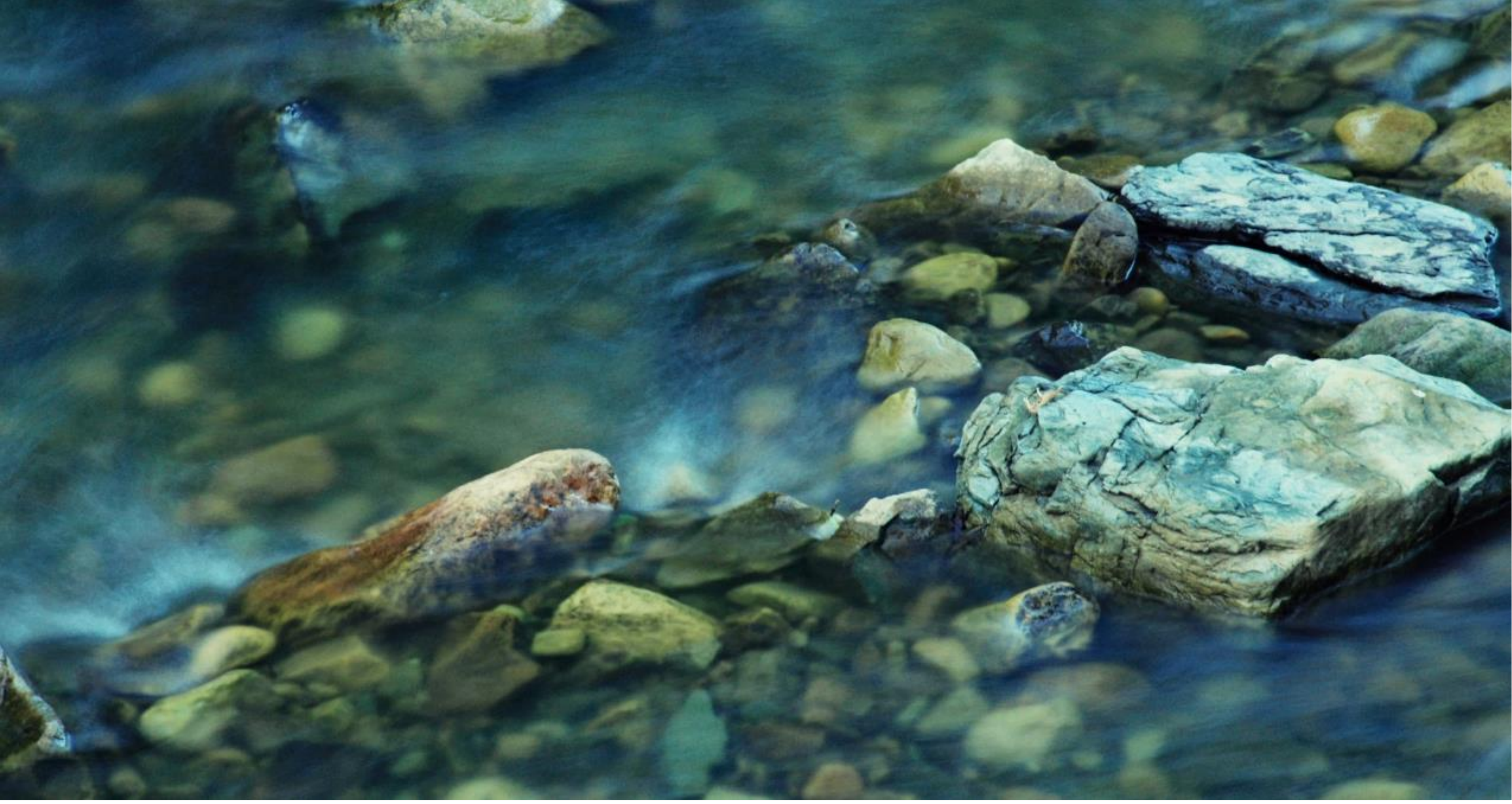

June 2019 (Revised: February 2020)
Plant Gorgas

Assessment of Corrective Measures
Plant Gorgas

Prepared for Alabama Power Company

June 2019 (Revised: February 2020)
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ABBREVIATIONS

ACM	Assessment of Corrective Measures
ADEM	Alabama Department of Environmental Management
Admin. Code	Administrative Code
APC	Alabama Power Company
ASD	Alternate Source Demonstration
BALF	Bottom Ash Landfill
bgs	below ground surface
CCR	coal combustion residuals
CCR Rule	80 Federal Register 21302 (April 17, 2015); "Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals from Electric Utilities"
CFR	Code of Federal Regulations
cm/sec	centimeter per second
CMS	Corrective Measures Study
CSM	conceptual site model
EPRI	Electric Power Research Institute
GCL	geosynthetic clay liner
GWPS	groundwater protection standard
HDPE	high-density polyethylene
MNA	monitored natural attenuation
PRB	permeable reactive barrier
RCRA	Resource Conservation and Recovery Act
RCRA FIRST Toolbox	*Resource Conservation and Recovery Act Facilities Investigation Remedy Selection Track: A Toolbox for Corrective Action*
Site	William Crawford Gorgas Electric Generating Plant
SSI	statistically significant increase
SSL	statistically significant level
USEPA	U.S. Environmental Protection Agency

1 Introduction

This revised Assessment of Corrective Measures (ACM) has been prepared pursuant to the U.S. Environmental Protection Agency (USEPA) coal combustion residuals (CCR) rule (40 Code of Federal Regulations [CFR] Part 257, Subpart D), Alabama Department of Environmental Management's (ADEM's) Administrative Code (Admin. Code) r. 335-13-15, and an Administrative Order issued by ADEM (AO 18-096-GW) to evaluate potential groundwater corrective measures for the occurrence of constituents in groundwater at statistically significant levels (SSLs) at William Crawford Gorgas Electric Generating Plant (Site). SSLs have been detected in groundwater at the Site as follows:

- Ash Pond: arsenic, lithium, and molybdenum
- Gypsum Pond: lithium
- Bottom Ash Landfill (BALF): arsenic
- CCR Landfill: lithium
- Gypsum Landfill: lithium

Specifically, this revised ACM is prepared pursuant to 40 CFR 257.96, ADEM Admin. Code r. 335-13-15-.06(7), and Part C of the Administrative Order. Pursuant to the requirements of Part C of the Administrative Order, this ACM also "include(s) the remedy proposed to the Department for approval."

The ACM for Plant Gorgas was initiated within 90 days of identifying the SSLs on January 13, 2019; on April 12, 2019, a 60-day extension was documented for a revised completion deadline of June 12, 2019. The ACM for Plant Gorgas was submitted to ADEM on June 12, 2019.

Alternate Source Demonstrations (ASDs) for the CCR Landfill (SCS 2019a) and Gypsum Landfill (SCS 2019b) were submitted to ADEM in February 2019, and an ASD for the BALF (SCS 2019c) was submitted to ADEM in July 2019. Based on the ASDs, these units were not included in the June 2019 ACM. In a letter dated November 14, 2019, ADEM responded that additional information is required before the ASDs can be approved (ADEM 2019). In a letter dated December 30, 2019, Alabama Power Company (APC) agreed to revise the ACM for Plant Gorgas to include the BALF, CCR Landfill, and Gypsum Landfill (APC 2019) pending ADEM's approval of the ASDs. This revised ACM is an expansion of the June 2019 ACM, modified to include the three additional CCR units.

This ACM is the first step in developing a long-term corrective action plan to address exceedances of groundwater protection standards (GWPSs) identified at the Site. Based on the results of the ACM, further evaluation will be performed, site-specific studies completed, and a final long-term corrective action plan developed and implemented pursuant to 40 CFR 257.97–98 and ADEM Admin. Code r. 335-13-15-.06(8) and (9).

In addition to the corrective measures discussed in this ACM, APC will close the Ash Pond, Gypsum Pond, and BALF as follows:

- The Ash Pond will be closed by excavation and consolidation of the unit's CCR material into a smaller area located within the current footprint of the Ash Pond. A final cover system will be installed that is designed to minimize infiltration and erosion.
- The Gypsum Pond will be closed by dewatering and removing the gypsum/CCR from the unit.
- The BALF will be closed by excavation and consolidation of the unit's CCR material into a smaller area located within the current footprint of the BALF. A final cover system will be installed that is designed to minimize infiltration and erosion.

The subgrade for the final cover of the consolidated footprints of the Ash Pond and BALF will be graded to create a stable subgrade for construction of the final cover system. The final cover system will be graded so that surface water does not pond over the closed units and will be designed to minimize infiltration and erosion. Summaries of the Closure Plans were published to APC's CCR compliance webpage in November 2016.

Completing a final long-term corrective action frequently takes several years. Therefore, corrective measures presented herein can be applied as warranted based on site conditions during closures and while implementing a long-term corrective action strategy to meet remedial objectives at the Site.

1.1 Purpose and Approach

The purpose of this ACM is to begin the process of selecting corrective measure(s). This process may be composed of multiple components to analyze the effectiveness of corrective measures and to address the potential prior migration of CCR constituents to groundwater at the Site.

The CCR rule (40 CFR Part 257, Subpart D), ADEM Admin. Code r. 335-13-15, and ADEM AO 18-096-GW provide requirements for an ACM. In addition, the subsequent 2016 USEPA report entitled *Resource Conservation and Recovery Act Facilities Investigation Remedy Selection Track: A Toolbox for Corrective Action* (RCRA FIRST Toolbox; USEPA 2016) provides general guidance for conducting a Corrective Measures Study (CMS) at Resource Conservation and Recovery Act (RCRA) facilities. Because a CMS is equivalent to an ACM, ACM will be used in this report for consistency with the CCR rule terminology. The RCRA FIRST Toolbox (USEPA 2016) describes three approaches for assessing the need for, or performing, an ACM at RCRA facilities:

1. **No ACM:** "This is a likely outcome when interim measures are suitable for the final remedy, when post-closure will include provisions for corrective action, or when the only additional requirements are institutional controls" (USEPA 2016). Examples where an ACM is not likely to be needed include the following:
   a. Low risk facilities
   b. Excavation/removal remedies
   c. Presumptive remedies/proven effective remedies in similar cases
2. **Limited ACM:** In some cases, the final remedy may be obvious, but additional field work, bench-scale testing, or pilot testing may be required to support the final decision. The RCRA FIRST Toolbox includes a path for additional study without requiring a full ACM.
3. **Full ACM:** USEPA recommends that a full ACM be used only when more than one viable alternative exists to meet site cleanup and other criteria. USEPA discourages creating alternatives (such as No Action) for comparison purposes only.

According to the RCRA FIRST Toolbox (USEPA 2016), a full ACM is not required in every case, and determining the appropriate level of study is the first step in an ACM. Because three Appendix IV constituents (arsenic, lithium, and molybdenum) were identified at the Site and several technologies are available for addressing the constituents, a full and thorough ACM was performed for the Site.

Per USEPA guidance (USEPA 2016), corrective measures that were clearly not viable were not evaluated. Initial steps in the ACM included analyzing existing Site information and developing a conceptual site model (CSM). Closure and source control plans were also considered for the Ash Pond, Gypsum Pond, and BALF since those activities are integral to the long-term strategy and will influence groundwater corrective measures performance. Potential groundwater corrective measures were then identified and evaluated against the applicable criteria.

Frequently used technologies that are unlikely to perform satisfactorily or reliably at the Site or that are technically impractical to implement were not thoroughly evaluated as part of this ACM. A brief explanation is provided for each remedy not thoroughly evaluated. Though several technologies and combinations of these technologies appear viable for the Site, further evaluation of the technologies is needed to identify a remedy (or remedies) that may be implemented as part of a long-term corrective action plan.

1.2 Remedy Evaluation Criteria

Once potential remedies were identified, they were evaluated using the criteria outlined in 40 CFR 257.96 and ADEM Admin. Code r. 335-13-15-.06(7), which state that the ACM should include an analysis of the effectiveness of potential corrective measures that considers the following:

- Performance
- Reliability
- Ease of implementation
- Potential impacts of the remedy (including safety, cross-media, and exposure)
- The time required to begin and complete the remedy
- Any institutional requirements (e.g., permitting or environmental and public health requirements) that could affect implementation of the remedy

These evaluation criteria, discussed in more detail in the following sections, were considered for each potential remedy.

1.2.1 Performance

Factors taken into consideration when determining the performance of a remedy include the degree to which the remedy removes released Appendix IV constituents from the environment and the ability of the remedy to achieve GWPS at compliance boundaries.

1.2.2 Reliability

Reliability includes the type and degree of long-term management (e.g., monitoring, operations, and maintenance) of a remedy, the reliability of the engineering and institutional controls to maintain the effectiveness of the remedy, potential need for replacement, or any other operational reliability issues that may arise for the remedy that will limit its use or effectiveness in meeting the corrective action objectives.

1.2.3 Ease of Implementation

Ease of implementation includes the degree of difficulty associated with installing or constructing a remedy due to Site conditions, including the need to obtain necessary approvals and/or permits from other agencies, the availability of necessary equipment and/or specialists to implement the remedy, and the available capacity and location of treatment, storage, or disposal services, if needed.

1.2.4 Potential Impacts of the Remedy

Potential impacts of a remedy include the short-term risks that might be posed to the community or the environment during implementation of the remedy (e.g., due to excavation, transportation, disposal, or containment of CCR material), potential for exposure of humans and environmental receptors to remaining CCR material following implementation of the remedy, and cross-media impacts due to the remedy.

1.2.5 Time Required to Begin and Complete the Remedy

The time required to begin and complete a remedy considers the amount of time needed to completely design and implement (i.e., begin) the remedy as well as the time it will take the implemented remedy to achieve applicable GWPS at compliance points.

1.2.6 Institutional, Environmental, or Public Health Requirements

Institutional requirements can vary from site to site and technology to technology. Any state, local, or site-specific requirements (e.g., permits), or other environmental or public health requirements, that could substantially affect construction or implementation of the remedy are considered.

2 Site Background and Characteristics

2.1 Location

APC's Plant Gorgas is located in southeastern Walker County, Alabama, approximately 15 miles south of Jasper, Alabama. The physical address is 460 Gorgas Road, Parrish, Alabama 35580. Plant Gorgas lies in Sections 7, 8, 9, 16, 17, 18, 19, 20, 21, 28, and 29, Township 16 South, Range 6 West and Sections 12, 13, and 24, Township 16 South, Range 7 West. Section/Township/Range data are based on visual inspection of U.S. Geological Survey topographic quadrangle maps and GIS maps (USGS 2018a, 2018b).

The Ash Pond is located east-southeast of the main plant, on the opposite side of the Mulberry Fork of the Black Warrior River. The Gypsum Pond is located west-northwest of the main plant and to the north of Black Warrior River. The BALF, CCR Landfill, and Gypsum Landfill are adjacent to each other to the northeast of the Plant Gorgas proper and are located between Highway 269 to the north and the Mulberry Fork of the Black Warrior River to the south. The locations of the Plant Gorgas CCR units are shown on Figure 1.

2.2 Hydrogeologic Conceptual Model and Groundwater Flow Characteristics

The Ash Pond is located east-southeast of the main plant and the Gypsum Pond is located west-northwest of the main plant, while the BALF, Gypsum Landfill, and CCR Landfill are located adjacent to each other east and northeast of the main plant (Figure 1). This section provides a synopsis of the hydrogeological conceptual model and groundwater flow characteristics for the area underlying the five CCR units at Plant Gorgas.

The major components of the hydrogeological CSM for the Ash Pond (SCS 2018a) include the following:

- Stratigraphy (Figure 2)—Complex lithologic sequences of shale, mudstone, sandstone (Units 2 and 3), and coal seams separated by sandstone intraburden with lesser amounts of claystone and mudstone (Unit 1) with significant vertical and horizontal heterogeneity due to depositional environment
- Uppermost Aquifer (Unit 1 Pratt coal group and Pratt to Cobb coal group transition)—Described locally as the Pottsville aquifer; depth to the uppermost aquifer ranges from 30 to 240 feet below ground surface (bgs); aquifer is generally considered confined due to large permeability contrasts within the Pottsville Formation; groundwater yield is generally via interconnected fractures, bedding planes, and coal seams; groundwater

yield is often insufficient for low-flow purging of monitoring wells; successful wells generally yield between 0.01 and 0.4 gallons per minute

- Three slug tests were performed at three locations at the Site, and twenty-six packer tests were performed at different depth intervals at eight locations at the nearby APC James H. Miller Plant to estimate the horizontal hydraulic conductivity of the Pottsville Formation (SCS 2018b). Calculated horizontal hydraulic conductivities ranged from 6.0×10^{-7} to 6.0×10^{-3} centimeters per second (cm/sec). Calculated horizontal hydraulic conductivities from slug tests ranged from 1.22×10^{-5} to 1.19×10^{-3} cm/sec.
- Groundwater flow characteristics:
  - Groundwater flow occurs primarily by means of fracture flow, where groundwater flows along more conductive secondary discontinuities in the rock mass.
  - Fractures at the Site are typically high-angle to near vertical (75° to 88°).
  - Bedding planes at the Site are near flat lying with dips ranging from 0° to 6° towards the south.
  - Paired well locations and heat pulse flowmeter logging indicate that downward vertical flow is an important component of groundwater flow within the uppermost aquifer at the Site.
  - Complex lithostratigraphy, sharp permeability contrasts, and the fractured nature of the Pottsville Formation contribute to vertical groundwater flow at the Site.
  - Horizontal hydraulic conductivity values in the uppermost aquifer are typically in the range of 10^{-5} to 10^{-4} cm/sec with an average of 6.15×10^{-4} cm/sec (1.74 feet per day) as determined from slug testing and packer testing.
  - Groundwater flows radially away from the Site, and the flow velocities are estimated to range from 0.33 to 3.14 feet per day.
  - In general, groundwater elevation data indicate that water levels tend to be higher in the early spring and lower during the fall and winter seasons.
  - Groundwater elevations fluctuate in response to rainfall. Seasonal variations of 0.2 to 14.0 feet are typical. Fluctuations are typically greater in magnitude in wells to the south. Piezometers PZ-16, PZ-18, and PZ-22 installed in the American seam – Maxine Mine display uniform variations with respect to one another and level changes on the order of 20 feet over the monitoring period. The groundwater response in these locations show that the American seam and Maxine Mine are hydraulically disconnected from the uppermost aquifer at the Site. A typical Ash Pond potentiometric surface map is shown on Figure 3. Table 1 provides a summary of historical groundwater elevation data for the Site.

The major components of the hydrogeological CSM for the Gypsum Pond (SCS 2018c) include the following:

- Plant Gorgas is directly underlain by rocks belonging to the Pratt coal group. In general, the Pratt group consists of mudstone, shale, fine-grained sandstone, and interbedded coal.
- Much of the narrow valley that the Gypsum Pond occupies was strip-mined for the Pratt coal seam, and some of this area has seen the American coal seam underground-mined.
- The overburden beneath the disposal facility is dominated by backfilled mine overburden and is characterized by weathered shale and sandstone boulders with lenses of fine sediments and small amounts of coal fragments and coarse sediments.
- Where mining did not occur, there may be a shallow layer of mine overburden overlying natural overburden materials before transitioning into Pratt coal group strata.
- Uppermost Aquifer—Beneath the Gypsum Pond, groundwater producing zones are sparse. When present, two water-bearing zones are identified beneath the Site: 1) the mine overburden/top-of-rock interface; and 2) the underlying Pottsville aquifer.
- Groundwater Flow Characteristics—Groundwater flow is influenced by natural topography where gravity is the dominant force driving flow. Groundwater flows from higher topographic elevations north of the Gypsum Pond to lower topographic elevations to the south. Mine spoil layering and complex Pottsville Formation lithofacies contribute to the vertical and horizontal heterogeneity present within the aquifer system. This heterogeneity focuses groundwater flow along more permeable coal seams, bedding planes, or along vertical or subvertical discontinuities in the rock fabric. Slug testing provided horizontal hydraulic conductivities for the uppermost aquifer between 0.46 cm/sec and 2.47×10^{-4} cm/sec. A typical potentiometric surface map for the Gypsum Pond area is presented as Figure 4.

Geologic cross-sections for the landfills are included on Figures 5a and 5b. The major components of the hydrogeological CSM for the BALF, CCR Landfill, and Gypsum Landfill include the following (SCS 2018d):

- Strip mining was conducted over a large portion of the area down to the American coal seam. As a result, the overburden is dominated by backfilled mine spoil materials and is characterized by a heterogeneous mixture of weathered shale and sandstone boulders with lenses of fine sediments and small amounts of coal fragments and coarse sediments. Geologic logs generated during various on-site investigations indicate that the depth to rock varies significantly, ranging from as little as 5 feet (unmined areas) to as much as 155 feet bgs.

- The first saturated zone beneath the Site generally corresponds to the mine overburden/top-of-rock interface zone at which the mine spoil overburden transitions to bedrock of the Pottsville Formation. The depth of the first saturated zone is generally between 105 and 115 feet bgs, with potentiometric surfaces typically rising above the top of the well screens.
- Monitoring wells installed at the mine overburden/top of rock interface monitor quality of water passing to the Pottsville Formation. This water quality itself can be variable and enriched in trace metals owing to the heterogeneity of mine backfill deposits and mineralogy (e.g., clay and sulfide minerals). Based on published data, groundwater quality produced from the Pottsville Formation can be characterized by high concentrations of sulfate, iron, and other trace metals. Trace metals in Pottsville Formation groundwater are associated with sulfide minerals contained in organic-rich strata and siliceous/carbonate healed fractures and joints. Trace element enrichment is likely the result of migrating hydrothermal fluids generated during the late Paleozoic Allegheny orogeny. Arsenic, antimony, molybdenum, selenium, copper, thallium, and mercury are elevated in Warrior Basin coal strata (Diehl et al. 2004).
- The Pottsville aquifer system is the uppermost aquifer beneath the Site for groundwater monitoring purposes and primarily comprises Pennsylvanian-aged sandstones, shales, conglomerates, and coal.
- Recharge to the Pottsville Formation is primarily through infiltration of precipitation and to a lesser extent, surface water flows at hydraulically favored locations. Recharge is accommodated by fracture enhanced permeability. Recharge zones into the Pottsville Formation also include geologic structures such as fault zones or systematic fold axes.
- Slug testing provided horizontal hydraulic conductivities for the uppermost aquifer between 5.11×10^{-3} cm/sec and 2.47×10^{-4} cm/sec. The average hydraulic conductivity value derived from slug testing is 2.83×10^{-3} cm/sec or 8.01 feet per day.
- Groundwater flows from higher topographic elevations north of the Site to lower topographic elevations to the south and generally towards the Mulberry Fork of the Black Warrior River (Figure 6).

2.3 Ash Pond

The Ash Pond received and stored CCR produced during the coal-fired electricity generating process. The Ash Pond also served as a low-volume waste treatment pond for the plant, receiving process water and stormwater from various plant sources, sluiced ash, and decant water from the Gypsum Pond. As of April 15, 2019, the Ash Pond ceased receipt of all CCR and non-CCR waste streams.

The Ash Pond is formed by a cross-valley dam, which was originally constructed as a rockfill structure across Rattlesnake Creek using local borrow and quarried materials. The crest elevation of the original dam was 320 feet. In the mid-1970s, the dam was raised to an elevation of 375 feet mean sea level. During this construction, a relatively impervious blanket was constructed on the upstream face of the original dam. In addition to the blanket, additional rockfill was added on both the upstream and downstream sides of the dam, as well as the inclusion of a relatively impervious core and filter zone near the interior of the dike raise. In 2007, the dam was raised to an elevation of 395 feet. During this project, a 10-foot-wide roller compacted concrete upstream facing block, a 30-foot-thick clay core section, a 10-foot-thick fine and coarse filter section, and additional downstream rockfill were used to accommodate the raising of the dam (SCS 2017a).

The groundwater monitoring network at the Ash Pond is composed of 16 monitoring wells installed around the Ash Pond (Figure 3 and Table 2): 2 upgradient and 14 downgradient. Monitoring well locations GS-AP-MW-8 and GS-AP-MW-13 serve as upgradient locations for the Ash Pond; these well locations were screened above the Pratt coal group to monitor water quality recharging the uppermost aquifer and are representative of background groundwater quality at the Site. Upgradient wells are screened within the same uppermost aquifer as downgradient locations and are representative of background groundwater quality at the Site (SCS 2019d).

Background sampling occurred between August 2016 and June 2017. Compliance detection sampling began following completion of background sampling, with sampling occurring in August 2017. Statistically significant increases (SSIs) of Appendix III constituents were noted during the September 2017 compliance detection sampling event, as described in the *2017 Annual Groundwater Monitoring and Corrective Action Report* (SCS 2018e). The Appendix III SSIs triggered assessment sampling for Appendix IV constituents, with sampling events occurring in February, May, and October 2018. Appendix IV GWPS values are shown in Table 3. The May and October 2018 sampling events noted Appendix IV constituents arsenic, lithium, and molybdenum at SSLs above GWPS (Table 4 and 5, respectively). SSLs above the GWPS for arsenic (0.01 mg/L), lithium (0.04 mg/L), and molybdenum (0.1 mg/L) from the May and October 2018 sampling events are summarized as follows (SCS 2019d):

- Arsenic was reported at SSLs above the GWPS at the following monitoring wells for both the May and October 2018 sampling events: GS-AP-MW-6D, GS-AP-MW-7, GS-AP-MW-12, and GS-AP-MW-18.
- Lithium was reported at SSLs above the GWPS at the following monitoring wells for both the May and October 2018 sampling events: GS-AP-MW-6D, GS-AP-MW-7, GS-AP-MW-9,

GS-AP-MW-15, GS-AP-MW-18, and GS-APMW-21. Lithium was reported above the GWPS at monitoring well GS-AP-MW-17 only for the October 2018 sampling event.

- Molybdenum was reported at SSLs above the GWPS at monitoring well GS-AP-MW-7 for both the May and October 2018 sampling events. Note that molybdenum was only slightly above the GWPS.

To delineate groundwater impacts, additional monitoring wells consisting of four vertical delineation wells and nine horizontal delineation wells were installed at locations downgradient of monitoring wells where Appendix IV SSLs were observed (SCS 2019e). Vertical delineation wells were installed within the Pratt coal group. Horizontal delineation wells stepping out from the Ash Pond were installed towards the property line in the direction of groundwater flow. To the north, wells were installed at distances between 1,000 and 1,800 feet from the Ash Pond dam. Along the southern edges of the Ash Pond, step out wells were installed 200 to 300 feet south of the waste boundary. Horizontal delineation wells were installed in the Lower Cobb coal group or Pratt coal group. Three additional upgradient or background monitoring well locations were installed on an APC-owned property roughly 2 miles north-northeast of the Ash Pond. To discern the nature of source, porewater samples from three locations within the Ash Pond were collected and analyzed for Appendix III and Appendix IV constituents.

Closure of the Ash Pond will be accomplished by dewatering, consolidating, and capping the ash with a final cover system. This will effectively control the source of CCR constituents to groundwater by removing free liquid from the ash, reducing the area of ash, and preventing further infiltration through the ash. Dewatering is estimated to last several years. The mechanical treatment system will be adjusted to: 1) control Ash Pond drawdown at a rate to ensure structural integrity of the impoundment is maintained as determined by the Dam Safety Engineer; and 2) manage fluctuating site conditions due to the decrease of the Ash Pond volume as well as the addition of rainfall. The Ash Pond will be closed by capping CCR in place and consolidating the current site footprint of approximately 420 acres to an area of approximately 290 acres. Project design, dewatering, consolidating, and capping is currently scheduled to be completed by 2028.

As part of the ash consolidation, the Ash Pond will be dewatered sufficiently to remove the free liquids. Removing free liquids will reduce the volume of water available to migrate from the Ash Pond during closure and minimize hydraulic head within the pond, thereby reducing pressure to cause migration from the Ash Pond. CCR will be consolidated into a smaller footprint and graded to create a subgrade for the final cover system. Excavation will include removing all visible ash and over excavating into the subgrade soils.

The final cover will be constructed to control, minimize, or eliminate, to the maximum extent feasible, post-closure infiltration of liquids into the waste and potential releases of CCR from the unit. This will be prevented by providing sufficient grades and slopes to: 1) preclude the probability of future impoundment of water, slurry, or sediment; 2) ensure slope and cover system stability; 3) minimize the need for further maintenance; and 4) be completed in the shortest amount of time consistent with recognized and generally accepted good engineering practices.

The final cover system will be designed to minimize infiltration and erosion. The cover system to be used is currently being evaluated, and final design is not yet complete. The final cover system, at a minimum, will be designed to meet or exceed the requirements of ADEM Admin. Code r. 335-13-15-.07(3)(d)3.(i). The final cover will consist of a high-density polyethylene (HDPE) or linear low-density polyethylene geomembrane and geocomposite drainage layer covered with an 18-inch infiltration layer overlain by 6 inches of soil capable of sustaining vegetative growth. Final design will ensure that the disruption of the integrity of the final cover system is minimized through a design that accommodates settlement and subsidence, in addition to providing an erosion layer for protection from wind or water erosion (SCS 2016a).

2.4 Gypsum Pond

The Gypsum Pond received and stored CCR produced during the coal-fired electricity generating process. The Gypsum Pond was constructed in 2007 over a mix of mine spoil material, natural overburden, and Pottsville Formation sedimentary sequences. An area approximately 50 acres in size was used to create the first cell of the Gypsum Pond. The Gypsum Pond itself covers approximately 18 acres. To the south and at lower elevations, a sedimentation pond, clear pool, and emergency storage pond service the Gypsum Pond. These ponds are lined with an HDPE liner. As of April 15, 2019, the Gypsum Pond ceased receipt of all CCR and non-CCR waste streams.

As part of construction of the Gypsum Pond, the existing soils and mine spoil was graded, the subgrade compacted, and a granular fill was placed beneath the liner. Embankments were constructed of compacted soil fill obtained from nearby borrow pits. After initial construction, the downstream slopes of the embankment were surfaced with limestone riprap (SCS 2017b).

The certified detection groundwater monitoring network for the Gypsum Pond consists of four upgradient monitoring well locations and three downgradient monitoring well locations. Groundwater monitoring network details for the Gypsum Pond are summarized in Table 6 and are shown on Figure 4. Downgradient monitoring wells are located along the periphery of the

Gypsum Pond. Upgradient monitoring wells are located to the east and also serve as upgradient locations for the Plant Gorgas CCR Landfill, BALF, and Gypsum Landfill (SCS 2019f).

Background sampling for CCR constituents was conducted between August 2016 and June 2017. After collecting eight background samples, the first compliance detection event occurred in August 2017. SSIs for USEPA Appendix III constituents were documented in the first *Annual Groundwater Monitoring and Corrective Action Report* (SCS 2018f). The Appendix III SSIs triggered assessment monitoring for Appendix IV constituents, which occurred in February 2018, June 2018, and October 2018. The June and October 2018 sampling events noted Appendix IV constituent lithium at SSLs above GWPS (Tables 7 and 8, respectively). SSLs above the GWPS for lithium (0.237 mg/L and 0.323 mg/L) from the June and October 2018 sampling events are summarized as follows (SCS 2019f):

- Lithium was reported at SSLs above the GWPS at the following monitoring well for both the June and October 2018 sampling events: GS-GSA-MW-3.
- Lithium was reported at SSLs above the GWPS for only the June 2018 sampling event at monitoring well GS-GSA-MW-4.

To delineate groundwater impacts, additional monitoring wells consisting of two vertical delineation wells and four horizontal delineation wells were installed at locations downgradient of monitoring wells where Appendix IV SSIs were observed. Vertical delineation wells targeted deeper Pottsville stratigraphy, whereas horizontal delineation wells targeted the uppermost groundwater producing interval observed in the boring. One horizontal delineation well was installed at the property boundary to the south.

To discern the nature of source material, gypsum samples from locations within the Gypsum Pond were collected and analyzed by toxic characteristic leaching procedure and synthetic precipitation leaching procedure methods.

The Gypsum Pond will be closed through the removal of gypsum and CCR from the CCR unit. The Gypsum Pond will be dewatered as required to facilitate excavation of gypsum for removal. Closure will include removing all gypsum, followed by removal of the existing HDPE geomembrane. This closure strategy will eliminate the Gypsum Pond as a source area and will be protective of the mine spoil aquifer by removing the source of potential infiltration (SCS 2016b).

2.5 Bottom Ash Landfill

The groundwater monitoring network consists of nine monitoring wells, with wells MW-1 through MW-4 serving as upgradient locations. Groundwater monitoring network details for the

BALF are summarized in Table 9. Upgradient wells are screened within the same hydrostratigraphic interval as downgradient locations and are representative of background groundwater quality at the Site. Monitoring well locations MW-7, MW-8, and MW-10 through MW-12 serve as downgradient locations for the BALF (SCS 2019c).

Based on detection monitoring results, assessment monitoring was initiated and BALF wells were sampled for all Appendix IV parameters in February 2018. Analytical data from the 2018 semi-annual monitoring events in May and November were statistically analyzed. Appendix IV assessment monitoring parameters were evaluated to determine if concentrations statistically exceeded the established GWPS. Arsenic was reported at SSLs above the GWPS at monitoring well MW-12 for both the May and November 2018 sampling events (SCS 2019c). Assessment monitoring results for the May and October 2018 sampling events are summarized in Tables 10 and 11, respectively.

An ASD was prepared demonstrating that the SSLs for arsenic and lithium are not the result of a release from the BALF (SCS 2019g). This ASD has not yet been approved by ADEM.

The BALF will be closed by consolidating and capping the CCR material with a final cover system. The cover of the BALF will be graded to create a stable subgrade for construction of the final cover system. The final cover system will, to the maximum extent possible, control, minimalize, or eliminate infiltration of liquids into the waste and potential releases of CCR from the unit. Infiltration will be prevented by providing scheduled maintenance and attaining closure in the smallest window of time consistent with good engineering practices.

The final cover system will be less than or equal to the permeability of the surrounding natural subsoils present but no greater than 1×10^{-5} cm/sec. The final cover system will consist of an 18-inch infiltration layer overlain by 6 inches of soil capable of sustaining vegetative growth, or it may instead consist of an alternate cover system utilizing low-permeability geosynthetic materials. Final design will ensure that the disruption of the integrity of the final cover system is minimized through a design that accommodates settlement and subsidence, in addition to providing an erosion layer for protection from wind or water erosion (SCS 2019h).

2.6 CCR Landfill

The CCR Landfill consists of two cells (Cell 1 and Cell 2) constructed with a composite liner system consisting of 1 foot of compacted clay having a maximum hydraulic conductivity of 1×10^{-5} cm/sec overlain by a geosynthetic clay liner (GCL), and a 60 mil HDPE liner. The CCR Landfill is maintained in a dry state, such that drainage is not necessary (SCS 2016c).

The groundwater monitoring network consists of eight monitoring wells. Monitoring well locations MW-1 through MW-4 serve as upgradient locations. Groundwater monitoring network details for the CCR Landfill are summarized in Table 12. Upgradient wells are screened within the same hydrostratigraphic interval as downgradient locations and are representative of background groundwater quality at the Site. Monitoring well locations MW-5 through MW-8 serve as downgradient locations for the CCR Landfill (SCS 2019a).

Monitoring wells were sampled for all Appendix IV parameters in February 2018, within 90 days of initiating the assessment monitoring program. Monitoring wells were subsequently sampled for Appendix III and Appendix IV parameters in May and November 2018. Analytical data from the 2018 semi-annual monitoring events in May and November were evaluated to determine if concentrations statistically exceeded the established GWPS. Lithium was reported at SSLs above the GWPS at monitoring well MW-6 for the May 2018 sampling event. The November 2018 sampling event did not verify the lithium SSL at well MW-6, nor were any other SSLs identified above the GWPS (SCS 2019a). Assessment monitoring results for the May and October 2018 sampling events are summarized in Tables 13 and 14, respectively.

An ASD was prepared to demonstrate the natural occurrence of lithium in groundwater at the Site and that the SSLs were not the result of a release caused by the CCR Landfill. As described in more detail in the ASD (SCS 2019a), the following evidence supports a natural source of lithium in groundwater at the Site: lithium in upgradient groundwater monitoring wells and in wells downgradient of areas that have not yet received CCR; low and stable concentrations of CCR indicator parameters; similar upgradient and downgradient major ion chemistry; lack of correlation between lithium and other Appendix III and IV constituents (except sulfate); strontium geochemistry; and relatively high concentrations of iron and manganese in three wells, suggesting mechanisms for lithium release (dissolution of host minerals).

2.7 Gypsum Landfill

The Gypsum Landfill was constructed with a composite liner system consisting of 1 foot of compacted clay liner having a maximum hydraulic conductivity of 1 × 10^{-5} cm/sec, a GCL, and a 60 mil HDPE liner. The Site is maintained in a dry state, such that drainage is unnecessary (SCS 2016d).

The certified groundwater monitoring system for the Gypsum Landfill is designed to monitor groundwater passing the waste boundary of the CCR unit within the uppermost aquifer. Wells were located to serve as upgradient and downgradient monitoring locations based on groundwater flow direction as determined by the potentiometric surface elevation contour maps. The groundwater monitoring network consists of 12 monitoring wells. Groundwater monitoring network details for the Gypsum Landfill are summarized in Table 15. Monitoring well locations MW-1 through MW-4 and MW-13 through MW-15 serve as upgradient locations for the Gypsum Landfill. Upgradient wells are screened within the same hydrostratigraphic interval as downgradient locations and are representative of background groundwater quality at the Site. Monitoring well locations MW-16, MW-17R, MW-18, MW-19, and MW-20 serve as downgradient locations for the Gypsum Landfill (SCS 2019b).

Monitoring wells were sampled for Appendix III and Appendix IV parameters in May and November 2018. Analytical data from the 2018 semi-annual monitoring events in May and November were statistically analyzed. Appendix III statistical analysis was performed to determine if constituents have returned to background levels. Appendix IV assessment monitoring parameters were evaluated to determine if concentrations statistically exceeded the established GWPS. Lithium was reported at SSLs above the GWPS at monitoring well MW-20 for the May 2018 sampling event. The November 2018 sampling event did not identify any SSLs above the GWPS (SCS 2019b). Assessment monitoring results for the May and October 2018 sampling events are summarized in Tables 16 and 17, respectively.

An ASD was prepared supporting an alternative source of lithium in groundwater at the Site, and that the SSL observed in monitoring well MW-20 in 2018 is not the result of a release caused by the Gypsum Landfill. As described in more detail in the ASD (SCS 2019b), the following evidence supports an alternative source of lithium in groundwater at the Site: to date, no gypsum has been placed in the Gypsum Landfill; the Gypsum Landfill is lined with a low-permeability composite liner that meets state and federal regulations; and at least 5 feet of separation occurs between the bottom of the landfill and the water table.

3 Groundwater Corrective Measures Alternatives

3.1 Objectives of the Corrective Measures

Following 40 CFR 257.97(b) and ADEM Admin. Code r. 335-13-15-.06(8)(b), the following summarizes the criteria that must be met by the remedy:

- Protect human health and the environment.
- Attain applicable groundwater protection standards.
- Control the source of the release so as to reduce or eliminate, to the maximum extent feasible, further releases of Appendix IV constituents to the environment.
- Remove from the environment as much of the material released from the CCR unit as is feasible, considering factors such as avoiding inappropriate disturbances of sensitive ecosystems.
- Comply with any relevant standards (i.e., all applicable RCRA requirements) for management of wastes generated by the remedial actions.

All corrective measures selected for evaluation for potential use at the Site are anticipated to satisfy the above performance criteria to varying degrees of effectiveness.

3.2 Potential Groundwater Corrective Measures

The following presents a summary of potential groundwater corrective measures evaluated as part of this ACM. Based on site-specific information and knowledge of corrective alternatives, the following remedies—or combination of remedies—are being considered using the evaluation criteria specified in 40 CFR 257.96(c) and ADEM Admin. Code r. 335-13-15-.06(7)(c):

- Monitored natural attenuation (MNA)
- Hydraulic containment (pump-and-treat)
- Geochemical manipulation (via in situ injection)
- Permeation grouting

Three frequently considered remedies—phytoremediation, barrier walls, and permeable reactive barrier (PRB) walls—were not considered viable at the Ash Pond, Gypsum Pond, BALF, CCR Landfill, or Gypsum Landfill. Phytoremediation may be effective for impacts at or near the ground surface (or to about 50 feet if using a specialized TreeWell approach); however, at all sites, Appendix IV SSLs occur in groundwater at depths from about 50 to 190 feet, rendering phytoremediation technically impractical. Vertical barrier walls and PRB walls are technically infeasible because: 1) the depth is beyond the approximate 100-foot limitation of the technology; and 2) the thickness of rock below ground surface would preclude installing the walls with current technology.

3.2.1 Monitored Natural Attenuation

MNA has been a component of corrective action at RCRA and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) sites since the 1990s. MNA describes a range of physical and biological processes in the environment that reduce the concentration, toxicity, or mobility of constituents in groundwater. For inorganic constituents, the mechanisms of natural attenuation include biostabilization, sorption, dispersion, and precipitation. MNA as a remedial alternative is dependent on a good understanding of localized hydrogeologic conditions and may require considerable information and monitoring over an extended period of time. MNA is not an approach that will lead to rapid closure of a site and is frequently used in combination with other remedies at a site.

Where site conditions are conducive to MNA, it has the potential to provide a more sustainable, lower cost alternative to aggressive remediation technologies such as pump-and-treat. The Electric Power Research Institute (EPRI) has prepared a document describing implementation of MNA for 24 inorganic constituents, which includes most Appendix III and Appendix IV constituents (EPRI 2015a).

USEPA defines MNA as follows (USEPA 1999, 2015):

> 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 timeframe that is reasonable compared to that offered by other more active methods. The "natural remediation 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.

When properly implemented, MNA removes constituents from groundwater and immobilizes them onto aquifer solids. Decisions to utilize MNA as a remedy or remedy component should be thoroughly supported by site-specific data and analysis (USEPA 1999, 2015).

According to USEPA (2015) guidance, a four-phase approach should be used to establish whether MNA can be successfully implemented at a given site. These four phases (also referred to as "steps" or "tiers") are as follows (USEPA 1999, 2007a):

1. Demonstrate that the extent of groundwater impacts is stable.
2. Determine the mechanisms and rates of attenuation.
3. Determine if the capacity of the aquifer is sufficient to attenuate the mass of constituents in groundwater and that the immobilized constituents are stable and will not remobilize.
4. Design a performance monitoring program based on the mechanisms of attenuation and establish contingency remedies (tailored to site-specific conditions) should MNA not perform adequately.

Based on MNA case histories for inorganic constituents, MNA time frames range from a few years to decades (EPRI 2015a). Because facility closure activities at the Site are projected to take approximately 8 years, the time frame for MNA is compatible with the closure period.

Attenuation mechanisms can be placed in two broad categories: physical and chemical. Physical mechanisms include dilution, dispersion, flushing, and related processes. All constituents are subject to physical attenuation mechanisms, so physical processes should be considered in MNA evaluations. In its most recent guidance (USEPA 2015), USEPA discourages using dilution and dispersion as primary MNA mechanisms, as these mechanisms disperse contaminant mass rather than immobilize it. Further, USEPA advises that dilution and dispersion may be appropriate as a polishing step (e.g., at the boundaries of a plume when source control is complete, an active remedy is being used at the Site, and appropriate land use and groundwater controls are in place; USEPA 2015).

Common chemical mechanisms of attenuation for inorganic constituents include adsorption to, or coprecipitation with, oxides and hydrous oxides (oxyhydroxides) of iron and manganese; coprecipitation with, and adsorption to, iron sulfides such as pyrite (FeS_2); and precipitation as carbonates, sulfides, sulfates, and/or phosphates (USEPA 2007b).

Arsenic, lithium, and molybdenum are subject to physical attenuation mechanisms, and arsenic, molybdenum, and possibly lithium may be chemically attenuated (e.g., by sorption to naturally occurring oxyhydroxides of iron, manganese, and other metals, and by coprecipitating with common minerals such as iron sulfides). Therefore, MNA is a potentially viable corrective measure for groundwater at the Site.

3.2.2 Hydraulic Containment (Pump-and-Treat)

Hydraulic containment utilizes pumping wells (and sometimes injection wells, trenches, galleries, and/or trees) to contain and prevent the expansion of impacted groundwater. Effective hydraulic containment uses pumping wells or other subsurface hydraulic mechanisms to create a horizontal and vertical capture zone or a hydraulic barrier. After pumping, the water may be reused in beneficial applications or treated, discharged, or reinjected. Hydraulic containment is one of the most mature corrective action technologies, and it is described in *Pump-and-Treat Ground-Water Remediation: A Guide for Decision Makers and Practitioners* (USEPA 1996) and *Groundwater Contamination Optimal Capture and Containment* (Gorelick et al. 1993).

Hydraulic containment has been applied to fractured rock aquifers. Therefore, pump-and-treat is a feasible corrective measure for groundwater at the Site. Where on-site water treatment is not currently available, a water treatment plant would need to be constructed for this option.

3.2.3 Geochemical Manipulation (In Situ Injection)

Geochemical manipulation via subsurface injections is an emerging remediation technology for inorganic constituents in groundwater. Geochemical manipulation for inorganic constituents may be applied in three modes: redox manipulation; adsorption to iron or other metal oxyhydroxides under oxidizing groundwater conditions; and adsorption to, or coprecipitation with, iron or other metal sulfides under reducing conditions (sequestration in sulfides).

Redox manipulation has been applied to metals such as chromium since the 1990s, where reducing compounds are injected to chemically reduce chromium (VI) to the more benign chromium (III) (USEPA 2000; Ludwig et al. 2007). Geochemical processes such as adsorption and coprecipitation are applicable to arsenic, molybdenum, and possibly lithium. In adsorption under oxidizing conditions, an iron source (such as ferrous sulfate) is injected into the subsurface and oxidizes to iron oxyhydroxides (ferrihydrite) to which contaminants adsorb (Pugh et al. 2012; Redwine et al. 2004). Due to the generally mildly reducing conditions in groundwater at the Site, sequestration in sulfides may be the most viable of the geochemical manipulation technologies.

In the sequestration-in-sulfides technology, soluble sources of organic carbon, ferrous iron, and sulfate are injected into the subsurface to optimize conditions for sulfate-reducing bacteria growth (Saunders 1998). Sulfate-reducing bacteria produce sulfide minerals as a byproduct of their metabolism, and constituents are removed from groundwater and immobilized by the sulfide minerals. Trace constituents substitute for other elements in the sulfide mineral structure and are adsorbed to sulfide mineral surfaces. In recent successful applications for arsenic, a treatment solution consisting of molasses, ferrous sulfate heptahydrate, and small amounts of commercial fertilizer dissolved in unchlorinated water were injected to significantly decrease arsenic concentrations in groundwater.

The following metals may be removed from groundwater by sulfide mineral formation: antimony, arsenic, cadmium, cobalt, copper, mercury, lead, molybdenum, nickel, selenium, thallium, and zinc, in addition to some rarer elements (Abraitis et al. 2004; EPRI 2015b). The most common sulfide minerals include the iron sulfide family (FeS, FeS_2), though many other sulfide minerals are documented.

Geochemical manipulation should be effective for the constituents of interest (arsenic, lithium, and molybdenum). However, effectiveness of the mode of sequestration (coprecipitation with sulfides, adsorption to iron or manganese oxyhydroxides, and others) may be different for the different constituents. Laboratory treatability and/or field pilot tests would be necessary to completely evaluate geochemical manipulation prior to selection as a corrective measure.

Because of the generally mildly reducing groundwater conditions at the Site, and effectiveness for arsenic and molybdenum, sequestration in sulfide minerals is a potentially viable option for corrective action at the Site. Because the technology has not yet been demonstrated for large areas, its optimum application may be treatment of isolated areas (e.g., in the vicinity of a few impacted wells).

3.2.4 Grouting

Grouting is another way to construct a barrier to groundwater flow. Though there are several types of grouting, permeation grouting is likely the most applicable to groundwater corrective action at CCR settings. Permeation grouting is a method of impregnating the void space within a soil or rock mass, thereby displacing water and air from the voids and replacing it with grout, without displacing the soil particles or widening existing fractures in the rock (Wani 2015).

Permeation grouting utilizes low pressure injection to reduce the permeability and improve the strength of granular soils or fractured or solutioned (karst) rock (Keller Ground Engineering 2017). In groundwater corrective action applications, permeability (hydraulic conductivity) reduction and impeding the flow of impacted groundwater are the primary objectives. Permeation grouting can be effective in unconsolidated alluvial soils (Pearlman 1999), such as those often found at CCR settings, and in rock. In classic grouting theory, in porous material such as sand and gravel, overlapping columns are constructed by grouting to create a wall. In rock, the void space to be grouted is more irregular than that in porous media, though the wall concept still applies. Grout mixtures may be particulate, chemical, or a combination of both. Particulate mixtures contain a slurry of cement and bentonite and/or other additives combined with water. Chemical grout mixtures contain a chemical base (such as sodium silicate, acrylate, and urethane), catalyst, and solvent (typically water). Particulate grouts are generally more viscous and better suited for larger pore spaces, while chemical grouts are usually preferred for smaller voids (Pearlman 1999; USEPA 2014).

Grout barriers can be used either as stand-alone barriers to contain or control groundwater flow, or they may be used in conjunction with another type of technology. Grout may be injected at the bottom of geomembrane or PRB walls to address fracturing that may have occurred when these barriers were keyed into underlying bedrock. Grout barriers may also be installed at any angle, including horizontally, which may be beneficial at sites where there is no accessible underlying aquitard to tie into. However, maintaining continuity of the grout installation is typically more difficult for angled drilling and grouting (USEPA 1998; Pearlman 1999).

3.3 Potential Remedy Evaluation

The following remedies are considered potentially viable or corrective measures for groundwater at the Site:

- MNA
- Hydraulic containment (pump-and-treat)
- Geochemical manipulation via injections
- Permeation grouting

Although these technologies are potentially viable remedies, further data collection and evaluation are required to: 1) verify the feasibility of each; and 2) provide sufficient information to design a corrective action system that meets the criteria specified in 40 CFR 257.97(b) and ADEM Admin. Code r. 335-13-15-.06(8)(b). Table 18 provides a summary of these technologies compared to the evaluation criteria discussed in Section 1 as applied to Site conditions. Table 19 discusses advantages and disadvantages of each technology that should be considered.

3.3.1 Monitored Natural Attenuation

MNA is compatible with the other groundwater corrective actions that are potentially viable for the Site. At a minimum, MNA can serve as a polishing step (USEPA 2015), which may be all that is needed due to source control.

The performance of MNA requires further investigation, especially related to the identification of attenuating mechanisms, capacity of the Pottsville Formation for attenuation, and time to achieve GWPS. Dewatering, consolidation, and capping of the Ash Pond, however, will likely reduce the source contribution to groundwater such that the attenuation capacity of the

Pottsville Formation may be sufficient to achieve GWPS in a reasonable time frame. Removal of the Gypsum Pond will eliminate contribution from the source. Although ASDs have been prepared to demonstrate that these units are not the source of GWPS exceedances, consolidating and capping the BALF will reduce the potential for the BALF to be a source contribution to groundwater.

Implementation of MNA at the Site will be relatively straightforward. Most of the wells for MNA are already in place, though a few additional wells may need to be installed to monitor progress in critical areas. Solid (e.g., aquifer) samples will need to be collected to identify attenuating mechanisms and to test capacity and permanence and to help determine the time required to achieve GWPS. Reliability of MNA will be relatively high, and potential impacts of the remedy will be negligible because MNA is non-intrusive and produces no effluents or emissions.

Implementation of MNA would require some geochemical studies and possibly the installation of some new wells. Because MNA does not require design and construction of infrastructure other than new monitoring wells, it can be initiated within 6 months to a year. At least 1 year of groundwater monitoring data is recommended before implementation of MNA is considered complete. The additional data would be needed for statistical analysis and to determine if additional monitoring wells need to be installed. Therefore, complete implementation of MNA would take about 18 to 24 months.

Time for MNA to achieve GWPS is currently unknown and would require additional studies. Published and unpublished case histories for arsenic, and by inference molybdenum and lithium, suggest that MNA would take 2 decades or more to achieve GWPS.

3.3.2 Hydraulic Containment (Pump-and-Treat)

Hydraulic containment via pump-and-treat has been used for groundwater corrective action for decades. When the pump-and-treat system is online, the performance is considered high because arsenic and molybdenum are readily treated. Lithium treatment requires further investigation. If the system subsurface hydraulics are designed properly, the area of impact will stabilize or shrink. Because these systems require substantial operation and maintenance, the reliability is considered not quite as high as some other technologies. In other words, pumps, piping, and the water treatment system must be maintained and will be offline occasionally for various reasons.

Similarly, hydraulic containment is not as easy to implement as some other technologies (e.g., MNA or geochemical manipulation) due to design and installation of wells, pumps, and piping. An on-site water treatment plant would be required to accommodate both the quantity and constituents in the pumped groundwater. Since the quantity of water requiring treatment cannot be ascertained without further study, the design parameters of the treatment system would also need to be verified through additional investigations.

Hydraulic containment could be designed and installed within 1 to 2 years. Time to achieve GWPS could take more than a decade due to the slow desorption kinetics of arsenic, molybdenum, and possibly lithium from the Pottsville aquifer, though both the planned source control and MNA should accelerate this process.

Regulatory requirements and institutional controls may be greater for hydraulic containment than some of the other technologies. For example, permits may be required for the withdrawal and reinjection (if used) of water, and the chemistry of the effluent after treatment would need to be compatible with the National Pollutant Discharge Elimination System permit.

Active technologies such as hydraulic containment (pump-and-treat) may offer few or no advantages over MNA. For example, pump-and-treat for arsenic, lithium, molybdenum, and other inorganic constituents may reach a point of diminishing returns relatively quickly (a few months to a few years), as the concentration decreases and the subsequent reduction in concentration changes very little through time (EPRI 2018). The diminishing rate of concentration reduction is likely due to the slow desorption kinetics of constituents from aquifer solids (Bethke and Brady 2000; USEPA 2000). Due to the slow desorption kinetics, pump-and-treat may take a decade or more to achieve GWPS, such that it offers no time advantage over MNA (EPRI 2018).

3.3.3 Geochemical Manipulation (In Situ Injection)

Geochemical manipulation via injection is an emerging technology for inorganic constituents. The permanence of geochemical manipulation has not yet been demonstrated, due to its short history of application; therefore, performance is not considered high at present. Similarly, reliability is considered medium or moderate because Site geochemical conditions should not change beyond the tolerance of the treatment. The most effective use of this technology at the Site is probably for smaller isolated areas, where performance can be readily monitored and retreatment applied if needed.

Geochemical manipulation is relatively easy to moderate to implement, particularly in small areas. The main infrastructure required are injection wells. Even though infrastructure requirements are minimal, some laboratory and/or field pilot test work will need to be done, and a state underground injection control permit may be required, so geochemical manipulation is estimated to require a few years to implement. Because the longevity of this technology has not yet been demonstrated and multiple injections may be required, up to a decade or more may be needed to achieve GWPS.

3.3.4 Permeation Grouting

Performance of permeation grouting is considered high because grouting is a conventional and proven technology. Reliability is considered medium because some fractures may be missed in the grouting process. Implementation is considered moderate because angled grout holes may be required to intersect the near-vertical fractures at the Site. As with impermeable barrier walls, grouting will change groundwater flow (subsurface hydraulics), and the changes should be considered when evaluating this option. Grouting is estimated to take 12 to 24 months at the Site, based on grouting programs in similar terrain. Length and depth of the grout curtain (wall), spacings of grout holes (borings), and volume and composition of the mixture would need to be established through a test grouting program. Though grouting would likely stop the flow of impacted water, natural attenuation or other corrective measures would be required to meet GWPS in impacted water, so time to achieve GWPS is estimated to be from 10 to greater than 25 years.

4 Remedy Selection Process

Pursuant to 40 CFR 257.97 and ADEM Admin. Code r. 335-13-15-.06(8), after completing this ACM, the Site must select a remedy as soon as feasible. In contrast, Part C of the Administrative Order states that this ACM must include "the remedy proposed to the Department for approval."

To meet the requirement of Part C, the Site remedy is proposed to consist of the following:

1. a) Source control of the Ash Pond by consolidating the CCR material and capping it with a low-permeability cover system to prevent infiltration;

   b) Source control of the Gypsum Pond by dewatering and removing the CCR material eliminate the source and prevent infiltration;

   c) Source control of the BALF by consolidating and capping the CCR material with a low -permeability cover system to prevent infiltration;
2. MNA with routine evaluation of system performance to ensure that remediation goals are being met; and
3. Adaptive site management and remediation system enhancement or modification to ensure that remediation performance goals are met.

40 CFR 257.97(b) and ADEM Admin. Code r. 335-13-15-.06(8)(b) specify the following criteria that must be met by the remedy:

- Protect human health and the environment.
- Attain applicable groundwater protection standards.
- Control the source of the release so as to reduce or eliminate, to the maximum extent feasible, further releases of Appendix IV constituents to the environment.
- Remove from the environment as much of the material released from the CCR unit as is feasible, considering factors such as avoiding inappropriate disturbances of sensitive ecosystems.
- Comply with any relevant standards (i.e., all applicable RCRA requirements) for management of wastes generated by the remedial actions.

Combined closure/source control and MNA are anticipated to meet the requirements of 40 CFR 257.97(b) and ADEM Admin. Code r. 335-13-15-.06(8)(b). In an adaptive site management process, system performance is monitored, and one or more technologies identified in this ACM used to supplement the remedy as soon as feasible if the system is not performing as intended or corrective action goals are not met.

Using adaptive site management, a remedial approach will be implemented, conditions monitored, and results interpreted. The framework for future decision-making is as follows. Based on monitoring data, adjustments will be made to the corrective measures as necessary, leading to continuous improvements in site knowledge and corrective measures performance. Specifically, potential changes in site conditions associated with pond closure may require periodic changes to the corrective measure system. Moreover, site conditions may require the implementation of more than one corrective measure technology to meet remediation goals over the life of the project.

At the Site, Appendix IV SSLs have been identified, and facility closure is underway for the Ash Pond, Gypsum Pond, and BALF but not complete. As soon as practical, MNA will be implemented to address the SSLs based on the current Site conditions. Using an adaptive site management approach, a remediation approach will be used whereby: 1) the corrective measures system will be implemented to address current conditions; 2) the performance of the system will be monitored and evaluated semi-annually; 3) the CSM updated as more data are collected; and 4) adjustment and augmentation made to the corrective action system to ensure that performance criteria are met.

4.1 Additional Data Needs

Additional data and analysis will be required to perform a thorough site-specific evaluation and supplement the design of groundwater corrective actions for the Site. The following provides a summary of typical additional data needed to evaluate and select a remedy system:

- Geochemical studies of groundwater and aquifer media and geochemical modeling as needed
- Subsurface hydraulic calculations or models
- Laboratory treatability studies on groundwater, aquifer media, and potential treatment solutions for injection
- Field pilot studies based on results of laboratory treatability studies
- Design and implementation of a test grouting program

4.2 Schedule

Table 20 provides a generalized conceptual schedule for evaluating additional information and selecting a remedy to potentially supplement the proposed corrective action.

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Tables

Table 1
Historical Groundwater Elevations Summary

Well ID	Average GW Elevation (feet MSL)	Highest GW Elevation (feet MSL)	Lowest GW Elevation (feet MSL)	GW Elevation Variation (feet)
GS-AP-MW-2	376.55	376.71	376.28	0.43
GS-AP-MW-6S	257.71	258.77	256.70	2.07
GS-AP-MW-6D	263.42	264.52	261.95	2.57
GS-AP-MW-7	305.29	305.73	304.58	1.15
GS-AP-MW-8	388.72	391.02	386.81	4.21
GS-AP-MW-9	373.44	375.70	369.76	5.94
GS-AP-MW-10	340.60	344.10	330.26	13.84
GS-AP-MW-11	381.92	382.20	381.62	0.58
GS-AP-MW-12	380.82	380.92	380.70	0.22
GS-AP-MW-13	393.35	394.80	392.39	2.41
GS-AP-MW-14	371.58	372.11	371.26	0.85
GS-AP-MW-15	373.65	374.57	373.09	1.48
GS-AP-PZ-16	282.48	294.14	273.94	20.20
GS-AP-MW-16D	320.15	326.22	315.57	10.65
GS-AP-MW-17	352.58	358.80	349.16	9.64
GS-AP-MW-18	352.46	358.87	349.30	9.57
GS-AP-PZ-18	282.95	294.05	273.90	20.15
GS-AP-MW-19	382.74	383.52	381.86	1.66
GS-AP-MW-21	347.16	350.33	344.04	6.29

Notes:
GW: groundwater
MSL: mean sea level
Source: (SCS 2018a)

Table 2
Ash Pond – Groundwater Monitoring Network Details

Well Name	Northing	Easting	Ground Elevation	Top of Casing Elevation	Top of Screen Elevation	Bottom of Screen Elevation	Purpose
GS-AP-MW-2	1321951.860	2067629.250	518.77	522.03	329.770	309.770	Downgradient
GS-AP-MW-6S	1324533.130	2063864.630	271.57	274.67	237.570	227.570	Downgradient
GS-AP-MW-6D	1324547.480	2063881.960	271.39	274.50	220.390	210.390	Downgradient
GS-AP-MW-7	1324250.980	2063518.480	310.05	313.45	223.050	213.050	Downgradient
GS-AP-MW-8	1323405.230	2062398.470	431.63	434.61	390.630	370.630	Upgradient
GS-AP-MW-9	1322446.730	2062720.100	417.06	420.04	329.060	309.060	Downgradient
GS-AP-MW-11	1320953.140	2063257.730	465.34	468.34	348.840	328.840	Downgradient
GS-AP-MW-12	1320369.190	2063836.900	447.48	450.67	307.480	297.480	Downgradient
GS-AP-MW-13	1319377.840	2064083.370	461.03	464.20	371.030	351.030	Upgradient
GS-AP-MW-14	1318393.750	2063787.880	469.60	472.40	279.600	269.600	Downgradient
GS-AP-MW-15	1317267.070	2063959.210	452.21	454.89	272.210	262.210	Downgradient
GS-AP-MW-16D	1316152.700	2064850.230	459.09	462.27	259.090	239.090	Downgradient
GS-AP-MW-17	1314955.860	2066094.140	528.78	531.88	295.280	285.280	Downgradient
GS-AP-MW-18	1315052.820	2066824.840	400.17	403.39	320.170	300.170	Downgradient
GS-AP-MW-19	1316325.430	2066775.980	492.60	495.58	337.600	317.600	Downgradient
GS-AP-MW-21	1319122.820	2067233.100	506.51	509.48	283.510	273.510	Downgradient

Notes:

1. Northing and easting are in feet relative to the State Plane Alabama West North America Datum of 1983.
2. Elevations are in feet relative to the North American Vertical Datum of 1988.

Source: (SCS 2019d)

Table 3
Plant Gorgas GWPS

Constituent Name	Units	Ash Pond GWPS (SCS 2019d)	Gypsum Pond GWPS (SCS 2019f)	Bottom Ash Landfill GWPS (SCS 2019c)	CCR Landfill GWPS (SCS 2019a)	Gypsum Landfill GWPS (SCS 2019b)
Antimony	mg/L	0.006	0.006	0.006	0.006	0.006
Arsenic	mg/L	0.01	0.01	0.01	0.01	0.01
Barium	mg/L	2	2	2	2	2
Beryllium	mg/L	0.004	0.0121	0.0121	0.0121	0.0121
Boron	mg/L	4	4	4	4	4
Cadmium	mg/L	0.005	0.00598	0.00598	0.00598	0.00598
Chromium	mg/L	0.1	0.1	0.1	0.1	0.1
Cobalt	mg/L	0.006	1.07	1.07	1.07	1.07
Combined Radium 226+228	pCi/L	5	5	5	5	5
Fluoride	mg/L	4	4	4	4	4
Lead	mg/L	0.015	0.015	0.015	0.015	0.015
Lithium	mg/L	0.04	0.419	0.419	0.419	0.419
Mercury	mg/L	0.002	0.002	0.002	0.002	0.002
Molybdenum	mg/L	0.1	0.1	0.1	0.1	0.1
Selenium	mg/L	0.05	0.05	0.05	0.05	0.05
Thallium	mg/L	0.002	0.002	0.002	0.002	0.002

Notes:
--: Not applicable
GWPS: groundwater protection standard
mg/L: milligrams per liter
pCi/L: picocuries per liter

Table 4
Ash Pond – May 2018 Assessment Sampling Results

Well ID	Purpose	Sample Date	Arsenic[1] (mg/L)	Lithium[2] (mg/L)	Molybdenum[3] (mg/L)
GS-AP-MW-2	Downgradient	5/17/2018	ND	0.0451 J	0.00547 J
GS-AP-MW-6S	Downgradient	5/14/2018	0.00864	0.0238 J	0.00526 J
GS-AP-MW-6D	Downgradient	5/14/2018	0.074	0.239	0.00564 J
GS-AP-MW-7	Downgradient	5/15/2018	0.211	0.151	0.177
GS-AP-MW-8	Upgradient	5/15/2018	ND	ND	ND
GS-AP-MW-9	Downgradient	5/15/2018	0.00698	0.0861	0.00736 J
GS-AP-MW-11	Downgradient	5/15/2018	ND	0.013 J	ND
GS-AP-MW-12	Upgradient	5/15/2018	0.0253	0.0489 J	ND
GS-AP-MW-13	Downgradient	5/15/2018	ND	0.0101	ND
GS-AP-MW-14	Downgradient	5/16/2018	0.00112 J	0.0330 J	ND
GS-AP-MW-15	Downgradient	5/15/2018	0.0075	0.159	0.0344
GS-AP-MW-16D	Downgradient	5/16/2018	ND	0.0337 J	ND
GS-AP-MW-17	Downgradient	5/15/2018	0.00352 J	0.0551	0.00789 J
GS-AP-MW-18	Downgradient	5/16/2018	0.0876	0.172	0.0374
GS-AP-MW-19	Downgradient	5/16/2018	0.00114 J	0.0391 J	0.00515 J
GS-AP-MW-21	Downgradient	5/15/2018	ND	0.174	0.0687

Notes:

1. Groundwater protection standard for arsenic is 0.01 mg/L.
2. Groundwater protection standard for lithium is 0.04 mg/L.
3. Groundwater protection standard for molybdenum is 0.1 mg/L.

J: Estimated value; value may not be accurate. Spike recovery or relative percent difference outside of criteria.

mg/L: milligrams per liter

ND: non-detect

Table 5
Ash Pond – October 2018 Assessment Sampling Results

Well ID	Purpose	Sample Date	Arsenic[1] (mg/L)	Lithium[2] (mg/L)	Molybdenum[3] (mg/L)
GS-AP-MW-2	Downgradient	10/16/2018	ND	0.0511	0.00919 J
GS-AP-MW-6S	Downgradient	10/15/2018	0.00832	0.0300	0.00644 J
GS-AP-MW-6D	Downgradient	10/15/2018	0.0758	0.236	0.00538 J
GS-AP-MW-7	Downgradient	10/15/2018	0.217	0.155	0.168
GS-AP-MW-8	Upgradient	10/16/2018	ND	ND	ND
GS-AP-MW-9	Downgradient	10/16/2018	0.00473 J	0.0676	0.00425 J
GS-AP-MW-11	Downgradient	10/16/2018	ND	0.0120 J	ND
GS-AP-MW-12	Upgradient	10/16/2018	0.0203	0.0341	ND
GS-AP-MW-13	Downgradient	10/17/2018	ND	ND	ND
GS-AP-MW-14	Downgradient	10/17/2018	0.00132 J	0.0327	ND
GS-AP-MW-15	Downgradient	10/15/2018	0.0123	0.297	0.0525
GS-AP-MW-16D	Downgradient	10/17/2018	ND	0.0336	ND
GS-AP-MW-17	Downgradient	10/15/2018	0.00180 J	0.0606	0.00376 J
GS-AP-MW-18	Downgradient	10/16/2018	0.0158	0.314	0.0425
GS-AP-MW-19	Downgradient	10/16/2018	0.00216 J	0.0406	0.00593 J
GS-AP-MW-21	Downgradient	10/16/2018	ND	0.219	0.0610

Notes:

1. Groundwater protection standard for arsenic is 0.01 mg/L.
2. Groundwater protection standard for lithium is 0.04 mg/L.
3. Groundwater protection standard for molybdenum is 0.1 mg/L.

J: Estimated value; value may not be accurate. Spike recovery or relative percent difference outside of criteria.
mg/L: milligrams per liter
ND: non-detect

Table 6
Gypsum Pond – Groundwater Monitoring Network Details

Well Name	Northing	Easting	Ground Elevation	Top of Casing Elevation	Top of Screen Elevation	Bottom of Screen Elevation	Purpose
MW-1	1330794.064	594082.361	499.19	502.38	405.100	395.100	Upgradient
MW-2	1331053.309	593548.802	498.54	502.17	417.900	407.900	Upgradient
MW-3	1330842.402	593025.397	522.23	525.90	417.100	407.100	Upgradient
MW-4	1330289.727	592896.414	516.67	517.89	400.400	390.400	Upgradient
GS-GSA-MW-3	1329120.128	2054772.316	439.75	442.63	323.350	313.350	Downgradient
GS-GSA-MW-4	1329235.421	2054872.732	439.44	442.10	344.640	334.640	Downgradient
GS-GSA-MW-8	1328959.796	2054804.925	401.33	404.38	286.330	276.330	Downgradient

Notes:

1. Northing and easting are in feet relative to the State Plane Alabama West North America Datum of 1983.
2. Elevations are in feet relative to the North American Vertical Datum of 1988.

Source: (SCS 2019f)

Table 7
Gypsum Pond – June 2018 Assessment Sampling Results

Well ID	Purpose	Sample Date	Lithium[1] (mg/L)
MW-1	Upgradient	6/12/2018	0.0251
MW-2	Upgradient	6/12/2018	0.0472
MW-3	Upgradient	6/12/2018	0.194
MW-4	Upgradient	6/12/2018	0.0511
GS-GSA-MW-3	Downgradient	6/11/2018	0.425
GS-GSA-MW-4	Downgradient	6/11/2018	0.266
GS-GSA-MW-8	Downgradient	6/12/2018	0.1660

Notes:

1. Groundwater protection standard for lithium is 0.419 mg/L.

J: Estimated value; value may not be accurate. Spike recovery or relative percent difference outside of criteria.

mg/L: milligrams per liter

ND: non-detect

Table 8
Gypsum Pond – October 2018 Assessment Sampling Results

Well ID	Purpose	Sample Date	Lithium[1] (mg/L)
MW-1	Upgradient	10/17/2018	0.025
MW-2	Upgradient	10/17/2018	0.0633
MW-3	Upgradient	10/17/2018	0.384
MW-4	Upgradient	10/17/2018	0.0532
GS-GSA-MW-3	Downgradient	10/17/2018	0.494
GS-GSA-MW-4	Downgradient	10/17/2018	0.266
GS-GSA-MW-8	Downgradient	10/17/2018	0.1880

Notes:

1. Groundwater protection standard for lithium is 0.419 mg/L.

J: Estimated value; value may not be accurate. Spike recovery or relative percent difference outside of criteria.

mg/L: milligrams per liter

ND: non-detect

Table 9
Bottom Ash Landfill – Groundwater Monitoring Network Details

Well Name	Northing	Easting	Ground Elevation	Top of Casing Elevation	Well Depth BTOC (feet)	Top of Screen Elevation	Bottom of Screen Elevation	Screen Length (feet)	Purpose
MW-1	1330794.064	594082.361	499.19	502.25	107.56	405.09	395.09	10	Upgradient
MW-2	1331053.309	593548.802	498.54	502.12	94.58	417.94	407.94	10	Upgradient
MW-3	1330842.402	593025.397	522.23	525.90	119.07	417.23	407.23	10	Upgradient
MW-4	1330289.727	592896.414	516.67	518.63	128.66	400.37	390.37	10	Upgradient
MW-7	1328515.235	593408.341	391.59	394.59	74.00	330.99	320.99	10	Downgradient
MW-8	1329140.729	593813.964	413.15	416.10	72.25	354.25	344.25	10	Downgradient
MW-10	1327686.069	593704.952	391.66	395.10	108.64	306.86	286.86	20	Downgradient
MW-11	1328083.497	594546.311	403.69	406.96	135.00	282.36	272.36	10	Downgradient
MW-12	1328578.930	594708.212	470.70	474.24	169.04	315.60	305.60	10	Downgradient
MW-12V	1328481.680	2063196.250	478.64	481.32	206.08	285.64	275.64	10	Vertical Delineation

Notes:

1. Northing and easting are in feet relative to the State Plane Alabama West North America Datum of 1983.
2. Elevations are in feet relative to the North American Vertical Datum of 1988.
3. Top of screen and bottom of screen depths are calculated relative to Top of Casing elevation and less the well sump length of 0.4 feet.

BTOC: below top of casing

Table 10
Bottom Ash Landfill – May 2018 Assessment Sampling Results

Well ID	Purpose	Sample Date	Arsenic[1] (mg/L)
MW-1	Upgradient	5/22/2018	ND
MW-2	Upgradient	5/22/2018	ND
MW-3	Upgradient	5/24/2018	ND
MW-4	Upgradient	5/23/2018	ND
MW-7	Downgradient	5/23/2018	0.00155
MW-8	Downgradient	5/23/2018	0.00157
MW-10	Downgradient	5/24/2018	ND
MW-11	Downgradient	5/22/2018	0.00168
MW-12	Downgradient	5/24/2018	0.0478

Notes:
1. Groundwater protection standard for arsenic is 0.01 mg/L.
J: Estimated value; value may not be accurate. Spike recovery or relative percent difference outside of criteria.
mg/L: milligrams per liter
ND: non-detect

Table 11
Bottom Ash Landfill – November 2018 Assessment Sampling Results

Well ID	Purpose	Sample Date	Arsenic[1] (mg/L)
MW-1	Upgradient	11/19/2018	ND
MW-2	Upgradient	11/19/2018	ND
MW-3	Upgradient	11/19/2018	0.0012
MW-4	Upgradient	11/19/2018	ND
MW-7	Downgradient	11/20/2018	0.00133
MW-8	Downgradient	11/20/2018	0.00173
MW-10	Downgradient	11/19/2018	ND
MW-11	Downgradient	11/20/2018	ND
MW-12	Downgradient	11/19/2018	0.0405

Notes:
1. Groundwater protection standard for arsenic is 0.01 mg/L.
J: Estimated value; value may not be accurate. Spike recovery or relative percent difference outside of criteria.
mg/L: milligrams per liter
ND: non-detect

Table 12
CCR Landfill – Groundwater Monitoring Network Details

Well Name	Northing	Easting	Ground Elevation	Top of Casing Elevation	Well Depth BTOC (feet)	Top of Screen Elevation	Bottom of Screen Elevation	Screen Length (feet)	Purpose
MW-1	1330794.064	594082.361	499.19	502.25	107.56	405.09	395.09	10	Upgradient
MW-2	1331053.309	593548.802	498.54	502.12	94.58	417.94	407.94	10	Upgradient
MW-3	1330842.402	593025.397	522.23	525.90	119.07	417.23	407.23	10	Upgradient
MW-4	1330289.727	592896.414	516.67	518.63	128.66	400.37	390.37	10	Upgradient
MW-5	1328645.982	592436.538	471.55	474.55	137.00	351.95	341.95	10	Downgradient
MW-6	1327877.972	592829.837	409.99	412.99	129.00	294.39	284.39	10	Downgradient
MW-7	1328515.235	593408.341	391.59	394.59	74.00	330.99	320.99	10	Downgradient
MW-8	1329140.729	593813.964	413.15	416.10	72.25	354.25	344.25	10	Downgradient

Notes:

1. Northing and easting are in feet relative to the State Plane Alabama West North America Datum of 1983.
2. Elevations are in feet relative to the North American Vertical Datum of 1988.
3. Top of screen and bottom of screen depths are calculated relative to Top of Casing elevation and less the well sump length of 0.4 feet.

BTOC: below top of casing

Table 13
CCR Landfill – May 2018 Assessment Sampling Results

Well ID	Purpose	Sample Date	Lithium[1] (mg/L)
MW-1	Upgradient	5/22/2018	0.0263
MW-2	Upgradient	5/22/2018	0.0465
MW-3	Upgradient	5/24/2018	0.145
MW-4	Upgradient	5/23/2018	0.0513
MW-5	Downgradient	5/23/2018	0.103
MW-6	Downgradient	5/23/2018	0.266
MW-7	Downgradient	5/23/2018	0.129
MW-8	Downgradient	5/23/2018	0.194

Notes:

1. Groundwater protection standard for lithium is 0.419 mg/L.

J: Estimated value; value may not be accurate. Spike recovery or relative percent difference outside of criteria.

mg/L: milligrams per liter

ND: non-detect

Table 14
CCR Landfill – November 2018 Assessment Sampling Results

Well ID	Purpose	Sample Date	Lithium[1] (mg/L)
MW-1	Upgradient	11/19/2018	0.0241
MW-2	Upgradient	11/19/2018	0.0584
MW-3	Upgradient	11/19/2018	0.323
MW-4	Upgradient	11/19/2018	0.0467
MW-5	Downgradient	11/20/2018	0.102
MW-6	Downgradient	11/20/2018	0.245
MW-7	Downgradient	11/20/2018	0.12
MW-8	Downgradient	11/20/2018	0.181

Notes:

1. Groundwater protection standard for lithium is 0.419 mg/L.

J: Estimated value; value may not be accurate. Spike recovery or relative percent difference outside of criteria.

mg/L: milligrams per liter

ND: non-detect

Table 15
Gypsum Landfill – Groundwater Monitoring Network Details

Well Name	Northing	Easting	Ground Elevation	Top of Casing Elevation	Well Depth BTOC (feet)	Top of Screen Elevation	Bottom of Screen Elevation	Screen Length (feet)	Purpose
MW-1	1330794.064	594082.361	499.19	502.25	107.56	405.09	395.09	10	Upgradient
MW-2	1331053.309	593548.802	498.54	502.12	94.58	417.94	407.94	10	Upgradient
MW-3	1330842.402	593025.397	522.23	525.90	119.07	417.23	407.23	10	Upgradient
MW-4	1330289.727	592896.414	516.67	518.63	128.66	400.37	390.37	10	Upgradient
MW-13	1329383.939	595088.060	442.00	445.04	109.04	346.40	336.40	10	Upgradient
MW-14	1329549.381	595627.606	426.90	429.90	103.50	336.80	326.80	10	Upgradient
MW-15	1329680.612	595932.099	403.10	406.05	87.15	329.30	319.30	10	Upgradient
MW-16	1328655.721	596399.878	411.57	414.57	110.00	314.97	304.97	10	Downgradient
MW-17R	1328244.376	2064752.826	431.46	434.57	138.05	306.12	296.12	10	Downgradient
MW-18	1327977.419	595793.776	411.42	414.42	118.00	306.82	296.82	10	Downgradient
MW-19	1327697.305	595251.571	375.11	377.32	97.31	290.41	280.41	10	Downgradient
MW-20	1327792.527	594841.227	329.89	332.89	73.50	269.79	259.79	10	Downgradient

Notes:

1. Northing and easting are in feet relative to the State Plane Alabama West North America Datum of 1983.
2. Elevations are in feet relative to the North American Vertical Datum of 1988.
3. Top of screen and bottom of screen depths are calculated relative to Top of Casing elevation and less the well sump length of 0.4 feet.

BTOC: below top of casing

Table 16
Gypsum Landfill – May 2018 Assessment Sampling Results

Well ID	Purpose	Sample Date	Lithium[1] (mg/L)
MW-1	Upgradient	6/22/2018	0.0263
MW-2	Upgradient	6/22/2018	0.0465
MW-3	Upgradient	6/24/2018	0.145
MW-4	Upgradient	6/23/2018	0.0513
MW-13	Upgradient	5/21/2018	0.0241
MW-14	Upgradient	5/21/2018	0.0339
MW-15	Upgradient	5/21/2018	0.0634
MW-16	Downgradient	5/21/2018	0.0171
MW-17R	Downgradient	5/24/2018	0.0466
MW-18	Downgradient	5/22/2018	0.0604
MW-19	Downgradient	5/22/2018	0.0543
MW-20	Downgradient	5/22/2018	0.262

Notes:
1. Groundwater protection standard for lithium is 0.419 mg/L.
J: Estimated value; value may not be accurate. Spike recovery or relative percent difference outside of criteria.
mg/L: milligrams per liter
ND: non-detect

Table 17
Gypsum Landfill – November 2018 Assessment Sampling Results

Well ID	Purpose	Sample Date	Lithium[1] (mg/L)
MW-1	Upgradient	11/19/2018	0.0241
MW-2	Upgradient	11/19/2018	0.0584
MW-3	Upgradient	11/19/2018	0.323
MW-4	Upgradient	11/19/2018	0.0467
MW-13	Upgradient	11/19/2018	0.0195
MW-14	Upgradient	11/19/2018	0.0346
MW-15	Upgradient	11/19/2018	0.0664
MW-16	Downgradient	11/19/2018	0.0174
MW-17R	Downgradient	11/19/2018	0.0392
MW-18	Downgradient	11/19/2018	0.0586
MW-19	Downgradient	11/20/2018	0.0526
MW-20	Downgradient	11/20/2018	0.253

Notes:

1. Groundwater protection standard for lithium is 0.419 mg/L.

J: Estimated value; value may not be accurate. Spike recovery or relative percent difference outside of criteria.

mg/L: milligrams per liter

ND: non-detect

Table 18
Groundwater Corrective Action Evaluation Summary

Technology	Evaluation Criteria						
	Performance	Reliability	Ease or Difficulty of Implementation	Potential Impacts of Remedy	Time to Implement Remedy (Influenced by Regulatory Approval Process)	Time to Achieve Groundwater Protection Standard at the Waste Boundary	Institutional Requirements
Monitored Natural Attenuation[2]	Medium because processes may be primarily physical (i.e., less chemical attenuating potential for rock fractures)	High due to little operation and maintenance and other potential repair needs	Easy due to minimal infrastructure (e.g., monitoring wells) needed to implement remedy	None	18-24 months	Estimated > 25 years[1]	None identified
Hydraulic Containment (pump-and-treat)	High; reduces constituents to compliance levels when online	Medium to high; system offline at times for maintenance	Moderate due to design and installation of pump-and-treat system	Pumping could impact water supply wells, if present	12-24 months	Estimated > 25 years[1]	Needs to be compatible with Site NPDES permit; would potentially need to permit withdrawals
Geochemical Manipulation (in situ injection, spot treatment)	Medium	Medium; site geochemical conditions need to be maintained to prevent rebound	Easy to moderate due to minimal infrastructure (e.g., injection wells)	Constituents may be mobilized initially upon injection before ultimate immobilization	12-24 months	Estimated 10 years (for small, localized areas)	State Underground Injection Control permit may be required
Grout Curtain (permeation grouting)	High because grouting is a conventional and proven technology	Medium, some fractures may be missed	Moderate due to near vertical fractures that may require angled borings to effectively grout	Will alter groundwater flow hydraulics beneath and adjacent to the Site	12-24 months	Estimated 10 to greater than 25 years[2]	None identified

Notes:

1. Timeframes shown are estimated based on case histories of monitored natural attenuation and hydraulic containment of arsenic-impacted sites. Detailed estimate of time requires further investigation.
2. Monitored natural attenuation or other technologies may be required to remediate groundwater beyond the grout curtain. Detailed estimate of time requires further investigation.

Table 19
Technology Advantages and Disadvantages

Technology	Advantages (After EPRI 2015)	Disadvantages (After EPRI 2015)
MNA	• Minimal site disruption • Sustainable • Applicable in congested, sensitive or less accessible areas where other technologies may not be feasible	• Other treatment technologies may be required
Hydraulic Containment (pump-and-treat)	• Pump-and-treat systems are very effective at hydraulically containing impacted groundwater • Systems can be installed as deep as typical well drilling technology allows • Systems can be modified over time to increase or decrease extraction rates or modify the system to adapt changing site conditions • An on-site water treatment plant may be available for the Ash Pond	• More labor, O&M required than other technologies • Constituent levels can rebound if treatment is halted • System may reach a point of diminishing returns where concentrations stabilize above regulatory standards for inorganic constituents
Grout Curtain (permeation grouting)	• Reliable and widely accepted technology • Ability to be emplaced to greater depths than other methods (e.g. conventional barrier walls) • Applicable to fractured rock	• Heterogeneity of the subsurface can impact the ability to emplace the grout curtain • Time to completion difficult to estimate due to dependence on subsurface conditions
Geochemical Manipulation (in situ injection, spot treatment)	• Ability to treat small, localized areas • Minimal site disruption • Applicable in congested, sensitive or less accessible areas where other technologies may not be feasible	• Emerging technology; permanence for inorganic constituents being demonstrated • Not proven for large-scale corrective action

Notes:
EPRI: Electric Power Research Institute
MNA: monitored natural attenuation
O&M: operation and maintenance

Table 20
Schedule

Number	Task	Estimated Completion Date
1	Field Studies and Data Collection	June 2019 – May 2020
2	Groundwater Flow and Geochemical Modeling	June 2019 – May 2020
3	Bench Testing and Pilot Studies	October 2019 – September 2020
4	Preliminary Conceptual Design	October 2020 – March 2021

Figures

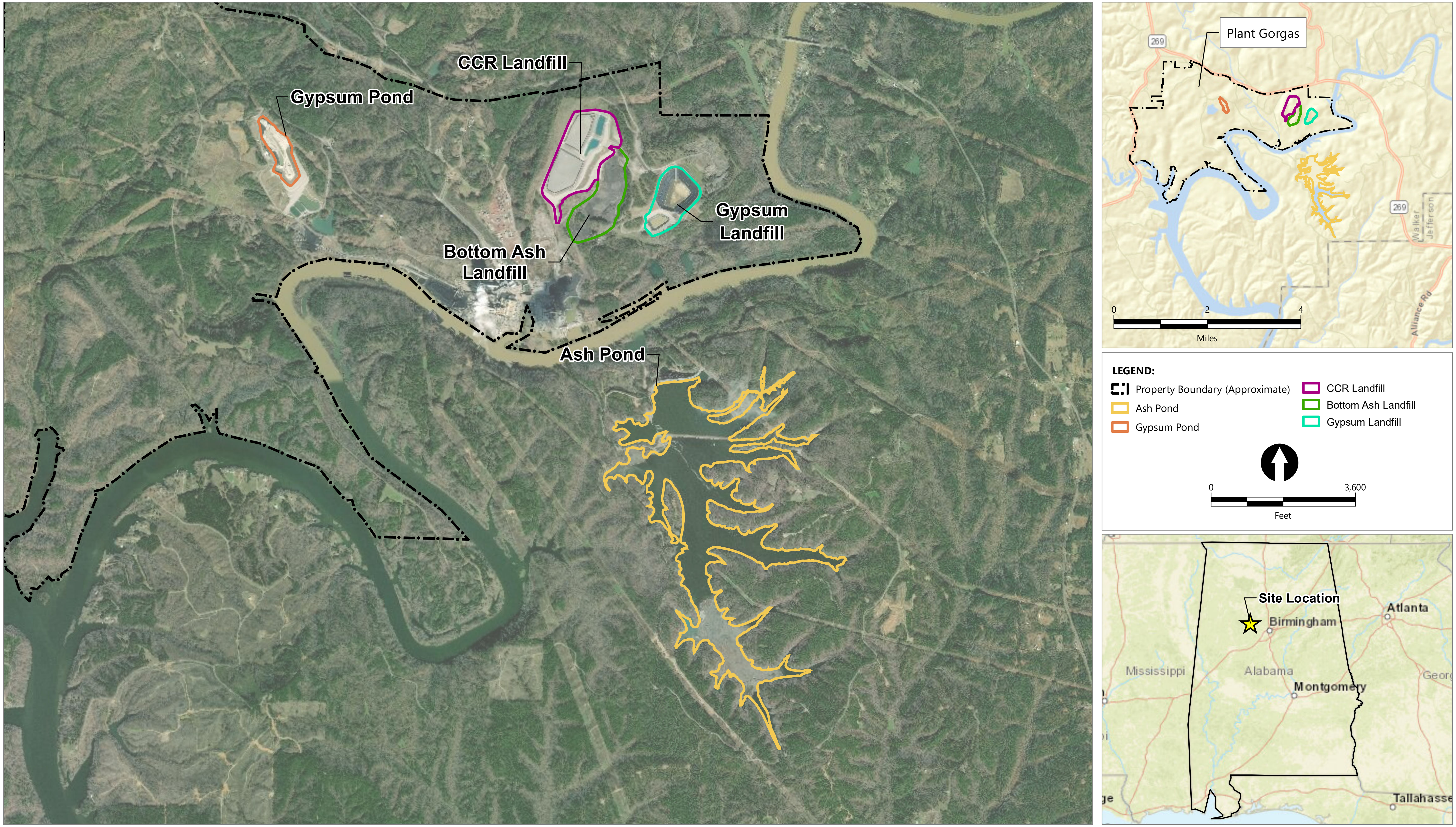

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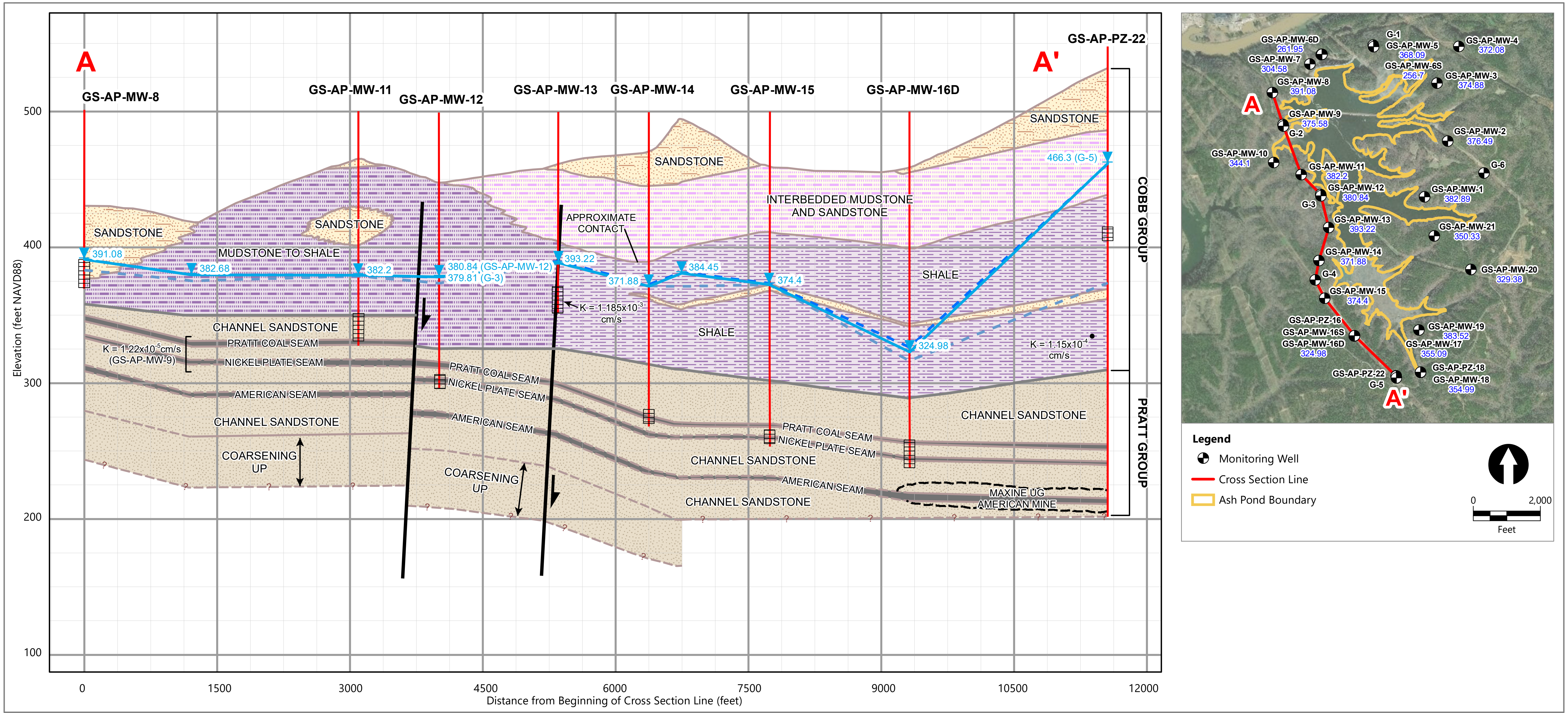
Figure 1
Site Location Map
Assessment of Corrective Measures
Plant Gorgas



Cross-Section Legend

▼	Approximate Groundwater Elevation	—	Monitoring Well Location	▤	Shale
—	Approximate Groundwater Elevation	—	Group Boundary	▤	Mudstone to Shale
- -	Maximum Groundwater Elevation	—	Strata Boundary	▤	Interbedded Mudstone and Sandstone
- -	Minimum Groundwater Elevation	- -	Inferred Strata Boundary	▨	Sandstone
▭	Screen Interval	—	Fault	▨	Channel Sandstone
		- -	Mine	■	Coal

NOTES:

1. Stratigraphic layers were correlated using a combination of boring data and gamma logs.
2. Approximate Groundwater Elevation data are reported using North American Vertical Datum of 1988 (NAVD88).
3. Approximate groundwater elevation data was collected from CCR network wells on May 14, 2018 and from G-series wells on January 5, 2016.
4. Maximum and minimum groundwater elevation data were derived from the highest and lowest groundwater elevation values recorded during events spanning July 27, 2012 to May 14, 2018 (CCR network) and January 21, 2014 to January 5, 2016 (G-series).
5. Cross-section data from *Plant Gorgas Ash Pond Facility Plan for Groundwater Investigation*, Southern Company Services, October 2018.

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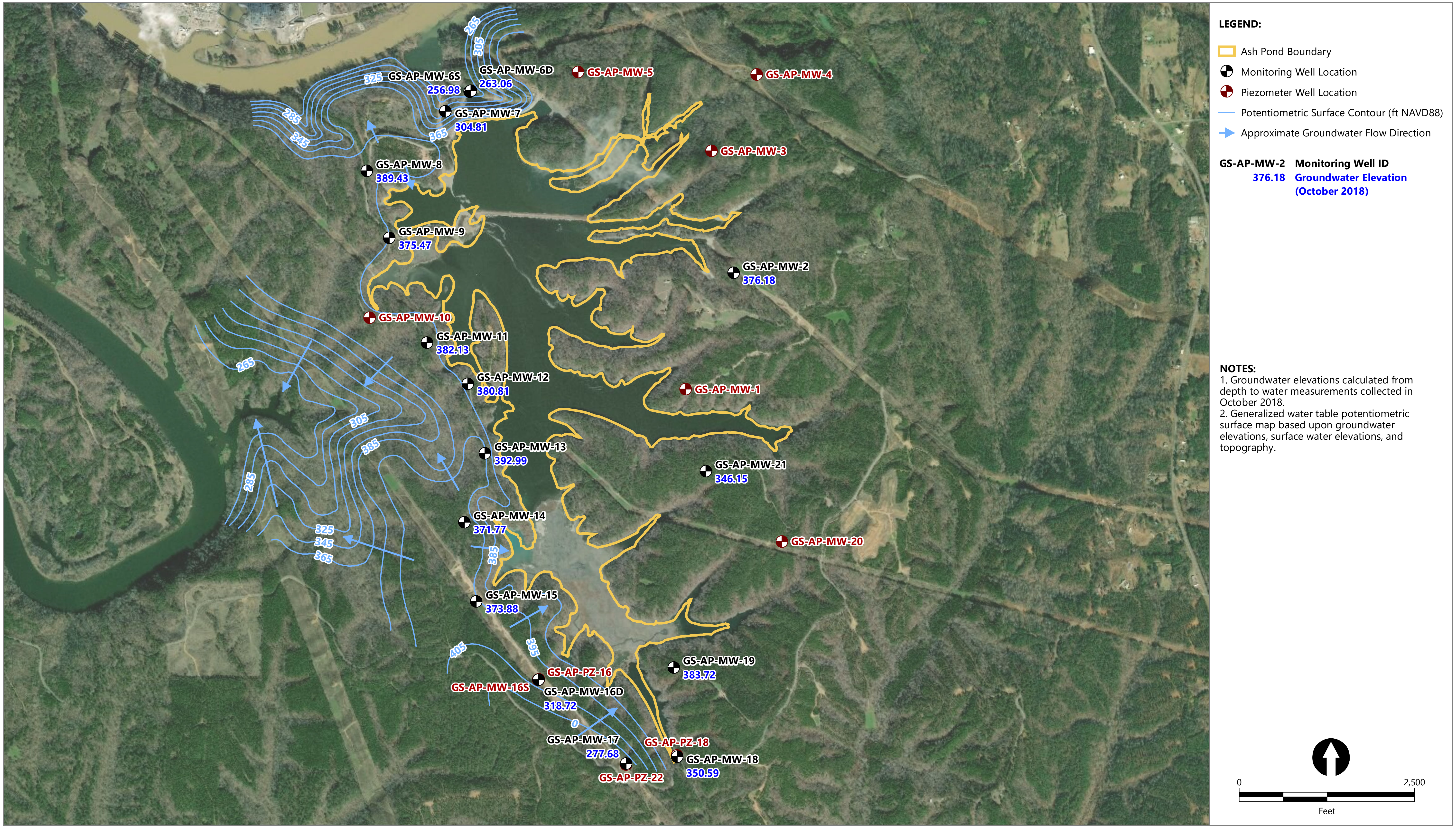
Figure 2
Geologic Cross-Section - Ash Pond
Assessment of Corrective Measures
Plant Gorgas



NOTES:

1. Groundwater elevations calculated from depth to water measurements collected in October 2018.
2. Generalized water table potentiometric surface map based upon groundwater elevations, surface water elevations, and topography.

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Figure 3
Typical Ash Pond Potentiometric Surface Map
Assessment of Corrective Measures
Plant Gorgas

LEGEND:

- 🟨 Gypsum Pond Boundary
- ◐ Monitoring Well
- — Groundwater Elevation Contour
- → Groundwater Flow Direction
- ▭ Property Boundary (Approximate)
- 🟩 Gypsum Landfill

GS-GSA-MW-4	**Monitoring Well ID**
351.02	**Groundwater Elevation (August 2017)**

NOTES:
1. Groundwater elevations calculated from depth to water measurements collected in August 2017.

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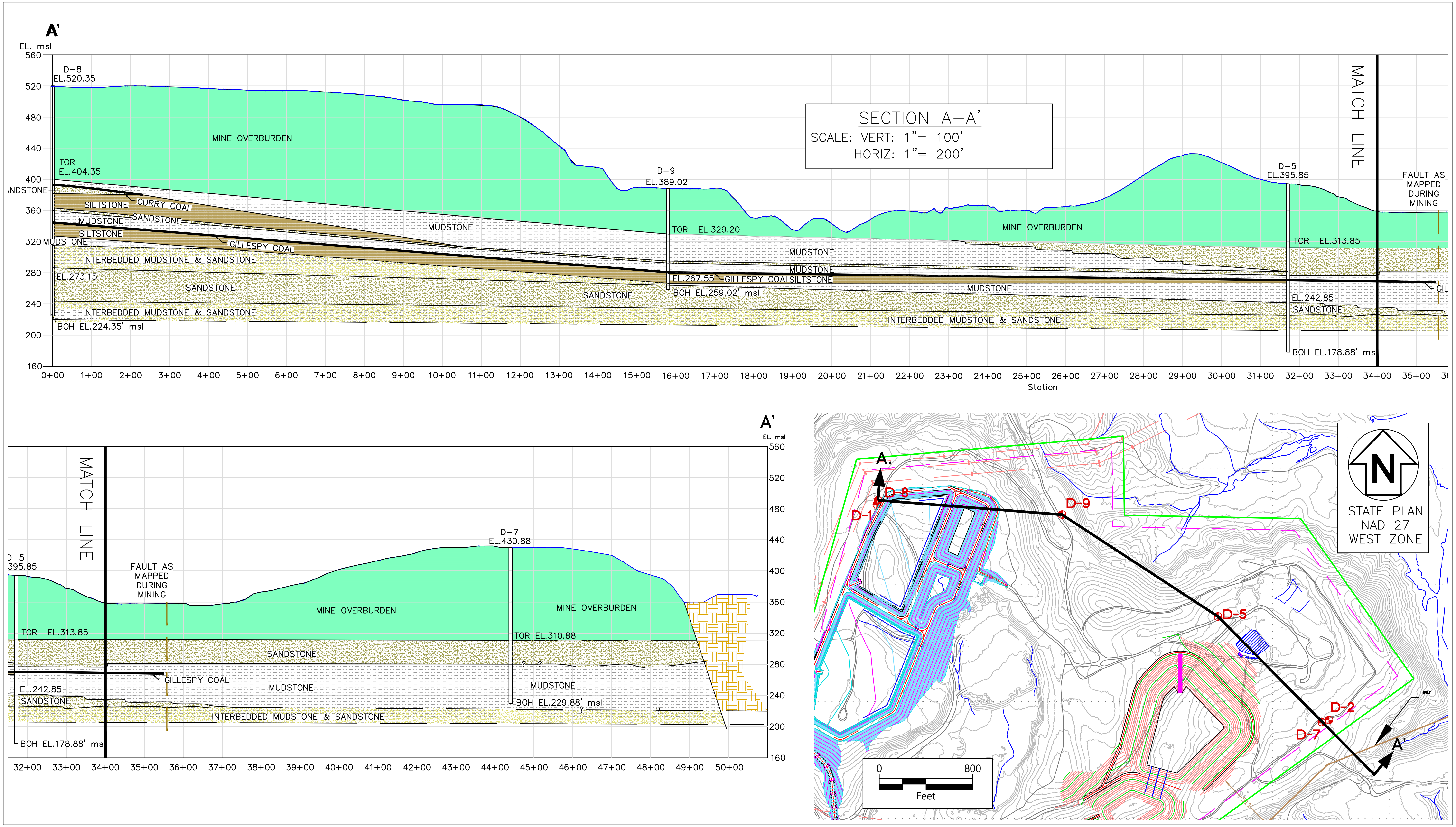
Figure 4
Typical Gypsum Pond Potentiometric Surface Map
Assessment of Corrective Measures
Plant Gorgas



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Filepath: K:\Projects\1114-Southern Company\Gorgas\1114-RP-001 (ES3016 FIG4_5 SECTIONS).dwg Figure 5a

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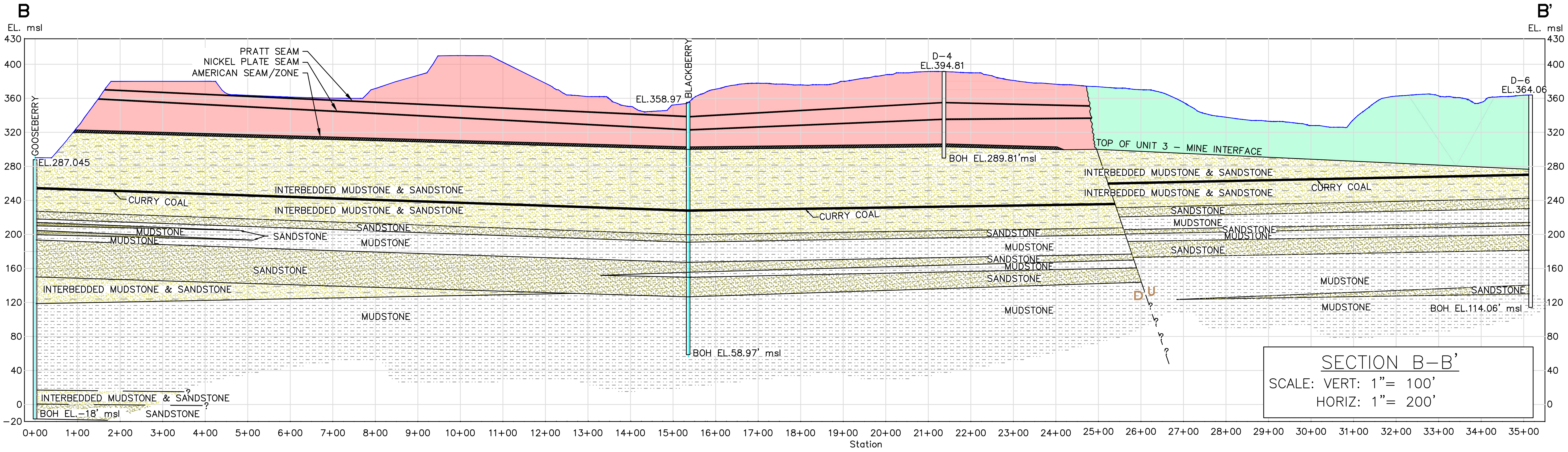
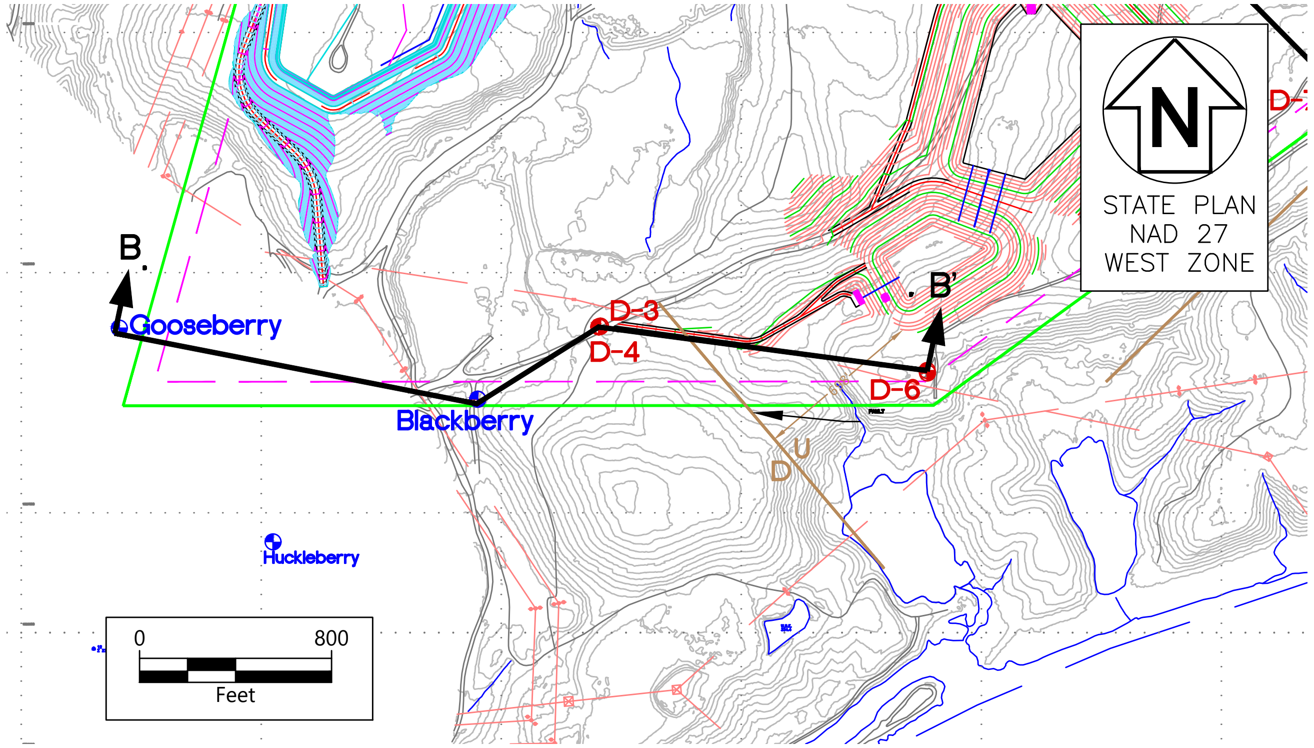
Figure 5a
Geologic Cross-Section – North of Landfills

Assessment of Corrective Measures
Plant Gorgas





Publish Date: 2020/02/21 4:42 PM | User: dholmer
Filepath: K:\Projects\1114-Southern Company\Gorgas\1114-RP-001 (ES3016 FIG4_5 SECTIONS).dwg Figure 5b

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Figure 5b
Geologic Cross-Section – South of Landfills

Assessment of Corrective Measures
Plant Gorgas

NOTES:
1. Groundwater elevations calculated from depth to water measurements collected in November 2018.
2. NAVD88 - North American Vertical Dataum of 1988

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Figure 6
Typical Landfill Potentiometric Surface Map
Assessment of Corrective Measures
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