DRAFT

REPORT

Final Closure Plan for the Gypsum Management Facility Pond

Duck Creek 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 Resource Generating, LLC's (IPRG's) Gypsum Management Facility (GMF) Pond at the Duck Creek Power Plant near Canton, Illinois. Specifically, this document addresses requirements pertaining to the development of a Final Closure Plan for the GMF Pond. The GMF Pond has identification codes as follow:

- IPRG ID Number: CCR Unit ID 203
- IEPA ID Number: W0578010001-04
- IDNR Dam ID Number: IL50573

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 (CBR) of CCR (Section 845.740). The results of an analysis of these closure alternatives are summarized in Attachment 1. Based on the Closure Alternatives Analysis, closure in place with a final cover system has been identified as the most appropriate closure method.

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.

Final cover system grades and details are shown in the Drawings included as Attachment 2. The CIP concept was developed to reduce the gypsum footprint at closure, while also recognizing the complications associated with handling and stacking wet gypsum materials. The final cover will have slopes of 4% to accommodate settlement, with an earthen berm constructed at the south end of the closure footprint to enhance stability. The location of the berm, as shown in Drawing 4, has been selected to accommodate the estimated volume of gypsum to be contained within the closure footprint based on the grading plan presented. The general sequencing plan for closure in place is as follows:

- Ponded water will be pumped out from the GMF Pond. Approximately 112 million gallons of water were contained in the GMF Pond as of a December 2020 survey by IngenAE, not including the pore water within the roughly 400,000 cubic yards (cy) of gypsum. Pumping out the ponded water will enable gravity drainage of the gypsum to begin. Water pumped out of the GMF Pond will be routed to the Recycle Pond immediately south of the GMF Pond and then to Duck Creek Reservoir, where it will be managed in accordance with the National Pollutant Discharge Elimination System (NPDES) permit for the site.
- The upper gypsum layer will be dewatered within the northern portion of the GMF Pond as necessary to allow mobile equipment traffic across the surface using a series of trenches and sumps. Water flowing to the sumps will be pumped out and managed in accordance with the NPDES permit for the site.

- Gypsum will be dewatered and relocated to allow the construction of the new berm in an east–west orientation at the south end of the closure footprint. The upstream face of the berm will be lined with a composite liner system, which will tie into the existing liner system. The new liner system will include (from bottom to top):
  - 2-foot compacted soil liner (permeability of 1 x 10^{-7} cm/sec or less)
  - 60-mil high-density polyethylene (HDPE) geomembrane
- The remaining wet gypsum south of the berm will be dewatered as necessary, collected, and deposited north of the berm (i.e., within the closure footprint) to achieve the approximate closure grades shown in Attachment 2. This may be accomplished by traditional earthwork methods and/or by washing the material towards sumps at the south end of the GMF Pond, where the material can be collected.
- In portions of the GMF Pond that are outside of (i.e., generally south of) the closure footprint, the geosynthetic components of the existing liner system will be removed and disposed in the closure footprint or in the existing permitted on-site landfill. The existing permitted on-site landfill has sufficient capacity to accept the removed materials. The earthen components of the existing primary liner system and leachate collection and removal system will be removed and stockpiled onsite. The subsoils will be visually observed for signs of CCR staining. If subsoils with CCR staining are observed, they will be removed and disposed.
- Once all gypsum is contained within the closure footprint and appropriate grades for closure have been achieved (with grading fill used as necessary), a final cover system will be installed over the closure footprint in accordance with Part 845.750. The final cover system will consist of (from top to bottom):
  - Based on a demonstration to be submitted to the Illinois Environmental Protection Agency (IEPA) for approval pursuant to Section 845.750(c)(2), a two-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 expected to consist primarily of low-plasticity silt or clay based on a review of site geotechnical information.
  - Geocomposite drainage layer.
  - 60-mil HDPE geomembrane.
- Surface water channels will be excavated as shown in Attachment 2 to route stormwater flows away from the closure footprint.

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 gypsum south of the berm has been relocated to within the closure footprint, the existing liner system will be removed and disposed in the existing permitted on-site landfill. An additional 12 inches of subsoil may also be removed. The subsoils will be visually observed for signs of CCR staining. If subsoils with CCR staining are observed, they will be removed and disposed.

2.3 Final Cover 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 a comparison between the permitted top-of-liner-system grades and the bathymetric and topographic data obtained by IngenAE in December 2020, the estimated volume of gypsum in the GMF Pond is approximately 400,000 cy. No additional CCR will be placed in the GMF Pond 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 USEPA's CCR Rule (40 CFR 257, Subpart D), the largest area of the GMF Pond ever requiring a final cover was estimated to be approximately 31 acres. This area represents the entire footprint of the GMF Pond. The area of the closure footprint requiring final cover under this Final Closure Plan is approximately 15 acres.

2.6 Closure Completion Schedule

Part 845.720(a)(1)(E): 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 (all preliminary estimates)
Final Closure Plan Submittal	February 2022
Final Design and Bid Process	6 to 12 months after Final Closure Plan approval
Agency Coordination and Permit Acquisition ▪ State permits for dewatering/water treatment (NPDES), land disturbance, and dam modification	
Dewater and Stabilize CCR ▪ Pump water from GMF Pond ▪ Dewater and stabilize gypsum	6 to 12 months after issuance of necessary permits, design completion, and bid award
Consolidate Waste Footprint ▪ Construct east-west berm ▪ Install new liner system on upstream face of berm ▪ Relocate gypsum south of berm to closure footprint	3 to 6 months after dewatering and gypsum stabilization
Installation of Final Cover System ▪ Prepare top of gypsum for cover system installation ▪ Install geomembrane ▪ Install geocomposite drainage layer ▪ Place protective cover soil	3 to 6 months after gypsum relocation to closure footprint
Site Restoration ▪ Remove existing liner system south of berm ▪ Excavate drainage channels ▪ Seed and mulch final cover and disturbed areas	3 to 6 months after final cover system installation
Timeframe to Complete Closure	Prior to April 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 Pond will be minimized by the construction of a final cover system. The final cover system will consist of (from top to bottom):

- Based on a demonstration to be submitted to IEPA for approval pursuant to Section 845.750(c)(2), a two-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 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.
- Geocomposite drainage layer. This layer will limit the potential for the final protective layer to become saturated.
- 60-mil HDPE geomembrane.

This cover system is compliant with the Part 845 final cover requirements, as described in Section 4.7. After closure, the gypsum stored in the facility will be contained by the composite cover and liner systems to minimize potential of releases from the GMF Pond. This is supported by groundwater modeling, as presented in Appendix G to the Part 845 Construction Permit Application for the GMF Pond.

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 will be crowned with 4% slopes to direct surface water away from the facility. Beyond the final cover, channels will direct surface water away from the GMF Pond 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 Pond structural stability was completed as part of compliance with USEPA's CCR Rule (AECOM 2016). This assessment concluded that the GMF Pond meets stability factor of safety requirements and does not pose a significant risk of instability.

An 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 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 final cover slopes are sufficient to adequately shed water from the facility, but are flat enough to limit erosion of the final cover soils. Minor maintenance of the final cover (potentially including filling of low areas, reseeding, fertilizing, etc.) will likely be necessary for several years after completion of the final cover 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 significant pumping of free water, but the CIP method will require relocation of less than 25% of the gypsum present in the GMF Pond. This reduced material handling volume means that the CIP construction can be completed in approximately 24 to 30 months, compared with 36 to 48 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 112 million gallons of water will be pumped from the GMF Pond prior to final cover construction. After removal of the ponded water, the gypsum 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 gypsum within the GMF Pond. The planned gypsum removal and relocation will rely on a series of trenches to facilitate passive dewatering of the material. The trenches will shorten drainage routes to facilitate gravity dewatering of gypsum in the vicinity of each trench and will direct the water to sumps from which the water can be pumped. Active dewatering options could be considered to expedite the process. The trenches will likely be on the order of 5 feet deep at regular spacing and graded to allow water to drain to the south. Sumps in the trenches along the south end of the gypsum deposit will be used to collect water, which will be pumped from the GMF Pond. The trenches will remain open until the top layer of gypsum across the GMF Pond is sufficiently dewatered to enable removal and transport without producing free water when disturbed. This process will repeat until all gypsum has been removed from the GMF Pond south of the new berm and the gypsum material within the facility has been adequately stabilized for final cover construction.

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) unless the owner or operator demonstrates that another construction technique or material provides equivalent or superior performance to the requirements of this subsection (c) and is approved by the Agency. 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 60-mil HDPE geomembrane placed on a prepared subgrade of gypsum (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-GM13 “Test Methods, Test Properties and Testing Frequency for HDPE Smooth and Textured Geomembranes” and will be installed per GRI-GM19a “Seam Strength and Related Properties of Thermally Bonded Homogeneous Polyolefin Geomembranes/Barriers” to help ensure that the material itself and the seams between panels will withstand the expected normal and tensile stress conditions. Furthermore, a 60-mil HDPE 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 two-foot-thick protective soil cover layer will be installed for the final cover system, immediately overlaying the geocomposite drainage layer and covering the entire low-permeability layer (see the Drawings in Attachment 2). The protective cover soil will comprise locally available soils compacted to between 80% and 95% of the standard Proctor maximum dry density. The uppermost 6 inches of protective cover soil 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 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 final cover 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 Pond is not closing under Section 845.700. Nevertheless, closure of the GMF Pond is anticipated to comply with the requirements of Subsection 845.750(d). Following dewatering of the GMF Pond, gypsum currently located within the facility (which was generated at Duck Creek Power Plant) will be relocated to within the closure footprint. A berm will be constructed in an east–west orientation at the south end of the closure footprint. The upstream face of the berm will be lined with a liner system compliant with Section 845.400, which will tie into the existing composite liner system. Gypsum currently located south of this berm (approximately 85,000 cy) will be removed and relocated to within the closure footprint, above the elevation of existing gypsum and completely within the perimeter berms, to achieve final grades. The final cover system has been designed with 4% slopes.

4.10 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 Inc.

DRAFT

Mark Haddock
Principal

https://golderassociates.sharepoint.com/sites/141778/project files/6 deliverables/reports/13-r-closure_plan_gypsum_mgmt_facility_pond/13-r-a/21454861-13-r-a-closure_plan_gypsum_mgmt_facility_pond_05nov21.docx

5.0 REFERENCES

AECOM. (2016). CCR Rule Report: Initial Structural Stability Assessment for GMF Pond at Duck Creek Power Station. Available online: https://www.luminant.com/ccr.

ATTACHMENT 1

Closure Alternatives Analysis

Draft

Closure Alternatives Analysis Duck Creek Power Plant Gypsum Management Facility (GMF) and Bottom Ash Basin (BAB) Canton, Illinois

November 7, 2021

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Abbreviations

AACE	Association for the Advancement of Cost Engineering
BAB	Bottom Ash Basin
bgs	Below Ground Surface
BMP	Best Management Practice
CAA	Closure Alternatives Analysis
CBR	Closure-by-Removal
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
CO	Carbon Monoxide
CO_2	Carbon Dioxide
EJ	Environmental Justice
FEMA	Federal Emergency Management Agency
GHG	Greenhouse Gas
GMF	Gypsum Management Facility
GWPS	Groundwater Protection Standard
HDPE	High-Density Polyethylene
IAC	Illinois Administrative Code
IDNR	Illinois Department of Natural Resources
IEPA	Illinois Environmental Protection Agency
IPRG	Illinois Power Resources Generating, LLC
N_2O	Nitrous Oxide
NID	National Inventory of Dams
NO_x	Nitrogen Oxides
NPDES	National Pollutant Discharge Elimination System
PM	Particulate Matter
SFWA	State Fish and Wildlife Area
SWPPP	Stormwater Pollution Prevention Plan
TVA	Tennessee Valley Authority
US BLS	United States Bureau of Labor Statistics
US DOT	United States Department of Transportation
US EPA	United States Environmental Protection Agency
US FWS	United States Fish & Wildlife Service
USGS	United States Geological Survey
VOC	Volatile Organic Compound

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) and the Bottom Ash Basin (BAB) located on the Illinois Power Resources Generating, LLC (IPRG) Duck Creek Power Plant property near Canton, Illinois. The GMF contains synthetic gypsum generated historically by the plant's flue gas desulfurization system. No significant volume of CCR remains in the BAB. CCR that was historically contained within the BAB has already been excavated from the impoundment.

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, Gradient evaluated three closure scenarios: Closure-in-Place (CIP), Closure-by-Removal with On-Site Disposal (CBR-Onsite), and Closure-by-Removal with Off-Site Disposal (CBR-Offsite). For the BAB, Gradient evaluated two closure scenarios: CBR-Onsite and CBR-Offsite. CIP was not evaluated for the BAB because there is no significant CCR remaining in the unit. The CIP scenario for the GMF entails consolidating all of the gypsum in the northern portion of the impoundment, then capping the impoundment with a new cover system. The CBR-Onsite scenario entails excavating the CCR and liner system materials from the GMF and/or the BAB and transporting these materials to an on-Site landfill for disposal. The CBR-Offsite scenario entails excavating the CCR and liner system materials from the GMF and/or the BAB and transporting these materials to an off-Site landfill.

Table S.1 summarizes the expected impacts of the CIP, CBR-Onsite, and CBR-Offsite closure scenarios at the GMF with regard to each of the factors specified under IAC Section 845.710 (IEPA, 2021a). Table S.2 summarizes the expected impacts of the CBR-Onsite and CBR-Offsite closure scenarios at the BAB 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 has been identified as the most appropriate closure scenario for the GMF. Key benefits of CIP at the GMF include the more rapid re-development of the Site for use in utility-scale solar generation and reduced impacts on 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, and less traffic). Based on this evaluation and the additional details provided in Section 3 of this report, CBR-Onsite has been identified as the most appropriate closure scenario for the BAB. Key benefits of CBR-Onsite at the BAB closure scenario are that no off-Site hauling of CCR is required and, consequently, reduced impacts to the community compared to CBR-Offsite. 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 December 2021 pursuant to requirements under IAC Section 845.710(e) (IEPA, 2021a). Following the public meeting, final closure decisions 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 recommendations 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 for the GMF

Evaluation Factor (Report Section; Part 845 Section)	Closure Scenario		
	CIP	**CBR-Onsite**	**CBR-Offsite**
Closure Alternative Descriptions (Section 2.1; IAC Section 845.710(c))	The CIP scenario would entail consolidating all of the gypsum in the GMF in the northern portion of the impoundment, then capping the impoundment with a new cover system consisting of, from bottom to top, a geomembrane layer, a geocomposite drain layer, and 24 inches of protective cover soil capable of supporting vegetative growth.	For CBR-Onsite, CCR and existing liner system materials would be excavated from the GMF and sent *via* truck to the on-Site landfill for disposal. The gypsum, the primary composite liner system, the leachate collection and removal system, the geosynthetic components of the secondary composite liner system, and the underlying 3-foot compacted clay liner would be hauled to the on-Site landfill for disposal. The on-Site landfill does not have sufficient capacity for these materials and would require expansion. This scenario meets the requirements of IAC Section 845.710(c)(2) (IEPA, 2021a) which requires an assessment in the CAA whether the Site has an on-Site landfill with available capacity or whether an on-Site landfill can be constructed.	For CBR-Offsite, CCR and existing liner system materials would be excavated from the GMF and sent *via* truck to an off-Site landfill for disposal. The gypsum, the primary composite liner system, the leachate collection and removal system, the geosynthetic components of the secondary composite liner system and the underlying 3-foot compacted clay liner would be hauled to the 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.
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 at the GMF for at least 30 years post-closure, or until GWPSs have been achieved, whichever is longer. The post-closure care plan under the CIP scenario additionally includes periodic inspections and mowing and maintenance of the final cover system for the GMF.	Monitoring would be performed at the GMF for at least 3 years post-closure, or until GWPSs have been achieved, whichever is longer.	Monitoring would be performed at the GMF for at least 3 years post-closure, or until GWPSs have been achieved, whichever is longer.
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 risks to any human or ecological receptors associated with the GMF. Because groundwater concentrations are expected to remain stable and/or decline under all closure scenarios, no risks to human or ecological receptors are expected post-closure.	There are no current risks to any human or ecological receptors associated with the GMF. Because groundwater concentrations are expected to remain stable and/or decline under all closure scenarios, no risks to human or ecological receptors are expected post-closure.	There are no current risks to any human or ecological receptors associated with the GMF. Because groundwater concentrations are expected to remain stable and/or decline under all closure scenarios, no risks to human or ecological receptors are expected post-closure.

Evaluation Factor (Report Section; Part 845 Section)	Closure Scenario		
	CIP	**CBR-Onsite**	**CBR-Offsite**
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 (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 (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.	During closure, there would be minimal risk of dike failure occurring (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.

Evaluation Factor (Report Section; Part 845 Section)	Closure Scenario		
	CIP	**CBR-Onsite**	**CBR-Offsite**
Worker Risks (Section 2.2.4.1; IAC Sections 845.710(b)(1)(D) and 845.710(b)(1)(F))	An estimated 0.14 injuries and 0.00093 fatalities would be expected to occur to workers due to major on-Site construction activities under this scenario. Overall, risks to workers would likely be highest under the CBR-Offsite scenario and lowest under the CIP scenario. Simultaneous with closure activities, the Site will be re-developed for use in utility-scale solar generation. The simultaneous pursuit of two large construction projects may lead to significant traffic congestion on Site access roads, resulting in greater overall risks to workers than would result from either project alone. The CIP scenario is expected to result in less traffic congestion – and, hence, a smaller increase in risks to workers – than the two CBR scenarios.	An estimated 0.31 injuries and 0.0020 fatalities would be expected to occur to workers due to major on-Site construction activities under this scenario. Overall, risks to workers would likely be highest under the CBR-Offsite scenario and lowest under the CIP scenario. Simultaneous with closure activities, the Site will be re-developed for use in utility-scale solar generation. The simultaneous pursuit of two large construction projects may lead to significant traffic congestion on Site access roads, resulting in greater overall risks to workers than would result from either project alone. The two CBR scenarios are expected to result in more traffic congestion – and, hence, a greater increase in risks to workers – than the CIP scenario.	An estimated 0.42 injuries and 0.0028 fatalities would be expected to occur to workers due to major on-Site construction activities under this scenario. An additional estimated 0.42 injuries and 0.0096 fatalities would be expected to occur to workers due to off-Site hauling under this scenario. In total, a minimum of 0.85 worker fatalities and 0.012 worker injuries would be expected under this scenario. Overall, risks to workers would likely be highest under the CBR-Offsite scenario and lowest under the CIP scenario. Simultaneous with closure activities, the Site will be re-developed for use in utility-scale solar generation. The simultaneous pursuit of two large construction projects may lead to significant traffic congestion on Site access roads, resulting in greater overall risks to workers than would result from either project alone. The two CBR scenarios are expected to result in more traffic congestion – and, hence, a greater increase in risks to workers – than the CIP scenario.

Evaluation Factor (Report Section; Part 845 Section)	Closure Scenario		
	CIP	**CBR-Onsite**	**CBR-Offsite**
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 Environmental Justice (EJ) Communities*	Off-Site impacts on nearby residents under this scenario (including accidents, traffic, noise, and air pollution) will be small relative to off-Site impacts under the CBR-Offsite scenario, because no off-Site hauling is required under this scenario. The on-Site landfill, the borrow site, and a portion of the GMF are all located within the one-mile buffer zone of the nearest EJ community (near Canton). All possible closure scenarios are therefore associated with potential negative impacts on this EJ community.	Off-Site impacts on nearby residents under this scenario (including accidents, traffic, noise, and air pollution) will be small relative to off-Site impacts under the CBR-Offsite scenario, because no off-Site hauling is required under this scenario. The on-Site landfill, the borrow site, and a portion of the GMF are all located within the one-mile buffer zone of the nearest EJ community (near Canton). All possible closure scenarios are therefore associated with potential negative impacts on this EJ community.	Off-Site impacts on nearby residents under this scenario (including accidents, traffic, noise, and air pollution) will be large relative to off-Site impacts under the CIP and CBR-Onsite scenarios, because off-Site hauling is required under this scenario. In total, an estimated 1.2 injuries and 0.044 fatalities are expected to occur among community members due to off-Site hauling under this scenario. Additionally, a haul truck is likely to pass a location near the Site every 7.2 minutes on average during working hours for the duration of excavation activities, resulting in substantial traffic demands for an extended period of time. The on-Site landfill, the borrow site, and a portion of the GMF are all located within the one-mile buffer zone of the nearest EJ community (near Canton). This EJ community is also located along the primary haul routes from the Site to the off-Site landfill. All possible closure scenarios are therefore associated with potential negative impacts on this EJ community.
Impacts on Scenic, Historical, and Recreational Value	There are no notable scenic, historical, or recreational areas located in the immediate vicinity of the GMF, the borrow soil location, or the on-Site landfill. Construction activities at the Site are therefore not expected to have direct negative impacts on any scenic, historical, or recreational areas under any closure scenario.	There are no notable scenic, historical, or recreational areas located in the immediate vicinity of the GMF, the borrow soil location, or the on-Site landfill. Construction activities at the Site are therefore not expected to have direct negative impacts on any scenic, historical, or recreational areas under any closure scenario.	There are no notable scenic, historical, or recreational areas located in the immediate vicinity of the GMF, the borrow soil location, or the on-Site landfill. Construction activities at the Site are therefore not expected to have direct negative impacts on any scenic, historical, or recreational areas under any closure scenario.

Evaluation Factor (Report Section; Part 845 Section)	Closure Scenario		
	CIP	CBR-Onsite	CBR-Offsite
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 two CBR scenarios, because the CIP scenario would have the shortest duration of construction activities and require the least amount of CCR dewatering and handling. The CIP scenario would have an additional, unquantified carbon footprint due to the need to manufacture geomembranes for the new GMF berm and the final GMF cover system. At the grid scale, construction of a solar facility at the Site will put energy back on the grid and reduce reliance on non-renewable energy sources. Re-development 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 two CBR closure scenarios than under the CIP scenario, because the two CBR scenarios would have longer durations of construction activities and require a greater amount of CCR dewatering and handling. Because expansion of the on-Site landfill would be necessary in order to accept all of the CCR and liner materials from the GMF, the CBR-Onsite scenario would also 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 will put energy back on the grid and reduce reliance on non-renewable energy sources. Re-development of the Site for solar would occur more slowly under the two CBR scenarios than under the CIP scenario.	Total energy demands and GHG emissions would be greater under the two CBR closure scenarios than under the CIP scenario, because the two CBR scenarios would have longer durations of construction activities and require a greater amount of CCR dewatering and handling. If expansion of the off-Site landfill became necessary in order to accept all of the CCR and liner materials from the GMF, then the CBR-Offsite scenario would also 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 will put energy back on the grid and reduce reliance on non-renewable energy sources. Re-development of the Site for solar would occur more slowly under the two CBR scenarios than under the CIP scenario.
Impacts on Natural Resources and Habitat	Construction may have a negative short-term impact on terrestrial species in the vicinity of the GMF and the on-Site borrow soil location. The duration of time over which impacts will occur (*i.e.*, the duration of construction activities) is longest under the two CBR scenarios (24-48 months) and shortest under the CIP scenario (12-24 months).	Construction may have a negative short-term impact on terrestrial species in the vicinity of the GMF and the on-Site borrow soil location. The duration of time over which impacts will occur (*i.e.*, the duration of construction activities) is longest under the two CBR scenarios (24-48 months) and shortest under the CIP scenario (12-24 months).	Construction may have a negative short-term impact on terrestrial species in the vicinity of the GMF and the on-Site borrow soil location. The duration of time over which impacts will occur (*i.e.*, the duration of construction activities) is longest under the two CBR scenarios (24-48 months) and shortest under the CIP scenario (12-24 months).

Evaluation Factor (Report Section; Part 845 Section)	Closure Scenario		
	CIP	CBR-Onsite	CBR-Offsite
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))	Based on statistical analysis and evaluation of potential exceedances, it has been determined that there are no potential groundwater exceedances of applicable groundwater standards attributable to the GMF.	Based on statistical analysis and evaluation of potential exceedances, it has been determined that there are no potential groundwater exceedances of applicable groundwater standards attributable to the GMF.	Based on statistical analysis and evaluation of potential exceedances, it has been determined that there are no potential groundwater exceedances of applicable groundwater standards attributable to the GMF.
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-Onsite 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.
Potential Need for Future Corrective Action (Section 2.2.8; IAC Section 845.710(b)(1)(H))	Corrective action is not expected to be required at this Site.	Corrective action is not expected to be required at this Site.	Corrective action is not expected to be required at this Site.
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. 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. 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. 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; Part 845 Section)	Closure Scenario		
	CIP	**CBR-Onsite**	**CBR-Offsite**
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 closing impoundments. However, dewatering and relocating saturated gypsum as part of closure activities at the GMF may be moderately challenging. Careful planning would be required to work safely on the wet gypsum within the GMF.	Relative to CIP, CBR-Onsite and CBR-Offsite pose additional implementation difficulties due to higher earthwork volumes, higher dewatering volumes, and longer construction schedules, and the need to remove and dispose of the existing bottom liner geomembrane. The construction schedule for excavation may be negatively impacted under the CBR-Onsite scenario, because the on-Site landfill will need to be expanded in order to receive all of the materials excavated from the GMF.	Relative to CIP, CBR-Onsite and CBR-Offsite pose additional implementation difficulties due to higher earthwork volumes, higher dewatering volumes, and 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 CBR-Onsite scenario, due to the need to use public roadways for hauling. Because the CCR would be hauled on public roads (*i.e.*, intrastate travel), it would also need to be dewatered to a greater extent than would be necessary under the CBR-Onsite 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 construction schedule for excavation may be negatively impacted under the CBR-Offsite scenario 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.
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.

Evaluation Factor (Report Section; Part 845 Section)	Closure Scenario		
	CIP	**CBR-Onsite**	**CBR-Offsite**
Need for Permits and Approvals	Regulatory approval will be needed under all closure scenarios. A stormwater pollution prevention plan (SWPPP) will also be required for all closure scenarios and a land disturbance permit may be required.	Regulatory approval will be needed under all closure scenarios. A stormwater pollution prevention plan (SWPPP) will also be required for all closure scenarios and a land disturbance permit may be required. The existing on-Site landfill would need to be expanded under the CBR-Onsite scenario in order to accommodate all of the material excavated from the GMF. The on-Site landfill has already been permitted for an additional 2-acre waste disposal footprint.	Regulatory approval will be needed under all closure scenarios. A stormwater pollution prevention plan (SWPPP) will also be required for all closure scenarios and a land disturbance permit may be required. Relative to the CIP and CBR-Onsite scenarios, additional permits and approvals may be required under the CBR-Offsite scenario for transport of the CCR and if the landfill must be expanded to receive all of the CCR and liner materials from the GMF.
Availability of Equipment and Specialists	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 or delays in the construction schedule under all scenarios, if supply chain resilience does not improve by the time of construction. A national shortage of truck drivers has also developed during the COVID-19 pandemic. Due to higher earthwork volumes and a longer construction schedule under the two CBR scenarios than under the CIP scenario, shortages in construction equipment 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 volume of CCR and liner materials to be hauled from the Site.	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 or delays in the construction schedule under all scenarios, if supply chain resilience does not improve by the time of construction. A national shortage of truck drivers has also developed during the COVID-19 pandemic. Due to higher earthwork volumes and a longer construction schedule under the two CBR scenarios than under the CIP scenario, shortages in construction equipment 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 volume of CCR and liner materials to be hauled from the Site.	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 or delays in the construction schedule under all scenarios, if supply chain resilience does not improve by the time of construction. A national shortage of truck drivers has also developed during the COVID-19 pandemic. Due to higher earthwork volumes and a longer construction schedule under the two CBR scenarios than under the CIP scenario, shortages in construction equipment 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 volume of CCR and liner materials to be hauled from the Site.

Evaluation Factor (Report Section; Part 845 Section)	Closure Scenario		
	CIP	**CBR-Onsite**	**CBR-Offsite**
Available Capacity and Location of Treatment, Storage, and Disposal Services	Under the CIP scenario, the gypsum currently within the GMF will be consolidated and stored within the existing footprint of the impoundment. The GMF will be unwatered at the start of construction *via* pumping. Pumped water will be managed in accordance with the facility's NPDES permit.	The on-Site landfill does not have sufficient capacity to receive all of the CCR and liner materials that are currently slated for landfilling under the CBR-Onsite scenario. Expansion of the on-Site landfill would thus be necessary The on-Site landfill is already permitted for a potential expansion, which would create an additional 2 acres of waste disposal area. The landfill expansion could be completed in a single construction season during the removal of ponded water at the GMF.	The Peoria City-County Landfill in Brimfield, Illinois has sufficient capacity to receive all of the CCR and liner materials from the GMF. However, due to the limited space remaining in this landfill and 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 will be received and the unique CCR waste characteristics. If expansion of the Peoria City-County Landfill is impractical or infeasible, then an alternative landfill located farther from the Site would need to be identified.
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 anticipated.	No current or future exceedances of any screening benchmarks for surface water would be anticipated.	No current or future exceedances of any screening benchmarks for surface water would be anticipated.
Potential Modes of Transportation Associated with CBR (Section 2.1; IAC Section 845.710(c)(1))	This factor is not relevant for CIP.	This factor is not relevant for CBR-Onsite.	Loadout facilities do not exist on-Site that would facilitate off-Site rail or barge CCR transport. Rail lines or waterbodies connecting to a potential off-site disposal location also do not exist. Thus, transport *via* rail or barge was considered infeasible. Thus, only transport *via* on-road haul trucks was assumed for CBR-Offsite. The local availability and use of natural gas-powered trucks, or other low-polluting trucks, will be evaluated prior to the start of construction.

Evaluation Factor (Report Section; Part 845 Section)	Closure Scenario		
	CIP	**CBR-Onsite**	**CBR-Offsite**
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 will effectively address residents' concerns regarding potential impacts to groundwater and surface water quality associated with the GMF. Relative to CBR-Offsite, CIP also presents fewer risks to workers and community members during construction in the form of accidents, traffic, and air pollution. Moreover, under the CIP scenario, the Site could be more rapidly re-developed for use in utility-scale solar generation.	Nonprofits representing community interests near the Site have expressed a preference for CBR over CIP. However, CBR has several disadvantages with regard to potential community concerns. Relative to CIP, the two CBR scenarios present greater risks to workers and community members during construction in the form of accidents, traffic, and air pollution. Moreover, under the two CBR scenarios, the Site could take longer to re-develop for use in utility-scale solar generation.	Nonprofits representing community interests near the Site have expressed a preference for CBR over CIP. However, CBR has several disadvantages with regard to potential community concerns. Relative to CIP, the two CBR scenarios presents greater risks to workers and community members during construction in the form of accidents, traffic, and air pollution. Moreover, under the two CBR scenarios, the Site could take longer to re-develop for use in utility-scale solar generation.
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 Disposal; CBR-Onsite = Closure-by-Removal with On-Site Disposal; CCR = Coal Combustion Residual; CIP = Closure-in-Place; EJ = Environmental Justice; GHG = Greenhouse Gas; GMF = Gypsum Management Facility; IAC = Illinois Administrative Code; NPDES = National Pollutant Discharge Elimination System.

Table S.2 Comparison of Proposed Closure Scenarios for the BAB

Evaluation Factor (Report Section; Part 845 Section)	Closure Scenario	
	CBR-Onsite	**CBR-Offsite**
Closure Alternative Descriptions (Section 3.1; IAC Section 845.710(c))	For CBR-Onsite, the concrete, compacted clay, geomembrane components of the existing liner system, and any remaining CCR will be excavated from the BAB and sent *via* truck to the on-Site landfill for disposal. This scenario meets the requirements of IAC Section 845.710(c)(2) (IEPA, 2021a) which requires an assessment in the CAA as to whether the Site has an on-Site landfill with available capacity or whether an on-Site landfill can be constructed.	For CBR-Offsite, the concrete, compacted clay, and geomembrane components of the existing liner system, and any remaining CCR will be excavated from the BAB and sent *via* truck to an off-Site landfill for disposal.
Type and Degree of Long-Term Management, Including Monitoring, Operation, and Maintenance (Section 3.2.3; IAC Section 845.710(b)(1)(C))	Monitoring would be performed at the BAB for at least 3 years post-closure, or until GWPSs have been achieved.	Monitoring would be performed at the BAB for at least 3 years post-closure, or until GWPSs have been achieved.
Magnitude of Reduction of Existing Risks (Section 3.2.1; IAC Sections 845.710(b)(1)(A) and 845.710(b)(1)(F))	There are no current risks to any human or ecological receptors associated with the BAB. Because groundwater concentrations are expected to remain stable and/or decline under all closure scenarios, no risks to human or ecological receptors are expected post-closure.	There are no current risks to any human or ecological receptors associated with the BAB. Because groundwater concentrations are expected to remain stable and/or decline under all closure scenarios, no risks to human or ecological receptors are expected post-closure.
Likelihood of Future Releases of CCR (Section 3.2.2; IAC Sections 845.710(b)(1)(B) and 845.710(b)(1)(F))	There is no current or future risk of CCR releases occurring at the BAB under either closure scenario. No significant volume of CCR currently remains in the BAB.	There is no current or future risk of CCR releases occurring at the BAB under either closure scenario. No significant volume of CCR currently remains in the BAB.
Worker Risks (Section 3.2.4.1; IAC Sections 845.710(b)(1)(D) and 845.710(b)(1)(F))	An estimated 0.056 injuries and 0.00036 fatalities would be expected to occur to workers due to major on-Site construction activities under this scenario. Overall, risks to workers would likely be of similar magnitude for both closure scenarios.	An estimated 0.050 injuries and 0.00033 fatalities would be expected to occur to workers due to major on-Site construction activities under this scenario. An additional estimated 0.0041 injuries and 0.000093 fatalities would be expected to occur to workers due to off-Site hauling. In total, a minimum of 0.054 worker fatalities and 0.00042 worker injuries would be expected under this scenario. Overall, risks to workers would likely be of similar magnitude for both closure scenarios.

Evaluation Factor (Report Section; Part 845 Section)	Closure Scenario	
	CBR-Onsite	**CBR-Offsite**
Community Risks (Section 3.2.4.2; IAC Sections 845.710(b)(1)(D) and 845.710(b)(1)(F)) *Off-Site Impacts on Nearby Residents and Environmental Justice (EJ) Communities*	Off-Site impacts on nearby residents under this scenario (including accidents, traffic, noise, and air pollution) will be smaller than off-Site impacts under the CBR-Offsite scenario, because no off-Site hauling is required under this scenario. The on-Site landfill and the borrow site are both located within the one-mile buffer zone of the nearest EJ community (near Canton). Both closure scenarios are therefore associated with potential negative impacts on this EJ community.	Off-Site impacts on nearby residents under this scenario (including accidents, traffic, noise, and air pollution) will be larger than off-Site impacts under the CBR-Onsite scenario, because off-Site hauling is required under this scenario. In total, an estimated 0.012 injuries and 0.00043 fatalities are expected to occur among community members due to off-Site hauling under this scenario. A haul truck is likely to pass a location near the Site every 49 minutes on average during working hours for the duration of excavation activities under this scenario. The on-Site landfill and the borrow site are both located within the one-mile buffer zone of the nearest EJ community (near Canton). This EJ community is also located along the primary haul routes from the Site to the off-Site landfill. Both closure scenarios are therefore associated with potential negative impacts on this EJ community.
Impacts on Scenic, Historical, and Recreational Value	There are no notable scenic, historical, or recreational areas located in the immediate vicinity of the BAB, the borrow soil location, or the on-Site landfill. Construction activities at the Site are therefore not expected to have direct negative impacts on any scenic, historical, or recreational areas under either closure scenario.	There are no notable scenic, historical, or recreational areas located in the immediate vicinity of the BAB, the borrow soil location, or the on-Site landfill. Construction activities at the Site are therefore not expected to have direct negative impacts on any scenic, historical, or recreational areas under either closure scenario.
Environmental Risks (Section 3.2.4.3; 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 likely be similar under the CBR-Onsite and CBR-Offsite scenarios, because both scenarios would have the same expected duration of construction activities and required earthwork volumes.	Total energy demands and GHG emissions would likely be similar under the CBR-Onsite and CBR-Offsite scenarios, because both scenarios would have the same expected duration of construction activities and required earthwork volumes.
Impacts on Natural Resources and Habitat	Construction may have a negative short-term impact on terrestrial species in the vicinity of the BAB and the on-Site borrow soil location. Both BAB closure scenarios are expected to have similar impacts on natural resources and habitat.	Construction may have a negative short-term impact on terrestrial species in the vicinity of the BAB and the on-Site borrow soil location. Both BAB closure scenarios are expected to have similar impacts on natural resources and habitat.

Evaluation Factor (Report Section; Part 845 Section)	Closure Scenario	
	CBR-Onsite	**CBR-Offsite**
Time Until Groundwater Protection Standards Are Achieved (Section 3.2.5; IAC Sections 845.710(b)(1)(E) and 845.710(d)(2 and 3))	There are no exceedances of potentially applicable groundwater standards attributable to the BAB.	There are no exceedances of potentially applicable groundwater standards attributable to the BAB.
Long-Term Reliability of the Engineering and Institutional Controls (Section 3.2.7; IAC Section 845.710(b)(1)(G))	CBR-Onsite 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.
Potential Need for Future Corrective Action (Section 3.2.8; IAC Section 845.710(b)(1)(H))	Corrective action is not expected to be required at this Site.	Corrective action is not expected to be required at this Site.
Effectiveness of the Alternative in Controlling Future Releases (Section 3.3; 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 BAB. There is no current or future risk of sudden CCR releases occurring at the BAB under either closure scenario.. There is no significant volume of CCR remaining in the BAB.	There are no current or future risks to any human or ecological receptors associated with the BAB. There is no current or future risk of sudden CCR releases occurring at the BAB under either closure scenario. There is no significant volume of CCR remaining in the BAB.
Ease or Difficulty of Implementing the Alternative (Section 3.4; IAC Section 845.710(b)(3))		
Degree of Difficulty Associated with Construction	Hauling would be easier to implement under the CBR-Onsite scenario than under the CBR-Offsite scenario, since it would not require the use of public roadways.	Hauling would be more difficult to implement under the CBR-Offsite scenario than under the CBR-Onsite scenario, since it would require the use of public roadways.
Expected Operational Reliability	Operational reliability would be expected under both closure scenarios.	Operational reliability would be expected under both closure scenarios.

Evaluation Factor (Report Section; Part 845 Section)	**Closure Scenario**	
	CBR-Onsite	**CBR-Offsite**
Need for Permits and Approvals	Regulatory approval will be needed under all closure scenarios. A stormwater pollution prevention plan (SWPPP) will also be required for all closure scenarios and a land disturbance permit may be required.	Regulatory approval will be needed under all closure scenarios. A stormwater pollution prevention plan (SWPPP) will also be required for all closure scenarios and a land disturbance permit may be required. Relative to the CBR-Onsite scenario, an additional permit and approval may be required under the CBR-Offsite scenario for waste transport.
Availability of Equipment and Specialists	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 or delays in the construction schedule under both closure scenarios, if supply chain resilience does not improve by the time of construction. A national shortage of truck drivers has also developed during the COVID-19 pandemic. The current shortage of truck drivers may be particularly impactful under the CBR-Offsite scenario, due to the materials that will be hauled from the Site.	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 or delays in the construction schedule under both closure scenarios, if supply chain resilience does not improve by the time of construction. A national shortage of truck drivers has also developed during the COVID-19 pandemic. The current shortage of truck drivers may be particularly impactful under the CBR-Offsite scenario, due to the materials that will be hauled from the Site.
Available Capacity and Location of Treatment, Storage, and Disposal Services	The on-Site landfill has sufficient capacity to receive all of the materials that would be excavated from the BAB.	The Peoria City-County Landfill in Brimfield, Illinois has sufficient capacity to receive all of the materials that would be excavated from the BAB.
Impact of Alternative on Waters of the State (Section 3.5; IAC Section 845.710(d)(4))	No current or future exceedances of any screening benchmarks for surface water would be anticipated.	No current or future exceedances of any screening benchmarks for surface water would be anticipated.
Potential Modes of Transportation Associated with CBR (Section 3.1; IAC Section 845.710(c)(1)	This factor is not relevant for CBR-Onsite.	Loadout facilities do not exist on-Site that would facilitate off-Site rail or barge CCR transport. Rail lines or waterbodies connecting to a potential off-site disposal location also do not exist. Thus, transport *via* rail or barge was considered infeasible. Thus, only transport *via* on-road haul trucks was assumed for CBR-Offsite. The local availability and use of natural gas-powered trucks, or other low-polluting trucks, will be evaluated prior to the start of construction.

Evaluation Factor (Report Section; Part 845 Section)	Closure Scenario	
	CBR-Onsite	**CBR-Offsite**
Concerns of Residents Associated with Alternatives (Section 3.6; IAC Section 845.710(b)(4))	Nonprofits representing community interests near the Site have expressed a preference for CBR over CIP. Both closure scenarios are equally responsive to this concern. Nearly all of the CCR that was historically contained within the BAB has already been excavated from the impoundment.	Nonprofits representing community interests near the Site have expressed a preference for CBR over CIP. Both closure scenarios are equally responsive to this concern. Nearly all of the CCR that was historically contained within the BAB has already been excavated from the impoundment.
Class 4 Cost Estimate (Section 3.7; 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.

Notes:

AACE = Association for the Advancement of Cost Engineering; BAB = Bottom Ash Basin; CBR-Offsite = Closure-by-Removal with Off-Site Disposal; CBR-Onsite = Closure-by-Removal with On-Site Disposal; CCR = Coal Combustion Residual; CIP = Closure-in-Place; CY = Cubic Yard; EJ = Environmental Justice; GHG = Greenhouse Gas; IAC = Illinois Administrative Code; NPDES = National Pollutant Discharge Elimination System.

1 Introduction

1.1 Site Description and History

1.1.1 Site Location and History

The Illinois Power Resources Generating, LLC (IPRG) Duck Creek Power Plant is an electric-power-generating facility with coal-fired units located approximately 9 miles southeast of the City of Canton in Fulton County, Illinois (AECOM, 2016a; Ramboll, 2021a). Beginning in the 1930s, strip mining took place within the boundaries of the Site. Mining operations on the property have since ceased (AECOM, 2016a; Ramboll, 2021b). The Duck Creek Power Plant began operating in 1976 and was retired in December 2019 (AECOM, 2016a; Appendix B).

1.1.2 CCR Impoundments

The Duck Creek Power Plant produced and stored coal combustion residuals (CCRs) as a part of its historical operations. The subjects of this report are the Gypsum Management Facility (GMF; Vistra CCR Unit ID No. 203; Illinois Environmental Protection Agency [IEPA] ID No. W0578010001-04; National Inventory of Dams [NID] No. IL50573) and the Bottom Ash Basin (BAB; Vistra CCR Unit ID No. 205; IEPA ID No. W0578010001-03; NID No. 50716) (Figure 1.1).

The GMF is a 31-acre lined surface impoundment constructed between 2007 and 2009 that operated from 2009 until the plant was retired in 2019. This facility was historically used to store gypsum and to clarify gypsum transport water for reuse (Appendix B; Golder, 2021a). The GMF has a dual-composite liner system with a leak detection layer (Appendix B). The GMF Recycle Pond, which is located immediately south of the GMF, historically received decanted water from the GMF and leachate from the on-Site landfill (described below). The GMF Recycle Pond never received CCR. A set of pumps on the western side of the GMF Recycle Pond were used to transport decanted water back to the flue gas desulfurization system for re-use (Appendix B). The GMF Recycle Pond has a liner system consisting of a 60-mil high-density polyethylene (HDPE) geomembrane, a reinforced bentonite mat, and a 36-inch layer of compacted clay (Natural Resource Technology, 2017). The GMF Recycle Pond has been closed, and the closure was approved by IEPA.

The BAB is a 2.2-acre lined surface impoundment constructed in late 2007 or early 2008 for the management of sluiced bottom ash. It operated from 2008 until the plant was retired in 2019 (Appendix B; Golder, 2021b). There are three cells within the BAB: Primary Pond 1, Primary Pond 2, and the Secondary Pond (Appendix B). Historically, ash was sluiced to either Primary Pond 1 or Primary Pond 2. The Secondary Pond received decanted water from the two primary ponds (Appendix B; Golder, 2021b). Decanted water from the Secondary Pond flowed to the Duck Creek Cooling Pond *via* a discharge channel to the south of the pond (Appendix B). During operation of the BAB, Primary Ponds 1 and 2 were cleaned out frequently *via* excavation, and excavated bottom ash was sent to the on-Site landfill for disposal (Appendix B; Golder, 2021b). Bottom ash was also removed from the BAB when the plant was retired in 2019, such that no significant bottom ash currently remains (Appendix B). The BAB is a lined impoundment. The components of the liner system include (from bottom to top): compacted native soils, a 60-mil HDPE geomembrane, a 1-foot compacted clay layer, and an 8-inch reinforced concrete layer (Appendix B).

Figure 1.1 Site Location Map. Adapted from Stantec (2017).

1.1.3 Surface Water Hydrology

Surface water bodies on the Site include the Duck Creek Cooling Pond, which is the cooling water impoundment for the plant, and various small ponds resulting from historical surface mining on the property, including Long Lake (AECOM, 2016a; Natural Resource Technology, 2017). Surface water in the vicinity of the GMF and the BAB drains into the Duck Creek Cooling Pond (Natural Resource Technology, 2017), which drains to the Illinois River *via* National Pollutant Discharge Elimination System (NPDES)-permitted outfalls (IEPA, 2013). Other surface water bodies in the vicinity of the Site include various backwater lakes of the Illinois River, including Buckheart Creek to the west and Rice Lake, Miserable Lake, Big Lake, and Goose Lake to the east (Ramboll, 2021b,c).

1.1.4 Hydrogeology

1.1.4.1 GMF

Three major hydrostratigraphic units have been identified near the GMF: (a) the uppermost aquifer, (b) the lower Radnor till/lower confining unit, and (c) the bedrock confining unit. The first of these layers, the uppermost aquifer, is composed of three units: (i) the Peoria/Roxanna loess, (ii) the upper Radnor till, and (iii) the shallow sand unit (Ramboll, 2021c). The Peoria/Roxanna loess zone is composed of silt, clayey silt, and minor amounts of sand. The upper Radnor till is composed of clayey silt with minor amounts of sand and gravel. The shallow sand unit is composed of medium-grained sand and silt with interbedded till seams. The shallow sand unit, which varies from less than 1- to 18-feet thick in the vicinity of the GMF, is the primary conduit for horizontal migration of shallow groundwater near the impoundment (Ramboll, 2021c). The Peoria/Roxanna loess has also been identified as a potential migration pathway (Ramboll, 2021c). The lower Radnor till layer has high silt content with varying amounts of clay, sand, and gravel. The bedrock confining unit is composed primarily of low-permeability, shaley siltstone and silty shale. The Hydrogeological Site Characterization Report prepared by Ramboll for the GMF (Ramboll, 2021c) provides more details regarding the hydrostratigraphic units in the vicinity of the GMF.

Near the GMF, shallow groundwater flows southeast through the uppermost aquifer toward the Duck Creek Cooling Pond (Natural Resource Technology, 2017; Ramboll, 2021a,c). The preferential flow of groundwater is horizontal rather than vertical because the underlying till and shale bedrock layers restrict vertical groundwater flow (Natural Resource Technology, 2017). Groundwater within the uppermost aquifer near the GMF flows into the Duck Creek Cooling Pond. No other potential groundwater transport pathways exist. Because the Duck Creek Cooling Pond serves as a sink for groundwater discharge in the area, shallow groundwater migration beneath or beyond the Duck Creek Cooling Pond is unlikely (Ramboll, 2021c).

Groundwater monitoring is ongoing at the GMF. The Hydrogeologic Site Characterization Report prepared by Ramboll for the GMF includes a summary of the groundwater data collected from GMF monitoring wells between 2015 and 2021 (Ramboll, 2021c).

1.1.4.2 BAB

Two distinct hydrostratigraphic units have been identified near the BAB: the uppermost aquifer and a confining shale bedrock unit (Ramboll, 2021b). The first of these layers, the uppermost aquifer, consists of the Peoria/Roxanna loess, which is characterized by medium to very stiff silt with little clay and trace very fine- to fine-grained sand, and the Radnor till, which is characterized by silty clay with trace very fine- to coarse-grained sand and trace small gravel to hard clay with little silt, few very fine- to coarse-grained sand, and trace small gravel (Ramboll, 2021b). The most permeable portion of the uppermost aquifer is the shallow sand unit, a two- to seven-foot-thick sand zone located within the Radnor till. The shallow sand unit, which is encountered at a depth of 18-40 feet below ground surface (bgs), forms the primary conduit for horizontal migration of shallow groundwater near the BAB (Ramboll, 2021b). The Peoria/Roxanna loess has also been identified as a potential migration pathway. A confining unit composed of Pennsylvanian shaley siltstone and silty shale bedrock underlies the uppermost aquifer from approximately 26-46 feet bgs (top of bedrock; Ramboll, 2021b). The bedrock acts as an aquitard due to its low hydraulic conductivity (AECOM, 2016a; Ramboll, 2021b). The Hydrogeological Site Characterization Report prepared by Ramboll for the BAB (Ramboll, 2021b) provides more details regarding the hydrostratigraphic units in the vicinity of the BAB.

Near the BAB, shallow groundwater flows southwards through the uppermost aquifer toward an unnamed drainage channel, which leads to the Duck Creek Cooling Pond (Ramboll, 2021b). Groundwater flows horizontally rather than vertically through the uppermost aquifer because: (i) vertical hydraulic conductivities within the uppermost aquifer are several orders of magnitude lower than horizontal hydraulic conductivities, and (ii) the underlying shale bedrock acts as an aquitard (AECOM, 2016a; Ramboll, 2021b). Groundwater within the uppermost aquifer near the BAB flows into the Duck Creek Cooling Pond. No other potential groundwater transport pathways exist. Because the Duck Creek Cooling Pond serves as a sink for groundwater discharge in the area, shallow groundwater migration beneath or beyond the Duck Creek Cooling Pond is unlikely (Ramboll, 2021b).

Groundwater monitoring is ongoing at the BAB. The Hydrogeologic Site Characterization Report prepared by Ramboll for the BAB includes a summary of the groundwater data collected from BAB monitoring wells between 2015 and 2021 (Ramboll, 2021b).

1.1.5 Site Vicinity

The Duck Creek property is surrounded by agricultural fields, pastures, and forests (Ramboll, 2021b). There are several scenic, recreational, and historical areas within a few miles of the Site, including the Rice Lake State Fish and Wildlife Area (SFWA) to the east and the Orendorf and Rice Lake Terrace Archaeological Sites to the east/northeast. The Rice Lake SFWA, which spans approximately 5,660 acres, was established in 1945 and includes Big Lake, Slim Lake, Goose Lake, Pond Lily Lake, Lock Pond, and the Copperas Creek Management Unit. Popular activities at the Rice Lake SFWA include picnicking, fishing, camping, and hunting (IDNR, c. 2008). The Orendorf Archaeological Site, which was added to the National Register of Historic Places in 1977 (National Park Service, 2021), encompasses at least four distinct Middle Mississippian settlement areas with known trade and migration linkages to the Mississippian city of Cahokia, the largest archaeological site in North America (Archaeological Institute of America, 2021; Emerson, c. 2016). The Rice Lake Terrace Archaeological Site is located south of the Orendorf Archaeological Site on the shore of Rice Lake and includes evidence of Archaic (8000-500 BC), Woodland (500 BC-1000 AD) and Mississippian (1000-1673 AD) cultures (Archaeological Institute of America, 2021). In addition to the sites listed above, there are several high-value scenic and recreational areas within 10 miles downstream along the Illinois River, including the Spring Lake SFWA, the Sand Ridge State Forest, the Chautauqua National Wildlife Refuge, and the Emiquon Preserve.

1.2 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 pursuant to requirements under IAC Section 845.710. Section 3 of this report presents a CAA for the BAB 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 – GMF

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

This section of the report presents a CAA for the GMF pursuant to requirements under IAC Section 845.710 (IEPA, 2021a). Gradient evaluated three closure scenarios: Closure-in-Place (CIP), Closure-by-Removal with On-Site Disposal (CBR-Onsite), and Closure-by-Removal with Off-Site Disposal (CBR-Offsite). Sections 2.1.1 through 2.1.3 describe the CIP, CBR-Onsite, and CBR-Offsite closure scenarios. These scenarios are based on information conveyed to Gradient by Golder (Appendix B; Golder, 2021c,d).

2.1.1 Closure-in-Place

Under the CIP scenario, the gypsum in the GMF will be consolidated in the northern portion of the impoundment and the impoundment will be capped with a new cover system. This scenario includes the following work elements for the closure of the GMF (Appendix B; Golder, 2021c):

- Removal of free water from the GMF *via* pumping. Pumped water will be managed in accordance with the NPDES permit for the facility.
- Dewatering of the upper gypsum layer within the northern portion of the GMF *via* trenches and sumps in order to support construction traffic across the surface.
- Construction of a new internal berm with an east-west orientation. The upstream slope of the berm will be lined with a new composite liner, which will tie into the existing primary composite liner system for the facility.
- Consolidation of all gypsum in an approximately 15-acre area north of the berm. All gypsum from the area south of the berm will be removed and placed north of the berm.
- Contouring and grading to promote stormwater management.
- Construction of a cover system north of the berm that will consist of a 60-mil HDPE geomembrane layer, a geocomposite drain layer, and 24 inches of protective soil cover suitable for supporting vegetative growth.
- Removal of the geosynthetic components of the dual-composite liner system south of the berm. Liner system materials will be disposed of in the northern portion of the capped GMF. Soil materials located between these components will be removed and stockpiled south of the GMF.
- Excavation of a surface water channel south of the GMF, including removal of sections of the GMF Recycle Pond perimeter dike, in order to promote passive stormwater drainage to the southeast of the impoundment.
- Long-term (post-closure) monitoring and maintenance, including:
  - Groundwater monitoring at the impoundment for a minimum of 30 years, or until groundwater protection standards (GWPSs) are achieved.

- Post-closure care for the final cover system, including cap inspections, mowing, and maintenance, for a minimum of 30 years.

Approximately 85,000 cubic yards of gypsum will be relocated from south of the berm to north of the berm under this scenario (an assumed travel distance of 0.2 miles; Appendix B). Hauling will also be required to relocate 17 acres of geosynthetic liner materials north of the berm and 55,700 cubic yards of liner soils excavated from south of the berm to a stockpile located south of the closure footprint (an assumed travel distance of 0.2 miles).

Soil required for construction of the new berm and the final GMF cover system will be sourced from a location on the property; a borrow location will not need to be established off-Site. The selected borrow soil location is approximately 0.4 miles north of the GMF (Appendix B). The estimated volume of borrow soil required for GMF closure *via* CIP is 73,800 cubic yards (Appendix B). Additionally, approximately 81,000 cubic yards of soil will be excavated during construction of the stormwater channel south of the GMF during Site restoration. This material will be hauled to the borrow soil location for stockpiling (Appendix B).

Under the CIP scenario, the expected duration of major construction activities at the GMF is 12-24 months (Appendix B; Golder, 2021c). Key parameters for the CIP scenario are shown in Table 2.1.

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

Parameter	Value	Notes
Surface Area of Impoundment (acres)	31	
Surface Area of Final Cover System (acres)	15	Area north of the proposed berm.
In-Place Volume of CCR (CY)	400,000	CCR contained in the GMF is gypsum from flue gas desulfurization.
Volume of CCR to be Relocated (CY)	85,000	Amount of gypsum to be removed from the southern portion of the GMF and relocated north of the berm.
Travel Distance for Relocation of CCR (miles)	0.2	
Distance to the On-Site Landfill (miles)	1.2	
Required Volume of Borrow Soil (CY)	73,800	Required for berm construction and the final cover system.
Volume of Material Stockpiled On-Site (CY)	137,000	Excavated during construction of the stormwater channel and removal of existing liner system components south of the berm (Site restoration).
Distance to the Borrow Soil Location (miles)	0.4	
Duration of Construction Activities (months)	12-24	
Total On-Site Labor Hours for Major Construction[a]	12,400	
Required On-Site Hauling Truckloads (Loaded)	16,000	
Required Off-Site Hauling Truckloads (Loaded)	0	
Required On-Site Hauling Miles	9,780	
Required Off-Site Hauling Miles	0	

Notes:
CY = Cubic Yards; CCR = Coal Combustion Residual; GMF = Gypsum Management Facility.
Sources: Appendix B; Golder (2021c).
(a) Major construction is defined as any operation occurring on-Site that requires one or more of the following equipment types: breaker, compactor, dozer, excavator, haul truck, loader, and telehandler. Labor is not included if it is limited to the use of one or more of the following equipment types: diesel pump, flatbed truck, generator, miscellaneous, pickup truck, and seed drill or hydroseeder. Labor performed by haul truck operators is only included in calculations if the hauling occurs on-Site. Workers assigned to relevant activities are assumed to work full-time (40 hours per week) on that activity for the duration of the activity.

2.1.2 Closure-by-Removal with On-Site Disposal

Under the CBR-Onsite scenario, CCR and existing liner system materials will be excavated from the GMF and sent to the on-Site landfill for final disposal. Excavation at the GMF will include all of the gypsum in the impoundment and the existing dual-composite liner system. The gypsum excavated from the GMF is currently expected to be hauled to the on-Site landfill. The primary composite liner system, the leachate collection and removal system, the geosynthetic components of the secondary composite liner system, and the 3-foot compacted clay layer beneath the GMF will also be hauled to the on-Site landfill for disposal. This scenario includes the following work elements for the closure of the GMF (Appendix B; Golder, 2021c,d):

- Free water removal and dewatering of the GMF.
- Excavation and transport of CCR and liner system materials to the on-Site landfill, as detailed above. All areas affected by CCR releases will be decontaminated, including potential over-excavation below the bottom of the liner system.
- Grading and filling to convey runoff away from the impoundments. This process will include excavation of a surface water channel south of the GMF and removal of sections of the GMF

Recycle Pond perimeter dike in order to promote passive stormwater drainage to the southeast of the impoundment.

- Site restoration, including revegetation with native grasses.
- Monitoring at the impoundments for at least 3 years, or until GWPSs are achieved.

Approximately 31 acres of geosynthetic liner system materials, 283,000 cubic yards of earthen liner system materials, 50,000 cubic yards of subsoil overexcavation, and 400,000 cubic yards of gypsum will be excavated from the GMF and hauled to the on-Site landfill for disposal. The on-Site landfill is located approximately 1.2 miles north of the GMF (Appendix B). Excavated materials will be hauled to the landfill using off-road haul trucks with an assumed capacity of 21.5 cubic yards. The on-Site landfill currently has approximately 445,000 cubic yards of available capacity. Of this, approximately 7,000 cubic yards may be used for the disposal of materials associated with excavation of the BAB. Thus, the on-Site landfill does not have sufficient capacity to receive all of the CCR and liner materials from the GMF that are slated for disposal under the CBR-Onsite scenario. Expansion of the landfill would thus be necessary. The on-Site landfill is already permitted for a potential expansion, which could create an additional 2-acre landfill cell (Appendix B). This scenario meets the requirements of IAC Section 845.710(c)(2) (IEPA, 2021a), which requires an assessment in the CAA of whether the Site has an on-Site landfill with available capacity or whether an on-Site landfill can be constructed.

No borrow soil is required for grading and filling the GMF under the CBR-Onsite scenario (Appendix B). Because the on-Site landfill only has 445,000 cubic yards of available capacity, the landfill would need to be expanded. Approximately 9,700 cubic yards of compacted clay is required for landfill expansion; this material will be hauled in from the borrow site, which is located 0.7 miles from the landfill. Finally, approximately 86,000 cubic yards of soil will be excavated during construction of the stormwater channel south of the GMF during Site restoration. This material will be hauled to the borrow soil location for stockpiling (Appendix B).

Under the CBR-Onsite scenario, the expected duration of major construction activities is expected to be 24-36 months at the GMF (Appendix B; Golder, 2021c,d). Key parameters for the CBR-Onsite scenario are shown in Table 2.2.

Table 2.2 Key Parameters for the Closure-by-Removal with On-Site Disposal Scenario – GMF

Parameter	Value	Notes
Surface Area of Impoundment (acres)	31	
In-Place Volume of CCR (CY)	400,000	CCR contained in the GMF is gypsum from flue gas desulfurization.
Volume of Earthen Components of Existing Liner System (CY)	283,000	
Distance to the On-Site Landfill (miles)	1.2	
Required Volume of Borrow Soil (CY)	9,700	Required for landfill expansion.
Volume of Soil Stockpiled at Borrow Soil Location (CY)	86,000	Soil excavated south of the impoundment during construction of the stormwater channel (Site restoration).
Distance to the Borrow Soil Location from the GMF (miles)	0.4	
Distance to the Borrow Soil Location from the On-Site Landfill (miles)	0.7	
Duration of Construction Activities (months)	24-36	
Total On-Site Labor Hours for Major Construction[a]	27,100	
Required On-Site Hauling Truckloads (Loaded)	44,200	
Required Off-Site Hauling Truckloads (Loaded)	0	
Required On-Site Hauling Miles	98,100	
Required Off-Site Hauling Miles	0	

Notes:
CY = Cubic Yards; CCR = Coal Combustion Residual; GMF = Gypsum Management Facility.
Sources: Appendix B; Golder (2021c,d).
(a) Major construction is defined as any operation occurring on-Site that requires one of the following equipment types: breaker, compactor, dozer, excavator, haul truck, loader, and telehandler. Labor is not included if it is limited to use of the following equipment types: diesel pump, flatbed truck, generator, miscellaneous, pickup truck, and seed drill or hydroseeder. Labor performed by haul truck operators is only included in calculations if the hauling occurs on-Site. Workers assigned to relevant activities are assumed to work full-time (40 hours per week) on that activity for the duration of the activity.

2.1.3 Closure-by-Removal with Off-Site Disposal

Under the CBR-Offsite scenario, CCR and existing liner system materials will be excavated from the GMF and sent to an off-Site landfill for final disposal. Excavation will include all of the gypsum in the impoundment and the existing dual-composite liner system (Golder, 2021c,d). All of the gypsum in the GMF and the primary composite liner system, the leachate collection and removal system, the geosynthetic components of the secondary composite liner system, and the 3-feet-thick compacted clay layer underlying the GMF will be hauled to the off-Site landfill for disposal.

Excavated materials will be sent to the Peoria City-County Landfill in Brimfield, Illinois (11501 W Cottonwood Road), which is approximately 33 miles from the Site (Appendix B). As is described below in Section 2.4.5, it is possible that the Peoria City-County Landfill will have to be expanded in order to accept all of the CCR and liner materials.

IAC Section 845.710(c)(1) requires CBR alternatives to consider multiple methods for transporting CCR off-site, including 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. Existing loadout facilities, which would facilitate off-Site rail or barge CCR transport, are not present on the property, and the construction of new loadout facilities is considered infeasible. Only transport *via* on-road haul trucks (with a 16.5-cubic-yard capacity) is considered feasible for CBR-Offsite. The local availability and use of natural gas-powered trucks, or other low-polluting trucks, will be evaluated prior to the start of construction.

The work elements included in this scenario are largely the same as those listed above in Section 2.1.2 for the CBR-Onsite scenario (Appendix B; Golder, 2021c,d):

- Free water removal and dewatering of the GMF.
- Excavation and transport of CCR and liner system materials to the off-Site landfill, as detailed above. All areas affected by CCR releases will be decontaminated, including potential over-excavation below the bottom of the liner system.
- Grading and filling to convey runoff away from the impoundments. This process will include excavation of a surface water channel south of the GMF and removal of sections of the GMF Recycle Pond perimeter dike in order to promote passive stormwater drainage to the southeast of the impoundment.
- Site restoration, including revegetation with native grasses.
- Monitoring at the impoundments for at least 3 years, or until GWPSs are achieved.

Approximately 31 acres of geosynthetic liner system materials, 283,000 cubic yards of earthen liner system materials, 50,000 cubic yards of subsoil overexcavation, and 400,000 cubic yards of gypsum will be excavated from the GMF and hauled to the off-Site landfill for disposal. No borrow soil is required for grading and filling of the GMF under the CBR-Offsite scenario (Appendix B). Finally, approximately 86,000 cubic yards of soil will be excavated during construction of the stormwater channel south of the GMF during Site restoration. This material will be hauled to the borrow soil location for stockpiling (Appendix B).

Under the CBR-Offsite scenario, the expected duration of major construction activities is expected to be 36-48 months at the GMF (Appendix B; Golder, 2021c,d). Key parameters for the CBR-Offsite scenario are shown in Table 2.3.

Table 2.3 Key Parameters for the Closure-by-Removal with Off-Site Disposal Scenario – GMF

Parameter	Value	Notes
Surface Area of Impoundment (acres)	31	
In-Place Volume of CCR (CY)	400,000	CCR contained in the GMF is gypsum from flue gas desulfurization.
Volume of Earthen Components of Existing Liner System (CY)	283,000	
Distance to the Off-Site Landfill (miles)	33	Peoria City-County Landfill in Brimfield, IL.
Required Volume of Borrow Soil (CY)	0	
Volume of Soil Stockpiled at Borrow Soil Location (CY)	86,000	Soil excavated south of the impoundment during construction of the stormwater channel (Site restoration).
Distance to the Borrow Soil Location (miles)	0.4	
Duration of Construction Activities (months)	36-48	
Total On-Site Labor Hours for Major Construction[a]	36,800	
Required On-Site Hauling Truckloads (Loaded)	4,700	
Required Off-Site Hauling Truckloads (Loaded)	50,900	
Required On-Site Hauling Miles	3,760	
Required Off-Site Hauling Miles	3,320,000	

Notes:

CY = Cubic Yards; CCR = Coal Combustion Residual; GMF = Gypsum Management Facility.

Sources: Appendix B; Golder (2021c,d).

(a) Major construction is defined as any operation occurring on-Site that requires one of the following equipment types: breaker, compactor, dozer, excavator, haul truck, loader, and telehandler. Labor is not included if it is limited to use of the following equipment types: diesel pump, flatbed truck, generator, miscellaneous, pickup truck, and seed drill or hydroseeder. Labor performed by haul truck operators is only included in calculations if the hauling occurs on-Site. Workers assigned to relevant activities are assumed to work full-time (40 hours per week) on that activity for the duration of the activity.

2.2 Long- and Short-Term Effectiveness of 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. This report concluded that there are no current unacceptable risks to any human or ecological receptors. Because groundwater concentrations are expected to remain stable and/or decline under all closure scenarios, there will also be no unacceptable risks to human health or the environment during or following closure at the GMF. Thus, there is no current risk or future risk under any closure scenario at the GMF, and the magnitude of reduction of existing risks is the same under all scenarios.

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 CCR releases that may occur during dike failure and storm-related events.

Storm-Related Releases and Dike Failure During Flood Conditions

Engineering analyses show that the existing dikes at the GMF are expected to remain stable under static, seismic, and flood conditions (AECOM, 2016b; Burns & McDonnell, 2021a). Prior to closure (*i.e.*, under current conditions), the risk of dike failure occurring during floods or other storm-related events is therefore minimal. Engineering analyses similarly show that the current risk of sudden CCR releases occurring at the GMF due to overtopping during flood conditions is minimal (AECOM, 2016c; Burns & McDonnell, 2021a). Post-closure, the risks of overtopping and dike failure occurring at the GMF will be even smaller than they are currently. Under the CIP scenario, all free water will be pumped from the GMF and a new cover system will be installed, which will include 24 inches of soil and a geomembrane liner. Construction activities at the GMF under the CIP scenario will also result in improved stormwater management. Relative to current conditions, this cover system and the associated stormwater management improvements will 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-Onsite and CBR-Offsite scenarios, all of the CCR in the GMF will be excavated and relocated, eliminating the risk of a sudden CCR release occurring under a dike failure or flood overtopping event. In summary, there is minimal risk of sudden CCR releases occurring during or prior to closure (*i.e.*, under current conditions). Additionally, post-closure there is minimal risk of sudden CCR releases occurring under the CIP scenario, and there is no risk of sudden CCR releases occurring under the CBR-Onsite or CBR-Offsite scenarios.

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). However, the Duck Creek property does not lie within a seismic impact zone. The property is also believed to have a "low risk level" for seismic risks based on the 2018 United States Geological Survey (USGS) National Seismic Hazard Map. Additionally, the GMF does 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; Burns & McDonnell, 2021b,c; Haley & Aldrich, Inc., 2018a,b). The nearest known fault is the Sicily Fault, which is located about 66 miles southeast of the GMF. The Sicily Fault does not have known recent activity (Haley & Aldrich, Inc., 2018a,b). Thus, the risk of dike failure occurring during or following closure activities due to seismic activity is exceedingly low at the GMF.

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 are described in Section 2.1 for each closure scenario. In summary, under the CIP scenario, the GMF will undergo monitoring for at least 30 years post-closure, or until such time as GWPSs are achieved. The post-closure care plan under the CIP scenario additionally includes periodic inspections and mowing and maintenance of the final cover system for the GMF. Under the CBR-Onsite and CBR-Offsite scenarios, the GMF will undergo monitoring for 3 years post-closure, or until such time as GWPSs are achieved.

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

2.2.4.1 Worker Risks

Best practices will 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 risks to workers 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 and demobilization, material deliveries, and the hauling of soil, CCR, and liner system materials to and from the borrow site, the on-Site landfill, and the off-Site landfill.

Risk of Worker Accidents Occurring On-Site

For the GMF, three closure scenarios were considered: CIP, CBR-Offsite, and CBR-Onsite. Based on labor requirements reported in Appendix B of this report, Gradient estimates that 12,400 total on-Site labor hours are required for major construction activities under the CIP scenario, 27,100 on-Site labor hours are required for major construction activities under the CBR-Onsite disposal scenario, and 36,800 on-Site labor hours are required for major construction activities under the CBR-Offsite scenario. The CIP scenario therefore requires the smallest number of on-Site labor hours for major construction activities across all scenarios.

The United States Bureau of Labor Statistics (US BLS) (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 BLS and the on-Site labor hours reported above, we estimate that approximately 0.14 worker injuries and 0.00093 worker fatalities will occur on-Site under the CIP scenario due to major construction activities at the GMF (Table 2.4). Approximately 0.31 worker injuries and 0.0020 worker fatalities are expected to occur under the CBR-Offsite scenario, and approximately 0.42 worker injuries and 0.0028 worker fatalities are expected to occur under the CBR-Onsite scenario (Table 2.4). Thus, the expected number of worker accidents occurring on-Site due to major construction activities is smallest under the CIP scenario and is largest under the CBR-Offsite scenario. Note that the calculations presented here focus on major construction activities (*e.g.*, excavation, loading, and hauling). They therefore do not account for the additional accidents that could occur on-Site during less intensive construction activities (*e.g.*, surveying, erosion control, and hydroseeding).

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

Closure Scenario	Injuries	Fatalities
CIP	0.14	0.00093
CBR-Onsite	0.31	0.0020
CBR-Offsite	0.42	0.0028

Notes:
CIP = Closure-in-Place; CBR-Onsite = Closure-by-Removal with On-Site CCR Disposal; CBR-Offsite = Closure-by-Removal with Off-Site CCR Disposal.

Concurrently with closure activities, a utility-scale solar facility will be constructed on the Duck Creek Site. The simultaneous pursuit of closure-related construction and solar facility construction may lead to significant traffic congestion on Site access roads, resulting in greater overall risks to workers than would result from closure or solar re-development alone. Conflicts are particularly likely to arise during GMF closure, because it is expected to take 1-4 years to complete and involve major earthmoving operations.

For the GMF, the CIP scenario requires less total hauling activity than either of the two CBR scenarios (Tables 2.1-2.3). The CIP scenario can also be completed within a shorter time frame than the two CBR scenarios (12-24 months *versus* 24-48 months). The CIP scenario is therefore expected to result in less congestion on Site access roads during Site re-development – and, hence, a smaller increase in the risks to workers – than either the CBR-Onsite or CBR-Offsite scenarios.

Risk of Worker Accidents Occurring Off-Site

The CBR-Offsite scenario is the only scenario which requires any off-Site hauling. Under the CBR-Offsite scenario, 3,320,000 vehicle travel miles are required to haul excavated materials from the GMF to the off-Site landfill (Tables 2.1-2.3). The United States Department of Transportation (US DOT, 2020) provides an estimate of the expected number of fatalities and injuries "per vehicle mile driven" for drivers and passengers of large trucks. Based on US DOT's statistics, an estimated 0.42 injuries and 0.0096 fatalities are expected to occur to drivers and passengers of haul trucks due to off-Site hauling under the CBR-Offsite scenario during closure of the GMF (Table 2.5).

Table 2.5 Expected Number of Off-Site Worker Accidents Due to Hauling Under Each Closure Scenario – GMF

Closure Scenario	Injuries	Fatalities
CIP	0	0
CBR-Onsite	0	0
CBR-Offsite	0.42	0.0096

Notes:
CIP = Closure-in-Place; CBR-Onsite = Closure-by-Removal with On-Site CCR Disposal; CBR-Offsite = Closure-by-Removal with Off-Site CCR Disposal.

These estimates reflect the minimum number of worker accidents that are likely to occur off-Site under each scenario, because they do not account for the additional vehicle accidents that may occur during non-hauling activities such as labor mobilization and demobilization, equipment mobilization and demobilization, and material deliveries. The vehicle mileages associated with these off-Site activities are not known. However, the mileages associated with these activities are expected to scale with the duration and intensity of the planned construction activities under each scenario. The CIP scenario is the closure scenario with the shortest expected duration of construction activities, the smallest required volume of CCR dewatering and handling, the least amount of total on-Site labor hours for major construction, and the least amount of required hauling truckloads (Tables 2.1-2.3). This scenario is therefore also likely to have the smallest amount of off-Site activity due to labor and equipment mobilization/demobilization and material deliveries – and, hence, the smallest number of off-Site vehicle accidents arising from these activities.

Taking into account both (i) accidents occurring on-Site due to major construction activities and (ii) accidents occurring off-Site due to hauling, a minimum of 0.14 worker injuries and 0.00093 worker fatalities are expected to occur during GMF closure under the CIP scenario. An estimated 0.31 worker injuries and 0.0020 worker fatalities are expected to occur during GMF closure under the CBR-Onsite scenario, and an estimated 0.85 worker injuries and 0.0012 worker fatalities are expected to occur during GMF closure under the CBR-Offsite scenario. Thus, for the GMF, the overall risks to workers are likely to be highest under the CBR-Offsite scenario and lowest under the CIP scenario.

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 for large trucks reported by US DOT (2020) and the off-Site haul truck mileages reported above for the GMF, haul truck accidents could result in an estimated 1.2 injuries and 0.044 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 CBR-Offsite scenario due to hauling of excavated materials from the GMF (Table 2.6). In contrast, no fatalities or injuries are expected to occur among community members under the CBR-Onsite or CIP scenarios due to haul truck accidents, because borrow soil will be taken from a location on the property and any excavated materials will be hauled to an off-Site landfill.

Table 2.6 Expected Number of Off-Site Community Accidents Due to Hauling Under Each Closure Scenario – GMF

Closure Scenario	Injuries	Fatalities
CIP	0	0
CBR-Onsite	0	0
CBR-Offsite	1.2	0.044

Notes:
CIP = Closure-in-Place; CBR-Onsite = Closure-by-Removal with On-Site CCR Disposal; CBR-Offsite = Closure-by-Removal with Off-Site CCR Disposal.

In addition to impacts due to off-Site hauling, all scenarios will have off-Site impacts due to labor mobilization and demobilization, equipment and vehicle mobilization and demobilization, and material deliveries. As described above (Risk of Worker Accidents Occurring Off-Site), the CIP scenario is likely to require the smallest amount of off-Site activity due to these off-Site vehicle uses – and, hence, the smallest number of off-Site vehicle accidents arising from these activities – across all scenarios evaluated for the GMF.

Traffic

Haul routes are expected to use major arterial roads and highways wherever possible, which will reduce the incidence of traffic. However, the heavy use of local roads for construction operations may result in traffic near the Site and, in the case of the CBR-Offsite scenario, the off-Site landfill.

Traffic may increase temporarily around the Site under all three closure scenarios due to the daily arrival and departure of the workforce, equipment mobilization/demobilization, and material deliveries. However, these impacts are expected to largely occur at the beginning or end of each work day (for the arrival/departure of the work force), at the beginning or end of the construction period (for equipment mobilization/demobilization), and at specific times throughout the construction period (for material deliveries). These impacts will therefore likely be less disruptive to community members than the constant and steady movement of haul trucks to and from the Site under the CBR-Offsite scenario.

Under the CBR-Offsite scenario, Golder estimates that approximately 50,900 truckloads will be required to transport excavated materials from the GMF to the off-Site landfill over 1,220 hauling days (Appendix B). Assuming a 10-hour work day, 6 work days per week, and 26 work days per month, a haul truck would therefore need to pass a given location near the Site once every 7.2 minutes on average for the duration of excavation activities under the CBR-Offsite scenario for the GMF. Thus, traffic demands are considerable. This level of traffic (one truck passing a location approximately once every 7.2 minutes) could potentially cause traffic delays on local roads and cause damage to local roadways. It could also cause delays in the re-development of the Site for use in utility-scale solar generation.

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." Because there are no residences or businesses within 1,500 feet of any of the construction areas on the Site (the GMF, the proposed borrow site, and the on-Site landfill), we do not anticipate that any residences or businesses will be adversely impacted by noise pollution at the Site under any closure scenario. Moreover, although there are several scenic, recreational, and historical areas located within a few miles of the Site (the Rice Lake SFWA and the Orendorf and Rice Lake Terrace Archaeological Sites), there are no notable scenic or recreational areas located within 1,500 feet of any of the construction areas on the Site. Noise impacts are therefore expected to be relatively minor under all closure scenarios.

In addition to impacts in the immediate vicinity of the GMF, local roads near the Site and the off-Site landfill (CBR-Offsite scenario only) may experience noise pollution due to high volumes of truck traffic. As described above (Traffic), the construction schedule under the CBR-Offsite scenario requires haul trucks to pass by a given location every 7.2 minutes on average for 10 hours each day while excavation is occurring at the GMF. 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 along local roads from the daily arrival and departure of the workforce, equipment mobilization/demobilization, and material deliveries. These impacts are expected to largely occur at the beginning or end of each work day (for the arrival/departure of the work force), at the beginning or end of the construction period (for equipment mobilization/demobilization), and at specific times throughout the construction period (for material deliveries); these impacts will therefore likely be less disruptive to community members than the constant and steady movement of haul trucks to and from the Site.

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 regards 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 used to haul material to and from the Site. Diesel exhaust contains hundreds of 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 Best Management Practices (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.

The air pollutant mass released under a given closure scenario will be proportional to the expected duration and intensity of construction activities under that scenario. As initially described in Section 2.2.4.1 (Worker Risks), the CIP scenario is the GMF closure scenario with the shortest expected duration of construction activities, the smallest required volumes of CCR dewatering and handling, the least amount of total on-Site labor hours for major construction, and the least amount of required hauling truckloads. This scenario is therefore likely to result in the least amount of air emissions of the three closure scenarios.

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, 2019). Relative to other communities, EJ communities experience an increased risk of adverse health impacts due to environmental pollution and other factors associated with remediation activities (US EPA, 2016).

As shown in a map of EJ communities throughout the state (Figure 2.1; IEPA, 2019), the on-Site landfill, the borrow site, and a portion of the GMF are all located within the one-mile buffer zone of the nearest EJ community (near Canton). Due to its close proximity to the Site, the EJ community near Canton may be disproportionately impacted by air emissions, traffic, accidents and other factors arising from various closure activities occurring on or near the Site. Activities occurring near the GMF, the borrow site, and the on-Site landfill may have particularly negative impacts. Unfortunately, each of the evaluated closure scenarios requires significant construction activity in at least one of these three on-Site areas.

In addition to impacts arising from construction activity on or near the Site, EJ communities may be also impacted by off-Site activities, including the hauling of CCR and liner materials from the Site to the off-Site landfill, labor and equipment mobilization/demobilization, and material deliveries. Unfortunately, in addition to being located near the on-Site landfill, the borrow site, and the GMF, the EJ community near Canton is also located along the three primary haul routes from the Site to the off-Site landfill suggested by Google Maps (Google LLC, 2021). In summary, due to both on-Site and off-Site activities, all possible closure scenarios are associated with potential negative impacts on the EJ community near Canton (Figure 2.1).

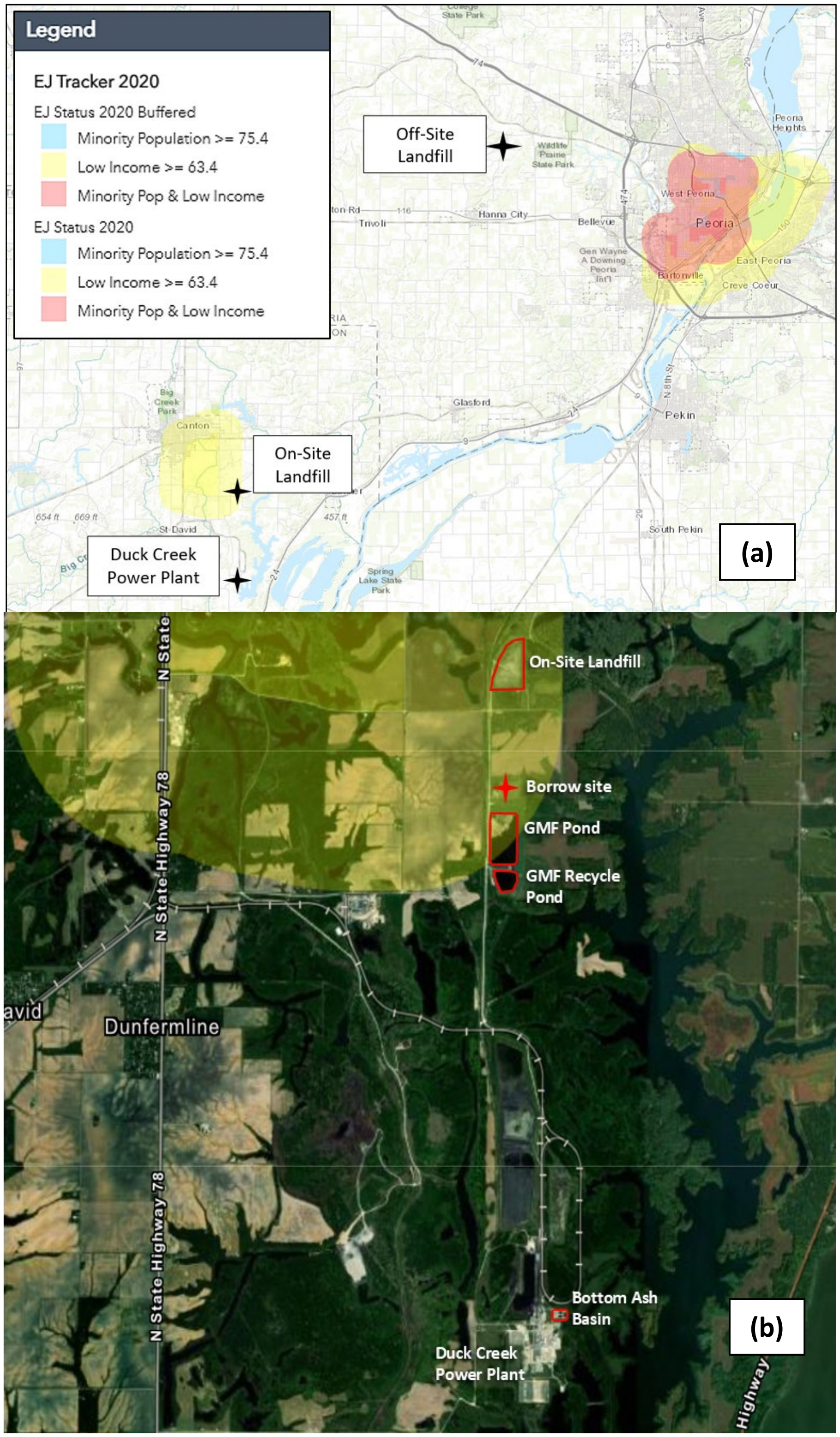

Figure 2.1 Environmental Justice Communities in the Vicinity of Site Features and the Off-Site Landfill – GMF. Adapted from IEPA (2019). (a) Regional map. (b) Site map.

Scenic, Historical, and Recreational Value

There are several scenic, recreational, and historical areas located within a few miles of the Site, including the Rice Lake SFWA and the Orendorf and Rice Lake Terrace Archaeological Sites (Google LLC, 2021; Ramboll, 2021b,c). However, there are no notable scenic or recreational areas located in the immediate vicinity of the GMF, the borrow soil location, or the on-Site landfill. The nearest scenic, recreational, or historical area is the Rice Lake SFWA, which is located over 2.5 miles from the GMF, the borrow soil location, and the on-Site landfill. We therefore do not expect construction activities at the Site to have any direct negative impacts on the scenic, historical, or recreational value of the areas listed above (due to, *e.g.*, noise, obstructions of the view, or restricted access), regardless of the closure scenario.

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 gas emissions (GHGs), including carbon dioxide (CO_2) and possibly nitrous oxide (N_2O). The potential impact of each closure scenario on GHG emissions is similar 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. For the GMF, the CIP scenario has the shortest duration of construction activities and requires the least amount of CCR dewatering and handling; this scenario is therefore likely to have the lowest amount of predicted GHG emissions.

We did not quantify the carbon footprint of the approximately 31 acres of 60-mil HDPE geomembrane liner required for the final GMF cover system under the CIP scenario, or the carbon footprint of the additional composite liner that will be required for the upstream slope of the berm to be constructed under this scenario (Appendix B). The carbon footprint of these geomembranes (*i.e.*, the fossil fuel emissions required to manufacture them) is an additional source of GHG emissions at the Site under the CIP scenario. Expansion of the on-Site landfill and the potential expansion of the off-Site landfill under the CBR-Onsite and CBR-Offsite scenarios 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. In summary, for the GMF, the energy requirements of construction are expected to be smallest under the CIP scenario. We did not quantify the energy demands of the geomembranes required for the construction of the final GMF cover system or the new GMF berm under the CIP scenario or the geomembranes required for the expansion of the on-Site landfill or, potentially, the off-Site landfill under the CBR-Onsite or CBR-Offsite scenarios.

The Duck Creek Site is slated for re-development as a utility-scale solar power generating facility. At the grid scale, solar generation will 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 re-development efforts. The magnitude of expected delays will scale with the expected duration and intensity of construction activities during closure. For the GMF, the CIP scenario requires less total hauling activity than either of the two CBR scenarios (Tables 2.1-2.3). The CIP scenario can also be completed within a shorter time frame than the two CBR scenarios (12-24 months *versus* 24-48 months). The CIP scenario is therefore expected to result in fewer delays to re-development than either the CBR-Onsite or CBR-Offsite scenarios.

Natural Resources and Habitat

Construction is likely to have a negative short-term impact on the natural resources and habitat in the vicinity of the GMF, and the on-Site borrow soil location. For example, excavation of the impoundments and the borrow soil location will result in the destruction of some habitat that may currently overlie these areas under all closure scenarios. Closure will also result in long-term shifts in the habitat overlying the impoundments and the borrow soil location (*e.g.*, areas of the impoundments that are not currently grassland will be converted to grassland). Use of the on-Site and off-Site landfill under the CBR-Onsite and CBR-Offsite scenarios, in contrast, is not expected to result in significant habitat loss, because these landfills are already in use.

In addition to direct impacts on the existing habitat atop the impoundments and the borrow soil location, construction activities may have indirect impacts by causing alarm and escape behavior in wildlife near these locations. For the GMF, the duration of time over which direct and indirect habitat impacts will occur (*i.e.*, the duration of construction activities) is longest under the two CBR scenarios (24-48 months) and shortest under the CIP scenario (12-24 months). Thus, negative short-term impacts on natural resources and habitat are expected to be smallest under the CIP scenario.

The GMF is not located immediately adjacent to wetlands or notable surface water bodies, such as rivers or lakes (US FWS, 2021). For this reason, construction activities in the vicinity of these impoundments are not expected to have a significant negative impact on any wetland or aquatic species (due to, *e.g.*, erosion and sediment runoff). Impacts are expected to be limited to terrestrial species. According to the Illinois Department of Natural Resources (IDNR) Natural Heritage Database and the United States Fish & Wildlife Service (US FWS) Environmental Conservation Online System, there are 11 state threatened species, 12 state endangered species, three federally threatened species, and one federally endangered species within Fulton County (Ramboll, 2021b,c). To our knowledge, however, no threatened or endangered species have been identified at the Site (Ramboll, 2021b,c). 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 primary groundwater migration pathway near the GMF is within the shallow sand unit within the uppermost aquifer. Groundwater flow in the shallow sand unit is generally in a northwest to southeast direction. Seasonal variation of groundwater levels at the GMF are present and may fluctuate approximately 1 to 10 feet. There is no observable seasonal variation of groundwater flow direction at the GMF associated with the elevation changes. Groundwater flows toward the Duck Creek Cooling Pond, which is located approximately 2,100 feet east of the GMF (Ramboll, 2021d).

Based on statistical analysis and evaluation of potential exceedances, it was determined there are no potential groundwater exceedances of applicable groundwater standards attributable to the GMF (Ramboll, 2021d). However, a groundwater model was developed to evaluate if groundwater concentrations would maintain compliance with the GWPSs post-closure for the CIP scenario. For this evaluation, a groundwater flow model was developed and calibrated in MODFLOW; contaminant transport was evaluated with MODPATH; and vertical percolation from the GMF was evaluated using the HELP model (Ramboll, 2021d).

The results of contaminant transport modeling for the CIP scenario at the GMF indicates that all particles will remain within the footprint of the GMF. Over a model-simulated period of 100 years following closure by CIP, the mean travel distance of all particles within the liner system and gypsum in the GMF was 0.29 feet horizontally and 0.03 feet vertically (Ramboll, 2021). Based on these modeling results, it was concluded that groundwater concentrations under the CIP scenario are expected to maintain compliance with the GWPSs (Ramboll, 2021d).

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 potential leaching of CCR-associated constituents from the GMF. Section 2.2.2 evaluates the potential for sudden CCR releases to occur at the GMF due to, *e.g.*, dike failure or overtopping during floods or other storm-related events. In summary, under all evaluated closure scenarios, there is no current or future risk to any human or ecological receptors associated with the GMF. Additionally, there is minimal current or future risk of overtopping due to flood conditions at either impoundment. 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.

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

As described in Section 2.2.2, there is minimal risk of engineering or institutional failures leading to sudden releases of CCR post-closure under the CIP scenario. Under the CBR-Onsite and CBR-Offsite scenarios, there is no risk of engineering or institutional failures leading to sudden releases of CCR post-closure. Additionally, there are no current or future unacceptable risks to any human or ecological receptors associated with the GMF under any of the closure scenarios (see Section 2.2.1 above). Moreover, reliable engineering and institutional controls (*e.g.*, a bottom liner, a leachate management system, and groundwater monitoring) will be implemented at the on-Site and off-Site landfills under the CBR-Onsite and CBR-Offsite 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))

At this time, we do not anticipate a need for corrective action at the GMF under any closure scenario.

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 gypsum in the GMF 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 groundwater concentrations are expected to remain stable and/or decline post-closure, there will also be no unacceptable risks to human health or the environment following closure of the impoundments, regardless of the closure scenario.

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

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

At this time, we do not anticipate a need for the use of treatment technologies other than source control (*i.e.*, CIP, CBR-Onsite, and CBR-Offsite) at either the GMF or the BAB under any closure scenario.

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

Closure-in-Place using a final cover system is a reliable and standard method for closing impoundments. However, dewatering and relocating saturated gypsum as part of closure activities at the GMF may be moderately challenging. Careful planning will be required to work safely on the wet gypsum within the GMF.

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. Dewatering the gypsum in the GMF prior to excavation will require considerable effort and time. 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.

Hauling will be easier to implement under the CBR-Onsite scenario than under the CBR-Offsite scenario, due to less haul traffic on public roadways. Additionally, because the CBR-Offsite scenario involves hauling CCR off-Site (*i.e.*, intrastate travel), a higher level of dewatering will be required compared to the CBR-Onsite scenario. As described in Section 2.2.4.2 ("Community Impacts"), off-Site hauling may also have detrimental impacts due to an increased incidence of vehicle accidents, truck traffic, 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 will need to be developed between IPRG 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 liner materials 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.

2.4.2 Expected Operational Reliability of the Closure Alternative

The operational reliability of the CIP scenario, the CBR-Onsite scenario, and the CBR-Offsite scenario is expected to be similar. The GMF currently includes a bottom liner system, and CIP will utilize a final cover system that includes a geomembrane. Under the CIP scenario, the gypsum in the GMF will therefore be surrounded by an engineered containment system on the top, sides, and bottom. The CBR-Offsite and CBR-Onsite scenarios similarly involve placing the gypsum from the GMF in an engineered landfill system that has a bottom liner, leachate collection system, and final cover system, resulting in the gypsum being surrounded by an engineered containment system on the top, sides, and bottom. The operational reliability of all three closure scenarios is therefore expected to be similar for both impoundments. Moreover, high operational reliability is expected under all scenarios due to the full containment of CCR and liner materials.

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

Regulatory approval will be needed under all closure scenarios. A stormwater pollution prevention plan (SWPPP) will also be required for all of the closure scenarios. A land disturbance permit may also be required for all scenarios.

As discussed below in Section 2.4.5, the existing on-Site landfill will require expansion under the CBR-Onsite scenario in order to accommodate all of the material excavated from the GMF. The on-Site landfill has already been permitted for an expansion of an additional 2 acres of waste disposal area. Under the CBR-Offsite scenario, it may similarly be necessary to expand the off-Site landfill. 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 under the CBR-Onsite and CBR-Offsite scenarios than under the CIP scenario, shortages in construction equipment may cause greater challenges under the CBR-Onsite and CBR-Offsite 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 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 both impoundments 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 for landfill development and closure projects.

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

Under the CIP scenario, the gypsum currently within the GMF will be consolidated and stored within the existing footprint of the impoundment. The GMF will be unwatered at the start of construction *via* pumping. Pumped water will be managed in accordance with the facility's NPDES permit. Treatment is not expected to be necessary prior to discharge.

The existing landfill on the Duck Creek property does not have sufficient capacity to receive all of the CCR and liner materials that are currently slated for landfilling under the CBR-Onsite scenario. Expansion of the on-Site landfill would thus be necessary. The on-Site landfill is already permitted for added waste disposal capacity, which would create an additional 2 acres of landfill area (Appendix B). The landfill expansion could be completed in a single construction season during the removal of ponded water at the GMF.

Under the CBR-Offsite scenario, up to 733,000 cubic yards of gypsum, liner materials, and additional subsoil overexcavation and 31 acres of geosynthetic liner system materials excavated from the GMF will require disposal at an off-Site landfill. An additional 7,000 cubic yards of material excavated from the BAB would also require disposal at the off-Site landfill, if CBR-Offsite were selected for the BAB. According to the IEPA "Landfill Disposal Capacity Report" for 2020 (IEPA, 2021b), the closest third-party landfill with the ability to receive and dispose of CCR from the Site is the Peoria City-County Landfill in Brimfield, Illinois. This facility has 750,000 cubic yards of remaining capacity in its current permitted footprint. It receives 230,000 cubic yards of waste annually, and is located 33 miles from the Site. The Peoria City-County Landfill therefore has sufficient capacity to receive all of the CCR and liner materials from the GMF. However, due to the limited space remaining in this landfill and 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 will be received and the unique CCR and liner system 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 Peoria City-County Landfill is impractical or infeasible, then an alternative landfill located farther from the Site would need to be identified.

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 of this report), modeled surface water concentrations in the Illinois River are all below relevant human health and ecological screening benchmarks. Due to closure activities, surface water concentrations of CCR-associated constituents are expected to remain stable and/or decline over time under all three closure scenarios. Thus, no future exceedances of any human health or ecological screening benchmarks are anticipated under any closure scenario at either impoundment. Additionally, the lined landfills that will receive any materials excavated from the GMF and the BAB under the CBR-Onsite and CBR-Offsite scenarios will be managed to ensure that no surface water impacts occur in the vicinity of the landfills.

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 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). For the GMF, both CIP and CBR are being considered; however, it is not the case that closing the GMF *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 under any closure scenario. There is also minimal risk of future CCR releases occurring under any closure scenario. Furthermore, based on a model-simulated period of 100 years, groundwater concentrations under the CIP scenario are expected to maintain compliance with the GWPSs (Ramboll, 2021d). In summary, all closure scenarios are responsive to residents' concerns regarding groundwater and surface water quality.

For the GMF, the CIP scenario has advantages over the CBR-Offsite and CBR-Onsite scenarios with regard to likely community concerns. Specifically, compared to the other evaluated alternatives, CIP presents fewer risks to workers and community members during construction in the form of accidents, traffic, and air pollution (Section 2.2.4 above) and is also associated with the shortest time to closure. By minimizing the expected time to closure, this combination of closure scenarios minimizes the duration of negative impacts arising from construction activities and minimizes the time required to re-develop the Site for use in utility-scale solar generation. Re-development of the Site for use in solar generation and storage will 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 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, CBR-Onsite, and CBR-Offsite 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. Key benefits relative to other closure scenarios include the more rapid re-development of the Site for use in utility-scale solar generation and reduced impacts on workers, community members, and the environment during construction (*e.g.*, fewer constructed-related accidents, lower energy demands, less air pollution and GHG emissions, and less traffic). 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 December 2021 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).

3 Closure Alternatives Analysis – BAB

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

This section of the report presents a CAA for the BAB pursuant to requirements under IAC Section 845.710 (IEPA, 2021a). For the BAB, Gradient evaluated two closure scenarios: CBR-Onsite and CBR-Offsite. CIP was not evaluated for the BAB because no significant CCR remains in the impoundment. Sections 3.1.1 and 3.1.2 describe CBR-Onsite and CBR-Offsite closure scenarios. These scenarios are based on information and analyses conveyed to Gradient by Golder (Appendix B; Golder, 2021c,d).

3.1.1 Closure-by-Removal with On-Site Disposal

Under the CBR-Onsite scenario, CCR and existing liner system materials will be excavated from the BAB and sent to the on-Site landfill for final disposal. Excavation activities at the BAB will include any residual CCR that is still present in the impoundment; the concrete, compacted clay, and geomembrane components of the existing liner system; and additional subsoil overexcavation (Golder, 2021c,d). Excavated materials from the BAB will be hauled to the on-Site landfill (Appendix B; Golder, 2021d).

The on-Site landfill is located approximately 3.7 miles north of the BAB *via* Site roads (Appendix B). Excavated materials will be hauled to the landfill using haul trucks. The landfill on the property is currently expected to have sufficient capacity to receive all of the materials from the BAB slated for disposal under the CBR-Onsite scenario. This scenario meets the requirements of IAC Section 845.710(c)(2) (IEPA, 2021a) which requires an assessment in the CAA whether the Site has an on-Site landfill with available capacity or whether an on-Site landfill can be constructed.

This scenario includes the following work elements for the closure of the BAB (Appendix B; Golder, 2021c,d):

- Excavation and transport of CCR and liner system materials to the on-Site landfill, as detailed above.
- Grading and filling to convey runoff away from the impoundments.
- Site restoration, including revegetation with native grasses.
- Three years of monitoring at the impoundments, or until such time as GWPSs are achieved.

In total, approximately 3,550 cubic yards of concrete and compacted clay, 1 acre of geomembrane materials from the existing liner system, and 3,200 cubic yards of overexcavated subsoil will be excavated from the BAB under the CBR-Onsite scenario and hauled to the on-Site landfill for disposal. The selected borrow soil location is approximately 3.4 miles north of the BAB *via* Site roads (Appendix B). A total of 17,500 cubic yards of borrow soil are required for grading and filling of the BAB (Appendix B).

Under the CBR-Onsite scenario, the expected duration of major construction activities approximately 12-18 weeks (Appendix B; Golder, 2021c,d). Key parameters for the CBR-Onsite scenario are shown in Table 3.1.

Table 3.1 Key Parameters for the Closure-by-Removal with On-Site Disposal Scenario – BAB

Parameter	Value	Notes
Surface Area of Impoundment (acres)	2.2	Includes all three cells and the area around the cells.
In-Place Volume of CCR (CY)	Minimal	The CCR in the impoundment has been excavated previously.
Distance to the On-Site Landfill (miles)	3.7	
Required Volume of Borrow Soil (CY)	17,500	Required for grading and filling.
Volume of Soil Stockpiled at Borrow Soil Location (CY)	0	
Distance to the Borrow Soil Location (miles)	3.4	
Duration of Construction Activities (weeks)	12-18	
Total On-Site Labor Hours for Major Construction[a]	4,820	
Required On-Site Hauling Truckloads (Loaded)	1,330	
Required Off-Site Hauling Truckloads (Loaded)	0	
Required On-Site Hauling Miles	9,260	
Required Off-Site Hauling Miles	0	

Notes:
CY = Cubic Yards; CCR = Coal Combustion Residual; BAB = Bottom Ash Basin.
Sources: Appendix B; Golder (2021c,d).
(a) Major construction was defined as any operation occurring on-Site that required one of the following equipment types: breaker, compactor, dozer, excavator, haul truck, loader, and telehandler. Labor was not included if it was limited to use of the following equipment types: diesel pump, flatbed truck, generator, miscellaneous, pickup truck, and seed drill or hydroseeder. Labor performed by haul truck operators was only included in calculations if the hauling occurred on-Site. Workers assigned to relevant activities were assumed to work full-time (40 hours per week) on that activity for the duration of the activity.

3.1.2 Closure-by-Removal with Off-Site Disposal

Under the CBR-Offsite scenario, CCR and existing liner system materials will be excavated from the BAB and sent to an off-Site landfill for final disposal. Excavation activities at the BAB will include any residual CCR that is still present in the impoundment; the concrete, compacted clay, and geomembrane components of the existing liner system; and additional subsoil overexcavation (Golder, 2021c,d). Excavated materials in the BAB will all be hauled to the off-Site landfill (Appendix B; Golder, 2021d).

CCR and other excavated materials will be sent to the Peoria City-County Landfill (11501 W Cottonwood Road, Brimfield, IL 61517), which is approximately 33 miles from the Site (Appendix B).

IAC Section 845.710(c)(1) requires CBR alternatives to consider multiple methods for transporting CCR off-Site, including rail, barge, and trucks. Golder evaluated the feasibility of transporting excavated materials to the off-Site landfill *via* rail or barge and found that neither option is viable at this Site. Existing loadout facilities, which would facilitate off-Site rail or barge transport, are not present on the property, and the construction of new loadout facilities is considered infeasible. Only transport *via* on-road haul trucks (with a 16.5-cubic-yard capacity) is considered feasible for CBR-Offsite. The local availability and use of natural gas-powered trucks, or other low-polluting trucks, will be evaluated prior to the start of construction.

The work elements included in this scenario are largely the same as those listed above in Section 3.1.1 for the CBR-Onsite scenario (Appendix B; Golder, 2021):

- Excavation and transport of CCR and liner system materials to the off-Site landfill, as detailed above. All areas affected by CCR releases will be decontaminated, including potential over-excavation below the bottom of the liner system.
- Grading and filling to convey runoff away from the impoundments.
- Site restoration, including revegetation with native grasses.
- Three years of monitoring at the impoundments, or until such time as GWPSs are achieved.

In total, approximately 3,550 cubic yards of concrete and compacted clay, 1 acre of geomembrane materials from the existing liner system, and 3,200 cubic yards of overexcavated subsoil will be excavated from the BAB under the CBR-Offsite scenario and hauled to the off-Site landfill for disposal. The selected borrow soil location is approximately 3.4 miles north of the BAB *via* Site roads (Appendix B). A total of 17,500 cubic yards of borrow soil are required for grading and filling of the BAB (Appendix B).

Under the CBR-Offsite scenario, the expected duration of major construction activities is expected to be approximately 12 to 18 weeks for the BAB (Appendix B; Golder, 2021c,d). Key parameters for the CBR-Offsite scenario are shown in Table 3.2.

Table 3.2 Key Parameters for the Closure-by-Removal with Off-Site Disposal Scenario – BAB

Parameter	Value	Notes
Surface Area of Impoundment (acres)	2.2	Includes all three cells and the area around the cells.
In-Place Volume of CCR (CY)	Minimal	The CCR in the impoundment has been excavated previously.
Distance to the Off-Site Landfill (miles)	33	Peoria City-County Landfill in Brimfield, IL.
Required Volume of Borrow Soil (CY)	17,500	Required for grading and filling.
Volume of Soil Stockpiled at Borrow Soil Location (CY)	0	
Distance to the Borrow Soil Location (miles)	3.4	
Duration of Construction Activities (weeks)	12 to 18	
Total On-Site Labor Hours for Major Construction[a]	4,360	
Required On-Site Hauling Truckloads (Loaded)	956	
Required Off-Site Hauling Truckloads (Loaded)	489	
Required On-Site Hauling Miles	6,500	
Required Off-Site Hauling Miles	31,900	

Notes:
CY = Cubic Yards; CCR = Coal Combustion Residual; BAB = Bottom Ash Basin.
Sources: Appendix B; Golder (2021c,d).
(a) Major construction was defined as any operation occurring on-Site that required one of the following equipment types: breaker, compactor, dozer, excavator, haul truck, loader, and telehandler. Labor was not included if it was limited to use of the following equipment types: diesel pump, flatbed truck, generator, miscellaneous, pickup truck, and seed drill or hydroseeder. Labor performed by haul truck operators was only included in calculations if the hauling occurred on-Site. Workers assigned to relevant activities were assumed to work full-time (40 hours per week) on that activity for the duration of the activity.

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

3.2.1 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 BAB. This report concluded that there are no current unacceptable risks to any human or ecological receptors associated with the BAB. Moreover, because groundwater concentrations are expected to remain stable and/or decline over time under both closure scenarios, there will also be no unacceptable risks to human health or the environment during or following closure at either impoundment. Thus, there is no current risk or future risk under either closure scenario at either the BAB, and the magnitude of reduction of existing risks is the same under both scenarios.

3.2.2 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

There is no current or future risk of sudden CCR releases occurring at the BAB under any closure scenario. No significant amount of CCR remains in the impoundment.

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). However, the Duck Creek property does not lie within a seismic impact zone. The property is also believed to have a "low risk level" for seismic risks based on the 2018 United States Geological Survey (USGS) National Seismic Hazard Map. Additionally, the BAB does 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; Burns & McDonnell, 2021b,c; Haley & Aldrich, Inc., 2018a,b). The nearest known fault is the Sicily Fault, which is located about 64 miles southeast of the BAB. The Sicily Fault does not have known recent activity (Haley & Aldrich, Inc., 2018a,b). Thus, the risk of dike failure occurring during or following closure activities due to seismic activity is exceedingly low at the BAB.

3.2.3 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 BAB are described in Section 3.1 for each closure scenario. Under the both CBR-Onsite and CBR-Offsite scenarios, the BAB will undergo monitoring for 3 years post-closure, or until such time as GWPSs are achieved.

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

3.2.4.1 Worker Risks

Best practices will 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 risks to workers 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 and demobilization, material deliveries, and the hauling of soil, CCR, and liner system materials to and from the borrow site, the on-Site landfill, and the off-Site landfill.

Risk of Worker Accidents Occurring On-Site

For the BAB, two closure scenarios were considered: CBR-Offsite and CBR-Onsite. Based on labor requirements reported in Appendix B of this report, Gradient estimates that 4,820 total on-Site labor hours are required for major construction activities under the CBR-Onsite scenario, and 4,360 total on-Site labor hours are required for major construction activities under the CBR-Offsite scenario. The labor requirements under both scenarios are therefore similar. Slightly fewer on-Site labor hours are required under the CBR-Offsite scenario than under the CBR-Onsite scenario, because a greater percentage of hauling (a major construction activity) occurs off-Site rather than on-Site under the former scenario. Based on these values and US BLS labor statistics (US DOL, 2020a,b), we estimate that approximately 0.056 worker injuries and 0.00036 worker fatalities will occur on-Site under the CBR-Onsite scenario due to major construction activities at the BAB (Table 3.3). A slightly smaller number of worker injuries and fatalities (0.050 worker injuries and 0.00033 worker fatalities) are expected to occur on-Site under the CBR-Offsite scenario (Table 3.3). Note that the calculations presented here focus on major construction activities (*e.g.*, excavation, loading, and hauling). They therefore do not account for the additional accidents that could occur on-Site during less intensive construction activities (*e.g.*, surveying, erosion control, and hydroseeding).

Table 3.3 Expected Number of On-Site Worker Accidents Under Each Closure Scenario – BAB

Closure Scenario	Injuries	Fatalities
CBR-Onsite	0.056	0.00036
CBR-Offsite	0.050	0.00033

Notes:
CBR-Onsite = Closure-by-Removal with On-Site CCR Disposal; CBR-Offsite = Closure-by-Removal with Off-Site CCR Disposal.

Risk of Worker Accidents Occurring Off-Site

The CBR-Offsite scenario is the only scenario which requires any off-Site hauling. Under the CBR-Offsite scenario, 31,900 vehicle travel miles are required to haul excavated materials to the off-Site landfill (Table 3.2). The United States Department of Transportation (US DOT, 2020) provides an estimate of the expected number of fatalities and injuries "per vehicle mile driven" for drivers and passengers of large trucks. Based on US DOT's statistics, 0.0041 injuries and 0.000093 fatalities are expected to occur to drivers and passengers of haul trucks due to hauling under the CBR-Offsite scenario (Table 3.4).

Table 3.4 Expected Number of Off-Site Worker Accidents Due to Hauling Under Each Closure Scenario – BAB

Closure Scenario	Injuries	Fatalities
CBR-Onsite	0	0
CBR-Offsite	0.0041	0.000093

Notes:
CBR-Onsite = Closure-by-Removal with On-Site CCR Disposal; CBR-Offsite = Closure-by-Removal with Off-Site CCR Disposal.

These estimates reflect the minimum number of worker accidents that are likely to occur off-Site under each scenario, because they do not account for the additional vehicle accidents that may occur during non-hauling activities such as labor mobilization and demobilization, equipment mobilization and demobilization, and material deliveries. The vehicle mileages associated with these off-Site activities are not known. For the BAB, both scenarios (CBR-Onsite and CBR-Offsite) have the same expected duration of construction activities, the same required earthwork volumes, similar on-Site labor hours for major construction, and a similar total number of required hauling truckloads (on-Site + off-Site). These two scenarios are therefore likely to have similar impacts with regard to off-Site vehicle accidents arising from labor and equipment mobilization/demobilization and material deliveries.

Taking into account both (i) accidents occurring on-Site due to major construction activities and (ii) accidents occurring off-Site due to hauling, an estimated 0.056 worker injuries and 0.00036 worker fatalities are expected under the CBR-Onsite scenario, and an estimated 0.054 worker injuries and 0.00042 worker fatalities are expected to occur under the CBR-Offsite scenario. Thus, overall risks to workers are likely to be of similar magnitude for both closure scenarios.

3.2.4.2 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 for large trucks reported by US DOT (2020) and the off-Site haul truck mileages reported above for the BAB, haul truck accidents could result in an estimated 0.012 injuries and 0.00043 fatalities among community members (Table 3.5). In contrast, no fatalities or injuries are expected to occur among community members under the CBR-Onsite scenarios due to haul truck accidents, because borrow soil will be taken from a location on the property and any excavated materials will be hauled to an off-Site landfill.

Table 3.5 Expected Number of Community Accidents Due to Hauling Under Each Closure Scenario – BAB

Closure Scenario	Injuries	Fatalities
CBR-Onsite	0	0
CBR-Offsite	0.012	0.00043

Notes:
CBR-Onsite = Closure-by-Removal with On-Site CCR Disposal; CBR-Offsite = Closure-by-Removal with Off-Site CCR Disposal.

In addition to impacts due to off-Site hauling, both scenarios will have off-Site impacts due to labor mobilization and demobilization, equipment and vehicle mobilization and demobilization, and material deliveries. Both scenarios are likely to have similar impacts with regard to these off-Site activities.

Traffic

Haul routes are expected to use major arterial roads and highways wherever possible, which will reduce the incidence of traffic. However, the heavy use of local roads for construction operations may result in traffic near the Site and, in the case of the CBR-Offsite scenario, the off-Site landfill.

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

Under the CBR-Offsite scenario, Golder estimates that approximately 489 truckloads will be required to transport excavated materials to the off-Site landfill over approximately 80 hauling days (Appendix B). Assuming a 10-hour work day, 6 work days per week, and 26 work days per month, a haul truck would need to pass a given location near the Site once every 49 minutes on average for the duration of excavation activities.

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." Because there are no residences or businesses within 1,500 feet of any of the construction areas on the Site (the BAB, the proposed borrow site, and the on-Site landfill), we do not anticipate that any residences or businesses will be adversely impacted by noise pollution at the Site under either closure scenario. Moreover, although there are several scenic, recreational, and historical areas located within a few miles of the Site (the Rice Lake SFWA and the Orendorf and Rice Lake Terrace Archaeological Sites), there are no notable scenic or recreational areas located within 1,500 feet of any of the construction areas on the Site. Noise impacts are therefore expected to be relatively minor at BAB under both closure scenarios.

In addition to impacts in the immediate vicinity of the BAB, local roads near the Site and the off-Site landfill (CBR-Offsite scenario only) may experience noise pollution due to truck traffic. As described above (Traffic), a haul truck must pass a given location every 49 minutes on average for 10 hours a day while excavation is occurring. 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 along local roads from the daily arrival and departure of the workforce, equipment mobilization/demobilization, and material deliveries. These impacts are expected to largely occur at the beginning or end of each work day (arrival/departure of the work force), at the beginning or end of the construction period (equipment mobilization/demobilization), and at specific times throughout the construction period (material deliveries); these impacts will therefore likely be less disruptive to community members than the constant and steady movement of haul trucks to and from the Site.

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 regards 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 used to haul material to and from the Site. Diesel exhaust contains hundreds of 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 Best Management Practices (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.

The air pollutant mass released under a given closure scenario will be proportional to the expected duration and intensity of construction activities under that scenario. For the BAB, both scenarios (CBR-Onsite and CBR-Offsite) have the same expected duration of construction activities, the same required earthwork volumes, similar on-Site labor hours for major construction, and a similar total number of required hauling truckloads (on-Site + off-Site). These two scenarios therefore most likely have similar impacts with regard to air emissions.

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, 2019). Relative to other communities, EJ communities experience an increased risk of adverse health impacts due to environmental pollution and other factors associated with remediation activities (US EPA, 2016).

As shown in a map of EJ communities throughout the state (Figure 3.1; IEPA, 2019), the on-Site landfill, and the borrow site are located within the 1-mile buffer zone of the nearest EJ community (near Canton). The BAB lies approximately 2.5 miles from the outer perimeter of this buffer zone. Due to its close proximity to the Site, the EJ community near Canton may be disproportionately impacted by air emissions, traffic, accidents and other factors arising from various closure activities occurring on or near the Site. Each of the evaluated closure scenarios requires some construction activity in at least one of these on-Site areas.

In addition to impacts arising from construction activity on or near the Site, EJ communities may be also impacted by off-Site activities, including the hauling of CCR and liner materials from the Site to the off-Site landfill, labor and equipment mobilization/demobilization, and material deliveries. Unfortunately, in addition to being located near the on-Site landfill, the borrow site, the EJ community near Canton is also located along the three primary haul routes from the Site to the off-Site landfill suggested by Google Maps (Google LLC, 2021). In summary, due to both on-Site and off-Site activities, both closure scenarios are associated with potential negative impacts on the EJ community near Canton (Figure 3.1).

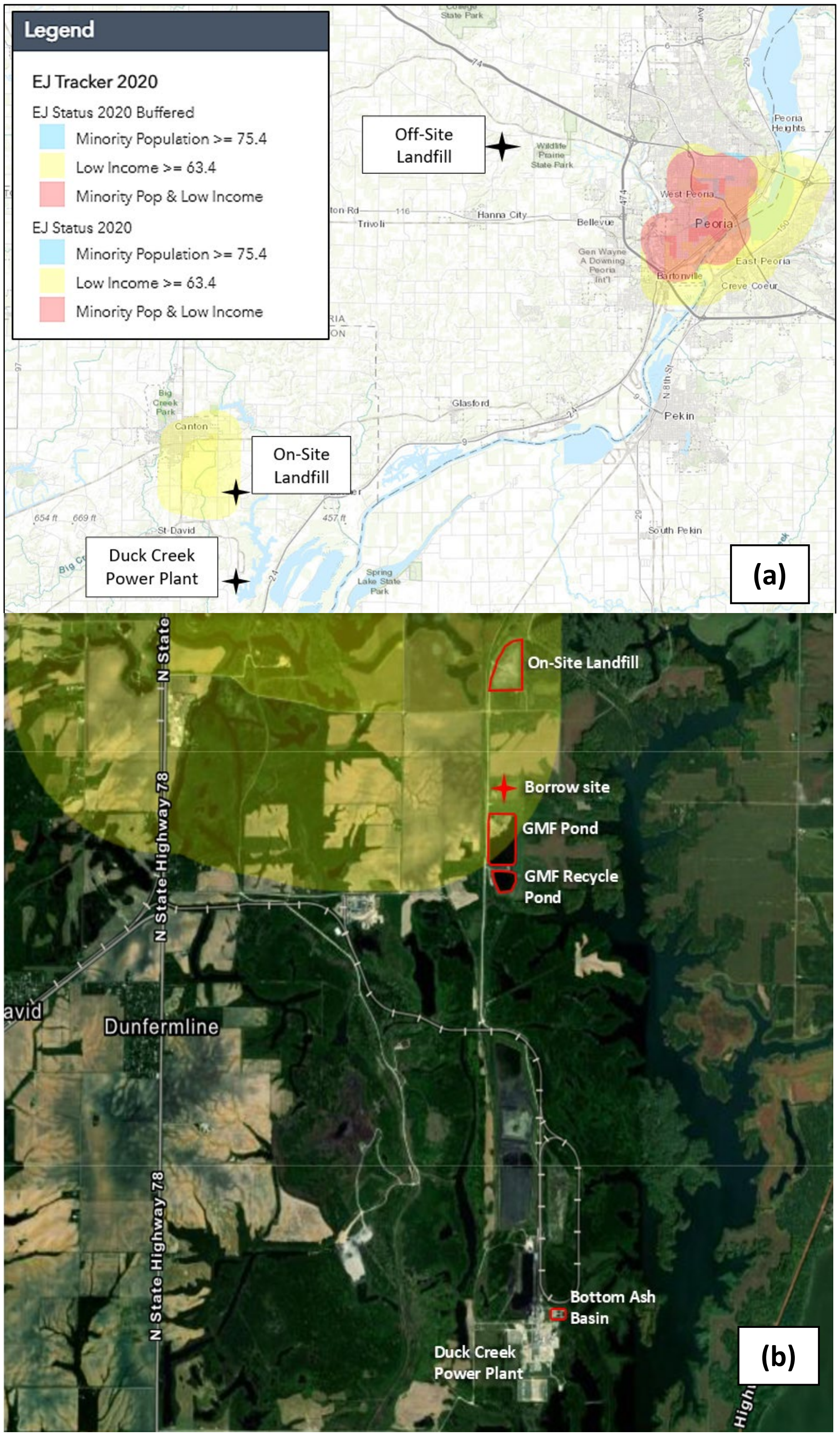

Figure 3.1 Environmental Justice Communities in the Vicinity of Site Features and the Off-Site Landfill – BAB. Adapted from IEPA (2019). (a) Regional map. (b) Site map.

Scenic, Historical, and Recreational Value

There are several scenic, recreational, and historical areas located within a few miles of the Site, including the Rice Lake SFWA and the Orendorf and Rice Lake Terrace Archaeological Sites (Google LLC, 2021; Ramboll, 2021b,c). However, there are no notable scenic or recreational areas located in the immediate vicinity of the BAB, the borrow soil location, or the on-Site landfill. The nearest scenic, recreational, or historical area is the Rice Lake SFWA, which is located over a mile away from the BAB and even further away from the borrow soil location and the on-Site landfill. We therefore do not expect construction activities at the Site to have any direct negative impacts on the scenic, historical, or recreational value of the areas listed above (due to, *e.g.*, noise, obstructions of the view, or restricted access), regardless of the closure scenario.

3.2.4.3 Environmental Risks

Greenhouse Gas Emissions

In addition to the air pollutants listed above in Section 3.2.4.2, 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 similar to the potential impact of each closure scenario on other emissions from construction vehicles and equipment, as described above in Section 3.2.4.2. For the BAB, both scenarios (CBR-Onsite and CBR-Offsite) have the same expected duration of construction activities and the same required earthwork volumes. These two scenarios therefore most likely have similar impacts with regard to GHG emissions.

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. For the BAB, energy requirements are expected to be similar under both the CBR-Onsite and CBR-Offsite scenarios.

Natural Resources and Habitat

Construction is likely to have a negative short-term impact on the natural resources and habitat in the vicinity of the BAB and the on-Site borrow soil location. Both BAB closure scenarios are expected to have similar impacts on natural resources and habitat.

The BAB is not located immediately adjacent to wetlands or notable surface water bodies, such as rivers or lakes (US FWS, 2021). For this reason, construction activities are not expected to have a significant negative impact on any wetland or aquatic species (due to, *e.g.*, erosion and sediment runoff). Impacts are expected to be limited to terrestrial species. According to the Illinois Department of Natural Resources (IDNR) Natural Heritage Database and the United States Fish & Wildlife Service (US FWS) Environmental Conservation Online System, there are 11 state threatened species, 12 state endangered species, three federally threatened species, and one federally endangered species within Fulton County (Ramboll, 2021b,c). To our knowledge, however, no threatened or endangered species have been identified at the Site (Ramboll, 2021b,c). Based on the information that is currently available, we do not expect construction activities to have negative impacts on any threatened or endangered species.

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

Based on statistical analysis and evaluation of potential exceedances, it was determined that there are no potential groundwater exceedances of applicable groundwater standards attributable to the BAB. Because there are no exceedances of the GWPS and there is no significant CCR remaining within the impoundment, modeling was not performed for either of the closure scenarios.

3.2.6 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 3.2.1 evaluates potential risks to human and ecological receptors arising from the leaching of CCR-associated constituents from the BAB. Section 3.2.2 evaluates the potential for sudden CCR releases to occur at the BAB due to, *e.g.*, dike failure or overtopping during floods or other storm-related events. In summary, under all evaluated closure scenarios, there is no current or future risk to any human or ecological receptors associated with the BAB. Additionally, there is minimal current or future risk of overtopping due to flood conditions at either impoundment. Dike failure due to, *e.g.*, seismic activity and storm-related events is also exceedingly unlikely.

Section 3.2.4 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.2.

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

As described in Section 3.2.2, there is no risk of engineering or institutional failures leading to sudden releases of CCR post-closure under either closure scenario. Additionally, there are no current or future unacceptable risks to any human or ecological receptors associated with the BAB under either closure scenario (see Section 3.2.1 above). Moreover, reliable engineering and institutional controls (*e.g.*, a bottom liner, a leachate management system, and groundwater monitoring) will be implemented at the on-Site and off-Site landfills under the CBR-Onsite and CBR-Offsite scenarios. All of the evaluated closure scenarios are therefore reliable with respect to long-term engineering and institutional controls.

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

At this time, we do not anticipate a need for corrective action at the BAB under any closure scenario.

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

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

There are no unacceptable risks to human health or the environment associated with the BAB (Section 3.2.1). Because current conditions do not present a risk to human health or the environment, and because groundwater concentrations are expected to remain stable and/or decline post-closure, there will also be no unacceptable risks to human health or the environment following closure of the impoundments, regardless of the closure scenario.

Section 3.2.2 discussed the potential for dike failure or flood overtopping to occur during or following closure activities, resulting in a sudden release of CCR. That analysis showed that there is no risk of CCR releases occurring at the BAB following closure under either closure scenario.

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

At this time, we do not anticipate a need for the use of treatment technologies other than source control (*i.e.*, CBR-Onsite, and CBR-Offsite) at the BAB under either closure scenario.

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

3.4.1 Degree of Difficulty Associated with Constructing the Closure Alternative

Excavation and landfilling of CCR is a reliable and standard method for closing impoundments. Hauling will be easier to implement under the CBR-Onsite scenario than under the CBR-Offsite scenario, due to less haul traffic on public roadways. As described in Section 3.2.4.2 ("Community Impacts"), off-Site hauling may also have detrimental impacts due to an increased incidence of vehicle accidents, truck traffic, noise, and air pollution.

3.4.2 Expected Operational Reliability of the Closure Alternative

The operational reliability of the CBR-Onsite scenario and the CBR-Offsite scenario is expected to be similar. CCR and liner system materials excavated from the BAB will similarly be fully contained after final disposal, regardless of which closure scenario is chosen. The operational reliability of all both closure scenarios is therefore expected to be similar. Moreover, high operational reliability is expected under both scenarios due to the full containment of CCR and liner materials.

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

Regulatory approval will be needed under all closure scenarios. An SWPPP will also be required for all closure scenarios. A land disturbance permit may also be required for all scenarios. Relative to the CBR-

Onsite scenario, an additional permit and approval may be required under the CBR-Offsite scenario for waste transport.

3.4.4 Availability of Necessary Equipment and Specialists

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. The current shortage of truck drivers may be particularly impactful under the CBR-Offsite scenario, due to the materials that will be hauled from the Site. If sufficient trucks and truck drivers are not available, delays in the construction schedule may arise.

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

The existing landfill on the Duck Creek property has sufficient capacity to receive all of the CCR and liner materials that are currently slated for landfilling under the CBR-Onsite scenario. Under the CBR-Offsite scenario, approximately 7,000 cubic yards of materials excavated from the BAB will require disposal at an off-Site landfill. 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 Peoria City-County Landfill in Brimfield, Illinois. This facility has 750,000 cubic yards of remaining capacity in its current permitted footprint. It receives 230,000 cubic yards of waste annually, and is located 33 miles from the Site. The Peoria City-County Landfill therefore has sufficient capacity to receive all of the CCR and liner materials from the BAB.

3.5 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 of this report), modeled surface water concentrations in the Illinois River are all below relevant human health and ecological screening benchmarks. Post-closure, surface water concentrations of CCR-associated constituents are expected to remain stable and/or decline over time under both closure scenarios. Thus, no future exceedances of any human health or ecological screening benchmarks are anticipated under either closure scenario. Additionally, the lined landfills that will receive any materials excavated from the BAB under the CBR-Onsite and CBR-Offsite scenarios will be managed to ensure that no surface water impacts occur in the vicinity of the landfills.

3.6 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 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). Most of the CCR that was historically contained within the BAB has already been excavated from the impoundment; no significant CCR remains. Moreover, only CBR is being considered at this impoundment. Thus, both closure scenarios (CBR-Offsite and CBR-Onsite) are equally responsive to community concerns regarding potential groundwater and surface water impacts.

3.7 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 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).

3.8 Summary

Table S.2 (Summary of Findings) summarizes the expected impacts of CBR-Onsite and CBR-Offsite closure scenarios for the BAB 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 3 above, CBR-Onsite has been identified as the most appropriate closure scenario for the BAB. Key benefits of CBR-Onsite at the BAB closure scenario are that no off-Site hauling of CCR is required and, consequently, there would be reduced impacts to the community compared to CBR-Offsite. 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 December 2021 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 Duck Creek Power Plant Gypsum Management Facility (GMF) and Bottom Ash Basin (BAB) Canton, Illinois

November 7, 2021

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Abbreviations

BAB	Bottom Ash Basin
bgs	Below Ground Surface
CAA	Closure Alternatives Assessment
CCR	Coal Combustion Residual
CEM	Conceptual Exposure Model
COI	Constituent of Interest
COPC	Constituent of Potential Concern
CSM	Conceptual Site Model
DCCP	Duck Creek Cooling Pond
DCPP	Duck Creek Power Plant
DWW	Drinking Water Watch
ESV	Ecological Screening Value
GMF	Gypsum Management Facility
GWPS	Groundwater Protection Standard
IAC	Illinois Administrative Code
ID	Identification
IEPA	Illinois Environmental Protection Agency
ILWATER	Illinois Water and Related Wells
IPRG	Illinois Power Resources Generating, LLC
ISGS	Illinois State Geological Survey
K_d	Equilibrium Partitioning Coefficient
NGWMN	National Groundwater Monitoring Network
NID	National Inventory of Dams
No.	Number
NPDES	National Pollutant Discharge Elimination System
SDWIS	Safe Drinking Water Information System
SI	Surface Impoundment
TEC	Threshold Effect Concentration
US DOE	United States Department of Energy
US EPA	United States Environmental Protection Agency
USGS	United States Geological Survey

1 Introduction

The Duck Creek Power Plant (DCPP, or "the Site") is an electric power-generating facility with coal-fired units located in Fulton County, Illinois, approximately 6 miles southeast of the town of Canton. The DCPP is owned by Illinois Power Resources Generating, LLC (IPRG). The facility began operation in 1976 and was retired in December 2019 (AECOM, 2016; Golder, 2021). The DCPP produced and stored coal combustion residuals (CCRs) as a part of its historical operations in several CCR ash ponds located north and east of the power plant. Two ash ponds are planned for closure and are the subject of this report; these include the Gypsum Management Facility (GMF; Vistra identification [ID] number [No.] 203, Illinois Environmental Protection Agency (IEPA) ID No. W0578010001-04, and National Inventory of Dams [NID] No. IL50573) and the Bottom Ash Basin (BAB; Vistra ID No. 205, IEPA ID No. W0578010001-03, and NID No. IL50716) (Vistra Energy Corp, 2021). The BAB is an inactive 2.2-acre lined CCR surface impoundment (SI) formerly used to manage CCR and non-CCR waste streams at the DCPP. The BAB consisted of three cells; the bottom and side slopes of all three cells are concrete lined. All bottom ash (*i.e.,* CCR) was removed from the BAB when the plant was retired; thus, the BAB currently contains no impounded water or CCR materials (Ramboll, 2021a). The GMF is located 2.4 miles north of the power plant, in Section 18 of Township 6 North, Range 5 East. The GMF is a 1,500 ft × 900 ft earthen berm double-lined CCR SI, which retains wet-sluiced gypsum produced in the flue-gas scrubber. The decant water from the GMF discharges to the lined GMF Recycle Pond located to the south of the GMF (Ramboll, 2021b). The Duck Creek Cooling Pond (DCCP) is a 719-acre surface water body (US Fish and Wildlife Service, 1983) located downgradient of the BAB and GMF. The DCCP was formed by damming Duck Creek (Ramboll, 2021a,b). The DCCP is part of the plant property and was used as a source of cooling water for the power plant when it was active. Currently, land adjacent to the DCPP is used for agriculture, pasture, and forest with minimal development (Ramboll, 2021b).

This report presents the results of an evaluation that characterizes potential risks to human and ecological receptors that may be exposed to CCR constituents in environmental media potentially impacted by the GMF and BAB. This risk evaluation was performed to support the Closure Alternatives Assessment (CAA) for the GMF and BAB in accordance with requirements in Title 35, Part 845, of the Illinois Administrative Code (IAC) (IEPA, 2021a). While this report specifically evaluates current risks, it also informs potential future risks under the different closure scenarios. Human and ecological risks were evaluated for Site-specific constituents of interest (COIs) that have the potential to migrate to the DCCP and affect DCCP surface water and sediment.

Consistent with United States Environmental Protection Agency (US EPA) guidance (US EPA, 1989), we 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: Compare maximum detected groundwater concentrations over the period from 2015 to 2021 to groundwater protection standards (GWPSs) listed in Title 35, Part 845.600 of the IAC (IEPA, 2021a), and relevant surface water quality standards (IEPA, 2019; US EPA, 2018).
3. 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. 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, 2013a, 2019), incorporating principles and assumptions consistent with the Federal CCR Rule (US EPA, 2015) and US EPA's "Human and Ecological Risk Assessment of Coal Combustion Residuals" (US EPA, 2014).

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

- No complete exposure pathways were identified for human receptors such as recreators.
- 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 and BAB 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.

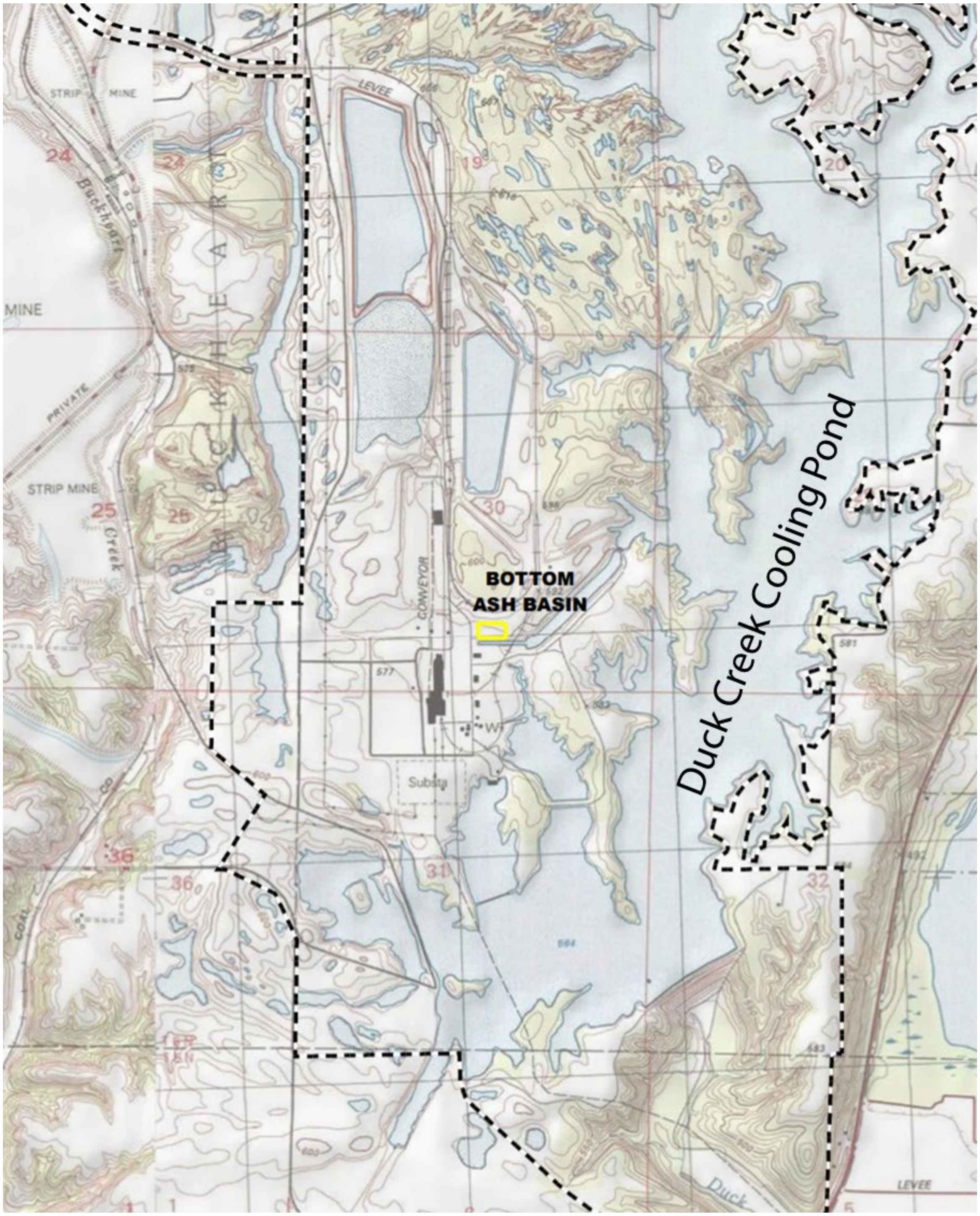

Figure 1.1 Location of BAB. BAB = Bottom Ash Basin; DCPP = Duck Creek Power Plant. DCPP property outline is shown with a dashed line. Source: Ramboll (2021c).

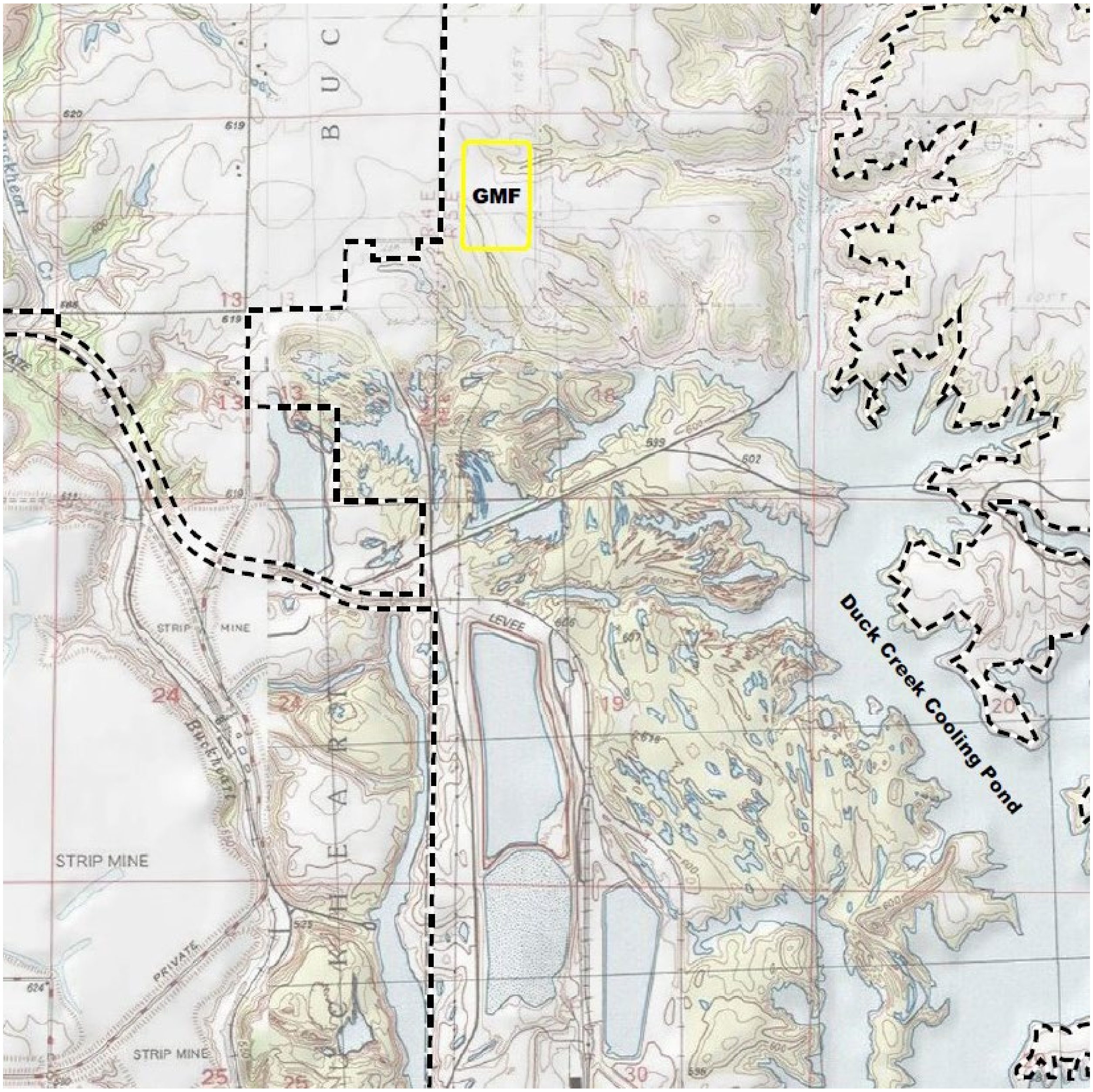

Figure 1.2 Location of GMF. DCPP = Duck Creek Power Plant; GMF = Gypsum Management Facility. DCPP property outline is shown with a dashed line. Source: Ramboll (2021d).

2 Site Overview

2.1 Site Description

2.1.1 Bottom Ash Basin (BAB)

Geology/Hydrogeology

The BAB is located just northeast of the DCPP. The geology underlying the Site in the vicinity of the BAB primarily consists of unconsolidated unlithified materials of loess and till deposits that overlie a Pennsylvanian-age shale bedrock unit (Ramboll, 2021a). Previous investigations completed outside of the BAB indicate that bedrock in the area is overlain by deposits of coal mine spoils[1] (AECOM, 2016). The DCCP, located approximately 500 ft to the east of the BAB, is the nearest major surface water body that is hydraulically downgradient of the BAB. The DCCP water flows south into Duck Creek *via* National Pollutant Discharge Elimination System (NPDES) outfalls and ultimately drains into the Illinois River (IEPA, 2013b).

Two distinct hydrostratigraphic units were identified near the BAB: (a) the uppermost aquifer and (b) a confining shale bedrock unit. A detailed description of these two units is provided below.

The uppermost aquifer consists of loess and till (Ramboll, 2021a). The most permeable portion of the uppermost aquifer is a 2- to 7-feet-thick sand layer located within the till. This sand unit, encountered at a depth of 18-40 ft below ground surface (bgs), forms the primary conduit for horizontal migration of shallow groundwater near the BAB (Ramboll, 2021a).

The geometric mean of field hydraulic conductivities measured in the uppermost aquifer is about 6.33×10^{-4} cm/sec (Ramboll, 2021a). However, the more permeable sand layer within the till has an average conductivity value of 3.4×10^{-2} cm/sec. Groundwater in the uppermost aquifer flows in the south-southeasterly direction toward the DCCP at a velocity of approximately 0.04 ft/day[2] (Ramboll, 2021a). An average horizontal hydraulic head gradient of approximately 0.01 ft/ft was estimated within the uppermost aquifer near the BAB[3] (Ramboll, 2021a).

Shale bedrock lies beneath the unconsolidated deposits between 26 and 46 ft bgs (Ramboll, 2021a). The bedrock acts as an aquitard with mean hydraulic conductivity values ranging between 2×10^{-6} and 9×10^{-6} cm/sec (AECOM, 2016; Ramboll, 2021a). Bedrock packer tests within the top 100 ft yielded virtually no water (AECOM, 2016). These results, indicate that the shale bedrock is a significant barrier to vertical migration of groundwater.

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[1] Several large-scale surface water coal mine operations had been reported in the vicinity of the BAB since the 1930s (AECOM, 2016; Ramboll, 2021); however, those mining activities ceased by 1984 (AECOM, 2016).
[2] The average velocities measured between BA05 and BA04, BA01 and BA03, and BA06 and BA02 were 0.032, 0.050, and 0.030 ft/day, respectively (Ramboll, 2021).
[3] The average head gradients measured between BA05 and BA04, BA01 and BA03, and BA06 and BA02 were 0.0132, 0.0062, and 0.0078 ft/ft, respectively (Ramboll, 2021).

2.1.2 Gypsum Management Facility (GMF)

Geology/Hydrogeology

The GMF is located 2.4 miles north of the DCPP. The geology underlying the Site near the GMF primarily consists of unlithified materials of loess and till deposits that overlie a Pennsylvanian-age shale bedrock unit (Ramboll, 2021b,e; Natural Resource Technology, 2017). The unlithified deposits are present in former coal mine spoils and form shallow water-bearing units beneath the GMF (Ramboll, 2021e; Natural Resource Technology, 2017).

Much of the surface water drainage in the vicinity of the GMF flows into the DCCP (Natural Resource Technology, 2017). The DCCP water drains into Duck Creek *via* NPDES-permitted outfalls and ultimately discharges to the Illinois River (IEPA, 2013b).

The three major hydrostratigraphic units near the GMF are: (a) the uppermost aquifer, (b) the lower confining unit, and (c) the shale bedrock confining unit. A detailed description of these three units is provided below.

Shallow groundwater occurs within two unconsolidated water-bearing units that form the uppermost aquifer: (i) the Peoria/Roxanna loess zone and (ii) the shallow sand unit (Ramboll, 2021b,e; Natural Resource Technology, 2017). The Peoria/Roxanna loess zone, composed of silt, silty-clay, and minor amounts of sand, is hydraulically connected to the 1- to 18-ft-thick shallow sand unit that is laterally extensive across the Site (Ramboll, 2021b,e; Natural Resource Technology, 2017). The shallow sand unit is the primary conduit for horizontal migration of shallow groundwater (Ramboll, 2021b). The geometric mean of field-measured hydraulic conductivities within the uppermost aquifer in the GMF area is 3.58×10^{-4} cm/sec (Ramboll, 2021b).

Groundwater in the uppermost aquifer flows to the east-southeast toward the DCCP from topographically high- to low-lying areas (Ramboll, 2021b; Natural Resource Technology, 2017). Groundwater in the uppermost aquifer flows at a velocity of approximately 0.24 ft/day[4] (Ramboll, 2021b). An average horizontal hydraulic head gradient of approximately 0.02 ft/ft was estimated within the uppermost aquifer near the GMF[5] (Ramboll, 2021b).

The lower confining unit consists of till that underlies the uppermost aquifer (Natural Resource Technology, 2017). The till layer restricts vertical migration of groundwater due to its low hydraulic conductivity value of 1.9×10^{-7} cm /sec (Ramboll, 2021b; Natural Resource Technology, 2017). Shale bedrock lies beneath the till in this area (Natural Resource Technology, 2017; Ramboll, 2021e). The bedrock is not hydraulically connected to the uppermost aquifer due to the presence of the till (Natural Resource Technology, 2017).

2.2 Conceptual Site Model

A Conceptual Site Model (CSM) describes the sources of contamination, hydrogeological units, and physical processes that control the transport of water and solutes. In this case, the CSM describes how groundwater underlying the BAB and GMF may migrate and interact with surface water and sediment in

[4] The average groundwater velocities measured between G50S and G64S, G50S and G60S, and G51S and G54S were 0.045, 0.625, and 0.041 ft/day, respectively (Ramboll, 2021b). [5] The average head gradients measured between G50S and G64S, G50S and G60S, and G51S and G54S were 0.0121, 0.0172, and 0.0199 ft/ft, respectively (Ramboll, 2021b).

[5] The average head gradients measured between G50S and G64S, G50S and G60S, and G51S and G54S were 0.0121, 0.0172, and 0.0199 ft/ft, respectively (Ramboll, 2021b).

the adjacent DCCP. The CSM was developed using available hydrogeological data (Natural Resource Technology, 2017; Ramboll, 2021e), including information on groundwater flow and surface water characteristics.

Near the BAB, shallow groundwater flows through the uppermost aquifer in a southward direction toward a surface water channel, located about 50 ft to the south, that leads to the DCCP (Ramboll, 2021a). The primary horizontal migration pathway is within the sand layers of the uppermost aquifer. Groundwater flows horizontally rather than vertically through the uppermost aquifer because: (i) vertical hydraulic conductivities within the uppermost aquifer are several orders of magnitude lower than horizontal hydraulic conductivities, and (ii) the underlying shale bedrock acts as an aquitard preventing downward migration (AECOM, 2016; Ramboll, 2021a). Groundwater within the uppermost aquifer near the BAB flows into the DCCP. No other potential groundwater transport pathways exist. At its discharge location, groundwater mixes with surface water in the DCCP. Because the DCCP serves as a sink for groundwater discharge in the area, shallow groundwater migration beneath or beyond the DCCP is unlikely.

Near the GMF, shallow groundwater flows horizontally through the uppermost aquifer from northwest to southeast toward the DCCP (Natural Resource Technology, 2017; Ramboll, 2021b,e). The preferential flow of groundwater is horizontal rather than vertical because the underlying till and shale bedrock restrict groundwater flow (Natural Resource Technology, 2017). Groundwater within the uppermost aquifer near the GMF flows into the DCCP. No other potential groundwater transport pathways exist. At its discharge location, groundwater mixes with surface water in the DCCP. Because the DCCP serves as a sink for groundwater discharge in the area, shallow groundwater migration beneath or beyond the DCCP is unlikely.

2.3 Groundwater Monitoring

The analyses presented in this report relied upon the data from the wells used to monitor the BAB and GMF. A total of ten wells were used to monitor the BAB (Table 2.1); of these, six wells are screened in the uppermost aquifer (UA), one well is screened in the bedrock unit (BR), and three wells are screened in a sandy layer within the uppermost aquifer that has been identified as the primary conduit for groundwater flow (Ramboll, 2021a). A total of 31 wells were used to monitor the GMF (Table 2.2); of these, 15 wells are screened in the uppermost aquifer (UA), 1 well is screened in the BR, 13 wells are screened in a sandy layer within the uppermost aquifer that has been identified as the primary conduit for groundwater flow; and the location of 2 wells is unspecified (Ramboll, 2021b).

The analyses presented in this report relied on all available data from the specified wells collected between 2015 and 2021, which is the period subsequent to the promulgation of the Federal CCR Rule (US EPA, 2015). Groundwater samples were analyzed for a suite of constituents specified in Illinois CCR Rule Part 845.600 (IEPA, 2021a). A summary of the groundwater data used in this risk evaluation is presented in Table 2.3 (for the BAB) and Table 2.4 (for the GMF).

Table 2.1 Groundwater Monitoring Wells Related to the BAB

Well	Date Constructed	Screen Top Depth (ft bgs)	Screen Bottom Depth (ft bgs)	Well Depth from Ground Surface (ft bgs)	Hydrogeologic Unit[a]
BA01	12/16/2015	33.06	37.73	38.20	UA
BA01C	02/08/2021	35.81	45.26	45.90	BR
BA01L	02/05/2021	11.90	21.37	22.15	UA-PMP
BA02	12/30/2015	23.63	28.43	28.80	UA
BA02L	02/04/2021	6.98	11.66	12.09	UA-PMP
BA03	12/29/2015	16.11	25.57	26.20	UA
BA03L	02/02/2021	5.25	9.94	10.29	UA-PMP
BA04	12/29/2015	24.58	29.38	29.80	UA
BA05	07/28/2016	36.48	46.08	46.60	UA
BA06	08/03/2016	32.32	41.93	42.40	UA

Notes:
BAB = Bottom Ash Basin; bgs = Below Ground Surface.
(a) BR = bedrock unit; UA = uppermost aquifer; UA-PMP = sandy layer within the uppermost aquifer that has been identified as the primary conduit for groundwater flow.

Table 2.2 Groundwater Monitoring Wells Related to the GMF

Well Number	Date Constructed	Screen Top Depth (ft bgs)	Screen Bottom Depth (ft bgs)	Well Depth (ft bgs)	Hydrogeologic Unit
G02S	09/29/2003	23.00	28.00	28.00	UA
G50S	03/13/2007	–	33.98	34.30	UA
G51L	01/28/2008	12.04	16.83	17.21	UA-PMP
G51S	01/28/2008	24.01	28.79	29.16	UA
G52L	01/22/2008	29.21	33.80	34.17	UA-PMP
G52S	01/22/2008	39.15	43.93	44.20	UA
G53L	02/05/2009	16.97	26.32	26.79	UA-PMP
G53S	02/05/2009	30.64	35.13	35.56	UA
G54C	02/05/2021	91.59	101.50	102.00	BR
G54L	02/12/2009	27.32	36.75	37.22	UA-PMP
G54S	02/12/2009	43.50	47.97	48.41	UA
G55L	02/19/2009	36.12	36.60	36.60	UA-PMP
G55S	02/19/2009	41.04	45.49	45.96	UA
G56L	02/16/2009	13.77	22.11	22.89	UA-PMP
G56S	02/16/2009	33.17	37.66	38.29	UA
G57L	01/30/2009	16.17	25.62	26.00	UA-PMP
G57S	01/30/2009	29.65	34.18	34.62	UA
G58L	01/26/2009	20.69	30.10	30.56	UA-PMP
G58S	01/26/2009	31.32	35.80	36.43	UA
G59L	01/23/2009	22.91	32.33	33.03	UA-PMP
G59S	01/23/2009	37.38	41.88	42.49	UA
G60L	01/17/2008	20.12	24.91	25.28	UA-PMP
G60S	01/16/2008	31.12	35.91	36.29	UA
G61S	01/21/2009	30.19	34.63	35.26	UA
G62L	01/22/2009	20.31	29.66	30.12	UA-PMP
G63L	02/02/2009	18.47	27.89	28.36	UA-PMP
G63S	02/02/2009	34.52	39.01	39.47	UA
G64L	01/22/2009	18.12	27.48	27.95	UA-PMP
G64S	01/22/2009	34.50	38.99	39.48	UA
P60	03/15/2017	29.55	34.14	34.60	–
R61L	03/14/2017	18.54	28.17	28.70	–

Notes:
bgs = Below Ground Surface; GMF = Gypsum Management Facility.
(a) – = data not available; BR = bedrock; UA = uppermost aquifer; UA-PMP = sandy layer within the uppermost aquifer that has been identified as the primary conduit for groundwater flow.

Figure 2.1 Groundwater Monitoring Well Locations – BAB. BAB = Bottom Ash Basin. Source: Ramboll US Corp. (2021a).

Figure 2.2 Groundwater Monitoring Well Locations – GMF. GMF = Gypsum Management Facility. Adapted from: Ramboll US Corp. (2021b).

Table 2.3 Groundwater Data Summary – BAB, 2015-2021

Constituent	Samples with Constituent Detected	Samples Analyzed	Minimum Detect	Maximum Detect	Maximum Detection Limit
Total Metals (mg/L)					
Antimony	0	80	–	–	0.003
Arsenic	61	80	0.001	0.024	0.001
Barium	80	80	0.046	0.48	0.001
Beryllium	4	80	0.0015	0.0068	0.001
Boron	128	128	0.017	7.8	0.015
Cadmium	0	80	–	–	0.001
Chromium	17	80	0.0044	0.073	0.004
Cobalt	29	80	0.002	0.037	0.002
Lead	34	80	0.0011	0.042	0.001
Lithium	10	80	0.011	0.068	0.02
Mercury	3	80	0.0002	0.0012	0.0002
Molybdenum	77	80	0.001	0.015	0.001
Selenium	12	80	0.0011	0.015	0.001
Thallium	1	80	0.001	0.001	0.001
Dissolved Metals (mg/L)					
Arsenic	1	2	0.0045	0.0045	0.001
Radionuclides (pCi/L)					
Radium-226+228	76	76	0.0508	9.64	0.944
Other (mg/L, unless otherwise specified)					
Chloride	127	128	2	700	250
Fluoride	71	128	0.25	0.692	0.25
pH (SU)	136	136	6.2	7.7	–
Sulfate	128	128	1.3	890	250
Total Dissolved Solids	128	128	200	2,300	26

Note:
– = Not Applicable; BAB = Bottom Ash Basin; SU = Standard Unit.

Table 2.4 Groundwater Data Summary – GMF, 2015-2021

Constituent	Samples with Constituent Detected	Samples Analyzed	Minimum Detect	Maximum Detect	Maximum Detection Limit
Total Metals (mg/L)					
Antimony	2	82	0.0037	0.0064	0.003
Arsenic	118	182	0.001	0.051	0.001
Barium	82	82	0.014	0.47	0.001
Beryllium	2	82	0.0013	0.0027	0.001
Boron	217	237	0.01	1.9	0.01
Cadmium	1	83	0.0016	0.0016	0.001
Chromium	7	82	0.0052	0.015	0.004
Cobalt	11	82	0.0021	0.0052	0.002
Lead	79	182	0.0011	0.041	0.001
Lithium	4	82	0.01	0.018	0.02
Mercury	4	82	0.00021	0.0004	0.0002
Molybdenum	42	82	0.001	0.041	0.001
Selenium	4	82	0.0013	0.0031	0.001
Thallium	3	82	0.001	0.0033	0.001
Dissolved Metals (mg/L)					
Antimony	4	665	0.0034	0.012	0.003
Arsenic	209	672	0.001	0.035	0.002
Barium	665	665	0.0076	0.47	0.001
Beryllium	0	18	–	–	0.001
Boron	561	666	0.011	3	0.02
Cadmium	7	666	0.0012	0.0085	0.002
Chromium	20	665	0.0043	0.041	0.004
Cobalt	63	642	0.0021	0.028	0.002
Lead	20	666	0.0011	0.19	0.002
Lithium	0	5	–	–	0.01
Mercury	2	665	0.00024	0.00026	0.0002
Selenium	19	107	0.0011	0.25	0.001
Radionuclides (pCi/L)					
Radium-226+228	83	83	0	5.38	5
Other (mg/L, unless otherwise specified)[a]					
Chloride	228	230	1.1	75	50
Fluoride	86	139	0.25	0.465	0.25
pH (SU)	299	299	6.1	7.5	–
Sulfate	231	232	1.2	540	250
Total Dissolved Solids	134	134	280	900	26

Note:
– = Not Applicable; GMF = Gypsum Management Facility; SU = Standard Unit
(a) Results for analytes in the "other" group are based on unfiltered samples.

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 and BAB 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, 2013a, 2019).

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

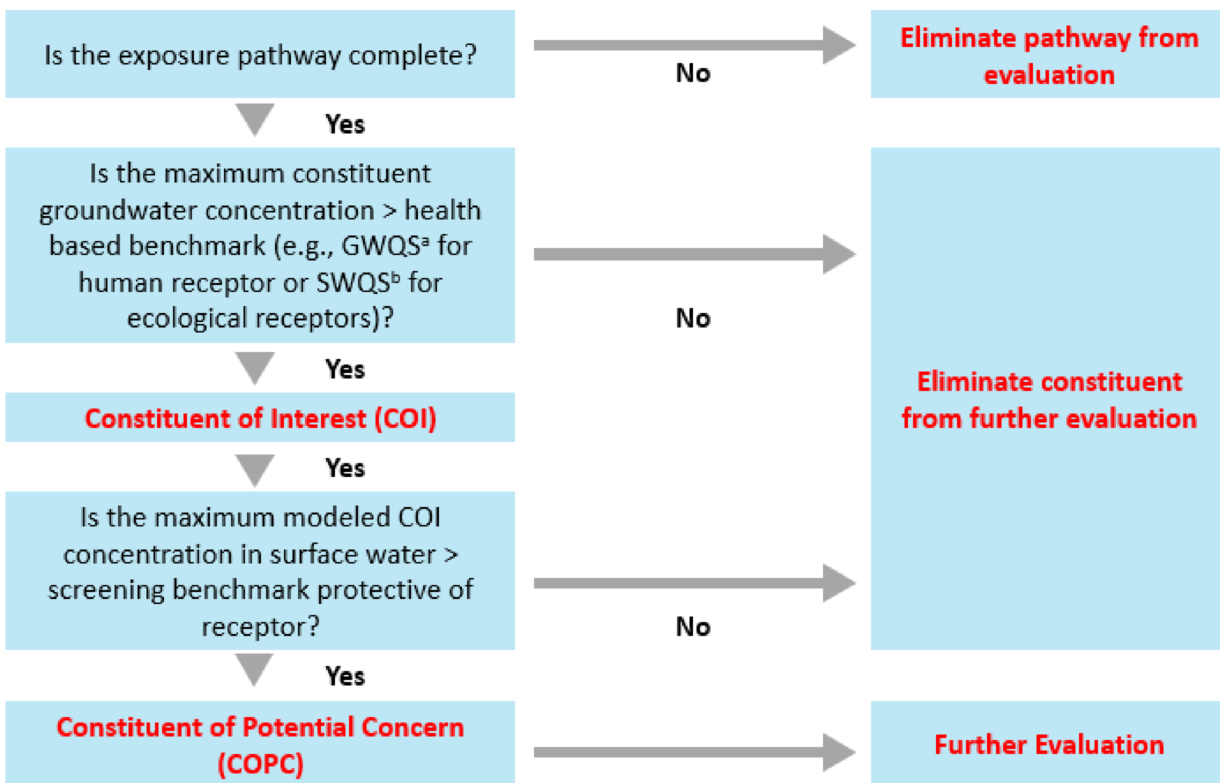

Figure 3.1 Overview of Risk Evaluation Methodology. CCR = Coal Combustion Residuals; COI = Constituent of Interest; IEPA = Illinois Environmental Protection Agency; GWQS = Groundwater Quality Standard; SWQS = Surface Water Quality Standard; US EPA = United States Environmental Protection Agency. (a) The Illinois CCR Rule Part 845.600 GWPS are used to identify human health COIs if human health exposure pathways are complete. (b) IEPA SWQS protective of chronic exposures are used to identify ecological COIs. In the absence of a SWQS, US EPA Region IV ecological screening values are 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 are incomplete were excluded from the evaluation. As described in Section 3.2, none of the human exposure pathways were considered complete; therefore, risks to human health were not evaluated further.

The risk assessment evaluated ecological risks in the DCCP. Ecological COIs were identified as constituents with maximum concentrations in groundwater in excess of a surface water quality standard (SWQS) for ecological receptors. Based on the CSM (Section 3.2.2), groundwater underlying the BAB and GMF flows east into the DCCP. Therefore, any potential CCR-related constituents in groundwater would flow toward and discharge into the DCCP.

Surface water and sediment samples have not been collected from the DCCP. Therefore, Gradient modeled the potential migration of COIs from groundwater to surface water and sediment to evaluate potential risks to ecological receptors (see Section 3.3.3). Gradient modeled the COI concentrations in surface water and sediment separately for BAB and GMF, based on the groundwater data from the wells associated with those two CCR management units. The modeled COI concentrations in surface water and sediment were compared to conservative, generic risk-based screening benchmarks for ecological receptors. These generic screening benchmarks rely on default assumptions with limited consideration of Site-specific characteristics. Ecological benchmarks are medium-specific values designed to be protective of all potential ecological receptors exposed to surface water. Ecological 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 modeled COI concentration exceeding a screening benchmark does not indicate an unacceptable risk, but does indicate 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 BAB and GMF do not pose an unacceptable ecological risk. That is, after the screening step, no COPCs were identified and further assessment was not warranted.

3.2 Human Conceptual Exposure Model

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.

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 BAB and the GMF into groundwater, surface water, sediment, and fish. The following human receptors and exposure pathways were considered for inclusion in the Site-specific CEM.

- Residents – exposure to groundwater/surface water as drinking water
- Residents – exposure to groundwater/surface water used for irrigation
- Recreators in the DCCP to the east of 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 *via* consumption of locally caught fish

3.2.1 Exposure from Recreational Activities in Surface Water

As shown in Figure 3.2, all of the exposure pathways related to recreational activities in surface water were considered incomplete, and thus were not evaluated in this risk assessment. Groundwater beneath the BAB and GMF flows into the DCCP. The DCCP is owned by IPRG, and access to it is restricted, thus the DCCP is not used for any recreational activities, including boating, swimming, or fishing.

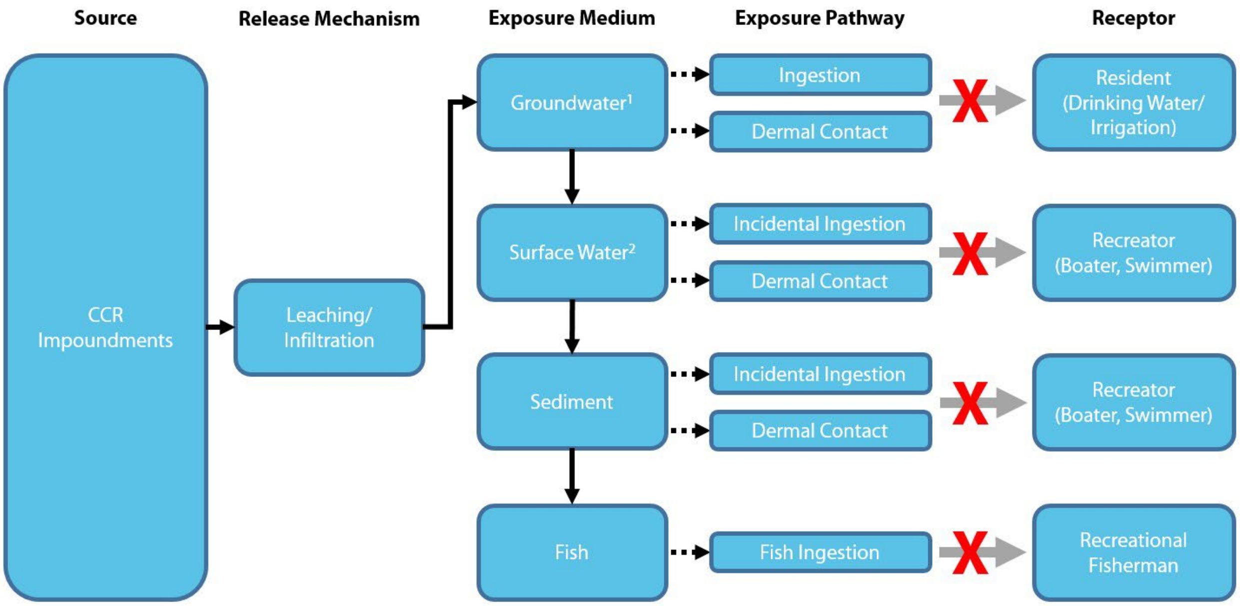

Figure 3.2 Human Conceptual Exposure Model. CCR = Coal Combustion Residual. Dashed line/Red X = Incomplete or insignificant exposure pathway. (1) Groundwater in the vicinity of the Site is not used as a drinking water or irrigation source. (2) Surface water is not used as a drinking water source.

3.2.2 Exposure from Groundwater or Surface Water as a Drinking Water/Irrigation Source

The following sections explain why the residential drinking water and irrigation pathways are incomplete.

3.2.2.1 BAB

Groundwater as a source of drinking water and/or irrigation water is not a complete exposure pathway for potential CCR-related constituents that originated from the BAB. Specifically, shallow groundwater from the uppermost aquifer in the vicinity of the BAB is not used as a source of drinking water, and no public groundwater systems are downgradient of the DCPP. Further, the downward migration of groundwater from the uppermost aquifer is largely restricted due to the presence of a thick, shale bedrock unit (Ramboll, 2021a; AECOM, 2016). A summary of the evidence supporting the conclusion that residential uses of the shallow groundwater and DCCP water adjacent to the BAB as sources of drinking water are incomplete exposure pathways is presented below.

- **No potential groundwater receptors are in the vicinity of the BAB**. To identify drinking water receptors within a 1,000 m radius of the BAB, a potable water well survey was completed in 2021 utilizing the following federal and state databases (as cited in Ramboll, 2021a): United States Geological Survey (USGS) National Groundwater Monitoring Network (NGWMN) (USGS, 2021); Illinois State Geological Survey (ISGS) Illinois Water and Related Wells (ILWATER) Map (ISGS, 2020); US EPA Safe Drinking Water Information System (SDWIS) (US EPA, 2021); and IEPA Illinois Drinking Water Watch (DWW) (IEPA, 2021b).
    - No potable public supply wells or intakes were identified within a 1,000 m radial distance from the BAB (Ramboll, 2021a).
    - In a prior investigation, only one water supply well was detected one mile north-northwest of Ash Pond 2, but that well is not located downgradient of the BAB (AECOM, 2016).
- **There is no potential off-Site migration of constituents in groundwater to nearby wells because all shallow groundwater discharges into the DCCP.** The DCCP is the discharge point for groundwater from the uppermost aquifer. Groundwater hydraulic head measurements in the uppermost aquifer indicate that groundwater flows southward toward a channel that is connected to the DCCP (Ramboll, 2021a). Because the DCCP serves as the regional groundwater discharge location in the area, constituents present in groundwater are not likely to migrate underneath or beyond the DCCP.
- **The DCCP adjacent to the Site is not used as a public water supply.** The DCCP is owned and maintained by IPRG. IPRG restricts the use of the pond as a source of drinking water or for recreation. Therefore, the human exposure pathway *via* surface water ingestion in the DCCP was not evaluated further.
- **The uppermost aquifer has a limited hydraulic connection to the underlying bedrock unit.** The bedrock acts as an aquitard with mean hydraulic conductivity values ranging between 2×10^{-6} and 9×10^{-6} cm /sec (AECOM, 2016; Ramboll, 2021a) and bedrock packer tests within the top 100 ft yielded virtually no water (AECOM, 2016). Based on these results, it was concluded that the shale bedrock is a significant barrier to groundwater migration.

3.2.2.2 GMF

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. Specifically, shallow groundwater from the uppermost aquifer in the vicinity of the GMF is not used as a source of drinking water, and no public groundwater systems are downgradient of Duck Creek. Additionally, the downward migration of groundwater from the uppermost water-bearing unit is largely restricted due to the presence of underlying low-permeability till and shale bedrock. A summary of the evidence supporting the conclusion that residential uses of the shallow groundwater and DCCP water adjacent to the GMF as sources of drinking water are incomplete exposure pathways is presented below.

- **No potential groundwater receptors are in the vicinity of the GMF.** To identify drinking water receptors within a 1,000 m radius of the GMF, a potable water well survey was completed in 2021 utilizing the following federal and state databases (Ramboll, 2021b): USGS NGWMN (USGS, 2021); ISGS ILWATER Map (ISGS, 2020); US EPA SDWIS (US EPA, 2021); and IEPA Illinois DWW (IEPA, 2021b).

- One private well was identified within a 1,000 m radial distance from the GMF (Ramboll, 2021b). However, the well is located southwest of the GMF, while the groundwater flow within the uppermost aquifer is toward the southeast (Ramboll, 2021b); therefore, this well is not considered to be downgradient of the GMF (Ramboll, 2021b).

- **There is no off-Site groundwater migration to any off-Site wells because all shallow groundwater flows into the DCCP.** The DCCP is the discharge point for groundwater from the uppermost aquifer. Groundwater hydraulic head measurements in a total of 7 wells[6] screened within the uppermost aquifer at the GMF indicate that groundwater flows toward the DCCP (Ramboll, 2021b,e). Because the DCCP serves as the regional groundwater discharge location, shallow groundwater near the GMF is not likely to migrate underneath or beyond the DCCP.

- **The DCCP adjacent to the Site is not used as a public water supply.** The DCCP is owned and maintained by IPRG. IPRG restricts the use of the pond as a source of drinking water and/or for recreation. Therefore, the human exposure pathway *via* surface water ingestion adjacent to the GMF was not evaluated further.

- **The GMF has a limited hydraulic connection to deep groundwater.** Three laboratory permeability tests on the lower confining till unit underlying the uppermost aquifer yielded a low mean hydraulic conductivity value of 1.9×10^{-7} cm/sec (Natural Resource Technology, 2017). In addition, the underlying shale bedrock acts as a low-permeability aquitard that restricts vertical intrusion of shallow groundwater. These results indicate that the till and shale bedrock are a significant barrier to groundwater migration.

3.3 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 3.3 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).

[6] Three CCR Rule background monitoring wells (G02S, G50S, and G51S), four CCR Rule downgradient monitoring wells (G54S, G57S, G60S, and G64S) (Ramboll, 2021e).

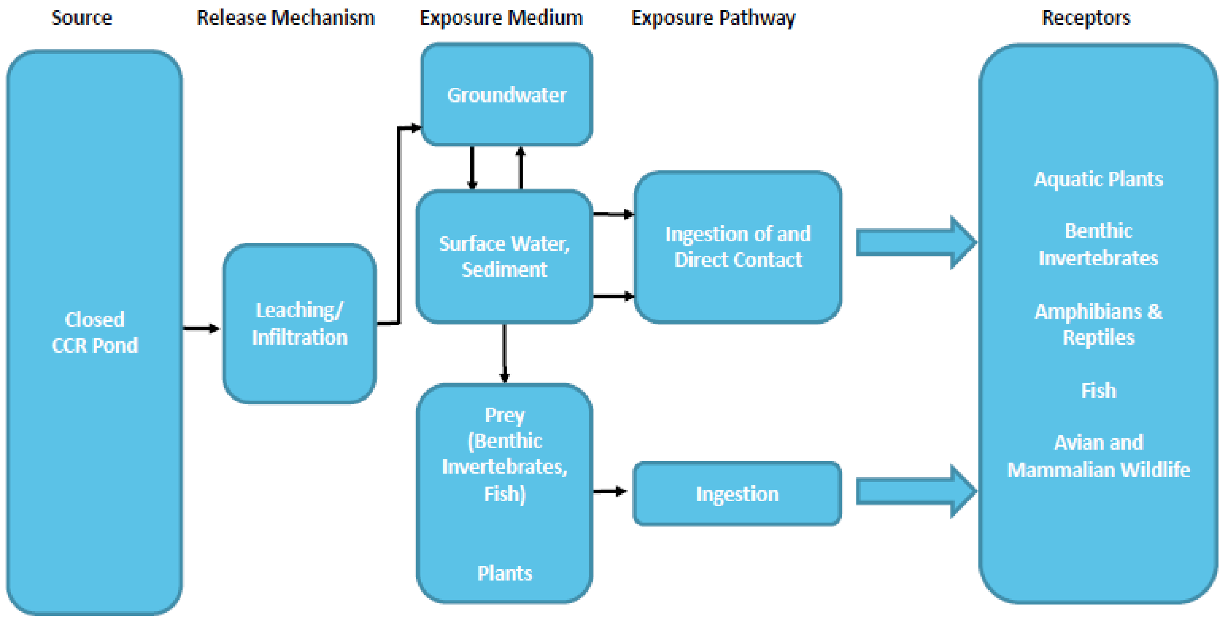

Figure 3.3 Ecological Conceptual Exposure Model. CCR = Coal Combustion Residual.

3.4 Identification of Ecological Constituents of Interest

Risks were evaluated for ecological COIs. A constituent was considered a COI if the maximum detected constituent concentration in groundwater exceeded a benchmark protective of ecological receptors. 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 DCCP surface water and sediment. As described above, there were no complete human health exposure pathways. Therefore, COIs were identified to support an ecological risk evaluation only.

3.4.1 Ecological Constituents of Interest

The Illinois GWPSs, 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, the maximum concentrations of analytes detected in groundwater were compared to ecological surface water benchmarks protective of aquatic life to identify ecological COIs.

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

- IEPA (2019) SWQSs. IEPA SWQSs are health-protective benchmarks for aquatic life exposed to surface water on a long-term basis (*i.e.*, chronic exposure). The SWQSs for several metals are hardness-dependent (in this case cadmium and lead). Screening benchmarks for these constituents were calculated assuming US EPA's (2019) default hardness of 100 mg/L because hardness data are not available for the DCCP.
- NRWQC – Aquatic Life Criteria Table (US EPA, 2019).

- US EPA Region IV (2018) surface water Ecological Screening Values (ESVs) for hazardous waste sites.

For radium, benchmarks from the United States Department of Energy (US DOE) guidance document "A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota" (US DOE, 2019) were used. US DOE presents benchmarks for radium-226 and radium-228 separately (4 and 3 pCi/L, respectively) (US DOE, 2019). 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. The IEPA (2019, Section 302.207) general Surface Water Quality Standard for radium notes that the annual average combined concentration of radium-226+228 must not exceed 3.75 pCi/L; however, this value is not necessarily based on protection of ecological receptors, therefore the benchmark of 3 pCi/L from US DOE (2019) was used.

Gradient used the maximum detected concentrations from groundwater samples collected from the wells associated with the BAB and GMF, 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.

Boron, cobalt, lead, mercury, radium-226+228, and chloride were identified as COIs for ecological receptors in the BAB (Table 3.1). Cadmium and cobalt were identified as COIs for ecological receptors in the GMF (Table 3.2).

Table 3.1 Ecological Constituents of Interest – BAB

Analyte[a]	Maximum Detected Concentration	Ecological Benchmark[b]	Basis	Ecological COI[c]
Dissolved Metals (mg/L)				
Arsenic	0.0045	0.19	US EPA Region IV ESV	No
Total Metals (mg/L)				
Arsenic	0.024	0.19	IEPA SWQC	No
Barium	0.48	5	IEPA SWQC	No
Beryllium	0.0068	0.064	US EPA Region IV ESV	No
Boron	7.8	7.6	IEPA SWQC	Yes
Chromium	0.073	0.21	IEPA SWQC	No
Cobalt	0.037	0.019	US EPA Region IV ESV	Yes
Lead	0.042	0.02	IEPA SWQC	Yes
Lithium	0.068	0.44	US EPA Region IV ESV	No
Mercury	0.0012	0.0011	IEPA SWQC	Yes
Molybdenum	0.015	7.2	US EPA Region IV ESV	No
Selenium	0.015	1	IEPA SWQC	No
Thallium	0.001	0.006	US EPA Region IV ESV	No
Radionuclides (pCi/L)				
Radium-226+228	9.64	3	US DOE	Yes
Other (mg/L unless otherwise specified)				
Chloride	700	500	IEPA SWQC	Yes
Fluoride	0.692	4	US EPA Region IV ESV	No
pH (SU)	7.7	6.5-9	US EPA NRWQC	No
Sulfate	890	NA	NA	No
Total Dissolved Solids	2,300	NA	NA	No

Notes:

BAB = Bottom Ash Basin; COI = Constituent of Interest; DL = Detection Limit; ESV = Ecological Screening Value; IEPA = Illinois Environmental Protection Agency; NA = Not Applicable; NRWQC = National Recommended Water Quality Criteria; SU = Standard Units; SWQC = Surface Water Quality Criteria; US DOE = United States Department of Energy; US EPA = United States Environmental Protection Agency.

(a) The list of constituents includes those with IL Part 845.600 Groundwater Protection Standards (IEPA, 2021a).

(b) Ecological benchmarks are from the hierarchy of sources discussed in Section 3.3.2: IEPA SWQS (IEPA, 2019), US EPA Region IV "Ecological Risk Assessment Supplemental Guidance" (US EPA Region IV, 2018), US EPA NRWQC (2021), and US DOE's guidance document, "A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota" (US DOE, 2019).

(c) COIs are constituents for which the maximum concentration exceeds the surface water criterion.

Table 3.2 Ecological Constituents of Interest – GMF

Analyte[a]	Maximum Detected Concentration	Ecological Benchmark[b]	Basis	Ecological COI[c]
Dissolved Metals (mg/L)				
Antimony	0.012	0.19	US EPA Region IV ESV	No
Arsenic	0.035	0.19	IEPA SWQC	No
Barium	0.47	5.00	IEPA SWQC	No
Boron	3	7.60	IEPA SWQC	No
Cadmium	0.0085	0.001	IEPA SWQC	Yes
Chromium	0.041	0.18	IEPA SWQC	No
Cobalt	0.028	0.02	US EPA Region IV ESV	Yes
Lead	0.19	0.02	IEPA SWQC	No
Mercury	0.00026	0.001	IEPA SWQC	No
Selenium	0.25	1.00	IEPA SWQC	No
Total Metals (mg/L)				
Antimony	0.0064	0.19	US EPA Region IV ESV	No
Arsenic	0.051	0.19	IEPA SWQC	No
Barium	0.47	5.00	IEPA SWQC	No
Beryllium	0.0027	0.06	US EPA Region IV ESV	No
Boron	1.9	7.60	IEPA SWQC	No
Cadmium	0.0016	0.001	IEPA SWQC	No
Chromium	0.015	0.21	IEPA SWQC	No
Cobalt	0.0052	0.02	US EPA Region IV ESV	No
Lead	0.041	0.02	IEPA SWQC	No
Lithium	0.018	0.44	US EPA Region IV ESV	No
Mercury	0.0004	0.001	IEPA SWQC	No
Molybdenum	0.041	7.20	US EPA Region IV ESV	No
Selenium	0.0031	1.00	IEPA SWQC	No
Thallium	0.0033	0.01	US EPA Region IV ESV	No
Radionuclides (pCi/L)				
Radium-226+228	5.38	3	US DOE	No[e]
Other (mg/L, unless otherwise specified)[f]				
Chloride	75	500	IEPA SWQC	No
Fluoride	0.465	4.0	IEPA SWQC	No
pH (SU)	7.5	5-9	US EPA NRWQC	No
Sulfate	540	NA	NA	No
Total Dissolved Solids	900	NA	NA	No

Notes:
COI = Constituent of Interest; DL = Detection Limit; ESV = Ecological Screening Value; GMF = Gypsum Management Facility; IEPA = Illinois Environmental Protection Agency; NA = Not Applicable; NRWQC = National Recommended Water Quality Criteria; SWQC = Surface Water Quality Criteria; US DOE = United States Department of Energy; US EPA = United States Environmental Protection Agency.
(a) The list of constituents includes those with IL Part 845.600 groundwater protection standards (IEPA, 2021a).
(b) Ecological benchmarks are from the hierarchy of sources discussed in Section 3.3.2: IEPA SWQS (IEPA, 2019), US EPA Region IV "Ecological Risk Assessment Supplemental Guidance" (US EPA Region IV, 2018), US EPA NRWQC (2021), and US DOE's guidance document "A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota" (US DOE, 2019).
(c) COIs are constituents for which the maximum concentration exceeds the surface water criterion.
(e) Of the 83 groundwater samples analyzed for radium-226+228, only 1 sample was detected above the ecological benchmark. Given that the maximum result is considered an outlier at the 1% and 5% significance levels, radium-226+228 was not considered an ecological COI.
(f) Results for analytes in the "other" group are based on unfiltered samples.

3.4.2 Surface Water and Sediment Modeling for the GMF and BAB

Surface water and sediment sampling has not been conducted in the DCCP. Many of the COIs are expected to be present in surface water or sediment from natural or non-Site-related anthropogenic sources. It would be difficult to attribute concentrations of these COIs to a particular source given the dynamic nature of the DCCP (as it flows south and discharges to Duck Creek, which drains into the Illinois River) and the multitude of potential sources. Gradient modeled concentrations in DCCP surface water and sediment as a result of groundwater discharge to the DCCP for all constituents that exceeded ecological benchmarks in groundwater. Surface water and sediment concentrations were modeled based on the maximum detected concentrations in groundwater[7] (from 2015 to 2021, regardless of well location).

For this evaluation, we 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, 2014). The original 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 porewater, 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 discharge of groundwater to the surface water.

The aquifer and surface water properties used to estimate the volume of groundwater flowing into the DCCP and surface water concentrations from the BAB and GMF are presented in Tables 3.3 and 3.5, respectively. The COI concentrations in sediment were modeled using the COI-specific sediment-to-water partition coefficients and the sediment properties presented in Tables 3.4 and 3.6 for the BAB and GMF, respectively. In the absence of Site-specific information for the DCCP, we used default assumptions (*e.g.*, depth of the upper benthic layer and bed sediment porosity) to model sediment concentrations. A description of the surface water and sediment modeling and the detailed results are presented in Appendix A.

The modeled surface water and sediment concentrations are discussed in Section 3.4. As described earlier, the modeled concentrations reflect conservative contributions from groundwater discharge.

[7] The maximum concentrations were taken, regardless of "total" or "dissolved" concentrations.

Table 3.3 Groundwater and Surface Water Properties Used in Modeling – BAB

Parameter	Unit	Value	Notes/Source
Groundwater			
COI Concentration	mg/L	Constituent-specific	Maximum detected dissolved or total concentration in groundwater.
Cross Section Area	m^2	260	Estimated by multiplying the maximum thickness of the permeable sand unit (7 ft or ~2.1 m) within the uppermost aquifer (Ramboll, 2021a) by the length of the BAB (400 ft or ~122 m).
Hydraulic Gradient	m/m	0.01	Average of field-measured hydraulic gradients reported in Ramboll (2021a).
Hydraulic Conductivity	cm/s	6.33×10^{-4}	Average of field-measured hydraulic conductivity values reported in Ramboll (2021a).
Surface Water			
Surface Water Flow Rate	L/yr	2.5×10^{10}	The rate of surface water discharge from the DCCP to Duck Creek *via* NPDES outfalls 1 and 2 (NPDES Permit No. IL0055620) (IEPA, 2013b).
TSS	mg/L	6	6 mg/L is the representative average river concentration (Hanson Professional Services Inc., 2019).
Depth of the Water Column	m	1.5	Conservative estimate of 5 ft or ~1.5 m near the edge of the DCCP (Bist LLC, 2021). Model results were not sensitive to an increase in the water column depth.
Suspended Sediment to Water Partition Coefficients	mg/L	Constituent-specific	Values based on US EPA (2014).

Notes:
BAB = Bottom Ash Basin; COI = Constituent of Interest; DCCP = Duck Creek Cooling Pond; NPDES = National Pollutant Discharge Elimination System; TSS = Total Suspended Solids; US EPA = United States Environmental Protection Agency.

Table 3.4 Sediment Properties Used in Modeling – BAB

Parameter	Unit	Value	Notes/Source
Sediment			
Depth of Upper Benthic Layer	m	0.03	Default (US EPA, 2014).
Depth of Water Body	m	1.55	Sum of depth of the water column and depth of the upper benthic layer.
Bed Sediment Particle Concentration	g/cm^3	1	Default (US EPA, 2014).
Bed Sediment Porosity	-	0.6	Default (US EPA, 2014).
TSS Mass Per Unit Area	kg/m^2	0.009	Depth of the 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 the 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 (2014).

Note:
BAB = Bottom Ash Basin; TSS = Total Suspended Solids; US EPA = United States Environmental Protection Agency.

Table 3.5 Groundwater and Surface Water Properties Used in Modeling – GMF

Parameter	Unit	Values	Notes/Source
Groundwater			
COI Concentration	mg/L	Constituent-specific	Maximum detected dissolved or total concentration in groundwater.
Cross Section Area	m^2	2,488	Estimated by multiplying the maximum thickness of the "shallow sand unit" of the uppermost aquifer (18 ft or 5.5 m) (Ramboll, 2021b) and the diagonal (NE-SW) length of the GMF (~453.5 m).
Hydraulic Gradient	m/m	0.02	Average hydraulic gradient within the uppermost aquifer (Ramboll, 2021b).
Hydraulic Conductivity	cm/s	3.58×10^{-4}	As reported by Ramboll for the uppermost aquifer (Ramboll, 2021b).
Surface Water			
Surface Water Flow Rate	L/yr	2.5×10^{10}	The rate of surface water discharge from the DCCP to Duck Creek *via* NPDES outfalls 1 and 2 (NPDES Permit No. IL0055620) (IEPA, 2013b).
TSS	mg/L	6	6 mg/L is the representative average river concentration (Hanson Professional Services Inc., 2019).
Depth of the Water Column	m	1.5	Conservative estimate of 5 ft or ~1.5 m near the edge of the DCCP (Bist LLC, 2021). Model results were not sensitive to an increase in the depth of the water column.
Suspended Sediment to Water Partition Coefficients	mg/L	Constituent-specific	Values based on US EPA (2014).

Note:
COI = Constituent of Interest; GMF = Gypsum Management Facility; TSS = Total Suspended Solids; US EPA = United States Environmental Protection Agency.

Table 3.6 Sediment Properties Used in Modeling – GMF

Parameter	Unit	Value	Notes/Source
Sediment			
Depth of Upper Benthic Layer	m	0.03	Default (US EPA, 2014).
Depth of Water Body	m	1.55	Sum of depth of water column and depth of upper benthic layer.
Bed Sediment Particle Concentration	g/cm^3	1	Default (US EPA, 2014).
Bed Sediment Porosity	-	0.6	Default (US EPA, 2014).
TSS Mass Per Unit Area	kg/m^2	0.009	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 (2014).

Note:
GMF = Gypsum Management Facility; TSS = Total Suspended Solids; US EPA = United States Environmental Protection Agency.

3.5 Ecological Risk Evaluation

Based on the ecological CEM (Figure 3.3), ecological receptors could be exposed to surface water, sediment, and dietary items (*i.e.*, prey and plants) potentially impacted by identified COIs (boron, cobalt, lead, and mercury in the BAB; cadmium and cobalt in the GMF).

3.5.1 Ecological Receptors Exposed to Surface Water

Screening Exposures: The ecological evaluation considered aquatic communities in the DCCP potentially impacted by identified ecological COIs. In the absence of surface water data, the maximum of the total and dissolved COI concentrations detected in groundwater was used to model surface water concentrations. 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 lead, the surface water benchmark is hardness-dependent and calculated using a default hardness of 100 mg/L. While IEPA's general water quality standard for chloride of 500 mg/L (IEPA, 2019) is not specified to be protective of ecological receptors, it was used because it is on the same order of magnitude as US EPA's NRWQC for chloride (230 and 860 mg/L for chronic and acute exposures, respectively), which is protective of aquatic life (US EPA, 2021).
- US EPA Region IV (2018) surface water ESVs for hazardous waste sites.
- For radium, US DOE presents benchmarks for radium-226 and radium-228 separately (4 and 3 pCi/L, respectively). Given that radium concentrations are expressed as total radium (the sum of radium-226 and radium-228), Gradient used the lower of the two US DOE benchmarks (3 pCi/L for radium-228) to evaluate the total radium concentrations. In addition, this benchmark is protective of bioaccumulative effects in higher trophic-level wildlife discussed further in Section 3.4.3.

Risk Evaluation: The maximum modeled COI concentrations in surface water were compared to the above hierarchy of benchmarks protective of aquatic life (Table 3.7). All modeled surface water concentrations were below their respective benchmarks. Thus, none of the COIs evaluated are expected to pose an unacceptable risk to aquatic life in the DCCP.

Table 3.7 Risk Evaluation for Ecological Receptors Exposed to Surface Water

COI[a]	Maximum Surface Water Concentration, Modeled	Ecological Freshwater Benchmark	Basis	COPC
BAB				
Boron (mg/L)	1.7×10^{-4}	7.6	IEPA (2019)	No
Cobalt (mg/L)	7.9×10^{-7}	0.019	US EPA Region IV (2018)	No
Lead[b] (mg/L)	8.9×10^{-7}	0.016	IEPA (2019)	No
Mercury (mg/L)	2.5×10^{-8}	0.8	US EPA Region IV (2018)	No
Chloride (mg/L)	1.5×10^{-2}	500	IEPA (2019)	No
Radium-226+228 (pCi/L)	2.1×10^{-4}	3	US DOE (2019)	No
GMF				
Cadmium[b] (mg/L)	2.0×10^{-6}	0.0009	IEPA (2019)	No
Cobalt (mg/L)	6.4×10^{-6}	0.019	US EPA Region IV (2018)	No

Notes:
BAB = Bottom Ash Basin; COI = Constituent of Interest; COPC = Constituent of Potential Concern; GMF = Gypsum Management Facility; IEPA = Illinois Environmental Protection Agency; US DOE = United States Department of Energy; US EPA = United States Environmental Protection Agency.
(a) Modeled COI concentrations reflect the potential maximum COI surface water concentrations from groundwater mixing with surface water.
(b) A default hardness value of 100 mg/L was used to calculate this hardness-dependent benchmark.

3.5.2 Ecological Receptors Exposed to Sediment

Screening Exposures: COIs in impacted groundwater discharging into the DCCP 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. Chloride was not modeled in sediment as it does not have a K_d value and is not expected to partition into sediment.

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.

For radium, benchmarks from US DOE's guidance document "A Graded Approach for Evaluating Radiation Doses to Aquatic and Terrestrial Biota" (US DOE, 2019), were used. US DOE (2019) presents benchmarks for radium-226 and radium-228 separately (101 and 876 pCi/kg, respectively). Similar to surface water, given that modeled radium is presented as the combined radium-226+228, the lower of the two benchmarks was used as the benchmark to be protective of ecological receptors for both radium-226 and radium-228. In addition, this benchmark is protective of bioaccumulative effects in the higher trophic-level wildlife discussed further in Section 3.4.3. The benchmarks used in this evaluation are listed in Table 3.8.

Screening Risk Results: The maximum modeled COI sediment concentrations were below their respective sediment screening benchmarks, for both the BAB and GMF (Table 3.8). The modeled sediment concentrations attributed to potential contributions from Site groundwater for all COIs were less than 1.5% 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 DCCP adjacent to the Site.

Table 3.8 Risk Evaluation for Ecological Receptors Exposed to Sediment

COI	Modeled Sediment Concentration	ESV[a]	COPC	Percentage of Benchmark
BAB				
Boron (mg/kg)	0.00100	38[b]	No	0.0026%
Cobalt (mg/kg)	0.00072	50	No	0.0014%
Lead (mg/kg)	0.0089	35.8	No	0.025%
Mercury (mg/kg)	0.00092	0.18	No	0.51%
Radium-226+228 (pCi/kg)	1.5	101	No	1.4%
GMF				
Cadmium (mg/kg)	0.0026	0.99	No	0.27%
Cobalt (mg/kg)	0.0059	50	No	0.012%

Notes:
BAB = Bottom Ash Basin; COI = Constituent of Interest; COPC = Constituent of Potential Concern; ESV = Ecological Screening Value; GMF = Gypsum Management Facility; NOEC = No Observed Effect Concentration; US DOE = United States Department of Energy; US EPA = United States Environmental Protection Agency.
(a) ESVs were taken from US EPA Region IV (2018) for all metal COIs. The benchmark for radium-226+228 is the lower of the US DOE (2019) benchmarks for Ra-226 and Ra-228.
(b) Boron NOEC of 38 mg/kg was used as a conservative benchmark for boron in the absence of an ESV (ECHA, 2019).

3.5.3 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).

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

Risk Evaluation: Mercury was the only COI[8] identified as having potential bioaccumulative effects. The modeled mercury concentration in surface water (1.3×10^{-8} mg/L) is well below the US EPA Region IV (2018) ecological benchmark for wildlife (0.0013 mg/L) that is protective of bioaccumulative effects. Therefore, mercury is not considered to pose an ecological risk *via* bioaccumulation.

Radium is not described in US EPA Region IV guidance, but it has been identified as bioaccumulative by other entities (*e.g.*, ATSDR, 1990). However, the benchmark used to screen radium concentrations in surface water and sediment already considers bioaccumulative exposures. Given that the modeled concentrations are below benchmarks which account for bioaccumulative exposures, radium-226+228 is not expected to pose a risk concern to ecological receptors based on its bioaccumulative properties.

3.6 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.

[8] US EPA Region IV (2018) identifies only mercury (including methyl mercury) and selenium as having potential bioaccumulative effects. IEPA (2019) identifies mercury as the only metal with bioaccumulative properties.

Exposure Estimates:

- The risk evaluation included the Illinois Part 845.600 (IEPA, 2021a) constituents detected in groundwater samples collected from wells downgradient of the BAB and GMF. However, it is possible that none of the detected constituents are related specifically to these ash ponds.
- The ecological risk characterization was based on the maximum modeled COI concentrations, rather than on average concentrations. Thus, the variability in exposure concentrations was not considered. Assuming continuous exposure to the maximum concentration overestimates 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, we have greater confidence that there is no risk concern.
- Only analytes 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 groundwater, the detection limits were below the Illinois Part 845.600 GWPS (IEPA, 2021a) and thus do not require further evaluation.
- COI concentrations in surface water were modeled using the maximum detected total or dissolved COI concentrations in groundwater. Surface water concentrations for the BAB were modeled using the maximum detected total groundwater COI concentrations, and maximum detected dissolved groundwater COI concentrations for the GMF. Modeling surface water concentrations using total metal concentrations for BAB 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 COIs identified in this evaluation also occur naturally in the environment. Contributions to exposure from natural or other non-BAB/GMF related sources 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 BAB/GMF-related groundwater contributions are likely to represent only a small fraction of the overall human and ecological exposure to COIs that also have natural or non-BAB/GMF-related sources.

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 and US EPA's default hardness of 100 mg/L was used due to a lack of hardness data for the DCCP. Regardless of the hardness, the maximum modeled cadmium concentration is orders of magnitude below the SWQS.
- In addition, for the ecological evaluation, we conservatively assumed all constituents to be 100% bioavailable. Modeled COI concentrations in surface water are considered total COI 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.

- For radium, groundwater concentrations were calculated as the sum of radium-226 and radium-228. US DOE (2019) presents surface water and sediment benchmarks protective of ecological receptors for radium-226 and radium-228 separately. Gradient relied on the lower of the two benchmarks to evaluate risks for radium-226+228. By comparing the total radium-226+228 concentration to the most stringent benchmark, it is assuming that all of the total radium concentrations has the toxicity of the more toxic isotope, which is an overestimation of risk. Despite the overestimation, the modeled exposure estimates are at least an order of magnitude lower than the conservative benchmark.

4 Summary and Conclusions

A screening-level risk evaluation was performed for Site-related constituents in groundwater at the DCPP in Canton, Illinois. The CSM developed for the Site indicates that groundwater beneath the GMF and BAB flows into the DCCP and may potentially impact surface water and sediment.

CEMs were developed for human and ecological receptors. There are no complete exposure pathways for humans, because the DCCP is part of the Site and does not have any recreational uses. 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 between 2015 and 2021 were used to estimate exposures. Gradient used the maximum detected concentrations from groundwater samples collected from the wells associated with the BAB and GMF, 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. For constituents identified as COIs for ecological receptors, surface water and sediment concentrations in the DCCP were modeled using the maximum detected groundwater concentration.

Ecological receptors exposed to surface water include aquatic and marsh plants, amphibians, reptiles, and fish. Surface water and sediment exposure estimates were screened against benchmarks protective of ecological receptors for this risk evaluation. The risk evaluation showed that none of the modeled 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). Based on the modeled concentration, 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 that tend to overestimate exposure and risk. The risk evaluation was based on the maximum detected COI concentration; however, 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 or BAB 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

List of Tables

Abbreviations

BAB	Bottom Ash Basin
CCR	Coal Combustion Residual
COI	Constituent of Interest
DCCP	Duck Creek Cooling Pond
GMF	Gypsum Management Facility
MGD	Million Gallons Per Day
NPDES	National Pollutant Discharge Elimination System
US EPA	United States Environmental Protection Agency

Gradient modeled concentrations in the Duck Creek Cooling Pond (DCCP) surface water and sediment based on available groundwater data. First, we estimated the flow rate of constituents of interest (COIs) potentially discharged to the DCCP *via* groundwater. Then, we 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 DCCP.

Model Overview

The groundwater flow into the DCCP is represented by a one-dimensional steady-state model. In this model, the groundwater migrates horizontally in the uppermost aquifer in the direction of the DCCP. For the Bottom Ash Basin (BAB), the groundwater flow entering the DCCP is the flow going through a cross-sectional area that has a length equal to the length of the DCCP adjacent to the BAB with potential coal combustion residual (CCR)-related impacts and a height equal to the saturated thickness of the permeable sand unit within the uppermost aquifer (Table 3.3). For the Gypsum Management Facility (GMF), the groundwater flow entering the DCCP is the flow going through a cross-sectional area that has a length equal to the length of the DCCP adjacent to the GMF with potential CCR-related impacts and a height equal to the saturated thickness of the "Shallow Sand Unit" of the uppermost aquifer (Table 3.5). It was assumed that all the groundwater flowing through the uppermost aquifer discharges to the DCCP.

The groundwater flow into the DCCP mixes with the surface water in the DCCP. The COIs potentially entering the DCCP *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 Discharge Rate

Gradient used conservative assumptions to evaluate the potential groundwater discharge rate of the COIs. We conservatively assumed that the groundwater concentrations were uniformly equal to the maximum detected concentration for each individual COI. We ignored adsorption by subsurface soil and assumed that all the groundwater flowing through the uppermost aquifer was discharged into the DCCP.

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

$$Q = KiA$$

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 the DCCP was then calculated by:

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

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 needed for unit conversion: 1,000 L/m^3; 31,557,600 s/year

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

Surface Water and Sediment Concentration

Groundwater discharged into the DCCP gets diluted in the surface water. Constituents transported by groundwater into the surface water migrate into the water column and the bed sediments. The surface water model we 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 our analysis, we used the partitioning coefficients given in Table J-1 of the US EPA CCR Risk Assessment for all COIs (US EPA, 2014) except radium (Sheppard, 2009). These coefficients are presented in Table A.3.

To be conservative, we assume that the constituents are not affected by dissipation or degradation once they enter the water body. The total water body concentration of the COI is calculated using the following equation from 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)
V_f = Water body annual flow (L/year)
f_{water} = Fraction of COI in the water column (unitless)
m_c = Mass discharge rate of the COI (mg/year)

For the DCCP flow rate, we used a discharge rate of about 18 million gallons per day (MGD), based on the estimated DCCP surface water discharge rates to Duck Creek *via* outfall 001 (0.038 MGD) and outfall 002 (18 MGD), as indicated in National Pollutant Discharge Elimination System (NPDES) Permit No. IL0055620 (IEPA, 2013b).

The fraction of COIs in the water column was calculated for each COI 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 calculated using the following equation from 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:

f_{water}	=	fraction of COI in the water column
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 representative average concentration of 6 mg/L (Hanson Professional Services Inc., 2019)
0.000001	=	Units conversion factor
d_w	=	Depth of the water column (m)
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)
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 are presented in Table A.4 for the BAB and in Table A.5 for the GMF. Other water body parameters are presented in Table A.6, which apply to both the BAB and GMF.

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

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

The dissolved water column concentration is 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, Table J-1-12):

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

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 (used the 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 is calculated using the following equation 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 are presented in Table A.7 for the BAB and in Table A.8 for the GMF.

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Tables

Table A.1 Parameters Used to Estimate Groundwater Discharge to Surface Water - BAB

GW Unit	Parameter	Full Name	Value	Unit
Uppermost Aquifer	A	Cross-Sectional Area	260	m^2
Uppermost Aquifer	i	Hydraulic Gradient	0.01	m/m
Uppermost Aquifer	K	Hydraulic Conductivity	0.00063	cm/s

Notes:
BAB = Bottom Ash Basin; GW = Groundwater.
Source: Hydraulic gradient and hydraulic conductivity values from Ramboll (2021).

Table A.2 Parameters Used to Estimate Groundwater Discharge to Surface Water - GMF

GW Unit	Parameter	Full Name	Value	Unit
Uppermost Aquifer	A	Cross-Sectional Area	2,488	m^2
Uppermost Aquifer	i	Hydraulic Gradient	0.02	m/m
Uppermost Aquifer	K	Hydraulic Conductivity	0.00036	cm/s

Notes:
GW = Groundwater.
Source: Hydraulic gradient and hydraulic conductivity values from Ramboll (2021).

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)
Antimony	3.6	3.98E+03	4.8	6.31E+04
Arsenic	2.4	2.51E+02	3.9	7.94E+03
Beryllium	2.8	6.31E+02	4.2	1.58E+04
Boron	0.8	6.31E+00	3.9	7.94E+03
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
Radium-226 + 228	3.9	7.40E+03	3.9	7.40E+03
Selenium	0.6	3.98E+00	3.8	6.31E+03
Thallium	1.3	2.00E+01	4.1	1.26E+04

Notes:
Lithium was not modeled because it lacks a Kd value in US EPA (2014).
Sources: US EPA (2014); Sheppard (2009).

Table A.4 Calculated Parameters for the BAB

Constituent	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	0.1741	0.8259	0.9545
Beryllium	0.0808	0.9192	0.9132
Boron	0.8848	0.1152	0.9545
Cobalt	0.0525	0.9475	0.7254
Lead	0.0051	0.9949	0.2496
Mercury	0.0014	0.9986	0.4551
Radium 226 + 228	0.0071	0.9929	0.9575

Note:
BAB = Bottom Ash Basin.

Table A.5 Calculated Parameters for the GMF

Constituent	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 $f_{dissolved}$
Antimony	0.0172	0.9828	0.7254
Arsenic	0.1741	0.8259	0.9545
Boron	0.8848	0.1152	0.9545
Cadmium	0.0361	0.9639	0.6772
Cobalt	0.0525	0.9475	0.7254
Lead	0.0051	0.9949	0.2496
Selenium (IV)	0.9199	0.0801	0.9635
Thallium	0.7261	0.2739	0.9298

Table A.6 Surface Water Parameters

Parameter	Full Name	Value	Unit
TSS	Total Suspended Solids	6	mg/L
V_{fx}	Surface Water Flow Rate	2.5E+10	L/yr
db	Depth of Upper Benthic Layer (default: 0.03)	0.03	m
dw	Depth of Water Column	1.52	m
dz	Depth of Water Body	1.55	m
bsc	Bed Sediment Bulk Density (default: 1.0)	1	g/cm^3
bsp	Bed Sediment Porosity (default: 0.6)	0.6	-
M_{TSS}	TSS Mass per Unit Area	0.009	kg/m^2
M_S	Sediment Mass per Unit Area	30	kg/m^2

Notes:
Sources of default values: US EPA (1998, 2014).

Table A.7 Input Groundwater Concentrations and Output Surface Water and Sediment Concentrations for the BAB

Constituent	Groundwater Concentration (mg/L)	Mass Discharge Rate to Surface Water (mg/year)	Total Water Column Concentration (mg/L)	Concentration Sorbed to Bottom Sediments (mg/kg)
Arsenic	2.40E-02	1.25E+04	5.10E-07	1.22E-04
Beryllium	6.80E-03	3.53E+03	1.44E-07	8.32E-05
Boron	7.80E+00	4.05E+06	1.66E-04	9.98E-04
Chloride	7.00E+02	3.64E+08	1.49E-02	Not Applicable
Cobalt	3.70E-02	1.92E+04	7.86E-07	7.18E-04
Lead	4.20E-02	2.18E+04	8.92E-07	8.86E-03
Lithium	6.80E-02	3.53E+04	1.44E-06	Not Applicable
Mercury	1.20E-03	6.23E+02	2.55E-08	9.22E-04
Constituent	**Groundwater Concentration (pCi/L)**	**Mass Discharge Rate to Surface Water (pCi/year)**	**Total Water Column Concentration (pCi/L)**	**Concentration Sorbed to Bottom Sediments (pCi/kg)**
Radium-226 + 228	9.64E+00	5.01E+06	2.05E-04	1.45E+00

Note:
K_d = Equilibrium Partitioning Coefficient; US EPA = United States Environmental Protection Agency.
Chloride and lithium were not modeled due to lack of K_d value in US EPA (2014).

Table A.8 Input Groundwater Concentrations and Output Surface Water and Sediment Concentrations for the GMF

Constituent	Groundwater Concentration (mg/L)	Mass Discharge Rate to Surface Water (mg/year)	Total Water Column Concentration (mg/L)	Concentration Sorbed to Bottom Sediments (mg/kg)
Antimony	1.20E-02	6.75E+04	2.76E-06	7.97E-03
Arsenic	5.10E-02	2.87E+05	1.17E-05	2.81E-03
Boron	3.00E+00	1.69E+07	6.90E-04	4.15E-03
Cadmium	8.50E-03	4.78E+04	1.95E-06	2.64E-03
Cobalt	2.80E-02	1.57E+05	6.44E-06	5.88E-03
Lead	1.90E-01	1.07E+06	4.37E-05	4.34E-01
Selenium (VI)	2.50E-01	1.41E+06	5.75E-05	2.20E-04
Thallium	3.30E-03	1.86E+04	7.59E-07	1.41E-05

Note:
Source: US EPA (2014).

Appendix B

Supporting Information

Supporting Information for Closure Alternatives Analysis – Gypsum Management Facility at Duck Creek Power Plant

GOLDER
MEMBER OF WSP

DRAFT

TECHNICAL MEMORANDUM

DATE November 5, 2021 **Reference No.** 21454861-11-TM-A

TO Illinois Power Resources Generating, LLC

FROM Golder Associates USA Inc.

SUPPORTING INFORMATION FOR CLOSURE ALTERNATIVES ANALYSIS – GYPSUM MANAGEMENT FACILITY POND AT DUCK CREEK POWER PLANT

Golder Associates USA Inc. (Golder), a Member of WSP, has prepared this technical memorandum for Illinois Power Resources Generating, LLC (IPRG) to support the Closure Alternatives Analysis for the Gypsum Management Facility (GMF) Pond at Duck Creek Power Plant (DCPP). The GMF Pond was used for containment of gypsum produced at DCPP and has not received gypsum since the power plant was retired in 2019. 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.

1.0 GMF POND HISTORY

1.1 Existing Liner System Information

Golder reviewed several documents related to the design, construction, and operation of the GMF Pond. Notable documents included the History of Construction (AECOM 2016), the Gypsum Stack Acceptance Report (Hanson 2009a), and the Initial Facility Report Volumes 1-4 (Hanson 2009b). Based on review of these documents, a dual composite liner system with a leak detection layer was installed for the GMF Pond consisting of (from top to bottom):

- primary composite liner
  - Solmax 460T-1000 60-mil textured high-density polyethylene (HDPE) geomembrane
  - one-foot cushion dirt layer (2 feet in select areas on the sideslopes)
- leak detection layer
  - SKAPS GT-142 4-oz/yd^2 geotextile separator
  - one-foot granular drainage layer
  - SKAPS GE-110 10-oz/yd^2 geotextile cushion
- secondary composite liner
  - Solmax 460T-4013 60-mil textured HDPE geomembrane

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- CETCO Bentomat SDN reinforced geosynthetic clay liner (GCL)
- three-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

According to the Acceptance Report (Hanson 2009a), the liner system was subjected to a rigorous construction quality assurance (CQA) program.

The GMF Pond was constructed by excavating the natural ground a minimum of 5.4 feet to reach foundation grades. During preparation of the foundation grades, unsuitable sand materials were removed from several areas and stockpiled separately. These areas were then backfilled with suitable material previously stockpiled or locally available. Backfilled areas were compacted to at least 95% of the standard Proctor maximum dry density at a moisture content within 2% of the OMC. Eight Shelby tube samples collected from the foundation grade berms were used for hydraulic conductivity testing, with results ranging from 2.2×10^{-8} centimeters per second (cm/s) to 1.0×10^{-7} cm/s.

After certification of the foundation grades, the 3-foot compacted clay layer was constructed in 8-inch lifts. Eighteen Shelby tube samples were collected during construction. Hydraulic conductivity results from tests on the Shelby tube samples ranged from 8.6×10^{-9} cm/s to 9.8×10^{-7} cm/s, significantly less than the construction specification of 1.0×10^{-4} cm/s. The compacted clay layer was proof rolled prior to installation of the overlying GCL.

After placement of the compacted clay layer, geosynthetic components of the secondary liner system were installed. Certified properties for the geosynthetic materials are provided in the Geosynthetics Quality Assurance Report (Feezor 2009).

A leak detection layer with leachate collection and recovery system (LD/LCRS) was installed above the lower geomembrane. The LD/LCRS included a 10-oz/yd^2 geotextile overlain by a 1-foot granular drainage layer with 6-inch- and 12-inch-diameter HDPE piping embedded. Laboratory hydraulic conductivity test results for the granular drainage layer soil ranged from 1.5×10^{-2} to 5.7×10^{-2} cm/s. Test reports from hydraulic conductivity and particle-size distribution testing are provided in the Acceptance Report (Hanson 2009a). The piping within the LD/LCRS directs leachate to two sumps at the toe of the south berm of the GMF Pond, with risers to facilitate removal of leachate. A 4-oz/yd^2 geotextile was installed above the 1-foot granular drainage layer. Certified properties for the geosynthetic materials are provided in the Geosynthetics Quality Assurance Report (Feezor 2009).

A 1-foot cushion soil layer compacted to at least 90% of the standard Proctor maximum dry density was placed above the 4-oz/yd^2 geotextile. According to the Acceptance Report (Hanson 2009a), the layer was constructed of general fill transported from a stockpile or borrow to the work area by truck and graded with a dozer to a depth of approximately 1 foot. The local stockpiles generally consisted of fine-grained soils, predominantly low-plasticity silts and clays (classified as CL and ML under the United Soil Classification System [USCS]). The cushion layer was then overlain by a 60-mil HDPE geomembrane constructed with the same installation specifications as the lower geomembrane. Certified properties for the upper geomembrane are provided in the Geosynthetics Quality Assurance Report (Feezor 2009).

In addition to the dual composite liner system, the GMF Pond has a ring drain system above the primary liner system that was used to recover and recycle water used for hydraulic conveyance of gypsum to the GMF Pond. The ring drain system consists of a rectangular array of 6-inch-diameter perforated HDPE pipe installed above the upper geomembrane around the perimeter of the GMF Pond floor. The pipe is surrounded by coarse aggregate and wrapped in a geotextile. The ring drain pipe network directs water to five sumps (one each along the toes of the north, east, and west embankments and two along the toe of the south embankment).

1.2 Operational History

The GMF Pond was constructed between 2007 and 2009 and was put into operation in 2009. The GMF Pond was used to store gypsum and to clarify gypsum transport water for reuse in the wet scrubber system until DCPP was retired in December 2019. Gypsum was hydraulically conveyed to the GMF Pond at approximately 20% solids (Hanson 2009b). It was deposited from the north end of the GMF Pond 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 relatively weak nature of the subaqueous gypsum. During the operational life, the beach expanded so that roughly one-third of the GMF Pond footprint had gypsum built up to the typical water level. The water level was (and still is) controlled by an overflow channel at the southeast corner of the GMF Pond. The overflow elevation was adjustable and could be as low as El. 614 or as high as approximately El. 616. Water decanted (or was siphoned early in the life of the GMF Pond) from the GMF Pond into the Recycle Pond, which is located immediately south of the GMF Pond. A set of pumps situated on the west side of the Recycle Pond was used to transfer the decanted water back to the wet scrubber system for reuse. The Operation and Maintenance Manual for the GMF Pond provides additional information and is included in the History of Construction (AECOM 2016).

It is Golder's understanding that the pumps for the LD/LCRS are controlled by the hydraulic head in the 1-foot granular drainage layer (i.e., they only operate when there has been enough infiltration into the LD/LCRS to build up the hydraulic head to a trigger level) and that the pumps have rarely needed to operate. This anecdotal information suggests that the primary composite liner is intact and provides an effective barrier to downward flow.

1.3 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 cushion layer (Hanson 2009a), approximately 400,000 cubic yards (cy) of gypsum are present in the GMF Pond. The GMF Pond footprint is approximately 31 acres, with approximately 60,800 cy of cushion dirt, 55,500 cy of granular drainage material, and 166,500 cy of compacted clay used in construction of the GMF Pond.

The wet scrubber system used for flue gas desulfurization at DCPP produced synthetic gypsum (calcium sulfate). The synthetic gypsum is generally of the same chemical structure as natural gypsum. Because the material was sluiced, the particle-size distribution of the gypsum in the GMF Pond is expected to be variable, becoming finer with increased distance from the deposition locations. Based on geotechnical testing Golder conducted on a composite of three samples of gypsum collected near the north end of the GMF Pond, the material is non-plastic with more than 97% by weight passing the No. 200 sieve (ML under the USCS) and a specific gravity of 2.66. Slurry consolidation testing conducted by Golder on a reconstituted sample of gypsum from the GMF Pond indicated a range of hydraulic conductivities from 6×10^{-5} cm/s to 1×10^{-4} cm/s under typical confining stresses in the GMF Pond.

1.4 Water Levels

At the time of the December 2020 survey by IngenAE, the water level in the GMF Pond was at El. 613.9 (North American Vertical Datum of 1988). Although the water level would be expected to respond to wet or dry climate conditions, this water level is likely typical for the GMF Pond. Based on this water level, approximately 95% of the gypsum in the GMF Pond is below the water level. Based on Golder's site observations, gypsum below the water level can be considered saturated. The gypsum above the water level forms a plateau at the north end of the GMF Pond with the highest point at approximately El. 616. Based on Golder's site observations, gypsum above the water level is moist, but not saturated, and is capable of supporting foot traffic, but likely not equipment traffic without dewatering.

2.0 CLOSURE CONCEPT INFORMATION

To provide necessary information for the Closure Alternatives Analysis, Golder developed a closure concept that would involve closure with CCR remaining in place and a closure concept that would involve closure by removal of CCR. These closure concepts are described in this section.

2.1 Closure in Place

2.1.1 Final Cover System Materials

For closure with CCR in place, Part 845 requires installation of a final cover system over the CCR. Based on a demonstration to be submitted to the Illinois Environmental Protection Agency for approval pursuant to Section 845.750(c)(2), an alternative final cover system is incorporated into the closure-in-place concept. The final cover system consists of (from top to bottom):

- 2-foot final protective layer – locally available soils compacted to between 80% and 95% of the standard Proctor maximum dry density for establishment of vegetation and protection of the underlying geomembrane. Material is likely to be primarily low-plasticity silt or clay based on review of site geotechnical information (e.g., Hanson 2009b).
- Geocomposite.
- 60-mil HDPE geomembrane.

To the extent possible, the gypsum would be graded to achieve final cover subgrade, and the final cover system would be constructed directly on the gypsum surface in most areas. 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 provide a firm subgrade.

2.1.2 Closure Construction Plan

Conceptual final cover system grades and details are shown in Exhibit 1. The closure-in-place concept was developed to reduce the waste footprint at closure, while also recognizing the complications associated with handling and stacking wet gypsum materials. The proposed closure-in-place option would have final cover slopes of 4% to accommodate moderate settlement, with a berm constructed at the south end of the consolidated footprint to enhance stability. The location of the berm has been selected to accommodate the estimated volume of gypsum 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 from the GMF Pond. Approximately 112 million gallons of water was contained in the GMF Pond as of the December 2020 survey by IngenAE, not including the pore water within the roughly 400,000 cy of gypsum. Pumping out the ponded water will enable gravity drainage of the gypsum to begin, but there will be a significant amount of saturated material that will need to be relocated.
- Once the ponded water has been removed from the GMF Pond, shallow gypsum zones in the consolidated footprint will be dewatered as needed to enable equipment trafficking. Gypsum south of the consolidated footprint will be dewatered as needed to enable relocation. The gypsum will dewater to some degree by gravity, but some dewatering by pumping from trenches and sumps is expected to be necessary.
- 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 south end of the consolidated footprint. The upstream face of the berm will be lined with a composite liner system consisting of a 60-mil HDPE geomembrane overlying a compacted clay layer, which will tie into the existing liner system.
- The remaining wet gypsum south of the berm will be collected and deposited north of the berm. This may be accomplished by traditional earthwork methods and/or by washing the material towards sumps at the south end of the GMF Pond, where the material can be collected and removed.
- Geosynthetic components of the existing dual composite liner system south of the berm will be removed and hauled away for disposal. Soil materials that must be removed to expose the geosynthetic layers will be stockpiled on site.

Ponded water removal from the GMF Pond will be a significant effort. Removal of the ponded water at the GMF Pond may take three to six months, depending on pumping rates, operating hours, and weather conditions. Once the ponded water is removed, we anticipate that the remaining efforts to relocate the 85,000 cy of gypsum south of the berm can be completed in single construction season. The final cover system could be installed during the following construction season.

2.1.3 Stormwater Management

Stormwater runoff from the GMF Pond closure area will be managed by sheet flow off the cover system. Runoff will be routed into existing drainage channels northeast and southeast of the GMF Pond. A new channel will be excavated along the northern perimeter of the consolidated footprint to route water into the existing drainage channel northeast of the GMF Pond. To prevent impoundment of water in the south end of the current GMF Pond footprint, existing earthen embankments will be removed in the southeast corner of the GMF Pond and in the Recycle Pond to allow stormwater to passively flow into the existing drainage southeast of the GMF Pond. No new stormwater management ponds or other features would be needed for closure.

2.2 Closure by Removal

Under the closure-by-removal option, the gypsum in the GMF Pond will be dewatered and all gypsum will be hauled by truck from the GMF Pond to the existing permitted on-site landfill located approximately 1 mile north of the GMF Pond, which would require a 2-acre expansion. Alternatively, the gypsum may be disposed of at an off-site landfill approximately 33 miles away. Additionally, the dual composite liner system described in Section 1.1 will be removed as required under 845.740(a) and disposed. Subsoil beneath the liner system may be excavated to a depth up to 1 foot and disposed. Additional details on the closure-by-removal option are shown in Exhibit 2.

2.2.1 Material Removal Phasing

To completely remove the gypsum material from the GMF Pond, the gypsum will need to be dewatered. As described in Section 2.1.2, removal of ponded water from the GMF Pond is expected to take several months.

After removal of the ponded water, the gypsum will still be unsuitable for supporting heavy construction traffic over much of the footprint. Careful planning will be required to safely remove the wet gypsum from the GMF Pond. The gypsum removal will likely be accomplished in phases, relying on a series of trenches to facilitate dewatering of the material. The trenches will shorten drainage routes to facilitate gravity dewatering of gypsum in the vicinity of each trench and will direct the water to sumps from which the water can be pumped. Dewatering means and methods would be determined by the gypsum removal contractor. The dewatering and closure-by-removal concept evaluated in the Closure Alternatives Analysis follows:

- Pump out ponded water from the GMF Pond. Approximately 112 million gallons of water was contained in the GMF Pond as of the December 2020 survey by IngenAE, not including the pore water within the roughly 400,000 cy of gypsum. Pumping out the ponded water will enable gravity drainage of the gypsum to begin, but there will be a significant amount of saturated material that will need to be relocated.
- Excavate a series of trenches from north to south in the gypsum. Conceptually, the trenches may be on the order of 5 feet deep at regular spacing (potentially every 50 feet) and graded to allow water to drain to the south. Sumps in the trenches along the south end of the gypsum deposit will be used to collect water, which will be pumped from the GMF Pond to the Recycle Pond. The trenches will remain open until the top layer of gypsum across the GMF Pond is sufficiently dewatered to enable removal and transport without producing free water when disturbed. This process will repeat until all gypsum has been removed from the GMF Pond. Each layer may take several weeks or months to dewater and remove. Active dewatering or multiple handling of the gypsum may be an option to expedite the closure construction. The ring drain system may also be used to facilitate dewatering of the gypsum.
- Once all gypsum has been removed from the GMF Pond, the existing dual composite liner system described in Section 1.1 will be removed as required under 845.740(a). The earthen and geosynthetic materials will be disposed in a permitted landfill.
- A tentative schedule for the closure-by-removal process is:
  - three to six months to pump ponded water out of the GMF Pond
  - between one and two construction seasons to dewater and remove saturated gypsum
  - one or two construction seasons to remove the existing liner system and establish final reclamation grades, depending on on-site or off-site disposal

2.2.2 Surface Reconstruction

Once the GMF Pond is completely dewatered and all gypsum has been removed, the site will be reconfigured to allow passive surface water flow. Earthen embankments in the southeast corner of the GMF Pond and in the Recycle Pond will be removed to allow surface water to flow into an existing drainage channel southeast of the GMF Pond.

2.2.3 Stormwater Management

Surface water will shed to the south across the footprint and will be directed to an existing drainage southeast of the GMF Pond. To prevent impoundment of water in the south end of the footprint, existing earthen embankments will be removed in the southeast corner of the GMF Pond and in the Recycle Pond to allow stormwater to passively flow into the existing drainage southeast of the GMF Pond. No new stormwater management ponds or other features would be needed for closure.

3.0 ADDITIONAL INFORMATION

Gradient provided a request for additional information to support the Closure Alternatives Analysis. The additional information compiled by Golder in response to the request is provided in Tables 1 through 4. Table 1 provides narrative responses for information requests based largely on Part 845 requirements for the closure alternatives analysis. Table 2 summarizes conceptual-level estimates of material quantities, equipment and vehicle usage, labor resources, and haul truck trips for the closure-in-place approach. Table 3 summarizes conceptual-level estimates of material quantities, equipment and vehicle usage, labor resources, and haul truck trips for the closure-by-removal approach with disposal in a permitted on-site landfill, which would require an approximate 2-acre expansion to the existing on-site landfill. Table 4 summarizes conceptual-level estimates of material quantities, equipment and vehicle usage, labor resources, and haul truck trips for the closure-by-removal approach with disposal in an off-site landfill.

A productivity-based approach was used to develop labor and heavy equipment spreads and corresponding production rates. The number and classification (e.g., operator, laborer) of personnel carrying out the activity and the number and type of heavy equipment pieces (e.g., dozer, loader, haul truck) were estimated based on our experience with similar construction operations. Production rates were developed based on equipment capabilities (e.g., haul truck capacity, estimated load and unload times, estimates of average speed) and checked against experience from similar projects. Material quantities correspond with the closure approaches shown in Exhibits 1 and 2 and were developed primarily in Autodesk Civil3D.

4.0 REFERENCES

AECOM. 2016. History of Construction, USEPA Final CCR Rule, 40 CFR § 257.73(c), Duck Creek Power Station. October. Available online: https://www.luminant.com/ccr/?wpdf_download_file=L25hcy9jb250ZW50L2xpdmUvbHVtaW5hbnQzL2RvY3VtZW50cy9jY3IvSWxsaW5vaXMvRHVjay1DcmVlay8yMDE2L0hpc3Rvcnkgb2YgQ29uc3RydWN0aW9uLnBkZg%3D%3D).

Feezor (Feezor Engineering, Inc.). 2009. Geosynthetics Quality Assurance Report, Gypsum Stack, AERG (Ameren) Duck Creek Power Station. July 2009.

Hanson (Hanson Professional Services Inc.). 2009a. Acceptance Report, Gypsum Stack, Gypsum Management Facility, AERG Duck Creek Power Generating Station. December 2009.

Hanson (Hanson Professional Services Inc.). 2009b. Initial Facility Report, Gypsum Stack, Gypsum Management Facility, Duck Creek Generating Station. February 2009.

Attachments: Table 1: Information Summary
Table 2: Closure Estimates - Closure In Place
Table 3: Closure Estimates - Closure by Removal with On-Site Disposal
Table 4: Closure Estimates - Closure by Removal with Off-Site Disposal

Exhibit 1 – Closure-In-Place Figures
Exhibit 2 – Closure-By-Removal Figures

https://golderassociates.sharepoint.com/sites/141778/project files/6 deliverables/techmemos/11-tm-supporting_info_gypsum_management_facility/11-tm-a/21454861-11-tm-a-supporting_info_gypsum_management_facility_05nov21.docx

Tables

Table 1: Information Summary

Background/Current Site Conditions	
Surface area of impoundment	30.8 acres
Volume of CCR in impoundment	400,000 cy
Published or draft engineering evaluations undertaken at the site to date	
Conceptual site models	Refer to the Groundwater Modeling Report.
Regional well (receptor) survey information	Refer to the Groundwater Modeling Report.
History of construction report	See [1].
Dike stability report	Observations and stability factors of safety described by AECOM [2] and [3] were adequate.
Hydraulic evaluation of basins (evaluation of possibility of overtopping and/or emergency spillway releases during flood conditions)	Hydraulic and hydrologic analyses performed by AECOM [4] found that the geomembrane-lined spillway can adequately manage flow during peak discharge from the 1,000-year storm event without overtopping of the embankments. This also means that the spillway is adequate to carry sustained flows.
Surface impoundment hazard assessment/hazard category determination	A hazard potential classification assessment performed by Stantec [5] found the GMF Pond to have significant hazard potential. 40 CFR 257.53 defines a significant hazard potential CCR surface impoundment as a diked surface impoundment for which failure or misoperation would result in no probable loss of human life but could cause economic loss, environmental damage, disruption of lifeline facilities, and/or impact other concerns.
Habitat survey	During site development, it was confirmed that the site did not contain wild or scenic rivers (per the National Park Service), the facility did not restrict the flow of a 100-year flood, the site did not qualify for listing on the National Register of Historic Places (per the Illinois Historic Preservation Agency), the site did not pose a threat to a dedicated nature preserve persuant to the Illinois Natural Areas Preservation Act (per the Illinois Nature Preserves Commission), and there were no records of the presence of endangered/threatened species or natural areas in the vicinity of the facility [6].
Wetlands survey	In March and May of 2007, field surveys were conducted to determine and delineate the existence of any potential wetland areas in accordance with the 1987 Corps of Engineers Wetland Delineation Manual. It was determined that six unnamed tributaries, a linear ditch wetland, and two headwater drainages were within the facility boundary. No defined hydrologic connection to Duck Creek was identified, so these were determined to be isolated waters and wetlands and not regulated under the Clean Water Act [6].

Table 1: Information Summary

Closure Design and Implementation	
Copy of draft of closure report, if available	Provided.
Engineering spreadsheet containing breakdown of labor, equipment/vehicle, and material requirements for each closure alternative, if available (expected on-site and off-site vehicle and equipment mileages, labor hours, etc.)	See Tables 2 through 4.
Overview of planned activities under each closure alternative	Closure in place: Under this scenario, gypsum will be contained in the northern portion of the GMF Pond, which will necessitate relocation of gypsum currently in the southern portion of the GMF Pond to this final containment area, followed by final cover installation. The general sequence is: -Ponded water will be pumped out of the GMF Pond. Approximately 112 million gallons of water was contained in the GMF Pond as of the December 2020 survey by IngenAE, not including the pore water within the roughly 400000 cy of gypsum. Pumping out the ponded water will allow gravity drainage of the gypsum to begin. -Gypsum within the final containment area will be dewatered as needed for trafficability using trenches and sumps and possibly the existing ring drain system. -Once the ponded water has been removed from the GMF Pond, a berm will be constructed across the GMF Pond in an east-west orientation at the south end of the final containment area. Gypsum in the berm footprint will need to be removed before the berm is constructed. The upstream face of the berm will be lined with a composite liner system, which will tie into the existing dual liner system. -The remaining wet gypsum south of the berm will be collected and deposited north of the berm. This may be accomplished by traditional earthwork methods and/or by washing the material towards sumps at the south end of the GMF Pond, where the material can be pumped or loaded. -Geosynthetic components of the existing dual composite liner system south of the berm will be removed and disposed in the closure footprint. Soil materials between these components will be removed and stockpiled south of the GMF Pond. -Compacted fill will be used as needed to achieve subgrade and a final cover system consisting of the following components (from top to bottom) will be constructed over the final containment area: -2-foot-thick final protective layer composed of locally available soils -Geocomposite -60-mil HDPE geomembrane -A channel will be excavated, including removal of sections of the perimeter embankment around the Recycle Pond, to allow surface water flow into an existing drainage channel southeast of the GMF Pond.

Table 1: Information Summary

Closure Design and Implementation	
Overview of planned activities under each closure alternative	Closure by removal: Under this scenario, the gypsum in the GMF Pond will be dewatered and hauled by truck from the GMF Pond to the existing permitted on-site landfill, which will require a 2-acre expansion, or to a permitted off-site landfill. Additionally, the existing dual composite liner system will be removed as required under Part 845.740(a). The general sequence is: -Ponded water will be pumped out of the GMF Pond. Approximately 112 million gallons of water was contained in the GMF Pond as of the December 2020 survey by IngenAE, not including the pore water within the roughly 400000 cy of gypsum. Pumping out the ponded water will allow gravity drainage of the gypsum to begin. -A series of trenches will be excavated from north to south in the gypsum. The trenches will likely be on the order of 5 feet deep at regular spacing (such as every 50 feet) and graded to allow water to drain to the south. Sumps will be excavated in the trenches along the south end of the gypsum deposit to collect water, which will be pumped from the GMF Pond to the Recycle Pond. The trenches will remain open until the surrounding gypsum is sufficiently dewatered to enable removal and transport without producing free water. This process will repeat until all gypsum has been removed from the GMF Pond. Each layer may take several weeks or months to dewater and remove. The ring drain system may also be used to facilitate dewatering of the gypsum. -Once all gypsum has been removed from the GMF Pond, the existing dual composite liner system will be removed and the subsoil will be overexcavated an additional 1 foot. The geosynthetic materials and soils will be disposed in the on-site landfill or in an off-site landfill. -A channel will be excavated, including removal of sections of the perimeter embankment around the Recycle Pond, to allow surface water flow into an existing drainage channel southeast of the GMF Pond.
Expected duration of major construction activities under each closure activity	Closure in place: Approximately two years. Removal of ponded water from the GMF Pond may take 3 to 6 months, depending on pumping rates, operating hours, and weather conditions. It is anticipated that the necessary dewatering in the final containment area can be completed during this time. Once the ponded water is removed, it is anticipated that the efforts to construct the berm and relocate the 85,000 cy of gypsum south of the berm can be completed in a single construction season. It is anticipated that final cover construction and establishment of final grades could be completed during the following construction season.
	Closure by removal: Approximately three years for on-site disposal and four years for off-site disposal. Removal of ponded water from the GMF Pond may take 3 to 6 months, depending on pumping rates, operating hours, and weather conditions. Expansion of the existing landfill can take place during this time. It is anticipated that dewatering and removal of the gypsum will take one or two construction seasons for on-site disposal or two full years for off-site disposal. It is anticipated that removal of the dual composite liner system and establishment of final grades will require an additional construction season for on-site disposal or 18 months for off-site disposal.

Table 1: Information Summary

Closure Design and Implementation	
If an on-site landfill will be constructed on the site under a given closure alternative, please include the years required to construct and later close the on-site landfill	Closure in place: Not applicable. The existing permitted on-site landfill has sufficient capacity to accept waste generated from closure in place without expansion of the existing landfill or construction of a new on-site landfill.
	Closure by removal: If disposal will be on site, the landfill expansion could be completed in a single construction season. Landfill closure could be completed in a single construction season following closure of the GMF Pond.
If an on-Site landfill must first be constructed on the Site, please estimate the anticipated delay in the commencement of excavation activities while the landfill is being sited, designed, and constructed. Will dewatering/unwatering of the ponds begin immediately, or after the landfill is constructed?	Closure in place: Not applicable.
	Closure by removal: The landfill has already been sited and permitted, including the expansion area. Final design and construction of the expansion could be completed while removal of ponded water and gypsum dewatering are occurring at the GMF Pond.
Proposed location of the on-site landfill if on-site disposal is being considered for CBR scenario	The existing on-site landfill is approximately 1 mile north of the GMF Pond via site roads.
Surface area of the on-site landfill, if a new landfill must be constructed at the site	If a landfill expansion is required (on-site disposal), the additional surface area is estimated as 2 acres.
Name and location of proposed off-site landfill	If an off-site landfill were to be used, the Peoria City-County Landfill is the nearest suitable facility (33 miles away).
Location of borrow area, if a borrow area will be established (for either the impoundment or construction/closure of an on-Site landfill). If location is unknown, please estimate a likely distance to the borrow area.	The anticipated on-site borrow source location is approximately 0.4 miles north of the GMF via site roads and approximately 0.7 miles south of the on-site landfill by site roads.
Estimated volume of soil to be hauled from the borrow area under each closure alternative	Closure in place: The amount of borrow material required is estimated as 73,800 cubic yards.
	Closure by removal: If a landfill expansion is not required, no borrow material will be needed. If a landfill expansion is required (on-site disposal), the maximum amount of borrow material required is estimated as 18,000 cubic yards.
Difficulty associated with implementation of each closure alternative (e.g., do any alternatives pose particular engineering/implementation challenges?)	Closure in place: Dewatering and relocation of gypsum may be moderately challenging. Establishing the surface water drainage channel through the Gypsum Recycle Pond perimeter berm will be challenging because of the excavation depths involved.
	Closure by removal: Dewatering of the gypsum prior to removal will require considerable effort and time. Establishing the surface water drainage channel through the Gypsum Recycle Pond perimeter berm will be challenging because of the excavation depths involved.
Availability of necessary equipment and specialists for each closure alternative	Good availability of equipment and services is anticipated for all closure alternatives.
Available capacity and location of needed treatment, storage, and disposal services for each closure alternative	The distance to the nearest off-site landfill (approximately 33 miles) presents a significant challenge for the option that involves off-site disposal.

Table 1: Information Summary

Post-Closure Plan/Long-Term Management Plan	
Planned duration of post-closure care activities	Closure in place: The owner or operator of the CCR surface impoundment must conduct post-closure care for 30 years. The owner or operator must continue to conduct post-closure care beyond the 30-year post-closure care period until groundwater monitoring data shows the concentrations are (a) below groundwater protection standards given in Section 845.600 of Part 845 or (b) not increasing for those constiuents over background using the statistical procedures and performance standards in Section 845.640(f) and (g), provided that concentrations have been reduced to the maximum extent feasible and they are protective of human health and the environment.
	Closure by removal: An owner or operator of a CCR surface impoundment that elects to close a CCR surface impoundment by removing CCR as provided in Section 845.740 must continue groundwater monitoring for three years after the completion of closure or until concentrations have been reduced to the maximum extent feasible and they are protective of human health and the environment.
Expected frequency of groundwater and surface water monitoring during post-closure period	Closure in place: Quarterly for 5 years and semi-annually thereafter.
	Closure by removal: Quarterly.
Expected frequency of inspections post closure	Monthly for the first year and annually thereafter [6].
Summary of planned maintenance activities post-closure	Closure in place: Groundwater monitoring will be conducted. Site inspections will be conducted on a quarterly basis for a minimum of 5 years after closure. An annual site inspection will be performed until settlement has ceased and there are no eroded or scoured areas or until the end of the 30-year post-closure care period. Over these 30 years, repair and maintenance, including soil filling and reseeding, will be performed if ponding is observed, cracks greater than 1 inch wide or gullies 6 inches or deeper have formed, vegetative or vector problems arise, or leachate seeps are present. Areas susceptible to erosion will be recontoured and reseeded. Eroded and scoured drainage channels will be repaired and the liner material replaced if necessary. Vegetation will be mowed annually. Areas of failed or eroded vegetation in excess of 100 square feet will be revegetated. Minor repairs to ensure the integrity and proper function of fencing, surface water drainage features, monitoring points, and groundwater monitoring wells may be required. Leachate will be pumped from the leachate collection sumps into storage tanks or tanker trucks and transported to a wastewater treatment plant for treatment and disposal [6].
	Closure by removal: Groundwater monitoring will be conducted.
Summary of planned post-closure care activities at the on-site landfill, if a new on-site landfill is going to be constructed	Not applicable.

Table 1: Information Summary

Corrective Measures Assessment	
Corrective measures being considered post-closure	None anticipated.
Overview of planned activities for each corrective measure	None anticipated.

References

1) AECOM. (2016). History of Construction, USEPA Final CCR Rule, 40 CFR 257.73(c), Duck Creek Power Station, Canton, Illinois. Available online: https://www.luminant.com/ccr.

2) AECOM (2016). CCR Rule Report: Initial Structural Stability Assessment for GMF Pond at Duck Creek Power Station. Available online: https://www.luminant.com/ccr.

3) AECOM (2016). CCR Rule Report: Initial Safety Factor Assessment for GMF Pond at Duck Creek Power Station. Available online: https://www.luminant.com/ccr.

4) AECOM (2016). CCR Rule Report: Initial Inflow Design Flood Control System Plan for GMF Pond at Duck Creek Power Station. Available online: https://www.luminant.com/ccr.

5) Stantec. (2016). Initial Hazard Potential Classification Assessment, EPA Final CCR Rule, GMF Pond, Duck Creek Power Station, Fulton County, Illinois. Available online: https://www.luminant.com/ccr.

6) Hanson (Hanson Professional Services, Inc.) 2009. Geosynthetics Quality Assurance Report, Gypsum Stack, AERG (Ameren) Duck Creek Power Station.

Table 2: Closure Estimates - Closure In Place

Description	Unit	Quantity	Labor	Equipment	Truck Trips
Mobilization/Demobilization	LS	1	1 superintendent	Pickup truck, flatbed truck	
Survey	LS	1	1 surveyor	Pickup truck	
Borrow Area Preparation and Reclamation	LS	1	2 equipment operators	Dozer, seed drill or hydroseeder	
Ponded Water Removal	LS	1	1 superintendent (part-time), 1 laborer (part-time)	Pickup truck (part-time), diesel pump, generator	
Pipe Removal/Abandonment	LS	1	2 equipment operators, 2 laborers	Excavator, haul truck	
Embankment Fill	CY	25,700	7 equipment operators	Excavator, dozer, compactor, water truck, 3 haul trucks	1,405 (0.4 miles one way)
Geomembrane - Berm Liner	SF	58,600	5 laborers, 1 equipment operator, 1 superintendent, 1 quality assurance technician	Pickup truck, telehandler	
Geosynthetic Clay Liner - Berm Liner	SF	29,300		Pickup truck, telehandler	
Geocomposite Drainage Layer - Berm Liner	SF	29,300		Pickup truck, telehandler	
Gypsum Dewatering and Bridging Fill	LS	1	1 superintendent, 2 laborers (half-time), 3 operators (half-time)	Excavator (half-time), dozer (half-time), haul truck (half-time), diesel pump	
Gypsum Relocation	CY	85,000	9 equipment operators	2 excavators, dozer, 2 loaders, 4 haul trucks, diesel pump	4,382 (0.2 miles one way)
Geosynthetics Removal and Disposal	AC	17	4 equipment operators, 2 laborers	Loader, 3 haul trucks	100 (0.2 miles one way)
Cushion Soil Removal and Stockpiling	CY	29,100	5 equipment operators	Excavator, dozer, 3 haul trucks, diesel pump	1,590 (0.2 miles one way)
Drainage Soil Removal and Stockpiling	CY	26,600	5 equipment operators	Excavator, dozer, 3 haul trucks, diesel pump	1,454 (0.2 miles one way)
Geomembrane - Final Cover	SF	648,600	5 laborers, 1 equipment operator, 1 superintendent, 1 quality assurance technician	Pickup truck, telehandler	
Geocomposite Drainage Layer - Final Cover	SF	648,600			
Protective Soil Layer	CY	48,100	10 equipment operators	2 excavators, dozer, water truck, 6 haul trucks	2,629 (0.4 miles one way)
Fertilize, Seed, and Mulch	AC	35	2 equipment operators	Seed drill or hydroseeder	
Stormwater Channel Excavation	CY	81,000	3 equipment operators	Excavator, 2 haul trucks, diesel pump	4,426 (0.4 miles one way)
Erosion Controls	LS	1	2 laborers		
Construction Quality Assurance	LS	1	1 to 2 technicians	1 to 2 pickup trucks	
Miscellaneous Construction	LS	1	Miscellaneous	Miscellaneous	

Notes:
Miscellaneous Construction includes other work not captured in the items shown.
Soil components were assumed to be taken from the stockpile north of the GMF (0.4-mile haul).
Disposal was assumed to occur in the on-site landfill (1.2-mile haul).
Stockpiling was assumed to occur south of the closure footprint (0.2-mile haul).
Soil excavated for the stormwater channel was assumed to be stockpiled 0.4 miles from the excavation.

Table 3: Closure Estimates - Closure by Removal with On-Site Disposal

Description	Unit	Quantity	Labor	Equipment	Truck Trips
Mobilization/Demobilization	LS	1	1 superintendent	Pickup truck, flatbed truck	
Survey	LS	1	1 surveyor	Pickup truck	
Ponded Water Removal	LS	1	1 superintendent (part-time), 1 laborer (part-time)	Pickup truck (part-time), diesel pump	
Pipe Removal/Abandonment	LS	1	2 equipment operators, 2 laborers	Excavator, haul truck	
Gypsum Dewatering	LS	1	1 superintendent, 2 laborers (half-time), 2 operators (half-time)	Excavator (half-time), haul truck (half-time), diesel pump	
Gypsum Loading and Disposal	CY	400,000	13 equipment operators	2 excavators, dozer, 2 loaders, 8 haul trucks, diesel pump	20,619 (1.2 miles one way)
Geosynthetics Removal and Disposal	AC	31	4 equipment operators, 2 laborers	Loader, 3 haul trucks	180 (1.2 miles one way)
Cushion Soil Removal and Disposal	CY	60,800	6 equipment operators	Excavator, dozer, 4 haul trucks, diesel pump	3,322 (1.2 miles one way)
Drainage Soil Removal and Disposal	CY	55,500	6 equipment operators	Excavator, dozer, 4 haul trucks, diesel pump	3,033 (1.2 miles one way)
Compacted Clay Removal and Disposal	CY	166,500	6 equipment operators	Excavator, dozer, 4 haul trucks, diesel pump	9,099 (1.2 miles one way)
Subsoil Overexcavation and Disposal	CY	50,000	6 equipment operators	Excavator, dozer, 4 haul trucks, diesel pump	2,733 (1.2 miles one way)
Fertilize, Seed, & Mulch	AC	36	2 equipment operators	Seed drill or hydroseeder	
Stormwater Channel Excavation	CY	86,000	3 equipment operators	Excavator, 2 haul trucks, diesel pump	4,700 (0.4 miles one way)
Erosion Controls	LS	1	2 laborers		
Subgrade Preparation - Landfill Expansion	AC	2	2 equipment operators, laborer	Dozer, loader	
Compacted Clay - Landfill Expansion	CY	9,700	7 equipment operators	Excavator, dozer, compactor, water truck, 3 haul trucks	530 (0.7 miles one way)
Geomembrane - Landfill Expansion	SF	87,100	5 laborers, 1 equipment operator, 1 superintendent, 1 quality assurance technician	Pickup truck, telehandler	
Geosynthetic Clay Liner - Landfill Expansion	SF	87,100		Pickup truck, telehandler	
Geotextile - Landfill Expansion	SF	174,200		Pickup truck, telehandler	
Drainage Soil - Landfill Expansion	CY	3,200	2 equipment operators	Dozer, loader	
Leachate Collection System - Landfill Expansion	LS	1	5 laborers		
Miscellaneous Construction	LS	1	Miscellaneous	Miscellaneous	

Notes:

Miscellaneous Construction includes other work not captured in the items shown.

Disposal was assumed to occur in the on-site landfill (1.2-mile haul).

Soil excavated for the stormwater channel was assumed to be stockpiled 0.4 miles from the excavation.

Soil components for landfill expansion except drainage soil (imported) were assumed to be taken from the stockpile north of the GMF (0.7-mile haul).

Table 4: Closure Estimates - Closure by Removal with Off-Site Disposal

Description	Unit	Quantity	Labor	Equipment	Truck Trips
Mobilization/Demobilization	LS	1	1 superintendent	Pickup truck, flatbed truck	
Survey	LS	1	1 surveyor	Pickup truck	
Ponded Water Removal	LS	1	1 superintendent (part-time), 1 laborer (part-time)	Pickup truck (part-time), diesel pump	
Pipe Removal/Abandonment	LS	1	2 equipment operators, 2 laborers	Excavator, haul truck	
Gypsum Dewatering	LS	1	1 superintendent, 2 laborers (half-time), 2 operators (half-time)	Excavator (half-time), haul truck (half-time), diesel pump	
Gypsum Removal	CY	400,000	5 equipment operators	2 excavators, dozer, 2 loaders, diesel pump	
Gypsum Disposal	CY	400,000	8 equipment operators	8 on-highway trucks	26,846 (32.6 miles one way)
Geosynthetics Removal	AC	31	Equipment operator, 2 laborers	Loader	
Geosynthetics Hauling and Disposal	AC	31	3 equipment operators	3 on-highway trucks	245 (32.6 miles one way)
Cushion Soil Removal	CY	60,800	2 equipment operators	2 excavators, diesel pump	
Cushion Soil Hauling and Disposal	CY	60,800	8 equipment operators	8 on-highway trucks	4,343 (32.6 miles one way)
Drainage Soil Removal	CY	55,500	2 equipment operators	2 excavators, diesel pump	
Drainage Soil Hauling and Disposal	CY	55,500	8 equipment operators	8 on-highway trucks	3,964 (32.6 miles one way)
Compacted Clay Removal	CY	166,500	2 equipment operators	2 excavators, diesel pump	
Compacted Clay Hauling and Disposal	CY	166,500	8 equipment operators	8 on-highway trucks	11,893 (32.6 miles one way)
Subsoil Overexcavation	CY	50,000	2 equipment operators	2 excavators, diesel pump	
Subsoil Hauling and Disposal	CY	50,000	8 equipment operators	8 on-highway trucks	3,571 (32.6 miles one way)
Fertilize, Seed, & Mulch	AC	36	2 equipment operators	Seed drill or hydroseeder	
Stormwater Channel Excavation	CY	86,000	3 equipment operators	Excavator, 2 haul trucks, diesel pump	4,700 (0.4 miles one way)
Erosion Controls	LS	1	2 laborers		
Miscellaneous Construction	LS	1	Miscellaneous	Miscellaneous	

Notes:

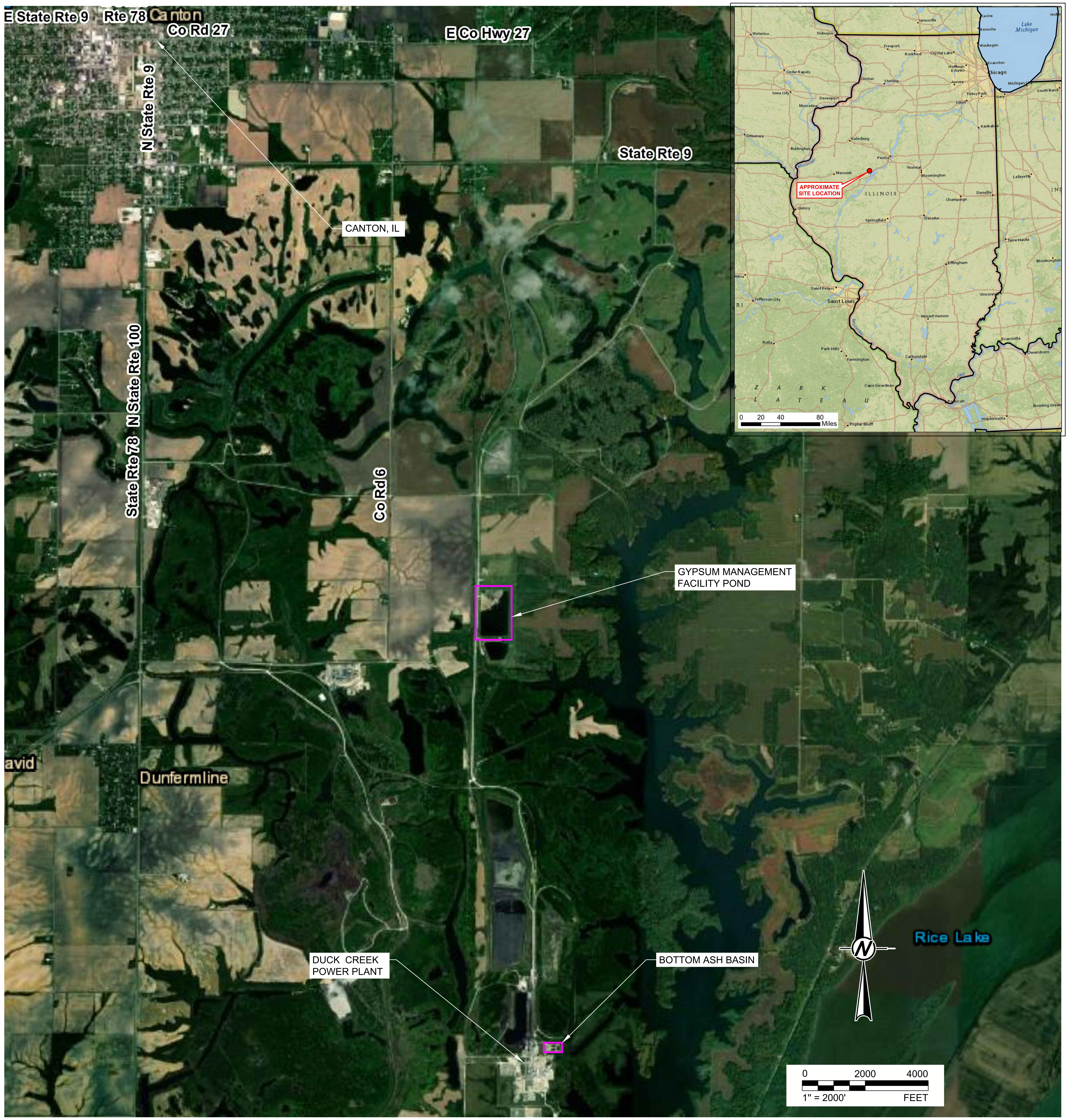
Miscellaneous Construction includes other work not captured in the items shown.

Disposal was assumed to occur in an off-site landfill (32.6-mile haul).

Soil excavated for the stormwater channel was assumed to be stockpiled 0.4 miles from the excavation.

EXHIBIT 1

Closure-In-Place Figures



ILLINOIS POWER RESOURCES GENERATING, LLC
DUCK CREEK POWER PLANT
GYPSUM MANAGEMENT FACILITY POND
CONSTRUCTION PERMIT APPLICATION

PREPARED BY:

GOLDER ASSOCIATES INC.
13515 BARRETT PARKWAY DRIVE, SUITE 260
BALLWIN, MISSOURI USA 63021

NOTE(S)

1. AERIAL IMAGERY FROM ESRI PROVIDED BASEMAP SERVICE. IMAGERY COLLECTED 5/14/2017, 10/21/2017, 8/22/2018, AND 4/1/2019.
2. INSET MAP BOUNDARIES FROM ESRI PROVIDED FEATURE SERVICE. USA STATE BOUNDARIES. 2021
3. INSET MAP BACKGROUND FROM ESRI PROVIDED BASEMAP SERVICE. NATIONAL GEOGRAPHIC BASEMAP. 2021.

DRAFT

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
A	2021-11-05	ISSUED FOR REVIEW	DVS	DVS	JJS	JEO

SEAL

CLIENT
ILLINOIS POWER RESOURCES GENERATING, LLC
DUCK CREEK POWER PLANT

PROJECT
GYPSUM MANAGEMENT FACILITY POND
CONSTRUCTION PERMIT APPLICATION

CONSULTANT

GOLDER
MEMBER OF WSP
13515 BARRETT PARKWAY DRIVE, SUITE 260
BALLWIN, MO 63021
UNITED STATES
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TITLE
TITLE SHEET

PROJECT NO. 21454861 | REV. A | 1 of 7 | DRAWING 1

Path: \\Denver\acad\VISTRA\Duck Creek\99_PROJECTS\21454861\Gypsum Management Facility\02_PRODUCTION\DWG\A_CIP Permit DWGs_revB 2 ft cover\ | File Name: 21454861A001.dwg | Last Edited By: dvsmith Date: 2021-11-05 Time:9:44:35 AM | Printed By: KCernik Date: 2021-11-05 Time:3:50:00 PM

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

LEGEND

- 600 — EXISTING GROUND ELEVATION CONTOURS (NOTE 1)
- EXISTING ROAD
- LIMIT OF GMF LINER SYSTEM (NOTE 2)
- WATER LEVEL LINE (NOTE 3)
- EXISTING PIPING (NOTE 3)

NOTES

1. EXISTING CONTOURS ARE A COMPOSITE OF AN AERIAL SURVEY COMPLETED BY DRAGONFLY AEROSOLUTIONS DATED 11/17/2020, TOPOGRAPHIC/BATHYMETRIC SURVEYS COMPLETED BY INGENAE DATED 11/4/2020 & 11/5/2020, AND U.S. GEOLOGICAL SURVEY LIDAR POINT CLOUD DATA DATED 2/12/2018.
2. LIMIT OF LINER ESTIMATED FROM CONSTRUCTION RECORD DRAWINGS PREPARED BY HANSON PROFESSIONAL SERVICES, DATED 03-05-2009.
3. WATER LEVEL LINE AND EXISTING PIPING FROM INGENAE SURVEY RECORD DRAWING DATED 3/19/2021.
4. AERIAL IMAGERY FROM DRAGONFLY AEROSOLUTIONS DATED 11/17/2020.

0 120 240
1" = 120' FEET

DRAFT

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
A	2021-11-05	ISSUED FOR REVIEW	DVS	DVS	JJS	JEO

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PROJECT
GYPSUM MANAGEMENT FACILITY POND
CONSTRUCTION PERMIT APPLICATION

TITLE
EXISTING CONDITIONS

PROJECT NO. 21454861 | REV. A | 2 of 7 | DRAWING 2

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

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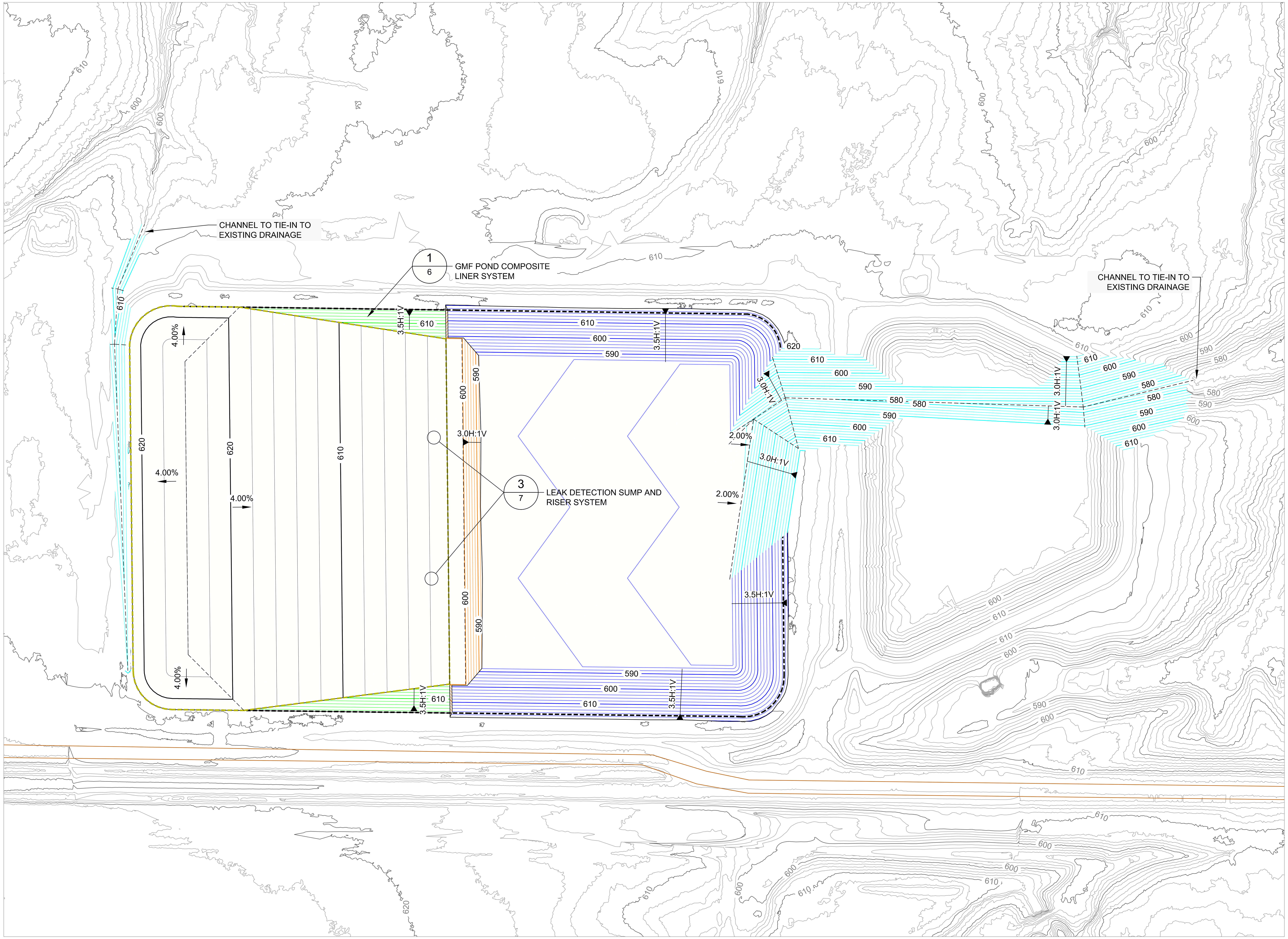

LEGEND

600	TOP OF RELOCATED GYPSUM
600	TOP OF COMPOSITE LINER SYSTEM (SEE NOTE 1)
600	TOP OF CLAY LINER (SEE NOTE 1)
600	DRAINAGE CHANNEL GRADES
600	EARTHEN BERM GRADES
600	EXISTING GROUND CONTOURS (SEE NOTE 2)
	EXISTING ROAD
	LIMIT OF GMF POND LINER SYSTEM (NOTE 1)
	LIMIT OF WASTE

NOTES

1. GYPSUM MANAGEMENT FACILITY (GMF) POND BASE GRADES AND LIMIT OF LINER SYSTEM WERE DEVELOPED FROM CONSTRUCTION RECORD DRAWINGS PREPARED BY HANSON PROFESSIONAL SERVICES.
2. EXISTING CONTOURS ARE A COMPOSITE OF AN AERIAL SURVEY COMPLETED BY DRAGONFLY AEROSOLUTIONS DATED 11/17/2020, TOPOGRAPHIC/BATHYMETRIC SURVEYS COMPLETED BY INGENAE DATED 11/4/2020 & 11/5/2020, AND U.S. GEOLOGICAL SURVEY LIDAR POINT CLOUD DATA DATED 2/12/2018.
3. CLOSURE WILL INVOLVE REMOVAL OF PONDED WATER, CONSTRUCTION OF AN EARTHEN BERM WITH A LINER SYSTEM ON THE UPSTREAM SLOPE, REMOVAL AND RELOCATION OF GYPSUM SOUTH OF THE BERM TO WITHIN THE CLOSURE FOOTPRINT, AND FINAL COVER SYSTEM CONSTRUCTION.

0 120 240
1" = 120' FEET

DRAFT

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
A	2021-11-05	ISSUED FOR REVIEW	DVS	DVS	JJS	JEO

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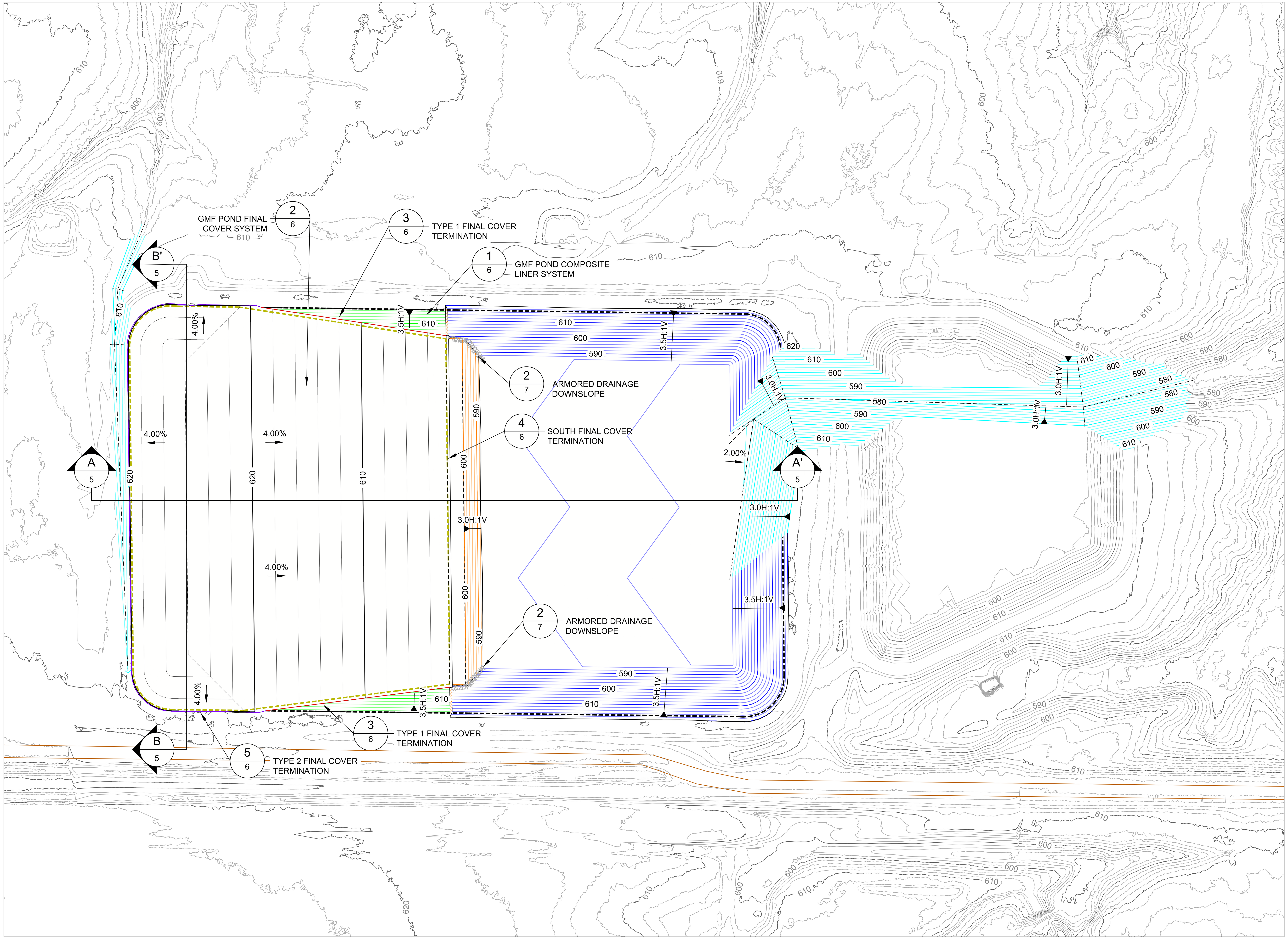
PROJECT
GYPSUM MANAGEMENT FACILITY POND
CONSTRUCTION PERMIT APPLICATION

TITLE
GYPSUM REGRADING AND CONTAINMENT PLAN

PROJECT NO. 21454861 | REV. A | 3 of 7 | DRAWING 3

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



LEGEND

- 600 — TOP OF FINAL COVER
- 600 — TOP OF COMPOSITE LINER SYSTEM (SEE NOTE 1)
- 600 — TOP OF CLAY LINER (SEE NOTE 1)
- 600 — EARTHEN BERM GRADES
- 600 — EXISTING GROUND CONTOURS (SEE NOTE 2)
- EXISTING ROAD
- LIMIT OF GMF POND LINER SYSTEM (NOTE 1)
- LIMIT OF WASTE
- TYPE 1 FINAL COVER TERMINATION
- TYPE 2 FINAL COVER TERMINATION

NOTES

1. GYPSUM MANAGEMENT FACILITY (GMF) POND BASE GRADES AND LIMIT OF LINER SYSTEM WERE DEVELOPED FROM CONSTRUCTION RECORD DRAWINGS PREPARED BY HANSON PROFESSIONAL SERVICES.
2. EXISTING CONTOURS ARE A COMPOSITE OF AN AERIAL SURVEY COMPLETED BY DRAGONFLY AEROSOLUTIONS DATED 11/17/2020, TOPOGRAPHIC/BATHYMETRIC SURVEYS COMPLETED BY INGENAE DATED 11/4/2020 & 11/5/2020, AND U.S. GEOLOGICAL SURVEY LIDAR POINT CLOUD DATA DATED 2/12/2018.
3. CLOSURE WILL INVOLVE REMOVAL OF PONDED WATER, CONSTRUCTION OF AN EARTHEN BERM WITH A LINER SYSTEM ON THE UPSTREAM SLOPE, REMOVAL AND RELOCATION OF GYPSUM SOUTH OF THE BERM TO WITHIN THE CLOSURE FOOTPRINT, AND FINAL COVER CONSTRUCTION.

0 120 240
1" = 120' FEET

DRAFT

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
A	2021-11-05	ISSUED FOR REVIEW	DVS	DVS	JJS	JEO

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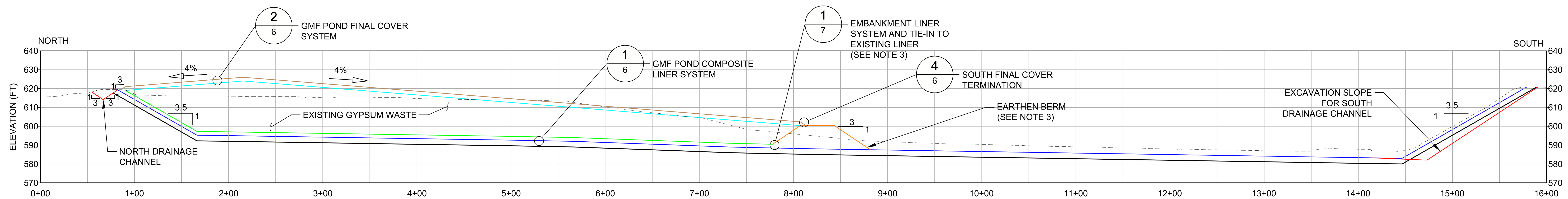
PROJECT
GYPSUM MANAGEMENT FACILITY POND
CONSTRUCTION PERMIT APPLICATION

TITLE
FINAL COVER AND STORMWATER PLAN

PROJECT NO. 21454861 | REV. A | 4 of 7 | DRAWING 4

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

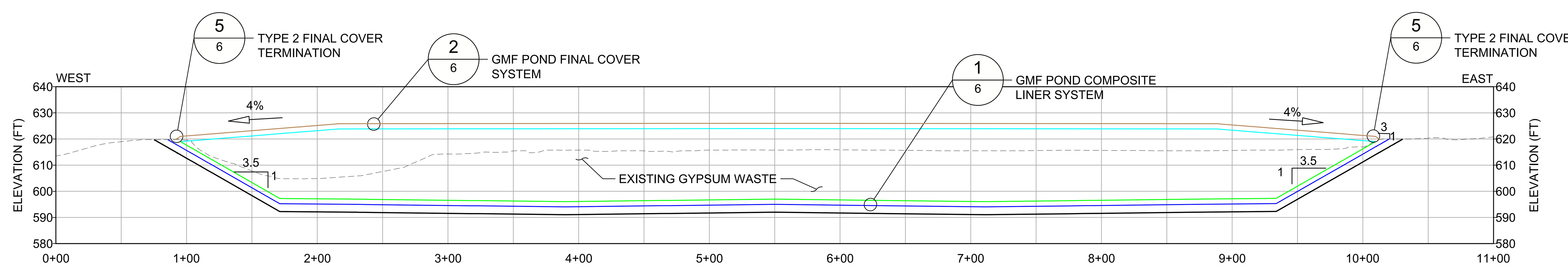


SCALE 1"=60'
VERT. SCALE X2

A
5

SECTION A-A'

0 60 120
1" = 60' FEET



SCALE 1" = 60'
VERT. SCALE X2

B
5

SECTION B-B'

0 60 120
1" = 60' FEET

LEGEND

- TOP OF FINAL COVER
- TOP OF RELOCATED GYPSUM
- TOP OF COMPOSITE LINER SYSTEM (SEE NOTE 1)
- TOP OF CLAY LINER (SEE NOTE 1)
- BOTTOM OF COMPOSITE LINER SYSTEM (SEE NOTE 1)
- EXISTING GROUND CONTOURS (SEE NOTE 2)
- EARTHEN BERM (SEE NOTE 3)
- DRAINAGE CHANNEL GRADING

NOTES

1. GYPSUM MANAGEMENT FACILITY (GMF) POND BASE GRADES SHOWN WERE DEVELOPED FROM CONSTRUCTION RECORD DRAWINGS PREPARED BY HANSON PROFESSIONAL SERVICES.
2. EXISTING CONTOURS ARE A COMPOSITE OF AN AERIAL SURVEY COMPLETED BY DRAGONFLY AEROSOLUTIONS DATED 11/17/2020, TOPOGRAPHIC/BATHYMETRIC SURVEYS COMPLETED BY INGENAE DATED 11/4/2020 & 11/5/2020, AND U.S. GEOLOGICAL SURVEY LIDAR POINT CLOUD DATA DATED 2/12/2018.
3. CLOSURE WILL INVOLVE REMOVAL OF PONDED WATER, CONSTRUCTION OF AN EARTHEN BERM WITH A LINER ON THE UPSTREAM SLOPE, REMOVAL AND RELOCATION OF GYPSUM SOUTH OF THE BERM TO WITHIN THE CLOSURE FOOTPRINT, AND FINAL COVER CONSTRUCTION.

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REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
A	2021-11-05	ISSUED FOR REVIEW	DVS	DVS	JJS	JEO

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CONSULTANT
GOLDER
MEMBER OF WSP

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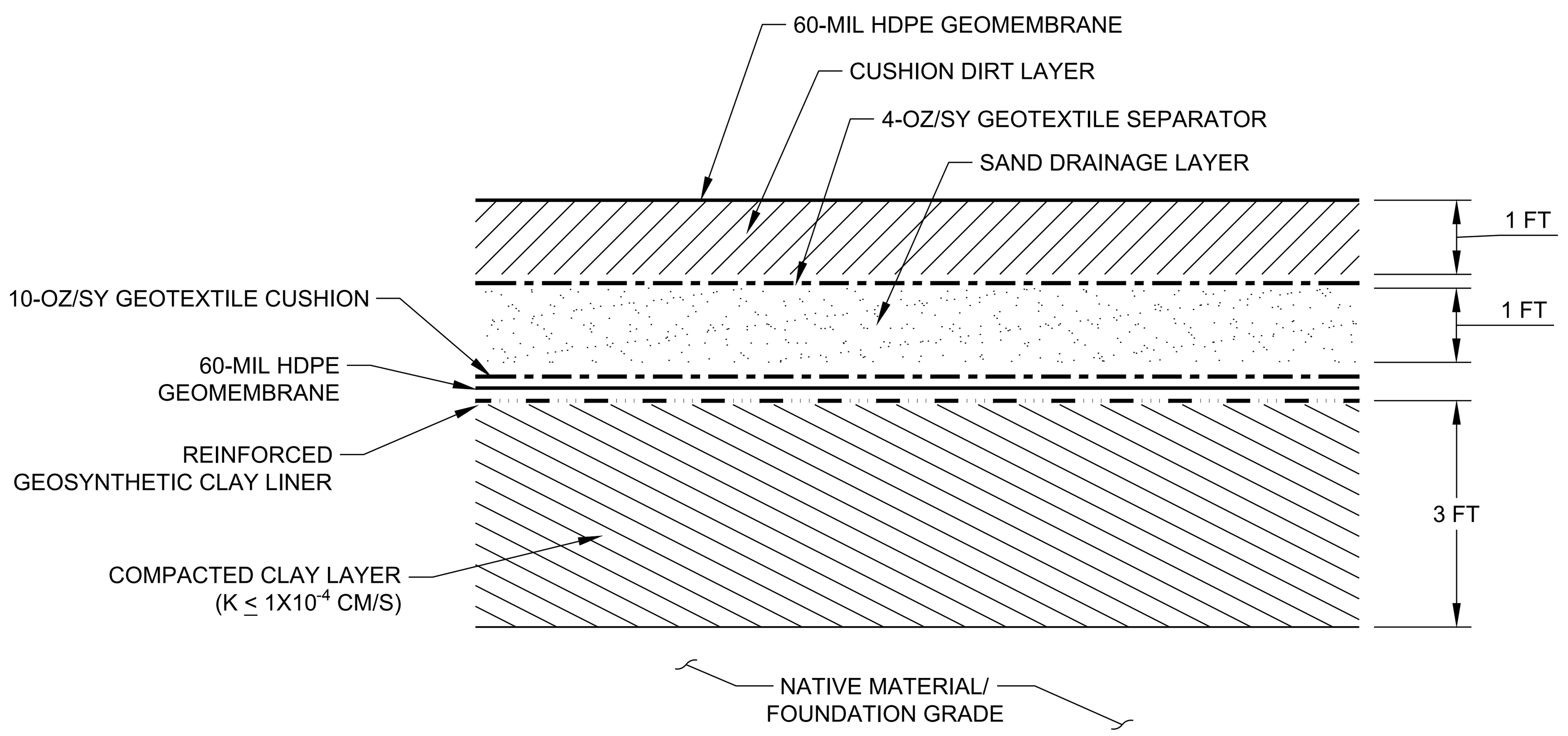
PROJECT
GYPSUM MANAGEMENT FACILITY POND
CONSTRUCTION PERMIT APPLICATION

TITLE
SECTIONS

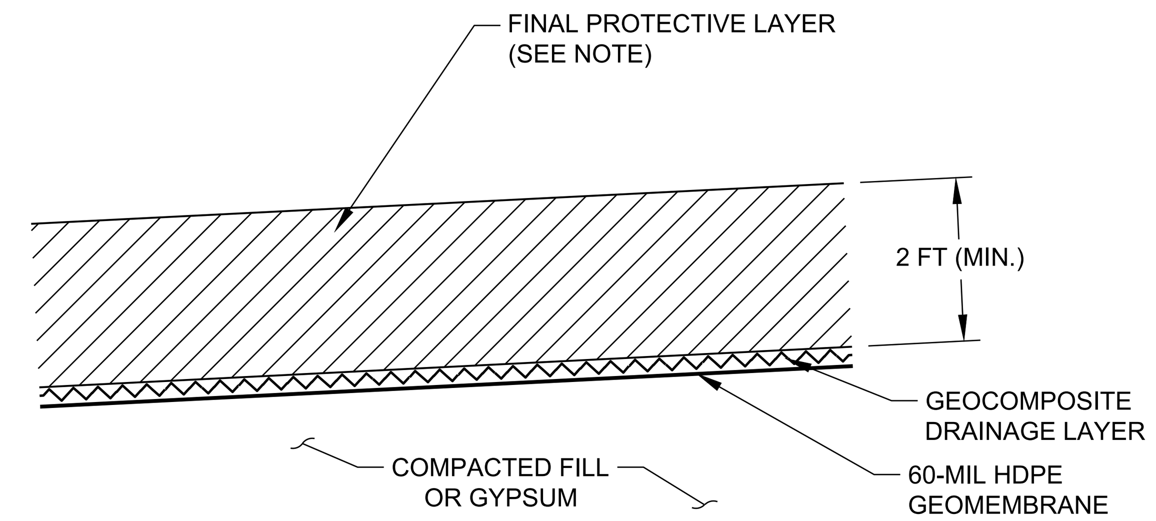
PROJECT NO. 21454861
REV. A
5 of 7
DRAWING 5



SCALE N.T.S. 1/6 GMF POND COMPOSITE LINER SYSTEM

MATERIAL REMOVAL NOTES (SOUTH OF EARTHEN BERM)

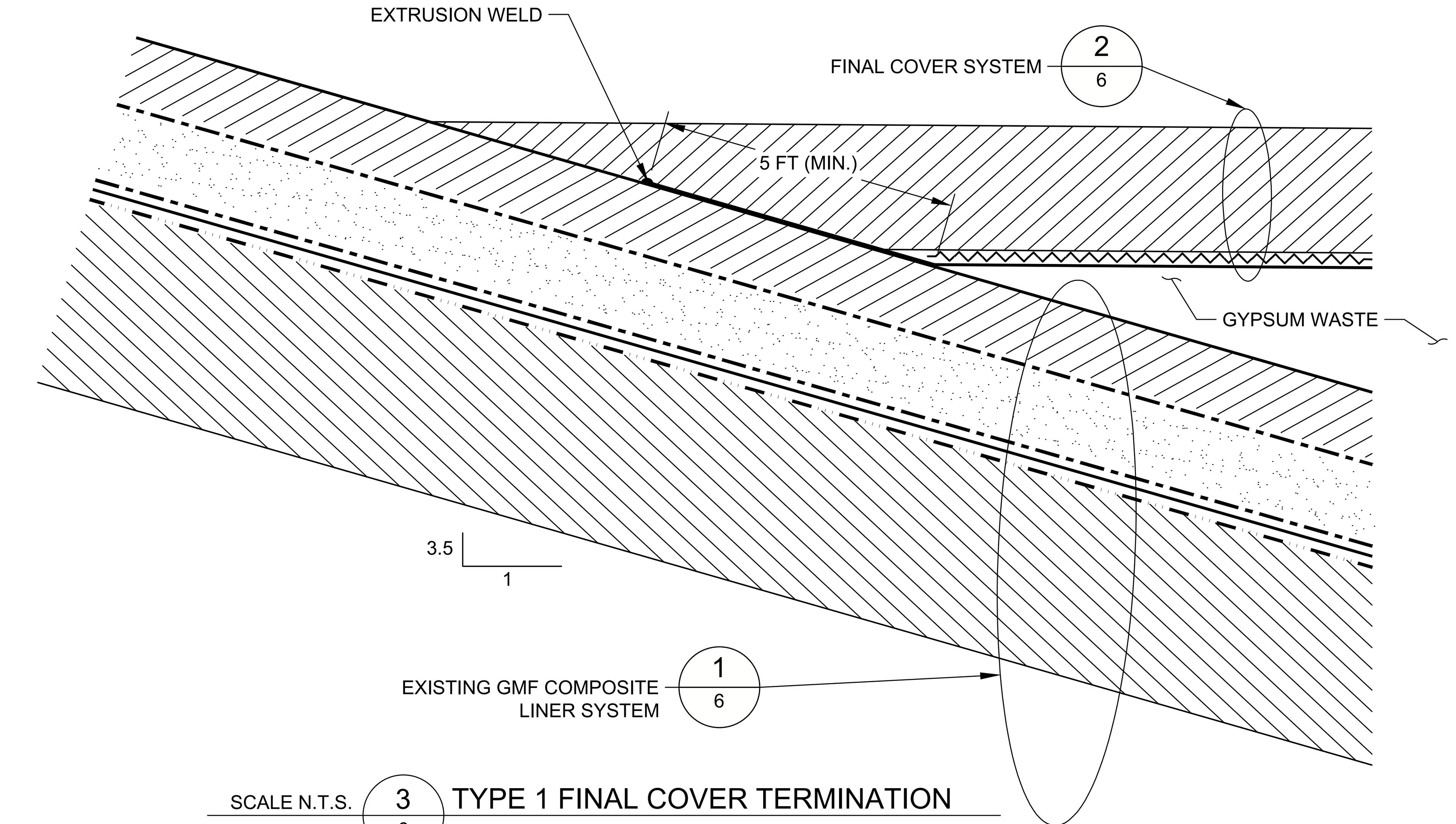
- THE CUSHION DIRT LAYER AND DRAINAGE LAYER WILL BE REMOVED AND STOCKPILED ON-SITE.
- GEOSYNTHETIC COMPONENTS OF THE LINER SYSTEM WILL BE REMOVED AND DISPOSED. GEOSYNTHETIC MATERIALS TO BE REMOVED INCLUDE: PRIMARY AND SECONDARY 60-MIL HDPE GEOMEMBRANE, GEOTEXTILE SEPARATOR, GEOTEXTILE CUSHION, AND GEOSYNTHETIC CLAY LINER.
- THE COMPACTED CLAY LAYER WILL REMAIN IN PLACE.



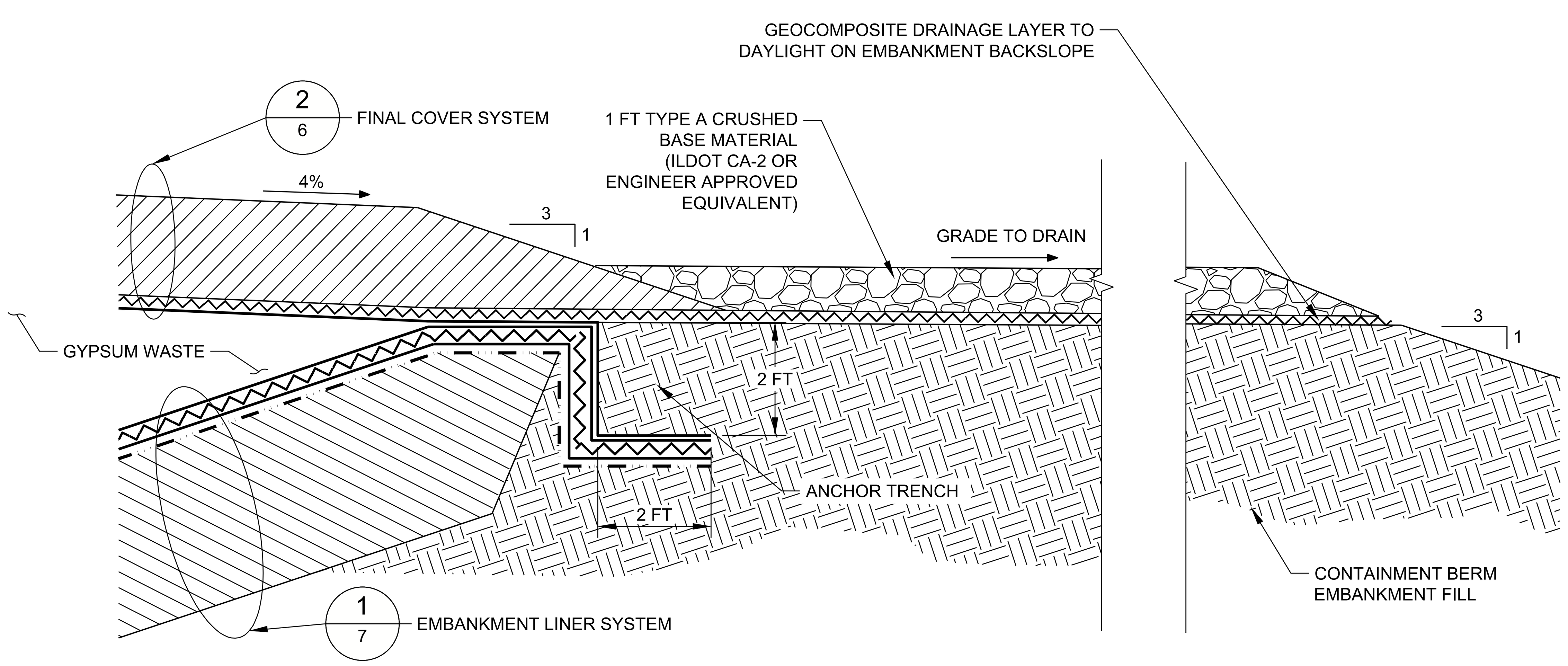
SCALE N.T.S. 2/6 FINAL COVER SYSTEM

NOTE

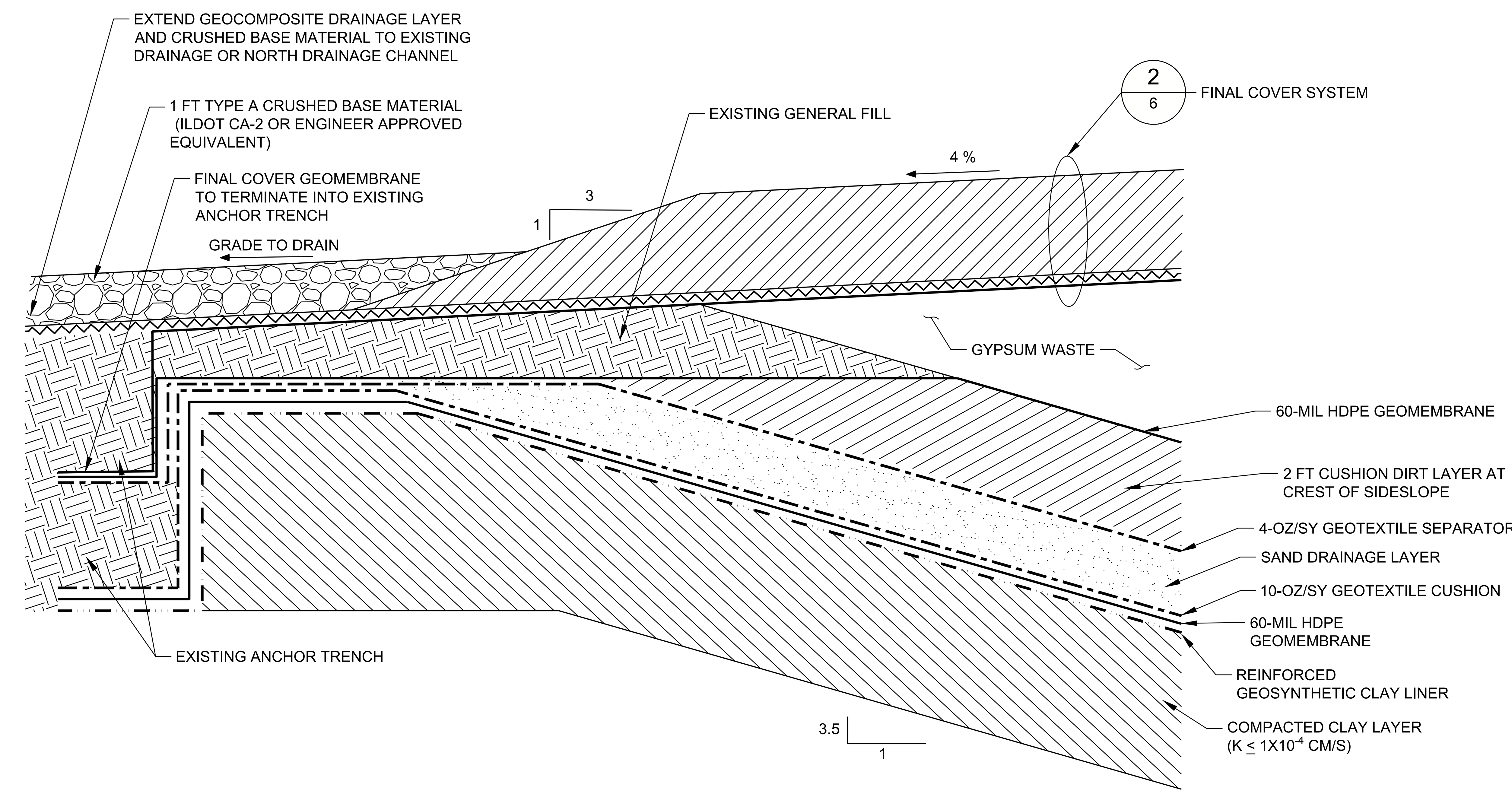
- THE FINAL PROTECTIVE LAYER WILL BE COMPOSED OF LOCALLY AVAILABLE SOILS COMPACTED TO BETWEEN 80% AND 95% OF THE STANDARD PROCTOR. THE UPPERMOST 6 INCHES OF THE FINAL PROTECTIVE LAYER SHALL BE TRACKED IN PLACE WITH DENSITY SUITABLE FOR ESTABLISHMENT OF VEGETATION.
- THE GEOMEMBRANE WILL MEET THE REQUIREMENTS OF GRI-GM13 AND WILL BE INSTALLED IN ACCORDANCE WITH GRI GM-19A.



SCALE N.T.S. 3/6 TYPE 1 FINAL COVER TERMINATION



SCALE N.T.S. 4/6 SOUTH FINAL COVER TERMINATION



SCALE N.T.S. 5/6 TYPE 2 COVER TERMINATION

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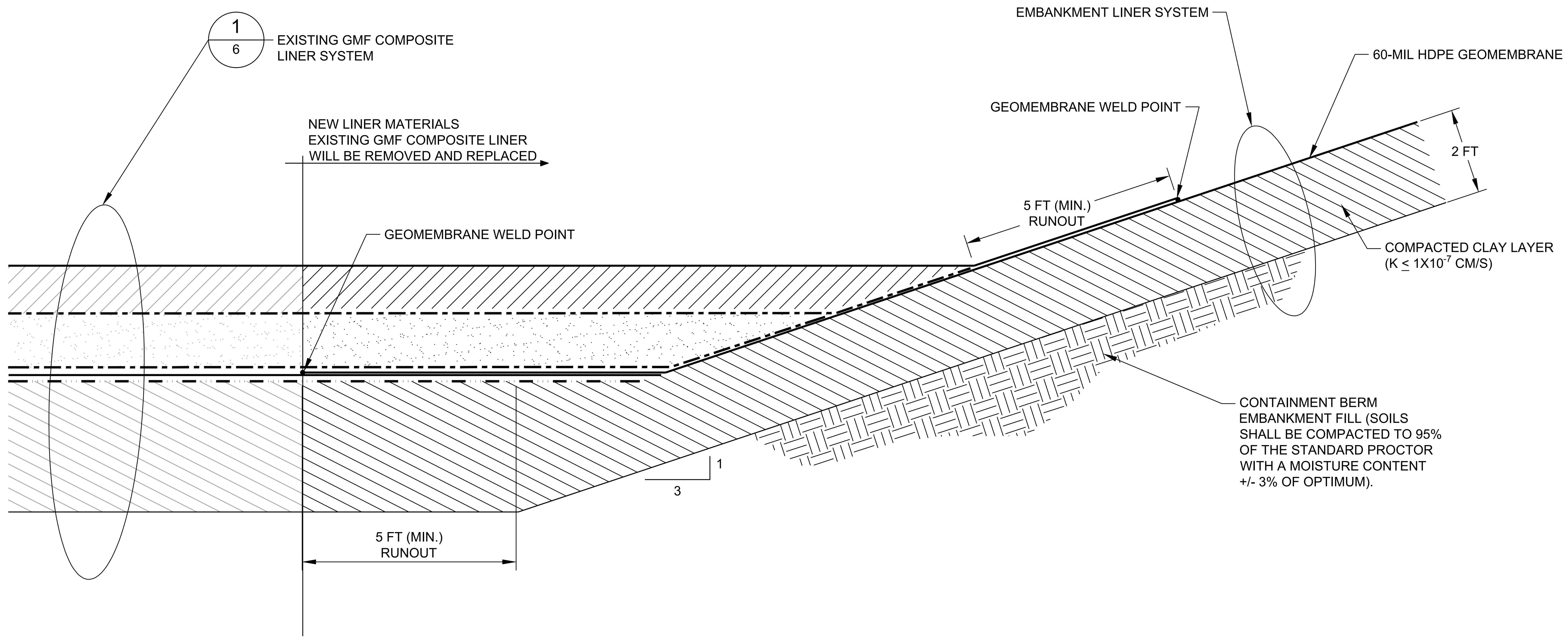
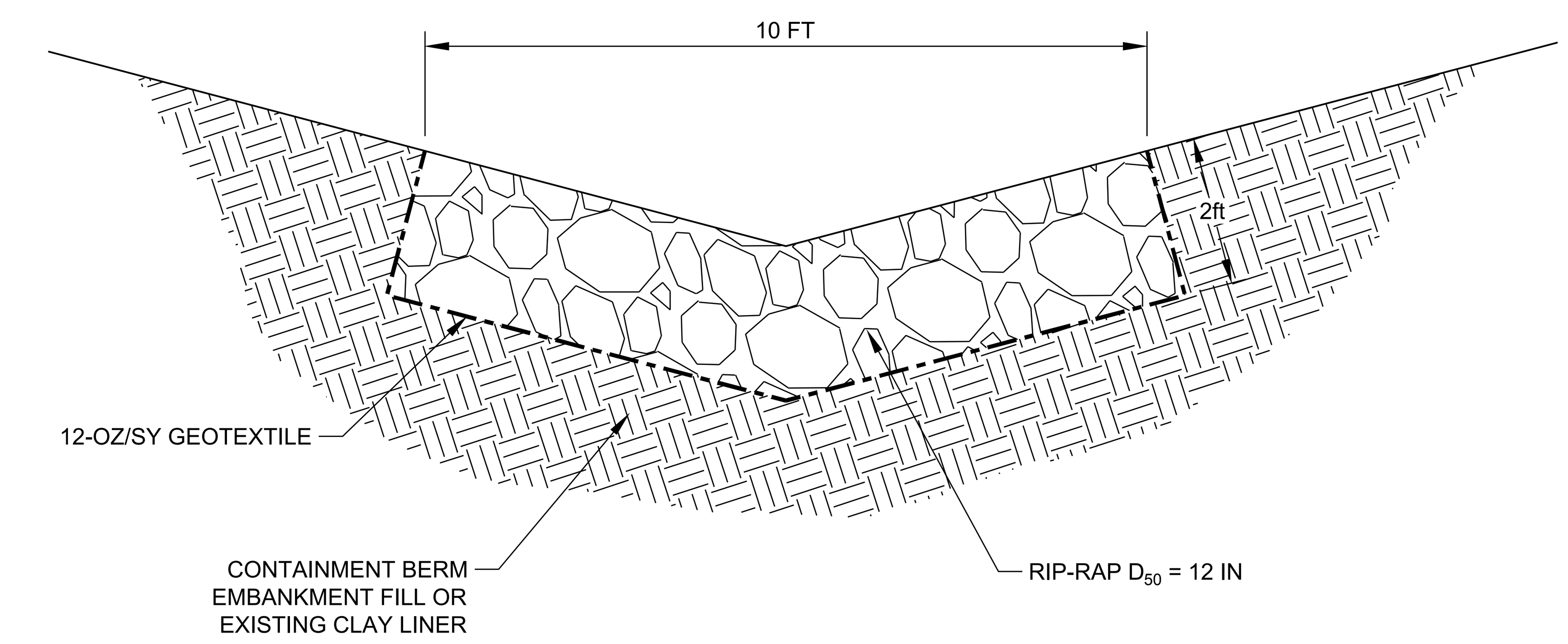
TITLE
DETAILS (1 OF 2)

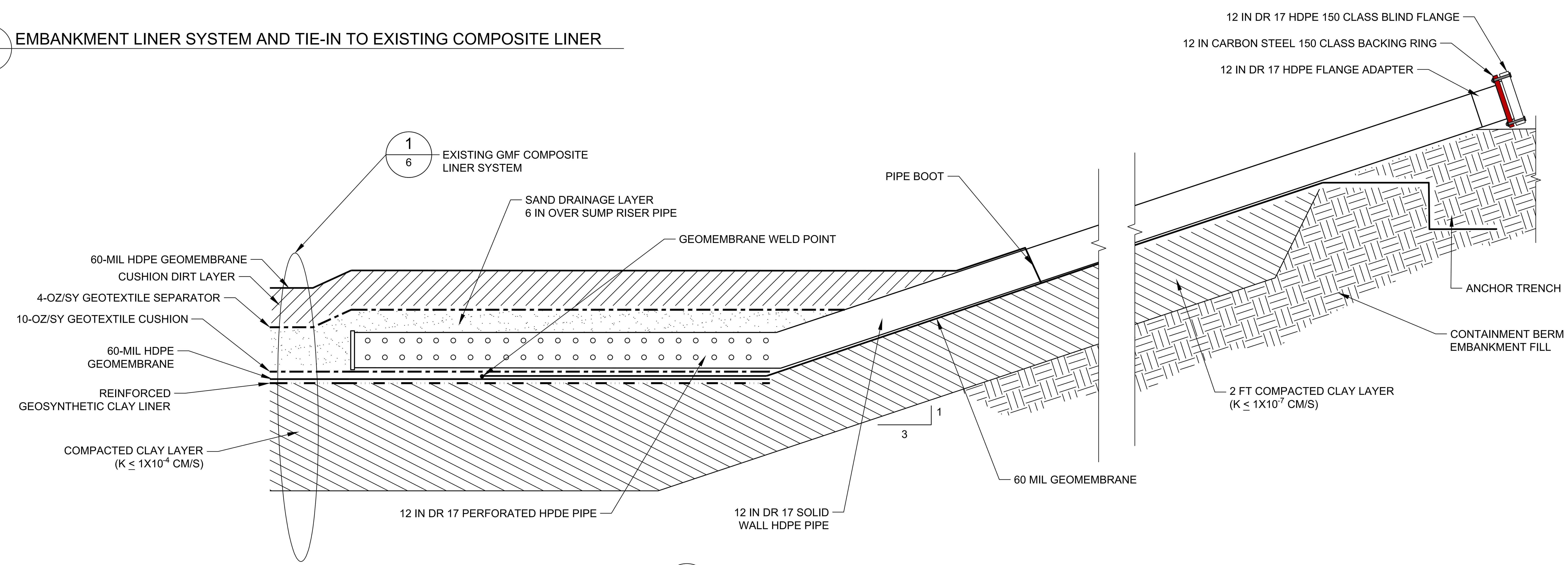
PROJECT NO. 21454861 | REV. A | 6 of 7 | DRAWING 6



SCALE N.T.S. 1/7 EMBANKMENT LINER SYSTEM AND TIE-IN TO EXISTING COMPOSITE LINER



SCALE N.T.S. 2/7 ARMORED DRAINAGE DOWNSLOPE



SCALE N.T.S. 3/7 LEAK DETECTION SYSTEM SUMP AND RISER

NOTE

EXISTING 6 INCH LEACHATE COLLECTION PIPE NOT SHOWN IN DETAIL. LEACHATE COLLECTION PIPE WILL TERMINATE AND BE CAPPED AT THE TOE OF THE CONTAINMENT BERM

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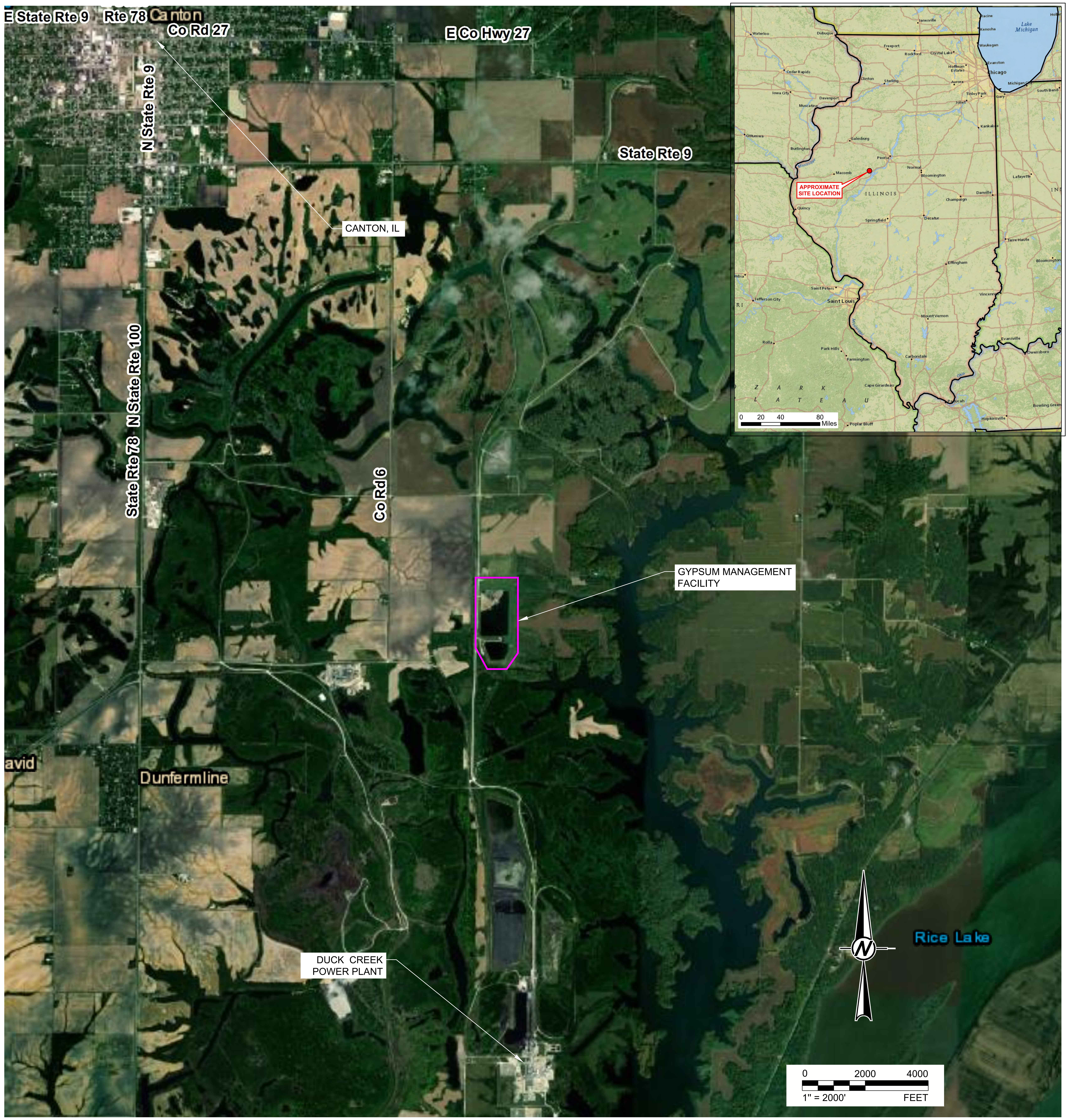
TITLE
DETAILS (2 OF 2)

PROJECT NO. 21454861 | REV. A | 7 of 7 | DRAWING 7

EXHIBIT 2

Closure-By-Removal Figures



ILLINOIS POWER RESOURCES GENERATING, LLC
DUCK CREEK POWER PLANT
GYPSUM MANAGEMENT FACILITY POND
CLOSURE-BY-REMOVAL

PREPARED BY:

GOLDER ASSOCIATES INC.
13515 BARRETT PARKWAY DRIVE, SUITE 260
BALLWIN, MISSOURI USA 63021

DRAWING LIST		
NUMBER	TITLE	REVISION
1	TITLE SHEET	A
2	EXISTING CONDITIONS	A
3	EXCAVATION PLAN	A
4	SECTIONS	A
5	DETAILS	A

NOTE(S)

1. AERIAL IMAGERY FROM ESRI PROVIDED BASEMAP SERVICE. IMAGERY COLLECTED 5/14/2017, 10/21/2017, 8/22/2018, AND 4/1/2019.
2. INSET MAP BOUNDARIES FROM ESRI PROVIDED FEATURE SERVICE. USA STATE BOUNDARIES. 2021

   INSET MAP BACKGROUND FROM ESRI PROVIDED BASEMAP SERVICE. NATIONAL GEOGRAPHIC BASEMAP. 2021.

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PROJECT
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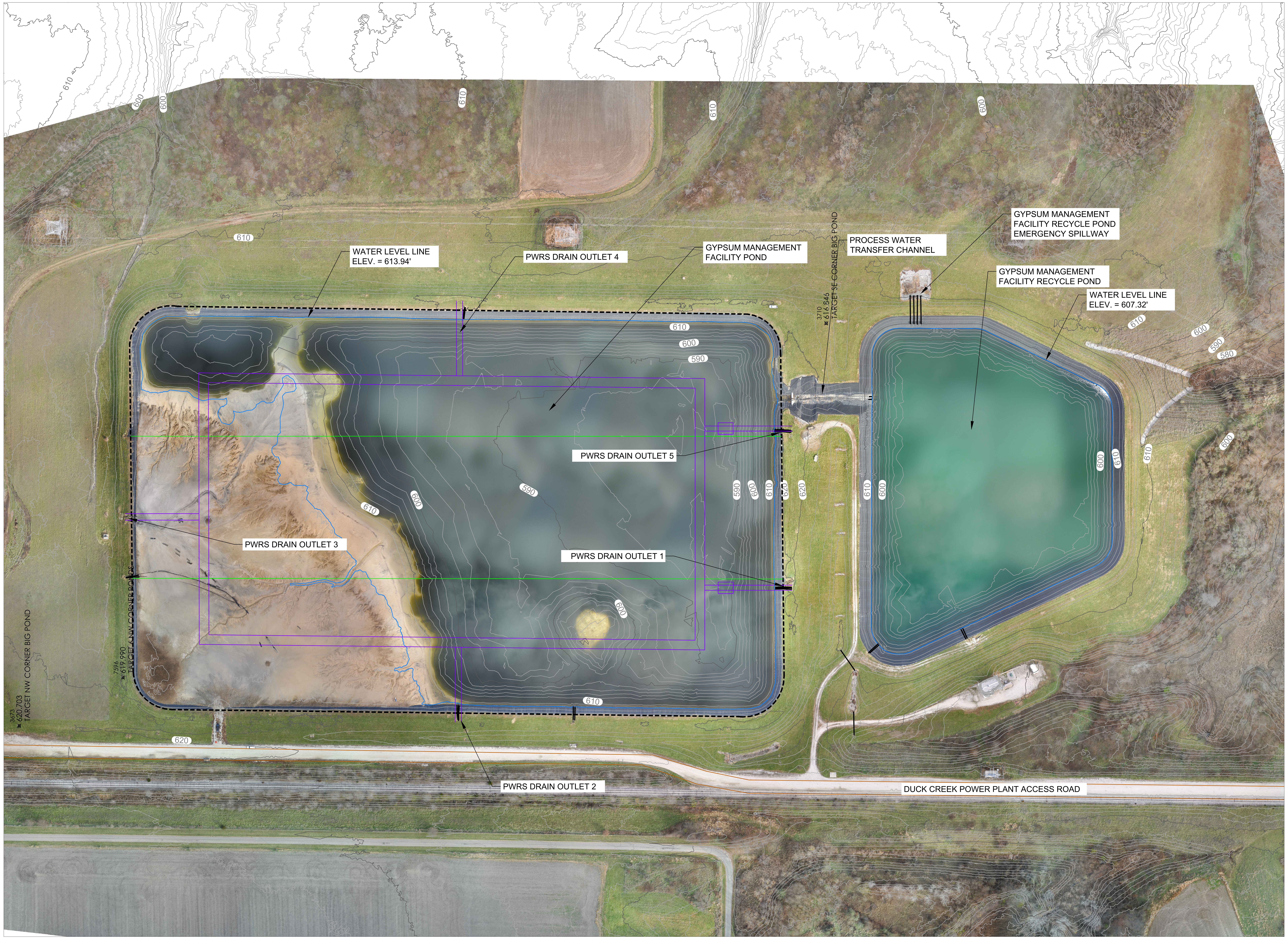
TITLE
TITLE SHEET

PROJECT NO.	CONTROL	REV.	of	DRAWING
21454861		A		1

Path: \\Denver\acad\VISTRA\Duck Creek\99_PROJECTS\21454861\Gypsum Management Facility\02_PRODUCTION\DWG\8_CBR Permit DWGs\ | File Name: 21454861B001.dwg | Last Edited By: jsauer Date: 2021-11-05 Time:3:47:07 PM | Printed By: JSauer Date: 2021-11-05 Time:3:51:49 PM

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



LEGEND

600	EXISTING GROUND ELEVATION CONTOURS (NOTE 1)
	EXISTING ROAD
	LIMIT OF GMF LINER SYSTEM (NOTE 2)
	WATER LEVEL LINE (NOTE 3)
	EXISTING PIPING (NOTE 3)
	LCRS PIPING (SEE NOTE 4)
	PWRS RING DRAIN SYSTEM (NOTE 4)

NOTES

1. EXISTING CONTOURS ARE A COMPOSITE OF AN AERIAL SURVEY COMPLETED BY DRAGONFLY AEROSOLUTIONS DATED 11/17/2020, TOPOGRAPHIC/BATHYMETRIC SURVEYS COMPLETED BY INGENAE DATED 11/4/2020 & 11/5/2020, AND U.S. GEOLOGICAL SURVEY LIDAR POINT CLOUD DATA DATED 2/12/2018.
2. LIMIT OF LINER ESTIMATED FROM CONSTRUCTION RECORD DRAWINGS PREPARED BY HANSON PROFESSIONAL SERVICES, DATED 03/05/2009.
3. WATER LEVEL LINE AND EXISTING PIPING FROM INGENAE SURVEY RECORD DRAWING DATED 3/19/2021.
4. LEACHATE COLLECTION AND REMOVAL SYSTEM (LCRS) PIPING AND PROCESS WATER RECOVERY SYSTEM (PWRS) RING DRAIN INFRASTRUCTURE LOCATION ARE ESTIMATED FROM CONSTRUCTION RECORD DRAWINGS PREPARED BY HANSON PROFESSIONAL SERVICES, DATED 03-05-2009. LCRS PIPING AND PWRS RING DRAIN MATERIALS WILL BE REMOVED AND DISPOSED OFFSITE. DETAILS AND MATERIALS FOR LCRS PIPING AND PWRS INFRASTRUCTURE CAN BE FOUND IN THE CONSTRUCTION RECORD DRAWINGS. DETAILS AND MATERIALS FOR LCRS PIPING AND PWRS INFRASTRUCTURE CAN BE FOUND IN THE CONSTRUCTION RECORD DRAWINGS.
5. AERIAL IMAGERY FROM DRAGONFLY AEROSOLUTIONS DATED 11/17/2020.

DRAFT

0 120 240
1" = 120' FEET

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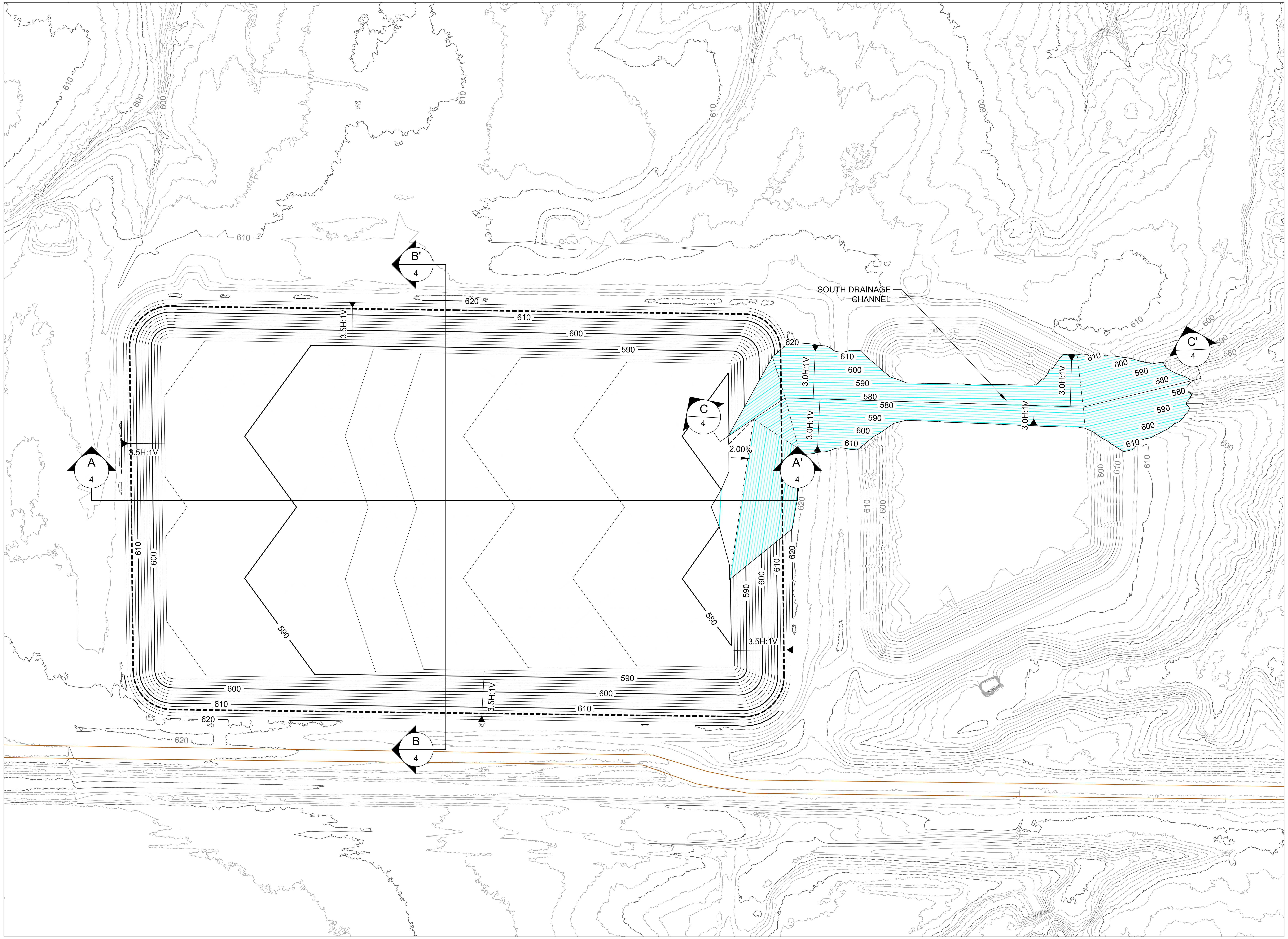
TITLE
EXISTING CONDITIONS

PROJECT NO.	CONTROL	REV.	of	DRAWING
21454861		A		2

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



LEGEND

600 — BOTTOM OF GMF POND COMPOSITE LINER SYSTEM (NOTE 1)

600 — EXISTING GROUND ELEVATION CONTOURS (NOTE 2)

600 — DRAINAGE CHANNEL GRADES

EXISTING ROAD

LIMIT OF GMF POND LINER SYSTEM (NOTE 1)

NOTES

1. GYPSUM MANAGEMENT FACILITY (GMF) POND BASE GRADES AND LIMIT OF LINER SHOWN WERE DEVELOPED FROM CONSTRUCTION RECORD DRAWINGS PREPARED BY HANSON PROFESSIONAL SERVICES. SOUTH DRAINAGE CHANNEL DESIGNED BY GOLDER ASSOCIATES.
2. EXISTING CONTOURS ARE A COMPOSITE OF AN AERIAL SURVEY COMPLETED BY DRAGONFLY AEROSOLUTIONS DATED 11/17/2020, TOPOGRAPHIC/BATHYMETRIC SURVEYS COMPLETED BY INGENAE DATED 11/4/2020 & 11/5/2020, AND U.S. GEOLOGICAL SURVEY LIDAR POINT CLOUD DATA DATED 2/12/2018.
3. CLOSURE-BY-REMOVAL INCLUDES REMOVAL OF PONDED WATER, REMOVAL OF GYPSUM, AND REMOVAL OF THE EXISTING GMF POND LINER AS SPECIFIED IN DETAIL 1 ON DRAWING 5. GYPSUM REMOVED FROM THE GMF POND WILL BE DISPOSED IN THE EXISTING ASH LANDFILL OR TRANSPORTED FOR OFF-SITE DISPOSAL.

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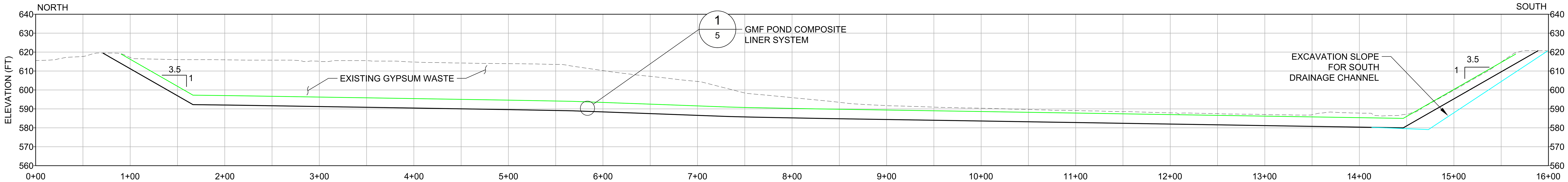
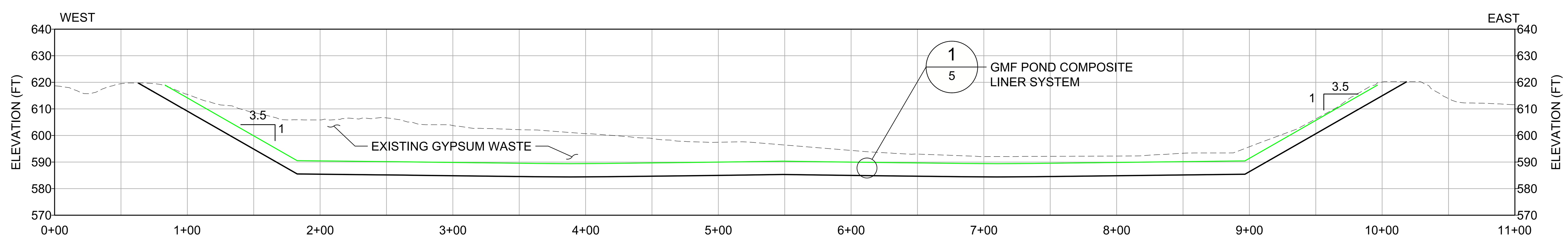
TITLE
EXCAVATION PLAN

PROJECT NO.	CONTROL	REV.	of	DRAWING
21454861		A		3



SCALE 1"=60' VERT. SCALE X2 A 4 SECTION A-A'

0 60 120 1" = 60' FEET



SCALE 1"=60' VERT. SCALE X2 B 4 SECTION B-B'

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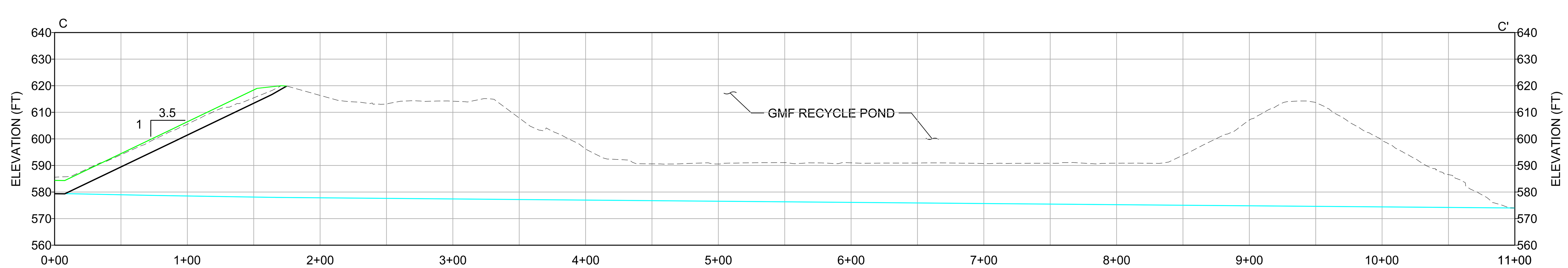

SCALE 1" = 60' VERT. SCALE X2 C 4 SECTION C-C'

0 60 120 1" = 60' FEET

LEGEND

- TOP OF GMF POND COMPOSITE LINER SYSTEM (SEE NOTE 1)
- BOTTOM OF GMF POND COMPOSITE LINER SYSTEM (SEE NOTE 1)
- DRAINAGE CHANNEL GRADING
- EXISTING GROUND CONTOURS (SEE NOTE 2)

NOTES

1. GYPSUM MANAGEMENT FACILITY (GMF) POND BASE GRADES SHOWN WERE DEVELOPED FROM CONSTRUCTION RECORD DRAWINGS PREPARED BY HANSON PROFESSIONAL SERVICES.
2. EXISTING CONTOURS ARE A COMPOSITE OF AN AERIAL SURVEY COMPLETED BY DRAGONFLY AEROSOLUTIONS DATED 11/17/2020, TOPOGRAPHIC/BATHYMETRIC SURVEYS COMPLETED BY INGENAE DATED 11/4/2020 & 11/5/2020, AND U.S. GEOLOGICAL SURVEY LIDAR POINT CLOUD DATA DATED 2/12/2018.
3. CLOSURE-BY-REMOVAL INCLUDES REMOVAL OF PONDED WATER, REMOVAL OF GYPSUM, AND REMOVAL OF THE EXISTING GMF POND LINER AS SPECIFIED IN DETAIL 1 ON DRAWING 5. GYPSUM REMOVED FROM THE GMF POND WILL BE DISPOSED IN THE EXISTING ASH LANDFILL OR TRANSPORTED FOR OFF-SITE DISPOSAL.

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A	2021-11-05	ISSUED FOR REVIEW	DVS	DVS	JJS	JEO

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PROJECT NO.	CONTROL	REV.	of	DRAWING
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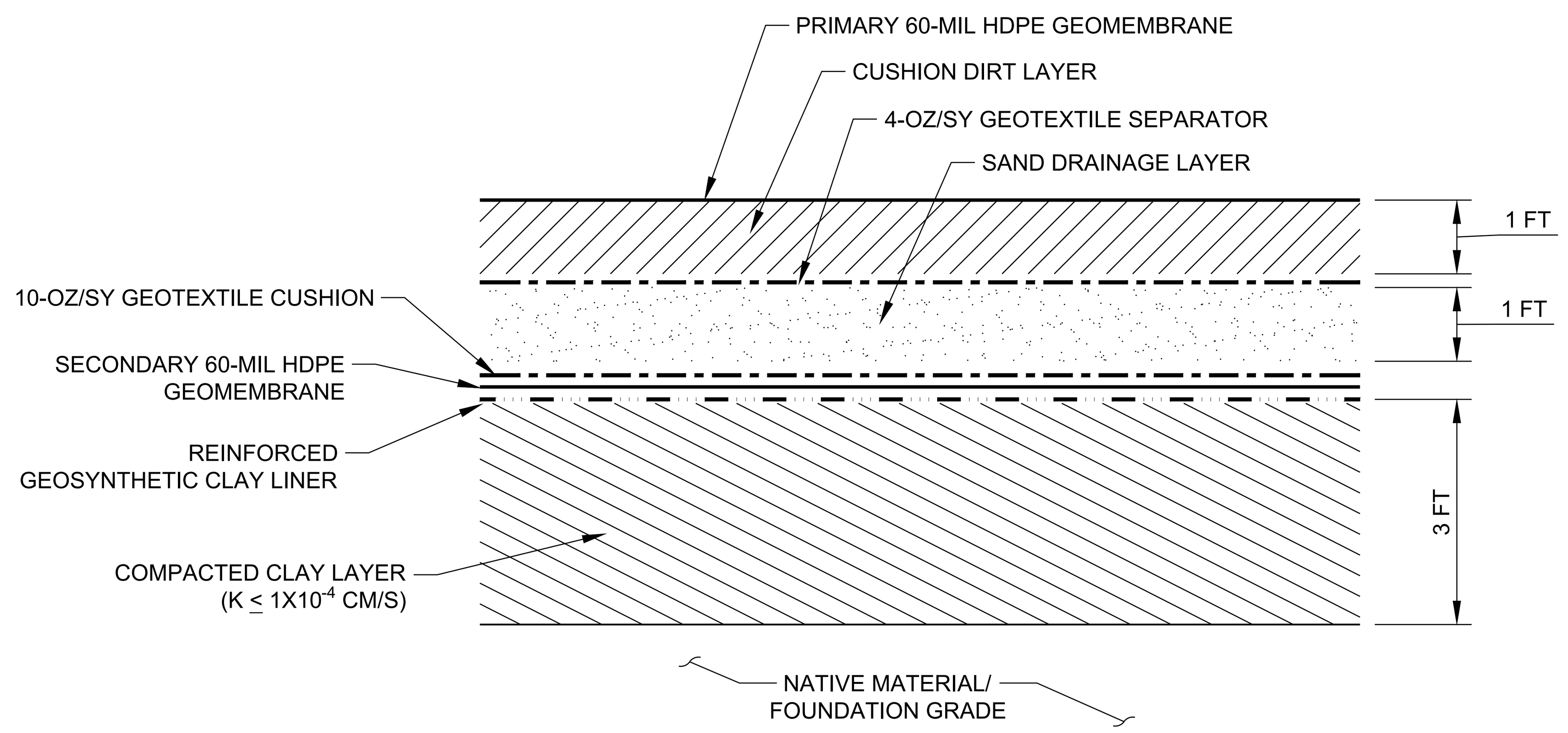

SCALE N.T.S. 1/5 GMF POND COMPOSITE LINER SYSTEM

MATERIAL REMOVAL NOTES

1. ALL COMPONENTS OF LINER SYSTEM WILL BE REMOVED AND DISPOSED OF IN THE ON-SITE LANDFILL OR TRANSPORTED FOR OFF-SITE DISPOSAL. AN ADDITIONAL 12 INCHES OF SOIL MAY BE EXCAVATED BENEATH THE LINER SYSTEM FOR DISPOSAL.

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PROJECT NO.	CONTROL	REV.	of	DRAWING
21454861		A		5

Supporting Information for Closure Alternatives Analysis – Bottom Ash Basin at Duck Creek Power Plant

GOLDER
MEMBER OF WSP

DRAFT

TECHNICAL MEMORANDUM

DATE November 5, 2021 **Reference No.** 21454861-10-TM-A

TO Illinois Power Resources Generating, LLC

FROM Golder Associates USA Inc.

SUPPORTING INFORMATION FOR CLOSURE ALTERNATIVES ANALYSIS – BOTTOM ASH BASIN AT DUCK CREEK POWER PLANT

Golder Associates USA Inc. (Golder), a Member of WSP, has prepared this technical memorandum for Illinois Power Resources Generating, LLC (IPRG) to support the Closure Alternatives Analysis for the Bottom Ash Basin at Duck Creek Power Plant (DCPP). The Bottom Ash Basin was used to temporarily store and dewater sluiced bottom ash produced at DCPP and has not received bottom ash since the power plant was retired in 2019. 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.

1.0 BOTTOM ASH BASIN HISTORY

1.1 Existing Liner System Information

Based on construction drawings by Sargent & Lundy (2007a), the existing liner system for the facility consists of (from top to bottom):

- 8 inches of reinforced concrete
- 1 foot of compacted clay, placed in 6-inch-thick lifts to at least 95% of the standard Proctor maximum dry density
- 60-mil HDPE geomembrane
- minimum 6 inches of prepared subgrade (presumably native soils) compacted to at least 95% of the standard Proctor maximum dry density

According to the Bottom Ash and Low Volume Sump Water Basin and Piping General Work Contract Specifications (Sargent & Lundy 2007b), the liner system was subjected to a rigorous construction quality assurance (CQA) program.

According to the technical specifications for the reinforced concrete layer from Sargent & Lundy (2007b), the concrete appears to have used a conventional mix design (28-day compressive strength of 4,000 pounds per square inch, water-to-cement ratio of 0.5 or less).

The technical specifications for composite-lined ponds from Sargent & Lundy (2007b) required a hydraulic conductivity of 1 x 10^{-6} centimeters per second (cm/s) or less for the compacted clay.

According to the technical specifications for geomembrane liner from Sargent & Lundy (2007b), the geomembrane was specified to conform to GRI - GM 13, which is a common HDPE geomembrane product for waste containment. According to the technical specifications (Sargent & Lundy 2007b), the CQA program for the liner system included destructive and non-destructive testing of geomembrane seams.

Based on borehole logs from the area of the Bottom Ash Basin (Hanson 2006), native soils at the subgrade elevations (roughly El. 568 to 580) generally consist of clayey silt with trace sand (ML under the Unified Soil Classification System). The hydraulic conductivity of these soils at the degree of compaction required by the technical specifications ranged from 6.0 x 10^{-7} to 2.4 x 10^{-5} cm/s, with a geometric mean of 6.1 x 10^{-6} cm/s, in permeability testing reported by Hanson (2006).

1.2 Operational History

The Bottom Ash Basin is an incised CCR surface impoundment with reinforced concrete slopes and floor. It that was used to manage sluiced bottom ash at DCPP from the time construction of the Bottom Ash Basin was completed in 2009 until the power plant was retired in December 2019. During operation, bottom ash was hydraulically conveyed (sluiced) from the power plant in 10-inch-diameter basalt-lined piping and deposited at the Bottom Ash Basin in one of the two western cells, known as Primary Pond 1 and Primary Pond 2. Coarse bottom ash particles settled by gravity in the cell where they were deposited, and the sluice water was decanted via 12-inch-diameter corrugated HDPE piping into the eastern cell, known as the Secondary Pond. Further gravity settling occurred in the Secondary Pond before the clarified water was decanted via 12-inch-diameter corrugated HDPE piping into the Discharge Canal, which flows into Duck Creek Reservoir, with discharge at a permitted outfall in accordance with the site's National Pollutant Elimination System (NPDES) permit. Bottom ash particles accumulated in Primary Pond 1 and Primary Pond 2, requiring periodic cleanout events. During cleanout events, mobile equipment was used to excavate bottom ash out of the cell, stage it on the concrete apron for dewatering as needed, and load it into trucks for beneficial reuse or permanent disposal at the on-site landfill. Primary Pond 1 and Primary Pond 2 could operate alternately, so that bottom ash could be deposited into one cell while the other cell was being cleaned out. When DCPP was retired, nearly all of the remaining bottom ash was removed and disposed, with no appreciable bottom ash remaining at the Bottom Ash Basin.

1.3 Type and Volume of Materials

The Bottom Ash Basin does not contain appreciable amounts of CCR. Precipitation is stored in the Bottom Ash Basin when it occurs.

2.0 CLOSURE CONCEPT INFORMATION

Although appreciable amounts of CCR are not present in the Bottom Ash Basin, two concepts have been developed regarding closure of the facility. The first option for closure of the Bottom Ash Basin is to leave the existing concrete structure and underlying liner system intact, place fill to establish positive surface water drainage, and construct a final cover system compliant with Part 845 (i.e., closure in place). The second option for the closure of the Bottom Ash Basin is to remove and dispose the existing liner system components and place fill to promote positive surface water drainage (i.e., closure by removal). Additional discussion of these concepts is presented in the following sections.

2.1 Closure in Place

Under this scenario, the liner system for the Bottom Ash Basin described in Section 1.1 is to remain in place. Since 845.740(a) requires removal of the liner system for closure by removal, Golder interprets that this concept would be subject to the requirements for closure in place (845.750), including installation of a final cover system, even though no CCR would remain in place. Fill will be brought in to reach subgrade elevations designed to promote positive drainage. The facility will then be closed as described in the following section.

2.1.1 Final Cover System Materials

For closure with CCR in place, Part 845 requires installation of a final cover system over the CCR. Based on a demonstration to be submitted to the Illinois Environmental Protection Agency for approval pursuant to Section 845.750(c)(2), an alternative final cover system is incorporated into the closure-in-place concept. The final cover system consists of (from top to bottom):

- 2-foot final protective layer – locally available soils compacted to between 80% and 95% of the standard Proctor maximum dry density for establishment of vegetation and protection of the geomembrane. Material is likely to be primarily low-plasticity silt based on review of site geotechnical information (Hanson 2006).
- Geocomposite.
- 60-mil HDPE geomembrane.

Compacted fill, composed of locally available soils, would be placed 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 provide a firm subgrade.

2.1.2 Cover System Grades

The closure design consists of the final cover system covering the concrete-lined areas. The final cover system is sloped at a 2% grade, and then terminates at the edge of concrete. A 4H:1V slope composed of compacted fill ties the final cover system at the edge of concrete into existing ground. Cover system grades and details are provided in Figures 1 and 2.

2.1.3 Closure Construction Timeline

The closure construction will require approximately 10,750 cubic yards (cy) of import fill to reach subgrade, followed by installation of 87,500 square feet (sf) of geomembrane and geocomposite. Approximately 6,500 cy of soil fill will be installed for the final protective layer. The area is not currently ponding water, and significant dewatering is not anticipated prior to beginning closure construction. Based on these construction quantities, closure is anticipated to be completed in a single construction season, and a phased construction plan is unnecessary.

2.1.4 Stormwater Management

Stormwater runoff from the Bottom Ash Basin closure area will be managed by sheet flow off the cover system into an existing storm channel (Sargent & Lundy 2007a). Stormwater in this channel is routed into the existing Discharge Canal south of the Bottom Ash Basin. No new stormwater management ponds or features are planned for closure.

2.2 Closure by Removal

Under this scenario, the concrete, compacted clay, and geomembrane components of the liner system for the Bottom Ash Basin, as described in Section 1.1, will be removed as required under 845.740(a) and disposed of in the existing permitted on-site landfill located approximately 3.7 miles north of the Bottom Ash Basin. Alternatively, the materials may be disposed of at an off-site landfill approximately 33 miles away. Subsoil beneath the liner system will be excavated to a depth up to 1 foot and disposed. Fill will be brought in to reach subgrade elevations designed to promote positive surface water drainage. The facility will then be closed as described in the following section.

2.2.1 Closure Materials

Because no appreciable amounts of bottom ash remain in the Bottom Ash Basin, once the concrete, compacted clay, geomembrane, and subsoil are removed, closure will consist of grading of the area to promote positive drainage and prevent significant ponding. The closed area will be seeded and mulched to promote long-term vegetation.

Based on a review of the soil materials available on site, the fill to reach closure grades is anticipated to consist of low-plasticity silts (Hanson 2006). To limit the potential for excessive settlement, the fill will be compacted to a minimum of 95% of the standard Proctor maximum dry density.

2.2.2 Closure Grades

Because no engineered final cover is necessary for this concept, the closure grades for the closure by removal option are lower in elevation compared to those shown for the closure in place concept. The final grades are still sloped at a 2% grade, and then terminate at the edge of concrete. A 4H:1V slope composed of compacted fill will be used to tie the final surface at the edge of concrete into existing ground. The plan grades and details for this concept are provided in Figures 3 and 4.

2.2.3 Closure Construction Timeline

The closure construction will require removal of approximately 1,950 cy of concrete, 1,600 cy of compacted clay, up to 3,200 cy of subsoil, and 1 acre of geomembrane. Approximately 17,500 cy of fill will be required to reach closure grades. No final cover system is needed for this closure scenario. The area is not currently ponding water, and significant dewatering is not anticipated prior to beginning closure construction. Based on these construction quantities, the closure is anticipated to be completed in a single construction season, and a phased construction plan was deemed unnecessary.

2.2.4 Stormwater Management

Stormwater runoff from the Bottom Ash Basin closure area will be managed by sheet flow off the final surface into an existing storm channel (Sargent & Lundy 2007a). Stormwater in this channel is routed into the existing Discharge Canal south of the Bottom Ash Basin. No new stormwater management ponds or features are planned for closure.

3.0 ADDITIONAL INFORMATION

Gradient provided a request for additional information to support the Closure Alternatives Analysis. The additional information compiled by Golder in response to the request is provided in Tables 1 through 4. Table 1 provides narrative responses for information requests based largely on Part 845 requirements for the Closure Alternatives

Analysis. Table 2 summarizes conceptual-level estimates of material quantities, equipment and vehicle usage, labor resources, and haul truck trips for the closure-in-place approach. Table 3 summarizes conceptual-level estimates of material quantities, equipment and vehicle usage, labor resources, and haul truck trips for the closure-by-removal approach with disposal in the existing permitted on-site landfill, which has ample remaining capacity to accept these materials. Table 4 summarizes conceptual-level estimates of material quantities, equipment and vehicle usage, labor resources, and haul truck trips for the closure-by-removal approach with disposal in an off-site landfill.

A productivity-based approach was used to develop labor and heavy equipment spreads and corresponding production rates. The number and classification (e.g., operator, laborer) of personnel carrying out the activity and the number and type of heavy equipment pieces (e.g., dozer, loader, haul truck) were estimated based on our experience with similar construction operations. Production rates were developed based on equipment capabilities (e.g., haul truck capacity, estimated load and unload times, estimates of average speed) and checked against experience from similar projects. Material quantities correspond with the closure approaches shown in Figures 1 through 4 and were developed primarily in Autodesk Civil3D.

4.0 REFERENCES

Hanson (Hanson Professional Services Inc.). 2006. Geotechnical Investigation Results. Bottom Ash Basin. Duck Creek Power Station. February.

Sargent & Lundy. 2007a. Bottom Ash and Low Volume Sump Water Basin and Piping Drawings, Issued for Construction. Duck Creek Power Station. September.

Sargent & Lundy. 2007b. Bottom Ash and Low Volume Sump Water Basin and Piping Construction Specifications. Duck Creek Power Station. September.

Attachments: Table 1: Information Summary
Table 2: Closure Estimates - Closure in Place
Table 3: Closure Estimates - Closure by Removal with On-Site Disposal
Table 4: Closure Estimates - Closure by Removal with Off-Site Disposal

Figure 1: Closure-In-Place Conceptual Design Plan
Figure 2: Closure-In-Place Sections and Details
Figure 3: Closure-By-Removal Conceptual Design Plan
Figure 4: Closure-By-Removal Profiles and Sections

https://golderassociates.sharepoint.com/sites/141778/project files/6 deliverables/techmemos/10-tm-supporting_info_bottom_ash_basin/10-tm-a/21454861-10-tm-a-supporting_info_bottom_ash_basin_05nov21.docx

Tables

Table 1: Information Summary

Background/Current Site Conditions	
Surface area of impoundment	2.2 acres total (includes all three cells and the concrete area around the cells). 0.9 acres maximum wetted area.
Volume of CCR in impoundment	No appreciable amount (CCR has already been removed and disposed).
Published or draft engineering evaluations undertaken at the site to date	
Conceptual site models	None.
Regional well (receptor) survey information	None.
History of construction report	See (1)
Dike stability report	Stability analysis not completed for the CCR Rule (volume is less than 20 acre-feet and height is less than 20 feet)(2). Based on site observations, there is no risk associated with dike stability.
Hydraulic evaluation of basins (evaluation of possibility of overtopping and/or emergency spillway releases during flood conditions)	Hydraulic and hydrologic analyses performed by AECOM found that the Bottom Ash Basin adequately manages outflow during the 25-year IDF, as overtopping of the BAB is not expected(3).
Surface impoundment hazard assessment/hazard category determination	Hazard category determination not completed for the CCR Rule (not required for incised CCR surface impoundments).
Habitat survey	Not available.
Wetlands survey	Not available. Based on visual observation, wetlands do not appear to be present in the area to be disturbed for closure construction.

Table 1: Information Summary

Closure Design and Implementation	
Copy of draft of closure report, if available	Provided.
Engineering spreadsheet containing breakdown of labor, equipment/vehicle, and material requirements for each closure alternative, if available (expected on-site and off-site vehicle and equipment mileages, labor hours, etc.)	See Tables 2 through 4.
Overview of planned activities under each closure alternative	Closure by removal: Under this scenario, approximately 1950 cy of concrete, 1600 cy of compacted clay, and 1 acre of geomembrane that make up the BAB liner system, along with 3200 cy of overexcavated subsoil, will be removed and disposed in the on-site landfill or in an off-site landfill. Approximately 17500 cy of low-plasticity silts available on site will be used as fill to reach reclamation grades, and it will be compacted to at least 95% of the standard Proctor maximum dry density to prevent excessive settlement. The site will be graded to promote positive drainage and prevent significant ponding (2% grade to the edge of concrete, 4H:1V from edge of concrete to existing ground), and it will be seeded to promote long-term vegetation.
	Closure in place: Under this scenario, the concrete, compacted clay, and geomembrane that make up the BAB liner system will remain in place. Approximately 10750 cy of low-plasticity silt available on site will be used as fill to reach reclamation grades, and it will be compacted to at least 95% of the standard Proctor maximum dry density to prevent excessive settlement. The final cover system will be composed of (from top to bottom): 2 feet of locally available low-plasticity silt, compacted to between 80% and 95% of the standard Proctor maximum dry density; a drainage layer of approximately 87500 sq ft of geocomposite; and approximately 87500 sq ft of 60-mil HDPE geomembrane. To promote drainage and prevent excessive ponding, the cover system will be sloped at a 2% grade to the edge of concrete, and compacted fill with a 4H:1V slope will extend from the edge of concrete to the existing grades. It will be seeded to promote long-term vegetation.
Expected duration of major construction activities under each closure activity	Closure by removal: 12 weeks.
	Closure in place: 6 weeks.
If an on-site landfill will be constructed on the site under a given closure alternative, please include the years required to construct and later close the on-site landfill	Not applicable. The existing permitted on-site landfill has sufficient capacity to accept waste generated from closure by removal without expansion of the existing landfill or construction of a new on-site landfill.
If an on-site landfill must first be constructed on the site, please estimate the anticipated delay in the commencement of excavation activities while the landfill is being sited, designed, and constructed; indicate whether dewatering/unwatering of the ponds will begin immediately, or after the landfill is constructed	Not applicable.
Proposed location of the on-site landfill if on-site disposal is being considered for CBR scenario	The existing on-site landfill is approximately 3.7 miles north of the Bottom Ash Basin via site roads.

Table 1: Information Summary

Closure Design and Implementation	
Surface area of the on-site landfill, if a new landfill must be constructed at the site	Not applicable.
Name and location of proposed off-site landfill	If an off-site landfill were to be used, the Peoria City-County Landfill is the nearest suitable facility (33 miles away).
Location of borrow area, if a borrow area will be established (for either the impoundment or construction/closure of an on-site landfill); if location is unknown, please estimate a likely distance to the borrow area	The anticipated on-site borrow source location is approximately 3.4 miles north of the Bottom Ash Basin via site roads.
Estimated volume of soil to be hauled from the borrow area under each closure alternative	Closure by removal: 18,000 cy.
	Closure in place: 17,000 cy.
Difficulty associated with implementation of each closure alternative (e.g., do any alternatives pose particular engineering/implementation challenges?)	No major challenges are anticipated for any closure alternative.
Availability of necessary equipment and specialists for each closure alternative	Good availability of equipment and services is anticipated for all closure alternatives.
Available capacity and location of needed treatment, storage, and disposal services for each closure alternative	The distance to the nearest off-site landfill (approximately 33 miles) presents a significant challenge for the option that involves off-site disposal.

Table 1: Information Summary

Post-Closure Plan/Long-Term Management Plan	
Planned duration of post-closure care activities	Closure by removal: An owner or operator of a CCR surface impoundment that elects to close a CCR surface impoundment by removing CCR as provided in Section 845.740 must continue groundwater monitoring for three years after the completion of closure or until concentrations have been reduced to the maximum extent feasible and they are protective of human health and the environment.
	Closure in place: The owner or operator of the CCR surface impoundment must conduct post-closure care for 30 years. The owner or operator must continue to conduct post-closure care beyond the 30-year post-closure care period until groundwater monitoring data shows the concentrations are (a) below groundwater protection standards given in Section 845.600 of Part 845 or (b) not increasing for those constiuents over background using the statistical procedures and performance standards in Section 845.640(f) and (g), provided that concentrations have been reduced to the maximum extent feasible and they are protective of human health and the environment.
Expected frequency of groundwater and surface water monitoring during post-closure period	Closure by removal: Quarterly.
	Closure in place: Quarterly for 5 years and semi-annually thereafter.
Summary of planned maintenance activities post-closure	Closure by removal: Groundwater monitoring will be conducted.
	Closure in place: Groundwater monitoring will be conducted. Site inspections will be conducted on a quarterly basis for a minimum of 5 years after closure. An annual site inspection will be performed until settlement has ceased and there are no eroded or scoured areas or until the end of the 30-year post-closure care period. Over these 30 years, repair and maintenance, including soil filling and reseeding, will be performed if ponding is observed, cracks greater than 1 inch wide or gullies 6 inches or deeper have formed, vegetative or vector problems arise, or leachate seeps are present. Areas susceptible to erosion will be recontoured and reseeded. Eroded and scoured drainage channels will be repaired and the liner material replaced if necessary. Vegetation will be mowed annually. Areas of failed or eroded vegetation in excess of 100 square feet will be revegetated. Minor repairs to ensure the integrity and proper function of fencing, surface water drainage features, monitoring points, and groundwater monitoring wells may be required.
Summary of planned post-closure care activities at the on-site landfill, if a new on-site landfill is going to be constructed	Not applicable.

Corrective Measures Assessment	
Corrective measures being considered post-closure	None anticipated.
Overview of planned activities for each corrective measure	None anticipated.

References

1) Golder (2021). History of Construction for the Bottom Ash Basin, Duck Creek Power Plant.

2) AECOM (2016). CCR Rule Report: Initial Structural Stability Assessment for Bottom Ash Basin at Duck Creek Power Station. Available online: https://www.luminant.com/ccr.

3) AECOM (2016). CCR Rule Report: Initial Inflow Design Flood Control System Plan for Bottom Ash Basin at Duck Creek Power Station. Available online:

Table 2: Closure Estimates - Closure in Place

Description	Unit	Quantity	Labor	Equipment	Truck Trips
Mobilization/Demobilization	LS	1	1 superintendent	Pickup truck, flatbed truck	
Survey	LS	1	1 surveyor		
Borrow Area Preparation and Reclamation	LS	1	2 equipment operators	Dozer, seed drill or hydroseeder	
Pipe Removal/Abandonment	LS	1	1 equipment operator, 4 laborers	Excavator	
Embankment Fill	CY	10,750	8 equipment operators	Excavator, dozer, compactor, water truck, 4 haul trucks	585 (3.4 miles one way)
Geomembrane	SF	87,500	5 laborers, 1 equipment operator, 1 superintendent, 1 quality assurance technician	Telehandler	
Geocomposite Drainage Layer	SF	87,500			
Final Protective Soil Layer	CY	6,500	7 equipment operators	Excavator, dozer, water truck, 4 haul trucks	355 (3.4 miles one way)
Fertilize, Seed, and Mulch	AC	3	2 equipment operators	Seed drill or hydroseeder	
Erosion Control	LS	1	1 equipment operator, 2 laborers	Excavator	
Construction Quality Assurance	LS	1	1 technician		
Miscellaneous Construction	LS	1	Miscellaneous	Miscellaneous	

Notes:

Miscellaneous Costruction includes other work not captured in the items shown.

Soil components were assumed to be taken from the stockpile north of the GMF (3.4-mile haul).

Table 3: Closure Estimates - Closure by Removal with On-Site Disposal

Description	Unit	Quantity	Labor	Equipment	Truck Trips
Mobilization/Demobilization	LS	1	1 superintendent	Pickup truck, flatbed truck	
Survey	LS	1	1 surveyor		
Borrow Area Preparation and Reclamation	LS	1	2 equipment operators	Dozer, seed drill or hydroseeder	
Pipe Removal/Abandonment	LS	1	1 equipment operator, 4 laborers	Excavator	
Concrete Demolition and Disposal	CY	1,950	5 equipment operators, 4 laborers	2 breakers, dozer, loader, haul truck	105 (3.7 miles one way)
Geomembrane Removal and Disposal	AC	1	3 equipment operators, 4 laborers	Dozer, loader, haul truck	6 (3.7 miles one way)
Liner Soil Removal and Disposal	CY	1,600	6 equipment operators	Excavator, dozer, 4 haul trucks	87 (3.7 miles one way)
Subsoil Overexcavation and Disposal	CY	3,200	6 equipment operators	Excavator, dozer, 4 haul trucks	175 (3.7 miles one way)
Embankment Fill	CY	17,500	8 equipment operators	Excavator, dozer, compactor, water truck, 4 haul trucks	956 (3.4 miles one way)
Fertilize, Seed, and Mulch	AC	3	2 equipment operators	Seed drill or hydroseeder	
Erosion Control	LS	1	1 equipment operator, 2 laborers	Excavator	
Construction Quality Assurance	LS	1	1 technician		
Miscellaneous Construction	LS	1	Miscellaneous	Miscellaneous	

Notes:
Miscellaneous Construction includes other work not captured in the items shown.
Soil components were assumed to be taken from the stockpile north of the GMF (3.4-mile haul).
Disposal was assumed to occur in the on-site landfill (3.7-mile haul).

Table 4: Closure Estimates - Closure by Removal with Off-Site Disposal

Description	Unit	Quantity	Labor	Equipment	Truck Trips
Mobilization/Demobilization	LS	1	1 superintendent	Pickup truck, flatbed truck	
Survey	LS	1	1 surveyor		
Borrow Area Preparation and Reclamation	LS	1	2 equipment operators	Dozer, seed drill or hydroseeder	
Pipe Removal/Abandonment	LS	1	1 equipment operator, 4 laborers	Excavator	
On-Site Concrete Demolition	CY	1,950	4 equipment operators, 4 laborers	2 breakers, dozer, loader	
Off-Site Concrete Hauling and Disposal			Equipment operator	On-highway truck	140 (32.6 miles one way)
On-Site Geomembrane Removal	AC	1	2 equipment operators, 4 laborers	Dozer, loader	
Off-Site Geomembrane Hauling and Disposal			Equipment operator	On-highway truck	6 (32.6 miles one way)
On-Site Liner Soil Removal	CY	1,600	2 equipment operators	Excavator, dozer	
Off-Site Liner Soil Hauling and Disposal			4 equipment operators	4 on-highway trucks	114 (32.6 miles one way)
On-Site Subsoil Overexcavation	CY	3,200	2 equipment operators	Excavator, dozer	
Off-Site Subsoil Hauling and Disposal			4 equipment operators	4 on-highway trucks	229 (32.6 miles one way)
Embankment Fill	CY	17,500	8 equipment operators	Excavator, dozer, compactor, water truck, 4 haul trucks	956 (3.4 miles one way)
Fertilize, Seed, and Mulch	AC	3	2 equipment operators	Seed drill or hydroseeder	
Erosion Control	LS	1	1 equipment operator, 2 laborers	Excavator	
Construction Quality Assurance	LS	1	1 technician		
Miscellaneous Construction	LS	1	Miscellaneous	Miscellaneous	

Notes:
Miscellaneous Construction includes other work not captured in the items shown.
Soil components were assumed to be taken from the stockpile north of the GMF (3.4-mile haul).
Disposal was assumed to occur in an off-site landfill (32.6-mile haul).

Figures

LEGEND

600	PROPOSED CLOSURE GRADES
600	EXISTING GROUND CONTOURS (SEE NOTE 1)
- - - -	EDGE OF CONCRETE (SEE NOTE 3)
	GRADING BREAKLINE

NOTE(S)

1. EXISTING CONTOURS SHOWN ARE FROM AERIAL SURVEY COMPLETED BY DRAGONFLY AEROSOLUTIONS DATED 11/17/2020 AND TOPOGRAPHIC/BATHYMETRIC SURVEYS COMPLETED BY INGENAE DATED 11/4/2020 & 11/5/2020. NO UNDERGROUND OR OVERHEAD UTILITIES WERE LOCATED DURING THIS SURVEY.
2. ELEVATIONS ARE IN NAVD 88.
3. EDGE OF CONCRETE PROVIDED IN INGENAE SURVEY RECORD DRAWING DATED 2/9/2021.

NOT FOR CONSTRUCTION

DRAFT

CLIENT
ILLINOIS POWER RESOURCES GENERATING, LLC
DUCK CREEK POWER PLANT

PROJECT
BOTTOM ASH BASIN
CLOSURE ALTERNATIVES ANALYSIS

CONSULTANT

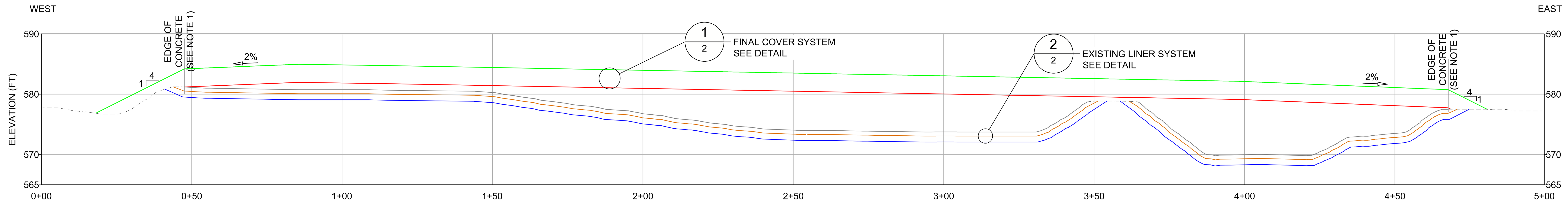
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2021-11-05
DESIGNED	JEO
PREPARED	KAC
REVIEWED	JJS
APPROVED	JEO

TITLE
CLOSURE-IN-PLACE
CONCEPTUAL DESIGN PLAN

PROJECT NO.	REV.	FIGURE
21454861	A	1

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



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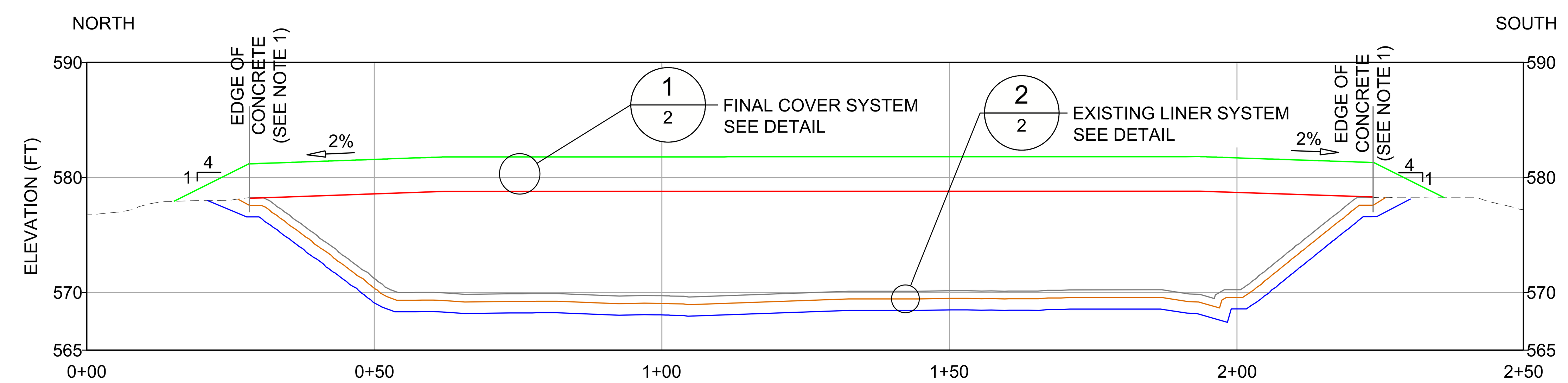
VERT. SCALE = 2X
A / 2 CROSS SECTION A

0 20 40
1" = 20' FEET



SCALE 1" = 20'
VERT. SCALE = 2X
B / 2 CROSS SECTION B

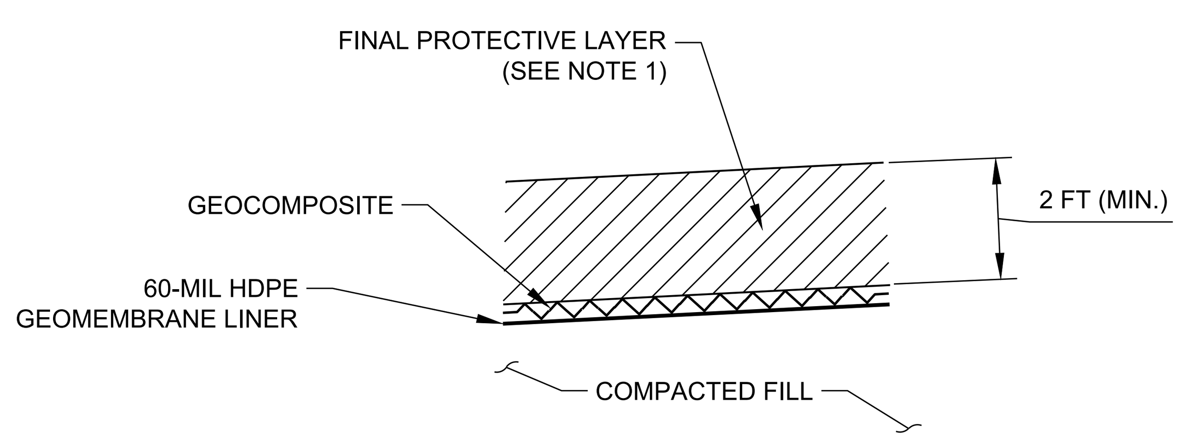
0 20 40
1" = 20' FEET

CROSS SECTION LEGEND

- PROPOSED TOP OF COVER (SEE NOTE 2)
- PROPOSED TOP OF COMPACTED FILL
- EXISTING GROUND
- EXISTING LINER - TOP OF CONCRETE
- EXISTING LINER - TOP OF COMPACTED CLAY
- EXISTING LINER - GEOMEMBRANE

NOTE(S)

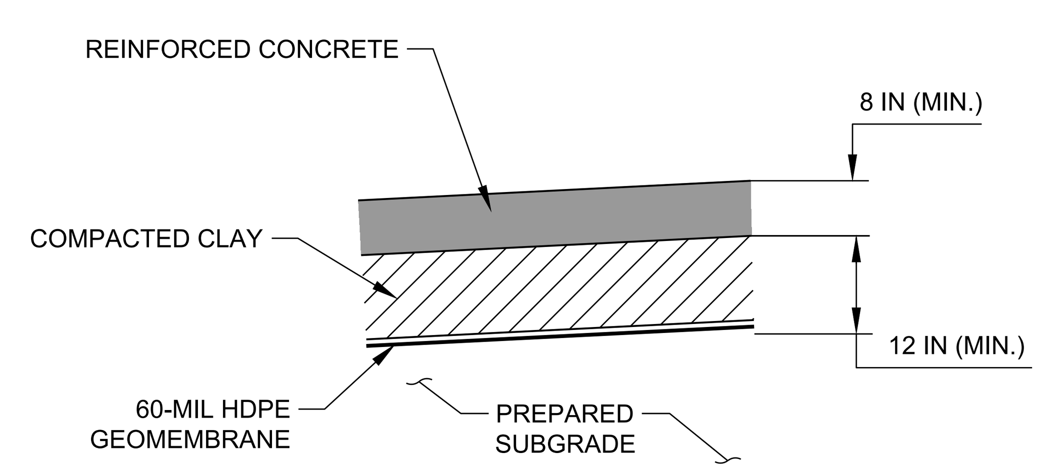
1. EDGE OF CONCRETE PROVIDED IN INGENAE SURVEY RECORD DRAWING DATED 2/9/2021.
2. FINAL COVER SYSTEM EXTENDS TO EDGE OF CONCRETE. GENERAL FILL MATERIAL WILL BE USED TO DAYLIGHT THE COVER INTO EXISTING GROUND.



SCALE N.T.S. 1 / 2 FINAL COVER SYSTEM

NOTE(S)

1. FINAL PROTECTIVE 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 GEOMEMBRANE.



SCALE N.T.S. 2 / 2 EXISTING LINER SYSTEM

NOT FOR CONSTRUCTION
DRAFT

CLIENT
ILLINOIS POWER RESOURCES GENERATING, LLC
DUCK CREEK POWER PLANT

PROJECT
BOTTOM ASH BASIN
CLOSURE ALTERNATIVES ANALYSIS

CONSULTANT
GOLDER
MEMBER OF WSP

YYYY-MM-DD	2021-11-05
DESIGNED	JEO
PREPARED	KAC
REVIEWED	JJS
APPROVED	JEO

TITLE
CLOSURE-IN-PLACE
SECTIONS AND DETAILS

PROJECT NO. 21454861 | REV. A | FIGURE 2

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

LEGEND

600 (solid line)	PROPOSED CLOSURE GRADES
600 (grey line)	EXISTING GROUND CONTOURS (SEE NOTE 1)
(dashed line)	EDGE OF CONCRETE (SEE NOTE 3)
(green line)	GRADING BREAKLINE

NOTE(S)

1. EXISTING CONTOURS SHOWN ARE FROM AERIAL SURVEY COMPLETED BY DRAGONFLY AEROSOLUTIONS DATED 11/17/2020 AND TOPOGRAPHIC/BATHYMETRIC SURVEYS COMPLETED BY INGENAE DATED 11/4/2020 & 11/5/2020. NO UNDERGROUND OR OVERHEAD UTILITIES WERE LOCATED DURING THIS SURVEY.
2. ELEVATIONS ARE IN NAVD 88.
3. EDGE OF CONCRETE PROVIDED IN INGENAE SURVEY RECORD DRAWING DATED 2/9/2021.

NOT FOR CONSTRUCTION

DRAFT

CLIENT
ILLINOIS POWER RESOURCES GENERATING, LLC
DUCK CREEK POWER PLANT

PROJECT
BOTTOM ASH BASIN
CLOSURE ALTERNATIVES ANALYSIS

CONSULTANT

GOLDER
MEMBER OF WSP

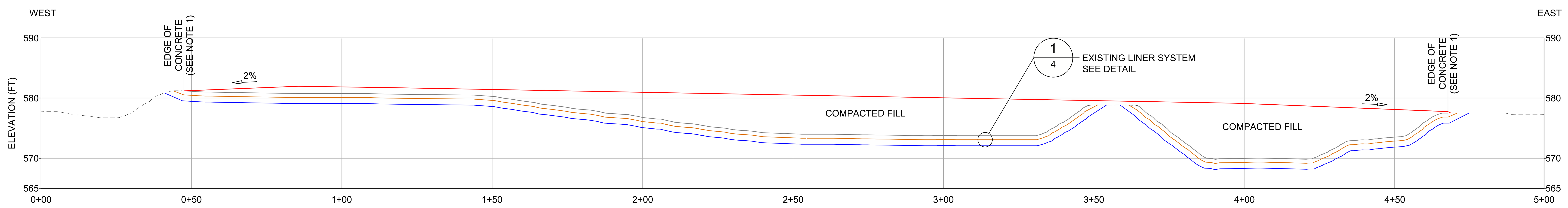
YYYY-MM-DD	2021-11-05
DESIGNED	JEO
PREPARED	KAC
REVIEWED	JJS
APPROVED	JEO

TITLE
CLOSURE-BY-REMOVAL CONCEPTUAL DESIGN PLAN

PROJECT NO.	REV.	FIGURE
21454861	A	3

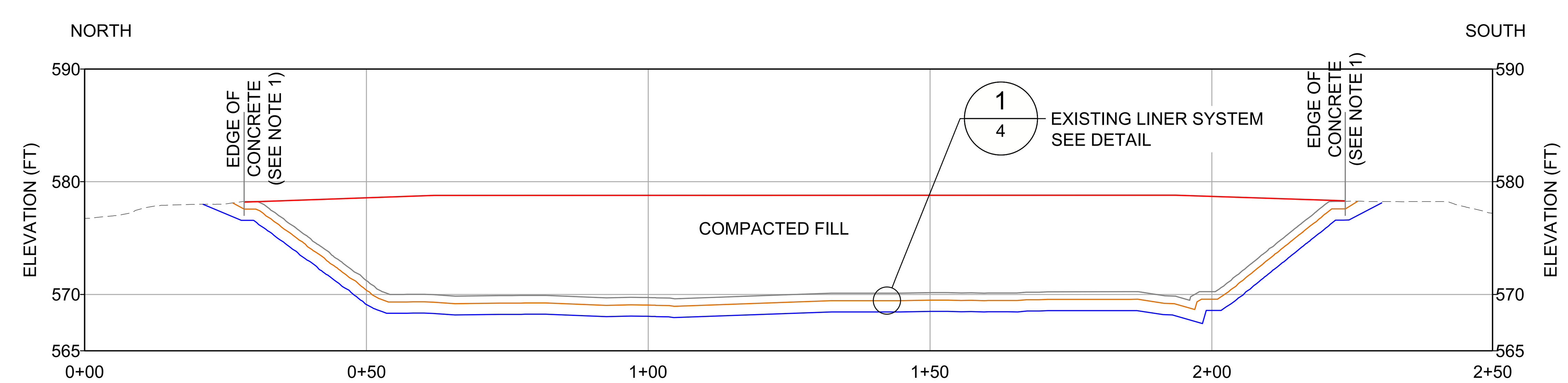
Path: \\Denver\acad\VISTRA\Duck Creek\99_PROJECTS\21454861\Bottom Ash Basin Figures\ | File Name: Closure By Removal.dwg | Last Edited By: kcernik Date: 2021-11-05 Time: 12:38:34 PM | Printed By: KCernik Date: 2021-11-05 Time:12:39:04 PM

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



SCALE 1" = 20'
VERT. SCALE = 2X
A/4 CROSS SECTION A

0 20 40
1" = 20' FEET



SCALE 1" = 20'
VERT. SCALE = 2X
B/4 CROSS SECTION B

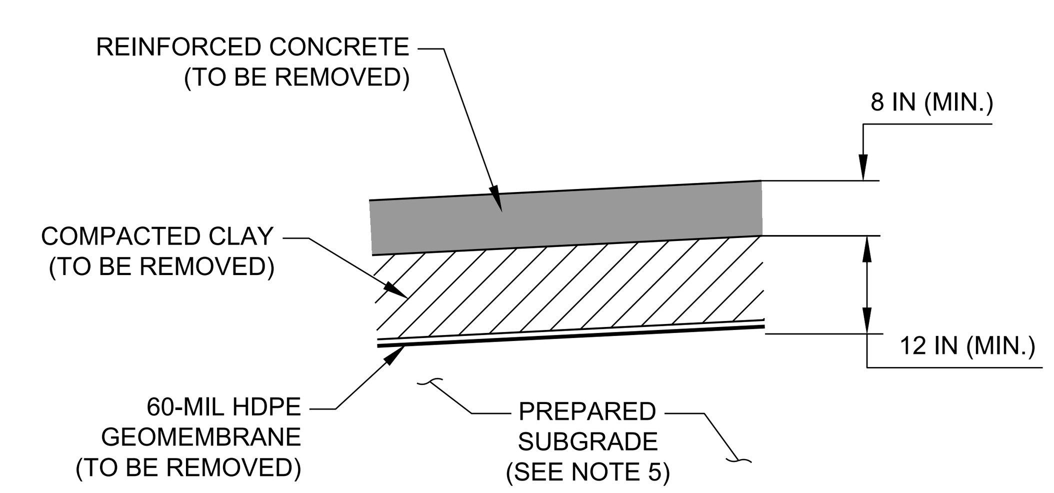
0 20 40
1" = 20' FEET

CROSS SECTION LEGEND

- PROPOSED TOP OF COMPACTED FILL (SEE NOTE 4)
- EXISTING GROUND
- EXISTING LINER - TOP OF CONCRETE
- EXISTING LINER - TOP OF COMPACTED CLAY
- EXISTING LINER - GEOMEMBRANE

NOTE(S)

1. EDGE OF CONCRETE PROVIDED IN INGENAE SURVEY RECORD DRAWING DATED 2/9/2021.
2. THERE IS NO APPRECIABLE AMOUNT OF BOTTOM ASH PRESENT IN THE BOTTOM ASH BASIN.
3. EXISTING LINER SYSTEM TO BE REMOVED WILL BE DISPOSED OF IN A PERMITTED LANDFILL.
4. COMPACTED FILL WILL BE PLACED TO 95% OF MAXIMUM STANDARD PROCTOR DRY DENSITY.
5. AN ADDITIONAL 12 INCHES OF SOIL MAY BE EXCAVATED BENEATH THE BOTTOM OF THE LINER SYSTEM.



SCALE N.T.S.
1/4 EXISTING LINER SYSTEM

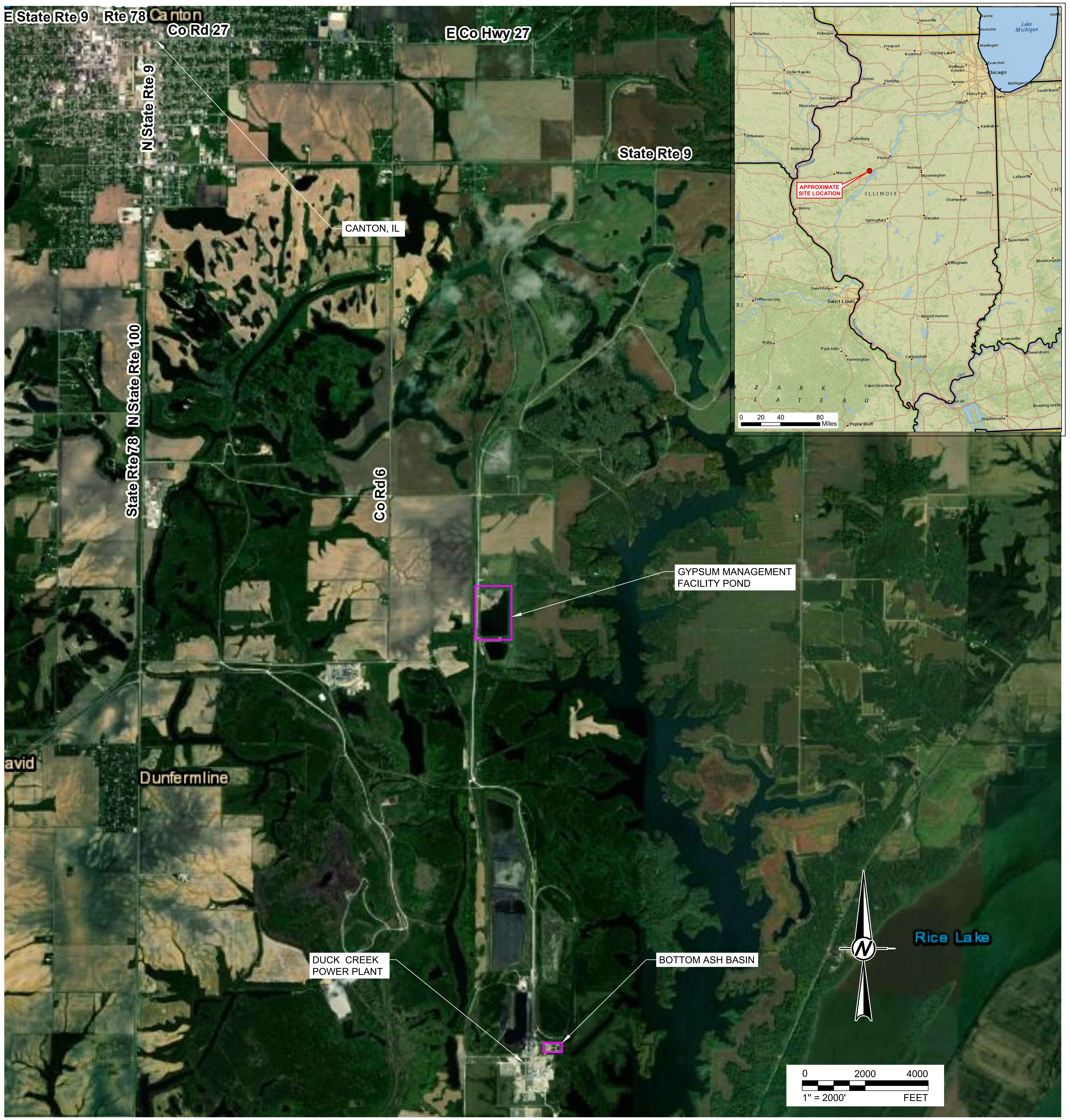
NOT FOR CONSTRUCTION

DRAFT

CLIENT	ILLINOIS POWER RESOURCES GENERATING, LLC DUCK CREEK POWER PLANT	PROJECT	BOTTOM ASH BASIN CLOSURE ALTERNATIVES ANALYSIS
CONSULTANT	GOLDER MEMBER OF WSP		
YYYY-MM-DD	2021-11-05	TITLE	**CLOSURE-BY-REMOVAL PROFILES AND SECTIONS**
DESIGNED	JEO		
PREPARED	KAC		
REVIEWED	JJS	PROJECT NO. 21454861	REV. A
APPROVED	JEO	FIGURE	4

ATTACHMENT 2

Drawings



ILLINOIS POWER RESOURCES GENERATING, LLC
DUCK CREEK POWER PLANT
GYPSUM MANAGEMENT FACILITY POND
CONSTRUCTION PERMIT APPLICATION

PREPARED BY:

GOLDER ASSOCIATES INC.
13515 BARRETT PARKWAY DRIVE, SUITE 260
BALLWIN, MISSOURI USA 63021

PERMIT APPLICATION 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	SECTIONS	A
6	DETAILS (1 OF 2)	A
7	DETAILS (2 OF 2)	A

NOTE(S)

1. AERIAL IMAGERY FROM ESRI PROVIDED BASEMAP SERVICE. IMAGERY COLLECTED 5/14/2017, 10/21/2017, 8/22/2018, AND 4/1/2019.
2. INSET MAP BOUNDARIES FROM ESRI PROVIDED FEATURE SERVICE. USA STATE BOUNDARIES. 2021
3. INSET MAP BACKGROUND FROM ESRI PROVIDED BASEMAP SERVICE. NATIONAL GEOGRAPHIC BASEMAP. 2021.

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REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
A	2021-11-05	ISSUED FOR REVIEW	DVS	DVS	JJS	JEO

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DUCK CREEK POWER PLANT

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TITLE
TITLE SHEET

PROJECT NO. 21454861 | REV. A | 1 of 7 | DRAWING 1

LEGEND

600	EXISTING GROUND ELEVATION CONTOURS (NOTE 1)
	EXISTING ROAD
	LIMIT OF GMF LINER SYSTEM (NOTE 2)
	WATER LEVEL LINE (NOTE 3)
	EXISTING PIPING (NOTE 3)

NOTES

1. EXISTING CONTOURS ARE A COMPOSITE OF AN AERIAL SURVEY COMPLETED BY DRAGONFLY AEROSOLUTIONS DATED 11/17/2020, TOPOGRAPHIC/BATHYMETRIC SURVEYS COMPLETED BY INGENAE DATED 11/4/2020 & 11/5/2020, AND U.S. GEOLOGICAL SURVEY LIDAR POINT CLOUD DATA DATED 2/12/2018.
2. LIMIT OF LINER ESTIMATED FROM CONSTRUCTION RECORD DRAWINGS PREPARED BY HANSON PROFESSIONAL SERVICES, DATED 03-05-2009.
3. WATER LEVEL LINE AND EXISTING PIPING FROM INGENAE SURVEY RECORD DRAWING DATED 3/19/2021.
4. AERIAL IMAGERY FROM DRAGONFLY AEROSOLUTIONS DATED 11/17/2020.

0 120 240
1" = 120' FEET

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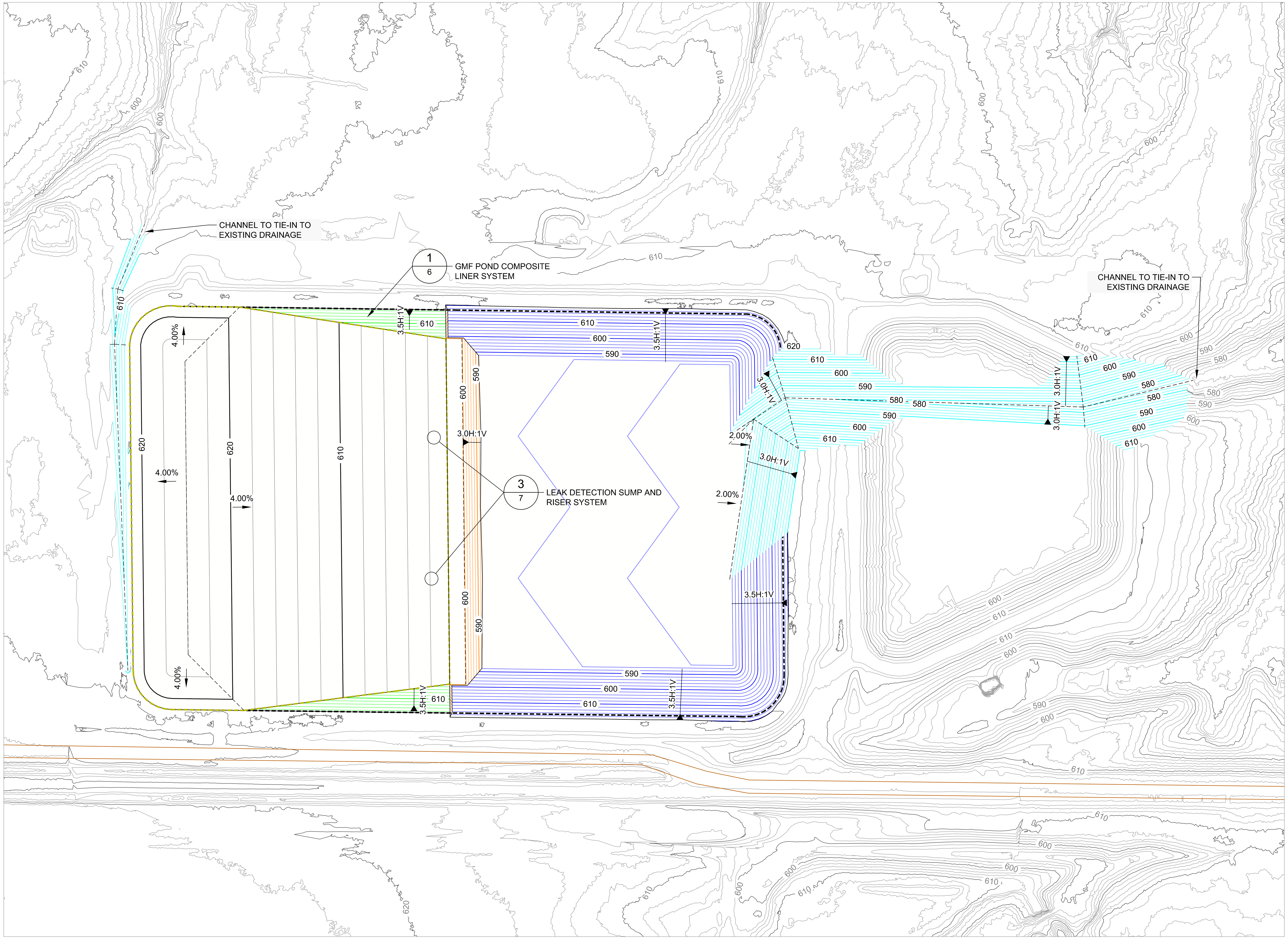
CONSTRUCTION PERMIT APPLICATION

TITLE
EXISTING CONDITIONS

PROJECT NO. 21454861 REV. A 2 of 7 DRAWING 2



LEGEND

- 600 TOP OF RELOCATED GYPSUM
- 600 TOP OF COMPOSITE LINER SYSTEM (SEE NOTE 1)
- 600 TOP OF CLAY LINER (SEE NOTE 1)
- 600 DRAINAGE CHANNEL GRADES
- 600 EARTHEN BERM GRADES
- 600 EXISTING GROUND CONTOURS (SEE NOTE 2)
- EXISTING ROAD
- LIMIT OF GMF POND LINER SYSTEM (NOTE 1)
- LIMIT OF WASTE

NOTES

1. GYPSUM MANAGEMENT FACILITY (GMF) POND BASE GRADES AND LIMIT OF LINER SYSTEM WERE DEVELOPED FROM CONSTRUCTION RECORD DRAWINGS PREPARED BY HANSON PROFESSIONAL SERVICES.
2. EXISTING CONTOURS ARE A COMPOSITE OF AN AERIAL SURVEY COMPLETED BY DRAGONFLY AEROSOLUTIONS DATED 11/17/2020, TOPOGRAPHIC/BATHYMETRIC SURVEYS COMPLETED BY INGENAE DATED 11/4/2020 & 11/5/2020, AND U.S. GEOLOGICAL SURVEY LIDAR POINT CLOUD DATA DATED 2/12/2018.
3. CLOSURE WILL INVOLVE REMOVAL OF PONDED WATER, CONSTRUCTION OF AN EARTHEN BERM WITH A LINER SYSTEM ON THE UPSTREAM SLOPE, REMOVAL AND RELOCATION OF GYPSUM SOUTH OF THE BERM TO WITHIN THE CLOSURE FOOTPRINT, AND FINAL COVER SYSTEM CONSTRUCTION.

0 120 240
1" = 120' FEET

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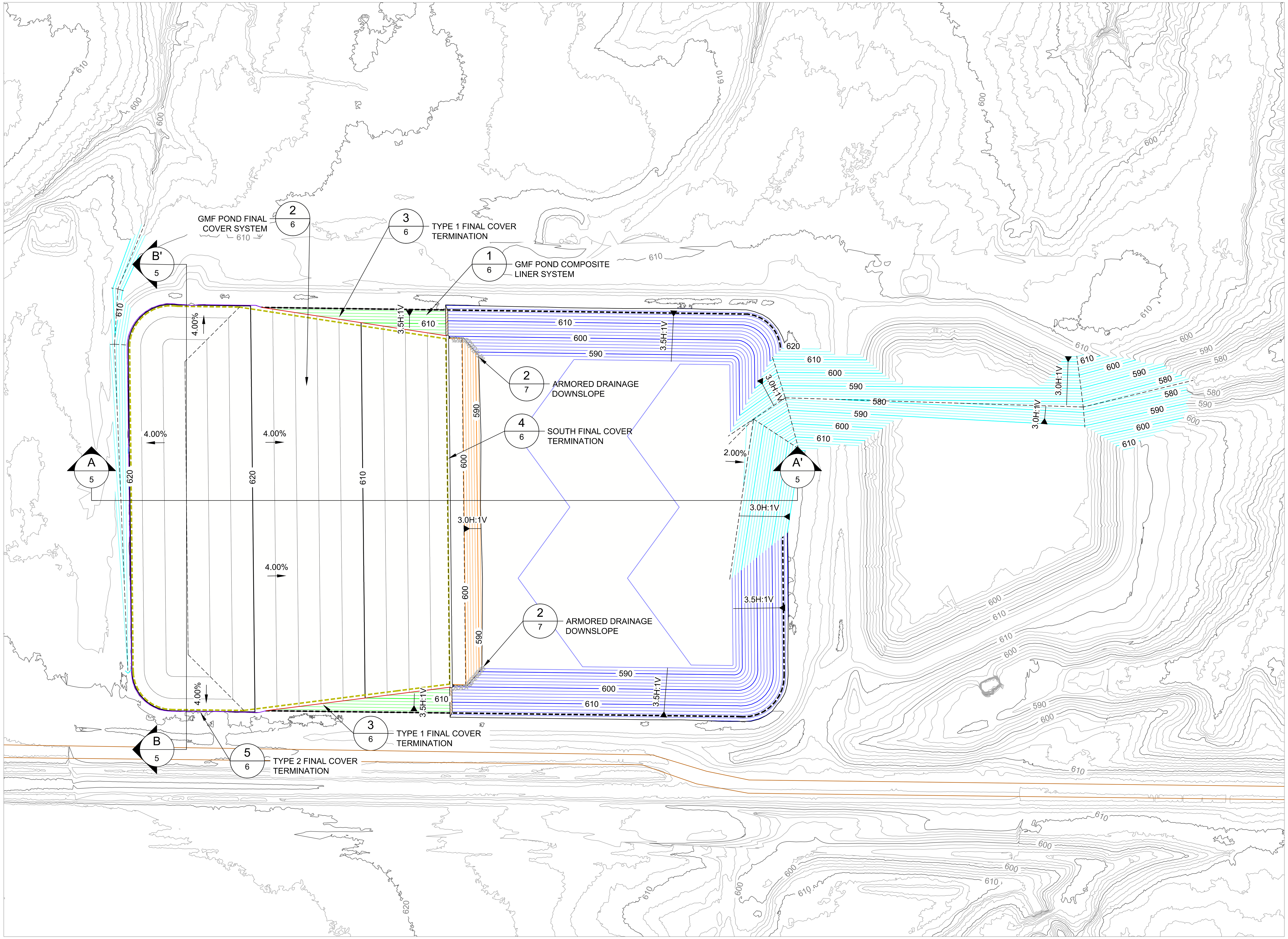
PROJECT
GYMSUM MANAGEMENT FACILITY POND
CONSTRUCTION PERMIT APPLICATION

TITLE
GYPSUM REGRADING AND CONTAINMENT PLAN

PROJECT NO. 21454861 | REV. A | 3 of 7 | DRAWING 3



LEGEND

600	TOP OF FINAL COVER
600	TOP OF COMPOSITE LINER SYSTEM (SEE NOTE 1)
600	TOP OF CLAY LINER (SEE NOTE 1)
600	EARTHEN BERM GRADES
600	EXISTING GROUND CONTOURS (SEE NOTE 2)
	EXISTING ROAD
	LIMIT OF GMF POND LINER SYSTEM (NOTE 1)
	LIMIT OF WASTE
	TYPE 1 FINAL COVER TERMINATION
	TYPE 2 FINAL COVER TERMINATION

NOTES

1. GYPSUM MANAGEMENT FACILITY (GMF) POND BASE GRADES AND LIMIT OF LINER SYSTEM WERE DEVELOPED FROM CONSTRUCTION RECORD DRAWINGS PREPARED BY HANSON PROFESSIONAL SERVICES.
2. EXISTING CONTOURS ARE A COMPOSITE OF AN AERIAL SURVEY COMPLETED BY DRAGONFLY AEROSOLUTIONS DATED 11/17/2020, TOPOGRAPHIC/BATHYMETRIC SURVEYS COMPLETED BY INGENAE DATED 11/4/2020 & 11/5/2020, AND U.S. GEOLOGICAL SURVEY LIDAR POINT CLOUD DATA DATED 2/12/2018.
3. CLOSURE WILL INVOLVE REMOVAL OF PONDED WATER, CONSTRUCTION OF AN EARTHEN BERM WITH A LINER SYSTEM ON THE UPSTREAM SLOPE, REMOVAL AND RELOCATION OF GYPSUM SOUTH OF THE BERM TO WITHIN THE CLOSURE FOOTPRINT, AND FINAL COVER CONSTRUCTION.

N

0 120 240
1" = 120' FEET

DRAFT

REV.	YYYY-MM-DD	DESCRIPTION	DESIGNED	PREPARED	REVIEWED	APPROVED
A	2021-11-05	ISSUED FOR REVIEW	DVS	DVS	JJS	JEO

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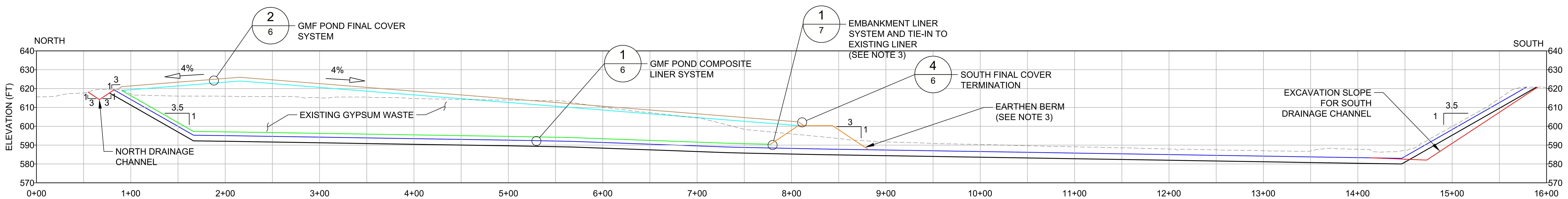
PROJECT
GYPSUM MANAGEMENT FACILITY POND
CONSTRUCTION PERMIT APPLICATION

TITLE
FINAL COVER AND STORMWATER PLAN

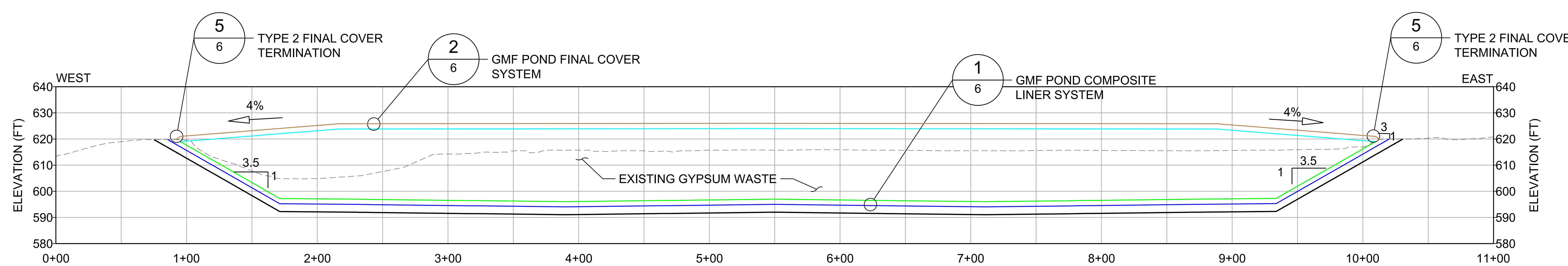
PROJECT NO. 21454861 | REV. A | 4 of 7 | DRAWING 4

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



SCALE 1"=60' | VERT. SCALE X2 | A/5 | SECTION A-A'

0 | 60 | 120 | 1" = 60' | FEET



SCALE 1" = 60' | VERT. SCALE X2 | B/5 | SECTION B-B'

0 | 60 | 120 | 1" = 60' | FEET

LEGEND

- TOP OF FINAL COVER
- TOP OF RELOCATED GYPSUM
- TOP OF COMPOSITE LINER SYSTEM (SEE NOTE 1)
- TOP OF CLAY LINER (SEE NOTE 1)
- BOTTOM OF COMPOSITE LINER SYSTEM (SEE NOTE 1)
- EXISTING GROUND CONTOURS (SEE NOTE 2)
- EARTHEN BERM (SEE NOTE 3)
- DRAINAGE CHANNEL GRADING

NOTES

1. GYPSUM MANAGEMENT FACILITY (GMF) POND BASE GRADES SHOWN WERE DEVELOPED FROM CONSTRUCTION RECORD DRAWINGS PREPARED BY HANSON PROFESSIONAL SERVICES.
2. EXISTING CONTOURS ARE A COMPOSITE OF AN AERIAL SURVEY COMPLETED BY DRAGONFLY AEROSOLUTIONS DATED 11/17/2020, TOPOGRAPHIC/BATHYMETRIC SURVEYS COMPLETED BY INGENAE DATED 11/4/2020 & 11/5/2020, AND U.S. GEOLOGICAL SURVEY LIDAR POINT CLOUD DATA DATED 2/12/2018.
3. CLOSURE WILL INVOLVE REMOVAL OF PONDED WATER, CONSTRUCTION OF AN EARTHEN BERM WITH A LINER ON THE UPSTREAM SLOPE, REMOVAL AND RELOCATION OF GYPSUM SOUTH OF THE BERM TO WITHIN THE CLOSURE FOOTPRINT, AND FINAL COVER CONSTRUCTION.

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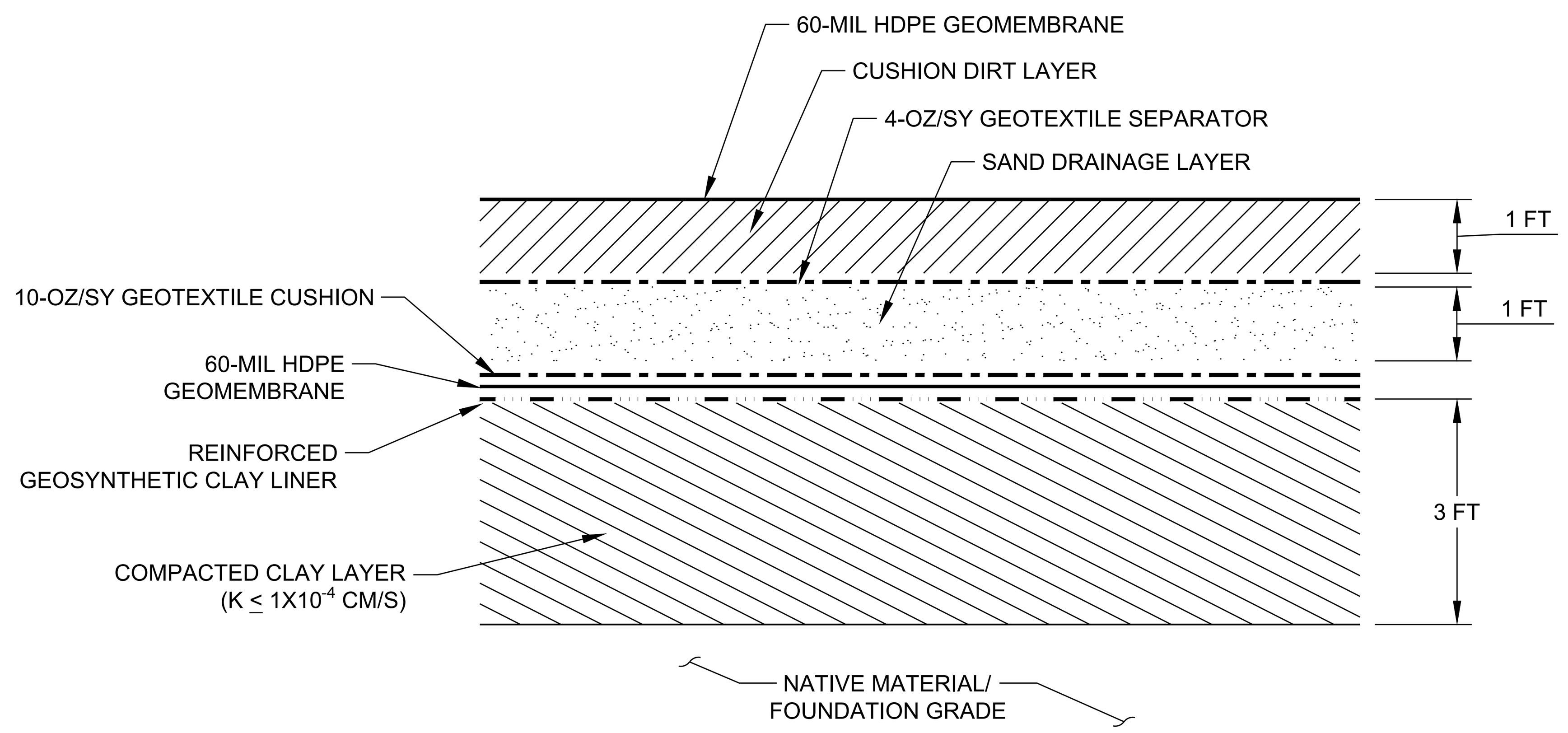
PROJECT
GYPSUM MANAGEMENT FACILITY POND
CONSTRUCTION PERMIT APPLICATION

TITLE
SECTIONS

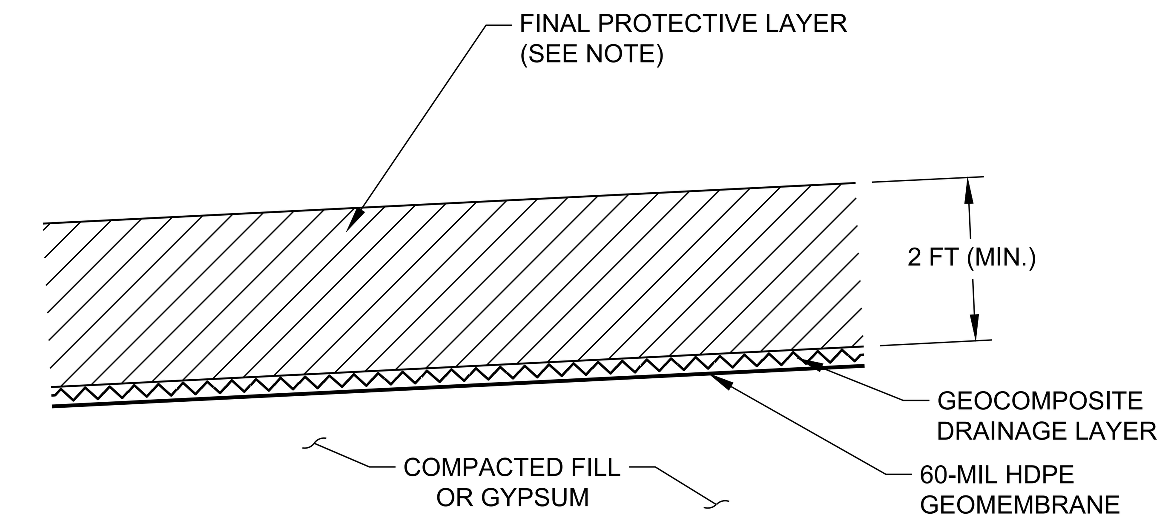
PROJECT NO. 21454861 | REV. A | 5 of 7 | DRAWING 5



SCALE N.T.S. 1/6 **GMF POND COMPOSITE LINER SYSTEM**

MATERIAL REMOVAL NOTES (SOUTH OF EARTHEN BERM)

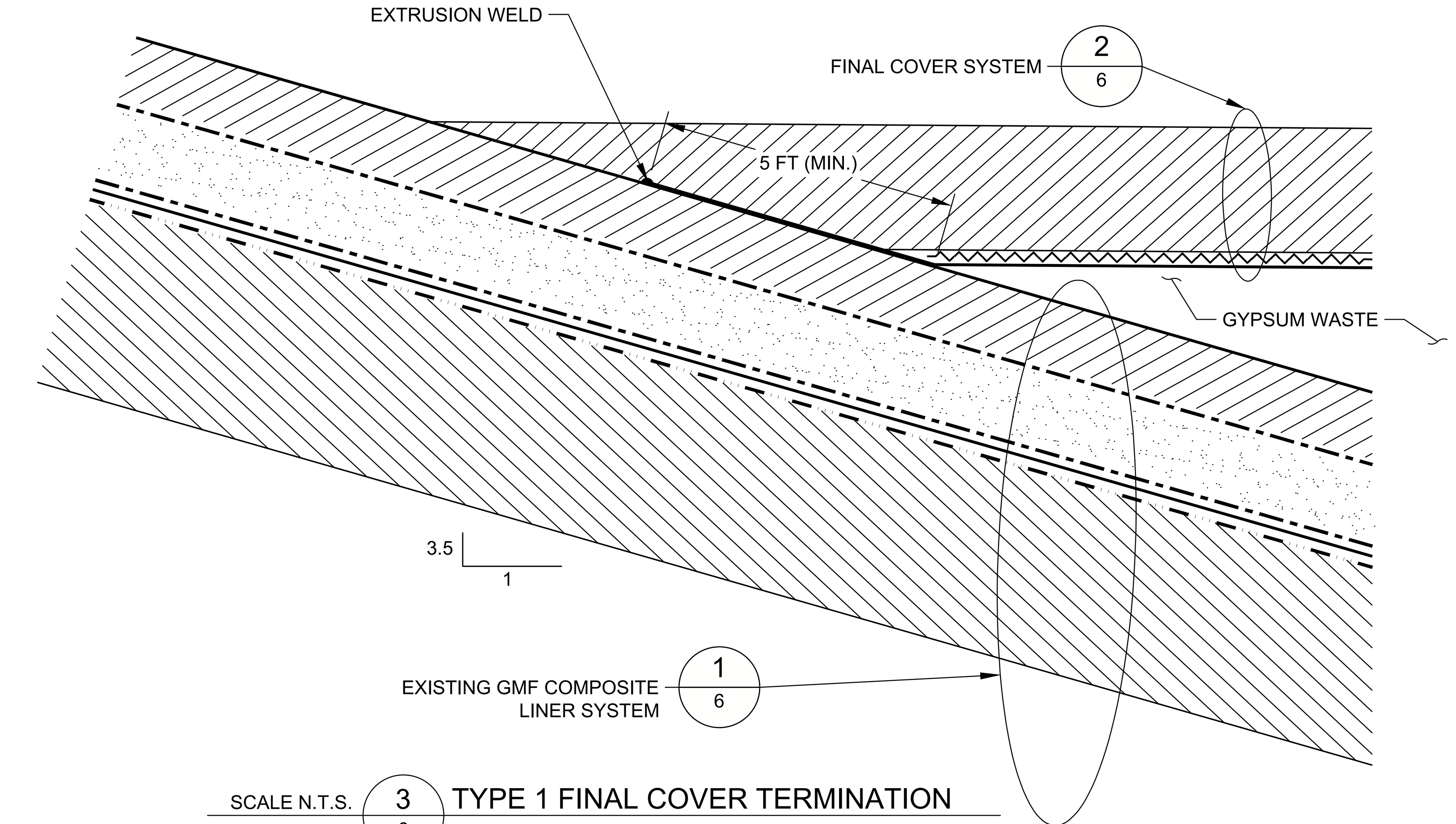
- THE CUSHION DIRT LAYER AND DRAINAGE LAYER WILL BE REMOVED AND STOCKPILED ON-SITE.
- GEOSYNTHETIC COMPONENTS OF THE LINER SYSTEM WILL BE REMOVED AND DISPOSED. GEOSYNTHETIC MATERIALS TO BE REMOVED INCLUDE: PRIMARY AND SECONDARY 60-MIL HDPE GEOMEMBRANE, GEOTEXTILE SEPARATOR, GEOTEXTILE CUSHION, AND GEOSYNTHETIC CLAY LINER.
- THE COMPACTED CLAY LAYER WILL REMAIN IN PLACE.



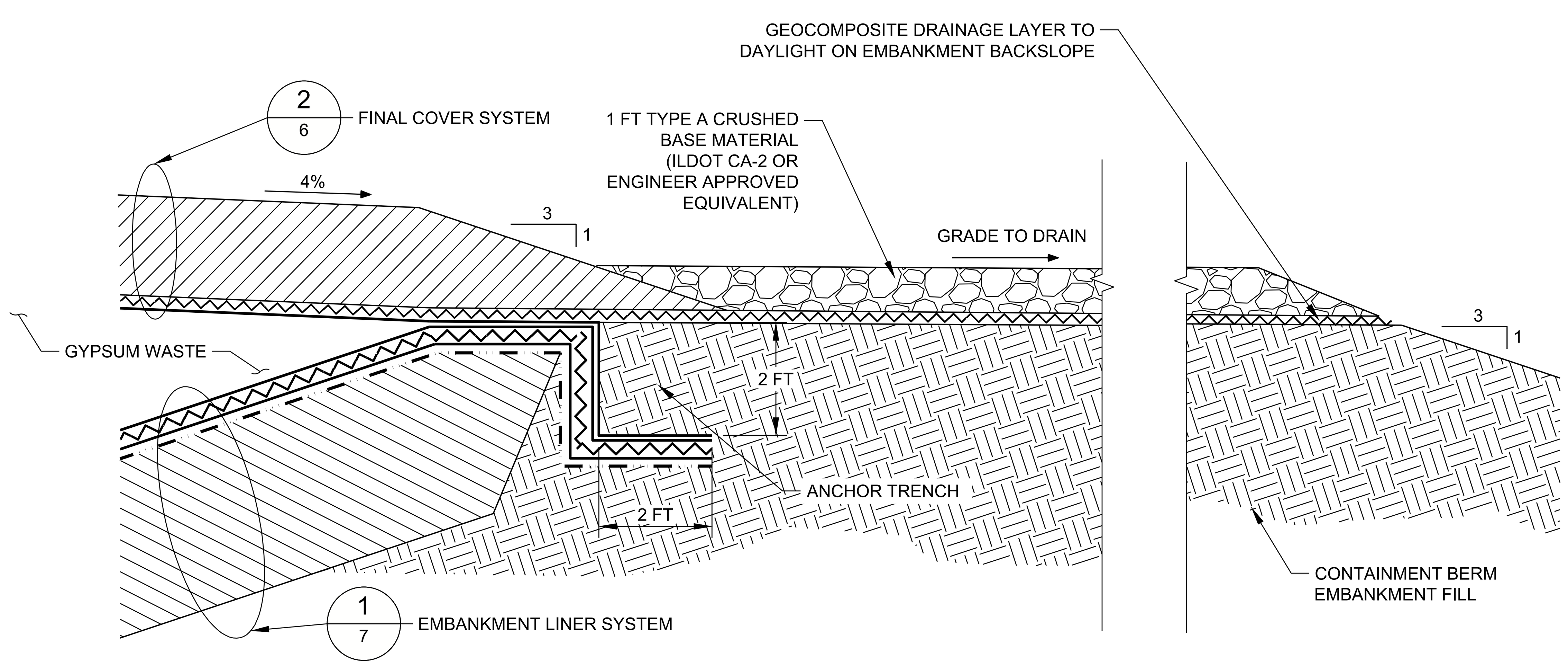
SCALE N.T.S. 2/6 **FINAL COVER SYSTEM**

NOTE

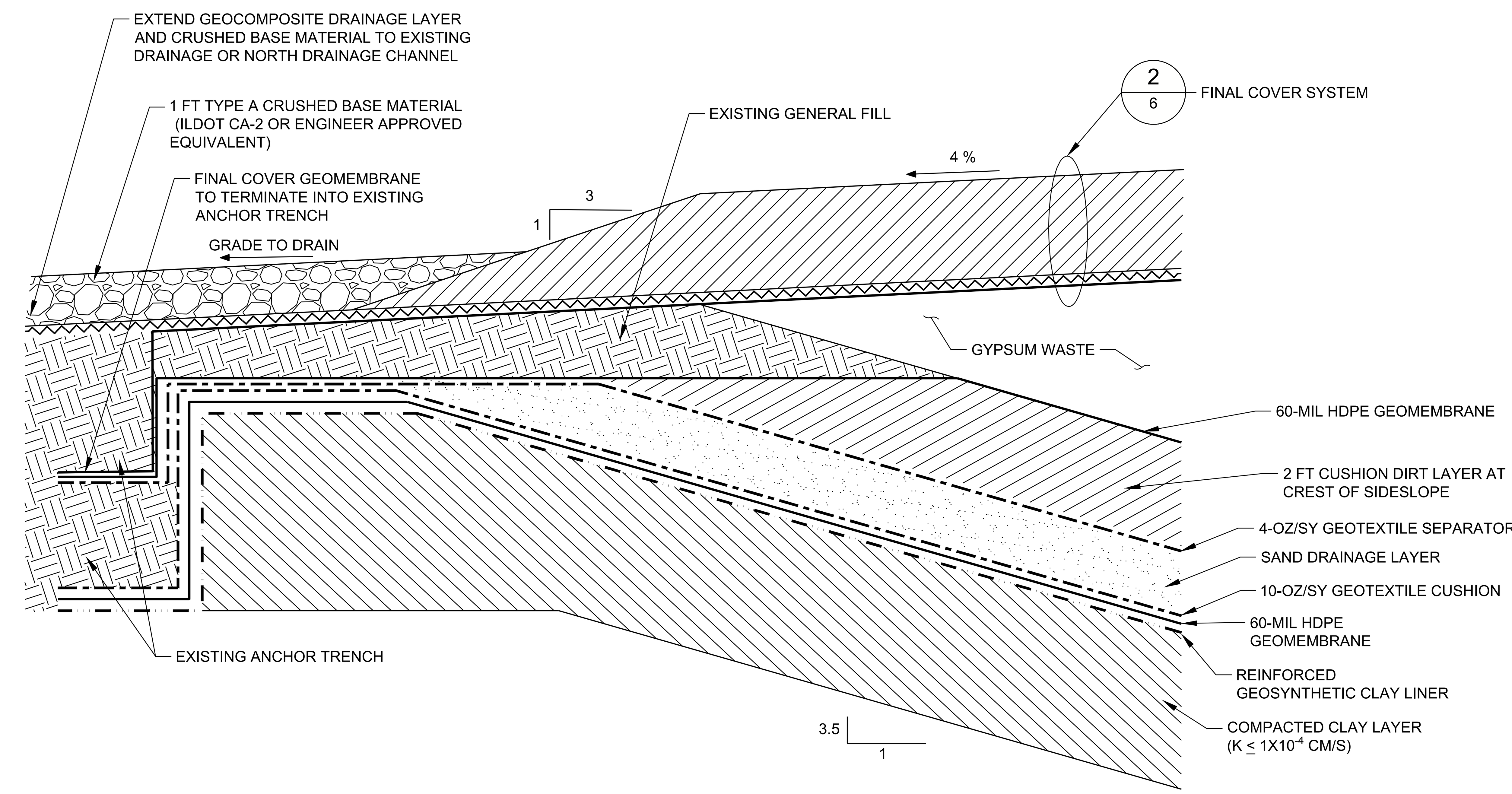
- THE FINAL PROTECTIVE LAYER WILL BE COMPOSED OF LOCALLY AVAILABLE SOILS COMPACTED TO BETWEEN 80% AND 95% OF THE STANDARD PROCTOR. THE UPPERMOST 6 INCHES OF THE FINAL PROTECTIVE LAYER SHALL BE TRACKED IN PLACE WITH DENSITY SUITABLE FOR ESTABLISHMENT OF VEGETATION.
- THE GEOMEMBRANE WILL MEET THE REQUIREMENTS OF GRI-GM13 AND WILL BE INSTALLED IN ACCORDANCE WITH GRI GM-19A.



SCALE N.T.S. 3/6 **TYPE 1 FINAL COVER TERMINATION**



SCALE N.T.S. 4/6 **SOUTH FINAL COVER TERMINATION**



SCALE N.T.S. 5/6 **TYPE 2 COVER TERMINATION**

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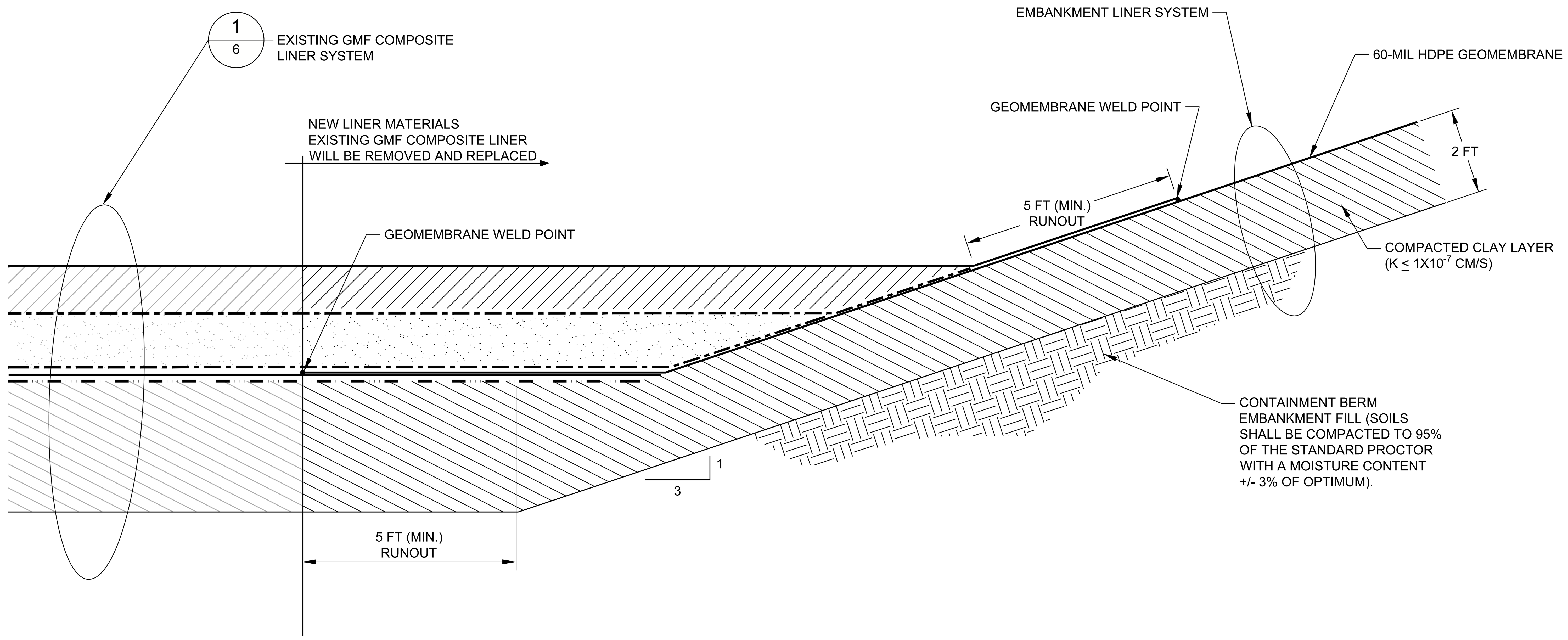
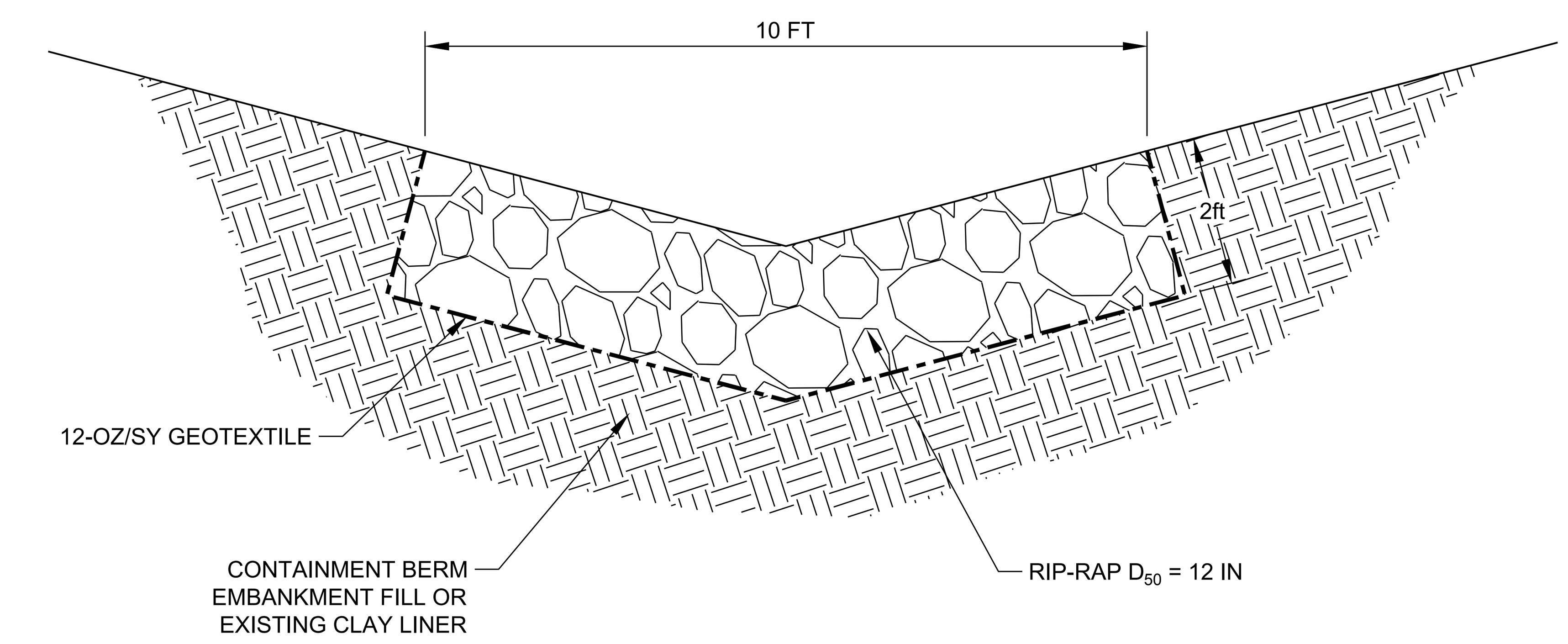
TITLE
DETAILS (1 OF 2)

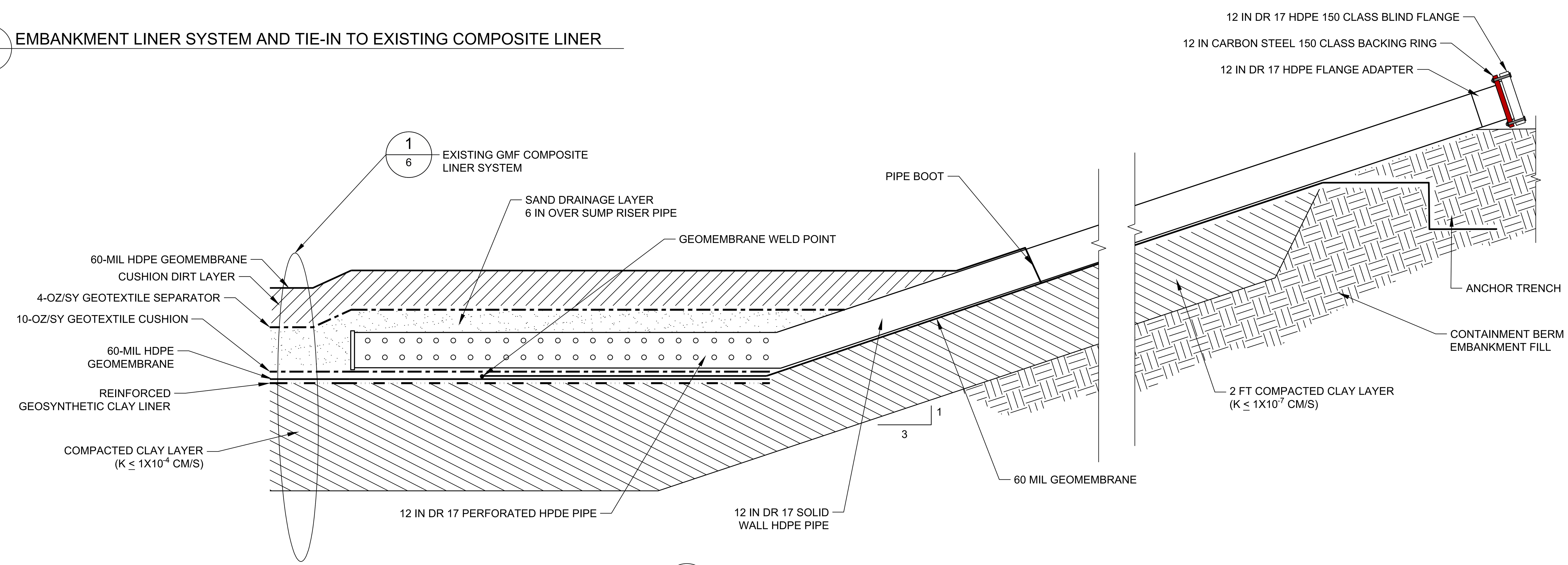
PROJECT NO. 21454861 | REV. A | 6 of 7 | DRAWING 6



SCALE N.T.S. 1/7 EMBANKMENT LINER SYSTEM AND TIE-IN TO EXISTING COMPOSITE LINER



SCALE N.T.S. 2/7 ARMORED DRAINAGE DOWNSLOPE



SCALE N.T.S. 3/7 LEAK DETECTION SYSTEM SUMP AND RISER

NOTE

EXISTING 6 INCH LEACHATE COLLECTION PIPE NOT SHOWN IN DETAIL. LEACHATE COLLECTION PIPE WILL TERMINATE AND BE CAPPED AT THE TOE OF THE CONTAINMENT BERM

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PROJECT NO. 21454861 | REV. A | 7 of 7 | DRAWING 7

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ATTACHMENT 3

Slope Stability Calculations

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MEMBER OF WSP

DRAFT

CALCULATION

DATE October 18, 2021 **Reference No.** 21454861-7-R-A

PREPARED BY: Jason Obermeyer

CHECKED BY: Jeff Rusch

REVIEWED BY: Mark Haddock, PE **CLIENT NAME: Illinois Power Resources Generating, LLC**

SLOPE STABILITY ANALYSIS – GYPSUM MANAGEMENT FACILITY POND CLOSURE

1.0 OBJECTIVE

Evaluate slope stability for the Gypsum Management Facility (GMF) Pond 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. 2020). 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 Pond 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 Pond, as the GMF Pond 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):

- sixty-mil textured high-density polyethylene (HDPE) geomembrane
- one foot of cushion soil (primarily silt and clay)

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- four-ounce-per-square-yard (oz/yd^2) nonwoven needle-punched (NWNP) geotextile
- one foot of granular drainage aggregate
- ten oz/yd^2 NWNP geotextile
- sixty-mil textured HDPE geomembrane
- reinforced geosynthetic clay liner (GCL)
- three feet of compacted clay

The containment berm is designed with 3H:1V slopes and a crest width of 36 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:1V slope to the crest. The final cover system will consist of the following components (from top to bottom):

- two feet of protective soil cover, anticipated to consist primarily of locally available low-plasticity silt or clay
- double-sided geocomposite drainage layer
- sixty-mil textured HDPE 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 consist of the following components (from top to bottom):

- sixty-mil textured HDPE geomembrane
- two feet of compacted clay

Downstream of the containment berm, the closure grades represent the top of the compacted clay layer in the existing liner system, as the components of the existing liner system above this layer will be removed during closure of the GMF Pond.

For simplification of the model geometry, the liner systems are each represented as a layer having a thickness of 2 feet and the final cover system geosynthetics are represented as a layer having a thickness of 1 foot.

Groundwater levels in the vicinity of the GMF Pond 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. 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 pseudostatic approach. The United States Geological Survey (USGS) Unified Hazard Tool indicates a 2% probability of exceeding a peak ground acceleration (PGA) of 0.06 g in 50 years at the site. In an actual seismic event, the peak acceleration would be sustained for only a fraction of a second. A pseudostatic analysis conservatively models seismic events as a force with constant acceleration and direction (i.e., an infinitely long seismic pulse). Consequently, it is common geotechnical practice to reduce the predicted PGA when performing pseudostatic analyses. For conservatism, however, the pseudostatic analysis for the GMF Pond is conducted for the long-term condition using a horizontal seismic coefficient of 0.06, corresponding to the PGA.
- Material unit weights were selected based on engineering judgment.
- Strength parameters for zones that may consist of cohesive soils (i.e., containment berm, protective soil cover, and subsoil) are selected based on engineering judgment. These zones are assigned a friction angle of 28 degrees. 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 systems and final cover systems associated with the closed GMF Pond are evaluated from laboratory testing data published by Koerner and Narejo (2005) and summarized in Table 1.
- 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.

Table 1: Characteristic Geosynthetic Interface Strengths

Interface	Peak Friction Angle	Peak Adhesion
Textured HDPE geomembrane against cohesive soil	18 degrees	209 psf
NWNP geotextile against cohesive soil	30 degrees	104 psf
NWNP geotextile against granular soil	33 degrees	0 psf
NWNP geotextile against textured HDPE geomembrane	25 degrees	167 psf
Textured HDPE geomembrane against reinforced GCL	23 degrees	167 psf
Reinforced GCL against cohesive soil	Use NWNP geotextile against cohesive soil	
Geocomposite against cohesive soil	Use NWNP geotextile against cohesive soil	
Geocomposite against textured HDPE geomembrane	26 degrees	0 psf

Source: Koerner and Narejo 2005.

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

Table 2: Material Properties

Zone	Unit Weight	Friction Angle	Cohesion or Adhesion	Vertical Stress Ratio
Existing liner system	120 pcf	18 degrees	0 psf	–
New liner system	120 pcf	23 degrees	0 psf	–
Final cover geosynthetics	120 pcf	18 degrees	0 psf	–
Final cover soil	120 pcf	28 degrees	0 psf	–
Containment berm	120 pcf	28 degrees	0 psf	–
Gypsum	100 pcf	–	–	0.22
Subsoil	120 pcf	28 degrees	0 psf	–

3.3 Results and Conclusions

The factor of safety for slope stability under static loading conditions is calculated as 1.6, 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 1.3, as shown in Figure 2. As with the static analysis, the critical slip surface is surficial on the downstream face of the containment berm.

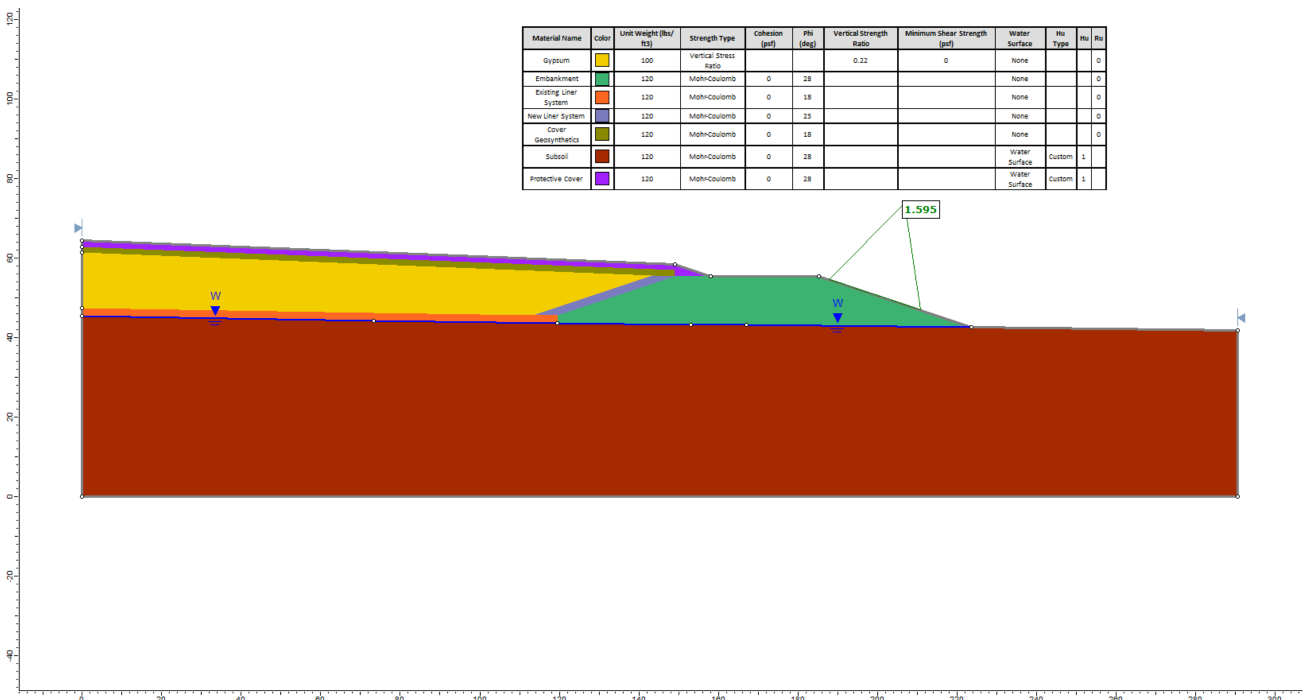
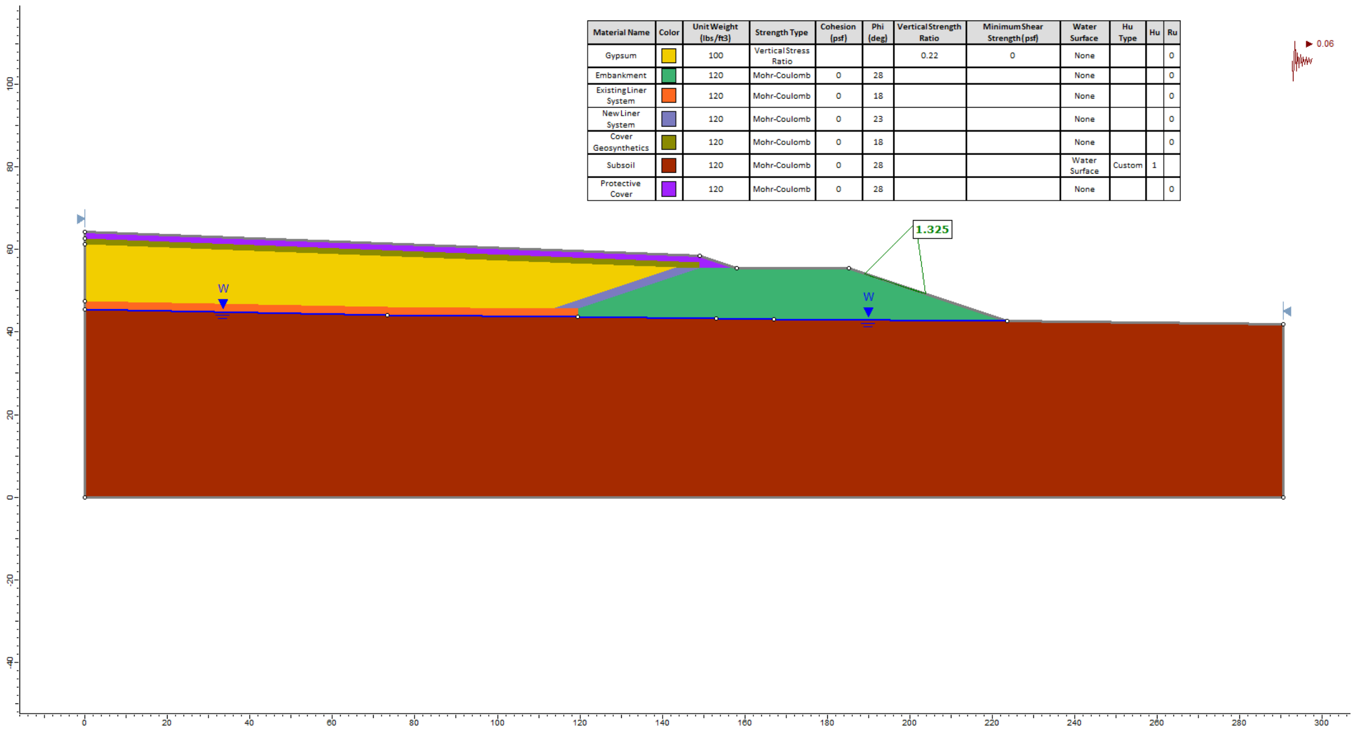


Figure 1: Analysis Result – Static Loading



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Vertical Strength Ratio	Minimum Shear Strength (psf)	Water Surface	Hu Type	Hu	Ru
Gypsum		100	Vertical Stress Ratio			0.22	0	None			0
Embankment		120	Mohr-Coulomb	0	28			None			0
Existing Liner System		120	Mohr-Coulomb	0	18			None			0
New Liner System		120	Mohr-Coulomb	0	23			None			0
Cover Geosynthetics		120	Mohr-Coulomb	0	18			None			0
Subsoil		120	Mohr-Coulomb	0	28			Water Surface	Custom	1	
Protective Cover		120	Mohr-Coulomb	0	28			None			0

Figure 2: Analysis Result – Seismic Loading

Based on the factors of safety computed using the methods and assumptions described, the closed GMF Pond is expected to remain stable with an acceptable safety margin for global and veneer stability. A factor of safety greater than 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

RocScience Inc. 2020. Slide2 Version 9.012. Build date: December 11, 2020.

Mesri G. 1989. A Reevaluation of $S_{u(mob)} = 0.22\sigma'_p$ Using Laboratory Shear Tests. Canadian Geotechnical Journal, No. 26, pp. 162-164.

Spencer E. 1967. A Method of Analysis of the Stability of Embankments Assuming Parallel Inter-Slice Forces. Geotechnique, Vol. XVII, No. 1, pp. 11-26.

USGS (United States Geological Survey). 2014. Unified Hazard Tool. Available online: https://earthquake.usgs.gov/hazards/interactive/index.php (accessed October 14, 2021).

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https://golderassociates.sharepoint.com/sites/141778/project files/6 deliverables/reports/7-r-gmf_permit_app/7-r-a/apph/att3_gmf_slope_stability.docx

ATTACHMENT 4

Hydrologic Calculations

DRAFT

CALCULATION

DATE	October 18, 2021	**Reference No.** 21454861-7-R-A
PREPARED BY:	Micah Richey, PE	
CHECKED BY:	Brendan Purcell	
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HYDROLOGY CALCULATIONS FOR CLOSURE OF THE GYPSUM MANAGEMENT FACILITY POND AT THE DUCK CREEK POWER PLANT

1.0 OBJECTIVE

Evaluate the hydrology (routing of stormwater runoff) after closure of the Duck Creek Gypsum Management Facility (GMF) Pond. These calculations were done to support the closure plan by determining the minimum channel dimensions.

2.0 METHODOLOGY

The areas contributing to the GMF were delineated in AutoCAD, as shown in 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 a proposed channel south of the closed GMF and another proposed channel north 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 Pond (NRCS 2021).
- The design storm (25-year, 24-hour) depth from NOAA Atlas 14 (NOAA 2006) is 5.25 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 south of the closed GMF Pond is estimated as 48.6 cubic feet per second (cfs).

- The peak flow rate at the proposed stormwater channel north of the closed GMF Pond is estimated as 12.6 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 channel should function as designed.

5.0 REFERENCES

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

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

NRCS. 2021. Web Soil Survey. Available online: http://websoilsurvey.sc.egov.usda.gov/ (accessed September 22, 2021)

USACE (United States Army Corps of Engineers). 2021. Hydrologic Modeling System (HEC-HMS), Version 4.8.0. Release date: April 8, 2021.

Golder Associates Inc.

https://golderassociates.sharepoint.com/sites/141778/project files/6 deliverables/reports/7-r-gmf_permit_app/7-r-a/apph/att4/att4_duck_creek_gmf_hydrologic_calculations.docx

Tables

TABLE 1
SUBBASIN SUMMARY TABLE

Illinois Power Resources Generating, LLC
Duck Creek Gypsum Management Facility
Project Number: 21454861

Date:	10/18/21
By:	MBR
Chkd:	BJP
Apprvd:	JEO

Design Storm 25 -Year Recurrence Interval

Storm Duration (hours)	2-Year Depth (inches)	25 -Year Depth (inches)	Storm Distribution
24	3.01	5.25	II

				CN = 58	CN = 99					
Subbasin ID	Subbasin Area (ft^2)	Subbasin Area (acres)	Subbasin Area (sq mile)	Meadow HSG B (acres)	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)
CIP	1,871,960	42.97	0.0671	42.97		CN = 58	7.24	1.31	4.69	204,167
CIP N	445,396	10.22	0.0160	10.22		CN = 58	7.24	1.31	1.12	48,577

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TABLE 2
BASIN TIME OF CONCENTRATION CALCULATIONS

Illinois Power Resources Generating, LLC
Duck Creek Gypsum Management Facility
Project Number: 21454861

Date:	10/18/21
By:	MBR
Chkd:	BJP
Apprvd:	JEO

					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		Typical Hydraulic Radius (Channel Only) (ft)	Travel Time (min)	Type of Flow	Length (ft)	Slope (ft/ft)	Roughness Condition		Typical Hydraulic Radius (Channel Only) (ft)	Travel Time (min)	Type of Flow	Length (ft)	Slope (ft/ft)	Roughness Condition		Typical Hydraulic Radius (Channel Only) (ft)	Travel Time (min)
CIP	0.0671	58	15.9	26.5	Sheet	100	0.040	G	Bermuda Grass		17.1	Shallow	550	0.040	U	Unpaved		2.8	Channel	1,700	0.0094	G	Grass-lined	1.07	6.6
CIP N	0.0160	58	13.9	23.1	Sheet	100	0.040	G	Bermuda Grass		17.1	Shallow	100	0.050	U	Unpaved		0.5	Channel	950	0.0105	G	Grass-lined	0.53	5.6

TABLE 3
FLOW RESULTS FROM HEC-HMS

Illinois Power Resources Generating, LLC
Duck Creek Gypsum Management Facility
Project Number: 21454861

Date:	10/18/21
By:	MBR
Chkd:	BJP
Apprvd:	JEO

HEC-HMS Basin Model:	GMF
HEC-HMS Met. Model:	25-yr, 24-hr
HEC-HMS Control Specs:	48-hr, 1-min

Hydrologic Element	Drainage Area (sq mile)	Peak Discharge (cfs)	Time of Peak	Total Volume (ac-ft)
CIP	0.067	48.6	02Jun2525, 01:10	4.7
CIP N	0.016	12.6	02Jun2525, 01:08	1.1

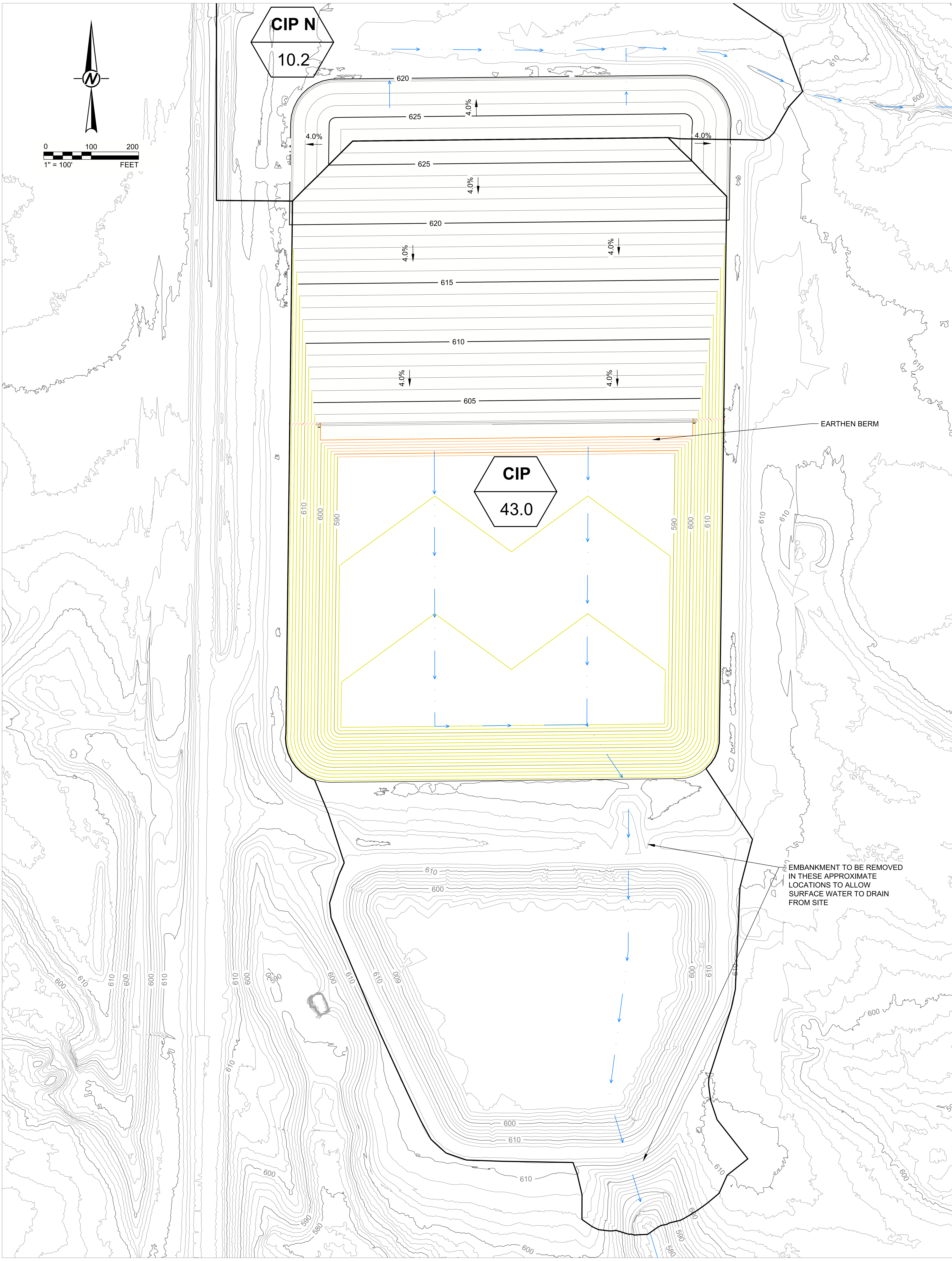
Table 4
Channel Hydraulic Calculations

Illinois Power Resources Generating, LLC
Duck Creek Gypsum Management Facility
Project Number: 21454861

Date:	10/18/21
By:	MBR
Chkd:	BJP
Apprvd:	JEO

			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)	
CIP	48.6	CIP	1,770	0.0075	3.0	3.0	0	11.7	G	Grass-lined	0.035	0.030	4.1	2.10	0.73	0.98	58.81	12.6	70.2	9.6	Suitable
CIP N	12.6	CIP N	950	0.0110	3.0	3.0	0	2.2	G	Grass-lined	0.035	0.030	3.4	1.18	0.80	0.81	39.86	7.1	13.2	1.0	Suitable

Figures



NOTE(S)

1. GYPSUM MANAGEMENT FACILITY (GMF) BASE GRADES SHOWN ARE TOP OF CUSHION DIRT LAYER. ELEVATION CONTOURS WERE DEVELOPED FROM CONSTRUCTION RECORD DRAWINGS PREPARED BY HANSON PROFESSIONAL SERVICES.
2. EXISTING CONTOURS ARE A COMPOSITE OF AN AERIAL SURVEY COMPLETED BY DRAGONFLY AEROSOLUTIONS DATED 11/17/2020, TOPOGRAPHIC/BATHYMETRIC SURVEYS COMPLETED BY INGENAE DATED 11/4/2020 & 11/5/2020, AND U.S. GEOLOGICAL SURVEY LIDAR POINT CLOUD DATA DATED 2/12/2018.
3. THE PROPOSED STORMWATER DRAINAGE CONCEPT IS TO SHED WATER INTO EXISTING DRAINAGE CHANNELS NORTHEAST AND SOUTHEAST OF THE FACILITY. DRAINAGE TO THE SOUTHEAST WILL BE DIRECTED INTO AN OPEN CHANNEL THAT BREACHES CONSTRUCTED BERMS TO CONNECT TO AN EXISTING DRAINAGE SOUTHEAST OF THE GMF.

LEGEND

- 600 — PROPOSED TOP OF COVER GRADES
- 600 — GMF BASE GRADES (SEE NOTE 1)
- 600 — EXISTING GROUND CONTOURS (SEE NOTE 2)
- 600 — EARTHEN BERM GRADES
- PROPOSED STORMWATER ROUTING (SEE NOTE 3)
- BASIN DELINEATION
- BASIN / ACRES

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DUCK CREEK GYPSUM HANDLING FACILITY
SURFACE WATER DRAINAGE BASINS

FIGURE 1

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