Corrective Measures Assessment

Ash Pond No. 2
Hennepin Power Station
Hennepin, Illinois

Dynegy Midwest Generation, LLC

September 5, 2019

OBG
Part of Ramboll

SEPTEMBER 5, 2019 | PROJECT #72857

Corrective Measures Assessment

Ash Pond No. 2
Hennepin Power Station
Hennepin, Illinois

Prepared for:
Dynegy Midwest Generation, LLC

SARAH L. MEYER
Senior Managing Scientist

FRANCES ACKERMAN
Senior Managing Engineer

ERIC J. TLACHAC, PE
Managing Engineer

BRIAN G. HENNINGS
Managing Hydrogeologist

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

Ash Pond No. 2 (AP2) at the Hennepin Power Station (HPS) is an inactive, unlined coal combustion residuals (CCR) surface impoundment (SI), located near the Village of Hennepin, in Putnam County, Illinois. The locations of HPS and AP2 are shown on Figures 1 and 2.

The Closure and Post-Closure Care Plan for AP2 (Closure Plan, Civil & Environmental Consultants, Inc (CEC), 2018), consisting of a corrective action process, was submitted to the Illinois Environmental Protection Agency (IEPA) for approval, along with a Closure Plan Addendum (OBG, 2018). IEPA provided comments on the Closure Plan in May of 2019 and responses to those comments were submitted to IEPA in July 2019 (OBG, 2019a). Therefore, the approval process is near completion. The Closure Plan and Closure Plan Addendum are consistent with the written closure plan required by 40 C.F.R. § 257.102. The Closure Plan summarized the planned closure and corrective measures for AP2, which included constructing a compacted soil cover system in direct contact with the graded CCR, establishment of a vegetative cover, and monitored natural attenuation (MNA). The closure construction activities are scheduled to begin following IEPA approval of the Closure Plan and be completed by November 2020. After closure activities are complete, post-closure activities, which include groundwater monitoring and maintenance of the final cover system, will occur.

The new cover system will significantly minimize water infiltration into the closed CCR unit (the primary source of CCR constituents in groundwater) and allow surface water to drain off the cover system. AP2 is partially underlain by sands and gravels that have a geometric mean permeability of 5.6×10^{-2} cm/sec. The compacted earthen cover material with a maximum permeability of 1×10^{-5} cm/sec is well below that of the foundation soils. This will reduce generation of potentially impacted water and the extent of groundwater impacts from AP2 in the Uppermost Aquifer by natural attenuation. The planned cover system will limit the migration of potentially impacted groundwater, control surface water on the cover system, and reduce contaminant transport off site, both spatially and temporally. Groundwater modeling results of post-closure AP2 indicate construction of the cover system and MNA will result in achieving groundwater quality standards within two years after cover construction is complete.

Statistically significant levels (SSLs) of total lithium and molybdenum were identified in the Uppermost Aquifer during groundwater monitoring required by 40 C.F.R. § 257.90. There are no existing off-site water wells, potable or non-potable, that are likely to be impacted by groundwater from the HPS property. **There are no impairments to groundwater usage on the HPS property or surrounding properties caused by AP2.**

Impacts of groundwater with elevated concentrations of CCR constituents from beneath the closed AP2 on nearby surface waters are not expected. Concentrations of sulfate and boron in the Illinois River, adjacent to HPS, were calculated in the Hydrogeologic Site Characterization Report (NRT/OBG, 2017b). These calculations were replicated for lithium and molybdenum and presented in the July 2019 response to comment letter (OBG, 2019a). The calculated concentrations of constituents in surface water attributed to AP2 are less than the laboratory detection limit for all four parameters evaluated (boron, sulfate, lithium, and molybdenum). Comparisons of the molybdenum and lithium concentrations to boron presented in the response to comment letter (OBG, 2019a) indicate that boron and lithium concentrations have strong linear correlations and boron and molybdenum have strong exponential correlations. These correlations are further evidence that concentrations of lithium and molybdenum are expected to decrease at similar rates to those of boron as predicted in the computer model.

This Corrective Measures Assessment (CMA) was prepared to address the requirements of 40 C.F.R. § 257.96. The following potential corrective measures were identified based upon site-specific conditions:

- Presumptive Alternative 1) Closure In Place (CIP) (Soil Cover System) and MNA
- Alternative 2) Closure by Removal (CBR) and MNA
  - Alternative 2A) On-site CCR disposal and MNA
  - Alternative 2B) Off-site CCR disposal and MNA

- Alternative 3) Closure In Place (Soil Cover System) with groundwater cutoff wall, hydraulic gradient control system, and MNA

These alternatives were evaluated with respect to the following remedy selection evaluation factors in 40 C.F.R. § 257.97 and their associated considerations.

LONG- AND SHORT-TERM EFFECTIVENESS, PROTECTIVENESS, AND CERTAINTY

In general, CIP alternatives (Presumptive Alternative 1 and Alternative 3) are more effective and protective than CBR alternatives (Alternatives 2A and 2B). This is primarily due to: 1) the relatively short timeframe for permitting and constructing a CIP alternative, relative to the long implementation timeframe for CBR (approximately 7-12 years, depending on permitting), during which time groundwater would continue to be impacted from CCR remaining on site; and 2) the increased potential for human health and environmental impacts during excavation and transport of CCR during removal activities, particularly off-site disposal (Alternative 2B).

SOURCE CONTROL

Groundwater modeling for Presumptive Alternative 1 indicates that, although the secondary source of groundwater impacts (underlying saturated soils that have been in contact with CCR-impacted groundwater) will remain in place, concentrations will begin to decline after cover system construction is complete and are predicted to meet the GWPS within two years after cover completion.

Adding a groundwater cutoff wall and hydraulic gradient control system to Presumptive Alternative 1 (*i.e.*, Alternative 3) may enhance the secondary source control effectiveness, but would increase the implementation timeframe, such that it is not expected to have a meaningful impact on the time to meet the GWPS relative to Presumptive Alternative 1. The ability of Alternative 3 to effectively reduce groundwater concentrations and attain GWPS will have a high dependence upon the ability to key the groundwater cutoff wall into a low-permeability geologic unit beneath AP2 (presumably bedrock).

The CBR alternatives (Alternatives 2A and 2B) achieve long-term source control, but present short-term environmental risk associated with implementation. The primary source of groundwater impacts (CCR) would remain in place during implementation, allowing transport of lithium and molybdenum into the groundwater throughout the extended permitting and implementation timeframe (7 to 12 years, depending on permitting requirements). Human and environmental receptors would also be exposed to CCR over this timeframe and the secondary source of groundwater impacts would remain after remedy implementation.

IMPLEMENTABILITY

Presumptive Alternative 1 is currently under review by IEPA and approval and commencement of construction is expected. Alternative 3 would require detailed site investigation and design activities prior to implementation. CBR alternatives (2A and 2B) would entail significant difficulty in permitting, construction, and transportation, which would delay potential benefits associated with this remedy.

Presumptive Alternative 1 provides performance that is as good as, or better than, the other alternatives for each of the evaluation factors considered. A public meeting will be held, in accordance with 40 C.F.R. § 257.96(e). Following receipt of public input, a corrective measure will be selected and documented in the remedy selection report required by 40 C.F.R. § 257.97(a).

1 INTRODUCTION

O'Brien & Gere Engineers, Inc, part of Ramboll (OBG), has prepared this Corrective Measures Assessment (CMA) for Ash Pond No. 2 (AP2). AP2 is a coal combustion residuals (CCR), Unit ID 802, located at Hennepin Power Station (HPS) near the Village of Hennepin, in Putnam County, Illinois. This CMA report complies with the requirements of Title 40 of the Code of Federal Regulations (C.F.R.) § 257, Subpart D Standards for the Disposal of Coal Combustion Residuals in Landfills and Surface Impoundments (CCR Rule). Under the CCR Rule, owners and operators of existing CCR surface impoundments (SIs) must initiate a CMA, in accordance with 40 C.F.R. § 257.96, when one or more Appendix IV constituents are detected at statistically significant levels (SSLs) above groundwater protection standards (GWPS) and the owner or operator has not demonstrated that a source other than the CCR unit has caused the SSLs. This CMA is responsive to the 40 C.F.R. § 257.96 and § 257.97 requirements for assessing potential corrective measures to address the exceedances of the GWPS for lithium and molybdenum.

1.1 SITE DESCRIPTION AND HISTORY

The Hennepin East Ash Pond Complex at HPS is composed of AP2 (inactive), Ash Pond No. 4 (classified as capped or otherwise maintained), East Ash Pond (active), Hennepin Landfill (active but not currently accepting CCR), Leachate Pond (non-CCR impoundment) and Polishing Pond (non-CCR impoundment). The subject of this CMA is AP2. AP2 is an inactive, unlined CCR SI located in the northeast quarter of Section 26, Township 33 North, Range 2 West, Putnam County, Illinois (Figure 1). The impoundment is situated less than 200 feet south of the Illinois River and approximately one mile east of the Big Bend, where the river shifts course from predominantly west to predominantly south. The surrounding area includes industrial properties to the east and south, agricultural land to the southwest, and the Illinois River to the north.

The HPS has two coal-fired units constructed in 1953 and 1959 with a total capacity of 280 megawatts (MW). Dynegy Midwest Generation, LLC (DMG) operated AP2 from 1958 to 1996 after which it was removed from service and dewatered. CCR was removed from the eastern portion of AP2 when Phase I of Hennepin Landfill and the associated Leachate Pond were constructed from 2009-2011. AP2 is currently approximately 18 acres in size.

In accordance with the CCR Rule, AP2 is classified as an inactive, unlined CCR SI (Figure 2). The pond is surrounded by a perimeter road and is bounded to the north by the Illinois River, to the east by the Hennepin Landfill, to the southeast by the East Ash Pond, to the southwest by Ash Pond No. 4 (by definition, a non-CCR Unit, capped or otherwise maintained) and a gravel pit (non-CCR Unit). AP2 was used to store and dispose of fly ash, bottom ash, and other non-CCR waste streams, including coal pile runoff. The pond is unlined with a variable, but lowermost, bottom elevation of 451 feet NAVD88 (OBG, 2017b).

In February 2018, DMG submitted the Closure and Post-Closure Care Plan for the Hennepin East Ash Pond No. 2 (Closure Plan, Civil & Environmental Consultants, Inc (CEC), 2018) to the Illinois Environmental Protection Agency (IEPA). The Closure Plan set forth corrective measures and sought approval to close AP2 by leaving CCR in place and constructing a final soil cover system of compacted earthen material. The final cover system will have lower permeability than the subsoils underlying the CCR, control the potential for water infiltration into the closed CCR unit, and allow drainage of water off, and out of, the closed CCR unit. The Closure Plan included provisions for maintaining the final cover system and groundwater monitoring to assess natural attenuation. If a statistically significant increasing trend is observed to continue over a period of two or more years, and a subsequent hydrogeologic site investigation demonstrates that such exceedances are due to a release from the OWAP and corrective actions are necessary and appropriate to mitigate the release, a corrective action plan will be proposed as a modification to the post-closure care plan. IEPA provided comments on the Closure Plan in May of 2019 and responses to those comments were submitted to IEPA in July 2019 (OBG, 2019a). Therefore, the approval process is near completion.

1.2 CORRECTIVE MEASURES ASSESSMENT OBJECTIVES AND METHODOLOGY

The objective of this CMA is to document the assessment of potential corrective measures considered for impacted groundwater associated with AP2 at HPS. The CMA evaluates the effectiveness of potential corrective measures (including the Closure Plan currently under review by IEPA) in meeting all requirements and objectives of the remedy, as described under 40 C.F.R. § 257.96(c) by addressing the following:

- The performance, reliability, ease of implementation, and potential impacts of appropriate potential remedies, including safety impacts, cross-media impacts, and control of exposure to any residual contamination.
- The time required to begin and complete the remedy.
- The institutional requirements, such as state or local permit requirements, or other environmental or public health requirements, that may substantially affect implementation of the remedy(s).

The CMA provides a systematic, rational method for evaluating potential corrective measure alternatives. The assessment process evaluates potential corrective measures against a set of general performance standards (threshold criteria) that act as filters to screen out alternatives that do not meet minimum standards for protectiveness. Alternatives that meet the performance standards are then evaluated against a series of evaluation factors and considerations (balancing criteria) to evaluate the relative effectiveness of each alternative. The performance standards are requirements that must be met to ensure a successful remedy, whereas, the evaluation factors and considerations provide flexibility and guidance to aid decision-making to best meet the performance standards. Corrective measures will likely not effectively address each and every evaluation factor and consideration; rather, they are compared against one another to inform a rational selection of a corrective measure for AP2.

The following performance standards, per 40 C.F.R. § 257.97, were used to screen potential corrective measures for AP2 at the HPS (threshold criteria) to ensure they are met by the selected alternative:

- Be protective of human health and the environment.
- Attain the GWPS per 40 C.F.R. § 257.95(h).
- Provide source control to reduce or eliminate, to the maximum extent feasible, further releases of Appendix IV constituents.
- Remove from the environment as much of the contaminated material as feasible.
- Comply with waste management standards per 40 C.F.R. § 257.98(d).

40 C.F.R. § 259.102 specifically allows either closure-by-removal (CBR) or closure-in-place (CIP) approaches to site closure. Site-specific considerations regarding the AP2 Conceptual Site Model (CSM, Section 2) were used to evaluate potential corrective measures. The following potential corrective measures were considered during CMA process:

- Presumptive Alternative 1) Closure in Place (Soil Cover System) and MNA
- Alternative 2) Closure by Removal and MNA
  - Alternative 2A) On-site CCR disposal and MNA
  - Alternative 2B) Off-site CCR disposal and MNA
- Alternative 3) Closure in Place (Soil Cover System) with groundwater cutoff wall, hydraulic gradient control system, and MNA

Each of these corrective measure alternatives meets the threshold criteria and were comparatively evaluated per the 40 C.F.R. § 257.97 remedy selection evaluation factors and considerations, which implicitly encompass the requirements and objectives included under 40 C.F.R. § 257.96(c) and summarized above. Other alternatives described below were considered, but not retained for further analysis, because they are technically infeasible given the site-specific geologic and hydrogeologic setting and/or chemical characteristics of the groundwater impacts identified at AP2.

The highly transmissive, but heterogeneous Uppermost Aquifer at AP2 (see Section 2) and the nature, extent, and detected concentrations of groundwater contaminants, constrained the selection of potentially applicable engineering controls. Specifically, the effectiveness of a pump and treat system to hydraulically contain and capture the lithium and molybdenum plumes in close proximity to the Illinois River, and in an Uppermost Aquifer with relatively high conductivity, was weighed against the effectiveness of other alternatives that were considered. The proximity of the plumes to the Illinois River presents challenges for plume capture and containment, which would require removal and treatment of high volumes of water. Because pump and treat would yield little net benefit, at much greater energy demands, pump wear and tear, and aquifer stresses, compared to a groundwater cutoff wall paired with hydraulic gradient control (*e.g.*, Alternative 3), construction of a pump and treat system was not retained for further analysis in this CMA.

In a similar manner, in-situ solidification/stabilization (ISS) was considered, but not retained for analysis, based on practical considerations relative to other alternatives. ISS is a treatment technology which consists of encapsulating waste within a cured monolith having increased compressive strength and reduced hydraulic conductivity. Hazards can be reduced by both converting waste constituents into less soluble and mobile forms and isolating waste from groundwater, thus facilitating groundwater remediation and reduction of leaching to groundwater. The timeframe to implement ISS, including bench-scale and pilot-scale testing to support the detailed design, is longer than other alternatives and would delay source control relative to other alternatives. In addition, the effects on groundwater chemistry associated with the addition of large volumes of Portland cement and other amendments to the subsurface would require detailed evaluation. Implementation would also require specialized contractors and equipment.

2 CONCEPTUAL SITE MODEL

The currently defined extent of the release of CCR constituents to the environment does not threaten public health. There are currently no impairments to groundwater usage on HPS property or surrounding properties associated with constituents from AP2. CCR dewatering and the soil cover system will reduce generation of potentially-impacted water and migration from AP2, and minimize CCR constituents entering the environment, as described in the Groundwater Model Report (OBG, 2017a). The calculated low concentrations of CCR indicator parameters mixing with surface water near AP2 are evidence that current conditions are protective of surface water receptors.

2.1 GEOLOGY AND HYDROGEOLOGY

The geology and hydrogeology described in the Hydrogeologic Site Characterization Report (OBG, 2017b) are summarized below, and define the conceptual site model for AP2; cross-sections are provided in the Hydrogeologic Site Characterization Report:

- Fill Unit – CCRs within AP2, consisting primarily of fly ash, bottom ash, and other non-CCR waste streams, including coal pile runoff. This unit also includes man made berms constructed of a variety of locally available materials.
- Alluvial sandy silts and clays interbedded with sands and gravels, classified as Cahokia Alluvium.
- Sand and gravel with boulders, deposited by glacial meltwaters and classified as Henry Formation.

AP2 was constructed on the lower of two river terraces between the Illinois River and adjacent uplands. The Henry Formation sands and gravels make up the upper and lower terraces. Discontinuous observations of silty clay in two borings (B29 and 18D) indicate the possible presence of alluvial fine-grained deposits of silts and clays, classified as Cahokia Alluvium, in the western portion of HPS.

The Henry Formation sits directly on top of bedrock at AP2. The uppermost bedrock near HPS, including AP2, is the Pennsylvanian Carbondale Formation, which consists of shale with thin limestone, sandstone, and coal beds. Three deeper borings around the perimeter of the East Ash Pond System indicate the presence of shale bedrock between elevations 400 and 410 feet NAVD88, approximately 85 to 90 feet below ground surface (OBG, 2017b).

The Henry Formation and Cahokia Alluvium comprise the Uppermost Aquifer at the Site and extend from the water table to the bedrock. The groundwater monitoring well system is shown on Figure 2. The Illinois River is the local and regional groundwater discharge area under normal river stage; the primary directions of groundwater flow are north and northwest at AP2. River stage is usually lowest during the months of August through October. The river basin experiences annual spring flooding during the months of March, April, May, and sometimes June, whereas, lesser flooding occasionally occurs during autumn. River stage during high precipitation and/or flood events seasonally rises above adjacent groundwater elevations and low-lying areas of the floodplain. Horizontal hydraulic gradients are moderate (0.002 to 0.004 foot per foot [ft/ft]) as groundwater approaches AP2 south of the East Ash Pond and Polishing Pond. The horizontal gradient becomes nearly flat before steepening between AP2 and the river. The flattening of the horizontal gradient is attributed to the highly permeable sand and gravel that runs beneath the East Ash Pond Complex.

Groundwater flow velocity ranged from approximately 0.5 to 0.7 feet per day (ft/day), as groundwater flowed from south to north through the southern portion of the East Ash Pond Complex in September and December 2015, during periods of normal flow conditions (*i.e.*, no flow reversals). As groundwater flowed from south to north through AP2, along the northern portion of the East Ash Pond Complex, the flow velocity was slightly higher and ranged from approximately 0.9 to 1.5 ft/day in September and December 2015.

A groundwater flow and transport model was developed for AP2 to evaluate the effect that the cover system construction and MNA would have on surrounding groundwater quality. Boron is a common indicator parameter for the presence of CCR impacts in groundwater, in part because it is more mobile than other contaminants potentially associated with CCR. Therefore, boron was modeled to document the impact of the proposed cover system and MNA at AP2 and the results were presented in the Groundwater Model Report (OBG, 2017b). The transport and fate of lithium in the groundwater is expected to be similar to that of boron because both are mobile in groundwater and relatively unaffected by sorption to organic matter or iron hydroxides in the aquifer. Molybdenum has the potential to be sorbed onto iron hydroxides or organic matter in the aquifer materials and is typically mobile though dependent on geochemical conditions (EPRI, 2012). The potential for sorption of molybdenum onto particles may increase the length of time required for molybdenum to reach applicable groundwater protection standards, as molybdenum will desorb from the aquifer materials as dissolved concentrations decline.

Modeling results indicate that boron concentrations are predicted to meet groundwater quality standards within two years after cover completion. The occasional saturation of ash during flood events will not have significant effect on the predicted concentration of boron, which also applies to reductions in lithium and molybdenum concentrations (OBG, 2019a). The flow and transport model was calibrated against long-term observed groundwater elevations and boron concentrations in monitoring wells, using a river stage elevation of 444 ft NGVD 29 (OBG, 2017b). Although there were significant transient river flood events that caused short-term deviations in groundwater elevations and boron concentrations, overall, the calibrated model accounts for the longer term baseflow conditions to the Illinois River that control the extent and concentration of the modeled plume.

A hydrostatic model was also developed for AP2 to evaluate the hydrostatic conditions following implementation of the proposed cover system (OBG, 2017c). Results indicate hydrostatic equilibrium can be attained for the system and hydraulic head in the proposed cover system is expected to decrease to near-zero level at equilibrium two years after completion of cover construction.

2.2 POTABLE WATER WELL INVENTORY

A comprehensive water well survey conducted by NRT and Kelron (2009) for a 2,500-foot radius around the entire HPS property boundary, inclusive of AP2, concluded that there are no existing off-site water wells, potable or non-potable, likely to be impacted by groundwater from the HPS property. There were only two wells located outside of the HPS property boundary and within 2,500 feet of AP2. The two wells, constructed in 1844 and 1922 to depths of 30 and 17 feet below ground surface, respectively, according to State of Illinois records, have been verified and were most likely abandoned decades ago. There are no homes, farms, or other potential users present at these two locations. There are also no public water supply (PWS), community water supply (CWS), or non-CWS wells or wellhead protection areas (WHPAs) within 2,500 feet of AP2.

Within the plant property boundary, there are four wells owned by DMG, all of which are non-potable and non-contact industrial wells.

2.3 GROUNDWATER QUALITY

Groundwater monitoring per 40 C.F.R. § 257.90 commenced in December 2015. Monitoring wells around AP2 were installed beginning in 1994, and additional wells and piezometers were installed in 1995, 2009, and 2015 to define the extent of CCR impacts and comply with the CCR Rule. Monitoring includes groundwater elevation measurements and collection of water quality samples from background monitoring wells 07, 08, 08D, and downgradient wells 03R, 18S, 18D, and 45S (Figure 2). Detection monitoring, per 40 C.F.R. § 257.90, was initiated in November 2017; statistically significant increases (SSIs) of Appendix III parameters over background concentrations were detected. Alternate source evaluations were inconclusive for one or more of the SSIs. Therefore, in accordance with 40 C.F.R. § 257.94(e)(2), an Assessment Monitoring Program was established for AP2 on April 9, 2018. Assessment Monitoring results identified statistically significant levels (SSLs) of the Appendix IV parameters lithium and molybdenum over the GWPSs of 0.04 milligrams per Liter (mg/L) and 0.1 mg/L, respectively. SSLs for total lithium were identified in downgradient monitoring well 18S (0.0659 mg/L to 0.0920 mg/L). SSLs for total molybdenum were identified in downgradient monitoring wells 03R (0.15 mg/L to 0.238 mg/L) and 18S (0.301 mg/L to 0.320 mg/L). No other SSLs have been identified for AP2.

Comparisons of the molybdenum and lithium concentrations to boron indicate that these compounds are relatively well-correlated at downgradient wells 18S, 3R, and 45S, as evaluated in the response to comment letter to IEPA (OBG, 2019a). Boron and lithium have a strong linear correlation coefficient of 0.94. Boron and molybdenum have a good linear correlation coefficient of 0.72; and, molybdenum shows a stronger exponential correlation coefficient of 0.94 with boron, likely due to sorption of molybdenum on aquifer materials as discussed above. Based on the data collected and the existing strong linear or exponential correlations, lithium and molybdenum are expected to behave similarly to boron and concentrations of lithium and molybdenum are expected to decrease at similar rates to those of boron as predicted in the computer model.

2.4 IMPACTED GROUNDWATER DISCHARGE TO SURFACE WATER

Boron, sulfate, lithium, and molybdenum concentrations were calculated to assess the potential impact to surface water due to groundwater below AP2 discharging to the Illinois River. The boron and sulfate calculations were presented in the Hydrogeologic Site Characterization Report (OBG, 2017b) and indicated that groundwater discharge to the Illinois River could potentially increase surface water concentrations of boron by 0.0066 mg/L and sulfate by 0.29 mg/L. Boron and sulfate concentrations were predicted to be below their respective detection limits reported by the laboratory, indicating that changes in surface water concentrations would not likely be detected and impacts would be negligible. These calculations were replicated for lithium and molybdenum and presented in the July 2019 response to comment letter (OBG, 2019a). The calculated lithium and molybdenum concentrations were also less than their respective laboratory detection limits.

3 CORRECTIVE MEASURES ALTERNATIVE DESCRIPTIONS

The corrective measure alternatives described below meet the threshold criteria summarized in Section 1.2 and are capable of mitigating groundwater impacts from AP2.

3.1 PRESUMPTIVE ALTERNATIVE 1: CLOSURE IN PLACE (SOIL COVER SYSTEM) WITH MNA

Presumptive Alternative 1: Design of the Closure in Place (soil cover system) with MNA has been completed and the Closure Plan and Closure Plan Addendum have been submitted to IEPA. IEPA provided comments on the Closure Plan in May of 2019 and responses to those comments were submitted to IEPA in July 2019 (OBG, 2019a). Therefore, the approval process is near completion.

This alternative includes regrading the existing CCR within AP2 to achieve acceptable grades for closure and constructing a cover system that complies with the CCR Rule. The final cover system, described in detail below, will comply with the applicable design requirements of the CCR Rule, including establishment of a vegetative cover to minimize long-term erosion. Portions of the berm around AP2 will be excavated to construct low-level crossings and the soils will be used as crown fill. The low-level crossings will convey stormwater across the perimeter berm while allowing vehicles to drive through the crossings. Soil from a borrow source will be used to supplement the fill volume in order to reach final grades in preparation for the final cover system. The compacted soil cover system will significantly minimize water infiltration into the closed CCR unit (the primary source of CCR constituents in groundwater). This will allow surface water to drain off the cover system, thus reducing generation of potentially impacted water and reducing the extent of lithium and molybdenum impact in the Uppermost Aquifer. Following construction of the cover system, natural attenuation of lithium and molybdenum in groundwater will be monitored, as described in the Groundwater Monitoring Plan (OBG, 2019b) attached to the IEPA response to comments (OBG, 2019a).

Stormwater runoff from the final cover system will be collected and managed. A stormwater management system will be constructed to convey stormwater runoff from the cover system to perimeter drainage channels. The stormwater will be routed to the Illinois River on the north, and adjacent areas to the south, that follow the natural drainage patterns.

Both federal and state regulators have long recognized that MNA can be an acceptable component of a remedial action, when it can achieve remedial action objectives in a reasonable timeframe. In 1999, the USEPA published a final policy directive (USEPA, 1999) for use of MNA for groundwater remediation and described the process as follows:

- The 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. The 'natural attenuation processes' that are at work in such a remediation approach include a variety of physical, chemical, or biological processes that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater. These in-situ processes include biodegradation; dispersion; dilution; sorption; volatilization; radioactive decay; and chemical or biological stabilization, transformation, or destruction of contaminants.

It is important to note that USEPA has stated that source control (such as in the alternative submitted for IEPA approval for the AP2 soil cover system) was the most effective means of ensuring the timely attainment of remediation objectives (USEPA, 1999). Natural attenuation processes will constitute a "finishing step" after effective source control at AP2 by means of the soil cover system (Presumptive Alternative 1). Ongoing groundwater monitoring will document the attenuation and long-term effectiveness of the source control. Based on the groundwater prediction model (OBG, 2017a), concentrations of CCR constituents will decline and GWPS will be attained in two years following soil cover completion.

Presumptive Alternative 1 includes, but is not limited to, the following primary project components:

- The existing CCR within AP2 will be regraded to achieve acceptable grades for closure and constructing a cover system that complies with the CCR Rule.
- A final cover system will be constructed on the regraded CCR material. The final cover system design meets the requirements of the CCR Rule such that the permeability of the cover will be less than or equal to the permeability of the existing subsoils present below the CCR. This will allow water in the pore space of the CCR to drain into the foundation soils and not accumulate in the closed CCR impoundment. AP2 is unlined and the subsoils have a geometric mean permeability of 5.6 x 10^{-2} cm/sec, based on field hydraulic conductivity tests performed on the underlying sand and gravel units (CEC, 2018). The final cover for AP2 consists of two layers: 1) a compacted soil barrier layer that is a minimum of 18 inches of compacted earthen material with a maximum permeability of 1x10^{-5} cm/sec; and 2) a vegetative layer that is a minimum of 6 inches of earthen material capable of sustaining native plant growth. The final cover system achieves the requirements of the low permeability layer to limit accumulation of water in the CCR impoundment and meets the requirements in 40 CFR 257.102(d).
- The final cover will be graded to convey stormwater runoff to perimeter drainage channels for ultimate routing and discharge to nearby surface water.
- The perimeter berm of AP2 will be excavated where low-level crossings are installed. Letdown structures will be installed on the exterior berm slopes at each low-level crossing.
- Groundwater will be monitored to evaluate post-closure groundwater quality and trends to demonstrate that the extent of groundwater impact is decreasing in extent and concentration following closure. In accordance with the Groundwater Monitoring Plan (OBG, 2019b), if a statistically significant increasing trend is observed to continue over a period of two or more years, and a subsequent hydrogeologic site investigation demonstrates that such exceedances are due to a release from AP2, and corrective actions are necessary and appropriate to mitigate the release, a corrective action plan will be proposed as a modification to the Closure Plan.
- Ongoing inspection and maintenance of the cover system, groundwater monitoring system, and stormwater system; and property management, per the Closure Plan.

Presumptive Alternative 1 addresses the primary source of CCR constituents in groundwater by significantly minimizing surface water infiltration and reducing generation of potentially impacted water. The secondary source of groundwater impacts (underlying saturated soils that have been in contact with CCR-impacted groundwater) will be addressed by monitoring natural attenuation processes. Construction is planned to begin following IEPA approval of the Closure Plan and be completed by November 2020. Potential impacts to public health and safety for Presumptive Alternative 1 are much lower than Alternatives 2A and 2B, because there is significantly less CCR handling associated with Alternative 1. During the 1- to 2-year construction period, there could be some increase in off-site traffic due to the increased need for on-site workers. Source control measures will be implemented more rapidly for Presumptive Alternative 1 than for Alternatives 2A and 2B. Alternatives 2A and 2B would require a much longer timeframe to attain GWPS, because implementation timeframes would be much longer. Groundwater modeling indicates that Presumptive Alternative 1 is expected to achieve compliance with GWPS within two years after cover system completion.

3.2 ALTERNATIVE 2: CLOSURE BY REMOVAL WITH MNA

Alternative 2 would include removal of all CCR from AP2, moisture conditioning the CCR, as needed, to facilitate excavating, loading, and transporting CCR to either an on-site or off-site landfill, backfilling the excavation, and groundwater monitoring.

Alternative 2 would require transporting more than an estimated 33,600 truckloads of materials (420,000 CY of CCR; assuming 12.5 CY per load) to either an on-site or off-site location for disposal. This would result in increased risk to the public, particularly for the off-site disposal alternative, increased greenhouse gas emissions and carbon footprint, and increased potential for fugitive dust exposure. The existing on-site landfill does not have adequate capacity and the regulatory approval process for a new on-site landfill could take multiple levels of approval, including environmental permits and local authorization. Opposition to such projects and regulatory approvals would take 5 to 10 years before construction could commence. Transporting ash to an off-site landfill also presents concerns about available landfill capacity and community impacts, safety concerns, and project duration. Given the volume of ash, it is expected to take approximately 2 years (assuming 60 truckloads per day, 5 days per week) to remove the ash and transport it to an off-site landfill.

Alternative 2 would address the primary source of groundwater impacts by removing the CCR (the primary source of groundwater impacts), but the secondary source of groundwater impacts (underlying saturated soils that have been in contact with CCR-impacted groundwater) would not begin to diminish until the primary source is removed.

Over the long term, Alternative 2 would attain GWPS by removing the primary source and through MNA of the secondary source. In the short term, continued release of CCR constituents to the groundwater would occur from the CCR during removal activities, extending the time during which groundwater concentrations are above GWPS.

3.2.1 Alternative 2A – Disposal in On-Site Landfill

The HPS landfill, which lies at the east end of AP2, is active but not currently accepting CCR and has inadequate capacity for most of the material from AP2. There may be adequate usable space available at HPS to site a new landfill on the property to the south and west of AP2, south of the power plant (Figure 1). Disposal of excavated CCR in an on-site landfill would require siting, permitting, design, and construction. It is anticipated that several new permits would be required to allow siting and construction of an on-site landfill, including a modification of an existing NPDES permit, fugitive dust, and a solid waste disposal permit from the IEPA Bureau of Land. Permitting requirements for an on-site landfill are estimated to extend the overall timeframe for remedy implementation by an additional 5 to 10 years before CCR removal from AP2 could begin, resulting in a total implementation timeframe of 7 to 12 years, depending upon permitting. If any component of siting or permitting is found to be not feasible, then this alternative would be no longer be an option.

3.2.2 Alternative 2B – Disposal in Off-Site Landfill

Disposal of CCR in an off-site landfill would result in a significantly increased potential for impacts to the surrounding community, including potential safety concerns related to the volume of material to be transported (420,000 CY) and the distance to an existing, permitted, Subtitle D landfill that accepts CCR. Adequate off-site disposal capacity is potentially available within 60 miles from the HPS (IEPA, 2018). Coordination with the landfill operator would be required to confirm disposal options. Complete removal of CCR would require material hauling for approximately 2 years. Approximately 60 daily round-trip truck hauls, 5 days per week, from the site to the landfill would be required and would result in the potential for increased injuries and possible fatalities from traffic accidents. Transportation of the excavated CCR would require design and construction of on-site access roads and may require upgrades to existing public roads to withstand the increased haul truck traffic for the duration of excavation activities. Coordination with the Illinois Department of Transportation may be required to evaluate existing road capacities, improvement strategies, and permitting with unknown schedule implications.

3.3 ALTERNATIVE 3: CLOSURE IN PLACE - SOIL COVER SYSTEM WITH CUTOFF WALL, HYDRAULIC GRADIENT CONTROL SYSTEM, AND MNA

Alternative 3 would include all components of Presumptive Alternative 1. It would also include a groundwater cutoff wall and hydraulic gradient control system that would be designed and constructed to contain groundwater impacted by lithium and molybdenum in the Uppermost Aquifer. Similar to Presumptive Alternative 1, Alternative 3 would significantly minimize infiltration into the closed CCR unit (the primary source of CCR constituents in groundwater) and allow surface water to drain off the cover system, thus reducing the generation of potentially-impacted water and reducing the extent of groundwater impact. In addition, a low-permeability groundwater cutoff wall would be constructed around AP2 and keyed into bedrock. A system of groundwater extraction control wells would be placed within the cutoff wall to establish an inward gradient and capture groundwater within the footprint of AP2. Extracted groundwater would be managed in accordance with a modification to the existing NPDES permit, including treatment prior to discharge, if necessary.

Alternative 3 would include the following primary project components:

- The existing CCR within AP2 would be regraded to achieve acceptable grades for closure and constructing a cover system that complies with the CCR Rule.
- A final cover system would be constructed above the regraded CCR material. The final cover system design would meet the requirements of the CCR Rule. The final cover for the AP2 would have a compacted soil barrier layer, that is a minimum of 18 inches of earthen material with a maximum permeability of 1×10^{-5} cm/sec, and a vegetative layer, that is a minimum of 6 inches of earthen material capable of sustaining native plant growth. AP2 is partially underlain by sands and gravels that have a geometric mean permeability of 5.6×10^{-2} cm/sec. The final cover system would achieve the requirements of the low permeability layer to limit accumulation of water in the CCR impoundment and meets the requirements in 40 CFR 257.102(d).
- The final cover would be graded to convey stormwater runoff to perimeter drainage channels for ultimate routing and discharge to nearby surface water.
- The perimeter berm of AP2 would be excavated where low-level crossings are installed. Letdown structures will be installed on the exterior berm slopes at each low-level crossing.
- A groundwater cutoff wall and hydraulic gradient control system would be designed and constructed. The low-permeability cutoff wall would surround AP2 and be keyed into bedrock, and a system of groundwater extraction wells would be installed to capture groundwater within the footprint of AP2 to establish an inward hydraulic gradient.
- Ongoing inspection and maintenance of the cover system and hydraulic gradient control system, groundwater monitoring to demonstrate that the extent of groundwater impact is decreasing in size and concentration following closure, and stormwater and property management.

The design of a groundwater cutoff wall and hydraulic gradient control system will require additional site characterization and may result in a high density of wells and borings that may extend 100 ft or more below ground surface to identify a unit into which to key the cutoff wall (presumed to be bedrock).

In addition to the primary source control provided by Alternative 1, Alternative 3 would also contain the secondary source (saturated soils containing CCR constituents) located beneath the footprint of AP2. Alternative 3 would require completion of detailed design for the cutoff wall and hydraulic gradient control system. Construction would take longer than Alternative 1. Ongoing groundwater extraction for hydraulic gradient control would be required as part of regular operation and maintenance. Potential impacts to the public health and safety posed by implementation would be similar to Presumptive Alternative 1, and significantly less than that posed by Alternatives 2A and 2B, because all work would be completed on site. There would be some increases in off-site traffic due to increased need for on-site workers. Alternative 3 would take longer to attain GWPS than Presumptive Alternative 1, because the time required for Presumptive Alternative 1 to attain GWPS is less than the timeframe that would be required to conduct the necessary site investigation, design, permitting, and construction associated with Alternative 3.

4 COMPARISON OF CORRECTIVE MEASURES ALTERNATIVES

4.1 EVALUATION FACTORS AND CONSIDERATIONS

The corrective measures alternatives described in the previous section meet the threshold criteria presented in Section 1.3 and were compared to each other, relative to the following remedy selection evaluation factors identified in 40 C.F.R. § 257.97:

- Long and short-term effectiveness, protectiveness and certainty
- Source control effectiveness
- Implementability

These factors and associated considerations are presented in Table 1, along with qualitative comparison of the ability of each alternative to address each consideration. The goal is to understand which alternative will protect human health and the environment (including consideration of potential impacts associated with implementation), provide source control to minimize the risk of future releases, and be permitted, constructed, and operated easily and reliably. The corrective measures and qualitative comparison presented on Table 1 are discussed relative to each of the specific considerations in the following report sections.

4.2 LONG- AND SHORT-TERM EFFECTIVENESS, PROTECTIVENESS, AND CERTAINTY

The first evaluation factor addresses the potential for alternatives to effectively and reliably protect human health and the environment from impacts related to CCR management and/or disposal at AP2. This evaluation factor is focused on the ability of alternatives to address existing impacts, on site and off site, both short-term (during the implementation phase) and long-term (after implementation of the alternative), along with the degree of certainty that the alternatives will remain protective of human health and the environment.

In general, CIP alternatives (Presumptive Alternative 1 and Alternative 3) are more effective and protective than CBR alternatives (Alternatives 2A and 2B). This is primarily due to: 1) the relatively short timeframe for permitting and constructing a CIP alternative, relative to the long implementation timeframe for CBR (approximately 7-12 years, depending on permitting), during which time groundwater would continue to be impacted from CCR remaining on site; and 2) the increased potential for human health and environmental impacts during excavation and transport of CCR during removal activities, particularly off-site disposal (Alternative 2B).

4.2.1 Magnitude of Reduction of Existing Risks

As discussed in Section 2, there are no threats to public health associated with the release of CCR constituents to the environment from AP2. No private or public groundwater users were identified in the vicinity of AP2 during the potable well survey. Mixing calculations indicated that lithium and molybdenum concentrations discharging to the Illinois River would be below laboratory detection limits.

All alternatives will require some amount of on-site construction or off-site transport and disposal of CCR. These activities will introduce risks with different impacts on different community and environmental receptors over different timeframes. Presumptive Alternative 1 and Alternative 3 represent the lowest risk (highest risk reduction) to the surrounding community, because corrective measure activities would be limited to the HPS property. There would be some additional construction worker traffic, the possibility of community exposure to fugitive dust emissions, and the increased potential for safety and noise impacts during the comparatively short construction period (1 to 2 years for Presumptive Alternative 1 and 6 to 7 years for Alternative 3 [including permitting]). There would be similar impacts from Alternative 2A, but the impacts would continue for a longer time (approximately 7 to12 years, depending on permitting) and there would be increased direct contact impacts because the CCR would be exposed over the removal implementation timeframe and transported offsite.

Risks to community and environmental receptors would be greatest (lowest risk reduction) for Alternative 2B. The increased risks are due to the extended implementation schedule required for the large volume of CCR to be excavated, transported offsite, and disposed (estimated 60 trucks per day, 5 days per week for 2 years). Increased potential for safety and noise impacts, exposure to fugitive dust during transport, and increases in greenhouse gas emissions and carbon footprint are also associated with Alternative 2B. Alternative 2A would have somewhat less risk (somewhat greater risk reduction) because the corrective measures would be contained on site but implementation timeframes would be greater than Alternative 2B with the addition of permitting for a new on-site landfill.

4.2.2 Magnitude of Residual Risks, Likelihood of Further CCR Releases Following Implementation

Presumptive Alternative 1 and Alternative 3 provide the lowest level of residual risk or likelihood of further CCR releases following implementation. Both alternatives significantly minimize infiltration of surface water into the CCR (the primary source of groundwater impacts), and Alternative 3 would isolate the secondary source below AP2. Groundwater modeling performed for Presumptive Alternative 1 indicated that the concentrations of boron in groundwater, and by extension, lithium and molybdenum, will attain GWPS two years after cover placement, resulting in a relatively low potential for future CCR releases after construction. Alternative 3 may further reduce the likelihood of releases through inhibition of groundwater throughflow beneath the footprint of AP2, but the delay in implementation related to system design and permitting is expected to offset the improved performance relative to Alternative 1. The effectiveness of groundwater control is uncertain for Alternative 3 due to currently unknown site characteristics that are required for design of this alternative and will depend in part on the ability to effectively key the cutoff wall into a low-permeability geologic unit at depth below AP2.

Alternatives 2A and 2B would have a higher potential for further CCR releases because the primary source of groundwater impacts would remain in place throughout the extended siting, permitting and implementation timeframe (7-12 years depending on permitting requirements). During that time period, transport of contaminants into the groundwater would continue. In addition, the secondary source of groundwater impacts would remain in place after CCR removal and disposal in either an on-site or an off-site landfill. Alternatives 2A and 2B have the lowest long-term residual risk resulting from source removal. Alternatives 2A and 2B also have a higher potential for further CCR releases due to the extensive transportation and CCR-handling processes necessary to move the CCR to a landfill.

4.2.3 Type and Degree of Long-Term Management Required, Including Monitoring, O&M

All alternatives would require some degree of long-term management. Presumptive Alternative 1 will have the simplest long-term maintenance, because there are no active systems requiring monitoring or maintenance to ensure performance. Maintenance of the cover and erosion control systems would be performed in accordance with the approved Closure Plan. Furthermore, a Post-Closure Care Plan for Presumptive Alternative 1 includes provisions for monitoring and maintenance for a post-closure period anticipated to continue for 30 years. The post-closure period may extend beyond 30 years if additional groundwater monitoring results indicate the necessity.

Alternative 2B would require ongoing coordination with landfill and transportation operators during the approximate 2-year implementation period. Alternatives 2A and 2B would require operation and maintenance in conformance with Subtitle D requirements, including long-term groundwater monitoring. Alternative 3 would also require long-term management, including routine operation and maintenance and regular replacement of materials and parts, to ensure hydraulic gradient control system performance.

4.2.4 Short-Term Risks to the Community or the Environment During Implementation

The least short-term risks to the community or the environment are posed by Presumptive Alternative 1 and Alternative 3. The majority of the work would be completed on site for both alternatives, limiting exposure primarily to workers during on-site construction activities. Alternative 2A would have somewhat greater potential for short-term risk to the community, relative to Alternatives 1 and 3, because of the longer timeframe required for CCR excavation. Alternative 2A would also have an increased potential for community exposure from fugitive dust emissions during on-site work, and the increased safety and noise impacts.

Risks to community and environmental receptors would be greatest for Alternative 2B. The extended implementation schedule required for transport and disposal of CCR offsite has increased potential for safety and noise impacts, exposure to fugitive dust during transport, and increases in greenhouse gas emissions and carbon footprint.

4.2.5 Time Until Full Protection is Achieved

Source control and natural attenuation are capable of reducing CCR constituent concentrations in groundwater to below GWPS over time.

All alternatives under consideration would address the primary source of groundwater impacts and would ultimately attain GWPS. Presumptive Alternative 1 will provide the shortest time to attain GWPS. Construction of the soil cover system will be completed in 1 to 2 years. Groundwater modeling performed for Presumptive Alternative 1 indicated that concentrations of boron, and by extension, lithium and molybdenum, potentially attributable to AP2, will achieve GWPS two years after cover placement.

Alternative 3 will rapidly reduce the migration of groundwater from below AP2, thus reducing the time required to attain GWPS. However, the reduced time to attain GWPS is expected to be offset by the longer implementation timeframe required for Alternative 3. Construction of the cover system would be completed in 1 to 2 years, resulting in declining contaminant concentrations and reduction in the extent of groundwater impacts within months after cover construction. However, detailed site characterization, design, and permitting required for construction of the groundwater cutoff wall and hydraulic gradient control system for Alternative 3 would likely extend remedy implementation of that alternative by another 2 to 5 years.

Alternatives 2A and 2B are expected to require the longest time to attain GWPS because the primary source of groundwater impacts would remain in place during implementation, allowing transport of contaminants into the groundwater throughout the extended permitting and implementation timeframe (7 to 12 years, depending on permitting requirements) and the secondary source of groundwater impacts would remain after remedy implementation. Subsequent natural attenuation would allow attainment of the GWPS, although the timeframe would be longer than for Presumptive Alternative 1 and Alternative 3. In addition, if any component of siting or permitting for Alternative 2A is found to be not feasible, then the alternative would be no longer be an option and another alternative would need to be developed thereby extending the time until full protection is achieved by the period of time spent developing Alternative 2A.

4.2.6 Potential for Exposure of Human and Environmental Receptors to Remaining Wastes

Presumptive Alternative 1 and Alternative 3 have the lowest potential for exposure to remaining waste. The soil cover system construction activities will be completed within 1 to 2 years and potential exposures would be limited to on-site workers during construction. The cover will serve as a barrier to remaining waste and will prevent future potential exposures. Alternative 2A would have more potential for on-site worker exposure than Presumptive Alternative 1 and Alternative 3 because CCR excavation would increase both the accessibility of the CCR and the timeframe over which exposures could occur. Alternative 2B would have the highest potential for human and environmental receptor exposure because of the long implementation timeframe and the off-site transport of CCR, which would result in long-term potential for exposure to off-site human and environmental receptors.

4.2.7 Long Term Reliability of the Engineering and Institutional Controls

Presumptive Alternative 1 has been submitted and reviewed by IEPA and will provide a high degree of reliability. Alternative 3 would also have a high degree of reliability, because Alternative 3 would have a similar cover system design and the hydraulic gradient control system would be managed by defined, routine operation and maintenance procedures similar to landfills. Landfilling, as presented in Alternatives 2A and 2B, is an accepted method for long-term waste management, and engineered landfills (on- or off-site) would be designed and constructed using mandatory design standards and performance criteria to ensure long-term reliability.

4.2.8 Potential Need for Replacement of the Remedy

There is limited potential for any of the remedies under consideration to require replacement with other remedies. Each of the potential remedies are accepted waste management techniques and have well-defined operation and maintenance procedures. Presumptive Alternative 1 will not have any active systems that would require maintenance or parts replacement; each of the other alternatives would require ongoing operation and maintenance procedures and parts replacement over time.

4.3 SOURCE CONTROL EFFECTIVENESS

The second evaluation factor addresses the source control effectiveness of the alternatives and the extent to which treatment technologies could be used to enhance the source control measures. Addressing the source of contaminants is a critical factor in improving groundwater quality by eliminating contaminant transport and attaining GWPS.

Groundwater modeling for Presumptive Alternative 1 indicates that, although the secondary source of groundwater impacts (underlying saturated soils that have been in contact with CCR-impacted groundwater) will remain in place, concentrations are predicted to meet the GWPS within two years after cover completion. Adding a groundwater cutoff wall and hydraulic gradient control system to Presumptive Alternative 1 (*i.e.*, Alternative 3) may enhance the secondary source control effectiveness, but also increases the implementation timeframe due to the need to design and permit the hydraulic gradient control system. The timeframe for implementing Alternative 3 would be approximately the same as the timeframe required for Presumptive Alternative 1 to attain GWPS. The potentially reduced time to meet GWPS relative to IEPA-Approved Alternative 1 is expected to be offset by the time required to design and permit the Alternative 3 groundwater cutoff wall and hydraulic gradient control system.

The CBR alternatives (Alternatives 2A and 2B) achieve long-term source control, but present short-term environmental risk associated with implementation. The primary source of groundwater impacts (CCR) would remain in place during implementation, allowing transport of lithium and molybdenum into the groundwater throughout the extended permitting and implementation timeframe (7-12 years, depending on permitting requirements). Human and environmental receptors would also be exposed to CCR over this timeframe and the secondary source of groundwater impacts would remain after remedy implementation.

4.3.1 Extent to Which Containment Practices Will Reduce Further Releases

All potential corrective measures would address the primary source of CCR constituents in groundwater; Alternative 3 would also address the groundwater in the Uppermost Aquifer that comes into contact with secondary source material. Groundwater modeling, completed as part of the Closure Plan for Presumptive Alternative 1, indicated that concentrations of boron, and by extension, lithium and molybdenum, potentially attributable to AP2, will achieve GWPS two years after cover construction is complete. Alternative 3 would be expected to provide a similar, or possibly higher, level of source control effectiveness with the addition of a groundwater cutoff wall and hydraulic gradient control system. However, the ability of Alternative 3 to effectively reduce groundwater concentrations and attain GWPS will have a high dependence upon the ability to key the cutoff wall into a low-permeability geologic unit beneath AP2 (presumably bedrock).

Alternatives 2A and 2B would be less effective in controlling future releases in the short-term because the secondary source of groundwater impacts will remain in place after excavation and disposal of CCR in either an on-site or an off-site landfill.

4.3.2 Extent to Which Treatment Technologies May be Used

No groundwater treatment technologies, other than natural attenuation, would be implemented with these alternatives. Groundwater that is withdrawn during gradient control under Alternative 3 could be treated to meet applicable discharge requirements, if necessary. Treatment technologies are not expected to be necessary for the corrective measure alternatives evaluated. However, if groundwater data demonstrates that attenuation is not occurring as expected, treatment technologies will be reconsidered.

4.4 IMPLEMENTABILITY

The third evaluation factor addresses the ease and operational reliability of implementing the alternatives and includes consideration of permitting requirements and availability of resources to implement the remedy.

Presumptive Alternative 1 is currently under review by IEPA and approval is expected. Presumptive Alternative 1 is, thus, the most easily implementable alternative. Alternative 3 would require detailed site investigation and design activities prior to implementation. CBR alternatives (2A and 2B) would entail significant difficulty in permitting, construction, and transportation.

4.4.1 Degree of Difficulty Associated with Constructing the Technology

Presumptive Alternative 1 will be the most easily implemented alternative because it will employ relatively common construction activities and can be constructed within 1 to 2 years. Alternative 3 would require a somewhat higher degree of difficulty due to the need to design and construct an effective hydraulic gradient control system in a heterogeneous aquifer, in addition to the cover system. Alternative 2B could likely be implemented without permitting a new off-site landfill, because adequate disposal capacity is potentially available at one existing off-site landfill within 60 miles from the HPS (IEPA, 2018), but this would need to be coordinated with the landfill operator(s). Alternative 2B would require approximately 60 trucks per day, 5 days per week over a 2-year period, to dispose of the 420,000 CY of CCR that would be excavated from AP2. The siting, permitting, design, and construction of an on-site landfill (Alternative 2A) represents the highest degree of difficulty. Permitting a new on-site landfill introduces significant uncertainty and could add 5 to 10 years to the estimated 2 years required for CCR excavation and removal that would be required to implement Alternative 2A.

4.4.2 Expected Operational Reliability of Technologies

Presumptive Alternative 1 is an accepted containment technology with high operational reliability. Disposal of waste in an engineered landfill, either onsite or offsite (Alternative 2A and Alternative 2B), is an accepted waste management procedure with a high degree of operational reliability. CCR disposal would occur in a permitted facility that would have defined and regulated operational procedures and performance criteria. The addition of an active engineering control system (gradient control), heterogeneity within the Uppermost Aquifer, and uncertainty of the depth to a key-in unit for the cutoff wall would result in Alternative 3 being somewhat less reliable than Alternatives 1 and 2.

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

The Closure Plan for Presumptive Alternative 1 has been submitted to IEPA for approval. IEPA provided comments on the Closure Plan in May of 2019 and responses to those comments were submitted to IEPA in July 2019 (OBG, 2019a). Therefore, the approval process is near completion. Alternative 3 would require design and permitting for the cutoff wall and hydraulic gradient control system. Alternative 2B may require permitting for transportation and/or disposal of CCR at an off-site landfill, and significant coordination with the landfill operator and CCR transporters to manage disposal options. Alternative 2A would require significant permitting processes for siting and constructing a new on-site Subtitle D landfill that could extend the implementation schedule and introduce significant uncertainty into the remedy implementation. All corrective measures would require updates to the existing site NPDES permit.

4.4.4 Availability of Necessary Equipment and Specialists

Landfilling is a standard waste management method for which equipment and specialists are readily available. Similarly, the earthwork and capping activities that would be required for Presumptive Alternative 1 and Alternative 3 are routine construction activities, for which equipment and manpower would be readily available. The hydraulic gradient control system and groundwater cutoff wall associated with Alternative 3 may require specialized equipment; however, there are several nationally-known contractors who specialize in groundwater remediation and cutoff wall construction, so the availability of equipment and specialists would not pose an obstacle for implementation.

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

Presumptive Alternative 1 would not require treatment, storage and disposal services. Adequate disposal capacity is likely available at off-site landfills within 60 miles from the HPS (IEPA, 2018) to allow implementation of Alternative 2B, although coordination with the landfill operator(s) and CCR transporters would be required. Available disposal capacity for Alternative 2A is possible, as unused acreage is available on-site; however, there may be physical constraints related to siting and constructing an additional new on-site landfill (*e.g.*, aquifer susceptibility).

5 SUMMARY

This Corrective Measures Assessment was prepared to address the requirements of 40 C.F.R. § 257.96. The following corrective measure alternatives were identified based upon site-specific conditions:

- Presumptive Alternative 1) Closure in Place (Soil Cover System) with MNA
- Alternative 2) Closure by Removal
  - Alternative 2A) On-site CCR disposal and MNA
  - Alternative 2B) Off-site CCR disposal and MNA
- Alternative 3) Closure in Place (Soil Cover System) with groundwater cutoff wall, hydraulic gradient control system, and MNA

These alternatives were evaluated with respect to the following remedy selection evaluation factors in 40 C.F.R. § 257.97 and their associated considerations.

5.1 LONG- AND SHORT-TERM EFFECTIVENESS, PROTECTIVENESS, AND CERTAINTY

In general, CIP alternatives (Presumptive Alternative 1 and Alternative 3) are more effective and protective than CBR alternatives (Alternatives 2A and 2B). This is primarily due to: 1) the relatively short timeframe for permitting and constructing a CIP alternative, relative to the long implementation timeframe for CBR (approximately 7 to12 years, depending on permitting), during which time groundwater would continue to be impacted from CCR remaining on-site; and 2) the increased potential for human health and environmental impacts during excavation and transport of CCR during removal activities, particularly off-site disposal (Alternative 2B).

5.2 SOURCE CONTROL

Groundwater modeling for Presumptive Alternative 1 indicates that, although the secondary source of groundwater impacts (underlying saturated soils that have been in contact with CCR-impacted groundwater) will remain in place, concentrations are predicted to meet the GWPS within two years after cover completion.

Adding a groundwater cutoff wall and hydraulic gradient control system to Presumptive Alternative 1 (*i.e.*, Alternative 3) may enhance the secondary source control effectiveness, but would increase the implementation timeframe. The potentially reduced time to meet GWPS relative to IEPA-Approved Alternative 1 may be offset by the time required to design and permit the Alternative 3 groundwater cutoff wall and hydraulic gradient control system. The ability of Alternative 3 to effectively reduce groundwater concentrations and attain GWPS will have a high dependence upon the ability to key the groundwater cutoff wall into a low-permeability geologic unit beneath AP2 (presumably bedrock).

The CBR alternatives (Alternatives 2A and 2B) achieve long-term source control, but present short-term environmental risk associated with implementation. The primary source of groundwater impacts (CCR) would remain in place during implementation, allowing transport of lithium and molybdenum into the groundwater throughout the extended permitting and implementation timeframe (7 to 12 years, depending on permitting requirements). Human and environmental receptors would also be exposed to CCR over this timeframe and the secondary source of groundwater impacts would remain after remedy implementation.

5.3 IMPLEMENTABILITY

Presumptive Alternative 1 is currently under review by IEPA and approval is expected. Thus, Presumptive Alternative 1 is the most easily implementable alternative. Alternative 3 would require detailed site investigation and design activities prior to implementation. CBR alternatives (2A and 2B) would entail significant difficulty in permitting, construction, and transportation, which would delay potential benefits associated with this remedy.

Presumptive Alternative 1 provides performance that is as good as, or better than, the other alternatives for each of the evaluation factors considered. A public meeting will be held, in accordance with 40 C.F.R. § 257.96(e). Following receipt of public input, a corrective measure will be selected and documented in the remedy selection report required by 40 C.F.R. § 257.97(a).

6 REFERENCES

Civil & Environmental Consultants, Inc., 2018. Closure and Post-Closure Care Plan for the Hennepin East Ash Pond No. 2, February 2018.

Electric Power Research Institute (EPRI), 2012. Groundwater Quality Signatures for Assessing Potential Impacts from Coal Combustion Product Leachate, Technical Report #1017923, November 15, 2012.

Illinois Environmental Protection Agency, 2018. Illinois Landfill Projections of Disposal Capacity as of January 1, 2015. Prepared for the Governor of the State of Illinois and the General Assembly in accordance with Section 4 of the Illinois Solid Waste Management Act by IEPA Bureau of Land Waste Reduction and Compliance Section. July 2018.

Kelron Environmental/Natural Resource Technology, 2009. Water Well Survey, Hennepin Power Station. June 3, 2009.

O'Brien & Gere Engineers, Inc., 2017a. Groundwater Model Report, Hennepin East Ash Pond No. 2, Hennepin, Illinois. Prepared for Dynegy Midwest Generation, LLC by O'Brien & Gere Engineers, Inc. December 20, 2017.

O'Brien & Gere Engineers, Inc., 2017b. Hydrogeologic Site Characterization Report, Hennepin East Ash Pond No. 2, Hennepin, Illinois. Prepared for Dynegy Midwest Generation, LLC by O'Brien & Gere Engineers, Inc. December 20, 2017.

O'Brien & Gere Engineers, Inc. 2017c. Hydrostatic Modeling Report, Hennepin East Ash Pond No. 2, Hennepin, Illinois. Prepared for Dynegy Midwest Generation, LLC by O'Brien & Gere Engineers, Inc. December 20, 2017.

O'Brien & Gere Engineers, Inc (OBG), Part of Ramboll. 2019a. Response to IEPA Comments – Closure and Post-Closure Care Plan for the Hennepin East Ash Pond No. 2, and Closure Plan Addendum Hennepin East Ash Pond No. 2 which includes closure of Ash Pond No. 4 Prepared for Dynegy Midwest Generation, LLC by O'Brien & Gere Engineers, Part of Ramboll. July 22, 2019.

OBG, Part of Ramboll, 2019b. Groundwater Monitoring Plan, Hennepin East Ash Pond No. 2 and No. 4, Hennepin, Illinois. Prepared for Dynegy Midwest Generation, LLC by O'Brien & Gere Engineers, Inc. July 22, 2019.

USEPA (United States Environmental Protection Agency), 1999. Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites. Directive No. 9200.U-17P. Washington, D.C.: EPA, Office of Solid Waste and Emergency Response.

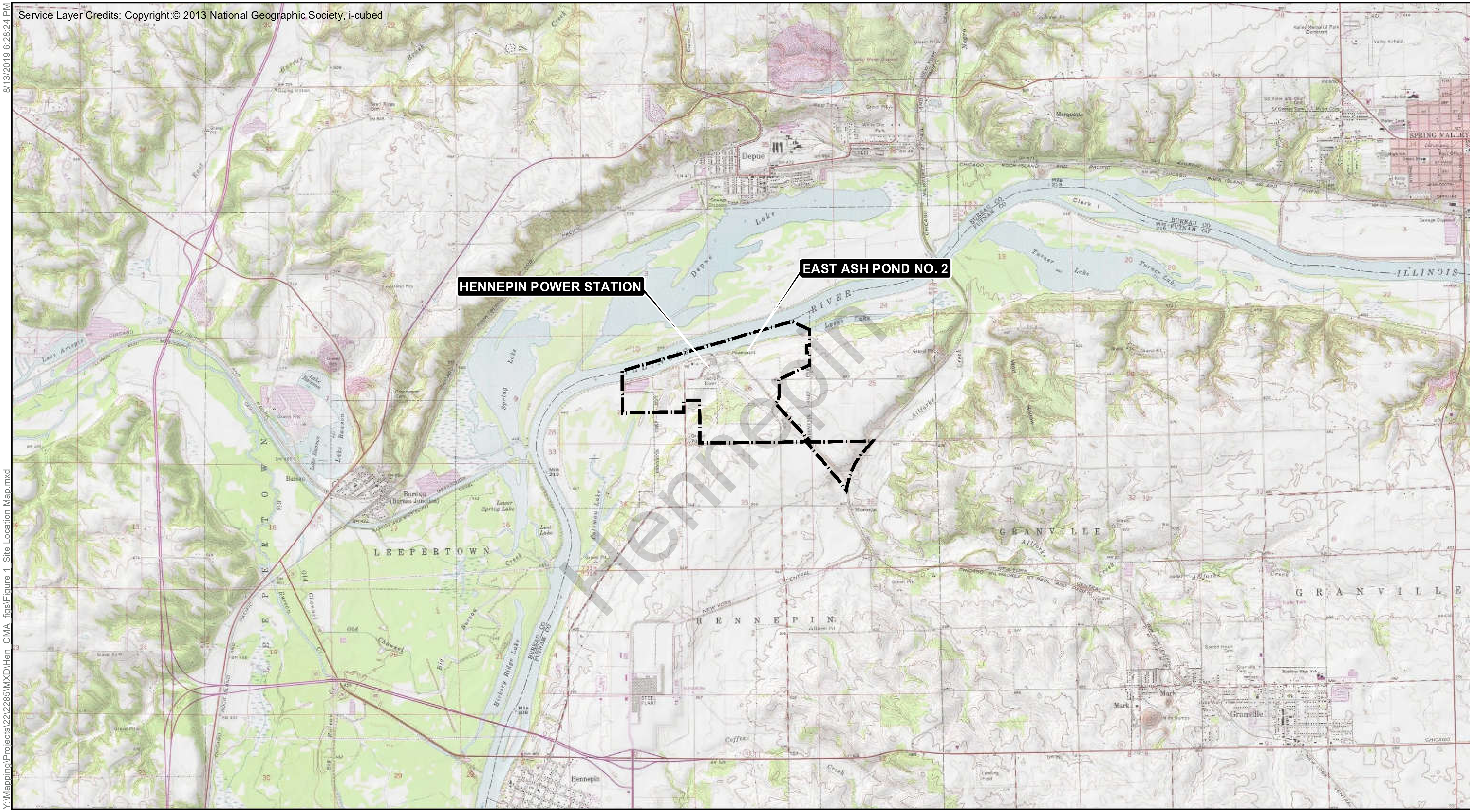
Tables

Table 1 - Corrective Measures Assessment Matrix
Hennepin Ash Pond No. 2
September 5, 2019

Evaluation Factors	Considerations	Rating That Indicates Best Performance[1]	Presumptive Alternative 1 Closure-in-Place Soil Cover System and MNA [2]	Alternative 2 Closure-by-Removal with MNA		Alternative 3 Closure-in-Place Soil Cover System with Cut-off Wall and Gradient Control
				2A On-Site Landfill (New Construction)	2B Off-Site Landfill	
Long and short-term effectiveness, protectiveness and certainty	Magnitude of reduction of existing risks	High	High. Risks to the community or environmental receptors is minimal because cover system construction does not include significant excavation, transportation or re-disposal and would be limited to on-site activities. Some small increase in short term risk to workers during construction of cover.	Medium. Limited short term risk to the community as work limited to HPS property. Some increased short term environmental risk during excavation and on-site transport of CCR due to increased potential for limited exposure to CCR during on-site excavation, transport and re-disposal.	Low. Increased short term risks to the community and the environment during excavation, transport and re-disposal of CCR in an off-site landfill due to potential increased number of receptors during transport. Excavation and transport of CCR would require approximately 2 years to complete assuming 60 trucks per day to transport CCR to off-site landfill.	High. Risks to the community or environmental receptors is low because cover and groundwater extraction system construction does not include significant excavation, transportation or re-disposal and would be limited to on-site activities. Some small increase in short term risk to workers during construction of cover.
	Magnitude of residual risks in terms of likelihood of further releases due to CCR remaining following implementation of remedy	Low	Low. Construction of the cover will reduce infiltration into primary source. Modeling indicates groundwater impacts will be contained within the property and GWPS will be attained within 2 years of completion of cover system construction.	Medium. Removal of primary source reduces the potential for further releases from primary source (CCR) due to placement in an engineered landfill. However, extended permitting and implementation timeframe leaves primary source in place for longer. Secondary source (underlying saturated soils) remains.	Medium. Removal of primary source significantly reduces the potential for further releases from primary source (CCR) due to placement in an engineered landfill. However, extended permitting and implementation timeframe leaves primary source in place for longer. Secondary source (underlying saturated soils) remains.	Medium. Construction of the cover will reduce infiltration into primary source, and groundwater gradient control may address groundwater that comes into contact with the secondary source, but design and construction will delay this process.
	Type and degree of long term management required, including monitoring, O&M	Low	Low. Soil cover system does not include any active operational systems; minimal maintenance is required to ensure cover performance; and the Post-Closure Care Plan includes procedures for cover monitoring and maintenance.	Medium. Landfills are required to implement routine operation & maintenance activities, including groundwater monitoring.	Medium. Landfills are required to implement routine operation & maintenance activities, including groundwater monitoring.	Medium. Operation of gradient control system will include routine equipment maintenance and regular materials & parts replacement. Groundwater monitoring will be required to verify performance.
	Short term risks that might be posed to the community or the environment during implementation of such a remedy, including potential threats to human health and the environment associated with excavation, transportation, and re-disposal of contaminant	Low	Low. Short term risk to the community or environmental receptors is low because soil cover system construction does not include significant excavation, transportation or re-disposal. Some small increase in short term risk to workers during construction of cover.	Medium. Limited short term risk to the community and some increased short term environmental risk during excavation and on-site transport of CCR. Work contained with HPS property. Risk due to potential for limited exposure to CCR during on-site excavation, transport and re-disposal.	High. Increased short term risks to the community and the environment during excavation, transport and re-disposal of CCR in an off-site landfill due to potential increased number of receptors during transport. Excavation and transport of CCR would require approximately 2 years to complete assuming 60 trucks per day to transport CCR to off-site landfill.	Low. Short term risks to the community or environmental receptors is low because hydraulic gradient control system construction does not include significant excavation, transportation or re-disposal. Some small increase in short term risk to workers during construction of cover.
	Time until full protection is achieved	Low	Low. Source control using soil cover system that can be constructed in 1-2 years. Groundwater modeling indicates that GWPS will be attained 2 years after completion of cover system construction.	High. Complete source removal would ultimately result in compliance with GWPS by source removal, flushing and attenuation. Long implementation timeframe for permitting and CCR excavation (estimated minimum 5 to 10 years, depending on permitting) would result in longest time to meet GWPS.	High. Complete source removal would ultimately result in compliance with GWPS by source removal, flushing and attenuation. Long implementation timeframe for permitting and CCR excavation (estimated over 2 years) would result in longest time to meet GWPS.	Medium. Source control using a soil cover system could be completed in 1 to 2 years; GWPS attained 2 years after completion of soil cover system construction. Detailed site characterization, design and permitting would be required for constructing the cutoff wall and hydraulic gradient control system and would likely extend remedy implementation by 2 to 5 years. The time to meet GWPS will be increased due to increased implementation timeframe.
	Potential for exposure of human and environmental receptors to remaining wastes, considering the potential threat to human health and the environment associated with excavation, transportation, re-disposal	Low	Low. Potential for exposure to human or environmental receptors is low because closure in place (CIP) does not include significant excavation, transportation or re-disposal. Some small increase in potential exposure to workers during construction of cover.	Medium. Some limited potential for exposure of human and environmental receptors to CCR during relocation to on-site landfill.	High. Potential for exposure to human and environmental receptors to CCR during relocation due to long duration off-site transportation of CCR to landfill. Excavation and transport of CCR would require approximately 2 years to complete assuming 60 trucks per day to transport CCR to off-site landfill.	Low. Potential for exposure to human or environmental receptors is low because cutoff wall and hydraulic gradient control system construction do not include significant excavation, transportation or re-disposal. Some small increase in potential exposure to workers during construction of cover.
	Long term reliability of the engineering and institutional controls	High	High. Soil cover system has been designed in accordance with applicable requirements; will be managed by defined, routine operation and maintenance procedures; and closure plan approval by IEPA is pending.	High. Engineered landfills are designed and constructed using mandatory design standards and performance criteria and have long term operations and monitoring.	High. Engineered landfills are designed and constructed using mandatory design standards and performance criteria and have long term operations and monitoring.	High. Gradient control system will be managed by defined, routine operation and maintenance procedures similar to landfills.
	Potential need for replacement of the remedy	Low	Low. Soil cover will not need replacement, post-closure care plan includes procedures for cover system monitoring and maintenance.	Medium. Landfill cover would not need replacement, leachate collection system would require maintenance and parts replacement over time.	Medium. Landfill cap would not need replacement, leachate collection system would require maintenance and parts replacement over time.	Medium. Cover system would not need replacement, regular maintenance would be required to maintain cover performance. Gradient control system could require maintenance and parts replacement over time.
Source control effectiveness	Extent to which containment practices will reduce further releases	High	High. Groundwater modeling indicates that two years after soil cover system construction is complete, groundwater impacts will be contained within the property.	Medium. Future releases will be mitigated by removal of CCR and re-disposal in an engineered landfill; secondary source will remain in place.	Medium. Future releases will be mitigated by removal of CCR and re-disposal in an engineered landfill; secondary source will remain in place.	Medium. Cut-off wall and hydraulic gradient control system will address the primary and secondary source, but effectiveness will depend upon ability to key cutoff wall into a low-permeability geologic unit beneath AP2 (presumably bedrock).
	Extent to which treatment technologies may be used	Low	Low. Use of treatment technologies is not necessary.	Low. Use of treatment technologies is not necessary.	Low. Use of treatment technologies is not necessary.	Low. Use of treatment technologies is not necessary.
Implementability	Degree of difficulty associated with constructing the technology	Low	Low. Cover system construction could be completed quickly (1-2 years) and the required construction would not be difficult.	High. The existing on-site landfill does not have adequate capacity for CCR disposal. A new on-site landfill would require siting, permitting, design and construction prior to implementing closure activities. Limited space available for on-site landfill.	Medium. There is adequate off-site landfill capacity for CCR that would be excavated from Ash Pond No. 2. Excavation and transport of CCR would require approximately 2 years to complete assuming 60 trucks per day to transport CCR to off-site landfill.	Medium. Gradient control system effectiveness is a function of degree of heterogeneity of the uppermost aquifer. Cover construction could be completed quickly and the required construction would not be difficult.
	Expected operational reliability of technologies	High	High. The soil cover has good reliability characteristics and an engineered soil cover is an accepted waste management technology subject to defined operating procedures and performance criteria.	High. Engineered landfilling is an accepted waste management technology subject to defined operating procedures and performance criteria.	High. Engineered landfilling is an accepted waste management technology subject to defined operating procedures and performance criteria.	Medium. The cover has good reliability characteristics, similar to alternatives 1 and 2, and the gradient control system is an active engineering control that will be managed by routine monitoring and maintenance. Reliability will also be affected by heterogeneity of the Uppermost Aquifer.
	Need to coordinate with and obtain necessary approvals and permits from other agencies	Low	Low. Closure Plan approval by IEPA is pending for construction of a soil cover system and long-term inspection, maintenance and monitoring.	High. Siting, design and construction of a new on-site landfill will require permitting through the IEPA Bureau of Land and construction would require a modification to the existing NPDES permit.	Medium. Excavation, transport and disposal in an existing landfill may require permits for transportation and/or disposal.	Medium. Cover and gradient control system design will require design review and approval by IEPA and modification to the existing NPDES permit would be required.
	Availability of necessary equipment and specialists	High	High. Earthwork and cover construction are routine construction activities.	High. Earthwork and landfill construction are routine construction activities.	High. Earthwork and landfill construction are routine construction activities.	Medium. Earthwork for cover construction are routine construction activities; specialty contractors may be required for slurry wall and groundwater control system construction.
	Available capacity and location of needed treatment, storage and disposal services	High/None	None. No treatment, storage or disposal services required for soil cover construction. Construction would require a modification to the existing NPDES permit.	Low. The existing on-site landfill does not have sufficient capacity for the 420,000 CY of CCR that would be removed under this alternative. Permitting for a new on-site landfill is estimated to extend the overall timeframe for remedy implementation by an additional 5 to 10 years before CCR excavation could begin. Construction would require a modification to the existing NPDES permit.	Medium. There is adequate off-site landfill capacity for the CCR that would be excavated from Ash Pond No. 2. Excavation and transport of CCR would require approximately 2 years to complete assuming 60 trucks per day to transport CCR to off-site landfill.	Medium. No treatment, storage or disposal services required for cover construction; extracted groundwater would be disposed of via existing NPDES outfall.

Notes: [1] The rating for each consideration is a representation of relative performance between alternatives. In some instances, a rating of high indicates best performance relative to the specific consideration, while in other instances a rating of low indicates best performance relative to the consideration. The rating shown in this column defines which rating indicates best performance.
[2] Closure Plan prepared for submittal to IEPA in February, 2018; Closure Plan Addendum prepared for submittal to IEPA in July, 2019

Figures



8/13/2019 6:28:24 PM

Y:\Mapping\Projects\22\2285\MXD\Hen_CMA_figs\Figure 1_Site Location Map.mxd

APPROXIMATE PROPERTY BOUNDARY

CORRECTIVE MEASURES ASSESSMENT
ASH POND NO. 2
HENNEPIN POWER STATION
HENNEPIN, ILLINOIS

0 2,000 4,000 8,000
Feet

N

SITE LOCATION MAP

OBG
Part of Ramboll

DOWNGRADIENT WELL LOCATION
UPGRADIENT WELL LOCATION
NON-CCR WELL LOCATION
CCR MONITORED UNIT

CORRECTIVE MEASURES ASSESSMENT
ASH POND NO. 2
HENNEPIN POWER STATION
HENNEPIN, ILLINOIS

0 175 350 700
Feet

N

CCR GROUNDWATER MONITORING SYSTEM

OBG
Part of Ramboll

8/14/2019 3:04:38 PM
Y:\Mapping\Projects\22\2285\MXD\Hen_CMA_figs\Figure 2_CCR GW Monitoring System.mxd

OBG
Part of Ramboll