Tennessee Valley Authority Kingston Fossil Plant Harriman, Roane County, Tennessee	**Perimeter Containment** **North Dredge Cell (Dike C) Segment 1** **Sta. A161+50 to A179+50**
Document Control Number	RDP-0113-E
Calculation Package	FPGKIFFESCDX00030020100006

Exhibit 2
Design Basis and Criteria

Purpose:

- Establish the design goals, criteria, procedures, and design references for the Dredge Cell Closure.
- Provide guidance for design factors including stability, site geometry, surface and ground water, design elements, and site management during construction.

Methods:

- Review of applicable design standards and site requirements, as established by TVA.
- Drafts and revisions of the document were reviewed by TVA for concurrence.

Results:

- Criteria documented in attached report.

Calculation Performed by: Stantec Consulting Services, Inc.	
Prepared by: Stantec	*Reviewed by:* TVA and others
Revisions: 20-Oct-10	

Kingston Ash Recovery Project (KRP)
Design Basis and Criteria
Dredge Cell Closure
Kingston Fossil Plant
Harriman, Roane County, Tennessee

1. Purpose

The purpose of the Design Basis and Criteria is to establish the design goals, criteria procedures and design references for Dredge Cell Closure. This document provides guidance for design factors including stability, site geometry, surface and groundwater, design elements and site management during construction. This is a living document that may be amended or revised as the project proceeds

2. Scope

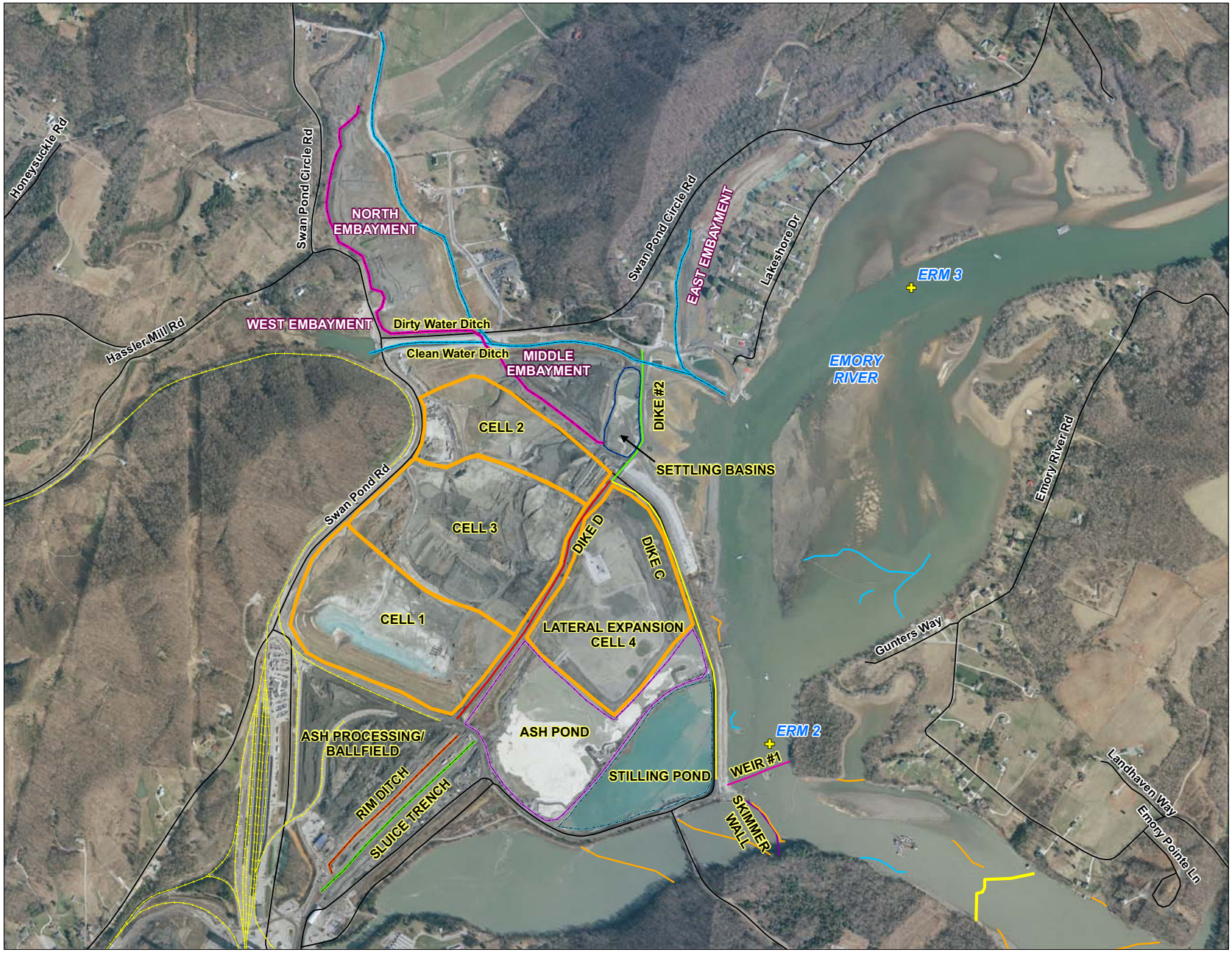
The objective of the closure project is to design a stable ash storage facility meeting stakeholder criteria within approved boundaries. Please see the attached drawing from EPA showing Cells 1, 2 and 3 of the Dredge Cell and providing an overview of the site.

2.1. Design Basis

- Construct dry (unsaturated) ash embankment within approved boundaries;
- Construct a stable embankment that will contain retrieved ash under static and seismic loading conditions;
- Construct a facility that accommodates predicted stormwater flows;
- Control infiltration of precipitation through the final cover ;
- Meet applicable regulatory closure requirements relative to stability and final cover; and
- Meet requirements of the approved Action Memorandum including ARARs.

2.2. Design Goals

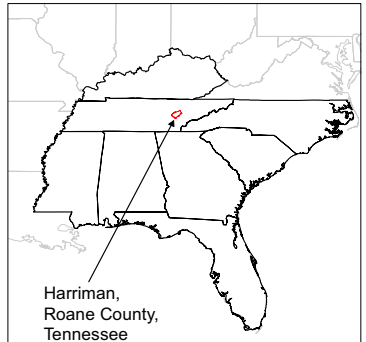
- Design with the understanding that additional areas such as the ash pond and lateral expansion will be integrated;



Legend

- RiverMiles
- Dirty Water Ditch
- Railroads
- Sluice Trench
- Rim Ditch
- Clean Water Ditch
- Weir 1
- Skimmer Wall
- Ash Settling Pond
- Cells
- Dike D
- Dike C
- Dike 2
- Settling Basins
- Stilling Ponds
- Roads
- Booms
- Closure Booms
- Turbidity Curtains

0 500 1,000 2,000
Feet



United States Environmental Protection Agency

TVA KINGSTON FOSSIL PLANT
HARRIMAN, ROANE COUNTY, TENNESSEE
TDD No. TNA-05-001-0079

EE/CA OPERATIONS
MARCH 19, 2010

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- Address the documented contributing factors to the Dredge Cell failure as identified by AECOM. For design we should consider:
  - Control height of ash and loading on wet ash and in areas of slimes;
  - Construct containment dike on good foundation conditions or mitigate the poor foundation conditions;
  - Design to mitigate against creep failure; and
  - Control rate of construction on sluiced ash and analyze undrained conditions.
- Constructability – Safe use of construction equipment and processes to complete the project in accordance with project goals;
- Conduct phased embankment construction concurrent to perimeter improvements;
- Use industry best practices for design;
  - TVA Coal Combustion Products Management Program - Master Programmatic Document;
  - Tennessee Department of Environment & Conservation (TDEC) Regulations;
  - U.S. Army Corps of Engineers Manuals;
  - Established engineering methods; and
  - Independent peer review;
- Foster stakeholder buy-in;
- Monitor construction and post closure condition; and
- Consider existing NPDES permit requirements.

2.3. Proposed Improvements

The proposed improvements involve closure of the Dredge Cell in accordance with applicable TDEC regulations. The proposed improvements for this site address slope stability for static and dynamic loading conditions, defined geometric considerations, surface water control, and erosion/sediment control. Specific design items include:

- Compacted dry ash embankment (unsaturated);
- Capillary break;
- Stabilized perimeter (included foundation improvements and berm);
- Surface water drainage facilities;
- Site revegetation, final cover, and erosion controls;
- Performance monitoring instrumentation shall be installed and monitored during and after closure; and
- Perimeter riprap and slope protection next to Watts Bar Reservoir to prevent scour and erosion during flooding and reservoir drawdown.

3. Static and Dynamic Slope Stability

3.1. Slope Stability

Stability analyses of the closure design shall be performed using established methods of engineering analysis.

3.2. Stability During Construction

The following factors of safety against slope stability shall be maintained during construction:

- Drained Stability (FS_d) $FS_d \geq 1.5$
- Undrained Stability (FS_u) $FS_u \geq 1.3$
- Undrained Stability After Next Lift (FS_{ul}) $FS_{ul} \geq 1.5$

The criteria for FS_{ul} applies only to potential failures through saturated fly ash. The stability of the embankment during construction shall be verified through monitoring, instrumentation, and engineering evaluation. Strengths to be used for analysis are shown in Table 1.

Table 1 – Material Parameters used in Stability Analyses

Material Name	Unit Weight		Static Drained Strength		Static Undrained Strength	
	γ_m, (pcf)	γ_{sat}, (pcf)	ϕ', (deg.)	c', (psf)	ϕ, (deg.)	c, (psf)
Hydraulically Placed Ash Above Groundwater	100	--	25	0	25	0
Hydraulically Placed Ash Below Groundwater	--	107	25	0	10	0
Landfilled Ash Embankment	109	111	30	0	30	0
Lean Clay Foundation Soil	--	130	32	0	24	0
Sandy Silt to Silty Sand	--	128	30	0	12	1,000

3.3. Stability Following Construction

The following factors of safety against static slope stability shall be maintained in the long-term, following project completion:

- Drained Stability (FS_d) $FS_d \geq 1.5$
- Veneer Sliding (FS_v) $FS_v \geq 1.0$

3.4. Liquefaction Analysis

3.4.1. For soils susceptible to classical liquefaction

$FS_{liq} \leq 1.1$	Assume layer liquefies under design event
$1.1 < FS_{liq} \leq 1.4$	Assume partial liquefaction and strength loss in layer
$FS_{liq} > 1.4$	Assume no liquefaction

3.4.2. For soils susceptible to cyclic softening

$FS_{CS} \leq 1.4$	Assume cyclic softening occurs as a result of design event
$FS_{CS} > 1.4$	Assume no cyclic softening occurs

3.5. Seismic Stability

3.5.1. Design Earthquake Event

- 10% Probability of Exceedance in 250 years (recurrence interval – 2,373 years) per Section 1.4.2.2.1 of the TVA Coal Combustion Products Management Program Master Programmatic Document;
- The facility will be designed to meet the criteria for stability after the occurrence of only one design earthquake event;
- The post-earthquake factor of safety for slope and foundation stability shall be greater than unity (1.0); and
- Following the design seismic event, ash from the closed facility shall not displace beyond the permitted boundary of the facility. Deformations that do not exceed this limit will be considered acceptable.

4. Geometry and Elevations

4.1. General Design Criteria

4.1.1. On the northern and eastern perimeters of the site, in areas bounded by Watts Bar Lake, the closed facility shall not extend beyond the limits of the previous Dredge Cell and ash pond;

4.1.2. The closed facility shall not encroach within 100 feet of the edge of the existing pavement along Swan Pond Road, on the western perimeter of the site;

4.1.3. The closed Dredge Cell, including the final cover, shall not exceed an elevation of 790 feet (plus or minus five feet);

4.1.4. Ash within the closed Dredge Cell shall be contained within a berm constructed of structural fill materials that meet the stability objectives. The berm shall have a crest that is no lower than an elevation of 765 feet around the perimeter;

4.1.5. An access road having a minimum width of 16 feet shall be established around the full perimeter of the closed facility. Surface grade on the access road shall not exceed five percent at any location;

4.1.6. Criteria for excavation in the northwest corner of the Dredge Cell will be defined by TVA Management; and

4.1.7. Maintain and monitor performance monitoring instrumentation to validate design assumptions.

5. Water Elevations

5.1. Assumptions for Design

- Watts Bar Lake - Summer Pool Elevation: 741 feet;
- Watts Bar Lake - Winter Pool Elevation: 737 feet;
- Watts Bar Lake – 100 Year Flood Elevation: 746.8;
- Watts Bar Lake – 500 Year Flood Elevation: 748.0;
- Ash Pond in Operation During Construction - Pool Elevation: 761 feet;
- Stilling Pond in Operation During Construction – Pool Elevation: 755 feet; and
- Stilling pond, if decommissioned in the future, then pool elevation = Watts Bar Lake elevation.

6. Groundwater Seepage

6.1. Predictions of the long-term ground water levels within the closed facility shall be included in the design analyses. The predictions shall only consider the potential infiltration with the capped condition. The long term phreatic surface outside the Dredge Cell limits should be modeled as the existing groundline.

6.2. The facility will be an unlined facility. Regulations (TDEC Division of Solid Waste Management Chapter 1200-01-07, Rule 1200-01-07.04) that require less percolation through the cover than through the liner do not apply.

6.3. Groundwater from the facility shall not be collected and/or discharged at specified design points (no point discharges). Design of the top elevation of the Deep Soil Mixing (DSM) shall be based on the "Best Estimate" of the long term groundwater elevation based on modeling results.

6.4. The impact of elevated groundwater levels within the closed ash facility shall be evaluated. The capillary break will be constructed above the "Best Estimate" long-term groundwater elevation discussed in 6.1. and 6.3. The maximum acceptable groundwater elevation shall be below the capillary break and elevations at or above the DSM shall be evaluated.

6.5. Long-term monitoring of groundwater levels will be included with the closure plan, to allow the assessment of water levels in comparison to the maximum acceptable limits.

7. Stabilized Perimeter

7.1. General Design Criteria

7.1.1. Ash will be placed in a facility that is fully enclosed (in plan) with a stabilized perimeter. The foundation soils will be stabilized, treated, or otherwise improved so the perimeter will support the lateral pressure of the facility and achieve the required performance for static and dynamic stability. The stabilized perimeter will be designed to contain material during a seismic event.

7.1.2. The stabilization process may reduce the hydraulic conductivity of various foundation layers, but the stabilized perimeter will not be designed for groundwater retention.

8. Compaction of Ash Fill

8.1. General Design Criteria

8.1.1. Recovered ash to be placed inside the Dredge Cell will be compacted in conformance with engineering controls. The material will be placed within specified ranges of water content in an unsaturated condition.

8.1.2. In some areas of the ash pond, ash may be sluiced to fill submerged areas. After a ground surface above water is established, additional fill in these areas will be compacted.

9. Capillary Break

9.1. General Design Criteria

- The design will include an internal layer of coarse material that will serve as a capillary break; and
- The purpose of the capillary break is to mitigate the upward migration of water by capillarity to elevations where stability criteria would not be achieved.

10. Final Cover

10.1. General Performance

Per TDEC Division of Solid Waste Management Chapter 1200-01-07 (Rule 1200-01-07.04):

- Provide long-term control of infiltration for the closed facility;
- Function with minimum maintenance;
- Promote positive surface drainage; and

- Accommodate settling and subsidence so that the cap's integrity is maintained.

10.2. Cap Requirements

A total of 36 inches of soil are required of which a minimum of 12 inches shall be for the support of vegetative cover. This cap shall include a compacted soil layer of at least 24 inches which has a permeability no greater than 1 x 10^{-7} cm/sec.

Per Section 1.3.4.2 of the TVA Coal Combustion Products Management Program Master Programmatic Document, and in TDEC regulations, an alternate cap system may be considered, if clay materials are unavailable or difficult to obtain.

The alternate system should consist of the following layers: vegetative cover soil of 24 inches; drainage layer and a geomembrane liner (FML).

The slope of all cap system layers should not exceed 3 Horizontal to 1 Vertical (3H:1V).

Final slopes will be based on stability analyses. The cap system and final cover should not be constructed until after perimeter containment for that segment has been constructed.

10.3. Erosion Protection

Run-on from adjacent areas should be controlled and diverted around the subject area.

- Run-off from the landfilled area should be collected in a manner that controls erosive forces. This can be accomplished by:
    - Controlling erosion of cover material (e.g., no steep slopes);
    - Controlling drainage of precipitation falling on the disposal facility or disposal facility parcel (e.g., prevent pooling); and
    - Providing a surface drainage system which is consistent with the surrounding area and in no way significantly adversely affects proper drainage from these adjacent lands. Establish a protective vegetative cover of acceptable grasses over disturbed areas of the site.

In general, requirements of TDEC Division of Solid Waste Rule 1200-01-07.04 shall be met or exceeded for design and the site wide Stormwater Management Plan (SWMP) will be followed.

11. Anchor Trench (if applicable)

11.1. General Design Criteria:

Per Section 1.4.5 of the TVA Coal Combustion Products Management Program Master Programmatic Document:

- Anchorage shall be designed for a worst-case temporary scenario occurring during construction;
- Anchor trench design should be in general accordance with the methodology given in Qian, Koerner, and Gray (2002); and
- A minimal anchor trench or combination runout section and anchor trench should be specified in the facility design.

12. Stormwater Management

12.1. Requirements

Per TDEC Division of Solid Waste Management Chapter 1200-01-07 (Rule 1200-01-07.04), the following are required:

- A run-on control system for all flow up to and including peak discharge from a 24-hour, 25-year storm;
- A run-off management system to collect and control at least the peak flow volume resulting from a 24-hour, 25-year storm;
- Holding facilities (e.g., sediment basins) designed to detain at least the water volume resulting from a 24 hour, 25 year storm and to divert through emergency spillways at least the peak flow resulting from a 24-hour, 100-year storm;
- Collection and holding facilities must be emptied after storms to maintain design capacity of the system; and
- Other erosion control measures (e.g., temporary mulching or seeding, silt barriers) as necessary to control erosion of the site.

12.2. Cap System Erosion Control

Per Section 1.6.1 of the TVA Coal Combustion Products Management Program Master Programmatic Document, the Revised Universal Soil Loss Equation (RUSLE) shall be used to predict maximum soil loss from the final cap system.

12.3. Erosion Control During Construction

12.3.1. Per Section 1.6.1 of the TVA Coal Combustion Products Management Program Master Programmatic Document, sediment and erosion control BMPs shall be provided during all construction activities, and to manage sediment from the facility area and stockpiles during operations. For the Kingston site, a site specific Stormwater Management Plan (SWMP) has been prepared and will be referenced in design documents.

12.3.2. Surface water calculations shall be prepared using the Soil Conservation Service (SCS) method (previously by the USDA Soil Conservation Service, now by the Natural Resources Conservation Service (NRCS)).

12.3.3. All surface water drainage structures, including channels, culverts, and benches on the facility cap system shall be designed to carry expected flows based on the 24-hour, 25-year storm event for the particular region.

12.3.4. The following additional design elements shall be considered during the design of the surface water system:

- Velocity of the surface water flow. The dimensions and slope of the surface water drainage structure energy dissipation devices; and
- The use of non-mechanical gravity-flow surface water conveyance structures is most desirable and recommended.

12.4. Assumptions

- Rainfall data used for design purposes will be obtained from National Oceanic and Atmospheric Administration (NOAA)-14 and Natural Resources Conservation Service (NRCS) publications;
- SEDCAD (Sediment, Erosion, Discharge by Computer Aided Design) will be utilized to design and evaluate the surface water, erosion and sediment control systems;
- Technical Release 55 (TR-55) methods will be utilized to calculate storm runoff volume, peak rate of discharge, hydrographs, and storage volumes required for the watershed;
- Runoff from the Dredge Cell prior to closure shall be routed to permitted NPDES discharge points; and
- Runoff from the closed cover of the facility may be discharged directly offsite at multiple locations.

13. Filter or Separation Criteria (if applicable)

13.1. Granular Filter Criteria

Granular filter design must meet the criteria as established in the USACE Manual EM 1110-2-2300, Appendix B dated July 30, 2004.

13.2. Geotextile Design by Specification

The Geotextile must satisfy the American Association of State Highway and Transportation Officials (AASHTO) requirements established in the AASHTO M288 specifications.

13.3. Filter Cover and Protection

Adequate cover materials shall be placed over filter before allowing transit of heavy equipment. Manufacturer's recommendations for geotextile protection shall be followed.

Geotextile shall be protected from ultraviolet degradation as per the manufacturer's recommendations.