DRAFT

REPORT

Final Closure Plan for the Gypsum Management Facility Gypsum Stack Pond

Coffeen Power Plant

Submitted to:

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1.0 INTRODUCTION

This Final Closure Plan has been prepared to address certain requirements of Illinois Administrative Code Title 35, Part 845, Standards for the Disposal of Coal Combustion Residuals (CCR) in Surface Impoundments (Part 845) for Illinois Power Resources Generating, LLC's (IPRG's) Gypsum Management Facility (GMF) Gypsum Stack Pond (GSP) at the Coffeen Power Plant near Coffeen, Illinois. Specifically, this document addresses requirements pertaining to the development of a Final Closure Plan for the GMF GSP. The GMF GSP has identification codes as follow:

- IPRG ID Number: CCR Unit ID 103
- IEPA ID Number: W1350150004-03
- IDNR Dam ID Number: IL50579

1.1 Proposed Selected Closure Method

Part 845.720 (b)(3): The final closure plan must identify the proposed selected closure method, and must include the information required in subsection (a)(1) and the closure alternatives analysis specified in Section 845.710.

IPRG evaluated closure with a final cover system (hereafter referred to as closure-in-place or CIP) (Section 845.750) and closure-by-removal of CCR (CBR) (Section 845.740). An analysis of these closure alternatives is summarized in Attachment 1. Based on the Closure Alternatives Analysis, CIP with a final cover system has been identified as the most appropriate closure method. In combination with the existing liner system beneath the GMF GSP, the final cover system will provide complete encapsulation of gypsum (CCR) in the GMF GSP, physically isolating it from contact with surrounding soils, groundwater, surface water, and the atmosphere, and minimizing the potential for release of CCR or leachate. The final cover system has been designed to minimize the post-closure infiltration of liquids into the waste.

During the closure process, IPRG will continue to assess off-Site CCR beneficial use opportunities. Ash consolidation and closure in place in combination with offsite beneficial use may result in a smaller footprint for purposes of our ultimate cap design along with a reduced construction schedule.

2.0 FINAL CLOSURE PLAN

2.1 Narrative Closure Description

Part 845.720(a)(1)(A): A narrative description of how the CCR surface impoundment will be closed in accordance with this Part.

Closure grades and details are shown in the Drawings included as Attachment 2. The closure-in-place concept for the GMF GSP was developed to reduce the waste footprint at closure. The proposed closure-in-place option would have final cover slopes of 25H:1V (4%) to accommodate moderate settlement and promote drainage. A berm will be constructed at the south end of the consolidated footprint for stability. The location of the berm has been selected to accommodate the estimated 295,500 CY of CCR and 38,000 CY of clayey soil from the GMF GSP to be contained within the consolidated footprint based on the grading plan presented. The general sequencing plan for the closure-in-place option is as follows:

- Pump out ponded water [approximately 106 million gallons (MG)] from the GMF GSP to the existing drainage to the east through Outfall 023 where it will be managed in accordance with the NPDES permit for the site.

- Resume pumping of the perimeter drains surrounding the GSP to lower the groundwater level beneath the GSP and outside the existing liner system to facilitate closure construction. Discharge water to the existing drainage to the east through Outfall 023 where it will be managed in accordance with the NPDES permit for the site.
- A temporary water management system will be constructed within the GMF GSP, including ditches and sumps. The system will maintain the GMF GSP in an unwatered state by collecting contact stormwater during closure construction. Stormwater flow will be conveyed through Outfall 023 to the existing drainage to the east where it will be managed in accordance with the NPDES permit for the site.
- Once the ponded water has been removed from the GMF GSP, the CCR in the consolidated footprint will be dewatered. Approximately 131,000 CY of CCR will be dewatered as needed to enable relocation. It is anticipated that approximately 8.8 MG of water removal will be required to dewater the CCR. The CCR will dewater to some degree by gravity, but dewatering by pumping from trenches and sumps is expected to be necessary. Liquid waste and water flowing to sumps will be managed in accordance with the NPDES permit for the site and discharged through Outfall 023.
- CCR will be removed from the berm footprint and relocated into the consolidated footprint. The berm will be constructed in an east-west orientation at the east end of the consolidated footprint. The upstream face of the berm will be lined with a composite liner system consisting of 60-mil HDPE geomembrane overlying a compacted clay layer, which will tie into the existing composite liner system.
- The remaining CCR south of the berm in the GMF GSP will be collected and deposited north of the berm.
- Geosynthetic components of the existing liner system and PWRS south of the berm in the GMF GSP will be removed and disposed in the closure footprint or hauled away for disposal. It is anticipated that up to 1 foot of clay soil beneath the geomembrane may also be removed. The soils will be visually observed for signs of CCR. If soils with signs of CCR are observed, they will be removed and deposited north of the berm (for the purposes of conceptual design, assume 1 foot, or approximately 38,000 CY, will need to be removed).
- Compacted fill, composed of locally available soils, would be placed only as needed to achieve final cover subgrade. The compacted fill is anticipated to be compacted to a minimum of 95% of the standard Proctor maximum dry density to reduce settlement.
- Construction of an alternate final cover system, consisting of (from top to bottom):
  - 24-inch final protective soil layer. The final protective soil layer would include 18 inches of protective soil cover overlain by a 6-inch-thick topsoil layer, and be revegetated with native grasses. The 18 inches of protective soil cover will be constructed of locally available soils removed from the embankment containment berm and compacted to between 80% and 95% of the standard Proctor maximum dry density for establishment of vegetation and protection of the underlying geomembrane. Protective soil layer material is likely to be primarily low-plasticity silt or clay based on review of site geotechnical information.
  - Drainage geocomposite (pending HELP model results from others, a nonwoven cushion geotextile may be possible as a substitute for geocomposite)
  - 40-mil linear low-density polyethylene (LLDPE) geomembrane layer

- All areas of the cover system will be sloped at a minimum of 4% to positively drain to the exterior of the GMF GSP.
- To prevent impoundment of water in the south end of the current GMF GSP footprint after CCR removal, existing earthen embankments not required for the consolidated footprint will be removed on the eastern side of the GMF GSP and a channel will be excavated to allow stormwater to flow through existing NPDES Outfall 023 into the existing drainage to the east.
- The final ground surface of the southern part of the GMF GSP will be sloped to drain a minimum of 0.5% towards the channel excavated in the southeast corner, in order to allow post-closure, non-contact stormwater to gravity flow into the existing drainage. Soil fill, sourced from existing berms no longer required to contain waste in the consolidated footprint or from the on-Site soil borrow area southeast of AP1, will be used to achieve the necessary slopes. Additional fill will come from off-Site borrow sources assumed to be located within 2 miles of the GMF GSP.
- Vegetation will be established on the final surface of the GMF GSP. Stormwater best management practices (BMPs) such as erosion control blankets will be used, as needed, to reduce erosion during vegetation establishment.
- After vegetation is established, BMPs will be removed, and closure construction will be considered complete.

2.2 Decontamination of CCR Surface Impoundment

Part 845.720(a)(1)(B): If closure of the CCR surface impoundment will be accomplished through removal of CCR from the CCR surface impoundment, a description of the procedures to remove the CCR and decontaminate the CCR surface impoundment in accordance with Section 845.740.

After CCR south of the berm has been relocated to within the closure footprint, the geosynthetic components of the existing liner system and PWRS south of the berm in the GMF GSP will be removed and disposed in the closure footprint or hauled away for disposal. It is anticipated that up to 1 foot of clay soil beneath the geomembrane may also be removed. The soils will be visually observed for signs of CCR. If soils with signs of CCR are observed, they will be removed and deposited north of the berm.

2.3 Final Cover System Performance Standards

Part 845.720(a)(1)(C): If closure of the CCR surface impoundment will be accomplished by leaving CCR in place, a description of the final cover system, designed in accordance with Section 845.750, and the methods and procedures to be used to install the final cover. The closure plan must also discuss how the final cover system will achieve the performance standards specified in Section 845.750.

The final cover system is described in Section 2.1 and shown in the Drawings (Attachment 2). Documentation in support of the final cover system achieving the performance standards of Section 845.750 is provided in Section 4.7.

2.4 Maximum CCR Inventory Estimate

Part 845.720(a)(1)(D): An estimate of the maximum inventory of CCR ever on-site over the active life of the CCR surface impoundment.

Based on Golder's comparison (using Autodesk Civil 3D) of the existing conditions (December 2020 survey by IngenAE) and the approximate top-of-liner-system grades developed from the as-built top of liner, the estimated volume of CCR in the GMF GSP is approximately 298,500 CY. No additional CCR will be placed in the GMF GSP before it is closed.

2.5 Largest Surface Area Estimate

Part 845.720(a)(1)(E): An estimate of the largest area of the CCR surface impoundment ever requiring a final cover (see Section 845.750), at any time during the CCR surface impoundment's active life.

In the Closure Plan developed for compliance with the United States Environmental Protection Agency's (USEPA's) CCR Rule (40 CFR 257, Subpart D), the largest area of the GMF GSP ever requiring a final cover system was estimated to be approximately 36 acres. This area represents the entire footprint of the GMF GSP. The area of the closure footprint requiring a final cover system under this Final Closure Plan is approximately 12.4 acres.

2.6 Closure Completion Schedule

Part 845.720(a)(1)(F): A schedule for completing all activities necessary to satisfy the closure criteria in this Section, including an estimate of the year in which all closure activities for the CCR surface impoundment will be completed. The schedule should provide sufficient information to describe the sequential steps that will be taken to close the CCR surface impoundment, including identification of major milestones such as coordinating with and obtaining necessary approvals and permits from other agencies, the dewatering and stabilization phases of CCR surface impoundment closure, or installation of the final cover system, and the estimated timeframes to complete each step or phase of CCR surface impoundment closure. When preparing the preliminary written closure plan, if the owner or operator of a CCR surface impoundment estimates that the time required to complete closure will exceed the timeframes specified in Section 845.760(a), the preliminary written closure plan must include the site-specific information, factors and considerations that would support any time extension sought under Section 845.760(b).

Table 1: Closure Completion Milestone Schedule

Milestone	Timeframe (Preliminary Estimates)
Final Closure Plan Submittal	August 2022
Final Design and Bid Process ▪ Complete final design of the closure and select a construction contractor Agency Coordination, Approvals, and Permitting ▪ Obtain state permits, as needed, for dewatering, water discharge, land disturbance, and dam modifications	8 to 12 months after Final Closure Plan Approval
Dewater and Stabilize CCR ▪ Complete contractor mobilization, installation of stormwater BMPs, and unwatering of GMF GSP ▪ Pump water from GMF GSP ▪ Dewater and stabilize GMF GSP	11 to 16 months after issuance of necessary permits, design completion, and bid award

Milestone	Timeframe (Preliminary Estimates)
Consolidate Waste Footprint ■ Construct east-west berm ■ Install new liner system on upstream face of berm ■ Relocate CCR south of berm to closure footprint	4 to 6 months after dewatering and CCR stabilization
Installation of Final Cover System ■ Prepare top of CCR for cover system installation ■ Install geomembrane ■ Install geocomposite drainage layer ■ Place protective cover soil	4 to 6 months after CCR relocation to closure footprint
Site Restoration ■ Remove existing liner south of berm ■ Excavate drainage channels ■ Seed and stabilize GMF GSP	3 to 5 months after the final cover system is complete
Timeframe to Complete Closure	Prior to November 2026

3.0 AMENDMENT OF THE FINAL CLOSURE PLAN

Part 845.720(b)(4): If a final written closure plan revision is necessary after closure activities have started for a CCR surface impoundment, the owner or operator must submit a request to modify the construction permit within 60 days following the triggering event.

IPRG will submit a written request to modify the construction permit within 60 days of a triggering event.

4.0 CLOSURE WITH A FINAL COVER SYSTEM

4.1 Minimization of Post-Closure Infiltration and Releases

Part 845.750(a): The owner or operator of a CCR surface impoundment must ensure that, at a minimum, the CCR surface impoundment is closed in a manner that will:

1) Control, minimize or eliminate, to the maximum extent feasible, post-closure infiltration of liquids into the waste and releases of CCR, leachate, or contaminated run-off to the ground or surface waters or to the atmosphere.

Post-closure infiltration into the GMF GSP will be minimized by the construction of a final cover system. The final cover system will consist of (from top to bottom) the following:

- Based on a demonstration to be submitted to IEPA for approval pursuant to Section 845.750(c)(2), a 2-foot-thick final protective layer consisting of locally available soils compacted to between 80% and 95% of the standard Proctor maximum dry density. The uppermost 6 inches of the final protective layer will be tracked in place with a density suitable for establishment of vegetation. Soils are likely to consist primarily of low-plasticity silt or clay based on a review of site geotechnical information.
- Drainage geocomposite. This layer will provide lateral drainage to limit the potential for the final protective layer to become saturated.
- 40-mil LLDPE geomembrane.

The use of HDPE geomembrane was considered, but LLDPE geomembrane was selected because it can be installed more easily in a wider range of cold-temperature conditions. This final cover system is compliant with the Part 845 requirements, as described in Section4.7, and will minimize the post-closure infiltration of liquids into the waste. After closure, the CCR stored in the facility will be completely encapsulated by the final cover and liner systems, physically isolating it from contact with surrounding soils, groundwater, surface water, and the atmosphere, and minimizing the potential for release of CCR or leachate. This is supported by groundwater modeling, as presented in Appendix G to the Part 845 Construction Permit Application for the GMF GSP.

4.2 Preclusion of Future Impoundment

Part 845.750(a): The owner or operator of a CCR surface impoundment must ensure that, at a minimum, the CCR surface impoundment is closed in a manner that will:

2) Preclude the probability of future impoundment of water, sediment, or slurry.

The final cover system will be crowned with 4% slopes to direct surface water away from the facility. Beyond the final cover system, channels will direct surface water away from the GMF GSP to existing site drainages.

4.3 Provisions for Preventing Instability, Sloughing and Movement

Part 845.750(a): The owner or operator of a CCR surface impoundment must ensure that, at a minimum, the CCR surface impoundment is closed in a manner that will:

3) Include measures that provide for major slope stability to prevent the sloughing or movement of the final cover system during the closure and post-closure care period.

An assessment of the GMF GSP structural stability was completed as part of compliance with USEPA’s CCR Rule (AECOM 2016). This assessment concluded that the GMF GSP meets stability factor of safety requirements and does not pose a significant risk of instability.

A new earthen berm is provided in the closure design to enhance stability along the southern end of the closure footprint. Slope stability calculations are included in Attachment 3 to demonstrate that factors of safety for static and seismic stability after closure are acceptable. The slope stability calculations also considered veneer stability to verify that the final cover system will not be susceptible to instability, sloughing, or movement during the closure and post-closure care period.

4.4 Minimize the Need for Future Maintenance

Part 845.750(a): The owner or operator of a CCR surface impoundment must ensure that, at a minimum, the CCR surface impoundment is closed in a manner that will:

4) Minimize the need for further maintenance of the CCR surface impoundment

The 4% design closure slopes are sufficient to adequately shed water from the facility but are flat enough to limit erosion of the final protective layer. Minor maintenance of the final cover system (potentially including filling of low areas, reseeding, fertilizing, etcetera) will likely be necessary for several years after completion of final cover system construction, as described in the Post-closure Care Plan (Appendix J to the Part 845 Construction Permit Application for the GMF Pond). The need for long-term future maintenance is expected to be minimal after installation of the final cover system has been completed and vegetation has been established.

The channels designed to convey surface water runoff away from the closed facility have been sized to accommodate the 25-year, 24-hour storm event. The design calculations are provided in Attachment 4.

4.5 Be Completed in the Shortest Amount of Time

Part 845.750(a): The owner or operator of a CCR surface impoundment must ensure that, at a minimum, the CCR surface impoundment is closed in a manner that will:

5) Be completed in the shortest amount of time consistent with recognized and generally accepted engineering practices.

The CIP method will require significantly less material handling compared with a CBR approach. Both approaches require the removal of liquid wastes, but the CIP method will require relocation of less than 60% of the CCR present in the GMF GSP. This reduced material handling volume means that the CIP construction can be completed in approximately 30 to 45 months, compared with 41 to 60 months, or possibly more, for CBR.

4.6 Drainage and Stabilization

Part 845.750(b): Drainage and Stabilization of CCR Surface Impoundments. The owner or operator of a CCR surface impoundment or any lateral expansion of a CCR surface impoundment must meet the requirements of this subsection (b) before installing the final cover system required by subsection (c).

1) Free liquids must be eliminated by removing liquid wastes or solidifying the remaining wastes and waste residues.

2) Remaining wastes must be stabilized sufficiently to support the final cover system.

Approximately 106 million gallons of water will be pumped from the GMF GSP as the initial step for facility closure. After removal of the ponded water, the CCR will still be unsuitable for supporting heavy construction traffic over much of the footprint. Careful planning will be required to safely work on the wet CCR within the GMF GSP. The planned CCR removal and relocation will rely on a series of trenches or other engineering measures to remove liquid wastes or solidify the remaining wastes. Trenches will shorten drainage routes to facilitate gravity removal of liquid wastes in the CCR in the vicinity of each trench and direct the liquid wastes to sumps. Other engineering measures may be considered to facilitate removal of liquid wastes. Sumps will be used to collect liquid wastes, which will be managed in accordance with the NPDES permit for the site. Using the process described or other engineering measures for removal of liquid wastes or solidification of the remaining wastes, the CCR remaining in place will be stabilized sufficiently to support the final cover system.

4.7 Final Cover System

Part 845.750(c): Final Cover System. If a CCR surface impoundment is closed by leaving CCR in place, the owner or operator must install a final cover system that is designed to minimize infiltration and erosion, and, at a minimum, meets the requirements of this subsection (c). The final cover system must consist of a low permeability layer and a final protective layer. The design of the final cover system must be included in the preliminary and final written closure plans required by Section 845.720 and the construction permit application for closure submitted to the Agency.

4.7.1 Low-Permeability Layer

Part 845.750(c)(1) Standards for the Low Permeability Layer. The low permeability layer must have a permeability less than or equal to the permeability of any bottom liner system or natural subsoils present, or a hydraulic conductivity no greater than 1 x 10^{-7} cm/sec, whichever is less. The low permeability layer must be constructed in accordance with the standards in either subsection (c)(1)(A) or (c)(1)(B), unless the owner or operator demonstrates that another low permeability layer construction technique or material provides equivalent or superior performance to the requirements of either subsection (c)(1)(A) or (c)(1)(B) and is approved by the Agency.

A) A compacted earth layer constructed in accordance with the following standards:

i) The minimum allowable thickness must be 0.91 meter (three feet); and

ii) The layer must be compacted to achieve a hydraulic conductivity of 1 x 10^{-7} cm/sec or less and minimize void spaces.

B) A geomembrane constructed in accordance with the following standards:

i) The geosynthetic membrane must have a minimum thickness of 40 mil (0.04 inches) and, in terms of hydraulic flux, must be equivalent or superior to a three-foot layer of soil with a hydraulic conductivity of 1 x 10^{-7} cm/sec;

ii) The geomembrane must have strength to withstand the normal stresses imposed by the waste stabilization process; and

iii) The geomembrane must be placed over a prepared base free from sharp objects and other materials that may cause damage.

The final cover system will include a 40-mil LLDPE geomembrane placed on a prepared subgrade of CCR (see the Drawings in Attachment 2). The prepared subgrade will be free of sharp objects prior to geomembrane installation. The geomembrane material will conform with the specifications of Geosynthetic Institute GRI-GM17 “Test Methods, Test Properties and Testing Frequency for Linear Low Density Polyethylene (LLDPE) Smooth and Textured Geomembranes” and will be installed per GRI-GM19a “Seam Strength and Related Properties of Thermally Bonded Homogeneous Polyolefin Geomembranes/Barriers” so that the material itself and the seams between panels will withstand the expected normal and tensile stress conditions. Furthermore, a 40-mil LLDPE geomembrane manufactured and installed to these specifications is widely accepted to be equivalent or superior to a 3-foot-thick layer of soil with a hydraulic conductivity of 1 x 10^{-7} cm/sec.

4.7.2 Final Protective Layer

Part 845.750(c)(2): Standards for the Final Protective Layer. The final protective layer must meet the following requirements, unless the owner or operator demonstrates that another final protective layer construction technique or material provides equivalent or superior performance to the requirements of this subsection (c)(2) and is approved by the Agency.

A) Cover the entire low permeability layer;

B) Be at least three feet thick, be sufficient to protect the low permeability layer from freezing, and minimize root penetration of the low permeability layer;

C) Consist of soil material capable of supporting vegetation;

D) Be placed as soon as possible after placement of the low permeability layer; and

E) Be covered with vegetation to minimize wind and water erosion.

Based on a demonstration to be submitted to IEPA for approval pursuant to Section 845.750(c)(2), a 2-foot-thick final protective layer will be installed for the final cover system, immediately overlaying the drainage geocomposite and covering the entire low-permeability layer (see the Drawings in Attachment 2). The final protective layer will comprise locally available soils compacted to between 80% and 95% of the standard Proctor maximum dry density. The uppermost 6 inches of the final protective layer will be tracked in place to a density suitable for establishment of vegetation. This soil is expected to consist primarily of low-plasticity silt or clay based on a review of site geotechnical information. This soil is capable of supporting vegetation, will be placed as soon as possible after placement of the low-permeability layer, and will be covered with vegetation to limit wind and water erosion.

4.8 Final Cover System Settling

Part 845.750(c)(3): The disruption of the integrity of the final cover system must be minimized through a design that accommodates settling and subsidence.

The closure slopes are designed at 4% to accommodate settlement while still maintaining positive drainage off the facility. Additional discussion on this subject is provided in Section 4.4.

4.9 Use of CCR in Closure

Part 845.750(d): This subsection specifies the allowable uses of CCR in the closure of CCR surface impoundments closing under Section 845.700. Notwithstanding the prohibition on further placement in Section 845.700, CCR may be placed in these surface impoundments, but only for purposes of grading and contouring in the design and construction of the final cover system, if:

1) The CCR placed was generated at the facility and is located at the facility at the time closure was initiated;

2) CCR is placed entirely above the elevation of CCR in the surface impoundment, following dewatering and stabilization (see subsection (b));

3) The CCR is placed entirely within the perimeter berms of the CCR surface impoundment; and

4) The final cover system is constructed with either:

A) A slope not steeper than 5% grade after allowance for settlement; or

B) At a steeper grade, if the Agency determines that the steeper slope is necessary, based on conditions at the site, to facilitate run-off and minimize erosion, and that side slopes are evaluated for erosion potential based on a stability analysis to evaluate possible erosion potential. The stability analysis, at a minimum, must evaluate the site geology; characterize soil shear strength; construct a slope stability model; establish groundwater and seepage conditions, if any; select loading conditions; locate critical failure surface; and iterate until minimum factor of safety is achieved.

The GMF GSP is not closing under Section 845.700. Following dewatering of the GMF GSP, CCR currently located within the GMF GSP (which was generated at Coffeen Power Plant) will be relocated to within the closure footprint. Closure of the GMF GSP will comply with the requirements of Subsection 845.750(d) in the event CCR from a unit other than the GMF GSP is utilized.

5.0 CERTIFICATION

Part 845.750(c)(4): The owner or operator of the CCR surface impoundment must obtain and submit with its construction permit application for closure a written certification from a qualified professional engineer that the design of the final cover system meets the requirements of this Section.

The undersigned qualified professional engineer registered in Illinois certifies that the design of the final cover system meets the requirements of Section 845.750.

Signature Page

Golder Associates USA Inc.

I, Mark Haddock, being a registered professional engineer in good standing in the State of Illinois, certify to the best of my knowledge that this Final Closure Plan meets the requirements of Illinois Administrative Code Title 35, Part 845.

-UNCERTIFIED DRAFT-

Mark Haddock
Principal

https://golderassociates.sharepoint.com/sites/145229/project files/6 deliverables/reports/05-closure_plan_gmf_and_recycle/gmf gsp_20220428-reva/21465046-closure_plan_gmf_gsp_20220512-rev0.docx

6.0 REFERENCES

AECom. 2016. CCR Certification Report: GMF Pond, At Coffeen Power Station. October.

ATTACHMENT 1

Closure Alternatives Analysis

Draft

Closure Alternatives Analysis for the Gypsum Management Facility Stack Pond and Recycle Pond at the Coffeen Power Plant Coffeen, Illinois

May 15, 2022

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Abbreviations

AACE	Association for the Advancement of Cost Engineering
BMP	Best Management Practice
CAA	Closure Alternatives Analysis
CBR-Offsite	Closure-by-Removal with Off-Site CCR Disposal
CBR-Onsite	Closure-by-Removal with On-Site CCR Disposal
CCR	Coal Combustion Residual
CFR	Code of Federal Regulation
CIP	Closure-in-Place
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CY	Cubic Yard
DA	Deep Aquifer
DCU	Deep Confining Unit
EJ	Environmental Justice
FEMA	Federal Emergency Management Agency
GHG	Greenhouse Gas
GMF	Gypsum Management Facility
GSP	Gypsum Stack Pond
GWPS	Groundwater Protection Standard
HUC	Hydrologic Unit Code
IAC	Illinois Administrative Code
IDNR	Illinois Department of Natural Resources
IEPA	Illinois Environmental Protection Agency
IPGC	Illinois Power Generating Company
ISGS	Illinois State Geological Survey
LCU	Lower Confining Unit
LLDPE	Linear Low-Density Polyethylene
N_2O	Nitrous Oxide
NID	National Inventory of Dams
NO_x	Nitrogen Oxides
NPDES	National Pollutant Discharge Elimination System
PM	Particulate Matter
RP	Recycle Pond
SFWA	State Fish and Wildlife Area
TMDL	Total Maximum Daily Load
TVA	Tennessee Valley Authority
UA	Uppermost Aquifer
UCU	Upper Confining Unit
US DOT	United States Department of Transportation
US FWS	United States Fish & Wildlife Service
VOC	Volatile Organic Compound
WPC Permit	Water Pollution Control Construction and Operating Permit

Summary of Findings

Title 35, Part 845 of the Illinois Administrative Code (IAC; IEPA, 2021a) requires the development of a Closure Alternatives Analysis (CAA) prior to undertaking closure activities at certain surface impoundments containing coal combustion residuals (CCRs) in the state of Illinois. Pursuant to requirements under IAC Section 845.710, this report presents a CAA for the Gypsum Management Facility (GMF) Gypsum Stack Pond (GSP) and the GMF Recycle Pond (RP) located on Illinois Power Generating Company's (IPGC) Coffeen Power Plant property near the City of Coffeen, Illinois. The goal of a CAA is to holistically evaluate potential closure scenarios with respect to a wide range of factors, including the efficiency, reliability, and ease of implementation of the closure scenario; its potential positive and negative short- and long-term impacts on human health and the environment; and its ability to address concerns raised by residents (IAC Part 845; IEPA, 2021a). For the GMF GSP, Gradient evaluated two specific closure scenarios: Closure-in-Place (CIP) and Closure-by-Removal with off-Site disposal (CBR-Offsite). The CIP scenario entails consolidating CCR into the northern portion of the GMF GSP and capping it with a new cover system consisting of, from bottom to top, a geomembrane layer, a geotextile cushion if needed, and 24 inches of vegetated soil. The CBR-Offsite scenario entails excavating all of the CCR and liner system materials from the GMF GSP and transporting it to an off-Site landfill for disposal. For the GMF RP, Gradient evaluated one closure scenario: Closure-by-Removal with on-Site disposal (CBR-Onsite). The CBR-Onsite scenario entails excavating the CCR and liner system materials from the GMF RP and transporting these materials to an on-Site landfill for disposal. IPGC will also continue to evaluate potential opportunities for beneficial re-use of CCR excavated from the GMF GSP and the GMF RP as an alternative to disposal.

IAC Section 845.710(c)(2) requires CAAs to "[i]dentify whether the facility has an onsite landfill with remaining capacity that can legally accept CCR, and, if not, whether constructing an onsite landfill is possible" (IEPA, 2021a). There is an existing on-Site landfill at the Coffeen Power Plant Site with enough capacity to accept CCR from the GMF RP, but it does not have enough capacity to contain all of the material that would also be removed from the GMF GSP. Furthermore, due to the planned redevelopment of the Site as a utility-scale solar energy generation and battery energy storage facility, there is not sufficient space available to expand the existing landfill. Thus, for the CBR scenarios evaluated in this CAA, Gradient assumed that CCR from the GMF GSP would be disposed in an off-Site landfill, but CCR from the GMF RP would be disposed in an on-Site landfill.

Table S.1 summarizes the expected impacts of the CIP (GMF GSP), CBR-Offsite (GMF GSP), and CBR-Onsite (GMF RP) closure scenarios with regard to each of the factors specified under IAC Section 845.710 (IEPA, 2021a). Based on this evaluation and the additional details provided in Section 2 of this report, CIP of the GMF GSP and CBR-Onsite of the GMF RP have been identified as the most appropriate closure scenarios for the GMF GSP and the GMF RP. Key benefits of the CIP scenario relative to the CBR-Offsite scenario for the GMF GSP include the more rapid redevelopment of the Site for use in utility-scale solar generation and battery energy storage and reduced impacts to workers, community members, and the environment during construction (*e.g.*, fewer construction-related accidents, lower energy demands, less air pollution and greenhouse gas [GHG] emissions, less traffic-related impacts). This conclusion is subject to change as additional data are collected and following the completion of an upcoming public meeting, which will be held in June 2022 pursuant to requirements under IAC Section 845.710(e). Following the public meeting, a final closure decision will be made based on the considerations identified in this report, the results of additional data collection, and any additional considerations that arise during the public meeting. The final closure recommendation will be provided in a Final Closure Plan, which will be submitted to the Illinois Environmental Protection Agency (IEPA) as described under IAC Section 845.720(b) (IEPA, 2021a).

Table S.1 Comparison of Proposed Closure Scenarios

Evaluation Factor (Report Section; IAC Part 845 Section)	Closure Scenario CIP (GMF GSP)	 CBR-Offsite (GMF GSP)	 CBR-Onsite (GMF RP)
Closure Alternative Descriptions (Section 2.1, IAC Section 845.710(c))	The GMF GSP would be consolidated and capped in place with a new cover system consisting of, from bottom to top, a geomembrane layer, a geotextile cushion if needed, and 24 inches of vegetated soil. During the closure process, we will continue to assess off-Site CCR beneficial use opportunities. Ash consolidation and CIP in combination with off-Site beneficial use may result in a smaller footprint for purposes of our ultimate cap design along with a reduced construction schedule.	All CCR and existing liner materials would be excavated from the GMF GSP and transported *via* truck to an off-Site landfill for disposal. Expansion of the off-Site landfill may be necessary in order to accept all of the CCR and liner materials from the GMF GSP. The on-Site landfill does not have the capacity for all of the CCR from both the GMF GSP and the GMF RP, nor can it be expanded due to future redevelopment plans. This scenario meets the requirements of IAC Section 845.710(c)(2) (IEPA, 2021a), which requires an assessment be included in the CAA of whether the Site has an on-Site landfill with available capacity or whether an on-Site landfill can be constructed.	All CCR and existing liner materials would be excavated from the GMF RP and transported *via* truck to an on-Site landfill for disposal. This scenario meets the requirements of IAC Section 845.710(c)(2) (IEPA, 2021a), which requires an assessment be included in the CAA of whether the Site has an on-Site landfill with available capacity or whether an on-Site landfill can be constructed.
Type and Degree of Long-Term Management, Including Monitoring, Operation, and Maintenance (Section 2.2.3, IAC Section 845.710(b)(1)(C))	Monitoring would be performed for 30 years post-closure or until GWPSs are achieved, whichever is longer. Additionally, the final cover system for the GMF GSP would undergo 30 years of annual inspections, mowing, and maintenance.	Monitoring would be performed for 3 years post-closure or until GWPSs are achieved, whichever is longer.	Monitoring would be performed for 3 years post-closure or until GWPSs are achieved, whichever is longer. Additionally, the on-Site landfill cover would undergo 30 years of annual inspections, mowing, and maintenance.
Magnitude of Reduction of Existing Risks (Section 2.2.1, IAC Sections 845.710(b)(1)(A) and 845.710(b)(1)(F))	There are no current unacceptable risks to any human or ecological receptors associated with the GMF GSP. Because there are no current risks, and dissolved constituent concentrations would be expected to decline post-closure, no risks to human or ecological receptors would be expected post-closure.	There are no current unacceptable risks to any human or ecological receptors associated with the GMF GSP. Because there are no current risks, and dissolved constituent concentrations would be expected to decline post-closure, no risks to human or ecological receptors would be expected post-closure.	There are no current unacceptable risks to any human or ecological receptors associated with the GMF RP. Because there are no current risks, and dissolved constituent concentrations would be expected to decline post-closure, no risks to human or ecological receptors would be expected post-closure.
Likelihood of Future Releases of CCR (Section 2.2.2, IAC Sections 845.710(b)(1)(B) and 845.710(b)(1)(F))	During closure, there would be minimal risk of dike failure occurring at the GMF GSP (due to, *e.g.*, flooding or seismic activity) and minimal risk of dike overtopping during flood conditions. Post-closure, the risks of overtopping and dike failure would be even smaller than they are currently, due to the installation of a protective soil cover and new stormwater control structures. Dikes, final cover, and stormwater control features have been designed to withstand earthquakes and storm events.	During closure, there would be minimal risk of dike failure occurring at the GMF GSP (due to, *e.g.*, flooding or seismic activity) and minimal risk of dike overtopping during flood conditions. Following excavation, there would be no risk of CCR releases due to dike failure. Changing geochemical conditions during an extended excavation can be a mechanism that results in the mobilization and increased transport in groundwater for some constituents.	During closure, there would be minimal risk of dike failure occurring at the GMF RP (due to, *e.g.*, flooding or seismic activity) and minimal risk of dike overtopping during flood conditions. Following excavation, there would be no risk of CCR releases due to dike failure. Changing geochemical conditions during an extended excavation can be a mechanism that results in the mobilization and increased transport in groundwater for some constituents.
Worker Risks (Section 2.2.4.1, IAC Sections 845.710(b)(1)(D) and 845.710(b)(1)(F))	An estimated 0.0027 worker fatalities and 0.42 worker injuries would be expected to occur due to on-Site activities under this closure scenario. An additional 0.0027 worker fatalities and 0.21 worker injuries would be expected to occur off-Site due to vehicle accidents during hauling, labor and equipment mobilization and demobilization, and material deliveries. In total, 0.0054 worker fatalities and 0.62 worker injuries would be expected under this closure scenario. Overall, risks to workers would likely be higher under the CBR-Offsite scenario and lower under the CIP scenario. Simultaneous with closure activities, the Site would be redeveloped for use in utility-scale solar generation and battery energy storage. The simultaneous pursuit of two large construction projects may lead to traffic congestion on Site access roads, resulting in greater overall risks to workers than would result from either project alone. The CIP scenario would likely result in less traffic congestion – and, hence, a smaller increase in risks to workers – than the CBR-Offsite scenario.	An estimated 0.0017 worker fatalities and 0.26 worker injuries would be expected to occur due to on-Site activities under this closure scenario. An additional 0.0083 worker fatalities and 0.52 worker injuries would be expected to occur off-Site due to vehicle accidents during hauling, labor and equipment mobilization and demobilization, and material deliveries. In total, 0.010 worker fatalities and 0.78 worker injuries would be expected under this closure scenario. Overall, risks to workers would likely be higher under the CBR-Offsite scenario and lower under the CIP scenario. Simultaneous with closure activities, the Site would be redeveloped for use in utility-scale solar generation and battery energy storage. The simultaneous pursuit of two large construction projects may lead to traffic congestion on Site access roads, resulting in greater overall risks to workers than would result from either project alone. The CIP scenario would likely result in less traffic congestion – and, hence, a smaller increase in risks to workers – than the CBR-Offsite scenario.	An estimated 0.00088 worker fatalities and 0.14 worker injuries would be expected to occur due to on-Site activities under this closure scenario. An additional 0.0010 worker fatalities and 0.072 worker injuries would be expected to occur off-Site due to vehicle accidents during hauling, labor and equipment mobilization and demobilization, and material deliveries. In total, 0.0018 worker fatalities and 0.21 worker injuries would be expected under this closure scenario.

Evaluation Factor (Report Section; IAC Part 845 Section)	Closure Scenario		
	CIP (GMF GSP)	**CBR-Offsite (GMF GSP)**	**CBR-Onsite (GMF RP)**
Community Risks (Section 2.2.4.2, IAC Sections 845.710(b)(1)(D) and 845.710(b)(1)(F))			
▪ *Off-Site Impacts on Nearby Residents and EJ Communities*	Off-Site impacts on nearby residents (including accidents, traffic, noise, and air pollution) would be less under this closure scenario than under the CBR-Offsite scenario because it would require less off-Site vehicle and equipment travel miles than the CBR scenarios. In total, an estimated 0.0021 fatalities and 0.11 injuries would be expected to occur among community members due to off-Site activities under this scenario. No off-Site transport of CCR and/or borrow soil is required under this closure scenario. No impacts to nearby EJ communities are anticipated under this closure scenario.	Off-Site impacts on nearby residents would be greater under the CBR-Offsite closure scenario than under the CIP scenario because they would require significantly more off-Site vehicle and equipment travel miles and a longer construction duration. In total, an estimated 0.019 fatalities and 0.63 injuries would be expected to occur among community members due to off-Site activities under this scenario. With regard to traffic impacts, a haul truck would be likely to pass a location near the Site every 9.9 minutes on average during working hours for approximately 31-46 months under this closure scenario. No impacts to nearby EJ communities are anticipated under this closure scenario.	Limited off-Site impacts on nearby residents from the CBR-Onsite (GMF RP) would occur. In total, the CBR-Onsite (GMF RP) would result in an estimated 0.00085 fatalities and 0.041 injuries. No off-Site transport of CCR and/or borrow soil is required under this closure. No impacts to nearby EJ communities are anticipated under this closure scenario.
▪ *Impacts on Scenic, Historical, and Recreational Value*	Due to (*e.g.*) noise and visual disturbances, construction activities may have short-term negative impacts on the recreational use of the Coffeen Lake State Fish and Wildlife Area. Because the expected duration of construction activities is shorter under this closure scenario compared to the CBR-Offsite scenario, short-term impacts on the scenic and recreational value of natural areas near the Site would be less under this closure scenario than under the CBR-Offsite scenario. There are no historic sites in the vicinity of the impoundment, the on-Site landfill, or the on-Site borrow soil location. Thus, no impacts on historic sites would be expected under any closure scenario.	Due to (*e.g.*) noise and visual disturbances, construction activities may have short-term negative impacts on the recreational use of the Coffeen Lake State Fish and Wildlife Area. Because the expected duration of construction activities is longer under this scenario than under the CIP scenario, short-term impacts on the scenic and recreational value of natural areas near the Site would be greater under this closure scenario than under the CIP scenario. There are no historic sites in the vicinity of the impoundment or the on-Site borrow soil location. Thus, no impacts on historic sites would be expected under any closure scenario.	Due to (*e.g.*) noise and visual disturbances, construction activities may have short-term negative impacts on the recreational use of the Coffeen Lake State Fish and Wildlife Area. There are no historic sites in the vicinity of the impoundment or the on-Site landfill. Thus, no impacts on historic sites would be expected under any closure scenario.
Environmental Risks (Section 2.2.4.3, IAC Sections 845.710(b)(1)(D) and 845.710(b)(1)(F))			
▪ *Impacts on Greenhouse Gas Emissions and Energy Consumption*	Total energy demands and GHG emissions would be smaller under this closure scenario than under the CBR-Offsite scenarios, because the total equipment and vehicle mileages required under this closure scenario would be smaller than those required under the CBR-Offsite scenario The CIP scenario would have an additional, unquantified carbon footprint due to the need to manufacture geomembranes for use in the final cover system. At the grid scale, construction of a solar facility at the Site would put energy back on the grid and reduce reliance on non-renewable energy sources. Redevelopment of the Site for solar would occur more rapidly under the CIP scenario than under the two CBR scenarios.	Total energy demands and GHG emissions would be greater under the CBR-Offsite closure scenario than under the CIP scenario, because the total equipment and vehicle mileages required under this closure scenarios would be greater than those required under the CIP scenario. If expansion of the off-Site landfill becomes necessary in order to accept all of the CCR and liner materials from the GMF GSP, then the CBR-Offsite scenario would have an additional, unquantified carbon footprint due to the need to manufacture geomembranes for use in the expanded landfill liner. At the grid scale, construction of a solar facility at the Site would put energy back on the grid and reduce reliance on non-renewable energy sources. Redevelopment of the Site for solar would occur more slowly under the CBR-Offsite scenario than under the CIP scenario.	Energy demands and GHG emissions would result from equipment and vehicle mileage required for the CBR-Onsite scenario. The CBR-Onsite scenario would have an additional, unquantified carbon footprint due to the need to manufacture geomembranes for use in the final on-Site landfill cover system. At the grid scale, construction of a solar facility at the Site would put energy back on the grid and reduce reliance on non-renewable energy sources.

Evaluation Factor (Report Section; IAC Part 845 Section)	Closure Scenario		
	CIP (GMF GSP)	**CBR-Offsite (GMF GSP)**	**CBR-Onsite (GMF RP)**
▪ *Impacts on Natural Resources and Habitat*	Construction activities may have short-term negative impacts on species located near the GMF GSP, the on-Site borrow soil location, the off-Site borrow soil location, the on-Site landfill, and the off-Site landfill. Short-term impacts on natural resources and habitat would be smaller under the CIP scenario than under the CBR-Offsite scenario, because the overall duration of construction is shorter under the former scenario.	Construction activities may have short-term negative impacts on species located near the GMF GSP, the on-Site borrow soil location, the off-Site borrow soil location, the on-Site landfill, and the off-Site landfill. Short-term impacts on natural resources and habitat would be greater under the CBR-Offsite scenario than under the CIP scenario, because the overall duration of construction is longer under the former scenarios.	Construction activities may have short-term negative impacts on species located near the GMF GSP, the on-Site borrow soil location, the off-Site borrow soil location, the on-Site landfill, and the off-Site landfill.
Time Until Groundwater Protection Standards Are Achieved (Section 2.2.5, IAC Sections 845.710(b)(1)(E) and 845.710(d)(2 and 3))	Groundwater modeling was performed to evaluate future groundwater quality in the vicinity of the GMF GSP under each of the proposed closure scenarios (Ramboll, 2022). The modeling demonstrated that there are limited differences between CIP and CBR-Offsite in the timeframes to achieve the GWPSs at the GMF GSP. For most constituents at the GMF GSP, the GWPSs will be achieved in approximately 7 years after implementation of closure for both scenarios.	Groundwater modeling was performed to evaluate future groundwater quality in the vicinity of the GMF GSP under each of the proposed closure scenarios (Ramboll, 2022). The modeling demonstrated that there are limited differences between CIP and CBR-Offsite in the timeframes to achieve the GWPSs at the GMF GSP. For most constituents at the GMF GSP, the GWPSs will be achieved in approximately 7 years after implementation of closure for both scenarios. Additionally, changing geochemical conditions during an extended excavation can be a mechanism that results in the mobilization and increased transport in groundwater for some constituents. This may result in GWPS exceedance durations in excess of the model predictions.	Groundwater modeling was performed to evaluate future groundwater quality in the vicinity of the GMF RP under each of the proposed closure scenarios (Ramboll, 2022). The modeling demonstrated that for most constituents at the GMF RP, the GWPSs will be achieved in approximately 2.5 years after implementation of the CBR-Offsite closure scenario. Additionally, changing geochemical conditions during an extended excavation can be a mechanism that results in the mobilization and increased transport in groundwater for some constituents. This may result in GWPS exceedance durations in excess of the model predictions.
Long-Term Reliability of the Engineering and Institutional Controls (Section 2.2.7; IAC Section 845.710(b)(1)(G))	CIP would be expected to be a reliable closure alternative over the long term.	CBR-Offsite would be expected to be a reliable closure alternative over the long term.	CBR-Onsite would be expected to be a reliable closure alternative over the long term.
Potential Need for Future Corrective Action (Section 2.2.8; IAC Section 845.710(b)(1)(H))	Corrective action is expected at the Site. An evaluation of potential corrective measures and corrective actions has not yet been completed, but will be conducted consistent with the requirements in IAC Section 845.660 and IAC Section 845.670.	Corrective action is expected at the Site. An evaluation of potential corrective measures and corrective actions has not yet been completed, but will be conducted consistent with the requirements in IAC Section 845.660 and IAC Section 845.670.	Corrective action is expected at the Site. An evaluation of potential corrective measures and corrective actions has not yet been completed, but will be conducted consistent with the requirements in IAC Section 845.660 and IAC Section 845.670.
Effectiveness of the Alternative in Controlling Future Releases (Section 2.3; IAC Section 845.710(b)(2)(A and B))	There are no current or future risks to any human or ecological receptors associated with the GMF GSP. During closure, there would be minimal risk of dike failure occurring and minimal risk of dike overtopping during flood conditions. Post-closure, the risks of overtopping and dike failure would be even smaller than they are currently, due to the installation of a protective soil cover and new stormwater control structures. Dikes, final cover, and stormwater control features have been designed to withstand earthquakes and storm events.	There are no current or future risks to any human or ecological receptors associated with the GMF GSP. During closure, there would be minimal risk of dike failure occurring and minimal risk of dike overtopping during flood conditions. Following excavation, there would be no risk of CCR releases due to dike failure.	There are no current or future risks to any human or ecological receptors associated with the GMF RP. During closure, there would be minimal risk of dike failure occurring and minimal risk of dike overtopping during flood conditions. Following excavation, there would be no risk of CCR releases due to dike failure.

Evaluation Factor (Report Section; IAC Part 845 Section)	Closure Scenario		
	CIP (GMF GSP)	**CBR-Offsite (GMF GSP)**	**CBR-Onsite (GMF RP)**
Ease or Difficulty of Implementing the Alternative (Section 2.4, IAC Section 845.710(b)(3))			
▪ *Degree of Difficulty Associated with Construction*	CIP is a reliable and standard method for managing and closing waste impoundments. Dewatering saturated CCR to construct a stabilized final cover system subgrade may present challenges during closure; however, these challenges are common to most CCR surface impoundment closures and are commonly addressed *via* surface water management and dewatering techniques.	Relative to CIP, CBR-Offsite poses additional implementation difficulties due to higher earthwork volumes, higher dewatering volumes, longer construction schedules, and the need to remove and dispose of the existing bottom liner geomembrane. Hauling would be more difficult to implement under the CBR-Offsite scenario than under the CIP scenario, due to the longer haul distance required and the need to use public roads for hauling. Because the CCR would be hauled on public roads, it would require haul trucks with a smaller capacity (16.5 cubic yards *versus* 34 cubic yards) and would also need to be dewatered to a greater extent than would be necessary under the CIP scenario. Off-Site landfilling would additionally require the development of a disposal plan and could raise issues related to the co-disposal of CCR and other non-hazardous wastes. The off-Site landfill may also need to be expanded to receive all of the CCR generated during excavation.	CBR-Onsite poses several implementation difficulties due to earthwork volumes, dewatering volumes, construction schedules, and the need to remove and dispose of the existing bottom liner geomembrane.
▪ *Expected Operational Reliability*	Operational reliability would be expected under all closure scenarios.	Operational reliability would be expected under all closure scenarios.	Operational reliability would be expected under all closure scenarios.
▪ *Need for Permits and Approvals*	Permits required under all closure scenarios would include a modification to the existing NPDES permit; a construction permit from the IDNR Dam Safety Program to allow the embankment and spillways of the GMF GSP to be modified as part of closure; a construction stormwater permit through IEPA; and a joint water pollution control construction and operating permit (WPC permit).	Permits required under all closure scenarios would include a modification to the existing NPDES permit; a construction permit from the IDNR Dam Safety Program to allow the embankment and spillways of the GMF GSP to be modified as part of closure; a construction stormwater permit through IEPA; and a WPC permit. Additional permits and approvals may be required under this scenario if the off-Site landfill must be expanded to receive all of the CCR from the GMF GSP.	Permits required under all closure scenarios would include a modification to the existing NPDES permit; a construction permit from the IDNR Dam Safety Program to allow the embankment and spillways of the GMF RP to be modified as part of closure; a construction stormwater permit through IEPA; and a WPC permit.
▪ *Availability of Equipment and Specialists*	CIP and CBR rely on common construction equipment and materials and typically do not require the use of specialists. However, global supply chains have been disrupted due to the COVID-19 pandemic, resulting in shortages in the availability of construction equipment and parts. There may be delays in construction under all scenarios if supply chain resilience does not improve by the time of construction. Due to smaller earthwork volumes and a lesser need for construction equipment under the CIP scenario than under the CBR scenarios, shortages may cause fewer challenges under the CIP scenario than under the CBR scenarios.	CIP and CBR rely on common construction equipment and materials and typically do not require the use of specialists. However, global supply chains have been disrupted due to the COVID-19 pandemic, resulting in shortages in the availability of construction equipment and parts. There may be delays in construction under all scenarios if supply chain resilience does not improve by the time of construction. Due to higher earthwork volumes and a greater need for construction equipment under the CBR scenarios than under the CIP scenario, shortages may cause greater challenges under the CBR scenarios than under the CIP scenario. The current shortage of truck drivers may be particularly impactful under the CBR-Offsite scenario, due to the large volumes of borrow soil required and CCR to be hauled to and from the Site.	CBR relies on common construction equipment and materials and typically do not require the use of specialists. However, global supply chains have been disrupted due to the COVID-19 pandemic, resulting in shortages in the availability of construction equipment and parts. There may be delays in construction under all scenarios if supply chain resilience does not improve by the time of construction.

Evaluation Factor (Report Section; IAC Part 845 Section)	Closure Scenario		
	CIP (GMF GSP)	CBR-Offsite (GMF GSP)	CBR-Onsite (GMF RP)
▪ *Available Capacity and Location of Treatment, Storage, and Disposal Services*	Under the CIP scenario, all of the CCR currently within the GMF GSP would be stored within the existing footprint of the impoundment. Treatment would consist of unwatering the GMF GSP at the start of construction, performing limited dewatering to stabilize the CCR subgrade, and managing stormwater inflow. Water from unwatering and dewatering of the GMF GSP would be discharged in accordance with the NPDES permit for the facility.	The capacity remaining at the chosen off-Site landfill in Litchfield, Illinois, would be sufficient to receive all of the CCR and liner materials in the GMF GSP. However, due to the relatively short period over which CCR would be received at the landfill, vertical and/or lateral expansions may become necessary. Additionally, the landfill operators may need to develop a disposal plan to account for the increased volume of material that would be received and the unique CCR waste characteristics. If expansion of the chosen off-Site landfill were found to be impractical or infeasible, then an alternative landfill located farther from the Site would need to be identified. A likely alternative to the Litchfield-Hillsboro Landfill is the Five Oaks Landfill in Taylorville, Illinois. Water from unwatering and dewatering of the GMF GSP would be discharged in accordance with the NPDES permit for the facility.	The capacity remaining at the on-Site landfill would be sufficient to receive all of the CCR and liner materials in the GMF RP. Water from unwatering and dewatering of the GMF RP would be discharged in accordance with the NPDES permit for the facility.
Impact of Alternative on Waters of the State (Section 2.5, IAC Section 845.710(d)(4))	No current or future exceedances of any screening benchmarks for surface water would be expected under any closure scenario.	No current or future exceedances of any screening benchmarks for surface water would be expected under any closure scenario.	No current or future exceedances of any screening benchmarks for surface water would be expected under any closure scenario.
Potential Modes of Transportation Associated with CBR (Section 2.1; IAC Section 845.710(c)(1)	This factor is not relevant for CIP.	IAC Section 845.710(c)(1) requires CBR alternatives to consider multiple methods for transporting CCR off-Site, including *via* rail, barge, and trucks. Golder evaluated the feasibility of transporting CCR to the off-Site landfill *via* rail or barge and found that neither option is viable at this Site. Truck transport has been identified as the preferred option for transport of CCR to the off-Site landfill. The local availability and use of natural gas-powered trucks, or other low-polluting trucks, will be evaluated prior to the start of construction.	This factor is not relevant for CBR-Onsite.
Concerns of Residents Associated with Alternatives (Section 2.6, IAC Section 845.710(b)(4))	Despite the preference for CBR that has been expressed by nonprofits representing community interests near the Site, CIP would effectively address residents' concerns regarding potential impacts to groundwater and surface water quality at the Site. Relative to CBR-Offsite, CIP also presents less risks to nearby residents and potentially EJ communities in the form of accidents, traffic, noise, and air pollution. Moreover, under the CIP scenario, the Site could be more rapidly redeveloped for use in utility-scale solar generation and battery energy storage.	Nonprofits representing community interests near the Site have expressed a preference for CBR over CIP. However, the CBR-Offsite scenario has several disadvantages with regard to potential community concerns. Relative to CIP, the CBR-Offsite scenario presents greater risks to nearby residents and potentially EJ communities in the form of accidents, traffic, noise, and air pollution. Moreover, under the CBR-Offsite scenario, the Site could take longer to redevelop for use in utility-scale solar generation and battery energy storage.	CBR-Onsite would effectively address residents' concerns regarding potential impacts to groundwater and surface water quality at the Site.
Class 4 Cost Estimate (Section 2.7, IAC Section 845.710(d)(1))	A Class 4 cost estimate will be prepared in the Final Closure Plan consistent with AACE classification standards.	A Class 4 cost estimate will be prepared in the Final Closure Plan consistent with AACE classification standards.	A Class 4 cost estimate will be prepared in the Final Closure Plan consistent with AACE classification standards.

Notes:

AACE = Association for the Advancement of Cost Engineering; CBR-Offsite = Closure-by-Removal with Off-Site CCR Disposal; CBR-Onsite = Closure-by-Removal with On-Site CCR Disposal; CCR = Coal Combustion Residual; CIP = Closure-in-Place; EJ = Environmental Justice; GHG = Greenhouse Gas; GMF = Gypsum Manufacturing Facility; GSP = Gypsum Stack Pond; GWPS = Groundwater Protection Standard; IAC = Illinois Administrative Code; IDNR = Illinois Department of Natural Resources; IEPA = Illinois Environmental Protection Agency; NPDES = National Pollutant Discharge Elimination System; RP = Recycle Pond.

1 Introduction

1.1 Site Description and History

1.1.1 Site Location and History

Illinois Power Generating Company's (IPGC) Coffeen Power Plant is an electric power generating facility with coal-fired units located approximately two miles south of Coffeen, Illinois, and is situated between two lobes of Coffeen Lake. Historically, three room and pillar coal mines operated within the boundaries of the Site. From north to south, they are the Clover Leaf No. 1 Mine, which operated from 1889 to 1901; the Clover Leaf No. 4 Mine, which operated from 1906 to 1924; and the Hillsboro Mine, which operated from 1964 to 1983 (Ramboll, 2021a; ISGS and University of Illinois at Urbana-Champaign, 2011). The Coffeen Power Plant began operating in 1964 and was retired in November 2019 (Ramboll, 2021a,b).

1.1.2 CCR Impoundments

The Coffeen Power Plant produced and stored coal combustion residuals (CCRs) as a part of its historical operations. There are two gypsum management facility (GMF) units that are subject of this report: (1) the GMF Gypsum Stack Pond (GMF GSP); Vistra ID No. CCR Unit 103, Illinois Environmental Protection Agency [IEPA] ID No. W1350150004-03, and National Inventory of Dams [NID] ID No. IL50579), and (2) the GMF Recycle Pond (GMF RP); Vistra ID No. CCR Unit 104, IEPA ID No. W1350150004-04, and NID ID No. IL50578).

The GMF GSP (Figure 1.1) is a 43.3-acre surface impoundment constructed in 2010 to manage synthetic gypsum generated by the wet scrubber system and to clarify recycled process water from the plant (Ramboll, 2021a,b; Appendix B). It operated from 2010 until 2021 (Ramboll, 2021a,b). The GMF GSP received inflow from the Coffeen Power Plant. Clear water discharge from the GMF GSP flowed south to the GMF RP *via* a 580 foot lined transfer channel and a low-flow high-density polyethylene (HDPE) pipe beneath the transfer channel. The GMF GSP has a liner system consisting of a composite 60-millimeter (mil) HDPE geomembrane and a 36-inch layer of compacted clay with internal piping and drains to collect contact water (Ramboll, 2021a,b, Appendix B).

The GMF RP (Figure 1.1) is an 18.3 acre surface impoundment constructed in 2010 and located immediately south of the GMF GSP. Acting as a polishing pond, the GMF RP received decanted water from the GMF GSP (Ramboll, 2021a,b; Appendix B). It operated from 2010 until 2021 (Ramboll, 2021a,b). Outflow from the GMF RP was pumped back to the Coffeen Power Plant for use in the wet scrubber system (Appendix B). The GMF RP has an emergency spillway that discharges to the Unnamed Tributary *via* a National Pollutant Discharge Elimination System (NPDES)-permitted outfall. The GMF RP has a liner system consisting of a composite 60-mil textured HDPE geomembrane installed over smooth drum-rolled native soil with internal piping and drains to collect contact water (Ramboll, 2021a,b; Appendix B).

There are three former room and pillar coal mines within 1,000 meters of the GMF GSP and the GMF RP. From north to south, they are Clover Leaf No. 1 Mine (ISGS Mine No. 3001), Clover Leaf No. 4 Mine (ISGS Mine No. 442), and Hillsboro Mine (ISGS Mine No. 871). The GMF GSP overlies the southernmost portion of the Clover Leaf No. 4 Mine. The GMF RP does not directly overlie any of the former mines on the Site (Ramboll, 2021a,b).

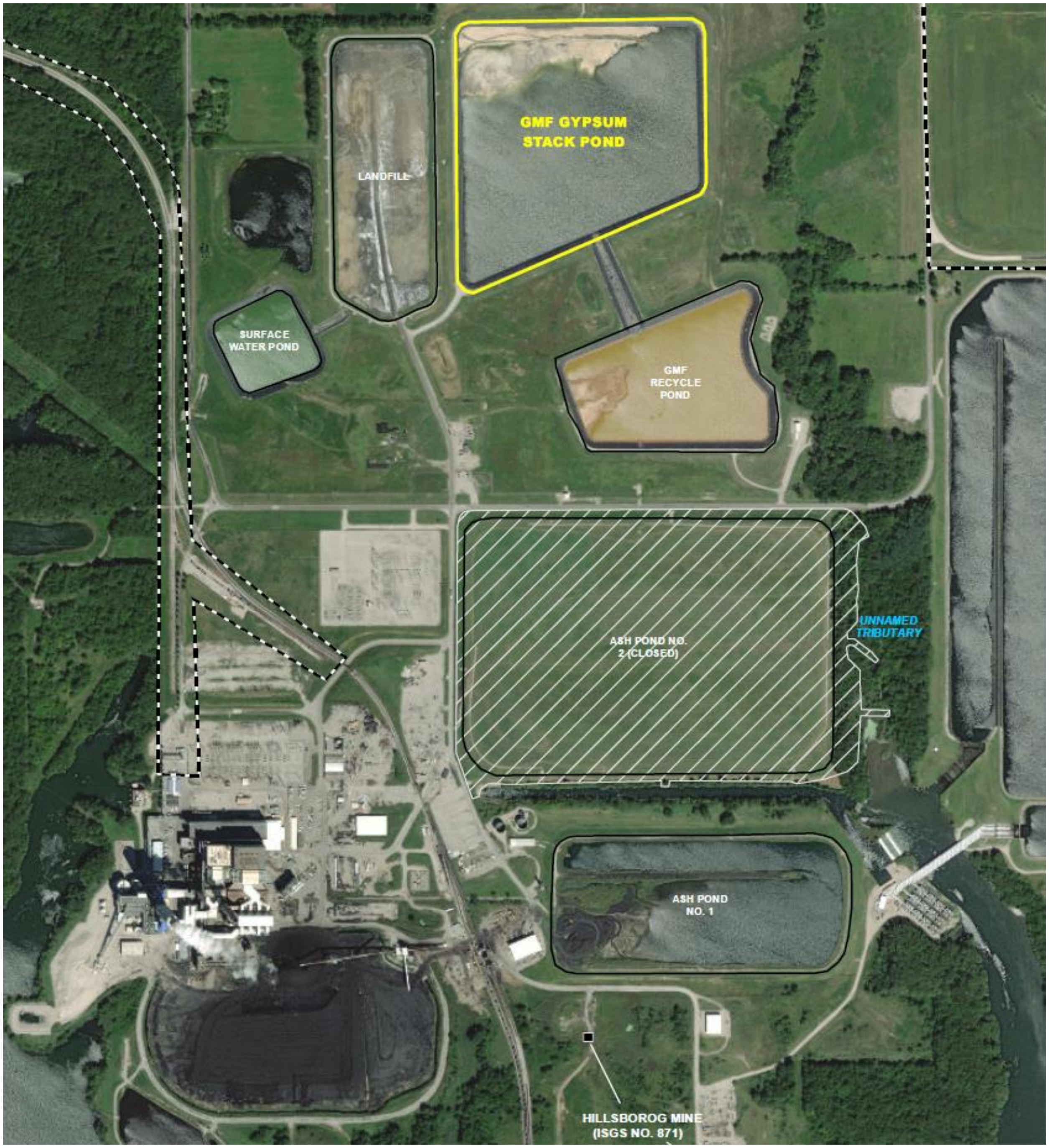

Figure 1.1 Site Location Map. Adapted from Ramboll (2021a).

1.1.3 Surface Water Hydrology

Coffeen Lake has two lobes that border the Coffeen Power Plant on the west, south, and part of the eastern Site boundary. East of the Site, the Unnamed Tributary flows into the eastern lobe of Coffeen

Lake. The facility is permitted to discharge to Coffeen Lake under NPDES Permit No. IL 0000108 and an emergency spillway is located in the northeast corner of the GMF RP (Ramboll, 2021b).

The GMF GSP and the GMF RP are located within the Shoal Creek Watershed (Hydrologic Unit Code [HUC] 07140203) and the outer perimeters of the impoundments are located 400 feet and 150 feet west of the Unnamed Tributary, respectively (Ramboll, 2021a,b). Within 1,000 meters of the GMF GSP and the GMF RP, there are several unnamed freshwater ponds and wetlands (Figure 1.2). The ponds range in size from 0.1 acre to 0.8 acre. There is an approximately 0.6 acre freshwater forested/shrub wetland located northwest of the GMF GSP and a 1.6 acre freshwater emergent wetland located to the southeast of the GMF RP where the Unnamed Tributary enters Coffeen Lake (Ramboll, 2021a,b).

The 1,100-acre Coffeen Lake was built by damming the McDavid Branch of the East Fork of Shoal Creek to aid with cooling for the facility (Ramboll, 2021a,b). The IEPA classifies Coffeen Lake as a General Use Water (IEPA, 2007): it is designated for aquatic life and use in primary contact recreation; however, it is not designated for use in food processing or as a public water supply. Coffeen Lake (Assessment Unit ID IL_ROG) is listed on the 2018 Illinois Section 303(d) List as being impaired for fish consumption due to mercury (IEPA, 2019a; US EPA, 2022). In addition, US EPA approved in 2007 a Total Maximum Daily Load (TMDL) for phosphorus to address aesthetic quality impairments in Coffeen Lake due to excess algae and total suspended solids (IEPA, 2007).

Surface water samples were collected from six locations in Coffeen Lake south of the GMF GSP and the GMF RP in August 2021 (Geosyntec Consultants, 2021). These data are summarized in Gradient's Human Health and Ecological Risk Assessment for the Site, which is provided as Appendix A of this report.

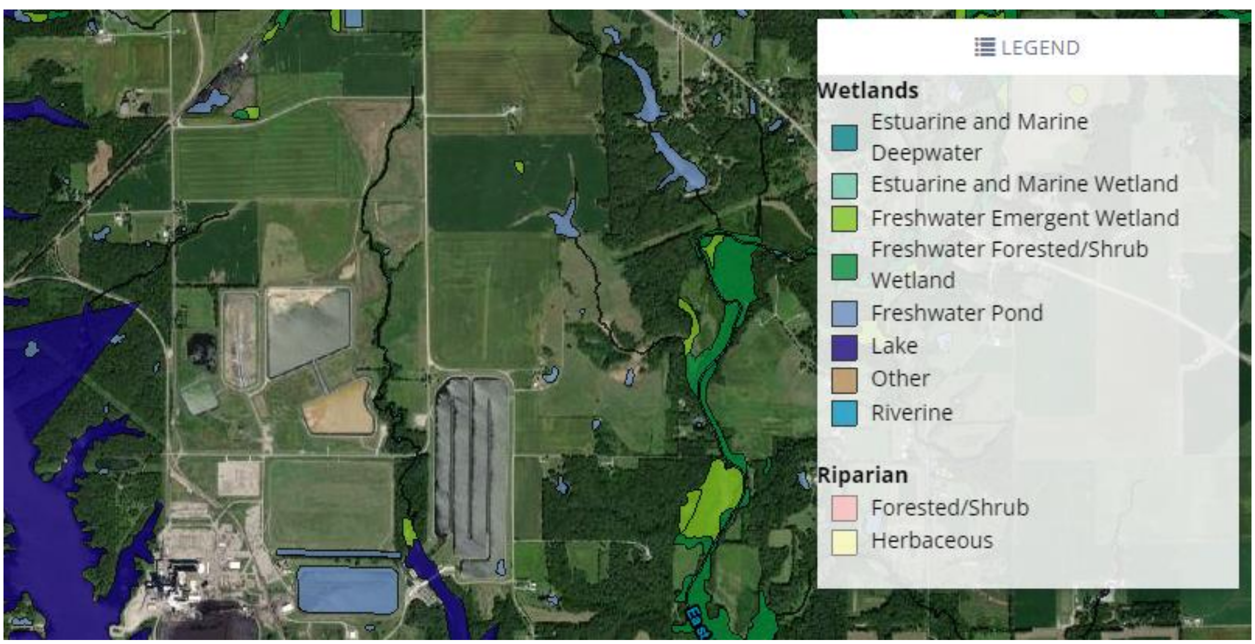

Figure 1.2 Wetlands and Surface Water Bodies in the Vicinity of the Coffeen Power Plant Gypsum Management Facility Gypsum Stack Pond and Recycle Pond. Adapted from US FWS (2021).

1.1.4 Hydrogeology

The geology underlying the Site in the vicinity of the GMF GSP and the GMF RP consists of several distinct layers (Ramboll, 2021a,b).

- Upper Confining Unit (UCU): The UCU underlies the GMF GSP and the GMF RP. It consists of the Loess Unit and the upper portion of the Hagarstown Member which has low permeability clays and silts with generally greater than 60 percent fines. The UCU was encountered across most of the Coffeen Power Plant Site, except near the Unnamed Tributary, where the unit was eroded where it has been excavated for construction.
- Uppermost Aquifer (UA): The UA is comprised of moderately permeable sands, silty sand, and clayey gravel of the Hagarstown Member and, in some portions of the Site, the Vandalia Member. The UA unit is missing in several locations due to both excavation and weathering.
- Lower Confining Unit (LCU): The LCU underlies the UA. It consists of three low hydraulic conductivity soils: the sandy clay till of the Vandalia Member, the silt of the Mulberry Grove Formation, and the compacted clay till of the Smithboro Member.
- Deep Aquifer (DA): The DA is a thin (generally less than 5 feet thick), discontinuous unit composed of sands and silty sands.
- Deep Confining Unit (DCU): The DCU underlies the DA. It consists of the Lierle Clay of the Banner Formation and acts as an aquitard due to its low hydraulic conductivity.

The Hydrogeological Site Characterization Reports prepared by Ramboll (2021a,b) provide more details regarding the hydrostratigraphic units in the vicinity of the GMF GSP and the GMF RP.

There is a groundwater flow divide within the UA in the center of the Coffeen Power Plant property between the two lobes of Coffeen Lake. Groundwater in the UA flows from the center of the Coffeen Power Plant property west toward Coffeen Lake and east toward the Unnamed Tributary. Groundwater predominantly flows east/southeast across the GMF GSP to the Unnamed Tributary; however, the western side of the GMF GSP aligns with the groundwater divide and groundwater in this area flows west toward Coffeen Lake. The GMF RP is located east of the divide, and groundwater flows southeast across the GMF RP. The Unnamed Tributary serves as a regional sink for shallow groundwater discharge and shallow groundwater migration beneath or beyond the tributary is unlikely (Ramboll, 2021a,b). Groundwater flow within the UA is mostly in the horizontal direction because the UA is underlain by the low-permeability LCU (Ramboll, 2021a,b).

During groundwater interaction with surface water, CCR-related constituents may partition between sediments and the surface water column. It should be noted that many CCR-related constituents occur naturally in sediments and surface water (and can also arise from other industrial sources). As a result, their presence in the sediments and/or surface water of the Coffeen Lake and the Unnamed Tributary does not necessarily signify contributions from the GMF GSP and the GMF RP.

The Hydrogeologic Site Characterization Reports prepared by Ramboll as part of the operating permit for the GMF GSP and the GMF RP include an evaluation of groundwater data collected from GMF GSP and GMF RP monitoring wells between 2015 and 2021 (Ramboll, 2021a,b).

1.1.5 Site Vicinity

The Coffeen Power Plant property is bordered by Coffeen Lake to the west and south, by the Unnamed Tributary and Coffeen Lake to the east, and by agricultural land to the north (Ramboll, 2021a, Figure 1.1). Coal mining operations occurred in the vicinity of the GMF GSP and the GMF RP from 1906 until 1983. Three mines were identified within a 1,000 meter radius of the GMF GSP and the GMF RP. From north to south, they are the Clover Leaf No. 1 Mine (Illinois State Geological Survey [ISGS] Mine No. 3001), which operated from 1889 to 1901; the Clover Lead No. 4 Mine (ISGS Mine No. 442), which operated from 1906 to 1924; and the Hillsboro Mine (ISGS Mine No. 871), which operated from 1964 to 1983. (Ramboll, 2021a,b; ISGS and University of Illinois at Urbana-Champaign, 2011). The GMF GSP partially overlies the southernmost extent of the Clover Leaf No. 4 Mine. The GMF RP does not directly overlie any of the former mines.

Although the area surrounding the Coffeen Power Plant is predominantly agricultural, Coffeen Lake and the surrounding land are used for recreational activities. Since 1986, Coffeen Lake State Fish and Wildlife Area (SFWA) has been open to the public under a lease and management agreement between the Illinois Department of Natural Resources (IDNR) and Ameren Energy Generating Company (IDNR, 1999). To the north of the Coffeen Power Plant, there are walking and hiking trails and bank fishing. Coffeen Lake also entertains fishing and picnicking on the western shore. Based on a review of the IDNR Historic Preservation Division database and the Illinois State Archaeological Survey database, there are no historic sites located within 1,000 meters of the GMF GSP and the GMF RP (Ramboll, 2021a,b).

1.2 IAC Part 845 Regulatory Review and Requirements

Title 35, Part 845 of the Illinois Administrative Code (IAC; IEPA, 2021a) requires the development of a Closure Alternatives Analysis (CAA) prior to undertaking closure activities at certain CCR-containing surface impoundments in the State of Illinois. Section 2 of this report presents a CAA for the GMF GSP and GMF RP pursuant to requirements under IAC Section 845.710. The goal of a CAA is to holistically evaluate each potential closure scenario with respect to a wide range of factors, including the efficiency, reliability, and ease of implementation of the closure scenario; its potential positive and negative short- and long-term impacts on human health and the environment; and its ability to address concerns raised by residents (IEPA, 2021a). A CAA is a decision-making tool that is designed to aid in the selection of an optimal closure alternative for the impoundments at a site.

2 Closure Alternatives Analysis

2.1 Closure Alternative Descriptions (IAC Section 845.710(c))

This section of the report presents a CAA for the GMF GSP and the GMF RP pursuant to requirements under IAC Section 845.710 (IEPA, 2021a). For the GMF GSP, Gradient evaluated two specific closure scenarios: Closure-in-Place (CIP) and Closure-by-Removal with off-Site disposal (CBR-Offsite). The CIP scenario entails consolidating CCR into the northern portion of the GMF GSP and capping it with a new cover system consisting of, from bottom to top, a geomembrane layer, a geotextile cushion if needed, and 24 inches of vegetated soil. The CBR-Offsite scenario entails excavating all of the CCR and liner system materials from the GMF GSP and transporting it to an off-Site landfill for disposal. For the GMF RP, Gradient evaluated one closure scenario: Closure-by-Removal with on-Site disposal (CBR-Onsite). The CBR-Onsite scenario entails excavating the CCR and liner system materials from the GMF RP and transporting these materials to an on-Site landfill for disposal. IPGC will also continue to evaluate potential opportunities for beneficial re-use of CCR excavated from the GMF GSP and GMF RP as an alternative to disposal.

IAC Section 845.710(c)(2) requires CAAs to, "[i]dentify whether the facility has an onsite landfill with remaining capacity that can legally accept CCR, and, if not, whether constructing an onsite landfill is possible" (IEPA, 2021a). There is an existing on-Site landfill at the Coffeen Power Plant Site with some remaining capacity to accept CCR. It has enough capacity to contain all of the material that would be removed from the GMF RP, but it does not have enough capacity to also contain the material that would be removed from the GMF GSP. Due to the planned redevelopment of the Site as a utility-scale solar energy generation and battery storage facility, there is not sufficient space available to expand the existing landfill. Thus, for the CBR scenarios evaluated in this CAA, Gradient assumed that the on-Site landfill would be used for disposal of CCR from the GMF RP, but CCR from the GMF GSP would be disposed in an off-Site landfill.

Sections 2.1.1 and 2.1.2 provide detailed descriptions of the CIP and CBR-Offsite closure scenarios for the GMF GSP, and Section 2.1.3 provides a detailed description of the CBR-Onsite closure scenario for the GMF RP. These scenarios are based on closure documents and analyses provided to Gradient by Golder, which are attached to this report as Appendix B.

2.1.1 GMF GSP Closure-in-Place

Under the CIP scenario, the GMF GSP would be capped in place with a final cover system. This scenario includes the following work elements (Golder Associates, 2022a):

- Unwatering and dewatering of the impoundment *via* pumping and passive dewatering methods. In addition to pumping ponded water, perimeter drains would also be pumped to lower the groundwater level beneath the GMF GSP, if needed. The CCR would dewater to some degree by gravity, but pumping from trenches and sumps may also be necessary. Water would be pumped to the existing drainage to the east of the GMF GSP and managed in accordance with the NPDES permit for the facility.

- Consolidation of the CCR from the GMF GSP by excavating CCR from the southern portion of the GMF GSP into the northern portion of the GMF GSP.
- Construction of a berm with a composite liner system consisting of a 60-mil HDPE geomembrane overlying a compacted clay layer that would be oriented east-west on the south end of the consolidated footprint.
- Removal and disposal of the existing liner system, components of the process water recovery system, and subsoil with CCR staining (up to 1 foot) within the consolidated footprint.
- Placement of compacted fill as needed to achieve final cover subgrade.
- Construction of an alternative cover system consisting of a 40-mil linear low-density polyethylene (LLDPE) geomembrane layer, a nonwoven geotextile cushion, and 24 inches of protective soil cover suitable for supporting vegetative growth. An alternative cover performance demonstration will be submitted to IEPA for approval pursuant to Section 845.750(c)(2).
- Removal of existing earthen embankments not required for the consolidated footprint and excavation of a channel to allow stormwater to flow off Site in accordance with the NPDES permit for the facility.
- Contouring and grading to manage stormwater.
- Site restoration including placement of vegetative cover on the final surface of the GMF GSP. Implementation of stormwater best management practices (BMPs) to reduce erosion, such as the use of erosion control blankets.
- Long-term (post-closure) monitoring and maintenance, including at least 30 years of groundwater monitoring at the impoundment, or until such time as groundwater protection standards (GWPSs) are achieved. Additionally, 30 years of post-closure care would be undertaken for the final cover system, including annual cap inspections, mowing, and maintenance.

This CIP plan meets all closure requirements of IAC Section 845.750 (IEPA, 2021a). Key closure elements that address the Part 845 closure requirements are summarized below. Further details are provided in the Closure Plan (Golder Associates, Inc., 2022a).

- An alternative cover system would be installed over the CCR that remains in the GMF GSP. The cover, consisting of a 40-mil LLDPE geomembrane low-permeability layer, a geotextile cushion if needed, and 24 inches of soil, would minimize vertical infiltration of precipitation into the basin (Section 845.750(a)(1)).
- The final cover system would be gently sloped to direct surface water away from the impoundment. Beyond the final cover system, channels would direct surface water away from the GMF GSP to existing Site drainages (Section 845.750(a)(2)).
- Impounded water would be removed from the GMF GSP and managed in accordance with the NPDES permit for the facility (Sections 845.750(b)(1) and 845.750(b)(2)).
- Free liquids in the CCR would be eliminated by removing liquid wastes. Trenches would facilitate gravity drainage of liquid wastes in the CCR and direct the liquid wastes to sumps. Other engineering measures may be considered to facilitate removal of liquid wastes and stabilization of wastes. Sumps would be used to collect liquid wastes, which would be managed in accordance with the NPDES permit for the Site (Sections 845.750(b)(1) and 845.750(b)(2)).

As an additional consideration, the proposed alternative cover system and the existing bottom liner system would provide complete encapsulation of the CCR, physically isolating it from contact with surrounding soils, groundwater, surface water, and the atmosphere. Lateral infiltration of groundwater into the impoundment would also be controlled due to the presence of the existing dual-composite bottom liner system, which would prevent groundwater from flowing into the impoundment (Golder Associates, Inc., 2022a). Furthermore, during the closure process, we will continue to assess off-Site CCR beneficial use opportunities. Ash consolidation and CIP in combination with off-Site beneficial use may result in a smaller footprint for purposes of our ultimate cap design along with a reduced construction schedule.

Under this scenario, approximately 177,000 cubic yards (CY) of CCR and subsoil would be relocated to the northern portion of the GMF GSP (an assumed travel distance of 2,000 feet; Appendix B). Additionally, 271,000 CY of material would be required for contouring and grading of the GMF GSP. Of this material, 229,000 CY would be sourced from an on-Site soil borrow area within 2,000 feet of the GMF GSP. Construction of the final cover system would require an additional 42,100 CY of soil to be hauled from a second on-Site borrow area within 2 miles of the GMF GSP (Appendix B). Haul truck capacities are assumed to be 34 CY for the on-Site transport of borrow soil (Appendix B).

Under the CIP (GMF GSP) scenario, the overall expected duration of closure activities (including closure of the impoundment and Site restoration) is approximately 22-33 months (1.8-2.8 years; Golder Associates, Inc., 2022a). The total expected number of on-Site workdays is 758 (Appendix B). Key parameters for the CIP (GMF GSP) scenario are shown in Table 2.1.

Table 2.1 Key Parameters for the GMF GSP Closure-in-Place Scenario

Parameter	Value
Surface Area of GMF GSP	43.3 acres
Surface Area of Final Cover System	12.4 acres
Average Travel Distance for Relocation of CCR	2,000 feet
Hauled Volume of CCR and Liner to be Relocated	177,000 CY
Average Distance to On-Site Borrow Soil Location	2,000 feet
Hauled Volume of Soil from On-Site Borrow Location	229,000 CY
Average Distance to Second On-Site Borrow Soil Location	2 miles
Hauled Volume of Soil from Second On-Site Borrow Location	42,100 CY
Duration of Construction Activities	758 days
Labor Hours	
Total On-Site Labor	36,200 hours
Total Off-Site Labor	4,660 hours
30% Contingency	12,200 hours
Total Labor Hours:	53,100 hours
Vehicle and Equipment Travel Miles	
Vehicles On-Site	13,400 miles
Equipment On-Site	56,900 miles
On-Site Haul Trucks (Unloaded + Loaded)	14,000 miles
Labor Mobilization	319,000 miles
Equipment Mobilization (Unloaded + Loaded)	65,000 miles
Off-Site Haul Trucks (Unloaded + Loaded)	0 miles
Material Deliveries (Unloaded + Loaded)	13,900 miles
Total On-Site Vehicle and Equipment Travel:	84,200 miles
Total Off-Site Vehicle and Equipment Travel:	397,000 miles
Total Vehicle and Equipment Travel:	482,000 miles

Notes:
CCR = Coal Combustion Residual; CY = Cubic Yards; GMF GSP = Gypsum Management Facility Gypsum Stack Pond.
Hauled volumes of CCR and soil are 5% greater than "in-place" volumes.
Due to rounding, totals may not match the sum of the values.
Source: Appendix B.

2.1.2 GMF GSP Closure-by-Removal with Off-Site CCR Disposal

Under the CBR-Offsite (GMF GSP) scenario, all CCR and liner system materials would be excavated from the GMF GSP and transported to an off-Site landfill for disposal. The preferred off-Site landfill for final disposal of the CCR is Republic Services' Litchfield-Hillsboro Landfill in Litchfield, Illinois, which is located approximately 18 miles from the Site (Appendix B). CCR would be hauled to the off-Site landfill using haul trucks with a capacity of 16.5 CY, a smaller capacity than that of the haul trucks that would haul CCR to the consolidated footprint under the CIP (GMF GSP) scenario (34 CY) due to restrictions placed on the size of trucks that can be used on public roadways. As is described below in Section 2.4.5, it is possible that the Litchfield-Hillsboro Landfill would have to be expanded in order to accept all of the material excavated from the GMF GSP.

IAC Section 845.710(c)(1) requires CBR alternatives to consider multiple methods for transporting CCR off-Site, including *via* rail, barge, and trucks. Golder evaluated the feasibility of transporting CCR to the off-Site landfill *via* rail or barge and found that neither option is viable at this Site (Appendix B). Transporting CCR by rail would require the construction of a new rail loading terminal on-Site and the construction of a new rail unloading terminal near the off-Site landfill. The construction of new rail terminals would require coordination with the railroad and additional permitting, which could negatively impact the project schedule. Trucks would still be needed to haul CCR to and from the terminals, and additional CCR exposures could occur during the loading and unloading of CCR into trucks and rail cars. Moreover, because there is no direct rail route from the Site to the off-Site landfill, the transport of CCR to the off-Site landfill would require 25 miles of rail transport on tracks owned by three separate rail lines.

The Coffeen Power Plant is not located near a navigable waterway; thus, transportation of CCR by barge is not feasible. For these reasons, truck transport has been identified as the preferred option for transport of CCR to the off-Site landfill. Transport *via* truck would not require the construction of additional loading or unloading infrastructure and would not result in project delays due to permitting and coordination with other parties. The existing travel routes from the Site to the off-Site landfill are suitable for CCR transport *via* truck (Appendix B). The local availability and use of natural gas-powered trucks, or other low-polluting trucks, will be evaluated prior to the start of construction.

This scenario includes the following work elements (Appendix B):

- Unwatering and dewatering of the impoundment *via* pumping and passive dewatering methods. In addition to pumping ponded water, perimeter drains would also be pumped to lower the groundwater level beneath the GMF GSP, if needed. The CCR would dewater to some degree by gravity, but pumping from trenches and sumps may also be necessary. Water would be pumped to the existing drainage to the east of the GMF GSP and managed in accordance with the NPDES permit for the facility.
- Excavation of CCR from the impoundment and transport of these materials to the off-Site landfill.
- Removal and disposal of the existing liner system, components of the process water recovery system, and subsoil with CCR staining (up to 1 foot) in the off-Site landfill.
- Removal of existing earthen embankments and excavation of a channel to allow stormwater to flow off Site in accordance with the NPDES permit for the facility.
- Contouring and grading to manage stormwater.
- Site restoration, including the placement of protective cover soil along the side slopes and bottom of the GMF GSP and revegetation with native grasses.
- Monitoring for 3 years post-closure or until such time as GWPSs are achieved, whichever is longer.

Under this scenario, approximately 556,000 CY of CCR and subsoil would be relocated to the off-Site landfill (an assumed travel distance of 18 miles; Appendix B). Additionally, 377,500 CY of material would be required for contouring and grading of the GMF GSP and Site restoration. Of this material, 256,000 CY would be sourced from an on-Site soil borrow area within 2,000 feet of the GMF GSP, 95,600 CY of soil would be sourced from an on-Site borrow area within 2 miles of the GMF GSP, and 25,900 CY of soil would be sourced from an off-Site borrow area within 2 miles of the Site. It is expected that a suitable off-Site borrow location can be identified within 2 miles of the Site (Appendix B). Haul truck capacities are assumed to be 34 CY for the on-Site transport of borrow soil and 16.5 CY for the off-Site transport of borrow soil (Appendix B).

Under the CBR-Offsite (GMF GSP) scenario, the overall expected duration of closure activities (including closure of the impoundment and Site restoration) is approximately 31-46 months (2.6-3.8 years). The total expected number of on-Site workdays is 1,160 (Appendix B). Key parameters for the CBR-Offsite (GMF GSP) scenario are shown in Table 2.2.

Table 2.2 Key Parameters for the GMF GSP Closure-by-Removal with Off-Site CCR Disposal Scenario

Parameter	Value
Surface Area of GMF GSP	43.3 acres
Distance to the Off-Site Landfill	18 miles
Hauled Volume of CCR and Liner to Off-Site Landfill	556,000 CY
Distance from the GMF GSP to the On-Site Borrow Location	2,000 feet
Hauled Volume of Borrow Soil from On-Site Borrow Location	256,000 CY
Distance from the GMF GSP to the Second On-Site Borrow Location	2 miles
Hauled Volume of Borrow Soil from the Second On-Site Borrow Location	95,600 CY
Distance from the GMF GSP to the Off-Site Borrow Location	2 miles
Hauled Volume of Borrow Soil from Off-Site Borrow Location	25,900 CY
Duration of Construction Activities	1,160 days
Labor Hours	
Total On-Site Labor	22,700 hours
Total Off-Site Labor	53,600 hours
30% Contingency	22,900 hours
Total Labor Hours:	99,300 hours
Vehicle and Equipment Travel Miles	
Vehicles On-Site	21,700 miles
Equipment On-Site	104,000 miles
On-Site Haul Trucks (Unloaded + Loaded)	17,000 miles
Labor Mobilization	569,000 miles
Equipment Mobilization (Unloaded + Loaded)	99,500 miles
Off-Site Haul Trucks (Unloaded + Loaded)	1,210,000 miles
Material Deliveries (Unloaded + Loaded)	9,000 miles
Total On-Site Vehicle and Equipment Travel:	143,000 miles
Total Off-Site Vehicle and Equipment Travel:	1,890,000 miles
Total Vehicle and Equipment Travel:	2,030,000 miles

Notes:
CCR = Coal Combustion Residual; CY = Cubic Yard; GMF GSP = Gypsum Management Facility Gypsum Stack Pond.
Hauled volumes of CCR and soil are 5% greater than "in-place" volumes.
Due to rounding, totals may not match the sum of the values.
Source: Appendix B.

2.1.3 GMF RP Closure-by-Removal with On-Site CCR Disposal

Under the CBR-Onsite (GMF RP) scenario, all CCR and existing liner system materials would be excavated from the GMF RP and transported to the on-Site landfill for disposal (Appendix B).

This scenario includes the following work elements (Golder Associates, Inc., 2022b):

- Unwatering and dewatering of the impoundment *via* pumping and passive dewatering methods. The CCR would dewater to some degree by gravity, but pumping from trenches and sumps may also be necessary. Water would be pumped to the existing drainage to the east of the GMF RP and managed in accordance with the NPDES permit for the facility.

- Excavation of CCR, the existing liner system, and subsoil with CCR staining (up to 1 foot) from the impoundment and disposal in the on-Site landfill.
- Removal of existing earthen embankments and excavation of a channel to allow stormwater to flow off Site in accordance with the NPDES permit for the facility.
- Contouring and grading to manage stormwater.
- Site restoration including placement of vegetative cover on the final surface of the GMF RP. Implementation of stormwater BMPs to reduce erosion, such as the use of erosion control blankets.
- Monitoring for 3 years post-closure or until such time as GWPSs are achieved, whichever is longer.

For the CBR-Onsite (GMF RP) closure scenario, approximately 83,000 CY of CCR and subsoil would be relocated to the on-Site landfill (an assumed travel distance of 2,000 feet; Appendix B). Additionally, 153,000 CY of material would be required for contouring and grading of the GMF RP and Site restoration. This material would be sourced from an on-Site soil borrow area within 2,000 feet of the GMF RP. Haul truck capacities are assumed to be 16.5 CY for the on-Site transport of borrow soil (Appendix B).

The on-Site landfill currently has approximately 375,500 CY of available capacity. Thus, the on-Site landfill has sufficient capacity to receive all of the CCR and liner materials from the GMF RP that are slated for disposal. This scenario meets the requirements of IAC Section 845.710(c)(2) (IEPA, 2021a), which requires an assessment be included in the CAA of whether the Site has an on-Site landfill with available capacity or whether an on-Site landfill can be constructed.

For the CBR-Onsite (GMF RP) closure scenario, the overall expected duration of closure activities (including closure of the impoundment and Site restoration) is approximately 12-17 months (1.0-1.4 years; Golder Associates, Inc., 2022b). The total expected number of on-Site workdays is 389 (Appendix B). Key parameters for the CBR-Onsite (GMF RP) scenario are shown in Table 2.3.

Table 2.3 Key Parameters for the GMF RP Closure-by-Removal with On-Site CCR Disposal Scenario

Parameter	Value
Surface Area of GMF RP	18.3 acres
Distance to the On-Site Landfill	2,000 feet
Hauled Volume of CCR and Liner	83,000 CY
Distance to the Borrow Site	2,000 feet
Hauled Volume of Borrow Soil	153,000 CY
Duration of Construction Activities	389 days
Labor Hours	
Total On-Site Labor	11,800 hours
Total Off-Site Labor	2,320 hours
30% Contingency	4,240 hours
Total Labor Hours:	18,400 hours
Vehicle and Equipment Travel Miles	
Vehicles On-Site	5,990 miles
Equipment On-Site	17,500 miles
On-Site Haul Trucks (Unloaded + Loaded)	5,250 miles
Labor Mobilization	109,000 miles
Equipment Mobilization (Unloaded + Loaded)	33,400 miles
Off-Site Haul Trucks (Unloaded + Loaded)	0 miles
Material Deliveries (Unloaded + Loaded)	4,400 miles
Total On-Site Vehicle and Equipment Travel:	28,700 miles
Total Off-Site Vehicle and Equipment Travel:	147,000 miles
Total Vehicle and Equipment Travel:	175,000 miles

Notes:
CCR = Coal Combustion Residual; CY = Cubic Yard; GMF RP = Gypsum Management Facility Recycle Pond.
Hauled volumes of CCR and soil are 5% greater than "in-place" volumes.
Due to rounding, totals may not match the sum of the values.
Source: Appendix B.

2.2 Long- and Short-Term Effectiveness of the Closure Alternative (IAC Section 845.710(b)(1))

2.2.1 Magnitude of Reduction of Existing Risks (IAC Section 845.710(b)(1)(A))

This section of the report addresses the potential risks to human and ecological receptors due to exposure to CCR-associated constituents in groundwater or surface water. Gradient has performed a Human Health and Ecological Risk Assessment for the Site (Appendix A of this report), which provides a detailed evaluation of the magnitude of existing risks to human and ecological receptors associated with the GMF GSP and the GMF RP. This report concluded that there are no current unacceptable risks to any human or ecological receptors associated with the GMF GSP and the GMF RP. Because there are no current risks to any human or ecological receptors, and dissolved constituent concentrations would be expected to decline post-closure, no post-closure risks would be expected under any closure scenario. Thus, there would be no current risk or future risk under any closure scenario, and the magnitude of reduction of existing risks would be the same under each closure scenario (CIP [GMF GSP], CBR-Offsite [GMF GSP], and CBR-Onsite [GMF RP]).

2.2.2 Likelihood of Future Releases of CCR (IAC Section 845.710(b)(1)(B))

This section of the report quantifies the risk of future releases of CCR that may occur during dike failure and storm-related events.

Storm-Related Releases and Dike Failure During Flood Conditions

Based on the effective Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map for the Site, the GMF GSP and the GMF RP are not located within the 100-year flood zone for Coffeen Lake and the Unnamed Tributary (FEMA, 1981; Ramboll, 2021a,b). Engineering analyses show that the risk of overtopping occurring during flood conditions is also minimal under current conditions. Specifically, AECOM and Hanson Professional Services (Hanson) evaluated the risk of flood overtopping occurring at the GMF GSP and the GMF RP, respectively, and found that the impoundments can adequately manage flow during peak discharge periods from the probable maximum flood (PMF) storm event, thus preventing overtopping (AECOM, 2016a; Hanson, 2016a). Additionally, engineering analyses show that the GMF GSP and the GMF RP dikes are expected to remain stable under static, seismic, and flood conditions (AECOM, 2016b; Hanson, 2016b). Prior to closure (*i.e.*, under current conditions), the risk of dike failure occurring during floods or other storm-related events is therefore minimal. Post-closure, the risks of overtopping and dike failure occurring due to floods or other storm-related events would be even smaller than they are currently. Under the CIP (GMF GSP) scenario, a new cover system would be installed, which would include 24 inches of soil and a geomembrane liner, as well as new stormwater control structures. Relative to current conditions, this cover system would provide increased protection against berm and surface erosion, groundwater infiltration, and other adverse effects that could potentially trigger a dike slope failure event. Under the CBR scenarios, all of the CCR in the GMF GSP and the GMF RP would be excavated and relocated, eliminating the risk of a CCR release occurring post-closure. In summary, there is minimal current or future risk of sudden CCR releases occurring under any closure scenario either during or following closure.

Dike Failure Due to Seismicity

Sites in Illinois may be subject to seismic risks arising from the Wabash Valley Seismic Zone and the New Madrid Seismic Zone (IEMA, 2020). The Coffeen Power Plant property lies within a seismic impact zone (Ramboll, 2021a,b). However, all structural components of the GMF GSP and the GMF RP have been designed to resist the maximum horizontal acceleration in lithified earth material for the Site. The GMF GSP and the GMF RP therefore meet the seismic safety requirements of 40 Code of Federal Regulations (CFR) Section 257.63(a) and IAC Section 845.330, and the overall risk of dike failure due to seismicity is expected to be low (Haley & Aldrich, 2018a,b; Ramboll, 2021a,b). Additionally, the GMF GSP and the GMF RP do not lie within 200 feet of an active fault or fault damage zone at which displacement has occurred within the current geological epoch (*i.e.*, within the last ~11,650 years; Haley & Aldrich, Inc., 2018c,d). The nearest known mapped faults are the Crown Fault, which is located about 31 miles northwest of the Coffeen Power Plant, and the Centralia Fault zone, which is located about 35 miles southeast of the Coffeen Power Plant. These faults do not have known recent activity (Haley & Aldrich, 2018a,b); however, a magnitude 3.8 earthquake occurred approximately 15 miles south of the Site in 1981 and a magnitude 3.6 earthquake occurred approximately 20 miles southeast of the Site in 1990 (Ramboll, 2021a,b). Having met the seismic safety requirements, the risk of dike failure occurring during or following closure activities due to seismic activity is low at the GMF GSP and the GMF RP.

2.2.3 Type and Degree of Long-Term Management, Including Monitoring, Operation, and Maintenance (IAC Section 845.710(b)(1)(C))

The long-term operation and management plans for the GMF GSP and the GMF RP are described in Section 2.1 (Closure Alternatives Descriptions). In summary, under the CIP scenario, the GMF GSP would undergo monitoring for 30 years post-closure, or until such time as GWPSs are achieved. Under the CBR-Offsite scenario for the GMF GSP and the CBR-Onsite scenario for the GMF RP, the GMF GSP and the GMF RP would undergo monitoring for 3 years post-closure, or until such time as GWPSs are achieved. The post-closure care plan for the CIP scenario for the GMF GSP would include annual inspections, mowing, and maintenance of the final cover system.

2.2.4 Short-Term Risks to the Community or the Environment During Implementation of Closure (IAC Section 845.710(b)(1)(D))

This section of the report evaluates the risks to workers, the community, and the environment during closure implementation. Relative comparisons are made between risks associated with the CIP (GMF GSP) scenario and the CBR-Offsite (GMF GSP) scenario. Risks for the CBR-Onsite (GMF RP) scenario are also presented.

2.2.4.1 Worker Risks

Best practices would be employed during construction in order to ensure worker safety and comply with all relevant regulations, permit requirements, and safety plans. However, it is impossible to completely eliminate the risk of accidents occurring during construction activities, both on- and off-Site. On-Site accidents include injuries and deaths arising from the use of heavy equipment and/or earthmoving operations during construction activities. Off-Site accidents include injuries and deaths due to vehicle accidents during labor and equipment mobilization/demobilization, material deliveries, and the hauling of borrow soil and CCR.

As shown in Tables 2.1 through 2.3, Golder estimates that the CIP (GMF GSP) scenario would require 36,200 on-Site labor hours (Appendix B). The CBR-Offsite (GMF GSP) scenario would require approximately 22,700 on-Site labor hours, and the CBR-Onsite (GMF RP) scenario would require approximately 11,800 on-Site labor hours. The US Bureau of Labor Statistics (US DOL, 2020a,b) provides an estimate of the hourly fatality and injury rates for construction workers. Based on the accident rates reported by US Bureau of Labor Statistics and the on-Site labor hours reported in Appendix B, we estimate that approximately 0.42 worker injuries and 0.0027 worker fatalities would occur on-Site under the CIP (GMF GSP) scenario; approximately 0.26 worker injuries and 0.0017 worker fatalities would occur on-Site under the CBR-Offsite (GMF GSP) scenario; and approximately 0.14 worker injuries and 0.00088 worker fatalities would occur on-Site under the CBR-Onsite (GMF RP) scenario (Table 2.4). The rate of on-Site worker accidents is therefore expected to be higher under the CIP (GMF GSP) scenario and lower under the CBR-Offsite (GMF GSP) scenario.

Table 2.4 Expected Number of On-Site Worker Accidents Under Each Closure Scenario

Closure Scenario	Injuries	Fatalities
CIP (GMF GSP)	0.42	0.0027
CBR-Offsite (GMF GSP)	0.26	0.0017
CBR-Onsite (GMF RP)	0.14	0.00088

Notes:
CBR-Offsite = Closure-by-Removal with Off-Site CCR Disposal; CBR-Onsite = Closure-by-Removal with On-Site CCR Disposal; CCR = Coal Combustion Residual; CIP = Closure-in-Place; GMF = Gypsum Manufacturing Facility; GSP = Gypsum Stack Pond; RP = Recycle Pond.

Off-Site, a greater number of haul truck miles, labor and equipment mobilization/demobilization miles, and material delivery miles would be required under the CBR-Offsite (GMF GSP) scenario than would be required under the CIP (GMF GSP) scenario (Tables 2.1 through 2.3). For example, under the CBR-Offsite (GMF GSP) scenario, 1,210,000 haul truck miles would be required to haul CCR and borrow soil to and from the Site, and for the CIP (GMF GSP) scenario and the CBR-Onsite (GMF RP) scenario, off-Site hauling is not required (Appendix B). The United States Department of Transportation (US DOT, 2020) provides estimates of the expected number of fatalities and injuries "per vehicle mile driven" for drivers and passengers of large trucks and passenger vehicles. Table 2.5 shows the expected number of off-Site accidents under each closure scenario due to all categories of off-Site vehicle usage. For these calculations, it was assumed that labor mobilization/demobilization would rely on passenger vehicles (cars or light trucks, including pickups, vans, and sport utility vehicles) and that hauling, equipment mobilization/demobilization, and material deliveries would rely on large trucks. Based on US DOT's accident statistics and the mileage estimates in Appendix B, an estimated 0.21 worker injuries and 0.0027 worker fatalities would be expected to occur due to off-Site activities under the CIP (GMF GSP) scenario; an estimated 0.52 worker injuries and 0.0083 worker fatalities would be expected to occur due to off-Site activities under the CBR-Offsite (GMF GSP) scenario; and an estimated 0.072 worker injuries and 0.0010 worker fatalities would be expected to occur due to off-Site activities under the CBR-Onsite (GMF RP) scenario (Table 2.5).

Table 2.5 Expected Number of Off-Site Worker Accidents Under Each Closure Scenario

Off-Site Vehicle Use Category	CIP (GMF GSP)		CBR-Offsite (GMF GSP)		CBR-Onsite (GMF RP)	
	Injuries	Fatalities	Injuries	Fatalities	Injuries	Fatalities
Hauling	0	0	0.16	0.0035	0	0
Labor Mobilization/Demobilization	0.20	0.0025	0.35	0.0045	0.067	0.00085
Equipment Mobilization/ Demobilization	0.0083	0.00019	0.013	0.00029	0.0043	0.00010
Material Deliveries	0.0018	0.000040	0.0012	0.000026	0.00056	0.000013
Total:	0.21	0.0027	0.52	0.0083	0.072	0.0010

Notes:
CBR-Offsite = Closure-by-Removal with Off-Site CCR Disposal; CBR-Onsite = Closure-by-Removal with On-Site CCR Disposal; CCR = Coal Combustion Residual; CIP = Closure-in-Place; GMF = Gypsum Manufacturing Facility; GSP = Gypsum Stack Pond; RP = GMF Recycle Pond.

Overall, taking into account accidents occurring both on- and off-Site, 0.62 worker injuries and 0.0054 worker fatalities would be expected under the CIP (GMF GSP) scenario; 0.78 worker injuries and 0.010 worker fatalities would be expected under the CBR-Offsite (GMF GSP) scenario. Thus, overall risks to workers would be higher under the CBR-Offsite (GMF GSP) scenario and lower under the CIP (GMF GSP) scenario. Additionally, 0.21 worker injuries and 0.0018 worker fatalities would be expected under the CBR-Onsite (GMF RP) scenario.

Concurrently with closure activities, a utility-scale solar facility and battery energy storage facility would be constructed on the Coffeen Power Plant Site. The simultaneous pursuit of closure-related construction and solar/energy storage facility construction may lead to traffic congestion on Site access roads, resulting in greater overall risks to workers than would result from closure or solar/energy storage redevelopment alone. Because the CIP (GMF GSP) scenario would require less hauling activity (and other forms of ingress and egress to and from the Site) than the CBR-Offsite (GMF GSP) scenario and would also be completed over a shorter time period, the CIP (GMF GSP) scenario would be expected to result in less congestion on Site access roads during Site redevelopment – and, hence, a smaller increase in the risks to workers – than would occur under the CBR scenario.

In summary, risks to workers due to accidents would be expected to be greater under the CBR-Offsite (GMF GSP) scenario than under the CIP (GMF GSP) scenario. Differences in worker risks between the two scenarios would largely be driven by off-Site activities.

2.2.4.2 Community Risks

Accidents

Vehicle accidents that occur off-Site can result in injuries or fatalities among community members, as well as workers. Based on the accident statistics reported by US DOT (2020) and the off-Site travel mileages reported in Appendix B, off-Site vehicle accidents could result in an estimated 0.11 injuries and 0.0021 fatalities among community members (*i.e.*, people involved in haul truck accidents that are neither haul truck drivers nor passengers, including pedestrians, drivers of other vehicles, *etc.*) under the CIP (GMF GSP) scenario (Table 2.6). Under the CBR-Offsite (GMF GSP) scenario, off-Site vehicle accidents could result in an estimated 0.63 community injuries and 0.019 community fatalities. Under the CBR-Onsite (GMF RP) scenario, off-Site vehicle accidents could result in an estimated 0.041 community injuries and 0.00085 community fatalities. Risks to community members arising from vehicle accidents are therefore higher under the CBR-Offsite (GMF GSP) scenario than under the CIP (GMF GSP) scenario.

Table 2.6 Expected Number of Community Accidents Under Each Closure Scenario

Off-Site Vehicle Use Category	CIP (GMF GSP)		CBR-Offsite (GMF GSP)		CBR-Onsite (GMF RP)	
	Injuries	Fatalities	Injuries	Fatalities	Injuries	Fatalities
Hauling	0	0	0.45	0.016	0	0
Labor Mobilization/Demobilization	0.079	0.0010	0.14	0.0018	0.027	0.00034
Equipment Mobilization/ Demobilization	0.024	0.00087	0.037	0.0013	0.012	0.00044
Material Deliveries	0.0051	0.00018	0.0033	0.00012	0.0016	0.000059
Total:	0.11	0.0021	0.63	0.019	0.041	0.00085

Notes:
CBR-Offsite = Closure-by-Removal with Off-Site CCR Disposal; CBR-Onsite = Closure-by-Removal with On-Site CCR Disposal; CCR = Coal Combustion Residual; CIP = Closure-in-Place; GMF = Gypsum Manufacturing Facility; GSP = Gypsum Stack Pond; RP = Recycle Pond.

Traffic

Haul routes would be expected to use major arterial roads and highways wherever possible, which would reduce the incidence of traffic. However, the heavy use of local roads for construction operations may result in traffic near the Site, the off-Site landfill, and the off-Site borrow site. Traffic could potentially cause travel delays on local roads and damage to local roadways. It could also cause delays in the redevelopment of the Site for use in utility-scale solar generation and battery energy storage.

Traffic may increase temporarily around the Site under all closure scenarios due to the daily arrival and departure of the workforce, equipment mobilization/demobilization, and material deliveries. However, these impacts would be expected to largely occur at the beginning or end of each workday (during the arrival/departure of the work force), at the beginning or end of the construction period (during equipment mobilization/demobilization), and at specific times throughout the construction period (during material deliveries). These impacts would therefore likely be less disruptive to community members than the constant and steady movement of haul trucks to and from the Site due to CCR hauling and borrow soil hauling.

Off-Site CCR hauling would only be required under the CBR-Offsite (GMF GSP) scenario. Under this scenario, hauling-related construction activities would be expected to span approximately 1,160 workdays and require approximately 35,300 truckloads (33,700 truckloads of CCR and 1,600 truckloads of borrow soil; Appendix B). Assuming 10-hour workdays, a haul truck would need to pass a given location near the Site once every 9.9 minutes on average for the duration of hauling-related activities under this closure scenario.

Noise

Construction generates a great deal of noise, both in the vicinity of the Site and along haul routes. In a closure impact analysis performed by the Tennessee Valley Authority (TVA, 2015), the authors found that "[T]ypical noise levels from construction equipment used for closure are expected to be 85 dBA or less when measured at 50 ft. These types of noise levels would diminish with distance… at a rate of approximately 6 dBA per each doubling of distance and therefore would be expected to attenuate to the recommended EPA noise guideline of 55 dBA at 1,500 ft." There is one residence northwest of the on-Site landfill, and several residences east of the second on-Site borrow area that are within 1,500 feet of construction areas that could be temporarily impacted by construction noise under the CBR-Onsite (GMF RP) and CBR-Offsite (GMF GSP) scenarios. Likewise, recreators and wildlife in the Coffeen Lake SFWA, which lies within 1,500 feet of the GMF GSP and the GMF RP, could be temporarily impacted by construction noise under all scenarios. The duration of noise impacts in the vicinity of the GMF GSP and the GMF RP would be greater under the CBR-Offsite (GMF GSP) scenario than under the CIP (GMF GSP) scenario, because the expected duration of construction is longer (31-46 months under the CBR-Offsite (GMF GSP) scenario *versus* 22-33 months under the CIP (GMF GSP) scenario). The duration of noise impacts for the CBR-Onsite (GMF RP) scenario is 12-17 months.

In addition to impacts in the immediate vicinity of planned construction areas at the Site, local roads near the Site, the off-Site landfill, and the off-Site borrow site may also experience noise pollution under the CBR-Offsite (GMF GSP) scenario due to high volumes of haul truck traffic. As described above (Traffic), the construction schedule for the CBR-Offsite (GMF GSP) scenario requires haul trucks to pass by a given location every 9.9 minutes on average for 10 hours each day for approximately 31-46 months. Dump trucks generate significant noise pollution, with noise levels of approximately 88 decibels or higher expected within a 50-foot radius of the truck (Exponent, 2018). This noise level is similar to the noise level of a gas-powered lawnmower or leaf blower (CDC, 2019). Decibel levels above 80 can damage hearing after 2 hours of exposure (CDC, 2019).

In addition to haul truck impacts, noise pollution may also arise from the daily arrival and departure of the workforce, equipment mobilization/demobilization, and material deliveries. These impacts would be expected to largely occur at the beginning or end of each workday (during the arrival/departure of the work force), at the beginning or end of the construction period (during equipment mobilization/demobilization), and at specific times throughout the construction period (during material deliveries). These impacts would therefore likely be less disruptive to community members than the constant and steady movement of haul trucks to and from the Site. In summary, noise impacts are likely to be greater under the CBR-Offsite (GMF GSP) scenario than under the CIP (GMF GSP) scenario.

Air Quality

Construction can adversely impact air quality. Air pollution can occur both on-Site and off-Site (*e.g.*, along haul routes), potentially impacting workers as well as community members. With regard to construction activities, two categories of air pollution are of particular concern: equipment emissions and fugitive dust. The equipment emissions of greatest concern are those found in diesel exhaust. Most construction equipment is diesel-powered, including the dump trucks that would be used to haul material to and from the Site. Diesel exhaust contains numerous air pollutants, including nitrogen oxides (NO_x), particulate matter (PM), carbon monoxide (CO), and volatile organic compounds (VOCs; Hesterberg *et al*., 2009; Mauderly and Garshick, 2009). Fugitive dust, another major air pollutant at construction sites, is generated by earthmoving operations and other soil- and CCR-handling activities. Along haul routes, an additional source of fugitive dust is road dust along unpaved dirt roads. Careful planning and the use of BMPs such as wet suppression are used to minimize and control fugitive dust during construction activities; however, it is not possible to prevent dust generation entirely.

On-Site, emissions would be higher under the CBR-Offsite (GMF GSP) scenarios than under the CIP (GMF GSP) scenario, due to the greater amount of on-Site vehicle and equipment travel miles required under these scenarios (84,200 total on-Site travel miles under the CIP (GMF GSP) scenario *versus* 143,000 total on-Site travel miles under the CBR-Offsite (GMF GSP) scenario with an additional 28,700 total on-Site travel miles under the CBR-Onsite (GMF RP) scenario; Tables 2.1 through 2.3). Off-Site, emissions would similarly be higher under the CBR-Offsite (GMF GSP) scenario than under the CIP (GMF GSP) scenario due to the greater amount of off-Site vehicle and equipment travel miles required under these scenarios (397,000 total off-Site travel miles under the CIP [GMF GSP] scenario *versus* 1,890,000 total off-Site travel miles under the CBR-Offsite [GMF GSP] scenario with an additional 147,000 total off-Site travel miles under the CBR-Onsite [GMF RP] scenario).

Environmental Justice

The State of Illinois defines environmental justice (EJ) communities to be those communities with a minority population above twice the state average and/or a total population below twice the state poverty rate (IEPA, 2019b).

As shown in a map of EJ communities throughout the state (IEPA, 2019b), the outer perimeter of the 1-mile buffer zone for the nearest EJ community lies approximately 10 miles south of the Site near Greenville (Figure 2.1). As described above (Noise), significant noise impacts due to construction are expected to be limited to potential receptors located within 1,500 feet (0.28 miles) of the Site. Similarly, the air quality impacts of construction are expected to be limited to potential receptors located within 1,000 feet (0.19 miles) of the Site (CARB, 2005; BAAQMD, 2017). Along heavily trafficked roadways, air quality impacts are expected to be limited to potential receptors located within 600 feet of the roadway (0.11 miles; US EPA, 2014). The EJ community near Greenville is therefore unlikely to be directly impacted by on-Site air emissions, noise pollution, or other negative impacts arising at the Site. However, they may be impacted by labor and equipment mobilization/demobilization, and material deliveries. Off-Site impacts due to labor and equipment mobilization/demobilization and material deliveries would be expected to be diffuse (*i.e.*, to span a wide range of transport routes originating over a wide area). Additionally, these impacts would be expected to largely occur at the beginning or end of each workday (during the arrival/departure of the work force), at the beginning or end of the construction period (during equipment mobilization/demobilization), and at specific times throughout the construction period (during material deliveries).

Two types of off-Site hauling are evaluated in this report under the CBR-Offsite (GMF GSP) scenario: CCR hauling and borrow soil hauling. Overall, haul truck impacts on EJ communities due to borrow soil hauling are expected to be small, because borrow soil would be sourced from within two miles of the Site, and there are no EJ communities within two miles of the Site. EJ communities located along the haul route to the off-Site landfill or near the off-Site landfill itself may be negatively impacted throughout the excavation period by the air pollution, noise, traffic, and accidents generated by CCR-hauling activities. A review of the Illinois map of EJ communities reveals that the off-Site landfill is not located within the 1-mile buffer zone of an EJ community. Additionally, based on the two major haul routes suggested by Google Maps (Google, LLC, 2022), transport of CCR to the landfill will not require hauling CCR through the buffer zone of the EJ community (Figure 2.1).

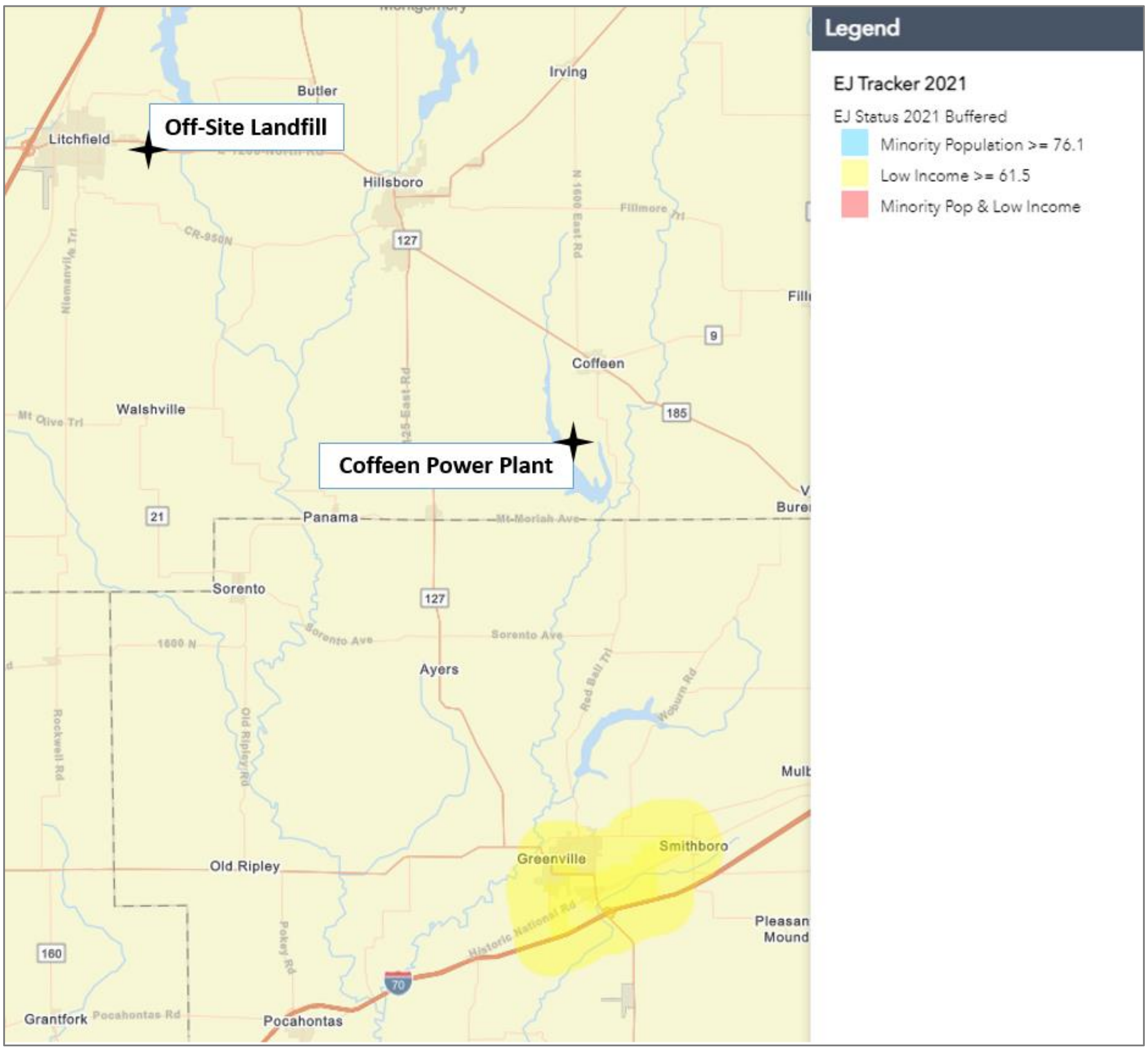

Figure 2.1 Environmental Justice Communities in the Vicinity of the Site and the Off-Site Landfill. EJ = Environmental Justice. Adapted from IEPA (2019b).

Scenic, Historical, and Recreational Value

During construction activities, negative impacts on scenic and recreational value may occur within the Coffeen Lake SFWA. Noise impacts were described above. In addition, construction activities at the GMF GSP and the GMF RP may be visible to recreators using these scenic and recreational areas, potentially interfering with enjoyment of the view. Negative impacts would not be expected to occur within any scenic or recreational areas located further away from the Site. The expected duration of construction activities is longer under the CBR-Offsite (GMF GSP) scenario than under the CIP (GMF GSP) scenario (22-33 months under the CIP [GMF GSP] scenario *versus* 31-46 months under the CBR-Offsite [GMF GSP] scenario with an additional 12-17 months under the CBR-Onsite [GMF RP] scenario). It is therefore anticipated that short-term impacts on the scenic and recreational value of natural areas near the Site would be greater under the CBR-Offsite (GMF GSP) scenario than under the CIP (GMF GSP) scenario.

Based on a review of the IDNR Historic Preservation Division database and the Illinois State Archaeological Survey database, there are no historic sites located within 1,000 meters of the GMF GSP and the GMF RP, the on-Site landfill, or the on-Site borrow soil location (Ramboll, 2021a,b).

2.2.4.3 Environmental Risks

Greenhouse Gas Emissions

In addition to the air pollutants listed above in Section 2.2.4.2, construction equipment emits greenhouse gases (GHGs), including carbon dioxide (CO_2) and possibly nitrous oxide (N_2O). The potential impact of each closure scenario on GHG emissions is proportional to the potential impact of each closure scenario on other emissions from construction vehicles and equipment, as described above in Section 2.2.4.2. In summary, GHG emissions from construction equipment and vehicles would be greater under the CBR-Offsite (GMF GSP) scenario than under the CIP (GMF GSP) scenario, because the total on-Site and off-Site vehicle and equipment travel miles required under the CBR-Offsite (GMF GSP) scenario (2,030,000 total vehicle and equipment travel miles) are greater than the total required under the CIP (GMF GSP) scenario (482,000 total vehicle and equipment travel miles; Tables 2.1 through 2.3).

We did not quantify the carbon footprint of the approximately 12.4 acres of a 40-mil LLDPE geomembrane liner required for the final GMF GSP cover system under the CIP (GMF GSP) scenario. The carbon footprint of this geomembrane (*i.e.*, the fossil fuel emissions required to manufacture it) is an additional source of GHG emissions at the Site under the CIP (GMF GSP) scenario. The potential expansion of the off-Site landfill under the CBR-Offsite (GMF GSP) scenario would have an additional, unquantified carbon footprint due to the manufacture of geomembranes used in the expanded landfill liners.

Energy Consumption

Energy consumption at a construction site is synonymous with fossil fuel consumption, because the energy to power construction vehicles and equipment comes from the burning of fossil fuels. Fossil fuel demands considered in this analysis include the burning of diesel fuel during construction activities and the carbon footprint of manufacturing geomembrane textiles. Because GHG emission impacts and energy consumption impacts both arise from the same sources at construction sites, the trends discussed above with respect to GHG emissions also apply to the evaluation of energy demands. Specifically, the energy demands of construction equipment and vehicles would be greater under the CBR-Offsite (GMF GSP) scenario than under the CIP (GMF GSP) scenario. We did not quantify the energy demands of the geomembranes required for the construction of the final cover system under the CIP (GMF GSP) scenario, the geomembranes potentially required for the expansion of the off-Site landfill under the CBR-Offsite scenario.

The Coffeen Power Plant Site is slated for redevelopment as a utility-scale solar power generating facility and battery energy storage facility. At the grid scale, solar generation would add energy back onto the grid and reduce reliance on non-renewable energy sources. In the short-term, closure activities at the Site may delay and obstruct these redevelopment efforts. The magnitude of expected delays will scale with the expected duration and intensity of construction activities during closure. Because the CIP (GMF GSP) scenario requires less construction activity than CBR-Offsite (GMF GSP) scenario and would be completed over a shorter time period, the CIP (GMF GSP) scenario would be expected to result in fewer delays to redevelopment – and, hence, the more rapid realization of grid-scale energy benefits – than the CBR-Offsite (GMF GSP) scenario.

Natural Resources and Habitat

During closure, major construction activities such as the excavation of the impoundment, the excavation of the borrow area, and, potentially, the expansion of the off-Site landfill may require the destruction of some existing habitat atop portions of these construction areas, resulting in negative impacts to natural resources and habitat within the footprint of these areas. Construction may also have indirect negative impacts on the natural resources and habitat in the immediate vicinity of these locations by causing alarm and escape behavior in nearby wildlife (*e.g.*, due to noise disturbances). Finally, although erosion prevention and sediment control measures will be undertaken under all closure scenarios, it is possible that limited negative short-term impacts could occur to sensitive aquatic and wetland species in Coffeen Lake and other wetlands or surface water bodies located near the GMF GSP and the GMF RP (see Section 1.1.3) due to sediment runoff during construction. The duration of time over which various short-term negative habitat impacts might occur due to construction would be longer under the CBR-Offsite (GMF GSP) scenario than under the CIP (GMF GSP) scenario, due to the longer expected duration of construction activities (22-33 months under the CIP [GMF GSP] scenario *versus* 31-46 months under the CBR-Offsite [GMF GSP] scenario with an additional 12-17 months under the CBR-Onsite [GMF RP] scenario). Thus, negative short-term impacts to natural resources and habitat due to closure activities would likely be greater under the CBR-Offsite (GMF GSP) scenarios than under the CIP (GMF GSP) scenario.

In addition to the short-term negative habitat impacts caused by construction activities, closure may also result in long-term shifts in the habitat types overlying the major construction locations associated with closure. This assessment does not make any value judgments regarding the relative value of the habitat types currently overlying these locations and the habitat types that could potentially overlie these locations post-closure under the various closure scenarios. For example, we did not attempt to determine whether the conversion of open water to grassland within the footprint of the GMF GSP or the GMF RP would constitute a positive or negative long-term change with regard to factors such as biodiversity, ecosystem services, or the preferences of recreators/sightseers.

According to the IDNR Natural Heritage Database and the United States Fish & Wildlife Service (US FWS) Environmental Conservation Online System, there are four state threatened species, five state endangered species, one federally threatened species, and one federally endangered species within Montgomery County (Ramboll, 2021a,b). To our knowledge, however, no threatened or endangered species have been identified at the Site (Ramboll, 2021a,b). Based on the information that is currently available, we do not expect construction activities to have negative impacts on any threatened or endangered species.

2.2.5 Time Until Groundwater Protection Standards Are Achieved (IAC Sections 845.710(b)(1)(E) and 845.710(d)(2 and 3))

The time horizon over which GWPSs would be exceeded at the Site is immaterial from a risk perspective, because there is no unacceptable risk associated with exceedances of a GWPS at the Site (see Section 2.2.1). Nonetheless, pursuant to requirements under IAC Section 845.710, this section of the text describes the time required to achieve GWPSs at the Site.

As described in Section 1.1.4 (Hydrogeology), water and CCR-related constituents from the GMF GSP and the GMF RP may migrate vertically downward until they reach the UA. There is a groundwater flow divide within the UA in the center of the Coffeen Power Plant property between the two lobes of Coffeen Lake. Groundwater in the UA flows from the center of the Coffeen Power Plant property west toward Coffeen Lake and east toward the Unnamed Tributary. Groundwater predominantly flows east/southeast across the GMF GSP to the Unnamed Tributary; however, the western side of the of the GMF GSP aligns with the groundwater divide and groundwater in this area flows west toward Coffeen Lake. The GMF RP is located east of the divide, and groundwater flows southeast across the GMF RP. The Unnamed Tributary serves as a regional sink for shallow groundwater discharge and shallow groundwater migration beneath or beyond the tributary is unlikely (Ramboll, 2021a,b). Groundwater flow within the UA is mostly in the horizontal direction because the UA is underlain by the low-permeability LCU (Ramboll, 2021a,b).

At the Coffeen Site, no seasonal variation in groundwater levels has been observed. Surface water elevations in Coffeen Lake similarly do not fluctuate significantly over time, since the lake elevation is controlled by a dam. As a result, groundwater flow directions at the Site are not generally affected by seasonal variabilities (Ramboll, 2021a,b).

Groundwater modeling was performed to evaluate future groundwater quality in the vicinity of the GMF GSP and the GMF RP under each of the proposed closure alternatives (Ramboll, 2022). The modeling demonstrated that there are limited differences between CIP and CBR-Offsite in the timeframes to achieve the GWPSs (7.4 years for CIP and 6.4 years for CBR-Offsite) at the GMF GSP. In general, with the exception of sulfate, the simulated groundwater concentrations in the monitoring wells within the UA will achieve the GWPSs within 7 years after closure implementation for both the CIP and the CBR-Offsite scenarios at the GMF GSP. For the CBR-Onsite scenario at the GMF RP, the simulated groundwater concentrations in the monitoring wells within the UA will achieve the GWPSs in 2.5 years. The model indicates that sulfate will decline over time under both the CIP, CBR-Offsite, and CBR-Onsite scenarios at the GMF GSP and the GMF RP, while remaining in close proximity to the impoundments. For both the CIP and CBR-Offsite scenarios at the GMF GSP, the model predicts that sulfate concentrations will decline below the sulfate GWPS (400 mg/L) in approximately 14 years after the implementation of closure. For the CBR-Onsite scenario at the GMF RP, the model predicts that sulfate concentrations will decline below the sulfate GWPS in approximately 9 years after the implementation of closure.

Additionally, changing geochemical conditions during an extended excavation associated with the CBR-Offsite and CBR-Onsite scenarios can be a mechanism that results in the mobilization and increased transport in groundwater for some constituents. This may result in GWPS exceedance durations in excess of the model predictions for the CBR-Offsite and CBR-Onsite scenarios.

2.2.6 Potential for Exposure of Humans and Environmental Receptors to Remaining Wastes, Considering the Potential Threat to Human Health and the Environment Associated with Excavation, Transportation, Re-disposal, Containment, or Changes in Groundwater Flow (IAC Section 845.710(b)(1)(F))

Section 2.2.1 evaluates potential risks to human and ecological receptors arising from the leaching of CCR-associated constituents into groundwater during closure activities and following closure of the GMF GSP and the GMF RP. Section 2.2.2 evaluates the potential for CCR releases to occur due to dike failure or overtopping during floods or other storm-related events. In summary, there is no current or future risk to any human or ecological receptors associated with the GMF GSP or the GMF RP. Additionally, there is minimal current or future risk of overtopping occurring at the embankments due to flood conditions at the Site. Dike failure due to, *e.g.*, seismic activity and storm-related events is also exceedingly unlikely.

Section 2.2.4 evaluates several potential risks to human health and the environment during closure activities, including risks of accidents occurring among workers; risks to nearby residents and EJ communities related to accidents, traffic, noise, and air pollution; and risks to natural resources and wildlife. The findings from this section of the text are summarized in Table S.1 (Summary of Findings).

2.2.7 Long-Term Reliability of the Engineering and Institutional Controls (IAC Section 845.710(b)(1)(G))

Post-closure, there is minimal risk of engineering or institutional failures leading to sudden releases of CCR from the impoundment under the CIP (GMF GSP) scenario. There is no post-closure risk of engineering or institutional failures under the CBR-Offsite (GMF GSP) or the CBR-Onsite (GMF RP) scenarios (see Section 2.2.2 above). Additionally, there are no current or future unacceptable risks to any human or ecological receptors under any closure scenario (see Section 2.2.1 above). Moreover, reliable engineering and institutional controls (*e.g.*, a bottom liner, a leachate management system, and groundwater monitoring) would be implemented at the on-Site and off-Site landfills under the CBR-Onsite (GMF RP) and CBR-Offsite (GMF GSP) scenarios. All of the evaluated closure scenarios are therefore reliable with respect to long-term engineering and institutional controls.

2.2.8 Potential Need for Future Corrective Action Associated with the Closure (IAC Section 845.710(b)(1)(H))

Corrective action is expected at the Site. An evaluation of potential corrective measures and corrective actions has not yet been completed, but will be conducted consistent with the requirements in IAC Sections 845.660 and 845.670.

2.3 Effectiveness of the Closure Alternative in Controlling Future Releases (IAC Section 845.710(b)(2))

2.3.1 Extent to Which Containment Practices Will Reduce Further Releases (IAC Section 845.710(b)(2)(A))

The CCR in the GMF GSP and the GMF RP currently poses no unacceptable risks to human health or the environment (Section 2.2.1). Because current conditions do not present a risk to human health or the environment, and dissolved constituent concentrations would be expected to decline post-closure, there would also be no unacceptable risks to human health or the environment following closure, regardless of the closure scenario.

Section 2.2.2 discussed the potential for dike failure or overtopping to occur during or following closure activities, resulting in a sudden release of CCR. That analysis showed that there is minimal risk of sudden CCR releases occurring during or following closure under any closure scenario.

2.3.2 Extent to Which Treatment Technologies May Be Used (IAC Section 845.710(b)(2)(B))

Under all three closure scenarios, water generated during the dewatering and unwatering of the impoundment would be treated if necessary prior to disposal. Following treatment, water from unwatering and dewatering would be discharged to the Unnamed Tributary in accordance with the NPDES permit for the facility.

2.4 Ease or Difficulty of Implementing Closure Alternative (IAC Section 845.710(b)(3))

2.4.1 Degree of Difficulty Associated with Constructing the Closure Alternative

CIP using a final cover system is a reliable and standard method for managing and closing impoundments that relies on common construction activities. Dewatering saturated CCR to construct a stabilized final cover system subgrade can present challenges during closure; however, these challenges are common to most CCR surface impoundment closures and are commonly addressed *via* surface water management and dewatering techniques.

Excavation and landfilling of CCR is also a reliable and standard method for closing impoundments. However, relative to CIP, CBR-Onsite and CBR-Offsite pose additional implementation difficulties due to higher earthwork volumes, higher dewatering volumes, and longer construction schedules. Removal and disposal of the existing bottom liner geomembranes may also prove challenging during CBR activities. Specifically, it may be difficult to remove and handle the geomembranes. Additionally, the geomembranes may need to be decontaminated prior to disposal. Finally, the geomembranes may not be accepted for disposal at the off-Site landfill.

Off-Site hauling would be more difficult to implement under the CBR-Offsite (GMF GSP) scenario than then on-Site hauling under the CIP (GMF GSP) scenario, due to the longer haul distance required for off-Site disposal than for CIP and the need to haul the CCR over public roads. Hauling over public roads would require the use of lower-volume haul trucks, which would increase the number of trucks and trips required for CCR excavation and transport. Additionally, because the CBR-Offsite scenario would involve hauling CCR off-Site (*i.e.*, intrastate travel), a higher level of dewatering would be required under this scenario compared to the CIP scenario. As described in Section 2.2.4.2 ("Community Risks"), off-Site hauling may also have detrimental community impacts due to an increased incidence of vehicle accidents, traffic-related impacts, noise, and air pollution.

In addition to off-Site hauling, off-Site landfilling under the CBR-Offsite scenario may pose particular challenges. A disposal plan would need to be developed between IPGC and the owner/operator of the third-party landfill in order to outline acceptable waste conditions upon delivery, daily waste production rates, and the expected duration of the project. Off-Site landfilling may additionally raise issues related to the co-disposal of CCR and other non-hazardous wastes. Finally, the construction schedule for excavation may be negatively impacted if, during the course of closure, it is determined that the off-Site landfill must be expanded in order to receive all of the materials excavated from the GMF GSP.

2.4.2 Expected Operational Reliability of the Closure Alternative

The operational reliability of the two closure scenarios is expected to be similar. CIP would utilize a final cover system that includes a geomembrane, and the GMF GSP currently includes a bottom liner system. Therefore, under the CIP scenario, the CCR would be surrounded by an engineered containment system on the top, sides, and bottom. The CBR-Offsite (GMF GSP) and CBR-Onsite (GMF RP) scenarios similarly involve placing the CCR in an engineered landfill system that has a bottom liner and a leachate collection system and would eventually be capped with a final cover system, resulting in the CCR being surrounded by an engineered containment system on the top, sides, and bottom. The operational reliability of all closure scenarios is therefore expected to be similar. Moreover, high reliability would be expected under all scenarios due to the full containment of the CCR.

2.4.3 Need to Coordinate with and Obtain Necessary Approvals and Permits from Other Agencies

Permits and approvals would be needed under all closure scenarios. Components of the three closure scenarios that would be expected to require a permit include:

- A modification to the existing NPDES permit through IEPA to allow the disposal of water generated from unwatering and dewatering operations to the Unnamed Tributary *via* the existing NPDES-permitted outfall for the Site;
- A construction permit from the IDNR, Office of Water Resources, Dam Safety Program to allow the embankment and spillways of the GMF GSP and the GMF RP to be modified as part of closure;
- A construction stormwater permit through IEPA, including construction stormwater controls and other BMPs such as silt fences and other measures; and
- A joint water pollution control construction and operating permit (WPC permit).

As discussed below in Section 2.4.5, under the CBR-Offsite (GMF GSP) scenario, it may be necessary to expand the off-Site landfill to accommodate all of the material excavated from the GMF GSP. Additional permitting may be required under this scenario for transport of the CCR and to expand the off-Site landfill. It may also be necessary to modify the operating plan for the off-Site landfill in order to accommodate the increased rate of filling of the landfill and the likely need for additional equipment and personnel to manage the receipt and disposal of the CCR and liner system materials.

2.4.4 Availability of Necessary Equipment and Specialists

CIP, CBR-Onsite, and CBR-Offsite are reliable and standard methods for managing waste that rely on common construction equipment and materials and typically do not require the use of specialists, outside of typical construction labor and equipment operators. However, global supply chains have been disrupted due to the COVID-19 pandemic, resulting in shortages in the availability of construction equipment and parts. There may be some shortages in construction equipment under all scenarios, if supply chain resilience does not improve by the time of construction. Alternatively, extended downtime may be required for equipment repairs and maintenance. A national shortage of truck drivers has also developed during the COVID-19 pandemic. Due to higher earthwork volumes and a longer construction schedule, the CBR-Offsite (GMF GSP) scenario may cause greater challenges than under the CIP (GMF GSP) scenario. The current shortage of truck drivers may be particularly impactful under the CBR-Offsite (GMF GSP) scenario, due to the large volume of CCR and liner materials to be hauled from the Site. If sufficient trucks and truck drivers are not available, the construction schedule at the impoundment may lengthen based on hauling-related delays.

The availability of critical materials such as metal, wood, and electronic chips has also been impacted by the COVID-19 pandemic. However, soil materials and geomembrane liner materials have generally been available during 2021 and early 2022 for landfill development and closure projects.

2.4.5 Available Capacity and Location of Needed Treatment, Storage, and Disposal Services

Under the CIP scenario, all of the CCR currently within the GMF GSP would be stored within the existing footprint of the GMF GSP. Treatment would consist of unwatering the GMF GSP at the start of construction, performing limited dewatering to stabilize the CCR subgrade, and managing stormwater inflow. Water from unwatering and dewatering of the GMF GSP would be discharged in accordance with the NPDES permit for the facility. Under the two CBR scenarios, water treatment would similarly consist of unwatering and dewatering the GMF GSP and the GMF RP at the start of construction and discharging water from unwatering/dewatering in accordance with the NPDES permit for the facility. Due to the need for dewatering prior to CCR hauling, a higher volume of water would be expected to be generated during dewatering under the CBR-Offsite (GMF GSP) scenario than under the CIP (GMF GSP) scenario.

For the CBR-Offsite (GMF GSP) scenario, 556,000 CY of CCR and liner materials would be excavated from the GMF GSP and require disposal. According to the IEPA "Landfill Disposal Capacity Report" for 2020 (IEPA, 2021b), the closest nearby third-party landfill with the ability to receive and dispose of CCR from the Site is the Hillsboro-Litchfield Landfill in Litchfield, Illinois. This facility has 1,540,000 CY of remaining capacity in its current permitted footprint. It receives 83,000 CY of waste annually, and is located 18 miles from the Site by road. The Litchfield-Hillsboro Landfill therefore has sufficient capacity to receive CCR from the GMF GSP. However, closure of the GMF GSP would increase the annual waste receipt rate at the off-Site landfill. Due to the short time frame over which CCR would be received at the landfill, vertical and/or lateral expansions may become necessary. Additionally, the landfill operators may need to develop a disposal plan to account for the increased volume of material that would be received and the unique CCR waste characteristics. Elements of this disposal plan might include increasing daily operational capacity and procedures, expediting planned airspace construction, and potentially expediting landfill expansion.

If expansion of the Litchfield-Hillsboro Landfill is impractical or infeasible, then an alternative landfill located farther from the Site would need to be identified. A likely alternative to the Litchfield-Hillsboro Landfill is the Five Oaks Landfill in Taylorville, Illinois. It has 7,050,000 CY of remaining capacity in its current permitted footprint, receives 250,000 CY of waste annually, and is located 44 miles from the Site (IEPA, 2021b).

2.5 Impact of Closure Alternative on Waters of the State (IAC Section 845.710(d)(4))

As demonstrated in Gradient's Human Health and Ecological Risk Assessment (Appendix A), both modeled and measured surface water concentrations in Coffeen Lake are all below relevant human health and ecological screening benchmarks. Surface water concentrations of CCR-associated constituents would be expected to decline over time under all closure scenarios. Thus, no current or future exceedances of any human health or ecological screening benchmarks would be anticipated under any closure scenario.

The lined landfills that would receive the CCR excavated from the impoundment under the CBR-Onsite (GMF RP) and CBR-Offsite (GMF GSP) scenarios would be managed to ensure that no surface water impacts would occur in the vicinity of the landfill. In summary, no impacts on any waters of the state would be expected under any closure scenario.

2.6 Concerns of Residents Associated with Closure Alternatives (IAC Section 845.710(b)(4))

Several nonprofits representing community interests near the Site have raised concerns regarding the potential impacts of the coal ash impoundments at this Site on groundwater and surface water quality, including Earthjustice, the Prairie Rivers Network, and the Sierra Club (Earthjustice *et al*., 2018; Sierra Club, 2014; Sierra Club and CIHCA, 2014). These parties generally prefer CBR to CIP, citing fears that allowing CCR to remain in place "allows the widespread groundwater contamination to continue indefinitely" (Earthjustice *et al*., 2018, p. 24). However, it is not the case that closing the GMF GSP *via* CIP rather than CBR would result in undue risks to groundwater and surface water post-closure. As described in Sections 2.2.1 and 2.2.2, no current or future unacceptable risks to human or ecological receptors are associated with the GMF GSP under any scenario. There is also minimal risk of future CCR releases occurring under any scenario. Furthermore, groundwater modeling conducted at the Site demonstrated that there would be limited differences between CIP and CBR-Offsite in the timeframes to achieve the GWPSs at the GMF GSP. For most constituents at the GMF GSP, the GWPSs will be achieved in approximately 7 years after implementation of closure under both scenarios. For most constituents at the GMF RP, the GWPSs will be achieved in approximately 2.5 years after implementation of the CBR-Onsite closure scenario (Ramboll, 2022). All three closure scenarios are therefore responsive to residents' concerns regarding impacts to groundwater and surface water quality.

The CIP (GMF GSP) scenario has several advantages over the CBR-Offsite (GMF GSP) scenario with regard to likely community concerns. Notably, the CIP scenario presents fewer risks to workers and nearby residents during construction in the form of accidents, traffic-related impacts, noise, and air pollution (Section 2.2.4 above). Closure would also be achieved more rapidly under the CIP scenario than under the CBR-Offsite scenario, due to the shorter duration of construction activities. Finally, the Site can be more rapidly redeveloped for use in utility-scale solar generation and battery energy storage under the CIP scenario than under the CBR-Offsite scenario. Redevelopment of the Site for use in solar generation and battery energy storage would bring new jobs to the community and contribute positively to Illinois's growing renewable energy portfolio.

2.7 Class 4 Cost Estimate (IAC Section 845.710(d)(1))

A Class 4 cost estimate will be prepared in the Final Closure Plan consistent with the Association of Advancement of Cost Engineering (AACE) Classification Standard (or a comparable classification practice as provided in the AACE Classification Standard), as required by IAC Section 845.710 (IEPA, 2021a).

2.8 Summary

Table S.1 (Summary of Findings) summarizes the expected impacts of the CIP (GMF GSP), CBR-Onsite (GMF RP), and CBR-Offsite (GMF GSP) closure scenarios with regard to each of the factors specified under IAC Section 845.710 (IEPA, 2021a). Based on this evaluation and the details provided in Section 2 above, CIP has been identified as the most appropriate closure scenario for the GMF GSP paired with CBR-Onsite for the GMF RP. Key benefits of the CIP (GMF GSP) scenario relative to the CBR-Offsite (GMF GSP) scenarios include more rapid redevelopment of the Site for use in utility-scale solar energy generation and battery energy storage and greatly reduced impacts to workers, community members, and the environment due to construction activities (*e.g.*, fewer constructed-related accidents, lower energy demands, less air pollution and GHG emissions, less traffic-related impacts, and potentially lower impacts to EJ communities). These conclusions are subject to change as additional data are collected and following the completion of an upcoming public meeting, which will be held in June 2022 pursuant to requirements under IAC Section 845.710(e). Following the public meeting, a final closure decision will be made based on the considerations identified in this report, the results of additional data that are collected, and any additional considerations that arise during the public meeting. The final closure recommendation will be provided in a Final Closure Plan, which will be submitted to IEPA as described under IAC Section 845.720(b) (IEPA, 2021a).

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Appendix A

Human Health and Ecological Risk Assessment

Draft

Human Health and Ecological Risk Assessment Gypsum Management Facility Gypsum Stack Pond and Gypsum Management Facility Recycle Pond Coffeen Power Plant Coffeen, Illinois

May 15, 2022

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Abbreviations

ADI	Acceptable Daily Intake
BCF	Bioconcentration Factor
BCG	Biota Concentration Guide
CAA	Closure Alternatives Assessment
CCR	Coal Combustion Residuals
CEM	Conceptual Exposure Model
COI	Constituent of Interest
COPC	Constituent of Potential Concern
CPP	Coffeen Power Plant
CSF	Cancer Slope Factor
CSM	Conceptual Site Model
CWS	Community Water Supply Well
DA	Deep Aquifer
DCU	Deep Confining Unit
ESV	Ecological Screening Value
GMF	Gypsum Management Facility
GSP	Gypsum Stack Pond
GWPS	Groundwater Protection Standards
GWQS	Groundwater Quality Standards
HTC	Human Threshold Criteria
IAC	Illinois Administrative Code
ID	Identification
IDNR	Illinois Department of Natural Resources
IEPA	Illinois Environmental Protection Agency
ILWATER	Illinois Water and Related Wells
IPGC	Illinois Power Generating Company
ISGS	Illinois State Geological Survey
LCU	Lower Confining Unit
MCL	Maximum Contaminant Level
NID	National Inventory of Dams
NRWQC	National Recommended Water Quality Criteria
ORNL RAIS	Oak Ridge National Laboratory's Risk Assessment Information System
RfD	Reference Dose
RME	Reasonable Maximum Exposure
RP	Recycle Pond
RSL	Regional Screening Level
SI	Surface Impoundment
SWQC	Surface Water Quality Criteria
SWQS	Surface Water Quality Standards
TEC	Threshold Effect Concentration
UA	Uppermost Aquifer
UCU	Upper Confining Unit
US DOE	United States Department of Energy

US EPA	United States Environmental Protection Agency
USGS	US Geological Survey

1 Introduction

Illinois Power Generating Company's (IPGC) Coffeen Power Plant (CPP, or "the Site") is an electric power generating facility with coal-fired units located approximately two miles south of Coffeen, Illinois. The CPP operated as a coal-fired power plant from 1964 until November 2019 and has five coal combustion residuals (CCR) management units (Ramboll, 2021a). The CCR units that are the subjects of this report are two gypsum management facility (GMF) ponds: the GMF gypsum stack pond (GMF GSP, Vistra Identification [ID] Number [No.] 103, Illinois Environmental Protection Agency [IEPA] ID No. W1350150004-03, and National Inventory of Dams [NID] No. IL50579) and the GMF recycle pond (GMF RP, Vistra ID No. 104, IEPA ID No. W1350150004-04, and NID No. IL50578) (Ramboll, 2021a,b). The GMF GSP is a 77-acre lined surface impoundment (SI) and the GMF RP is a 17-acre lined SI; they were used to manage CCR and non-CCR waste streams at the CPP (Ramboll, 2021a,b).

This report presents the results of an evaluation that characterizes potential risk to human and ecological receptors that may be exposed to CCR constituents in environmental media originating from the GMF GSP and RP. This risk evaluation was performed to support the Closure Alternatives Assessment (CAA) for the GMF GSP and the GMF RP in accordance with requirements in Title 35 Part 845 of the Illinois Administrative Code (IAC) (IEPA, 2021). Human and ecological risks were evaluated for Site-specific constituents of interest (COIs). The conceptual site model (CSM) assumed that Site-related COIs in groundwater may migrate to the adjacent Coffeen Lake and affect surface water and sediment in the vicinity of the Site.

Consistent with United States Environmental Protection Agency (US EPA) guidance (US EPA, 1989), this report used a tiered approach to evaluate potential risks, which included the following steps:

1. Identify complete exposure pathways and develop a conceptual exposure model (CEM).
2. Identify Site-related COIs: Constituents detected in groundwater were considered COIs if their maximum detected concentration over the period from 2015 to 2021 exceeded a groundwater protection standard (GWPS) identified in Part 845.600 (IEPA, 2021), or a relevant surface water quality standard (SWQS) (IEPA, 2019; US EPA Region IV, 2018).
3. Perform screening-level risk analysis: Compare maximum measured or modeled COI concentrations in surface water and sediment to conservative, health-protective benchmarks to determine constituents of potential concern (COPCs).
4. Perform refined risk analysis: If COPCs are identified, perform a refined analysis to evaluate potential risks associated with the COPCs.
5. Formulate risk conclusions and discuss any associated uncertainties.

This assessment relies on a conservative (*i.e.*, health-protective) approach and is consistent with the risk approaches outlined in US EPA guidance. Specifically, we considered evaluation criteria detailed in IEPA guidance documents (*e.g.*, IEPA, 2013, 2019), incorporating principles and assumptions consistent with the Federal CCR Rule (US EPA, 2015a) and US EPA's "Human and Ecological Risk Assessment of Coal Combustion Residuals" (US EPA, 2014a).

Based on the evaluation presented in this report, no unacceptable risks to human and ecological receptors resulting from CCR exposures associated with the GMF GSP and the GMF RP were identified. Specific risk assessment results include the following:

- No completed exposure pathways were identified for any groundwater receptors; consequently, no risks were identified relating to the use of groundwater.
- No unacceptable risks were identified for recreators boating in Coffeen Lake adjacent to the Site.
- No unacceptable risks were identified for recreators exposed to sediment in Coffeen Lake adjacent to the Site.
- No unacceptable risks were identified for anglers consuming locally caught fish.
- No unacceptable risks were identified for ecological receptors exposed to surface water or sediment.
- No bioaccumulative ecological risks were identified.

It should be noted that this evaluation incorporates a number of conservative assumptions that tend to overestimate exposure and risk. Moreover, it should be noted that because current conditions do not present a risk to human health or the environment, there will also be no unacceptable risk to human health or the environment for future conditions when the GMF GSP and the GMF RP are closed. For all future closure scenarios, potential releases of CCR-related constituents will decline over time and consequently potential exposures to CCR-related constituents in the environment will also decline.

2 Site Overview

2.1 Site Description

The CPP is located in Montgomery County, Illinois, approximately two miles south of the city of Coffeen and about eight miles southeast of the city of Hillsboro, Illinois. The CPP operated as a coal-fired power plant from 1964 until November 2019 (Ramboll, 2021a). Five CCR units are present on the CPP property: Ash Pond 1, Ash Pond 2, GMF RP, GMF GSP, and Landfill (Ramboll, 2021a). The GMF GSP and the GMF RP are the subjects of this report. The GMF GSP is a 77-acre lined SI, identified by Vistra ID No. 103, IEPA ID No. W1350150004-03, and NID No. IL50579. The GMF RP is a 17-acre lined SI identified by Vistra ID No. 104, IEPA ID No. W1350150004-04, and NID No. IL50578 (Ramboll, 2021a,b). Both units were put into operation in 2010, and stopped receiving waste prior to April 11, 2021 (Ramboll, 2021a).

The CPP is bordered by Coffeen Lake to the west, east, and south, and is bordered by agricultural land to the north. An unnamed tributary, located east of the GMF GSP, flows south into Coffeen Lake (Figure 2.1) (Ramboll, 2021a). Coffeen Lake (approximately 1,100-acres) was formed in 1963 for use as an artificial cooling lake for the CPP, by damming the McDavid Branch of the East Fork of Shoal Creek (Ramboll, 2021a).

Figure 2.1 Site Location Map. Source: Ramboll (2021a).

2.2 Geology/Hydrogeology

The geology underlying the CPP Site in the vicinity of the GMF GSP and the GMF RP primarily consists of unlithified deposits (Ramboll, 2021a,b). The unlithified deposits were categorized into the following hydrostratigraphic units (from the surface downward): the Upper Confining Unit (UCU), composed of Roxana and Peoria Silts (Loess Unit); the Uppermost Aquifer (UA), primarily composed of sandy to gravelly silts and clays of the Hagarstown Member; the Lower Confining Unit (LCU), comprised of the Vandalia Member, the Mulberry Grove Member, and the Smithboro Member; the Deep Aquifer (DA), comprised of sand and sandy silts/clays of the Yarmouth Soil; and the Deep Confining Unit (DCU), comprised of clays, silts, and sands of the Banner Formation (Ramboll, 2021a).

The Hagarstown Member is separated into two units: a gravelly clay till unit on top of a sandy unit (Ramboll, 2021a,b). The sandy unit at the base of the Hagarstown Member was identified as the UA. However, in some locations, the uppermost weathered sandy clay portion of the Vandalia Member was also identified as the UA (Ramboll, 2021a). The UA (*i.e.*, sandy portion of the Hagarstown Member) is generally less than 3 feet (ft) thick but is absent at several locations due to weathering or construction-related excavation (Ramboll, 2021a,b). The UA is not present beneath the entire footprint of the GMF GSP or the GMF RP (Ramboll, 2021a,b). The top of the UA is separated from the overlying CCR materials in the GMF GSP and the GMF RP by the low permeability Loess (UCU) and the gravelly clay till portions of the Hagarstown Member. The bottom of the UA is separated from the DA by low-permeability tills of the LCU (Ramboll, 2021a,b). The UA has moderate permeability with a geometric mean horizontal hydraulic conductivity of 1.4×10^{-3} cm/s near the GMF GSP (Ramboll, 2021a) and a geometric mean horizontal hydraulic conductivity of 1.2×10^{-3} cm/s near the GMF RP (Ramboll, 2021b).

In the vicinity of the GMF RP, groundwater within the UA generally flows southeast towards an unnamed tributary (Ramboll, 2021b). In the vicinity of the GMF GSP, groundwater within the UA flows southeast/east towards the unnamed tributary and southwest/west towards the western branch of Coffeen Lake (Ramboll, 2021a). For the southeastern/eastern flow component, the horizontal hydraulic gradients within the UA range from 0.003 to 0.01 ft/ft (Ramboll, 2021a,b). For the southwestern/western flow component, the average horizontal hydraulic gradient in the UA is about 0.018 ft/ft (Ramboll, 2021a).

2.3 Conceptual Site Model

A CSM describes sources of contamination, the hydrogeological units, and the physical processes that control the transport of water and solutes. In this case, the CSM describes how groundwater underlying the GMF GSP and the GMF RP migrates and interacts with surface water and sediment in the adjacent unnamed tributary and Coffeen Lake. The CSM was developed using available hydrogeologic data specific to the GMF GSP and the GMF RP, including information on groundwater flow and surface water characteristics (Ramboll, 2021a).

Due to the presence of a groundwater divide on the Site, groundwater in the UA flows both toward the eastern and western branches of Coffeen Lake (Figure 2.2). On the east side of the groundwater divide, groundwater flows east and southeast into an unnamed tributary that flows south into the eastern branch of Coffeen Lake. On the west side of the divide, groundwater flows west and southwest into the western branch of Coffeen Lake.

All groundwater originating from the GMF RP ultimately flows into the unnamed tributary, whereas a component of groundwater originating from the GMF GSP flows into the unnamed tributary, and the rest flows into the western branch of Coffeen Lake (Figure 2.2). The GMF RP and much of the GMF GSP are located to the east side of the groundwater divide, thus groundwater (and any CCR-related constituents) originating from these SIs may migrate vertically downward through the UCU into the UA and eventually flow into the unnamed tributary (Ramboll, 2021a,b). The western edge of the GMF GSP is on the west side of the groundwater divide; therefore, groundwater (and any CCR-related constituents) originating from this portion of the SI may migrate vertically downward through the UCU into the UA and eventually flow into the western branch of Coffeen Lake. Groundwater flow within the UA is mostly in the horizontal direction because the UA is underlain by the LCU, which is a low-permeability till unit inhibiting vertical flow of groundwater. Groundwater near the GMF ponds may mix with surface water in the unnamed tributary to the east and with surface water in the western branch of Coffeen Lake to the west. The dissolved constituents in groundwater may partition between sediments and surface water.

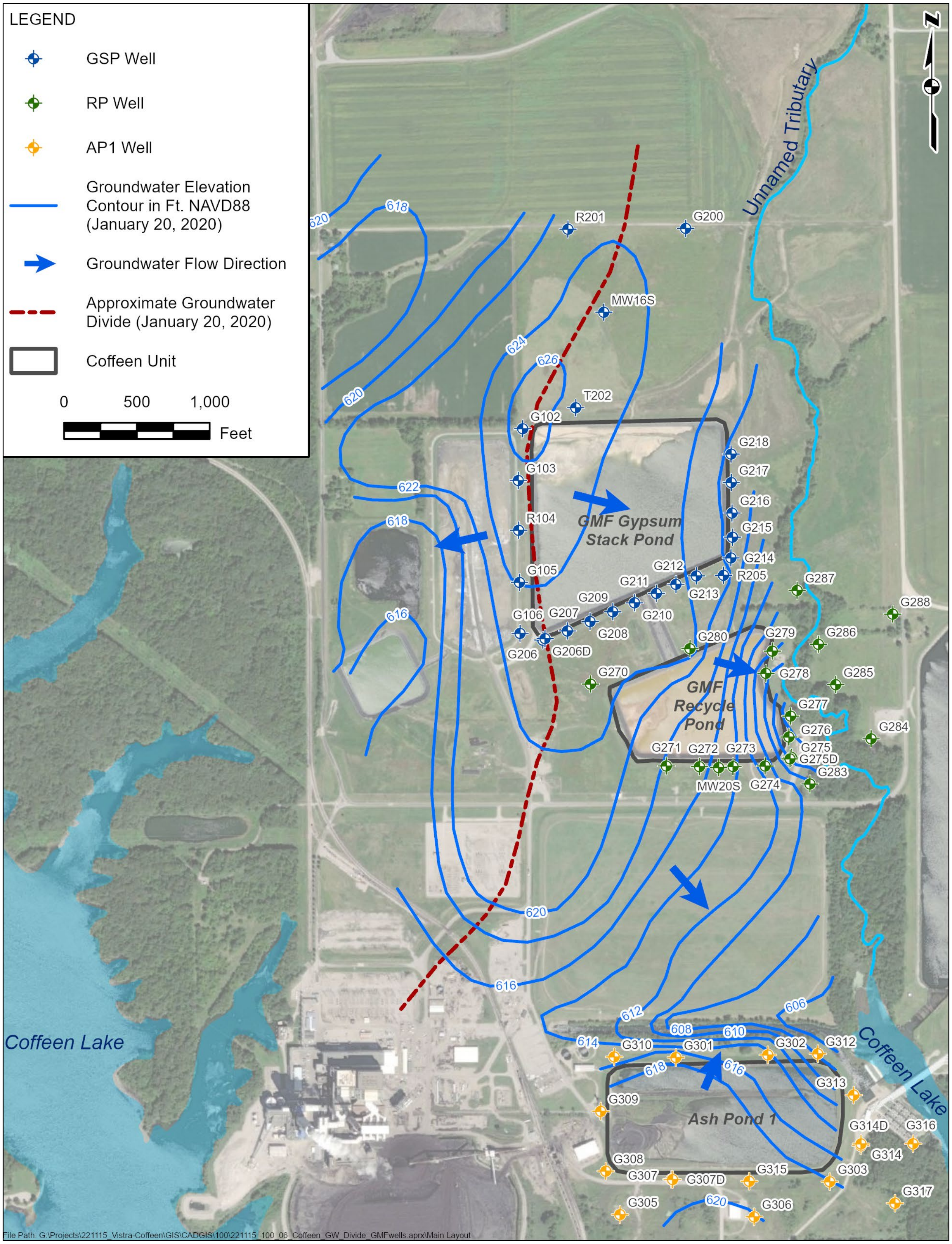

Figure 2.2 Groundwater Flow Direction. Source: Ramboll (2021a).

2.4 Groundwater Monitoring

A total of 43 wells have been used to monitor the groundwater quality near and downgradient of the GMF GSP and the GMF RP; 24 wells are associated with the GMF GSP and 19 wells are associated with the GMF RP. Of the 24 wells associated with the GMF GSP, 23 wells are screened in the UA and 1 well is screened in the DA (Table 2.1). Of the 19 wells associated with the GMF RP, 16 wells are screened in the UA, 2 wells are screened in the LCU, and 1 well is screened in the DA (Table 2.1). The analyses presented in this report conservatively relied on all available data from the 43 wells collected between 2015 and 2021, which is the period subsequent to the promulgation of the Federal CCR Rule. Groundwater samples were analyzed for a suite of total metals, specified in Illinois CCR Rule Part 845.600 (IEPA, 2021).[1] A summary of the groundwater data for the 43 wells used in this risk evaluation is presented in Table 2.2. The GMF GSP and the GMF RP well locations used in this risk evaluation are shown in Figure 2.3. Note that the groundwater data were split into two groups to model surface water concentrations for the unnamed tributary (19 GMF RP and 16 GMF RP wells on the east side of the groundwater divide) and the western branch of Coffeen Lake (8 GMF GSP wells on the west side of the groundwater divide). The use of groundwater data in this risk evaluation does not imply that detected constituents are associated with the GMF GSP or the GMF RP or that they have been identified as potential groundwater exceedances.

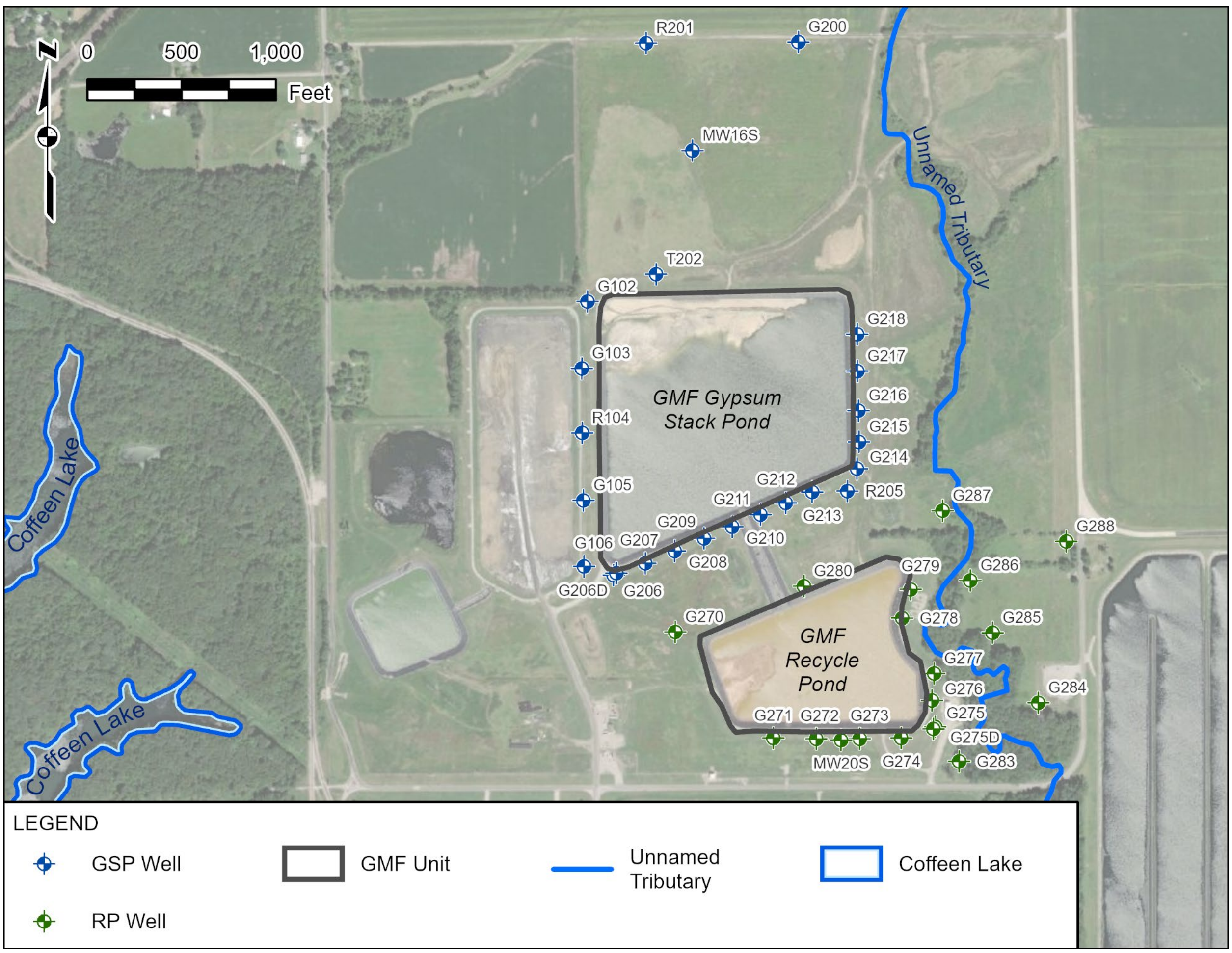

Figure 2.3 Monitoring Well Locations. Source: Ramboll (2021a).

[1] Samples were analyzed for a longer list of inorganic constituents and general water quality parameters (chloride, fluoride, sulfate, and total dissolved solids), but these constituents were not evaluated in the risk evaluation.

Table 2.1 Groundwater Monitoring Wells Related to the GMF GSP and the GMF RP

Associated GMF Pond	Side of Groundwater Divide	Well	Hydrogeologic Unit	Date Constructed	Screen Top Depth (ft bgs)	Screen Bottom Depth (ft bgs)	Well Depth (ft bgs)
GMF GSP	East	G200	UA	2/25/2008	12.19	16.98	17.36
GMF GSP	East	G207	UA	10/8/2010	18.24	22.77	23.30
GMF GSP	East	G208	UA	10/7/2010	17.53	22.06	22.60
GMF GSP	East	G209	UA	10/7/2010	17.74	22.28	22.81
GMF GSP	East	G210	UA	10/6/2010	19.39	23.93	24.46
GMF GSP	East	G211	UA	10/11/2010	17.34	21.88	22.41
GMF GSP	East	G212	UA	10/11/2010	16.74	21.29	21.81
GMF GSP	East	G213	UA	10/12/2010	16.75	21.29	21.82
GMF GSP	East	G214	UA	10/14/2010	17.75	22.14	22.65
GMF GSP	East	G215	UA	10/13/2010	19.41	23.80	24.31
GMF GSP	East	G216	UA	10/13/2010	20.04	24.42	24.93
GMF GSP	East	G217	UA	10/12/2010	20.49	24.88	25.38
GMF GSP	East	G218	UA	10/12/2010	20.33	24.77	25.27
GMF GSP	East	MW16S	UA	4/25/2006	14.59	19.41	19.76
GMF GSP	East	R205	UA	3/20/2017	11.32	16.01	16.42
GMF GSP	East	T202	UA	10/15/2010	12.27	16.65	17.21
GMF GSP	West	G206D	DA	1/25/2021	49.20	59.00	59.39
GMF GSP	West	G102	UA	4/28/2006	12.02	16.78	17.15
GMF GSP	West	G103	UA	2/15/2010	15.88	20.67	21.09
GMF GSP	West	G105	UA	2/16/2010	16.11	20.90	21.37
GMF GSP	West	G106	UA	2/16/2010	14.37	18.96	19.44
GMF GSP	West	G206	UA	10/14/2010	17.51	21.92	22.42
GMF GSP	West	R104	UA	10/8/2010	14.59	19.32	19.85
GMF GSP	West	R201	UA	10/8/2010	14.59	19.32	19.85
GMF RP	East	G275D	DA	1/14/2021	49.76	59.55	59.89
GMF RP	East	G283	LCU	1/14/2021	8.39	18.17	18.36
GMF RP	East	G285	LCU	1/25/2021	13.68	23.45	23.83
GMF RP	East	G270	UA	2/26/2008	13.13	17.92	18.27
GMF RP	East	G271	UA	9/10/2009	9.96	14.31	14.79
GMF RP	East	G272	UA	9/10/2009	9.11	13.98	14.32
GMF RP	East	G273	UA	9/10/2009	9.08	14.56	15.10

Associated GMF Pond	Side of Groundwater Divide	Well	Hydrogeologic Unit	Date Constructed	Screen Top Depth (ft bgs)	Screen Bottom Depth (ft bgs)	Well Depth (ft bgs)
GMF RP	East	G274	UA	9/16/2009	12.90	17.67	18.06
GMF RP	East	G275	UA	9/16/2009	8.22	12.62	13.19
GMF RP	East	G276	UA	9/16/2009	22.41	27.22	27.65
GMF RP	East	G277	UA	9/14/2009	14.29	18.77	19.24
GMF RP	East	G278	UA	9/11/2009	18.93	23.70	24.06
GMF RP	East	G279	UA	9/10/2009	22.40	26.79	27.30
GMF RP	East	G280	UA	2/26/2008	12.79	17.63	17.98
GMF RP	East	G284	UA	2/3/2021	8.08	12.85	13.23
GMF RP	East	G286	UA	1/18/2021	3.37	8.16	8.50
GMF RP	East	G287	UA	1/20/2021	5.43	10.25	10.59
GMF RP	East	G288	UA	1/19/2021	7.59	12.26	12.75
GMF RP	East	MW20S	UA	5/1/2007	8.41	13.22	13.67

Notes:
Source: Ramboll (2021a).
bgs = Below Ground Surface; DA = Deep Aquifer; ft = Feet; LCU = Lower Confining Unit; UA = Uppermost Aquifer.

Table 2.2 Groundwater Data Summary

Constituent	Samples with Constituent Detected	Samples Analyzed	Minimum Detected Value	Maximum Detected Value	Maximum Laboratory Detection Limit
Total Metals (mg/L)					
Antimony	2	434	0.0040	0.0045	0.0030
Arsenic	158	477	0.0010	0.11	0.0010
Barium	452	452	0.018	0.78	0.0010
Beryllium	9	436	0.0013	0.0067	0.0010
Boron	336	549	0.010	4.6	0.015
Cadmium	8	462	0.0012	0.0041	0.0010
Chromium	65	447	0.0040	0.086	0.0040
Cobalt	46	447	0.0021	0.053	0.0020
Lead	85	477	0.0010	0.082	0.0010
Lithium	25	265	0.011	0.030	0.020
Mercury	8	434	0.00024	0.0014	0.00020
Molybdenum	184	422	0.0010	0.044	0.0010
Selenium	189	451	0.0010	0.020	0.0010
Thallium	9	440	0.0010	0.0035	0.0010
Radionuclides (pCi/L)					
Radium-226 + 228	268	268	0	4.2	5.0
Other (mg/L, unless otherwise noted)					
Chloride	552	552	1.7	440	250
Fluoride	480	530	0.25	0.99	0.25
Sulfate	549	549	9.8	1,800	500
Total Dissolved Solids	555	555	230	3,400	26

Note:
pCi/L = PicoCuries Per Liter.

2.5 Surface Water Monitoring

Geosyntec Consultants collected a total of six surface water samples from Coffeen Lake (south of the GMF GSP and the GMF RP) in August 2021 (Geosyntec Consultants, 2021). The sample locations are shown in Figure 2.4, and the sampling results are summarized in Table 2.3.

Figure 2.4 Surface Water Sampling Locations. Source: Geosyntec Consultants (2021).

Table 2.3 Surface Water Data Summary

Constituent	Samples with Constituent Detected	Samples Analyzed	Minimum Detected Value	Maximum Detected Value	Maximum Laboratory Detection Limit
Total Metals (mg/L)					
Boron	5	5	0.086	0.33	0.05
Calcium	5	5	21	53	0.2
Cobalt	0	5	ND	ND	0.005
Iron	5	5	0.23	0.38	0.2
Lithium	0	5	ND	ND	0.01
Magnesium	5	5	10	16	0.1
Manganese	5	5	0.03	0.2	0.01
Potassium	5	5	2.5	4.9	0.5
Sodium	5	5	11	19	1
Other (mg/L)					
Chloride	5	5	7.2	11	0.4
Phosphorus	5	5	0.095	0.24	0.15
Sulfate	5	5	31	110	2
Total Dissolved Solids	5	5	120	240	10

Notes:
ND = Not Detected.
Source: Geosyntec Consultants (2021).
The background sample (BKG-1 on Figure 2.4) was not included in the summary statistics.
Surface water was analyzed for both total and dissolved metals; only the total metals are reported here, because they are generally higher concentrations than dissolved metals. The only exception was iron, which had a maximum dissolved concentration 1.8 times higher than the maximum total concentration. However, iron was not measured in groundwater, therefore, was not identified as a COI.

3 Risk Evaluation

3.1 Risk Evaluation Process

A risk evaluation was conducted to determine whether constituents present in groundwater underlying and downgradient of the GMF GSP and the GMF RP have the potential to pose adverse health effects to human and ecological receptors. The risk evaluation is consistent with the principles of risk assessment established by US EPA and has considered evaluation criteria detailed in Illinois guidance documents (*e.g.*, IEPA, 2013, 2019).

The general risk evaluation approach is summarized in Figure 3.1 and discussed below.

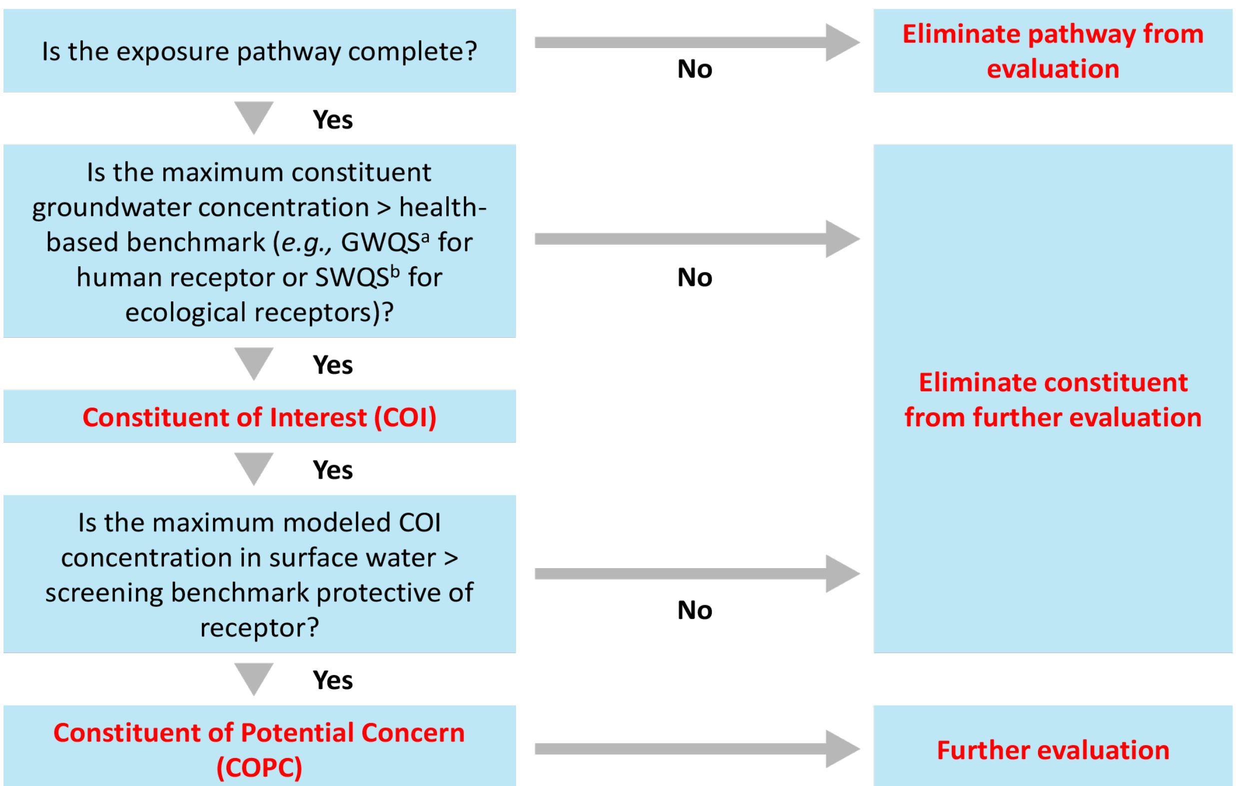

Figure 3.1 Overview of Risk Evaluation Methodology. GWQS = Groundwater Quality Standards; IEPA = Illinois Environmental Protection Agency; SWQS = Surface Water Quality Standards. (a) The IEPA Part 845 groundwater protection standards were used to identify COIs. (b) IEPA SWQS protective of chronic exposures to aquatic organisms were used to identify ecological COIs. In the absence of an SWQS, US EPA Region IV ecological screening values were used.

The first step in the risk evaluation was to develop the CEMs and identify complete exposure pathways. All potential receptors and exposure pathways based on groundwater use and surface water use in the vicinity of the Site were considered. Exposure pathways that were incomplete were excluded from the evaluation.

Groundwater data were used to identify COIs. COIs were identified as constituents with maximum concentrations in groundwater in excess of groundwater quality standards (GWQS)[2] for human receptors and SWQS for ecological receptors. Based on the CSM (Section 2.2), some groundwater underlying the GMF GSP and the GMF RP has the potential to interact with surface water in the unnamed tributary and Coffeen Lake. Therefore, constituents in groundwater potentially related to the GMF GSP and the GMF RP may potentially flow into the unnamed tributary and subsequently into surface water in Coffeen Lake.

Surface water samples have been collected from Coffeen Lake adjacent to the Site; however, sediment samples have not been collected from the lake. Gradient modeled the potential migration of COIs from groundwater to surface water and sediment to evaluate potential risks to receptors (see Section 3.3.3).

Gradient modeled the COI concentrations in surface water and sediment based on the groundwater data from the wells related to the GMF GSP and the GMF RP. The measured and modeled COI concentrations in surface water and sediment were compared to conservative, generic risk-based screening benchmarks for human health and ecological receptors. These generic screening benchmarks rely on default assumptions with limited consideration of site-specific characteristics. Human health benchmarks are receptor-specific values calculated for each pathway and environmental medium that are designed to be protective of human health. Ecological benchmarks are medium-specific values designed to be protective of all potential ecological receptors exposed to surface water. Ecological and human health screening benchmarks are inherently conservative because they are intended to screen out chemicals that are of no concern with a high level of confidence. Therefore, a measured or modeled COI concentration exceeding a screening benchmark does not indicate an unacceptable risk, but only that further risk evaluation is warranted. COIs with maximum concentrations exceeding a conservative screening benchmark are identified as COPCs requiring further evaluation.

As described in more detail below, this evaluation relied on the screening assessment to demonstrate that constituents present in groundwater underlying the GMF GSP and the GMF RP do not pose an unacceptable human health or ecological risk. That is, after the screening step, no COPCs were identified and further assessment was not warranted.

3.2 Human and Ecological Conceptual Exposure Models

A CEM provides an overview of the receptors and exposure pathways requiring risk evaluation. The CEM describes the source of the contamination, the mechanism that may lead to a release of contamination, the environmental media to which a receptor may be exposed, the route of exposure (exposure pathway), and the types of receptors that may be exposed to these environmental media.

3.2.1 Human Conceptual Exposure Model

The human CEM for the Site depicts the relationships between the off-Site environmental media potentially impacted by constituents in groundwater and human receptors that could be exposed to these media. Figure 3.2 presents a human CEM for the Site. It considers a human receptor who could be exposed to COIs hypothetically released from the GMF GSP and the GMF RP into groundwater, surface water, sediment, and fish. The following human receptors and exposure pathways were evaluated for inclusion in the Site-specific CEM.

[2] As discussed further in Section 3.3.2, GWQS are protective of human health and not necessarily of ecological receptors. While ecological receptors are not exposed to groundwater, groundwater can potentially enter into the adjacent surface water and impact ecological receptors. Therefore, two sets of COIs were identified: one for humans and another for ecological receptors.

- Residents – exposure to groundwater/surface water as drinking water;
- Residents – exposure to groundwater/surface water used for irrigation;
- Recreators in the lake adjacent to the Site:
  - Boaters – exposure to surface water and sediment while boating;
  - Swimmers – exposure to surface water and sediment while swimming;
  - Anglers – exposure to surface water and sediment and consumption of locally caught fish.

All of these exposure pathways were considered to be complete, except for residential exposure to groundwater or surface water used for drinking water or irrigation, and swimming. Section 3.2.1.1 explains why the residential drinking water and irrigation pathways are incomplete, and Section 3.2.1.2 provides additional description of the recreational exposures. While a recreator's potential exposure to surface water in Coffeen Lake was evaluated, swimming is prohibited in Coffeen Lake and thus was not evaluated (IDNR, 2014). Although swimming and boating are unlikely to occur in the unnamed tributary due to its shallow depth (flow depth of 2.1 feet) (Golder Associates Inc., 2020), the unnamed tributary was evaluated for recreator exposure due to its potential use by recreational anglers.

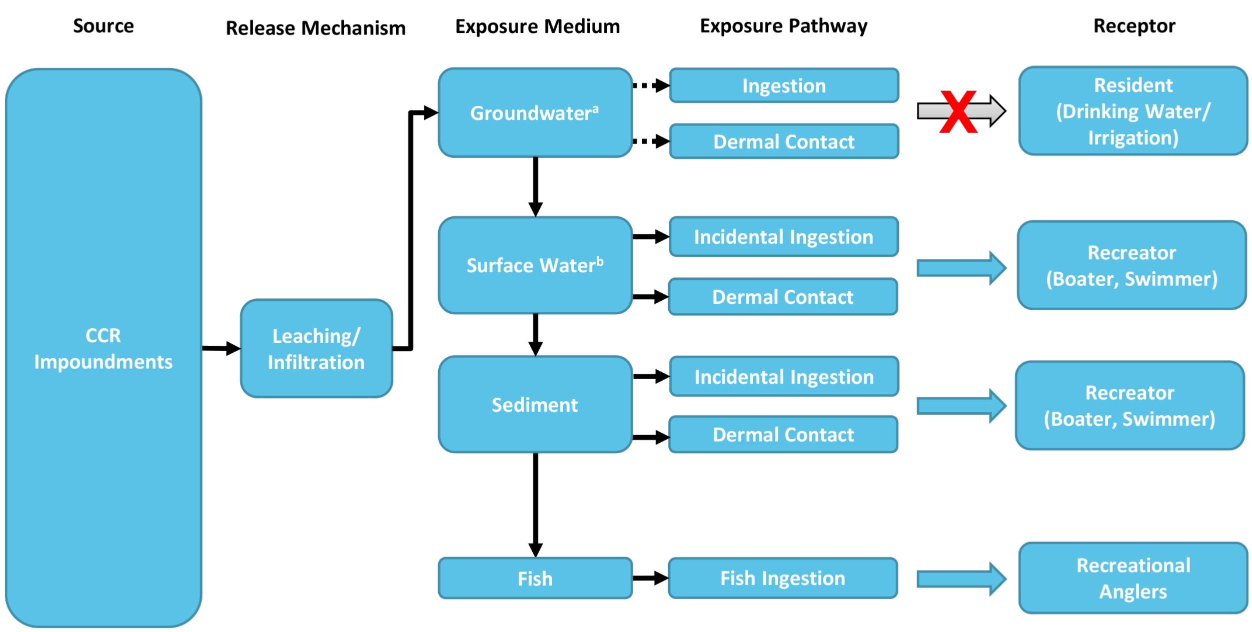

Figure 3.2 Human Conceptual Exposure Model. CCR = Coal Combustion Residuals. Dashed line/Red X = Incomplete or insignificant exposure pathway. (a) Groundwater in the vicinity of the Site is not used as a drinking water or irrigation source. (b) Surface water is not used as a drinking water source.

3.2.1.1 Groundwater or Surface Water as a Drinking Water/Irrigation Source

Using groundwater as a source of drinking water and/or irrigation water is not a complete exposure pathway for CCR-related constituents originating from the GMF GSP or the GMF RP. Specifically, there are no users of shallow groundwater from the UA in the vicinity of the GMF GSP or the GMF RP; thus, no receptors can be exposed to any CCR-related constituents in groundwater originating from either of the GMF ponds.

Relying on State databases, Ramboll completed a water well survey in 2021 (Ramboll, 2021a). A total of 18 water wells were identified within a 1,000-meter radius of the GMF ponds during a comprehensive search of the Illinois State Geological Survey's (ISGS) Illinois Water and Related Wells (ILWATER) Map (Ramboll, 2021a,b). These included 12 monitoring wells, 5 farm/domestic wells,[3] and 1 industrial use well (Ramboll, 2021a,b) (Figure 3.3). There is no information available about the current use of these wells. However, site-specific groundwater flow conditions support the conclusion that none of the farm/domestic wells are or can ever be affected by potential CCR-related constituents originating from the GMF GSP/GMF RP.

- **There is no off-Site migration of CCR-related constituents in groundwater**. All groundwater originating from the GMF RP ultimately flows into the unnamed tributary, whereas a component of groundwater originating from the GMF GSP flows into the unnamed tributary, and the rest flows into the western branch of Coffeen Lake. Groundwater from the UA flows southeast/east before flowing into the unnamed tributary, and flows southwest/west before flowing into the western branch of Coffeen Lake (Ramboll, 2021a,b). Three (3) of the 5 farm/domestic wells (*i.e.*, Well IDs 73, 25, and 28) and one industrial well (*i.e.*, 08) located within the 1,000 m buffer area are upgradient of both the GMF GSP and the GMF RP (Figure 3.3). Therefore, there is no plausible mechanism by which those 4 wells (*i.e.*, 73, 08, 25, and 28) could be impacted by any potential constituents in groundwater associated with the GMF GSP and the GMF RP.

  Two (2) water wells (73 and 02) are located on the northeast and southeast side of the unnamed tributary, *i.e.*, the opposite side of the tributary from GMF GSP and the GMF RP (Figure 3.3). The surface water bodies in the vicinity of the GMF ponds are hydraulic boundaries that prevent shallow groundwater from flowing past or underneath them. Furthermore, the surface waters are regional "sinks," which means that groundwater flows into the surface water bodies both from the east and the west, but cannot flow past. Thus, because the eastern branch of Coffeen Lake and the unnamed tributary separate those two farm/domestic wells (*i.e.*, 73 and 02) from the GMF GSP and the GMF RP (Figure 3.3), there is no plausible mechanism by which the wells could be impacted by any potential constituents in groundwater associated with the GMF GSP and the GMF RP.

  There is one domestic/farm well located southeast of the GMF GSP and the GMF RP (Well ID 32 on Figure 3.3), on the west side of the unnamed tributary. It is likely that this well is not in use and not in existence. The well, which was installed in 1981, is located near the former location of several prior residents (Figure 3.4). However, the property in this area has been purchased by IPGC.

- **Coffeen Lake is not used as a public water supply.** Coffeen Lake is a cooling water pond owned and maintained by IPGC, and IPGC restricts the use of the lake as a source of drinking water. Therefore, the human exposure pathway of surface water ingestion (as potable water) adjacent to the GMF GSP is not a complete pathway and was not evaluated further.

[3] The Ramboll 2021 GMF GSP Hydrogeologic Characterization Report states there are four farm/domestic wells, but Figure 3.3 in that report shows that there are five wells (Ramboll, 2021a).

- **The GMF GSP and the GMF RP have a limited hydraulic connection to underlying groundwater**. The LCU underlying the UA forms a hydraulic barrier between the GMF ponds and deeper groundwater resources. Due to the very low hydraulic conductivity of the LCU, downward migration of shallow groundwater is expected to be limited. Therefore, the likelihood of GMF pond-related impacts to deep groundwater is minimal.

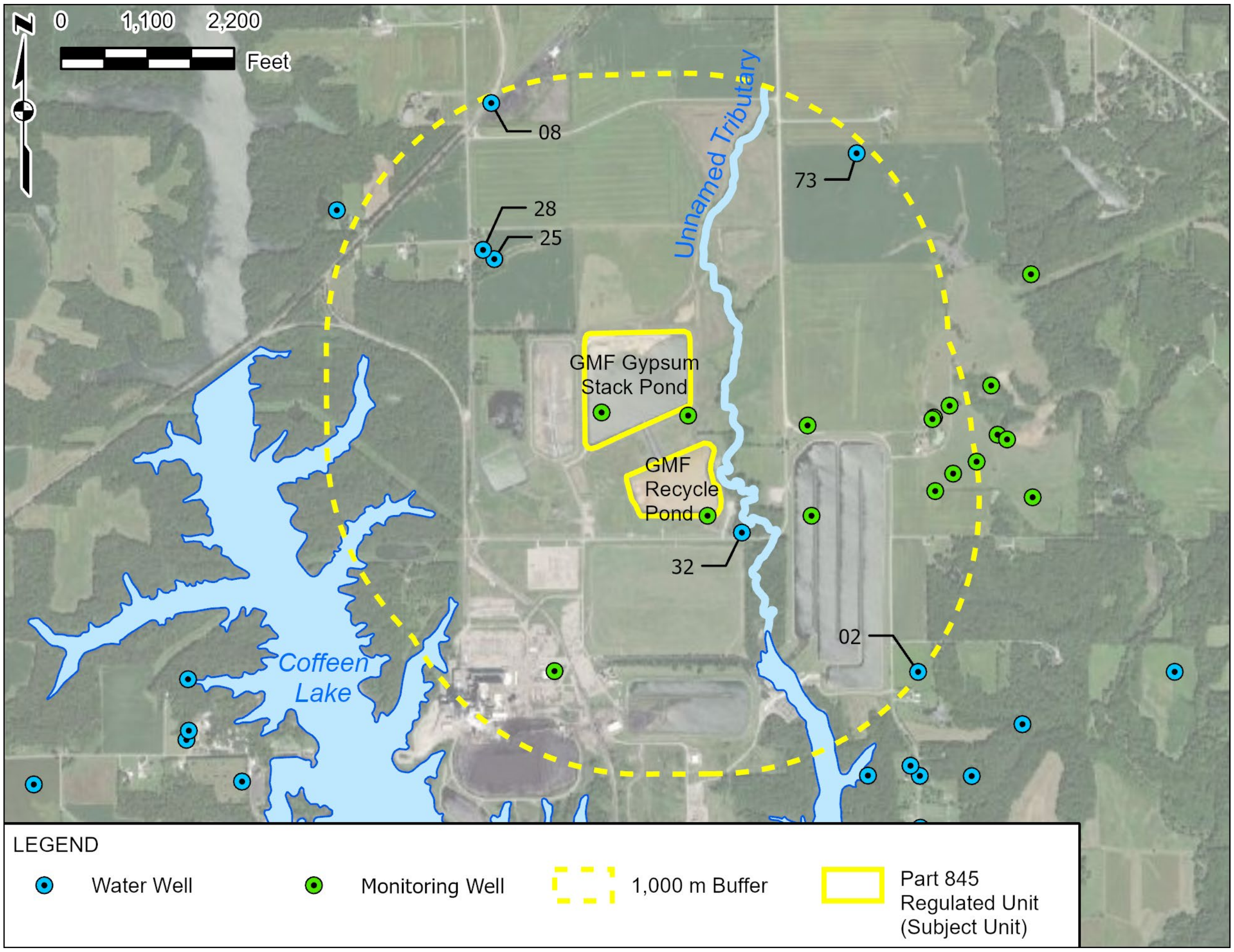

Figure 3.3 Water Wells Within 1,000 Meters of the GMF GSP and the GMF RP. GMF = Gypsum Manufacturing Facility; GSP = Gypsum Stack Pond; RP = Recycle Pond. The industrial well is shown as "08" in the northwest corner of the buffer zone. Sources: Ramboll (2021a,b).

Figure 3.4 Historic Property Use In the Vicinity of Well 32. (a) 1998; (b) 2005; (c) 2009. Sources: USGS (1998a,b, 2005a,b); USDA (2009a,b).

3.2.1.2 Recreational Exposures

Coffeen Lake is located adjacent to the Site, and is owned by IPGC. Property along the lake has been leased to Illinois Department of Natural Resources (IDNR) for use as a State Fish and Wildlife Area (Ramboll, 2021a), and the lake is used for recreational fishing (IDNR, 2022). Recreational exposure to surface water and sediment may occur during activities such as boating or fishing in the lake. Recreational anglers may also consume locally caught fish from Coffeen Lake. While a recreator's potential exposure to surface water in Coffeen Lake was evaluated, swimming is prohibited in Coffeen Lake and thus was not evaluated (IDNR, 2014). Although swimming and boating are unlikely to occur in the unnamed tributary due to its shallow depth (flow depth of 2.1 feet) (Golder Associates Inc., 2020), the unnamed tributary was evaluated for recreator exposure due to its potential use by recreational anglers.

3.2.2 Ecological Conceptual Exposure Model

The ecological CEM for the Site depicts the relationships between off-Site environmental media (surface water and sediment) potentially impacted by COIs in groundwater and ecological receptors that may be exposed to these media. The ecological risk evaluation considered both direct toxicity as well as secondary toxicity *via* bioaccumulation. Figure 3.4 presents the ecological CEM for the Site. The following ecological receptor groups and exposure pathways were considered:

- **Ecological Receptors Exposed to Surface Water:**
  - Aquatic plants, amphibians, reptiles, and fish.
- **Ecological Receptors Exposed to Sediment:**
  - Benthic invertebrates (*e.g.*, insects, crayfish, mussels).
- **Ecological Receptors Exposed to Bioaccumulative COIs:**
  - Higher trophic-level wildlife (avian and mammalian) *via* direct exposures (surface water and sediment exposure) and secondary exposures through the consumption of prey (*e.g.*, plants, invertebrates, small mammals, fish).

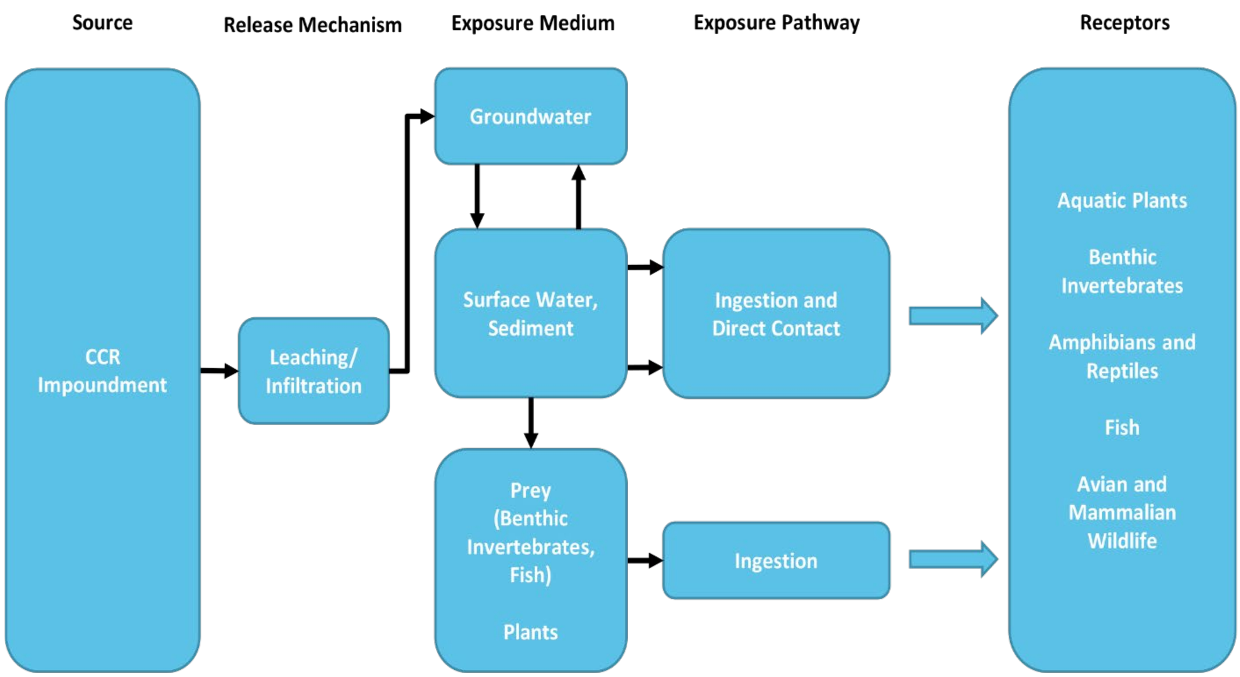

Figure 3.5 Ecological Conceptual Exposure Model. CCR = Coal Combustion Residuals.

3.3 Identification of Constituents of Interest

Risks were evaluated for COIs. A constituent was considered a COI if the maximum detected constituent concentration in groundwater exceeded a health-based benchmark. According to US EPA risk assessment guidance (US EPA, 1989), this screening step is designed to reduce the number of constituents carried through the risk evaluation that are anticipated to have a minimal contribution to the overall risk. Identified COIs are the constituents that are most likely to pose a risk concern in the surface water adjacent to the Site.

3.3.1 Human Health Constituents of Interest

For the human health risk evaluation, COIs were conservatively identified as constituents with maximum concentrations in groundwater above the GWPS listed in the Illinois CCR Rule Part 845.600 (IEPA, 2021). Gradient used the maximum detected concentrations from groundwater samples collected from all of the wells associated with the GMF GSP and the GMF RP, regardless of hydrostratigraphic unit. The use of groundwater data in this risk evaluation does not imply that detected constituents are associated with the GMF GSP or the GMF RP or that they have been identified as potential groundwater exceedances. Using this approach, six COIs (arsenic, beryllium, boron, cobalt, lead, and thallium) were identified for the human health risk evaluation *via* the surface water pathway for the unnamed tributary (Table 3.1) and two COIs (beryllium and lead) were identified for the western branch of Coffeen Lake (Table 3.2).

The water quality parameters that exceeded the GWPS included chloride, sulfate, and total dissolved solids; however, these constituents were not included in the risk evaluation because the GWPS are based on aesthetic quality. The US EPA secondary maximum contaminant levels (MCLs) for chloride, sulfate, and total dissolved solids are based on aesthetic quality. The secondary MCLs for chloride and sulfate (250 mg/L) are based on salty taste (US EPA, 2021a). The secondary MCL for total dissolved solids (500 mg/L) is based on hardness, deposits, colored water, staining, and salty taste (US EPA, 2021a). Given that these parameters are not likely to pose a human health risk concern in the event of exposure, they were not considered to be human health COIs.

Table 3.1 Human Health Constituents of Interest for the Unnamed Tributary

Constituent[a]	Maximum Concentration	GWPS[b]	Human Health COI[c]
Total Metals (mg/L)			
Antimony	0.0045	0.0060	No
Arsenic	0.11	0.010	Yes
Barium	0.78	2.0	No
Beryllium	0.0042	0.0040	Yes
Boron	4.6	2.0	Yes
Cadmium	0.0041	0.0050	No
Chromium	0.086	0.10	No
Cobalt	0.053	0.0060	Yes
Lead	0.082	0.0075	Yes
Lithium	0.030	0.040	No
Mercury	0.0014	0.0020	No
Molybdenum	0.043	0.10	No
Selenium	0.020	0.050	No
Thallium	0.0035	0.0020	Yes
Radionuclides (pCi/L)			
Radium-226 + 228	4.2	5.0	No
Other (mg/L, unless otherwise noted)			
Chloride	440	200	No[d]
Fluoride	0.73	4.0	No
Sulfate	1,800	400	No[d]
Total Dissolved Solids	3,400	1,200	No[d]

Notes:
COI = Constituent of Interest; GMF = Gypsum Manufacturing Facility; GSP = Gypsum Stack Pond; GWPS = Groundwater Protection Standards; IEPA = Illinois Environmental Protection Agency; MCL = Maximum Contaminant Level; pCi/L = PicoCuries Per Liter; RP = Recycle Pond.
Shaded = Compound identified as a COI.
(a) The constituents are those listed in the Illinois Part 845.600 GWPS (IEPA, 2021). This table presents the maximum concentration from all wells from the GMF GSP and the GMF RP combined.
(b) The Illinois Part 845.600 GWPS (IEPA, 2021) were used to identify COIs.
(c) COIs are constituents for which the maximum concentration exceeds the groundwater standard.
(d) This constituent is not likely to pose a human health risk concern due to the absence of studies regarding toxicity to human health. Therefore, this constituent is not considered a COI.

Table 3.2 Human Health Constituents of Interest for the Western Branch of Coffeen Lake

Constituent[a]	Maximum Concentration	GWPS[b]	Human Health COI[c]
Total Metals (mg/L)			
Antimony	ND	0.0060	No
Arsenic	0.010	0.010	No
Barium	0.17	2.0	No
Beryllium	0.0067	0.0040	Yes
Boron	0.13	2.0	No
Cadmium	0.0012	0.0050	No
Chromium	0.032	0.10	No
Cobalt	0.0058	0.0060	No
Lead	0.0097	0.0075	Yes
Lithium	0.016	0.040	No
Mercury	0.0011	0.0020	No
Molybdenum	0.044	0.10	No
Selenium	0.0091	0.050	No
Thallium	ND	0.0020	No
Radionuclides (pCi/L)			
Radium-226 + 228	2.8	5.0	No
Other (mg/L, unless otherwise noted)			
Chloride	88	200	No[d]
Fluoride	0.99	4.0	No
Sulfate	600	400	No[d]
Total Dissolved Solids	1,300	1,200	No[e]

Notes:
COI = Constituent of Interest; GMF = Gypsum Manufacturing Facility; GSP = Gypsum Stack Pond; GWPS = Groundwater Protection Standards; IEPA = Illinois Environmental Protection Agency; MCL = Maximum Contaminant Level; pCi/L = PicoCuries Per Liter; RP = Recycle Pond.
Shaded = Compound identified as a COI.
(a) The constituents are those listed in the Illinois Part 845.600 GWPS (IEPA, 2021). This table presents the maximum concentration from all wells from the GMF GSP and the GMF RP combined.
(b) The Illinois Part 845.600 GWPS (IEPA, 2021) were used to identify COIs.
(c) COIs are constituents for which the maximum concentration exceeds the groundwater standard.
(d) This constituent is not likely to pose a human health risk concern due to the absence of studies regarding toxicity to human health. Therefore, this constituent is not considered a COI.
(e) Total dissolved solids are not considered a COI because the MCL is based on aesthetic quality.

3.3.2 Ecological Constituents of Interest

The Illinois GWPS, as defined in IEPA's guidance, were developed to protect human health but not necessarily ecological receptors. While ecological receptors are not exposed to groundwater, groundwater can potentially migrate into the adjacent surface water and impact ecological receptors. Therefore, to identify ecological COIs, the maximum concentrations of constituents detected in groundwater were compared to ecological surface water benchmarks protective of aquatic life.

The surface water screening benchmarks for freshwater organisms were obtained from the following hierarchy of sources:

- IEPA (2019) SWQS. IEPA SWQS are health-protective benchmarks for aquatic life exposed to surface water on a long-term basis (*i.e.*, chronic exposure). The SWQS for several metals are hardness-dependent (cadmium, chromium, copper, lead, manganese, nickel, and zinc). Screening benchmarks for these constituents were calculated assuming US EPA's default hardness of 100 mg/L (US EPA, 2022).[4]
- US EPA Region IV (2018) surface water Ecological Screening Values (ESVs) for hazardous waste sites.

Benchmarks from the United States Department of Energy's (US DOE) guidance document ("A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota") were used for radium (US DOE, 2019). US DOE presents benchmarks for radium-226 and radium-228 (4 and 3 picoCuries per liter [pCi/L], respectively). Given that radium concentrations are expressed as total radium (radium-226+228, *i.e.*, the sum of radium-226 and radium-228), Gradient used the lower of the two benchmarks (3 pCi/L for radium-228) to evaluate total radium concentrations.

Consistent with the human health risk evaluation, Gradient used the maximum detected concentrations from groundwater samples collected from all of the wells associated with the GMF GSP and the GMF RP, (regardless of hydrostratigraphic unit) without considering spatial or temporal representativeness for ecological receptor exposures. The use of the maximum constituent concentrations in this evaluation is designed to conservatively identify COIs that warrant further investigation. Cadmium, cobalt, lead, mercury, and radium-226+228 were identified as COIs for ecological receptors at the unnamed tributary (Table 3.3), and cadmium was identified as a COI for the western branch of Coffeen Lake (Table 3.4).

[4] Hardness data are not available for Coffeen Lake or the unnamed tributary adjacent to the Site; therefore, the US EPA (2022) default hardness of 100 mg/L was used. Use of a higher hardness value would result in less stringent screening values; thus, use of the US EPA default hardness is conservative.

Table 3.3 Ecological Constituents of Interest for the Unnamed Tributary

Constituents[a]	Maximum Groundwater Concentration	Ecological Benchmark[b]	Basis	Ecological COI[c]
Total Metals (mg/L)				
Antimony	0.0045	0.19	US EPA R4 ESV	No
Arsenic	0.11	0.19	IEPA SWQC	No
Barium	0.78	5.0	IEPA SWQC	No
Beryllium	0.0042	0.064	US EPA R4 ESV	No
Boron	4.6	7.6	IEPA SWQC	No
Cadmium	0.0041	0.0011	IEPA SWQC	Yes
Chromium	0.086	0.21	IEPA SWQC	No
Cobalt	0.053	0.019	US EPA R4 ESV	Yes
Lead	0.082	0.020	IEPA SWQC	Yes
Lithium	0.030	0.44	US EPA R4 ESV	No
Mercury	0.0014	0.0011	IEPA SWQC	Yes
Molybdenum	0.043	7.2	US EPA R4 ESV	No
Selenium	0.020	1.0	IEPA SWQC	No
Thallium	0.0035	0.0060	US EPA R4 ESV	No
Radionuclides (pCi/L)				
Radium-226 + 228	4.2	3.0	US DOE	Yes
Other (mg/L, unless otherwise noted)				
Chloride	440	500	IEPA SWQC	No
Fluoride	0.73	4.0	IEPA SWQC	No
Sulfate	1,800	NA	NA	No
Total Dissolved Solids	3,400	NA	NA	No

Notes:
COI = Constituent of Interest; ESV = Ecological Screening Value; GWPS = Groundwater Protection Standards; IEPA = Illinois Environmental Protection Agency; SWQC = Surface Water Quality Criteria; NA = Not Available; pCi/L = PicoCuries Per Liter; US DOE = United States Department of Energy; US EPA R4 = United States Environmental Protection Agency Region IV.
Shaded = Compound identified as a COI.
(a) The constituents are those listed in the Illinois Part 845.600 GWPS (IEPA, 2021). This table presents the maximum concentration from all wells from the GMF GSP and the GMF RP combined.
(b) Ecological benchmarks are from the hierarchy of sources discussed in Section 3.3.2: IEPA SWQS (IEPA, 2019); US EPA R4 "Ecological Risk Assessment Supplemental Guidance" (US EPA Region IV, 2018); and US DOE's guidance document "A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota" (US DOE, 2019).
(c) Constituents with maximum detected concentrations exceeding a benchmark protective of surface water exposure are considered ecological COIs.

Table 3.4 Ecological Constituents of Interest for the Western Branch of Coffeen Lake

Constituents[a]	Maximum Groundwater Concentration	Ecological Benchmark[b]	Basis	Ecological COI[c]
Total Metals (mg/L)				
Antimony	ND	0.19	US EPA R4 ESV	No
Arsenic	0.010	0.19	IEPA SWQC	No
Barium	0.17	5.0	IEPA SWQC	No
Beryllium	0.0067	0.064	US EPA R4 ESV	No
Boron	0.13	7.6	IEPA SWQC	No
Cadmium	0.0012	0.0011	IEPA SWQC	Yes
Chromium	0.032	0.21	IEPA SWQC	No
Cobalt	0.0058	0.019	US EPA R4 ESV	No
Lead	0.0097	0.020	IEPA SWQC	No
Lithium	0.016	0.44	US EPA R4 ESV	No
Mercury	0.0011	0.0011	IEPA SWQC	No
Molybdenum	0.044	7.2	US EPA R4 ESV	No
Selenium	0.0091	1.0	IEPA SWQC	No
Thallium	ND	0.0060	US EPA R4 ESV	No
Radionuclides (pCi/L)				
Radium-226 + 228	2.8	3.0	US DOE	No
Other (mg/L, unless otherwise noted)				
Chloride	88	500	IEPA SWQC	No
Fluoride	0.99	4.0	IEPA SWQC	No
Sulfate	600	0	NA	No
Total Dissolved Solids	1,300	0	NA	No

Notes:

COI = Constituent of Interest; ESV = Ecological Screening Value; GWPS = Groundwater Protection Standards; IEPA = Illinois Environmental Protection Agency; NA = Not Available; pCi/L = PicoCuries Per Liter; SWQC = Surface Water Quality Criteria; US DOE = United States Department of Energy; US EPA R4 = United States Environmental Protection Agency Region IV.

Shaded = Compound identified as a COI.

(a) The constituents are those listed in the Illinois Part 845.600 GWPS (IEPA, 2021). This table presents the maximum concentration from all wells from the GMF GSP and the GMF RP combined.

(b) Ecological benchmarks are from the hierarchy of sources discussed in Section 3.3.2: IEPA SWQS (IEPA, 2019); US EPA R4 "Ecological Risk Assessment Supplemental Guidance" (US EPA Region IV, 2018); and US DOE's guidance document "A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota" (US DOE, 2019).

(c) Constituents with maximum detected concentrations exceeding a benchmark protective of surface water exposure are considered ecological COIs.

3.4 Surface Water and Sediment Modeling

Surface water sampling has been conducted in Coffeen Lake adjacent to the Site. To estimate the potential contribution to surface water (and sediment) from groundwater specifically associated with the GMF GSP and the GMF RP, Gradient modeled concentrations in surface water and sediment from two water bodies (the unnamed tributary and western branch of Coffeen Lake) for the human and ecological COIs in groundwater. This is because the constituents detected in groundwater above an ecological or health-based benchmark are most likely to pose a risk concern in the adjacent surface waters. Gradient modeled human health and ecological COI concentrations in the surface water and sediment using a mass balance calculation based on the surface water and groundwater mixing. The model assumes a well-mixed groundwater-surface water location. The maximum detected concentrations in groundwater (regardless of well location) from 2015 to 2021 were conservatively used to model COI concentrations in surface water and sediment.

Groundwater data from the east side of the groundwater divide were used for modeling surface water concentrations in the unnamed tributary. Groundwater data from the west side of the groundwater divide were used for modeling surface water concentrations in the western branch of Coffeen Lake. All of the GMF RP wells (n = 19) and a subset of the GMF GSP wells (n = 16), located on the east side of the divide, were used to model surface water concentrations in the unnamed tributary. Eight (8) of the GMF GSP wells, located on the west side of the divide, were used to model surface water concentrations in the western branch of Coffeen Lake (Figure 2.1). Due to the fact that different sets of wells were used to model surface water concentrations to the east and west, the list of COIs differs on the east and west sides of the groundwater divide. The surface water modeling for the unnamed tributary and the western branch of Coffeen Lake included only the COIs relevant for the east and west sides of the groundwater divide, respectively. The human health and/or ecological COIs on the east side of the divide included arsenic, beryllium, boron, cadmium, cobalt, lead, mercury, thallium, and radium-226+228. The human health and/or ecological COIs on the west side of the divide included beryllium, cadmium, and lead.

The groundwater data were measured as total metals. Use of the total metals concentration for these COIs may overestimate surface water concentrations because dissolved concentrations, which are lower than total concentrations, represent the mobile fractions of constituents that could likely flow into and mix with surface water.

The modeling approach does not account for geochemical transformations that may occur during groundwater mixing with surface water. Gradient assumed that predicted surface water concentrations were influenced only by the physical mixing of groundwater as it enters the surface water and were not further influenced by the geochemical reactions in the water and sediment, such as precipitation. In addition, the model only predicts surface water and sediment concentrations as a result of the potential migration of COI concentrations in groundwater related to the GMF GSP and the GMF RP and does not account for background concentrations in surface water or sediment.

For this evaluation, Gradient adapted a simplified and conservative form of US EPA's indirect exposure assessment methodology (US EPA, 1998) that was used in US EPA's coal combustion waste risk assessment (US EPA, 2014a). The model is a mass balance calculation based on surface water and groundwater mixing and the concept that the dissolved and sorbed concentrations can be related through an equilibrium partitioning coefficient (K_d). The model assumes a well-mixed groundwater-surface water location, with partitioning among total suspended solids, dissolved water column, sediment pore water, and solid sediments.

Sorption to soil and sediment is highly dependent on the surrounding geochemical conditions. To be conservative, we ignored the natural attenuation capacity of soil and sediment and estimated the surface water concentration based only on the physical mixing of groundwater and surface water (*i.e.*, dilution) at the point of entry of groundwater to the surface water.

The aquifer and surface water properties used to estimate the volume of groundwater flowing into the unnamed tributary and surface water concentrations are presented in Table 3.5. The COI concentrations in sediment in the unnamed tributary were modeled using the COI-specific sediment-to-water partitioning coefficients and the sediment properties presented in Table 3.6. In the absence of Site-specific information, Gradient used default assumptions (*e.g.*, depth of the upper benthic layer and bed sediment porosity) to model sediment concentrations. The modeled surface water and sediment concentrations for the unnamed tributary are presented in Table 3.7. These modeled concentrations reflect conservative contributions from groundwater flow.

The groundwater and surface water properties used in modeling for the western branch of Coffeen Lake are presented in Table 3.8. The sediment properties used in modeling for the western branch of Coffeen Lake are presented in Table 3.9. The modeled surface water and sediment concentrations for the western branch of Coffeen Lake are presented in Table 3.10. A description of the modeling and the detailed results are presented in Appendix A.

Table 3.5 Groundwater and Surface Water Properties Used in Modeling for the Unnamed Tributary

Parameter	Unit	Values	Notes/Source
Groundwater			
COI Concentration	mg/L	Constituent-specific	Maximum detected concentration in groundwater
Cross Section Area for the Uppermost Aquifer[a]	m^2	664	The average thickness of the UA near the GMF ponds (*i.e.*, approximately 3 ft) multiplied by the total length of the GMF ponds near the unnamed tributary (*i.e.*, ~726 m) (Ramboll, 2021b).
Hydraulic Gradient	m/m	0.0075	The average hydraulic gradient determined for the UA towards the unnamed tributary (Ramboll, 2021b).
Hydraulic Conductivity of the Uppermost Aquifer	cm/s	0.0013	The average of the geometric mean horizontal hydraulic conductivities measured for the UA (Ramboll, 2021b).
Surface Water			
Surface Water Flow Rate in the Unnamed Tributary	L/yr	8.04×10^{10}	There are no flow records available for the unnamed tributary that flows from north to south into the eastern branch of Coffeen Lake. According to Golder Associates Inc. (2020), the flow rate was assumed to be 90 cfs.
Total Suspended Solids	mg/L	3.2	Average Coffeen Lake concentration (Hanson, 2020).
Depth of the Water Column	m	0.64	Flow depth of the unnamed tributary (Golder Associates Inc., 2020).
Suspended Sediment to Water Partition Coefficient	mg/L	Constituent-specific	Values based on US EPA (2014a).

Notes:
cfs = Cubic Feet per Second; cm/s = Centimeter Per Second; COI = Constituent of Interest; ft = feet; GMF = Gypsum Management Facility; UA = Uppermost Aquifer; US EPA = United States Environmental Protection Agency.
(a) Cross-sectional area represents the area through which groundwater flows from the UA into the unnamed tributary.

Table 3.6 Sediment Properties Used in Modeling for the Unnamed Tributary

Parameter	Unit	Value	Notes/Source
Sediment			
Depth of Upper Benthic Layer	m	0.03	Default (US EPA, 2014a)
Depth of Water Body	m	0.67	Flow depth of the unnamed tributary (Golder Associates Inc., 2020) plus the depth of the upper benthic layer
Bed Sediment Particle Concentration	g/cm^3	1	Default (US EPA, 2014a)
Bed Sediment Porosity	-	0.6	Default (US EPA, 2014a)
TSS Mass Per Unit Area	kg/m^2	0.0038	Depth of water column × TSS × conversion factors (10^{-6} kg/mg and 1,000 L/m^3)
Sediment Mass Per Unit Area	kg/m^2	30	Depth of upper benthic layer × bed sediment particulate concentration × conversion factors (0.001 kg/g, 10^6 cm^3/m^3)
Sediment to Water Partition Coefficients	mg/L	Constituent specific	Values based on US EPA (2014a)

Notes:
TSS = Total Suspended Solids; US EPA = United States Environmental Protection Agency.

Table 3.7 Surface Water and Sediment Modeling Results for the Unnamed Tributary

COI	Groundwater Concentration (mg/L or pCi/L)	Mass Discharge Rate (mg/year or pCi/year)	Total Water Column Concentration (mg/L or pCi/L)	Concentration Sorbed to Bottom Sediments (mg/kg or pCi/kg)
Total Metals				
Arsenic	0.11	2.2E+05	2.9E-06	7.0E-04
Beryllium	0.0042	8.6E+03	1.1E-07	6.4E-05
Boron	4.6	9.4E+06	1.2E-04	7.4E-04
Cadmium	0.0041	8.4E+03	1.1E-07	1.5E-04
Cobalt	0.053	1.1E+05	1.4E-06	1.3E-03
Lead	0.082	1.7E+05	2.2E-06	2.2E-02
Mercury	0.0014	2.9E+03	3.7E-08	1.3E-03
Thallium	0.0035	7.1E+03	9.3E-08	1.7E-06
Radionuclides				
Radium-226 + 228	4.2	8.6E+06	1.1E-04	7.9E-01

Notes:
COI = Constituent of Concern; K_d = Equilibrium Partition Coefficient; pCi/L = PicoCuries Per Liter; pCi/kg = PicoCuries Per Kilogram.

Table 3.8 Groundwater and Surface Water Properties Used in Modeling for the Western Branch of Coffeen Lake

Parameter	Unit	Values	Notes/Source
Groundwater			
COI Concentration	mg/L	Constituent-specific	Maximum detected concentration in groundwater
Cross Section Area for the Uppermost Aquifer[a]	m^2	427	The average thickness of the UA near the GMF GSP (*i.e.*, approximately 3 ft) multiplied by the length of the GMF GSP on the west side of the divide (*i.e.*, about 467 m) (Ramboll, 2021a).
Hydraulic Gradient	m/m	0.018	The average hydraulic gradient for the UA from the GMF GSP towards the western branch of Coffeen Lake (Ramboll, 2021a).
Hydraulic Conductivity of the Uppermost Aquifer	cm/s	0.0014	The geometric mean horizontal hydraulic conductivity measured for the UA near the GMF GSP (Ramboll, 2021a).
Surface Water			
Surface Water Flow Rate in the western branch of Coffeen Lake	L/yr	9.02×10^{11}	There are no flow records available for the western branch of Coffeen Lake. According to the USGS (2022) Streamstats program, the western branch of Coffeen Lake has a two-year flow peak flow prediction of 1,010 cfs.
Total Suspended Solids	mg/L	3.2	Average Coffeen Lake concentration (Hanson, 2020).
Depth of the Water Column	m	5.7	Mean depth of Coffeen Lake (Austen *et al*., 1993).
Suspended Sediment to Water Partition Coefficient	mg/L	Constituent-specific	Values based on US EPA (2014a)

Notes:
cfs = Cubic Feet Per Second; cm/s = Centimeter Per Second; COI = Constituent of Interest; ft = feet; GMF = Gypsum Management Facility; GSP = Gypsum Stack Pond; UA = Uppermost Aquifer; US EPA = United States Environmental Protection Agency; USGS = United States Geological Survey; yr = Year.
(a) Cross-sectional area represents the area through which groundwater flows from the UA into Coffeen Lake (*i.e.*, the groundwater flow area that intersects with Coffeen Lake).

Table 3.9 Sediment Properties Used in Modeling for the Western Branch of Coffeen Lake

Parameter	Unit	Value	Notes/Source
Sediment			
Depth of Upper Benthic Layer	m	0.03	Default (US EPA, 2014a)
Depth of Water Body	m	5.73	Depth of water column (5.7 m, depth of Coffeen Lake) (Austen *et al*., 1993) plus depth of upper benthic layer (0.03 m) (US EPA, 2014a)
Bed Sediment Particle Concentration	g/cm^3	1	Default (US EPA, 2014a)
Bed Sediment Porosity	-	0.6	Default (US EPA, 2014a)
TSS Mass per Unit Area	kg/m^2	0.0342	Depth of water column × TSS × conversion factors (10^{-6} kg/mg and 1,000 L/m^3)
Sediment Mass per Unit Area	kg/m^2	30	Depth of upper benthic layer × bed sediment particulate concentration × conversion factors (0.001 kg/g, 10^6 cm^3/m^3)
Sediment to Water Partition Coefficients	mg/L	Constituent-specific	Values based on US EPA (2014a)

Notes:
TSS = Total Suspended Solids; US EPA = United States Environmental Protection Agency.

Table 3.10 Surface Water and Sediment Modeling Results for the Western Branch of Coffeen Lake

COI	Groundwater Concentration (mg/L)	Mass Discharge Rate (mg/year)	Total Water Column Concentration (mg/L)	Concentration Sorbed to Bottom Sediments (mg/kg)
Total Metals				
Beryllium	0.01	2.3E+04	2.6E-08	1.5E-05
Cadmium	0.0012	4.1E+03	4.6E-09	6.2E-06
Lead	0.010	3.3E+04	3.7E-08	3.7E-04

Note:
COI = Constituent of Concern.

3.5 Human Health Risk Evaluation

The section below presents the results of the human health risk evaluation for recreators in Coffeen Lake and the unnamed tributary adjacent to the Site. Risks were assessed using the maximum measured or modeled COIs in surface water.

3.5.1 Recreators Exposed to Surface Water

Screening Exposures: Recreators could be exposed to surface water *via* incidental ingestion and dermal contact while boating. In addition, anglers could consume fish caught in Coffeen Lake or the unnamed tributary. The maximum measured or modeled COI concentrations in surface water were used as conservative upper-end estimates of the COI concentrations to which a recreator might be exposed directly (incidental ingestion of COIs in surface water while boating) and indirectly (consumption of locally caught fish exposed to COIs in surface water).

Screening Benchmarks: Illinois surface water criteria (IEPA, 2019), known as human threshold criteria (HTC), are based on incidental exposure through contact or ingestion of small volumes of water while swimming or during other recreational activities, as well as the consumption of fish. The HTC values were calculated from the following equation (IEPA, 2019):

$$\mathrm{HTC} = \frac{\mathrm{ADI}}{\mathrm{W} + (\mathrm{F} \times \mathrm{BCF})}$$

where:

HTC = Human health protection criterion in milligrams per liter (mg/L)
ADI = Acceptable daily intake (mg/day)
W = Water consumption rate (L/day)
F = Fish consumption rate (kg/day)
BCF = Bioconcentration factor (L/kg-tissue)

Illinois defines the acceptable daily intake (ADI) as the "maximum amount of a substance which, if ingested daily for a lifetime, results in no adverse effects to humans" (IEPA, 2019). US EPA defines its chronic reference dose (RfD) as an "estimate (with uncertainty spanning perhaps an order of magnitude) of a daily oral exposure for a chronic duration (up to a lifetime) to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime" (US EPA, 2011a). Illinois lists methods to derive an ADI from the primary literature (IEPA, 2019). In accordance with Illinois guidance, Gradient derived an ADI by multiplying the MCL by the default water ingestion rate of 2 L/day (IEPA, 2019). In the absence of an MCL, Gradient applied the RfD used by US EPA to derive its Regional Screening Levels (RSLs) (US EPA, 2021b) as a conservative estimate of the ADI. The RfDs are given in mg/kg-day, while the ADIs are given in mg/day; thus, Gradient multiplied the RfD by a standard body weight of 70 kg to obtain the ADI in mg/day. The calculation of the HTC values is shown in Appendix B, Table B.1.

Gradient used bioconcentration factors (BCFs) from a hierarchy of sources. The primary BCFs were those that US EPA used to calculate the National Recommended Water Quality Criteria (NRWQC) for human health (US EPA, 2002). Other sources included BCFs used in the US EPA coal combustion ash risk assessment (US EPA, 2014a) and BCFs reported by Oak Ridge National Laboratory's Risk Assessment Information System (ORNL RAIS) (ORNL, 2020).[5] Lithium did not have a BCF value available from any authoritative source; therefore, the water quality criterion for lithium was calculated assuming a BCF of 1. This is a conservative assumption, as lithium does not readily bioaccumulate in the aquatic environment (ECHA, 2020).

Illinois recommends a fish consumption rate of 0.020 kg/day (20 g/day) for an adult weighing 70 kg (IEPA, 2019). Illinois recommends a water consumption rate of 0.01 L/day for "incidental exposure through contact or ingestion of small volumes of water while swimming or during other recreational activities" (IEPA, 2019). Appendix B, Table B.1 presents the calculated HTC for fish and water and for fish consumption only.

Screening Risk Evaluation: The maximum modeled and measured COI concentrations in surface water were compared to the calculated Illinois HTC values for the unnamed tributary and the western branch of Coffeen Lake in Tables 3.11 and 3.12, respectively. Surface water samples were collected from Coffeen Lake, but not the unnamed tributary. All surface water concentrations were below their respective

[5] Although recommended by US EPA (2015b), US EPA EpiSuite 4.1 (US EPA, 2019) was not used as a source of BCFs because inorganic compounds are outside the estimation domain of the program.

benchmarks. The HTC values are protective of recreational exposure *via* water and/or fish ingestion and do not account for dermal exposures to COIs in surface water while boating. However, given that the measured and modeled COI surface water concentrations are orders of magnitude below HTC protective of water and/or fish ingestion, dermal exposures to COIs are not expected to be a risk concern. Moreover, the dermal uptake of metals is considered to be minimal and only a small proportion of ingestion exposures. Thus, none of the COIs evaluated would be expected to pose an unacceptable risk to recreators exposed to surface water while boating in Coffeen Lake and anglers consuming fish caught in Coffeen Lake or the unnamed tributary.

Table 3.11 Risk Evaluation for Recreators Exposed to Surface Water in the Unnamed Tributary

COI	Modeled Surface Water Concentration[a]	HTC for Water and Fish	HTC for Water Only	HTC for Fish Only	COPC
Total Metals (mg/L)					
Arsenic	2.9E-06	0.022	2.0	0.023	No
Beryllium	1.1E-07	0.021	0.80	0.021	No
Boron	1.2E-04	467	1,400	700	No
Cobalt	1.4E-06	0.0035	2.1	0.0035	No
Lead	2.2E-06	0.015	0.015	0.015	No
Thallium	9.3E-08	0.0017	0.40	0.0017	No

Notes:
COI = Constituent of Interest; COPC = Constituent of Potential Concern; HTC = Human Threshold Criteria.
(a) Surface water samples were not collected from the unnamed tributary.

Table 3.12 Risk Evaluation for Recreators Exposed to Surface Water in the Western Branch of Coffeen Lake

COI	Maximum Surface Water Concentration		HTC for Water and Fish	HTC for Water Only	HTC for Fish Only	COPC	
	Modeled	Measured				Based on Modeled Concentration	Based on Measured Concentration
Total Metals (mg/L)							
Beryllium	2.6E-08	NA	0.021	0.80	0.021	No	NA
Lead	3.7E-08	NA	0.015	0.015	0.015	No	NA

Notes:
COI = Constituent of Interest; COPC = Constituent of Potential Concern; HTC = Human Threshold Criteria.
NA = Not Applicable; COI was not measured in surface water collected from Coffeen Lake.

3.5.2 Recreators Exposed to Sediment

Recreational exposure to sediment may occur during boating activity in Coffeen Lake or while angling in the unnamed tributary; exposure to sediment may occur through incidental ingestion and dermal contact.

Screening Exposures: COIs in impacted groundwater flowing into the river can sorb to sediments. In the absence of sediment data, sediment concentrations were modeled using maximum detected groundwater concentrations.

Screening Benchmarks: There are no established recreator RSLs that are protective of recreational exposures to sediment (US EPA, 2021c). Therefore, benchmarks that are protective of recreational exposures to sediment *via* incidental ingestion and dermal contact were calculated using US EPA's RSL guidance (US EPA, 2021c). These benchmarks were calculated using the recommended assumptions (*i.e.*, oral bioavailability, body weights, averaging time) and toxicity reference values (*i.e.*, RfD and cancer slope factor [CSF]), with the following changes: Recreators were assumed to be exposed to sediment while recreating 60 days a year (or two weekend days per week for 30 weeks a year, from April to October). The exposure duration was assumed for a child 6 years of age and an adult 20 years of age, per US EPA guidance (US EPA, 2014b). The daily recommended residential soil ingestion rates of 200 mg/day for a child and 100 mg/day for an adult are based on an all-day exposure to residential soils (US EPA, 2011b, 2014b). Since recreational exposures to sediment are assumed to occur for less than four hours per day, one-third of the daily residential soil ingestion (67 mg/day for a child and 33 mg/day for an adult) was used as a conservative assumption. For dermal exposures, recreators were assumed to be exposed to sediment on their lower legs and feet (1,026 cm^2 for the child and 3,026 cm^2 for the adult, based on the age-weighted surface areas reported in US EPA (2011b). While other body parts may be exposed to sediment, the contact time will likely be very short, as the sediment would wash off in the surface water. Gradient used US EPA's recommended adherence factor of 0.2 mg/cm^2 based on child exposure to wet soil (US EPA, 2004, 2014b), which was used in the US EPA RSL User's Guide for a child recreator exposed to soil or sediment (US EPA, 2021c). The sediment screening benchmarks were calculated based on a target hazard quotient of 1, or a target cancer risk of 1×10^{-5}. Appendix B, Table B.2 presents the calculation of screening benchmarks protective of recreational exposures to sediment.

Screening Risk Evaluation: The modeled sediment concentrations at the unnamed tributary and the western branch of Coffeen Lake were well below the recreational sediment screening benchmarks (Tables 3.13 and 3.14, respectively). Therefore, exposure to sediment is not expected to pose an unacceptable risk to recreators while angling in the unnamed tributary or boating in Coffeen Lake.

Table 3.13 Risk Evaluation for Recreators Exposed to Sediment in the Unnamed Tributary

COI	Modeled Sediment Concentration (mg/kg)	Recreator Sediment Screening Benchmark (mg/kg)	COPC
Total Metals (mg/kg)			
Arsenic	7.0E-04	6.8E+01	No
Beryllium	6.4E-05	2.7E+03	No
Boron	7.4E-04	2.7E+05	No
Cobalt	1.3E-03	4.1E+02	No
Lead	2.2E-02	4.0E+02	No
Thallium	1.7E-06	1.4E+01	No

Notes:
COI = Constituent of Interest; COPC = Constituent of Potential Concern.

Table 3.14 Risk Evaluation for Recreators Exposed to Sediment in the Western Branch of Coffeen Lake

COI	Modeled Sediment Concentration (mg/kg)	Recreator Sediment Screening Benchmark (mg/kg)	COPC
Total Metals (mg/kg)			
Beryllium	1.5E-05	2.7E+03	No
Lead	3.7E-04	4.0E+02	No

Notes:
COI = Constituent of Interest; COPC = Constituent of Potential Concern.

3.6 Ecological Risk Evaluation

Based on the ecological CEM (Figure 3.4), ecological receptors could be exposed to surface water and dietary items (*i.e.*, prey and plants) potentially impacted by identified COIs (cadmium, cobalt, lead, mercury, and radium-226+228).

3.6.1 Ecological Receptors Exposed to Surface Water

Screening Exposures: The ecological evaluation considered aquatic communities in Coffeen Lake and the unnamed tributary potentially impacted by identified ecological COIs. Measured and modeled surface water concentrations were compared to risk-based ecological screening benchmarks.

Screening Benchmarks: Surface water screening benchmarks protective of aquatic life were obtained from the following hierarchy of sources:

- IEPA SWQS (IEPA, 2019), regulatory standards that are intended to protect aquatic life exposed to surface water on a long-term basis (*i.e.*, chronic exposure). For cadmium, the surface water benchmark is hardness dependent and calculated using a default hardness of 100 mg/L (US EPA, 2022)[6];
- US EPA Region IV (2018) surface water ESVs for hazardous waste sites; and
- US DOE benchmarks from the guidance document, "A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota" (US DOE, 2019).

Risk Evaluation: The maximum modeled COI concentrations in surface water in the unnamed tributary were compared to the benchmarks protective of aquatic life (Table 3.15). The maximum measured COI concentrations in Coffeen Lake, and modeled COI concentrations in the western branch of Coffeen Lake, were compared to the benchmarks protective of aquatic life (Table 3.16). The measured and modeled surface water concentrations for the COIs were below their respective benchmarks. Thus, none of the COIs evaluated are expected to pose an unacceptable risk to aquatic life in the unnamed tributary or Coffeen Lake.

[6] Conservatisms associated with using a default hardness value are discussed in Section 3.6.

Table 3.15 Risk Evaluation for Ecological Receptors Exposed to Surface Water in the Unnamed Tributary

COI	Modeled Surface Water Concentration[a]	Ecological Freshwater Benchmark	Basis	COPC
Total Metals (mg/L)				
Cadmium	1.1E-07	0.0011	IEPA SWQC	No
Cobalt	1.4E-06	0.019	US EPA R4 ESV	No
Lead	2.2E-06	0.020	IEPA SWQC	No
Mercury	3.7E-08	0.0011	IEPA SWQC	No
Radionuclides (pCi/L)				
Radium-226 + 228	1.1E-04	3.0	US DOE	No

Notes:
COI = Constituent of Interest; COPC = Constituent of Potential Concern; ESV = Ecological Screening Value; IEPA = Illinois Environmental Protection Agency; pCi/L = PicoCuries Per Liter; SWQC = Surface Water Quality Criteria; US DOE = United States Department of Energy; US EPA R4 = United States Environmental Protection Agency Region IV.
(a) Surface water samples were not collected from the unnamed tributary.

Table 3.16 Risk Evaluation for Ecological Receptors Exposed to Surface Water in the Western Branch of Coffeen Lake

COI	Maximum Surface Water Concentration		Ecological Freshwater Benchmark	Basis	COPC	
	Modeled	Measured			Based on Modeled Concentration	Based on Measured Concentration
Total Metals (mg/L)						
Cadmium	4.6E-09	NA	0.0011	IEPA SWQC	No	NA

Notes:
COI = Constituent of Interest; COPC = Constituent of Potential Concern; IEPA = Illinois Environmental Protection Agency; SWQC = Surface Water Quality Criteria.
NA = Not Applicable; COI was not measured in surface water collected from Coffeen Lake.

3.6.2 Ecological Receptors Exposed to Sediment

Screening Exposures: COIs in impacted groundwater discharging into Coffeen Lake or the unnamed tributary can sorb to sediments *via* chemical partitioning. In the absence of sediment data, sediment concentrations were modeled using maximum detected groundwater concentrations. Therefore, the modeled COI sediment concentrations reflect the potential maximum Site-related sediment concentration from groundwater discharge.

Screening Benchmarks: Sediment screening benchmarks were obtained from US EPA Region IV (2018). The majority of the sediment ESVs are based on threshold effect concentrations (TECs) from MacDonald *et al.* (2000), which provide consensus values that identify concentrations below which harmful effects on sediment-dwelling organisms are unlikely to be observed. In the absence of an ESV for radium-226+228, a sediment screening value of 90,000 pCi/kg was used, based on the biota concentration guide (BCG) for radium-228 (US DOE, 2019).[7] The benchmarks used in this evaluation are listed in Table 3.17 for the unnamed tributary, and Table 3.18 for the western branch of Coffeen Lake.

Screening Risk Results: The maximum modeled COI sediment concentrations for the unnamed tributary and the western branch of Coffeen Lake were below their respective sediment screening benchmarks (Tables 3.17 and 3.18, respectively). The modeled sediment concentrations attributed to potential contributions from Site groundwater for all COIs were less than or equal to 1% of the sediment screening benchmark. Therefore, the modeled sediment concentrations attributed to potential contributions from Site groundwater are not expected to significantly contribute to ecological exposures in the unnamed tributary or Coffeen Lake adjacent to the Site.

Table 3.17 Risk Evaluation for Ecological Receptors Exposed to Sediment in the Unnamed Tributary

COI	Modeled Sediment Concentration	ESV[a]	COPC	Percentage of Benchmark
Total Metals (mg/kg)				
Cadmium	1.5E-04	0.99	No	0.01%
Cobalt	1.3E-03	50	No	0.003%
Lead	2.2E-02	35.8	No	0.06%
Mercury	1.3E-03	0.18	No	0.7%
Radionuclides (pCi/kg)				
Radium-226 + 228	7.9E-01	90,000[b]	No	0.001%

Notes:
COI = Constituent of Interest; COPC = Constituent of Potential Concern; ESV = Ecological Screening Value; pCi/g = PicoCuries Per Gram; pCi/kg = PicoCuries Per Kilogram; US DOE = United States Department of Energy; US EPA = United States Environmental Protection Agency.
(a) ESV from US EPA Region IV (2018).
(b) ESV from US DOE (2019); value converted from 90 pCi/g to 90,000 pCi/kg.

Table 3.18 Risk Evaluation for Ecological Receptors Exposed to Sediment in the Western Branch of Coffeen Lake

COI	Modeled Sediment Concentration	ESV[a]	COPC	Percentage of Benchmark
Total Metals (mg/kg)				
Cadmium	6.2E-06	0.99	No	0.00063%

Notes:
COI = Constituent of Interest; COPC = Constituent of Potential Concern; ESV = Ecological Screening Value; US EPA = United States Environmental Protection Agency.
(a) ESV from US EPA Region IV (2018).

3.6.3 Ecological Receptors Exposed to Bioaccumulative Constituents of Interest

Screening Exposures: COIs with bioaccumulative properties can impact higher-trophic-level wildlife exposed to these COIs *via* direct exposures (surface water and sediment exposure) and secondary exposures through the consumption of dietary items (*e.g.*, plants, invertebrates, small mammals, and fish).

[7] The BCG for sediment is 90 pCi/g for Ra-228 and 100 pCi/g for Ra-226; the lower of the two values was used for Ra-226+228, and converted to pCi/kg (US DOE, 2019).

Screening Benchmark: US EPA Region IV (2018) guidance and IEPA SWQS (IEPA, 2019) guidance were used to identify constituents with potential bioaccumulative effects.

Risk Evaluation: With the exception of mercury, the ecological COIs (cadmium, cobalt, lead, and radium-226+228) were not identified as having potential bioaccumulative effects. Therefore, these COIs are not considered to pose an ecological risk *via* bioaccumulation. IEPA (2019) identifies mercury as the only metal with bioaccumulative properties. US EPA Region IV (2018) also identifies mercury (including methyl mercury) as having potential bioaccumulative effects.[8]

The modeled mercury concentration in surface water in the unnamed tributary (3.7×10^{-8} mg/L) was below the mercury surface water ESV for wildlife (1.3×10^{-6} mg/L), and the modeled mercury concentration in sediment at the unnamed tributary (1.3×10^{-3} mg/kg) was below the sediment ESV for wildlife (0.18 mg/kg) (US EPA Region IV, 2018).[9] Both the modeled surface water and sediment concentrations were below benchmarks protective of receptors accounting for bioaccumulative properties. Therefore, in addition to not posing an ecological risk from direct toxicity, mercury does not pose a risk from bioaccumulation exposures.

3.7 Uncertainties and Conservatisms

A number of uncertainties and their potential impacts on the risk evaluation are discussed below. Wherever possible, conservative assumptions were used in an effort to minimize uncertainties and overestimate rather than underestimate risks.

Exposure Estimates:

- The risk evaluation included the Illinois Part 845.600 constituents detected in groundwater samples (above GWPS) collected from wells associated with the GMF GSP and the GMF RP. However, it is possible that not all of the detected constituents are related specifically to the GMF GSP and the GMF RP.
- The human health and ecological risk characterizations were based on the maximum measured or modeled COI concentrations, rather than on averages. Thus, the variability in exposure concentrations was not considered. Assuming continuous exposure to the maximum concentration overestimates human and ecological exposures, given that receptors are mobile and concentrations change over time. For example, US EPA guidance states that risks should be estimated using average exposure concentrations as represented by the 95% upper confidence limit on the mean (US EPA, 1992). Given that exposure estimates based on the maximum concentrations did not exceed risk benchmarks, Gradient has greater confidence that there is no risk concern.
- Only constituents detected in groundwater were used to identify COIs and model COI concentrations in surface water and sediment. For the constituents that were not detected in the GMF GSP and the GMF RP groundwater, the detection limits were below the Illinois Part 845.600 GWPS and thus do not require further evaluation.
- COI concentrations in surface water were modeled using the maximum detected total COI concentrations in groundwater. Modeling surface water concentrations using total metal concentrations may overestimate surface water concentrations because dissolved concentrations,

[8] US EPA Region IV (2018) identifies selenium as having potential bioaccumulative effects. Although selenium was detected in groundwater, it was not considered an ecological COI.

[9] Mercury was not an ecological COI on the west side of the groundwater divide; thus, it was not evaluated for the western branch of Coffeen Lake.

which are lower than total concentrations, represent the mobile fractions of constituents that could likely flow into and mix with surface water.

- The COIs identified in this evaluation also occur naturally in the environment. Contributions to exposure from natural sources or other sources unrelated to the GMF GSP and the GMF RP were not considered in the evaluation of modeled concentrations; only exposure contributions potentially attributable to Site groundwater mixing with surface water were evaluated. While not quantified, exposures from potential groundwater contributions related to the GMF GSP and the GMF RP are likely to represent only a small fraction of the overall human and ecological exposure to COIs that also have natural sources or sources unrelated to the GMF GSP and the GMF RP.
- Screening benchmarks for human health were developed using exposure inputs based on US EPA's recommended values for reasonable maximum exposure (RME) assessments (US EPA, 2014b). RME is defined as "the highest exposure that is reasonably expected to occur at a site but that is still within the range of possible exposures" (US EPA, 2004). US EPA states the "intent of the RME is to estimate a conservative exposure case (*i.e.*, well above the average case) that is still within the range of possible exposures" (US EPA, 1989). US EPA also notes that this high-end exposure "is the highest dose estimated to be experienced by some individuals, commonly stated as approximately equal to the 90th percentile exposure category for individuals" (US EPA, 2015c). Thus, most individuals will have lower exposures than those presented in this risk assessment.

Toxicity Benchmarks:

- Screening-level ecological benchmarks were compiled from IEPA and US EPA guidance and designed to be protective of the majority of Site conditions, leaving the option for Site-specific refinement. In some cases, these benchmarks may not be representative of the Site-specific conditions or receptors found at the Site, or may not accurately reflect concentration-response relationships encountered at the Site. For example, the ecological benchmark for cadmium is hardness-dependent. However, hardness data are not available for Coffeen Lake or the unnamed tributary; therefore, Gradient relied on US EPA's default hardness of 100 mg/L. Use of a higher hardness value would increase the cadmium SWQS because benchmarks become less stringent with higher levels of hardness. Regardless of the hardness, the maximum modeled cadmium concentration is orders of magnitude below the SWQS.
- In addition, for the ecological evaluation, Gradient conservatively assumed all constituents to be 100% bioavailable. Modeled COI concentrations in surface water are considered total COI concentrations. In addition, the measured surface water data used in this report represent total concentrations. US EPA recommends using dissolved metals as a measure of exposure to ecological receptors because it represents the bioavailable fraction of metal in water (US EPA, 1993). Therefore, the modeled surface water COI concentrations may be an overestimation of exposure concentrations to ecological receptors.
- In general, it is important to appreciate that the human health toxicity factors used in this risk evaluation are developed to account for uncertainties, such that safe exposure levels used as benchmarks are often many times lower (even orders of magnitude lower) than the levels that cause effects that have been observed in human or animal studies. For example, toxicity factors incorporate a 10-fold safety factor to protect sensitive subpopulations. This means that a risk exceedance does not necessarily equate to actual harm.

4 Summary and Conclusions

A screening-level risk evaluation was performed for potential Site-related constituents in groundwater at the CPP in Coffeen, Illinois. The CSM developed for the Site indicates that groundwater beneath the GMF GSP and the GMF RP flows into Coffeen Lake and the unnamed tributary adjacent to the Site and may potentially impact surface water and sediment.

CEMs were developed for human and ecological receptors. The complete exposure pathways for humans include anglers who consume locally caught fish from Coffeen Lake or the unnamed tributary, and recreators (boaters) in Coffeen Lake, groups which could be exposed to surface water and sediment. Based on the local hydrogeology, residential exposure to groundwater used for drinking water or irrigation is not a complete pathway and was not evaluated. The complete exposure pathways for ecological receptors include aquatic life (including aquatic and marsh plants, amphibians, reptiles, and fish) exposed to surface water; benthic invertebrates exposed to sediment; and avian and mammalian wildlife exposed to bioaccumulative COIs in surface water, sediment, and dietary items.

Groundwater data collected from 2015 to 2021 were used to estimate exposures. Surface water data collected from Coffeen Lake were also evaluated. For groundwater constituents retained as COIs, surface water and sediment concentrations were modeled using the maximum detected groundwater concentration. Surface water and sediment exposure estimates were screened against benchmarks protective of human health and ecological receptors for this risk evaluation.

For recreators exposed to surface water, all COIs were below the conservative risk-based screening benchmarks. Therefore, none of the COIs evaluated in surface water are expected to pose an unacceptable risk to recreators in Coffeen Lake or the unnamed tributary adjacent to the Site.

For recreators exposed to sediment *via* incidental ingestion and dermal contact, the modeled sediment concentrations were below health-protective sediment benchmarks. Therefore, the modeled sediment concentrations are not expected to pose an unacceptable risk to recreators exposed to sediment in Coffeen Lake or the unnamed tributary adjacent to the Site.

For anglers consuming locally caught fish, the modeled concentrations of all COIs in surface water were below conservative benchmarks protective of fish consumption. Therefore, none of the COIs evaluated are expected to pose an unacceptable risk to recreators consuming fish caught in Coffeen Lake or the unnamed tributary.

Ecological receptors exposed to surface water include aquatic and marsh plants, amphibians, reptiles, and fish. The risk evaluation showed that none of the modeled or measured COIs in surface water exceeded protective screening benchmarks. Ecological receptors exposed to sediment include benthic invertebrates. The modeled sediment COIs did not exceed the conservative screening benchmarks; therefore, none of the COIs evaluated in sediment are expected to pose an unacceptable risk to ecological receptors.

Ecological receptors were also evaluated for exposure to bioaccumulative COIs. This evaluation considered higher-trophic-level wildlife with direct exposure to surface water and sediment and secondary exposure through the consumption of dietary items (*e.g.*, plants, invertebrates, small mammals, fish). Mercury was the only ecological COI identified as having potential bioaccumulative effects. However, the modeled concentrations did not exceed benchmarks protective of bioaccumulative effects. Therefore, mercury is not considered to pose an ecological risk *via* bioaccumulation. Overall, this evaluation demonstrated that none of the COIs evaluated are expected to pose an unacceptable risk to ecological receptors.

It should be noted that this evaluation incorporates a number of conservative assumptions which tend to overestimate exposure and risk. While the risk evaluation was based on the maximum detected COI concentration, US EPA guidance states that risks should be based on a representative average concentration such as the 95% upper confidence limit on the mean; thus, using the maximum concentration tends to overestimate exposure. Although the COIs identified in this evaluation also occur naturally in the environment, the contributions to exposure from natural background sources and nearby industry were not considered; thus, CCR-related exposures were likely overestimated. Exposure estimates assumed 100% metal bioavailability, which likely results in overestimates of exposure and risks. Exposure estimates were based on inputs to evaluate the "reasonable maximum exposure"; thus, most individuals will have lower exposures than those estimated in this risk assessment.

Finally, it should be noted that because current conditions do not present a risk to human health or the environment, there will also be no unacceptable risk to human health or the environment for future conditions when the GMF GSP and the GMF RP are closed. For all future closure scenarios, potential releases of CCR-related constituents will decline over time and, consequently, potential exposures to CCR-related constituents in the environment will also decline.

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Appendix A

Surface Water and Sediment Modeling

Gradient modeled surface water concentrations in the unnamed tributary and the western branch of Coffeen Lake and associated sediments based on available groundwater data. First, Gradient estimated the flow rate of constituents of interest (COIs) that may flow into these waterbodies *via* groundwater. Then, Gradient adapted United States Environmental Protection Agency's (US EPA's) indirect exposure assessment methodology (US EPA, 1998) in order to model surface water and sediment water concentrations in the unnamed tributary and the western branch of Coffeen Lake.

Model Overview

Two separate surface water models were carried out: one for the unnamed tributary, located to the east of a groundwater divide, and one for the western branch of Coffeen Lake, located to the west of a groundwater divide (see Section 2). Groundwater flow into these waterbodies is represented by a one-dimensional steady-state model. In this model, the groundwater plume migrates horizontally in the Uppermost Aquifer (UA) before flowing into surface water. The groundwater flow entering the surface water is the flow going through a cross-sectional area with a length equal to the length of the surface water bodies adjacent to the GMF ponds (*i.e.*, the GMF Gypsum Stack Pond [GSP] and the GMF Recycle Pond [RP]) with potential CCR-related impacts and a height equal to the average saturated thickness of the UA. It was assumed that all groundwater originating from the GMF RP ultimately flows into the unnamed tributary, whereas a component of groundwater originating from the GMF GSP flows into the unnamed tributary, and the rest flows into the western branch of Coffeen Lake.

Groundwater flow into the unnamed tributary mixes with the surface water in the tributary whereas groundwater flow into the western branch of Coffeen Lake mixes with the surface water in the lake. The COIs entering the unnamed tributary as well as the western branch of Coffeen Lake *via* groundwater can dissolve into the water column, sorb to suspended sediments, or sorb to benthic sediments. Using US EPA's indirect exposure assessment methodology (US EPA, 1998), the model evaluates the surface water and sediment concentrations at a location downstream of the groundwater discharge, assuming a well-mixed water column.

Groundwater Flow Rate

The groundwater flow rate was evaluated using conservative assumptions. Gradient conservatively assumed that the groundwater concentrations were uniformly equal to the maximum detected concentration for each individual COI. Gradient ignored adsorption by subsurface soil and assumed that groundwater flowing through the UA was discharged into surface water.

For each groundwater unit, the groundwater flow rate into surface water was derived using Darcy's Law:

$$Q = K \times i \times A$$

where:

- Q = Groundwater flow rate (m^3/s)
- K = Hydraulic conductivity (m/s)
- i = Hydraulic gradient (m/m)
- A = Cross-sectional area (m^2)

For each COI, the mass discharge rate into surface water was then calculated from the following equation:

$$m_c = C_c \times Q \times CF$$

where:

m_c	=	Mass discharge rate of the COI (mg/year)
C_c	=	Maximum groundwater concentration of the COI (mg/L)
Q	=	Groundwater flow rate (m^3/s)
CF	=	Conversion factors: 1,000 L/m^3; 31,557,600 s/year

The values of the aquifer parameters used for these calculations for the unnamed tributary are provided in Table A.1 and for the western branch of Coffeen Lake are provided in Table A.2. The calculated mass discharge rates were then used as inputs for the surface water and sediment partitioning model.

The cross-sectional area for the UA was approximately 664 m^2 for the unnamed tributary and approximately 427 m^2 for the western branch of Coffeen Lake. The length of the water bodies through which groundwater flows was estimated to be approximately 726 m for the unnamed tributary and about 467 m for the western branch of Coffeen Lake. In both cases, the height of the UA was approximately 3 feet (ft) (*i.e.*, 0.91 m) (Ramboll, 2021a,b).

Towards the unnamed tributary, the average hydraulic gradient within the UA was estimated to be 0.0075 m/m (Ramboll, 2021a,b). Towards the western branch of Coffeen Lake, the mean hydraulic gradient determined for the UA was 0.018 m/m (Ramboll, 2021a).

To model surface water concentrations in the unnamed tributary, we used the average of the geometric mean horizontal hydraulic conductivities (*i.e.*, 0.0013 cm/sec) measured for the UA near the GMF GSP and the GMF RP (Ramboll, 2021a,b). To model surface water concentrations in the western branch of Coffeen Lake, we used the geometric mean horizontal hydraulic conductivity (*i.e.*, 0.0014 cm/sec) determined for the UA near the GMF GSP (Ramboll, 2021a).

Surface Water and Sediment Concentration

Groundwater flowing into the lake will be diluted in the surface water flow. Constituents transported by groundwater into the surface water migrate into the water column and the bed sediments. The surface water model Gradient used to estimate the surface water and sediment concentrations is a steady-state model described in US EPA's indirect exposure assessment methodology (US EPA, 1998), and also used in US EPA's "Human and Ecological Risk Assessment of Coal Combustion Residuals" (US EPA, 2014). This model describes the partitioning of constituents between surface water, suspended sediments, and benthic sediments based on equilibrium partition coefficients. It estimates the concentrations of constituents in surface water, suspended sediments, and benthic sediments at steady-state equilibrium at a theoretical location downstream of the discharge point after complete mixing of the water column. In the analysis, Gradient used the partitioning coefficients given in Table J-1 of the US EPA CCR Risk Assessment for all COIs (US EPA, 2014). These coefficients are presented in Table A.3.

To be conservative, Gradient assumed that the constituents were not affected by dissipation or degradation once they entered the water body. The total water body concentration of the COI was calculated as (US EPA, 1998):

$$C_{wtot} = \frac{m_c}{V_f \times f_{water}}$$

where:

C_{wtot}	=	Total water body concentration of the constituent (mg/L)
m_c	=	Mass discharge rate of the COI (mg/year)
V_f	=	Water body annual flow (L/year)
f_{water}	=	Fraction of COI in the water column (unitless)

There are no flow records available for the unnamed tributary and the western branch of Coffeen Lake. According to Golder Associates, the flow rate in the unnamed tributary was assumed to be 90 cubic feet per second (cfs) (Golder Associates, Inc., 2020). According to the US Geological Survey (USGS) Streamstats program, the western branch of Coffeen Lake has a two-year flow peak flow prediction of 1,010 cfs (USGS, 2022). The surface water parameters for the unnamed tributary are presented in Table A.4 and the surface water parameters for the western branch of the Coffeen Lake are presented in Table A.5.

The fraction of COI in the water column was calculated for each COI (11 COIs determined for the unnamed tributary and 4 COIs determined for the western branch of Coffeen Lake) using the sediment/water and suspended solids/water partition coefficients (US EPA, 2014, Table J-1). The fraction of COIs in the water column is defined as (US EPA, 2014):

$$f_{water} = \frac{(1 + [K_{dsw} \times TSS \times 0.000001]) \times \frac{d_w}{d_z}}{\left([1 + (K_{dsw} \times TSS \times 0.000001)] \times \frac{d_w}{d_z}\right) + ([bsp + K_{dbs} \times bsc] \times \frac{d_b}{d_z})}$$

where:

K_{dsw}	=	Suspended sediment-water partition coefficient (mL/g)
K_{dbs}	=	Sediment-water partition coefficient (mL/g)
TSS	=	Total suspended solids in the surface water body (mg/L), set equal to the average Coffeen Lake concentration of 3.2 mg/L (Hanson, 2020)
0.000001	=	Units conversion factor
d_w	=	Depth of the water column (m). The mean depth of the surface water column for the western branch of Coffeen Lake was estimated as 5.7 m (Austen *et al.*, 1993), whereas the flow depth of the unnamed tributary was estimated as 0.6 m (Golder Associates, Inc., 2020).
d_b	=	Depth of the upper benthic layer (m), set equal to 0.03 m (US EPA, 2014)
$d_z = d_w + d_b$	=	Depth of the water body (m) = 5.73 m for the western branch of Coffeen Lake and 0.67 m for the unnamed tributary.
bsp	=	Bed sediment porosity (unitless), set equal to 0.6 (US EPA, 2014)
bsc	=	Bed sediment particle concentration (g/cm^3), set equal to 1.0 g/cm^3 (US EPA, 2014)

The fraction of COIs dissolved in the water column (f_d) is calculated as (US EPA, 2014):

$$f_d = \frac{1}{1 + K_{dsw} \times TSS \times 0.000001}$$

The values of the fraction of COIs in the water column and other calculated parameters for the unnamed tributary are presented in Table A.6 and for the western branch of Coffeen Lake are presented in Table A.7.

The total water column concentration (C_{wcTot}) of the COIs, comprising both the dissolved and suspended sediment phases, is then calculated as (US EPA, 2014):

$$C_{wcTot} = C_{wtot} \times f_{water} \times \frac{d_z}{d_w}$$

Finally, the dissolved water column concentration (C_{dw}) for the COIs is calculated as (US EPA, 2014):

$$C_{dw} = f_d \times C_{wcTot}$$

The dissolved water column concentration was then used to calculate the concentration of COIs sorbed to suspended solids in the water column (US EPA, 1998):

$$C_{sw} = C_{dw} \times K_{dsw}$$

where:

C_{sw}	=	Concentration sorbed to suspended solids (mg/kg)
C_{dw}	=	Concentration dissolved in the water column (mg/L)
K_{dsw}	=	Suspended solids/water partition coefficient (mL/g)

In the same way, using the total water body concentration and the fraction of COIs in the benthic sediments, the model derives the total concentration in benthic sediments (US EPA, 2014):

$$C_{bstot} = f_{benth} \times C_{wtot} \times \frac{d_z}{d_b}$$

where:

C_{bstot}	=	Total concentration in bed sediment (mg/L or g/m^3)
C_{wtot}	=	Total water body concentration of the constituent (mg/L)
f_{benth}	=	Fraction of contaminant in benthic sediments (unitless)
d_b	=	Depth of the upper benthic layer (m)
$d_z = d_w + d_b$	=	Depth of the water body (m)

This value can be used to calculate dry weight sediment concentration as follows:

$$C_{sed-dw} = \frac{C_{bstot}}{bsc}$$

where:

C_{sed-dw}	=	Dry weight sediment concentration (mg/kg)
C_{bstot}	=	Total sediment concentration (mg/L)
bsc	=	Bed sediment bulk density (default value of 1 g/cm^3 from US EPA, 2014)

The total sediment concentration is composed of the concentration dissolved in the bed sediment pore water (equal to the concentration dissolved in the water column) and the concentration sorbed to benthic sediments (US EPA, 1998).

The concentration sorbed to benthic sediments was calculated from US EPA (1998):

$$C_{sb} = C_{dbs} \times K_{dbs}$$

where:

C_{sb}	=	Concentration sorbed to bottom sediments (mg/kg)
C_{dbs}	=	Concentration dissolved in the sediment pore water (mg/L)
K_{dbs}	=	Sediments/water partition coefficient (mL/kg)

For each COI, the modeled total water column concentration, the modeled dry weight sediment concentration, and the modeled concentration sorbed to sediment for the unnamed tributary are presented in Table A.8 and for the western branch of Coffeen Lake are presented in Table A.9.

Table A.1 Parameters Used to Estimate Groundwater Flow to the Surface Water of the Unnamed Tributary

Groundwater Unit	Parameter	Name	Value	Unit
Uppermost Aquifer	A	Cross-Sectional Area	664	m^2
Uppermost Aquifer	i	Hydraulic Gradient	0.0075	m/m
Uppermost Aquifer	K	Hydraulic Conductivity	0.0013	cm/s

Note:
Sources: Hydraulic gradient and hydraulic conductivity values from Ramboll (2021a,b).

Table A.2 Parameters Used to Estimate Groundwater Flow to the Surface Water of the Western Branch of Coffeen Lake

Groundwater Unit	Parameter	Name	Value	Unit
Uppermost Aquifer	A	Cross-Sectional Area	427	m^2
Uppermost Aquifer	i	Hydraulic Gradient	0.018	m/m
Uppermost Aquifer	K	Hydraulic Conductivity	0.0014	cm/s

Note:
Source: Hydraulic gradient and hydraulic conductivity values from Ramboll (2021a).

Table A.3 Partition Coefficients

Constituent	Sediment-Water, Mean, K_{dbs}		Suspended Sediment-Water, Mean, K_{dsw}	
	Value (log_{10}) (mL/g)	Value (mL/g)	Value (log_{10}) (mL/g)	Value (mL/g)
Metals				
Arsenic	2.4	2.51E+02	3.9	7.94E+03
Boron	0.8	6.31E+00	3.9	7.94E+03
Beryllium	2.8	6.31E+02	4.2	1.58E+04
Cadmium	3.3	2.00E+03	4.9	7.94E+04
Cobalt	3.1	1.26E+03	4.8	6.31E+04
Lead	4.6	3.98E+04	5.7	5.01E+05
Mercury	4.9	7.94E+04	5.3	2.00E+05
Thallium	1.3	2.00E+01	4.1	1.26E+04
Radionuclides				
Radium-226+228	-	7.40E+03	-	7.40E+03

Note:
Source: US EPA (2014).

Table A.4 Surface Water Parameters for the Unnamed Tributary

Parameter	Name	Value	Unit
TSS	Total Suspended Solids	6	mg/L
V_{fx}	Surface Water Flow Rate	8.04×10^{10}	L/yr
d_b	Depth of Upper Benthic Layer (default)	0.03	m
d_w	Depth of Water Column	0.64	m
d_z	Depth of Water Body	0.67	m
bsc	Bed Sediment Bulk Density (default)	1	g/cm^3
bsp	Bed Sediment Porosity (default)	0.6	-
M_{TSS}	TSS Mass per Unit Area[a]	0.00384	kg/m^2
M_S	Sediment Mass per Unit Area[b]	30	kg/m^2

Notes:
L/yr = Liter Per Year.
Source of default values: US EPA (2014).
(a) Determined by multiplying total suspended solids, TSS by the depth of water column, d_w.
(b) Determined by multiplying depth of the upper benthic layer, d_b, by sediment bed particle concentration of 1 g/cc.

Table A.5 Surface Water Parameters for the Western Branch of Coffeen Lake

Parameter	Name	Value	Unit
TSS	Total Suspended Solids	6	mg/L
V_{fx}	Surface Water Flow Rate	9.02×10^{11}	L/yr
d_b	Depth of Upper Benthic Layer (default)	0.03	m
d_w	Depth of Water Column	5.70	m
d_z	Depth of Water Body	5.73	m
bsc	Bed Sediment Bulk Density (default)	1	g/cm^3
bsp	Bed Sediment Porosity (default)	0.6	-
M_{TSS}	TSS Mass per Unit Area[a]	0.0342	kg/m^2
M_S	Sediment Mass per Unit Area[b]	30	kg/m^2

Notes:
L/yr = Liter Per Year.
Source of default values: US EPA (2014).
(a) Determined by multiplying total suspended solids, TSS by the depth of water column, d_w.
(b) Determined by multiplying depth of the upper benthic layer, d_b, by the default sediment bed particle concentration of 1 g/cc.

Table A.6 Calculated Parameters for the Unnamed Tributary

COI	Fraction of Constituent in the Water Column f_{water}	Fraction of Constituent in the Benthic Sediments $f_{benthic}$	Fraction of Constituent Dissolved in the Water Column $f_{dissolved}$
Arsenic	0.082	0.918	0.955
Beryllium	0.0357	0.9643	0.9132
Boron	0.7639	0.2361	0.9545
Cadmium	0.0155	0.9845	0.6772
Cobalt	0.023	0.977	0.725
Lead	0.002	0.998	0.250
Mercury	0.001	0.999	0.455
Thallium	0.528	0.472	0.930
Radium-226+228	0.003	0.997	0.957

Note:
COI = Constituent of Interest.

Table A.7 Calculated Parameters for the Western Branch of Coffeen Lake

COI	Fraction of Constituent in the Water Column f_{water}	Fraction of Constituent in the Benthic Sediments $f_{benthic}$	Fraction of Constituent Dissolved in the Water Column $f_{dissolved}$
Beryllium	0.248	0.752	0.913
Cadmium	0.1232	0.8768	0.6772
Lead	0.019	0.981	0.250

Note:
COI = Constituent of Interest.

Table A.8 Surface Water and Sediment Modeling Results for the Unnamed Tributary

COI	Groundwater Concentration (mg/L or pCi/L)	Mass Discharge Rate (mg/year or pCi/year)	Total Water Column Concentration (mg/L or pCi/L)	Concentration Sorbed to Bottom Sediments (mg/kg or pCi/kg)
Arsenic	0.11	2.2E+05	2.9E-06	7.0E-04
Beryllium	0.0042	8.6E+03	1.1E-07	6.4E-05
Boron	4.6	9.4E+06	1.2E-04	7.4E-04
Cadmium	0.0041	8.4E+03	1.1E-07	1.5E-04
Cobalt	0.053	1.1E+05	1.4E-06	1.3E-03
Lead	0.082	1.7E+05	2.2E-06	2.2E-02
Mercury	0.0014	2.9E+03	3.7E-08	1.3E-03
Thallium	0.0035	7.1E+03	9.3E-08	1.7E-06
Radium-226 + 228	4.2	8.6E+06	1.1E-04	7.9E-01

Notes:
COI = Constituent of Concern; K_d = Equilibrium Partition Coefficient; pCi/kg = PicoCuries Per Kilogram; pCi/L = PicoCuries Per Liter; pCi/year = PicoCuries Per Year.

Table A.9 Surface Water and Sediment Modeling Results for the Western Branch of Coffeen Lake

COI	Groundwater Concentration (mg/L)	Mass Discharge Rate (mg/year)	Total Water Column Concentration (mg/L)	Concentration Sorbed to Bottom Sediments (mg/kg)
Beryllium	0.01	2.3E+04	2.6E-08	1.5E-05
Cadmium	0.0012	4.1E+03	4.6E-09	6.2E-06
Lead	0.010	3.3E+04	3.7E-08	3.7E-04

Notes:
COI = Constituent of Concern; K_d = Equilibrium Partition Coefficient.

Appendix A References

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Appendix B

Screening Benchmarks

Table B.1 Calculated Water Quality Standards Protective of Incidental Ingestion and Fish Consumption

Human Health COI	BCF[a] (L/kg-tissue)	Basis	MCL (mg/L)	RfD (mg/kg-day)	ADI[b] (mg/day)	Human Threshold Criteria		
						Water & Fish (mg/L)	Water Only (mg/L)	Fish Only (mg/L)
Arsenic	44	NRWQC (2002)	0.010	0.00030	0.020	0.022	2.0	0.023
Beryllium	19	NRWQC (2002)	0.0040	0.0020	0.0080	0.021	0.80	0.021
Boron	1	(c)	NC	0.20	14	467	1,400	700
Cobalt	300	ORNL (2020)	NC	0.00030	0.021	0.0035	2.1	0.0035
Lead	46	US EPA (2014)	0.015	NC	0.030	0.015	0.015	0.015
Thallium	116	NRWQC (2002)	0.0020	0.000010	0.0040	0.0017	0.40	0.0017

Notes:

ADI = Acceptable Daily Intake; BCF = Bioconcentration Factor; MCL = Maximum Contaminant Level; NC = No Criterion Available; NRWQC = National Recommended Water Quality Criteria; ORNL = Oak Ridge National Laboratory; RAIS = Risk Assessment Information System; RfD = Reference Dose; US EPA = United States Environmental Protection Agency.

(a) BCFs from the following hierarchy of sources:

NRWQC (US EPA, 2002). National Recommended Water Quality Criteria: 2002. Human Health Criteria Calculation Matrix.

US EPA (2014a). Human and Ecological Risk Assessment of Coal Combustion Residuals.

ORNL RAIS (ORNL, 2020). Risk Assessment Information System (RAIS) Toxicity Values and Chemical Parameters.

(b) ADI based on the MCL is calculated as the MCL (mg/L) multiplied by a water ingestion rate of 2 L/day. In the absence of an MCL, the ADI was calculated as the RfD (mg/kg-day) multiplied by the body weight (70 kg).

(c) BCF of 1 was used as a conservative assumption, due to a lack of a published BCF.

Equations from IEPA (2019):

Consumption of Water and Fish

$$HTC = \frac{ADI}{W + (F \times BCF)}$$

Incidental Consumption of Water Only

$$HTC = \frac{ADI}{W}$$

Consumption of Fish Only

$$HTC = \frac{ADI}{F \times BCF}$$

Where:

Human Threshold Criteria (HTC)	Chemical-specific	mg/L
Acceptable Daily Intake (ADI)	Chemical-specific	mg/day
Fish Consumption Rate (F)	0.02	kg/day
Bioconcentration Factor (BCF)	Chemical-specific	L/kg-tissue
Water Consumption Rate (W)	0.01	L/day
Body Weight	70	kg

Table B.2 Recreator Exposure to Sediment

COI	Relative Bioavailability (unitless)	Dermal Absorption Fraction (unitless)	Cancer				Cancer SL (mg/kg)	Non-Cancer								Recreator RSL Sediment (mg/kg)	Basis[a]
			TRV		Child + Adult			TRV		Child		Adult		Child	Adult		
			CSF $(mg/kg\text{-}day)^{-1}$	Dermal CSF $(mg/kg\text{-}day)^{-1}$	Incidental Ingestion SL (mg/kg)	Dermal Contact SL (mg/kg)		RfD (mg/kg-day)	Dermal RfD (mg/kg-day)	Incidental Ingestion SL (mg/kg)	Dermal Contact SL (mg/kg)	Incidental Ingestion SL (mg/kg)	Dermal Contact SL (mg/kg)	Non-Cancer SL (mg/kg)			
Total Metals																	
Arsenic	1	3.0E-02	1.5E+00	1.5E+00	8.1E+01	4.1E+02	6.8E+01	3.0E-04	3.0E-04	4.1E+02	4.4E+03	4.4E+03	8.0E+03	3.8E+02	2.8E+03	6.8E+01	c
Beryllium	1	NA	NC	NC	NC	NC	NC	2.0E-03	1.4E-05	2.7E+03	NA	2.9E+04	NA	2.7E+03	2.9E+04	2.7E+03	nc
Boron	1	NA	NC	NC	NC	NC	NC	2.0E-01	2.0E-01	2.7E+05	NA	2.9E+06	NA	2.7E+05	2.9E+06	2.7E+05	nc
Cobalt	1	NA	NC	NC	NC	NC	NC	3.0E-04	3.0E-04	4.1E+02	NA	4.4E+03	NA	4.1E+02	4.4E+03	4.1E+02	nc
Lead	1	NA	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	4.0E+02	L
Thallium	1	NA	NC	NC	NC	NC	NC	1.0E-05	1.0E-05	1.4E+01	NA	1.5E+02	NA	1.4E+01	1.5E+02	1.4E+01	nc

Notes:

ABS = Dermal Absorption Fraction; COI = Constituent of Interest; CSF = Cancer Slope Factor; NC = No Criterion Available; RfD = Reference Dose; RSL = Regional Screening Level; SL = Screening Level; TRV = Toxicity Reference Value; US EPA = United States Environmental Protection Agency.

(a) Screening benchmark defined as the lower of the Screening Levels for cancer and non-cancer. The basis of the benchmark presented as c = based on cancer endpoint, nc = based on non-cancer endpoint, or L = based on blood lead levels.

Equations for Screening Benchmark and Screening Levels:

$$\text{Screening Benchmark} = \frac{1}{\frac{1}{SL_{ing}} + \frac{1}{SL_{derm}}}$$

$$\text{Non-cancer } SL_{ing} = \frac{THQ * RfD}{Intake} \qquad \text{Cancer } SL_{ing} = \frac{TR}{Intake * CSF}$$

$$\text{Non-cancer } SL_{derm} = \frac{THQ * RfD}{Intake * ABS} \qquad \text{Cancer } SL_{derm} = \frac{TR}{Intake * ABS * CSF}$$

Where:

Target Risk (TR)	1E-05	
Target Hazard Quotient (THQ)	1	
Reference Dose (RfD)	Chemical-specific	mg/kg-day
Dermal Absorption Fraction (ABS)	Chemical-specific	
Cancer Slope Factor (CSF)	Chemical-specific	mg/kg
Incidental Ingestions Screening Level (SL_{ing})	Chemical-specific	mg/kg
Dermal Contact Screening Level (SL_{derm})	Chemical-specific	mg/kg

Sediment – Ingestion (Chemical)

		Non-Cancer		Cancer		
Intake Factor (IF) =	$\frac{IR \times EF \times ED \times CF}{BW \times AT}$ =	7.3E-07	6.8E-08	6.3E-08	2.0E-08	Basis
		Child	Adult	Child	Adult	
IR	Ingestion Rate (mg/day)	67	33	67	33	One-third of US EPA residential soil ingestion rate (Professional Judgment)
EF	Sediment Exposure Frequency (days/year)	60	60	60	60	2 days/week between April and October when air temperature >70°F (Professional Judgment)
ED	Exposure Duration (years)	6	20	6	20	Default value for Resident (US EPA, 2021b)
CF	Conversion Factor (kg/mg)	0.000001	0.000001	0.000001	0.000001	
BW	Body Weight (kg)	15	80	15	80	Default value for Resident (US EPA, 2021b)
AT	Averaging Time (days)	2,190	7,300	25,550	25,550	Default value for Resident (US EPA, 2021b)

Sediment – Dermal Contact (Chemical)

		Non-Cancer		Cancer		
Intake Factor (IF) =	$\frac{SA \times AF \times EF \times ED \times CF}{BW \times AT}$ =	2.2E-06	1.2E-06	1.9E-07	3.6E-07	Basis
		Child	Adult	Child	Adult	
SA	Surface Area Exposed to Sediment (cm^2/day)	1,026	3,026	1,026	3,026	Age-weighted SA for lower legs and feet (US EPA, 2011b)
AF	Sediment Skin Adherence Factor (mg/cm^2)	0.2	0.2	0.2	0.2	Age-weighted AF for children exposed to sediment (US EPA, 2011b)
EF	Sediment Exposure Frequency (days/year)	60	60	60	60	2 days/week between April and October when air temperature >70°F (Professional Judgment)
ED	Exposure Duration (years)	6	20	6	20	Default value for Resident (US EPA, 2021b)
CF	Conversion Factor (kg/mg)	0.000001	0.000001	0.000001	0.000001	
BW	Body Weight (kg)	15	80	15	80	Default value for Resident (US EPA, 2021b)
AT	Averaging Time (days)	2,190	7,300	25,550	25,550	Default value for Resident (US EPA, 2021b)

Appendix B

Supporting Information for Closure Alternatives Analysis – Gypsum Management Facility Gypsum Stack Pond and Recycle Pond at Coffeen Power Station

DRAFT

TECHNICAL MEMORANDUM

DATE April 22, 2022 **Reference No.** 21465046

TO Victor Modeer
Illinois Power Generating Company, LLC

CC David Mitchell (Illinois Power Generating Company, LLC)

FROM Michael Dreyer **EMAIL michael_dreyer@golder.com**

SUPPORTING INFORMATION FOR CLOSURE ALTERNATIVES ANALYSIS – GYPSUM MANAGEMENT FACILITY GYPSUM STACK POND AND RECYCLE POND AT COFFEEN POWER STATION

Golder Associates USA Inc. (Golder), a Member of WSP, has prepared this technical memorandum for Illinois Power Generating Company, LLC (IPGC) to support the Closure Alternatives Analysis for the Gypsum Management Facility (GMF) Gypsum Stack Pond (GSP) and GMF Recycle Pond (RP) at Coffeen Power Station. The Closure Alternatives Analysis is being completed in accordance with Illinois Administrative Code Title 35, Part 845, Standards for the Disposal of Coal Combustion Residuals (CCR) in Surface Impoundments (Part 845), by Gradient. With this technical memorandum, Golder summarizes the design basis and references used in developing the closure concepts evaluated by the Closure Alternatives Analysis.

Golder reviewed several documents related to the design, construction, and operation of the GMF GSP and GMF RP. Notable documents included the History of Construction (AECOM 2016a), the GMF GSP CCR Certification Report (AECOM 2016b), the GMF RP CCR Documentation Report (Hanson 2016), and the Gypsum Stack Cell G1 Acceptance Report (Hanson 2010).

1.0 INTRODUCTION AND BACKGROUND

1.1 Operational History

The GMF GSP served as the primary wet impoundment basin for gypsum produced by the wet scrubber system at the Coffeen Power Station. The GMF GSP and GMF RP were constructed between July 2008 and October 2010 and operated from 2010 until the Coffeen Power Station was retired in 2019. The GMF GSP has an area of approximately 43.3 acres. Base grade elevations range from approximate El. 605 feet (North American Vertical Datum of 1988) to El. 614 feet. The interior side slopes of the liner system are 3H:1V (horizontal to vertical) and have a height that varies from 15 to 24 feet. An exterior perimeter berm surrounds the entire GMF GSP and has side slopes of 3H:1V. The GMF RP has an area of approximately 18.3 acres and was formed with a continuous embankment ring dike, which has a total length of approximately 3,600 feet and a maximum height of approximately 16 feet above the surrounding grade. Base grade elevations range from approximately El. 604 feet to El. 606 feet. The interior side slopes of the liner system and the exterior slopes of the embankment ring dike are both 3H:1V.

The GMF GSP received inflow from two pairs of high-density polyethylene (HDPE) gypsum slurry pipes, which deposited gypsum from the west side of the GMF GSP and in the northwest corner, which formed a delta or beach of built-up gypsum in these locations during the operational life. The gypsum would build up to the water level and then expand laterally (rather than vertically) due to the subaqueous deposition method. During the operational life, the beach expanded so that roughly one-third of the GMF footprint had gypsum built up to the typical water level. Clear water discharge from the GMF GSP flowed downstream into the GMF RP via a lined channel (transfer channel) and 14-inch HDPE low-flow pipe buried beneath the transfer channel. The transfer channel effectively acted as a gap in the dike of the GMF GSP, as the bottom elevation of the transfer channel is equal to the adjacent exterior toe elevation of the dike. The transfer channel is approximately 580 feet in length, is trapezoidal in shape, is lined with 60-mil HDPE geomembrane, has 3H:1V side slopes, and has a bottom elevation that decreases from El. 624 feet at the upstream (north) end to El. 622 feet at the downstream (south) end. The 14-inch low flow pipe has an invert of El. 619.0 feet at the upstream end and El. 617.6 feet at the downstream end. The GMF RP acted as a polishing pond, and outflow was pumped to Coffeen Power Station to be recycled for use in the wet scrubber system. The GMF RP has an emergency spillway located at the northeast corner that consists of three precast 6-foot by 6-foot reinforced concrete risers with crest elevations at approximate El. 624 feet. The risers are connected to 48-inch diameter HDPE pipes that convey flow from the risers and discharge through existing NPDES Outfall 023 into the unnamed tributary creek east of the GMF RP that discharges to Coffeen Lake.

1.2 Existing GMF GSP Liner System Information

Based on review of the available documents, a composite liner system was installed for the GMF GSP consisting of (from top to bottom):

- GSE HDT060VW00 - 60-mil textured HDPE geomembrane
- 3-foot compacted clay layer placed in 8-inch lifts, compacted to at least 95% of the standard Proctor maximum dry density at a moisture content between the standard Proctor optimum moisture content (OMC) and 5% wet of the OMC

As documented in the Acceptance Report (Hanson 2010), the liner system was subjected to a rigorous construction quality assurance (CQA) program.

The side slopes and portions of the bottom of the GMF GSP were excavated to foundation grade. The bottom of the GMF GSP was excavated to and into the Vandalia Till. The excavated till was used to raise portions of the GMF GSP bottom to foundation grade. During preparation of the side slope and foundation grades, unsuitable sand materials were removed from several areas and stockpiled separately. These areas were then backfilled with material previously stockpiled or locally available material. Backfilled areas were compacted to at least 95% of the standard Proctor maximum dry density at a moisture content within 2% of the OMC. Four Shelby tube samples collected from the foundation grade berms were used for hydraulic conductivity analysis, with results ranging from 1.5×10^{-9} centimeters per second (cm/s) to 5.4×10^{-9} cm/s.

After certification of the foundation grades, the 3-foot compacted clay layer was constructed in 8-inch lifts and compacted to at least 95% of the standard Proctor maximum dry density at a moisture content between the OMC and 5% wet of the OMC. Twenty-one Shelby tube samples were collected during construction. Hydraulic conductivity results from tests on the Shelby tube samples range from 7.4×10^{-10} cm/s to 2.4×10^{-8} cm/s, significantly less than the construction specification of 1.0×10^{-7} cm/s. The compacted clay layer was smooth drum rolled prior to installation of the overlying GCL.

After placement of the compacted clay layer, a 60-mil textured HDPE geomembrane liner was installed on the floor and side slopes of the GMF GSP.

A 10-oz/yd^2 cushion geotextile was placed over the 60-mil textured HDPE geomembrane liner in the anchor trench and approximately 3.5 feet down the side slopes before the anchor trench was backfilled with flowable fill. The GMF GSP floor was constructed to slope towards four Process Water Recovery System (PWRS) sumps located at the inside toe of the east and south perimeter berms. An HDPE geomembrane rub sheet was placed on top of the geomembrane liner at the location of the sumps and side slope pipes. A 16-oz/yd^2 cushion geotextile was placed over the top of the geomembrane rub sheet in each sump. Each sump consists of a 12-inch HDPE SDR 11 perforated pipe placed on top of the 16-oz/yd^2 cushion geotextile surrounded by coarse aggregate placed over the pipe. A 6-oz/yd^2 geotextile filter fabric was placed over the top of the coarse aggregate. A sump access riser, 12-inch HDPE solid pipe, was connected to the 12-inch HDPE perforated pipe in each sump and extended upward along the side slopes. Filter sand was then placed over the 6-oz/yd^2 geotextile fabric at each sump location.

1.3 Existing GMF RP Liner System Information

Based on review of the available documents, a liner system was installed for the GMF RP consisting of (from top to bottom):

- 60-mil textured HDPE geomembrane
- Smooth drum-rolled native soil

Based on the evaluation of design drawings and available construction records, the GMF RP was constructed with a 60-mil textured HDPE geomembrane liner over smooth drum-rolled native soils. No compaction testing was performed on the smooth drum-rolled native soils. Permeability requirements were not specified for the native soils.

1.4 Type and Volume of Materials

Based on Golder's comparison (using Autodesk Civil 3D) of the existing conditions (December 2020 survey by IngenAE) and the approximate top-of-liner-system grades developed from the as-built top of liner, approximately 298,500 cubic yards (CY) of gypsum are present in the GMF GSP and approximately 51,500 CY of gypsum are present in the GMF RP.

The wet scrubber system used for flue gas desulfurization at Coffeen Power Station produced synthetic gypsum (calcium sulfate). The synthetic gypsum is generally of the same chemical structure as natural gypsum. Minimal information on the specific gypsum material produced at Coffeen Power Station is available. Because the material was sluiced, the particle-size distribution of the gypsum in the GMF GSP and GMF RP is expected to be variable, becoming finer with increased distance from the deposition locations. The Federal Highway Administration (FHWA) (2011) indicates that gypsum typically comprises approximately 17% sand-sized particles, 81% silt-sized particles, and 2% clay-sized particles. We Energies (2013) shows a comparable grain-size distribution for gypsum produced at Pleasant Prairie Power Plant, but with a less significant sand-sized fraction. Recent testing of gypsum produced at Duck Creek Power Plant showed the gypsum was comprised of approximately 3.5% sand-sized particles, 91.6% silt-sized particles, and 4.9% clay-sized particles.

We Energies (2013) cites a typical hydraulic conductivity of $1x10^{-5}$ cm/s for dewatered gypsum but indicates a measured hydraulic conductivity of $3x10^{-3}$ cm/s for gypsum produced at Pleasant Prairie Power Plant. Recent permeability testing of gypsum produced at Duck Creek Power Plant showed a typical hydraulic conductivity of $6.9x10^{-5}$ cm/s for gypsum at 10 psi confining pressure.

1.5 Water Levels

At the time of the December 2020 survey by IngenAE, the water level in the GMF GSP was at El. 625.2 feet and the water level in the GMF RP was at El. 617.6 feet. Although the water level would be expected to respond to wet or dry climate conditions, this water level is likely typical. Based on this water level, all the gypsum in the GMF GSP and GMF RP is below the water level and can be considered saturated. The gypsum forms a plateau at the north end of the GMF GSP with the highest point just below the water level at approximately El. 625 feet and the gypsum on the western side of the GMF RP has its highest point at approximately El. 613.5 feet.

Ramboll has provided a surface corresponding to the top of the uppermost aquifer unit. Based on a comparison of this surface and the as-built liner system grades, the top of the liner system appears to be below the top of the uppermost aquifer across the majority of the GMF GSP and GMF RP.

2.0 CLOSURE-BY-REMOVAL INFORMATION

Section 845.710(c)(1) requires the evaluation of complete removal of CCR and Section 845(d)(2) requires Closure Alternatives Analysis to identify if the Power Plant has a landfill that can accept the CCR or if constructing an on-Site landfill is feasible. Additionally, Section 845.710(c)(1) requires the evaluation of multiple modes of transportation of CCR, including rail, barge, and truck. This section includes evaluation of on-Site landfill options, potential off-Site landfills, and potential methods for transporting CCR to off-Site landfills.

2.1 Evaluation of On-Site CCR Landfill Options

There is an existing CCR landfill at the Coffeen Site, which currently has capacity for up to approximately 375,500 CY of additional material. The approximately 79,000 CY of CCR and subsoil resulting from closure-by-removal of the GMF RP are planned for disposal in the on-Site landfill. Under a closure-by-removal scenario, approximately 296,000 CY of material from Ash Pond No. 1 (AP1) would also be disposed of in the on-Site landfill. Therefore, the on-Site landfill does not currently have the capacity to contain all the CCR and subsoil that would be excavated from both the GMF RP and GMF GSP under the closure-by-removal scenario. Under closure-by-removal, material from the GMF GSP will be hauled off-Site for disposal.

Due to planned future land use of the surrounding property dedicated to renewable power generation, the landfill also cannot be expanded to sufficiently increase its capacity. Neither expansion of the existing on-site landfill nor construction of a new on-site landfill is a viable alternative at this site.

2.2 Potential Off-Site CCR Receiving Landfills

Potential off-Site landfills suitable for disposing of the approximately 295,500 CY of CCR and 234,000 CY of clay liner and subsoil within the GMF GSP were evaluated using IEPA's online Illinois Disposal Capacity Report. The closest landfills to the site, by road miles, were determined to be Republic Services' Litchfield-Hillsboro Landfill (a.k.a. Litchfield Landfill) in Litchfield, Illinois and Waste Management's Five Oaks Recycling and Disposal Facility (a.k.a. Five Oaks Landfill) in Taylorville, Illinois.

The Litchfield Landfill is the preferred landfill due to its location being closer to the Coffeen Power Plant (17.9 vs. 43.5 one-way miles, respectively), thereby resulting in reduced hauling mileage. Both landfills have sufficient remaining capacity to receive the approximately 529,500 CY of CCR, clay, and subsoil. Both landfills have been contacted but, as of the date of this memo, only the Litchfield Landfill has confirmed that they would be willing to accept the CCR. Golder has requested a quote for disposal costs (tipping fees) but has not yet received a quote. Information on both landfills is provided in Table 1 below.

Table 1: Off-Site Landfill Information

Landfill Name	Owner	Location	One-Way Distance from Site by Road (Miles)	2020 Five-Year Average Disposal Volume (in-place CY)	2020 Remaining Capacity Reported (in-place CY)
Litchfield Landfill	Republic Services	Litchfield, IL	17.9	82,620	1,535,189
Five Oaks Landfill	Waste Management	Taylorville, IL	43.5	249,664	7,051,864

2.3 Potential Off-Site CCR Transportation Methods

Section 845.710(c)(1) requires Closure-by-Removal to consider multiple methods for transporting removed CCR, including using rail, barge, and trucks. An evaluation of each method is included within this section.

2.3.1 Transportation by Rail

The Coffeen Power Plant currently has a rail spur on-Site that was historically used to receive coal shipments, which were unloaded via an unloading terminal. The terminal is not currently suitable for the loading of CCR into rail cars as it was designed and constructed for unloading, rather than loading. Additionally, the terminal was partially decommissioned by removing associated transformers and disconnecting the electrical supply after the Coffeen Power Plant was closed in 2019. For CCR to be hauled by rail from the Coffeen Power Plant, a new loading terminal would need to be constructed, thereby increasing the project schedule due to the need to complete design, permitting, and construction.

While the Lichfield Landfill is located within approximately 2.3 miles of an existing rail line, an existing terminal suitable for the unloading of CCR is not present. A rail unloading terminal would need to be constructed, which would increase the project schedule due to the need to coordinate with the railroad, complete design and permitting, and construct the terminal. CCR would still need to be hauled by truck from the new off-Site unloading terminal to the landfill, resulting in additional CCR handling and exposure to the surrounding environment. The Five Oaks Landfill has a rail spur on-site.

Furthermore, a direct rail route from the Coffeen Power Plant to either landfill does not exist. Hauling CCR to the Lichfield or Five Oaks Landfills would involve approximately 25 and 63 miles, respectively, of hauling by rail on tracks owned by three separate rail lines (Norfolk Southern Ry. Co., BNSF Ry. Co., and Illinois & Midland R.R. Inc.). The ability of CCR to be hauled over multiple lines and transferred from line to line is currently unknown.

Therefore, transporting CCR by rail is unlikely to be a viable option for the GMF GSP at the Coffeen Power Plant, due to the need to design, permit, and construct additional loading and unloading infrastructure, resulting in corresponding project schedule delays, and the distance and number of rail lines which the CCR would need to be transported over.

2.3.2 Transportation by Barge

The Coffeen Power Plant is not located near a navigable waterway and, therefore, transportation of CCR by barge is not feasible.

2.3.3 Transportation by Truck

The Coffeen Power Plant is located approximately 2.9 miles from Illinois Route 185 (IL-185), which is suitable for receiving truck hauling traffic. Red Ball Trail links the Coffeen Power Plant to IL-185 and routinely receives truck traffic associated with adjacent industrial facilities and the Coffeen Power Plant. Potential travel routes between the Coffeen Power Plant and Litchfield and Five Oaks Landfills have been assumed for cost estimate purposes, although actual travel routes may vary.

Transporting CCR by truck will not require the construction of additional loading or unloading infrastructure at either the receiving landfill or the Coffeen Power Plant. CCR would be loaded into trucks using heavy equipment at the GMF GSP. CCR will then be unloaded at the receiving landfill by the truck directly. Since no construction is required, project delays related to coordination with other entities, design, and permitting are unlikely to occur. Therefore, transporting CCR by truck is a viable option for the GMF GSP at the Coffee Power Plant.

3.0 CLOSURE DESCRIPTION NARRATIVES

Section 845.720(a)(1)(A) requires narrative description of CCR impoundment closures to be prepared. Narrative descriptions have been prepared for both closure-in-place and closure-by-removal and are included in this section.

3.1 GMF GSP Closure-in-Place

The closure-in-place concept for the GMF GSP was developed to reduce the waste footprint at closure. The proposed closure-in-place option would have final cover slopes of 25H:1V (4%) to accommodate moderate settlement and promote drainage. A berm will be constructed at the south end of the consolidated footprint for stability. The location of the berm has been selected to accommodate the estimated 295,500 CY of gypsum and 38,000 CY of clayey soil from the GMF GSP to be contained within the consolidated footprint based on the grading plan presented. The general sequencing plan for the closure-in-place option is as follows:

- Pump out ponded water [approximately 106 million gallons (MG)] from the GMF GSP to the existing drainage to the east through Outfall 023 where it will be managed in accordance with the NPDES permit for the site.
- Resume pumping of the perimeter drains surrounding the GSP to lower the groundwater level beneath the GSP and facilitate closure construction. Discharge water to the existing drainage to the east through Outfall 023 where it will be managed in accordance with the NPDES permit for the site.
- A temporary water management system will be constructed within the GMF GSP, including ditches and sumps. The system will maintain the GMF GSP in an unwatered state by collecting contact stormwater during closure construction. Stormwater flow will be conveyed through Outfall 023 to the existing drainage to the east where it will be managed in accordance with the NPDES permit for the site.

- Once the ponded water has been removed from the GMF GSP, the gypsum in the consolidated footprint will be dewatered. Approximately 131,000 CY of gypsum will be dewatered as needed to enable relocation. It is anticipated that approximately 8.8 MG of water removal will be required to dewater the gypsum. The gypsum will dewater to some degree by gravity, but dewatering by pumping from trenches and sumps is expected to be necessary. Liquid waste and water flowing to sumps will be managed in accordance with the NPDES permit for the site and discharged through Outfall 023.
- Gypsum will be removed from the berm footprint and relocated into the consolidated footprint. The berm will be constructed in an east-west orientation at the east end of the consolidated footprint. The upstream face of the berm will be lined with a composite liner system consisting of 60-mil HDPE geomembrane overlying a compacted clay layer, which will tie into the existing composite liner system.
- The remaining gypsum south of the berm in the GMF GSP will be collected and deposited north of the berm.
- Geosynthetic components of the existing liner system and PWRS south of the berm in the GMF GSP will be removed and disposed in the closure footprint or hauled away for disposal. It is anticipated that up to 1 foot of clay soil beneath the geomembrane may also be removed. The soils will be visually observed for signs of CCR. If soils with signs of CCR are observed, they will be removed and deposited north of the berm (for the purposes of conceptual design, assume 1 foot, or approximately 38,000 CY, will need to be removed).
- Compacted fill, composed of locally available soils, would be placed only as needed to achieve final cover subgrade. The compacted fill is anticipated to be compacted to a minimum of 95% of the standard Proctor maximum dry density to reduce settlement.
- Construction of an alternate final cover system, consisting of (from top to bottom):
  - 24-inch final protective soil layer. The final protective soil layer would include 18 inches of protective soil cover overlain by a 6-inch-thick topsoil layer, and be revegetated with native grasses. The 18 inches of protective soil cover will be constructed of locally available soils removed from the embankment containment berm and compacted to between 80% and 95% of the standard Proctor maximum dry density for establishment of vegetation and protection of the underlying geomembrane. Protective soil layer material is likely to be primarily low-plasticity silt or clay based on review of site geotechnical information.
  - Drainage geocomposite (pending HELP model results from others, a nonwoven cushion geotextile may be possible)
  - 40-mil linear low-density polyethylene (LLDPE) geomembrane layer
- All areas of the cover system will be sloped at a minimum of 4% to positively drain to the exterior of the GMF GSP.
- To prevent impoundment of water in the south end of the current GMF GSP footprint after gypsum removal, existing earthen embankments not required for the consolidated footprint will be removed on the eastern side of the GMF GSP and a channel will be excavated to allow stormwater to flow through existing NPDES Outfall 023 into the existing drainage to the east.

- The final ground surface of the southern part of the GMF GSP will be sloped to drain a minimum of 0.5% towards the channel excavated in the southeast corner, in order to allow post-closure, non-contact stormwater to gravity flow into the existing drainage. Soil fill, sourced from existing berms no longer required to contain waste in the consolidated footprint or from the on-Site soil borrow area southeast of AP1, will be used to achieve the necessary slopes. Additional fill will come from off-Site borrow sources assumed to be located within 2 miles of the GMF GSP.
- Vegetation will be established on the final surface of the GMF GSP. Stormwater best management practices (BMPs) such as erosion control blankets will be used, as needed to reduce erosion during vegetation establishment.
- After vegetation is established, BMPs will be removed, and closure construction will be considered complete.

3.2 GMF GSP Closure by Removal

A narrative description of closure-by-removal activities associated with the GMF GSP include:

- Pump out ponded water [approximately 106 million gallons (MG)] from the GMF GSP to the existing drainage to the east through Outfall 023 where it will be managed in accordance with the NPDES permit for the site.
- Resume pumping of the perimeter drains surrounding the GSP to lower the groundwater level beneath the GSP and facilitate closure construction. Discharge water to the existing drainage to the east through Outfall 023 where it will be managed in accordance with the NPDES permit for the site.
- A temporary water management system will be constructed within the GMF GSP, including ditches and sumps. The system will maintain the GMF GSP in an unwatered state by collecting contact stormwater during closure construction. Stormwater flow will be conveyed through Outfall 023 to the existing drainage to the east where it will be managed in accordance with the NPDES permit for the site.
- Once the ponded water has been removed from the GMF GSP, the gypsum will be dewatered. Approximately 295,500 CY of gypsum is located below the current water level in the GMF GSP and it is anticipated that approximately 8.8 MG of water removal will be required to dewater the gypsum. The gypsum will dewater to some degree by gravity, but dewatering by pumping from trenches and sumps is expected to be necessary. Liquid waste and water flowing to sumps will be managed in accordance with the NPDES permit for the site and discharged through Outfall 023.
- Gypsum will be removed from the GMF GSP using mass mechanical excavation techniques.
- Approximately 295,500 CY of gypsum will be loaded into over-the-road dump trucks and hauled to the off-Site receiving landfill.
- the PWRS and composite liner system, consisting of the HDPE geomembrane and 3-foot compacted clay layer (176,000 CY), will be removed as required and disposed. It is anticipated that up to 1 foot of subsoil beneath the liner system may also be removed. The subsoils will be visually observed for signs of CCR. If subsoils with signs of CCR are observed, they will be removed and disposed (assume 1 foot of subsoil removal, approximately 58,000 CY, will be required for conceptual designs).

- To prevent impoundment of water in the GMF GSP footprint after gypsum removal, existing earthen embankments will be removed on the eastern side of the GMF GSP and a channel will be excavated to allow stormwater to flow through existing NPDES Outfall 023 into the existing drainage to the east.
- The final ground surface of the GMF GSP will be sloped to drain a minimum of 0.5% towards the channel excavated in the southeast corner, in order to allow post-closure, non-contact stormwater to gravity flow into the existing drainage. Soil fill, sourced from existing berms no longer required to contain waste in the consolidated footprint or from the on-Site soil borrow area southeast of AP1, will be used to achieve the necessary slopes. Additional fill will come from off-Site borrow sources assumed to be located within 2 miles of the GMF GSP.
- Vegetation will be established on the final surface of the GMF GSP. Stormwater best management practices (BMPs) such as erosion control blankets will be used, as needed to reduce erosion during vegetation establishment.
- After vegetation is established, BMPs will be removed, and closure construction will be considered complete.

3.3 GMF RP Closure by Removal

A narrative description of closure-by-removal activities associated with the GMF RP include:

- Pump out ponded water (approximately 45.5 MG) from the GMF RP to the existing drainage to the east through Outfall 023 where it will be managed in accordance with the NPDES permit for the site.
- A temporary water management system will be constructed within the GMF RP, including ditches and sumps. The system will maintain the GMF RP in an unwatered state by collecting contact stormwater during closure construction. Stormwater flow will be conveyed through Outfall 023 to the existing drainage to the east where it will be managed in accordance with the NPDES permit for the site.
- Once the ponded water has been removed from the GMF RP, the gypsum will be dewatered. Approximately 51,000 CY of gypsum is located below the current water level in the GMF RP and it is anticipated that approximately 1.5 MG of water removal will be required to dewater the gypsum. The gypsum will dewater to some degree by gravity, but dewatering by pumping from trenches and sumps is expected to be necessary. Liquid waste and water flowing to sumps will be managed in accordance with the NPDES permit for the site and discharged through Outfall 023.
- Gypsum will be removed from the GMF RP using mass mechanical excavation techniques.
- Approximately 51,000 CY of gypsum will be hauled by truck from the GMF RP to the on-Site CCR Landfill for disposal.
- The geomembrane liner system will be removed as required and disposed. It is anticipated that up to 1 foot of subsoil beneath the geomembrane may also be removed and disposed in the on-Site CCR Landfill. The subsoils will be visually observed for signs of CCR. If subsoils with signs of CCR are observed, they will be removed and disposed (assume 1 foot of subsoil removal, approximately 28,000 CY, will be required for conceptual designs).

- To prevent impoundment of water in the GMF RP footprint after gypsum removal, existing earthen embankments will be removed on the eastern side of the GMF GSP and a channel will be excavated to allow stormwater to flow through existing NPDES Outfall 023 into the existing drainage to the east.
- The final ground surface of the GMF RP will be sloped to drain a minimum of 0.5% towards the channel excavated in the northeast corner, in order to allow post-closure, non-contact stormwater to gravity flow into the existing drainage. Soil fill, sourced from existing berms no longer required to contain waste will be used to achieve the necessary slopes.
- Vegetation will be established on the final surface of the GMF RP. Stormwater best management practices (BMPs) such as erosion control blankets will be used, as needed to reduce erosion during vegetation establishment.
- After vegetation is established, BMPs will be removed, and closure construction will be considered complete.

4.0 CONSTRUCTION SCHEDULES

Section 845.720(a)(1)(F) requires a schedule including all activities necessary to complete closure to be prepared. Schedules have been prepared for both closure-in-place and closure-by-removal and are included within this section. Schedules were prepared using estimates of task durations based on Golder's experience, typical weather conditions at the site, and expected construction rates relative to estimated construction quantities.

4.1 GMF GSP Closure-in-Place

The proposed closure completion schedule for GMF GSP closure-in-place is provided in Table 2.

Table 2: Construction Schedule – GMF GSP Closure-in-Place

Milestone	Timeframe (Preliminary Estimates)
Agency Coordination, Approvals, and Permitting ■ Obtain state permits, as needed, for dewatering, water discharge, land disturbance, and dam modifications	8 to 12 months after Final Closure Plan Approval
Final Design and Bid Process ■ Complete final design of the closure and select a construction contractor	8 to 14 months after Agency Coordination, Approvals, and Permitting
Dewater and Stabilize CCR, Install Final Cover System ■ Complete contractor mobilization, installation of stormwater BMPs, and unwatering of GMF GSP ■ Stabilize GMF GSP, and complete grading ■ Install the final cover system and stormwater conveyances	18 to 27 months after necessary permits are issued

Milestone	Timeframe (Preliminary Estimates)
▪ Winter weather delays are assumed between November and March of each construction year	
Site Restoration ▪ Seed and stabilize GMF GSP ▪ Complete contractor demobilization	2 to 3 months after the final cover system is complete
Timeframe to Complete Closure	36 to 56 months

4.2 GMF GSP Closure-by-Removal

The proposed closure completion schedule for GMF GSP closure-by-removal is provided in Table 3.

Table 3: Construction Schedule – GMF GSP Closure-by-Removal

Milestone	Timeframe (Preliminary Estimates)
Agency Coordination, Approvals, and Permitting ▪ Obtain state permits, as needed, for dewatering, water discharge, land disturbance, and dam modifications	8 to 12 months after Final Closure Plan Approval
Final Design and Bid Process ▪ Complete final design of the closure and select a construction contractor	8 to 14 months after Agency Coordination, Approvals, and Permitting
Dewater and Excavate CCR, Decontaminate CCR Unit ▪ Complete contractor mobilization, installation of stormwater BMPs, and unwatering of GMF GSP ▪ Complete mass excavation of CCR and decontamination of GMF GSP ▪ Winter weather delays are assumed between November and March of each construction year	23 to 34 months after necessary permits are issued
Backfill with Clean Soil ▪ Regrade GMF GSP base grade and slope to drain.	6 to 9 months after decontamination is complete
Site Restoration	2 to 3 months after backfill is complete

Milestone	Timeframe (Preliminary Estimates)
■ Seed and stabilize GMF GSP ■ Complete contractor demobilization	
Timeframe to Complete Closure	47 to 72 months

4.3 GMF RP Closure-by-Removal

The proposed closure completion schedule for GMF RP closure-by-removal is provided in Table 4.

Table 4: Construction Schedule – GMF RP Closure-by-Removal

Milestone	Timeframe (Preliminary Estimates)
Agency Coordination, Approvals, and Permitting ■ Obtain state permits, as needed, for dewatering, water discharge, land disturbance, and dam modifications	8 to 12 months after Final Closure Plan Approval
Final Design and Bid Process ■ Complete final design of the closure and select a construction contractor	8 to 14 months after Agency Coordination, Approvals, and Permitting
Dewater and Excavate CCR, Decontaminate CCR Unit ■ Complete contractor mobilization, installation of stormwater BMPs, and unwatering of GMF RP ■ Complete mass excavation of CCR and decontamination of GMF RP ■ Winter weather delays are assumed between November and March of each construction year	7 to 11 months after necessary permits are issued
Backfill with Clean Soil ■ Regrade GMF RP base grade and slope to drain.	2 to 3 months after decontamination is complete
Site Restoration ■ Seed and stabilize GMR RP ■ Complete contractor demobilization	1 to 2 months after backfill is complete
Timeframe to Complete Closure	26 to 42 months

5.0 MATERIAL, QUANTITY, COST, LABOR, AND MILEAGE ESTIMATES

Section 845.720(d)(1) requires that a cost estimate be prepared in accordance with the Class 4 standards of the Association for the Advancement of Cost Engineering (AACE). Cost estimates for both closure-in-place and closure-by-removal were prepared in accordance with the AACE Class 4 standards.

In addition to construction cost and quantity estimates, Golder has also prepared estimates of construction labor hours, equipment usage, haul truck mileage, daily labor mobilization vehicle mileage, material delivery mileage, and on-Site vehicle mobilization mileage.

Estimates were prepared using the following approach:

- Major construction components and line items were identified, in accordance with the narrative closure description
- Construction quantities were estimated based on volume estimates, area estimates, and proposed construction schedules
- Unit costs were estimated for each construction line item using RS Means Heavy Construction Cost Data. For line items where RS Means data was not available, unit costs were estimated based on Golder's experience.
- RS Means unit costs were developed assuming Union labor for Effingham, Illinois (located approximately 51 miles from the Coffeen Power Plant), for 2022
- Soil fill beyond what is available on-Site was assumed to come from off-Site borrow sources located within 2 miles of the site, as limited borrow soil is expected to be available at the Coffeen Power Plant, due to planned future land use of the surrounding property dedicated to renewable power generation
- For line items where RS Means was used to develop the costs, the corresponding RS Means crew size, equipment description, and daily output were used to estimate the total number of man-hours and equipment hours. For line items where RS Means data was unavailable, the crew size, equipment description, and daily output were estimated based on Golder's experience.
- Daily labor mobilization miles were estimated assuming an average one-way commute of 35 miles for each individual working on-Site. The number of working days were estimated from the construction schedules.
- Estimates of haul truck mileage were based on the assumed round-trip haul distance and dump truck size. All dump trucks were assumed to be filled to capacity.
- Estimates of material delivery miles were prepared based on Golder's experience
- A contingency of 30% was applied for the construction cost estimate total, based on the level of design and quantity estimate prepared as part of this Memo

The total cost estimate for GMF GSP closure-in-place is **$11,692,000**, including contingency. The detailed cost estimate and labor and mileage estimates are provided in Tables 5 and 6, respectively.

The total cost estimate for GMF GSP closure-by-removal is **$104,632,000**, including contingency. The detailed cost estimate and labor and mileage estimates are provided in Tables 7 and 8, respectively.

The total cost estimate for GMF RP closure-by-removal is **$4,892,000**, including contingency. The detailed cost estimate and labor and mileage estimates are provided in Tables 9 and 10, respectively.

6.0 REFERENCES

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APPENDIX A

Tables

AACE Class 4 Estimate
Coffeen Power Station
Closure-in-Place of GMF Gypsum Stack Pond

Item No.	Item Description	Quantity	Unit	Unit Rate (USD$/unit)	Cost (USD$)	Crew	Daily Output	Labor Hours	Equipment Hours	Notes/Assumptions/Reference
	Pre-Construction									
1	Mobilization and Demobilization (10% of Construction Subtotal)	1	LS	$ 711,000.0	$ 711,000					Typical Industry Value
	Pre-Construction Subtotal				***$ 711,000***					
	Site Preparation									
2	Mow Vegetation in limits of disturbance	250	MSF	$ 40.74	$ 10,185	B84	22	91	91	RS Means 320190191660: Mowing, mowing brush, light density, tractor with rotary mower
3	Construction Soil Erosion & Sediment Controls (Silt Fence)	7000	LF	$ 3.39	$ 23,730	B62	650	258	86	RS Means 312514161000: Synthetic erosion control, silt fence, install and remove, 3' high
4	Construction Facilities	25	MO - in use	$ 969.61	$ 24,515	-	-	-	-	
	Office Trailer	25	MO - in use	$ 258.53	$ 6,536	-	-	-	-	RS Means 015213200350: Office trailer, furnished, rent per month, 32' x 8', excl. hookups
	Storage Trailers (x2)	25	MO - in use	$ 291.92	$ 7,381	-	-	-	-	RS Means 015213201350: Storage boxes, rent per month, 40' x 8'
	Portable Toilet (x2)	25	MO - in use	$ 419.16	$ 10,598	-	-	-	-	RS Means 015433406410: Rent toilet portable chemical, incl. hourly oper. cost
5	Dust Control	217	Day	$ 2,206.88	$ 479,665	B59	0.5	3,478	3,478	RS Means 312323202510: Hauling, heavy, dust control, includes loading
6	Haul Road Maintenance	109	Day	$ 1,502.78	$ 163,315	B86A	1	869	869	RS Means 312323202600: Hauling, haul road maintenance, includes loading
	Site Preparation Subtotal				***$ 701,000***			***4,700***	***4,520***	
	Dewatering, Unwatering, and Stormwater Management									
7	Unwatering of GMF GSP ponded water	409	Day	$ 1,105.32	$ 452,021	Dewater	4	818	204	RS Means 312319200650: Dewatering, pumping 8 hours, attended 2 hours per day, 4" dischage pump used for 8 hours, includes 20 LF of suction hose and 100 LF of discharge hose
8	Dewatering and Stormwater Management for GMF GSP	350	Day	$ 1,105.32	$ 386,363	Dewater	4	699	175	RS Means 312319200650: Dewatering, pumping 8 hours, attended 2 hours per day, 4" dischage pump used for 8 hours, includes 20 LF of suction hose and 100 LF of discharge hose
9	Dewatering Sumps Installation	10	EA	$ 10,000.00	$ 100,000	Sump Install	4	40	20	Unit Rate, Crew, and Daily Output based on experience. Materials include 24" corrugated HDPE pipe with geotextile wrapping, and 1 CY of gravel backfill
	Dewatering, Unwatering, and Stormwater Management Subtotal				***$ 938,000***			***1,560***	***400***	
	GMF Gypsum Stack Pond Closure									
11	Relocation of Gypsum Material and Contaminated Clay	169000	CY - in place	$ 8.34	$ 1,408,953	-	-	4,876	3,948	
	Excavation and Loading of Material	177450	CY - as excavated	$ 1.50	$ 266,175	B14A	3230	659	440	RS Means 312316435400: Excavating, large volume projects; excavation with truck loading; excavator, 4.5 CY bucket, 95% fill factor (assume 5% shrinkage factor from ground to in-place)
	Hauling of Material	177450	CY - as excavated	$ 4.06	$ 720,447	B34G	680	2,088	2,088	RS Means 312323206020: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 34 C.Y. off-road, 15 min wait/ld/uld., 5 MPH, cycle 4000 feet
	Spreading of Material	177450	CY - as excavated	$ 2.38	$ 422,331	B10B	1000	2,129	1,420	RS Means 312323170020: Fill, dumped material, spread, by dozer, excludes compaction
12	Excavation and Placement of Embankment Fill	111100	CY - in place	$ 8.89	$ 987,346	-	-	3,718	2,936	
	Excavation and Loading of Material	116655	CY - as excavated	$ 1.50	$ 174,983	B14A	3230	433	289	RS Means 312316435400: Excavating, large volume projects; excavation with truck loading; excavator, 4.5 CY bucket, 95% fill factor (assume 5% shrinkage factor from ground to in-place)
	Hauling of Material	116655	CY - as excavated	$ 4.06	$ 473,619	B34G	680	1,372	1,372	RS Means 312323206020: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 34 C.Y. off-road, 15 min wait/ld/uld., 5 MPH, cycle 4000 feet
	Spreading of Material	116655	CY - as excavated	$ 2.38	$ 277,639	B10B	1000	1,400	933	RS Means 312323170020: Fill, dumped material, spread, by dozer, excludes compaction
	Compaction of Material	111100	CY - in place	$ 0.55	$ 61,105	B10F	2600	513	342	RS Means 312323235100: Compaction; Riding, vibrating roller, 12" lifts, 4 passes (RSMeans Crew is B10Y; altered to B10F based on experience)
15	Geomembrane - Berm Liner	76000	SF - in place	$ 1.52	$ 115,520	B63B	1600	1,520	380	RS Means 310519531200: Pond and reservoir liners, membrane lining systems HDPE, 100,000 S.F. or more, 60 mil thick, per S.F. (multiplied unit rate by 0.5 based on experience)
14	Excavation and Placement of Soil Fill for Final Grades	106890	CY - in place	$ 8.89	$ 949,931	-	-	3,577	2,825	
	Excavation and Loading of Material	112235	CY - as excavated	$ 1.50	$ 168,352	B14A	3230	417	278	RS Means 312316435400: Excavating, large volume projects; excavation with truck loading; excavator, 4.5 CY bucket, 95% fill factor (assume 5% shrinkage factor from ground to in-place)
	Hauling of Material	112235	CY - as excavated	$ 4.06	$ 455,672	B34G	680	1,320	1,320	RS Means 312323206020: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 34 C.Y. off-road, 15 min wait/ld/uld., 5 MPH, cycle 4000 feet
	Spreading of Material	112235	CY - as excavated	$ 2.38	$ 267,118	B10B	1000	1,347	898	RS Means 312323170020: Fill, dumped material, spread, by dozer, excludes compaction
	Compaction of Material	106890	CY - in place	$ 0.55	$ 58,790	B10F	2600	493	329	RS Means 312323235100: Compaction; Riding, vibrating roller, 12" lifts, 4 passes (RSMeans Crew is B10Y; altered to B10F based on experience)
15	Final Cover Geomembrane	541400	SF - in place	$ 1.52	$ 822,928	B63B	1600	10,828	2,707	RS Means 310519531200: Pond and reservoir liners, membrane lining systems HDPE, 100,000 S.F. or more, 60 mil thick, per S.F. (multiplied unit rate by 0.5 based on experience)
16	Final Cover Geocomposite	541400	SF - in place	$ 0.75	$ 406,050	B63B	4800	3,609	902	Unit Rate, and Output based on experience. Crew based on RS Means 310519531200.
17	Anchor Trench Installation	2900	LF	$ 2.71	$ 7,849	-	-	87	58	
	Excavation of Material	451	CY - as excavated	$ 10.05	$ 4,534	B11C	150	48	24	RS Means 312316130050: Excavating, Trench or continuous footing, common earth with no sheeting or dewatering included, 1' to 4' deep, 3/8 C.Y. excavator
	Backfilling Material	451	CY - as excavated	$ 3.14	$ 1,416	B10R	400	14	9	RS Means 312316133020: Backfill trench, F.E. Loader, wheel mtd., 1 C.Y. bucket, minimal haul
	Compaction of Material	430	CY - in place	$ 4.42	$ 1,899	A1D	140	25	25	RS Means 312323237040: Compaction, walk behind, vibrating plate 18" wide, 6" lifts, 4 passes
19	Placement of Protective Cover Soil	40100	CY - in place	$ 11.50	$ 461,342	-	-	1,182	953	
	Excavation and Loading of Material	42105	CY - as excavated	$ 1.50	$ 63,158	B14A	5000	101	67	RS Means 312316435400: Excavating, large volume projects; excavation with truck loading; excavator, 4.5 CY bucket, 95% fill factor (assume 5% shrinkage factor from ground to in-place)
	Hauling of Material	42105	CY - as excavated	$ 6.75	$ 284,209	B34G	680	495	495	RS Means 312323206120: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 34 C.Y. off-road, 15 min wait/ld/uld., 10 MPH, cycle 4 miles
	Spreading of Material	42105	CY - as excavated	$ 2.38	$ 100,210	B10B	1000	505	337	RS Means 312323170020: Fill, dumped material, spread, by dozer, excludes compaction
	Finish Grading of Material	59851	SY	$ 0.23	$ 13,766	B10W	8900	81	54	RS Means 312216103300: Fine grading, Finish grading slopes, gentle. Crew altered to reflect likely equipment to be used based on experience
	GMF Gypsum Stack Pond Closure Subtotal				***$ 5,160,000***			***29,400***	***14,710***	
	Site Restoration									
22	Erosion Control Blanket	40000	SF - in place	$ 0.25	$ 10,000	ECB	22500	43	14	RS Means 312514160100. Rolled erosion control mats and blankets, plastic netting, stapled, 2" x 1" mesh, 20 mil.
23	Straw Wattle Ditch Checks	2500	LF - in place	$ 3.98	$ 9,950	A2	1000	60	20	RS Means 312514160705: Compost or mulch filter sock, 9" diameter
24	Seed, Mulch, and Maintain Vegetated Surfaces	45	AC	$ 6,463.00	$ 290,835	-	-	405	405	
	Lime	1960	MSF	$ 26.88	$ 52,690	B66	700	22	22	RS Means 329113234250: Soil preparation, structural soil mixing, spread soil conditioners, ground limestone, 1#/S.Y., tractor spreader
	Fertilizer	1960	MSF	$ 13.54	$ 26,541	B66	700	22	22	RS Means 329113234150: Soil preparation, tructural soil mixing, spread soil conditioners, fertilizer, 0.2#/S.Y., tractor spreader
	Seed	1960	MSF	$ 39.20	$ 76,840	B66	52	302	302	RS Means 329219142300: Seeding athletic fields, seeding fescue, tall, 5.5 lb. per M.S.F., tractor spreader
	Mulch	1960	MSF	$ 68.75	$ 134,764	B65	530	59	59	RS Means 329113160350: Mulching, Hay, 1" deep, power mulcher, large
	Site Restoration Subtotal				***$ 311,000***			***510***	***440***	
	Engineering & Construction Support Tasks and Contingency									
25	Final Closure Design and Bid Support (5% of Construction Subtotal)	1	LS	$ 391,050.00	$ 391,050.00	-	-	-	-	Typical Industry Value
26	Engineering Support and CQA During Construction (10% of Construction Subtotal)	466	Day	$ 782,100.00	$ 782,100.00	Eng	1	4,664	1,866	Unit Rate, Crew, and Output based on experience.
	Engineering & Construction Support Tasks Subtotal				***$ 1,173,000***			***4,660***	***1,870***	
Construction Costs Subtotal					**$ 7,821,000**			**36,200**	**20,100**	
Project Subtotal					**$ 8,994,000**			**40,900**	**22,000**	
30% Contingency					**$ 2,698,000**			**12,300**	**6,600**	
ENGINEER'S ESTIMATE OF TOTAL CONSTRUCTION AND ENGINEERING COST AND HOURS					**$ 11,692,000**			**53,200**	**28,600**	

Notes and Assumptions:
1. LS = Lump Sum, AC = Acre, LF = Linear Foot, EA = Each, SY = Square Yard, MO = Month, YR = Year, CY = Cubic Yard, MSF = Thousand Square Feet
2. Where possible, costs were developed using RS Means 2022 Heavy Construction Costs
3. 2022 RS Means unit rates include overhead and profit and refer to standard union labor in Effingham, IL.
4. Subtotal and total costs have been rounded to the nearest $1,000. Subtotal and total hours have been rounded to the nearest 100.
5. Earthwork quantities assume that the excavation and placement of fill within construction limits will be balanced so that no off-Site fill will be required to reach the final contours. The final elevations may need to be adjusted during final design to achieve balanced quantities.

Coffeen Power Station
Closure-in-Place of GMF Gypsum Stack Pond

Crew	Labor	Daily Labor Hours	Equipment	Daily Equipment Hours	Project Total: Labor Hours	Project Total: Equipment Hours
B84	Operator x1	8	Rotary Mower/Tractor	8	91	91
B62	Laborer x2 Operator x1	24	Loader, Skid Steer, 30 H.P.	8	258	86
B59	Truck Driver x1	8	Truck Tractor, 220 H.P. Water Tank Trailer, 5000 Gal	8	3478	3478
B86A	Operator x1	8	Grader, 30,000 lbs	8	869	869
B14A	Operator x1 Laborer x0.5	12	Hyd. Excavator, 4.5 CY	8	1610	1074
B34G	Truck Driver x1	8	Dump Truck, Off Hwy, 54 ton	8	5275	5275
B10B	Operator x1 Laborer x0.5	12	Dozer, 200 H.P.	8	5381	3588
B63B	Labor Foreman x1 Laborer x2 Operator (light) x1	32	Loader, Skid Steer, 78 H.P.	8	15957	3989
A2	Laborer x2 Truck Driver x1	24	Flatbed Truck, Gas, 1.5 ton	8	60	20
B66	Operator (light) x1	8	Loader-Backhoe, 40 H.P.	8	346	346
B65	Laborer x1 Truck Driver (light) x1	16	Power Mulcher (large) Flatbed Truck, Gas, 1.5 ton	16	59	59
B11C	Laborer x1 Operator (medium) x1	16	Backhoe Loader, 48 H.P.	8	48	24
B10R	Operator (medium) x1 Laborer x0.5	12	F.E. Loader, W.M., 1 CY	8	14	9
ECB	Laborer x3	24	Tractor	8	43	14
Dewater	Laborer x1	8	8" Diesel Pump	2	1517	379
Sump Install	Laborer x1 Operator x1	16	Hyd. Excavator, 4.5 CY	8	40	20
Eng	Engineering Staff x1.2	10	Side by Side x1	4	4664	1866
A1D	Laborer x1	8	Vibrating Plate, Gas, 18"	8	25	25
B10F	Operator (medium) x1 Laborer x0.5	12	Tandem Roller, 10 ton	8	1006	671
B10W	Operator (medium) x1 Laborer x0.5	12	Dozer, 105 H.P.	8	81	54
PROJECT TOTAL					**40822**	**21937**

Notes and Assumptions:
1. Crew names in itallics were created by Golder based on experience and are not from RS Means.

Item	Quantity	Assumptions
Labor Total Hours	40,822	Per projected total in cost estimate
Duration of Onsite Construction - Days	758	Per Construction Schedule
Average Daily Crew Size	6	10 hour days
Labor Mobilization Miles	318,570	Average of 70 miles round trip per day
Vehicle Miles On-Site	13,350	1 mile round trip from gate to parking 5 miles per day for CQA tech and Construction Supervisor 10% Contingency for Site visitors (client and engineering support)
Equipment Mobilization Miles - Unloaded	32,507	Average of 300 miles one way for equipment hauling Average 1 load of equipment per working week
Equipment Mobilization Miles - Loaded	32,507	Average of 300 miles one way for equipment hauling Average 1 load of equipment per working week
Total Equipment Miles On-Site	56,887	Average of 4 of 6 crew members running equipment Assume 15 miles per piece of equipment (based on 15 minute round trip path across GMF GSP 10 miles per day used for water truck 5 miles per day for grader
On-Site Haul Truck Miles - Unloaded	7,004	34 CY Haul Truck 4000 ft and 4 mile cycles
On-Site Haul Truck Miles - Loaded	7,004	34 CY Haul Truck 4000 ft and 4 mile cycles
Off-Site Haul Truck Miles - Unloaded	-	16.5 CY Dump Truck 4 mile cycle
Off-Site Haul Truck Miles - Loaded	-	16.5 CY Dump Truck 4 mile cycle
Material Delivery Miles - Unloaded	6,925	Same geosynthetic material source, trailer quantities, and roll sizes as Coffeen AP2 project assumed 45 extra trips for seed, fertilizer, lime, mulch, ECBs, straw wattles, and concrete
Material Delivery Miles - Loaded	6,925	Same geosynthetic material source, trailer quantities, and roll sizes as Coffeen AP2 project assumed 45 extra trips for seed, fertilizer, lime, mulch, ECBs, straw wattles, and concrete

Table 7: Material Quantity and Cost Estimate - GMF GSP Closure-by-Removal

AACE Class 4 Estimate
Coffeen Power Station
Closure-by-Removal of GMF Gypsum Stack Pond

Item No.	Item Description	Quantity	Unit	Unit Rate (USD$/unit)	Cost (USD$)	Crew	Daily Output	Labor Hours	Equipment Hours	Notes/Assumptions/Reference
	Pre-Construction									
1	Mobilization and Demobilization (10% of Construction Subtotal)	1	LS	$ 7,069,400.0	$ 7,069,500					Typical Industry Value
	Pre-Construction Subtotal				***$ 7,070,000***					
	Site Preparation									
2	Mow Vegetation in limits of disturbance	250	MSF	$ 40.74	$ 10,185	B84	22	91	91	RS Means 320190191660: Mowing, mowing brush, light density, tractor with rotary mower
3	Construction Soil Erosion & Sediment Controls (Silt Fence)	7000	LF	$ 3.39	$ 23,730	B62	650	258	86	RS Means 312514161000: Synthetic erosion control, silt fence, install and remove, 3' high
4	Construction Facilities	39	MO - in use	$ 969.61	$ 37,500	-	-	-	-	
	Office Trailer	39	MO - in use	$ 258.53	$ 9,999	-	-	-	-	RS Means 015213200350: Office trailer, furnished, rent per month, 32' x 8', excl. hookups
	Storage Trailers (x2)	39	MO - in use	$ 291.92	$ 11,290	-	-	-	-	RS Means 015213201350: Storage boxes, rent per month, 40' x 8'
	Portable Toilet (x2)	39	MO - in use	$ 419.16	$ 16,211	-	-	-	-	RS Means 015433406410: Rent toilet portable chemical, incl. hourly oper. cost
5	Dust Control	169	Day	$ 2,206.88	$ 373,514	B59	0.5	2,708	2,708	RS Means 312323202510: Hauling, heavy, dust control, includes loading
6	Haul Road Maintenance	114	Day	$ 1,502.78	$ 171,317	B86A	1	912	912	RS Means 312323202600: Hauling, haul road maintenance, includes loading
	Site Preparation Subtotal				***$ 616,000***			***3,970***	***3,800***	
	Dewatering, Unwatering, and Stormwater Management									
7	Unwatering, Dewatering, and Stormwater Management for GMF GSP	409	Day	$ 1,105.32	$ 452,021	Dewater	4	818	204	RS Means 312319200650: Dewatering, pumping 8 hours, attended 2 hours per day, 4" dischage pump used for 8 hours, includes 20 LF of suction hose and 100 LF of discharge hose
8	Dewatering and Stormwater Management for GMF GSP	751	Day	$ 1,105.32	$ 830,438	Dewater	4	1,503	376	RS Means 312319200650: Dewatering, pumping 8 hours, attended 2 hours per day, 4" dischage pump used for 8 hours, includes 20 LF of suction hose and 100 LF of discharge hose
9	Dewatering Sumps Installation	10	EA	$ 10,000.00	$ 100,000	Sump Install	4	40	20	Unit Rate, Crew, and Daily Output based on experience. Materials include 24" corrugated HDPE pipe with geotextile wrapping, and 1 CY of gravel backfill
	Dewatering, Unwatering, and Stormwater Management Subtotal				***$ 1,382,000***			***2,360***	***600***	
	GMF Gypsum Stack Pond Closure									
12	Disposal of Gypsum/Liner/Subsoil at Off-Site Landfill	529500	CY - in place	$ 122.40	$ 64,810,013	-	-	48,679	47,147	
	Excavation and Loading of Material	555975	CY - as excavated	$ 1.50	$ 833,963	B14A	3230	2,066	1,377	RS Means 312316435400: Excavating, large volume projects; excavation with truck loading; excavator, 4.5 CY bucket, 95% fill factor (assume 5% shrinkage factor from ground to in-place)
	Hauling of Material	555975	CY - as excavated	$ 13.11	$ 7,288,832	B34C	99	44,927	44,927	RS Means 312323203284: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 16.5 C.Y. truck, 20 min wait/ld/uld., 40 MPH, cycle 40 miles
	Finish Grading of Excavation Surface	175645	SY	$ 1.23	$ 216,043	B32C	5000	1,686	843	RS Means 312216101020: Fine grading, loam or topsoil fine grade for large area, 15,000 S.Y. or more
	Landfill Tipping Fee	714825	Ton	$ 79.00	$ 56,471,175	-	-	-	-	Unit Rate based on actual tipping fee from Republic Services Litchfield Landfill (nearest landfill to Site). Unit Rate subject to increase upon Landfill's soil classification.
13	Excavation and Placement of On-Site Soil Fill for Final Grades	244003	CY - in place	$ 8.89	$ 2,168,455	-	-	8,166	6,450	
	Excavation and Loading of Material	256203	CY - as excavated	$ 1.50	$ 384,305	B14A	3230	952	635	RS Means 312316435400: Excavating, large volume projects; excavation with truck loading; excavator, 4.5 CY bucket, 95% fill factor (assume 5% shrinkage factor from ground to in-place)
	Hauling of Material	256203	CY - as excavated	$ 4.06	$ 1,040,185	B34G	680	3,014	3,014	RS Means 312323206020: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 34 C.Y. off-road, 15 min wait/ld/uld., 5 MPH, cycle 4000 feet
	Spreading of Material	256203	CY - as excavated	$ 2.38	$ 609,763	B10B	1000	3,074	2,050	RS Means 312323170020: Fill, dumped material, spread, by dozer, excludes compaction
	Compaction of Material	244003	CY - in place	$ 0.55	$ 134,202	B10F	2600	1,126	751	RS Means 312323235100: Compaction; Riding, vibrating roller, 12" lifts, 4 passes (RSMeans Crew is B10Y; altered to B10F based on experience)
14	Placement of On-Site Borrow Soil Fill for Final Grades	91000	CY - in place	$ 11.71	$ 1,065,747	-	-	2,920	2,321	
	Excavation and Loading of Material	95550	CY - as excavated	$ 1.50	$ 143,325	B14A	5000	229	153	RS Means 312316435400: Excavating, large volume projects; excavation with truck loading; excavator, 4.5 CY bucket, 95% fill factor (assume 5% shrinkage factor from ground to in-place)
	Hauling of Material	95550	CY - as excavated	$ 6.75	$ 644,963	B34G	680	1,124	1,124	RS Means 312323206120: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 34 C.Y. off-road, 15 min wait/ld/uld., 10 MPH, cycle 4 miles
	Spreading of Material	95550	CY - as excavated	$ 2.38	$ 227,409	B10B	1000	1,147	764	RS Means 312323170020: Fill, dumped material, spread, by dozer, excludes compaction
	Compaction of Material	91000	CY - in place	$ 0.55	$ 50,050	B10F	2600	420	280	RS Means 312323235100: Compaction; Riding, vibrating roller, 12" lifts, 4 passes (RSMeans Crew is B10Y; altered to B10F based on experience)
15	Placement of Imported Borrow Soil Fill for Final Grades	24697	CY - in place	$ 13.73	$ 338,973	-	-	1,063	810	
	Excavation and Loading of Material	25932	CY - as excavated	$ 1.50	$ 38,898	B14A	3230	96	64	RS Means 312316435400: Excavating, large volume projects; excavation with truck loading; excavator, 4.5 CY bucket, 95% fill factor (assume 5% shrinkage factor from ground to in-place)
	Purchase of Material	25932	CY - as excavated	$ 2.50	$ 64,830	-	-	-	-	Unit Rate based on experience.
	Hauling of Material	25932	CY - as excavated	$ 4.61	$ 119,546	B34G	680	305	305	RS Means 312323203032: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 16.5 C.Y. truck, 15 min wait/ld/uld., 20 MPH, cycle 4 miles
	Spreading of Material	25932	CY - as excavated	$ 2.38	$ 61,718	B10B	1000	311	207	RS Means 312323170020: Fill, dumped material, spread, by dozer, excludes compaction
	Finish Grading of Material	175645	SY	$ 0.23	$ 40,398	B10W	8900	237	158	RS Means 312216103300: Fine grading, Finish grading slopes, gentle. Crew altered to reflect likely equipment to be used based on experience.
	Compaction of Material	24697	CY - in place	$ 0.55	$ 13,583	B10F	2600	114	76	RS Means 312323235100: Compaction; Riding, vibrating roller, 12" lifts, 4 passes (RSMeans Crew is B10Y; altered to B10F based on experience)
	GMF Gypsum Stack Pond Closure Subtotal				***$ 68,383,000***			***60,830***	***56,730***	
	Site Restoration									
16	Erosion Control Blanket	48000	SF - in place	$ 0.25	$ 12,000	ECB	22500	51	17	RS Means 312514160100. Rolled erosion control mats and blankets, plastic netting, stapled, 2" x 1" mesh, 20 mil.
17	Straw Wattle Ditch Checks	2500	LF - in place	$ 3.98	$ 9,950	A2	1000	60	20	RS Means 312514160705: Compost or mulch filter sock, 9" diameter
18	Seed, Mulch, and Maintain Vegetated Surfaces	45	AC	$ 6,463.00	$ 290,835	-	-	405	405	
	Lime	1960	MSF	$ 26.88	$ 52,690	B66	700	22	22	RS Means 329113234250: Soil preparation, structural soil mixing, spread soil conditioners, ground limestone, 1#/S.Y., tractor spreader
	Fertilizer	1960	MSF	$ 13.54	$ 26,541	B66	700	22	22	RS Means 329113234150: Soil preparation, tructural soil mixing, spread soil conditioners, fertilizer, 0.2#/S.Y., tractor spreader
	Seed	1960	MSF	$ 39.20	$ 76,840	B66	52	302	302	RS Means 329219142300: Seeding athletic fields, seeding fescue, tall, 5.5 lb. per M.S.F., tractor spreader
	Mulch	1960	MSF	$ 68.75	$ 134,764	B65	530	59	59	RS Means 329113160350: Mulching, Hay, 1" deep, power mulcher, large
	Site Restoration Subtotal				***$ 313,000***			***520***	***440***	
	Engineering & Construction Support Tasks and Contingency									
19	Final Closure Design and Bid Support (1.5% of Construction Subtotal)	1	LS	$ 1,166,460.00	$ 1,166,460.00	-	-	-	-	Typical Industry Value
20	Engineering Support and CQA During Construction (2% of Construction Subtotal)	868	Day	$ 1,555,280.00	$ 1,555,280.00	Eng	1	8,682	3,473	Unit Rate, Crew, and Output based on experience.
	Engineering & Construction Support Tasks and Contingency Subtotal				***$ 2,722,000***			***8,680***	***3,470***	
Construction Costs Subtotal					**$ 77,764,000**			**67,700**	**61,600**	
Project Subtotal					**$ 80,486,000**			**76,400**	**65,100**	
30% Contingency					**$ 24,146,000**			**22,900**	**19,500**	
ENGINEER'S ESTIMATE OF TOTAL CONSTRUCTION AND ENGINEERING COST AND HOURS					**$ 104,632,000**			**99,300**	**84,600**	

Notes and Assumptions:
1. LS = Lump Sum, AC = Acre, LF = Linear Foot, EA = Each, SY = Square Yard, MO = Month, YR = Year, CY = Cubic Yard, MSF = Thousand Square Feet
2. Where possible, costs were developed using RS Means 2022 Heavy Construction Costs
3. 2022 RS Means unit rates include overhead and profit and refer to standard union labor in Effingham, IL.
4. Subtotal and total costs have been rounded to the nearest $1,000. Subtotal and total hours have been rounded to the nearest 100.
5. Earthwork quantities assume that the excavation and placement of fill within construction limits will be balanced so that no off-Site fill will be required to reach the final contours. The final elevations may need to be adjusted during final design to achieve balanced quantities.

Coffeen Power Station
Closure-by-Removal of GMF Gypsum Stack Pond

Crew	Labor	Daily Labor Hours	Equipment	Daily Equipment Hours	Project Total: Labor Hours	Project Total: Equipment Hours
B84	Operator x1	8	Rotary Mower/Tractor	8	91	91
B62	Laborer x2 Operator x1	24	Loader, Skid Steer, 30 H.P.	8	258	86
B59	Truck Driver x1	8	Truck Tractor, 220 H.P. Water Tank Trailer, 5000 Gal	8	2708	2708
B86A	Operator x1	8	Grader, 30,000 lbs	8	912	912
B14A	Operator x1 Laborer x0.5	12	Hyd. Excavator, 4.5 CY	8	3343	2229
B34G	Truck Driver x1	8	Dump Truck, Off Hwy, 54 ton	8	4443	4443
B10B	Operator x1 Laborer x0.5	12	Dozer, 200 H.P.	8	4532	3021
A2	Laborer x2 Truck Driver x1	24	Flatbed Truck, Gas, 1.5 ton	8	60	20
B66	Operator (light) x1	8	Loader-Backhoe, 40 H.P.	8	346	346
B65	Laborer x1 Truck Driver (light) x1	16	Power Mulcher (large) Flatbed Truck, Gas, 1.5 ton	16	59	59
B32C	Labor Foreman x1 Laborer x2 Operator (medium) x3	48	Grader, 30,000 lbs Tandem Roller, 10 ton Dozer, 200 H.P.	24	1686	843
ECB	Laborer x3	24	Tractor	8	51	17
Dewater	Laborer x1	8	8" Diesel Pump	2	2321	580
Sump Install	Laborer x1 Operator x1	16	Hyd. Excavator, 4.5 CY	8	40	20
Eng	Engineering Staff x1.2	10	Side by Side x1	4	8682	3473
B10F	Operator (medium) x1 Laborer x0.5	12	Tandem Roller, 10 ton	8	1660	1107
B34C	Truck Driver (heavy) x1	8	Truck Tractor, 6x4, 380 H.P. Dump Trailer, 16.5 CY	8	44927	44927
B10W	Operator (medium) x1 Laborer x0.5	12	Dozer, 105 H.P.	8	237	158
PROJECT TOTAL					**76356**	**65040**

Notes and Assumptions:
1. Crew names in itallics were created by Golder based on experience and are not from RS Means.

Item	Quantity	Assumptions
Labor Total Hours	76,356	Per projected total in cost estimate
Duration of Onsite Construction - Days	1,160	Per Construction Schedule
Average Daily Crew Size	7	10 hour days
Labor Mobilization Miles	568,528	Average of 70 miles round trip per day
Vehicle Miles On-Site	21,697	1 mile round trip from gate to parking 5 miles per day for CQA tech and Construction Supervisor 10% Contingency for Site visitors (client and engineering support)
Equipment Mobilization Miles - Unloaded	49,725	Average of 300 miles one way for equipment hauling Average 1 load of equipment per working week
Equipment Mobilization Miles - Loaded	49,725	Average of 300 miles one way for equipment hauling Average 1 load of equipment per working week
Total Equipment Miles On-Site	104,423	Average of 5 of 7 crew members running equipment Assume 15 miles per piece of equipment (based on 15 minute round trip path across AP1 10 miles per day used for water truck 5 miles per day for grader
On-Site Haul Truck Miles - Unloaded	8,475	34 CY Haul Truck 4000 ft cycle and 4 mile cycle on-site
On-Site Haul Truck Miles - Loaded	8,475	34 CY Haul Truck 4000 ft cycle and 4 mile cycle on-site
Off-Site Haul Truck Miles - Unloaded	606,292	16.5 CY Dump Truck 36 mile cycle to off-Site Landfill
Off-Site Haul Truck Miles - Loaded	606,292	16.5 CY Dump Truck 36 mile cycle to off-Site Landfill
Material Delivery Miles - Unloaded	4,500	45 extra trips for seed, fertilizer, lime, mulch, ECBs, straw wattles, and concrete
Material Delivery Miles - Loaded	4,500	45 extra trips for seed, fertilizer, lime, mulch, ECBs, straw wattles, and concrete

GOLDER - DRAFT

Table 9: Material Quantity and Cost Estimate - GMF RP Closure-by-Removal

AACE Class 4 Estimate
Coffeen Power Station
Closure-by-Removal of GMF Recycle Pond

Item No.	Item Description	Quantity	Unit	Unit Rate (USD$/unit)	Cost (USD$)	Crew	Daily Output	Labor Hours	Equipment Hours	Notes/Assumptions/Reference
	Pre-Construction									
1	Mobilization and Demobilization (10% of Construction Subtotal)	1	LS	$ 306,800.0	$ 307,000					Typical Industry Value
				Pre-Construction Subtotal	***$ 307,000***					
	Site Preparation									
2	Mow Vegetation in limits of disturbance	250	MSF	$ 40.74	$ 10,185	B84	22	91	91	RS Means 320190191660: Mowing, mowing brush, light density, tractor with rotary mower
3	Construction Soil Erosion & Sediment Controls (Silt Fence)	7000	LF	$ 3.39	$ 23,730	B62	650	258	86	RS Means 312514161000: Synthetic erosion control, silt fence, install and remove, 3' high
4	Construction Facilities	13	MO - in use	$ 969.61	$ 12,577	-	-	-	-	
	Office Trailer	13	MO - in use	$ 258.53	$ 3,353	-	-	-	-	RS Means 015213200350: Office trailer, furnished, rent per month, 32' x 8', excl. hookups
	Storage Trailers (x2)	13	MO - in use	$ 291.92	$ 3,786	-	-	-	-	RS Means 015213201350: Storage boxes, rent per month, 40' x 8'
	Portable Toilet (x2)	13	MO - in use	$ 419.16	$ 5,437	-	-	-	-	RS Means 015433406410: Rent toilet portable chemical, incl. hourly oper. cost
5	Dust Control	139	Day	$ 2,206.88	$ 307,529	B59	0.5	2,230	2,230	RS Means 312323202510: Hauling, heavy, dust control, includes loading
6	Haul Road Maintenance	70	Day	$ 1,502.78	$ 105,195	B86A	1	560	560	RS Means 312323202600: Hauling, haul road maintenance, includes loading
				Site Preparation Subtotal	***$ 459,000***			***3,140***	***2,970***	
	Dewatering, Unwatering, and Stormwater Management									
7	Unwatering, Dewatering, and Stormwater Management for GMF GSP	219	Day	$ 1,105.32	$ 242,535	Dewater	4	439	110	RS Means 312319200650: Dewatering, pumping 8 hours, attended 2 hours per day, 4" dischage pump used for 8 hours, includes 20 LF of suction hose and 100 LF of discharge hose
8	Dewatering and Stormwater Management for GMF GSP	170	Day	$ 1,105.32	$ 187,569	Dewater	4	339	85	RS Means 312319200650: Dewatering, pumping 8 hours, attended 2 hours per day, 4" dischage pump used for 8 hours, includes 20 LF of suction hose and 100 LF of discharge hose
9	Dewatering Sumps Installation	8	EA	$ 10,000.00	$ 80,000	Sump Install	4	32	16	Unit Rate, Crew, and Daily Output based on experience. Materials include 24" corrugated HDPE pipe with geotextile wrapping, and 1 CY of gravel backfill
				Dewatering, Unwatering, and Stormwater Management Subtotal	***$ 510,000***			***810***	***210***	
	GMF Recycle Pond Closure									
12	Disposal of Gypsum/Subsoil at On-Site Landfill	79000	CY - in place	$ 8.57	$ 677,245	-	-	2,970	2,024	
	Excavation and Loading of Material	82950	CY - as excavated	$ 1.50	$ 124,425	B14A	3230	308	205	RS Means 312316435400: Excavating, large volume projects; excavation with truck loading; excavator, 4.5 CY bucket, 95% fill factor (assume 5% shrinkage factor from ground to in-place)
	Hauling of Material	82950	CY - as excavated	$ 4.06	$ 336,777	B34G	680	976	976	RS Means 312323206020: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 34 C.Y. off-road, 15 min wait/ld/uld., 5 MPH, cycle 4000 feet
	Finish Grading of Excavation Surface	175645	SY	$ 1.23	$ 216,043	B32C	5000	1,686	843	RS Means 312216101020: Fine grading, loam or topsoil fine grade for large area, 15,000 S.Y. or more
13	Excavation and Placement of On-Site Soil Fill for Final Grades	66670	CY - in place	$ 9.18	$ 611,816	-	-	2,345	1,838	
	Excavation and Loading of Material	70004	CY - as excavated	$ 1.50	$ 105,005	B14A	3230	260	173	RS Means 312316435400: Excavating, large volume projects; excavation with truck loading; excavator, 4.5 CY bucket, 95% fill factor (assume 5% shrinkage factor from ground to in-place)
	Hauling of Material	70004	CY - as excavated	$ 4.06	$ 284,214	B34G	680	824	824	RS Means 312323206020: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 34 C.Y. off-road, 15 min wait/ld/uld., 5 MPH, cycle 4000 feet
	Spreading of Material	70004	CY - as excavated	$ 2.38	$ 166,608	B10B	1000	840	560	RS Means 312323170020: Fill, dumped material, spread, by dozer, excludes compaction
	Finish Grading of Material	84000	SY	$ 0.23	$ 19,320	B10W	8900	113	76	RS Means 312216103300: Fine grading, Finish grading slopes, gentle. Crew altered to reflect likely equipment to be used based on experience.
	Compaction of Material	66670	CY - in place	$ 0.55	$ 36,669	B10F	2600	308	205	RS Means 312323235100: Compaction; Riding, vibrating roller, 12" lifts, 4 passes (RSMeans Crew is B10Y; altered to B10F based on experience)
14	Excavation and Stockpiling of Excess Cut Material	78573	CY - in place	$ 8.34	$ 655,063	-	-	2,268	1,835	
	Excavation and Loading of Material	82502	CY - as excavated	$ 1.50	$ 123,752	B14A	3230	307	204	RS Means 312316435400: Excavating, large volume projects; excavation with truck loading; excavator, 4.5 CY bucket, 95% fill factor (assume 5% shrinkage factor from ground to in-place)
	Hauling and Dumping of Material	82502	CY - as excavated	$ 4.06	$ 334,957	B34G	680	971	971	RS Means 312323206020: Hauling; no loading equipment, including hauling, waiting, loading/dumping; 34 C.Y. off-road, 15 min wait/ld/uld., 5 MPH, cycle 4000 feet
	Spreading of Material	82502	CY - as excavated	$ 2.38	$ 196,354	B10B	1000	990	660	RS Means 312323170020: Fill, dumped material, spread, by dozer, excludes compaction
				GMF Recycle Pond Closure Subtotal	***$ 1,944,000***			***7,580***	***5,700***	
	Site Restoration									
15	Erosion Control Blanket	26000	SF - in place	$ 0.25	$ 6,500	ECB	22500	28	9	RS Means 312514160100. Rolled erosion control mats and blankets, plastic netting, stapled, 2" x 1" mesh, 20 mil.
16	Straw Wattle Ditch Checks	1500	LF - in place	$ 3.98	$ 5,970	A2	1000	36	12	RS Means 312514160705: Compost or mulch filter sock, 9" diameter
17	Seed, Mulch, and Maintain Vegetated Surfaces	22	AC	$ 6,463.00	$ 142,186	-	-	198	198	
	Lime	958	MSF	$ 26.88	$ 25,760	B66	700	11	11	RS Means 329113234250: Soil preparation, structural soil mixing, spread soil conditioners, ground limestone, 1#/S.Y., tractor spreader
	Fertilizer	958	MSF	$ 13.54	$ 12,976	B66	700	11	11	RS Means 329113234150: Soil preparation, tructural soil mixing, spread soil conditioners, fertilizer, 0.2#/S.Y., tractor spreader
	Seed	958	MSF	$ 39.20	$ 37,566	B66	52	147	147	RS Means 329219142300: Seeding athletic fields, seeding fescue, tall, 5.5 lb. per M.S.F., tractor spreader
	Mulch	958	MSF	$ 68.75	$ 65,885	B65	530	29	29	RS Means 329113160350: Mulching, Hay, 1" deep, power mulcher, large
				Site Restoration Subtotal	***$ 155,000***			***260***	***220***	
	Engineering & Construction Support Tasks and Contingency									
18	Final Closure Design and Bid Support (1.5% of Construction Subtotal)	1	LS	$ 50,625.00	$ 50,625.00	-	-	-	-	Typical Industry Value
19	Engineering Support and CQA During Construction (10% of Construction Subtotal)	232	Day	$ 337,500.00	$ 337,500.00	Eng	1	2,324	930	Unit Rate, Crew, and Output based on experience.
				Engineering & Construction Support Tasks Subtotal	***$ 388,000***			***2,320***	***930***	
Construction Costs Subtotal					**$ 3,375,000**			**11,800**	**9,100**	
Project Subtotal					**$ 3,763,000**			**14,100**	**10,000**	
30% Contingency					**$ 1,129,000**			**4,200**	**3,000**	
ENGINEER'S ESTIMATE OF TOTAL CONSTRUCTION AND ENGINEERING COST AND HOURS					**$ 4,892,000**			**18,300**	**13,000**	

Notes and Assumptions:
1. LS = Lump Sum, AC = Acre, LF = Linear Foot, EA = Each, SY = Square Yard, MO = Month, YR = Year, CY = Cubic Yard, MSF = Thousand Square Feet
2. Where possible, costs were developed using RS Means 2022 Heavy Construction Costs
3. 2022 RS Means unit rates include overhead and profit and refer to standard union labor in Effingham, IL.
4. Subtotal and total costs have been rounded to the nearest $1,000. Subtotal and total hours have been rounded to the nearest 100.
5. Earthwork quantities assume that the excavation and placement of fill within construction limits will be balanced so that no off-Site fill will be required to reach the final contours. The final elevations may need to be adjusted during final design to achieve balanced quantities.

Coffeen Power Station
Closure-by-Removal of GMF Recycle Pond

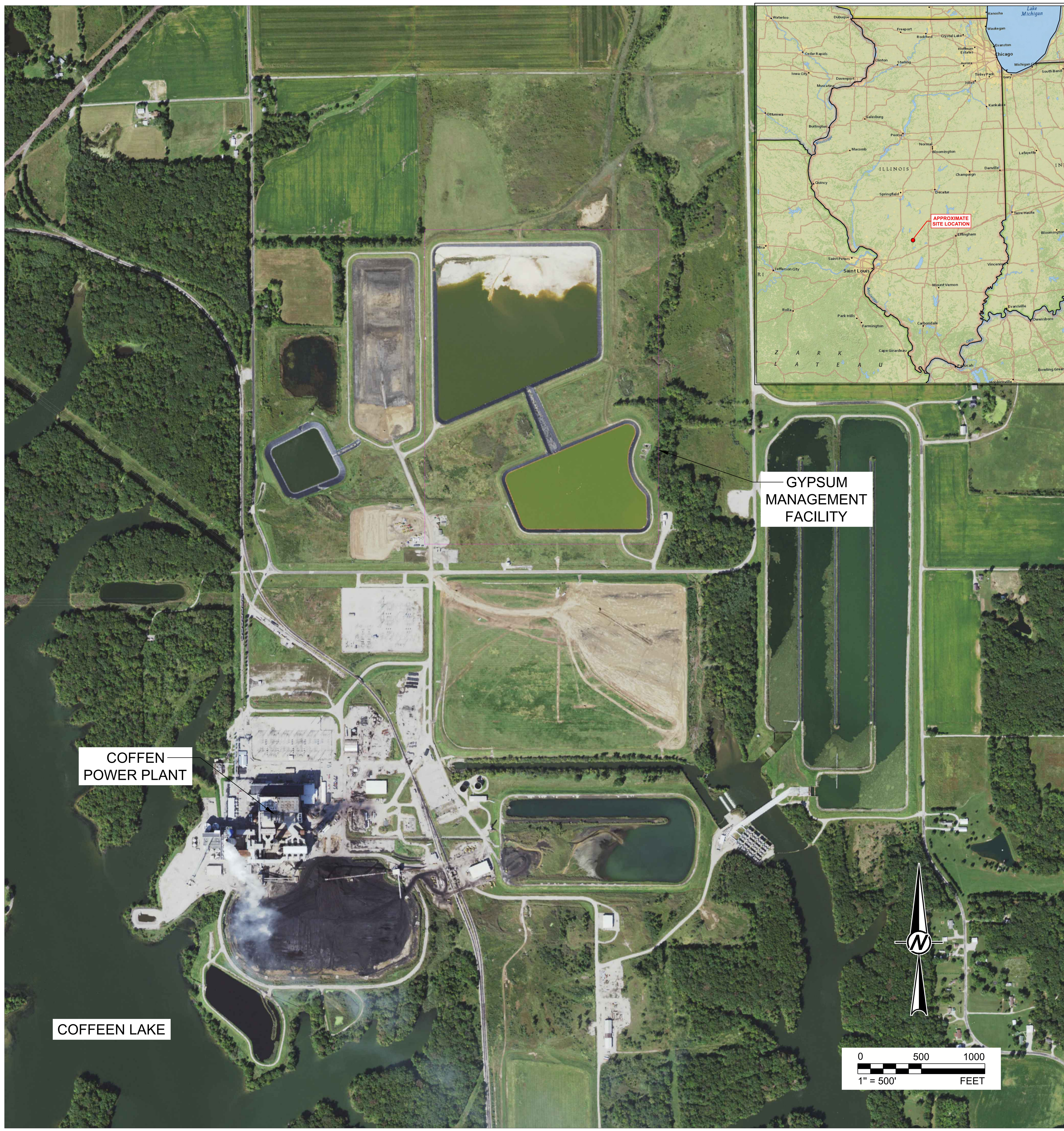
Crew	Labor	Daily Labor Hours	Equipment	Daily Equipment Hours	Project Total: Labor Hours	Project Total: Equipment Hours
B84	Operator x1	8	Rotary Mower/Tractor	8	91	91
B62	Laborer x2 Operator x1	24	Loader, Skid Steer, 30 H.P.	8	258	86
B59	Truck Driver x1	8	Truck Tractor, 220 H.P. Water Tank Trailer, 5000 Gal	8	2230	2230
B86A	Operator x1	8	Grader, 30,000 lbs	8	560	560
B14A	Operator x1 Laborer x0.5	12	Hyd. Excavator, 4.5 CY	8	875	582
B34G	Truck Driver x1	8	Dump Truck, Off Hwy, 54 ton	8	2771	2771
B10B	Operator x1 Laborer x0.5	12	Dozer, 200 H.P.	8	1830	1220
A2	Laborer x2 Truck Driver x1	24	Flatbed Truck, Gas, 1.5 ton	8	36	12
B66	Operator (light) x1	8	Loader-Backhoe, 40 H.P.	8	169	169
B65	Laborer x1 Truck Driver (light) x1	16	Power Mulcher (large) Flatbed Truck, Gas, 1.5 ton	16	29	29
B32C	Labor Foreman x1 Laborer x2 Operator (medium) x3	48	Grader, 30,000 lbs Tandem Roller, 10 ton Dozer, 200 H.P.	24	1686	843
ECB	Laborer x3	24	Tractor	8	28	9
Dewater	Laborer x1	8	8" Diesel Pump	2	778	195
Sump Install	Laborer x1 Operator x1	16	Hyd. Excavator, 4.5 CY	8	32	16
Eng	Engineering Staff x1.2	10	Side by Side x1	4	2324	930
B10F	Operator (medium) x1 Laborer x0.5	12	Tandem Roller, 10 ton	8	308	205
B34C	Truck Driver (heavy) x1	8	Truck Tractor, 6x4, 380 H.P. Dump Trailer, 16.5 CY	8	0	0
B10W	Operator (medium) x1 Laborer x0.5	12	Dozer, 105 H.P.	8	113	76
PROJECT TOTAL					**14118**	**10024**

Notes and Assumptions:
1. Crew names in itallics were created by Golder based on experience and are not from RS Means.

Item	Quantity	Assumptions
Labor Total Hours	14,118	Per projected total in cost estimate
Duration of Onsite Construction - Days	389	Per Construction Schedule
Average Daily Crew Size	4	10 hour days
Labor Mobilization Miles	108,954	Average of 70 miles round trip per day
Vehicle Miles On-Site	5,992	1 mile round trip from gate to parking 5 miles per day for CQA tech and Construction Supervisor 10% Contingency for Site visitors (client and engineering support)
Equipment Mobilization Miles - Unloaded	16,677	Average of 300 miles one way for equipment hauling Average 1 load of equipment per working week
Equipment Mobilization Miles - Loaded	16,677	Average of 300 miles one way for equipment hauling Average 1 load of equipment per working week
Total Equipment Miles On-Site	17,510	Average of 2 of 4 crew members running equipment Assume 15 miles per piece of equipment (based on 15 minute round trip path across AP1 10 miles per day used for water truck 5 miles per day for grader
On-Site Haul Truck Miles - Unloaded	2,623	34 CY Haul Truck 4000 ft cycle on-site
On-Site Haul Truck Miles - Loaded	2,623	34 CY Haul Truck 4000 ft cycle on-site
Off-Site Haul Truck Miles - Unloaded	-	16.5 CY Dump Truck 36 mile cycle to off-Site Landfill
Off-Site Haul Truck Miles - Loaded	-	16.5 CY Dump Truck 36 mile cycle to off-Site Landfill
Material Delivery Miles - Unloaded	2,200	45 extra trips for seed, fertilizer, lime, mulch, ECBs, straw wattles, and concrete
Material Delivery Miles - Loaded	2,200	45 extra trips for seed, fertilizer, lime, mulch, ECBs, straw wattles, and concrete

ATTACHMENT 2

Drawings



ILLINOIS POWER RESOURCES GENERATING, LLC
COFFEEN POWER PLANT
GYPSUM MANAGEMENT FACILITY
CONSTRUCTION PERMIT APPLICATION

PREPARED BY:

GOLDER ASSOCIATES INC.
701 EMERSON ROAD, SUITE 250
CREVE COEUR, MISSOURI 63141

DRAWING LIST

NUMBER	TITLE	REVISION
1	TITLE SHEET	A
2	EXISTING CONDITIONS	A
3	GYPSUM REGRADING AND CONTAINMENT PLAN	A
4	FINAL COVER AND STORMWATER PLAN	A
5	CROSS SECTIONS	A
6	DETAILS - 1 OF 2	A
7	DETAILS - 2 OF 2	A

REFERENCE(S)

1. AERIAL IMAGERY OBTAINED FROM UNITED STATES DEPARTMENT OF AGRICULTURE (USDA) NATIONAL AGRICULTURAL IMAGERY PROGRAM. IMAGERY CAPTURED 7/13/2019.

DRAFT

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
A	2022-04-29	ISSUED FOR REVIEW	DVS	AGD	MWD	MNH

SEAL

CLIENT
ILLINOIS POWER RESOURCES GENERATING, LLC
COFFEEN POWER PLANT

CONSULTANT
wsp GOLDER
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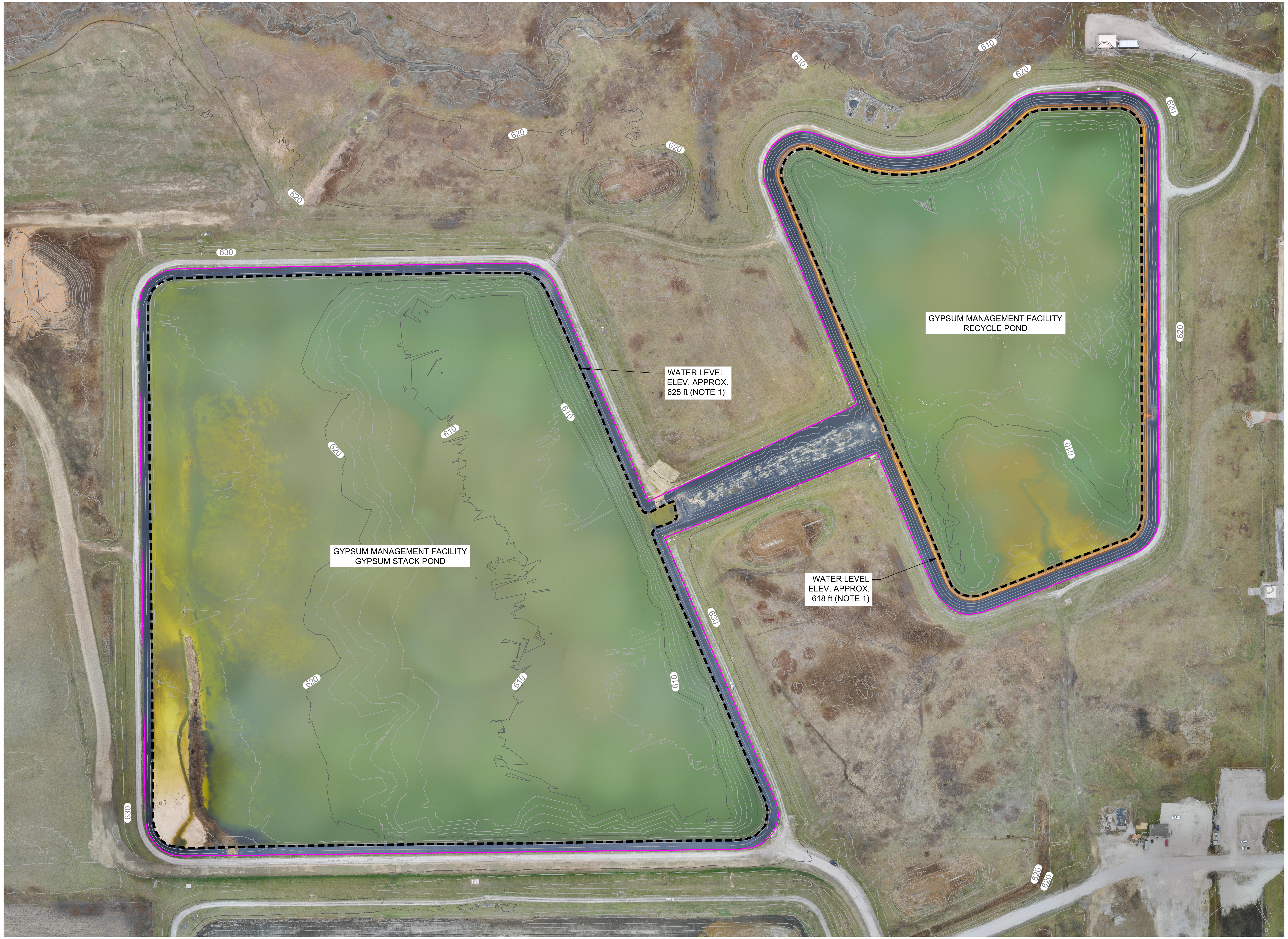
CREVE COEUR, MO 63141
UNITED STATES
(313) 984 8800

PROJECT
GYPSUM MANAGEMENT FACILITY
CONSTRUCTION PERMIT APPLICATION

TITLE
TITLE SHEET

PROJECT NO. 21465046 | REV. A | DRAWING 1



LEGEND

- 600 — EXISTING GROUND CONTOURS (SEE NOTE 1)
- WATER LEVEL (SEE NOTE 2)
- LIMITS OF LINER SYSTEM (SEE NOTE 3)

NOTE(S)

1. EXISTING CONTOURS ARE A COMPOSITE OF AN AERIAL SURVEY COMPLETED BY DRAGONFLY AEROSOLUTIONS DATED 12/3/2020, TOPOGRAPHIC/BATHYMETRIC SURVEYS COMPLETED BY INGENAE DATED 12/3/2020 & 12/4/2020.
2. WATER LEVEL LINE FROM SURVEY COMPLETED BY INGENAE DATED MARCH 24, 2021.
3. LIMITS OF THE LINER SYSTEM ARE APPROXIMATE BASED ON GYPSUM MANAGEMENT FACILITY (GMF) BASE GRADES DEVELOPED FROM CONSTRUCTION RECORD DRAWINGS DATED 1/5/2011.

REFERENCE(S)

1. AERIAL IMAGERY OBTAINED FROM AERIAL SURVEY COMPLETED BY DRAGONFLY AEROSOLUTIONS DATED 12/03/2020.

DRAFT

0 120 240
1" = 120' FEET

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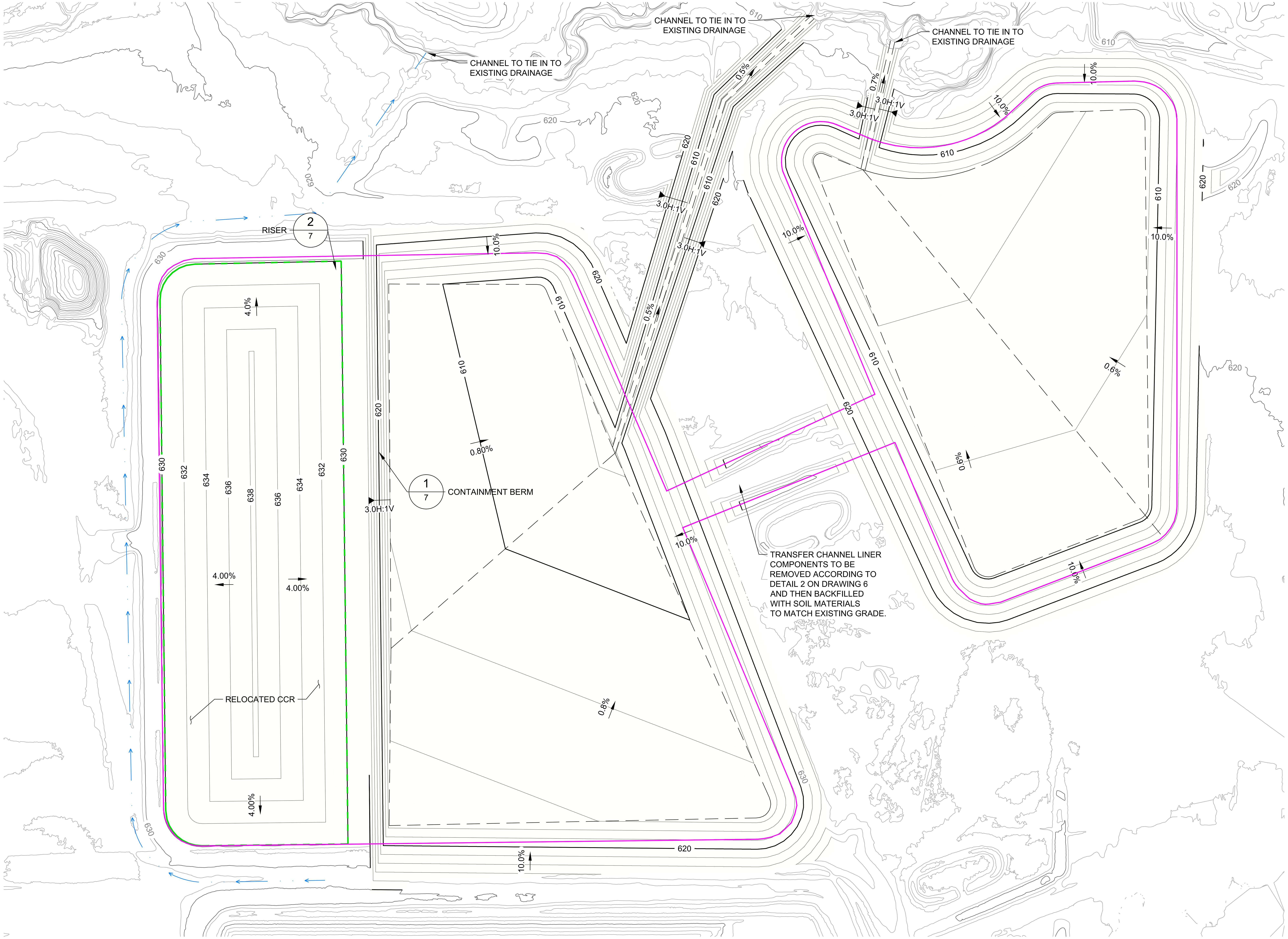
UNITED STATES
(313) 984 8800

PROJECT
GYPSUM MANAGEMENT FACILITY
CONSTRUCTION PERMIT APPLICATION

TITLE
EXISTING CONDITIONS

PROJECT NO. 21465046 | REV. A | DRAWING 2



LEGEND

600	GMF CLOSURE IN PLACE GRADES (SEE NOTES 1, 2, AND 3)
600	EXISTING GROUND CONTOURS (SEE NOTE 4)
	LIMIT OF RELOCATED CCR WASTE
	PROPOSED STORM WATER FLOW PATH
	LIMITS OF LINER SYSTEM (SEE NOTE 5)

NOTE(S)

1. THE CLOSURE-IN-PLACE CONCEPT FOR THE GYPSUM MANAGEMENT FACILITY (GMF) GYPSUM STACK POND (GSP) INVOLVES REMOVAL OF PONDED WATER, CONSTRUCTION OF A STRUCTURAL BERM (WITH COMPOSITE LINER ON THE UPSTREAM SLOPE), REMOVAL AND RELOCATION OF GYPSUM AND 1 FT (MAX.) OF CLAY LINER SOUTH OF THE BERM TO WITHIN THE CONSOLIDATED FOOTPRINT, PLACEMENT OF SOIL COVER ON GSP FLOOR SOUTH OF THE BERM FOR DRAINAGE, REMOVAL OF PERIMETER EMBANKMENT SOUTH OF RELOCATED WASTE, AND FINAL COVER CONSTRUCTION. EXISTING LINER COMPONENTS TO BE REMOVED SOUTH OF THE BERM ARE SPECIFIED IN DETAIL 1 ON DRAWING 7.
2. THE GMF RECYCLE POND CLOSURE WILL BE BY REMOVAL.
3. GMF GSP CLOSURE IN PLACE GRADES INCLUDE RELOCATED CCR WASTE, WASTE CONTAINMENT BERM, SOIL FILL FOR DRAINAGE ON GSP FLOOR, AND EXCAVATION GRADING FOR REMOVAL OF GSP PERIMETER EMBANKMENT SOUTH OF THE CONTAINMENT BERM. GMF RECYCLE POND GRADES ARE SOIL FILL FOR DRAINAGE ON RECYCLE POND FLOOR AND EXCAVATION GRADING FOR REMOVAL OF RECYCLE POND PERIMETER EMBANKMENT.
4. EXISTING CONTOURS ARE A COMPOSITE OF AN AERIAL SURVEY COMPLETED BY DRAGONFLY AEROSOLUTIONS DATED 12/3/2020, TOPOGRAPHIC/BATHYMETRIC SURVEYS COMPLETED BY INGENAE DATED 12/3/2020 & 12/4/2020.
5. LIMITS OF THE LINER SYSTEM ARE APPROXIMATE BASED ON GYPSUM MANAGEMENT FACILITY (GMF) GYPSUM STACK POND (GSP) AND RECYCLE POND (RP) BASE GRADES DEVELOPED FROM CONSTRUCTION RECORD DRAWINGS DATED 1/5/2011.

DRAFT

0 120 240
1" = 120' FEET

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
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COFFEEN POWER PLANT

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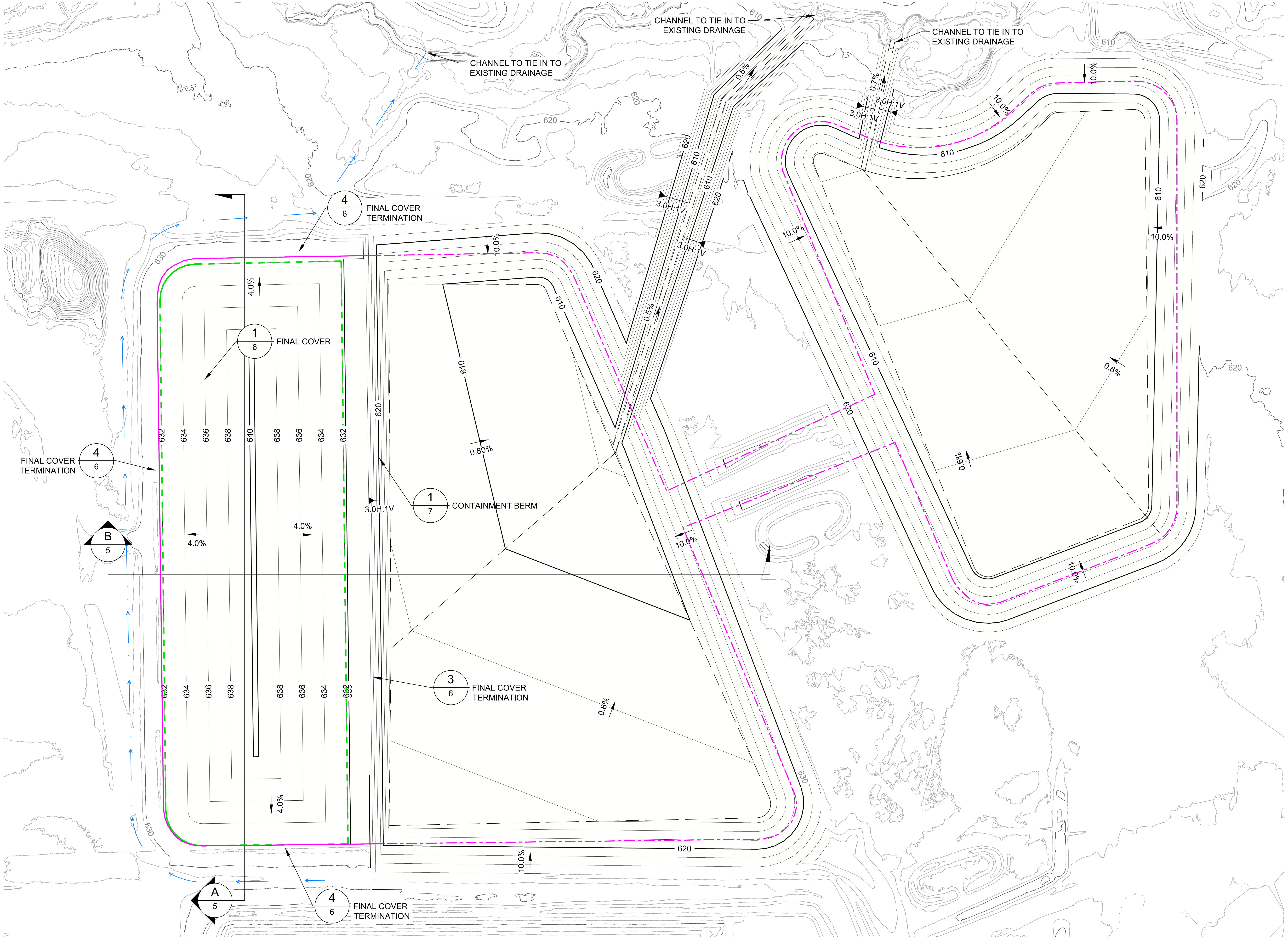
UNITED STATES
(313) 984 8800

PROJECT
GYPSUM MANAGEMENT FACILITY
CONSTRUCTION PERMIT APPLICATION

TITLE
GYPSUM REGRADING AND CONTAINMENT PLAN

PROJECT NO. 21465046 REV. A DRAWING 3



LEGEND

600	GMF CLOSURE IN PLACE GRADES (SEE NOTES 1 AND 2)
600	EXISTING GROUND CONTOURS (SEE NOTE 4)
	LIMIT OF RELOCATED CCR WASTE
	PROPOSED STORM WATER FLOW PATH
	EXISTING LINER TO REMAIN IN PLACE (SEE NOTE 5)
	EXISTING LINER TO BE REMOVED (SEE NOTE 5)

NOTE(S)

1. THE CLOSURE-IN-PLACE CONCEPT FOR THE GYPSUM MANAGEMENT FACILITY (GMF) GYPSUM STACK POND (GSP) INVOLVES REMOVAL OF PONDED WATER, CONSTRUCTION OF A STRUCTURAL BERM (WITH COMPOSITE LINER ON THE UPSTREAM SLOPE), REMOVAL AND RELOCATION OF GYPSUM AND 1 FT (MAX.) OF CLAY LINER SOUTH OF THE BERM TO WITHIN THE CONSOLIDATED FOOTPRINT, PLACEMENT OF SOIL COVER ON GSP FLOOR SOUTH OF THE BERM FOR DRAINAGE, REMOVAL OF PERIMETER EMBANKMENT SOUTH OF RELOCATED WASTE, AND FINAL COVER CONSTRUCTION. EXISTING LINER COMPONENTS TO BE REMOVED SOUTH OF THE BERM ARE SPECIFIED IN DETAIL 1 ON DRAWING 7.
2. THE GMF RECYCLE POND CLOSURE WILL BE BY REMOVAL.
3. GMF GSP CLOSURE IN PLACE GRADES INCLUDE RELOCATED CCR WASTE, WASTE CONTAINMENT BERM, SOIL FILL FOR DRAINAGE ON GSP FLOOR, AND EXCAVATION GRADING FOR REMOVAL OF GSP PERIMETER EMBANKMENT SOUTH OF THE CONTAINMENT BERM. GMF RECYCLE POND GRADES ARE SOIL FILL FOR DRAINAGE ON RECYCLE POND FLOOR AND EXCAVATION GRADING FOR REMOVAL OF RECYCLE POND PERIMETER EMBANKMENT.
4. EXISTING CONTOURS ARE A COMPOSITE OF AN AERIAL SURVEY COMPLETED BY DRAGONFLY AEROSOLUTIONS DATED 12/3/2020, TOPOGRAPHIC/BATHYMETRIC SURVEYS COMPLETED BY INGENAE DATED 12/3/2020 & 12/4/2020.
5. THE PROPOSED STORMWATER DRAINAGE CONCEPT IS TO SHED WATER INTO EXISTING DRAINAGE CHANNEL EAST OF THE FACILITY. STORMWATER COLLECTED WITHIN THE GMF GSP AND RECYCLE POND WILL BE DIRECTED INTO AN OPEN CHANNEL THAT BREACHES CONSTRUCTED BERMS TO CONNECT TO THE EXISTING DRAINAGE.
6. LIMITS OF THE LINER SYSTEM ARE APPROXIMATE BASED ON GYPSUM MANAGEMENT FACILITY (GMF) BASE GRADES DEVELOPED FROM CONSTRUCTION RECORD DRAWINGS DATED 1/5/2011.

DRAFT

0 120 240
1" = 120' FEET

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
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CONSULTANT
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UNITED STATES
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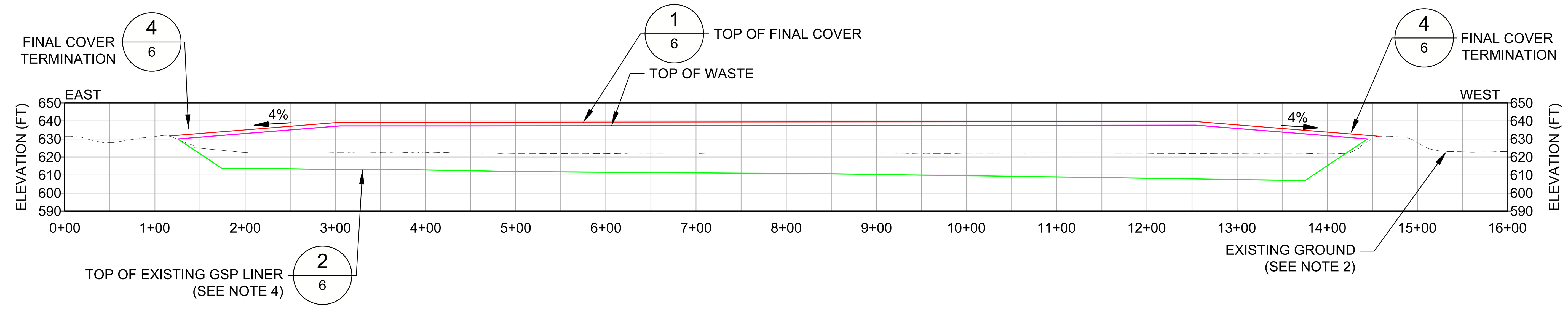
PROJECT
GYPSUM MANAGEMENT FACILITY
CONSTRUCTION PERMIT APPLICATION

TITLE
FINAL COVER AND STORMWATER PLAN

PROJECT NO. 21465046 | REV. A | DRAWING 4



SCALE NOT TO SCALE
VERTICAL SCALE X2
A / 5 SECTION A

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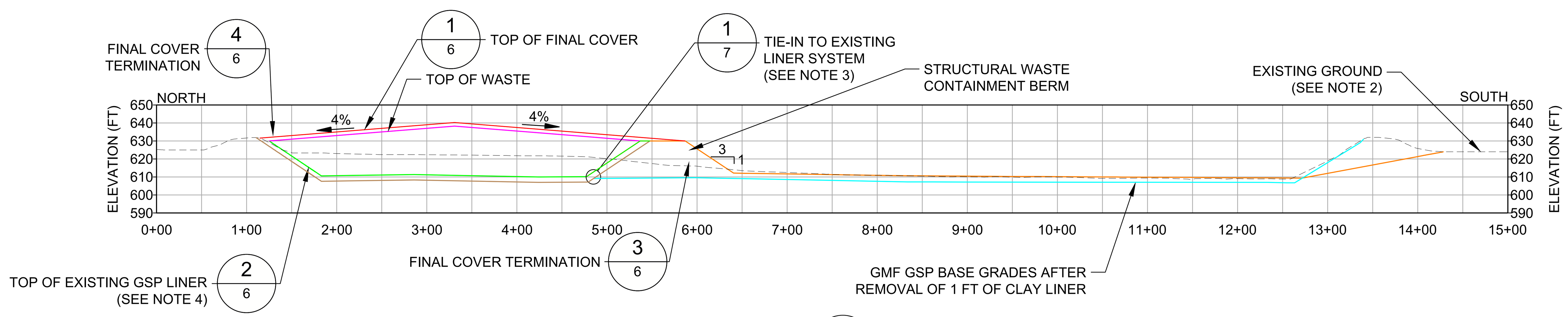
1" = 100' FEET



SCALE NOT TO SCALE
VERTICAL SCALE X2
B / 5 SECTION B

0 100 200
1" = 100' FEET

NOTE(S)

1. THE CLOSURE-IN-PLACE CONCEPT FOR THE GYPSUM MANAGEMENT FACILITY (GMF) GYPSUM STACK POND (GSP) INVOLVES REMOVAL OF PONDED WATER, CONSTRUCTION OF A STRUCTURAL BERM (WITH COMPOSITE LINER ON THE UPSTREAM SLOPE), REMOVAL AND RELOCATION OF GYPSUM AND 1 FT (MAX.) OF CLAY LINER SOUTH OF THE BERM TO WITHIN THE CONSOLIDATED FOOTPRINT, PLACEMENT OF SOIL COVER ON GSP FLOOR SOUTH OF THE BERM FOR DRAINAGE, REMOVAL OF PERIMETER EMBANKMENT SOUTH OF RELOCATED WASTE, AND FINAL COVER CONSTRUCTION.
2. EXISTING CONTOURS ARE A COMPOSITE OF AN AERIAL SURVEY COMPLETED BY DRAGONFLY AEROSOLUTIONS DATED 12/3/2020, TOPOGRAPHIC/BATHYMETRIC SURVEYS COMPLETED BY INGENAE DATED 12/3/2020 & 12/4/2020.
3. THE GSP EXISTING LINER SYSTEM WILL BE EXTENDED UP THE UPSTREAM SLOPE OF THE BERM.
4. GMF GSP TOP OF EXISTING LINER GRADES WERE DEVELOPED FROM CONSTRUCTION RECORD DRAWINGS DATED 1/5/2011.

DRAFT

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
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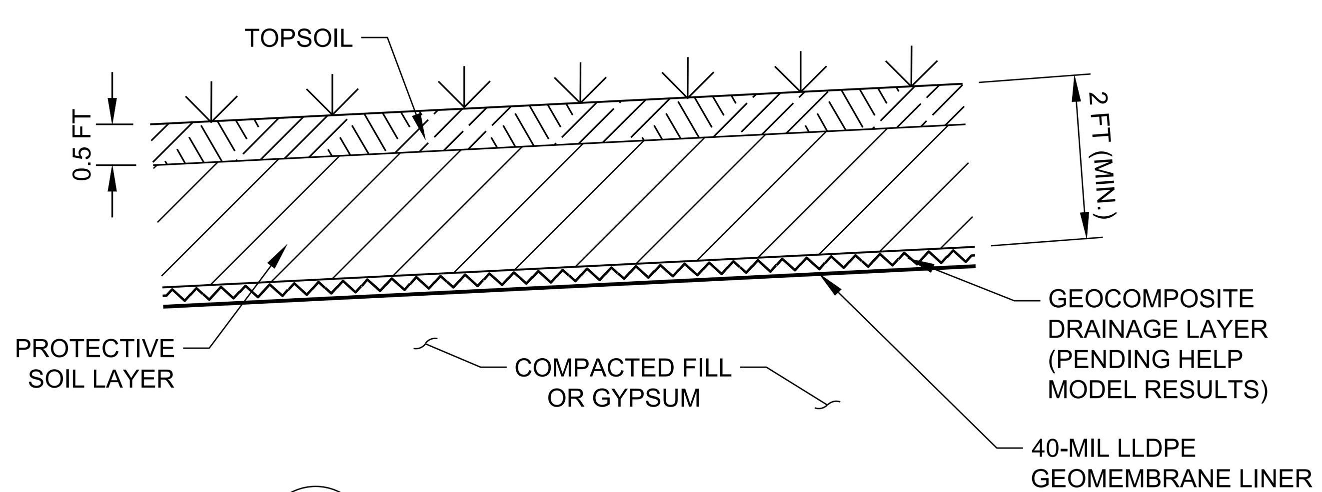
PROJECT
GYPSUM MANAGEMENT FACILITY
CONSTRUCTION PERMIT APPLICATION

TITLE
CROSS SECTIONS

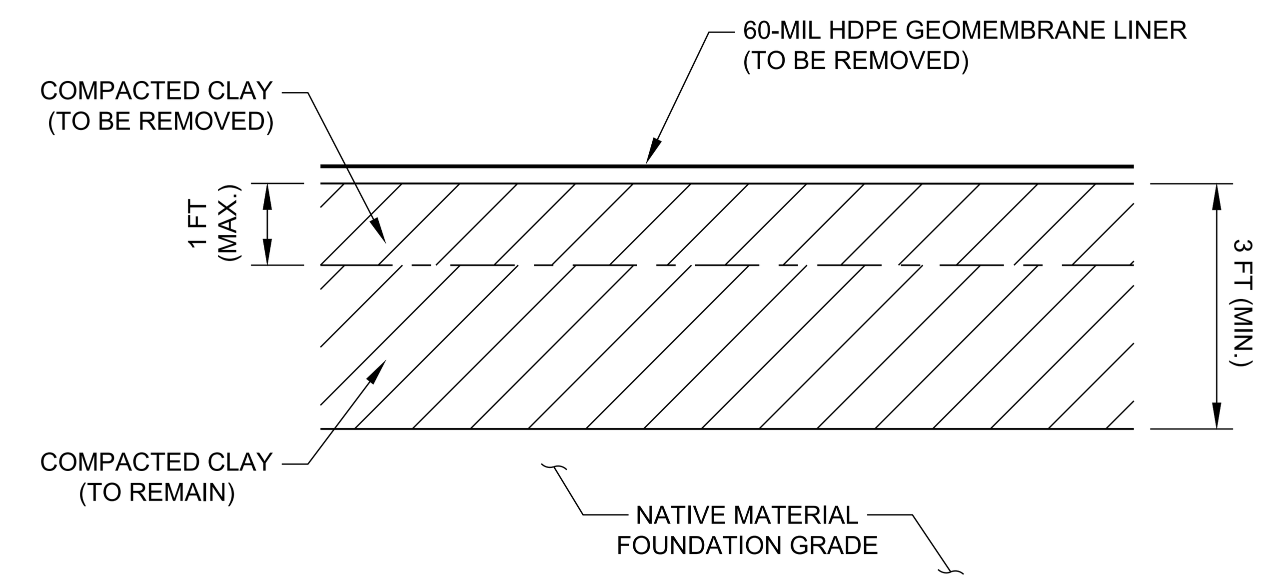
PROJECT NO. 21465046 | REV. A | DRAWING 5



SCALE NOT TO SCALE 1/6 FINAL COVER DETAIL

NOTE

THE FINAL PROTECTIVE SOIL LAYER WILL BE COMPOSED OF LOCALLY AVAILABLE SOILS COMPACTED TO BETWEEN 80% AND 95% OF THE STANDARD PROCTOR MAXIMUM DRY DENSITY FOR ESTABLISHMENT OF VEGETATION AND PROTECTION OF THE GEOSYNTHETICS.



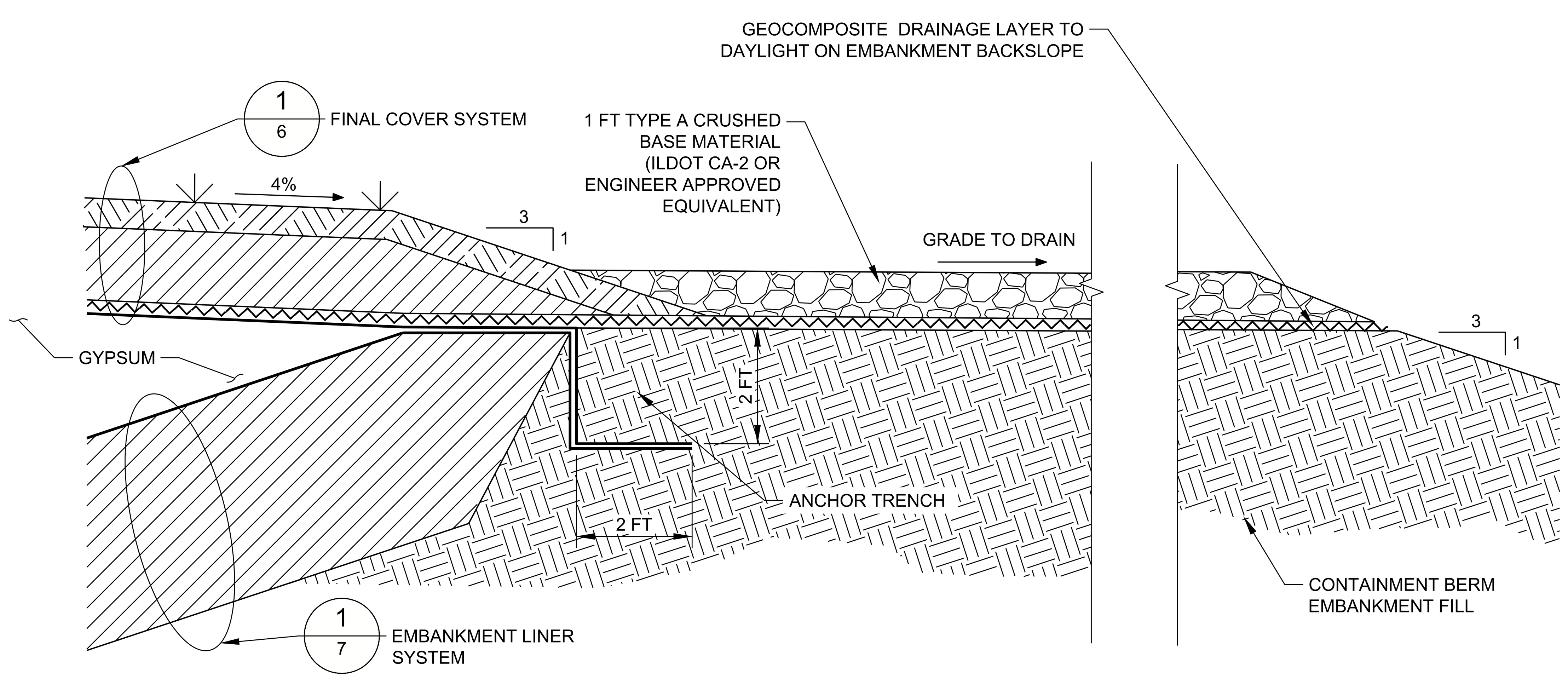
SCALE NOT TO SCALE 2/6 EXISTING GYPSUM STACK POND LINER SYSTEM DETAIL

MATERIAL REMOVAL NOTES (WHERE APPLICABLE)

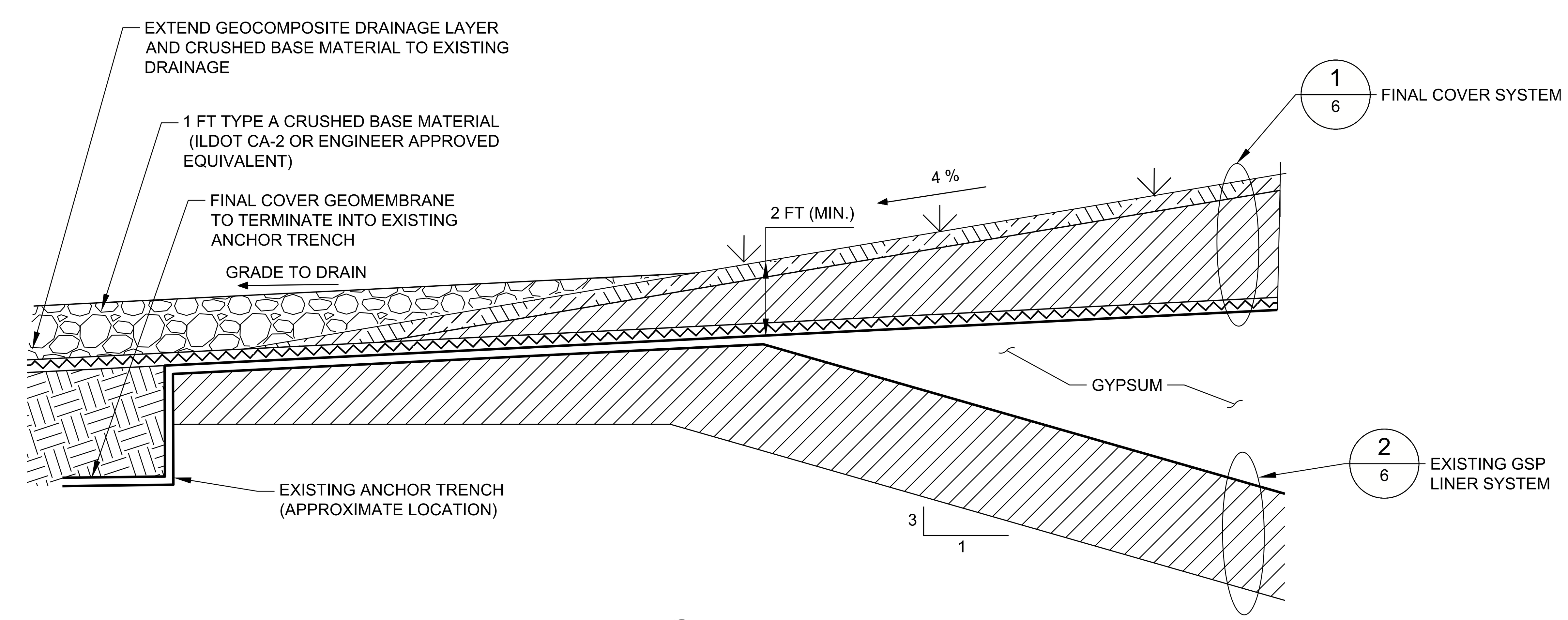
- 60-MIL HDPE GEOMEMBRANE WILL BE REMOVED AND DISPOSED OF IN THE CLOSURE FOOTPRINT OR DISPOSED OFFSITE.
- UP TO 1 FT COMPACTED CLAY LAYER WHERE SIGNS OF CCR ARE OBSERVED WILL BE REMOVED AND RELOCATED TO WITHIN THE CONSOLIDATED FOOTPRINT.

NOTE(S)

1. THE CLOSURE-IN-PLACE CONCEPT FOR THE GYPSUM MANAGEMENT FACILITY (GMF) GYPSUM STACK POND (GSP) INVOLVES REMOVAL OF PONDED WATER, CONSTRUCTION OF A STRUCTURAL BERM (WITH COMPOSITE LINER ON THE UPSTREAM SLOPE), REMOVAL AND RELOCATION OF GYPSUM AND 1 FT (MAX.) OF CLAY LINER SOUTH OF THE BERM TO WITHIN THE CONSOLIDATED FOOTPRINT, PLACEMENT OF SOIL COVER ON GSP FLOOR SOUTH OF THE BERM FOR DRAINAGE, REMOVAL OF PERIMETER EMBANKMENT SOUTH OF RELOCATED WASTE, AND FINAL COVER CONSTRUCTION.
2. EXISTING CONTOURS ARE A COMPOSITE OF AN AERIAL SURVEY COMPLETED BY DRAGONFLY AEROSOLUTIONS DATED 12/3/2020, TOPOGRAPHIC/BATHYMETRIC SURVEYS COMPLETED BY INGENAE DATED 12/3/2020 & 12/4/2020.
3. TOP OF UPPERMOST AQUIFER SURFACE BASED ON GROUNDWATER ELEVATION CONTOURS PROVIDED BY RAMBOLL.
4. THE GSP EXISTING LINER SYSTEM WILL BE EXTENDED UP THE UPSTREAM SLOPE OF THE BERM.
5. GMF GSP TOP OF EXISTING LINER GRADES WERE DEVELOPED FROM CONSTRUCTION RECORD DRAWINGS DATED 1/5/2011.



SCALE NOT TO SCALE 3/6 SOUTH FINAL COVER TERMINATION



SCALE NOT TO SCALE 4/6 OUTER PERIMETER FINAL COVER

DRAFT

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WSP GOLDER

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CREVE COEUR, MO 63141
UNITED STATES
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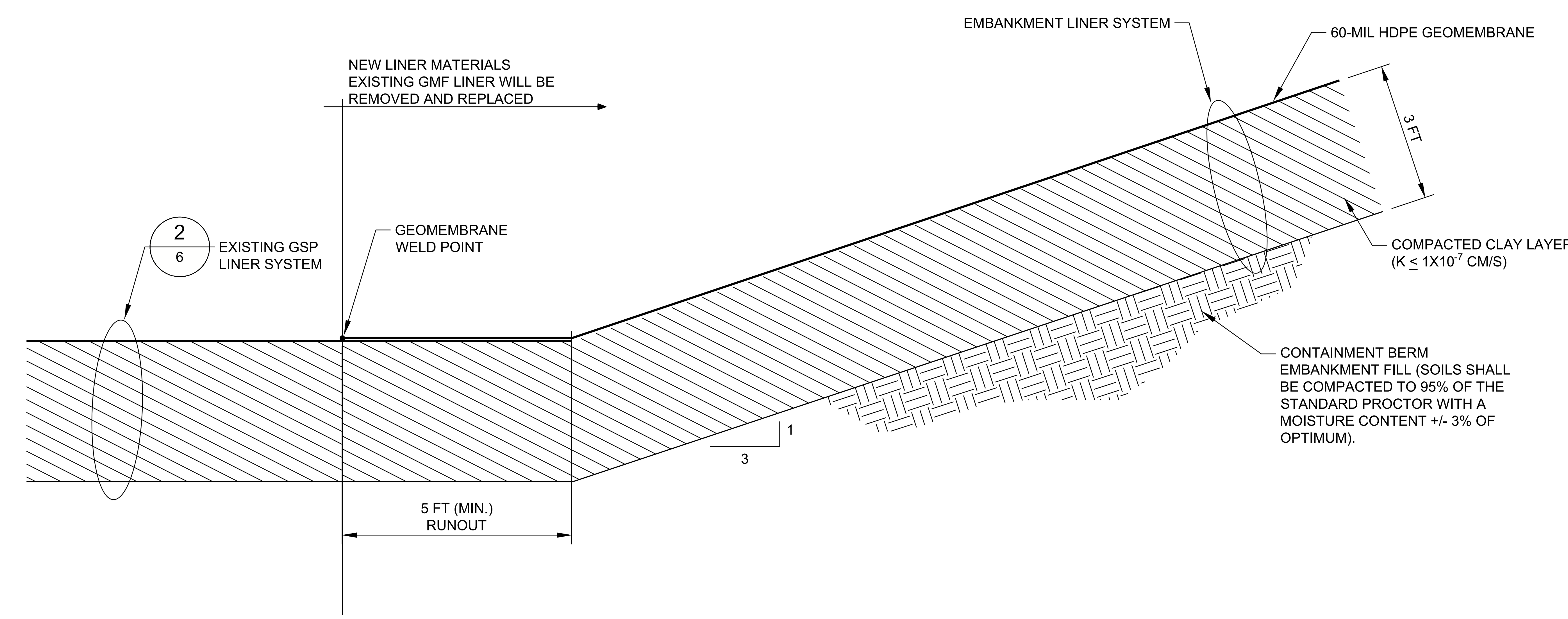
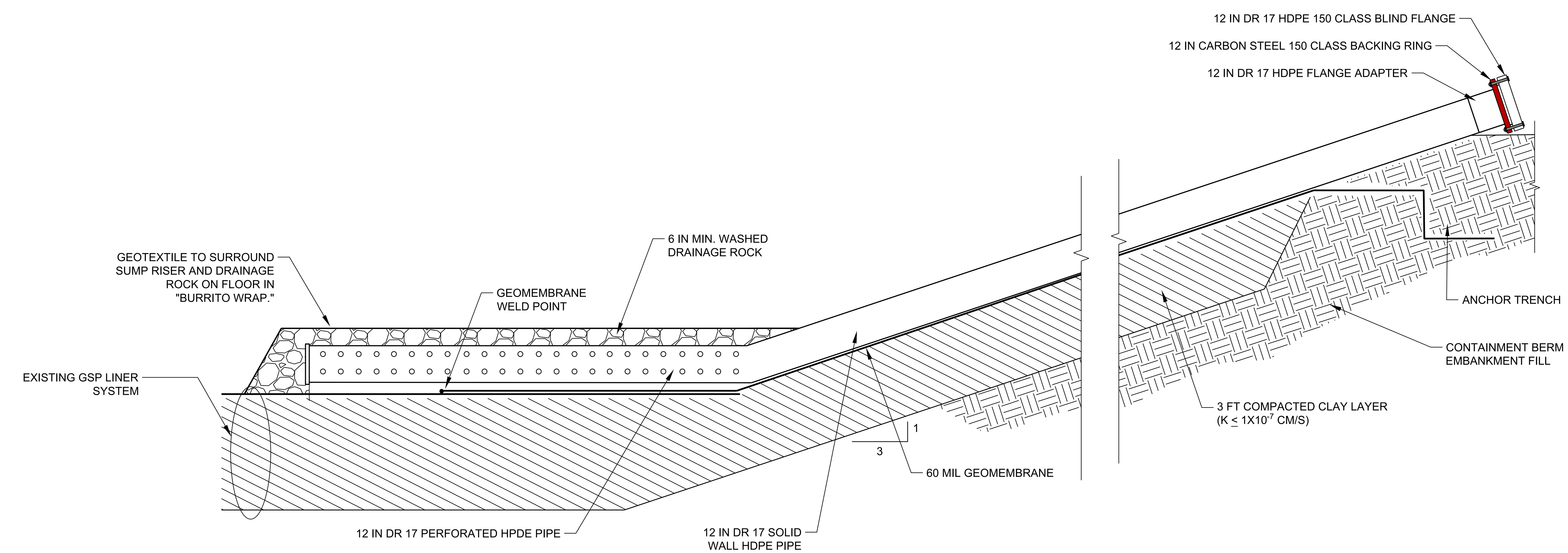
PROJECT
GYPSUM MANAGEMENT FACILITY
CONSTRUCTION PERMIT APPLICATION

TITLE
DETAILS - 1 OF 2

PROJECT NO.	REV.	DRAWING
21465046	A	6



SCALE NOT TO SCALE (1/7) EMBANKMENT LINER SYSTEM AND TIE-IN TO EXISTING GSP LINER



SCALE NOT TO SCALE (2/7) LEAK DETECTION SYSTEM SUMP AND RISER

DRAFT

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PROJECT
GYPSUM MANAGEMENT FACILITY
CONSTRUCTION PERMIT APPLICATION

TITLE
DETAILS - 2 OF 2

PROJECT NO. 21465046
REV. A
DRAWING 7

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI D

ATTACHMENT 3

Slope Stability Calculations

CALCULATION

DATE May 12, 2022 **Project No.** 21465046

PREPARED BY: Elizabeth Hanna

CHECKED BY Michael Dreyer

REVIEWED BY: Jacob Sauer **CLIENT NAME: Illinois Power Resources Generating, LLC**

SLOPE STABILITY ANALYSIS – GYPSUM MANAGEMENT FACILITY GYPSUM STACK POND

1.0 OBJECTIVE

Evaluate slope stability for the Gypsum Management Facility (GMF) Gypsum Stack Pond (GSP) closure design in terms of global stability and veneer stability for the final cover system and containment berm.

2.0 METHODOLOGY

Limit-equilibrium slope stability analyses were performed using Spencer's method of slices (Spencer 1967) in Slide2, a two-dimensional slope stability modeling software platform (Rocscience Inc. 2022). Spencer's method of slices considers both moment and force equilibrium. It is common geotechnical practice to analyze the stability of embankment slopes using limit-equilibrium methods.

2.1 Target Factors of Safety

The following target factors of safety are based on the values presented in Illinois Administrative Code Title 35, Subsection 845.460(a), as pertinent to the GMF GSP following closure:

- Target minimum factor of safety under static long-term conditions = 1.5
- Target minimum factor of safety under seismic loading conditions = 1.0

The locally available soils that will be used for closure construction have relatively high silt and clay contents. Therefore, they are not expected to be susceptible to liquefaction.

3.0 SLOPE STABILITY ANALYSIS

3.1 Geometry

A typical cross-section through the containment berm along the south end of the closure footprint was selected for the slope stability analysis. This is identified as the critical cross-section for slope stability following closure of the GMF GSP, as the GMF GSP is mostly incised around the remainder of the closure footprint perimeter.

The existing liner system will remain in place beneath the closure footprint and consists of (from top to bottom):

- 60-mil textured high-density polyethylene (HDPE) geomembrane

- 3 feet of compacted clay

The containment berm is designed with 3H-to-1V slopes and a crest width of 40 feet. The final cover system will be sloped at 4%. The base of the final cover system is designed to meet the upstream edge of the containment berm crest and terminate with a 3H-to-1V slope to the crest. The final cover system will consist of the following components (from top to bottom):

- 2 feet of protective soil cover, anticipated to consist primarily of locally available low-plasticity silt or clay
- double-sided geocomposite drainage layer
- 40-mil textured LLDPE geomembrane

A liner system will be installed on the upstream containment berm slope and tied into the existing liner system at the toe of the slope. The liner system will be the same as the existing liner system.

Downstream of the containment berm, the closure grades represent soil fill (locally available low-plasticity silt or clay) over the top of the compacted clay layer in the existing liner system, as the geomembrane components of the existing liner system above this layer will be removed during closure of the GMF GSP. Previous stability analyses (AECOM 2016) determined that the GMF GSP is underlain by a native clay layer, a relatively thin layer (approximately 3 feet) of soft native clay, and till.

For simplification of the model geometry, the liner system is represented as a layer having a thickness of 3 feet and the final cover system is represented as a layer having a thickness of 2 feet.

Groundwater levels in the vicinity of the GMF GSP are elevated above the existing liner system. For slope stability analysis, the phreatic surface is modeled along the top of the compacted clay layer in the existing liner system. Within the closure footprint, the liner system will prevent the phreatic surface from rising above this level and the CCR will be dewatered. Downstream of the containment berm, elevated groundwater is expected to present as surface water that will be managed in a stormwater channel, resulting in phreatic levels near the ground surface.

3.2 Approach and Input Parameters

The slope stability analysis uses the following approach and input parameters:

- Circular and non-circular slip surfaces are evaluated. Analysis of non-circular slip surfaces enables evaluation of veneer stability for the final cover system.
- Earthquake (seismic) loading conditions are simulated using a pseudo-static approach. Pseudo-static stability analyses apply a constant horizontal force to the system to represent the forces generated during an earthquake event, with the magnitude of the applied force typically related to the peak ground acceleration (PGA) of a specific earthquake hazard risk. A pseudo-static limit equilibrium analysis was conducted to evaluate the stability of the slope under a seismic load for the earthquake hazard representing a 2% probability of exceedance in 50 years (equaling 0.212g; i.e. a return period of 2475 years) based on the United States Geological Survey (USGS) Hazard Maps. As recommended by Hynes-Griffin and Franklin (1984), a horizontal force of ½ of the maximum PGA (EPA 1995) was used in the analysis (0.106g). In addition, the shear strength properties of the materials were reduced by 20% per the method's requirements.

- Material properties of soils are selected based on previous stability calculations (AECOM 2016). Cohesion is neglected for conservatism.
- For conservatism, undrained strengths are applied for gypsum. A vertical stress ratio (ratio of undrained strength to initial vertical effective stress) of 0.22 is used, consistent with the typical value for normally consolidated fine-grained material (Mesri 1989).
- Strength parameters for the geosynthetic interfaces included in the liner system and final cover system associated with the closed GMF GSP are evaluated from laboratory testing data published by Koerner and Narejo (2005) and summarized in Table 1.

Table 1: Characteristic Geosynthetic Interface Strengths (Koerner and Narejo 2005)

Interface	Peak Friction Angle	Peak Adhesion
Textured geomembrane against cohesive soil	18 degrees	209 psf
Textured geomembrane against granular soil	28 degrees	0 psf
NWNP geotextile against cohesive soil	30 degrees	104 psf
NWNP geotextile against textured geomembrane	25 degrees	167 psf
Geocomposite against cohesive soil	Use NWNP geotextile against cohesive soil	
Geocomposite against textured geomembrane	26 degrees	0 psf

- The lowest geosynthetic interface strength parameters in a given system (liner or final cover) from Table 1 are selected for analysis. Adhesion is conservatively neglected for all geosynthetic interfaces.

A summary of material properties used in the slope stability analysis is presented in Table 2.

Table 2: Material Properties

Material	Unit Weight	Friction Angle	Cohesion or Adhesion	Vertical Stress Ratio
Embankment	135	31	0	N/A
Gypsum	100	N/A	N/A	0.22
Liner System	120	18	0	N/A
Protective Cover	120	26	0	N/A
Native Clay	125	32	0	N/A
Soft Native Clay	125	30	0	N/A
Till	135	40	0	N/A

3.3 Results and Conclusions

The factor of safety for slope stability under static loading conditions is calculated as 1.8, as shown in Figure 1. The critical slip surface is surficial on the downstream face of the containment berm. The factor of safety for global stability under seismic loading conditions is calculated as 1.1, as shown in Figure 2. As with the static analysis, the critical slip surface is surficial on the downstream face of the containment berm.

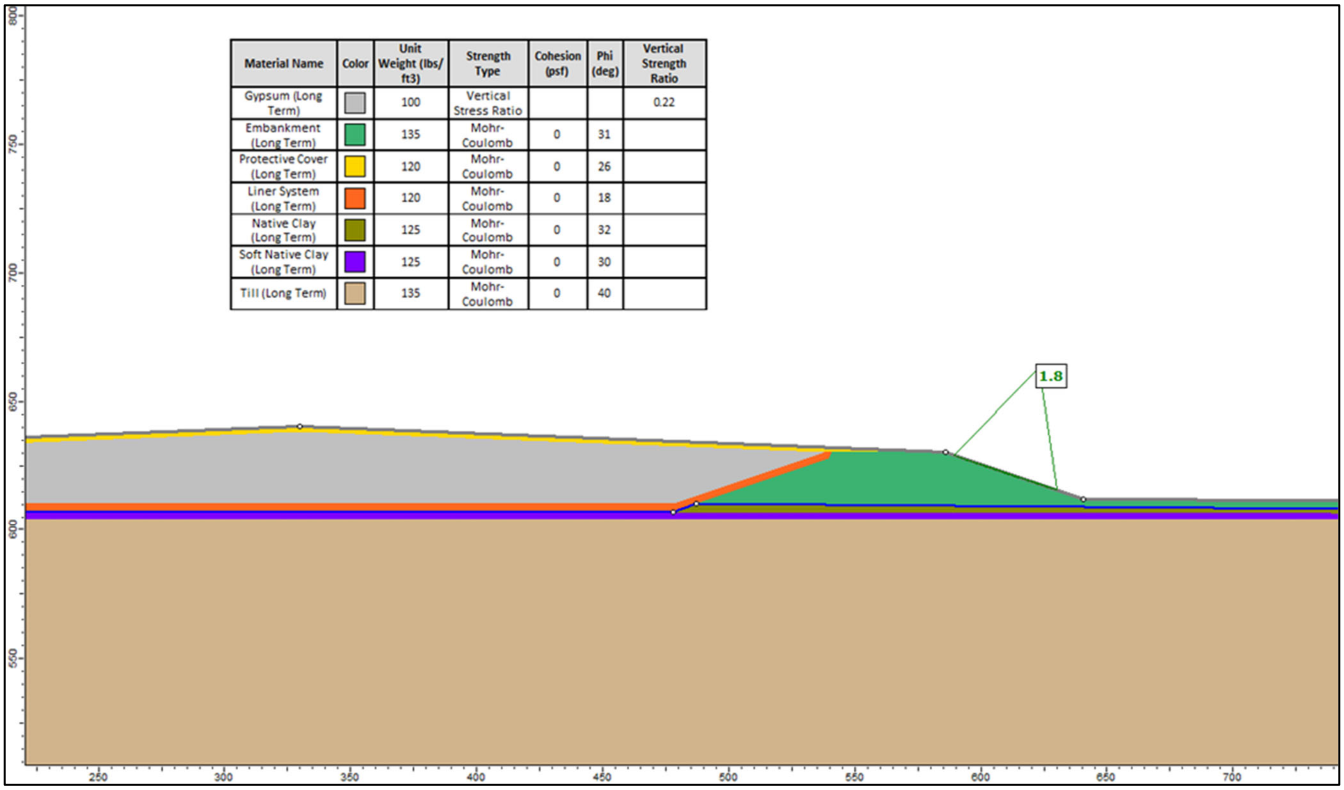

Figure 1: Analysis Result - Static Loading

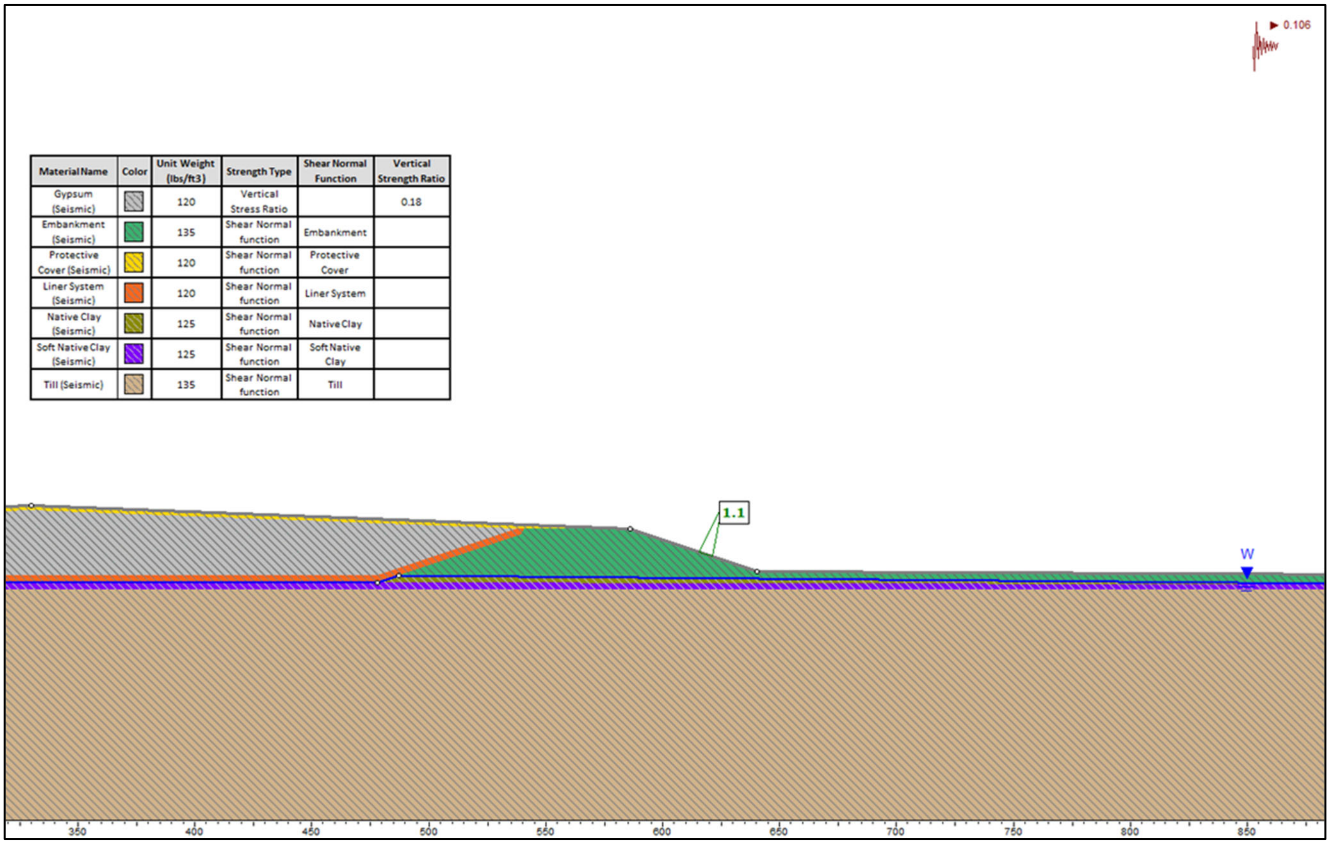

Figure 2: Analysis Result - Seismic Loading

Based on the factors of safety computed using the methods and assumptions described, the closed GMF GSP is expected to remain stable with an acceptable safety margin for global and veneer stability. A factor of safety greater that 1.5 was computed for static loading conditions. A factor of safety greater than 1.0 was computed for seismic loading conditions.

4.0 REFERENCES

AECOM 2016. Geotechnical Report Coffeen Power Station AP1. October 2016.

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Koerner, G.R. and Narejo, D. 2005. Direct Shear Database of Geosynthetic-to-Geosynthetic and Geosynthetic-to-Soil Interfaces. GRI Report #30, 2005.

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ATTACHMENT 4

Hydrologic Calculations

CALCULATION

DATE	May 10, 2022	**PREPARED BY**	Gustavo Guerrero, EIT
PROJECT NO.	21465046	**CHECKED BY**	DVS
CLIENT NAME	Illinois Power Resource Generating, LLC	**REVIEWED BY**	MWD

HYDROLOGY CALCULATIONS FOR CLOSURE OF THE GYPSUM MANAGEMENT FACILITY GYPSUM STACK POND AND RECYCLE POND AT THE COFFEEN POWER PLANT

1.0 OBJECTIVE

Evaluate the hydrology (routing of stormwater runoff) after closure of the Coffeen Power Plant Gypsum Management Facility (GMF) Gypsum Stack Pond (GSP) and Recycle Pond (RP). These calculations were performed to support the closure plan by determining the minimum channel dimensions.

2.0 METHODOLOGY

The areas contributing to the GMF GSP and GMF RP were delineated in AutoCAD, as shown on Figure 1. The ground conditions were used to estimate a lag time using NRCS methodology (NRCS 1986). The calculations for the hydrologic parameters are included in Tables 1 and 2. The hydrologic parameters were used to model the stormwater runoff reporting to proposed channels to the east of the closed GMF during the 25-year, 24-hour design storm event using HEC-HMS software (USACE 2021). The channels were analyzed using Manning's equation to evaluate the steady-state hydraulics.

3.0 INPUTS AND ASSUMPTIONS

Information and assumptions regarding input parameters used in the analyses include the following:

- A curve number of 58 was used to be consistent with the closed condition of Meadow and hydrologic soil group B (NRCS 1986) based on a review of the Web Soil Survey in the vicinity of the GMF GSP and GMF RP (NRCS 2021).
- The design storm (25-year, 24-hour) depth from NOAA Atlas 14 (NOAA 2006) is 5.33 inches.
- Lag time was estimated using NRCS TR-55 methodology.
- Manning's number used for channel design was 0.030 for capacity and 0.035 for depth assuming a grass-lined channel.

4.0 RESULTS AND CONCLUSIONS

The HEC-HMS model results provide the estimated peak flow from the 25-year, 24-hour design storm to discharge points of interest:

- The peak flow rate at the proposed stormwater channel for the GMF GSP is estimated as 44.0 cubic feet per second (cfs).
- The peak flow rate at the proposed stormwater channel for the GMF RP is estimated as 26.0 cfs.

- The peak flow rate at the proposed stormwater channel north and east of the relocated CCR is estimated as 19.6 cfs.

The output from the HEC-HMS model is shown in Table 3.

The channels were designed with dimensions as indicated in Table 4. Freeboard is shown to be at least 1 foot and at least one-half of the velocity head. The calculations indicate that the channels should function as designed.

5.0 REFERENCES

National Oceanic and Atmospheric Administration (NOAA). 2006. Precipitation-Frequency Atlas of the United States, Volume 2 Version 3.0.

Natural Resources Conservation Service (NRCS). 1986. Urban Hydrology for Small Watersheds. 2nd edition Technical Release 55). June.

Natural Resources Conservation Service (NRCS). 2021. Web Soil Survey. Available online: http://websoilsurvey.sc.egov.usda.gov/. Accessed September 22, 2021.

United States Army Corps of Engineers (USACE). 2021. Hydrologic Modeling System (HEC-HMS), Version 4.9.0. Release date: Jan 21, 2022.

TABLES

Table 1: Subbasin Summary Table

Illinois Power Resource Generating, LLC
Gypsum Management Facility Ponds
Project Number: 21465046

Date:	5/10/22
By:	GMG
Chkd:	DVS
Apprvd:	MWD

Design Storm **25 -Year Reccurence Interval**

Storm Duration (hours)	2-Year Depth (inches)	25 -Year Depth (inches)	Storm Distribution
24	3.14	5.33	II

Subbasin ID	Subbasin Area (ft^2)	Subbasin Area (acres)	Subbasin Area (sq mile)	CN = 58 Meadow HSG B (acres)	CN = 99 Open Water or Impervious (acres)	Composite SCS Curve No.	$S = \frac{1000}{CN} - 10$	Unit Runoff Q (in)	Runoff Volume (ac-ft)	Runoff Volume (ft^3)
STK	1,801,416	41.4	0.0646	41.4	0.00	CN = 58	7.24	1.35	4.67	203,356
RCY	1,649,368	37.9	0.0592	37.9	0.00	CN = 58	7.24	1.35	4.27	186,191
CCR	746,014	17.1	0.0268	17.1	0.00	CN = 58	7.24	1.35	1.93	84,215
		0.0	0.0000							
Total:	4,196,798	96.3	0.15						10.88	473,762

TABLE 2
BASIN TIME OF CONCENTRATION CALCULATIONS

Table 2: Basin Time of Concentration Calculations
Illinois Power Resource Generating, LLC
Gypsum Management Facility Ponds
Project Number: 21465046

Date:	5/10/22
By:	GMG
Chkd:	DVS
Apprvd:	MWD

					Flow Segment 1							Flow Segment 2							Flow Segment 3						
Subbasin ID	Subbasin Area (sq mile)	Composite Curve Number	Total Lag (0.6*Tc) (min)	Total Travel Time (min)	Type of Flow	Length (ft)	Slope (ft/ft)	Roughness Condition[(1)]		Typical Hydraulic Radius (Channel Only) (ft)	Travel Time (min)	Type of Flow	Length (ft)	Slope (ft/ft)	Roughness Condition[(1)]		Typical Hydraulic Radius (Channel Only) (ft)	Travel Time (min)	Type of Flow	Length (ft)	Slope (ft/ft)	Roughness Condition[(1)]		Typical Hydraulic Radius (Channel Only) (ft)	Travel Time (min)
STK	0.0646	58	15.2	25.3	Sheet	100	0.212	G	Bermuda Grass		8.6	Shallow	1230	0.016	U	Unpaved		10.2	Channel	1105	0.005	G	Grass-lined	0.89	6.5
RCY	0.0592	58	31.3	52.2	Sheet	100	0.007	G	Bermuda Grass		33.8	Shallow	1765	0.012	U	Unpaved		16.7	Channel	280	0.007	G	Grass-lined	0.66	1.7
CCR	0.0268	58	13.4	22.3	Sheet	100	0.205	G	Bermuda Grass		0.0	Channel	2850	0.005	G	Grass-lined	0.61	22.3							

Notes:
(1) Refer to Attachment A for Roughness Condition descriptions and Tc Coeffiecients.

TABLE 3
FLOW RESULTS FROM HEC-HMS

Illinois Power Resource Generating, LLC
Gypsum Management Facility Ponds
Project Number: 21465046

Date:	5/10/22
By:	GMG
Chkd:	DVS
Apprvd:	MWD

HEC-HMS Basin Model:	GMF
HEC-HMS Met. Model:	25-yr, 24-hr
HEC-HMS Control Specs:	48-hr, 6-min

Hydrologic Element	Drainage Area (sq mile)	Peak Discharge (cfs)	Time of Peak	Total Volume (ac-ft)
CCR	0.027	19.6	02May2050, 00:06	1.9
CCR-Sink	0.027	19.6	02May2050, 00:06	1.9
Recycle Pond	0.059	26	02May2050, 00:30	4.3
Recycle-Sink	0.059	26	02May2050, 00:30	4.3
Stack	0.065	44	02May2050, 00:12	4.7
Stack-Sink	0.065	44	02May2050, 00:12	4.7

GOLDER - DRAFT

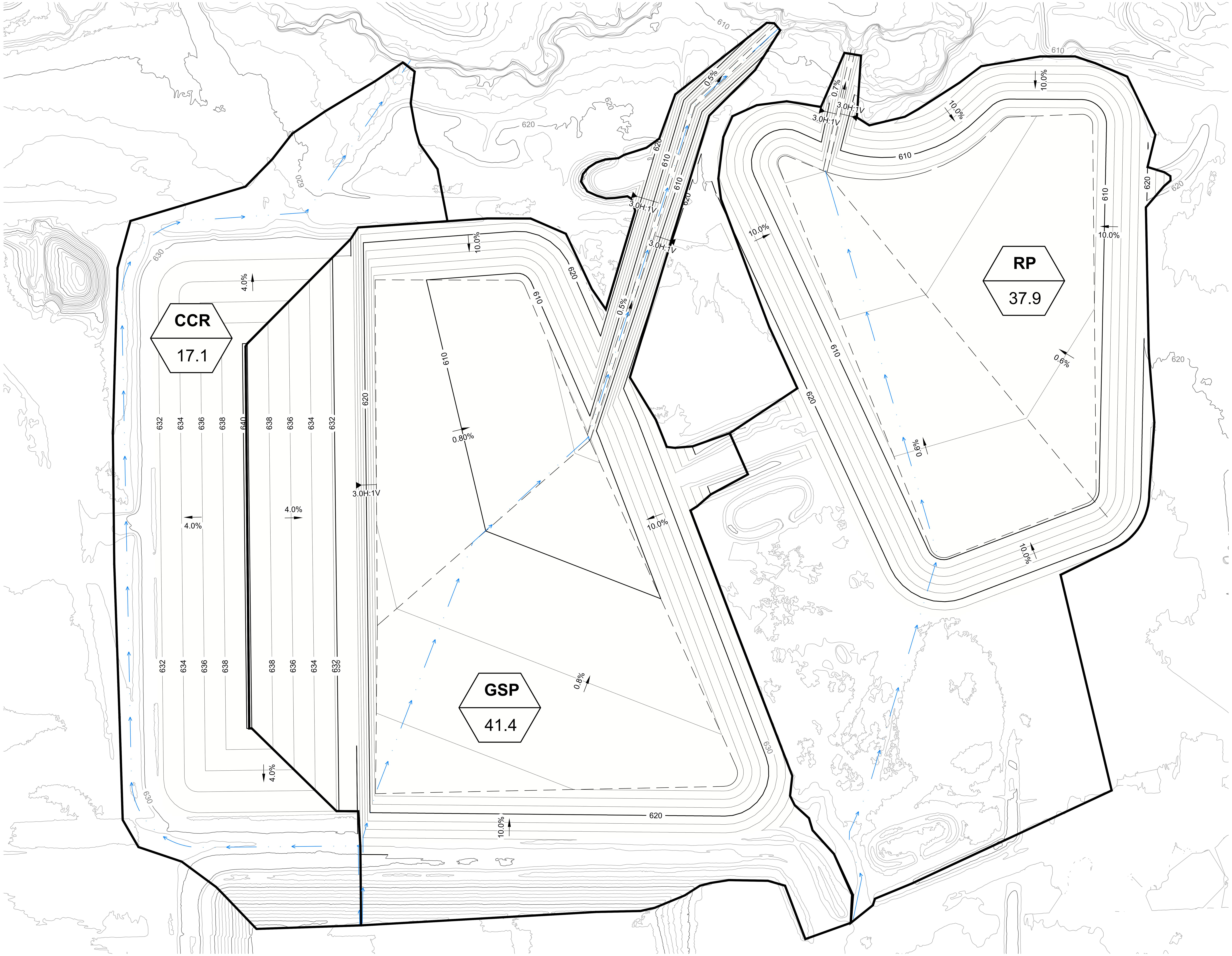
Table 4
Channel Hydraulic Calculations

Illinois Power Resource Generating, LLC
Gypsum Management Facility Ponds
PROJECT NO.: 21465046

Date:	5/10/22
By:	GMG
Chkd:	DVS
Apprvd:	MWD

			Channel Design Geometry						Channel Roughness Parameters				Hydraulic Calculations							Channel Evaluations	
Reach Designation	Q25 from HEC-HMS (cfs)	HEC HMS Element ID for Q	Approximate Channel Length (ft)	Bed Slope (ft/ft)	Left Side Slope (H:1V)	Right Side Slope (H:1V)	Bottom Width (ft)	Minimum Channel Depth (ft)	Design Channel Lining		Mannings 'n' for Capacity (Depth Calculation)	Mannings 'n' for Stability (Velocity Calculation)	Maximum Velocity (ft/sec)	Maximum Normal Flow Depth (ft)	Froude Number	Normal Depth Shear Stress (lb/ft^2)	Stream Power (W/m^2)	Top Width of Flow (ft)	Top Width of Channel (ft)	Available Freeboard (ft)	
STK Channel	44.0	Stack-Sink	1105	0.005	3.0	3.0	10	4.0	G	Grass-lined	0.035	0.030	3.2	1.15	0.60	0.37	16.92	16.9	34.0	2.8	Suitable
RCY Channel	26.0	Recycle Pond	280	0.007	3.0	3.0	10	5.0	G	Grass-lined	0.035	0.030	3.0	0.78	0.67	0.35	15.10	14.7	40.0	4.2	Suitable
CCR Channel	19.6	CCR-Sink	2850	0.005	3.0	3.0	0	3.0	G	Grass-lined	0.035	0.030	2.8	1.62	0.56	0.49	19.98	9.7	18.0	1.4	Suitable

FIGURE



LEGEND

- 600 — GMF CLOSURE IN PLACE GRADES (SEE NOTE 1)
- 600 — EXISTING GROUND CONTOURS (SEE NOTE 2)
- PROPOSED STORM WATER FLOW PATH
- BASIN DELINEATION
- RP — BASIN ID
- 37.9 — BASIN ACREAGE

NOTE(S)

1. GMF GSP CLOSURE IN PLACE GRADES INCLUDE RELOCATED CCR WASTE, WASTE CONTAINMENT BERM, SOIL FILL FOR DRAINAGE ON GSP FLOOR, AND EXCAVATION GRADING FOR REMOVAL OF GSP PERIMETER EMBANKMENT SOUTH OF THE CONTAINMENT BERM. GMF RECYCLE POND GRADES ARE SOIL FILL FOR DRAINAGE ON RECYCLE POND FLOOR AND EXCAVATION GRADING FOR REMOVAL OF RECYCLE POND PERIMETER EMBANKMENT.
2. EXISTING CONTOURS ARE A COMPOSITE OF AN AERIAL SURVEY COMPLETED BY DRAGONFLY AEROSOLUTIONS DATED 12/3/2020, TOPOGRAPHIC/BATHYMETRIC SURVEYS COMPLETED BY INGENAE DATED 12/3/2020 & 12/4/2020.
3. THE PROPOSED STORMWATER DRAINAGE CONCEPT IS TO SHED WATER INTO EXISTING DRAINAGE CHANNEL EAST OF THE FACILITY. STORMWATER COLLECTED WITHIN THE GMF GSP AND RECYCLE POND WILL BE DIRECTED INTO AN OPEN CHANNEL THAT BREACHES CONSTRUCTED BERMS TO CONNECT TO THE EXISTING DRAINAGE.

0 120 240
1" = 120' FEET

WSP GOLDER

COFFEEN POWER PLANT GYPSUM MANAGEMENT FACILITY

SURFACE WATER DRAINAGE BASINS

FIGURE 1