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GROUNDWATER MODELING REPORT

BOTTOM ASH POND
BALDWIN POWER PLANT
BALDWIN, ILLINOIS

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BALDWIN POWER PLANT BOTTOM 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
BAP	Bottom Ash Pond
BPP	Baldwin Power Plant
CCR	coal combustion residuals
CIP	closure in place
cm/s	centimeters per second
Cooling Pond	Baldwin Lake
CSM	conceptual site model
DMG	Dynegy Midwest Generation, LLC
FAPS	Fly Ash Pond System
ft/day	feet/foot per day
ft^2/d	feet squared per day
Geosyntec	Geosyntec Consultants
GMR	Groundwater Modeling Report
HCR	Hydrogeologic Site Characterization Report
HELP	Hydrologic Evaluation of Landfill Performance
HUC	Hydrologic Unit Code
ID	Identification
IEPA	Illinois Environmental Protection Agency
Kh/Kv	vertical anisotropy
NAVD88	North American Vertical Datum of 1988
NGVD29	National Geodetic Vertical Datum of 1929
NID	National Inventory of Dams
No.	number
NPDES	National Pollutant Discharge Elimination System
NRT	Natural Resource Technology, Inc.
PMP	Potential Migration Pathway
Ramboll	Ramboll Americas Engineering Solutions, Inc.
SI	surface impoundment
Site	combined area including the BAP, FAPS, Secondary Pond, Tertiary Pond, and Cooling Pond
SDA	spray dry absorption
SSR	sum of squared residuals
S_y	specific yield
UA	uppermost aquifer
UGU	Upper Groundwater Unit
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey

EXECUTIVE SUMMARY

Ramboll Americas Engineering Solutions, Inc. (Ramboll) has prepared this Groundwater Modeling Report (GMR) on behalf of the Baldwin Power Plant (BPP), operated by Dynegy Midwest Generation, LLC (DMG), 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 (Illinois Environmental Protection Agency [IEPA], April 15, 2021). This document presents the results of predictive groundwater modeling simulations for the proposed closure scenario for the Bottom Ash Pond (BAP). The BAP (coal combustion residuals [CCR] unit Identification [ID] number [No.] 601, IEPA ID No. W1578510001-06, and National Inventory of Dams [NID] No. IL50721) is the only active CCR unit present on the BPP property. The Fly Ash Pond System (FAPS) is a closed CCR unit on the BPP property (CCR unit ID 605; IEPA ID Nos.W1578510001-01, W1578510001-02, and W1578510001-03; and NID No. IL50721).

The BPP is located in Baldwin, Illinois (**Figure 1-1**). The BPP property is situated in an agricultural area. The BPP property is bordered to the west by the Kaskaskia River; to the east by Baldwin Road, farmland, and strip-mining areas; to the southeast by the Village of Baldwin; to the south by the Illinois Central Gulf railroad tracks, scattered residences, and State Route 154; and to the north by farmland (**Figure 1-2**).

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

- **CCR**: CCR, consisting primarily of fly ash, bottom ash, and boiler slag. Also includes earthen fill deposits of predominantly clay and silt materials from on-site excavations that were used to construct berms and roads surrounding the various impoundments across the Site.
- **Upper Groundwater Unit (UGU)**: Predominantly clay with some silt and minor sand, silt layers, and occasional sand lenses. Includes the lithologic layers identified as the Cahokia Formation, Peoria Loess, Equality Formation, and Vandalia Till. This unit is composed of unlithified natural geologic materials and extends from the upper saturated materials to the bedrock. Thin sand seams and the interface (contact) between the UGU and bedrock have been identified as potential migration pathways (PMPs). No continuous sand seams were observed within or immediately adjacent to the BAP; however, the sand seams may act as a PMP due to relatively higher hydraulic conductivities.
- **Bedrock Unit**: This unit is considered the uppermost aquifer (UA). Pennsylvanian and Mississippian-aged bedrock is composed of interbedded shale and limestone bedrock, which underlies and is continuous across the entire Site.

The extent of sand and gravel aquifers in the region are primarily found along the Kaskaskia River Valley where sand and gravel deposits are highly permeable, thick, and extensive. Outside of the Kaskaskia River Valley, the unlithified materials in upland areas are predominantly clay, which generally provide a low probability of encountering sand and gravel layers for dependable groundwater supply. Although some thin sand seams and layers occur intermittently within the Vandalia Till in localized areas around the BPP, most groundwater supplies in upland areas are obtained from large diameter shallow bored wells. Typical water wells in the vicinity of the BPP are between 25 and 55 feet deep, 36 to 48 inches in diameter, and collect groundwater through slow percolation into the wells, which are large diameter to allow for greater water storage to compensate for the low rate of groundwater infiltration (Ramboll, 2021).

The shallow bedrock is the only water-bearing unit that is continuous across the Site. Groundwater in the bedrock mainly occurs under semi-confined to confined conditions with the overlying unlithified unit behaving as the upper confining unit to the UA. Shallow sandstone and creviced limestone may yield small supplies in some areas, but water quality becomes poorer (*i.e.*, highly mineralized) with increasing depth.

Data collected from previous field investigations, as well as the lithologic contact and groundwater elevation data from 2022 field investigations, were used to develop a groundwater model for the BAP. The MODFLOW model was used to evaluate one closure scenario: CCR consolidation and CIP using information provided in the CCR Surface Impoundment Final Closure Plan (Geosyntec, 2022a).

The results of the MODFLOW modeling of the CIP scenario presented in this report indicate post-construction heads decrease at monitoring wells surrounding the CCR removal and consolidated CIP areas of the BAP following dewatering and implementation of CIP. The heads at these wells continue to decrease until they are predicted to stabilize (approximate hydraulic steady state) at approximately 78 years after implementation of CIP. Groundwater flow directions remain consistent with current flow directions; however, the estimated horizontal hydraulic gradient is increased across the CIP area.

The CIP closure scenario was predicted to reduce total flux in and out of the BAP CCR by approximately 92 and 91 percent, respectively, when simulated post-construction heads in the groundwater monitoring wells are predicted to stabilize. Immediately following implementation of the CIP scenario, influx into the CCR unit is reduced by greater than 80 percent compared to pre-construction conditions. Outflux is reduced by greater than 50 percent within approximately one year and continues to decline toward 91 percent reduction as heads approach hydraulic stabilization.

Contaminant transport modeling will be completed in 2023 following the collection of additional groundwater samples from the new monitoring wells completed in 2022. Transport modeling results will be provided in a revised GMR and included in a construction permit application for submittal to IEPA no later than August 1, 2023, as required by 35 I.A.C. § 845.

1. INTRODUCTION

1.1 Overview

In accordance with requirements of 35 I.A.C. § 845 (IEPA, 2021), Ramboll has prepared this GMR on behalf of the BPP, operated by DMG. This report applies specifically to the CCR unit referred to as the BAP (**Figure 1-1**). The BAP is a 177-acre unlined CCR surface impoundment (SI) used to manage CCR and non-CCR waste streams at the BPP. This GMR presents and evaluates the results of predictive groundwater modeling simulations for a proposed CIP closure scenario which includes: CCR removal from the western areas of the BAP, consolidation to the southeast, and eventually northeastern portions of the BAP, and construction of a cover system over the remaining CCR following initial corrective action measures (removal of free liquids from the BAP).

1.2 Site Location and Background

The BPP is located in southwest Illinois in Randolph and St. Clair Counties. The Randolph County portion of the BPP is located within Sections 2, 3, 4, 9, 10, 11, 14, 15, and 16 of Township 4 South and Range 7 West. The St. Clair County portion of the property is located within Sections 33, 34, and 35 of Township 3 South and Range 7 West. The BAP is approximately one-half mile west-northwest of the Village of Baldwin (**Figure 1-1**).

The BPP property is bordered to the west by the Kaskaskia River; to the east by Baldwin Road, farmland, and strip-mining areas; to the southeast by the Village of Baldwin; to the south by the Illinois Central Gulf railroad tracks, scattered residences, and State Route 154; and to the north by farmland. The St. Clair/Randolph County Line crosses east-west at approximately the midpoint of Baldwin Lake (*i.e.,* Cooling Pond). **Figure 1-1** shows the location of the BPP; **Figure 1-2** is a site map showing the location of the BAP (a 35 I.A.C. § 845 regulated CCR unit and the subject of this GMR), FAPS (an IEPA closed CCR unit), Secondary Pond, Tertiary Pond, and Cooling Pond. The combined area including the BAP, FAPS, Secondary Pond, Tertiary Pond, and Cooling Pond will hereinafter be referred to as the Site.

1.3 Site History and Unit Description

The BPP is a coal-fired electrical generating plant that began operation of its first unit in 1970; two additional generating units were put into service in 1973 and 1975. The plant initially burned bituminous coal from Illinois and switched to subbituminous coal in 1999. Total plant generating capacity is approximately 1,892 megawatts.

The BAP is classified as an existing, unlined CCR SI and covers an area of approximately 177 acres in the southern portion of the BPP property (**Figure 1-2**). The BAP is surrounded by a perimeter road and is bounded to the north by the Cooling Pond, and to the east and south by the closed FAPS CCR Multi-Unit. The BAP is also bounded to the west by the easternmost wooded area that surrounds the Secondary and Tertiary Ponds. The BAP is being used to store and dispose of sluiced bottom ash, some of which is mined for beneficial use, to temporarily store spray dry absorption (SDA) waste, and to clarify plant process water, including other non-CCR station process wastewaters, prior to discharge in accordance with the BPP's National Pollutant Discharge Elimination System (NPDES) permit (AECOM, 2016b; IEPA, 2016).

The FAPS at the BPP is a closed CCR Multi-Unit consisting of three unlined SIs: Old East Fly Ash Pond (IEPA Unit ID W1578510001-01), the East Fly Ash Pond (IEPA Unit ID W1578510001-02), and West Fly Ash Pond (IEPA Unit ID W1578510001-03), with a combined surface area of approximately 232 acres (**Figure 1-2**). During operation, the FAPS discharged water to the BAP. The receiving water bodies for the BAP were the Secondary Pond, and in turn the Tertiary Pond, which ultimately discharges towards a tributary of the Kaskaskia River, south of the Cooling Pond intake structure. A Groundwater Quality Assessment and Phase II Hydrogeologic Investigation (Phase II; Natural Resource Technology, Inc. [NRT], 2014a) was followed by a Supplemental Hydrogeologic Site Characterization and Groundwater Monitoring Plan dated March 31, 2016 (NRT, 2016a) with revised pages included in the response to IEPA July 13, 2016 comments in the technical memorandum dated August 8, 2016 (NRT, 2016b) to define the hydrogeology and to assess the groundwater impacts related to the FAPS. Groundwater models were also completed to assess the groundwater impacts associated with closure and predict the fate and transport of CCR leachate components, as well as estimate the time required for hydrostatic equilibrium of groundwater beneath the FAPS (NRT, 2014b; NRT, 2014c; NRT, 2016c). Based on these assessments, a Closure and Post-Closure Care Plan (AECOM, 2016a), which included a groundwater monitoring program sufficient for long-term, post-closure monitoring, was developed and approved by IEPA in a letter to the Dynegy Operating Company dated August 16, 2016. Closure activities, which included constructing a final cover system to control the potential for water infiltration into the closed CCR unit, were completed, and FAPS closure was completed November 17, 2020. The approximate dates of construction of each successive stage of the BAP and FAPS are summarized in **Table A** below (AECOM, 2016b).

Table A. History of Construction

Date	Event
1969	Construction of Old East Fly Ash Pond, East Fly Ash Pond, and West Fly Ash Pond external perimeter embankment
1979	Construction of East Fly Ash Pond and West Fly Ash Pond northern embankment
1989	Inboard perimeter raise of the entire East Fly Ash Pond and West Fly Ash Pond
1995	Construction of interior dike between the East Fly Ash Pond and West Fly Ash Pond
1999	Raise of interior dike between the East Fly Ash Pond and West Fly Ash Pond; replacement of outlet pipe from the West Fly Ash Pond to the Secondary Pond
2012	Modification of Bottom Ash Pond embankment (original construction date unknown)
2016	Closure Plan developed and approved by IEPA for the FAPS
2020	FAPS closure activities, including construction of a final cover system, and FAPS closure completed

2. SITE GEOLOGY AND HYDROGEOLOGY

BAP hydrogeologic data presented in the HCR (Ramboll, 2021) were used to establish a conceptual site model (CSM) for this GMR and is summarized below, see the HCR for more details of regional and local site characteristics. The BAP has surface elevations ranging from approximately 415 feet North American Vertical Datum of 1988 (NAVD88) in the east to 450 feet NAVD88 in the west. Topographic maps drawn prior to construction indicate the areas of the BAP were generally between 400 and 430 feet National Geodetic Vertical Datum of 1929 (NGVD29), which included a drainage feature near the west end of the BAP (Figure 2-2 of the HCR). Topography in the vicinity of the Site (**Figure 1-1**) ranges from approximately 370 feet NAVD88 along the Kaskaskia River southwest of the Site to 450 feet NAVD88 towards the south and east. The principal surface drainage for the region is the Kaskaskia River.

There are five principal types of unlithified materials above the bedrock in the vicinity of the BAP, these include the following in descending order:

- Fill, predominantly coal ash (fly ash, bottom ash, and slag) within the CCR units, but also including general fill within constructed levees around the Cooling Pond, constructed berms around the Site, and constructed railroad embankments south of the Site;
- Alluvial clay, sandy clay, and clayey sand of the Cahokia Formation (ranging in thickness at the BAP from 13 to 27 feet);
- Silt and silty clay of the Peoria Loess (ranging in thickness at the BAP from 2 to 23 feet);
- Clay and sandy clay of the Equality Formation (ranging in thickness at the BAP from 8 to 20 feet), with occasional sand seams and lenses; and
- Clay and sandy clay diamictons of the Vandalia Till (ranging in thickness at the BAP from 11 to 37 feet) with intermittent and discontinuous sand lenses.

Depth to bedrock ranges from approximately 12.5 feet in the direction of the Kaskaskia River to approximately 70 feet immediately north of the BAP.

Three distinct water-bearing units have been identified in the vicinity of the BAP based on stratigraphic relationships and common hydrogeologic characteristics. The units are described as follows from the surface downward:

- **CCR**: CCR, consisting primarily of fly ash, bottom ash, and boiler slag. Also includes earthen fill deposits of predominantly clay and silt materials from on-site excavations that were used to construct berms and roads surrounding the various impoundments across the Site. The overall (geometric mean) vertical hydraulic conductivity for the CCR determined from laboratory test results during the Phase II investigation is 1.6×10^{-4} cm/s, and ranges from 9.7×10^{-6} to 6.5×10^{-4} cm/s.
- **UGU**: Predominantly clay with some silt and minor sand, silt layers, and occasional sand lenses. Includes the lithologic layers identified as the Cahokia Formation, Peoria Loess, Equality Formation, and Vandalia Till. This unit is composed of unlithified natural geologic materials and extends from the upper saturated materials to the bedrock. The overall (geometric mean) horizontal and vertical hydraulic conductivities for this unit determined during the Phase II investigation are 3.2×10^{-5} cm/s and 8.6×10^{-7} cm/s, respectively. Horizontal and vertical hydraulic conductivities for this unit determined during the Phase II

investigation ranged from 3.5×10^{-7} to 6.8×10^{-4} cm/s and 6.3×10^{-9} to 4.2×10^{-4} cm/s, respectively. Thin sand seams and the interface (contact) between the UGU and bedrock have been identified as PMPs. No continuous sand seams were observed within or immediately adjacent to the BAP; however, the sand seams may act as a PMP due to relatively higher hydraulic conductivities (on the order of 10^{-4} cm/s) than the surrounding clays (on the order of 10^{-5} cm/s). The contacts between the unlithified material and bedrock have also been identified as PMPs where horizontal hydraulic conductivity data in Site monitoring wells with screens and/or filter packs across or immediately above the bedrock range from 3×10^{-7} to 6×10^{-4} cm/s and have a geometric mean horizontal hydraulic conductivity of 2×10^{-5} cm/s.

- **Bedrock Unit**: This unit is composed of interbedded shale and limestone bedrock, which underlies and is continuous across the entire Site and has been identified as the UA. The horizontal hydraulic conductivity for this unit ranges from 1.7×10^{-6} to 3.5×10^{-5} cm/s with a geometric mean of 5.0×10^{-6} cm/s (Ramboll, 2021).

In general, the UGU consists of low permeability clays and silts. Within the UGU, only thin and intermittent sand lenses are present within predominantly clay deposits; thus, the unlithified materials do not represent a continuous aquifer unit. Thin, non-continuous sandy deposits (*i.e.,* PMPs) that exist across the Site, do not appear to extend to the FAPS and BAP as evidenced by soil borings adjacent to the CCR units in which no sand was observed.

The extent of sand and gravel aquifers in the region are primarily found along the Kaskaskia River Valley where sand and gravel deposits are highly permeable, thick, and extensive. Outside of the Kaskaskia River Valley, the unlithified materials in upland areas are predominantly clay, which generally provide a low probability of encountering sand and gravel layers for dependable groundwater supply. Although some thin sand seams and layers occur intermittently within the Vandalia Till in localized areas around the BPP, most groundwater supplies in upland areas are obtained from large diameter shallow bored wells. Typical water wells in the vicinity of the BPP are between 25 and 55 feet deep, 36 to 48 inches in diameter, and collect groundwater through slow percolation into the wells, which are large diameter to allow for greater water storage to compensate for the low rate of groundwater infiltration (Ramboll, 2021).

The underlying bedrock at the Site is Pennsylvanian and Mississippian bedrock, mainly limestone and shale. A bedrock low is present at the southwest corner of the Site and extends northeastward. The Tertiary Pond in the southwest corner of the Site corresponds to the lowest observed bedrock surface elevation (372.6 feet NAVD88). Higher bedrock elevations are present east of the BPP and FAPS as observed at TPZ-158 (428.6 feet NAVD88). The bedrock in the vicinity of the BAP yields small amounts of water from interconnected pores, cracks, fractures, crevices, joints, and bedding planes. The shallow bedrock is the only water-bearing unit that is continuous across the Site. Shallow sandstone and creviced limestone may yield small supplies in some areas, but water quality becomes poorer (*i.e.,* highly mineralized) with increasing depth. The Pennsylvanian and Mississippian rocks generally have low porosities and permeabilities, are not a reliable source of groundwater, and the quality varies considerably (Pryor, 1956). Limestones intercepted at the Site are generally light to dark gray, fine-grained, thin bedded, banded, argillaceous, and competent except where weathered. Weathering of the limestone produces a calcareous clay. Limestone layers are often interbedded with thin shale layers and are sometimes fossiliferous or sandy. The shale layers are generally weathered, competent, silty, slightly micaceous, fissile, and dark gray. Where highly weathered shale (*i.e.,* decomposed bedrock) was encountered, the shale was non-fissile and resembled an unlithified stiff clay with medium to high plasticity.

The locations of groundwater monitoring wells are provided on **Figure 2-1**. Based on elevation measurements, lateral groundwater flow in the shallow unlithified materials and bedrock is generally to the west and southwest across the Site (**Figure 2-2**) toward the Kaskaskia River. Groundwater flow in bedrock is toward the northwest in the east and central areas of the BAP, and southwest to northwest on the east area of the FAPS until groundwater reaches the bedrock valley feature underlying the Secondary and Tertiary Ponds west of the BAP and FAPS, at which point the flow direction veers towards this bedrock surface low. Groundwater elevations vary seasonally, generally less than 7 feet, while across the Site they range between approximately 370 and 450 feet NAVD88, although flow directions are generally consistent. Additional groundwater contour maps are located in Figures 3-2 to 3-9 of the HCR (Ramboll, 2021).

Adjacent to the BAP, horizontal hydraulic gradients in the shallow unlithified materials as determined in the western area of the FAPS were approximately 0.015, 0.017, 0.018, and 0.015 ft/ft, respectively, based on groundwater data collected in the four quarters of 2020, as groundwater flowed from east to west across the FAPS. In the bedrock, horizontal hydraulic gradients as determined in the western area of the FAPS were approximately 0.010, 0.021, 0.015, and 0.017 ft/ft based on groundwater data collected in the four quarters of 2020, respectively, as groundwater flowed from east to west across the FAPS. In general, less than 0.004 ft/ft change in horizontal hydraulic gradients was observed in shallow unlithified materials and less than 0.011 ft/ft change in horizontal hydraulic gradients was observed in bedrock over the period from March to December 2020 (Ramboll, 2021).

Groundwater velocities in the shallow unlithified materials as determined for the HCR (Ramboll, 2021) in the area downgradient of the BAP and north of the Secondary Pond ranged from 0.0062 to 0.0068 feet per day (ft/day) based on groundwater data collected in 2020. In the bedrock, groundwater flow velocities in the east and central areas of the BAP were approximately 0.0007 and 0.0006 ft/day based on the first and third quarters of 2020, respectively. Bedrock groundwater velocities in the west area of the BAP were approximately 0.0008 and 0.0006 ft/day in the first and third quarters of 2020, respectively. In general, flow velocities are consistent, varying only 0.0006 ft/day in shallow unlithified materials and 0.0002 ft/day in bedrock in the vicinity of the BAP over the period from March to December 2020.

Groundwater velocities in the shallow unlithified materials in the western area of the FAPS near the BAP as determined for the HCR (Ramboll, 2021) ranged from 0.0091 to 0.011 ft/day during the four quarters of monitoring in 2020. In the bedrock, groundwater velocities in the western area of the FAPS ranged from 0.0005 to 0.0010 ft/day during the four quarters of monitoring in 2020. In general, less than 0.0018 ft/day change in groundwater velocities was observed in shallow unlithified materials and less than 0.0005 ft/day change in groundwater velocities was observed in bedrock over the period from March to December 2020.

Groundwater in the Pennsylvanian and Mississippian-aged bedrock mainly occurs under semi confined to confined conditions as demonstrated with vertical hydraulic gradient calculations presented in the HCR, with the overlying unlithified unit behaving as the upper confining unit to the uppermost aquifer (Bedrock Unit). The flat horizontal groundwater gradient beneath the Site, and the mostly upward vertical gradients, inconsistent upward/downward vertical gradients or flowing artesian conditions observed in the UGU and UA, suggests the BAP and neighboring ponds are not areas of increased recharge or infiltration (Ramboll 2021).

In 2022, additional wells were installed after the HCR was completed for further hydrogeologic investigation and water quality evaluation. A summary of monitoring well locations and construction details for wells used in this GMR are included in **Table 2-1** and depicted on **Figure 2-1**. Groundwater elevation readings and lithologic contact information from the wells completed in 2022 have been incorporated into this GMR. Groundwater elevation data from 48 of the 78 total monitoring wells included in **Table 2-1** and depicted on **Figure 2-1,** were utilized as groundwater model flow calibration targets to develop this GMR as summarized in **Table 2-2** and described in **Sections 4.2 and 4.2.2**. Complete documentation of the investigation activities completed in 2022 at the BAP including boring logs, monitoring well and piezometer construction forms, and summary tables of testing results (*e.g.,* groundwater analytical results, horizontal and vertical gradient calculations, and single well aquifer test results), will be provided in a revised HCR following completion of eight independent groundwater sampling events.

3. GROUNDWATER MODEL

3.1 Overview

Data collected from previous field investigations, as well as the lithologic contact and groundwater elevation data from 2022 field investigations, were used to develop a groundwater model for the BAP. The MODFLOW model was used to evaluate one closure scenario: CCR consolidation and CIP using information provided in the CCR Surface Impoundment Final Closure Plan (Geosyntec, 2022a). The results of the MODFLOW modeling of the CIP scenario are summarized in this GMR. Associated model files are included as **Appendix A.** Contaminant transport modeling will be completed in 2023 following the collection of additional groundwater samples from the new monitoring wells completed in 2022. Transport modeling results will be provided in a revised GMR and included in a construction permit application for submittal to IEPA no later than August 1, 2023, as required by 35 I.A.C. § 845.

3.2 Conceptual Site Model

The HCR (Ramboll, 2021) is the foundation document for the site setting and CSM that describes groundwater flow at the Site. The BAP overlies the recharge area for the underlying geologic media (*i.e.,* low permeability clays of the UGU). Groundwater enters the model domain vertically via recharge. Groundwater may also enter or exit the model through the Cooling Pond, Secondary and Tertiary Ponds, the Kaskaskia River, or the many tributary streams located within the model domain. Groundwater may also exit the model through surface water management features within the BAP. Groundwater in the unlithified materials consistently flows east to west towards the Kaskaskia River. Groundwater flow in bedrock is northwest in the east and central areas of the BAP, and southwest to northwest on the east area of the FAPS until groundwater reaches the bedrock valley feature underlying the Secondary and Tertiary Ponds west of the BAP and FAPS, at which point the flow direction veers towards this bedrock surface low.

3.3 Model Approach

A three-dimensional groundwater flow model was calibrated to represent the conceptual flow system described above. Initial steady state modeling was performed to represent current Site conditions in 2022 following closure of the FAPS in 2020. This model was calibrated to match median groundwater elevations for recent groundwater elevation data. The calibrated model was then used to evaluate the effectiveness of the CIP scenario using a transient flow model. The start of the transient flow model was initiated in 1970 (model year 0) when the BPP began operation and the BAP and FAPS were active (initial conditions model) through 2020 (51 model years) when closure at the FAPS was complete. Two models were included for the closure prediction simulation. The first model simulated an extended period of current conditions, 2021 to 2024 (4 model years); and, a period for the removal of free liquids, 2025 to 2027 (3 model years). The second model simulated the final closure conditions, 2028 to 3027 (1,000 model years). The prediction modeling timeline for the CIP scenario is illustrated in **Figure 3-1**.

Two model codes were used to simulate groundwater flow:

- Groundwater flow was modeled in three dimensions using MODFLOW 2005
- Percolation (recharge) after consolidation of CCR and cover system construction was modeled using the results of the Hydrologic Evaluation of Landfill Performance (HELP) model.

4. MODEL SETUP AND CALIBRATION

4.1 Model Descriptions

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

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

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 consolidation areas.

4.2 Flow Model Setup

The modeled area was approximately 11,125 feet (445 rows) by 16,375 feet (655 columns) with the BAP located in the east-central portion of the model. The western edge of the model is bounded by the Kaskaskia River. The north, east, and south edges of the model were selected to maintain sufficient distance from the BAP to reduce boundary interference with model calculations, while not extending too far past the extent of available calibration data. The model area is displayed in **Figure 4-1**. The model grid and boundary conditions are displayed in **Figures 4-2 through 4-7**.

The MODFLOW model was calibrated to median groundwater elevation collected from December 2015 to June 2022. The flow model calibration targets are presented in **Table 2-2**. Multiple iterations of MODFLOW calibration were performed to achieve an acceptable match to observed flow data. For the BAP, the calibrated flow model was used in predictive modeling to evaluate the CIP closure scenario by consolidating CCR and using HELP modeled recharge values to simulate changes proposed in the closure scenario.

4.2.1 Grid and Boundary Conditions

A six-layer, 445 x 655 node grid was established with 25-foot grid spacing in the vicinity of the BAP and BPP property. The grid increases gradually to a maximum 450-foot row spacing and

225-foot column spacing near the edges of the model. Boundary conditions are illustrated in **Figures 4-2 through 4-7**. All edges of the model are no-flow (*i.e.,* Neumann) boundaries in all layers of the model with the exceptions of the western edge in layer 4, where a river (mixed) boundary was placed to simulate the mean flow conditions of the Kaskaskia River, and vary between no-flow (*i.e.,* Neumann) and river (*i.e.,* mixed) boundaries on the northern edge in layers 2 through 4, where a river (*i.e.,* mixed) boundary was placed to simulate the Cooling Pond, and the southern edge in layers 2 through 4, where river (*i.e.,* mixed) boundary was placed to simulate the southernmost tributary. The limits of the model domain approximate the limits of the Kaskaskia River subwatershed (Hydrologic Unit Code [HUC] boundary) in which the BPP and BAP reside. The top of the model was a time-dependent specified flux (*i.e.,* Neumann) boundary, with specified flux rates equal to the recharge rate. Surface water features within the active BAP were simulated in the model as head dependent flux boundaries (*i.e.,* drain).

4.2.2 Flow Model Input Values and Sensitivity

Flow model input values and sensitivity analysis results are presented in **Table 4-1** and described below.

The modeled well location layers and flow model calibration targets (*i.e.*, median groundwater elevations from December 2015 to June 2022 [or November 2022 groundwater elevations for wells constructed or reoccupied in 2022] and target well locations) are summarized in **Table 2-2**. Anomalous groundwater elevations (*e.g.,* groundwater elevations that do not represent static groundwater conditions, groundwater elevation outliers, or groundwater elevations measured in error) monitored between December 2015 and June 2022 were removed from the median groundwater elevation calculations used as flow calibration targets. UGU wells MW-151, MW-154, MW-252, and MW-253 are screened just above or at the interface between the UGU and decomposed bedrock of the UA and may be hydraulically connected to multiple hydrostratigraphic units (*i.e.,* multiple modeled layers). In the flow calibration model, flow calibration targets for UGU wells MW-151, MW-154, MW-252, and MW-253 were placed in the decomposed bedrock model layer, which exhibited heads more representative of the groundwater observations in these wells.

Sensitivity analysis was conducted by changing input values and observing changes in the sum of squared residuals (SSR). Horizontal conductivity, vertical conductivity, and river and drain conductance terms were all varied between one-tenth and ten times calibrated values. Recharge terms were varied between one-half and two times calibrated values. River stage for river reach 0 (*i.e.,* Cooling Pond) and river reach 1 (*i.e.,* Kaskaskia River) were varied between 98.5 and 101.5 percent of calibrated values. River stage for river reaches 2 through 8 were varied between 99.5 and 100.5 percent of calibrated values. When the calibrated model was tested, SSR was 1422.5. Sensitivity test results were categorized into negligible, low, moderate, moderately high, and high sensitivity based on the change in SSR as summarized in the notes in **Table 4-1**.

4.2.2.1 Model Layers

All available boring log data included in the HCR (Ramboll, 2021) and lithologic contacts from the 2022 investigation activities were used to develop surfaces utilizing Surfer® software for each of the three distinct water-bearing units described in **Section 2**. Layer 1 (**Figure 4-8**) modeled only CCR material within the limits of the BAP and FAPS, where no flow cells were used outside the limits of the CCR units. The approximate base of ash surface in the BAP was provided by

Geosyntec, which was developed using historic pre-construction topographic maps and incorporated base of ash data collected by Ramboll from borings within the BAP completed in 2022. The approximate base of ash surface in the FAPS was developed using historic pre-construction topographic maps. The modeled UGU was split into three modeled layers, where model layer 2 (**Figure 4-9**) represented the upper silty clay of the UGU, model layer 3 (**Figure 4-10**) represented a discontinuous transmissive zone within the UGU (this unit is considered a PMP) or represented the approximate top of Vandalia Till/lower silty clay of UGU in absence of a transmissive zone, and model layer 4 (**Figure 4-11**) represented the lower silty clay of the UGU. Model layer 5 (**Figure 4-12**) represented the decomposed bedrock of the UA near the contact between the UGU and UA. Model layer 6 (**Figure 4-13**) represented the deeper more competent bedrock of the UA. The bottom elevation of the UA (*i.e.,* bedrock) in layer 6 was flat lying and assumed to be an elevation of 200 feet NAVD88. The resulting surfaces were imported as layers into the model to represent the distribution and change in thickness of each water-bearing unit across the model domain.

4.2.2.2 Hydraulic Conductivity

Hydraulic conductivity values and sensitivity results are summarized in **Table 4-1**. When available, these values were derived from field or laboratory measured values reported in the HCR (Ramboll, 2021), to be representative of site-specific conditions. The sources of the hydraulic conductivity values are summarized in **Table 4-1**. Conductivity zones that did not have representative site data were determined through model calibration. No horizontal anisotropy was assumed. Vertical anisotropy (presented as Kh/Kv in **Table 4-1**) was applied to conductivity zones to simulate preferential flow in the horizontal direction in the UA (*i.e.,* bedrock).

The spatial distribution of the hydraulic conductivity zones in each layer (**Figures 4-14 through 4-19**) simulates the distribution of hydraulic conductivity as reported in the HCR (Ramboll, 2021). All hydraulic conductivity zones were laterally continuous within the model with the exception of the CCR hydraulic conductivity zones Old East Fly Ash Pond, East Fly Ash Pond, West Fly Ash Cell, and Bottom Ash Pond (zones 2, 3, 4, and 7); the river alluvium hydraulic conductivity zone (zone 12); and the PMP hydraulic conductivity zone (zone 14). The limits of the ash fill were determined from data presented in the HCR (Ramboll, 2021). The ash fill extent was propagated through all related ash fill property zones (*i.e.*, recharge, storage, and effective porosity). Conductivity zone 100 (identified on figures as "Above River BC") was placed above river cells to improve communication between the river and the groundwater in layers above the layer in which the river boundary condition was placed.

The model had a moderately high sensitivity to changes in horizontal conductivity in zones 9 (*i.e.,* UA), and a moderate sensitivity in zone 1 (*i.e.,* UGU) and zone 14 (*i.e.,* PMP); the model had a low or negligible sensitivity to changes in horizontal conductivity in the remaining hydraulic conductivity zones. The model had a moderately high sensitivity to changes in vertical conductivity in zone 9 (*i.e.,* UA), while the model exhibited a negligible sensitivity in the remaining hydraulic conductivity zones.

4.2.2.3 Recharge

Recharge rates (**Table 4-1**) were determined through calibration of the model to median groundwater elevation collected from December 2015 to June 2022, as presented in **Table 2-2**. The spatial distribution of recharge zones was based on the location and type of material present at land surface (**Figure 4-20**). Seven different zones were created to simulate recharge in the model area. A single silty clay zone (zone 1) was used to simulate ambient recharge over the upper silty clay of the UGU outside the limits of the CCR units. Zones 5 and 6 were used to simulate recharge over the upper silty clay of the UGU in the area of the Secondary Pond and Tertiary Pond, respectively. The recharge occurring through the ash fill placed in the FAPS and BAP was split into four different values, where recharge was varied based upon the historical use of each ash fill area and the response of flow calibration target heads. Post-closure FAPS recharge rates for the Old East Ash Pond, East Fly Ash Pond, and West Fly Ash Cell (zones 2, 3, and 4) were consistent with previous prediction modeling values used for the proposed cover system at the FAPS (NRT, 2014b). The BAP was simulated with a single zone (zone 7) which also had the greatest recharge value within the model domain.

The model had a moderate sensitivity to changes in recharge in zones 1 (upper silty clay [*i.e.,* UGU]). The model had negligible sensitivity to changes in recharge in the remaining zones, with the exception of zone 7 (BAP), where sensitivity was low.

4.2.2.4 Storage and Specific Yield

The calibration model did not use these terms because it was run at steady state. For the prediction models, which were run in transient, no field data defining these terms were available so published values were used consistent with Fetter (1988) (**Table 4-1**). Specific yield (S_Y) was set to equal effective porosity values described in **Section 4.2.2.7**. The spatial distribution of the storage and specific yield zones were consistent with those of the hydraulic conductivity zones. The sensitivity of these parameters was not tested for flow modeling. Future modeling efforts which may include three-dimensional contaminant transport modeling will test storage and specific yield sensitivity by evaluating their effect on the transport model.

4.2.2.5 River Parameters

River reaches are illustrated in **Figure 4-1**. The Kaskaskia River was simulated using head-dependent flux nodes in modeled river reach 1 that required inputs for river stage, width, bed thickness, and bed hydraulic conductivity (**Table 4-1**). River width, bed thickness, and bed hydraulic conductivity parameters were used to calculate a conductance term for the boundary node. This conductance term was determined by adjusting hydraulic conductivity during model calibration. The calibrated hydraulic conductivity value was set at 5.17 ft/day. The length of the modeled river extends from the northernmost extent of the model domain to the southernmost extent of the model domain using river reach 1. The modeled river stage in the calibration model was based on available Kaskaskia River stage data at Red Bud, Illinois (USGS 05595240) and at New Athens, Illinois (USGS 05595000) gaging stations in 2021 and 2022. No slope was applied to the upstream and downstream modeled river stage as calculated gradients between the two gaging stations were determined to be negligible across the length of the model domain. The river boundary was placed in layer 4 corresponding with simulated river elevation (**Figure 4-5**).

The Cooling Pond was simulated using head-dependent flux nodes in modeled river reach 0 (**Table 4-1**). The conductance term was determined by adjusting hydraulic conductivity during model calibration. The calibrated hydraulic conductivity value was set at 3.8 ft/day. The river stage in the calibration model approximated the elevation at which the Cooling Pond is maintained (Ramboll, 2021). The river boundary was placed in layers 2 through 4 corresponding with simulated river elevation (**Figures 4-3 through 4-5**).

The Secondary and Tertiary ponds were simulated using head-dependent flux nodes in modeled river reach 8 (**Table 4-1**). The conductance term was determined by adjusting hydraulic conductivity during model calibration. The calibrated hydraulic conductivity value was set at 0.26 ft/day. The river stage in the calibration model approximated historic groundwater elevations measured in monitoring well TPZ-165 placed within the limits of the Secondary Pond (**Figure 2-1**) (NRT, 2014a). The bottom of the river boundary was estimated using historic topographic maps and placed in layers 2 through 6 corresponding with simulated river elevation (**Figures 4-3 through 4-7**).

The remaining tributaries were simulated using head-dependent flux nodes in modeled river reaches 2 through 5 and reach 7 (**Table 4-1**). The conductance terms were determined by adjusting hydraulic conductivity during model calibration. Calibrated hydraulic conductivity values by tributary river reach are shown in **Table 4-1**. The river stage in the calibration model approximated local topography for each reach. The river boundaries were placed in layers 2 through 5 corresponding with simulated river elevation (**Figures 4-3 through 4-6**).

The model had negligible to low sensitivity to changes in river stage, with the exception of reach 1 (Kaskaskia River) and reach 0 (Cooling Pond), where the sensitivity was high and moderate, respectively. The model had negligible sensitivity to changes in river conductance.

4.2.2.6 Drain Parameters

Surface water features within the active BAP were simulated in the model as head dependent flux boundaries (drain). The drain boundaries required inputs for elevation of the stage of the drain, width, bed thickness, and bed hydraulic conductivity parameters which were used to calculate a conductance term for the boundary node in modeled drain reaches 0 and 1. This conductance term was determined by adjusting hydraulic conductivity during model calibration. The final hydraulic conductivity value was set at 6.0 ft/day in modeled drain reaches 0 and 1 (**Table 4-1**). These drain head-dependent flux boundaries features act as discharge features within the BAP which is consistent with stormwater management practices within the active BAP (AECOM, 2016b). The stages of drain reaches 0 and 1 estimated water surface elevation within the BAP. The drain boundaries were placed in layer 1 within the BAP (**Figure 4-2**).

The model had low and high sensitivity to changes in drain stage, in reach 0 (BAP drain west) and reach 1 (BAP drain central), respectively. The model had negligible sensitivity to changes in drain conductance.

4.2.2.7 Effective Porosity

The calibration model did not use these terms because it was run at steady state. For the prediction models, which were run in transient, no field data defining these terms were available so effective porosity for each modeled zone were derived from an average between estimated values of 0.20 for silt material, 0.267 for gravel, 0.07 for clay, and 0.28 for sand (Morris and Johnson, 1967; Heath, 1983), for each material modeled then adjusted during model calibration and presented in **Table 4-1**. The spatial distribution of the effective porosity zones were consistent with those of the hydraulic conductivity zones. The sensitivity of these parameters was not tested for flow modeling. Future modeling efforts which may include three-dimensional transport modeling will test effective porosity sensitivity by evaluating their effect on the transport model.

4.3 Flow Model Assumptions and Limitations

Simplifying assumptions were made while developing this model:

- Following closure of the FAPS in 2020, the groundwater flow system can be simulated as steady state.
- Natural recharge is constant over the long term.
- Fluctuations in river stage do not affect groundwater flow over the long term.
- Hydraulic conductivity is consistent within each material (hydraulic conductivity zone) modeled.
- The approximate base of ash surface in the BAP was provided by Geosyntec, which was developed using historic pre-construction topographic maps and incorporated base of ash data collected by Ramboll from borings within the BAP completed in 2022. The approximate base of ash surface in the FAPS was developed using historic pre-construction topographic maps.
- Drain cells (BAP) or constant head cells (FAPS) were used to simulate surface water management features during operation of the CCR units.
- Recharge rates were modified and constant head cells were removed after 2020 in the area of the FAPS to simulate closure.

The model is limited by the data used for calibration, which adequately define the local groundwater flow system. Since data used for calibration are near the BAP, model predictions of flow 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 elevations observed between 2015 and 2022.

4.4 Calibration Flow Model Results

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

Observed and simulated heads are presented in **Figure 4-21 through Figure 4-28**. The mass balance error for the flow model was 0.15 percent and the ratio of the residual standard deviation to the range was 5.6 percent; the mass balance error for the flow model was within the target for the criteria of 1 percent and the ratio of the residual standard deviation to the range was within the target for the criteria of 10 percent. Another flow model calibration goal is that residuals are evenly distributed such that there is no bias affecting modeled flow. The observed heads are plotted versus the simulated heads and identified by layer in **Figure 4-21**. The near-linear relationship between observed and simulated values indicates that the model adequately represents the calibration dataset. The residual mean was -2.18 feet; in general the simulated values were evenly distributed above and below the observed values. This is also illustrated by layer in the observed versus residuals plot **Figure 4-22**. Some simulated values were overpredicted, where the most significant overpredicted values (exceeding 10 feet) were primarily within the UA (bedrock) of layer 6, largely near the Secondary and Tertiary Ponds, near the southwest boundary of the West Ash Pond of the FAPS, or in bedrock wells screened below the decomposed bedrock. These residuals plot in the lower left quadrant of **Figure 4-22**.

5. SIMULATION OF CIP CLOSURE SCENARIO

5.1 Overview and Prediction Model Development

Prediction simulations were performed to evaluate the effects of closure (source control) measures (CCR consolidation and CIP scenario) for the BAP on the groundwater flow system following initial corrective action measures, which includes removal of free liquids from the BAP. The following methods were used to develop the prediction models and simulate the CIP closure scenario:

- Extend the modeled existing conditions (calibration conditions) approximately 2 years prior to applying initial corrective action measures to allow time for IEPA coordination, approvals, and permitting; as well as, the final design and bid process according to the schedule in the CCR Surface Impoundment Final Closure Plan (Geosyntec, 2022a).
- Define CCR removal and consolidation areas based on designs provided in the CCR Surface Impoundment Final Closure Plan (Geosyntec, 2022a).
- Apply several drain cell areas to the BAP for the dewatering period (approximately 3 years) to remove free liquids within the BAP (initial corrective action measures).
- Apply drains (drain input parameters approximated designs provided in the CCR Surface Impoundment Final Closure Plan [Geosyntec, 2022a]) to simulate storm water management within CCR removal areas following closure.
- Apply high hydraulic conductivity and remove recharge in the CCR removal areas to simulate the absence of material in model layer 1 following consolidation and cover system construction.
- Apply reduced recharge in the consolidated CIP areas to simulate the effects of the cover system on the groundwater flow system (HELP calculated percolation rates were developed based on cover system construction materials and designs provided in the CCR Surface Impoundment Final Closure Plan (Geosyntec, 2022a).

HELP modeling input and output values are summarized in **Table 5-1** and described in detail below. Prediction simulations were performed to evaluate changes in the groundwater flow system from the CIP closure scenario. The following simplifying assumptions were made during the simulations:

- In the CIP closure scenario, HELP-calculated average annual percolation rates were developed from a 30-year HELP model run. This 30-year HELP-calculated percolation rate remained constant over duration of the closure scenario prediction model run following closure.
- Changes in recharge resulting from dewatering, CCR removal, consolidation, construction of the cover system, and final grading (recharge rates are based on HELP-calculated average annual percolation rates) have an instantaneous effect on recharge and percolation through surface materials.
- The geocomposite drainage layer and geomembrane liner placed over the ash consolidation area were assumed to have good field placement and assumed to have the same slope as the final grade of the overlying cover materials based on the design drawings provided in the CCR Surface Impoundment Final Closure Plan (Geosyntec, 2022a).

- CCR removal areas were assumed to have the same topography as the former approximated base of ash surface in the BAP.

5.2 HELP Model Setup and Results

HELP (Version 4.0; Tolaymat and Krause, 2020) was used to estimate percolation through the top and slopes of the BAP CIP Consolidation area. HELP files are included electronically (**Appendix A**), and outputs are attached to this report (**Appendix B**).

HELP input data and results are provided in **Table 5-1**. All scenarios were modeled for a period of 30 years. Climatic inputs were synthetically generated using default equations developed for Belleville Scott Air Force Base, Illinois (the closest weather station included in the HELP database). Precipitation, temperature, and solar radiation was simulated based on the latitude of the BAP. Thickness and type of the geosynthetic drainage layer, geotextile protective cushion layer, geomembrane liner, soil backfill, and soil runoff input parameters were developed for the ash consolidation scenario using data provided the CCR Surface Impoundment Final Closure Plan (Geosyntec, 2022a).

HELP model results (**Table 5-1**) indicated 0.000239 inches of percolation per year through the top of the BAP CIP consolidation and cover system area, and 0.000007 inches of percolation per year through the slopes of the BAP consolidation and cover system areas. The differences in HELP model runs for each area included the type of lateral drainage layer or cushion, soil runoff slope, and the soil runoff slope length; all other HELP model input parameters were the same for each simulated area. Two additional HELP model simulations were completed to support the *Proposed Alternative Final Protective Layer Equivalency Demonstration* (Geosyntec, 2022b) which is an appendix to the Construction Permit Application to which this report is also attached. Results of these two additional HELP simulations were not incorporated in the MODFLOW simulations for closure. Simulation inputs and output results are presented in **Appendix B**.

5.3 Simulation of CIP Closure Scenario

The calibrated model was used to evaluate the effectiveness of the CIP scenario by defining CCR removal and consolidation area, reducing head to simulate a dewatering period (approximately 3 years), applying drains to simulate storm water management within CCR removal areas following closure, applying hydraulic conductivity and removing recharge in the CCR removal areas to simulate the absence of material in model layer 1 following closure, and applying reduced recharge in the consolidation and closure in place areas to simulate the effects of the cover system on the groundwater flow system.

As discussed in the model approach **Section 3.3**, the start of the transient flow model was initiated in 1970 (model year 0) when the BPP began operation and the BAP and FAPS were active (initial conditions model) through 2020 (51 model years) when closure at the FAPS was complete. Two models were included for the closure prediction simulation. The first model simulated an extended period of current conditions, 2021 to 2024 (4 model years); and, a period for the removal of free liquids, 2025 to 2027 (3 model years). The second model simulated the final closure conditions, 2028 to 3027 (1,000 model years). The prediction modeling timeline for the CIP scenario is illustrated in **Figure 3-1**. The prediction model input values are summarized in **Table 5-2**.

5.3.1 CIP Closure Scenario Groundwater Flow System

The design for CIP includes an initial 3-year dewatering period to remove free liquids followed by CCR removal from the western areas of the BAP, consolidation to the southeast, and eventually northeastern portions of the BAP, and construction of a cover system over the remaining CCR (**Figure 5-1**).

Post-construction heads decrease at monitoring wells surrounding the CCR removal and consolidated CIP areas of the BAP following dewatering and implementation of CIP. The heads at these wells continue to decrease until they are predicted to stabilize (approximate hydraulic steady state) approximately 78 years after implementation of CIP. Heads decrease within the CIP area by approximately 5 feet on the east side of the CIP area and approximately 10 feet in the southwest corner of the CIP area at approximate hydraulic steady state. The decrease in heads is accompanied by a significant increase in dry model cells throughout the central region of the CIP area. Groundwater flow directions remain consistent with current flow directions; however, the estimated horizontal hydraulic gradient is increased across the CIP area.

Evaluations of post-construction water flux through the consolidated and covered BAP CCR were completed using data obtained from the CIP scenario prediction model when simulated post-construction heads in the groundwater monitoring wells reach approximate hydraulic steady state (*i.e.*, the post-construction movement of water in and out of the consolidated BAP CCR were compared to pre-construction conditions). The pre-construction (calibration model) and post-construction CIP scenario prediction model simulated water flux values are summarized in **Appendix C** and discussed below. Data export files used for flux evaluations are found along with model files in **Appendix A**.

The CIP scenario was predicted to reduce total flux in and out of the BAP CCR by approximately 92 and 91 percent, respectively, when simulated post-construction heads reach approximate hydraulic steady state as illustrated in **Figure 5-2**. Prior to construction (*i.e.*, current existing conditions) the total groundwater flux into the CCR is 30.4 gallons per minute (gpm) versus a total flux out of 30.3 gpm (total flux out includes flux through modeled drains used to simulate surface water management within the active BAP). Following consolidation and CIP, the groundwater flux into and out of the CCR is equal at approximately 2.5 gpm with no surface water management within the CIP area.

Figure 5-3 is a plot showing the changes in flux reduction (shown as negative percentage) over time, starting from implementation of the CIP scenario through approximate hydraulic steady state conditions. Immediately following implementation of the CIP scenario, influx into the CCR unit is reduced by greater than 80 percent compared to pre-construction conditions. Following the dewatering period, influx into the CCR unit increases for approximately 3.5 years as free liquids are no longer being actively removed from the CCR unit, then influx to the CCR unit decreases as illustrated in **Figure 5-3**. Outflux is reduced by greater than 50 percent within approximately one year and continues to decline toward 91 percent reduction as heads approach hydraulic stabilization (**Figure 5-3**).

6. CONCLUSIONS

This GMR has been prepared to evaluate the groundwater flow system at the BAP and how the proposed CIP scenario will reduce total flux in and out of the CCR in the BAP. Groundwater elevation data collected from sampling events from December 2015 to June 2022 (or November 2022 groundwater elevations for wells constructed or reoccupied in 2022) were used to develop a groundwater model for the BPP BAP and surrounding area. The MODFLOW model was then used to evaluate the CIP scenario which includes: CCR removal from the western areas of the BAP, consolidation to the southeast, and eventually northeastern portions of the BAP, and construction of a cover system over the remaining CCR following initial corrective action measures (removal of free liquids from the BAP) using information provided in the CCR Surface Impoundment Final Closure Plan (Geosyntec, 2022a).

Post-construction heads decrease at monitoring wells surrounding the CCR removal and consolidated CIP areas of the BAP following dewatering and implementation of CIP. The heads at these wells continue to decrease until they are predicted to stabilize (approximate hydraulic steady state) at approximately 78 years after implementation of CIP. Groundwater flow directions remain consistent with current flow directions; however, the estimated horizontal hydraulic gradient is increased across the CIP area.

The CIP closure scenario was predicted to reduce total flux in and out of the BAP CCR by approximately 92 and 91 percent, respectively, when simulated post-construction heads in the groundwater monitoring wells are predicted to stabilize.

Contaminant transport modeling will be completed in 2023 following the collection of additional groundwater samples from the new monitoring wells completed in 2022. Transport modeling results will be provided in a revised GMR and included in a construction permit application for submittal to IEPA no later than August 1, 2023, as required by 35 I.A.C. § 845.

7. REFERENCES

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TABLES

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

Well Number	HSU	Date Constructed	Top of PVC Elevation (ft)	Measuring Point Elevation (ft)	Measuring Point Description	Ground Elevation (ft)	Screen Top Depth (ft BGS)	Screen Bottom Depth (ft BGS)	Screen Top Elevation (ft)	Screen Bottom Elevation (ft)	Well Depth (ft BGS)	Bottom of Boring Elevation (ft)	Screen Length (ft)	Screen Diameter (inches)	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)
MW-104SR	PMP	2011-08-01	455.54	455.54	Top of PVC	452.52	4.80	14.80	447.80	437.70	15.00	437.50	10	2	38.188355	-89.853434
MW-104DR	PMP	2011-08-01	455.62	455.62	Top of PVC	452.62	23.20	28.20	429.40	424.40	28.50	417.60	5.1	2	38.188344	-89.853434
MW-116	UGU	1991-09-30	457.97	547.97	Top of PVC	454.90	15.00	25.00	439.90	429.90	25.00	429.90	10	2	--	--
MW-126	UGU	2009-06-19	469.84	469.84	Top of PVC	466.84	9.95	19.31	456.89	447.53	19.31	446.87	9.36	2	--	--
MW-150	PMP	2010-09-01	396.54	396.54	Top of PVC	393.84	15.00	24.70	378.80	369.20	25.20	368.70	9.6	2	38.189401	-89.878468
MW-151	PMP	2010-09-01	399.96	399.96	Top of PVC	397.22	6.10	15.80	391.10	381.40	16.30	380.90	9.6	2	38.188449	-89.872354
MW-152	PMP	2010-09-01	424.99	424.99	Top of PVC	422.18	7.50	16.70	414.70	405.50	17.20	405.00	9.3	2	38.187569	-89.866764
MW-153	PMP	2010-09-01	445.67	445.67	Top of PVC	442.77	10.40	20.00	432.40	422.80	20.50	422.30	9.6	2	38.185884	-89.86101
MW-154	PMP	2010-09-01	387.76	387.76	Top of PVC	384.99	7.50	12.20	377.50	372.80	12.70	372.30	4.6	2	38.196555	-89.883732
MW-155	PMP	2010-09-01	393.55	393.55	Top of PVC	390.62	10.30	19.90	380.30	370.70	20.50	370.20	9.6	2	38.193312	-89.882878
MW-158R	UGU	2022-10-08	456.24	456.24	Top of PVC	453.56	8.00	18.00	445.56	435.56	18.00	435.56	10	2	38.195275	-89.849411
MW-161	PMP	2013-08-01	431.27	431.27	Top of PVC	428.74	23.30	32.80	405.40	396.00	33.40	384.00	9.5	2	38.19631	-89.879159
MW-162	PMP	2013-08-01	433.20	433.20	Top of PVC	430.83	15.90	25.30	415.00	405.50	25.90	404.90	9.5	2	38.192595	-89.879221
MW-192	UGU	2022-09-27	436.94	436.94	Top of PVC	434.04	20.00	30.00	414.04	404.04	30.00	400.04	10	2	38.199203	-89.866927
MW-193	UGU	2022-10-04	438.06	438.06	Top of PVC	434.51	22.00	32.00	412.51	402.51	32.00	402.51	10	2	38.199173	-89.862658
MW-194	UGU	2022-10-05	438.20	438.20	Top of PVC	435.43	18.00	28.00	407.43	397.43	28.00	405.43	10	2	38.199138	-89.858653
MW-204	UA	1991-09-30	456.02	456.02	Top of PVC	453.30	68.00	78.00	385.30	375.30	79.00	79.00	10	2	--	--
MW-252	PMP	2010-09-01	425.07	425.07	Top of PVC	422.27	44.40	49.00	377.90	373.20	49.50	372.70	4.6	2	38.187563	-89.866745
MW-253	PMP	2010-09-01	445.84	445.84	Top of PVC	442.70	29.90	34.50	412.80	408.20	35.00	407.70	4.6	2	38.185885	-89.861026
MW-258	UA	2022-10-07	456.12	456.12	Top of PVC	453.50	40.00	50.00	413.59	403.59	50.00	390.50	10	2	38.195276	-89.849429
MW-262	PMP	2013-08-01	433.21	433.21	Top of PVC	430.86	42.10	46.60	388.70	384.20	47.20	379.90	4.5	2	38.192605	-89.87922
MW-304	UA	2015-10-20	455.49	455.49	Top of PVC	453.03	45.00	55.00	408.00	398.00	55.00	317.60	10	2	38.188332	-89.853441
MW-306	UA	1991-09-25	453.17	453.17	Top of PVC	450.91	72.70	87.70	378.20	363.20	87.70	361.20	15	2	38.20114	-89.846756

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

Well Number	HSU	Date Constructed	Top of PVC Elevation (ft)	Measuring Point Elevation (ft)	Measuring Point Description	Ground Elevation (ft)	Screen Top Depth (ft BGS)	Screen Bottom Depth (ft BGS)	Screen Top Elevation (ft)	Screen Bottom Elevation (ft)	Well Depth (ft BGS)	Bottom of Boring Elevation (ft)	Screen Length (ft)	Screen Diameter (inches)	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)
MW-307	UA	1991-09-16	436.66	436.66	Top of PVC	434.00	57.00	72.00	377.00	362.00	74.00	333.00	15	2	--	--
MW-350	UA	2010-09-01	396.80	396.80	Top of PVC	394.11	41.60	46.20	352.50	347.90	46.60	347.40	4.6	2	38.189416	-89.878477
MW-352	UA	2010-09-01	425.04	425.04	Top of PVC	422.36	67.90	72.50	354.50	349.80	73.00	348.60	4.6	2	38.187554	-89.866729
MW-355	UA	2010-09-01	393.69	393.69	Top of PVC	390.82	27.40	32.00	363.40	358.80	32.50	358.20	4.6	2	38.193305	-89.882865
MW-356	UA	2015-10-01	427.60	427.60	Top of PVC	425.18	56.00	66.00	369.20	359.20	66.00	290.20	10	2	38.198963	-89.869578
MW-358	UA	2022-10-08	455.73	455.73	Top of PVC	453.59	80.00	90.00	373.73	363.73	90.00	363.59	10	2	38.195275	-89.849417
MW-366	UA	2015-12-04	425.08	425.08	Top of PVC	422.54	42.00	52.00	380.50	370.50	52.00	368.20	10	2	38.192191	-89.872345
MW-369	UA	2015-11-19	422.71	422.71	Top of PVC	420.49	56.00	66.00	364.50	354.50	66.00	349.80	10	2	38.196986	-89.870258
MW-370	UA	2015-11-25	420.85	420.85	Top of PVC	418.67	53.00	63.00	365.70	355.70	63.00	352.70	10	2	38.195603	-89.869669
MW-373	UA	2015-10-28	391.32	391.32	Top of PVC	388.80	20.00	30.00	368.80	358.80	30.00	293.70	10	2	38.190726	-89.879258
MW-374	UA	2015-11-10	400.91	400.91	Top of PVC	398.41	30.00	40.00	368.40	358.40	40.00	356.10	10	2	38.189682	-89.877242
MW-375	UA	2015-11-06	423.05	423.05	Top of PVC	420.50	57.00	67.00	363.50	353.50	67.00	335.80	10	2	38.189045	-89.873514
MW-377	UA	2015-11-02	421.36	421.36	Top of PVC	418.75	46.00	56.00	372.80	362.80	56.00	360.50	10	2	38.188386	-89.869742
MW-382	UA	2015-11-23	431.19	431.19	Top of PVC	428.67	56.00	66.00	372.70	362.70	66.00	358.10	10	2	38.19454	-89.868044
MW-383	UA	2015-12-21	459.49	459.49	Top of PVC	457.18	58.00	68.00	399.20	389.20	68.00	384.20	10	2	38.194913	-89.858286
MW-384	UA	2015-12-18	458.95	458.95	Top of PVC	456.70	60.50	70.50	396.20	386.20	70.50	362.60	10	2	38.191789	-89.860699
MW-385	UA	2015-12-16	454.56	454.56	Top of PVC	454.82	80.00	90.00	374.80	364.80	90.00	361.80	10	2	38.191729	-89.86847
MW-386	UA	2015-12-11	454.17	454.17	Top of PVC	454.67	76.00	86.00	378.70	368.70	86.00	365.70	10	2	38.189441	-89.866991
MW-387	UA	2015-11-18	426.63	426.63	Top of PVC	424.01	48.00	58.00	376.00	366.00	58.00	362.70	10	2	38.190905	-89.874773
MW-388	UA	2015-12-12	408.92	408.92	Top of PVC	406.28	33.00	43.00	373.30	363.30	43.00	361.10	10	2	38.191785	-89.87773
MW-389	UA	2015-12-01	419.90	419.90	Top of PVC	417.30	42.00	52.00	375.30	365.30	52.00	361.60	10	2	38.193679	-89.877076
MW-390	UA	2016-03-04	428.06	428.06	Top of PVC	425.98	50.00	65.00	376.00	361.00	65.00	358.00	15	2	38.192956	-89.869793
MW-391	UA	2016-03-10	426.63	426.63	Top of PVC	424.24	55.00	70.00	369.20	354.20	70.00	349.80	15	2	38.190869	-89.874759
MW-392	UA	2022-09-26	437.02	437.02	Top of PVC	434.07	74.00	84.00	360.07	350.07	84.00	350.07	10	2	38.199203	-89.866934

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

Well Number	HSU	Date Constructed	Top of PVC Elevation (ft)	Measuring Point Elevation (ft)	Measuring Point Description	Ground Elevation (ft)	Screen Top Depth (ft BGS)	Screen Bottom Depth (ft BGS)	Screen Top Elevation (ft)	Screen Bottom Elevation (ft)	Well Depth (ft BGS)	Bottom of Boring Elevation (ft)	Screen Length (ft)	Screen Diameter (inches)	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)
MW-393	UA	2022-10-04	437.86	437.86	Top of PVC	434.59	75.00	85.00	359.59	349.59	85.00	349.59	10	2	38.199174	-89.862666
MW-394	UA	2022-10-05	438.29	438.29	Top of PVC	435.51	73.00	83.00	362.51	352.51	83.00	350.51	10	2	38.199136	-89.85866
OW-156	PMP	2010-09-01	427.87	427.87	Top of PVC	425.14	7.90	17.20	417.30	407.90	17.70	407.40	9.3	2	38.198969	-89.869592
OW-157	PMP	2010-09-01	432.64	432.64	Top of PVC	429.90	7.80	17.10	422.10	412.80	17.60	412.30	9.3	2	38.19384	-89.867384
OW-256	PMP	2013-08-01	427.70	427.70	Top of PVC	425.20	28.00	32.50	397.20	392.70	33.10	389.20	4.5	2	38.198966	-89.86961
OW-257	PMP	2013-08-01	431.02	431.02	Top of PVC	428.17	34.00	38.50	394.20	389.70	39.10	388.60	4.5	2	38.193865	-89.867456
PZ-169	PMP	2015-07-28	422.60	422.60	Top of PVC	420.01	31.50	41.50	388.50	378.50	41.50	378.00	10	2	38.196962	-89.870253
PZ-170	PMP	2015-07-29	421.43	421.43	Top of PVC	418.58	21.10	31.10	397.50	387.50	31.10	387.50	10	2	38.195585	-89.869632
PZ-171	PMP	2015-07-31	434.15	434.15	Top of PVC	431.54	28.00	38.00	403.50	393.50	38.00	393.50	10	2	38.194595	-89.879189
PZ-172	PMP	2015-08-03	412.95	412.95	Top of PVC	410.22	16.00	26.00	394.20	384.20	26.00	384.00	10	2	38.191491	-89.879283
PZ-173	PMP	2015-08-03	391.46	391.46	Top of PVC	388.43	3.50	13.50	384.90	374.90	13.50	374.30	10	2	38.1907	-89.879247
PZ-174	PMP	2015-08-04	401.92	401.92	Top of PVC	398.97	14.50	24.50	384.50	374.50	24.50	374.30	10	2	38.189682	-89.877209
PZ-175	PMP	2015-08-07	423.01	423.01	Top of PVC	419.87	40.00	50.00	379.90	369.90	50.00	369.70	10	2	38.189032	-89.873481
PZ-176	PMP	2015-08-06	406.44	406.44	Top of PVC	403.46	18.10	28.10	385.40	375.40	28.60	374.90	10	2	38.188565	-89.871623
PZ-177	PMP	2015-08-06	420.90	420.90	Top of PVC	417.93	20.50	30.50	397.40	387.40	30.50	387.20	10	2	38.188361	-89.869736
PZ-178	PMP	2015-08-05	431.26	431.26	Top of PVC	428.45	33.00	43.00	395.50	385.50	43.00	385.00	10	2	38.188076	-89.867868
PZ-182	PMP	2015-07-30	431.61	431.61	Top of PVC	428.47	24.00	34.00	404.50	394.50	34.00	394.50	10	2	38.194512	-89.86801
TPZ-158	PMP	2013-08-01	456.26	456.26	Top of PVC	453.26	9.20	18.30	444.00	435.00	18.90	434.30	9.1	1.3	38.195308	-89.849428
TPZ-159	PMP	2013-08-01	447.64	447.64	Top of PVC	444.69	20.00	29.00	424.70	415.70	29.60	394.70	9.1	1.3	38.199022	-89.862558
TPZ-160	PMP	2013-08-01	431.49	431.49	Top of PVC	428.59	9.80	18.80	418.80	409.80	19.40	393.60	9.1	1.3	38.19896	-89.875586
TPZ-163	CCR	2013-08-01	458.41	458.41	Top of PVC	455.51	8.60	18.10	446.90	437.40	18.70	410.50	9.5	2	38.19274	-89.857249
TPZ-164	CCR	2013-08-01	435.10	435.10	Top of PVC	432.50	5.20	9.70	427.30	422.80	10.30	422.20	4.5	2	38.195586	-89.862797
TPZ-165	PMP	2013-08-01	398.85	398.85	Top of PVC	396.10	7.80	16.80	388.30	379.30	17.40	378.70	9.1	1.3	38.193174	-89.874746
TPZ-166	PMP	2013-08-01	425.18	425.18	Top of PVC	422.33	15.30	24.70	407.10	397.60	25.30	396.80	9.5	2	38.1922	-89.872297

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

Well Number	HSU	Date Constructed	Top of PVC Elevation (ft)	Measuring Point Elevation (ft)	Measuring Point Description	Ground Elevation (ft)	Screen Top Depth (ft BGS)	Screen Bottom Depth (ft BGS)	Screen Top Elevation (ft)	Screen Bottom Elevation (ft)	Well Depth (ft BGS)	Bottom of Boring Elevation (ft)	Screen Length (ft)	Screen Diameter (inches)	Latitude (Decimal Degrees)	Longitude (Decimal Degrees)
TPZ-167	CCR	2013-08-01	441.38	441.38	Top of PVC	438.63	21.40	30.90	417.20	407.70	31.50	389.90	9.5	2	38.190478	-89.869723
TPZ-168	CCR	2013-08-01	457.53	457.53	Top of PVC	454.93	15.80	25.30	439.20	429.70	25.80	384.90	9.5	2	38.188681	-89.863954
XPW01	CCR	2022-09-23	437.66	437.66	Top of PVC	435.12	7.00	12.00	428.12	423.12	12.00	421.12	5	2	38.197522	-89.864474
XPW02	CCR	2022-09-24	437.92	437.92	Top of PVC	434.86	6.00	11.00	428.86	423.86	11.00	420.86	5	2	38.197894	-89.86188
XPW04	CCR	2022-09-24	434.58	434.58	Top of PVC	430.59	6.50	16.50	424.09	414.09	16.50	410.59	10	2	38.194698	-89.863819
XPW05	CCR	2022-09-24	437.27	437.27	Top of PVC	434.12	18.00	28.00	416.12	406.12	28.00	404.12	10	2	38.196233	-89.862366
XPW06	CCR	2022-09-22	417.72	417.72	Top of PVC	418.06	5.00	10.00	412.99	407.99	10.00	402.06	5	2	38.196967	-89.868954

Notes:
All elevation data are presented relative to the North American Vertical Datum 1988 (NAVD88), GEOID 12A
-- = data not available
BGS = below ground surface
CCR = coal combustion residuals
ft = foot or feet
HSU = Hydrostratigraphic Unit
PMP = potential migration pathway
PVC = polyvinyl chloride
UA = uppermost aquifer
UGU = upper groundwater unit
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TABLE 2-2. FLOW MODEL CALIBRATION TARGETS

GROUNDWATER MODELING REPORT

BALDWIN POWER PLANT

BOTTOM ASH POND

BALDWIN, IL

Well ID	Monitored Hydrogeologic Unit	Modeled Target Location (Layer Number)	Flow Model Target Groundwater Elevation (Modified Median Value December 2015 to June 2022 [feet NAVD88][1])
MW-104DR	UGU	3	445.01
MW-104SR	UGU	2	446.42
MW-116	UGU	4	449.61 [2]
MW-126	UGU	2	459.57 [2]
MW-150	UGU	3	377.70
MW-151	UGU	5	395.62
MW-152	UGU	3	419.87
MW-153	UGU	2	432.69
MW-154	UGU	5	379.61
MW-155	UGU	3	373.98
MW-158R	UGU	2	442.63 [2]
MW-192	UGU	2	428.57 [2]
MW-193	UGU	3	429.02 [2]
MW-194	UGU	3	431.32 [2]
MW-204	UA	6	442.82 [2]
MW-252	UGU	5	424.93
MW-253	UGU	5	434.66
MW-258	UA	5	441.95 [2]
MW-304	UA	6	445.93
MW-306	UA	6	435.63
MW-307	UA	6	431.10 [2]
MW-350	UA	6	374.27
MW-352	UA	6	423.42
MW-355	UA	6	370.39
MW-356	UA	6	424.92
MW-366	UA	6	409.99
MW-369	UA	6	413.31
MW-370	UA	6	402.35
MW-374	UA	6	388.62
MW-375	UA	6	392.00
MW-377	UA	6	416.56
MW-382	UA	5	414.96
MW-383	UA	6	441.03

TABLE 2-2. FLOW MODEL CALIBRATION TARGETS

GROUNDWATER MODELING REPORT

BALDWIN POWER PLANT

BOTTOM ASH POND

BALDWIN, IL

Well ID	Monitored Hydrogeologic Unit	Modeled Target Location (Layer Number)	Flow Model Target Groundwater Elevation (Modified Median Value December 2015 to June 2022 [feet NAVD88][1])
MW-384	UA	6	445.34
MW-388	UA	6	393.34
MW-389	UA	6	400.58
MW-390	UA	6	423.44
MW-392	UA	6	428.08 [2]
MW-393	UA	6	429.29 [2]
MW-394	UA	6	432.69 [2]
OW-156	UGU	2	421.74
OW-157	UGU	2	426.61
TPZ-164	CCR	1	431.14
XPW01	CCR	1	426.15 [2]
XPW02	CCR	1	433.52 [2]
XPW04	CCR	1	426.56 [2]
XPW05	CCR	1	432.43 [2]
XPW06	CCR	1	415.07 [2]

Notes:

[1] Target groundwater elevations represent modified median groundwater elevations from December 2015 to June 2022. Anomalous groundwater elevations (e.g., groundwater elevations that do not represent static groundwater conditions, groundwater elevation outliers, or groundwater elevations measured in error) monitored between December 2015 and June 2022 were removed from the median groundwater elevation calculations used as flow calibration targets.

[2] Target groundwater elevation used most recent measurement (November 2022) for wells constructed or reoccupied in 2022

ID = identification
NAVD88 = North American Vertical Datum of 1988

Hydrogeologic Unit:
CCR = coal combustion residuals
UA = uppermost aquifer
UGU = upper groundwater unit

TABLE 4-1. FLOW MODEL INPUT AND SENSITIVITY ANALYSIS RESULTS
GROUNDWATER MODELING REPORT
BALDWIN POWER PLANT
BOTTOM ASH POND
BALDWIN, ILLINOIS

Zone	Zone Description	Materials	ft/d	cm/s	Kh/Kv	Value Source	Sensitivity[1]
Horizontal Hydraulic Conductivity			**Calibration Model**				
1	UGU	silty clay	0.35	1.23E-04	NA	Calibrated - Within Range of Upper Groundwater Unit Horizontal Hydraulic Conductivity Field Test Results (Ramboll, 2021)	Moderate
2	Old East Fly Ash Pond	CCR	0.5	1.76E-04	NA	Calibrated - Near Geomean of Vertical Hydraulic Conductivity Laboratory Test Results (Ramboll, 2021)	Negligible
3	East Fly Ash Pond	CCR	0.5	1.76E-04	NA	Calibrated - Near Geomean of Vertical Hydraulic Conductivity Laboratory Test Results (Ramboll, 2021)	Negligible
4	West Fly Ash Cell	CCR	0.5	1.76E-04	NA	Calibrated - Near Geomean of Vertical Hydraulic Conductivity Laboratory Test Results (Ramboll, 2021)	Negligible
7	Bottom Ash Pond	CCR	1.5	5.29E-04	NA	Calibrated - Near TPZ-164 Vertical Hydraulic Conductivity Laboratory Test Results (Ramboll, 2021)	Low
8	UA (Decomposed Bedrock)	bedrock	0.35	1.23E-04	NA	Calibrated - Within Range of Hydraulic Conductivity Field Test Results for Wells Screened Near Unlithified and Bedrock Interface (Ramboll, 2021)	Low
9	UA	bedrock	0.2	7.06E-05	NA	Calibrated - Near Maximum of Horizontal Hydraulic Conductivity Field Test Results (Ramboll, 2021)	Moderately High
10	UGU (Top of Vandalia)	silty clay	0.35	1.23E-04	NA	Calibrated - Within Range of Upper Groundwater Unit Horizontal Hydraulic Conductivity Field Test Results (Ramboll, 2021)	Low
12	River Alluvium	silty clay	1	3.53E-04	NA	Calibrated	Low
14	PMP	sand seams	1.5	5.29E-04	NA	Calibrated	Moderate
100	Above River Boundary Condition	NA	500	1.76E-01	NA	Calibrated - Conductivity Value to Allow Groundwater Flow to River Boundary Conditions	Negligible
Vertical Hydraulic Conductivity			**Calibration Model**				
1	UGU	silty clay	0.35	1.23E-04	1	Calibrated - Within Range of Upper Groundwater Unit Vertical Hydraulic Conductivity Laboratory Test Results (Ramboll, 2021)	Low
2	Old East Fly Ash Pond	CCR	0.5	1.76E-04	1	Calibrated - Near Geomean of Vertical Hydraulic Conductivity Laboratory Test Results (Ramboll, 2021)	Negligible
3	East Fly Ash Pond	CCR	0.5	1.76E-04	1	Calibrated - Near Geomean of Vertical Hydraulic Conductivity Laboratory Test Results (Ramboll, 2021)	Negligible
4	West Fly Ash Cell	CCR	0.5	1.76E-04	1	Calibrated - Near Geomean of Vertical Hydraulic Conductivity Laboratory Test Results (Ramboll, 2021)	Negligible
7	Bottom Ash Pond	CCR	1.5	5.29E-04	1	Calibrated - Near TPZ-164 Vertical Hydraulic Conductivity Laboratory Test Results (Ramboll, 2021)	Negligible
8	UA (Decomposed Bedrock)	bedrock	0.35	1.23E-04	1	Calibrated	Negligible

TABLE 4-1. FLOW MODEL INPUT AND SENSITIVITY ANALYSIS RESULTS
GROUNDWATER MODELING REPORT
BALDWIN POWER PLANT
BOTTOM ASH POND
BALDWIN, ILLINOIS

Zone	Zone Description	Materials	ft/d	cm/s	Kh/Kv	Value Source	Sensitivity[1]
Vertical Hydraulic Conductivity			**Calibration Model**				
9	UA	bedrock	0.02	7.06E-06	10	Calibrated	Moderately High
10	UGU (Top of Vandalia)	silty clay	0.35	1.23E-04	1	Calibrated	Negligible
12	River Alluvium	silty clay	1	3.53E-04	1	Calibrated	Negligible
14	PMP	sand seams	1.5	5.29E-04	1	Calibrated	Negligible
100	Above River Boundary Condition	NA	500	1.76E-01	1	Calibrated - Conductivity Value to Allow Groundwater Flow to River Boundary Conditions	Negligible
Zone	**Zone Description**	**Materials**	**ft/d**	**in/yr**	**Kh/Kv**	**Value Source**	**Sensitivity[1]**
Recharge			**Calibration Model**				
1	Silty Clay	silty clay	1.00E-04	0.44	NA	Calibrated	Moderate
2	Old East Fly Ash Pond	CCR	6.80E-05	0.30	NA	Calibrated	Negligible
3	East Fly Ash Pond	CCR	6.80E-05	0.30	NA	Calibrated	Negligible
4	West Fly Ash Cell	CCR	6.80E-05	0.30	NA	Calibrated	Negligible
5	Secondary Pond	silty clay	1.00E-04	0.44	NA	Calibrated	Negligible
6	Tertiary Pond	silty clay	1.00E-04	0.44	NA	Calibrated	Negligible
7	Bottom Ash Pond	CCR	5.00E-04	2.19	NA	Calibrated	Low
Zone	**Zone Description**	**Materials**	**Storage**	**Specific Yield**	**Effective Porosity**	**Value Source**	**Sensitivity[1]**
Storage, Specific Yield and Effective Porosity (*not used in steady-state*)			**Calibration Model**				
1	UGU	silty clay	0.003	0.15	0.15	Storage Estimated from Literature (Fetter, 1988); Specific Yield Set Equal to Effective Porosity; Calibrated - Effective Porosity Esitmated from Literature (Morris and Johnson, 1967; Heath, 1983)	*The sensitivity of these parameters was not tested for flow modeling. Future modeling efforts which may include three dimensional transport modeling will test storage, specific yield and effective porosity sensitivity by evaluating their effect on the transport model.*
2	Old East Fly Ash Pond	CCR	0.003	0.2	0.2	Storage Estimated from Literature (Fetter, 1988); Specific Yield Set Equal to Effective Porosity; Calibrated - Effective Porosity Esitmated from Literature (Morris and Johnson, 1967; Heath, 1983)	
3	East Fly Ash Pond	CCR	0.003	0.2	0.2	Storage Estimated from Literature (Fetter, 1988); Specific Yield Set Equal to Effective Porosity; Calibrated - Effective Porosity Esitmated from Literature (Morris and Johnson, 1967; Heath, 1983)	
4	West Fly Ash Cell	CCR	0.003	0.2	0.2	Storage Estimated from Literature (Fetter, 1988); Specific Yield Set Equal to Effective Porosity; Calibrated - Effective Porosity Esitmated from Literature (Morris and Johnson, 1967; Heath, 1983)	
7	Bottom Ash Pond	CCR	0.003	0.25	0.25	Storage Estimated from Literature (Fetter, 1988); Specific Yield Set Equal to Effective Porosity; Calibrated - Effective Porosity Esitmated from Literature (Morris and Johnson, 1967; Heath, 1983)	
8	UA (Decomposed Bedrock)	bedrock	0.003	0.15	0.15	Storage Estimated from Literature (Fetter, 1988); Specific Yield Set Equal to Effective Porosity; Calibrated - Effective Porosity Esitmated from Literature (Morris and Johnson, 1967; Heath, 1983)	

TABLE 4-1. FLOW MODEL INPUT AND SENSITIVITY ANALYSIS RESULTS
GROUNDWATER MODELING REPORT
BALDWIN POWER PLANT
BOTTOM ASH POND
BALDWIN, ILLINOIS

Zone	Zone Description	Materials	Storage	Specific Yield	Effective Porosity	Value Source	Sensitivity[1]
Storage, Specific Yield and Effective Porosity (*not used in steady-state*)			**Calibration Model**				
9	UA	bedrock	0.003	0.3	0.15	Storage Estimated from Literature (Fetter, 1988); Specific Yield Set Equal to Effective Porosity; Calibrated - Effective Porosity Esitmated from Literature (Morris and Johnson, 1967; Heath, 1983)	*The sensitivity of these parameters was not tested for flow modeling. Future modeling efforts which may include three dimensional transport modeling will test storage, specific yield and effective porosity sensitivity by evaluating their effect on the transport model.*
10	UGU (Top of Vandalia)	silty clay	0.003	0.15	0.15	Storage Estimated from Literature (Fetter, 1988); Specific Yield Set Equal to Effective Porosity; Calibrated - Effective Porosity Esitmated from Literature (Morris and Johnson, 1967; Heath, 1983)	
12	River Alluvium	silty clay	0.003	0.15	0.15	Storage Estimated from Literature (Fetter, 1988); Specific Yield Set Equal to Effective Porosity; Calibrated - Effective Porosity Esitmated from Literature (Morris and Johnson, 1967; Heath, 1983)	
14	PMP	sand seams	0.003	0.25	0.25	Storage Estimated from Literature (Fetter, 1988); Specific Yield Set Equal to Effective Porosity; Calibrated - Effective Porosity Esitmated from Literature (Morris and Johnson, 1967; Heath, 1983)	
100	Above River Boundary Condition	NA	0.003	0.5	0.5	Storage Estimated from Literature (Fetter, 1988); Specific Yield Set Equal to Effective Porosity; Calibrated - Effective Porosity Esitmated from Literature (Morris and Johnson, 1967; Heath, 1983)	
River Parameters							
	Relative Location	**Stage of River (feet)**	**Sensitivity**	**River Bottom Elevation (feet)**	**Hydraulic Conductivity (ft/d)**	**Average River Conductance (ft^2/d)**	**Sensitivity**
Reach 0	Cooling Pond	429	Moderate	410	3.80	3.80E+04	Negligible
Reach 1	Kaskaskia River	370	High	365	5.17	5.17E+04	Negligible
Reach 2	South Stream (Southern Limit of Model Domain)	456.03-370	Negligible	452.03-365.54	2.08	2.08E+04	Negligible
Reach 3	South Stream (Between Reach 2 and Reach 4)	449.98-370.06	Negligible	447.98-368.06	2.05	2.05E+04	Negligible
Reach 4	South Stream (Adjacent to FAPS)	447-370	Low	443-366	0.09	9.00E+02	Negligible
Reach 5	Northwest Stream (West of Cooling Pond)	410.66-370	Negligible	408.66-368	3.89	3.89E+04	Negligible
Reach 7	Northeast Stream (East of Cooling Pond)	454.75-427	Low	452.75-425	2.60	2.60E+04	Negligible
Reach 8	Secondary and Tertiary Pond	396	Low	394.99-376.17	0.26	2.60E+03	Negligible

TABLE 4-1. FLOW MODEL INPUT AND SENSITIVITY ANALYSIS RESULTS
GROUNDWATER MODELING REPORT
BALDWIN POWER PLANT
BOTTOM ASH POND
BALDWIN, ILLINOIS

River Parameters							
Value Source	NA	Calibrated - Cooling Pond Stage (Reach 0) Approximates Elevation at which Pond is Maintained; Kaskasia River Stage (Reach 1) at Baldwin Power Plant Based on Interpolated Stage Data Provided at New Athens, Illinois (USGS 5595000) and Red Bud (USGS 5595240); River Stage at Reaches 2 through 7 Approximate Topography; River Stage at Reach 8 Based on Historic Groundwater Elevation within Secondary and Tertiary Ponds at TPZ-165; Drainage Feature Stage at Reaches 0 through 1 Based on Estimated Water Surface Elevation within BAP	NA	Calibrated	Calibrated	Calibrated	NA
Drain Parameters							
	Relative Location	**Stage of Drain (feet)**	**Sensitivity**	**Thickness of Drain Bed**	**Hydraulic Conductivity (ft/d)**	**Drain Conductance (ft^2/d)**	**Sensitivity**
Reach 0	BAP Drain West	415	Low	1	6.00	6.00E+04	Negligible
Reach 1	BAP Drain Central	425	High	1	6.00	6.00E+04	Negligible
Value Source	NA	Calibrated - Drainage Feature Stage at Reaches 0 through 1 Based on Estimated Water Surface Elevation within BAP	NA	Calibrated	Calibrated	Calibrated	NA

[O: JJW 12/8/2022 ; C: EGP 1/4/23]

Notes:
[1] Sensitivity Explanation:
Negligible - SSR changed by less than 1%
Low - SSR change between 1% and 10%
Moderate - SSR change between 10% and 50%
Moderately High - SSR change between 50% and 100%
High - SSR change greater than 100%
SSR = sum of squared residuals
- - - = not tested
cm/s = centimeters per second
ft/d = feet per day
ft^2/day = feet squared per day
in/yr = inches per year
Kh/Kv = anisotropy ratio
NA = not applicable

Hydrogeologic Unit:
CCR = coal combustion residuals
PMP = potential migration pathway
UA = uppermost aquifer
UGU = upper groundwater unit

References:

Ramboll Americas Engineering Solutions, Inc. (Ramboll), 2021. Hydrogeologic Site Characterization Report. Bottom Ash Pond. Baldwin Power Plant. Baldwin, Illinois.
Fetter, C.W., 1988, Applied Hydrogeology, Merrill Publishing Company, Columbis, Ohio.
Morris, D.A and A.I. Johnson, 1967. Summary of hydrologic and physical properties of rock and soil materials
as analyzed by the Hydrologic Laboratory of the U.S. Geological Survey. U.S. Geological Survey Water-Supply Paper 1839-D, 42p.
Heath, R.C., 1983. Basic ground-water hydrology, U.S. Geological Survey Water-Supply Paper 2220, 86p.

TABLE 5-1. HELP MODEL INPUT AND OUTPUT VALUES
GROUNDWATER MODELING REPORT
BALDWIN POWER PLANT
BOTTOM ASH POND
BALDWIN, ILLINOIS

Closure Scenario Number (Drainage Length)	BAP CIP - Consolidation Area (Top)	BAP CIP - Consolidation Area (Slopes)	Notes
Input Parameter			
Climate-General			
City	Baldwin, IL	Baldwin, IL	Nearby city to the Site within HELP database
Latitude	38.18	38.18	Site latitude
Evaporative Zone Depth	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	Maximum for geographic location (Illinois) (Tolaymat, T. and Krause, M, 2020)
Growing Season Period, Average Wind Speed, and Quarterly Relative Humidity	Belleville Scott Air Force Base, IL	Belleville Scott Air Force Base, IL	Nearby city to the Baldwin Ash Pond within HELP database
Number of Years for Synthetic Data Generation	30	30	
Temperature, Evapotranspiration, and Precipitation	Precipitation, temperature, and solar radiation was simulated based on HELP V4 weather simulation for: Lat/Long: 38.18/ -89.85	Precipitation, temperature, and solar radiation was simulated based on HELP V4 weather simulation for: Lat/Long: 38.18/ -89.85	
Soils-General			
% where runoff possible	100	100	
Area (acres)	53.73	21.39	CIP - Consolidation and Cover System Area based on construction drawing for Baldwin Ash Pond
Specify Initial Moisture Content	No	No	
Surface Water/Snow	Model Calculated	Model Calculated	
Soils-Layers			
1	Vegetative Soil Layer (HELP Final Cover Soil [topmost layer])	Vegetative Soil Layer (HELP Final Cover Soil [topmost layer])	Layers details for CIP areas based on grading plans, construction drawings, and cover system design for Baldwin BAP
2	Protective Soil Layer (HELP Vertical Percolation Layer)	Protective Soil Layer (HELP Vertical Percolation Layer)	
3	Geotextile Protective Layer (Custom)	Geocomposite Drainage Layer (HELP Geosynthetic Drainage Net)	
4	Geomembrane Liner	Geomembrane Liner	
5	Unsaturated CCR Material (HELP Waste)	Unsaturated CCR Material (HELP Waste)	
Soil Parameters--Layer 1			
Type	1	1	Vertical Percolation Layer (Cover Soil)
Thickness (in)	6	6	Layer 1 thickness is the average thickness of unsaturated backfill material
Texture	26	26	Default used for CIP Consolidation area
Description	Silty Clay Loam (Moderate)	Silty Clay Loam (Moderate)	
Saturated Hydraulic Conductivity (cm/s)	1.90E-06	1.90E-06	Default used for CIP Consolidation area

TABLE 5-1. HELP MODEL INPUT AND OUTPUT VALUES
GROUNDWATER MODELING REPORT
BALDWIN POWER PLANT
BOTTOM ASH POND
BALDWIN, ILLINOIS

Closure Scenario Number (Drainage Length)	BAP CIP - Consolidation Area (Top)	BAP CIP - Consolidation Area (Slopes)	Notes
Soil Parameters--Layer 2			
Type	1	1	Vertical Percolation Layer (BAP)
Thickness (in)	18	18	design thickness
Texture	28	28	Defaults used
Description	Silty Clay (Moderate)	Silty Clay (Moderate)	
Saturated Hydraulic Conductivity (cm/s)	1.20E-06	1.20E-06	Defaults used
Soil Parameters--Layer 3			
Type	2	2	Lateral Drainage Layer
Thickness (in)	0.175	0.2	design thickness
Texture	43	20	Custom used for the top area of the CIP and a Default used for the slopes
Description	16 oz Nonwoven Geotextile	Geosynthetic Drainage Net	
Saturated Hydraulic Conductivity (cm/s)	3.00E-01	1.00E+01	Custom used for the top area of the CIP and a Defaults used for the slopes
Soil Parameters--Layer 4			
Type	4	4	Flexible Membrane Liner
Thickness (in)	0.04	0.04	design thickness
Texture	36	36	Defaults used
Description	LDPE Membrane	LDPE Membrane	
Saturated Hydraulic Conductivity (cm/s)	4.00E -13	4.00E -13	Defaults used
Soil Parameters--Layer 5			
Type	1	1	Vertical Percolation Layer (Waste)
Thickness (in)	545.28	231.72	design thickness
Texture	83	83	Custom used for CCR material
Description	Unsaturated CCR Material (HELP Waste)	Unsaturated CCR Material (HELP Waste)	
Saturated Hydraulic Conductivity (cm/s)	5.29E-04	5.29E-04	Custom used for CCR material from HCR average
Soils--Runoff			
Runoff Curve Number	89.8	91.1	HELP-computed curve number
Slope	2.00%	25.00%	Estimated from construction design drawings
Length (ft)	600	150	estimated maximum flow path
Vegetation	fair	fair	fair indicating fair stand of grass on surface of soil backfill
Execution Parameters			
Years	30	30	
Report Daily	No	No	
Report Monthly	No	No	
Report Annual	Yes	Yes	
Output Parameter			
Unsaturated Percolation Rate (in/yr)	**0.000239**	**0.000007**	

Notes:
% = percent
ft = feet
HELP = Hydrologic Evaluation of Landfill Performance
in = inches
in/yr = inches per year
Lat = latitude
Long = longitude
CBR = Closure By Removal
CIP = Closure In Place
HCR = Hydrogeologic Characterization Report

References:

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

TABLE 5-2. PREDICTION MODEL INPUT VALUES
GROUNDWATER MODELING REPORT
BALDWIN POWER PLANT
BOTTOM ASH POND
BALDWIN, ILLINOIS

Scenario: CIP (CCR removal from the western areas of the Bottom Ash Pond, consolidation to the eastern areas of the Bottom Ash Pond, and construction of a cover system over the remaining CCR)						
Prediction Model	**Construction Period (years)**	**Zone Description**	**Recharge Zone**	**Recharge (ft/day)**	**Recharge (in/yr)**	**Constant Head (feet)**
Initial Conditions	51	CCR - Old East Fly Ash Pond (Pre-Closure)	2	4.00E-04	1.75	--
Initial Conditions	51	CCR - East Fly Ash Pond (Pre-Closure)	3	1.40E-03	6.13	--
Initial Conditions	51	CCR - West Fly Ash Cell (Pre-Closure)	4	6.00E-04	2.63	424.3
Initial Conditions	51	silty clay - Secondary Pond	5	1.00E-04	0.44	--
Initial Conditions	51	silty clay - Tertiary Pond	6	1.00E-04	0.44	--
Initial Conditions	51	CCR - Bottom Ash Pond	7	5.00E-04	2.19	--
Exisiting Conditions	4	CCR - Old East Fly Ash Pond (Post-Closure)	2	6.80E-05	0.30	--
Exisiting Conditions	4	CCR - East Fly Ash Pond (Post-Closure)	3	6.80E-05	0.30	--
Exisiting Conditions	4	CCR - West Fly Ash Cell (Post-Closure)	4	6.80E-05	0.30	--
Exisiting Conditions	4	silty clay - Secondary Pond	5	1.00E-04	0.44	--
Exisiting Conditions	4	silty clay - Tertiary Pond	6	1.00E-04	0.44	--
Exisiting Conditions	4	CCR - Bottom Ash Pond	7	5.00E-04	2.19	--
Dewatering	3	CCR - Old East Fly Ash Pond (Post-Closure)	2	6.80E-05	0.30	--
Dewatering	3	CCR - East Fly Ash Pond (Post-Closure)	3	6.80E-05	0.30	--
Dewatering	3	CCR - West Fly Ash Cell (Post-Closure)	4	6.80E-05	0.30	--
Dewatering	3	silty clay - Secondary Pond	5	1.00E-04	0.44	--
Dewatering	3	silty clay - Tertiary Pond	6	1.00E-04	0.44	--
Dewatering	3	CCR - Bottom Ash Pond	7	5.00E-04	2.19	--

TABLE 5-2. PREDICTION MODEL INPUT VALUES
GROUNDWATER MODELING REPORT
BALDWIN POWER PLANT
BOTTOM ASH POND
BALDWIN, ILLINOIS

Scenario: CIP (CCR removal from the western areas of the Bottom Ash Pond, consolidation to the eastern areas of the Bottom Ash Pond, and construction of a cover system over the remaining CCR)							
CIP	1000	CCR - Old East Fly Ash Pond (Post-Closure)	2		6.80E-05	0.30	--
CIP	1000	CCR - East Fly Ash Pond (Post-Closure)	3		6.80E-05	0.30	--
CIP	1000	CCR - West Fly Ash Cell (Post-Closure)	4		6.80E-05	0.30	--
CIP	1000	silty clay - Secondary Pond	5		1.00E-04	0.44	--
CIP	1000	silty clay - Tertiary Pond	6		1.00E-04	0.44	--
CIP	1000	Removal Area - Bottom Ash Pond (Post-Closure)	7		0	0	--
CIP	1000	CIP Top (CCR) - Bottom Ash Pond (Post-Closure)	8		5.46E-08	2.39E-04	--
CIP	1000	CIP Slopes (CCR) - Bottom Ash Pond (Post-Closure)	9		1.60E-09	7.01E-06	--
Prediction Model	**Construction Period (years)**	**Zone Description**	**Hydraulic Conductivity Zone**	**Horizontal Hydraulic Conductivity (ft/d)**	**Horizontal Hydraulic Conductivity (cm/s)**	**Vertical Hydraulic Conductivity (ft/d)**	**Vertical Hydraulic Conductivity (cm/s)**
Initial Conditions	51	CCR - Bottom Ash Pond	7	1.5	5.29E-04	1.5	5.29E-04
Exisiting Conditions	4	CCR - Bottom Ash Pond	7	1.5	5.29E-04	1.5	5.29E-04
Dewatering	3	CCR - Bottom Ash Pond	7	1.5	5.29E-04	1.5	5.29E-04
CIP	1000	Removal Area - Bottom Ash Pond (Post-Closure)	11	500	1.76E-01	500	1.76E-01
CIP	1000	CIP Top (CCR) - Bottom Ash Pond (Post-Closure)	18	1.5	5.29E-04	1.5	5.29E-04
CIP	1000	CIP Slopes (CCR) - Bottom Ash Pond (Post-Closure)	19	1.5	5.29E-04	1.5	5.29E-04
Prediction Model	**Construction Period (years)**	**Drain Reach**	**Relative Location**	**Stage of Drain (feet)**	**Thickness of Drain Bed (feet)**	**Hydraulic Conductivity (ft/d)**	**Drain Conductance (ft^2/d)**
Initial Conditions	51	0	BAP Drain West	415	1	6.00	6.00E+04
Initial Conditions	51	1	BAP Drain Central	425	1	6.00	6.00E+04
Exisiting Conditions	4	0	BAP Drain West	415	1	6.00	6.00E+04
Exisiting Conditions	4	1	BAP Drain Central	425	1	6.00	6.00E+04
Dewatering	3	0	BAP Drain West	415	1	6.00	6.00E+04
Dewatering	3	1	BAP Drain Central	425	1	6.00	6.00E+04
Dewatering	3	6	BAP Drain Northeast	433	1	6.00	6.00E+04
Dewatering	3	3	BAP Drain Central East	420	1	6.00	6.00E+04
Dewatering	3	4	BAP Drain Southeast	433	1	6.00	6.00E+04
CIP	1000	10	BAP Drain West	410	1	6.00	6.00E+04

Notes:
-- = boundary condition or property zone not included in prediction model
CCR = coal combustion residuals
CIP = Closure In Place
ft^2/day = feet squared per day
ft/day = feet per day
in/yr = inches per year
cm/s = centimeters per second

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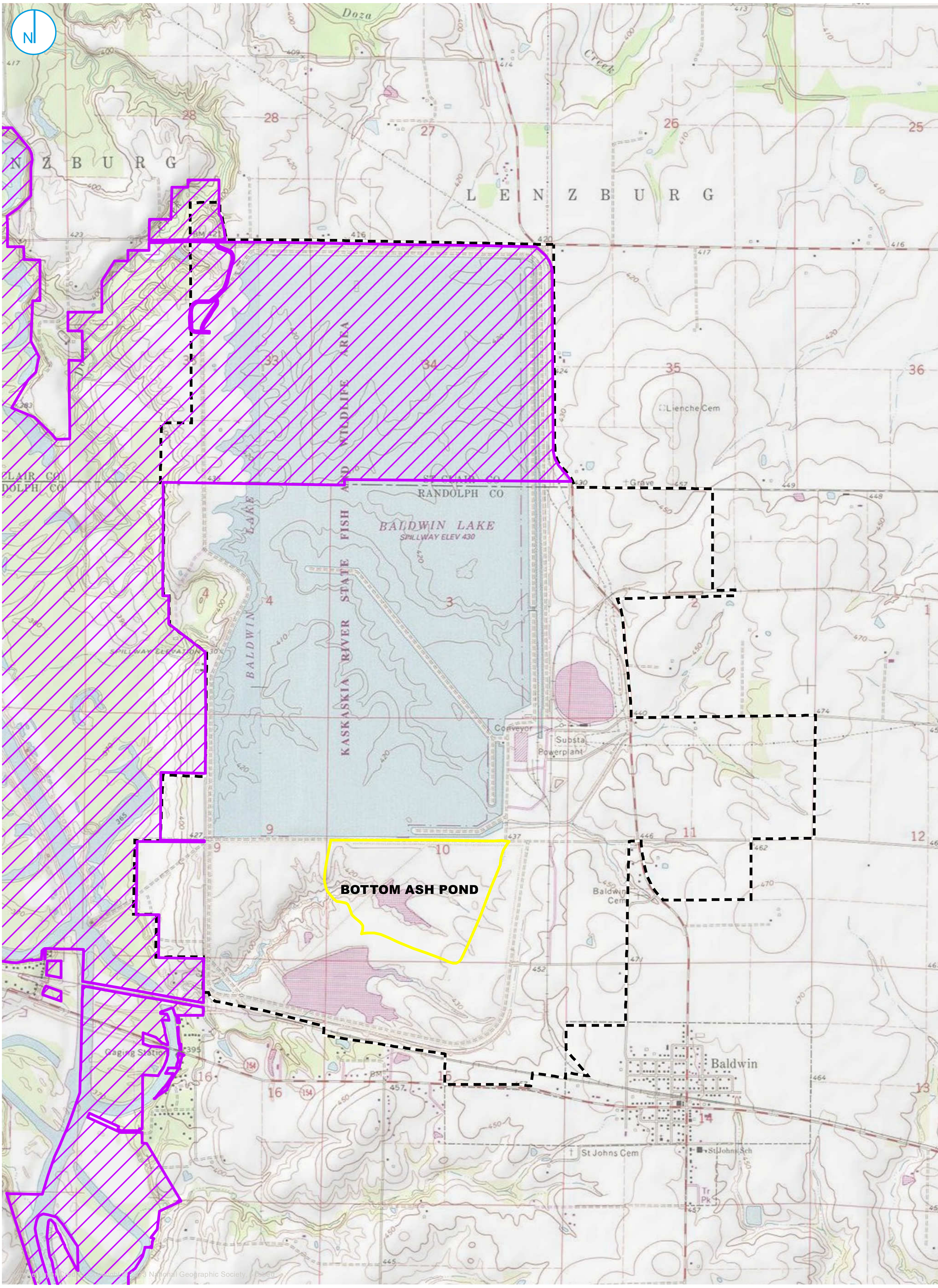
FIGURES



BOTTOM ASH POND BOUNDARY
PROPERTY BOUNDARY
KASKASKIA RIVER STATE FISH AND WILDLIFE AREA

SOURCE NOTE
I-View, Prairie State Conservation Coalition accessed via Illinois Department of Natural Resources Division of Natural Heritage Website
https://www2.illinois.gov/sites/naturalheritage/DataResearch/Pages/Access-Our-Data.aspx

0 1,000 2,000 Feet

SITE LOCATION MAP

FIGURE 1-1

GROUNDWATER MODELING REPORT
BOTTOM ASH POND
BALDWIN POWER PLANT
BALDWIN, ILLINOIS

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

Y:\Mapping\Projects\22\2285\MXD\845_Operating_Permit\Baldwin\BAP\Groundwater_Modeling_Report\Figure 1-2_Base Map.mxd

PROJECT: 169000XXXX | DATED: 1/6/2023 | DESIGNER: galarnmc

PART 845 REGULATED UNIT (SUBJECT UNIT)
LIMITS OF FINAL COVER
SITE FEATURE
FLY ASH POND SYSTEM (CLOSED)
PROPERTY BOUNDARY

0 400 800 Feet

DRAFT

SITE MAP

GROUNDWATER MODELING REPORT
BOTTOM ASH POND
BALDWIN POWER PLANT
BALDWIN, ILLINOIS

FIGURE 1-2

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

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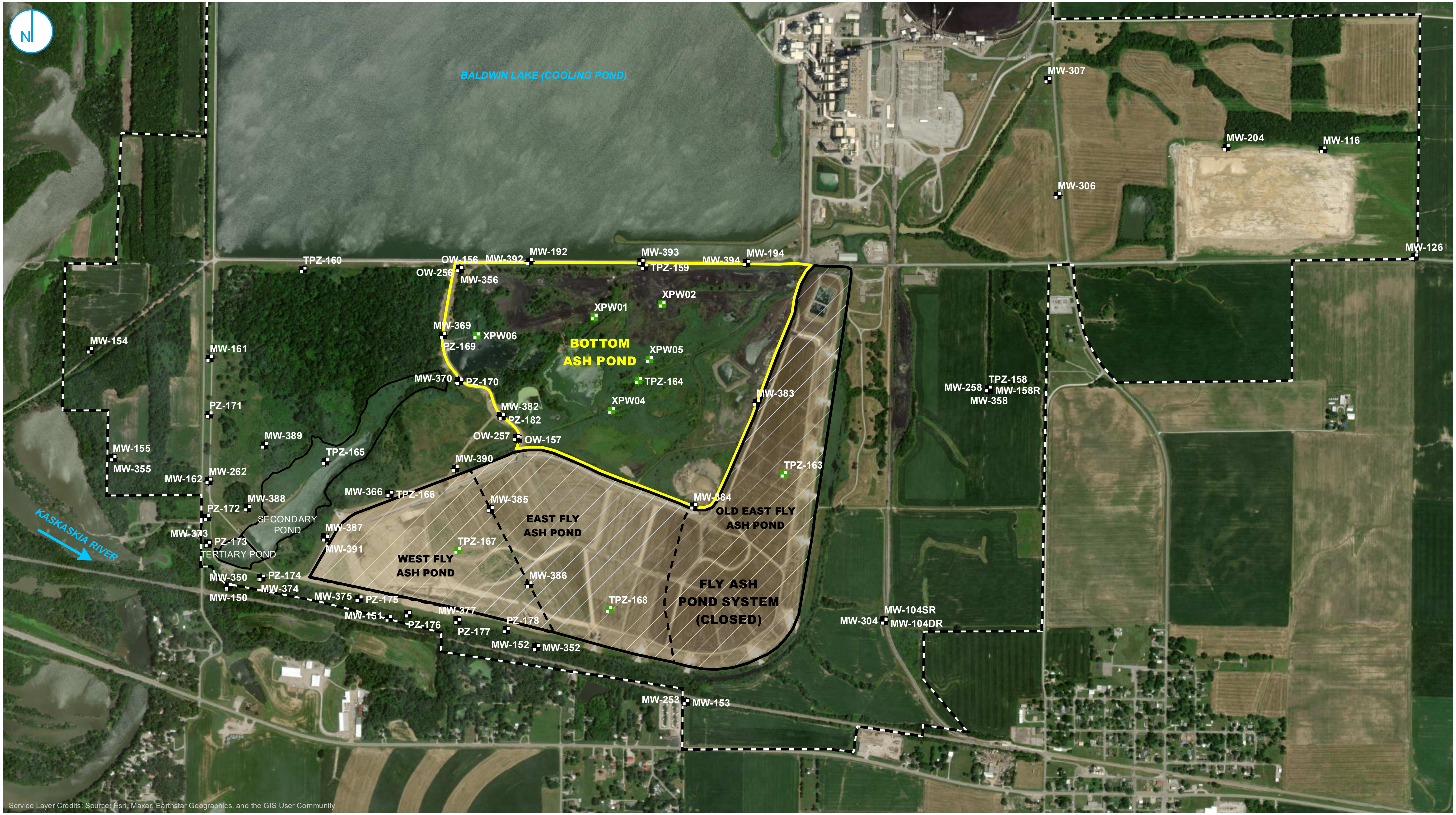

PROJECT: 169000XXXX | DATED: 1/6/2023 | DESIGNER: galarnmc

Y:\Mapping\Projects\22\2285\MXD\845_Operating_Permit\Baldwin\BAP\Groundwater_Modeling_Report\Figure 2-1_Monitoring Well Location Map.mxd

PART 845 REGULATED UNIT (SUBJECT UNIT)
LIMITS OF FINAL COVER
SITE FEATURE
FLY ASH POND SYSTEM (CLOSED)
PROPERTY BOUNDARY

MONITORING WELL
PORE WATER WELL

0 500 1,000 Feet

DRAFT

MONITORING WELL LOCATION MAP

GROUNDWATER MODELING REPORT
BOTTOM ASH POND
BALDWIN POWER PLANT
BALDWIN, ILLINOIS

FIGURE 2-1

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

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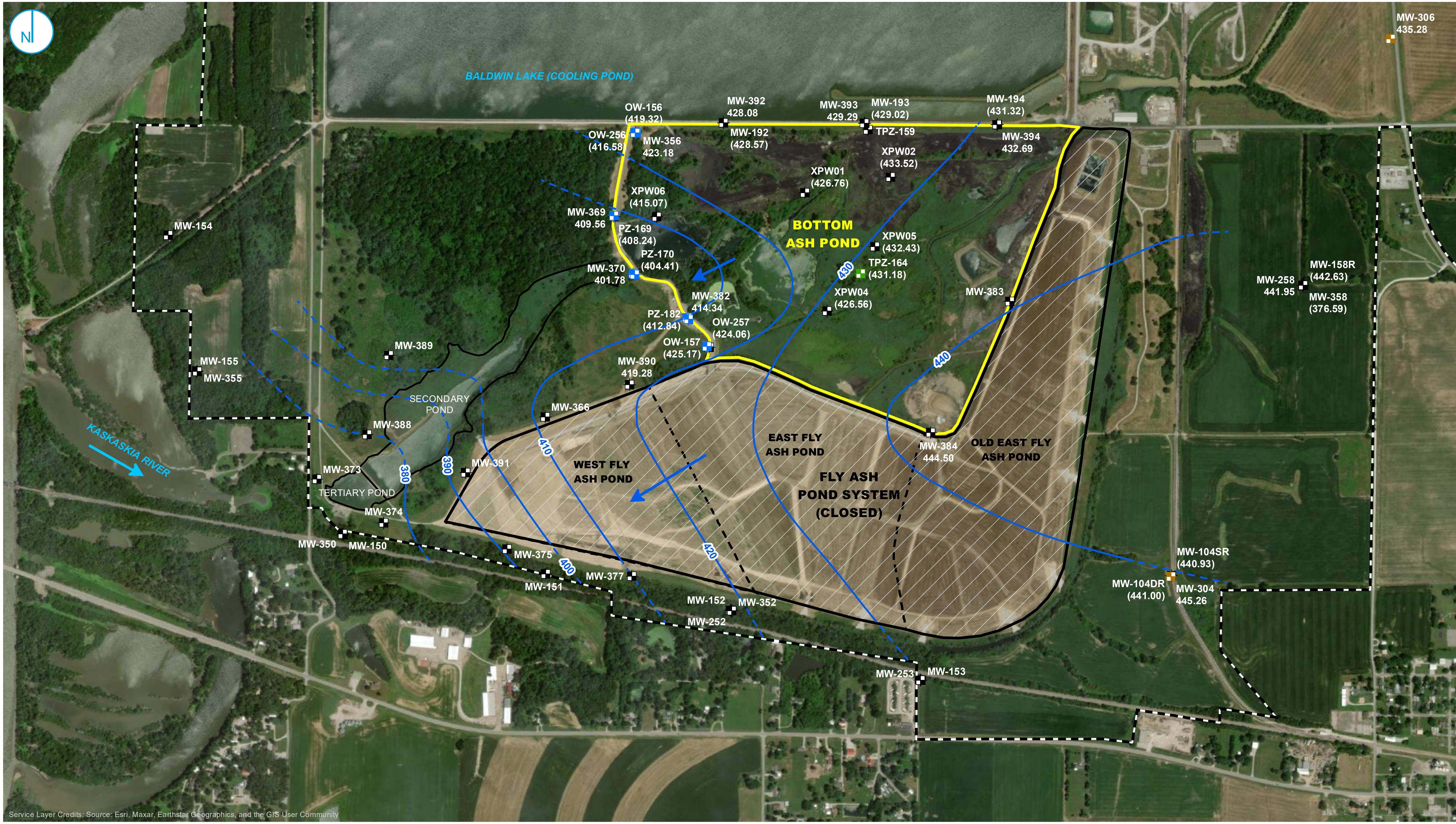

BACKGROUND WELL
COMPLIANCE WELL
PORE WATER WELL
MONITORING WELL

GROUNDWATER ELEVATION CONTOUR (10-FT CONTOUR INTERVAL, NAVD88)
INFERRED GROUNDWATER ELEVATION CONTOUR
GROUNDWATER FLOW DIRECTION

PART 845 REGULATED UNIT (SUBJECT UNIT)
FLY ASH POND SYSTEM (CLOSED)
SITE FEATURE
CAPPED AREA
PROPERTY BOUNDARY

0 400 800 Feet

NOTES:
1. ELEVATIONS IN PARENTHESES WERE NOT USED FOR CONTOURING.
2. ELEVATION CONTOURS SHOWN IN FEET, NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88).

BEDROCK POTENTIOMETRIC SURFACE MAP
NOVEMBER 14, 2022

GROUNDWATER MODELING REPORT
BOTTOM ASH POND
BALDWIN POWER PLANT
BALDWIN, ILLINOIS

FIGURE 2-2

RAMBOLL AMERICAS ENGINEERING SOLUTIONS, INC.

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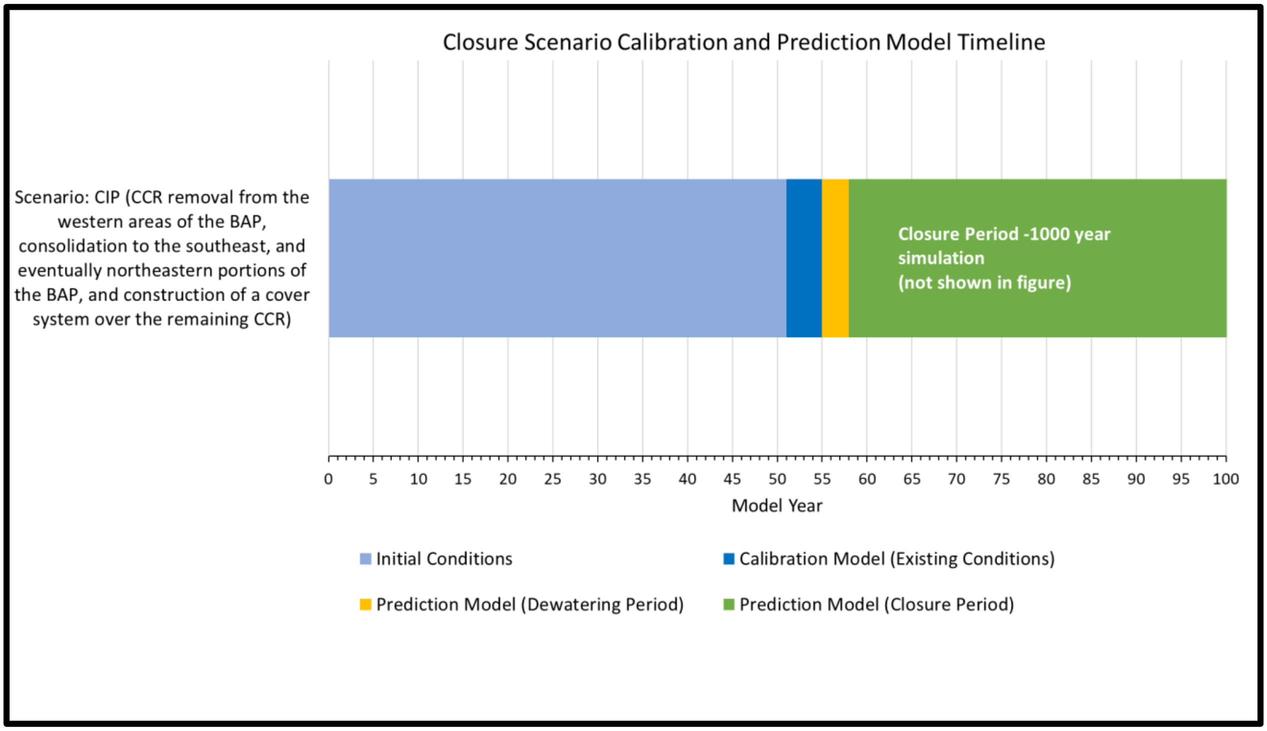
Y:\Mapping\Projects\22\2285\MXD\845_Operating_Permit\Baldwin\BAP\Groundwater_Modeling_Report\Figure 2-2_Pot Surface 20221114.mxd
PROJECT: 169000XXXX | DATED: 1/6/2023 | DESIGNER: galammc



CLOSURE SCENARIO CALIBRATION AND PREDICTION MODEL TIMELINE

GROUNDWATER MODELING REPORT
BOTTOM ASH POND
BALDWIN POWER PLANT
BALDWIN, ILLINOIS

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PROJECT: 169000XXXX | DATED: 1/6/2023 | DESIGNER: galarnmc Y:\Mapping\Projects\22\2285\MXD\845_Operating_Permit\Baldwin\BAP\Groundwater_Modeling_Report\Figure 5-1_Model Area Map.mxd

PART 845 REGULATED UNIT (SUBJECT UNIT)
FLY ASH POND SYSTEM (CLOSED)
LIMITS OF FINAL COVER
SITE FEATURE
MODEL DOMAIN
NO FLOW AREA
RIVER
WATERBODY

0 1,250 2,500
Feet

DRAFT

MODEL AREA MAP

FIGURE 4-1

GROUNDWATER MODELING REPORT
BOTTOM ASH POND
BALDWIN POWER PLANT
BALDWIN, ILLINOIS

RAMBOLL AMERICAS
ENGINEERING SOLUTIONS, INC.

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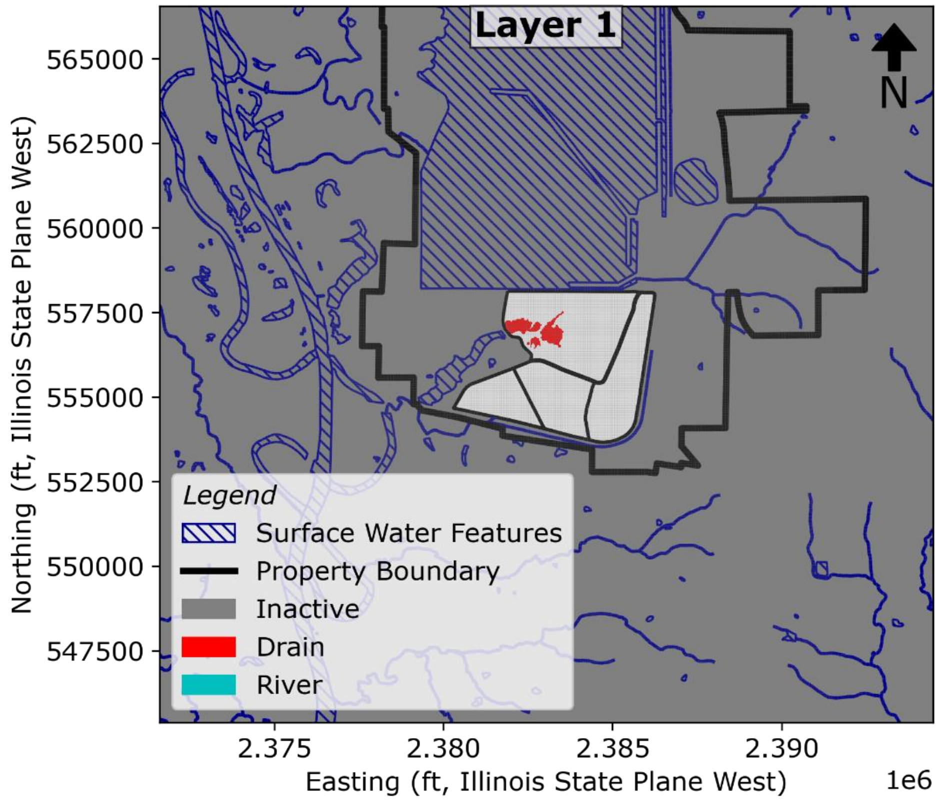
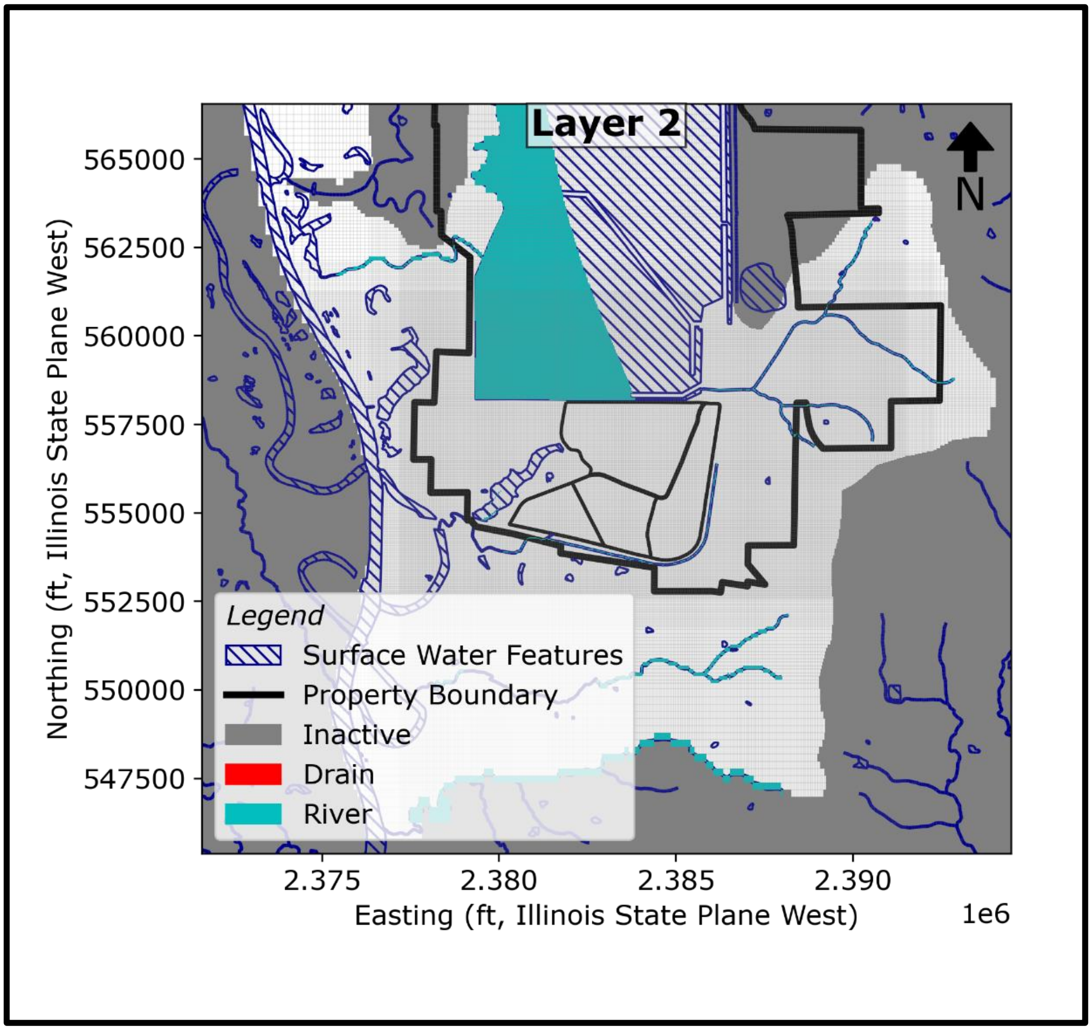


BOUNDARY CONDITIONS FOR LAYER 1 OF THE CALIBRATED NUMERICAL MODEL

GROUNDWATER MODELING REPORT
BOTTOM ASH POND
BALDWIN POWER PLANT
BALDWIN, ILLINOIS



BOUNDARY CONDITIONS FOR LAYER 2 OF THE CALIBRATED NUMERICAL MODEL

GROUNDWATER MODELING REPORT
BOTTOM ASH POND
BALDWIN POWER PLANT
BALDWIN, ILLINOIS

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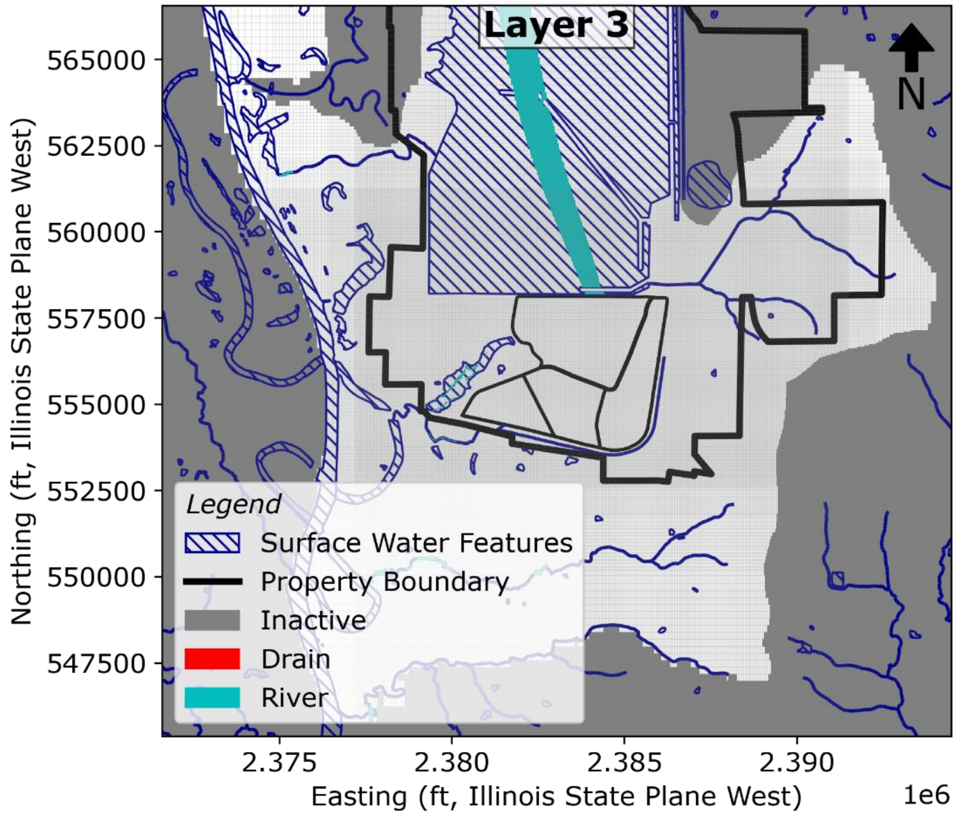
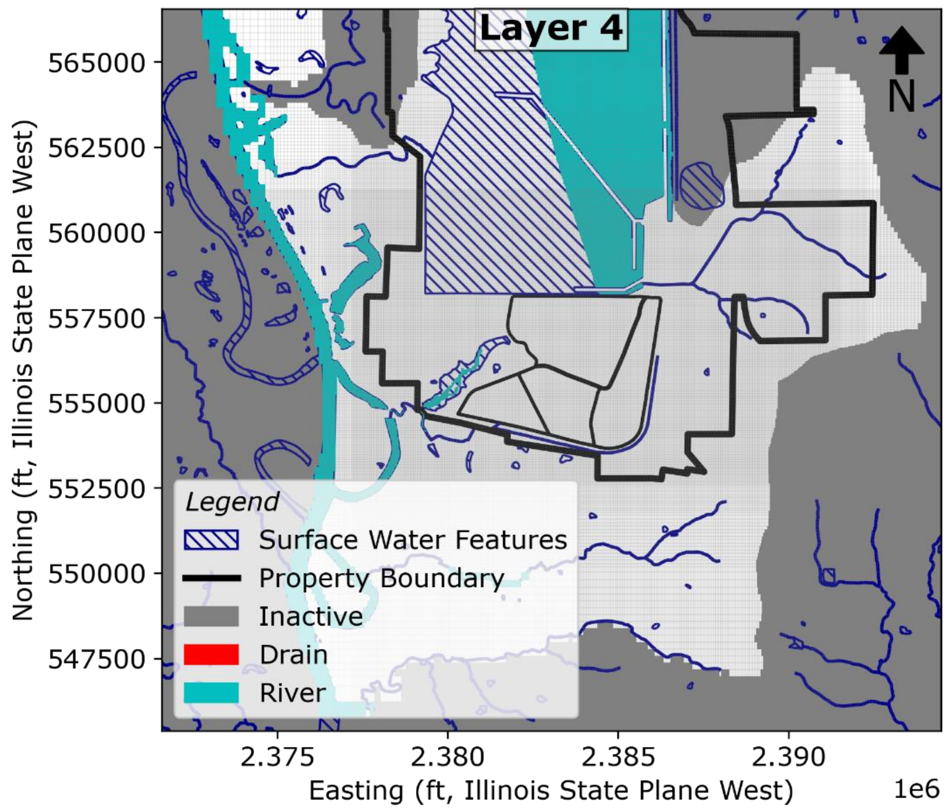


BOUNDARY CONDITIONS FOR LAYER 3 OF THE CALIBRATED NUMERICAL MODEL

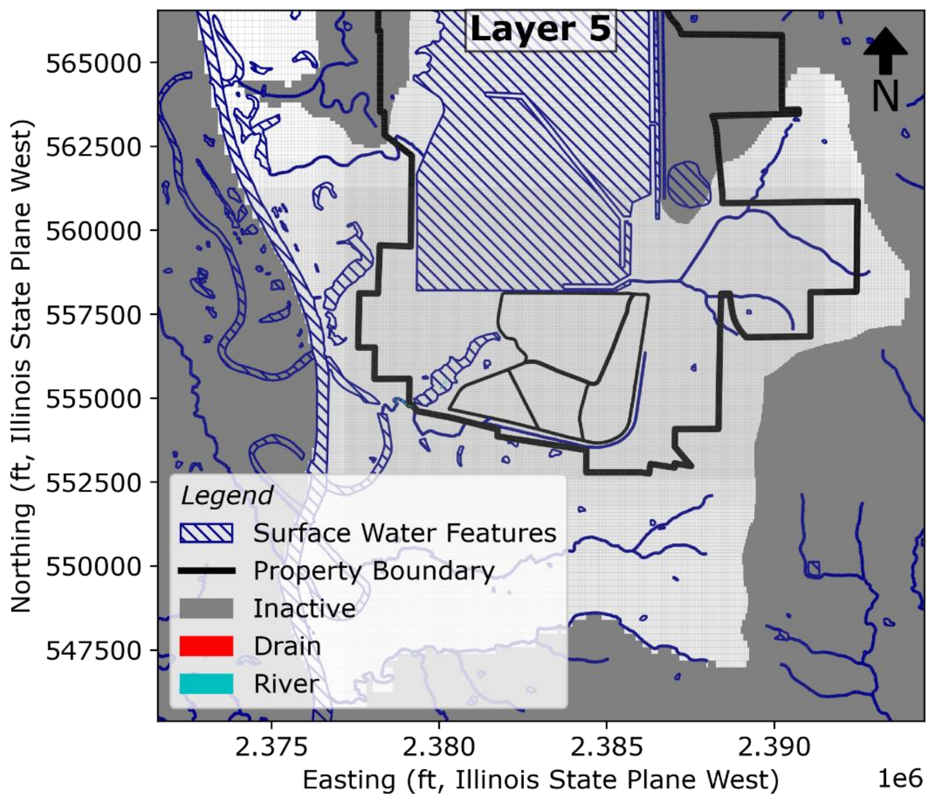
GROUNDWATER MODELING REPORT
BOTTOM ASH POND
BALDWIN POWER PLANT
BALDWIN, ILLINOIS

RAMBOLL



BOUNDARY CONDITIONS FOR LAYER 4 OF THE CALIBRATED NUMERICAL MODEL

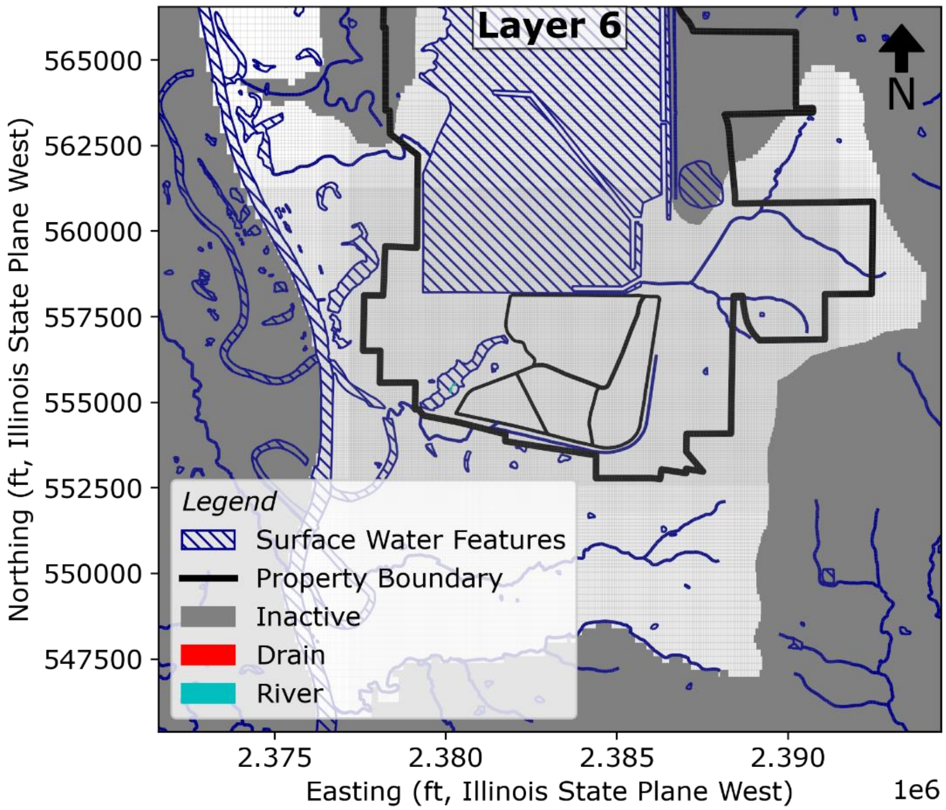
GROUNDWATER MODELING REPORT
BOTTOM ASH POND
BALDWIN POWER PLANT
BALDWIN, ILLINOIS



BOUNDARY CONDITIONS FOR LAYER 5 OF THE CALIBRATED NUMERICAL MODEL

GROUNDWATER MODELING REPORT
BOTTOM ASH POND
BALDWIN POWER PLANT
BALDWIN, ILLINOIS

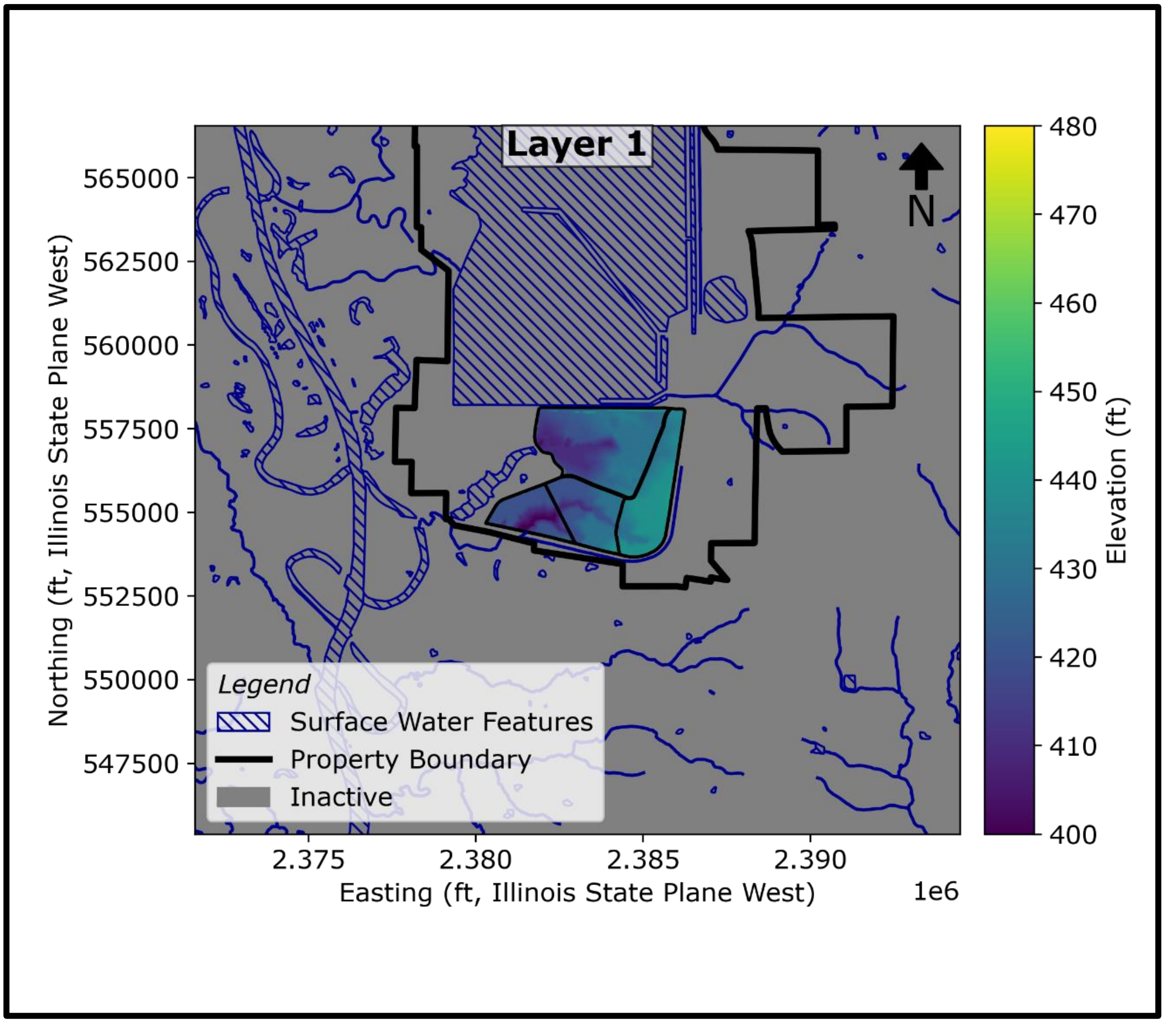
RAMBOLL



BOUNDARY CONDITIONS FOR LAYER 6 OF THE CALIBRATED NUMERICAL MODEL

GROUNDWATER MODELING REPORT
BOTTOM ASH POND
BALDWIN POWER PLANT
BALDWIN, ILLINOIS

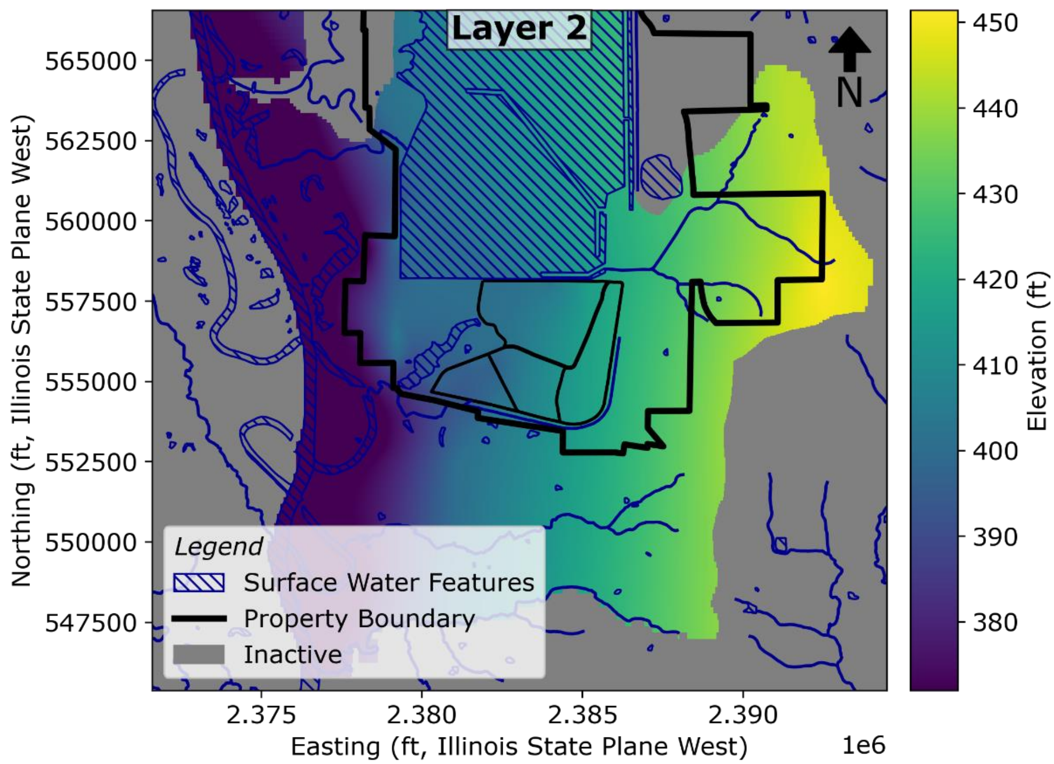
RAMBOLL



BOTTOM ELEVATION OF
MODEL LAYER 1

GROUNDWATER MODELING REPORT
BOTTOM ASH POND
BALDWIN POWER PLANT
BALDWIN, ILLINOIS

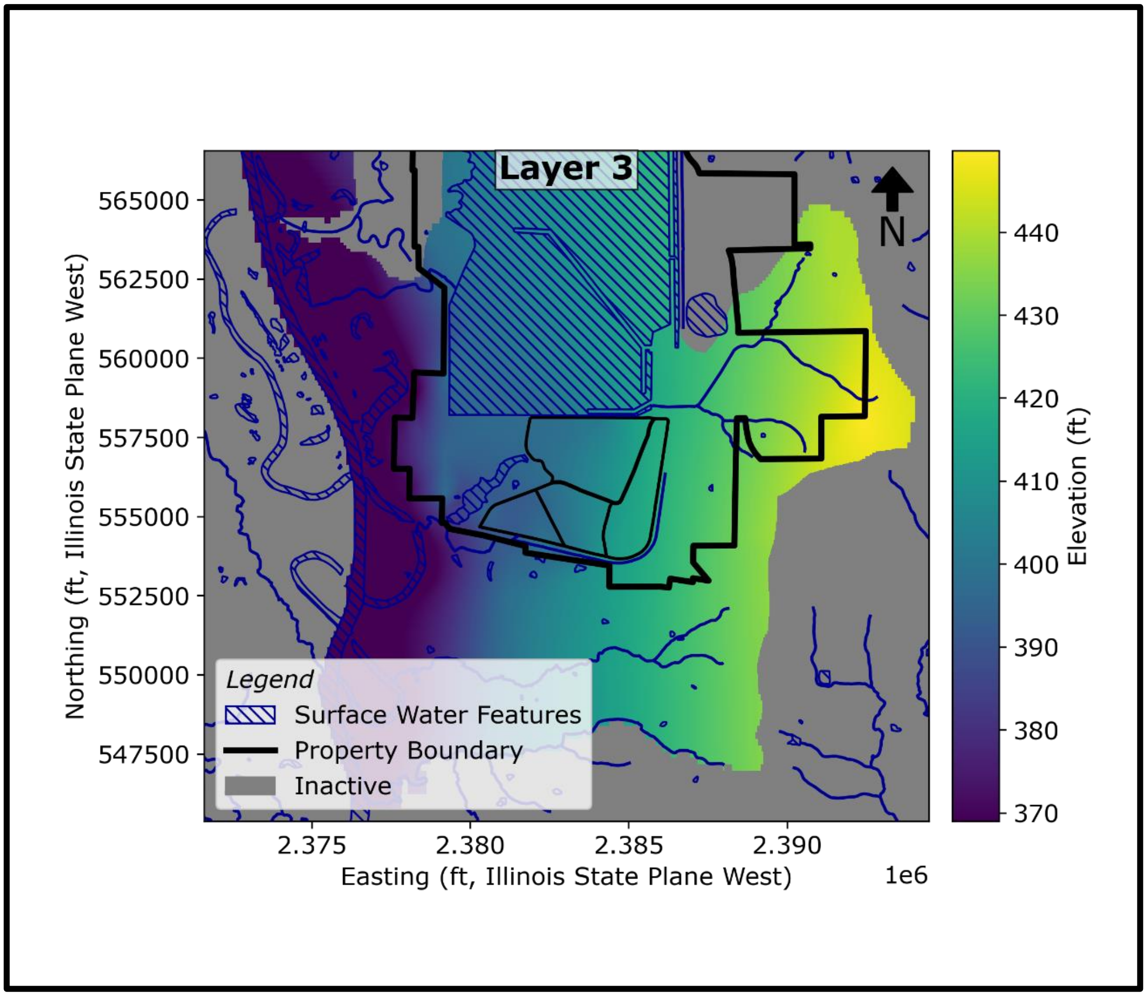
RAMBOLL



BOTTOM ELEVATION OF
MODEL LAYER 2

GROUNDWATER MODELING REPORT
BOTTOM ASH POND
BALDWIN POWER PLANT
BALDWIN, ILLINOIS

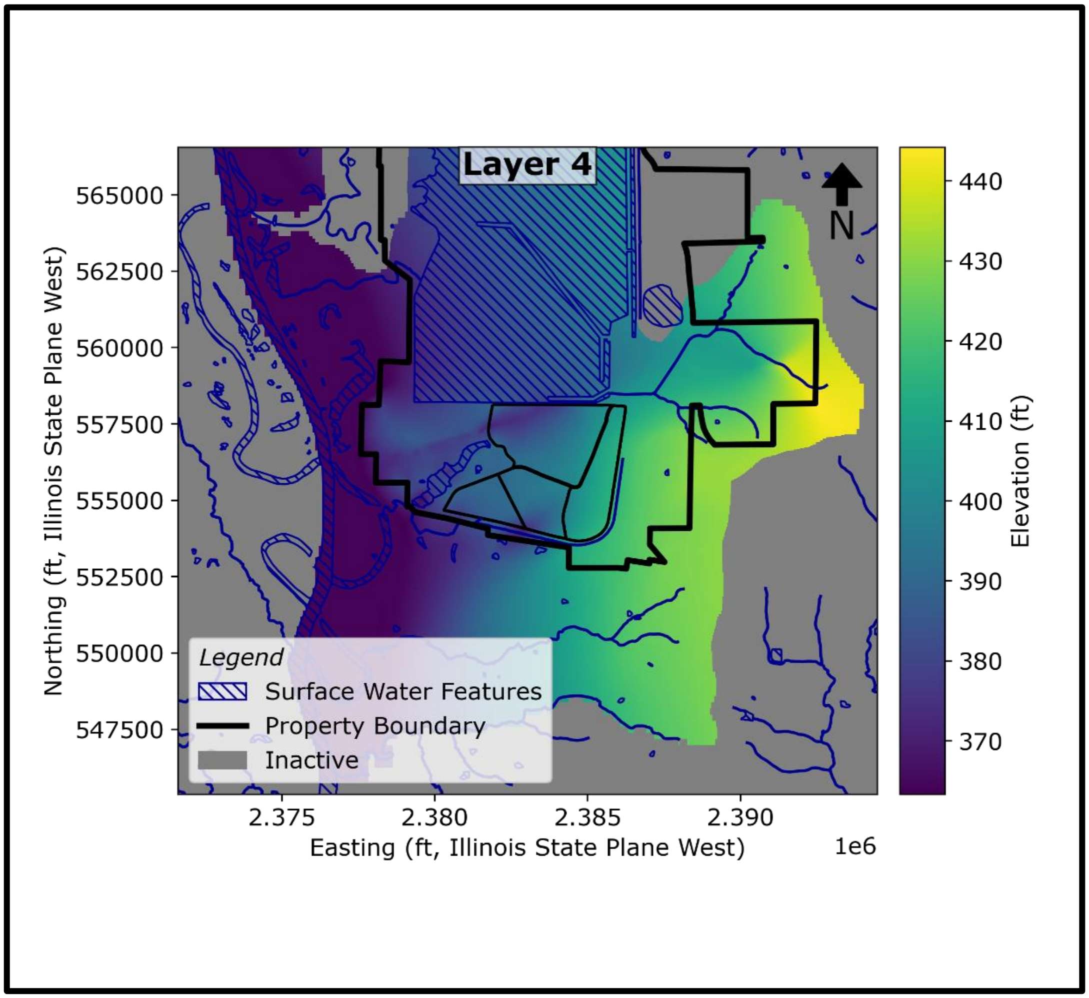
RAMBOLL



BOTTOM ELEVATION OF
MODEL LAYER 3

GROUNDWATER MODELING REPORT
BOTTOM ASH POND
BALDWIN POWER PLANT
BALDWIN, ILLINOIS

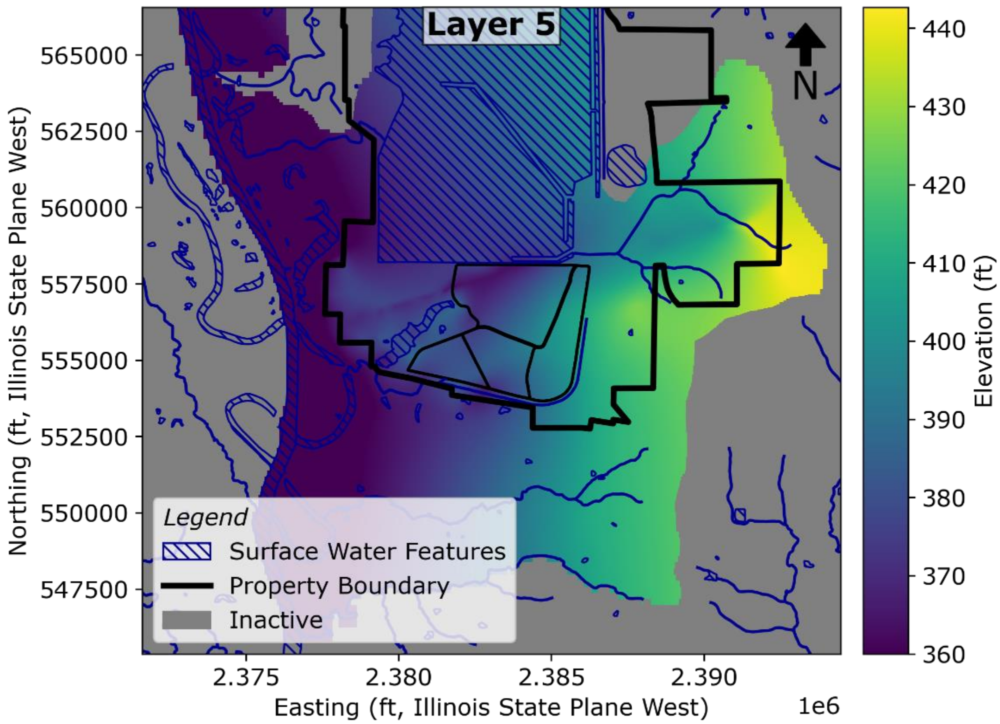
RAMBOLL



BOTTOM ELEVATION OF
MODEL LAYER 4

GROUNDWATER MODELING REPORT
BOTTOM ASH POND
BALDWIN POWER PLANT
BALDWIN, ILLINOIS

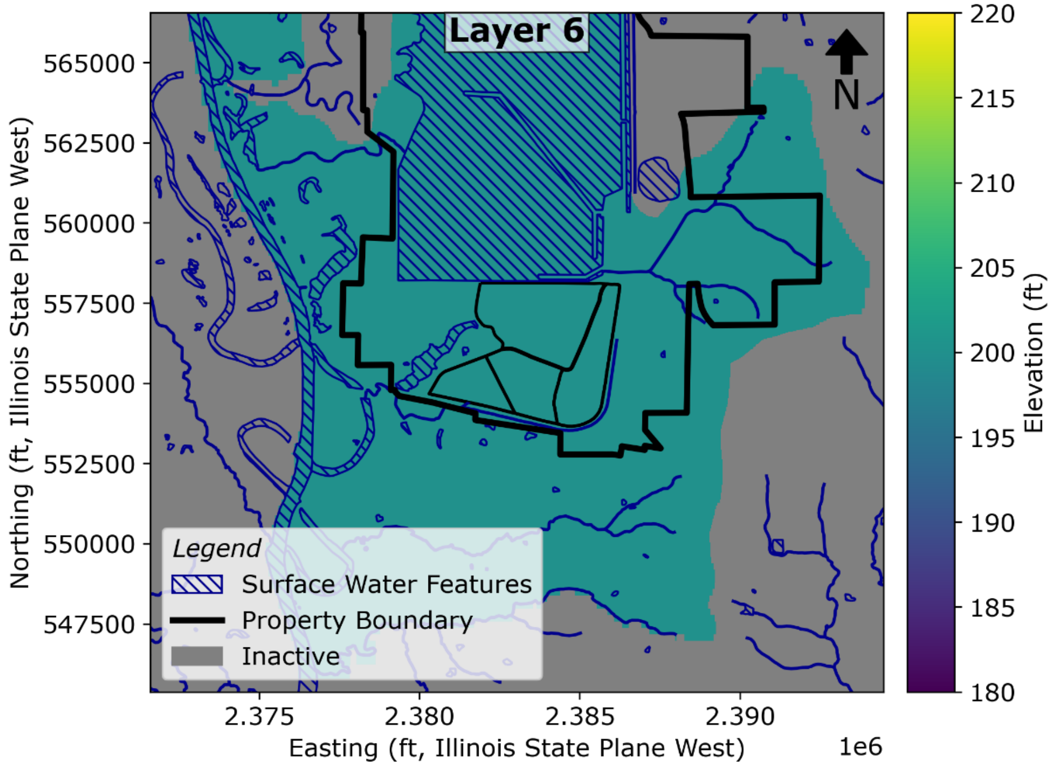
RAMBOLL



BOTTOM ELEVATION OF
MODEL LAYER 5

GROUNDWATER MODELING REPORT
BOTTOM ASH POND
BALDWIN POWER PLANT
BALDWIN, ILLINOIS

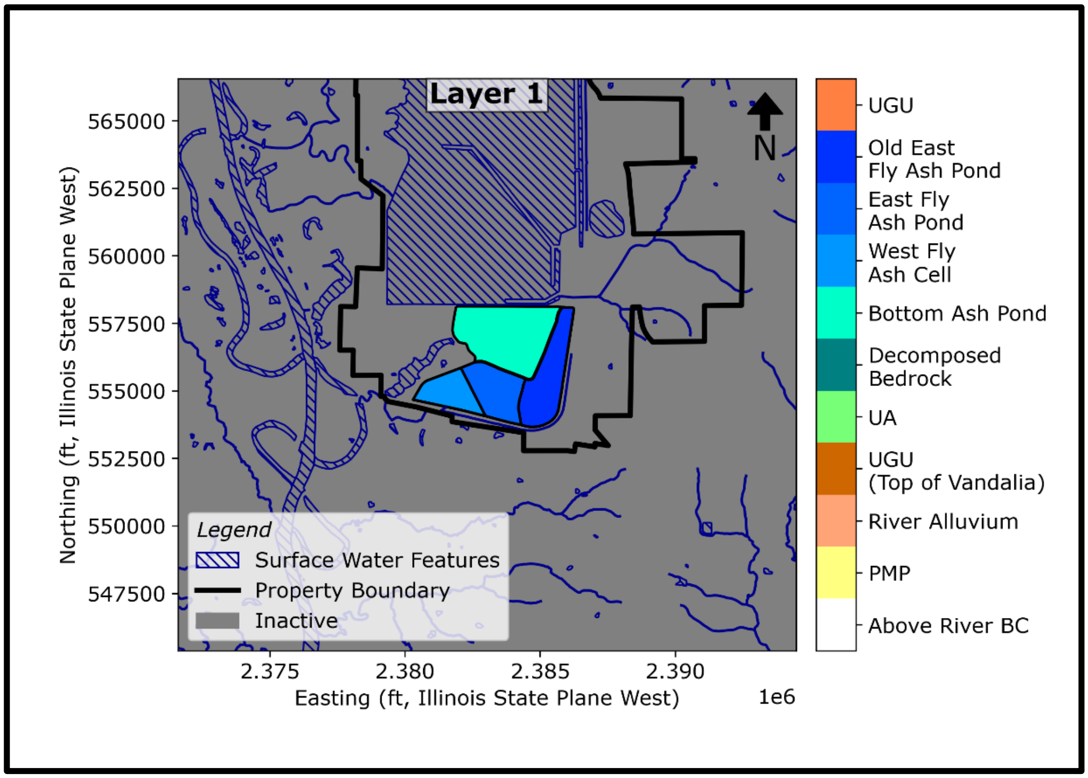
RAMBOLL



BOTTOM ELEVATION OF
MODEL LAYER 6

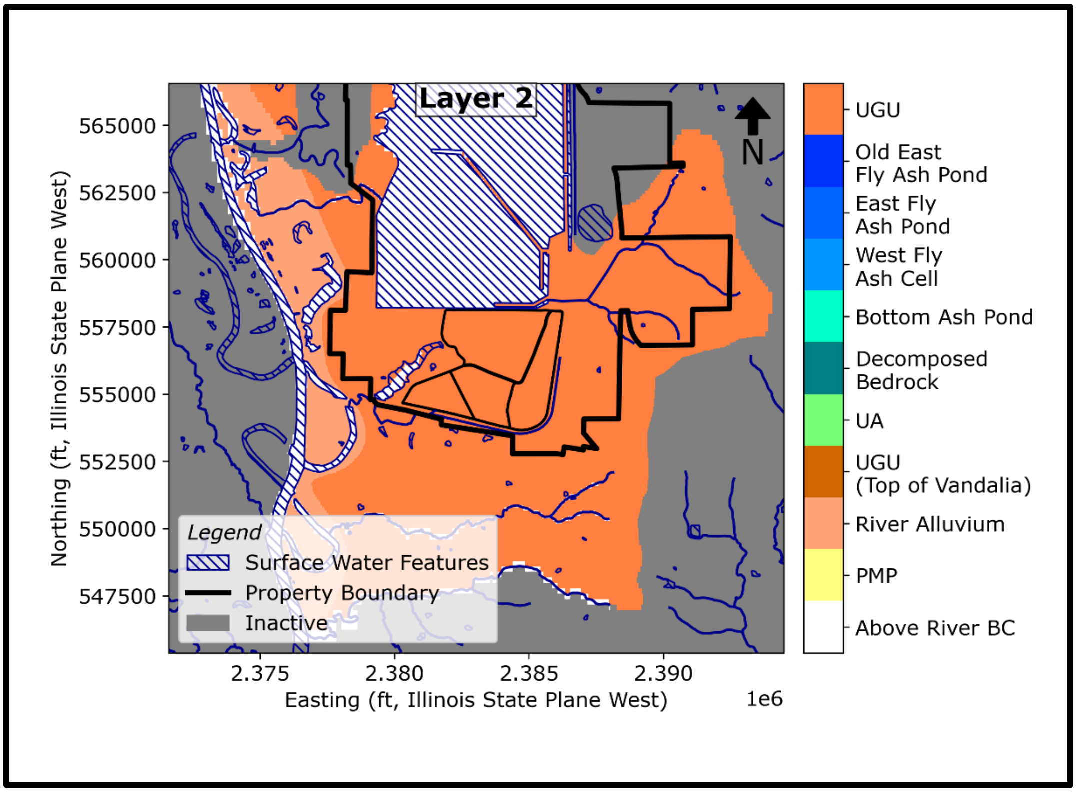
GROUNDWATER MODELING REPORT
BOTTOM ASH POND
BALDWIN POWER PLANT
BALDWIN, ILLINOIS

RAMBOLL



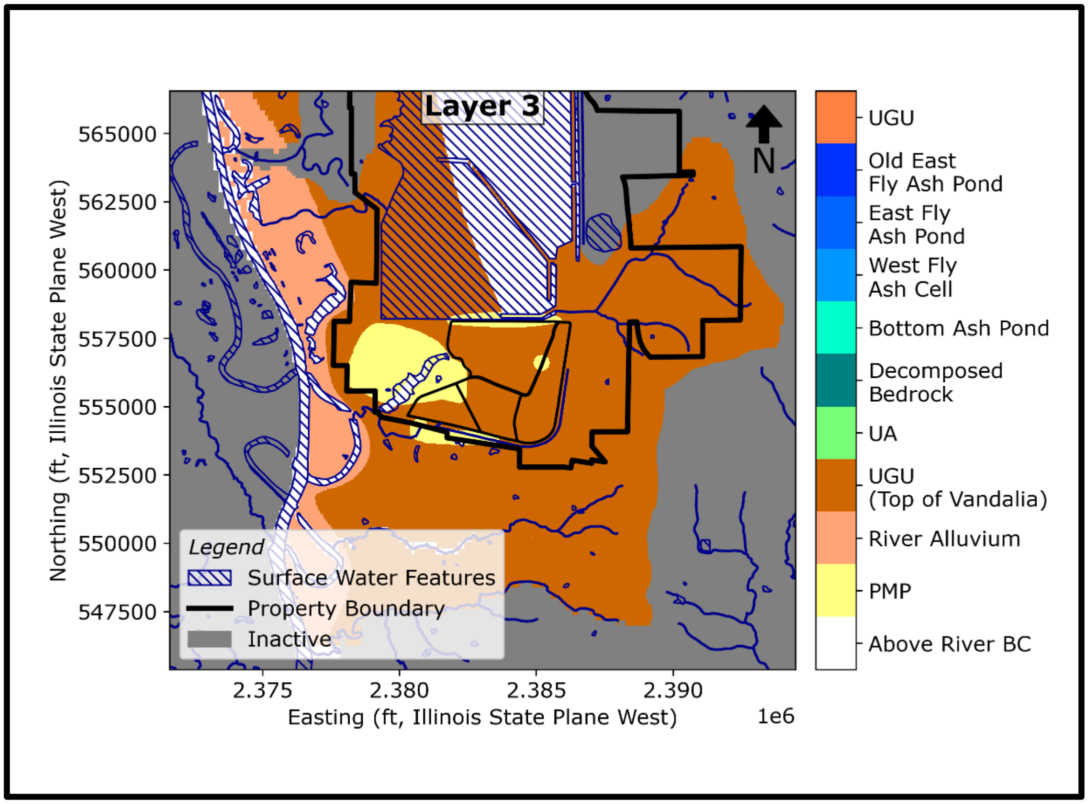
SPATIAL DISTRIBUTION OF HYDRAULIC CONDUCTIVITY ZONES FOR LAYER 1 IN THE NUMERICAL MODEL

GROUNDWATER MODELING REPORT
BOTTOM ASH POND
BALDWIN POWER PLANT
BALDWIN, ILLINOIS



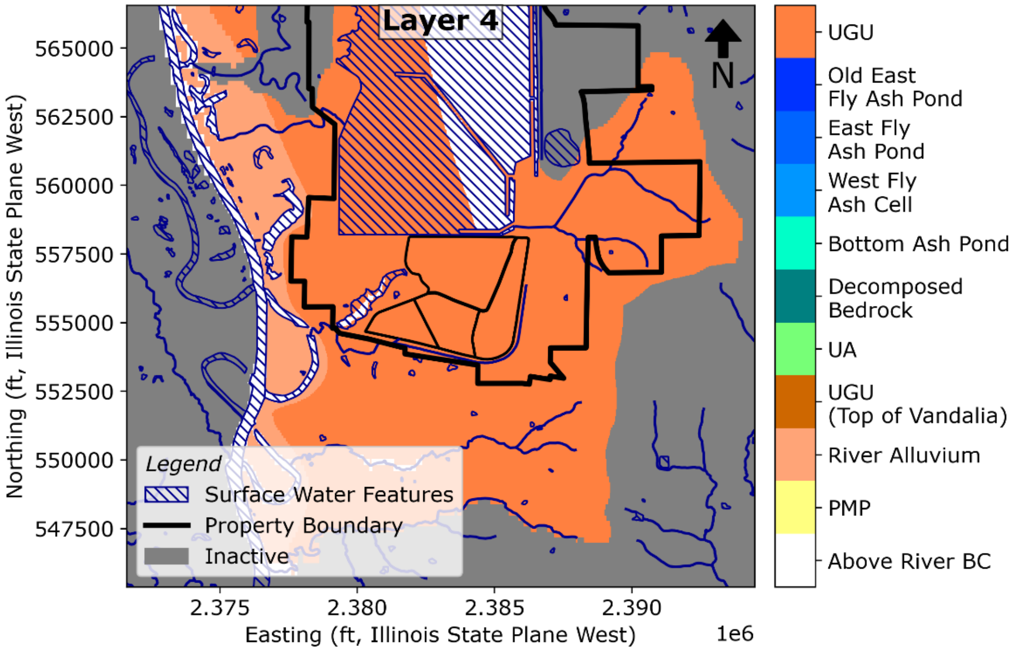
SPATIAL DISTRIBUTION OF HYDRAULIC CONDUCTIVITY ZONES FOR LAYER 2 IN THE NUMERICAL MODEL

GROUNDWATER MODELING REPORT
BOTTOM ASH POND
BALDWIN POWER PLANT
BALDWIN, ILLINOIS



SPATIAL DISTRIBUTION OF HYDRAULIC CONDUCTIVITY ZONES FOR LAYER 3 IN THE NUMERICAL MODEL

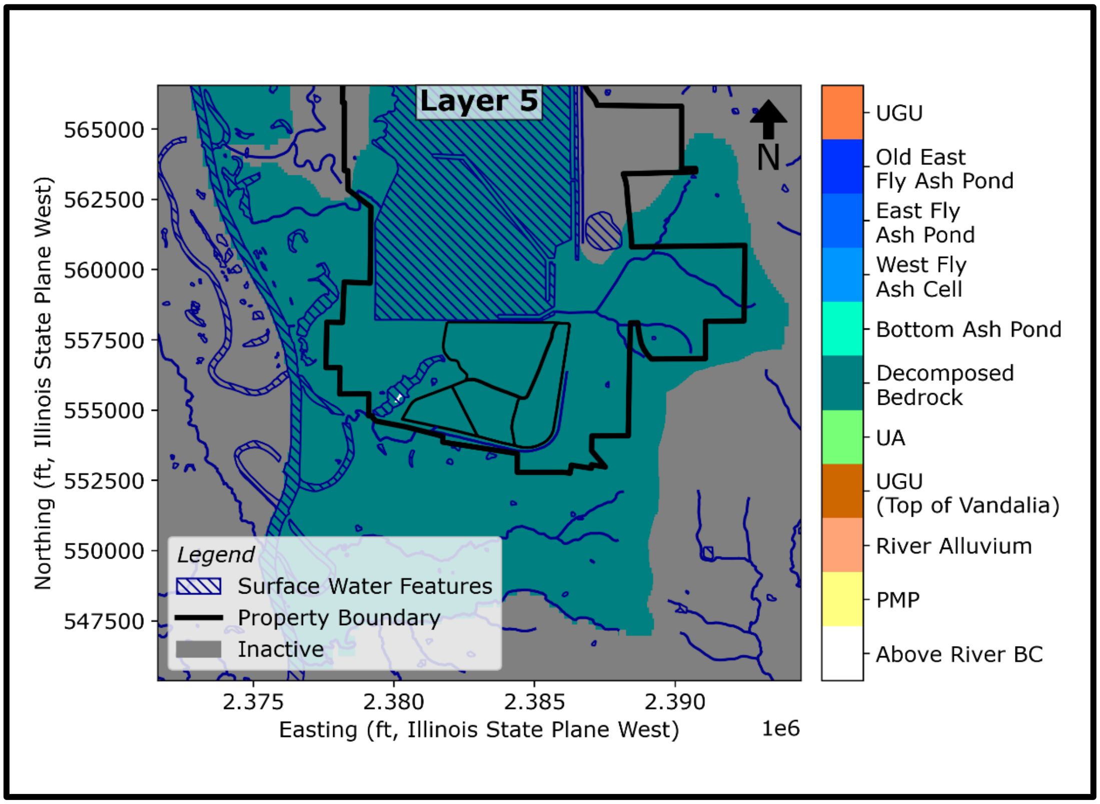
GROUNDWATER MODELING REPORT
BOTTOM ASH POND
BALDWIN POWER PLANT
BALDWIN, ILLINOIS



SPATIAL DISTRIBUTION OF HYDRAULIC CONDUCTIVITY ZONES FOR LAYER 4 IN THE NUMERICAL MODEL

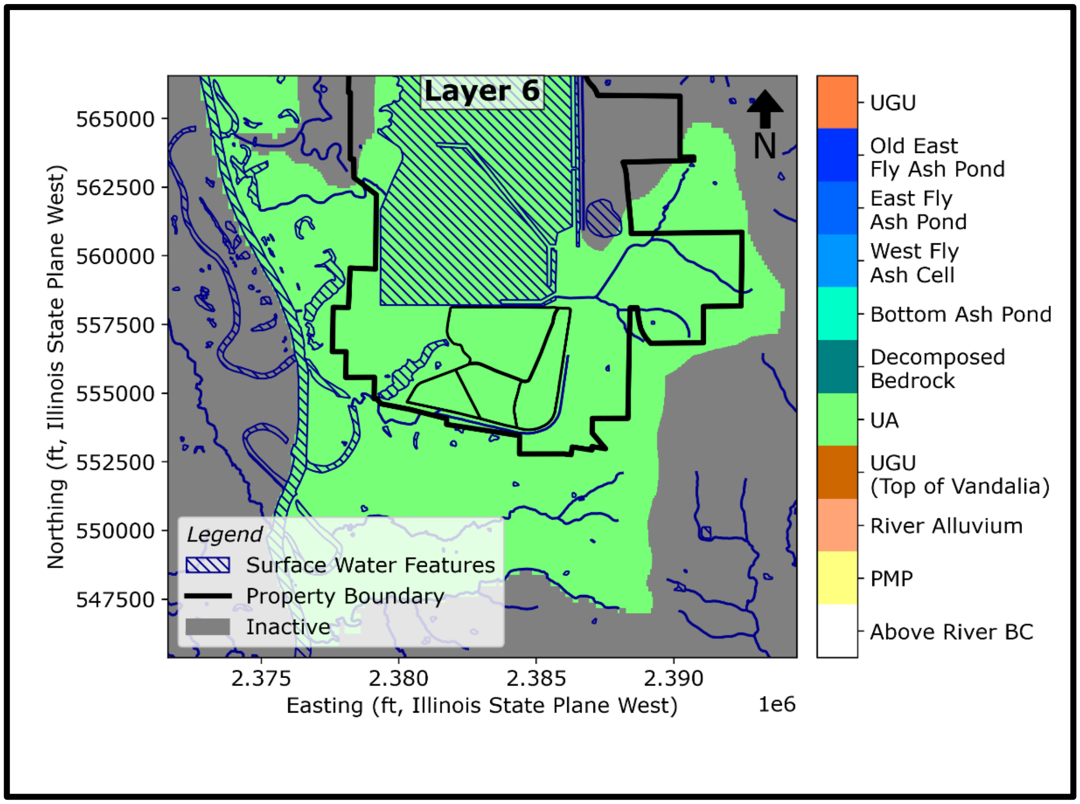
GROUNDWATER MODELING REPORT
BOTTOM ASH POND
BALDWIN POWER PLANT
BALDWIN, ILLINOIS

RAMBOLL



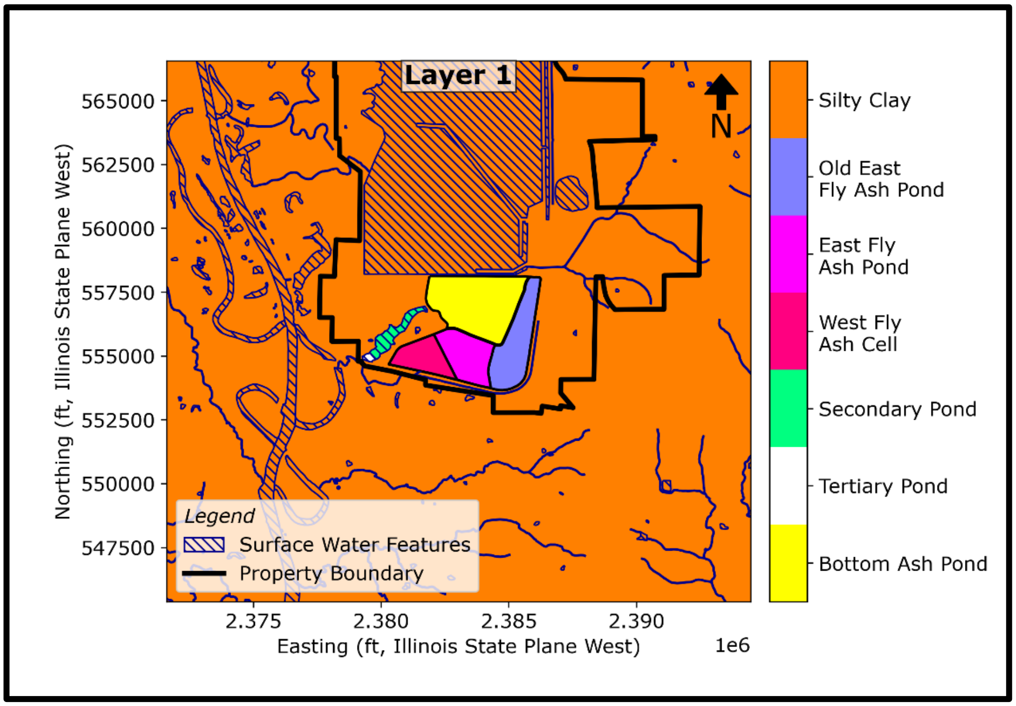
SPATIAL DISTRIBUTION OF HYDROSTRATIGRAPHIC LAYERS FOR LAYER 5 IN THE NUMERICAL MODEL

GROUNDWATER MODELING REPORT
BOTTOM ASH POND
BALDWIN POWER PLANT
BALDWIN, ILLINOIS



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

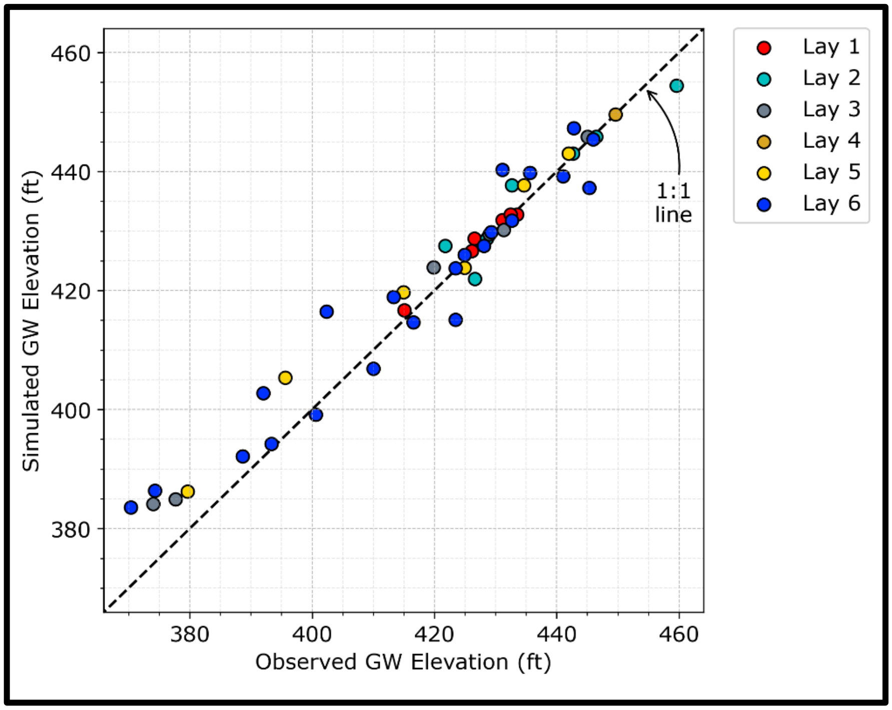
GROUNDWATER MODELING REPORT
BOTTOM ASH POND
BALDWIN POWER PLANT
BALDWIN, ILLINOIS



MODEL RECHARGE DISTRIBUTION (STEADY STATE CALIBRATION MODEL)

GROUNDWATER MODELING REPORT
BOTTOM ASH POND
BALDWIN POWER PLANT
BALDWIN, ILLINOIS

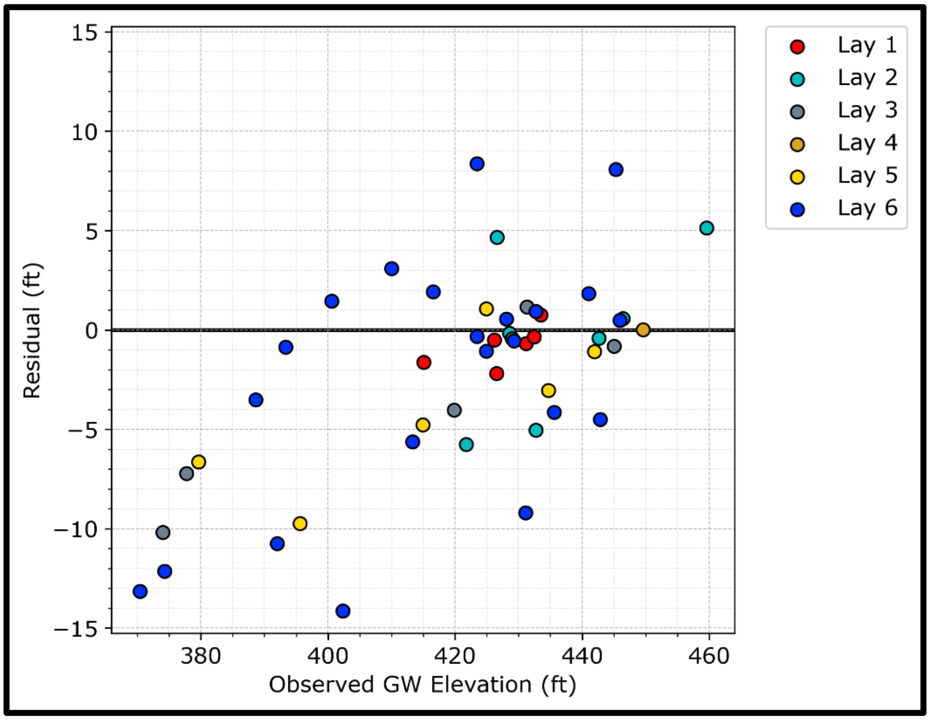
RAMBOLL



OBSERVED VERSUS SIMULATED STEADY STATE GROUNDWATER LEVELS FROM THE CALIBRATION MODEL

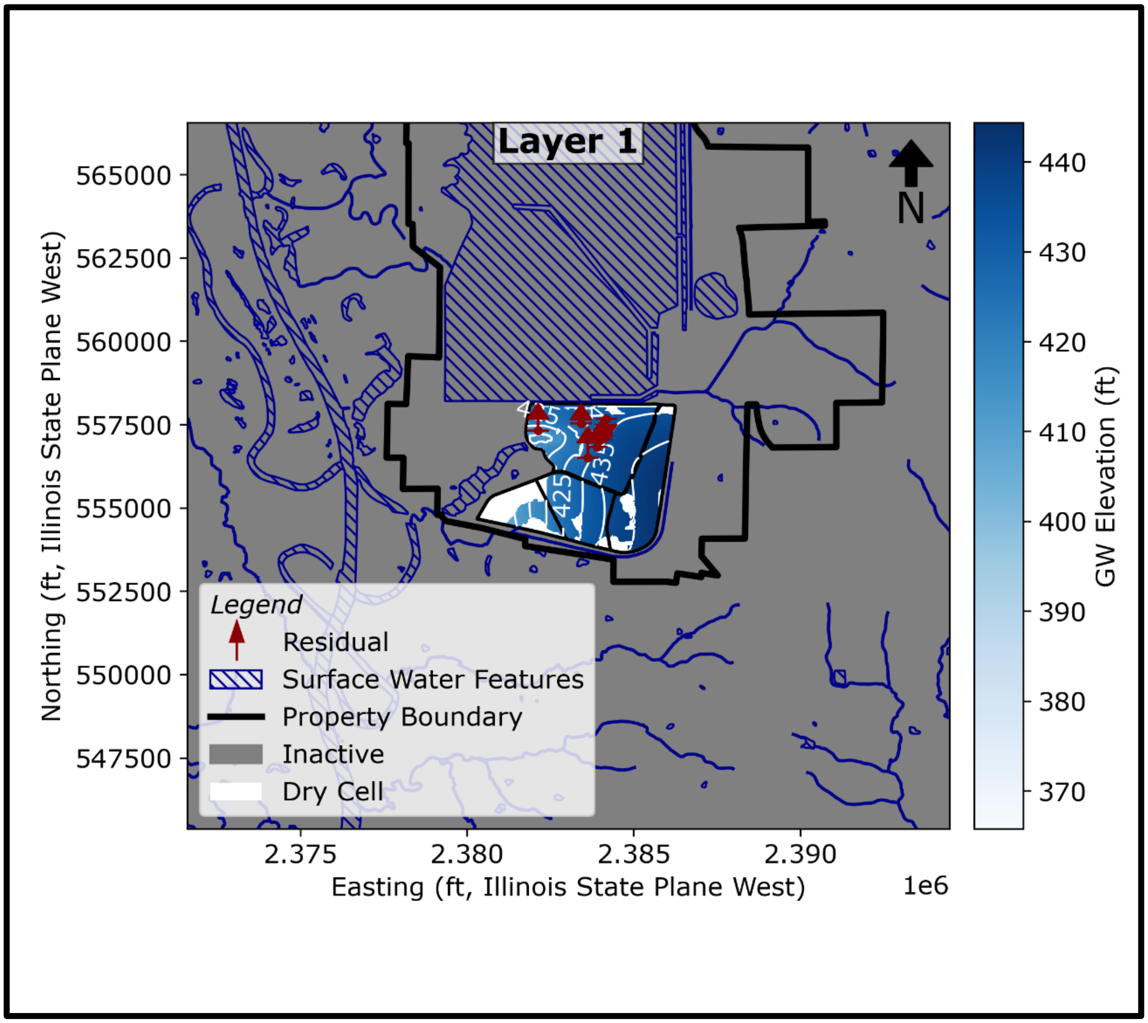
GROUNDWATER MODELING REPORT
BOTTOM ASH POND
BALDWIN POWER PLANT
BALDWIN, ILLINOIS

RAMBOLL



SIMULATED GROUNDWATER LEVEL RESIDUALS FROM THE CALIBRATED MODEL

GROUNDWATER MODELING REPORT
BOTTOM ASH POND
BALDWIN POWER PLANT
BALDWIN, ILLINOIS

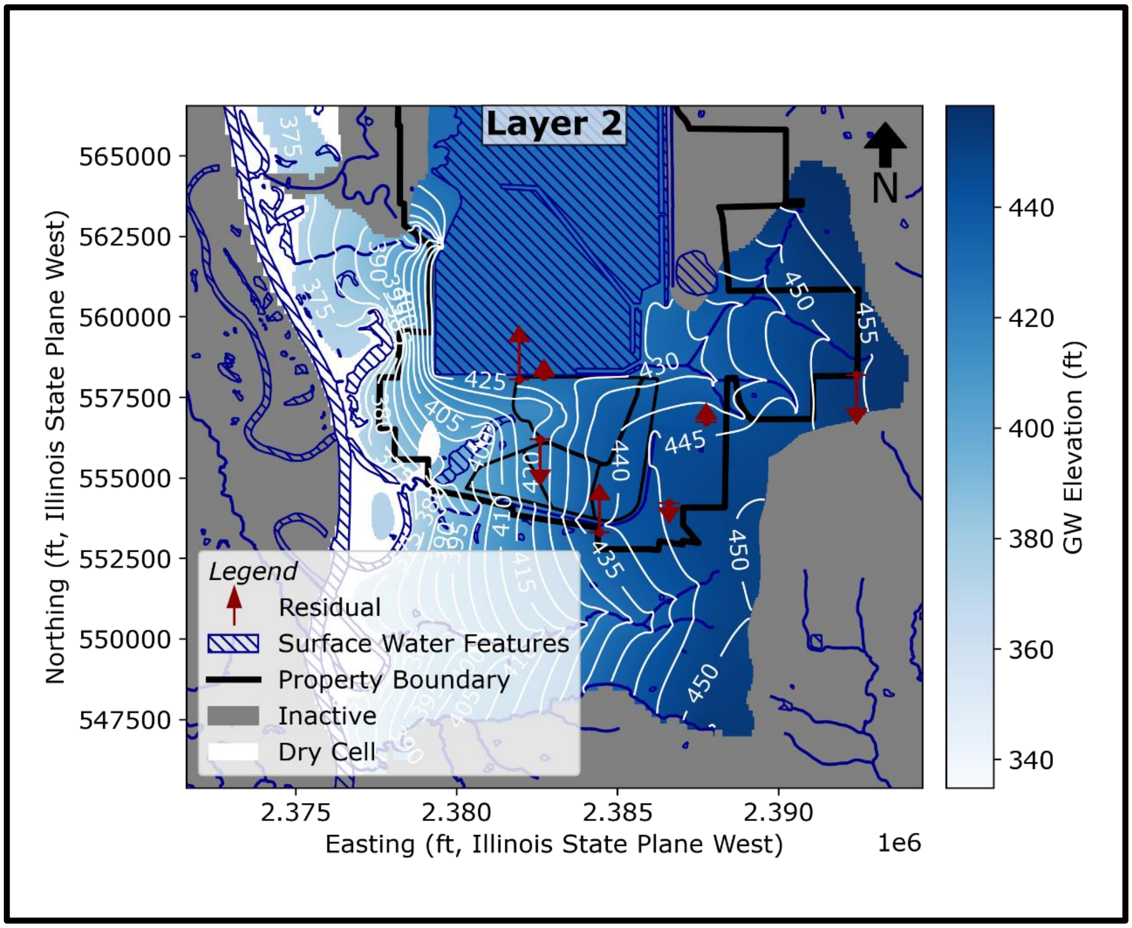


NOTE: RED DOTS INDICATE WELLS AND ARROW DIRECTION INDICATES BIAS IN SIMULATED GROUNDWATER LEVEL (NORTH ARROW = OVERESTIMATION, SOUTH ARROW = UNDERESTIMATION)

SIMULATED STEADY STATE GROUNDWATER LEVEL CONTOURS FROM LAYER 1 OF THE CALIBRATED MODEL

GROUNDWATER MODELING REPORT
BOTTOM ASH POND
BALDWIN POWER PLANT
BALDWIN, ILLINOIS

RAMBOLL

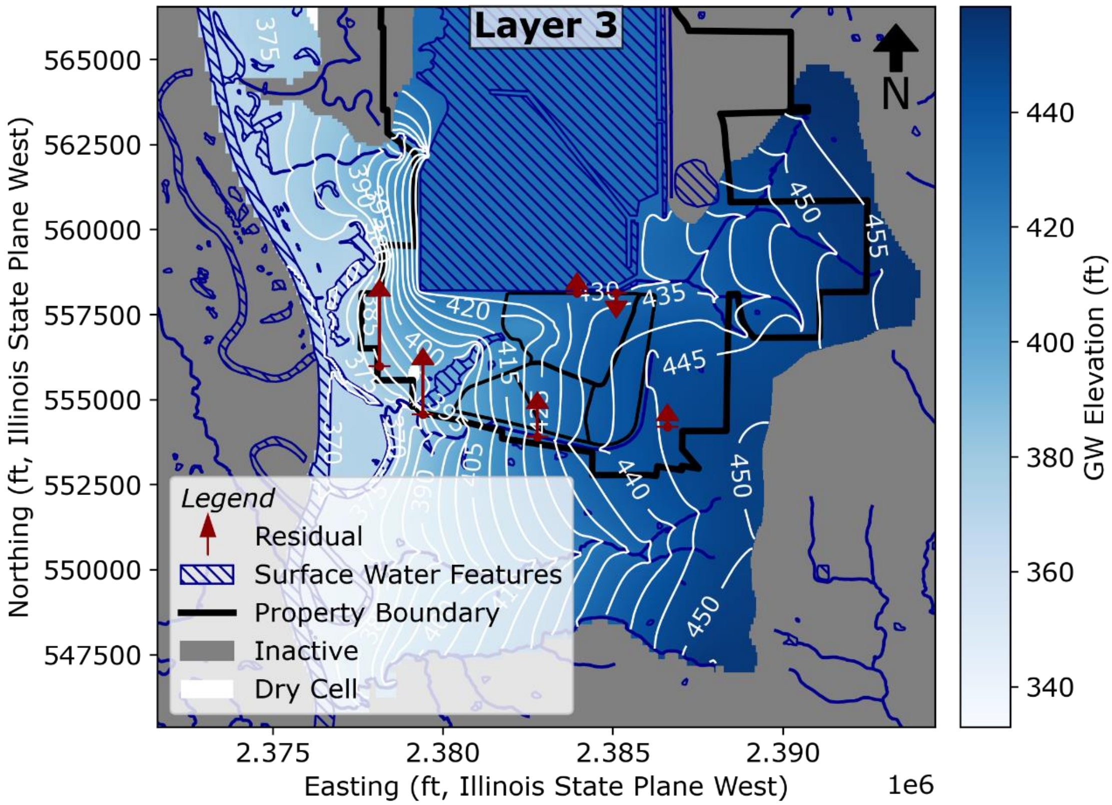


NOTE: RED DOTS INDICATE WELLS AND ARROW DIRECTION INDICATES BIAS IN SIMULATED GROUNDWATER LEVEL (NORTH ARROW = OVERESTIMATION, SOUTH ARROW = UNDERESTIMATION)

SIMULATED STEADY STATE GROUNDWATER LEVEL CONTOURS FROM LAYER 2 OF THE CALIBRATED MODEL

GROUNDWATER MODELING REPORT
BOTTOM ASH POND
BALDWIN POWER PLANT
BALDWIN, ILLINOIS

RAMBOLL

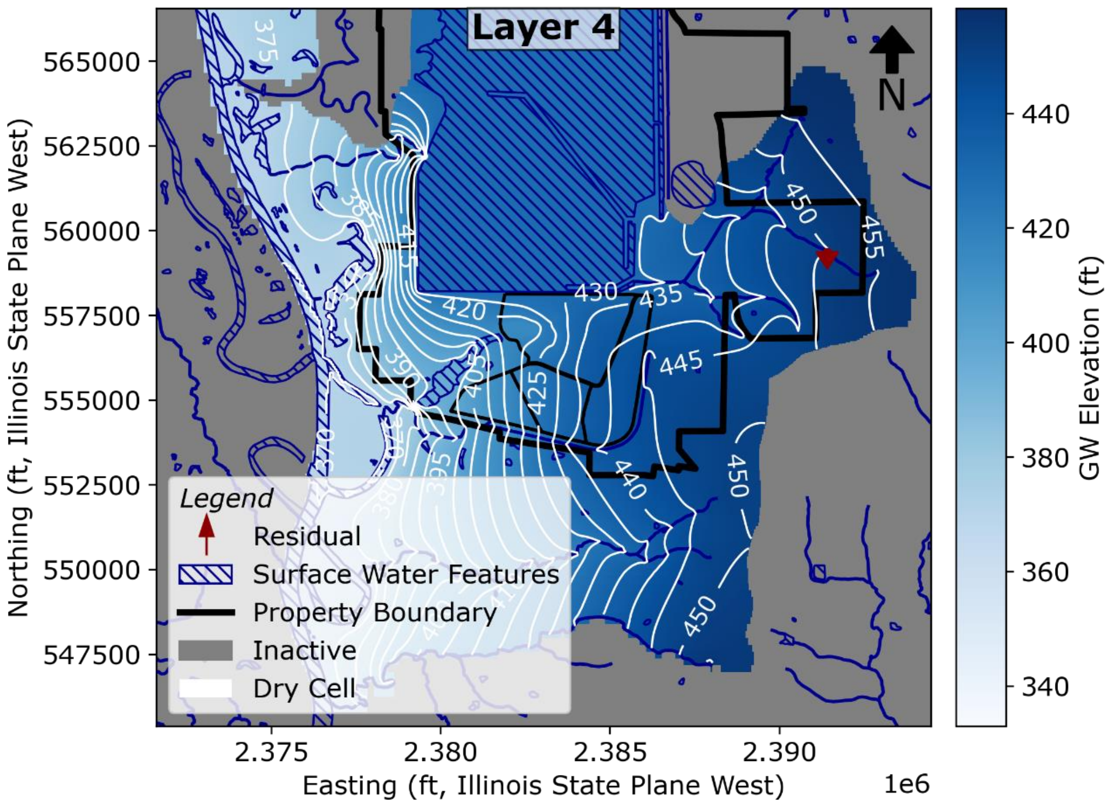


NOTE: RED DOTS INDICATE WELLS AND ARROW DIRECTION INDICATES BIAS IN SIMULATED GROUNDWATER LEVEL (NORTH ARROW = OVERESTIMATION, SOUTH ARROW = UNDERESTIMATION)

SIMULATED STEADY STATE GROUNDWATER LEVEL CONTOURS FROM LAYER 3 OF THE CALIBRATED MODEL

GROUNDWATER MODELING REPORT
BOTTOM ASH POND
BALDWIN POWER PLANT
BALDWIN, ILLINOIS

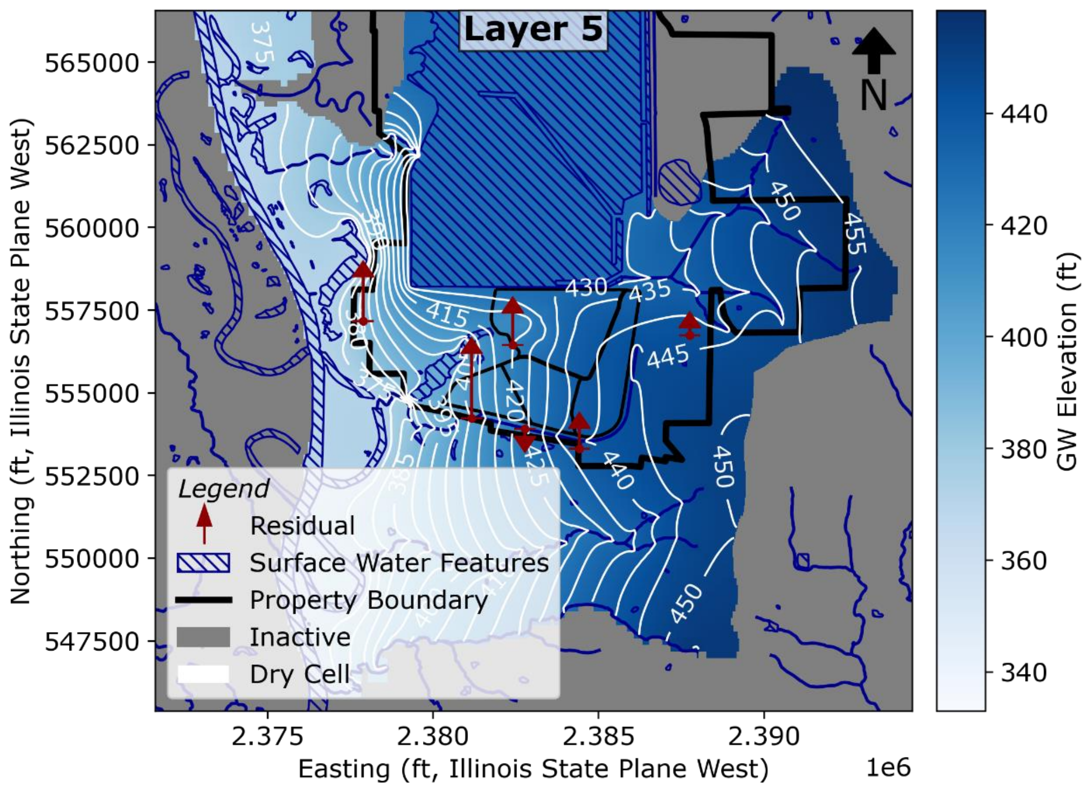
FIGURE 4-26



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

SIMULATED STEADY STATE GROUNDWATER LEVEL CONTOURS FROM LAYER 4 OF THE CALIBRATED MODEL

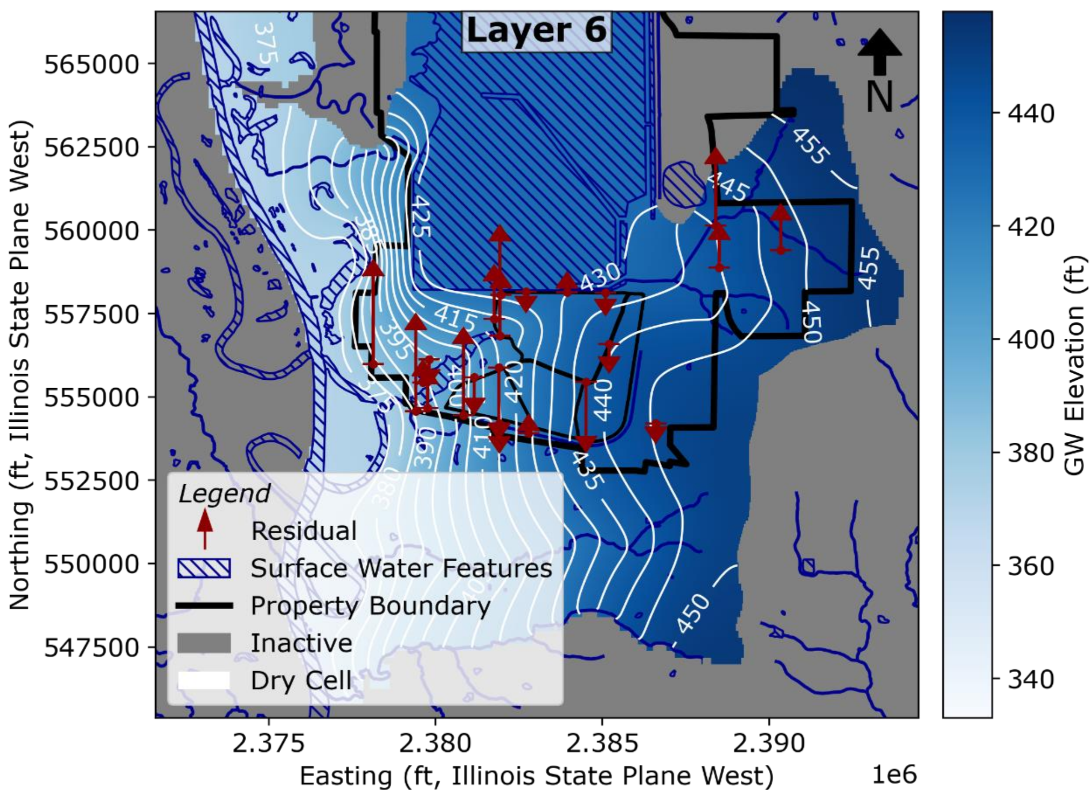
GROUNDWATER MODELING REPORT
BOTTOM ASH POND
BALDWIN POWER PLANT
BALDWIN, ILLINOIS



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

SIMULATED STEADY STATE GROUNDWATER LEVEL CONTOURS FROM LAYER 5 OF THE CALIBRATED MODEL

GROUNDWATER MODELING REPORT
BOTTOM ASH POND
BALDWIN POWER PLANT
BALDWIN, ILLINOIS

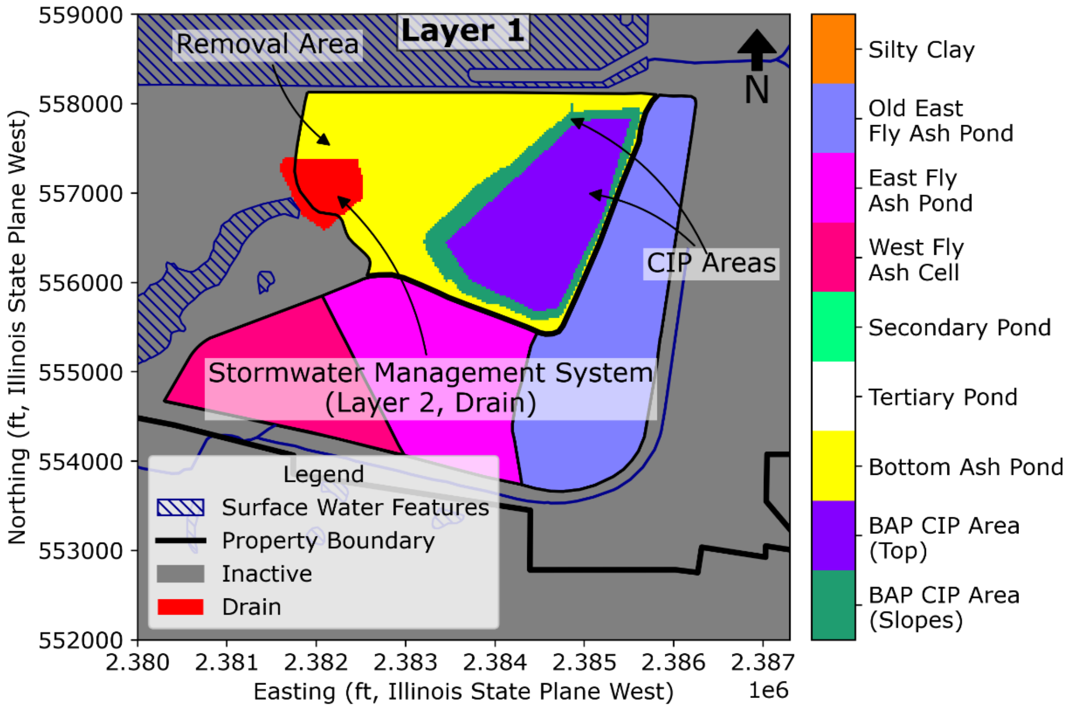


NOTE: RED DOTS INDICATE WELLS AND ARROW DIRECTION INDICATES BIAS IN SIMULATED GROUNDWATER LEVEL (NORTH ARROW = OVERESTIMATION, SOUTH ARROW = UNDERESTIMATION)

SIMULATED STEADY STATE GROUNDWATER LEVEL CONTOURS OF LAYER 6 FROM THE CALIBRATED MODEL

GROUNDWATER MODELING REPORT
BOTTOM ASH POND
BALDWIN POWER PLANT
BALDWIN, ILLINOIS

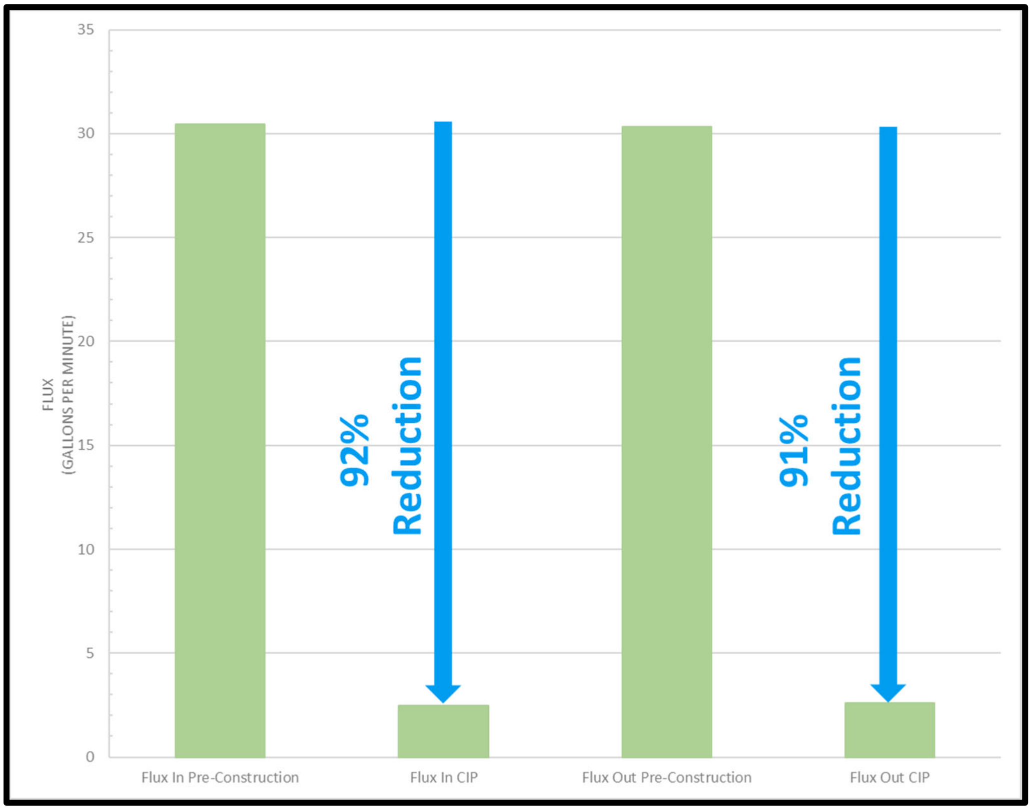
RAMBOLL



RECHARGE AND STORMWATER MANAGEMENT MODIFICATIONS FOR CLOSURE IN PLACE

GROUNDWATER MODELING REPORT
BOTTOM ASH POND
BALDWIN POWER PLANT
BALDWIN, ILLINOIS

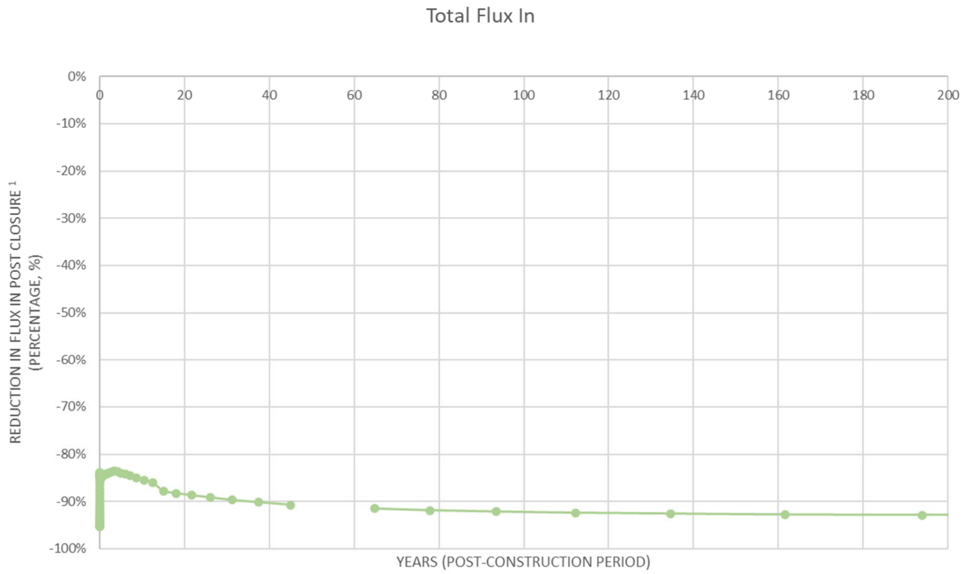
FIGURE 5-2



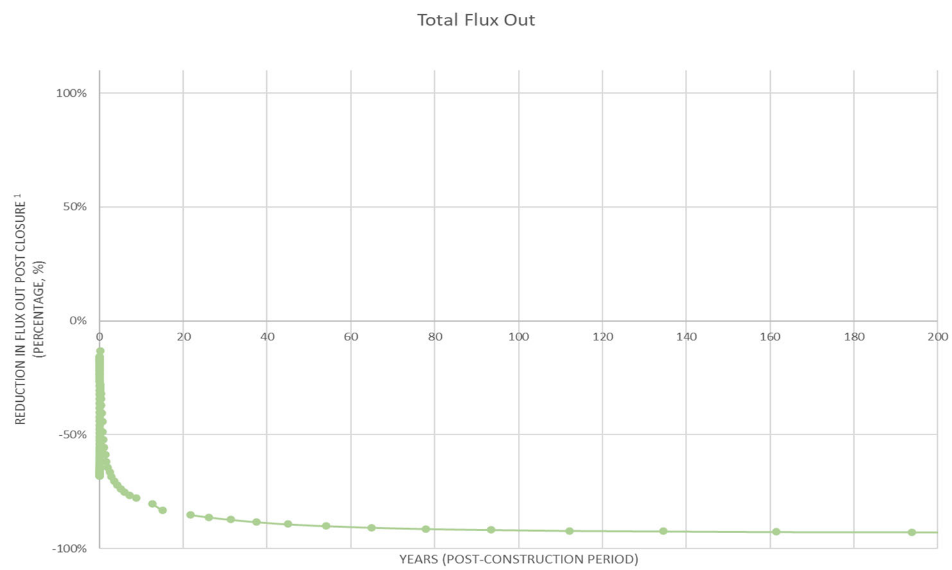
SCENARIO (CIP) –
HYDRAULIC STEADY STATE REDUCTIONS IN TOTAL FLUX IN AND OUT OF CCR

GROUNDWATER MODELING REPORT
BOTTOM ASH POND
BALDWIN POWER PLANT
BALDWIN, ILLINOIS

RAMBOLL



Notes:
1. Reduction in flux as compared to flux at the end of calibration model (model period of 53 years) including flux through drain boundary conditions in steady-state calibration model when applicable (flux out). Reductions in flux in are expressed as negative percentages to illustrate a decreases in flux over time.
2. Anamolous data point removed from timeseries plot at approximately 54 years.



Notes:
1. Reduction in flux as compared to flux at the end of calibration model (model period of 53 years) including flux through drain boundary conditions in steady-state calibration model when applicable (flux out). Reductions in flux out are expressed as negative percentages to illustrate a decreases in flux over time.
2. Anamolous data points removed from timeseries plot at approximately 10 and 18 years.

SCENARIO (CIP) –
REDUCTIONS IN TOTAL FLUX IN AND OUT OF CCR

GROUNDWATER MODELING REPORT
BOTTOM ASH POND
BALDWIN POWER PLANT
BALDWIN, ILLINOIS

APPENDICES

APPENDIX A
MODFLOW, HELP MODEL, AND FLUX EVALUATION DATA EXPORT FILES (ELECTRONIC ONLY)

APPENDIX B
HELP MODEL OUTPUT FILES

HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE
HELP MODEL VERSION 4.0 BETA (2018)
DEVELOPED BY USEPA NATIONAL RISK MANAGEMENT RESEARCH LABORATORY

Title:	BAL BAP CIP Cons Slopes	**Simulated On:**	1/6/2023 7:23

Layer 1
Type 1 - Vertical Percolation Layer (Cover Soil)
SiCL - Silty Clay Loam (Moderate)
Material Texture Number 26

Thickness	=	6	inches
Porosity	=	0.445	vol/vol
Field Capacity	=	0.393	vol/vol
Wilting Point	=	0.277	vol/vol
Initial Soil Water Content	=	0.3673	vol/vol
Effective Sat. Hyd. Conductivity	=	1.90E-06	cm/sec

Layer 2
Type 1 - Vertical Percolation Layer
SiC - Silty Clay (Moderate)
Material Texture Number 28

Thickness	=	18	inches
Porosity	=	0.452	vol/vol
Field Capacity	=	0.411	vol/vol
Wilting Point	=	0.311	vol/vol
Initial Soil Water Content	=	0.3948	vol/vol
Effective Sat. Hyd. Conductivity	=	1.20E-06	cm/sec

Layer 3
Type 2 - Lateral Drainage Layer
Drainage Net (0.5 cm)
Material Texture Number 20

Thickness	=	0.2	inches
Porosity	=	0.85	vol/vol
Field Capacity	=	0.01	vol/vol
Wilting Point	=	0.005	vol/vol
Initial Soil Water Content	=	0.01	vol/vol
Effective Sat. Hyd. Conductivity	=	1.00E+01	cm/sec
Slope	=	25	%
Drainage Length	=	150	ft

Layer 4

Type 4 - Flexible Membrane Liner
LDPE Membrane
Material Texture Number 36

Thickness	=	0.04	inches
Effective Sat. Hyd. Conductivity	=	4.00E-13	cm/sec
FML Pinhole Density	=	1	Holes/Acre
FML Installation Defects	=	1	Holes/Acre
FML Placement Quality	=	3	Good

Layer 5

Type 1 - Vertical Percolation Layer (Waste)
Electric Plant Coal Bottom Ash
Material Texture Number 83

Thickness	=	231.72	inches
Porosity	=	0.578	vol/vol
Field Capacity	=	0.076	vol/vol
Wilting Point	=	0.025	vol/vol
Initial Soil Water Content	=	0.076	vol/vol
Effective Sat. Hyd. Conductivity	=	5.29E-04	cm/sec

Note: Initial moisture content of the layers and snow water were computed as nearly steady-state values by HELP.

General Design and Evaporative Zone Data

SCS Runoff Curve Number	=	91.1	
Fraction of Area Allowing Runoff	=	100	%
Area projected on a horizontal plane	=	21.39	acres
Evaporative Zone Depth	=	18	inches
Initial Water in Evaporative Zone	=	6.845	inches
Upper Limit of Evaporative Storage	=	8.094	inches
Lower Limit of Evaporative Storage	=	5.394	inches
Initial Snow Water	=	0	inches
Initial Water in Layer Materials	=	26.923	inches
Total Initial Water	=	26.923	inches
Total Subsurface Inflow	=	0	inches/year

Note: SCS Runoff Curve Number was calculated by HELP.

Evapotranspiration and Weather Data

Station Latitude	=	38.18	Degrees
Maximum Leaf Area Index	=	4.5	
Start of Growing Season (Julian Date)	=	104	days

End of Growing Season (Julian Date)	=	285	days
Average Wind Speed	=	8	mph
Average 1st Quarter Relative Humidity	=	72	%
Average 2nd Quarter Relative Humidity	=	64	%
Average 3rd Quarter Relative Humidity	=	71	%
Average 4th Quarter Relative Humidity	=	72	%

Note: Evapotranspiration data was obtained for Baldwin, Illinois

Normal Mean Monthly Precipitation (inches)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
2.421014	2.032335	4.330912	4.401604	4.511846	4.068128
4.023992	2.88724	2.952714	2.941943	4.289265	2.800511

Note: Precipitation was simulated based on HELP V4 weather simulation for:
Lat/Long: 38.18/-89.85

Normal Mean Monthly Temperature (Degrees Fahrenheit)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
35	44.8	49.4	61.2	72.7	82.1
84.9	81.7	72.6	59.4	50.1	43.9

Note: Temperature was simulated based on HELP V4 weather simulation for:
Lat/Long: 38.18/-89.85
Solar radiation was simulated based on HELP V4 weather simulation for:
Lat/Long: 38.18/-89.85

Average Annual Totals Summary

Title: BAL BAP CIP Cons Slopes
Simulated on: 1/6/2023 7:24

	Average Annual Totals for Years 1 - 30*			
	(inches)	[std dev]	(cubic feet)	(percent)
Precipitation	41.66	[4.8]	3,234,836.6	100.00
Runoff	16.562	[3.613]	1,285,952.1	39.75
Evapotranspiration	24.541	[2.705]	1,905,475.7	58.90
Subprofile1				
Lateral drainage collected from Layer 3	0.5339	[0.485]	41,451.4	1.28
Percolation/leakage through Layer 4	0.000007	[0.000006]	0.5720	0.00
Average Head on Top of Layer 4	0.0002	[0.0002]	---	---
Subprofile2				
Percolation/leakage through Layer 5	0.000007	[0.000007]	0.5716	0.00
Water storage				
Change in water storage	0.0252	[0.7492]	1,956.9	0.06

* Note: Average inches are converted to volume based on the user-specified area.

HYDROLOGIC EVALUATION OF LANDFILL PERFORMANCE
HELP MODEL VERSION 4.0 BETA (2018)
DEVELOPED BY USEPA NATIONAL RISK MANAGEMENT RESEARCH LABORATORY

Title: BAL BAP CIP Cons Top **Simulated On:** 1/6/2023 7:18

Layer 1

Type 1 - Vertical Percolation Layer (Cover Soil)
SiCL - Silty Clay Loam (Moderate)
Material Texture Number 26

Thickness	=	6	inches
Porosity	=	0.445	vol/vol
Field Capacity	=	0.393	vol/vol
Wilting Point	=	0.277	vol/vol
Initial Soil Water Content	=	0.3673	vol/vol
Effective Sat. Hyd. Conductivity	=	1.90E-06	cm/sec

Layer 2

Type 1 - Vertical Percolation Layer
SiC - Silty Clay (Moderate)
Material Texture Number 28

Thickness	=	18	inches
Porosity	=	0.452	vol/vol
Field Capacity	=	0.411	vol/vol
Wilting Point	=	0.311	vol/vol
Initial Soil Water Content	=	0.3951	vol/vol
Effective Sat. Hyd. Conductivity	=	1.20E-06	cm/sec

Layer 3

Type 2 - Lateral Drainage Layer
16 oz Nonwoven Geotextile
Material Texture Number 43

Thickness	=	0.11	inches
Porosity	=	0.85	vol/vol
Field Capacity	=	0.01	vol/vol
Wilting Point	=	0.005	vol/vol
Initial Soil Water Content	=	0.01	vol/vol
Effective Sat. Hyd. Conductivity	=	3.00E-01	cm/sec
Slope	=	2	%
Drainage Length	=	600	ft

Layer 4

Type 4 - Flexible Membrane Liner
LDPE Membrane
Material Texture Number 36

Thickness	=	0.04	inches
Effective Sat. Hyd. Conductivity	=	4.00E-13	cm/sec
FML Pinhole Density	=	1	Holes/Acre
FML Installation Defects	=	1	Holes/Acre
FML Placement Quality	=	3	Good

Layer 5

Type 1 - Vertical Percolation Layer (Waste)
Electric Plant Coal Bottom Ash
Material Texture Number 83

Thickness	=	545.28	inches
Porosity	=	0.578	vol/vol
Field Capacity	=	0.076	vol/vol
Wilting Point	=	0.025	vol/vol
Initial Soil Water Content	=	0.076	vol/vol
Effective Sat. Hyd. Conductivity	=	5.29E-04	cm/sec

Note: Initial moisture content of the layers and snow water were computed as nearly steady-state values by HELP.

General Design and Evaporative Zone Data

SCS Runoff Curve Number	=	89.8	
Fraction of Area Allowing Runoff	=	100	%
Area projected on a horizontal plane	=	53.73	acres
Evaporative Zone Depth	=	18	inches
Initial Water in Evaporative Zone	=	6.849	inches
Upper Limit of Evaporative Storage	=	8.094	inches
Lower Limit of Evaporative Storage	=	5.394	inches
Initial Snow Water	=	0	inches
Initial Water in Layer Materials	=	50.759	inches
Total Initial Water	=	50.759	inches
Total Subsurface Inflow	=	0	inches/year

Note: SCS Runoff Curve Number was calculated by HELP.

Evapotranspiration and Weather Data

Station Latitude	=	38.18	Degrees
Maximum Leaf Area Index	=	4.5	
Start of Growing Season (Julian Date)	=	104	days

End of Growing Season (Julian Date)	=	285	days
Average Wind Speed	=	8	mph
Average 1st Quarter Relative Humidity	=	72	%
Average 2nd Quarter Relative Humidity	=	64	%
Average 3rd Quarter Relative Humidity	=	71	%
Average 4th Quarter Relative Humidity	=	72	%

Note: Evapotranspiration data was obtained for Baldwin, Illinois

Normal Mean Monthly Precipitation (inches)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
2.421014	2.032335	4.330912	4.401604	4.511846	4.068128
4.023992	2.88724	2.952714	2.941943	4.289265	2.800511

Note: Precipitation was simulated based on HELP V4 weather simulation for:
Lat/Long: 38.18/-89.85

Normal Mean Monthly Temperature (Degrees Fahrenheit)

Jan/Jul	Feb/Aug	Mar/Sep	Apr/Oct	May/Nov	Jun/Dec
35	44.8	49.4	61.2	72.7	82.1
84.9	81.7	72.6	59.4	50.1	43.9

Note: Temperature was simulated based on HELP V4 weather simulation for:
Lat/Long: 38.18/-89.85
Solar radiation was simulated based on HELP V4 weather simulation for:
Lat/Long: 38.18/-89.85

Average Annual Totals Summary

Title: BAL BAP CIP Cons Top
Simulated on: 1/6/2023 7:19

	Average Annual Totals for Years 1 - 30*			
	(inches)	[std dev]	(cubic feet)	(percent)
Precipitation	41.66	[4.8]	8,125,655.5	100.00
Runoff	16.544	[3.658]	3,226,692.1	39.71
Evapotranspiration	24.605	[2.679]	4,798,963.4	59.06
Subprofile1				
Lateral drainage collected from Layer 3	0.4260	[0.3581]	83,079.3	1.02
Percolation/leakage through Layer 4	0.061216	[0.074113]	11,939.6	0.15
Average Head on Top of Layer 4	0.7474	[0.9614]	---	---
Subprofile2				
Percolation/leakage through Layer 5	0.000239	[0.000259]	46.6	0.00
Water storage				
Change in water storage	0.0865	[0.7368]	16,874.2	0.21

* Note: Average inches are converted to volume based on the user-specified area.

APPENDIX C
FLUX EVALUATION DATA

APPENDIX C. FLUX EVALUATION DATA

GROUNDWATER MODELING REPORT

BALDWIN POWER PLANT

BOTTOM ASH POND

BALDWIN, ILLINOIS

Calibration Model					
Model	**Years (Model Period)**	**HSU**	**Total Flux In[1] (ft^3/d)**	**Total Flux In (gpm)**	
Calibration Model	53	CCR	5858.69	30.43	
Model	**Years (Model Period)**	**HSU**	**Total Flux Out[1] (ft^3/d)**	**Total Flux Out (gpm)**	
Calibration Model	53	CCR	-2415.44	-12.55	
Model	**Model Period**	**Boundary Condition**	**Total Flux Out[1] (ft^3/d)**	**Total Flux Out (gpm)**	
Calibration Model (Steady-State)	Existing Conditions (Steady-State)	Drains (Stormwater Management within Active BAP)	-3418.80	-17.76	
Scenario: CIP (CCR removal from the western areas of the BAP, consolidation to the southeast, and eventually northeastern portions of the BAP, and construction of a cover system over the remaining CCR)					
Prediction Model	**Years (Post-Construction Period)**	**HSU**	**Total Flux In[1] (ft^3/d)**	**Total Flux In (gpm)**	**Reduction in Flux In Post Closure[2] (Percentage, %)**
CIP	78	CCR	475.44	2.47	92%
Prediction Model	**Years (Post-Construction Period)**	**HSU**	**Total Flux Out[1] (ft^3/d)**	**Total Flux Out (gpm)**	**Reduction in Flux Out Post Closure[2] (Percentage, %)**
CIP	78	CCR	-503.25	-2.61	91%

[O: JJW 1/5/23; C: EGP 1/6/23; C: BGH 1/19/23]

Notes:

1. Reduction in flux as compared to flux at the end of calibration model (model period of 53 years) including flux through drain boundary conditions in steady-state calibration model when applicable (flux out).
2. Total flux in and out source data provided in flux calculation data files included in Appendix C.

BAP = Bottom Ash Pond
CCR = coal combustion residuals
CIP = closure in place
HSU = Hydrostratigraphic Unit
% = percentage
ft^3/d = cubic feet per day
gpm = gallons per minute