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CORRECTIVE MEASURES ASSESSMENT
SANTEE COOPER CLASS 2 LANDFILL
CROSS, SOUTH CAROLINA

by
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for
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Overview

This Corrective Measures Assessment (CMA) was prepared by Haley & Aldrich, Inc. (Haley & Aldrich) on behalf of South Carolina Public Service Authority (Santee Cooper) for the Class 2 Landfill at the Cross Generating Station (CGS; Site) located in Berkeley County near the communities of Cross and Pineville, South Carolina. The CMA was completed in accordance with requirements stated in the U.S. Environmental Protection Agency's (EPA) rule entitled *Hazardous and Solid Waste Management System; Disposal of Coal Combustion Residuals from Electric Utilities*. 80 Fed. Reg. 21302 (Apr. 17, 2015) (promulgating 40 CFR §257.61); 83 Fed. Reg. 36435 (July 30, 2018) (amending 40 CFR §257.61) (CCR Rule).

Assessment monitoring conducted in 2018 identified the presence of cobalt in one downgradient well (POZ-4) at a statistically significant level (SSL) exceeding the established groundwater protection standards (GWPS). In accordance with the CCR Rule update the EPA Regional Screening Level (RSL) for cobalt of 0.006 mg/L was established as the GWPS. As a result, and in accordance with the Rule, Santee Cooper initiated an evaluation of the horizontal and vertical nature and extent of cobalt downgradient of the Class 2 Landfill, including the installation of monitoring wells at the downgradient property line. Groundwater sampling from the newly installed monitoring wells showed that cobalt is confined to the uppermost aquifer and does not extend into the underlying bedrock unit (Santee Limestone). In addition, cobalt was detected in the shallow unconsolidated aquifer at the downgradient property line, on the opposite side of Bulltown Ditch from the Landfill, above the GWPS.

In performing this CMA, Haley & Aldrich considered the following: presence and distribution of cobalt, Class 2 Landfill configuration and closure, hydrogeologic setting, and the results of the evaluation of the nature and extent available at this time.

The Class 2 Landfill was certified closed on February 2017 under a South Carolina Department of Health and Environmental Control (SC DHEC) approved closure plan and post-closure care, which includes long-term groundwater monitoring. As a result, closure by removal is not considered in this CMA.

The remedial alternatives evaluated in this CMA include the following:

- Alternative 1: Landfill closure[1] plus monitored natural attenuation (MNA), which is currently being implemented under a SC DHEC approved groundwater monitoring program[2];
- Alternative 2: Landfill closure plus MNA with modifications to the existing closure to improve water management and reduce potential infiltration;
- Alternative 3: Landfill closure plus hydraulic containment with direct discharge;
- Alternative 4: Landfill closure plus hydraulic containment with ex-situ groundwater treatment; and,
- Alternative 5: Landfill closure plus in-situ groundwater treatment.

[1] The landfill has already been closed by installing a low-permeability geomembrane and clay cap and cover along with surface water controls for drainage and erosion protection.
[2] Cobalt, which is the focus of this corrective measures assessment, is not a constituent included in the SC DHEC-approved groundwater monitoring program.

These five alternatives were evaluated based on the threshold criteria provided in §257.97(b) of the CCR rule and then compared to three of the four balancing criteria listed in §257.97(c)(1) of the CCR Rule. The four balancing criteria consider:

1. The long- and short-term effectiveness and protectiveness of the potential remedy(s), along with the degree of certainty that the remedy will prove successful;
2. The effectiveness of the remedy in controlling the source to reduce further releases;
3. The ease or difficulty of implementing a potential remedy; and,
4. The degree to which community concerns are addressed by a potential remedy.

Balancing criteria number four, above (consideration of community concerns), cannot be evaluated until after a public meeting is held and public input is obtained. Accordingly, a remedy cannot be selected until thirty days after the public meeting is held.

The following observations regarding groundwater remedial alternatives for the Class 2 Landfill are provided below and described more fully in this report:

- **Landfill Cap and Hydrogeologic Conditions:** The Class 2 Landfill is closed, and precipitation infiltration is minimized by the very low-permeability landfill cap comprised of geomembrane and clay. The cap far exceeds the minimum criteria set forth in the CCR Rule and is referred to in this CMA as a "low permeability cap". With negligible vertical infiltration of precipitation through the CCR material within the landfill, leaching of CCR constituents to groundwater is significantly minimized.
- **Groundwater Compliance**: Because the landfill is permanently closed and capped, cobalt concentrations are expected to decline below the GWPS over time through the chemical, physical, and biological processes of natural attenuation that occur without human intervention. MNA is currently being implemented under a SC DHEC approved post-closure groundwater monitoring program. Additional, or supplemental, remedial alternatives are included in this document for consideration in addition to MNA.
- **Groundwater Treatment:** Laboratory testing will be required to demonstrate treatability of cobalt using either ex-situ methods, such as ion exchange, or in-situ treatment. Following laboratory-scale testing, pilot-scale treatment evaluations for cobalt would be required if such remedies were selected as part of the CMA process.

While Santee Cooper is addressing groundwater downgradient of the Class 2 Landfill under a SC DHEC approved post-closure groundwater monitoring program, to the extent necessary and appropriate and in accordance with §257.98 of the CCR Rule, Santee Cooper will also implement a groundwater monitoring program to document the effectiveness of the selected remedial alternative. Corrective measures are considered complete when monitoring reflects groundwater downgradient of the Class 2 Landfill has fallen to below Appendix IV GWPS for three consecutive years. The corrective measures alternatives evaluated in this CMA are based on the data available at this time. Weather events and lack of availability to qualified drilling subcontractors has delayed completion of the nature and extent determination and as a result, a portion of the data generated by that evaluation has not yet been processed or collected. Additional data will be evaluated as it becomes available and modifications to the CMA, as necessary and appropriate, will be considered at that time. If the additional data results in changes to the CMA prior to the Public Meeting, the CMA will be amended, placed in the operating record, and posted to the facilities CCR website.

In addition, EPA is in the process of modifying certain CCR Rule requirements and, depending upon the nature of such changes, assessments made herein could be modified or supplemented to reflect such future regulatory revisions. See *Federal Register (March 15, 2018; 83 FR 11584*).

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1. Introduction

Haley & Aldrich, Inc. (Haley & Aldrich) has prepared this Corrective Measures Assessment (CMA) on behalf of Santee Cooper for the Class 2 Landfill located at the Cross Generating Station (CGS) in Cross, Berkeley County, South Carolina (see Figure 1).

1.1 FACILITY DESCRIPTION/BACKGROUND

The CGS is an electric power generating station with four steam units which utilize coal as the primary fuel source. Santee Cooper currently owns the land and operates the station for supplying electric power to electric cooperatives throughout the state and to the industrial, commercial, and residential customers in its service territory.

The Class 2 Landfill was constructed in 1982 for disposal of Poz-o-Tec, a proprietary fixated mixture of FGD sludge, fly ash and lime; and gypsum filtrate pond sludge. Since the CGS was fitted with a forced oxidation scrubber system, the landfill was permitted to receive fixated fly ash, scrubber sludge, bottom ash material from the Cross Bottom Ash Pond, and some small amounts of ditch cleaning materials and alum sludge from the Regional Water Plant.

1.2 GROUNDWATER MONITORING

Haley and Aldrich prepared a Groundwater Monitoring Plan (GMP) as required by the CCR Rule. The GMP presents the design of the groundwater monitoring system, groundwater sampling and analysis procedures, and groundwater statistical analysis methods. For the Class 2 Landfill, three downgradient groundwater monitoring wells were installed along with two upgradient/background wells identified for the Site (see Figure 2). Well placement was determined based on interpretations of site-specific hydrogeology including groundwater flow direction and rate of groundwater movement and exceeds the CCR Rule requirement for at least one background monitoring well. The water quality of the upgradient/background wells is not impacted or affected by the CCR management units at the CGS. The groundwater monitoring well network for the Class 2 Landfill was designed to comply with the Rule by monitoring the uppermost aquifer at the CCR unit boundary.

Detection monitoring sampling events occurred in 2017. The results of the sampling events, summarized on Table 1 were compared to background, or natural groundwater values, using statistical methods to determine if Appendix III constituents downgradient of the Class 2 Landfill were present at concentrations above background, called statistically significant increases (SSI). The results of this analysis indicated SSIs for boron, calcium, chloride, sulfate, and total dissolved solids (TDS) in one or more downgradient well necessitating the establishment of an Assessment Monitoring Program and respective notification of the same. The location of the Appendix III SSI's is shown on Figure 3.

During the Assessment Monitoring phase, CCR groundwater samples were collected and subsequently analyzed for Appendix IV constituents. The results of the two Assessment Sampling rounds are summarized on Table 2. Statistical analysis of the assessment monitoring results indicated that cobalt exists at statistically significant levels (SSLs) above the GWPS, which was set as the EPA Regional Screening Level (RSL) for cobalt of 0.006 mg/L, at downgradient monitoring well POZ-4 as shown on Figure 4. Following the identification of an SSL for cobalt, an evaluation of the nature and extent of a potential release of cobalt was initiated as required by §257.95(g). A Corrective Measures Assessment was also initiated in accordance with §257.96.

1.3 CORRECTIVE MEASURES ASSESSMENT PROCESS

The CMA process involves identification of an array of groundwater remediation technologies that will result in the following threshold criteria: protection of human health and the environment, attainment of GWPS, source control, constituent removal, and compliance with standards for waste management. Once these technologies are demonstrated to meet these criteria, they are compared to one another with respect to long- and short-term effectiveness, source control, and implementability. Input from the community on such proposed measures will occur as part of a public meeting scheduled for September 2019.

1.4 RISK REDUCTION AND REMEDY

The CCR Rule in §257.97 (Selection of Remedy) at (b)(1) requires that remedies must be protective of human health and the environment. Further, at (c) the CCR Rule requires that in selecting a remedy, the owner or operator of the CCR unit shall consider specific evaluation factors, including the reduction in risk achieved by each of the proposed corrective measures. The evaluation factors listed below are those that consider risk to human health or the environment.

- (1)(i) Magnitude of reduction of existing risks;
- (1)(ii) Magnitude of residual risks in terms of likelihood of further releases due to CCR remaining following implementation of a remedy;
- (1)(iv) Short-term risks that might be posed to the community or the environment during implementation of such a remedy, including potential threats to human health and the environment associated with excavation, transportation, and re-disposal of contaminant;
- (1)(vi) Potential for exposure of humans and environmental receptors to remaining wastes, considering the potential threat to human health and the environment associated with excavation, transportation, re-disposal, or containment;
- (4) Potential risks to human health and the environment from exposure to contamination prior to completion of the remedy[3];
- (5)(i) Current and future uses of the aquifer;
- (5)(ii) Proximity and withdrawal rate of users; and
- (5)(iv) The potential damage to wildlife, crops, vegetation, and physical structures caused by exposure to CCR constituents.

[3] Factors 4 and 5 are not part of the CMA evaluation process as described in §257.97(d)(4), §257.97(d)(5)(i)(ii)(iv); rather they are factors the owner or operator must consider as part of the schedule for remedy implementation.

2. Groundwater Conceptual Site Model

The Site geology and hydrogeology was initially described in the *Site Hydrogeologic Characterization Report* prepared by Garrett & Moore in March 2012 and in the *Sampling and Analysis Plan* prepared by Santee Cooper in October 2013. This conceptual Site Model (CSM) has been updated to reflect information gathered during installation of the groundwater monitoring network and groundwater sampling to comply with the Rule.

2.1 SITE SETTING

The CGS is located north of the diversion canal that connects Lake Marion, northwest of the plant, to Lake Moultrie, southeast of the plant. The Site is located within the Lower Coastal Plain of the Atlantic Coastal Plain physiographic province in South Carolina between the Surry Scarp to the west and the Summerville Scarp to the east.

2.2 SITE TOPOGRAPHY

The Site is relatively flat with natural ground surface elevations varying from 79- to 83-feet above mean sea level (msl). Surface water runoff occurs via sheet flow to low lying areas surrounding the Site and into storm water drainage canals located adjacent to the primary and secondary roads and parking areas.

2.3 GEOLOGY AND HYDROGEOLOGY

In addition to the ongoing, recent deposition of fluvial sediments and organic matter in low-lying areas or streams, previous investigations have described four geologic units beneath the Site. From youngest to oldest these units include the Wicomico Formation, the Raysor Formation, the Santee Limestone, and the Black Mingo Group. The four geologic units encountered beneath the Site are described below for reference, with emphasis on the Wicomico Formation and the Raysor Formation, which make up the uppermost aquifer and, as required by the Rule, was the focus of the detection groundwater monitoring program. Beginning at ground surface and continuing downward from youngest to oldest, the geologic units beneath the site are described as follows:

Formation Name	Age	Hydrogeologic Unit	Description	Thickness in Feet
Wicomico Formation	Pleistocene	Uppermost Aquifer	Unconsolidated, upward-fining sequences of poorly sorted sand, silt, and clay deposited in a near-shore marine depositional setting that includes barrier island and back-barrier depositional environments. This depositional setting produces soil types that grade laterally and vertically from more sandy types to more clayey soil types.	12-23

Formation Name	Age	Hydrogeologic Unit	Description	Thickness in Feet
Raysor Formation	Pleistocene	Uppermost Aquifer	Unconsolidated or weakly cemented, discontinuous layer of sandy limestone that contains abundant weathered mollusk shells deposited in a shallow marine-shelf environment.	0-17
Santee Limestone	Eocene	Intermediate Aquifer	Thin highly weathered layer consisting of relatively dense partially indurated, shelly, fine to medium sand. This thin layer is underlain by a thick consolidated layer of variably weathered crystalline, soft to hard, medium to light gray, shelly to muddy limestone.	23-47
Black Mingo Group	Eocene	Lower Aquifer	These sediments are generally described as dark greenish gray sands with intervals of silty fine sand and silty clay.	100-125

The groundwater monitoring network for the Class 2 Landfill was developed based on information contained in the existing reports prepared by others and reviewed by Haley & Aldrich to monitor the uppermost aquifer up and downgradient of the Class 2 Landfill (see Figure 2). Hydrogeologic units are defined based on their ability to transmit groundwater or serve as confining units between zones of groundwater. The uppermost aquifer at CGS includes saturated sediments of the Wicomico and Raysor Formation (uppermost deposits). In the western portion of the site recharge to the uppermost aquifer occurs through direct surface infiltration as well as recharge from Lake Marion. Near the CCR unit, recharge to the uppermost aquifer occurs by direct surface infiltration. Groundwater discharge to surface water is interpreted to occur at the diversion canal to the south and Lake Moultrie to the northeast.

Piezometric data recorded from the existing on-site monitoring wells, as presented in Table 3, shows that the unconfined, uppermost aquifer is relatively flat and that variable recharge in the vicinity of storm water conveyances and retention areas can have a short-term effect on groundwater flow patterns. As shown in Figure 5, under equilibrium water table conditions, groundwater flow in the vicinity of the closed Class 2 Landfill is radial. Groundwater flow velocity in the uppermost aquifer is calculated to be approximately 30-feet per year. Under equilibrium groundwater flow conditions, groundwater flows away from areas where the elevation of the Santee Limestone is high into surrounding areas where the elevation of the top of the Santee Limestone is low, with the primary direction of baseline flow to be toward the west-northwest, north, and northeast.

2.4 GROUNDWATER PROTECTION STANDARDS

Haley and Aldrich completed a statistical evaluation of groundwater samples using the methods and procedures outlined in the Groundwater Monitoring Plan's *Statistical Data Analysis Plan* to develop site-specific GWPS for each Appendix IV constituent. For the CGS, background concentrations of Appendix IV constituents did not exceed either the Maximum Contaminant Level (MCL) or the Regional Screening Level (RSL) established by EPA as default GWPS. Accordingly, the MCL or the RSL (for those constituents that do not have a promulgated MCL) where used as GWPS.

2.5 CURRENT CONDITIONS/NATURE AND EXTENT OF GROUNDWATER IMPACTS

Assessment monitoring results were compared to the GWPS and cobalt was identified as the only Appendix IV constituent detected at statistically significant levels (SSL) above the GWPS. As a result, and in accordance with the Rule, Santee Cooper initiated an evaluation of the horizontal and vertical nature and extent (N&E) of cobalt downgradient of the Class 2 Landfill. The N&E wells are screened in three different zones including two zones within the uppermost aquifer and one zone within the underlying bedrock aquifer (Santee Limestone). Included in this evaluation was the installation of monitoring wells at the downgradient property line between the Class 2 Landfill and potable water wells that supply drinking water to nearby residences. Cobalt was detected in the shallow zone of the uppermost aquifer at the property line at concentrations greater than the GWPS. Analytical results are summarized in Table 4.

Information obtained by Santee Cooper via e-mail from SC DHEC indicated that the potable well at the adjacent property was screened at 67-feet below ground surface in the Santee Limestone. Results obtained from the newly installed wells on-site showed that cobalt was not present in the Santee Limestone confirming that cobalt does not extend vertically into the bedrock aquifer.

Even though cobalt was not detected in the lower portion of the uppermost aquifer at the property line or in the Santee Limestone where migration of cobalt to the potable water wells could occur, Santee Cooper chose to notify the adjacent property owner(s) and residents of the recent groundwater findings, collected samples of their drinking water, and expedited analysis to ensure that cobalt was not present in their drinking water. The results of these analyses confirmed that cobalt is not present in the drinking water.

Additional investigations are being considered to complete the N&E evaluation and may be required to fully understand the interaction between groundwater in the uppermost aquifer and surface water in Bulltown Ditch. The results of these additional investigations will be used to determine if the Corrective Measures Assessment discussed herein would require modification.

3. Corrective Measures Alternatives

3.1 CORRECTIVE MEASURES ASSESSMENT GOALS

The overall goal of this CMA is to identify and evaluate the appropriateness of potential corrective measures to prevent further releases of cobalt above the GWPS, to remediate releases above the GWPS that have already occurred, and to restore groundwater in the affected area to a condition that is below the GWPS. The corrective measures assessment provides an analysis of the effectiveness of five potential corrective measures in meeting the requirements and objectives of remedies as described under §257.97 (also shown graphically on Tables 5 and 6). This assessment also meets the requirements in §257.96 by evaluating the following:

- The performance, reliability, ease of implementation, and potential impacts of appropriate potential remedies, including safety impacts, cross-media impacts, and control of exposure to residual contamination;
- The time required to complete the remedy; and,
- The institutional requirements, such as state or local permit requirements or other environmental or public health requirements that may substantially affect implementation of the remedy.

The criteria listed above are included in the balancing criteria considered during the corrective measure's evaluation as described herein.

3.2 GROUNDWATER FATE AND TRANSPORT

Groundwater at the Site was modeled utilizing Groundwater Vista version 7 for flow and solute transport. A description of the model construction, calibration and subsequent simulations of remedy alternatives for Appendix IV constituents above the Groundwater Protection Standard (GWPS) is provided as Appendix A. Site specific parameters (i.e. groundwater elevations and hydraulic conductivity) were utilized for model preparation. MODFLOW 2005, a finite difference three-dimensional solver, was utilized for groundwater flow estimation. Modeled groundwater elevations were compared to observed values from the onsite well network (February 2019) to achieve a calibration of less than 10% scaled RMS. Once groundwater flow was calibrated in the model, solute transport was completed using MT3DMS a three-dimensional solute transport modeling program. Parameters effecting transport such as advection, diffusion, dispersion, and adsorption are utilized within the MT3D package to estimate solute transport within the model domain. Outputs from the groundwater model from the various CMA options are presented in the attached graphs.

In addition, Haley & Aldrich evaluated the groundwater geochemistry to develop a site-specific attenuation/degradation factor for cobalt. The groundwater flow and solute transport model is being used to simulate the risks and remediation timeframes that can be predicted under each of the remedy alternatives to compare each of the alternatives to one another.

3.3 CORRECTIVE MEASURES ALTERNATIVES

Corrective measures may be terminated when groundwater impacted by the Class 2 Landfill does not exceed the GWPS for three consecutive years of groundwater monitoring. In accordance with §257.97, the groundwater corrective measures alternatives evaluated herein meet the following threshold criteria:

1. Protect human health and the environment;
2. Attain the GWPS;
3. Control the source(s) of releases to reduce or eliminate, to the maximum extent feasible, further releases of COCs to the environment;
4. Remove from the environment as much of the contaminated material that was released from the CCR unit as is feasible, considering factors such as avoiding inappropriate disturbance of sensitive ecosystems; and,
5. Comply with standards (regulations) for waste management.

Because cobalt does not extend vertically into the Santee Limestone, which is the source of potable water off-site, and is not present on the lower portion of the unconsolidated shallow aquifer at the property line, each of the remedial alternatives assembled as part of this CMA meet the requirements of the threshold criteria listed above. Groundwater monitoring will continue in the future to ensure that offsite groundwater is not adversely impacted.

Because the Class 2 Landfill has been closed and capped, this CMA includes an evaluation of five groundwater remediation alternatives described below and presented on Table 5 and evaluated against the threshold and balancing criteria on Table 6, including:

- Alternative 1: Landfill closure[4] plus monitored natural attenuation (MNA), which is currently being implemented under a SC DHEC approved groundwater monitoring program[5];
- Alternative 2: Landfill closure plus MNA with enhanced water management improvements;
- Alternative 3: Landfill closure plus hydraulic containment with direct discharge;
- Alternative 4: Landfill closure plus hydraulic containment with ex-situ groundwater treatment; and,
- Alternative 5: Landfill closure plus in-situ groundwater treatment.

This CMA, and the input received during the public comment period, will be used to identify a final corrective measure for implementation at the Class 2 Landfill.

3.3.1 Alternative 1: Landfill closure plus monitored natural attenuation (MNA)

MNA is a viable remedial technology recognized by both state and federal regulators that is applicable to inorganic compounds in groundwater. The USEPA defines MNA as "the reliance on natural attenuation processes to achieve site-specific remediation objectives within a time frame that is reasonable compared to that offered by other more active methods". The 'natural attenuation processes' that are at work in such a remediation approach include a variety of physical, chemical, or biological processes that, under favorable conditions, act without human intervention to reduce the mass, toxicity, mobility, volume, or concentration of contaminants in soil or groundwater. These in-situ processes include biodegradation; dispersion; dilution; sorption; volatilization; radioactive decay; and chemical or biological stabilization, transformation, or destruction of contaminants" (USEPA, 2015).

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[4] The landfill has already been closed by installing a low-permeability geomembrane and clay cap and cover along with surface water controls for drainage and erosion protection.

[5] The landfill has already been closed by installing a low-permeability geomembrane and clay cap and cover along with surface water controls for drainage and erosion protection.

With infiltration of precipitation limited or eliminated by the low-permeability landfill cap, MNA can over time reduce concentrations of cobalt downgradient from the Class 2 Landfill.

Through on-going monitoring of the groundwater to gauge the success of MNA, this alternative could be amended if the predicted success is not shown within the appropriate amount of time. At that time, other Alternatives could be reconsidered and implemented.

3.3.2 Alternative 2: Landfill closure plus MNA with enhanced water management improvements

The Class 2 Landfill is constructed with a series of toe drains around the perimeter of the landfill to remove water present in the landfill at the time of closure. This minor amount of water flows into unlined stormwater conveyances and is managed with other site stormwater. Alternative 2 would include engineering evaluations designed to assess the water management practices associated with the Class 2 Landfill and their potential effect on achieving GWPS in a reasonable timeframe. Corrective actions, as appropriate would be implemented to address issues identified. Following implementation of these corrective actions, MNA as described in Alternative 1, would continue.

3.3.3 Alternative 3: Landfill closure plus hydraulic containment with direct discharge

Pumping wells would be used to hydraulically control the horizontal migration of cobalt. Pumping would be limited to the uppermost aquifer since cobalt has not been detected in the bedrock aquifer. If possible, the pumping well effluent would be discharged directly to surface water under existing or future discharge permits. No treatment would be used prior to discharge. Verification that the effluent could be discharged under current permits, or application for a new permit and approval, would be required.

Implementation of a large-scale hydraulic containment system will require a detailed and lengthy design effort. Additional pilot testing, such as pumping tests and additional groundwater modeling, will be needed to verify the hydraulic capture zone. While hydraulic containment is a widely used remediation technology, it has not been commonly used as part of a large-scale CCR unit closure strategy.

Following the installation of the groundwater pumping well network, Santee Cooper would implement post-closure care activities that includes operation and maintenance of the hydraulic containment system, long-term groundwater sampling to monitor hydraulic control system performance, and landfill cover system maintenance. Over time, processes of MNA would decrease source concentrations of cobalt to values less than the GWPS and operation of the hydraulic containment system would cease.

3.3.4 Alternative 4: Hydraulic containment with ex-situ groundwater treatment

Pumping wells would be used to hydraulically control the horizontal migration of cobalt. Pumping would be limited to the uppermost aquifer since cobalt has not been detected in the bedrock aquifer. The pumping well effluent would be treated ex-situ, likely with an ion exchange or a reverse osmosis (RO) treatment system. Both treatment systems are complex with ongoing operation and maintenance and would generate a secondary waste stream – including regeneration/replacement of the ion exchange media or concentration reject water from the RO system. Approvals and permitting would be required for the construction and installation of the treatment systems and discharge of the treated groundwater.

Implementation of a large-scale hydraulic containment system will require a detailed lengthy design effort with additional bench scale testing to verify groundwater treatment. Pilot testing, such as pumping tests and additional groundwater modeling, will also be needed to verify the hydraulic capture zone. While hydraulic containment is a widely used remediation technology, it has not been commonly used as part of a large-scale CCR unit closure strategy.

Following the installation of the groundwater pumping well network, and ex-situ treatment system, Santee Cooper would implement post-closure care activities that includes operation and maintenance of the hydraulic containment system, operation and maintenance of the treatment system, long-term groundwater sampling to monitor hydraulic control system performance, and landfill cover system maintenance. Over time, processes of MNA would decrease source concentrations of cobalt to values less than the GWPS and operation of the hydraulic containment system would cease.

3.3.5 Alternative 5: In-situ groundwater treatment

Cobalt would be addressed through in-situ addition of groundwater treatment amendments downgradient of the Class 2 Landfill with the objective of accelerating the time required to achieve the GWPS within the treatment zone. Approvals and permitting would be required for the construction and installation of the treatment system and injection/application of amendments to the subsurface.

Implementation of an in-situ treatment system will require a detailed lengthy design effort with additional bench scale testing to verify groundwater treatment. The bench scale testing will evaluate the efficacy of treating cobalt in-situ, while factoring in potential changes in groundwater geochemistry which may adversely affect the stability of other CCR-related constituents.

Following the installation of the in-situ treatment system, Santee Cooper would implement post-closure care activities that include periodic amendment injections or periodic replenishment of the treatment reagents within the treatment zone or reactive barrier, long-term groundwater sampling to monitor treatment system performance, and cover system maintenance. Over time, processes of MNA would decrease source concentrations of cobalt to values less than the GWPS and in-situ treatment would cease.

4. Comparison of Corrective Measures Alternatives

The purpose of this section is to evaluate, compare, and rank the five corrective measures alternatives using the balancing criteria described in §257.97.

4.1 EVALUATION CRITERIA

In accordance with §257.97, remedial alternatives that satisfy the threshold criteria are then compared to four balancing (evaluation) criteria. The balancing criteria allow a comparative analysis for each corrective measure, thereby providing the basis for final corrective measure selection. The four balancing criteria include the following:

1. The long- and short-term effectiveness and protectiveness of the potential remedy(s), along with the degree of certainty that the remedy will prove successful;
2. The effectiveness of the remedy in controlling the source to reduce further releases;
3. The ease or difficulty of implementing a potential remedy; and,
4. The degree to which community concerns are addressed by a potential remedy.

Public input and feedback will be considered following a public information session to be held in the fall of 2019.

4.2 COMPARISON OF ALTERNATIVES

This section compares the alternatives to each other based on evaluation of the balancing criteria listed above. The goal of this analysis is to identify the alternative that is technologically feasible, relevant and readily implementable, provides adequate protection to human health and the environment, and minimizes impacts to the community.

A graphic is provided within each subsection below to provide a visual snapshot of the favorability of each alternative, where green represents favorable, yellow represents less favorable, and red represents least favorable.

4.2.1 The Long- and Short-Term Effectiveness and Protectiveness of the Potential Remedy, along with the Degree of Certainty that the Remedy Will Prove Successful

This balancing criterion takes into consideration the following sub criteria relative to the long-term and short-term effectiveness of the remedy, along with the anticipated success of the remedy.

4.2.1.1 Magnitude of reduction of existing risks

As indicated by the sampling results from the off-site drinking water, no unacceptable risk to human health and the environment exists with respect to the Class 2 Landfill. Therefore, none of the remedial alternatives are necessary to reduce risks because no such exposure to cobalt currently exists. However, other types of impacts can be posed by the various remedial alternatives considered here. The remedial alternatives that pose the least external impact are Alternative 1 (MNA) and 2 (MNA with enhanced water management improvements) because they are implemented onsite and involve the least amount of construction and operations and maintenance (O&M) activities and associated impacts. Alternative 4 (hydraulic containment with ex-situ groundwater treatment) has the highest potential impact due to the installation of pumping wells, construction of treatment systems, long-term operation, and generation of secondary waste streams. Construction and system operations will also be required for Alternatives 3 and 5 (hydraulic containment with direct discharge and In-situ groundwater treatment).

	Alternative 1 CIP with MNA	**Alternative 2** CIP with MNA and Water Management Improvements	**Alternative 3** CIP with Hydraulic Containment and Direct Discharge	**Alternative 4** CIP with Hydraulic Containment and Ex-Situ Treatment	**Alternative 5** CIP with In-Situ Treatment
Category 1 - Subcriteria i) Magnitude of reduction of risks					

4.2.1.2 *Magnitude of residual risks in terms of likelihood of further releases due to CCR remaining following implementation of a remedy*

Alternative 1 (MNA) and 2 (MNA with enhanced water management improvements) have the lowest long-term residual risk because the landfill is closed with a low permeability cap that virtually eliminates infiltration of precipitation and isolates the source material. With alternatives 1 and 2 the cobalt is treated through naturally occurring processes in-situ and involve the least amount of construction and operations and maintenance (O&M) activities. For Alternatives 3 and 4, the source is also controlled through the installation of the low permeability cap, but the affected groundwater is extracted from the subsurface and either directly discharged to the environment through an existing or new permit or treated and disposed in a separate off-site location.

	Alternative 1 CIP with MNA	**Alternative 2** CIP with MNA and Water Management Improvements	**Alternative 3** CIP with Hydraulic Containment and Direct Discharge	**Alternative 4** CIP with Hydraulic Containment and Ex-Situ Treatment	**Alternative 5** CIP with In-Situ Treatment
Category 1 - Subcriteria ii) Magnitude of residual risk in terms of likelihood of further release					

4.2.1.3 *The type and degree of long-term management required, including monitoring, operation, and maintenance*

Alternative 1 (MNA) and 2 (MNA with enhanced water management improvements) are the most favorable alternatives with respect to this criterion because they require the least amount of long-term management and involve no mechanical systems as part of the remedy. Alternative 4 (hydraulic containment with ex-situ groundwater treatment) is the least favorable because it requires maintaining permits and operation of pumping and treatment systems. The remaining alternatives fall between Alternatives 2 and 4 because they involve more intensive systems to implement and/or maintain throughout their remediation life cycle.

	Alternative 1 CIP with MNA	**Alternative 2** CIP with MNA and Water Management Improvements	**Alternative 3** CIP with Hydraulic Containment and Direct Discharge	**Alternative 4** CIP with Hydraulic Containment and Ex-Situ Treatment	**Alternative 5** CIP with In-Situ Treatment
Category 1 - Subcriteria iii) Type and degree of long-term management required					

4.2.1.4 *Short-term risks that might be posed to the community or the environment during implementation of such a remedy*

The highest short-term impact posed to the community or environment would be during implementation of Alternative 4 (hydraulic containment with ex-situ groundwater treatment) followed by Alternative 3 (hydraulic containment with direct discharge) and 5 (In-situ groundwater treatment), making these alternatives least favorable. Potential environmental impacts are from groundwater pumping, direct discharge to the environment, and/or injection of remediation amendments. Community impacts include general impacts to the community due to increased truck traffic on public roads during construction and operation of the remedies, along with generation of secondary waste streams with transportation and off-site disposal of waste streams.

	Alternative 1 CIP with MNA	**Alternative 2** CIP with MNA and Water Management Improvements	**Alternative 3** CIP with Hydraulic Containment and Direct Discharge	**Alternative 4** CIP with Hydraulic Containment and Ex-Situ Treatment	**Alternative 5** CIP with In-Situ Treatment
Category 1 - Subcriteria iv) Short term risk to community or environment during implementation					

4.2.1.5 *Time until full protection is achieved*

As previously stated, there is currently no exposure to groundwater impacted by cobalt and associated with the Class 2 Landfill; therefore, protection is already achieved. The timeframes to achieve GWPS were evaluated using a predictive model as described in Section 3.2. Because cobalt concentrations have not yet declined as expected following closure, Alternative 1 (MNA) was not modeled and for this evaluation was assumed to require the greatest amount of time. Based upon predictive modeling of the other four alternatives, Alternative 2 (MNA with enhanced water management improvements) which assumes no continuing source, cobalt concentrations will attain GWPS in the shortest amount of time (see Figure 6). With the exception of Alternative 1, Alternative 5 (In-situ groundwater treatment) is predicted to take the greatest amount of time to reduce COC concentrations and is therefore the least favorable. With groundwater pumping (Alternatives 3 and 4), remediation timeframes fall between Alternative 2 and 5.

	Alternative 1 CIP with MNA	**Alternative 2** CIP with MNA and Water Management Improvements	**Alternative 3** CIP with Hydraulic Containment and Direct Discharge	**Alternative 4** CIP with Hydraulic Containment and Ex-Situ Treatment	**Alternative 5** CIP with In-Situ Treatment
Category 1 - Subcriteria v) Time until full protection is achieved					

4.2.1.6 *Potential for exposure of humans and environmental receptors to remaining wastes, considering the potential threat to human health and the environment associated with excavation, transportation, re-disposal, or containment*

Except for Alternative 4 (hydraulic containment with ex-situ groundwater treatment), the remaining alternatives all have similar, minimal potential for exposure to humans and environmental receptors since the landfill is capped and closed. Alternatives 1and 2 are the most favorable alternative since no additional contact with CCR or impacted groundwater would be needed beyond routine groundwater sampling. Alternative 5 (In-situ groundwater treatment) is also favorable because treatment occurs below ground and no waste stream is generated. A waste stream would be generated under Alternative

4 (hydraulic containment with ex-situ groundwater treatment) that would need to be managed either on-site or off-site, which creates a potential for exposure.

	Alternative 1 CIP with MNA	**Alternative 2** CIP with MNA and Water Management Improvements	**Alternative 3** CIP with Hydraulic Containment and Direct Discharge	**Alternative 4** CIP with Hydraulic Containment and Ex-Situ Treatment	**Alternative 5** CIP with In-Situ Treatment
Category 1 - Subcriteria vi) Potential for exposure of humans and environmental receptors to remaining wastes					

4.2.1.7 Long-term reliability of the engineering and institutional controls

Alternatives 1 (MNA) and Alternative 2 (MNA with enhanced water management improvements) are all expected to have high long-term reliability, as capping and long-term monitoring are common methods for long-term waste management and are considered most favorable. Hydraulic control and ex-situ treatment (Alternative 4) is considered reliable, proven technologies and would have high long-term reliability, but require field pilot studies and bench scale testing and rely on mechanical systems (groundwater pumping and treatment systems) to operate and maintain. Alternative 3 will require field pilot scale testing to confirm hydraulic capture of cobalt.

For all the Alternatives institutional controls such as the recording of an environmental covenant restricting the use of groundwater can easily be implemented because the Class 2 Landfill is located on property owned by Santee Cooper.

	Alternative 1 CIP with MNA	**Alternative 2** CIP with MNA and Water Management Improvements	**Alternative 3** CIP with Hydraulic Containment and Direct Discharge	**Alternative 4** CIP with Hydraulic Containment and Ex-Situ Treatment	**Alternative 5** CIP with In-Situ Treatment
Category 1 - Subcriteria vii) Long-term reliability of engineering and institutional controls					

4.2.1.8 Potential need for replacement of the remedy

Alternative 2 (MNA with enhanced water management improvements) is considered the most reliable since it relies on naturally occurring processes that occur without human intervention to achieve GWPS. Alternative 1 (MNA) is also considered reliable so long as cobalt concentrations are shown to decrease in the near future. Should monitoring results indicate that the selected remedial alternative is not effective at reducing the concentration of COCs over time, alternate and/or additional active remedial methods for groundwater may be considered in the future.

For the remaining Alternatives detailed engineering assessments would need to be completed before the viability of such an approach could be considered at the Class 2 Landfill. Field pilot testing would also be needed for to confirm the spacing of pumping wells and the efficacy of in-situ and ex-situ treatment technologies. From the perspective of needing to replace the remedy, the alternatives that rely on operating systems (Alternatives 3 through 5) are considered less reliable.

	Alternative 1 CIP with MNA	**Alternative 2** CIP with MNA and Water Management Improvements	**Alternative 3** CIP with Hydraulic Containment and Direct Discharge	**Alternative 4** CIP with Hydraulic Containment and Ex-Situ Treatment	**Alternative 5** CIP with In-Situ Treatment
Category 1 - Subcriteria viii) Potential need for replacement of the remedy					

4.2.1.9 Long- and short-term effectiveness and protectiveness criterion summary

The graphic below provides a summary of the long- and short-term effectiveness and protectiveness of the potential remedy, along with the degree of certainty that the remedy will prove successful. Alternative 2 (MNA with enhanced water management improvements) is the most favorable, while Alternative 4 (hydraulic containment with ex-situ groundwater treatment) is the least favorable. Alternative 1 (MNA) is also expected to be effective both short- and long-term and does not include additional treatment technology aside from MNA, however the lack of a decreasing concentration trend in the CCR monitoring results adds a level of uncertainty. Alternatives 3 (hydraulic control with direct discharge) and 5 (In-situ groundwater treatment) are considered less favorable because they require longer periods of time to achieve GWPS as well as lengthy design, field pilot studies, and construction period, and therefore are not effective in the short-term.

	Alternative 1 CIP with MNA	**Alternative 2** CIP with MNA and Water Management Improvements	**Alternative 3** CIP with Hydraulic Containment and Direct Discharge	**Alternative 4** CIP with Hydraulic Containment and Ex-Situ Treatment	**Alternative 5** CIP with In-Situ Treatment
CATEGORY 1 Long- and Short Term Effectiveness, Protectiveness, and Certainty of Success					

4.2.2 The Effectiveness of the Remedy in Controlling the Source to Reduce Further Releases

This balancing criterion takes into consideration the ability of the remedy to control a future release, and the degree of complexity of treatment technologies that will be required.

4.2.2.1 The extent to which containment practices will reduce further releases

For all remedial alternatives, the Class 2 Landfill is currently constructed with a low-permeability cap which reduces the infiltration of surface water into the landfill and therefore decreases the potential for cobalt to enter groundwater over time. Alternative 1 (MNA) relies on natural attenuation to decrease the downgradient concentration of cobalt over time. Alternative 2 includes improvements the water management system at the Class 2 Landfill to further decrease the amount of cobalt entering groundwater, which is expected to shorten the duration that will be needed for MNA to achieve the GWPS. Alternative 2 is considered more favorable since the enhanced water management will further reduce the potential release of cobalt to groundwater.

For Alternatives 3 (hydraulic containment with direct discharge) and 4 (hydraulic containment with ex-situ treatment), additional containment and/or treatment practices will address cobalt in groundwater migrating downgradient, achieving the performance criteria at the waste boundary. However, pumping system effluent is discharged elsewhere on the property without treatment under Alternative 3. Alternative 4 will create additional waste streams requiring management on and off site, but the groundwater will be treated prior to discharge.

Alternative 5 will address cobalt in groundwater by treating groundwater in the subsurface. The GWPS is expected to be achieved in the subsurface treatment zone immediately downgradient from Landfill 2. This alternative is considered favorable since the in-situ treatment prevents further migration of cobalt by reducing the concentration of cobalt in groundwater immediately downgradient from Landfill 2.

	Alternative 1 CIP with MNA	**Alternative 2** CIP with MNA and Water Management Improvements	**Alternative 3** CIP with Hydraulic Containment and Direct Discharge	**Alternative 4** CIP with Hydraulic Containment and Ex-Situ Treatment	**Alternative 5** CIP with In-Situ Treatment
Category 2 - Subcriteria i) Extent to which containment practices will reduce further releases					

4.2.2.2 The extent to which treatment technologies may be used

No groundwater treatment technologies, other than natural attenuation, will be used for Alternatives 1 and 2. There would be no ongoing operation and maintenance of a treatment technology, other than periodic groundwater monitoring. In addition to MNA, Alternative 2 also includes enhancements to the Class 2 Landfill water management system.

Alternatives 3 and 5 will use one technology (hydraulic containment and in-situ treatment, respectively) while Alternative 4 will use two additional technologies, hydraulic containment and ex-situ treatment. The operation of an ex-situ treatment system will create a secondary waste stream, such as concentrated reject water (RO) requiring off-site disposal, or depleted resin (ion exchange), requiring regeneration or off-site disposal.

	Alternative 1 CIP with MNA	**Alternative 2** CIP with MNA and Water Management Improvements	**Alternative 3** CIP with Hydraulic Containment and Direct Discharge	**Alternative 4** CIP with Hydraulic Containment and Ex-Situ Treatment	**Alternative 5** CIP with In-Situ Treatment
Category 2 - Subcriteria ii) Extent to which treatment technologies may be used					

4.2.2.3 Effectiveness of the remedy in controlling the source to reduce further releases summary

The graphic below provides a summary of the effectiveness of the remedial alternatives to control the source to reduce further releases. Alternative 2 (MNA with enhanced water management improvements) and Alternative 5 (in-situ groundwater treatment) are the most favorable, while Alternatives 1, 3, and 4 are less favorable.

	Alternative 1 CIP with MNA	**Alternative 2** CIP with MNA and Water Management Improvements	**Alternative 3** CIP with Hydraulic Containment and Direct Discharge	**Alternative 4** CIP with Hydraulic Containment and Ex-Situ Treatment	**Alternative 5** CIP with In-Situ Treatment
CATEGORY 2 Effectiveness in controlling the source to reduce further releases					

4.2.3 The Ease or Difficulty of Implementing a Potential Remedy

This balancing criterion takes into consideration technical and logistical challenges required to implement a remedy, including practical considerations such as equipment availability and disposal facility capacity.

4.2.3.1 Degree of difficulty associated with constructing the technology

For all remedial alternatives, the Class 2 Landfill is currently constructed with a low-permeability cap which reduces the infiltration of surface water into the landfill and the potential for cobalt to reach groundwater over time. Minimal or no construction is required for Alternatives 1 and 2 making these alternatives the most favorable. Construction difficulties are also not anticipated for Alternative 3 as specialty equipment or contractors are not required. Alternative 4 (hydraulic containment with ex-situ treatment) and Alternative 4 (in-situ groundwater treatment) will be more difficult to implement and will require additional treatability testing, field scale pilot studies and specialty contractors.

	Alternative 1 CIP with MNA	**Alternative 2** CIP with MNA and Water Management Improvements	**Alternative 3** CIP with Hydraulic Containment and Direct Discharge	**Alternative 4** CIP with Hydraulic Containment and Ex-Situ Treatment	**Alternative 5** CIP with In-Situ Treatment
Category 3 - Subcriteria i) Degree of difficulty associated with constructing the technology					

4.2.3.2 Expected operational reliability of the technologies

Alternatives 1 (MNA) and Alternative 2 (MNA with enhanced water management improvements) are considered the most favorable from an operational perspective because capping with MNA has a proven track record and requires limited O&M. While Alternative 3 (hydraulic containment with direct discharge) is a proven technology, pilot testing would be required to establish capture zones and pumping well spacing. The potential for geochemical impact on the groundwater aquifer from the groundwater treatment amendments associated with Alternative 5 (in-situ treatment) would need to be evaluated. Alternative 4 is also expected to be reliable but will utilize additional groundwater treatment technologies which will require treatability studies and operations and maintenance and therefore considered the least favorable when compared to the other alternatives.

	Alternative 1 CIP with MNA	**Alternative 2** CIP with MNA and Water Management Improvements	**Alternative 3** CIP with Hydraulic Containment and Direct Discharge	**Alternative 4** CIP with Hydraulic Containment and Ex-Situ Treatment	**Alternative 5** CIP with In-Situ Treatment
Category 3 - Subcriteria ii) Expected operational reliability of the technologies					

4.2.3.3 Need to coordinate with and obtain necessary approvals and permits from other agencies

Alternative 1 (MNA) and Alternative 2 (MNA with enhanced water management improvements) are the most favorable since the implementation of the remedy is straightforward and only includes MNA. The remaining alternatives will all require extensive permitting and approvals for groundwater discharge, groundwater treatment, disposal of secondary waste streams, and injection of remediation amendments. Alternative 5 (in-situ groundwater treatment) in particular, has the potential to present the greatest permitting challenge because this alternative will require additional treatability testing to support underground injection permitting.

	Alternative 1 CIP with MNA	**Alternative 2** CIP with MNA and Water Management Improvements	**Alternative 3** CIP with Hydraulic Containment and Direct Discharge	**Alternative 4** CIP with Hydraulic Containment and Ex-Situ Treatment	**Alternative 5** CIP with In-Situ Treatment
Category 3 - Subcriteria iii) Need to coordinate with and obtain necessary approvals and permits from other agencies					

4.2.3.4 Availability of necessary equipment and specialists

Alternative 1 (MNA) and Alternative 2 (MNA with enhanced water management improvements) are the most favorable since specialty equipment and specialists will not be required to implement the MNA remedy. Alternative 3 and Alternative 4 will require equipment for pumping and treatment and is less favorable than Alternatives 1 and 2 but equipment required should not present great challenge.

Alternative 5 (in-situ groundwater treatment) is the least favorable since it will require specialty remediation contractors to implement this remedy.

	Alternative 1 CIP with MNA	**Alternative 2** CIP with MNA and Water Management Improvements	**Alternative 3** CIP with Hydraulic Containment and Direct Discharge	**Alternative 4** CIP with Hydraulic Containment and Ex-Situ Treatment	**Alternative 5** CIP with In-Situ Treatment
Category 3 - Subcriteria iv) Availability of necessary equipment and specialists					

4.2.3.5 Available capacity and location of needed treatment, storage, and disposal services

Because the Class 2 Landfill has been closed storage, and disposal of CCR material will not be needed. Except for Alternative 4 (hydraulic containment with ex-sit treatment) the remaining alternatives would not generate a waste stream and therefore would not require treatment, storage, or disposal services. For Alternative 4, the ex-situ treatment system may generate a concentrated waste stream which would require onsite treatment or off-site transportation and disposal that the other alternatives would not require and is therefore considered the least favorable.

	Alternative 1 CIP with MNA	**Alternative 2** CIP with MNA and Water Management Improvements	**Alternative 3** CIP with Hydraulic Containment and Direct Discharge	**Alternative 4** CIP with Hydraulic Containment and Ex-Situ Treatment	**Alternative 5** CIP with In-Situ Treatment
Category 3 - Subcriteria v) Available capacity and location of needed treatment, storage, and disposal services					

4.2.3.6 Ease or difficulty of implementation summary

The graphic below provides a summary of the ease or difficulty that will be needed to implement each alternative. Alternatives 1 (MNA) and 2 (MNA with enhanced water management improvements) are the most favorable, while Alternatives 4 (hydraulic containment with ex-situ treatment) and 5 (in-situ groundwater treatment) are the least favorable.

	Alternative 1 CIP with MNA	**Alternative 2** CIP with MNA and Water Management Improvements	**Alternative 3** CIP with Hydraulic Containment and Direct Discharge	**Alternative 4** CIP with Hydraulic Containment and Ex-Situ Treatment	**Alternative 5** CIP with In-Situ Treatment
CATEGORY 3 Ease of implementation					

5. Summary

This Corrective Measures Assessment has evaluated the following alternatives:

- Alternative 1: Landfill closure plus monitored natural attenuation (MNA), which is currently being implemented under a SC DHEC approved groundwater monitoring program;
- Alternative 2: Landfill closure plus MNA with enhanced water management improvements;
- Alternative 3: Landfill closure plus hydraulic containment with direct discharge;
- Alternative 4: Landfill closure plus hydraulic containment with ex-situ groundwater treatment; and,
- Alternative 5: Landfill closure plus in-situ groundwater treatment.

In accordance with §257.97, each of these alternatives has been evaluated in the context of the following threshold criteria:

- Protect human health and the environment;
- Attain the GWPS;
- Control the source(s) of releases to reduce or eliminate, to the maximum extent feasible, further releases of COCs to the environment;
- Remove from the environment as much of the contaminated material that was released from the CCR unit as is feasible, considering factors such as avoiding inappropriate disturbance of sensitive ecosystems; and,
- Comply with standards (regulations) for waste management.

In addition, in accordance with §257.96, each of the alternatives has been evaluated in the context of the following balancing criteria:

- The performance, reliability, ease of implementation, and potential impacts of appropriate potential remedies, including safety impacts, cross-media impacts, and control of exposure to residual contamination;
- The time required to complete the remedy; and,
- The institutional requirements, such as state or local permit requirements or other environmental or public health requirements that may substantially affect implementation of the remedy.

This Corrective Measures Assessment, and the input received during the public comment period, will be used to select a final corrective measure for implementation at the Class 2 Landfill.

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TABLES

TABLE 1
DETECTION MONITORING ANALYTICAL RESULTS
CROSS GENERATING STATION - CLASS 2 LANDFILL
SANTEE COOPER
CROSS, SOUTH CAROLINA

			Chemical Group	Detection Monitoring - EPA Appendix III Constituents						Field Parameters				
			Chemical Name	Boron, Total	Calcium, Total	Chloride	Fluoride	Sulfate	Total Dissolved Solids (TDS)	Dissolved Oxygen	ORP	pH	Temperature	Turbidity
			MCL/RSL	-	-	-	4	-	-	-	-	-	-	-
			Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mv	pH units	Deg C	NTU
Impound-ment	**Location**	**Sample Date**	**Sample Name**											
Background	CBW-1	10/19/2015	CBW-1-20151019	0.032	27	3.21	0.25	81.5	150	0.91	340	4.45	21.29	291
Background	CBW-1	01/26/2016	CBW-1-20160126	0.0218	27	2.95	0.3	88.2	120	0.8	346	4.12	17.01	7.9
Background	CBW-1	04/19/2016	CBW-1-20160419	0.0183	29.4	2.33	0.29	86	120	0.5	146	4.33	18.72	0
Background	CBW-1	07/18/2016	CBW-1-20160718	0.0217	28.7	2.95	0.27	90.1	132	0.84	64	4.38	22.89	0
Background	CBW-1	10/11/2016	CBW-1-20161011	0.0302	22.7	3	0.28	73.7	151.7	1.08	98	4.14	19.9	1.9
Background	CBW-1	01/23/2017	CBW-1-20170123	0.0249	26.2	2.45	0.25	77.7	148	0.81	150	4.32	16.58	1.3
Background	CBW-1	04/17/2017	CBW-1-20170417	0.018	25.6	2.96	0.22	71.2	62	0.72	248	4.26	22.55	2.8
Background	CBW-1	07/25/2017	CBW-1-20170725	0.022	-	2.61	-	73.3	92	3.52	75	4.21	24.41	0
Background	CBW-1	09/25/2017	CBW-1-20170925	0.024	21.9	2.51	0.23	74.5	< 40	0.76	142	4.32	25.07	41.3
Background	CBW-1	10/09/2017	CBW-1-20171009	0.023	23	2.73	0.22	76.8	115	0.83	111	4.25	25.04	0
Background	PM-1	01/26/2015	PM-1-012615	-	-	-	-	-	142.5	0.47	117	4.53	17.13	0
Background	PM-1	02/16/2015	PM-1-021615	-	-	-	-	-	106.2	-	74	4.68	14.88	26.5
Background	PM-1	06/16/2015	PM-1-061615	-	-	-	-	-	158	-	63	4.74	21.8	3.7
Background	PM-1	07/06/2015	PM-1-070615	-	-	-	-	-	151	-	-	5.25	23.05	0.4
Background	PM-1	10/19/2015	PM-1-20151019	0.0178	26	12.7	< 0.1	26.5	206	1.33	20	5.47	20.94	19
Background	PM-1	01/26/2016	PM-1-20160126	< 0.015	27	11.3	< 0.1	25.5	165	1.2	65	5.2	15.83	22.3
Background	PM-1	04/19/2016	PM-1-20160419	< 0.015	23.3	12.1	< 0.1	20.2	130	0.52	81	5.32	18.9	0
Background	PM-1	07/18/2016	PM-1-20160718	0.0163	18.8	13.2	< 0.1	16	124	0.97	61	5.2	24.19	0
Background	PM-1	10/11/2016	PM-1-20161011	0.0165	16.4	12.8	< 0.1	19.3	200	1.37	54	5.01	19.75	2.2
Background	PM-1	01/23/2017	PM-1-20170123	< 0.015	10.4	13.5	< 0.1	8.82	138	0.9	87	5.01	15.45	1.9
Background	PM-1	04/17/2017	PM-1-20170417	0.019	12.5	12.7	< 0.1	9.71	56	0.85	84	5.19	21.17	1.4
Background	PM-1	07/12/2017	PM-1-20170712	-	18.5	12.1	-	11.1	108	0.87	89	5.11	27.03	0
Background	PM-1	08/31/2017	PM-1-20170831-RS	< 0.015	-	-	-	-	-	0.8	96	5.17	25.04	1.1
Background	PM-1	09/25/2017	PM-1-20170925	0.018	15.4	13.3	< 0.1	8.03	< 40	0.92	92	5.27	24.37	0
Background	PM-1	10/09/2017	PM-1-20171009	0.021	17	12.6	< 0.1	8.77	80	1.13	66	5.21	24.3	1.6
C2_Landfill	POZ-4	02/16/2015	POZ-4-021615	-	-	-	-	-	1262	-	18	6.04	15.11	4.1
C2_Landfill	POZ-4	06/17/2015	POZ-4-061715	-	-	-	-	-	2480	-	59	5.53	29.52	0
C2_Landfill	POZ-4	10/22/2015	POZ-4-20151022	0.0222	420	644	0.13	233	2180	0.42	-9	5.94	22.9	0
C2_Landfill	POZ-4	01/27/2016	POZ-4-20160127	0.0151	260	325	0.17	105	1245	3.21	230	6.35	15.19	5.3
C2_Landfill	POZ-4	04/25/2016	POZ-4-20160425	0.0233	577	920	< 0.1	351	2750	0.54	87	5.63	20.96	0
C2_Landfill	POZ-4	07/18/2016	POZ-4-20160718	0.0193	431	646	< 0.1	226	1988	0.45	34	5.96	29.88	0
C2_Landfill	POZ-4	10/13/2016	POZ-4-20161013	0.0237	338	485	0.1	171	1798	0.63	20	6.04	22.46	0
C2_Landfill	POZ-4	01/24/2017	POZ-4-20170124	0.0201	457	598	< 0.1	199	2046	0.83	98	6.06	16.69	0
C2_Landfill	POZ-4	04/18/2017	POZ-4-20170418	0.023	614	872	< 0.1	303	2678	0.73	162	5.73	20.06	0
C2_Landfill	POZ-4	08/01/2017	POZ-4-20170801	< 0.015	-	455	-	128	1896	0.47	74	6.06	22.31	5
C2_Landfill	POZ-4	09/26/2017	POZ-4-20170926	0.019	387	620	< 0.1	164	2032	0.52	36	6.05	25.3	0
C2_Landfill	POZ-4	10/11/2017	POZ-4-20171011	0.025	520	826	< 0.1	278	2415	0.8	54	5.77	24.52	0
C2_Landfill	POZ-4	10/11/2017	POZ-4-20171011-FD	0.024	530	804	< 0.1	269	2322	-	-	-	-	-
C2_Landfill	POZ-5D	02/16/2015	POZ-5D-021615	-	-	-	-	-	2630	-	-37	6.39	15.57	76.9
C2_Landfill	POZ-5D	06/17/2015	POZ-5D-061715	-	-	-	-	-	2881	-	-74	6.26	26.51	3.3
C2_Landfill	POZ-6	10/22/2015	POZ-6-20151022	0.0732	520	474	0.15	524	2330	4.75	-76	6.79	24.75	39.3
C2_Landfill	POZ-6	10/22/2015	POZ-6-20151022-FD	0.0928	540	195	0.14	215	2198	-	-	-	-	-
C2_Landfill	POZ-6	01/26/2016	POZ-6-20160126	0.048	490	433	0.15	529	2305	2.1	34	6.72	19.35	27.2
C2_Landfill	POZ-6	04/25/2016	POZ-6-20160425	0.054	511	414	0.13	518	2415	0.56	-13	6.54	21.78	13
C2_Landfill	POZ-6	04/25/2016	POZ-6-20160425-FD	0.0618	521	434	< 0.1	519	2465	-	-	-	-	-
C2_Landfill	POZ-6	07/18/2016	POZ-6-20160718	0.0751	523	506	< 0.1	611	2362	0.81	-53	6.59	28.3	4.3
C2_Landfill	POZ-6	10/13/2016	POZ-6-20161013	0.0674	426	319	< 0.1	478	1883	1.05	-41	6.47	19.91	113
C2_Landfill	POZ-6	01/24/2017	POZ-6-20170124	0.0614	433	284	< 0.1	454	1848	2.26	85	6.62	15.78	49.9
C2_Landfill	POZ-6	04/18/2017	POZ-6-20170418	0.058	476	278	< 0.1	467	1756	0.89	136	6.58	26.39	7.4
C2_Landfill	POZ-6	07/27/2017	POZ-6-20170727	0.054	-	209	-	460	1590	0.68	-36	6.58	26.31	1
C2_Landfill	POZ-6	09/26/2017	POZ-6-20170926	0.068	413	233	< 0.1	459	1442	2.64	-28	6.53	24.79	3
C2_Landfill	POZ-6	10/11/2017	POZ-6-20171011	0.062	450	329	< 0.1	517	1808	2.7	-25	6.46	24.35	3.5
C2_Landfill	POZ-7	10/22/2015	POZ-7-20151022	0.0236	110	159	0.13	6.43	504	2.06	161	6.33	21.47	14.7
C2_Landfill	POZ-7	01/26/2016	POZ-7-20160126	< 0.015	59	90	0.12	3.39	388.3	2.43	232	5.81	17.82	6.6
C2_Landfill	POZ-7	01/26/2016	POZ-7-20160126-FD	< 0.015	63	97.7	0.13	3.68	426.7	-	-	-	-	-
C2_Landfill	POZ-7	04/25/2016	POZ-7-20160425	0.0197	138	184	< 0.1	6.77	775	1.7	80	6.42	23.03	0
C2_Landfill	POZ-7	07/18/2016	POZ-7-20160718	0.0152	45.1	90.9	< 0.1	2.53	270	2.31	137	5.83	25.17	0
C2_Landfill	POZ-7	07/18/2016	POZ-7-20160718-FD	0.017	62.2	103	< 0.1	2.89	330	-	-	-	-	-
C2_Landfill	POZ-7	10/12/2016	POZ-7-20161012	0.016	34.7	65.8	0.1	11.8	255	2.03	118	5.64	24.29	0
C2_Landfill	POZ-7	10/12/2016	POZ-7-20161012-FD	0.0154	38.7	70.1	0.11	13.2	296.7	-	-	-	-	-
C2_Landfill	POZ-7	01/24/2017	POZ-7-20170124	< 0.015	22.9	46.8	< 0.1	< 2	182	3.05	195	5.42	14.73	4.5
C2_Landfill	POZ-7	01/24/2017	POZ-7-20170124-FD	< 0.015	30.5	53.3	< 0.1	< 2	200	-	-	-	-	-
C2_Landfill	POZ-7	04/18/2017	POZ-7-20170418	< 0.015	46.9	70.9	< 0.1	< 2	230	2.59	110	5.88	20.49	0
C2_Landfill	POZ-7	04/18/2017	POZ-7-20170418-FD	< 0.015	49.1	77.5	< 0.1	2.27	248	-	-	-	-	-
C2_Landfill	POZ-7	07/27/2017	POZ-7-20170727	< 0.015	-	57	-	< 2	192	2.47	143	5.51	21.11	4.4
C2_Landfill	POZ-7	09/26/2017	POZ-7-20170926	< 0.015	41.4	69.2	0.1	< 2	122	2.11	145	5.81	24.82	0

TABLE 1
DETECTION MONITORING ANALYTICAL RESULTS
CROSS GENERATING STATION - CLASS 2 LANDFILL
SANTEE COOPER
CROSS, SOUTH CAROLINA

			Chemical Group	Detection Monitoring - EPA Appendix III Constituents						Field Parameters				
			Chemical Name	Boron, Total	Calcium, Total	Chloride	Fluoride	Sulfate	Total Dissolved Solids (TDS)	Dissolved Oxygen	ORP	pH	Temperature	Turbidity
			MCL/RSL	-	-	-	4	-	-	-	-	-	-	-
			Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mv	pH units	Deg C	NTU
Impound-ment	**Location**	**Sample Date**	**Sample Name**											
C2_Landfill	POZ-7	09/26/2017	POZ-7-20170926-FD	< 0.015	**45.8**	**73.9**	< 0.1	< 2	**192**	-	-	-	-	-
C2_Landfill	POZ-7	10/10/2017	POZ-7-20171010	**0.018**	**74**	**118**	**0.12**	**4.42**	**513.3**	**1.63**	**87**	**6.02**	**23.66**	**0**

ABBREVIATIONS AND NOTES:
mg/L: milligram per liter
mv: millivolt
NTU: Nephelometric Turbidity Units
< 0.015: Analyte not detected above detection limit
-: Not Analyzed
MCL/RSL: The applicable Mximum Contaminant Level (MCL) or Regional Screening Level (RSL) is shown. Dashed where a standard is not provided.
RS: Resample
FD: Field Duplicate

- Criteria used for cobalt, lithium, and molybdenum are RSL for Tapwater where THQ=1.0 (May 2018)
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TABLE 2
ASSESSMENT MONITORING ANALYTICAL RESULTS
CROSS GENERATING STATION - CLASS 2 LANDFILL
SANTEE COOPER
CROSS, SOUTH CAROLINA

			Chemical Group	Assessment Monitoring - EPA Appendix IV Constituents														Radiological				
			Chemical Name	Antimony, Total	Arsenic, Total	Barium, Total	Beryllium, Total	Cadmium, Total	Chromium, Total	Cobalt, Total	Fluoride	Lead, Total	Lithium, Total	Mercury, Total	Molybdenum, Total	Selenium, Total	Thallium, Total	Radium-226	Radium-228	Radium-226 & 228	Conductivity	Dissolved Oxygen
			MCL/RSL	0.006	0.01	2	0.004	0.005	0.1	0.006	4	0.015	0.04	0.002	0.1	0.05	0.002	-	-	5	-	-
			Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	pCi/L	pCi/L	pCi/L	uS/cm	mg/L
Impound-ment	Location	Sample Date	Sample Name																			
Background	CBW-1	02/07/2018	CBW-1-20180207	< 0.005	< 0.005	0.0436	< 0.0005	< 0.0005	< 0.005	0.00088	0.19	0.0027	< 0.01	< 0.0002	< 0.01	< 0.01	< 0.001	1 U	3 U	4 U	199	0.93
Background	CBW-1	06/20/2018	CBW-1-20180620	< 0.025	< 0.005	0.043	< 0.0005	< 0.0005	< 0.005	0.001	0.2	0.003	< 0.01	< 0.0002	< 0.01	< 0.01	< 0.001	1 U	3 U	4 U	196	0.85
Background	CBW-1	10/01/2018	CBW-1-20181001	-	< 0.005	0.0428	< 0.0005	-	-	0.00076	0.19	0.0031	< 0.01	< 0.0002	-	< 0.01	-	2.11	3 U	5.11 J	196	0.92
Background	CBW-1	11/29/2018	CBW-1-20181129-RS	-	-	-	-	-	-	-	-	-	-	< 0.0002	-	-	-	-	-	-	-	-
Background	CBW-1	02/12/2019	CBW-1-021219	< 0.005	< 0.005	0.0427	-	< 0.0005	< 0.005	0.00084	0.18	0.0025	< 0.01	< 0.0002	< 0.01	< 0.01	< 0.001	1 U	3 U	0.346	202	0.99
Background	CBW-1	05/20/2019	CBW-1-052019	-	-	-	< 0.0005	-	-	0.00079	-	-	< 0.01	-	-	-	-	-	-	-	202	0.99
Background	PM-1	02/07/2018	PM-1-20180207	< 0.005	< 0.005	0.0756	< 0.0005	< 0.0005	< 0.005	0.00089	< 0.1	< 0.001	< 0.01	< 0.0002	< 0.01	< 0.01	< 0.001	1 U	3 U	4 U	188	1.09
Background	PM-1	06/20/2018	PM-1-20180620	< 0.025	< 0.005	0.103	< 0.0005	< 0.0005	< 0.005	0.001	< 0.1	< 0.001	< 0.01	< 0.0002	< 0.01	< 0.01	< 0.001	4.09	3 U	7.09 J	279	0.81
Background	PM-1	10/01/2018	PM-1-20181001	-	< 0.005	0.0769	< 0.0005	-	-	0.00084	< 0.1	< 0.001	< 0.01	< 0.0002	-	< 0.01	-	13.3	3 U	16.3 J	201	0.99
Background	PM-1	11/29/2018	PM-1-20181129-RS	-	-	-	-	-	-	-	-	-	-	< 0.0002	-	-	-	-	-	-	-	-
Background	PM-1	02/12/2019	PM-1-021219	< 0.005	< 0.005	0.0817	< 0.0005	< 0.0005	< 0.005	0.00091	< 0.1	< 0.001	< 0.01	< 0.0002	< 0.01	< 0.01	< 0.001	1 U	3 U	0.585	191	0.92
Background	PM-1	05/20/2019	PM-1-052019	-	-	-	< 0.0005	-	-	0.00091	-	-	< 0.01	-	-	-	-	-	-	-	187	0.77
C2_Landfill	POZ-4	02/07/2018	POZ-4-20180207	< 0.005	< 0.005	0.0702	< 0.0005	< 0.0005	< 0.005	0.0533	< 0.1	< 0.001	0.011	< 0.0002	< 0.01	< 0.01	< 0.001	1 U	3 U	4 U	2170	1.45
C2_Landfill	POZ-4	06/28/2018	POZ-4-20180628	< 0.025	< 0.005	0.09	0.001	< 0.0005	< 0.005	0.177	0.16	< 0.001	0.02	< 0.0002	< 0.01	< 0.01	< 0.001	3.29	3 U	6.29 J	2880	0.52
C2_Landfill	POZ-4	02/13/2019	POZ-4-021319	< 0.005	< 0.005	0.188	< 0.0005	< 0.0005	< 0.005	0.0451	< 0.1	< 0.001	< 0.01	< 0.0002	< 0.01	< 0.01	< 0.001	1 U	3 U	1.37	1880	1.23
C2_Landfill	POZ-4	04/17/2019	POZ-4-041719	-	-	-	-	-	-	0.158 / 0.15	-	-	-	-	-	-	-	-	-	-	2760	0.49
C2_Landfill	POZ-4	04/17/2019	POZ-4-041719-FD	-	-	-	-	-	-	0.155 / 0.14	-	-	-	-	-	-	-	-	-	-	-	-
C2_Landfill	POZ-4	05/03/2019	POZ-4-050319	-	-	-	-	-	-	0.0036	-	-	-	-	-	-	-	-	-	-	-	-
C2_Landfill	POZ-4	05/22/2019	POZ-4-052219	-	-	-	-	-	-	0.198	-	-	-	-	-	-	-	-	-	-	2780	0.59
C2_Landfill	POZ-5D	02/07/2018	POZ-5D-20180207	-	< 0.005	0.0807	-	< 0.0005	< 0.005	-	-	< 0.001	-	-	-	< 0.01	-	-	-	-	3950	1.85
C2_Landfill	POZ-5D	06/28/2018	POZ-5D-20180628	-	< 0.005	0.134	-	< 0.0005	< 0.005	-	-	< 0.001	-	-	-	< 0.01	-	-	-	-	5090	0.62
C2_Landfill	POZ-6	02/08/2018	POZ-6-20180208	< 0.005	< 0.005	0.0436	< 0.0005	< 0.0005	< 0.005	0.00099	< 0.1	< 0.001	< 0.01	< 0.0002	< 0.01	< 0.01	< 0.001	1 U	3 U	4 U	2190	2.53
C2_Landfill	POZ-6	06/28/2018	POZ-6-20180628	< 0.025	< 0.005	0.045	< 0.0005	< 0.0005	< 0.005	0.005	0.15	< 0.001	< 0.01	< 0.0002	< 0.01	< 0.01	< 0.001	1 U	3 U	4 U	2070	3.99
C2_Landfill	POZ-6	02/14/2019	POZ-6-021419	< 0.005	< 0.005	0.0452	< 0.0005	< 0.0005	< 0.005	0.0032	< 0.1	< 0.001	< 0.01	< 0.0002	< 0.01	< 0.01	< 0.001	1 U	3 U	1.31	2250	4.74
C2_Landfill	POZ-6	05/21/2019	POZ-6-052119	-	-	-	-	-	-	0.0082	-	-	-	-	-	-	-	-	-	-	2420	0.91
C2_Landfill	POZ-7	02/07/2018	POZ-7-20180207	< 0.005	< 0.005	0.235	0.00083	< 0.0005	< 0.005	0.0009	< 0.1	< 0.001	< 0.01	< 0.0002	< 0.01	< 0.01	< 0.001	1.14	3 U	4.14 J	226	3.18
C2_Landfill	POZ-7	02/07/2018	POZ-7-20180207-FD	< 0.005	< 0.005	0.272	0.00077	< 0.0005	< 0.005	0.00074	< 0.1	< 0.001	< 0.01	< 0.0002	< 0.01	< 0.01	< 0.001	1 U	3 U	4 U	-	-
C2_Landfill	POZ-7	06/27/2018	POZ-7-20180627	< 0.025	< 0.005	0.389	< 0.0005	< 0.0005	< 0.005	< 0.0005	0.13	< 0.001	0.02	0.00025	< 0.01	< 0.01	< 0.001	2.39	3 U	5.39 J	817	1.61
C2_Landfill	POZ-7	06/27/2018	POZ-7-20180627-FD	< 0.025	< 0.005	0.402	< 0.0005	< 0.0005	0.017	< 0.0005	0.13	< 0.001	0.022	0.0003	< 0.01	< 0.01	< 0.001	1.83	3 U	4.83 J	-	-
C2_Landfill	POZ-7	02/14/2019	POZ-7-021419	< 0.005	< 0.005	0.269	< 0.0005	< 0.0005	< 0.005	< 0.0005	< 0.1	< 0.001	< 0.01	< 0.0002	< 0.01	< 0.01	< 0.001	1.2	3 U	2.6	443	2.55
C2_Landfill	POZ-7	02/14/2019	POZ-7-021419-FD	< 0.005	< 0.005	0.264	< 0.0005	< 0.0005	< 0.005	< 0.0005	< 0.1	< 0.001	< 0.01	< 0.0002	< 0.01	< 0.01	< 0.001	1 U	3 U	1.53	-	-
C2_Landfill	POZ-7	05/20/2019	POZ-7-052019	-	-	-	-	-	-	0.0011	-	-	-	-	-	-	-	-	-	-	547	2.11
C2_Landfill	POZ-7	05/20/2019	POZ-7-052019-FD	-	-	-	-	-	-	< 0.0005	-	-	-	-	-	-	-	-	-	-	-	-

ABBREVIATIONS AND NOTES:
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mv: millivolt
NTU: Nephelometric Turbidity Units
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TABLE 2
ASSESSMENT MONITORING ANALYTICAL RESULTS
CROSS GENERATING STATION - CLASS 2 LANDFILL
SANTEE COOPER
CROSS, SOUTH CAROLINA

			Chemical Group	Field Parameters			
			Chemical Name	ORP	pH	Temperature	Turbidity
			MCL/RSL	-	-	-	-
			Units	mv	pH units	Deg C	NTU
Impound-ment	Location	Sample Date	Sample Name				
Background	CBW-1	02/07/2018	CBW-1-20180207	138	4.42	19.15	0.9
Background	CBW-1	06/20/2018	CBW-1-20180620	105	4.32	22.69	1.9
Background	CBW-1	10/01/2018	CBW-1-20181001	127	4.09	23.78	0
Background	CBW-1	11/29/2018	CBW-1-20181129-RS	-	-	-	-
Background	CBW-1	02/12/2019	CBW-1-021219	111	4.5	18.04	0.5
Background	CBW-1	05/20/2019	CBW-1-052019	111	4.5	18.04	0.5
Background	PM-1	02/07/2018	PM-1-20180207	85	5.29	17.02	1
Background	PM-1	06/20/2018	PM-1-20180620	123	5.58	23.54	1.6
Background	PM-1	10/01/2018	PM-1-20181001	104	5.08	25.31	0
Background	PM-1	11/29/2018	PM-1-20181129-RS	-	-	-	-
Background	PM-1	02/12/2019	PM-1-021219	78	5.47	17.02	9.4
Background	PM-1	05/20/2019	PM-1-052019	39	5.26	25.6	0
C2_Landfill	POZ-4	02/07/2018	POZ-4-20180207	135	6.22	20.22	0
C2_Landfill	POZ-4	06/28/2018	POZ-4-20180628	68	5.78	22.88	0
C2_Landfill	POZ-4	02/13/2019	POZ-4-021319	95	6.28	16.06	0.2
C2_Landfill	POZ-4	04/17/2019	POZ-4-041719	39	5.95	18	0
C2_Landfill	POZ-4	04/17/2019	POZ-4-041719-FD	-	-	-	-
C2_Landfill	POZ-4	05/03/2019	POZ-4-050319	-	-	-	-
C2_Landfill	POZ-4	05/22/2019	POZ-4-052219	40	5.89	23.32	0
C2_Landfill	POZ-5D	02/07/2018	POZ-5D-20180207	-19	6.49	20.78	2.8
C2_Landfill	POZ-5D	06/28/2018	POZ-5D-20180628	10	6.23	23.16	0.6
C2_Landfill	POZ-6	02/08/2018	POZ-6-20180208	106	6.63	16.36	2.5
C2_Landfill	POZ-6	06/28/2018	POZ-6-20180628	3	6.7	27.41	0
C2_Landfill	POZ-6	02/14/2019	POZ-6-021419	57	6.67	19.08	0
C2_Landfill	POZ-6	05/21/2019	POZ-6-052119	1	6.39	20.04	6.7
C2_Landfill	POZ-7	02/07/2018	POZ-7-20180207	196	5.68	19.05	0
C2_Landfill	POZ-7	02/07/2018	POZ-7-20180207-FD	-	-	-	-
C2_Landfill	POZ-7	06/27/2018	POZ-7-20180627	153	6.11	23.85	0
C2_Landfill	POZ-7	06/27/2018	POZ-7-20180627-FD	-	-	-	-
C2_Landfill	POZ-7	02/14/2019	POZ-7-021419	146	5.75	16.59	0
C2_Landfill	POZ-7	02/14/2019	POZ-7-021419-FD	-	-	-	-
C2_Landfill	POZ-7	05/20/2019	POZ-7-052019	96	5.91	20.76	0.6
C2_Landfill	POZ-7	05/20/2019	POZ-7-052019-FD	-	-	-	-

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TABLE 3
SUMMARY OF GROUNDWATER MEASUREMENTS
CROSS GENERATING STATION - CLASS 2 LANDFILL
SANTEE COOPER
CROSS, SOUTH CAROLINA

Location	Measurement Date	Depth to Water	Groundwater Elevation
CBW-1	10/19/2015	7.78	78.02
CBW-1	1/26/2016	8.11	77.69
CBW-1	4/19/2016	9.13	76.67
CBW-1	7/18/2016	10.67	75.13
CBW-1	10/11/2016	7.32	78.48
CBW-1	1/23/2017	8.33	77.47
CBW-1	4/17/2017	8.90	76.90
CBW-1	7/25/2017	8.99	76.81
CBW-1	9/25/2017	8.80	77.00
CBW-1	10/9/2017	9.73	76.07
CBW-1	2/7/2018	9.80	76.00
CBW-1	6/20/2018	10.35	75.45
CBW-1	10/1/2018	10.51	75.29
CBW-1	11/29/2018	9.79	76.01
CBW-1	2/12/2019	8.66	77.14
CBW-1	5/20/2019	8.66	77.14
PM-1	1/26/2015	7.25	75.99
PM-1	2/16/2015	7.60	75.64
PM-1	6/16/2015	7.92	75.32
PM-1	7/6/2015	8.45	74.79
PM-1	10/19/2015	7.42	75.82
PM-1	1/26/2016	7.03	76.21
PM-1	4/19/2016	7.62	75.62
PM-1	7/18/2016	8.36	74.88
PM-1	10/11/2016	7.10	76.14
PM-1	1/23/2017	7.16	76.08
PM-1	4/17/2017	7.48	75.76
PM-1	7/12/2017	7.58	75.66
PM-1	8/31/2017	7.11	76.13
PM-1	9/25/2017	7.81	75.43
PM-1	10/9/2017	8.42	74.82
PM-1	2/7/2018	7.91	75.33
PM-1	6/20/2018	8.88	74.36
PM-1	10/1/2018	8.01	75.23
PM-1	11/29/2018	7.55	75.69
PM-1	2/12/2019	7.32	75.92
PM-1	5/20/2019	8.52	74.72
CCMLF-1	4/18/2019	4.37	76.49
CCMLF-1	5/3/2019	5.60	75.26
CCMLF-1	5/22/2019	7.12	73.42
CCMLF-1	6/21/2019	5.61	75.25
CCMLF-1D	4/18/2019	4.22	76.43
CCMLF-1D	5/3/2019	5.36	75.29
CCMLF-1D	5/21/2019	6.77	73.88
CCMLF-1D	6/21/2019	5.56	75.09
POZ-4	2/16/2015	4.39	78.34
POZ-4	6/17/2015	7.03	75.70
POZ-4	10/22/2015	4.72	78.01
POZ-4	1/27/2016	4.01	78.72
POZ-4	4/25/2016	5.66	77.07
POZ-4	7/18/2016	8.75	73.98
POZ-4	10/13/2016	3.76	78.97
POZ-4	1/24/2017	3.95	78.78
POZ-4	2/2/2017	4.59	78.14
POZ-4	4/18/2017	5.19	77.54
POZ-4	8/1/2017	5.21	77.52
POZ-4	9/26/2017	5.25	77.48
POZ-4	10/11/2017	6.25	76.48
POZ-4	2/7/2018	4.65	78.08
POZ-4	6/28/2018	7.71	75.02
POZ-4	2/13/2019	4.67	78.06

TABLE 3
SUMMARY OF GROUNDWATER MEASUREMENTS
CROSS GENERATING STATION - CLASS 2 LANDFILL
SANTEE COOPER
CROSS, SOUTH CAROLINA

Location	Measurement Date	Depth to Water	Groundwater Elevation
POZ-4	4/17/2019	5.79	76.94
POZ-4	5/3/2019	7.06	75.67
POZ-4	5/22/2019	8.62	74.11
POZ-4	6/21/2019	7.01	75.72
POZ-5D	2/16/2015	4.54	77.95
POZ-5D	6/17/2015	7.22	75.27
POZ-5D	1/27/2016	4.22	78.27
POZ-5D	7/18/2016	8.96	73.53
POZ-5D	1/24/2017	4.14	78.35
POZ-5D	2/2/2017	4.76	77.73
POZ-5D	7/27/2017	5.55	76.94
POZ-5D	2/7/2018	4.85	77.64
POZ-5D	6/28/2018	7.91	74.58
POZ-5D	2/13/2019	4.84	77.65
POZ-5D	4/17/2019	5.96	76.53
POZ-5D	5/3/2019	7.25	75.24
POZ-5D	5/22/2019	8.76	73.73
POZ-6	10/22/2015	7.98	75.86
POZ-6	1/26/2016	5.40	78.44
POZ-6	4/25/2016	7.15	76.69
POZ-6	7/18/2016	10.21	73.63
POZ-6	10/13/2016	5.35	78.49
POZ-6	1/24/2017	5.41	78.43
POZ-6	2/1/2017	5.71	78.13
POZ-6	4/18/2017	77.21	6.63
POZ-6	7/27/2017	6.31	77.53
POZ-6	9/26/2017	6.80	77.04
POZ-6	10/11/2017	12.00	71.84
POZ-6	2/8/2018	5.85	77.99
POZ-6	6/28/2018	9.91	73.93
POZ-6	2/14/2019	6.10	77.74
POZ-6	5/21/2019	9.84	74.00
POZ-7	10/22/2015	5.70	76.32
POZ-7	1/26/2016	4.12	77.90
POZ-7	4/25/2016	5.42	76.60
POZ-7	7/18/2016	7.75	74.27
POZ-7	10/12/2016	3.47	78.55
POZ-7	1/24/2017	4.25	77.77
POZ-7	2/1/2017	4.78	77.24
POZ-7	4/18/2017	76.91	5.11
POZ-7	7/27/2017	5.68	76.34
POZ-7	9/26/2017	5.21	76.81
POZ-7	10/10/2017	6.31	75.71
POZ-7	2/7/2018	5.04	76.98
POZ-7	6/27/2018	7.48	74.54
POZ-7	2/14/2019	4.80	77.22
POZ-7	5/20/2019	7.57	74.45
POZ-8	6/4/2019	10.42	69.45
POZ-8	6/21/2019	7.88	75.25

Notes and Abbreviations:

TABLE 4
SUMMARY OF GROUNDWATER ANALYTICAL RESULTS FOR NATURE AND EXTENT
CROSS GENERATING STATION - CLASS 2 LANDFILL
SANTEE COOPER
CROSS, SOUTH CAROLINA

			Chemical Group								Field Parameters					
			Chemical Name	Calcium, Total	Chloride	Sulfate	Total Dissolved Solids (TDS)	Beryllium, Total	Cobalt, Total	Lithium, Total	Conductivity	Dissolved Oxygen	ORP	pH	Temperature	Turbidity
			MCL/RSL	-	-	-	-	0.004	0.006	0.04	-	-	-	-	-	-
			Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	uS/cm	mg/L	mv	pH units	Deg C	NTU
Impound-ment	**Location**	**Sample Date**	**Sample Name**													
Background	CBW-1	05/20/2019	CBW-1-052019	**42.2**	**2.9**	**115**	**181.2**	< 0.0005	**0.00079**	< 0.01	**202**	**0.99**	**111**	**4.5**	**18.04**	**0.5**
Background	PM-1	05/20/2019	PM-1-052019	**16.4**	**12.7**	**10.5**	**162.5**	< 0.0005	**0.00091**	< 0.01	**187**	**0.77**	**39**	**5.26**	**25.6**	**0**
C2_Landfill	CCMLF-1	05/22/2019	CCMLF-1-052219	**20.8**	**8**	**15.1**	**136.2**	-	**0.0074**	-	**1630**	**0.91**	**66**	**6.06**	**22**	**1.9**
C2_Landfill	CCMLF-1D	05/21/2019	CCMLF-1D-052119	**56.4**	**6.13**	**5.43**	**262.5**	-	< 0.0005	-	**3110**	**0.68**	**-68**	**7.16**	**29.02**	**1.2**
C2_Landfill	POZ-4	05/03/2019	POZ-4-050319	-	-	-	-	-	**0.0036**	-	-	-	-	-	-	-
C2_Landfill	POZ-4	05/22/2019	POZ-4-052219	**468**	**705**	**225**	**1711**	-	**0.198**	-	**2780**	**0.59**	**40**	**5.89**	**23.32**	**0**
C2_Landfill	POZ-5D	04/17/2019	POZ-5D-041719	-	-	-	**4155**	-	**0.0131 / 0.012**	-	**3690**	**0.36**	**-123**	**6.69**	**21.91**	**0**
C2_Landfill	POZ-5D	04/17/2019	POZ-5D-041719-FD	-	-	-	**3952**	-	**0.0133 / 0.012**	-	-	-	-	-	-	-
C2_Landfill	POZ-5D	05/03/2019	POZ-5D-050319	-	-	-	-	-	**0.0233**	-	-	-	-	-	-	-
C2_Landfill	POZ-5D	05/22/2019	POZ-5D-052219	**738**	**840**	**619**	**3682**	-	**0.0284**	-	**3820**	**0.75**	**-36**	**6.41**	**22.59**	**48.1**
C2_Landfill	POZ-6	05/21/2019	POZ-6-052119	**450**	**334**	**483**	**2128**	-	**0.0082**	-	**2420**	**0.91**	**1**	**6.39**	**20.04**	**6.7**
C2_Landfill	POZ-7	05/20/2019	POZ-7-052019	**80.3**	**128**	**5.24**	**533.8**	-	**0.0011**	-	**547**	**2.11**	**96**	**5.91**	**20.76**	**0.6**
C2_Landfill	POZ-7	05/20/2019	POZ-7-052019-FD	**94.3**	**162**	**8.67**	**637.5**	-	< 0.0005	-	-	-	-	-	-	-
C2_Landfill	POZ-8	06/04/2019	POZ-8-060419	**110**	**111**	< 2	**612.5**	-	< 0.001	-	-	-	-	-	-	-
C2_Landfill	POZ-8	06/04/2019	POZ-8-060419-FD	**117**	**102**	< 2	**621.2**	-	< 0.001	-	-	-	-	-	-	-

ABBREVIATIONS AND NOTES:
mg/L: milligram per liter
µS/cm: microSiemen per centimeter
mv: millivolt
NTU: Nephelometric Turbidity Units
< 0.005: Analyte not detected above detection limit
-: Not Analyzed
MCL/RSL: The applicable Mximum Contaminant Level (MCL) or Regional Screening Level (RSL) is shown. Dashed where a standard is not provided.
RS: Resample
FD: Field Duplicate
Highlighted where result exceeds the applicable MCL/RSL

- Criteria used for cobalt, lithium, and molybdenum are RSL for Tapwater where THQ=1.0 (May 2018)
- USEPA. 2016. Final Rule: Disposal of Coal Combustion Residuals from Electric Utilities. July 26. 40 CFR Part 257. https://www.epa.gov/coalash/coal-ash-rule

TABLE 4
SUMMARY OF GROUNDWATER ANALYTICAL RESULTS FOR NATURE AND
CROSS GENERATING STATION - CLASS 2 LANDFILL
SANTEE COOPER
CROSS, SOUTH CAROLINA

			Chemical Group	Dissolved Metals									Total Metals					Other				
			Chemical Name	Beryllium, Dissolved	Calcium, Dissolved	Cobalt, Dissolved	Iron, Dissolved	Lithium, Dissolved	Magnesium, Dissolved	Manganese, Dissolved	Potassium, Dissolved	Sodium, Dissolved	Iron, Total	Magnesium, Total	Manganese, Total	Potassium, Total	Sodium, Total	Alkalinity, Bicarbonate	Alkalinity, Total (as CaCO3)	Dissolved Organic Carbon (DOC)	Total Organic Carbon (TOC)	Sulfide
			MCL/RSL	0.004	-	0.006	-	0.04	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Impound-ment	Location	Sample Date	Sample Name																			
Background	CBW-1	05/20/2019	CBW-1-052019	< 0.0005	**41.1**	**0.00075**	< 0.05	< 0.01	**2.3**	**0.015**	**0.58**	**1.9**	**0.141**	**2.1**	**0.0147**	**0.57**	**1.8**	**19.7**	**19.7**	**3.21**	**2.71**	< 0.1
Background	PM-1	05/20/2019	PM-1-052019	< 0.0005	**15.8**	**0.00088**	**15.6**	< 0.01	**0.8**	**0.0135**	**0.57**	**5.5**	**16.9**	**0.75**	**0.0122**	**0.57**	**5.3**	**58.6**	**58.6**	**7.21**	**6.72**	< 0.1
C2_Landfill	CCMLF-1	05/22/2019	CCMLF-1-052219	-	**19.6**	**0.0067**	**0.302**	-	**1**	**1.56**	**1.3**	**6.3**	**0.323**	**1.1**	**1.63**	**1.4**	**6.9**	**51.7**	**51.7**	< 1	< 1	< 0.1
C2_Landfill	CCMLF-1D	05/21/2019	CCMLF-1D-052119	-	**58.4**	< 0.0005	**0.186**	-	**1.6**	**0.149**	**1.3**	**7**	**0.615**	**1.7**	**0.15**	**1.4**	**7.7**	**146**	**146**	**1.02**	< 1	< 0.1
C2_Landfill	POZ-4	05/03/2019	POZ-4-050319	-	-	**0.001**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C2_Landfill	POZ-4	05/22/2019	POZ-4-052219	-	**411**	**0.182**	**0.651**	-	**7.9**	**4.97**	**3.4**	**105**	**0.735**	**8840**	**5.27**	**3.8**	**118**	**158**	**158**	**1.8**	**1.33**	< 0.1
C2_Landfill	POZ-5D	04/17/2019	POZ-5D-041719	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C2_Landfill	POZ-5D	04/17/2019	POZ-5D-041719-FD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C2_Landfill	POZ-5D	05/03/2019	POZ-5D-050319	-	-	**0.0226**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
C2_Landfill	POZ-5D	05/22/2019	POZ-5D-052219	-	**635**	**0.0262**	**8.3**	-	**12.8**	**2.35**	**2.4**	**95.5**	**10.9**	**105**	**2.61**	**2.6**	**105**	**258**	**258**	**2.19**	**1.5**	< 0.1
C2_Landfill	POZ-6	05/21/2019	POZ-6-052119	-	**443**	**0.0075**	**5.6**	-	**7**	**0.903**	**1.1**	**61.9**	**7.53**	**7.6**	**1.15**	**1.2**	**62.5**	**309**	**309**	**2.59**	**2.16**	< 0.1
C2_Landfill	POZ-7	05/20/2019	POZ-7-052019	-	**76.4**	< 0.0005	< 0.05	-	**3.3**	< 0.001	**3.8**	**14**	**0.237**	**3**	**0.0118**	**3.6**	**13.3**	**60.6**	**60.6**	< 1	< 1	< 0.1
C2_Landfill	POZ-7	05/20/2019	POZ-7-052019-FD	-	**86.4**	< 0.0005	< 0.05	-	**3.4**	< 0.001	**3.7**	**14.7**	**0.0552**	**3.3**	**0.0034**	**3.8**	**15.1**	**111**	**111**	< 1	< 1	< 0.1
C2_Landfill	POZ-8	06/04/2019	POZ-8-060419	-	**95.5**	< 0.001	**1.15**	-	**4.29**	**0.0849**	**3.13**	**14.3**	**1.22**	**3.55**	**0.0717**	**2.66**	**12.7**	**195**	-	**1.12**	**1.18**	< 0.1
C2_Landfill	POZ-8	06/04/2019	POZ-8-060419-FD	-	**102**	< 0.001	**1.05**	-	**3.93**	**0.078**	**2.95**	**13**	**1.54**	**3.99**	**0.0819**	**2.96**	**12.1**	**199**	-	**1.11**	**1.11**	< 0.1

ABBREVIATIONS AND NOTES:
mg/L: milligram per liter
µS/cm: microSiemen per centimeter
mv: millivolt
NTU: Nephelometric Turbidity Units
< 0.005: Analyte not detected above detection limit
-: Not Analyzed
MCL/RSL: The applicable Mximum Contaminant Level (MCL) or Regional Screeni
RS: Resample
FD: Field Duplicate
Highlighted where result exceeds the applicable MCL/RSL

- Criteria used for cobalt, lithium, and molybdenum are RSL for Tapwater where T
- USEPA. 2016. Final Rule: Disposal of Coal Combustion Residuals from
  Electric Utilities. July 26. 40 CFR Part 257.
  https://www.epa.gov/coalash/coal-ash-rule

TABLE 5
REMEDIAL ALTERNATIVE ROADMAP
CROSS GENERATING STATION - CLASS 2 LANDFILL
SANTEE COOPER
CROSS, SOUTH CAROLINA

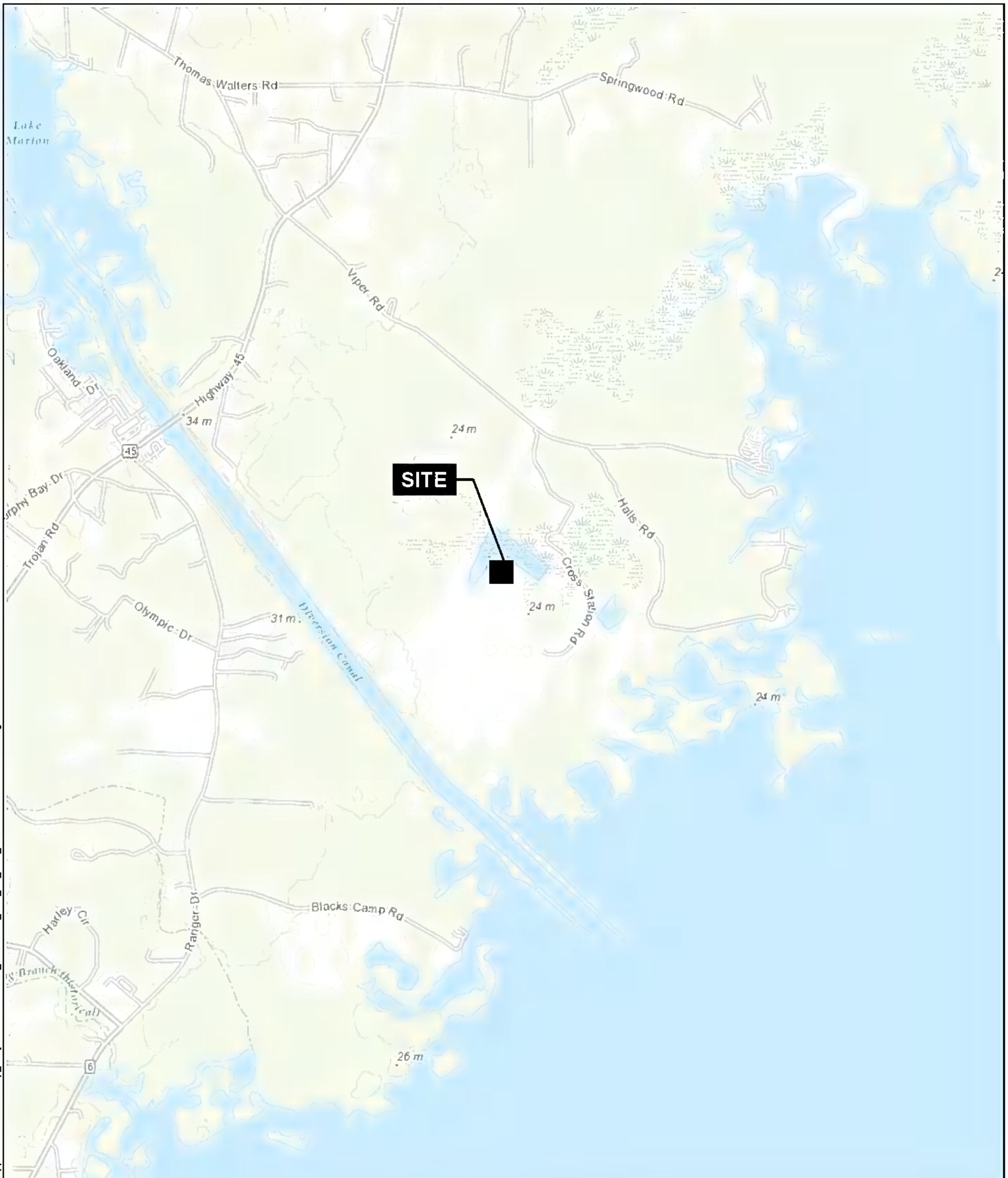
Alternative Number	Remedial Alternative Description	Landfill 2 Closure Description	Groundwater Remedy Components: 1. Groundwater Remedy Approach	Groundwater Remedy Components: 2. Groundwater Treatment Method	Groundwater Remedy Components: 3. Long-Term Monitoring Actions
1	**Monitored Natural Attenuation (MNA)**	**Closed in Place with Low Permeability Cap**	**Natural Attenuation with Monitoring** Monitor downgradient groundwater to confirm decreasing concentrations of cobalt	**No Active Treatment** No Active treatment of groundwater to address cobalt	**MNA** Long-term groundwater monitoring to confirm reduction of cobalt
2	**MNA with Water Management Improvements**	**Closed in Place with Low Permeability Cap**	**Natural Attenuation with Monitoring** Monitor downgradient groundwater to confirm decreasing concentrations of cobalt along with improvements to landfill drainage and water management	**No Active Treatment** No Active treatment of groundwater to address cobalt	**MNA** Long-term groundwater monitoring to confirm reduction of cobalt
3	**Hydraulic Containment (HC) with Direct Discharge**	**Closed in Place with Low Permeability Cap**	**Hydraulic Containment** Mitigate down-gradient migration of groudnwater with cobalt above GWPS using extraction wells	**No Active Treatment** Direct discharge of untreated groundwater under existing permits	**Pump & Discharge Long-Term** Operate hydraulic containment system to maintain reduction of cobalt in groundwater
4	**HC with Ex-Situ Treatment**	**Closed in Place with Low Permeability Cap**	**Hydraulic Containment** Mitigate down-gradient migration of groudnwater with cobalt above GWPS using extraction wells	**Ex-Situ Treatment** Treatment system (for example, ion exchange) to remove cobalt from groundwater and discharge treated water under applicable permits	**Pump & Treat Long-Term** Operate hydraulic containment system and treatment system to maintain reduction of cobalt in groundwater
5	**In-Situ Treatment**	**Closed in Place with Low Permeability Cap**	**Subsurface Treatment System** Mitigate down-gradient migration of groundwater with cobalt above GWPS using in-situ amendments	**Amendment Injections or Permeable Reactive Barrier (PRB)** Subsurface treatment to reduce cobalt concentrations in groundwater	**In-Situ Treatment Long-Term** Continue periodic in-situ treatment of groundwater to maintain reduction of cobalt

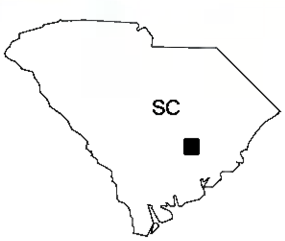
TABLE 6
SUMMARY OF CORRECTIVE MEASURES
CROSS GENERATING STATION - CLASS 2 LANDFILL
SANTEE COOPER
CROSS, SOUTH CAROLINA

Remedial Alternative Synopsis		THRESHOLD CRITERIA: § 257.97(b)(1) Be Protective of Human Health and the Environment	THRESHOLD CRITERIA: § 257.97(b)(2) Attain the groundwater protective standard	THRESHOLD CRITERIA: § 257.97(b)(3) Control the Source of Releases	THRESHOLD CRITERIA: § 257.97(b)(4) Remove as much material from the environment released from the CCR unit as is feasible	THRESHOLD CRITERIA: § 257.97(b)(5) Management of waste all applicable RCRA requirements	BALANCING CRITERIA: § 257.97(c)(1) Long- and Short Term Effectiveness, Protectiveness, and Certainty of Success[1]	BALANCING CRITERIA: § 257.97(c)(2) Effectiveness to Control Further Releases	BALANCING CRITERIA: § 257.97(c)(3) Difficulty of Implementation
1	Closed in Place (CIP) with Monitored Natural Attenuation (MNA)	Meets Criteria	Meets Criteria	Meets Criteria	Meets Criteria	Meets Criteria	Effective short-term since the source is contained within the closed and capped landfill. Expected to be effective long-term since the source is not exposed to infiltration/leaching therefore concentrations will decrease over time.	Moderately effective since remedy relies on naturally occurring physical, chemical, and/or biological attenuation processes only. Technology verified through long-term groundwater monitoring.	Readily implementable and currently underway at the Landfill (approved by DHEC)
2	CIP with MNA and Water Management Improvements	Meets Criteria	Meets Criteria	Meets Criteria	Meets Criteria	Meets Criteria	Effective short-term since the source is contained within the closed and capped landfill. Expected to be effective long-term since the source is not exposed to infiltration/leaching therefore concentrations will decrease over time. Improvements to current landfill drainage collection would further reduce cobalt entering groundwater.	Effective since remedy relies on naturally occurring physical, chemical, and/or biological attenuation processes only. Technology verified through long-term groundwater monitoring. Improvements to drainage system expected to further reduce the amount of cobalt entering groundwater.	Readily implementable and currently underway at the Landfill (approved by DHEC)
3	CIP with Hydraulic Containment (HC) and Direct Discharge	Meets Criteria	Meets Criteria	Meets Criteria	Meets Criteria	Meets Criteria	Effective short-term since the source is contained within the closed and capped landfill. Expected to be effective long-term since the source is not exposed to infiltration/leaching therefore concentrations will decrease over time. In addition, groundwater migrating downgradient will be controlled by hydraulic containment system.	Effective since hydraulic containment system will eliminate down-gradient migration of cobalt in groundwater, but does not treat system effluent. Technology includes extraction well network and monitoring well network.	Readily implementable, requires installation of extraction well network. May require permits for extraction system effluent.
4	CIP with HC and Ex-Situ Treatment	Meets Criteria	Meets Criteria	Meets Criteria	Meets Criteria	Meets Criteria	Effective short-term since the source is contained within the closed and capped landfill. Expected to be effective long-term since the source is not exposed to infiltration/leaching therefore concentrations will decrease over time and groundwater moving downgradient will be controlled by hydraulic containment system. Treatment system operation will generate a secondary waste stream, which will need to be disposed off-site.	Effective since hydraulic containment system will eliminate down-gradient migration of cobalt in groundwater, the system effluent is treated ex-situ. However, creates secondary waste stream. Technology includes extraction well network, ex-situ treatment system, and monitoring well network.	Implementable, will require installation of extraction well network and treatment system. May require permits for treatment system effluent. Will require disposal of secondary waste stream.
5	CIP with In-Situ Treatment	Meets Criteria	Meets Criteria	Meets Criteria	Meets Criteria	Meets Criteria	Effective short-term since the source is contained within the closed and capped landfill. Expected to be effective long-term since the source is not exposed to infiltration/leaching therefore concentrations will decrease over time and groundwater moving downgradient will be treated by subsurface treatment system. Treatment system will require bench scale and pilot testing to demonstrate effectiveness.	Effective since subsurface treatment system will eliminate down-gradient migration of cobalt in groundwater. Technology includes injection well network or PRB and monitoring well network.	Implementable, will require installation of injection well network or PRB. Will likely require subsurface injection permits. May require specialists to design in-situ treatment system or specialized equipment to install a PRB.

1 The long- and short- term effectiveness evaluation considered the following criteria:
(i) Magnitude of reduction of existing risks;
(ii) Magnitude of residual risks in terms of likelihood of further releases due to CCR remaining following implementation of a remedy;
(iii) The type and degree of long-term management required, including monitoring, operation, and maintenance;
(iv) Short-term risks that might be posed to the community or the environment during implementation of such a remedy, including potential threats to human health and the environment associated with excavation, transportation, and redisposal of contaminant;
(v) Time until full protection is achieved;
(vi) Potential for exposure of humans and environmental receptors to remaining wastes, considering the potential threat to human health and the environment associated with excavation, transportation, re-disposal, or containment;
(vii) Long-term reliability of the engineering and institutional controls; and
(viii) Potential need for replacement of the remedy.

FIGURES





MAP SOURCE: ESRI

HALEY ALDRICH

SANTEE COOPER
CROSS GENERATING STATION
CROSS, SOUTH CAROLINA

SITE LOCATION MAP

APPROXIMATE SCALE: 1 IN = 2000 FT
JULY 2019

FIGURE 1

GIS FILE PATH: G:\Projects\42122_Santee_Cooper\Global\GIS\Map_Projects\Cross\2015_08\42122_000_01_Site_Location.mxd — USER: gcarson — LAST SAVED: 9/8/2015 2:28:34 PM

GIS FILE PATH: \\haleyaldrich.com\share\gm_common\131539 - Santee Cooper\GIS\Maps\2019_07\132892_004_0002_CROSS_EXPLORATIONS.mxd — USER: ajospe — LAST SAVED: 7/1/2019 2:52:02 PM

LEGEND

- CLASS 2 LANDFILL WELL
- BACKGROUND WELL

NOTES

1. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE.
2. AERIAL IMAGER SOURCE: ESRI

0 1,000 2,000
SCALE IN FEET

HALEY ALDRICH

SANTEE COOPER
CROSS GENERATING STATION
CROSS, SOUTH CAROLINA

LOCATION OF GORUNDWATER MONITORING WELLS FOR CCR COMPLIANCE - 2019

JULY 2019

FIGURE 2

LEGEND

CLASS 2 LANDFILL WELL

BACKGROUND WELL

LOCATION OF SSI

NOTES

1. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE.

2. AERIAL IMAGER SOURCE: ESRI

0 1,000 2,000
SCALE IN FEET

HALEY ALDRICH

SANTEE COOPER
CROSS GENERATING STATION
CROSS, SOUTH CAROLINA

LOCATION OF APPENDIX III SSI

JULY 2019

FIGURE 3

GIS FILE PATH: \\haleyaldrich.com\share\gm_common\131539 - Santee Cooper\GIS\Maps\2019_07\132892_004_0002_CROSS_EXPLORATIONS.mxd — USER: ajospe — LAST SAVED: 7/1/2019 2:52:02 PM

GIS FILE PATH: \\haleyaldrich.com\share\gm_common\131539 - Santee Cooper\GIS\Maps\2019_07\132892_004_0002_CROSS_EXPLORATIONS.mxd — USER: ajospe — LAST SAVED: 7/1/2019 2:52:02 PM

LEGEND

- CLASS 2 LANDFILL WELL
- BACKGROUND WELL
- LOCATION OF SSL

NOTES

1. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE.
2. AERIAL IMAGER SOURCE: ESRI

0 1,000 2,000
SCALE IN FEET

HALEY ALDRICH

SANTEE COOPER
CROSS GENERATING STATION
CROSS, SOUTH CAROLINA

LOCATION OF APPENDIX IV SSL

JULY 2019

FIGURE 4

LEGEND

- ASH POND WELL
- BACKGROUND WELL
- CLASS 2 LANDFILL WELL
- CLASS 3 LANDFILL AREA B WELL
- GROUNDWATER ELEVATION CONTOUR, IN FT (DASHED WHERE INFERRED)

NOTES

1. GROUNDWATER ELEVATION DATA COLLECTED IN FEBRUARY 2019.
2. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE.
3. AERIAL IMAGER SOURCE: ESRI

N

0 1,000 2,000
SCALE IN FEET

HALEY ALDRICH

SANTEE COOPER
CROSS GENERATING STATION
CROSS, SOUTH CAROLINA

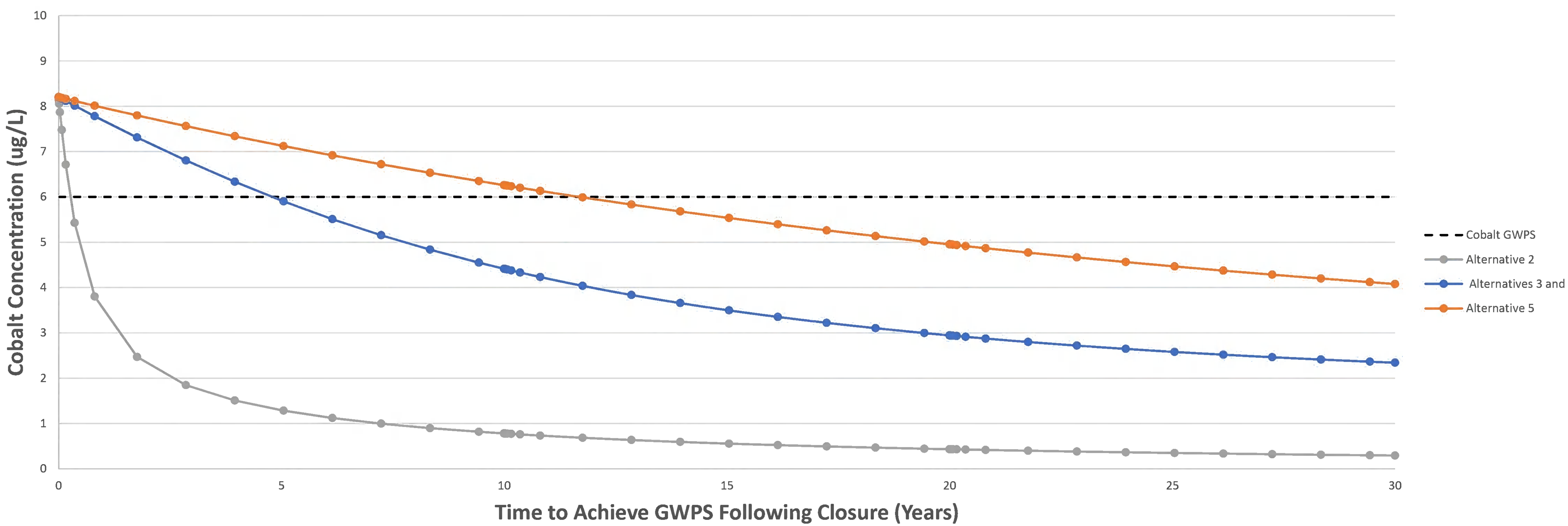
WATER TABLE CONFIGURATION MAP

JULY 2019

FIGURE 5

Modeled Cobalt Concentrations Following Remedy Implementation - Class 2 Landfill

Cross Generating Station - Berkeley County, South Carolina



NOTES:

1.) ug/L - Micrograms per liter
2.) GWPS - Groundwater Protection Standard.
3.) Concentrations are representative of monitoring point approximately 250 feet downgradient
4.) Alternative 2: Monitored natural attenuation with enhanced water management improvements
5.) Alternative 3: Hydraulic containment with direct discharge
6.) Alternative 4: Hydraulic containment with ex-situ treatment
6.) Alternative 5: In-situ groundwater treatment

HALEY ALDRICH

SANTEE COOPER
CROSS GENERATING STATION
CROSS, SOUTH CAROLINA

MODELED COBALT CONCENTRATIONS FOLLOWING REMEDY IMPLEMENTATION - CLASS 2 LANDFILL

July 2019

APPENDIX A

Groundwater Model Output

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APPENDIX A:

GROUNDWATER FLOW MODELING SANTEE COOPER CLASS 2 LANDFILL CROSS, SOUTH CAROLINA

by
Haley & Aldrich of New York
Rochester, New York

for
Santee Cooper
Moncks Corner, South Carolina

File No. 131539-003
July 2019

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1. Groundwater Flow Modeling

A groundwater flow and solute transport model was constructed to evaluate and compare potential corrective measures in support of the Corrective Measures Assessment (CMA) for the Santee Cooper Class 2 Landfill in Cross, South Carolina. The following text describes the model construction, calibration and subsequent simulations of remedy alternatives for Appendix IV constituents above the Groundwater Protection Standard (GWPS).

The numerical model MODFLOW-2005 (Harbaugh, 2005) was selected for the modeling effort and is a three-dimensional, finite difference groundwater flow model capable of simulating the groundwater conditions under various scenarios including pumping and changes to infiltration over time.

1.1 MODEL DOMAIN

The model domain was established to encompass the Santee Cooper Cross generating station (Site) and surrounding areas that represented model boundaries including the nearby and unnamed surface water channel located to the south of the landfill and Lake Moultrie to the east. Given its distance from the Site, it was not necessary to encompass Lake Marion to the west within the model domain.

MODFLOW uses a rectangular grid within the domain and allows for establishing irregular groundwater flow boundary conditions that represent actual and Site-specific features in the study area. The setup is facilitated by assigning boundary types and values to specific grid cells. Figure 1 depicts the model domain boundary overlain on an aerial photograph of the Site.

Figure 2 depicts the model domain with the grid spacing selected for the model. The three-dimensional finite difference groundwater flow model domain covers a length of 11,710 feet in the x-direction (west to east), 14,330 feet in the y-direction (north to south), and approximately 50 feet in the z-direction (vertical). The grid layers were set to a minimum thickness of 0.1 feet to avoid model inconsistencies associated with pinch outs and rapid cell drying. The model consists of 413 rows 450 columns, and 5 layers for a total of 929250 cells covering an approximate area of 3852 acres. In MODFLOW, the groundwater-flow system is subdivided laterally and vertically into rectilinear blocks called cells. The hydraulic properties of the material in each cell are assigned and assumed to be uniform within each cell. The row and column dimension of each cell is variable based on proximity to the Site. This variability was created to allow for finer resolution within the vicinity of the primary flow pathway for the Site.

A Digital Elevation Model (DEM) was obtained from the USGS website to create the surface of the model for the Site. Lithologic descriptions contained in the boring logs generated during various phases of environmental investigations as well as cross-sections prepared as part of the 2011 Site Hydrogeologic Characterization report were used to develop formation geometry and hydraulic properties. The cross-sections that were utilized to build the model are provided in Appendix A. The Site was divided into three vertical lithologic units to represent geologic conditions underlying the Site and to account for vertical heterogeneities within the model.

A summary of each geologic unit is as follows:

- Wicomico Formation – Unconsolidated, upward-fining sequences of poorly sorted sand, silt, and clay deposited in a near-shore marine depositional setting that includes barrier islands and back-barrier depositional environments. This depositional setting produces soil types that grade laterally and vertically from more sandy types to more clayey soil types.

- Raysor Formation – Unconsolidated or weakly cemented discontinuous layer of sandy limestone that contains abundant weathered mollusk shells deposited in a shallow marine-shelf environment.

- Santee Limestone – Thin highly weathered layer consisting of relatively dense partially indurated, shelly, fine to medium sand. This thin layer is underlain by a thick consolidated layer of variably weathered crystalline, soft to hard, medium to light gray, shelly to muddy limestone.

Elevations used in the model were determined from digital elevation models for the area. The topography of the ground surface is mimicked in the subsequent lower layers; however, the elevation has been reduced by the layer thickness. Layer thicknesses were determined through the review of the above-mentioned Site geology.

Figure 3 depicts the two-dimensional views of the model layer elevations. The surfaces shown in Figure 3 represent the model top (i.e., land surface), the flat model bottom, and all the lithologic interfaces between.

1.2 BOUNDARY CONDITIONS

Boundary conditions define the locations and manner in which water enters and exits the active model domain. The conceptual model for the groundwater system that forms the basis for the model boundaries are as follows:

1. Nearby lakes Marion (used to estimate western boundary elevations) and Moultrie in addition to the nearby connection canal between the two lakes control groundwater flow on three sides of the model,
2. Recharge at the Site creates radial flow away from the Site toward the nearby water bodies,
3. There is an easterly component of flow from Lake Marion to Lake Moultrie.

The specified boundaries of the model coincide with predicted natural hydrologic boundaries. To recreate observed groundwater flow, two types of model boundaries were used: specified head boundaries, and the Modflow River package. The locations of these boundary conditions in the model are illustrated in Figure 4 through Figure 8.

1.2.1 Specified Head Boundaries

The MODFLOW Time Variant Specified Head Package (Harbaugh, 2005), also known as the Constant Head Package, was used to simulate boundaries presented in Figure 4 through Figure 8. The package is used to fix the head values in selected grid cells regardless of the conditions in the surrounding grid cells. The cell with the assigned constant head acts either as a source of water entering or a sink of water leaving the system. The values for this boundary are referenced to datum NAVD 88 and range from 76 to 71 feet for Layer 1 through Layer 5. These values were estimated based on topography, the depths to water in wells at the Site, the pattern of groundwater flow, elevations of nearby water bodies, and through calibration of the groundwater flow model as described in Section 1.3 below.

1.2.2 River Boundaries

River boundaries in Modflow are a special form of the head-dependent boundary condition. In a head-dependent boundary, the model computes the difference in head between the boundary and the model cell to calculate the amount of water flowing into or out of the model through the boundary. Figure 4 represents the river boundary condition representing the canal between the two lakes near the Site. The head assigned to this boundary was calibrated based on the water levels observed in nearby wells, however, the elevation was restricted to elevations observed between the two lakes.

1.3 HYDRAULIC MODEL PROPERTIES

Hydraulic properties were initially assigned consistent with data presented in the 2011 Site Hydrogeologic Characterization Report. Values were assigned for horizontal hydraulic conductivity and vertical hydraulic conductivity. These parameters were iteratively varied during model calibration to achieve the best fit to observed hydraulic patterns including head elevations, hydraulic gradients, and flow directions.

For calibration, uniform hydraulic properties were applied within discrete model layers. Results of the initial calibration indicated that hydraulic conductivities in the range of those values determined from slug tests were representative with regard to groundwater flow observed at the Site. The hydraulic conductivity values used in the model are presented below for the three hydrogeologic units underlying at the Site:

- Wicomico Formation – 25 feet per day (ft/day) or 8.9 x 10-3 centimeters per second (cm/s)
- Raysor Formation – 57.6 ft/day or 2.0 x 10-2 cm/s
- Santee Limestone – 17.7 ft/day or 6.0 x 10-3 cm/s

1.3.1 Calibrated Horizontal and Vertical Hydraulic Conductivity

The calibrated horizontal (K_X and K_Y) and vertical (K_Z) hydraulic conductivity values in Model layer 1 through 5 were distributed uniformly across the model domain. Vertical hydraulic conductivity values were estimated at 1/10th of the horizontal hydraulic conductivity values. As previously stated, hydraulic conductivity from slug test data presented in the 2011 Site Hydrogeologic Characterization Report were utilized in the calibration process for hydraulic conductivity in the model.

1.3.2 Porosity, Storage, and Yield

Effective porosity values are needed for particle tracking and solute transport simulations. The effective porosity values were conservatively estimated based on the soil type through the examination of boring logs. Due to the generally sandy aquifer make-up a porosity of 0.25 was utilized for the model. This value is slightly higher than clean sand as most logs depict some amount of fine-grained material. As such, specific storage and specific yield were estimated as being 0.02 and 0.23, respectively.

1.4 METHODS OF EVALUATING MODEL CALIBRATION QUALITY

Model calibration is the process of refining the model representation of the hydrogeologic framework, hydraulic properties, and boundary conditions to minimize the difference between the simulated heads and fluxes to the measured data. Construction of a complex model with more parameters than the data support may reduce the residuals (difference between measured and simulated values) but does not ensure a more accurate model. Therefore, calibrated model parameters also need to be checked for their validity. Throughout the calibration process, no adjustments were made that conflicted with the general understanding of the groundwater system and previously documented information.

The iterative calibration process of "trial and error" was used for model calibration. It involves making changes to the input values, running MODFLOW, and assessing the impact of the changes. Beside the trial and error approach, a model independent parameter optimization software tool – PEST was used to adjust selected input values to further improve model calibration (Doherty, 2010).

The quality of model fit can be assessed from many statistical and graphical methods. One method is based on the difference between simulated and observed heads and flows, or residuals. The overall magnitude of the residuals is considered, but the distribution of those residuals, both statistically and spatially, can be equally important. The magnitude of residuals can initially point to gross errors in the model, the data (measured quantity), or how the measured quantity is simulated (Hill, 1998). A useful graphical analysis is a simple scatter plot of all simulated values as a function of all observed values.

For the flow calibration, the statistics of the mean error (ME), mean absolute error (MAE), and the root mean square (RMS) error were used to assess the calibration quality. They are defined as follows:

$$ME = \frac{\sum_{i=1}^{n}(O_i - C_i)}{n}$$

$$MAE = \frac{\sum_{i=1}^{n}|O_i - C_i|}{n}$$

$$RMS = \frac{\sum_{i=1}^{n}(O_i - C_i)^2}{n}$$

Where:
Oi = Observed head at observation point i
Ci = Calculated head at observation point i
n = Number of observation points

The mean error is the average of the differences between the observed and calculated heads (or residuals) and can indicate the overall comparison between computed and observed data. Negative and positive residuals can cancel each other out, resulting in a mean error close to zero even when the calibration is not good. The sign of the mean error is an indication of the overall comparison of the model to the data (e.g. a positive mean error indicates the model is generally computing heads that are too high).

The mean absolute error is the average of the absolute values of the residuals. The absolute value prevents positive and negative residuals from canceling each other, providing a clearer picture of the magnitude of errors across the model, without an indication of the direction (high or low) of the errors.

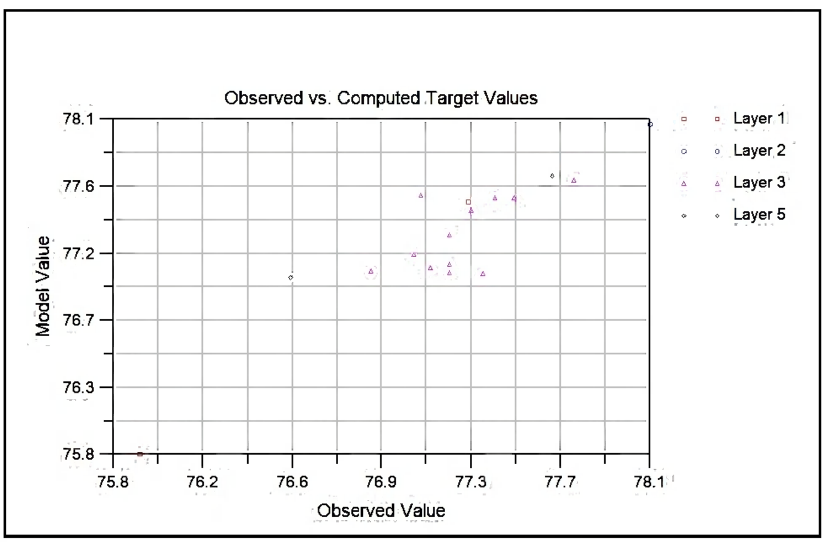
The RMS error is the square root of the average of the squares of the residuals. The RMS adds additional weight to points where the residual is greatest. If the residuals at all points are very similar, the RMS will be close to the mean absolute error. Alternatively, a few points with high errors can add significantly to the RMS for an otherwise well calibrated model. For all three of these criteria the optimal value is zero.

The numerical goals for the groundwater flow model calibration are to (1) minimize the ME and MAE errors and (2) achieve the ratio of the root mean square (RMS) error of the head residuals to the range of observed heads (i.e., normalized RMS error) to be at least less than 10 percent (Anderson and Woessner, 1992).

Groundwater flow field calibration for the Site has been conducted to provide a reasonable representation of the groundwater flow field in the vicinity of the Site, which forms the basis of assessing cobalt migration potential through the fate and transport process. To accomplish this objective, a MODFLOW numerical model was developed to simulate observed groundwater conditions at the Site through calibrating a representative steady-state flow field. The decision of using a steady-state flow field for the flow model calibration was made through an evaluation of the available groundwater elevation data for the Site. Most importantly is that historical flow patterns have been relatively consistent at the Site; therefore, a steady-state flow model was deemed reasonable to represent average flow conditions.

The evaluation of gauging data resulted in the selection of 12-14 February 2019 as the observed heads for the flow model calibration for representing Site conditions (Table 1).

The numerical calibration goals have been achieved. The mean error in head was -0.04 feet or 1.8 % of the head observation range, 2.14 feet. The absolute residual is +0.16 feet. The RMS error for the calibrated model was +0.20 feet and the normalized RMS error was 9.5%. Presented below is the scatter plot of the observed versus simulated heads, which generally fall along the theoretical slope of 1 to 1. Table 1 provides the observed heads on 12-14 February 2019, as discussed above, used to generate the plot below. The quality of the flow model calibration meets the calibration goals as described herein.



Because the calibration has met the acceptable calibration goals, the groundwater flow model is considered to be usable for the development of the cobalt fate and transport models described in Section 2.0.

2. Fate and Transport Modeling

Contaminant fate and transport modeling was conducted utilizing the three-dimensional, numerical model MT3DMS (Version 5 of MT3D) (Zheng, 1990). MT3DMS simulates advection, dispersion, adsorption and decay of dissolved constituents in groundwater using a modular structure similar to MODFLOW to permit simulation of transport components independently or jointly. MT3D interfaces directly with MODFLOW for the head solution and supports all the hydrologic and discretization features of MODFLOW. The MT3D code has a comprehensive set of solution options, including the method of characteristics (MOC), the modified method of characteristics (MMOC), a hybrid of these two methods (HMOC), and the standard finite-difference method (FDM). MT3D was originally released in 1990 as a public domain code from the United State Environmental Protection Agency (USEPA) and has been widely used and accepted by federal and state regulatory agencies.

For this modeling effort, the MT3DMS model utilized the flow regime from the steady-state, calibrated Site groundwater flow model presented in Section 1.0 to simulate transport of cobalt. The steady state model was transformed into a transient model so various CMA options could be evaluated with respect to time. The strength and locations of the potential cobalt sources specified in the transport models were based on current dissolved-phase concentration distributions from groundwater monitoring data at the Site.

In addition to the MODFLOW groundwater flow field discussed in Section 1.0, the fate and transport models require inputs of effective porosity values, dispersivity coefficients, and adsorption rate constants for cobalt. In the modeling effort, input parameter values were defined from Site data, whenever possible, or through the use of conservative literature values.

2.1 TRANSPORT MODELING APPROACH

The solute transport portion of the modeling effort focused mainly on the future flow pathway for cobalt at the Site. As such, the initial concentration including the current plume extent and the estimated leachable mass near the existing landfill were utilized in place as a constant source. The location and initial concentrations for cobalt within the model (layer 3) is presented in Figure 9.

The calibrated flow model was allowed to run for 100 years following implementation of the groundwater remedy. Calibration of the concentrations through time was not performed on the predictive model as the starting conditions were the current conditions at the Site and thus represent a conservative estimate of transport through the Site.

2.2 KEY PARAMETERS FOR TRANSPORT MODELING

The following sections describe the key input parameters of the transport model, and how they were derived.

2.2.1 Effective Porosity

The effective porosities used in the model were presented in previous Section 1.3.2.

2.2.2 Dispersivity

Dispersion incorporates the effects of fluid mixing that result from heterogeneities within the groundwater system and molecular diffusion, which is the random movement of ions or molecules. If the molecules of water and dissolved constituents traveled at the average seepage velocity, there would be an abrupt interface and dispersion would be negligible. However, in natural systems water molecules and dissolved contaminants do not all travel at the same rate; some travel faster and some slower. Dispersion in the model accounts for the spreading of the dissolved plume. Diffusion is time dependent and is significant at low velocities. In general, dispersion acts to decrease the contaminant concentration on the leading edge of the plume, while increasing the size and rate of transport of the dissolved plume. Longitudinal dispersion occurs in the direction of advective groundwater flow, while transverse dispersion occurs perpendicular to groundwater flow.

The groundwater modeling generally accepted longitudinal dispersity value (α_L) estimate is 1 to 100. The horizontal transverse dispersivity (α_T) can be estimated as approximately one-tenth of the α_L, and vertical transverse (α_v) dispersivity can be estimated as one-hundredth of the α_L. The values utilized for dispersivity values are as follows:

- α_L - 100 ft,
- α_T – 10 ft, and
- α_V - 1 ft

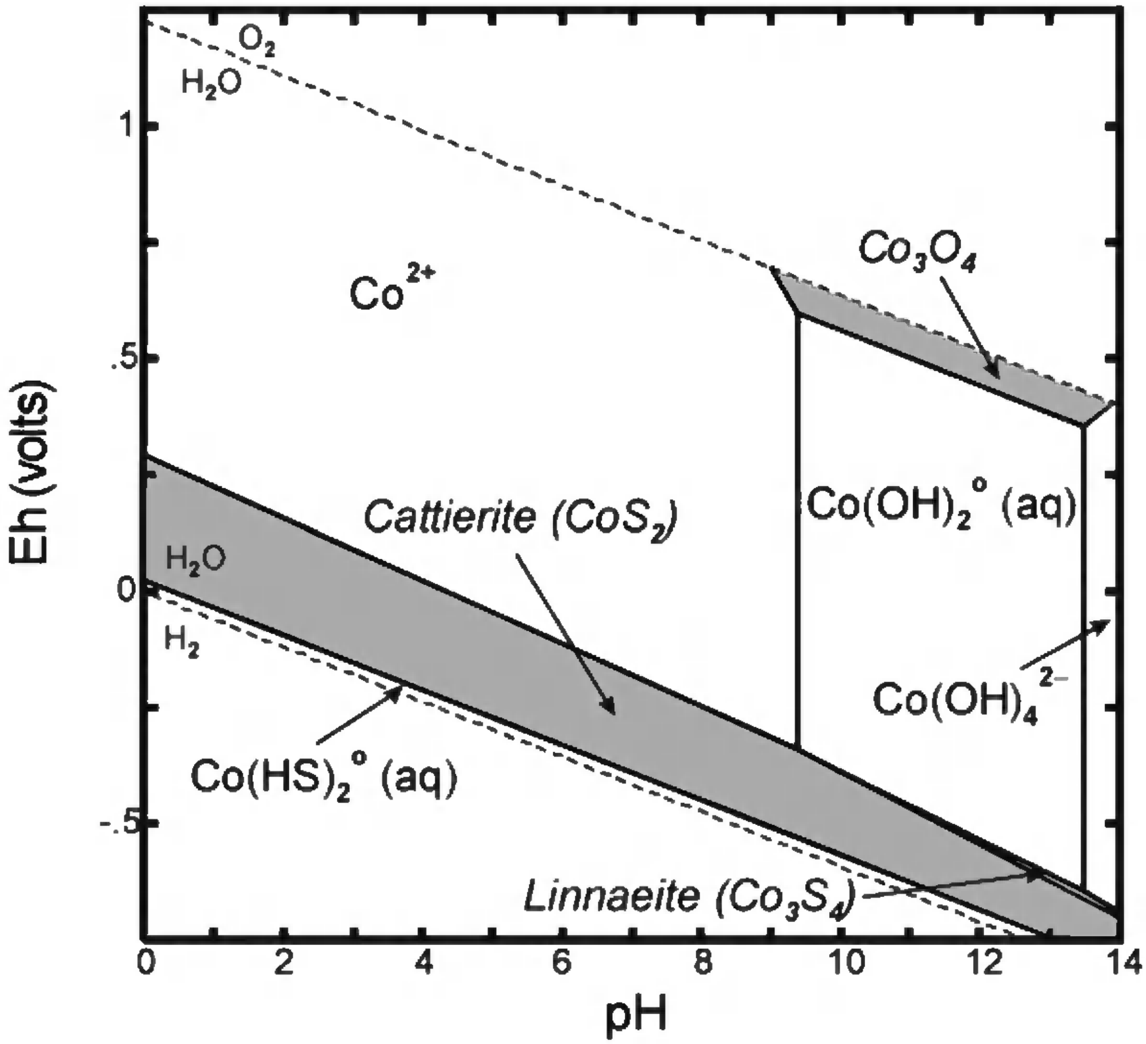
2.2.3 First-Order Degradation Rate Constant – Lambda (λ)

Another input parameter for the fate and transport model is the first order degradation rate constant (λ) for cobalt. This rate constant only takes into account degradation of the dissolved constituent during transport, as it leaves the source. This rate constant does not factor in effects of advection, sorption or dispersivity (dispersion). The field-scale degradation rate constant usually can be expressed as a first order decay process. Due to the general lack of decay for metals within the groundwater system, a first-order decay rate was not specified for model simulations.

2.2.4 Retardation Effects

The affinity for cobalt to sorb to the geologic matrix is a function of the k_d (distribution coefficient) and bulk density of the groundwater system. A description of each parameter is presented below.

Cobalt (Co) (atomic number 27) is a transition metal in Group VIII of the periodic classification of the elements. The aqueous speciation and potential formation of Co-related minerals of Co under a spectrum of the electro-potential (Eh) and pH conditions are shown below. Based on Site groundwater monitoring results, the range of pH is approximately between 4 and 7 and the range of oxidation-reduction potential is approximately between 40 to 170. Since the Site geochemical conditions is not sulfide-genic, the main Co species in groundwater is expected to be Co^{2+} related species.



Eh-pH Diagram Showing Dominant Aqueous Species of Cobalt and Eh-pH Region (Shaded Area) Where the Solubilities of Cobalt Solids Have Been Exceeded [Diagram was calculated at 25 ºC and a concentration of 10^{-12} mol/L total dissolved cobalt in the presence of dissolved chloride, nitrate, carbonate, and sulfate.]

2.2.4.1 Adsorption of Cobalt on Aquifer Solids

2.2.4.2 Adsorption in the absence of organic ligands

The adsorption of Co has been studied on a variety of minerals, sediments, soils, and crushed rock materials. Typically, at near neutral and basic pH values, Co in the absence of organic complexants exhibits high adsorption affinity for minerals. The linear adsorption coefficient (Kd) values commonly reported in the literature range from 10^3 to 10^5 Liter/Kilogram (L/Kg).[1] Metal oxides (iron, manganese, and aluminum oxides) in aquifer solids are shown to play a major role in Co adsorption. The extent of adsorption is greatly influenced by pH. Generally, the degree of adsorption increases with pH. It was

[1] Krupka, K.M. and Serne, R.J., 2002. Geochemical Factors Affecting the Behavior of Antimony, Cobalt, Europium, Technetium, and Uranium in Vadose Zone Sediments (No. PNNL-14126). Pacific Northwest National Lab.(PNNL), Richland, WA (United States).

also found that the surface-bound humic acid functional moieties on aquifer solids increased Co adsorption on all mineral sorbents by 10 to 60%. The largest increase in Co adsorption occurred in the pH range from 4.5 to 6.5, where the humic acid adsorption was the greatest; Co adsorption due to surface bound humic acid was weak and dominated by ion exchange.[2]

Sheppard et al. evaluated a large set of Co sorption and desorption data and summarized the geometric mean Kd values for various soil types and conditions as follows: Sand Kd = 260 L/Kg, Loam Kd = 810 L/Kg, Clay Kd = 3,800 L/Kg, Organic Matter Kd = 87 L/Kg, and Soil with pH ≤ 5 Kd = 12 L/Kg.[3]

Because the site aquifer solids are sandy and the geochemical conditions for Site groundwater is generally acidic (pH< 6), a Kd value of 2 L/Kg is considered to be a representative, yet conservative estimate for evaluation of Co transport in the saturated zone.

2.2.4.3 Adsorption in the Presence of organic ligands

The presence of certain natural and synthetic organic ligands is known to reduce the adsorption of Co on sediments, soils, minerals, and other geologic materials especially at basic conditions. This decrease in Co adsorption is typically caused by the formation of anionic cobalt complexes at near neutral and basic pH conditions, which do not readily adsorb on mineral surfaces at basic pH values. Co in the absence of organic complexants normally exhibits cationic adsorption behavior, and the adsorption of Co to oxide minerals is low at acidic conditions and then increases with increasing pH. The formation of anionic cobalt complexes (inorganic or organic) reverses this trend in adsorption at basic pH conditions.

Site groundwater exhibits a range of total organic carbon (TOC) concentrations in groundwater between 1 mg/L and 7 mg/L, which is a typical range for groundwater. Because the observed Co concentrations do not show a positive correlation with the TOC concentrations, the influence of organic ligands for Co sorption to aquifer solids at the Site is not considered to be important.

2.2.5 Source Initial Concentration Data

To conservatively predict the transport of cobalt and preserve the mass transported through the Site, the source area was defined utilizing initial concentration and constant sources in the form of recharge. The current extent of the groundwater plume for cobalt was generated based on current groundwater concentrations in the monitoring well network.

Three discrete areas with concentrations of cobalt above detection are present at the Site within the vicinity of the Landfill. Initial concentrations were created near the following wells at concentrations observed from groundwater sampling events.

- POZ-4 – 198 micrograms per liter (mg/L)
- POZ-6 – 8.2 mg/L
- CCMLF-1 – 5.7 mg/L

[2] Zachara J.M., Resch, C.T., and Smith, S.C., 1994. Influence of Humic Substances on Co2+ Sorption by a Subsurface Mineral Separate and Its Mineralogic Components. Geochimica et Cosmochimica Acta, 58:553-566.

[3] Sheppard, S., Long, J., Sanipelli, B. and Sohlenius, G., 2009. *Solid/liquid partition coefficients (Kd) for selected soils and sediments at Forsmark and Laxemar-Simpevarp* (No. SKB-R--09-27). Swedish Nuclear Fuel and Waste Management Co.

2.3 TRANSPORT MODEL RESULTS- COBALT

The following section summarizes the predictive results from the model runs 100 years following the groundwater CMA option assessment. This estimate shows the relative relation between each option for assessment purposes. Concentrations of cobalt were observed at monitoring well located approximately 600 feet downgradient of the landfill in the direction of groundwater flow. A detailed discussion of each option is presented in the CMA report.

TABLES

Table 1
February Groundwater Elevations
Santee Cooper
Cross, South Carolina

Well	Easting Feet	Northing Feet	Depth To Water Feet	Groundwater Elevation Feet (NAVD88)
CAP-1	2273089.38	561223.22	5.4	77.3
CAP-3	2272207.61	562513.7	14.39	77.1
CAP-5	2272846.82	563697.1	14.89	76.89
CAP-7	2274081.72	562969.45	14.57	77.07
CAP-9	2274593.46	561813.37	14.37	77.22
PM-1	2269801.59	558532.71	7.32	75.92
POZ-5D	2269944.514	566182.0385	4.84	77.65
CLF-1B-5D	2270721.025	565588.3164	4.38	76.55
POZ-4	2269884.716	566240.5539	4.67	78.06
POZ-6	2269283.405	566617.3156	6.1	77.74
POZ-7	2267285.398	564244.465	4.8	77.22
CLF-1B-1	2269396.353	562812.1258	6.27	77.49
CLF-1B-2	2269816.783	563348.3265	4.63	77.41
CLF-1B-3	2270176.281	564122.1617	5.44	77.31
CLF-1B-4	2270652.222	565630.1312	5.38	77.36
CLF-1B-5	2270493.127	564774.133	3.87	77.22
CBW-1	2268722.248	560522.1348	8.66	77.14

FIGURES

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SITE PLAN WITH MODEL DOMAIN

JULY 2019

FIGURE 1

GIS FILE PATH: D:\2_GIS\Santee Cooper\Cross Station\Groundwater Flow Model\Santee_Cooper_Cross_Flow_Model.mxd — USER: dquafisi — LAST SAVED: 7/11/2019 7:04:40 AM

LEGEND

- Monitor Well Locations
- Model Grid
- Model Domain

NOTES

1. Aerial Imagery Provided By ESRI
2. All Locations and Extents Approximate

0 1,600 3,200
SCALE IN FEET

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SITE PLAN WITH MODEL GRID

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FIGURE 2

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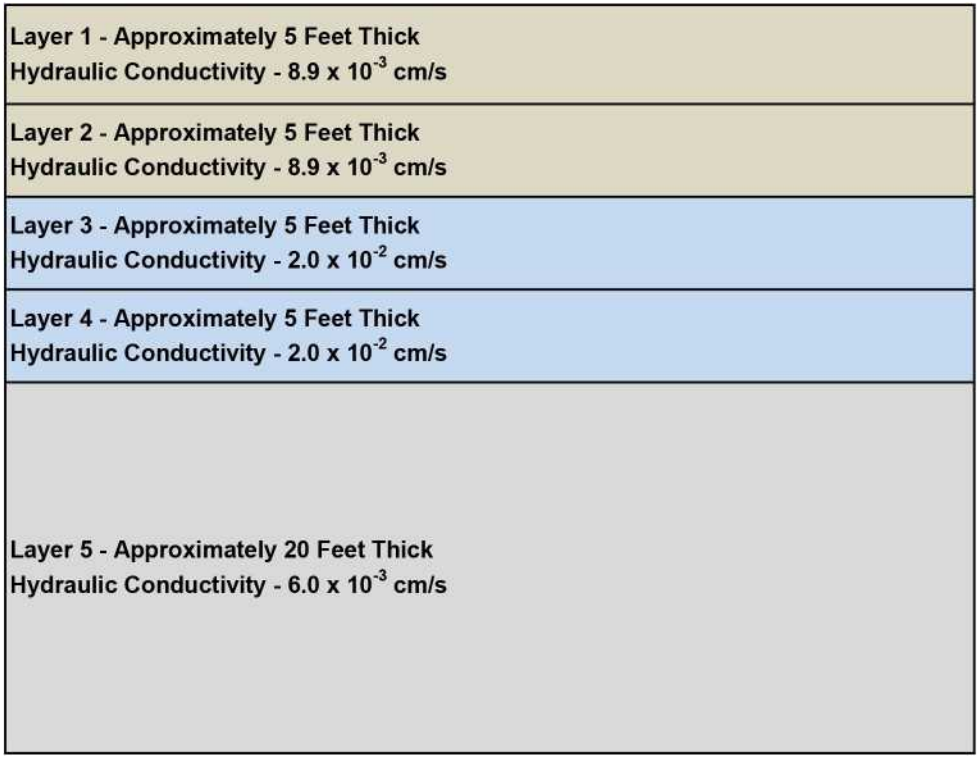

NOTES:

1. Layer Thicknesses Approximate Due To Variability In Model

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NEW PROVIDENCE, NEW JERSEY

Model Layers 1 Through 5
With Hydraulic Conductivities

July 2019 **Figure 3**

NOTES

1. Aerial Imagery Provided By ESRI

2. All Locations and Extents Approximate

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SITE PLAN WITH BOUNDARY CONDITIONS LAYER 1

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FIGURE 4

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LEGEND

Monitor Well Locations
Model Domain
River Boundary

Constant Head Boundary

71 Ft
74.22 Ft
76 Ft

NOTES

1. Aerial Imagery Provided By ESRI
2. All Locations and Extents Approximate

N

0 1,600 3,200
SCALE IN FEET

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CROSS, SOUTH CAROLINA

SITE PLAN WITH BOUNDARY CONDITIONS LAYER 2

JULY 2019

FIGURE 5

LEGEND

- Monitor Well Locations
- Model Domain
- River Boundary

Constant Head Boundary

- 71 Ft
- 74.22 Ft
- 76 Ft

NOTES

1. Aerial Imagery Provided By ESRI
2. All Locations and Extents Approximate

0 1,600 3,200
SCALE IN FEET

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SITE PLAN WITH BOUNDARY CONDITIONS LAYER 3

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FIGURE 6

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LEGEND

- Monitor Well Locations
- Model Domain
- River Boundary

Constant Head Boundary

- 71 Ft
- 74.22 Ft
- 76 Ft

NOTES

1. Aerial Imagery Provided By ESRI
2. All Locations and Extents Approximate

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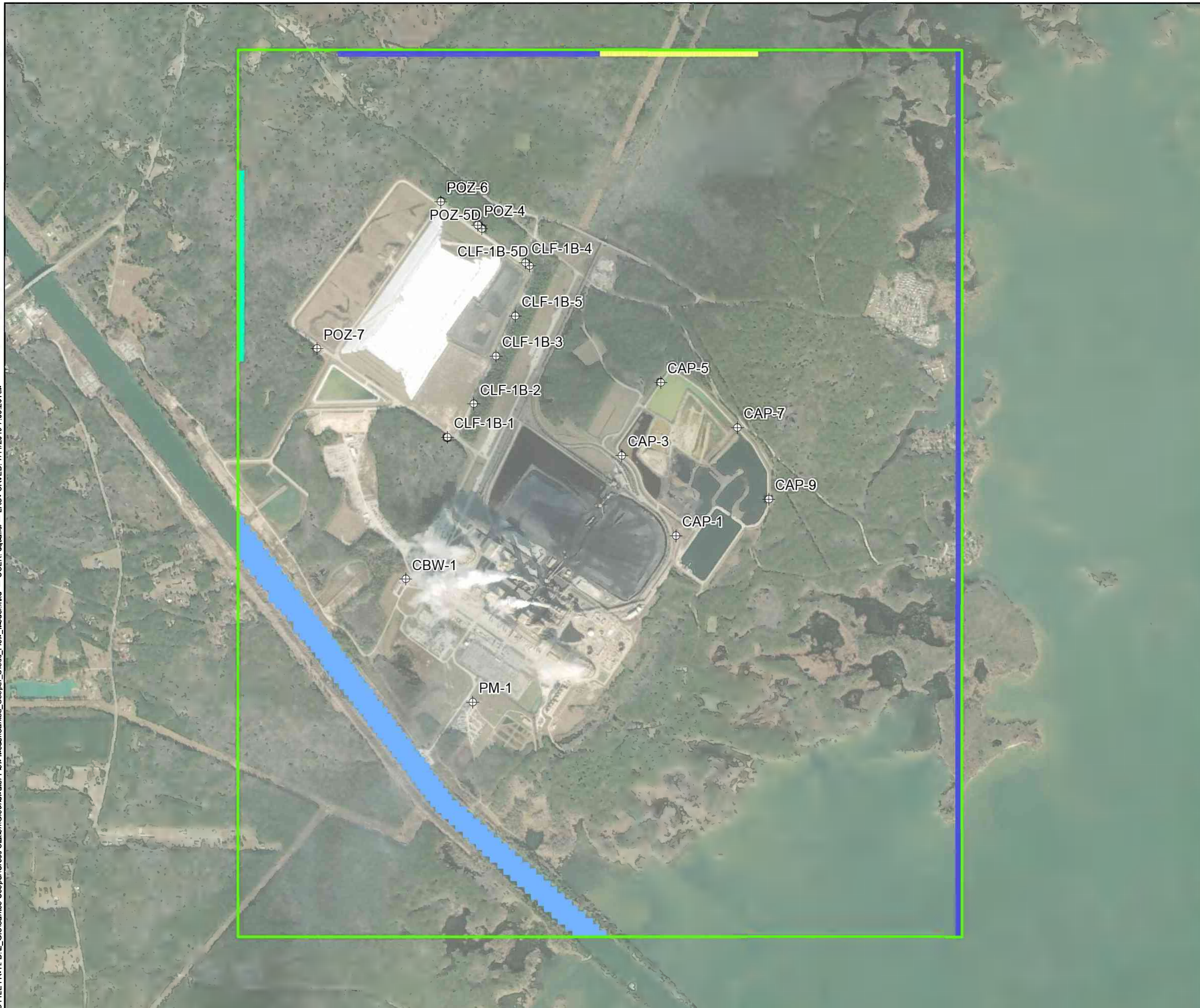
SITE PLAN WITH BOUNDARY CONDITIONS LAYER 4

JULY 2019

FIGURE 7

GIS FILE PATH: D:\2_GIS\Santee Cooper\Cross Station\Groundwater Flow Model\Santee_Cooper_Cross_Flow_Model.mxd — USER: dquafisi — LAST SAVED: 7/11/2019 7:08:26 AM



LEGEND

Monitor Well Locations

Model Domain

River Boundary

Constant Head Boundary

71 Ft

74.22 Ft

76 Ft

NOTES

1. Aerial Imagery Provided By ESRI
2. All Locations and Extents Approximate

0 1,600 3,200
SCALE IN FEET

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CROSS GENERATION STATION
CROSS, SOUTH CAROLINA

SITE PLAN WITH BOUNDARY CONDITIONS LAYER 5

JULY 2019

FIGURE 8

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LEGEND

- Monitor Well Locations
- Model Domain

Initial Concentration

- 5.7 ug/L
- 8.2 ug/L
- 198 ug/L
- River Boundary

NOTES

1. Aerial Imagery Provided By ESRI
2. All Locations and Extents Approximate

0 1,600 3,200
SCALE IN FEET

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CROSS GENERATION STATION
CROSS, SOUTH CAROLINA

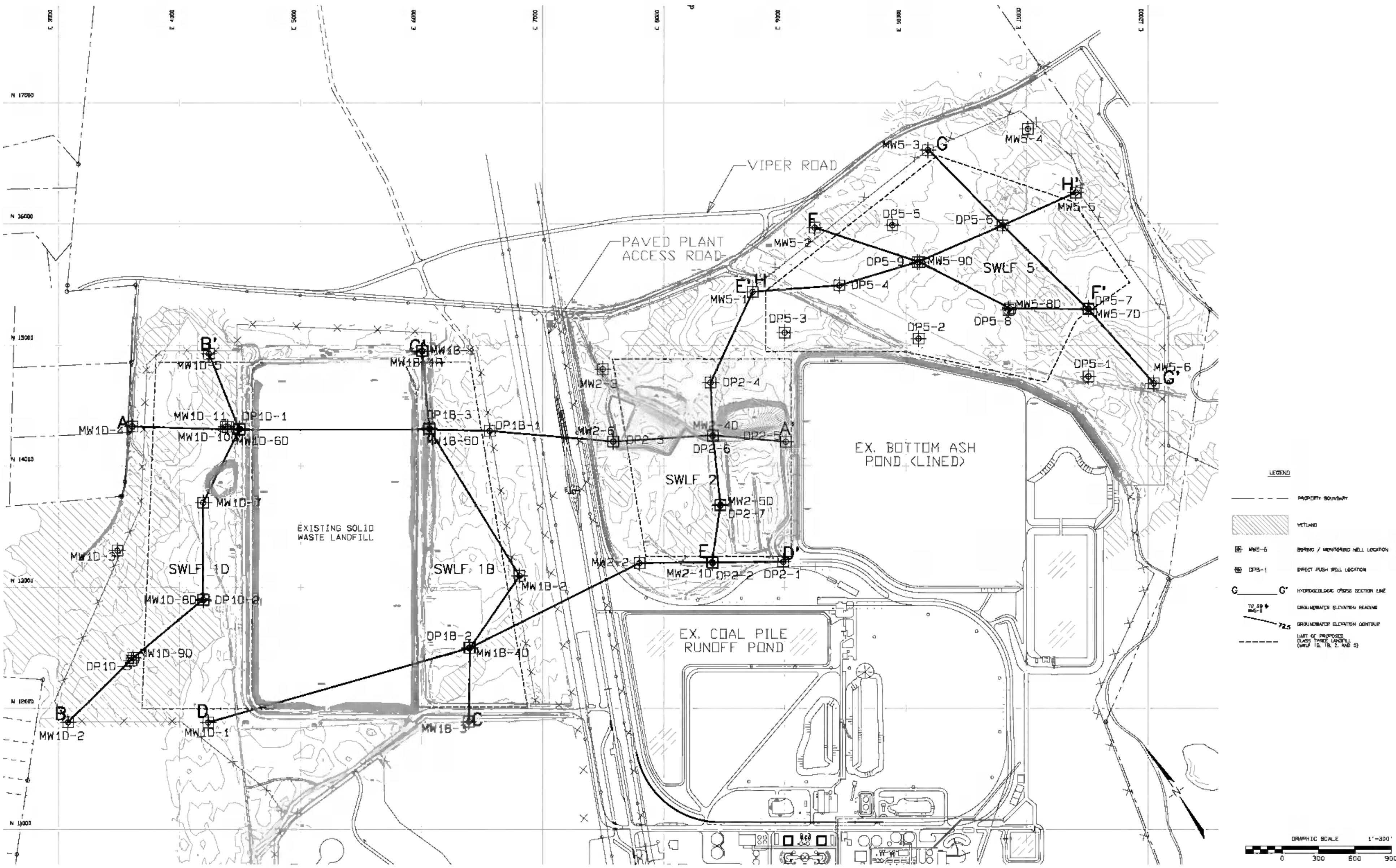
SITE PLAN WITH INITIAL CONCENTRATIONS LAYER 3

JULY 2019

FIGURE 9

APPENDIX A

Cross Sections



REVISION	DATE
1)	
2)	
3)	
4)	

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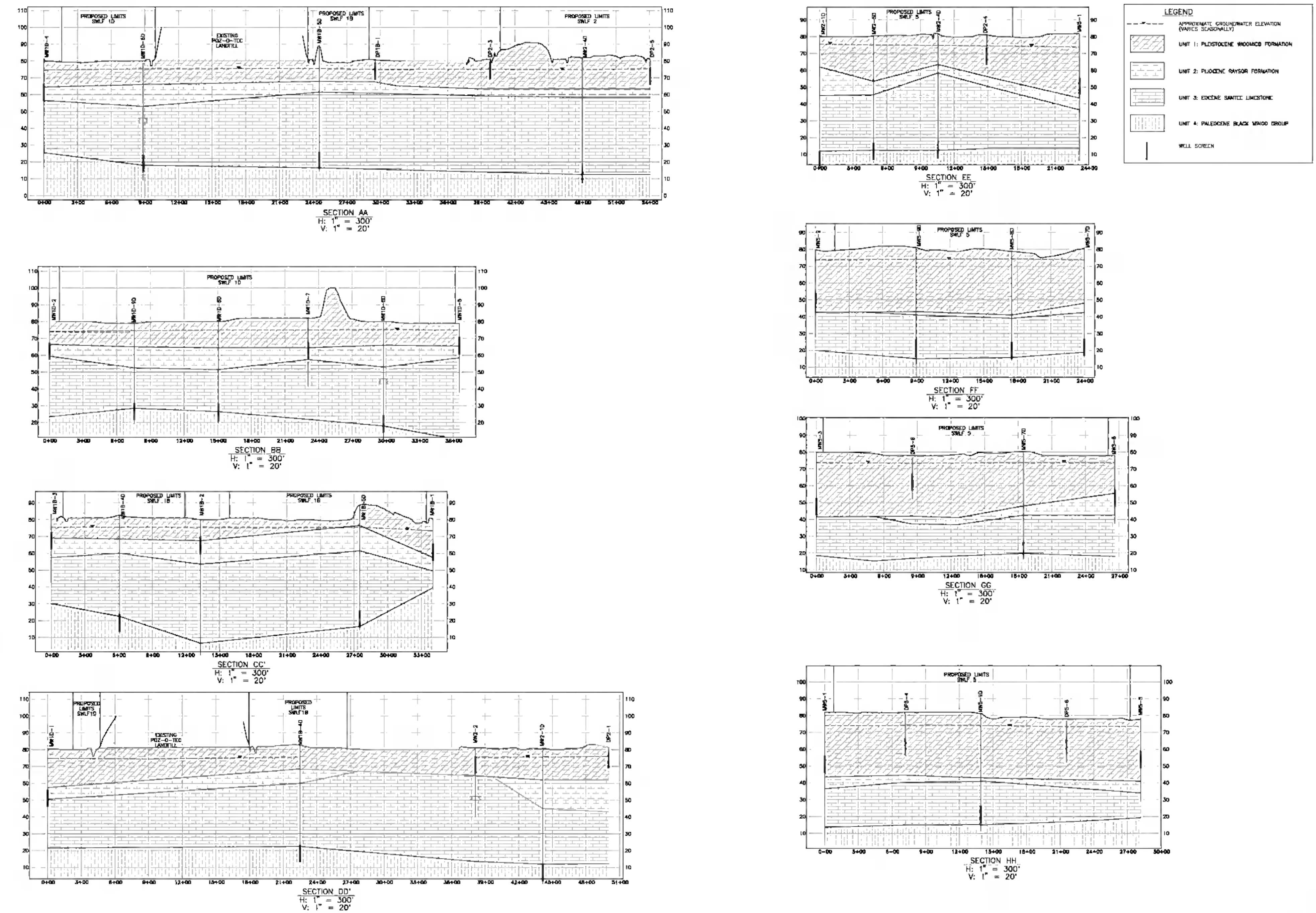
CLASS THREE LANDFILL PROJECT

SITE HYDROGEOLOGICAL CHARACTERIZATION STUDY
SITE INVESTIGATION MAP

JOB NUMBER

SHEET
FIGURE 3



REVISION	DATE
1	
2	
3	
4	

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GEOLOGIC CROSS SECTIONS

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SHEET
FIGURE 5