth (ft): **70**		Well Depth (ft):	**70**
Drilling End Date:	**09/23/2021**	Boring Diameter (in): **4**		Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft): **360.34**		Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft): **357.56**		Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
40								(40') Blind drill.		40
45										45
50								(50') SAND (SP); light gray, trace gravel, fine grained, moist.		50
								(52') Gravelly SAND (SP); reddish brown, coarse grained, saturated, 10 inch sand lense at 53 ft bgs.		
55										55
60										60

NOTES:

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Client: Vistra
Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG

Well No. G12S

Drilling Start Date:	**09/23/2021**	Boring Depth (ft):	**70**	Well Depth (ft):	**70**
Drilling End Date:	**09/23/2021**	Boring Diameter (in):	**4**	Well Diameter (in):	**2**
Drilling Company:	**Cascade**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Drilling Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**360.34**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**357.56**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
60								(60.5') As above: dark brown lense.		60
65								(64.5') As above: dark brown lense.		65
70								(60') Boring terminated. Monitoring well G12S installed at 60-70 ft bgs.		70
75										75

NOTES:

WELL LOG

Geosyntec consultants	Client: Vistra	**WELL LOG**
	Project: GLP8030, Joppa Power Station	Well No. G13D
	Address: 2100 Portland Rd, Joppa, IL	Page: 1 of 6

Drilling Start Date:	**09/24/2021**	Boring Depth (ft):	**110**	Well Depth (ft):	**90**
Drilling End Date:	**09/24/2021**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**354.11**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**351.31**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
0								(0') SILT (ML); light gray with light brown mottling, orange.		0
								(3.5') Clayey SILT (ML); light gray with light brown mottling, medium stiff, medium plasticity, moist.		
5										5
10								(10') Sandy CLAY (CL); orange with light gray mottling, medium soft, medium plasticity, moist.		10
15										15
20										20

NOTES:

Client:	**Vistra**	**WELL LOG**	
Project:	**GLP8030, Joppa Power Station**	**Well No.**	**G13D**
Address:	**2100 Portland Rd, Joppa, IL**	**Page:**	**2 of 6**

Drilling Start Date:	**09/24/2021**	Boring Depth (ft):	**110**	Well Depth (ft):	**90**
Drilling End Date:	**09/24/2021**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**354.11**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**351.31**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
20								(20') Clayey SAND (SC); red with some orange, soft, fine grained, medium to high plasticity, moist.		20
25										25
30										30
								(33') As above: light grayish brown, coarse grained sand.		
35										35
40										40

NOTES:

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Client:	Vistra
Project:	GLP8030, Joppa Power Station
Address:	2100 Portland Rd, Joppa, IL

WELL LOG

Well No. G13D

Drilling Start Date:	**09/24/2021**	Boring Depth (ft):	**110**	Well Depth (ft):	**90**
Drilling End Date:	**09/24/2021**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft): Top		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	of Casing Elev. (ft):	**354.11**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**351.31**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
40								(40') SAND (SP); red, trace clay, fine grained, cohesive, moist.		40
								(42.75') As above: no clay.		
								(44.25') As above: no clay, loose.		
45								(44.75') Gravelly SAND (SP); tan, fine grained, loose, saturated.		45
50								(50') As above: fine grained sand lens at 50.75 ft bgs, 56 ft bg, gravel lense at 52 ft bgs, saturated.		50
55										55
60										60

NOTES:

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Client: Vistra
Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG
Well No. G13D

Drilling Start Date:	**09/24/2021**	Boring Depth (ft):	**110**	Well Depth (ft):	**90**
Drilling End Date:	**09/24/2021**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft): Top		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	of Casing Elev. (ft):	**354.11**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**351.31**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
60										60
65										65
70										70
75								(74.5') Sandy GRAVEL (GP); dark brown, well-graded, rounded, loose, saturated.		75
80										80

NOTES:

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Client: Vistra		**WELL LOG**
Project: GLP8030, Joppa Power Station		Well No. G13D
Address: 2100 Portland Rd, Joppa, IL		Page: 5 of 6

Drilling Start Date: **09/24/2021**	Boring Depth (ft): **110**	Well Depth (ft): **90**
Drilling End Date: **09/24/2021**	Boring Diameter (in): **6**	Well Diameter (in): **2**
Drilling Company: **Cascade Drilling**	DTW During Drilling (ft):	Screen Slot (in): **0.010**
Drilling Method: **Sonic**	DTW After Drilling (ft): Top	Riser Material: **Sch 40 PVC**
Drilling Equipment: **Truck-mounted**	of Casing Elev. (ft): **354.11**	Screen Material: **Sch 40 PVC Slotted**
Driller: **Dave Gordon**	Ground Elev. (ft): **351.31**	Seal Material(s): **NA**
Logged By: **Amanda Toye**	Northing, Easting (NAD83):	Filter Pack: **NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Recovery (ft)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
80								(80') Gravelly SAND (SP); orange, coarse grained, well-graded, loose, saturated.		80
								(82.5') SAND (SP); orange, fine grained, semi cohesive, saturated.		
85										85
90										90
								(93') CLAY (CL); light gray, trace silt, medium stiff, moist.		
95										95
100										100

NOTES:

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Client:	Vistra
Project:	GLP8030, Joppa Power Station
Address:	2100 Portland Rd, Joppa, IL

WELL LOG
Well No. G13D

Drilling Start Date:	**09/24/2021**	Boring Depth (ft):	**110**	Well Depth (ft):	**90**
Drilling End Date:	**09/24/2021**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**354.11**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**351.31**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
100								(100') SAND (SP); light gray, fine grained, very cohesive, moist.		100
105										105
110								(110') Boring terminated. Monitoring well G-13D installed at 80-90 ft bgs.		110
115										115

NOTES:

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Client: **Vistra**		**WELL LOG**
Project: **GLP8030, Joppa Power Station**		**Well No.** **G13S**
Address: **2100 Portland Rd, Joppa, IL**		**Page:** **1 of 3**

Drilling Start Date: **09/24/2021**	Boring Depth (ft): **60**	Well Depth (ft): **60**
Drilling End Date: **09/24/2021**	Boring Diameter (in): **4**	Well Diameter (in): **2**
Drilling Company: **Cascade Drilling**	DTW During Drilling (ft):	Screen Slot (in): **0.010**
Drilling Method: **Sonic**	DTW After Drilling (ft): Top	Riser Material: **Sch 40 PVC**
Drilling Equipment: **Truck-mounted**	of Casing Elev. (ft): **354.28**	Screen Material: **Sch 40 PVC Slotted**
Driller: **Dave Gordon**	Ground Elev. (ft): **351.72**	Seal Material(s): **NA**
Logged By: **Amanda Toye**	Northing, Easting (NAD83):	Filter Pack: **NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
0								(0') Blind drill.		0
5										5
10										10
15										15
20										20

NOTES:

Client:	Vistra
Project:	GLP8030, Joppa Power Station
Address:	2100 Portland Rd, Joppa, IL

WELL LOG

Well No. G13S

Drilling Start Date:	**09/24/2021**	Boring Depth (ft):	**60**	Well Depth (ft):	**60**
Drilling End Date:	**09/24/2021**	Boring Diameter (in):	**4**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**354.28**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**351.72**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
20								(20') Blind drill.		20
25										25
30										30
35										35
40										40

NOTES:

Client:	Vistra
Project:	GLP8030, Joppa Power Station
Address:	2100 Portland Rd, Joppa, IL

WELL LOG

Well No. G13S

Drilling Start Date:	**09/24/2021**	Boring Depth (ft):	**60**	Well Depth (ft):	**60**
Drilling End Date:	**09/24/2021**	Boring Diameter (in):	**4**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**354.28**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**351.72**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Recovery (ft)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
40								(40') SAND (SP); red, trace clay, fine grained, cohesive, moist.		40
								(43') As above: no clay.		
								(44') As above: no clay, loose.		
45								(45') Gravelly SAND (SP); tan, fine grained, loose, saturated.		45
50								(50') As above: fine grained sand lense at 51 ft bgs, 56 ft bgs, gravel lense at 52 ft bgs, saturated.		50
55										55
60								(60') Boring terminated. Monitoring well G-13S installed at 50-60 ft bgs.		60

NOTES:

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Client: Vistra		**WELL LOG**
Project: GLP8030, Joppa Power Station		Well No. G14D
Address: 2100 Portland Rd, Joppa, IL		

Drilling Start Date:	09/16/2021	Boring Depth (ft):	143	Well Depth (ft):	130
Drilling End Date:	09/16/2021	Boring Diameter (in):	4	Well Diameter (in):	2
Drilling Company:	Cascade Drilling	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Sonic	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	Truck-mounted	Top of Casing Elev. (ft):	348.09	Screen Material:	Sch 40 PVC Slotted
Driller:	Dave Gordon	Ground Elev. (ft):	345.31	Seal Material(s):	NA
Logged By:	Amanda Toye	Northing, Easting (NAD83):		Filter Pack:	NA

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Recovery (ft)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
0								(0') Clayey SILT (ML); orange with light gray mottling, fine grained, medium stiff, moist.		0
5										5
10								(10') Silty CLAY (CL); orange with light gray mottling, low plasticity, moist.		10
15										15
17								(17') CLAY with some silt (CL); orange with light gray mottling, medium plasticity, moist.		
20										20

NOTES:

Client:	Vistra
Project:	GLP8030, Joppa Power Station
Address:	2100 Portland Rd, Joppa, IL

WELL LOG

Well No. G14D

Drilling Start Date:	09/16/2021	Boring Depth (ft):	143	Well Depth (ft):	130
Drilling End Date:	09/16/2021	Boring Diameter (in):	4	Well Diameter (in):	2
Drilling Company:	Cascade Drilling	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Sonic	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	Truck-mounted	Top of Casing Elev. (ft):	348.09	Screen Material:	Sch 40 PVC Slotted
Driller:	Dave Gordon	Ground Elev. (ft):	345.31	Seal Material(s):	NA
Logged By:	Amanda Toye	Northing, Easting (NAD83):		Filter Pack:	NA

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
20								(20') Clayey SILT (ML); light gray with orange mottling, fine grained, cohesive, low plasticity, moist.		20
								(21') Clayey SAND (SC); burnt orange, some gravel, fine grained sand, well-graded gravel, cohesive, moist.		
25										25
								(27') Gravelly SAND (SP); light gray with orange mottling, fine grained sand, well-graded gravel, loose, moist.		
								(28') No Recovery.		
30								(30') SILT with some clay (ML); light brown, very soft, fine grained, saturated but cant be influenced by rig.		30
								(31.5') Silty CLAY (CL); light brown, trace sand and gravel, medium plasticity, moist.		
								(34.5') Gravelly sandy CLAY (CL); light brown, well-graded, fine grained, medium plasticity, 3" coal seam at 39 ft bgs, moist.		
35										35
40										40

NOTES:

Geosyntec consultants	Client: Vistra Project: GLP8030, Joppa Power Station Address: 2100 Portland Rd, Joppa, IL	**WELL LOG** Well No. G14D Page: 3 of 8

Drilling Start Date:	**09/16/2021**	Boring Depth (ft): **143**		Well Depth (ft):	**130**
Drilling End Date:	**09/16/2021**	Boring Diameter (in): **4**		Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft): **348.09**		Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft): **345.31**		Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
40								(40') SAND (SP); dark to light orange, little to some well-graded gravel, fine grained, cohesive, moist.		40
45										45
								(48.25') As above: increased gravel content.		
50								(50') Sandy GRAVEL (GP); orange, well-graded, loose, saturated.		50
55										55
60										60

NOTES:

Geosyntec consultants	Client: Vistra Project: GLP8030, Joppa Power Station Address: 2100 Portland Rd, Joppa, IL	**WELL LOG** **Well No. G14D** **Page: 4 of 8**

Drilling Start Date:	**09/16/2021**	Boring Depth (ft):	**143**	Well Depth (ft):	**130**
Drilling End Date:	**09/16/2021**	Boring Diameter (in):	**4**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**348.09**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**345.31**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
60								(60') SAND with gravel (SP); orange, fine grained, well-graded, saturated.		60
								(64') As above: dark brown.		
65								(65.5') As above: orange.		65
70								(70') Sandy GRAVEL (GP); orange, well-graded, loose, saturated, 6" clay lense at 28".		70
								(73') SAND (SP); light gray to light orange, little silt, fine grained, cohesive, saturated.		
75										75
80										80

NOTES:

WELL LOG

Geosyntec consultants — engineers | scientists | innovators

Client: Vistra		Well No. G14D
Project: GLP8030, Joppa Power Station		
Address: 2100 Portland Rd, Joppa, IL		

Drilling Start Date:	**09/16/2021**	Boring Depth (ft):	**143**	Well Depth (ft):	**130**
Drilling End Date:	**09/16/2021**	Boring Diameter (in):	**4**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**348.09**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**345.31**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Recovery (ft)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
80								(80') SAND (SP); orange with light orange and dark gray throughout, fine grained, semi loose, saturated.		80
85										85
90								(90') As above: little to some silt.		90
95										95
100										100

NOTES:

Geosyntec consultants (engineers | scientists | innovators)	Client: Vistra Project: GLP8030, Joppa Power Station Address: 2100 Portland Rd, Joppa, IL	**WELL LOG** Well No. G14D Page: 6 of 8

Drilling Start Date:	**09/16/2021**	Boring Depth (ft):	**143**	Well Depth (ft):	**130**
Drilling End Date:	**09/16/2021**	Boring Diameter (in):	**4**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**348.09**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**345.31**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
100										100
105										105
110										110
								(114') Silty CLAY (CL); gray, fine grained, medium plasticity, moist.		
115										115
								(117') SAND (SP); gray, fine grained, cohesive, moist.		
								(118') CLAY (CL); gray, stiff, medium to high plasticity, moist.		
								(118.5') SAND (SP); gray, fine grained, cohesive, moist.		
120										120

NOTES:

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Client:	Vistra	**WELL LOG**
Project:	GLP8030, Joppa Power Station	Well No. G14D
Address:	2100 Portland Rd, Joppa, IL	Page: 7 of 8

Drilling Start Date:	**09/16/2021**	Boring Depth (ft):	**143**	Well Depth (ft):	**130**
Drilling End Date:	**09/16/2021**	Boring Diameter (in):	**4**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**348.09**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**345.31**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Recovery (ft)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
120										120
125										125
								(126') As above: some clay, 4" clay lense at 127 ft bgs.		
								(129') Gravelly SAND (SP); gray, well-graded, loose.		
130										130
								(130.5') Sandy CLAY (CL); gray, medium stiff, medium plasticity, dry.		
135										135
								(138') CLAY (CL); gray, stiff, medium to high plasticity, dry.		
140										140

NOTES:

Drilling Start Date:	09/16/2021	Boring Depth (ft):	143	Well Depth (ft):	130
Drilling End Date:	09/16/2021	Boring Diameter (in):	4	Well Diameter (in):	2
Drilling Company:	Cascade Drilling	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Sonic	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	Truck-mounted	Top of Casing Elev. (ft):	348.09	Screen Material:	Sch 40 PVC Slotted
Driller:	Dave Gordon	Ground Elev. (ft):	345.31	Seal Material(s):	NA
Logged By:	Amanda Toye	Northing, Easting (NAD83):		Filter Pack:	NA

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
140								(142') 1' of bedrock, limestone.		140
								(143') Boring terminated. Monitoring well G-14D installed at 120-130 ft bgs.		
145										145

NOTES:

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Client: Vistra Project: GLP8030, Joppa Power Station Address: 2100 Portland Rd, Joppa, IL		**WELL LOG** **Well No. G14S** **Page: 1 of 4**

Drilling Start Date: **9/16/2021**	Boring Depth (ft): **63**	Well Depth (ft): **63**
Drilling End Date: **9/16/2021**	Boring Diameter (in): **4**	Well Diameter (in): **2**
Drilling Company: **Cascade Drilling**	DTW During Drilling (ft):	Screen Slot (in): **0.010**
Drilling Method: **Sonic**	DTW After Drilling (ft):	Riser Material: **Sch 40 PVC**
Drilling Equipment: **Truck-mounted**	Top of Casing Elev. (ft): **348.26**	Screen Material: **Sch 40 PVC Slotted**
Driller: **Dave Gordon**	Ground Elev. (ft): **345.46**	Seal Material(s): **NA**
Logged By: **Amanda Toye**	Northing, Easting (NAD83):	Filter Pack: **NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
0								(0') Blind drill.		0
5										5
10										10
15										15
20										20

NOTES:

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Client:	Vistra
Project:	GLP8030, Joppa Power Station
Address:	2100 Portland Rd, Joppa, IL

WELL LOG

Well No. G14S

Drilling Start Date:	**9/16/2021**	Boring Depth (ft):	**63**	Well Depth (ft):	**63**
Drilling End Date:	**9/16/2021**	Boring Diameter (in):	**4**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**348.26**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**345.46**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
20								(20') Blind drill.		20
25										25
30										30
35										35
40										40

NOTES:

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Client: Vistra
Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG

Well No. G14S

Drilling Start Date:	**9/16/2021**
Drilling End Date:	**9/16/2021**
Drilling Company:	**Cascade Drilling**
Drilling Method:	**Sonic**
Drilling Equipment:	**Truck-mounted**
Driller:	**Dave Gordon**
Logged By:	**Amanda Toye**
Boring Depth (ft):	**63**
Boring Diameter (in):	**4**
DTW During Drilling (ft):	
DTW After Drilling (ft):	
Top of Casing Elev. (ft):	**348.26**
Ground Elev. (ft):	**345.46**
Northing, Easting (NAD83):	
Well Depth (ft):	**63**
Well Diameter (in):	**2**
Screen Slot (in):	**0.010**
Riser Material:	**Sch 40 PVC**
Screen Material:	**Sch 40 PVC Slotted**
Seal Material(s):	**NA**
Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Recovery (ft)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
40								(40') SAND (SP); dark to light orange, little to some well-graded gravel, fine grained, cohesive, moist.		40
45										45
50								(50') Sandy GRAVEL (GP); orange, fine grained, well-graded, loose, saturated.		50
55										55
60										60

NOTES:

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Client: Vistra	WELL LOG
Project: GLP8030, Joppa Power Station	Well No. G14S
Address: 2100 Portland Rd, Joppa, IL	Page: 4 of 4

Drilling Start Date:	**9/16/2021**	Boring Depth (ft):	**63**	Well Depth (ft):	**63**
Drilling End Date:	**9/16/2021**	Boring Diameter (in):	**4**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**348.26**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**345.46**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Recovery (ft)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
60								(60') SAND with gravel (SP); orange, fine grained, well-graded, saturated.		60
								(60') Boring terminated. Monitoring well G-15S installed at 53-63 ft bgs.		
65										65

NOTES:

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Client:	Vistra
Project:	GLP8030, Joppa Power Station
Address:	2100 Portland Rd, Joppa, IL

WELL LOG

Well No. G15D

Drilling Start Date:	**9/15/2021**	Boring Depth (ft):	**125**	Well Depth (ft):	**93**
Drilling End Date:	**9/15/2021**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**346.72**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**343.97**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Recovery (ft)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
0								(0') Silty CLAY (CL); brownish orange, low plasticity, dry.		0
5								(5') CLAY with some silt (CL); light gray with orange mottling, low plasticity, moist.		5
10								(10') As above: trace coal throughout.		10
15										15
20										20

NOTES:

Drilling Start Date: **9/15/2021**	Boring Depth (ft): **125**	Well Depth (ft): **93**
Drilling End Date: **9/15/2021**	Boring Diameter (in): **6**	Well Diameter (in): **2**
Drilling Company: **Cascade Drilling**	DTW During Drilling (ft):	Screen Slot (in): **0.010**
Drilling Method: **Sonic**	DTW After Drilling (ft):	Riser Material: **Sch 40 PVC**
Drilling Equipment: **Truck-mounted**	Top of Casing Elev. (ft): **346.72**	Screen Material: **Sch 40 PVC Slotted**
Driller: **Dave Gordon**	Ground Elev. (ft): **343.97**	Seal Material(s): **NA**
Logged By: **Amanda Toye**	Northing, Easting (NAD83):	Filter Pack: **NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
20								(20') Silty CLAY (CL); light gray with orange mottling, trace gravel, fine grained, medium plasticity, moist.		20
								(22.5') Clayey SILT (ML); light gray with orange mottling, trace gravel, low plasticity, moist.		
25										25
								(26') As above.		
								(27.5') SAND (SP); light gray with orange mottling, trace gravel, fine grained, moist, silt lense at 28.5 ft bgs.		
30								(30') As above.		30
								(32.5') Clayey SAND with gravel (SC); light gray with orange mottling, fine to coarse grained, moist.		
35								(35') SAND with gravel (SP); burnt orange and light gray throughout, fine to coarse grained, cohesive, moist.		35
40										40

NOTES:

Drilling Start Date:	**9/15/2021**	Boring Depth (ft): **125**	Well Depth (ft): **93**
Drilling End Date:	**9/15/2021**	Boring Diameter (in): **6**	Well Diameter (in): **2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):	Screen Slot (in): **0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):	Riser Material: **Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft): **346.72**	Screen Material: **Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft): **343.97**	Seal Material(s): **NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):	Filter Pack: **NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
40								(40') As above: saturated, loose.		40
45										45
50								(50') GRAVEL (GP); burnt orange, well-graded, loose, moist.		50
								(51') SAND with gravel (SP); burnt orange, fine to coarse grained, increasing cohesiveness with depth, loose, saturated.		
								(54') SAND (SP); burnt orange, trace gravel, fine grained, cohesive, moist.		
55										55
								(57.5') Gravelly SAND (SP); brownish orange, coarse grained, loose, moist.		
60										60

NOTES:

Geosyntec consultants	Client: Vistra Project: GLP8030, Joppa Power Station Address: 2100 Portland Rd, Joppa, IL	WELL LOG Well No. G15D Page: 4 of 7

Drilling Start Date:	**9/15/2021**	Boring Depth (ft):	**125**	Well Depth (ft):	**93**
Drilling End Date:	**9/15/2021**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**346.72**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**343.97**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
60								(60') As above.		60
65								(65') SAND (SP); light orange, trace gravel, fine grained, cohesive, moist.		65
								(67.5') Sandy GRAVEL (GP); dark orange, well-graded, loose, saturated.		
70								(70') GRAVEL (GP); dark orange, well-graded, loose, saturated.		70
75								(75') Sandy gravelly CLAY (CL); light gray with orange mottling, medium to high plasticity, moist.		75
								(76') Clayey sandy GRAVEL (GP); orange, well-graded, cohesive, saturated.		
								(77') Clayey GRAVEL (GP); orange, well-graded, saturated.		
80										80

NOTES:

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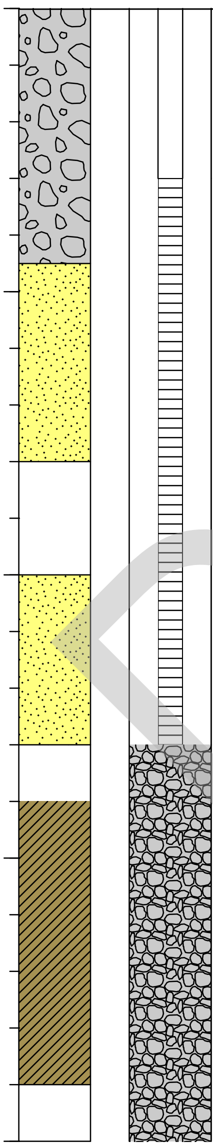
Client: Vistra
Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

WELL LOG
Well No. G15D

Drilling Start Date:	**9/15/2021**	Boring Depth (ft):	**125**	Well Depth (ft):	**93**
Drilling End Date:	**9/15/2021**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**346.72**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**343.97**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
80										80
								(83') GRAVEL (GP); orange, poorly graded, loose, saturated.		
								(84.5') Gravelly SAND (SP); orange, loose, fine grained, well-graded, medium loose, saturated.		
85										85
								(88') No Recovery.		
90								(90') SAND (SP); light brown to dark orange, fine grained, cohesive, moist.		90
								(94') Sandy CLAY (CL); burnt orange, medium plasticity, stiff, moist.		
95								(95') Sandy gravelly CLAY (CL); light gray, fine grained, well-graded gravel, low plasticity, moist.		95
								(98') CLAY with sand (CL); light gray clay, burnt orange sand, stiff, low to medium plasticity, moist.		
								(99') No Recovery.		
100										100



NOTES:

Client:	Vistra	**WELL LOG**	
Project:	GLP8030, Joppa Power Station	Well No.	G15D
Address:	2100 Portland Rd, Joppa, IL	Page:	6 of 7

Drilling Start Date:	9/15/2021	Boring Depth (ft):	125	Well Depth (ft):	93
Drilling End Date:	9/15/2021	Boring Diameter (in):	6	Well Diameter (in):	2
Drilling Company:	Cascade Drilling	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Sonic	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:	Truck-mounted	Top of Casing Elev. (ft):	346.72	Screen Material:	Sch 40 PVC Slotted
Driller:	Dave Gordon	Ground Elev. (ft):	343.97	Seal Material(s):	NA
Logged By:	Amanda Toye	Northing, Easting (NAD83):		Filter Pack:	NA

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Recovery (ft)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
100								(100') As above.		100
								(101') CLAY (CL); light gray with orange mottling, stiff, medium to high plasticity, moist.		
								(102') SAND (SP); light gray with orange mottling, fine grained, cohesive, saturated.		
105								(105') As above: clay inclusions throughout.		105
								(106') 8" Gravel lense at 106 ft bgs.		
110								(110') CLAY (CL); gray to light orange, medium stiff, medium plasticity, dry.		110
								(111.5') Silty clayey SAND (SC); gray, fine grained, cohesive, moist.		
								(113') CLAY (CL); gray, stiff, medium plasticity, dry.		
115								(115') CLAY (CL); black, stiff, low plasticity, moist.		115
120										120

NOTES:

WELL LOG

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Client: Vistra
Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

Well No. G15D

Drilling Start Date:	**9/15/2021**	Boring Depth (ft):	**125**	Well Depth (ft):	**93**
Drilling End Date:	**9/15/2021**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**346.72**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	Dave Gordon	Ground Elev. (ft):	**343.97**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
120										120
125								(125') Boring terminated. Monitoring well G-15D installed at 83-93 ft bgs.		125
130										130

NOTES:

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Client: Vistra		**WELL LOG**
Project: GLP8030, Joppa Power Station		**Well No.** G15S
Address: 2100 Portland Rd, Joppa, IL		**Page:** 1 of 3

Drilling Start Date: **9/15/2021**	Boring Depth (ft): **60**	Well Depth (ft): **60**
Drilling End Date: **9/15/2021**	Boring Diameter (in): **4**	Well Diameter (in): **2**
Drilling Company: **Cascade Drilling**	DTW During Drilling (ft):	Screen Slot (in): **0.010**
Drilling Method: **Sonic**	DTW After Drilling (ft):	Riser Material: **Sch 40 PVC**
Drilling Equipment: **Truck-mounted**	Top of Casing Elev. (ft): **346.81**	Screen Material: **Sch 40 PVC Slotted**
Driller: **Dave Gordon**	Ground Elev. (ft): **343.76**	Seal Material(s): **NA**
Logged By: **Amanda Toye**	Northing, Easting (NAD83):	Filter Pack: **NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
0								(0') Blind drill.		0
5										5
10										10
15										15
20										20

NOTES:

Geosyntec consultants — engineers | scientists | innovators	Client: Vistra Project: GLP8030, Joppa Power Station Address: 2100 Portland Rd, Joppa, IL	**WELL LOG** **Well No.** G15S **Page:** 2 of 3

Drilling Start Date: **9/15/2021**	Boring Depth (ft): **60**	Well Depth (ft): **60**
Drilling End Date: **9/15/2021**	Boring Diameter (in): **4**	Well Diameter (in): **2**
Drilling Company: **Cascade Drilling**	DTW During Drilling (ft):	Screen Slot (in): **0.010**
Drilling Method: **Sonic**	DTW After Drilling (ft):	Riser Material: **Sch 40 PVC**
Drilling Equipment: **Truck-mounted**	Top of Casing Elev. (ft): **346.81**	Screen Material: **Sch 40 PVC Slotted**
Driller: **Dave Gordon**	Ground Elev. (ft): **343.76**	Seal Material(s): **NA**
Logged By: **Amanda Toye**	Northing, Easting (NAD83):	Filter Pack: **NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Recovery (ft)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
20								(20') Blind drill.		20
25										25
30								(30') SAND (SP); tan to burnt orange, fine to medium grained, moist, loose, trace clay, trace gravel.		30
35								(35') Gravelly SAND (SP); burnt orange, medium to large grains, moist, stiff to hard.		35
								(37') As above: tan.		
40										40

NOTES:

WELL LOG

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Client: Vistra
Project: GLP8030, Joppa Power Station
Address: 2100 Portland Rd, Joppa, IL

Well No. G15S

Drilling Start Date:	**9/15/2021**	Boring Depth (ft):	**60**	Well Depth (ft):	**60**
Drilling End Date:	**9/15/2021**	Boring Diameter (in):	**4**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**346.81**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**343.76**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Recovery (ft)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
40								(40') As above: tan to burnt orange.		40
45										45
50								(50') Gravelly SAND (SP); burnt orange, medium to large grained, saturated to moist, loose, trace fine sand.		50
								(54') SAND (SP); burnt orange, fine to medium grained, moist, loose.		
55								(55') Gravelly SAND (SP); burnt orange, medium to large grained, saturated to moist, loose, trace fine sand.		55
60								(60') Boring terminated. Monitoring well G-15S installed at 50-60 ft bgs.		60

NOTES:

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Client:	Vistra
Project:	GLP8030, Joppa Power Station
Address:	2100 Portland Rd, Joppa, IL

WELL LOG

Well No. G16D

Drilling Start Date:	**09/13/2021**	Boring Depth (ft):	**130**	Well Depth (ft):	**108**
Drilling End Date:	**09/13/2021**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**352.44**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**349.56**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
0				DP	10/10			(0') Silty CLAY (CL); dry, tan (2.5Y 7/6), some organics. [Topsoil]		0
								(1') Silty CLAY (CL); moist, tan (2.5Y 7/6) to brown (2.5Y 3/3).		
5										5
10				DP	10/10					10
								(12') As above: tan (2.5Y 7/6) with orange/brown (10YR 6/8) and gray (10YR 7/1) mottling.		
15										15
								(18') As above: increased moisture content.		
20										20

NOTES:

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Client: Vistra		**WELL LOG**
Project: GLP8030, Joppa Power Station		Well No. G16D
Address: 2100 Portland Rd, Joppa, IL		

Drilling Start Date: **09/13/2021**	Boring Depth (ft): **130**	Well Depth (ft): **108**
Drilling End Date: **09/13/2021**	Boring Diameter (in): **6**	Well Diameter (in): **2**
Drilling Company: **Cascade Drilling**	DTW During Drilling (ft):	Screen Slot (in): **0.010**
Drilling Method: **Sonic**	DTW After Drilling (ft):	Riser Material: **Sch 40 PVC**
Drilling Equipment: **Truck-mounted**	Top of Casing Elev. (ft): **352.44**	Screen Material: **Sch 40 PVC Slotted**
Driller: **Dave Gordon**	Ground Elev. (ft): **349.56**	Seal Material(s): **NA**
Logged By: **Amanda Toye**	Northing, Easting (NAD83):	Filter Pack: **NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
20				DP	10/10			(20') As above.		20
25										25
30				DP	10/10					30
31								(31') Clayey SILT with fine sand (ML); moist, tan (2.5Y 7/6) with orange/brown (10YR 6/8) and gray (10YR 7/1) mottling.		
34								(34') SAND (SP); fine grained, some silt, moist, gray (10YR 7/1).		
35										35
36								(36-37.5') Fat CLAY (CH); moist, gray (10YR 7/1) with tan (2.5Y 7/6) mottling.		
37.5								(37.5') SAND (SP); fine grained, some silt, moist, gray (10YR 7/1).		
40										40

NOTES:

Geosyntec consultants (engineers / scientists / innovators)	Client: Vistra Project: GLP8030, Joppa Power Station Address: 2100 Portland Rd, Joppa, IL	WELL LOG Well No. G16D Page: 3 of 7

Drilling Start Date:	**09/13/2021**	Boring Depth (ft):	**130**	Well Depth (ft):	**108**
Drilling End Date:	**09/13/2021**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**352.44**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**349.56**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
40				DP	9/10			(40') As above.		40
								(42') As above: becomes coarser with depth.		
45										45
								(49') Sandy GRAVEL to gravelly SAND with silt (SP-GP); wet, brown (10YR 6/8).		
50				DP	9/10					50
55										55
60										60

NOTES:

Client:	Vistra
Project:	GLP8030, Joppa Power Station
Address:	2100 Portland Rd, Joppa, IL

WELL LOG
Well No. G16D

Drilling Start Date:	**09/13/2021**	Boring Depth (ft):	**130**	Well Depth (ft):	**108**
Drilling End Date:	**09/13/2021**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**352.44**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**349.56**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	Recovery (ft)	Blow Counts	N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
60				DP	9/10			(60') As above.		60
65										65
								(67') ~1 ft layer brown (10YR 4/6).		
70				DP	10/10			(70') As above.		70
75										75
								(78') ~8" layer of Gravelly CLAY, orange, moist, stiff, moderate to high plasticity.		
80										80

NOTES:

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Client:	Vistra
Project:	GLP8030, Joppa Power Station
Address:	2100 Portland Rd, Joppa, IL

WELL LOG

Well No. G16D

Drilling Start Date:	**09/13/2021**	Boring Depth (ft):	**130**	Well Depth (ft):	**108**
Drilling End Date:	**09/13/2021**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**352.44**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**349.56**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
80				DP	10/10			(80') Sandy GRAVEL (GP); light brown with orange mottling, wet, hard, trace silt.		80
								(83') Silty CLAY (CL); mottled red-purple-tan-brown, moist, stiff to slightly hard, trace clay.		
85										85
								(86.5') SAND (SP); fine grained, tan with medium orange mottling, moist, loose.		
90				DP	10/10			(90') As above: orange, fine to lower medium grains.		90
95										95
100										100

NOTES:

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Client:	**Vistra**
Project:	**GLP8030, Joppa Power Station**
Address:	**2100 Portland Rd, Joppa, IL**

WELL LOG

Well No. **G16D**

Drilling Start Date:	**09/13/2021**	Boring Depth (ft):	**130**	Well Depth (ft):	**108**
Drilling End Date:	**09/13/2021**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**352.44**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**349.56**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
100								(100') As above: SAND, orange to tan with red staining at 106', fine to lower medium grains, moist, loose.		100
105										105
								(107') 1 ft Silty SAND, tan, moist, loose, fine grained.		
								(108') Silty CLAY (CL); reddish brown to purple brown, moist, hard to very stiff, low plasticity.		
110								(110') SAND (SP); tan to orange, fine grained, moist, loose, trace large sand grains and small gravel.		110
115										115
								(116.5') Sandy silty CLAY (CL); burnt orange with mottled gray and purple, moist, stiff to slightly hard, moderate to high plasticity.		
120										120

NOTES:

Client: Vistra		**WELL LOG**
Project: GLP8030, Joppa Power Station		**Well No.** G16D
Address: 2100 Portland Rd, Joppa, IL		**Page:** 7 of 7

Drilling Start Date:	**09/13/2021**	Boring Depth (ft):	**130**	Well Depth (ft):	**108**
Drilling End Date:	**09/13/2021**	Boring Diameter (in):	**6**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**352.44**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**349.56**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
120								(120') SAND (SP); black, fine grained, moist, loose, trace medium sand grains.		120
								~4" CLAY layer, black, moderate plasticity.		
								(123.5') CLAY (CL); black, very stiff to slightly hard, low plasticity.		
125										125
130								(130') Boring terminated. Monitoring well G-16D installed at 98-108 ft bgs.		130
135										135

NOTES:

WELL LOG

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Client: Vistra		**Well No.** G16S
Project: GLP8030, Joppa Power Station		**Page:** 1 of 3
Address: 2100 Portland Rd, Joppa, IL		

Drilling Start Date: **09/14/2021**	Boring Depth (ft): **60**	Well Depth (ft): **60**
Drilling End Date: **09/14/2021**	Boring Diameter (in): **4**	Well Diameter (in): **2**
Drilling Company: **Cascade Drilling**	DTW During Drilling (ft):	Screen Slot (in): **0.010**
Drilling Method: **Sonic**	DTW After Drilling (ft):	Riser Material: **Sch 40 PVC**
Drilling Equipment: **Truck-mounted**	Top of Casing Elev. (ft): **352.32**	Screen Material: **Sch 40 PVC Slotted**
Driller: **Dave Gordon**	Ground Elev. (ft): **349.60**	Seal Material(s): **NA**
Logged By: **Amanda Toye**	Northing, Easting (NAD83):	Filter Pack: **NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
0								(0') Blind drill.		0
5										5
10										10
15										15
20										20

NOTES:

Geosyntec consultants — engineers | scientists | innovators	Client: Vistra Project: GLP8030, Joppa Power Station Address: 2100 Portland Rd, Joppa, IL	**WELL LOG** Well No. **G16S** Page: **2 of 3**

Drilling Start Date: **09/14/2021**	Boring Depth (ft): **60**	Well Depth (ft): **60**
Drilling End Date: **09/14/2021**	Boring Diameter (in): **4**	Well Diameter (in): **2**
Drilling Company: **Cascade Drilling**	DTW During Drilling (ft):	Screen Slot (in): **0.010**
Drilling Method: **Sonic**	DTW After Drilling (ft):	Riser Material: **Sch 40 PVC**
Drilling Equipment: **Truck-mounted**	Top of Casing Elev. (ft): **352.32**	Screen Material: **Sch 40 PVC Slotted**
Driller: **Dave Gordon**	Ground Elev. (ft): **349.60**	Seal Material(s): **NA**
Logged By: **Amanda Toye**	Northing, Easting (NAD83):	Filter Pack: **NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
20								(20') Blind drill.		20
25										25
30										30
35										35
40										40

NOTES:

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Client:	**Vistra**
Project:	**GLP8030, Joppa Power Station**
Address:	**2100 Portland Rd, Joppa, IL**

WELL LOG

Well No. **G16S**

Drilling Start Date:	**09/14/2021**	Boring Depth (ft):	**60**	Well Depth (ft):	**60**
Drilling End Date:	**09/14/2021**	Boring Diameter (in):	**4**	Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:	**Truck-mounted**	Top of Casing Elev. (ft):	**352.32**	Screen Material:	**Sch 40 PVC Slotted**
Driller:	**Dave Gordon**	Ground Elev. (ft):	**349.60**	Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (ft)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
40								(40') SAND (SP); light gray with orange mottling, fine grained, moist.		40
45										45
50								(50') Gravelly SAND (SP); orange, fine to coarse grained, moist.		50
55										55
60								(60') Boring terminated. Monitoring well G-16S installed at 50-60 ft bgs.		60

NOTES:

WELL LOG

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Client:	Vistra
Project:	GLP8030, Joppa
Address:	2100 Portland Rd, Joppa, IL
Well No.	Well 3
Page:	1 of 3

Drilling Start Date:	**09/23/2021**	Boring Depth (ft):	**50**	Well Depth (ft):	**50**
Drilling End Date:	**09/23/2021**	Boring Diameter (in):		Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:		Top of Casing Elev. (ft)		Screen Material:	**Sch 40 PVC Slotted**
Driller:		Ground Elev. (ft):		Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
0								(0') Silty CLAY (CL); brown with light gray mottling, medium stiff, low palsticity, moist.		0
5										5
10								(10') As above: brown, soft, medium plasticity, moist.		10
15										15
20										20

NOTES:

Client:	**Vistra**	**WELL LOG**	
Project:	**GLP8030, Joppa**	**Well No.**	**Well 3**
Address:	**2100 Portland Rd, Joppa, IL**	**Page:**	**2 of 3**

Drilling Start Date:	**09/23/2021**	Boring Depth (ft):	**50**	Well Depth (ft):	**50**
Drilling End Date:	**09/23/2021**	Boring Diameter (in):		Well Diameter (in):	**2**
Drilling Company:	**Cascade Drilling**	DTW During Drilling (ft):		Screen Slot (in):	**0.010**
Drilling Method:	**Sonic**	DTW After Drilling (ft):		Riser Material:	**Sch 40 PVC**
Drilling Equipment:		Top of Casing Elev. (ft)		Screen Material:	**Sch 40 PVC Slotted**
Driller:		Ground Elev. (ft):		Seal Material(s):	**NA**
Logged By:	**Amanda Toye**	Northing, Easting (NAD83):		Filter Pack:	**NA**

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
20								(20') SAND (SP); brown and light gray with orange throughout, fine grained, cohesive, moist.		20
25								(25') As above: saturated.		25
								(28') Gravelly SAND (SW); light gray with orange mottling, fine grained, well graded gravel, loose, saturated.		
30								(30') CLAY with sand (CL); light gray with orange mottling, 3" sand lens at 30'9" bgs, medium plasticity, cohesive, moist.		30
35								(35') As above: sand and clay pockets present.		35
								(38') SILT (ML); light gray with orange mottling, trace clay, cohesive, saturated.		
								(38.5') Gravelly CLAY (CL); brown, fine to coarse grained, well graded, loose, saturated.		
40										40

NOTES:

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Client: Vistra
Project: GLP8030, Joppa
Address: 2100 Portland Rd, Joppa, IL

WELL LOG

Well No. Well 3

Drilling Start Date:	09/23/2021	Boring Depth (ft):	50	Well Depth (ft):	50
Drilling End Date:	09/23/2021	Boring Diameter (in):		Well Diameter (in):	2
Drilling Company:	Cascade Drilling	DTW During Drilling (ft):		Screen Slot (in):	0.010
Drilling Method:	Sonic	DTW After Drilling (ft):		Riser Material:	Sch 40 PVC
Drilling Equipment:		Top of Casing Elev. (ft)		Screen Material:	Sch 40 PVC Slotted
Driller:		Ground Elev. (ft):		Seal Material(s):	NA
Logged By:	Amanda Toye	Northing, Easting (NAD83):		Filter Pack:	NA

DEPTH (ft)	LITHOLOGY	WATER LEVEL	WELL COMPLETION	COLLECT: Sample Type	COLLECT: Recovery (in)	COLLECT: Blow Counts	COLLECT: N Value RQD (%)	SOIL/ROCK VISUAL DESCRIPTION	MEASURE: Lab Sample	DEPTH (ft)
40								(40') As above: very dark brown, poorly graded small gravel.		40
								(40.75') As above.		
45										45
								(46.5') SAND (SP); brown with some light gray throughout, little gravel, fine grained, semi cohesive, saturated.		
50								(50') End of Boring.		50
55										55

NOTES:

MONITORING WELL CONSTRUCTION DETAIL

Geosyntec consultants
1420 Kensington Rd., Suite 103
Oak Brook, Illinois 60523
(630) 203-3340

Well ID	G12D	Site Location	Joppa, IL
Project Name	Vistra - Joppa Power Station	Field Personnel	Amanda Toye
Project Number	GLP8030	Recorded By	Amanda Toye

Permit Number ______
Installation Date(s) 9/23/21
Drilling Method Sonic
Borehole Diameter 4"
Drilling Contractor Cascade
Driller Dave Gordon
Drilling Fluid Water
Fluid Loss During Drilling 700 Gallons

Materials Used

Riser Pipe: Diameter 2 inches
Construction
☑ PVC schedule 40
☐ Stainless Steel
☐ Other ______

Slotted Area: Length 10 feet
Diameter 2 inches
Slot Size 0.01 inches
Construction
☑ PVC schedule 40
☐ Stainless Steel
☐ Other ______
Silt Trap Used ☐ Yes ☑ No

Bottom End Cap: ☐ Male ☐ Female ☐ Slip
☑ PVC
☐ Stainless Steel
☐ Other ______

Top Cap: ☐ Male ☐ Female ☐ Slip ☑ J Plug
☐ PVC
☐ Stainless Steel
☐ Other ______

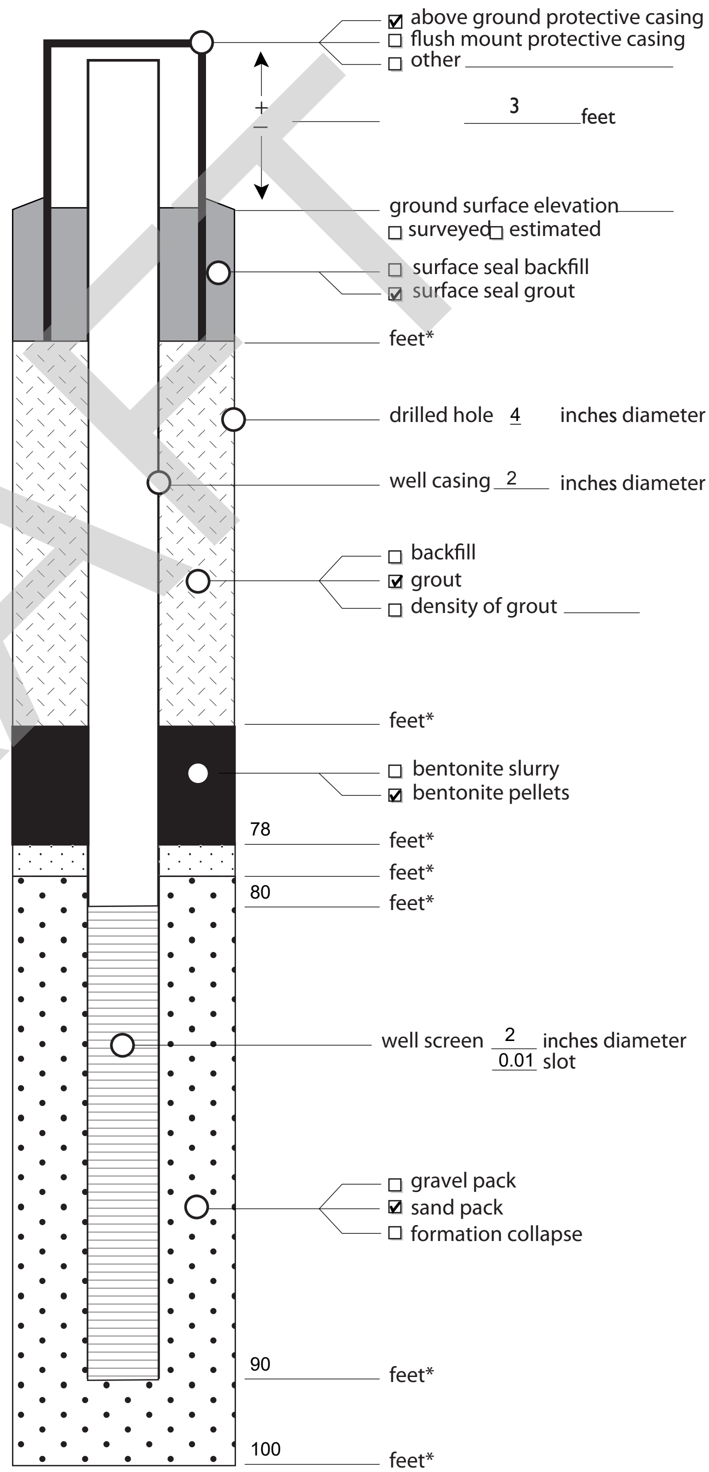
Protective Casing: Length ______ feet
Diameter ______ inches
Construction ☐ Cast Aluminum
☑ Cast Steel
☐ Other ______

Casing Installation: Length 90 feet
Diameter 2 inches
Material PVC

Sandpack:
Coarse Sand: ___ bags of ___ lb per bag Size ______
Fine Sand: 10 bags of 50 lb per bag Size ______

Seal:
Bentonite Pellets: 5 bags of 50 lb per bag Type Hole Plug 5/8"
Bentonite Slurry: ___ bags of ___ lb per bag Type ______

Grout:
Cement: 5 bags of 50 lb per bag Type dry mix
Bentonite: ___ bags of ___ lb per bag Type ______



Measuring Point is Top of Well Casing Unless Otherwise Noted

* Depth Below Ground Surface

MONITORING WELL CONSTRUCTION DETAIL

Geosyntec consultants
1420 Kensington Rd., Suite 103
Oak Brook, Illinois 60523
(630) 203-3340

Well ID: G12S
Project Name: Vistra - Joppa Power Station
Project Number: GLP8030
Site Location: Joppa, IL
Field Personnel: Amanda Toye
Recorded By: Amanda Toye

Permit Number: ______
Installation Date(s): 9/23/21
Drilling Method: Sonic
Borehole Diameter: 4"
Drilling Contractor: Cascade
Driller: Dave Gordon
Drilling Fluid: Water
Fluid Loss During Drilling: 300 Gallons

Materials Used

Riser Pipe:
Diameter 2 inches
Construction
☑ PVC schedule 40
☐ Stainless Steel
☐ Other ______

Slotted Area:
Length 10 feet
Diameter 2 inches
Slot Size 0.01 inches
Construction
☑ PVC schedule 40
☐ Stainless Steel
☐ Other ______
Silt Trap Used ☐ Yes ☑ No

Bottom End Cap: ☐ Male ☐ Female ☐ Slip
☑ PVC
☐ Stainless Steel
☐ Other ______

Top Cap: ☐ Male ☐ Female ☐ Slip ☑ J Plug
☐ PVC
☐ Stainless Steel
☐ Other ______

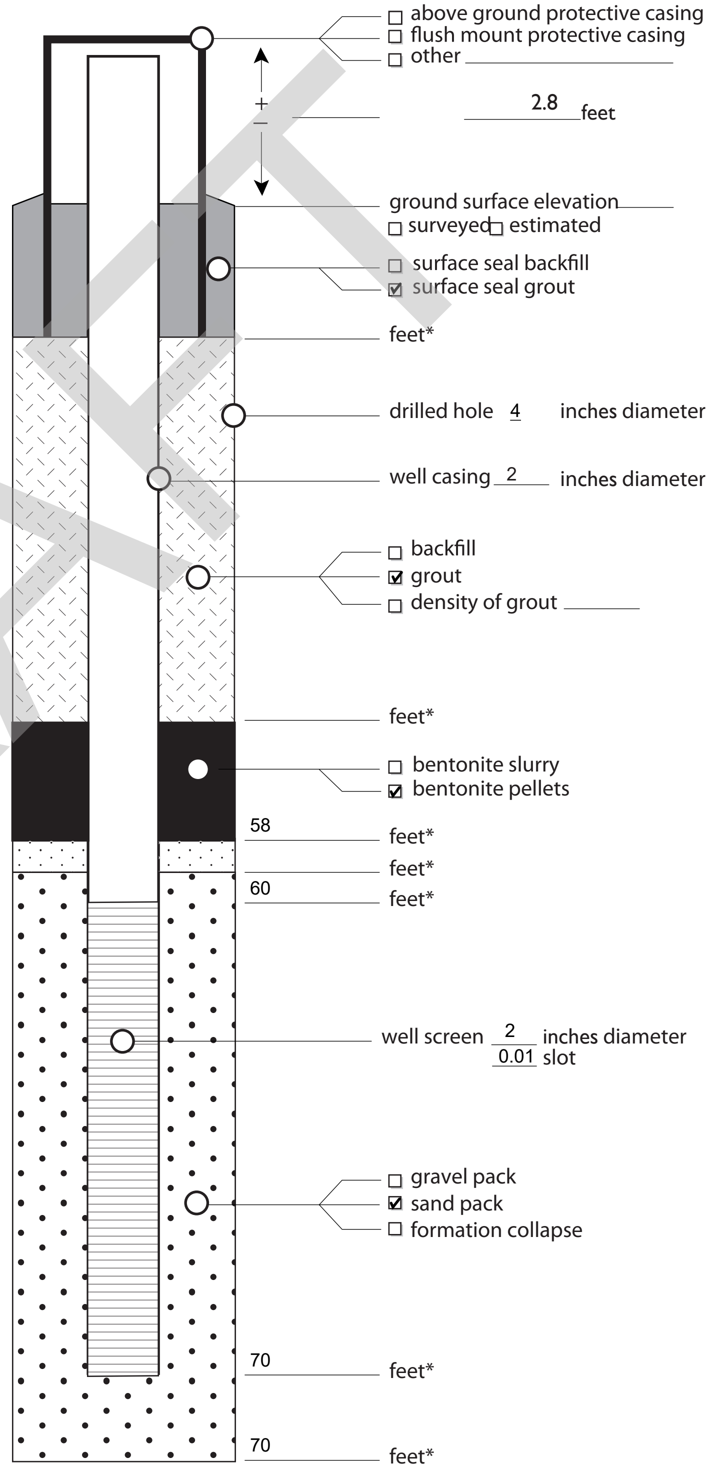
Protective Casing:
Length ______ feet
Diameter ______ inches
Construction ☐ Cast Aluminum
☑ Cast Steel
☐ Other ______

Casing Installation:
Length 70 feet
Diameter 2 inches
Material PVC

Sandpack:
Coarse Sand: ___ bags of ___ lb per bag Size ___
Fine Sand: 10 bags of 50 lb per bag Size ___

Seal:
Bentonite Pellets: 5 bags of 50 lb per bag Type Hole Plug 5/8"
Bentonite Slurry: ___ bags of ___ lb per bag Type ___

Grout:
Cement: 5 bags of 50 lb per bag Type dry mix
Bentonite: ___ bags of ___ lb per bag Type ___



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* Depth Below Ground Surface

MONITORING WELL CONSTRUCTION DETAIL

Geosyntec consultants
1420 Kensington Rd., Suite 103
Oak Brook, Illinois 60523
(630) 203-3340

Well ID: G13D
Project Name: Vistra - Joppa Power Station
Project Number: GLP8030
Site Location: Joppa, IL
Field Personnel: Amanda Toye
Recorded By: Amanda Toye

Permit Number:
Installation Date(s): 9/23/21
Drilling Method: Sonic
Borehole Diameter: 4"
Drilling Contractor: Cascade
Driller: Dave Gordon
Drilling Fluid: Water
Fluid Loss During Drilling: 700 Gallons

Materials Used

Riser Pipe: Diameter 2 inches
Construction
☑ PVC schedule 40
☐ Stainless Steel
☐ Other

Slotted Area: Length 10 feet
Diameter 2 inches
Slot Size 0.01 inches
Construction
☑ PVC schedule 40
☐ Stainless Steel
☐ Other
Silt Trap Used ☐ Yes ☐ No

Bottom End Cap: ☐ Male ☐ Female ☐ Slip
☑ PVC
☐ Stainless Steel
☐ Other

Top Cap: ☐ Male ☐ Female ☐ Slip ☑ J Plug
☐ PVC
☐ Stainless Steel
☐ Other

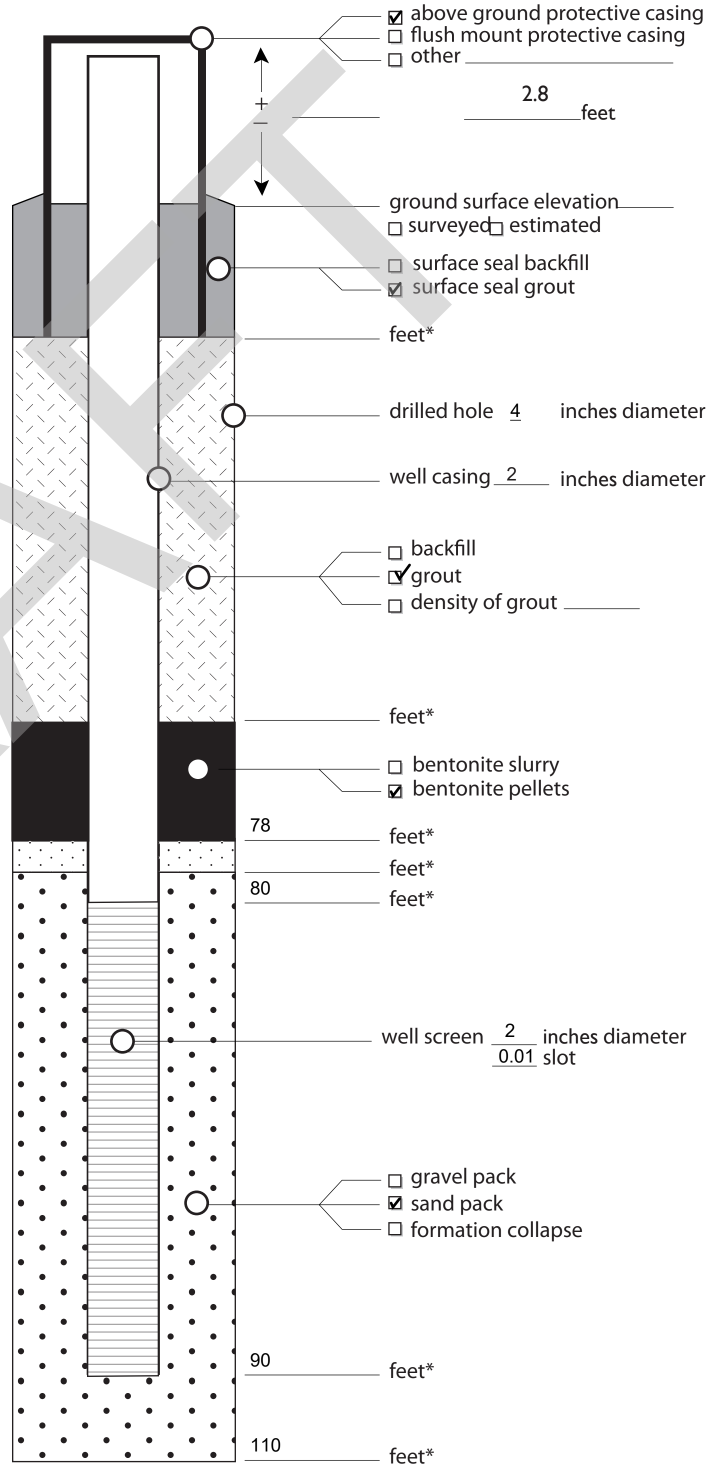
Protective Casing: Length ____ feet
Diameter ____ inches
Construction ☐ Cast Aluminum
☑ Cast Steel
☐ Other

Casing Installation: Length 90 feet
Diameter 2 inches
Material PVC

Sandpack:
Coarse Sand: ___ bags of ___ lb per bag Size ___
Fine Sand: 10 bags of 50 lb per bag Size ___

Seal:
Bentonite Pellets: 5 bags of 50 lb per bag Type Hole Plug 5/8"
Bentonite Slurry: ___ bags of ___ lb per bag Type ___

Grout:
Cement: 5 bags of 50 lb per bag Type dry mix
Bentonite: ___ bags of ___ lb per bag Type ___



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* Depth Below Ground Surface

MONITORING WELL CONSTRUCTION DETAIL

Geosyntec consultants
1420 Kensington Rd., Suite 103
Oak Brook, Illinois 60523
(630) 203-3340

Well ID: G13S
Project Name: Vistra - Joppa Power Station
Project Number: GLP8030
Site Location: Joppa, IL
Field Personnel: Amanda Toye
Recorded By: Amanda Toye

Permit Number: ______
Installation Date(s): 9/23/21
Drilling Method: Sonic
Borehole Diameter: 4"
Drilling Contractor: Cascade
Driller: Dave Gordon
Drilling Fluid: Water
Fluid Loss During Drilling: 300 Gallons

Materials Used

Riser Pipe:
Diameter 2 inches
Construction
☑ PVC schedule 40
☐ Stainless Steel
☐ Other ______

Slotted Area:
Length 10 feet
Diameter 2 inches
Slot Size 0.01 inches
Construction
☑ PVC schedule 40
☐ Stainless Steel
☐ Other ______
Silt Trap Used ☐ Yes ☐ No

Bottom End Cap: ☐ Male ☐ Female ☐ Slip
☑ PVC
☐ Stainless Steel
☐ Other ______

Top Cap: ☐ Male ☐ Female ☐ Slip ☑ J Plug
☐ PVC
☐ Stainless Steel
☐ Other ______

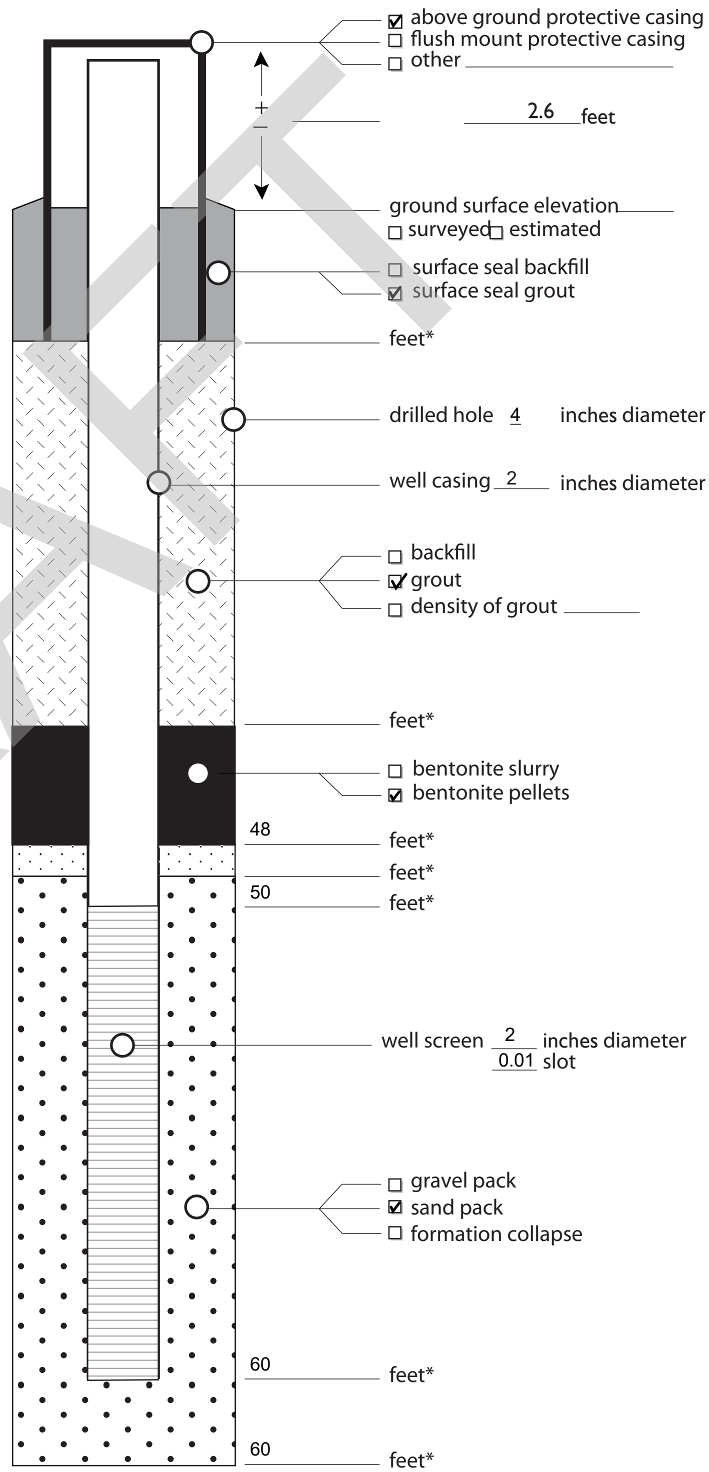
Protective Casing:
Length ______ feet
Diameter ______ inches
Construction ☐ Cast Aluminum
☑ Cast Steel
☐ Other ______

Casing Installation:
Length 60 feet
Diameter 2 inches
Material PVC

Sandpack:
Coarse Sand: ___ bags of ___ lb per bag Size ___
Fine Sand: 10 bags of 50 lb per bag Size ___

Seal:
Bentonite Pellets: 5 bags of 50 lb per bag Type Hole Plug 5/8"
Bentonite Slurry: ___ bags of ___ lb per bag Type ___

Grout:
Cement: 5 bags of 50 lb per bag Type dry mix
Bentonite: ___ bags of ___ lb per bag Type ___



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* Depth Below Ground Surface

Geosyntec consultants
1420 Kensington Rd., Suite 103
Oak Brook, Illinois 60523
(630) 203-3340

MONITORING WELL CONSTRUCTION DETAIL

Well ID: G14D
Project Name: Vistra - Joppa Power Station
Project Number: GLP8030
Site Location: Joppa, IL
Field Personnel: Amanda Toye & Michael Jury
Recorded By: Amanda Toye

Permit Number: ______
Installation Date(s): 9/16/21
Drilling Method: Sonic
Borehole Diameter: 4"
Drilling Contractor: Cascade
Driller: Dave Gordon
Drilling Fluid: Water
Fluid Loss During Drilling: 700 Gallons

Materials Used

Riser Pipe: Diameter 2 inches
Construction
- ☑ PVC schedule 40
- ☐ Stainless Steel
- ☐ Other ______

Slotted Area: Length 10 feet
Diameter 2 inches
Slot Size 0.01 inches
Construction
- ☑ PVC schedule 40
- ☐ Stainless Steel
- ☐ Other ______

Silt Trap Used ☐ Yes ☐ No

Bottom End Cap: ☐ Male ☐ Female ☐ Slip
- ☑ PVC
- ☐ Stainless Steel
- ☐ Other ______

Top Cap: ☐ Male ☐ Female ☐ Slip ☑ J Plug
- ☐ PVC
- ☐ Stainless Steel
- ☐ Other ______

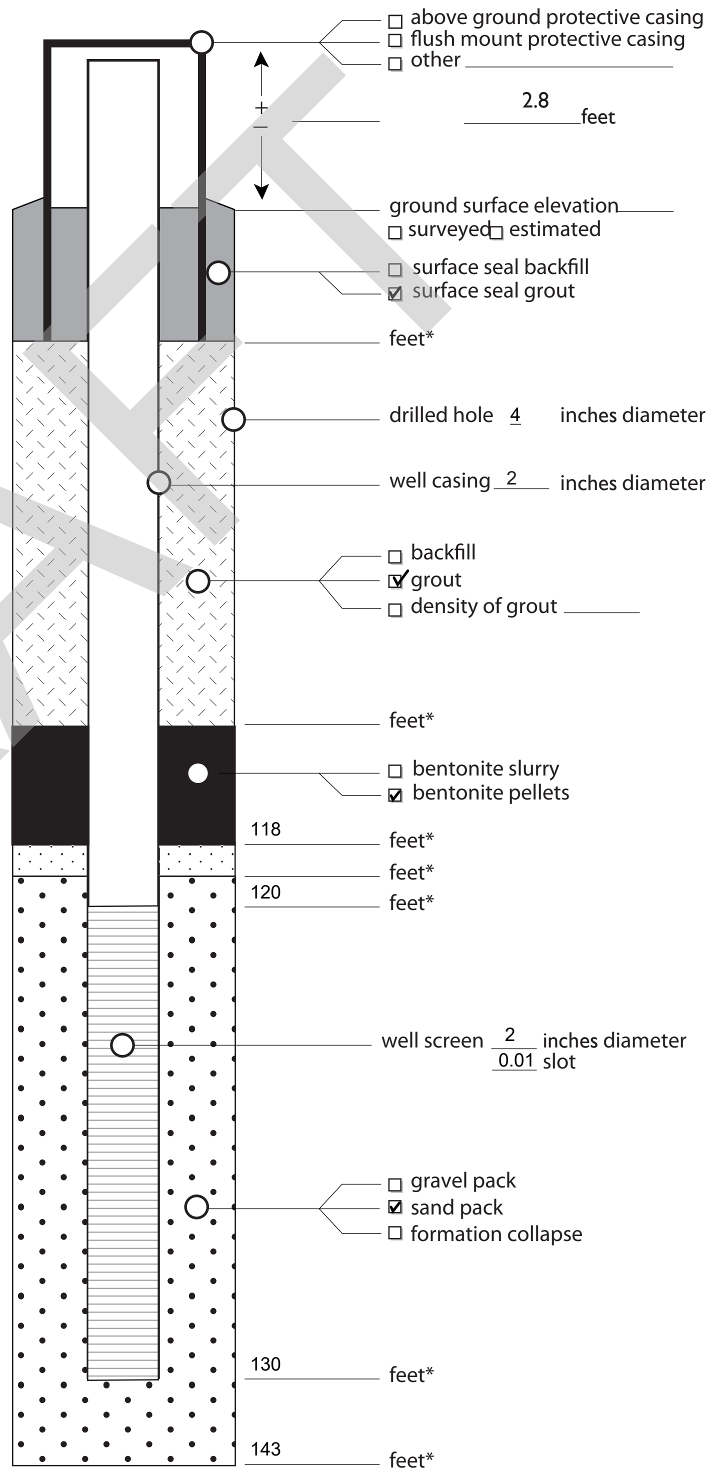
Protective Casing: Length ______ feet
Diameter ______ inches
Construction ☐ Cast Aluminum ☑ Cast Steel ☐ Other ______

Casing Installation: Length 130 feet
Diameter 2 inches
Material PVC

Sandpack:
Coarse Sand: ___ bags of ___ lb per bag ___ Size
Fine Sand: 5 bags of 50 lb per bag ___ Size

Seal:
Bentonite Pellets: 5 bags of 50 lb per bag Type Hole Plug 5/8"
Bentonite Slurry: ___ bags of ___ lb per bag Type ______

Grout:
Cement: 7 bags of 50 lb per bag Type Quickcrete cement
Bentonite: ___ bags of ___ lb per bag Type ______



Measuring Point is Top of Well Casing
Unless Otherwise Noted

* Depth Below Ground Surface

Geosyntec consultants
1420 Kensington Rd., Suite 103
Oak Brook, Illinois 60523
(630) 203-3340

MONITORING WELL CONSTRUCTION DETAIL

Well ID	G14S	Site Location	Joppa, IL
Project Name	Vistra - Joppa Power Station	Field Personnel	Amanda Toye & MJ
Project Number	GLP8030	Recorded By	Amanda Toye

Permit Number ______
Installation Date(s) 9/16/21
Drilling Method Sonic
Borehole Diameter 4"
Drilling Contractor Cascade
Driller Dave Gordon
Drilling Fluid Water
Fluid Loss During Drilling 500 Gallons

Materials Used

Riser Pipe: Diameter 2 inches
Construction
☑ PVC schedule 40
☐ Stainless Steel
☐ Other ______

Slotted Area: Length 10 feet
Diameter 2 inches
Slot Size 0.01 inches
Construction
☑ PVC schedule 40
☐ Stainless Steel
☐ Other ______
Silt Trap Used ☐ Yes ☐ No

Bottom End Cap: ☐ Male ☐ Female ☐ Slip
☑ PVC
☐ Stainless Steel
☐ Other ______

Top Cap: ☐ Male ☐ Female ☐ Slip ☑ J Plug
☐ PVC
☐ Stainless Steel
☐ Other ______

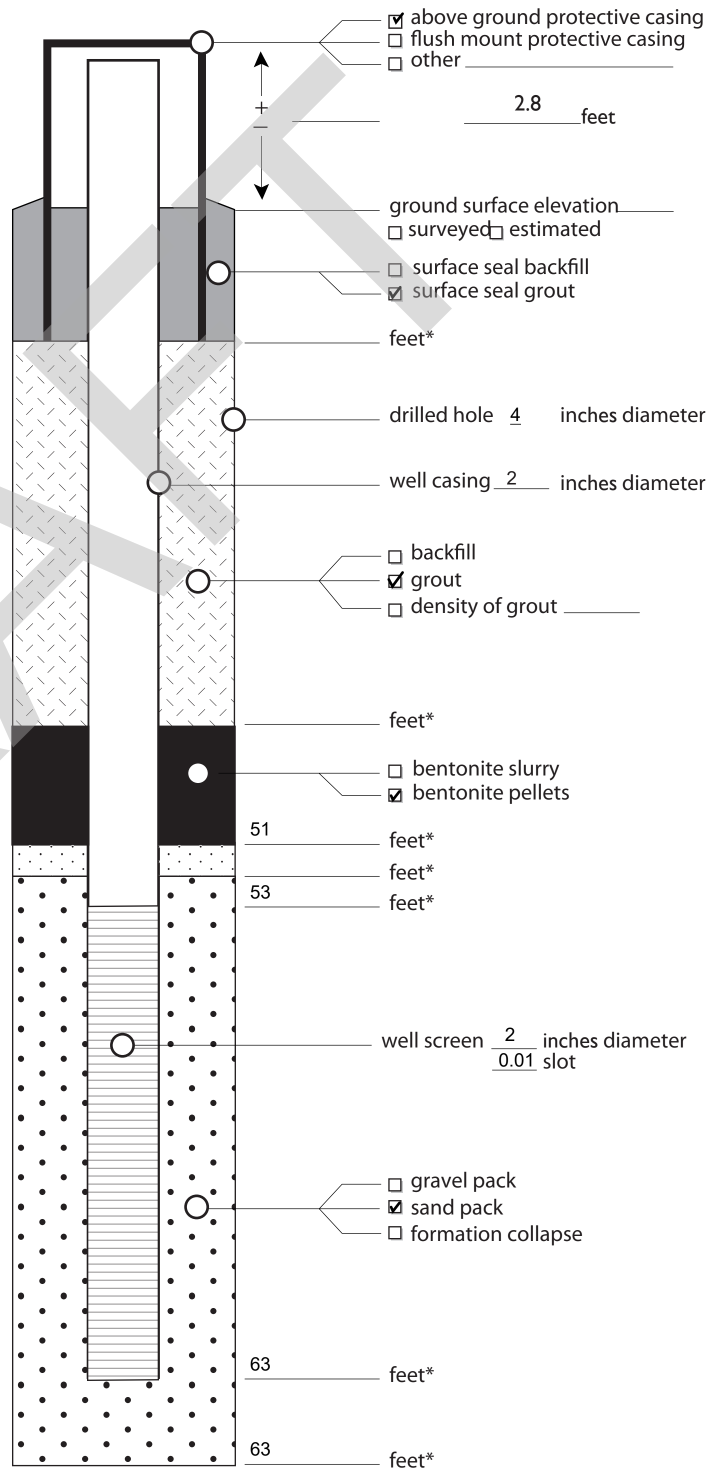
Protective Casing: Length ______ feet
Diameter ______ inches
Construction ☐ Cast Aluminum
☑ Cast Steel
☐ Other ______

Casing Installation: Length 63 feet
Diameter 2 inches
Material PVC

Sandpack:
Coarse Sand: ___ bags of ___ lb per bag Size ___
Fine Sand: 10 bags of 50 lb per bag Size ___

Seal:
Bentonite Pellets: 5 bags of 50 lb per bag Type Hole Plug 3/8"
Bentonite Slurry: ___ bags of ___ lb per bag Type ___

Grout:
Cement: ___ bags of ___ lb per bag Type ___
Bentonite: 5 bags of 50 lb per bag Type dry mix



Measuring Point is Top of Well Casing
Unless Otherwise Noted

* Depth Below Ground Surface

MONITORING WELL CONSTRUCTION DETAIL

Geosyntec consultants
1420 Kensington Rd., Suite 103
Oak Brook, Illinois 60523
(630) 203-3340

Well ID: G15D
Project Name: Vistra - Joppa Power Station
Project Number: GLP8030
Site Location: Joppa, IL
Field Personnel: Amanda Toye & Michael Jury
Recorded By: Amanda Toye

Permit Number: ____
Installation Date(s): 9/15/21
Drilling Method: Sonic
Borehole Diameter: 4"
Drilling Contractor: Cascade
Driller: Dave Gordon
Drilling Fluid: Water
Fluid Loss During Drilling: 600 Gallons

Materials Used

Riser Pipe:
Diameter 2 inches
Construction
☑ PVC schedule 40
☐ Stainless Steel
☐ Other ____

Slotted Area:
Length 10 feet
Diameter 2 inches
Slot Size 0.01 inches
Construction
☑ PVC schedule 40
☐ Stainless Steel
☐ Other ____
Silt Trap Used ☐ Yes ☐ No

Bottom End Cap: ☐ Male ☐ Female ☐ Slip
☑ PVC
☐ Stainless Steel
☐ Other ____

Top Cap: ☐ Male ☐ Female ☐ Slip ☑ J Plug
☐ PVC
☐ Stainless Steel
☐ Other ____

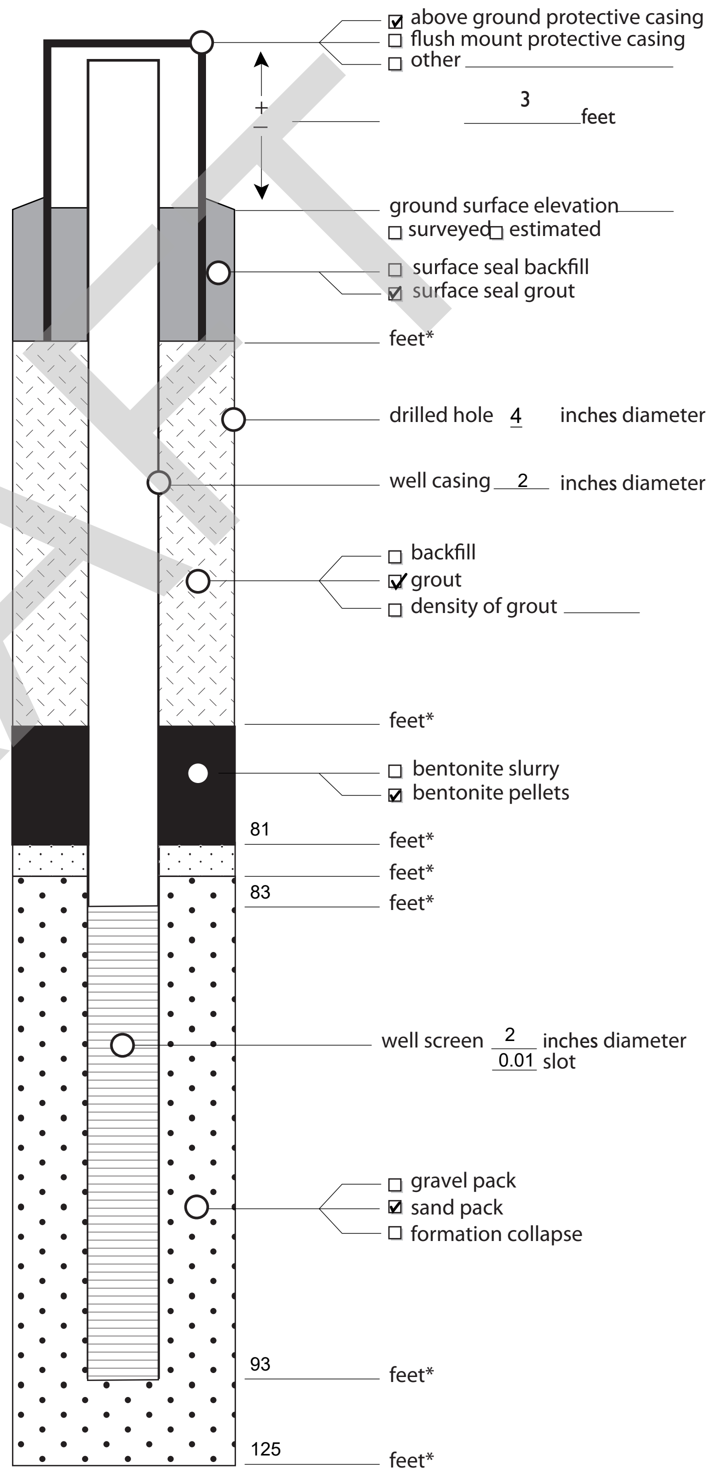
Protective Casing:
Length 93 feet
Diameter ____ inches
Construction ☐ Cast Aluminum
☑ Cast Steel
☐ Other ____

Casing Installation:
Length 108 feet
Diameter 2 inches
Material PVC

Sandpack:
Coarse Sand: 9 bags of 80 lb per bag Size ____
Fine Sand: 10 bags of 50 lb per bag Size ____

Seal:
Bentonite Pellets: 5 bags of 80 lb per bag Type Hole Plug 5/8"
Bentonite Slurry: ____ bags of ____ lb per bag Type ____

Grout:
Cement: 5 bags of 50 lb per bag Type dry mix
Bentonite: ____ bags of ____ lb per bag Type ____



Measuring Point is Top of Well Casing
Unless Otherwise Noted

* Depth Below Ground Surface

MONITORING WELL CONSTRUCTION DETAIL

Geosyntec consultants
1420 Kensington Rd., Suite 103
Oak Brook, Illinois 60523
(630) 203-3340

Well ID: G15S
Project Name: Vistra - Joppa Power Station
Project Number: GLP8030
Site Location: Joppa, IL
Field Personnel: Amanda Toye & Michael Jury
Recorded By: Amanda Toye

Permit Number: ____
Installation Date(s): 9/15/21
Drilling Method: Sonic
Borehole Diameter: 4"
Drilling Contractor: Cascade
Driller: Dave Gordon
Drilling Fluid: Water
Fluid Loss During Drilling: 300 Gallons

Materials Used

Riser Pipe: Diameter 2 inches
Construction
☑ PVC schedule 40
☐ Stainless Steel
☐ Other ____

Slotted Area: Length 10 feet
Diameter 2 inches
Slot Size 0.01 inches
Construction
☑ PVC schedule 40
☐ Stainless Steel
☐ Other ____
Silt Trap Used ☐ Yes ☐ No

Bottom End Cap: ☐ Male ☐ Female ☐ Slip
☑ PVC
☐ Stainless Steel
☐ Other ____

Top Cap: ☐ Male ☐ Female ☐ Slip ☑ J Plug
☐ PVC
☐ Stainless Steel
☐ Other ____

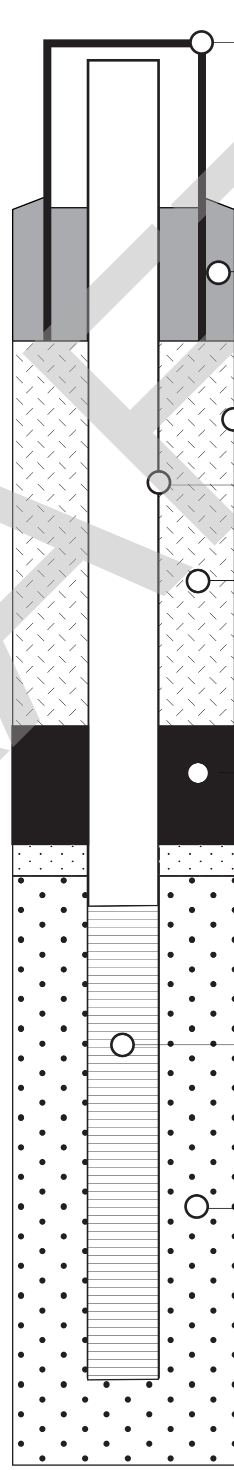
Protective Casing: Length ____ feet
Diameter ____ inches
Construction ☐ Cast Aluminum
☑ Cast Steel
☐ Other ____

Casing Installation: Length 60 feet
Diameter 2 inches
Material PVC

Sandpack:
Coarse Sand: __ bags of ____ lb per bag Size ____
Fine Sand: 5 bags of 50 lb per bag Size ____

Seal:
Bentonite Pellets: 2 bags of 50 lb per bag Type Hole Plug 3/8"
Bentonite Slurry: __ bags of __ lb per bag Type ____

Grout:
Cement: 5 bags of 50 lb per bag Type Quickcrete cement
Bentonite: __ bags of __ lb per bag Type ____



Measuring Point is Top of Well Casing Unless Otherwise Noted

* Depth Below Ground Surface

MONITORING WELL CONSTRUCTION DETAIL

Geosyntec consultants
1420 Kensington Rd., Suite 103
Oak Brook, Illinois 60523
(630) 203-3340

Well ID: G16D
Project Name: Vistra - Joppa Power Station
Project Number: GLP8030
Site Location: Joppa, IL
Field Personnel: Amanda Toye & Michael Jury
Recorded By: Amanda Toye

Permit Number:
Installation Date(s): 9/14/21
Drilling Method: Sonic
Borehole Diameter: 4"
Drilling Contractor: Cascade
Driller: Dave Gordon
Drilling Fluid: Water
Fluid Loss During Drilling: 600 Gallons

Materials Used

Riser Pipe: Diameter 2 inches
Construction
☑ PVC schedule 40
☐ Stainless Steel
☐ Other

Slotted Area: Length 10 feet
Diameter 2 inches
Slot Size 0.01 inches
Construction
☑ PVC schedule 40
☐ Stainless Steel
☐ Other
Silt Trap Used ☐ Yes ☐ No

Bottom End Cap: ☐ Male ☐ Female ☐ Slip
☑ PVC
☐ Stainless Steel
☐ Other

Top Cap: ☐ Male ☐ Female ☐ Slip ☑ J Plug
☐ PVC
☐ Stainless Steel
☐ Other

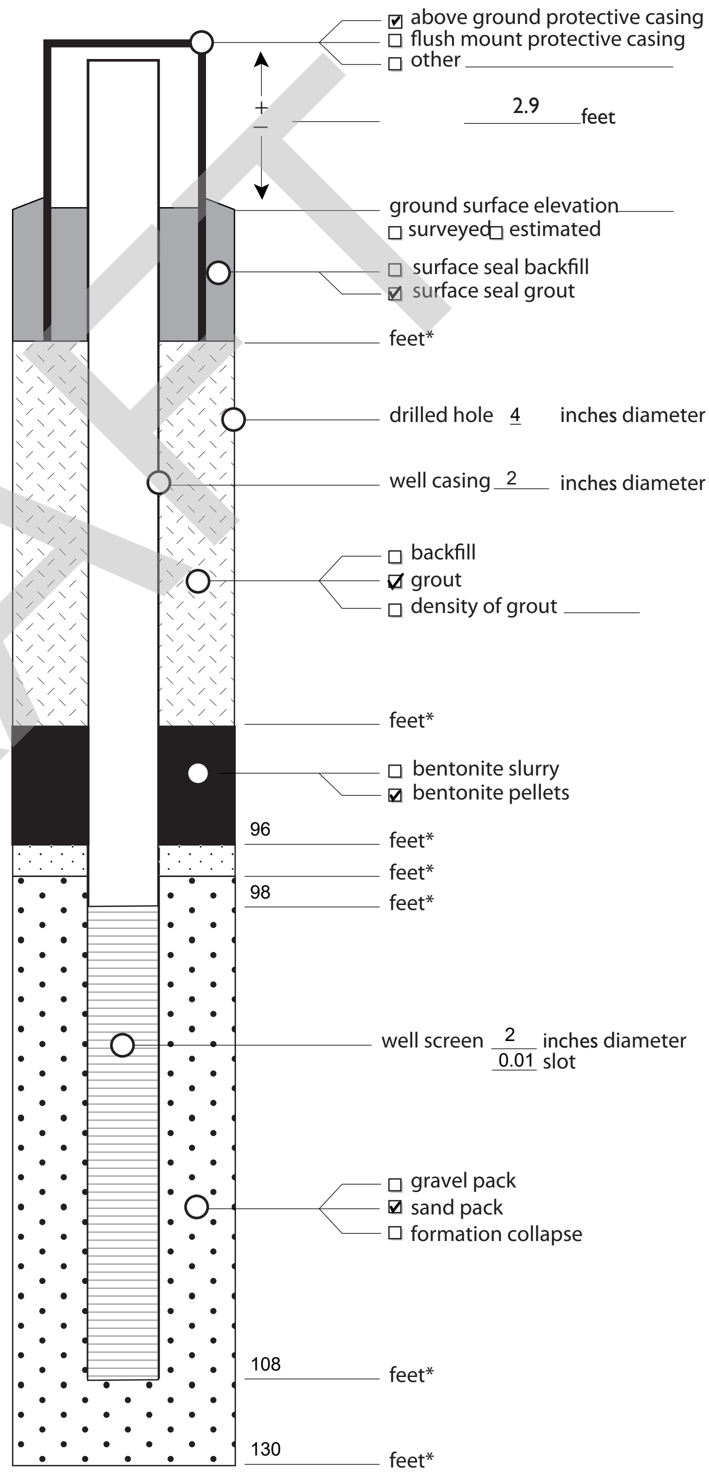
Protective Casing: Length 108 feet
Diameter 2 inches
Construction ☐ Cast Aluminum
☑ Cast Steel
☐ Other

Casing Installation: Length 108 feet
Diameter 2 inches
Material PVC

Sandpack:
Coarse Sand: ___ bags of ___ lb per bag Size ___
Fine Sand: 4 bags of 50 lb per bag Size ___

Seal:
Bentonite Pellets: 6 bags of 50 lb per bag Type Hole Plug 5/8"
Bentonite Slurry: ___ bags of ___ lb per bag Type ___

Grout:
Cement: 5 bags of 50 lb per bag Type Quickcrete cement
Bentonite: ___ bags of ___ lb per bag Type ___



Measuring Point is Top of Well Casing Unless Otherwise Noted

* Depth Below Ground Surface

MONITORING WELL CONSTRUCTION DETAIL

Geosyntec consultants
1420 Kensington Rd., Suite 103
Oak Brook, Illinois 60523
(630) 203-3340

Well ID: G16S
Project Name: Vistra - Joppa Power Station
Project Number: GLP8030
Site Location: Joppa, IL
Field Personnel: Amanda Toye & Michael Jury
Recorded By: Amanda Toye

Permit Number: ______
Installation Date(s): 9/14/21
Drilling Method: Sonic
Borehole Diameter: 4"
Drilling Contractor: Cascade
Driller: Dave Gordon
Drilling Fluid: Water
Fluid Loss During Drilling ______ Gallons

Materials Used

Riser Pipe:
Diameter 2 inches
Construction
☑ PVC schedule 40
☐ Stainless Steel
☐ Other ______

Slotted Area:
Length 10 feet
Diameter 2 inches
Slot Size 0.01 inches
Construction
☑ PVC schedule 40
☐ Stainless Steel
☐ Other ______
Silt Trap Used ☐ Yes ☐ No

Bottom End Cap: ☐ Male ☐ Female ☐ Slip
☑ PVC
☐ Stainless Steel
☐ Other ______

Top Cap: ☐ Male ☐ Female ☐ Slip ☑ J Plug
☐ PVC
☐ Stainless Steel
☐ Other ______

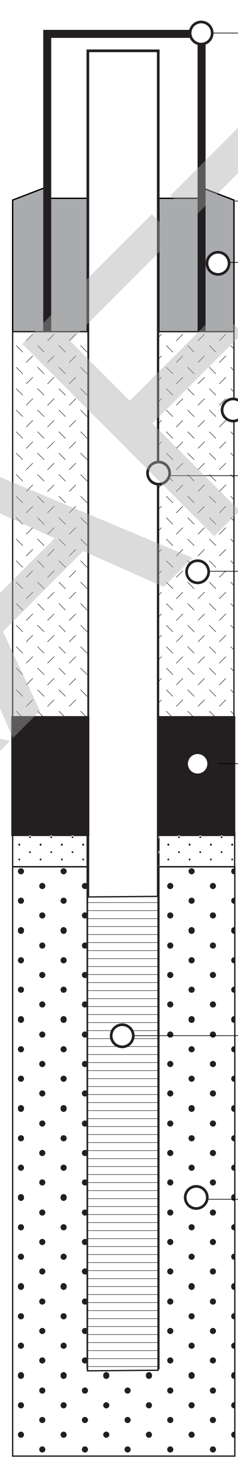
Protective Casing:
Length ______ feet
Diameter ______ inches
Construction ☐ Cast Aluminum
☑ Cast Steel
☐ Other ______

Casing Installation:
Length 60 feet
Diameter 2 inches
Material PVC

Sandpack:
Coarse Sand: ___ bags of ___ lb per bag Size ______
Fine Sand: 4 bags of 50 lb per bag Size ______

Seal:
Bentonite Pellets: 6 bags of 50 lb per bag Type Hole Plug 5/8"
Bentonite Slurry: ___ bags of ___ lb per bag Type ______

Grout:
Cement: 5 bags of 50 lb per bag Type Quickcrete cement
Bentonite: ___ bags of ___ lb per bag Type ______



☑ above ground protective casing
☐ flush mount protective casing
☐ other ______

2.7 feet

ground surface elevation ______
☐ surveyed ☐ estimated

☐ surface seal backfill
☑ surface seal grout
______ feet*

drilled hole 4 inches diameter

well casing 2 inches diameter

☐ backfill
☑ grout
☐ density of grout ______

______ feet*

☐ bentonite slurry
☑ bentonite pellets

48 feet*
______ feet*
50 feet*

well screen 2 inches diameter
0.01 slot

☐ gravel pack
☑ sand pack
☐ formation collapse

60 feet*

60 feet*

Measuring Point is Top of Well Casing
Unless Otherwise Noted

* Depth Below Ground Surface

Geosyntec consultants
1420 Kensington Rd., Suite 103
Oak Brook, Illinois 60523
(630) 203-3340

MONITORING WELL CONSTRUCTION DETAIL

Well ID: Well 3
Site Location: Joppa, IL
Project Name: Vistra - Joppa Power Station
Field Personnel: AT, GA
Project Number:
Recorded By: AT

Permit Number:
Installation Date(s): 9/22/2021
Drilling Method: Sonic
Borehole Diameter: 6
Drilling Contractor: Cascade
Driller: Dave Gordon
Drilling Fluid: Water
Fluid Loss During Drilling: 300 Gallons

Materials Used

Riser Pipe: Diameter 2 inches
Construction
☑ PVC schedule 40
☐ Stainless Steel
☐ Other

Slotted Area: Length 10 feet
Diameter 2 inches
Slot Size 0,010 inches
Construction
☑ PVC schedule 40
☐ Stainless Steel
☐ Other

Silt Trap Used ☐ Yes ☐ No

Bottom End Cap: ☐ Male ☐ Female ☐ Slip
☑ PVC
☐ Stainless Steel
☐ Other

Top Cap: ☐ Male ☐ Female ☐ Slip ☑ J Plug
☐ PVC
☐ Stainless Steel
☐ Other

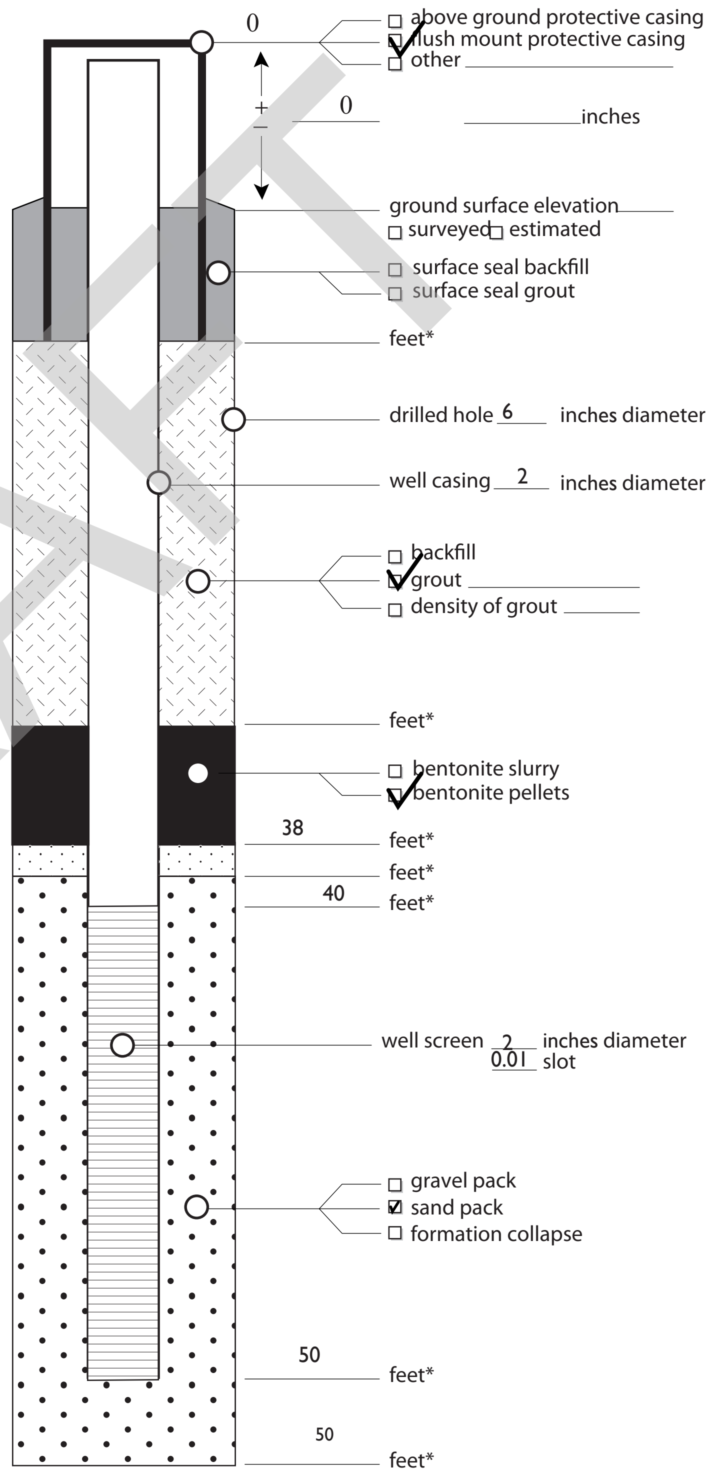
Protective Casing: Length feet
Diameter inches
Construction ☐ Cast Aluminum
☐ Cast Steel
☑ Other

Casing Installation: Length 68 feet
Diameter 2 inches
Material PVC

Sandpack: Filter sil
Coarse Sand: __ bags of __ lb per bag Size
Fine Sand: 7 bags of 50 lb per bag Size

Seal: Holeplug
Bentonite Pellets: 5 bags of 50 lb per bag Type 5/8
Bentonite Slurry: __ bags of __ lb per bag Type

Grout: Quikcrete
Cement: 5 bags of 50 lb per bag Type
Bentonite: __ bags of __ lb per bag Type



Measuring Point is Top of Well Casing Unless Otherwise Noted

* Depth Below Ground Surface

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

APPENDIX D
EVALUATION OF PARTITION COEFFICIENT RESULTS

1 McBride and Son Center Drive, Suite 202
Chesterfield, MO 63005
www.geosyntec.com

Memorandum

Date:	May 24, 2022
To:	David Mitchell, Stu Cravens, Vic Modeer Electric Energy Inc.
Copies to:	Brian Hennings - Ramboll
From:	Allison Kreinberg, Ryan Fimmen – Geosyntec Consultants, Inc.
Subject:	Draft Evaluation of Partition Coefficient Results – Joppa East Ash Pond CCR Unit 401, Joppa Power Plant, Joppa, Illinois

INTRODUCTION

Electric Energy, Inc. currently operates the Joppa Power Plant (JPP) and its associated ash ponds located in Joppa, Illinois. The East Ash Pond (EAP) (Vistra identification [ID] No. 401; Illinois Environmental Protection Agency [IEPA] ID No. W1270100004-02; National Inventory of Dams [NID] No. IL50714) is an active 111-acre unlined surface impoundment used to manage CCR and non-CCR waste streams at the JPP. Geosyntec Consultants (Geosyntec) is assisting Electric Energy, Inc. with Part 845 compliance at the Site.

Electric Energy, Inc. is currently preparing a Construction Permit application for the EAP as required under Section 845.220. As part of the Construction Permit application, groundwater modeling is being completed for known potential exceedances of groundwater protection standards (GWPS) identified in the Operating Permit (Burns & McDonnell, 2021). In the Operating Permit (October 2021), Burns & McDonnell identified potential GWPS exceedances for several constituents potentially associated with the EAP, including boron, pH (field), and sulfate. An evaluation of potential exceedances of applicable GWPS found that the pH potential exceedances are not related to the EAP (Ramboll, 2022). Batch adsorption testing was conducted for boron to generate site-specific partition coefficients. This technical memorandum summarizes the results of the batch adsorption testing and calculation of partition coefficients.

BATCH ATTENUATION TESTING

In 2021, Geosyntec conducted a field investigation at the EAP which included completion of three (3) soil/rock borings ranging in depth from 50 to 80 feet below ground surface. As part of that investigation, soil and groundwater samples were submitted to SiREM Laboratories (Guelph, ON) for batch solid/liquid partitioning testing.

One groundwater sample (G07) and one soil sample (SB-03) were used for batch attenuation testing at five (5) soil:solution ratios (**Table 1**), each ran in duplicate. For each treatment, 0.1 L of groundwater was brought into contact with varying amounts of soil (0.004 to 0.2 kg) and equilibrated over a seven-day period. Each microcosm was amended (i.e., spiked) with boric acid (H_3BO_3) to achieve the desired initial concentration (5 mg/L) of boron (**Table 2**).

An initial sample of the stock solution for each experimental design was collected on Day 0, and a control sample (i.e., only amended G07 groundwater with no aquifer solids) was collected on Day 7 after tumbling in polypropylene bottleware to evaluate any loss due to interactions with the bottleware or changes in ambient conditions. Duplicates were constructed for each microcosm, including the control samples. After seven days of contact time, an aliquot of the free liquid was collected and filtered through a 0.45-micron (µm) filter prior to analysis for dissolved concentrations of boron. 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.

Data obtained from the test (**Table 3**) were used to construct isotherms for boron; 5-point isotherms were constructed by averaging duplicate results for each soil:solution ratio. Mathematical fitting was used to calculate the attenuation distribution coefficients (K_d), assuming linear adsorption. The linear adsorption equation was used:

$$q_e = K_d \times C_e \qquad \text{Eq. 1}$$

where q_e is the mass of constituent adsorbed to the solid phase at equilibrium, C_e is the remaining aqueous constituent concentration at equilibrium, and K_d is the linear sorption coefficient (reported in liters per kilogram [L/kg]). The data showed a deviation from a linear trend, and so were also fitted using non-linear isotherms. The non-linear Langmuir isotherm was used:

$$q_e = \frac{q_m K_L C_e}{1 + K_L C_e} \qquad \text{Eq. 2}$$

where q_m is the inverse of the slope and K_L is the Langmuir distribution coefficient. The adsorption data were linearized according to:

$$\frac{C_e}{q_e} = \frac{1}{(K_L \times q_m)} + \frac{C_e}{q_m} \qquad \text{Eq. 3}$$

A common non-linear Freundlich equation was also used:

$$q_e = K_F(C_e)^{1/n} \qquad \text{Eq. 4}$$

where q_e is the mass of constituent adsorbed to the solid phase at equilibrium, C_e is the remaining aqueous constituent concentration at equilibrium, K_F is the Freundlich distribution coefficient, and $1/n$ is a non-linearity constant. The adsorption data were plotted as log-transformed values to perform the non-linear isotherm fitting using the linearized Freundlich equation:

$$log(q_e) = \log(K_F) + (1/n)\log(C_e) \qquad \text{Eq. 5}$$

The calculated linear, Langmuir, and Freundlich distribution coefficients (K_d, K_L, and K_F, respectively) and $1/n$ values are shown in **Table 4**.

SUMMARY OF RESULTS

The partition coefficient values for G07 are presented in **Table 4**. A figure which shows the linear, Langmuir, and Freundlich isotherms for boron is provided in **Appendix A**.

All boron partition coefficients for G07 were calculated using four of the five datapoints provided by batch attenuation testing. The results for the 1:27.3 soil:solution ratio were excluded because they consistently reduced the goodness-of-fit of each isotherm, and resulted in unrealistic values for both the partition coefficients (i.e., negative values) and isotherm fitting parameters (i.e., 1/n). Removal of the 1:27.3 soil:solution ratio also resulted in a more conservative linear partition coefficient. The linear boron partition coefficient of 2.4 L/kg, calculated using the four-point isotherm, was chosen for G07 based on its goodness-of-fit ($R^2 > 0.99$) and comparability to other values reported in the literature, which range from 0.19 to 1.3 L/kg depending on pH conditions and the amount of sorbent present (EPRI, 2005; Strenge & Peterson, 1989). Despite their high goodness-of-fit, both the linearized Langmuir and Freundlich isotherms yielded partition coefficients orders of magnitude higher than anticipated relative to values reported in the literature.

REFERENCES

Burns & McDonnell. 2021. Initial Operating Permit Joppa East Ash Pond. October

EPRI, 2005. *Chemical Constituents In Coal Combustion Product Leachate: Boron. Final Report 1005258.*

Ramboll Americas Engineering Solutions, Inc. (Ramboll), 2022. *Evaluation of Potential GWPS Exceedances, Joppa Power Plant, East Ash Pond, CCR Unit 401, May 2022.*

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

TABLES

Table 1 - Batch Attenuation Testing Data Summary
Joppa EAP

Groundwater Sample ID	Soil Sample ID	Soil: Water Ratio
G07	SB-03 (57.5-62.5, 63.5-70.0 ft bgs)	2:1.3
		1:1.2
		1:5.6
		1:11.0
		1:27.3

Notes:

ft bgs = feet below ground surface

Table 2 - Microcosm Amendment and Target Concentration
Joppa EAP

Groundwater Sample ID	Soil Sample ID	Compound	Amendment	Target Concentration (mg/L)
G07	SB-03 (57.5-62, 63.5-70.0 ft bgs)	Boron	7.89 mL of a 2 g/L H_3BO_3	5

Notes:
ft bgs - feet below ground surface
mg/L - milligrams per liter
mL - milliliters
H_3BO_3 - boric acid

Table 3 - Batch Attenuation Testing Results, G07
Joppa EAP

Groundwater Sample ID	Geologic Material Sample ID	Treatment	Date	Day	Replicate	Dissolved Boron	pH	ORP
						mg/L	SU	mV
G07	--	Water Control Only	23-Dec-21	0	G07-1a	5.8	7.23	81
					G07-2a	5.4	7.3	73
					Average Concentration (mg/L)	**5.6**	**7.3**	**77**
			30-Dec-21	7	G07-1	4.1	7.14	193
					G07-2	4.3	7.09	168
					Average Concentration (mg/L)	**4.2**	**7.1**	**181**
	SB-03	2:1.3 Soil:Water Ratio	23-Dec-21	0				
			30-Dec-21	7	SB-03: G07 2:1-1	2.5	6.85	148
					SB-03: G07 2:1-2	3.1	6.75	132
					Average Concentration (mg/L)	**2.8**	**6.8**	**140**
		1:1.2 Soil:Water Ratio	23-Dec-21	0				
			30-Dec-21	7	SB-03: G07 1:1-1	3.1	6.84	146
					SB-03: G07 1:1-2	3.1	6.95	142
					Average Concentration (mg/L)	**3.1**	**6.9**	**144**
		1:5.6 Soil:Water Ratio	23-Dec-21	0				
			30-Dec-21	7	SB-03: G07 1:5-1	3.8	6.96	134
					SB-03: G07 1:5-2	4.3	6.91	135
					Average Concentration (mg/L)	**4.1**	**6.9**	**135**
		1:11 Soil:Water Ratio	23-Dec-21	0				
			30-Dec-21	7	SB-03: G07 1:10-1	4.4	6.98	136
					SB-03: G07 1:10-2	4.4	6.89	131
					Average Concentration (mg/L)	**4.4**	**6.9**	**134**
		1:27.3 Soil:Water Ratio	23-Dec-21	0				
			30-Dec-21	7	SB-03: G07 1:20-1	4.5	7.08	146
					SB-03: G07 1:20-2	4.4	6.92	150
					Average Concentration (mg/L)	**4.5**	**7.0**	**148**

Notes:
mg/L - milligrams per liter
mV - millivolts
SU - Standard Units
ORP - oxidation/reduction potential

Table 4 - Partition Coefficient Results, G07
Joppa EAP

Materials	Analyte	Isotherm	Variable	Value
G07/SB-03	Boron	Linear	R^2	0.998
			K_D (L/kg)	2.40
		Langmuir	R^2	0.982
			q_m (mg/g)	0.06
			K_L (L/kg)	5.66E+04
		Freundlich	R^2	0.999
			1/n	0.83
			K_F (L/kg)	86.4

Notes:

K_D - linear partition coefficient

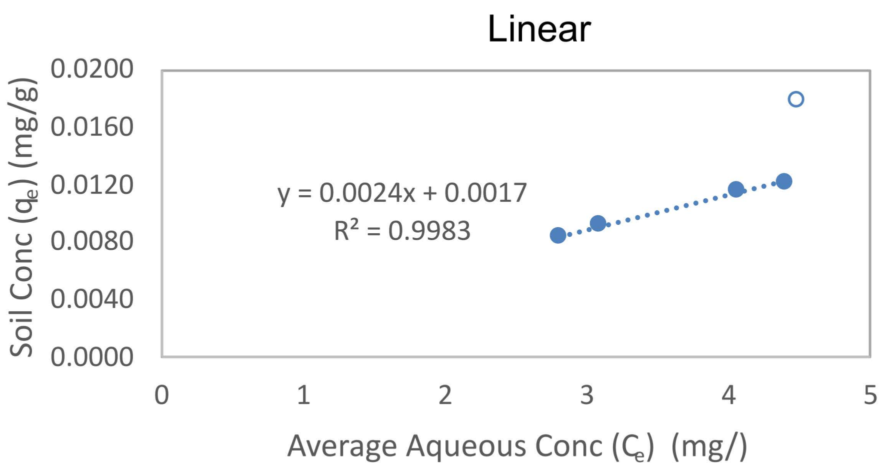
K_L - Langmuir partition coefficient

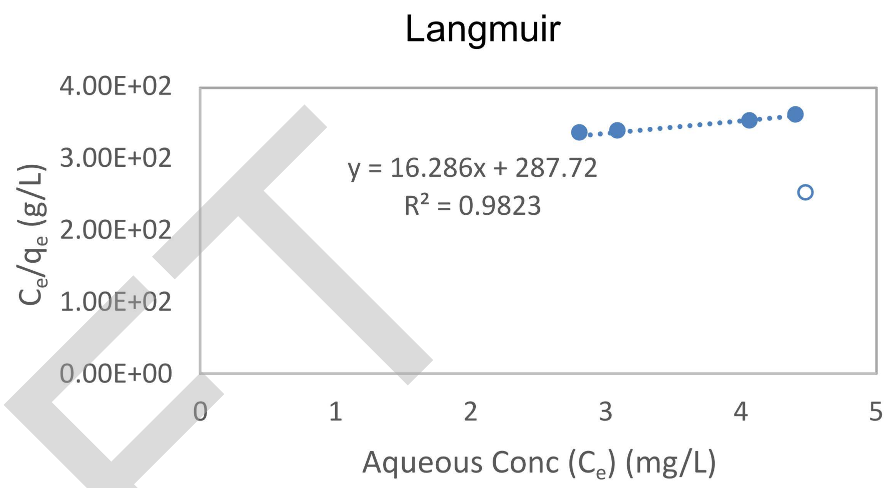
K_F - Freundlich partition coefficient

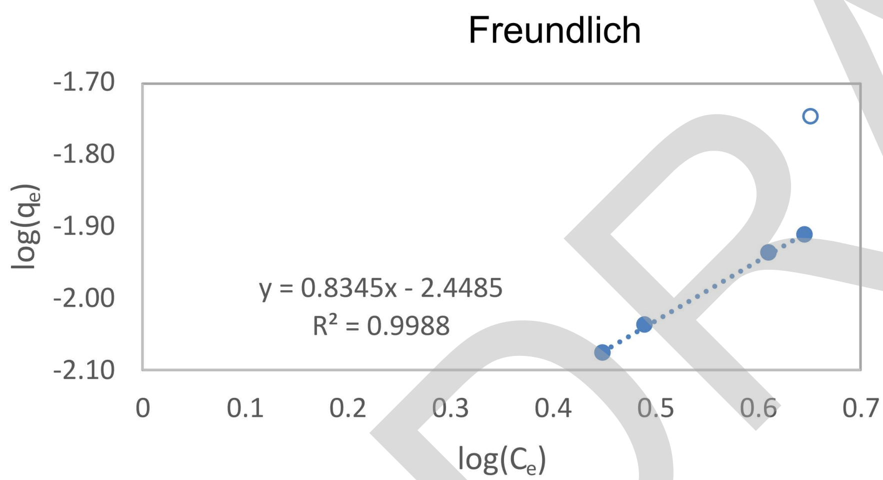
q_m - inverse of the slope of the linearized Langmuir isotherm

n - non-linearity constant of the Freundlich isotherm

APPENDIX A
BATCH TESTING ISOTHERM PLOTS







Notes:

q_e - mass of constituent adsorbed to the solid phase
C_e - remaining aqueous constituent concentration
mg/L - milligrams per liter
mg/g - milligrams per gram
g/L - grams per liter

The results from the 1:27.3 soil:solution ratio, shown as hollow symbols, were not used to calculate the partition coefficients.

G07 Boron Partitioning Coefficients
Joppa Power Plant EAP
Joppa, Illinois

Geosyntec consultants

Columbus, OH | May 2022

Figure 1