CLOSURE PLAN

CLOSURE PLAN
FGD PONDS

Oak Grove Steam Electric Station

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Golder Associates

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1.0 INTRODUCTION

1.1 Purpose

The "Standards for Disposal of Coal Combustion Residuals (CCR) in Landfills and Surface Impoundments" (40 Code of Federal Regulations (40 CFR) Part 257, Subpart D), effective October 19, 2015, requires that existing CCR units have a written Closure Plan prepared in accordance with §257.102(b). This Closure Plan provides the following information for the Oak Grove Steam Electric Station's (OGSES's) CCR Impoundments identified as flue gas desulphurization (FGD) Ponds FGD-A, FGD-B, and FGD-C.

- A description of steps necessary to close CCR unit at any point during the active life of the CCR unit, including:
  - A description of how CCR unit will be closed;
  - A description of how the final cover will meet the performance standards §257.102(d), and the methods and procedures used to install the final cover;
  - An estimate of maximum inventory of CCR ever on-site during the active life of the CCR unit;
  - An estimate of largest area requiring final cover at any time during the CCR unit's active life; and
  - A schedule, including steps, major milestones, durations.

1.2 Site Background

The OGSES generates bottom ash, fly ash, boiler slag and flue gas desulfurization (FGD) sludge (gypsum) during electricity generation. The following surface impoundments, shown on Figure 1, are in operation at the OGSES:

- FGD-A Pond;
- FGD-B Pond; and
- FGD-C Pond.

The Closure Plan addresses the existing CCR surface impoundments at the OGSES. A separate Closure Plan addresses the existing ash landfill (Ash Landfill 1).

2.0 DESCRIPTION OF CLOSURE [§257.102(b)(1)(i)]

The existing surface impoundments at the OGSES will be closed in-place and capped with a final cover system. The final cover design will vary depending on the existing lining system within the CCR surface impoundment. The components of the final cover for each CCR surface impoundment are presented in Section 2.3.

The final cover grades will depend on conditions present at closure. Conceptual final cover grades are presented on Figure 2.

2.1 Removal of Liquid and Stabilization of CCR [§257.102(d)(2)]

Prior to construction of the final cover, the surface impoundments will be dewatered by constructing dewatering sumps and actively pumping liquid from the impoundments. Free liquids removed from the impoundments will be managed in accordance with applicable regulations.

It is anticipated that, once dewatered, CCR within the surface impoundments will have sufficient strength properties to accommodate and support the proposed closure grades. If the dewatered CCR materials do not have the strength to accommodate earthwork equipment and/or fill material required to meet the closure grades, then the CCR material will be stabilized as necessary prior to closure construction.

Inlet pipes along the crest of the surface impoundments will be removed. Below-grade inlet and outlet pipes will be abandoned by filling with grout, “flowable fill” or other methods.

2.2 Grading Layer

A grading layer will be placed over the dewatered/stabilized CCR material to achieve closure grades. The grading layer will be placed below the final cover system to allow the final cover systems described in this section to meet the grades as shown on Figure 2 – Final Cover Grading Plan,. Once the grading layer has been placed to its design grades, the final cover system will be installed.

Based on an evaluation of the contents of FGD-A (Golder, 2013), the CCR material consists predominantly of silt-size particles with 5 to 40% sand and typically less than 10% clay (< 5 microns). Once fill placement begins, Golder anticipates some consolidation of the CCR will occur; but expects that the majority of the settlement will occur during or shortly after closure construction (due to the noncohesive nature of the CCR and fill materials), thus, limiting long term subsidence.

2.3 Final Cover System [§257.102(b)(1)(iii)]

The components of the final cover system will depend on the existing liner system within the CCR surface impoundment. As described in the following sections, the final cover system in FGD-A will differ from the final cover system in FGD-B and FGD-C.

2.3.1 FGD-B & C Ponds Final Cover Design

FGD-B and FGD-C Ponds are lined with a composite liner system (consisting of a 2-foot thick compacted clay liner with a hydraulic conductivity (k) of 1 x 10^{-7} cm/sec or less, and a 60-mil high density polyethylene (HDPE) geomembrane) and will be closed with a composite final cover system meeting the requirements of §257.102(d)(3)(i)(A) through (D). Specifically, the final cover system over FGD-B and FGD-C Ponds will:

(A) Have a permeability less than or equal to the permeability of bottom liner system or natural subsoils or no greater than 1 x 10^{-5} cm/sec, whichever is less;

(B) Include an infiltration layer with a minimum 18 inches of earthen material;

(C) Include an erosion layer containing a minimum 6 inches of earthen material and capable of sustaining native plant growth; and

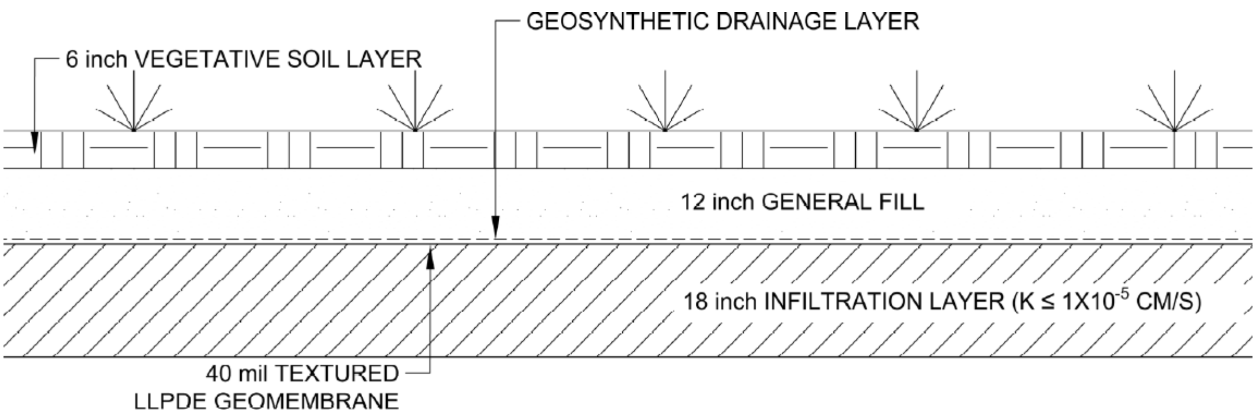
(D) Accommodate settling and subsidence.

The final cover system for FGD-B and FGD-C will be comprised of (from the top to bottom):

- 18-inch erosion layer consisting of 12 inches of general fill overlain with 6 inches of soil capable of supporting native vegetation;
- Geosynthetic drainage layer;
- 40-mil linear low-density polyethylene (LLDPE) textured geomembrane; and
- 18-inch thick soil infiltration layer with a permeability of 1 x 10^{-5} cm/sec or less.

The final cover system for FGD-B and FGD-C is illustrated below.

Final Cover System – FGD-B & FGD-C



2.3.2 FGD-A Pond Final Cover Design

FGD-A Pond is lined with a 3-foot thick compacted clay with a hydraulic conductivity less than 1 x 10^{-7} cm/sec and will be closed with an alternate final cover meeting the requirements of §257.102(d)(3)(ii)(A) through (C)[1]. Specifically, the final cover system over FGD-A Pond will:

- Achieve an equivalent reduction in infiltration as §257.102(d)(3)(i)(A) and (B) (See Section 2.3.1 above);
- Include an erosion layer providing equivalent protection from wind or water erosion as specified in §257.102(d)(3)(i)(C); and
- Accommodate settling and subsidence.

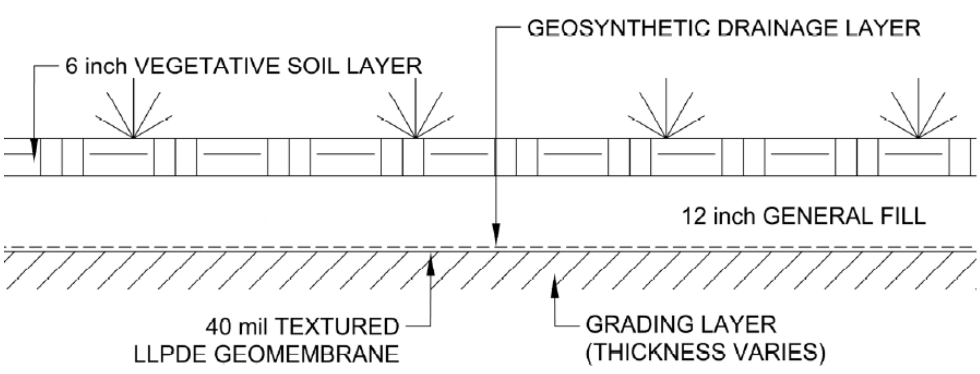
The final cover system for FGD-A will be comprised of (from the top to bottom):

- 18-inch erosion layer consisting of 12 inches of general fill overlain with 6 inches of soil capable of supporting native vegetation;
- Geosynthetic drainage layer; and
- 40-mil linear low-density polyethylene (LLDPE) textured geomembrane.

The proposed alternate final cover replaces the soil infiltration layer with a geomembrane. Since infiltration is limited to potential defects in the geomembrane, the infiltration through the proposed cover will be lower than through a soil infiltration layer. A comparison of infiltration rates to demonstrate that an equivalent reduction in infiltration is included in Appendix A.

The final cover system for FGD-A Pond is illustrated below.

Final Cover System – FGD-A Pond



[1] The CCR Rule references (f)(3)(ii)(A) through (D), but this appears to be a typo.

2.3.3 Final Cover Design and Performance

Table 1 describes how the final cover systems meet the performance standards in §257.102(d).

Table 1 - Performance Standards

Standard	Discussion
Control, minimize or eliminate post-closure infiltration, releases of CCR, leachate, or contaminated run-off	Geomembranes are very effective barriers to infiltration and contact with CCR. Liquid will be removed from the CCR prior to final cover construction.
Preclude future impoundment of water sediment, or slurry	The pipes leading to the surface impoundments will be removed or abandoned and the final cover will be sloped to drain surface water.
Include measures for major slope stability	The textured geomembrane will improve interface shear strength and the geosynthetic drainage layer will prevent development of hydrostatic forces in the overlying erosion layer.
Minimize maintenance	Routine maintenance will consist of mowing the vegetative cover. Other anticipated maintenance activities are limited to repair of erosion rills, and placement of fill in depressions.
Complete in time consistent with good practice	Both proposed final cover systems are routinely used at waste containment facilities. Well-developed industry experiences in installing such final cover systems will ensure most efficient construction time.

2.3.4 Methods and Procedures

The final cover system design, particularly the final cover grades, will be re-evaluated prior to initiation of final closure, based on the actual CCR grades at the time of closure. As discussed in Section 2.1, the strength properties of the CCR materials present at that time will be evaluated and addressed in the final design of the final cover system and an amended closure plan. The final cover will be installed in accordance with a construction quality assurance (CQA) plan, which will be developed prior to commencing the work. The CQA plan will require monitoring of final cover construction to ensure that the final cover system will meet the design intent and conforms to the performance standards.

As described in Section 4.3 of this Closure Plan, a certification that the final cover system meets the requirements of §257.102(d)(3)(iii) will be provided by a qualified professional engineer, prior to initiation of final closure.

3.0 CCR QUANTITY AND AREA [§257.102(b)(1)(iv-v)]

For the purposes of this closure plan, in-place closure of CCR within the surface impoundments is based on the assumed volume of CCR (solids) being limited to 50 percent of the total capacity of the impoundment. The final cover surface area will be approximately equal to the total area within the crest of the surface impoundment as listed in Table 2.

The approximate maximum CCR volume and maximum final cover area over the active life of the CCR unit for each surface impoundment are summarized in Table 2.

Table 2 – Approximate CCR Volume and Area

Surface Impoundment	Total Capacity (acre-ft)	CCR Volume (cy)	Final Cover Area (acre)
FGD-A	172	138,500	9.0
FGD-B	104	83,500	11.2
FGD-C	218	176,000	15.2

4.0 CLOSURE COMPLETION SCHEDULE [§257.102(b)(1)(vi)]

The timeframe for initiation final closure of the CCR units depends on several factors and is unknown; therefore, the year in which all closure activities will be completed is unknown.

4.1 Commencement of the Closure Plan [§257.102(e)]

In accordance with §257.102(e), commencement of this Closure Plan will occur as specified in either timeframe defined below:

- No later than 30 days after the date on which either:
  - The CCR unit receives the known final receipt of waste; or
  - The last known CCR is removed for beneficial use.

- Within 2 years of either:
  - The CCR unit last receives waste; or
  - The last CCR is removed for beneficial use.

Initiation of closure work may be extended two years with documentation in accordance with §257.102(e)(2)(ii) that there is reasonable likelihood that the CCR unit will accept wastes in the foreseeable future or CCR will be removed from the unit for beneficial use.

Closure of CCR unit has commenced if waste placement has ceased and any of the following are completed (§257.102(e)(3)):

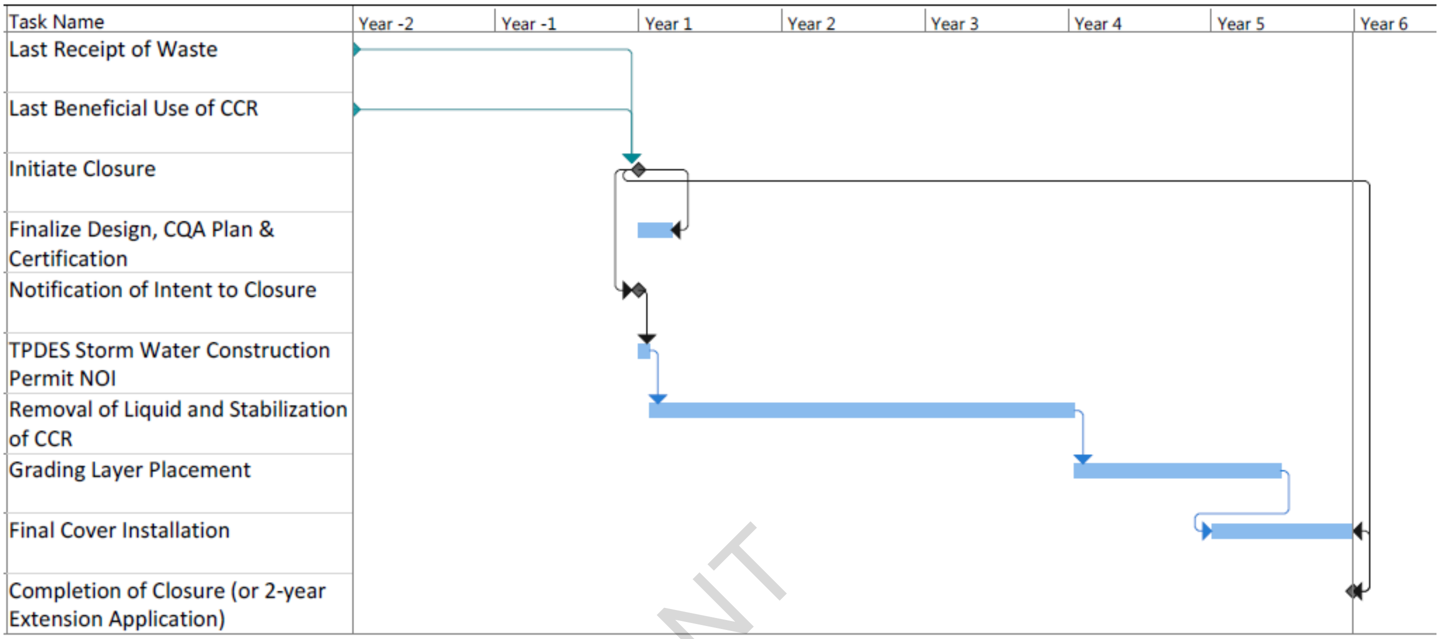
- Taken any steps necessary to implement steps in the Closure Plan;
- Submitted a completed application for any required state or agency permit or permit modification; or
- Taken any steps necessary to comply with prerequisite state standards to initiate or complete the closure of a CCR unit.

4.2 Completion of Closure Activities [§257.102(f)]

Closure of each surface impoundment must be completed within 5 years of commencing closure. Completion of closure may be extended 2 years with documentation in accordance with §257.102(f)(2)(i) that, due to factors beyond the facility's control (e.g. significant weather delays, time required for dewatering CCR, delays due to state permitting or approval, etc.), it is not feasible to complete the closure within the required timeframe. An extension may also apply if the alternative closure requirements should apply to the CCR units in accordance with §257.103.

A Gantt chart illustrating the sequential steps of the CCR closure process, including identification of major milestones and estimated timeframes to complete each closure phase, is provided below.

Final Closure Schedule



4.2.1 Closure Certification

A certification from a qualified professional engineer verifying that closure has been completed in accordance with the Closure Plan must be obtained in accordance with §257.102(f)(3).

4.3 Notification of Intent to Close CCR Unit [§257.102(g)]

No later than the date of final closure initiation, a notification of intent to close the CCR unit must be prepared. The notification must include certification by a qualified professional engineer that the final cover system meets the requirements of §257.102(d)(3)(i) or (ii).

4.4 Notification of Closure Completion [§257.102(h)]

No later than 30 days after of completion of closure, a notification of closure of a CCR unit must be prepared. The notification must include certification by a qualified professional engineer that closure was completed in accordance with the Closure Plan.

4.5 Deed Notations [§257.102(i)]

Following closure of the CCR unit, a certified notation on the deed to the facility or site property, or on some other instrument that is normally examined during title searches, that will in perpetuity notify any potential purchaser of the property that the land has been used as a CCR unit and that future uses of the land are restricted will be filed and recorded in the deed records of the office of the County Clerk of Robertson County.

A notification will be placed in the facilities operating record within 30 days of recording a notation to the deed to the property.

4.6 Closure Recordkeeping [§257.102(j)]

The owner or operator of the CCR unit must comply with the closure recordkeeping requirements specified in §257.105(i), the closure notification requirements specified in §257.106(i), and the closure internet requirements specified in §257.107(i).

5.0 CONCLUSION

This Final Closure Plan has been prepared by Golder Associates Inc. to describe the steps necessary to close the existing CCR surface impoundments at OGSES at any point during the active life of the units with recognized and generally accepted good engineering practices.

If further information from Golder, please contact the undersigned at (281) 821-6868.

GOLDER ASSOCIATES INC.

William E. Gordon, PE
Senior Engineer

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Associate Geotechnical Engineer

JBF/WEG

6.0 CERTIFICATION

I hereby certify that this Closure Plan has been prepared in general accordance with normally accepted civil engineering practices and in accordance with the requirements of 40 CFR §257.102.

Jeffrey B. Fassett, PE
Golder Associates Inc.
Firm Registration Number F-2578

7.0 REFERENCES

Golder Associates Inc. 2013, Report on Engineering Evaluation of Strategies for Removal of Accumulated Solids in FGD-A Pond - Oak Grove SES, Robertson County, Texas.

REFERENCE(S)
AERIAL PHOTO SOURCED FROM GOOGLE EARTH PRO DATED 2016

JEFFREY B. FASSETT 85675 — STATE OF TEXAS — LICENSED PROFESSIONAL ENGINEER — 10/10/16

Professional Engineering Firm
Registration Number F-2578

0 400 800
1" = 800' FEET

CLIENT LUMINANT POWER OAK GROVE		PROJECT 2016 COAL COMBUSTION RESIDUALS ENGINEERING SERVICES	
CONSULTANT Golder Associates	YYYY-MM-DD: 2016-09-29 DESIGNED: VK PREPARED: TNB REVIEWED: MX APPROVED: JBF	TITLE **GENERAL SITE MAP**	
		PROJECT NO. 1648164	REV. ---- / FIGURE 1

LEGEND

430 — FGD POND FINAL COVER CONTOURS

REFERENCE(S)

AERIAL PHOTO SOURCED FROM GOOGLE EARTH PRO DATED 2016

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1" = 300' FEET

CLIENT
LUMINANT POWER
OAK GROVE

PROJECT
2016 COAL COMBUSTION RESIDUALS
ENGINEERING SERVICES

CONSULTANT

Golder Associates

YYYY-MM-DD	2016-09-29
DESIGNED	VK
PREPARED	TNB
REVIEWED	MX
APPROVED	JBF

TITLE
FINAL COVER GRADING PLAN FGD PONDS

PROJECT NO.	REV.	FIGURE
1648164	----	2

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

APPENDIX A
ALTERNATE FINAL COVER – INFILTRATION RATE COMPARISON

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CALCULATIONS

Date:	9/26/2016	**Made by:**	JBF
Project No.:	1648164	**Checked by:**	MX
Subject:	Alternate Final Cover - Infiltration Rate Comparison	**Reviewed by:**	JBF
Project Short Title:	OGSES - SI Final Cover Plan		

OBJECTIVE

Compare the infiltration rate through a "prescriptive" final cover system with the infiltration rate through the alternate final cover system proposed for use in FGD-A Pond.

GIVEN

The prescriptive final cover infiltration layer consists of a minimum 18-inch thick layer of earthen material with a permeability less than or equal to the permeability of the bottom liner. FGD-A was lined with a clay layer with a permeability of 1×10^{-7} cm/s. The alternate final cover system will replace the earthen material infiltration layer with a geomembrane. In addition, the proposed alternate final cover includes a geosynthetic drainage layer above the geomembrane.

METHOD

Estimate the infiltration rate through the earthen material infiltration layer using Darcy's equation. Estimate the infiltration through the geomembrane infiltration layer using the Giroud Equation (Ref. 1). Compare the infiltration rate through earthen material infiltration layer to the geomembrane infiltration layer.

<u>**Infiltration Through 18-inch earthen Infiltration Layer**</u>

Darcy's Equation

$$Q = kiA$$

where:

- Q = Leakage rate
- k = hydraulic conductivity
- i = hydraulic gradient = (h+t)/t
- h= head
- t = thickness
- A = area

<u>Infiltration Layer Properties</u>

k =	1.00E-07	cm/s
t =	1.5	ft
h =	0.5	ft (erosion layer saturated)
i =	1.33	
A =	1	acre

Q = 123 gal/acre/day

Golder Associates

CALCULATIONS

Date:	9/26/2016	**Made by:**	JBF
Project No.:	1648164	**Checked by:**	MX
Subject:	Alternate Final Cover - Infiltration Rate Comparison	**Reviewed by:**	JBF
Project Short Title:	OGSES - SI Final Cover Plan		

<u>Infiltration through geomembrane</u>

Giroud's Equation — Ref 1

$$Q = C[1+0.1(h/t_s)^{0.95}]a^{0.1}h^{0.9}k_s^{0.74}$$

where:

$C =$ 0.21 for good contact
1.15 for poor contact

$h =$ head (m)

$t_s =$ thickness of underlying soil component (i.e. grading layer) (m)

$a =$ area of hole (m^2)

$k_s =$ hydraulic conductivity of underlying soil (m/s)

<u>Geomembrane & Subgrade Properties</u>

$C =$	1.15	(conservative)
$h =$	0.2	in (approximate thickness of drainage layer)
$t_s =$	1	ft (conservative)
$a =$	1	cm^2 (equivalent to a 0.44 inch diameter hole - conservative)
$k_s =$	1.00E-03	cm/s (conservative for site soils)
Number of Defects =	2	per acre (conservative for good installation quality)

Q = 1.58E-06 m^3/sec/acre
36 gal/acre/day

CONCLUSION

Based on this analysis, the infiltration rate through a geomembrane final cover system will be less than the infiltration through a 1.5-ft thick infiltration layer with permeability of 1 x 10^{-7} cm/s.

REFERENCE

1) Giroud, J.P., "Equations for Calculating the Rate of Liquid Migration Through Composite Liners Due to Geomembrane Defects", Geosynthetics International, Vol. 4, Nos. 3-4, pp. 335-348, 1997.

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Golder Associates

Engineering Earth's Development, Preserving Earth's Integrity