Corrective Measures Assessment

Coffeen Ash Pond No. 2 – CCR Unit ID 102
Coffeen Power Station
134 Cips Lane
Coffeen, Illinois 62017

Illinois Power Generating Company

July 8, 2019

OBG
Part of Ramboll

JULY 8, 2019 | PROJECT #72856

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Prepared for:

Illinois Power Generating Company

FRANCES ACKERMAN, RG, PE
Senior Managing Engineer

BRIAN G. HENNINGS, PG
Managing Hydrogeologist

ERIC J. TLACHAC, PE
Managing Engineer

NICOLE M. PAGAO, PE, PG
Senior Managing Engineer

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EXECUTIVE SUMMARY

Ash Pond No. 2 (AP2) is an inactive coal combustion residuals (CCR) surface impoundment (SI) located at the Coffeen Power Station (CPS) near the City of Coffeen, in Montgomery County, Illinois. The location of AP2 is shown on Figure 1.

The Illinois Environmental Protection Agency (IEPA) has approved the Closure and Post Closure Care Plan (Closure Plan) for the Coffeen Ash Pond No. 2 at Illinois Power Generating Company Coffeen Power Station (AECOM, 2017). The Closure Plan is consistent with the written closure plan required by 40 C.F.R. § 257.102. The approved Closure Plan summarized the planned closure of AP2 by dewatering the CCR, constructing a geomembrane cover system in direct contact with the graded CCR and existing soil cover material, and monitored natural attenuation. The closure activities are scheduled to begin in July 2019 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 minimize water infiltration into the closed CCR unit (primary source of CCR constituents in groundwater) and allow surface water to drain off the cover system, thus reducing generation of potentially impacted water and reducing the extent of groundwater impacts from AP2 in the Uppermost Aquifer by natural attenuation. The approved cover system and low permeability soils present below the ash will limit the migration of potentially impacted groundwater, control surface water on the cover system and surrounding AP2, and will reduce contaminant transport off-site both spatially and temporally. Groundwater modeling results of post-closure AP2 indicate construction of the cover system would result in declining contaminant concentrations approximately 1 year after cover construction.

Statistically significant levels of total cobalt were identified at AP2 during groundwater monitoring required by 40 C.F.R. § 257.90. All known water wells in the area are located either east or west of Coffeen Lake, which is a hydraulic boundary for potentially impacted groundwater, and there are no impacts to potable wells in the area. **There are no impairments to groundwater usage on the CPS property or surrounding properties caused by AP2.**

Concentrations of sulfate and boron in Unnamed Creek, Coffeen Lake, and the discharge flume associated with CPS were either observed or calculated in the IEPA-approved Closure Plan to be below surface water quality standards. 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. Since cobalt has a higher sorption potential (which reduces mobility in groundwater) than boron (EPRI, 2012), the percentage of cobalt released from AP2 that potentially discharges to surface water is anticipated to be less than the percentage of boron that potentially discharges to surface waters. As such, no adverse effects to surface water are expected.

This Corrective Measures Assessment 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:

- Alternative 1) Closure by removal with on-site (A) or off-site (B) CCR disposal, and monitored natural attenuation
- IEPA-Approved Alternative 2) Closure-in-Place (Geomembrane Cover System) and monitored natural attenuation
- Alternative 3) Closure-in-Place (Geomembrane Cover System) and a groundwater extraction system

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, Closure-in Place (CIP) alternatives (IEPA-Approved Alternative 2 and Alternative 3) are more effective and protective than Closure by removal (CBR) alternatives (Alternatives 1A and 1B). 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 10 years), 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 1B).

SOURCE CONTROL

Groundwater modeling for IEPA-Approved Alternative 2 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 and the extent of groundwater impacts will begin to reduce approximately 1 year after cover construction.

Adding a groundwater extraction system to IEPA-Approved Alternative 2 (i.e., Alternative 3) may enhance the overall source control effectiveness, but would increase the implementation timeframe due to the need to design and permit the groundwater extraction system. The thin, discontinuous, and heterogenous character of the Uppermost Aquifer (Hagarstown beds), consisting of sand, silty sand, and weathered sandy/silty till with discontinuous lenses of silt, sand and gravel sandwiched between low permeability confining units, is expected to limit the radius of influence between groundwater extraction wells. Design of a groundwater extraction system that provides containment via removal of groundwater from the upper aquifer will require additional site characterization and may result in a high density of wells. Groundwater extraction systems also generate a waste stream and require routine operation and maintenance.

The CBR alternatives (Alternatives 1A and 1B) achieve greater source control in the long-term, but present greater environmental risk in the short-term associated with implementation. The primary source of groundwater impacts (CCR) would remain in place during implementation, allowing transport of cobalt into the groundwater throughout the extended permitting and implementation timeframe (ten to twenty 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

IEPA-Approved Alternative 2 has a low degree of difficulty and is scheduled for construction in July 2019 using readily available materials and resources making it the most easily implementable alternative. Alternative 3 would require detailed site investigation and design activities prior to implementation. CBR alternatives (1A and 1B) would entail significant difficulty in permitting, construction and transportation, which would delay potential benefits associated with this remedy.

IEPA-Approved Alternative 2 provides performance that is as good 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 and Gere Engineers, Inc, part of Ramboll (OBG) has prepared this Corrective Measures Assessment (CMA) for Ash Pond No. 2 (AP2; CCR Unit ID 102) located at Coffeen Power Station (CPS; the Site) near the City of Coffeen, in Montgomery 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 contamination. This CMA is responsive to the 40 C.F.R. § 257.96 and § 257.97 requirements for assessing potential corrective measures to address the exceedance of the GWPS for cobalt at AP2.

1.1 SITE DESCRIPTION AND HISTORY

The CPS is owned and operated by Illinois Power Generating Company and is located on a peninsula between two lobes of Coffeen Lake which was created in 1963 by damming a portion of the East Fork of Shoal Creek. The lake covers approximately 1,100 acres and provides cooling water for the CPS. The city of Coffeen is approximately 2 miles north of the CPS and the city of Hillsboro, IL is about 8 miles to the northwest. The CPS is located in an agricultural area. Historically, several coal mines were operated at depth in the vicinity of the site. The CPS property is bordered by Coffeen Lake on the west, east, and south, and by agricultural land to the north. AP2 is located within Section 11 Township 7 North and Range 7 East. Figure 1 shows the location of the plant, Figure 2 is a site plan showing the location of AP2 and CCR monitoring wells.

The CPS began operation in 1972 and CCR from the coal fired units was disposed of in Ash Pond No. 1. AP2 was also utilized in the early 1970's and Ash Pond No. 1 was reconstructed in 1978. Both of these units were used until the mid-1980's. Currently, two coal fired units at Coffeen generate 945 MW of electricity with CCR being handled and filled in Ash Pond No. 1, the Landfill, the GMF Gypsum Stack Pond, and the GMF Recycle Pond.

AP2 is an unlined surface impoundment (SI) with a surface area of approximately 60 acres and berms up to 47 feet higher than the surrounding land surface. AP2 was removed from service and capped in the mid 1980's. It contains about 2,200,000 cubic yards (CY) of CCR, covered by vegetated soil. A 2-foot thick clay and soil cap was placed on the surface of the pond with contouring and drainage provided to direct storm water to four engineered revetment down drain structures (NRT, 2013).

In January 2017, Dynegy Operating Company (subsequently acquired by Vistra Energy) submitted the Closure and Post-Closure Care Plan for the Coffeen Ash Pond No. 2 (Closure Plan, AECOM, 2017) to the Illinois Environmental Protection Agency (IEPA) seeking approval to close AP2 by dewatering the CCR, constructing a geomembrane cover system in direct contact with the graded CCR and existing soil cover material, and performing groundwater monitoring to assess natural attenuation. The IEPA subsequently approved the Closure Plan on January 30, 2018 (IEPA, 2018).

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 the CPS. The CMA identifies corrective measure alternatives that would prevent further releases to groundwater, remediate any past releases to groundwater and restore any affected areas of groundwater to their original conditions. This report presents an analysis of the effectiveness of potential corrective measures (including the IEPA-approved Closure Plan) 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 while the evaluation factors and considerations provide flexibility and guidance to aid decision-making regarding how best to 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 CPS (threshold criteria):

- Be protective of human health and the environment.
- Attain the groundwater protection standards 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:

- Alternative 1) Closure by removal, with on-site or off-site CCR disposal, and monitored natural attenuation (MNA)
- IEPA-Approved Alternative 2) Closure-in-Place (Geomembrane Cover System) and MNA
- Alternative 3) Closure-in-Place (Geomembrane Cover System) and groundwater extraction

Each of these corrective measure alternatives meet 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 were considered technically infeasible given the site-specific geologic and hydrogeologic setting and/or chemical characteristics of the groundwater impacts identified at AP2. The relatively thin, discontinuous and partially confined nature of the 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 logistical implications of constructing a cutoff wall to contain the cobalt plume, with its limited areal extent, were weighed against the practicability of the alternatives that were considered. The limited access along the eastern perimeter of AP2 would pose constructability challenges as well as significant potential for adverse environmental impacts related to creating adequate access for construction equipment. As discussed in Section 2 below, mounding of water creates a component of radial flow out from AP2. However, the extent of this groundwater water movement appears to be limited, as the elevated heads overlying the Upper Confining Unit dissipate across the AP2 berms. Placement of a cutoff wall would also result in similar hydraulic conditions: mounding of water within AP2 and limited migration past the barrier. Because the hydraulic conditions that would be created by a cutoff wall already exist, and construction would result in adverse environmental impacts and increased constructability challenges, construction of a cutoff wall 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. An ISS approach would disrupt the geosynthetic cover system being constructed, and may be limited by the same access considerations for construction as a cutoff wall. 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 require bench-scale and pilot-scale testing to support the detailed design, thus increasing the time to implementation, and would 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 the CPS property or surrounding properties associated with AP2. CCR dewatering and the geomembrane 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 (NRT, 2017a). Observed and calculated concentrations of CCR indicator parameters in 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 Characterization Report (NRT, 2017b) are summarized and grouped into the following hydrostratigraphic units to define the conceptual site model for AP2; cross-sections are provided in Figures 4-6:

- CCR Fill Unit – CCR within the various CCR Units; the total volume is approximately 2.2 million CY (NRT, 2017c).
- Upper Confining Unit – Low permeability clays and silts, including the Loess Unit (combined silts of the Roxana Silt and Peoria Silt stratigraphic units) and the upper clayey till portion of the Hagarstown Member (unit consisting of gravelly clay till and sandy materials, also referred to as Hagarstown beds).
- Uppermost Aquifer (Groundwater Monitoring Zone) – Thin (generally less than 3 feet), moderate to high permeability sand, silty sand, and sandy silt/clay units that include the sandy materials of the Hagarstown beds and the upper Vandalia Member (unit consisting of a sandy/silty till with thin, discontinuous lenses of silt, sand, and gravel), where weathered. Regionally, the Hagarstown beds can be found in elongate ridges consisting of well sorted gravel and interbedded sand. In the drift plain between those ridges the beds contain gravely till which grades into poorly sorted gravel near the ridges. The different types of Hagarstown beds grade into one another, varying with the degree of water sorting during deposition (Jacobs and Lineback, 1969). The beds were deposited when till was thrust to the surface of the glacier, subjected to washing and mass movement and deposited when the ice melted beneath it (ablation). This depositional environment is responsible for the variability within the unit, which is gradational between till and outwash, The thin and variable composition of the Hagarstown beds observed at AP2 indicate deposition occurred in the drift plains between ridges of gravel deposits.
- Lower Confining Unit – Thick (generally greater than 15 feet), very low permeability sandy silt till or clay till that includes the unweathered lower Vandalia Member, discontinuous Mulberry Grove Member (consists of a thin, lenticular unit of gray sandy silt), and Smithboro Member (gray, compact, silty, clayey diamicton).

CCR is underlain by the low-permeability Upper Confining Unit in the majority (98.3%) of the AP2 footprint. The remaining areas of the AP2 footprint overlie the Vandalia Till and may be in contact with the Hagarstown beds where former drainage features were present prior to construction and filling (Figure 3). Mounding of water saturates CCR in AP2 and creates a component of radial flow out from AP2. However, the extent of this water movement appears to be limited because the hydraulic head within AP2 are elevated and the elevated heads overlying the Upper Confining Unit dissipate across the AP2 berms. In the areas where the Vandalia Till is in contact with CCR, the CCR may also come into contact with the profile of the Hagarstown beds along the sidewalls of the drainage features (see Figures 4-6). The thin, discontinuous nature of the Hagarstown beds and the limited opportunity for ash to be in contact with the Hagarstown beds significantly reduces the potential for lateral migration out of AP2, which is expressed in the accumulation and mounding of groundwater presently observed within AP2. Water from seeps observed along the berms may partially infiltrate through the Upper Confining Unit and/or run off with surface water toward the discharge flume or Unnamed Creek. The Uppermost Aquifer is confined except where the Hagarstown beds are exposed along the eastern-side of the impoundment within the sidewalls of former ravines. In these areas, groundwater appears to migrate in the Uppermost Aquifer beneath the constructed berms and discharges through seeps along the ravine into the Unnamed Creek to the east.

Groundwater within the Hagarstown beds beyond AP2 flows predominantly to the east and south. There is limited groundwater flow from AP2 toward the west due to a thinning or lower hydraulic conductivity of the Hagarstown beds and radial flow toward the discharge flume and unnamed creek. Based on hydraulic conductivities and vertical gradients, horizontal groundwater flow in the overlying clays and underlying tills are negligible. Groundwater flow occurs primarily in the more permeable zones within the Hagarstown beds. However, migration of impacts to the east and south is limited by the presence of the Unnamed Creek and a surface water discharge flume associated with CPS, both of which are areas of groundwater discharge and act as hydraulic barriers and/or groundwater divides.

A groundwater flow and transport model was developed for AP2 and attached to the IEPA-approved Closure Plan with the objective of evaluating the effect constructing a cover system will have on surrounding groundwater quality. Boron was modeled to simulate migration of CCR leachate because it is relatively conservative for simulating transport in the subsurface since it is not as subject to processes that retard migration, such as sorption, as other CCR parameters are. The conceptual model for transport assumes boron leaching to recharge water during percolation through CCR above the water table. The model also includes changes in concentration applied to recharge zones where saturated CCR is known or likely to be present. For prediction modeling, constant concentration cells were placed into the model in portions of AP2 that contain CCR at or below the elevation of the Hagarstown beds to simulate leaching from groundwater flow through AP2 CCR where in contact with the Hagarstown beds.

The Hagarstown beds were simulated in the model using contoured surfaces generated from soil boring observations and maintaining a minimum thickness of 2 feet with a calibrated horizontal hydraulic conductivity of 1.6×10^{-3} centimeters per second (cm/sec). The model simulation of the Hagarstown beds as a homogenous unit with consistent hydraulic conductivity was done to make the upper aquifer as transmissive as possible for the conservative evaluation of boron transport, and likely overestimates the interconnectedness of the Uppermost Aquifer. The simulated maximum extent of the boron groundwater plume occurs 1 year after placement of the cap. Although boron concentrations above the Class I Standard are present in the upper portion of the Lower Confining Unit, these concentrations also recede following cap placement, and they do not exceed the maximum footprint of boron concentration exceedances simulated in the Uppermost Aquifer (Hagarstown beds). Boron exceedances do not extend into the lower portion of the Lower Confining Unit. During the prediction scenario following cap placement, concentrations of boron within AP2 decline and the footprint of the boron plume retreats toward the limits of AP2.

2.2 POTABLE WATER WELL INVENTORY

A potable water well inventory was completed in 2013. Public records were searched to identify water supply wells located within 2,500 feet of the unlined impoundments at the CPS and the results are discussed in the Hydrogeologic Site Characterization Report (NRT, 2017b). All but one of the wells identified in the well search were located either east or west of Coffeen Lake, which is a hydraulic boundary for potentially impacted groundwater. The one water well located between the east and west branches of the lake was reportedly removed during construction of the CPS Recycle Pond (NRT, 2017b). Public water supply (PWS) wells within a ten-mile radius of the CPS were also identified. Three wells belonging to the Village of Fillmore are located within the search radius, the closest one is approximately eight miles northeast of the CPS.

2.3 GROUNDWATER QUALITY

Groundwater monitoring per 40 C.F.R. § 257.90 commenced in November 2015. Monitoring wells around AP2 were installed beginning in 2010, and additional wells and piezometers were installed in 2015 and 2016 to comply with the CCR Rule and define the extent of CCR impacts. Monitoring includes groundwater elevation measurements and collection of water quality samples from background monitoring wells G270 and G281, and downgradient wells G401, G402, G403, G404, and G405 (Figure 2). Detection monitoring per 40 C.F.R. § 257.90 was initiated in October 2017; statistically significant increases (SSIs) of Appendix III parameters over background concentrations were detected in October 2017. 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 parameter cobalt over the GWPS of 0.006 milligrams per Liter (mg/L). SSLs for total cobalt were identified in downgradient monitoring wells G401 and G402 at concentrations from 0.0047 mg/L to 0.42 mg/L. No other SSLs have been identified for AP2.

2.4 IMPACTED GROUNDWATER DISCHARGE TO SURFACE WATER

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. Boron and sulfate loading calculations into the discharge flume to the south and the Unnamed Creek to the east were completed in the Closure Plan for AP2 (NRT, 2017b) and indicated that calculated boron concentrations into the Unnamed Creek would be approximately 0.115 mg/L and calculated sulfate concentrations would be approximately 1.9 mg/L. In the discharge flume the calculated concentration of boron was 0.01 mg/L; the calculated concentration of sulfate was estimated at 50.1 mg/L. In both discharge areas the resulting concentrations do not exceed the Public Food Processing Water Supply Use Standard at 35 Illinois Adm. Code 302 Subpart C Section 302.304 (1.0 mg/L boron and 250 mg/L sulfate). Nor does the calculated boron concentration exceed the General Use Standards for Protection of Aquatic Organisms at 35 Ill. Adm. Code 302 Subpart C Section 302.208 (40.1 mg/L, acute & 7.6 mg/L, chronic). Compared to these protection standards, the low levels of calculated concentrations under current conditions are protective of surface water receptors.

Surface water sampling confirmed that Coffeen Lake was not impacted by AP2 because measured concentrations of boron, ≤280 micrograms per Liter (ug/L) (0.280 mg/L), and sulfate (~55 mg/L) are well below standards and similar to background groundwater concentrations measured elsewhere onsite (NRT, 2017b).

35 Ill. Adm Code 302 does not contain a published surface water standard for cobalt. Also, cobalt has a recognized higher potential for sorption to aquifer solids than boron (EPRI, 2012). Consequently, the percentage of cobalt that may be released from AP2 that potentially discharges to surface water is anticipated to be less than the percentage of boron that may be released from AP2 that potentially discharges to surface water.

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 the former CPS AP2.

3.1 ALTERNATIVE 1: CLOSURE BY REMOVAL AND MNA

Alternative 1, closure by removal (CBR) 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, and backfilling the excavation.

Alternative 1 would require transporting more than 175,000 loads of materials (2.2 million 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 regulatory approval process for modifying the existing on-site landfill could take multiple levels of approval including environmental permits and local authorization. Opposition to such projects and regulatory approvals would take 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 magnitude of ash, it is expected to take nearly 9 years to remove the ash and transport it to an off-site landfill.

This alternative would address the primary source of groundwater impacts by removing the CCR (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, approximately 9 years later.

Over the long term, Alternative 1 would attain GWPS by removing the primary source and through monitored natural attenuation (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.

3.1.1 Alternative 1A – Disposal in On-Site Landfill

The existing on-site landfill does not have adequate capacity for the 2.2 million CY of CCR that would be removed under this alternative and landfill expansion is not currently permitted. Disposal of excavated CCR in an on-site landfill, or expansion of the existing landfill, would require siting, permitting, design and construction. It is anticipated that several new permits, or modifications to existing permits, would be required to allow siting and construction of an on-site landfill, including a modification of the 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.

3.1.2 Alternative 1B – Disposal in Off-Site Landfill

Disposal of CCR in an off-site landfill would result in significantly increased potential for impacts to the surrounding community, including potential safety concerns related to the volume of material to be transported (2.2 million CY) and the distance to an existing, permitted, Subtitle D landfill. Adequate disposal capacity is potentially available at one off-site landfill within 50 miles from the CPS (IEPA, 2015), but coordination with the landfill operator would be required to confirm disposal options. Complete removal of CCR would require material hauling for nearly 10 years, with approximately 60 daily round-trip truck hauls from the site to the landfill with potential for increased injuries and possibly fatalities from traffic accidents. Transportation of the excavated CCR would require design and construction of on-site access roads and may require upgrading 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.

3.2 IEPA-APPROVED ALTERNATIVE 2: CLOSURE IN PLACE (GEOMEMBRANE COVER SYSTEM) AND MNA

IEPA-Approved Alternative 2: Design of the Closure in Place (CIP; geomembrane cover system) alternative has been completed and the Closure Plan has been approved by IEPA (IEPA, 2018). This alternative includes dewatering the CCR, constructing a geomembrane cover system in direct contact with the graded CCR and existing soil cover material, and monitored natural attenuation. The new cover system will minimize water infiltration into the closed CCR unit (primary source of CCR constituents in groundwater) and allow surface water to drain off the cover system, thus reducing generation of potentially impacted water and reducing the extent of cobalt impact in the Uppermost Aquifer. Alternative 2 will attain GWPS by mitigating primary source material and monitoring natural attenuation of the secondary source.

Both federal and state regulators have long recognized that monitored natural attenuation (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 the approved AP2 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 a geomembrane cover system (IEPA-Approved Alternative 2 Geomembrane Cover System), and ongoing groundwater monitoring will document the attenuation and long-term effectiveness of the source control.

Based on the groundwater prediction model (NRT, 2017b), concentrations of CCR constituents will begin to decline and the extent of groundwater impacts will begin to reduce starting approximately 1 year after cover placement. The GWPS will be attained in a reasonable time frame.

IEPA-Approved Alternative 2 includes, but is not limited to, the following primary project components:

- Removal of free water and grading the CCR to allow cover system construction.
- Relocating and/or reshaping the existing CCR and cover material within AP2 to achieve acceptable grades for closure. Borrow soil will be used to supplement fill volume, if necessary, to reach final design grades.
- Constructing a geomembrane cover system that complies with the CCR Rule, including establishment of a vegetative cover to minimize long-term erosion.
- Constructing a stormwater management system to convey runoff from the final cover system to a system of perimeter drainage channels for ultimate routing and discharge to nearby surface water.
- Monitoring attenuation processes in groundwater to demonstrate that the extent of groundwater impact is decreasing in size and concentration following closure. In accordance with the IEPA-approved groundwater monitoring plan, 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 Ash Pond 2 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.
- Ongoing inspection and maintenance of the cover system and stormwater and property management per the approved Post-Closure Care Plan.

IEPA-Approved Alternative 2 addresses the primary source of CCR constituents in groundwater by minimizing surface water infiltration and reducing generation of potentially impacted water. The secondary source will be addressed by monitoring natural attenuation processes to confirm contaminant reduction benchmarks established by groundwater modeling are achieved. Construction is planned to begin in July 2019 and be completed by November 2020. Potential impacts to public health and safety for IEPA-Approved Alternative 2 are much lower than Alternatives 1A and 1B, because there is significantly less CCR handling associated with Alternative 2. 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. IEPA-Approved Alternative 2 is expected to achieve compliance with GWPS more quickly than Alternatives 1A and 1B because source control measures will be implemented more rapidly which starts the finishing step of monitored natural attenuation earlier than the other options. Since the cap construction will only require 2 years to complete, reductions in groundwater impacts will begin approximately 7 years sooner than Alternative 1. By controlling the primary source 7 years earlier with Alternative 2, the mass released is reduced relative to Alternatives 1A and 1B.

3.3 ALTERNATIVE 3: CLOSURE IN PLACE (GEOMEMBRANE COVER SYSTEM) WITH GROUNDWATER EXTRACTION

Alternative 3 would include all components of IEPA-Approved Alternative 2, and a groundwater extraction system that would be designed and constructed to remove groundwater impacted by cobalt in the Uppermost Aquifer. Similar to IEPA-Approved Alternative 2, Alternative 3 would minimize infiltration into the closed CCR unit (primary source of CCR constituents in groundwater) and allow surface water to drain off the cover system, thus reducing generation of potentially impacted water and reducing the extent of groundwater impact. 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 attain GWPS by mitigating primary source material and collection of groundwater in the Uppermost Aquifer that comes into contact with the secondary source.

Alternative 3 would include the following primary project components:

- Removal of free water and grading of CCR to allow cover system construction.
- Relocating and/or reshaping the existing CCR and cover material within AP2 to achieve acceptable grades for closure. Borrow soil will be used to supplement fill volume, if necessary, to reach final design grades.
- Constructing a geomembrane cover system that complies with the CCR Rule, including establishment of a vegetative cover to minimize long-term erosion.
- Constructing a stormwater management system to convey runoff from the final cover system to a system of perimeter drainage channels for ultimate routing and discharge to nearby surface water.
- Designing and constructing a groundwater extraction system consisting of a series of extraction wells located around the perimeter of AP2 and operating at a rate to allow capture of CCR impacted groundwater within the Uppermost Aquifer.
- Ongoing inspection and maintenance of the cover system, groundwater monitoring, and stormwater and property management.

The Uppermost Aquifer is comprised of thin (generally less than 3 feet) sand, silty sand, and weathered sandy/silty till with discontinuous lenses of silt, sand and gravel sandwiched between low permeability confining units which are expected to limit the radius of influence between groundwater extraction wells. Design of a groundwater extraction system that provides containment via removal of groundwater from the upper aquifer will require additional site characterization and may result in a high density of wells.

Alternative 3 would effectively address both the primary source of CCR constituents by reducing infiltration into the CCR and groundwater in the Uppermost Aquifer that comes into contact with the secondary source by removing impacted groundwater from the Uppermost Aquifer. Alternative 3 would require additional site investigation and detailed design activities for the groundwater extraction system before permitting and construction, which could extend the implementation schedule by 2 to 5 years. Groundwater extraction would be anticipated to continue for a long period of time following implementation. Potential impacts to the public health and safety posed by implementation would be similar to IEPA-Approved Alternative 2 and significantly less than that posed by the Alternatives 1A and 1B because all work would be completed on-site. There would be some increases in off-site traffic due to increase need for on-site workers. Alternative 3 would achieve compliance with GWPS more quickly than Alternative 1 because of the relatively short construction timeframe and, potentially more quickly than IEPA-Approved Alternative 2 because groundwater extraction would likely result in more rapid reduction of the extents of cobalt in groundwater potentially attributable to AP2.

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 by attaining groundwater protection standards (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 environmental from impacts related to CCR management and/or disposal at AP2. This evaluation factor is focused on the ability of alternatives to address existing and future site impacts, on-site and off-site, both short term (during the implementation phase) and long term (after implementation of the alternative).

All alternatives under consideration would address the primary source of groundwater impacts, either by removing the CCR (Alternatives 1A and 1B) or by limiting surface water infiltration and generation of potentially impacted water (IEPA-Approved Alternative 2 and Alternative 3), and would ultimately, over a period of decades, result in attaining GWPS. Alternatives 1, 2, and 3 would leave the underlying saturated soils (secondary source) in place as a potential continuing source of groundwater impacts. Alternatives 1 and 2 will monitor natural attenuation until concentrations meet the GWPS. Alternative 3 would address the groundwater in the Uppermost Aquifer that comes into contact with the secondary source by extracting impacted groundwater, thus preventing ongoing and future releases beginning immediately after remedy implementation.

All alternatives considered would be protective of surface water because closure of AP2 will prevent contact of stormwater runoff with CCR upon completion and reduce seepage through the containment berms by either removing the CCR (Alternatives 1A and 1B) or reducing the hydraulic head within the CCR (IEPA-Approved Alternative 2 and Alternative 3). Addressing the groundwater impacts referenced above is also protective of surface water since groundwater flow in the Uppermost Aquifer discharges to surface water.

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 that could be impacted by these releases were identified during the potable well survey. Concentrations of sulfate and boron in Unnamed Creek, Coffeen Lake and the discharge flume were either observed or calculated to be below surface water quality standards. Since cobalt has a higher sorption potential than boron (EPRI, 2012), the percentage of cobalt released from AP2 that potentially discharges to surface water is anticipated to be less than the percentage of boron released from AP2 that potentially discharges to surface water. Cobalt also does not have a published surface water quality standard. In the absence of existing risk from cobalt in groundwater or surface water, the alternatives are evaluated with respect to additional/new risks that arise due to implementation of the alternative.

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. IEPA-Approved Alternative 2 and Alternative 3 represent the lowest risk (highest risk reduction) to the surrounding community because corrective measure activities would be limited to the CPS 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 (2 to 3 years) for IEPA-Approved Alternative 2 and Alternative 3, respectively. There would be similar impacts from Alternative 1B, but the impacts would continue for a longer time (approximately 10 years) and there would be increased direct contact impacts because the CCR would be exposed over the removal implementation timeframe.

Risks to community and environmental receptors would be greatest (lowest risk reduction) for Alternative 1B due to the extended implementation schedule required for the large volume of CCR to be excavated, transported and disposed (approximately 60 trucks per day for 10 years), and the increased potential for safety and noise impacts, exposure to fugitive dust during transport, and increases in greenhouse gas emissions and carbon footprint. Alternative 1A would have somewhat less risk (somewhat greater risk reduction) since the corrective measures would be constrained to the site.

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

Alternatives 2 and 3 provide the lowest level of residual risk or likelihood of further CCR releases following implementation. Groundwater modeling performed for IEPA-Approved Alternative 2 indicated that the concentrations of boron, and by extension cobalt, potentially attributable to AP2 will begin to decline and the extent of groundwater impacts will begin to reduce starting approximately 1 year 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 removal of groundwater, but design and construction will delay this process and effectiveness of groundwater removal is uncertain due to aquifer heterogeneity.

Alternatives 1A and 1B would have a higher potential for further CCR releases because the primary source of groundwater impacts would remain in place, allowing transport of contaminants into the groundwater throughout the extended permitting and implementation timeframe (ten to twenty years depending on permitting requirements) and 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 1A and 1B have the lowest long-term residual risk resulting from source removal. Alternatives 1A and 1B 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. IEPA-Approved Alternative 2 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 Post-Closure Care Plan. Furthermore, a Post-Closure Care Plan for IEPA-Approved Alternative 2 has been approved by IEPA that includes provisions for monitoring and maintenance for a post-closure period that is anticipated to continue for 30 years. The post-closure period may extend beyond 30 years if additional groundwater monitoring results indicate the necessity.

Alternative 1B would require ongoing coordination with landfill and transportation operators during the approximately 10-year implementation period. Alternatives 1A and 1B would require the 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 system performance.

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

The least short-term risk to the community or the environment is posed by Alternatives 2 and 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 1B would have somewhat greater potential for short-term risk to the community relative to Alternatives 2 and 3 because of the longer timeframe required for CCR excavation and the associated increased potential for community exposure from fugitive dust emissions during on-site work and the increased potential for safety and noise impacts.

Risks to community and environmental receptors would be greatest for Alternative 1B due to the extended implementation schedule required for the large volume of CCR to be excavated, transported and disposed, and the increased potential for safety and noise impacts, exposure to fugitive dust during transport, and increases in greenhouse gas emissions and carbon footprint. Alternative 1A would have somewhat less risk since the corrective measures would be constrained to the site.

4.2.5 Time Until Full Protection is Achieved

Full protection of the groundwater resource will be achieved when the GWPS are met. 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, over a period of decades, reduce existing risks and attain GWPS. Alternative 3 may provide the shortest time to attain GWPS, depending upon the technical challenges of designing and operating a groundwater extraction system in the thin, discontinuous Uppermost Aquifer. 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 approximately 1 year after cover construction. However, detailed site characterization, design and permitting would be required for constructing the groundwater extraction system and would likely extend remedy implementation by 2 to 5 years. The reduced time to meet GWPS under Alternative 3 may be offset by the increased implementation timeframe and be similar to IEPA-Approved Alternative 2. Groundwater modeling performed for IEPA-Approved Alternative 2 indicated that concentrations of boron, and by extension cobalt, potentially attributable to AP2 will begin to decline and the extent of groundwater impacts will begin to reduce starting approximately 1 year after cover placement and GWPS will be attained in a reasonable time frame.

Alternatives 1A and 1B 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 (10 to 20 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 IEPA-Approved Alternative 2 and Alternative 3.

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

IEPA-Approved Alternative 2 and Alternative 3 have the lowest potential for exposure to remaining waste. The approved Closure Plan 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 1A would have more potential for on-site worker exposure than IEPA-Approved Alternative 2 and Alternative 3 because CCR excavation would increase both the accessibility of the CCR and the timeframe over which exposures could occur. Alternative 1B 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

IEPA-Approved Alternative 2 has been designed and approved 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 groundwater extraction system would be managed by defined, routine operation and maintenance procedures similar to landfills. Landfilling 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. IEPA-Approved Alternative 2 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.

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 upper aquifer that comes into contact with secondary source material. Groundwater modeling of the cover system completed as part of the Closure Plan for IEPA-Approved Alternative 2 indicated that concentrations of boron, and by extension cobalt, potentially attributable to AP2 will begin to decline and the extent of groundwater impacts will begin to reduce starting approximately 1 year after cover placement, thus significantly reducing future releases. Alternative 3 would be expected to provide a similar, or possibly higher, level of source control effectiveness with the addition of groundwater extraction. However, the ability of the groundwater extraction system to effectively reduce groundwater concentrations and attain GWPS will have a high dependence upon the geologic and hydrogeologic heterogeneity.

Alternatives 1A and 1B 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. Extracted groundwater from 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. **<u>However, if groundwater data demonstrates that attenuation is not occurring as expected, treatment technologies will be reconsidered.</u>**

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.

4.4.1 Degree of Difficulty Associated with Constructing the Technology

IEPA-Approved Alternative 2 will be the most easily implemented alternative because it will employ relatively common construction activities and is required to be completed by November 2020. Alternative 3 would require a somewhat higher degree of difficulty due to the need to design and construct an effective groundwater extraction system in a heterogeneous aquifer, in addition to the geomembrane cover system. Alternative 1B 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 50 miles from the CPS (IEPA, 2015), but this would need to be coordinated with the landfill operator(s). Alternative 1B would require approximately 60 trucks per day over a 10-year period to dispose of the 2.2 million CY of CCR that would be excavated from AP2. The siting, permitting, design and construction of an on-site landfill (Alternative 1A) 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 9 years required for CCR excavation and removal that would be required to implement Alternative 1A.

4.4.2 Expected Operational Reliability of Technologies

IEPA-Approved Alternative 2 is an accepted containment technology with high operational reliability. Disposal of waste in an engineered landfill, either on-site or off-site (Alternative 1A and Alternative 1B) 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 (groundwater extraction) and heterogeneity within the Uppermost Aquifer 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 IEPA-Approved Alternative 2 has been approved by IEPA; therefore, no additional approvals are required. Alternative 3 would require design and permitting for the groundwater extraction system. Alternative 1B 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 1A 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 IEPA-Approved Alternative 2 and Alternative 3 are routine construction activities for which equipment and manpower would be readily available. The groundwater extraction system associated with Alternative 3 is expected to require specialized equipment and contractors if treatment is required to permit discharge of extracted groundwater.

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

IEPA-Approved Alternative 2 would not require treatment, storage and disposal services. Alternative 3 would require modification of the existing NPDES permit for discharge of extracted groundwater. Adequate disposal capacity is likely available at off-site landfills within 50 miles from the CPS (IEPA, 2015) to allow implementation of Alternative 1B, although coordination with the landfill operator(s) and CCR transporters would be required. Available disposal capacity for Alternative 1A is low due to the lack of available capacity in the existing on-site landfill and the physical constraints related to siting and constructing a new on-site landfill.

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:

- Alternative 1) Closure by removal, with on-site (A) or off-site (B) CCR disposal, and monitored natural attenuation
- IEPA-Approved Alternative 2) Closure-in-Place (Geomembrane Cover System) and monitored natural attenuation
- Alternative 3) Closure-in-Place (Geomembrane Cover System) and groundwater extraction

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 (IEPA-Approved Alternative 2 and Alternative 3) are more effective and protective than CBR alternatives (Alternatives 1A and 1B). 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 10 years), 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 1B).

5.2 SOURCE CONTROL

Groundwater modeling for IEPA-Approved Alternative 2 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 and the extent of groundwater impacts will begin to reduce approximately 1 year after cover construction.

Adding a groundwater extraction system to IEPA-Approved Alternative 2 (i.e., Alternative 3) may enhance the overall source control effectiveness, but would increase the implementation timeframe due to the need to design and permit the groundwater extraction system.

The CBR alternatives (Alternatives 1A and 1B) achieve greater source control in the long-term, but present greater environmental risk in the short-term associated with implementation. The primary source of groundwater impacts (CCR) would remain in place during implementation, allowing transport of cobalt into the groundwater throughout the extended permitting and implementation timeframe (10 to 20 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

IEPA-Approved Alternative 2 has been approved by IEPA and is thus the most easily implementable alternative. Alternative 3 would require detailed site investigation and design activities prior to implementation. CBR alternatives (1A and 1B) would entail significant difficulty in permitting, construction and transportation.

IEPA-Approved Alternative 2 provides performance that is as good 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

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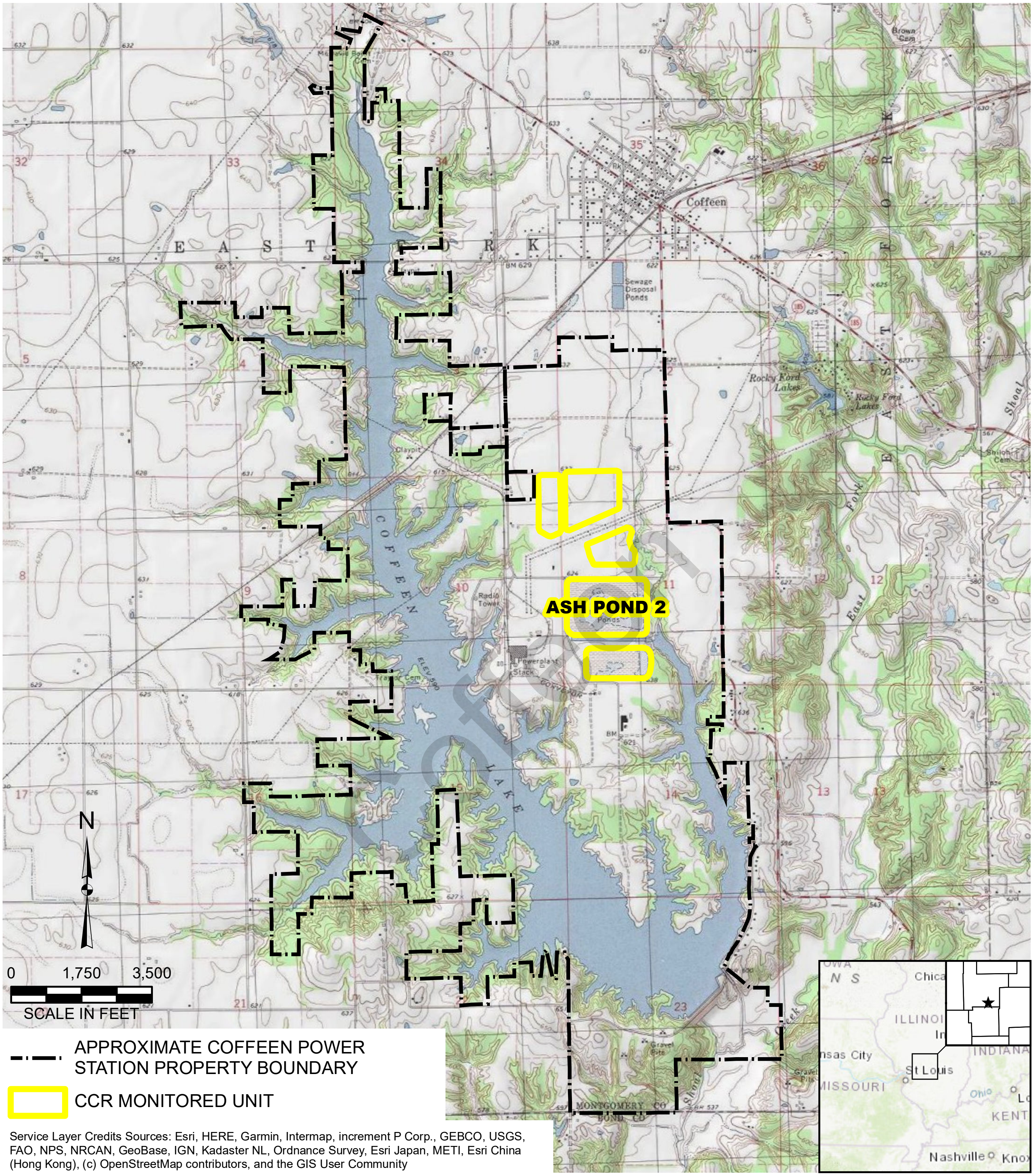
Tables

Table 1 - Corrective Measures Assessment Matrix
Coffeen Power Station Ash Pond No. 2
July 8, 2019

Evaluation Factors	Considerations	Rating That Indicates Best Performance[1]	Alternative 1 Closure by Removal: 1A On-Site Landfill (New Construction)	Alternative 1 Closure by Removal: 1B Off-Site Landfill	IEPA-Approved Alternative 2 Closure in Place Geomembrane Cover System[2]	Alternative 3 Closure in Place Geomembrane Cover System with Groundwater Extraction
Long and short-term effectiveness, protectiveness and certainty	Magnitude of reduction of existing risks	High	Medium. Risks to the community or environmental receptors is medium because although excavation, transportation or re-disposal of CCR would be limited to the CPS property, the implementation timeframe is long, thus extending potential exposures to workers during construction, potential fugitive dust and noise impact to community members.	Low. Increased 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 10 years to complete and would require approximately 60 trucks per day to transport CCR to off-site landfill.	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.	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	Medium. Removal of primary source reduces the potential for further releases from primary source (CCR) due to placement in an engineered landfill. 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. Secondary source (underlying saturated soils) remains.	Low. Groundwater modeling indicates that contaminant concentrations will begin to decline and the plume will begin to retreat approximately 1 year after cover construction, reducing the potential for further CCR releases.	Low. Construction of the cover will reduce infiltration into primary source, and groundwater extraction may address groundwater that comes into contact with the secondary source, but design and construction will delay this process and effectiveness of groundwater removal is uncertain due to aquifer heterogeneity.
	Type and degree of long term management required, including monitoring, O&M	Low	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.	Low. The approved geomembrane cover system does not include any active operational systems, minimal maintenance is required to ensure cover performance and the approved Post-Closure Care Plan includes procedures for cover monitoring and maintenance.	Medium. Operation of groundwater extraction 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	Medium. Limited short term risk to the community and 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.	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 10 years to complete and would require approximately 60 trucks per day to transport CCR to off-site landfill.	Low. Short term risks to the community or environmental receptors is low because CIP does not include significant excavation, transportation or re-disposal. Some small increase in short term risk to workers during construction of cover.	Low. Short term risks to the community or environmental receptors is low because groundwater extraction 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	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 (10 to 20 years) 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 (10 to 20 years) would result is longest time to meet GWPS.	Low. Source control using a geomembrane cover system will be completed in 1 to 2 years. Groundwater modeling indicates that contaminant concentrations will begin to decline and the plume will begin to retreat approximately 1 year after cover construction, reducing the time to attain GWPS.	Low. Source control using a geomembrane cover system could be completed in 1 to 2 years, resulting in declining contaminant concentrations and plume retreat approximately 1 year after cover construction. Detailed site characterization, design and permitting would be required for constructing the groundwater extraction system and would likely extend remedy implementation by 2 to 5 years. The reduced time to meet GWPS may be offset by the increased implementation timeframe, depending on the geologic and hydrogeologic heterogeneity.
	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	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 10 years to complete and would require approximately 60 trucks per day to transport CCR to off-site landfill.	Low. Potential for exposure to human or environmental receptors is low because CIP does not include significant excavation, transportation or re-disposal. Some small increase in potential exposure to workers during construction of cover.	Low. Potential for exposure to human or environmental receptors is low because groundwater control does 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. 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. Approved geomembrane cover system has been designed in accordance with applicable requirements and approved by IEPA.	High. Groundwater control system will be managed by defined, routine operation and maintenance procedures similar to landfills.
	Potential need for replacement of the remedy	Low	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.	Low. Cover will not need replacement, approved post-closure care plan includes procedures for cover system monitoring and maintenance.	Medium. Cover system would not need replacement, regular maintenance would be required to maintain cover performance. Groundwater extraction system could required maintenance and parts replacement over time.
Source control effectiveness	Extent to which containment practices will reduce further releases	High	Medium. Future releases will be mitigated by removal of CCR and re-disposal in an engineered landfill, but secondary source will remain in place.	Medium. Future releases will be mitigated by removal of CCR and re-disposal in an engineered landfill, but secondary source will remain in place.	High. Remaining limited quantity of potentially saturated CCR may act as a source for continued groundwater releases. However, groundwater modeling indicates that contaminant concentrations will begin to decline and the plume will begin to retreat approximately 1 year after cover construction.	High. Groundwater extraction system will address the primary source, and may address groundwater that comes into contact with the secondary source, but design and construction will delay this process and effectiveness of groundwater removal is uncertain due to aquifer heterogeneity.
	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	High. The existing on-site landfill does not have adequate capacity for disposal of the 2.2 million CY of CCR in AP2. 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 the 2.2 million CY of CCR that would be excavated from AP2. Excavation and transport of CCR would require 10 years to complete and would require approximately 60 trucks per day to transport CCR to off-site landfill.	Low. Cover construction could be completed within 1 to 2 years and the required earthwork would not be difficult.	Medium. Groundwater extraction 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. 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.	High. Geomembrane cover system design approved by IEPA.	Medium. The cover has good reliability characteristics, similar to the landfill alternative, and the groundwater 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/None	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 and a modification to the existing NPDES permit would be required.	None. The IEPA has approved the closure plan for construction of a geomembrane cover system and long-term inspection, maintenance and monitoring.	Medium. Cover and groundwater extraction system design will require design review and approval by IEPA and modification to existing NPDES permit.
	Availability of necessary equipment and specialists	High	High availability. Earthwork and landfill construction are routine construction activities.	High availability. Earthwork and landfill construction are routine construction activities.	High availability. Earthwork and cover construction are routine construction activities.	High availability. Cover construction and groundwater extraction system are routine construction activities.
	Available capacity and location of needed treatment, storage and disposal services	High/None	Low. The existing on-site landfill does not have sufficient consolidation/disposal capacity for the 2.2 million CY of CCR that would be removed under this alternative and landfill expansion is not currently permitted. Permitting for a new on-site landfill or cell is estimated to extend the overall timeframe for remedy implementation by an additional 5 to 10 years before CCR excavation could begin.	Medium. There is adequate off-site landfill capacity for the 2.2 million CY of CCR that would be excavated from AP2. Excavation and transport of CCR would require 10 years to complete and would require approximately 60 trucks per day to transport CCR to off-site landfill.	None. No treatment, storage or disposal services required for cover system construction.	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 approved by IEPA January 30, 2018

Figures



SITE LOCATION MAP

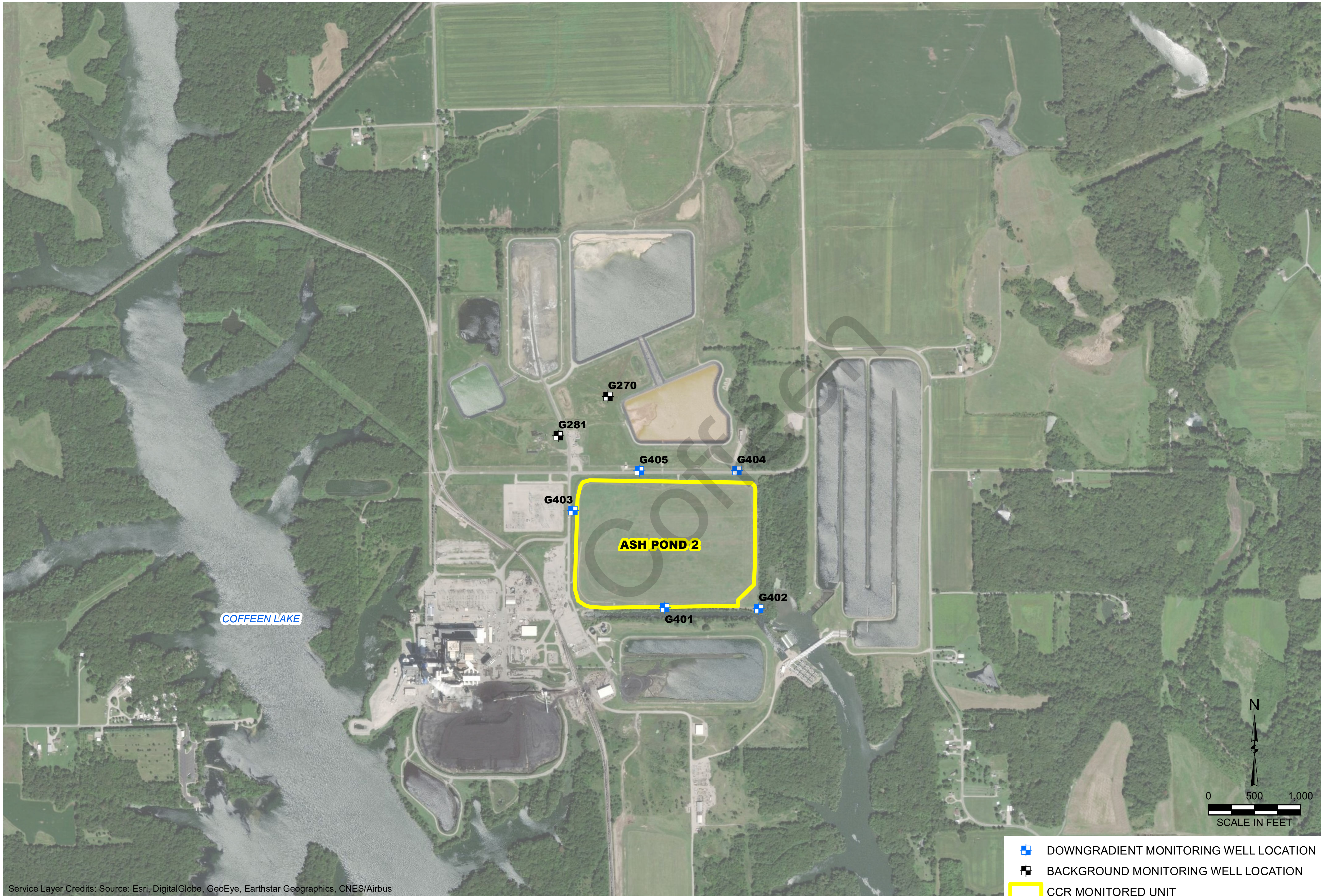
CORRECTIVE MEASURES ASSESSMENT
ASH POND 2
COFFEEN POWER STATION
COFFEEN, IL

DRAWN BY/DATE:
SDS 12/21/16
REVISED BY/DATE:
SAE 6/21/19
APPROVED BY/DATE:
AFA 6/21/19

PROJECT NO: 72856

FIGURE NO: 1

OBG Part of Ramboll



DRAWN BY/DATE:
SDS 11/28/18
REVISED BY/DATE:
SAE 6/21/2019
APPROVED BY/DATE:
AFA 6/21/19

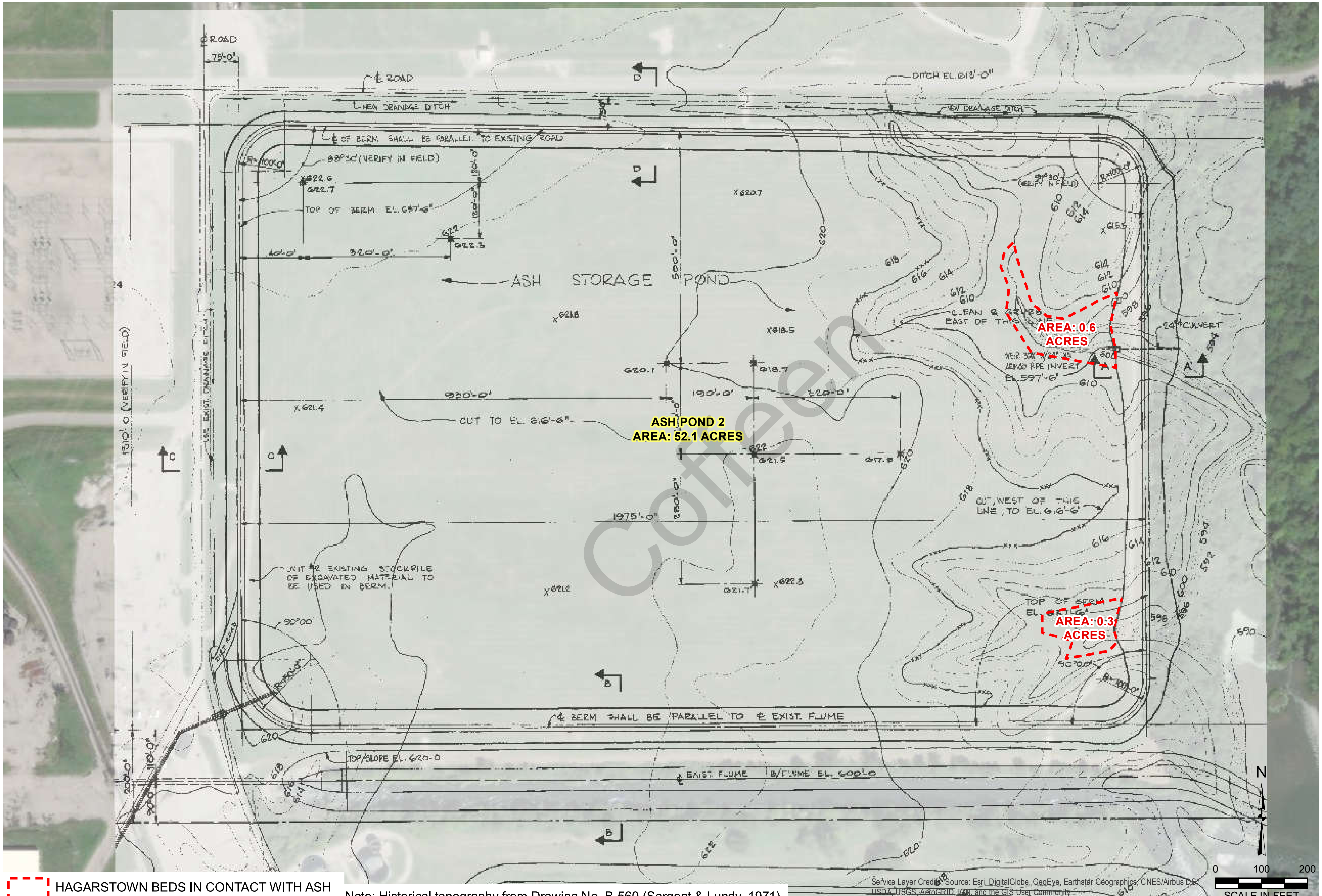
COFFEEN ASH POND NO. 2
WITH CCR GROUNDWATER MONITORING SYSTEM

CORRECTIVE MEASURES ASSESSMENT
ASH POND 2
COFFEEN POWER STATION
COFFEEN, ILLINOIS

PROJECT NO: 72856

FIGURE NO: 2

OBG
Part of Ramboll



DRAWN BY/DATE: SDS 7/1/19
REVIEWED BY/DATE: NRK 7/1/19
APPROVED BY/DATE: EJT 7/1/19

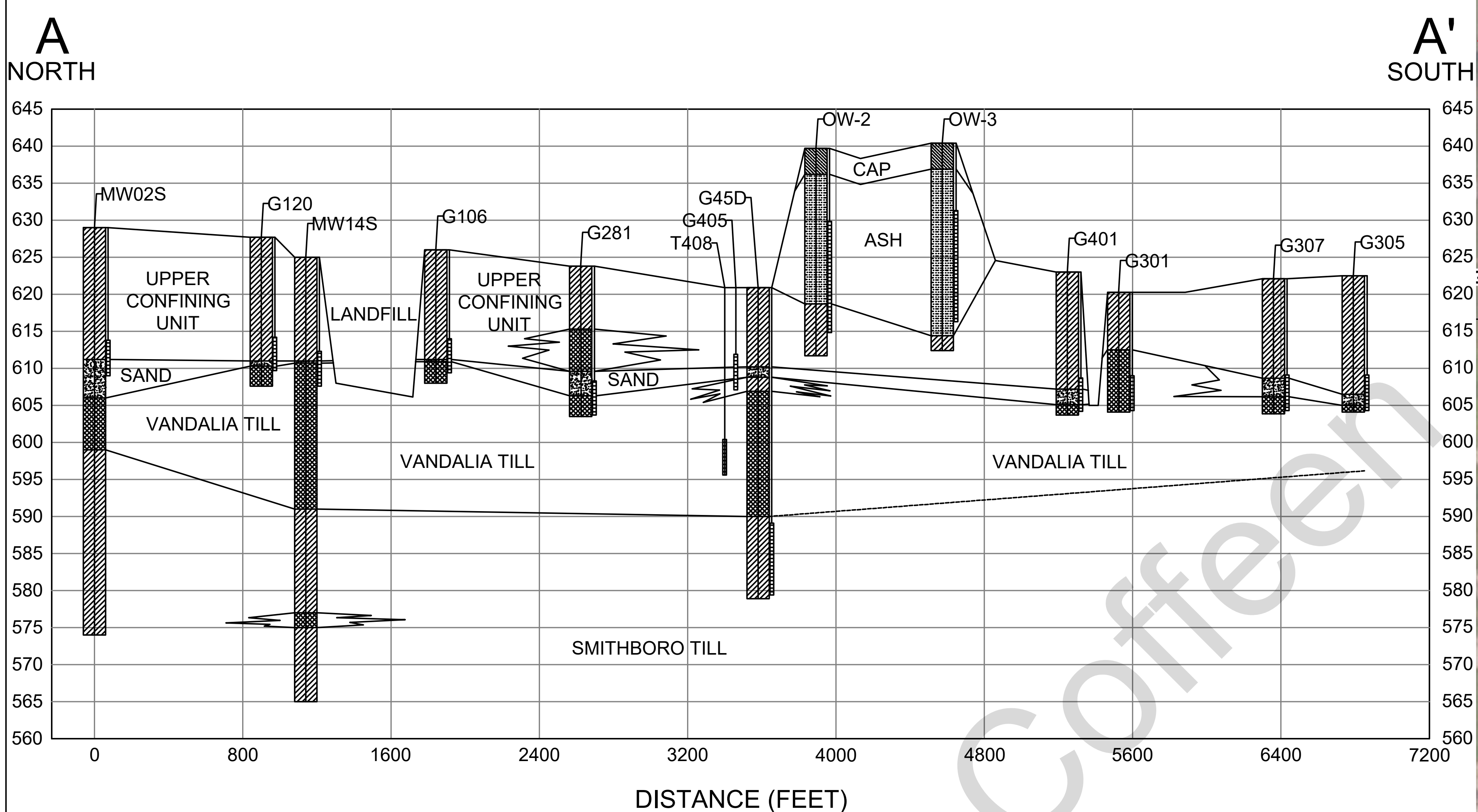
AREAL EXTENT OF UPPER CONFINING UNIT

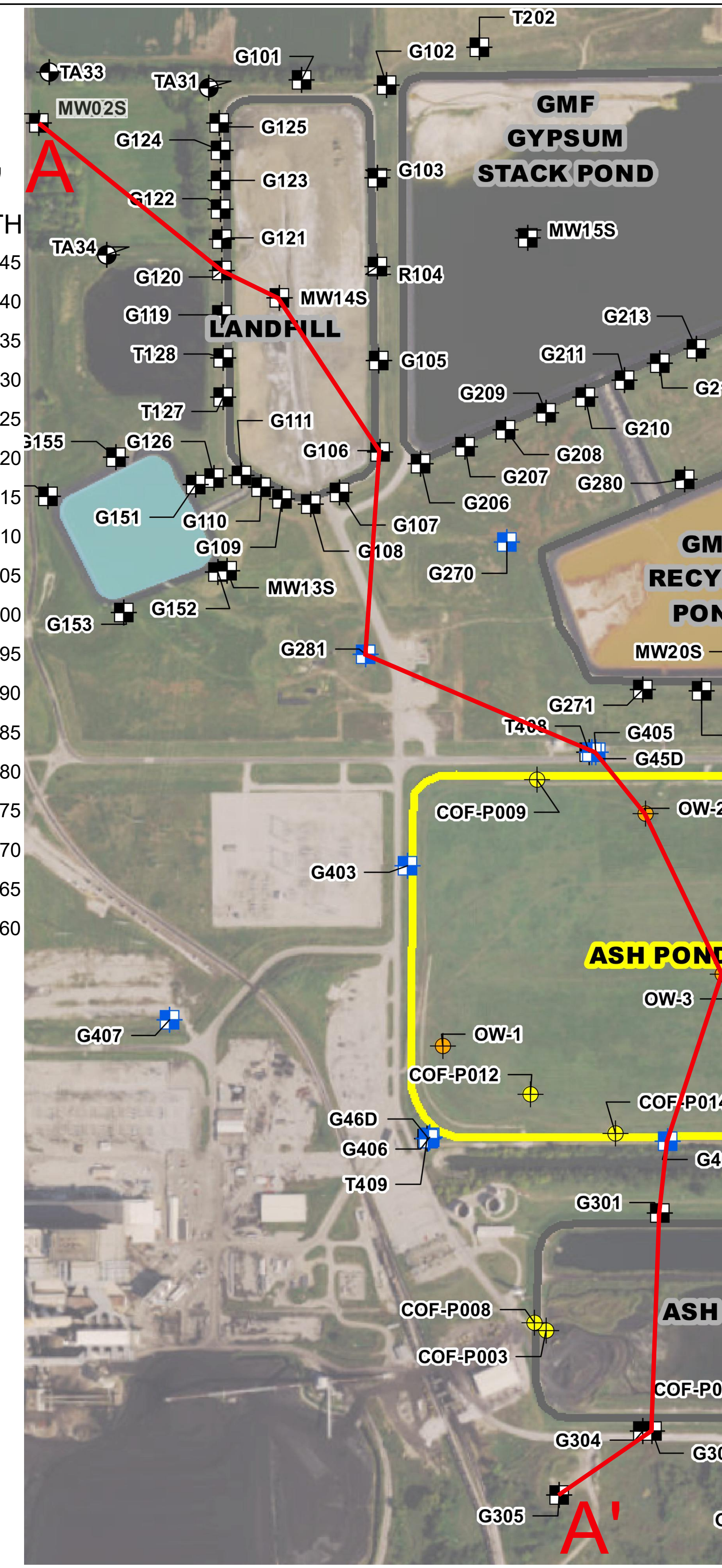
CORRECTIVE MEASURES ASSESSMENT
ASH POND 2
COFFEEN POWER STATION
COFFEEN, IL

PROJECT NO: 72856

FIGURE NO: 3

OBG Part of Ramboll





VERTICAL SCALE IN FEET 20

HORIZONTAL SCALE IN FEET 800

VERTICAL EXAGGERATION =40

B—B'	CROSS-SECTION TRANSECT
	CLAY
	SOIL
	SAND
	SILT
	ASH
	WELL SCREEN

DRAWN BY / DATE: AGC 11/30/16
REVISED BY / DATE: SAE 7/1/19
APPROVED BY / DATE: NP 7/1/19

GEOLOGIC CROSS-SECTION A-A'

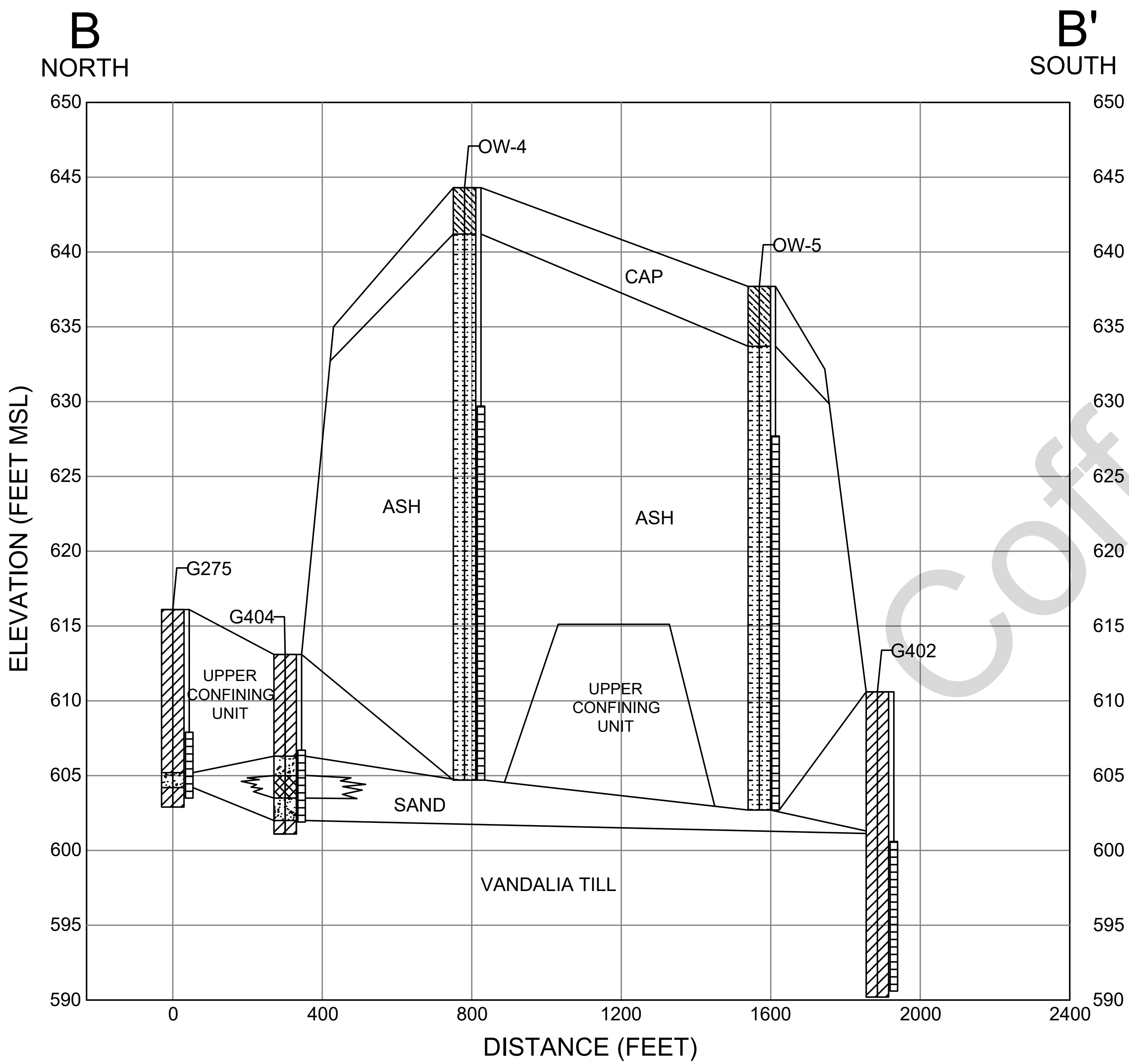
CORRECTIVE MEASURES ASSESSMENT
ASH POND 2
COFFEEN POWER STATION
COFFEEN, IL

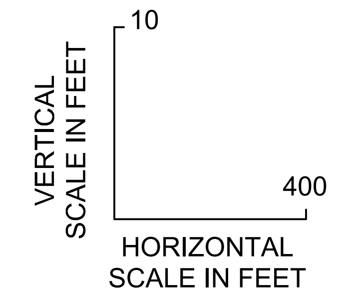
PROJECT NO. 72856

FIGURE NO. 4

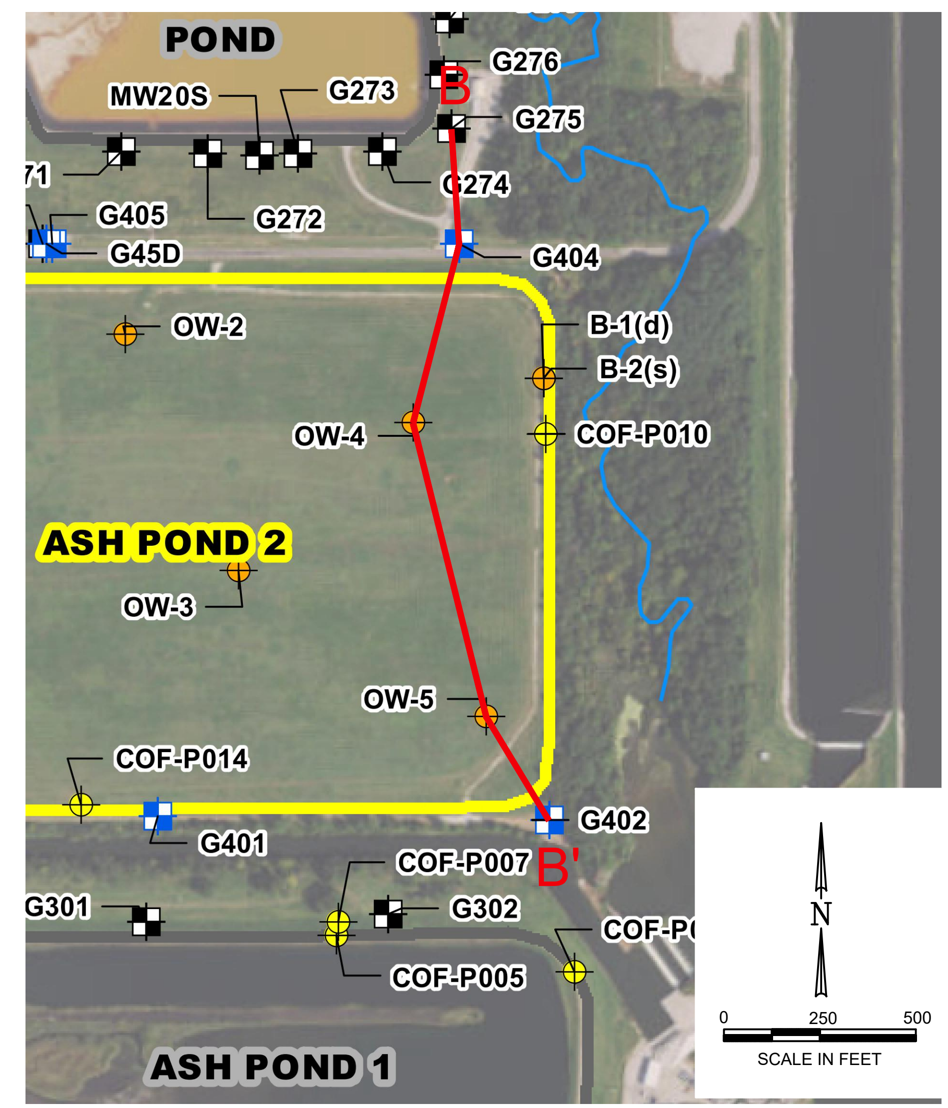
OBG Part of Ramboll

\\server27-01\Y Drive\Mapping\Projects\22\2285\CAD\Coffeen-CMA\Figure 4_Geologic Cross-Section A-A'.dwg





B — B' CROSS-SECTION TRANSECT
CLAY
SOIL
SAND
SILT
ASH
WELL SCREEN



Coffeen

DRAWN BY / DATE: AGC 11/30/16
REVISED BY / DATE: SAE 7/1/19
APPROVED BY / DATE: NP 7/1/19

GEOLOGIC CROSS-SECTION B-B'

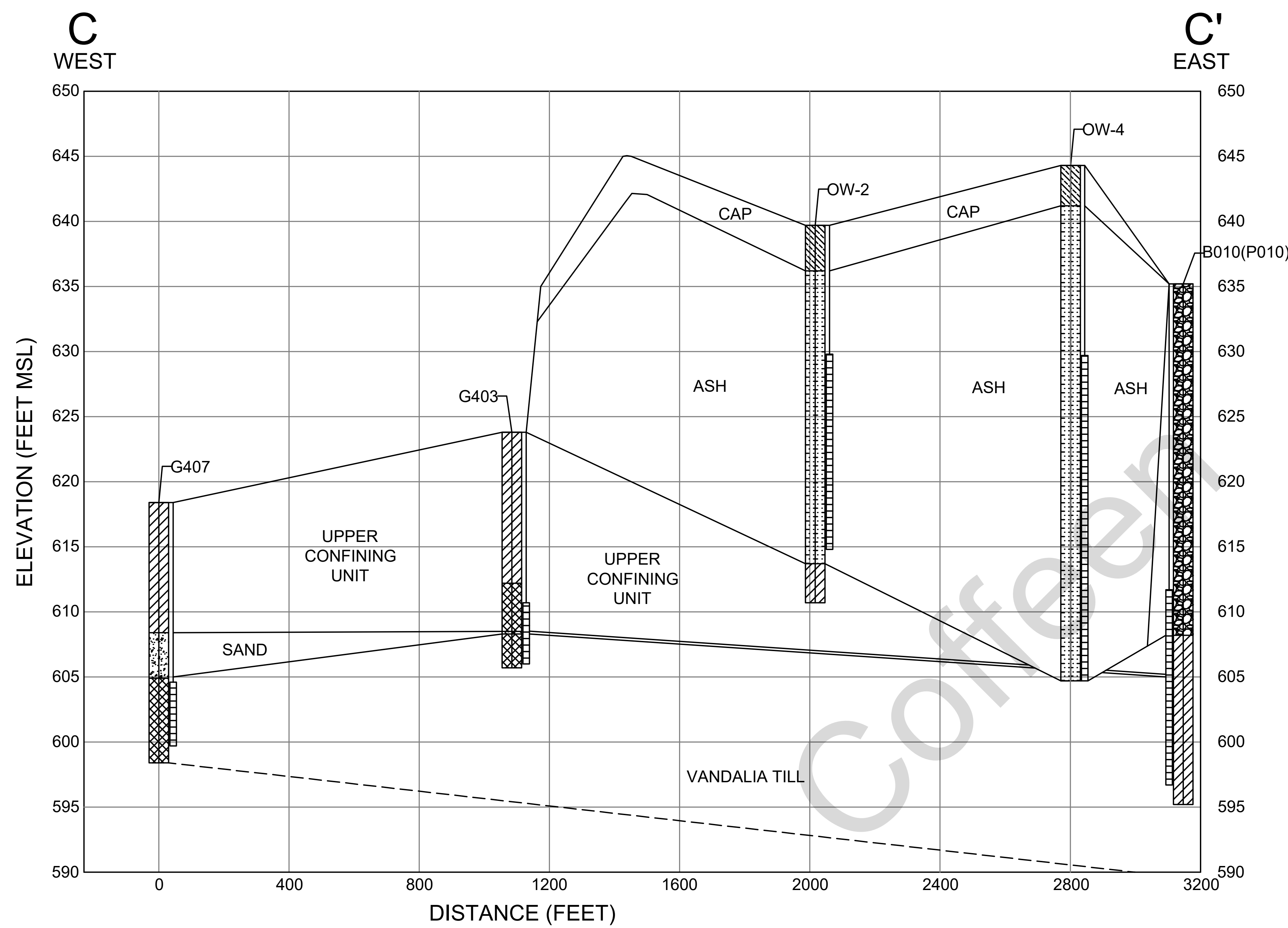
CORRECTIVE MEASURES ASSESSMENT
ASH POND 2
COFFEEN POWER STATION
COFFEEN, IL

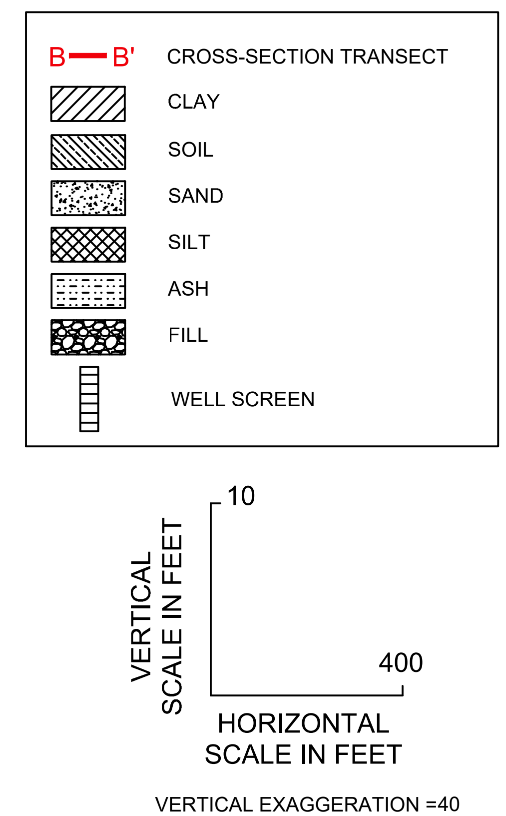
PROJECT NO. 72856

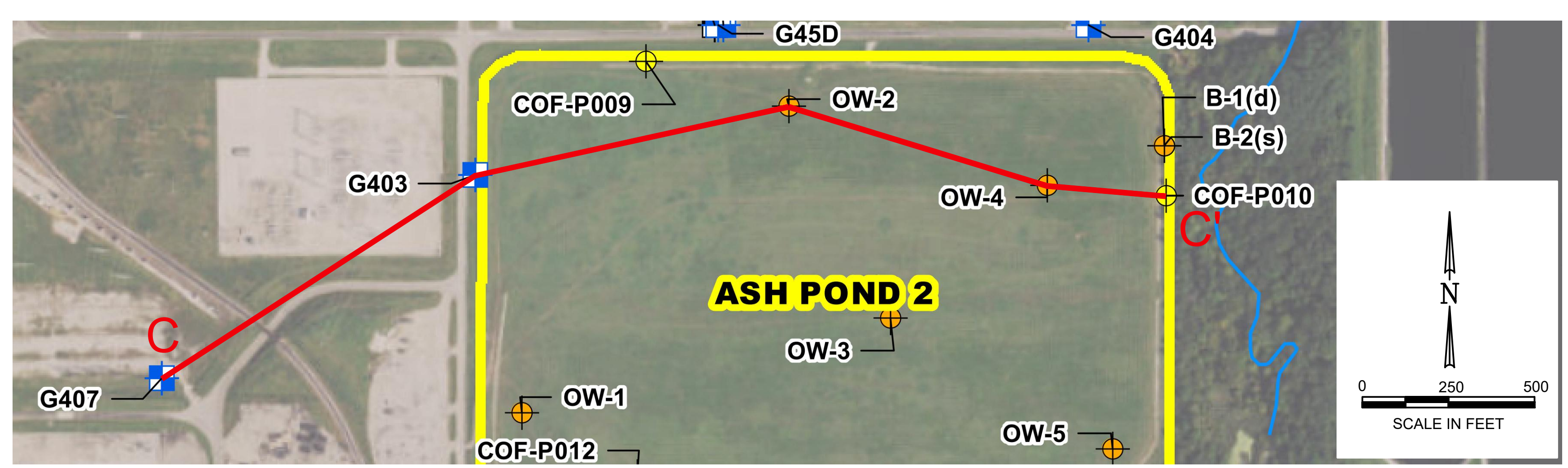
FIGURE NO. 5

OBG
Part of Ramboll

\\server27-01\Y Drive\Mapping\Projects\22\2285\CAD\Coffeen-CMA\Figure 5_Geologic Cross-Section B-B'.dwg







DRAWN BY / DATE: AGC 11/30/16
REVISED BY / DATE: SAE 7/1/19
APPROVED BY / DATE: NP 7/1/19

GEOLOGIC CROSS-SECTION C-C'

CORRECTIVE MEASURES ASSESSMENT
ASH POND 2
COFFEEN POWER STATION
COFFEEN, IL

PROJECT NO. 72856

FIGURE NO. 6

OBG Part of Ramboll

\\server27-01\Y Drive\Mapping\Projects\22\2285\CAD\Coffeen-CMA\Figure 6_Geologic Cross-Section C-C'.dwg

OBG

Part of Ramboll