Prepared for

Dynegy Midwest Generation, LLC
1500 Eastport Plaza Drive
Collinsville, Illinois 62234

CCR FINAL CLOSURE PLAN

VERMILION POWER PLANT
NEW EAST ASH POND
OAKWOOD, ILLINOIS

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Prepared by

Geosyntec consultants

engineers | scientists | innovators

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Project Number CHE8404B

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TABLE OF CONTENTS

DRAFT

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF APPENDICES

DRAFT

1. INTRODUCTION

Dynegy Midwest Generation, LLC (Dynegy) is the owner of the inactive coal-fired Vermilion Power Plant (Plant), also referred to as Vermilion Power Station, located approximately 13 miles Northwest of Danville, Illinois. The New East Ash Pond (NEAP) is an inactive surface impoundments storing coal combustion residuals (CCR). The requirements for the NEAP are specified in 35 Ill. Admin. Code 845, Standards for the Disposal of Coal Combustion Residuals in Surface Impoundments (Part 845).

This Final Closure Plan addresses the requirements of Section 845.720(b) for the New East Ash Pond (NEAP). A Corrective Measures Assessment (CMA) and Corrective Action Alternatives Assessment (CAAA) has been prepared in combination with a Closure Alternatives Assessment (CAA) because they are being conducted simultaneously. This combined CAA/CMA/CAAA is provided in **Appendix 1**. The Final Closure Plan proposes a new Onsite Landfill to receive onsite wastes. A Feasibility Study (FS) to utilize the new Onsite Landfill is provided in as Attachment Q of the Construction Permit Application.

1.1. Facility Information

Facility:	Vermilion Power Plant 10188 East 2150 North Rd Oakwood, IL 61858
CCR Unit:	New East Ash Pond (NEAP)
Owner/Operator:	Dynegy Midwest Generation, LLC 1500 Eastport Plaza Drive Collinsville, IL 62234
Closure Method:	Closure by Removal

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2. FINAL CLOSURE PLAN

2.1. General Requirements

<u>Section 845.720(b)(1):</u> *The owner or operator of a CCR surface impoundment must submit to the Agency, as a part of a construction permit application for closure, a final closure plan. The plan must be submitted before the installation of a final cover system or removal of CCR from the surface impoundment for the purpose of closure.*

This Final Closure Plan will be submitted with the construction permit application for closure for NEAP.

<u>Section 845.720(b)(2):</u> *Except as otherwise provided in Section 22.59 of the Act, the owner or operator of a CCR surface impoundment must not close a CCR surface impoundment without a construction permit issued under this Part.*

The owner will not close the NEAP without a construction permit issued under Section 845.720.

<u>Section 845.720(b)(3):</u> *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.*

The following sections describe the proposed selected closure method for NEAP. The Closure Alternatives Analysis as specified by Section 845.710 is provided in **Appendix 1**. Based on the Closure Alternatives Analysis, closure by removal to an on-site landfill has been identified as the most appropriate closure for the NEAP.

2.2. Proposed Selected Closure Method

2.2.1. Description of Closure

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

The NEAP contains water in its eastern section. The NEAP is not covered; it has exposed coal ash above the impounded water level and coal ash below the impounded water. The visible CCR will be removed, as well as any pipes and discharge structures within the surface impoundment. The coal ash will be hauled to an onsite landfill that meets State requirements of IAC Part 811 and 40 C.F.R. Part 257. The area will be graded and/or backfilled as necessary to minimize the potential for ponding and vegetated with native grasses.

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General fill will be placed to provide positive drainage following excavation of the coal ash from the NEAP. The eastern berms do not contain coal ash. The select portions of the eastern berms will be excavated and used as low permeability soil or general fill. This fill will promote positive drainage on the final closure area to convey non-contact stormwater offsite.

2.2.2. Description of Removal Plan

Section 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.*

The closure of the NEAP will be accomplished by removal of CCR from the surface impoundment. The NEAP contains water in its eastern section. Water from the CCR Impoundments is required to be removed and the CCR dewatered in accordance with the Illinios Attorney General (IAG) Interim Order (IO) entered June 30, 2021. The existing coal ash will be consolidated and removed from the NEAP. All areas affected by releases of CCR from the CCR surface impoundment will be decontaminated. Groundwater monitoring will be performed in accordance with Section 845.740(b). All structures and conveyances used to manage CCR will be decontaminated or removed and sent to an onsite landfill.

Section 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.*

Closure by removal is the chosen closure method for the NEAP, and therefore, this requirement is not applicable.

2.2.3. Estimate of the Maximum Inventory

Section 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.*

Closure by removal at the facility will include removing approximately 376,000 cubic yards of coal ash from the NEAP.

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2.2.4. Estimate of the Largest Area

<u>Section 845.720(a)(1)(E):</u> 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.

A final cover is not required because the Closure by Removal method will be implemented.

2.2.5. Closure Completion Schedule

Section 845.720(a)(1)(F): A schedule for completing all activities necessary to satisfy the closure criteria in this Section, including an estimate of the year in which all closure activities for the CCR surface impoundment will be completed. The schedule should provide sufficient information to describe the sequential steps that will be taken to close the CCR surface impoundment, including identification of major milestones such as coordinating with and obtaining necessary approvals and permits from other agencies, the dewatering and stabilization phases of CCR surface impoundment closure, or installation of the final cover system, and the estimated timeframes to complete each step or phase of CCR surface impoundment closure.

The closure schedule is provided for the scenario where a new on site landfill (Landfill) is provided. To construct the Landfill, the Plant will be demolished.

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Table 2-1. CCR Proposed Closure Schedule

Milestone	**Timeframe (all preliminary estimates)**
Final Closure Plan	February 2022
Notification of Intent to Close Placed in Operating Record	By the date the owner or operator initiates closure of a CCR surface impoundment, the owner or operator must prepare a notification of intent to close a CCR surface impoundment. The notification must be placed in the facility's operating record as required by Section 845.800(d)(22) and Section 845.730(d).
Agency Coordination and Permit Acquisition • Coordinating with State Agencies for Compliance for Closure and On site Landfill	Year 1 – 8

• Acquiring various State permits	Year 2 – 8
Dewater and Stabilize CCR	
• Complete pond water removal and CCR Dewatering, as necessary	Year 1 - Ongoing
• Complete Stabilization	NA
Mobilization (Plant Demolition)	Year 2
Plant Demolition (for on site Landfill)	Year 2 through 6
Mobilization New Landfill	Year 6
Mobilization CCR Closure	Year 7
Excavate CCR and Haul to Landfill	Year 8 – 12
Estimate of Year in Which All Closure Activities Will be Completed	Year 2033

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3. AMENDMENTS OF FINAL CLOSURE PLAN

<u>Section 845.720(b)(4):</u> *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.*

If revisions are required for this Final Closure Plan, the owner will submit a request to modify the construction permit within 60 days following the triggering event.

Table 3-1. CCR Final Closure Plan Revisions

Revision Number and Date	Pages or Section	Description of Revision	Professional Engineer Certifying Plan
Version 0 November 2021	NA	Final Closure Plan	John Seymour, PE

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4. CLOSURE BY REMOVAL

This section includes a description of the final closure by removal that will be completed for the NEAP surface impoundment, including principal design and construction features, material specifications, and a discussion of how each feature is in accordance with the requirements of Section 845.740. Drawings showing each design feature are provided in the NEAP Construction Permit Application.

4.1. Groundwater Corrective Action

Section 845.740(a): *Closure by Removal of CCR. An owner or operator may elect to close a CCR surface impoundment by removing all CCR and decontaminating all areas affected by releases of CCR from the CCR surface impoundment. CCR removal and decontamination of the CCR surface impoundment are complete when all CCR and CCR residues, containment system components such as the impoundment liner and contaminated subsoils, and CCR impoundment structures and ancillary equipment have been removed. Closure by removal must be completed before the completion of a groundwater corrective action under Subpart F.*

The owner has proposed to close the CCR impoundments by CBR.

4.2. Post-Closure Groundwater Monitoring

Section 845.740(b): *After closure by removal has been completed, the owner or operator must continue groundwater monitoring under Subpart F for three years after the completion of closure or for three years after groundwater monitoring does not show an exceedance of the groundwater protection standard established under Section 845.600, whichever is longer.*

The owner shall continue the groundwater monitoring under Subpart F for at least three years following the completion of closure and continue until groundwater monitoring does not show an exceedance of the groundwater protection standard.

4.3. Handle and Transport CCR

Section 845.740(c): *The owner or operator of a CCR surface impoundment removing CCR during closure must responsibly handle and transport the CCR consistent with this subsection.*

The CCR impoundments shall be closed utilizing CBR to a proposed onsite landfill. Therefore, Section 845.740(c)(1) does not apply.

Section 845.740(c)(2): *The owner or operator of a CCR surface impoundment must develop and implement onsite dust controls, which must include: A) A water spray or other commercial dust*

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suppressant to suppress dust in CCR handling areas and haul roads; and B) Handling of CCR to minimize airborne particulates and offsite particulate movement during any weather event or condition.

The design documents will include ongoing wetting of exposed CCR materials in accordance with the site Fugitive Dust Plan.

Section 845.740(c)(3): *The owner or operator of a CCR surface impoundment must provide the following public notices: A) Signage must be posted at the property entrance warning of the hazards of CCR dust inhalation; and B) When CCR is transported off-site, a written notice explaining the hazards of CCR dust inhalation, the transportation plan, and tentative transportation schedule must be provided to units of local government through which the CCR will be transported.*

Signage shall be posted at the property entrance warning of the hazards of CCR dust inhalation. The language included in the signage will be specified in the Construction Bid Documents. The CCR impoundments shall be closed utilizing CBR to an onsite landfill. Therefore, Section 845.740(c)(3)(B) does not apply.

Section 845.740(c)(4): *The owner or operator of the surface impoundment must take measures to prevent contamination of surface water, groundwater, soil and sediments from the removal of CCR, including the following:*

A): CCR removed from the surface impoundment may only be temporarily stored, and must be stored in a lined landfill, CCR surface impoundment, enclosed structure, or CCR storage pile.

B): CCR storage piles must:

i) Be tarped or constructed with wind barriers to suppress dust and to limit stormwater contact with storage piles;

ii) Be periodically wetted or have periodic application of dust suppressants;

iii) Have a storage pad, or a geomembrane liner, with a hydraulic conductivity no greater than 1 x 10 7 cm/sec, that is properly sloped to allow appropriate drainage;

iv) Be tarped over the edge of the storage pad where possible;

v) Be constructed with fixed and mobile berms, where appropriate, to reduce run-on and run-off of stormwater to and from the storage pile, and minimize stormwater-CCR contact; and

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vi) Have a groundwater monitoring system that is consistent with the requirements of Section 845.630 and approved by the Agency.

C): The owner or operator of the CCR surface impoundment must incorporate general housekeeping procedures such as daily cleanup of CCR, tarping of trucks, maintaining the pad and equipment, and good practices during unloading and loading.

D): The owner or operator of the CCR must minimize the amount of time the CCR is exposed to precipitation and wind.

E): The discharge of stormwater runoff that has contact with CCR must be covered by an individual National Pollutant Discharge Elimination System (NPDES) permit. The owner or operator must develop and implement a Stormwater Pollution Prevention Plan (SWPPP) in addition to any other requirements of the facility's NPDES permit. Any construction permit application for closure must include a copy of the SWPPP.

The final CBR design documents shall include specifications in accordance with this Section. Stockpiling of CCR materials will only be conducted within the existing surface impoundment and within the onsite Landfill. Stockpiling will not occur outside of these limits. Any stockpiling will include measures such as tarping or temporary berms to reduce wind and precipitation exposure.

The owner shall incorporate general housekeeping procedures such as daily cleanup of CCR, tarping of trucks, maintaining the pad and equipment, and good practices during unloading and loading. The design documents will include ongoing wetting of exposed CCR materials in accordance with the site Fugitive Dust Plan. The discharge of stormwater runoff that has contact with CCR shall be covered by an individual NPDES permit and copy of the Stormwater Pollution Prevention Plan (SWPPP) is included in the NEAP Construction Permit Application. Dynegy will be applying for a modification to NPDES Permit No. IL0004057 to reflect the planned physical alterations and short-term discharges of waters from the ponds.

4.4. Monthly Reporting

Section 845.740(d): *At the end of each month during which CCR is being removed from a CCR surface impoundment, the owner or operator must prepare a report that:*

1) Describes the weather, precipitation amounts, the amount of CCR removed from the CCR surface impoundment, the amount and location of CCR being stored on-site, the amount of CCR transported offsite, the implementation of good housekeeping procedures required by subsection (c)(4)(C), and the implementation of dust control measures; and

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2) Documents worker safety measures implemented. The owner or operator of the CCR surface impoundment must place the monthly report in the facility's operating record as required by Section 845.800(d)(23).

The owner shall prepare a monthly report during construction in accordance with the Section 845.740(d).

4.5. Completion of CCR Removal

Section 845.740(e): Upon completion of CCR removal and decontamination of the CCR surface impoundment under subsection (a), the owner or operator of the CCR surface impoundment must submit to the Agency a completion of CCR removal and decontamination report and a certification from a qualified professional engineer that CCR removal and decontamination of the CCR surface impoundment has been completed in accordance with this Section. The owner or operator must place the CCR removal and decontamination report and certification in the facility's operating record as required by Section 845.800(d)(32).

Upon completion of CCR removal and decontamination of the CCR surface impoundment under subsection (a), the owner shall submit to the Agency a completion of CCR removal and decontamination report and a certification from a qualified professional engineer that CCR removal and decontamination of the CCR surface impoundment has been completed in accordance with this Section and place the documents in the facility's operating record.

4.6. Completion of Groundwater Monitoring

Section 845.740(f): Upon completion of groundwater monitoring required under subsection (b), the owner or operator of the CCR surface impoundment must submit to the Agency a completion of groundwater monitoring report and a certification from a qualified professional engineer that groundwater monitoring has been completed in accordance with this Section. The owner or operator must place the groundwater monitoring report and certification in the facility's operating record as required by Section 845.800(d)(24).

Upon completion of the groundwater monitoring program in accordance with subsection (b), the owner shall submit to the Agency a completion of groundwater monitoring report and a certification from a qualified professional engineer that groundwater monitoring has been completed in accordance with this Section and place the documents in the facility's operating record.

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5. CERTIFICATION

CCR Unit: Dynegy Midwest Generation, LLC; Vermilion Power Plant, New East Ash Pond

I, John Seymour, being a Registered Professional Engineer in good standing in the State of Illinois, do hereby certify in accordance with Section 845.720(b)(5), to the best of my knowledge, information, and belief, that the information contained in this plan has been prepared in accordance with the accepted practice of engineering and meets the requirements of Section 845.720(b).

John Seymour
Printed Name

Signature Date

062.040562 Illinois 30 November 2021
Registration Number State Expiration Date

Affix Seal

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APPENDIX 1

Closure Alternatives Analysis (CAA), Corrective Measures Assessment (CMA), and Corrective Action Alternatives Analysis (CAAA)

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Closure Alternatives Analysis and Corrective Measures Assessment/ Corrective Action Alternatives Analysis for the North Ash Pond/Old East Ash Pond (NAP/OEAP) and New East Ash Pond (NEAP)

Vermilion Power Plant
Oakwood, Illinois

November 9, 2021

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Table of Contents

Page

List of Tables

List of Figures

Abbreviations

AACE	Association for the Advancement of Cost Engineering
BMP	Best Management Practice
CAA	Closure Alternatives Analysis
CAAA	Corrective Action 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
CMA	Corrective Measures Assessment
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CW	Cutoff Wall
CY	Cubic Yard
DMG	Dynegy Midwest Generation, LLC
EJ	Environmental Justice
FEMA	Federal Emergency Management Agency
FIRM	Flood Insurance Rate Map
GE	Groundwater Extraction
Geosyntec	Geosyntec Consultants
GHG	Greenhouse Gas
GWPS	Groundwater Protection Standard
HDPE	High-Density Polyethylene
IAC	Illinois Administrative Code
IDNR	Illinois Department of Natural Resources
IDW	Investigation-Derived Waste
IEPA	Illinois Environmental Protection Agency
IFR	Initial Facility Report
LGU	Lower Groundwater Unit
LLDPE	Linear Low-Density Polyethylene
MCY	Million Cubic Yards
MGU	Middle Groundwater Unit
MNA	Monitored Natural Attenuation
N_2O	Nitrous Oxide
NAP	North Ash Pond
NEAP	New East Ash Pond
NID	National Inventory of Dams
NO_x	Nitrogen Oxides
NPDES	National Pollutant Discharge Elimination System
O&M	Operations and Maintenance
OEAP	Old East Ash Pond
PM	Particulate Matter
PMP	Potential Migration Pathway

PRB	Permeable Reactive Barrier
SERP	Safety Emergency Response Plan
SHPO	State Historic Preservation Office
Source Control-CW	Source Control with Construction of a Cutoff Wall
Source Control-GE	Source Control with Groundwater Extraction
Source Control-MNA	Source Control with Monitored Natural Attenuation
Source Control-MNA/GE	Source Control with Monitored Natural Attenuation and Groundwater Extraction
Source Control-PRB	Source Control with Construction of a Permeable Reactive Barrier
Stantec	Stantec Consulting Services Inc.
SWPPP	Stormwater Pollution Prevention Plan
TVA	Tennessee Valley Authority
US DOT	United States Department of Transportation
US EPA	United States Environmental Protection Agency
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. Part 845 additionally requires that a Corrective Measures Assessment (CMA) be performed prior to undertaking any corrective measures at CCR surface impoundments. Pursuant to requirements under IAC Section 845.710, this report presents a CAA for the retired North Ash Pond/Old East Ash Pond (NAP/OEAP) impoundment system and the retired New East Ash Pond (NEAP) impoundment located on Dynegy Midwest Generation, LLC's (DMG) Vermilion Power Plant property near the Village of Oakwood, Illinois. This report also presents a CMA for the NAP/OEAP and the NEAP pursuant to requirements under IAC Section 845.660 and a Corrective Action Alternatives Analysis (CAAA) pursuant to requirements under IAC Section 845.670 (IEPA, 2021a).

Closure Alternatives Analysis

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). As mandated by the Agreed Interim Order entered on June 30, 2021 (Illinois, Attorney General, 2021), Gradient evaluated only Closure-by-Removal (CBR) as source control for the NAP/OEAP and the NEAP. Two specific closure scenarios were considered: Closure-by-Removal with On-Site CCR Disposal (CBR-Onsite) and Closure-by-Removal with Off-Site CCR Disposal (CBR-Offsite). Consistent with the Agreed Interim Order, the CAA does not address Closure-in-Place (CIP). Both of the CBR scenarios that were evaluated entail excavating all of the CCR from the former NAP/OEAP and NEAP impoundments and transporting it to a landfill for disposal. Both scenarios also include the construction and operation of a groundwater collection trench that will be installed and operated until closure has been completed, as required by the Agreed Interim Order (Illinois, Attorney General, 2021); the groundwater collection trench will prevent seeps and discolored water from reaching the Middle Fork of the Vermilion River. Under the CBR-Onsite disposal option, the Vermilion Power Plant would be demolished and a landfill will be constructed over a portion of its footprint. Under the CBR-Offsite option, CCR would instead be hauled to an off-Site landfill.

Table S.1 summarizes the expected impacts of the CBR-Onsite and CBR-Offsite closure alternatives with regards 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, CBR-Onsite has been identified as the most appropriate closure alternative for the NAP/OEAP and the NEAP. Key benefits of the CBR-Onsite scenario relative to the CBR-Offsite scenario include near-term plans for the demolition of the power plant, which will have scenic benefits along Illinois's only National Scenic River, and reduced impacts to community members and the environment due to construction activities (*e.g.*, fewer constructed-related community accidents, lower energy demands, less air pollution and greenhouse gas [GHG] emissions, less traffic, and lower impacts to environmental justice [EJ] communities). 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) and the Agreed Interim Order (IEPA, 2021a; Illinois, Attorney General, 2021). 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 the Illinois Environmental Protection Agency (IEPA) as described under IAC Section 845.720(b) (IEPA, 2021a).

Table S.1 Comparison of Proposed Closure Scenarios

Evaluation Factor (Report Section; Part 845 Section)	Closure Scenario	
	CBR-Onsite	**CBR-Offsite**
Closure Alternative Descriptions (Section 2.1; IAC Section 845.710(c))	The Vermilion Power Plant would be demolished and a landfill will be constructed over a portion of its footprint. All CCR would be excavated from the NAP/OEAP and NEAP and transported to the on-Site landfill for disposal. This scenario meets the requirement of IAC Section 845.710(c)(2) (IEPA, 2021a) that an assessment be conducted in the CAA regarding whether the Site has an on-Site landfill with available capacity or whether an on-Site landfill can be constructed.	All CCR would be excavated from the NAP/OEAP and NEAP and transported to an off-Site landfill for disposal.
Type and Degree of Long-Term Management, Including Monitoring, Operation, and Maintenance (Section 2.2.3; IAC Section 845.710(b)(1)(C))	Groundwater and surface water monitoring would be performed at the closed impoundments until groundwater protection standards (GWPSs) have been achieved. A minimum of 30 years of post-closure care would be performed at the on-Site landfill, including leachate management and cap inspection, mowing and maintenance, and groundwater and surface water monitoring.	Groundwater and surface water monitoring would be performed at the closed impoundments until GWPSs have been achieved.
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. Because there are no current risks, and dissolved constituent concentrations are expected to decline post-closure, no risks to human or ecological receptors are expected post-closure.	There are no current risks to any human or ecological receptors. Because there are no current risks, and dissolved constituent concentrations are expected to decline post-closure, no risks to human or ecological receptors are expected post-closure.

Evaluation Factor (Report Section; Part 845 Section)	**Closure Scenario**	
	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 due to flooding or seismic activity and minimal risk of dike overtopping during flood conditions. Similarly, there would be minimal risk to the on-Site landfill due to flooding or seismic activity. Risk of dike failure occurring due to riverbank erosion would be managed with riverbank monitoring and, if needed, temporary riverbank maintenance measures. The risk of needing temporary riverbank maintenance measures would be slightly higher for the CBR-Onsite scenario compared to the CBR-Offsite scenario, because the excavation of CCR from the impoundments would be delayed by approximately 6 years in order to demolish the power plant and construct the landfill. However, the overall risk of dike failure would be low because of the riverbank monitoring and mitigation measures that are in place. Post-closure, there would be no risk of CCR releases due to dike failure. Furthermore, there would be no risk to the on-Site landfill associated with future meandering and erosion of the river (Geosyntec, 2021a).	During closure, there would be minimal risk of dike failure due to flooding or seismic activity and minimal risk of dike overtopping during flood conditions. Risk of dike failure occurring due to riverbank erosion would be managed with riverbank monitoring and, if needed, temporary riverbank maintenance measures. The risk of needing temporary riverbank maintenance measures would be slightly lower for the CBR-Offsite scenario compared to the CBR-Onsite scenario, because it would result in CCR being removed from the impoundments more quickly. Post-closure, there would be no risk of CCR releases due to dike failure. Overall, while the timing of various risks differs for the two closure scenarios, the magnitude of the likelihood of future releases under both scenarios would be expected to be approximately the same.
Worker Risks (Section 2.2.4.1; IAC Sections 845.710(b)(1)(D) and 845.710(b)(1)(F))	An estimated 0.051 fatalities and 6.4 injuries would be expected to occur to workers due to on-Site activities under this scenario. An estimated 0.061 fatalities and 4.7 injuries would be expected to occur to workers due to off-Site activities (hauling, labor and equipment mobilization and demobilization, and materials deliveries) under this scenario. In total, 0.11 worker fatalities and 11 worker injuries would be expected under this scenario.	An estimated 0.027 fatalities and 2.8 injuries would be expected to occur to workers due to on-Site activities under this scenario. An estimated 0.055 fatalities and 3.8 injuries would be expected to occur to workers due to off-Site activities (hauling, labor and equipment mobilization and demobilization, and materials deliveries) under this scenario. In total, 0.082 worker fatalities and 6.6 worker injuries would be expected under this scenario.

Evaluation Factor (Report Section; Part 845 Section)	**Closure Scenario**	
	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 and EJ communities (including accidents, traffic, noise, and air pollution) would be less under this scenario, because it would only require transport of workers, equipment, and materials to and from the Site. No off-Site transport of CCR would be required. An estimated 0.031 fatalities and 2.1 injuries would be expected to occur among community members due to off-Site activities related to closure.	Off-Site impacts on nearby residents and EJ communities would be greater under this scenario, because it would require substantial off-Site CCR hauling in addition to the transport of workers, equipment, and materials to and from the Site. An estimated 0.090 fatalities and 3.3 injuries would be expected to occur among community members due to off-Site activities related to closure. A haul truck would likely pass a location near the Site every 2.5 minutes on average for the duration of excavation activities, resulting in substantial traffic demands. Additionally, the proposed off-Site landfill location would be within the buffer zone of the EJ community near Tilton, and the transport of CCR to the landfill would require hauling CCR through the EJ communities near Tilton and Danville. Oakwood Junior High School is located at 21600 North 900 East Road in Danville, at the entrance to the Vermilion Power Plant. As a result of considerable off-Site hauling activities, the CBR-Offsite scenario would create greater traffic, nuisance, and safety concerns at the school than would occur under the CBR-Onsite scenario.

Evaluation Factor (Report Section; Part 845 Section)	**Closure Scenario**	
	CBR-Onsite	**CBR-Offsite**
Impacts on Scenic and Recreational Value	Due to (*e.g.*) noise and visual disturbances, construction activities may have short-term negative impacts on the recreational use of the Orchid Hill Natural Heritage Landmark and the Middle Fork of the Vermilion River. The overall magnitude of the short-term impacts to scenic and recreational value under both scenarios would be expected to be approximately the same. Despite causing some negative short-term impacts, this closure scenario would be expected to have long-term scenic and recreational benefits. These include near-term plans to demolish the power plant, which would have scenic benefits to the Middle Fork of the Vermilion River and increase public access to the Orchid Hill Natural Heritage Landmark.	Due to (*e.g.*) noise and visual disturbances, construction activities may have short-term negative impacts on the recreational use of the Orchid Hill Natural Heritage Landmark and the Middle Fork of the Vermilion River. The overall magnitude of the short-term impacts to scenic and recreational value under both scenarios would be expected to be approximately the same. Long-term scenic and recreational benefits would be less certain under this closure scenario than under the CBR-Onsite scenario. Eventually, we assume that the power plant would be demolished under this scenario, resulting in scenic benefits to the Middle Fork of the Vermilion River and increased public access to the Orchid Hill Natural Heritage Landmark. However, these benefits may not be realized for an undetermined amount of time following closure.
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*	Overall (on-Site + off-Site) energy demands and GHG emissions from construction equipment and vehicles would expected to be lower under this closure scenario than under the CBR-Offsite scenario. The CBR-Onsite scenario would have an additional, unquantified carbon footprint due to the need to manufacture >50 acres of geomembranes for the on-Site landfill bottom liner and final cover system.	Overall (on-Site + off-Site) energy demands and GHG emissions from construction equipment and vehicles would be expected to be greater under this closure scenario. If expansion of the off-Site landfill becomes necessary in order to accept all of the CCR from the impoundments, then the CBR-Offsite scenario may also have an additional, unquantified carbon footprint due to the need to manufacture geomembranes for use in the expanded landfill liner.

Evaluation Factor (Report Section; Part 845 Section)	**Closure Scenario**	
	CBR-Onsite	**CBR-Offsite**
Impacts on Natural Resources and Habitat	Construction activities may have short-term negative impacts on terrestrial and aquatic species located near the impoundments and the on-Site landfill location. Construction would also cause a long-term shift in the habitat type atop portions of the impoundments. The overall magnitude of the short-term impacts to natural resources and habitat under both scenarios would be expected to be approximately the same. Despite causing some negative short-term impacts, this closure scenario would be expected to have long-term benefits to natural resources and habitat. These include near-term plans to demolish the power plant, which would result in the creation of new habitat atop the footprint of the impoundment (and, post-closure, atop the footprint of the new on-Site landfill).	Construction activities may have short-term negative impacts on terrestrial and aquatic species located near the impoundments, along the haul roads, and near the off-Site landfill location. Construction would also cause a long-term shift in the habitat type atop portions of the impoundments. The overall magnitude of the short-term impacts to natural resources and habitat value under both scenarios would be expected to be approximately the same. Long-term benefits to natural resources and habitat would be less certain under this closure scenario than under the CBR-Onsite scenario. Eventually, we assume that the power plant would be demolished under this scenario, resulting in the creation of new habitat atop the footprint of the power plant. However, these benefits may not be realized for an undetermined amount of time following closure.
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))	At sites where groundwater corrective action will be implemented, it is inappropriate to evaluate the time to achieve GWPSs based on closure alone, because both closure and corrective actions will affect future groundwater concentrations. See Section 4.1.6 of the CAAA for an evaluation of the times to achieve GWPSs at the Site based both on source control and the corrective action alternatives.	At sites where groundwater corrective action will be implemented, it is inappropriate to evaluate the time to achieve GWPSs based on closure alone, since both closure and corrective actions will affect future groundwater concentrations. See Section 4.1.6 of the CAAA for an evaluation of the times to achieve GWPSs at the Site based both on source control and the corrective action alternatives.
Long-Term Reliability of the Engineering and Institutional Controls (Section 2.2.7; 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 2.2.8; IAC Section 845.710(b)(1)(H))	There would be no difference between the two closure scenarios regarding the potential need for future corrective actions (or regarding the extent to which treatment technologies may be used).	There would be no difference between the two closure scenarios regarding the potential need for future corrective actions (or regarding the extent to which treatment technologies may be used).

Evaluation Factor (Report Section; Part 845 Section)	**Closure Scenario**	
	CBR-Onsite	**CBR-Offsite**
Effectiveness of the Alternative in Controlling Future Releases (Section 2.3; IAC Section 845.710(b)(2)(A and B))	There would be no risk of CCR releases occurring post-closure under either closure scenario.	There would be no risk of CCR releases occurring post-closure under either closure scenario.
Ease or Difficulty of Implementing the Alternative (Section 2.4; IAC Section 845.710(b)(3)) *Degree of Difficulty Associated with Construction*	Excavation of the impoundments would present the same level of difficulty under both closure scenarios. Hauling would be easier to implement under the CBR-Onsite scenario than under the CBR-Offsite scenario, due to the shorter haul distance required, the larger haul truck capacity, and the lack of need to haul over public roads under this scenario. A smaller number of trucks and truck trips would also be required under the CBR-Onsite scenario than under the CBR-Offsite scenario. Constructing a new on-Site landfill under this scenario would require additional planning, design, and construction.	Excavation of the impoundments would present the same level of difficulty under both closure scenarios. Hauling would be more difficult to implement under the CBR-Offsite scenario than under the CBR-Onsite scenario, due to the longer haul distance required, the smaller haul truck capacity, and the need to haul over public roads under this scenario. A larger number of trucks and truck trips would also be required under the CBR-Offsite scenario than under the CBR-Onsite scenario. Additionally, because the CBR-Offsite scenario involves hauling ash off-Site (*i.e.*, intrastate travel), a higher level of dewatering would be required compared to the CBR-Onsite scenario. Off-Site landfilling under the CBR-Offsite scenario would require the development of a disposal plan and may raise issues related to the co-disposal of CCR and other non-hazardous wastes. The off-Site landfill may also need to be expanded to receive all of the CCR generated during excavation.
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	Permits and approvals required under both closure scenarios would include modifications to the existing NPDES permit, a Land Disturbance Permit, and a 309 Wastewater Treatment Permit. As required by the Agreed Interim Order (Illinois, Attorney General, 2021), construction of the on-Site landfill under the CBR-Onsite scenario would also require a permit. Non-contact stormwater from the on-Site landfill would be discharged under the existing NPDES permit in accordance with a Stormwater Pollution Prevention Plan (SWPPP).	Permits and approvals required under both scenarios would include modifications to the existing NPDES permit, a Land Disturbance Permit, and a 309 Wastewater Treatment Permit. Additional permits and approvals may be required under the CBR-Offsite scenario if the landfill must be expanded to receive all of the CCR from the impoundments.
Availability of Equipment and Specialists	CBR-Onsite and CBR-Offsite would rely on common construction equipment and materials and typically would not require the use of specialists. However, global supply chains have been disrupted due to the COVID-19 pandemic, resulting in shortages in the availability of construction equipment and parts. There may be delays in construction under both scenarios if supply chain resilience does not improve by the time construction begins.	CBR-Onsite and CBR-Offsite would rely on common construction equipment and materials and typically would not require the use of specialists. However, global supply chains have been disrupted due to the COVID-19 pandemic, resulting in shortages in the availability of construction equipment and parts. There may be delays in construction under both scenarios if supply chain resilience does not improve by the time construction begins. The current shortage of truck drivers may be particularly impactful under the CBR-Offsite scenario, due to the longer hauling distance required, the smaller haul truck capacity, and the need to haul over public roads under this scenario.

Evaluation Factor (Report Section; Part 845 Section)	**Closure Scenario**	
	CBR-Onsite	**CBR-Offsite**
Available Capacity and Location of Treatment, Storage, and Disposal Services	The new on-Site Landfill would be designed and constructed to be able to receive all CCR that has been generated on-Site.	The capacity remaining at the chosen off-Site landfill in Danville, Illinois, would be sufficient to receive all of the CCR in the impoundments. However, due to the relatively short period over which CCR would be received at this 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. 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 Danville landfill were found to be 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))	There are no current exceedances of any human health or ecological screening benchmarks in the Middle Fork of the Vermilion River (Appendices A and B). Modeling concluded that mass flux to the Middle Fork of the Vermilion River from the MGU will be reduced by approximately 50% 10 years after closure is completed and by approximately 80% 35 years after closure is completed (Ramboll, 2021a). Mass flux declines will occur more slowly in the LGU, which has lower concentrations, due to its lower-permeability deposits (Ramboll, 2021a). Thus, no future exceedances of any screening benchmarks for surface water are anticipated and no impact on any waters of the state are expected.	There are no current exceedances of any human health or ecological screening benchmarks in the Middle Fork of the Vermilion River (Appendices A and B). Modeling concluded that mass flux to the Middle Fork of the Vermilion River from the MGU will be reduced by approximately 50% 10 years after closure is completed and by approximately 80% 35 years after closure is completed (Ramboll, 2021a). Mass flux declines will occur more slowly in the LGU, which has lower concentrations, due to its lower-permeability deposits (Ramboll, 2021a). Thus, no future exceedances of any screening benchmarks for surface water are anticipated and no impact on any waters of the state are expected.

Evaluation Factor (Report Section; Part 845 Section)	**Closure Scenario**	
	CBR-Onsite	**CBR-Offsite**
Potential Modes of Transportation Associated with CBR (Section 2.1; IAC Section 845.710(c)(1))	Not relevant for this scenario.	There is no established rail terminal or a railroad track near the power plant area. In order for CCR to be transported by rail, a new rail line to the Union Pacific Railroad line located more than 5 miles to the northwest would need to constructed and a loading terminal would need to be constructed on-Site. This was considered infeasible, because it would increase the project schedule due to the need to coordinate with the railroad, complete design and permitting, and construct the terminal, and because additional land would need to be acquired. Furthermore, CCR would still need to be hauled by truck to the on-Site loading terminal and loaded into rail cars, resulting in additional CCR exposures and potential releases. The Middle Fork of the Vermilion River is not open to barge traffic. Therefore, transporting CCR by barge is not feasible for this site. 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 2.6; IAC Section 845.710(b)(4))	Source control under this closure scenario would address the primary concerns of residents (potential impacts to groundwater and surface water quality, and the potential for dike failure to occur due to riverbank migration). Under this scenario, dewatering would commence immediately, reducing the risks of dike failure and the leaching of CCR-associated constituents from the impoundment. CCR excavation would begin once the plant is demolished and the on-Site landfill is constructed. Because this scenario does not require off-Site hauling of CCR, it presents less risks to nearby residents and EJ communities in the form of accidents, traffic, noise, and air pollution. Additionally, this scenario would more rapidly address stakeholder concerns about having an inactive power plant located along Illinois's only National Scenic River.	Source control under this closure scenario would address the primary concerns of residents (potential for CCR in the impoundments to impact groundwater and surface water, and the potential for dike failure to occur due to riverbank migration). Under this scenario, excavation can begin immediately. However, this scenario presents greater risks to nearby residents and EJ communities in the form of accidents, traffic, noise, and air pollution due to the substantial off-Site hauling of CCR required.
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.

Notes:

AACE = Association for the Advancement of Cost Engineering; CAAA = Corrective Action Alternatives Analysis; CBR = Closure by Removal; CCR = Coal Combustion Residual; GHG = Greenhouse Gas; IAC = Illinois Administrative Code; NAP = North Ash Pond; NPDES = National Pollutant Discharge Elimination System; OEAP = Old East Ash Pond.

Corrective Measures Assessment and Corrective Action Alternatives Analysis

The goal of performing a CMA and a CAAA is to holistically evaluate proposed corrective measures/corrective action alternatives in order to remediate groundwater and achieve compliance with the groundwater protection standards (GWPSs) specified under IAC Section 845.600 (IEPA, 2021a). These analyses assess proposed corrective measures/corrective action alternatives based on a wide range of factors, including the performance, reliability, and ease of implementation of the corrective measure; its potential impacts on human health and the environment; and its ability to address concerns raised by residents (IEPA, 2021a). The CMA provides a high-level screening of potential corrective measures. This analysis determines which corrective measures are potentially viable at a site and subject to further evaluation in the CAAA. The CAAA provides a more detailed analysis of potentially viable remedies, based on results of the CMA.

It is important to note that many CCR sites are complex groundwater environments where remedial actions will inherently take many years to complete. While no formal definition of a complex groundwater environment exists, most would agree that there a number of common characteristics at complex groundwater sites, including the following (National Research Council, 2013):

- Highly heterogeneous subsurface environments;
- Large source zones;
- Multiple, recalcitrant constituents; and
- Long timeframes over which releases occurred.

Each of these characteristics are common at CCR sites. Surface impoundments are often tens to hundreds of acres in size and many have operated for decades, leading to large source zones and prolonged releases. Furthermore, CCR impoundments are often located in alluvial geologic settings where sands are interbedded with silts and clays. This results in a heterogeneous environment where constituent mass may persist for many years in low-permeability deposits. Finally, the constituents that are most common at CCR sites include metals and inorganics that do not naturally biodegrade. The combination of these factors results in a complex groundwater environment where remediation, even under the best of circumstances, may take many years to achieve GWPSs. It is for these reasons that US EPA refused to specify what is a reasonable *versus* an unreasonable timeframe for groundwater corrective actions at CCR sites, stating that "EPA was truly unable to establish an outer limit on the necessary timeframes—including even a presumptive outer bound" (US EPA, 2015a, p. 21419).

It is also important to note that source control, which at a CCR impoundment could include either capping or excavation, is generally considered to be one of the more effective remedial action approaches. Source control involves removing the hydraulic head from an impoundment (*i.e.*, unwatering and dewatering) and preventing further downward migration of constituents. US EPA has found that "releases from surface impoundments [to groundwater] drop dramatically after closure" (US EPA, 2014, pp. 5-18 to 5-19). As a result, the implementation of source control often has a more substantial and more immediate effect on groundwater quality improvements than other groundwater corrective measures. In this CMA and CAAA, source control is paired with other additional groundwater remediation strategies.

Five potential corrective measures were selected for consideration in the CMA for this Site. Each corrective measure includes source control based on the CBR-Onsite scenario (*i.e.*, Closure-by-Removal with CCR disposal at an on-Site landfill). Corrective measures considered in the CMA include Source Control with Monitored Natural Attenuation (Source Control-MNA), Source Control with Groundwater Extraction (Source Control-GE), Source Control with Monitored Natural Attenuation and Groundwater

Extraction (Source Control-MNA/GE), Source Control with Construction of a Cutoff Wall (Source Control-CW), and Source Control with Construction of a Permeable Reactive Barrier (Source Control-PRB). Each of these corrective measures was evaluated in the CMA for its potential viability at the Site. Under the Source Control-MNA alternative, groundwater concentrations of dissolved constituents will attenuate *via* naturally occurring physical and chemical processes in areas downgradient of the NAP/OEAP; active monitoring will be performed to verify and document the remediation processes. Under the Source Control-GE alternative, the groundwater collection trench will continue operating post-closure in the OEAP area, and an additional GE system comprised of either groundwater pumping wells or a groundwater collection trench will be installed in the NAP area in order to extract potentially impacted groundwater from the aquifer, helping to contain the contaminant plume and prevent the lateral migration of constituents off-Site. Under the Source Control-MNA/GE alternative, the groundwater collection trench will continue operating post-closure in the OEAP area, and groundwater concentrations of dissolved constituents will attenuate *via* natural physical and chemical processes in areas downgradient of the NAP. Under the Source Control-CW alternative, a trench will be dug along the downgradient perimeter of the NAP/OEAP and filled with a soil-bentonite mixture, creating a low-permeability subsurface barrier to the lateral migration of constituents off-Site. Under the Source Control-PRB alternative, a subsurface barrier of reactive materials (*e.g.*, zerovalent iron) will be placed in the path of groundwater flow downgradient of the NAP/OEAP in order to promote the *in situ* transformation and/or immobilization of CCR-associated constituents.

Table S.2 evaluates the corrective measures included in this CMA with regards to each of the factors specified under IAC Section 845.660(c) (IEPA, 2021a). Based on this evaluation and the details provided in Section 3 of this report, two corrective measures, Source Control-MNA and Source Control-MNA/GE, have been identified as potentially viable corrective actions for the Site. Source Control-GE, Source Control-CW, and Source Control-PRB were not selected as viable corrective actions for consideration in the CAAA, for the following reasons:

- It is unlikely that Source Control-PRB would perform well at this Site, because PRBs have not been proven effective for lithium and boron in groundwater (both of which are CCR-associated constituents);
- Construction of the CW and the PRB would likely be very difficult, due to the required location, length, and depth of these structures;
- Source Control-GE may have a detrimental effect on the baseflow in the Middle Fork of the Vermilion River, because the GE system may capture/intercept water from the river. Furthermore, if groundwater pumping wells were installed at the NAP, the high iron content in the formation could lead to fouling of the well screens, which would create the need for frequent maintenance and, potentially, GE well replacement. If a groundwater collection trench were instead installed at the NAP, it would need to be deeper than the trench to be installed during closure at the OEAP, because groundwater from both the middle groundwater unit (MGU) and the lower groundwater unit (LGU) would need to be intercepted. Due to limited construction area between the river and the NAP perimeter berm, installation of a groundwater collection trench through both the MGU and the LGU near the NAP is likely infeasible. Furthermore, installation of a groundwater collection trench at the NAP could create a hydraulic connection between the MGU and the LGU, which could delay cleanup times.
- Both Source Control-CW and Source Control-PRB would likely have a large potential impact on the Middle Fork of the Vermilion River due to the extent of construction required in close proximity to the river; and

- Both Source Control-CW and Source Control-PRB would likely have relatively large impacts on worker safety, air quality, and surface water, and sediment quality compared to the other alternatives due to the substantial construction activities required.

Table S.3 evaluates the two potentially viable corrective actions included in this CAAA, Source Control-MNA and Source Control-MNA/GE, with regard to each of the factors specified under IAC Section 845.670(e) (IEPA, 2021a). Based on this evaluation and the details provided in Section 4 of this report, the most appropriate corrective action for this Site is Source Control-MNA. Source Control-MNA and Source Control-MNA/GE both have similar design, construction, and operations and maintenance (O&M) requirements and, as a result, similar expected impacts on workers, nearby communities, and the environment. Modeling has also shown that there is no material difference between the two scenarios in terms of the time to achieve the GWPSs (Ramboll, 2021a). Source Control-MNA is the preferred alternative at this Site.

The remedy will be selected following the completion of an upcoming public meeting, which will be held in December 2021. Following the public meeting, a final 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 recommendation will be provided in a Corrective Action Plan, which will be submitted to IEPA as described under IAC Section 845.670 (IEPA, 2021a).

Table S.2 Comparison of Proposed Corrective Measure Alternatives with Respect to Factors Specified in IAC Section 845.660(c)

Evaluation Factor (Report Section; Part 845 Section)	Corrective Measure Alternative				
	Source Control-MNA	**Source Control-GE**	**Source Control-MNA/GE**	**Source Control-CW**	**Source Control-PRB**
Corrective Measure Alternative Descriptions (Section 3.1)	Source Control-MNA would rely on naturally occurring physical and chemical processes to immobilize and attenuate concentrations of CCR-associated constituents in groundwater in the OEAP and NAP areas. Active groundwater monitoring would be performed to ensure that the remedy is working as intended.	Under Source Control-GE, the groundwater collection trench would continue operating post-closure in the OEAP area. An additional GE system comprised of either groundwater pumping wells or a groundwater collection trench would be installed in the NAP area to extract potentially impacted groundwater and prevent the lateral migration of constituents off-Site. Groundwater captured by the GE system would be treated, if necessary, and discharged to the Middle Fork of the Vermilion River *via* one of the facility's NPDES-permitted outfalls. Monitoring would be performed to ensure that the remedy is working as intended.	Under Source Control-MNA/GE, the groundwater collection trench would continue operating post-closure in the OEAP area. Naturally occurring physical and chemical processes would immobilize and attenuate concentrations of CCR-associated constituents in groundwater in the NAP area. Active groundwater monitoring would be performed to ensure that the remedy is working as intended. Groundwater and seep water captured by the groundwater collection trench would be treated, if necessary, sent to the NAP Secondary Pond, and discharged *via* the NPDES-permitted outfall.	Under Source Control-CW, a trench would be dug along the downgradient perimeter of the former impoundments and filled with a soil-bentonite mixture, creating a low-permeability subsurface barrier that would prevent the lateral migration of constituents off-Site. Hydraulic control wells would likely be required to prevent groundwater mounding behind the CW. Monitoring would be performed to ensure that the remedy is working as intended.	Under Source Control-PRB, a subsurface barrier of reactive materials would be placed in the path of groundwater flow in order to promote the *in situ* transformation and/or immobilization of CCR-associated constituents. Monitoring would be performed to ensure that the remedy is working as intended.
Performance – Controlling the Source (Section 3.2.1; IAC Section 845.660(c)(1))	All of the alternatives would be fully protective with regard to primary source control. Source Control-MNA would also likely be effective with regard to secondary source control (Geosyntec, 2021b).	All of the alternatives would be fully protective with regard to primary source control. Source Control-GE would also likely be effective with regard to secondary source control, although GE system performance can vary from site-to-site.	All of the alternatives would be fully protective with regard to primary source control. Source Control-MNA/GE would also likely be effective with regard to secondary source control, through the combination of MNA and operation of the groundwater collection trench.	All of the alternatives would be fully protective with regard to primary source control. Source Control-CW would also likely be effective with regard to secondary source control due to natural processes and GE (hydraulic controls), which would promote the attenuation of constituent concentrations upgradient of the CW.	All of the alternatives would be fully protective with regard to primary source control. Source Control-PRB would also likely be effective with regard to secondary source control due to natural processes, which would promote the attenuation of constituent concentrations upgradient of the PRB.
Performance – Likelihood of Future Releases of CCR (Section 3.2.2; IAC Section 845.660(c)(1))	There would be no likelihood of CCR releases occurring post-closure under any of the alternatives.	There would be no likelihood of CCR releases occurring post-closure under any of the alternatives.	There would be no likelihood of CCR releases occurring post-closure under any of the alternatives.	There would be no likelihood of CCR releases occurring post-closure under any of the alternatives.	There would be no likelihood of CCR releases occurring post-closure under any of the alternatives.

Evaluation Factor (Report Section; Part 845 Section)	**Corrective Measure Alternative**				
	Source Control-MNA	**Source Control-GE**	**Source Control-MNA/GE**	**Source Control-CW**	**Source Control-PRB**
Performance – Long-Term Management (Section 3.2.3; IAC Section 845.660(c)(1))	Minimal long-term O&M efforts would be required under Source Control-MNA, because it would not require the installation, operation, or maintenance of any engineered systems or structures other than monitoring wells. Groundwater sampling would continue until GWPSs have been achieved.	Moderate to high long-term O&M efforts would be required under Source Control-GE, including the monitoring and maintenance of the GE system and the management and discharge of extracted groundwater. Treatment of extracted water may be required prior to discharge. If extraction wells were installed at the NAP, high iron concentrations in the formation could cause fouling of the well screens, which would require frequent maintenance. Additionally, iron fouling could create a need for the replacement of extraction wells over time. If a groundwater collection trench were instead installed at the NAP, a hydraulic connection may be created between the MGU and LGU, which may delay groundwater remediation times. Groundwater sampling would continue until GWPSs have been achieved. Once the remedy is complete, the system would be decommissioned in a manner that meets applicable regulatory standards.	Moderate long-term O&M efforts would be required under Source Control-MNA/GE, including the monitoring and maintenance of the groundwater collection trench and the management and discharge of extracted groundwater. Groundwater and seep water collected at the groundwater collection trench would be treated, if necessary, sent to the NAP Secondary Pond, and discharged *via* the NPDES-permitted outfall. Groundwater sampling would continue until GWPSs have been achieved.	Moderate long-term O&M efforts would be required under Source Control-CW, including the monitoring and maintenance of the CW and hydraulic gradient control system and the management and discharge of extracted groundwater. Treatment of extracted water may be required prior to discharge. Groundwater sampling would continue until GWPSs have been achieved. Once the remedy is complete, the system would be decommissioned in a manner that meets applicable regulatory standards.	Minimal long-term O&M efforts would be required under Source Control-PRB, including regular groundwater sampling downgradient of the PRB until GWPSs are achieved. The PRB would also be monitored for treatment efficacy. If necessary, the PRB media may be amended or exchanged to extend the life of the PRB.
Reliability - Engineering and Institutional Controls (Section 3.2.4; IAC Section 845.660(c)(1))	High long-term reliability would be expected for Source Control-MNA, because this alternative would rely on natural processes, rather than the installation, operation, and maintenance of engineered systems or structures.	Long-term reliability would be expected for Source Control-GE, as long as the system is designed and constructed for Site-specific conditions.	Long-term reliability would be expected for Source Control-MNA/GE, as long as the groundwater collection trench is operated and maintained appropriately.	Long-term reliability would be expected for Source Control-CW, as long as the system is designed and constructed for Site-specific conditions.	Source Control-PRB may not be reliable over the long term with respect to engineering and institutional controls, because PRBs generally have limited success at treating lithium and boron in groundwater (both of which are CCR-associated constituents). The effectiveness of the PRB would also decrease over time, resulting in a potential need for the eventual replacement of the remedy.
Reliability - Potential Need for Replacement of the Corrective Measure (Section 3.2.5; IAC Section 845.660(c)(1))	Replacement of Source Control-MNA would be unlikely. The MNA evaluation provided by Geosyntec (2021b) notes that, if MNA is selected as the remedy, a contingency plan that will identify the circumstances under which replacement of the remedy may be appropriate will be developed.	Unless groundwater flow conditions change significantly at the Site, replacement of the entire remedy would be unlikely under Source Control-GE. If extraction wells were installed at the NAP, iron fouling may reduce the system effectiveness and create a need for the replacement of extraction wells over time. Replacement pumps may also be necessary, because groundwater hydraulic controls would need to be maintained on a long-term basis.	Replacement of Source Control-MNA/GE would be unlikely, as long as the groundwater collection trench is operated and maintained appropriately. The MNA evaluation provided by Geosyntec (2021b) notes that, if MNA is selected as the remedy, a contingency plan that will identify the circumstances under which replacement of the remedy may be appropriate will be developed.	Unless groundwater flow conditions change significantly at the Site, replacement of the entire remedy would be unlikely under Source Control-CW. Replacement of individual hydraulic control wells may be necessary, because groundwater hydraulic controls would need to be maintained on a long-term basis.	Given the low effectiveness of PRBs for boron and lithium in groundwater, replacement of the Source Control-PRB remedy would likely be necessary. Replacement of the remedy may also be necessary if the effectiveness of the PRB declines over time.

Evaluation Factor (Report Section; Part 845 Section)	**Corrective Measure Alternative**				
	Source Control-MNA	**Source Control-GE**	**Source Control-MNA/GE**	**Source Control-CW**	**Source Control-PRB**
Ease of Implementation (Section 3.2.6; IAC Section 845.660(c)(1))	Source Control-MNA would rely on natural processes and active monitoring and therefore would not pose any significant construction challenges.	Construction of the GE system under Source Control-GE at the NAP would likely be difficult, due to the proximity of the former impoundments to the Middle Fork of the Vermilion River. GE using wells may be difficult to implement, because the alluvial deposits at the NAP vary in composition laterally and vertically. Additional testing would be required to estimate the number, spacing, screened intervals, and extraction rates for capture of impacted groundwater. Additionally, due to a limited construction area between the river and the NAP perimeter berm, installation of a groundwater collection trench through both the MGU and the LGU near the NAP is likely infeasible.	Source Control-MNA/GE would rely on natural processes and a groundwater collection trench, which would already have been installed based on the Agreed Interim Order (Illinois, Attorney General, 2021). Therefore, no significant construction challenges would be expected.	Construction of the CW under Source Control-CW would likely be very difficult, due to the required location, length, and depth of the CW.	Construction of the PRB under Source Control-PRB would likely be very difficult, due to the required location, length and depth of the PRB.
Potential Impacts – Risks to the Community or the Environment During Implementation of Remedy (Section 3.2.7; IAC Section 845.660(c)(1))	Minimal impacts to worker safety, air quality, and surface water and sediment quality would be expected under Source Control-MNA, due to the minimal nature of the construction activities required under this alternative.	Modest impacts to worker safety, air quality, and surface water and sediment quality would be expected under Source Control-GE, due to the modest construction activities required for the installation of the GE system. This alternative could potentially also have a detrimental effect on the baseflow in the Middle Fork of the Vermilion River, particularly during low-flow conditions, because the GE system could capture and/or intercept water from the river.	Minimal impacts to worker safety, air quality, and surface water and sediment quality would be expected under Source Control-MNA/GE, due to the minimal nature of the construction activities required under this alternative.	Relatively large impacts to worker safety, air quality, and surface water and sediment quality would be expected under Source Control-CW, due to the substantial construction activities required for the installation of the CW.	Relatively large impacts to worker safety, air quality, and surface water and sediment quality would be expected under Source Control-PRB, due to the substantial construction activities required for the installation of the PRB.
The Time Required to Begin and Complete the Corrective Action Plan (Section 3.3; IAC Section 845.660(c)(2))	A Corrective Action Plan must be submitted within 1 year of submission of a CMA (IAC Section 845.670). We would not anticipate any delays in the completion of a Corrective Action Plan for this Site.	A Corrective Action Plan must be submitted within 1 year of submission of a CMA (IAC Section 845.670). We would not anticipate any delays in the completion of a Corrective Action Plan for this Site.	A Corrective Action Plan must be submitted within 1 year of submission of a CMA (IAC Section 845.670). We would not anticipate any delays in the completion of a Corrective Action Plan for this Site.	A Corrective Action Plan must be submitted within 1 year of submission of a CMA (IAC Section 845.670). We would not anticipate any delays in the completion of a Corrective Action Plan for this Site.	A Corrective Action Plan must be submitted within 1 year of submission of a CMA (Section 845.670). We would not anticipate any delays in the completion of a Corrective Action Plan for this Site.
State or Local Permit Requirements or Other Environmental or Public Health Requirements that May Substantially Affect Implementation of the Corrective Action Plan (Section 3.4; IAC Section 845.660(c)(3))	Source Control-MNA would require regulatory approval prior to implementation. The approval process would not be expected to substantially affect the implementation of the Corrective Action Plan.	Source Control-GE would require regulatory approval prior to implementation, and may require modifications to the Site's NPDES permit. The approval process and, if needed, NPDES permit modification would not be expected to substantially affect the implementation of the Corrective Action Plan.	Source Control-MNA/GE would require regulatory approval prior to implementation, and may require modifications to the Site's NPDES permit. The approval process and, if needed, NPDES permit modification would not be expected to substantially affect the implementation of the Corrective Action Plan.	Source Control-CW would require regulatory approval prior to implementation, and may require modifications to the Site's NPDES permit. The approval process and, if needed, NPDES permit modification would not be expected to substantially affect the implementation of the Corrective Action Plan.	Source Control-PRB would require regulatory approval prior to implementation. The approval process would not be expected to substantially affect the implementation of the Corrective Action Plan.

Notes:

CCR = Coal Combustion Residual; CMA = Corrective Measures Assessment; Geosyntec = Geosyntec Consultants; GWPS = Groundwater Protection Standard; LGU = Lower Groundwater Unit; MGU = Middle Groundwater Unit; NAP = North Ash Pond; NPDES = National Pollutant Discharge Elimination System; O&M = Operations and Maintenance; OEAP = Old East Ash Pond; Source Control-CW = Source Control with Construction of a Cutoff Wall; Source Control-GE = Source Control with Groundwater Extraction; Source Control-MNA = Source Control with Monitored Natural Attenuation; Source Control-MNA/GE = Source Control with Monitored Natural Attenuation and Groundwater Extraction; Source Control-PRB = Source Control with Construction of a Permeable Reactive Barrier.

Table S.3 Comparison of Proposed Corrective Action Alternatives with Respect to Factors Specified in IAC Section 845.670(e)

Evaluation Factor (Report Section; Part 845 Section)	**Source Control-MNA**	**Source Control-MNA/GE**
Magnitude of Reduction of Existing Risks (Section 4.1.1; IAC Section 845.670(e)(1)(A))	There are no current risks to any human or ecological receptors at the Site. Because dissolved constituent concentrations are expected to decline due to source control and corrective measures, there would also be no future risks to human and ecological receptors.	There are no current risks to any human or ecological receptors at the Site. Because dissolved constituent concentrations are expected to decline due to source control and corrective measures, there would also be no future risks to human and ecological receptors.
Effectiveness of the Remedy in Controlling the Source (Section 4.1.2; IAC Section 845.670(e)(2))	Both of the alternatives would be fully protective with regard to primary source control. Source Control-MNA would also likely be effective with regard to secondary source control (Geosyntec, 2021b).	Both of the alternatives would be fully protective with regard to primary source control. Source Control-MNA/GE would also likely be effective with regard to secondary source control, through the combination of MNA and operation of the groundwater collection trench.
Likelihood of Future Releases of CCR (Section 4.1.3; IAC Section 845.670(e)(1)(B))	There would be no likelihood of CCR releases occurring post-closure under either of the alternatives.	There would be no likelihood of CCR releases occurring post-closure under either of the alternatives.
Type and Degree of Long-Term Management, Including Monitoring, Operation, and Maintenance (Section 4.1.4; IAC Section 845.670(e)(1)(C))	Minimal long-term O&M efforts would be required under Source Control-MNA, because it would not require the installation, operation, or maintenance of any engineered systems or structures other than monitoring wells. Groundwater sampling would continue until GWPSs have been achieved.	Moderate long-term O&M efforts would be required under Source Control-GE, including the maintenance of the groundwater collection trench and discharge of extracted groundwater. Groundwater and seep water collected at the groundwater collection trench would be treated, if necessary, sent to the NAP Secondary Pond, and discharged *via* the NPDES-permitted outfall. Groundwater sampling would continue until GWPSs have been achieved.
Short-Term Risks to the Community or the Environment During Implementation of Remedy (Section 4.1.5; IAC Section 845.670(e)(1)(D))	Minimal impacts to worker safety, air quality, and surface water and sediment quality would be expected under Source Control-MNA, due to the minimal nature of the construction activities required under this alternative. Under both source control/corrective action scenarios, the constituent mass flux that flows from groundwater into surface water would decline over time after closure has been completed (Ramboll, 2021a).	Minimal impacts to worker safety, air quality, and surface water and sediment quality would be expected under Source Control-MNA, due to the minimal nature of the construction activities required under this alternative. Under both source control/corrective action scenarios, the constituent mass flux that flows from groundwater into surface water would decline over time after closure has been completed (Ramboll, 2021a).

Evaluation Factor (Report Section; Part 845 Section)	Source Control-MNA	Source Control-MNA/GE
Time Until Groundwater Protection Standards Are Achieved (Section 4.1.6; IAC Section 845.670(e)(1)(E))	Results of the modeling indicate that groundwater will attain the GWPSs for all constituents identified as potential exceedances in the primary migration pathway within approximately 50 years after closure for both the Source Control-MNA and Source Control-MNA/GE scenarios (Ramboll, 2021a). There is no significant difference between the two scenarios in the time to achieve the GWPSs at the Site.	Results of the modeling indicate that groundwater will attain the GWPSs for all constituents identified as potential exceedances in the primary migration pathway within approximately 50 years after closure for both the Source Control-MNA and Source Control-MNA/GE scenarios (Ramboll, 2021a). There is no significant difference between the two scenarios in the time to achieve the GWPSs at the Site.
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 (Section 4.1.7; IAC Section 845.670(e)(1)(F))	There are no current or future risks to any human or ecological receptors at the Site, and there would be no risk of CCR releases occurring post-closure. Potential risks to workers that come in contact with secondary sources of CCR-associated constituents would be managed through the use of rigorous safety protocols and personal protective equipment.	There are no current or future risks to any human or ecological receptors at the Site, and there would be no risk of CCR releases occurring post-closure. Potential risks to workers that come in contact with secondary sources of CCR-associated constituents would be managed through the use of rigorous safety protocols and personal protective equipment.
Long-Term Reliability of the Engineering and Institutional Controls (Section 4.1.8; IAC Section 845.670(e)(1)(G))	High long-term reliability would be expected for Source Control-MNA, because this alternative would rely on natural processes and active monitoring.	Long-term reliability would be expected for Source Control-MNA/GE, as long as the groundwater collection trench is maintained and operated appropriately.
Potential Need for Replacement of the Remedy (Section 4.1.9; IAC Section 845.670(e)(1)(H))	Replacement of Source Control-MNA would likely be unnecessary. The MNA evaluation provided by Geosyntec (2021b) notes that, if MNA is selected as the remedy, a contingency plan that will identify the circumstances under which replacement of the remedy may be appropriate will be developed.	Replacement of Source Control-MNA/GE would likely be unnecessary. The MNA evaluation provided by Geosyntec (2021b) notes that, if MNA is selected as the remedy, a contingency plan that will identify the circumstances under which replacement of the remedy may be appropriate will be developed.
Degree of Difficulty Associated with Constructing the Remedy (Section 4.2.1; IAC Section 845.670 (e)(3)(A)	Source Control-MNA would rely on natural processes and therefore would not pose any significant construction challenges.	Source Control-MNA would rely on natural processes and continued operation of the groundwater collection trench, which is required by the Agreed Interim Order (Illinois, Attorney General, 2021). Therefore, no significant construction challenges would be expected.

Evaluation Factor (Report Section; Part 845 Section)	Source Control-MNA	Source Control-MNA/GE
Expected Operational Reliability of the Remedy (Section 4.2.2; IAC Section 845.670 (e)(3)(B))	High operational reliability would be expected for Source Control-MNA, because this scenario would rely on natural processes and active monitoring.	Operational reliability would be expected for Source Control-MNA/GE, as long as the groundwater collection trench is maintained and operated appropriately.
Need to Coordinate with and Obtain Necessary Approvals and Permits from Other Agencies (Section 4.2.3; IAC Section 845.670 (e)(3)(C))	Source Control-MNA would require regulatory approval, but no additional permits would be needed.	Source Control-MNA/GE would require regulatory approval. Groundwater and seep water collected at the groundwater collection trench would be sent to the NAP Secondary Pond and discharged *via* the NPDES-permitted outfall.
Availability of Necessary Equipment and Specialists (Section 4.2.4; IAC Section 845.670 (e)(3)(D)	Source Control-MNA would require standard environmental monitoring equipment. Specialists would be available to evaluate the data after they are collected.	Source Control-MNA/GE would require standard remedial action and environmental monitoring equipment. The required equipment and specialists would be available.
Available Capacity and Location of Needed Treatment, Storage, and Disposal Services (Section 4.2.5; IAC Section 845.670 (e)(3)(D))	A minimal amount of investigation-derived waste would be generated under Source Control-MNA. This waste could be managed by a standard waste management contractor.	The groundwater collection system would generate water. Groundwater and seep water collected at the groundwater collection trench would be treated, if necessary, sent to the NAP Secondary Pond, and discharged *via* the NPDES-permitted outfall.
The Degree to Which Community Concerns Are Addressed by the Remedy (Section 4.3; IAC Section 845.670(e)(4))	Source control measures would address the primary concerns of residents.	Source control measures would address the primary concerns of residents.

Notes:

CCR = Coal Combustion Residual; Geosyntec = Geosyntec Consultants; IAC = Illinois Administrative Code; GWPS = Groundwater Protection Standard; NAP = North Ash Pond; NPDES = National Pollutant Discharge Elimination System; O&M = Operations and Maintenance; Source Control-MNA = Source Control with Monitored Natural Attenuation; Source Control-MNA/GE = Source Control with Monitored Natural Attenuation and Groundwater Extraction.

1 Introduction

1.1 Site Description and History

1.1.1 Site Location and History

Dynegy Midwest Generation, LLC's (DMG) Vermilion Power Plant is an electric power generating facility with coal-fired units located approximately 5 miles north of the Village of Oakwood, Illinois, along the Middle Fork of the Vermilion River. The facility began operating in the mid-1950s (OBG, 2019a) and was retired in November 2011 (IEPA, 2013). The power plant remains in place and has not yet been demolished.

1.1.2 CCR Impoundments

The Vermilion Power Plant produced and stored coal combustion residuals (CCRs) as a part of its historical operations. There are two decommissioned ash ponds at the Site, both located east of the power plant (Figure 1.1):

- Old East Ash Pond (OEAP) area (Vistra ID No. CCR Unit 911 and Illinois Environmental Protection Agency [IEPA] ID No. W1838000002-03)/North Ash Pond (NAP) area (Vistra ID No. CCR Unit 910 and IEPA ID No. W1838000002-01), including a secondary pond associated with the NAP; and
- New East Ash Pond (NEAP; Vistra ID No. CCR Unit 912, IEPA ID No. W1838000002-04, and National Inventory of Dams [NID] No. IL50291), including an associated secondary pond.

The OEAP is the oldest of the ash-receiving ponds and was put into service in the mid-1950s as part of the original plant construction. Use of the OEAP continued until the NAP, which is hydraulically connected with the OEAP, was constructed in 1977. Use of the NAP continued until 1989, after which ash was diverted to the NEAP (Geosyntec, 2021c, Appendix A; OBG, 2019a). None of the ash-receiving ponds at the Site have received CCR since the plant was retired in 2011 (Geosyntec, 2021c, Appendix A).

The OEAP is bordered on the north and northeast by the Middle Fork of the Vermilion River. Steep bluffs lie directly south, southeast, and west of the impoundment, and the NAP lies to the northwest. The groundwater elevation in the vicinity of the OEAP exceeds the base elevation of the impoundment, resulting in intersecting conditions (*i.e.*, groundwater is in direct contact with ash in the OEAP; Natural Resource Technology, Inc., 2014a). Between approximately 1986 and 1997, the OEAP was capped with soil and vegetation. The OEAP does not contain any ponded water (Geosyntec, 2021c, Appendix A).

The NAP is bordered by fallow fields to the north, the Middle Fork of the Vermilion River to the east, the OEAP to the south, and steep bluffs to the west. As with the OEAP, there are intersecting conditions in the NAP (Natural Resource Technology, Inc., 2014b). Although the NAP no longer receives ash, it does receive stormwater runoff. Currently, the NAP discharges decanted water into the NAP Secondary Pond, which subsequently discharges into the Middle Fork of the Vermilion River during heavy rainfall events, which only occur one or two times per year (OBG, 2019a). The NAP does not have a soil cover;

however, a layer of vegetation overlies the CCR throughout much of the impoundment (Geosyntec, 2021c, Appendix A). Ponded water occurs in the northern section of the impoundment (Geosyntec, 2021c, Appendix Q).

The NEAP was constructed in the bottomlands of the Middle Fork of the Vermilion River with earthen berms with a clay core. The berms are located on the north, east, and south sides of the primary cell of the NEAP, and were keyed into the underlying shale at the time of construction using 4-foot-thick soil/bentonite slurry walls (Kelron Environmental, 2003). The west side of the primary cell of the NEAP is formed by the bluff, which is composed of low-permeability clays. In 2002, the original 1989 footprint of the NEAP was expanded to form the present extent of the NEAP. The height of the berms was also raised using additional low-permeability clay, and a trench filled with low-permeability fill was keyed into the shale along the natural bluff on the west side of the NEAP (OBG, 2019b). The NEAP does not have a soil cover, and ponded water occurs in the eastern section of the impoundment. The secondary pond of the NEAP discharges to the Middle Fork of the Vermilion River (Geosyntec, 2021d, Appendix Q). The NEAP overlies a former coal mine, which has impacted groundwater quality in the area (OBG, 2019b).

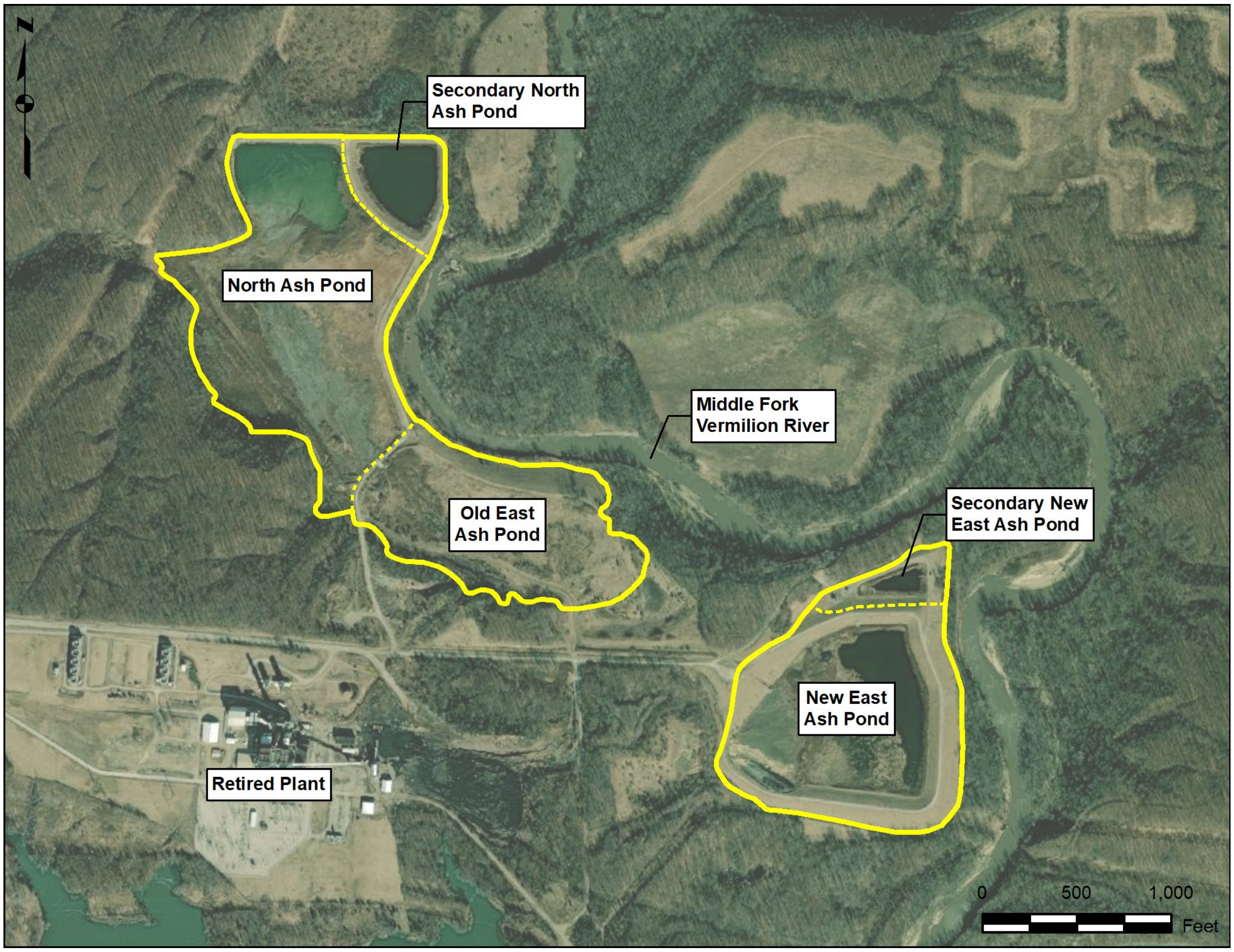

Figure 1.1 Site Location Map. Based on DMG *et al.* (2019).

1.1.3 Surface Water Hydrology

The NAP and the NEAP are both currently permitted to discharge decanted water to the Middle Fork of the Vermilion River *via* their secondary ponds (Geosyntec, 2021c, Appendix A). The 17-mile reach of the Vermilion River known as the Middle Fork is Illinois's only National Scenic River, and is protected due to its high-value historical, scenic, geologic, ecological, fish and wildlife, and recreational resources. The Middle Fork is popular for a wide range of recreational activities, including canoeing, kayaking, fishing, hiking, and wildlife viewing (US DOI, 2010; Barkley, 2012). Over recent decades, the Middle Fork has been slowly migrating towards the impoundment embankments at the Site. Riverbank migration and its potential impact on closure activities is discussed later in this report.

Surface water samples were collected from three locations in the Middle Fork of the Vermilion River in 2019 (Hanson Professional Services Inc., 2019). These data are summarized in Gradient's Human Health and Ecological Risk Assessment for the Site, which is provided as Appendix A of this report. Surface water samples were also collected and analyzed in June and July 2021 (Eurofins TestAmerica and Geosyntec, 2021).

In addition to the Middle Fork of the Vermilion River, there is an approximately 200-acre surface water reservoir (cooling pond) located on the Site called Company Lake (Ramboll, 2021b).

1.1.4 Hydrogeology

1.1.4.1 NAP/OEAP

The geology underlying the Site in the vicinity of the NAP/OEAP consists of several distinct layers (Ramboll, 2021b):

1. An upper unit composed of the clayey sands to sandy clays of the Cahokia Alluvium;
2. A middle groundwater unit (MGU) composed of the coarser-grained material encountered at the base of the Cahokia Alluvium. This unit is laterally continuous below the NAP/OEAP and is designated as the uppermost aquifer;
3. A low-permeability upper confining unit composed of clay with isolated sand lenses. This unit is present both below the NAP/OEAP and, in the uplands, limits the vertical migration of groundwater;
4. A lower groundwater unit (LGU) composed of glacial outwash and re-worked glacial deposits of the Henry formation. This unit is the lowermost, most laterally extensive coarse-grained unlithified deposit identified beneath the Site and in the uplands. Based on permeability and continuous lateral extent, this unit is identified as a Potential Migration Pathway (PMP);
5. A low-permeability lower confining unit composed of silty or sandy clay with isolated sand lenses. This unit is the lowermost unlithified deposit and limits the vertical migration of groundwater; and
6. A bedrock confining unit, the lowermost unit identified at the site, which underlies all unlithified deposits. This unit occurs within Pennsylvanian shale, which is the uppermost lithified unit at the Site.

Hydrogeologic data collected at the Site show that groundwater flow occurs in the MGU and LGU, while the upper and lower confining units act as barriers to groundwater flow (Ramboll, 2021b). Groundwater migrates within the high-permeability sands and gravels of the MGU and LGU, which flow eastward to the Middle Fork under normal river conditions. At the NAP/OEAP, potential dissolved CCR-related constituents may migrate vertically downward under the influence of gravity into the MGU and, to a lesser extent, through the middle confining unit into the LGU.

Groundwater in the MGU and the LGU flows primarily eastward toward the Middle Fork of the Vermilion River. The Middle Fork is the regional sink of shallow groundwater in the area (Kelron Environmental, 2003, 2012), *i.e.*, all of the groundwater in the MGU and LGU in this area flows upward and into the river. Groundwater modeling, potentiometric head maps, and vertical gradients confirm that groundwater in both the MGU and LGU flows into the Middle Fork of the Vermilion River (OBG, 2019a; Kelron Environmental, 2003, 2012; Ramboll, 2021b). There may be limited groundwater migration in a northerly direction; however, this groundwater flow ultimately turns eastward and flows into the river. There is no transport of CCR-related constituents toward the western and southern property boundaries.

During groundwater interaction with surface water, CCR-related constituents may partition between sediments and the surface water column. It should be noted that many CCR-related constituents occur naturally in sediments and surface water. As a result, their presence in the sediments and/or surface water of the Middle Fork does not necessarily signify contributions from the ash ponds.

Groundwater samples have been collected from wells in the vicinity of the NAP/OEAP since 1988. The Hydrogeologic Site Characterization Report and Groundwater Monitoring Plan prepared by Ramboll as part of the Operating Permits for the NAP/OEAP and NEAP include a summary of groundwater data collected between 2015 and 2021 at the Site (Ramboll, 2021b,c). These reports also outline the additional monitoring and analysis that will be performed at the NAP/OEAP going forward, as required under Part 845 (IEPA, 2021a).

1.1.4.2 NEAP

The geology underlying the Site in the vicinity of the NEAP is distinct from the geology in the vicinity of the NAP/OEAP. The NAP/OEAP are built atop terraces, whereas the NEAP was constructed directly atop shale bedrock in the lower-elevation bottomlands. The geology near the NEAP consists of three layers (Ramboll, 2021d):

1. An upper unit composed of mixed alluvial deposits of sand with occasional layers of silty clay. This unit is present outside of the NEAP and in the bottomlands of the Middle Fork;
2. An upper confining unit composed of predominantly low-permeability silty and clayey diamictons (glacial till) with intermittent sand layers and lenses. This unit is present outside of the NEAP and along the western bluff of the Middle Fork; and
3. A bedrock confining unit, which contains a major coal seam that was historically mined beneath the NEAP. This is the lowermost unit identified at the site and underlies all unlithified deposits; it occurs within Pennsylvanian shale, which is the uppermost lithified unit at the Site.

None of the units described above have been identified as an aquifer. However, the upper unit and bedrock confining unit have been identified as PMPs. Groundwater surrounding the NEAP flows into the Middle Fork of the Vermilion River (OBG, 2019b).

Groundwater quality data and detailed statistical analyses have demonstrated that CCR-related constituents from the NEAP have not impacted groundwater outside the low-permeability barriers and are not impacting the Middle Fork (Kelron Environmental, 2003; OBG, 2019b). These data are summarized in Gradient's Human Health and Ecological Risk Assessment for the Site, which is provided as Appendix A of this report. Additional groundwater samples collected and analyzed in 2020 and 2021 are provided by Geosyntec Consultants (Geosyntec, 2021b).

1.1.5 Site Vicinity

The Site is bordered by fallow fields owned by the Illinois Department of Natural Resources (IDNR) to the north, the Middle Fork of the Vermilion River to the east, Kickapoo State Recreation Area to the south, and steep bluffs to the west. High-value natural areas and recreational areas near the Site include the Middle Fork of the Vermilion River, the Kickapoo State Recreation Area, and the Orchid Hill Natural Heritage Landmark. As described in Section 1.1.3, the Middle Fork of the Vermilion River is Illinois's only National Scenic River and is a popular spot for canoeing and other forms of water recreation. Kickapoo State Recreation Area is one of the most popular parks in Illinois, with 1.3 million visitors in 2020 (La, 2021). This 2,842-acre park is popular for hiking, camping, hunting, fishing, canoeing, and scuba diving (IDNR, 2021). The Orchid Hill Natural Heritage Landmark is a >100-acre natural area located immediately northwest of the retired power plant. This area, which lies partially on Vermilion Power Plant property but is managed by IDNR, is notable for its high-quality barrens, which are rare in Illinois, as well as the occurrence of six species of native orchid, including the rare yellow lady's slipper (Various, 1990-2010).

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. Part 845 additionally requires that a Corrective Measures Assessment (CMA) and a Corrective Action Alternatives Analysis (CAAA) be performed prior to undertaking any corrective measures at certain CCR-containing impoundments. Section 2 of this report presents a CAA for the NAP/OEAP and the NEAP pursuant to requirements under IAC Section 845.710. Based on potential groundwater exceedances identified at the Site (Ramboll, 2021b,d), Section 3 presents a CMA for the NAP/OEAP and the NEAP pursuant to requirements under IAC Section 845.660 and Section 4 presents a CAAA pursuant to the requirements under IAC Section 845.670. 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). The CMA/CAAA similarly evaluate a range of factors for the various corrective measures being considered at each impoundment. A CAA and CMA/CAAA are decision-making tools that are designed to aid in the selection of a closure alternative or corrective action alternatives for the impoundments at a site.

2 Closure Alternatives Analysis

This section of the report presents a CAA for the NAP/OEAP and the NEAP pursuant to requirements under IAC Section 845.710 (IEPA, 2021a). Closure is evaluated separately in this report for the combined NAP/OEAP system and the NEAP. For purposes of closure, DMG characterizes the OEAP and NAP as a single multi-unit system because (a) there is a continuous layer of ash running between the OEAP and NAP, (b) the NAP was designed such that the outer berms were an extension of the outer berms of the OEAP, (c) the NAP was designed and constructed to incorporate the ash located within the OEAP, (d) the NAP and OEAP share a groundwater monitoring network, and (e) the NAP and OEAP fall within the same areal extent of the local groundwater flow regime.

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

The two closure scenarios evaluated in this CAA are Closure-by-Removal with On-Site CCR Disposal (CBR-Onsite) and Closure-by-Removal with Off-Site CCR Disposal (CBR-Offsite). Both of these scenarios entail excavating all of the CCR from the former NAP/OEAP and NEAP impoundments and transporting it to a landfill for disposal. Under the CBR-Onsite scenario, a landfill will be constructed on the Site. Under the CBR-Offsite scenario, CCR will instead be hauled to an off-Site landfill. While Closure-in-Place (CIP) is widely recognized as another viable closure approach that can be protective of human health and the environment at many sites (US EPA, 2015a), CIP is not being evaluated as a potential closure alternative at this Site because the Agreed Interim Order dated June 30, 2021, states that the CAA for the Site "shall only consider and discuss closure by removal for the Ponds" (Illinois, Attorney General, 2021). Additionally, a groundwater collection trench will be constructed downstream of the OEAP under both closure scenarios. The groundwater collection trench, which is required by the June 2021 agreement between DMG and the Illinois Attorney General (Illinois, Attorney General, 2021), will intercept seepage and discolored water until excavation of the CCR has been completed.

Sections 2.1.1 and 2.1.2 provide detailed descriptions of the CBR-Onsite and CBR-Offsite closure scenarios. These scenarios are based on detailed spreadsheets and closure reports provided to Gradient by Geosyntec (Geosyntec [2021e] and Appendix Q of Geosyntec [2021c,d,f]).

2.1.1 Closure-by-Removal with On-Site CCR Disposal

Under the CBR-Onsite scenario, all of the CCR excavated from the NAP/OEAP and the NEAP will be hauled to a landfill located on the Site. Currently, however, the Site does not have a landfill. Under this scenario, the retired power plant located on the property will be demolished, and a "state-of-the-art," lined landfill will be constructed over a portion of its footprint. The landfill will be used to contain CCR excavated from the impoundments as well as non-hazardous material arising from the demolition of the power plant and other historical plant operations. Excavation and transport of CCR from the impoundments will begin once the on-Site landfill has been constructed. CCR will be hauled to the landfill using haul trucks with a capacity of 34 cubic yards (CY). This scenario meets the requirement of IAC Section 845.710(c)(2) (IEPA, 2021a) that an assessment be conducted in the CAA regarding 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 both the NAP/OEAP and the NEAP (Geosyntec, 2021a,e):

- **Construction of the on-Site landfill, including:**
  - Stripping vegetation and topsoil, followed by excavation and stockpiling of soil;
  - Construction of the composite bottom liner system, which will include a minimum of 3 feet of low-permeability soil and a 60-mil high-density polyethylene (HDPE) geomembrane liner;
  - Construction of the leachate collection and management system; and
  - Construction of an access road.
- **CCR impoundment excavation and on-Site landfill operation, followed by Site restoration, including:**
  - Free water removal and dewatering of surface impoundments.
  - Excavation of cover soils. Excavated soils and topsoil will be segregated and set aside for later use during Site restoration.
  - Excavation of CCR from the impoundments and transport of CCR to the on-Site landfill. Any pipes and discharge structures within the impoundment will also be removed.
  - Construction of stormwater control structures to convey runoff away from the former impoundments.
  - Site restoration, including grading and backfilling as needed to manage stormwater, followed by revegetation with native grasses.
- **Closure of the on-Site landfill, including:**
  - Construction of the final composite cover system, which will tie into the bottom liner system and will include 1 foot of low-permeability clay/cohesive soil subgrade, a 40-mil linear low-density polyethylene (LLDPE) geomembrane liner, a geocomposite drainage layer (if needed), and 3 feet of additional protective soil cover;
  - Seeding and mulching; and
  - Stormwater management, including excavation of a detention basin.
- **Long-term (post-closure) monitoring and maintenance, including:**
  - Groundwater and surface water monitoring at the closed impoundments until groundwater protection standards (GWPSs) have been achieved.
  - A minimum of 30 years of post-closure care at the on-Site landfill, including leachate management and cap inspection, mowing and maintenance, and groundwater and surface water monitoring.

Soil for grading and revegetating the impoundment covers will be sourced from the perimeter dikes, the original ash basin covers, and the on-Site landfill excavation (Geosyntec, 2021e). Soil for the bottom liner, cover system, and daily cover at the on-Site landfill is similarly expected to be sourced from within the footprint of the on-Site landfill (Geosyntec, 2021a). As such, we assume that an off-Site borrow soil location will not need to be established.

In addition to the work elements listed above, a groundwater collection trench will be constructed downstream of the OEAP. The groundwater collection trench, which is required by the June 2021 agreement between DMG and the Illinois Attorney General (Illinois, Attorney General, 2021), will intercept seepage and discolored water until excavation of the CCR has been completed. Water collected in the trench will be sent to the NAP Secondary Pond and discharged *via* the National Pollutant Discharge Elimination System (NPDES)-permitted outfall. For the purposes of the calculations below, this activity is included as part of the construction activities for the NAP/OEAP closure (Geosyntec, 2021e).

In addition to groundwater collection trench construction, our analysis also accounts for the potential construction of a temporary riverbank maintenance measure/buttress along 1,000 feet of riverbank near the NAP/OEAP in order to arrest riverbank migration, as discussed in Section 2.2.2. This work element is tentative, because the need for the buttressing at this Site will be evaluated throughout the removal process and has not yet been determined. Ultimately, buttressing may or may not be required at the NAP/OEAP.

The existing power plant is assumed to be demolished under both scenarios; however, the timing of the demolition will likely vary. The power plant will be demolished sooner under the CBR-Onsite scenario, because the on-Site landfill will be constructed within a portion of the existing footprint of the power plant. In contrast, under the CBR-Offsite scenario, it was assumed for this analysis that the power plant would eventually be demolished at an undetermined point in the future. Therefore, we did not include the impacts of power plant demolition (worker safety, waste disposal, equipment emissions, fugitive dust emissions, *etc*.) in this assessment, because only work elements that result in differential impacts across closure scenarios are of interest for the purposes of selecting between multiple options.

Demolition of the power plant and design, permitting, and construction of the on-Site landfill will delay the start of excavation at the NAP/OEAP and NEAP under the CBR-Onsite scenario (relative to the CBR-Offsite scenario) by an estimated 6 years (Geosyntec, 2021a,g). Landfill permitting is a significant component of this estimated 6-year period; if IEPA is able to review and approve the on-Site landfill permit application faster than expected, then it may be possible to reduce the delay before the start of excavation. However, even though CCR excavation would not begin immediately under the CBR-Onsite scenario, dewatering of the impoundments would begin at the same time under both scenarios in accordance with the Safety Emergency Response Plan (SERP; Geosyntec, 2021h) and the requirements of the Agreed Interim Order (Illinois, Attorney General, 2021). Construction of the on-Site landfill will require approximately 1.8 years (Geosyntec, 2021e). Excavation and closure of the NAP/OEAP will take an estimated 7.1 years, excavation and closure of the NAP will take an estimated 3 years, and closure of the on-Site landfill will take an estimated 0.6 years (Geosyntec, 2021e). Key parameters for the CBR-Onsite scenario are shown in Table 2.1.

Table 2.1 Key Parameters for the Closure-by-Removal with On-Site CCR Disposal Scenario

Parameter	Value	Notes
Haul Truck Capacity (CY)	34	
NAP/OEAP Closure		
Surface Area (acres)	60	**NAP:** 40 acres **OEAP:** 20 acres
In-Place Volume of CCR (CY)	2,160,000	**NAP:** 1,170,000 CY **OEAP:** 992,000 CY
Duration of Construction Activities (years)[b]	7.1	4.8 years for the NAP and 2.3 years for the OEAP. Excludes the time required for landfill construction and closure.
Total Labor Hours	285,000	
Vehicle and Equipment On-Site Miles	229,000	
Vehicle and Equipment Off-Site Miles[a]	1,620,000	
NEAP Closure		
Surface Area (acres)	21	
In-Place Volume of CCR (CY)	376,000	
Duration of Construction Activities (years)	3	Excludes the time required for landfill construction and closure.
Labor Total Hours	94,800	
Vehicle and Equipment On-Site Travel Miles	58,900	
Vehicle and Equipment Off-Site Travel Miles[a]	443,000	
Long-Term Operations & Maintenance		
Labor Total Hours	84,800	
Vehicle and Equipment On-Site Travel Miles	9,400	
Vehicle and Equipment Off-Site Travel Miles[a]	2,570,000	
On-Site Landfill		
Surface Area (acres)	27	
Duration of Construction Activities (years)	2.4	Includes landfill construction (1.8 years) and closure (0.6 years).
Time to Place CCR in the On-Site Landfill (years)[b]	10.1	Total time required to excavate the OEAP (2.3 years), NAP (4.8 years), and NEAP (3 years).
Total On-Site Landfill Operation Time: Construction, Operation, and Closure (years)[b]	12.5	
Labor Total Hours	355,000	
Vehicle and Equipment On-Site Travel Miles	106,000	
Vehicle and Equipment Off-Site Travel Miles[a]	3,500,000	
Scenario Totals		
Total Labor Hours:	820,000	
Vehicle and Equipment On-Site Travel Miles:	403,000	
Vehicle and Equipment Off-Site Travel Miles:[a]	8,130,000	

Notes:

CCR = Coal Combustion Residual' CY = Cubic Yard; NAP = North Ash Pond; NEAP = New East Ash Pond; OEAP = Old East Ash Pond.

Source: Geosyntec (2021e).

(a) Includes Daily Labor Mobilization Miles, Vehicle and Equipment Mobilization/Demobilization Miles, and Material Delivery Miles (Loaded + Unloaded).

(b) Conservatively assumes that each impoundment is excavated sequentially, rather than simultaneously.

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

Under the CBR-Offsite scenario, CCR excavated from the NAP/OEAP and NEAP will be transported to an off-Site landfill for disposal. For the purposes of this analysis, we assume that CCR will be sent to the Republic Services Brickyard Disposal Landfill in Danville, Illinois (601 E. Brickyard Road), which is approximately 15 miles from the Site (Geosyntec, 2021e). As is described below in Section 2.4.5, it is possible that the Brickyard Disposal Landfill would have to be expanded in order to accept all of the CCR from the impoundments. CCR would be hauled to the off-Site landfill using haul trucks with a capacity of 16.5 cubic yards under the CBR-Offsite scenario, which is a smaller capacity than that for the trucks that would be used to haul CCR to the on-Site landfill under the CBR-Onsite scenario (*i.e.*, 34 cubic yards), due to restrictions placed on the size of trucks that can be used on public roadways.

IAC Section 845.710(c)(1) requires CBR alternatives to consider multiple methods for transporting CCR off-site, including rail, barge, and trucks. There is no established rail terminal or a railroad track near the power plant area at the Site. In order for CCR to be transported by rail, a new rail line to the Union Pacific Railroad line located more than 5 miles to the northwest would need to constructed, and a loading terminal would need to be constructed on-Site. This was considered infeasible, because it would increase the project schedule due to the need to coordinate with the railroad, complete design and permitting, and construct the terminal, and because additional land would need to be acquired. Furthermore, CCR would still need to be hauled by truck to the on-Site loading terminal and loaded into rail cars, resulting in additional CCR exposures and potential releases. Additionally, the Middle Fork of the Vermilion River, which is the only river near the Site, is not open to barge traffic. Therefore, transporting CCR by barge is not feasible for this site. The local availability and use of natural gas-powered trucks, or other low-polluting trucks, will be evaluated prior to the start of construction.

This scenario includes the following work elements (Geosyntec, 2021e):

- Free water removal and dewatering of surface impoundments.
- Excavation of cover soils. Excavated soils and topsoil will be segregated and set aside for later use during Site restoration.
- Excavation of CCR from the impoundments and transport of CCR to the off-Site landfill. Any pipes and discharge structures within the impoundment will also be removed.
- Construction of stormwater control structures to convey runoff away from the former impoundments.
- Site restoration, including grading and backfilling as needed to manage stormwater, followed by revegetation with native grasses.
- Groundwater and surface water monitoring until GWPSs have been achieved.

As with the CBR-Onsite scenario, we assume that an off-Site borrow soil location will not be needed. Similarly, additional work elements included under this scenario include the construction of a groundwater collection trench and potential construction of a temporary riverbank maintenance measure/buttress. The impacts of power plant demolition were not quantified, because the power plant is assumed to be demolished under both scenarios. However, plant demolition may not occur until an undetermined point in the future under the CBR-Offsite scenario.

Under the CBR-Offsite scenario, the overall duration of closure activities is expected to be 7.6 years for the NAP/OEAP and 3.1 years for the NEAP. Key parameters for the CBR-Offsite scenario are shown in Table 2.2.

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

Parameter	Value	Notes
Distance to the Off-Site Landfill (miles)	15	
Haul Truck Capacity (CY)	16.5	Capacity restricted due to use of public roads.
NAP/OEAP Closure		
Surface Area (acres)	60	NAP: 40 acres OEAP: 20 acres
In-Place Volume of CCR (CYs)	2,160,000	**NAP:** 1,170,000 CY **OEAP:** 992,000 CY
Duration of Construction Activities (years)[b]	7.6	5.1 years for the NAP and 2.5 years for the OEAP.
Total Labor Hours	471,000	
Vehicle and Equipment On-Site Travel Miles	125,000	
Vehicle and Equipment Off-Site Travel Miles[a]	6,630,000	
NEAP Closure		
Surface Area (acres)	21	
In-Place Volume of CCR (cubic yards)	376,000	
Duration of Construction Activities (years)	3.1	
Labor Total Hours	125,000	
Vehicle and Equipment On-Site Travel Miles	39,000	
Vehicle and Equipment Off-Site Travel Miles[a]	1,290,000	
Long-Term Operations & Maintenance		
Labor Total Hours	85,600	
Vehicle and Equipment On-Site Travel Miles	9,490	
Vehicle and Equipment Off-Site Travel Miles[a]	2,590,000	
Scenario Totals		
Total Labor Hours:	682,000	
Vehicle and Equipment On-Site Travel Miles:	173,000	
Vehicle and Equipment Off-Site Travel Miles:[a]	10,500,000	

Notes:

CCR = Coal Combustion Residual' CY = Cubic Yard; NAP = North Ash Pond; NEAP = New East Ash Pond; OEAP = Old East Ash Pond.

Source: Geosyntec (2021e).

(a) Includes Daily Labor Mobilization Miles, Vehicle and Equipment Mobilization/Demobilization Miles, Material Delivery Miles (Loaded + Unloaded), and Daily Haul Truck Miles (Loaded + Unloaded).

(b) Conservatively assumes that each impoundment is excavated sequentially, rather than simultaneously.

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's February 2020 Human Health and Ecological Risk Assessment (Appendix A) provides a detailed evaluation of the magnitude of existing risks to human and ecological receptors at the Site. This report concluded that there are no current unacceptable risks to any human or ecological receptors at or near the Site. An additional risk analysis performed in 2021, which included an analysis of several constituents (*i.e.*, lithium and molybdenum) that have recently been included in sampling programs but were not included in prior sampling events, also concluded that there are no unacceptable risks to any human or ecological receptors at or near the Site (Appendix B). Because there are no current risks to any human or ecological receptors, and dissolved constituent concentrations are expected to decline post-closure, no post-closure risks are expected under either closure scenario. Thus, the magnitude of reduction of existing risks is the same under both closure 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 releases of CCR that may occur during dike failure and storm-related events. The likelihood of future releases was evaluated both during and following closure activities at the NAP/OEAP and the NEAP under both closure scenarios.

Dike Failure Due to Riverbank Migration

The Middle Fork of the Vermilion River has been migrating towards the ash basin embankments for decades. This phenomenon presents a threat to the long-term stability of the embankments (Stantec, 2017, 2019). Dike failure could thus conceivably occur prior to or during excavation of the impoundments. However, risks related to dike failure will be minimized and managed through monitoring and inspection under both closure scenarios. Under the Agreed Interim Order that DMG entered into with the Illinois Attorney General in June 2021, DMG is required to inspect the riverbank in the vicinity of the NAP/OEAP monthly, as well as after any 25-year, 24-hour storm events, in order to determine whether damage is occurring to the dikes and whether emergency action is required to prevent dike failure (Illinois, Attorney General, 2021). The SERP submitted by DMG on August 16, 2021, details the temporary riverbank maintenance measures that will be undertaken, if needed, to ensure that dike failure does not occur (Geosyntec, 2021h).

Moreover, a reliability assessment was performed by Geosyntec (2021i) with the purpose of determining when temporary riverbank stabilization measures would be implemented, if necessary. The reliability assessment estimated "the probability of slope failure based on the variability of soil and groundwater conditions" (Geosyntec, 2021i). Geosyntec calculated a reliability index that can be used to identify when stabilization measures should be undertaken, allowing sufficient time to design, permit, and construct the stabilization measures. The reliability assessment determined, based on the best information available, that the average riverbank erosion rate along the OEAP ranges from 0.5 to 0.7 feet/year (Geosyntec, 2021i). This rate is significantly slower than prior riverbank erosion rates that have been estimated for the Site (*i.e.*, 2.3 feet/year; Stantec, 2017, 2019).

Overall, while the risk of needing temporary riverbank maintenance measures is slightly higher under the CBR-Onsite scenario compared to the CBR-Offsite scenario, because the excavation of CCR from the impoundments will be delayed by approximately 6 years in order to demolish the power plant and construct the landfill under the former scenario, the overall risk of failure is low under both scenarios because of the riverbank monitoring and mitigation measures that are already in place. Post-closure, there is no risk of CCR releases occurring due to dike failure under either closure scenario.

Storm-Related Releases and Dike Failure During Flood Conditions

Under both the CBR-Offsite scenario and the CBR-Onsite scenario, there is no post-closure risk of CCR releases occurring due to dike failure or overtopping under flood conditions, because all of the CCR will be excavated from the impoundments under both scenarios. However, as with dike failure due to riverbank encroachment, it is conceivable that flood-related releases could occur prior to or during excavation of the impoundments. We have therefore evaluated the risk of dike failure occurring during this interim period.

The risk of dike failure occurring during floods or other storm-related event is exceedingly low under both closure scenarios. Engineering analyses show that both the NAP/OEAP dikes and the NEAP dikes are expected to remain stable under static, seismic, and flood conditions (Appendix W of Geosyntec [2021c,d,f]). The risk of overtopping occurring during flood conditions is also exceedingly low under both scenarios, because dewatering of the basins can begin immediately following the start of construction activities; *i.e.*, dewatering will not be delayed by power plant demolition or construction of the on-Site landfill under the CBR-Onsite scenario. Geosyntec evaluated the risk of flood overtopping occurring at the NAP/OEAP and the NEAP after dewatering and found that the relevant spillways for each impoundment can adequately manage flow during peak discharge from even a 1,000-year storm event, thus preventing overtopping (Appendix V of Geosyntec [2021c,d,f]).

Dike Failure Due to Seismicity

Sites in Illinois may be subject to seismic risks due to their proximity to the Wabash Valley Seismic Zone and the New Madrid Seismic Zone (IEMA, 2021). However, the Vermilion property does not lie within a seismic impact zone and is also believed to have a "low risk level" for seismic risks based on the 2018 USGS National Seismic Hazard Map (Appendix G of Geosyntec [2021c,d,f]). Additionally, none of the impoundments at the Site 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; Appendix F of Geosyntec [2021c,d,f]). Thus the risk of dike failure occurring prior to or during excavation activities due to seismic activity is low (Appendix W of Geosyntec [2021c,d,f]). Once all of the CCR has been excavated from the impoundments, there will be no risk of CCR releases occurring due to seismic conditions under either the CBR-Offsite or CBR-Onsite scenario.

Risks of Future Releases of CCR at the On-Site Landfill

The effective Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (Effective FIRM) for the Site demonstrates that the proposed on-Site landfill location, which would be located atop the bluff on the property, does not lie within the 100-year floodplain (FEMA, 2012). Inundation maps prepared by DMG (2021) demonstrate further that the on-Site landfill location also does not lie within the 500-year floodplain or the 1,000-year floodplain. Furthermore, there is no risk to the on-Site landfill associated with future meandering and erosion of the river (Geosyntec, 2021a). The river alignment and geologic floodplain have been constrained historically by the floodplain bluffs. The on-Site landfill would be located approximately 100 vertical feet above the river's 1,000-year flood event elevation and 1,400 feet horizontally from the river. Based on the geomorphology of the valley since the river channel and floodplain bluffs were formed at the end of the Pleistocene Epoch (around 11,000 years ago), there is no evidence that the river has ever flowed through the location of the proposed landfill or overtopped the valley wall. The river is not expected to ever move significantly beyond the floodplain bluffs/valley walls (Geosyntec, 2021a). Thus, there is no practical risk of CCR releases occurring at the On-Site landfill due to flood conditions or riverbank erosion. Additionally, the seismic risks at the Site are low, as described above. In summary, the overall risk of CCR escaping the on-Site landfill during flood or seismic conditions is minimal.

We did not evaluate flooding risks and seismic risks at the off-Site landfill, because it has previously been constructed and permitted and is already in operation. We assume that the off-Site landfill will operate in compliance with all state and federal regulations designed to minimize the threat of waste releases, including under seismic and flood conditions.

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 impoundments and the on-Site landfill under each closure scenario are described in Section 2.1 (Closure Alternatives Descriptions). In summary, under both closure scenarios, the former impoundments will undergo groundwater and surface water monitoring following the completion of excavation activities until GWPSs have been achieved. The post-closure care plan for the on-Site landfill (CBR-Onsite scenario only) additionally includes leachate management; landfill cap inspection, mowing, and maintenance; and 30 years of groundwater and surface water monitoring in the vicinity of the landfill.

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/demobilization, materials deliveries, and transportation and offloading of CCR at the off-Site landfill.

The expected number of on-Site accidents is higher under the CBR-Onsite scenario than under the CBR-Offsite scenario. Although the time required to excavate the impoundments is shorter by 0.6 years under the CBR-Onsite scenario, the overall duration of construction activities is longer by 1.8 years under this scenario due to the need to construct and then close the On-Site landfill (estimated to take 2.4 years). Moreover, all of the CCR excavated from the impoundments under the CBR-Onsite scenario will be hauled to the on-Site landfill, resulting in continuous hauling activity on-Site. Due to CCR hauling on-Site, Geosyntec estimates that the total number of equipment and vehicles travel miles required on-Site is over two times greater under the CBR-Onsite scenario than under the CBR-Offsite scenario (Geosyntec, 2021e). Based on on-Site labor hour estimates provided to us by Geosyntec for each closure scenario (Geosyntec, 2021e) and accident rates reported by the US Bureau of Labor Statistics for laborers and supervisors at construction sites (US DOL, 2020a-c), we estimated numbers of injuries and fatalities that would occur on-Site under each closure scenario. Under the CBR-Onsite scenario, we estimate that 6.4 injuries and 0.051 fatalities will occur on-Site. Under the CBR-Offsite scenario, we estimate that 2.8 injuries and 0.027 fatalities will occur on-Site. The expected number of on-Site accidents and injuries is broken down by labor category in Table 2.3.

Table 2.3 Expected Number of On-Site Worker Accidents Under Each Closure Scenario

Labor Category	CBR-Onsite		CBR-Offsite	
	Injuries	Fatalities	Injuries	Fatalities
Laborer	5.5	0.036	2.1	0.014
Site Supervisor/ Construction Project Manager/ Construction Observation Tech/Engineer	0.89	0.015	0.77	0.013
Total:	6.4	0.051	2.8	0.027

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

Under the CBR-Offsite scenario, truck accidents may occur during the hauling of CCR from the Site to an off-Site landfill. Given the volume of CCR in the impoundments, off-Site hauling under the CBR-Offsite scenario is expected to require approximately 5,180,000 vehicle travel miles (Geosyntec, 2021e). 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 0.66 injuries and 0.015 fatalities would be expected to occur among drivers and passengers of haul trucks due to hauling under the CBR-Offsite scenario.

In addition to hauling, both scenarios will also have off-Site impacts due to labor mobilization and demobilization, equipment and vehicle mobilization and demobilization, and materials delivery. When considering only CCR excavation, the magnitude of these factors is similar under both closure scenarios. However, construction and closure of the on-Site landfill requires additional mobilization/demobilization efforts and materials deliveries. Thus, the impact of these activities on the total off-Site risk to workers is greater under the CBR-Onsite scenario than under the CBR-Offsite scenario.[1] Table 2.4 shows the expected number of off-Site accidents under each closure scenario due to all categories of off-Site vehicle usage. For these calculations, we assumed that labor mobilization/demobilization relied upon passenger vehicles (cars or light trucks, including pickups, vans, and sport utility vehicles) and that hauling, equipment mobilization/demobilization, and material deliveries relied upon large trucks. Crash statistics for passenger vehicles and large trucks are reported by US DOT (2020). Summing together impacts across all forms of off-Site transport, 4.7 injuries and 0.061 fatalities would be expected under the CBR-Onsite scenario and 3.8 injuries and 0.055 fatalities would be expected under the CBR-Offsite scenario.

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

Off-Site Vehicle Use Category	CBR-Onsite		CBR-Offsite	
	Injuries	Fatalities	Injuries	Fatalities
Hauling	0	0	0.66	0.015
Labor Mobilization/Demobilization	4.7	0.059	3.0	0.039
Equipment Mobilization/Demobilization	0.025	0.00056	0.014	0.00032
Materials Delivery	0.046	0.0010	0.037	0.00084
Total:	4.7	0.061	3.8	0.055

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

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[1] The additional impacts of labor and equipment mobilization and materials delivery under the CBR-Onsite scenario (relative to the CBR-Offsite scenario) may be offset to an unknown degree by additional construction impacts required to expand the off-Site landfill under the CBR-Offsite scenario, if expansion of the landfill is determined to be necessary at some point in the future. However, the potential impacts of off-Site landfill expansion were not quantified in our report, because it is not known at this time whether expansion will be required.

Overall, taking into account accidents occurring both on- and off-Site, 11 injuries and 0.11 fatalities would be expected under the CBR-Onsite scenario, and 6.6 injuries and 0.082 fatalities would be expected under the CBR-Offsite scenario. Thus, overall risks to workers would be higher under the CBR-Onsite scenario and lower under the CBR-Offsite scenario.

2.2.4.2 Community Risks

Accidents

Truck accidents that occur off-Site can result in injuries or fatalities to 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 travel mileage required under the CBR-Offsite scenario (*i.e.*, 5,180,000 vehicle travel miles; Geosyntec, 2021e), haul truck accidents could result in an estimated 1.9 injuries and 0.069 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 this scenario. No fatalities or injuries would be expected to occur among community members under the CBR-Onsite scenario due to hauling, because no CCR will be hauled off-Site under this scenario.

Because the CBR-Onsite scenario requires additional construction activities relative to the CBR-Offsite scenario (namely, construction and closure of the on-Site landfill), the CBR-Onsite scenario is associated with a higher risk of accidents occurring off-Site due to non-hauling activities, including labor and equipment mobilization/demobilization and materials delivery. However, as shown in Tables 2.1 and 2.2, when summing together all forms of off-Site transport required (labor and equipment mobilization/demobilization, materials delivery, and off-Site hauling), the CBR-Onsite scenario requires a total of 8,130,000 off-Site vehicle and equipment travel miles and the CBR-Offsite scenario requires a total of 10,500,000 off-Site vehicle and equipment travel miles. Thus, the additional travel mileage required under the CBR-Offsite scenario to haul CCR to the off-Site landfill exceeds the additional travel mileage required under the CBR-Onsite scenario to construct and close the on-Site landfill. The risk of accidents occurring among community members is higher under the CBR-Offsite scenario than under the CBR-Onsite scenario. Overall, non-hauling activities could result in an estimated 1.4 injuries and 0.021 fatalities among community members under the CBR-Offsite scenario. Under the CBR-Onsite scenario, non-hauling activities could result in an estimated 2.1 injuries and 0.031 fatalities among community members. Summing together impacts across all forms of off-Site transport required, 2.1 community injuries and 0.031 community fatalities would be expected under the CBR-Onsite scenario, and 3.3 community injuries and 0.090 community fatalities would be expected under the CBR-Offsite scenario (Table 2.5).

Table 2.5 Expected Number of Community Accidents Under Each Closure Scenario

Off-Site Vehicle Use Category	CBR-Onsite		CBR-Offsite	
	Injuries	Fatalities	Injuries	Fatalities
Hauling	0	0	1.9	0.069
Labor Mobilization/Demobilization	1.9	0.024	1.2	0.016
Equipment Mobilization/Demobilization	0.071	0.0026	0.040	0.0015
Materials Delivery	0.13	0.0048	0.11	0.0039
Total:	2.1	0.031	3.3	0.090

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

Traffic

Haul routes would be 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, near the off-Site landfill.

Traffic may increase temporarily around the Site under both closure scenarios due to the daily arrival and departure of the workforce, equipment mobilization/demobilization, and material deliveries. These demands will be greater under the CBR-Onsite scenario than under the CBR-Offsite scenario due to the additional construction activities associated with construction and closure of the on-Site landfill. However, these impacts would be 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 materials 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, Geosyntec (2021e) estimates that approximately 173,000 truckloads will be required to transport CCR from the NAP/OEAP and the NEAP to the off-Site landfill over approximately 1,450 hauling days. Assuming a 10-hour work day, a haul truck would therefore need to pass a given location near the Site once every 2.5 minutes on average for the duration of excavation activities under the CBR-Offsite scenario. The traffic demands of the CBR-Offsite scenario would therefore be considerable. This level of traffic could potentially cause traffic delays on local roads and cause damage to local roadways.

Moreover, Oakwood Junior High School is located at 21600 North 900 East Road in Danville, at the entrance to the Vermilion Power Plant. As a result of considerable off-Site hauling activities, the CBR-Offsite scenario would create greater traffic, nuisance, and safety concerns at the school than would occur under the CBR-Onsite scenario. A haul truck would likely pass the school once every 2.5 minutes on average, for the duration of the school day, under the CBR-Offsite scenario.

Noise

Construction generates a great deal of noise, both in the vicinity of the Site and along haul routes. In a closure impact analysis performed by the Tennessee Valley Authority (TVA, 2015), the authors found that "[T]ypical noise levels from construction equipment used for closure are expected to be 85 dBA or less when measured at 50 ft. These types of noise levels would diminish with distance… at a rate of approximately 6 dBA per each doubling of distance and therefore would be expected to attenuate to the recommended EPA noise guideline of 55 dBA at 1,500 ft." Because there are no residences or businesses within 1,500 feet of the Site, we do not anticipate that any residences or business will be adversely impacted by noise pollution under either closure scenario. However, recreators and wildlife could be temporarily impacted by construction noise under both scenarios. Major recreational and high-value natural areas with 1,500 feet of the impoundments include the Middle Fork and the Orchid Hill Natural Heritage Landmark. The Orchid Hill Natural Heritage Landmark is also located within 1,500 feet of the proposed location of the on-Site landfill (*i.e.*, the power plant area).

The duration of noise impacts in the immediate vicinity of the impoundments will be slightly greater under the CBR-Offsite scenario than under the CBR-Onsite scenario, because the expected duration of excavation activities is longer by 0.6 years under this scenario (due to the need to haul CCR off-Site, which requires the use of lower-capacity haul trucks). However, across the entire Site, the overall duration of noise impacts from construction is also 1.8 years longer under the CBR-Onsite scenario than under the CBR-Offsite scenario, due to the 2.4 years of construction required to construct and then close the on-Site landfill. Unlike construction activities near the impoundments (which will impact the Orchid

Hill Natural Heritage Landmark and the Middle Fork), construction activities in the vicinity of the on-Site landfill will only impact the Orchid Hill Natural Heritage Landmark. The Orchid Hill Natural Heritage Landmark has more limited foot traffic relative to the Middle Fork. Taking all these factors into account, we estimate that the noise impacts of construction in the immediate vicinity of the Site will be approximately the same under both closure scenarios.

Local roads near the Site (and the off-Site landfill, under the CBR-Offsite scenario) may also experience noise pollution due to high volumes of truck traffic. As described above (Traffic), the construction schedule for the CBR-Offsite scenario requires haul trucks to pass by a given location every 2.5 minutes on average for 10 hours each day for years 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 from the daily arrival and departure of the workforce, equipment mobilization/demobilization, and materials deliveries. These impacts would be 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 materials 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. Off-Site noise impacts on residents would therefore be expected to be greater under the CBR-Offsite scenario than under the CBR-Onsite scenario.

Air Quality

Construction can adversely impact air quality. Air pollution can occur both on-Site and off-Site (*e.g.*, along haul routes), potentially impacting workers as well as community members. With regard to construction activities, two categories of air pollution are of particular concern: equipment emissions and fugitive dust. The equipment emissions of greatest concern are those found in diesel exhaust. Most construction equipment is diesel-powered, including the dump trucks 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.

On-Site, emissions would be expected to be significantly higher under the CBR-Onsite scenario than under the CBR-Offsite scenario. The CBR-Onsite scenario includes construction and closure of the landfill, which will add 1.8 years to the overall duration of construction activities at the Site and will also increase the overall level of construction activity occurring on the Site relative to the CBR-Offsite scenario. Moreover, under the CBR-Onsite scenario, there will be haul trucks moving CCR around the Site continuously during excavation of the impoundments. Overall, Geosyntec estimates that the total number of on-Site equipment and vehicles travel miles required under the CBR-Onsite scenario is over two times greater than the number of on-Site travel miles required under the CBR-Offsite scenario (Geosyntec, 2021e).

Off-Site, hauling CCR to the off-Site landfill under the CBR-Offsite scenario will result in approximately 5,180,000 vehicle travel miles' worth of off-Site diesel vehicle emissions that will not occur under the CBR-Onsite scenario. Other types of off-Site vehicle emissions, including those resulting from labor and equipment mobilization/demobilization and materials deliveries, would be larger under the CBR-Onsite scenario than under the CBR-Offsite scenario due to the need to construct and close the on-Site landfill. However, taking all forms of off-Site vehicle transport into account, the CBR-Offsite scenario requires more off-Site vehicle and equipment travel miles than the CBR-Onsite scenario (10,500,000 off-Site vehicle and equipment travel miles under the CBR-Offsite scenario *versus* 8,130,000 off-Site vehicle and equipment travel miles under the CBR-Onsite scenario). Off-Site, emissions would therefore be expected to be higher under the CBR-Offsite scenario than the under CBR-Onsite scenario.

Summing across all of the on-Site and off-Site vehicle and equipment demands for each scenario, as presented in Tables 2.1 and 2.2, the CBR-Onsite scenario requires 8,530,000 total vehicle and equipment travel miles, and the CBR-Offsite scenario requires 10,700,000 total vehicle and equipment travel miles. Thus, the total air emissions from construction equipment and vehicles would likely be larger under the CBR-Offsite scenario than under the CBR-Onsite scenario.

Environmental Justice

The State of Illinois defines environmental justice (EJ) communities to be those communities with a minority population above twice the state average and/or a total population below twice the state poverty rate (IEPA, 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 (IEPA, 2019), the nearest EJ communities (near Danville/Tilton) lie approximately 4.8 miles from the Site. It is unlikely that these communities would be directly impacted by on-Site air emissions, noise pollution, traffic, accidents, or other negative impacts arising at the Site. However, they may be impacted by off-Site impacts, including CCR hauling, labor and equipment mobilization/demobilization, and material deliveries. Off-Site impacts due to labor and equipment mobilization/demobilization and material deliveries would be expected to be diffuse (*i.e.*, to span a wide range of transport routes originating over a wide area). Additionally, these impacts would be expected to largely occur at the beginning or end of each 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 materials deliveries). Haul truck impacts, in contrast, will rely on a single transport route and will result in significant traffic impacts on local roads throughout the entire excavation period. Therefore, off-Site hauling, which will only occur under the CBR-Offsite scenario, would more likely have a significant impact on EJ communities than other types of off-Site vehicle use. For this reason, the EJ impacts of the CBR-Onsite scenario would be expected to be relatively small. In contrast, under the CBR-Offsite scenario, EJ communities located along the haul route to the off-Site landfill or near the off-Site landfill itself may be negatively impacted throughout the excavation period by the air pollution, noise, traffic, and accidents generated by CCR-hauling activities. A review of the Illinois map of EJ communities reveals that the off-Site landfill is located within the buffer zone of the EJ community near Tilton, and that transport of CCR to the landfill will require hauling CCR through the EJ communities near Tilton and Danville (Figure 2.1).

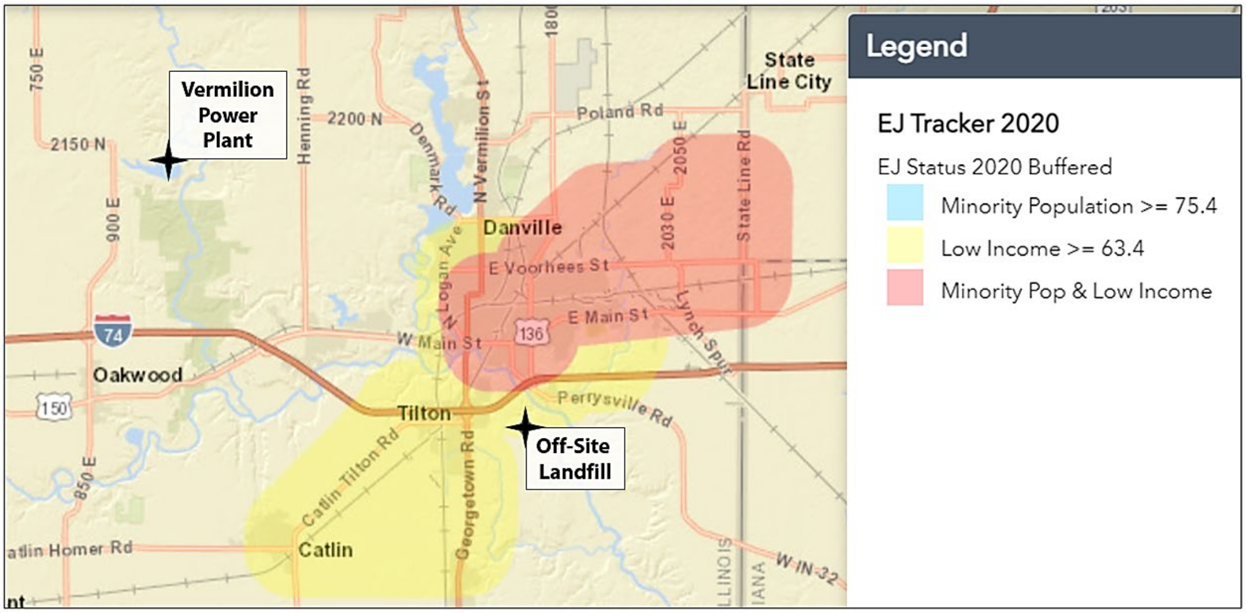

Figure 2.1 Environmental Justice Communities in the Vicinity of the Off-Site Landfill. Adapted from IEPA (2019).

Scenic and Recreational Value

During construction activities, negative impacts on scenic and recreational value may occur at recreational areas immediately adjacent to the Site, including the Orchid Hill Natural Heritage Landmark and the Middle Fork of the Vermilion River. Noise impacts were described above. In addition, construction activities at the impoundments may be visible to recreators on the Middle Fork, potentially interfering with enjoyment of the view. Access to the Orchid Hill Natural Heritage Landmark could also potentially be restricted during the construction period, because this area borders on both the proposed on-Site landfill location and the NAP/OEAP. Unfortunately, because both closure scenarios require complete excavation of the CCR, there is no way to avoid these potential impacts under either the CBR-Onsite or CBR-Offsite scenario. The duration of excavation activities is expected to be approximately 0.6 years longer under the CBR-Offsite scenario than the under CBR-Onsite scenario; however, the CBR-Onsite scenario may have greater impacts on the Orchid Hill Natural Heritage Landmark than the CBR-Offsite scenario, because it will require 2.4 years of additional work to construct and then close the on-Site landfill. Overall, we anticipate that the short-term impacts of both closure scenarios on the scenic and recreational value of nearby recreational areas will be approximately the same.

Although there is the potential for short-term negative impacts to occur at recreational areas near the Site under both closure scenarios, there would also be long-term positive impacts that may arise post-closure. These include:

- Demolition of the power plant, which may improve the view from the Middle Fork of the Vermilion River (known for its pristine and undeveloped landscapes). Because the CBR-Onsite scenario includes near-term plans for power plant demolition, this benefit will occur earlier and with greater certainty for that alternative compared to the CBR-Offsite alternative, for which these benefits may not be realized for years or even decades following closure; and

- Increased public access to the Orchid Hill Natural Heritage Landmark, which is located adjacent to the current power plant location (Various, 1990-2010). Because power plant demolition will occur earlier and with greater certainty under the CBR-Onsite scenario, this benefit will likely occur earlier for that scenario compared to the CBR-Offsite 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 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 2.2.4.2. In summary, the CBR-Onsite scenario requires 8,530,000 total on- and off-Site vehicle and equipment travel miles, and the CBR-Offsite scenario requires 10,700,000 total on- and off-Site vehicle and equipment travel miles (Tables 2.1 and 2.2). Thus, GHG emissions from construction equipment and vehicles would likely be greater under the CBR-Offsite scenario than under the CBR-Onsite scenario.

We did not quantify the carbon footprint of the composite bottom liner system and the composite final cover system that would be required for the on-Site landfill under the CBR-Onsite scenario. Each of these liner systems requires approximately 27 acres of geomembrane materials, including a 60-mil HDPE geomembrane liner for the bottom liner and a 40-mil LLDPE geomembrane liner for the final cover system (Geosyntec, 2021a). The carbon footprint of these geomembrane materials (*i.e.*, the fossil fuel emissions required to manufacture them) is an additional source of GHG emissions at the Site under the CBR-Onsite scenario. If expansion of the off-Site landfill becomes necessary in order to accept all of the CCR from the impoundments, then the CBR-Offsite scenario may also have an additional, unquantified carbon footprint due to the manufacture of geomembranes used in the expanded landfill's liner.

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. Overall, the energy demands of construction equipment and vehicles would likely be larger under the CBR-Offsite scenario than under the CBR-Onsite scenario. We did not quantify the energy demands of the geomembranes required for the construction and closure of the on-Site landfill under the CBR-Onsite scenario or, potentially, the expansion of the off-Site landfill under the CBR-Offsite scenario.

Natural Resources and Habitat

Construction would likely have a negative short-term impact on the natural resources and habitat in the vicinity of the impoundments and the proposed on-Site landfill location. For example, excavation of the impoundments will result in the destruction of some habitat that may currently overlie impoundments under both closure scenarios. Dewatering, excavation, and Site restoration will also result in long-term shifts in the habitat overlying the impoundment (*e.g.*, areas of the impoundment that are not currently grassland will be converted to grassland).

Construction of the on-Site landfill under the CBR-Onsite scenario is not expected to result in significant habitat loss, because the landfill will be constructed over the site of the retired power plant rather than over existing high-quality habitat. Thus, the magnitude of direct impacts on habitat is expected to be approximately the same under both the CBR-Onsite and CBR-Offsite scenarios. However, the duration of time over which these direct habitat impacts occur will be slightly longer under the CBR-Offsite scenario than under the CBR-Onsite scenario, because excavation of the impoundments is expected to take 0.6 years longer under the CBR-Offsite scenario.

In addition to direct impacts to the existing habitat atop the impoundments, construction activities may have indirect impacts by causing alarm and escape behavior in wildlife found near the impoundments. In the vicinity of the impoundments, these indirect impacts will be slightly worse under the CBR-Offsite scenario than under the CBR-Onsite scenario, because the duration of CCR excavation activities is longer by 0.6 years under the former scenario. However, indirect impacts in the vicinity of the on-Site landfill location will be worse under the CBR-Onsite scenario, due to the construction and closure of the on-Site landfill. Indirect impacts on habitat would likely be somewhat worse overall under the CBR-Onsite scenario, because the overall duration of construction activities is 1.8 years longer than under the CBR-Offsite scenario.

The likelihood of negative impacts occurring to sensitive aquatic organisms is small under both closure scenarios. There is potential, however, for limited negative short-term impacts to aquatic species in the Middle Fork of the Vermilion River due to, *e.g.*, sediment runoff during construction. Although erosion prevention and sediment control measures will be undertaken under both of the closure scenarios, some small impacts could still conceivably occur. Eight state threatened or endangered aquatic species may be found in the Middle Fork of the Vermilion River near the Site, including the bluebreast darter, clubshell, little spectaclecase, northern riffleshell, purple wartyback, salamander mussel, silvery salamander, and the wavy-rayed lampmussel (Hanson Professional Services Inc., 2019, Appendix A). All but two of these species (the bluebreast darter and the silvery salamander) are freshwater mussels. Around 2010, IDNR performed a mussel survey on behalf of the National Park Service in the vicinity of the NEAP (extending approximately 200 feet upstream and 700 feet downstream) and found that the aquatic habitat in this area was not suitable for mussels due to an abundance of scoured bedrock. Only a single live mussel was found during this survey, on the opposite bank of the Middle Fork of the Vermilion River (NPS, 2010). In 2018, Stantec performed a mussel survey over a longer reach near the embankments in support of potential riverbank stabilization efforts. It similarly found that "the mussel densities within the project area were described as low and suitable habitat as sparse" (US FWS, 2019). The likelihood of negative impacts occurring to sensitive aquatic organisms is small under both closure scenarios. The duration of time over which these impacts may occur is slightly longer under the CBR-Offsite scenario than under the CBR-Onsite scenario, because excavation of the impoundments is expected to take 0.6 years longer under the former scenario.

In summary, there is some potential for short-term negative impacts to occur to terrestrial and aquatic species during construction activities under both scenarios. However, long-term positive impacts would likely also occur post-closure due to the demolition of the power plant, which will result in the establishment of new habitat atop the footprint of the plant and (in the case of the CBR-Onsite scenario) the new on-Site landfill. The long-term benefits of power plant demolition will be realized more rapidly, and potentially with greater certainty, under the CBR-Onsite scenario than under the CBR-Offsite scenario, because the CBR-Onsite scenario includes near-term plans for plant demolition. Under the CBR-Offsite scenario, demolition of the power plant may not occur for decades.

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

The time horizon over which GWPSs will be exceeded at the Site is immaterial from a risk perspective, because there is no unacceptable risk associated with exceedances of a GWPS at the Site (see Section 2.2.1). Additionally, at sites where groundwater corrective action will be implemented, it is inappropriate to evaluate the time to achieve GWPSs based on closure alone, because both closure and corrective actions will affect future groundwater concentrations. See Section 4.1.6 of the CAAA for an evaluation of the times to achieve GWPSs at the Site based both on source control and the corrective action alternatives.

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

Section 2.2.1 evaluates potential risks to human and ecological receptors arising from the leaching of CCR-associated constituents into groundwater during closure activities and following closure of the impoundments. Section 2.2.2 evaluates the potential for CCR releases to occur due to dike failure or overtopping during flood conditions. In summary, there is no current or future risk to any human or ecological receptors due to CCR-associated constituents leaching into groundwater at this Site. Additionally, there is no current or future risk of overtopping occurring at the embankments due to flood conditions at the Site. Dike failure due to seismic activity and flood conditions is also exceedingly unlikely. Due to the steady migration of the Middle Fork of the Vermilion River towards the embankments over time, dike failure could conceivably occur at the Site prior to the complete excavation of the basins, if no riverbank stabilization infrastructure is put in place. However, because the erosion of the riverbank is being closely monitored and an emergency response plan has recently been developed (Geosyntec, 2021h), we judge that there is little practical risk of dike failure occurring due to riverbank migration.

Section 2.2.4 provides an evaluation of several additional potential risks to human health and the environment during closure activities, including risks of accidents occurring to workers; risks to nearby residents and EJ communities related to accidents, traffic, noise, and air quality; and risks of natural resource impacts and habitat impacts occurring in the vicinity of construction areas at the Site. 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))

After all of the CCR has been removed from the impoundments, there will be no long-term risk of engineering or institutional failures leading to releases of CCR from the impoundments or the leaching of CCR-associated constituents from the impoundments (see Sections 2.2.1 and 2.2.2 above). Reliable engineering and institutional controls (*e.g.*, a bottom liner, a leachate management system, and groundwater monitoring) will also be implemented at the on- and off-Site landfills. The CBR-Onsite and CBR-Offsite scenarios would therefore both be 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))

Sections 3 and 4 of this report present and evaluate the corrective measures being considered at the Site. Because both closure scenarios involve complete excavation of CCR from the impoundments, we anticipate that there will be no difference in the potential need for future corrective actions under either 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))

All CCR will be excavated from all the impoundments under both closure scenarios. Both closure scenarios would be expected to be fully effective in controlling future releases. Because both scenarios entail CBR, there is no expected difference between scenarios in terms of the extent to which containment practices will reduce further releases.

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

All of the CCR in the impoundments will be excavated under both closure scenarios. Both closure scenarios would therefore be expected to require treatment technologies to the same extent. Sections 3 and 4 evaluate the various corrective measures being considered at the Site, including treatment technologies.

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

Excavation and landfilling are both highly reliable and well-standardized methods for managing waste that rely on common construction activities. Dewatering and excavating saturated CCR can present challenges during closure; however, those challenges will be the same for both closure scenarios. In general, complete excavation of the impoundments will present the same level of difficulty for both closure scenarios. However, the expected ease of implementation may vary between the two closure scenarios due to other factors, including the demands of on-Site landfill construction and the relative impacts of off-Site *versus* on-Site hauling and disposal of CCR.

Constructing a new on-Site landfill will require planning, design, and construction. While these elements are unique to the CBR-Onsite scenario, the tasks and processes associated with the addition of a new on-Site landfill are straightforward and standard. We anticipate that these elements of the CBR-Onsite scenario can be completed in coordination with the necessary permitting for closure of the existing CCR surface impoundments.

Hauling will be easier to implement under the CBR-Onsite scenario than under the CBR-Offsite scenario, due to the shorter haul distance required for on-Site disposal of the CCR from the impoundments than for off-Site disposal and the lack of need to haul the CCR over public roads. When using public roads, there are limits placed on the capacity of haul trucks traveling on those roads. The need to utilize only on-Site private roads will allow for the use of higher-volume haul trucks, thereby reducing the number of trucks and trips required for CCR excavation and transport. Additionally, the off-road haul trucks that will be used under the CBR-Onsite scenario can work in inclement weather, whereas the interstate vehicles that will be used under the CBR-Offsite scenario will require cleaning and preparation prior to leaving the Site in poor weather conditions. Finally, because the CBR-Offsite scenario involves hauling ash 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 Risks), off-Site hauling may additionally have detrimental impacts due to an increased incidence of trucking accidents, truck traffic, noise, and air pollution. Extensive traffic due to hauling activity may also cause damage to public roadways.

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 DMG and the owner/operator of the third-party landfill in order to outline acceptable waste conditions upon delivery, daily waste production rates, and the expected duration of the project. Off-Site landfilling may additionally raise issues related to the co-disposal of CCR and other non-hazardous wastes. Finally, the construction schedule for excavation may be negatively impacted if, during the course of closure, it is determined that the off-Site landfill must be expanded in order to receive all of the CCR excavated from the impoundments.

2.4.2 Expected Operational Reliability of the Closure Alternative

After all of the CCR has been removed from the impoundments, there will be no long-term risk of operational failures leading to releases of CCR from the impoundments or the leaching of CCR-associated constituents from the impoundments. Reliable operational controls (*e.g.*, a bottom liner, a leachate management system, and groundwater monitoring) will also be implemented at the on- and off-Site landfills. Thus, the operational reliability of both closure scenarios is expected to be high.

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

Permits and approvals will be needed under both closure scenarios. All permits would be expected to be approved. Components of the closure scenarios that may require a permit include the disposal of water from unwatering and dewatering of the impoundments, which will be managed under the existing NPDES permit. Additional permits addressed in this report include those associated with the on- and off-Site landfills.

As required by the Agreed Interim Order (Illinois, Attorney General, 2021), construction of the on-Site landfill under the CBR-Onsite scenario will require a permit. In addition, the new on-Site landfill will require a Stormwater Pollution Prevention Plan (SWPPP). Non-contact stormwater will be discharged under the existing NPDES permit.

Under the CBR-Offsite scenario, it may be necessary to construct additional, pre-approved cells at the off-Site landfill in order to accommodate the mass of CCR to be received. 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.

Per the Agreed Interim Order (Illinois, Attorney General, 2021), both closure scenarios will require the following permit applications:

- NPDES Permit Modification for closure construction, to be submitted to IEPA;
- Land Disturbance Permit, to be submitted to State Historic Preservation Office (SHPO); and
- 309 Wastewater Treatment Permit, to be submitted to IEPA.

The permit documents will also be submitted to the Middle Fork River Corridor Advisory Committee for review.

2.4.4 Availability of Necessary Equipment and Specialists

Excavation, hauling, and landfilling are reliable and standardized 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 the availability of construction equipment under both scenarios if supply chain resilience does not improve by the time construction begins. 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 longer hauling distance required, the smaller haul truck capacity, and the need to haul over public roads under this scenario. If sufficient trucks and truck drivers are not available, the construction schedule may lengthen based on hauling-related delays.

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

The new on-Site landfill would be designed and constructed to be able to receive all CCR wastes that will be generated on-Site. Treatment would consist of the removal of water from wet CCR prior to loading the CCR into haul trucks. Water from unwatering and dewatering of the impoundments would be discharged *via* the existing NPDES permit.

The volume of CCR that will be excavated from the NAP/OEAP and NEAP and require disposal is estimated to be 2.6 million cubic yards (MCY). 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 Republic Services Brickyard Disposal Landfill in Danville, Illinois. This facility has 5.9 MCY of remaining capacity in its current permitted footprint. It receives 0.3 MCY of waste annually, and is located 16 miles from the Site. Thus, the Republic Services Brickyard Disposal and Recycling Inc. landfill has sufficient capacity to receive CCR from the NAP/OEAP and NEAP.

Due to the relatively short period over which CCR would be received at the landfill, vertical and/or lateral expansions may become necessary. Additionally, the landfill operators may need to develop a disposal plan to account for the increased volume of material that will be received and the unique CCR waste characteristics. Elements of this disposal plan might include increasing daily operational capacity and procedures, expediting planned airspace construction, and potentially expediting landfill expansion.

If expansion of the Brickyard Disposal Landfill is impractical or infeasible, then an alternative landfill located farther from the Site would need to be identified. A likely alternative to the Brickyard Disposal Landfill is the Republic Services Illinois Landfill in Hoopeston, Illinois. It has 12.3 MCY of remaining capacity in its current permitted footprint, receives 0.06 MCY of waste annually, and is located 29 miles from the Site (IEPA, 2021b).

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

As demonstrated in the February 2020 Human Health and Ecological Risk Assessment (Appendix A), modeled surface water concentrations in the Middle Fork of the Vermilion River are all below relevant human health and ecological screening benchmarks. Due to the complete removal of the source material from the NAP/OEAP and NEAP under both closure scenarios, surface water concentrations of CCR-associated constituents are expected to decline over time. Modeling was performed to evaluate future groundwater quality in the vicinity of the NAP/OEAP resulting from source control (Ramboll, 2021a). The modeling concluded that mass flux to the Middle Fork of the Vermilion River from the MGU will be reduced by approximately 50% 10 years after closure is completed and by approximately 80% 35 years after closure is completed (Ramboll, 2021a). Mass flux declines will occur more slowly in the LGU, which has lower concentrations, due to its lower-permeability deposits (Ramboll, 2021a). Thus, no future exceedances of any human health or ecological screening benchmarks are anticipated under either closure scenario.

Additionally, the lined landfills that receive the CCR excavated from the impoundments under both closure scenarios will be managed to ensure that no surface water impacts occur in the vicinity of the landfills. In summary, no impacts on any waters of the state are expected.

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

Several nonprofits representing community interests near the Site have campaigned for complete excavation of the CCR impoundments at the Site, including the Eco-Justice Collaborative, Earthjustice, American Rivers, and the Prairie Rivers Network (American Rivers, 2018; Earthjustice, 2021; Eco-Justice Collaborative, 2021; Barkley, 2012). Major concerns cited by these groups include potential impacts to groundwater and surface water quality and the potential threat to dike stability posed by riverbank migration. Because the CBR-Offsite and CBR-Onsite scenarios both involve complete excavation of the impoundments, these scenarios should address all of the major concerns raised by these groups.

Under the CBR-Offsite scenario, excavation can begin immediately. Under the CBR-Onsite scenario, dewatering can begin immediately, reducing risks of dike failure and the leaching of CCR-associated constituents from the impoundment; CCR excavation will then begin once the plant is demolished and the on-Site landfill is constructed. Because the CBR-Onsite scenario does not require off-Site hauling of CCR, it presents less risks to nearby residents and EJ communities in the form of accidents, traffic, noise, and air pollution. Additionally, this scenario will more rapidly address stakeholder concerns about having an inactive power plant located along Illinois's only National Scenic River.

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 summarizes the expected impacts of the 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, CBR-Onsite has been identified as the most appropriate closure scenario for the NAP/OEAP and the NEAP. Key benefits of the CBR-Onsite scenario relative to the CBR-Offsite scenario include near-term plans for the demolition of the power plant, which will have scenic benefits along Illinois's only National Scenic River, and reduced impacts to community members and the environment due to construction activities (*e.g.*, fewer constructed-related community accidents, lower energy demands, less air pollution and GHG emissions, less traffic, and lower impacts to EJ communities). This conclusion is subject to change following completion of an upcoming public meeting, which will be held in December 2021 pursuant to requirements under IAC Section 845.710(e) and the Agreed Interim Order (IEPA, 2021a; Illinois, Attorney General, 2021). 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 Corrective Measures Assessment

This section of the report presents a CMA pursuant to requirements under IAC Section 845.660 (IEPA, 2021a). The goal of a CMA is to provide a high-level screening of potential corrective measures based on expected remedy performance, reliability, ease of implementation, and other factors (IEPA, 2021a). A detailed analysis of potentially viable corrective actions, as identified in the CMA, is provided in the CAAA (Section 4).

It is important to note that many CCR sites are complex groundwater environments where remedial actions will inherently take many years to complete. While no formal definition of a complex groundwater environment exists, most would agree that there a number of common characteristics at complex groundwater sites, including the following (National Research Council, 2013):

- Highly heterogeneous subsurface environments;
- Large source zones;
- Multiple, recalcitrant constituents; and
- Long time frames over which releases occurred.

Each of these characteristics are common at CCR sites. Surface impoundments are often tens to hundreds of acres in size and many have operated for decades, leading to large source zones and prolonged releases. Furthermore, CCR impoundments are often located in alluvial geologic settings where sands are interbedded with silts and clays. This results in a heterogeneous environment where constituent mass may persist for many years in low-permeability deposits. Finally, the constituents that are most common at CCR sites include metals and inorganics that do not naturally biodegrade. The combination of these factors results in a complex groundwater environment where remediation, even under the best of circumstances, may take many years to achieve GWPSs. It is for these reasons that US EPA refused to specify what is a reasonable *versus* an unreasonable timeframe for groundwater corrective actions at CCR sites, stating that "EPA was truly unable to establish an outer limit on the necessary timeframes—including even a presumptive outer bound" (US EPA, 2015a, p. 21419).

It is also important to note that source control, which at a CCR impoundment could include either capping or excavation, is generally considered to be one of the more effective remedial action approaches. Source control involves removing the hydraulic head from an impoundment (*i.e.*, unwatering and dewatering) and preventing further downward migration of constituents. US EPA has found that "releases from surface impoundments [to groundwater] drop dramatically after closure" (US EPA, 2014, pp. 5-18 to 5-19). As a result, the implementation of source control often has a more substantial and more immediate effect on groundwater quality improvements than other groundwater corrective measures. In this CMA (Section 3) and CAAA (Section 4), every scenario evaluated pairs source control with other additional groundwater remediation strategies.

3.1 Corrective Measure Alternative Descriptions

Five potential corrective measures were selected for evaluation in the CMA for this Site. Each corrective measure includes source removal based on the CBR-Onsite scenario (*i.e.*, Closure-by-Removal with CCR disposal at an on-Site landfill), as evaluated and tentatively selected in the CAA. Corrective measures considered in the CMA include Source Control with Monitored Natural Attenuation (Source Control-MNA), Source Control with Groundwater Extraction (Source Control-GE), Source Control with Monitored Natural Attenuation and Groundwater Extraction (Source Control-MNA/GE), Source Control with Construction of a Cutoff Wall (Source Control-CW), and Source Control with Construction of a Permeable Reactive Barrier (Source Control-PRB). Each of these corrective measures was evaluated in the CMA for its potential viability at the Site. Under the Source Control-MNA alternative, groundwater concentrations of dissolved constituents will attenuate *via* naturally occurring physical and chemical processes in areas downgradient of OEAP/NAP; active monitoring will be performed to verify and document the remediation processes. Under the Source Control-GE alternative, the groundwater collection trench will continue operating post-closure in the OEAP area, and an additional GE system will be installed in the NAP area in order to extract potentially impacted groundwater from the aquifer, helping to contain the contaminant plume and prevent the lateral migration of constituents off-Site. Under the Source Control-MNA/GE alternative, the groundwater collection trench will continue operating post-closure in the OEAP area, and groundwater concentrations of dissolved constituents will attenuate *via* natural physical and chemical processes in areas downgradient of the NAP. Under the Source Control-CW alternative, a trench will be dug along the downgradient perimeter of the OEAP and NAP and filled with a soil-bentonite mixture, creating a low-permeability subsurface barrier to the lateral migration of constituents off-Site. Under the Source Control-PRB alternative, a subsurface barrier of reactive materials (*e.g.*, zerovalent iron) will be placed in the path of groundwater flow downgradient of the NAP/OEAP in order to promote the *in situ* transformation and/or immobilization of CCR-associated constituents.

The performance of each of these corrective measures is influenced by the closure activities described above in Section 2, including excavation of the CCR from the impoundments (Closure-by-Removal with on-Site landfill CCR disposal, or CBR-Onsite) and construction of a groundwater collection trench, as required by the Agreed Interim Order (Illinois, Attorney General, 2021). The groundwater collection trench will be located downstream of the OEAP and will intercept seepage from the impoundment prior to and during the excavation of CCR from the impoundment. Groundwater and seep water collected in the trench will be sent to the NAP Secondary Pond and discharged *via* the NPDES-permitted outfall. For all corrective measures considered in this CMA, the groundwater collection trench will operate at least until closure has been completed. Because the impacts of the closure activities, including the construction of the groundwater collection trench, on human health and the environment, engineering reliability, and other factors were already evaluated in the CAA (Section 2), they were not re-evaluated in this section. Additionally, because complete excavation of the CCR and installation of the groundwater collection trench will occur under all the corrective measure alternatives, the impacts of source control and the trench will be the same under all the alternatives. We have therefore omitted discussion of the impacts of the closure-related activities from this section of the report.

This report evaluates the potential performance, reliability, and impacts of the various corrective measures, but does not make any judgements regarding the need for these corrective measures. It should be noted, however, that the primary pond of the NEAP was constructed atop bedrock using earthen berms that contain a low-permeability clay core keyed into the underlying shale. Constituent migration from this impoundment is therefore expected to be very limited, and there are no exceedances of the relevant GWPSs that have been attributed to the NEAP. Thus, corrective measures other than source control may not be necessary for the NEAP.

3.1.1 Source Control with Monitored Natural Attenuation

The United States Environmental Protection Agency (US EPA, 1999) defines MNA as "[t]he reliance on natural attenuation processes (within the context of a carefully controlled and monitored site cleanup approach) to achieve site-specific remediation objectives within a time frame that is reasonable compared to that offered by other more active methods." MNA relies on naturally occurring physical and chemical processes to immobilize potentially problematic constituents in groundwater and attenuate dissolved concentrations of those constituents. Chemical processes that naturally promote the attenuation of dissolved inorganic constituent concentrations in groundwater include sorption, precipitation, and redox reactions. Physical processes that promote attenuation include dispersion and dilution (US EPA, 2015b). US EPA has determined that MNA can be a viable alternative at sites impacted by inorganic constituents such as metals and metalloids, especially when implemented alongside source control measures (US EPA, 1999, 2015b). A site-specific analysis prepared by Geosyntec for the Vermilion Site (Geosyntec, 2021b) demonstrates that MNA is a promising alternative for this Site. The following factors make the Vermilion Site well-suited to the use of MNA (Geosyntec, 2021b; US EPA, 2015b):

- MNA will be implemented in conjunction with a source control measure,
- No receptors at or near the Site are currently being exposed to a contaminant,
- The contaminant plume is not expanding,
- Contaminant immobilization is happening naturally in the subsurface, and
- GWPSs can be achieved within a reasonable timeframe.

Because MNA relies on natural processes, implementation of the Source Control with Monitored Natural Attenuation (Source Control-MNA) alternative does not require the installation, operation, or maintenance of any engineered systems or structures other than maintenance of the monitoring well network. Long-term management associated with groundwater monitoring will be undertaken to ensure that attenuation is occurring as planned. Groundwater monitoring will continue until GWPSs are achieved. Following the completion of source control measures, the Source Control-MNA remedy will require 1-2 years to design, construct, and implement, which includes any additional investigations required to characterize Site conditions and additional work related to the design and installation of the groundwater monitoring system.

3.1.2 Source Control with Groundwater Extraction

Under the Source Control with Groundwater Extraction (Source Control-GE) alternative, the groundwater collection trench will continue to operate post-closure downgradient of the OEAP, and an additional GE system will be installed downgradient of the NAP to extract potentially impacted groundwater from the aquifer. The GE system at the NAP will either be comprised of groundwater pumping wells or a groundwater collection trench. Extraction will help contain the contaminant plume and prevent the lateral migration of constituents off-Site. If groundwater monitoring reveals a need for treatment of extracted groundwater prior to discharge, then a treatment system will be designed and implemented at the Site. Water treatment, if needed, will include a settling pond and possibly pH adjustment. Under this scenario, groundwater captured by the GE system will be discharged to the Middle Fork of the Vermilion River *via* one of the facility's NPDES-permitted outfalls.

GE using wells may be difficult to implement, because the alluvial deposits at the NAP vary in composition laterally and vertically. Additional testing would be required to estimate the number, spacing, screened intervals, and extraction rates for capture of impacted groundwater. Additionally, due to a limited construction area between the river and the NAP perimeter berm, the installation of a groundwater collection trench through both the MGU and the LGU near the NAP is likely to be an infeasible alternative to GE using wells.

In total, following the completion of source control measures, the Source Control-GE remedy will require 2-3 years to design and construct. Long-term management of the GE system will include periodic inspections and routine maintenance, including the replacement of worn or damaged parts. Monitoring will also be undertaken to ensure that the GE system is working as intended and will continue until GWPSs are achieved.

3.1.3 Source Control with Monitored Natural Attenuation and Groundwater Extraction

The Source Control with Monitored Natural Attenuation and Groundwater Extraction (Source Control-MNA/GE) alternative is a combination of the MNA and GE corrective measures. Specifically, the groundwater collection trench will continue operating post-closure in the OEAP area and groundwater concentrations of dissolved constituents will attenuate *via* natural physical and chemical processes (*i.e.*, MNA) in areas downgradient of the NAP. Groundwater and seep water collected by the groundwater collection trench will be routed to the NAP Secondary Pond and discharged to the Middle Fork of the Vermilion River *via* one of the facility's NPDES-permitted outfalls. If monitoring reveals a need for treatment of collected groundwater and seep water prior to discharge, then a treatment system will be designed and implemented at the Site. Water treatment, if needed, will include a settling pond and possibly pH adjustment.

Because MNA relies on natural attenuation processes and the groundwater collection trench will already have been installed as required by the Agreed Interim Order (Illinois, Attorney General, 2021), this alternative does not require the installation, operation, or maintenance of any additional engineered systems or structures, unless a treatment system is found to be required for the treatment of collected groundwater. The only long-term management activity required under this alternative is groundwater monitoring and maintenance of the groundwater collection trench (and, if needed, maintenance of the treatment system). Groundwater monitoring will continue until GWPSs are achieved. Following the completion of source control measures, the Source Control-MNA/GE remedy will require 1-2 years to design, construct, and implement, which includes any additional investigations required to characterize Site conditions and additional work related to the design and installation of the groundwater monitoring system.

3.1.4 Source Control with Construction of a Cutoff Wall

Under the Source Control with Construction of a Cutoff Wall (Source Control-CW) alternative, a trench will be dug along the downgradient perimeter of the former impoundments and filled with a soil-bentonite mixture. This process will create a low-permeability subsurface barrier to the lateral migration of constituents off-Site. The slurry wall will extend all the way down to the underlying bedrock, creating a barrier to constituent transport both immediately beneath the impoundment and at depth.

In the absence of additional hydraulic controls, CWs can unintentionally function as subsurface dams, routing groundwater around the wall rather than preventing its lateral migration. In order to ensure that this does not occur, a series of hydraulic control wells will be installed in the vicinity of the CW. These wells will serve as a "hydraulic gradient control system," ensuring that groundwater flows inward through the wall, rather than flowing outward (thus containing any potentially impacted groundwater behind the wall). If groundwater monitoring reveals a need for treatment of extracted groundwater prior to discharge, then a treatment system will be designed and implemented at the Site. Water treatment, if needed, will include a settling pond and possibly pH adjustment.

Site investigations and engineering analyses must be conducted prior to designing a CW system. In total, following the completion of source control measures, the Source Control-CW remedy will require 2-3 years to design, construct, and implement. Long-term management under the Source Control-CW alternative will include periodic inspections and routine maintenance of the CW and the hydraulic gradient control system. Monitoring will also be undertaken to ensure that the corrective measure is working as intended and will continue until GWPSs are achieved.

3.1.5 Source Control with Construction of a Permeable Reactive Barrier

Under the Source Control with Construction of a Permeable Reactive Barrier (Source Control-PRB) alternative, a subsurface barrier of reactive materials will be placed in the path of groundwater flow in order to promote the *in situ* transformation and/or immobilization of CCR-associated constituents. A permeable barrier is used so that the barrier does not hinder groundwater flow. At the Vermilion Site, the PRB would extend all the way down to the underlying bedrock.

One potential reactive material that can effectively immobilize many CCR-associated constituents is zerovalent iron. Zerovalent iron is effective at immobilizing arsenic, chromium, cobalt, molybdenum, selenium, and sulfate. However, zerovalent iron has not been proven effective for boron, antimony, or lithium (EPRI, 2006).

Site investigations and engineering analyses must be conducted prior to designing a PRB. In total, following the completion of source control measures, the Source Control-PRB remedy will require 2-3 years to design, construct, and implement. Long-term management under the Source Control-PRB alternative will include periodic maintenance and possibly replacement of the reactive media in order to extend the life of the PRB. Monitoring will also be undertaken to ensure that the corrective measure is working as intended and will continue until GWPSs are achieved.

3.2 Performance, Reliability, Ease of Implementation, and Potential Impacts of the Corrective Measure Alternative (IAC Section 845.660(c)(1))

3.2.1 Performance of the Corrective Measure Alternative – Controlling the Source (IAC Section 845.660(c)(1))

"Primary source control" means the prevention of CCR-associated constituents leaching from the impoundments into underlying groundwater. Because source control will be undertaken at the Site prior to the implementation of any corrective measures, all corrective measure alternatives will eliminate the potential for CCR within the impoundments to impact groundwater. All of the corrective measure alternatives would be equally and fully protective with regard to primary source control. However, impacted soils underlying the impoundments can potentially act as a secondary source of CCR-associated impacts to groundwater even after the primary source (CCR) has been excavated and hauled to a landfill for disposal.

The effectiveness of the various corrective measure alternatives with respect to secondary source control are summarized as follows:

- Under the Source Control-MNA alternative, the attenuation of dissolved constituent concentrations remaining after source control would be achieved through natural processes. An analysis by Geosyntec (2021b) demonstrates that MNA would likely perform well at this Site, both within the secondary source area and downgradient.
- Under the Source Control-GE alternative, GE would be used to capture dissolved constituent concentrations emanating from secondary source areas and prevent lateral migration off-Site. GE is a widely used corrective measure. However, its performance can vary from site to site. Although good performance would generally be expected for this alternative, additional Site investigations and engineering analyses may be required to design the GE system.
- Under the Source Control-MNA/GE alternative, source control would be achieved by GE at the groundwater collection trench near the OEAP and *via* the natural attenuation of dissolved constituent concentrations near the NAP. An analysis by Geosyntec (2021b) demonstrates that MNA would likely perform well at this Site, both within the secondary source area and downgradient. Additionally, GE is a widely used corrective measure. While its performance can vary from site to site, good performance would generally be expected.
- Under the Source Control-CW alternative, a low-permeability subsurface barrier would prevent the lateral migration of constituents off-Site. This barrier, which would extend all the way down to the bedrock, is expected to be highly effective at preventing lateral constituent migration. Although the CW would not be designed to promote the attenuation of dissolved constituent concentrations within the secondary source area (*i.e.*, under the former impoundment and upgradient of the CW), some attenuation would nonetheless occur in this area due to natural processes. Additional Site investigations and engineering analyses may be required to design the CW and associated hydraulic control system.
- Under the Source Control-PRB alternative, a PRB would be placed into the path of groundwater flow in order to promote the transformation and immobilization of constituents. The ability of this barrier to prevent the lateral migration of constituents would depend on Site-specific factors, such as Site hydrogeology and geochemical conditions. Moreover, the effectiveness of the barrier would vary by constituent. PRBs generally have limited success at treating lithium and boron in groundwater, for example, which may limit the effectiveness of PRB at the Vermilion Site (because both of these are CCR-related constituents). Although the PRB would not be designed to promote the attenuation of dissolved constituent concentrations within the secondary source area (*i.e.*, under the former impoundment and upgradient of the PRB), some attenuation would nonetheless occur in this area due to natural processes. Additional Site investigations and engineering analyses may be required to design the PRB.

3.2.2 Performance of the Corrective Measure Alternative – Likelihood of Future Releases of CCR (IAC Section 845.660(c)(1))

All corrective measure alternatives include source control. There would be no risk of accidental CCR releases occurring post-closure under any of the corrective measure alternatives.

3.2.3 Performance of the Corrective Measure Alternative – Long-Term Management (IAC Section 845.660(c)(1))

The type and degree of long-term management under each corrective measure alternative are summarized as follows:

- The Source Control-MNA alternative would not require the installation, operation, or maintenance of any engineered systems or structures, other than maintenance of the monitoring well network. Long-term management associated with groundwater sampling would continue until GWPSs have been achieved or until it was determined that the measure is not meeting the requirements of IAC Section 845.670(d).
- The Source Control-GE alternative would require the management and discharge of extracted groundwater. Treatment may also be required prior to discharge. Water treatment, if necessary, would be expected to potentially include a settling pond and pH adjustment. Operations and maintenance (O&M) under this scenario would include routine groundwater sampling and hydraulic gradient monitoring to ensure that the GE system is working as intended, which would continue until GWPSs have been achieved or until it was determined that the measure is not meeting the requirements of IAC Section 845.670(d). If extraction wells were installed at the NAP, high iron concentrations in the formation could cause fouling of the well screens, which would require frequent maintenance. Additionally, iron fouling could create a need for the replacement of extraction wells over time. If a groundwater collection trench were instead installed at the NAP, a hydraulic connection may be created between the MGU and LGU, which may delay groundwater remediation times. The GE and (if necessary) treatment systems would also need to be regularly inspected and maintained to prevent fouling and scaling issues from impacting the effectiveness of the remedy. Any sediments generated by the treatment system, if one is required, would periodically have to be removed and brought to a solid waste landfill for disposal. Once the remedy is complete, the system would need to be decommissioned in a manner that meets applicable regulatory standards. In total, the long-term O&M efforts under the Source Control-GE alternative would be expected to be moderate to high.
- The Source Control-MNA/GE alternative would not require the installation of any new engineered systems or structures, because the groundwater collection trench would already have been installed as required by the Agreed Interim Order (Illinois, Attorney General, 2021). The groundwater collection trench would have to be operated and maintained appropriately beyond the closure of the impoundments. Groundwater and seep water collected at the groundwater collection trench would be sent to the NAP Secondary Pond and discharged *via* the NPDES-permitted outfall. Treatment may be required prior to discharge. Water treatment, if necessary, would be expected to potentially include a settling pond and pH adjustment. Any sediments generated by the treatment system, if one is required, would periodically have to be removed and brought to a solid waste landfill for disposal. Additionally, routine groundwater sampling would continue until GWPSs have been achieved or until it was determined that the measure is not meeting the requirements of IAC Section 845.670(d).
- Long-term O&M efforts under the Source Control-CW scenario would include periodic maintenance of the CW and hydraulic gradient control system and the management and discharge of groundwater extracted by the hydraulic gradient control system. Extracted groundwater may need to be treated prior to discharge. Water treatment, if necessary, would be expected to include a settling pond and possibly pH adjustment. Once the cutoff wall is constructed and the necessary extraction well installations are complete, O&M would include long-term groundwater flow monitoring and periodic inspections and routine maintenance of the hydraulic gradient control system, including the replacement of worn or damaged parts. Any sediments generated

by the treatment system, if one is required, would periodically have to be removed and brought to a solid waste landfill for disposal. Routine groundwater sampling would be performed downgradient of the CW until GWPSs have been achieved or until it is determined that the measure is not meeting the requirements of IAC Section 845.670(d). Once the remedy is complete, the system would need to be decommissioned in a manner that meets applicable regulatory standards. In total, the long-term O&M efforts under the Source Control-GE alternative would be expected to be moderate.

- Long-term O&M efforts under the Source Control-PRB scenario would include routine groundwater sampling downgradient of the PRB until GWPSs are achieved or until it is determined that the measure is not meeting the requirements of IAC Section 845.670(d). The PRB will also be monitored for treatment efficacy. If necessary, the PRB media may be amended or exchanged to extend the life of the PRB. In total, the long-term O&M efforts under the Source Control-GE alternative would be expected to be minimal.

3.2.4 Reliability of the Corrective Measure Alternative – Engineering and Institutional Controls (IAC Section 845.660(c)(1))

The long-term reliability of the corrective measure alternatives summarized as follows:

- The Source Control-MNA alternative would be expected to be reliable over the long term at this Site, because it would rely on natural processes, rather than the installation, operation, and maintenance of engineered systems or structures. Under this alternative, engineering failure would not occur and no O&M activities would be required to ensure the success of the alternative (other than those required for groundwater monitoring). A review of Site conditions performed by Geosyntec finds that, in combination with source control measures, MNA would likely result in the reduction in groundwater concentrations downgradient of the Site to below GWPSs (Geosyntec, 2021b).
- The Source Control-GE alternative would be expected to be reliable over the long term at this Site, as long as the system is designed and constructed for Site-specific conditions. The long-term reliability of this alternative would depend on the management and maintenance of the GE system and (if necessary) the treatment system for extracted groundwater. However, maintenance of these systems would be expected to be relatively straightforward to implement.
- The Source Control-MNA/GE alternative would be expected to be reliable over the long term at this Site, because it relies on a combination of natural processes at the NAP and a groundwater collection trench at the OEAP. Under this alternative, no additional engineering structures, other than what is required by the Agreed Interim Order (Illinois, Attorney General, 2021), would require design or installation, unless a treatment system is found to be required for the treatment of groundwater and seep water collected in the trench. Maintenance of a treatment system, if one is required, would be expected to be relatively straightforward. A review of Site conditions performed by Geosyntec finds that, in combination with source control measures, MNA would likely result in the reduction of groundwater concentrations downgradient of the Site to below GWPSs (Geosyntec, 2021b).
- The Source Control-CW alternative would be expected to be reliable over the long term at this Site, as long as the system is designed and constructed for Site-specific conditions. Because implementation of the CW would require the installation of hydraulic controls *via* a GE system, the long-term reliability of this alternative would also depend on the management and maintenance of the GE system and (if necessary) the treatment system for extracted groundwater.

However, maintenance of these systems would be expected to be relatively straightforward to implement.

- The Source Control-PRB alternative may not be reliable over the long term at this Site. The reliability of this alternative would depend on Site-specific groundwater hydraulics and geochemical conditions, including the behavior of the constituents of concern. PRBs generally have limited success at treating lithium and boron in groundwater (both of which are CCR-related constituents). The effectiveness of the PRB would also decrease over time, resulting in a potential need for the eventual replacement of the remedy.

3.2.5 Reliability of the Corrective Measure Alternative - Potential Need for Replacement of the Corrective Measure (IAC Section 845.660(c)(1))

The potential need for the eventual replacement of each corrective measure alternative is summarized as follows:

- Source Control-MNA would rely on natural processes to achieve reductions in groundwater concentrations to below GWPSs. Without the installation, operation, and maintenance of engineered systems or structures, it would be unlikely that the Source Control-MNA remedy would need to be replaced. The MNA evaluation provided by Geosyntec (2021b) notes that, if MNA is selected as the remedy, a contingency plan that will identify the circumstances under which replacement of the remedy may be appropriate will be developed.
- For the Source Control-GE alternative, implementation of the GE system would rely on physical management of the groundwater flow path. If extraction wells were installed at the NAP, iron fouling may reduce the system effectiveness and create a need for the replacement of extraction wells over time. Replacement of pumps would also be likely under this alternative, because groundwater hydraulic controls would need to be maintained on a long-term basis. However, it is unlikely that the entire remedy would need to be replaced; this would only be necessary if groundwater flow conditions changed significantly at the Site.
- Source Control-MNA/GE would rely on a combination of natural processes at the NAP and a groundwater collection trench at the OEAP to achieve reductions in groundwater concentrations to below GWPSs. While the groundwater collection trench would need to be maintained, no additional engineering structures will require design, installation, or replacement. It is therefore unlikely that the remedy would need to be replaced. The MNA evaluation provided by Geosyntec (2021b) notes that, if MNA is selected as the remedy, a contingency plan that will identify the circumstances under which replacement of the remedy may be appropriate will be developed.
- Like the Source Control-GE alternative, the Source Control-CW alternative would rely on physical management of the groundwater flow path. Replacement of individual GE wells and pumps would likely be necessary under this alternative, because groundwater hydraulic controls would need to be maintained on a long-term basis, and pumps and well screens would ultimately need to be replaced. However, it would be unlikely that the entire remedy would need to be replaced; this would only be necessary if groundwater flow conditions changed significantly at the Site.
- PRBs would rely on the chemical treatment of groundwater along the flow path. Given the low effectiveness of PRBs for boron and lithium, replacement of the PRB remedy would be likely. Replacement of this remedy would also be necessary if the effectiveness of the PRB declined over time or if groundwater flow conditions changed at the Site.

3.2.6 Ease of Implementation (IAC Section 845.660(c)(1))

The expected degree of difficulty associated with implementing the corrective measure alternatives is summarized as follows:

- The Source Control-MNA alternative would rely entirely on natural processes and therefore should not pose any significant construction challenges. This alternative would only require the installation of monitoring wells.
- Construction under the Source Control-GE alternative would be limited to the installation of the GE system and monitoring wells. However, construction of the GE system at the NAP would likely be difficult, due to the proximity of the former impoundments to the Middle Fork of the Vermilion River, which may restrict access to the Site. Design of this remedy would also require a good understanding of groundwater flow conditions at the Site, including an evaluation of the ability to capture groundwater effectively and an evaluation of the relationship between groundwater and the Middle Fork of the Vermilion River. GE using wells may be difficult to implement, because the alluvial deposits at the NAP vary in composition laterally and vertically. Additional testing would be required to estimate the number, spacing, screened intervals, and extraction rates for capture of impacted groundwater. Additionally, due to a limited construction area between the river and the NAP perimeter berm, installation of a groundwater collection trench through both the MGU and the LGU near the NAP is likely to be an infeasible alternative to GE using wells.
- The Source Control-MNA/GE alternative relies on natural processes and a groundwater collection trench, which would already have been installed as required by the Agreed Interim Order (Illinois, Attorney General, 2021). Therefore, no significant construction challenges are expected. This alternative would only require the additional installation of monitoring wells.
- Construction of a CW under the Source Control-CW scenario would likely be highly difficult due to the required location, length, and depth of the CW. The CW would be constructed along the bank of the Middle Fork of the Vermilion River. Construction of the CW, which would be on the order of 40 feet deep, would entail excavating into the low-permeability bedrock unit underlying the NAP/OEAP and then backfilling the excavated trench. Specialized equipment may be required. Access ramps, roads, and the CW itself would have to be constructed using controlled practices that avoid potential flood impacts to construction materials and equipment, such as equipment washing into the river. Design of the hydraulic control system would also require a good understanding of groundwater flow conditions at the Site, including an evaluation of the ability to contain groundwater effectively and an evaluation of the relationship between groundwater and the adjacent river system.
- Construction of the PRB under the Source Control-PRB alternative would likely be highly difficult due to the required location, length, and depth of the PRB. The PRB would be constructed along the bank of the Middle Fork of the Vermilion River. The PRB may need to be extended down to the low-permeability bedrock unit underlying the NAP/OEAP, which is approximately 40 feet below ground surface. Access ramps, roads, and the PRB itself would have to be constructed using controlled practices that avoid potential flood impacts to construction materials and equipment, such as equipment washing into the river.

3.2.7 Potential Impacts – Risks to the Community or the Environment During Implementation of Remedy (IAC Section 845.660(c)(1))

Safety Impacts

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. For example, injuries and fatalities can occur due to truck accidents or equipment malfunctions. Truck accidents that occur off-Site can also result in injuries or fatalities to community members. The safety impacts of construction under each corrective measure alternative are summarized as follows:

- The Source Control-MNA alternative would not require the construction of any engineered systems or structures other than monitoring wells. Construction activity would not be expected to result in any significant negative safety impacts under this alternative.
- A moderate level of construction activity would be required under the Source Control-GE alternative. Construction activities under this alternative would include the construction of the GE system and monitoring wells. Therefore, the construction-related safety impacts of this alternative would be modest. Impacts would largely be limited to workers, rather than community members, because construction activities would largely be limited to the Site.
- The Source Control-MNA/GE alternative would rely on natural processes and a groundwater collection trench, which would already have been installed as required by the Agreed Interim Order (Illinois, Attorney General, 2021). No additional construction of any engineered systems or structures other than monitoring wells would be required. Construction activity would not be expected to result in any significant negative safety impacts under this alternative.
- The construction requirements of the Source Control-CW alternative would be considerable due to the planned extent of construction activities (*i.e.*, excavation and backfilling of an approximately 40-foot-deep earthen trench). The Source Control-CW alternative therefore would pose relatively significant construction-related safety risks to workers. The negative impacts of construction activities would largely be limited to workers, rather than community members, because construction activities would largely be limited to the Site.
- The construction requirements of the Source Control-PRB alternative would be similar to those of the Source Control-CW alternative. Relatively intensive construction activities would be required, including the excavation of an approximately 40-foot-deep earthen trench. The Source Control-CW scenario therefore would pose relatively significant construction-related safety risks to workers. The negative impacts of construction activities would largely be limited to workers, rather than community members, because construction activities would largely be limited to the Site.

Cross-Media Impacts to Air

Diesel emissions are a major source of air pollutants and GHG emissions at construction sites. Corrective measures that require a greater level of construction activity will result in larger overall air impacts in the form of diesel emissions. The Source Control-MNA and Source Control-MNA/GE alternatives would be expected to have minimal air impacts, because they would not require the construction of any engineered systems or structures (other than monitoring wells and the groundwater collection trench, which is required by the Agreed Interim Order [Illinois, Attorney General, 2021]). The Source Control-GE alternative would be expected to have moderate air impacts, because it would have modest construction requirements. The Source Control-CW and Source Control-PRB alternatives would be expected to have the most considerable air impacts across all the corrective measure alternatives, because they would have the most significant construction requirements.

Cross-Media Impacts to Surface Water and Sediments

Due to erosion and runoff, construction can have short-term negative impacts on surface water and sediment quality immediately adjacent to a site. These impacts are of particular concern at the Vermilion Site, due to the proximity of the former impoundments to the Middle Fork of the Vermilion River, Illinois's only National Scenic River. Minimal surface water or sediment impacts due to erosion and runoff during construction would be expected under the Source Control-MNA and Source Control-MNA/GE alternatives because they would not require the construction of any engineered systems or structures (other than monitoring wells and the groundwater collection trench, which is required by the Agreed Interim Order [Illinois, Attorney General, 2021]). In contrast, the Source Control-GE, Source Control-CW, and Source Control-PRB alternatives may have short-term negative impacts on the Middle Fork of the Vermilion River due to erosion and sediment runoff during construction. These impacts would be greater under the Source Control-CW and Source Control-PRB alternatives than under the Source Control-GE alternative, due to the greater extent and duration of construction activities required for the former (*i.e.*, excavation of a 40-foot-deep earthen trench).

Under the Source Control-MNA/GE, Source Control-GE, and Source Control-CW alternatives, extracted groundwater would be discharged to the Middle Fork of the Vermilion River *via* one of the facility's NPDES-permitted outfalls. If necessary, extracted groundwater would be treated prior to discharge to ensure compliance with water quality standards. Thus, no surface water or sediment impacts would be expected under any of the corrective measure alternatives due to the discharge of extracted groundwater into the Middle Fork of the Vermilion River.

Source Control-GE could also have a detrimental effect on the baseflow in the Middle Fork of the Vermilion River, particularly during low-flow conditions, because the GE system could capture and/or intercept water from the river.

Control of Exposure to Any Residual Contamination During Implementation of the Remedy

Source Control will be undertaken at the Site prior to the implementation of any of the corrective measure alternatives. Thus, no residual CCR exposures would be expected to occur during the implementation of any corrective measure alternative. However, impacted soils and groundwater underlying the impoundments can act as a secondary source of CCR-associated constituent exposures for workers even after the primary source (CCR) has been excavated and hauled to a landfill for disposal. Risks to workers arising from potential contact with secondary sources during construction, operation, and maintenance activities (*e.g.*, contact with impacted groundwater extracted by the GE system under the Source Control-MNA/GE and Source Control-GE alternatives or extracted by the hydraulic gradient control system under the Source Control-CW alternative) would be managed through the use of rigorous safety protocols and personal protective equipment.

Other Identified Impacts

In addition to safety impacts, cross-media impacts, and the potential for workers to be exposed to residual contamination, construction activities can have significant energy demands and can cause nuisance impacts such as traffic and noise. Moreover, construction activities can negatively impact natural resources and habitat near the Site, as well as scenic and recreational value. High-quality natural areas and recreational areas in the immediate vicinity of the former impoundments include the Orchid Hill Natural Heritage Landmark and the Middle Fork of the Vermilion River. The magnitude of all construction-related impacts would be expected to increase with the duration and intensity of construction activities. Because the Source Control-MNA and Source Control-MNA/GE alternatives would not require any significant construction activity, the construction-related impacts listed above would not be a concern under this alternative. In contrast, moderate construction-related impacts would be expected under the Source Control-GE alternative. The most significant construction-related impacts would be expected to occur under the Source Control-CW and Source Control-PRB alternative, both of which would require excavation of an approximately 40-foot-deep earthen trench.

3.3 The Time Required to Begin and Complete the Corrective Action Plan (IAC Section 845.660(c)(2))

IAC Section 845.670 states that a Corrective Action Plan must be submitted to the Agency within 1 year of submission of a CMA. We do not anticipate that any delays would occur in the completion of a Corrective Action Plan for this Site. Work would begin on the Corrective Action Plan following completion of a public meeting, which will be held in December 2021.

3.4 State or Local Permit Requirements or Other Environmental or Public Health Requirements that May Substantially Affect Implementation of the Corrective Action Plan (IAC Section 845.660(c)(3))

All the corrective measure alternatives would require regulatory approvals prior to implementation. The Source Control-GE, Source Control-MNA/GE, and Source Control-CW alternatives may also require modifications to the Site's existing NPDES permit in order to manage groundwater extracted by the GE system (Source Control-GE alternative), collected by the groundwater collection trench (Source Control-MNA/GE alternative), or extracted by the hydraulic gradient control system (Source Control-CW alternative). However, these requirements would not be expected to substantially affect the implementation of the Corrective Action Plan.

3.5 Summary

Table S.2 evaluates the five corrective measures included in this CMA with regards to each of the factors specified under IAC Section 845.660(c) (IEPA, 2021a). Based on this evaluation and the details provided above, two corrective measures have been identified as potentially viable technologies for further consideration pursuant to IAC Section 845.670 (CAAA): Source Control-MNA and Source Control-MNA/GE. Source Control-GE, Source Control-CW, and Source Control-PRB were not selected as viable corrective measures for further consideration, for the following reasons:

- It is unlikely that Source Control-PRB would perform well at this Site, because PRBs have not been proven effective for lithium and boron in groundwater (both of which are CCR-associated constituents);
- Construction of the CW and the PRB would likely be very difficult, due to the required location, length, and depth of these structures;
- Source Control-GE may have a detrimental effect on the baseflow in the Middle Fork of the Vermilion River, because the GE system may capture/intercept water from the river.

Furthermore, if groundwater pumping wells were installed at the NAP, the high iron content in the formation could lead to fouling of the well screens, which would create the need for frequent maintenance and, potentially, GE well replacement. If a groundwater collection trench were instead installed at the NAP, it would need to be deeper than the trench to be installed during closure at the OEAP, because groundwater from both the MGU and the LGU would need to be intercepted. Due to limited construction area between the river and the NAP perimeter berm, the installation of a groundwater collection trench through both the MGU and the LGU near the NAP is likely infeasible. Furthermore, installation of a groundwater collection trench at the NAP could create a hydraulic connection between the MGU and the LGU, which could delay cleanup times.

- Both Source Control-CW and Source Control-PRB would likely have a large potential impact on the Middle Fork of the Vermilion River due to the extent of construction required in close proximity to the river; and
- Both Source Control-CW and Source Control-PRB would likely have relatively large impacts on worker safety, air quality, and surface water, and sediment quality compared to the other remedies due to the substantial construction activities required.

4 Corrective Action Alternatives Analysis

This section of the report presents a CAAA pursuant to requirements under IAC Section 845.670 (IEPA, 2021a). The goal of a CAAA is to more fully evaluate proposed viable corrective measures that were identified in the CMA. The CAAA evaluates potential corrective actions with respect to a wide range of factors, including the performance, reliability, and ease of implementation of the corrective action; its potential impacts on human health and the environment; and its ability to address concerns raised by residents (IEPA, 2021a).

Per IAC Section 845.670(d), any corrective actions selected under a Corrective Action Plan must (IEPA, 2021a):

1) Be protective of human health and the environment;

2) Attain the groundwater protection standards specified in Section 845.600;

3) Control the sources of releases to reduce or eliminate, to the maximum extent feasible, further releases of constituents listed in Section 845.600 into the environment;

4) Remove from the environment as much of the contaminated material that was released from the CCR surface impoundment as is feasible, taking into account factors such as avoiding inappropriate disturbance of sensitive ecosystems; and

5) Comply with standards for management of wastes as specified in Section 845.680(d).

Two potential corrective actions were selected for consideration under IAC Section 845.670 for this Site, based on the evaluation presented in the CMA: Source Control-MNA and Source Control-MNA/GE. These corrective actions are described above in Section 3.1.

This report evaluates the potential performance, reliability, and impacts of the various corrective actions, but does not make any judgements regarding the need for these corrective actions. It should be noted, however, that the primary pond of the NEAP was constructed atop bedrock using earthen berms that contain a low-permeability clay core keyed into the underlying shale. Constituent migration from this impoundment is therefore expected to be very limited, and there are no exceedances of the relevant GWPSs that have been attributed to the NEAP. Thus, corrective actions other than source control may not be necessary for the NEAP.

4.1 Long- and Short-Term Effectiveness and Protectiveness of Corrective Action Alternative (IAC Section 845.670(e)(1))

4.1.1 Magnitude of Reduction of Existing Risks (IAC Section 845.670(e)(1)(A))

As described in Section 2.2.1 of the CAA (Magnitude of Reduction of Existing Risks), there are no current unacceptable risks to human or ecological receptors at this Site (Appendices A and B). Both corrective actions considered here include source control. Moreover, both corrective actions would reduce the concentrations of dissolved constituents in the vicinity of the impoundments post-closure. Because current conditions do not present any existing risks at the Site and dissolved constituent concentrations would be expected to decline over time with the implementation of the corrective actions being considered, there would be no future risks to human and ecological receptors under either of the corrective action alternatives.

4.1.2 Effectiveness of the Remedy in Controlling the Source (IAC Section 845.670(e)(2))

Extent to Which Containment Practices Will Reduce Further Releases (IAC Section 845.670(e)(2)(A))

"Primary source control" means the prevention of CCR-associated constituents leaching from the impoundments into underlying groundwater. Because source control will be undertaken at the Site prior to the implementation of any corrective actions, both corrective action alternatives would eliminate the potential for CCR within the impoundments to impact groundwater. Both corrective action alternatives would therefore equally and fully protective with regard to primary source control. However, impacted soils underlying the impoundments can potentially act as a secondary source of CCR-associated impacts to groundwater even after the primary source (CCR) has been excavated and hauled to a landfill for disposal. The effectiveness of the corrective action alternatives with respect to secondary source control are summarized as follows:

- Under the Source Control-MNA alternative, the attenuation of dissolved constituent concentrations remaining after source control would be achieved through natural processes. An analysis by Geosyntec (2021b) demonstrates that MNA would likely perform well at this Site, both within the secondary source area and downgradient.
- Under the Source Control-MNA/GE alternative, source control would be achieved by GE at the groundwater collection trench near the OEAP and *via* the natural attenuation of dissolved constituent concentrations near the NAP. An analysis by Geosyntec (2021b) demonstrates that MNA would likely perform well at this Site, both within the secondary source area and downgradient. Additionally, GE is an accepted corrective measure. While, its performance can vary from site to site, good performance would generally be expected.

Extent to Which Treatment Technologies May Be Used (IAC Section 845.670(e)(2)(B))

Because Source Control-MNA would rely on natural attenuation processes, no treatment technologies would be required under this alternative. Treatment would be not an integral part of the Source Control-MNA/GE alternative; however, it may be necessary to treat groundwater and seep water extracted from the groundwater collection trench prior to discharge. Water treatment, if necessary, could potentially include a settling pond and pH adjustment.

4.1.3 Likelihood of Future Releases of CCR (IAC Section 845.670(e)(1)(B))

Both corrective action alternatives include source control. There would therefore be no risk of accidental CCR releases occurring post-closure under either of the corrective action alternatives.

4.1.4 Type and Degree of Long-Term Management, Including Monitoring, Operation, and Maintenance (IAC Section 845.670(e)(1)(C))

The type and degree of long-term management under each corrective action alternative are summarized as follows:

- The Source Control-MNA alternative would not require the installation, operation, or maintenance of any engineered systems or structures. The only long-term management activity required under this alternative would be routine groundwater sampling, which would continue until GWPSs have been achieved or until it was determined that the measure is not meeting the requirements of IAC Section 845.670(d).
- The Source Control-MNA/GE alternative would not require the installation of any new engineered systems or structures, because the groundwater collection trench would already have been installed as required by the Agreed Interim Order (Illinois, Attorney General, 2021). Under this alternative, the groundwater collection trench would have to be operated and maintained appropriately beyond the closure of the impoundments. Groundwater and seep water collected at the groundwater collection trench would be sent to the NAP Secondary Pond and discharged *via* the NPDES-permitted outfall. Treatment of this groundwater and seep water may be required prior to discharge. Water treatment, if necessary, could potentially include a settling pond and pH adjustment. Any sediments generated by the treatment system, if one is required, would periodically have to be removed and brought to a solid waste landfill for disposal. Additionally, routine groundwater sampling would continue until GWPSs have been achieved or until it was determined that the measure is not meeting the requirements of IAC Section 845.670(d).

4.1.5 Short-Term Risks to the Community or the Environment During Implementation of Remedy (IAC Section 845.670(e)(1)(D))

Safety Impacts

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. For example, injuries and fatalities can occur due to truck accidents or equipment malfunctions. Truck accidents that occur off-Site can also result in injuries or fatalities to community members. The safety impacts of construction under each corrective action alternative are summarized as follows:

- The Source Control-MNA alternative would not require the construction of any engineered systems or structures other than monitoring wells. Construction activity would not be expected to result in any significant negative safety impacts under this alternative.
- The Source Control-MNA/GE alternative would rely on natural processes and a groundwater collection trench, which would already have been installed as required by the Agreed Interim Order (Illinois, Attorney General, 2021). No additional construction of any engineered systems or structures other than monitoring wells would be required. Construction activity would not be expected to result in any significant negative safety impacts under this alternative. Furthermore, impacts would largely be limited to workers, rather than community members, because construction activities would largely be limited to the Site.

Cross-Media Impacts to Air

Diesel emissions are a major source of air pollutants and GHG emissions at construction sites. Corrective actions that require a greater level of construction activity will result in larger overall air impacts in the form of diesel emissions. The Source Control-MNA and Source Control-MNA/GE alternatives would be expected to have minimal air impacts, because they would not require the construction of any engineered systems or structures (other than monitoring wells and the groundwater collection trench, which is required by the Agreed Interim Order [Illinois, Attorney General, 2021]).

Cross-Media Impacts to Surface Water and Sediments

Under both source control/corrective action scenarios, the constituent mass flux that flows from groundwater into surface water would decline over time after closure has been completed (Ramboll, 2021a). Modeling was performed to evaluate future groundwater quality in the vicinity of the NAP/OEAP under each of the proposed source control and corrective action alternatives (Ramboll, 2021a). The modeling concluded that mass flux to the Middle Fork of the Vermilion River from the MGU will be reduced by approximately 50% 10 years after closure is completed and by approximately 80% 35 years after closure is completed (Ramboll, 2021a). Mass flux declines will occur more slowly in the LGU, which has lower concentrations, due to the lower-permeability deposits (Ramboll, 2021a).

Due to erosion and runoff, construction can have short-term negative impacts on surface water and sediment quality immediately adjacent to a site. These impacts are of particular concern at the Vermilion Site, due to the proximity of the former impoundments to the Middle Fork of the Vermilion River, Illinois's only National Scenic River. However, minimal surface water and sediment impacts would be expected under the Source Control-MNA and Source Control-MNA/GE alternatives, because they would not require the construction of any engineered systems or structures (other than monitoring wells and the groundwater collection trench, which is required by the Agreed Interim Order [Illinois, Attorney General, 2021]).

Under the Source Control-MNA/GE alternative, groundwater and seep water collected by the groundwater collection trench would be discharged to the Middle Fork of the Vermilion River *via* one of the facility's NPDES-permitted outfalls. If necessary, collected groundwater would be treated prior to discharge to ensure compliance with water quality standards. Thus, no surface water or sediment impacts are expected due to the discharge of extracted groundwater into the Middle Fork of the Vermilion River under the Source Control-MNA/GE alternative.

Control of Exposure to Any Residual Contamination During Implementation of the Remedy

Source control and the installation of the groundwater trench will be undertaken at the Site prior to the implementation of any of the corrective action alternatives. Thus, no residual CCR exposures would be expected to occur during the implementation of either corrective action alternative. However, impacted soils and groundwater underlying the impoundments can act as a secondary source of CCR-associated constituent exposures for workers even after the primary source (CCR) has been excavated and hauled to a landfill for disposal. Risks to workers arising from potential contact with secondary sources during construction, operation, and maintenance activities (*e.g.*, contact with impacted groundwater or seep water collected by the groundwater collection trench under the Source Control-MNA/GE alternative) would be managed through the use of rigorous safety protocols and personal protective equipment.

Other Identified Impacts

In addition to safety impacts, cross-media impacts, and the potential for workers to be exposed to residual contamination, construction activities can have significant energy demands and can cause nuisance impacts such as traffic and noise. Moreover, construction activities can negatively impact natural resources and habitat near the Site, as well as scenic and recreational value. However, because the Source Control-MNA and Source Control-MNA/GE alternatives would not require any significant construction activity, the construction-related impacts listed above would not be expected to be a concern under this alternative.

4.1.6 Time Until Groundwater Protection Standards Are Achieved (IAC Section 845.670(e)(1)(E))

The time required to achieve GWPSs is immaterial from a risk to human health or the environment perspective, because there are currently no unacceptable risks to human or ecological receptors at this Site (see Section 2.2.1 of the CAA, Magnitude of Reduction of Existing Risks). At the NAP/OEAP, potential dissolved CCR-related constituents may migrate vertically downward under the influence of gravity into the MGU. The MGU is the primary conduit for groundwater flow at the Site. Groundwater flow in the MGU is primarily eastward, toward the Middle Fork of the Vermilion River. Some potentially dissolved CCR-related constituents may migrate downward through the middle confining unit into the LGU. Groundwater flow rates are lower in the LGU relative to the MGU, due to the difference in the hydraulic conductivities of the two units. Groundwater flow in the LGU is also primarily eastward, toward the Middle Fork of the Vermilion River. CCR-related constituents in both the MGU and LGU may potentially flow into the Middle Fork of the Vermilion River (Ramboll, 2021b). Based on Site-specific numerical groundwater modeling performed at the Site (OBG, 2018; Ramboll, 2021a), all groundwater impacted with potential CCR-related constituents is ultimately discharged into the Middle Fork of the Vermilion River, and no CCR-related constituents migrate away from the Site underneath the river. Similarly, there is no transport of CCR-related constituents toward the western or southern property boundaries. There may be limited groundwater migration in a northerly direction; however, this groundwater flow ultimately also turns eastward and flows into the river (Ramboll, 2021b).

At the NEAP, because the pond is built atop low-permeability shale and surrounded by low-permeability clay/bentonite layers, limited or negligible constituent migration is expected out of the pond. There is no or negligible impact of CCR-related constituents from the NEAP on groundwater quality. Additionally, while groundwater underlying the NEAP migrates toward and discharges into the Middle Fork of the Vermilion River, there is no evidence of CCR-related impacts from the NEAP in surface water (Kelron Environmental, 2003; OBG, 2019b).

Groundwater modeling was performed to evaluate future groundwater quality in the vicinity of the NAP/OEAP under each of the proposed source control and corrective action alternatives (Ramboll, 2021a). The modeling assumed that seasonal fluctuations in groundwater and river elevations do not affect groundwater flow and transport over the long term (Ramboll, 2021a). The results of the modeling indicate that groundwater will attain the GWPSs for all constituents identified as having potential exceedances in the primary migration pathway (the MGU) within approximately 50 years after closure for both the Source Control-MNA and Source Control-MNA/GE scenarios. Furthermore, flux to the Middle Fork of the Vermilion River from the MGU will be reduced by approximately 50% 10 years after closure is completed and by approximately 80% 35 years after closure is completed (Ramboll, 2021a). The LGU, which has much lower boron concentrations, is estimated to take approximately another 50 years to reach the GWPS due to the longer flow paths through low-permeability deposits (Ramboll, 2021a).

From a modeling perspective, small differences between the predicted times for boron to reach the GWPS in the MGU for the Source Control-MNA and Source Control-MNA/GE scenarios is negligible (Ramboll, 2021a). The results indicate there is no significant benefit in the modeled time to reach the GWPSs for continued operation and maintenance of the GE (*i.e.*, groundwater collection trench at the OEAP) beyond the completion of the closure activities (Ramboll, 2021a).

4.1.7 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 845.670(e)(1)(F))

Section 4.1.1 describes the magnitude of reduction of existing risks under each corrective action alternative. Section 4.1.2 describes the effectiveness of the remedy in controlling the source, including the extent to which containment practices will reduce further releases. Section 4.1.3 describes the likelihood of future releases of CCR occurring under each corrective action alternative, and Section 4.1.5 describes the short-term risks to workers, the community, and the environment during implementation of the remedy, including safety impacts and control of exposure to any residual contamination. In summary, source control measures (CBR with construction of a groundwater collection trench) will be undertaken at the Site prior to the implementation of either of the corrective action alternatives. Thus, both corrective action alternatives would completely eliminate the potential for a sudden CCR release to occur post-closure (due, *e.g.*, to flooding or a dike failure event). Similarly, due to the source control common to both of the corrective action alternatives, both alternatives would completely eliminate the potential for CCR within the impoundments to impact groundwater post-closure. Both corrective action alternatives would therefore be equally and fully protective with regard to exposure to residual CCR. For construction workers, impacted soils and groundwater underlying the impoundments can potentially act as a secondary source of CCR-associated constituent exposures even after the primary source (CCR) has been excavated and hauled to a landfill for disposal. During the implementation of the selected corrective action, exposure potential would be managed through the use of rigorous safety protocols and personal protective equipment.

Some changes in groundwater flow (*i.e.*, reduction in groundwater flow into the river) may occur under the Source Control-MNA/GE alternative, due to the operation of the groundwater collection trench. However, changes to groundwater flow would not be expected to have an effect on the potential for exposure of humans and environmental receptors to remaining wastes.

4.1.8 Long-Term Reliability of the Engineering and Institutional Controls (IAC Section 845.670(e)(1)(G))

The long-term reliability of the engineering and institutional controls of the corrective action alternatives are summarized as follows:

- The Source Control-MNA alternative would be expected to be reliable over the long term with respect to engineering and institutional controls, because it would rely on natural processes, rather than the installation, operation, and maintenance of engineered systems or structures. Under this alternative, engineering failure would not occur and no O&M activities would be required to ensure the success of the alternative (other than those required for groundwater monitoring). A review of Site conditions performed by Geosyntec finds that, in combination with source control measures, MNA would likely result in the reduction in groundwater concentrations downgradient of the Site to below GWPSs (Geosyntec, 2021b).

- The Source Control-MNA/GE alternative would be expected to be reliable over the long term at this Site, because it would rely on a combination of natural processes at the NAP and a groundwater collection trench at the OEAP. Under this alternative, no additional engineering structures, other than what is required by the Agreed Interim Order (Illinois, Attorney General, 2021), would require design or installation. A review of Site conditions performed by Geosyntec finds that, in combination with source control measures, MNA would likely result in the reduction of groundwater concentrations downgradient of the Site to below GWPSs (Geosyntec, 2021b).

4.1.9 Potential Need for Replacement of the Remedy (IAC Section 845.670(e)(1)(H))

The potential need for the eventual replacement of each corrective action alternative is summarized as follows:

- MNA would rely on natural processes to achieve reductions in groundwater concentrations to below GWPSs. Without the installation, operation, and maintenance of engineered systems or structures, it would be unlikely that the Source Control-MNA remedy would need to be replaced. The MNA evaluation provided by Geosyntec (2021b) notes that, if MNA is selected as the remedy, a contingency plan that will identify the circumstances under which replacement of the remedy may be appropriate will be developed.

  Source Control-MNA/GE would rely on a combination of natural processes at the NAP and a groundwater collection trench at the OEAP to achieve reductions in groundwater concentrations to below GWPSs. While the groundwater collection trench would need to be maintained, no additional engineering structures would require design, installation, or replacement. It is therefore unlikely that the remedy would need to be replaced. The MNA evaluation provided by Geosyntec (2021b) notes that, if MNA is selected as the remedy, a contingency plan that will identify the circumstances under which replacement of the remedy may be appropriate will be developed.

4.2 The Ease or Difficulty of Implementing a Remedy (IAC Section 845.670 (e)(3))

4.2.1 Degree of Difficulty Associated with Constructing the Remedy (IAC Section 845.670(e)(3)(A)

The expected degree of difficulty associated with constructing each corrective action alternative is summarized as follows:

- The Source Control-MNA alternative would rely on natural processes and therefore would not pose any significant construction challenges. This alternative would only require the installation of monitoring wells.
- The Source Control-MNA/GE alternative would rely on natural processes and a groundwater collection trench, which would already have been installed as required by the Agreed Interim Order (Illinois, Attorney General, 2021). Therefore, no significant construction challenges would be expected. This alternative requires the installation of additional monitoring wells.

4.2.2 Expected Operational Reliability of the Remedy (IAC Section 845.670(e)(3)(B))

Both corrective action alternatives would likely be highly reliable with respect to operational controls. MNA would be highly reliable because it would rely on natural processes, rather than the installation, operation, and maintenance of engineered systems or structures (other than monitoring wells). Under the Source Control-MNA alternative, engineering failure would not occur and no O&M activities would be required to ensure the success of the alternative. The Source Control-MNA/GE alternative would also be highly reliable, as long as the groundwater collection trench is maintained appropriately in accordance with standard practices.

4.2.3 Need to Coordinate with and Obtain Necessary Approvals and Permits from Other Agencies (IAC Section 845.670(e)(3)(C))

Both corrective action alternatives would require regulatory approvals. No additional permits would be needed for the Source Control-MNA. If groundwater and seep water collected from the groundwater collection trench under the Source Control-MNA/GE alternative need to be treated prior to discharge, then the Source Control-MNA/GE alternative may require modification of the Site's existing NPDES permit. However, if needed, NPDES permit modifications related to the operation of the trench would likely be undertaken during closure activities, rather than during the implementation of corrective measures (*i.e.*, the ongoing operation of the trench post-closure).

4.2.4 Availability of Necessary Equipment and Specialists (IAC Sections 845.670(e)(3)(D) and 845.660(c)(1), "Ease of Implementation")

The availability of equipment and specialists for each corrective action alternative is summarized as follows:

- The Source Control-MNA alternative would require standard environmental monitoring equipment. MNA specialists would be available to evaluate the data, once they are collected.
- The Source Control-MNA/GE alternative would require standard remedial action and environmental monitoring equipment. The required equipment and specialists for implementation of this remedy would be available.

4.2.5 Available Capacity and Location of Needed Treatment, Storage, and Disposal Services (IAC Section 845.670(e)(3)(D))

The available capacity and location of needed treatment, storage, and disposal services under each corrective action alternative is summarized as follows:

- The Source Control-MNA remedy would generate a minimal amount of investigation-derived waste (IDW) that could be managed by a standard waste management contractor.
- The Source Control-MNA/GE alternative would generate water. Groundwater and seep water collected from the groundwater collection trench would be discharged to the Middle Fork of the Vermilion River. If treatment of the groundwater and seep water is found to be necessary prior to discharge, then a treatment pond would need to be constructed. Any sediments generated by the treatment system, if one is required, would periodically have to be removed and brought to a licensed disposal facility.

4.3 The Degree to Which Community Concerns Are Addressed by the Remedy (IAC Section 845.670(e)(4))

Several citizen action groups representing community members near the Site have campaigned for complete excavation of the CCR impoundments at the Site, including the Eco-Justice Collaborative, Earthjustice, American Rivers, and the Prairie Rivers Network (American Rivers, 2018; Earthjustice, 2021; Eco-Justice Collaborative, 2021; Barkley, 2012). Both corrective action alternatives evaluated here would include source control, thereby addressing the major concerns raised by these groups.

4.4 Summary

Table S.3 evaluates both corrective action alternatives included in this CAAA with regards to each of the factors specified in IAC Section 845.670(e) (IEPA, 2021a). Based on this evaluation and the details provided in Section 4 of this report, Source Control-MNA has been identified as the most appropriate corrective action at this Site. Source Control-MNA and Source Control-MNA/GE both have similar design, construction, and O&M requirements and, as a result, also have similar expected impacts on workers, nearby communities, and the environment. Modeling has also shown that there is no material difference between the two scenarios in terms of the time to achieve the GWPSs (Ramboll, 2021a). Source Control-MNA is the preferred alternative at this Site.

The remedy will be selected following the completion of an upcoming public meeting, which will be held in December 2021. Following the public meeting, a final 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 recommendation will be provided in a Corrective Action Plan, which will be submitted to IEPA as described under IAC Section 845.670 (IEPA, 2021a).

References

American Rivers. 2018. "Middle Fork of the Vermilion River [IL]." Accessed on July 22, 2019 at https://www.americanrivers.org/endangered-rivers/middle-fork-of-the-vermilion-river-il.

Barkley, T. [Prairie Rivers Network]. 2012. Letter to B. Buscher (IEPA) re: Dynegy Midwest Generation's Vermilion Power Station Proposed Action Plan. Submitted to Illinois Environmental Protection Agency (IEPA). 18p., September 10.

Centers for Disease Control and Prevention (CDC). 2019. "What noises cause hearing loss?" National Center for Environmental Health (NCEH), October 7. Accessed on April 30, 2021 at https://www.cdc.gov/nceh/hearing_loss/what_noises_cause_hearing_loss.html.

Dynegy Energy Services (DMG). 2021. "Inundation Map, Vistra Vermilion Power Station, Vermilion County, IL." 19E0096C. 1p., August 17.

Dynegy Midwest Generation, LLC (DMG); Stantec Consulting Services Inc.; OBG, Part of Ramboll. 2019. "Closure and Post-Closure Care Plan for North Ash Pond, Old East Ash Pond, and New East Ash Pond at the Vermilion Site (Draft)." 29p., June 28.

Earthjustice. 2021. "Interim agreement reached on protecting the Middle Fork of the Vermilion." June 23. Accessed on August 25, 2021 at https://earthjustice.org/news/press/2021/interim-agreement-reached-on-protecting-the-middle-fork-of-the-vermilion.

Eco-Justice Collaborative. 2021. "Dynegy's coal ash threat." Accessed on August 25, 2021 at https://ecojusticecollaborative.org/dynegys-coal-ash-threat.

Electric Power Research Institute (EPRI). 2006. "Groundwater Remediation of Inorganic Constituents at Coal Combustion Product Management Sites: Overview of Technologies, Focusing on Permeable Reactive Barriers (Final Report)." 1012584. 102p., October.

Eurofins TestAmerica; Geosyntec Consultants (Geosyntec). 2021. "June and July 2021 surface water sampling results, Vermilion Power Station, Illinois."

Exponent. 2018. "Community Impact Analysis of Ash Basin Closure Options at the Allen Steam Station." Report to Duke Energy Carolinas, LLC. 210p., November 15.

Federal Emergency Management Agency (FEMA). 2012. "FIRM Flood Insurance Rate Map, Vermilion County, Illinois and Incorporated Areas." National Flood Insurance Program (NFIP). Map Number 17183C0275D, May 16.

Geosyntec Consultants (Geosyntec). 2021a. "Proposed On-Site Landfill Feasibility Study, Vermilion Power Plant, Oakwood, Illinois." Report to Dynegy Midwest Generation. 84p., August.

Geosyntec Consultants (Geosyntec). 2021b. "Monitored Natural Attenuation Evaluation, Vermilion Power Plant North Ash Pond (CCR Unit #910) and Old East Ash Pond (CCR Unit #911) Areas (Final Draft)." Report to Dynegy Midwest Generation. 30p., November.

Geosyntec Consultants (Geosyntec). 2021c. "Initial Operating Permit, Vermilion Power Plant North Ash Pond, Oakwood, Illinois." Submitted to Dynegy Midwest Generation. 421p., October.

Geosyntec Consultants (Geosyntec). 2021d. "Initial Operating Permit, Vermilion Power Plant New East Ash Pond, Oakwood, Illinois." Submitted to Dynegy Midwest Generation. 421p., October.

Geosyntec Consultants (Geosyntec). 2021e. "Construction schedule and labor, vehicle, and equipment demands for closure of the North Ash Pond/Old East Ash Pond and the New East Ash Pond, Vermilion Power Station, Illinois." September. [Provided in Appendix C]

Geosyntec Consultants (Geosyntec). 2021f. "Initial Operating Permit, Vermilion Power Plant Old East Ash Pond, Oakwood, Illinois." Submitted to Dynegy Midwest Generation. 413p., October.

Geosyntec Consultants (Geosyntec). 2021g. "CCR Final Closure Plan, Vermilion Power Plant Old East Ash Pond and North Ash Pond, Oakwood, Illinois." Report to Dynegy Midwest Generation. 14p., November.

Geosyntec Consultants (Geosyntec). 2021h. "Safety Emergency Response Plan, Vermilion Power Plant, Oakwood, Illinois." Report to Dynegy Midwest Generation. 39p., August.

Geosyntec Consultants (Geosyntec). 2021i. Letter to Dynegy Midwest Generation re: Summary of Old East Ash Pond Area Slope Stability Reliability Assessment, Vermillion Power Plant. November. [Provided in Appendix C]

Hanson Professional Services Inc. 2019. "Antidegradation Assessment for Management of Waters from Closure and Post-Closure Care of Ash Ponds, Vermilion Site, Dynegy Midwest Generation, LLC, NPDES Permit No. IL0004057." Report to Dynegy Midwest Generation, LLC. 151p., June 1.

Hesterberg, TW; Valberg, PA; Long, CM; Bunn, WB III; Lapin, C. 2009. "Laboratory studies of diesel exhaust health effects: Implications for near-roadway exposures." *EM Mag*. August:12-16. Accessed on March 05, 2014 at http://pubs.awma.org/gsearch/em/2009/8/hesterberg.pdf.

Illinois Dept. of Natural Resources (IDNR). 2021. "Kickapoo State Recreation Area." Accessed on August 25, 2021 at https://www2.illinois.gov/dnr/Parks/Pages/Kickapoo.aspx.

Illinois Emergency Management Agency (IEMA). 2020. "Earthquake preparedness." Accessed on September 7, 2021 at https://www2.illinois.gov/iema/Preparedness/Pages/Earthquake.aspx.

Illinois Environmental Protection Agency (IEPA). 2013. "Dynegy Midwest Generation, L.L.C., Vermilion Power Station Public Hearing, Tuesday, August 6, 2013 (Notice of Water Discharge Permit Public Hearing)." 2p., July 29.

Illinois Environmental Protection Agency (IEPA). 2019. "Illinois EPA Environmental Justice (EJ) Start." Accessed on April 30, 2021 at https://illinois-epa.maps.arcgis.com/apps/webappviewer/index.html?id=f154845da68a4a3f837cd3b880b0233c.

Illinois Environmental Protection Agency (IEPA). 2021a. "Standards for the disposal of coal combustion residuals in surface impoundments." Accessed on October 4, 2021 at https://www.ilga.gov/commission/jcar/admincode/035/03500845sections.html.

Illinois Environmental Protection Agency (IEPA). 2021b. "Illinois Landfill Disposal Capacity Report." 11p., August. Accessed on October 4, 2021 at https://www2.illinois.gov/epa/topics/waste-management/landfills/landfill-capacity/Documents/landfill-capacity-report-2021.pdf.

Illinois, Attorney General. 2021. "Plaintiff's motion to enter agreed interim order [re: People of the State of Illinois, ex rel. Kwame Raoul, Attorney General of the State of Illinois, and ex re. Jacqueline M. Lacy, State's Attorney of Vermilion County, Illinois v. Dynegy Midwest Generation, LLC, a Delaware limited liability co.]." Submitted to Illinois Circuit Court, Fifth Judicial Circuit, Vermilion County, Chancery Division. No. 2021CH000024. 22p., June 23.

Kelron Environmental. 2003. "Regional and Local Hydrogeology and Geochemistry: Vermilion Power Plant, Illinois. Volumes 1-2 (Draft)." Report to Dynegy Midwest Generation, Inc. 495p., November 30.

Kelron Environmental. 2012. "Hydrogeology and Groundwater Quality of the North Ash Pond System, Vermilion Power Station, Oakwood, Illinois, Dynegy Midwest Generation, LLC." Report to Dynegy Operating Co. 226p., March 15.

La, V. 2021. "State parks officials see increase in visitors amid understaffing, encourage compliance with rules." *Illinois Newsroom* July 29. Accessed on August 25, 2021 at https://illinoisnewsroom.org/state-parks-officials-see-increase-in-visitors-amid-understaffing-encourage-compliance-with-rules.

Mauderly, JL; Garshick, E. 2009. "Diesel exhaust." In *Environmental Toxicants: Human Exposures and Their Health Effects (Third Edition)*. (Ed.: Lippmann, M), John Wiley & Sons, Inc., Hoboken, NJ. p551-631.

National Research Council. 2013. "Alternatives for Managing the Nation's Complex Contaminated Groundwater Sites." Division of Earth and Life Sciences, Water Science and Technology Board, Committee on Future Options for Management in the Nation's Subsurface Remediation Effort. National Academies Press, Washington, DC. 422p. Accessed on April 17, 2014 at http://www.nap.edu/catalog.php?record_id=14668.

Natural Resource Technology, Inc. 2014a. "Corrective Action Plan, Old East Ash Pond, Vermilion Power Station, Oakwood, Illinois, Dynegy Midwest Generation, LLC." Report to Dynegy Operating Co. 74p., April 2.

Natural Resource Technology, Inc. 2014b. "Corrective Action Plan, North Ash Pond System, Vermilion Power Station, Oakwood, Illinois, Dynegy Midwest Generation, LLC." Report to Dynegy Operating Co. 78p., April 2.

US Dept. of the Interior (US DOI). 2010. "Eading Section 7(a) Final Review and Determination, Vermilion Power Station Bank Stabilization Project - Location 2, Middle Fork Vermilion National Scenic River, Vermilion County, Illinois." National Park Service. 8p., August.

OBG. 2018. "2018 Groundwater Monitoring and Modeling Report, Vermilion Site North Ash Pond System and Old East Ash Pond System Coal Combustion Residual Units, Vermilion, Illinois (Draft)." Report to Dynegy Midwest Generation, LLC. 602p., October.

OBG. 2019a. "Update to the Hydrogeology and Groundwater Quality of the North Ash Pond and Old East Ash Pond, Vermilion Site North Ash Pond and Old East Ash Pond, Oakwood, Illinois (Draft)." Report to Dynegy Midwest Generation, LLC. 94p., June.

OBG. 2019b. "Update to the Regional and Local Hydrogeology and Geochemistry: New East Ash Pond, Vermilion Site New East Ash Pond, Oakwood, Illinois (Draft)." Report to Dynegy Midwest Generation, LLC. 778p., June.

Ramboll. 2021a. "Groundwater Modeling Report, Vermilion Power Plant North Ash, Vermilion Power Plant, Oakwood, Illinois (Draft Final)." Report to Dynegy Midwest Generation, LLC, November 3.

Ramboll. 2021b. "Hydrogeologic Site Characterization Report, Vermilion North Ash Pond and Old East Ash Pond, Vermilion Power Plant, Oakwood, Illinois." Report to Dynegy Midwest Generation, LLC. 48p., August 4.

Ramboll. 2021c. "Groundwater Monitoring Plan, Vermilion North Ash Pond and Old East Ash Pond, Vermilion Power Plant, Oakwood, Illinois." Report to Dynegy Midwest Generation, LLC. 19p., August 4.

Ramboll. 2021d. "Hydrogeologic Site Characterization Report, New East Ash Pond, Vermilion Power Station, Illinois." Report to Dynegy Midwest Generation, LLC. 43p., August 20.

Stantec Consulting Services Inc. (Stantec). 2017. "Vermilion Site Riverbank Assessment." Report to Dynegy Midwest Generation, LLC. Submitted to Illinois Environmental Protection Agency (IEPA), Bureau of Water; Division of Public Water Supplies. 24p., November 2.

Stantec Consulting Services Inc. (Stantec). 2019. "Technical Memorandum to V. Modeer (Dynegy Midwest Generation, LLC) re: Reliability Analysis for Slope Stability with Assumed Riverbank Erosion, Dynegy Midwest Generation Vermilion Site." Submitted to US Army Corps of Engineers, Louisville District. 4p., March 11.

Tennessee Valley Authority (TVA). 2015. "Draft Ash Impoundment Closure Environmental Impact Statement. Part I - Programmatic NEPA Review." 164p., December.

US Dept. of Labor (US DOL). 2020a. "Employer-Reported Workplace Injuries and Illnesses - 2019." Bureau of Labor Statistics. USDL-20-2030. 9p., November 4.

US Dept. of Labor (US DOL). 2020b. "Fatal occupational injuries, total hours worked, and rates of fatal occupational injuries by selected worker characteristics, occupations, and industries, civilian workers, 2019." Bureau of Labor Statistics, December. Accessed on October 5, 2021 at https://www.bls.gov/iif/oshwc/cfoi/cfoi_rates_2019hb.xlsx.

US Dept. of Labor (US DOL). 2020c. "Table R100. Incidence rates for nonfatal occupational injuries and illnesses involving days away from work per 10,000 full-time workers by occupation and selected events or exposures leading to injury or illness, private industry, 2019." Bureau of Labor Statistics, October. Accessed on October 5, 2021 at https://www.bls.gov/iif/oshwc/osh/case/cd_r100_2019.xlsx.

US Dept. of Transportation (US DOT). 2020. "Large Truck and Bus Crash Facts 2018." Federal Motor Carrier Safety Administration, Analysis Division. FMCSA-RRA-19-018. 118p., September.

US EPA. 1999. "Use of monitored natural attenuation at Superfund, RCRA corrective action and underground storage tank sites (Final)." Office of Solid Waste and Emergency Response (OSWER). OSWER Directive 9200.4-17P. 32p., April 21.

US EPA. 2014. "Human and Ecological Risk Assessment of Coal Combustion Residuals (Final)." Office of Solid Waste and Emergency Response (OSWER), Office of Resource Conservation and Recovery. 1237p., December. Accessed on October 16, 2015 at http://www.regulations.gov/#!documentDetail; D=EPA-HQ-RCRA-2009-0640-11993.

US EPA. 2015a. "Hazardous and solid waste management system; Disposal of coal combustion residuals from electric utilities (Final rule)." *Fed. Reg.* 80(74):21302-21501. 40 CFR 257; 40 CFR 261, April 17.

US EPA. 2015b. "Use of Monitored Natural Attenuation for Inorganic Contaminants in Groundwater at Superfund Sites." Office of Solid Waste and Emergency Response (OSWER). OSWER Directive 9200.1-36. 83p., August.

US EPA. 2016. "Technical Guidance for Assessing Environmental Justice in Regulatory Analysis." 120p., June.

US Fish and Wildlife Service (US FWS). 2019. "Biological Opinion: Effects to the Clubshell and Northern Riffleshell Mussels from the proposed Dynegy Midwest Generation Streambank Stabilization Project in Vermilion County, Illinois." Southern Illinois Sub-Office. 22p., July.

Various. 1990-2010. "Compilation of files related to Orchid Hill Natural Heritage Landmark, Illinois."

Appendix A

2020 Human Health and Ecological Risk Assessment

Draft

Human Health and Ecological Risk Assessment
Vermilion Generating Station
Oakwood, Illinois

Prepared for

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Table of Contents

List of Tables

List of Figures

Abbreviations

ADI	Acceptable Daily Intake
BCF	Bioconcentration Factor
CCR	Coal Combustion Residual
CEM	Conceptual Exposure Model
COI	Constituent of Interest
Cr	Chromium
Cr(VI)	Hexavalent Chromium
CSF	Cancer Slope Factor
CSM	Conceptual Site Model
ESV	Ecological Screening Value
GWPS	Groundwater Protection Standard
K_d	Equilibrium Partitioning Coefficient
K_p	Permeability Coefficient
HTC	Human Threshold Criteria
IEPA	Illinois Environmental Protection Agency
IL SWQS	Illinois Surface Water Quality Standards
ISGS	Illinois State Geologic Survey
LGU	Lower Groundwater Unit
MCL	Maximum Contaminant Level
MGU	Middle Groundwater Unit
NAP	North Ash Pond
NEAP	New East Ash Pond
NOEC	No Observed Effect Concentration
NPDES	National Pollutant Discharge Elimination System
OEAP	Old East Ash Pond
RfD	Reference Dose
RME	Reasonable Maximum Exposure
RSL	Regional Screening Level
TEC	Threshold Effect Concentration
US EPA	United States Environmental Protection Agency
USGS	United States Geological Survey
VGS	Vermilion Generating Station

Executive Summary

Dynegy Midwest Generation Company's Vermilion Generating Station (VGS or the Site) is an electric power generating facility with coal fired units in Oakwood, Illinois. The facility began operations in the mid-1950s (OBG, 2019a) and was retired in November 2011 (IEPA, 2013). The VGS produced and stored coal combustion residuals (CCRs) as a part of its historical operations in several CCR ash ponds located east of the power plant (North Ash Pond [NAP], Old East Ash Pond [OEAP], New East Ash Pond [NEAP]) (Figure ES.1).

This report presents the results of a human health and ecological risk evaluation for potential CCR constituents in environmental media at the Site. The groundwater monitoring data indicate that groundwater beneath the ash ponds may be impacted by potential CCR-related constituents. The Conceptual Site Model (CSM) developed for the Site indicates that groundwater beneath the former CCR ash ponds flows into the Middle Fork of the Vermilion River adjacent to the Site and may potentially impact surface water and sediment (OBG, 2019a,b). Key observations and conclusions of the risk evaluation are highlighted below.

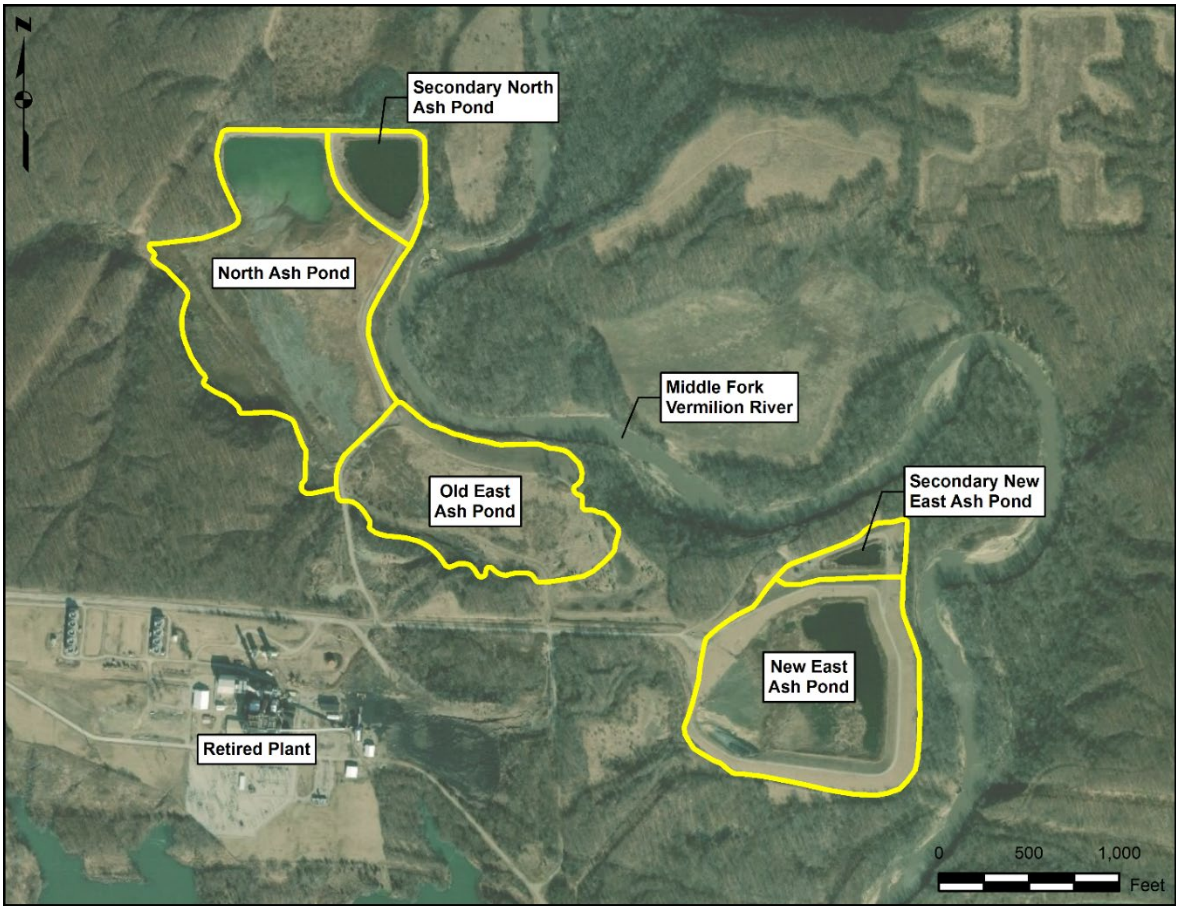

Figure ES.1 Site Location Map. (Based on Dynegy Midwest Generation, LLC, *et al.*, 2019.)

Regarding the Conceptual Site Model:

- The CSM describes how potential CCR constituents in the ash ponds may have come into contact with groundwater and migrated off-Site into other media such as surface water and sediment. The CSM is informed by the hydrogeology of the Site, including information on groundwater depth, groundwater flow, and the characteristics of nearby surface water bodies. Site documents, including original site investigations (*e.g.*, Kelron Environmental, 2003) and site-specific numerical groundwater modeling reports (OBG, 2018) were reviewed to develop the CSM.
- There are two groundwater units below the site in the vicinity of the NAP/OEAP: the Middle Groundwater Unit (MGU) and Lower Groundwater Unit (LGU). The MGU is the primary conduit for groundwater flow at the Site. Groundwater flow in the MGU is primarily eastward toward the Middle Fork of the Vermilion River. Groundwater flow in the LGU is also primarily eastward toward the Middle Fork of the Vermilion River. CCR-related constituents in both the MGU and LGU may potentially discharge *via* groundwater into the Middle Fork of the Vermilion River.
- The effect of the NEAP on groundwater quality in the unlithified materials and bedrock is either negligible or not present as a result of limited or no hydraulic connection.
- Potentiometric groundwater elevation data indicate that groundwater in the bedrock aquifer flows upward into the unlithified materials rather than downward into the bedrock aquifer (Kelron Environmental, 2003). Isotopic radiocarbon dating of the groundwater also confirms that the ash ponds are not a source of recharge to the bedrock aquifer (Kelron Environmental, 2003; OBG, 2019b).
- Based on site-specific numerical groundwater modeling (OBG, 2018) and potentiometric groundwater elevation data (Kelron Environmental, 2003; Kelron Environmental, 2012a), all groundwater potentially impacted with CCR-related constituents discharges into the Middle Fork of the Vermilion River. Thus, there is no migration of potentially impacted groundwater beneath the river, and there are no human or environmental exposures to potential CCR-related constituents on the opposite side of the Middle Fork of the Vermilion River.
- Groundwater is not used for any purpose at the Site. Based on a well survey (Kelron Environmental, 2012b), private residential wells are only located hydraulically upgradient of the Site and, thus, cannot plausibly be impacted by any CCR-related constituents. Also, there is no off-Site migration of CCR-related constituents in groundwater to the south or west of the Site because all shallow groundwater at the NEAP and NAP/OEAP discharges to the Middle Fork of the Vermilion River (OBG, 2019a; Kelron Environmental, 2003, 2012a).
- Groundwater samples from both the MGU and the LGU were collected from a total of 34 monitoring wells between 1998 and 2019. The analyses presented in this report relied on groundwater data collected from 20 monitoring wells between 2011 and 2019, which is the dataset considered to be representative of current conditions at the Site. Surface water samples were collected from three locations in the Middle Fork of the Vermilion River, in February and March 2019, providing a total of six samples. Surface water concentrations were modeled for two analytes (beryllium and cobalt) that were detected in groundwater, but not analyzed in surface water. In addition, to supplement the measured surface water data, we modeled the Site-related contributions to surface water for all constituents detected in groundwater at the Site. Sediment sampling has not been conducted in the Middle Fork of the Vermilion River. Sediment concentrations were modeled for all constituents that were detected in groundwater at the Site.
- Many CCR-related constituents are naturally occurring in the environment. Thus detected concentrations of these constituents in surface water or groundwater do not necessarily indicate that these media have been impacted by CCR.

Regarding the Potential Risk to Human Health:

- An exposure pathway is the way a person is exposed to constituents in environmental media. Exposure pathways consist of the following four elements: (1) a source; (2) a mechanism of release, retention, or transport of a constituent to a given medium (*e.g.*, groundwater, surface water, sediment, or fish); (3) a point where a person can contact the medium (*i.e.*, exposure point); and (4) a route of exposure at the point of contact (*e.g.*, incidental ingestion, dermal contact). If any of these elements is missing, the pathway is considered incomplete (*i.e.,* it does not present a means of exposure). Only those exposure pathways judged to be complete are of concern for human exposure and were evaluated further at the Site.
- The Site-related constituents of interest (COIs) for surface water included all analytes detected in surface water, or analytes detected in groundwater but not analyzed in surface water. The COIs for sediment included all analytes that were detected in groundwater.
- Based on the local hydrogeology, a private well survey, and the location of residences relative to the Site, residential exposure to groundwater used for drinking water or irrigation is not a complete exposure pathway and was not evaluated.
- The following complete exposure pathways for humans were identified and evaluated at the Site: recreators in the Vermilion River who are exposed to surface water and sediment (boaters and swimmers), and anglers who consume locally caught fish.
- None of the complete human exposure pathways at the Site are expected to pose an unacceptable risk, for the following reasons.
  - For recreators exposed to surface water, all the maximum measured or modeled concentrations of COIs in surface water were below the conservative risk-based screening values derived for this assessment. Therefore, none of the COIs evaluated for surface water are expected to pose an unacceptable risk to recreators swimming or boating or tubing in the Middle Fork of the Vermilion River adjacent to the Site.
  - For recreators exposed to sediment, the modeled maximum sediment concentrations of COIs were well below their respective recreational sediment benchmark. Therefore, exposure to sediment is not expected to pose an unacceptable risk to recreators while swimming or boating.
  - For anglers consuming locally caught fish, the maximum concentrations for all COIs in surface water were below risk-based concentrations derived to be protective of fish consumption. Therefore, none of the COIs evaluated are expected to pose an unacceptable risk to recreators consuming fish caught in the Middle Fork of the Vermilion River.

Regarding the Potential Risk to Ecological Receptors:

- The following complete exposure pathways for ecological receptors in the Middle Fork of the Vermilion River were identified and evaluated: 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. None of the complete ecological exposure pathways at the Site are expected to pose an unacceptable risk.
  - The maximum measured or modeled concentrations for all COIs in surface water were below conservative risk-based surface water benchmarks. Therefore, none of the COIs evaluated for

surface water are expected to pose an unacceptable risk to ecological receptors in the Middle Fork of the Vermilion River.

- The maximum modeled concentrations for all COIs in sediment were below conservative risk-based sediment screening benchmarks. Therefore, none of the COIs evaluated for sediment are expected to pose an unacceptable risk to ecological receptors in the Middle Fork of the Vermilion River.
- 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). None of the COIs were identified to have potential bioaccumulative effects. Overall, this evaluation demonstrated that none of the COIs evaluated are expected to pose an unacceptable risk to ecological receptors.

Regarding Overall Risk Conclusions and Health-protective Assumptions:

- Our overall conclusion is that groundwater from the ash ponds at the VGS and potential groundwater contributions to surface water and sediment COI concentrations in the Middle Fork of the Vermilion River pose no unacceptable risks to human health or the environment. We reach this conclusion because modeled or detected maximum concentrations of all COIs in surface water and sediment in the Middle Fork of the Vermilion River were below conservative risk-based screening benchmarks. This conclusion was reached using methodology consistent with applicable US EPA risk assessment principles (*e.g.*, US EPA, 1989). The assessment relied on conservative assumptions meant to overestimate possible exposures and risks and provide an additional level of certainty in the conclusions. Some of the key health-protective assumptions used in the assessment are as follows:
  - We assumed that CCR constituents in groundwater could migrate into surface water and sediment. Where measured surface water data were available, these were used in the risk assessment, but for analytes where surface water data were not available and which were detected in groundwater, surface water concentrations were modeled and evaluated using the maximum detected concentrations in groundwater.
  - In our assessment we assumed that measured or modeled COI concentrations were from the site. Reliance on the maximum detected COI concentration is not representative of conditions across the entire Site and resulted in overestimates of potential human and ecological exposures.
  - While measured surface water concentrations were used for the risk assessment, surface water concentrations were also modeled to estimate the impact of Site-related COIs on surface water, and to supplement available surface water data. The modeled surface water concentrations demonstrated that Site-related COIs were in agreement with the measured surface water concentrations and further demonstrated that Site-related COIs do not pose an unacceptable risk to human health and the environment..
  - We conservatively assumed that human and ecological receptors would be exposed to the maximum modeled or measured concentration for the entire exposure period regardless of location, even though the average concentration is more representative of exposures within an exposure area over a long period of time. Ignoring the variability in exposure over time and location may result in a substantial overestimation of actual risk.

  - For the human health evaluation, we used conservative exposure assumptions that likely overestimate actual exposures. For example, we assumed that children and adults would swim or go tubing for 4 hours/day for 40 days/year for 26 years. For perspective, according to the US EPA "Exposure Factors Handbook," which provides guidance on values to use in a risk assessment, a high-end estimate of swimming activities for adults and children is under 3.3 hours per month, on average (US EPA, 2011a).
  - For the ecological evaluation, we conservatively assumed all constituents to be 100% bioavailable. However, several metal COIs (*e.g.*, cadmium, copper, lead, nickel, and zinc) form insoluble metal sulfides in sediment in the presence of sulfide or bind to organic carbon, reducing their bioavailability and toxicity to benthic invertebrates. Similarly, depending on the mineralogy and chemical form, the oral bioavailability to wildlife of several metals (*e.g.*, cadmium, lead) has been shown to be much lower than 100%.
- 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 ash ponds have been 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. Moreover, the modeled time horizon to achieving the groundwater protection standards (GWPSs) under the various closure alternatives (OBG, 2018) is immaterial from a risk perspective since there is no unacceptable risk associated with exceedances of the GWPSs. Because of this, other factors, such as the impact to the environment and nearby communities and worker safety should be considered when evaluating closure options.

1 Introduction

Dynegy Midwest Generation Company's Vermilion Generating Station (VGS or the Site) is an electric power generating facility with coal fired units in Oakwood, Illinois. The facility began operations in the mid-1950s (OBG, 2019a) and was retired in November 2011 (IEPA, 2013). The VGS produced and stored coal combustion residuals (CCRs) as a part of its historical operations in several CCR ash ponds located east of the power plant (North Ash Pond, Old East Ash Pond, New East Ash Pond). The CCR ash ponds are planned for closure.

An alternatives analysis was performed to select an optimal closure plan (OBG, 2018). This analysis included construction of a numerical model in order to evaluate future groundwater impacts under different closure scenarios. Specifically, groundwater flow hydraulics and the future boron concentrations in groundwater[1] were evaluated using the numerical model for different closure scenarios, including closure in place, closure by removal (on-site and off-site), beneficial reuse with monitored natural attenuation (MNA), and the selected hybrid closure plan (known as Scenario 4A). Scenario 4A entails excavating and consolidating the OEAP to the NAP, consolidating ash to the west end of the NEAP, closing the consolidated NAP and NEAP in place, and using existing or new subsurface barrier walls around each former pond to limit any additional potential impacts to groundwater. Scenario 4A was selected because it was determined to be as protective of groundwater as closure by removal, but does not require off-site transportation of the ash that could generate additional negative impacts (OBG, 2018).

This report presents the results of an evaluation that characterizes potential risk to human and ecological receptors that may be exposed to CCR constituents in environmental media. While this report specifically evaluates current risks, it also informs what potential risks may be under the different closure scenarios. Human and ecological risks were evaluated for Site-specific constituents of interest (COIs), which included all constituents detected in groundwater or surface water. The conceptual site model (CSM) assumed that Site-related COIs in groundwater may migrate to the river and affect surface water and sediment in the vicinity of the Site.

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

1. Identify complete exposure pathways and develop a conceptual exposure model (CEM).
2. Identify Site-related COIs: All constituents detected in groundwater or surface water.
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 for the COPCs.
5. Formulate risk conclusions and discuss any associated uncertainties.

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[1] Boron was selected as a representative analyte for coal ash impacts to groundwater due to its common, unique presence at coal ash sites, its observed exceedance of groundwater protection standards at the VGS Site, and its high mobility in groundwater (OBG, 2018, p. 2).

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 relied on US EPA's Regional Screening Levels (RSLs) User's Guide (US EPA, 2019a), incorporating principles and assumptions consistent with the Federal CCR Rule (US EPA, 2015a) and US EPA's Human and Ecological Risk Assessment of Coal Combustion Residuals (US EPA, 2014a).

Section 2 of this report presents a description and CSM for the Site, and the human and ecological conceptual exposure models. Section 3 presents the groundwater and surface water data used in the risk evaluation, and the methodology used for modeling surface water and sediment concentrations. Section 4 describes the human health and ecological risk evaluations and associated uncertainties. Section 5 presents the overall conclusions of the risk evaluation.

2 Site Overview

2.1 Site Description

The VGS is located approximately five miles north of the Village of Oakwood, Illinois, along the Middle Fork of the Vermilion River. The Site includes a retired plant and multiple decommissioned ash ponds (Figure 2.1):

- Old East Ash Pond (OEAP);
- North Ash Pond (NAP), including an associated secondary pond; and
- New East Ash Pond (NEAP), including an associated secondary pond.

The OEAP is the oldest of the ash receiving ponds and was put into service in the mid-1950s as part of the original plant construction. Use of the OEAP continued until the NAP, which is hydraulically connected with the OEAP, was constructed and put into service in the mid-1970s. For purposes of closure, the company characterizes the OEAP and NAP as a single multi-unit system because (a) there is a continuous layer of ash running between the OEAP and NAP, (b) the NAP was subsequently designed such that the outer berms were an extension of the outer berms of the OEAP, (c) the NAP was designed and constructed to incorporate the ash located within the OEAP, (d) they share a groundwater monitoring network, (e) they fall within the same areal extent of the local groundwater flow regime, and (f) they are covered by a single closure plan. Use of the NAP continued until 1989-1990, after which ash was diverted to the NEAP (OBG, 2019a).

The IEPA approved NEAP was constructed in the bottomlands of the Middle Fork of the Vermilion River with low permeability clay earthen berms built with an eight-foot thick low permeability core on the north, east, and south sides that were keyed into the underlying shale with four-foot thick soil/bentonite slurry walls (Kelron Environmental, 2003). The west side of the NEAP is formed by a cut into the bluff and capped with a six-foot thick low permeability clay keyed at the base of the bluff into the underlying shale. The original 1989 footprint of the NEAP was expanded in 2002 to form the present extent of the NEAP. The height of the berms surrounding the NEAP was raised with more low permeability clay in 2002, and a trench filled with low permeability fill was keyed into the shale along the natural bluff on the west side of the NEAP (OBG, 2019b). The NEAP overlies a historical coal mine, which has impacted groundwater quality in the area (OBG, 2019b).

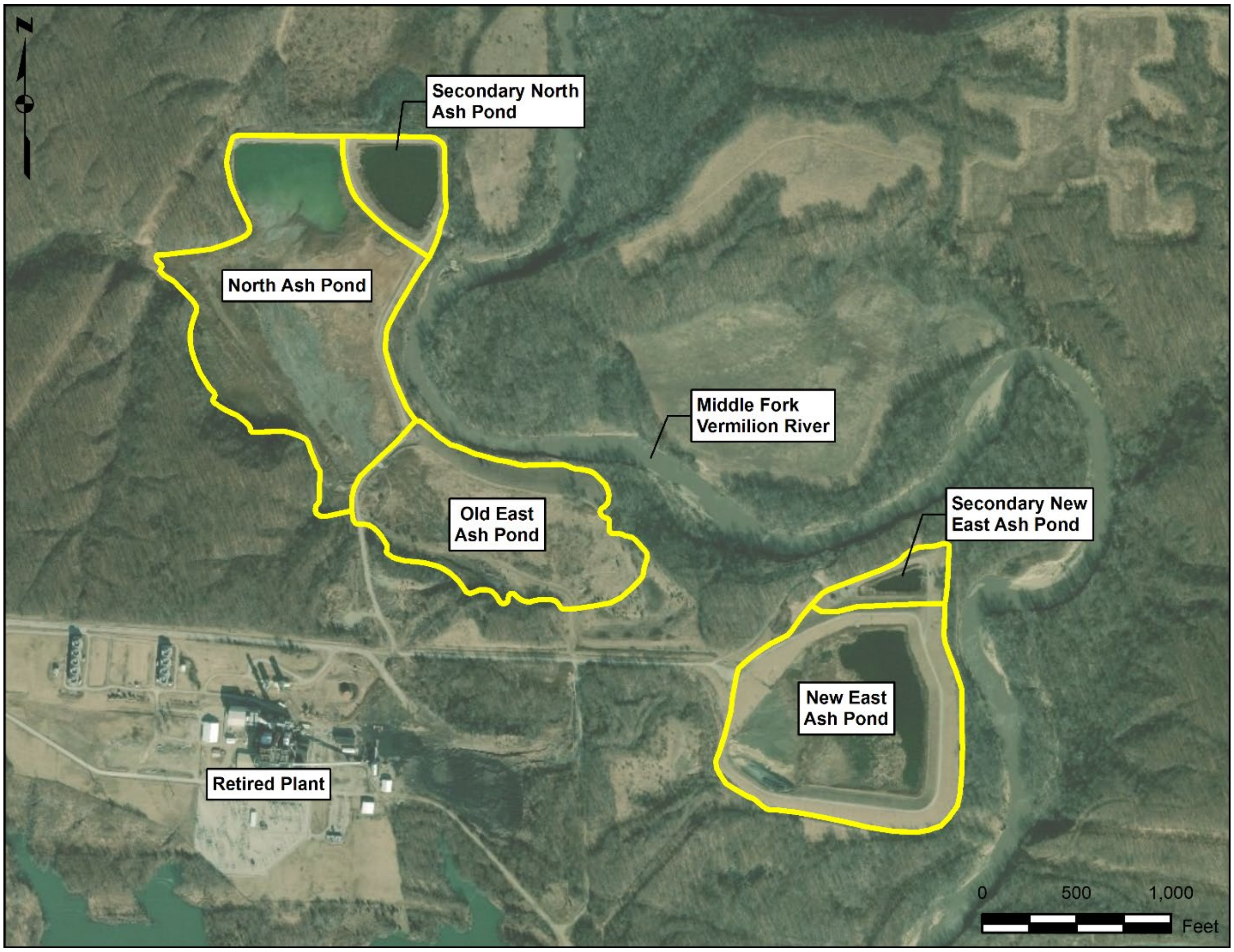


Figure 2.1 Site Location Map. (Based on Dynegy Midwest Generation, LLC, *et al.*, 2019.)

1. An upper unit composed of silt deposits and alluvium;
2. A Middle Groundwater Unit (MGU) composed of alluvial sand and gravel with some silt;
3. A middle confining unit composed of alluvial and re-worked glacial deposits, clay, and silty clay with occasional sand lenses;
4. A Lower Groundwater Unit (LGU) composed of glacial outwash and re-worked glacial deposits of sand, silty sand, and clayey sand;
5. A lower confining unit composed of till, primarily clay, silty clay, and sandy clay with occasional sand lenses; and
6. Bedrock composed of shale with deep coal seams and occasional layers of limestone and sandstone.

Hydrogeologic data collected at the site show that groundwater flow occurs in the MGU and LGU, while the middle and lower confining units act as barriers to groundwater flow (OBG, 2019a). The MGU is more conductive than the LGU and is the primary conduit for groundwater flow at the Site. Groundwater in both the MGU and LGU flows to the east toward the Middle Fork of the Vermilion River. Potentiometric head maps, vertical gradients, and geochemistry data confirm that groundwater in both the MGU and LGU discharge into the Middle Fork of the Vermilion River (OBG, 2019a; Kelron Environmental, 2003, 2012a).

The geology underlying the Site in the vicinity of the NEAP is distinct from the geology in the vicinity of the NAP/OEAP because the NAP/OEAP are built atop terraces, while the NEAP was constructed in the lower elevation bottomlands directly atop shale bedrock. The geology near the NEAP consists of three layers: (OBG, 2019b).

1. Alluvial deposits of sand with occasional layers of silty clay;
2. Glacial deposits of low plasticity silty to sandy clays with occasional silt, sand, and gravel layers; and
3. Bedrock, which contains a major coal seam.

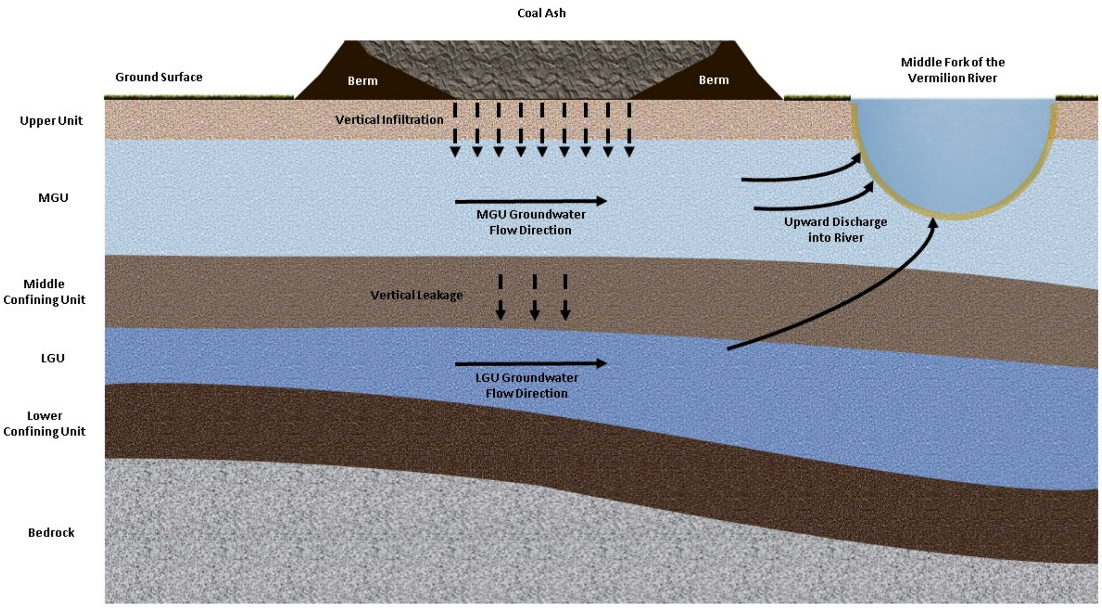
The NEAP is hydraulically isolated from the alluvial deposits by low permeability clay/bentonite barriers installed along its boundaries and keyed into the underlying low permeability shale (OBG, 2019b). Groundwater surrounding the NEAP discharges into the Middle Fork of the Vermilion River (OBG, 2019b). Groundwater quality data have demonstrated that CCR-related constituents from the NEAP have negligible or no impact on groundwater outside the low permeability barriers and are not impacting the Middle Fork of the Vermilion River (OBG, 2019b).

2.2 Conceptual Site Model

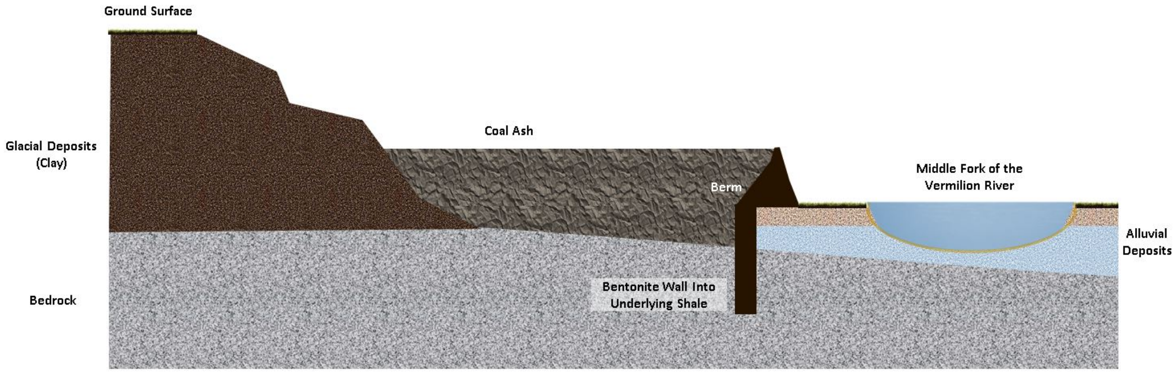
A conceptual site model (CSM) describes the sources of contamination, the hydrogeologic units, and the physical processes that control the transport of constituents in and between environmental media. In this case, the CSM describes how CCR constituents in the ash ponds may have come into contact with groundwater and migrated off-Site into other media such as surface water and sediment. The CSM was developed using historical hydrogeologic and groundwater quality data (OBG, 2019a,b). The CSM is informed by the hydrogeology of the Site, including information on groundwater depth, groundwater flow, and the characteristics of nearby surface water bodies. At the OEAP/NAP, potential dissolved CCR-related constituents may migrate vertically downward under the influence of gravity into the MGU (Figure 2.2). The MGU is the primary conduit for groundwater flow at the Site. Groundwater flow in the MGU is primarily eastward toward the Middle Fork of the Vermilion River. Some potentially dissolved CCR-related constituents may migrate downward through the middle confining unit into the LGU. Groundwater flow rates are lower in the LGU relative to the MGU due to the difference in the hydraulic conductivities of the two units. Groundwater flow in the LGU is also primarily eastward toward the Middle Fork of the Vermilion River. CCR-related constituents in both the MGU and LGU may potentially discharge with groundwater into the Middle Fork of the Vermilion River. Based on site-specific numerical groundwater modeling performed at the Site (OBG, 2018), all groundwater impacted with potential CCR-related constituents is ultimately discharged into the Middle Fork of the Vermilion River and no CCR-related constituents migrate away from the Site underneath the river. Similarly, there is no transport of CCR-related constituents toward the northern, western, and southern property boundaries.

There have been either no observed or negligible CCR-related impacts in the bedrock aquifer, which underlies the NEAP and OEAP/NAP. Hydraulic head data indicate that groundwater in the bedrock aquifer flows upward into the overlying unlithified deposits rather than downward into the bedrock aquifer. Isotopic radiocarbon dating of the groundwater also confirms that the ash ponds are not a source of recharge to the bedrock aquifer (Kelron Environmental, 2003; OBG, 2019b).

During groundwater discharge into the river, CCR-related constituents may partition between sediments and surface water. It should be noted that many of the CCR-related constituents occur naturally in sediments and surface water. As a result, their presence in sediments and/or surface water of the Vermilion River does not necessarily signify contributions from the ash ponds.



At the NEAP, since the pond is built atop low permeability shale and surrounded by low permeability clay/bentonite layers (Figure 2.3), no constituent migration is expected out of the pond. There is no or negligible impact of CCR-related constituents from the NEAP on groundwater quality. Additionally, while groundwater underlying the NEAP migrates toward and discharges into the Middle Fork of the Vermilion River, there is no evidence of CCR-related impacts from the NEAP in surface water (OBG, 2019b, discussed further in Section 2.3.1).



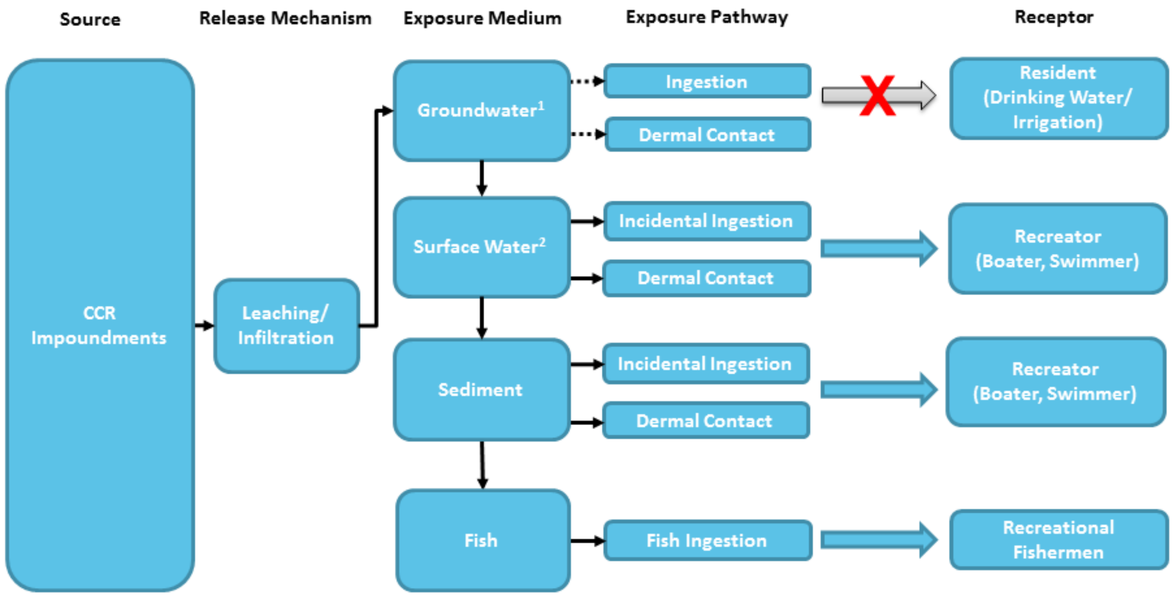
2.3 Human Conceptual Exposure Model

A Conceptual Exposure Model (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 2.4 presents a human CEM for the Site. It considers a human receptor who could be exposed to COIs hypothetically released from the ash ponds into groundwater, surface water, sediment, and fish. The following human receptors and exposure pathways were evaluated 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 river near the site;
  - Boaters – exposure to surface water and sediment while boating;
  - Swimmers – exposure to surface water and sediment while swimming or tubing;
  - Anglers – exposure to surface water and sediment and consumption of locally caught fish.

All of these exposure pathways were considered complete except for residential exposure to groundwater or surface water used for drinking water or irrigation. Section 2.3.1 (below) explains why the residential drinking water and irrigation pathways are incomplete, and Section 2.3.2 provides additional description of the recreational exposures.



2.3.1 Groundwater as a Drinking Water/Irrigation Source

Groundwater as a source of drinking water and/or irrigation water is not a complete exposure pathway for CCR-related constituents originating from the OEAP/NAP, or the NEAP. Although the OEAP/NAP may be the source of several CCR constituents that were detected above the Illinois Class I Potable standard in shallow groundwater (*i.e.*, the MGU and LGU) (OBG 2018; Kelron Environmental, 2012a,b), shallow groundwater in the Site vicinity is not used as a source of drinking water. Hydrogeological and geochemical evidence indicate that potential CCR-impacted groundwater near the ponds cannot plausibly impact distant and hydraulically upgradient residential wells that may be used as sources of drinking water or irrigation. Further, the NEAP is not a source of impacts to groundwater, based on the hydrogeological studies of groundwater underlying and adjacent to the NEAP. A summary of the evidence supporting the conclusion that CCR-related constituents originating from the ash ponds do not impact residential wells is presented below.

- **Groundwater for residential use is limited in the vicinity of the ash ponds**. Based on a water well survey conducted in 2009, only one drinking water well was identified within a 750-meter radius of the ash ponds (Kelron Environmental, 2012b). This non-community well, as well as several other drinking water sources identified in the upland areas (outside the 750-meter radius) are all located hydraulically upgradient of the ash ponds. This means that groundwater underlying and near the ash ponds migrates in the opposite direction of the residential drinking water sources that were identified. Therefore, pond-derived CCR constituents in groundwater cannot impact these hydraulically upgradient residential wells (Kelron Environmental, 2012b).
- **There is no off-Site migration of CCR-related constituents to residential wells because all shallow groundwater discharges to the Middle Fork of the Vermilion River**. The Middle Fork of the Vermilion River is the regional sink of shallow groundwater in the area (Kelron Environmental, 2003, 2012a), *i.e.*, all of the groundwater in the MGU and LGU in this area

discharges to the river. Potentiometric surface maps using wells on both sides of the Middle Fork of the Vermilion River show that groundwater discharge from the underlying shale is toward the river (Kelron Environmental, 2003). Potentiometric surface maps for the MGU and the LGU similarly show groundwater flow toward the river (Kelron Environmental, 2012a). Hydraulic head measurements show that the surface water elevation in the Middle Fork of the Vermilion River is about 1.5 to 4 feet lower than the head in wells screened in the alluvium across the river from the NEAP portion of the Site (MW26 and MW28) (Kelron Environmental, 2003). Based on this site data, the Middle Fork is the discharge point for groundwater at the Site (OBG, 2018). In sum, this evidence confirms that CCR-related constituents in MGU and LGU groundwater will discharge to the Middle Fork and will not migrate off-Site.

- **The NEAP is not hydraulically connected to shallow groundwater**. Since the expansion of the NEAP in 2002, changes in the pond stage elevation in the NEAP have been shown to not impact surrounding groundwater levels, as the pond is hydraulically isolated by soil/bentonite slurry walls and a compacted clay core (Kelron Environmental, 2003). The hydraulic separation between the pond water and shallow groundwater suggests that the groundwater in the vicinity of the pond is not impacted by pond-derived CCR constituents.
- **Water quality data in the vicinity of the NEAP confirm that pond water and shallow groundwater are not connected**. Water quality data collected for both groundwater and NEAP water indicate that trace metals (*e.g.*, molybdenum, selenium, and vanadium) that were elevated above background levels in pond water were at background levels in both the alluvium and in the bedrock groundwater (Kelron Environmental, 2003). Detailed statistical analyses (box-whisker plots, cluster analyses, stiff diagrams, piper diagrams) were performed to compare groundwater chemical measurements to background concentrations (Kelron Environmental, 2003). No NEAP-derived impacts were identified in the surrounding groundwater. Moreover, hydrochemical facies analyses indicate that water from the alluvial aquifer (MW26 and MW28) represents a Ca-Mg-HCO_3 water-type, whereas the NEAP water represents a distinct Ca-SO_4 water-type (Kelron Environmental, 2003). The different chemical compositions of the NEAP pond water and groundwater confirm that CCR-related constituents in the NEAP are not migrating to surrounding groundwater (OBG, 2019b).
- **Isotopic measurements confirm the bedrock aquifer did not receive recharge from the ash ponds at the Site**. Isotopic data from the Site were analyzed by the Illinois State Geologic Survey (ISGS).[2] Based on carbon-14 (^{14}C) and tritium (^{3}H) data, groundwater in the bedrock aquifer is thousands of years older than groundwater in the alluvium. In the NEAP area, radiocarbon (^{14}C) ages of groundwater in the bedrock aquifer ranged between 13,000 and 35,000 years old. In the same subset of bedrock groundwater samples, no detectable tritium was observed, confirming a longer residence time (more than 50 years) for groundwater in the bedrock aquifer (Kelron Environmental, 2003; OBG, 2019b). The observations of ^{14}C and ^{3}H data confirm that the ash ponds are not a source of recharge to the bedrock aquifer.

2.3.2 Recreational Exposures

The Middle Fork of the Vermilion River flows south past the Site and into the Kickapoo State Recreation Area approximately 4.5 miles downstream of the site (Hanson Professional Services Inc., 2019). The river is used for recreational activities and is the only federally designated Wild and Scenic River in Illinois (Hanson Professional Services Inc., 2019, American Rivers, 2018). Recreational activities that occur on

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[2] The atmospheric testing of nuclear weapons released tritium (^{3}H), a radioactive isotope of hydrogen that peaked in the 1960s, and since then has made it possible to track recently recharged groundwater (*e.g.*, Schlosser *et al.*, 1989). Carbon-14 ($^{14}C/^{12}C$) isotopic analysis of dissolved inorganic carbon in groundwater allows the dating of old groundwater (Fontes and Garnier, 1979).

the Middle Fork of the Vermilion River include fishing, paddling, canoeing, tubing, and camping in the state park (Illinois Department of Natural Resources, 2018; Kickapoo Adventures, 2017). The Middle Fork of the Vermilion River is designated by the IEPA as a primary contact recreation site and is not designated for public and food processing water supplies (IEPA, 2018). Therefore, it was concluded that this river is not used as a public drinking water supply.

Recreational exposure to surface water and sediment may occur during boating and swimming/tubing activity along the river. The Middle Fork of the Vermilion River is shallow enough to walk in during low flow periods, and there are sediment deposition areas along the shoreline adjacent to and near the Site that could be accessible by boat. Risks were evaluated separately for boaters and swimmers, as boaters were assumed to have a higher exposure frequency than swimmers (*i.e.*, exposure more days/year), due to temperature constraints that favor a longer boating season. Exposure estimates for swimmers provide a health protective means to evaluate exposure during other recreational activities.

2.4 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 2.5 presents the ecological CEM for the Site. The following ecological receptor groups and exposure pathways were considered.

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

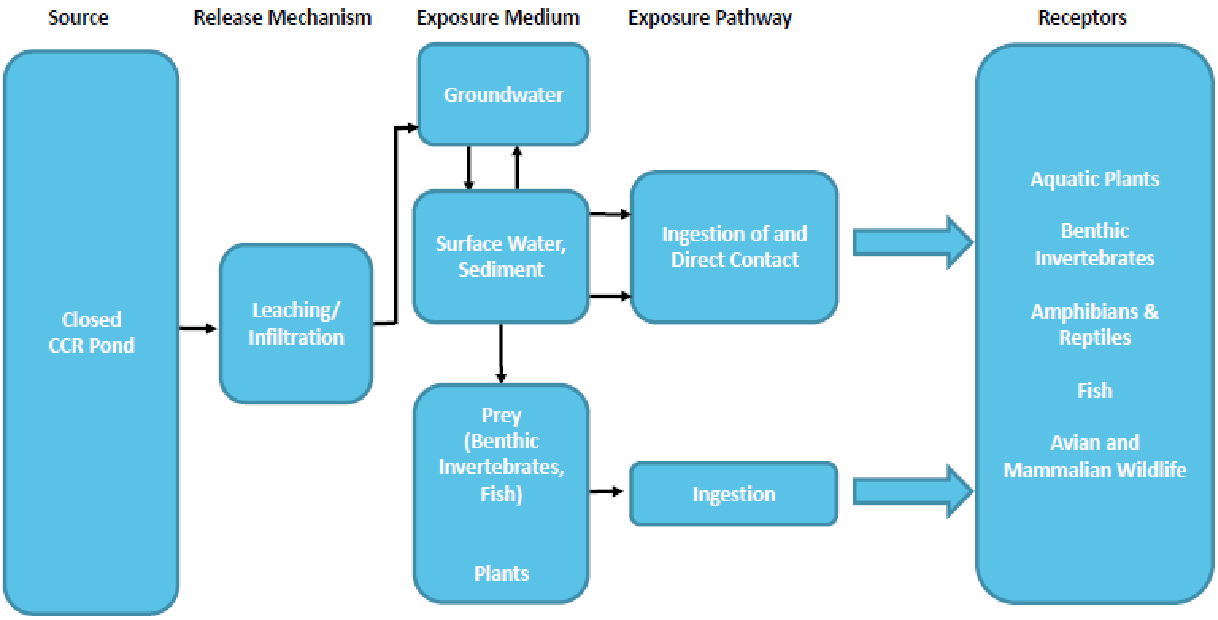

Figure 2.5 Ecological Conceptual Exposure Model. CCR = Coal Combustion Residual.

3 Data Summary

3.1 Groundwater Data

Groundwater samples at the Site were collected from a total of 34 monitoring wells between 1998 and 2019, and the data were provided to Gradient in electronic files that were imported to a project database. The analyses presented in this report relied upon the more recent groundwater data collected from 20 monitoring wells between 2011 and 2019, which is a dataset considered to be representative of current conditions at the Site (Figure 3.1). The chemical constituents that were analyzed in groundwater samples (Table 3.1) were based on the Illinois Environmental Protection Agency (IEPA)-approved analyte list presented in the Site's groundwater monitoring plan (OBG, 2019c) and National Pollutant Discharge Elimination System (NPDES) Permit (IEPA, 2012).

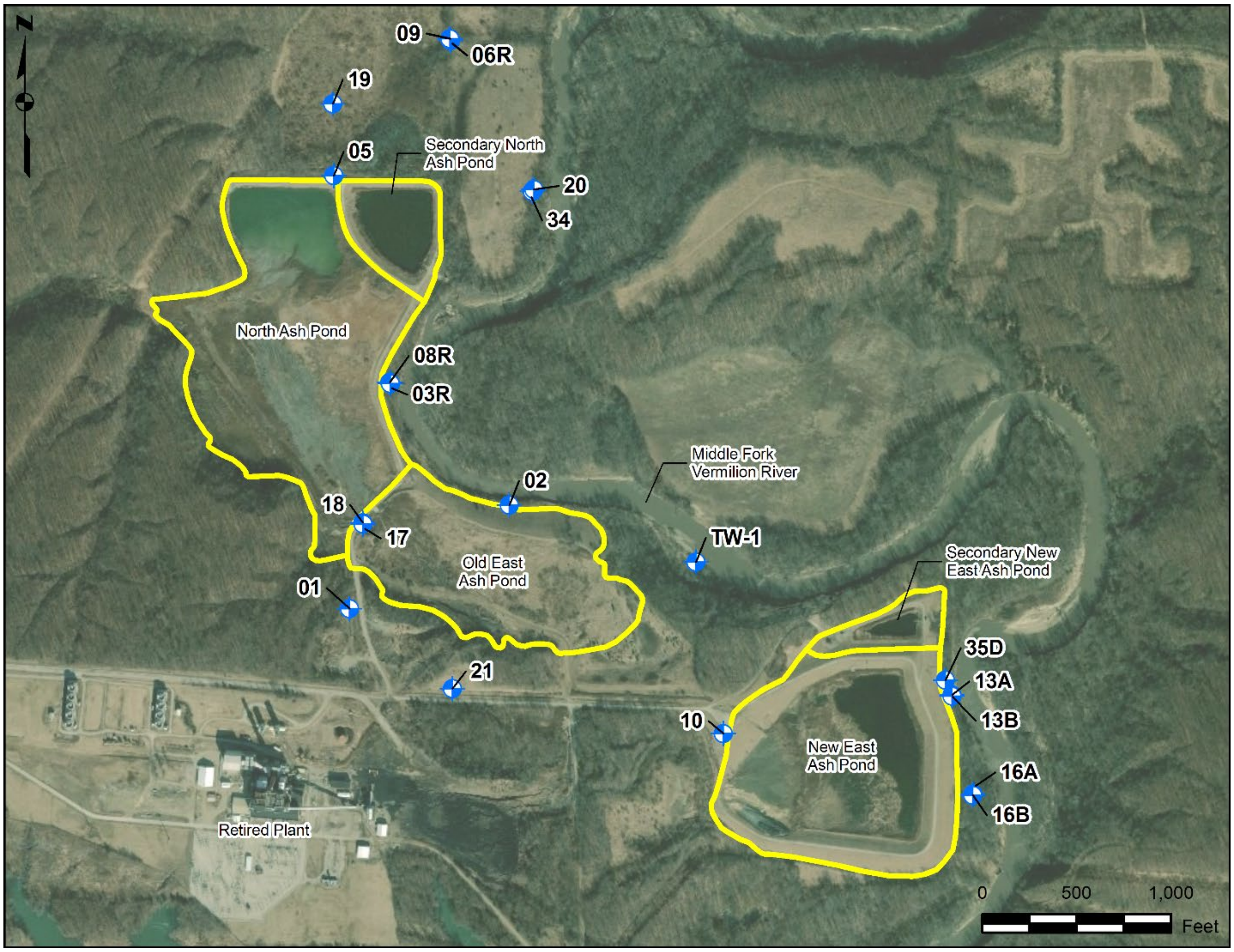

Table 3.1 Constituents Analyzed in Groundwater (2011-2019) – Based on IEPA-approved Monitoring Plan

Analyte
Antimony
Arsenic
Barium
Beryllium
Boron
Cadmium
Chromium
Chromium, Hexavalent
Cobalt
Copper
Fluoride
Iron
Lead
Magnesium
Manganese
Mercury
Nickel
Potassium
Selenium
Silver
Sodium
Thallium
Zinc

Notes:
IEPA = Illinois Environmental Protection Agency.
General water quality parameters were also analyzed, but not evaluated in the risk evaluation, including alkalinity, calcium, chloride, nitrate nitrogen, nitrite nitrogen, total Kjeldahl nitrogen, phosphorus, sulfate, total dissolved solids, and total suspended solids.

Table 3.2 Groundwater Data Summary (2011-2019)

Analyte	Samples with Constituent Detected	Samples Collected	Minimum Detect (mg/L)	Maximum Detect (mg/L)	Maximum Detection Limit (mg/L)
Dissolved Metals					
Antimony	0	50			0.0050
Arsenic	64	122	0.00050	0.073	0.073
Barium	122	122	0.0097	0.19	0.19
Beryllium	1	50	0.0084	0.0084	0.0084
Boron	206	212	0.030	53	53
Cadmium	1	50	0.0024	0.0024	0.0024
Calcium	13	13	69	390	390
Chromium	1	50	0.0066	0.0066	0.0066
Chromium, Hexavalent	0	1			0.0050
Cobalt	1	50	0.021	0.021	0.021
Copper	1	52	0.079	0.079	0.079
Fluoride	106	122	0.060	1.2	1.2
Iron	101	124	0.010	8.6	8.6
Lead	0	50			0.0050
Magnesium	13	13	23	150	150
Manganese	204	212	0.0052	1.6	1.6
Mercury	0	50			0.0020
Nickel	2	52	0.0081	0.073	0.073
Potassium	13	13	1.1	10	10
Selenium	13	122	0.00090	0.026	0.026
Silver	0	50			0.0050
Sodium	13	13	3.4	75	75
Thallium	0	50			0.0020
Zinc	4	52	0.0055	0.36	0.36

Analyte	Samples with Constituent Detected	Samples Collected	Minimum Detect (mg/L)	Maximum Detect (mg/L)	Maximum Detection Limit (mg/L)
Total Metals					
Arsenic	0	2			0.025
Barium	2	2	0.11	0.12	0.12
Boron	2	2	31	38	38
Cadmium	0	2			0.00100
Chromium	0	2			0.0050
Chromium, Hexavalent	0	1			0.0050
Cyanide	0	52			0.0080
Fluoride	0	2			0.100
Iron	1	2	0.15	0.15	0.15
Lead	0	2			0.0150
Manganese	2	2	0.033	0.073	0.073
Mercury	0	2			0.00000080
Nickel	0	2			0.0050
Selenium	0	2			0.00100
Silver	0	2			0.0030
Zinc	0	2			0.0100

Note:
The maximum detection limit is the highest detection limit reported for the groundwater samples from 2011-2019.

3.2 Surface Water Data

Surface water samples have been collected from the Middle Fork of the Vermilion River, which flows adjacent to the ash ponds at the Site (Figure 3.2) (Hanson Professional Services Inc., 2019). Surface water samples from the river were collected from three locations (VR1, VR2, and VR3), in February and March 2019. Sample location VR1 is located upstream of the Site, VR2 is located adjacent to the Site, and VR3 is located adjacent and downstream of the Site (Figure 3.2). Constituents that were analyzed in surface water samples are summarized in Table 3.3. Table 3.4 presents a summary of the surface water data at the Site.

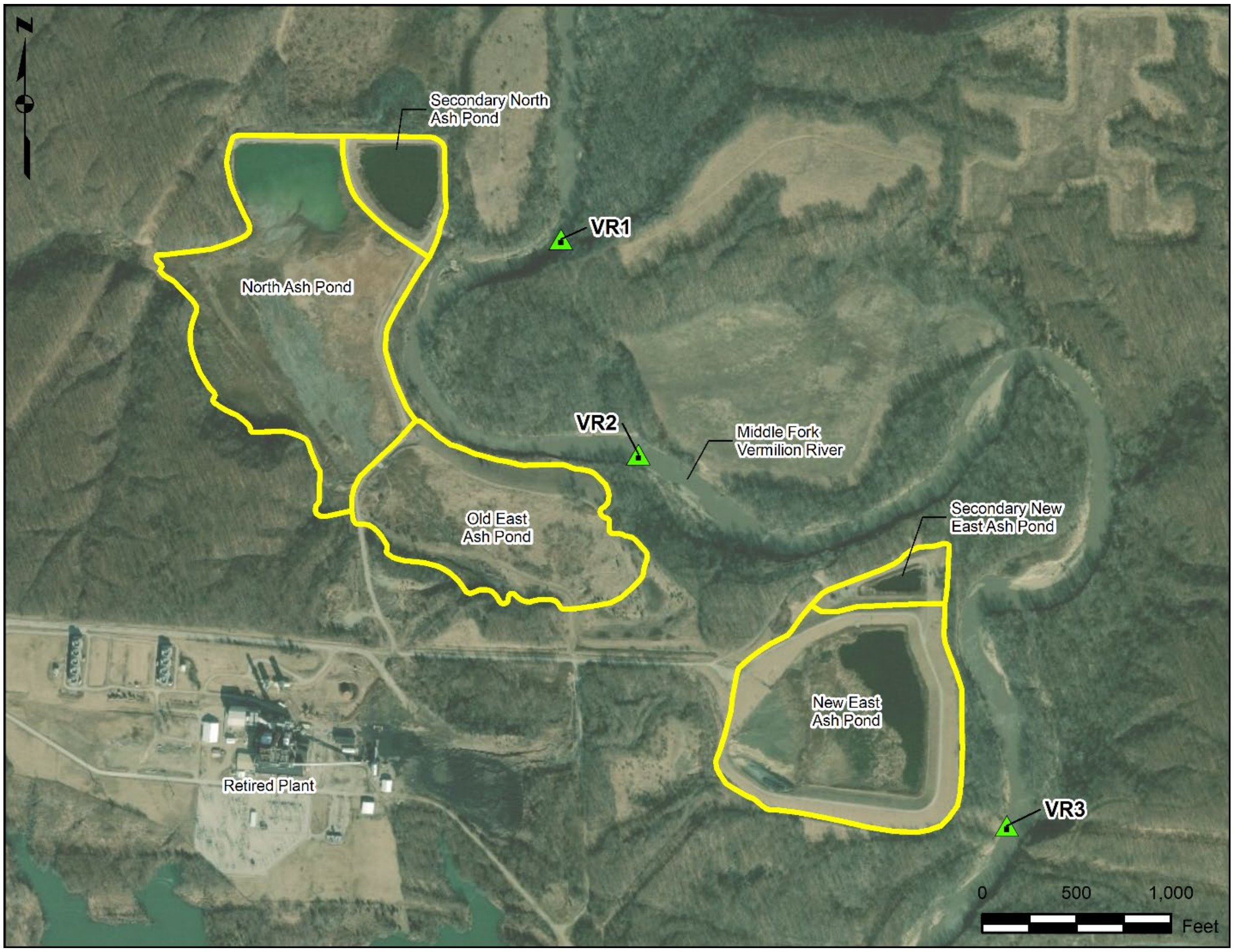

Figure 3.2 Surface Water Sample Locations. (Based on Hanson Professional Services Inc., 2019.)

Table 3.3 Constituents Analyzed in Surface Water (2019)

Analyte	
Arsenic	Iron*
Barium	Lead
Boron	Manganese
Cadmium	Mercury
Chromium	Nickel*
Chromium, Hexavalent*	Selenium
Copper*	Silver
Cyanide	Zinc*
Fluoride	

Notes:

General water quality parameters were also analyzed, but not evaluated further in the risk evaluation, including ammonia, nitrogen, chloride, nitrate nitrogen, nitrite nitrogen, total Kjeldahl nitrogen, phosphorus, sulfate, total dissolved solids, and total suspended solids.

*Metal also analyzed as dissolved metals.

Table 3.4 Surface Water Data Summary

Analyte	Samples Detected	Samples Collected	Minimum Detect (mg/L)	Maximum Detect (mg/L)	Maximum Detection Limit (mg/L)
Dissolved Metals					
Chromium, Hexavalent	0	3			0.0050
Copper	0	6			0.0050
Iron	0	6			0.040
Nickel	0	6			0.0050
Zinc	0	6			0.010
Total Metals					
Arsenic	0	6			0.025
Barium	6	6	0.036	0.040	0.040
Boron	6	6	0.041	0.17	0.17
Cadmium	0	6			0.0010
Chromium	0	6			0.0050
Chromium, Hexavalent	0	3			0.0050
Cyanide	0	6			0.0050
Fluoride	6	6	0.15	0.17	0.17
Iron	6	6	0.34	0.65	0.65
Lead	0	6			0.015
Manganese	6	6	0.023	0.045	0.045
Mercury	3	6	0.0000012	0.0000013	0.0000013
Nickel	0	6			0.0050
Selenium	0	6			0.0010
Silver	0	6			0.0030
Zinc	0	6			0.010

3.3 Surface Water and Sediment Modeling

Sediment sampling has not been conducted in the Middle Fork of the Vermilion River. Many of the COIs are expected to be present in 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 river systems and the multitude of potential sources. In the absence of sediment data, Gradient modeled concentrations in river sediments as a result of groundwater discharge to the Middle Fork of the Vermilion River for all constituents that were detected in groundwater. Similarly, surface water modeling was conducted for all constituents detected in groundwater, in order to supplement the dataset of measured surface water concentrations. Surface water and sediment were modeled based on the maximum detected dissolved concentration in groundwater, since the dissolved concentration represents the mobile portion of a constituent that could likely discharge into surface water and sediment.

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, 2014a). 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 (dilution) at the point of discharge of groundwater to the surface water.

The maximum detected dissolved concentrations in groundwater (from 2011 to 2019, regardless of well location) were conservatively used to model COI concentrations in surface water and sediment.

The aquifer and surface water properties used to estimate the volume of groundwater flowing into the Middle Fork of the Vermilion River and surface water concentrations are presented in Table 3.5. The COI concentrations in sediment were modeled using the COI-specific sediment-to-water partition coefficients and the sediment properties presented in Table 3.6. In the absence of site-specific information for the Middle Fork of the Vermilion River, we used default assumptions (*e.g.*, depth of the upper benthic layer, bed sediment particulate concentration, and bed sediment porosity) to model sediment concentrations. A description of the sediment modeling and the detailed results are presented in Appendix C.

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.

Table 3.5 Groundwater and Surface Water Properties Used in Modeling

Parameter	Unit	Value	Notes/Source
Groundwater			
COI Concentration	mg/L	Constituent specific	Maximum detected dissolved concentration in groundwater
Cross Section Area for the MGU Layer	m^2	3,931	Estimated using the thickness of the MGU layer (5.2 m) and the length of the river intersected by the modeled plume of Boron in the MGU (756 m; OBG [2018])
Cross Section Area for the LGU Layer	m^2	978	Estimated using the thickness of the LGU layer (3 m) and the length of the river intersected by the modeled plume of Boron in the LGU (326 m; OBG [2018])
Aquifer Hydraulic Gradient in the MGU Layer	m/m	0.0093	Average of the hydraulic gradients measured in the MGU (OBG, 2018)
Aquifer Hydraulic Gradient in the LGU Layer	m/m	0.0075	Average of the hydraulic gradients measured in the LGU (OBG, 2018)
Aquifer Hydraulic Conductivity in the MGU Layer	cm/s	0.00215	As reported in OBG (2018)
Aquifer Hydraulic Conductivity in the LGU Layer	cm/s	0.000847	As reported in OBG (2018)
Surface Water			
Surface Water Flow Rate	L/yr	1.52×10^{10}	Representative low flow discharge rate for the Middle Fork of the Vermilion River (17 cfs), as reported in OBG (2019b)
Total Suspended Solids (TSS)	mg/L	6	Representative average river concentration (Hanson Professional Services Inc., 2019)
Depth of the Water Column	m	0.5	Conservative estimate. Variations in the parameter were tested and did not produce a significant change in the results.
Suspended Sediment to Water Partition Coefficients	mg/L	Constituent specific	Values based on US EPA (2014a)

Notes:

COI = Constituent of Interest; LGU = Lower Groundwater Unit; MGU = Middle Groundwater Unit; US EPA = United States Environmental Protection Agency.

Table 3.6 Sediment Properties Used in Modeling

Parameter	Unit	Value	Notes/Source
Sediment			
Depth of Upper Benthic Layer	m	0.03	Default (US EPA, 2014a)
Depth of Water Body	m	0.53	Depth of water column plus depth of upper benthic layer
Bed Sediment Particle Concentration	g/cm^3	1	Default (US EPA, 2014a)
Bed Sediment Porosity	-	0.6	Default (US EPA, 2014a)
TSS Mass per Unit Area	kg/m^2	0.003	Depth of water column × TSS × conversion factors (10^{-6} kg/mg and 1,000 L/m^3)
Sediment Mass per Unit Area	kg/m^2	30	Depth of upper benthic layer × bed sediment particulate concentration × conversion factors (0.001 kg/g, 10^6 cm^3/m^3)
Sediment to Water Partition Coefficients	mg/L	Constituent specific	Values based on US EPA (2014a)

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

3.4 Exposure Estimates

3.4.1 Surface Water

As noted in Section 3.2, six surface water samples were collected in 2009. Samples were analyzed for total metals, five dissolved metals (hexavalent chromium, copper, iron, nickel, and zinc) and other field parameters that more generally characterize water chemistry. While total metal concentrations are typically used to quantify human exposures (US EPA, 1989) and dissolved metals are a better indicator of toxicity for ecological receptors (US EPA, 1993), the maximum detected concentrations (regardless of total or dissolved) were conservatively used to quantify exposures for both types of receptors. Calcium, magnesium, potassium, and sodium were also detected in surface water. However, these analytes are essential nutrients with low toxicity for both human and ecological receptors and typically not evaluated in a risk assessment (US EPA, 1989). Therefore, they were not carried forward in the risk evaluation. Arsenic, cadmium, chromium, hexavalent chromium, copper, cyanide, lead, nickel, selenium, silver, and zinc were not detected in surface water, and thus were not carried forward in the risk evaluation. In addition, surface water modeling was conducted for two analytes that were detected in groundwater but not analyzed in surface water (beryllium and cobalt). The surface water COIs include the constituents detected in surface water (barium, boron, fluoride, iron, manganese, and mercury) plus two constituents (beryllium and cobalt) that were detected in groundwater but were not analyzed in surface water. Table 3.7 presents the surface water concentration estimates used in both the human health and ecological risk evaluation.

In addition, to supplement the measured surface water data, we modeled the contributions to surface water of all Site-related COIs in groundwater. The modeled concentrations for all constituents modeled in surface water were below the screening benchmarks for ecological and human receptors (swimmer/tuber, boater, and angler) (see Table C.6 in Appendix C).

Table 3.7 Surface Water Exposure Estimates

COI	Measured Concentration	Modeled[a] Concentration	Surface Water Exposure Concentration	Basis
Barium	0.040	--	0.040	Measured
Beryllium	--	0.000016	0.000016	Modeled
Boron	0.17	--	0.17	Measured
Cobalt	--	0.000039	0.000039	Modeled
Fluoride	0.17	--	0.17	Measured
Iron	0.65	--	0.65	Measured
Manganese	0.045	--	0.045	Measured
Mercury	0.0000013	--	0.0000013	Measured

Notes:
All concentrations reported in mg/L.
-- = Not analyzed; COI = Constituent of Interest.
(a) Modeled data presented for analytes that were not analyzed in surface water, but detected in groundwater. Surface water was modeled using the maximum dissolved concentration in groundwater.

3.4.2 Sediment

Sediment COIs included the metals detected in groundwater (arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, fluoride, iron, manganese, nickel, selenium, and zinc). Sediment concentrations were modeled for these COIs as described in Section 3.3. Table 3.8 presents the modeled sediment concentrations used to estimate exposure in both the human health and ecological risk evaluation.

Table 3.8 Sediment Exposure Estimates

COI	Measured Groundwater Dissolved Concentration (mg/L)	Modeled Sediment Concentration (mg/kg)
Arsenic	0.073	0.033
Barium	0.19	0.11
Beryllium	0.0084	0.0090
Boron	53	0.65
Cadmium	0.0024	0.0060
Chromium	0.0066	0.55
Cobalt	0.021	0.036
Copper	0.079	0.36
Fluoride	1.2	0.35
Iron	8.6	0.41
Manganese	1.6	71
Nickel	0.073	0.94
Selenium	0.026	0.00021
Zinc	0.36	5.3

Note:
COI = Constituent of Interest.

4 Risk Evaluation

4.1 Risk Evaluation Process

A risk evaluation was conducted to determine whether CCR constituents present in groundwater at the Site have the potential to pose adverse health effects to human and ecological receptors. The media evaluated included groundwater, surface water, and sediment. Fish consumption by anglers was evaluated indirectly by comparing surface water concentrations with risk-based water concentrations protective of fish consumption. 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, 2015).

The general risk evaluation approach is summarized in Figure 4.1 and discussed below.

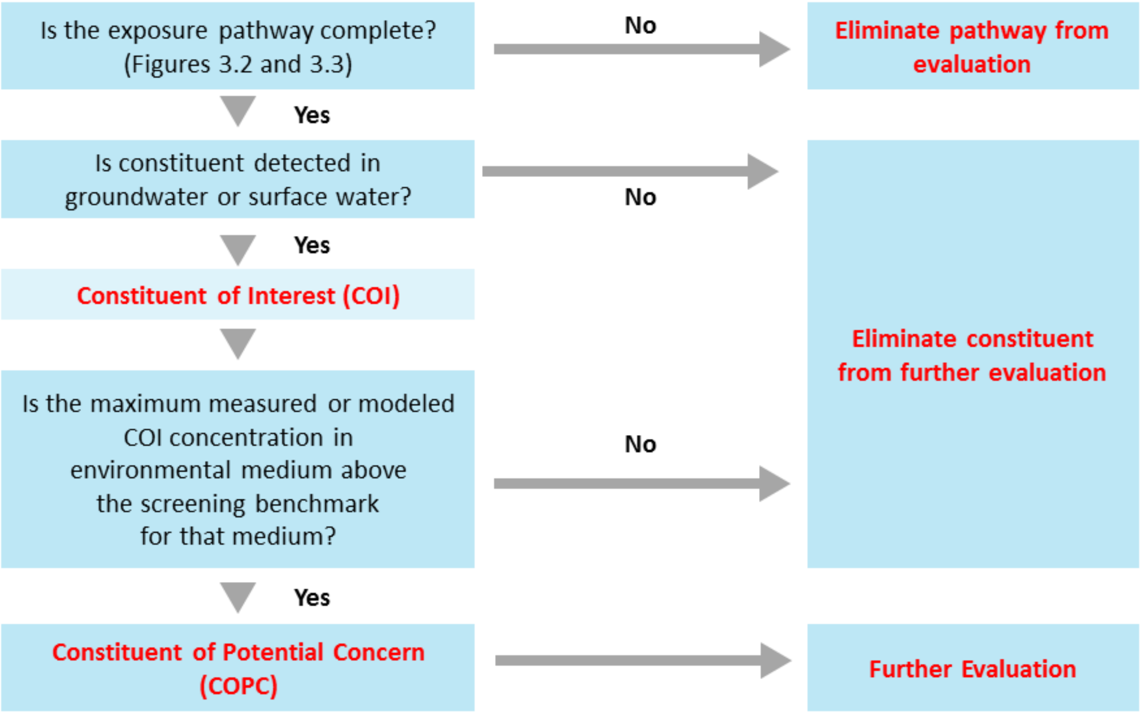

Figure 4.1 Overview of Risk Evaluation Methodology

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

Second, measured or modeled COI concentrations in surface water and modeled concentrations in sediment were compared to conservative, generic risk-based screening benchmarks for human health and ecological receptors. These generic screening benchmarks rely on default assumptions with limited consideration of site-specific characteristics. Human health benchmarks are receptor-specific values calculated for each pathway and environmental medium that are designed to be protective of human health. Ecological benchmarks are medium-specific values designed to be protective of all potential ecological receptors exposed to surface water or sediment. 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 maximum COI concentration exceeding an ecological screening benchmark does not indicate an unacceptable ecological risk, but only that further risk evaluation is warranted. COIs with maximum concentrations exceeding a conservative screening benchmark are identified as constituents of potential concern (COPCs) requiring further evaluation.

As described in more detail below, this evaluation relied on the screening assessment to demonstrate that the potential groundwater CCR constituents do not pose an unacceptable human health or ecological risk to the Vermilion River. That is, after the screening step, no COPCs were identified and an additional assessment was not warranted.

4.2 Human Health Risk Evaluation

The sections below present the results of the human health risk evaluation for recreators (swimmers, boaters, anglers) along the Middle Fork of the Vermilion River adjacent to the Site. For each pathway determined to be complete, risks were assessed for detected or modeled COIs in surface water and sediment.

4.2.1 Recreators Exposed to Surface Water While Swimming or Tubing

Screening Exposures: Recreators could be exposed to surface water *via* incidental ingestion and dermal contact while swimming or tubing. The maximum detected (or modeled) surface water concentration was used as a conservative upper-end estimate of the COI concentration to which a recreator might be exposed (Table 4.1).

Screening Benchmarks: US EPA develops RSLs using generic default assumptions designed to identify constituents that warrant further investigation (US EPA, 2019a). However, because recreational exposure scenarios are site-specific, US EPA has not established recreator RSLs that are protective of recreational exposures to surface water (US EPA, 2019a). Therefore screening benchmarks protective of recreational exposures to surface water were derived using US EPA's RSL guidance (US EPA, 2019a). The recreator benchmarks were calculated using US EPA's recommended assumptions (*i.e.*, dermal permeability coefficient [K_p], body weights, averaging time, target cancer risk, target hazard) and toxicity reference values (*i.e.*, reference dose [RfD] and cancer slope factor [CSF]), along with the following changes. Recreators were assumed to be exposed to surface water as a child for 6 years and as an adult for 20 years.

The entire body was assumed to be submerged while swimming and tubing (recommended surface area of 6,365 cm^2 for a child and 19,652 cm^2 for an adult, based on Stalcup, 2014). Recreators were assumed to incidentally ingest surface water while swimming (0.01 L/day, based on IEPA recommended water ingestion rate while swimming).

US EPA does not recommend a specific exposure frequency for a swimmer. We assumed swimming occurs primarily on days when the water temperature is above 70°F. Based on USGS data for the Vermilion River near Danville, Illinois (five miles east of the site) (USGS, 2019a), in the 2018 water year (October 2017 to September 2018) the mean water temperature was consistently above 70°F between mid-May and the end of September (20 weeks). As a conservative assumption, the recreator is assumed to swim or go tubing in the river two days a week during those 20 weeks, which results in an exposure frequency of 40 days a year. The recreator was assumed to go swimming or tubing for four hours/day. The number of hours spent swimming or tubing is important for quantifying dermal exposure, which requires an estimate of the amount of chemical that can be absorbed through the skin per unit of time. A target hazard quotient of 1 was used based on US EPA's Risk Assessment Guidance for Superfund (RAGS; US EPA, 1989). The target cancer risk was 1×10^{-5} based on the risk target used in US EPA's CCR risk assessment and the guidance US EPA has provided on the evaluation of CCRs in beneficial use assessments (US EPA, 2014a,b).

Surface water data were also compared to the Illinois surface water criteria (IEPA, 2015) known as the Human Threshold Criteria (HTC). The HTC are based on incidental exposure through contact or ingestion of small volumes of water while swimming or during other recreational activities, as well as consumption of fish. The comparison to the HTC is discussed in Section 4.2.4.

Table 4.1 presents the recreational RSLs that are protective of recreational exposures to surface water while swimming or tubing. Appendix Table B.1 presents the calculation of RSLs protective of recreational exposures to surface water while swimming or tubing.

Screening Risk Results: The maximum surface water exposure concentrations for all COIs were compared to the conservative benchmarks protective of surface water exposures during swimming and tubing. The maximum detected or modeled concentrations for all COIs were below their respective conservative benchmarks (Table 4.1). Therefore, none of the COIs evaluated in surface water are expected to pose an unacceptable risk to recreators swimming in the Vermilion River adjacent to the Site.

Table 4.1 Risk Evaluation of Recreators Exposed to Surface Water While Swimming

COI	Maximum Detected or Modeled Surface Water Concentration (mg/L)	Recreator Benchmark for Swimming (mg/L)	COPC
Barium	0.040	74	No
Beryllium[a]	0.000016	0.1	No
Boron	0.17	776	No
Cobalt[a]	0.000039	2	No
Fluoride	0.17	155	No
Iron	0.65	2,716	No
Manganese	0.045	5.1	No
Mercury	0.0000013	0.1	No

Notes:
COI = Constituent of Interest; COPC = Constituent of Potential Concern.
(a) Beryllium and cobalt are modeled concentrations. Modeled concentrations for beryllium and cobalt reflect the potential maximum Site-related surface water concentrations from groundwater discharge.

4.2.2 Recreators Exposed to Surface Water While Boating

Screening Exposures: Recreators in the Vermilion River could be exposed to surface water *via* incidental ingestion and dermal contact while boating. The surface water exposure concentrations used for the swimmer were also used for the boater (Table 4.2). Boaters were evaluated separately from swimmers, as boaters are assumed to have a higher exposure frequency, but less skin surface area exposed to water.

Screening Benchmarks: We calculated recreator benchmarks for a boater exposed to surface water. While boaters can potentially be exposed to surface water *via* incidental ingestion, the amount of water incidentally ingested is expected to be *de minimis* because they are not submerged in the water. Therefore, RSLs for the boater were calculated for the protection of dermal exposures only using the same recommended assumptions as the swimmer (*i.e.*, K_p, body weights, averaging time, target cancer risk, target hazard, exposure duration) and toxicity reference values, along with the following changes.

We assumed that boaters are exposed to surface water on their hands, forearms, lower legs, and feet. The age-weighted surface areas of 1,733 cm^2 and 4,824 cm^2 were used for the child and adult, respectively. We assumed boaters could be exposed to surface water four hours a day. We assumed boating activity on the river occurs primarily in the warmer weather. Weather data from the National Oceanic and Atmospheric Administration (NOAA) from Danville, Illinois (five miles east of the site) show that most of the days with a mean air temperature above 60°F occur from April to October, a period of 30 weeks (NOAA, 2008-2018). Based on professional judgment, the recreator is assumed to go boating for two days per week over those 30 weeks, which results in an exposure frequency of 60 days per year.

Table 4.2 presents the recreational RSLs that are protective of recreational exposures to surface water while boating. Appendix Table B.2 presents the calculation of RSLs protective of recreational exposures to surface water while boating.

Screening Risk Results: The maximum surface water exposure concentrations for all COIs were compared to the conservative benchmarks protective of surface water exposures during boating. The maximum detected or modeled concentrations for all analytes were below their respective conservative benchmarks (Table 4.2). Therefore, none of the analytes evaluated in surface water are expected to pose an unacceptable risk to recreators boating in the Vermilion River adjacent to the Site.

Table 4.2 Risk Evaluation of Recreators Exposed to Surface Water While Boating

COI	Maximum Detected or Modeled Surface Water Concentration (mg/L)	Recreator Benchmark for Boating (mg/L)	COPC
Barium	0.040	184	No
Beryllium[a]	0.000016	0.18	No
Boron	0.17	2,632	No
Cobalt[a]	0.000039	9.9	No
Fluoride	0.17	526	No
Iron	0.65	9,213	No
Manganese	0.045	13	No
Mercury	0.0000013	0.28	No

Notes:
COI = Constituent of Interest; COPC = Constituent of Potential Concern.
(a) Beryllium and cobalt are modeled concentrations. Modeled concentrations for beryllium and cobalt reflect the potential maximum Site-related surface water concentrations from groundwater discharge.

4.2.3 Recreators Exposed to Sediment While Swimming or Boating

Recreational exposure to sediment may occur during boating and swimming activity along the river. The Middle Fork of the Vermilion River is shallow enough to walk in during low flow periods, and there are sediment deposition areas along the shoreline adjacent to and near the Site that could be accessible by boat.

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

Screening Benchmarks: There are no established recreator RSLs that are protective of recreational exposures to sediment (US EPA, 2019a). Therefore, benchmarks that are protective of recreational exposures to sediment via incidental ingestion and dermal contact were calculated using US EPA's RSL guidance (US EPA, 2019a). These benchmarks were calculated using the recommended assumptions (*i.e.*, oral bioavailability, body weights, averaging time) and toxicity reference values (*i.e.*, RfD and CSF), with the following changes. Recreators were assumed to be exposed to sediment while recreating 60 days a year (or two weekend days per week for 30 weeks a year). The exposure duration was for 6 years as a child and 20 years as an adult, per US EPA guidance (Stalcup, 2014). The daily recommended residential soil ingestion rates of 200 mg/day for a child and 100 mg/day for an adult are based on an all-day exposure to residential soils (Stalcup, 2014; US EPA, 2011a). Since recreational exposures to sediment are assumed to occur for less than four hours per day, one-third of the daily residential soil ingestion (67 mg/day for a child and 33 mg/day for an adult) was used as a conservative assumption.

For dermal exposures, recreators were assumed to be exposed to sediment on their lower legs and feet (1,026 cm^2 for the child and 3,026 cm^2 for the adult, based on the age-weighted surface areas reported in US EPA, 2011a). While other body parts may be exposed to sediment, the contact time will likely be very short, as the sediment would wash off in the surface water. We used US EPA's recommended adherence factor of 0.2 mg/cm^2 based on child exposure to wet soil (US EPA, 2004; Stalcup, 2014), which was used in the US EPA RSL User's Guide for a child recreator exposed to soil or sediment (US EPA, 2019a). As discussed above, screening benchmarks for COIs with carcinogenic endpoints were calculated based on a target risk of 1×10^{-5} and COIs with non-cancer endpoints were calculated based on a target hazard quotient of 1. Appendix Table B.3 presents the calculation of RSLs protective of recreational exposures to sediment.

Screening Risk Evaluation: The calculated RSLs for recreational exposures to sediment are presented in Table 4.3. The modeled sediment concentrations were well below the recreational sediment RSL (Table 4.3). Therefore, exposure to sediment is not expected to pose an unacceptable risk to recreators while swimming or boating.

Table 4.3 Risk Evaluation of Recreators Exposed to Sediment

COI	Modeled Sediment Concentration (mg/kg)	Recreator Benchmark (mg/kg)	COPC
Arsenic	0.033	101	No
Barium	0.11	273,750	No
Beryllium	0.009	2,738	No
Boron	0.65	273,750	No
Cadmium	0.0060	1,219	No
Chromium	0.55	2,053,125	No
Cobalt	0.036	411	No
Copper	0.36	54,750	No
Fluoride	0.35	54,750	No
Iron	0.41	958,125	No
Manganese	71	32,850	No
Nickel	0.94	27,375	No
Selenium	0.00021	6,844	No
Zinc	5.3	410,625	No

Notes:
COI = Constituent of Interest; COPC = Constituent of Potential Concern.
Modeled sediment concentrations reflect the potential maximum Site-related sediment concentrations from groundwater discharge.

4.2.4 Recreators Consuming Fish Caught Near the Site

Screening Exposures: Anglers could consume fish caught in the Middle Fork of the Vermilion River. The maximum detected surface water (or modeled) concentrations were used as conservative upper-end estimates to evaluate potential risks from fish consumption by anglers.
Screening Benchmarks: Illinois provides equations to calculate HTC values, which are surface water quality criteria that account for recreational fish consumption, and incidental ingestion and dermal exposure to surface water (IEPA 2015).

The HTC values were calculated from the following equation (IEPA 2015):

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

where:

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

Illinois defines the Acceptable Daily Intake (ADI) as the "maximum amount of a substance which, if ingested daily for a lifetime, results in no adverse effects to humans" (IEPA, 2015). US EPA defines the chronic RfD as an "estimate (with uncertainty spanning perhaps an order of magnitude) of a daily oral exposure for a chronic duration (up to a lifetime) to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime" (US EPA, 2011b). Illinois lists methods to derive an ADI from the primary literature (IEPA 2015). As per Illinois guidance, we derived an ADI by multiplying the MCL by the default water ingestion rate of 2 L/day (IEPA, 2015). In the absence of an MCL, we used the RfDs used by US EPA to derive the RSLs (US EPA, 2019b) as a conservative estimate of the ADI. The RfDs are given in mg/kg-day, while the ADI are given in mg/day, thus we multiplied the RfD by a standard body weight of 70 kg to obtain the ADI in mg/day.

We used bioconcentration factors (BCFs) from a hierarchy of sources. The primary source of BCFs were those that US EPA used to calculate the National Recommended Water Quality Criteria (NRWQC) Human Health Criteria (US EPA, 2002, 2016). Other sources included BCFs used in the US EPA combustion coal ash risk assessment (US EPA, 2014a), and BCFs reported by Oak Ridge National Laboratory's Risk Assessment Information System (ORNL RAIS).[3]

Illinois recommends a fish consumption rate of 0.020 kg/day (20 g/day) for an adult weighing 70 kg (IEPA 2015). Illinois recommends a water consumption rate of 0.01 L/day for "incidental exposure through contact or ingestion of small volumes of water while swimming or during other recreational activities" (IEPA 2015). Appendix Table B.4 presents the calculated HTC for fish consumption.

Screening Risk Evaluation: The maximum detected or modeled concentrations in surface water were compared to the calculated Illinois HTC (Table 4.4), and all surface water concentrations were below their

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

respective benchmarks. Thus, none of the COIs evaluated would be expected to pose an unacceptable risk to recreators consuming fish caught in the Vermilion River.

Table 4.4 Risk Evaluation of Recreators Consuming Locally Caught Fish

COI[a]	Maximum Surface Water Concentration (mg/L)	HTC for Fish and Water (mg/L)	HTC for Fish Only (mg/L)	COPC
Barium	0.040	1.5	1.5	No
Beryllium[a]	0.000016	0.021	0.021	No
Boron	0.17	1,400	NA	No
Cobalt[a]	0.000039	0.0035	0.0035	No
Fluoride	0.17	143	174	No
Iron	0.65	126	129	No
Manganese	0.045	93	210	No
Mercury	0.0000013	0.000053	0.000053	No

Notes:

COI = Constituent of Interest; COPC = Constituent of Potential Concern; HTC = Human Threshold Criteria; NA = Bioconcentration factor was not available, therefore, an HTC based on fish ingestion alone could not be calculated.

(a) Beryllium and cobalt are modeled concentrations. Modeled concentrations for beryllium and cobalt reflect the potential maximum Site-related surface water concentrations from groundwater discharge.

Tables B.5 to B.10 in Appendix B compare the detection limits for non-detects in surface water (and the modeled sediment concentrations for undetected metals in groundwater) to human and ecological benchmarks. The detection limits do not exceed the benchmarks, except for arsenic, where the detection limit in surface water (0.025 mg/L) is slightly above the human threshold concentration for the angler for consumption of fish (0.023 mg/L).

4.3 Ecological Risk Evaluation

Based on the ecological CEM (Figure 2.5), ecological receptors could be exposed to surface water, sediment, and dietary items (*i.e.*, prey and plants) potentially impacted by Site-related COIs. The following COIs were evaluated: all constituents detected in surface water and all constituents detected in groundwater but not analyzed in surface water (*i.e.*, beryllium and cobalt). Concentrations for these COIs in sediment were modeled based on maximum groundwater concentrations.

4.3.1 Ecological Receptors Exposed to Surface Water

Screening Exposures: The ecological evaluation considered aquatic communities in the Vermilion River potentially impacted by groundwater from the Site. While dissolved concentrations are a better indicator of toxicity for ecological receptors (US EPA, 1993), the maximum of the total and dissolved analyte concentration detected in surface water was conservatively compared to risk-based ecological screening benchmarks. Beryllium and cobalt were not analyzed in surface water but were detected in groundwater. Therefore, these two analytes were modeled in surface water based on their maximum groundwater concentration and modeled surface water concentrations were compared to risk-based ecological screening benchmarks.

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

- Illinois Surface Water Quality Standards (IL SWQS) (IEPA, 2015). IL SWQS are regulatory standards that are intended to protect aquatic life exposed to surface water on a long-term basis (*i.e.*, chronic exposure). The IL SWQS for several metals are hardness dependent (cadmium, chromium, copper, fluoride, lead, manganese, nickel, zinc). Screening benchmarks for these analytes were calculated using an average hardness of 300 mg/L for the Middle Fork of Vermilion River based on measured data from a monitoring site located above Oakwood, IL (USGS, 2019b)[4];
- National Recommended Water Quality Criteria – Aquatic Life Criteria Table (US EPA, 2019d); and
- US EPA Region IV (2018) Surface Water Ecological Screening Values (ESVs) for Hazardous Waste Sites.

Risk Evaluation: The maximum detected or modeled concentrations in surface water were compared to the above hierarchy of benchmarks protective of aquatic life (Table 4.5). All 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 Middle Fork of the Vermilion River.

The modeled concentrations for all constituents modeled in surface water (including additional constituents not analyzed or not detected in surface water) were below the ecological screening benchmarks (Table C.6 in Appendix C), which supports the results from the measured surface water data.

Table 4.5 Risk Evaluation of Ecological Receptors Exposed to Surface Water

COI	Maximum Surface Water Concentration (mg/L)	Ecological Freshwater Benchmark (mg/L)	Basis	COPC
Barium	0.040	5.0	IEPA (2015)	No
Beryllium[c]	0.000016	0.064	US EPA R4 (2018)	No
Boron	0.17	7.6	IEPA (2015)	No
Cobalt[c]	0.000039	0.019	US EPA R4 (2018)	No
Fluoride[d]	0.17	9.1	IEPA (2015)	No
Iron	0.65	1.0	IEPA (2015)	No
Manganese[d]	0.045	4.0	IEPA (2015)	No
Mercury	0.0000013	0.0011	IEPA (2015)	No

Notes:
COI = Constituent of Interest; COPC = Constituent of Potential Concern; IEPA = Illinois Environmental Protection Agency; US EPA R4 = United States Environmental Protection Agency Region IV.
(c) Beryllium and cobalt are modeled concentrations. Modeled concentrations for beryllium and cobalt reflect the potential maximum Site-related surface water concentrations from groundwater discharge.
(d) An average hardness of 300 mg/L was used to calculate hardness-dependent benchmarks (fluoride and manganese).

4.3.2 Ecological Receptors Exposed to Sediment

Screening Exposures: COIs in impacted groundwater discharging into the Middle Fork of the Vermilion River can sorb to sediments *via* chemical partitioning. In the absence of sediment data, sediment concentrations were modeled using maximum detected groundwater concentrations. Therefore, the

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[4] Hardness data include 135 samples collected from 1980 to 1997 (USGS, 2019b).

modeled COI sediment concentrations reflect the potential maximum Site-related sediment concentration from groundwater discharge.

Screening Benchmarks: Sediment screening benchmarks were obtained from US EPA Region IV (2018). The majority of the sediment ESVs are based on threshold effect concentrations (TECs) from MacDonald *et al.* (2000), which provide consensus values that identify concentrations below which harmful effects on sediment-dwelling organisms are unlikely to be observed. The ESVs for constituents not reported in MacDonald *et al.* (2000) (*i.e.*, iron and manganese) are the lowest effect levels, or the lowest level that can be tolerated by a majority of sediment-dwelling organisms from Persaud *et al.* (1993). The benchmarks used in this evaluation are listed in Table 4.6.

The above sources did not have sediment benchmarks for beryllium, boron, and fluoride. Therefore, the following additional sources were searched for sediment benchmarks:

- US EPA (2014a)
- US EPA (1999)
- ORNL RAIS (Oak Ridge National Laboratory, 2018)
- Los Alamos National Laboratory (LANL) EcoRisk Database (US DOE, 2017)
- European Chemicals Agency Substance Evaluation (ECHA, 2007)
- NOAA Screening Quick Reference Tables (Buchman, 2008)

Boron did not have a published benchmark in the above sources, thus a no observed effect concentration (NOEC) for boron was used as a conservative benchmark (ECHA, 2019). Sediment benchmarks protective of aquatic receptors were not available for beryllium and fluoride.

Screening Risk Results: The maximum modeled COI sediment concentrations were all below their respective sediment screening benchmarks (Table 4.6). The modeled sediment concentrations attributed to potential contributions from site groundwater for all COIs (with the exception of manganese) were less than 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 Vermilion River adjacent to the Site.

Screening benchmarks were not available for beryllium and fluoride. However, beryllium primarily absorbs to clay and does not readily bioaccumulate from sediment to bottom feeders (WHO, 2001). Similarly, fluoride entering a water body bonds strongly to the sediment particles (ATSDR, 2003). Further, the modeled concentrations for beryllium and fluoride are low in comparison to typical concentrations found in sediment. For example, the maximum modeled beryllium concentration (0.009 mg/kg) is well below beryllium concentrations measured in Illinois lakes (1.4-7.4 mg/kg) (WHO, 2001) and concentrations measured in US rivers (0.1-3.8 mg/kg) (ATSDR, 2002). The maximum modeled fluoride concentration (0.35 mg/kg) is orders of magnitude lower than the concentrations measured in freshwater lakes (450-1,100 mg/kg) (ATSDR, 2003). Therefore, potential Site-related contributions of beryllium and fluoride from groundwater to sediment are deemed *de minimis*.

Table 4.6 Risk Evaluation of Ecological Receptors Exposed to Sediment

COI	Modeled Sediment Concentration (mg/kg)	ESV[a] (mg/kg)	COPC	% of Benchmark
Arsenic	0.033	9.8	No	0.3%
Barium	0.11	20	No	0.5%
Beryllium	0.0090	NC	No[b]	--
Boron	0.65	38[c]	No	2%
Cadmium	0.0060	0.99	No	0.6%
Chromium	0.55	43	No	1%
Cobalt	0.036	50	No	0.07%
Copper	0.36	32	No	1%
Fluoride	0.35	NC	No[b]	--
Iron	0.41	20,000	No	0.002%
Manganese	71	460	No	15%
Nickel	0.94	23	No	4%
Selenium	0.00021	0.8	No	0.03%
Zinc	5.3	121	No	4%

Notes:

COI = Constituent of Interest; COPC = Constituent of Potential Concern; ESV = Ecological Screening Value; NC = No criterion available, therefore, not evaluated; NOEC = No Observed Effect Concentration.

(a) ESV from US EPA Region IV (2018).

(b) Maximum modeled concentrations from groundwater contributions are low compared to typical sediment levels and are therefore not expected to meaningfully contribute to ecological exposures and potential risks.

(c) Boron NOEC of 38 mg/kg was used as a conservative benchmark for boron in the absence of an ESV (ECHA, 2019).

4.3.3 Ecological Receptors Exposed to Bioaccumulative COIs

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

Screening Benchmark: US EPA Region IV guidance (2018) was used to identify analytes with potential bioaccumulative effects.

Risk Evaluation: Of the metals detected in surface water and/or groundwater, US EPA Region IV (2018) identifies only mercury[5] and selenium as having potential bioaccumulative effects. However, the maximum detected mercury concentration in surface water[6] is below the screening benchmark protective of bioaccumulative exposures. Selenium was undetected in surface water and the maximum detection limit was below the screening benchmark protective of bioaccumulative exposures. Using the maximum detected concentration is conservative and not reflective of long term wildlife exposures, especially since mercury and selenium were not detected in all surface water and groundwater samples, respectively. In addition, the modeled selenium sediment concentration[7] was below the sediment benchmark protective of

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[5] US EPA Region IV (2018) notes that both mercury and methyl mercury have bioaccumulative properties.

[6] The maximum detected mercury concentration (0.0000013 mg/L) is below the acute benchmark (0.000012 mg/L) protective of wildlife accounting for bioaccumulative exposures (US EPA Region IV, 2018). The maximum modeled selenium concentration in sediment was below the benchmark protective of wildlife accounting for bioaccumulative exposures (US EPA Region IV, 2018).

[7] Mercury was not detected in groundwater, therefore a sediment concentration was not modeled. However, the modeled mercury concentration in sediment based on the maximum detection limit is also below the sediment benchmark protective of bioaccumulative exposures.

bioaccumulative exposures. Therefore, potential groundwater contributions of mercury and selenium to the Middle Fork of the Vermilion River are not expected to pose an unacceptable risk from bioaccumulation exposures.

Although arsenic, cadmium, hexavalent chromium, copper, lead, nickel, silver, and zinc were not identified as bioaccumulative in US EPA Region IV (2018), they were identified as bioaccumulative in US EPA (2000). However, these analytes were undetected in surface water and hexavalent chromium, lead, and silver were undetected in groundwater.

Overall, COIs with potential bioaccumulative effects are not expected to meaningfully contribute to potential Site-related ecological exposures in the Vermilion River and are therefore not considered to pose an ecological risk *via* bioaccumulation.

4.4 Uncertainties and Conservatisms

A number of uncertainties and their potential impact on the risk evaluation are discussed below. Wherever possible, conservative assumptions were used (use of maximum detected concentration and conservative screening benchmarks) in an effort to minimize uncertainties and overestimate rather than underestimate risks.

Exposure Estimates:

- The human health and ecological risk characterizations were based on the maximum COI concentrations, rather than on averages. Thus, the variability in exposure concentrations was not considered. Assuming continuous exposure to the maximum concentration overestimates human and ecological exposures given that receptors are mobile and concentrations change over time. For example, US EPA guidance states that risks should be estimated using average exposure concentrations, as represented by the 95% upper confidence limit on the mean (US EPA, 1992). Given that exposure estimates based on the maximum concentration did not exceed risk benchmarks, the use of the maximum is not considered a significant source of uncertainty in the risk evaluation.
- Only analytes detected in surface water and/or groundwater were evaluated. However, multiple analytes were not detected (*i.e.*, below detection limits) in surface water and groundwater. For human health, the maximum detection limits for non-detected analytes in surface water were below surface water benchmarks protective of recreational exposures from swimming/tubing and boating. Arsenic was the only non-detected analyte with a maximum detection limit (0.025 mg/L) that exceeded the HTC (0.022 mg/L for water and fish ingestion and 0.023 mg/L for fish ingestion only). However, a maximum detection limit is an overestimation of exposure for an analyte that is not detected, as it could be present at any concentration below the detection limit. Analytes not detected in groundwater were modeled in sediment using the maximum detection limits. The modeled sediment concentrations for these analytes were all below sediment benchmarks protective of recreational exposures.
- For ecological receptors, the maximum detection limits for analytes not detected in surface water and the modeled sediment concentrations for analytes not detected in groundwater are all below their respective surface water and sediment benchmarks. Therefore, although only constituents detected in surface water and groundwater were evaluated, excluding analytes that were not detected does not change our risk conclusions.

- The COIs identified in this evaluation also occur naturally in the environment. Contributions to exposure from natural or other non-Site-related sources were not considered in the evaluation of modeled concentrations; only exposure contributions potentially attributable to the discharge of groundwater into sediment and surface water were evaluated. While not quantified, exposures from potential Site-related groundwater contributions are likely to present only a small fraction of the overall human and ecological exposure to COIs that also have natural or non-Site-related sources.
- The surface water data set from the Middle Fork of the Vermilion River includes six samples, collected at three locations in February and March 2019. Surface water concentrations resulting from the groundwater discharge were also modeled (Appendix C). The concentrations for all modeled constituents in surface water were below the screening benchmarks for human receptors (swimmer/tuber, boater, and angler) (Table C.6 in Appendix C). The modeled data are consistent with the available surface water data, confirming that the measured and modeled data accurately characterize conditions in the Middle Fork of the Vermilion River.
    - For example, the measured concentration of boron at the upriver sampling location ranged from 41 to 46 µg/L (VR-1; OBG, 2019b) and from 103 to 170 µg/L at the sampling location adjacent to the ash ponds (VR-2; OBG, 2019b), which is an increase in boron concentrations between the two sampling locations of 57 to 129 µg/L. This is comparable to the model predicted contribution of boron to the surface water concentration, as a result of groundwater discharge, of 98 µg/L (Appendix C).
    - Surface water sampling did not detect the presence of several analytes (arsenic, cadmium, copper, lead, nickel, silver, zinc; Hanson Professional Services Inc., 2019). The model-predicted surface water concentrations for these constituents were below their respective analytical detection limits (Appendix C). These results indicate that the model-predicted surface water data are in agreement with the measured data.
    - Fluoride was detected in surface water upgradient, adjacent to, and downgradient of the Site at similar concentrations (Hanson Professional Services Inc., 2019, Table 3). These results indicate that the fluoride in surface water is related to a naturally occurring source and that there are only limited contributions of fluoride in surface water resulting from Site-related groundwater discharges. The model predicts low fluoride concentrations (2 µg/L; Appendix C) in surface water as a result of Site-related groundwater discharges. These results indicate that the model-predicted surface water data are in agreement with the measured data.
    - Similarly, iron was detected in surface water upgradient, adjacent to, and downgradient of the Site. Given the number of natural sources of iron and the high concentrations at which iron is naturally present and the fact that iron is not typically a constituent associated with coal ash, it is likely that iron concentrations in surface water are the result of naturally occurring sources. Further, the dissolved iron concentrations were non-detect in every surface water sample (Hanson Professional Services Inc., 2019, Appendix D), which is consistent with the model-predicted surface water concentrations (Appendix C). Since iron contributed to surface water through groundwater discharge would be soluble, the dissolved data are a more appropriate comparison to model predictions.
    - The model conservatively over-predicts mercury concentrations, but at very low concentrations. The model predicts mercury concentrations of 0.004 µg/L (Appendix C), while measured concentrations were 0.001 µg/L (Hanson Professional Services Inc., 2019, Table 3). A factor of 4, erring on the conservative side, is reasonably good agreement for the complexity of the modeling performed in this assessment.
- Sediment samples have not been collected from the Middle Fork of the Vermilion River. As noted earlier, constituents in sediment collected adjacent to the site would not necessarily reflect impacts

from the site because of sediment dynamics in river systems. COIs in sediment were modeled based on maximum detected groundwater concentrations. These model predictions carry uncertainties due to gaps in scientific knowledge. For instance, the relationship between K_d and sediment/water concentrations may result in different predictions depending on environmental factors (*e.g.*, dissolved oxygen content, particle size, *etc.*) giving rise to model uncertainty. The modeling approach and K_d values, however, are consistent with the US EPA (2014a) CCR risk assessment.

- Exposure estimates for human and ecological receptors to metals in sediment assumed 100% bioavailability.[8] This assumption is known to be invalid for most chemical substances under varying environmental conditions (*e.g.*, pH, organic matter content, aging, temperature, humidity, and chemical form) and likely results in overestimates of exposure and risks. In humans, site-specific bioavailability data can be used to increase the accuracy of the exposure estimate and risk calculation (US EPA, 1989). However, in the absence of data, US EPA recommends assuming a chemical is 100% bioavailable. For ecological receptors, sediment characteristics can impact the bioavailability and subsequent toxicity of various metals to benthic organisms. Consequently, US EPA recommends supplementing the sediment chemistry analysis with additional analyses measuring bioavailability (*e.g.*, acid volatile sulfides, organic carbon, particle size, pH) and/or toxicity studies to address the uncertainties of assuming metals are 100% bioavailable (US EPA, 2005, 2007).
- Screening benchmarks for human health were developed using exposure inputs based on US EPA's recommended values for reasonable maximum exposure (RME) assessments (Stalcup, 2014). RME is defined as "the highest exposure that is reasonably expected to occur at a site but that is still within the range of possible exposures" (US EPA, 2004). US EPA states that "intent of the RME is to estimate a conservative exposure case (*i.e.*, well above the average case) that is still within the range of possible exposures" (US EPA, 1989). US EPA also notes that this high-end exposure "is the highest dose estimated to be experienced by some individuals, commonly stated as approximately equal to the 90th percentile exposure category for individuals" (US EPA, 2015c). Thus, most individuals will have lower exposures than those presented in this risk assessment.

Toxicity Benchmarks:

- Screening level ecological benchmarks were compiled from 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, generic sediment benchmarks protective of ecological receptors do not incorporate site-specific bioavailability or organic carbon content. The use of generic screening benchmarks in lieu of more refined site-specific benchmarks is expected to have resulted in more stringent benchmarks and a more conservative estimate of potential risks.
- In general, it is important to appreciate that the toxicity factors used in risk assessment are developed to account for uncertainties such that safe exposure levels used as benchmarks are often many times lower (even orders of magnitude lower) than the levels that resulted in the effects observed in human or animal studies. This means that a risk exceedance does not necessarily equate to actual harm.

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[8] The exception is for recreators exposed to arsenic in sediment, where the screening value is calculated using US EPA's default bioavailability of 0.6 (US EPA, 2012).

5 Summary and Conclusions

A screening-level risk evaluation was performed for Site-related constituents in groundwater at the Vermilion Generating Station in Oakwood, Illinois. The groundwater monitoring data indicate that groundwater beneath the ash ponds may be impacted by Site-related constituents. The CSM developed for the Site indicates that groundwater beneath the former CCR ash ponds flows into the Middle Fork of the Vermilion River adjacent to the Site and may potentially impact surface water and sediment.

CEMs were developed for human and ecological receptors. The complete exposure pathways for humans include recreators in the Vermilion River who are exposed to surface water and sediment (boaters and swimmers) and anglers who consume locally caught fish. 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.

Surface water data collected in 2019, and groundwater data collected from 2011 to 2019, were used to estimate exposures. The maximum detected concentrations in surface water were used for human and ecological receptors exposed to surface water. For analytes that were not analyzed in surface water, but detected in groundwater, a surface water concentration was modeled using the maximum detected groundwater concentration. In the absence of sediment data, modeled sediment concentrations based on the maximum detected groundwater concentrations were used as the exposure estimate for human and ecological receptors. Surface water and sediment exposure estimates were screened against benchmarks protective of human health and ecological receptors for this risk evaluation.

For recreators (boaters and swimmers/tubers) exposed to surface water, all COIs were below the conservative risk-based screening benchmarks. Therefore, none of the COIs evaluated in surface water are expected to pose an unacceptable risk to recreators swimming, tubing or boating in the Middle Fork of the Vermilion River adjacent to the Site.

For recreators exposed to sediment *via* incidental ingestion and dermal contact, all modeled sediment concentrations were below health protective sediment benchmarks. Therefore, none of the COIs modeled in sediment are expected to pose an unacceptable risk to recreators exposed to sediment in the Middle Fork of the Vermilion River adjacent to the Site.

For anglers consuming locally caught fish, the maximum concentrations of all COIs in surface water were below conservative benchmarks protective of fish consumption. Therefore, none of the COIs evaluated are expected to pose an unacceptable risk to recreators consuming fish caught in the Middle Fork of the Vermilion River.

Ecological receptors exposed to surface water include aquatic and marsh plants, amphibians, reptiles, and fish. The risk evaluation showed that none of the 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 US EPA Region IV (2018), mercury and selenium were identified as bioaccumulative COIs. However, the maximum detected concentration for mercury and the maximum detection limit for selenium (which was undetected) in surface water were below benchmarks protective of bioaccumulative effects. In addition, modeled sediment concentrations were also below benchmarks protective of bioaccumulative exposures. 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 (95 UCL); 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 ash ponds have been 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. Moreover, the modeled time horizon to achieving the groundwater protection standards (GWPSs) under the various closure alternatives (OBG, 2018) is immaterial from a risk perspective since there is no unacceptable risk associated with exceedances of the GWPSs. Because of this, other factors, such as the impact to the environment and nearby communities and worker safety should be considered when evaluating closure options.

References

Agency for Toxic Substances and Disease Registry (ATSDR). 2002. "Toxicological Profile for Beryllium." 290p., September. Accessed at https://www.atsdr.cdc.gov/ToxProfiles/tp.asp?id=1441&tid=33.

Agency for Toxic Substances and Disease Registry (ATSDR). 2003. "Toxicological Profile for Fluorides, Hydrogen Fluoride, and Fluorine." 404p., September.

American Rivers. 2018. "Middle Fork of the Vermilion River [IL]." Accessed at https://www.americanrivers.org/endangered-rivers/middle-fork-of-the-vermilion-river-il/

Buchman, MF. 2008. "NOAA Screening Quick Reference Tables (SQuiRTS) (NOAA OR&R Report 08-1)." National Oceanic and Atmospheric Administration, Office of Response and Restoration Division (Seattle, WA) 34p. Accessed at http://response.restoration.noaa.gov/cpr/sediment/squirt/squirt.html.

Dynegy Midwest Generation, LLC; Stantec Consulting Services Inc.; OBG. 2019. "Closure and Post-Closure Care Plan for North Ash Pond, Old East Ash Pond, and New East Ash Pond at the Vermilion Site (Draft)." 29p., June 28.

European Chemicals Agency (ECHA). 2007. "Guidance on Dossier and Substance Evaluation." 139p., June. Accessed at http://ecb.jrc.it/documents/REACH/RIP_FINAL_REPORTS/RIP_4.1_4.2_EVALUATION/RIP_4.1_4.2_evaluation_en.pdf.

European Chemicals Agency (ECHA). 2019. "Ecotoxicological information: Sediment toxicity: 001 Weight of evidence." In *Reach dossier for Boron (CAS No. 7740-42-8)*. Accessed at https://echa.europa.eu/registration-dossier/-/registered-dossier/14776/6/3.

Fontes, JC; Garnier, JM. 1979. "Determination of the initial ^{14}C activity of the total dissolved carbon: A review of the existing models and a new approach." *Water Resour. Res*. 15(2):399-413. doi: 10.1029/WR015i002p00399.

Hanson Professional Services Inc. 2019. "Antidegradation Assessment for Management of Waters from Closure and Post-Closure Care of Ash Ponds, Vermilion Site, Dynegy Midwest Generation, LLC, NPDES Permit No. IL0004057." Report to Dynegy Midwest Generation, LLC. 151p., June 1,

Illinois Dept. of Natural Resources. 2018. "Activities at Middle Fork." Accessed at https://www.dnr.illinois.gov/Parks/Activity/Pages/MiddleFork.aspx.

Illinois Environmental Protection Agency (IEPA). 2012. "Draft Reissued NPDES Permit to Discharge into Waters of the State." Submitted to Dynegy Midwest Generation, LLC. NPDES Permit No. IL0004057. 12p.

Illinois Environmental Protection Agency (IEPA). 2013. "Dynegy Midwest Generation, L.L.C., Vermilion Power Station Public Hearing, Tuesday, August 6, 2013 (Notice of Water Discharge Permit Public Hearing)." 2p., July 29.

Illinois Environmental Protection Agency (IEPA). 2015. "Title 35: Environmental Protection, Subtitle C: Water Pollution, Chapter 1: Pollution Control Board, Part 302 Water Quality Standards." 193p.

Illinois Environmental Protection Agency (IEPA). 2018. "Illinois Integrated Water Quality Report and Section 303(d) List, 2018 (Draft)." 145p., November 14.

Kelron Environmental. 2003. "Regional and Local Hydrogeology and Geochemistry: Vermilion Power Plant, Illinois. Volumes 1-2 (Draft)." Report to Dynegy Midwest Generation, Inc. 495p., November 30.

Kelron Environmental. 2012a. "Hydrogeology and Groundwater Quality of the North Ash Pond System, Vermilion Power Station, Oakwood, Illinois, Dynegy Midwest Generation, LLC." Report to Dynegy Operating Co. 226p., March 15.

Kelron Environmental. 2012b. "Hydrogeology and Groundwater Quality of the Old East Ash Pond System, Vermilion Power Station, Oakwood, Illinois, Dynegy Midwest Generation, LLC." Report to Dynegy Operating Co. 226p., March 15.

Kickapoo Adventures. 2017. "Recreation information [Middle Fork of the Vermilion River at the Kickapoo State Recreation Area]." Accessed at http://kickapooadventures.com/

MacDonald, DD; Ingersoll, CG; Berger, TA. 2000. "Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems." *Arch. Environ. Contam. Toxicol.* 39:20-31. doi: 10.1007/s002440010075.

National Oceanic and Atmospheric Administration (NOAA). 2008-2018. "Global Surface Summary of Day (GSOD) average temperature and precipitation data: Danville, IL." National Centers for Environmental Information (NCEI). Accessed at https://www.ncei.noaa.gov.

Oak Ridge National Laboratory. 2018. "Risk Assessment Information System (RAIS) Toxicity Values and Chemical Parameters: Chemical Toxicity Values." Accessed at https://rais.ornl.gov/cgi-bin/tools/TOX_search?select=chem.

OBG. 2018. "2018 Groundwater Monitoring and Modeling Report and Addendum 1, Vermilion Site North Ash Pond System and Old East Ash Pond System Coal Combustion Residual Units, Vermilion, Illinois (Draft)." Report to Dynegy Midwest Generation, LLC. 602p., October.

OBG. 2019a. "Update to the Hydrogeology and Groundwater Quality of the North Ash Pond and Old East Ash Pond, Vermilion Site North Ash Pond and Old East Ash Pond, Oakwood, Illinois (Draft)." Report to Dynegy Midwest Generation, LLC. 94p., June.

OBG. 2019b. "Update to the Regional and Local Hydrogeology and Geochemistry: New East Ash Pond, Vermilion Site New East Ash Pond, Oakwood, Illinois (Draft)." Report to Dynegy Midwest Generation, LLC. 778p., June.

OBG. 2019c. "Groundwater Monitoring Plan, Vermilion Site, North Ash Pond and Old East Ash Pond, Oakwood, Illinois (Draft)." Report to Dynegy Midwest Generation, LLC (Collinsville, IL). June. 109p.

OBG. 2019d. "Groundwater Monitoring Plan, Vermilion Site, New East Ash Pond, Oakwood, Illinois (Draft)." Report to Dynegy Midwest Generation, LLC (Collinsville, IL). June. 62p.

Persaud, D; Jaagumagi, R; Hayton, A. 1993. "*Guidelines for the protection and management of aquatic sediment quality in Ontario*" Ontario Ministry of the Environment, Toronto, Ontario. 32p., August. Accessed at http://www.ene.gov.on.ca/envision/gp/B1-3.pdf.

Prothro, MG. [US EPA, Office of Water]. 1993. Memorandum to US EPA Directors and Regions re: Office of Water policy and technical guidance on interpretation and implementation of aquatic life metals criteria. EPA-822-F93-009. 49p. October 1.

Schlosser, P; Stute, M; Sonntag, C; Munnich, KP. 1989. "Tritiogenic ^{3}He in shallow groundwater." *Earth Planet. Sci. Lett*. 94(3-4):245-256. doi: 10.1016/0012-821X(89)90144-1.

Stalcup, D. [US EPA, Office of Solid Waste and Emergency Response (OSWER)]. 2014. "Memorandum to Superfund National Policy Managers, Regions 1-10 re: Human Health Evaluation Manual, Supplemental Guidance: Update of standard default exposure factors." OSWER Directive 9200.1-120, 7p., February 6. Accessed at https://www.epa.gov/sites/production/files/2015-11/documents/oswer_directive_9200.1-120_exposurefactors_corrected2.pdf.

US Dept. of Energy (US DOE). 2017. "ECORISK Database (Release 4.1)." Los Alamos National Laboratory. Accessed at https://www.lanl.gov/environment/protection/eco-risk-assessment.php.

US EPA. 1989. "Risk Assessment Guidance for Superfund (RAGS). Volume I: Human Health Evaluation Manual (Part A) (Interim final)." Office of Emergency and Remedial Response, NTIS PB90-155581, EPA-540/1-89-002, 287p., December.

US EPA. 1992. "Risk Assessment Guidance for Superfund: Supplemental Guidance to RAGS: Calculating the Concentration Term." Office of Emergency and Remedial Response, OSWER Directive 9285.7-08I, NTIS PB92-963373, 8p., May.

US EPA. 1998. "Methodology for assessing health risks associated with multiple pathways of exposure to combustor emissions." National Center for Environmental Assessment (NCEA), EPA 600/R-98/137, December. http://www.epa.gov/nceawww1/combust.htm.

US EPA. 1999. "Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities. Volumes 1 - 3 (Peer Review Draft)." Solid Waste and Emergency Response, EPA530-D-99-001A, August. Accessed at http://www.epa.gov/waste/hazard/tsd/td/combust/ecorisk.htm.

US EPA. 2000. "Bioaccumulation Testing and Interpretation for the Purpose of Sediment Quality Assessment: Status and Needs." Bioaccumulation Analysis Workgroup, EPA-823-R-00-001, 136p., February.

US EPA. 2002. "National Recommended Water Quality Criteria: 2002. Human Health Criteria Calculation Matrix." Office of Water, EPA-822-R-02-012, 23p., November.

US EPA. 2004. "Risk Assessment Guidance for Superfund (RAGS). Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) (Final)." Office of Superfund Remediation and Technology Innovation, EPA/540/R/99/005, OSWER 9285.7-02EP; PB99-963312, 156p., July. Accessed at http://www.epa.gov/oswer/riskassessment/ragse/pdf/part_e_final_revision_10-03-07.pdf.

US EPA. 2005. "Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: Metal Mixtures (Cadmium, Copper, Lead, Nickel, Silver, and Zinc)." Office of Research and Development, National Health and Environmental Effects Research Laboratory, EPA/600/R-02/011, January.

US EPA. 2007. "Framework for Metals Risk Assessment." Office of the Science Advisor, EPA 120/R-07/001, 172p., March. Accessed at http://www.epa.gov/raf/metalsframework/pdfs/metals-risk-assessment-final.pdf.

US EPA. 2011a. "Exposure Factors Handbook: 2011 Edition." Office of Research and Development, US EPA, National Center for Environmental Assessment (NCEA), EPA/600/R-090/052F, 1436p., September. Accessed at http://www.epa.gov/ncea/efh/pdfs/efh-complete.pdf.

US EPA. 2011b. "IRIS Glossary." August 31. Accessed at https://ofmpub.epa.gov/sor_internet/registry/termreg/searchandretrieve/glossariesandkeywordlists/search.do?details=&glossaryName=IRIS%20Glossary#formTop 17p.

US EPA. 2012. "Recommendations for Default Value for Relative Bioavailability of Arsenic in Soil." Office of Solid Waste and Emergency Response, OSWER Directive 9200.1-113, 4p., December.

US EPA. 2014a. "Human and Ecological Risk Assessment of Coal Combustion Residuals (Final)." Office of Solid Waste and Emergency Response (OSWER), Office of Resource Conservation and Recovery, 1237p., December. Accessed at http://www.regulations.gov/#!documentDetail;D=EPA-HQ-RCRA-2009-0640-11993.

US EPA. 2014b. "Coal Combustion Residual Beneficial Use Evaluation: Fly Ash Concrete and FGD Gypsum Wallboard (Final)." Office of Solid Waste and Emergency Response (OSWER), Office of Resource Conservation and Recovery (ORCR), 91p., February.

US EPA. 2015a. "Hazardous and solid waste management system; Disposal of coal combustion residuals from electric utilities (Final rule)." *Fed. Reg.* 80(74):21302-21501, 40 CFR 257, 40 CFR 261, April 17.

US EPA. 2015b. "Human Health Ambient Water Quality Criteria: 2015 Update." Office of Water, EPA 820-F-15-001, 3p., June

US EPA. 2015c. "Conducting a Human Health Risk Assessment." October 14. Accessed at http://www2.epa.gov/risk/conducting-human-health-risk-assessment#tab-4.

US EPA. 2016. "National Recommended Water Quality Criteria - Aquatic Life Criteria Table." April 18. Accessed at https://www.epa.gov/wqc/national-recommended-water-quality-criteria-aquatic-life-criteria-table.

US EPA. 2019a. "Regional Screening Levels (RSLs) - User's Guide." 143p., May. Accessed at https://www.epa.gov/risk/regional-screening-levels-rsls-users-guide.

US EPA. 2019b. "Regional Screening Level (RSL) Summary Table (TR=1E-06, HQ=0.1)." 12p., April. Accessed at https://semspub.epa.gov/work/HQ/199434.pdf.

US EPA. 2019c. "EPI Suite™ - Estimation Program Interface." March 12. Accessed at https://www.epa.gov/tsca-screening-tools/epi-suitetm-estimation-program-interface.

US EPA. 2019d. "National Recommended Water Quality Criteria - Aquatic Life Criteria Table." Accessed at https://www.epa.gov/wqc/national-recommended-water-quality-criteria-aquatic-life-criteria-table.

US EPA Region IV. 2018. "Region 4 Ecological Risk Assessment Supplemental Guidance (March 2018 Update)." Superfund Division, Scientific Support Section, 98p., March.

US Geological Survey (USGS). 2019a. "Water-Year Summary 2018 for Site USGS 03339000 Vermilion River near Danville, IL." Accessed at https://nwis.waterdata.usgs.gov/nwis/wys_rpt?dv_ts_ids=&48117&adr_begin_date=2017-10-01&adr_end_date=2018-09-30&site_no=03339000&agency_cd=USGS.

US Geological Survey (USGS). 2019b. "National Water Information System Water Quality Database: Hardness Data (parameter code 900) for Site No. 03336645, Middle Fork Vermilion River Above Oakwood, IL." Accessed at https://nwis.waterdata.usgs.gov/il/nwis/qwdata/?site_no=03336645&agency_cd=USGS.

World Health Organization (WHO). 2001. "Beryllium and Beryllium Compounds." In *Concise International Chemical Assessment Document 32*. 76p.

Appendix A

Data Summary

Table A.1 Groundwater Data Summary (2011-2019)

Group	Analyte	Detects	Total Samples	Min Detect	Max Detect	Min Date	Max Date	Max DL	Units
Metals Dissolved	Antimony	0	50			2011	2011	0.0050	mg/L
Metals Dissolved	Arsenic	64	122	0.00050	0.073	2011	2018	0.073	mg/L
Metals Dissolved	Barium	122	122	0.0097	0.19	2011	2018	0.19	mg/L
Metals Dissolved	Beryllium	1	50	0.0084	0.0084	2011	2011	0.0084	mg/L
Metals Dissolved	Boron	206	212	0.030	53	2011	2019	53	mg/L
Metals Dissolved	Cadmium	1	50	0.0024	0.0024	2011	2011	0.0024	mg/L
Metals Dissolved	Calcium	13	13	69	390	2011	2011	390	mg/L
Metals Dissolved	Chromium	1	50	0.0066	0.0066	2011	2011	0.0066	mg/L
Metals Dissolved	Chromium, Hexavalent	0	1			2019	2019	0.0050	mg/L
Metals Dissolved	Cobalt	1	50	0.021	0.021	2011	2011	0.021	mg/L
Metals Dissolved	Copper	1	52	0.079	0.079	2011	2019	0.079	mg/L
Metals Dissolved	Fluoride	106	122	0.060	1.2	2011	2018	1.2	mg/L
Metals Dissolved	Iron	101	124	0.010	8.6	2011	2019	8.6	mg/L
Metals Dissolved	Lead	0	50			2011	2011	0.0050	mg/L
Metals Dissolved	Magnesium	13	13	23	150	2011	2011	150	mg/L
Metals Dissolved	Manganese	204	212	0.0052	1.6	2011	2019	1.6	mg/L
Metals Dissolved	Mercury	0	50			2011	2011	0.0020	mg/L
Metals Dissolved	Nickel	2	52	0.0081	0.073	2011	2019	0.073	mg/L
Metals Dissolved	Potassium	13	13	1.1	10	2011	2011	10	mg/L
Metals Dissolved	Selenium	13	122	0.00090	0.026	2011	2018	0.026	mg/L
Metals Dissolved	Silver	0	50			2011	2011	0.0050	mg/L
Metals Dissolved	Sodium	13	13	3.4	75	2011	2011	75	mg/L
Metals Dissolved	Thallium	0	50			2011	2011	0.0020	mg/L
Metals Dissolved	Zinc	4	52	0.0055	0.36	2011	2019	0.36	mg/L
Metals Total	Arsenic	0	2			2019	2019	0.025	mg/L
Metals Total	Barium	2	2	0.11	0.12	2019	2019	0.12	mg/L
Metals Total	Boron	2	2	31	38	2019	2019	38	mg/L
Metals Total	Cadmium	0	2			2019	2019	0.00100	mg/L
Metals Total	Chromium	0	2			2019	2019	0.0050	mg/L
Metals Total	Chromium, Hexavalent	0	1			2019	2019	0.0050	mg/L
Metals Total	Cyanide	0	52			2011	2019	0.0080	mg/L
Metals Total	Fluoride	0	2			2019	2019	0.100	mg/L
Metals Total	Iron	1	2	0.15	0.15	2019	2019	0.15	mg/L
Metals Total	Lead	0	2			2019	2019	0.0150	mg/L
Metals Total	Manganese	2	2	0.033	0.073	2019	2019	0.073	mg/L
Metals Total	Mercury	0	2			2019	2019	0.00000080	mg/L
Metals Total	Nickel	0	2			2019	2019	0.0050	mg/L
Metals Total	Selenium	0	2			2019	2019	0.00100	mg/L
Metals Total	Silver	0	2			2019	2019	0.0030	mg/L
Metals Total	Zinc	0	2			2019	2019	0.0100	mg/L
Field	Dissolved Oxygen	22	72	1.0	7.4	2017	2018	7.4	mg/L
Field	Oxidation reduction potential	72	72	-231	139	2017	2018	139	mV
Field	pH (field)	214	214	5.1	8.8	2011	2019	8.8	SU
Field	Specific conductance at 25C	214	214	364	7680	2011	2019	7680	micromhos/cm

Group	Analyte	Detects	Total Samples	Min Detect	Max Detect	Min Date	Max Date	Max DL	Units
Field	Temperature	190	190	7.3	22	2011	2019	22	deg. C
Field	Temperature	24	24	47	70	2018	2019	70	deg. F
Field	Turbidity	34	72	1.0	126	2017	2018	126	JCU
Inorganic	Alkalinity, total	25	25	74	550	2011	2011	550	mg/L
Inorganic	Chloride, total in water	113	124	2.0	51	2011	2019	51	mg/L
Inorganic	Nitrate nitrogen, total	57	124	0.010	1.7	2011	2019	1.7	mg/L
Inorganic	Nitrite nitrogen, total	2	74	0.050	0.060	2017	2019	0.060	mg/L
Inorganic	Nitrogen, Ammonia, Total	2	2	0.63	0.64	2019	2019	0.64	mg/L
Inorganic	Phosphorus, total	0	2			2019	2019	0.100	mg/L
Inorganic	Residue, total filterable (dried at 180C)	212	212	224	4420	2011	2019	4420	mg/L
Inorganic	Sulfate	184	214	6.4	1940	2011	2019	1940	mg/L
Inorganic	Total dissolved solids	2	2	1400	1400	2019	2019	1400	mg/L
Inorganic	Total Kjeldahl nitrogen	0	2			2019	2019	1.00	mg/L
Inorganic	Total suspended solids	0	2			2019	2019	6.0	mg/L

Notes:

DL = Detection Limit; JCU = Jackson Candle Turbidity Units; SU = Standard Units.

Table A.2 Surface Water Data Summary, Middle Fork of the Vermilion River (2019)

Group	Analyte	Detects	Samples	Min Detect	Max Detect	Max DL	Units
Field	pH (field)	6	6	7.6	8.2	8.2	SU
Field	Specific conductance at 25C	6	6	662	696	696	micromhos/cm
Field	Temperature	3	3	7.4	8.6	8.6	deg. C
Field	Temperature	3	3	37	38	38	deg. F
Inorganic	Chloride, total in water	6	6	19	22	22	mg/L
Inorganic	Nitrate nitrogen, total	6	6	4.3	5.6	5.6	mg/L
Inorganic	Nitrite nitrogen, total	0	6			0.050	mg/L
Inorganic	Nitrogen, Ammonia, Total	0	6			0.10	mg/L
Inorganic	Phosphorus, total	6	6	0.11	0.32	0.32	mg/L
Inorganic	Sulfate	6	6	25	40	40	mg/L
Inorganic	Total Dissolved Solids	6	6	290	370	370	mg/L
Inorganic	Total Kjeldahl Nitrogen	1	6	1.5	1.5	1.5	mg/L
Inorganic	Total Suspended Solids	4	6	6.0	9.0	9.0	mg/L
Metals Dissolved	Chromium, Hexavalent	0	3			0.0050	mg/L
Metals Dissolved	Copper	0	6			0.0050	mg/L
Metals Dissolved	Iron	0	6			0.040	mg/L
Metals Dissolved	Nickel	0	6			0.0050	mg/L
Metals Dissolved	Zinc	0	6			0.010	mg/L
Metals Total	Arsenic	0	6			0.025	mg/L
Metals Total	Barium	6	6	0.036	0.040	0.040	mg/L
Metals Total	Boron	6	6	0.041	0.17	0.17	mg/L
Metals Total	Cadmium	0	6			0.0010	mg/L
Metals Total	Chromium	0	6			0.0050	mg/L
Metals Total	Chromium, Hexavalent	0	3			0.0050	mg/L
Metals Total	Cyanide	0	6			0.0050	mg/L
Metals Total	Fluoride	6	6	0.15	0.17	0.17	mg/L
Metals Total	Iron	6	6	0.34	0.65	0.65	mg/L
Metals Total	Lead	0	6			0.015	mg/L
Metals Total	Manganese	6	6	0.023	0.045	0.045	mg/L
Metals Total	Mercury	3	6	0.0000012	0.0000013	0.0000013	mg/L
Metals Total	Nickel	0	6			0.0050	mg/L
Metals Total	Selenium	0	6			0.0010	mg/L
Metals Total	Silver	0	6			0.0030	mg/L
Metals Total	Zinc	0	6			0.010	mg/L

Notes:

DL = Detection limit.

Appendix B

Screening Benchmarks

Table B.1 Recreator Exposure to Surface Water While Swimming

Detected Chemicals	Dermal Permeability Coefficient Kp (cm/hr)	Cancer					Non-Cancer								Swimmer RSL Surface Water (mg/L)	Basis
		TRV		Child + Adult		Child + Adult	TRV		Child		Adult		Child	Adult		
		CSF $(mg/kg\text{-}d)^{-1}$	Derm. CSF $(mg/kg\text{-}d)^{-1}$	Incidental Ingestion SL_{ing} (mg/L)	Dermal Contact SL_{derm} (mg/L)	Cancer SL (mg/L)	RfD (mg/kg-d)	Derm. RfD (mg/kg-d)	Incidental Ingestion SL_{ing} (mg/L)	Dermal Contact SL_{derm} (mg/L)	Incidental Ingestion SL_{ing} (mg/L)	Dermal Contact SL_{derm} (mg/L)	Non-Cancer SL (mg/L)			
Barium	0.0010	NC	NC	NC	NC	NC	0.20	0.014	2751	76	14673	131	74	130	74	nc
Beryllium	0.0010	NC	NC	NC	NC	NC	0.0020	0.000014	28	0.076	147	0.13	0.075	0.13	0.075	nc
Boron	0.0010	NC	NC	NC	NC	NC	0.20	0.20	2751	1081	14673	1867	776	1656	776	nc
Cobalt	0.00040	NC	NC	NC	NC	NC	0.00030	0.00030	4.1	4.1	22	7.0	2.0	5.3	2.0	nc
Fluoride	0.0010	NC	NC	NC	NC	NC	0.040	0.040	550	216	2935	373	155	331	155	nc
Iron	0.0010	NC	NC	NC	NC	NC	0.70	0.70	9629	3782	51357	6533	2716	5796	2716	nc
Manganese	0.0010	NC	NC	NC	NC	NC	0.024	0.00096	330	5.2	1761	9.0	5.1	8.9	5.1	nc
Mercury	0.0010	NC	NC	NC	NC	NC	0.00030	0.000021	4.1	0.11	22	0.20	0.11	0.19	0.11	nc
Thallium	0.0010	NC	NC	NC	NC	NC	0.000010	0.000010	0.14	0.054	0.73	0.093	0.039	0.083	0.039	nc

Notes:

AL = EPA Action Level; COI = Constituent of Interest; CSF = Cancer Slope Factor; derm = Dermal Contact; ing = Ingestion; NC = No criterion available; RfD = Reference Dose; SL = Screening Level; TRV = Toxicity Reference Value.

Health Benchmark defined as the lower of the Screening Levels for cancer and non-cancer. The basis of the Health Benchmark presented as c = based on cancer endpoint or nc = based on non-cancer endpoint.

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

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

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

Target Cancer Risk (TR) = 1E-05
Target Hazard Quotient (THQ) = 1

Surface Water – Ingestion (Chemical)

$$\text{Intake Factor (IF)} = \frac{IR \times EF \times ED}{BW \times AT} =$$

		Non-Cancer		Cancer		
		7.3E-05 Child	1.4E-05 Adult	6.2E-06 Child	3.9E-06 Adult	Basis
IR	Ingestion Rate (L/day)	0.01	0.01	0.01	0.01	Recommended water consumption rate while swimming (IEPA, 201X)
EF	Surface Water Exposure Frequency (days/year)	40	40	40	40	2 days/week between mid-May and end of Sept when water temp. > 70°F (Prof. Judgment)
ED	Exposure Duration (years)	6	20	6	20	Default value for Resident (US EPA, 2019)
BW	Body Weight (kg)	15	80	15	80	Default value for Resident (US EPA, 2019)
AT	Averaging Time (d)	2,190	7,300	25,550	25,550	Default value for Resident (US EPA, 2019)

Surface Water – Dermal Contact (Chemical)

$$\text{Intake Factor (IF)} = \frac{SA \times ET \times EF \times ED \times CF}{BW \times AT} =$$

		Non-Cancer		Cancer		
		1.9E-01 Child	1.1E-01 Adult	1.6E-02 Child	3.1E-02 Adult	Basis
SA	Surface Area Exposed to Surface Water (cm^2)	6,365	19,652	6,365	19,652	Whole Body Default value for Resident (US EPA, 2019)
ET	Exposure Time (hr/d)	4	4	4	4	Professional Judgment
EF	Surface Water Exposure Frequency (days/year)	40	40	40	40	2 days/week between mid-May and end of Sept when water temp. > 70°F (Prof. Judgment)
ED	Exposure Duration (years)	6	20	6	20	Default value for Resident (US EPA, 2019)
CF	Conversion Factor (L/cm^3)	0.001	0.001	0.001	0.001	
BW	Body Weight (kg)	15	80	15	80	Default value for Resident (US EPA, 2019)
AT	Averaging Time (d)	2,190	7,300	25,550	25,550	Default value for Resident (US EPA, 2019)

Table B.2 Recreator Exposure to Surface Water While Boating

Detected Chemicals	Dermal Permeability Coefficient Kp (cm/hr)	Cancer			Non-Cancer					Boater RSL Surface Water (mg/L)	Basis
		TRV	Child + Adult		TRV	Child	Adult	Child	Adult		
		Derm. CSF $(mg/kg\text{-}d)^{-1}$	Dermal Contact SL_{derm} (mg/L)	Cancer SL (mg/L)	Derm. RfD (mg/kg-d)	Dermal Contact SL_{derm} (mg/L)	Dermal Contact SL_{derm} (mg/L)	Non-Cancer SL (mg/L)			
Barium	0.0010	NC	NC	NC	0.014	184	353	184	353	184	nc
Beryllium	0.0010	NC	NC	NC	0.000014	0.18	0.35	0.18	0.35	0.18	nc
Boron	0.0010	NC	NC	NC	0.20	2632	5045	2632	5045	2632	nc
Cobalt	0.00040	NC	NC	NC	0.00030	9.9	19	9.9	19	9.9	nc
Fluoride	0.0010	NC	NC	NC	0.040	526	1009	526	1009	526	nc
Iron	0.0010	NC	NC	NC	0.70	9213	17656	9213	17656	9213	nc
Manganese	0.0010	NC	NC	NC	0.00096	13	24	13	24	13	nc
Mercury	0.0010	NC	NC	NC	0.000021	0.28	0.53	0.28	0.53	0.28	nc
Thallium	0.0010	NC	NC	NC	0.000010	0.13	0.25	0.13	0.25	0.13	nc

Notes:

AL = EPA Action Level; COI = Constituent of Interest; CSF = Cancer Slope Factor; derm = Dermal Contact; ing = Ingestion; NC = No criterion available; RfD = Reference Dose; SL = Screening Level; TRV = Toxicity Reference Value.

Health Benchmark defined as the lower of the Screening Levels for cancer and non-cancer. The basis of the Health Benchmark presented as c = based on cancer endpoint or nc = based on non-cancer endpoint.

Screening Benchmark = SL_{derm}

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

Target Cancer Risk (TR) = 1E-05
Target Hazard Quotient (THQ) = 1

Surface Water – Dermal Contact (Chemical)

$$\text{Intake Factor (IF)} = \frac{SA \times ET \times EF \times ED \times CF}{BW \times AT} =$$

		Non-Cancer		Cancer		
Intake Factor (IF)	=	7.6E-02	4.0E-02	6.5E-03	1.1E-02	Basis
		Child	Adult	Child	Adult	
SA	Surface Area Exposed to Surface Water (cm²)	1,733	4,824	1,733	4,824	Age weighted SA for hands, forearms, lower legs and feet (EPA, 2011a)
ET	Exposure Time (hr/d)	4	4	4	4	Professional Judgment
EF	Surface Water Exposure Frequency (days/year)	60	60	60	60	2 days/week between April and Oct when air temp. > 70°F (Prof. Judgment)
ED	Exposure Duration (years)	6	20	6	20	Default value for Resident (US EPA, 2019)
CF	Conversion Factor (L/cm^3)	0.001	0.001	0.001	0.001	
BW	Body Weight (kg)	15	80	15	80	Default value for Resident (US EPA, 2019)
AT	Averaging Time (d)	2,190	7,300	25,550	25,550	Default value for Resident (US EPA, 2019)

Table B.3 Recreator Exposure to Sediment While Swimming or Boating

Chemical COIs	Relative Bioavailability B (unitless)	Dermal Absorption Fraction ABS (unitless)	Cancer				Cancer SL (mg/kg)	Non-Cancer								Recreator RSL Sediment (mg/kg)	Basis
			TRV		Child + Adult			TRV		Child		Adult		Child	Adult		
			CSF $(mg/kg\text{-}d)^{-1}$	Derm. CSF $(mg/kg\text{-}d)^{-1}$	Incidental Ingestion SL_{ing} (mg/kg)	Dermal Contact SL_{derm} (mg/kg)		RfD (mg/kg-d)	Derm. RfD (mg/kg-d)	Incidental Ingestion SL_{ing} (mg/kg)	Dermal Contact SL_{derm} (mg/kg)	Incidental Ingestion SL_{ing} (mg/kg)	Dermal Contact SL_{derm} (mg/kg)	Non-Cancer SL (mg/kg)			
Arsenic	0.60	0.030	1.5	1.5	135	405	101	0.00030	0.00030	684	4445	7,300	8,042	593	3,827	101	c
Barium	1.0	NA	NC	NC	NC	NC	NC	0.20	0.014	273,750	NA	2,920,000	NA	273,750	2,920,000	273,750	nc
Beryllium	1.0	NA	NC	NC	NC	NC	NC	0.0020	0.000014	2,738	NA	29,200	NA	2,738	29,200	2,738	nc
Boron	1.0	NA	NC	NC	NC	NC	NC	0.20	0.20	273,750	NA	2,920,000	NA	273,750	2,920,000	273,750	nc
Cadmium	1.0	0.0010	NC	NC	NC	NC	NC	0.0010	0.000025	1,369	11114	14,600	20,105	1,219	8,458	1,219	nc
Chromium	1.0	NA	NC	NC	NC	NC	NC	1.5	0.020	2,053,125	NA	21,900,000	NA	2,053,125	21,900,000	2,053,125	nc
Cobalt	1.0	NA	NC	NC	NC	NC	NC	0.00030	0.00030	411	NA	4,380	NA	411	4,380	411	nc
Copper	1.0	NA	NC	NC	NC	NC	NC	0.040	0.040	54,750	NA	584,000	NA	54,750	584,000	54,750	nc
Fluoride	1.0	NA	NC	NC	NC	NC	NC	0.040	0.040	54,750	NA	584,000	NA	54,750	584,000	54,750	nc
Iron	1.0	NA	NC	NC	NC	NC	NC	0.70	0.70	958,125	NA	10,220,000	NA	958,125	10,220,000	958,125	nc
Manganese	1.0	NA	NC	NC	NC	NC	NC	0.024	0.00096	32,850	NA	350,400	NA	32,850	350,400	32,850	nc
Nickel	1.0	NA	NC	NC	NC	NC	NC	0.020	0.00080	27,375	NA	292,000	NA	27,375	292,000	27,375	nc
Selenium	1.0	NA	NC	NC	NC	NC	NC	0.0050	0.0050	6,844	NA	73,000	NA	6,844	73,000	6,844	nc
Zinc	1.0	NA	NC	NC	NC	NC	NC	0.30	0.30	410,625	NA	4,380,000	NA	410,625	4,380,000	410,625	nc

Notes:

AL = EPA Action Level; COI = Constituent of Interest; CSF = Cancer Slope Factor; derm = Dermal Contact; ing = Ingestion; NC = No criterion available; RfD = Reference Dose; SL = Screening Level; TRV = Toxicity Reference Value.

Health Benchmark defined as the lower of the Screening Levels for cancer and non-cancer. The basis of the Health Benchmark presented as c = based on cancer endpoint or nc = based on non-cancer endpoint; Lead = based on US EPA's residential standard for lead.

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

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

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

Target Cancer Risk (TR) = 1E-05
Target Hazard Quotient (THQ) = 1

Sediment – Ingestion (Chemical)

		Non-Cancer		Cancer		
Intake Factor (IF) =	$\frac{IR \times EF \times ED \times CF}{BW \times AT}$ =	7.3E-07	6.8E-08	6.3E-08	2.0E-08	Basis
		Child	Adult	Child	Adult	
IR	Ingestion Rate (mg/day)	67	33	67	33	One-third of US EPA residential soil ingestion rate (Prof. Judgment)
EF	Sediment Exposure Frequency (days/year)	60	60	60	60	2 days/week between April and Oct when air temp. > 70°F (Prof. Judgment)
ED	Exposure Duration (years)	6	20	6	20	Default value for Resident (US EPA, 2019)
CF	Conversion Factor (kg/mg)	0.000001	0.000001	0.000001	0.000001	
BW	Body Weight (kg)	15	80	15	80	Default value for Resident (US EPA, 2019)
AT	Averaging Time (d)	2,190	7,300	25,550	25,550	Default value for Resident (US EPA, 2019)

Sediment – Dermal Contact (Chemical)

		Non-Cancer		Cancer		
Intake Factor (IF) =	$\frac{SA \times AF \times EF \times ED \times CF}{BW \times AT}$ =	2.2E-06	1.2E-06	1.9E-07	3.6E-07	Basis
		Child	Adult	Child	Adult	
SA	Surface Area Exposed to Sediment (cm²/day)	1,026	3,026	1,026	3,026	Age weighted SA for lower legs and feet (EPA, 2011a)
AF	Sediment Skin Adherence Factor (mg/cm²)	0.2	0.2	0.2	0.2	Age weighted AF for children exposed to sediment (EPA, 2011a)
EF	Sediment Exposure Frequency (days/year)	60	60	60	60	2 days/week between April and Oct when air temp. > 70°F (Prof. Judgment)
ED	Exposure Duration (years)	6	20	6	20	Default value for Resident (US EPA, 2019)
CF	Conversion Factor (kg/mg)	0.000001	0.000001	0.000001	0.000001	
BW	Body Weight (kg)	15	80	15	80	Default value for Resident (US EPA, 2019)
AT	Averaging Time (d)	2,190	7,300	25,550	25,550	Default value for Resident (US EPA, 2019)

Table B.4 Calculated Water Quality Standards Protective of Fish Consumption

Analytes	Bioconcentration Factor (BCF)		Average Daily Intake (ADI)			Human Threshold Criteria (HTC)	
	BCF[a] (L/kg-tissue)	Basis	MCL (mg/L)	RfD (mg/kg-d)	ADI[c] (mg/day)	Water & Fish (mg/L)	Fish Only (mg/L)
Barium	130	US EPA, 2014	2.0	0.20	4.0	1.5	1.5
Beryllium	19	NRWQC 2002	0.0040	0.0020	0.0080	0.021	0.021
Boron	NA		NC	0.20	14	1400	NA
Cobalt	300	ORNL RAIS	NC	0.00030	0.021	0.0035	0.0035
Fluoride	2.3	US EPA, 2014	4.0	0.040	8.0	143	174
Iron	19	US EPA, 2014	NC	0.70	49	126	129
Manganese	0.4	US EPA, 2014	NC	0.024	1.7	93	210
Mercury	3,760	NRWQC 2002	0.0020	0.00030	0.0040	0.000053	0.000053
Thallium	116	NRWQC 2002	0.0020	0.000010	0.0040	0.0017	0.0017

Notes:

ADI = Average Daily Intake; BCF = Bioconcentration Factor; COI = Constituent of Interest; F = Fish Consumption Rate; HTC = Human Threshold Criteria; MCL = Maximum Contaminant Level; NA = BCF not available, therefore, WQC for fish only not calculated; NC = No Criterion Available; NRWQC = National Recommended Water Quality Criteria; ORNL RAIS = Oak Ridge National Laboratory Risk Assessment Information System; RfD = Reference Dose, RSC = Relative Source Contribution; THQ = Target Hazard Quotient; W = Water Consumption Rate; WQS = Water Quality Standard; US EPA = United States Environmental Protection Agency.

(a) BCFs from the following hierarchy of sources:

NRWQC (US EPA, 2016). National Recommended Water Quality Criteria.
NRWQC (US EPA, 2002). National Recommended Water Quality Criteria: 2002. Human Health Criteria Calculation Matrix.
US EPA (2014a). Human and Ecological Risk Assessment of Coal Combustion Residuals.
ORNL RAIS (2018). Risk Assessment Information System (RAIS) Toxicity Values and Chemical Parameters.

(b) In the absence of chemical specific RCS, an RCS of 100% was used.

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

(d) WQS based on US EPA's action levels.

Evaluation of Non-detects

Table B.5 Risk Evaluation for Recreators Exposed to Surface Water While Swimming

Undetected Metals in Surface Water	Surface Water Concentration^a (mg/L)	Recreator Benchmark for Swimming (mg/L)	Exceedance
Arsenic	ND (0.025)	0.12	No
Cadmium	ND (0.001)	0.13	No
Chromium	ND (0.005)	105	No
Chromium, Hexavalent	ND (0.005)	0.0054	No
Copper	ND (0.005)	155	No
Cyanide	ND (0.005)	2.3	No
Lead	ND (0.015)	0.015	No
Nickel	ND (0.005)	20	No
Selenium	ND (0.001)	19	No
Silver	ND (0.003)	1.8	No
Zinc	ND (0.01)	1,633	No

Notes:

COPC = Constituent of Potential Concern; ND = Not Detected, maximum detection limit presented.

(a) Surface water concentration is the maximum detection limit of the total or dissolved metals analyses.

Table B.6 Risk Evaluation for Recreators Exposed to Surface Water While Boating

Undetected Metals in Surface Water	Surface Water Concentration[a] (mg/L)	Recreator Benchmark for Boating (mg/L)	Exceedance
Arsenic	ND (0.025)	0.37	No
Cadmium	ND (0.001)	0.33	No
Chromium	ND (0.005)	257	No
Chromium, Hexavalent	ND (0.005)	0.014	No
Copper	ND (0.005)	526	No
Cyanide	ND (0.005)	7.9	No
Lead	ND (0.015)	0.015	No
Nickel	ND (0.005)	53	No
Selenium	ND (0.001)	66	No
Silver	ND (0.003)	4.4	No
Zinc	ND (0.01)	6,581	No

Notes:

COPC = Constituent of Potential Concern; ND = Not Detected, maximum detection limit presented.

(a) Surface water concentration is the maximum detect limit of the total or dissolved metals analyses.

Table B.7 Risk Evaluation for Recreators Exposed to Sediment

Undetected Metals in Groundwater	Modeled Sediment Concentration[a] (mg/kg)	Recreator Benchmark (mg/kg)	Exceedance
Antimony	ND (0.027)	548	No
Chromium, Hexavalent	ND (0.00057)	243	No
Cyanide	ND[b]	821	No
Lead	ND (0.28)	400	No
Mercury	ND (0.13)	411	No
Silver	ND (0.011)	6,844	No
Thallium	ND (0.000071)	14	No

Notes:

COPC = Constituent of Potential Concern; ND = Not Detected, maximum detection limit presented.

(a) Sediment concentration is modeled using the maximum detect limit of the total or dissolved metals groundwater analyses.

(b) Cyanide concentration in sediment was not modeled, however, the modeled concentration is expected to be lower than the sediment benchmark.

Table B.8 Risk Evaluation for Recreators Consuming Locally Caught Fish

Undetected Metals in Surface Water	Surface Water Concentration^a (mg/L)	HTC for Fish and Water (mg/L)	HTC for Fish Only (mg/L)	Exceedance
Arsenic	ND (0.025)	0.022	0.023	Yes
Cadmium	ND (0.001)	0.013	1.5	No
Chromium	ND (0.005)	318	328	No
Chromium, Hexavalent	ND (0.005)	0.64	0.66	No
Copper	ND (0.005)	1.3	1.3	No
Cyanide	ND (0.005)	13	20	No
Lead	ND (0.015)	0.015	0.015	No
Nickel	ND (0.005)	1.5	1.5	No
Selenium	ND (0.001)	0.94	1.0	No
Silver	ND (0.003)	18	35	No
Zinc	ND (0.01)	22	22	No

Notes:

COPC = Constituent of Potential Concern; HTC = Human Threshold Criteria; ND = Not Detected, maximum detection limit presented.

(a) Surface water concentration is the maximum detect limit of the total or dissolved metals analyses.

Table B.9 Risk Evaluation for Ecological Receptors Exposed to Surface Water

Undetected Metals in Surface Water	Surface Water Concentration[a] (mg/L)	Ecological Freshwater Benchmark[b] (mg/L)	Exceedance
Arsenic	ND (0.025)	0.19	No
Cadmium	ND (0.001)	0.0021	No
Chromium	ND (0.005)	0.44	No
Chromium, Hexavalent	ND (0.005)	0.011	No
Copper	ND (0.005)	0.029	No
Cyanide	ND (0.005)	0.0052	No
Lead	ND (0.015)	0.051	No
Nickel	ND (0.005)	0.013	No
Selenium	ND (0.001)	1.0	No
Silver	ND (0.003)	0.0050	No
Zinc	ND (0.01)	0.079	No

Notes:

COPC = Constituent of Potential Concern; ND = Not Detected, maximum detection limit presented.

(a) Surface water concentration is the maximum detect limit of the total or dissolved metals analyses.

(b) Surface water benchmarks from Illinois Environmental Protection Agency (IEPA, 2015) Water Quality Standards. An average hardness of 30 mg/L was used to calculated hardness-dependent benchmarks (cadmium, chromium, copper, lead, nickel, and zinc).

Table B.10 Risk Evaluation for Ecological Receptors Exposed to Sediment

Undetected Metals in Groundwater	Modeled Sediment Concentration[a] (mg/kg)	ESV[b] (mg/kg)	Exceedance
Antimony	ND (0.027)	2.0	No
Chromium, Hexavalent	ND (0.00057)	43	No
Cyanide	ND[c]	NC	NC
Lead	ND (0.28)	36	No
Mercury	ND (0.13)	0.17	No
Silver	ND (0.011)	1.0	No
Thallium	ND (0.000071)	NC	NC

Notes:

COPC = Constituent of Potential Concern; ESV = Ecological Screening Value; ND = Not Detected, maximum detection limit presented; US EPA = United States Environmental Protection Agency.

(a) Sediment concentration is modeled using the maximum detect limit of the total or dissolved metals groundwater analyses.

(b) Ecological Screening Value (ESV) from US EPA Region IV (2018).

(c) Cyanide concentration in sediment was not modeled; however, the modeled concentration is expected to be lower than the sediment benchmark.

Appendix C

Surface Water and Sediment Modeling

Gradient modeled concentrations in river surface water and sediment based on available groundwater data. First, we estimated the flow rate of constituents of interest (COIs) discharged to the river *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 Middle Fork of the Vermilion River ("Vermilion River").

Model Overview

The groundwater flow into the river is represented by a one-dimensional steady-state model. In this model, the groundwater plume migrates horizontally in the Middle Groundwater Unit (MGU) and the Lower Groundwater Unit (LGU), in the direction of the river. For both layers, the groundwater flow entering the river is the flow going through a cross-sectional area that has a length equal to the length of the river adjacent to the ash ponds with potential coal combustion residual (CCR)-related impacts and a height equal to each layer's thickness. All the groundwater flowing through these two layers discharges to the river; thus the total flow into the river is the sum of the flows in the two layers. The length of the river adjacent to the ponds was estimated based on the modeled boron plume obtained from the existing groundwater flow model for the Site (OBG, 2018). Using the modeled boron plume length to represent the length of potential CCR-impacted groundwater discharging into surface water is conservative because boron has very low retardation in groundwater; thus boron will be more widely distributed in groundwater than other CCR-related constituents.

The groundwater flow into the river mixes with the surface water in the Middle Fork of the Vermilion River. The COIs entering the river *via* groundwater can dissolve into the water column, sorb to suspended sediments, or sorb to benthic sediments. Using the 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

We used conservative assumptions to evaluate the groundwater discharge rate of the COIs. We assumed that the groundwater concentrations were uniformly equal to the maximum detected concentration for each individual COI, in both the MGU and the LGU. For COIs that were not detected in groundwater, but for which the maximum detection limit exceeded the surface water ecological benchmark, we used the maximum detection limit. We ignored absorption by subsurface soil and assumed that all the groundwater flowing through MGU and LGU and intersecting the river bank was discharged into the river.

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 river 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 or the maximum detection limit if the constituent was not detected (mg/L)
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 C.1. The total mass discharge rate for each COI is the sum of the mass discharge rates in the MGU and the LGU. The calculated mass discharge rates were used as inputs for the surface water and sediment partitioning model.

Surface Water and Sediment Concentration

Groundwater discharged into the river gets diluted in the surface water flow. Constituents transported by groundwater into the surface water migrate into the water column and the bed sediments. The surface water model 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, 2014a). 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 (US EPA, 2014a). These coefficients are presented in Table C.2.

To be conservative, we assumed that the constituents were not affected by dissipation or degradation once they entered the waterbody. The total waterbody concentration of the COI was calculated as (Table J-1-9 in US EPA, 2014a):

$$C_{waterbody} = \frac{m_c}{V_f \times f_{water} \times \frac{d_z}{d_w}}$$

where:

$C_{waterbody}$	Total waterbody concentration of the constituent (mg/L)
V_f	Waterbody annual flow (L/year)
d_z	Waterbody depth (m)
d_w	Water column depth (m)
f_{water}	Fraction of COI in the water column (unitless)
m_c	Mass discharge rate of the COI (mg/year)

The fraction of COI in the water column was calculated for each COI using the sediment/water and suspended solids/water partition coefficients (Table J-1-1 in US EPA 2014a). The values of the fraction of COIs in the water column and other calculated parameters are presented in Table C.3. For the Vermilion River annual flow rate, we conservatively used a value reported by OBG as representative of low flow conditions (OBG, 2019b); a flow rate of 17 cfs was calculated as the 90th percentile low of the daily mean discharge rates between 1979 and 2018 at the Oakwood gaging station. Other waterbody parameters are presented in Table C.4.

The equation above calculates the total concentration of constituents in the waterbody. Using the fraction of COIs in the water column, we derived the concentration of COIs in the water column (Table J-1-10 in US EPA, 2014a). From these values, and based on the equilibrium partition coefficients, we computed the fraction of water column sediments that are dissolved in the water column and those that are sorbed to suspended solids in the water column. These were used to calculate the concentration of dissolved COIs in the water column and the concentration of COIs sorbed to suspended solids in the water column (Table J-1-11 in US EPA, 1998, 2014a):

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

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 waterbody concentration and the fraction of COIs in the benthic sediments, the model derives the total concentration in benthic sediments (Table J-1-12 in US EPA 2014a). This value can be used to calculate dry weight sediment concentration as follows:

$$C_{sed-dw} = \frac{C_{bs-tot}}{bsc}$$

where:

C_{sed-dw}	Dry weight sediment concentration (mg/kg)
C_{bs-tot}	Total sediment concentration (mg/L)
bsc	Bed sediment bulk density (used the default value from US EPA, 2014a : 1 g/m^3)

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

The concentration sorbed to benthic sediments was calculated from:

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

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 C.5.

Table C.1 Parameters Used to Estimate Groundwater Discharge to Surface Water

GW Unit	Parameter	Full Name	Value	Unit
MGU	A	Cross-Sectional Area	3,931	m^2
MGU	i	Hydraulic Gradient	0.0093	m/m
MGU	K	Hydraulic Conductivity	2.15E-03	cm/s
LGU	A	Cross-Sectional Area	978	m^2
LGU	i	Hydraulic Gradient	0.0075	m/m
LGU	K	Hydraulic Conductivity	8.47E-04	cm/s

Notes:

GW = Groundwater Unit; LGU = Lower Groundwater Unit; MGU = Middle Groundwater Unit; NEAP = New East Ash Pond.

Mass discharge from the NEAP was not included, because groundwater monitoring results indicate that impacted groundwater from the NEAP is not reaching the Middle Fork (OBG, 2019b).

Source: OBG, 2018.

Table C.2 Partition Coefficients

	Sediment-Water, Mean, Kdbs		Suspended Sediment-Water, Mean, Kdsw	
Constituent	**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
Barium	2.5	3.16E+02	4.0	1.00E+04
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
Chromium III	4.9	7.94E+04	5.1	1.26E+05
Chromium VI	1.7	5.01E+01	4.2	1.58E+04
Cobalt	3.1	1.26E+03	4.8	6.31E+04
Copper	3.5	3.16E+03	4.7	5.01E+04
Cyanide	-	--	-	--
Fluoride	2.2	1.58E+02	2.2	1.58E+02
Iron	1.4	2.51E+01	1.4	2.51E+01
Lead	4.6	3.98E+04	5.7	5.01E+05
Manganese	4.4	2.80E+04	4.4	2.80E+04
Mercury	4.9	7.94E+04	5.3	2.00E+05
Nickel	3.9	7.94E+03	4.4	2.51E+04
Selenium	0.6	3.98E+00	3.8	6.31E+03
Silver	3.6	3.98E+03	5.2	1.58E+05
Thallium	1.3	2.00E+01	4.1	1.26E+04
Zinc	4.1	1.26E+04	5.0	1.00E+05

Notes:

Cyanide was not modeled because it lacks a Kd value in US EPA, 2014a.

Source: US EPA, 2014a.

Table C.3 Calculated Parameters

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	0.0057	0.9943	0.7254
Arsenic	0.0649	0.9351	0.9545
Barium	0.0528	0.9472	0.9434
Beryllium	0.0281	0.9719	0.9132
Boron	0.7165	0.2835	0.9545
Cadmium	0.0122	0.9878	0.6772
Chromium (III)	0.0004	0.9996	0.5697
Chromium (VI)	0.2646	0.7354	0.9132
Cobalt	0.0179	0.9821	0.7254
Copper	0.0068	0.9932	0.7688
Cyanide	--	--	--
Fluoride	0.0949	0.9051	0.9990
Iron	0.3933	0.6067	0.9998
Lead	0.0017	0.9983	0.2496
Manganese	0.0007	0.9993	0.8562
Mercury	0.0005	0.9995	0.4551
Nickel	0.0024	0.9976	0.8690
Selenium (IV)	0.7906	0.2094	0.9635
Silver	0.0081	0.9919	0.5126
Thallium	0.4659	0.5341	0.9298
Zinc	0.0021	0.9979	0.6250

Table C.4 Surface Water Parameters

Parameter	Full Name	Value	Unit
TSS	Total Suspended Solids	6	mg/L
V_{fx}	Surface Water Flow Rate	1.52E+10	L/yr
db	Depth of Upper Benthic Layer (default: 0.03)	0.03	m
dw	Depth of Water Column	0.5	m
dz	Depth of Water Body	0.53	m
bsc	Bed Sediment Bulk Density (default: 1.0)	1	g/cm3
bsp	Bed Sediment Porosity (default: 0.6)	0.6	-
M_{TSS}	TSS Mass per Unit Area	0.003	kg/m2
M_S	Sediment Mass per Unit Area	30	kg/m2

Notes:

Source of default values: US EPA, 2014a.

Table C.5 Input Groundwater Concentrations and Output Surface Water and Sediment Concentrations

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	Total Concentration in Benthic Sediments (Dry Weight) mg/kg.dw
Antimony	5.00E-03	1.33E+05	9.29E-06	2.68E-02	2.68E-02
Arsenic	7.30E-02	1.94E+06	1.36E-04	3.25E-02	3.26E-02
Barium	1.90E-01	5.06E+06	3.53E-04	1.05E-01	1.06E-01
Beryllium	8.40E-03	2.24E+05	1.56E-05	8.99E-03	9.00E-03
Boron	5.28E+01	1.41E+09	9.81E-02	5.91E-01	6.47E-01
Cadmium	2.40E-03	6.39E+04	4.46E-06	6.03E-03	6.03E-03
Chromium (III)	6.60E-03	1.76E+05	1.23E-05	5.55E-01	5.55E-01
Chromium (VI)	6.60E-03	1.76E+05	1.23E-05	5.61E-04	5.68E-04
Cobalt	2.10E-02	5.59E+05	3.90E-05	3.56E-02	3.57E-02
Copper	7.90E-02	2.10E+06	1.47E-04	3.57E-01	3.57E-01
Cyanide	8.00E-03	2.13E+05			
Fluoride	1.20E+00	3.20E+07	2.23E-03	3.53E-01	3.54E-01
Iron	8.60E+00	2.29E+08	1.60E-02	4.01E-01	4.11E-01
Lead	1.50E-02	3.99E+05	2.79E-05	2.77E-01	2.77E-01
Manganese	1.60E+00	4.26E+07	2.97E-03	7.13E+01	7.13E+01
Mercury	2.00E-03	5.33E+04	3.72E-06	1.34E-01	1.34E-01
Nickel	7.30E-02	1.94E+06	1.36E-04	9.36E-01	9.36E-01
Selenium (VI)	2.60E-02	6.92E+05	4.83E-05	1.85E-04	2.13E-04
Silver	3.00E-03	7.99E+04	5.57E-06	1.14E-02	1.14E-02
Thallium	2.00E-03	5.33E+04	3.72E-06	6.89E-05	7.10E-05
Zinc	3.60E-01	9.59E+06	6.69E-04	5.26E+00	5.26E+00

Notes:

Cyanide was not modeled due to lack of Kd value in US EPA, 2014a.

Table C.6 Modeled Surface Water Concentrations Compared to Benchmarks

Status	Constituent	Modeled Surface Water Concentration (mg/L)	Ecological Freshwater Benchmark (mg/L)	Recreator Benchmark for Swimming (mg/L)	Recreator Benchmark for Boating (mg/L)	HTC Water & Fish (mg/L)	Exceedances
NA in SW, ND in GW	Antimony	9.29E-06	0.19	--	--	--	No
ND in SW	Arsenic	1.36E-04	0.19	0.12	0.37	0.022	No
Detected in SW	Barium	3.53E-04	5	74	184	1.5	No
NA in SW	Beryllium	1.56E-05	0.064	0.1	0.18	0.021	No
Detected in SW	Boron	9.81E-02	7.6	776	2,632	1400	No
ND in SW	Cadmium	4.46E-06	0.0021	0.13	0.33	0.013	No
ND in SW	Chromium (III)	1.23E-05	0.44	105	257	318	No
ND in SW	Chromium (VI)	1.23E-05	0.011	0.0054	0.014	0.64	No
NA in SW	Cobalt	3.90E-05	0.019	2	9.9	0.0035	No
ND in SW	Copper	1.47E-04	0.029	155	526	1.3	No
ND in SW	Cyanide	[not modeled]	0.0052	2.3	7.9	13	No
Detected in SW	Fluoride	2.23E-03	9.1	155	526	143	No
Detected in SW	Iron	1.60E-02	1	2,716	9,213	126	No
ND in SW	Lead	2.79E-05	0.051	0.015	0.015	0.015	No
Detected in SW	Manganese	2.97E-03	4	5	13	93	No
Detected in SW	Mercury	3.72E-06	0.0011	0.1	0.28	0.000053	No
ND in SW	Nickel	1.36E-04	0.013	20	53	1.5	No
ND in SW	Selenium (VI)	4.83E-05	1	19	66	0.94	No
ND in SW	Silver	5.57E-06	0.005	1.8	4.4	18	No
NA in SW, ND in GW	Thallium	3.72E-06	0.006	--	--	0.0017	No
ND in SW	Zinc	6.69E-04	0.079	1,633	6581	22	No

Notes:
ND - not detected
NA - not analyzed

Appendix B

2021 Update to 2020 Human Health and Ecological Risk Assessment

Draft

Memorandum

To: Dynegy Midwest Generation, LLC **Date:** October 27, 2021

From: Gradient

Subject: Lithium and Molybdenum Risks at Dynegy Midwest Generation, LLC's Vermilion Power Plant, Oakwood, Illinois

1 Introduction

Gradient (2020) conducted a screening-level Human Health and Ecological Risk Assessment for the Dynegy Midwest Generation LLC (DMG) Vermilion Power Plant (VPP) using a tiered approach consistent with United States Environmental Protection Agency (US EPA) guidance (US EPA, 1989). The groundwater monitoring data indicate that groundwater beneath the former coal combustion residue (CCR) ash ponds may be impacted by Site-related constituents. While no one is exposed to this groundwater,[1] the hydrogeology of the area indicates that the groundwater is flowing into the Middle Fork of the Vermilion River adjacent to the Site, potentially impacting surface water and sediment. Recreators (swimmers and boaters) in the Vermilion River who are exposed to surface water and sediment and anglers who consume locally caught fish could potentially be exposed to these Site-specific constituents of interest (COIs). 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. Gradient (2020) concluded that none of the COIs measured in surface water and modeled in surface water and sediment using Site groundwater data pose an unacceptable risk to the identified human (swimmers, boaters, and anglers) or ecological (aquatic life, benthic invertebrates, and wildlife) receptors.

Risks were not evaluated for lithium and molybdenum in the 2020 Risk Assessment because no data were available for these constituents. Additional groundwater and surface water samples were collected in 2021 and analyzed for lithium and molybdenum, in addition to other constituents already evaluated in the 2020 risk assessment. Therefore, this memorandum focuses on potential risks to human health and the environment associated with lithium and molybdenum using the same approach as the original Risk Assessment (Gradient, 2020).

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[1] Based on the local hydrogeology, residential exposure to groundwater used for drinking water or irrigation is not a complete pathway and was not evaluated.

2 Exposure Data and Estimates

Groundwater samples were collected from 41 wells[2] between March and July 2021. Surface water samples[3] were collected from five locations downstream of VPP in June and July 2021. Table 1 presents a summary of the lithium and molybdenum groundwater and surface water results from the recent sampling events.

Table 1 Summary Statistics of 2021 Lithium and Molybdenum Data

Media	Constituent of Interest	Detected	Sampled	Maximum Detection Limit (mg/L)	Minimum Detected (mg/L)	Average (mg/L)	Maximum Detected (mg/L)
Groundwater	Lithium (total)	176	211	0.0050	0.0031	0.10	1.2
	Molybdenum (total)	165	211	0.0017	0.0011	0.049	0.79
Surface Water	Lithium (total)	5	5	–	0.0047	0.0056	0.0070
	Lithium (dissolved)	3	3	–	0.0055	0.0057	0.0059
	Molybdenum (total)	0	5	0.01	ND	ND	ND
	Molybdenum (dissolved)	0	3	0.01	ND	ND	ND

Notes:
– = Not Applicable; ND = Not Detected.

Similar to the risk assessment, potential risks associated with lithium and molybdenum were evaluated for the identified human (boaters, swimmers, and anglers) and ecological (aquatic life, benthic invertebrates, and wildlife) receptors with complete exposure pathways to surface water and sediment. While none of the receptors are exposed to groundwater, surface water and sediment concentrations were modeled based on the maximum detected concentration in groundwater, which may flow into surface water.

Both the total and dissolved fractions of lithium and molybdenum were analyzed in surface water. While total metal concentrations are typically used to quantify human exposures (US EPA, 1989) and dissolved metals are a better indicator of toxicity for ecological receptors (US EPA, 1993), the maximum total lithium concentration was used to quantify exposures for both types of receptors, because it is higher than the dissolved concentration. Total and dissolved molybdenum were not detected in surface water; therefore, using the approach used in the 2020 Risk Assessment (Gradient, 2020), they would not be carried forward in the risk evaluation. However, to supplement the measured surface water data, we modeled the lithium and molybdenum contributions to surface water based on groundwater flow into the river.

Sediment sampling has not been conducted in the Middle Fork of the Vermilion River. In the absence of sediment data, Gradient modeled molybdenum concentrations in river sediments as a result of groundwater flow into the river. Gradient used the same modeling approach presented in the 2020 Risk Assessment

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[2] Groundwater samples from the following wells were included: 1, 2, 3R, 4, 5, 7R, 8R, 10, 17, 16A, 18, 20-22, 34, 35D, 36-38, 40-44, 70D, 70S, 71D, 71S, 101-105, 101S-105S, ND3, NED1, and OED1.

[3] Surface water samples from locations SW-1 through SW-5 were included. Two field duplicate samples collected in June 2021 were excluded because the locations of the parent samples were unknown. Excluding these field duplicate samples is not expected to change the conclusions of this risk evaluation, because these field duplicate samples do not contain the maximum concentrations used as the exposure estimate.

(Gradient, 2020, Section 3.3). Equilibrium partitioning coefficients (K_d values) for molybdenum were based on values from US EPA (2014a) (Table 2).

Table 2 Equilibrium Partitioning Coefficients for Molybdenum

Parameter	Value (mL/g)
Suspended Sediment-Water (Kd_{sw})	25,119
Sediment-Water (Kd_{bs})	316

Sediment lithium concentrations were not modeled because lithium is highly soluble and does not readily partition into sediment. US EPA (2014a) used a conservative K_d of zero (no partitioning) to estimate lithium fate and transport, citing the insufficient information on adsorption and known low retardation of this constituent. A K_d of zero indicates that the chemical constituent remains in solution and enters the surface water with no partitioning into the sediment. The Agency acknowledges that a lithium K_d of zero will result in an overestimate of downgradient surface water exposures (US EPA, 2014a). Because lithium does not readily sorb to sediments *via* chemical partitioning, we did not model lithium concentrations in sediment and assumed that the lithium sediment concentration is zero.

Total concentrations were used for both the surface water and sediment modeling, because groundwater samples were only analyzed for total concentrations. This may result in an overestimation of exposure, as the dissolved groundwater concentration is generally lower and represents the mobile portion of a constituent that could likely discharge into surface water and sediment. Table 3 presents the exposure estimates used for all receptors in this risk evaluation.

Table 3 Lithium and Molybdenum Exposure Estimates for Surface Water and Sediment

Exposure Medium	Lithium	Molybdenum
Measured Surface Water Concentration (mg/L)^a	0.0070	ND (0.01)
Modeled Surface Water Concentration (mg/L)^a	0.0023^b	0.0015^c
Modeled Sediment Concentration (mg/kg)	0^d	0.40^c

Notes:

ND = Not Detected (detection limit presented).

(a) Measured surface water concentrations may be different from modeled concentrations, because measured data include the effects of background and other industrial sources. Modeled concentrations only represent the potential effect on surface water quality resulting from the measured groundwater concentrations.

(b) Modeled based on the maximum measured groundwater lithium concentration of 1.2 mg/L.

(c) Modeled based on the maximum measured groundwater molybdenum concentration of 0.79 mg/L.

(d) Sediment concentrations were not modeled because lithium does not readily sorb to sediments *via* chemical partitioning.

3 Human Health Risk Evaluation

Risks to recreators (swimmers and boaters) and anglers were evaluated using the exposure estimates presented in Table 3 and screening benchmarks protective of the various receptors. The screening benchmarks were calculated using the same methodology presented in the 2020 Risk Assessment (Gradient, 2020), as summarized below.

Recreators Exposed to Surface Water

Recreators can be exposed to surface water while swimming, boating, and fishing. Recreators could be exposed to surface water *via* incidental ingestion and dermal contact while swimming or boating.[4] Anglers could consume locally caught fish and incidentally ingest water while fishing.

For calculating Human Threshold Criteria (HTC), which are benchmarks protective of fish consumption or fish and water consumption, a BCF of 4 from US EPA (2014a) was used for molybdenum. A BCF was not available for lithium. Therefore, Gradient assumed a BCF of 1, indicating that the fish concentration is equal to the water concentration. This is a conservative assumption, as lithium is not noted to have bioaccumulative properties (US EPA Region IV, 2018) and does not readily bioaccumulate in the aquatic environment (ECHA, 2020a).

The surface water exposure concentrations were compared to conservative benchmarks protective of surface water exposures during swimming, boating, and fishing, *via* (1) fish consumption and water ingestion, and (2) fish consumption only. The maximum detected and modeled lithium and molybdenum concentrations were orders of magnitude lower than their respective conservative benchmarks for all three exposure scenarios (Table 4). Therefore, lithium and molybdenum in surface water do not result in unacceptable risk to recreators swimming, boating, or fishing in the Middle Fork of the Vermilion River adjacent to the Site.

Table 4 Risk Evaluation of Recreators Exposed to Surface Water

Constituent of Interest	Surface Water Exposure Estimate (mg/L)	Swimmer	Boater	Angler	
		Recreator Benchmark for Swimming (mg/L)	Recreator Benchmark for Boating (mg/L)	HTC for Fish and Water (mg/L)	HTC for Fish Only (mg/L)
Lithium (measured)	0.0070	7.8	26	4.7	7.0
Lithium (modeled)[a]	0.0023	7.8	26	4.7	7.0
Molybdenum (modeled)[b]	0.0015	19	63	3.9	4.4

Notes:

HTC = Human Threshold Criteria.

(a) Although lithium was detected in surface water, the modeled concentration was also compared to surface water benchmarks protective of various human receptors to supplement the measured surface water data. The modeled surface water concentration is based on the maximum groundwater concentration and reflects the potential maximum Site-related surface water concentration from groundwater discharge.

(b) Molybdenum was not detected in surface water, thus only the modeled concentration was used. The modeled concentration reflects the potential maximum Site-related surface water concentration from groundwater discharge.

Recreators Exposed to Sediment

Recreational exposure to sediment may occur during boating and swimming activity along the river. The Middle Fork of the Vermilion River is shallow enough to walk in during low-flow periods, and there are sediment deposition areas along the shoreline adjacent to and near the Site that could be accessible by boat.

Conservative benchmarks protective of sediment exposures during swimming and boating were calculated using the same approach and assumptions noted in the risk assessment. The maximum modeled molybdenum concentration (0.40 mg/kg) was orders of magnitude below the benchmark protective of sediment recreational exposures (6,844 mg/kg). As noted above, lithium does not readily sorb to sediments

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[4] Boaters were evaluated separately from swimmers, as boaters are assumed to have a higher exposure frequency, but less skin surface area exposed to water.

via chemical partitioning, eliminating potential sediment exposure and risk (*e.g.*, exposure concentration of 0 mg/kg). Therefore, lithium and molybdenum in sediment do not result in unacceptable risk to recreators swimming or boating in the Middle Fork of the Vermilion River adjacent to the Site.

4 Ecological Risk Evaluation

Ecological receptors could be exposed to surface water, sediment, and dietary items (*i.e.*, prey and plants) potentially impacted by lithium and molybdenum in groundwater. The screening benchmarks were obtained from the same methodology presented in the 2020 Risk Assessment (Gradient, 2020), as summarized below.

Ecological Receptors Exposed to Surface Water

The surface water exposure concentrations were compared to screening benchmarks protective of aquatic life. The maximum detected and modeled lithium and molybdenum concentrations are at least an order of magnitude lower than their respective benchmarks (Table 5). Therefore, lithium and molybdenum in surface water do not result in unacceptable risk to aquatic life in the Middle Fork of the Vermilion River adjacent to the Site.

Table 5 Risk Evaluation of Ecological Receptors Exposed to Surface Water

Constituent of Interest	Surface Water Exposure Estimate (mg/L)	Ecological Freshwater Benchmark[a] (mg/L)
Lithium (measured)	0.0070	0.44
Lithium (modeled)[b]	0.0023	0.44
Molybdenum (modeled)[c]	0.0015	0.80

Notes:

(a) Benchmarks from US EPA Region IV (2018).

(b) Although lithium was detected in surface water, the modeled concentration was also compared to surface water benchmarks protective of various human receptors to supplement the measured surface water data. The modeled surface water concentration is based on the maximum groundwater concentration and reflects the potential maximum Site-related surface water concentration from groundwater discharge.

(c) Because molybdenum was not detected in surface water, the exposure estimate is modeled using the maximum detected groundwater concentration. The modeled concentration reflects the potential maximum Site-related surface water concentration from groundwater discharge.

Ecological Receptors Exposed to Sediment

A hierarchy of sources outlined in the 2020 Risk Assessment (Gradient, 2020) was reviewed for lithium and molybdenum sediment screening benchmarks. US EPA does not have sediment screening benchmarks[5] for lithium or molybdenum (US EPA 2014a,b; US EPA Region IV, 2018). As part of the molybdenum chemical registration under the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) regulation, a predicted no effects level (PNEC) of 22,600 mg/kg for sediment was estimated using the equilibrium partitioning method and the PNEC for water of 12.7 mg/L (ECHA, 2020b). No benchmarks were identified for lithium.

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[5] US EPA (2014a,b) did not evaluate sediment risks for lithium and molybdenum and acknowledged that not characterizing risks for constituents with benchmarks that are not available (*i.e.*, lithium and molybdenum) is not a significant source of uncertainty.

The maximum modeled molybdenum concentration (0.40 mg/kg) was orders of magnitude lower than the REACH benchmark protective of sediment exposures (22,600 mg/kg). As noted above, lithium does not readily sorb to sediments *via* chemical partitioning, resulting in an exposure concentration of 0 mg/kg. Therefore, the modeled sediment concentrations attributed to potential lithium and molybdenum contributions from Site groundwater are not expected to significantly contribute to ecological exposures in the Vermilion River adjacent to the Site.

Ecological Receptors Exposed to Bioaccumulative COIs

Lithium and molybdenum are not identified as analytes with potential bioaccumulative effects (US EPA Region IV, 2018). Therefore, these COIs are not considered to pose an ecological risk *via* bioaccumulation.

5 Conclusions

Similar to the 2020 Risk Assessment (Gradient, 2020), this risk evaluation for lithium and molybdenum incorporates a number of conservative assumptions that tend to overestimate exposure and risk. However, despite the conservative assumptions, this evaluation demonstrates that the lithium and molybdenum surface water and groundwater concentrations are not expected to pose an unacceptable risk to human (swimmers, boater, and anglers) or ecological (aquatic life, benthic invertebrates, and wildlife) receptors exposed to surface water and sediment in the Middle Fork of the Vermilion River adjacent to the Site. These results are consistent with the overall conclusions of the 2020 Risk Assessment that groundwater from the ash ponds at the VPP and potential groundwater contributions to surface water and sediment concentrations in the Middle Fork of the Vermilion River pose no unacceptable risks to human health or the environment.

References

European Chemicals Agency (ECHA). 2020a. "REACH dossier for lithium (CAS No. 7439-93-2)." Accessed on January 1, 2020 at https://echa.europa.eu/registration-dossier/-/registered-dossier/14178.

European Chemicals Agency (ECHA). 2020b. "REACH dossier for molybdenum (CAS No. 7439-98-7)." Accessed on January 1, 2020 at https://echa.europa.eu/registration-dossier/-/registered-dossier/15524.

Gradient. 2020. "Human Health and Ecological Risk Assessment, Vermilion Generating Station, Oakwood, Illinois (Draft)." Report to Schiff Hardin LLP. 77p., February 27.

US EPA Region IV. 2018. "Region 4 Ecological Risk Assessment Supplemental Guidance (March 2018 Update)." Superfund Division, Scientific Support Section. 98p., March. Accessed at https://www.epa.gov/sites/production/files/2018-03/documents/era_regional_supplemental_guidance_report-march-2018_update.pdf.

US EPA. 1989. "Risk Assessment Guidance for Superfund (RAGS). Volume I: Human Health Evaluation Manual (Part A) (Interim final)." Office of Emergency and Remedial Response. NTIS PB90-155581; EPA-540/1-89-002. 287p., December.

US EPA. 1993. Memorandum from M.G. Prothro (US EPA, Office of Water) to US EPA Directors and Regions re: Office of Water policy and technical guidance on interpretation and implementation of aquatic life metals criteria. EPA-822-F93-009. 49p., October 1.

US EPA. 2014a. "Human and Ecological Risk Assessment of Coal Combustion Residuals (Final)." Office of Solid Waste and Emergency Response (OSWER), Office of Resource Conservation and Recovery. 1237p., December. Accessed at http://www.regulations.gov/#!documentDetail;D=EPA-HQ-RCRA-2009-0640-11993.

US EPA. 2014b. "Coal Combustion Residual Beneficial Use Evaluation: Fly Ash Concrete and FGD Gypsum Wallboard (Final)." Office of Solid Waste and Emergency Response (OSWER), Office of Resource Conservation and Recovery (ORCR). 91p., February.

Appendix C

Supporting Information

Geosyntec Consultants Construction Schedule and Labor, Vehicle, and Equipment Demands for Closure of the North Ash Pond/Old East Ash Pond and the New East Ash Pond, Vermilion Power Station, September

Draft

Worksheet 1 - General Questions

	NAP	OEAP	NEAP	Note
Surface area of CCR layer (sq. ft.):	1,742,400	871,200	914,760	Areas provided by Others in the closure plan and associated cost estimates.
Total ash volume (cubic yards):	1,150,000	992,000	343,000	Volume provided by Others in the closure plan and associated cost estimates.
Dry bulk density of CCR (pcf):	70.9	82.5	80.7	2 density tests were available for the NAP. 11 density tests were available for the OEAP. No density tests were available for the NEAP, all tests were averaged for this entry.

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Worksheet 2 -Key Transportation Distances and Questions

Description	Distance (miles)	Notes
Distance between landfill and surface impoundments for closure by removal alternative	15	Republic Services Brickyard Disposal Landfill has been tentatively identified as the landfill.
Distance between soil depot (origin of fill soil) and surface impoundments (to bring in topsoil)	8	A borrow site is assumed to be 8 miles from the project site; however, a borrow site has not been identified.
Distance between origin of raw materials and surface impoundment (bentonite, geomembrance)	1000	Bentonite material may come from ash far away as Wyoming. Geomembrane may come from Huston, Texas.
Distance between origin of raw materials and surface impoundment (for geotextile, etc.)	250	This encompasses Chicago, Indianapolis, Cincinnati, and St. Louis. Most materials would be available within this range. Some specific materials (liner) may come from a much greater distance.
Distance between origin of raw materials and landfill (for geotextile, etc.)	250	This encompasses Chicago, Indianapolis, Cincinnati, and St. Louis. Most materials would be available within this range. Some specific materials (liner) may come from a much greater distance.
Average distance between offsite offices and the site	250	This encompasses Chicago, Indianapolis, Cincinnati, and St. Louis.
Average distance between the workers residence and surface impoundment	15	Assume the workers reside in Danville, IL.
Average distance between the workers residence and landfill	5	Assume the workers reside in Danville, IL.
Average distance for onsite hauling	12	0.75 round trip, assume 16 trips per day.
Average distance of travel for onsite vehicles	5	Daily onsite mileage usage.

Question	Answer (CY)	Notes
Do on-site workers use personal vehicles for daily commute? What are other alternatives and what percentage of workers use each alternative?	Yes. No other alternatives are available.	Public transportation is not present near the site.
Capacity of dump trucks used for CCR transport on-site (within or between SIs)	34	Assume CAT 745
Capacity of dump trucks used for CCR transport off-site (to landfill)	16.5	Tandem dump truck
Capacity of trucks used for transportation of top soil	16.5	Tandem dump truck
Capacity of trucks used for transportation of bulk materials to the site	26	Trailer dump truck

Typical workday	10	Assume 10 hours per day
Bulk material delivery	10	Assume 55 MPH
Bulk material delivery (bentonite, geomembrane)	37	Assume 55 MPH

Worksheet 2 -Key Transportation Distances and Questions

Equipment List	Engine Size (Horsepower)	Notes
support truck (standard pickup truck)	300	standard pickup truck
track hoe excavator (standard)	359	Komatsu PC490LC-11
track hoe excavator (standard with extended boom)	359	Komatsu PC490LC-10SLF
very large track hoe excavator	775	Komatsu PC1250
clamshell excavator	530	Liebherr Clamshell with HS 8100 Duty Cycle Crawler Crane
articulating dump truck	504	CAT 745
tandem dump truck	485	2020 WESTERN STAR 4900SF DUMP TRUCK
dozer	436	CAT D8
front end loader	263	CAT 950M
sheepsfoot roller	405	CAT C15
smooth drum roller	100	CAT CS44B
tractor pulled disc	300	2006 JOHN DEERE 8430 (this is the tractor, not the disc)
skid steer	95	CAT 272D2
4-inch pump	5.5	BE TP-4013HM - 580 GPM (4") Trash Pump w/ Honda GX Engine
6-inch pump	44	Thompson Pump 6HT-DIS-4LE2T
generator	410	Doosan G325 Generator (270kW)
geomembrane welder (wedge welder and extrusion welder)	2.5 5	Pro-Wedge VM20 Pro-X5 Model 600-0105/X5/A
delivery truck (flatbed with 48,000 lbs. capacity or 26 cy load)	475	2020 KENWORTH T880 FLATBED TRUCK, ROLLBACK TOW TRUCK
fuel truck	430	2003 PETERBILT 385 FUEL TRUCK - LUBE TRUCK, WASTE OIL TRUCKS, TANKER TRUCK
water truck	565	2019 INTERNATIONAL HX WATER TRUCK

hydroseeding truck	450	2018 Finn T-170 Hydroseeder and International Truck
drilling rig	115	Diedrich D-50

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Worksheet 3.1 - Work Element Details, Equipment, Hours, Labor and Materials Detail (Closure By Removal, Offsite Landfill).

Closure By Removal Closure Plan																												
Alternative Component	Work Element	Details/Questions for Each Work Element	Project Quantity	Project Unit	Production Rate (Unit/Time)	Equipment Amount	Equipment Units	Equipment/ Material	One way travel per day (miles) for vehicles	hrs	total time	unit	# Drivers	# Additional Workers per day	Equipment and Vehicle Total Hours	Labor Total Hours	Daily Labor Mobilization Miles	Vehicles Miles Onsite	Vehicle Mob/Demob Mileage	Equipment Mobilization Miles - Unloaded	Equipment Mobilization Miles - Loaded	Daily Equipment Miles Onsite	Daily Haul Truck Miles - Unloaded	Daily Haul Truck Miles - Loaded	Material Delivery Miles - Unloaded	Material Delivery Miles - Loaded	Notes	Production Rate / Duration Reference
2.1 NAP Closure	2.1.1 Project Duration Items	Project duration	-	-	-	0	-	-	0	0	5.1	years	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	Schedule not defined, assume 5.1 years total project duration.
		Owner's representative site visits	-	-	-	1	vehicle per day	support truck (daily mob)	250	10	265	day	1	0	2,650	2,650	132,500	1,325	0	0	0	0	0	0	0	0	Weekly site visits.	
		Contractor Construction & Safety Managers	-	-	-	2	vehicle per day	support truck	15	10	1,326	day	2	1	26,520	39,780	119,340	13,260	500	0	0	0	0	0	0	0	Three full time staff.	
		Office facilities	-	-	-	2	equipment per day	work trailer	0	10	1,326	day	0	0	26,520	0	0	0	0	0	0	0	0	0	0	0	Office Trailer.	
		Electric usage (average per day)	1,326,000	KWH	100	0	KWH per day	electricity	0	10	1,326	day	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Assume 50 kWh per trailer.	
		Site specific security	-	-	-	1	vehicle per day	support truck	15	10	1,326	day	1	0	13,260	13,260	39,780	6,630	500	0	0	0	0	0	0	0	One full time staff.	
		CQA Officer / Engineer site visit	-	-	-	1	vehicle per day	support truck (daily mob)	250	10	265	day	1	0	2,650	2,650	132,500	1,325	0	0	0	0	0	0	0	0	Weekly site visits.	
		CQA staff	-	-	-	1	vehicle per day	support truck	15	10	1,326	day	1	0	13,260	13,260	39,780	6,630	500	0	0	0	0	0	0	0	One full time staff.	
		Equipment mobilization	-	-	-	61	equipment mob	heavy equipment mob	250	10	1	mob	61	0	610	610	1,830	0	0	15,250	15,250	0	0	0	0	0	Estimated mobilization for heavy equipment. Includes all non vehicles. Vehicles are assumed to travel to the site daily.	
		Equipment fueling	-	-	-	1	vehicle per day	fuel truck	15	2	1,326	day	1	0	2,652	2,652	39,780	6,630	0	0	0	0	0	0	0	0	Daily refueling.	
		Portable restrooms	-	-	-	1	equipment per day	restroom units	0	10	1,326	day	0	0	13,260	0	0	0	0	0	0	0	0	0	0	0	Full time.	
		Portable restroom service	-	-	-	1	vehicle per day	maintenance vehicle	15	2	265	day	1	0	530	530	7,950	1,325	0	0	0	0	0	0	0	0		
		Dust suppression	-	-	-	1	equipment per day	water truck	12	10	1,326	day	1	0	13,260	13,260	39,780	0	0	0	0	15,912	0	0	0	0		
		Groundwater monitoring	-	-	-	0	-	-	0	0	0	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Monitoring included in Task 2.4.	-
		NPDES monitoring	-	-	-	0	-	-	0	0	0	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	2.1.2 Install EPSC Measures	Silt fence	2,650	LF	1,300	1	vehicle per day	support truck	15	10	3	day	1	1	30	60	180	15	500	0	0	0	0	0	0	0	Assumes silt fence not required along west side.	RSMeans 3125 1416 1000.
		Material deliveries	1	EA	1	1	materials	truck delivery - silt fence	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250	Assume to be delivered in 1 load.	Assume 26 CY truck or 48,000 LB flat bed delivery truck.
	2.1.3 Unwatering NAP and Secondary NAP	Pump NAP to Secondary NAP, pump Secondary NAP to NPDES Outfall 001	14	MG	1	2	equipment per day	6-inch pump	0	10	14	day	1	0	280	140	420	0	0	0	0	0	0	0	0	0	Assume 1 pump from the NAP to the Secondary NAP and 1 pump from the Secondary NAP to Outfall 001. Assume 40 hp pump.	Volumes and pump rates provided in Stantec Unwatering and Dewatering Memo (4/19/19). Assume effort consistent with the closure plan.
			10,360	KWH	74	0	KWH per hour	electricity	0	10	14	day	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
			-	-	-	1	vehicle per day	support truck	15	10	14	day	0	0	140	0	0	70	500	0	0	0	0	0	0	0		
	2.1.4 Dewatering and Stormwater Management	Excavate dewatering ditches and install dewatering sumps	31,700	CY	540	3	equipment per day	track hoe excavator	0	10	20	day	3	0	600	600	1,800	0	0	0	0	0	0	0	0	0	Assume dewatering to a depth of 10 feet with 15-foot ditches and sumps. Assume 2,000 LF of 15-foot, 1:1 slope ditches, 4-foot base. Assume effort consistent with the closure plan.	RSMeans 3123 1613 0130.
			-	-	-	3	equipment per day	articulating dump truck	12	10	20	day	3	0	600	600	1,800	0	0	0	0	720	0	0	0	0		
			-	-	-	1	equipment per day	dozer	0	10	20	day	1	0	200	200	600	0	0	0	0	0	0	0	0	0		
			-	-	-	1	equipment per day	smooth drum roller	0	10	20	day	1	0	200	200	600	0	0	0	0	0	0	0	0	0		
			-	-	-	1	vehicle per day	support truck	0	10	20	day	1	0	200	200	0	100	500	0	0	0	0	0	0	0		
		Dewater for Excavation	83	MG	0	3	equipment per day	sump pump	0	10	730	day	1	0	21,900	7,300	21,900	0	0	0	0	0	0	0	0	0	Assume 3 sump locations, 7 days per week for 6 months dewatering. Assume stormwater management for 5.1 years. Assume 40 hp pump. Assume a 50% increase of the effort for the closure plan split between the NAP (2/3) and OEAP (1/3) for stormwater management.	Volumes provided in Stantec Unwatering and Dewatering Memo (4/19/19). Assume effort consistent with the closure plan.
			810,300	KWH	111	0	KWH per hour	electricity	0	10	730	day	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
		Stormwater Management	381	MG	0	3	equipment per day	sump pump	0	10	1,862	day	1	0	55,860	18,620	55,860	0	0	0	0	0	0	0	0	0		
			2,066,820	KWH	111	0	KWH per hour	electricity	0	10	1,862	day	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
			-	-	-	1	vehicle per day	support truck	15	10	2,592	day	0	0	25,920	0	0	12,960	500	0	0	0	0	0	0	0		
	2.1.5 Soil Stripping and Stockpiling	Excavation and loading soil	65,300	BCY	3,400	1	equipment per day	track hoe excavator	0	10	14	day	1	0	140	140	420	0	0	0	0	0	0	0	0	0	Soil to be stockpiled onsite and used to regraded excavated areas.	A swell of 10% was included. Production rate based on 0.75 mile around trip onsite with a speed of 10 MPH, wait time of 25 minutes and capacity of 34 CYs.
		Hauling and dumping in stockpile	71,830	LCY	544	10	equipment per day	articulating dump truck	12	10	14	day	10	1	1,400	1,540	4,620	0	0	0	0	1,680	0	0	0	0		
		Place and spread in stockpile	71,830	LCY	3,500	1	equipment per day	dozer	0	10	14	day	1	1	140	280	840	0	0	0	0	0	0	0	0	0		
		Laborer Support	-	-	-	1	vehicle per day	support truck	15	10	14	day	1	0	140	140	420	70	500	0	0	0	0	0	0	0		
	2.1.6 Excavate CCR Material and Haul to Landfill	Excavate and load CCR	1,171,000	BCY	3,400	1	equipment per day	track hoe excavator	0	10	654	day	1	0	6,540	6,540	19,620	0	0	0	0	0	0	0	0	0	Excavation of CCR from the NAP and haul to offsite landfill. Includes 1-ft overexcavation.	A swell of 10% was included. Production rate based on 30 mile around trip with a speed of 35 MPH, wait time of 15 minutes and capacity of 16.5 CYs. Roughly 2,000 CY/DAY.
		Hauling and dumping	1,288,100	LCY	116	17	haul trucks per day	tandem dump truck	15	10	654	day	17	1	111,180	117,720	353,160	0	0	0	0	0	1,171,000	1,171,000	0	0		
		Laborer Support	-	-	-	1	vehicle per day	support truck	15	10	654	day	1	1	6,540	13,080	39,240	3,270	500	0	0	0	0	0	0	0		
		Moisture conditioning	1,288,100	LCY	10,000	1	equipment per day	tractor pulled disc	0	10	129	day	1	0	1,290	1,290	3,870	0	0	0	0	0	0	0	0	0	In place MC is ~35% and assume a target of ~30%. The majority of samples were above 30%, assume conditioning of total quantity. 10% of the samples had a MC over 45%.	Assume addition effort from track hoe for above MC 45%.
			128,810	LCY	3,400	1	equipment per day	excavator	0	10	38	day	1	0	380	380	1,140	0	0	0	0	0	0	0	0	0		
	2.1.7 Excavate Coal Yard Material and Haul to Landfill	Excavate and load CCR	50,000	BCY	3,400	1	equipment per day	track hoe excavator	0	10	28	day	1	0	280	280	840	0	0	0	0	0	0	0	0	0	Excavation of coal from the Coal Yard and haul to offsite landfill. Includes 1-ft overexcavation.	Volume provided by the Owner. A swell of 10% was included. Production rate based on 30 mile around trip onsite with a speed of 35 MPH, wait time of 15 minutes and capacity of 16.5 CYs. Roughly 2,000 CY/DAY.
		Hauling and dumping	55,000	LCY	116	17	haul trucks per day	tandem dump truck	15	10	28	day	17	0	4,760	4,760	14,280	0	0	0	0	0	50,000	50,000	0	0		
		Laborer Support	-	-	-	1	vehicle per day	support truck	15	10	28	day	1	0	280	280	840	140	500	0	0	0	0	0	0	0		
	2.1.8 Seed and Mulch	Hydroseed and mulch	40	AC	2	1	equipment per day	hydroseeder truck	250	10	20	day	1	1	200	400	1,200	0	0	0	0	5,000	0	0	0	0	Hydromulch assumed.	RSMeans 3292 1913 1100.
			-	-	-	1	vehicle per day	support truck	250	10	20	day	1	0	200	200	10,000	100	500	0	0	0	0	0	0	0		
		Material deliveries	30	TON	24	1	materials	truck delivery - hydroseed/mulch	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250	-	Assume 26 CY truck or 48,000 LB flat bed delivery truck.

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Worksheet 3.1 - Work Element Details, Equipment, Hours, Labor and Materials Detail (Closure By Removal, Offsite Landfill).

Closure By Removal Closure Plan

Alternative Component	Work Element	Details/Questions for Each Work Element	Project Quantity	Project Unit	Production Rate (Unit/Time)	Equipment Amount	Equipment Units	Equipment/ Material	One way travel per day (miles) for vehicles	hrs	total time	unit	# Drivers	# Additional Workers per day	Equipment and Vehicle Total Hours	Labor Total Hours	Daily Labor Mobilization Miles	Vehicles Miles Onsite	Vehicle Mob/Demob Mileage	Equipment Mobilization Miles - Unloaded	Equipment Mobilization Miles - Loaded	Daily Equipment Miles Onsite	Daily Haul Truck Miles - Unloaded	Daily Haul Truck Miles - Loaded	Material Delivery Miles - Unloaded	Material Delivery Miles - Loaded	Notes	Production Rate / Duration Reference
2.1 NAP Closure	2.1.9 Install monitoring / observation wells	Drilling for monitoring well and observation well installations, drilling for abandonment of monitoring wells	4	EA	1	1	equipment per day	drilling rig	0	10	6	day	1	0	60	60	180	0	0	0	0	0	0	0	0	0	Assumes wells will be powered with onsite power. Includes 2 days for mobilization/demobilization.	Install 4 new monitoring wells.
			-	-	-	1	vehicle per day	support truck (daily mob)	250	10	6	day	1	0	60	60	3,000	30	0	0	0	0	0	0	0	0		
			-	-	-	1	equipment per day	skid steer	0	10	6	day	1	0	60	60	180	0	0	0	0	0	0	0	0	0		
		Clearing for monitoring wells	-	-	-	1	equipment per day	track hoe excavator	0	10	5	day	1	0	50	50	150	0	0	0	0	0	0	0	0	0	8 locations are currently vegetated.	
		Material deliveries	1	EA	1	1	materials	truck delivery - flush mount	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250	Assume to be delivered in 1 load.	Assume 26 CY truck or 48,000 LB flat bed delivery truck.
			1	EA	1	1	materials	truck delivery - well steel	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250		
			1	EA	1	1	materials	truck delivery - PVC	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250		
			1	EA	1	1	materials	truck delivery - sand	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250		
			1	EA	1	1	materials	truck delivery - bentonite	250	37	1	load	1	0	37	37	0	0	0	0	0	0	0	0	250	250		
			1	EA	1	1	materials	truck delivery - cement	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250		
	2.1.10 General Grading	Excavate and load from stockpile	253,000	BCY	3,400	2	equipment per day	track hoe excavator	0	10	56	day	2	0	1,120	1,120	3,360	0	0	0	0	0	0	0	0	0	To promote positive drainage once the ash is removed. Assumes onsite material from soil stripping and other sources.	A swell of 20% was included. Production rate based on 0.75 mile around trip onsite with a speed of 10 MPH, wait time of 25 minutes and capacity of 34 CYs.
		Hauling and dumping general fill	303,600	LCY	544	10	equipment per day	articulating dump truck	12	10	56	day	10	0	5,600	5,600	16,800	0	0	0	0	6,720	0	0	0	0		
		Place and spread general fill	303,600	LCY	3,500	2	equipment per day	dozer	0	10	56	day	2	0	1,120	1,120	3,360	0	0	0	0	0	0	0	0	0		
		Compact general fill	303,600	LCY	2,400	3	equipment per day	sheepsfoot roller	0	10	56	day	3	0	1,680	1,680	5,040	0	0	0	0	0	0	0	0	0		
		Laborer Support	-	-	-	1	vehicle per day	support truck	15	10	1	day	1	0	10	10	30	5	500	0	0	0	0	0	0	0		
		Riprap Protection for Stormwater Inflow Into the NAP	-	-	-	2	equipment per day	track hoe excavator	0	10	15	day	2	0	300	300	900	0	0	0	0	0	0	0	0	0	Riprap at geotextile fabric to reduce velocity in the NAP.	
			-	-	-	1	equipment per day	articulating dump truck	12	10	15	day	1	0	150	150	450	0	0	0	0	180	0	0	0	0		
			-	-	-	1	equipment per day	dozer	0	10	15	day	1	0	150	150	450	0	0	0	0	0	0	0	0	0		
			-	-	-	1	vehicle per day	support truck	15	10	15	day	1	0	150	150	450	75	500	0	0	0	0	0	0	0		
			-	-	-	2	vehicle per day	support truck	15	10	15	day	2	1	300	450	1,350	150	500	0	0	0	0	0	0	0		
			11,111	CY	26	1	materials	truck delivery - riprap	250	10	427	load	1	0	4,270	4,270	0	0	0	0	0	0	0	0	106,750	106,750	Assume 100,000 SF of riprap at 18-inches thick.	
			1	EA	1	1	materials	truck delivery - geotextile	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250		
2.2 OEAP Closure	2.2.1 Preconstruction Tasks	Groundwater Collection Trench	-	-	-	1	equipment per day	one pass trencher	0	10	40	day	1	0	400	400	1,200	0	0	0	0	0	0	0	0	0	Scope not defined. Improvements may not be necessary dependent on results of stability analyses. Work depicted assumed based on current understanding of the project. Includes Construction Manager, laborers, and CQA staff.	2 months, to be refined during design phase.
			-	-	-	2	equipment per day	front end loader	0	10	40	day	2	0	800	800	2,400	0	0	0	0	0	0	0	0	0		
			-	-	-	1	equipment per day	dozer	0	10	40	day	1	0	400	400	1,200	0	0	0	0	0	0	0	0	0		
						1	equipment per day	articulating dump truck	12	10	40		1	0	400	400	1,200	0	0	0	0	480	0	0	0	0		
						1	equipment per day	6-inch pump	0	10	40		1	0	400	400	1,200	0	0	0	0	0	0	0	0	0		
			-	-	-	1	vehicle per day	support truck	15	10	40	day	1	0	400	400	1,200	200	500	0	0	0	0	0	0	0		
			-	-	-	2	vehicle per day	support truck	15	10	40	day	2	0	800	800	2,400	400	500	0	0	0	0	0	0	0		
			1,500	LF	1,500	1	materials	truck delivery - 6-inch piping	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250	Piping to dewater trench excavation and take to the NEAP.	
			3,000	LF	1,500	1	materials	truck delivery - 4-inch piping	250	10	2	load	1	0	20	20	0	0	0	0	0	0	0	0	500	500		
			1,222	CY	26	1	materials	truck delivery - coarse aggregate	250	10	47	load	1	0	470	470	0	0	0	0	0	0	0	0	11,750	11,750	Assume emergency buttress of 1,100 ft x 30 ft x 2 ft .	
			1	EA	1	1	materials	truck delivery - geotextile	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250		
		OEAP Riverslope Stabilization Installation	-	-	-	2	equipment per day	track hoe excavator	0	10	30	day	2	0	600	600	1,800	0	0	0	0	0	0	0	0	0	Scope not defined. Improvements may not be necessary dependent on results of stability analyses. Work depicted assumed based on current understanding of the project. Includes Construction Manager, laborers, and CQA staff.	6 weeks, to be refined during design phase.
			-	-	-	1	equipment per day	articulating dump truck	12	10	30	day	1	0	300	300	900	0	0	0	0	360	0	0	0	0		
			-	-	-	1	equipment per day	dozer	0	10	30	day	1	0	300	300	900	0	0	0	0	0	0	0	0	0		
			-	-	-	1	vehicle per day	support truck	15	10	30	day	1	0	300	300	900	150	500	0	0	0	0	0	0	0		
			-	-	-	2	vehicle per day	support truck	15	10	30	day	2	1	600	900	2,700	300	500	0	0	0	0	0	0	0		
			1,852	CY	26	1	materials	truck delivery - riprap	250	10	71	load	1	0	710	710	0	0	0	0	0	0	0	0	17,750	17,750	Assume emergency buttress of 1,000 ft x 10 ft x 10 ft .	
			1	EA	1	1	materials	truck delivery - geotextile	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250		
		OEAP Riverslope Stabilization Removal	-	-	-	1	equipment per day	track hoe excavator	0	10	10	day	1	0	100	100	300	0	0	0	0	0	0	0	0	0	Temporary improvement that will be removed in the future.	2 weeks.
			-	-	-	1	equipment per day	articulating dump truck	12	10	10	day	1	0	100	100	300	0	0	0	0	120	0	0	0	0		
			-	-	-	1	equipment per day	dozer	0	10	10	day	1	0	100	100	300	0	0	0	0	0	0	0	0	0		
			-	-	-	1	vehicle per day	support truck	15	10	10	day	1	0	100	100	300	50	500	0	0	0	0	0	0	0		

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Worksheet 3.1 - Work Element Details, Equipment, Hours, Labor and Materials Detail (Closure By Removal, Offsite Landfill).

Closure By Removal Closure Plan

Alternative Component	Work Element	Details/Questions for Each Work Element	Project Quantity	Project Unit	Production Rate (Unit/Time)	Equipment Amount	Equipment Units	Equipment/ Material	One way travel per day (miles) for vehicles	hrs	total time	unit	# Drivers	# Additional Workers per day	Equipment and Vehicle Total Hours	Labor Total Hours	Daily Labor Mobilization Miles	Vehicles Miles Onsite	Vehicle Mob/Demob Mileage	Equipment Mobilization Miles - Unloaded	Equipment Mobilization Miles - Loaded	Daily Equipment Miles Onsite	Daily Haul Truck Miles - Unloaded	Daily Haul Truck Miles - Loaded	Material Delivery Miles - Unloaded	Material Delivery Miles - Loaded	Notes	Production Rate / Duration Reference
2.2 OEAP Closure	2.2.2 Project Duration Items	Project duration	-	-	-	0	-	-	0	0	2.5	years	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	Schedule not defined, assume 2.5 years total project duration.
		Owner's representative site visits	-	-	-	1	vehicle per day	support truck (daily mob)	250	10	130	day	1	0	1,300	1,300	65,000	650	0	0	0	0	0	0	0	0	Weekly site visits.	
		Contractor Construction & Safety Managers	-	-	-	2	vehicle per day	support truck	15	10	650	day	2	1	13,000	19,500	58,500	6,500	500	0	0	0	0	0	0	0	Three full time staff.	
		Office facilities	-	-	-	2	equipment per day	work trailer	0	10	650	day	0	0	13,000	0	0	0	0	0	0	0	0	0	0	0	Office Trailer.	
		Electric usage (average per day)	650,000	KWH	100	0	KWH per day	electricity	0	10	650	day	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Assume 50 kWh per trailer.	
		Site specific security	-	-	-	1	vehicle per day	support truck	15	10	650	day	1	0	6,500	6,500	19,500	3,250	500	0	0	0	0	0	0	0	One full time staff.	
		CQA Officer / Engineer site visit	-	-	-	1	vehicle per day	support truck (daily mob)	250	10	130	day	1	0	1,300	1,300	65,000	650	0	0	0	0	0	0	0	0	Weekly site visits.	
		CQA staff	-	-	-	1	vehicle per day	support truck	15	10	650	day	1	0	6,500	6,500	19,500	3,250	500	0	0	0	0	0	0	0	One full time staff.	
		Equipment mobilization	-	-	-	63	equipment mob	heavy equipment mob	250	10	1	mob	63	0	630	630	1,890	0	0	15,750	15,750	0	0	0	0	0	Estimated mobilization for heavy equipment. Includes all non vehicles. Vehicles are assumed to travel to the site daily.	
		Equipment fueling	-	-	-	1	vehicle per day	fuel truck	15	2	650	day	1	0	1,300	1,300	19,500	3,250	0	0	0	0	0	0	0	0	Daily refueling.	
		Portable restrooms	-	-	-	1	equipment per day	restroom units	0	10	650	day	0	0	6,500	0	0	0	0	0	0	0	0	0	0	0	Full time.	
		Portable restroom service	-	-	-	1	vehicle per day	maintenance vehicle	15	2	130	day	1	0	260	260	3,900	650	0	0	0	0	0	0	0	0		
		Dust suppression	-	-	-	1	equipment per day	water truck	0	10	650	day	1	0	6,500	6,500	19,500	0	0	0	0	0	0	0	0	0		
		Groundwater monitoring	-	-	-	0	-	-	0	0	0	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Monitoring included in Task 2.4.	-
		NPDES monitoring	-	-	-	0	-	-	0	0	0	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	2.2.3 Install EPSC Measures	Silt fence	2,350	LF	1,300	1	vehicle per day	support truck	15	10	2	day	1	1	20	40	120	10	500	0	0	0	0	0	0	0	Assumes silt fence not required along south side.	RSMeans 3125 1416 1000.
		Material deliveries	1	EA	1	1	materials	truck delivery - silt fence	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250	Assume to be delivered in 1 load.	Assume 26 CY truck or 48,000 LB flat bed delivery truck.
	2.2.4 Dewatering and Stormwater Management	Excavate dewatering ditches and install dewatering sumps	15,900	CY	540	3	equipment per day	track hoe excavator	0	10	10	day	3	0	300	300	900	0	0	0	0	0	0	0	0	0	Assume dewatering to a depth of 10 feet with 15-foot ditches and sumps. Assume 1,000 LF of 15-foot, 1:1 slope ditches, 4-foot base. Assume effort consistent with the closure plan.	RSMeans 3123 1613 0130.
			-	-	-	3	equipment per day	articulating dump truck	12	10	10	day	3	0	300	300	900	0	0	0	0	360	0	0	0	0		
			-	-	-	1	equipment per day	dozer	0	10	10	day	1	0	100	100	300	0	0	0	0	0	0	0	0	0		
			-	-	-	1	equipment per day	smooth drum roller	0	10	10	day	1	0	100	100	300	0	0	0	0	0	0	0	0	0		
			-	-	-	1	vehicle per day	support truck	0	10	10	day	1	0	100	100	0	50	500	0	0	0	0	0	0	0		
		Dewater for Excavation	0	MG	-	3	equipment per day	sump pump	0	10	0	day	1	0	0	0	0	0	0	0	0	0	0	0	0	0	Assume 3 sump locations, 7 days per week for 6 months dewatering. Assume stormwater management for 2.5 years. Assume 40 hp pump. Assume a 50% increase of the effort for the closure plan split between the NAP (2/3) and OEAP (1/3).	Volumes provided in Stantec Unwatering and Dewatering Memo (4/19/19). Assume effort consistent with the closure plan.
			0	KWH	111	0	KWH per hour	electricity	0	10	0	day	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
		Stormwater Management	93	MG	0	3	equipment per day	sump pump	0	10	913	day	1	0	27,390	9,130	27,390	0	0	0	0	0	0	0	0	0		
			1,013,430	KWH	111	0	KWH per hour	electricity	0	10	913	day	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
			-	-	-	1	vehicle per day	support truck	15	10	913	day	0	0	9,130	0	0	4,565	500	0	0	0	0	0	0	0		
	2.2.5 Soil Stripping and Stockpiling	Excavation and loading soil	283,000	BCY	3,400	1	equipment per day	track hoe excavator	0	10	58	day	1	0	580	580	1,740	0	0	0	0	0	0	0	0	0	Soil to be stockpiled onsite and used to regraded excavated areas.	A swell of 20% was included. Production rate based on 0.75 mile around trip onsite with a speed of 10 MPH, wait time of 25 minutes and capacity of 34 CYs.
		Hauling and dumping in stockpile	311,300	LCY	544	10	equipment per day	articulating dump truck	12	10	58	day	10	1	5,800	6,380	19,140	0	0	0	0	6,960	0	0	0	0		
		Place and spread in stockpile	311,300	LCY	3,500	1	equipment per day	dozer	0	10	58	day	1	1	580	1,160	3,480	0	0	0	0	0	0	0	0	0		
		Laborer Support	-	-	-	1	vehicle per day	support truck	15	10	58	day	1	0	580	580	1,740	290	500	0	0	0	0	0	0	0		
	2.2.6 Excavate CCR Material and Haul to Landfill	Excavate and load CCR	992,000	BCY	3,400	1	equipment per day	track hoe excavator	0	10	554	day	1	0	5,540	5,540	16,620	0	0	0	0	0	0	0	0	0	Excavation of CCR from the OEAP and haul to offsite landfill. Includes 1-ft overexcavation.	A swell of 10% was included. Production rate based on 30 mile around trip with a speed of 35 MPH, wait time of 15 minutes and capacity of 16.5 CYs. Roughly 2,000 CY/DAY.
		Hauling and dumping	1,091,200	LCY	116	17	haul trucks per day	tandem dump truck	15	10	554	day	17	1	94,180	99,720	299,160	0	0	0	0	0	992,000	992,000	0	0		
		Laborer Support	-	-	-	1	vehicle per day	support truck	15	10	554	day	1	1	5,540	11,080	33,240	2,770	500	0	0	0	0	0	0	0		
		Moisture conditioning	1,091,200	LCY	10,000	1	equipment per day	tractor pulled disc	0	10	110	day	1	0	1,100	1,100	3,300	0	0	0	0	0	0	0	0	0	In place MC is ~39% and assume a target of ~30%. The majority of samples were above 30%, assume conditioning of total quantity. 10% of the samples had a MC over 45%.	Assume addition effort from track hoe for above MC 45%.
			109,120	LCY	3,400	1	equipment per day	excavator	0	10	33	day	1	0	330	330	990	0	0	0	0	0	0	0	0	0		
	2.2.7 Abandon or Removal of OEAP Drainage Pipes	Excavation and backfill	-	-	-	1	equipment per day	track hoe excavator	0	10	1	day	1	0	10	10	30	0	0	0	0	0	0	0	0	0	Two pipes have been located that require removal from the ash ponds.	Assume 1 day to excavated and haul off.
		Compact	-	-	-	1	equipment per day	sheepsfoot roller	0	10	1	day	1	0	10	10	30	0	0	0	0	0	0	0	0	0		
		Haul Off	-	-	-	1	haul trucks per day	tandem dump truck	15	10	1	day	1	0	10	10	30	0	0	0	0	0	15	15	0	0		
		Laborer Support	-	-	-	1	vehicle per day	support truck	15	10	1	day	1	1	10	20	60	5	500	0	0	0	0	0	0	0		
	2.2.8 Seed and Mulch	Hydroseed and mulch	20	AC	2	1	equipment per day	hydroseeder truck	250	10	10	day	1	1	100	200	600	0	0	0	0	2,500	0	0	0	0	Hydromulch assumed.	RSMeans 3292 1913 1100.
			-	-	-	1	vehicle per day	support truck	250	10	10	day	1	0	100	100	5,000	50	500	0	0	0	0	0	0	0		
		Material deliveries	15	TON	24	1	materials	truck delivery - hydroseed/mulch	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250	-	Assume 26 CY truck or 48,000 LB flat bed delivery truck.

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Worksheet 3.1 - Work Element Details, Equipment, Hours, Labor and Materials Detail (Closure By Removal, Offsite Landfill).

Closure By Removal Closure Plan																												
Alternative Component	Work Element	Details/Questions for Each Work Element	Project Quantity	Project Unit	Production Rate (Unit/Time)	Equipment Amount	Equipment Units	Equipment/ Material	One way travel per day (miles) for vehicles	hrs	total time	unit	# Drivers	# Additional Workers per day	Equipment and Vehicle Total Hours	Labor Total Hours	Daily Labor Mobilization Miles	Vehicles Miles Onsite	Vehicle Mob/Demob Mileage	Equipment Mobilization Miles - Unloaded	Equipment Mobilization Miles - Loaded	Daily Equipment Miles Onsite	Daily Haul Truck Miles - Unloaded	Daily Haul Truck Miles - Loaded	Material Delivery Miles - Unloaded	Material Delivery Miles - Loaded	Notes	Production Rate / Duration Reference
2.2 OEAP Closure	2.2.9 Install monitoring / observation wells	Drilling monitoring well and observation well installations, drilling for abandonment monitoring wells	4	EA	1	1	equipment per day	drilling rig	0	10	6	day	1	0	60	60	180	0	0	0	0	0	0	0	0	0	Includes 2 days for mobilization/demobilization.	Install 4 new monitoring wells.
			-	-	-	1	vehicle per day	support truck (daily mob)	250	10	6	day	1	0	60	60	3,000	30	0	0	0	0	0	0	0	0		
			-	-	-	1	equipment per day	skid steer	0	10	6	day	1	0	60	60	180	0	0	0	0	0	0	0	0	0		
		Clearing for monitoring wells	-	-	-	1	equipment per day	track hoe excavator	0	10	5	day	1	0	50	50	150	0	0	0	0	0	0	0	0	0	2 locations are currently vegetated.	
		Material deliveries	1	EA	1	1	materials	truck delivery - flush mount	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250	Assume to be delivered in 1 load.	Assume 26 CY truck or 48,000 LB flat bed delivery truck.
			1	EA	1	1	materials	truck delivery - well steel	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250		
			1	EA	1	1	materials	truck delivery - PVC	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250		
			1	EA	1	1	materials	truck delivery - sand	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250		
			1	EA	1	1	materials	truck delivery - bentonite	0	37	1	load	1	0	37	37	0	0	0	0	0	0	0	0	0	0		
			1	EA	1	1	materials	truck delivery - cement	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250		
	2.2.10 General Grading	Excavate and load from stockpile	84,000	BCY	3,400	2	equipment per day	track hoe excavator	0	10	19	day	2	0	380	380	1,140	0	0	0	0	0	0	0	0	0	To promote positive drainage once the ash is removed. Assumes onsite material from soil stripping and other sources. OEAP is not assumed to be usable.	A swell of 20% was included. Production rate based on 0.75 mile around trip onsite with a speed of 10 MPH, wait time of 25 minutes and capacity of 34 CYs.
		Hauling and dumping general fill	100,800	LCY	544	10	equipment per day	articulating dump truck	12	10	19	day	10	0	1,900	1,900	5,700	0	0	0	0	2,280	0	0	0	0		
		Place and spread general fill	100,800	LCY	3,500	2	equipment per day	dozer	0	10	19	day	2	0	380	380	1,140	0	0	0	0	0	0	0	0	0		
		Compact general fill	100,800	LCY	2,400	3	equipment per day	sheepsfoot roller	0	10	19	day	3	0	570	570	1,710	0	0	0	0	0	0	0	0	0		
		Laborer Support	-	-	-	1	vehicle per day	support truck	15	10	19	day	1	0	190	190	570	95	500	0	0	0	0	0	0	0		
2.3 NEAP Closure	2.3.1 Project Duration Items	Project Duration	-	-	-	0	-	-	0	0	3.1	years	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	Schedule not defined, assume 3.1 years total project duration.
		Owner's representative site visits	-	-	-	1	vehicle per day	support truck (daily mob)	250	10	161	day	1	0	1,612	1,612	80,600	806	0	0	0	0	0	0	0	0	Weekly site visits.	
		Contractor Construction & Safety Managers	-	-	-	2	vehicle per day	support truck	15	10	806	day	2	1	16,120	24,180	72,540	8,060	500	0	0	0	0	0	0	0	Three full time staff.	
		Office facilities	-	-	-	2	unit per day	work trailer	0	10	806	day	0	0	16,120	0	0	0	0	0	0	0	0	0	0	0	Office Trailer.	
		Electric usage (average per day)	806,000	KWH	100	0	KWH per day	electricity	0	10	806	day	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Assume 50 kWh per trailer.	
		Site specific security	-	-	-	1	vehicle per day	support truck	15	10	806	day	1	0	8,060	8,060	24,180	4,030	500	0	0	0	0	0	0	0	One full time staff.	
		CQA Officer / Engineer site visit	-	-	-	1	vehicle per day	support truck (daily mob)	250	10	38	day	1	0	380	380	19,000	190	0	0	0	0	0	0	0	0	Monthly site visits.	
		CQA staff	-	-	-	1	vehicle per day	support truck	15	10	806	day	1	0	8,060	8,060	24,180	4,030	500	0	0	0	0	0	0	0	One full time staff.	
		Equipment mobilization	-	-	-	53	equipment mob	heavy equipment mob	250	10	1	mob	53	0	530	530	1,590	0	0	13,250	13,250	0	0	0	0	0	Estimated mobilization for heavy equipment. Includes all non vehicles. Vehicles are assumed to travel to the site daily.	
		Equipment fueling	-	-	-	1	vehicle per day	fuel truck	15	1	806	day	1	0	806	806	24,180	4,030	0	0	0	0	0	0	0	0	Daily refueling.	
		Portable restrooms	-	-	-	1	equipment per day	restroom units	0	10	806	day	0	0	8,060	0	0	0	0	0	0	0	0	0	0	0	Full time.	
		Portable restroom service	-	-	-	1	vehicle per day	maintenance truck	15	2	162	day	1	0	324	324	4,860	810	0	0	0	0	0	0	0	0		
		Dust suppression	-	-	-	1	equipment per day	water truck	0	10	806	day	1	0	8,060	8,060	24,180	0	0	0	0	0	0	0	0	0		
		Groundwater monitoring	-	-	-	0	-	-	0	0	0	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Monitoring included in Task 2.4.	-
		NPDES monitoring	-	-	-	0	-	-	0	0	0	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	2.3.2 Install EPSC Measures	Silt fence	5,000	LF	1,300	1	vehicle per day	support truck	15	10	4	day	1	1	40	80	240	20	500	0	0	0	0	0	0	0	Assumes silt fence not required along west side.	RSMeans 3125 1416 1000.
		Material deliveries	1	EA	1	1	materials	truck delivery - silt fence	0	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	0	0	Assume to be delivered in 1 load.	Assume 26 CY truck or 48,000 LB flat bed delivery truck.
	2.3.3 Unwatering NEAP and Secondary NEAP	Pump NEAP to Secondary NEAP, pump Secondary NEAP to NPDES Outfall 003	3	MG	0	2	equipment per day	6-inch pump	0	10	15	day	2	0	300	300	900	0	0	0	0	0	0	0	0	0	Assume 1 pump from the NEAP to the Sec. NEAP and 1 pump from the Secondary NEAP to Outfall 003. Assume 40 hp pump.	Volumes and pump rates provided in Stantec Unwatering and Dewatering Memo (4/19/19). Assume effort consistent with the closure plan.
			11,100	KWH	74	0	KWH per hour	electricity	0	10	15	day	2	0	0	0	0	0	0	0	0	0	0	0	0	0		
			-	-	-	1	vehicle per day	support truck	15	10	15	day	2	0	150	300	900	75	500	0	0	0	0	0	0	0		
	2.3.4 Dewatering and Stormwater Management	Excavate dewatering ditches and install dewatering sumps	10,600	CY	540	1	equipment per day	track hoe excavator	0	10	20	day	1	0	200	200	600	0	0	0	0	0	0	0	0	0	Assume dewatering to a depth of 10 feet with 15-foot ditches and sumps. Assume 1,000 LF of 15-foot, 1:1 slope ditches, 4-foot base. Assume effort consistent with the closure plan.	RSMeans 3123 1613 0130.
			-	-	-	1	equipment per day	articulating dump truck	12	10	20	day	1	0	200	200	600	0	0	0	0	240	0	0	0	0		
			-	-	-	1	equipment per day	dozer	0	10	20	day	1	0	200	200	600	0	0	0	0	0	0	0	0	0		
			-	-	-	1	equipment per day	smooth drum roller	0	10	20	day	1	0	200	200	600	0	0	0	0	0	0	0	0	0		
			-	-	-	1	vehicle per day	support truck	0	10	20	day	1	0	200	200	0	100	500	0	0	0	0	0	0	0		
		Dewater for Excavation	17	MG	0	3	equipment per day	sump pump	0	10	730	day	1	0	21,900	7,300	21,900	0	0	0	0	0	0	0	0	0	Assume 3 sump locations, 7 days per week for 6 months dewatering. Assume stormwater management for 3.1 years. Assume 40 hp pump. Assume effort consistent with the closure plan.	Volumes provided in Stantec Unwatering and Dewatering Memo (4/19/19). Assume effort consistent with the closure plan.
			810,300	KWH	111	0	KWH per hour	electricity	0	10	730	day	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
		Stormwater Management	103	MG	0	3	equipment per day	sump pump	0	10	1,132	day	1	0	33,960	11,320	33,960	0	0	0	0	0	0	0	0	0		
			1,256,520	KWH	111	0	KWH per hour	electricity	0	10	1,132	day	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
			-	-	-	1	vehicle per day	support truck	15	10	1,862	day	0	0	18,620	0	0	9,310	500	0	0	0	0	0	0	0		
	2.3.5 Soil Stripping and Stockpiling	Excavation and loading soil	119,500	BCY	3,400	1	equipment per day	track hoe excavator	0	10	25	day	1	0	250	250	750	0	0	0	0	0	0	0	0	0	Soil to be stockpiled onsite and used to regraded excavated areas.	A swell of 20% was included. Production rate based on 0.75 mile around trip onsite with a speed of 10 MPH, wait time of 25 minutes and capacity of 34 CYs.
		Hauling and dumping in stockpile	131,450	LCY	544	10	equipment per day	articulating dump truck	12	10	25	day	10	1	2,500	2,750	8,250	0	0	0	0	3,000	0	0	0	0		
		Place and spread in stockpile	131,450	LCY	3,500	1	equipment per day	dozer	0	10	25	day	1	1	250	500	1,500	0	0	0	0	0	0	0	0	0		
		Laborer Support	-	-	-	1	vehicle per day	support truck	15	10	25	day	1	0	250	250	750	125	500	0	0	0	0	0	0	0		

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Worksheet 3.1 - Work Element Details, Equipment, Hours, Labor and Materials Detail (Closure By Removal, Offsite Landfill).

Closure By Removal Closure Plan

Alternative Component	Work Element	Details/Questions for Each Work Element	Project Quantity	Project Unit	Production Rate (Unit/Time)	Equipment Amount	Equipment Units	Equipment/ Material	One way travel per day (miles) for vehicles	hrs	total time	unit	# Drivers	# Additional Workers per day	Equipment and Vehicle Total Hours	Labor Total Hours	Daily Labor Mobilization Miles	Vehicles Miles Onsite	Vehicle Mob/Demob Mileage	Equipment Mobilization Miles - Unloaded	Equipment Mobilization Miles - Loaded	Daily Equipment Miles Onsite	Daily Haul Truck Miles - Unloaded	Daily Haul Truck Miles - Loaded	Material Delivery Miles - Unloaded	Material Delivery Miles - Loaded	Notes	Production Rate / Duration Reference
2.3 NEAP Closure	2.3.6 Excavate CCR Material and Haul to Landfill	Excavate and load CCR	376,000	BCY	3,400	2	equipment per day	track hoe excavator	0	10	210	day	2	0	4,200	4,200	12,600	0	0	0	0	0	0	0	0	0	Excavation of CCR from the NEAP and hauling to onsite landfill. Includes 1-ft overexcavation.	A swell of 10% was included. Production rate based on 1.5 mile around trip onsite with a speed of 10 MPH, wait time of 15 minutes and capacity of 34 CYs. Roughly 1,900 CY/DAY.
		Hauling and dumping	413,600	LCY	116	17	haul trucks per day	tandem dump truck	15	10	210	day	17	1	35,700	37,800	113,400	0	0	0	0	0	376,000	376,000	0	0		
		Laborer Support	-	-	-	1	vehicle per day	support truck	15	10	210	day	1	1	2,100	4,200	12,600	1,050	500	0	0	0	0	0	0	0		
		Moisture conditioning	413,600	LCY	10,000	1	equipment per day	tractor pulled disc	0	10	42	day	1	0	420	420	1,260	0	0	0	0	0	0	0	0	0	In place MC is ~59% and assume a target of ~30%. All samples were above 30%, assume conditioning of total quantity. All samples had a MC over 45%.	Assume addition effort from track hoe for above MC 45%.
			413,600	LCY	3,400	1	equipment per day	excavator	0	10	122	day	1	0	1,220	1,220	3,660	0	0	0	0	0	0	0	0	0		
	2.3.7 Seed and Mulch	Hydroseed and mulch	21	AC	2	1	equipment per day	hydroseeder truck	250	10	11	day	1	1	110	220	660	0	0	0	0	2,750	0	0	0	0	Hydromulch assumed.	RSMeans 3292 1913 1100.
			-	-	-	1	vehicle per day	support truck	250	10	11	day	1	0	110	110	5,500	55	500	0	0	0	0	0	0	0		
		Material deliveries	0	TON	24	1	materials	truck delivery - hydroseed/mulch	250	10	0	load	1	0	0	0	0	0	0	0	0	0	0	0	0	0	-	Assume 26 CY truck or 48,000 LB flat bed delivery truck.
	2.3.8 Constructing run off ditches and stormwater outfalls	construction details (earth work volume, materials used)?	4,000	CY	540	1	equipment per day	track hoe excavator	0	10	7	day	1	0	70	70	210	0	0	0	0	0	0	0	0	0	Ditch quantity based on closure plan drawings. Assume effort consistent with the closure plan.	RSMeans 3123 1613 0130.
			-	-	-	1	equipment per day	articulating dump truck	12	10	7	day	1	0	70	70	210	0	0	0	0	84	0	0	0	0		
		Turf reinforcement mat	5,100	SY	2,400	1	vehicle per day	support truck	15	10	2	day	1	1	20	40	120	10	500	0	0	0	0	0	0	0		RSMeans 3125 1416 0020.
		Material deliveries	1	EA	1	1	materials	truck delivery - turf reinforcement mat	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250	Assume to be delivered in 1 load.	Assume 26 CY truck or 48,000 LB flat bed delivery truck.
			42	EA	26	1	materials	truck delivery - riprap	250	10	2	load	1	0	20	20	0	0	0	0	0	0	0	0	500	500	Assume 3 aprons at 150 SF.	
			0	EA	0	0	materials	truck delivery - pipe material	250	10	0	load	1	0	0	0	0	0	0	0	0	0	0	0	0	0	Piping not currently included in design.	
			0	EA	0	0	materials	truck delivery - discharge pipe(s)	250	10	0	load	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	2.3.9 Install monitoring / observation wells	Drilling for monitoring well installations and abandonments	4	EA	1	1	equipment per day	drilling rig	0	10	6	day	1	0	60	60	180	0	0	0	0	0	0	0	0	0	Installed to a depth of 30-40 feet. Includes 2 days for mobilization/demobilization.	Install 4 new monitoring wells.
			-	-	-	1	vehicle per day	support truck	15	10	6	day	1	0	60	60	180	30	500	0	0	0	0	0	0	0		
			-	-	-	1	equipment per day	skid steer	0	10	6	day	1	0	60	60	180	0	0	0	0	0	0	0	0	0		
		Clearing for monitoring wells	-	-	-	1	equipment per day	track hoe excavator	0	10	1	day	1	0	10	10	30	0	0	0	0	0	0	0	0	0	2 locations are currently vegetated.	
		Material deliveries	1	EA	1	1	materials	truck delivery - flush mount	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250	Assume to be delivered in 1 load.	Assume 26 CY truck or 48,000 LB flat bed delivery truck.
			1	EA	1	1	materials	truck delivery - well steel	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250		
			1	EA	1	1	materials	truck delivery - PVC	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250		
			1	EA	1	1	materials	truck delivery - sand	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250		
			1	EA	1	1	materials	truck delivery - bentonite	1,000	37	1	load	1	0	37	37	0	0	0	0	0	0	0	0	1,000	1,000		
			1	EA	1	1	materials	truck delivery - cement	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250		
	2.3.10 General Grading	Excavate and load from stockpile	7,800	BCY	3,400	2	equipment per day	track hoe excavator	0	10	2	day	2	0	40	40	120	0	0	0	0	0	0	0	0	0	To promote positive drainage ash is removed. Assumes onsite material from soil stripping and other sources.	A swell of 20% was included. Production rate based on 0.75 mile around trip onsite with a speed of 10 MPH, wait time of 25 minutes and capacity of 34 CYs.
		Hauling and dumping general fill	9,360	LCY	544	10	equipment per day	articulating dump truck	12	10	2	day	10	0	200	200	600	0	0	0	0	240	0	0	0	0		
		Place and spread general fill	9,360	LCY	3,500	2	equipment per day	dozer	0	10	2	day	2	0	40	40	120	0	0	0	0	0	0	0	0	0		
		Compact general fill	9,360	LCY	2,400	3	equipment per day	sheepsfoot roller	0	10	2	day	3	0	60	60	180	0	0	0	0	0	0	0	0	0		
		Laborer Support	-	-	-	1	vehicle per day	support truck	15	10	2	day	1	0	20	20	60	10	500	0	0	0	0	0	0	0		

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Worksheet 3.1 - Work Element Details, Equipment, Hours, Labor and Materials Detail (Closure By Removal, Offsite Landfill).

Closure By Removal Closure Plan

Alternative Component	Work Element	Details/Questions for Each Work Element	Project Quantity	Project Unit	Production Rate (Unit/Time)	Equipment Amount	Equipment Units	Equipment/ Material	One way travel per day (miles) for vehicles	hrs	total time	unit	# Drivers	# Additional Workers per day	Equipment and Vehicle Total Hours	Labor Total Hours	Daily Labor Mobilization Miles	Vehicles Miles Onsite	Vehicle Mob/Demob Mileage	Equipment Mobilization Miles - Unloaded	Equipment Mobilization Miles - Loaded	Daily Equipment Miles Onsite	Daily Haul Truck Miles - Unloaded	Daily Haul Truck Miles - Loaded	Material Delivery Miles - Unloaded	Material Delivery Miles - Loaded	Notes	Production Rate / Duration Reference
2.4 Long Term Operations and Maintenance	2.4.1 Groundwater Monitoring	Years During construction (quarterly sampling)	21	TRIP	1	1	vehicle per day	support truck (daily mob)	250	28	21	day	1	1	588	1,176	21,000	105	0	0	0	0	0	0	0	0	Assumes 8 hours round trip travel (STL to Site) and 20 hours on site. Assume 2 person crew for safety.	Sampling intervals noted in closure plan by Others. NAP: 16 monitoring wells will be sampled and 15 observations wells will be read each trip. NEAP: 8 monitoring wells will be sampled per trip. Based on Geosyntec experience. Added sampling for 5.1 years of construction based on Owner comments.
		Years 1-5 (quarterly sampling)	20	TRIP	1	1	vehicle per day	support truck (daily mob)	250	28	20	day	1	1	560	1,120	20,000	100	0	0	0	0	0	0	0	0		
		Years 6-10 (semiannual sampling)	10	TRIP	1	1	vehicle per day	support truck (daily mob)	250	28	10	day	1	1	280	560	10,000	50	0	0	0	0	0	0	0	0		
		Years 11-30 (annual sampling)	20	TRIP	1	1	vehicle per day	support truck (daily mob)	250	28	20	day	1	1	560	1,120	20,000	100	0	0	0	0	0	0	0	0		
		Field Equipment	71	TRIP	1	1	field equipment	water level meter	0	28	71	day	0	0	1,988	0	0	0	0	0	0	0	0	0	0	0		
			71	TRIP	1	1	field equipment	ground water sampler	0	28	71	day	0	0	1,988	0	0	0	0	0	0	0	0	0	0	0		
			71	TRIP	1	8	field equipment	sample containers	0	28	71	day	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
			71	TRIP	1	1	field equipment	pH meter	0	28	71	day	0	0	1,988	0	0	0	0	0	0	0	0	0	0	0		
			71	TRIP	1	1	field equipment	thermometer	0	28	71	day	0	0	1,988	0	0	0	0	0	0	0	0	0	0	0		
			71	TRIP	1	1	field equipment	specific conductance meter	0	28	71	day	0	0	1,988	0	0	0	0	0	0	0	0	0	0	0		
		Lab Testing	71	EA	22	1	lab test	boron test	0	1	1,562	test	0	1	1,562	1,562	46,860	0	0	0	0	0	0	0	0	0	Each trip.	
			71	EA	22	1	lab test	manganese test	0	1	1,562	test	0	1	1,562	1,562	46,860	0	0	0	0	0	0	0	0	0	Each trip.	
			8	EA	22	1	lab test	silver test	0	1	176	test	0	1	176	176	5,280	0	0	0	0	0	0	0	0	0	1st 8 quarterly trips.	
			71	EA	22	1	lab test	total dissolved solids test	0	1	1,562	test	0	1	1,562	1,562	46,860	0	0	0	0	0	0	0	0	0	Each trip.	
			71	EA	22	1	lab test	total sulfate	0	1	1,562	test	0	1	1,562	1,562	46,860	0	0	0	0	0	0	0	0	0	Each trip.	
			8	EA	22	1	lab test	radium 226	0	1	176	test	0	1	176	176	5,280	0	0	0	0	0	0	0	0	0	1st 8 quarterly trips.	
			8	EA	22	1	lab test	radium 228	0	1	176	test	0	1	176	176	5,280	0	0	0	0	0	0	0	0	0	1st 8 quarterly trips.	
	2.4.2 Surface Water Monitoring	Years During construction (weekly sampling)	266	TRIP	1	1	vehicle per day	support truck (daily mob)	250	16	266	day	1	1	4,256	8,512	266,000	1,330	0	0	0	0	0	0	0	0	Assumes 8 hours round trip travel (STL to Site) and 8 hours on site. Assume 2 person crew for safety.	Sampling intervals are weekly for Outfalls 001 (NAP) and 003 (NEAP) as noted in permit. Based on Geosyntec experience. Added sampling for 5.1 years of construction based on Owner comments.
		Years 1-30 (weekly sampling)	1,560	TRIP	1	1	vehicle per day	support truck (daily mob)	250	16	1,560	day	1	1	24,960	49,920	1,560,000	7,800	0	0	0	0	0	0	0	0		
		Lab Testing	1,826	TRIP	2	1	lab test	total suspended solids	0	1	3,652	test	0	1	3,652	3,652	109,560	0	0	0	0	0	0	0	0	0	Each trip. 24 hour composite sample.	
			457	TRIP	2	1	lab test	oil and grease	0	1	913	test	0	1	913	913	27,390	0	0	0	0	0	0	0	0	0	Monthly. Grab sample.	
			1,826	TRIP	2	1	lab test	total dissolved solids	0	1	3,652	test	0	1	3,652	3,652	109,560	0	0	0	0	0	0	0	0	0	Each trip. 24 hour composite sample.	
			1,826	TRIP	2	1	lab test	sulfates	0	1	3,652	test	0	1	3,652	3,652	109,560	0	0	0	0	0	0	0	0	0	Each trip. 24 hour composite sample.	
			1,826	TRIP	2	1	lab test	boron	0	1	3,652	test	0	1	3,652	3,652	109,560	0	0	0	0	0	0	0	0	0	Each trip. 24 hour composite sample.	
			457	TRIP	2	1	lab test	iron	0	1	913	test	0	1	913	913	27,390	0	0	0	0	0	0	0	0	0	Monthly. 24 hour composite sample.	

	Equipment and Vehicle Total Hours	Labor Total Hours	Daily Labor Mobilization Miles	Vehicles Miles Onsite	Vehicle Mob/Demob Mileage	Equipment Mobilization Miles - Unloaded	Equipment Mobilization Miles - Loaded	Daily Equipment Miles Onsite	Daily Haul Truck Miles - Unloaded	Daily Haul Truck Miles - Loaded	Material Delivery Miles - Unloaded	Material Delivery Miles - Loaded
Selected Closure Plan Totals	**845,959**	**681,723**	**4,934,950**	**123,501**	**21,500**	**44,250**	**44,250**	**49,586**	**2,589,015**	**2,589,015**	**144,500**	**144,500**

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Worksheet 3.2 - Work Element Details, Equipment, Hours, Labor and Materials Detail (Closure By Removal, Onsite Landfill).

Closure By Removal Closure Plan																												
Alternative Component	Work Element	Details/Questions for Each Work Element	Project Quantity	Project Unit	Production Rate (Unit/Time)	Equipment Amount	Equipment Units	Equipment/ Material	One way travel per day (miles) for vehicles	hrs	total time	unit	# Drivers	# Additional Workers per day	Equipment and Vehicle Total Hours	Labor Total Hours	Daily Labor Mobilization Miles	Vehicles Miles Onsite	Vehicle Mob/Demob Mileage	Equipment Mobilization Miles - Unloaded	Equipment Mobilization Miles - Loaded	Daily Equipment Miles Onsite	Daily Haul Truck Miles - Unloaded	Daily Haul Truck Miles - Loaded	Material Delivery Miles - Unloaded	Material Delivery Miles - Loaded	Notes	Production Rate / Duration Reference
2.1 NAP Closure	2.1.1 Project Duration Items	Project duration	-	-	-	0	-	-	0	0	4.8	years	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	Schedule not defined, assume 4.8 years total project duration.
		Owner's representative site visits	-	-	-	1	vehicle per day	support truck (daily mob)	250	10	250	day	1	0	2,500	2,500	125,000	1,250	0	0	0	0	0	0	0	0	Weekly site visits.	
		Contractor Construction & Safety Managers	-	-	-	2	vehicle per day	support truck	15	10	1,248	day	2	1	24,960	37,440	112,320	12,480	500	0	0	0	0	0	0	0	Three full time staff.	
		Office facilities	-	-	-	2	equipment per day	work trailer	0	10	1,248	day	0	0	24,960	0	0	0	0	0	0	0	0	0	0	0	Office Trailer.	
		Electric usage (average per day)	1,248,000	KWH	100	0	KWH per day	electricity	0	10	1,248	day	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Assume 50 kWh per trailer.	
		Site specific security	-	-	-	1	vehicle per day	support truck	15	10	1,248	day	1	0	12,480	12,480	37,440	6,240	500	0	0	0	0	0	0	0	One full time staff.	
		CQA Officer / Engineer site visit	-	-	-	1	vehicle per day	support truck (daily mob)	250	10	250	day	1	0	2,500	2,500	125,000	1,250	0	0	0	0	0	0	0	0	Weekly site visits.	
		CQA staff	-	-	-	1	vehicle per day	support truck	15	10	1,248	day	1	0	12,480	12,480	37,440	6,240	500	0	0	0	0	0	0	0	One full time staff.	
		Equipment mobilization	-	-	-	61	equipment mob	heavy equipment mob	250	10	1	mob	61	0	610	610	1,830	0	0	15,250	15,250	0	0	0	0	0	Estimated mobilization for heavy equipment. Includes all non vehicles. Vehicles are assumed to travel to the site daily.	
		Equipment fueling	-	-	-	1	vehicle per day	fuel truck	15	2	1,248	day	1	0	2,496	2,496	37,440	6,240	0	0	0	0	0	0	0	0	Daily refueling.	
		Portable restrooms	-	-	-	1	equipment per day	restroom units	0	10	1,248	day	0	0	12,480	0	0	0	0	0	0	0	0	0	0	0	Full time.	
		Portable restroom service	-	-	-	1	vehicle per day	maintenance vehicle	15	2	250	day	1	0	500	500	7,500	1,250	0	0	0	0	0	0	0	0		
		Dust suppression	-	-	-	1	equipment per day	water truck	12	10	1,248	day	1	0	12,480	12,480	37,440	0	0	0	0	14,976	0	0	0	0		
		Groundwater monitoring	-	-	-	0	-	-	0	0	0	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Monitoring included in Task 2.4.	-
		NPDES monitoring	-	-	-	0	-	-	0	0	0	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	2.1.2 Install EPSC Measures	Silt fence	2,650	LF	1,300	1	vehicle per day	support truck	15	10	3	day	1	1	30	60	180	15	500	0	0	0	0	0	0	0	Assumes silt fence not required along west side.	RSMeans 3125 1416 1000.
		Material deliveries	1	EA	1	1	materials	truck delivery - silt fence	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250	Assume to be delivered in 1 load.	Assume 26 CY truck or 48,000 LB flat bed delivery truck.
	2.1.3 Unwatering NAP and Secondary NAP	Pump NAP to Secondary NAP, pump Secondary NAP to NPDES Outfall 001	14	MG	1	2	equipment per day	6-inch pump	0	10	14	day	1	0	280	140	420	0	0	0	0	0	0	0	0	0	Assume 1 pump from the NAP to the Secondary NAP and 1 pump from the Secondary NAP to Outfall 001. Assume 40 hp pump.	Volumes and pump rates provided in Stantec Unwatering and Dewatering Memo (4/19/19). Assume effort consistent with the closure plan.
			10,360	KWH	74	0	KWH per hour	electricity	0	10	14	day	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
			-	-	-	1	vehicle per day	support truck	15	10	14	day	0	0	140	0	0	70	500	0	0	0	0	0	0	0		
	2.1.4 Dewatering and Stormwater Management	Excavate dewatering ditches and install dewatering sumps	31,700	CY	540	3	equipment per day	track hoe excavator	0	10	20	day	3	0	600	600	1,800	0	0	0	0	0	0	0	0	0	Assume dewatering to a depth of 10 feet with 15-foot ditches and sumps. Assume 2,000 LF of 15-foot, 1:1 slope ditches, 4-foot base. Assume effort consistent with the closure plan.	RSMeans 3123 1613 0130.
			-	-	-	3	equipment per day	articulating dump truck	12	10	20	day	3	0	600	600	1,800	0	0	0	0	720	0	0	0	0		
			-	-	-	1	equipment per day	dozer	0	10	20	day	1	0	200	200	600	0	0	0	0	0	0	0	0	0		
			-	-	-	1	equipment per day	smooth drum roller	0	10	20	day	1	0	200	200	600	0	0	0	0	0	0	0	0	0		
			-	-	-	1	vehicle per day	support truck	0	10	20	day	1	0	200	200	0	100	500	0	0	0	0	0	0	0		
		Dewater for Excavation	80	MG	0	3	equipment per day	sump pump	0	10	730	day	1	0	21,900	7,300	21,900	0	0	0	0	0	0	0	0	0	Assume 3 sump locations, 7 days per week for 6 months dewatering. Assume stormwater management for 4.8 years. Assume 40 hp pump. Assume a 50% increase of the effort for the closure plan split between the NAP (2/3) and OEAP (1/3) for stormwater management.	Volumes provided in Stantec Unwatering and Dewatering Memo (4/19/19). Assume effort consistent with the closure plan.
			810,300	KWH	111	0	KWH per hour	electricity	0	10	730	day	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
		Stormwater Management	358	MG	0	3	equipment per day	sump pump	0	10	913	day	1	0	27,390	9,130	27,390	0	0	0	0	0	0	0	0	0		
			1,013,430	KWH	111	0	KWH per hour	electricity	0	10	913	day	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
			-	-	-	1	vehicle per day	support truck	15	10	1,643	day	0	0	16,430	0	0	8,215	500	0	0	0	0	0	0	0		
	2.1.5 Soil Stripping and Stockpiling	Excavation and loading soil	65,300	BCY	3,400	1	equipment per day	track hoe excavator	0	10	14	day	1	0	140	140	420	0	0	0	0	0	0	0	0	0	Soil to be stockpiled onsite and used to regraded excavated areas.	A swell of 10% was included. Production rate based on 0.75 mile around trip onsite with a speed of 10 MPH, wait time of 25 minutes and capacity of 34 CYs.
		Hauling and dumping in stockpile	71,830	LCY	544	10	equipment per day	articulating dump truck	12	10	14	day	10	1	1,400	1,540	4,620	0	0	0	0	1,680	0	0	0	0		
		Place and spread in stockpile	71,830	LCY	3,500	1	equipment per day	dozer	0	10	14	day	1	1	140	280	840	0	0	0	0	0	0	0	0	0		
		Laborer Support	-	-	-	1	vehicle per day	support truck	15	10	14	day	1	0	140	140	420	70	500	0	0	0	0	0	0	0		
	2.1.6 Excavate CCR Material and Haul to Landfill	Excavate and load CCR	1,171,000	BCY	3,400	1	equipment per day	track hoe excavator	0	10	588	day	1	0	5,880	5,880	17,640	0	0	0	0	0	0	0	0	0	Excavation of CCR from the NAP and haul to onsite landfill. Includes 1-ft overexcavation.	A swell of 10% was included. Production rate based on 30 mile around trip with a speed of 35 MPH, wait time of 15 minutes and capacity of 16.5 CYs. Roughly 2,000 CY/DAY.
		Hauling and dumping	1,288,100	LCY	510	4	haul trucks per day	articulating dump truck	12	10	588	day	4	1	25,284	31,164	93,492	0	0	0	0	0	30,341	30,341	0	0		
		Laborer Support	-	-	-	1	vehicle per day	support truck	15	10	588	day	1	1	5,880	11,760	35,280	2,940	500	0	0	0	0	0	0	0		
		Moisture conditioning	1,288,100	LCY	10,000	1	equipment per day	tractor pulled disc	0	10	129	day	1	0	1,290	1,290	3,870	0	0	0	0	0	0	0	0	0	In place MC is ~35% and assume a target of ~30%. The majority of samples were above 30%, assume conditioning of total quantity. 10% of the samples had a MC over 45%.	Assume addition effort from track hoe for above MC 45%.
			128,810	LCY	3,400	1	equipment per day	excavator	0	10	38	day	1	0	380	380	1,140	0	0	0	0	0	0	0	0	0		
	2.1.7 Excavate Coal Yard Material and Haul to Landfill	Excavate and load CCR	50,000	BCY	3,400	1	equipment per day	track hoe excavator	0	10	26	day	1	0	260	260	780	0	0	0	0	0	0	0	0	0	Excavation of coal from the Coal Yard and haul to offsite landfill. Includes 1-ft overexcavation.	Volume provided by the Owner. A swell of 10% was included. Production rate based on 1 mile around trip onsite with a speed of 10 MPH, wait time of 15 minutes and capacity of 34 CYs. Roughly 2,200 CY/DAY.
		Hauling and dumping	55,000	LCY	510	4	haul trucks per day	articulating dump truck	12	10	26	day	4	0	1,118	1,118	3,354	0	0	0	0	0	1,342	1,342	0	0		
		Laborer Support	-	-	-	1	vehicle per day	support truck	15	10	26	day	1	0	260	260	780	130	500	0	0	0	0	0	0	0		
	2.1.8 Seed and Mulch	Hydroseed and mulch	40	AC	2	1	equipment per day	hydroseeder truck	250	10	20	day	1	1	200	400	1,200	0	0	0	0	5,000	0	0	0	0	Hydromulch assumed.	RSMeans 3292 1913 1100.
			-	-	-	1	vehicle per day	support truck	250	10	20	day	1	0	200	200	10,000	100	500	0	0	0	0	0	0	0		
		Material deliveries	30	TON	24	1	materials	truck delivery - hydroseed/mulch	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250	-	Assume 26 CY truck or 48,000 LB flat bed delivery truck.

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Worksheet 3.2 - Work Element Details, Equipment, Hours, Labor and Materials Detail (Closure By Removal, Onsite Landfill).

Closure By Removal Closure Plan

Alternative Component	Work Element	Details/Questions for Each Work Element	Project Quantity	Project Unit	Production Rate (Unit/Time)	Equipment Amount	Equipment Units	Equipment/ Material	One way travel per day (miles) for vehicles	hrs	total time	unit	# Drivers	# Additional Workers per day	Equipment and Vehicle Total Hours	Labor Total Hours	Daily Labor Mobilization Miles	Vehicles Miles Onsite	Vehicle Mob/Demob Mileage	Equipment Mobilization Miles - Unloaded	Equipment Mobilization Miles - Loaded	Daily Equipment Miles Onsite	Daily Haul Truck Miles - Unloaded	Daily Haul Truck Miles - Loaded	Material Delivery Miles - Unloaded	Material Delivery Miles - Loaded	Notes	Production Rate / Duration Reference
2.1 NAP Closure	2.1.9 Install monitoring / observation wells	Drilling for monitoring well and observation well installations, drilling for abandonment of monitoring wells	4	EA	1	1	equipment per day	drilling rig	0	10	6	day	1	0	60	60	180	0	0	0	0	0	0	0	0	0	Assumes wells will be powered with onsite power. Includes 2 days for mobilization/demobilization.	Install 4 new monitoring wells.
			-	-	-	1	vehicle per day	support truck (daily mob)	250	10	6	day	1	0	60	60	3,000	30	0	0	0	0	0	0	0	0		
			-	-	-	1	equipment per day	skid steer	0	10	6	day	1	0	60	60	180	0	0	0	0	0	0	0	0	0		
		Clearing for monitoring wells	-	-	-	1	equipment per day	track hoe excavator	0	10	5	day	1	0	50	50	150	0	0	0	0	0	0	0	0	0	8 locations are currently vegetated.	
		Material deliveries	1	EA	1	1	materials	truck delivery - flush mount	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250	Assume to be delivered in 1 load.	Assume 26 CY truck or 48,000 LB flat bed delivery truck.
			1	EA	1	1	materials	truck delivery - well steel	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250		
			1	EA	1	1	materials	truck delivery - PVC	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250		
			1	EA	1	1	materials	truck delivery - sand	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250		
			1	EA	1	1	materials	truck delivery - bentonite	250	37	1	load	1	0	37	37	0	0	0	0	0	0	0	0	250	250		
			1	EA	1	1	materials	truck delivery - cement	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250		
	2.1.10 General Grading	Excavate and load from stockpile	253,000	BCY	3,400	2	equipment per day	track hoe excavator	0	10	56	day	2	0	1,120	1,120	3,360	0	0	0	0	0	0	0	0	0	To promote positive drainage once the ash is removed. Assumes onsite material from soil stripping and other sources.	A swell of 20% was included. Production rate based on 0.75 mile around trip onsite with a speed of 10 MPH, wait time of 25 minutes and capacity of 34 CYs.
		Hauling and dumping general fill	303,600	LCY	544	10	equipment per day	articulating dump truck	12	10	56	day	10	0	5,600	5,600	16,800	0	0	0	0	6,720	0	0	0	0		
		Place and spread general fill	303,600	LCY	3,500	2	equipment per day	dozer	0	10	56	day	2	0	1,120	1,120	3,360	0	0	0	0	0	0	0	0	0		
		Compact general fill	303,600	LCY	2,400	3	equipment per day	sheepsfoot roller	0	10	56	day	3	0	1,680	1,680	5,040	0	0	0	0	0	0	0	0	0		
		Laborer Support	-	-	-	1	vehicle per day	support truck	15	10	1	day	1	0	10	10	30	5	500	0	0	0	0	0	0	0		
		Riprap Protection for Stormwater Inflow Into the NAP	-	-	-	2	equipment per day	track hoe excavator	0	10	15	day	2	0	300	300	900	0	0	0	0	0	0	0	0	0	Riprap at geotextile fabric to reduce velocity in the NAP.	
			-	-	-	1	equipment per day	articulating dump truck	12	10	15	day	1	0	150	150	450	0	0	0	0	180	0	0	0	0		
			-	-	-	1	equipment per day	dozer	0	10	15	day	1	0	150	150	450	0	0	0	0	0	0	0	0	0		
			-	-	-	1	vehicle per day	support truck	15	10	15	day	1	0	150	150	450	75	500	0	0	0	0	0	0	0		
			-	-	-	2	vehicle per day	support truck	15	10	15	day	2	1	300	450	1,350	150	500	0	0	0	0	0	0	0		
			11,111	CY	26	1	materials	truck delivery - riprap	250	10	427	load	1	0	4,270	4,270	0	0	0	0	0	0	0	0	106,750	106,750	Assume 100,000 SF of riprap at 18-inches thick.	
			1	EA	1	1	materials	truck delivery - geotextile	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250		
2.2 OEAP Closure	2.2.1 Preconstruction Tasks	Groundwater Collection Trench	-	-	-	1	equipment per day	one pass trencher	0	10	40	day	1	0	400	400	1,200	0	0	0	0	0	0	0	0	0	Scope not defined. Improvements may not be necessary dependent on results of stability analyses. Work depicted assumed based on current understanding of the project. Includes Construction Manager, laborers, and CQA staff.	2 months, to be refined during design phase.
			-	-	-	2	equipment per day	front end loader	0	10	40	day	2	0	800	800	2,400	0	0	0	0	0	0	0	0	0		
			-	-	-	1	equipment per day	dozer	0	10	40	day	1	0	400	400	1,200	0	0	0	0	0	0	0	0	0		
						1	equipment per day	articulating dump truck	12	10	40		1	0	400	400	1,200	0	0	0	0	480	0	0	0	0		
						1	equipment per day	6-inch pump	0	10	40		1	0	400	400	1,200	0	0	0	0	0	0	0	0	0		
			-	-	-	1	vehicle per day	support truck	15	10	40	day	1	0	400	400	1,200	200	500	0	0	0	0	0	0	0		
			-	-	-	2	vehicle per day	support truck	15	10	40	day	2	0	800	800	2,400	400	500	0	0	0	0	0	0	0		
			1,500	LF	1,500	1	materials	truck delivery - 6-inch piping	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250	Piping to dewater trench excavation and take to the NEAP.	
			3,000	LF	1,500	1	materials	truck delivery - 4-inch piping	250	10	2	load	1	0	20	20	0	0	0	0	0	0	0	0	500	500		
			1,222	CY	26	1	materials	truck delivery - coarse aggregate	250	10	47	load	1	0	470	470	0	0	0	0	0	0	0	0	11,750	11,750	Assume emergency buttress of 1,100 ft x 30 ft x 2 ft .	
			1	EA	1	1	materials	truck delivery - geotextile	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250		
		OEAP Riverslope Stabilization Installation	-	-	-	2	equipment per day	track hoe excavator	0	10	30	day	2	0	600	600	1,800	0	0	0	0	0	0	0	0	0	Scope not defined. Improvements may not be necessary dependent on results of stability analyses. Work depicted assumed based on current understanding of the project. Includes Construction Manager, laborers, and CQA staff.	6 weeks, to be refined during design phase.
			-	-	-	1	equipment per day	articulating dump truck	12	10	30	day	1	0	300	300	900	0	0	0	0	360	0	0	0	0		
			-	-	-	1	equipment per day	dozer	0	10	30	day	1	0	300	300	900	0	0	0	0	0	0	0	0	0		
			-	-	-	1	vehicle per day	support truck	15	10	30	day	1	0	300	300	900	150	500	0	0	0	0	0	0	0		
			-	-	-	2	vehicle per day	support truck	15	10	30	day	2	1	600	900	2,700	300	500	0	0	0	0	0	0	0		
			1,852	CY	26	1	materials	truck delivery - riprap	250	10	71	load	1	0	710	710	0	0	0	0	0	0	0	0	17,750	17,750	Assume emergency buttress of 1,000 ft x 10 ft x 10 ft .	
			1	EA	1	1	materials	truck delivery - geotextile	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250		
		OEAP Riverslope Stabilization Removal	-	-	-	1	equipment per day	track hoe excavator	0	10	10	day	1	0	100	100	300	0	0	0	0	0	0	0	0	0	Temporary improvement that will be removed in the future.	2 weeks.
			-	-	-	1	equipment per day	articulating dump truck	12	10	10	day	1	0	100	100	300	0	0	0	0	120	0	0	0	0		
			-	-	-	1	equipment per day	dozer	0	10	10	day	1	0	100	100	300	0	0	0	0	0	0	0	0	0		
			-	-	-	1	vehicle per day	support truck	15	10	10	day	1	0	100	100	300	50	500	0	0	0	0	0	0	0		

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Closure By Removal Closure Plan

Alternative Component	Work Element	Details/Questions for Each Work Element	Project Quantity	Project Unit	Production Rate (Unit/Time)	Equipment Amount	Equipment Units	Equipment/ Material	One way travel per day (miles) for vehicles	hrs	total time	unit	# Drivers	# Additional Workers per day	Equipment and Vehicle Total Hours	Labor Total Hours	Daily Labor Mobilization Miles	Vehicles Miles Onsite	Vehicle Mob/Demob Mileage	Equipment Mobilization Miles - Unloaded	Equipment Mobilization Miles - Loaded	Daily Equipment Miles Onsite	Daily Haul Truck Miles - Unloaded	Daily Haul Truck Miles - Loaded	Material Delivery Miles - Unloaded	Material Delivery Miles - Loaded	Notes	Production Rate / Duration Reference
2.2 OEAP Closure	2.2.2 Project Duration Items	Project duration	-	-	-	0	-	-	0	0	2.3	years	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	Schedule not defined, assume 2.5 years total project duration.
		Owner's representative site visits	-	-	-	1	vehicle per day	support truck (daily mob)	250	10	120	day	1	0	1,200	1,200	60,000	600	0	0	0	0	0	0	0	0	Weekly site visits.	
		Contractor Construction & Safety Managers	-	-	-	2	vehicle per day	support truck	15	10	598	day	2	1	11,960	17,940	53,820	5,980	500	0	0	0	0	0	0	0	Three full time staff.	
		Office facilities	-	-	-	2	equipment per day	work trailer	0	10	598	day	0	0	11,960	0	0	0	0	0	0	0	0	0	0	0	Office Trailer.	
		Electric usage (average per day)	598,000	KWH	100	0	KWH per day	electricity	0	10	598	day	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Assume 50 kWh per trailer.	
		Site specific security	-	-	-	1	vehicle per day	support truck	15	10	598	day	1	0	5,980	5,980	17,940	2,990	500	0	0	0	0	0	0	0	One full time staff.	
		CQA Officer / Engineer site visit	-	-	-	1	vehicle per day	support truck (daily mob)	250	10	120	day	1	0	1,200	1,200	60,000	600	0	0	0	0	0	0	0	0	Weekly site visits.	
		CQA staff	-	-	-	1	vehicle per day	support truck	15	10	598	day	1	0	5,980	5,980	17,940	2,990	500	0	0	0	0	0	0	0	One full time staff.	
		Equipment mobilization	-	-	-	63	equipment mob	heavy equipment mob	250	10	1	mob	63	0	630	630	1,890	0	0	15,750	15,750	0	0	0	0	0	Estimated mobilization for heavy equipment. Includes all non vehicles. Vehicles are assumed to travel to the site daily.	
		Equipment fueling	-	-	-	1	vehicle per day	fuel truck	15	2	598	day	1	0	1,196	1,196	17,940	2,990	0	0	0	0	0	0	0	0	Daily refueling.	
		Portable restrooms	-	-	-	1	equipment per day	restroom units	0	10	598	day	0	0	5,980	0	0	0	0	0	0	0	0	0	0	0	Full time.	
		Portable restroom service	-	-	-	1	vehicle per day	maintenance vehicle	15	2	120	day	1	0	240	240	3,600	600	0	0	0	0	0	0	0	0		
		Dust suppression	-	-	-	1	equipment per day	water truck	0	10	598	day	1	0	5,980	5,980	17,940	0	0	0	0	0	0	0	0	0		
		Groundwater monitoring	-	-	-	0	-	-	0	0	0	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Monitoring included in Task 2.4.	-
		NPDES monitoring	-	-	-	0	-	-	0	0	0	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	2.2.3 Install EPSC Measures	Silt fence	2,350	LF	1,300	1	vehicle per day	support truck	15	10	2	day	1	1	20	40	120	10	500	0	0	0	0	0	0	0	Assumes silt fence not required along south side.	RSMeans 3125 1416 1000.
		Material deliveries	1	EA	1	1	materials	truck delivery - silt fence	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250	Assume to be delivered in 1 load.	Assume 26 CY truck or 48,000 LB flat bed delivery truck.
	2.2.4 Dewatering and Stormwater Management	Excavate dewatering ditches and install dewatering sumps	15,900	CY	540	3	equipment per day	track hoe excavator	0	10	10	day	3	0	300	300	900	0	0	0	0	0	0	0	0	0	Assume dewatering to a depth of 10 feet with 15-foot ditches and sumps. Assume 1,000 LF of 15-foot, 1:1 slope ditches, 4-foot base. Assume effort consistent with the closure plan.	RSMeans 3123 1613 0130.
			-	-	-	3	equipment per day	articulating dump truck	12	10	10	day	3	0	300	300	900	0	0	0	0	360	0	0	0	0		
			-	-	-	1	equipment per day	dozer	0	10	10	day	1	0	100	100	300	0	0	0	0	0	0	0	0	0		
			-	-	-	1	equipment per day	smooth drum roller	0	10	10	day	1	0	100	100	300	0	0	0	0	0	0	0	0	0		
			-	-	-	1	vehicle per day	support truck	0	10	10	day	1	0	100	100	0	50	500	0	0	0	0	0	0	0		
		Dewater for Excavation	0	MG	-	3	equipment per day	sump pump	0	10	0	day	1	0	0	0	0	0	0	0	0	0	0	0	0	0	Assume 3 sump locations, 7 days per week for 6 months dewatering. Assume stormwater management for 2.3 years. Assume 40 hp pump. Assume a 50% increase of the effort for the closure plan split between the NAP (2/3) and OEAP (1/3).	Volumes provided in Stantec Unwatering and Dewatering Memo (4/19/19). Assume effort consistent with the closure plan.
			0	KWH	111	0	KWH per hour	electricity	0	10	0	day	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
		Stormwater Management	86	MG	0	3	equipment per day	sump pump	0	10	840	day	1	0	25,200	8,400	25,200	0	0	0	0	0	0	0	0	0		
			932,400	KWH	111	0	KWH per hour	electricity	0	10	840	day	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
			-	-	-	1	vehicle per day	support truck	15	10	840	day	0	0	8,400	0	0	4,200	500	0	0	0	0	0	0	0		
	2.2.5 Soil Stripping and Stockpiling	Excavation and loading soil	283,000	BCY	3,400	1	equipment per day	track hoe excavator	0	10	58	day	1	0	580	580	1,740	0	0	0	0	0	0	0	0	0	Soil to be stockpiled onsite and used to regraded excavated areas.	A swell of 20% was included. Production rate based on 0.75 mile around trip onsite with a speed of 10 MPH, wait time of 25 minutes and capacity of 34 CYs.
		Hauling and dumping in stockpile	311,300	LCY	544	10	equipment per day	articulating dump truck	12	10	58	day	10	1	5,800	6,380	19,140	0	0	0	0	6,960	0	0	0	0		
		Place and spread in stockpile	311,300	LCY	3,500	1	equipment per day	dozer	0	10	58	day	1	1	580	1,160	3,480	0	0	0	0	0	0	0	0	0		
		Laborer Support	-	-	-	1	vehicle per day	support truck	15	10	58	day	1	0	580	580	1,740	290	500	0	0	0	0	0	0	0		
	2.2.6 Excavate CCR Material and Haul to Landfill	Excavate and load CCR	992,000	BCY	3,400	1	equipment per day	track hoe excavator	0	10	498	day	1	0	4,980	4,980	14,940	0	0	0	0	0	0	0	0	0	Excavation of CCR from the OEAP and haul to offsite landfill. Includes 1-ft overexcavation.	A swell of 10% was included. Production rate based on 1 mile around trip onsite with a speed of 10 MPH, wait time of 15 minutes and capacity of 34 CYs. Roughly 2,200 CY/DAY.
		Hauling and dumping	1,091,200	LCY	510	4	haul trucks per day	articulating dump truck	12	10	498	day	4	1	21,414	26,394	79,182	0	0	0	0	0	25,697	25,697	0	0		
		Laborer Support	-	-	-	1	vehicle per day	support truck	15	10	498	day	1	1	4,980	9,960	29,880	2,490	500	0	0	0	0	0	0	0		
		Moisture conditioning	1,091,200	LCY	10,000	1	equipment per day	tractor pulled disc	0	10	110	day	1	0	1,100	1,100	3,300	0	0	0	0	0	0	0	0	0	In place MC is ~39% and assume a target of ~30%. The majority of samples were above 30%, assume conditioning of total quantity. 10% of the samples had a MC over 45%.	Assume addition effort from track hoe for above MC 45%.
			109,120	LCY	3,400	1	equipment per day	excavator	0	10	33	day	1	0	330	330	990	0	0	0	0	0	0	0	0	0		
	2.2.7 Abandon or Removal of OEAP Drainage Pipes	Excavation and backfill	-	-	-	1	equipment per day	track hoe excavator	0	10	1	day	1	0	10	10	30	0	0	0	0	0	0	0	0	0	Two pipes have been located that require removal from the ash ponds.	Assume 1 day to excavated and haul off.
		Compact	-	-	-	1	equipment per day	sheepsfoot roller	0	10	1	day	1	0	10	10	30	0	0	0	0	0	0	0	0	0		
		Haul Off	-	-	-	1	haul trucks per day	tandem dump truck	15	10	1	day	1	0	10	10	30	0	0	0	0	0	15	15	0	0		
		Laborer Support	-	-	-	1	vehicle per day	support truck	15	10	1	day	1	1	10	20	60	5	500	0	0	0	0	0	0	0		
	2.2.8 Seed and Mulch	Hydroseed and mulch	20	AC	2	1	equipment per day	hydroseeder truck	250	10	10	day	1	1	100	200	600	0	0	0	0	2,500	0	0	0	0	Hydromulch assumed.	RSMeans 3292 1913 1100.
			-	-	-	1	vehicle per day	support truck	250	10	10	day	1	0	100	100	5,000	50	500	0	0	0	0	0	0	0		
		Material deliveries	15	TON	24	1	materials	truck delivery - hydroseed/mulch	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250	-	Assume 26 CY truck or 48,000 LB flat bed delivery truck.

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Worksheet 3.2 - Work Element Details, Equipment, Hours, Labor and Materials Detail (Closure By Removal, Onsite Landfill).

Closure By Removal Closure Plan

Alternative Component	Work Element	Details/Questions for Each Work Element	Project Quantity	Project Unit	Production Rate (Unit/Time)	Equipment Amount	Equipment Units	Equipment/ Material	One way travel per day (miles) for vehicles	hrs	total time	unit	# Drivers	# Additional Workers per day	Equipment and Vehicle Total Hours	Labor Total Hours	Daily Labor Mobilization Miles	Vehicles Miles Onsite	Vehicle Mob/Demob Mileage	Equipment Mobilization Miles - Unloaded	Equipment Mobilization Miles - Loaded	Daily Equipment Miles Onsite	Daily Haul Truck Miles - Unloaded	Daily Haul Truck Miles - Loaded	Material Delivery Miles - Unloaded	Material Delivery Miles - Loaded	Notes	Production Rate / Duration Reference
2.2 OEAP Closure	2.2.9 Install monitoring / observation wells	Drilling monitoring well and observation well installations, drilling for abandonment monitoring wells	4	EA	1	1	equipment per day	drilling rig	0	10	6	day	1	0	60	60	180	0	0	0	0	0	0	0	0	0	Includes 2 days for mobilization/demobilization.	Install 4 new monitoring wells.
			-	-	-	1	vehicle per day	support truck (daily mob)	250	10	6	day	1	0	60	60	3,000	30	0	0	0	0	0	0	0	0		
			-	-	-	1	equipment per day	skid steer	0	10	6	day	1	0	60	60	180	0	0	0	0	0	0	0	0	0		
		Clearing for monitoring wells	-	-	-	1	equipment per day	track hoe excavator	0	10	5	day	1	0	50	50	150	0	0	0	0	0	0	0	0	0	2 locations are currently vegetated.	
		Material deliveries	1	EA	1	1	materials	truck delivery - flush mount	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250	Assume to be delivered in 1 load.	Assume 26 CY truck or 48,000 LB flat bed delivery truck.
			1	EA	1	1	materials	truck delivery - well steel	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250		
			1	EA	1	1	materials	truck delivery - PVC	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250		
			1	EA	1	1	materials	truck delivery - sand	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250		
			1	EA	1	1	materials	truck delivery - bentonite	0	37	1	load	1	0	37	37	0	0	0	0	0	0	0	0	0	0		
			1	EA	1	1	materials	truck delivery - cement	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250		
	2.2.10 General Grading	Excavate and load from stockpile	84,000	BCY	3,400	2	equipment per day	track hoe excavator	0	10	19	day	2	0	380	380	1,140	0	0	0	0	0	0	0	0	0	To promote positive drainage once the ash is removed. Assumes onsite material from soil stripping and other sources. OEAP is not assumed to be usable.	A swell of 20% was included. Production rate based on 0.75 mile around trip onsite with a speed of 10 MPH, wait time of 25 minutes and capacity of 34 CYs.
		Hauling and dumping general fill	100,800	LCY	544	10	equipment per day	articulating dump truck	12	10	19	day	10	0	1,900	1,900	5,700	0	0	0	0	2,280	0	0	0	0		
		Place and spread general fill	100,800	LCY	3,500	2	equipment per day	dozer	0	10	19	day	2	0	380	380	1,140	0	0	0	0	0	0	0	0	0		
		Compact general fill	100,800	LCY	2,400	3	equipment per day	sheepsfoot roller	0	10	19	day	3	0	570	570	1,710	0	0	0	0	0	0	0	0	0		
		Laborer Support	-	-	-	1	vehicle per day	support truck	15	10	19	day	1	0	190	190	570	95	500	0	0	0	0	0	0	0		
2.3 NEAP Closure	2.3.1 Project Duration Items	Project Duration	-	-	-	0	-	-	0	0	3.0	years	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	Schedule not defined, assume 3.1 years total project duration.
		Owner's representative site visits	-	-	-	1	vehicle per day	support truck (daily mob)	250	10	156	day	1	0	1,560	1,560	78,000	780	0	0	0	0	0	0	0	0	Weekly site visits.	
		Contractor Construction & Safety Managers	-	-	-	2	vehicle per day	support truck	15	10	780	day	2	1	15,600	23,400	70,200	7,800	500	0	0	0	0	0	0	0	Three full time staff.	
		Office facilities	-	-	-	2	unit per day	work trailer	0	10	780	day	0	0	15,600	0	0	0	0	0	0	0	0	0	0	0	Office Trailer.	
		Electric usage (average per day)	780,000	KWH	100	0	KWH per day	electricity	0	10	780	day	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Assume 50 kWh per trailer.	
		Site specific security	-	-	-	1	vehicle per day	support truck	15	10	780	day	1	0	7,800	7,800	23,400	3,900	500	0	0	0	0	0	0	0	One full time staff.	
		CQA Officer / Engineer site visit	-	-	-	1	vehicle per day	support truck (daily mob)	250	10	36	day	1	0	360	360	18,000	180	0	0	0	0	0	0	0	0	Monthly site visits.	
		CQA staff	-	-	-	1	vehicle per day	support truck	15	10	780	day	1	0	7,800	7,800	23,400	3,900	500	0	0	0	0	0	0	0	One full time staff.	
		Equipment mobilization	-	-	-	53	equipment mob	heavy equipment mob	250	10	1	mob	53	0	530	530	1,590	0	0	13,250	13,250	0	0	0	0	0	Estimated mobilization for heavy equipment. Includes all non vehicles. Vehicles are assumed to travel to the site daily.	
		Equipment fueling	-	-	-	1	vehicle per day	fuel truck	15	1	780	day	1	0	780	780	23,400	3,900	0	0	0	0	0	0	0	0	Daily refueling.	
		Portable restrooms	-	-	-	1	equipment per day	restroom units	0	10	780	day	0	0	7,800	0	0	0	0	0	0	0	0	0	0	0	Full time.	
		Portable restroom service	-	-	-	1	vehicle per day	maintenance truck	15	2	156	day	1	0	312	312	4,680	780	0	0	0	0	0	0	0	0		
		Dust suppression	-	-	-	1	equipment per day	water truck	0	10	780	day	1	0	7,800	7,800	23,400	0	0	0	0	0	0	0	0	0		
		Groundwater monitoring	-	-	-	0	-	-	0	0	0	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Monitoring included in Task 2.4.	-
		NPDES monitoring	-	-	-	0	-	-	0	0	0	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	2.3.2 Install EPSC Measures	Silt fence	5,000	LF	1,300	1	vehicle per day	support truck	15	10	4	day	1	1	40	80	240	20	500	0	0	0	0	0	0	0	Assumes silt fence not required along west side.	RSMeans 3125 1416 1000.
		Material deliveries	1	EA	1	1	materials	truck delivery - silt fence	0	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	0	0	Assume to be delivered in 1 load.	Assume 26 CY truck or 48,000 LB flat bed delivery truck.
	2.3.3 Unwatering NEAP and Secondary NEAP	Pump NEAP to Secondary NEAP, pump Secondary NEAP to NPDES Outfall 003	3	MG	0	2	equipment per day	6-inch pump	0	10	15	day	2	0	300	300	900	0	0	0	0	0	0	0	0	0	Assume 1 pump from the NEAP to the Sec. NEAP and 1 pump from the Secondary NEAP to Outfall 003. Assume 40 hp pump.	Volumes and pump rates provided in Stantec Unwatering and Dewatering Memo (4/19/19). Assume effort consistent with the closure plan.
			11,100	KWH	74	0	KWH per hour	electricity	0	10	15	day	2	0	0	0	0	0	0	0	0	0	0	0	0	0		
			-	-	-	1	vehicle per day	support truck	15	10	15	day	2	0	150	300	900	75	500	0	0	0	0	0	0	0		
	2.3.4 Dewatering and Stormwater Management	Excavate dewatering ditches and install dewatering sumps	10,600	CY	540	1	equipment per day	track hoe excavator	0	10	20	day	1	0	200	200	600	0	0	0	0	0	0	0	0	0	Assume dewatering to a depth of 10 feet with 15-foot ditches and sumps. Assume 1,000 LF of 15-foot, 1:1 slope ditches, 4-foot base. Assume effort consistent with the closure plan.	RSMeans 3123 1613 0130.
			-	-	-	1	equipment per day	articulating dump truck	12	10	20	day	1	0	200	200	600	0	0	0	0	240	0	0	0	0		
			-	-	-	1	equipment per day	dozer	0	10	20	day	1	0	200	200	600	0	0	0	0	0	0	0	0	0		
			-	-	-	1	equipment per day	smooth drum roller	0	10	20	day	1	0	200	200	600	0	0	0	0	0	0	0	0	0		
			-	-	-	1	vehicle per day	support truck	0	10	20	day	1	0	200	200	0	100	500	0	0	0	0	0	0	0		
		Dewater for Excavation	17	MG	0	3	equipment per day	sump pump	0	10	730	day	1	0	21,900	7,300	21,900	0	0	0	0	0	0	0	0	0	Assume 3 sump locations, 7 days per week for 6 months dewatering. Assume stormwater management for 3 years. Assume 40 hp pump. Assume effort consistent with the closure plan.	Volumes provided in Stantec Unwatering and Dewatering Memo (4/19/19). Assume effort consistent with the closure plan.
			810,300	KWH	111	0	KWH per hour	electricity	0	10	730	day	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
		Stormwater Management	99	MG	0	3	equipment per day	sump pump	0	10	1,095	day	1	0	32,850	10,950	32,850	0	0	0	0	0	0	0	0	0		
			1,215,450	KWH	111	0	KWH per hour	electricity	0	10	1,095	day	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
			-	-	-	1	vehicle per day	support truck	15	10	1,825	day	0	0	18,250	0	0	9,125	500	0	0	0	0	0	0	0		
	2.3.5 Soil Stripping and Stockpiling	Excavation and loading soil	119,500	BCY	3,400	1	equipment per day	track hoe excavator	0	10	25	day	1	0	250	250	750	0	0	0	0	0	0	0	0	0	Soil to be stockpiled onsite and used to regraded excavated areas.	A swell of 20% was included. Production rate based on 0.75 mile around trip onsite with a speed of 10 MPH, wait time of 25 minutes and capacity of 34 CYs.
		Hauling and dumping in stockpile	131,450	LCY	544	10	equipment per day	articulating dump truck	12	10	25	day	10	1	2,500	2,750	8,250	0	0	0	0	3,000	0	0	0	0		
		Place and spread in stockpile	131,450	LCY	3,500	1	equipment per day	dozer	0	10	25	day	1	1	250	500	1,500	0	0	0	0	0	0	0	0	0		
		Laborer Support	-	-	-	1	vehicle per day	support truck	15	10	25	day	1	0	250	250	750	125	500	0	0	0	0	0	0	0		

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Worksheet 3.2 - Work Element Details, Equipment, Hours, Labor and Materials Detail (Closure By Removal, Onsite Landfill).

Closure By Removal Closure Plan																												
Alternative Component	Work Element	Details/Questions for Each Work Element	Project Quantity	Project Unit	Production Rate (Unit/Time)	Equipment Amount	Equipment Units	Equipment/ Material	One way travel per day (miles) for vehicles	hrs	total time	unit	# Drivers	# Additional Workers per day	Equipment and Vehicle Total Hours	Labor Total Hours	Daily Labor Mobilization Miles	Vehicles Miles Onsite	Vehicle Mob/Demob Mileage	Equipment Mobilization Miles - Unloaded	Equipment Mobilization Miles - Loaded	Daily Equipment Miles Onsite	Daily Haul Truck Miles - Unloaded	Daily Haul Truck Miles - Loaded	Material Delivery Miles - Unloaded	Material Delivery Miles - Loaded	Notes	Production Rate / Duration Reference
2.3 NEAP Closure	2.3.6 Excavate CCR Material and Haul to Landfill	Excavate and load CCR	376,000	BCY	3,400	2	equipment per day	track hoe excavator	0	10	185	day	2	0	3,700	3,700	11,100	0	0	0	0	0	0	0	0	0	Excavation of CCR from the NEAP and hauling to onsite landfill. Includes 1-ft overexcavation.	A swell of 10% was included. Production rate based on 1 mile around trip onsite with a speed of 10 MPH, wait time of 15 minutes and capacity of 34 CYs. Roughly 2,200 CY/DAY.
		Hauling and dumping	413,600	LCY	476	5	haul trucks per day	articulating dump truck	12	10	185	day	5	1	8,695	10,545	31,635	0	0	0	0	0	10,434	10,434	0	0		
		Laborer Support	-	-	-	1	vehicle per day	support truck	15	10	185	day	1	1	1,850	3,700	11,100	925	500	0	0	0	0	0	0	0		
		Moisture conditioning	413,600	LCY	10,000	1	equipment per day	tractor pulled disc	0	10	42	day	1	0	420	420	1,260	0	0	0	0	0	0	0	0	0	In place MC is ~59% and assume a target of ~30%. All samples were above 30%, assume conditioning of total quantity. All samples had a MC over 45%.	Assume addition effort from track hoe for above MC 45%.
			413,600	LCY	3,400	1	equipment per day	excavator	0	10	122	day	1	0	1,220	1,220	3,660	0	0	0	0	0	0	0	0	0		
	2.3.7 Seed and Mulch	Hydroseed and mulch	21	AC	2	1	equipment per day	hydroseeder truck	250	10	11	day	1	1	110	220	660	0	0	0	0	2,750	0	0	0	0	Hydromulch assumed.	RSMeans 3292 1913 1100.
			-	-	-	1	vehicle per day	support truck	250	10	11	day	1	0	110	110	5,500	55	500	0	0	0	0	0	0	0		
		Material deliveries	0	TON	24	1	materials	truck delivery - hydroseed/mulch	250	10	0	load	1	0	0	0	0	0	0	0	0	0	0	0	0	0	-	Assume 26 CY truck or 48,000 LB flat bed delivery truck.
	2.3.8 Constructing run off ditches and stormwater outfalls	construction details (earth work volume, materials used)?	4,000	CY	540	1	equipment per day	track hoe excavator	0	10	7	day	1	0	70	70	210	0	0	0	0	0	0	0	0	0	Ditch quantity based on closure plan drawings. Assume effort consistent with the closure plan.	RSMeans 3123 1613 0130.
			-	-	-	1	equipment per day	articulating dump truck	12	10	7	day	1	0	70	70	210	0	0	0	0	84	0	0	0	0		
		Turf reinforcement mat	5,100	SY	2,400	1	vehicle per day	support truck	15	10	2	day	1	1	20	40	120	10	500	0	0	0	0	0	0	0		RSMeans 3125 1416 0020.
		Material deliveries	1	EA	1	1	materials	truck delivery - turf reinforcement mat	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250	Assume to be delivered in 1 load.	Assume 26 CY truck or 48,000 LB flat bed delivery truck.
			42	EA	26	1	materials	truck delivery - riprap	250	10	2	load	1	0	20	20	0	0	0	0	0	0	0	0	500	500	Assume 3 aprons at 150 SF.	
			0	EA	0	0	materials	truck delivery - pipe material	250	10	0	load	1	0	0	0	0	0	0	0	0	0	0	0	0	0	Piping not currently included in design.	
			0	EA	0	0	materials	truck delivery - discharge pipe(s)	250	10	0	load	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	2.3.9 Install monitoring / observation wells	Drilling for monitoring well installations and abandonments	4	EA	1	1	equipment per day	drilling rig	0	10	6	day	1	0	60	60	180	0	0	0	0	0	0	0	0	0	Installed to a depth of 30-40 feet. Includes 2 days for mobilization/demobilization.	Install 4 new monitoring wells.
			-	-	-	1	vehicle per day	support truck	15	10	6	day	1	0	60	60	180	30	500	0	0	0	0	0	0	0		
			-	-	-	1	equipment per day	skid steer	0	10	6	day	1	0	60	60	180	0	0	0	0	0	0	0	0	0		
		Clearing for monitoring wells	-	-	-	1	equipment per day	track hoe excavator	0	10	1	day	1	0	10	10	30	0	0	0	0	0	0	0	0	0	2 locations are currently vegetated.	
		Material deliveries	1	EA	1	1	materials	truck delivery - flush mount	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250	Assume to be delivered in 1 load.	Assume 26 CY truck or 48,000 LB flat bed delivery truck.
			1	EA	1	1	materials	truck delivery - well steel	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250		
			1	EA	1	1	materials	truck delivery - PVC	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250		
			1	EA	1	1	materials	truck delivery - sand	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250		
			1	EA	1	1	materials	truck delivery - bentonite	1,000	37	1	load	1	0	37	37	0	0	0	0	0	0	0	0	1,000	1,000		
			1	EA	1	1	materials	truck delivery - cement	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250		
	2.3.10 General Grading	Excavate and load from stockpile	7,800	BCY	3,400	2	equipment per day	track hoe excavator	0	10	2	day	2	0	40	40	120	0	0	0	0	0	0	0	0	0	To promote positive drainage ash is removed. Assumes onsite material from soil stripping and other sources.	A swell of 20% was included. Production rate based on 0.75 mile around trip onsite with a speed of 10 MPH, wait time of 25 minutes and capacity of 34 CYs.
		Hauling and dumping general fill	9,360	LCY	544	10	equipment per day	articulating dump truck	12	10	2	day	10	0	200	200	600	0	0	0	0	240	0	0	0	0		
		Place and spread general fill	9,360	LCY	3,500	2	equipment per day	dozer	0	10	2	day	2	0	40	40	120	0	0	0	0	0	0	0	0	0		
		Compact general fill	9,360	LCY	2,400	3	equipment per day	sheepsfoot roller	0	10	2	day	3	0	60	60	180	0	0	0	0	0	0	0	0	0		
		Laborer Support	-	-	-	1	vehicle per day	support truck	15	10	2	day	1	0	20	20	60	10	500	0	0	0	0	0	0	0		

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Worksheet 3.2 - Work Element Details, Equipment, Hours, Labor and Materials Detail (Closure By Removal, Onsite Landfill).

Closure By Removal Closure Plan

Alternative Component	Work Element	Details/Questions for Each Work Element	Project Quantity	Project Unit	Production Rate (Unit/Time)	Equipment Amount	Equipment Units	Equipment/ Material	One way travel per day (miles) for vehicles	hrs	total time	unit	# Drivers	# Additional Workers per day	Equipment and Vehicle Total Hours	Labor Total Hours	Daily Labor Mobilization Miles	Vehicles Miles Onsite	Vehicle Mob/Demob Mileage	Equipment Mobilization Miles - Unloaded	Equipment Mobilization Miles - Loaded	Daily Equipment Miles Onsite	Daily Haul Truck Miles - Unloaded	Daily Haul Truck Miles - Loaded	Material Delivery Miles - Unloaded	Material Delivery Miles - Loaded	Notes	Production Rate / Duration Reference
2.4 Long Term Operations and Maintenance	2.4.1 Groundwater Monitoring	Years During construction (quarterly sampling)	20	TRIP	1	1	vehicle per day	support truck (daily mob)	250	28	20	day	1	1	560	1,120	20,000	100	0	0	0	0	0	0	0	0	Assumes 8 hours round trip travel (STL to Site) and 20 hours on site. Assume 2 person crew for safety.	Sampling intervals noted in closure plan by Others. NAP: 16 monitoring wells will be sampled and 15 observations wells will be read each trip. NEAP: 8 monitoring wells will be sampled per trip. Based on Geosyntec experience. Added sampling for 4.8 years of construction based on Owner comments.
		Years 1-5 (quarterly sampling)	20	TRIP	1	1	vehicle per day	support truck (daily mob)	250	28	20	day	1	1	560	1,120	20,000	100	0	0	0	0	0	0	0	0		
		Years 6-10 (semiannual sampling)	10	TRIP	1	1	vehicle per day	support truck (daily mob)	250	28	10	day	1	1	280	560	10,000	50	0	0	0	0	0	0	0	0		
		Years 11-30 (annual sampling)	20	TRIP	1	1	vehicle per day	support truck (daily mob)	250	28	20	day	1	1	560	1,120	20,000	100	0	0	0	0	0	0	0	0		
		Field Equipment	70	TRIP	1	1	field equipment	water level meter	0	28	70	day	0	0	1,960	0	0	0	0	0	0	0	0	0	0	0		
			70	TRIP	1	1	field equipment	ground water sampler	0	28	70	day	0	0	1,960	0	0	0	0	0	0	0	0	0	0	0		
			70	TRIP	1	8	field equipment	sample containers	0	28	70	day	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
			70	TRIP	1	1	field equipment	pH meter	0	28	70	day	0	0	1,960	0	0	0	0	0	0	0	0	0	0	0		
			70	TRIP	1	1	field equipment	thermometer	0	28	70	day	0	0	1,960	0	0	0	0	0	0	0	0	0	0	0		
			70	TRIP	1	1	field equipment	specific conductance meter	0	28	70	day	0	0	1,960	0	0	0	0	0	0	0	0	0	0	0		
		Lab Testing	70	EA	22	1	lab test	boron test	0	1	1,540	test	0	1	1,540	1,540	46,200	0	0	0	0	0	0	0	0	0	Each trip.	
			70	EA	22	1	lab test	manganese test	0	1	1,540	test	0	1	1,540	1,540	46,200	0	0	0	0	0	0	0	0	0	Each trip.	
			8	EA	22	1	lab test	silver test	0	1	176	test	0	1	176	176	5,280	0	0	0	0	0	0	0	0	0	1st 8 quarterly trips.	
			70	EA	22	1	lab test	total dissolved solids test	0	1	1,540	test	0	1	1,540	1,540	46,200	0	0	0	0	0	0	0	0	0	Each trip.	
			70	EA	22	1	lab test	total sulfate	0	1	1,540	test	0	1	1,540	1,540	46,200	0	0	0	0	0	0	0	0	0	Each trip.	
			8	EA	22	1	lab test	radium 226	0	1	176	test	0	1	176	176	5,280	0	0	0	0	0	0	0	0	0	1st 8 quarterly trips.	
			8	EA	22	1	lab test	radium 228	0	1	176	test	0	1	176	176	5,280	0	0	0	0	0	0	0	0	0	1st 8 quarterly trips.	
	2.4.2 Surface Water Monitoring	Years During construction (weekly sampling)	250	TRIP	1	1	vehicle per day	support truck (daily mob)	250	16	250	day	1	1	4,000	8,000	250,000	1,250	0	0	0	0	0	0	0	0	Assumes 8 hours round trip travel (STL to Site) and 8 hours on site. Assume 2 person crew for safety.	Sampling intervals are weekly for Outfalls 001 (NAP) and 003 (NEAP) as noted in permit. Based on Geosyntec experience. Added sampling for 4.8 years of construction based on Owner comments.
		Years 1-30 (weekly sampling)	1,560	TRIP	1	1	vehicle per day	support truck (daily mob)	250	16	1,560	day	1	1	24,960	49,920	1,560,000	7,800	0	0	0	0	0	0	0	0		
		Lab Testing	1,810	TRIP	2	1	lab test	total suspended solids	0	1	3,620	test	0	1	3,620	3,620	108,600	0	0	0	0	0	0	0	0	0	Each trip. 24 hour composite sample.	
			453	TRIP	2	1	lab test	oil and grease	0	1	905	test	0	1	905	905	27,150	0	0	0	0	0	0	0	0	0	Monthly. Grab sample.	
			1,810	TRIP	2	1	lab test	total dissolved solids	0	1	3,620	test	0	1	3,620	3,620	108,600	0	0	0	0	0	0	0	0	0	Each trip. 24 hour composite sample.	
			1,810	TRIP	2	1	lab test	sulfates	0	1	3,620	test	0	1	3,620	3,620	108,600	0	0	0	0	0	0	0	0	0	Each trip. 24 hour composite sample.	
			1,810	TRIP	2	1	lab test	boron	0	1	3,620	test	0	1	3,620	3,620	108,600	0	0	0	0	0	0	0	0	0	Each trip. 24 hour composite sample.	
			453	TRIP	2	1	lab test	iron	0	1	905	test	0	1	905	905	27,150	0	0	0	0	0	0	0	0	0	Monthly. 24 hour composite sample.	

	Equipment and Vehicle Total Hours	Labor Total Hours	Daily Labor Mobilization Miles	Vehicles Miles Onsite	Vehicle Mob/Demob Mileage	Equipment Mobilization Miles - Unloaded	Equipment Mobilization Miles - Loaded	Daily Equipment Miles Onsite	Daily Haul Truck Miles - Unloaded	Daily Haul Truck Miles - Loaded	Material Delivery Miles - Unloaded	Material Delivery Miles - Loaded
Selected Closure Plan Totals	**597,004**	**464,574**	**4,230,493**	**113,035**	**21,500**	**44,250**	**44,250**	**48,650**	**67,828**	**67,828**	**144,500**	**144,500**

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Worksheet 3.3 - Work Element Details, Equipment, Hours, Labor and Materials Detail (Onsite Landfill).

Onsite Landfill																												
Component	Work Element	Details/Questions for Each Work Element	Project Quantity	Project Unit	Production Rate (Unit/Time)	Equipment Amount	Equipment Units	Equipment/ Material	One way travel per day (miles) for vehicles	hrs	total time	unit	# Drivers	# Additional Workers per day	Equipment and Vehicle Total Hours	Labor Total Hours	Daily Labor Mobilization Miles	Vehicles Miles Onsite	Vehicle Mob/Demob Mileage	Equipment Mobilization Miles - Unloaded	Equipment Mobilization Miles - Loaded	Daily Equipment Miles Onsite	Daily Haul Truck Miles - Unloaded	Daily Haul Truck Miles - Loaded	Material Delivery Miles - Unloaded	Material Delivery Miles - Loaded	Notes	Production Rate / Duration Reference
3.1 Onsite Landfill	3.1.1 Preconstruction Tasks	Conduct landfill design exploration and laboratory testing program	-	-	-	1	equipment per day	drilling rig	0	10	20	day	1	1	200	400	1,200	0	0	0	0	0	0	0	0	0	Scope not defined. Work depicted assumed based on current understanding of the project. Drilling crew consists of three workers (engineer, driller, helper). Materials brought to the site by the drilling crew.	4 weeks, to be refined during design or gap analysis phase.
			-	-	-	2	vehicle per day	support truck	15	10	20	day	1	0	400	200	600	200	500	0	0	0	0	0	0	0		
			-	-	-	1	equipment per day	skid steer	0	10	20	day	0	0	200	0	0	0	0	0	0	0	0	0	0	0		
			4,000	LB	-	0	materials	truck delivery - bentonite	250	10	0	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
			15,040	LB	-	0	materials	truck delivery - cement	250	10	0	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
		Lab testing	-	-	-	1	vehicle per day	ship samples	250	10	1	day	1	0	10	10	500	5	0	0	0	0	0	0	0	0	Lab testing assumed based on experience with similar projects.	
			50	EA	-	0	lab test	moisture content	0	0	50	test	0	1	0	13	1,500	0	0	0	0	0	0	0	0	0		
			10	EA	-	0	lab test	classification testing	0	3	10	test	0	1	0	30	300	0	0	0	0	0	0	0	0	0		
			6	EA	-	0	lab test	Proctor testing	0	4	6	test	0	1	0	24	180	0	0	0	0	0	0	0	0	0		
			5	EA	-	0	lab test	liner destructive testing	0	4	5	test	0	1	0	20	150	0	0	0	0	0	0	0	0	0		
			5	EA	-	0	lab test	liner interface testing	0	4	5	test	0	1	0	20	150	0	0	0	0	0	0	0	0	0		
			52	EA	-	0	lab test	Sieve Analysis	0	4	52	test	0	1	0	207	1,551	0	0	0	0	0	0	0	0	0		
			46	EA	-	0	lab test	Standard Proctor Density	0	4	46	test	0	1	0	185	1,386	0	0	0	0	0	0	0	0	0		
			216	EA	-	0	lab test	Hydraulic Conductivity	0	4	216	test	0	1	0	863	6,469	0	0	0	0	0	0	0	0	0		
			6	EA	-	0	lab test	remolded permeability test	0	4	6	test	0	1	0	24	180	0	0	0	0	0	0	0	0	0		
	3.1.2 Project Duration Items	Project duration	-	-	-	0	-	-	0	0	2.4	years	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	Schedule not defined, assume 2.4 years total project duration.
		Owner's representative site visits	-	-	-	1	vehicle per day	support truck (daily mob)	250	10	125	day	1	0	1,250	1,250	62,500	625	0	0	0	0	0	0	0	0	Weekly site visits.	
		Contractor Construction & Safety Managers	-	-	-	2	vehicle per day	support truck	15	10	624	day	2	1	12,480	18,720	56,160	6,240	500	0	0	0	0	0	0	0	Three full time staff.	
		Office facilities	-	-	-	2	equipment per day	work trailer	0	10	624	day	0	0	12,480	0	0	0	0	0	0	0	0	0	0	0	Office Trailer.	
		Electric usage (average per day)	624,000	KWH	100	0	KWH per day	electricity	0	10	624	day	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Assume 50 kWh per trailer.	
		Site specific security	-	-	-	1	vehicle per day	support truck	15	10	624	day	1	0	6,240	6,240	18,720	3,120	500	0	0	0	0	0	0	0	One full time staff.	
		CQA Officer / Engineer site visit	-	-	-	1	vehicle per day	support truck (daily mob)	250	10	125	day	1	0	1,250	1,250	62,500	625	0	0	0	0	0	0	0	0	Weekly site visits.	
		CQA staff	-	-	-	1	vehicle per day	support truck	15	10	624	day	1	0	6,240	6,240	18,720	3,120	500	0	0	0	0	0	0	0	One full time staff.	
		Equipment mobilization	-	-	-	139	equipment mob	heavy equipment mob	250	10	1	mob	139	0	1,390	1,390	4,260	0	0	34,750	34,750	0	0	0	0	0	Estimated mobilization for heavy equipment. Includes all non vehicles. Vehicles are assumed to travel to the site daily.	
		Equipment fueling	-	-	-	1	vehicle per day	fuel truck	15	2	624	day	1	0	1,248	1,248	18,720	3,120	0	0	0	0	0	0	0	0	Daily refueling.	
		Portable restrooms	-	-	-	1	equipment per day	restroom units	0	10	624	day	0	0	6,240	0	0	0	0	0	0	0	0	0	0	0	Full time.	
		Portable restroom service	-	-	-	1	vehicle per day	maintenance vehicle	15	2	125	day	1	0	250	250	3,750	625	0	0	0	0	0	0	0	0		
		Dust suppression	-	-	-	1	equipment per day	water truck	12	10	624	day	1	0	6,240	6,240	18,720	0	0	0	0	7,488	0	0	0	0		
		Groundwater monitoring	-	-	-	0	-	-	0	0	0	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Monitoring included in Task 3.2.	-
		NPDES monitoring	-	-	-	0	-	-	0	0	0	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	3.1.3 Install EPSC Measures	Silt fence	5,000	LF	1,300	1	vehicle per day	support truck	15	10	4	day	1	1	40	80	240	20	500	0	0	0	0	0	0	0	Assumed for entire perimeter	RSMeans 3125 1416 1000.
		Riprap & rock check dams	-	-	-	1	equipment per day	track hoe	0	10	1	day	1	0	10	10	30	0	0	0	0	0	0	0	0	0	Installation and removal.	-
			-	-	-	1	vehicle per day	support truck	15	10	1	day	1	1	10	20	60	5	500	0	0	0	0	0	0	0		-
		Waddles	-	-	-	1	vehicle per day	support truck	15	10	1	day	1	1	10	20	60	5	500	0	0	0	0	0	0	0	-	-
		Material deliveries	100	CY	26	1	materials	truck delivery - riprap	250	10	4	load	1	0	40	40	0	0	0	0	0	0	0	0	1,000	1,000	Assumed 100 cubic yards.	Assume 26 CY truck or 48,000 LB flat bed delivery truck.
			1	EA	1	1	materials	truck delivery - waddles	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250		
			1	EA	1	1	materials	truck delivery - silt fence	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250		
	3.1.4 Stripping, Landfill Area, Excavating and Stockpiling	Excavation and loading soil	1,325,000	BCY	3,400	1	equipment per day	track hoe excavator	0	10	347	day	1	0	3,470	3,470	9,630	0	0	0	0	0	0	0	0	0	Soil to be stockpiled onsite and used to regraded excavated areas.	Production rate based on 0.75 mile around trip onsite with a speed of 10 MPH, wait time of 25 minutes and capacity of 34 CYs.
		Hauling and dumping in stockpile	1,766,666	LCY	510	10	equipment per day	articulating dump truck	12	10	347	day	10	1	34,700	38,170	105,930	0	0	0	0	41,640	0	0	0	0		
		Place and spread in stockpile	1,766,666	LCY	3,500	1	equipment per day	dozer	0	10	347	day	1	1	3,470	6,940	19,260	0	0	0	0	0	0	0	0	0		
		Laborer Support	-	-	-	1	vehicle per day	support truck	15	10	347	day	1	0	3,470	3,470	9,630	1,605	500	0	0	0	0	0	0	0		

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Worksheet 3.3 - Work Element Details, Equipment, Hours, Labor and Materials Detail (Onsite Landfill).

Onsite Landfill

Component	Work Element	Details/Questions for Each Work Element	Project Quantity	Project Unit	Production Rate (Unit/Time)	Equipment Amount	Equipment Units	Equipment/ Material	One way travel per day (miles) for vehicles	hrs	total time	unit	# Drivers	# Additional Workers per day	Equipment and Vehicle Total Hours	Labor Total Hours	Daily Labor Mobilization Miles	Vehicles Miles Onsite	Vehicle Mob/Demob Mileage	Equipment Mobilization Miles - Unloaded	Equipment Mobilization Miles - Loaded	Daily Equipment Miles Onsite	Daily Haul Truck Miles - Unloaded	Daily Haul Truck Miles - Loaded	Material Delivery Miles - Unloaded	Material Delivery Miles - Loaded	Notes	Production Rate / Duration Reference
3.1 Onsite Landfill	3.1.5 Composite Bottom Liner System	Excavation and loading of low permeability layer from Stockpile	144,444	BCY	3,400	1	equipment per day	track hoe excavator	0	10	34	day	1	0	340	340	1,020	0	0	0	0	0	0	0	0	0	Bottom liner to be excavated at least 30 feet over 26 acres.	Production rate based on 0.75 mile around trip onsite with a speed of 10 MPH, wait time of 25 minutes and capacity of 34 CYs.
		Hauling and dumping of low permeability layer from Stockpile	173,333	LCY	510	10	equipment per day	articulating dump truck	12	10	34	day	10	0	3,400	3,400	10,200	0	0	0	0	4,080	0	0	0	0		
		Place and spread low permeability layer	173,333	LCY	3,500	1	equipment per day	dozer	0	10	34	day	1	0	340	340	1,020	0	0	0	0	0	0	0	0	0		
		Compact low permeability layer	173,333	LCY	2,400	1	equipment per day	sheepsfoot roller	0	10	34	day	1	0	340	340	1,020	0	0	0	0	0	0	0	0	0		
		Compact - fine finish	173,333	LCY	4,100	1	equipment per day	smooth drum roller	0	10	34	day	1	0	340	340	1,020	0	0	0	0	0	0	0	0	0		
		Laborer Support	-	-	-	1	vehicle per day	support truck	15	10	34	day	1	0	340	340	1,020	170	500	0	0	0	0	0	0	0		
		Construct a test pad	1	EA	1	1	equipment per day	track hoe excavator	0	10	1	day	1	0	10	10	30	0	0	0	0	0	0	0	0	0	-	Assume to be completed in 1 day.
			-	-	-	1	equipment per day	articulating dump truck	12	10	1	day	1	0	10	10	30	0	0	0	0	12	0	0	0	0	-	
			-	-	-	1	equipment per day	dozer	0	10	1	day	1	0	10	10	30	0	0	0	0	0	0	0	0	0	-	
			-	-	-	1	equipment per day	smooth drum roller	0	10	1	day	1	1	10	20	60	0	0	0	0	0	0	0	0	0	-	
		Slope Liner (60 MIL HDPE Geomembrane)	130,680	SY	9,000	2	equipment per day	front end loader (with roller bar)	0	10	16	day	2	0	320	320	960	0	0	0	0	0	0	0	0	0	Geomembrane.	Area noted in closure plan and associated cost estimates by Others. Based on Geosyntec experience. Includes two days for demobilization.
			130,680	SY	-	2	equipment per day	welder	0	10	16	day	2	0	320	320	960	0	0	0	0	0	0	0	0	0		
			130,680	SY	-	2	vehicle per day	support truck	15	10	16	day	2	10	320	1,920	5,760	160	500	0	0	0	0	0	0	0		
		Material deliveries	107	ROLLS	20	1	vehicle per day	truck delivery - geomembrane	1,000	37	6	load	1	0	222	222	12,000	30	0	0	0	0	0	0	0	0		Assumes 48,000 LB flat bed trailer.
		Geotextile - 8 oz/sy cushion	130,680	SY	18,000	2	equipment per day	front end loader (with roller bar)	0	10	10	day	2	0	200	200	600	0	0	0	0	0	0	0	0	0	-	-
			130,680	SY	-	2	vehicle per day	support truck	15	10	10	day	2	8	200	1,000	3,000	100	500	0	0	0	0	0	0	0	-	-
		Material deliveries	330	ROLLS	27	1	materials	truck delivery - geotextile	250	37	14	load	1	0	518	518	0	0	0	0	0	0	0	0	3,500	3,500	-	-
	3.1.6 Landfill Leachate Collection and Transmission System	Place and spread 1-foot thick sand layer and gravel for V-trench	45,465	LCY	3,500	1	equipment per day	dozer	0	10	9	day	1	0	90	90	270	0	0	0	0	0	0	0	0	0	Drainage layer.	-
		Laborer Support	-	-	-	1	vehicle per day	support truck	15	10	9	day	1	0	90	90	270	45	500	0	0	0	0	0	0	0	-	-
		Material deliveries	1	EA	1	1	materials	truck delivery - sand	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250	-	-
			4	EA	1	1	materials	truck delivery - collection pipe material	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250	-	-
			4	EA	1	1	materials	truck delivery - pumps	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250	-	-
			1	EA	1	1	materials	truck delivery - Gravel	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250	-	-
			1	EA	1	1	materials	truck delivery - Tank	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250	-	-
			4	EA	1	1	materials	truck delivery - riser pipe material	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250	-	-
			4	EA	1	1	materials	truck delivery - forcemain pipe material	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250	-	-
			4	EA	1	1	materials	truck delivery - electric control panel	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250	-	-
			4	EA	1	1	materials	truck delivery - sump pumps	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250	-	-
			1	EA	1	1	materials	truck delivery - leachate storage tanks	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250	-	-
			1	EA	1	1	materials	truck delivery load-out facility	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250	-	-
		Geotextile - 4 oz/sy cushion	130,680	SY	18,000	2	equipment per day	front end loader (with roller bar)	0	10	10	day	2	0	200	200	600	0	0	0	0	0	0	0	0	0	-	-
			130,680	SY	-	2	vehicle per day	support truck	15	10	10	day	2	8	200	1,000	3,000	100	500	0	0	0	0	0	0	0	-	-
		Material deliveries	330	ROLLS	27	1	materials	truck delivery - geotextile	250	37	14	load	1	0	518	518	0	0	0	0	0	0	0	0	3,500	3,500	-	-
	3.1.7 Access Road at Borrow Area and Landfill	Hauling and dumping coarse aggre	2,366	LCY	0	2	equipment per day	articulating dump truck	12	10	3	day	2	0	60	60	180	0	0	0	0	72	0	0	0	0	Assumed 6-inches of base coarse aggregate, 20-ft wide	-
		Place and spread coarse aggregate	2,366	LCY	3,500	3	equipment per day	dozer	0	10	3	day	3	0	90	90	270	0	0	0	0	0	0	0	0	0		-
		Laborer Support	-	-	-	1	vehicle per day	support truck	15	10	3	day	1	0	30	30	90	15	500	0	0	0	0	0	0	0		-
		Material deliveries	1	EA	1	1	materials	truck delivery - coarse aggregatre	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250		-
			56	ROLLS	27	1	materials	truck delivery - geotextile	250	37	4	load	1	0	148	148	0	0	0	0	0	0	0	0	1,000	1,000		-
	3.1.8 Landfill Daily Operations	Place and spread CCR material	2,847,900	LCY	3,500	4	equipment per day	dozer	0	10	1,446	day	4	0	57,840	57,840	173,520	0	0	0	0	0	0	0	0	0	-	-
		Compact CCR material	2,847,900	LCY	4,100	4	equipment per day	smooth drum roller	0	10	1,446	day	4	0	57,840	57,840	173,520	0	0	0	0	0	0	0	0	0	-	-
		Laborer Support	-	-	-	1	vehicle per day	support truck	15	10	1,446	day	1	1	14,460	28,920	86,760	7,230	500	0	0	0	0	0	0	0	-	-
		Excavate and load daily cover	21,758	BCY	3,400	1	equipment per day	track hoe excavator	0	10	5	day	1	0	50	50	150	0	0	0	0	0	0	0	0	0	To promote positive drainage once the ash is removed from the OEAP and Secondary NAP. Assumes onsite material from soil stripping and other sources. OEAP is not assumed to be usable.	Volume noted in closure plan and associated cost estimates by Others. Volume provided is 105,000 CYs for all 3 ash ponds. Assume 95,000 CYs for NEAP, consistent with volume provided for Options 2 and 4 as noted in the cost estimates. A shrink/swell of 10/20% was included. Production rate based on 0.75 mile around trip onsite with a speed of 10 MPH, wait time of 25 minutes and capacity of 34 CYs.
		Hauling and dumping daily cover	21,758	LCY	510	10	equipment per day	articulating dump truck	12	10	5	day	10	0	500	500	1,500	0	0	0	0	600	0	0	0	0		
		Place and spread daily cover	21,758	LCY	3,500	1	equipment per day	dozer	0	10	5	day	1	0	50	50	150	0	0	0	0	0	0	0	0	0		
		Laborer Support	-	-	-	1	vehicle per day	support truck	15	10	5	day	1	0	50	50	150	25	500	0	0	0	0	0	0	0		
		Excavate and load intermediate cover	43,516	BCY	3,400	1	equipment per day	track hoe excavator	0	10	9	day	1	0	90	90	270	0	0	0	0	0	0	0	0	0	To promote positive drainage once the ash is removed from the OEAP and Secondary NAP. Assumes onsite material from soil stripping	Volume noted in closure plan and associated cost estimates by Others. Volume provided is 105,000 CYs for all 3 ash ponds. Assume 95,000 CYs for NEAP, consistent with volume provided for Options 2 and 4 as noted in the cost
		Hauling and dumping intermediate	43,516	LCY	510	10	equipment per day	articulating dump truck	12	10	9	day	10	0	900	900	2,700	0	0	0	0	1,080	0	0	0	0		
		Place and spread intermediate cove	43,516	LCY	3,500	1	equipment per day	dozer	0	10	9	day	1	0	90	90	270	0	0	0	0	0	0	0	0	0		

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Worksheet 3.3 - Work Element Details, Equipment, Hours, Labor and Materials Detail (Onsite Landfill).

Onsite Landfill

Component	Work Element	Details/Questions for Each Work Element	Project Quantity	Project Unit	Production Rate (Unit/Time)	Equipment Amount	Equipment Units	Equipment/ Material	One way travel per day (miles) for vehicles	hrs	total time	unit	# Drivers	# Additional Workers per day	Equipment and Vehicle Total Hours	Labor Total Hours	Daily Labor Mobilization Miles	Vehicles Miles Onsite	Vehicle Mob/Demob Mileage	Equipment Mobilization Miles - Unloaded	Equipment Mobilization Miles - Loaded	Daily Equipment Miles Onsite	Daily Haul Truck Miles - Unloaded	Daily Haul Truck Miles - Loaded	Material Delivery Miles - Unloaded	Material Delivery Miles - Loaded	Notes	Production Rate / Duration Reference
		Laborer Support	-	-	-	1	vehicle per day	support truck	15	10	9	day	1	0	90	90	270	45	500	0	0	0	0	0	0	0	and other sources. OEAP is not assumed to be usable.	estimates. A shrink/swell of 10/20% was included. Production rate based on 0.75 mile around trip onsite with a speed of 10 MPH, wait time of 25 minutes and capacity of 34 CYs.
3.1 Onsite Landfill	3.1.9 Landfill Composite Final Cover System	Excavation and loading of low permeability layer	48,111	BCY	3,400	1	equipment per day	track hoe excavator	0	10	12	day	1	0	120	120	360	0	0	0	0	0	0	0	0	0	-	-
		Hauling and dumping of low permeability layer	57,733	LCY	510	10	equipment per day	articulating dump truck	12	10	12	day	10	0	1,200	1,200	3,600	0	0	0	0	1,440	0	0	0	0	-	-
		Place and spread low permeability layer	57,733	LCY	3,500	1	equipment per day	dozer	0	10	12	day	1	0	120	120	360	0	0	0	0	0	0	0	0	0	-	-
		Compact low permeability layer	57,733	LCY	2,400	1	equipment per day	sheepsfoot roller	0	10	12	day	1	0	120	120	360	0	0	0	0	0	0	0	0	0	-	-
		Laborer Support	-	-	-	1	vehicle per day	support truck	15	10	12	day	1	0	120	120	360	60	500	0	0	0	0	0	0	0	-	-
		Double Sided Geocomposite Drainage Layer	130,680	SY	18,000	2	equipment per day	front end loader (with roller bar)	0	10	10	day	2	0	200	200	600	0	0	0	0	0	0	0	0	0	-	-
			130,680	SY	-	2	vehicle per day	support truck	15	10	10	day	2	8	200	1,000	3,000	100	500	0	0	0	0	0	0	0	-	-
		Material deliveries	330	ROLLS	27	1	materials	truck delivery - geocomposite	1,000	37	14	load	1	0	518	518	0	0	0	0	0	0	0	0	14,000	14,000	-	-
		40 MIL LLDPE Geomembrane	130,680	SY	9,000	2	equipment per day	front end loader (with roller bar)	0	10	15	day	2	0	300	300	900	0	0	0	0	0	0	0	0	0	Geomembrane.	Area noted in closure plan and based on conceptual design. Based on Geosyntec experience. Includes two days for demobilization.
			130,680	SY		3	equipment per day	welder	0	10	15	day	3	0	450	450	1,350	0	0	0	0	0	0	0	0	0		
			130,680	SY	-	2	vehicle per day	support truck	15	10	15	day	2	10	300	1,800	5,400	150	500	0	0	0	0	0	0	0		
		Material deliveries	107	ROLLS	20	1	materials	truck delivery - geomembrane	1,000	37	6	load	1	0	222	222	0	0	0	0	0	0	0	0	6,000	6,000		Assumes 48,000 LB flat bed trailer.
		Excavation and loading of protective cover soil	130,000	BCY	3,400	1	equipment per day	track hoe excavator	0	10	29	day	1	0	290	290	840	0	0	0	0	0	0	0	0	0	-	-
		Hauling and dumping of protective cover soil	143,000	LCY	510	10	equipment per day	articulating dump truck	12	10	29	day	10	0	2,900	2,900	8,400	0	0	0	0	3,480	0	0	0	0	-	-
		Place and spread protective cover soil	143,000	LCY	3,500	1	equipment per day	dozer	0	10	29	day	1	0	290	290	840	0	0	0	0	0	0	0	0	0	-	-
		Laborer Support	-	-	-	1	vehicle per day	support truck	15	10	29	day	1	0	290	290	840	140	500	0	0	0	0	0	0	0	-	-
	3.1.10 Seed and Mulch Final Cover	Hydroseed and mulch	27	AC	2	1	equipment per day	hydroseeder truck	250	10	14	day	1	1	140	280	780	0	0	0	0	3,500	0	0	0	0	Hydromulch assumed.	Area based on conceptual design. RSMeans 3292 1913 1100.
			-	-	-	1	vehicle per day	support truck	250	10	14	day	1	0	140	140	6,500	65	500	0	0	0	0	0	0	0		
		Material deliveries	20	TON	24	1	materials	truck delivery - hydroseed/mulch	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250	-	Assume 26 CY truck or 48,000 LB flat bed delivery truck.
	3.1.11 Stormwater Management	Excavate Detention Basin	20,000	CY	540	3	equipment per day	track hoe excavator	0	10	12	day	3	0	360	360	1,080	0	0	0	0	0	0	0	0	0	Area is estiamted. Basin is not currently designed	RSMeans 3123 1613 0130.
			-	-	-	3	equipment per day	articulating dump truck	12	10	12	day	3	0	360	360	1,080	0	0	0	0	432	0	0	0	0	-	
			-	-	-	1	equipment per day	dozer	0	10	12	day	1	0	120	120	360	0	0	0	0	0	0	0	0	0	-	
			-	-	-	1	equipment per day	smooth drum roller	0	10	12	day	1	0	120	120	360	0	0	0	0	0	0	0	0	0	-	
			-	-	-	1	vehicle per day	support truck	15	10	12	day	1	0	120	120	360	60	500	0	0	0	0	0	0	0	-	
		Hydroseed and mulch for basin	5	AC	2	1	equipment per day	hydroseeder truck	250	10	3	day	1	1	30	60	180	0	0	0	0	750	0	0	0	0	Hydromulch assumed. Basin is not designed so values are estimated.	RSMeans 3292 1913 1100.
			-	-	-	1	vehicle per day	support truck	250	10	3	day	1	0	30	30	1,500	15	500	0	0	0	0	0	0	0		
		Material deliveries	4	TON	24	1	materials	truck delivery - hydroseed/mulch	250	10	0	load	1	0	0	0	0	0	0	0	0	0	0	0	0	0	-	Assume 26 CY truck or 48,000 LB flat bed delivery truck.
			0	EA	0	0	materials	truck delivery - discharge pipe(s), culverts, outlet structure	250	10	0	load	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
		Excavate perimeter stormwater ditches and install outfalls	10,600	CY	540	1	equipment per day	track hoe excavator	0	10	20	day	1	0	200	200	600	0	0	0	0	0	0	0	0	0	-	-
			-	-	-	1	equipment per day	articulating dump truck	12	10	20	day	1	0	200	200	600	0	0	0	0	240	0	0	0	0	-	-
			-	-	-	1	equipment per day	dozer	0	10	20	day	1	0	200	200	600	0	0	0	0	0	0	0	0	0	-	-
			-	-	-	1	equipment per day	smooth drum roller	0	10	20	day	1	0	200	200	600	0	0	0	0	0	0	0	0	0	-	-
			-	-	-	1	vehicle per day	support truck	15	10	20	day	1	0	200	200	600	100	500	0	0	0	0	0	0	0	-	-
		Material deliveries	0	EA	0	0	materials	truck delivery - discharge pipe(s)	250	10	0	load	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
		Terrace berm construction	15,556	CY	540	1	equipment per day	track hoe excavator	0	10	29	day	1	0	290	290	870	0	0	0	0	0	0	0	0	0	Values are estimated.	-
			-	-	-	1	equipment per day	articulating dump truck	12	10	29	day	1	0	290	290	870	0	0	0	0	348	0	0	0	0	-	-
			-	-	-	1	equipment per day	dozer	0	10	29	day	1	0	290	290	870	0	0	0	0	0	0	0	0	0	-	-
			-	-	-	1	equipment per day	smooth drum roller	0	10	29	day	1	0	290	290	870	0	0	0	0	0	0	0	0	0	-	-
			-	-	-	1	vehicle per day	support truck	15	10	29	day	1	0	290	290	870	145	500	0	0	0	0	0	0	0	-	-
		Drainage Downchutes	2,400	CY	540	1	equipment per day	track hoe excavator	0	10	4	day	1	0	40	40	120	0	0	0	0	0	0	0	0	0	Values are estimated.	-
			-	-	-	1	equipment per day	articulating dump truck	12	10	4	day	1	0	40	40	120	0	0	0	0	48	0	0	0	0	-	-
			-	-	-	1	equipment per day	dozer	0	10	4	day	1	0	40	40	120	0	0	0	0	0	0	0	0	0	-	-
			-	-	-	1	equipment per day	smooth drum roller	0	10	4	day	1	0	40	40	120	0	0	0	0	0	0	0	0	0	-	-
			-	-	-	1	vehicle per day	support truck	15	10	4	day	1	0	40	40	120	20	500	0	0	0	0	0	0	0	-	-
		Material deliveries	100	CY	26	1	materials	truck delivery - riprap	250	10	4	load	1	0	40	40	0	0	0	0	0	0	0	0	1,000	1,000	Value is estimated	-

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Worksheet 3.3 - Work Element Details, Equipment, Hours, Labor and Materials Detail (Onsite Landfill).

Onsite Landfill

Component	Work Element	Details/Questions for Each Work Element	Project Quantity	Project Unit	Production Rate (Unit/Time)	Equipment Amount	Equipment Units	Equipment/ Material	One way travel per day (miles) for vehicles	hrs	total time	unit	# Drivers	# Additional Workers per day	Equipment and Vehicle Total Hours	Labor Total Hours	Daily Labor Mobilization Miles	Vehicles Miles Onsite	Vehicle Mob/Demob Mileage	Equipment Mobilization Miles - Unloaded	Equipment Mobilization Miles - Loaded	Daily Equipment Miles Onsite	Daily Haul Truck Miles - Unloaded	Daily Haul Truck Miles - Loaded	Material Delivery Miles - Unloaded	Material Delivery Miles - Loaded	Notes	Production Rate / Duration Reference
3.2 Onsite Landfill Post-Closure Care and Long Term Monitoring	3.2.1 Landfill Cap Inspection and Maintenance	Mowing	-	-	-	1	equipment per day	mower (local)	15	10	120	day	1	0	1,200	1,200	3,600	0	0	0	0	1,800	0	0	0	0	Quarterly mowing for 30 years. Local equipment.	-
			-	-	-	1	vehicle per day	support truck	15	10	120	day	1	0	1,200	1,200	3,600	600	500	0	0	0	0	0	0	0		
		Maintenance	-	-	-	1	equipment per day	track hoe (local)	0	10	120	day	1	0	1,200	1,200	3,600	0	0	0	0	0	0	0	0	0	Quarterly maintenance for 30 years. Local equipment.	-
			-	-	-	1	vehicle per day	support truck (local)	15	10	120	day	1	0	1,200	1,200	3,600	600	0	0	0	0	0	0	0	0		
		Inspections	-	-	-	1	vehicle per day	support truck (local)	15	10	120	day	1	1	1,200	2,400	7,200	600	0	0	0	0	0	0	0	0	Quarterly inspections for 30 years.	-
	3.2.2 Groundwater Monitoring	Years During construction (quarterly sampling)	10	TRIP	1	1	vehicle per day	support truck (daily mob)	250	28	10	day	1	1	280	560	10,000	50	0	0	0	0	0	0	0	0	Assumes 8 hours round trip travel (STL to Site) and 20 hours on site. Assume 2 person crew for safety.	Sampling intervals noted in closure plan. NAP: 16 monitoring wells will be sampled and 15 observations wells will be read each trip. NEAP: 8 monitoring wells will be sampled per trip. Based on Geosyntec experience. Added sampling for 2.4 years of construction based on Owner comments.
		Years 1-5 (quarterly sampling)	20	TRIP	1	1	vehicle per day	support truck (daily mob)	250	28	20	day	1	1	560	1,120	20,000	100	0	0	0	0	0	0	0	0		
		Years 6-10 (semiannual sampling)	10	TRIP	1	1	vehicle per day	support truck (daily mob)	250	28	10	day	1	1	280	560	10,000	50	0	0	0	0	0	0	0	0		
		Years 11-30 (annual sampling)	20	TRIP	1	1	vehicle per day	support truck (daily mob)	250	28	20	day	1	1	560	1,120	20,000	100	0	0	0	0	0	0	0	0		
		Field Equipment	60	TRIP	1	1	field equipment	water level meter	0	28	60	day	0	0	1,680	0	0	0	0	0	0	0	0	0	0	0		
			60	TRIP	1	1	field equipment	ground water sampler	0	28	60	day	0	0	1,680	0	0	0	0	0	0	0	0	0	0	0		
			60	TRIP	1	8	field equipment	sample containers	0	28	60	day	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
			60	TRIP	1	1	field equipment	pH meter	0	28	60	day	0	0	1,680	0	0	0	0	0	0	0	0	0	0	0		
			60	TRIP	1	1	field equipment	thermometer	0	28	60	day	0	0	1,680	0	0	0	0	0	0	0	0	0	0	0		
			60	TRIP	1	1	field equipment	specific conductance meter	0	28	60	day	0	0	1,680	0	0	0	0	0	0	0	0	0	0	0		
		Lab Testing	60	EA	22	1	lab test	boron test	0	1	1,320	test	0	1	1,320	1,320	39,600	0	0	0	0	0	0	0	0	0	Each trip.	
			60	EA	22	1	lab test	manganese test	0	1	1,320	test	0	1	1,320	1,320	39,600	0	0	0	0	0	0	0	0	0	Each trip.	
			8	EA	22	1	lab test	silver test	0	1	176	test	0	1	176	176	5,280	0	0	0	0	0	0	0	0	0	1st 8 quarterly trips.	
			60	EA	22	1	lab test	total dissolved solids test	0	1	1,320	test	0	1	1,320	1,320	39,600	0	0	0	0	0	0	0	0	0	Each trip.	
			60	EA	22	1	lab test	total sulfate	0	1	1,320	test	0	1	1,320	1,320	39,600	0	0	0	0	0	0	0	0	0	Each trip.	
			8	EA	22	1	lab test	radium 226	0	1	176	test	0	1	176	176	5,280	0	0	0	0	0	0	0	0	0	1st 8 quarterly trips.	
			8	EA	22	1	lab test	radium 228	0	1	176	test	0	1	176	176	5,280	0	0	0	0	0	0	0	0	0	1st 8 quarterly trips.	
	3.2.3 Leachate Removal and Maintenance	Leachate removal and jetting	296	TRIP	-	1	vehicle per day	5,000 gal. tanker truck	250	10	1	load	1	0	10	10	500	5	0	0	0	0	0	0	0	0	Assumed 5 gallons per acre per day for leachate generation over 30 years, and removal by a 5,000-gallon tanker truck and disposal at the nearest POTW.	-
		Replacement of leachate pumps	40	EA	1	1	materials	truck delivery - pumps	250	10	1	load	1	0	10	10	0	0	0	0	0	0	0	0	250	250	Replacement of 4 pumps every 3 years for 30 years	-
	3.2.4 Surface Water Monitoring	Years During construction (weekly sampling)	125	TRIP	1	1	vehicle per day	support truck (daily mob)	250	16	125	day	1	1	2,000	4,000	125,000	625	0	0	0	0	0	0	0	0	Assumes 8 hours round trip travel (STL to Site) and 8 hours on site. Assume 2 person crew for safety.	Sampling intervals are weekly for Outfalls 001 (NAP) and 003 (NEAP) as noted in permit. Based on Geosyntec experience. Added sampling for 2.4 years of construction based on Owner comments.
		Years 1-30 (weekly sampling)	1,560	TRIP	1	1	vehicle per day	support truck (daily mob)	250	16	1,560	day	1	1	24,960	49,920	1,560,000	7,800	0	0	0	0	0	0	0	0		
		Lab Testing	1,685	TRIP	2	1	lab test	total suspended solids	0	1	3,370	test	0	1	3,370	3,370	101,100	0	0	0	0	0	0	0	0	0	Each trip. 24 hour composite sample.	
			421	TRIP	2	1	lab test	oil and grease	0	1	843	test	0	1	843	843	25,275	0	0	0	0	0	0	0	0	0	Monthly. Grab sample.	
			1,685	TRIP	2	1	lab test	total dissolved solids	0	1	3,370	test	0	1	3,370	3,370	101,100	0	0	0	0	0	0	0	0	0	Each trip. 24 hour composite sample.	
			1,685	TRIP	2	1	lab test	sulfates	0	1	3,370	test	0	1	3,370	3,370	101,100	0	0	0	0	0	0	0	0	0	Each trip. 24 hour composite sample.	
			1,685	TRIP	2	1	lab test	boron	0	1	3,370	test	0	1	3,370	3,370	101,100	0	0	0	0	0	0	0	0	0	Each trip. 24 hour composite sample.	
			421	TRIP	2	1	lab test	iron	0	1	843	test	0	1	843	843	25,275	0	0	0	0	0	0	0	0	0	Monthly. 24 hour composite sample.	

	Equipment and Vehicle Total Hours	Labor Total Hours	Daily Labor Mobilization Miles	Vehicles Miles Onsite	Vehicle Mob/Demob Mileage	Equipment Mobilization Miles - Unloaded	Equipment Mobilization Miles - Loaded	Daily Equipment Miles Onsite	Daily Haul Truck Miles - Unloaded	Daily Haul Truck Miles - Loaded	Material Delivery Miles - Unloaded	Material Delivery Miles - Loaded
Totals	**317,897**	**355,182**	**3,349,377**	**38,620**	**14,000**	**34,750**	**34,750**	**67,010**	**0**	**0**	**34,000**	**34,000**

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Worksheet 3.4 - Work Element Details, Equipment, Hours, Labor and Materials Detail (Power Station Demolition).

Power Station Demolition

Alternative Component	Work Element	Details/Questions for Each Work Element	Project Quantity	Project Unit	Production Rate (Unit/Time)	Equipment Amount	Equipment Units	Equipment/ Material	One way travel per day (miles) for vehicles	hrs	total time	unit	# Drivers	# Additional Workers per day	Equipment and Vehicle Total Hours	Labor Total Hours	Daily Labor Mobilization Miles	Vehicles Miles Onsite	Vehicle Mob/Demob Mileage	Equipment Mobilization Miles - Unloaded	Equipment Mobilization Miles - Loaded	Daily Equipment Miles Onsite	Daily Haul Truck Miles - Unloaded	Daily Haul Truck Miles - Loaded	Material Delivery Miles - Unloaded	Material Delivery Miles - Loaded	Notes	Production Rate / Duration Reference
3.4 Demolition	3.4.1 Preconstruction Tasks	Supplemental Pre-Demolition Assessment (update of asbestos and other regulated materials survey) (2 asbestos inspectors)	10	DAY	-	2	vehicle per day	support truck	15	10	10	day	2	0	200	200	600	100	500	0	0	0	0	0	0	0	-	-
		Lab Testing	-	-	-	2	vehicle per day	ship samples	250	10	1	day	2	0	20	20	1,000	10	0	0	0	0	0	0	0	0	-	-
			600	EA		0	lab test	asbestos	0	0	600	test	0	1	0	150	18,000	0	0	0	0	0	0	0	0	0	-	-
			100	EA		0	lab test	lead	0	0	100	test	0	1	0	25	3,000	0	0	0	0	0	0	0	0	0	-	-
			100	EA		0	lab test	PCBs	0	0	100	test	0	1	0	25	3,000	0	0	0	0	0	0	0	0	0	-	-
	3.4.2 Project Duration Items	Project duration	-	-	-	0	-	-	0	0	1.0	years	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
		Equipment Mob	-	-	-	118	equipment mob	heavy equipment mob	250	10	2	mob	118	0	2,360	2,360	7,080	0	0	59,000	59,000	0	0	0	0	0	-	-
		Equipment fueling (daily)	-	-	-	1	vehicle per day	fuel truck	15	2	260	day	1	0	520	520	7,800	1,300	0	0	0	0	0	0	0	0	-	-
		Work Trailers	-	-	-	5	equipment per day	work trailer	0	10	260	day	0	0	13,000	0	0	0	0	0	0	0	0	0	0	0	-	-
		Work Trailers Electric Usage (average per day)	650,000	KWH	250	0	KWH per day	electricity	0	10	260	day	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
		Portable Restrooms	-	-	-	2	equipment per day	restroom units	0	10	260	day	0	0	5,200	0	0	0	0	0	0	0	0	0	0	0	-	-
		Portable restroom service	-	-	-	1	vehicle per day	maintenance vehicle	15	2	52	day	1	0	104	104	1,560	260	0	0	0	0	0	0	0	0	-	-
		Air Monitoring Stations	-	-	-	4	equipment per day	monitoring stations	12	10	260	day	2	0	10,400	5,200	15,600	0	0	0	0	12,480	0	0	0	0	-	-
		Air Monitoring Stations Electric Usage (average per day)	104,000	KWH	40	0	KWH per day	electricity	0	10	260	day	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-	-
		Jobsite Dust Suppression	-	-	-	1	equipment per day	water truck	12	10	260	day	1	0	2,600	2,600	7,800	0	0	0	0	3,120	0	0	0	0	-	-
		Owner's Representative Site Visits	-	-	-	2	vehicle per day	support truck	250	10	52	day	2	0	1,040	1,040	52,000	520	500	0	0	0	0	0	0	0	-	-
		Constractor Construction and Safety Managers	-	-	-	3	vehicle per day	support truck	15	10	260	day	3	0	7,800	7,800	23,400	3,900	500	0	0	0	0	0	0	0	-	-
		Site Security	-	-	-	1	vehicle per day	support truck	15	10	260	day	1	0	2,600	2,600	7,800	1,300	500	0	0	0	0	0	0	0	-	-
		Engineer Oversight and Air Monitoring	-	-	-	3	vehicle per day	support truck	15	10	260	day	3	0	7,800	7,800	23,400	3,900	500	0	0	0	0	0	0	0	-	-
		Engineer Safety Officer	-	-	-	1	vehicle per day	support truck	250	2	52	day	1	0	104	104	26,000	260	500	0	0	0	0	0	0	0	-	-
	3.4.3 Install Temporary Controls	Construction Fence	1	EA	1	2	materials	truck delivery - construction fence	250	10	2	load	2	0	40	40	0	0	0	0	0	0	0	0	1,000	1,000	-	-
			5,500	LF	800	1	haul trucks per day	flatbed truck	12	10	7	day	1	0	70	70	210	0	0	0	0	0	84	84	0	0	-	-
			5,500	LF	800	2	equipment per day	skid steer	0	10	7	day	2	0	140	140	420	0	0	0	0	0	0	0	0	0	-	-
		Laborers	5,500	LF	800	4	vehicle per day	support truck	15	10	7	day	4	0	280	280	840	140	500	0	0	0	0	0	0	0	-	-
		Silt Fence	1	EA	1	2	materials	truck delivery - silt fence	250	10	2	load	2	0	40	40	0	0	0	0	0	0	0	0	1,000	1,000	-	-
			5,500	LF	1,300	2	equipment per day	skid steer	0	10	5	day	2	0	100	100	300	0	0	0	0	0	0	0	0	0	-	-
		Laborers	5,500	LF	1,300	4	vehicle per day	support truck	15	10	5	day	4	0	200	200	600	100	500	0	0	0	0	0	0	0	-	-
	3.4.4 Asbestos Containing Materials (ACM) Abatement	Abatement Equipment	90	DAY	-	2	equipment per day	chip hammers	0	10	90	day	2	0	1,800	1,800	5,400	0	0	0	0	0	0	0	0	0	estimate based on table titled "Summary of Asbestos-Containing Materials (ACMs)" provided in October 19, 2012 "Asbestos Survey Activities" report for Vermillion Power Station	-
			90	DAY	-	1	equipment per day	truck-mounted wet/dry vac	0	10	90	day	1	0	900	900	2,700	0	0	0	0	0	0	0	0	0		-
			90	DAY	-	1	equipment per day	scissor lift	0	10	90	day	1	0	900	900	2,700	0	0	0	0	0	0	0	0	0		-
			90	DAY	-	1	equipment per day	telescoping boom lift	0	10	90	day	1	0	900	900	2,700	0	0	0	0	0	0	0	0	0		-
			90	DAY	-	2	equipment per day	skid steer	0	10	90	day	2	0	1,800	1,800	5,400	0	0	0	0	0	0	0	0	0		-
			90	DAY	-	4	equipment per day	blowers (negative pressure enclosures)	0	10	90	day	4	0	3,600	3,600	10,800	0	0	0	0	0	0	0	0	0		-
		Blowers (negative pressure enclosures) Electric Usage	360,000	KWH	400	0	KWH per day	electricity	0	10	90	day	0	0	0	0	0	0	0	0	0	0	0	0	0	0		-
		Transport to Off-Site Disposal Facility	5	DAY	-	5	haul trucks per day	tractor trailer	15	10	5	day	5	0	250	250	750	0	0	0	0	0	375	375	0	0		-
		Asbestos Foreman (3), Asbestos Workers (21)	90	DAY	-	24	vehicle per day	support truck	15	10	90	day	24	0	21,600	21,600	64,800	10,800	500	0	0	0	0	0	0	0		-
		Laborer Foreman, Laborers (2)	90	DAY	-	3	vehicle per day	support truck	15	10	90	day	3	0	2,700	2,700	8,100	1,350	500	0	0	0	0	0	0	0		-
		Clearance Inspector/Sampler	90	DAY	-	1	vehicle per day	support truck	15	10	90	day	1	0	900	900	2,700	450	500	0	0	0	0	0	0	0		-
	3.4.5 Other Regulated Materials Removal, Piping and Tank Decommissioning	Removal Equipment	40	DAY	-	1	equipment per day	telescoping boom lift	0	10	40	day	1	0	400	400	1,200	0	0	0	0	0	0	0	0	0	types and quantities unknown; assume the following materials to be removed/addressed: Universal waste, oil-containing equipment, electrical cabling with oil-impregnated insulation, storage tank and aboveground piping decommissioning, removal of accumulations of lead-based paint, removal of coal and ash residuals from structures, cleaning of slabs with oily accumulations	-
			40	DAY	-	1	equipment per day	scissor lift	0	10	40	day	1	0	400	400	1,200	0	0	0	0	0	0	0	0	0		-
			40	DAY	-	2	equipment per day	off-road dump truck	12	10	40	day	2	0	800	800	2,400	0	0	0	0	960	0	0	0	0		-
			40	DAY	-	2	equipment per day	skid steer	0	10	40	day	2	0	800	800	2,400	0	0	0	0	0	0	0	0	0		-
			40	DAY	-	1	equipment per day	truck-mounted wet/dry vac	0	10	40	day	1	0	400	400	1,200	0	0	0	0	0	0	0	0	0		-
			40	DAY	-	1	equipment per day	truck-mounted pressure washer	0	10	40	day	1	0	400	400	1,200	0	0	0	0	0	0	0	0	0		-
			10	DAY	-	1	equipment per day	vac truck	0	10	10	day	1	0	100	100	300	0	0	0	0	0	0	0	0	0		-
			40	DAY	-	1	equipment per day	backhoe loader	0	10	40	day	1	0	400	400	1,200	0	0	0	0	0	0	0	0	0		-
		Transport to Off-Site Disposal Facility	10	DAY	-	10	haul trucks per day	flatbed truck	250	10	10	day	10	0	1,000	1,000	3,000	0	0	0	0	0	25,000	25,000	0	0		-
			10	DAY	-	10	haul trucks per day	tractor trailer dump truck	250	10	10	day	10	0	1,000	1,000	3,000	0	0	0	0	0	25,000	25,000	0	0		-
			10	DAY	-	10	haul trucks per day	tanker truck	250	10	10	day	10	0	1,000	1,000	3,000	0	0	0	0	0	25,000	25,000	0	0		-
		Disposal On-Site (coal and ash residuals)	40	DAY	-	1	equipment per day	dozer	0	10	10	day	1	0	100	100	300	0	0	0	0	0	0	0	0	0		-
		Skilled Foreman (2), Skilled Workers (14)	40	DAY	-	16	vehicle per day	support truck	15	10	40	day	16	0	6,400	6,400	19,200	3,200	500	0	0	0	0	0	0	0		-
		Foreman, Laborers (7)	40	DAY	-	8	vehicle per day	support truck	15	10	40	day	8	0	3,200	3,200	9,600	1,600	500	0	0	0	0	0	0	0		-
	3.4.6 Pre-Demo Surface Cleaning	Cleaning Equipment	25	DAY		3	equipment per day	truck-mounted wet/dry vac	0	10	25	day	3	0	750	750	2,250	0	0	0	0	0	0	0	0	0	cleaning and removal of accumulations from surfaces, such as walls, floors, structural framing, shallow trenches, mezzanines, stairwells, ductwork, piping, and other horizontal surfaces	-
			25	DAY	-	3	equipment per day	skid steer	0	10	25	day	3	0	750	750	2,250	0	0	0	0	0	0	0	0	0		-
			25	DAY		1	equipment per day	scissor lift	0	10	25	day	1	0	250	250	750	0	0	0	0	0	0	0	0	0		-
		Transport to Off-Site Disposal Facility	2	DAY	-	2	haul trucks per day	haul truck	250	10	2	day	2	0	40	40	120	0	0	0	0	0	1,000	1,000	0	0		-
		Foreman, Laborers (6)	25	DAY	-	7	vehicle per day	support truck	15	10	25	day	7	0	1,750	1,750	5,250	875	500	0	0	0	0	0	0	0		-
	3.4.7 Other Pre-Demo Activities (utility disconnect, misc.)	Equipment	10	DAY	-	1	equipment per day	excavator	0	10	10	day	1	0	100	100	300	0	0	0	0	0	0	0	0	0	-	-
			10	DAY	-	1	equipment per day	vac truck (minor dewatering)	0	10	10	day	1	0	100	100	300	0	0	0	0	0	0	0	0	0	-	-
		Transport to Off-Site Disposal Facility (removed water)	2	DAY	-	2	haul trucks per day	tanker truck	250	10	2	day	2	0	40	40	120	0	0	0	0	0	1,000	1,000	0	0	-	-
		Skilled Trades (Electrician, Plumber)	10	DAY	-	4	vehicle per day	support truck	15	10	10	day	4	0	400	400	1,200	200	500	0	0	0	0	0	0	0	-	-
		Foreman, Laborers (2)	10	DAY	-	3	vehicle per day	support truck	15	10	10	day	3	0	300	300	900	150	500	0	0	0	0	0	0	0	-	-

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Worksheet 3.4 - Work Element Details, Equipment, Hours, Labor and Materials Detail (Power Station Demolition).

Power Station Demolition																												
Alternative Component	Work Element	Details/Questions for Each Work Element	Project Quantity	Project Unit	Production Rate (Unit/Time)	Equipment Amount	Equipment Units	Equipment/ Material	One way travel per day (miles) for vehicles	hrs	total time	unit	# Drivers	# Additional Workers per day	Equipment and Vehicle Total Hours	Labor Total Hours	Daily Labor Mobilization Miles	Vehicles Miles Onsite	Vehicle Mob/Demob Mileage	Equipment Mobilization Miles - Unloaded	Equipment Mobilization Miles - Loaded	Daily Equipment Miles Onsite	Daily Haul Truck Miles - Unloaded	Daily Haul Truck Miles - Loaded	Material Delivery Miles - Unloaded	Material Delivery Miles - Loaded	Notes	Production Rate / Duration Reference
3.4 Demolition	3.4.8.1 Structural Razing - Large Structures (metal, concrete, masonry structures)	Demolition Equipment	120	DAY	-	3	equipment per day	crane	0	10	120	day	3	0	3,600	3,600	10,800	0	0	0	0	0	0	0	0	0	estimate based on 2011/2012 survey map depicting structure footprint dimensions and heights; concrete and masonry demolition debris to be disposed in on-site landfill	-
			120	DAY	-	3	equipment per day	demolition excavator (extended boom)	0	10	120	day	3	0	3,600	3,600	10,800	0	0	0	0	0	0	0	0	0		-
			120	DAY	-	6	equipment per day	loader	0	10	120	day	6	0	7,200	7,200	21,600	0	0	0	0	0	0	0	0	0		-
			120	DAY	-	3	equipment per day	off-road dump truck	12	10	120	day	3	0	3,600	3,600	10,800	0	0	0	0	4,320	0	0	0	0		-
			120	DAY	-	6	equipment per day	skid steer	0	10	120	day	6	0	7,200	7,200	21,600	0	0	0	0	0	0	0	0	0		-
			120	DAY	-	6	equipment per day	dust misting cannon w/diesel gen	0	10	120	day	6	0	7,200	7,200	21,600	0	0	0	0	0	0	0	0	0		-
		Disposal On-Site (concrete, masonry)	120	DAY	-	1	equipment per day	excavator w/ hammer	0	10	120	day	1	0	1,200	1,200	3,600	0	0	0	0	0	0	0	0	0		-
			120	DAY	-	1	equipment per day	dozer	0	10	120	day	1	0	1,200	1,200	3,600	0	0	0	0	0	0	0	0	0		-
		Foreman, Laborers (8)	120	DAY	-	9	vehicle per day	support truck	15	10	120	day	9	0	10,800	10,800	32,400	5,400	500	0	0	0	0	0	0	0		-
	3.4.8.2 Structural Razing - Small Structures (primarily metal structures)	Demolition Equipment	40	DAY	-	1	equipment per day	demolition excavator (extended boom)	0	10	40	day	1	0	400	400	1,200	0	0	0	0	0	0	0	0	0	estimate based on 2011/2012 survey map depicting structure footprint dimensions and heights; primarily metal buildings	-
			40	DAY	-	1	equipment per day	loader	0	10	40	day	1	0	400	400	1,200	0	0	0	0	0	0	0	0	0		-
			40	DAY	-	1	equipment per day	off-road dump truck	12	10	40	day	1	0	400	400	1,200	0	0	0	0	480	0	0	0	0		-
			40	DAY	-	2	equipment per day	skid steer	12	10	40	day	2	0	800	800	2,400	0	0	0	0	960	0	0	0	0		-
			40	DAY	-	2	equipment per day	dust misting cannon w/diesel gen	0	10	40	day	2	0	800	800	2,400	0	0	0	0	0	0	0	0	0		-
		Foreman, Laborers (3)	40	DAY	-	4	vehicle per day	support truck	15	10	40	day	4	0	1,600	1,600	4,800	800	500	0	0	0	0	0	0	0		-
	3.4.8.3 Structural Razing - Stack (assume primarily concrete, masonry, non-ACM)	Demolition Equipment	15	DAY	-	1	equipment per day	demolition excavator	0	10	15	day	1	0	150	150	450	0	0	0	0	0	0	0	0	0	assume stack will be razed by explosive demolition; demolition debris to be disposed in on-site landfill	-
			15	DAY	-	1	equipment per day	loader	0	10	15	day	1	0	150	150	450	0	0	0	0	0	0	0	0	0		-
			15	DAY	-	1	equipment per day	off-road dump truck	12	10	15	day	1	0	150	150	450	0	0	0	0	180	0	0	0	0		-
			15	DAY	-	1	equipment per day	dust misting cannon w/diesel gen	0	10	15	day	1	0	150	150	450	0	0	0	0	0	0	0	0	0		-
		Disposal On-Site (concrete, masonry)	15	DAY	-	1	equipment per day	excavator w/ hammer	0	10	15	day	1	0	150	150	450	0	0	0	0	0	0	0	0	0		-
			15	DAY	-	1	equipment per day	dozer	0	10	15	day	1	0	150	150	450	0	0	0	0	0	0	0	0	0		-
		Foreman, Powderman, Laborers (4)	15	DAY	-	6	vehicle per day	support truck	15	10	15	day	6	0	900	900	2,700	450	500	0	0	0	0	0	0	0		-
	3.4.9 Slab Removals (and on-Site Landfill placement)	Demolition Equipment	30	DAY	-	2	equipment per day	excavator w/ hammer	0	10	30	day	2	0	600	600	1,800	0	0	0	0	0	0	0	0	0	estimate based on 2011/2012 survey map depicting structure footprint and exterior concrete slab dimensions	-
			30	DAY	-	2	equipment per day	loader	0	10	30	day	2	0	600	600	1,800	0	0	0	0	0	0	0	0	0		-
			30	DAY	-	2	equipment per day	off-road dump truck	12	10	30	day	2	0	600	600	1,800	0	0	0	0	720	0	0	0	0		-
		Disposal On-Site	30	DAY	-	1	equipment per day	dozer	0	10	30	day	1	0	300	300	900	0	0	0	0	0	0	0	0	0		-
		Foreman, Laborers (3)	30	DAY	-	4	vehicle per day	support truck	15	10	30	day	4	0	1,200	1,200	3,600	600	500	0	0	0	0	0	0	0		-
	3.4.10 Sub-Surface Demolition	Demolition Equipment	30	DAY	-	1	equipment per day	excavator w/ hammer	0	10	30	day	1	0	300	300	900	0	0	0	0	0	0	0	0	0	break floors (or remove) below-ground structures; pits, basements, trenches, hoppers, shafts, vaults, sumps; quantities unknown (duration based on type and number of site structures)	-
			30	DAY	-	1	equipment per day	excavator	0	10	30	day	1	0	300	300	900	0	0	0	0	0	0	0	0	0		-
			30	DAY	-	1	equipment per day	loader	0	10	30	day	1	0	300	300	900	0	0	0	0	0	0	0	0	0		-
			30	DAY	-	1	equipment per day	off-road dump truck	12	10	30	day	1	0	300	300	900	0	0	0	0	360	0	0	0	0		-
			30	DAY	-	1	equipment per day	vac truck	0	10	10	day	1	0	100	100	300	0	0	0	0	0	0	0	0	0		-
		Disposal On-Site	30	DAY	-	1	equipment per day	dozer	0	10	30	day	1	0	300	300	900	0	0	0	0	0	0	0	0	0		-
		Transport to Off-Site Disposal Facility (removed residual liquids)	5	DAY	-	5	haul trucks per day	tanker truck	250	10	5	day	5	0	250	250	750	0	0	0	0	0	6,250	6,250	0	0		-
		Foreman, Laborers (7)	30	DAY	-	8	vehicle per day	support truck	15	10	30	day	8	0	2,400	2,400	7,200	1,200	500	0	0	0	0	0	0	0		-
	3.4.11 Demolition Debris Management (Off-Site Disposal)	Supplemental Processing (size reduction, etc.)	120	DAY	-	2	equipment per day	excavator w/ shear	0	10	120	day	2	0	2,400	2,400	7,200	0	0	0	0	0	0	0	0	0	demolition debris not placed in on-site landfill (non-concrete and masonry); assume demolition debris transport and disposal conducted currently with demolition	-
		Loading	120	DAY	-	2	equipment per day	loader	0	10	120	day	2	0	2,400	2,400	7,200	0	0	0	0	0	0	0	0	0		-
		Transport to Disposal or Scrap Facility	20	DAY	-	60	haul trucks per day	haul truck	15	10	20	day	60	0	12,000	12,000	36,000	0	0	0	0	0	18,000	18,000	0	0		-
		Foreman, Laborers (3)	120	DAY	-	4	vehicle per day	support truck	15	10	120	day	4	0	4,800	4,800	14,400	2,400	500	0	0	0	0	0	0	0		-
	3.4.12 Piping Abandonment (Filling)	Equipment	20	DAY	-	1	equipment per day	loader/excavator	0	10	20	day	1	0	200	200	600	0	0	0	0	0	0	0	0	0	filling intake/discharge, water circulation piping and other larger underground piping systems; quantities unknown (piping drawings not available)	-
		Materials (grout, flowable fill and/or concrete)	1	EA	1	100	materials	truck delivery - materials	250	10	4	load	100	0	4,000	4,000	0	0	0	0	0	0	0	0	100,000	100,000		-
		Pipe Abandonment	20	DAY	-	2	equipment per day	grout pump	0	10	20	day	2	0	400	400	1,200	0	0	0	0	0	0	0	0	0		-
			20	DAY	-	2	equipment per day	air compressor	0	10	20	day	2	0	400	400	1,200	0	0	0	0	0	0	0	0	0		-
			20	DAY	-	2	equipment per day	diesel generator	0	10	20	day	2	0	400	400	1,200	0	0	0	0	0	0	0	0	0		-
		Foreman, Laborers (5)	20	DAY	-	6	vehicle per day	support truck	15	10	20	day	6	0	1,200	1,200	3,600	600	500	0	0	0	0	0	0	0		-
	3.4.13 Backfilling Below-Ground Voids (with on-site soil) and Interim Surface Stabilization (gravel)	Excavate and Load from stockpile	20	DAY	-	1	equipment per day	loader/excavator	0	10	20	day	1	0	200	200	600	0	0	0	0	0	0	0	0	0	-	-
		Hauling from stockpile	20	DAY	-	1	equipment per day	off-road dump truck	12	10	20	day	1	0	200	200	600	0	0	0	0	240	0	0	0	0	backfilling of all below-ground structures; pits, basements, trenches, hoppers, shafts, vaults, sumps, and other depressions; placing interim gravel surface (3 inches) over disturbed areas (assumed approximately 4 acres)	-
		Placement	20	DAY	-	1	equipment per day	loader	0	10	20	day	1	0	200	200	600	0	0	0	0	0	0	0	0	0		-
		Compaction	20	DAY	-	1	equipment per day	excavator w/ tamper	0	10	20	day	1	0	200	200	600	0	0	0	0	0	0	0	0	0		-
		Foreman, Laborers (5)	20	DAY	-	6	vehicle per day	support truck	15	10	20	day	6	0	1,200	1,200	3,600	600	500	0	0	0	0	0	0	0		-
		Gravel Borrow Delivery	1	EA	1	100	materials	truck delivery - materials	250	10	2	load	100	0	2,000	2,000	0	0	0	0	0	0	0	0	50,000	50,000		-
		Gravel Spreading	2,000	CY	600	1	equipment per day	dozer	12	10	4	day	1	0	40	40	120	0	0	0	0	48	0	0	0	0		-
		Laborers (2)	2,000	CY	600	2	vehicle per day	support truck	15	10	4	day	2	0	80	80	240	40	500	0	0	0	0	0	0	0		-

	Equipment and Vehicle Total Hours	Labor Total Hours	Daily Labor Mobilization Miles	Vehicles Miles Onsite	Vehicle Mob/Demob Mileage	Equipment Mobilization Miles - Unloaded	Equipment Mobilization Miles - Loaded	Daily Equipment Miles Onsite	Daily Haul Truck Miles - Unloaded	Daily Haul Truck Miles - Loaded	Material Delivery Miles - Unloaded	Material Delivery Miles - Loaded
Totals	**202,518**	**179,318**	**626,110**	**42,505**	**12,500**	**59,000**	**59,000**	**23,868**	**101,709**	**101,709**	**152,000**	**152,000**

Letter from Geosyntec Consultants to Dynegy Midwest Generation Re: Summary of Old East Ash Pond Area Slope Stability Reliability Assessment, Vermillion Power Plant, November 2021

Geosyntec consultants

134 N. La Salle Street, Suite 300
Chicago, Illinois 60602
PH 312.658.0500
FAX 312.658.0576
www.geosyntec.com

4 November 2021

Mr. Victor Modeer, P.E., D.G.E.
Senior Project Engineer
Vistra Energy
1500 Eastport Plaza Drive
Collinsville, Illinois 62234

Subject: Summary of Old East Ash Pond Area Slope Stability Reliability Assessment
Vermillion Power Plant
Dynegy Midwest Generation, LLC

Dear Mr. Modeer:

Geosyntec has completed the slope stability reliability assessment for the Old East Ash Pond area (OEAP) at the Vermillion Power Plant (VPP) at the request of Dynegy Midwest Generation, LLC (Dynegy). The assessment was conducted as part of the potential need for temporary riverbank stabilization measures along the Middle Fork of the Vermilion River (River). This summary provides a synopsis of the calculations prepared by Geosyntec that documents the details of the reliability assessment.

CLOSURE REQUIREMENTS

The Final Closure Plan for the OEAP is undergoing the Construction Permit Application and approval process. The Agreed Interim Order (Illinois Attorney General, June 2021) ("Interim Order") includes the requirement for closure by removal (CBR) of the OEAP, North Ash Pond area (NAP), and New East Ash Pond (NEAP).

Until the Closure Plan is implemented, continued riverbank erosion along the OEAP creates a concern for the destabilization of the perimeter embankment caused by the loss of riverbank soils.

PUROSE OF RELIABILITY ASSESSMENT

The purpose of the reliability assessment was to have information to reach an informed decision of when to implement the temporary riverbank stabilization measures, if necessary, prior to closure of the OEAP. Once the OEAP is closed, the coal combustion residuals (CCR) and most of the embankment would be removed and the temporary riverbank stabilization measures will not be necessary.

APPROACH

The reliability assessment was conducted based on the "best practice" document series prepared by the United States Bureau of Reclamation (USBR) and the United States Army Corps of Engineers (USACE) for "Probabilistic Stability Analysis (Reliability Analysis)" updated most recently as of July 2018. The reliability assessment is a probabilistic analysis that accounts for the inherent variability of key soil properties that affect the stability of the slope. Unlike deterministic slope stability analyses that yield a factor of safety based on a single estimate of the soil properties, the reliability assessment estimates the probability of slope failure based on the variability of soil and groundwater conditions.

An erosion assessment was conducted to assess the time to when erosion would be at the stage that could require initiation of design and permitting of the temporary riverbank stabilization measures and when they would need to be installed. The assessment was completed using historical aerials and spatial data.

Using this approach, the reliability of existing and future conditions resulting from progressing riverbank erosion were evaluated.

RELIABILITY ASSESSMENT

The reliability assessment approach relies on the calculation of the reliability index, β, of the slope, which is related to the probability of failure—the larger the reliability index, the farther the slope is from failure. The reliability index value that defines the condition when the temporary riverbank stabilization measures could be implemented, $\beta_{trigger}$, was set at 3.0, which is a common target for critical designs with little redundancy based on available sources.

When the $\beta_{trigger}$ is reached, it should not be conflated with a condition that could lead to imminent movement of the slope. It is the condition where action should be taken with sufficient time to conduct design, permitting and construction, to restore the condition to a higher degree of reliability.

Geosyntec conducted the reliability assessment in the following general order:

1) Review existing geotechnical data and establish subsurface stratigraphy and engineering parameters, including statistical parameters describing the expected variability of engineering parameters.
2) Select the slope stability analysis cross-sections for the OEAP that are deemed as the most critical, based on OEAP geometry, subsurface material layering, and the depth of the river channel.
3) Identify whether undrained or drained shear strength parameters are to be used in the reliability analysis and explained the basis of the selection.
4) Estimate the rate of erosion and the approximate time that it would take for riverbank erosion to initiate the implementation of temporary mitigation measures.
5) Conduct reliability analyses on cross-sections deemed as critical as part of item 2 using SLOPE/W software, as part of the GeoStudio software package (2019) [1].
6) Compare the β value for the existing slope configuration from the analysis to $\beta_{trigger}$. If the β value is greater than $\beta_{trigger}$, the cross-section was modified based on the expected erosion progression until the β value is equal to or below $\beta_{trigger}$.

This iterative process identified the geometric conditions and time frame based on estimated riverbank erosion rates when temporary riverbank stabilization measures, initiating with design and permitting, would be required.

Geosyntec examined six potentially critical cross sections and performed analyses at three cross-sections (A, D and F) along the OEAP. The plan view depicting the sections are shown on Figure 1 and the sections are shown on Figures 2 and 3.

EROSION ASSESSMENT

The erosion rate was evaluated to estimate when the edge of the River, which is also the toe of the slope for the OEAP containment embankment, reaches a position where the reliability index reaches the $\beta_{trigger}$ criterion.

Geosyntec reviewed several sources to the estimate erosion rate for the riverbank along the OEAP. Sources that were utilized included aerial imagery after 2000 and spatial data from Vermilion County [2].

Imagery and spatial data provided by Vermilion County provided the clearest demarcation of the edge of water. The edge of water for the Vermilion River was digitized using the 2004 and 2018 aerial images. The two lines depicting the edge of water were overlaid on the aerial images using GIS, and the two lines from the two different times were compared to estimate the rate of erosion.

Appendix A provides a comparison of the edge of water from 2004 and 2018 aerial images. The difference between the two lines depicting the edge of water ranges from an approximate distance of few feet to 10 feet. In general, a distance of 7 to 10 feet between the two lines is consistently visible. Based on this assessment, which utilizes the best information available to us, the average riverbank erosion along the OEAP is 10 feet over the course of 14 years resulting in a range of 0.5 to 0.7 ft/year. For purposes of this evaluation, an overall rate of 1 ft/year may be used representing an upper range.

RESULTS

The critical slope stability analyses are presented in **Appendix B** and **Table 1**. In summary, Geosyntec obtained the following results:

- The reliability index, β is greater than 3.0 for the existing conditions.
- The estimated lateral riverbank erosion rate is 1 ft/year.
- Stability analyses containing the eroded riverbank condition were not modeled for Section A because the ash pond is approximately 250 ft from the river channel; therefore, riverbank erosion is not expected to impact stability of the ash pond for many years relative to Sections D and F.
- The $\beta_{trigger}$ value is reached after 10 ft of riverbank erosion for cross-section D and 15 ft of riverbank erosion for cross-section F for varying groundwater conditions.
- The $\beta_{trigger}$ value is reached after 16 ft of riverbank erosion for cross-section D and 20 ft of riverbank erosion for cross-section F for fixed groundwater conditions.

Table 1 – Summary of Reliability Indices

Section	Groundwater Condition	Reliability Index, β		Riverbank Erosion (ft)
		Existing Condition	Eroded Condition	
Section A	Varied	3.6	Not Modeled	
	Fixed	4.3		
Section D	Varied	4.0	2.9	10
	Fixed	4.8	3.2	15
Section F	Varied	6.2	2.9	15
	Fixed	7.3	3.1	20

CONCLUSIONS

The following is concluded:

- Based on the approximated erosion rate of 1 ft/year, it may take 10 years to reach $\beta_{trigger}$ value of 3.0 at the critical cross-section assuming *varying* groundwater condition.
- Based on the approximate erosion rate of 1 ft/year, it may take 16 years to reach $\beta_{trigger}$ value of 3.0 at the critical cross-section assuming a *fixed* groundwater condition.

Please call John Seymour at (312) 416-3919 or Omer Bozok at (312) 416-3924 if you have any questions.

John Seymour

Omer Bozok, P.E.
Senior Engineer

John Seymour, P.E.
Senior Principal

cc: David Mitchell
Phil Morris

REFERENCES

[1] GeoStudio, "Slope/W, Version 10.0.2.18035," GeoStudio, 2019.

[2] "Vermilion County GIS," 2019. [Online]. Available: http://vermilion.il.bhamaps.com/.

FIGURES

LEGEND

	EXISTING MAJOR CONTOUR (5- FT INTERVAL)
	EXISTING MINOR CONTOUR (1- FT INTERVAL)
×	SEPTEMBER 2019 SURVEY POINT (NOTE 4)
● ST-07	BORING LOCATION
— — —	APPROXIMATE LIMITS OF EXISTING ASH
—— - · - ——	APPROXIMATE ORDINARY HIGH WATER MARK (OHWM)
— — — — — — —	GRAVEL ACCESS ROAD
—— OHE ——	OVERHEAD ELECTRIC LINE
▬▬▬	DRAFT PROFILE ALONG THE CENTERLINE OF NAP RIVERBANK STABILIZATION TRENCH

NOTES:

1. BASE MAP IS AN AMALGAM OF PUBLICLY AVAILABLE LIDAR DATA AND SURVEY CONDUCTED BY INGENAE ON MARCH 2018.
2. COORDINATE SYSTEM IS NORTH AMERICAN DATUM OF 1983 (NAD 83) ILLINOIS STATE PLANE EAST, AND VERTICAL DATUM IS IN NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD 88).
3. THE DATE OF AERIAL IMAGE IS APRIL 20, 2019 OBTAINED FROM GOOGLE EARTH PRO.
4. ADDITIONAL TOPOGRAPHIC SURVEY WAS COMPLETED BY INGENAE ON SEPTEMBER 19, 2019.

0 50 100
SCALE IN FEET

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REV	DATE	DESCRIPTION	DRN	APP

Geosyntec consultants
1 MCBRIDE AND SON CENTER DRIVE, SUITE 202
CHESTERFIELD MO 63005 USA
TELEPHONE: 636.812.0800

DYNEGY MIDWEST GENERATION
1500 EASTPORT PLAZA DRIVE
COLLINSVILLE, IL 62234 USA

TITLE:
OLD EAST ASH POND RIVERBANK PLAN VIEW

PROJECT:
VERMILION RIVERBANK STABILIZATION

SITE:
VERMILION COUNTY, ILLINOIS

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DESIGN BY:
DRAWN BY:
CHECKED BY:
REVIEWED BY:
APPROVED BY:

FIGURE 1

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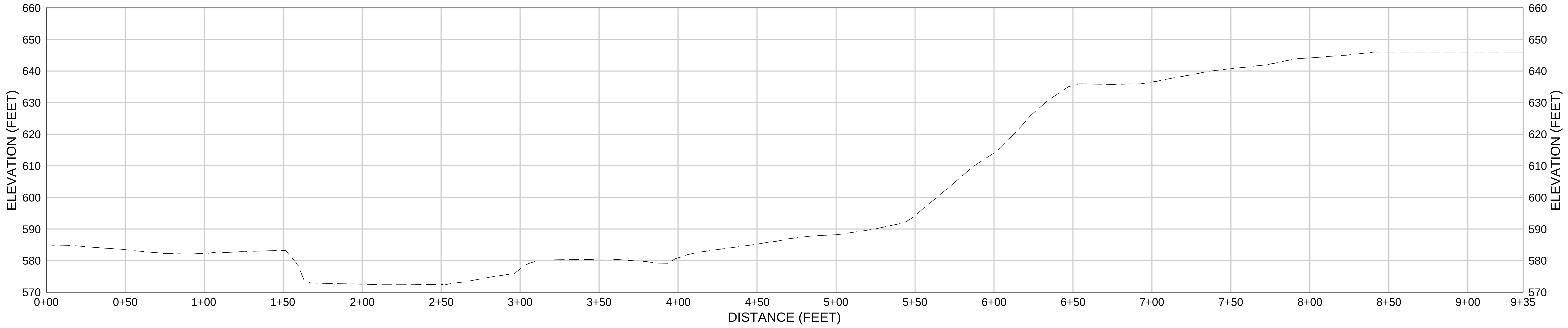
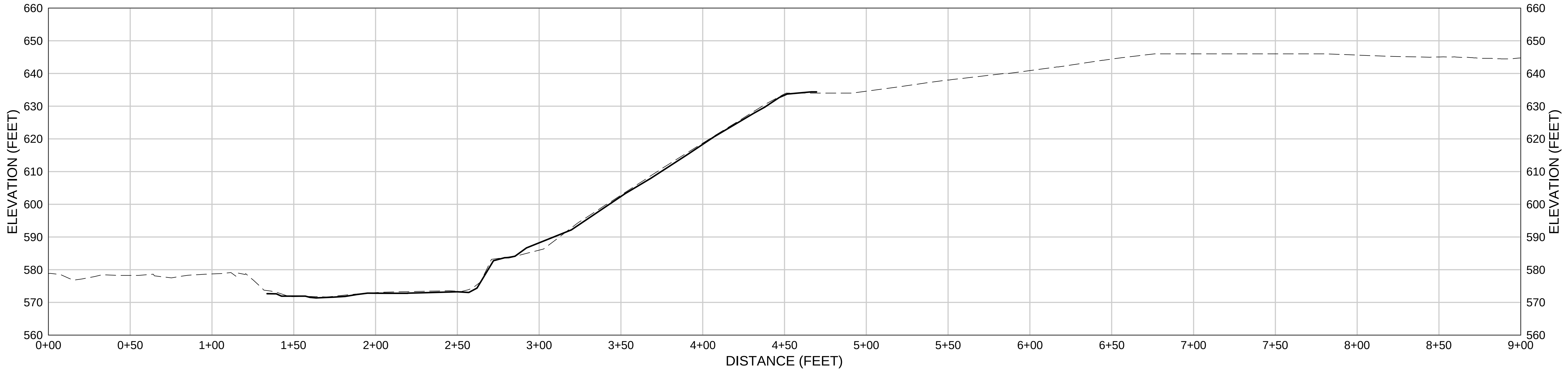
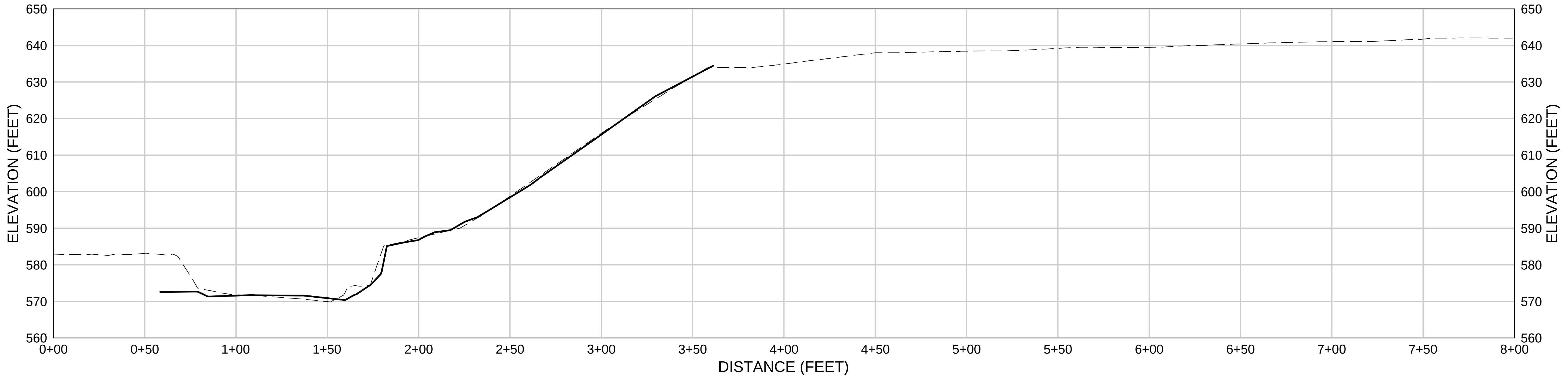
FIGURE 2 - OLD EAST ASH POND RIVERBANK PLAN VIEW



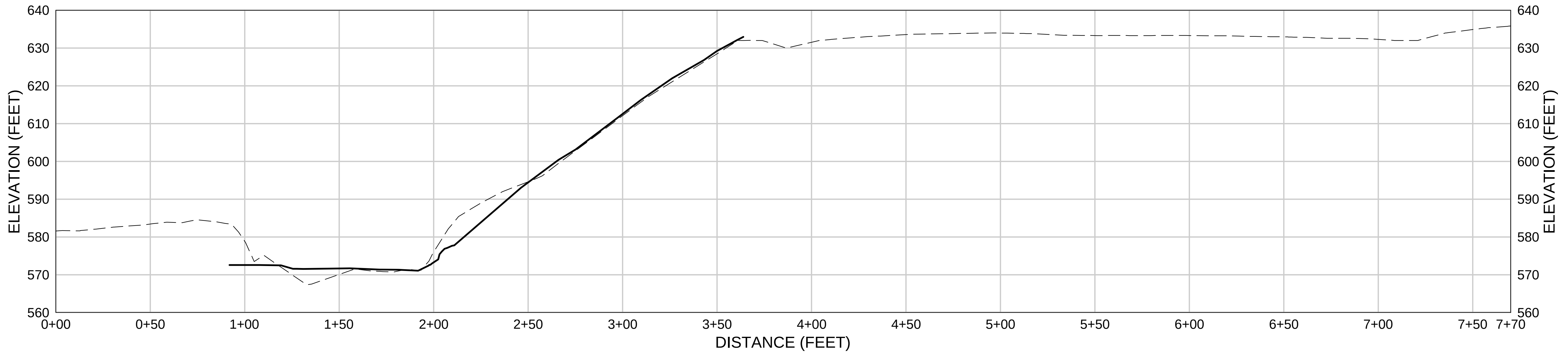
SECTION A



SECTION B



SECTION C



SECTION D

LEGEND

╌╌╌╌ BASE MAP GRADE (NOTE 1)

──── SEPTEMBER 2019 TOPOGRAPHY (NOTE 3)

NOTES:

1. BASE MAP IS AN AMALGAM OF PUBLICLY AVAILABLE LIDAR DATA AND SURVEY CONDUCTED BY INGENAE ON MARCH 2018.
2. VERTICAL DATUM IS IN NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD 88).
3. SEPTEMBER 2019 TOPOGRAPHY IS BASED ON A SURFACE ESTABLISHED USING GROUND SURVEY POINTS.

0 50' 100'
HORIZONTAL SCALE IN FEET

0 25' 50'
VERTICAL SCALE IN FEET

REV	DATE	DESCRIPTION	DRN	APP

Geosyntec consultants
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1500 EASTPORT PLAZA DRIVE
COLLINSVILLE, IL 62234 USA

TITLE: OLD EAST ASH POND RIVERBANK SECTIONS I

PROJECT: VERMILION RIVERBANK STABILIZATION

SITE: VERMILION COUNTY, ILLINOIS

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SIGNATURE

DATE

DRAFT

DESIGN BY:	DATE: NOVEMBER 2019
DRAWN BY:	PROJECT NO.: CHE8404
CHECKED BY:	FILE:
REVIEWED BY:	
APPROVED BY:	FIGURE 2

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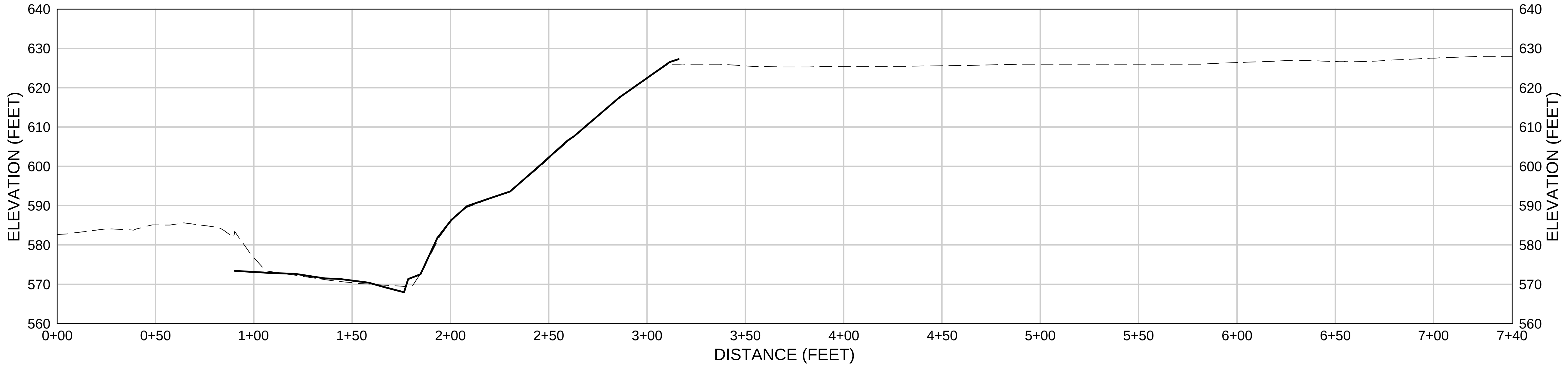
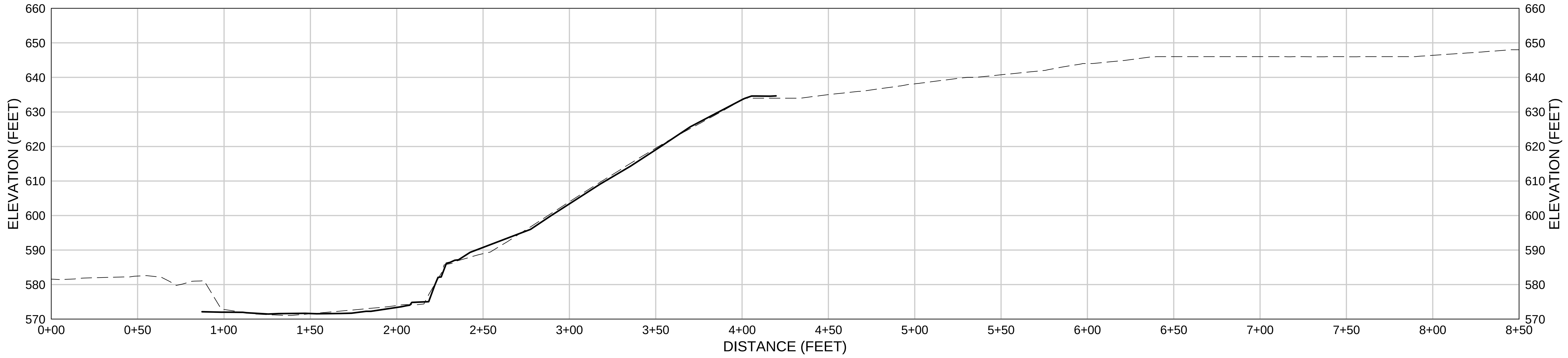
FIGURE 3 - OLD EAST ASH POND RIVERBANK SECTIONS I



SECTION E



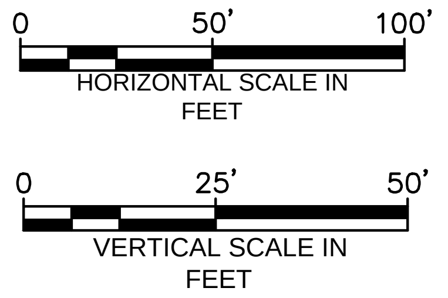
SECTION F

LEGEND

- – – – – – BASE MAP GRADE (NOTE 1)
- —— SEPTEMBER 2019 TOPOGRAPHY (NOTE 3)

NOTES:

1. BASE MAP IS AN AMALGAM OF PUBLICLY AVAILABLE LIDAR DATA AND SURVEY CONDUCTED BY INGENAE ON MARCH 2018.
2. VERTICAL DATUM IS IN NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD 88).
3. SEPTEMBER 2019 TOPOGRAPHY IS BASED ON A SURFACE ESTABLISHED USING GROUND SURVEY POINTS.



REV	DATE	DESCRIPTION	DRN	APP

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TITLE:
OLD EAST ASH POND RIVERBANK SECTIONS II

PROJECT:
VERMILION RIVERBANK STABILIZATION

SITE:
VERMILION COUNTY, ILLINOIS

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SIGNATURE

DATE

DRAFT

DESIGN BY:
DRAWN BY:
CHECKED BY:
REVIEWED BY:
APPROVED BY:

DATE: NOVEMBER 2019
PROJECT NO.: CHE8404
FILE:

FIGURE 3

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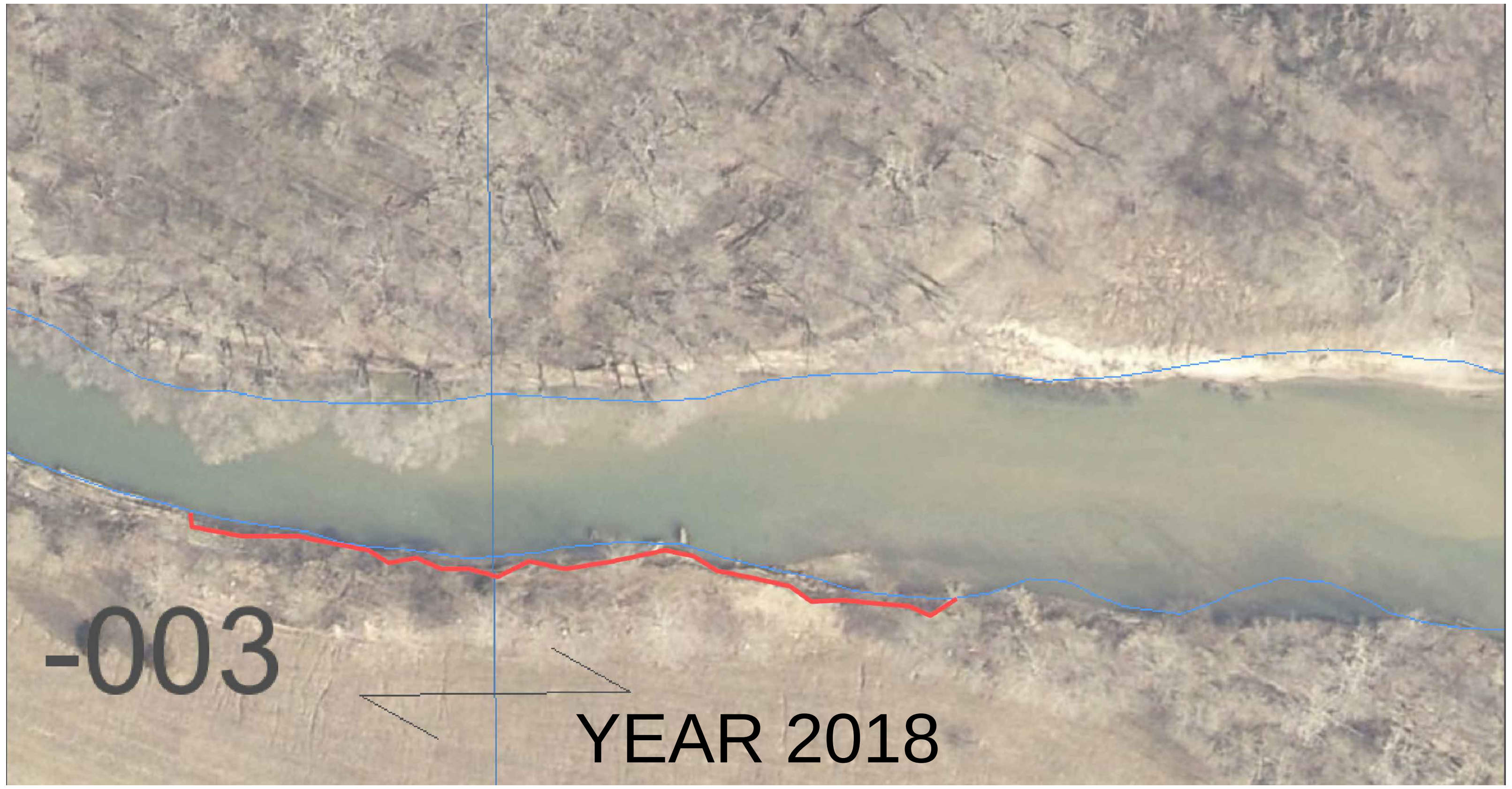
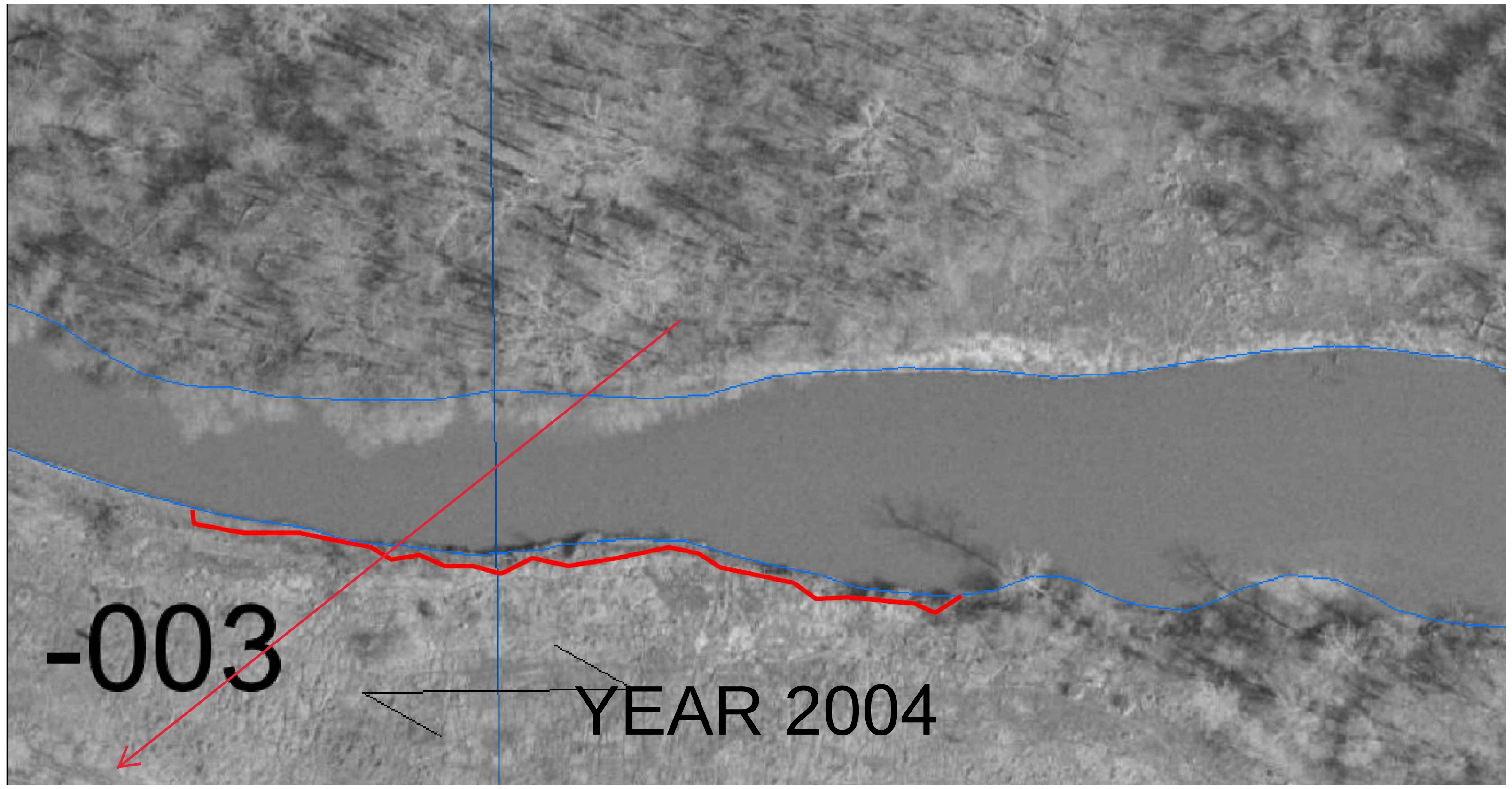
FIGURE 4 - OLD EAST ASH POND RIVERBANK SECTIONS II

APPENDIX A

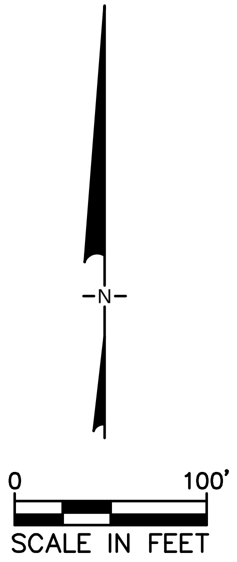




NOTE:

OEAP EMBANKMENT EROSION:

THE BLUE LINE REPRESENTS THE EDGE OF WATER DIGITIZED FROM THE SURFACE IN THE RED LINE DRAWN FROM TOP OF BANK IN 2018 SHOWS THE DEPARTURE.



DISCLAIMER:

IMAGERY AND VECTOR DATA SHOWN ARE THE PROPERTY OF VERMILLION COUNTY, IL.

OEAP EMBANKMENT EROSION
VERMILION RIVERBANK STABILIZATION

VERMILION COUNTY, ILLINOIS

Geosyntec
consultants

FIGURE

1

PROJECT NO: CHE8404

DECEMBER 2019

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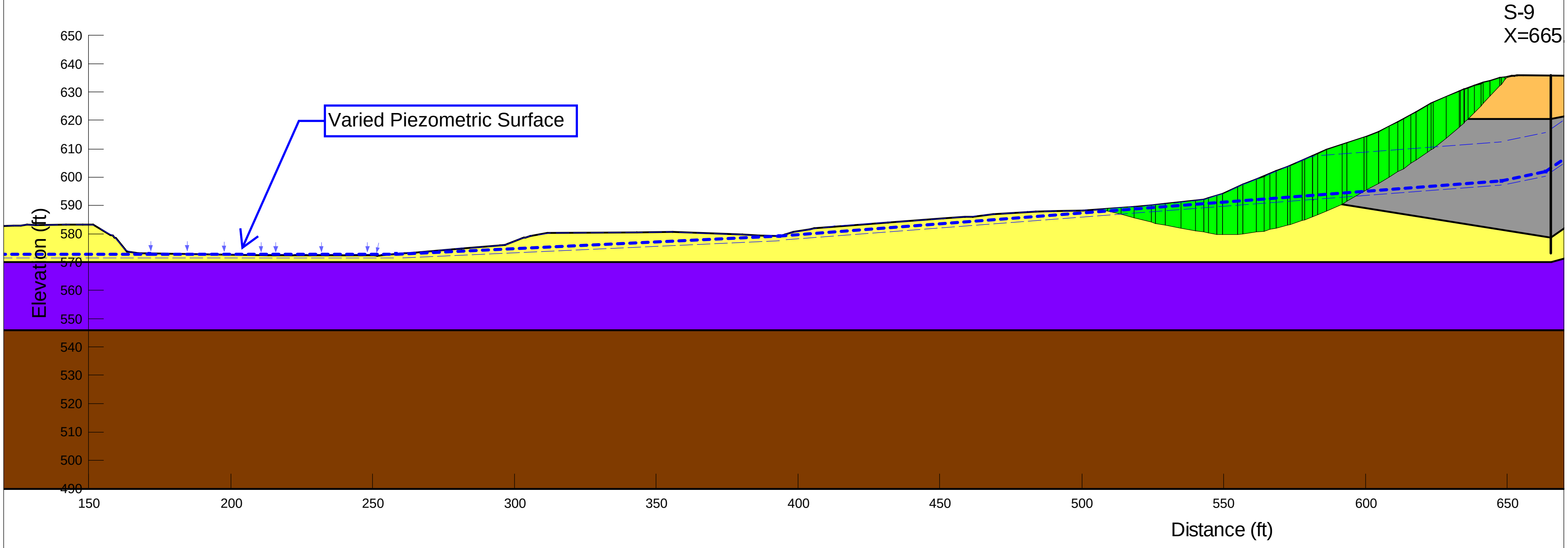
APPENDIX B

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Piezometric Line
🟧	01_Fill	Mohr-Coulomb	131	0	40	1
⬛	02_Coal Ash	Mohr-Coulomb	107	0	37	1
🟨	03_Clay Alluvium	Mohr-Coulomb	112	0	34	1
🟪	06_Glacial Till	Mohr-Coulomb	129	0	37	1
🟫	07_Bedrock	Mohr-Coulomb	140	0	45	1

Mean F of S: 1.7157467
Std. Dev. F of S: 0.20150183
Reliability Index: 3.5520608



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engineers | scientists | innovators

Vermillion OEAP Stability and Reliability Analysis

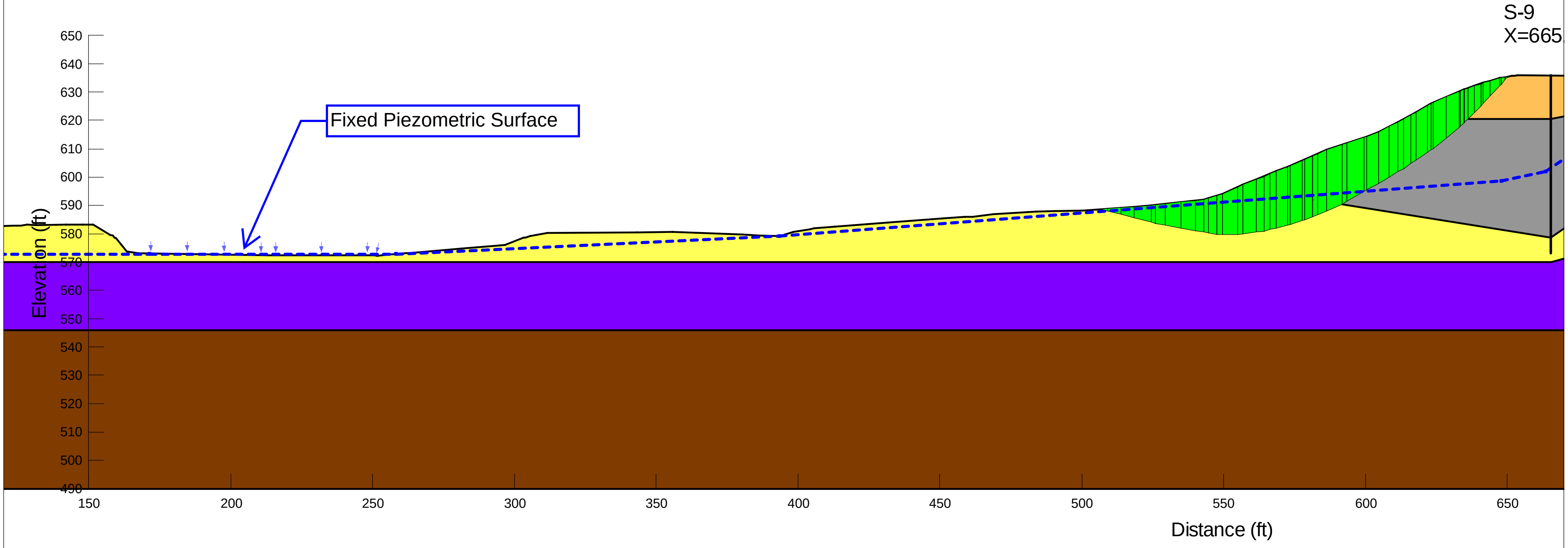
SectionA - Probabilistic FS

Created By: Zachary Fallert	Date:12/2/2019	Checked By: Alex Stern	Date:12/3/2019

Existing Condition

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Piezometric Line
🟧	01_Fill	Mohr-Coulomb	131	0	40	1
◼	02_Coal Ash	Mohr-Coulomb	107	0	37	1
🟨	03_Clay Alluvium	Mohr-Coulomb	112	0	34	1
🟪	06_Glacial Till	Mohr-Coulomb	129	0	37	1
🟫	07_Bedrock	Mohr-Coulomb	140	0	45	1

Mean F of S: 1.7802087
Std. Dev. F of S: 0.18164199
Reliability Index: 4.29531



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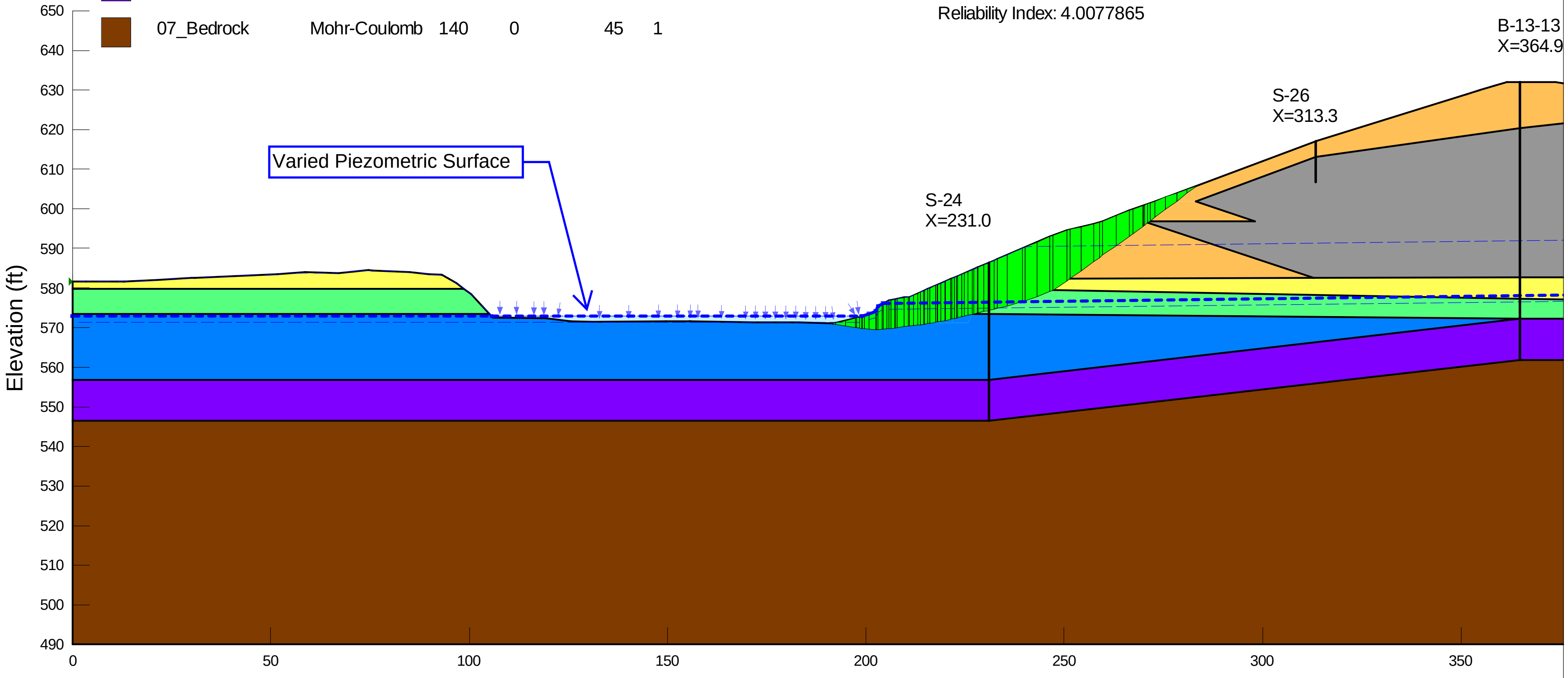
Vermillion OEAP Stability and Reliability Analysis

SectionA - Probabilistic FS

Created By: Zachary Fallert	Date:12/2/2019	Checked By: Alex Stern	Date:12/3/2019

Existing Condition

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Piezometric Line
🟧	01_Fill	Mohr-Coulomb	131	0	40	1
▨	02_Coal Ash	Mohr-Coulomb	107	0	37	1
🟨	03_Clay Alluvium	Mohr-Coulomb	112	0	34	1
🟩	04_Sand Alluvium	Mohr-Coulomb	122	0	37	1
🟦	05_Reworked Till	Mohr-Coulomb	141	0	35	1
🟪	06_Glacial Till	Mohr-Coulomb	129	0	37	1
🟫	07_Bedrock	Mohr-Coulomb	140	0	45	1



Mean F of S: 1.7736721
Std. Dev. F of S: 0.19304223
Reliability Index: 4.0077865

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Vermillion OEAP Stability and Reliability Analysis

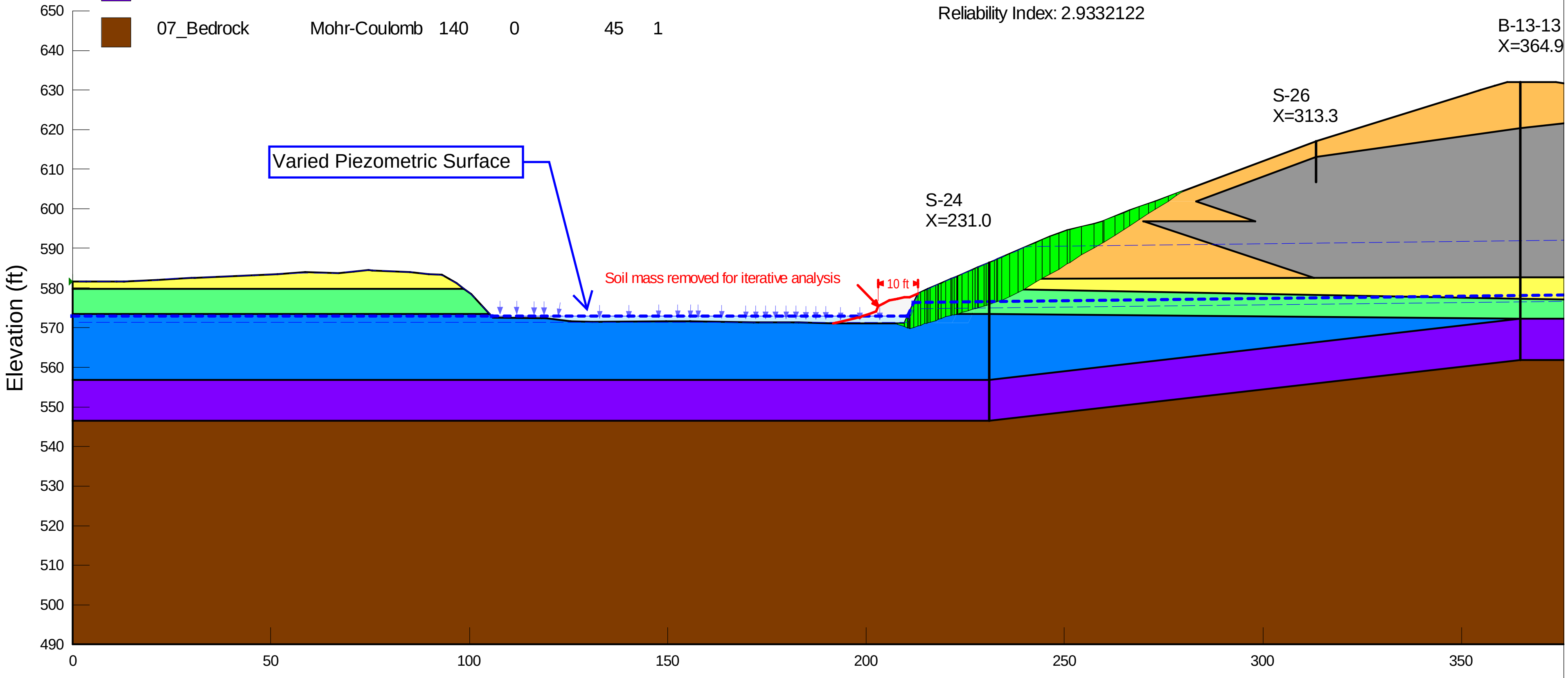
01_Section D - Probabilistic FS

Created By: Zachary Fallert	Date:12/2/2019	Checked By: Alex Stern	Date:12/3/2019

Stage
01

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Piezometric Line
🟧	01_Fill	Mohr-Coulomb	131	0	40	1
▨	02_Coal Ash	Mohr-Coulomb	107	0	37	1
🟨	03_Clay Alluvium	Mohr-Coulomb	112	0	34	1
🟩	04_Sand Alluvium	Mohr-Coulomb	122	0	37	1
🟦	05_Reworked Till	Mohr-Coulomb	141	0	35	1
🟪	06_Glacial Till	Mohr-Coulomb	129	0	37	1
🟫	07_Bedrock	Mohr-Coulomb	140	0	45	1

Mean F of S: 1.5236749
Std. Dev. F of S: 0.1785329
Reliability Index: 2.9332122



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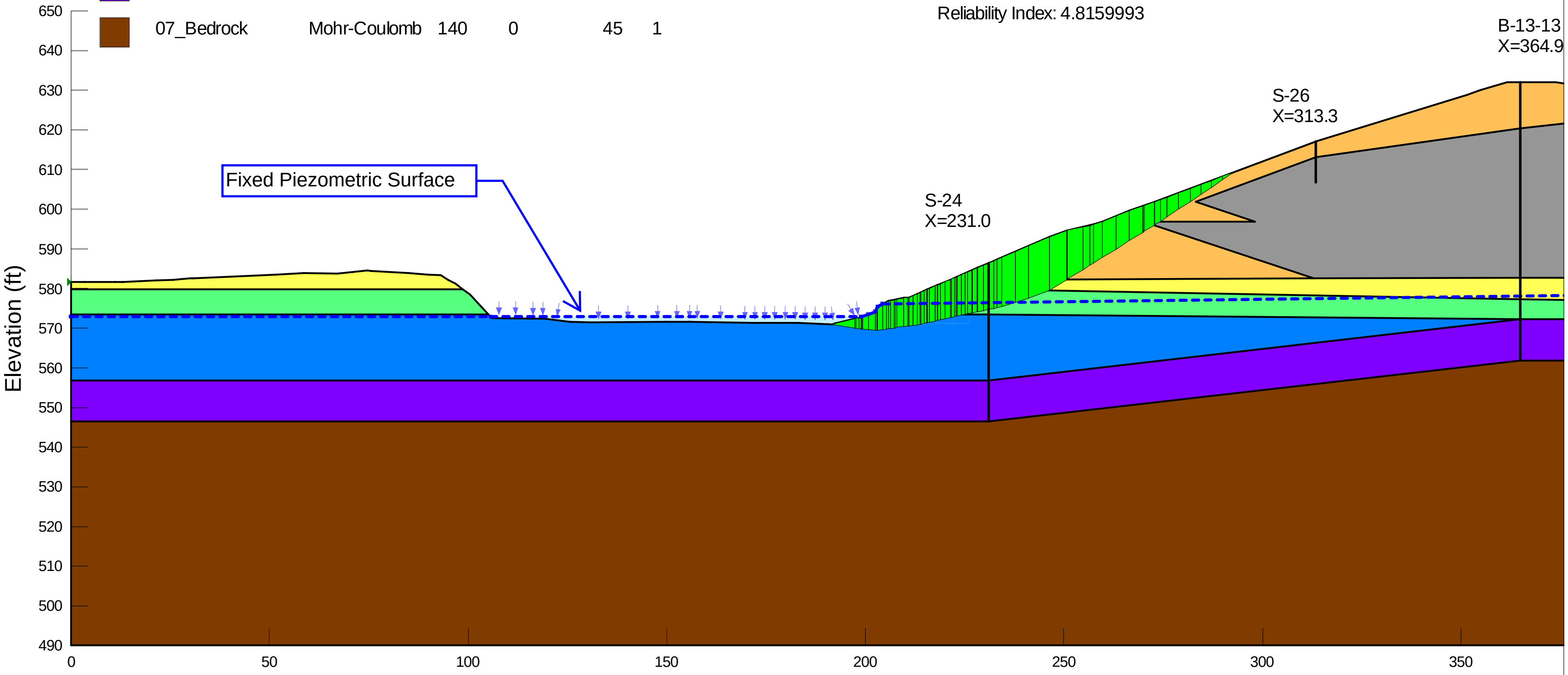
Vermillion OEAP Stability and Reliability Analysis

03_Section D - Probabilistic FS

Created By: Zachary Fallert	Date:12/2/2019	Checked By: Alex Stern	Date:12/3/2019

Stage
03



Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Piezometric Line
🟧	01_Fill	Mohr-Coulomb	131	0	40	1
⬛	02_Coal Ash	Mohr-Coulomb	107	0	37	1
🟨	03_Clay Alluvium	Mohr-Coulomb	112	0	34	1
🟩	04_Sand Alluvium	Mohr-Coulomb	122	0	37	1
🟦	05_Reworked Till	Mohr-Coulomb	141	0	35	1
🟪	06_Glacial Till	Mohr-Coulomb	129	0	37	1
🟫	07_Bedrock	Mohr-Coulomb	140	0	45	1

Mean F of S: 1.8555076
Std. Dev. F of S: 0.17763864
Reliability Index: 4.8159993

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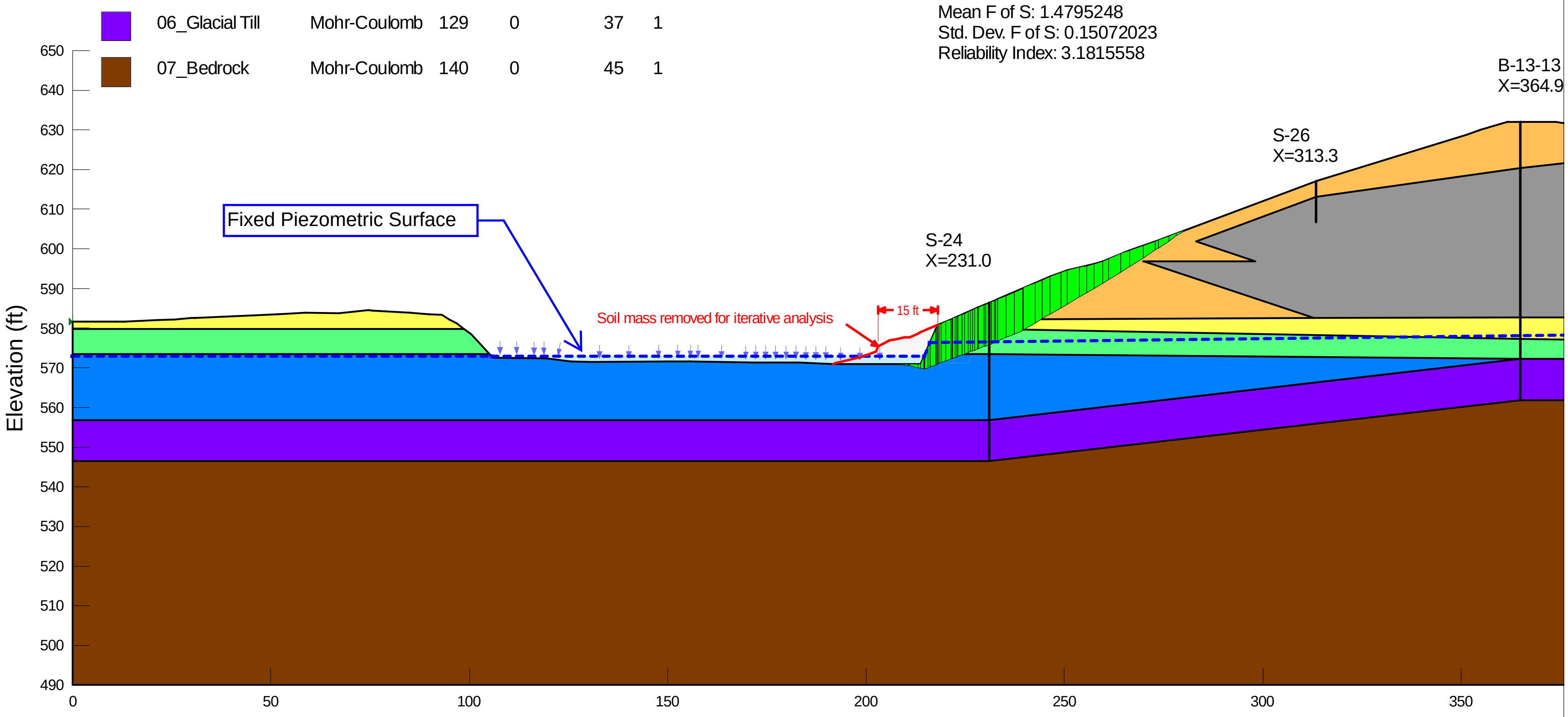
Vermillion OEAP Stability and Reliability Analysis

01_Section D - Probabilistic FS

Created By: Zachary Fallert	Date:12/2/2019	Checked By: Alex Stern	Date:12/3/2019

Stage
01

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Piezometric Line
🟧	01_Fill	Mohr-Coulomb	131	0	40	1
⬛	02_Coal Ash	Mohr-Coulomb	107	0	37	1
🟨	03_Clay Alluvium	Mohr-Coulomb	112	0	34	1
🟩	04_Sand Alluvium	Mohr-Coulomb	122	0	37	1
🟦	05_Reworked Till	Mohr-Coulomb	141	0	35	1
🟪	06_Glacial Till	Mohr-Coulomb	129	0	37	1
🟫	07_Bedrock	Mohr-Coulomb	140	0	45	1



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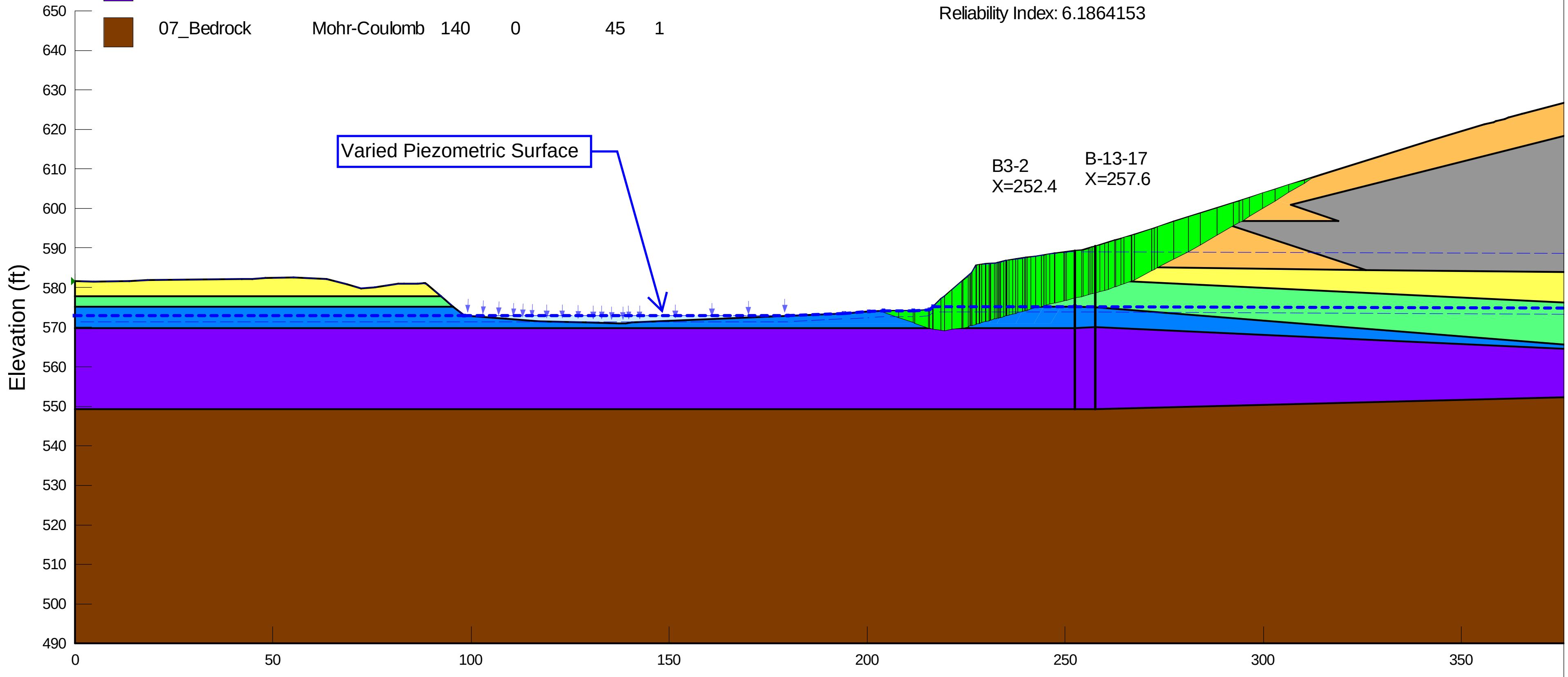
04_Section D - Probabilistic FS

Created By: Zachary Fallert	Date:12/2/2019	Checked By: Alex Stern	Date:12/3/2019

Stage
04

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Piezometric Line
🟧	01_Fill	Mohr-Coulomb	131	0	40	1
⬛	02_Coal Ash	Mohr-Coulomb	107	0	37	1
🟨	03_Clay Alluvium	Mohr-Coulomb	112	0	34	1
🟩	04_Sand Alluvium	Mohr-Coulomb	122	0	37	1
🟦	05_Reworked Till	Mohr-Coulomb	141	0	35	1
🟪	06_Glacial Till	Mohr-Coulomb	129	0	37	1
🟫	07_Bedrock	Mohr-Coulomb	140	0	45	1

Mean F of S: 2.2163944
Std. Dev. F of S: 0.19662346
Reliability Index: 6.1864153



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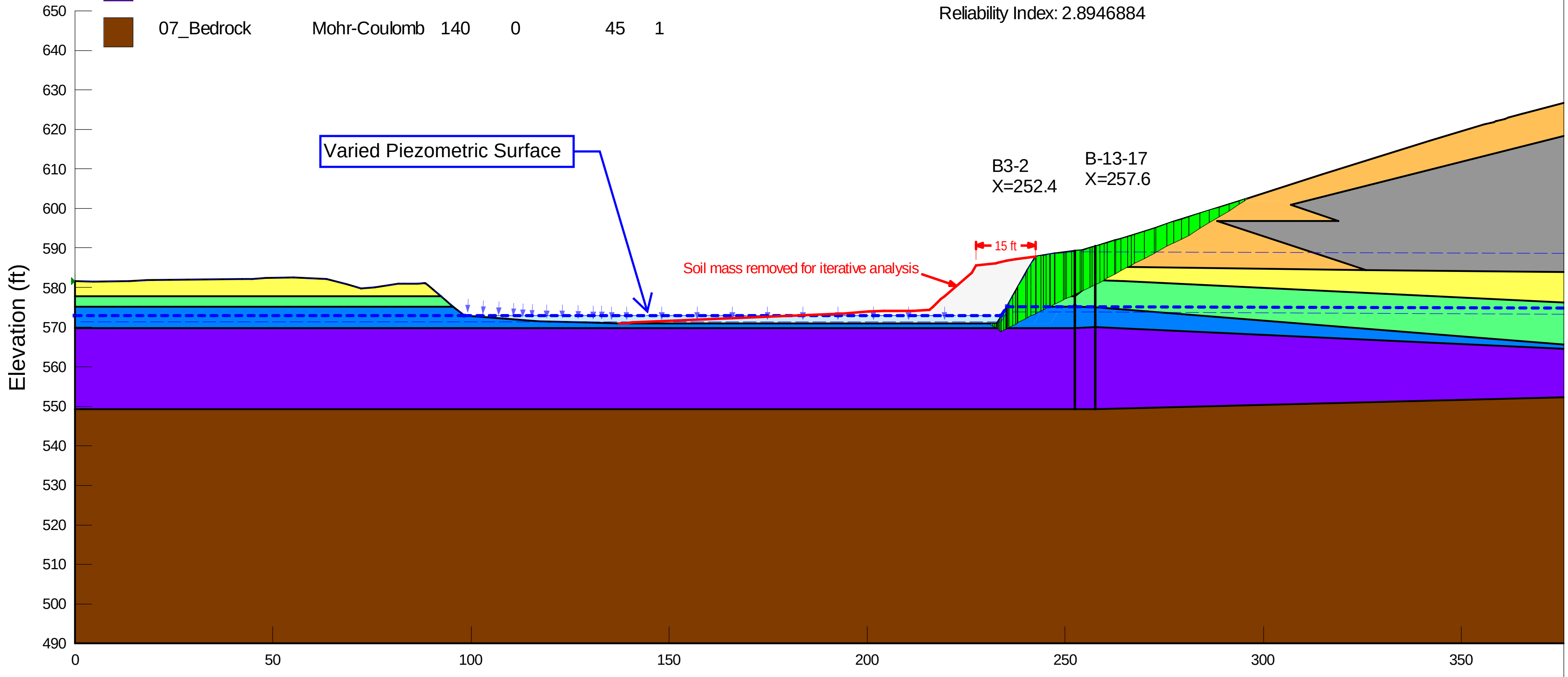
01_Section F - Probabilistic FS

Created By: Zachary Fallert | Date:12/2/2019 | Checked By: Alex Stern | Date:12/3/2019

Stage
01

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Piezometric Line
🟧	01_Fill	Mohr-Coulomb	131	0	40	1
▨	02_Coal Ash	Mohr-Coulomb	107	0	37	1
🟨	03_Clay Alluvium	Mohr-Coulomb	112	0	34	1
🟩	04_Sand Alluvium	Mohr-Coulomb	122	0	37	1
🟦	05_Reworked Till	Mohr-Coulomb	141	0	35	1
🟪	06_Glacial Till	Mohr-Coulomb	129	0	37	1
🟫	07_Bedrock	Mohr-Coulomb	140	0	45	1

Mean F of S: 1.4326183
Std. Dev. F of S: 0.14945245
Reliability Index: 2.8946884



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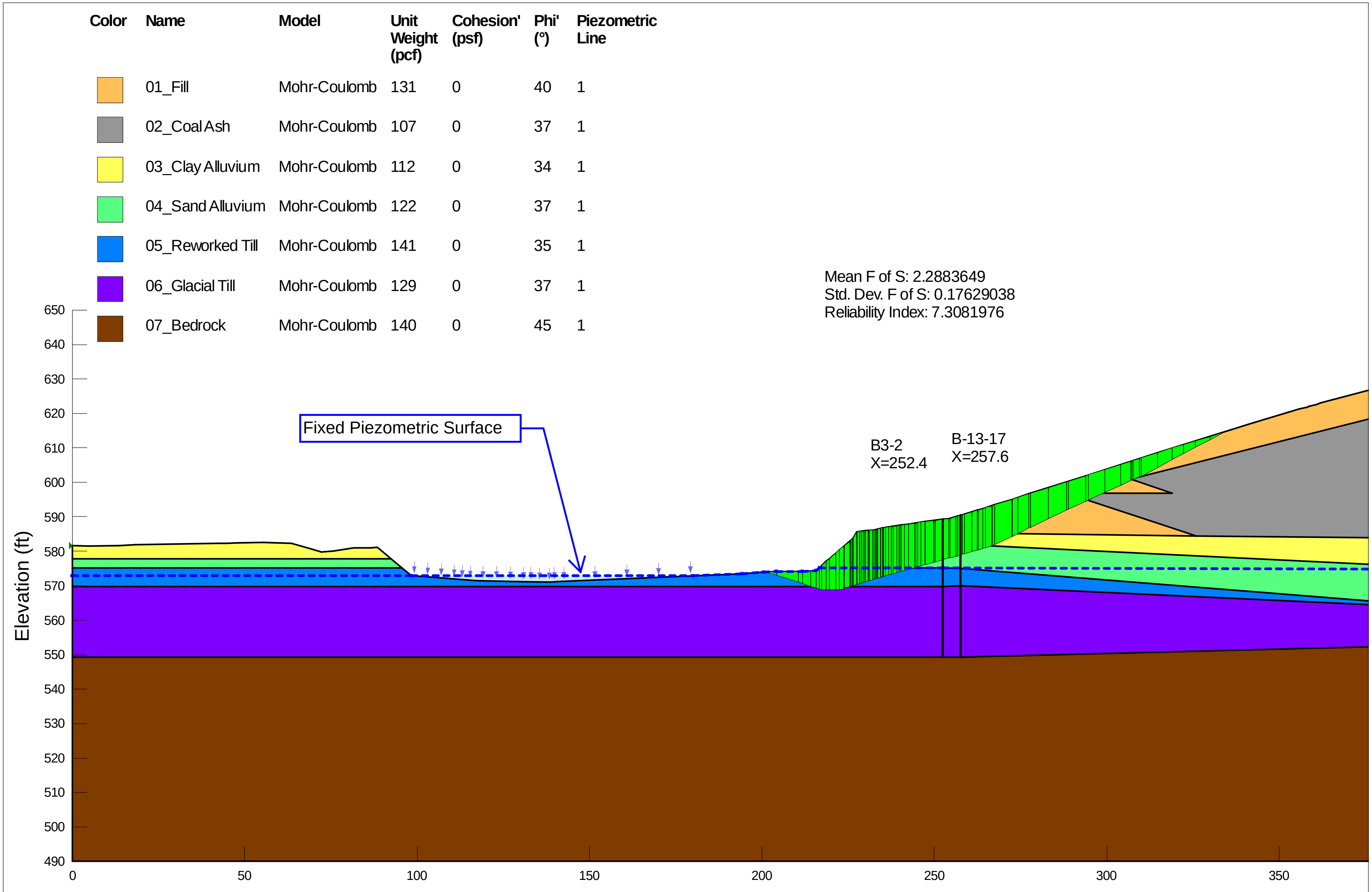
05_Section F - Probabilistic FS

Created By: Zachary Fallert	Date:12/2/2019	Checked By: Alex Stern	Date:12/3/2019

Stage
05



Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Piezometric Line
🟧	01_Fill	Mohr-Coulomb	131	0	40	1
⬛	02_Coal Ash	Mohr-Coulomb	107	0	37	1
🟨	03_Clay Alluvium	Mohr-Coulomb	112	0	34	1
🟩	04_Sand Alluvium	Mohr-Coulomb	122	0	37	1
🟦	05_Reworked Till	Mohr-Coulomb	141	0	35	1
🟪	06_Glacial Till	Mohr-Coulomb	129	0	37	1
🟫	07_Bedrock	Mohr-Coulomb	140	0	45	1

Mean F of S: 2.2883649
Std. Dev. F of S: 0.17629038
Reliability Index: 7.3081976

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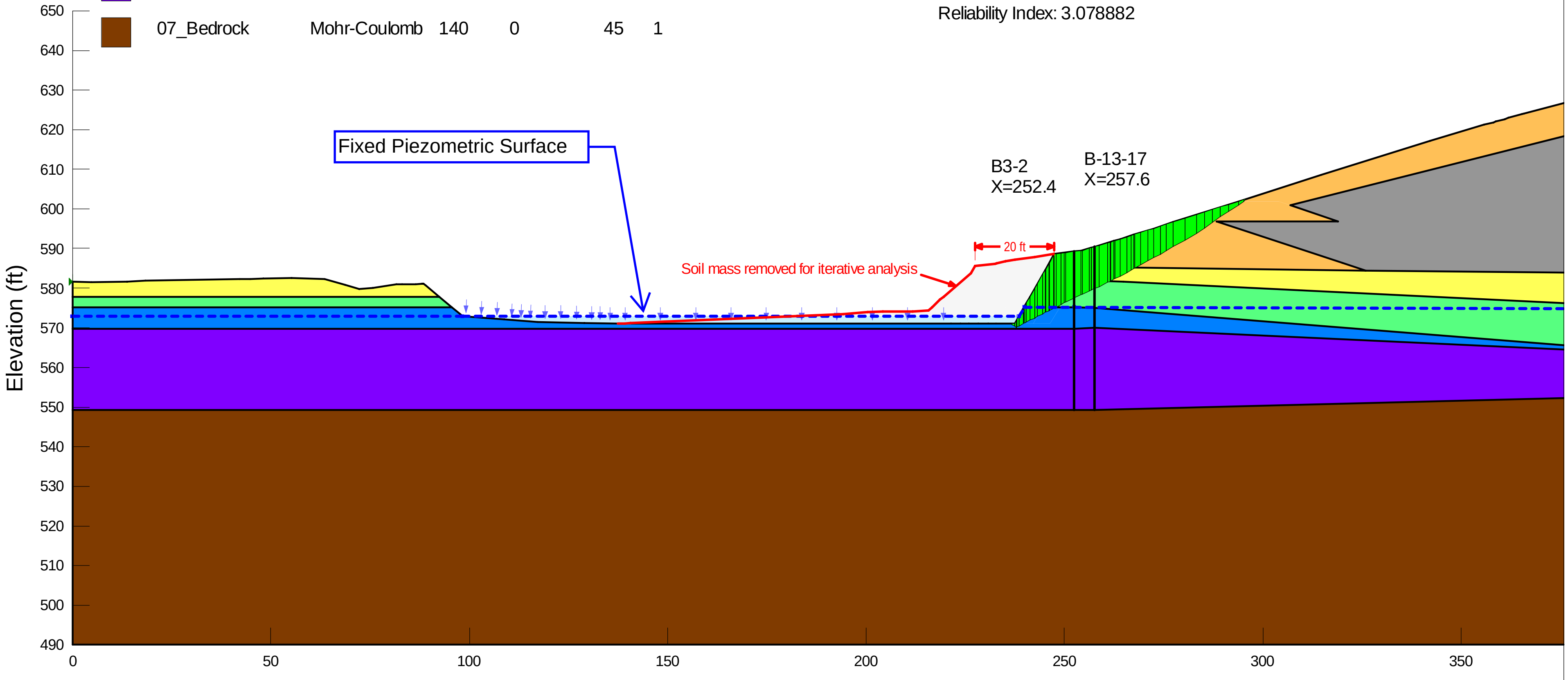
01_Section F - Probabilistic FS

Created By: Zachary Fallert	Date:12/2/2019	Checked By: Alex Stern	Date:12/3/2019

Stage
01

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Piezometric Line
🟧	01_Fill	Mohr-Coulomb	131	0	40	1
⬜	02_Coal Ash	Mohr-Coulomb	107	0	37	1
🟨	03_Clay Alluvium	Mohr-Coulomb	112	0	34	1
🟩	04_Sand Alluvium	Mohr-Coulomb	122	0	37	1
🟦	05_Reworked Till	Mohr-Coulomb	141	0	35	1
🟪	06_Glacial Till	Mohr-Coulomb	129	0	37	1
🟫	07_Bedrock	Mohr-Coulomb	140	0	45	1

Mean F of S: 1.411626
Std. Dev. F of S: 0.13369335
Reliability Index: 3.078882



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06_Section F - Probabilistic FS

Created By: Zachary Fallert	Date:12/2/2019	Checked By: Alex Stern	Date:12/3/2019

Stage
06