Tennessee Valley Authority
Regulatory Submittal for Kingston Fossil Plant

Documents submitted:
Test Embankment Program

Date submitted
6/ 10/ 2009

Submitted to whom
Glen Pugh, TDEC

Concurrence

Received	Not Applicable	TVA
☒	☐	Anda Ray
☒	☐	Mike Scott
☐	☒	Kathryn Copeland
☐	☒	Cynthia Anderson
☐	☒	Dennis Yankee
☐	☒	David Stephenson
☐	☐	_____
☐	☐	_____
☐	☐	_____

Received	Not Applicable	Jacobs
☐	☒	John Moebes
☒	☐	Julie Pfeffer
☐	☒	Jack Howard
☐	☒	Donna Cueroni
☐	☒	Paul Clay
☐	☐	_____

Approvals

TVA Michael T Scott Date 6/10/09

TDEC _____ Date _____
Phase 1 of Plan

TDEC _____ Date _____
Phase 1 and 2 of Plan

cc:

- ☒ Anda Ray, TVA
- ☒ Barbara Scott, TDEC
- ☒ Leo Francendese, EPA
- ☒ Mike Scott, TVA
- ☒ Dennis Yankee, TVA
- ☒ Kathryn Copeland, TVA
- ☒ Cynthia Anderson, TVA
- ☐ John Moebes, Jacobs
- ☒ EDM
- ☒ Julie Pfeffer, Jacobs
- ☒ David Stephenson, TVA
- ☒ Michelle Cagley, TVA
- ☒ Greg Signer, TVA
- ☒ KIF Incident Document Control
- ☒ Katie Kline, TVA
- ☒ Gretchen Wahl, Jacobs
- ☒ Barbara Scott, TDEC
- ☒ Dannena Bowman, EPA
- ☒ Jeff Gary, Jacobs

STATE OF TENNESSEE
DEPARTMENT OF ENVIRONMENT AND CONSERVATION
Division of Solid Waste Management
Fifth Floor, L & C Tower
401 Church Street
Nashville, Tennessee 37243 – 1535
615-532-0780

June 24, 2009

Ms. Anda Ray
Tennessee Valley Authority
1101 Market Street
Chattanooga, TN 37402-2801

Re: TVA – Kingston Test Embankment Program

Dear Ms. Ray:

The Tennessee Department of Environment and Conservation, Division of Solid Waste Management received the above document as prepared by Stantec Consultants on June 12, 2009. The test embankment program is divided into two phases. The first phase involves preparation of a base layer (working platform) using either geogrid or stone and the removal of the top of the relic ash fill and using it as fill to promote drainage. The second phase is placement of certain recovered ash in the test fill.

TDEC hereby approves phase one of the test embankment program for immediate implementation. Placement of recovered ash in the test fill is not included in this approval and may not begin without separate approval.

Sincerely,

Glen Pugh
Solid Waste Program Manager
Division of Solid Waste Management

Cc: Chuck Head - TDEC
Barabara Scott - TDEC
Leo Francendese - EPA
Cynthia Anderson - TVA

STATE OF TENNESSEE
DEPARTMENT OF ENVIRONMENT AND CONSERVATION
Division of Solid Waste Management
Fifth Floor, L & C Tower
401 Church Street
Nashville, Tennessee 37243 – 1535
615-532-0780

July 13, 2009

Ms. Anda Ray
Tennessee Valley Authority
1101 Market Street
Chattanooga, TN 37402-2801

Re: TVA – Kingston Test Embankment Program – Phase Two Approval

Dear Ms. Ray:

The Tennessee Department of Environment and Conservation, Division of Solid Waste Management received the above document as prepared by Stantec Consultants on June 12, 2009. The test embankment program is divided into two phases. The first phase involves preparation of a base layer (working platform) using either geogrid or stone and the removal of the top of the relic ash fill and using it as fill to promote drainage. Phase One was approved on June 24, 2009.
Phase Two consists of controlled, monitored placement of recovered ash in the test fill. TDEC hereby approves Phase Two of the test embankment program. This approval does not include permanent placement of recovered ash in the test fill area.

Sincerely,

Glen Pugh
Solid Waste Program Manager
Division of Solid Waste Management

Cc: Chuck Head -TDEC
Barabara Scott -TDEC
Leo Francendese - EPA
Cynthia Anderson - TVA

Test Embankment Work Plan

1.0 Purpose of Work

The test embankment program is intended to observe the response to loading within various foundation layers as well as portions of Dike D under instrumented conditions. The embankment shall be constructed using maximum 3(H):1(V) slopes with intermediate benching to a peak elevation of 802 feet in accordance with the quality control protocols established in approved program documents. Results of preliminary stability analyses indicate that in order to maintain drained (or stable) conditions, instruments (i.e. piezometers, slope inclinometers and settlement plates) shall be monitored to determine that embankment construction proceeds at a rate wherein targeted threshold limits are not exceeded. These limits have been established for the ratio of excess pore water pressure to the applied embankment load and the ratio of horizontal to vertical displacements as outlined herein. The data and information gained from this test fill, regardless of whether the entire test fill is completed, will provide a basis for the closure design of the dredge cell.

There are two primary phases to this activity. The initial phase of work will be placing the base layer as well as providing proper drainage for the area by removing the top of the relic layer and using it as fill material. A decision has already been made to not use bottom ash as the base layer. This decision is reflected in the response to comments contained in the attached plan. Instead rock or a geogrid will be used. The second phase will be the placing of ash in the dredge cell. Once phase 1 has begun phase 2 activities can begin. It is expected that for some period of time that work for both phases will be ongoing.

Approval for this work plan can be granted holistically or in phases.

2.0 Design Components

The design of this program is found in the attached Test Embankment Program report prepared by Stantec.

3.0 Construction Management

The construction requirements of this program are found in the attached Test Embankment Program report prepared by Stantec.

4.0 Schedule

Because one of the variables being tested is the rate of ash placement and because of the size of the test required, this activity is anticipated to take 6 to 10 months depending on the conditions observed. In the event that potentially unstable conditions are realized

based on the instrumentation readings and/or field observations, all embankment test activities will cease and an evaluation will be made by qualified personnel relative toward established program objectives and the resulting path forward. It may be necessary to stop the test early. This will be a decision made by the engineers and project manager, along with consultation with TDEC and EPA.

5.0 Waste Management

Only minor construction debris such as material packaging is anticipated to be generated through this activity. This will be disposed with other construction debris at the site on an approved construction debris landfill.

6.0 Health and Safety

The major risks are from heavy equipment. All construction activities will be done in accordance with site-wide Health and Safety Plan. Dust control will be done in accordance with the Site Dust Control Plan.

Test Embankment Work Plan

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Stantec

Test Embankment Program

Kingston Fossil Plant
Harriman, Roane County, Tennessee

Stantec Consulting Services Inc
One Team. Infinite Solutions
1409 North Forbes Road
Lexington KY 40511-2050
Tel: (859) 422-3000 • Fax: (859) 422-3100
www.stantec.com

Prepared for
Tennessee Valley Authority
Chattanooga, Tennessee

June 3, 2009

Stantec

Stantec Consulting Services Inc.
1409 North Forbes Road
Lexington KY 40511-2050
Tel: (859) 422-3000
Fax: (859) 422-3100

June 3, 2009

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Ms. Julie Pfeffer
TVA Kingston Fossil Ash Recovery Operations
714 Swan Pond Road, Trailer Park
KFP 1A-KST
Harriman, Tennessee 37748

Re: Test Embankment Program
Kingston Fossil Plant
Harriman, Roane County, Tennessee

Dear Ms. Pfeffer:

Stantec Consulting Services Inc. (Stantec) has developed a revised test embankment program for the above referenced facility. This version addresses the May 19, 2009 Tennessee Department of Environmental and Conservation (TDEC) – Division of Solid Waste Management review comments to the initial program documents dated April 22, 2009. Responses to the TDEC comments are provided herein.

The test embankment program includes two primary areas (test embankment and relic placement areas) as defined herein. Testing of the embankment loading methodology will include instrumentation installation and on-site quality control activities. Instrumentation will consist of piezometers, slope inclinometers and settlement plates to measure pore water pressure, lateral displacement and vertical displacement, respectively, in response to embankment loading. Information collected from the instrumentation, and the subsequent data analysis, will be combined with the visual field observations to evaluate the embankment operations performance.

The following test embankment program includes an introduction, drawings, construction quality control plan, summary of stability analysis and responses to AECOM peer review comments.

Stantec appreciates the opportunity to provide these services and we look forward to continue working with you toward successful completion of the project. If you have any questions or need additional information, please call.

Sincerely,

STANTEC CONSULTING SERVICES INC.

MICHAEL J. STEELE
REGISTERED ENGINEER
AGRICULTURE
COMMERCE
No. 113118
STATE OF TENNESSEE

Michael J. Steele, PE
Associate

Don W. Fuller II, PE
Principal

/rdr

Test Embankment Program
Kingston Fossil Plant
Harriman, Roane County, Tennessee

Responses to Review Comments
June 3, 2009

Comments received via e-mail from Glen Pugh with the Tennessee Department of Environment and Conservation (TDEC) – Division of Solid Waste Management dated May 19, 2009. Initial program documents were dated April 22, 2009.

Comment No. 1: The scale of the test makes it appear as a stabilization project. If that is one of the objectives, it is best included in the closure plan.

Response No. 1: Stabilization is not a primary goal, but is a side benefit of test embankments. A relatively large-scale program is proposed to address design and construction challenges associated with potential embankment loads across hydraulically placed ash and native soil foundation materials to include those identified in the Root Cause Analysis as they relate to structural integrity. The program is also intended to assess the effects of loading along portions of Dike D, which may serve as the embankment toe within eastern portions of the site.

It is noted that the revised layout reduces the designated test embankment area capacity by roughly 45 percent (based on digital terrain models), while still maintaining stated program objectives.

Comment No. 2: TDEC prefers that the ash already in the failed landfill be used to construct the test fill.

Response No. 2: Based on recent concerns expressed by TDEC, the test embankment program now includes grading portions of the dredge cell relics located south of the proposed test embankment area. Spoils generated from this effort will be placed within a designated area (referred to herein as the relic placement area) located along portions of Dike D in support of the program. Remaining embankment materials will consist of displaced ash materials obtained from outside the dredge cell limits, preferably from the area east of Dike 2. It is noted that removal of materials from failed portions of the dredge cell is not conducive to facility drainage and would likely impact dredged material processing efforts due to additional moisture conditioning (or dewatering) requirements and impede the overall recovery initiative. Preliminary volume estimates indicate that sufficient quantities of relatively dry displaced ash (situated above normal pool) exist to support the test embankment program and are expected to be suitable for immediate use with little to no moisture conditioning. However, if the material is not available in a timely fashion, the next priority will be to

use material from the top of the relic area. Finally, under the direction of the EPA OSC, material could be brought in from the ash recovery and processing area if needed to meet the objectives of the time-critical removal action.

Comment No. 3: Off site waste material is not acceptable for use.

Response No. 3: Concur. Ash materials from other plants will not be used in the test embankment program. Working platform requirements allow for other materials, which are currently proposed as aggregate and geogrid.

Comment No. 4: Bottom ash already on site may be used for platform (working base) construction.

Response No. 4: See response to Comment No. 3.

Comment No. 5: With concurrence from the EPA on scene coordinator that time critical ash recovery efforts will be delayed without it, TVA may request placement of recovered ash into the test fill (such a request would obviously happen at a latter date..

Response No. 5: Discussions with the EPA OSC have indicated acceptance of this concept. Under the direction of the OSC, ash from the processing area could be used in the test. Please see response to Comment No. 2 for the other material that will be used in the test.

Test Embankment Program

Kingston Fossil Plant
Harriman, Roane County, Tennessee

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Attachment 3 Summary of Stability Analysis

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Test Embankment Program
Kingston Fossil Plant
Harriman, Roane County, Tennessee

1. Background

The conditions present within the dredge cell limits include hydraulically placed ash deposits, material displaced during the December 22, 2008 incident, and relatively unaffected relics. As part of the future decision process that will be conducted under the Comprehensive Environment Response, Compensation, and Liability Act (CERCLA) as a non-time critical removal action, a range of dredge cell closure alternatives must be evaluated. Although this range will be developed in the future, it is anticipated to vary from complete removal of above grade ash materials and perimeter dikes to developing the area as an on-site dry ash disposal facility. The reason to develop a range is to allow an evaluation of the alternatives against various criteria and then present that evaluation to responsible stakeholders, including appropriate regulatory agencies and the public so their input is considered in the decision. Alternatives must be protective of human health and the environment and meet applicable regulatory requirements unless a waiver can be granted.

To support a fair evaluation of developing the dredge cell as a dry ash disposal facility, sufficient data are required to reduce the number of design assumptions. A relatively large-scale program is proposed to resemble potentially constructed (or closed) embankment configurations to observe the response within various foundation layers and portions of Dike D under instrumented test conditions. The test embankment program is intended to represent the initial data collection effort required to support the final closure decision. Identifying other data collection efforts for alternative evaluations will occur in early summer 2009 and will be documented in a separate work plan.

Ash material brought into the dredge cell as part of this test will be removed upon completion of the test unless an alternate work plan or decision document supersedes this work plan.

2. Objectives

The closure plan engineering group knowledgebase includes significant experience in geotechnical characterization of hydraulically placed ash deposits similar to those present on-site. Conceptual models of ash and other foundation materials identified as part of the Root Cause Analysis (RCA) along with portions of Dike D contain numerous assumptions relative to structural integrity in response to embankment loading. The test embankment program is intended to verify both geotechnical design parameters and construction methodology.

Design Parameter Verification. The test embankment program is structured to provide key design parameters that will facilitate conceptual design of dredge cell closure in support of the CERCLA decision process. Geotechnical instrumentation will be used to observe the response of various foundation layers and portions of Dike D under embankment loading.

These results will also be used to provide direct correlations in future design efforts, if pursued, to foster stakeholder confidence that the primary failure mechanisms will be addressed. Targeted design parameters include:

- Settlement in response to loading;
- Horizontal (lateral displacement) parameters;
- Short-term and long-term strength projections;
- Pore pressure dissipation characteristics; and
- Subsurface drainage methods.

Construction Methodology Verification. The variable consistency and moisture conditions present within the foundation design limits will need to be addressed with specific handling, processing and construction methods. The test embankment program will verify current conceptual methods for both foundation mitigation and embankment construction.

3. Methodology

The primary ash material recovery and closure design condition is that embankment construction be performed using dry handling methods which specifically comply with structural fill protocols to be developed by the closure plan engineering group. Construction methods will largely consist of conventional heavy equipment excavation, hauling and placement methods. Subgrade stabilization will include trial studies for various methods based on anticipated conditions with modifications developed in association with the work. Material processing such as drying, is anticipated to be addressed through either conventional means to accelerate draining and evaporation or material admixtures.

The program is structured to address design challenges associated with foundation ash and native soil layers to include those identified in the RCA as they relate to structural integrity. The principal challenges associated with these foundation conditions will be addressed through varying embankment test scenarios within the cell.

The test embankment program will include two primary operational areas, one of which is structured to address the varying foundation conditions. These areas (referred to herein as the test embankment and relic placement areas) are located north and east of the remaining dredge cell relic and along portions of Dike D as shown on Sheet 1 in Attachment 1.

Embankment load testing methodology will include the following primary elements as outlined herein:

- Instrumentation;
- On-site quality control documentation;
- Construction planning; and
- Engineered earthwork solutions.

Monitoring Plan. Load test operations will be performance-based conducted under a structured monitoring plan. The primary monitoring guidance protocols are established in the Construction Quality Control Plan provided as Attachment 2. Overall program monitoring input will include documented visual observations and field data sources followed by engineering evaluation of the results obtained from the program.

Geotechnical instrumentation will include the following:

- Settlement Plates;
- Slope Inclinometers; and
- Piezometers.

Settlement plates will be installed at the base of the embankment to provide data sources related to vertical consolidation of the foundation materials with time in response to loading. Slope inclinometers will be installed to provide data to characterize lateral movement of the embankment and foundation materials. Piezometers will be installed at strategic locations to monitor variations in pore water pressure in response to loading. Piezometer monitoring zones will include the embankment base and multiple zones within the ash and native soil foundation materials. Proposed instrumentation locations and typical details are presented as Sheets 2 through 7 in Attachment 1.

Based on recent concerns expressed by the Tennessee Department of Environment and Conservation (TDEC) – Division of Solid Waste Management, the test embankment program now includes grading portions of the dredge cell relics located south of the proposed test embankment area. Spoils generated from this effort will be placed within the designated relic placement area located along portions of Dike D in support of the program. The objective of relic material placement here is to provide necessary drainage around the test area. The relic placement area is not part of the test and no instrumentation or monitoring will specifically occur. Test embankment materials in the test embankment area will preferentially consist of displaced ash materials obtained from outside the dredge cell limits, primarily from the area east of Dike 2. It is noted that removal of materials from failed portions of the dredge cell is not conducive to facility drainage and would likely impact dredged material processing efforts due to additional moisture conditioning (or dewatering) requirements and impede the overall recovery initiative. Preliminary volume estimates indicate that sufficient quantities of relatively dry displaced ash (situated above normal pool) exist east of Dike 2 to support the test embankment program and are expected to be suitable for immediate use with little to no moisture conditioning. If sufficient material east of Dike 2 is not available in a timely manner, the next priority will be to use more of the dredge cell relics located south of the test. Finally, if deemed necessary by the Environmental Protection Agency's On-Scene Coordinator, processed recovered ash from the processing area may be used to alleviate any short-term storage limitations in that area.

4. Work Sequence and Schedule

The work sequence will include the following five major elements for the load test areas:

1) Instrumentation

2) Working platform and base stabilization

3) Material source characterization, processing and placement plans

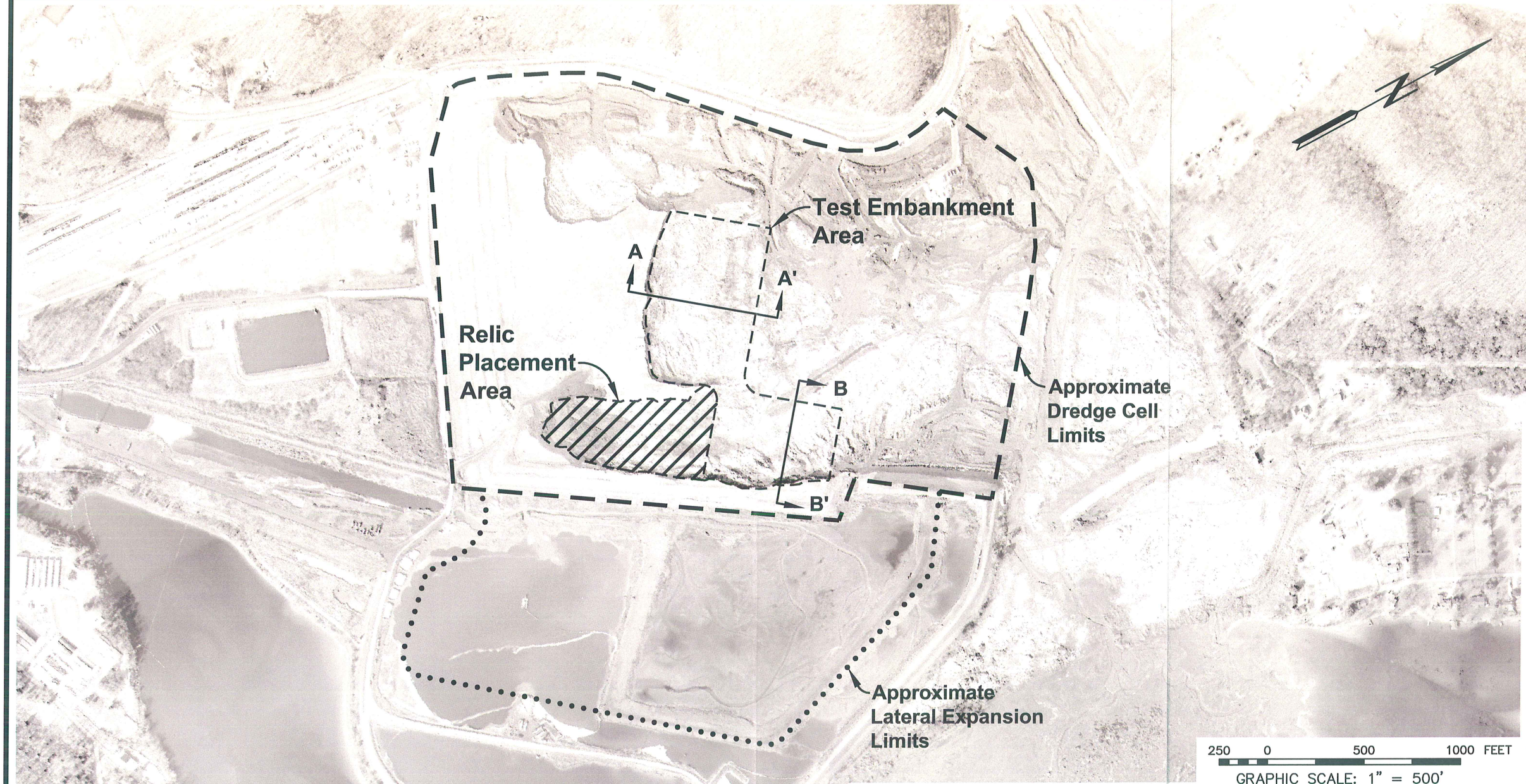
4) Embankment loading

5) Data collection and evaluation

The planned work sequence includes initiating the embankment loading within the test embankment and relic placement areas at roughly the same time.

Attachment 1

Drawings



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NOTE:
Aerial mapping was provided by Tennessee Valley Authority on February 2, 2009. File nomenclature indicates an imagery date of January 24, 2009.

MICHAEL J. STEELE
REGISTERED ENGINEER
AGRICULTURE
COMMERCE
No. 113118
STATE OF TENNESSEE
6/3/2009

PLAN LIMITS
KINGSTON TEST
EMBANKMENT PROGRAM
TENNESSEE VALLEY AUTHORITY

Stantec

Stantec Consulting Services Inc.
1409 N. Forbes Rd.
Lexington, Kentucky
40511-2050
859-422-3000
www.stantec.com

DRAWN BY	TJ	DATE	JUNE, 2009	REVISED		SHEET
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CHECKED BY	MJS	SCALE	1"=200'	2.	4.	

Test Embankment Area

SI–1
PZ–1
SI–2
SP–1
SI–8
PZ–4
PZ–7
SP–2
SI–3
SI–6
PZ–2
A
A'
PZ–5
PZ–8
SP–3
SI–7
PZ–3
SI–4
PZ–6
SI–5

Approximate Dredge Cell Limits

Relic Placement Area

B
SI–10
SI–9
PZ–9
SI–13
PZ–13
SP–5
PZ–11
SP–4
PZ–12
SI–12
B'

Approximate Lateral Expansion Limits

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NOTE:
Aerial mapping was provided by Tennessee Valley Authority on February 2, 2009. File nomenclature indicates an imagery date of January 24, 2009.

LEGEND

PZ–1	Piezometer
SI–1	Slope Inclinometer
SP–1	Settlement Platform

100 0 200 400 FEET
GRAPHIC SCALE: 1" = 200'

MICHAEL J. STEELE
REGISTERED ENGINEER
AGRICULTURE
COMMERCE
No. 113118
STATE OF TENNESSEE
6/3/2009

INSTRUMENTATION PLAN
KINGSTON TEST
EMBANKMENT PROGRAM
TENNESSEE VALLEY AUTHORITY

Stantec

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40511-2050
859-422-3000
www.stantec.com

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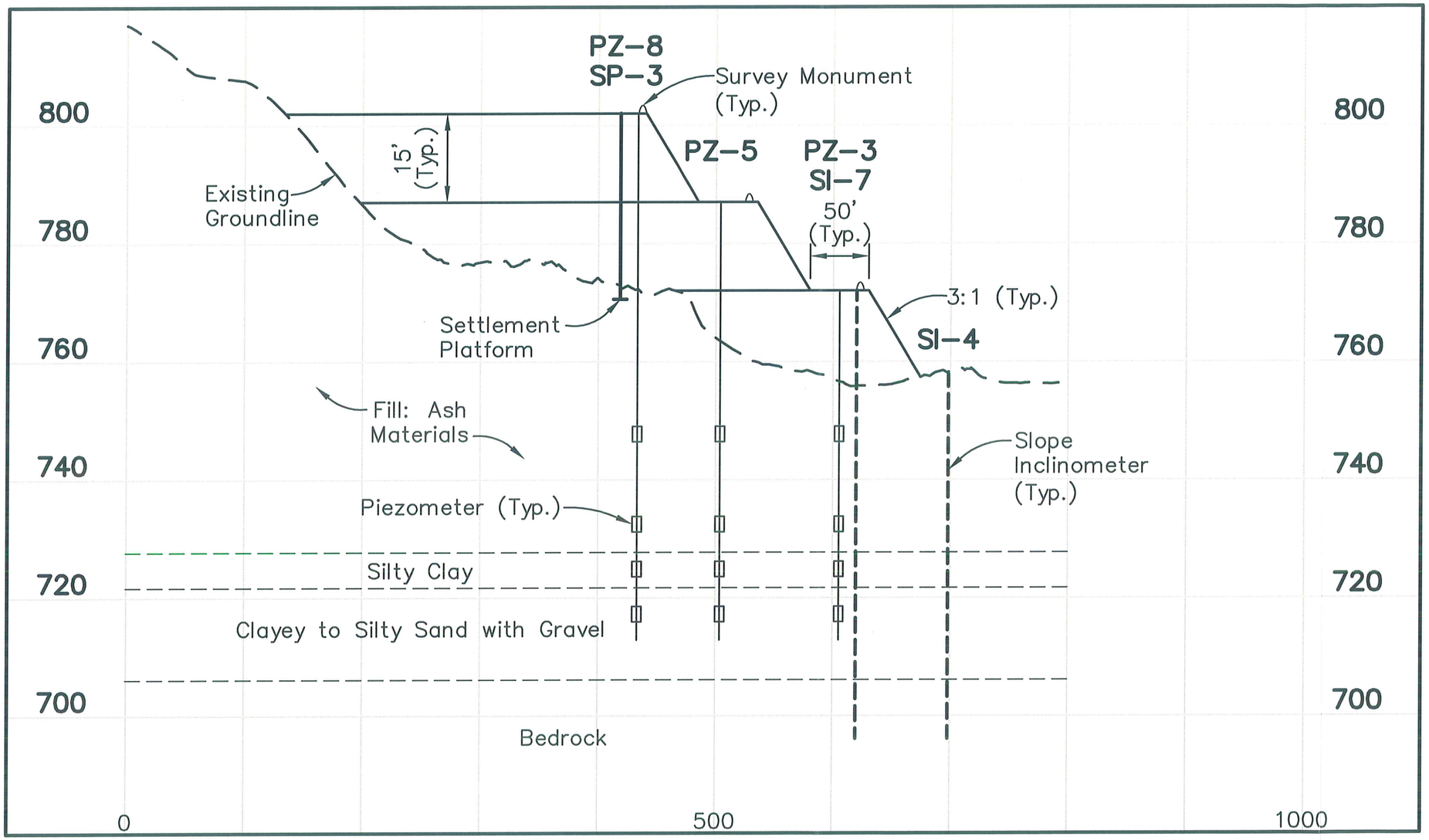

CROSS SECTION A-A'

SCALE: 1" = 100' (HORIZ.) XSECAA.DWG
1" = 20' (VERT.)

MICHAEL J. STEELE
REGISTERED ENGINEER
AGRICULTURE
COMMERCE
No. 113118
STATE OF TENNESSEE
6/3/2009

CROSS SECTION
KINGSTON TEST
EMBANKMENT PROGRAM
TENNESSEE VALLEY AUTHORITY

Stantec

Stantec Consulting Services Inc.
1409 N. Forbes Rd.
Lexington, Kentucky
40511-2050
859-422-3000
www.stantec.com

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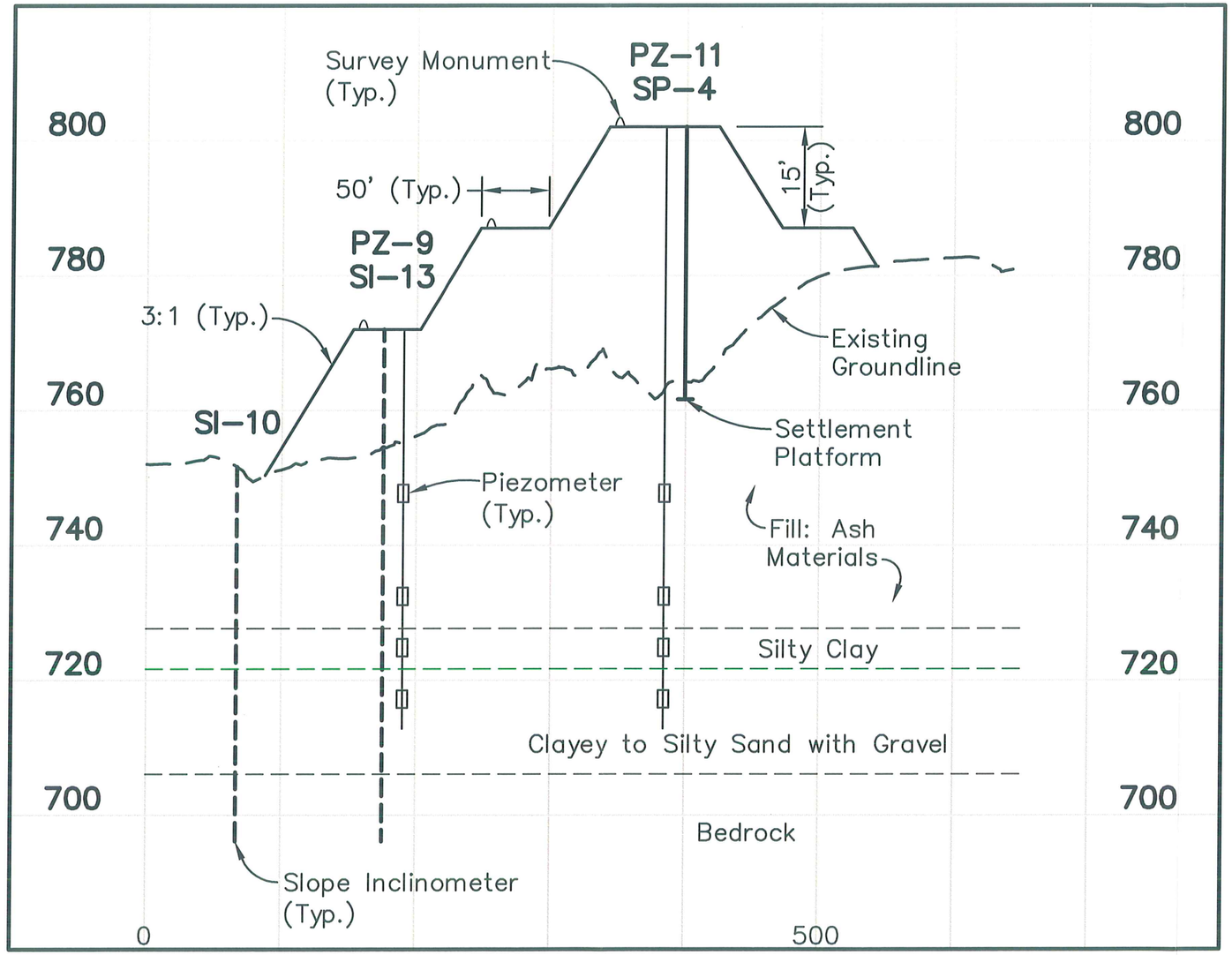

CROSS SECTION B-B'

SCALE: 1" = 100' (HORIZ.) XSECBB.DWG
1" = 20' (VERT.)

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MICHAEL J. STEELE
REGISTERED ENGINEER
AGRICULTURE
COMMERCE
No. 113118
STATE OF TENNESSEE
6/3/2009

CROSS SECTION
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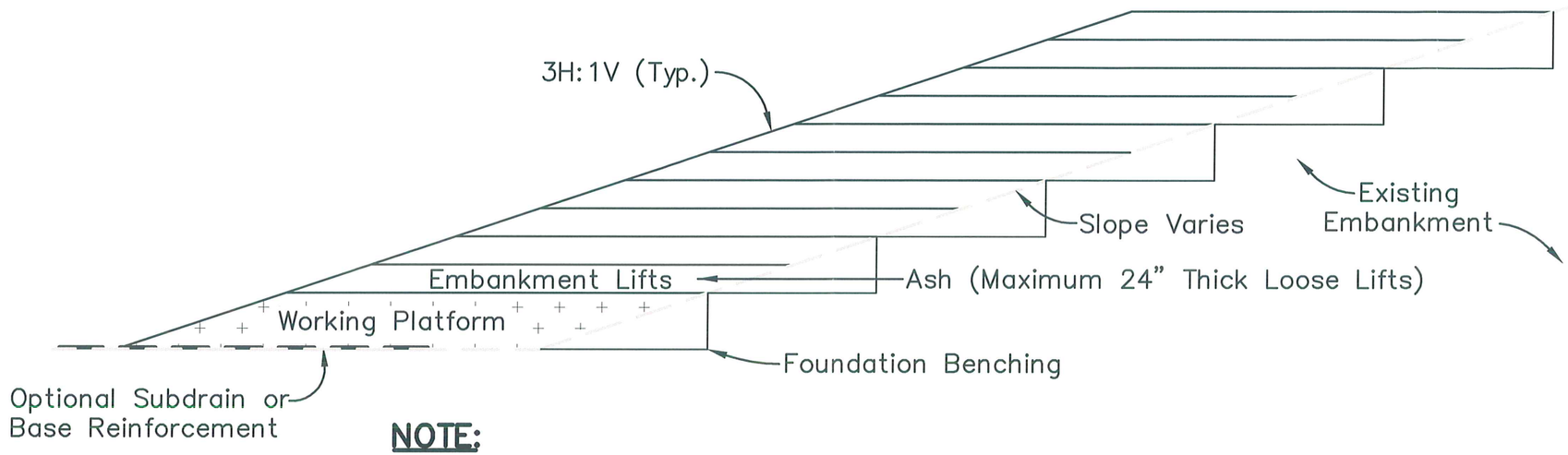

NOTE:
Working platform elevation and associated depth to underlying ash will be established based on proofrolling and foundation response as outlined in the Construction Quality Control Plan.

DETAIL – TEST EMBANKMENT LIFT PLACEMENT

NOT TO SCALE

LIFTPLACE.DWG

PLOT DATE: 06/03/2009 USER: JOHNSON, TRACY
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MICHAEL J. STEELE
REGISTERED ENGINEER
AGRICULTURE
COMMERCE
No. 113118
STATE OF TENNESSEE
6/3/2009

TYPICAL DETAILS
KINGSTON TEST
EMBANKMENT PROGRAM
TENNESSEE VALLEY AUTHORITY

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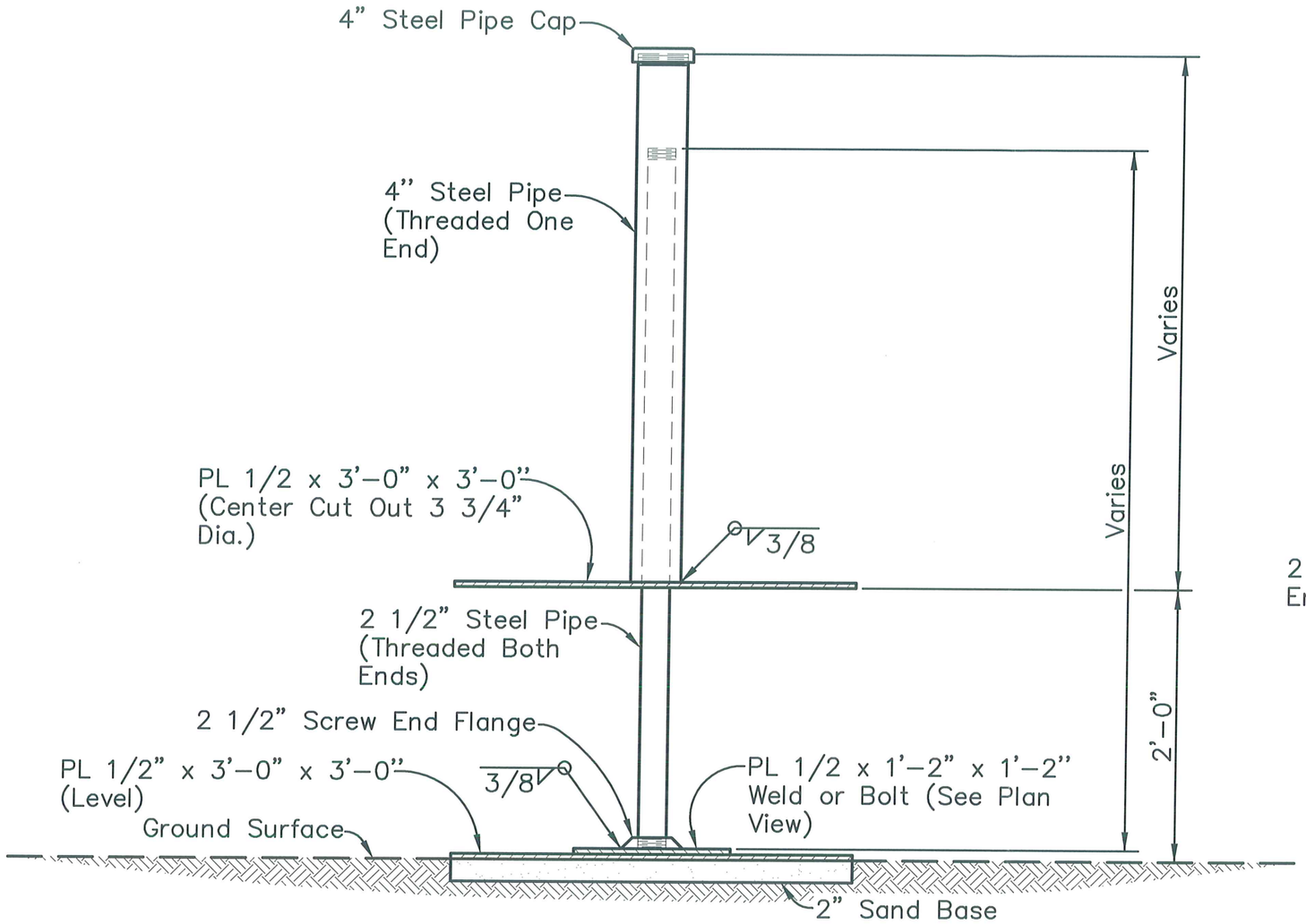
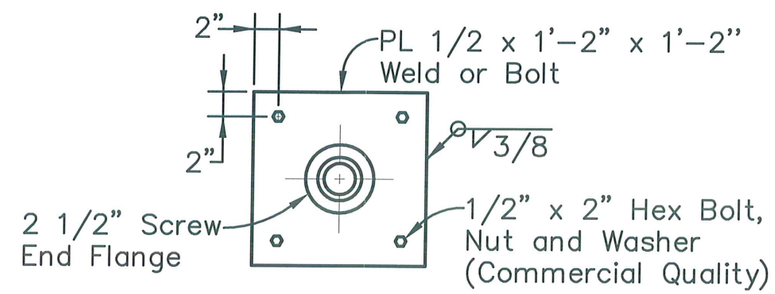


ELEVATION VIEW



PLAN VIEW

NOTES:

1. Additional pipe shall be furnished in 5'-3" sections (due to commercial pipe lengths of 21'-0") threaded on both ends.
2. Pipe sizes are given in nominal diameters.

DETAIL – SETTLEMENT PLATFORM INSTALLATION

NOT TO SCALE

SETPLAT.DWG

MICHAEL J. STEELE
REGISTERED ENGINEER
AGRICULTURE
COMMERCE
No. 113118
STATE OF TENNESSEE
6/3/2009

TYPICAL DETAILS
KINGSTON TEST
EMBANKMENT PROGRAM
TENNESSEE VALLEY AUTHORITY

Stantec

Stantec Consulting Services Inc.
1409 N. Forbes Rd.
Lexington, Kentucky
40511-2050
859-422-3000
www.stantec.com

DRAWN BY	TJ	DATE	JUNE, 2009	REVISED		SHEET
CHECKED BY	KDL	PROJ. NO.	175669015	1.	3.	6 OF 7
CHECKED BY	MJS	SCALE	AS SHOWN	2.	4.	

PLOT DATE: 06/03/2009 USER: JOHNSON, TRACY
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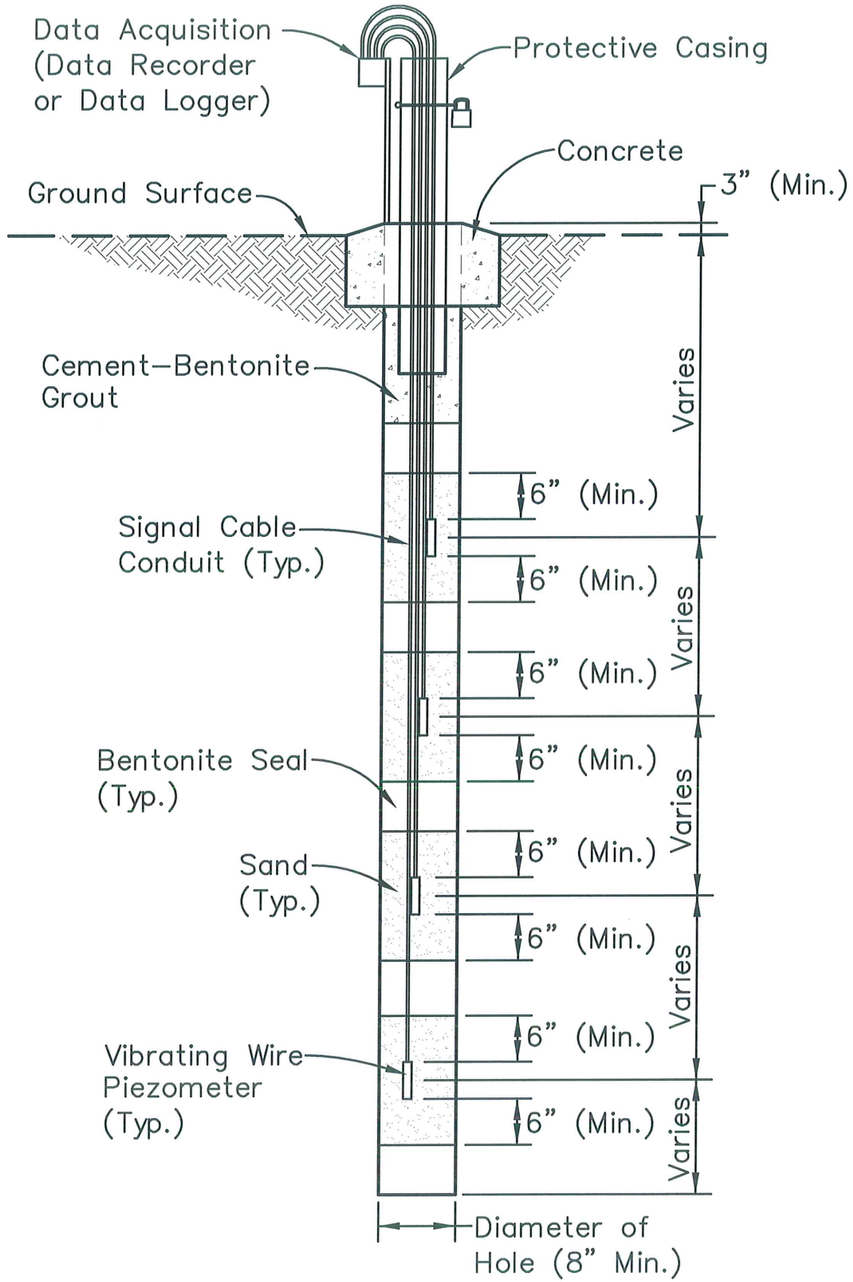
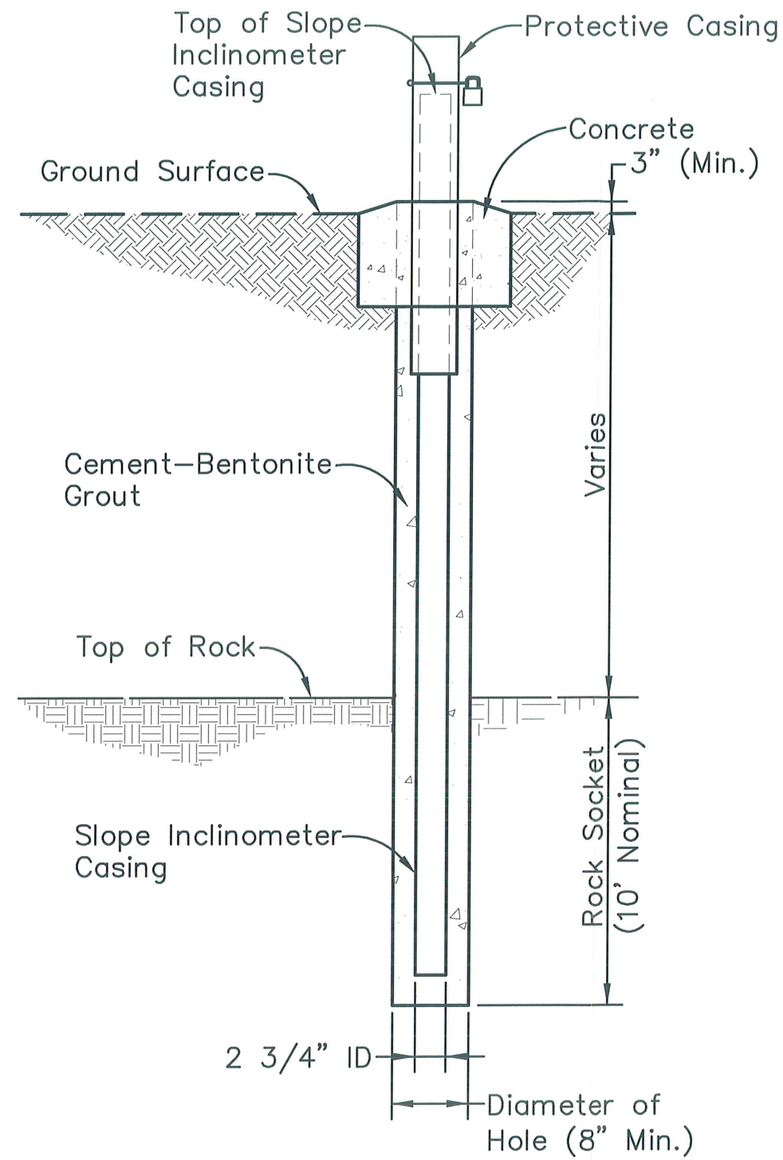


NOTE:
The vibrating wire piezometers shall be set in the ash materials, silty clay and clayey to silty sand with gravel layers. Piezometer tip elevations shall be determined in the field based on encountered subsurface conditions at each instrument location.

DETAIL – VIBRATING WIRE PIEZOMETER INSTALLATION
NOT TO SCALE
TYPPZ.DWG



DETAIL – SLOPE INCLINOMETER INSTALLATION
NOT TO SCALE
SLPINCMTR.DWG

PLOT DATE: 06/03/2009 USER: JOHNSON, TRACY
V:\1756\ACTIVE\175669015\ENVIRONMENTAL\DRAWING\TEST_EMB\REV1\681170-KIF-503-D03.DWG

MICHAEL J. STEELE
REGISTERED ENGINEER
AGRICULTURE
COMMERCE
No. 113118
STATE OF TENNESSEE
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TYPICAL DETAILS
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CHECKED BY	KDL	PROJ. NO.	175669015	1.	3.	7 OF 7
CHECKED BY	MJS	SCALE	AS SHOWN	2.	4.	

Attachment 2

Construction Quality Control Plan

Test Embankment Program
Kingston Fossil Plant
Harriman, Roane County, Tennessee

Construction Quality Control Plan

1. Purpose and Scope

This document is a site specific Quality Control (QC) plan that addresses construction and monitoring in association with the test embankment program. The QC plan is intended to present minimum program requirements and shall serve as an outline for use in developing site specific protocols based on conditions encountered during the work.

2. Responsibility and Authority

A summary of QC personnel and associated responsibilities is presented below.

2.1. Regulatory Agency

Work conducted under this test embankment program shall be coordinated with the Tennessee Department of Environment and Conservation (TDEC) – Division of Solid Waste Management and U.S. Environmental Protection Agency (EPA). Designated TDEC and EPA personnel shall serve as the regulatory contacts.

2.2. Quality Control Manager and Team

A qualified engineer shall be designated as the QC Manager and shall be responsible for overall management of construction monitoring, testing and related documentation as outlined herein. The QC Manager shall determine appropriate test standards and methods for designated field observations and/or laboratory testing and shall be responsible for review of QC data to assess conformance with program requirements.

The QC Team shall consist of qualified personnel working under the direct supervision of the QC Manager. The QC Team shall be familiar with the materials used and the functional intent of the respective test embankment components.

The QC Manager, QC Team and/or any designated Tennessee Valley Authority Project Manager(s) shall have the authority to stop the test embankment program for any reason.

2.3. Owner

The plant and its ancillary functions are owned by Tennessee Valley Authority (Owner). The Owner shall be responsible for overall management of construction activities to include but not be limited to contracting, administration and retaining the services of qualified consultants as required during the program.

The Owner and/or their Designee shall appoint one representative to serve as the Construction Manager. The Construction Manager shall be responsible for construction activities to include but not be limited to the character and sequence of work, coordination and scheduling.

The Owner shall also be responsible for providing qualified professionals to establish and enforce safety protocols related to the program.

3. Quality Control Activities

3.1. Meetings

Meetings shall be coordinated and conducted by the QC Manager and/or the Construction Manager on a weekly basis. The primary purpose of these meetings shall be to confirm that all parties involved with the test embankment program are familiar with the program, required procedures and associated QC objectives along with any safety issues related to construction. Specific safety issues shall be the responsibility of designated safety professionals. Minutes of each meeting shall be documented for inclusion with the program records.

Pre-construction meetings shall be held prior to initiating individual phases of construction. The QC Manager and other parties that will actively participate in the construction activities shall attend these meetings.

3.2. Alternative Methods

Consistent with the overall objectives of the program, alternative construction and QC methods may be used during the course of the work. Proposed modifications shall be developed by the QC Manager and submitted to the Owner for review prior to incorporation into the program. Documentation of these alternative methods shall be prepared with copies retained for inclusion with the program records.

3.3. Contractor Submittals

Contractor submittals shall be reviewed and approved by the QC Manager prior to delivery and/or use of the respective construction materials. Copies of all submittals shall be included with the program records.

3.4. Conformance Testing

Conformance testing consists of periodic testing of materials and/or constructed products. Conformance testing shall be conducted by the QC Team as required by this plan and by additional discretion of the QC Manager. Results of conformance testing shall be reviewed by the QC Manager to assess conformance with the program requirements. Copies of all conformance testing results shall be included with the program records.

3.5. Field Observations

The QC Team shall observe and document (as outlined herein) all construction activities associated with the program. Results shall be reported to the QC Manager (with the Owner copied) on a daily basis.

4. Subgrade and Subbase

4.1. General

The term subgrade references existing ground surface to be prepared or in the case of earthwork excavation areas, the exposed ground surface graded in accordance with the test embankment program requirements. The term subbase refers to the surface of structural fill layers to be constructed in accordance with the program requirements. All materials proposed for use as structural fill in subbase construction shall receive prior approval by the QC Manager.

4.2. Placement

Prior to placement of structural fill and/or construction of other embankment components, exposed surfaces shall be stripped of all vegetation, organic soils and vegetative cover soils as well as any other deleterious materials. Once stripping is completed, the existing surface shall be proofrolled as outlined below. The response of the surface shall be observed by the QC Team. Areas that rut, settle or pump shall be corrected as directed by the QC Manager until satisfactory results are attained. Following approval by the QC Manager and prior to placement of structural fill and/or construction of other embankment components, all exposed surfaces shall be scarified to promote lift bonding.

The sequence of filling shall commence at the lowest section (in elevation) of the subject footprint and proceed upward in maximum eight-inch loose lifts in a manner to maintain positive drainage at all times. Positive drainage through minimum two percent cross slopes shall be maintained on all fill surfaces. The fill sequence shall also be performed in a manner that reduces the potential for uncontrolled sediment runoff and adequately controls runoff from the embankment area. For areas with slopes greater than 20 percent, embankment benches shall be provided which are conducive to horizontal lift construction.

4.3. Compaction

Each lift of structural fill shall be compacted with appropriate heavy equipment to minimum requirements established by the QC Manager. Field conformance testing shall include periodic in-place density and device calibration testing to provide documentation of the compaction operations at prescribed intervals as established by the QC Manager. Device calibration/confirmation testing shall consist of in-situ density tests (sand cone, water replacement, etc.) every 10 nuclear field density tests or as established by the QC Manager. Following initial compaction, the surface shall be sealed with a smooth drum roller to reduce the potential for surface water infiltration. Prior to placement of subsequent lifts the surface shall be lightly scarified to promote lift bonding.

Structural fill to achieve subbase shall be compacted as follows:

a. **Type I Material** shall consist of plastic soil materials, free of organic or other deleterious materials that are suitable for the subject application as determined by the QC Manager. Type I material shall be compacted with a tamping foot or sheep foot roller, or equivalent approved by the QC Manager, to a minimum density and moisture content determined by the QC Manager. The compaction equipment shall traverse the entire surface area of each lift a minimum of three full passes.

b. **Type II Material** shall consist of ash materials, free of organic or other deleterious materials that are suitable for the subject application as approved by the QC Manager. Type II material shall be compacted with an appropriate roller as approved by the QC Manager for the subject material to a minimum density and moisture content determined by the QC Manager. The compaction equipment shall traverse the entire surface area of each lift a minimum of three full passes.

4.4. Quality Control Requirements

Prior to construction of any embankment component across completed subgrade or subbase, the QC Team shall verify the following:

a. The subgrade or subbase, where applicable, was constructed in accordance with the program requirements.

b. The exposed surface was inspected to:

   i. confirm the subgrade or subbase, where applicable, is properly compacted and uniform and is suitable to support subsequent embankment construction;

   ii. observe a proofroll using appropriate heavy equipment approved by the QC Manager. Significant pumping or rutting observed during proofrolls shall be corrected as directed by the QC Manager until satisfactory proofroll results are attained. Each proofroll shall be documented for inclusion with the program records;

   iii. confirm that elevations are consistent with the program; and

   iv. confirm that foundation benching has been provided which is conducive to horizontal lift construction in areas with slopes of 20 percent or greater.

5. Working Platform (Optional)

5.1. General

The function of the working platform is to provide a stable base across existing surfaces that do not possess sufficient bearing capacity to support subsequent embankment construction. The working platform shall be constructed from select bottom ash (or other) materials approved by the QC Manager.

5.2. Placement

Working platform placement shall commence at the limit of areas suitable to support construction equipment and proceed outward in a manner deemed appropriate by the Construction Manager and the QC Manager based on encountered conditions. Each lift shall be constructed in maximum eight-inch loose lifts.

Transport of working platform materials shall be performed in accordance with methodology approved by the Construction Manager and the QC Manager. Loaded hauling equipment should be strategically routed over areas requiring additional compaction during construction.

5.3. Compaction

Compaction of working platform materials shall be performed in a manner deemed appropriate by the QC Manager based on encountered conditions. Bearing capacity of compacted surfaces shall be assessed by proofrolls as outlined below.

Remedial measures of areas that do not meet proofroll objectives shall include consideration of drainage and/or base reinforcement (biaxial geogrid, etc.) elements.

5.4. Quality Control Requirements

Prior to construction of any embankment component across completed working platform surfaces, the QC Team shall verify the following:

a. The working platform was constructed in accordance with the program requirements.

b. The exposed surface was inspected to:

   i. confirm the working platform is properly compacted and uniform and is suitable to support subsequent embankment construction;

   ii. observe a proofroll using appropriate heavy equipment approved by the QC Manager. Significant pumping or rutting observed during proofrolls shall be corrected as directed by the QC Manager until satisfactory proofroll results are attained. Each proofroll shall be documented for inclusion with the program records; and

   iii. confirm that elevations are consistent with the program.

6. Test Embankment

6.1. General

The test embankment shall be constructed over approved subgrade, subbase and/or working platform in accordance with the program requirements. Embankment materials shall consist of ash materials, free of organic or other deleterious materials that are suitable for the subject application as approved by the QC Manager.

6.2. Placement

The sequence of filling shall commence at the lowest section (in elevation) of the subject footprint and proceed upward in maximum 24-inch loose lifts in a manner to maintain positive drainage at all times. Positive drainage through minimum two percent cross slopes shall be

maintained on all fill surfaces. The fill sequence shall also be performed in a manner that reduces the potential for uncontrolled sediment runoff and adequately controls runoff from waste disposal areas. For areas with slopes greater than 20 percent, embankment benches shall be provided which are conducive to horizontal lift construction.

The rate of embankment construction shall be varied by the QC Manager as part of the overall program objectives.

6.3. Compaction

Each embankment lift shall be compacted with an appropriate roller as approved by the QC Manager for the subject material. Materials shall be compacted to a minimum of 90 percent of standard proctor maximum dry density at a moisture content within minus four percent and plus two percent of optimum or as established by the QC Manager based on field observations, testing and results of the test pads.

Following initial compaction, the surface shall be sealed with a smooth drum roller to reduce the potential for surface water infiltration. Prior to placement of subsequent lifts the surface shall be lightly scarified to promote lift bonding.

6.4. QC Requirements

Embankment placement and compaction methods shall be monitored by the QC Team to assess conformance with program requirements.

Test pads shall be constructed periodically, as established by the QC Manager, to evaluate material placement and compaction methods. Test pads shall be constructed following the same methodology and with the same equipment proposed for use during site operations and shall be evaluated by the QC Team. Evaluation criteria shall include overall compaction results. Appropriate modifications to embankment placement and compaction methodology shall be developed by the QC Manager if compacted materials do not meet program requirements.

The rate of embankment construction shall be measured by the QC Team every 24-hour period in which work has been performed as well as for a weekly total.

Field conformance testing shall include periodic in-place density and device calibration testing to provide documentation of the compaction operations at prescribed intervals as directed by the QC Manager. Device calibration/confirmation testing shall consist of in-situ density tests (sand cone, water replacement, etc.) every 10 nuclear field density tests or as established by the QC Manager.

7. Non-Woven Geotextile Filter Fabric (Optional)

7.1. General

Geotextile materials shall be unloaded and stored in accordance with manufacturer recommendations. The contractor shall generate a material inventory log during unloading of material shipments to the program site.

Requirements for geotextile are as follows:

a. Geotextile shall be non-woven, polyester or polypropylene fabric meeting the minimum requirements as established by the QC Manager.

b. Geotextile shall be protected from direct sunlight, ultraviolet rays, temperature greater that 140 degrees Fahrenheit, mud, dirt, dust and debris. During storage, geotextile filter fabric shall be wrapped in a heavy duty protective covering.

c. Installation shall be in accordance with manufacturer recommendations.

d. Surfaces to receive geotextile shall be prepared to a relatively smooth condition, free of obstructions, depressions and debris.

e. Geotextile shall be placed with the long dimension parallel with the centerline of ditches and roads, and/or parallel to embankment slopes, as applicable. Geotextile shall be laid smooth, and free of tension, stress, folds, wrinkles or creases.

f. On slopes greater than or equal to four horizontal to one vertical (4H:1V), adjacent strips of geotextile or reinforcing fabric shall be joined by stitching together continuously. All stitched seam strengths shall be greater than 90 percent of the grab tensile strength of the geotextile as determined by ASTM D 1682.

g. On slopes less than four horizontal to one vertical (4H:1V), overlaps shall be at least two feet.

h. Geotextile shall be covered with a minimum of two feet of designated materials within 15 days of deployment for ultraviolet light protection.

7.2. QC Requirements

QC requirements are as follows:

a. Prior to delivery, manufacturer and supplier certifications shall be submitted to the QC Manager indicating that all materials meet, or exceed, the minimum established properties. Certifications shall be accompanied by supporting QC testing.

b. Conformance testing schedule and procedures shall be performed as directed by the QC Manager.

c. Construction monitoring and field acceptance of geotextile installation shall be documented by the QC Team.

8. Drainage Structures (Optional)

Drainage structures shall be installed as directed by the QC Manager. All drainage structures shall comply with project requirements.

8.1. General

Drainage structures shall be unloaded and stored in accordance with manufacturer recommendations. The contractor shall generate a material inventory log during unloading of material shipments to the program site.

8.2. QC Requirements

QC requirements are as follows:

a. Prior to delivery, manufacturer and supplier certifications shall be submitted to the QC Manager indicating that all materials meet, or exceed, the minimum properties established in this section. Certifications shall be accompanied by supporting QC testing.

b. The QC Team shall observe all drainage structures upon delivery. Any structures showing signs of shipment damage or non-conformance to program specifications shall be replaced.

c. Construction monitoring and field acceptance of drainage structure installation shall be documented by the QC Team.

d. Drainage structures shall be installed to the lines and grades shown in the drawings. Any deviation in location shall be subject to the approval of the QC Manager and documented by as-built survey.

9. Durable Coarse Aggregate Materials (Optional)

Coarse aggregate materials shall conform to the gradation and material requirements shown on the drawings.

9.1. General

Coarse aggregates shall be placed to the lines and grades shown in the drawings. Placement shall be performed in such a manner that underlying geotextiles or adjacent structures shall not be damaged.

9.2. QC Requirements

QC requirements are as follows:

a. Prior to construction, aggregate supplier(s) shall submit required material documentation to the QC Manager.

b. Conformance testing schedule and procedures shall be performed as directed by the QC Manager.

c. Construction monitoring and field acceptance of durable coarse aggregate placement shall be documented by the QC Team.

10. Erosion and Sediment Control

Erosion and sediment control measures shall be provided as field conditions dictate and approved by the QC Manager, or as directed by the regulatory agency.

The QC Team shall periodically monitor these structures as well as overall site drainage conditions. Reports shall be prepared weekly, or after each precipitation event exceeding ½ inch, on the condition of sediment structures as documentation of monitoring. Appropriate adjustments to site drainage and related sediment control structures shall be made as necessary based on current site conditions during test embankment construction.

11. Instrumentation

11.1. General

Instrumentation monitoring has been established for the test embankment area to monitor the embankment slopes and the underlying foundation materials. Instrumentation for geotechnical monitoring shall be installed according to the attached Plan and Detail Sheets. The instrumentation program includes the prescribed use of the instrumentation and the specific monitoring of these devices as further detailed.

11.2. Types

a. Piezometers shall be installed and monitored to characterize the increase and dissipation of pore pressures within the existing ash and native cohesive foundation soils due to embankment loading.

b. Slope inclinometers shall be used to measure lateral displacements within the embankment and foundation materials due to loading. The inclinometers shall be anchored a minimum of 10 feet into bedrock.

c. Settlement plates shall be utilized to measure the vertical deformation of the foundation soils due to embankment loading.

If any instruments are damaged during construction, they shall be repaired/replaced as directed by the QC Manager.

11.3. Measurements

Baseline data shall be confirmed prior to embankment loading. Piezometers, inclinometers and settlement plates shall be measured once a day, unless directed otherwise by the QC Manager. One select instrument cluster of four vibrating wire piezometers per test embankment shall be instrumented. The vibrating wire piezometers at these locations shall be connected to a data logger that will upload data via air card technology to a password access website. This website may be accessed by select individuals in order to review real-time pore pressure data. These data acquisition systems will be configured so that they may be moved to different piezometer clusters, if necessary. The rate of embankment construction shall be varied by the QC Manager as part of the overall program objectives. Measured instrumentation responses shall be reviewed and evaluated by the QC Manager.

11.4. Thresholds

Embankment loading models have been analyzed which take into account the existing subsurface conditions and the proposed embankment heights. The following threshold limits shall be used for the test embankments.

a. Piezometers – Embankment filling may continue, with regular monitoring frequency, as long as the ratio of excess pore pressure to the applied embankment load is 10 percent or below. When excess pore pressure ratio ranges from 10 to 15 percent, embankment filling may continue, but with an increase in instrumentation monitoring specified by the QC Manager. All fill placements shall stop immediately when the excess pore pressure ratio is above the 15 percent level. Embankment loading may not resume until the excess pore pressure ratio drops below 10 percent. All excess pore pressure measurements shall be evaluated from baseline data values.

b. Slope Inclinometers and Settlement Plates – Embankment filling may continue with regular monitoring frequency, as long as the displacement ratio of lateral inclinometer movement to vertical settlement plate movement is 20 percent or below. When the displacement ratio ranges from 20 to 30 percent, embankment filling may continue, but with an increase in instrumentation monitoring specified by the QC Manager. All fill placements shall stop immediately when the displacement ratio is above the 30 percent level. Embankment loading may not resume until the displacement ratio drops below 20 percent.

It should be noted that embankment loading may also be restricted and/or modified at the discretion of the QC Manager based on other potentially unstable conditions not outlined herein.

12. Program Documentation

Documentation shall be collected and maintained by the QC Manager (copied to the Owner) during the test embankment program. This documentation shall include but not be limited to the following:

- Daily construction field reports;
- Weekly construction summary reports;
- Observation reports;
- Contractor submittals;
- Material conformance data;
- Photographic documentation;

- Survey data;
- Construction issue and solution reports;
- Plan modifications; and
- Meeting minutes.

Attachment 3

Summary of Stability Analysis

Test Embankment Program
Kingston Fossil Plant
Harriman, Roane County, Tennessee

Summary of Stability Analysis
Test Embankment Program – Area "A"

1. Introduction

A test embankment program is currently planned at the Kingston Fossil Plant. The purpose of this program is to verify geotechnical design parameters and construction methodology.

Geotechnical instrumentation, including settlement plates, inclinometers, and piezometers, will be installed at selected locations to monitor vertical consolidation of foundation soils, lateral movement of embankment and foundation materials, and pore water pressure generated by the embankment loading. The measured data will be used to regulate the rate of fill placement to reduce the potential for global failure of the embankment.

To assist in developing the test embankment program, preliminary slope stability analyses were performed. Presented herein is a summary of the preliminary results for previously defined Area "A" only.

2. Stability Analysis

Two cross sections were analyzed. Section 1A passes through the approximate center of Area "A" and is roughly parallel to Swan Pond Road. Section 2A is perpendicular to Section 1A and cuts through the slope to the west. The geometries of these two sections are summarized in Table 1.

Table 1. Cross Section Geometries

	Section 1A	Section 2A
Slope Crest Elevation, (ft)	El. 802	El. 802
Slope Toe Elevation, (ft)	El. 756	El. 768
Slope Height, (ft)	46	34
Slope Inclination	3H:1V	3H:1V
Intermediate Benches	@ El. 772 and El. 787	@ El. 772 and El. 787
Bench Width, (ft.)	50	50

Soil parameters used in the analyses, as summarized in Table 2, were developed from the preliminary field exploration and laboratory testing performed by AECOM and our experience with similar soils. A total of five consolidated undrained (CU) triaxial tests have been performed by AECOM on remolded fly ash material. The specimens were prepared by drained slurry techniques. Vane shear tests were performed to measure both peak shear strength and remolded shear strength of the native clay soils. The data are scattered and do not indicate any recognizable correlations with depth (i.e. overburden pressure). The undrained clay strengths presented in Table 2 are the "two-thirds" values. This is generally supported by the following USACE recommendations: "Prior Corps of Engineers' practice has been to draw the strength envelope in a position such that data from two-thirds of the tests lie above the failure envelope. This recommendation is reasonable (USACE EM 1110-2-1902, 2003)." Five CU triaxial tests were performed by AECOM on the clay soil. The lowest friction angle was conservatively selected as the drained strength for the clay material. A conservative cohesion (100 psf) was assumed for the compacted ash embankment, such that critical slip surfaces do not occur near the surface. It should be noted that the lab testing program is still a work-in-progress, thus these parameters may be updated or revised in the future.

Table 2. Summary of Soil Parameters

Soil Type	Unit Weight (pcf)		Undrained Strength		Drained Strength	
	Above Ground Water	Saturated	Peak (psf)	Remolded (psf)	Friction Angle (deg.)	Cohesion (psf)
Compacted Ash Embankment	100	110	--	--	28	100
Existing Fly Ash	100	110	--	--	23	0
Native Clay	120	125	1,380	280	22	0
Native Silty Sand	125	130	--	--	26	0
Dense Sand	110	115	--	--	35	0
Bedrock	Very Strong [1]					

Note: [1] – Assumed strong enough that critical slip surfaces do not occur in rock

Stability analyses were performed using the computer program SLOPE/W (GEO-SLOPE International Ltd). The Morgenstern-Price method was used to compute the factor of safety for the considered failure surfaces. An optimization process was then conducted to obtain the critical failure surface.

First, the stability analyses were performed using the undrained clay strengths. The results indicate that the analyzed slopes exceed the minimum required factor of safety of 1.5 with the peak strength (factors of safety of 1.86 and 2.09 for Sections 1A and 2A, respectively); however, the required factor of safety is not met with the remolded strength (factors of safety of 0.90 and 1.28 for Sections 1A and 2A, respectively). Therefore, monitoring program must be implemented for construction of the test embankments.

Subsequent analyses were then performed using the effective stress approach. Excess pore water pressures (P.W.P) generated by the applied embankment load were considered for the native clay and existing fly ash layers. These analyses do not account for shear-induced pore pressures. Lateral shear will be monitored by the inclinometers. The results of the stability analyses are summarized in Table 3. The Excess P.W.P Ratio is defined as "increase in pore water pressure at a location divided by change in vertical stress due to

added embankment weight at the same location." The groundwater level was assumed to be at the existing ground surface. The results indicate the failure mode is generally circular.

Table 3. Results of Stability Analyses

Excess P.W.P. Ratio (%)	Calculated Factor of Safety			
	Section 1A		Section 2A	
	Excess P.W.P. Applied to Clay Only [1]	Excess P.W.P. Applied to Both Clay & Existing Ash [2]	Excess P.W.P. Applied to Clay Only	Excess P.W.P. Applied to Both Clay & Existing Ash
0	1.89	1.89	2.09	2.09
10	1.87	1.79	2.10	2.00
20	1.86	1.67	2.09	1.89
30	1.85	1.57	2.09	1.79
40	1.80	1.49	2.09	1.68
50	1.77	1.37	2.09	1.58
60	1.74	1.27	2.10	1.47
70	1.69	1.18	2.10	1.35
80	1.64	1.06	2.10	1.24
90	1.58	0.93	2.10	1.11
100	1.52	0.82	2.10	0.98

Note: [1] The clay layer is subjected to static pore water pressure plus excess pore water pressure generated by embankment weight; all other layers are subjected to static pore water pressure only.

[2] Both clay layer and existing fly ash layer are subjected to static pore water pressure plus excess pore water pressure generated by embankment weight; all other layers are subjected to static pore water pressure only.

The above data are plotted as the calculated factor of safety vs. Excess P.W.P Ratio in Figures 1 and 2.

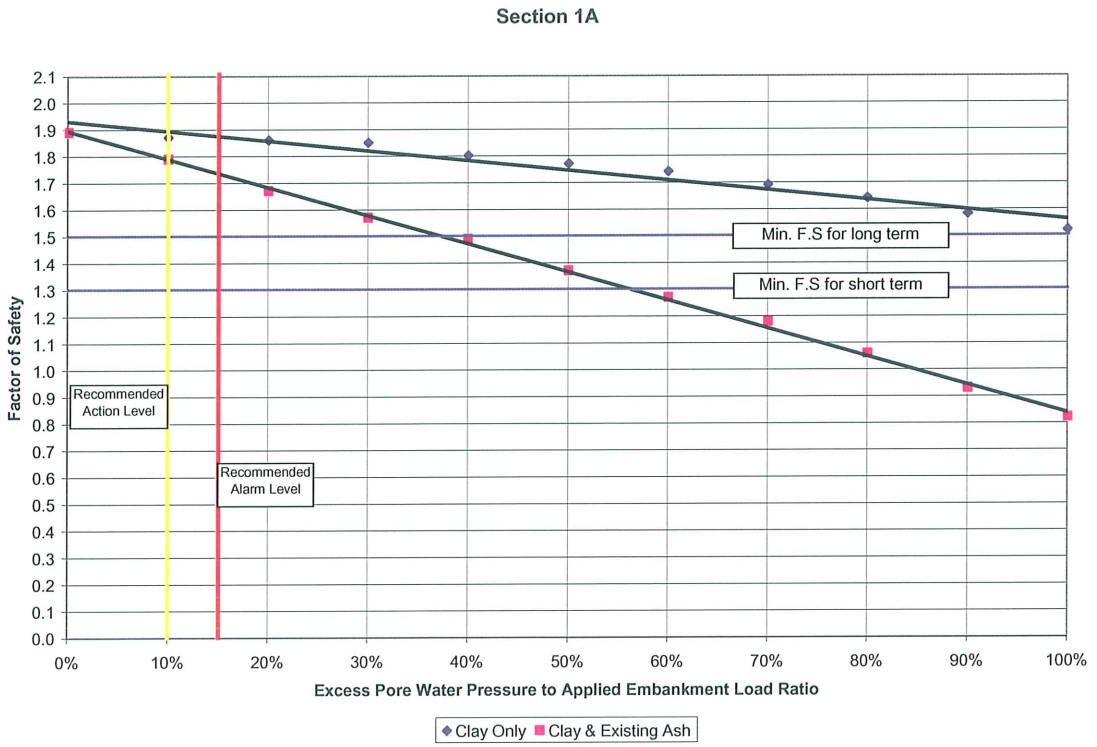

Figure 1 – Factor of Safety vs. Excess P.W.P Ratio (Section 1A)

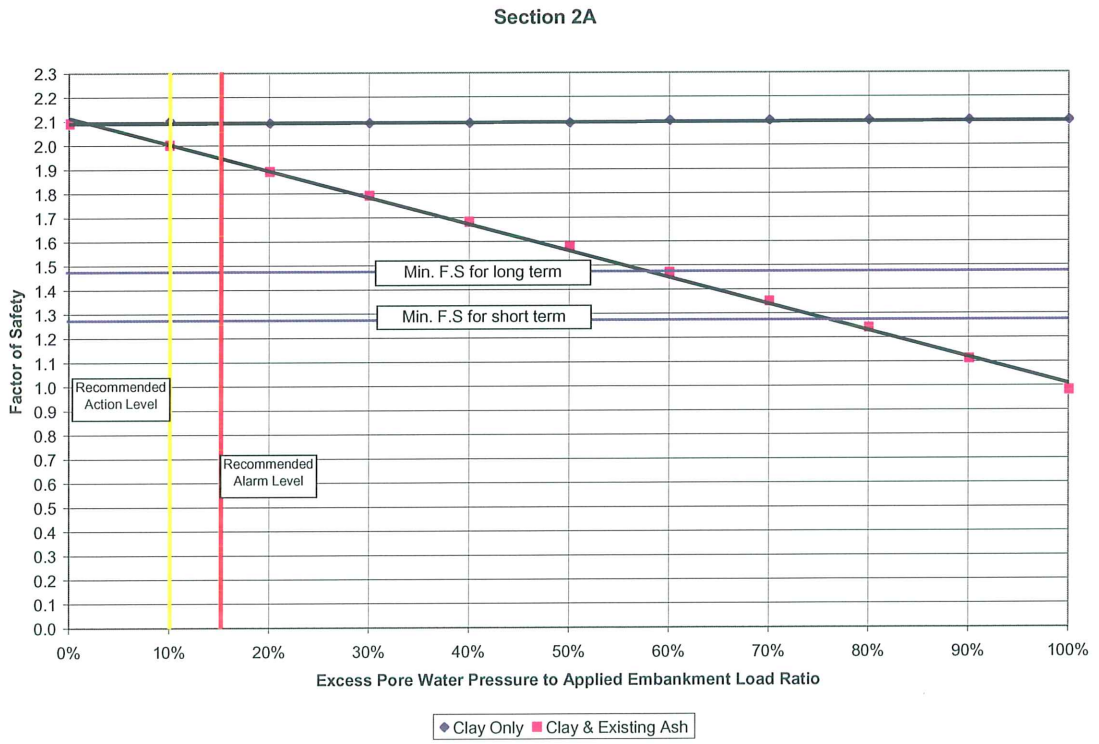

Figure 2 – Factor of Safety vs. Excess P.W.P Ratio (Section 2A)

- The analyzed Sections 1A and 2A slopes exceed the minimum required factor of safety of 1.5 under long-term conditions (excess pore water pressure is zero). Section 1A has lower factors of safety than Section 2A due mostly to differences in embankment height.

- If no excess pore water pressure is built up in the existing ash layer, then both analyzed sections exceed the minimum required factor of safety of 1.3 even for the scenario of the excess pore water pressure equaling the embankment weight.

- If the rate of fill placement is fast enough for the existing ash layer to develop excess pore water pressure, then the test embankments may have a potential to fail. Figure 1 indicates that the factors of safety are 1.5, 1.3, and 1.1 at the Excess P.W.P Ratio of 37, 56, and 75 percent, respectively.

- To reduce the potential for global failure of the embankments, the following criteria are recommended for the monitoring program:

    - Action Level: The Excess P.W.P Ratio reaches 10 percent. If this condition occurs, increased frequency of monitoring and inspections must be implemented.

    - Alarm Level: The Excess P.W.P Ratio reaches 15 percent. If this condition occurs, fill placement should be stopped until the ratio decreases to below 10 percent.

    - In addition to the above Excess P.W.P Ratio criteria, fill placement should be stopped if the inclinometer data, settlements, or other observed deformations indicate movements along a potential failure plane.

    - During fill placement, it is recommended piezometer readings be taken twice a day, and inclinometers and settlement plates be measured once a day. This frequency of measurement may be increased or decreased based on the instrument readings as construction progresses.

3. Limitations

The recommendations presented herein are based on theoretical analyses that reflect current, but limited, information on the subsurface conditions at the site. The validity of the factor of safety relationships depend on the validity and completeness of this information. Unknown subsurface conditions could adversely affect the embankment stability during construction. The reliability of the instrumentation is dependent, in part, in their location in critical areas, which may be difficult to predict. For these reasons, the preliminary analyses presented here and the field monitoring data should be viewed only as indicators of the embankment stability. Field observations during construction will be a necessary component to ensuring the safety of test embankments.

Plots of Stability Analysis

Summary of Soil Parameters

Soil Type	Material No. in Plots		Unit Weight (pcf)		Drained Strength	
	1A Plots	2A Plots	Above Ground Water	Saturated	Friction Angle (deg.)	Cohesion (psf)
Compacted Ash Embankment	6	5	100	110	28	100
Existing Ash	1	1	100	110	23	0
Native Clay	2	2	120	125	22	0
Native Silty Sand	3	3	125	130	26	0
Dense Sand	4	--	110	115	35	0
Bedrock	5	4	Very Strong			

Section 1A Plots

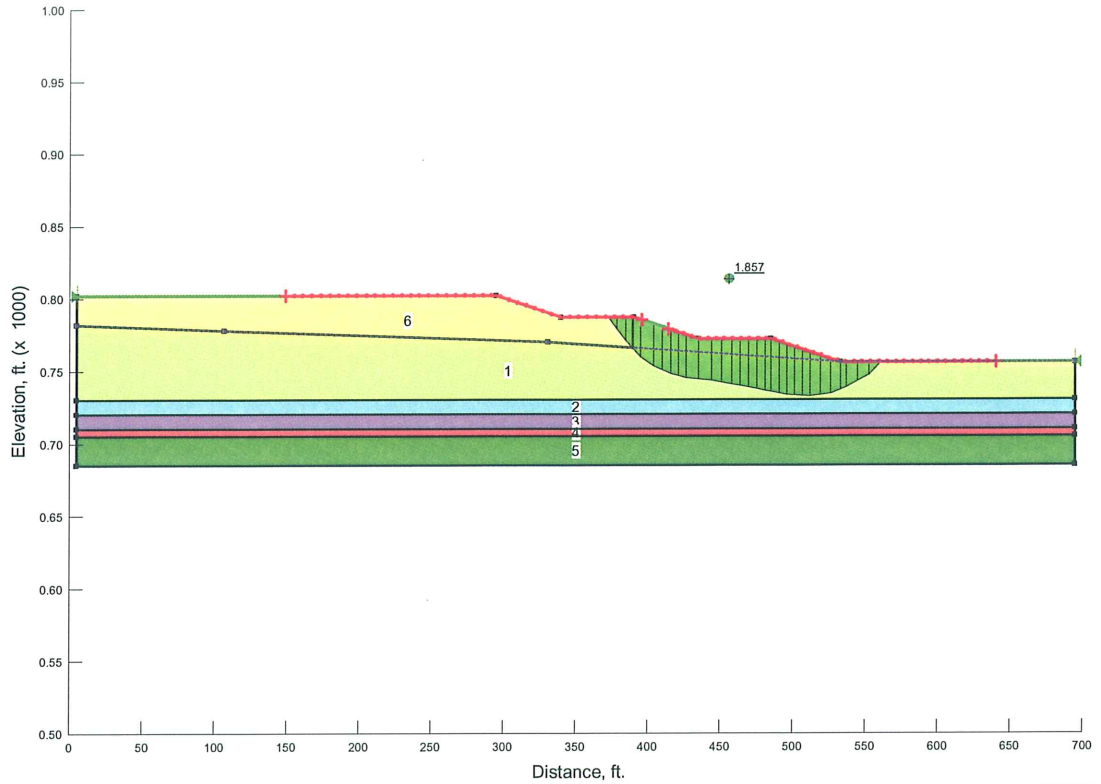

Figure 1A (A) – Peak Undrained Strength for Clay (c=1,380 psf)

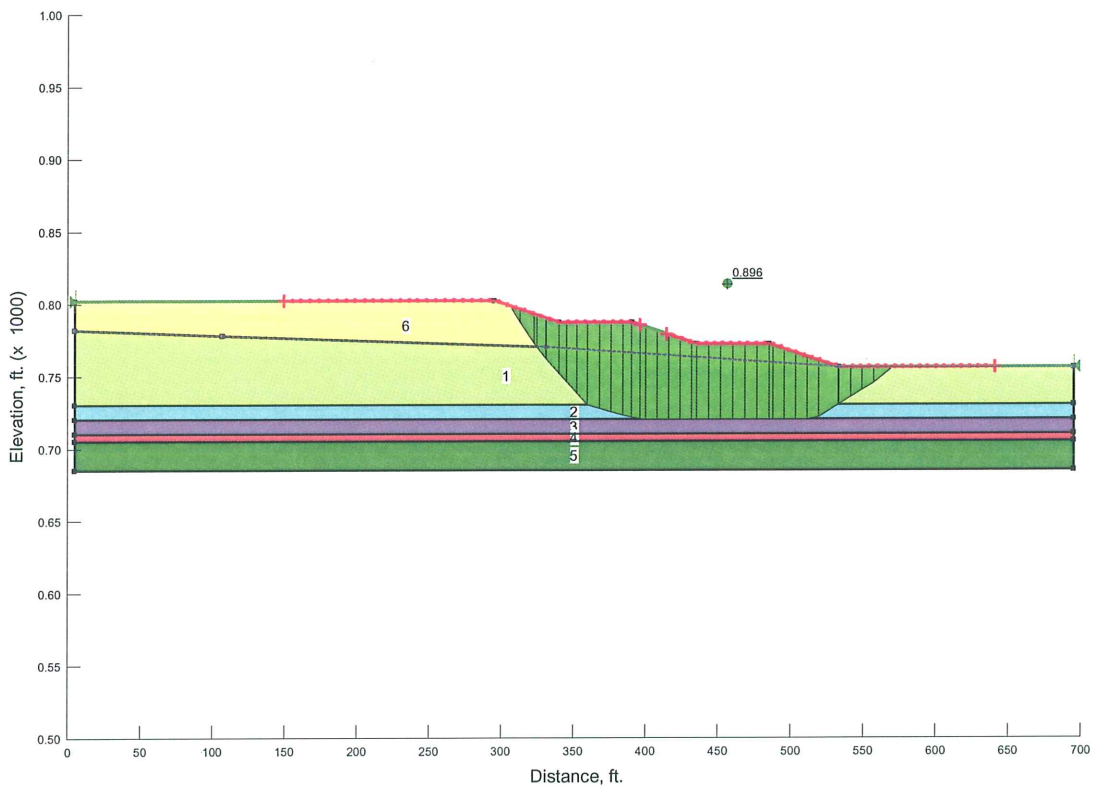

Figure 1A (B) – Residual Undrained Strength for Clay (c=280 psf)

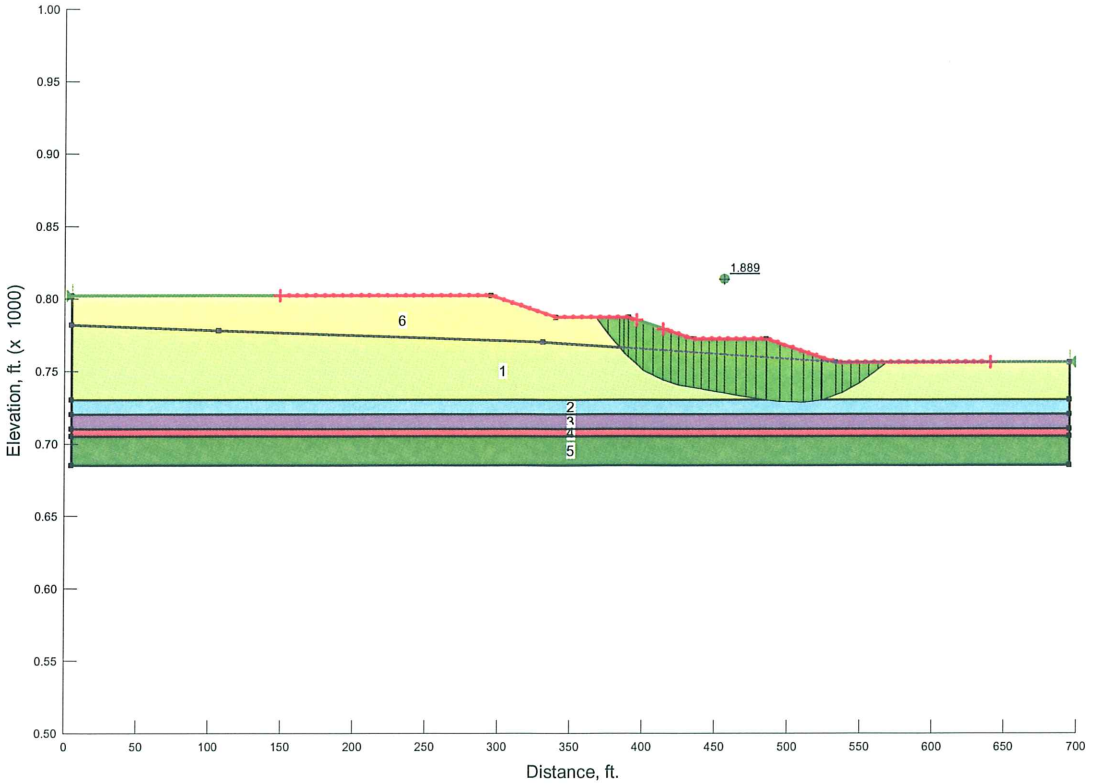

Figure 100 – No Excess P.W.P

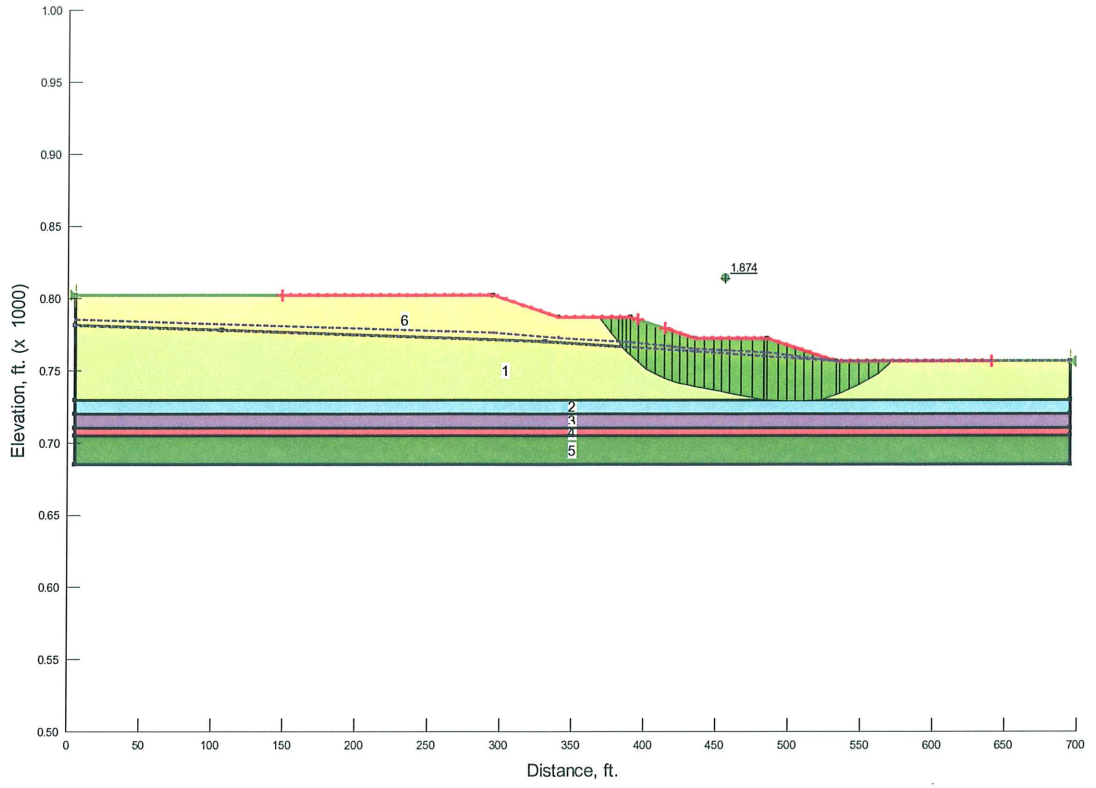

Figure 101 (A) – 10% Excess P.W.P in Clay Only

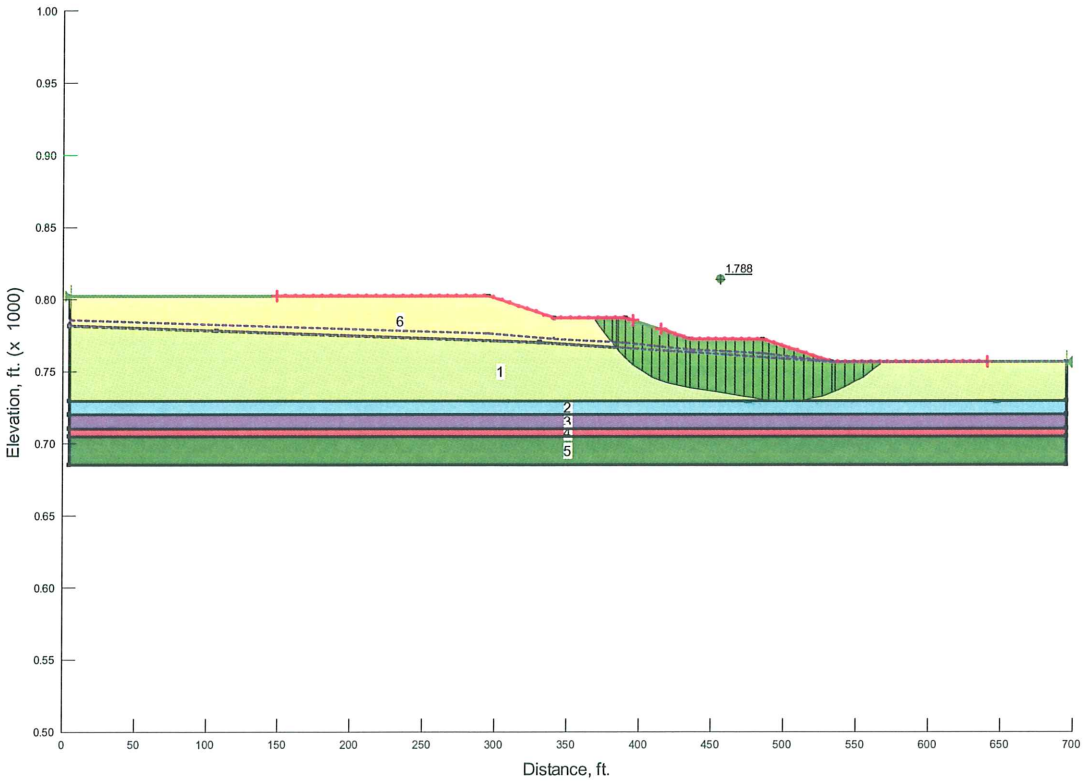

Figure 101 (B) – 10% Excess P.W.P in Both Clay and Existing Ash

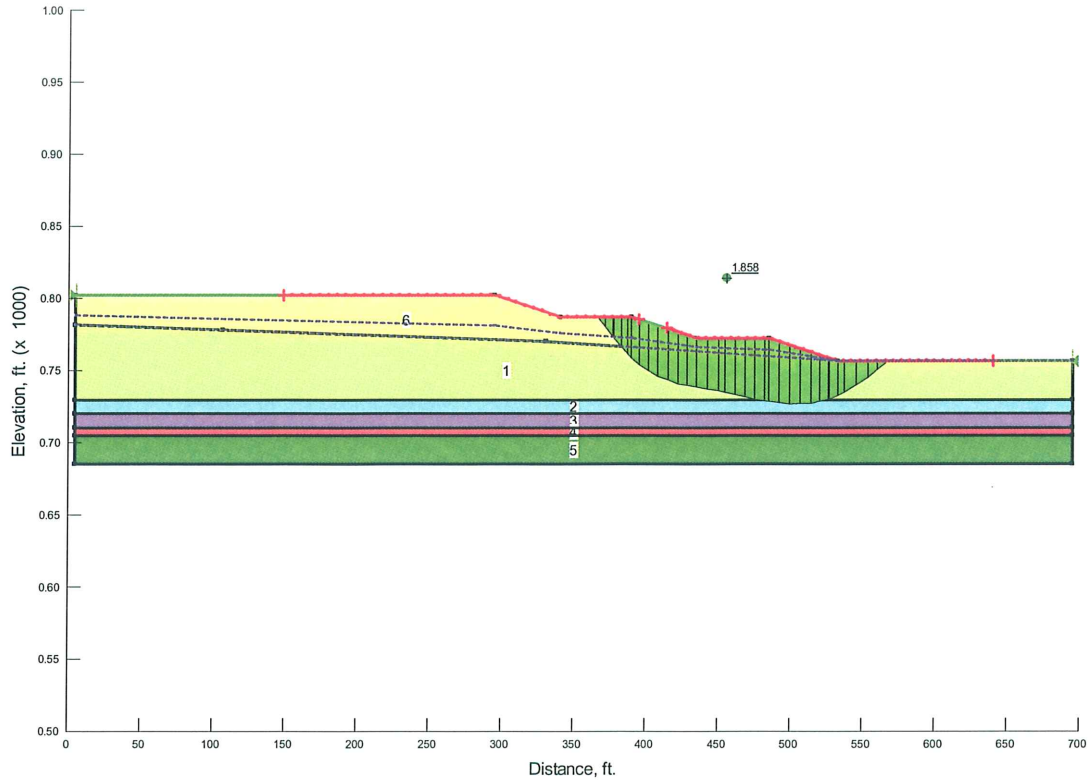

Figure 102 (A) – 20% Excess P.W.P in Clay Only

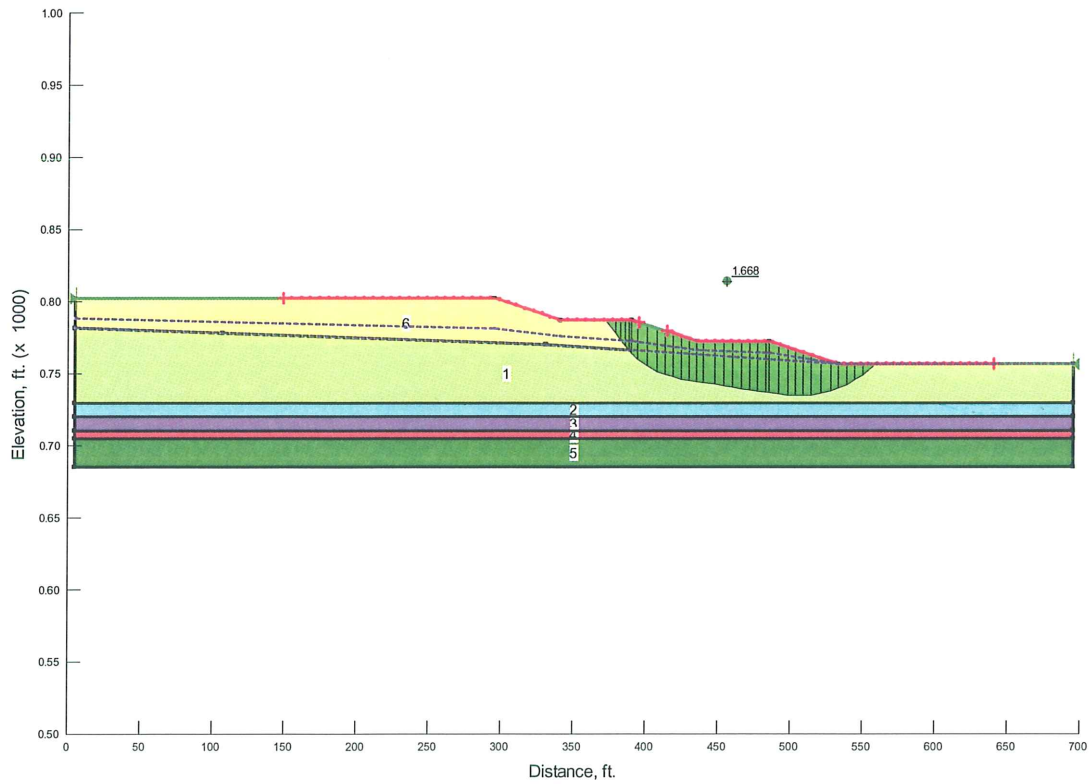

Figure 102 (B) – 20% Excess P.W.P in Both Clay and Existing Ash

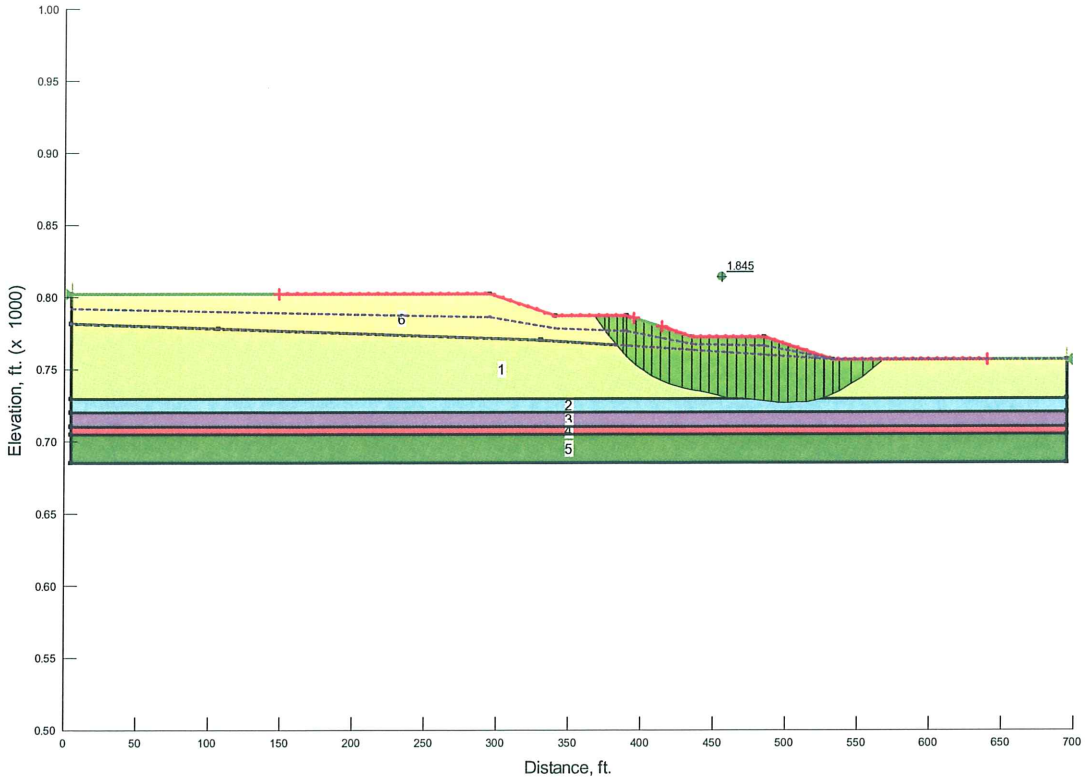

Figure 103 (A) – 30% Excess P.W.P in Clay Only

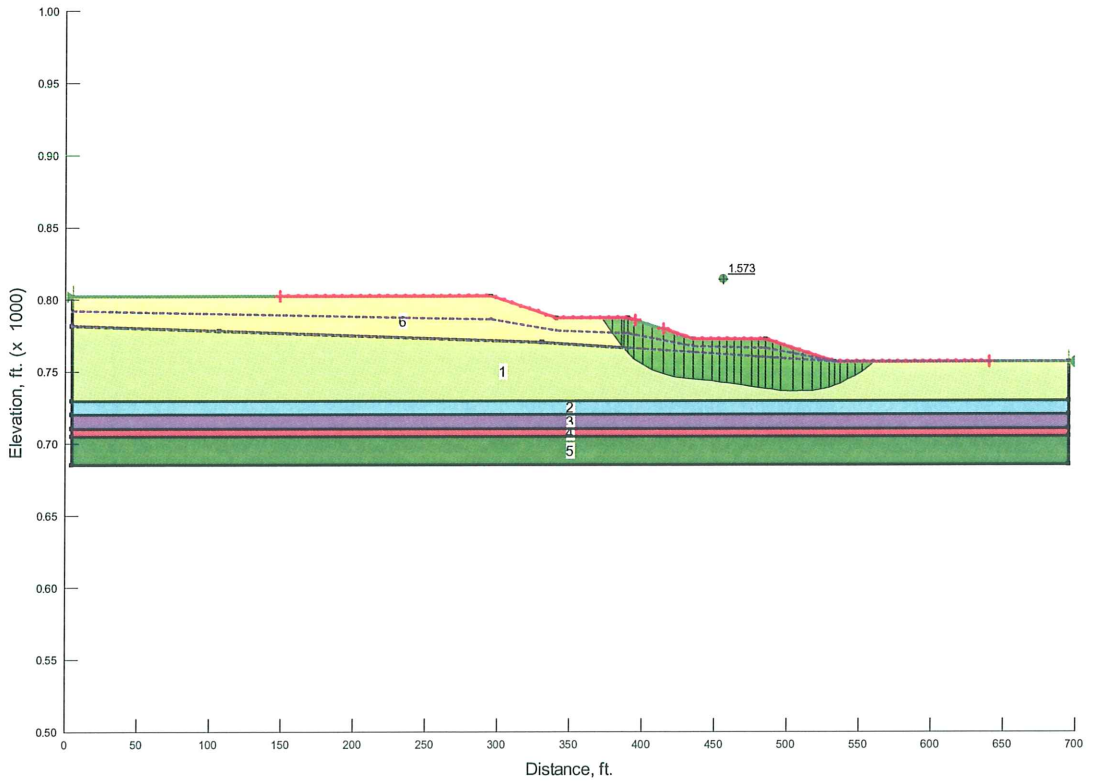

Figure 103 (B) – 30% Excess P.W.P in Both Clay and Existing Ash

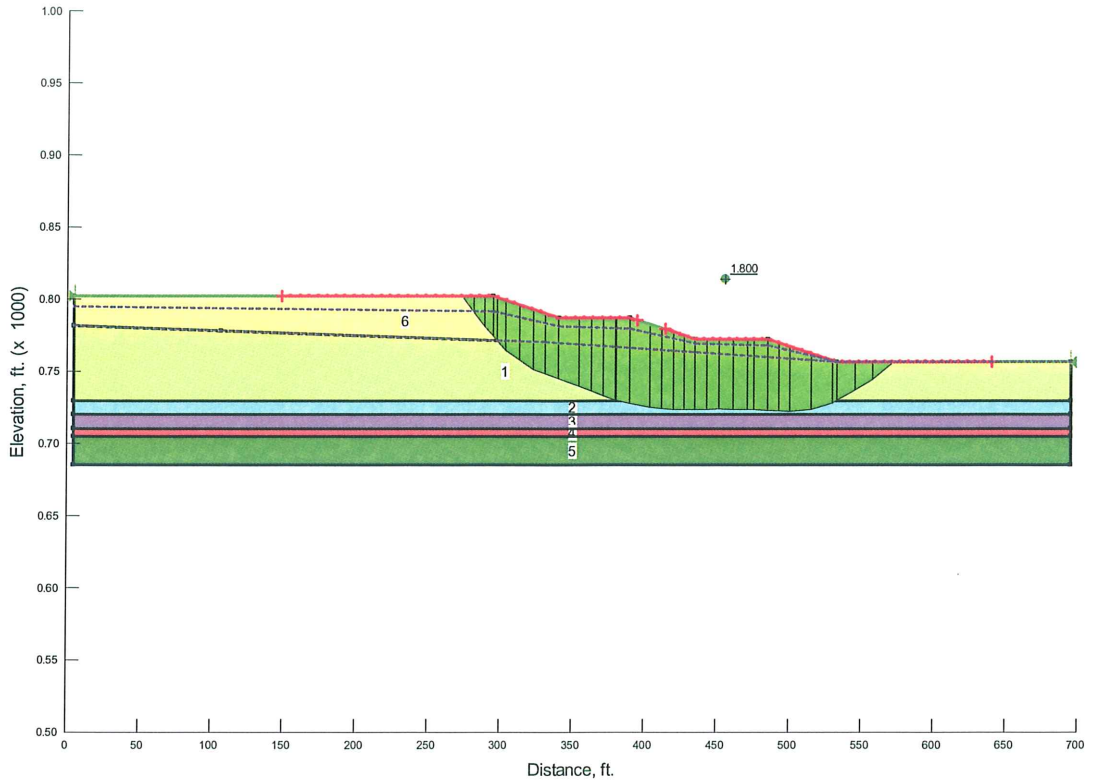

Figure 104 (A) – 40% Excess P.W.P in Clay Only

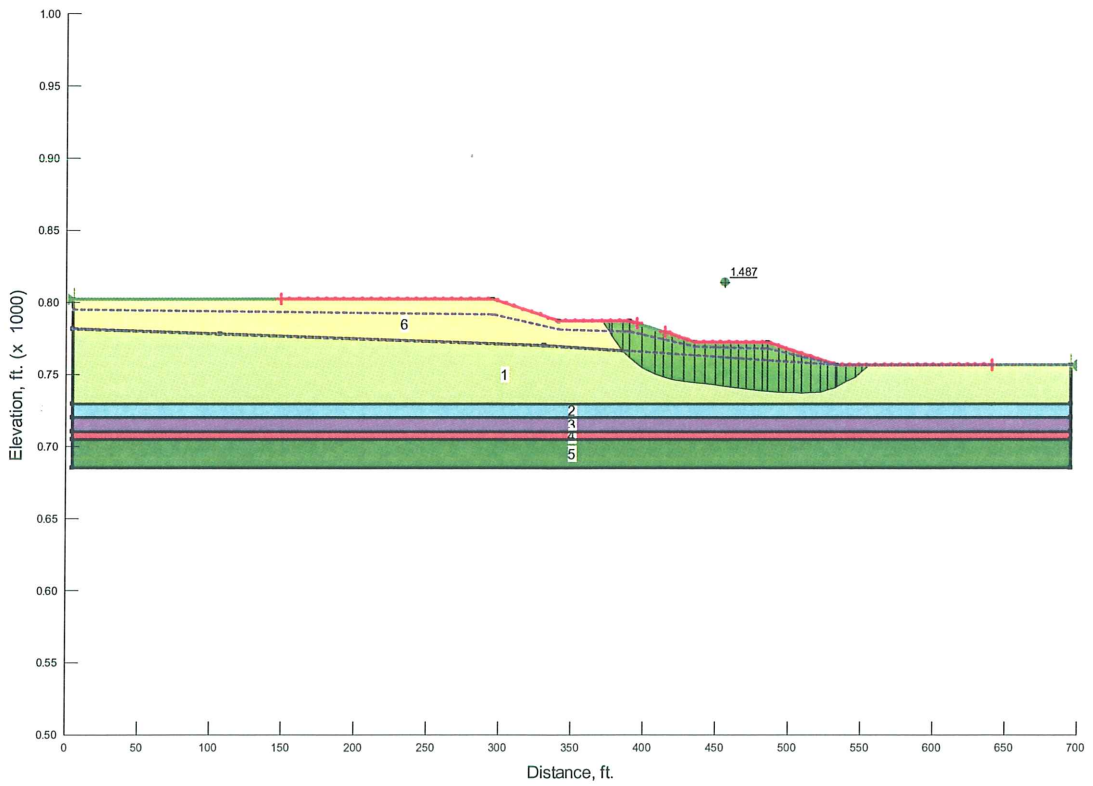

Figure 104 (B) – 40% Excess P.W.P in Both Clay and Existing Ash

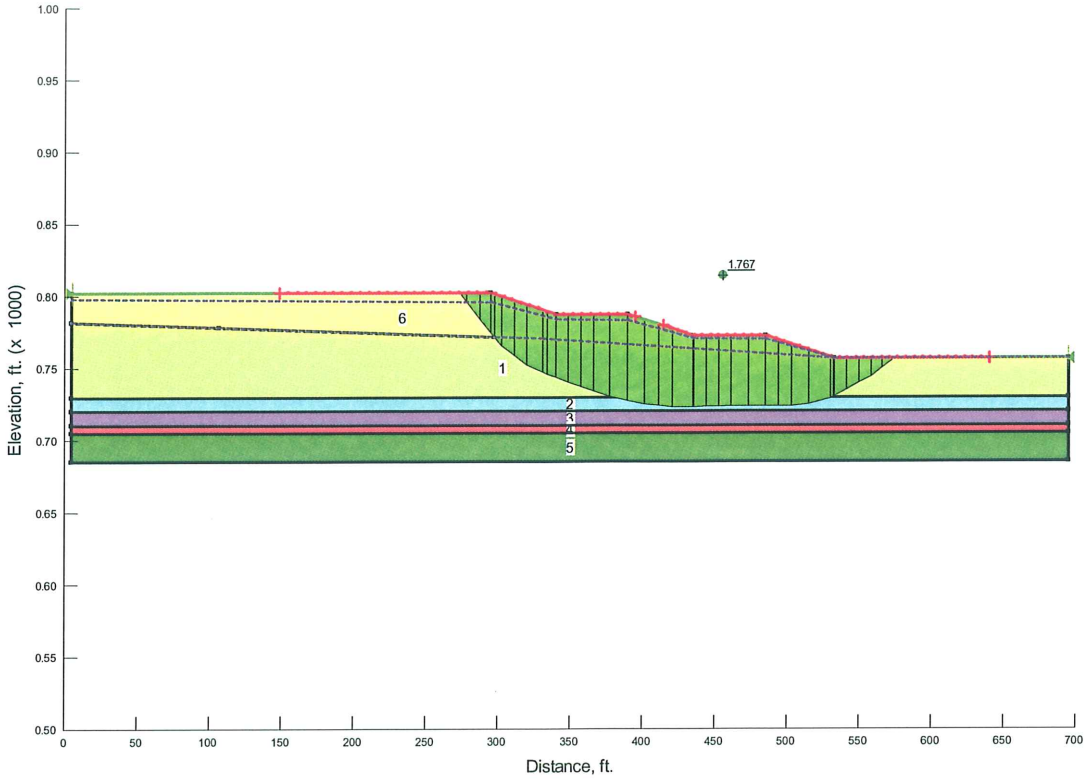

Figure 105 (A) – 50% Excess P.W.P in Clay Only

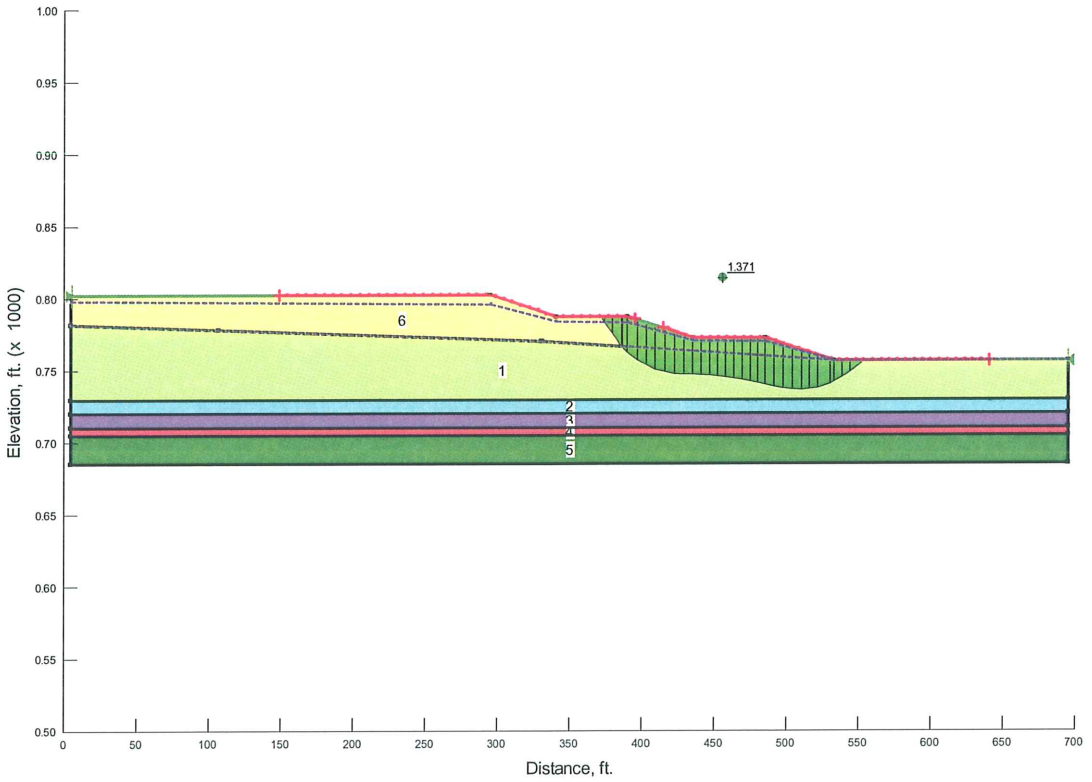

Figure 105 (B) – 50% Excess P.W.P in Both Clay and Existing Ash

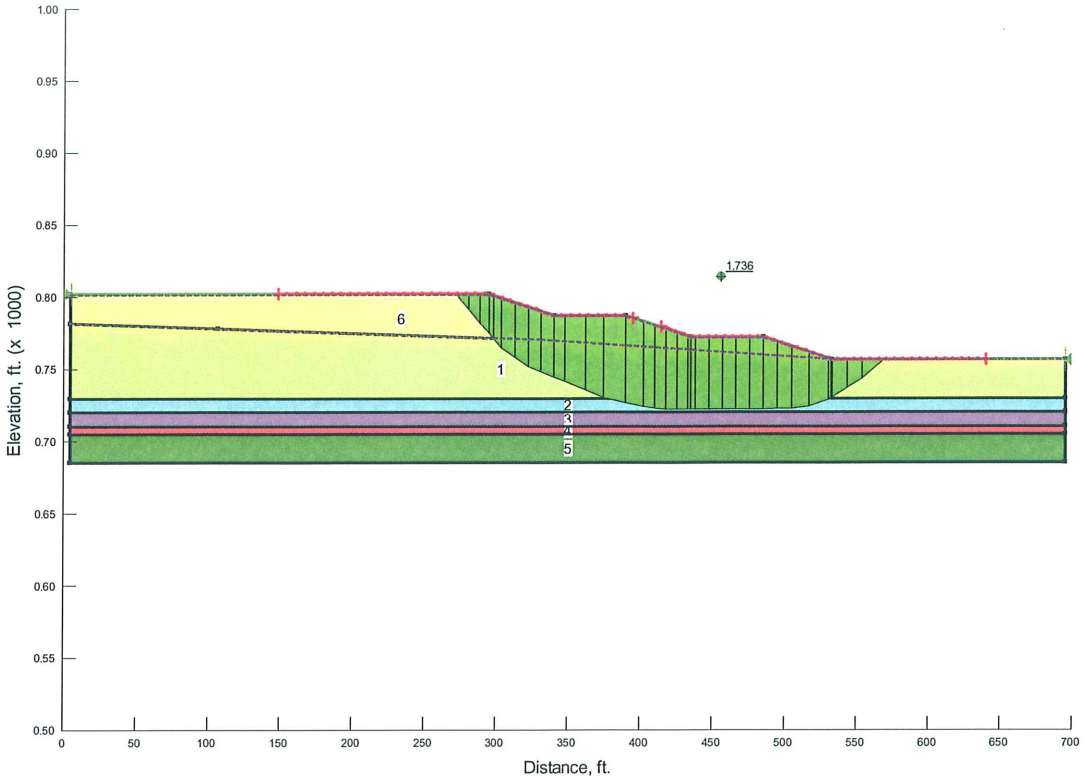

Figure 106 (A) – 60% Excess P.W.P in Clay Only

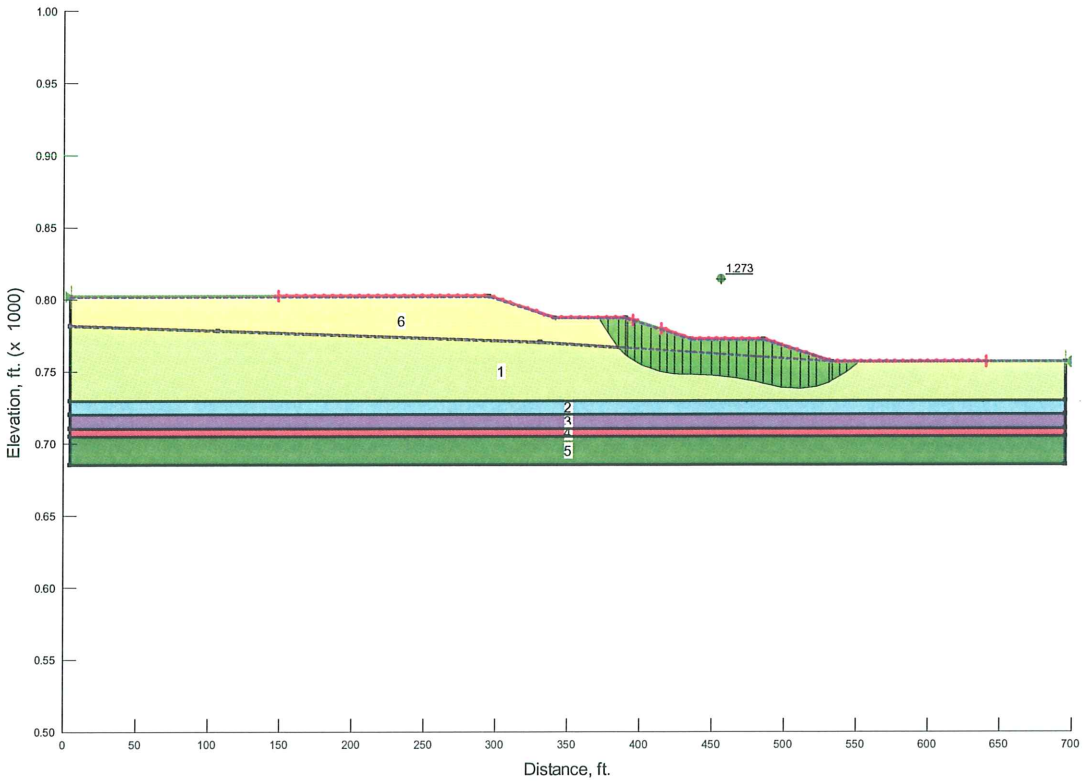

Figure 106 (B) – 60% Excess P.W.P in Both Clay and Existing Ash

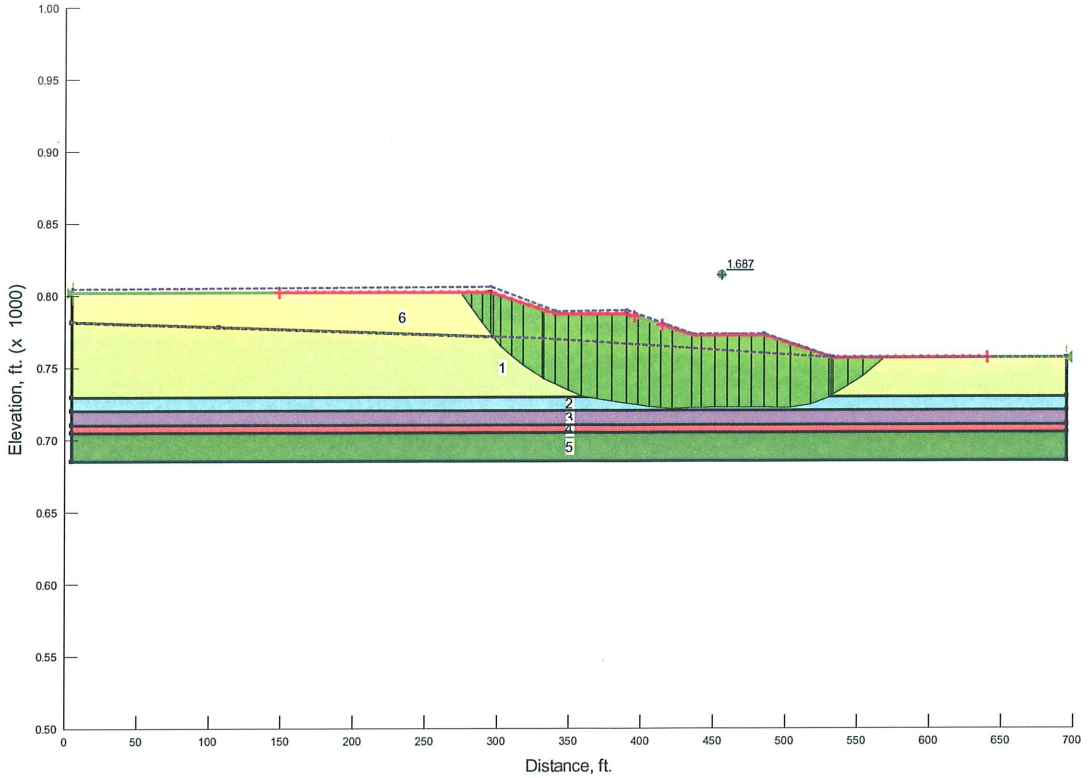

Figure 107 (A) – 70% Excess P.W.P in Clay Only

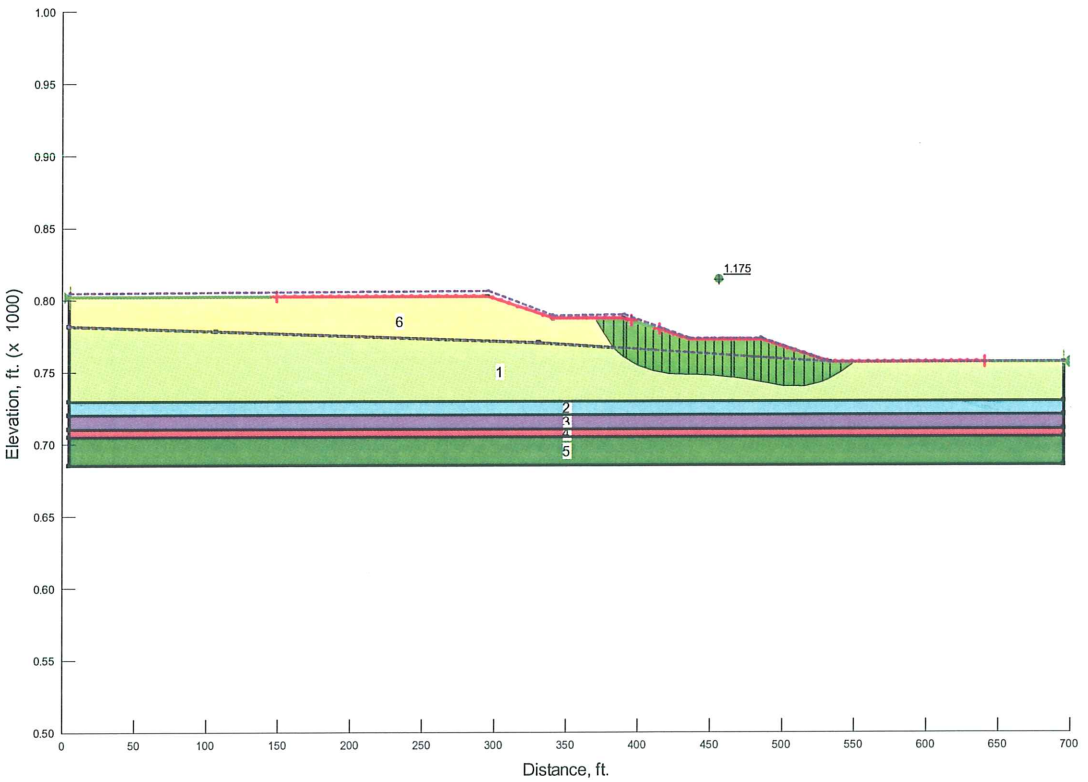

Figure 107 (B) – 70% Excess P.W.P in Both Clay and Existing Ash

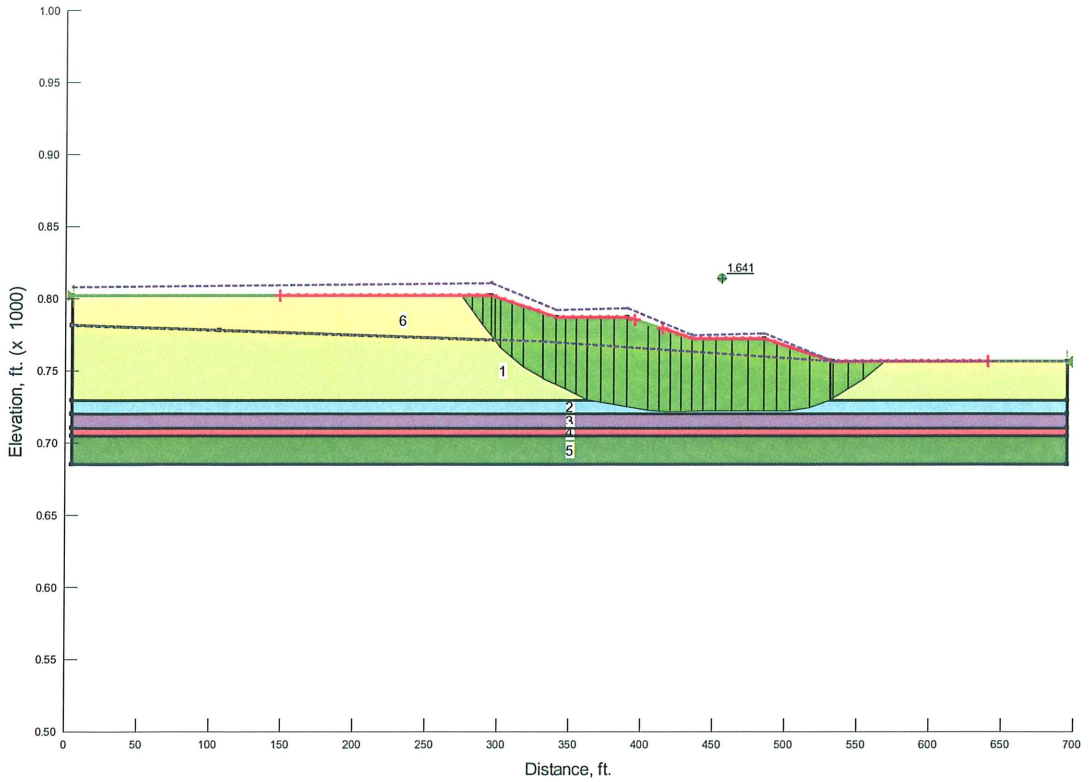

Figure 108 (A) – 80% Excess P.W.P in Clay Only

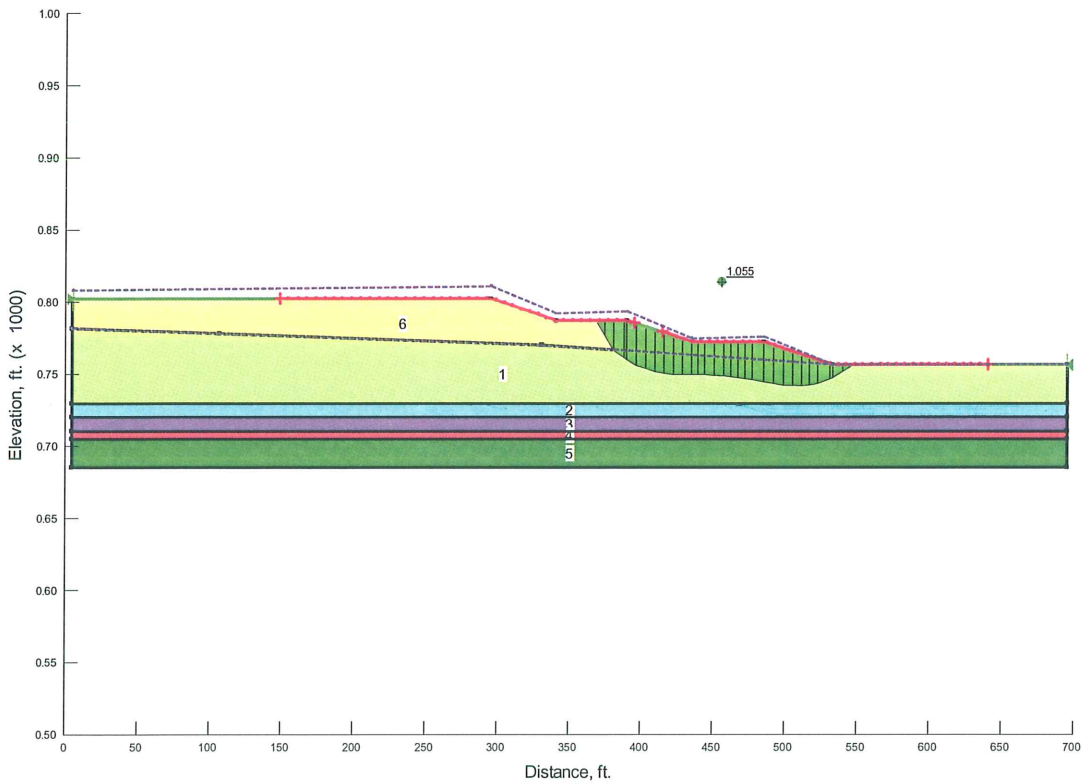

Figure 108 (B) – 80% Excess P.W.P in Both Clay and Existing Ash

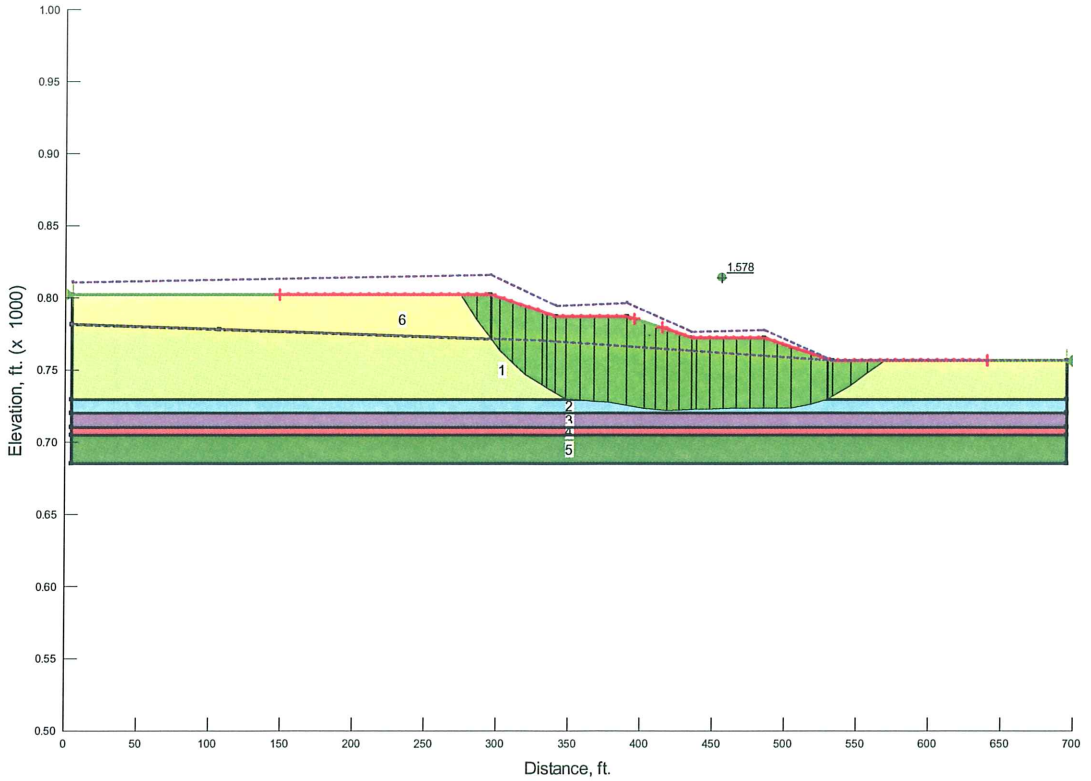

Figure 109 (A) – 90% Excess P.W.P in Clay Only

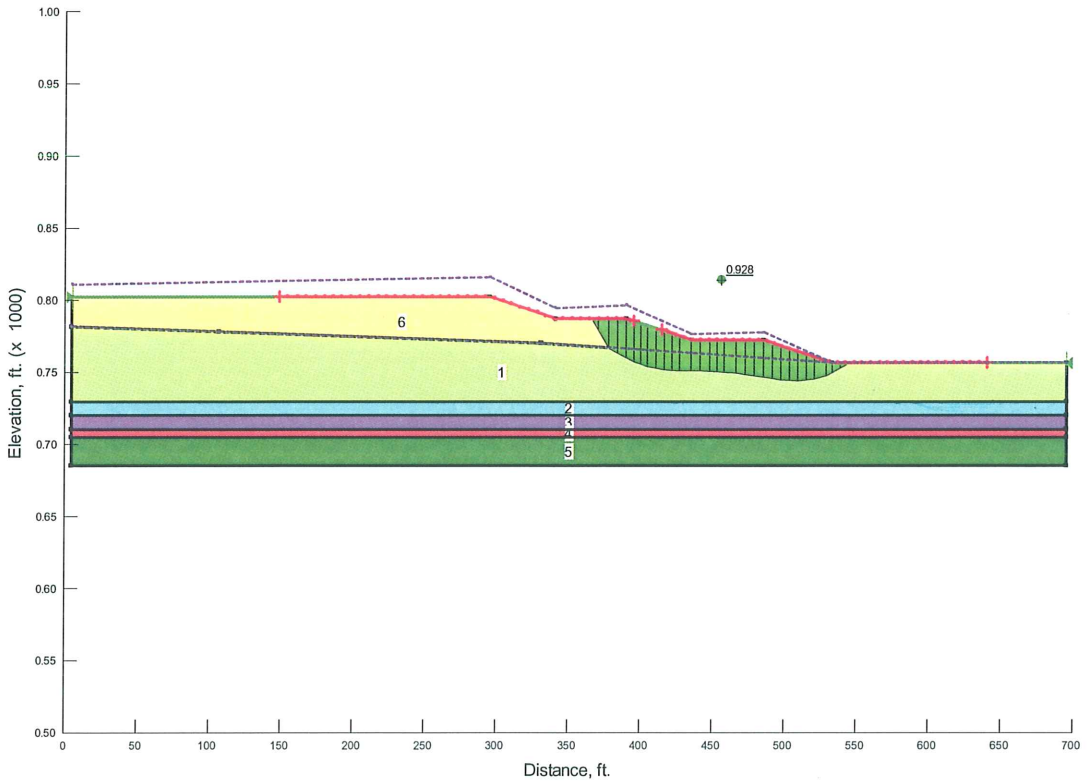

Figure 109 (B) – 90% Excess P.W.P in Both Clay and Existing Ash

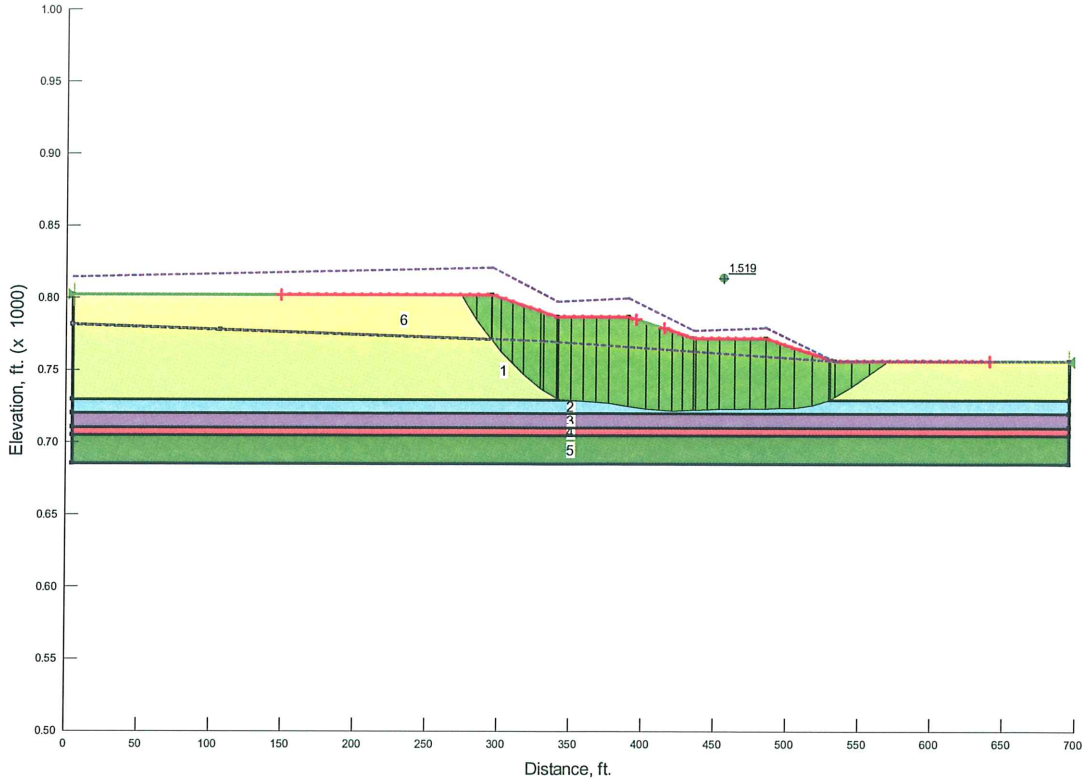

Figure 110 (A) – 100% Excess P.W.P in Clay Only

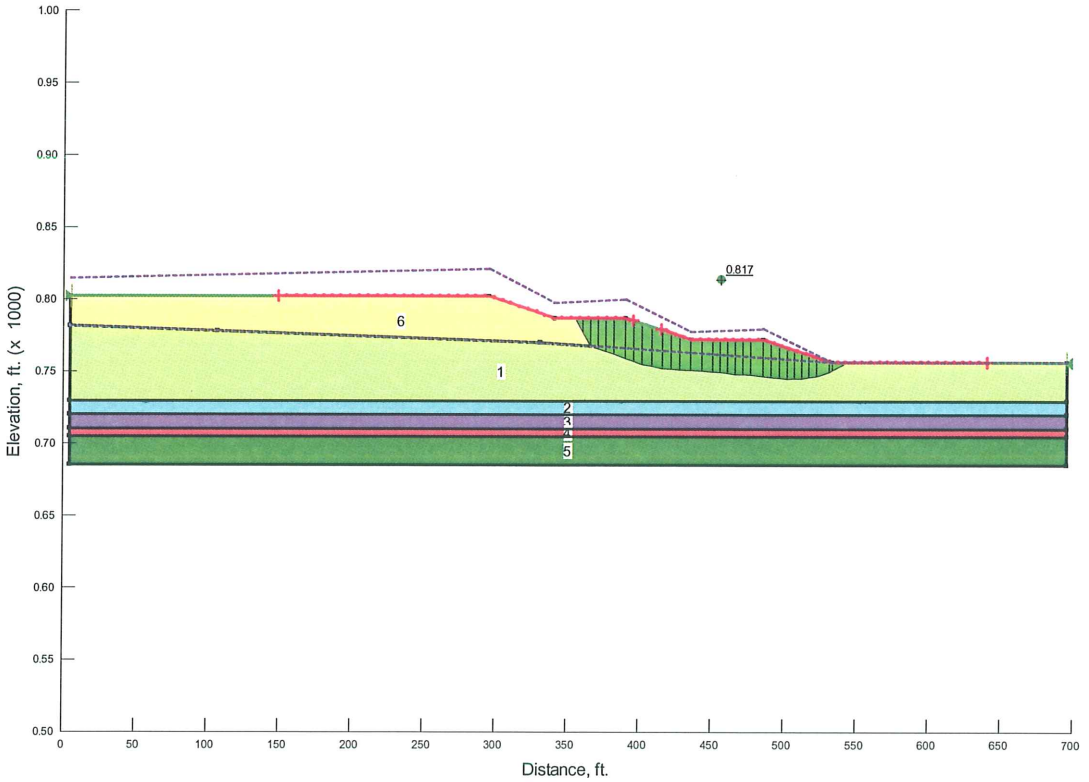

Figure 110 (B) – 100% Excess P.W.P in Both Clay and Existing Ash

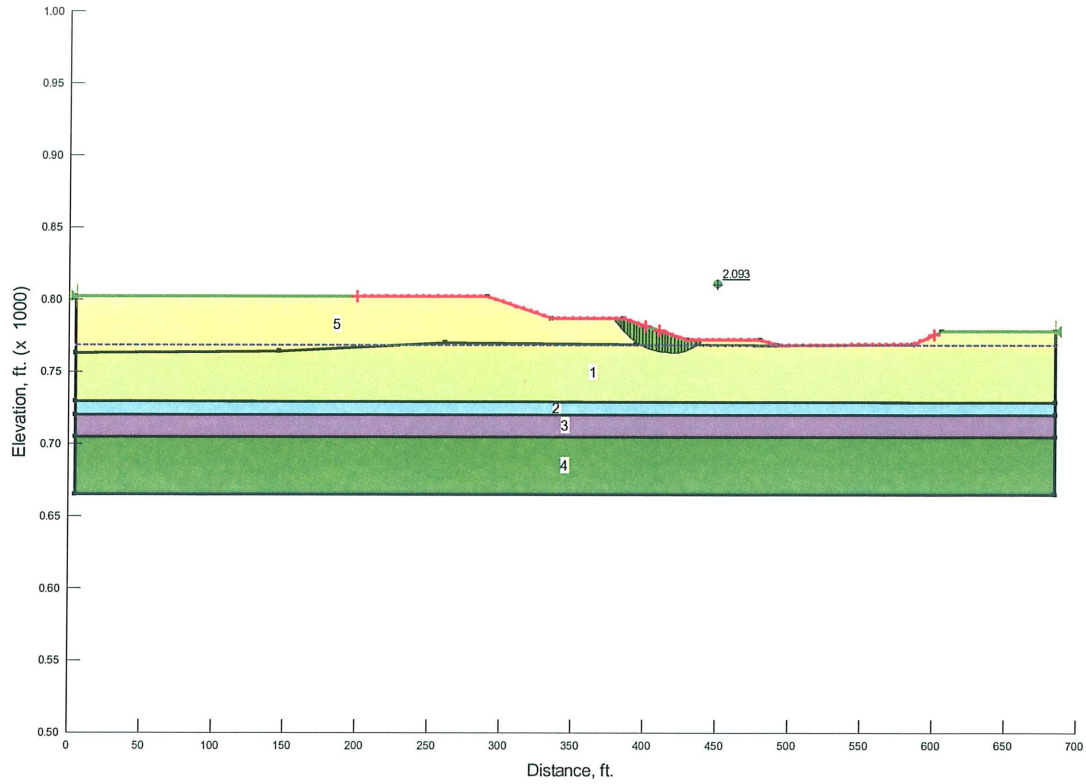

Figure 2A (A) – Peak Undrained Strength in Clay (c=1,380 psf)

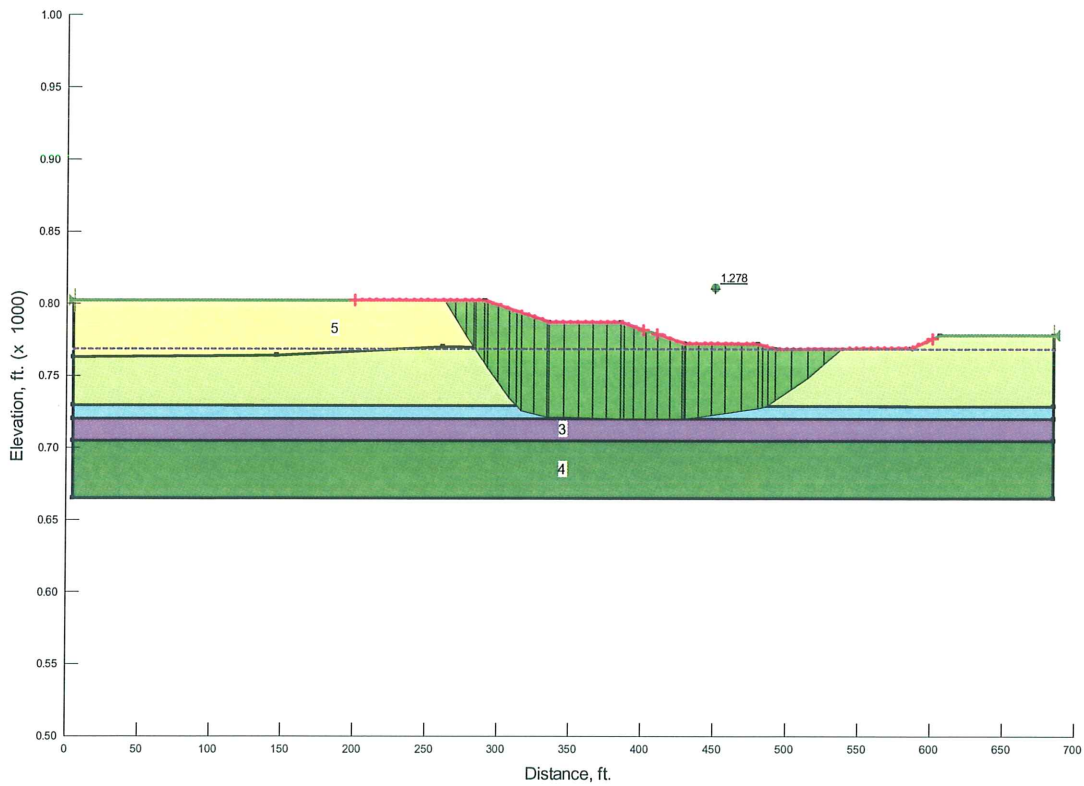

Figure 2A (B) – Residual Undrained Strength for Clay (c=280 psf)

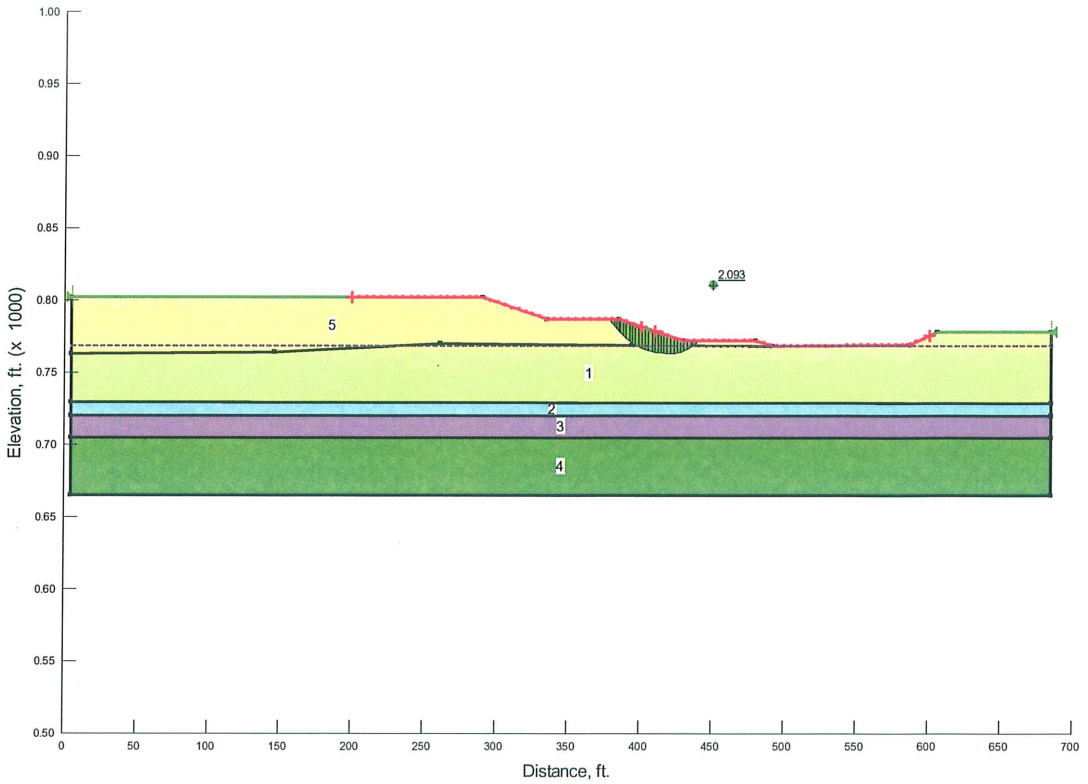

Figure 200 – No Excess P.W.P

Section 2A Plots

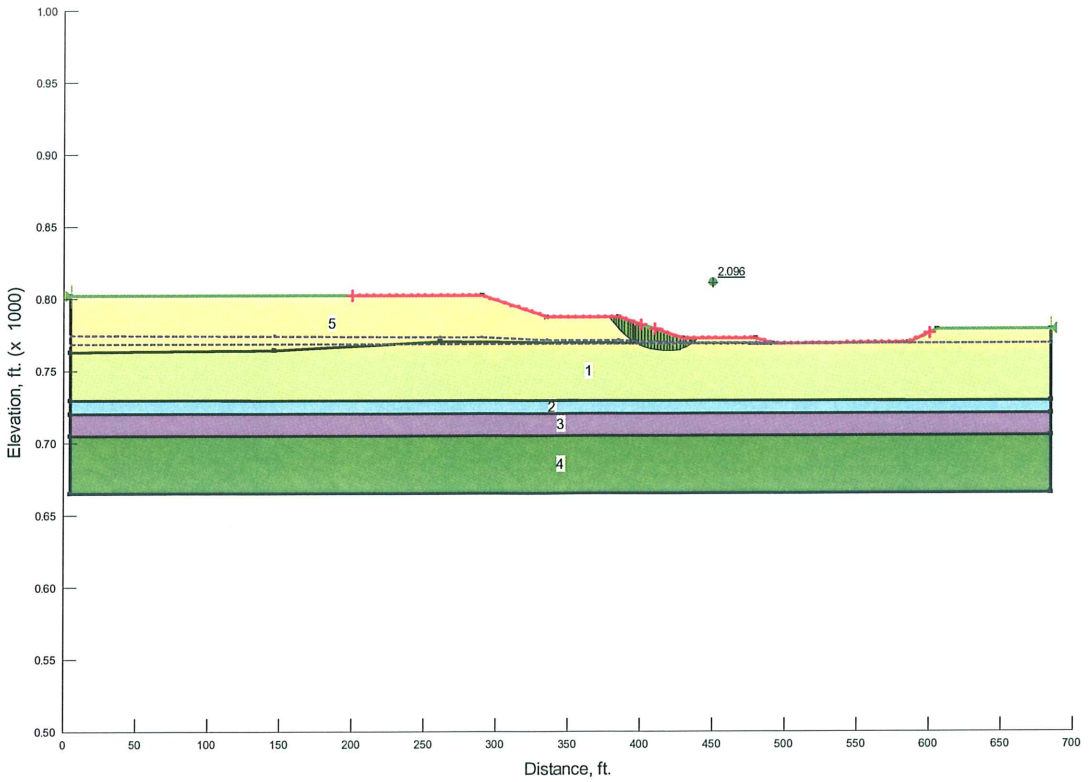

Figure 201 (A) – 10% Excess P.W.P in Clay Only

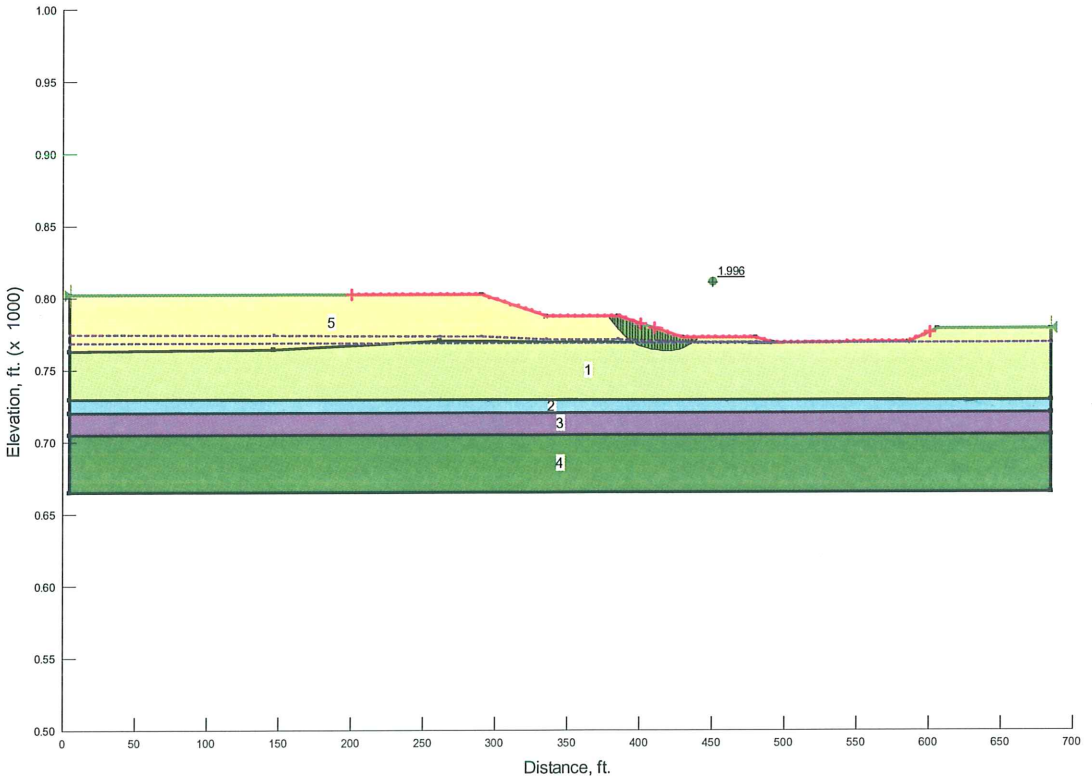

Figure 201 (B) – 10% Excess P.W.P in Both Clay and Existing Ash

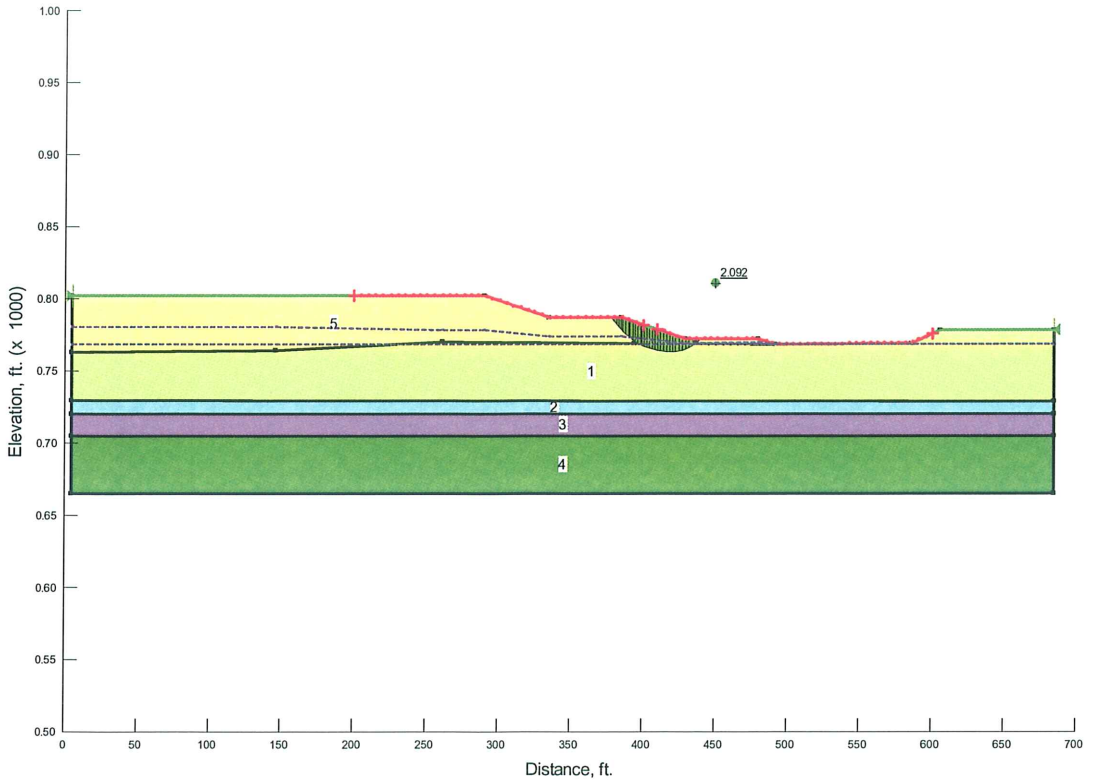

Figure 202 (A) – 20% Excess P.W.P in Clay Only

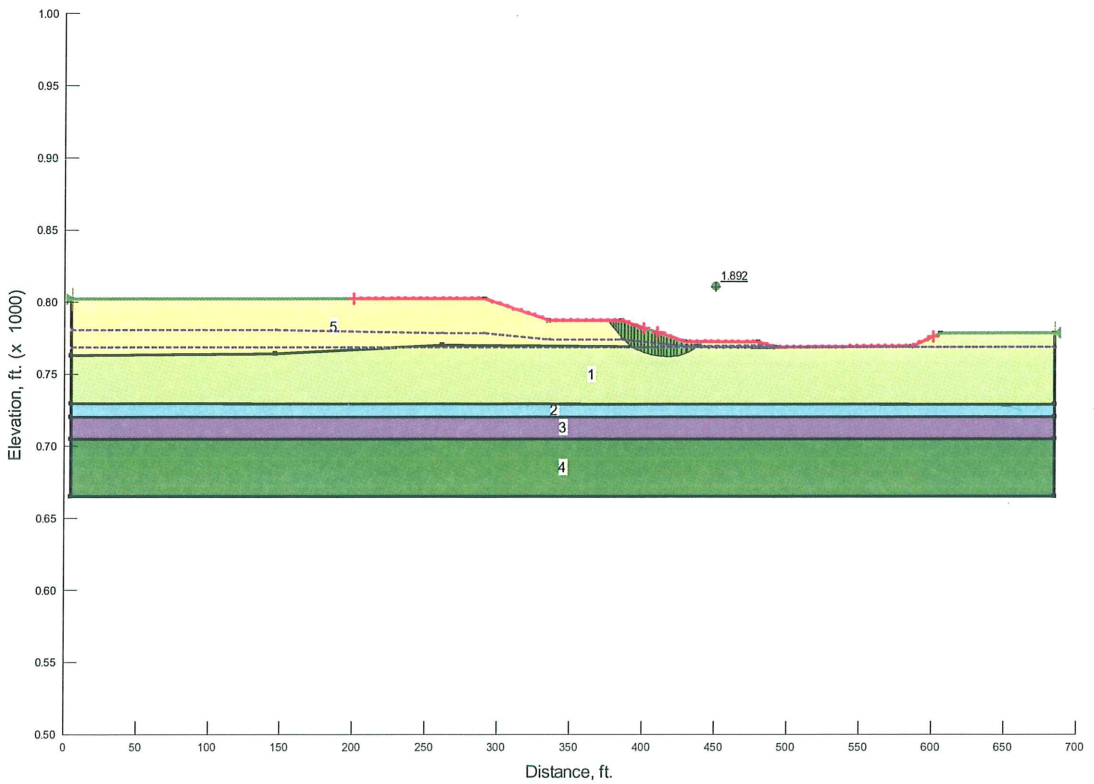

Figure 202 (B) – 20% Excess P.W.P in Both Clay and Existing Ash

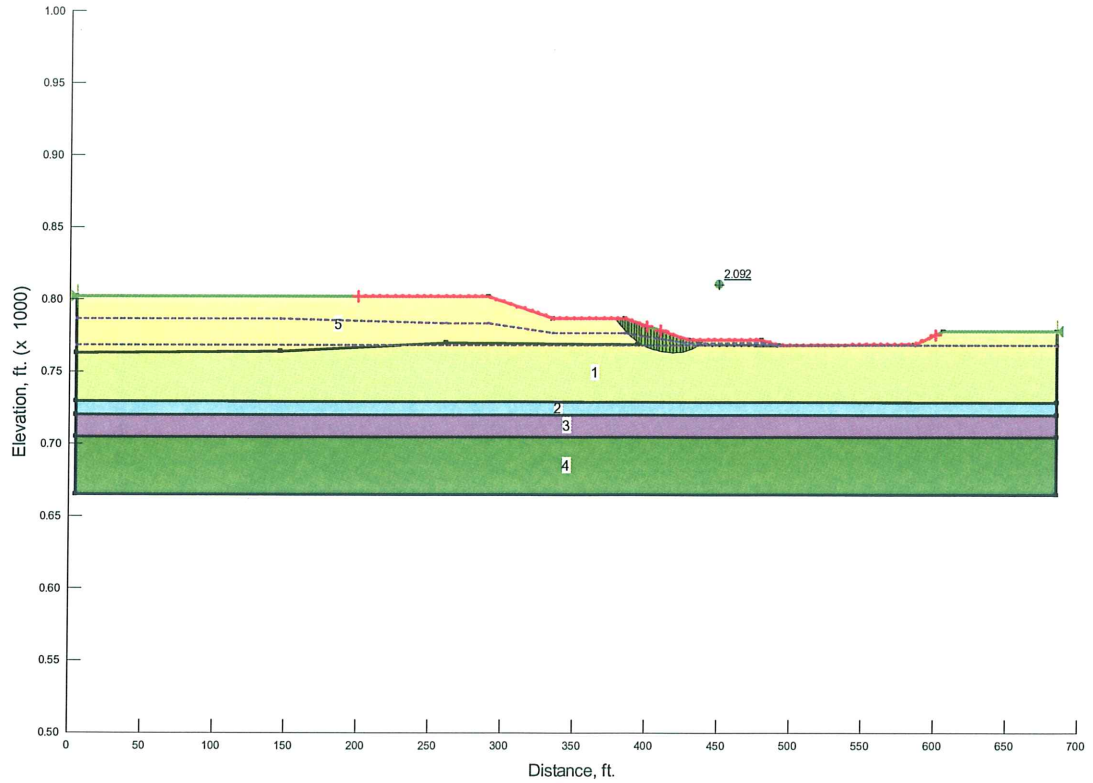

Figure 203 (A) – 30% Excess P.W.P in Clay Only

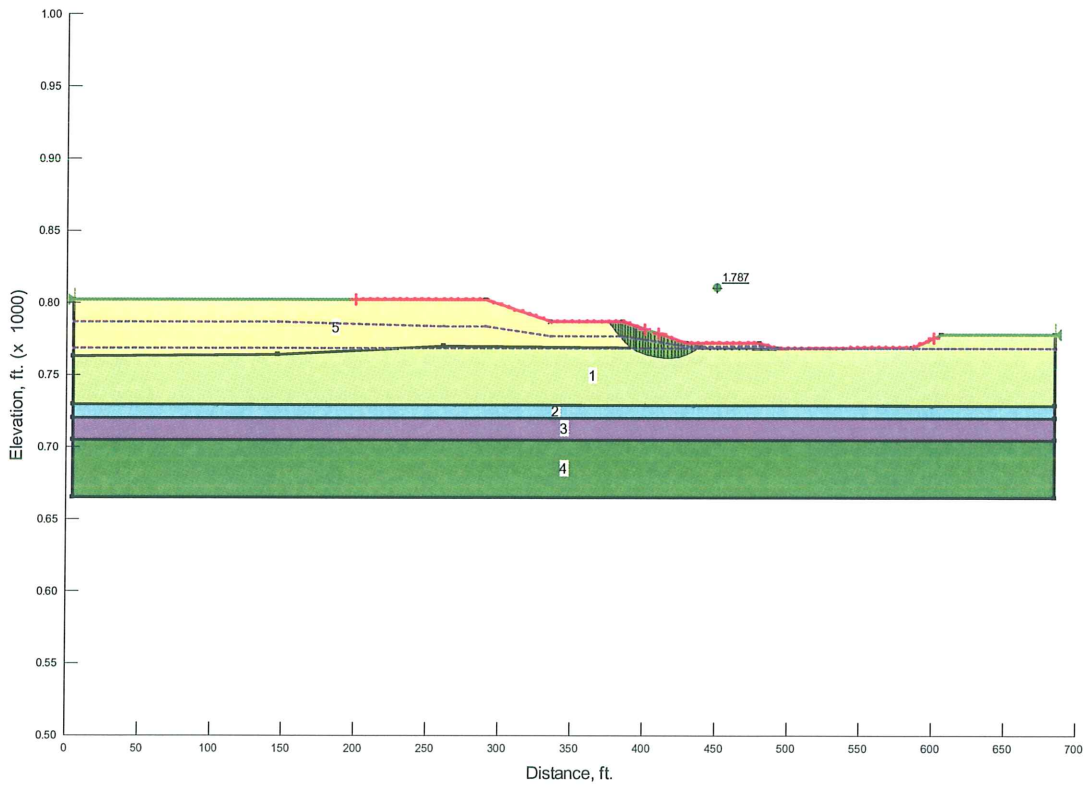

Figure 203 (B) – 30% Excess P.W.P in Both Clay and Existing Ash

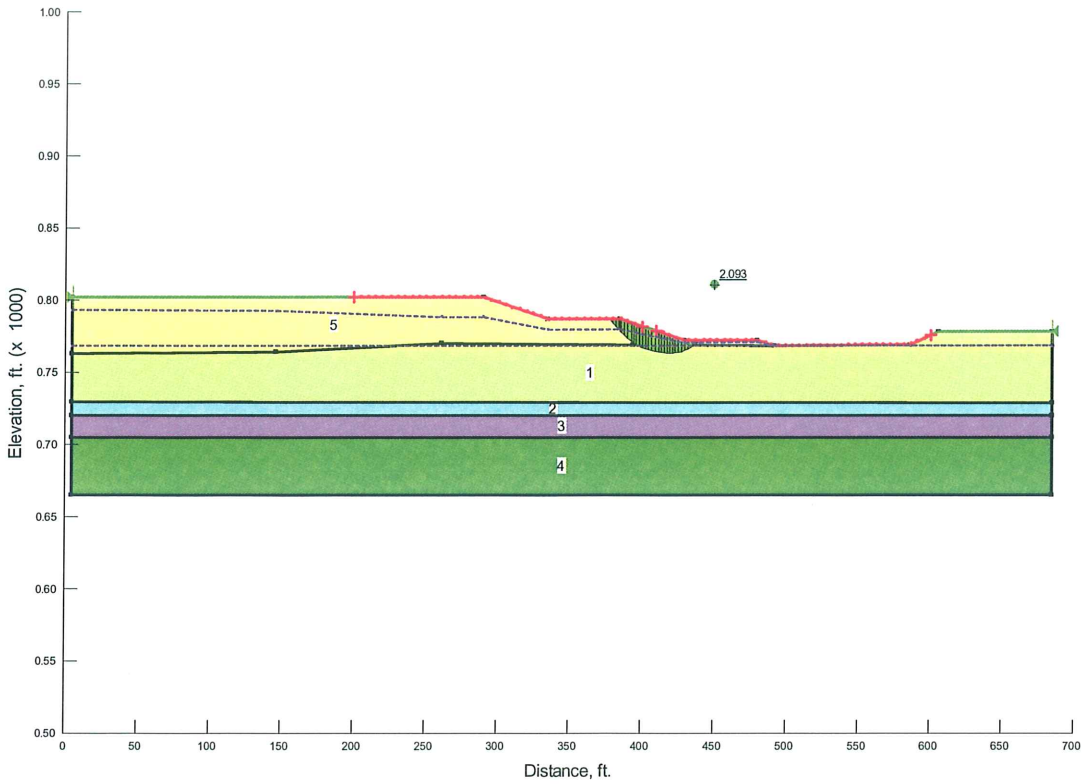

Figure 204 (A) – 40% Excess P.W.P in Clay Only

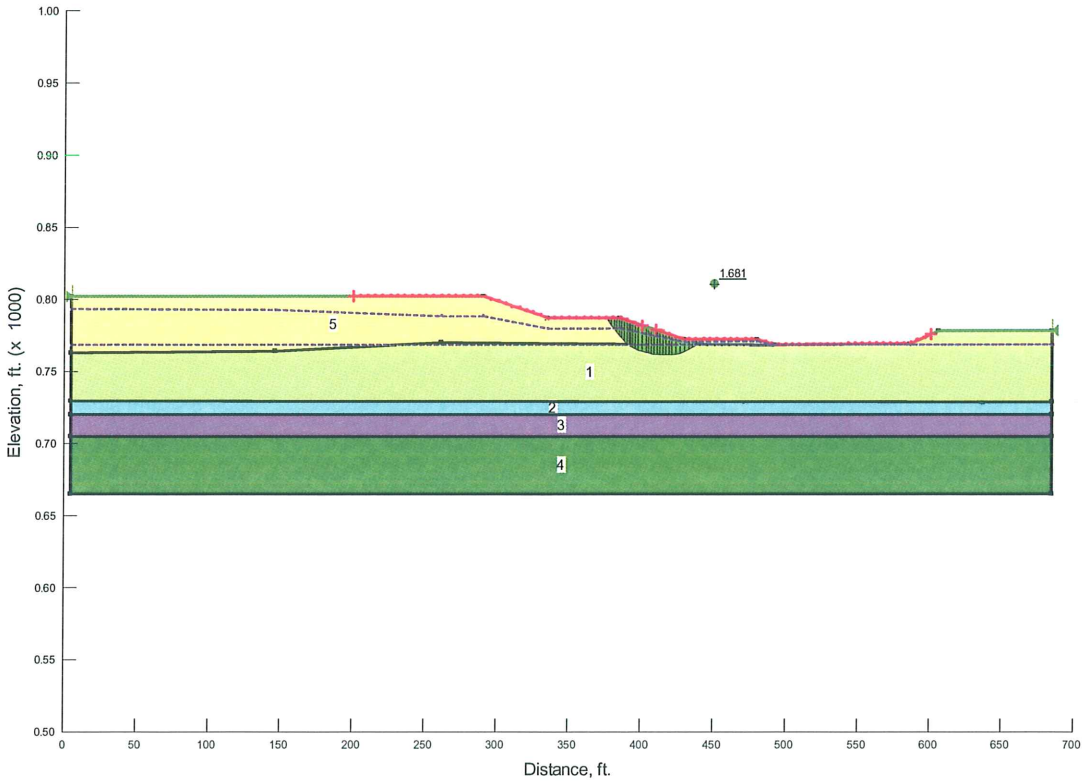

Figure 204 (B) – 40% Excess P.W.P in Both Clay and Existing Ash

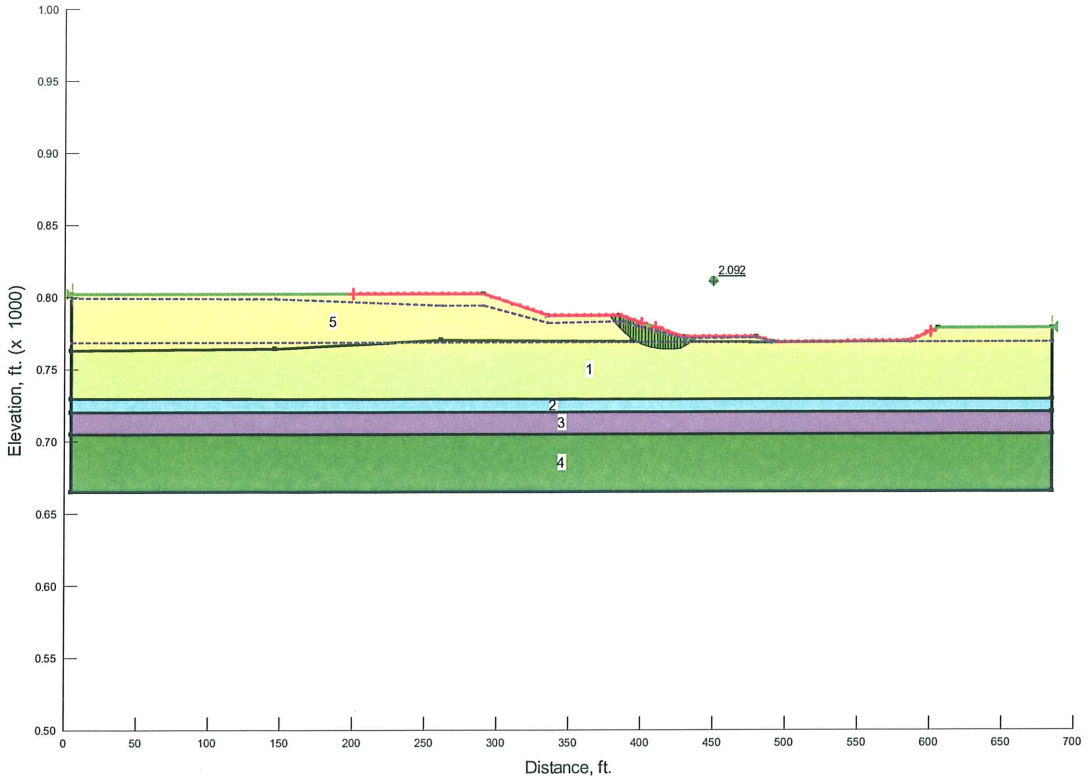

Figure 205 (A) – 50% Excess P.W.P in Clay Only

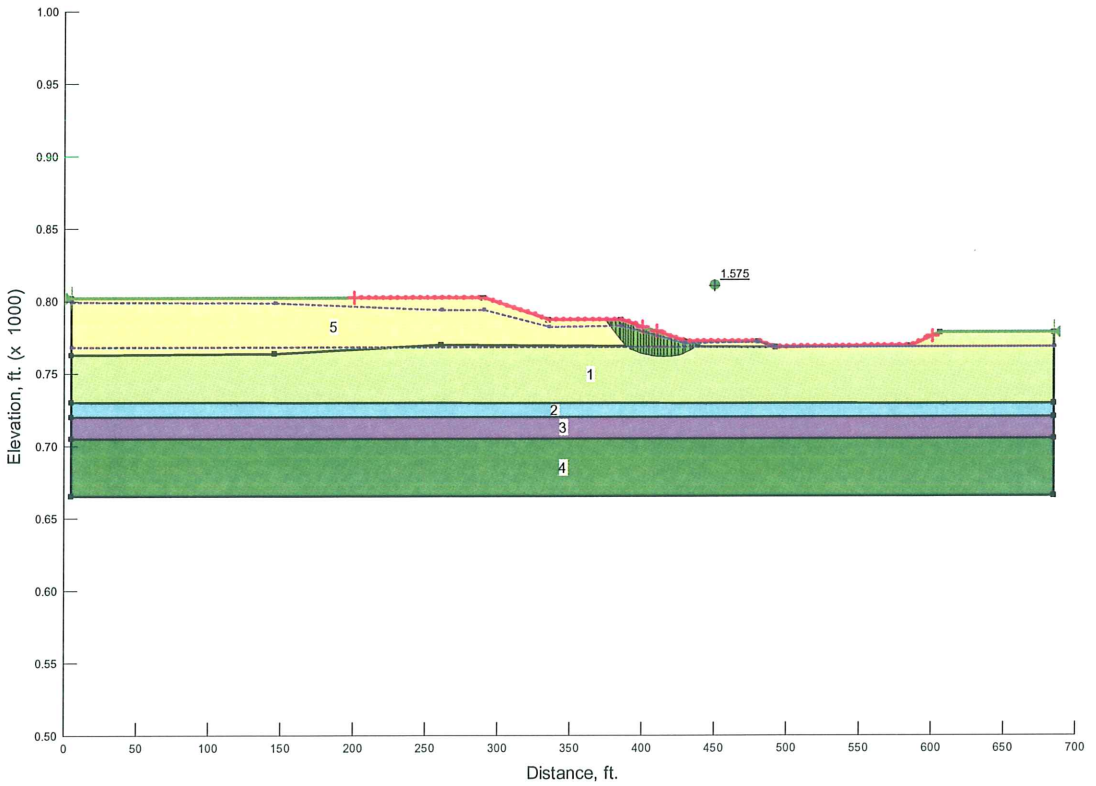

Figure 205 (B) – 50% Excess P.W.P in Both Clay and Existing Ash

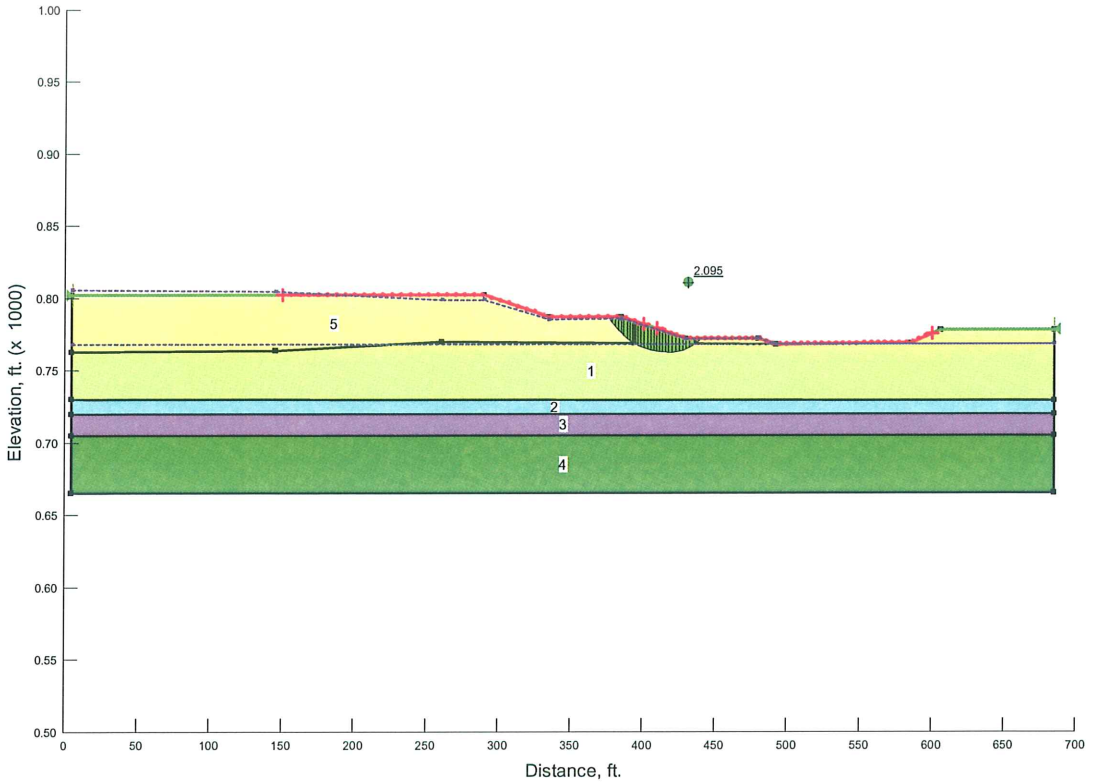

Figure 206 (A) – 60% Excess P.W.P in Clay Only

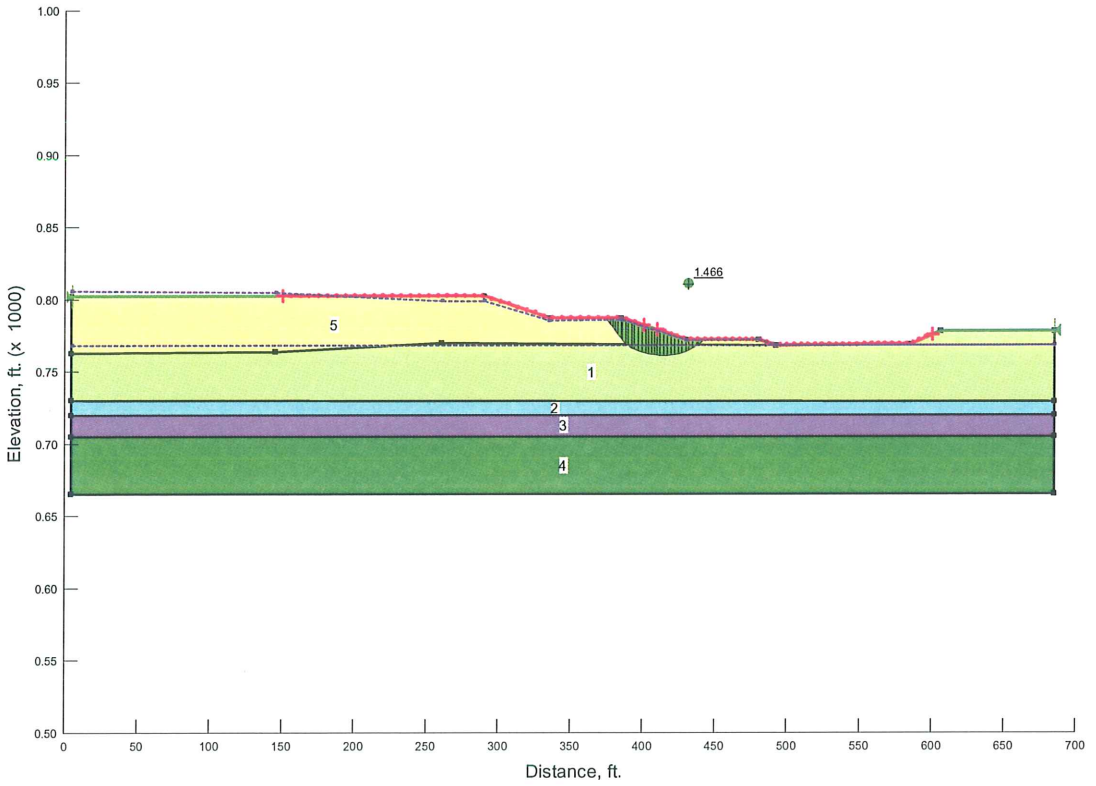

Figure 206 (B) – 60% Excess P.W.P in Both Clay and Existing Ash

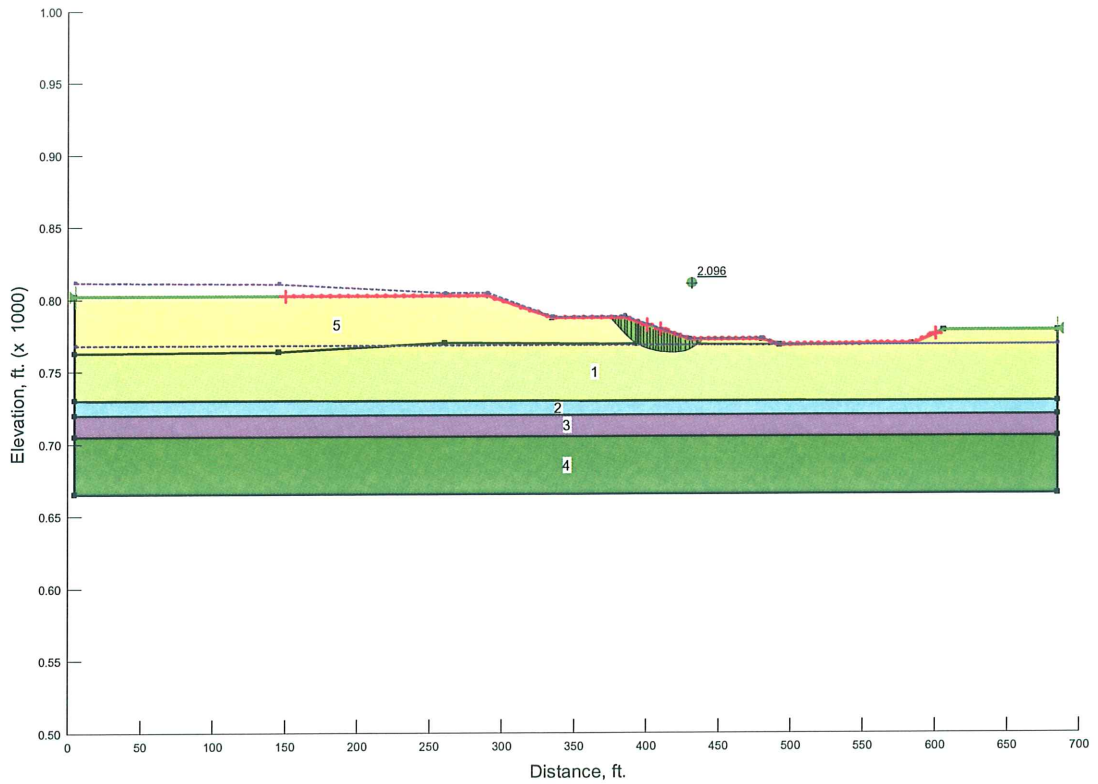

Figure 207 (A) – 70% Excess P.W.P in Clay Only

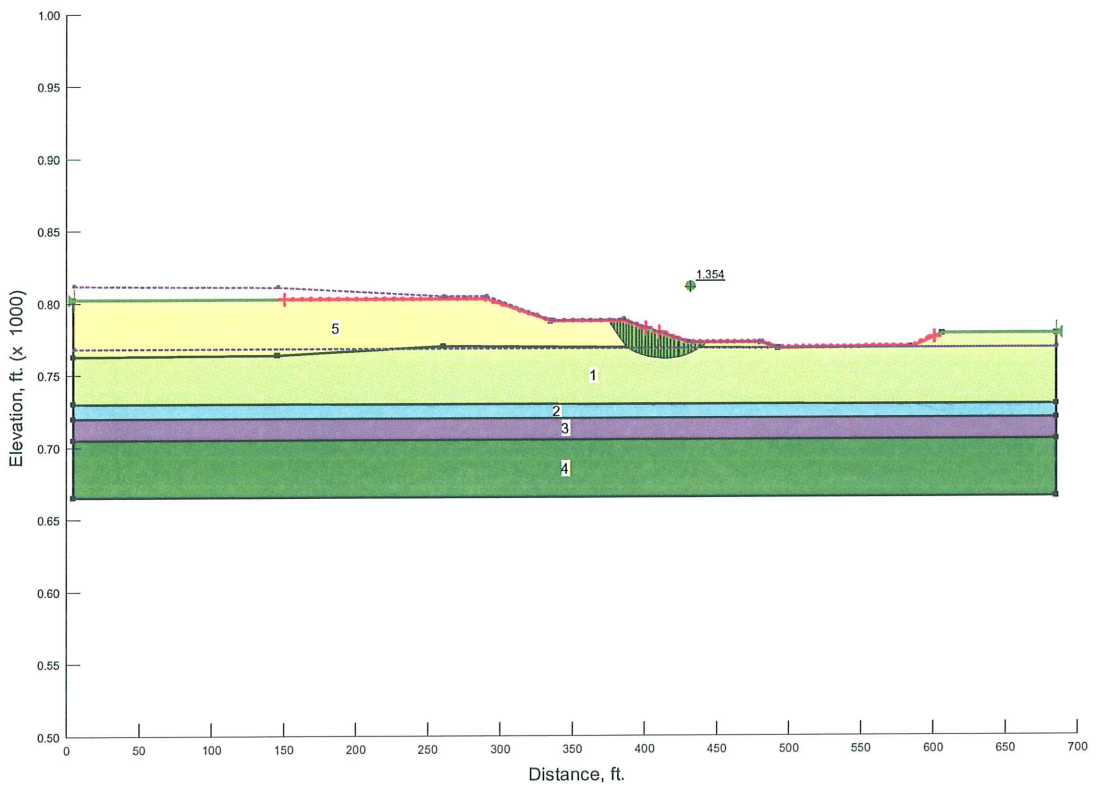

Figure 207 (B) – 70% Excess P.W.P in Both Clay and Existing Ash

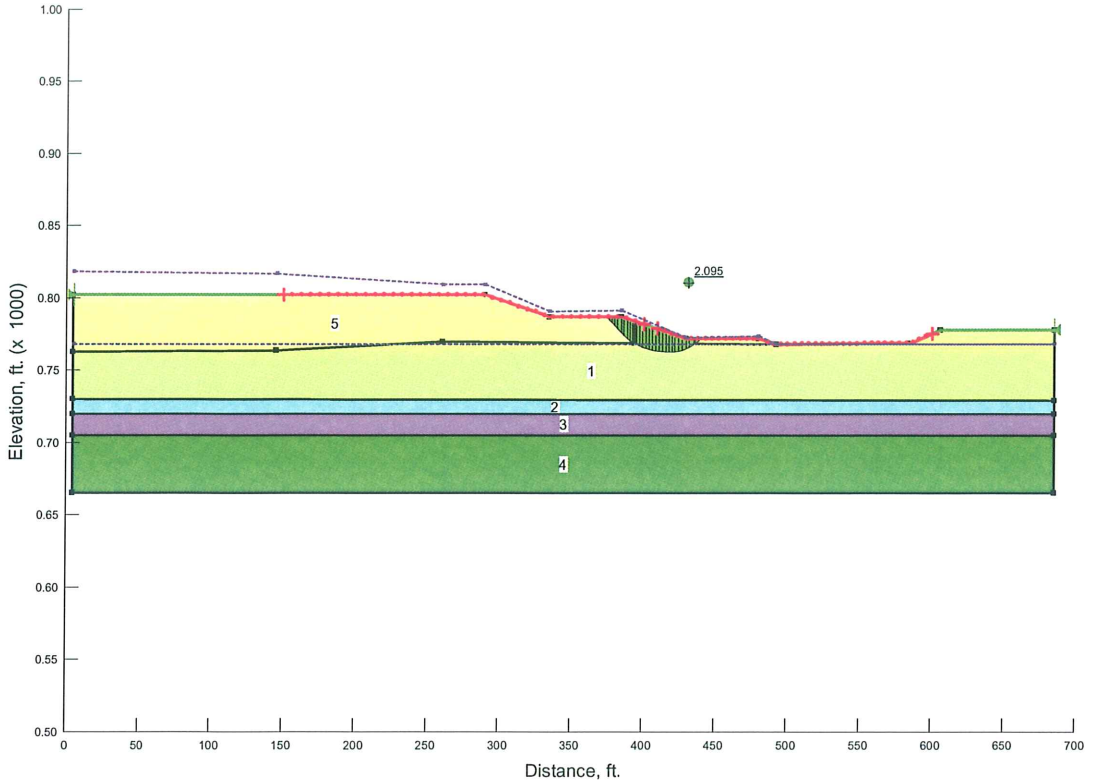

Figure 208 (A) – 80% Excess P.W.P in Clay Only

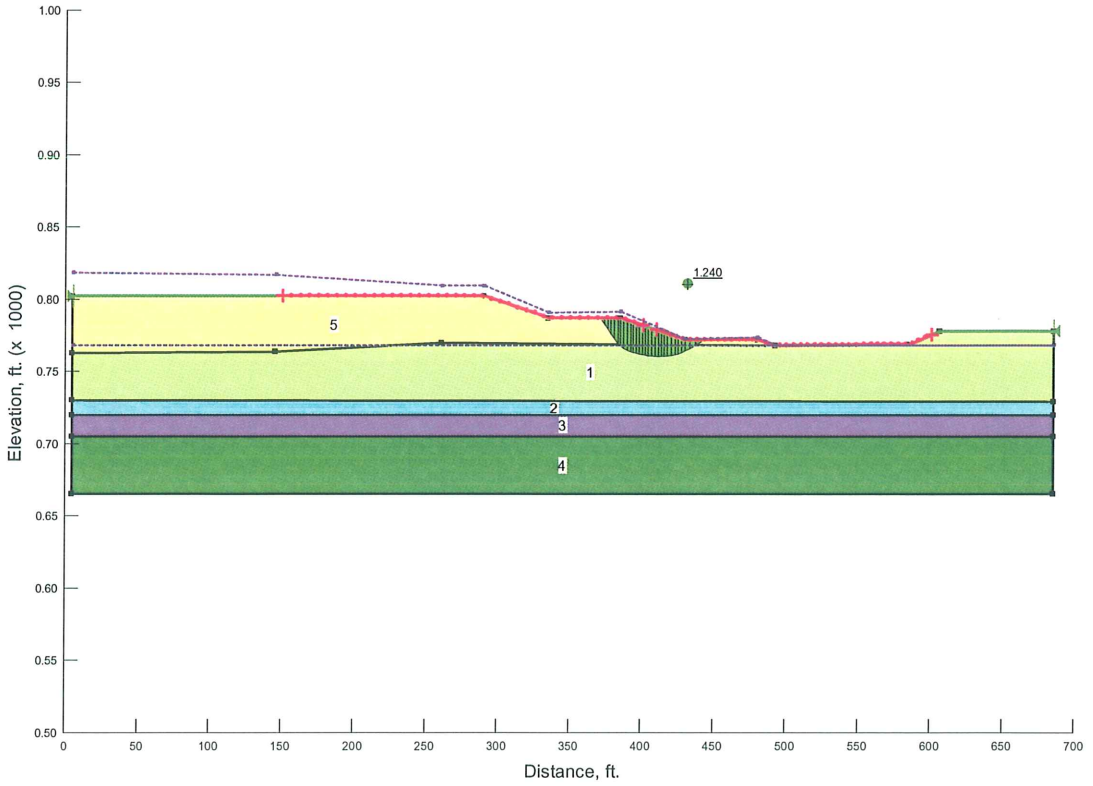

Figure 208 (B) – 80% Excess P.W.P in Both Clay and Existing Ash

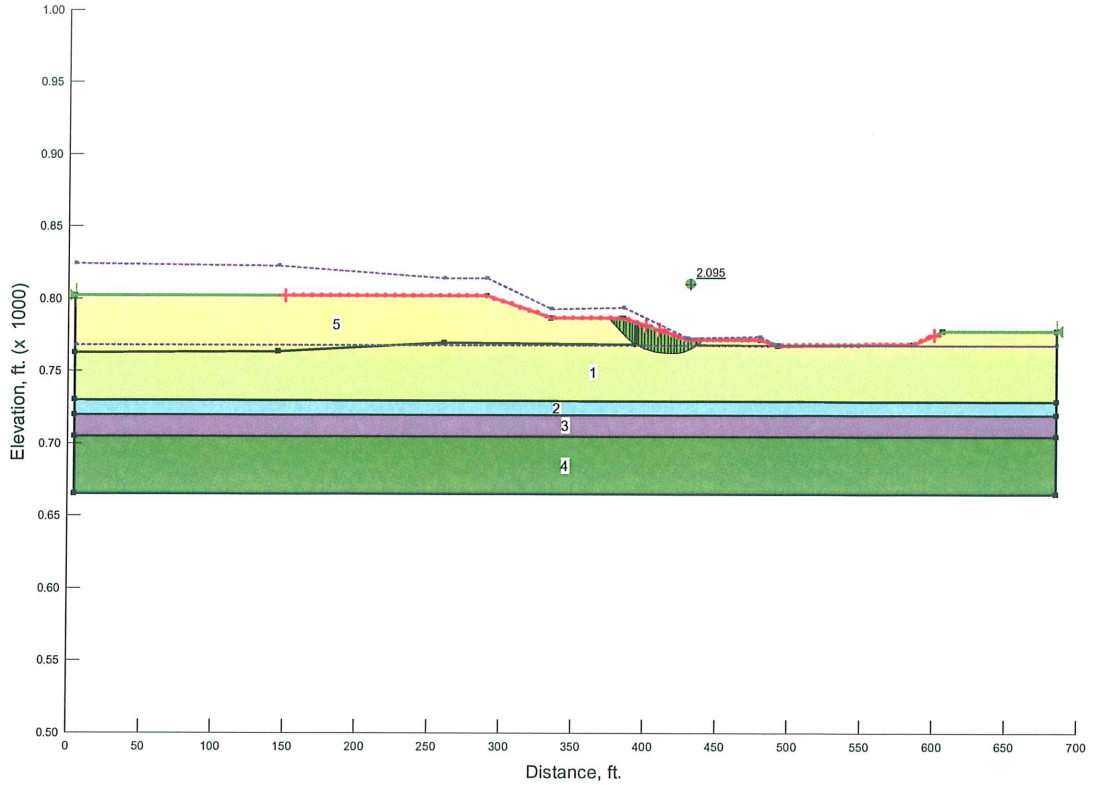

Figure 209 (A) – 90% Excess P.W.P in Clay Only

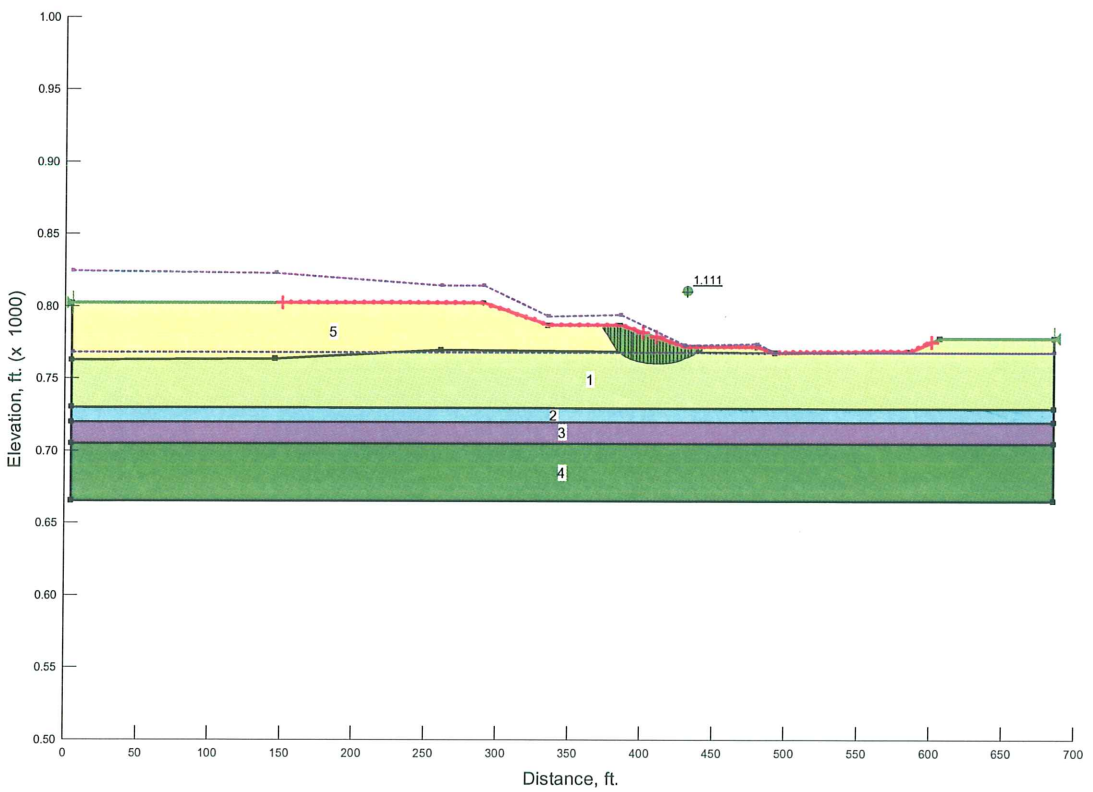

Figure 209 (B) – 90% Excess P.W.P in Both Clay and Existing Ash

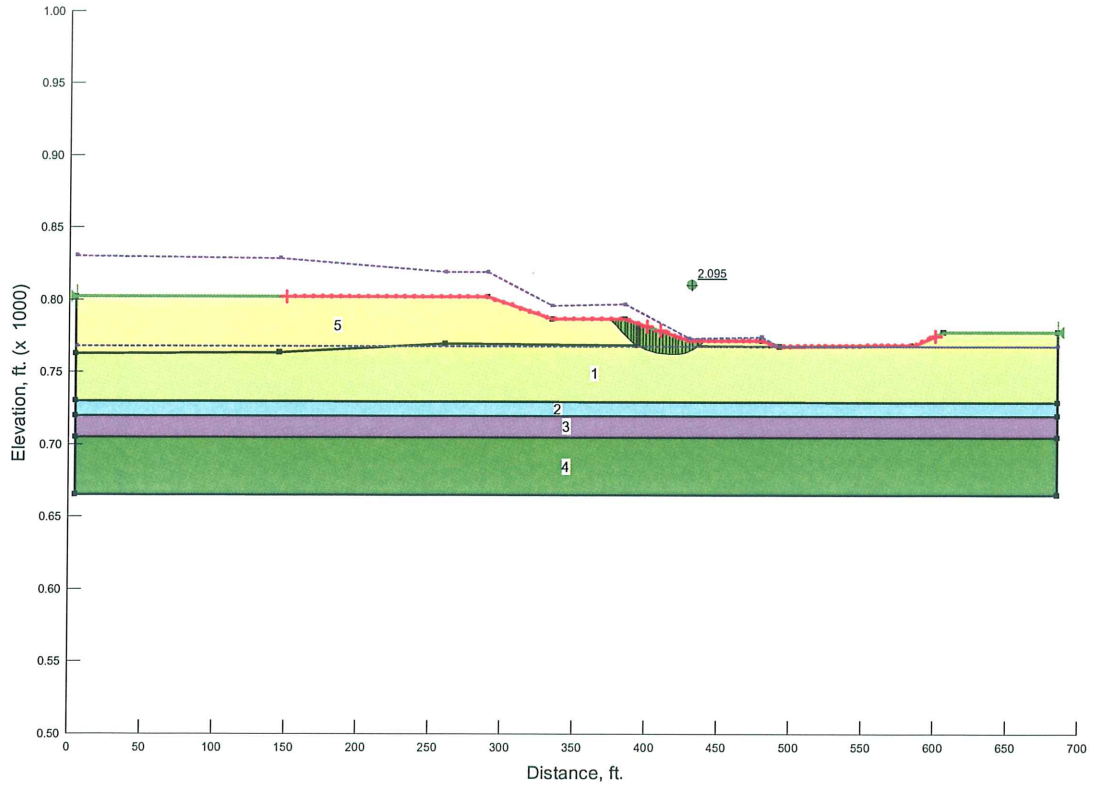

Figure 210 (A) – 100% Excess P.W.P in Clay Only

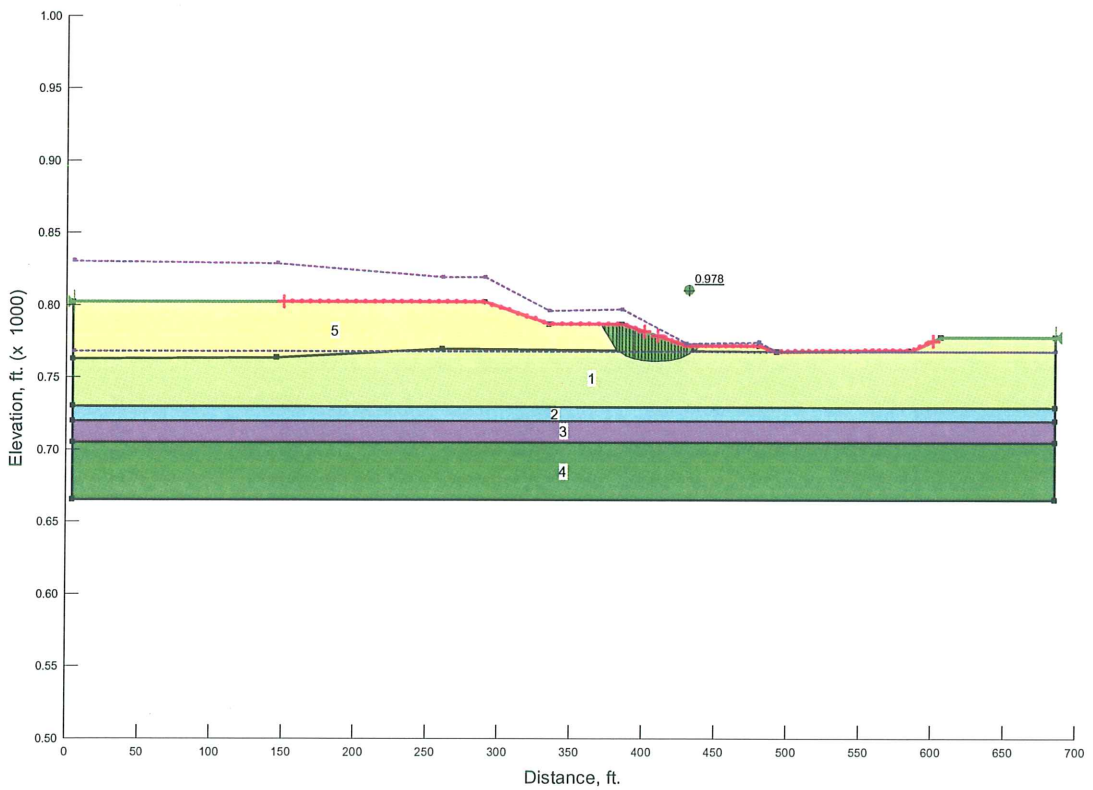

Figure 210 (B) – 100% Excess P.W.P in Both Clay and Existing Ash

Attachment 4

AECOM Peer Review Comments

AECOM

AECOM
750 Corporate Woods Parkway, Vernon Hills, IL 60061
T 847.279.2500 F 847.279.2510 www.aecom.com

March 25, 2009

sent via e-mail : rerodgers@tva.gov

Mr. Ralph E. Rodgers
Tennessee Valley Authority
400 West Summit Hill Drive
Knoxville, Tennessee 37902-1401

Re: Review of Stantec Updated Test Embankment Program at Area A at Kingston Fossil Plant, Harriman, Roane County, Tennessee – AECOM Project No. 60095742

Dear Mr. Rodgers,

As requested by TVA's Barry Snider, we have reviewed the following work in progress documents provided by Stantec in emails to AECOM dated March 23, 2009.

1. Test Embankment Program, Kingston Fossil Plant, Harriman, Roane County TN." 4 pages, updated March 23, 2009.
2. Construction Quality Control Plan (CQCP), Test Embankment Program, Kingston Fossil Plant, Harriman, Roane County TN." 10 pages, updated March 23, 2009.
3. Sheet 1 of 6, Plan Limits, Kingston Test Embankment Program, updated March 2009.
4. Sheet 2 of 6, Instrumentation Plan, Kingston Test Embankment Program, March 2009.
5. Sheet 3 of 6, Cross Section, Kingston Test Embankment Program, updated March 2009.
6. Sheet 4 of 6, Typical Details, Kingston Test Embankment Program, updated March 2009.
7. Sheet 5 of 6, Typical Details (Settlement Plate), Kingston Test Embankment Program, updated March 2009.
8. Sheet 6 of 6, Typical Details (Inclinometer and Piezometer), Kingston Test Embankment Program, updated March 2009.

There was no cross-section for Test Embankment Area B. It would be very useful for TDEC to see the proposed cross-section for this test area.

Per TDEC directive, the remedial design documents for containment and closure of the Kingston Ash Pond and Dredge Cells will be reviewed by AECOM and TVA to promote short and long term structural stability and integrity of ash ponds. AECOM has been requested to review remedial designs as we are the Root Cause Analyst (RCA) of failure at this site. Both TVA and AECOM have been appointed to the TDEC structural integrity group of reviewers.

Performance Monitoring at Test Embankment at Area A

We assume Test Embankment A will be completed prior to constructing Test Embankment B. With this in mind, we offer the following comments and recommendations to measure the foundation response of failed wet flyash and lake bed silty clay for relocated ash placed at Test Area A.

1. We acknowledge that Stantec prepare a supplemental Sheet 2 of 6 showing their proposed instrumentation plan. We superimposed their data on our instrumentation plan and concur with their plan. Attached is our superimposed plan of Stantec's and AECOM instrumentation plan.
2. We understand Stantec will install either pneumatic piezometers or vibrating wire low pressure transducers rather than high volume Casagrande-type piezometers shown of Sheet 5 of 6. We agree with multi-level deep piezometers shown on Sheet 3 of 6 to be installed to monitor pressures along two lines under the Area A fill in failed flyash and foundation clay. We recommend that Sheet 6 of 6 be revised to show low volume electronic or pnuematic piezometers.

3. These instruments will be used to demonstrate rate of filling and the effectiveness and time for drainage. We also recommend at one or two locations under the deepest portion of the fill that vibrating wire piezometers be installed and connected to a data logger (i.e., RST Model No. DT2011) to better evaluate the rate of dissipation of excess porewater pressure after fill placement within the loose flyash and underlying clays. We suggest the details include tip elevations for the vibrating wire or pneumatic piezometers in the clay and in the ash just above the clay.
4. We recommend survey points be installed on the fill slope or bench surfaces to monitor top of relocated fill settlements.
5. We acknowledge the Stantec use of excess pore water pressure ratio as triggering thresholds for fill performance:
   - Less than 30% of below regular monitoring
   - Between 30% and 50% , fill with more instrumentation monitoring
   - Greater than 50% stop filling

   However, there were no stability computations attached to justify these threshold levels. We suggest these analyses be included subject to modification during filling.
6. We suggest several triggering limits be defined to slow or halt filling if:
   - Piezometer measure pore water pressures exceed certain predefined limits related to during construction slope stability effective stress analysis (ESA) factor of safety of 1.3 (trigger) and 1.1 (stop work or unload).
   - Inclinometer and settlement plate derived DR ratio of lateral inclinometer movement to vertical settlement plate movement (dh/dv) exceeds 0.2 (trigger) or 0.3 (stop work or unload), per the recommendations of Dr. Charles Ladd's 1991 Terzaghi Lecture.
7. AECOM has installed piezometer nests and rock socketed inclinometers at boring locations 09-408, 09-503, 09-500, and 09-502 located along our RCA east-west test boring and instrumentation line immediately north of Stantec's fill Area A. Furthermore, we have piezometer nests and a deep inclinometer though the unfailed hydraulic filled flyash and clayey foundation soils at 09-303 in Cell 1 located immediately south of the Area A Test Embankment.
8. We understand Stantec will take over monitoring AECOM installed instrumentation (pneumatic piezometers and inclinometers) starting tentatively the first week of April 2009.
9. Change references to the Emergency Dredge Cell to the TDEC permitted Phase 1 Dredge Cell.

Relocated Ash Placement Procedures at Areas A and B

We suggest the Construction Quality Control Plan (CQCP) address the following issues:

1. Identify alternatives to 50-ton heavy equipment proof-rolling of wet failed flyash.
2. Avoid using woven geotextile over failed ash. We suggest non-woven geotextile, geogrid, bottom ash, concrete sand or crushed stone over non-woven geocomposite drainage strips to promote blanket drainage under the test embankments and fill stability for relocated ash over failed wet flyash under fill Area A.
3. Provide fill lift thickness recommendations in the CQCP. We suggest lift thickness not exceed 24 inches.
4. Address the fact that the CQCP technical specifications are silent regarding the degree of compaction needed for the dewatered flyash that will be placed over the Ball Field area. We concur with Stantec's verbal recommendation of 90% of the maximum dry density per ASTM D698, Standard Proctor Test, be used to reduce the potential for liquid fill or slurry to be placed over the new fill area. There should be moisture limits defined in the CQCP after bench scale testing.
5. Recognize that in Section 6.3 of the QCCP we recommend that a large static smooth drum roller or loaded off-road haul truck be used to compact the reworked flyash above the working platform. Compaction of new ash fill may not be possible for the first couple of lifts as the compaction effort may fail the loose ash.
6. If nuclear density testing is used to measure the in-place density of compacted flyash, we recommend that a sand cone or water replacement density tests be performed every 10 tests to confirm the nuclear density meter results.
7. Provide a cross-section of Test Embankment B showing the intended height of fill and bench layout.

Recommended Stability Analyses for Test Embankments A and B

Prior to filling Areas A and b, Stantec should run shallow and deep global circular and wedge block, limit equilibrium stability analyses to show adequate factors of safety (FS) for staged fills up to 45 feet high. We would like to see hold periods between the 15, 30 and 45-foot high fill stages to ensure stability and falling pore-water pressures, settlement of the ash and inward movement of the inclinometers. This is important since it will allow time for thorough review of the instrumentation data before proceeding further.

Please note that the existing failed and unfailed ash do not show decreasing void ratio with depth. There is evidence that the ash may not consolidate as much as expected. This could impact the undrained shear strength of the ash if it does not consolidate under surcharge loading. We have attached sheets showing void ratio versus elevation in failed and unfailed ash.

We also suggest that bench scale laboratory studies identify the moisture-density relationship for the relocate flyash material to provide actual friction angles for relocated flyash. We recommend Stantec run effective stress and total stress analysis analyses (ESA and TSA) rapid undrained loading analyses to demonstrate computed FS will be greater than 1.3. However, the project will be using performance monitoring instrumentation to demonstrate relatively drained fill and soil behavior.

Summary

We are in favor of this engineered test embankment at Areas A and B with performance monitoring based on stability analyses. We will learn much about the foundation clay and failed flyash under relatively rapid loading for relocated flyash fills up to 45 feet high above failed Cell 1 and 3 located at the north end of failed stack section using benched fill slopes no steeper than 3H:1V. AECOM supports the premise that this engineered test fill solution based on analysis, design assumptions and testing be verified by daily monitoring and surveys. It would also be interesting to see if rapid filling can re-initiate minor movement along the December 22, 2008 failure plane. The failed section has little to no inertia in the failure mass to see movement at this time.

The TVA should avoid excavating deep continuous west to east drainage trenches along the series 09-200 holes and do not dig drainage trenches parallel to the toe of the Test Embankment A and B fills. The fact the failed ash has an angle of repose of less than 1% if evidence that the failed ash is loose (high void) and we want to avoid increasing shear stresses under the test embankments by creating higher driving forces due increase differential height of failed ash.

It would be very useful to run test borings or CPTu after the test fill to see if there has been an increase in fill strength or consolidation of the failed loose and submerged flyash. We suggest their plan include some post-fill testing and CPTu probes to see if there have been ground improvements due to surcharge loading.

We suggest TVA and AECOM be copied on this performance data on a timely basis to assist in site remediation design and review.

Please call us if you have any questions.

Very truly yours,

William H. Walton, P.E., S.E.
Vice President, Senior Principal Engineer

William Butler, P.E.
Senior Geotechnical Engineer

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Attachments – Instrumentation Plan
Void Ratio Plots

cc: Barry Snider – bssnider@tva.gov
Gonzalo Castro – gv.castro@verizon.net

Test Embankment Program
Kingston Fossil Plant
Harriman, Roane County, Tennessee

Responses to Review Comments
March 31, 2009

Comments from William H. Walton and William Butler with AECOM dated March 25, 2009.

Performance Monitoring at Test Embankment at Area A

Comment No. 1: We acknowledge that Stantec prepare a supplemental Sheet 2 of 6 showing their proposed instrumentation plan. We superimposed their data on our instrumentation plan and concur with their plan. Attached is our superimposed plan of Stantec's and AECOM instrumentation plan.

Response No. 1: N/A

Comment No. 2: We understand Stantec will install either pneumatic piezometers or vibrating wire low pressure transducers rather than high volume Casagrande-type piezometers shown of Sheet 5 of 6. We agree with multi-level deep piezometers shown on Sheet 3 of 6 to be installed to monitor pressures along two lines under the Area A fill in failed flyash and foundation clay. We recommend that Sheet 6 of 6 be revised to show low volume electronic or pneumatic piezometers.

Response No. 2: Concur. The piezometer detail has been revised to illustrate a vibrating wire piezometer.

Comment No. 3: These instruments will be used to demonstrate rate of filling and the effectiveness and time for drainage. We also recommend at one or two locations under the deepest portion of the fill that vibrating wire piezometers be installed and connected to a data logger (i.e., RST Model No. DT2011) to better evaluate the rate of dissipation of excess porewater pressure after fill placement within the loose flyash and underlying clays. We suggest the details include tip elevations for the vibrating wire or pneumatic piezometers in the clay and in the ash just above the clay.

Response No. 3: Concur. Data acquisition has been incorporated into the program. Piezometer tip elevations will be determined in the field based on encountered subsurface conditions at each instrument location. It is noted that the referenced monitoring zones will be targeted.

Comment No. 4: We recommend survey points be installed on the fill slope or bench surfaces to monitor top of relocated fill settlements.

Response No. 4: Concur. Cross Sections A-A' and B-B' were revised to illustrate survey monuments on each bench.

Comment No. 5: We acknowledge the Stantec use of excess pore water pressure ratio as triggering thresholds for fill performance:

- *Less than 30% of below regular monitoring*
- *Between 30% and 50% , fill with more instrumentation monitoring*
- *Greater than 50% stop filling*

However, there were no stability computations attached to justify these threshold levels. We suggest these analyses be included subject to modification during filling.

Response No. 5: Concur. Stability calculations and associated narrative have been forwarded under separate cover.

Comment No. 6: We suggest several triggering limits be defined to slow or halt filling if:

- *Piezometer measure pore water pressures exceed certain predefined limits related to during construction slope stability effective stress analysis (ESA) factor of safety of 1.3 (trigger) and 1.1 (stop work or unload).*
- *Inclinometer and settlement plate derived DR ratio of lateral inclinometer movement to vertical settlement plate movement (dh/dv) exceeds 0.2 (trigger) or 0.3 (stop work or unload), per the recommendations of Dr. Charles Ladd's 1991 Terzaghi Lecture.*

Response No. 6: Excess pore water pressure ratios for target factors of safety of 1.5, 1.3 and 1.1 are included in the referenced calculations. Stantec has reviewed the document of Dr. Charles Ladd's 1991 Terzaghi Lecture and have noted trigger limits should be set on a case-by-case basis. Stantec concurs that trigger limits should be set. Accordingly, AECOM's recommended trigger limits of 0.2 (trigger) or 0.3 (stop work or unload) will be used for this program.

Comment No. 7: AECOM has installed piezometer nests and rock socketed inclinometers at boring locations 09-408, 09-503, 09-500, and 09-502 located along our RCA east-west test boring and instrumentation line immediately north of Stantec's fill Area A. Furthermore, we have piezometer nests and a deep inclinometer though the unfailed hydraulic filled flyash and clayey foundation soils at 09-303 in Cell 1 located immediately south of the Area A Test Embankment.

Response No. 7: NA

Comment No. 8: We understand Stantec will take over monitoring AECOM installed instrumentation (pneumatic piezometers and inclinometers) starting tentatively the first week of April 2009.

Response No. 8: Concur. Stantec will read AECOM's instrumentation as part of continued closure activities.

Comment No. 9: Change references to the Emergency Dredge Cell to the TDEC permitted Phase 1 Dredge Cell.

Response No. 9: Concur. All references to "Emergency Dredge Cell" have been modified to "Phase 1 Dredge Cell".

Relocated Ash Placement Procedures at Areas A and B

We suggest the Construction Quality Control Plan (CQCP) address the following issues:

Comment No. 1: Identify alternatives to 50-ton heavy equipment proof-rolling of wet failed flyash.

Response No. 1: Section 4 – Subgrade and Subbase, Subsection 4.4 – Quality Control Requirements states "The exposed surface was inspected to observe a proofroll using appropriate heavy equipment approved by the QC Manager".

Comment No. 2: Avoid using woven geotextile over failed ash. We suggest non-woven geotextile, geogrid, bottom ash, concrete sand or crushed stone over non-woven geocomposite drainage strips to promote blanket drainage under the test embankments and fill stability for relocated ash over failed wet flyash under fill Area A.

Response No. 2: Concur. Section 7 – Geotextile Filer Fabric (Optional) has been revised to specify non-woven fabric.

Comment No. 3: Provide fill lift thickness recommendations in the CQCP. We suggest lift thickness not exceed 24 inches.

Response No. 3: Concur. Section 4 – Subgrade and Subbase, Subsection 4.2 – Placement has been revised to state "The sequence of filling shall commence at the lowest section (in elevation) of the subject footprint and proceed upward in maximum eight-inch loose lifts in a manner to maintain positive drainage at all times." Section 5 – Working Platform (Optional), Subsection 5.2 – Placement has been revised to state "Each lift shall be constructed in maximum eight-inch loose lifts." Section 6 – Test Embankment, Subsection 6.2 – Placement has been revised to state "The sequence of filling shall commence at the lowest section (in elevation) of the subject footprint and proceed upward in maximum 24-inch loose lifts in a manner to maintain positive drainage at all times."

Comment No. 4: Address the fact that the CQCP technical specifications are silent regarding the degree of compaction needed for the dewatered flyash that will be placed over the Ball Field area. We concur with Stantec's verbal recommendation of 90% of the maximum dry density per ASTM D698, Standard Proctor Test, be used to reduce the potential for liquid fill or slurry to be placed over the new fill area. There should be moisture limits defined in the CQCP after bench scale testing.

Response No. 4: Concur. Section 6 – Test Embankment, Subsection 6.3 – Compaction has been revised to include "Materials shall be compacted to a minimum of 90 percent of standard Proctor maximum dry density at a moisture content within minus four percent and plus two percent of optimum or as established by the QC Manager based on field observations, testing and results of the test pads."

Comment No. 5: Recognize that in Section 6.3 of the QCCP we recommend that a large static smooth drum roller or loaded off-road haul truck be used to compact the reworked flyash above the working platform. Compaction of new ash fill may not be possible for the first couple of lifts as the compaction effort may fail the loose ash.

Response No. 5: Concur. Initial ash compaction efforts will likely be accomplished with loaded trucks. Smooth drum rollers will be used to seal working surfaces as required.

Comment No. 6: If nuclear density testing is used to measure the in-place density of compacted flyash, we recommend that a sand cone or water replacement density tests be performed every 10 tests to confirm the nuclear density meter results.

Response No. 6: Concur. Section 4 – Subgrade and Subbase, Subsection 4.3 – Compaction and Section 6 – Test Embankment, Subsection 6.4 – QC Requirements have been revised to include "Device calibration/confirmation testing shall consist of in-situ density tests (sand cone, water replacement, etc.) every 10 nuclear field density tests or as established by the QC Manager."

Comment No. 7: Provide a cross-section of Test Embankment B showing the intended height of fill and bench layout.

Response No. 7: Concur. A cross section for Test Embankment B has been included as Sheet 4 of 7.

AECOM

AECOM
750 Corporate Woods Parkway, Vernon Hills, IL 60061
T 847.279.2500 F 847.279.2510 www.aecom.com

April 2, 2009

Mr. Ralph E. Rodgers
Tennessee Valley Authority
400 West Summit Hill Drive
Knoxville, Tennessee 37902-1401

Re: Review of Stantec Stability Submittal for the Test Embankment Program at Area A at Kingston Fossil Plant, Harriman, Roane County, TN – AECOM Project No. 60095742

Dear Mr. Rodgers,

As requested by TVA's Barry Snider, we have reviewed the following work in progress documents provided by Stantec in emails to AECOM dated March 31, 2009.

1. Stantec Responses to AECOM Review Comments, Test Embankment Program, Kingston Fossil Plant, Harriman, Roane County TN, 4 pages, dated March 31, 2009.
2. Stantec Summary of Stability Analysis, Test Embankment Program – Area A, Test Embankment Program, Kingston Fossil Plant, Harriman, Roane County TN, 5 pages, undated.
3. Stantec Plots of Stability Analysis, Test Embankment Program – Area A, Kingston Test Embankment Program, 27 pages, undated.

Per TDEC directive, the remedial design documents for containment and closure of the Kingston Ash Pond and Dredge Cells will be reviewed by AECOM and TVA in regards to promote short and long term structural stability and integrity of ash ponds. AECOM has been requested to review remedial designs as we are the Root Cause Analyst (RCA) of failure at this site. Both TVA and AECOM have been appointed to the TDEC structural integrity peer review for this structure.

Review Comments

A. Stantec Responses to AECOM Review Comments to Test Embankment Program

We appreciate Stantec's responses to AECOM's March 25, 2008 letter and expect the Stantec documents will be updated to include the information necessary to construct the Test Embankment at Areas A and B in stages at controlled rates to ensure drained behavior.

B. AECOM Review Comments to Test Embankment – Area A Stability Analyses

There are several issues that should be understood by all parties involved with the instrumented Test Embankments:

1. Stantec Stability Analyses – The computed factors of safety focus on effective stress strength (ESA) parameters and assumed excess positive pore water pressures due to rapid filling and limited drainage. The analysis did not evaluate the undrained behavior (TSA) or undrained strength of the loose, wet ash. As an alternative, we performance monitoring to evaluate positive pore water pressures, settlement, lateral movement to detect shear strains under the test fill and ash foundation toward the north or east. There is a risk that too rapid a loading could trigger undrained behavior especially when the undrained strength of ash could be as low as 100 to 500 psf. Upon further review of our ash testing in the laboratory, we recommend Stantec reduce the threshold "Action" and "Alarm" levels or the excess pore water pressure measured in the deep flyash be reduced to 10 percent and 15 percent, respectively due to the contractive behavior of the ash.

Based on recently completed laboratory testing, the 30 and 50 percent limits discussed a week ago pose too much risk for another flow slide from AECOM's perspective. We have attached our computations for fill stability if full undrained conditions were to occur. For each stage, the computed safety factor is less than unity for undrained ash strength. This shows the importance of loading the ash in a slow to ensure drained behavior.

2. High Void Ratio Ash – The failed, saturated flyash south of AECOM Boring 09-500 has high void ratios (average of 1.0 or more). Furthermore, the void ratios under non-failed portions of the Dredge Cell 1 increase with depth; this is contrary to what is expected for normally consolidated materials deposited hydraulically. Normally sluiced dredged fill material become denser with depth due to higher vertical stress, resulting increasing normal consolidation of a particulate media by increased overburden stresses.

3. Measure Excess Pore Pressures – In addition to using pneumatic piezometers we also recommend several, real-time, continuous readout, vibrating wire piezometers with alarms located in the bottom of the failed ash to detect fill induced excess pore water pressure that could develop due to rapid placement of fill over saturated high void flyash. For normal soft soils there should be excess pore water pressure generated when fill is placed over it until upward seepage occurs into a drainage blanket or sideways to lesser hydraulic head locations under or around the Test Embankments.

4. Ash Placement Rates – We expect the ash will be placed in uniform lifts across the entire footprint of the Test Area A and B. Once the first lift is complete a second lift can be placed. Time should be provided to ensure that all of the piezometers and inclinometers are read before the next lift is placed. Our goal should be to make sure filling rates are slow enough to allow drained behavior in the ash during the test embankment construction.

5. Settlement Plates - Settlement plates placed over the failed ash at the base of the test fill will to measure actual vertical compression of the failed ash to complement the concept that with increasing more surcharge pore water is forced out of the ash resulting in a denser material, therefore resulting in settlement or consolidation.

6. Clay Strengths – We have run vane shears under the Cell 1 and next to the Test Embankment at Area A. We concur with Stantec use of 1,380 psf for the shear strength of the foundation clay under Area A. The lowest AECOM measured peak vane shear strengths were 1,400 psf at 09-500 and 1,900 psf at 09-303.

7. Vertical Inclinometers – The inclinometers are used to monitor fill induced lateral shear strains created by the presence of the adjacent slope or driving forces created by the construction of the Test Embankment. The purpose of these instruments is to measure lateral movements and check to see if lateral movements are substantially less than measured vertical movements (determined from the settlement plate readings).

8. Rate of Filling – The contractor should be flexible in fill placement rates to ensure the footprint can allow full lift coverage before the next lift is placed. Should pore water pressures become too high, alternate filling should be done in Area 2 or at the Ball Field area. The goal should be to fill at a rate that allows ash drainage with low pore water pressure buildup.

9. Construction Oversight – It is very important that Stantec have skilled personnel on site that can will take daily readings and have the authority to stop filling if the ash shows undrained behavior.

The test embankment will confirm whether filling will cause excess pore water pressures in the ash and evaluate the dissipation of excess pore into the overlying drainage layer constructed under the base of the test fill.

If there is little excess pore water pressure generated and minimal settlement, the ash is carrying the load on particle edges, like an uniformly graded fine sand or silt deposit. The concern here is that the loose sand or silt particles can suddenly shift under load from an edge to edge orientation to attempt to nest into a more stable denser structure, thus causing a rapid rise in excess pore water pressure and loss of the ash shear strength. This could lead to a sudden flow slide or static liquefaction. Since there is level ground beyond the test fill, the consequences of a flow slide or shift is minor. Furthermore, the existing 3H:1V cut slope from the north crest of Cell No. 1 is from elevation 817 feet down to the failed ash plain at elevation 757 feet. This 60-foot high mass will be buttressed with a terraced 40-foot high benched fill with average slopes flatter than 4H:1V. If ash performs in a drained manner, the Area A fill will provide added stability berm against the Cell No.1 relic.

As further confidence to move forward with the Test Embankment construction at Area A, the initial test embankment over failed ash next to AECOM boring 09-404 constructed of excavated ash from the Cell No. 1 test trench did not result in excessive settlement or lateral displacement. For 6 feet of fill placed over failed ash over a two week period, the settlement plates on ash settled less than 1 to 2.5 inches and the inclinometer showed lateral outward movement down 20 feet but limited to a maximum of ¼ inch at grade. There was no increase in pressure in the Boring 09-404 multi-level piezometers as they were situated just outside the footprint of the test fill and experienced minimal shear strains at depth from the construction of the test fill. We have observed the stockpiling of failed ash in the sloughs over failed wet ash. Several of these stockpiles exceed 15 feet in height but were built slowly.

The importance of the test fill is to demonstrate whether loading creates excess pore water pressures within the failed ash and underlying clay soils. We suggest that the fill be placed in three stages (e.g., 15-foot, 15-foot and then 10 foot high lifts) with hold periods to allow for data analysis and time to perform CPTu testing done after each stage to measure if there has been ash strengthening or densification. During hold periods, the Test Embankment at Area B can be raised to a lesser height than fill levels at Area A.

Summary

We are in favor of this engineered test embankment at Areas A and B with performance monitoring based on drained conditions. We can learn much about the foundation clay and failed flyash under monitored loading for relocated flyash built in stages up to 40 feet high above failed Cell 1 and 3 located at the north end of failed stack section using benched fill slopes no steeper than 3H:1V, with 50 foot wide benches for every 15 foot rise in fill. AECOM supports the premise that this engineered test fill solution based on analysis, design assumptions and testing be verified by daily monitoring and surveys. It would also be interesting to see if test filling can re-initiate minor movement along the December 22, 2008 failure plane. The failed section has little to no inertia in the failure mass to see movement at this time.

The TVA should avoid excavating deep continuous west to east drainage trenches along the series 09-200 holes and do not dig drainage trenches parallel to the toe of the Test Embankment A and B fills. The fact the failed ash has an angle of repose of less than 1% if evidence that the failed ash is loose (high void). We want to avoid flow slides than can occur due to increasing shear stresses caused by undrained loading under the test embankments by creating higher driving forces due to an increasing differential height of failed ash.

It would be very useful to run SPT test borings and/or CPTu after the test fill stage to see if there has been an increase in fill strength or consolidation of the failed loose and submerged flyash. We suggest their plan include some post-fill testing and CPTu probes to see if there have been ground improvements due to surcharge loading.

We suggest TVA and AECOM be copied on this daily instrumentation performance data to assist in site remediation design and review.

Please call us if you have any questions.

Very truly yours,

William H. Walton, P.E., S.E.
Vice President, Senior Principal Engineer

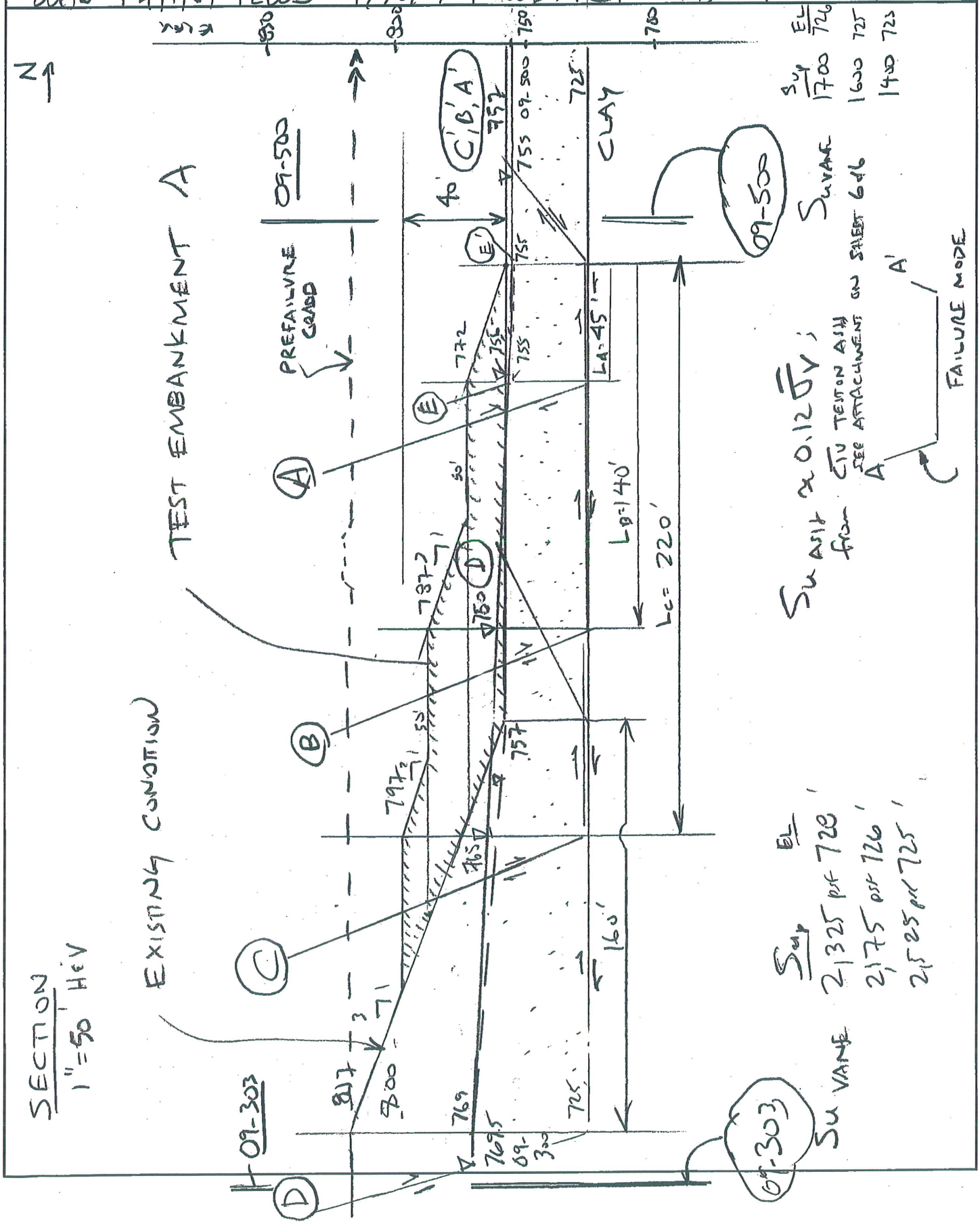
William Butler, P.E.
Senior Geotechnical Engineer

Attachments – Staged Stability Check of Test Embankment A

cc: Barry Snider – TVA – bssnider@tva.gov
Gonzalo Castro – Consultant – gv.castro@verizon.net

Calculation Sheet

Project	KINGSTON			Subject	TEST EMBANKMENT ANALYSIS		
Originated By	Date	Checked By	Date	STS Job No.	Scale	Sheet No.	
[illegible]	4/1/09	LWB	4/2/09	60095742	NTS	1	Of 6



Calculation Sheet

Project				Subject		
KINGSTON				TEST EMBANKMENT ANALYSIS		
Originated By	Date	Checked By	Date	STS Job No.	Scale	Sheet No.
ASH	4/1/09	LWB	4/2/09	60045742		2 of 6

ESTIMATE $S_u = SR\,\bar{\sigma}_{vo} = 0.12\,\bar{\sigma}_{vo}$

ASH

$SR = 23.18/2/96 = 0.12$

PRELIMINARY

CASE E: $\frac{772' + 757'}{2} - 755' = 764.5 - 755 = 9.5'$

@ EL 764.5 w/ ▽ EL 755.5'

$\bar{\sigma}_v = (0.5(0.0476) + 9(0.11))$

$\bar{\sigma}_v = (0.02 + 0.99) = 1.01$ ksf

$S_u = 1.01(0.12)$

$\therefore S_u = 0.12$ ksf

CASE A: @ EL = 766.5 ± w/ ▽ EL 755.5'

$\bar{\sigma}_v = (9.0(0.11) + 30.5(0.0476))$ (0.99)

$\bar{\sigma}_v = (0.99 + 1.45) = 2.44$ ksf

$S_u = 2.44(0.12)$

$\therefore S_u = 0.29$ ksf

CASE B: @ EL. 772 ± w/ ▽ EL 759'

$\bar{\sigma}_v = (15(0.11) + 32(0.0476))$

$\bar{\sigma}_v = (1.65 + 1.52) = 3.17$ ksf

$S_u = 3.17(0.12)$

$\therefore S_u = 0.38$ ksf

CASE C: @ EL 787 ± w/ ▽ EL 759'

$\bar{\sigma}_v = (27(0.11) + 35(0.0476))$

$\bar{\sigma}_v = (2.97 + 1.67) = 4.64$ ksf

$S_u = 4.64(0.12)$

$\therefore S_u = 0.57$ ksf

CASE D @ EL. 787 ± w/ ▽ EL 765'

$\bar{\sigma}_v = (22(0.11) + 40(0.0476)) = (2.42 + 1.90) = 4.32$ ksf

$S_u = 0.12(4.32)$

$\therefore S_u = 4.8$ ksf

Calculation Sheet

Project	Subject				
KINGSTON	TEST EMBANKMENT ANALYSIS				
Originated By: MAN	Date: 4/1/09	Checked By	Date	STS Job No.: 60095742	Scale: NTS	Sheet No. 3 Of 5

CHECK WEDGE A

$SF = 1.0 = \frac{S_u(L)}{E_A - E_p}$

SOLVE FOR S_u

$\phi_{ASH} = 28°$ $K_a = 1 - \sin\phi = 0.53$

$P_a = 0.53(772 - \overset{16}{756})(0.11) = 0.93$

$P_b = 0.93 + 0.53(\overset{0.78}{0.0476})31 + 31(\overset{1.93}{0.0624})$

$P_b = 3.64$

P_c $2(0.11)(0.53) = 0.12$

$P_d = 0.12 + 0.0476(\overset{0.757}{30})(0.53)$

$+30(\overset{1.872}{0.0624})$

$P_d = 2.75$

$E_A = \frac{0.93(16)}{2} + \frac{0.93 + 3.64}{2}(31)$

$E_A = 7.44 + 70.84 = 78.28$ k/ft

$E_p = \frac{2(0.12)}{2} + \frac{2.75 + 0.12}{2}(30)$

$E_p = 0.12 + 43.1$

$E_p = 43.2$

S_u reqd $= \frac{78.28 - 43.2}{45'}$ k/ft $= 0.78$ ksf > 0.29

S_u CLAY AT 09-500 1400 to 1700 psf

S_u ASH $= 290$ psf

CHECK WEDGE E

$P_a = 0.93$

$P_b = 0.93 + 1(\overset{0.062}{0.0624}) + 1(\overset{0.025}{0.0476})0.53$

$P_b = 1.02$

$P_b = 2(0.11)(0.53)$

$P_b = 0.12$

$E_p = \frac{0.12(2)}{2} = 0.12$

$E_A = \frac{0.93(16)}{2} + \frac{0.93 + 1.02}{2}(1)$

$E_A = 7.44 + 0.98 = 8.42$

$S_u = \frac{8.42 - 0.12}{45} = 0.184$ ksf

S_u ASH $= 120$ PSF

Calculation Sheet

Project	KINGSTON			Subject	TEST EMBANKMENT ANALYSIS		
Originated By	Date 4/1/09	Checked By	Date 4/2/09	STS Job No.	60095742	Scale NTS	Sheet No. 4 of 6

CHECK WEDGE B

$\phi_{ASH} = 28°$, $K_o = 0.53$

$P_a = 27(0.11)0.53 = 1.57$ ksf/ft $\qquad E_p = 43.2$ k/ft

$P_b = 1.57 + 35(0.0624) + 0.53(0.0476)(35)$

$P_b = 1.57 + 2.184 + 0.88 = 4.64$ ksf/ft

$E_A = \frac{1.57}{2}(27) + \frac{1.57 + 4.64}{2}(35) = 21.2 + 108.7 = 129.9$

$S_{u\,req'd} = \frac{129.9 - 43.2}{140'} = 0.61$ ksf > 0.38 ksf ASH

CHECK WEDGE C

$\phi_{ASH} = 28°$ $\qquad K_o = 0.53$

$P_a = 32(0.11)0.53 = 1.87$ ksf/ft $\qquad E_p = 43.2$ k/ft

$P_b = 1.87 + \overset{2.496}{40(0.0624)} + 0.53(40)\overset{1.01}{(0.0476)}$

$P_b = 5.38$ ksf/ft

$E_A = \frac{1.87(32)}{2} + \frac{1.87 + 5.38}{2}(40) = 29.9 + 145.0$

$E_A = 174.9$ k/ft

$S_{u\,req'd} = \frac{174.9 - 43.2}{L = 220'} = 0.60$ ksf > 0.57 ksf

Calculation Sheet

Project				Subject		
KINGSTON				TEST EMBANKMENT ANALYSIS		
Originated By	Date	Checked By	Date	STS Job No.	Scale	Sheet No.
[illegible]	4/1/09	[illegible]	4/2/09	60095742	NTS	5 Of 6

CHECK WEDGE D (Current Stability AT SITE)

$\phi_{ASH} = 30°$ $K_o = 0.53$

$P_a = 48(0.11)0.53 = 2.79$

$P_b = 2.79 + \overset{2.75}{44(0.0624)} + \overset{1.10}{0.047(44)(0.53)}$

$P_b = 6.64$ ksf/ft

$E_A = \frac{2.79(40)}{2} + \frac{2.79 + 6.64}{2}(44)$

$E_A = 66.96 + 207.46 = 274.4$ k/ft

$P_c = 40(0.0476)(0.53) + 40(0.0624)$

$P_c = 1.01 + 2.496$

$P_c = 3.51$ ksf/ft

$E_p = \frac{3.51(40)}{2}$

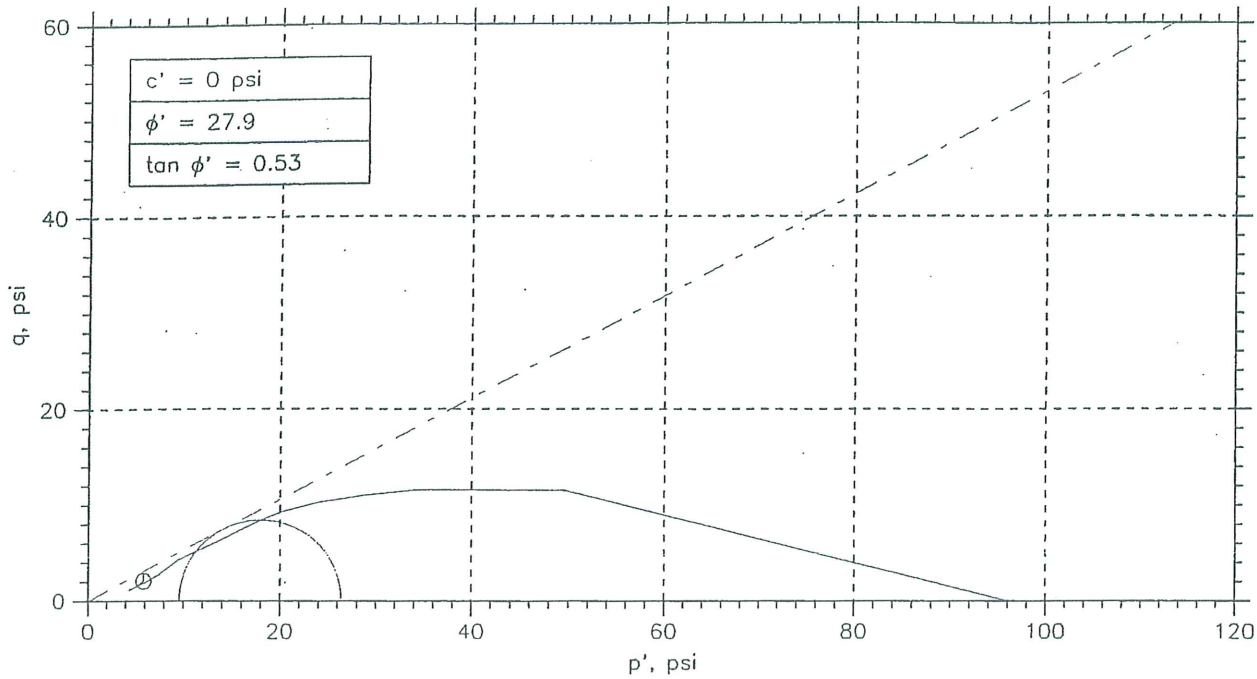
$E_p = 70.2$ k/ft

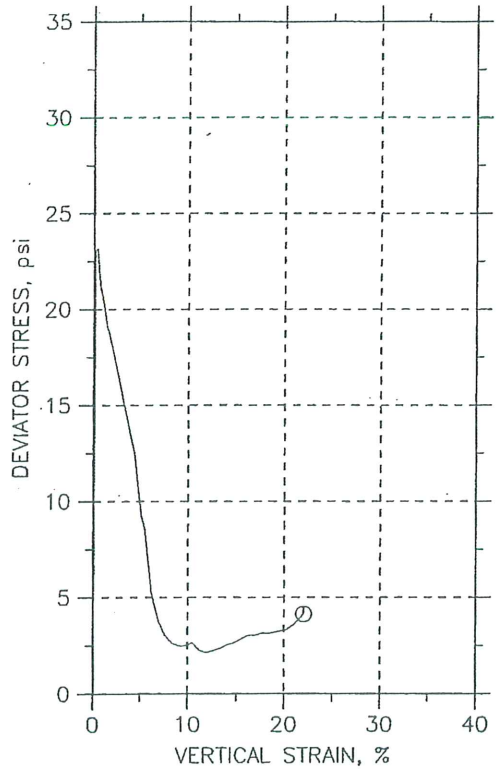
$S_{req'd} = \frac{(274.4 - 70.2)\ k/ft}{160'} = 1.28$ ksf > 0.48 ksf

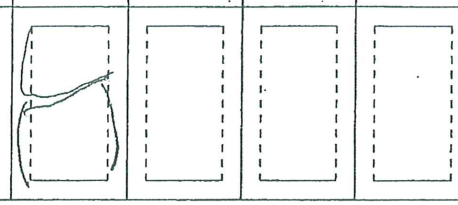
- Cell No. 1 North Slope was flattened and buttressed is currently stable due to drained behavior.

CONCLUSIONS: WE NEED TO ENSURE DRAINED BEHAVIOR DURING TEST EMBANKMENT FILLING. ONLY NOMINAL PWP CAN BE TOLERATED UNDRAINED FS ≤ UNITY. NEED INSTRUMENTATION

TRIAXIAL COMPRESSION TEST REPORT





Symbol		⦶			
Test No.		5742200B T2			
Initial	Diameter, mm	71.37			
	Height, mm.	165.36			
	Water Content, %	70.21			
	Dry Density, pcf	63.73			
	Saturation, %	128.87			
	Void Ratio	1.2531			
Before Shear	Water Content, %	43.24			
	Dry Density, pcf	71.99			
	Saturation, %	100.00			
	Void Ratio	0.99452			
	Back Press., psi	70			
Minor Prin. Stress, psi		96			
Max. Dev. Stress, psi		23.177			
Time to Failure, min		4.0005			
Strain Rate, %/min		0.15			
B-Value		---			
Estimated Specific Gravity		2.30			
Liquid Limit		NP			
Plastic Limit		NP			
Plasticity Index		NP			
Failure Sketch					

Project: KINGSTON COAL TVA
Location: TN
Project No.: 60095742
Boring No.: 09-200 SET
Sample Type: RECONST

Description: COAL ASH - DARK GRAY SPECIMEN RECONSTITUTED BY DRAINED SLURRY TECHNIQUE (B=0.99)

Remarks: FAILURE CRITERIA = MAXIMUM EFFECTIVE STRESS RATIO TEST PERFORMED AS PER ASTM D 4767

Tue, 31-MAR-2009 12:50:16

WORK-IN-PROGRESS

Test Embankment Program
Kingston Fossil Plant
Harriman, Roane County, Tennessee

Responses to Review Comments
April 7, 2009

Comments from William H. Walton and William Butler with AECOM dated April 2, 2009.

Comment No. 1: Stantec Stability Analyses – The computed factors of safety focus on effective stress strength (ESA) parameters and assumed excess positive pore water pressures due to rapid filling and limited drainage. The analysis did not evaluate the undrained behavior (TSA) or undrained strength of the loose, wet ash. As an alternative, we performance monitoring to evaluate positive pore water pressures, settlement, lateral movement to detect shear strains under the test fill and ash foundation toward the north or east. There is a risk that too rapid a loading could trigger undrained behavior especially when the undrained strength of ash could be as low as 100 to 500 psf. Upon further review of our ash testing in the laboratory, we recommended Stantec reduce the threshold "Action" and Alarm" levels or the excess pore water pressure measured in the deep flyash be reduced to 10 percent and 15 percent, respectively due to the contractive behavior of the ash.

Based on recently completed laboratory testing, the 30 and 50 percent limits discussed a week ago pose too much risk for another flow slide from AECOM's perspective. We have attached our computations for fill stability if full undrained conditions were to occur. For each stage, the computed safety factor is less than unity for undrained ash strength. This shows the importance of loading the ash in a slow to ensure drained behavior.

Response No. 1: Concur. It is recognized that on-going laboratory testing of recovered ash materials may impact conclusions/recommendations developed during earlier stages of the project. Accordingly, AECOM's previous recommended limits of 0.3 (trigger) and 0.5 (stop work or unload) have been reduced to 0.1 and 0.15, respectively.

Comment No. 2: High Void Ratio Ash – The failed, saturated flyash south of AECOM Boring 09-500 has high void ratios (average of 1.0 or more). Furthermore, the void ratios under non-failed portions of the Dredge Cell 1 increase with depth; this is contrary to what is expected for normally consolidated materials deposited hydraulically. Normally sluiced dredged fill material become denser with depth due to higher vertical stress, resulting increasing normal consolidation of a particulate media by increased overburden stresses.

Response No. 2: N/A.

Comment No. 3: Measure Excess Pore Pressures – In addition to using pneumatic piezometers we also recommend several, real-time, continuous readout, vibrating wire piezometers with alarms located in the bottom of the failed ash to detect fill induced excess pore water pressure that could develop due to rapid placement of fill over saturated high void flyash. For normal soft soils there should be excess pore water pressure generated when fill is placed over it until upward seepage occurs into a drainage blanket or sideways to lesser hydraulic head locations under or around the Test Embankments.

Response No. 3: Concur. Stantec proposes to instrument one select instrument cluster of four vibrating wire piezometers per test embankment. At these locations it is anticipated that vibrating wire piezometers will be connected to a data logger that will upload data via air card technology to a password access website. This website may be accessed by select individuals in order to review real-time pore pressure data. These data acquisition systems will be configured so that they may be moved to different piezometer clusters, if necessary.

Comment No. 4: Ash Placement Rates – We expect the ash will be placed in uniform lifts across the entire footprint of the Test Area A and B. Once the first lift is complete a second lift can be placed. Time should be provided to ensure that all of the piezometers and inclinometers are read before the next lift is placed. Our goal should be to make sure filling rates are slow enough to allow drained behavior in the ash during the test embankment construction.

Response No. 4: Concur.

Comment No. 5: Settlement Plates – Settlement plates placed over the failed ash at the base of the test fill will to measure actual vertical compression of the failed ash to complement the concept that with increasing more surcharge pore water is forced out of the ash resulting in a denser material, therefore resulting in settlement or consolidation.

Response No. 5: N/A

Comment No. 6: Clay Strengths – We have run vane shears under the Cell 1 and next to the Test Embankment at Area A. We concur with Stantec use of 1,380 psf for the shear strength of the foundation clay under Area A. The lowest AECOM measured peak vane shear strengths were 1,400 psf at 09-500 and 1,900 psf at 09-303.

Response No. 6: N/A

Comment No. 7: Vertical Inclinometers – The inclinometers are used to monitor fill induced lateral shear strains created by the presence of the adjacent slope or driving forces created by the construction of the Test Embankment. The purpose of these instruments is to measure lateral movements and check to see if lateral movements are substantially less than measured vertical movements (determined from the settlement plate readings).

Response No. 7: N/A

Comment No. 8: Rate of Filling – The contractor should be flexible in fill placement rates to ensure the footprint can allow full lift coverage before the next lift is placed. Should pore water pressures become too high, alternate filling should be done in Area 2 or at the Ball Field area. The goal should be to fill at a rate that allows ash drainage with low pore water pressure buildup.

Response No. 8: Concur.

Comment No. 9: Construction Oversight – It is very important that Stantec have skilled personnel on site that can will take daily readings and have the authority to stop filling if the ash shows undrained behavior.

Response No. 9: Concur.

Stantec intends to perform additional site characterization within the test embankment limits during various stages of the project. The primary purpose of this work is to assess the effect of embankment loading across various foundation materials.

AECOM

AECOM
750 Corporate Woods Parkway, Vernon Hills, IL 60061
T 847.279.2500 F 847.279.2510 www.aecom.com

April 9, 2009

sent via e-mail rerodgers@tva.gov

Mr. Ralph E. Rodgers
Tennessee Valley Authority
400 West Summit Hill Drive
Knoxville, Tennessee 37902-1401

Re: Review of Stantec Stability Submittal for the Test Embankment Program at Area A at Kingston Fossil Plant, Harriman, Roane County, TN – AECOM Project No. 60095742

Dear Mr. Rodgers,

As requested by TVA's Barry Snider, we have reviewed the following work in progress document provided by Stantec in an email to AECOM dated April 7, 2009.

1. Stantec Responses to AECOM Review Comments for the Summary of Stability Analysis, Test Embankment Program – Area A, Test Embankment Program, Kingston Fossil Plant, Harriman, Roane County TN, 3 pages, dated April 7, 2009.

Per TDEC directive, the remedial design documents for containment and closure of the Kingston Ash Pond and Dredge Cells will be reviewed by AECOM and TVA to promote short and long term structural stability and integrity of ash ponds. AECOM has been requested to review remedial designs as we are the Root Cause Analyst (RCA) of failure at this site. Both TVA and AECOM have been appointed to the TDEC structural integrity peer review for this structure.

Review Comments

We appreciate and concur with Stantec's responses to AECOM's review letter dated April 2, 2008 and expect the Stantec documents will be updated to include the information necessary to construct the Test Embankment at Areas A and B in stages at controlled rates to ensure drained behavior.

Summary

We are in favor of conducting engineered test embankments at Areas A and B with performance monitoring to maintain drained loading conditions. We can learn much about the foundation clay and failed flyash under monitored loading during construction of the test embankments. The relocated flyash built using benched fill slopes no steeper than 3H:1V, with 50 foot wide benches for every 15-foot rise in fill in stages up to a maximum 40-foot height. We are pleased Stantec will be performing explorations after each the completion of each bench. AECOM supports the premise that this engineered test fill solution, based on analysis, design assumptions and testing will be verified by daily by Stantec using instrumentation monitoring and surveys to demonstrate drained behavior. It would also be interesting to see if test filling can re-initiate minor movement along the December 22, 2008 failure plane. The failed section has little to no inertia in the failure mass to obsevered movement along the failure plane at this time.

We suggest TVA and AECOM be copied on this daily instrumentation performance data to assist in site remediation design and review.

Please call us if you have any questions.

Very truly yours,

William H. Walton, P.E., S.E.
Vice President, Senior Principal Engineer

William Butler, P.E.
Senior Geotechnical Engineer

cc: Barry Snider – TVA – bssnider@tva.gov
Gonzalo Castro – Consultant – gv.castro@verizon.net