

# RECLAMATION

*Managing Water in the West*

## Kingston Generating Facility Flyash Impoundment Failure.

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# Presentation Outline

**Site History**

**Failure Event and Consequences**

**Cleanup – Time Critical Removal Action**

**Failure Root Cause Analysis**

**Failure Modes Analysis for Remainder of the Site**

**Dike C Buttress**

**Remedial Action - Seismic Retrofit**



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# Kingston Generating Facility

An aerial photograph of the Kingston Generating Facility. The facility is a large industrial complex with a prominent tall smokestack emitting a plume of white smoke. The facility is situated near a river and several large circular water treatment tanks. The surrounding area is a mix of industrial structures, roads, and some greenery.

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# Site History

Located 30 miles west of Knoxville, Tennessee

Electric power plant built in the 1950's

World's largest coal fired electric plant when built

Produces about 1,200 tons per day of flyash residue

Stores flyash in wet impoundments

Flyash storage evolved over time as original pond filled new ones were developed.

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# Site Features



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# Impoundment Failure

December 22, 2008

Failure occurred after midnight

5.4 million cubic yards of flyash were released

300 acres of land and water covered in ash

Response started after alert given by telephone call to 911 from a man trapped in home

Everyone responded

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**FILLS IN  
SWAN POND  
SLOUGH**

**FILLS IN  
EMORY RIVER  
WEST SLOUGH**

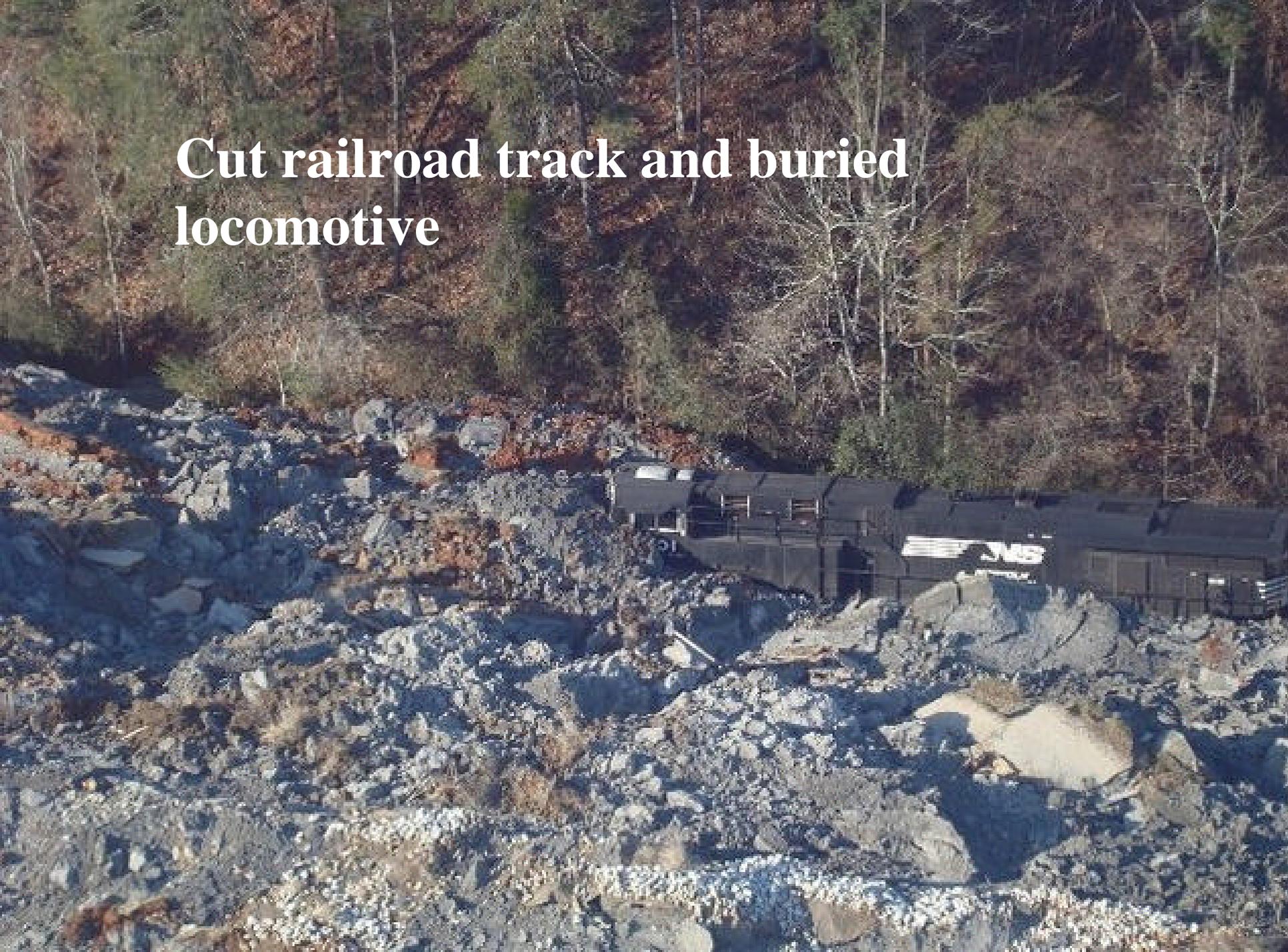
**EMPTIES INTO  
EMORY RIVER  
MAIN CHANNEL**

TVA purchased over 100 properties for about \$65 million.



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# Cut railroad track and buried locomotive



**Road, power line, water and sewer lines disrupted.**





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# Cleanup

**Removing ash using excavators and dredges**

**Up to 22,000 cubic yards per day removed**

**Shipping 8,000 tons per day by rail to Alabama**

**Estimated cost \$800 million to cleanup**

**Largest industrial spill in the United States**

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03/20/2010



















03/19/2010

# Failure Root Cause Analysis



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# Cell Configuration 4/5/2005



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# Cell Configuration 11/3/1996



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# Failure Root Cause Analysis

Title: TVA - Kingston RCA  
 Comments: Slope Stability Analysis for Cell 2 Northwest Section Stage 2 Case 2 (Low Bound Strength of Ash Slimes)  
 Method: Morgenstern-Price  
 Analysis Sluiced Ash Undrained Condition  
 Block Specified Failure Surface

Name: Ash - Dike  
 Model: Mohr-Coulomb  
 Unit Weight: 107 pcf  
 Unit Wt. Above Water Table: 102 pcf  
 Cohesion: 600 psf  
 Phi: 37 °

Name: Dike - Compacted Clay Fill  
 Model: Mohr-Coulomb  
 Unit Weight: 120 pcf  
 Cohesion: 600 psf  
 Phi: 15 °

Name: Ash - Sluiced  
 Model: S=(overburden)  
 Unit Weight: 107 pcf  
 Tau/Sigma Ratio: 0.3  
 Minimum Strength: 0

Name: Soft Clay  
 Model: Mohr-Coulomb  
 Unit Weight: 110 pcf  
 Cohesion: 600 psf  
 Phi: 0 °

Name: Alluvium - Clays and Silts  
 Model: Mohr-Coulomb  
 Unit Weight: 119 pcf  
 Cohesion: 1200 psf  
 Phi: 0 °

Name: Alluvium - Silty Sands and Silts  
 Model: Mohr-Coulomb  
 Unit Weight: 130 pcf  
 Cohesion: 600 psf  
 Phi: 30 °

Name: Laminated Sensitive Silts and Ash Slimes 1  
 Model: Mohr-Coulomb  
 Unit Weight: 90 pcf  
 Cohesion: 600 psf  
 Phi: 0 °

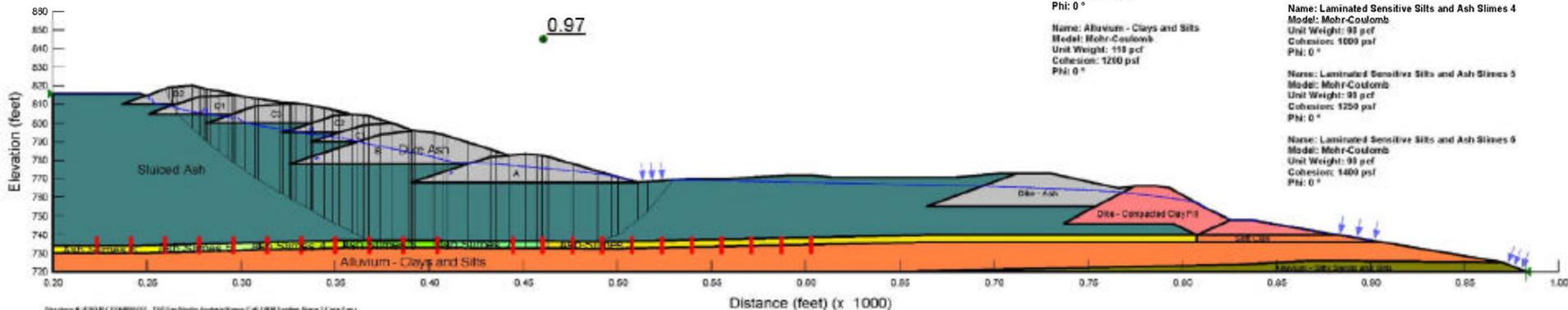
Name: Laminated Sensitive Silts and Ash Slimes 2  
 Model: Mohr-Coulomb  
 Unit Weight: 90 pcf  
 Cohesion: 700 psf  
 Phi: 0 °

Name: Laminated Sensitive Silts and Ash Slimes 3  
 Model: Mohr-Coulomb  
 Unit Weight: 90 pcf  
 Cohesion: 800 psf  
 Phi: 0 °

Name: Laminated Sensitive Silts and Ash Slimes 4  
 Model: Mohr-Coulomb  
 Unit Weight: 93 pcf  
 Cohesion: 1000 psf  
 Phi: 0 °

Name: Laminated Sensitive Silts and Ash Slimes 5  
 Model: Mohr-Coulomb  
 Unit Weight: 93 pcf  
 Cohesion: 1250 psf  
 Phi: 0 °

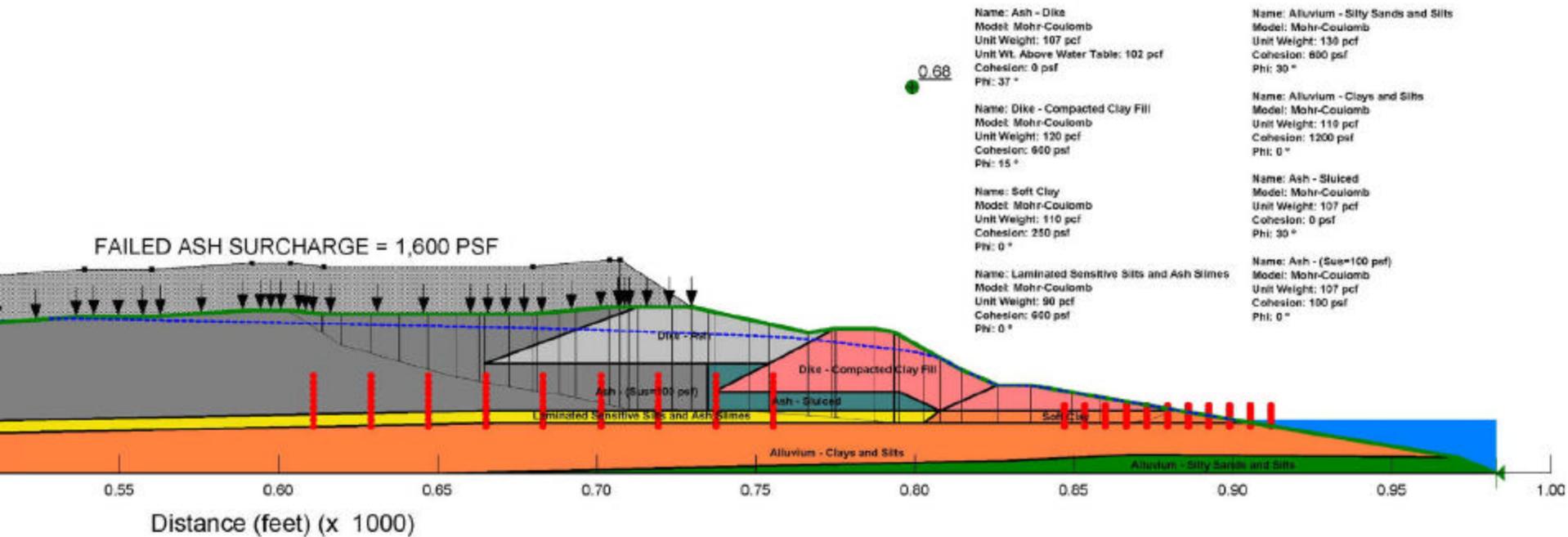
Name: Laminated Sensitive Silts and Ash Slimes 6  
 Model: Mohr-Coulomb  
 Unit Weight: 93 pcf  
 Cohesion: 1400 psf  
 Phi: 0 °



Geology & Foundation Engineering - TVA Kingston Analysis - Case 2 - Northwest Section Stage 2 Case 2.gpr

# Failure Root Cause Analysis

Title: TVA - Kingston RCA  
 Comments: Stability Analysis for Cell 2 Northwest Section Stage 3 Post-Failure Case 1  
 Method: Morgenstern-Price  
 Block Specified Failure Surface



Directory: K:\PROJECTS\60095742 - TVA\GeoStudio Analysis\Name: Cell 2 NW Section - Stage 3 Post-Failure.gsz

# Failure Modes Analysis for Remainder of the Site



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# Dike C Buttress

**TVA management review concerning failure concluded that TVA needs to change from a reactive manager of problems to a proactive manager who anticipates problems and takes action to reduce risks.**

**Management wanted to act now!**

**Consultants said cut down the trees.**

**Reclamation said no, its too risky. Rich Kramer (consultant to State of TN also said no)**

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# Dike C Buttress

**TVA pressed for limited tree removal in one area**

**Reclamation allowed it with controls:**

- 1. Must have at least one truck load of road base (mixture of silt, sand , gravel) stockpiled at dike.**
- 2. Stantec engineer present to observe the work.**
- 3. Install road base material in the stump holes.**
- 4. Place road base over any seeps that occur.**
- 5. Locate and monitor seeps.**

# Dike C Buttress

Seeps showed up at several of the tree holes.

We required daily inspections of each seep.

They finally got serious about doing the failure modes analysis we had been asking for. Two months later:

Dike C slope stability Factors of Safety as low as 1.16

Dike C seepage heave Factors of Safety as low as 1.4

Seismic analysis not done but looking bad.

Later admitted that seismic failure is likely due to weak sand underneath the 10 feet of clay foundation.

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# Dike C Buttress

TVA management then wanted Dike C fixed in 2 months time.

It took that long to design the buttress which is filter sand, fine gravel, coarse gravel, and riprap.



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# Dike C Buttress



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# Dike C Buttress First Panel





01/22/2010



# **Remedial Action - Seismic Retrofit**

**The failed cell will be converted to a landfill.**

**Plant will be modified to stop wet removal of ash.**

**Dry ash will be produced which is a saleable product**

**Nationwide about 45% of flyash is sold for use in concrete and other purposes.**

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# Questions

It was a great blowout.

