Prepared for

Santee Cooper Power
1 Riverwood Drive
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LOCATION RESTRICTIONS COMPLIANCE DEMONSTRATION

CLASS THREE LANDFILL
CROSS GENERATING STATION
PINEVILLE, SOUTH CAROLINA

Prepared by

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Certification Statement – Demonstration of Compliance with Location Restrictions

Federal CCR Rule: 40 CFR §257.64

CCR Unit: Class Three Landfill at Cross Generating Station

Certification:

This Location Restrictions Compliance Demonstration was prepared in accordance with current practices and the standard of care exercised by scientists and engineers performing similar tasks in the field of civil engineering, and no other warranty is provided in connection therewith. Consistent with applicable professional standards of care, our opinions and recommendations were based in part on data furnished by others. The information contained in this report is intended for use solely by Santee Cooper and their subconsultants.

In my professional opinion, the CCR Unit design considered unstable conditions at the site and selected recognized and generally accepted good engineering practices capable of mitigating said conditions. Therefore, it has been demonstrated to be in compliance with the United States Environmental Protection Agency (USEPA) minimum location restriction requirements for the siting criteria of 40 CFR §257. 64 for existing coal combustion residuals (CCR) landfills.

SOUTH CAROLINA PROFESSIONAL ENGINEER LICENSED No. 32067 CARLOS FABIAN BENAVENTE

SOUTH CAROLINA GEOSYNTEC CONSULTANTS, INC. No. 773 CERTIFICATE OF AUTHORIZATION

Seal and Signature: __________ Firm Seal

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PE License Number: 32067 State: South Carolina

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1. INTRODUCTION

Geosyntec Consultants (Geosyntec) prepared this *Location Restrictions Compliance Demonstration* (Report) on behalf of the South Carolina Public Service Authority doing business as (d.b.a.) Santee Cooper (Santee Cooper). The compliance demonstration pertains to the coal combustion residuals (CCR) unit referred to as the Class Three Landfill at the Cross Generating Station (CGS) located in Pineville, South Carolina (SC).

On 17 April 2015, the United States Environmental Protection Agency (USEPA) promulgated the federal CCR Rule that establishes national minimum criteria for existing and new CCR landfills and surface impoundments. The Class Three Landfill is subject to the CCR Rule as an existing landfill as defined in 40 Code of Federal Regulations (CFR) §257.53, and as such the owner or operator is to demonstrate whether the CCR unit complies with the location restriction requirements under 40 CFR §257.64 and place appropriate documentation within the site's Operating Record. This Report serves as the location restrictions demonstration for the Class Three Landfill at CGS.

1.1 Facility Location

CGS is a coal-fired electric generating facility with four generation units and is located at 533 Cross Station Road, Pineville, SC 29468. CGS is owned and operated by Santee Cooper. CGS is located approximately five miles southwest of the city of Pineville, Berkeley County, SC, and is accessed via SC Hwy 45 (Trojan Road) to Viper Road. CGS is located along a diversion canal that connects Lake Marion to Lake Moultrie from northwest to the southeast within the property boundary. A general site vicinity map is presented on Figure 1. CGS includes an approximately 513-acre parcel utilized for station operations and an adjacent approximately 1,720-acre parcel which contains CCR ponds, two CCR landfills, and undeveloped forest land.

The Class Three Landfill is an existing CCR landfill located immediately adjacent to the eastern and western slopes of the closed Class Two Landfill as shown on Figure 2. The east and west slopes and the top deck of the Class Two Landfill are covered with a high-density polyethylene (HDPE) liner capable of serving as the bottom liner for the Class Three Landfill. The Class Three Landfill consists of four lined cells with a geocomposite drainage net and sand drainage layer. Cell 1B-1 is the only operational cell of the Class Three Landfill at this time. Placement of CCR into the landfill began in December 2015.

1.2 Previous Investigations and Reports

For numerous projects, Santee Cooper implemented subsurface investigations at the CGS to collect geologic, hydrogeologic, and geotechnical data, several of which collected data within and directly adjacent to the Class Three Landfill footprint. This Report was prepared and is supported by the detailed information contained within the following reports:

- *Final Report Cross Generating Station,* Law Engineering Testing Company, 9 February 1978;
- *Final Report Unit 1 Generating Station*, Woodward-Clyde Consultants, 26 January 1981;
- *Site Hydrogeologic Characterization Report*, Cross Generating Station Proposed Class Three Landfill, October 2011, prepared by Garrett & Moore; and
- *Landfill Siting Study*, Cross Generating Station, Pinewood, South Carolina, April 2016, prepared by Garrett & Moore.

1.3 Site Geology and Hydrogeology

The lithostratigraphic units at the CGS, in descending order, include Holocene sediments, the Wicomico Formation, the Raysor Formation, Santee Limestone and the Black Mingo Group.

Holocene sediments are sparsely distributed at CGS and consist typically of loose, silty or clayey fine sand with abundant organic material. "Wicomico sediments encountered at the CGS are predominantly soft, clayey sands and sandy clays varying in texture from fine to coarse and range in thickness from approximately 12 to 39 feet. The sandy clay and clayey sand are interbedded with silty fine to coarse sand and localized clay and relatively clean sand. The sandy clay, silty sand and clay beds are of variable thickness and discontinuous and appear to transition laterally and vertically into clayey sand" (Garrett & Moore, 2011). The Raysor Formation sediments are discontinuous at CGS and are generally, unconsolidated to partially indurated, shelly, fine to medium sand (calcarenite). In general, the Raysor Formation sediments are relatively dense; however, some soft zones were encountered during drilling and vary in thickness from approximately 5 to 17 feet.

The Santee Limestone encountered at the CGS consists of a variably weathered crystalline, soft to hard, medium to light gray, shelly to muddy limestone. Rock Quality Designation (RQD) values of recovered rock cores varied considerably from 0 to 96 percent, with most values falling in the range of approximately 0 to 60 percent. In general, lower RQD values were observed near the top and bottom of the geologic unit, while a basal gray to greenish gray, shelly, silty to clayey, fine to medium sand layer was observed within many soil borings. The thickness of the Santee Limestone ranges from approximately 10 to 60 feet. The basal sand layer was likely reworked from the underlying greenish gray, silty sand of the upper Black Mingo Group sediments during initial deposition of the Santee Limestone.

The surficial aquifer at CGS is unconfined and includes the saturated sediments of the Wicomico Formation and the underlying Raysor Formation. Groundwater recharge to the surficial aquifer occurs via direct precipitation infiltration. Hydrogeological characterization at CGS did not provide evidence of a laterally continuous, definable confining unit that separates the surficial aquifer from the underlying Santee Limestone. "Consequently, the surficial aquifer is directly hydraulically connected to the underlying regional Santee Limestone aquifer" (Garrett & Moore, 2011).

Sinkholes (karst) are natural geologic features that occur in areas underlain by limestone and other types of soluble rock. Limestone is susceptible to dissolution from the percolation of slightly acidic groundwater. Limestone composition also controls dissolution and cavity development. Pure limestone is more easily dissolved by natural waters; however, the presence of impurities (such as quartz sand and clay) within the rock will reduce and limit the rate of dissolution.

The type of sinkhole that may develop in a given area is largely controlled by the geology and hydrogeology at a specific site. Limestone, like most bedrock, generally lies beneath unconsolidated material such as sand and clay. The variable thickness and composition of the overlying soil is important in sinkhole development. There are three general types of sinkholes: solution sinkholes, cover-subsidence sinkholes, and soil-collapse sinkholes. Conditions at CGS are most conducive to the formation of cover-subsidence sinkholes.

Cover-subsidence sinkholes occur where the overlying soil is relatively incohesive and permeable and individual grains of sand move downward in sequence to replace grains that have themselves moved downward to occupy space formerly held by the dissolved limestone. In areas where the overlying sand soils are 50 to 100 feet thick, subsidence sinkholes generally are only a few feet in diameter and depth. Where the limestone is buried beneath a sufficient thickness of unconsolidated material, few sinkholes generally occur. Spalling of sand into solution cavities that have developed along joints in the limestone may cause subsidence due to upward migration of the cavities (a process known as piping) to form cylindrical holes at the land surface. If the overburden is non-cohesive sand, the upward-migrating cavity is dissipated by a general lessening of density over a large area, and the result will be a relatively broad and extensive subsidence of the land surface that occurs over a period of time.

2. LOCATION RESTRICTIONS EVALUATION

As stated previously, the CGS Class Three Landfill is an existing CCR Landfill and is subject to 40 CFR §257.64, which is the location restriction with respect to unstable areas.

40 CFR §257.64(a) indicates that existing landfills "*must not be located in an unstable area unless the owner or operator demonstrates… that recognized and generally accepted good engineering practices have been incorporated into the design of the CCR unit to ensure that the integrity of the structural components of the CCR unit will not be disrupted.*" An unstable area is defined as "*a location that is susceptible to natural or human-induced events or forces capable of impairing the integrity, including structural components of some or all of the CCR unit that are responsible for preventing releases from such unit. Unstable areas can include poor foundation conditions, areas susceptible to mass movements, and karst terrains.*" To assess whether the Class Three Landfill is situated within an unstable area, the following conditions were evaluated:

- *On-site or local soil conditions that may result in significant differential settling;*
- *On-site or local geologic or geomorphologic features* (i.e., potential karst terrain)*; and*
- *On-site or local human-made features or events (both surface and subsurface).*

Historical subsurface investigations and reports indicate the following relevant information with respect to potential unstable areas in the vicinity of the Class Three Landfill:

- CGS is not situated in an area with geologic features or the potential for geomorphically-induced phenomena that could be indicators of susceptibility to mass movements (i.e., landslides, avalanches, debris slides and flows, soil flocculation, block sliding, rock falls, or excessive surface erosion).

- CGS is not situated in an area that is subject to excessive coastal or river erosion.
- CGS is not situated in an area of known subsurface mines, or in an area experiencing significant water or mineral withdrawal, nor do there appear to be evidence of other human-made features or man-induced events that could result in the downslope transport of soil and rock material that would make the CCR unit susceptible to mass movements or otherwise impair the integrity of the unit.
- CGS is not situated in an area where active faults have been observed.
- CGS is known to be situated in an area that may be classified as karst terrain.
- CGS and more specifically the Class Three Landfill may be underlain by weaker soil strata or soils that may experience loss in shear strength.

The last two points warrant further discussion to evaluate site-specific conditions and how they pertain to requirements of §257.64 for unstable areas.

2.1 Occurrence of Karst Features

The Santee Limestone formation at CGS was evaluated extensively during construction of the generating units and byproduct management facilities. Law Engineering and Testing (1978) and Woodward-Clyde Consultants (1981) reported the presence or indication of voids within the Santee Limestone and identified that aerial photography supported the presence of voids within the stratum. In addition, Law Engineering and Testing reported the "overall site topography has a hummocky appearance with numerous circular and elongate shallow depressions throughout the site." Ponded water was not initially observed in these depressions; however, Law Engineering and Testing noted the water presence subsequent with increased rainfall. Circular and elongate shallow depressions with a saucer-shaped were observed at CGS and direct evidence of soil raveling into voids in the underlying sediments was noted in several steep-sided, conical to elongate depressions observed.

Voids were commonly encountered in the Santee Limestone during extensive geotechnical drilling conducted at the site during initial plant design and construction. "Over 1,000 borings were drilled at the site for the geotechnical drilling program to support plant design and construction. Approximately 450 voids were encountered at approximately 400 boring locations, ranging from approximately 0.1 to 14 feet in thickness, with an average void thickness of approximately 2 feet (Garrett & Moore, 2011)."

2.2 Potential Development of Karst (Sinkhole) Features

The generalized lithology for CGS includes a varying thickness (up to 50 feet) of unconsolidated sediments (sands, silts and clays) overlying the Santee Limestone. This type of geologic setting is more likely to produce subsidence sinkholes through the mechanism where the cover material is relatively incohesive and permeable (unconsolidated Wicomico and Raysor Formation sediments) and individual grains of sand, silt and clay move downward in sequence to replace grains that have themselves moved downward to occupy space formerly held by the dissolved limestone.

Aquifer test data reported by Garrett & Moore (2011) indicate that the average (geometric mean) hydraulic conductivity from monitoring wells installed within Wicomico and Raysor Formations is 8.93×10^{-3} centimeters per second (cm/s) and 2.03×10^{-2} cm/s, respectively. The average hydraulic conductivity in monitoring wells installed in the Santee Limestone was reported as 1.16×10^{-3} cm/s. Hydrogeologic data also indicate that the surficial aquifer and the Santee Limestone are hydraulically connected with varying vertical hydraulic gradients (both upward and downward) that indicates a limited vertical flow component between the two aquifers. Limited vertical groundwater flow from the surficial aquifer will minimize the amount of dissolution. The horizontal gradients (0.001 to 0.002 feet/foot) and groundwater flow velocity (29.2 feet/year) reported by Garrett & Moore (2011), in the surficial aquifer (including the Santee Limestone) are also not conducive to the development of significant karst features in the Santee Limestone.

The lithology at the CGS indicates that a continuous low permeability layer (clay) is not present above the Santee Limestone and cohesion and strength of the overlying sediments controls whether the cover material subsides slowly or collapses. Therefore, cover-collapse karst features are not likely to occur at the CGS due to the lack of a continuous clay overlying the limestone and the observed hydraulic connection and similarity between the hydraulic conductivity in the unconsolidated sediments and the Santee Limestone.

Additionally, the composition of the Santee Limestone (Campbell and Coes, 2010), includes a significant amount (up to 25 percent) quartz sand and clay minerals that are not susceptible to dissolution. The presence of these non-soluble minerals will also limit the magnitude and extent of potential voids that could develop in the Santee Limestone.

Based on a review of the geologic and hydrogeologic data, the primary type of karst features that have occurred or are likely to occur at the CGS are cover-subsidence sinkholes. The lithology at the CGS indicates that a continuous low permeability layer (clay) is not present above the Santee Limestone and cohesion and strength of the overlying sediments controls whether the cover material subsides slowly or collapses. WorleyParsons considered the geologic data when designing the Class Three Landfill in accordance with recognized and generally accepted good engineering practices.

2.3 Foundation Conditions

The clarification letter submitted to SCDHEC on 21 January 2013 (WorleyParsons, 2013) presents analyses to address on-site or local conditions in and around the Class Three Landfill. A subsurface investigation was performed to "obtain a large amount of high-quality subsurface information over the entire Site and interpolate the data to provide a logical picture of the subsurface geometry and shear strength characteristic within each area of interest in order to ensure that the stability analyses are uniformly and consistently representative of the critical global scenario for each loading condition. The extensive soil data verifies and demonstrates the existence of uniform and predictable soil conditions." A full description of the tests performed is included in the clarification letter (WorleyParsons, 2013).

3. CONCLUSIONS

Geosyntec has reviewed the information associated with the Class Three Landfill for the purpose of determining compliance with location restrictions per 40 CFR §257.64. The CCR Unit design considered unstable conditions at the site and selected recognized and generally accepted good engineering practices capable of mitigating said conditions. Therefore, it has been demonstrated to be in compliance with the minimum location restriction requirements for the siting criteria of 40 CFR §257.64 for existing CCR landfills.

4. REFERENCES

Campbell, B.G., and Coes, A.L., eds., 2010. Groundwater Availability in the Atlantic Coastal Plain of North and South Carolina: U.S. Geological Survey Professional Paper 1773, 241 p., 7 pls.

Garrett & Moore, 2011. *Santee Cooper Cross Generating Station Proposed Class Three Landfill –Site Hydrogeologic Characterization Report.* 27 October 2011.

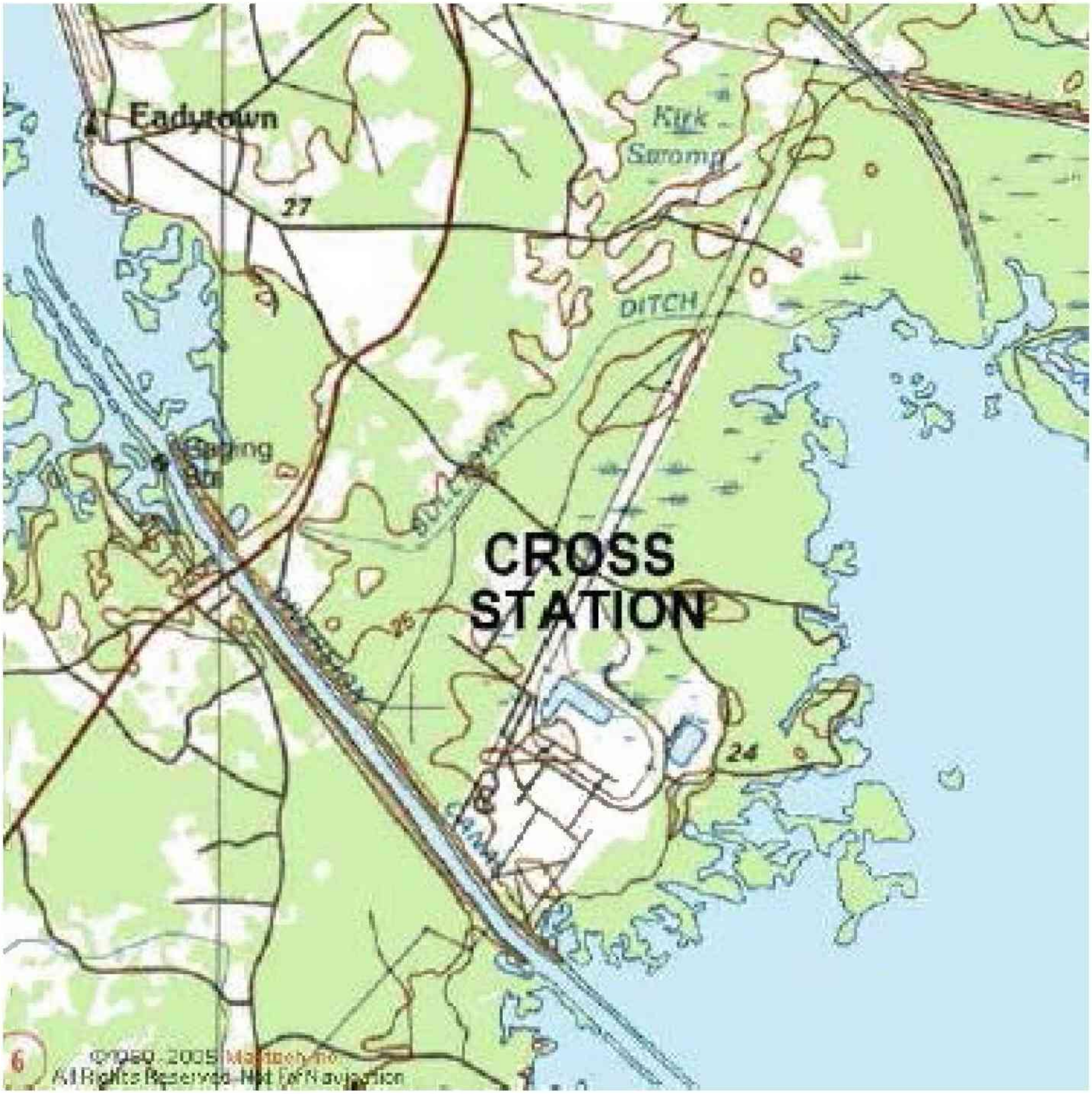
Garrett & Moore, 2011. *Santee Cooper Cross Generating Station Proposed Class Three Landfill – Landfill Siting Report.* 27 October 2011.

Law Engineering and Testing Company, 1978. Phase 2 Report, Cross Generating Station, Cross, South Carolina. Volume 2.

Woodward-Clyde Consultants, 1981. Unit 1 Subsurface Investigation, Cross Generating Station, Cross South Carolina. Volumes 1 and 2.

WorleyParsons Group, Inc., 2013. Clarification Letter Report to SCDHEC. 21 January.

FIGURES



Vicinity Map
Santee Cooper Cross Generating Station
Pinewood, South Carolina

Excerpt from Garrett & Moore, 2011. *Site Hydrogeologic Characterization Report*, Santee Cooper Cross Generating Station.

Geosyntec consultants

Santee Cooper

Figure 1

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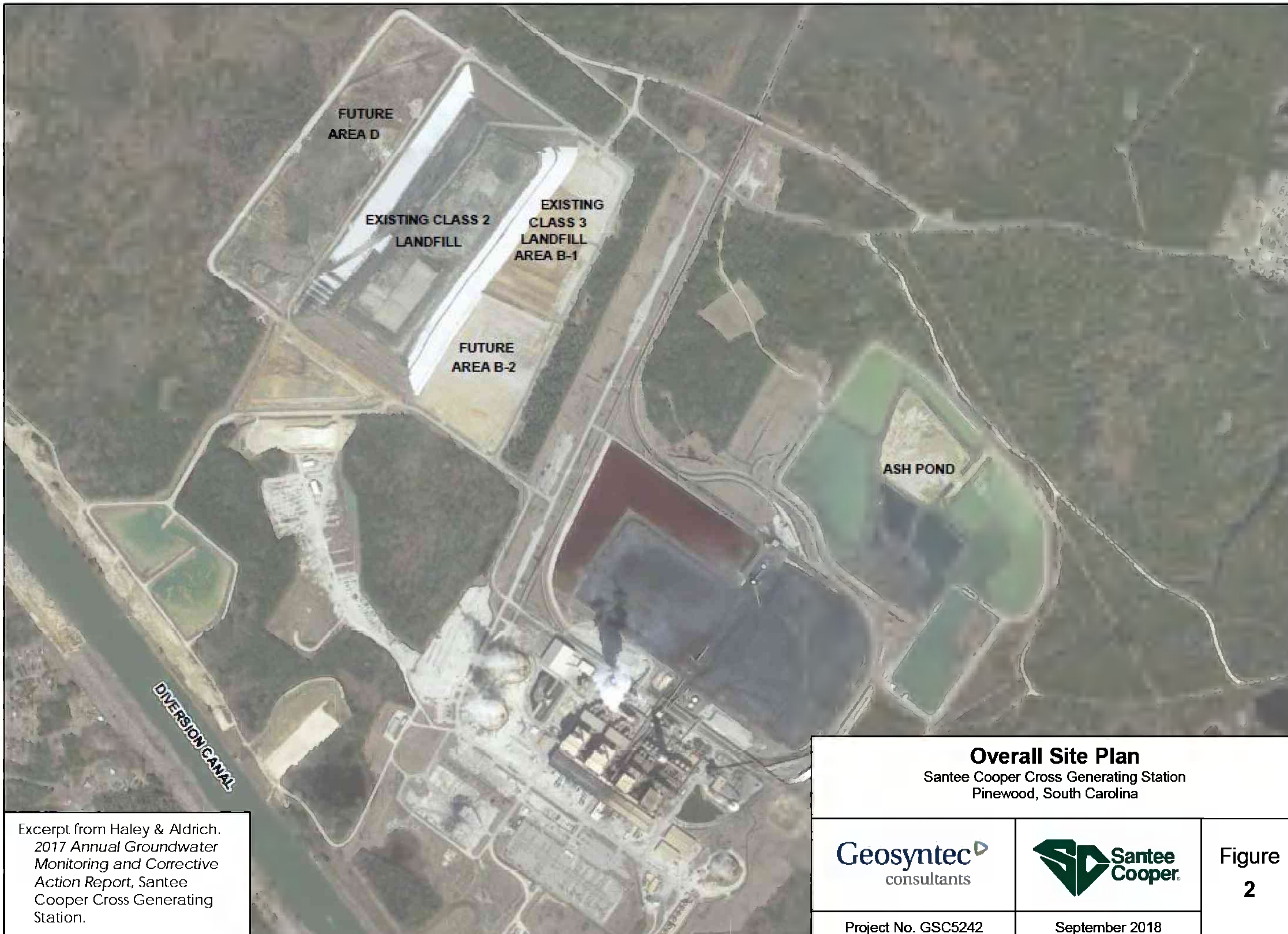

Excerpt from Haley & Aldrich. *2017 Annual Groundwater Monitoring and Corrective Action Report*, Santee Cooper Cross Generating Station.

Overall Site Plan
Santee Cooper Cross Generating Station
Pinewood, South Carolina

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