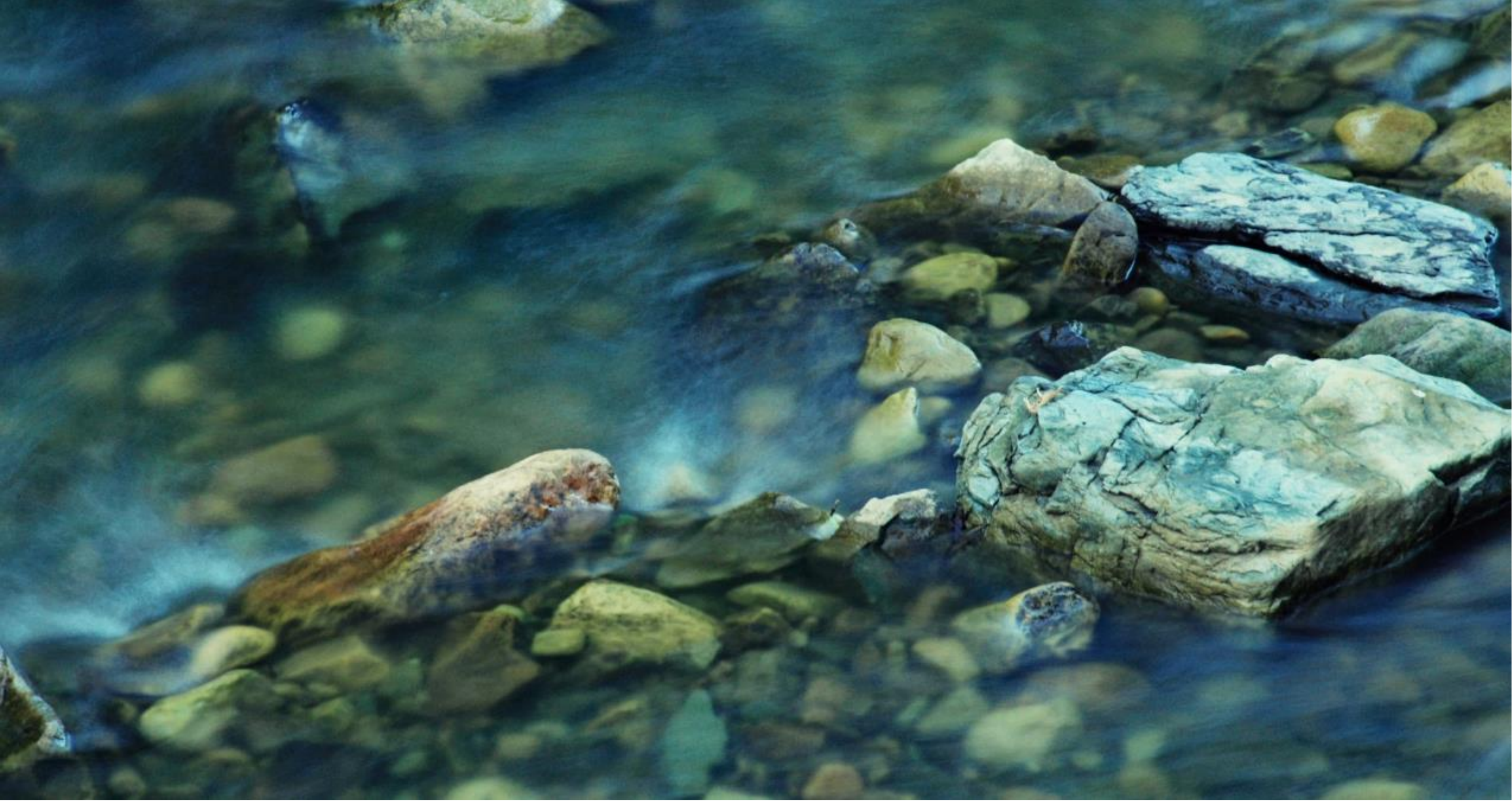


June 2019
Plant Gorgas

Assessment of Corrective Measures
Plant Gorgas

Prepared for Alabama Power Company

June 2019
Plant Gorgas

Assessment of Corrective Measures
Plant Gorgas

Prepared for
Alabama Power Company
1313 6th Avenue North
Birmingham, AL 35203

Prepared by
Anchor QEA, LLC
One Perimeter Park South, Suite 100N
Birmingham, AL 35243

Project Number: 171114-02.01
https://anchorqea-my.sharepoint.com/personal/aaccardi_anchorqea_com/Documents/PRIVILEGED & CONFIDENTIAL_ACMs/Gorgas/Text/Assessment of Corrective Measures_Gorgas_6-12-19.docx

TABLE OF CONTENTS

TABLES

FIGURES

ABBREVIATIONS

ACM	Assessment of Corrective Measures
ADEM	Alabama Department of Environmental Management
Admin. Code	Administrative Code
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"
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act, or Superfund
CFR	Code of Federal Regulations
cm/sec	centimeters per second
CMS	Corrective Measures Study
CSM	conceptual site model
EPRI	Electric Power Research Institute
FeS_2	pyrite
GWPS	groundwater protection standard
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	Plant Gorgas
SSI	statistically significant increase
SSL	statistically significant level
USEPA	U.S. Environmental Protection Agency

1 Introduction

This 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 the Ash Pond at Plant Gorgas (Site). SSLs of arsenic, lithium and molybdenum have been detected in groundwater at the Ash Pond and SSLs of lithium identified at the Gypsum Pond. Specifically, this 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."

This ACM was initiated within 90 days of identifying the SSLs on January 13, 2019; a 60-day extension until June 12, 2019, for completion of the ACM was documented on April 12, 2019.

This ACM is the first step in developing a long-term corrective action plan to address exceedances of groundwater protection standards (GWPS) 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 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 all of the gypsum/CCR from the unit. 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 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 (2016) guidance, 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 since those activities are integral to the long-term strategy and will influence groundwater corrective measures performance. Potential groundwater correction measures were then identified and evaluated against the applicable criteria.

Frequently-used technologies that are unlikely to perform satisfactorily or reliably at the Sites, 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

Alabama Power Company's William Crawford Gorgas Electric Generating Plant (Site) 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 Section 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. Figure 1 depicts the location of the Site with respect to the surrounding area. The Ash Pond went into service in 1964 and is approximately 420 acres in size.

2.2 Site History

The Ash Pond and Gypsum 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 and Gypsum 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.

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 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.

Gypsum was sluiced to the unit and periodically removed for beneficial reuse purposes. Therefore, the volume of gypsum stored in the unit varied with time.

2.3 Hydrogeological Conceptual Site Models and Groundwater Flow

The following subsection provide high level overviews of hydrogeologic conceptual site models for the Plant Gorgas Ash and Gypsum Ponds.

2.3.1 Ash Pond

The major components of the hydrogeological CSM include (Southern Company Services 2018a):

- 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; 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 Alabama Power Company James H. Miller Plant to estimate the horizontal hydraulic conductivity of the Pottsville Formation. 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/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 presented in Figure 3. Table 1 provides a summary of historical groundwater elevation data for the Site.

2.3.2 Gypsum Pond

The major components of the hydrogeological CSM include (Southern Company Services 2018a):

- 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 Plant Gorgas 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 plains, or along vertical or sub-vertical 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.

2.4 Delineation of Appendix IV Constituents

2.4.1 Ash Pond Delineation

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-12 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.

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* (Southern Company Services 2018b). 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. 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:

- 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-AP-MW-21.
- 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 eight horizontal delineation wells were installed at locations downgradient of monitoring wells where Appendix IV SSIs were observed. 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 Alabama Power-owned property roughly 2 miles north-northeast of the Plant Gorgas Ash Pond.

To discern the nature of source, pore water samples from three locations within the Ash Pond were collected and analyzed for Appendix III and IV constituents.

2.4.2 Gypsum Pond Delineation

The certified detection groundwater monitoring network for the Gypsum Pond consists of 4 upgradient monitoring well locations and 3 downgradient monitoring well locations (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, Bottom Ash Landfill, and Gypsum Landfill.

Background sampling for CCR constituents was conducted between August 2016 and June 2017. After collecting 8 background samples, the first compliance detection event occurred in August 2017. SSIs for EPA Appendix III constituents were documented in the first Annual Groundwater Monitoring and Corrective Action Report (January 2018). 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. 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:

- 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 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, gypsum samples from locations within the gypsum pond were collected and analyzed by toxic characteristic leaching procedure and synthetic precipitation leaching procedure methods.

2.5 Pond Closure and Source Control

The following describes closure plans and source control methods for the Ash Pond and Gypsum Pond. Closure plans were submitted to ADEM in December 2018.

2.5.1 Ash Pond

The Plant Gorgas 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 Plant Gorgas Ash Pond will be closed by leaving CCR in place and consolidating the current site footprint of approximately 420 acres to an area of approximately 290 acres. Current designs project dewatering, consolidation and capping to be completed in 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 r. 335-13-15-.07(3)(d)3.(i). The final cover will consist of an HDPE or LLDPE geomembrane and geocomposite drainage layer covered with an 18-in infiltration layer overlain by 6-in of soil capable of sustaining vegetative growth. Final design will ensure 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.

2.5.2 Gypsum Pond

The Plant Gorgas Gypsum Pond will be closed through the removal of gypsum/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.

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 or Gypsum Pond. 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 both sites Appendix IV SSIs 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 the (1) depth is well 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 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. The phases (also referred to as “steps” or “tiers”) include (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 timeframes range from a few years to decades (EPRI 2015a). Because pond closure activities at the Site are projected to take approximately 8 years, the timeframe 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) discourages using dilution and dispersion as primary MNA mechanisms, as these mechanisms disperse contaminant mass rather than immobilize it. Further, USEPA (2015) 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).

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 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. On-site water treatment is not currently available, so 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 by-product 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.

With the possible exception of lithium, geochemical manipulation should be effective for the constituents of interest (arsenic and molybdenum). Geochemical manipulation for lithium is currently under development. However, effectiveness of the mode of sequestration (coprecipitation with sulfides, adsorption to iron 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), a 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:

- Monitored natural attenuation
- Hydraulic containment (pump and treat)
- Geochemical manipulation via injections, particularly sequestration in sulfide minerals
- 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 6 provides a summary of these technologies compared to the evaluation criteria discussed in Section 1 as applied to Site conditions. Table 7 discusses advantages and disadvantages of each technology that should be considered.

3.3.1 MNA

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 at the Site due to source control, and the small reduction in concentrations required to meet GWPS for molybdenum.

The performance of MNA requires further investigation, especially related to the identification of an 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 timeframe. Removal of the Gypsum Pond will eliminate contribution from the source.

Implementation of MNA at the Site will be relatively easy. 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, permanence, and 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 re-injection (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 (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 re-treatment 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 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:

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;

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

2. Monitored natural attenuation with routine evaluation of system performance to assure that remediation goals are being met; and

3. Adaptive site management and remediation system enhancement or modification to assure 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 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 pond closure is underway 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 site conceptual model updated as more data is collected, and (4) adjustment and augmentation made to the corrective action system to assure 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 8 provides a generalized conceptual schedule for evaluating additional information and selecting a remedy to potentially supplement the proposed corrective action.

5 References

Abraitis, P.K., R.A.D. Patrick, and D.J. Vaughan, 2004. "Variations in the Compositional, Textural and Electrical Properties of Natural Pyrite: A Review." *International Journal of Mineral Processing* 47:41-59.

Bethke, C.M., and P.V. Brady, 2000. *How the* K_d *Approach Undermines Ground Water Cleanup*. Groundwater 38(3):435-443.

EPRI (Electric Power Research Institute), 2015a. *Monitored Natural Attenuation for Inorganic Constituents in Coal Combustion Residuals*. EPRI, Palo Alto, California: December 2015. 3002006285.

EPRI, 2015b. *Corrective Action for Closed and Closing Ash Ponds*. Final Report. EPRI, Palo Alto, California: December 2015. 3002006292.

EPRI, 2018. *Groundwater Remediation Planning, Applications, Limitations, Cost Model*. EPRI, Palo Alto, California: 2018. 3002012313.

Gorelick, S.M, R.A. Freeze, D. Donohue, and J.F. Keely, 1993. *Groundwater Contamination Optimal Capture and Containment*. Boca Raton, Florida: Lewis Publishers.

Keller Ground Engineering, 2017. "Permeation Grouting." Accessed September 29, 2017. Available at: http://www.kellerge.com.au/techniques/permeation-grouting/.

Ludwig, R.D., C. Su, T.R. Lee, R.T. Wilkin, S.D. Acree, R.R. Ross, and A. Keeley, 2007. "In situ chemical reduction of Cr(VI) in groundwater using a combination of ferrous sulfate and sodium dithionate: a field investigation." *Environmental Science and Technology* 15(42):7726.

Pearlman, L., 1999. *Subsurface Containment and Monitoring Systems: Barriers and Beyond – Overview Report*. Prepared for the U.S. Environmental Protection Agency Office of Solid Waste and Emergency Response Technology Innovation Office. March 1999.

Pugh, J.D., D.W. Morris, and J.C. Redwine, 2012. U.S. Patent 8,157,476: In situ Systems and Methods for the Immobilization of Contaminants. Original Assignee: Southern Company Services, Inc. April 2012.

Redwine, J.C., J.R. Howell, R.J. Donahoe, and L. Yang, 2004. "In situ Chemical Fixation of Arsenic in Soil: Laboratory and Field Results." In: *Proceedings, Air and Waste Management Association 97th Annual Conference and Exhibition, Indianapolis, Indiana*.

Saunders, J.A., 1998. In-situ Bioremediation of Metal-Contaminated Groundwater, U.S. Patent No. 5,833,855.

Southern Company Services, 2017. *Closure Plan for Existing CCR Surface Impoundment. Plant Gorgas Ash Pond*. October 2017.

Southern Company Services, 2018a. *Facility Plan for Groundwater Investigation, Plant Gorgas Ash Pond*. October 2018.

Southern Company Services, 2018b. *2017 Annual Groundwater Monitoring and Corrective Action Report*. Plant Gorgas Ash Pond. January 2018.

USEPA (U.S. Environmental Protection Agency), 1996. *Pump-and-Treat Groundwater Remediation: A Guide for Decision Makers and Practitioners*. EPA 625/R-95/005, July 1996.

USEPA, 1998. *Evaluation of Subsurface Engineered Barriers at Waste Sites*. EPA 542-R-98-005, August 1998.

USEPA, 1999. *Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites*. EPA/OSWER No. 9200.4-17P, Office of Solid Waste and Emergency Response, Washington D.C.

USEPA, 2000. *In Situ Treatment of Soil and Groundwater Contaminated with Chromium*. Technical Resource Guide. EPA-625/R-00/005. October 2000.

USEPA, 2007a. *Monitored Natural Attenuation of Inorganic Contaminants in Ground Water. Volume 1– Technical Basis for Assessment*. EPA/600/R-07/139. October 2007.

USEPA, 2007b. *Monitored Natural Attenuation of Inorganic Contaminants in Ground Water. Volume 2. Assessment for Non-Radionuclides Including Arsenic, Cadmium, Chromium, Copper, Lead, Nickel, Nitrate, Perchlorate, and Selenium*. EPA/600/R-07/140. October 2007.

USEPA, 2014. "Dense Nonaqueous Phase Liquids (DNAPLS) Treatment Technologies: Containment." Updated: September 8, 2017. Accessed September 29, 2017. Available at: http://www.cluin.org/contaminantfocus/default.focus/sec/dense_nonaqueous_phase_liquids_(dnapls)/cat/Treatment_Technologies/p/2.

USEPA, 2015. *Use of Monitored Natural Attenuation for Inorganic Contaminants in Groundwater at Superfund Sites*. U.S. Environmental Protection Agency Office of Solid Waste and Emergency Response Directive 9283.1-36. August 2015.

USEPA, 2016. *Resource Conservation and Recovery Act Facilities Investigation Remedy Selection Track: A Toolbox for Corrective Action*. May 20, 2016.

USGS (U.S. Geological Survey), 2018a. Goodsprings Alabama Quadrangle, 7.5 Minute Series Topographic Map.

USGS, 2018b. Gilmore Alabama Quadrangle, 7.5 Minute Series Topographic Map.

Wani, S.B., 2015. Presentation on Grouting in Soils. January 18. Available at: https://www.slideshare.net/shoaibwani/grouting-in-soils.

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:

Source: Southern Company Services, 2018. *Plant Gorgas Ash Pond, Facility Plan for Groundwater Investigation.*

GW: groundwater

MSL: mean sea level

Table 2
Groundwater Monitoring Network Details

Well Name	Installation Date	Northing	Easting	Ground Elevation	Top of Casing Elevation	Top of Screen Elevation	Bottom of Screen Elevation	Purpose
GS-AP-MW-2	03/10/2016	1321951.860	2067629.250	518.77	522.03	329.770	309.770	Downgradient
GS-AP-MW-6S	01/19/2016	1324533.130	2063864.630	271.57	274.67	237.570	227.570	Downgradient
GS-AP-MW-6D	01/18/2016	1324547.480	2063881.960	271.39	274.50	220.390	210.390	Downgradient
GS-AP-MW-7	01/26/2016	1324250.980	2063518.480	310.05	313.45	223.050	213.050	Downgradient
GS-AP-MW-8	02/26/2016	1323405.230	2062398.470	431.63	434.61	390.630	370.630	Upgradient
GS-AP-MW-9	04/22/2016	1322446.730	2062720.100	417.06	420.04	329.060	309.060	Downgradient
GS-AP-MW-11	02/4/2016	1320953.140	2063257.730	465.34	468.34	348.840	328.840	Downgradient
GS-AP-MW-12	04/20/2016	1320369.190	2063836.900	447.48	450.67	307.480	297.480	Upgradient
GS-AP-MW-13	02/4/2016	1319377.840	2064083.370	461.03	464.20	371.030	351.030	Downgradient
GS-AP-MW-14	01/30/2016	1318393.750	2063787.880	469.60	472.40	279.600	269.600	Downgradient
GS-AP-MW-15	02/8/2016	1317267.070	2063959.210	452.21	454.89	272.210	262.210	Downgradient
GS-AP-MW-16D	04/20/2016	1316152.700	2064850.230	459.09	462.27	259.090	239.090	Downgradient
GS-AP-MW-17	02/11/2016	1314955.860	2066094.140	528.78	531.88	295.280	285.280	Downgradient
GS-AP-MW-18	03/29/2016	1315052.820	2066824.840	400.17	403.39	320.170	300.170	Downgradient
GS-AP-MW-19	04/29/2016	1316325.430	2066775.980	492.60	495.58	337.600	317.600	Downgradient
GS-AP-MW-21	02/20/2016	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 (ft MSL).

Source: Southern Company Services, 2019. *Plant Gorgas Ash Pond, 2018 Annual Groundwater Monitoring and Corrective Action Report.*

Table 3
Plant Gorgas GWPS

Constituent Name	Units	Ash Pond GWPS	Gypsum Pond GWPS
Antimony	mg/L	0.006	0.006
Arsenic	mg/L	0.01	0.01
Barium	mg/L	2	2
Beryllium	mg/L	0.004	0.007
Cadmium	mg/L	0.005	0.005
Chromium	mg/L	0.1	0.1
Cobalt	mg/L	0.006	0.006
Combined Radium 226+228	pCi/L	5	5
Fluoride	mg/L	4	4
Lead	mg/L	0.015	0.015
Lithium	mg/L	0.04	0.276
Mercury	mg/L	0.002	0.002
Molybdenum	mg/L	0.1	0.1
Selenium	mg/L	0.05	0.05
Thallium	mg/L	0.002	0.002

Notes:

Source: Southern Company Services, 2019. *Plant Gorgas Ash Pond, 2018 Annual Groundwater Monitoring and Corrective Action Report.*

Table 4
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
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
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 from Unit 3 aquifer
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 7
Technology Advantages and Disadvantages

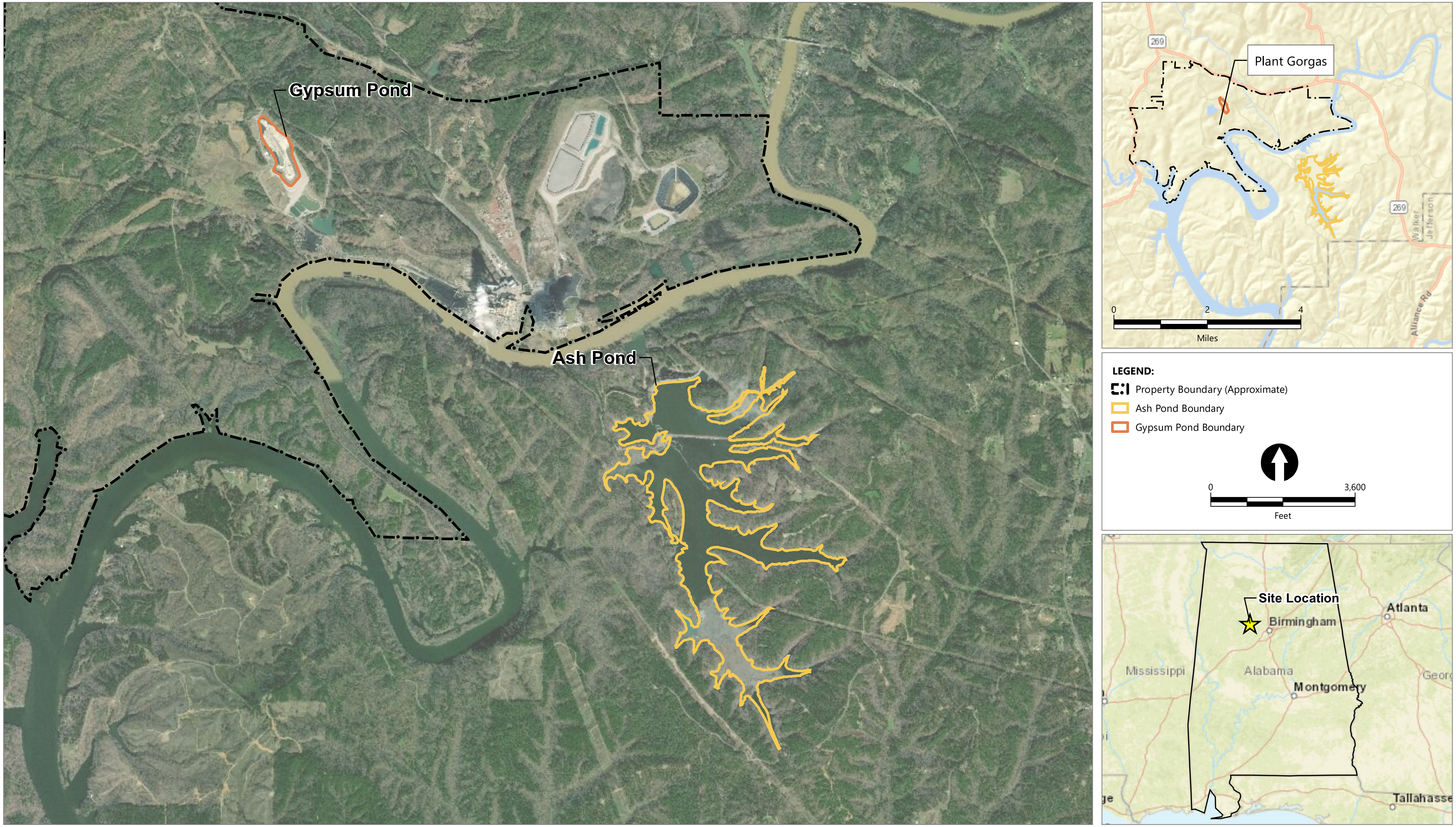
Technology	Advantages (After EPRI 2015)	Disadvantages (After EPRI 2015)
MNA	• Minimal site disruption • Sustainable • Applicable in congested, sensitive or less accessible areas where other technologies may not be feasible	• Other treatment technologies may be required
Hydraulic Containment (pump-and-treat)	• Existing onsite water treatment plant • 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	• 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 8
Schedule

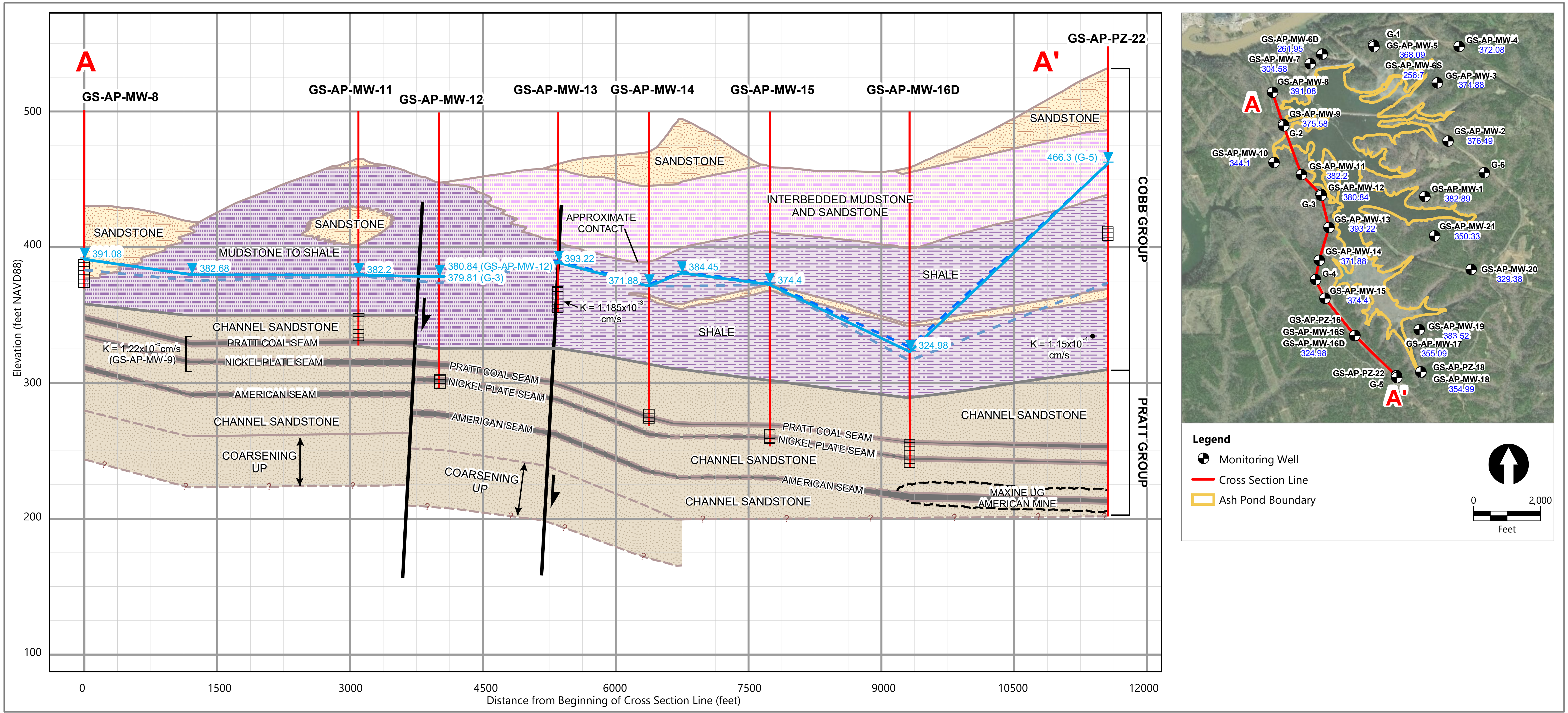
Number	Task	Estimated Completion Date
1	Field Studies and Data Collection	June 2019 – May 2020
2	Groundwater Flow and Geochemical Modeling	June 2019 – May 2020
3	Bench Testing and Pilot Studies	October 2019 – September 2020
4	Preliminary Conceptual Design	October 2020 – March 2021

Figures



Publish Date: 2019/06/12, 10:54 AM | User: alesueur
Filepath: \\orcas\gis\Jobs\SouthernCompany_1114\PlantGorgas\Maps\2019_04_ACM\AQ_PlantGorgas_Fig01_SiteLocationMap.mxd

Figure 1
Site Location Map
Assessment of Corrective Measures
Alabama Power Company - Plant Gorgas



Cross-Section Legend

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

NOTES:

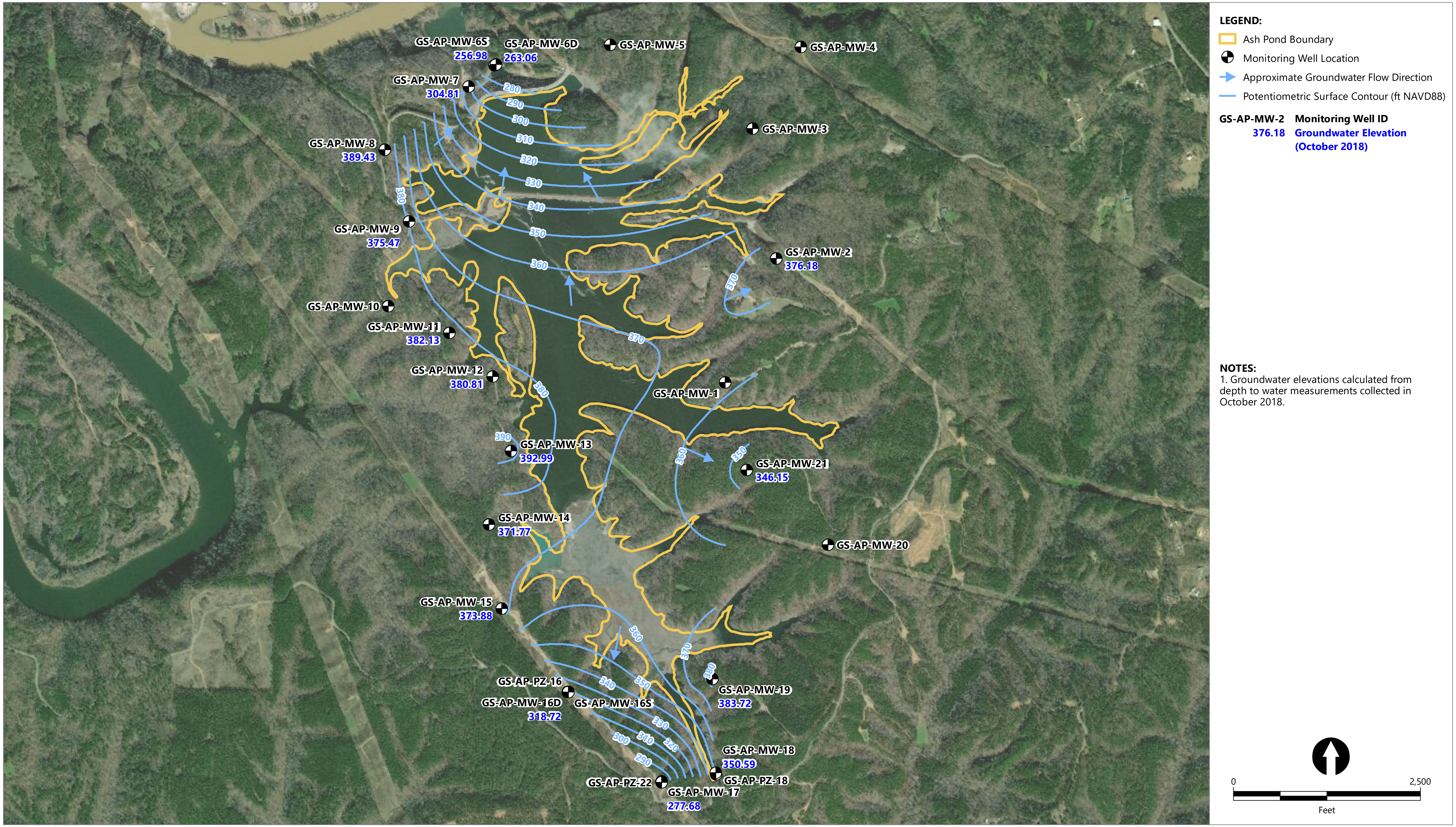
1. Stratigraphic layers were correlated using a combination of boring data and gamma logs.
2. Approximate Groundwater Elevation data are reported using North American Vertical Datum of 1988 (NAVD88).
3. Approximate groundwater elevation data was collected from CCR network wells on May 14, 2018 and from 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.

Publish Date: 2019/06/11, 9:45 AM | User: alesueur
Filepath: \\orcas\gis\Jobs\SouthernCompany_1114\PlantGorgas\Maps\2019_04_ACM\AQ_PlantGorgas_Fig02_GeologicXsection_A.mxd

Figure 2

Geologic Cross-Section A – A'

Assessment of Corrective Measures
Alabama Power Company - Plant Gorgas



NOTES:

1. Groundwater elevations calculated from depth to water measurements collected in October 2018.

Publish Date: 2019/06/12, 11:14 AM | User: alesueur
Filepath: \\orcas\gis\Jobs\SouthernCompany_1114\PlantGorgas\Maps\2019_04_ACM\AQ_PlantGorgas_Fig03_PotentiometricSurface.mxd

ANCHOR QEA

Figure 3

Typical Ash Pond Potentiometric Surface Map

Assessment of Corrective Measures
Alabama Power Company - Plant Gorgas

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

Publish Date: 2019/06/12, 11:12 AM | User: alesueur
Filepath: \\orcas\gis\Jobs\SouthernCompany_1114\PlantGorgas\Maps\2019_04_ACM\AQ_PlantGorgas_Fig04_GypsumPond_PotentiometricSurface.mxd

ANCHOR QEA

Figure 4
Typical Gypsum Pond Potentiometric Surface Map

Assessment of Corrective Measures
Alabama Power Company - Plant Gorgas