PLANT BARRY HYDROGEOLOGIC CONDITIONS SUMMARY

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This document is based on a review of publicly available documents: Alabama Power Company Plant Barry 2017 and 2018 Annual Groundwater Monitoring and Corrective Action Reports; Alabama Power Ash Pond History of Construction Report; Alabama Power Initial Safety Factor Assessment; Mobile Baykeeper Pollution Report: Coal Ash at Alabama Power's Plant Barry; and other available scientific reports, maps, and well data.

To begin, if Alabama Power and regulatory authorities knew in 1965 what we know now, coal ash would not have been disposed and stored in its present location. However, with current conditions, consideration must be given to available options to contain and neutralize the material. Whether the material is capped in place or excavated and moved, containment of the coal ash and its chemical constituents depends on a combination of natural hydrogeologic characteristics and engineered structures. Cook Hydrogeology, LLC, evaluated available data at and around the current Plant Barry Coal Ash Disposal Pond to characterize hydrogeologic conditions in the area that determine, in part, the hazard risk associated with the current coal ash disposal area.

Three primary hydrogeologic issues have been publicized, related to the Plant Barry coal ash disposal pond. First, is the material isolated from the surrounding surface-water and groundwater environment? Isolation means that hydrogeologic characteristics of the area around and under the ash disposal pond will keep it and its chemical constituents from migrating beyond the pond. Second, will future migration of the Mobile River channel threaten the coal ash pond? Third, will combinations of rising sea level, upstream flooding, and severe tropical storms cause catastrophic flooding that will threaten the ash pond?

To address the issue of isolation, stratigraphic characterization and lithologic composition are logical starting points for an evaluation of hydrogeology of the area. Plant Barry and the ash pond is underlain by two primary geologic units. The Miocene undifferentiated is about 600 feet thick under Plant Barry and is composed of alternating sand and clay of marine and estuarine origin. This unit is the primary aquifer for Baldwin County and much of rural Mobile County. Overlying the Miocene are alluvial, coastal, and low terrace deposits of Holocene age. These are fine to coarse grained sand layers with occasional gravel, interbedded with clay. This unit varies in thickness from 50 to 150 feet and is also termed the alluvial or water course aquifer. It provides domestic and irrigation water supplies in rural areas along major rivers, including the Mobile River. Underlying the ash pond, are clay and silty and sandy clay layers that form confining layers that overlie the alluvial aquifer. The 2017 Annual Groundwater Monitoring and Corrective Action Report states: "*Around the site, the uppermost stratigraphic layer varies from approximately 5 to 20 feet and is defined as fill material composed of sandy and silty lean clays that were placed during the construction of the ash pond*". However, subsequent investigations show that clay layers underlying the pond are from 4 to 28 feet thick and are natural, deposited as part of the alluvial, coastal, and low terrace deposits unit. Additional public statements by Alabama Power officials, based on consultant characterization, termed the ash and included water in the ash pond a "perched aquifer". This is a misstatement due to the fact that the definition of an aquifer is "*a geologic unit that can store and transmit water at rates fast enough to supply reasonable amounts to wells*" (Fetter, 1994) or "*a saturated, permeable geologic unit of sediment or rock that can transmit significant quantities of water under hydraulic gradients*"

(Glossary of Landforms and Geologic Terms, 2008). The ash pond is actually a surface-water impoundment and coal ash is not a geologic unit. Therefore, the term "perched aquifer" does not accurately describe hydrogeologic conditions in the coal ash pond.

Miocene and alluvial sediments in the Plant Barry area are aquifers that provide water to wells. Records for three domestic wells and one public water supply well, constructed in the Miocene aquifer were found within two miles of the Plant Barry coal ash pond. However, static water levels in the wells show that the screened intervals are highly confined and protected from surface contamination.

Since coal ash is soluble and chemical constituents in the ash are mobilized in water, key elements related to isolation of the coal ash are the lateral direction of groundwater movement and downward movement of water and contaminants through the bottom of the pond into the alluvial aquifer. The Mobile Baykeeper report (section 4.3) states "*groundwater generally flows outward in all directions from the coal ash pond.*" This is a false statement as shown in multiple potentiometric surface maps constructed from a network of monitor wells constructed in the alluvial aquifer around the perimeter of the coal ash pond. As expected, groundwater flows towards the Mobile River. There is no flow in the opposite direction from the River. The hydraulic gradient is 0.0003, which is low, meaning that the velocity of lateral water movement is relatively slow (Alabama Power 2018 report shows flow velocity=2.92 feet /year). Therefore, in regard to groundwater, coal ash contaminants are isolated inside the river meander that contains the coal ash pond.

Downward movement of water containing contaminants in the ash pond is a more complex issue, related to the magnitude of downward force on underlying confining layers and continuity of confining layers under the ash pond. The Mobile Baykeeper report (section 4.3) states "*In the vicinity of the ash pond, there are two major aquifers, the alluvial coastal aquifer, which is of Holocene age, and the Miocene and Pleistocene aquifer. These aquifers are regionally important as they are unconfined, which means groundwater is in direct contact with the atmosphere through open pore spaces of soil or rock. They are considered to be highly susceptible to contamination because they are hydraulically connected to surface water and each other.*" This is a false statement as shown by static water levels collected from a network of monitoring wells around the perimeter of the ash pond as well as other wells in the area. Hydraulic head values in 16 monitoring wells, measured in January 2018, ranged from 13.97 to 55.70 feet, indicating that the alluvial aquifer underlying the ash pond is confined. Other wells in the area, constructed in the Miocene aquifer, have hydraulic head values of 33 to 205 feet, indicating that the Miocene aquifer is confined.

Chemical analyses have shown that arsenic and other metals are present in water samples from the alluvial aquifer under the ash pond. Detected contamination results from the downward pressure of saturated coal ash and free water in the ash pond on confining layers overlying water-bearing sands in the alluvial aquifer in areas where the confining layer is thin or the lithologic composition of the confining layers has a large volume of silt or sand.

Isolation of coal ash and included contaminants also includes lateral migration. If the containment dike around the perimeter of the ash pond is not an impermeable barrier, contaminants may move laterally into adjacent surface-water bodies, including the Mobile River. A number of investigations of the ash pond containment dike have been performed over the years, including borings to characterize the lithologic character of the dike material. However, it is beyond the scope of this assessment to evaluate the containment dike.

The second issue is the potential for migration of the Mobile River channel, that would impact Plant Barry and the coal ash pond. The Mobile River is an old age, meandering stream with fluvial features such as meanders, cut banks, point bars, and oxbow lakes that indicate lateral migration of the river channel over geologic time. The Plant Barry ash pond is located on a bend of the river inside the meander belt. However, cut banks on either side of the Plant Barry facility are 1.7 miles apart. Any potential channel cutoff and relocation of the river channel, that would threaten the pond, would occur in a geologic time scale. But more importantly, the pond is located on a point bar, with a cut bank on the opposite side of the river, which means that the river channel is migrating eastward, away from the pond.

The third issue is flooding and erosion of material in the pond. The current dike surrounding the coal ash pond is built to a height of 21.5 feet above mean sea level (amsl). The 100-year flood elevation (one percent chance of occurrence in any year) at the site is 16 feet amsl and the flood of record at Plant Barry was 18.19 feet amsl in 1961. The dike was designed to protect from a 1,000-year 24-hour storm rainfall event in the pond area. However, the Mobile River level at Plant Barry responds to tidal influx and the Gulf of Mexico area is in a period of sea-level rise. Therefore, in the future, combinations of high tide with higher sea level, major upstream rainfall, and a major tropical storm could cause catastrophic flooding of the Mobile River. No modeling has been performed to simulate these catastrophic conditions. It is recommended that Alabama Power perform modeling to simulate multiple flood scenarios to estimate river levels and flow velocities at Plant Barry and the coal ash pond. These simulations will inform decisions related to plans for pond closure.

The Alabama Power Company Plant Barry Ash Pond Closure Plan describes closure of the ash pond in place by encapsulation. The plan relies on a combination of natural hydrogeologic characteristics with engineered solutions to ensure that the ash and its contaminants remain in place in a modified version of the existing pond. The only issue addressed in this document is prevention of downward movement of contaminants into underlying groundwater bearing geologic units. Most other issues are related to engineered structures that encapsulate the ash and are beyond the expertise of this investigator to evaluate.

Chemical constituents in the ash are mobilized by water. The primary current hydrogeologic threat is that saturated coal ash and free water in the pond cause downward hydraulic pressure that forces contaminants through the underlying aquiclude. A major component of the closure plan is to dewater the ash prior to encapsulation. Dewatering will accomplish two major goals of pond closure. First, ash with low water content prevents mobilization of contaminants. Secondly, downward hydraulic pressure on the underlying aquiclude is relieved, preventing downward movement of water and contaminants. However, when this downward pressure is relieved, the confined aquifer below the aquiclude will exert upward pressure, threatening the integrity of the aquiclude and dewatered ash. Therefore, the closure plan includes a number of relief wells that will remove water from the underlying alluvial aquifer, lowering the upward hydraulic pressure. Pumping will continue at a rate sufficient to maintain hydraulic equilibrium. If the dewatering plan is successful, migration of contaminants into the groundwater will be prevented.

Conclusions are that the location of the Plant Barry ash pond is less than desirable, based on current environmental standards. Whether excavated and moved or encapsulated in place, the goal is to isolate the material from the surrounding environment. In its current location, isolation depends on the ability of the dike around the pond to prevent lateral movement of contaminants into the Mobile River and to prevent flooding that would mobilize the ash and contaminants into

the river. It also depends on the ability of clay layers under the pond to prevent downward movement of contaminants into underlying water-bearing units. The coal ash pond position near the Mobile River limits migration of coal ash contaminants. Based in a review of available hydrogeologic information, the material and its included contaminants are hydrogeologically isolated, except for small concentrations of contaminants that have migrated through the underlying clay layers. However, as part of the closure plan, dewatering the ash will eliminate hydraulic head in the pond and will alleviate mobilization and downward migration of contaminants.

Mobile River channel migration and the potential for cutoff channel relocation through the Plant Barry facility and coal ash pond is not feasible due to current river meander and flow patterns. In actuality, the river channel is most likely migrating eastward away from Plant Barry facilities.

Although the chance of occurrence of a catastrophic flood on the Mobile River at Plant Barry is small, results of erosion and transport of coal ash from the containment pond warrants additional evaluation. Modeling of potential catastrophic flooding events is recommended to ensure that closure plans account for future river flow scenarios. However, prevention of flooding will require engineered solutions that were not evaluated in this document.

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